MILITARY MEDICAL MANUALS

GENERAL EDITOR:
SURGEON-GEN. SIR ALFRED KEOGH
G.C.B., M.D., F.R.C.P.

FRACTURES OF THE ORBIT

FELIX LAGRANGE
EDITED BY
J. HERBERT PARSONS

MILITARY MEDICAL MANUALS

General Editor :

SIR ALFRED KEOGH, G.C.B., M.D., F.R.C.S.

FRACTURES OF THE ORBIT

FRACTURES OF THE ORBIT

AND INJURIES TO THE EYE IN WAR

BY

FELIX LAGRANGE

Professeur à la Faculté de Médecine de Bordeaux

TRANSLATED BY

HERBERT CHILD

Captain R.A.M.C.(T.)

EDITED BY

J. HERBERT PARSONS

Captain R.A.M.C.

With Seventy-seven Illustrations and Six Plates

UNIVERSITY OF LONDON PRESS, LTD.
18 WARWICK SQUARE, LONDON, E.C. 4
PARIS: MASSON ET CIE
120 BOULEVARD SAINT-GERMAIN
1918

PRINTED IN GREAT BRITAIN
FOR THE UNIVERSITY OF LONDON PRESS, LTD.,
BY RICHARD CLAY & SONS, LTD.,
LONDON AND BUNGAY.

GENERAL INTRODUCTION

THE infinite variety of injuries which any war presents to the surgeon gives to military surgery a special interest and importance. The special interest and importance, in a surgical sense, of the great European War lies not so much in the fact that examples of every form of gross lesion of organs and limbs have been seen, for if we read the older writers we find little in the moderns that is new in this respect, but is to be found in the enormous mass of clinical material which has been presented to us and in the production of evidence sufficient to eliminate sources of error in determining important conclusions. For the first time also in any campaign the labours of the surgeon and the physician have had the aid of the bacteriologist, the pathologist, the physiologist and indeed of every form of scientific assistance in the solution of their respective problems. The clinician entered upon the great war armed with all the resources which the advances of fifty years had made available. If the surgical problems of modern war can be said not to differ sensibly from the campaigns of the past, the form in which they have been presented is certainly as different as are the methods of their solution. The achievements in the field of discovery of the chemist, the physicist and the biologist have given the military surgeon an advantage in diagnosis and treatment which was denied to his predecessors, and we are able to measure the effects of these advantages when we come to appraise the results which have been attained.

But although we may admit the general truth of these statements it would be wrong to assume that modern scientific knowledge was, on the outbreak of the war, immediately useful to those to whom the

wounded were to be confided. Fixed principles existed in all the sciences auxiliary to the work of the surgeon, but our scientific resources were not immediately available at the outset of the great campaign; scientific work bearing on wound problems had not been arranged in a manner adapted to the requirements, indeed the requirements were not fully foreseen; the workers in the various fields were isolated, or isolated themselves pursuing new researches rather than concentrating their powerful forces upon the one great quest.

However brilliant the triumphs of surgery may be, and that they have been of surpassing splendour no one will be found to deny, experiences of the war have already produced a mass of facts sufficient to suggest the complete remodelling of our methods of education and research.

The series of manuals, which it is my pleasant duty to introduce to English readers, consists of translations of the principal volumes of the "Horizon" Collection which has been appropriately named after the uniform of the French soldier.

The authors, who are all well-known specialists in the subjects which they represent, have given a concise but eminently readable account of the recent acquisitions to the medicine and surgery of war which had hitherto been disseminated in periodical literature.

No higher praise can be given to the Editors than to say that the clearness of exposition characteristic of the French original has not been lost in the rendering into English.

MEDICAL SERIES

The medical volumes which have been translated for this series may be divided into two main groups, the first dealing with certain epidemic diseases including syphilis, which are most liable to attack soldiers, and the second with various aspects of the neurology of war. The last word on *Typhoid Fever*, hitherto "the greatest scourge of armies in time of war," as it has been truly called, will be found in the mono-

graph by MM. Vincent and Muratet which contains a full account of recent progress in bacteriology and epidemiology as well as the clinical features of typhoid and paratyphoid fevers. The writers combat a belief in the comparatively harmless nature of paratyphoid and state that in the present war hæmorrhage and perforation have been as frequent in paratyphoid as in typhoid fever. In their chapter on diagnosis they show that the serum test is of no value in the case of those who have undergone anti-typhoid or anti-paratyphoid vaccination and that precise information can be gained by blood cultures only. The relative advantages of a restricted and liberal diet are discussed in the chapter on treatment, which also contains a description of serum-therapy and vaccine-therapy and the general management of the patient.

Considerable space is devoted to the important question of the carrier of infection. A special chapter is devoted to the prophylaxis of typhoid fever in the army. The work concludes with a chapter on preventive inoculation in which its value is conclusively proved by the statistics of all countries in which it has been employed.

MM. Vincent and Muratet have also contributed to the series a work on *Dysentery, Cholera and Typhus* which will be of special interest to those whose duties take them to the Eastern Mediterranean or Mesopotamia. The carrier problem in relation to dysentery and cholera is fully discussed, and special stress is laid on the epidemiological importance of mild or abortive cases of these two diseases.

In their monograph on *The Abnormal Forms of Tetanus*, MM. Courtois-Suffit and Giroux treat of those varieties of the disease in which the spasm is confined to a limited group of muscles, *e. g.* those of the head, or one or more limbs, or of the abdomino-thoracic muscles. The constitutional symptoms are less severe than in the generalised form of the disease, and the prognosis is more favourable.

The volume by Dr. G. Thibierge on *Syphilis in the*

Army is intended as a *vade-mecum* for medical officers in the army.

Turning now to the works of neurological interest, we have two volumes dealing with lesions of the peripheral nerves by Mme. Atanassio Benisty, who has been for several years assistant to Professor Pierre Marie at La Salpêtrière. The first volume contains an account of the anatomy and physiology of the peripheral nerves, together with the symptomatology of their lesions. The second volume is devoted to the prognosis and treatment of nerve lesions.

The monograph of MM. Babinski and Froment on *Hysteria or Pithiatism and Nervous Disorders of a Reflex Character* next claims attention. In the first part the old conception of hysteria, especially as it was built up by Charcot, is set forth, and is followed by a description of the modern conception of hysteria due to Babinski, who has suggested the substitution of the term "Pithiatism," *i. e.* a state curable by persuasion, for the old name hysteria. The second part deals with nervous disorders of a reflex character, consisting of contractures or paralysis following traumatism, which are frequently found in the neurology of war, and a variety of minor symptoms, such as muscular atrophy, exaggeration of the tendon reflexes, vasomotor, thermal and secretory changes, etc. An important section discusses the future of such men, especially as regards their disposal by medical boards.

An instructive companion volume to the above is to be found in the monograph of MM. Roussy and Lhermitte, which embodies a description of the psychoneuroses met with in war, starting with elementary motor disorders and concluding with the most complex represented by pure psychoses.

SURGICAL SERIES

When the present war began, surgeons, under the influence of the immortal work of Lister, had for more than a quarter of a century concerned themselves

almost exclusively with elaborations of technique designed to shorten the time occupied in or to improve the results obtained by the many complex operations that the genius of Lister had rendered possible. The good behaviour of the wound was taken for granted whenever it was made, as it nearly always was, through unbroken skin, and hence the study of the treatment of wounds had become largely restricted to the study of the aseptic variety. Septic wounds were rarely seen, and antiseptic surgery had been almost forgotten. Very few of those who were called upon to treat the wounded in the early autumn of 1914 were familiar with the treatment of grossly septic compound fractures and wounded joints, and none had any wide experience. To these men the conditions of the wounds came as a sinister and disheartening revelation. They were suddenly confronted with a state of affairs, as far as the physical conditions in the wounds were concerned, for which it was necessary to go back a hundred years or more to find a parallel.

Hence the early period of the war was one of earnest search after the correct principles that should be applied to the removal of the unusual difficulties with which surgeons and physicians were faced. It was necessary to discover where and why the treatment that sufficed for affections among the civil population failed when it was applied to military casualties, and then to originate adequate measures for the relief of the latter. For many reasons this was a slow and laborious process, in spite of the multitude of workers and the wealth of scientific resources at their disposal. The ruthlessness of war must necessarily hamper the work of the medical scientist in almost every direction except in that of providing him with an abundance of material upon which to work. It limits the opportunity for deliberate critical observation and comparison that is so essential to the formation of an accurate estimation of values; it often compels work to be done under such high pressure and such unfavourable conditions that it becomes of little value for educative purposes.

In all the armies, and on all the fronts, the pressure caused by the unprecedented number of casualties has necessitated rapid evacuation from the front along lines of communication, often of enormous length, and this means the transfer of cases through many hands, with its consequent division of responsibility, loss of continuity of treatment, and absence of prolonged observation by any one individual.

In addition to all this, it must be remembered that in this war the early conditions at the front were so uncertain that it was impossible to establish there the completely equipped scientific institutions for the treatment of the wounded that are now available under more assured circumstances, and that progress was thereby much hampered until definitive treatment could be undertaken at the early stage that is now possible.

But order has been steadily evolved out of chaos and many things are now being done at the front that would have been deemed impossible not many months ago. As general principles of treatment are established it is found practicable to give effect to them to their full logical extent, and though there are still many obscure points to be elucidated and many methods in use that still call for improvements, it is now safe to say that the position of the art of military medicine and surgery stands upon a sound foundation, and that its future may be regarded with confidence and sanguine expectation.

The views of great authorities who derive their knowledge from extensive first-hand practical experience gained in the field, cannot fail to serve as a most valuable asset to the less experienced, and must do much to enable them to derive the utmost value from the experience which will, in time, be theirs. The series covers the whole field of war surgery and medicine, and its predominating note is the exhaustive, practical and up-to-date manner in which it is handled. It is marked throughout not only by a wealth of detail, but by clearness of view and logical

sequence of thought. Its study will convince the reader that, great as have been the advances in all departments in the services during this war, the progress made in the medical branch may fairly challenge comparison with that in any other, and that not the least among the services rendered by our great Ally, France, to the common cause is this brilliant contribution to our professional knowledge.

A glance at the list of surgical works in the series will show how completely the ground has been covered. Appropriately enough, the series opens with the volume on *The Treatment of Infected Wounds*, by A. Carrel and G. Dehelly. This is a direct product of the war which, in the opinion of many, bids fair to become epoch-making in the treatment of septic wounds. It is peculiar to the war and derived directly from it, and the work upon which it is based is as fine an example of correlated work on the part of the chemist, the bacteriologist and the clinician as could well be wished for. This volume will show many for the first time what a precise and scientific method the "Carrel treatment" really is.

The two volumes by Prof. Leriche on *Fractures* contain the practical application of the views of the great Lyons school of surgeons with regard to the treatment of injuries of bones and joints. Supported as they are by an appeal to an abundant clinical experience, they cannot fail to interest English surgeons, and to prove of the greatest value. It is only necessary to say the *Wounds of the Abdomen* are dealt with by Dr. Abadie, *Wounds of the Vessels* by Prof. Sencert, *Wounds of the Skull and Brain* by MM. Chatelin and De Martel, and *Localisation and Extraction of Projectiles* by Prof. Ombrédanne and R. Ledoux-Lebard, to prove that the subjects have been allotted to very able and experienced exponents.

ALFRED KEOGH.

AUTHOR'S INTRODUCTION

"*Ars tota in observationibus.*"

THIS little book is a record of actual experience. It has been written, not in a library, but in a hospital. Devoted helpers have watched the cases with us, made the daily records, treated the patients for long periods, and followed their progress still longer.

The reader must not expect to find profuse bibliographical notes here. Moreover, at the outset, we beg to be excused for not having more largely drawn upon all that has been written in France and abroad by army surgeons on Fractures of the Orbit. It seemed to us that the experience of those whose attention has been especially directed to this variety of traumatism rested on an almost negligible number of cases compared with the extreme abundance of the material at hand to-day, and we decided, whilst always regarding authority with the deference compatible with free exercise of judgment, to concern ourselves almost exclusively with what we have seen and done ourselves.

The study of our very numerous cases has furthermore often carried us far beyond classic ideas, and, in consequence, we have learned much. That is our immediate recompense; to it will be added a still more precious reward, if this work, by reason of the descriptions and the clinical deductions which it contains, should come to be considered not altogether unworthy of French Ophthalmology.

EDITORIAL NOTE

The modest title, "Fractures of the Orbit," which Professor Lagrange has given this work does not adequately describe its scope. It has therefore been deemed advisable to elaborate it somewhat in the English edition.

CONTENTS

LIST OF ILLUSTRATIONS

FRACTURES OF THE ORBIT

AND

INJURIES TO THE EYE IN WAR

CHAPTER I

HISTORICAL

THE history of fractures of the orbit by projectiles of war obviously cannot be traced farther back than the use of gunpowder, but in the old writers are found interesting notes upon orbital traumatism in combatants of all ages.

HOMER, in the Fourth Book of the *Iliad*, tells us that "Penelius struck Ilioneus beneath the eyebrow towards the back of the eye, of which the pupil was torn away; and the spear, piercing the eye, came out at the back of the head; and Ilioneus, his hands stretched forth, fell."

Does this not clearly indicate an orbital fracture with cerebral lesion? . . . In the ancient books many similar indications are to be found.

It is not only among the poets that we can find much to interest us in this subject. Hippocrates gives wise counsel when he writes: "If it be needful to attempt the extraction of a foreign body deeply forced into the orbit through integuments and orbital muscles, only light traction should be used, and if the difficulties are great, it will be better to temporise." (HIPPOCRATES, *De morb. vulgar.*, Lib. V, Chap. XXI.)

When, in the wars of the middle ages, firearms appeared, injuries of the face and cranium multiplied.

In the writings of Italian surgeons of the period mention is made, in very imperfect manner, of fractures of the orbit, treated by the application of boiling oil.

It is not until we come to the sixteenth century, in ALBUCASIS, FABRICIUS of ACQUAPENDENTE, and especially AMBROSE PARÉ, that we find detailed descriptions of orbital lesions, accounts of the tolerance, sometimes very great, of these cavities with respect to projectiles, and of the necessity, in spite of everything, of hastening their extraction for fear of serious complications. The interference advocated by these surgeons was attempted by them whenever occasion presented; hence they designed a varied series of instruments, and the bullet extractors of RAVATON, PERET and BRAMBILLA remain as types of these instruments in medical literature.

In PERCY'S *Manuel de Chirurgié d'armée* (1792), a chapter headed "Wounds of the face, with foreign bodies," instructs us as to the state of knowledge of lesions of the orbit and of the eyes at this time; more particularly concerning affections of the walls of the orbit, with their effects on the neighbouring sinuses, frontal and maxillary. COLLIGNON and SCHMECKER have found pieces of iron and whole bullets which have remained *in situ* for many years and been finally eliminated by way of the nose. Curious cases of this kind are also to be found in the *Ephemerides*.

According to PERCY, not all the cases with a bullet in the eye were as fortunate as the one in which COVILLARD replaced the eyeball in the orbit, from which a foreign body had displaced it. "It is all over," said he, "with that organ, no matter how slightly a projectile has touched it. If it happened to be lodged in the fat at the back of the orbit we used one blade of our forceps and replaced the eye by COVILLARD'S method."

To show the gravity of such injuries, PERCY quotes two cases, one which came under his own observation, the other noted by STALPART VAN DER WIEL, of large

intra-orbital foreign bodies (points of swords or foils), which caused fractures of the roof of the orbit and in which extraction was followed by cerebral symptoms and rapid death.

In his *Manuel de Clinique chirurgicale*, published in 1832, LARREY devotes a chapter to wounds of the face by projectiles of war, and is the first to set forth original views on the mechanism, prognosis and treatment of these injuries.

The great surgeon of the First Empire, from his personal observation, cited cases of rapid recovery from orbital fractures, even when they presented a certain degree of gravity, and he remarks that the younger the subject the quicker the recovery.

On the other hand, he quotes two cases with cerebral complications and ultimate death from meningitis.

In the necropsies of these two cases, LARREY notes that as a sequence of the perforation of the orbit by the projectiles the bones had proliferated and so considerably reduced the volume of the cavities. He sees in this Nature's protective efforts to repair the damage caused by the shot. Intra-orbital foreign bodies, he adds, are sometimes tolerated for very long periods, and then evacuation takes place, sometimes by the mouth, sometimes by the nasal fossæ.

BAUDENS, in 1836, and VALLÉE, in 1838, collect the cases previously published, the first in the form of clinical lectures, the second in his inaugural thesis. We do not, however, find in these works anything to merit prolonged consideration.

More important and instructive is the article published in 1851 by BERTHERAND entitled "Des plaies d'armes à feu de l'orbite" (Gunshot wounds of the orbit). "If a shot," he writes, "strikes the eye, the spherical elastic surface which it presents may cause the ball to deviate; or it may happen that the eye, without being ruptured, may be forced outside the cavity. Deflected by the globe, the projectile may retain sufficient force to fracture the bony walls of the orbit and lodge in adjoining cavities (sinuses,

nasal fossæ, cranium). The resistance of the bones which form the anterior margin of the orbit and the convexity of the superciliary arch explain the deviation of gun-shots and the comminuted fractures which result when they strike these parts. It is superfluous to emphasise the gravity of the injuries due to the frequent penetration of projectiles into the cranial cavity" (*Annales d'Oculistique*, 1851, p. 127).

DUPUYTREN, and after him DESMARRES, give a classification of orbitral fractures (1854). They distinguish: 1st. Fracture of the margin (DUPUYTREN and BAUDENS); 2nd. Fracture of the walls (DUPUYTREN and HENNEN), extending sometimes to the apex of the orbit; 3rd. Fractures of the apex, almost always complicated by visual disturbances, because of injury to the optic nerve; 4th. Fractures by "contre-coup," from traumatism of the cranial bones or of the bones of the face.

A similar classification, as regards intra-orbital foreign bodies, is given by DEMARQUAY in his "Mémoire sur les corps étrangers arrêtés dans l'orbite" (An account of cases of foreign bodies lodged in the orbit) (*Union médicale*, 2nd series, Vol. IV, 1859). DEMARQUAY, making use of cases reported by DEMOURS, DESMARRES, GENSOUL, WALDON, CUNIER, JOEGER, divides them into: 1st, projectiles propelled by gunpowder—shot, particles of lead, other fragments; 2nd, portions of perforating instruments; 3rd, fragments of glass; 4th. pieces of wood. He describes with precision the concomitant symptoms: sub-conjunctival ecchymosis, hæmorrhage from nose and mouth, and insists upon the exophthalmos produced by a collection of blood or pus. Orbital inflammations are not frequent in gunshot wounds, he says, because of the relative asepsis due to the heating of the foreign body. We should certainly emphasise the correctness of this remark; orbital abscess following gunshot injuries has become more and more infrequent with the improvements in modern ballistics and the great initial velocity of projectiles. DEMARQUAY further draws

our attention to the cerebral injuries which may remain long in a latent condition and suddenly cause the death of the patient from cerebral abscess.

Although PERCY advises enucleation of the eyeball to facilitate the extraction of the offending foreign body, DEMARQUAY, and with him WARLOMONT and TESTELIN, find this procedure too energetic, and very prudently recommend keeping the eye so long as vision remains.

In the following years there is but little mention of fractures of the orbit. However, in 1862 DEVAL, DICKSON, and in 1865 MACKENZIE, mention some observations on foreign bodies tolerated during long periods (from three months to seventeen years). Later comes BERLIN, who, in an essay well provided with references to authorities, clearly sets forth the matter.

From this work we extract the details which appear to us of importance. Should the projectile, says the writer, strike the temporal region obliquely the eye may be torn away. If it penetrate horizontally, traversing both orbits, section of both optic nerves follows (Thompson's case). Injuries of the lower wall, rarer than the others, smash up the orbital floor and the maxillary sinus. In some cases the projectile exhausts its penetrative power on the bones of the face and comes to rest against the roof of the orbit.

In fractures of the superior wall there is often an accompanying cerebral lesion. Recovery is frequently due to the facility with which the wound gets rid of its discharges, if the orbital margin is involved in the loss of substance (16 cases out of 19). In fractures of the vault alone prognosis is graver (41 deaths in 55 cases). Frequently death is sudden from hæmorrhage; or, on the other hand, delayed, from encephalomeningitis. Diagnosis of the seat of fracture is therefore of great importance, and BERLIN advises, what would be wrong otherwise, exploration of the injury by means of a probe. He enlarges next on fractures of the optic foramen with secondary lesions of the nerve, due either to compression or to the

tearing of the nerve-elements, brought about by splinters or by effusion of blood into the sheaths. He describes at length the ophthalmoscopic appearances in those disorders which lead to white atrophy. As to the treatment of orbital fractures, BERLIN recommends the removal of the bony fragments of the vault and the establishment of as perfect a system of drainage as possible, and advises recourse to enucleation only when vision is irremediably compromised.

MANZ (1867), SCHABERS (1872), and LEGOUEST (1873) confirm the facts demonstrated by BERLIN.

According to GALEZOWSKI (1875), fractures of the orbital margin are not very frequent. Most often mentioned are fractures of the internal angle, particularly of the lacrymal bone, and fractures at the apex with damage to the optic nerve. He quotes the classic case of NÉLATON (punctured wound with umbrella, fracturing the roof) and that of BORSA (foreign body in the orbit tolerated twenty-four years, extracted with success).

DE WECKER and LANDOLT (*Treatise on Diseases of the Eyes*, Vol. IV, p. 784, 1889) divide fractures of the orbit into direct and indirect, the first provoking exophthalmos, the projection of the eye forwards, and actual dislocation. They describe minutely the affections of the different walls and conclude by condemning probing of the wound owing to fear of introducing infectious germs from the orbital cavity into the cranium.

They emphasise the fact that the absence of every symptom on the side of the general condition, and of the cerebro-spinal axis in particular, does not imply a benign injury, for cerebral affections, often latent, may blaze out suddenly and lead to a fatal issue in a few hours.

DELORME, in his very remarkable *Traité pratique de Chirurgie d'armée* (1890), also reviews the various forms which have been discovered by clinical observation; his chapter is an accurate *résumé* of the knowledge available at that date.

We are indebted for information, unpublished from the point of view of statistics, to CHAUVEL (article "Orbite," *Dictionnaire des Sciences médicales*) and to CHAUVEL and NIMIER in their work on Military Surgery published in 1890. These authors have ascertained that fractures of the orbit, as frequent in 1870 as those of the cranium, have caused, as in previous wars, a much lighter mortality than the latter (6·9 per cent. instead of 21·7 per cent.). In the Crimea, the difference amongst our soldiers was less pronounced (18·5 per cent. instead of 28 per cent.); whilst during the campaign of 1866, the deaths following wounds of the face were five times less numerous than the losses from cranial lesions (3·9 instead of 21·7 per cent.); in Tonquin the difference is still more marked (4·44 per cent. against 25·28 per cent.).

Fractures of the orbit with ocular complications are relatively frequent, which is doubtless due to the slight resistance of the tissues of the eye, and also to its situation in a bony cavity, fractures of which affect the organ which it contains. The proportion of injuries of the eye to wounds in general is : 0·5 per cent. (America), 0·81 per cent (1870–1871)—a relation which in the Crimea rose to 1·75 per cent., and in the Russo-Turkish war (1877–1878) to 2·5 or 3 per cent. Relatively to injuries to the head, out of 100 some 5·5 can be reckoned (America, War of Secession); 7·7 (Denmark); 8·5 (1870–1871); and in the wars of the Crimea and the Caucasus the proportion was 11·3 and 18 per cent. Finally, out of 100 ocular lesions in the German Report of 1870, there are 47·6 of the left eye, 40·3 of the right eye, and 9·7 of both eyes. These statistics have further established that, following injuries of the orbit, the eyeball was destroyed in only 39·4 per cent. of the cases, and that small missiles caused the loss of the organ more often than large, which penetrate less readily into the orbital cavity. While on the subject of these statistics, and to complete them, we quote the following details :—

(*a*) *Injuries of the orbit with preservation of the eye :—*

1870–1871. German Report, 37·6 per cent. ; CHENU, 51·6 per cent. of cases wounded by large projectiles.

(*b*) *Injuries followed by destruction of the eye :—*

1870–1871. German Report, 62·4 per cent. ; CHENU, 73·5 per cent. by small projectiles.

1870–1871. German Report, 35·9 per cent. ; CHENU, 48·4 per cent. by large projectiles.

OTIS, in the War of Secession, gives 1190 cases of orbital gunshot injuries, of which 63 resulted in blindness of both eyes, and 725 in loss of vision of one eye. He adds 51 cases of injuries with disorder more or less marked of the visual function, and 256 indeterminate cases. The mortality was considerable in the first category, 17 out of 63 ; and in the second series 57 out of 725, owing to cerebral complications or lesions of the greater vascular trunks. Sympathetic ophthalmia appeared very frequently, but OTIS gives no information on this subject.

Besides articles by SCHMIDT (1873), by PANAS (*Traité des Maladies des Yeux*, 1874), by GOLDZIEHER (*Gunshot Injuries of the Orbit, and sequent visual disorders*, 1877), we find a very complete account by DELENS (in *Duplay et Reclus*, Vol. IV, p. 508). According to DELENS, who has judiciously weighed the previous literature on the subject, when the different points of the base of the orbit are struck by a bullet, the resulting injuries are rarely limited to the bony margin, and present great variety. Extension of the fracture to one of the walls of the cavity is very frequent ; it is especially so when the superior wall is involved, and in this region assumes a peculiar gravity, because of the proximity of, and possible damage to, the brain, which is sometimes laid bare. Fractures of the external wall are the most frequent ; if the projectile does not completely traverse the orbital cavity fracture of the external wall displaces the globe inwards and forwards, without directly

injuring it. But most frequently, especially with the penetrating force of modern projectiles, the bullet continues its path, fractures the internal wall, and if its direction be transverse, breaks both walls of the orbit on the opposite side, emerging through the temporal fossa. In this course the brain is often injured at the same time as the visual apparatus. One has seen, rarely it is true, both optic nerves simultaneously divided. Fractures of the internal wall, by reason of the proximity of the nasal fossæ and nasal canal, give rise to two almost constant signs, epistaxis and emphysema. Fractures of the inferior wall are accompanied by injury to the maxillary antrum. Should the intra-orbital nerve have been injured, blepharospasm or anæsthesia of the cheek occur. Under other circumstances, the fracture is followed by a falling in of the eyeball, which is displaced into the antrum (cases of MASSOT, MAGEL, and LANGENBECK). If the roof of the orbit is involved, the traumatism is almost always accompanied by loss of consciousness, paralyses, convulsions and coma. These lesions are of peculiar seriousness, but difficult at times of diagnosis, nerve phenomena being the sole symptoms which would cause their presence to be suspected. The wound must not be probed, and if the foreign body is still lodged in it attempts at extraction are often more dangerous than abstention.

In the period which extends from the commencement of the twentieth century to the beginning of the war there is no comprehensive work dealing with the subject. Some cases are recorded, amongst which we may mention those of COPPEZ (1899), fracture of the orbital vault with contusion of the globe and traumatic intra-orbital adhesion of the levator palpebræ and superior rectus; of LAROYENNE and MOREAU (1907), three cases of cranial fracture complicated with probable fracture of the optic foramen; of NIEVOLINA (1908), a case of gunshot wound of the orbit.

It remains to point out and recommend the two

very complete articles by ROHMER and ROLLET, which will be found *in extenso* in the *Encyclopédie française d'Ophtalmologie.*

ROHMER, after having explained the mechanism of the affections of the bony walls of the orbital cavity, describes the various ocular complications which may arise in consequence. He relates cases of amaurosis after contusion of the orbital margin—amaurosis which the ancients attributed to reflex action, and which PANAS and ABADIE set down to effusion of blood in the sheaths. DELORME, who reports several such cases from the war of 1870–1871, has found hyperæmia of the optic disc and the appearance of peri-papillary pigment deposits. This amaurosis may be transitory, or may result in white atrophy of the optic nerve. ROHMER then enlarges on the intra-orbital effusions of blood so frequently found; upon the cellulitis, which is, on the other hand, so rare, but of grave import if it accompanies a fracture of the vault; upon acute œdema of the adipose tissue (NIMIER); upon injuries to the optic nerve (neuritis, atrophy, avulsion, etc.); and finally upon injuries to the motor nerves and muscles of the eye (WOHL, BERTHOLD, CHAUVEL and NIMIER'S cases).

ROLLET, in the same encyclopædia (Vol. VIII, p. 374), studies in the first chapter the indirect fractures of the orbit caused by a fracture, either of the skull-cap or of the base of the skull, the mechanism of which has been elucidated by the experiments of ARAN, FELIZET, BRAQUEHAYE, CHIPAULT and others, dealing with fractures by radiation, contre-coup, or smashing in. He next describes direct injuries and passes in review the different varieties of osseous lesions of the walls. The copious list of authorities attached to this article has enabled the author to set forth, as well as possible considering the few documents to hand, the symptomatology, prognosis and treatment of these orbital lesions. ROLLET has investigated all the cases previously published by clinicians; and those interested in the question will find in this article

a complete bibliography which the nature of our work will not permit us to reproduce here.

A recent thesis, written at our instigation, should be noticed. It is by Dr. Antonio de Menacho, and is entitled, "*Heridas orbito-oculares en cirurgia de guerra.*" (Thesis, Madrid, 1916.)

The principal object of this historical sketch is to prepare the reader for comparing what has been observed by military surgeons in former wars with what we see in the war to-day.

CHAPTER II

THE ORBITAL CAVITY

Its Conformation, its Protective Rôle, its Resistance to Traumatism, its Vulnerability

The bones of the face and cranium in uniting one with another form several cavities, the most important of which is the orbital cavity, destined to lodge the eyeball, the muscles which move it, the vessels and nerves which animate it, and the cellulo-adipose tissue which surrounds and supports it.

Conformation

The orbital cavity has the form of a quadrangular pyramid, the antero-posterior axis of which is directed obliquely from before backwards and from without inwards. This comparison of the orbit with a pyramid, although classic, is far from being rigorously correct, for two reasons. First, the widest part does not correspond to the margin of the orbit, but is about a centimetre behind (Fig. 1). Second, the edges of this quadrangular pyramid are so slightly marked that the orbit really resembles a cone. The cast of the orbital cavity shows, in fact, that its walls are gently rounded; indeed, that the comparison of the orbit with a conical cavity is certainly the most correct that can be made. If, following the classics, we still give to it a pyramidal form, it is because it is more convenient for purposes of description to speak of a base, an apex, four surfaces and four margins.

We shall adhere to this division, artificial though it

may appear, and shall describe successively the base, apex, the surfaces and the margins of the orbital cavity.

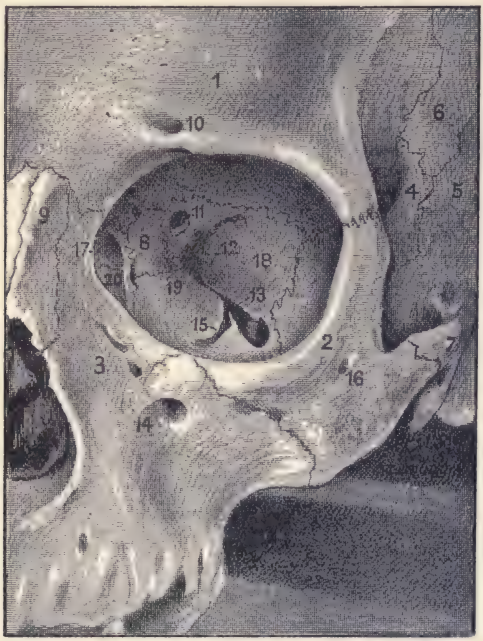

FIG. 1. *Bones of the Orbit.*—1. Frontal bone. 2. Malar bone. 3. Superior maxilla. 4. Superior portion of the great wing of the sphenoid. 5. Squamous portion of the temporal bone. 6. Anterior-inferior angle of the parietal bone. 7. Mastoid process. 8. Os planum of ethmoid. 9. Nasal bone. 10. Supra-orbital foramen. 11. Optic foramen. 12. Sphenoidal fissure. 13. Spheno-maxillary fissure. 14. Infra-orbital foramen. 15. Infra-orbital groove. 16. Foramen for malar nerve. 17. Lacrymal groove. 18. Lesser wing of sphenoid. 19. Orbital process of palate bone. 20. Lacrymal bone, os unguis.

Base.—The base of the orbit, circumscribed by the orbital margin, has the form of a quadrilateral with rounded angles. It is narrower than the cavity itself,

so much so that a solidified cast of the orbit cannot be withdrawn intact without breaking the bones.

The circumference of the orbit is formed above by the supra-orbital arch of the frontal bone, on each side by the angular processes, internal and external, of the same bone; internally and below, by the nasal process of the superior maxilla; externally and above, by the antero-posterior margin of the malar bone.

In passing the finger over the orbital margin several points are met with which merit special mention. Notice in the first place the supra-orbital notch or foramen (*incisura supra-orbitalis*), quite recognisable through the skin. This orifice is situated usually twenty-five millimetres from the median line. Very often to the inner side of the supra-orbital notch is to be found a small notch called the *incisura frontalis* (MERKEL). Outside this supra-orbital notch one notes that the orbital margin becomes particularly strong, prominent and resistant.

Apex.—The apex of the orbit corresponds to the most internal and widest portion of the sphenoidal fissure. This fissure is situated along the internal border of the great wings, and is the space between this border and the inferior surface of the lesser wings. The fissure, whose outline somewhat resembles that of a club, is wide internally and narrow externally, where it tapers off and is lost under the processes of Ingrassias (the lesser wings). The sphenoidal fissure transmits the third and fourth nerves, the ophthalmic branch of the trigeminal, the sixth nerve, the ophthalmic vein, a prolongation of the dura mater, and an arteriole, a branch of the middle meningeal. To the internal margin of the fissure is attached the ring of Zinn, inserted into a small bony tubercle, more or less developed according to the subject.

Walls and Surface.—The walls of the orbit are four in number: superior, inferior, external, internal.

The superior wall or roof is formed by two bones; the orbital plate of the frontal and the inferior surface of the lesser wing of the sphenoid. It takes the form

of a cupola, especially in its anterior part, by reason of the orbital margin which overhangs and tends to make the bend of the arch seem deeper.

In examining this superior wall of the orbit, there are to be seen: in front and externally, the lacrymal fossa in which is lodged the gland of the same name, behind this the suture of the frontal with the lesser wing of the sphenoid, externally that which unites the frontal with the great wing of the sphenoid; internally, that which joins the same bone with the paper-like os planum of the ethmoid. These sutures are quite invisible in the orbit when covered with periosteum.

The superior wall of the orbit is remarkable for its thinness; upon the dry bone, when the light passes through from above, the digital impressions of the anterior cerebral cavity can be readily seen. It should be noticed, however, that in the internal portion, in the adult, and still more in the aged, this surface is covered to a greater or less extent, by the frontal sinus, which is sometimes very large.

The inferior wall or floor is formed by the superior surface of the pyramid of the superior maxillary bone (the orbital process) and by the superior surface of the orbital process of the malar bone; posteriorly is to be seen the little orbital facet of the palate bone. This wall is smooth and regular, its highest portion is towards the inner side; thence the surface inclines forwards and laterally; it is slightly concave on the whole, but this concavity is not well marked; it may even give place to a certain amount of convexity, due to the maxillary antrum, which, like the frontal sinus, may attain excessive dimensions and become distended, and so in a manner raise the wall which separates it from the orbit.

Besides the sutures which unite the superior maxilla, the malar, and the palate bone, on the floor of the orbit is seen the intra-orbital groove, which, after a course averaging two centimetres, becomes a complete canal, the intra-orbital canal. The length of the groove in proportion to that of the canal varies in

different subjects; before it is roofed in by a plate of bone, the groove is changed into a canal by a fibrous membrane which is continuous with the periosteum of the orbit.

When the inferior wall of the orbit is examined on the living or dead subject the nerve is visible as a whitish cord, owing to the transparency of the periosteum.

The external wall is formed by three bones: the great wing of the sphenoid, the orbital process of the malar bone, and the most external portion of the orbital plate of the frontal bone.

The portion of this surface which belongs to the sphenoid is limited by the sphenoidal and the spheno-maxillary fissures; at this level the wall is flat; in front it is a little rounded; everywhere it is smooth, except in the vicinity of the sphenoidal fissure; quite at the posterior part there is a bony projection in the form of a spine, which serves for insertion of a portion of the external rectus (the lower head).

The sutures on this surface which unite the three bones, the malar, frontal, and sphenoid, have the form of a T, the horizontal branch of which extends from the outer extremity of the sphenoidal fissure to the external and superior angle of the base of the orbit, while the vertical branch, separating the malar bone from the great wing of the sphenoid, reaches the anterior extremity of the spheno-maxillary fissure. Further, on this surface must be noted the malar canal, which, commencing on the superior surface of the orbital process of the malar bone, bifurcates in the interior of the bone to open both on the internal and external surfaces; these two canals give passage to nerve filaments of the orbital branch of the superior maxillary nerve.

We will cut short this description, which must of necessity be brief; it will suffice if the reader, to grasp what follows, will carefully examine Fig. 1.

The Protective Rôle of the Orbit

Just as the cervical and dorsal vertebræ protect the spinal cord and the lumbar vertebræ the cauda equina, in the same manner the cranial vertebræ protect the encephalon and those advanced portions of the nervous system which are the sensory nerves, notably the optic nerve and the retina.

We are not concerned with taking sides for or against the vertebral theory of the cranium; we are quite aware that it is a much-discussed question, but we cannot forget that certain anatomist philosophers (Goethe, Oken) have not hesitated to describe four cranial vertebræ, and to find in each of them the constituent portions of a typical vertebra—a vertebral body, two vertebral arches and a spinous process. Those who accept these vertebræ classify them thus: Occipital, spheno-parietal, frontal and nasal; it is the third, the spheno-frontal vertebra, which interests us; its body is represented by the body of the anterior sphenoid, its foramen by the ethmoid notch, its laminæ by the lesser wings of the sphenoid and the frontal bone: it is this which forms the orbital chamber for the protection of the retina.

Grave objections have been brought against this theory. It is certain that the cranial bones have a special evolution; the base of the cranium comes from the endoskeleton, the cartilaginous skeleton, while the vault comes from the exoskeleton, the dermic skeleton; besides, above the basilar process, the notochord is no longer present, and *no notochord, no vertebræ.* Finally, in the cranium a phenomenon constant in the vertebral column is absent, viz. the appearance of small cubical masses separated by transverse lines, called protovertebræ. The cranium has no protovertebræ. However, these objections have not prevented Kölliker from accepting the vertebral theory of the cranium, relying upon the presence of certain swellings in the cephalic portion of the notochord, and upon the presence during fœtal life

of intervertebral discs; one of the most anterior of these discs, the third, is between the body of the anterior sphenoid and the posterior sphenoid. It belongs to the vertebra which surrounds and protects the eye.

Admitting that the vertebral theory of the cranium, properly so called, is no longer acceptable, there remains what is termed the segmental theory of the cranium (HERTWIG), which consists in supposing that the head of the vertebræ is the anterior prolongation of the trunk, and that, like the latter, it is composed of metameres (*Cephalic metamery*), in each of which three elements should be found—a mesodermic segment, a skeletal segment, and a nervous segment. It is evident that the cephalic metamery is much more complicated than that of the trunk, because the metameres of the head are sometimes divided into two, sometimes blended, and the different segments, mesodermic, skeletal and nervous, atrophy or develop according to the necessary adaptations of the organism.

Whatever share of scientific truth may be comprised in these different theories, it is none the less true that the fragment of brain which we term the optic nerve (commissural nerve), and the retina (cortical substance) find, in what the partisans of the vertebral theory of the cranium call the third vertebra, an efficient protection against traumatism. The box of bone which, like a substantial coffer containing a precious treasure, guards the cerebro-spinal axis is widely open at the level of the eye, because it is necessary that the eye should search the space in front of it; but behind and on every side, this box is solid and efficacious as a protective mechanism. Let us see by what fortunate arrangements it is enabled to resist injury.

RESISTANCE TO INJURY

It will be convenient to consider successively the base of the cavity and its four walls.

Resistance of the Base.—The base of the orbital cavity is built up, as we have seen, by the frontal, malar, and superior maxillary bones. These are three bones of great resisting power; a violent blow will be needed to fracture them, and in the mechanism by which they are locked together we again find conditions which add to the solidity they already possess from their thickness and the compactness of their substance.

In fact, it is evident that a traumatism, affecting the upper portion of the orbit at the level of the orbital arch, will be immediately communicated to the two pillars represented by the internal orbital and the external orbital processes of the frontal bone; the malar bone, so firmly locked into the facial foundation, and the superior maxilla, by means of its highly resistant upper portion, receive the shock. The vibrations produced by the blow of a blunt instrument will be spread over the bones of the face. In the same manner, the shock of the stroke of a hammer, handled by a giant, falling on the dome of a cathedral would be lost in the ground. If it is suggested further that the vault of the orbital arch is a vault like a basket-handle of the Roman type it will be seen how difficult it is to break it.

Should the blow strike the inferior orbital arch, the same conditions of resistance will be found. There again it is a question of an arch and a vault, and the blow, falling on the superior border of the maxilla or the horizontal ramus of the malar bone, will be propagated in the inverse direction to that of the shock to the superior arch, but under the same general conditions. The two orbital processes of the frontal bone in this case form the pillars; and the Roman vault, here as in the superior arch of the orbit, efficiently resists violent blows. When the injury affects the superior part of the orbit, its power will be dispersed in the facial mass; when it concerns the inferior part, the vibrations it sets up in the bones are lost in the cranial mass.

Finally, when a blow from a blunt instrument

strikes directly the external wall of the orbit, the malar bone itself, it meets a particularly efficacious resistance; for outside the pillars which receive the shock, and which are in this case the superior maxillary and the external process of the frontal, we find the zygomatic arch, which is quite comparable with the flying arches by means of which architects strengthen Gothic cathedrals. The crushing in of such a vault is particularly difficult; if a blow were struck on the dome of Notre Dame, the shock would be lost in the ground and would be transmitted there by the retaining walls or by the pillars, and by the flying buttresses. If a blow were struck on the malar bone, the two processes, frontal and maxillary, of that bone would transmit the vibrations through the superior maxillary and the frontal, whilst the zygomatic arch, a veritable cathedral flying buttress, would transmit them to the temporal. The base of the orbit resists the shock both like a Roman church and like a Gothic cathedral.

Resistance of the Walls.—The wall of the orbital cavity is extremely resistant from without; it is still solid below, but is thinner above, and paper-like within. Besides the thickness of its skeletal structures, the wall possesses in the mass of muscle covering the temple a most valuable defence, and on this side, which is really the only one exposed to traumatism, the eye is well protected. Moreover, when a blow reaches the external wall with sufficient force to cause fracture the track of the fracture cannot go very far; it is immediately checked above and below by the horse-shoe, concavity outwards, formed by the united sphenoidal and sphenomaxillary fissures.

The inferior wall is protected by the entire bulk of the face; to reach it, a projectile or a line of fracture must have in the first place involved the inferior maxilla and have crossed the antrum; besides, the wall is relatively thick, since it contains in its structure protection for an important nerve trunk, the intra-orbital.

The internal wall is slight, like the os planum of the

ethmoid which forms the greater part of it, but it is protected by all the ethmoidal cells, and is only reached when the traumatism has already produced great destruction in the surface of the opposite side. In this situation Nature has no need to oppose a strong barrier, the eye being protected by the actual thickness of the tissues and organs which separate it from the opposite side; the delicacy of the wall is not a disadvantage, so far as injury is concerned. But it is emphatically so from the point of view of the facility with which neoplasms, arising in the nasal cavities, affect the orbit, deflecting at first, and later perforating, the slight partition which separates them from the orbital cavity.

The superior wall of the orbit is equally thin, and more than this, it is at the same time orbital wall and cranial wall. It is this latter detail which explains why it is often injured. Of all the orbital walls it is perhaps that most often wounded, and this occurs because it can share in the cranial fractures (whose rôle will be studied later), and also because direct shocks on the superior orbital arch are easily conducted to it.

Application of the Laws of Dynamics to the Orbit.— In making use of the classic data put to profit by engineers and architects we can ascertain precisely and scientifically the manner in which the bones of the orbit offer resistance.

In the first place we may consider the structure of the bones which constitute the cavity; in the second place the specialised architecture of the orbital vaults.

(1) The bones of the orbit, like those of the cranium, are composed of two laminæ separated by spaces filled with bone-marrow; this separation is very favourable to resistance.

Thus, when a steel bullet is fired at a plate seven millimetres thick, it will pierce the plate of metal. Let this plate be split in two, and in the interval between the two plates, place sawdust, compressed

paper, or cork-powder; the bullet will not penetrate the two half-plates and their intermediate packing.

The projectile loses force in passing successively through media of varying density.

The frontal bone at its upper part, the malar bone, and the outer and inferior walls of the orbit may be compared to a metallic plate in two layers separated by a less dense substance, which is bone-marrow.

(2) Fig. 2 will demonstrate, without further words (save the accompanying explanation), how forces which attack the eye on the superior orbital region, on the malar bone, or on the inferior orbital region, act and are resolved.

Vulnerability of the Orbit

The cavity of the orbit in general is well protected where it is closed, but Nature has decreed that it should be vulnerable by reason of its numerous and wide apertures.

We will not discuss the principal opening. The eye is very fortunate in avoiding injury attacking it from the front, although nothing protects it beyond the membranous shield of the eyelids. Yet this shield fails when the nature or the speed of the projectile render it invisible.

But it is not alone by the base of the orbit that the cavity is vulnerable. The cavity communicates by important orifices: (1) with the cranium by the optic foramen and the sphenoidal fissure; (2) with the soft tissue of the facial mass and the pterygo-maxillary fossa.

The optic foramen, and especially the sphenoidal fissure, readily allow sanguinary effusions to pass from the base of the cranium. Orbital hæmatomata and exophthalmias occur, which are due solely to this cause, but it is especially the fissure and the pterygo-maxillary fossa which so well explain how injuries to this region may involve the eyeball. There is by this relatively large opening a ready communication between the orbital tissues and the soft parts, retro-

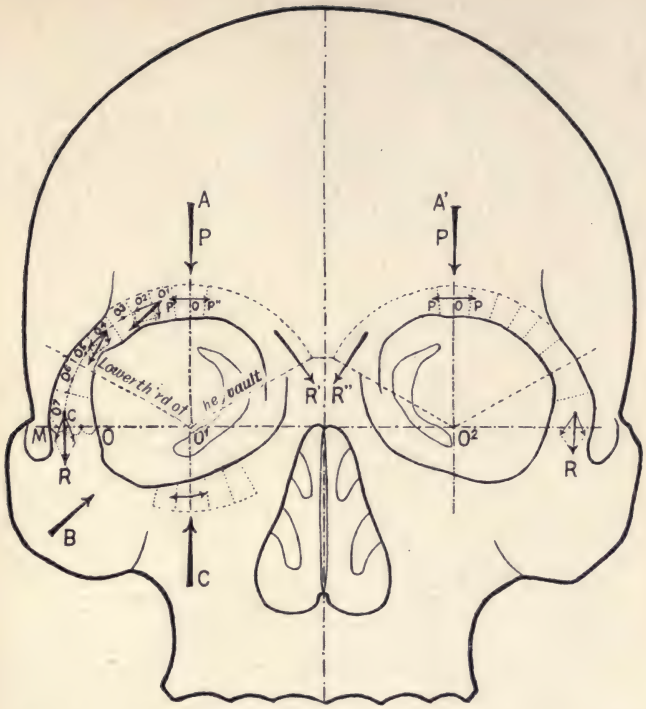

FIG. 2.—*Application of dynamic laws to the study of injuries to the orbit.*

A and A′. *Blow delivered on the superior part of the orbital arch.* This force divides into two components, thus : $P = OP' + OP''$. The total resultant of the forces due to propulsive force and weight must pass between O and C so that $MC = \frac{MO}{3}$; to obtain this result, it is necessary to enlarge the surface of the base of the courses (foundation) : hence the presence of the malar bone.

The resultants R′ and R″ which converge towards the nose, being equal and opposite, neutralise each other (principle of bridge piers).

B. *Blow delivered on the malar bone.*—The force in this case is resolved into three other forces whose resultants are lost in the process of the frontal bone = zygomatic arch (flying buttress of Gothic cathedral) and maxilla.

C. *Blow on the maxilla.*—The shock is resolved into two forces. The resultant of one is lost in the malar bone and the second in the upper portion of the superior maxillary bone.

maxillary and jugular (Fig. 3). Let a bullet or a piece of shrapnel penetrate sharply, either into the facial bony mass, or the soft parts, or more frequently into both, then by virtue of Pascal's hydrostatic law the rapid vibrations which result are transmitted to the orbit by the pterygo-maxillary fissure; the eye is struck after the manner of a rock submerged in the

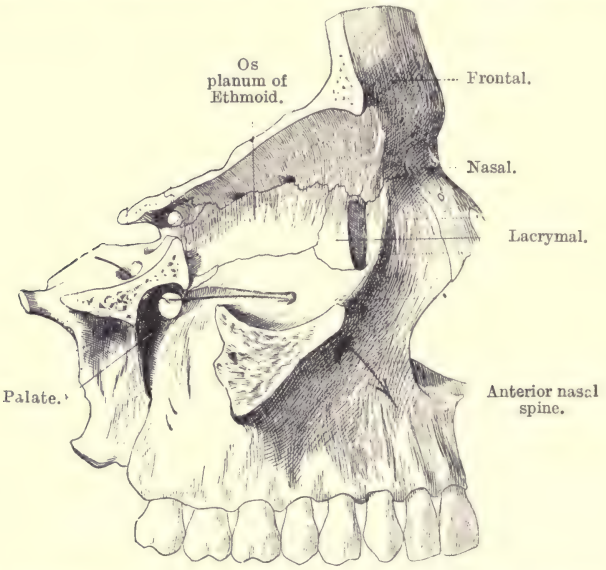

FIG. 3.—Pterygo-maxillary fossa (anterior wall and posterior opening).

sea and shaken by a deep wave. The first result of such a commotion in the orbit is the pushing forward of the eye as though to make it come forth from its normal situation, in spite of the optic nerve which resists and pulls it back, with more or less force, sometimes leading to rupture of the posterior part of the globe.

If we take into consideration the speed and the force of modern projectiles we shall understand that

the contents of the eye and its deep membranes cannot readily support such indirect and mediate traumatism, and that from it will result lesions, the descriptions of which will constitute one of the original features of the essay we have undertaken.

CHAPTER III

GENERAL CONSIDERATIONS UPON THE ÆTIOLOGY OF FRACTURES OF THE ORBIT

Their Frequency, Varieties and Pathogenesis

Fractures of the orbit by projectiles of war hold an important position in actual warfare, and they are important especially from the effect they have upon the visual apparatus and upon the organs which occupy the vicinity of the orbital cavity.

The following is a synoptical table which will show to the reader both a general survey of the Service d'Ophtalmologie de la 18e Région and the importance of the subject we are engaged in studying.

Fractures of the Orbit

609 *cases out of* 2554 *wounds inflicted in war.*

		Per cent.
(1) With preservation of the eyeball	397 say	65·5
(2) With destruction of the eyeball	212 ,,	34·5
(*a*) With preservation of the eye, without ocular lesion of any kind	105 ,,	17·2
(*b*) With ocular lesions	292 ,,	47·9

These lesions are :—

(1) Detachment of the retina	40 ,,	6·5
(2) Choroido-retinitis, atrophic and pigmented, macular and equatorial	94 ,,	15·5
(3) Choroido-retinitis proliferans	45 ,,	7·3
(4) Atrophy of optic nerve	29 ,,	4·7

			Per cent.
(5) Laceration of optic nerve	4	say	0·65
(6) Section of optic nerve	12	,,	1·96
(7) Optic neuritis, or retrobulbar neuritis	22	,,	3·6
(8) Hæmorrhage into the vitreous	31	,,	5
(9) Total cataract	7	,,	1·15
(10) Subluxation of the lens	2	,,	0·32
(11) Corneal lesions alone	6	,,	0·98

Furthermore, amongst these fractures we have observed :—

			Per cent.
(1) Complications in adjoining cavities—			
Sinus { frontal	31	say	5
Sinus { maxillary	110	,,	18·2
Brain	13	,,	2·1
(2) Complications of sensory nerves	43	,,	7
(3) Complications of muscles—			
Extrinsic	23	,,	3·77
Intrinsic	4	,,	0·65
(4) Blepharospasm from lesion of the infra-orbital nerve	2	,,	0·32
(5) Cellulitis of the orbit	2	,,	0·32
(6) Complications of the lacrymal passages	25	,,	4·1

The muscular lesions are divided thus :—

(1) Paralysis of the levator palpebræ	7
(2) ,, ,, ,, superior rectus	4
(3) ,, ,, ,, inferior rectus	4
(4) ,, ,, ,, internal rectus	2
(5) ,, ,, ,, external rectus	2
(6) ,, ,, ,, superior oblique	2
(7) ,, ,, ,, inferior oblique	1
(8) ,, ,, several nerves simultaneously	4
(9) ,, ,, intrinsic muscles alone	2

The fractures which bring about these affections may be divided into direct and indirect fractures; but they occupy in this respect positions singularly unequal; for while direct fractures are extremely

common in our service, it is impossible to quote more than two clear cases of indirect fracture. We must emphasise this clinical datum, which merits consideration.

Indirect fractures are sometimes fractures radiated from the superior portion or the base of the cranium to the orbital vault, or sometimes fractures by contre-coup ("independent," TRÉLAT), which continue the general directions of a line of cranial fracture. To judge from the classic authorities, and from the best of them, this type of orbital traumatism should form a prominent feature in the practice of ocular surgery, and cranial fractures—of which we do not need here to recall the numerous theories—should frequently implicate the sphenoid and the frontal in their orbital portion. Such is, however, not the case, for these lesions are extremely rare.

Doubtless the objection might be raised that such injuries have not come under our notice, because the cases have not had time to arrive at the base, where we have been engaged in the study of military ophthalmology, or perhaps still more that, amongst the important accidents experienced by the wounded, orbital injuries have passed unnoticed, and that general surgeons alone have been able to observe the variations in fractures of the vault of the orbit.

This latter objection loses all its force precisely because, in the Service Central de la 18^{e} Région, we met with a large number of very important cranial injuries which we observed with particular care. These were cases of fractures of the skull in the parietal and occipital regions which presented visual trouble, and in particular, hemianopia. Our pupil, DR. BEAUVIEUX, has written an elaborate memoir on this subject, not yet published, dealing with cases in which cranial traumatism, always very important, was sometimes pre-eminent. It treats of fractures by bullet or by shell which have made great breaches in the cranial walls and often caused fractures to radiate to great distances.

In none of these cases has the optic nerve been implicated; in none of them have the structures passing through the sphenoidal fissure been damaged. We must conclude that there have not been fracture-radiations over the vault of the orbit; and if, indeed, such traumatisms have neither produced fracture by radiation nor independent fracture by contre-coup we must deduce that, in sound military ophthalmology, there is no need to attach importance to a lesion whose frequency has been singularly exaggerated in previous literature.

Furthermore, we are not the only authors who have studied visual disturbances consequent on traumatism of the cranial regions which cover the visual psychic lobes; PIERRE MARIE and CHATELIN have published a very important essay on this subject in the *Revue de Neurologie* (December, 1915, Nos. 23 and 24). In this they report thirty-six observations of cranial fracture, of which thirty-one were complicated by hemianopic modifications of the fields of vision. In all these cases, save one, the authors have noted no damage to the transparent media nor to the deep ocular membranes, nor to the intrinsic or extrinsic muscles which might suggest a fissure radiating into the orbit. The diplopia mentioned in two or three of the cases has rapidly disappeared, and did not seem to be the consequence of attrition of nerve filaments at the site of the sphenoidal fissure.

In Case XXXI, however, MARIE and CHATELIN found a double optic atrophy, but they attribute it to a diffuse lesion of the chiasma, the patient having had a cerebral abscess with meningeal trouble.

We have had another proof of the extreme rarity of radiating fractures and fractures by contre-coup of the orbital vault; it is that we have never been able, in the numerous radiograms which we have had placed at our disposal, to see a fissure track indicating a solution of continuity of the vault extend as far as the sphenoidal fissure. We are quite aware that it is a difficult region to radiograph, and that this may be

the explanation of the absence of any trace of fracture upon our negatives; but as, on the other hand, there is no symptom indicating that the motor or sensory nerves of the eye have been damaged in the optic foramen or the sphenoidal fissure, it must be concluded that the orbital cavity in general does not suffer by radiation or contre-coup in the gravest gunshot fractures of the cranial vault.

Twice only have we found this condition; in one case the fracture was by radiation; in the other, by contre-coup. What are 2 out of 609 cases of fracture of the orbit?

The 607 other cases which have been examined by us have been direct fractures.

These *direct fractures* have been produced by bullets (150 times), by shrapnel (14 times) and by shell fragments (440 times). MENACHO has noted that more than half the orbito-ocular injuries were produced by bullets, because he studied the injuries at the outset of the campaign; later on, during the trench warfare, shells have played a much greater part. These injuries sometimes affected the wall of the orbit, sometimes the margins; it was the bullets especially that injured the walls, and they often perforated and traversed both orbits. All ophthalmologists have seen soldiers, both of whose optic nerves have been injured, sometimes divided by the same projectile. The pointed bullet, conical and endowed with great velocity, after having traversed the bony walls, readily passes into the neighbouring cavities. Shrapnel balls, on the contrary, having less velocity, very often remain in the orbit. We have removed a number of them with or without preservation of the eye; the same applies to shell fragments. Very rarely do they pass beyond the orbital cavity to lodge in the nose, the antrum, or the cranium; often, indeed, they are checked by the orbital wall, driving it in without passing through it, but they produce grave commotion in the contents of the cavity before coming to rest against one of the walls.

Pathogenesis

Three theories have been advanced to explain the mechanism of *indirect fractures* of the orbit by gunshot wounds—

(1) The scattering of the projectile, fragments of which strike the internal wall of the cranium.

(2) The cone of air produced by the flight of the bullet is the true projectile capable of smashing the wall of the cranium.

(3) The hydrostatic pressure, based upon Pascal's law. The projectile when entering the cranial cavity produces a sudden increase of pressure which is transmitted with equal force over the whole internal surface of the cranium. The orbital vault being the thinnest portion of the cranial wall should therefore be frequently fractured.

The last theory would appear, *a priori*, to appeal to the judgment, and with Braquehaye and Chipault we were quite disposed to accept it, if clinical experience had demonstrated to us the existence of such fractures; but since, as we have said above, we have studied minutely all the visual signs of the very large number of cases which have suffered from the entry of projectiles into the cranium without meeting with a single instance in which the orbital roof was fissured, we cannot attach great importance to a theory which is not upheld by the facts. We do not further labour the point, but we wish to make use of the wealth of material at our disposal to point out that, in gunshot wounds of the cranium, fractures of the orbital roof are produced neither by radiation nor by contrecoup.

With the help of Dr. Beauvieux, who, moreover, has been our constant and painstaking assistant in all the researches with which this little book is concerned, we have examined 193 gunshot fractures of the cranium. There were well-marked bone injuries in the greater number of the cases; we have noted in the parietal and occipital regions a loss of substance

over a surface larger than a crown-piece; often the bullet had traversed the cranium from side to side, that is to say, the traumatism had fulfilled all the conditions necessary for the applications of PASCAL'S law, and yet never—*we repeat, never*—has the patient presented the least evidence of injury about the optic foramen or the sphenoidal fissure. Not a motor paralysis, not a sensory paralysis, not an atrophy of the optic nerve, has resulted from the mischief in the bony box of the cranium. As clinical observers, we are therefore perfectly entitled to affirm that gunshot fractures of the cranial vault are not accompanied by either fracture or radiation, or by fracture by contre-coup, such as to implicate the orbital roof and the optic foramen.

We do not deny the existence of fracture by radiation as they were described long ago by ARAN, and afterwards by all those who have studied the pathology of fractures of the skull (FÉLIZET, CHIPAULT and BRAQUEHAYE, etc.); further, we do not deny fractures by contre-coup ("independent," TRÉLAT), that is to say, those which, interrupted for a moment in their course, continue in the orbital vault the line of fracture of the cranial vault; but we do affirm that these fractures are the consequence of falls upon the head, of violence to the skull produced by blunt bodies, and that they do not follow gunshot injuries. From this point of view it will be well to quote the authorities here and to interpret them; we shall see that the clinical facts and experiments are not in disagreement with our point of view.

If we read attentively the excellent article by ROLLET upon fractures of the orbit in the *Encyclopédie d'Ophtalmologie* (Vol. VIII, p. 375 *et seq.*), we see, in fact, that the fractures radiated from the vault to the base are due to falls on the vertex. These radiations to the orbital vault are very common (23 out of 68 cases, PRESCOT-HEWETT; 79 out of 86 cases, DE HOLDER); but in these cases, when one is dealing with gun-shot fractures, it is a question of suicide, and under

these circumstances the orbit is necessarily implicated. Suicides fire a bullet into the mouth, or under the chin, or in a region adjoining the orbit, so that a fissure of the orbit is produced by direct shock. The same applies to the case quoted by ROLLET, of assassination by the blow of a spade on the orbital region. Here it was not a question of fracture of the cranium propagated to the orbit, but of a fracture of the orbit spreading to the cranium. In examining the 79 cases of fissure of the orbit cited by DE HOLDER, we find 53 cases of fracture of the optic foramen; of these 53 cases, 42 are fractures from gunshot; but in these 42 cases, 32 are shots fired into the mouth, and 10 into the temple and forehead. These are evidently not radiated fractures, but direct fractures of the orbital vault; in the 10 other cases it was a question of a fall, or of a crushing blow. It is very evident that DE HOLDER'S statistics in no way contradict our opinion, which is, that fractures of the cranial vault do not secondarily affect the orbital vault by radiation or by contre-coup; orbital fractures are direct, or do not occur at all.

Let us see what the authorities in military surgery say.

CHAUVEL and NIMIER write: "Besides these direct fractures, the orbital vaults are sometimes implicated by fissures radiating from a fracture of the cranial vault; we may even observe there true fractures at a distance and by contre-coup" (*Chirurgie d'armée*, p. 336). They are speaking, however, in a general manner; they nowhere say that gunshot fractures of the cranium radiate over the roof of the orbit; on the contrary (p. 294 *et seq.*) they write that "in crania fractured by projectiles the fissures are parallel to the direction of the violence, that is to say, antero-posterior in fronto-occipital shots, transverse when the projectile has passed from one temple to the other; when the wound is frontal, the two superior fissures on each side run horizontally from front to back and tend to rejoin at the occiput, thus circumscribing the

skull-cap by a circular fissure ; the two oblique branches below and behind join the temporal fossa towards the base of the petrous portion ; these fissures tend to detach the cranium from the bony mass of the face. In transverse gunshots, we again find the circular fissure, which instead of detaching the superior part of the bony vault from the inferior, seems to prefer to divide the cranium into two portions, anterior and posterior."

CHAUVEL and NIMIER nowhere mention fissures radiating from the cranial vault to the orbit.

DELORME writes : " In bi-temporal, bi-parietal, and bi-occipital perforations, we sometimes see fissured radiations towards the base, but they are relatively rare. The fissures have a tendency to take the circular direction rather than the vertical " (*Traité de Chirurgie de guerre*, Vol. II, p. 547) ; and further, on p. 553, DELORME says again, concerning indirect fractures or those by contre-coup, that " of a large number of crania which we have opened after having fractured or perforated them by projectiles, we have not been able to discover one."

The assertion which we have made on the other side, and which at first might have caused surprise, is therefore quite in accord with classic findings, whether they belong to the clinical or experimental order ; and we might write here this aphorism : " Gunshot fractures of the cranial vault lead neither to fractures radiating into the orbital roof nor to fractures by contre-coup."

Fractures of the orbital vault and of the optic canal, when they are produced by radiation, are the result of falls on or violent contusions of the vertex ; more often they result from direct blows in the region of the orbit ; gunshot of the forehead, contusion of the superciliary arch, fractures by telescoping, due to a fall upon the feet.

The ætiology and pathology of *direct fractures* need not detain us long ; one expects to find that gunshot wounds often affect the circumference of the orbit and

its walls; we note the possibility, and even the relative frequency and gravity, of isolated fractures of the superior wall with integrity of the margin. The margin, thanks to the arrangement we have pointed out above (Fig. 2), has resisted, but the orbital vault, extremely thin, has yielded to the influence of the oscillatory vibrations imparted to neighbouring tissues by the violence of the blow. Grave accidents are to be anticipated to the optic foramen (atrophy of the nerve), and on the side of the brain (meningo-encephalitis), as a consequence of these latent fractures.

The projectile which smashes the superior border of the orbit often implicates the frontal sinus. LEGOUEST has reported the case of an officer who carried a bullet for eighteen years in this sinus, when it fell spontaneously into the pharynx.

The internal wall of the orbit is more fragile; it is easily perforated, even by small missiles. We have seen fragments of grenade perforate the os planum and lodge in the ethmoid, where, moreover, they are often well tolerated.

One of the most frequent amongst the injuries of war is that which affects the malar bone. It may be carried away by a bullet or crushed by a shell fragment. In a case of DELORME'S, a bullet struck obliquely the infero-external angle of the orbit and loosened a corner of the bone. Very often the bullet or shell fragment does away with the malar bone, destroys the eye, and in passing out leaves a notch in the supra-orbital arch.

Fracture of the external wall of the orbit is, *par excellence*, that which results from attempts at suicide; it has, however, not been rare in our experience, and reports will be found later. Sometimes a bullet perforates the two orbits and severs or destroys both optic nerves without touching the eyes. In several of our cases the bullet has entered near the tragus, traversed the orbit from behind forwards, from without inwards, and from below upwards, severing the optic nerve and emerging at the root of the nose.

Fig. 35 gives the ophthalmoscopic appearance in an old avulsion of the optic nerve, as well as Fig. 1, Plate III.

If we wished to enlarge upon the ætiology of these fractures of the orbit, we should only have to take one by one the cases cited later and expatiate on their peculiarities. Perusal of the case reports and the examination of the tables which accompany them will suffice.

Moreover, the pathology of the conditions resulting from direct fracture of the circumference and walls of the orbit is only interesting so far as it concerns the injuries to the orbital contents (including the eye). Lesions of the skeleton evidently depend upon the propulsive force of the wounding agent, its mass and its form; they depend also upon the point struck; when the projectile meets the malar bone, as very frequently happens, it causes a comminuted fracture of that bone and often lodges in its substance. There are no radiated fractures, because the pterygo-maxillary fissure checks the course of the fracture; on the other hand, when the wounding agent strikes the frontal bone at the level of the superior orbital margin, the violent contusion of this bone is accompanied by a fracture of the orbital vault spreading to the sphenoidal fissure and the optic foramen, implicating the very important organs found in this neighbourhood.

If the reader will add to these considerations what has been said above on the subject of the resistance of the orbit to traumatism, he will be in possession of all that concerns the pathogenesis of fractures; what remains to be said will be more appropriate when we come to speak of the various visual troubles which these fractures provoke.

CHAPTER IV

FRACTURES OF THE ORBIT WITH PRESERVATION OF THE EYEBALL

We shall divide the fractures of the orbit, from the point of view of their effects on the visual apparatus, into two great classes—

I.—Those in which the globe is preserved.
II.—Those in which the globe is destroyed.

We shall commence by speaking of the first, and we shall place immediately before the reader the chief data, viz. the principal clinical demonstrations gained from our experience.

§ I.—The Laws Governing the Affections of the Visual Apparatus in Injuries of the Orbit with Preservation of the Eyeball

(1) When the projectile passes above the orbit, implicating the frontal bone and the anterior cerebral region, it produces fractures of the orbital vault affecting the sensory, motor, and optic nerves in the region of the optic foramen and the sphenoidal fissure. The eyeball is not involved.

(2) When the projectile passes below the eyeball without traversing the orbit and without fracturing it, it produces concussion affecting the eye in the macular region. This is the great cause of diminution or loss of acuity of central vision.

(3) When the projectile has fractured the orbit, crushing in the wall more or less, without touching the eyeball, it produces in the globe grave concussion

injuries, macular lesions and choroidal ruptures. Macular lesions occur, irrespective of the wall damaged, whether external, internal, or inferior.

(4) When the projectile has traversed the orbit without touching the eyeball, it produces the same disorders together with those which result from the laceration of the organs contained in the orbital cavity. The optic nerve is often divided; the papilla is then lacerated as if torn away.

(5) When the projectile grazes the eyeball tangentially, without rupturing it, or when the globe is touched by the orbital wall being driven in upon it, it causes damage in immediate relationship with the bruised point (choroido-retinal lacerations with detachment of the retina and retinitis proliferans); the macular region is often involved in the damage, but it is not injured alone.

If these laws were based only on theoretical considerations they would certainly be ill-founded, but they rest on the study of cases, upon clinical evidence, and it is for this reason that we desire to make them known.

The case-reports are divided into two categories :—

First Category.—Fractures of the orbit with preservation of the eye, without retention of a foreign body.

Second Category.—Fractures of the orbit with preservation of the eye, with retention of a foreign body.

First Category

The first category of case-reports is divided into five groups.

First Group

Fracture of right orbit by rifle bullet. (Case 1.)

C. T., Cavalry, wounded May 10, 1915, at L. A rifle-bullet had penetrated the left supra-orbital region, at 1 cm. from the end of the eyebrow, and emerged from the right supra-orbital region near the temporal fossa, 2 cms. in front

of the temporo-maxillary articulation (Fig. 4). T. lost consciousness for twenty four hours and was trephined the next day.

Condition on admission, Jan. 15, 1916. The aperture of entrance of the projectile is extremely painful to the touch. The zone of emergence is very excavated, like a cupola; at this point there is depression of the bones, frontal and temporal, near the suture between the two bones, a little behind the external orbital process. No cerebral pulsation.

There is a fracture of the right superior orbital margin,

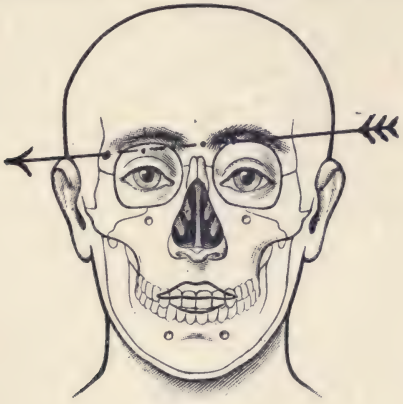

FIG. 4.

the seat of a large notch, and there is visible here a sinus from which purulent liquid wells up.

The right upper lid has ectropion; closure of the eyelids is almost impossible because of this vicious cicatrix. No defect of movement to the right or left.

Hyperæsthesia of nasal, frontal and lacrymal nerves is to be noted on the right side; they have all probably been implicated in the traumatism propagated to the sphenoidal fissure.

No lesion of the eyeball; median and deep membranes are intact.

R. and L. $V = 9/10$.

The central and peripheral nervous system is normal; no meningeal reaction.

Fracture of the superior wall of the left orbit and frontal sinus by shell fragment. (Case 2.)

R. M., Infantry, wounded May 4, 1916, at V.; shell wound left superior orbital region. Trephined May 6, at Saint-Dizier, with extraction of bone splinters. Slow recovery owing to suppuration. (Fig. 5.)

Condition on admission, June 15, 1916. There is an incision about 3 cm. long at the level of the superior margin of the left orbit, parallel with the superciliary arch. Another cicatrix is to be seen at right angles to this arch meeting the first incision at its external third.

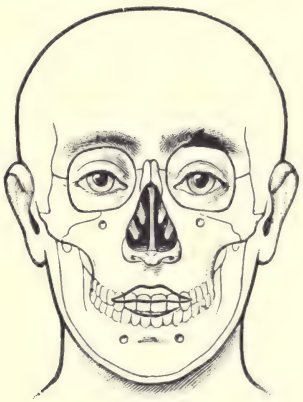

FIG. 5.

This cicatrix, not painful, is the seat of a slight depression following fracture of the subjacent layer of bone; no cerebral pulsation perceived.

Radiogram confirms fracture of the superior orbital margin.

There is insensibility of the left frontal region following section of filaments of the frontal nerve.

The left eye is absolutely intact; no lesion of the media or of the choroid or retina.

L. E. with + 1 D cyl. axis 90°, V = 5/10.

R. E. V = 1.

Diminished acuity of vision in left eye, explicable by injury to optic nerve in its bony canal.

Fracture of the right superior orbital margin with consecutive atrophy of the optic nerve. (Case 3.)

A. G., Infantry, wounded May 10, 1916, by grenade explosion, in the right supra-orbital region. Fragment extracted at B. On admission, Sep. 3, 1916, there was a cicatrix 1 cm. long in the middle of the right eyebrow. Palpation of the superior orbital margin reveals a notch in the bone, admitting the tip of the index finger; no foreign body to be felt. The patient found almost immediately that he could not see with the right eye.

This eye has slight external strabismus following the amblyopia; it is normal outwardly. No extrinsic muscular paralysis; the dilated pupil is insensible to natural stimuli. The consensual reflex from right to left is abolished, but persists from left to right. No injury to transparent media. The optic disc is the seat of complete white atrophy.

R. E. $V = 0$.

The left eye had suffered from a foreign body in the cornea, which had been extracted at B.

L. E., with $+ 0{\cdot}5$ D cyl. axis 0°. $V = 7/10$.

Second Group

Fracture of both orbits by bullets. (Case 4.)

A. R., Infantry, wounded Jan. 11, 1916, by a bullet fired from a distance of about eighty metres.

Leaving the military hospital at Chalons, Jan. 14, he entered our hospital on Feb. 23.

Condition.—The bullet had penetrated near the inferior border of the left orbit, quite near the inner inferior angle, in the lacrymal region, and came out near the right zygomatic arch, 3 cm. in front of the tragus. It had therefore traversed the nasal fossæ. At the aperture of exit there is to be felt a cicatrix adherent to the subjacent bone.

Examination of the nose shows a transfixion wound with intra-nasal adhesions.

The tip of the index finger detects, by the inferior external angle, a crack in the floor of the left orbit, a crack which appears to be prolonged far backwards. On the internal wall of the right orbit is an exostosis which impedes deep palpation of the cavity.

Ocular Examination.—The right eye, visual acuity = O, is outwardly normal. At the posterior pole is a large choroido-retinal rupture (concussion lesion); the whole of the papillo-macular region is the seat of patches of choroido-retinitis, pigmented and proliferating, secondary to hæmorrhage into the deep membranes (Plate III, Fig. 3).

The lower eyelid, slightly œdematous, is in a state of cicatricial ectropion at the inner angle.

The left eye is normal.

L. E. V = 10/10.

No injury to the transparent media or the deep

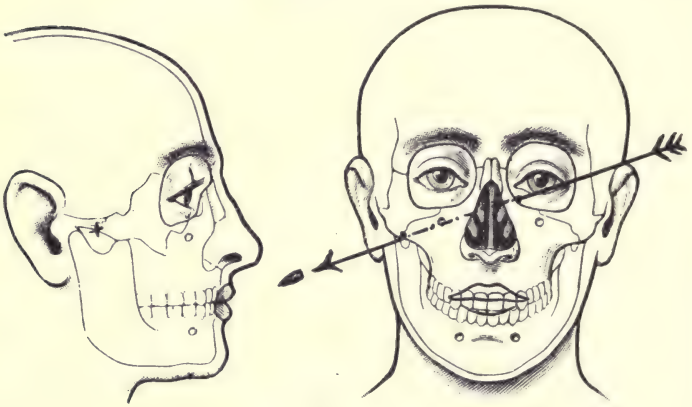

Fig. 6.

membranes. At the aperture of entrance suppuration from bone persists : some sequestra have been eliminated.

Condition stationary, June 20, 1916.

Fracture of both orbits by rifle-bullet, hæmorrhage into the vitreous body R. E. ; macular choroiditis L. E. (Case 5.)

L. M., Infantry, wounded Sep. 25, 1915, at S., by a rifle bullet, which traversed the facial bones from side to side. He did not lose consciousness. Admitted Sep. 27.

The bullet penetrated at the level of the zygomatic arch of the left side, about 5 cm. from the external auditory meatus and 3 cm. from the orbital margin. The orifice

of exit is a little below the right orbital margin, near the external angle of that orbit (Fig. 7).

Its course is therefore from left to right, and slightly from below upwards. In its course the projectile has fractured the floor of the left orbit, the nasal fossæ, the internal wall of the right orbit, and traversed the cavity in its lower part.

On admission no exophthalmos could be noticed.

The ocular lesions which L. presented are as follow—

R. E.—The vitreous body is the seat of a profuse hæmorrhage, preventing any red reflex. Little by little this

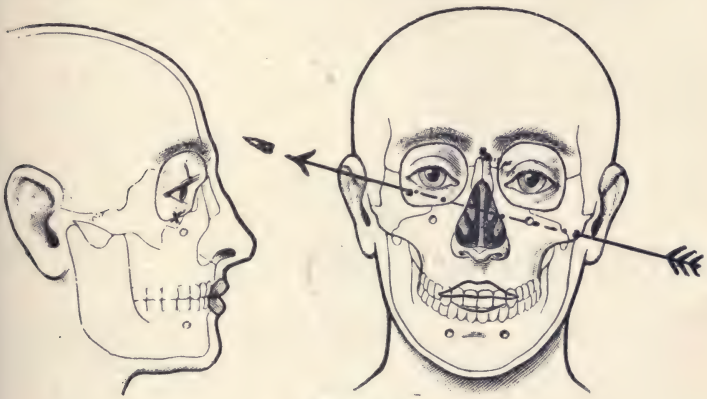

FIG. 7.

hæmorrhage became absorbed, and by April 4, 1916 there were—

(1) Large patches of whitish choroido-retinitis, star-shaped, in the macular region (concussion injuries).

(2) Large fibrous bands covering the optic disc, which is invisible to the ophthalmoscope (retinitis proliferans).

(3) Atrophy, with some pigmented foci disseminated about the inferior region of the retina and choroid, in the track of the bullet (contact lesions).

R. E. $V = 0$.

The eye has slight external squint.

L. E.—Sep. 27, the visual acuity of this eye was 3/10 barely.

Transparent media are intact. There is a cherry-red coloration extending over the whole macular field (concussion lesion), and a sprinkling of choroido-retinitis at the lower part.

April 4, 1916, on his discharge, the acuity of this eye had slightly diminished.

L. E. V = 2/10 barely.

Bullet traversing the face, bilateral macular hæmorrhage.
(Case 6.)

M. R., Infantry, wounded March 12, 1916. Admitted May 13, from Chaumont, viâ Orleans.

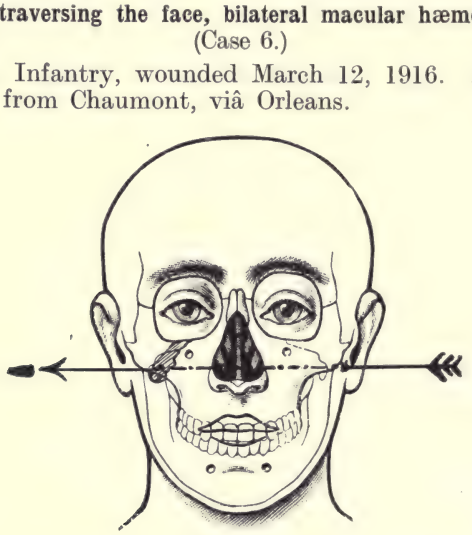

Fig. 8.

Examination.—A rifle bullet, from about 150 metres, had penetrated the left masseteric region, 3 cm. below the middle of the zygomatic arch and 2 cm. in front of the superior insertion of the lobule of the ear, in the interval comprised between the ascending ramus of the inferior maxilla and the coronoid process.

The orifice of exit, represented by a star-shaped cicatrix, adherent to the underlying fractured bone, is situated 4 cm. below the external angle of the right orbit and 7 cm. in front of the lobule of the right ear. The projectile has therefore traversed the face in a slightly oblique direction, from behind forwards and from left to right.

Palpation reveals on the right orbital margin, exactly in its middle, a loss of bone substance forming a notch of about 1 cm. (Fig. 8).

Examination of the Eyes.—R. E.—The eye is outwardly normal; no opacities in the media. The ophthalmoscope reveals a hæmorrhage of the macular region (concussion lesion), without other lesions of retina or choroid. Disc intact. The visual field shows the existence of an absolute central scotoma.

R. E. $V = 1/50$.

L. E.—Similar integrity of the transparent media and the deep membranes, except in the macular region, the seat of a slight hæmorrhage, cherry-red in colour (concussion lesion). The perimetric examination shows the presence of a relative scotoma.

L. E. $V = 3/10$.

Third Group

Fracture of the right orbit by a bullet, laceration of the choroid; optic atrophy, R. E. (Case 7.)

F. M., Infantry, wounded Oct. 31, 1914, near S. (Marne), by a rifle bullet. From Chalons he was sent to the Complementary Hospital No. 18 at Bordeaux, where he was admitted Dec. 4, 1914.

Condition.—The projectile entered the cheek on the left side, three fingers' breadth in front of the angle of the mandible, one finger's breadth above the lower border of the same bone. It divided the alveolar border of the maxilla, breaking the premolar and two molars; it crossed the mouth, slightly wounded the dorsum of the tongue, perforated the palatine arch near the median line, traversed the right nasal fossa and the right antrum, smashing in the floor of the orbit, and came out in the temporal fossa, near the orbital margin, at the level of the angle made by the malar bone with the external angular process of the frontal bone (Fig. 9). The bullet passed beneath and behind the eye without touching it.

At the time of our examination the right eye was proptosed; it deviated downwards and outwards, but there was no diplopia because of the low visual acuity of the eye.

No lesions of the anterior segment or the appendages of the eye were remarked.

The vision of this eye is quantitative. In the macular region there is to be seen a vast laceration of the choroid, extending by an arciform prolongation beneath the disc and resulting from concussion transmitted to the posterior pole of the eye. The optic nerve is in a fair way to almost complete white atrophy.

The visual field is not measurable.

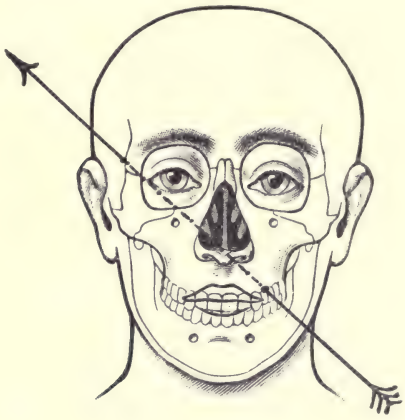

FIG. 9.

The left eye is normal. Acuity equals 7/10 and the visual field is lessened by 10° in all directions.

M. intermittently removes pus from the right nostril; there is a deviation of the septum to the right and a thickening to the left, resulting from the seton-like wound.

He was discharged Feb. 12, 1915, in the same condition.

Wound of the facial bones by rifle bullet; macular and peripheral choroido-retinitis, R. E. (Case 8.)

J. D., Sergeant, Infantry, wounded by rifle bullet, Nov. 3, 1915, at M.

The bullet, fired at close quarters, penetrated 1 cm. above the left zygomatic arch, and came out at the middle portion of the inferior orbital margin, where a depression exists in the bone in which one could place the tip of the index finger

(fracture of right orbital margin). At the level of the velum palati the orifices of entry and exit of the projectile are visible as it emerged from the facial mass. (Fig. 10.)

Condition.—The wound was cicatrised when we examined D., who complained that he could no longer see with the right eye.

This eye presented the following lesions, which are indirect, by contre-coup, by concussion, the projectile not having touched the eyeball.

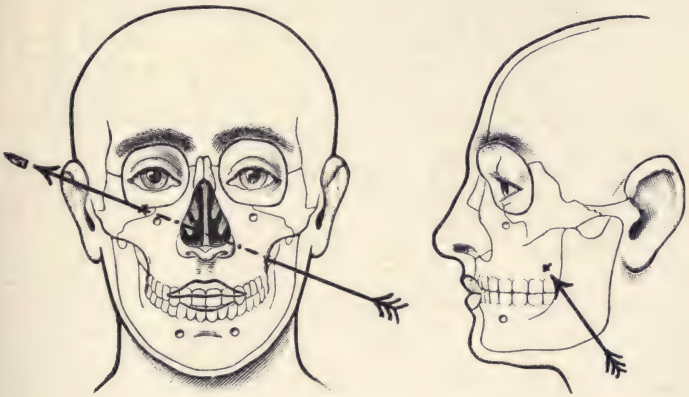

FIG. 10.

In the macular region there is a greyish white discoloration with pigmented spots, explaining the feebleness of visual acuity.

R. E. $V = 1/100$.

The visual field shows loss of central vision and defect in the superior peripheral field.

In the lower and outer part, *i. e.*, in relation with the aperture of exit of the projectile, the retina and choroid are greatly disturbed; laceration of the choroid with large patches of white atrophy and pigmented foci, probably secondary to a hæmorrhage *en nappe* of the deep membranes (contact lesions). (Plate I, Fig. 3.)

The left eye is intact, and its visual acuity normal.

At the end of three months the condition remained

stationary, and it is probable that these affections undergo little change.

Fracture of the external wall of the right orbit ; macular choroido-retinitis ; avulsion of optic nerve. (Case 9.)

J. L., Infantry, wounded at the Dardanelles, transported unconscious in hospital ship : he went to Egypt and thence to Marseilles.

Condition.—From the inferior external part of the right lower eyelid there commences a non-adherent arciform cicatrix, which passes 4 cm. behind the extremity of the eyebrow and is directed towards the upper portion of the temporal region. In the median portion of the wound is to be felt a little bony depression, which leads to an extensive fracture of the outer wall of the orbit, most marked above and behind, due to driving in of the orbital wall.

The right eye is outwardly normal. The pupil is slightly deformed because of a leucoma adhærens down and in. The vision of this eye = 0. There are floating opacities in the vitreous, but the lens has preserved its physiological transparency.

The deeper membranes are the seat of serious damage.

In the papillo-macular region, in place of the papilla there is a large atrophic zone, with, in the centre, a tinge of seagreen which seems to be due to a light fibrinous organised clot. The disc has disappeared under the mass of retinitis proliferans. There is also a narrow elongated laceration, somewhat arched, yellowish in colour, situated slightly below the macular region.

The globe has normal tension. Radiography has given a negative result as regards the possible presence of intra-orbital foreign bodies.

The left eye is normal.

Condition remained stationary until discharge from hospital, April 22, 1916.

Dec. 10, 1916, we again examined this case with the ophthalmoscope. The fundus of the eye, less encumbered by exudation, presented the condition shown in detail in Plate III, Fig. 1.

It is a perfect type of avulsion of the optic nerve (Plate III, Fig. 1).

Fracture of the external wall of the left orbit by rifle bullet; traumatic choroido-retinitis, L. E. (Case 10.)

R. D., Sergeant, Infantry, wounded April 25, 1915, at E. A rifle bullet had wounded the left external orbital region. The projectile had struck the lower and outer part of the left orbit and had come out a little in front of the left temporo-maxillary articulation. In its course it had fractured the zygomatic process and the external wall of the left orbit.

On admission, a large furrow, very deep, is seen on the left cheek; the cicatricial tissue adheres firmly to the underlying tissues.

Paralysis of the filaments of the facial nerve going to the orbicularis inferior was noted, whence a slight ectropion of the lower eyelid and lagophthalmos.

No disturbance of sensation.

Radiography yielded a negative result, both as to the possible presence of splinters and the nature of the fracture.

The eyeballs are normal exteriorly. Visual acuity R. E. = 10/10.

In the left eye the transparent media are intact, but there are grave injuries to the retina and choroid.

(1) In the region of the macula, an extensive cherry-red patch, resembling a hæmorrhage and giving rise to a central scotoma.

(2) In the superior and inferior peri-macular region, patches of atrophic and pigmented choroido-retinitis, secondary to choroidal hæmorrhages.

These damaged tissues explain the feebleness of visual acuity, which is 1/50; they are due to concussion of the region; the eye has not been touched.

Feb. 4, 1916, restoration of the vicious facial cicatrix was attempted by means of an adipose graft. Results excellent, and the case was discharged as a convalescent, April 3.

Fourth Group

Fracture of the orbit by a shrapnell ball; section of optic nerve, neuro-paralytic keratitis. (Case 11.)

H. B., Lieut., Zouaves; wounded Sep. 23, 1914, at Tr. The first-aid dressing was applied immediately after the injury, and reapplied at the dressing station. This officer

was afterwards sent to Compiègne, thence to Angers and Bordeaux, where he arrived Sep. 27.

Condition.—He was struck by a shrapnel ball at the moment of looking out of the trench. Sensation of having the eyeball torn out, with free temporal hæmorrhage and slight epistaxis. Le médecin-major de l'ambulance diagnosed hæmatoma of the orbit, which leads one to suppose that considerable exophthalmos existed from the outset.

The wound is very small, like a bullet-wound; it is situated at the superior external angle of the left orbital

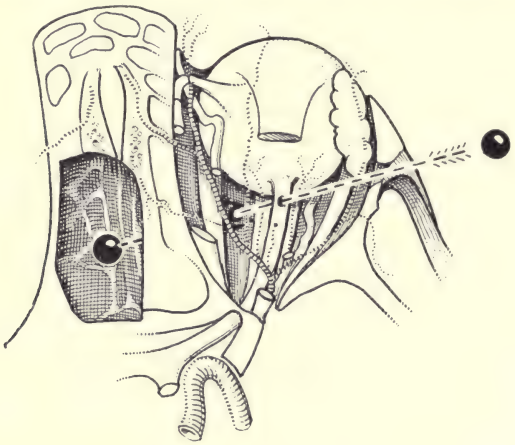

FIG. 11.

opening. There is marked exophthalmos, so that the cornea cannot be protected, closure of the lids being impossible.

The cornea is quite insensitive, save in its internal quadrant.

The pupil is dilated and immobile.

Examination of the fundus of the eye shows the typical picture of avulsion of the optic nerve; papilla invisible, covered by abundant hæmorrhage which extends far into the neighbouring retina and choroid; the posterior pole presents, moreover, milky white coloration due to traumatic retinal œdema, especially in the macular region.

Radiographic examination shows a shrapnel-ball, which after having crossed the left orbit, has perforated the os

planum, traversed the nasal fossæ, and come to rest in the right ethmoid, very near the partition and the right orbital cavity (Figs. 11 and 12).

In the days following the appearance of a neuro-paralytic keratitis was noted. Under the influence of astringent dressings the corneal ulceration improved, and there was diminution of conjunctival chemosis and exophthalmos.

On Oct. 29, 1914, extraction of the projectile was attempted. Incision outlining the wing of the left nostril, passing along the nose in front of the lacrymal region; section of the nasal bone by bone-forceps. The septum was

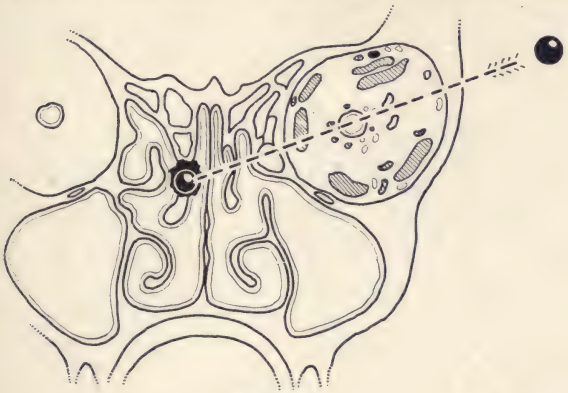

FIG. 12.

found to be much distorted. With a curette the track of the projectile could readily be traced, and it was easily extracted. Sutures. After-history normal.

Jan. 20, 1915. Notes on discharge—

L. E.—Loss of vision, consequent on section of the optic nerve. Mydriasis. Very slight corneal nebula. Perfect preservation of the globe and of its movements.

R. E.—Normal.

Fracture of the left orbit by bullet, section of left optic nerve; laceration of choroid, L. E. Detachment of retina, R. E.
(Case 12.)

Y. G., Algerian Sergeant; wounded Aug. 23, 1914, at O., by rifle bullet; was made prisoner on 25th. Went to

Charleroi and Düsseldorf. Returned as seriously wounded. G. came under our care Dec. 3, 1914, with a certificate attesting the seriousness of his condition.

Examination.—Injury by rifle bullet from distance of about 200 metres. The bullet entered the right cheek-bone and emerged from the left temporal fossa, two fingers' breadth behind the orbital arch. The projectile has not traversed the right orbit; it has broken the floor at the level of the malar bone and also near the internal angle (two fractures), traversed the nasal fossæ, and finally left the orbit (Fig. 13).

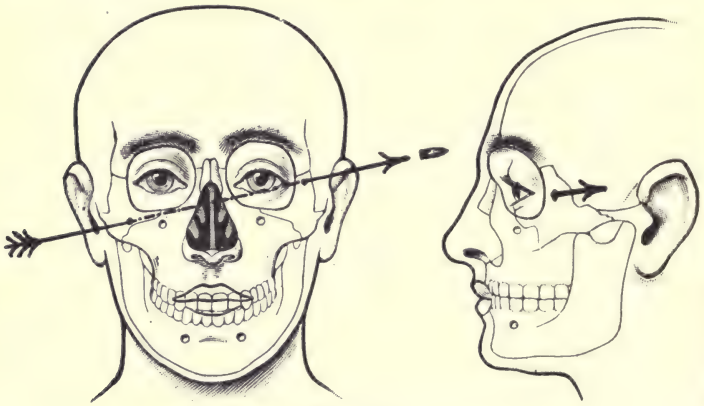

FIG. 13.

In its course it has caused the following injuries :—

R. E.—In the vitreous there are numerous floating bodies. Below and to the outer side are seen an extensive retinal detachment and concussion lesions extending to the macula. The upper part of the visual field is lost to near the point of fixation.

R. E., with + 1 D sph., V = 3/10 barely.

L. E.—The left optic nerve has been divided by the bullet; it is in a state of complete white atrophy; the vessels are normal. There is also a rupture of the choroid in the macular region with pigmentary deposit between the macula and the disc.

L. E. V = 0.

These injuries are produced by contusion and immediate pulling on the left eyeball at the moment of injury.

The retinal detachment of the right side was treated for two months (rest, compression, NaCl, etc.); on his discharge it was still present, and visual acuity remained about 3/10.

Fracture of both orbits ; retinal hæmorrhage, R. E. ; retinitis proliferans, L. E. (Case 13.)

A. G., Corporal, Infantry, was wounded at N. O. May 29, 1915, by a rifle bullet which traversed the face. Admitted, July 9, 1915.

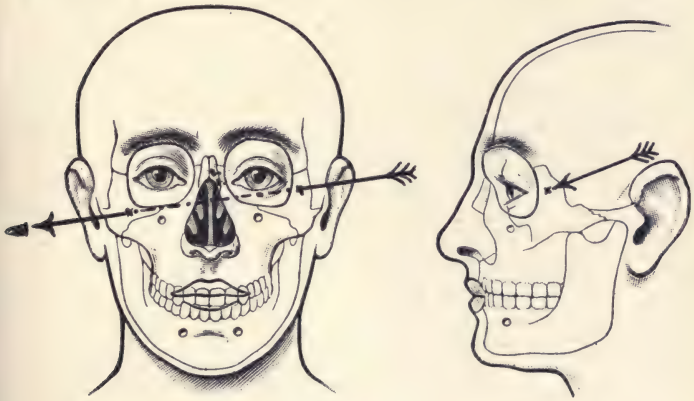

Fig. 14.

Condition.—The bullet entered by the left temporal region and emerged from the right temporal region. The course, slightly oblique from left to right and from above downwards, passes behind the external orbital margin, under the left optic nerve at the level of the posterior pole, and nearer the equator when passing the right eye. The projectile has, therefore, caused a fracture of both orbits (Fig. 14).

In the right eye numerous retinal hæmorrhages in the lower part are to be seen, corresponding to a partial loss of the upper part of the visual field. Macular and paramacular lesions from concussions; right eye not touched.

On the left side, numerous tracts of proliferating retinitis. In addition there are little hæmorrhagic patches to the outer side and below. In the vitreous are numerous flocculi; left eye probably touched.

The visual field is the seat of an extensive central scotoma.

R. E. V = 1/10.
L. E. V = 1/200.

G. has great difficulty in opening his mouth, due to a lesion of the temporal muscles. There is anæsthesia of

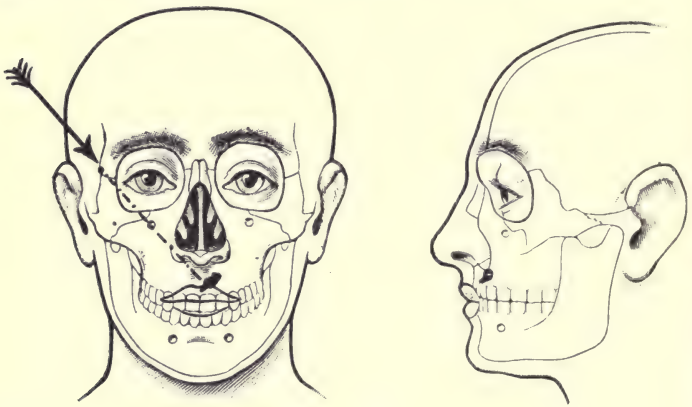

FIG. 15.

both infra-orbital nerves extending to the lower eyelid, the ala of the nose and the upper lip, more marked on the left side. He left hospital July 22, 1915; state of both eyes as on July 10.

Fracture of right orbit, shell wound; rupture of choroid, R. E.
(Case 14.)

A. St. P., Infantry, wounded Aug. 22, 1914, at L.; from Lunéville, he was admitted Dec. 7, 1914.

Condition.—The fragment has penetrated the temporal region a finger's breadth from the outer extremity of the eyebrow. It has crossed the orbit from above downwards and from behind forwards to lodge in the roof of the palate, where radiography revealed it, and where it still

remains (Figs. 15 and 16). The wound has been cicatrised for a long time. St. P. states that he noticed the loss of vision in the right eye immediately after the injury.

The right eye is slightly deviated downwards and outwards, due to paresis of the inferior oblique.

The anterior segment is normal; the pupil, which is equal to that of the other eye, reacts feebly to natural stimuli.

R. E. V = 1/200, not improved by glasses.

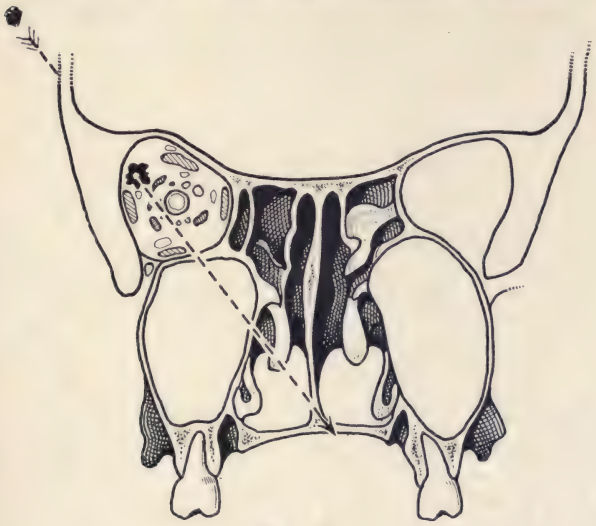

FIG. 16.

With the ophthalmoscope detachment of the retina is seen below; near the posterior pole, in the region of the macula, are extensive lesions of the retina and choroid (probably lacerations), pearly white with some spots of pigment along the borders. Lesions due to concussion; eye not touched.

There is, in addition, paræsthesia in the region supplied by the right frontal nerve.

Left eye normal, acuity = 9/10.

St. P. underwent no surgical interference, and on his discharge, Feb. 6, 1914, his condition remained stationary.

Fifth Group

Fracture by bullet of the floors of both orbits; double retinal detachment; macular lesion on the left by concussion. (Case 15.)

C., Adjutant-chef, Infantry, wounded Sep. 14, 1914, at C. From the divisional ambulance to Fismes and thence to Bordeaux, where he arrived Sep. 19.

Condition.—A rifle bullet, entering the right malar region near the lower and outer angle of the orbit emerged at a point almost identical, near the infero-external angle of the left orbit.

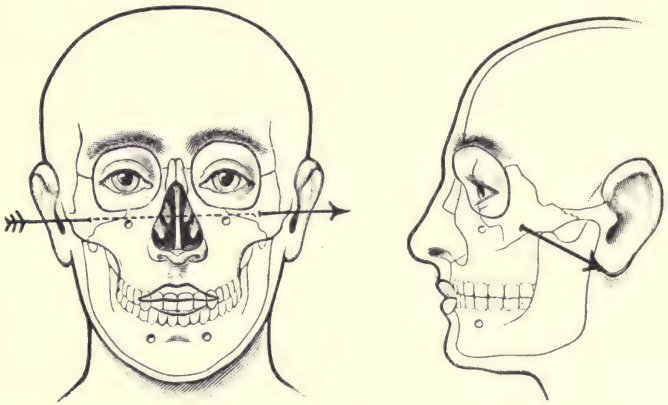

FIG. 17.

The aperture of exit is very extensive, about the size of a crown-piece.

The ocular affections were noticed immediately after the injury.

The right eye is outwardly normal; there exists no trace of wound or contusion of the appendages or of the anterior segment. Pupil dilated; tension manifestly diminished (T. — 1). R. E. V = Quantitative. The visual field persists in the temporal segment.

Ophthalmoscopic examination discloses a detachment of the retina, leaving only a small portion of the nasal area *in situ;* the right eye has been injured by the movement of a fragment of orbital bone (contact lesions).

The tension of the left eye is equally subnormal (T. — 1). Acuity barely 1/20. The visual field shows a lacuna in the temporal region, corresponding to a retinal detachment limited to the nasal portion. The vitreous is the seat of numerous floating bodies, due to hæmorrhage.

There is also to be noted anæsthesia of the regions supplied by the infra-orbital nerves (upper lip, supplied by anterior dental). C. also complains of a running of tears from both eyes, indicating that the nasal canals of the lacrymal passages have been damaged by the projectile.

Usual treatment for retinal detachment.

Feb. 16, 1915, condition as follows :—

R. E. V = Quantitative.
L. E. V = 1/10 good.

No modification of the visual fields. The retinal detachment on the right is extensive, principally below and to the outer side, and in the macular region.

On the left side the disc is pale and surrounded by pigment. The detachment is lessening, but in its place are large patches of choroido-retinitis in the macular region; right eye not touched (concussion lesions).

C. was discharged Feb. 20, 1915.

Fracture of left orbit by bullet; detachment of retina, L. E.
(Case 16.)

E. V., Infantry, aged 31, was wounded at Cr., Oct. 12, 1914. From Fontainebleau he was returned to his depot in the beginning of November, but, complaining of his left eye, he was sent to the ophthalmic centre of the 18th Region on Dec. 7.

Condition.—The bullet has penetrated the lower margin of the left orbit at about a centimetre from the inner canthus, lacerating the lower eyelid. The aperture of exit was found in the left malar bone, a little in front of the left tempero-malar articulation (Fig. 18).

V. has had no surgical interference. The wound is quite cicatrised. From Oct. 12, the visual acuity of the left eye has gradually diminished, until on the day of our examination it was—

L. E. V = 1/50, not improved by glasses.

The ophthalmoscopic examination (Plate VI, Fig. 1) shows a retinal detachment in the lower part, reaching

nearly up to the macular region. There are some floating opacities in the vitreous. It is probable that the bullet in its course has brushed against the lower part of the globe, without leaving any trace on the sclerotic; there is laceration of the retina and choroid extending to the macular region (contact lesion). (Plate VI, Fig. 1.)

The right eye is normal :—

R. E., with — 1 D sph., V = 9/10.

There is, in addition, anæsthesia of the left infra-orbital nerves (left half of the upper lip and left incisors).

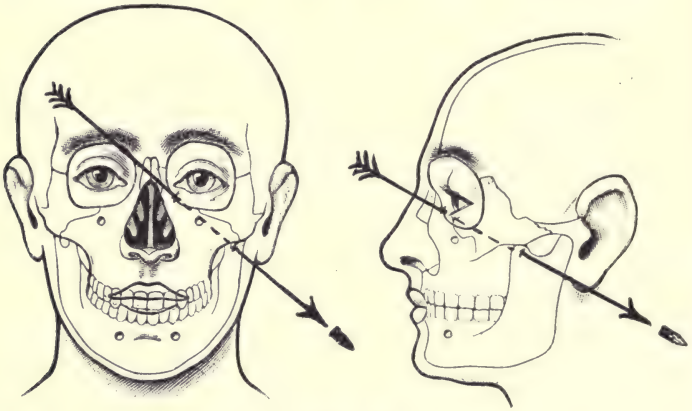

Fig. 18.

In spite of the orthodox treatment for retinal detachment, V. was discharged on Feb. 14, not improved.

Bullet wound of face ; fracture of left inferior orbital margin ; detachment of retina, L. E. (Case 17.)

A. J., Infantry, bullet wound, Sep. 9, 1914, left facial region. Dazed by the blow, J. noticed immediate and complete loss of vision of the left eye, accompanying profuse hæmorrhage in the inferior conjunctival cul-de-sac. Admitted Sep. 14, 1914.

Examination.—At the ambulance of Saintoing, three injuries were noted : one by the left lower lid, one in the left parotid region, the third on the left shoulder (Fig. 19).

These three wounds correspond to the course of the

same bullet, which entered at 1 cm. from the external angle of the orbit, perforating the lower eyelid, of which it divided the free border, fracturing the orbital margin. At this point the ocular conjunctiva and the sclerotic have been slightly wounded. The projectile emerged in the parotid region and wounded the shoulder at the end of its course. Radiography confirms the presence of a loss of bony substance from the inferior orbital margin, the crushing of the malar bone, and between them a line of fracture in the zygomatic arch (Fig. 19).

The pupil of the left is deformed; dilated below, in the direction of the scleral wound. The tension of the eye is

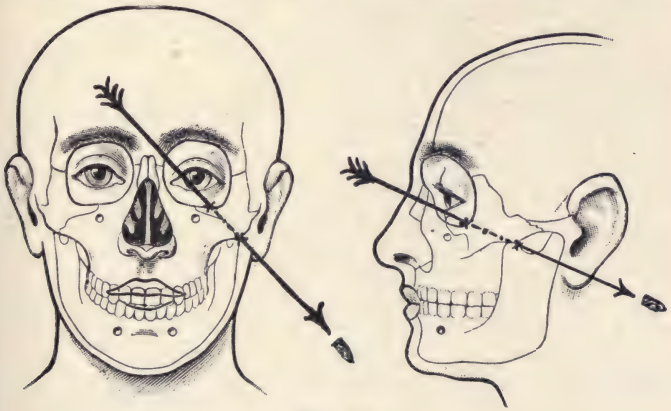

FIG. 19.

reduced (T. — 1). The ophthalmoscope discloses a very extensive retinal detachment (contact lesion).

This detachment is situated on the side of the scleral wound, near the aperture of entrance of the projectile.

The acuity of this eye is 1/100, the macular region being involved in the retinal detachment.

The right eye is normal.

Usual treatment for retinal detachment (compression bandage, atropine, sub-conjunctival injection of NaCl, rest in dorsal decubitus).

On leaving hospital, Dec. 12, 1914, no apparent improvement had been produced; persistence of detachment.

L. E. V = 1/100.

Fracture of the left orbit by rifle bullet; rupture of choroid. (Case 18.)

A. D., Infantry, wounded Sep. 15, 1914, at S.; under treatment till Nov. 23. Admitted Dec. 30 for visual trouble in the left eye.

Condition.—The bullet entered under the left eye, below a line dropped vertically from the external corneal margin. There is no trace of penetration upon the skin of the eyelid, but a small scar of the conjunctiva with slight symblepharon indicates the orifice of entry. The aperture of exit is found under the left ear immediately behind

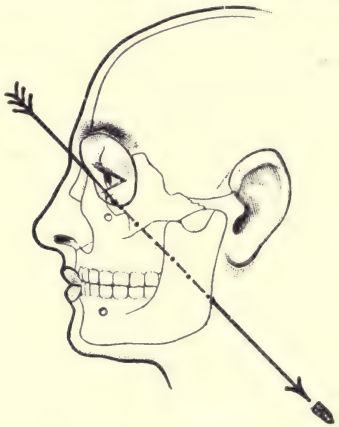

FIG. 20.

the ascending ramus of the mandible and a finger's breadth above the angle of the same bone (Fig. 20).

Radiography shows no bony lesions, although there was a fracture of the orbital floor.

In the period immediately following the injury he had fairly free hæmorrhage from the conjunctiva as well as from the mouth.

Sensation is preserved in the region supplied by the superior and inferior maxillary nerves; the malar region and the left cheek present evident signs of inflammation; the region is a little tense, red and painful.

The vision of the left eye is quantitative. After dilatation by atropine, no lesions of the anterior segment are

seen. The bullet has grazed the sclerotic. Transparent media normal. The deep membranes are the seat of very serious damage: optic disc softened in outline, peripapillary and macular pigmentation (concussion lesion), and pigmentation also in the lower part of the fundus. In this region an arciform choroidal laceration is also seen (contact lesion).

The right eye is normal. Visual field intact.

R. E. V = 1.

Discharged Feb. 1915, with the ophthalmoscopic appearance in the left eye unchanged.

L. E. V = Quantitative.

We come now to the second category of cases, that of fractures of the orbit with preservation of the eye and the presence of a retained foreign body.

Second Category

Fracture of right orbit; intra-orbital foreign body, macular choroido-retinitis. (Case 19.)

C. D., Infantry, wounded at C., Oct. 21, 1914, by shell fragment in the right temporal region. From A. viâ Pau; admitted Dec. 12, 1914.

The aperture of entry of the projectile is found in the right temporal region. A cicatrix is situated a finger's breadth in front of and above the insertion of the ear. Radiogram shows a large foreign body in the orbital cavity, very near the posterior pole of the eyeball. The direction followed by this foreign body appears to have been from without inwards and behind forwards, penetrating the orbit through the great wing of the sphenoid (Fig. 21).

Severe orbital inflammation with exophthalmos followed the injury, but there is no trace of this at the time of examination.

The movements of the extrinsic muscles are preserved, with the exception of those which concern the paralysed levator palpebræ (ptosis of the upper eyelid).

The anterior segment and the transparent media of the right eye are in good condition, but the deep membranes

are seriously affected. There is cicatricial and pigmentary degeneration near the macula and in the outer equatorial region. Some tracts of proliferating retinitis cover in places these atrophic patches (organised hæmorrhage of the choroid with retinal lacerations).

R. E. V = 0.

L. E., with + 1 D sph. ⌒ − 2·5 D cyl., axis 0°, V = 9/10.

Jan. 21, 1915, Krönlein's operation, following the orthodox procedure, readily permitted the extraction of a fragment of shell, with irregular outline, 1 cm. long by

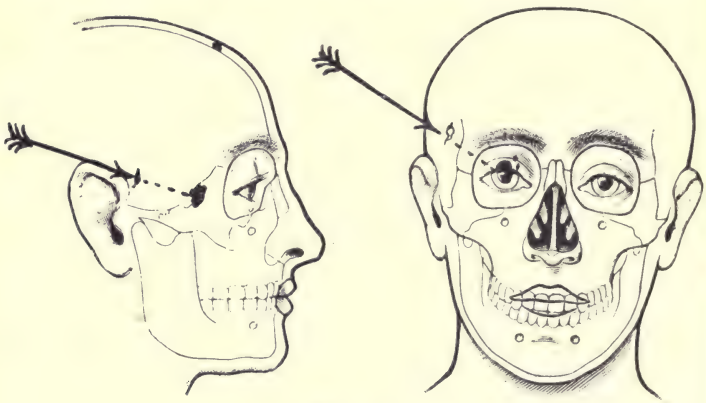

FIG. 21.

3 to 4 cm. wide, which was found behind the eyeball, against the optic nerve, inside the cone of the recti muscles.

Post-operative conditions normal; healing *per primam.*

D. left hospital Feb. 20, 1915, for discharge. He returned May 25, 1916, complaining of much pain behind the eye, and exhibiting slight blepharospasm. A new radiogram showed small fragments of shell disseminated in the fat of the orbit. The patient insisted upon their removal; a second operation, with turning back of the external orbital wall, was performed June 13; powdered fragments were extracted, no foreign body of any size being evident. Healing was rapid; relief was obtained from the symptoms, which were largely subjective. When

he went out, July 20, there was no change in the condition of the eyeball.

Fracture of the superior-external margin of the right orbit; intra-orbital foreign body; extensive choroido-retinitis, R. E. (Case 20.)

R., Captain, Infantry, wounded Sep. 25, 1915, by shell in the right orbital region; admitted three days later.

Condition.—The shell-fragment has penetrated the right upper eyelid, fracturing the upper and outer margin of the orbit. There is a deep notch in the bone, into which the tip of the index finger can be introduced (Fig. 22).

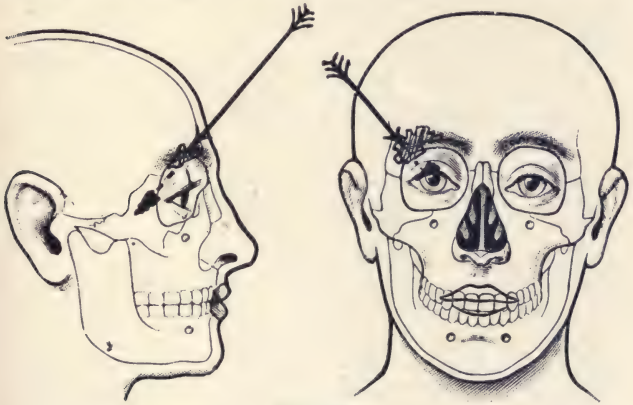

Fig. 22.

Almost complete ptosis of the upper eyelid is present; there is very pronounced exophthalmos, not reducible, probably due to an intra-orbital hæmatoma.

The pupil is dilated to the maximum owing to paralysis of the sphincter iridis. There is no effusion into the vitreous; the ophthalmoscope reveals a disc with softened contour, seen as though through a mist. In the macular region is a large hæmorrhage, which is continuous above and to the outer side with a choroidal hæmorrhage, resulting from rupture of this membrane.

R. E. $V = 0$. L. E. $V = 10/10$.

Radiography demonstrates the situation of the projectile

(Fig. 23); a voluminous shell-fragment has pierced the muscular cone, injuring the right external rectus and coming to rest behind the posterior pole of the eyeball which it has probably bruised directly.

Oct. 4, 1915, Krönlein's operation: after a curvilinear incision of the integuments external to the orbit, the outer orbital wall was raised by the gouge. A probe introduced in the track followed by the projectile allowed it to be felt and extracted.

Recovery from the operation was delayed by reason of several complications.

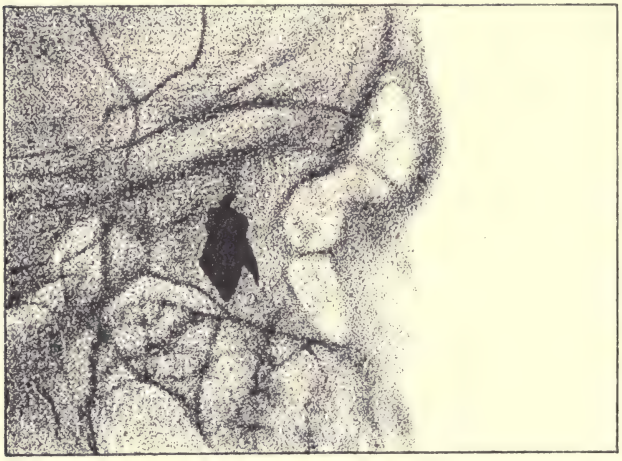

FIG. 23.

(1) A neuro-paralytic keratitis occurred, which was very long in healing, and complete recovery was only obtained by prolonged occlusion of the globe. A slight nebula remained when the patient was discharged.

(2) The breach in the orbital bones was the seat of suppurative osteitis, resulting in a sinus, which lasted till June, 1916, and was only cured by a further operation, in which a small fragment of shell and a splinter of bone were extracted.

On leaving hospital Aug. 4, 1916, the exophthalmos was not entirely reduced, but the upper eyelid had recovered

its mobility. There was complete paralysis of the right external rectus. Optic disc still a little blurred; large patches of post-hæmorrhagic atrophic and pigmentary choroido-retinitis in the macular region, above, to the outer side, and below.

R. E. V = 1/100.
L. E. V = 10/10.

Fracture of left orbit; intra-orbital, fragment of bullet; optic atrophy and atrophic and pigmentary choroido-retinitis. (Case 21.)

B., Adjutant, Curaissiers, wounded June 21, 1916, at

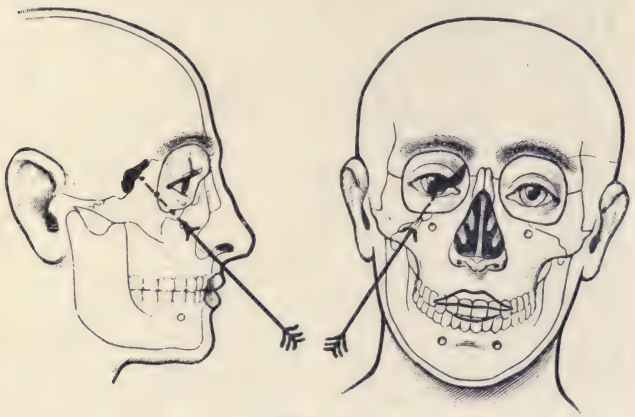

FIG. 24.

M., by a bullet in right orbital region. Was first at Ch. Admitted July 18, 1916.

The bullet has entered by the lower eyelid at 1½ cm. from the free border. It has fractured the inferior orbital margin, where, on palpation, a deep notch is felt. Radiography indicates the presence of the foreign body in the orbit, situated in the posterior part, near the apex and close to the roof (Fig. 24).

In the period immediately following the injury a considerable amount of exophthalmos was produced by the effusion of blood and inflammatory exudates. On July 18 this exophthalmos had almost disappeared. Some filaments

of the third nerve have been involved; the pupil is moderately dilated and immobile; the eye is divergent, owing to paralysis of the nerve to the right internal rectus.

Externally the eyeball is normal; transparent media intact.

Disc atrophic, with traces of old perineuritis.

The posterior pole, in the macular and perimacular zones, is the seat of numerous patches of cicatricial and pigmented choroido-retinitis. Vision reduced to simple perception of light. The left eye is normal.

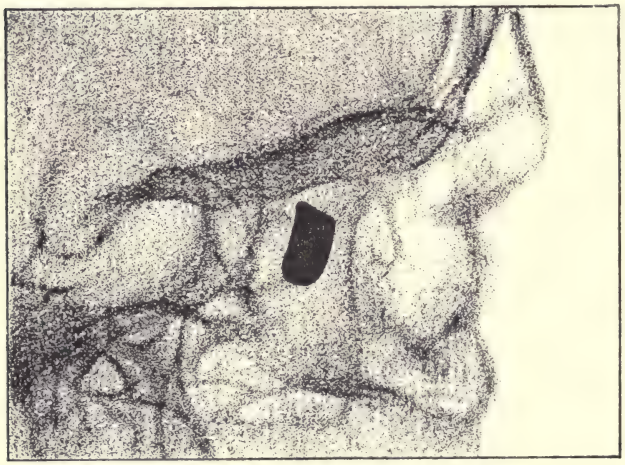

Fig 25.

July 25, Krönlein's operation. After resection of the orbital wall and section of the external rectus muscle the fibrous track resulting from the passage of the foreign body was reached. It was found at the apex of the orbit, near the sphenoidal fissure (Fig. 25).

The copper sheath of a bullet, greatly distorted, was extracted without difficulty. Post-operative progress normal. There remains only a slight paresis of the external rectus muscle, in a fair way to disappear. The exophthalmos, which reappeared after the surgical interference, passed away in eight or ten days.

Sep. 7, 1916, B. left for three months' sick leave.

Fracture of left orbit by shrapnell ball ; optic atrophy.
(Case 22.)

L. T., Infantry, wounded Sep. 16, at V. Was at Fimes two days later, and then at Casteljaloux. Sent on as convalescent, without any surgical interference, he noticed a rapid diminution of vision in the left eye, and was admitted Nov. 26, 1914.

Condition.—At the level of the left frontal sinus there is a cicatrix about $1\frac{1}{2}$ cm. above the internal superior angle of the orbit. The base of the frontal sinus has probably been crushed in.

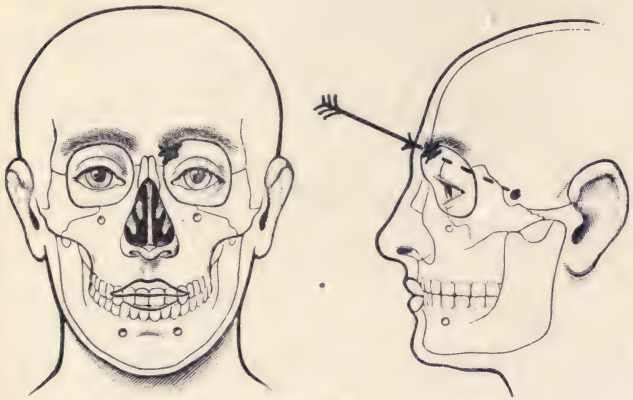

Fig. 26.

The left eye is slightly divergent, owing to paresis of the internal rectus, very faintly marked. The pupil reacts very feebly to its natural stimuli. The ocular media are normal, but the optic disc is in a fair way towards white atrophy, primary, not post-neuritic.

L. E. $V = 1/30$.

The visual field is concentrically contracted; blue and green are not perceived.

Radiography shows the presence of a shrapnel ball at the apex of the orbit.

R. E. normal. $V = 10/10$.

Dec. 3, 1914, the projectile was extracted by a curvilinear incision, situated above and to the inner side of the lacrymal sac. It was found in a bony mass in the wall at the apex; extraction difficult because of the tenacious adherence of the newly formed tissue.

Post-operative progress normal.

On discharge, Jan. 17, 1915, recovery was complete, but the optic atrophy had progressed. The pallor of the disc has increased and the visual acuity is scarcely 1/200.

In April, 1916, L. E. $V = 0$.

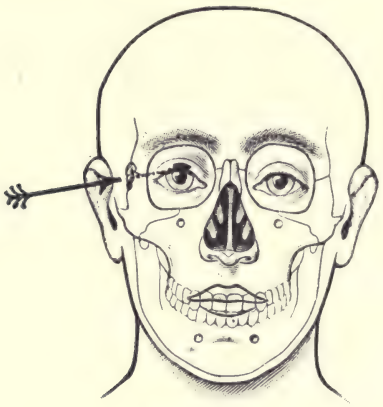

FIG. 27.

Fracture of the right orbit; intra-orbital foreign body; extraction by Krönlein's method. (Case 23.)

H. L., Zouaves, wound by revolver shot, June 9, 1914. The shot had penetrated the superior external region of the right orbit; the size of the projectile was 8 mm. Immediate loss of consciousness, lasting about half an hour; the sequelæ of the injury were of the simplest and only diplopia remained, due to paralysis of the external rectus.

L., by acquiring the habit of holding his head in an appropriate position, succeeded in suppressing the diplopia, and went on active service for eight months. In Nov. 1915, suffering from violent pains in the head, he was admitted June 1, 1916 (Fig. 27).

Condition —In the supero-external and lateral region of

the right orbit is a cicatrix, the aperture of entry of the projectile. This scar is $1\frac{1}{2}$ cm. behind the outer limit of the eyebrow. The bullet, following a horizontal course from without inwards, has perforated the external orbital wall behind the eyeball and come to rest in the muscular cone at a distance of $1\frac{1}{2}$ cm. from the posterior pole of the eye, in contact with the optic nerve, which has not been injured (Fig. 28).

The right eyeball is normal. The ocular media are

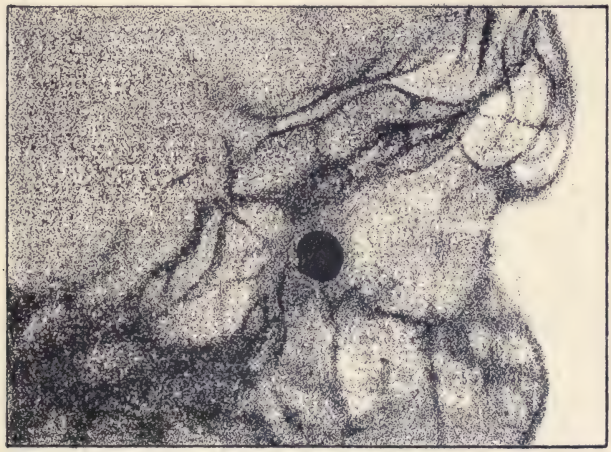

FIG. 28.

quite transparent; the disc presents no sign of atrophy. Visual acuity = 10/10.

The external rectus muscle is slightly paralysed, having probably been perforated by the bullet.

June 10, 1916, Krönlein's operation with large curvilinear incision of the integuments over the external orbital wall The projectile was found in the middle of the four recti muscles, ensheathed in very dense fibrous tissue. Extraction was easy. Post-operative conditions normal. There remains only marked paralysis of the external rectus muscle, accentuating the diplopia of which the patient previously complained.

Sep. 14, 1916, tenotomy of the internal rectus and advancement of the external rectus were performed. These operations, combined with fusion exercises with the diploscope, brought about a great improvement in the diplopia, which still exists to a slight extent in the region of action of the right external rectus muscle.

R. E. V = 10/10.

Shell wound with intra-orbital foreign body : fracture of the external wall of the left orbit ; multiple retinal detachments. (Case 24.)

J. R., Private, wounded at V., March 13, 1916; reached Bordeaux March 18.

Condition.—A Y-shaped cicatrix is seen in the left orbito-frontal region, the fork directed towards the ear, extending from the centre of the left eyebrow to the middle of the temporal fossa (Fig. 29).

The injury at its two extremities involved the soft parts only. In its median portion the scar is adherent to the superciliary ridge, in a bony depression corresponding to the external margin of the orbit, which has been bevelled off by the projectile.

Radiography discloses a loss of substance in the external and superior orbital region, a zone from which several splinters have been extracted, as well as a fragment of shell, which was intra-orbital and situated above the eyeball.

The violent contusion had caused profuse hæmorrhage into the vitreous of the left eye, which during the first months of his stay in hospital did not allow of examination of the fundus. Tension reduced (T — 2).

L. E. V = 0.

May 25, 1916, the ophthalmoscope showed almost complete disappearance of the hæmorrhage into the vitreous, only some floating opacities remaining. There are large retinal detachments, one peripheral in the nasal equatorial region, the other occupying the macular region and the temporal region (contact lesion). The disc is slightly pale (Fig. 30). Visual acuity 1/200.

This condition does not appear to be final, for traumatic

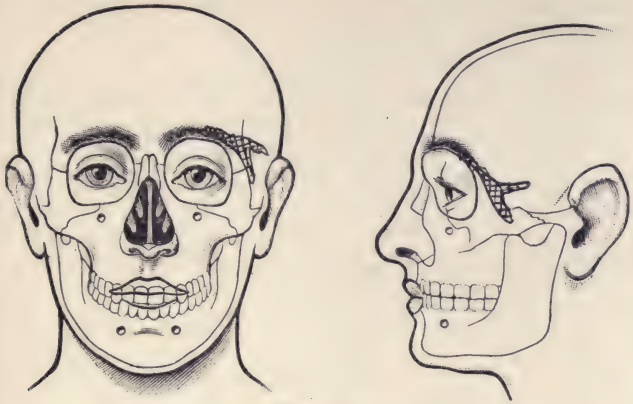

FIG. 29.

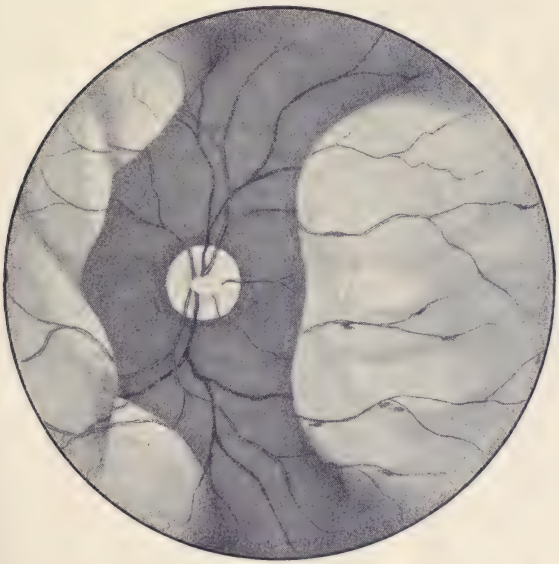

FIG. 30.

retinal detachments improve and disappear with the lapse of time.

R. E. normal. V = 10/10.

Fracture of left orbit; intra-orbital foreign body; macular choroiditis. (Case 25.)

J. H., Officer, Colonial Artillery; wounded Sep. 1, 1914, at A., by shell fragments, in left orbital region. At the Orleans hospital till Sep. 20, when he was returned to his depot. Complaining that he could not see, he was admitted Nov. 15, 1914.

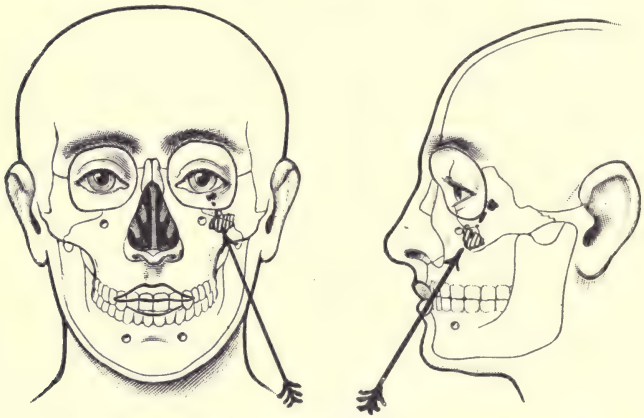

Fig. 31.

Condition.—H. presents a wound near the external canthus of the left eye. The projectile has penetrated the orbit, fracturing the infero-external margin, where there is a small cicatrix with symblepharon at the aperture of entry. Immediately following the injury considerable exophthalmos was produced by intra-orbital effusion of blood, of which no trace remains (Fig. 31).

There is no lesion of the appendages; the movements of the globe are well preserved; no affection of the anterior segment or the transparent media. With the ophthalmoscope, however, one notes a well-marked macular lesion, with a zone of atrophy, and below it a zone of pigmentation. Further, in the neighbourhood of the aperture of entry there is to be seen an extensive patch of atrophic

and pigmented choroido-retinitis, indicating that the shell fragment, in penetrating the orbit, has grazed the eyeball.

Perimetric examination reveals the existence of a central scotoma extending into the upper part of the visual field.

L. E., with + 0·50 D sph., V = Quantitative.
R. E. normal. V = 10/10.

Radiography shows two shell fragments. The more bulky seems to be in the antrum. The smaller is in the left orbit, behind the eyeball.

Nov. 22, 1914, the orbit was opened from the outer side, after a curvilinear incision, but without excision of bone. The eye, after section of the external rectus muscle, was hooked inwards; the portion of shell, encapsuled in fibrous scar-tissue, was readily removed.

Post-operative progress without inflammatory complications, but, shortly after, blepharospasm appeared, probably caused by irritation of the infra-orbital nerve, consecutive to the traumatism and the temporary sojourn in the region of the nerve of the foreign bodies which were now removed.

The nerve was resected in the orbit Dec. 15, 1914. Blepharospasm quickly disappeared, and H. was discharged Jan. 4, 1915, with the vision of the left eye unaltered.

§ II.—Pathology of the Visual Disorders

First Group

The visual affections of the first group are explained by damage to sensory nerves (lacrymal, frontal), the various motor nerves, and by lesion of the optic nerve, the consequences of the propagation to these organs of fractures of the orbital vault, radiated or by contre-coup.

Atrophy of the optic nerve, following injury of the nerve, upon which many authors, and particularly Chauvel and Nimier have insisted, explains itself: it is not so easy to account for the trophic and sensory affections presented by the patients, particularly by the cases of enophthalmos. (Case 39 *et seq.*)

It is probable that in cases where enophthalmos has occurred the sympathetic nerve has been injured at its entry into the orbit or within the orbit itself. Section of the cervical sympathetic, or rather, the suppression of the action of this nerve, will explain enophthalmos satisfactorily. Laceration of the nerve filaments produces this result, but irritation, continued excitation of the same nerve filaments, also induces it, for the excitability of a nerve diminishes in proportion as the excitation is prolonged and increased in intensity, so that a very prolonged irritation amounts to the same as section—that is to say, to enophthalmos.

This enophthalmos is therefore equally well explained by complete laceration, section of the trophic nerve filaments, and by irritation of these nerve filaments prolonged over a long period; continued excitation, prolonged irritation, as well as laceration of the nerves, are themselves explained by radiation of the cranial fracture into the sphenoidal fissure.

Second Group

The macular lesions we find in eyes which are to all appearance absolutely intact, disturbed at a distance by injury implicating the bony mass of the face, far from the orbit, result from the propagation of the vibratory concussion to the orbital contents by way of the fossa and the pterygo-maxillary fissure.

The eye is raised, shaken as a submerged boat would be when struck by a deep wave, attacking it from beneath. It is probable that this concussion of the whole mass of orbital fat, which is semi-fluid at the temperature of the body, is the cause of the ruptures produced in the deep membranes.

How is it that these injuries are often exclusively macular, and that when ruptures occur elsewhere the chief lesions are at the posterior pole? It is possible to explain such localisation: in the first place, by this fact, that the macular region is the most fragile, the most

sensitive to injury and to traumatism; in the second place, because the eye, tossed forward by the wave of oscillation which agitates the depths of the orbit behind the globe, is held back by the optic nerve firmly attached to the apex of the orbit.

This traction is exerted on the whole of the posterior pole, and hence localises ruptures and hæmorrhages to this region. Sometimes patients whose faces have been severely contused have lost central vision without the macula presenting any visible lesions. One must beware of concluding that this is due to malingering: central scotomata are quite well explained by the existence of disorders which are invisible by ophthalmoscopic examination.

Third Group

The affections of the third group, which are consecutive to the depression, the impaction, more or less marked, of one of the walls of the orbit, are amenable to the same explanation, and one can understand that they may be even more marked than when the projectile has traversed the bony mass of the face without altering the conformation of the orbital cavity. Here it is the pillars and the sides, not the basement of the vault, which are assailed; it is easy to understand that the organs which are contained in the orbital cavity are more seriously affected by the injuries which crack or perforate the actual walls and pillars of the edifice.

In this third group there are macular lesions which are explicable by the mechanism we have explained above; but there are also vast choroidal lesions which are ruptures resulting from the violence transmitted by the fluid material. These latter lesions vary in degree according to the amount of depression of the orbital walls and the severity of the shock.

They are remarkable from the point of view of localisation by the fact that they are always situated on the side of the orbital fracture; the wave which jars the soft

parts starts from the site of the fracture and strikes the eye in front of it with a sharp blow, rupturing its membranes. It is agreed that the tearing affects first and foremost the choroid, which bleeds; the blood lifts up the retina and detaches it. When the latter membrane is itself torn a choroido-retinitis proliferans is produced, a condition of which we have seen a large number of typical examples.

Summing up, in the third group we find—

(1) a definite macular lesion; (2) a choroidal rupture, most frequent; sometimes choroidal and retinal ruptures, on the side of the fractured orbital wall.

Fourth Group

When the projectile has traversed the orbit without touching the eye it is obvious that very different results may be produced according to the organs—muscles, motor and sensory nerves, etc.—which are injured. The same bullet may traverse both orbits and sever both optic nerves behind the globe. We have noted several cases of this nature. When the optic nerve has been divided, or when it has been severely bruised, much damage is done at the posterior pole owing to the traction exerted on the eye by the nerve. The force, before dividing and bruising the nerve, thrusts it violently forwards in the direction in which the projectile is travelling, and tends to tear it from its insertion in the eyeball.

Cases 9 and 10 (Plate III, Fig. 1; Fig, 35) are examples of this type. The pathogenesis of such lesions presents no obscurity.

Lacerations of motor and sensory nerves and of muscles can be readily explained; there is no need to stop to consider them.

Fifth Group

The fifth group of ocular disorders comprises cases of direct contusion of the globe, without rupture of its

walls, by a projectile which passes it tangentially and to some extent grazes it.

Under these conditions there are always lesions exactly where the missile has touched the eye. They are contact lesions, and are of the nature of ruptures of the choroid and retina.

Often the two membranes are simultaneously torn, owing to the violence of the shock; the destruction is very great, has its point of election at the point touched, and is readily propagated to the macular region. The macula is in consequence often implicated under these circumstances, but not as an isolated and separate lesion. In such cases the eyeball may be disorganised without being ruptured. Obviously, if the missile passes too near the eye it destroys it by making it burst, but we are not speaking of ruptures of the globe. Our fifth group comprises the cases in which the eye is directly contused by a projectile, which grazes it in passing, without rupturing it. It is evident that under such circumstances we must expect to find the greatest destruction in the deep membranes. From the site of contusion lacerations spread out into all directions, especially involving the posterior pole, which is always very sensitive to injury.

The visual troubles which are produced in the cases in which fracture of the orbit is complicated by the presence of a foreign body are explained in the same manner as in the cases belonging to the two last groups. It is needless to consider them further.

§ III.—Description of the Visual Defects

Such are, from the point of view of their mechanism, the affections of the visual apparatus which are caused by fractures of the orbit in which the eye is preserved.

We must now discuss each in turn, studying them in the following order:—

(A) *Nerve lesions:* 1st, motor; 2nd, sensory; 3rd, sympathetic; 4th, those of special sense.

(B) *Lesions of vessels:* Ophthalmic artery and vein; traumatic hæmorrhage into the orbit.

(C) *Lesions of the intrinsic and extrinsic muscles.*

(D) *Affections of the eyeball:* 1st, of the transparent media; cataracts, luxation of the lens: 2nd, of the membranes, (*a*) uveal tract; (*b*) retina, traumatic detachment.

(E) *Traumatic enophthalmos.*

We shall study these various disorders under their separate headings.

A.—Lesions of Nerves: Motor, Sensory, Sympathetic, and of Special Sense

In order thoroughly to grasp the nervous affections which are brought about in the visual apparatus by injuries to the orbit it is necessary to bear in mind the sphenoidal fissure, which we represent here according to the recognised authorities.

No anatomical description will be given—the reading of the legend which accompanies the illustration will suffice to enable our readers to follow the demonstration of the cases we have observed.

It is easy to understand which nerve trunks will be most likely to be implicated by a fracture radiating into the roof of the orbit, or by a direct blow upon the wall of the orbit.

(1) Motor Nerves

The nerve most often injured is the oculo-motor (IIIrd); this paralysis is due in the majority of cases to a fracture of the superior wall of the sphenoidal fissure, particularly of the anterior clinoid process, on account of the relations of the nerve with this process. Frequently there co-exists, for the same reason, a traumatic amaurosis. The same reasoning does not apply to the sixth nerve, which is the farthest removed from the superior wall of the sphenoidal fissure; paralysis of this nerve is usually due to fracture of the base.

Paralysis of the fourth nerve may be equally due to a fracture of the roof of the sphenoidal fissure, for this

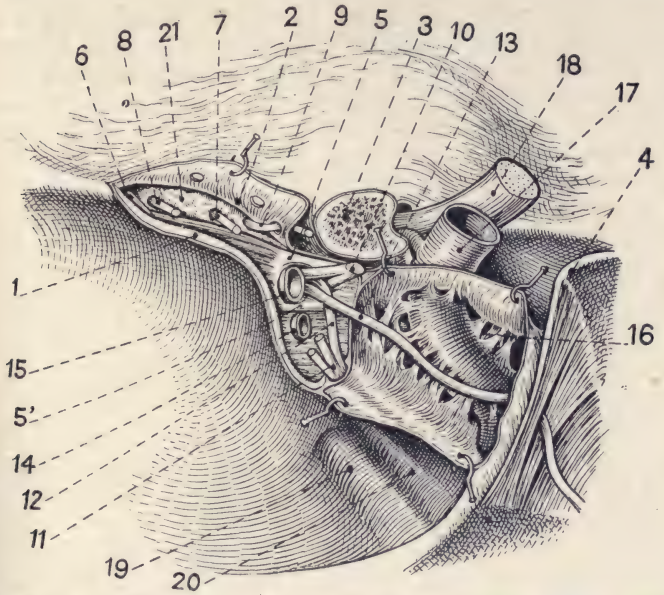

FIG. 32.—The sphenoidal fissure and the organs which pass through it (after Testut and Jacob).

The sphenoidal fissure is viewed from the interior of the cranium. The periosteum and the dura mater which close it have been incised and the flaps hooked back. The cavernous sinus has been opened.

1. Inferior border of the sphenoidal fissure. 2. Superior border. 3. Anterior clinoid process divided at its base. 4. Posterior clinoid process. 5, 5'. Ring of Zinn. 6. External rectus muscle. 7. Lacrymal nerve. 8. Frontal nerve. 9. Pathetic (fourth or trochlear). 10. Motor oculi (third). 11. Common trunk of lacrymal and frontal nerves. 12. Nasal nerve. 13. External motor oculi (sixth). 14. Inferior ophthalmic vein. 15. Inferior vein. 16. Cavernous sinus. 17. Internal carotid. 18. Optic nerve. 19. Superior maxillary nerve. 20. Ophthalmic of Willis (first division of the fifth). 21. Orbital fatty tissue.

nerve is quite close to it; paralysis of the ophthalmic branch of the trigeminal may be due to the same cause.

When the whole of the trigeminal is implicated the explanation of its paralysis must be sought in a fracture of the apex of the petrous portion of the temporal bone. These are the conclusions to which FERRON arrived in an excellent Thesis on this subject (Lyons, 1901). This author, moreover, very justly remarks that paralysis of the nerves of the orbit, when they have not an orbital cause, are symptoms of fracture of the base of the cranium.

This is not the place to demonstrate the mechanism by which fractures of the cranium are propagated to the orbital vault. We refer readers to the authorities on this question, especially to the article "Orbite" by ROLLET, in *l'Encyclopédie d'Ophtalmologie*" (Vol. VIII); in order to comprehend the cause of the nerve lesions which we have observed in orbital fractures it will be sufficient for us to recall the anatomical data given in Fig. 32.

We have seen four cases of paralysis of the third nerve, two of paralysis of the sixth, one of paralysis of the fourth. We have noted another disturbance in the action of the superior oblique due to dislocation of the pulley of this muscle. When the sixth nerve is affected the cause is most frequently orbital; we have twice found paralysis of abduction after fractures by direct shock upon the temporal wall of the orbit.

(2) SENSORY NERVE

The trigeminal, in fractures of the orbit, may be damaged not only in its first branch, the ophthalmic of WILLIS, but it is not uncommon to find that fracture of the floor of the orbit implicates the superior maxillary nerve, which is rarely divided, more often compressed. Anæsthesia in the corresponding region follows, and often too, signs of irritation, of which we have notes of two cases presenting an obstinate blepharospasm which yielded only to surgical interference. In the first case a piece of shell, penetrating 1 cm. below the inferior orbital margin, probably damaged the

infra-orbital nerve before coming to rest in the orbit, from which we extracted it. The second patient was struck by a projectile which smashed in the orbital floor without penetrating the tissues. The blepharospasm was confined to the lower eyelid. We performed on both subjects resection of the nerve trunk in the orbit, according to the orthodox procedure, and the contractions of the lids rapidly disappeared in the period following the surgical interference.

(3) Sympathetic Nerve

Branches of the ophthalmic nerve of Willis may be injured and with them the vaso-motor filaments they contain, and it is not rare, in addition to corneal anæsthesia, to see neuro-paralytic troubles, the more readily explicable because the sympathetic filaments may have been equally affected by the traumatism.

It is not impossible, however, for the injury to implicate all the nerves at the same time, with the exception of the sympathetic, and we have met with an interesting case which merits consideration from this point of view.

Fracture of left orbit; total ophthalmoplegia; optic atrophy
L. E. (Case 26.)

J. A., Infantry, wounded Sep. 30, 1914, near R. At Chalons till Dec. 4; admitted Dec. 8.

Condition.—Struck by shrapnel ball in the left temporo-parietal region, two fingers' breadth above the insertion of the ear, three fingers' breadth behind the extremity of the eyebrow.

Radiography in profile shows the projectile situated immediately in front of the sella turcica; and the radiogram, taken from in front, indicates its presence against the superior internal wall of the left orbit. It has therefore in its course involved the apex of the orbit slightly in front of the sphenoidal fissure, which it has doubtless smashed in (Figs. 33 and 34).

The upper eyelid is in a condition of complete ptosis. The eyeball is quite immobile; all the extrinsic muscles

are paralysed. There is no exophthalmos; but the eye is slightly deviated to the outer side, in the orbital axis.

The anterior segment is normal; the pupil, very dilated, reacts neither directly nor consensually (Fig. 34).

The anæsthesia extends over the whole of the region supplied by the trigeminal, total for the ophthalmic branch of WILLIS, partial so far as concerns the dental and infra-orbital branches.

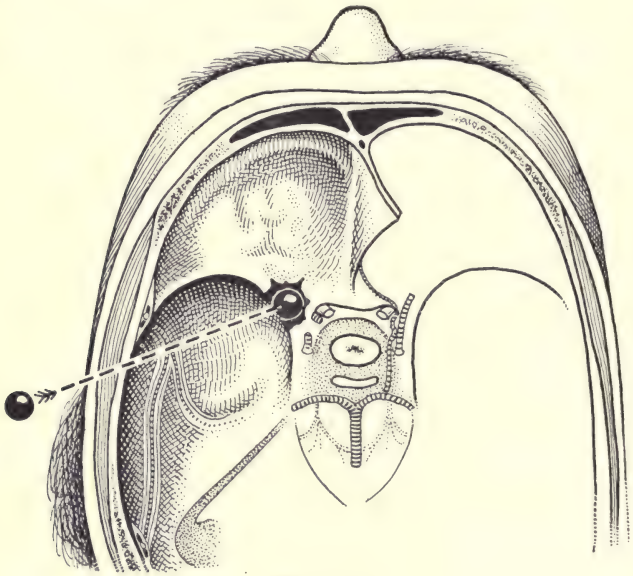

FIG. 33.

Ophthalmoscopic examination reveals white atrophy of the optic nerve; the veins are normal, but the arteries are very slender.

L. E. V = 0.

The right eye is intact. No lesion of the transparent media or deep membranes. The visual field is normal.

R. E., with + 1 D sph., V = 1.

Taking into consideration the very deep situation of the projectile, the dangers inseparable from its extraction,

and the perfect tolerance for it displayed by the brain, surgical interference was postponed, and the patient left hospital March 9, 1915.

In this curious case, all the nerves of the eye without exception were implicated, and still the eye survived. It only presented neuro-paralytic phenomena; the fact must be explained by preservation of the ophthalmic

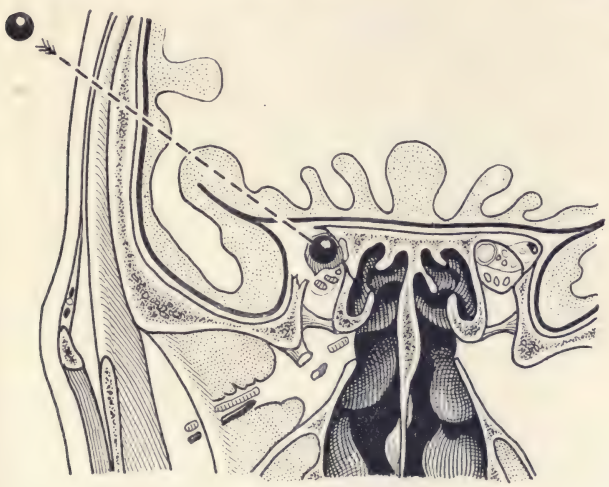

FIG. 34.

ganglion, that tiny brain of the eye, which continued to control its nutrition.

Of all the lesions presented by the nervous apparatus of the eye those of the optic nerve must be dealt with at greatest length.

(4) LESIONS OF THE OPTIC NERVE

It is convenient to divide the traumatic lesions of the optic nerve resulting from injuries of war into three classes, according to localisation: (*a*) the intra-ocular portion; (*b*) the retrobulbar portion, which

contains the central artery and veins; (*c*) the non-vascular portion, which extends from the optic foramen to the entrance of the central artery and vein.

(*a*) *Intra-ocular portion; traumatic lesions of the papilla.*—These are the injuries which we find when the papilla has been torn out by a sudden stretching of the optic nerve. A blunt instrument or a metallic

Fig. 35.—Avulsion of the optic nerve.

fragment sharply pushes aside the nerve, tears it out, so to speak, and detaches it from its insertion into the globe. We have observed several examples of this condition in which the ophthalmoscopic appearance was similar to that which Gonin gives in the *Encyclopédie française* (Vol. VII, p. 534).

Free hæmorrhage at once follows the avulsion, and when the blood has absorbed we see the remnants of torn vessels and sometimes a deep excavation due to

rupture of the sclerotic. In a case of Pagenstecher's the nerve had been absolutely torn out from the scleral ring, and the retina had been dragged into the opening.

In this manner a traumatic excavation of the disc is produced, a sort of coloboma or surgical conus, much more pronounced than the glaucomatous excavation. Gonin quotes a case of Birch-Hirschfeld's in which the difference of level was 2 mm. This excavation may become filled with proliferating connective tissue, in the same manner as in retinitis proliferans.

Gunshot wounds of the temple in attempts at suicide have afforded opportunities for the study of this type of lesion, of which we have notes of several cases amongst our wounded (Fig. 35, and Plate III, Figs. 1 and 2). It will be understood how, besides total or sub-total avulsion of the papilla, partial luxations, more or less pronounced, may occur, and between the most complete total detachment and the most moderate partial luxation it is easy to conceive all the varieties which have been demonstrated at our centres of military ophthalmology.

(*b*) *Lesions of the nerve in the retrobulbar portion which contains the central artery and vein.*—A projectile entering the orbit immediately behind the eye may divide the nerve more or less completely, tearing it, and with it the vessels which it contains. In these cases an ischæmia of the central artery is caused, presenting the ophthalmoscopic picture of embolism. To produce this ophthalmoscopic appearance it is not even necessary that the nerve should be lacerated; it is sufficient that the artery should be torn, with or without the vein. Hirschberg has reported a case of section of the optic nerve in which, in the course of two months, the retinal circulation became re-established at the same time as a visual acuity of 1/20. It is quite possible that in this case there was only a lesion of the central artery, and that the retinal circulation became restored

later by a collateral circulation between retinal arteries and those of the ciliary body; for anatomy demonstrates at the same time the difficulty, and the possibility, of the re-establishment of the retinal circulation by this mechanism.

The gravity of such a disaster does not need to be demonstrated. When the artery and the vein are lacerated the functions of the retina are abolished; and when the optic nerve is seriously contused the rupture of the nerve filaments adds an additional complication, and causes atrophy of the disc, a fatal consequence which also follows destruction of the vessels alone.

The condition is not so grave if the contusion of the nerve is so superficial as not to interfere with the circulation in the central artery and vein. It is known that the nerve can be pulled on fairly strongly without the vessels suffering; indeed, stretching of the optic nerve has been recommended in cases of atrophy by De Wecker, who hoped thus to restore the nutrition of the nerve by stimulating the circulation of blood in the vessels which it contains.

It is, however, rare for the optic nerve to be pulled on and bruised by a projectile without causing gross damage, and consecutive papillary atrophy is the ordinary result of traumatism. Moreover, when the foreign body is bulky, as in Case 20, at the same time as the optic nerve is bruised, the posterior pole is also the seat of grave lesions (profuse hæmorrhage in the macular region, and a veritable lake of blood in the choroid, resulting from the rupture of a vessel). Radiography and Krönlein's operation showed that in this case the projectile was behind the globe and in contact with the nerve.

(*c*) *Lesion of the nerve behind the site of entry of the vessels.*—In military surgery the optic nerve may be wounded directly by a penetrating foreign body, or indirectly by a fracture radiating towards the optic foramen, where a splinter may lacerate it as it passes through the foramen opticum.

(*d*) *Direct injuries.*—These occur after the entry into the orbit of foreign bodies, shrapnel, fragments of shell, etc.; at the same time as the injury to the optic nerve the projectile may have grazed and more or less bruised the eyeball, which may itself present direct lesions. It may happen that vision is only partially destroyed, and GONIN in his article in the *Encyclopédie française d'Ophtalmologie* (Vol. VII, p. 537) reports a case in which, after wound of the nerve by a fragment of lead, there was partial loss of vision; that is, a great exception to the rule that injury to the optic nerve by a projectile is followed sooner or later by complete atrophy of the nerve.

Such was our experience in a case in which the projectile, the sheathing of a bullet, was found after a Krönlein operation in the apex of the orbit, near the sphenoidal fissure (Case 21).

When the projectile is at the apex of the orbit, in contact with the nerve, in Cases 22 and 26, it may act by compression and bring about a simple primary white atrophy, *i. e.* not neuritic.

It may happen, further, that a large projectile enters the orbit, comes to rest within the muscular cone, without implicating the optic nerve, and leaving the eye with good vision. This happened in Case 23, where a shrapnel ball, following a horizontal course from without inwards, having perforated the external orbital wall behind the eyeball, came to rest in the cone of muscles $1\frac{1}{2}$ cm. from the posterior pole of the eye, at a very short distance from the optic nerve, which remained intact. When the intra-orbital foreign body is outside the muscular cone the optic nerve is much more likely to remain unharmed. This occurred in Case 20, where the shell fragment lodged above the globe and provoked, by direct contusion of the eyeball, serious damage in the deep membranes—hæmorrhage into the vitreous, choroidal rupture, retinal detachment.

(*e*) *Indirect injuries.*—These are consecutive to fractures. All ophthalmic surgeons who have experience

of industrial accidents know how frequently falls upon the head and fractures of the cranium are followed after a certain lapse of time by loss of vision on one side. Here we are dealing with those radiated fractures which, at the optic foramen and the sphenoidal fissure, lead to laceration of the vasculo-nervous bundle which represents the hilum of the orbit and the eye. It is now a long time since this anatomico-clinical theory, foreseen by some clinicians, was shown to be scientifically accurate by BERLIN. We have proved that in our cases these radiations were invariably due to injuries to the frontal bone.

Lesion of the optic nerve, moreover, may not be very serious, and absolute blindness does not always result. WILBRAND and SAENGER, out of 100 cases of unilateral optic lesions, following cranial traumatism, have recorded 50 cases of complete and permanent blindness, 4 cases of total blindness at the outset, which terminated by complete recovery, 17 by partial recovery with limitation of the visual field, and 24 cases in which the lesion of the nerve had been partial from the outset.

From this it follows that one must be very circumspect as to the prognosis of such lesions, especially when they affect soldiers, candidates for discharge and a pension, whose visual acuity is not always easy to determine. We have observed a recent example (Case 60), in which, after severe injury to the left temporal region, which demanded trephining, the visual acuity, by reason probably of lesion of the left optic nerve, had fallen to 1/10. The patient obstinately kept to this figure, when, by the test of the reversed image, we had convinced ourselves that it was at least 1/3.

In certain cases the traumatism is shown only by a central scotoma. In this case it is well to think of compression of the optic nerve; this compression affects by preference the macular bundle whose delicate functions are readily deranged. Under such circumstances probably there is swelling of the optic nerve,

or compression by a profuse intra-orbital hæmorrhage, or still more likely, hæmorrhage into the sheath.

This condition of hæmotoma in the tunics of the optic nerve merits particular attention.

Hæmatoma of the Sheaths of the Optic Nerve

Is effusion of blood into the sheaths of the optic nerve common after the orbit has been traversed by a projectile?

Is the classic opthalmoscopic picture, consisting of a brownish peri-papillary margin, often observed? These are the two questions which the military ophthalmic surgeon must put to himself, and our answers must be in accord with the observed facts and recorded cases.

A few words in the first place to set the question fairly before us.

Magnus and De Wecker and several others have sought to define precisely the clinical and anatomical signs of hæmorrhage into the sheaths of the optic nerve.

Magnus set himself to demonstrate: (1 that hæmorrhage of the nerve is followed in a few hours by characteristic peri-papillary and macular changes; (2) that the hæmorrhage is accompanied by a narrowing, more or less marked, of the arteries, with hyperæmia of the veins; (3) that the visual field becomes obscured from the centre towards the periphery in hæmorrhage of the nerve.

To all these signs De Wecker adds another which he considers to be very important, viz. the appearance of a peri-papillary flame-shaped hæmorrhage, and of minute hæmorrhages surrounding the macula. He agrees, therefore, that effusions of blood in the optic nerve extend to the retina, and he even believes that certain hæmorrhages of the vitreous come from the vaginal spaces of the optic nerve.

Rollet and Abadie support this view; they describe a peri-papillary layer of blood quite visible

with the ophthalmoscope, and we find similar assertions in the treatises of SCHWEIGGER and GREEFF, of DIMMER, in SCHMIDT-RIMPLER'S manual, etc.

GONIN, who has written a very interesting work on this subject, develops an opinion contrary to that of MAGNUS and DE WECKER.

He is of opinion that there is no case which supports these doctrines concerning the ophthalmoscopic signs of apoplexy of the optic nerve. He says that there is not a single case on record of this "sudden blindness which, after presenting the picture of retinal ischæmia, was proved by autopsy to be due to an effusion into the sheaths or the substance of the nerve; on the other hand, there is not a single case of proved vaginal apoplexy which manifested the ophthalmoscopic signs of obstruction of a central artery."

Following the same sequence of ideas, and in confirmation of GONIN'S opinion, particular attention should be given to a remarkable work by DUPUY-DUTEMPS upon hæmatoma of the sheaths of the optic nerve in meningeal hæmorrhage. In an historical essay of the highest value this author shows that hæmorrhage of the optic nerve of traumatic origin is due to the penetration into the vaginal cavity of blood effused in the cranial sub-arachnoid space.

Histological study in a first case proves that the intra-vaginal hæmatoma does not extend towards the globe beyond the anterior extremity of the cavity and does not cross the scleral barrier; blood does not penetrate farther along the trunk of the optic nerve. There were certainly in this case small islets of retinal hæmorrhage, but these hæmorrhages have no direct relation with the vaginal hæmatoma of the nerve of special sense of the eye.

In a second case, having to do with a spontaneous meningeal hæmorrhage, DUPUY-DUTEMPS has demonstrated the same precise anatomical facts; the hæmorrhage does not extend as far as the disc; it infiltrates the innermost fibrous bundles of the dural sheath, particularly as far as the central vessels, which it

surrounds with a continuous mantle. In these cases the ophthalmoscopic signs are not as MAGNUS, DE WECKER and the classic authorities in general have taught, those of retinal ischæmia, but simply œdema of the papilla, with dilatation of the veins, and retinal hæmorrhages which have arisen *in situ*, consecutive to difficulties in the circulation due to the compression of the central vessels.

Such are the older teachings (MAGNUS, DE WECKER, etc.) and the recent opinions (GONIN, DUPUY-DUTEMPS) concerning hæmatoma of the optic nerve. We make no pretension of writing an historical essay, however incomplete, on the question, our object being merely to contrast the two points of view, which are still *sub judice.*

It now remains only for us to state on which side we should range ourselves, after having observed a considerable number of grave injuries of the optic nerve which should certainly have been frequently accompanied by hæmorrhage into the sheaths. We say, modestly, " which should have been accompanied," because, as a matter of fact, we have not any histological examinations to throw into the arena of discussion, not having had, fortunately, to make autopsies on our wounded. It is, however, impossible that the optic nerves, bruised, lacerated by bullets, or shrapnel balls, or irregular shell fragments, which we have observed, should not have bled often into their sheaths, and, clinically speaking, we have many times been confronted with traumatic vaginal hæmatomata of the optic nerve.

We owe it to the truth to state that we have not found on a single occasion the ophthalmoscopic signs and clinical symptoms of retinal ischæmia, and that we have never observed the papillary effusion of blood upon which ABADIE has insisted. In civil ophthalmology it has been the same; after having examined, as happens to all ophthalmic surgeons in extensive practice, many injured persons who have suddenly lost the sight of one or both eyes, we have never seen

the blood well up into the eye from the sheaths of the optic nerve, and we have the impression that GONIN and DUPUY-DUTEMPS are right. Most certainly the anatomical researches made, notably by the latter author, count in the debate for much more than our impressions as clinicians, but it is not permissible to omit to state that our clinical observations and their pathological anatomy are in perfect accord.

One point, however, merits to be brought into relief. I have not found peri-papillary hæmatomata and intra-ocular effusions of blood consecutive to hæmorrhages of the optic nerve, but I have sometimes seen, a considerable time after the traumatism, the brownish pigmented ring of which the classic authorities speak.

I have observed it recently in patients suffering from serious injuries which caused at the outset, without any lesion, a complete loss of central visual acuity; vision became re-established gradually in the course of time.

Fracture of the right superior orbital margin; hæmorrhage into the sheaths of the optic nerve. (Case 27.)

P., Infantry, wounded Jan. 10, 1916, by shell-fragments, of which one had caused a slight depression of the right superior orbital margin, from which it had been extracted. According to the patient's story the shell burst at a distance of about 1 metre, and the explosion was followed by total loss of vision of both eyes. The sight of the left eye returned twelve hours later, but the right eye only commenced to perceive light three weeks after the injury.

On his arrival acuity was as follows—

R. E. Perception of light.
L. E. V = 3/10.

No lesion of transparent media nor of deep membranes. The visual field, taken Jan. 19, shows irregular contours on the left side, with peripheral contraction and a semi-annular para-central scotoma.

Condition.—March 3, 1916, the pupil reacted feebly to light. There is slight inequality of pupils.

The accommodation reflex exists, but is enfeebled; consensual more energetic in the L. E.

March 3.—R. E. V = 1/20.
L. E. V = 4/10.

On March 6 there is reported for the first time, on the temporal border of both discs, a blackish-red pigmentation, bordering the scleral ring, leading one to think of a hæmorrhage of the sheaths; these pari-papillary half-rings can only be blood or blood débris, which has taken several months to arrive at the disc.

L. E. V = 4/10.
R. E. V = 5/10.

The visual field taken at this date shows a concentric shrinking without central scotoma.

March 27, 1916, R. and L. E. Reflexes normal, no lesions of the fundus, except the pigmentation reported on March 6, which remains stationary in both eyes.

Visual fields normal. No contraction, no scotoma, no dyschromatopsia.

R. E. V = 10/10.
L. E. V = 10/10.

At this date one may regard the patient as having recovered. It remains to be seen what course will be taken by the pigmentation of part of the scleral ring.

April 4, 1916. The slight red pigmentation bordering the scleral ring persists, but shows a tendency to disappear.

Discharged April 4, 1916.

Fracture of left orbit; right macular choroido-retinitis.
(Case 28.)

J. B., Infantry, wounded at V., Feb. 29, 1916, by shell fragment. Dressed at once, he was sent to B. and Limoges. From his depot, July 13, 1916, on complaining of weakening of the visual acuity of the right eye, he was sent on to us.

Condition.—The existence of a mobile cicatrix is noted, not painful, 4 cm. long, in the form of an **E**, situated a little above the superior exterior angle of the left orbit. On palpation a slight depression of the subjacent bone is felt (frontal fossa and orbital process of the frontal bone).

The left eye, corresponding with the wounded side, is emmetropic; V = 10/10. The transparent media and the deep membranes are intact.

The right eye, which has not been bruised, is, on the contrary, the seat of slight mydriasis, with manifest slowness of action of the photo-motor reflexes.

The ophthalmoscope shows no lesion of the refringent media.

On a level, however, with the external margin of the disc there is a hæmorrhagic band, about 1 mm. broad, over two-thirds of the papillary circumference. This hæmorrhagic crescent in this position suggests hæmorrhage into the sheaths of the optic nerve.

In the sub-macular zone there is also a retinal hæmorrhage in the shape of a haricot bean, with the hilum upwards, corresponding on perimetric examination with a semi-annular scotoma, para-central and superior (Fig. 1, Plate I).

The visual acuity of this eye equals 1/10 barely.

B. was discharged June 5, 1916, convalescent. On his return, Aug. 5, his condition remained stationary.

Fall on the head from shell explosion; indirect lesion of optic nerve; hæmatoma of sheath. (Case 29.)

B. C., Infantry, wounded at Fl., Sep. 6, 1916, by the explosion of a shell which threw him to the ground; he fell on the back of his neck. A few moments afterwards, the patient tells us, there was a considerable hæmatoma of the eyelids and conjunctiva. He found that the sight of the left eye was damaged immediately after the injury. He was evacuated to Bourges a week later.

Oct. 26 he had seven days' leave. He returned to his depot, thence to Pau, afterwards to Bordeaux.

Condition.—Dec. 12, 1916, there was pigmentation from tattooing by powder of the sclerotic, and, at the internal border of the cornea, towards eleven o'clock, a speck which is probably consecutive to a traumatic keratitis; the anterior chamber is normal, the reflexes, although diminished, are present.

The lens and the vitreous are normal; the disc presents an unusual aspect. In the peri-papillary region there is an abnormal pigmentation of brownish colour, especially

well marked on the internal border (inverted image). (Fig. 36.)

In the inferior internal portion of the disc there is a notch; it seems as if in this position the pigmentation overlaps the border of the disc.

The rest of the papilla appears normal, the vessels

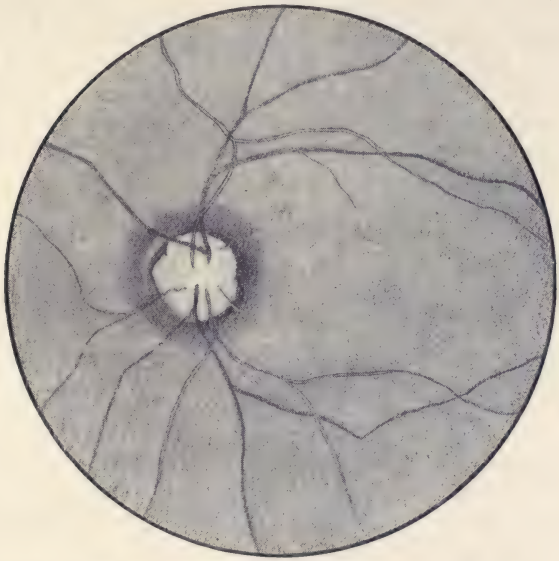

FIG. 36.—Peripapillary hæmatic pigmentation of traumatic origin.

having their physiological calibre. The macula presents a slightly congested aspect and is clearly differentiated from the rest of the fundus. It is, however, probably normal.

R. E. V = 10/10.
L. E. V = 2/10.

In this case we think that a traumatic hæmorrhage of the optic nerve has caused compression of the macular bundles, and that, little by little, the compression

has disappeared in proportion as the hæmorrhage has been absorbed.

The formation of this pigmented ring is not due to the propagation of the hæmorrhage, but to the migration of hæmatic pigment; and in the discussion which took place at the Société d'Ophtalmologie de Paris, in 1913, on the subject of DUPUY-DUTEMPS' work, KALT very rightly remarked that the production of this pigmented ring could be quite well brought into accord with the anatomical reports of DUPUY-DUTEMPS. The propagation of an effusion of blood and the migration of blood-pigment after the resorption of hæmorrhage are very different matters: the second might occur without the first.

There is a nutritive current going from the optic nerve towards the eye which is perfectly capable of carrying the pigment from behind forwards and of depositing it, on its entry into the eye, in the cribriform plate and in the choroidal zone which immediately surrounds the disc. It appears to us that this pigmented ring should always be regarded as the sign of an old hæmatoma of the optic nerve, and several times amongst our wounded cases we have been able to give it this signification (Fig. 36; Plate 1, Figs. 1 and 2).

B.—LESIONS OF THE VESSELS. TRAUMATIC HÆMORRHAGES INTO THE ORBIT

Traumatic effusions into the orbit have been known since CARRON DU VILLARDS, who well defined consecutive exophthalmos as "a compression and a hernia of the eye." He reports the case of an unfortunate colleague who died after a fall on the pavement; at the autopsy there was found "a fracture of the orbit near the optic foramen, the ophthalmic artery and vein having been ruptured; the eye was thrust forward by an enormous clot of blood."

Accoucheurs have long noted intra-orbital effusions after the application of the forceps, and in all the classic works on ophthalmology we find very precise

indications on the subject of orbital hæmorrhage. MACKENZIE mentions a very interesting case of intra-orbital hæmorrhage, accompanied by abundant epistaxis and ending in death. DESMARRES, in his chapter on affections of the orbit, speaks of tumours produced by the extravasation of blood in the cellular tissue (*Tumeurs de l'Orbite*, Vol. I, p. 230).

DEMARQUAY describes in his *Traité des Tumeurs de l'Orbite* (*a*) effusions of blood, following fracture; (*b*) effusions of blood, following wounds; (*c*) effusions of blood, following contusion; (*d*) spontaneous effusions of blood.

On the subject of traumatic effusions of blood, the only class which interests us, he recalls the cases of the authors we have just mentioned and gives several unpublished cases of his own, notably the case of a young man of sixteen who, falling from the mast of a ship upon the deck, had such an intra-orbital hæmorrhage that the eye came out of the orbit and hung over the nose immediately after the accident. The visual function was completely lost, but the eye completely resumed its place after some months, without surgical interference.

DE WECKER devotes a chapter to hæmorrhages into the orbit, and distinguishes two classes of traumatic hæmorrhages: those which are produced by direct lesions and those which are the result of indirect. He expressly mentions projectiles amongst the causes.

The authors who have written on the subject disagree entirely as to the relative frequency of this kind of accident. According to CARRON DU VILLARDS it is very common in injuries of the orbit; according to BERLIN it is very rare. According to our cases the first author is right, since all our orbital cases, wounded by projectiles of war, presented in the early period of their injury exophthalmos more or less pronounced, which must obviously be attributed to an effusion of blood, in many cases very abundant.

The source of this intra-orbital effusion of blood

varies; it may come from the vessels of the orbit or surrounding parts, or from the intra-cranial vessels.

The hæmorrhages arise sometimes from an injury to the ophthalmic artery or vein, and it is by such injuries that one can explain the appearance of an aneurism at a later stage. As a rule the blood which is poured out behind the eye comes from a lesion in the trunk itself or from one of the important vessels at the posterior part of the orbit. Sometimes, however, the extravasation of blood begins in the cellular tissue of the eyelids and works backwards, passing from the superficial to the deep portion of the orbital cavity. Further, in the greater number of cases, the cause of the hæmorrhage cannot be exactly located. That is precisely the position in which we find ourselves with regard to our patients, for they have all recovered, and hence we have not been able to study the anatomical condition in detail.

We must compare with these traumatic intra-orbital hæmorrhages those which sometimes result from a too free tenotomy and those which happen after a Krönlein's operation, or simply after an enucleation in which the operator's scissors have strayed behind Tenon's capsule.

Sometimes the blood comes from fractured bones; the bones of the orbit are in certain places thick and richly vascularised by the vessels which run either in the diploë or in the compact tissue. When ruptured they bleed into the orbit, and must often be the cause of the hæmatomata met with in our patients. The hæmatomata of the orbit in the newly born, delivered by means of forceps, have generally a hæmorrhage of bony origin as their cause.

When the blood comes from intra-cranial vessels it may enter the orbit in several ways, according to J. Rollet, who wrote an excellent account of the subject. Sometimes it passes through a fissure in the fractured orbital vault, thus bringing the blood extravasated beneath the pia mater into communication with the orbital chamber. In this case not only the vessels

of the pia mater, but also the vessels of the brain bleed. In certain fractures of the orbit, of which we shall report cases later, the frontal lobe is reduced to a pulp; above the orbit a large aperture establishes free communication between the cranial and orbital cavities, and we find behind the eye a blackish mass continuous with the brain.

In other cases extravasation of blood takes place under the detached dura mater and extends into the coverings of the optic nerve. There are, further, cases in which a splinter of bone, detached from the orbital wall, has wounded a meningeal vessel. MACKENZIE, again, quotes a case of comminuted fracture of the orbital vault, which lacerated the cavernous sinus, and produced in consequence a very large effusion.

Again, the blood may reach the orbit through a natural aperture, the optic foramen, follow the sheath of the optic nerve and produce an intra-orbital hæmorrhage, at the same time as a hæmatoma of the nerve-sheaths, the subject with which we were dealing above.

Moreover, to J. ROLLET is due the merit of having been the first to point out orbital hæmorrhage by contre-coup.

Finally, blood may also come from the nasal cavities and sinuses. It is not rare in orbital fractures for the orbital wall to be staved in. The mucous tissues of the nose, very richly vascular, almost erectile, bleed at the same time into the nasal fossæ and into the orbit; the frontal sinus is less vascular, but when it accidentally communicates with the orbit, it may also fill it with blood. Similarly the maxillary sinus when seriously injured may become filled with blood, which overflows into the orbital cavity.

Symptoms.—The chief symptom is exophthalmos; the accessory symptoms are subconjunctival ecchymosis and infiltration of the eyelids.

The exophthalmos is remarkable for the rapidity of its development. It is direct—that is, the eyeball is thrust forwards almost as if it were a question of a tumour of the optic nerve; it is easily reducible, and

becomes more marked when the patient leans the head forwards. The circumstances under which it has occurred scarcely permit of any error in diagnosis.

Subconjunctival ecchymosis may occur, even when there is no exophthalmos—that is to say, when the very moderate intra-orbital hæmorrhage merely suffuses the tissues. The fluid blood slowly spreads through the orbital tissues as far as the conjunctiva, which becomes ecchymosed only after the lapse of time, twenty-four to forty-eight hours, or sometimes more. It is one of the classic signs of fracture of the cranium which has been studied by QUESNAY in the *Mémoires de l'Académie de Chirurgie* and demonstrated by VELPEAU. Its delayed appearance in fractures of the orbit from projectiles of war indicates a fracture of the base of the skull.

It is well, moreover, to distinguish clearly between the outpouring of blood which results from a fracture of the orbit and that which follows a direct contusion of the soft parts. We are again indebted to J. ROLLET for a valuable article in which he has established, (1) that ecchymosis due to a fracture spreads by degrees; (2) that it is limited to the conjunctiva and its palpebral folds; (3) that it produces only a moderate amount of tumefaction: whereas that which follows on contusion is very rapid in its onset, spreads to the soft parts of the face, and readily assumes large proportions.

Hence, when we find (as in Cases 17, 20, 21, etc.) well-marked exophthalmos and profuse ecchymosis we must regard them as due to lesions of the soft parts with laceration of the orbital vessels.

When there is no infection of the wound hæmorrhage is often absorbed quickly, the exophthalmos disappears, and the visual functions are restored in proportion as the optic nerve and the sensori-motor apparatus have remained intact. But it may happen that the orbital wound becomes infected; orbital cellulitis then ensues, by no means a negligible complication. It must be pointed out, however, that this infection is quite rare. Perhaps the patients attacked with it do

not get as far as our hospital and have been treated at the front. It is remarkable, however, to note amongst the hundreds of fractures of the orbit which we have examined the smallness of the number of those complicated by infective cellulitis of the orbit. We have only seen two cases, which may be summed up thus:

In the first patient a bullet penetrated at the level of the left zygomatic arch and emerged by the left orbit, rupturing the eyeball, which was enucleated the day following the injury. When he came under our care, six days later, he presented all the signs of orbital cellulitis (extreme œdema of the lids, voluminous chemosis, conjunctival suppuration); further, the signs of meningeal reaction were present (KERNIG'S sign, slow pulse, temperature 38·6° C. (101·2° Fahr.) vomiting). A lumbar puncture proved negative; incision and drainage of the orbital cavity, with the application of ice to the head, brought the infection under control, and recovery rapidly followed.

The second patient was struck by a shell fragment which penetrated at the level of the root of the nose on the right side, traversed the right lacrymal sac, the nasal fossæ, the left orbit, and finally lodged in the left temporal region. The eye was in a condition of exophthalmos, and ophthalmoscopic examination showed detachment of the papillo-macular region of the retina. Three weeks after admission orbital cellulitis appeared; an incision through the external wall permitted the escape of a large quantity of fœtid pus; there was osteo-periostitis of the orbital wall. Recovery was very slow, and on Dec. 31 the patient showed signs of suppurating ethmoiditis, which necessitated his removal to the rhinological department. Jan. 13, he was returned to us as an urgent case, the orbital infection having returned; we then noted the evidences of meningeal reaction (KERNIG'S sign, vomiting, temperature 38·4° C. (Fahr. 100·6°).

The general symptoms rapidly grew worse, and we made a lumbar puncture which yielded almost pure pus. Jan. 22, the patient died, probably from a

cerebral abscess previously latent, opening secondarily into the meninges, consequent upon infection of the encephalon through the orbital aperture.

Orbital cellulitis is therefore an exceptional complication. We explain its rarity by suggesting that usually the bullet or fragment of shell which enters the orbit does not carry with it shreds of dirty clothing, and that the orifice of entry, usually very small, closes spontaneously sufficiently quickly to escape the dangers which may attack a wounded man who does not obtain immediate attention.

When the instrument of trauma is not infected or such as is capable of infecting the orbital cavity, it may happen sometimes that infection proceeds from the fractured nasal fossæ, which freely communicate with the focus of hæmorrhage. We have recently seen an example, which, although it is not a war case, merits none the less to be reported here.

A boy aged eleven, when running, fell suddenly on his nose; there was immediate epistaxis and very marked exophthalmos, indicating intra-orbital hæmorrhage from rupture of some important vessels; six days later inflammatory complications appeared (fever, great pain, well-marked and painful swelling at the angle of the eye, above the lacrymal sac). It soon became evident that a large purulent collection had formed behind the eye; it was necessary to incise and drain. This procedure resulted in rapid and uninterrupted recovery. It is quite probable that infection of the orbital pocket of blood resulted from the fracture of the os planum and laceration of the mucous membrane of the nasal fossæ. Thus the infection-carrying substances from the nose penetrated into the orbit.

It would be natural to expect that in fractures of the orbit by projectiles of war, in which the nasal fossæ and the nose are largely involved and put in communication with the orbital chamber, such an infection would be frequently produced. We are bound to admit that it is not so, and that in practice this complication is very rare.

What we have observed concerning intra-orbital hæmorrhages amongst our cases nearly always consists in a rapidly formed and well-marked exophthalmos, which yields little by little to the influence of time without resulting in permanent damage.

When fracture implicating the orbital vault allows of free communication between the orbital chamber and the brain events happen due to the cerebral lesion itself; some interesting cases of this will be given later.

C.—Traumatic Lesions of the Extrinsic and Intrinsic Muscles

A certain number of cases are reported of paralyses of muscles of the eye due to contusions and to orbital injuries. All instruments of violence, whether cold steel or projectiles, may implicate more or less gravely the recti and oblique muscles of the eye; the muscle is thrust against the orbital wall and crushed. Bernheim quotes the case of a child who, flinging himself against a door, ruptured the internal rectus near its bulbar insertion.

Panas, in 1902, collected the published cases of traumatism of the ocular muscles, and remarked that the chief agents were contusions, accidents with foils, horns of cattle, blows against hard substances, doors, sticks, etc.

The pathological anatomy of these muscular ruptures is not exactly known, for usually the surgeon intervenes too late, when the repair is already effected. In two cases only, one by Panas and one by Graefe, the muscle was torn at its insertion into the sclerotic. It is probable that in other cases the rupture occurred in the muscle itself. There is good reason for this view in that traumatic muscular paralysis is usually direct—that is, the muscle itself is contused or crushed, hence it is there that the solution of continuity should occur. Besides, ruptures of muscles are produced, as is demonstrated by the general surgeons, sometimes in the fleshy portion, sometimes in the tendon, according

as the muscle is injured at the moment of contraction or at the moment of relaxation. MALGAIGNE, taking the idea from DELPECH, carried out some noteworthy experiments in connection with this subject. "Muscular rupture," he says, "only takes place when the muscle is stretched and elongated, rupture of tendon when the muscle is shortened and contracted." So far as concerns the muscles of the eye there is no reason for refusing to accept this opinion of the general surgeons.

Since the work of PANAS, GARIPUY and DEMICHERI have published cases of paralysis of the superior oblique, and TERRIEN has reported a case of partial paralysis due to an effusion of blood which filled the cavity of the left maxillary sinus.

TERSON and COSMETATOS have published similar cases.

Sometimes the injury causes an effusion of blood into the sheath of the muscle; paralyses by intramuscular hæmorrhage (DE LAPERSONNE) are produced in this manner. We do not dwell upon this subject because we do not wish to pass in review all the published cases; it will suffice if we place on record here those which we have observed, and which are as follow:—

We have noted seventeen cases of this kind. The seat of the orbital fracture is in immediate proximity to the muscle attacked; we draw particular attention to fractures of the roof, which were accompanied nine times by paralysis, either of the levator palpebræ, or the rectus superior, or both together. In four of our cases paralysis of the inferior rectus alone coexisted with a depression of the median portion of the inferior orbital margin. Another patient, after an infero-internal wound of the orbit, was affected with diplopia due to paralysis of the inferior oblique. In another case the external rectus was traversed by a revolver bullet. Finally, we cite two cases of detachment of the pulley of the superior oblique following a smash of the corresponding frontal sinus.

In four other cases it is more plausible to admit the hypothesis of a fracture radiating to the apex of the orbit. These, after a depressed fracture of the frontal bone or of the supero-external angle of the orbit, had several extrinsic muscles paralysed at the same time. We may suppose that a lesion of the nerve filaments themselves at their entry into the orbit had occurred, for this best explains the multiplicity of symptoms. These four cases may be summed up in this manner—

(*a*) Paralysis of the superior rectus and the levator palpebræ, with internal ophthalmoplegia.

(*b*) Paralysis of the superior rectus, the levator palpebræ, and the internal rectus, with internal ophthalmoplegia.

(*c*) Paralysis of the superior rectus, the internal rectus, and the inferior oblique.

(*d*) Paralysis of the superior rectus, the inferior rectus, and the superior oblique.

Finally should be mentioned two cases of paralysis, one of the superior rectus, the other of the superior oblique, consecutive, one to a bullet going to the apex of the orbit, the second to a fracture of the fronto-temporal region after a fall on the head, in which the nerve-trunk alone seems to have been involved.

Intrinsic muscles.—In reviewing the action of gross injuries of the orbit upon the intrinsic muscles of the eye no one will be surprised if we give a considerable number of examples. We have very frequently observed paralysis of the sphincter and the mydriasis which results from it, a very real mydriasis, attributable to rupture of the muscular fibres, and only very rarely accompanied by paralysis of the accommodation.

The mechanism of traumatic mydriases, by direct shock upon the eye, is well known, and when the projectile has touched the eyeball tangentially it is not surprising that such a phenomenon should occur. But when the projectile has not touched the eye the case is more interesting and merits attention.

We have met with two cases of this kind amongst the wounded who had fracture of the superior orbital

margin; they presented no lesion of the ocular membranes, and visual acuity was preserved; hence we had to ascribe this paralysis of the pupillary and ciliary muscles to concussion.

We now come to the affections which implicate the eye itself. We shall consider successively those which occur—

(1) In the transparent media.

(2) In the deep membranes, where we shall make two subdivisions, (*a*) lesions of the uveal tract, (*b*) lesions of the retina.

D.—Lesions of the Eyeball

(1) Affections of the Transparent Media

Cataracts from Contusion and Concussion of the Lens

Opacification of the crystalline lens, consecutive to contusion of the lens without rupture of the capsule, is incontestable. It is not even rare, so that Arlt, Liebreich, Desmarres and Warlomont were wrong in doubting it. De Wecker, Berlin, Becker and Fuchs have demonstrated its existence both clinically and by experiment. The last author has written a remarkable essay upon the subject; he describes three types of anterior polar lesions.

(1) Starred form, with rays in arranged sectors, increasing in thickness towards the periphery.

(2) Rays terminating in a point towards the periphery.

(3) Arrangement in the form of leaflets.

These are superficial epithelial troubles, capable of disappearing. Lesions of the posterior pole are more serious and are dissipated with difficulty; is it possible that there is in this case a delicate invisible laceration of the capsule in the hyaloid fossa?

It is certainly not impossible, and it is the opinion to which Bonnefon, who has made an interesting study of the question, is inclined.

This author thinks that in the affections of the anterior pole of which FUCHS speaks it is a question of epithelial disorders not affecting the lens fibres. The normal unions of the various parts of the lens become separated, but there is no cataract properly so called; if the striæ persist, they are situated at the site of dislocation of the fibres, and he believes that when a rapidly developing cataract is produced after a contusion there exists a rupture of the capsule.

We have observed, clinically, cases which agree well with BONNEFON'S opinion; we have a very clear recollection of a patient who, after a contusion of the eyeball, presented at the posterior pole a star-shaped cataract which seemed likely to progress rapidly. This was an error in prognosis, for the polar and stellar opacity became absorbed. It is quite possible, in fact, as BONNEFON thinks, that posterior polar cataract may become absorbed when there is no rupture of the capsule, and on the contrary, will become complete when a rupture exists, however small this may be. We need not allow ourselves to be disturbed by the objections of those who quote as argument for cataract without rupture what happens in experimental (naphthalin) cataract. There it is a question of disturbance of the lens analogous to that in spontaneous cataract, which depends evidently upon an alteration of nutrition, more or less unknown, and which has nothing in common with traumatic cataract.

But still more interesting are the cases consecutive to air concussion—what the old writers called "the wind of the cannon-ball."

We have seen several typical cases, notably two instances reported by our assistant, DR. HARRIET, which deserve to be placed on record, because they are two very clear examples of lens opacity, of true cataracts, due to the shock of aerial waves on the eyeball: two men, walking side by side upon the same level were violently thrown to the ground by the bursting of a shell. In addition to superficial injuries and slight contusions, both immediately complained of a

sensation of burning in the eye and of a slight diminution of sight.

Nine days after the traumatism these cases presented, besides traumatic mydriasis, a star-shaped posterior polar cataract; the branches, to the number of six, very irregular in one case, a little more marked in the inferior portion in the other, occupied the posterior pole of the lens. Three months later the cataracts, evolving normally, were almost complete.

The offending agent here was the concussion of the aerial waves produced by the explosion of the shell, and it is probable that the posterior capsule was the seat of a small laceration.

We do not dwell upon these two cases, which do not strictly belong to fractures of the orbit; we have drawn attention to them on account of the analogy which they present to cataracts produced by the concussion imposed by projectiles upon neighbouring parts of the eye.

We are able to report three examples of these cataracts by concussion, due to traumatism in the neighbourhood of the eye.

One case had a fracture of the right temporal bone, with cerebral pulsation perceptible; the right eye had an intumescent cataract, and the excellent light reflexes allowed us to conjecture that the deep membranes were intact.

The second case also had an intumescent cataract of the right eye, with preservation of the globe, without injury to the media, an affection consecutive to a fracture of the superior margin of the orbit by a fragment of shell.

In the third case, with a fracture of the supero-external angle of the orbit, there was iridodialysis on the side of the bony depression and total cataract. Examination of the reflexes, however, indicated that there was serious damage to the choroid and retina (hæmorrhage or detachment).

It follows from what has just been said, and particularly from our cases, that we cannot accept the

conclusion of EGNER, admitted by DOR (*Encyclopédie française d'Ophtalmologie*, Vol. VII, p. 13): "Cataracts by simple contusion can no longer be considered as a rarity, whilst cases of rupture of the capsule by simple contusion are rare."

What do these authors know about it, and upon what are they basing their assertion concerning the rarity of capsular laceration?

In the cases of concussion by displacement, such as those which we report, where it seems at first sight that the capsule should have been spared, nothing is less certain, since we know that the shock of an aerial wave is capable of dislocating a lens or rupturing the uveal tract—why should it not be able to rupture the lens capsule?

We are of opinion, with BONNEFON, that the anterior epithelial mischief and the disturbances of the various segments dislocated backwards are susceptible of absorption when the capsule is not ruptured: there is no true cataract in such cases. When the cataract progresses and becomes complete, it is probable that the capsule is torn somewhere near the part which earliest becomes opaque.

Subluxation and Luxation of the Lens

We have observed several cases presenting no essential differences from lesions of the same order which are common enough in civil practice, notably in occupational accidents. We will quote only one case, concerning a luxation of the lens upwards, which remained for some months suspended by a narrow band of the suspensory ligament without falling into the vitreous. In saying that such lenses are not the seat of cataract we are saying nothing out of the common, because, in this case, the force which loosened the lens met with no resistance, and the lens escaped without contusion.

A more interesting fact from the point of view of military ophthalmic surgery is the tolerance of the

eye towards a dislocated lens; even in cases when the luxation has been complete we have generally found that it leads to no further damage. This was so in the two cases of subluxation we saw amongst cases of fracture of the orbit.

The first case was one of fracture of the left frontal bone and the vault of the orbit, with manifestation of cerebral pulsation; in the left eye we noted, besides optic atrophy and pigmented choroido-retinitis of the macular region, subluxation of the lens, which was still transparent, down and out. In the second case the left upper eyelid had been partially destroyed by a piece of shell; there was a breach in the superior orbital margin; the left eye presented complete optic atrophy, iridodialysis up and out, and subluxation of the lens down and out.

(2) Affections of the Membranes: (*a*) Uveal Tract

In the study of the complications which involve the sclerotic we have no case to report, because, when the projectile has fractured the orbit and directly injured the eye, the globe has burst, not at any peripheral spot, but over a very large extent; it has been destroyed.

Limited scleral ruptures do not apparently occur in military surgery. Out of 609 cases of fracture of the orbit, in 212 the globe has been destroyed by bursting; in 105 the globe has been spared completely; in 292 the deep membranes have been damaged; not once has the sclerotic been ruptured in a limited region.

The fact is indeed surprising, but one can only bow to the clinical evidence, and in our work there is no occasion to speak of partial ruptures of the eyeball.

We pass on, therefore, to traumatic lesions of the uveal tract.

In the serious contusions suffered by the eye in fractures of the orbit, we shall consider in the first place lacerations of the pupillary margin of the iris, and detachment of the ciliary border; in the second place ruptures of the choroid and detachment of this

membrane. We shall pass in review successively the distinctive features which these affections have presented amongst our wounded.

Lesions of the Iris

Laceration of the pupillary border.—It is known that lacerations more or less visible, though rarely visible even to oblique illumination, are the common cause of traumatic mydriasis after contusions of the eye. It has happened to us to be able to identify linear gashes in the form of triangular fissures. One of our patients, observed recently, had this condition in conjunction with a very marked mydriasis, showing two small radial fissures between six and seven o'clock; these tears must be looked for with the corneal loupe. They are visible under the great magnification given by this instrument when the most careful examination with an ordinary lens fails to detect them.

We are concerned, as we said above, with a traumatic paralysis directly affecting the muscle, and one in which there is no lesion of the nervous system. It is probable that these lesions of the sphincter happen when the contusion of the iris takes place through a cornea struck perpendicularly to its basal plane; the muscular fibres of the iris are themselves compressed, crushed between the cornea and the lens, which resists only so far as it is supported by the hyaloid fossa. In our cases it has been impossible to discover the direction in which the force acted most strongly.

Dialysis of the iris.—There are several theories to explain iridodialysis.

According to SCHMIDT-RIMPLER, traumatic iridodialysis is due to depression of the sclerotic by the object which strikes the blow. The insertion of the iris suffers an amount of traction which is all the greater because the injury produces at the same time contraction of the pupil, as was shown by BERLIN. The iris becomes torn away close to its attachment.

FÖRSTER, relying upon experimental researches,

points out that the aqueous humour is driven back towards the centre of the eye. The iris is closely applied to the lens, thus closing the communication between the anterior chamber and the posterior chamber; the pressure stretches the iris from before backwards and ends by causing it to give way in the part where it is not supported by the lens, *i. e.*, towards the periphery.

Sattler admits the simultaneous action of the depression of the sclerotic and the forcing back of the aqueous humour.

Ballaban, however, points out that, the globe being full of fluid, there can be no marked difference of pressure between the aqueous humour and the vitreous. The iris cannot therefore be driven back against the lens. According to this writer the sclerotic is depressed at the same time as the pupil contracts; the wall of the globe, which is very elastic, then recoils upon itself, overpassing the limits of its initial position. The iris cannot follow it and is torn at its base, which is the least resistant portion and the point of maximum traction.

It is essential, therefore, that the blow which strikes the eye should be sudden, indeed instantaneous, and that it should attack the sclero-corneal margin. The youth of the patients is a favourable condition, because the sclerotic is still very elastic in young subjects.

The most probable of these theories appears to us to be that which explains the detachment of the iris by compression of the aqueous humour, driven back into the angle of filtration. It is possible that this may be the mechanism by which separation of the uveal tract from the sclerotic is produced; but it is difficult to suppose that the pathogenic mechanism should always be essentially the same.

We have not observed iridodialysis as a complication of fractures of the orbit, but we think we ought to report here a case of this lesion in a subject who had a double dialysis of the iris after having been

violently thrown down by a shell-explosion and struck on both eyes by fragments which injured the centres of both corneæ (Fig. 37). It seems, in fact, in this case, that the anterior chamber had been flattened out by the shock, and that the cornea had been made to touch the lens, driving the aqueous humour into the spaces of FONTANA. The space of the iridic angle had been over-distended, and the iris became detached from its base by the excess of aqueous humour which accumulated in the angle. The detachment of the iris took place all the more readily because the iris is not supported by the lens at the site of its attachment to the ciliary body. In short, FÖRSTER'S theory seems to us to give the best explanation of the case represented by Fig. 37.

Injuries of the iris, laceration of the sphincter or dialysis, may be accompanied by hæmorrhages and inflammatory complications. Hæmorrhage explains itself in dialysis, because the vascular plexus at the base of the iris may be ruptured and bleed profusely. We have not seen these hæmorrhages in our cases, because the patients have usually arrived at the base several weeks after the infliction of their injuries, so that the effusion of blood has had time to become absorbed. Lacerations in the region of the sphincter do not bleed; there is only extravasation of a few red corpuscles in the muscular tissue of the sphincter iridis.

We have not gone into the inflammatory complications further; doubtless, after such traumatism, the blood, which is laden with all sorts of toxins, may deposit them in the lacerated tissues, and thus produce inflammation of endogenous origin; so that this inflammation may result from chemically irritating toxins or from microbes directly deposited in the wound by the circulation.

Contrary to certain ophthalmologists, we firmly believe in infections of internal origin, but we have not met with them in our patients.

We explain this fact by the age of the soldiers, who

are as a rule healthy subjects. It is worn-out subjects who are liable to inflammations of internal origin, especially old people with anterio-sclerosis. The old folk we operate on for cataract, cardiacs, with hyper-tension, will get iritis in spite of perfect asepsis, even with an operation with the conjunctival flap, because they resist so badly the poisons with which their aged organisms are laden. Soldiers, habitually very strong, have supple vessels and tissues which

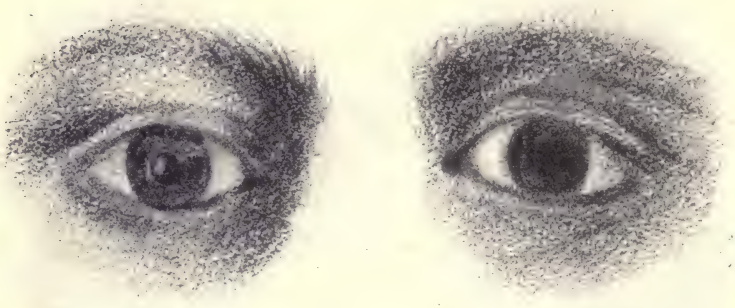

FIG. 37.

protect themselves well; hence injury of the iris is not complicated by inflammatory manifestations.

After traumatic lacerations of the sphincter and dialysis of the iris we must here notice cases of inversion of the iris.

This accident happens when, as a result of injury, the intra-ocular pressure in the anterior chamber is very suddenly raised: the sphincter of the iris is then thrust back into the triangular space which separates the membrane of the iris from the lens; the pupillary margin turns backwards on itself, and the whole breadth of the membrane of the iris follows the inversion of its margin; the result is that the entire

iris becomes finally flattened against the ciliary body; a true luxation of the pupil is thus produced.

We have not seen any cases of this nature.

Lesions of the Choroid

Choroidal lesions present for examination: (1) Ruptures of the choroid; (2) Hæmorrhages and detachment of the membrane.

These various disorders are met with either when the eye has been struck directly, or when a concussion in the vicinity has shaken the organ with sufficient violence to rupture one of its membranes.

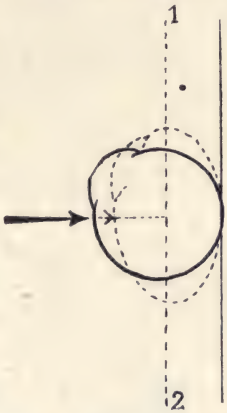

FIG. 38.—Equator of depression (Arlt).

(1) CHOROIDAL RUPTURES—These may be produced directly by traumatism implicating the eyeball itself, or may be the result of indirect lesions by concussion.

We shall now study the first variety.

(*A*) *Direct choroidal ruptures from a blow upon the eye.*—There are many theories to explain these.

(1) The theory of direct pressure (AMMON), applicable to lacerations of the anterior region of the choroid, and, exceptionally, to some lacerations at the posterior pole.

(2) The theory of contre-coup (KNAPP, BERLIN, SEIDLITZ), in which the mechanism of certain fractures of the skull is invoked.

(3) BECKER is of opinion that ruptures of the choroid at the posterior pole are due to the concentric pressure or traction of the optic nerve, exerted at the moment of traumatism upon the posterior pole of the globe.

(4) FAGE believes that at the moment of a contusion the eyeball finds itself between two resistances, the orbital wall on one side and the insertion of the

optic nerve on the other; between these two, the choroid, stretched, and only slightly extensible by reason of the vessels which bind it to the sclerotic, is torn in a direction perpendicular to that of the traction.

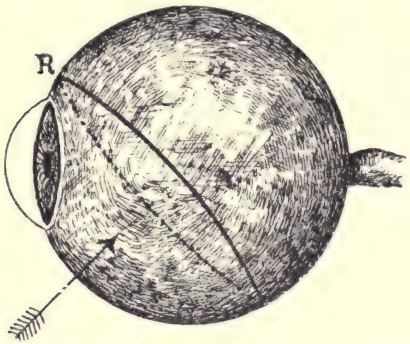

FIG. 39.—Traumatism affecting the lower part of the globe. Rupture at R, in the thinned intercalary space.

(5) SAEMISCH thinks that the choroid tears at the point where it is most firmly fixed, either behind in the region of the disc, or in front near the ora serrata.

(6) DE WECKER ascribes great importance to the sudden contraction of the muscles of the eye at the moment of injury; he thinks that this contraction deforms the globe and contributes to the choroidal rupture.

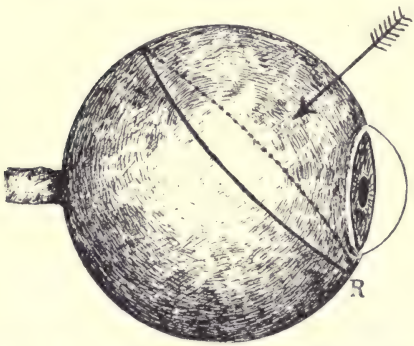

FIG. 40.—Traumatism affecting the upper part of the globe. Rupture at R, at the site of the intercalary space, the thinnest portion of the ocular wall.

ARLT defends the theory which he has brought forward to explain ruptures of the sclerotic. When a force is applied to the globe, an equator of depression perpendicular to the direction of this force is established (Fig. 38), and it is upon this equator that the rupture occurs.

We have amplified this theory of ARLT in an essay

on ruptures of the sclerotic (*Bulletin médical*, 1905, p. 201), by demonstrating that scleral ruptures are always produced at the thinnest portion of the wall of the eye—*i. e.*, between the insertion of the recti muscles and the cornea, because in the usual ocular injuries, whether the eye is struck from below (Fig. 39) or from above (Fig. 40), the equator of depression always passes through this thinned portion.

These theories retain their full value so far as ruptures of the choroid by direct shock are concerned; the uveal membrane is submitted to the same conditions as the fibrous coat and should therefore

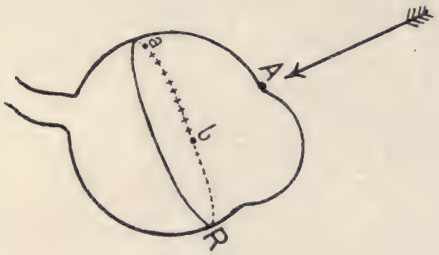

FIG. 41.

rupture on a line passing through the equator of depression.

We have had occasion to demonstrate the truth of this explanation in a case in which a young woman, looking at a display of fireworks, received the falling stick of a rocket in the eye, exactly in the position shown by Fig. 41; it was falling from a great height and consequently with much force.

The lesion produced in the eye is represented in Fig. 42, and in this case the explanation of the choroidal rupture appears to us to be as follows :—

The rocket-stick, falling with violence upon the wounded eye, struck it with great force in the direction of the arrow, at the point A (Fig. 41); there resulted an equator of depression, at the site of

which the sclerotic and the choroid were strongly stretched, and the rupture occurred from *a* to *b*; this line of rupture corresponds closely to the region lacerated in Fig. 42. The choroidal rupture takes place there all the more readily because, at this point, the choroid is not adherent; farther back, towards the disc, it adheres to the sclerotic; farther forwards it is attached to the fibrous coat of the eye by the vasa vorticosa. On the other hand, in the lacerated region, from *a* to *b*, it glides easily over the scleral wall and tears when the stretching becomes too great.

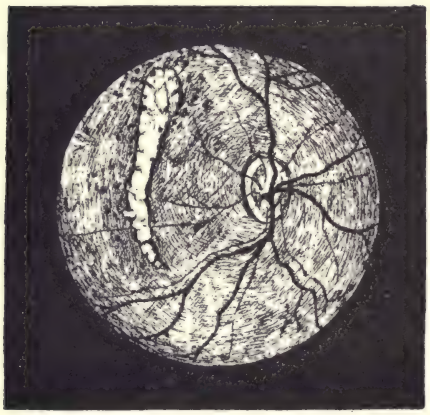

FIG. 42.—Choroidal rupture following the line of the equator of depression.

If the sclerotic of this patient had ruptured it would have yielded at R, because there the equator of depression meets the zone of least resistance of the sclerotic, as I laid down in a paper published in the *Bulletin médical* (1903). Rupture of the sclerotic, between the cornea and the insertion of the muscles, is explained by the fact that here the equator of depression meets the thinnest part of the wall of the eye.

In the same manner, when the sclerotic resists and the choroid is torn, the latter gives way at the posterior part of the equator of depression, at *a*, *b*, for example, because it is there that it is the least firmly fixed and least attached to the scleral envelope.

It is therefore the theory of the equator of depression which should be applied when the eye suffers contusion. Far from us be the thought that this

theory will explain every case, for we believe that there is great diversity in the pathogenesis of ruptures of the choroid; furthermore, there are few cases in which one is able to identify the exact seat of the initial traumatism and the direction of the force which has wounded the eye.

Perhaps it is by this mechanism that a certain number of the choroidal ruptures we have examined have been produced. The shock of the projectile upon the eye has been applied to a point of the sclerotic far removed from the choroidal rupture, which has occurred on the line of the equator of depression. But most frequently the shock has produced mischief at the actual spot where the globe has been struck; so that choroidal lesions by direct shock are usually at the contused point, much more rarely at a point removed from this spot.

It will be convenient here to make a distinction between the injuries of the eyeball caused by a blunt instrument, such as the clenched fist, stone thrown with force, etc. (the kind of contusion one meets with often enough in civil life), and the wounds which implicate the eye in war.

A blow from the fist involves the formation of the equator of depression of ARLT, and the choroidal laceration occurs far from the point struck. A projectile of war, a piece of shell, which strikes the eye directly, like a whip, does not produce an equator of depression; it destroys the organ, tearing it to pieces.

In military surgery the eye is only injured, without being destroyed, by a bullet which grazes it tangentially, or by a small fragment of shell which, with momentum diminished by its flight, strikes a circumscribed spot. There is then no equator of depression, but a wound at the place contused.

In short, what happens to the sclerotic happens to the choroid, in our cases. There are not, or at any rate very rarely, ruptures influenced by the equator of depression, because all projectiles, striking the eye

violently, perpendicular to it, lead to its destruction, pure and simple.

We have recalled ARLT'S theory and demonstrated its value, but in reality it applies very little to military surgery. In thirty months' observation in a military hospital, well supplied with patients, we have not seen a single case of scleral rupture bearing on this theory. We are less emphatic concerning choroidal ruptures; there may perhaps be a few examples, as in Fig. 44, which represents a longitudinal rupture, in a patient who had been struck by a piece of shell, exactly on the level of the left frontal sinus, the crushed inferior wall of which must have bruised the eyeball directly. It is possible that an equator was produced there, according to ARLT'S theory, and that the line of retino-choroidal rupture formed part of it. The cases in Plate IV, Figs. 1, 3 and 4, and Plate VI, Figs. 1 and 2, call forth the same reflections, but we believe that ruptures of the deep membranes rarely depend on this mechanism; the lesions of the uveal tract which result from a blow on the eye are situated at the point struck.

The lesion thus produced is, moreover, serious. There is free hæmorrhage, invading the vitreous—these are the cases which result in retinitis proliferans. We have noted a considerable number of cases of this condition, which would risk encumbering this work needlessly if reported here.

(*B*) *Indirect or mediate choroidal ruptures.*—The cases which I have now to bring forward are *intra-ocular disorders consecutive to concussion in the vicinity of the eye.*

These cases are rare, and have been but little studied. But they are not the only ones which have been reported in our scientific records, and, without pretending to give here a complete bibliography, we can quote a case from VON AMMON, which appears to be the first, of rupture of the choroid by concussion; CARL GENTH, at PAGENSTECHER'S Ophthalmological Institute, observed three cases in which lesions of the

ocular membranes occurred, without the eye having been touched, following injuries to the bones of the orbit.

Joy Jeffries, of Boston, reports a case of rupture of the choroid without direct lesion of the eye, which resembles in every respect the cases which the reader will find below.

A young man, aged fifteen, was about to enter a barn; he struck his forehead against a beam, and the shock stunned him. He was not, it seemed, very seriously injured, the effect of the blow having immediately passed off; but three days later he saw black patches before the left eye. On examination, two crescent-shaped lacerations of the choroid were found.

Two similar cases are reported in much detail by Mannhardt.

The first concerns a man of thirty-five who was carrying, with a comrade, a heavy load, which the latter dropped suddenly. A laceration of the choroid was produced, which the author does not hesitate to attribute to concussion.

In the second case the rupture of the choroid was due to a fall from a height of forty feet.

Parisotti and Haas have published similar cases. The latter author's case was a child of nine years, struck on the head in the neighbourhood of the right eye by a violent blow with a stick. He showed, after absorption, hæmorrhages into the vitreous, and crescent-shaped laceration of the choroid and retina immediately above the disc.

Choroidal injuries by vibratory shock are therefore well known; and Norman Hansen is certainly in error when he denies their possibility, as he does in a work entitled, "Under what conditions can a choroidal laceration be produced in gunshot wounds of the temporal region?" This author believes, from the study of eight cases, that choroidal rupture takes place only when the projectile strikes the eyeball directly, or when distension of the globe is produced, as in the case of violent laceration of the optic nerve.

Norman Hansen is right so far as injuries of the optic nerve are concerned. It is certain that a bullet, striking the nerve behind the eye, stretches the ocular membranes in a direct manner; and when the projectile has traversed the orbit behind the eyeball the traumatism is in some way directly transmitted to the intra-orbital membranes by the stretched optic nerve. We report several very clear cases, but Norman Hansen is in error when he denies the possibility of choroidal ruptures from lesions in the neighbourhood, where none of the organs contained in the orbit has been directly implicated.

De Wecker was better inspired when he wrote: "All those who, during the sad war of 1870, had occasion to examine many injuries to the head, submitting the wounded to ophthalmoscopic examinations, have been able to convince themselves that ruptures of the choroid constantly accompany, in some way or other, all the concussions and violent shocks to the bony framework of the upper portion of the face."

The possibility of the lesions which we are about to study, therefore, is generally accepted by ophthalmic surgeons, but we do not think that, up to now, these affections have been reported with any details, and it is for this reason that we wish to publish the cases which follow. They have already been the subject of a paper communicated to l'Académie de Médicine, May 15, 1915. Before this date Yarr, Lègues, Charles Lee, Harman, quoted by Prof. Baudry (*Traumatisms de l'œil au point de vue médico-légal*, p. 168), had reported cases of loss of vision following shell-explosion by indirect concussion, but, no more than the authors cited above, had they described the lesions in the fundus of the eye. Our publication of May 15, 1915 is the first in which the macular lesions and the choroidal lacerations have been studied and represented in detail. A little later, our colleague Terrien, in the *Archives d'Ophtalmologie* appearing at the end of June, 1915, quoted cases which may in every respect be placed beside ours, and which entirely

corroborate our conclusions relative to macular lesions by concussion. We would reproduce them here, were it not that the limits of this book, in which we are not publishing the fourth part of our own observations, forbade it. We may say the same of DANTRELLE'S cases (*Archives d'Ophtalmologie*, Sep.–Oct. 1915), who has published representations of the fundus of the eye, analogous to ours, some months after us, and who, perhaps, has not adequately noted that our article contained cases, similar to his, of macular lesions by concussion, following violent injury to the bones of the face.

Similar cases, moreover, are being quite generally observed; at the "Centre secondaire d'Angers" GINESTOUS has been able to collect a large number (*Gazette hebdomadaire de Bordeaux*, Nov. 1916).

All the personal observations which are now about to be placed before the reader would have found a natural place in groups II, III, and IV (p. 37 *et seq.*) of cases reported to demonstrate the truth of the laws which govern lesions of the eye in injuries implicating the orbital region. We thought it better to record them here, because we shall be able to describe in detail the lesions of the choroid and retina with their manifold ophthalmoscopic varieties.

The cases reported above (p. 38 *et seq.*), in five groups, are merely examples; we have only grouped a few in each category; we might have doubled or tripled the number, for on this subject we have abundance of evidence.

The same applies to the cases which follow; they are chosen from amongst many others, similar, and of equal clinical value.

Wound of right temporal fossa; detachment of retina, R. E.
(Case 30.)

C., wounded Oct. 29 by a rifle bullet which penetrated above the right eyebrow (at the level of the external third), traced a deep furrow in the temporal muscle and emerged a finger's breadth above the right tragus.

The external orbital margin is fractured, as well as the malar process of the maxilla; the latter fracture causes deformity of the floor of the orbit and the globe is slightly deviated downwards. Beyond this the eye presents no trace of injury.

Examination shows that the right eye has only quantitative vision. There is a large detachment of the retina.

The left eye, normal, has acuity 1 with + 0·75 D sph.

Perforating wound of the right temporal fossa; rupture of choroid, R. E. (Case 31.)

L., wounded at Ypres, Nov. 5. A bullet penetrated near the outer end of the right eyebrow, close to the orbital

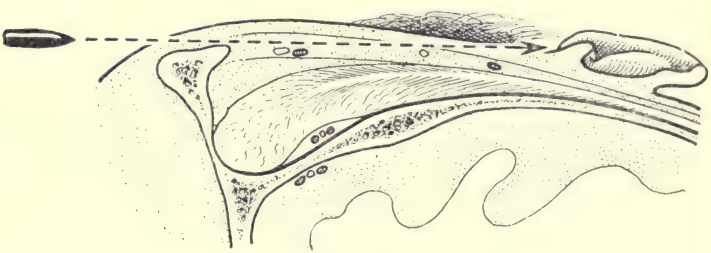

Fig. 43.

margin, which, however, it did not injure; it emerged from the temporal fossa after a perfectly horizontal course two fingers in breadth in the cellular tissue; radiography showed no bony lesion.

The right eye presents outwardly no trace of injury, but has only quantitative vision. Study of the visual field shows that central vision is abolished, and the ophthalmoscopic examination reveals grave lesions. The whole of the posterior pole is covered with abundant pigmentation, through which it is possible to see, near the macula, a severe laceration of the choroid in the form of a crescent, the convexity of which is turned towards the disc. The left eye is normal (Plate V, Fig. 1).

Contusions of the left orbital margin; rupture of choroid, L. E. (Case 32.)

P., wounded Oct. 6, near Arras. He was struck by a

la ge piece of shell, which injured at the same time the infra-orbital region and the bridge of the nose, producing in this region contused wounds, but leaving quite intact the eyelids and the globe itself.

R. E. has an acuity of 9/10 with correction; the visual field is normal; no lesion can be found.

L. E., acuity = 1/100, not improved by glasses; with the ophthalmoscope numerous floating bodies in the vitreous and serious lesions of the membranes are seen. A large laceration of the choroid, of irregular form, occupies the posterior pole quite close to the macular region.

It is surrounded by an inflammatory zone, characterised by dense black pigmentation.

A large detachment of the retina is situated below. This latter lesion disappeared after some weeks of treatment, but vision was not improved.

The lesions of this eye are manifestly and essentially choroidal lesions. Over the portion of the rupture nearest to the disc five retinal vessels may be seen passing over the tear in the choroid; in the same way, two vessels are very evident crossing the choroidal rupture perpendicularly in a part furthest from the papilla. Another vessel seems to have disappeared, but in reailty it has been covered by proliferating retinitis (Plate V, Fig. 2).

Traumatism of the malar region; optic neuritis; rupture of the choroid, R. E. (Case 33.)

R. was struck by a bullet, Sep. 6. The projectile penetrated one centimetre behind the right angle of the mandible, and emerged by a large wound near the malar process of the maxilla of the same side. The maxillary antrum had been widely laid open, and the man has had a fistula, healed when he came under our observation. He had lost the sight of the right eye since the injury.

R. E., with $-$ 2 D sph., V = 0.

The disc has the classic aspect of post-neuritic atrophy. Moreover, the macular region is covered by abundant pigmentation which doubtless hides the lesions of the choroid, probably small lacerations followed by hæmorrhage (Plate V, Fig. 3). The left eye, equally myopic, has the acuity 1 with $-$ 2 D sph., and presents no lesion.

Perforating wound of the right orbit ; rupture of the choroid, R. E. (Case 34.)

S. was wounded at Lunéville, Aug. 22. A piece of shell penetrated the right temporal region, a finger's breadth behind the extremity of the eyebrow ; it traversed the orbit from above downwards and from behind forwards, coming to rest in the vault of the palate.

Careful study of the course of the missile showed that it had passed outside the optic nerve and behind the eyeball, and it seems to us certain that the globe had not been touched, for two reasons : (1) because the rectilinear course of the projectile traced from the aperture of entry to the orifice of exit passes behind the eye ; (2) because such a projectile, capable of penetrating several bony chambers, would certainly have ruptured the eye if it had struck it ; further, the optic nerve itself has been spared, for lacerations of the optic nerve, of which we have seen several cases, are accompanied by much more definitely marked damage to the deep membranes.

The left eye is quite normal. The right eye (the affected side) has an acuity of no more than 1/200, not improved by glasses. The ophthalmoscope shows, near the macula, two lacerations of the choroid, parallel and fusiform. The retina is intact, as witnessed by the fine retinal vessels which pass over the choroidal rupture (Plate V, Fig. 4).

Perforating bullet-wound traversing the malar bones and the nasal fossæ ; Choroido-retinitis, L. E. (Case 35.)

P. was wounded Sep. 15, 1914. A bullet entered under the left eye and came out under the right eye after having traversed the nasal fossæ.

Case examined Nov. 10. The patient then presented no lesions of the anterior segments ; the cutaneous wounds have been healed for a long time, conjunctivæ and sclerotics are intact, no ophthalmoscopic lesions. Visual acuity, however, on the right is 1/10, not improved by glasses ; on the left it equals 0.

The patient has been regarded as a malingerer and examined in consequence, but it is impossible to prove him in fault. We confined ourselves to observing him. A fortnight later, in the lower portion of the retina of the left eye, pathological pigmentation appeared.

This pigmentation is probably the consequence of small choroidal hæmorrhages, themselves coinciding with slight lacerations disseminated about the uveal tract.

Traumatism of the malar region ; rupture of the choroid ; retinitis proliferans, L. E. (Case 36.)

Q., wounded Oct. 4, was made prisoner and returned from captivity. He had been struck on the face by numerous shell fragments : one had severed the right eye, which is no more than a stump ; another fragment penetrated at the level of the left malar bone, which it had fractured. The left eye presents no outward trace of injury ; it has not been touched by the fragment of shell. Nevertheless, it bears evidence of great damage. The disc is only recognisable by the presence of two veins, partly covered by traces of proliferating retinitis. Below and to the outer side is seen a large laceration of the choroid, with pigmentation on its margins. It is a large, pearly white plaque, over which pass the retinal vessels. Blindness is complete.

To these cases we will add the following, which is a very good example of the lesions which projectiles producing strong concussion in the bony mass of the face can bring about in the fundus of the eye.

Traumatism of the bones of the face ; rupture of the choroid, L. E. (Case 37.)

H. was wounded Aug. 22, 1914. The bullet penetrated behind the ascending ramus of the malar bone, two centimetres below the floor of the right orbit. It crossed the right antrum, the palatine vault, and came out on the left cheek, a little above the angle of the mandible. The patient thinks that the shot was fired from about 400 metres.

The loss of vision of the left eye was almost immediate ; at the same time severe conjunctival ecchymosis appeared, which remained for a long time.

Examination by the ophthalmoscope shows a large laceration of the choroid, situated in the macular region (Plate VI, Fig. 3). The left eye has also lost central vision. The right eye is normal ; its visual acuity equals unity.

With these derangements, due to the concussion of soft parts in relation with the eye, might be compared a very curious case of the effects of airconcussion upon a myope.

Progressive myopia ; macular choroido-retinitis, R. E.
(Case 38.)

Aug. 25, C. was thrown into the air by the explosion of a shell which burst alongside him. He remained about ten minutes unconscious. When he came to himself he discovered that he had not a scratch, and went on fighting. Next day there was some pain in the right eye ; however, he continued to fight, firing as before. Sep. 25, he was slightly wounded in the right arm, and sent to Bordeaux. There he stated that the visual acuity of the right eye was rapidly diminishing.

It should be noted that C. was an engraver on glass and that he carried on his calling without needing to wear glasses ; he had done his military service, having left the regiment with the rank of corporal ; he was a very good shot, and only used the right eye.

R. E., with -13 D sph. $\bigcirc -2$ D cyl., axis 30° V = quantitative, not improved by glasses. The anterior segment and the transparent media are normal. On ophthalmoscopic examination a myopic posterior staphyloma and a macular choroido-retinitis, with large uveal lacerations, are revealed.

L. E. is slightly hypermetropic ; with $+ 0{\cdot}50$ D sph., V = 4/10. This eye presents a slight commencing staphyloma, quite like a typical crescent-shaped myopic staphyloma (Plate VI, Fig. 4).

Jan. 20, his condition was stationary. It was impossible to come to a decision on his case ; so he was sent on convalescent leave in order that, in a few months, one might estimate definitively the condition of the eye, and come to a conclusion about the case. It did not appear to me to be probable that the myopia was entirely consecutive to the concussion of the deep membranes, but it is certain that the macular and peri-macular choroidal lacerations, which have caused the suppression of vision of this myopic eye, have been the result of traumatism by displacement of air. It might be equally considered probable that the

fundus of the eye has lost some of its resisting power under the influence of these lacerations, and that for this reason the eye is elongated, so much so as to reach the figure of thirteen dioptres of myopia. Perhaps myopia existed before the war, but it must have been very slight, since C. was considered an excellent shot, and, when shooting, used only the right eye.

Such are the precise observations, chosen from amongst many others, which we have been able to collect; they appear to us to be worthy to be placed on record, and I consider that they allow us to draw up here, in the form of a synthetic résumé, the four following conclusions.

1. Projectiles, when they penetrate the organism, are capable of producing at a distance serious or irreparable damage to nerve centres, to peripheral nerves, and to the organs of special sense (eye, ear, nose).

2. It is not necessary, to bring about this damage, that the projectile should actually strike the patient; the displacement of the air produced by the explosion of a shell is sufficient to cause the same lesions.

3. In injuries of the face or cranium an exhaustive examination of the visual apparatus should always be made.

4. The injuries are especially lesions of the posterior pole, macular and peri-macular.

Whether the choroid be implicated alone or whether the retina be lacerated with it, it is the macular region and its more or less immediate surroundings which suffer more or less, according to the force of the traumatism, and we might inscribe here this clinical law—*Concussion of the eye without direct shock = macular and peri-macular lesion.*

(2) Hæmorrhages and Detachment of the Choroid.—After ruptures of the choroid, and also with them, for they are closely connected, hæmorrhages of this membrane must be mentioned. The type of these disorders is the expulsive hæmorrhage (Albert Terson) which sometimes happens after the operation

for cataract. To a smaller degree this accident is met with in the serious contusions of the eyeball. The blood is extravasated in the supra-choroidal space and the choroid is lifted up at the same time as the retina. This detachment is distinguished from retinal detachment in that it has a darker tint and is supported by a coagulum, so that it does not undulate with the movement of the globe. In fact, we see the ophthalmoscopic picture yielded by certain sarcomata of the choroid; the fact of the traumatic origin and the use of transillumination will serve to establish the diagnosis.

The blood, poured out at first in the supra-choroidal space, soon diffuses into the anterior layers of the choroid. After a while the blood-clots organise; connective tissue cells appear at the periphery of the clot and soon invade it; numerous capillaries even are formed, which penetrate all the neighbouring tissues, including the retina, and the process ends in what we describe later under the name of proliferating choroido-retinitis.

Many ocular injuries, consecutive to fractures of the orbit, have this fate, for the violent contusion suffered by the globe in such a case is very often accompanied by hæmorrhage, with or without evident lacerations of the two membranes, choroid and retina; several examples are given in the illustrations published in this work, for we have had in our clinic plenty of cases to choose from.

(2) Affections of the Membranes: (*b*) Retina

It is very true, and Mangini in his thesis has already insisted upon this point, that pure choroidal lesions and unmixed retinal lesions are relatively rare, and that most frequently they are associated. In combination with a choroidal or peri-macular laceration in the form of the arc of a circle, for example, we may find a typical macular retinal lesion, and one frequently meets a laceration affecting at the same time both the choroid and the retina. Nevertheless the pure types are fairly

numerous, owing to the anatomical independence of the choroid (including in this term the pigmented epithelium) and the retina, properly so-called (the distal lamina of the secondary optic vesicle).

According to our views, those authors are quite wrong who have refused to admit the localisation of the rupture in the choroid. WENNEMANN, in the *Encyclopédie française d'Ophtalmologie* (Vol. VI, p. 486), has written that " the choroid can scarcely be torn so long as the sclerotic resists the shock of the violent contusion, and that we often take for ruptures of the choroid what are only simple folds of the retina." Clinical facts invalidate this opinion, and we are convinced of the contrary; Figs. 2 and 4 in Plate V are, in fact, demonstrative. Their value is increased by the fact that they represent photographs of oil-paintings, made by Thorner's method by an artist of great talent, who had no ophthalmoscopic knowledge, and who set himself to paint what he saw, and nothing but what he saw.

The retinal vessels, which in these illustrations cross over the choroidal laceration, belong to an intact retina.

On the other hand, there are pure lesions of the retina independent of any affection of the choroid; they are represented in Plate I, Figs. 1 and 2.

From the anatomico-clinical point of view we shall describe three varieties of retinal lesions: (*a*) Retinitis proliferans; (*b*) Proliferating choroido-retinitis; (*c*) Traumatic detachment of the retina.

The first and the third of these affections are well known and described in all the text-books; we have only to indicate here the peculiarities they have exhibited amongst our patients. The second has not hitherto been described.

(*a*) *Retinitis proliferans*

Proliferating retinitis is often of traumatic origin, according to SCHIÖTZ in 22 times out of 100, and

one cannot be surprised if, with the great majority of authors, we ascribe it to retinal hæmorrhages. GOLDZIEHER has upheld the view that proliferating retinitis may develop without hæmorrhage, and that it is a disease *sui generis*, resulting in the formation of masses of connective tissue by proliferation of the fibres of MÜLLER. MANZ, who first described the condition, ascribes great importance to effusions of blood, but does not think that hæmorrhages are essential to the proliferation of the retinal tissue. It was LEBER who insisted upon the important rôle played by extravasations of blood in the pathogeny of the affection. We believe that he is right; they have been the basis of all the cases of proliferating retinitis we have seen, and in SCHIÖTZ' statistics, out of 121 cases, these hæmorrhages were only lacking four times. Besides, it is sufficient to inject blood into the vitreous body of animals, as PROBSTING has done, to see, associated with the hæmorrhage, the proliferation of the connective tissue of the retina; the development of the retina attains in a few weeks three or four times the normal thickness of the membrane; three or four months after the injection the retina is in places transformed into strings of connective tissue, containing, in the thickness of fibrillar masses, red corpuscles, more or less altered.

These anatomical examinations, based on experimental facts, agree moreover with the results yielded by some examinations of the human eye, cases of retinitis proliferans; the examinations of MASSY, PURTSCHER, and VERKLI have shown the existence of a membrane of fibrillar connective tissues, adhering at certain points to the optic disc and the retina. MANZ, whose case was of four years' duration, did not find hæmorrhagic débris, probably because of the long duration of the affection. DENIG, PURTSCHER and VERKLI observed, in the masses of more recent formation, numerous traces of blood (lymphocytes, disorganised red corpuscles, numerous leucocytes). The external layers of the retina have often preserved their normal structure; the internal portions, the fibres of MÜLLER, are those

which have proliferated. The pigment epithelium is intact, so that the affection does not establish artificial adhesions between the two layers developed from the secondary optic vesicle, *i. e.*, between the pigmented epithelium and the retina, properly so-called. The result is that the fibrous contraction of the bands of connective tissue, of which we have just spoken, easily separates these two layers, which are simply apposed to one another, and produces what we call, clinically, detachment of the retina—*i. e.*, separation of the two layers of the optic vesicle.

Retinal detachment is in consequence frequent in proliferating retinitis.

Such are the general data which apply to this affection; it often occurs in relapsing spontaneous hæmorrhages of the retina. It is equally common, and indeed it should be looked for, after the lesions of the eyeball which accompany choroidal and retinal hæmorrhages, as well as effusion of blood into the vitreous body.

We have observed this very frequently, and we will now apply ourselves to the task of portraying the characteristics of the cases we have observed.

Symptomatology.—The symptoms at the onset of proliferating retinitis are those of hæmorrhages, and, as in the traumatic cases the affections are well marked, we find usually not photopsiæ and scotomata, but complete loss of vision. As the blood becomes gradually absorbed vision may return, and sometimes be even relatively good, with quite extensive lesions; this depends evidently on the seat of the retinal disorders visible with the ophthalmoscope, and also on the seat of the affections which cannot be seen, for a very slight alteration of the macular region is sufficient to diminish or suppress central visual acuity in a subject whose lesions appear to be of slight extent.

Moreover, it is by no means rare to find that diatheses or infections with which the subject has been attacked contribute to complicate the accidents by pouring toxins or infectious agents over the retinal laceration. The soldiers whom we have examined, in general healthy

and vigorous, have perhaps been less exposed to such complications than the generality of patients; but it has been evident to us, on several occasions, that syphilis has interfered with the normal evolution of the anatomical disorders.

The natural progress of these affections leads to the organisation of connective tissue, and for the same reason, being subject to the general laws of pathological anatomy, to contraction. This contraction has the great detriment of dragging on the retina and detaching it; sometimes it may even produce a tear in the new-formed membranous veil, thus laying bare a healthy portion of the retina, which is rendered capable of discharging its functions. GONIN, in an excellent article in the *Encyclopédie*, reports the history of a case in which the central visual acuity came back to 5/10 by reason of a laceration occurring in the macular region; the patient related how he had seen, in the space of a very few days, as it were a window open in the centre of the thick veil which covered his eye.

After having described classic retinitis proliferans, such as has always been present to our minds while examining our wounded patients, we are of opinion that we should call attention particularly to a variety which we have ascertained to follow fractures of the orbit. It is a matter of an affection, very different on the whole, from those described by authors. We propose to call it "proliferating choroido-retinitis," and we proceed to give the description of it.

(β) *Traumatic Proliferating Choroido-retinitis*

Choroido-retinitis follows, not hæmorrhages into the vitreous body, such as the relapsing hæmorrhages of adolescents, but hæmorrhages of the retina and choroid due to lacerations.

This traumatic proliferating retinitis results from the organisation of effusions which are situated outside the vitreous. Here is a characteristic which distinguishes this affection from the proliferating retinitis compli-

cating the relapsing hæmorrhages of the vitreous of adolescents. There the disorders belong to the vitreous; a retinal vessel bleeds in the eye, the first intra-ocular epistaxis is absorbed, the second leaves behind some traces, and after the third or fourth relapse the effused blood ends by becoming organised, by the aid of the elements of the most internal layer of the retina (fibres of MÜLLER, perivascular mesodermic tissue), which, when irritated, proliferates and gives birth to the great fibrous tracts which the classic authorities have taught us to recognise, and which trespass, not only on the most internal parts of the retina, but also on the peripheral layers of the vitreous body.

The conditions of the proliferating choroido-retinitis of our wounded are quite otherwise; in their case there is no relapse, the vessels which bleed do not proceed from the retina, nor do the proliferation and post-hæmorrhagic organisation of the connective tissue; the seat of the trouble is not retino-vitreous.

Under the influence of shock or of ocular concussion a rupture of the uveal tract and of the retina has taken place; there has been a more or less extensive effusion into the meshes of these membranes. Is it small in quantity? Then it will be absorbed, and the choroido-retinal scar will take on the appearance so well known as atrophic and pigmented choroido-retinitis. Is the amount of blood more considerable? The vitreous may then be implicated, but the clots which are in its meshes rapidly disappear. But the hæmorrhage, on the contrary, which in these cases is present in the whole thickness of the retino-choroid and in the retino-vitreous space, experiences much difficulty in becoming absorbed; it becomes organised, at the same time provoking irritation of the connective tissue of the uveal tract in the region of the rupture. The connective tissue proliferation takes place at its expense, and results in the formation of fibrous tracts, which, at first slight, might be taken for proliferating retinitis, properly so-called. We see therefore that traumatic proliferating retinitis differs much from the classic type as

regards its situation. We have to deal, in our soldiers, with *a proliferating choroido-retinitis*, the choroid participating in fact in its formation as much as the retina, and even more than the retina itself.

We are dealing, therefore, with a choroido-retinal cicatricial process secondary to the rupture or laceration of these membranes, and this statement will explain why the papillo-macular region should be the habitual seat, since it is also that of the traumatic choroido-retinal disorders sequent to orbital fractures.

One of the appearances which best demonstrates this is offered by the disc when a projectile has caused avulsion of the optic nerve. The papillary hole which follows this tearing-out is filled up little by little by a proliferating connective tissue formation in which the peripapillary uveal tract, infiltrated by great hæmorrhagic patches, participates with the papilla (see Plates III and IV).

Being cicatricial tissue, the result is that traumatic proliferating choroido-retinitis, once organised, cannot be modified. The loss of vision, more or less complete, the modifications of the visual field which follow, are definitive. Retinal detachments, which are caused by secondary traction of the retina towards the vitreous, by the contraction of the fibrous vitreo-retinal cords, are common in proliferating retinitis, since in this affection the disorganisation concerns the deep layers of the retina, and especially the uveal tract, to which this membrane is simply applied. But with our soldiers the cicatrix involves both retina and choroid; the organised patches intimately attach the retina to the underlying ocular membranes, and thus prevent slow detachment.

Ophthalmoscopic appearances.—From the ophthalmoscopic point of view its characters are as follow: a greyish white mass surrounded by a zone more or less extensive, sometimes very large, blackish, pigmented (Fig. 44); this mass is raised, a fact which testifies to the proliferation of the connective tissue; the retinal vessels are seen to pass over it, turning out

of the direct line to do so (Plate IV, Fig. 3); vessels too pass underneath, some are seen to perforate it, forming loops which project forwards (Plate III, Fig. 2).

In Plate IV, Fig. 1, below the atrophied disc can be distinguished a raised white patch, upon which climb vessels emerging from the papilla and making a visible

FIG. 44.—Fracture of the left frontal sinus; eyeball contused by the inferior wall of the sinus thrust downwards. Proliferating retino-choroiditis of the posterior pole implicating the macular region.

bend, precisely at the moment when they mount upon this elevation; whilst these retinal vessels are manifestly situated above and in front of the plaque of proliferating newly-formed tissue, other vessels traverse the plaque in the middle of its substance, and others pass beneath.

The two figures (Fig. 35; Plate III, Fig. 1, papillary avulsion) are amongst the most interesting of our

collection; they have to do with a total or subtotal avulsion of the disc.

The first deals with a partial tearing-away, affecting the upper part of the papilla (inverted image); the half of the disc which has been torn away is covered by new formation, whence the vessels spring; it is remarkable that this fibroid mass is not everywhere sufficiently prominent to fill the fossa created by the papillary avulsion; it is only exuberant in its inferior portion; at the upper part it is still upon a plane deeper than the rest of the fundus of the eye. The other figure is a truly admirable example of total avulsion of the papilla, a papillary detachment which is accompanied by two lacerations starting from the macula, the one above and to the outer side, the other down and in; there is a third tear in the macular region. All around the disc the choroido-retinal lacerations have proliferated, but the excavation has not been filled up; there remains a cavity recalling the ophthalmoscopic image of certain cases of chronic senile glaucoma; there has been a true avulsion of the papilla in the correct sense of the word.

Often the laceration of the choroid and retina, which entails the proliferation, is seated exclusively in the macular region (Plate IV, Fig. 2); the mass of new formation then has no direct relation to the larger vessels; it takes the form of a fibrous "cake," irregularly star-like (Plate III, Fig. 2); or of the arc of a circle, (Plate IV, Fig. 4); frequently around this fibrous "cake" is found a pigmented zone, indicating the considerable participation of the uveal tract in the proliferation.

The figures which represent this proliferating choroido-retinitis, in addition to all those of Plates I, II, III and IV, have been drawn from nature by M. Pesme, student of medicine, hospital orderly in the service, to whom we desire here to render thanks.

COMPARATIVE TABLE SHOWING THE DIFFERENCES BETWEEN PROLIFERATING RETINITIS AND TRAUMATIC PROLIFERATING CHOROIDO-RETINITIS.

Retinitis Proliferans	*Traumatic Proliferating Choroido-retinitis*
Proliferation due to organisation of effused blood; may be produced without previous hæmorrhage.	Always consecutive to a hæmorrhage and a rupture of the deep membranes.
Membranes with multiple prolongations; appearance of a spider's web spread over a large portion of the fundus of the eye.	Fibrous plaque, more localised, of a more regular thickness.
Membranes translucent in certain points.	Everywhere opaque.
Projections ending free in the vitreous.	Simple relation of propinquity with the vitreous body.
Masses, pedunculated, polymorphous, with uneven surface, outline well marked.	No very prominent masses in the vitreous body; even surface, projecting moderately.
Situated in all parts of the retina.	Much more common in the macula, the disc and its circumference.
Focus of pigmentation very frequently around the membranes.	Foci of pigmentation very frequent.
Often complicated by detachment of the retina, due to traction of the vitreous bands.	Is not accompanied by detachment consecutive to the proliferation, which, on the contrary, attaches the retina to the choroid.

(γ) *Traumatic Detachment of the Retina*

In this class of retinal detachments we may admit several varieties which can be succinctly enumerated thus.

(1) Detachment by subretinal hæmorrhage.

(2) Detachment by post-traumatic retraction of the vitreous body.

(3) Detachment which results from the cicatricial contraction of a wound.

(4) That which follows a loss of vitreous.

(5) That which results from concussion at a distance, with or without laceration of the retina.

We have met with all these varieties, and we have noted forty retinal detachments amongst our hospital cases; a very frequent form is the detachment by concussion.

The shock upon the eye causes a subretinal hæmorrhage and a laceration of the retina and choroid; three months afterwards one finds a large plaque of atrophy and not a detachment of the membrane.

We have rarely met with this affection in the cases of foreign bodies of the orbit; amongst our cases we can recall only one (Case 24, Fig. 30) in which a piece of shell injured the external orbital process, resulting in a profuse vitreous hæmorrhage, which after a certain time allowed large detachments to be seen, one peripheral to the external equatorial portion, the other in the macular region. There was a shell fragment below the eye; this fragment must have contused the organ and a great part of the derangements should be attributed to direct shock. But it should also be remarked that a violent contusion, the fracture of the external orbital process, must have set up in the eye concussion quite sufficient in itself to produce the detachment of the retina.

The number of cases of retinal detachment caused by simple concussion at a distance is not very considerable, but we believe nevertheless that we ought to draw attention to this type of disorder because of this special pathogeny.

We have four cases to quote: the two first are Cases 15 and 16, in which the projectile traversed the facial mass from one side to the other, without lesion of the eyeball, and provoked, in the first, retinal detachment at the inferior part of both eyes, in the second, detach-

ment at the infero-external portion of one eye. The two other cases are identical as to pathogeny, although they deal with two fractures of the external wall of the orbit, which have brought about total detachment of the retina on the side of the fracture.

In relation to these four cases, moreover, we can bring forward two others in which there was no fracture of the orbit, but, as a result of simple displacement of air, caused by the near explosion of a shell, the two cases were affected, one on the right side, the other on the left, with detachment limited to the inferior portion of the retina, without direct shock to the globe.

We have considered it our duty to chronicle this variety of traumatic detachment here with some details, for it is less common than the other forms of this condition.

We do not think we need insist upon the varieties which result from subretinal traumatic hæmorrhages, nor upon the detachments consecutive to fibrous organisation of the vitreous body; what we have said on proliferating retinitis, and all that the authorities have taught on this subject, will certainly be prominent in the mind of the reader.

Practical considerations on the prognosis and treatment of this kind of lesion will be found later in the book. (See Treatment of Fractures of the Orbit and their Complications.)

E.—Traumatic Enophthalmos

Enophthalmos is a symptom which occurs in a certain number of varied conditions, and too many authors have sought to give it a single pathogenesis, as if it were a question of an affection always the same and well defined.

Sinking of the eye in the orbit may happen under a great number of circumstances, all different :—

(1) When the means of suspension, passive or active, of the eye are torn or paralysed; the capsule

of Tenon ruptured; the oblique muscles paralysed; or when the recti muscles are retracted.

(2) When the cervical sympathetic is paralysed by too prolonged action or excitation.

(3) When after a profuse hæmorrhage of the orbit or chronic inflammation of the cellulo-adipose tissue there occurs cicatricial retraction of the retro-bulbar tissue.

(4) When trophic troubles occur, involving absorption of the cellulo-adipose tissue.

(5) When the orbital cavity is enlarged by a fracture which produces a depression of any one of its walls.

The fact is that enophthalmos may occur whenever there is default of any of the forces which maintain the eye in the exact equilibrium which is normal to it. These forces are the following: (1) the traction backwards of the recti muscles and the traction forwards of the oblique muscles; (2) the capsule of Tenon and the smooth-fibred muscle of Müller, which represent an active element capable of being immediately modified by the excitation or the paralysis of the sympathetic; (3) the cellulo-adipose cushion upon which the eye rests; (4) lastly, the bony cavity whose firmly fixed walls give stability and rigidity to the visual apparatus.

It is obvious that these diverse conditions of the ocular equilibrium, when modified, may bring about enophthalmos, and that each ætiological variety corresponds with the clinical varieties we have met with amongst our wounded.

We shall pass in review each of these varieties, laying under contribution what has been said by the different writers who have busied themselves with the question, and utilising the cases we have collected.

(1) The enophthalmos which results from defective equilibrium between traction of the recti muscles behind and the obliques in front is the rarest form; we do not think it exists in the science of ascertained facts; *a priori*, it is evident that paralysis of the two

obliques should be followed by a retreat of the eyeball; but, clinically, paralysis of the pathetic and of the branch of the oculo-motor destined for the inferior oblique must be extremely rare, and this variety should be looked upon as so exceptional that in ordinary practice it need not be considered.

It is, however, not only the muscles, the active ligaments, which maintain the eye in position; there is also the action of the aponeuroses and passive ligaments in the ocular enarthrosis; the means of suspension may be torn or dislocated by traumatism. PICHLER admits in the ætiology of the affection the rupture of the *septum orbitale;* KILBRUN (*Archives d'Ophtalmologie,* 1902) reports the case of a man who, ten days after having fallen from a sledge, presented ptosis by enophthalmos, and explains his case by laceration of TENON'S capsule, or its ligamentous appendages.

Such ætiological conditions must be very rare; we have not seen them amongst our patients, and in the great majority of cases it is to the other mechanisms, previously enumerated, that we must look for the processes capable of explaining enophthalmos.

(2) The paralysis of the unstriped muscle of MÜLLER is a cause of enophthalmos, and it will be fitting here to give some anatomical and physiological details.

This muscle, upon which, after MÜLLER, SAPPEY has insisted, is a layer, fibrous in appearance, but in reality muscular, extending transversely from the internal to the external part of the orbit, continuous below with the adherent border of the tarsal cartilage and giving insertion above to the levator palpebræ and to the subjacent prolongation of the orbital fascia. It has a fixed origin and a mobile insertion, like all muscles; its origin, by its union with the levator, corresponds to the apex of the orbit and its insertion is the adherent margin of the tarsal cartilage.

Into its constitution enter a great number of laminated fibres and of elastic fibres, but these are only

accessory elements; the fundamental elements are the unstriped muscular fibres.

The bundles which form the median portion are directed from above downwards, the divisions interlacing and forming a sort of network with irregularly elliptical meshes. This muscle represents a segment of a hollow sphere which surrounds the eye over a large portion of its area.

There is also a MÜLLER'S muscle in the lower eyelid; its attachments are, on the one hand the deep surface of the palpebral expansion of the tendon of the inferior rectus muscle, on the other hand the convex margin of the tarsal cartilage; at the level of the inferior fornix of the conjunctiva it splits into two layers: one, palpebral, which goes to the tarsal cartilage, the other going between the bulbar conjunctiva and the eyeball.

MÜLLER'S muscle contains groups of nerve-cells analogous to ganglionic nerve cells, in such a manner that it possesses its own innervation, independent of the oculo-motor which innervates the levator palpebræ.

It is innervated by the cervical sympathetic. When this nerve is divided MÜLLER'S muscle is paralysed, and, the eye sinking back into the orbit, the patient has enophthalmos. Excitation of the sympathetic, by exaggeration of the action of the muscle, produces exophthalmos. It must therefore be admitted that, according to physiology, the unstriped muscular fibres, which form the muscle of which we are speaking, surround the eye, pass behind its equator, and, in contracting, push it forwards. The anatomical description given above, although strictly according to the authorities, does not make the action of the muscle clear to the comprehension; it is more than probable that smooth muscular fibres exist right into the capsule of TENON, facing the posterior hemisphere of the ocular globe, for without them we confess that we fail to understand the physiological action of the muscle of MÜLLER.

The description which the anatomists give shows

why excitation of the sympathetic, acting upon the muscle, increases the palpebral opening, whilst section of the sympathetic closes that opening; but it in no way enables us to understand why the subject should become exophthalmic in the first case and enophthalmic in the second.

We present these reflections to the anatomists and physiologists in passing.

Here we publish a case of enophthalmos due to section of the cervical sympathetic by shrapnel.

Section of the sympathetic by a shrapnel ball; enophthalmos; Claude Bernard's syndrome; recovery. (Case 39.)

P. L., aged 22 years, Infantry, was wounded Sep. 5 by two shrapnel balls. One struck him in the arm, the other in the neck, at the level of the fourth cervical. It

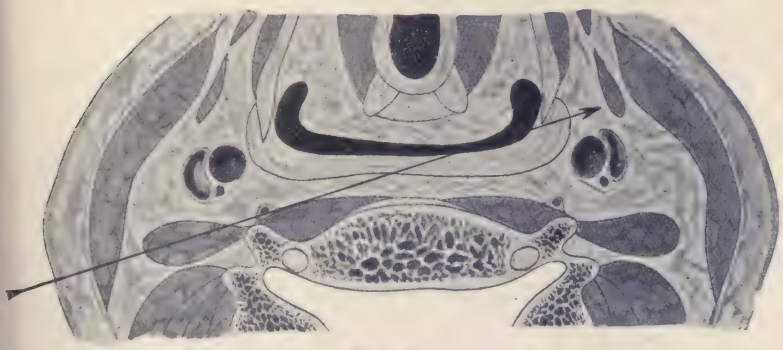

FIG. 45.

penetrated the right side at the posterior border of the sterno-cleido-mastoid, and taking a horizontal course, came to rest in the left carotid region.

The orifice of entry is narrow and has not bled, but immediately after the injury L. spat blood. Pharyngeal hæmorrhages occurred for several days; at the same time the patient swallowed with difficulty and experienced a burning sensation in the pharynx. The pharynx, therefore, has been traversed by the ball. The left carotid

region, where it is lodged, presented for some time a lively inflammatory reaction, but the ball was soon discovered by palpation, and extracted by an incision similar to that used for ligature of the carotid.

It was then that the case was sent to us. There is marked enophthalmos of the right eye. The palpebral fissure is narrowed, the pupil in a condition of miosis. L. states that his eye has been very red, that he has had a sensation of gritty particles in the conjunctiva, and that there was running of the eyes directly after the injury, but that these symptoms have disappeared.

Visual acuity equal to unity; visual field intact.

The left eye is healthy. There is nothing abnormal to be found in the spheres of action of the glosso-pharyngeal, pneumogastric, spinal accessory, and hypoglossal nerves. The enophthalmos rapidly diminished, and the case only presented a slight narrowing of the palpebral fissure when he was discharged, Dec. 31, 1914.

In this case is realised, in the clearest manner, the experiment of POURFOUR DU PETIT and of CLAUDE BERNARD; a well-known fact is noted, to wit, that the greater portion of the ocular results of section of the sympathetic are transitory; of this number is the enophthalmos, which, strongly marked at the time of the accident, had completely disappeared four months later. It must not be thought that, under such circumstances, the enophthalmos is only apparent, and due solely to the peculiar appearance given to the eye by the narrowing of the palpebral aperture; the enophthalmos is very real. The eye is carried backwards in a very definite manner, as though one of the forces which draw it forwards had suddenly failed to act. It is this action upon the globe, well demonstrated by physiologists and by clinical experience (as our case testifies), which the anatomical study of MÜLLER'S muscle would not teach us to foresee.

(3) Enophthalmos, due to paralysis of MÜLLER'S muscle, is rapid—so to speak, immediate—when the cervical sympathetic is divided. In the classic experiments of POURFOUR DU PETIT and CLAUDE BERNARD,

retraction of the eyeball is part of the paralytic syndrome of the cervical sympathetic, but this enophthalmos, which the surgeon who resects the superior cervical ganglion for the cure of glaucoma, for example, (JONNESCO, ABADIE, etc.) produces in spite of himself, is still very rarely observed clinically as a sequence of accidents which happen to the orbit and its contents. The case we have just reported is, perhaps, unique in science.

The nervous theory of enophthalmos should be extended to cover the trophic disturbances which lesions of the sympathetic entail upon the nutrition of the cellulo-adipose tissue upon which the eye rests. When vaso-motor innervation is at fault the orbital tissues are badly nourished, become less solid, and the eye follows them in their retraction; this theory has already been defended by BEER in 1893. In a patient, kicked by a horse, without the orbital walls being enlarged or driven in, there appeared a well-marked enophthalmos which this writer attributed to rarefaction of osseous tissue. PURTSCHER has also adopted this view; he very properly remarks that there is only true enophthalmos in cases where there is no depression of the orbital walls or cicatricial bands; true enophthalmos, strictly speaking, as in our cases, Nos. 40, 41, 42, is that which is produced in an orbit in which the cellulo-adipose mass has lost its normal volume as a sequence to faulty innervation.

The cases in which the appearance of profuse hæmorrhage has been noted at the moment of traumatism, causing at first exophthalmos, and afterwards enophthalmos by cicatricial organisation of the clot, are no longer to be considered pure cases. These pure cases of enophthalmos, those which we may look upon as cases of essential enophthalmos, are those which correspond to simple atrophy of neuro-trophic origin. When the enophthalmos is preceded by a clot becoming organised and retracting in the orbit, or still more when cellulitis has previously developed, a particular variety is in question, having, in a way, a

mechanical origin; this form is rare, we have not seen it in either civil or military practice. The mobility of the globe, well preserved in general, and the rapidity with which the enophthalmos appears do not accord with the organisation, always leisurely, of cicatricial tissue. COHN is the sole author who has insisted upon the limitation of the movements of the globe, which he found in one case adherent to the surrounding parts. With all our patients, as in all the cases of which we have been able to read the reports, the ocular movements have preserved all the freedom compatible with the vicious position occupied by the organ in the orbit.

It results from what has been said that the great majority of cases of sympathetic enophthalmos should be explained by trophic derangements due to disorders bearing upon the innervation of the orbit, and we do not see wherefore certain authors maintain absolutely that a fracture of the orbit exists (MORAX, CHAILLOUS). Doubtless in violent orbital traumatism, by contusion most frequently, a fissure will exist in the orbital walls, and, even in fractures by projectiles of war, the lesion will be always more or less marked; but in the cases of essential enophthalmos, of true enophthalmos, the osseous lesion will hold an accessory and relative place; otherwise, in all orbital fractures in military surgery, there would be enophthalmos. We are confronted by quite different clinical facts, because out of several hundreds of orbital fractures we have only been able to find four cases of traumatic enophthalmos. These are fractures affecting the ciliary ganglion or the carotid plexus which enters the orbit with the ophthalmic artery, and they are accompanied by true enophthalmos. It is not the fracture which matters; what does matter is the lesion of nerves capable of interfering with the nutrition of the retro-bulbar cellulo-adipose tissue.

Here are three unpublished cases of traumatic enophthalmos from trophic troubles.

Fracture of the right orbit ; traumatic enophthalmos consecutive to trophic troubles. (Case 40.)

H. G., Infantry, wounded at M., July 5, 1915, by a fall from the edge of a trench, due to the explosion of a shell. He lost consciousness for three or four minutes; he was immediately sent to be treated at T. Sent back to the front twenty days later, he had two successive attacks of giddiness, and came viâ Chalons to Bordeaux, where he was admitted Sep. 5, 1915.

Case-sheet on entry : " Fracture of right orbit from fall on the right orbito-ocular region, with wound over the superior orbital margin and detachment of upper eyelid."

Examination.—March 12, 1916, the right palpebral fissure has its opening diminished by retraction of the eyeball. This latter, in fact, is sunk at least 4 mm. This enophthalmos is not the consequence of depression of the walls of the orbit, as is evidenced by radiography. It is due, it seems, to trophic disturbance of the orbital contents, thus realising the classic type of traumatic enophthalmos by derangement of nutrition.

There is paresis of the external rectus muscle, the superior rectus, and the inferior oblique, causing well-marked homonymous diplopia.

There is probably a nerve lesion caused by the fracture having injured at the apex of the orbit, in the sphenoidal fissure, filaments of the sympathetic at the same time as the motor nerves.

The right eye has normal tension. The pupil reacts perfectly, directly and consensually; there is no lesion of the deep membranes or of the transparent media. Acuity equals 7/10 with a spherical convex of + 1 D.

The left eye is normal, V = 10/10.

This condition has remained stationary up to to-day (May 25, 1916).

Contusion of the left orbital region, probably fracture ; traumatic enophthalmos of the left eye : consecutive trophic troubles. (Case 41.)

E. R., wounded Nov. 16, 1915, at bombing exercise, at H. Sent by medical board Sep. 24, 1916.

Examination.—R. presents at the level of the left upper eyelid a cicatricial wound resulting from the violent

traumatism suffered by the orbito-ocular region at the moment of bursting of the grenade. The soft parts of the orbit, including the globe of the eye, have been severely contused by displacement of air; as concerns the orbit, there have resulted trophic troubles ending in the disappearance of the retro- and circum-ocular adipose cushion, and producing sinking of the globe in the orbital cavity.

This enophthalmos, very marked, is accompanied by ptosis of the upper eyelid, due partly to paralysis of the levator, partly to the retraction of the globe.

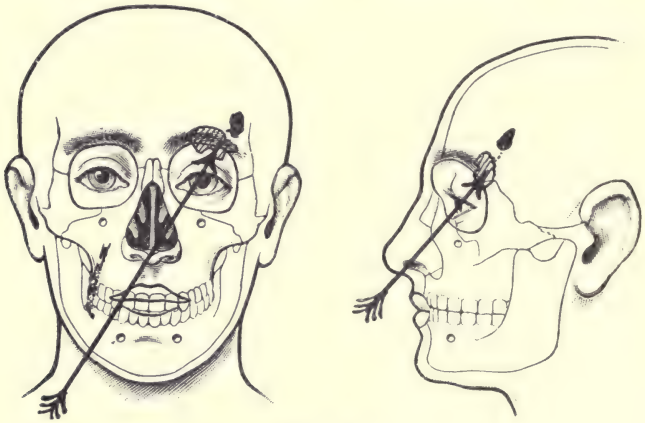

FIG. 46.

Radiography shows that there is no intra-orbital projectile. But, by touch alone, it is easy to localise in the left fronto-parietal region a large piece of shell, encrusted in the bony wall (Fig. 47). It is impossible to make certain by radiography if there is a fracture irradiated to the vault of the orbit, recollecting the interval of time between the date of the injury and our examination. The presence of the fragment shows clearly, however, that the left orbital region was in the sphere of action of the traumatism.

The left eye is on the way to atrophy. There is a total detachment of the retina, with the exception of a small segment of the infero-internal region.

Ocular tension lessened : T — 2.

Right eye normal, V = 10/10.

No disturbance in the transparent media; examination of the deep membranes reveals to us no lesion.

Paralysis of the external rectus and consecutive trophic troubles (enophthalmos). (Case 42.)

R., Dragoon, kick of horse, Nov. 28, 1897, under the following conditions. Wishing to pick up a snaffle lying on the ground in the stable, about 50 cm. from his mare,

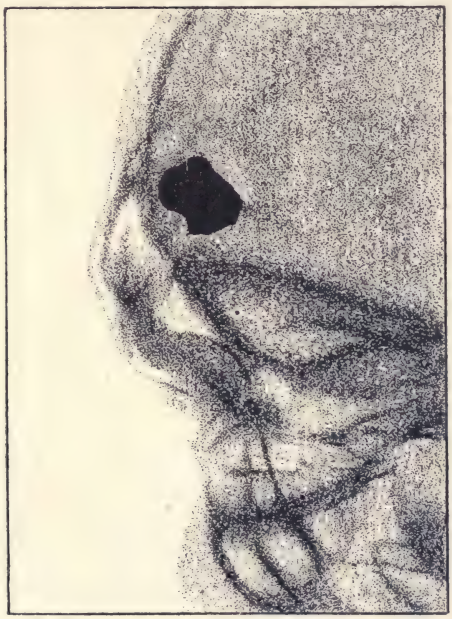

FIG. 47.

at the moment when he was about to incline, the body being almost in the vertical position, save for a slight bending backwards of the back, R. received a kick a little below the right eye, which caused a wound about 3 cm. long by 5 mm. wide; he then fell heavily upon his back, making a deep wound of the occipital region, about a centimetre in diameter. Nevertheless, he did not lose

consciousness, and was assisted by two comrades to walk to hospital.

In hospital the patient presented only a well-marked palpebro-conjunctival ecchymosis, in addition to the two wounds which were sutured and dressed.

At the end of a month, the wounds being cicatrised, dressings were discontinued; at this date, he complained of diplopia.

At the beginning of Jan. 1898, the date when he came to us, he had evident signs of paralysis of the external rectus of the right eye, with contraction of the antagonising muscle; further, the face is thinner on the damaged side, and the eye suffers from enophthalmos: V = 1. Emmetropia both sides.

No trouble of accommodation. Diagnosis: basilar paralysis of the sixth nerve.

During the whole of the year 1898, R. was kept under observation, in the hope that, if the nerve were simply contused, all would come right; but it was not so. With the object of remedying the trophic trouble, thirty sittings of electrisation with continued current were given. The trophic disturbances were a little improved.

In Jan. 1899, more than a year after the accident, the patient had, besides his enophthalmos, a very unbecoming strabismus which caused diplopia, always very extensive and very tiresome.

To remedy the enophthalmos and correct the strabismus, Feb. 7, 1899, we performed the double operation of capsular advancement of the external rectus and tenotomy of the internal.

The result of this operation was excellent in this sense, that the patient had no longer strabismus, and easily remedied, by turning the head, the diplopia which still existed in the right temporal region. He easily walked with the head upright, looking straight ahead without seeing double, and his enophthalmos had disappeared.

He still had complete paralysis of the external rectus of the right eye, but the inconveniences of this paralysis are reduced to the minimum.

(4) We arrive at last at a variety of enophthalmos which is really a false enophthalmos; it is that which depends upon a depression of one of the walls of

the orbit, causing enlargement of its cavity; it is, indeed, a "false enophthalmos" if we reserve the name "true enophthalmos" to that which results from trophic troubles; but in military surgery it is the form most frequently met with. We put forward here three good illustrations.

The eye, acted on by gravity, may fall into the maxillary antrum, or be thrust there by the wounding instrument itself. The cases of SMETIUS DE LEDA, of BECKER, of LANGENBECK, fall into the same category. It is also by fracture that LANG explains his case; he thinks that the orbit is enlarged by traumatism, and that the eye sinks in under atmospheric pressure; NAGEL in his case accepts the same explanation. The reality of this mechanism allows of no doubt. NEUBEN, however, is wrong in wishing to apply it to every case. It will not do to maintain that there is always depression of the orbital walls in enophthalmos: from the violence of the shock there may be frequently an osseous fissure; but, as we have already said, it is not this fissure which is the cause of the sinking in of the eye.

We must distinguish, therefore, two principal varieties of enophthalmos—

(1) True enophthalmos, properly so-called, due to the nervous troubles which we have placed in evidence, following many writers, notably DR. DAULNOY and PROF. ROHMER.

(2) False traumatic enophthalmos from enlargement of the orbital cavity, of which we have collected three cases which we report here.

Fracture of the left orbit; large piece of shell in the right orbit; atrophic and pigmentary choroido-retinitis. (Case 43.)

Commandant R., Infantry, wounded Sep. 14, 1914, at C., by a shell. From F. he was sent to us, and examined Oct. 26, 1915.

Condition.—The shell fragment has penetrated the infero-external portion of the left orbit, where there is a scar 3 cm. in length, direction vertical, the upper extremity of which starts from the external canthus. The projectile is

lodged in the right ethmoido-orbital region, having followed a path from left to right and from before backwards. It has therefore traversed, first, the floor of the left orbit; second, the left orbit; third, the left nasal fossa and the septum; fourth, the right ethmoid and the internal wall of the right orbit.

The radiogram of Nov. 14 shows the presence of a large piece of shell, 3 cm. long by $1\frac{1}{2}$ wide, two-thirds of which are enclosed in the ethmoid and the other third projects into the right orbit, after having pierced the internal wall.

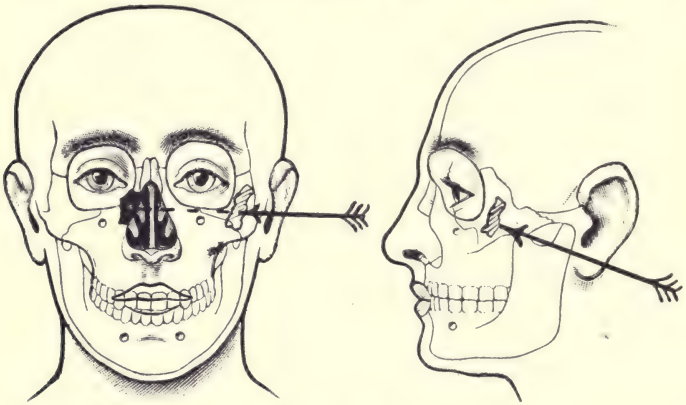

FIG. 48.

Commandant R. refused all interference; moreover, the foreign body had been well tolerated for sixteen months.

From the orbito-ocular point of view, we note the following—

(1) A fracture of the infero-external portion of the left orbit, from which a splinter 1 cm. long was extracted eight days after the injury: a depression of the floor of the orbit has resulted, with sinking in of the eyeball (traumatic enophthalmos from orbital fracture).

(2) Lesions of the left eyeball. This eye, normal exteriorly and with extrinsic musculature intact, presents on the crystalline lens a slight, well-defined opacity, situated above and to the outer side. The disc is a little reddened, its contours blurred and ill-defined (neuritis and perineuritis). The macular region on careful examination is

found to be œdematous, thus explaining the metamorphopsia of which the patient complains. At the lower part, near the equatorial region, is a large patch of atrophic and pigmented choroido-retinitis, remains of rupture and hæmorrhage of these deep membranes.

L. E. $V = 1/10$.

(3) On the right, we note a proliferating macular choroido-retinitis surrounded by pigment, causing a central scotoma in the visual field and lowering the acuity to 1/100 (Plate IV, Fig. 2).

The right eye shows slight external strabismus, due to disuse. There exists a diplopia in which the false image is very dim, but extremely annoying, especially when looking downwards (paralysis of the left inferior rectus muscle).

Fracture of the left orbit ; traumatic enophthalmos ; total detachment of the retina. (Case 44.)

G. Sergeant, Zouaves, wounded July 1, 1916, in the left orbital region, by shell fragment. Treated at St. M. and at Ch. Admitted July 18, 1916.

The projectile has caused a large fracture of the superior orbital margin and the external region of the left orbit. The superciliary arch is completely smashed in over the external two-thirds and the gap in the bone is prolonged to the ascending process of the malar bone.

The upper eyelid is in a condition of ptosis owing to paralysis of the levator, and also because of the retraction of the eyeball.

The latter, in fact, is pushed back into the orbit, and the enophthalmos measures 4 or 5 mm. No movement is possible by reason of the extreme relaxation of the extrinsic muscles.

The pupil is dilated to the maximum. The anterior segment of the eye is intact; ophthalmoscopic examination reveals total detachment of the retina, explaining the hypotony of the eye.

Vision equals 0.

The enophthalmos may be explained either by the depression of the orbital walls or by the retraction of the retrobulbar adipose cushion. Depression of the walls is the more probable because a large piece of shell was extracted, two

days after the injury, from behind the eye against the inferior wall. Besides, the radiogram shows this depression (Fig. 49).

Sep. 2, 1916, section of the four recti muscles, an attempt to palliate the retraction of the globe, gave no result.

Sep. 11, restoration of the superciliary arch was attempted by means of a graft of costal cartilage; a piece six centi-

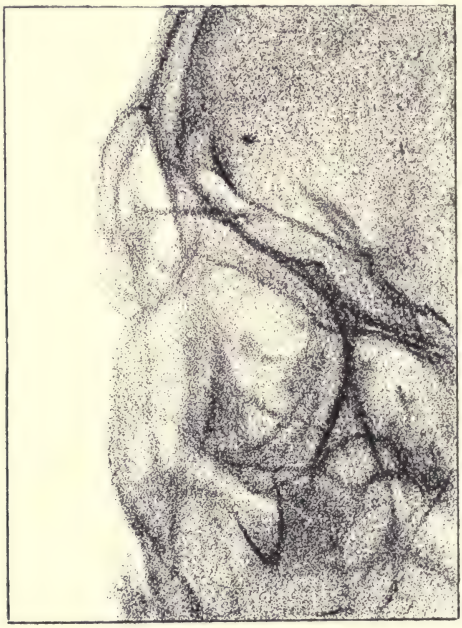

FIG. 49.

metres long was removed from the rib, and at the same time a portion of pre-costal adipose tissue.

The cutaneous orbital cicatrix was carefully excised; then, by splitting the subcutaneous layer of tissue, a cavity was made, large enough to contain the cartilaginous and fatty grafts. Suture of the superficial layers by silk-worm gut.

Post-operative progress entirely satisfactory; the wound healed by first intention, and a fortnight later the restora-

tion of the superior wall of the orbit was as successful as possible. But as the enophthalmos made the region most unsightly the patient asked for enucleation, which was done Sep. 26, 1916, and an artificial substitute gave an excellent result.

G. left Oct. 24, 1916, completely recovered.

A case of post-traumatic enophthalmos; depression of the external orbital wall and of the inferior orbital margin. (Case 45.)

J. R., Mechanic, aged twenty-one years, living at Poitiers, was cycling, March 16, 1912, when he collided with a carriage. R. was struck in the right orbital region by the mud-guard; the shock was so violent that it was broken and the patient thrown to the ground. At the hospital at Poitiers, where he was immediately taken, depression of the root of the nose and a smash of the external orbital margin were discovered. A large splinter of wood was taken from the temporal region, where it had lodged above the zygomatic arch; one of the nasal bones was eliminated through the nostril during an attack of hæmorrhage.

Suppuration was overcome with difficulty, and it was only after eighty eight days of treatment that cicatrisation could be obtained. R. then stated that he saw double, and as this constant diplopia rendered all work impossible he came to consult us on Oct. 17, 1912.

The patient bears numerous scars situated about the internal canthus of the right eye and on the lower eyelid, which is ectropionized; there is ptosis due to the enophthalmos; it is not accompanied by any lesion of the levator, which functions perfectly, as does also the superior rectus.

The eyeball is very markedly retracted, estimated at 5 mm. by comparison with the sound eye. This sinking in of the globe does not vary with the position of the head, and is not modified by effort. The eye, which is not supported by the external wall, has slipped outwards upon the orbital floor and is plainly deviated to the outer side and below. Hence the patient complains of crossed diplopia in every direction. The images are 20 cm. apart when looking ahead; this separation is much increased (80 cm.) when the candle is moved to the nasal side; it is slightly less on the temporal side. The patient complains

that in every direction the images are on a different level. The visual field is, however, normal; acuity = 1. Examination by oblique illumination shows that the cornea, quite transparent, has been entirely spared by the injury. The anterior chamber is of normal depth, the pupil presents nothing pathological, the iris reacts well to light and to accommodation. No trouble can be found in the transparent media, and the ophthalmoscope reveals nothing worthy of being put on record.

The left eye is quite untouched, the injuries not extending beyond the bridge of the nose; this eye is emmetropic and possesses acuity = 1.

In short, this was a traumatic enophthalmos due to depression of the external orbital wall, and perhaps also, in part, to the effects of prolonged suppuration of the tissues of the orbit.

By tenotomy of the four recti muscles the enophthalmos was considerably ameliorated.

Symptoms and Diagnosis

In the cases in which enophthalmos is due to depression of the orbital walls there are always signs and traces, more or less old, of severe traumatism of the orbit. At the time of the accident there is abundant epistaxis and sub-conjunctival ecchymosis; profuse retrobulbar hæmorrhage may take place and bring about in the early stages an exophthalmos, which gives place later to enophthalmos.

During the whole of this early period the patient opens the eyes with difficulty, and it is only when the disappearance of palpebral swelling allows the ready separation of the eyelids that the more or less pronounced sinking in of the eyeball is noticed.

Usually it is about a fortnight before the patient opens his eyes; he habitually remarks in the first place that he sees double; this is the rule when visual acuity is good. It is often on account of the diplopia that the patient, till then in the hands of the general surgeon, seeks the advice of the ophthalmic specialist.

The latter immediately notices two principal symp-

toms, viz., ptosis and restriction in the ocular movements. The ptosis is generally due, not to paralysis of the levator, but to the fact that the upper eyelid has partly lost its natural support, which is the eye; it sinks in with it, and is lowered because it is sunk in, and in the same proportion.

In one of our cases, however, we noticed paralysis of the elevator, consecutive to traumatism of the supra-orbital region, which had directly implicated the levator palpebræ.

The eye is usually well fixed in its new position, and it is only in exceptional cases that intermittent enophthalmos and exophthalmos have been found; Jean Terson has reported three such cases.

The visual field is normal, the range of outlook restricted by the difficulty of excursion of the muscles; usually the media of the eye and the deep membranes are healthy. We shall not spend more time upon the symptomatology, which will be found in all the textbooks, as well as in the thesis of Dr. Daulnoy (Nancy, 1898–9), which is well supplied with references. We must limit ourselves to bringing forward here the symptoms presented by the cases we have reported above.

Our patient in Case 43 was a typical example of traumatic enophthalmos; the enophthalmic eye presented a slight opacity of the lens and papillary inflammatory troubles, but, the extrinsic musculature being intact, the diplopia complained of by the patient was the result of lowering of the eye by depression of the floor of the orbit.

In the same manner in Case 44 the radiogram shows a very clear depression of the inferior orbital wall; in this case, further, the eye, lessened in tension, was itself diminished in volume and had lost all acuity by reason of total detachment of the retina.

In Case 45, which was an example of grave traumatism worthy to be compared with traumatism of war, the enophthalmos, again due to bony depression, was very marked (5mm.); the subject had good visual acuity,

so good that he complained of a very tiresome diplopia some months after the injury. In his case a tenotomy of the four recti muscles, following DARIER's procedure in similar cases, brought about great improvement.

Our other cases differ from the preceding in that trophic disorders were the cause of the enophthalmos. In one of the patients (Case 41) we had to do with a lesion of the frontal region due to an extra-orbital foreign body, which had perhaps caused a fracture of the orbit, irradiated to the apex, and which had implicated the motor and sensory nerves; the eye had preserved a good exterior appearance, but showed extensive detachment of the retina.

Finally, our Case 42 is a case of enophthalmos from nerve lesions and trophic troubles characterised by the following signs. The patient had a wound in the supra-orbital region; the visual acuity of the enophthalmic eye was 7/10, and there was paralysis of the superior rectus, the external rectus and the inferior oblique, entailing a very distressing diplopia. Probably the third and sixth nerves had been injured in the sphenoidal fissure, and at the same time the sympathetic filaments, emanating from the carotid plexus, had been torn at this level. The trophic disturbances were consecutive to this lesion. These two cases are types of true enophthalmos, as is also Case 40.

Diagnosis.—We do not think we need linger over the diagnosis of enophthalmos.

The appearance of the patient is usually characteristic and the diagnosis is made from a distance, at the first glance. In doubtful cases, at the onset of the affection, we may have recourse to the orthometers and ophthalmeters, recommended by HASNER, WAKNAM, ZEHENDER, COCCIUS, and MAKLAKOW; but it will be simpler and more practical to use for the same purpose the ophthalmometer of JAVAL. The eyes must be placed in a plane exactly parallel with the plane of the instrument, and, reflecting the "mires" of the instrument successively from each cornea, one notes how many millimetres it is necessary to advance the

instrument to focus it when examining the enophthalmic eye; this procedure is quite satisfactory and enables one to dispense with special apparatus.

We shall say nothing here concerning prognosis which is not familiar; the affection remains stationary when it is left to itself, and treatment yields but very mediocre results. We should here, however, mention the good results quoted by some writers, from electrical treatment by the continuous current; also tenotomy of the four recti muscles, advocated by DARIER.

This gave us a favourable result in one of our cases (Case 45).

CHAPTER V

FRACTURES OF THE ORBIT WITH DESTRUCTION OF THE EYEBALL

THE destruction of the eyeball may occur either with the presence of a foreign body or without the foreign body remaining in the orbit. The immediate disorders are the same; but in the second category of cases, the complications which result from the presence of the foreign body, come in to darken the picture.

Most frequently pieces of shell smashing in the external wall of the orbit, crushing the eye, and coming to rest near it or in the neighbouring cavities are the objects of interest in the cases of the second category. Bullets traverse the orbit and fracture it, but escape after having destroyed the eye and traversed the bony mass of the face.

We could report a large number of cases of this kind, but shall limit ourselves to the four following.

Fracture of left orbit; rupture of eyeball; arterio-venous aneurism of the left internal carotid. (Case 46.)

A., Sergeant, Infantry, was wounded April 14, 1915, by a rifle-bullet at M. Treated for ten days at Ch., he came to us April 27.

The rifle-bullet entered the left lateral part of the neck along the posterior border of the sterno-cleido-mastoid, three fingers' breadth below the inferior extremity of the mastoid process.

Following a course from below upwards and from behind forwards it came out at the level of the floor of the left orbit.

The left eyelid is totally destroyed; the aperture of exit is found almost in the inferior conjunctival cul-de-sac. The projectile has caused the rupture of the eyeball, which

is now reduced to a small shapeless stump, inflamed and painful.

The radiogram, whilst enabling us to determine the absence of a foreign body, shows a depression of the anterior portion of the floor and of the orbital margin. R. E. normal.

Enucleation of the left eye was performed April 30. During the next few days, A. drew our attention to a continuous buzzing in the ear, and left migraine. This

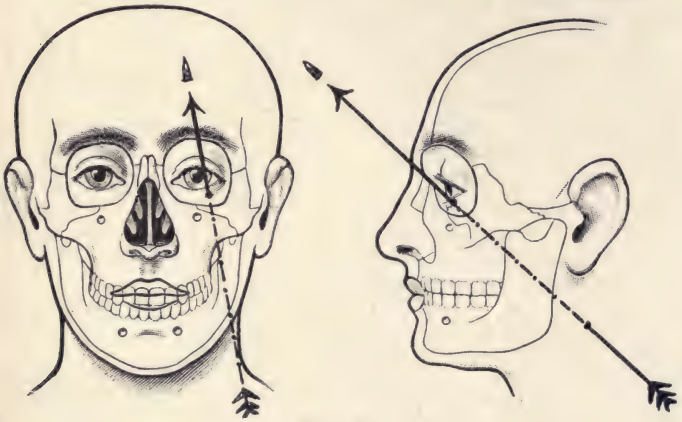

FIG. 50.

whistling, synchronous with the cardiac beat, was exasperating, causing atrocious headaches, and entirely preventing sleep. Extreme vaso-constriction of the face.

DR. LACOUTURE, called in consultation, concluded from his examination that there was an arterio-venous aneurism seated on the left internal carotid. Artery and jugular vein must have been injured by the bullet in its course.

May 5, 1915, ligature of the internal carotid. Post-operative progress most satisfactory; disappearance of all the symptoms; no complication has occurred since this intervention.

A blepharoplasty of the lower eyelid was done July 15, 1915, by means of a fronto-parietal flap. This operation allowed the patient to wear an artificial eye easily.

He left hospital June 17, 1915, completely recovered.

Fracture of left orbit ; rupture of eyeball. (Case 47.)

J. S., Infantry, rifle-bullet in the face, Aug. 28, 1914, at R. Made a prisoner, he was released June 25, 1915, and was admitted Aug. 4, the same year.

Condition.—The bullet penetrated the right ala of the nose; after having traversed the nasal fossæ from side to side it has fractured the left internal orbital wall a little above the lacrymal sac; continuing its course, it has ruptured the globe and emerged from the fronto-temporal region at the supero-external angle of the orbit.

At this point is to be seen a deep depression of the bone, the size of a crown-piece, produced by the fracture of the ascending process of the malar bone and the external process of the frontal bone. The cutaneous cicatrix extends to the external third of the eyebrow, which is much drawn downwards.

There is ptosis of the upper eyelid and symblepharon over the external third of the two eyelids; the lower eyelid is torn in the neighbourhood of the lacrymal sac, and is adherent below, in a vicious position.

The eyeball, entirely destroyed, was enucleated eight days after the injury.

The right eye is normal, V = 10/10.

Aug. 12, 1915, surgical intervention. In the first stage, the two eyelids were freed (section of the symblepharon); next, after freshening the inferior and internal palpebral border, it was drawn upwards, restoring the canthus. After dissection of the skin about the external orbital cicatrix, the very unsightly depression of the bone was filled up by means of adipose tissue taken from the left buttock. Sutures and dressings. Post-operative conditions excellent; the adipose graft took by first intention. In spite of this operation the conjunctival cavity remained atypical, very narrow, permitting, however, the use of an artificial eye.

S. left hospital Sep. 21, 1915.

Fracture of the right orbit ; rupture of right eyeball ; traumatic choroido-retinitis and optic atrophy, L. E. (Case 48.)

M. P., Infantry, wounded Jan. 14, 1916, by rifle-bullet. Taken to Ch. Jan. 15, he came to us Feb. 8, 1916.

Condition.—P. was struck by a rifle-bullet from a distance of about 150 metres. The projectile traversed the face from left to right, obliquely upwards and outwards; it penetrated at the union of the malar with the zygomatic arch, emerging by the supero-external angle of the right orbit, near the outer extremity of the eyebrow, traversing this cavity throughout its width, and causing an extensive fracture of the external wall, which can be felt depressed.

The right eye, ruptured and only existing in the form of débris, had been enucleated at once. The upper eyelid is destroyed in its external two-thirds; and surgical interference in two stages, Feb. 20 and Mar. 12, blepharoplasty by transplantation (pedicle) and Snellen's sutures, permitted the wearing of an artificial eye.

On the left side visual troubles appeared immediately after the injury. P. declares that on arrival at Ch. he found a very great diminution of visual acuity in that eye; it improved in the period immediately following, and since then it has remained stationary.

L. E. $V = 1/10$ good.

The globe is normal exteriorly. The pupillary reflexes are good; the transparent media clear.

In the macular region, especially marked below and to the inner side, there is atrophic and pigmented choroido-retinitis, secondary to a hæmorrhage of the membranes and causing a slight ascending atrophy of the optic nerve (concussion lesions). The disc is, in fact, decoloured, whitish, with contours somewhat pigmented.

Discharged July 7, 1916, in the same condition.

Fracture of right orbit; rupture of eyeball. (Case 49.)

E. S., Infantry, wounded Oct. 6, 1915, by grenade fragment. From Tarbes, he arrived Dec. 10, 1915.

Condition.—Cicatrix about 3 cm. long, direction vertical, in right superior orbital region. It starts from the anterior frontal region, 2 cm. above the eyebrow and two fingers' breadth from the root of the nose; the superior orbital margin is fractured at the junction of the inner third and the outer two-thirds. A deep notch of the underlying bony wall can be felt.

The upper eyelid is divided and in a condition of

cicatricial ectropion; the palpebral borders are adherent to the depressed bone.

The ruptured eyeball was enucleated two days after the injury. The left eye is normal, V = 10/10.

Jan. 10, 1916, restoration of the upper eyelid was proceeded with. The cicatricial tissue was undermined, and after refreshing the two ciliary borders the palpebral portions were sewn together. Snellen's sutures were used to deepen the superior conjunctival cul-de-sac. An artificial eye was given.

S. left hospital Feb. 6, 1916, completely recovered.

These four cases all present remarkable peculiarities.

The first concerns a patient who, in addition to his serious orbital lesion, had an arterio-venous aneurism of the internal carotid and the jugular; this aneurism was cured by ligature of the internal carotid performed by Dr. Lacouture; it was afterwards possible, by means of a blepharoplasty, to restore the eyelids in such a manner as to permit the wearing of an artificial eye.

The second case furnished us with the opportunity for practising with success our first adipose graft, permitting us to repair the large loss of substance resulting from the destruction by a bullet of the external process of the frontal and of the malar bone.

The third is a subject in whom, besides the rupture of the right eye, we noted in the left eye macular concussion lesions already fully described (see p. 120).

The fourth case is remarkable for the presence of an important fracture of the whole of the superior margin of the orbit, coupled with an extensive destruction of the upper eyelid. A Snellen's suture above and an appropriate blepharoplasty allowed us to place this subject under conditions for an æsthetic prothesis.

In all these cases, as well as in those in which the eye has been struck by a bullet, the organ was destroyed in such a manner that only débris remained, and it is impossible to give an account of the mechanism which has been responsible for the rupture.

Shrapnel balls or shell fragments reduce the eye to the condition of a stump, but do not like bullets tear it in pieces; one finds still in the orbit a more or less painful stump, with a foreign body in its vicinity. The injury to the eyeball is not less serious; on the contrary, this shrivelled and torn globe retains in its interior the inflamed uveal tract, which is brought in contact with the infected orbital cavity by means of the ruptures in the sclerotic, and thus serious irritation may result, implicating the other eye.

When the eye has been torn to pieces by a ball, or opened by the explosion of a grenade, usually the uveal tract begins to suppurate, and suppuration is the enemy, the antagonist, of sympathetic ophthalmia; the choroid is eliminated and very soon nothing remains of the contents of the burst ocular envelope. On the other hand, when there has been attrition and rupture of the eye by a shell-fragment the withered eye shrivels up, keeping in its interior inflamed uveal tissue; the painful stump remains, with all its danger. This is demonstrated by the following cases.

Wound of the left temporo-orbital region; fracture of the external wall of the orbit; rupture of the eyeball; persistence of foreign body in the orbit. (Case 50.)

C. D. Infantry, wounded in Champagne by shell fragments; after twelve days reached Bordeaux, April 12, 1916.

Condition.—On his arrival, there was a large wound, extending from about 2 cms. from the meatus of the left ear to the external third of the left lower eyelid. There was a comminuted fracture of the zygomatic process and of the malar bone.

The inferior orbital margin is also the seat of a notch caused by the projectile.

The left lower eyelid is pulled down on its outer side. The eyeball persists, at the bottom of the orbital cavity, in the form of a small inflamed and painful stump.

Radiography shows the existence of a large shell fragment lodged in the orbit behind the stump (Fig. 51).

May 18, 1916, enucleation of the eyeball and extraction of the foreign body. We then proceeded to restore the

outer third of the destroyed lower eyelid by transplantation of a flap taken from the external orbital region.

Cicatrisation by first intention.

R. E. intact. V = 10/10.

The prothesis has been specially moulded; after progressive dilatation, the wearing of an artificial eye of almost normal size has been tolerated.

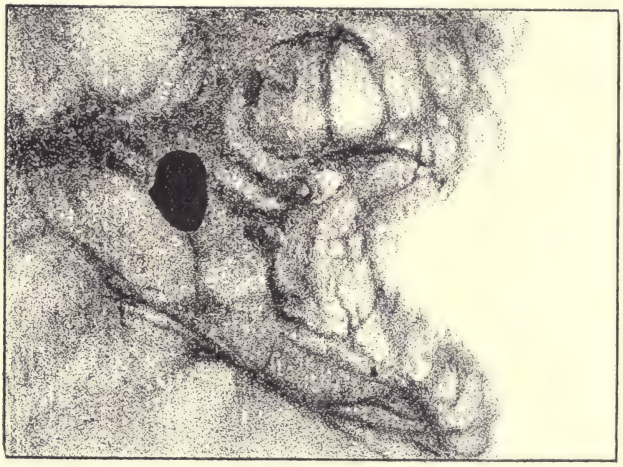

FIG. 51.

Fracture of the right orbit; rupture of the eyeball; shrapnel ball at the apex of the orbit. (Case 51.)

A. C., Sergeant, Infantry, wounded at A., Aug. 24, 1914. From Troyes, viâ Casteljaloux, he arrived at Bordeaux Oct. 20, 1914.

Condition.—In the external orbital region is seen a depressed cicatrix, with starred margins, probably the orifice of entry of the projectile. Beneath can be felt the fractured ascending process of the malar bone.

Two months after the injury there was still voluminous chemosis below, evidence of an intra-orbital effusion of blood, absorbed, with inflammatory sequelæ.

The eyeball is reduced to a small stump covered by conjunctiva, clearly felt on palpation.

Since the injury C. has experienced sharp pains in the right supra-orbital region.

Radiography shows the presence of a shrapnel ball, lodged in the right orbit, towards the apex (Fig. 52).

Oct. 28, 1914, we proceeded to enucleate the stump. Orbital exploration allowed us to mark the exact location of the projectile, which was extracted by the gouge with difficulty.

Post-operative progress excellent.

C. left hospital Nov. 12, after the fitting of an artificial eye. The left eye was normal.

L. E., with + 0·50 D sph.,V = 9/10.

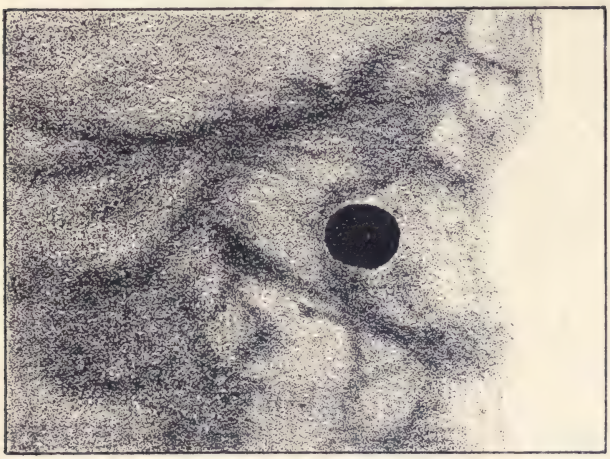

FIG. 52.

Still more curious is the following case, in which we found a foreign body by the side of the optic nerve, irritating it to the point of determining, not attenuated sympathetic phenomena, but a true ophthalmia.

Foreign body irritating the optic nerve ; sympathetic ophthalmia. (Case 52.)

A. T., Infantry, wounded Oct. 11, 1915, at P. Admitted Oct. 24 of the same year.

Symptoms on Admission.—T. had a perforating wound of the eyeball from a shell wound. The eye was in a condition of complete panophthalmitis at the time of our first examination. The left eye was normal, V = 10/10. Evisceration of the globe was performed Oct. 28, 1915, with all possible care to leave no trace of the uveal tract in the scleral envelope.

Nov. 7, T. complained, for the first time, of a sensation of mistiness and diminution of vision in his left eye. Ophthalmoscopic examination revealed the existence of a well-marked optic neuritis; acuity then equalled 1/10.

The next day enucleation of the stump on the right side was performed. Dissection of this stump showed that a tiny portion of shell was in the substance of the sclerotic, *in contact with the optic nerve.* Intensive mercurial treatment was commenced (intravenous injection of cyanide, friction with mercurial ointment, counter-irritation atropine).

The neuritis improved slowly and progressively, so that on May 30, 1916, the visual acuity, with + 1·25 D sph. again equalled 10/10; the disc presented a normal aspect, its scleral borders quite clear.

He was discharged May 27, 1916, completely recovered.

We now arrive at a variety of fractures of the orbit of the greatest interest, those which are accompanied by destruction of the eyeball with implication of the neighbouring cavities.

Fractures Implicating the Neighbouring Cavities

We shall group the cases of this kind into three series, according as the orbital fractures involve: (*a*) the maxillary antrum; (*b*) the frontal sinus; (*c*) the cerebral cavity.

It is evident that these three varieties present different degrees of gravity and characteristic symptoms, but they have everything in common from the ætiological point of view. It is almost always pieces of shell, fragments of grenades, rarely shrapnel balls, very exceptionally bullets, which bring about the great facial and cranial derangements. The bullet is a narrow

projectile, involving disorders at a distance by vibration or oscillation of the tissues. The pieces of shell shake the neighbouring regions less, but they break the bones, drive in the walls, and cause the orbital cavity to communicate freely with the cavities which surround it. By way of a specimen we reproduce here

FIG. 53.—Smash of the orbital region by a large piece of shell.

a photograph (Fig. 53) portraying the lesions produced in such a case in the orbital region; and two radiograms (Figs. 54 and 55), which represent two good examples of fracture with loss of substance.

Of these two radiograms, one (Fig. 54) refers to a subject in whom the loss of substance has been repaired by a cartilaginous graft; it is drawn from a very correct proof. The other (Fig. 55) refers to Case 64 (p. 188).

One can see plainly there the crushing in of the external wall of the orbit. We give these two types of fracture by way of example; we have many others in our collection.

The attrition which results from such traumatism is quickly followed by suppuration, and thus is developed sinusitis, interminable if not remedied, or

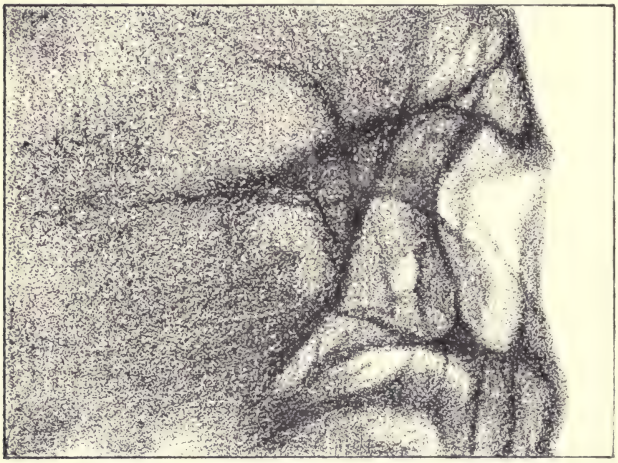

FIG. 54.—Fracture and loss of substance of the left external orbital region.

rapidly fatal cranial disorders, if efficacious interference is not quickly brought to bear.

It is these cases of fracture of the orbit with opening of the sinus and destruction of the orbital margins which need the plastic operations with grafts of which we shall speak later.

(*a*) MAXILLARY ANTRUM

We could multiply cases here, but as in our other groups we shall be content with choosing a few out of our collection.

Fracture of the floor of the left orbit; crushing of eyeball. (Case 53.)

L. O., Sergeant, Infantry, wounded Aug. 28, 1914, at B., by shell. No loss of consciousness. Dressed the same

FIG. 55.—Fracture of the supero-external region of the left orbit.

evening, he went first to Libourne, thence to Bordeaux, admitted Oct. 7.

Examination.—There is an extensive wound of the left infero-external orbital region; the divided lower eyelid is wanting in its external two-thirds; in this region the

integuments are absent and leave the maxilla bare; its vault and anterior wall are smashed in. The outer part of the upper eyelid is equally destroyed as far as the outer extremity of the eyebrow, and is adherent to the underlying bone.

The patient discharged large quantities of pus due to well-marked sinusitis, from the wound and from the nose, and on Sep. 13 expectorated a large splinter, which came from the anterior wall of the sinus.

The left eyeball presents a rupture of the sclerotic at its lower part, on the side of the orbital fracture. Reduced

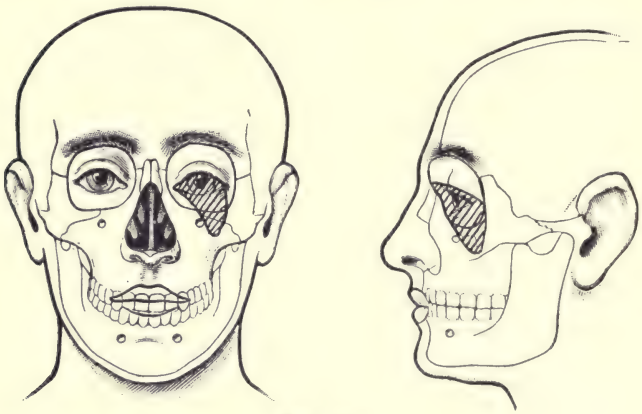

FIG. 56.

to the condition of a stump, its enucleation was judged to be necessary, and this was done Oct. 14.

Upon the radiogram we see very clearly the depression of the anterior wall of the antrum and the crushing in of the floor of the orbit. There is a small foreign body in the sinus. Some small bone fragments are situated near the hole in the maxilla; one, larger, is in the pharyngeal region, explaining the difficulty in chewing and swallowing.

Oct. 14, besides enucleation, we proceeded to repair the anterior wall of the antrum and the eyelids; the drainage of the antrum was afterwards effected, after cleaning up with a curette.

In the second stage, blepharoplasty of the two eyelids,

by transplantation with a pedicle. The result of the operations was most satisfactory.

Fracture of the left orbit and of the left maxillary sinus; rupture of the left eyeball. (Case 54.)

E. C., Infantry, wounded Feb. 25, 1916, by a grenade which burst one metre from him. He was immediately trephined in a field hospital. He stayed twelve days at C., and reached us March 27, 1916.

Examination.—The projectile had penetrated the left maxillary antrum, and after having traversed the left orbit from side to side emerged from the fronto-parietal region of the same side.

There is a large wound of the fronto-parietal region, in a fair way to cicatrisation.

At the anterior portion of the antrum is seen an irregular wound (aperture of entry of the shell fragment), which is freely suppurating. The ruptured left eye remains in the form of a small stump at the bottom of the conjunctival cavity.

Radiography shows a small projectile situated in the maxillary sinus; also two or three splinters, the cause of the prolonged suppuration of the wound. The inferior orbital margin and the floor of the orbit have both been fractured.

In the frontal bone is an extensive loss of bone substance, resulting from the trephining. A small shell fragment remains at the edge of the bony orifice.

April 7, the stump was enucleated; next, the maxillary antrum was carefully curetted; this permitted of the extraction of the shell fragment, the splinters mentioned above, and some fragments of calcareous stone.

June 8, 1916, maxillary fistula was cicatrised.

The orbital cavity, although reduced in volume by the lacerations of the conjunctival mucous membrane, allows the wearing of an artificial eye.

R. E. intact. $V = 10/10$.

Fracture of right orbit and frontal sinus; destruction of the eyelids and of the right eyeball; voluminous foreign body in the left maxillary antrum. (Case 55.)

E. M., Infantry, wounded Feb. 15, at M. Immediate

loss of consciousness; he was transported to Ch., where the right eye, reduced to a pulp, was enucleated. Admitted Feb. 25.

Examination.—This soldier has been struck in the right orbito-ocular region by several portions of shell, which have caused the following injuries—

(1) Fracture of the frontal bone, and wide opening up of the frontal sinus, which was freely suppurating at the time of our examination.

(2) Fracture of the superior orbital margin at its outer end. The right eyelid has been torn and partly destroyed at this point.

(3) Laceration of the lower eyelid, which, owing to œdema, assumes the shape of an inflated bag.

(4) Rupture of the right eyeball (enucleated), and fracture of the floor of the orbit, easily felt on palpation through the conjunctival sac.

The left eye is intact; its visual acuity equals 10/10. Radiography shows the presence, (1) of a small shell fragment in the right orbit; (2) of another somewhat larger in the left nasal cavity; (3) of a third, very large, measuring 2 cm. long by 1 broad, with irregular contour, lodged in the left maxillary sinus.

Penetrating at the level of the right orbit it has therefore crossed the nasal fossæ from side to side and fractured the right antrum.

March 1. After opening the anterior surface of the left sinus the projectile was extracted. Drainage; sutures. Recovery was rapidly obtained.

March 25. Blepharoplasty by the aid of a cutaneous flap from the frontal region, which allowed restoration of the outer part of the upper eyelid. Dissection of the injured tissues of the lower eyelid and their suture in good position.

Placing of Snellen's sutures to restore the inferior conjunctival cul-de-sac.

After dilatation and taking a cast of the conjunctival cavity, an artificial eye could be fitted; discharge, Aug. 12, 1916.

The wound of the frontal sinus had cicatrised without its being necessary to proceed to an operation for restoration.

Fracture of the internal wall of the left orbit; destruction of the nasal wall and of the antrum; rupture of eyeball; burying of the eye in the antrum. (Case 56.)

A. G., Infantry, wounded Aug. 24, 1915, by shell fragments. From Ch. he went to Arcachon, Sep. 5, thence to Bordeaux, Sep. 8.

Examination.—A large piece of shell penetrated at the level of the supero-internal angle of the left orbit, and came to rest at the anterior surface of the median portion of the left maxilla.

In its course it produced the following injuries—

(1) Laceration of the inner canthus.

(2) Fracture of the inferior orbital margin and of the floor of the orbit, entailing the almost complete destruction of the lower eyelid.

(3) Rupture of the left eyeball, reduced to the condition of a shapeless stump at the bottom of the conjunctival sac.

(4) Fracture of the maxilla, of the os unguis and the nasal bone on the left side, producing an irregular cavity formed by the widely open maxillary sinus and nasal fossæ. These two cavities communicate by a wide aperture.

The wound has been suppurating for a long time, and it has been necessary to wait two months before being able to attempt an operation for restoration.

Dec. 5, 1915, an attempt was made to close this opening, after dissecting up the cutaneous layers on the margins of the opening into the antrum and nose. Blepharorrhaphy and superficial sutures. Subsequently the sutures gave way and the cicatrisation of the flaps took place in bad position.

Three weeks later, blepharoplasty by transplantation of a flap with pedicle taken from the left fronto-parietal region. The two external thirds of the graft took by first intention, but the internal third, not sustained by a vascular base, necrosed after a short time, leaving the orifice open, but much smaller than before.

G. was sent on three months' convalescent leave before attempting a third operation; it was in the course of this third and last operation, the result of which was satisfactory, that we found the débris of the eye in the interior of the cavity of the antrum.

The right eye was normal. $V = 1$.

Fracture of the floor of the right orbit ; cicatricial ectropion ; traumatic choroido-retinitis ; large piece of shell in the antrum. (Case 57.)

A. L., Infantry, wounded Jan. 9, 1916, at M. ; from Ch. he arrived Feb. 4, 1916.

Condition.—The shell fragment has penetrated a centimetre below the right inferior orbital margin, in its median part ; at its entry we note upon the anterior surface of the antrum a depressed, suppurating, cicatrix ; a probe introduced into the orifice leads to the maxillary sinus itself, in a direction from before backwards and from below upwards, to beneath the floor of the orbit.

Radiography shows this fracture of the anterior wall of the sinus, and, in addition, a fracture of the orbital floor. The fragment is found in the cavity of the antrum at its posterior part, near the orbit.

The right eye is the seat of extensive disorder ; patches of peripapillary and macular choroido-retinitis (concussion lesions), numerous choroidal hæmorrhages below, on the side of the orbital fracture (contact lesions).

Acuity barely 1/100.

The lower eyelid has healed in a bad position ; cicatricial ectropion produced by the retraction of the palpebral tissue injured at the site of the wound.

At the first operation, Feb. 19, 1916, the wall of the antrum was widely laid open and a flood of pus escaped. The foreign body was easily extracted by means of a gouge, as well as some bone splinters coming from the floor of the orbit. Drainage and suture. The wound has been a long time healing by reason of the sinusitis.

When healed, blepharoplasty by transplantation of a pedunculated flap, for restoration of the lower eyelid.

Rapid healing by first intention.

Discharge July 3, 1916.

The reading of these five case-reports gives a clear idea of the diversity of the injuries to the maxillary antrum. In Case 53 all the infero-external orbital region was destroyed, the vault and the anterior wall of the maxillary sinus were crushed in ; the anterior wall of the sinus has been eliminated as a splinter. In

Cases 54 and 55 the anterior wall of the sinus has also been destroyed by a fragment of grenade, and its fragments have fallen in splinters into the sinus itself. Case-report 55 treats of a fracture of the maxillary sinus by a large piece of shell which was extracted from the cavity. The fourth case (56) is still more

Fig. 57.

interesting in the sense that, besides the large opening allowing the maxillary sinus to communicate with the nasal fossæ, we found, at the time of one of the reparatory operations which have been done, the left eye crushed down into the sinus. Finally, in the fifth report (Case 57), given here as a specimen, we again found a piece of shell (Fig. 57) in the posterior part of the cavity of the sinus, against the floor of the orbit.

(*b*) Frontal Sinus

The frontal sinus is sometimes attacked alone by the instruments of violence which fracture the orbital walls; here, most frequently, we have to do with a bullet whose course from below upwards, or from above downwards, meets the frontal sinus and traverses it. Out of the three cases we give of lesions of the frontal sinus, two are concerned with bullet wounds, the third with traumatism by shell fragment.

Fracture of the supero-internal orbital wall; opening of the left frontal sinus. (Case 58.)

L. H., Infantry, wounded Sep. 25, 1915, at Saint-H., by a rifle bullet at the level of the inner extremity of the left eyebrow. Transported to Saint-H., he reached our service Oct. 5, complaining of diplopia.

Condition.—The projectile has entered at the supero-internal angle of the left orbit and emerged at the internal third of the right eyebrow, at a centimetre distance from the latter.

In its course it has fractured the left frontal sinus, which at the time of our examination is widely open.

Palpation, very painful, reveals the existence of a notch of the orbital margin, at the point of penetration of the bullet. In addition there is a depressed cicatrix adherent to the deep parts.

Radiography confirms the fracture of the left frontal sinus. The left eyeball is normal; no lesion of the refringent media or deep membranes to be found.

Visual acuity of the left eye equals 10/10.

H. complains of a very distressing diplopia following the traumatism. Study of the false image reveals paralysis of the left superior oblique muscle. It is probable that the projectile has divided the pulley of the muscle situated at the fractured spot.

The frontal wound had cicatrised spontaneously, and H. went on convalescent leave with persistent diplopia and almost constant violent headaches.

Fracture of the facial bones by a bullet ; fracture of the frontal sinus and of the ethmoid ; adipose graft. (Case 59.)

E. H., Infantry, was wounded Oct. 17, 1915, at A. Sent to Sainte-Menehould, afterwards to Vichy, where ablation of splinters and extraction of the ethmoid were effected.

Condition.—On arrival July 7, 1915, it was found that the bullet had penetrated the root of the nose, passed along the internal wall of the right orbit, without fracturing it, traversed the superior maxilla and the roof of the

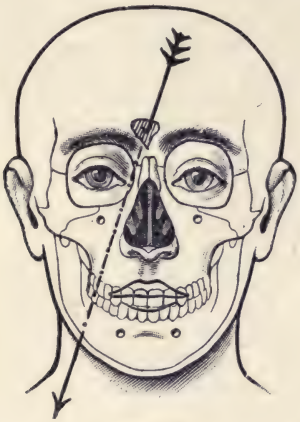

FIG. 58.

mouth, coming to rest in the lateral part of the neck. In its course it had broken into the frontal sinus and the ethmoid.

The eyes are intact, and their visual acuity is normal.

The sole lesion evident is obstruction of the right lacrymal passages, probably due to a fracture of the nasal canal.

The bullet was extracted Aug. 9, 1915, by the aid of the classic incision used for ligature of the carotid; it was found near the superior border of the thyroid cartilage, under the anterior border of the sterno-cleido-mastoid.

Post-operative progress normal.

H. left hospital in Sep. 1915, with persistence of lacrymation on the right side.

On his return from convalescent leave we proceeded to

resect the vicious cicatrix at the root of the nose. After splitting the cutaneous covering the cavity was filled in by the aid of fatty tissue taken from the right buttock.

Union by first intention.

The adipose graft gave an excellent result from the æsthetic point of view.

Fracture of the left fronto-orbital region involving the frontal sinus ; hæmorrhage into the vitreous body ; adipose graft. (Case 60.)

E. B., Infantry, wounded Sep. 25, 1915, at B., by a shell; viâ Perigueux to Bordeaux, where he arrived Nov. 9, 1915.

Condition.—The piece of shell had produced a wound seven centimetres long, beginning at the left upper eyelid, implicating the end of the eyelid and the frontal sinus, which was laid widely open. The wound had become infected, and suppuration has been fairly abundant.

On the patient's arrival the wound of the sinus had a fistulous aspect, some drops of purulent fluid welling up.

The upper eyelid is divided at the site of the internal third. The eyeball, severely contused, is of normal tension, but in the vitreous body numerous clots float (traumatic hæmorrhage); visual acuity equals 4/10.

Radiography shows a large loss of bony substance in the region of the frontal bone, its base in the form of a crescent with the concavity posterior.

During his stay in hospital there was elimination of several bone splinters from the fistulous opening into the sinus; slow healing.

When suppuration had ceased we proceeded to effect palpebral restoration by suture of the two divided portions. Result excellent. The sinus is filling up little by little, giving rise to a depressed cicatrix. May 25, 1916, adipose graft. The skin, very adherent to the deep parts, required most delicate dissection.

The graft, taken from the left buttock, preserved perfect vitality, and healing took place by first intention.

B. left in June 1916. The acuity of the left eye was always 4/10.

Case 58 is a type of fracture localised as it were by

the sinus itself; the sole region of the orbit concerned is that which limits the sinus at its internal and inferior aspect, and the only visual disorder ascertained was impotence of the superior oblique, due to the destruction of the pulley of this muscle. Case 59 is in much the same condition; the bullet, as shown in Fig. 58, has penetrated at the root of the nose and passed along the internal wall of the orbit without fracture, traversed the maxilla and the floor of the mouth, coming to rest in the carotid region whence it was extracted. In this case, in short, we were dealing with a fracture involving the orbit to the minimum, and traversing the face from top to bottom while causing as little mischief as possible.

Shell fragments affect the parts injured more severely; in Case 60 we have to do with a shell fragment which has caused a wound seven centimetres long in the region of the frontal sinus, which was widely laid open; the whole anterior wall of the sinus was eliminated, and a deep cupuliform cicatrix produced, which was satisfactorily filled up by an adipose graft.

(*c*) Cranial Cavities

The cases in which the cranial cavity has been opened ought evidently to be considered as cases of the gravest, *quoad vitam*, with which the ophthalmologist can have to deal. At the same time it would be an error to believe, even when the cerebral substance is largely laid bare and a portion of this substance has been sacrificed, that the prognosis is necessarily fatal. We shall cite cases subsequently, which demonstrate the relative benignity of such disorders. In the literature (brought under contribution as little as possible in this book), we find similar cases discussed. We shall content ourselves with making particular mention of those cases which have been recorded by our colleagues, the heads of the ophthalmic centres, in their monthly reports; the cases observed at the clinic of the Quinze-Vingts by Valude, Chevallereau,

Chaillons and Pompeani merit particular attention (Report of January, 1915).

In one case, a rifle bullet, penetrating the intersuperciliary region, traversed the anterior lobes of the brain, the left frontal sinus, the orbit and maxillary sinus, etc. The patient lost two tablespoonfuls of cerebral matter, but remained in excellent general condition. Another patient, wounded by a piece of shell in the median and superior portion of the frontal bone, presented a large opening communicating with the orbital cavity and quite near the frontal lobes, with pulsations synchronous with the cardiac beat; these two patients recovered. A third case, wounded in the same manner, died. We have cases to set beside these to the number of four, and, in one only, was the termination unfortunate. We report them here, as briefly as possible, but in all their essential details, on account of the gravity of the disorders concerned.

We are of opinion that we should distinguish in the cranial trouble consecutive to orbital fractures, or rather concomitant with them, two orders or classes of cases: those in which the phenomena observed are slight, temporary, without important symptoms; and those in which the aspect of the affection has been disturbing from the outset, by reason of inflammatory manifestations.

We publish these cases according to their increasing gravity, terminating by the only fatal case observed in our clinic.

Fracture of the left orbit; retrobulbar neuritis, L. E.
(Case 61.)

H. C., Infantry, wounded May 19, 1915, at N. V. by a shell. Trephined the same day, he was afterwards sent to Rennes, Saintes, and Bordeaux, where he came under our observation.

Condition.—There is an injury of the left fronto-parietal region and the orbito-ocular region. At two centimetres from the external angle of the orbit there is a depression

in which one can bury the tip of the index finger. The external wall of the orbit is therefore fractured.

The patient complains since the injury of enfeeblement of the left eye, the acuity of which equals no more than 1/10, verified by the tests in use to check malingering.

Ophthalmoscopic examination reveals no lesion. The disc and the vessels are normal. The visual field is slightly contracted, but there is no scotoma. We are probably

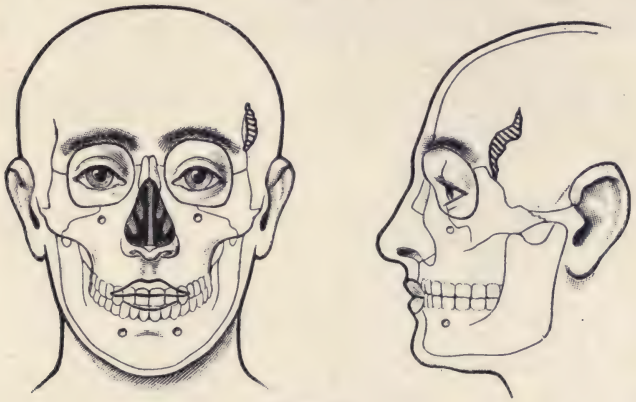

FIG. 59.

dealing with a retrobulbar neuritis, consecutive to the traumatism.

In addition there is paralysis of the external rectus muscle of the eye, causing homonymous diplopia, which the patient corrects by inclining his head towards the left shoulder.

C., besides his orbito-ocular troubles, has a fracture of the mandible.

He also presents some derangement of the nervous system. When upright, he is seized with vertigo, and is obliged to lean on a stick to support himself with his hands. Lying down, the vertigo is equally frequent, but much less violent.

Complete deafness on the left side.

Cutaneous anæthesia of the left part of the face is noted. Disappearance of the achillean and plantar reflexes. C.

complains of headaches and violent buzzing noises. His condition is the same at the time these notes are written, but the visual acuity equals 1/3.

Fracture of the left orbital vault by shell fragment ; perforation of the globe ; total detachment of the retina. (Case 62.)

J. N., Infantry, wounded Sep. 25, 1916, at S. by a shell; from Chalons Oct. 4, at Bordeaux Oct. 7.

He presents an injury of the left fronto-parietal region, at the level of the descending branch of the frontal. The

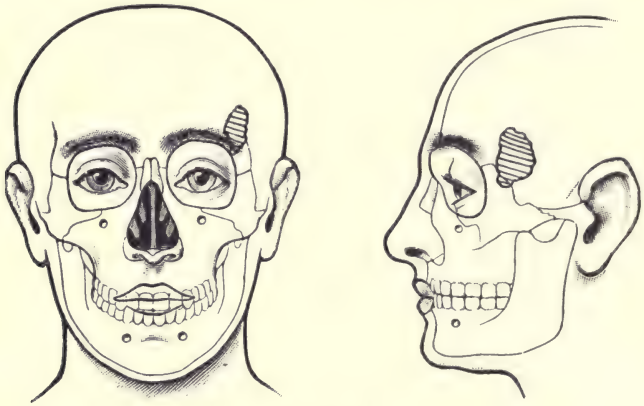

FIG. 60.

fragment has penetrated here into the cranial cavity, after having fractured the frontal portion of the orbital vault.

By the orifice of entry we note an extensive loss of bone substance of the size of a crown-piece, produced by the fracture and by the trephining done at S., Sep. 26, 1915, and a second time at Bordeaux, Oct. 21, 1915 (extraction of fragments and splinters and reduction of a cerebral hernia).

The eyeball has been perforated at its posterior part and is now reduced to the condition of a stump, not painful spontaneously or on pressure (traumatic irido-choroiditis and total detachment of the retina). The right eye is intact.

R. E. V = 10/10.
L. E. V = 0.

Radiography shows the presence in the neighbourhood of the wound of two projectiles (shell fragments) which have not been extracted.

A fortnight before the second trephining, N. was seized with complete aphasia, which disappeared after surgical interference and has not recurred since.

No disorder of the nervous system, central or peripheral.

His general condition has been most satisfactory, but on March 12, 1916, without cause, the patient had a sudden loss of consciousness, which lasted about half an hour.

Fracture of the apex of the left orbit ; bilateral papillary stasis ; " mal comitial " (epilepsy). (Case 63.)

F. B., Chasseur à pied, wounded Jan. 19, 1915, at A., by shell. The fragment has penetrated at the level of the left temporo-maxillary articulation. The patient remained eight days unconscious and delirious. B. was operated upon at Blois, July 3. His case-sheet bears the following note : " Extraction of a large piece of shell, lodged behind the left zygomatic process and the inferior maxilla. When the fragment was removed cerebral matter was seen in the wound. By radioscopy, a probe introduced into the breach passes into the cranium at the level of the temporal convolutions, passing behind the eyeball and through the fractured wing of the sphenoid. No operation."

Since his admission, July 18, 1915, B. has had two or three relapses, crises of delirium, preceded by headaches and a sensory aura (sensation of a bad smell). The crises are not accompanied by loss of consciousness, but by absolute amnesia, pallor of the face and difficulties of speech.

The patient was examined with reference to these attacks in the neurological clinic, where this diagnosis was made : " epileptiform attacks, probably of commissural origin consecutive to traumatism." No disturbance of the peripheral nervous system. The orifice of entry of the projectile is found a little in front of the left temporo-maxillary articulation. Radiography does not allow us definitely to assert the presence of a visible fracture, and there is no trace of a foreign body.

There is no trouble with the extrinsic musculature of the two eyes. On the left one notices a breach in the

iris similar to that produced by an iridectomy, but B. affirms that he has never been operated upon.

The transparent media are normal. The papillæ present *the classic type of choked disc*, and this œdema is more marked on the left than on the right.

R. E., with — 2·50 D sph., V = 1/10.
L. E., with — 1 D sph., V = 2/10.

In consideration of the meningeal irritation and the antecedents surgical interference was withheld, and B. went on convalescent leave Jan. 10, 1916.

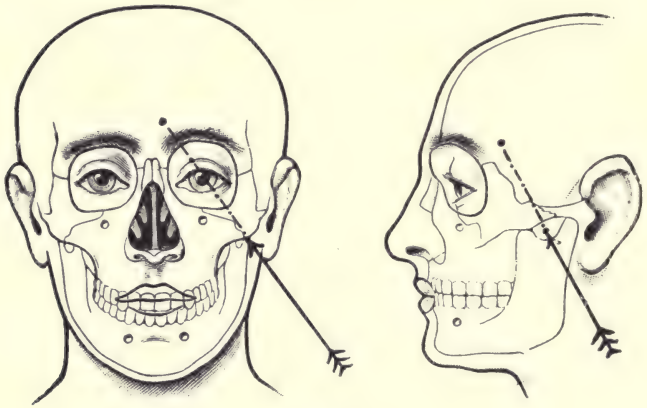

Fig. 61.

Fracture of the left orbital region in the fronto-temporal part ; fracture of the orbital vault ; loss of cerebral substance ; contusion of the globe ; hæmorrhage into the vitreous. (Case 64.)

B. V., Infantry, wounded June 27, 1916, at M. by shell, in the left fronto-temporal region. The field hospital case-sheet bears the following notes : " A large shell fragment has penetrated the left fronto-temporal region at two centimetres above the supero-external angle of the left orbit, severely fracturing the orbital vault, opening direct communication with the encephalon (Fig. 55, p. 173). Next, it has divided the left optic nerve, seriously contused the eye-

ball, and, after having traversed the nasal fossæ, has lodged on the anterior surface of the right maxillary sinus, whence it was extracted June 28, 1916. At the moment of the injury there was an abundant escape of cerebral matter.

In the following days the temperature rose; enormous exophthalmos appeared, due probably to inflammatory reaction of the intra-orbital tissues. The globe was enucleated July 2, 1916, and the vitreous was found to be full of blood-clot. Then was remarked a very extensive loss of bone substance from the vault and the supero-external wall of the orbit, making a communication between it and the cranial cavity on the one side, and the exterior on the other.

Rapid improvement in the condition of the patient, whom we saw Oct. 14. At this date there was complete cicatrisation of the left fronto-temporal fracture, where there was the sensation of cerebral pulsation.

An artificial eye was fitted.

There is no derangement of the central or peripheral nervous system.

R. E. normal; with + 1 D cyl., axis 165°, V = 10/10.

Fracture of the right orbit by grenade; rupture of the left eyeball; cerebral abscess, recovery. (Case 65.)

J. B., Infantry, wounded Jan. 11, 1916. Admitted Feb. 25, in a state of marked prostration; torpor, low temperature; slight Kernig's sign, no stiffness of the neck, pulse very slow (46). Two pieces of grenade had penetrated the lower portion of the right orbit, traversed the eyeball, which is reduced to its scleral envelope, perforated the orbital vault, and come to rest in the cerebral substance in the right superior parietal region.

Radiography enables us to locate the two projectiles, and at the same time to ascertain the loss of bone substance of the orbit. The general symptoms, added to these clinical reports, suggest a sub-dural cerebral abscess in course of development.

Feb. 20, 1916, enucleation of the stump was performed; then, by an incision at the level of the right eyebrow, the orbital periosteum was detached by means of a gouge. The whole roof of the orbit was thus laid bare, and we

noted the presence of two bone apertures in the upper part, one of which was the size of a half-franc piece.

Fig. 62.

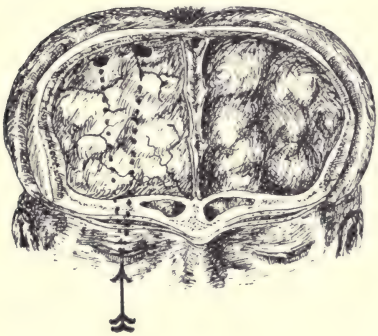

Fig. 63.

A splinter, 1 cm. long by 4 mm. wide, was extracted, and the orifice cleaned by means of a blunt curette. A large quantity of purulent liquid welled up from the sub-dural region. The parts were washed with hydrogen peroxide lotion; by removal of the external orbital process, dependent drainage was arranged. Sutures.

Post-operative conditions uneventful. The temperature, after having risen to 38·6° C. (101·5° Fahr.), quickly returned to the normal, and the pulse to 72.

May 7, 1916, B. had completely recovered, and his general condition was most satisfactory. The headaches had disappeared, and the patient attended to the occupations of daily life without complaining of his injury.

May 23, a palpebral fibrous band was incised; the wearing of an artificial eye then became practicable.

Smash of the orbital vault; rupture of eyeball; intra-orbital meningo-encephalocele. (Case 66.)

C. R., Infantry, wounded in A., Feb. 1, 1915, by rifle bullet. Immediate loss of consciousness. Treated in field ambulance. He there underwent an operation, upon the nature of which we have been unable to obtain information.

Admitted April 29, 1915.

Condition.—The projectile had penetrated in the right frontal region, at about 3 cm. from the supero-external angle of the right orbit. After having traversed the orbital cavity from side to side it emerged at the root of the nose.

Palpation of the injured region does not enable any bony depression to be detected, except at the point of penetration of the bullet. No cerebral pulsation.

The eyelids are intimately adherent to each other over their whole extent (total symblepharon). On palpation through this palpebral veil there is the sensation of a resistant mass, not fluctuating; and—we insist on this detail—no pulsation synchronous with the cardiac contractions was perceived; we thought it was probably the right eyeball, hidden behind the eyelids.

Radiography, moreover, gave negative results, and revealed no bony damage.

May 10, 1915, intending to proceed with enucleation of the right eyeball, the eyelids were carefully incised at the line of mutual adhesion. Immediately a greenish liquid, holding in suspension some purulent clots, flowed out in abundance.

After having enlarged the incision it was seen that we were dealing with an intra-orbital meningeal cyst, producing under tension a hernia behind the palpebral curtain.

The cerebro-spinal liquid having escaped, we could see, at the bottom of the orbital cavity, the cerebral substance to which a large opening in the orbital vault gave free passage. No trace of the eyeball. Immediate suture of the operation wound, after drainage.

The same evening the pulse slowed down, the patient became delirious, and the temperature rose to 39·8° C. (103·6° Fahr.). Symptoms of meningo-encephalitis appeared, and R. died May 12, 1915, from suppurative meningitis; the cerebro-spinal fluid withdrawn after puncture contained pus in great quantity.

The first patient, as a result of serious injury to the temple which necessitated trephining, presented only certain troubles in the nervous system, vertigo, deafness of the left side, cutaneous anæsthesia of the left side

of the face, disappearance of the plantar and tendo Achillis reflexes, and diminution of visual acuity of the left eye. The subject of Case 62 presented a large loss of substance in the left parietal region, with, as the only cerebral disorder, an aphasia which disappeared completely after trephining. The patient in Case 63 was wounded by a large piece of shell which lodged behind the left zygomatic process and the mandible; at the time of extraction of the projectile cerebral matter appeared; a probe introduced into the opening passed through the fractured wing of the sphenoid into the temporal convolutions, far from the eyeball. From the time of his admission under our care the patient had crises of delirium, preceded by pains in the head and a sensory aura (sensation of an unpleasant smell); the crises were not accompanied by loss of consciousness, but by amnesia, pallor of the face, and difficulties of speech. He had also serious disturbances of vision; there was acute optic neuritis on each side, and we have grave fears for this patient's future, at least so far as his eyes are concerned.

Case 65 is still more interesting; the patient was struck by portions of grenade, which, after having destroyed the eye and smashed up the roof of the orbit, came to rest in the brain (Figs. 62 and 63). They produced phenomena of meningo-encephalitis, with an abscess under the frontal lobe. We performed an operation consisting in the detachment of the whole of the periosteum of the orbital vault; a large fragment was removed, and, as in an atypical trephining, the edges of the opening resulting from the loss of substance were rounded off in such a way as greatly to enlarge it; a large quantity of pus flowed away. The cerebral phenomena related in the notes slowly disappeared, and the patient recovered, apparently retaining without damage, at least for the present, the two intra-cerebral foreign bodies which are seen in Figs. 62 and 63, and which the radiogram reveals clearly.

We also draw attention to another case of fracture

of the left orbital vault with loss of cerebral substance, in which recovery was readily obtained without inflammatory mishaps and without cerebral disorders of any kind.

It was not so, unhappily, with the last case, which terminated by death. An unsuspected fracture of the orbital vault was present in a patient coming under our care from a distant centre; he had a fracture of the superior orbital margin; radiography showed neither lesion of the roof of the orbit nor foreign body, and we felt in the orbit a soft swelling, so deep that it appeared to us to be a shrunken eye. In attempting to remove it we opened a cyst, filled with a suspicious serous fluid, communicating with the cranial cavity, and the patient rapidly succumbed to meningo-encephalitis. It is the only unfortunate case of this kind we have met with.

CHAPTER VI

TREATMENT OF FRACTURES OF THE ORBIT AND THEIR COMPLICATIONS

The immediate treatment which the military surgeon at the front should apply to fractures of the orbit will not detain us long; the first reason is that we have been working far removed at the base, for the past thirty months, and we have only seen fractures of which the most recent were several weeks old; the second reason is that in reality it is the complications of these fractures which present special indications.

The fractures themselves require, as a rule, only the ordinary attentions of antisepsis and asepsis, flushing with hydrogen peroxide, the application of tincture of iodine followed by an appropriate dressing, without prejudice to the immediate injection of anti-tetanic serum.

The most important question which arises is to know when it is permissible, in order to ascertain the extent of the mischief, to probe the track of the projectile; the best principle is to abstain until such time as carefully executed radiography has permitted the offending foreign body to be localised, and thus enabled the surgeon to appreciate exactly the dangers inherent to searching for it and the advantages which may follow its extraction.

It will be well to point out here the immediate steps to be taken in the different fractures of the orbit, according to the region injured.

Plate I

Ophthalmoscopic appearances, direct method.

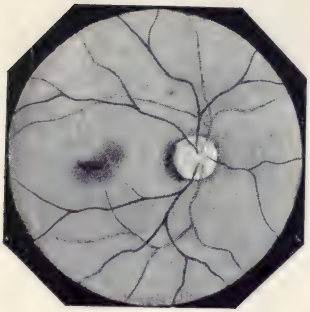

Fig. 1.—R. E. Fracture of left frontal region, severe concussion, hæmorrhage into the sheaths of the right optic nerve, right macular hæmorrhage.

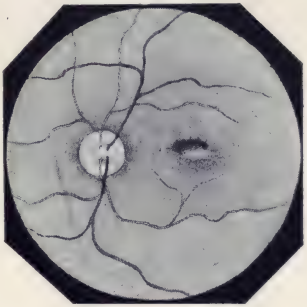

Fig. 2.—L. E. Fracture of left orbital arch and outer margin, concussion of tissues of orbit, macular hæmorrhage, optic atrophy.

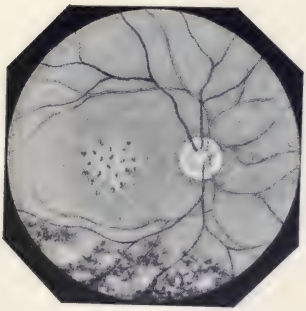

Fig. 3.—R. E. Fracture of floor of orbit and of right inferior orbital margin; macular choroido-retinitis (concussion lesion); atrophic and pigmented choroido-retinitis (contact lesions).

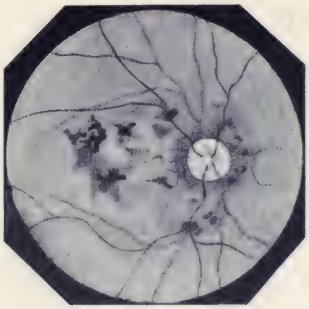

Fig. 4.—R. E. Fracture of the external orbital margin; macular and peri-papillary choroido-retinitis (concussion lesions).

Plate II

Ophthalmoscopic appearances, direct method.

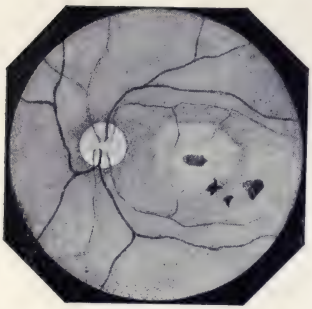

Fig. 1.—L. E. Fracture of ascending process of malar bone and of infero-external orbital margin; macular hæmorrhage and choroido-retinitis (concussion lesions).

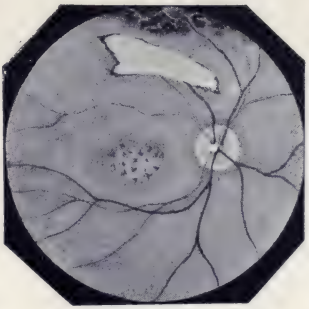

Fig. 2.—R. E. Fracture of frontal sinus with depression. Macular choroiditis (concussion lesions); choroido-retinitis above and to the inner side (contact lesions).

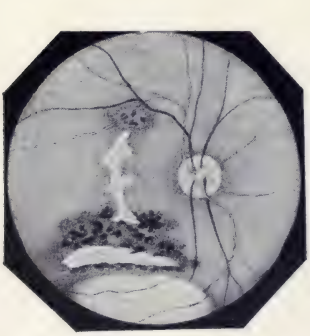

Fig. 3.—R. E. Fracture of the malar bone and of the inferior orbital margin; macular choroido-retinitis, rupture (concussion lesion); choroido-retinitis and detachment of the retina (contact lesions).

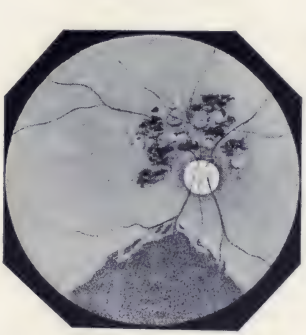

Fig. 4.—R. E. Fracture of the floor of the orbit; peri-papillary choroiditis (concussion lesion); hæmorrhage and pigmented choroido-retinitis below (contact lesions).

Plate III

Ophthalmoscopic appearances, direct method.

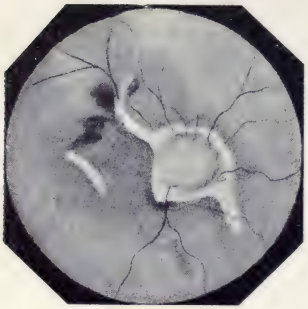

Fig. 1.—R. E. Fracture of the external orbital process and wall of the orbit; avulsion of optic nerve, deep excavation.

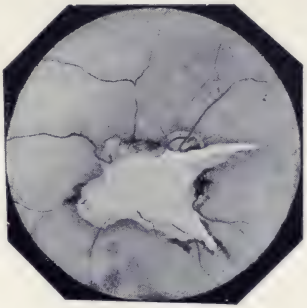

Fig. 2.—L. E. Fracture of external orbital wall, bullet having traversed the orbit; partial avulsion of optic nerve; below, traumatic proliferating choroido-retinitis.

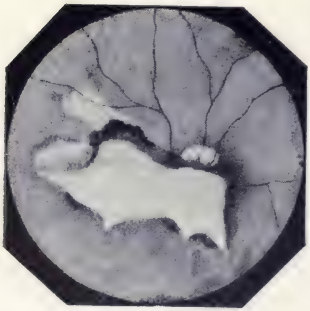

Fig. 3.—R. E. Fracture of facial bones; traumatic proliferating choroido-retinitis.

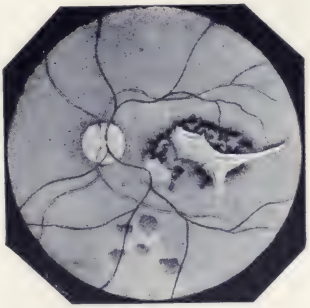

Fig. 4.—L. E. Fracture of the external orbital wall and inferior margin; laceration of the retina and choroid in the macular region (concussion lesion); proliferating choroido-retinitis; atrophic and pigmented choroido-retinitis below (contact lesion).

Plate IV

Ophthalmoscopic appearances, direct method.

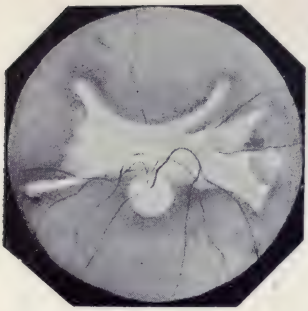

Fig. 1.—L. E. Fracture of the superior orbital margin; intra-orbital foreign body, section of optic nerve; proliferating choroido-retinitis of the superior papillo-macular region.

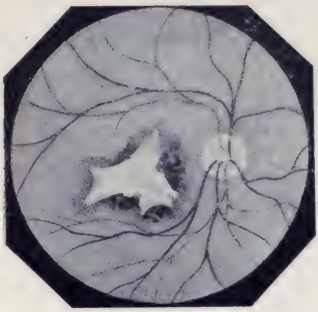

Fig. 2.—R. E. The projectile has traversed the facial bony mass without touching the right eye: laceration of the right macular retina and choroid; proliferating choroido-retinitis (concussion lesion).

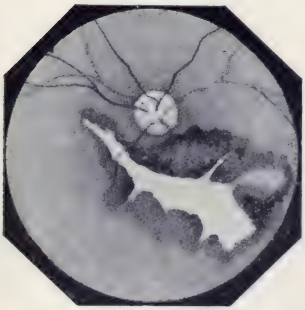

Fig. 3.—L. E. Fracture of the inferior wall of the orbit, with propulsion of the bony fragment towards the eye; large laceration of the retina and choroid (contact lesion).

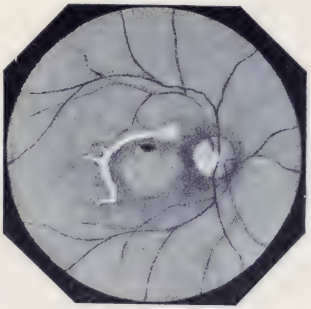

Fig. 4.—R. E. Fracture of the external orbital wall; rupture of the choroid in the macular region (concussion lesion); proliferating choroido-retinitis.

PLATE V

Ophthalmoscopic appearances, indirect method.

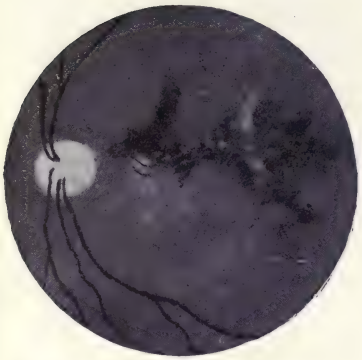

FIG. 1.—Case 31. The laceration crossing the choroid can be detected in the midst of the abundant pigmentation which covers the macular region (concussion lesion).

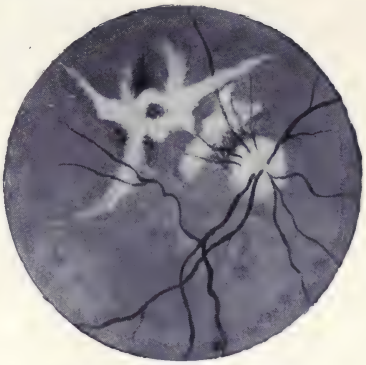

FIG. 2.—Case 32. Note the retinal vessels passing above the choroidal lacerations. One is interrupted in its course and is covered by a tract of proliferating retinitis (concussion lesion).

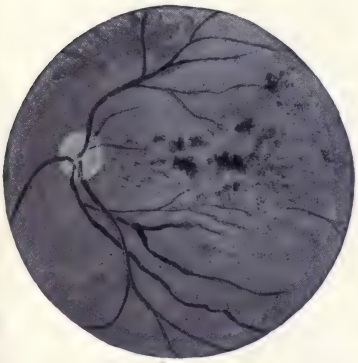

FIG. 3.—Case 33. The pigment here probably conceals fine choroidal lacerations (concussion lesion).

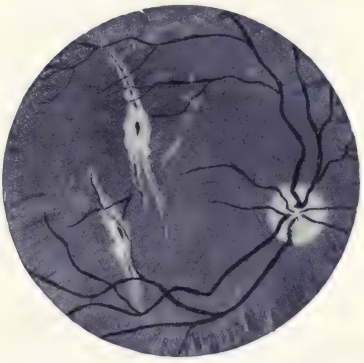

FIG. 4.—Case 34. The retina is intact at the site of the choroidal lacerations, as demonstrated by the vessels (concussion lesions).

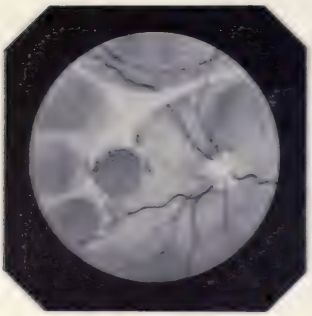

FIG. 1.—Case 16. The retina itself has been torn, like the choroid. Examination of the vessels furnishes the proof.

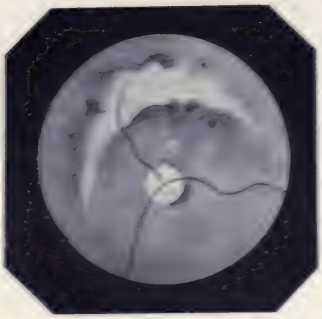

FIG. 2.—The disc is atrophied; a vast laceration of the choroid has destroyed the macular region: the bullet has divided the optic nerve, traversing the orbit without touching the eye (concussion lesion).

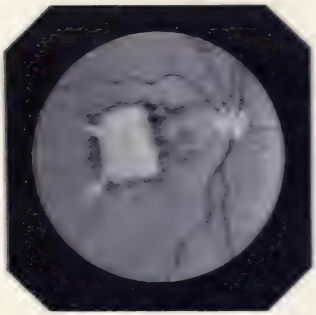

FIG. 3.—Case 37. The macular region is the seat of a vast choroidal laceration surrounded by pigment (concussion lesion).

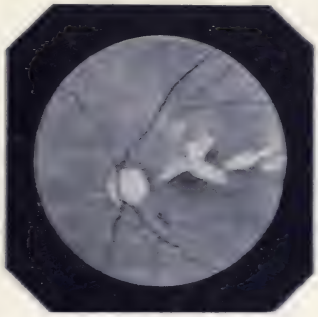

FIG. 4.—Case 38. The posterior myopic staphyloma is doubtless an old lesion; but the choroidal laceration in the macular region is due to traumatism (concussion lesion).

We shall not speak of the treatment indicated in indirect fractures, because these fractures do not exist in military surgery. We do not contest their existence in civil surgery; falls on the cranium may produce radiations over the orbital vault, but gunshot fractures of the skull do not lead to such radiations, and in this chapter on therapeutics we need not concern ourselves with them.

The immediate care to be devoted to direct fractures will alone occupy us; we shall consider successively fractures (*a*) of the superior margin and wall, (*b*) of the internal margin and wall, (*c*) of the inferior margin and wall, and (*d*) of the external margin and wall.

(*a*) Superior Orbital Margin and Wall

If a simple, not compound, fracture be in question, a light compress suffices. If there is an open wound any detached fragment should be restored to its place, after ensuring good asepsis. Delorme judiciously advises that all splinters of bone which are in the least adherent should be left, and only free portions removed. Further, great care must be taken in the removal of splinters and the cleansing of the wound when the eye is still present; we shall return to this later.

It should be remembered that fractures of the superior orbital margin and walls are less serious than those of the superior wall alone. De Wecker is of opinion that when the vulnerant force has broken both the margin and the wall the shock is deadened and reacts less seriously on the brain. It is also possible that fracture of the margin renders the natural drainage more efficacious and facilitates the escape of the septic discharges which are easily retained in a narrow, concealed fracture of the orbital wall. It is certain that one sees such fractures, at first apparently not serious, terminate rapidly in death. Dupuytren has already noticed under these circumstances the apparent benignity of the external wound, and amongst

the four cases of this kind reported by MACKENZIE there is one in a subject who, wounded by a sword in the left orbit, walked two leagues, ate with good appetite, feeling no pain, and then died the next day; his wound had penetrated to the brain. ROLLET recalls similar cases from DIEMERBROECK, GAYET and ARLOING.

BERLIN has laid great stress on the frequency of these rapid deaths after fracture of the roof of the orbit, quoting cases of immediate death due to the rupture of large vessels; but he brings especially into relief the part played by meningo-encephalitis, which appears from the third to the sixth day, and should therefore be borne in mind by the surgeons at the front who are charged with the early treatment.

In the presence of such injuries the surgeon should examine very attentively both the local conditions and the general state of the patient, and regard these small orbito-palpebral wounds very seriously from the outset. As soon as possible he should endeavour to have the subject radiographed, before any surgical treatment has been adopted; but if this preliminary measure is impossible it need only to be regretted so far as concerns the possible presence of a foreign body. Radiography, unhappily, will give no information as to fractures of the orbital vault; fractures in themselves extensive, with splinters of small dimension, pass unperceived; we have often been astonished at the impotence of X-rays in this respect. It is, however, a clinical fact which must be accepted and made the best of.

Hence the subject's general condition and the cerebral symptoms should be the basis of treatment. If the inflamed wound appears soiled, if there is fever, prostration, pains in the head and so on, there must be no hesitation in exploring the wound, cleansing the track and opening it up, so as to enable the discharges to flow away freely.

(*b*) Fractures of the Internal Margin and Wall

All the general considerations already mentioned apply to these fractures; so far as they are specially concerned, if the bones are smashed in, some attempt should be made to replace the fragments in good position. Hippocrates has already advised that the reduction be made by means of a finger introduced into the nostril; military surgeons have used an elastic cannula (Boyer) or a metallic tube (Charles Bell). Rollet, after Molière and Chandelux, advises replacing the fragments with the fingers and rounded instruments, employing anæsthesia if necessary, and maintaining the fracture in position by a gutta-percha appliance. Later, attention must be paid to the state of the lacrymal passages, which are usually obliterated, and attempts must be made to re-establish their permeability.

(*c*) Fractures of the Inferior Margin and Wall

When the malar bone is comminuted and driven in it will sometimes be possible to elevate the fragments, replace them, and so reconstitute the prominence of the cheek. The patient thus avoids the necessity for a later reparative operation. This elevation of the malar bone may even be effected a long time after the accident; Gayet and Cl. Martin (of Lyons) have succeeded in raising the malar bone and fixing it in its normal situation with platinum pins.

When the case first receives attention, the military surgeon should always bear in mind that the bones of the orbit are endowed with great vitality; not only should fragments of bone which possess any shred of adhesion not be removed, but it is advisable to replace completely detached bone in good position and graft the splinters in their normal situation, covering them with the soft parts.

(*d*) Fractures of the External Margin and Wall

The same rules will again inspire action here; the external orbital arch, if it is fractured and thrust in one or more pieces into the temporal fossa, must be put back in its place and preserved as much as possible. When the external wall is involved, the fracture is deeply placed at the bottom of a thick layer of muscular tissue; there must be no timidity in incising soft parts, both in order to seek splinters and foreign bodies in the wound, and also to facilitate the escape of discharge.

Nearly allied to these isolated fractures of the various borders and walls of the bony framework of the orbit are the comminuted fractures involving several of the walls, and here Larrey's well-known case may be recalled, in which the subject was struck on the face by a cannon-ball which carried away the whole of the lower jaw, the bones of the nose, the ethmoid, the two malar bones, and the zygomatic arches. In gunshot suicides, when the weapon is placed under the chin, the authorities in forensic medicine have frequently recorded similar disasters; the rules given on the subject of the treatment suitable in such a case follow from the principles and the special rules already referred to. The clinical instincts of the surgeon will here have full play.

To indicate with more detail the treatment to be followed we will now study what steps should be taken at the outset in fractures of the orbit according as: (1) the eye is preserved; (2) the eye is destroyed; (3) the neighbouring cavities are implicated; (4) a foreign body is or is not retained.

(1) The Eye is Preserved

If the eye is preserved it is necessary, above all, to do nothing which will compromise the mobility or the vitality of the globe.

Thus, as has been said above (pp. 96 *et seqq.*), the eye

is very often proptosed as the result of an intra-orbital hæmorrhage, which thrusts it forcibly forwards and will not allow the eyelids to cover it. It will be necessary by means of an appropriate dressing simply to close down the eyelids in front of the eye. If this cannot be done it will be well to reduce the exophthalmos by cautious aseptic incisions, made in the lower part of the orbit, in such a manner as not to injure the muscles, and keeping as far as possible away from the levator, which is less able to endure the traumatism of the scalpel than the extrinsic muscles of the globe. Unless the ophthalmic ganglion, that "little brain of the eye," be destroyed, we shall always be able to avoid inflammatory phenomena of the cornea, and, in the absence of lagophthalmos, the organ of vision is easily preserved.

If the blood clot should suppurate, it will be necessary to lay open more freely and drain in such a way that the pus may easily escape; the result may still prove very satisfactory.

(2) The Eye is Destroyed

If the eye is destroyed, the surgeon is relieved of anxiety; when the scleral wound has been large enough to permit a free escape of vitreous body, he will enucleate the globe without hesitation. Such an eye is destined to become nothing more than a dangerous withered stump, often painful, ready to stir up mischief; reserving further remarks on the subject later, we may say here that such a globe is nothing but an enemy to the other eye, and consequently to the patient. We think it is not wise to be contented with evisceration. Doubtless it is quite true that a carefully performed evisceration, in which absolutely no trace of the uveal tract is left behind, presents no dangers; but often, in the unavoidable haste imposed upon an operator at the front by the multiplicity of his duties, this evisceration will be hurried, and harmful débris of the choroid or ciliary body will

be left in the scleral sac. Further, evisceration is accompanied by more or less purulent secretion of considerable duration. A classic enucleation, within TENON'S capsule, quite according to rule, cutting the optic nerve level with the eye, is the operation to be chosen. We recommend it urgently to all our surgical colleagues into whose hands fractures of the orbit fall in the first instance, when the eye has been crushed, torn, or simply laid widely open by the projectile.

The eye once removed, nothing more is to be feared in the orbit, if after the operation antiseptic lavage is used, cleansing the orbital cavity according as the degree of infection requires.

The ophthalmic surgeon may here turn to good account the discussions which have taken place concerning CARREL'S method; it is not our place, nor our pretention, to guide those who are worthy to wield the scalpel. We say simply that, in such circumstances, free opening-up, to allow liquids to escape, free ablutions with hydrogen peroxide, and daily lavage with 7 per 1000 saline solution, are the means which we consider at the same time necessary and sufficient for success.

(3) FRACTURES IMPLICATING THE NEIGHBOURING CAVITIES

A problem of diagnosis arises here which is not easy to solve. Radiography does not give complete satisfaction on this subject; a fracture of the orbital vault is passed over easily, we may even say always escapes unnoticed; we are in this respect much less fortunate than the surgeons who deal with fractures of the limbs, for whom radiograms reveal the smallest crack; and it will be necessary, when dealing with a serious fracture of the orbit with or without loss of the eyeball, to inquire into all the ordinary clinical signs of extension to the brain.

When the projectile has to a great extent destroyed the roof of the orbit and penetrated into the cerebral

cavity one must not expect to see in every case the evidences of mischief burst forth immediately; they only come about consecutive to orbital infection, which is propagated secondarily, by way of the breach itself, to the encephalic mass. This is what took place in a very interesting case published by MORAX in his report of Oct. 1915. A soldier, wounded Sep. 27, 1915, went to the Lariboisière hospital, Oct. 10, with the diagnosis of bullet wounds which had caused fracture of the walls of the orbit, the nasal bones, and the anterior margin of the frontal, with rupture of the eyeball. The wound, which was very large, had been plugged with sterile gauze, and there was neither suppuration nor fever. On Oct. 12 no change had taken place in the condition of the wound; on the evening of the 12th, rise of temperature, vomiting, pains in the head; Oct. 14, pains in the head, great stiffness of the neck and Kernig's sign; lumbar puncture yields a turbid liquid; the 17th, death with signs of acute meningitis. The autopsy showed a fracture implicating the anterior floor and suppurative inflammation between the dura mater and the right frontal lobe.

With this case of MORAX'S we might compare VALUDE'S, wound by rifle bullet at the supero-external portion of the right frontal bone, with escape of cerebral matter by the frontal wound; there had been an abscess of the eyelid and keratitis with hypopyon. All seemed to be going well until encephalic infection set in, and the patient died. (Report of Jan. 1915.)

With these should be compared the report, quoted above, of a case in which the patient was enabled to recover, thanks to an operation done, late enough it is true, since the subject already presented serious cerebral symptoms, but as quickly as possible; we performed in this case an atypical trephining of the cranium by the orbital route. (Case 65.)

VALUDE was also fortunate in a case in which radiography showed a sub-cranial bullet beyond the

orbit. Enucleation had been performed, but the projectile, well tolerated, had not been extracted; it soon gave rise to serious symptoms of infection, œdema of the eyelids, and chemosis; VALUDE interfered, and removed the offending projectile from a depth of six centimetres, in lardaceous tissue; the patient recovered. (Report of April, 1915.)

The conclusion of these remarks is that, if infectious orbital and para-orbital phenomena appear after a fracture, the offending body must be at once looked for; we recommend that the periosteum of the orbital vault be detached with care, because of the thinness of the wall. Also, should a fracture exist which the radiogram does not show, the septic fluids may escape by way of the orbit, if it is well laid open and thoroughly cleansed. If in the course of the operation a fracture of the vault is met with, the roof must be trephined and a free communication thus established between the anterior encephalic region and the orbital cavity. In short, it is necessary to act in the presence of cranial fractures implicating the orbit as the surgeon is accustomed to act in fractures of the cranium in general. At the first sign of extension to the encephalon, or if it is suspected, one must act at once.

Moreover, we should add that the diagnosis of encephalic disorders coinciding with fractures of the orbit is far from being always easy, and that from this point of view we may meet with surprises, the more so since the best radiograms, as has already been said, give very little information in this kind of bony disturbance. We shall never forget the cruel misfortune which happened to us in Case 66, in which no encephalic symptom of any kind appeared, in which radiography showed nothing definite, and which presented, with a symblepharon of the upper eyelid, a fairly hard intra-orbital tumour, slightly resistant, which we believed to be the remains of the eye, destroyed by the injury. We set about removing this débris; at the first stroke of the scissors, sero-purulent liquid poured out, and at the bottom of the pouch

we found the pulsatile encephalic mass; in spite of careful antisepsis, a meningo-encephalitis developed which rapidly carried off the patient. There was nothing to warn us in the history of the patient, wounded a long time previously, nothing in the examination of his radiogram, or in any of his symptoms, to suggest that there might be free communication between the orbit and the cranium.

After these cases of orbital fracture, remarkable for the importance of their intra-cranial complications, it will be well to cite less serious cases, in which, in spite of evidence of cerebral disorders, infectious accidents being absent, it has not been necessary for the surgeon to interfere. We have noted cases in which the orbital fracture was accompanied only by optic neuritis, vertigo and anæsthesia of the face with intermittent headache.

In one case, after injury by a large piece of shell, lodged behind the left zygomatic process and the process of the mandible, there was escape of cerebral matter from the wound, and there occurred neuritis (choked disc) and epileptiform attacks which did not appear to warrant fresh interference (see Case 63).

After the fractures of the orbit implicating the cranial cavity, let us consider for a moment those which concern the maxillary and frontal sinuses. These are infinitely less serious; two classes of cases must be distinguished: (1) those in which the lesion of the sinus is accompanied by the presence of a projectile; (2) those in which there exists simply a sinusitis without retained projectile.

When a projectile is present it should be extracted without delay. Nothing is simpler; we will not quote all the cases in which we have been able to interfere under such conditions: it will be sufficient to recall here the cases quoted above (pp. 173 *et seqq.*), and to note amongst the foreign bodies we have found in the sinus the eye itself, luxated by the traumatism and thrust through the fracture in the floor of the orbit into the antrum.

The frontal sinus is less frequently injured than the antrum, and we have never found a foreign body in this cavity, but it is sometimes implicated by a projectile which ruptures its anterior wall, in such a manner that an unsightly depression results. In several cases of this kind, we have been able to fill up the cavity by the aid of an adipose graft, which has given a satisfactory result (see pp. 181 *et seqq.*).

In another case, quite analogous to these, and remarkable for destruction of the pulley of the superior oblique, the patient refused to have an adipose graft, which appeared to us under such circumstances highly desirable. We shall return later to this type of intervention, publishing some successful cases from our practice.

(4) Presence of a Foreign Body

When there is a foreign body in the orbit or in the neighbouring cavities it is not always necessary to extract it; it is certain that very often these foreign bodies, quite aseptic and fortunately situated, may be well tolerated. When they are situated in the cranial cavity they merit particular respect if they are giving no trouble; it is precisely the type of case in which the practitioner should rely upon his clinical sagacity. When the foreign body is in the orbit or in the maxillary antrum the surgeon's perplexity becomes much less; *a priori* it should be removed, however small it may be.

To remove a foreign body, well localised by radiography, from the maxillary sinus it is well to use the aperture made by the projectile if it is well in evidence; if not, open out the anterior wall of the sinus without hesitation, taking care of the infra-orbital nerve; the foreign body may be easily picked out of the sinus, which at the same time should be thoroughly cleansed and drained by the side of the nose.

When the foreign body is in the orbit two conditions must be distinguished, according as the eye is preserved

or destroyed. When it is destroyed nothing is simpler than to take hold of the foreign body by means of ordinary instruments, sparing as much as possible everything which is of importance for a good prothesis, especially the levator muscle of the eyelid. When the eye is intact, at least in appearance, it is indispensable to remove the foreign body without disturbing the eye. If the foreign body is in the anterior region of the orbit an incision of the soft parts will often suffice to

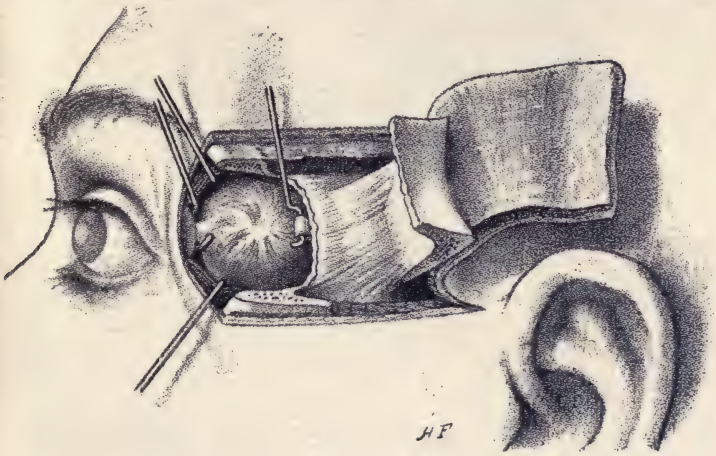

FIG. 64.

give the surgeon access to it. For the search, help is obtained of the electro-magnet and all the means of extraction in use in ordinary surgery; but when the foreign body is retrobulbar and deeply buried, there must be no hesitation in having recourse to Krönlein's operation, which we have no need to describe here, and which Fig. 64 will adequately recall to our readers.

When the foreign body is situated on the ethmoid side, in the internal region of the orbit, we recommend the operative procedure we have elsewhere advised for the ablation of certain orbital tumours placed to the inner side of the optic nerve. It is an advantage in this

case to mobilise Krönlein's flap, in order to be able to throw the eye outwards towards the external wall of the enlarged orbit (Fig. 65); by this device one has room to operate and *the ophthalmic ganglion is not touched*,

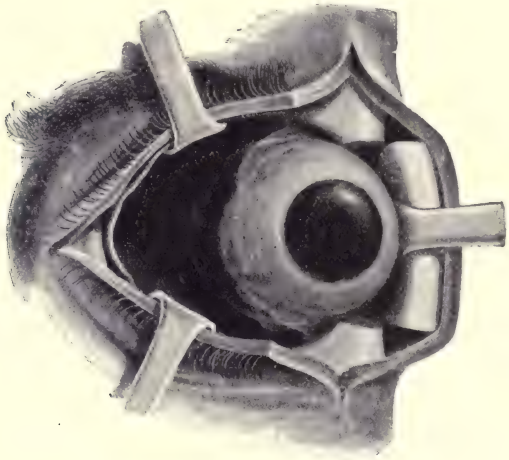

Fig. 65.

a most important organ to be considered when it is desired to preserve the eyeball intact.

The reader will have already found in this work reports of cases in which Krönlein's operation has been performed with extremely favourable results (see pp. 68 *et seqq.*).

CHAPTER VII

TREATMENT OF OCULAR COMPLICATIONS

The principal ocular complications which merit our attention are —

(1) Sympathetic ophthalmia.
(2) Traumatic cataract.
(3) Detachment of the retina.

(1) Sympathetic Ophthalmia

Projectiles of war fracturing the orbit often involve the eyeball, either by penetrating into its interior or by rupturing its envelope and so destroying it. To our great surprise, as we have said elsewhere (p. 115) we have not met with a single case of partial rupture of the sclerotic, permitting the eye to survive and to keep its appearance after such an injury.

When the eye is implicated to this degree by the projectile its shape is destroyed, the greater part of the vitreous body is expelled, and the surgeon is immediately faced with a stump more or less large, more or less inflamed, more or less torn, and whose future is the cause of great anxiety.

Two questions here present themselves :—

(1) What should be done with an eye which has a foreign body in its interior ?

(2) What should be done with an eye whose membranes are ruptured, and which, without a retained foreign body, has at the same time absolutely lost its outward appearance, and also its visual power irremediably ?

These two questions are serious because they involve

that subject, so distressing and still so much discussed by surgeons, sympathetic ophthalmia.

Sympathetic ophthalmia has not been dreaded to the same degree by all ophthalmic surgeons; there are those who do not believe in it, who declare they have never seen it (POULARD). There are others, and we are of the number, who, without considering it frequent, think it is not so rare that we may put it out of our thoughts altogether.

On the subject of its frequency in military surgery, we shall take as a basis abstracts from the reports of the ophthalmic centres which have been published during the past two years by our colleagues in the army. We find there the following evidence.

KALT (Report of Oct., 1915), is astonished at not having met with a single case, in spite of the number of atrophied globes which he has seen as a sequel of penetrating wounds, and it seems, he says, that there is here a discordance with what we observe in civil practice; but it does not happen that all our colleagues have made such a remark. COSSE (Dec., 1914) cites two cases, one of which terminated in blindness, and he notes a third grave case in April, 1915. COUTELA (Report of June, 1915) relates a case occurring seventeen days after enucleation, and two more in his Report of the following month; these cases, relatively benign (the attenuated ophthalmia of DE LAPERSONNE) recovered, but they presented real gravity. We must therefore resort to enucleation neither too much nor too little, says COUTELA. TERRIEN holds a similar opinion; he has performed, in order to prevent sympathetic ophthalmia, a relatively large number of enucleations and optico-ciliary neurotomies.

Among the cases of sympathetic ophthalmia published by the directors of the centres of military ophthalmology we should especially mention a case-report published by TEULIÈRES (Report of Feb., 1916) concerning a simple contusion of the eye without foreign body and without wound; enucleation of the atrophied stump on the right side controlled the affection whose sympathetic

origin was thus well established. Such cases are so rare that it is perhaps permissible to believe that there existed a small conjunctival wound, which passed undetected before the patient was submitted to the examination of our colleague.

To these cases we shall add the very interesting one reported by MORAX in June, 1916; it was a question of an operation for traumatic cataract; a prolapse of the iris had occurred which had been cauterised. Sympathetic ophthalmia resulted, not, to define it exactly, from the extraction of the lens, but from faulty cicatrisation after the latter operation.

Such is a rapid enumeration of the principal cases published during this war in the reports of our colleagues; doubtless others, in considerable numbers, have not been mentioned; we have a proof of the frequency of accidents of sympathetic origin in the work just published by DR. COUSIN, aide-major attaché au centre de la 9e Région; this author gives sixteen cases in which he has found sympathetic reactions following injuries of war; these sympathetic reactions are not ophthalmia, since after all there is no inflammation, no serous iritis as in attenuated sympathetic ophthalmia; but we say without hesitation that photophobia, lacrymation, fatigue in reading, and diminution of visual acuity, are the first degree of the affection, of which serous iritis is the second degree and of which irido-cyclitis is the third. All this pertains to sympathetic ophthalmia, and it is a misfortune if a patient, thus attacked, is under the care of an operator capable of hesitating and putting off the enucleation.

In our centre of military ophthalmology we have also met with cases of sympathetic ophthalmia amongst the cases sent to us; we shall not report them in detail in order not to overweight this chapter, which must be short.

Out of 2554 injuries involving the eyeball we have seen five cases of sympathetic ophthalmia. In the first four cases it was a matter of a perforating wound of one of the globes in the ciliary region, with presence

of an intra-ocular foreign body. Sympathetic iridocyclitis made its appearance on one occasion fourteen days after the traumatism; in the next case, forty; in the third case, nineteen; in the fourth case, thirty-two days after the injury.

In these four cases, prompt enucleation at the outset brought about complete recovery in three; the fourth had a relapse which yielded to treatment.

The fifth case was that of a soldier, wounded on Oct. 11, 1915, upon whom Dr. Lataillade performed evisceration of the right eye for panophthalmitis following a perforating wound, and which, on Nov. 7, 1915, presented optic neuritis of the left side, probably of sympathetic nature.

Enucleation of the right stump and its dissection revealed a small fragment lodged in the scleral envelope in contact with the optic nerve. Improvement of the neuritis followed very rapidly. The case has been, moreover, reported above.

What, therefore, is the course to take—

(1) In the case where the injured eyeball contains a foreign body?

(2) In the case where there is an eye, without a foreign body, but profoundly damaged, completely deprived of sight, after an open wound?

We expounded our views on the subject of the first case at the meeting of the Société française d'Ophtalmologie, April, 1916.

If the eye containing a foreign body has still useful vision it should be spared.

When it no longer has vision two classes of conditions must be considered:—

(1) The foreign body is in the ciliary region.

(2) The foreign body is in the eye, but outside the ciliary region.

If the foreign body is in the ciliary region of an eye deprived of vision, however good may be the appearance of the eye, even when the patient complains of no pain and no symptom of irritation it is necessary to enucleate the eye.

If the foreign body is not in the ciliary region and the eye is quite intact, neither irritable, nor painful, nor reduced in tension, the eye should be spared, at the same time warning the patient that, in the future, things may not always go so well.

If, on the contrary, the eye containing the foreign body elsewhere than in the ciliary region is reduced in tension, a little tender on pressure, if its nutrition is visibly suffering, it should be enucleated without delay, and not be allowed to leave the other eye in such a dangerous neighbourhood.

These are the rules which I should like to see officially recommended to surgeons who, without being ophthalmological specialists, are often forced by circumstances to treat wounds of the eye; and also to the younger ophthalmic surgeons, who are not yet fully experienced.

It is expedient that everybody should be able, in the case of intra-ocular foreign body, to do an enucleation at the fitting time; and, in my opinion, the time has come to formulate general practical rules which can be utilised in everyday clinical work.

The same rules are applicable to the second class of conditions. If the eye has still a satisfactory appearance, if its volume has been almost completely preserved, its diminution of tension moderate, its ciliary region insensitive to the touch, then it may be kept. But when it is the seat of a manifest cyclitis, of long standing, with evident inflammatory reaction, however slight this latter may be, and having resisted appropriate treatment for several months, one must not hesitate to consider the eye dangerous; much more so when in presence of an atrophied stump resulting from an open wound.

In this question of the treatment of sympathetic ophthalmia and with the views which we have laid down we take our stand, therefore, on the side of the enucleators. Enucleation of the globe renders great service with a minimum of inconvenience, and, in fact, the horror which certain of our confrères have of this operation makes us think of the ostracism with which

the Athenians sentenced Aristides because they were weary of hearing him called " the Just."

(2) Traumatic Cataract

Amongst the complications of fractures of the orbit which may arise in the visual apparatus it will be well to give a place to the injuries which bring about luxations or cataracts.

Here we shall be brief, because it is a subject which specially belongs to injuries of the eyeball alone; in fractures of the orbit lesions of the lens subject to ophthalmic surgery are relatively rare.

The first question which arises is, to know when to operate and when not to operate on traumatic cataracts in military surgery.

Our reply is ready: we must operate on these cataracts on the same principle that we operate upon cataracts occurring from industrial accidents in civil life. In restoring sight to a wounded man, we are useful at the same time to the patient and to the employer, and there is no reason for acting otherwise when the patient is a soldier and the employer is the Motherland.

The advantages to the patient are the enlargement of his visual field, the maintenance of the eye in its normal position, and finally the certitude, when the operation has had a fortunate result, that sight will be always preserved, whatever happens to the other eye.

To the State, the advantage is very considerable; these cases are no longer " réformés no. 1 " (discharged in the first class) from the moment when the eye operated upon has a vision equal to 1/20; the soldier escapes the law of 1831, and falls under the Decree of March 24, 1915, which provides for a gratuity proportional to the lessening of visual acuity. Instead of a pension of 600 francs, a fairly large sum for the loss of vision of a single eye, the subject of aphakia receives 200 francs, which we consider ample, and moreover it is

in conformity with the tariff of the law of April 9, 1898, concerning occupational accidents; the resultant saving to the State is very great, and deserves to be borne in mind in a quite exceptional manner.

Confronted with the statistics which have been published by a large number of ophthalmologists it is not possible seriously to maintain that intervention in traumatic cataracts yields no results. It is a question simply of doing it at the right time, when it is indicated; that is to say, it is only necessary to interfere in an early stage for glaucomatous accidents due to swelling of the lens, and, apart from these accidents, to operate only on cases which are quite settled down, of long standing, and in which one has good reports as to the state of the deep membranes.

As a general rule, we operate on uncomplicated traumatic cataracts six to twelve months after the injury. When the lens remains entire, a large incision in the cornea, without or with iridectomy, permits the evacuation of the débris, which lavage of the anterior chamber by the aid of Chibret's syringe satisfactorily completes.

If only a more or less thick membrane remains, we look upon the various methods of discission with needle or sickle-knife as evil interference, and as still worse, detachment of the capsule with forceps, so unfortunately advised by Panas; in this method one drags on the ciliary processes, perhaps reviving an extinct irido-cyclitis and compromising the future of the globe. Perhaps it is to this error of technique that one may look for the cause of the disappointments mentioned by some colleagues. The operation of choice in such a case is De Wecker's irido-capsulotomy; through a small subconjunctival scleral incision, two or three millimetres from the limbus, the thickest portions of membrane are divided with De Wecker's scissors with the minimum of traumatism and without loss of vitreous.

We may quote here our results obtained in our "Service central d'Ophtalmologie militaire."

Traumatic Cataracts

1. *Traumatic cataracts observed* = 175.
   - Complicated 116
   - Uncomplicated 59
2. *Number of operations* = 73.
   - Extraction with or without iridectomy . 52
   - Irido-capsulotomy 21

Results

- (*a*) Acuity superior to 1/20 = 37
  - 1/15 8
  - 1/10 6
  - 2/10 6
  - 3/10 9
  - 4/10 2
  - 5/10 5
  - 6/10 1
- (*b*) Acuity inferior to 1/20 25
- (*c*) Acuity nil = 11
  - Intra-ocular foreign body . 3
  - Hæmorrhage into vitreous. 5
  - Post-operative irido-cyclitis 3

(3) Retinal Detachment

The treatment of traumatic detachment does not differ from that of detachments in general.

Iridectomy, opotherapic injections into the vitreous body, removal by puncture of the sub-retinal fluid, and its replacement by sclerosing liquids (tincture of iodine), and electrolysis are not procedures to be recommended, for they provoke a new traumatism, serious to an eye already irritated, and risk arousing inflammatory phenomena which may result in the disorganisation of the ocular media and a consecutive phthisis of the globe.

Amongst the various procedures for treatment of detachment of the retina there is one which for several years we have been particularly able to recommend, and which is our choice; it consists in creating, in the

region of the canal of Schlemm, beneath the conjunctiva, cicatricial tissue obliterating the filtration spaces. We have termed it "colmatage," an operation which consists in dissecting up the whole of the conjunctiva of the intercalary region between the insertion of the recti muscles and the cornea; thus dissected up, the conjunctiva is flattened down upon the cornea, the whole of the region of the canal of Schlemm, up to 5 mm. behind it, is cauterised, and the mucous membrane put back in place and sutured. The newly formed connective tissue, under the influence of cauterisation, obliterates all the lymphatic spaces; the result is a kind of experimental glaucoma.

We have not, however, had to employ this procedure of "colmatage" on our patients, because it is indicated solely in hypotonic, relaxed eyes—a frequent symptom in myopic detachments, which have a physiognomy peculiar to themselves, but rare, very rare indeed amongst traumatic detachments.

The result is, that we are ourselves content with the classic treatment by subconjunctival injections of chloride of sodium, the instillation of atropine combined with compression of the eye, and finally prolonged decubitus in the dorsal position.

This line of treatment gives the most satisfactory results.

Do not, however, let us forget that time is the principal factor in the cure of this clinical entity. It is incontestable, in fact, that prognosis, while sombre, is much more favourable than for the myopic and symptomatic forms of a general affection. Sometimes the disappearance and more often the diminution of the traumatic detachment comes about in a certain number of cases at the end of a lapse of time, varying between five and six months.

Out of 135 cases of detachment with or without orbital fracture, we have observed three cases of complete recovery. There remain in place of the detachment, cicatrices in form of striæ, of whitish coloration. The first case was a man wounded on Oct. 28, 1914, with

a contusion of the orbital right margin, with scleral wound and a large retinal detachment at the infero-external portion; this detachment still persisted on Feb. 28, 1915. Dr. Cantonnet, called later to re-examine the case, noted the complete disappearance of the lesion, and we ourselves on Oct. 30, 1915, confirmed the complete recovery. The second was described in Case-report 2. The third patient, with a detachment at the infero-external portion of the left eye, after contusion, was well seven months after the traumatism.

Associated with these repositions of the retinal displacement, we have noted eight cases of marked amelioration in the extent of the lesion, in the raising of acuity and in the enlargement of the visual field. The proportion of these favourable results is, as one sees, restricted. To sum up, in 2·2 per cent. there was recovery from the detachment, and in 5·92 per cent. simple amelioration. It is well always to be on one's guard concerning the acuity admitted by patients, for it is certain that many of them are but little disposed to make known their true visual acuity. After the war, when the wounded men are no longer prompted by the hope of a gratuity or a discharge we shall know the truth better.

CHAPTER VIII

REPARATIVE SURGERY OF ORBITAL FRACTURES

In presence of the great destruction of the soft parts which very often accompanies fractures of the orbit, the malar bone crushed in, orbital arches broken, eyelids lacerated or torn to ribbons, the surgeon must consider how to repair these damages and restore to the wounded man an appearance as pleasing as circumstances admit.

Three dominating principles will be before his mind :

(1) To replace the eyelids in position and restore their normal form as closely as possible.

(2) To restore if possible, and very often it has been possible, the conjunctival culs-de-sac, so as to retain an artificial eye.

(3) To re-establish, so far as may be, the exterior form of the orbit, by filling up gaps in the bone by suitable grafts.

(A) *Restoration of the Eyelids*

It is unnecessary to write the history of blepharoplasty here. It is contained in all the textbooks, and quite recently it has been excellently retold by our colleague Magitot in the Reports of the Société d'Ophtalmologie de Paris, July 1916.

We prefer the Indian method, as he does, and the short pedicle has always sufficed for our patients in the numerous cases in which we have had to interfere. We have most often used the frontal flap, and when we have had both eyelids to restore, we have fashioned a frontal flap and a malar flap at the same time.

We always found it possible to remake suitable eyelids, and we could quote here a large number of satisfactory results; it seems to us that they do not greatly differ from those which have been obtained by our colleagues in military surgery, and we do not dwell on the point (Figs. 66 and 67).

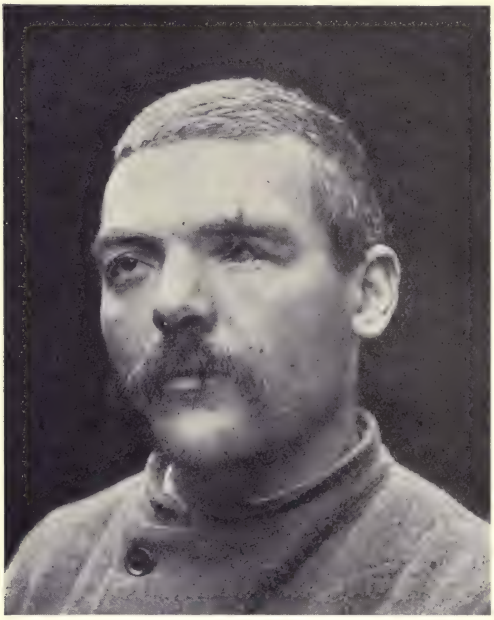

FIG. 66.

(B) *Restoration of the Conjunctival Culs-de-sac*

The restoration of the culs-de-sac is a very interesting question, one of the most difficult in ophthalmic surgery, but we think it is a subject upon which we must not expatiate, as it is only indirectly connected with that of orbital fractures by projectiles of war.

We will simply remind our readers that the essential condition for efficient action is to add to the portion of

conjunctiva which has been preserved a tissue capable of replacing the destroyed mucous membrane. To obtain it, some prefer a dermo-epidermic graft (FRANCK, WEEKS), others a graft limited to the epidermis (MAGITOT); the latter author dissects up from a part distant from the eye, the thigh for example, an epidermic

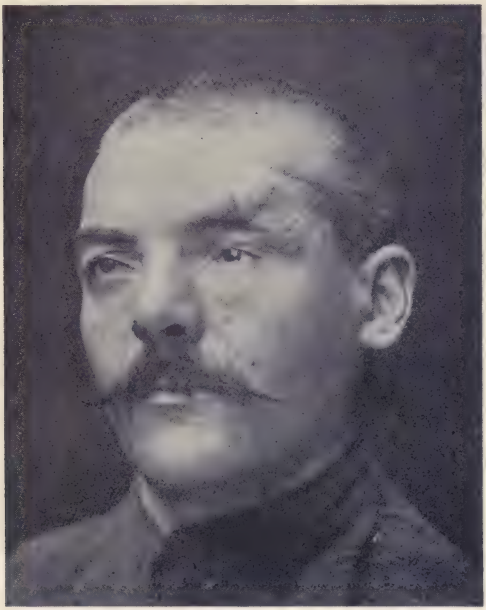

FIG. 67.

flap with which he covers a piece of metal introduced into the orbital cavity in such a manner that the raw surface of the flap is applied to the refreshed surface of the inner aspect of the eyelids. We have had no experience of this latter procedure. We have several times made use of that of FRANCK, with unsatisfactory results, and that is a sufficient reason for trying another method.

With our military patients we have been contented with restoring the culs-de-sac with SNELLEN'S sutures, of which we have made large use with great success, varying the form and the situation according to the individual case. We do not include the inferior cul-de-sac, which is often the more at fault and also the more important. We have enlarged, deepened, or even made it anew by splitting the eyelid, as TRUC indicates in his procedure *en vanne*, drawing the internal half of this eyelid forcibly downward by the aid of one or two sutures. The cul-de-sac does not remain as well-marked as at first, but a sulcus deep enough to retain an artificial eye constantly persists. We also believe that lining the lower eyelid with a morsel of skin borrowed from the temple (SNELLEN), the cheek (HARLAN), or the upper eyelid (SAMELSOHN) is worthy of recommendation.

In addition we have recourse to artificial dilatation by pieces of rubber in graduated sizes, inserting successively larger and larger pieces, following the advice given on this subject by DR. COULOMB, and we have had the satisfaction of rendering habitable a large number of sockets which at first seemed as ill-disposed as possible towards receiving a prothesis.

We do not dwell upon this question, for, like that of blepharoplasty, it is on the fringe of the subject, and does not belong, strictly speaking, to fractures of the orbit.

We hasten to discuss what dominates the reparative surgery of these fractures, namely, the treatment of loss of substance of the bony foundation and the re-establishment of the regular contour of the orbit. That is indeed the heart of the subject. The restoration of the eyelids and of the conjunctival sac have little to do with orbital fractures, and such matters as transplantation of labial mucous membrance (CARDO, SIZOREFF), the employment of the skin and cartilage of the ear (BUDINGER), etc., are scarcely germane to the subject.

(C) *Repair of Damage to the Orbital Walls and in the Bone*

We draw attention to three procedures, of unequal value : (1) metallic plates ; (2) adipose grafts ; (3) cartilaginous grafts.

(1) *Metallic Plates.*—We only know one author who makes use of metallic plates in such circumstances.

Pierre Duval, in a communication to the Société de Chirurgie de Paris (June 16, 1915) presented a case of prothesis of the left frontal and superior orbital margin by means of metallic plates. He used the aluminium plates which are manufactured for military purposes and which are four-tenths of a millimetre thick. The author confesses that this substance gradually becomes absorbed, but the process is usually slow and incomplete. " In a case of extensive depression of the frontal bone," says Duval, " the superior orbital margin was fractured and depressed, save at its extreme two centimetres. I restored it with a plate with a rounded margin anchored by its ends to the osseous margin." The extremities of the prothesis were let into the substance of the diploë at certain points where the operator had made small holes to receive the prolongations. The whole was covered by the refreshed integument. Duval showed the case four months after the prothesis, and the æsthetic result seemed to be most satisfactory, so far as one can judge from the photograph with the publication.

Perhaps we may be able to use in the same way the sheets of rubber advised by Professor Delbet for the restoration of the abdominal walls, but we do not believe that these procedures can bear comparison with the two following.

(2) *Adipose Grafts.*—In order to fill up the orbit and facilitate the wearing of a prothesis, it has long been recommended to graft the split skin with cellulo-adipose tissue ; and long before the interventions necessitated by the war, surgeons were cognisant of the means of filling-out and raising cicatrices which were in vicious position, sunk in and adherent to bone, by introducing

beneath them sufficient fat to transform the excavation into a rounded projection, rather more rounded in fact than seems at first necessary, in order that after the inevitable partial absorption, the aspect of the exterior should be as perfect as possible (VERDERAME, Annales d'Oculistique, 1910). In this

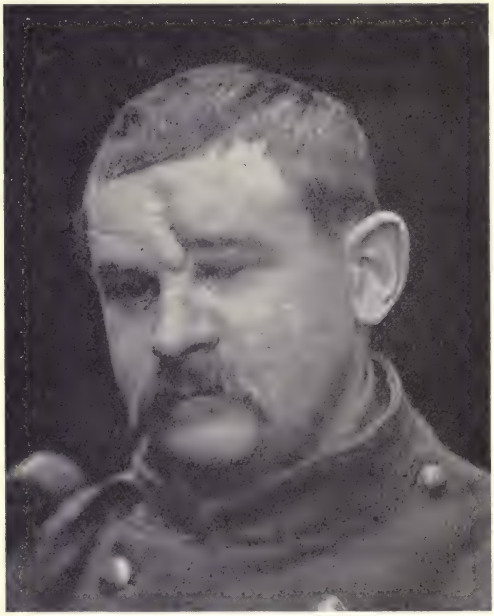

FIG. 68.

war, MORESTIN has made large use of these adipose grafts for the restoration of vicious cicatrices of the face, and the restoring of bony depressions of the orbital margin. In his communications to the Société de Chirurgie de Paris, July 21 and November 24, 1915, he quotes some cases of very extensive facial mutilations, in which a fragment of fatty tissue has been

used to fill up the osseous depressions consequent on injuries to the orbital and peri-orbital bony framework.

We have ourselves under similar circumstances had recourse to the same operation, and can cite several cases in which the result has been very satisfactory.

The adipose grafts should be taken from the subject

FIG. 69.

himself, from the lower part of the buttock when it is desired to graft adipose tissue, from the thorax if it is wished at the same time to use a cartilaginous graft. In the latter event a single operation on a costal cartilage enables us to obtain at the same time fat and cartilage.

There is always a tendency to resect more fat than is necessary; it is well to ascertain as closely as possible

the capacity of the cavity to be filled, and a graft of dimensions a little greater should be taken. If the adipose tissue presents connective-tissue partitions rather closely packed together so much the better; it is much better to graft cellulo-adipose tissue than pure adipose tissue.

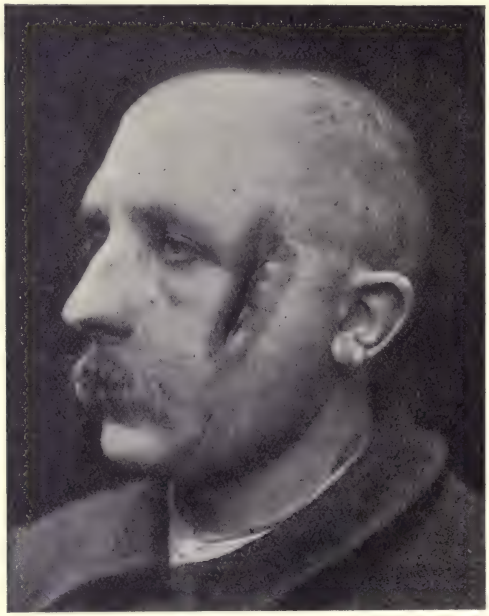

Fig. 70.

The cellulo-adipose graft needs very careful management, for it must not be roughly used. After having prepared it by a rapid dissection, it should be placed in a sterilised cloth and not allowed to undergo any unnecessary handling. The bed in which it is to be placed should be carefully prepared, so that the graft will not come in contact with hard cicatricial tissue, bloodless and without vitality; it will often

be necessary to resect this cicatricial tissue in such a manner that the graft is surrounded by living tissue, well disposed to receive its guest and to nourish it. We have several times failed in our attempt through having made this resection of cicatricial tissue badly and incompletely. Moreover, it is necessary that

FIG. 71.

all bleeding should have been completely stopped by hydrogen peroxide; and especially by pressure with tampons, or at need by catgut ligatures, if torsion of the small vessel has not sufficed. If local anæsthesia be used, one must beware of solutions containing adrenalin which yield a provisional hæmostasis, followed by a reflux of blood and a small post-operative hæmorrhage. A graft surrounded by blood, even if it be aseptic blood, is not under good conditions.

Hence complete asepsis, good hæmostasis, the preparation of a bed free from cicatricial tissue, and a graft filling the cavity well, are the needful conditions for a good adipose graft.

It is in this manner that we have been able to obtain

Fig. 72.

some good results, such as those shown in the Figs. 70 to 73, referring to Cases 59 and 60.

It may perhaps be remarked that these operative results leave something to be desired in the sense that there still persists a trace of the injury; that is due, first, to the circumstance that the photograph, which is very truthful, owing to not having been retouched, was taken before time had completed its work, and second, to the fact that our *poilus*, in a

hurry to "get through with it," refused the little complemental operations by the aid of which one could easily banish the vestiges still visible in Figs. 69, 71 and 73.

(3) *Cartilaginous Grafts.*—Transplantations of cartilage in reparative surgery were advocated by Von

Fig. 73.

Mangold in 1903, and afterwards by Nélaton and Ombredanne, in the chapter "Autoplasties et Rhinoplasties" in the treatise by Hartmann and Berger. Mutilations of the face having become very frequent since the war, the method has been employed anew with success by Morestin. This surgeon had, since 1913, made several attempts at facial restoration by means of autoplastic cartilaginous transplantation; his

first papers on the subject date from May 7, 1913 and November 11, 1914, before the Société de Chirurgie de Paris. At the Congress of the International Society of Surgery of New York (April, 1914) MORESTIN was in charge of the report on grafts and transplantations in reparatory surgery. Since 1915, by the aid of numerous communications, he has perfected our knowledge of the technique of the operation, and has shown the brilliant results obtained, not only in building up the nose or the lower jaw, but also in the restoration of the orbital walls destroyed by injuries of war.

We shall review some of the publications of this master of autoplastic surgery.

MORESTIN reports the case of a soldier [1] who presented a curvilinear cicatrix at the lower part of the forehead above the left eyebrow; the superciliary arch, the orbital margin and the lower portion of the frontal bone between the orbit and the frontal prominence were wanting. A deep depression corresponded to this loss of bone substance over which cerebral pulsation could be seen and felt. In two preliminary operations MORESTIN removed the projectile which was found at the inferior part of the frontal sinus, then extirpated a fistulous track at the internal part of the frontal cicatrix.

Two months after recovery from this operation, the cicatrix was in turn removed, ligaments were loosened to prepare a bed for the graft, which was borrowed from another subject; the cartilage was shaped to the form of the superior orbital arch and the wound hermetically closed. The result was most satisfactory, as the photographs testify.

In a second article,[2] MORESTIN publishes two similar cases. A man, wounded by a bullet, presented at the

[1] MORESTIN. On the repair of loss of substance of the cranium, and particularly of the forehead, by means of transplantation of cartilage.—*Société de Chirurgie de Paris, February* 9, 1916.

[2] On the reconstitution of the malar bone and the orbital margin by means of transplantation of cartilage.—*Société de Chirurgie de Paris, March* 1, 1916.

level of the right cheekbone a very deep scar in the form of a star with four rays, closely adherent to the subjacent tissue. The depression corresponded to the prominence of the malar bone and the orbital margin. The sixth and seventh costal cartilages were removed, united one to the other; the thoracic wound was closed in layers by sutures. The orbito-malar cicatrix having been extirpated, the surrounding integuments were freely undermined. After having examined the gap in the bone, a large piece, almost identical in shape, was carved out of the cartilaginous block, reconstituting the malar bone and the orbital margin. As it lacked stability, MORESTIN fixed it by means of another fragment, the whole being sutured to the temporal muscle and covered by the superficial layers. The wound healed in a week and the result was æsthetically perfect. The second case was a soldier, bearing a very apparent deformity, resulting from the destruction of the external portion of the right inferior orbital margin and the anterior portion of the right malar bone. The bony portion was filled up by means of split cartilaginous fragments derived from another subject, placed with the epidermic surface turned towards the deep portion of the cavity. MORESTIN completed their modelling in the wound, to ensure that their adaptation should be as perfect as possible. Rapid healing in a few days. MORESTIN finishes his paper by saying: "These two cases show what one may expect from cartilaginous transplantation in this kind of deformity. The method which I have recommended provides a very simple solution to a problem of reparatory surgery which has hitherto remained unsolved."

On May 31, 1916,[1] two new cases were presented

[1] MORESTIN. (1) Reconstitution of the malar bone and the orbital margin by means of cartilaginous transplantation. (2) Loss of left eye; comminuted fracture of the superior maxilla, destruction of the orbital margin, operation for repair; cartilaginous grafts. (3) Reconstitution of the malar bone and the external half of the orbital margin by cartilaginous transplantation.—*Société de Chirurgie de Paris, May*, 1916.

by this author, with complete operative and æsthetic success. In these cases there was very extensive damage to the orbital walls with and without preservation of the eyeball. At the same meeting, MORESTIN showed a soldier for whom, on August 10, 1915, he had reconstituted the malar bone and the external half of the orbital margin by cartilaginous transplantation (about ten months before), a case which suggested to him the following reflections : " It appears to me that it is interesting to demonstrate, by this example, how one can, on the same subject, perform successive graftings of cartilage borrowed from himself or from others; it is equally useful as showing the stability of the transplanted grafts. The cartilaginous mass has undergone no reduction in size during this lapse of time. I never lose an opportunity of insisting upon the stability of the results of cartilaginous grafts. That is an essential point, one of the fundamental reasons, which allow us to advocate this method in reparative surgery."

Speaking of another case, MORESTIN fully demonstrates his manner of procedure, and we cannot do better than summarise it

Amongst injuries of the face,[1] there is a type which one meets frequently. In it the eyelids are more or less torn through, the eyeball often injured, the malar bone and the external wall of the orbit carried away or destroyed over a large extent. The interrupted orbital margin is wanting in its infero-external portion, the integuments of the malar, temporal and mandibular regions participate in the deformity. There is an enormous bony depression, associated with shocking facial asymmetry and vicious position of the eyelids by reason of irregular and very extensive cicatrices.

In these cases, " Reparation has to be preceded by the excision and the gradual reduction of the cicatrices." It is best to proceed by two successive

[1] MORESTIN. Reconstitution of the malar bone and of the orbital margin by cartilaginous transplantation.—*Société de Chirurgie de Paris, August* 9, 1916.

operations. In the first place an autoplasty is made, having as its object the restoration of the destroyed integuments; after having liberated and brought the eyelids into good position and performed blepharorraphy, a flap is fashioned from the temple and the adjoining portion of the forehead, a flap whose pedicle must often be taken from behind because of the cicatrices which occupy the anterior part of the region. This flap is put in position and sutured.

After five or six weeks the restoration of the bony framework can be proceeded with. One of the cicatrices is reopened, the flap is detached with the neighbouring integuments, the conjunctival sac is put on one side, with the intra-orbital soft parts, avoiding, at all costs, the opening of the conjunctiva or the maxillary sinus. The boundaries of the loss of osseous substance are examined, the breach is prepared, the grafts, taken from the patient himself (the sixth and seventh costal cartilages), are trimmed to the size and shape required and installed in place. Finally the wound is hermetically sealed. It only remains, a few days later, to separate the eyelids and insert an artificial eye, if the globe has been destroyed by the injury or sacrificed by necessity.

With regard to this, it should be noted, adds MORESTIN, that in cases in which the eye is lost, it may be advisable during the course of the operation of grafting, to slip some fragments of cartilage into the interior of the orbit, so as to push forward the conjunctival sac and thus permit the wearing of an artificial eye under the best possible conditions.

After the account of the procedure employed and the results obtained by MORESTIN, whose methods seem to us particularly worthy of approval, we shall give an account of those we have used in our clinic during the same period as our colleague and often inspired by his counsel.

Two different conditions may present themselves: either the fractured orbit communicates with the neighbouring cavities, the maxillary sinus and the nasal

fossa, or the loss of substance affects only the orbital margin over a greater or less extent, without the adjoining cavities being implicated.

(*a*) *When the neighbouring cavities are in communication with the orbit*, it is needful in the first place to shut off this communication; should the maxillary sinus suppurate, it must be curetted, freely opened by the side of the nose, or if necessary a radical cure performed by the classic method. No surgical interference with the wall of the orbit is permissible until a complete result has been obtained on the side of the antrum. Moreover, it is unnecessary to hurry, deliberate operations are the best.

In a considerable number of cases the projectile, which has smashed up at the same time the floor of the orbit and the maxillary antrum, has spared the conjunctival mucous membrane; this torn mucous membrane, separated from its normal relations, is a great help in isolating the orbit from the neighbouring cavities; by dissecting it up in an appropriate manner, it can be drawn towards the opening, and sutured there, its deep surface against the neighbouring cavity. In this manner all communication with the nasal fossæ can be cut off. When the region of the lacrymal sac has been extensively destroyed, we have been able to obtain this result after several interventions; we could cite here several cases of this kind in which there has been great damage, opening up communications between the orbit, the nasal fossæ, and the antrum.

When the frontal sinus has been widely opened in front and on the orbital side, it is necessary to wait until suppuration has disappeared and a cicatrix has taken the place of the fleshy granulations; later, by an adipose or cartilaginous graft it will be possible, even easy, to fill up the cavity.

Hence, so long as the cavities adjoining the orbit communicate with it and suppurate, we must attend to them, to cure them in the first place so as to have to do with the orbit alone. Then we shall be in the con-

ditions realised at the outset by fractures which involve the orbital margins or the external surface, without communication with the neighbouring cavities.

(*b*) *When the orbit alone is fractured*, it is usually the region of the cheek-bone which bears the brunt of the traumatism. The malar bone is crushed and destroyed; in its place is a deep depression, the lower eyelid is torn to rags, and the eye usually carried away by the projectile or removed by the first surgeon who attends to the casualty. When the eye is preserved, it is often in a condition of enophthalmos because the floor of the orbit is sunk in towards the maxillary sinus, or because there is absorption of the cellulo-adipose cushion which supports the globe. The upper margin of the orbit is sometimes alone injured, and there exists in its place a large very unsightly hollow.

All these disfigurements can easily be repaired by cartilaginous grafts, and we cannot too strongly recommend to our colleagues the method initiated by Von Mangold, and admirably brought to perfection by Morestin.

We have acquired some experience in this method of surgical intervention, and we will place before our readers the results of our work, as well as the inevitable difficulties which we have encountered: the more because we performed the operations at the same period as Morestin, or a little later, before becoming well acquainted with our colleague's technique. We have therefore had to make, so far as concerns this subject, a personal apprenticeship.

Cartilaginous grafts are in truth a conquest of modern surgery; they are more useful, more readily affected, and more reparative than adipose grafts. Everything has been said by Morestin concerning the operative procedure, and we have intentionally quoted him fully above. We shall only add some details which will put our readers on their guard against certain mistakes which we have ourselves committed, and which will enable them to comprehend what we have to expect in this kind of operative interference.

In the first place we must emphasise that it is necessary to be resigned to successive operations. We have made the mistake of wishing to do too much at once. Some of our patients were eager to have finished with the business, and we allowed ourselves to be influenced by it in our surgical conduct. We

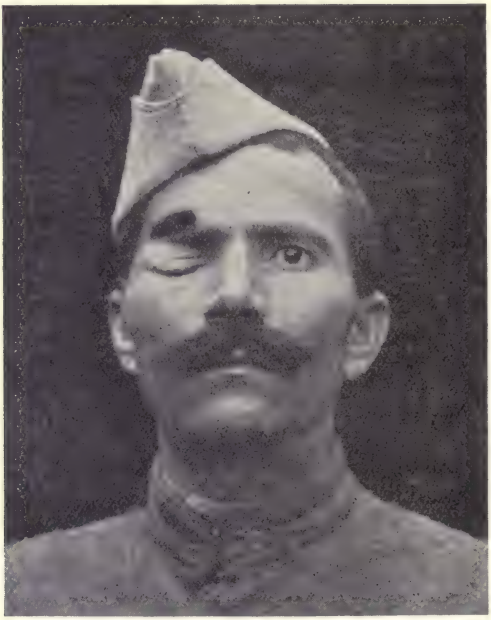

Fig. 74.

were not afraid to do, the same day, a large blepharoplasty with pedicle, an adipose graft and a cartilaginous graft; we have succeeded sometimes from all three points of view, and we have at this moment under our care a fortunate example; but we have failed several times, and we do not recommend this course of action. It is an error, in fact, to graft a piece of cartilage to take the place of the orbital margin, to

cover it with adipose tissue and to suture over the whole a raw flap. The flap destined to become an eyelid needs to rest upon a solid foundation, upon a tissue capable of giving it nourishment, not upon a graft which has need of receiving nourishment itself. It will be necessary, when dealing with such a case, to make

FIG. 75.

the patient understand that two operations are necessary. We commence at first with a blepharoplasty, and, six weeks later, we introduce under the skin the necessary cartilage and cellulo-adipose tissue. Figs. 74 and 75 are very instructive from this point of view; we attempted to do everything at once, with the result that the adipose graft has been eliminated.

The adipose graft is eliminated, but the cartilage

has held perfectly, and it is a detail to which I would particularly call attention; cartilage will easily live wherever it is put, it is content with aseptic surroundings and some interstitial liquids to penetrate it. It lives as a parasite, frugally, but it *does* live and remains as cartilage. It is quite remarkable to see it persist,

FIG. 76.

and maintain its position and its good appearance at the bottom of a cavity which has not been able to retain the fat with which we had filled it.

This demonstrates what one may expect from a graft of cartilage made aseptically, and introduced into its position by means of a button-hole which allows it to insinuate itself into the subcutaneous interstitial tissue to the desired depth. Cartilage

thus grafted always succeeds; MORESTIN has shown at the Société de Chirurgie cases which are relatively old; we can cite very instructive cases of a similar nature.

The illustrations above show some of our results. They would have been more complete if it had been possible for us to perform some small retouching

FIG. 77.

operations on the patients. Such as they are, however, Figs. 74 and 75, 76 and 77 show that the orbital arches can be restored. In the first case, the adipose tissue, grafted at the same time as the cartilage, was eliminated; in the second, the orbital arch has been completely re-established, the eye is not wide open because the subject was enophthalmic owing to depression of the orbital floor.

Moreover, it is quite easy to obtain the cartilaginous graft. Its dissection causes no inconvenience, immediate or remote; when aseptic the wound does not suppurate, and it is quite sufficient, in order to ensure that the thoraco-abdominal wall should also remain aseptic, that while the operator is finishing the orbital operation the assistant in charge of the thoracic wound should close the incision neatly with catgut, in layers, with a muscular, an aponeurotic, and a cutaneous series of sutures.

We take up a fragment of cartilage a little larger than is required, and shape it at will, cutting it to give it the requisite form. The little fragments serve as packing for the principal piece; thus one builds up in the site of the orbital margin or the malar bone an edifice, like a wall, which will replace that which the projectile has destroyed.

Such are the principal reflections inspired by our experience of cartilaginous grafts, we are doing this kind of operation, more and more, and with increasing confidence; and, if we do not cite a large number of cases, it is because many of them are too recent to take their place in this work.

When, by reason of their long standing they merit to be published, we shall make them the subject of a special article.

CONCLUSIONS

In conclusion, we wish to bring forward the original ideas developed in this work :

(1) We wish to call attention in the first place to this fact, that fractures of the cranium by projectiles of war, implicating the cranial vault, at a certain distance from the orbit, even when they are accompanied by large losses of substance and in consequence by well-marked concussion, do not give rise to either irradiation or fracture by contre-coup of the vault of the orbit. Contrary to what is taught in the classic literature, the sphenoidal fissure, the optic foramen, and the structures which pass through them remain unharmed after such traumatism.

In military surgery, fractures of the orbital vault are direct fractures.

(2) The eye is often involved in fractures of the orbit, even when neither the projectile nor bone fragments have directly touched it ; there are produced, at the macula or around it, concussion lesions, well-marked and very serious ; they can be seen by means of the ophthalmoscope in the form of hæmorrhages or lacerations, sometimes only choroidal, often choroido-retinal.

In addition to lesions visible to the ophthalmoscope we may note the disorders which cannot be seen. The central visual acuity of a subject, whose eye appears absolutely intact, may be very low ; these disorders may, further, up to a certain limit, be repaired, but their importance should be considered as of the first order by clinicians in the establishment of their diagnosis and in military medico-legal certificates. The affections described under the name of

"retinal concussion" are the first degree, the degree invisible to the ophthalmoscope, of these lesions due to concussion from a distance.

(3) Besides these concussion lesions we have, in this work, brought prominently forward the lesions of contact produced by a projectile which has grazed or slightly contused the eye while passing alongside it, or by an osseous fragment more or less violently projected towards the eyeball.

Concussion lesions and contact lesions often exist together; a minute ophthalmoscopic examination allows these varieties of lesions to be allotted their respective shares in the anatomical derangements undergone by the deep membranes.

(4) Between the production of these various disorders and the manner in which the projectile has injured the orbit, there exist relations so constant that we have been able to formulate the clinical data under the form of laws, the accuracy of which we are verifying every day, and to which we think we should draw the attention of our colleagues in a special manner (p. 37 et seqq.).

(5) When the retina and choroid are much torn, there is produced, as the result of more or less abundant intraocular hæmorrhage, not the classic proliferating retinitis, but a choroido-retinitis presenting peculiar characters, which we have attempted to bring into prominent relief, and which cause this affection to be a morbid type, not hitherto described.

The cases, frequent in military surgery and rare in civil ophthalmology, of total avulsion of the optic nerve, produce this proliferating choroido-retinitis in maximum degree.

(6) One detail which has impressed us, amongst our patients, is the absence of partial scleral ruptures produced according to the theory of the equator of depression. The projectiles which strike the eye tangentially cause lesions of contact; if they contuse the eye with sufficient directness to break its fibrous framework, they smash it completely and destroy

it; there is no place in military ophthalmology for ruptures of the sclerotic in the intercalary region and subconjunctival luxations of the lens, etc. . . . Projectiles which strike the eye directly penetrate its interior if they are small; if they are large they destroy it, the organ is entirely disorganised.

After thirty months of practice and seeing more than six hundred fractures of the orbit, we have not seen a single case which departs from this rule; doubtless exceptions may be met with, but the clinical verity, which we lay down here, remains on a basis none the less solid.

(7) We have further, by means of our cases, been able to make a special study of hæmatomata of the sheaths of the optic nerve, and we are confident that the hæmorrhage does not spread along them into the ocular cavity, as the best authorities have taught; but that the hæmatic pigment, after a rather long period of time, diffuses as far as the disc, and produces a pigmented crescent or ring, the direct consequence of the hæmorrhage. There is not propagation to the papilla of a recent hæmorrhage into the sheaths of the nerve; but there is, secondarily, somewhat slowly, migration of the hæmatic pigment.

(8) So far as therapeutics are concerned, this work contains information upon reparative surgery of the orbit by means of adipose and cartilaginous grafts, to which we consider it our duty to call the attention of ophthalmologists, whose place it is to maintain the surgery of the orbit abreast of progress of every kind.

INDEX

List of Case-Reports

MILITARY MEDICAL MANUALS

A Series of handy and profusely illustrated manuals translated from the French under the general Editorship of the DIRECTOR-GENERAL of the Army Medical Service,

SIR ALFRED KEOGH

G.C.B., LL.D., M.D., Hon. F.R.C.S., &c.

Each translation has been made by a practised hand, and is edited by a specialist in the branch of surgery or medicine covered by the volume.

It was felt to be a matter of urgent necessity to place in the hands of the medical profession a record of the new work and new discoveries which the war has produced, and to provide for everyday use a series of brief and handy monographs of a practical nature.

The present series is the result of this aim. Each monograph covers one of the many questions at present of surpassing interest to the medical world, written by a specialist who has himself been in close touch with the progress which he records in the medicine and surgery of the war.

Each volume of the series is complete in itself, while the whole will form a comprehensive picture of the medicine and surgery of the Great War.

LONDON:

UNIVERSITY OF LONDON PRESS

18, WARWICK SQUARE, LONDON, E.C. 4

PARIS:

MASSON ET Cie., 120, Boulevard St. Germain.

Extract from

the Introduction by the General Editor,

Sir Alfred Keogh.

THE special interest and importance, in a surgical sense, of the great European War lies not so much in the fact that examples of every form of gross lesion of organs and limbs have been seen, but is to be found in the enormous mass of clinical material which has been presented to us and in the production of evidence sufficient to eliminate sources of error in determining important conclusions. For the first time also in any campaign the labours of the surgeon and the physician have had the aid of the bacteriologist, the pathologist, the physiologist and indeed of every form of scientific assistance in the solution of their respective problems.

The achievements in the field of discovery of the chemist, the physicist and the biologist have given the military surgeon an advantage in diagnosis and treatment which was denied to his predecessors, and we are able to measure the effects of these advantages when we come to appraise the results which have been attained.

But although we may admit the general truth of these statements it would be wrong to assume that modern scientific knowledge was, on the outbreak of the war, immédiately useful to those to whom the wounded were to be confided. Fixed principles existed in all the sciences auxiliary to the work of the surgeon, but our scientific resources were not immediately available at the outset of the great campaign; scientific work bearing on wound problems had not been arranged in a manner adapted to the requirements,

were not fully foreseen; for the workers in the various fields were isolated or had isolated themselves pursuing new researches rather than concentrating their powerful forces upon the one great quest.

However brilliant the triumphs of surgery may be, and that they have been of surpassing splendour no one will be found to deny, experiences of the war have already produced a mass of facts sufficient to suggest the complete remodelling of our methods of education and research.

The series of manuals, which it is my pleasant duty to introduce to English readers, consists of translations of the principal volumes of the "Horizon" Collection which has been appropriately named after the uniform of the French soldier.

The views of great authorities, who derive their knowledge from extensive first-hand practical experience gained in the field cannot fail to serve as a most valuable asset to the less experienced, and must do much to enable them to derive the utmost value from the experience which will, in time, be theirs. The series covers the whole field of war surgery and medicine, and its predominating note is the exhaustive, practical and up-to-date manner in which it is handled. It is marked throughout not only by a wealth of detail, but by clearness of view and logical sequence of thought. Its study will convince the reader that, great as have been the advances in all departments in the services during this war, the progress made in the medical branch may fairly challenge comparison with that in any other, and that not the least among the services rendered by our great Ally, France, to the common cause, is this brilliant contribution to our professional knowledge.

UNIVERSITY OF LONDON PRESS, LTD.
18, WARWICK SQUARE, LONDON, E.C. 4

THE TREATMENT OF INFECTED WOUNDS

By A. CARREL and G. DEHELLY. Translated by HERBERT CHILD, Capt. R.A.M.C., with Introduction by Sir ANTHONY A. BOWLBY, K.C.M.G., K.C.V.O., F.R.C.S., Surgeon-General Army Medical Service. With 97 illustrations in the text and six plates. Price, 5*s.* net. Postage 5*d.* extra.

"Is as fine an example of correlated work on the part of the chemist, the bacteriologist, and the clinician as could well be wished for, and bids fair to become epoch-making in the treatment of septic wounds.

"I am glad to take the opportunity of expressing the appreciation of British Surgeons at the Front of the value of what is known to us as Carrel's method. The book itself will be found to convey in the clearest manner the knowledge of those details which have been so carefully elaborated by the patient work of two years' experience, but it is only by scrupulous attention to every detail that the best results will be obtained . . .

"The utility of Carrel's method is not confined to recent wounds, and in the following pages those surgeons who are treating the wounded in Great Britain will find all the necessary information for the treatment of both healthy and suppurating wounds."—*From Sir Anthony Bowlby's Introduction.*

This volume is included by arrangement with Messrs. Baillière, Tindall and Cox.

UNIVERSITY OF LONDON PRESS, LTD.
18, WARWICK SQUARE, LONDON, E.C. 4

THE CLINICAL FORMS OF NERVE LESIONS

By Mme. ATHANASSIO BENISTY, House Physician of the Hospitals of Paris (Salpêtrière), with a Preface by Prof. PIERRE MARIE. Edited with a Preface by E. FARQUHAR BUZZARD, M.D., F.R.C.P., Captain R.A.M.C.T., etc. With 81 illustrations in the text, and 7 full-page plates. Price, 6*s.* net. Postage 5*d.* extra.

In this volume will be found described some of the most recent acquisitions to our knowledge of the neurology of war. But its principal aim is to initiate the medical man who is not a specialist into the examination of nerve injuries. He will quickly learn how to recognise the nervous territory affected, and the development of the various clinical features ; he will be in a position to pronounce a precise diagnosis, and to foresee the consequences of this or that lesion. In this way his task as military physician will be facilitated.

With this end in view considerable space has been devoted to the illustrations, which are intended to remind the physician of the indispensable anatomical elements, and the most striking clinical pictures. Numerous diagrams in black and white enable him to effect the essential work of localisation. The diagnosis of nervous lesions is thus facilitated.

A second volume will be devoted to the study of the *lesions* themselves, together with their *restoration*, and all the methods of *treatment* which are applicable to such lesions. This will appear immediately.

Together these volumes will represent a complete epitome of one of the principal departments of "war neurology."

UNIVERSITY OF LONDON PRESS, LTD.
18, WARWICK SQUARE, LONDON, E.C. 4

FRACTURES OF THE LOWER JAW

By L. IMBERT, National Correspondent of the Société de Chirurgie, and PIERRE RÉAL, Dentist to the Hospitals of Paris. With a Preface by Medical Inspector-General FÉVRIER. Edited by J. F. COLYER, F.R.C.S., L.R.C.P., L.D.S. With 97 illustrations in the text and 5 full-page plates. Price, 6*s.* net. Postage 5*d.* extra.

Previous to the present war no stomatologist or surgeon possessed any very extensive experience of this subject. Claude Martin, of Lyons, who perhaps gave more attention to it than anyone else, aimed particularly at the restoration of the occlusion of the teeth, even at the risk of obtaining only fibrous union of the jaw. The authors of the present volume take the contrary view, maintaining that consolidation of the fracture is above all the result to be attained. The authors give a clear account of the various displacements met with in gunshot injuries of the jaw and of the methods of treatment adopted, the latter being very fully illustrated.

In this volume the reader will find a hundred original illustrations, which will enable him to follow, at a glance, the various techniques employed.

UNIVERSITY OF LONDON PRESS, LTD.
18, WARWICK SQUARE, LONDON, E.C. 4

WOUNDS OF THE SKULL AND THE BRAIN. Clinical forms and medico-surgical treatment.

By C. CHATELIN, and T. De MARTEL. With a Preface by Professor PIERRE MARIE. Edited by F. F. BURGHARD, C.B., M.S., F.R.C.S. Formerly Consulting Surgeon to the Forces in France. With 97 illustrations in the text, and 2 full-size plates. Price, 6*s.* net. Postage 6*d.* extra.

Of all the medical works which have appeared during the war, this is certainly one of the most original, both in form and in matter. It is, at all events, one of the most individual.

The authors have preferred to give only the results of their own experience, and if their conclusions are not always in conformity with those generally accepted, this, as Professor Pierre Marie states in his Preface, is because important advances have been made during the last two years; and of this the publication of this volume is the best evidence.

Thanks to the method of radiographing the convolutions after filling the furrows, which has become sufficiently exact to be of real service to the clinician, the authors have been able to work out a complete and novel cerebral pathology, which presented itself in lamentable abundance in the course of their duties, which enabled them to examine and give continued attention to many thousands of cases of head injuries.

Physicians and surgeons will read these pages with profit. They are pages whose substance is quickly grasped, which are devoid of any display of erudition, and which are accompanied by numerous original illustrations.

UNIVERSITY OF LONDON PRESS, LTD.
18, WARWICK SQUARE, LONDON, E.C. 4

LOCALISATION AND EXTRACTION OF PROJECTILES

By Assistant-Professor OMBRÉDANNE, of the Faculty of Medicine, Paris, and M. LEDOUX-LEBARD, Director of the Laboratory of Radiology of the Hospitals of Paris. Edited by A. D. REID, C.M.G., M.R.C.S., L.R.C.P., Major (Temp.) R.A.M.C., with a Preface on Extraction of the Globe of the Eye, by Colonel W. T. LISTER, C.M.G. With 225 illustrations in the text and 30 full-page photographs. Price, 10*s.* 6*d.* net. Postage 6*d.* extra.

Though intentionally elementary in appearance, this compendium is in reality a complete treatise concerning the localisation and extraction of projectiles. It appeals to surgeons no less than to radiologists.

It is a summary and statement—and perhaps it is the only summary recently published in French medical literature—of all the progress effected by surgery during the last two and a half years.

MM. Ombrédanne and Ledoux-Lebard have not, however, attempted to describe all the methods in use, whether old or new. They have rightly preferred to make a critical selection, and—after an exposition of all the indispensable principles of radiological physics—they examine, in detail, all those methods which are typical, convenient, exact, rapid, or interesting by reason of their originality: the technique of localisation, the compass, and various adjustments and forms of apparatus. A considerable space is devoted to the explanation of the method of extraction by means of *intermittent control*, in which the complete superiority of radio-surgical collaboration is demonstrated.

Special attention is drawn to the fact that the numerous illustrations contained in this volume (225 illustrations in the text and 30 full-page photographs) are entirely original.

UNIVERSITY OF LONDON PRESS, LTD.
18, WARWICK SQUARE, LONDON, E.C. 4

WOUNDS OF THE ABDOMEN

By G. ABADIE (of Oran), National Correspondent of the Société de Chirurgie. With a Preface by Dr. J. L. FAURE. Edited by Sir ARBUTHNOT LANE, Bart., C.B., M.S., Colonel (Temp.), Consulting Surgeon to the Forces in England. With 67 illustrations in the text and 4 full-page plates. Price, 6*s*. net. Postage 5*d*. extra.

Dr. Abadie, who, thanks to his past surgical experience and various other circumstances, has been enabled, at all the stations of the army service departments, to weigh the value of methods and results, considers the following problems in this volume, dealing with them in the most vigorous manner:

1. How to decide *what is the best treatment* in the case of penetrating wounds of the abdomen.

2. How to instal the *material organisation* which permits of the application of this treatment; and how to recognize those conditions which prevent its application.

3. How to decide *exactly what to do in each special* case; whether one should perform a radical operation, or a palliative operation, or whether one should resort to medical treatment.

This volume, therefore, considers the penetrating wounds of the abdomen encountered in our armies under the triple aspect of *doctrine, organisation, and technique.*

We may add that it contains nearly 70 illustrations, and the reproductions of sketches specially made by the author, or photographs taken by him.

UNIVERSITY OF LONDON PRESS, LTD.
18, WARWICK SQUARE, LONDON, E.C. 4

ARTIFICIAL LIMBS

By A. BROCA, Professor in the Faculty of Medicine, Paris, and Dr. DUCROQUET, Surgeon at the Rothschild Hospital. Edited and translated by R. C. ELMSLIE, M.S., F.R.C.S., etc. ; Orthopædic Surgeon to St. Bartholomew's Hospital, and Surgeon to Queen Mary's Auxiliary Hospital, Roehampton ; Major R.A.M.C.T. With 210 illustrations. Price, 6*s*. Postage 5*d*. extra.

The authors of this book have sought not to describe this or that piece of apparatus—more or less "new-fangled"—but to explain the anatomical, physiological, practical and technical conditions which an artificial arm or leg *should* fulfil.

It is, if we may so call it, a manual of *applied mechanics* written by physicians, who have constantly kept in mind the anatomical conditions and the professional requirements of the artificial limb.

Required, during the last two years, to examine and equip with appliances hundreds of mutilated soldiers, the authors have been inspired by this guiding idea, that the functional utilisation of an appliance should take precedence of considerations of external form. To endeavour, for æsthetic reasons, to give all subjects the same leg or the same arm is to risk disappointment. The mutilated soldier may have a "show hand" and an every-day hand-implement.

The manufacturer will derive no less profit than the surgeon or the mutilated soldier himself from acquaintance with this compendium, which is a substantial and abundantly illustrated volume. He will find in it a survey and a reasoned criticism of mechanisms which notably display the ingenuity of the makers —from the wooden "peg" of the poor man, together with his "best" leg and foot, to the artificial limb provided with the very latest improvements.

UNIVERSITY OF LONDON PRESS, LTD.
18, WARWICK SQUARE, LONDON, E.C. 4

TYPHOID FEVERS AND PARA-TYPHOID FEVERS (Symptomatology, Etiology, Prophylaxis)

By H. VINCENT, Medical Inspector of the Army, Member of the Academy of Medicine, and L. MURATET, Superintendent of the Laboratories at the Faculty of Medicine of Bordeaux. Second Edition. Translated and Edited by J. D. ROLLESTON, M.D. With tables and temperature charts. Price, 6*s.* net. Postage 5*d.* extra.

This volume is divided into two parts, the first dealing with the clinical features and the second with the epidemiology and prophylaxis of typhoid fever and paratyphoid fevers A & B. The relative advantages of a restricted and liberal diet are discussed in the chapter on treatment, which also contains a description of serum therapy and vaccine therapy, and general management of the patient.

A full account is to be found of recent progress in the bacteriology and epidemiology of these diseases, considerable space being given to the important question of the carrier in the dissemination of infection.

The excessive frequency of typhoid fever in war time is demonstrated by a sketch of its history from the War of Secession of 1861-1866 down to the present day.

The concluding chapter is devoted to preventive inoculation, the value of which is proved by the statistics of all countries in which it has been adopted.

UNIVERSITY OF LONDON PRESS, LTD.
18, WARWICK SQUARE, LONDON, E.C. 4

WAR OTITIS AND WAR DEAFNESS. Diagnosis, Treatment, Medical Reports.

By Drs. H. BOURGEOIS, Oto-rhino-laryngologist to the Paris hospitals, and SOURDILLE, former interne of the Paris hospitals. Edited by J. DUNDAS GRANT, M.D., F.R.C.S. (Eng.); Major, R.A.M.C., President, Special Aural Board (under Ministry of Pensions). With many illustrations in the text and full-page plates. Price, 6*s*. net. Postage 5*d*. extra.

This work presents the special aspects of inflammatory affections of the ear and deafness, as they occur in active military service. The instructions as to diagnosis and treatment are intended primarily for the regimental medical officer. The sections dealing with medical reports (*expertises*) on the valuation of degrees of disablement and claims to discharge, gratuity or pension, will be found of the greatest value to the officers of invaliding boards.

UNIVERSITY OF LONDON PRESS, LTD.
18, WARWICK SQUARE, LONDON, E.C. 4

PRINTED IN GREAT BRITAIN BY R. CLAY AND SONS, LTD.,
BRUNSWICK STREET, STAMFORD STREET, S.E. 1, AND BUNGAY, SUFFOLK.

LIST OF THE

LONDON MEDICAL PUBLICATIONS

ISSUED BY THE

UNIVERSITY OF LONDON PRESS

DISEASES OF WOMEN

By THOMAS GEORGE STEVENS, M.D., B.S. (Lond.), F.R.C.S. (Eng.), M.R.C.P. (Lond.); Obstetric Surgeon, with charge of out-patients, St. Mary's Hospital, Paddington; Surgeon (Gynæcological), the Hospital for Women, Soho Square; Physician to in-patients, Queen Charlotte's Lying-in Hospital; Examiner to the Central Midwives' Board. With 202 illustrations. Price, 15*s.* net. Postage 6*d.* extra.

". . . The whole book is a refreshingly good one; there is no chapter in it that the student or practitioner can read without profit, and it is particularly strong in its pathology. The illustrations are good, and the plan Dr. Stevens has adopted of reproducing his large microphotographs by direct photography upon a plate exposed in the rays of the epidiascope is certainly a success. . . ."—*Lancet.*

"May certainly claim to be regarded as a good textbook in which the student and practitioner will find much valuable information. . . .

"The manual presents a genuine attempt to deal with the subject in an up-to-date manner. . . .

"The author has handled the subject rationally and the treatment suggested is well considered. The language of the book is concise, it is well printed, and the text interspersed by numerous illustrations, which are not only interesting but useful."—*British Medical Journal.*

UNIVERSITY OF LONDON PRESS, LTD.
18, WARWICK SQUARE, LONDON. E.C. 4

LONDON MEDICAL PUBLICATIONS

THE UNIVERSITY OF LONDON PRESS has been founded in close relationship with the University of London with a view to its doing for London, what has been done for the Universities of Oxford and Cambridge by their respective Presses.

London teaching has in the past exerted a profound influence on medical thought and practice, and in presenting the series of London Medical Publications to the Profession, the Directors of the Press think it well to state the principles by which they have been guided and the general aim of the works in question.

The writers have been exclusively selected from among those who are London teachers, graduates or physicians or surgeons to hospitals, general or special, within the statutory London area of the University. Each writer has special knowledge and experience in the subject on which he writes.

The books are intended to be essentially practical manuals for Practitioners, of sufficient length to omit no important feature, but as concise as is consistent with lucidity.

They are freely illustrated, many drawings and photographs having been made specially for the purpose. Elaborate discussions of unproved theories and conflicting views have been carefully avoided, the authors in each case giving the result of their own experience and an account of the treatment they themselves adopt.

It is hoped by these means to present a fair view of the present London Medical thought and practice, and to provide practitioners with a series of works, giving reliable and easily accessible information in the various departments of Medicine and Surgery.

UNIVERSITY OF LONDON PRESS, LTD.
18 WARWICK SQUARE, LONDON, E.C. 4

PRINTED IN GREAT BRITAIN BY R. CLAY AND SONS, LTD.,