"BULLETS AND THEIR BILLETS."

Experiences with the X Rays in South Africa.

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THE exigencies of modern warfare, with its small-bore rifles and projectiles having immense penetrative capabilities, together with the almost entire absence of wounds other than those caused by bullets or shells, has necessitated a considerable alteration in the practice of military surgery. Up to the commencement of the present campaign in South Africa, most of our knowledge of the behaviour of small-bore projectiles was based upon experiment or hearsay, and the outcome of the knowledge gained during the present war should be of immense value to future generations.

The small number of deaths from gunshot wounds compared with the large number wounded is due on the one hand to the use of a more humane weapon, and on the other to our advanced knowledge of surgical procedure. A glance at the list of wonderful recoveries, after serious wounds received in what used to be considered "mortal parts," goes to prove that under normal conditions the Mauser and Lee-Metford bullets are, from a humanitarian point of view, much superior to their predecessors. Their use has necessitated not only a complete alteration in surgical methods, but even greater alterations in our methods of attack and defence. The immense distances covered by these bullets and their great penetrative power has vastly enlarged the area of the battlefield, and has rendered the conflict less bloody. Under normal conditions the injuries to bones are much less serious than those caused by the old round bullet or by the Martini-Henry. Under certain circumstances, however, the present bullet is capable of producing the most serious wounds. If it be tampered with in such a way that the continuity of its cupronickel casing is interfered with, it takes upon itself characters which can only be compared with those exhibited by the explosive bullet of days gone by.

Some of the worst wounds I saw in South Africa were undoubtedly the results of ricochet bullets. Such a bullet is, of course, the result of accident, but when it finds a billet it so closely resembles in effect that produced by a soft-nosed or other sporting bullet that there may be difficulty in deciding to which the result is due. A ricochet bullet has frequently imparted to it an amount of spin which renders its effect terrible, both upon the soft parts and upon the bones, the result being in direct ratio with the rate of spin. It will easily be seen that a bullet revolving upon its short axis, and making one revolution in a yard of travel, is not likely to produce anything like the effect upon the tissues which would be produced by one making two revolutions in an inch. In several cases which have come under my notice, in which severe lacerated wounds were caused by bullets which, upon extraction, showed but little evidence of injury, I feel convinced that the results were due to a spinning ricochet, the spin being imparted to the bullet by its having struck some semi-yielding body before finding its billet. In no other way could I account for the serious injury produced.

In one case which occurs to me, a patient was admitted to hospital with a severe lacerated wound an inch in diameter, situated about the middle of the crest of the ilium on the left side. The bullet was localized and extracted from the lumbar region, where it was found lying close to the spinal column near the transverse process of the third lumbar vertebra. On extraction, the bullet showed a dent upon its nose, which pointed to its having struck some fairly hard substance before entering the body. Under ordinary circumstances, I should have been told that the dent was due to its having struck the bone, but in this instance the size and shape of the entrance wound was undeniable evidence of the missile having entered the body under abnormal conditions.

I must admit that my experience agrees with those who contend that there is no evidence that an intact Mauser or Lee-Metford bullet can be flattened against bone, no matter at what range it may have been fired. All the flattened or misshapen bullets which have come under my notice were undoubtedly injured before entering the tissues, and I feel certain that in the cases recorded in which bullets are supposed to have been grooved by having come in contact with soft bones the result was the outcome of a ricochet. That this is not the generally accepted theory I am well aware, but there are differences of opinion on the point, and I claim to agree with those who contend that no intact Mauser or Lee-Metford bullet can be flattened against living bone.

Mr. George Henry Makins, F.R.C.S., in his "Surgical Experiences in South Africa," says: "Some of the specimens removed offered interesting evidence of the capacity of the ribs to withstand considerable violence from a bullet. These were slightly bent, and marked by a half spiral groove. I saw such bullets removed from the thoracic and abdominal wall, and the evidence seemed rather against the groove having been produced prior to their entrance into the body."

The fact that these bullets were retained goes to prove that, for some reason or another, their energy must have been nearly spent, and if they were fired at short range they therefore could not have made a direct entry into the tissues. I have seen several bullets extracted from the shafts of long bones which showed no evidence of having struck anything. On the other hand, in a case in which a soft lead shrapnel bullet passed completely through the head of the tibia, and lodged under the skin on the opposite side, it was found on removal to be perfectly intact, and exhibited no signs of injury from impact.

The injuries inflicted upon our soldiers differed widely according to circumstances; for whilst we used one form of projectile almost universally, the Boers employed several varieties, amongst the most common of which were the Spanish Mauser, the Guedes, the Krag-Jorgensen, and the Martini-Henry, in addition to which they not infrequently turn our own weapon against us. There can be little doubt that, with the exception of the Martini-Henry, there is little difference in the results produced, although it is probable that the steel-coated projectiles—viz., the Guedes and the Krag-Jorgensen—are less liable to injury from impact with anything but very hard substances.

"Nothing is more certain than that the outward appearances in bone injury produced by small-bore projectiles convey no certain indications of the extent of the damage which may exist within, and nothing will supply information on this point except exploration with the finger." This statement is taken from Surgeon-Colonel Stevenson's excellent book on "Wounds in War" (1897 edition); but since it was written a great change has come over things. Thanks to Professor Roentgen's wonderful discovery, we have at hand a method of examination and localization of unsurpassed accuracy and perfect freedom from danger, which constitutes one of the greatest advances in surgical procedure. To military surgeons, at least, the X rays offer immeasurable help, which, when taken full advantage of, will prove of equal importance with the introduction of aseptic methods.

In addressing you, gentlemen, I feel that it would be pure waste of time were I to attempt to point out the many advantages offered by the systematic application of the X rays to military surgery, in place of the time-worn and obsolete methods carried out in previous campaigns. How many deaths have been due to meddlesome interference in the past it would be impossible to even roughly estimate. Many valuable lives have been sacrificed to a not unnatural desire to obtain knowledge by manipulation with the fingers or with the probe. Under normal conditions, and except under exceptional circumstances, there should be no further need for meddlesome and undue exploration.

I freely admit that there are difficulties in the way of carrying out a careful radiographic examination under the conditions which exist in actual warfare, but I am equally certain that these difficulties can, and must be, overcome.

Before starting for South Africa I had an idea that it was in the field hospitals that the most useful work would be done. Actual experience, however, has taught me that this is not the case, and that, although a small portable set may prove of great use, it is not here that the bullets can be localized or the exact condition of the parts be shown by means of stereoscopic radiographs.

The great use of a portable set in a field-hospital is that of enabling the surgeons to discriminate between serious and slight cases, with a view to their ultimate disposal. It is true that time and pain may here occasionally be saved by rendering the removal of superficially retained bullets possible, but it is in the large general and base hospitals that the bulk of the work must be done. Had I not been in South Africa myself, I should have wondered at the small amount of praise accorded to the X rays by our chief surgeons; but, having seen for myself, my surprise has vanished. I have already (in the columns of the *Lancet* and elsewhere) pointed to some of the reasons, the others being due to the characteristic shyness of surgeons for anything that is new.

The absolute accuracy of localization by means of the X rays is certain sooner or later to meet with its due appreciation, and in time no other method will be dreamed of.

The timidity exhibited by surgeons when asked for

the first time to go for a bullet which had been localized by means of the X rays at a point situated inches, and perhaps feet, from the wound of entrance was only equalled at their astonishment on finding it, when their shyness disappeared, and they became firm converts to the new methods.

Prior to my proceeding to the front I had had but a limited experience in exact localization; but, being certain of my facts, I felt no anxiety about the result so long as the operation was carried out with care; and I am happy to say that in no single instance was a localized foreign body missed. I should like, with your kind permission, to here publicly thank my surgeon-colleagues for the kindness and consideration shown to me during my stay at the Imperial Yeomanry Hospital. I attended every operation for the removal of a foreign body, whilst my advice was eagerly sought for and courteously accepted.

The method of localization adopted was that of triangulation, the Mackenzie-Davidson couch, or my own localizing tube-holder, together with the cross-thread localizer, being always used.

The localization of bullets was carried out in the usual manner, with the exception that I prefer to make my two exposures on separate plates instead of upon one, as is frequently advocated. There is a distinct advantage in adopting this method, inasmuch as the first image is not obscured by the subsequent exposure, and as the Wheatstone's stereoscope can be appealed to if its evidence should be required. My method of securing measurements from the two negatives is as follows: Upon a sheet of tracing-paper are carefully drawn two lines, crossing one another at right angles, to correspond with the lines ruled upon the glass base of the "cross-thread" localizer. This is laid upon the negative, so that the ruled lines overlie and correspond with the image produced by the wires of the localizer. The negative is now either held up against a window or it is placed upon the glass base I have already referred to, and the outline of the bullet, or other foreign body, is carefully traced with a sharp lead-pencil. The procedure is now repeated with the second negative. The diagram produced is now laid upon the "cross-thread" localizer in the usual manner, being kept in its position by weights on the corners. From this diagram a localization can be made with as great accuracy as can be obtained by the one negative method, and even greater than that secured with one negative placed over another. All my localizations were made in the manner described, and, as I have before stated, they all proved successful.

Localization by means of the X rays is based upon mathematical calculations, and is so absolutely correct that I cannot imagine any surgeon even daring to consider any other method. Yet I am constantly hearing of the telephone probe, the latest competitor in the field of prehistoric instruments, which, even under the old conditions of warfare, were bad, and under the new are worse than useless. There is no position in the body in which a bullet cannot be found and exactly localized by means of the X rays. Moreover, this can be done without disturbing the patient or subjecting him to anything but the slightest inconvenience for at the most ten minutes. He runs no risk of infection from dirty probes, and the results are absolute. The telephone probe is alone useful for finding a bullet when its position is known, and may on occasion prove of slight assistance during an operation, when the bullet is in a difficult position to get at and cannot be seen. I am pleased to say that at the Imperial Yeomanry Hospital the telephone probe was never used, and yet, in every instance in which the operating surgeon was called in, the bullet was found.

Before leaving England I was well supplied with apparatus and a sufficient quantity of photographic plates and chemicals to last me at least twelve months. The only piece of apparatus the absence of which I had good reason to deplore was a Wheatstone's stereoscope. Many times I felt the want of this, and I would suggest that in future it forms a part of a base hospital equipment.

About this apparatus I should like to say a few words. In the first place, the woodwork generally was bad, or, at any rate, not suited to the climate of South Africa. Apart from the woodwork, the coils were unaffected by the high temperature.

The greatest trouble I experienced was with the accumulators. These caused me more anxiety than all the other apparatus put together. I was supplied with two E.P.S. accumulators of six cells each, having a capacity of 48 ampère hours. The charging of these gave me more trouble than all the other work I experienced. In the first instance, they were charged at Cape Town, and were sent up country by rail. They arrived with half the acid spilt, and had suffered considerably from the amount of bumping which they had sustained in the journey. On the second occasion (on

the advice of friends) I sent them to the De Beers workshops at Kimberley. On their arrival at Deelfontein I found them both leaking through their cases, and, to all intents and purposes, in a worse condition than when sent away. This was, of course, no fault of the engineers who had so kindly come to my assistance, but was due to the manner in which they had been handled by the railway officials. They were next sent to Cape Town to be repaired, but returned in a worse condition than when they were sent away. At this juncture I decided that it was impossible to continue my work under these conditions, and, having been presented with a dynamo before starting from England, I persuaded my commandant (Colonel Sloggett) to allow me to hire an oil-engine to drive it. A visit to Cape Town ended in my securing an engine (second-hand), which, after some preliminary experiments, worked very well. With it we lighted the dispensary, operating theatre, X-ray room, surgical stores, commandant's office, and officers' mess-tent in addition to the work I required. I so arranged matters that under ordinary circumstances my patients visited me in the evening between 5 and 7.30, at which time only a small amount of the current was being used for lighting purposes. In the event of my urgently requiring the current, the engine could be started at any time in a few minutes, and could be shut off when the work was done. With this amount of current at my disposal, I used by preference the electrolytic interrupter, which never failed me, and produced the most satisfactory results.

Included amongst the apparatus provided was a specially-designed foot-motor (of the bicycle type), and a small dynamo for charging the accumulators. The bicycle arrangement was constructed upon a firm metal frame, which was capable of being bolted to the floor. It was supplied with a heavy fly-wheel, which was driven by two riders by means of a chain; a belt from the fly-wheel drove the dynamo. The arrangement was as perfect—in theory—as could be wished for, but in practice it was a complete failure, as no one could be persuaded to work it. For the first few minutes the drivers of the dynamo beamed with delight, but they soon commenced to reek with perspiration, and gave in from sheer exhaustion. The Kaffirs took great interest in the proceedings, so I allowed them to have a turn; but they soon gave in, and lost all further interest in the object which had so bewildered them. I have no hesitation in saying that the bicycle arrangement is a failure, and that the machine I had so carefully designed is a monument of misplaced confidence.

During the first few weeks of my stay in South Africa, whilst the Imperial Yeomanry Hospital was in course of erection, I was compelled to work under difficulties; but when all was complete, I was furnished with a room which was all that could be desired, together with a convenient dark-room and general photographic-room. From this you will gather that my work was carried on under exceptional conditions; nevertheless, at No. 2 General Hospital at Pretoria the rooms were quite as pretentious, and even more convenient. If the work is to be well done, there can be no doubt that it must be carried out under favourable conditions. Localization requires exactitude, and it cannot be properly performed under "rough-and-tumble" circumstances.

I freely admit that my work was not heavy; at the same time, there was more than enough to justify my presence, and I found plenty of other work to do when I could spare the time. For the last few months I had charge of a ward, in addition to which I was Staff Officer, Intelligence Officer, and Censor, so that you will see I had little time to waste.

During an experience of fourteen months, some 280 cases of one sort or another came under my observation. Of course, many of these were examined on several occasions, and three negatives were invariably produced when a localization was necessary.

In a large number of cases of fracture as a result of gunshot injury, examination by means of the X rays greatly facilitated the treatment, and I may here mention that, as a result of the knowledge gained by this means and the careful carrying out of antiseptic precautions, it was only found necessary in two instances to resort to amputation.

As time will not permit of my dwelling at any length on the results of gunshot fractures, I shall limit my remarks as far as possible to those cases in which a retained bullet was suspected. Of these, 193 came under my notice, out of which, in 65 cases, bullets, portions of bullets, or fragments of shell were localized. The following table shows the parts injured, the number of cases radiographed, and the number in which foreign bodies were localized:

LIST OF CASES OF INJURY WITH BULLETS, PORTIONS OF BULLETS, AND FRAGMENTS OF SHELL, RADIOGRAPHED AT THE IMPERIAL YEOMANRY HOSPITALS AT DEELFONTEIN AND PRETORIA BETWEEN MARCH 19, 1900, AND MARCH 31, 1901.

Parts Injured.	Number of Cases Radiographed.	Number of Cases in which Foreign Bodies were Localized.
Eye...	3	1
Head	11	1
Neck	2	1
Chest	18	7
Shoulder	10	1
Arm	13	4
Elbow	14	2
Forearm	10	1
Wrist	3	0
Hand	19	8
Abdomen	2	0
Spine	1	1
Back	5	3
Pelvis	6	4
Thigh and Hip ...	30	18
Knee	8	3
Leg...	16	8
Ankle	—	—
Foot	18	2
Total... ...	193	65

In looking over this list, it is interesting to note the positions in the body in which the largest number of bullets were retained. I am not in a position to even guess at the percentage of retained bullets after gunshot injuries, but my table goes to prove that it is considerably higher than is generally believed.

There can be little doubt that bullets fired at long range are, under ordinary circumstances, much more liable to be retained than those fired at close quarters. The extreme variation of this distance given by my patients goes to prove, either that they had no idea of judging distance, or that some of the factors already mentioned must have contributed to the lessening of the speed of the projectile.

It is more than probable that some light will be thrown on these important points when the official report of the surgical work done in South Africa comes to be published. My figures must, of course, not be taken as throwing any light upon these points, for there can be little doubt that in many instances in which the presence of a bullet was suspected the cases were specially sent to us for purposes of localization.

The list is interesting as showing that by far the greater majority of retained bullets were found between the ankle and the abdomen, whilst the upper extremities were comparatively free, with the exceptions of the chest and hand. It will be noticed that out of eleven cases of injury to the head, only one bullet was localized; and as in all probability the head is one of the parts most frequently struck, and as the amount of resistance offered by the skull is comparatively great, the explanation of the small number of retentions must be due to the fact that in a very large majority of such cases the recipients of the wounds are killed outright or die shortly after receiving their injuries.

As to the number of bullets which were removed after localization, I am unable to give you absolutely accurate figures, owing to the fact that a considerable amount of my time was spent in Pretoria and elsewhere, and I omitted to make my list complete. From my notes, however, I can account for more than three-fourths of the total.

The question of the removal of bullets after localization (except in cases where the gravity of the symptoms urgently demand it) is one in which there are great differences of opinion; at the same time, it must be admitted that, when only a slight risk is run, the bullets are far safer in the patient's pockets than in their tissues. It is not an easy matter, especially when a bullet is situated in the soft parts away from bony surroundings, to find it even after an exact localization. This is due to the fact that the marked position of the foreign body is obliterated immediately the primary incision is made through the skin, and the incision may be continued at a different angle to that at which it was commenced.

The following diagram (Fig. 1), which represents a section of a thigh with a bullet *in situ*, will explain my meaning. *A* is the position marked upon the skin, *B* the bullet, and *C* the direct line which should be followed by the surgeon. The dotted lines show in an exaggerated degree the paths which may be taken by the surgeon after the primary incision, either of which make the finding of the bullet a matter of great difficulty. This difficulty may in some instances be overcome by passing a specially prepared pin through the tissues to the bullet and carrying the dissection down by its side; or, better still, the following method has suggested itself to me: A strip of metal provided with straps at either end is fixed on the opposite side of the limb to that upon which the localization has been made and from which the operation is to proceed. At right angles to this is a short strip of metal, to which is attached a hinged arm,

the end of which carries a metal pointer, which can be slid up and down in a tube, which always keeps it pointed to one fixed spot. This arrangement is so fixed upon the limb that the pointer is exactly over the marked position

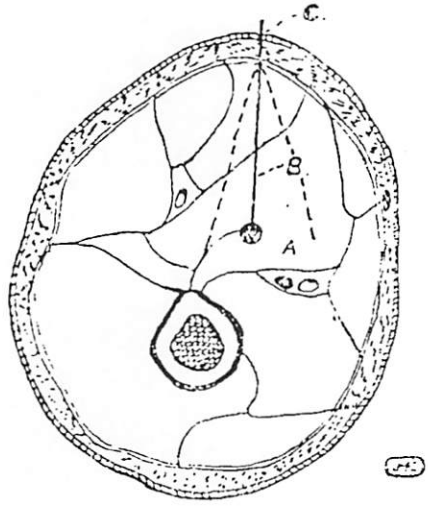


FIG. 1.

of the bullet. During the operation the hinge will allow of the arm and pointer being moved out of the way of the surgeon, whilst it can be replaced in its proper position at any moment, and, if necessary, the pointer can be lowered into the wound, so as to show whether or not the incision is being made in the right direction.

The following rough diagrams (Figs. 2 and 3) will give an idea of my arrangement and the manner of using it :

FIG. 2.

A A is the metal strip, provided with straps which keeps the apparatus in position. *B* the strip which, by means of the hinge *C*, carries the arm *D*, which supports the arrangement which carries the pointer. It will be seen that by means of the hinge, which should be provided with a spring, the apparatus can be moved aside out of the way of the operator, and that it can be rapidly replaced if required.

Such an apparatus would be of the greatest service to the surgeon in helping him to keep before him the exact position of the bullet during his dissection.

When the bullet is situated close to bony structures which can be recognised by palpation, the above-mentioned difficulty does not exist to such a marked

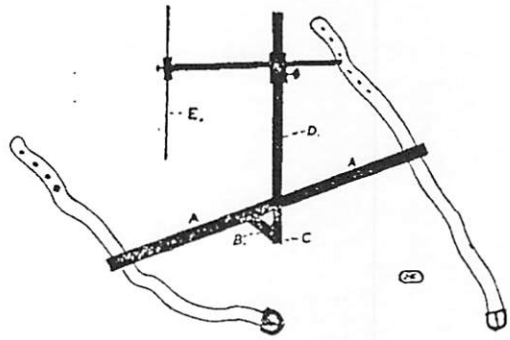


FIG. 3.

degree, and all anxiety can be set aside by the use of the reflecting stereoscope.

The reflecting stereoscope is, in my opinion, one of the most important adjuncts to a radiographic outfit. Several times I deplored my forgetfulness in not taking one out with me. No matter how carefully a localization may be made, questions may arise which can only be settled by its aid. A case in point : Private E. E——, Cameron Highlanders, was wounded on July 12, 1901, at Spitz Kop. He was advancing at the double, when a bullet struck him in the groin, just above Poupart's ligament, on the left side. There was no exit wound. He was sent to me by Mr. A. H. Ballance on August 27. The bullet-wound was then quite healed, and no tender spot could be located. Patient complained of pain after walking any distance, and the movements of the hip were somewhat limited. A radiograph showed the bullet apparently lying over the neck of the femur. A localization proved the bullet to be situated at a depth of $2\frac{3}{4}$ inches from the plate. At the time the radiographs were taken the patient was lying upon his buttock, so that at least an inch may be added to represent compression. The man was well nourished, and the question now arose as to the probability of the bullet being situated in the neck of the femur. This question would have been settled at once had a reflecting stereoscope been at hand; but, having decided to operate, Mr. Ballance prepared for emergencies. The bullet was found embedded in the bone, the nose only being free. After considerable trouble it was extracted, the patient making a rapid recovery, with perfect movement and

freedom from pain. The bullet was found to be uninjured, with the exception of the marks made upon it during the process of extraction.

The most interesting case which came under my notice was that of Major M——, who was shot on May 13, 1900, at Maritsani, whilst engaged with General Mahon's Mafeking relief column. A Mauser bullet struck him in the back, and he fell to the ground, paralyzed in both legs. He lay at a farmhouse for nearly two months, and was then removed to Mafeking for a short time, when he was sent to us. On his arrival at the Imperial Yeomanry Hospital, he had to an extent recovered the movement of one leg; but his sphincters and the other leg were still paralyzed. The patient was sent to me by Mr. Alfred Fripp, C.B., and I localized a Mauser bullet at the level of the first lumbar vertebra, at a depth of $2\frac{1}{16}$ inches from the skin. Mr. Fripp performed a laminectomy, and removed the bullet and a piece of bone which were found to be pressing upon the spinal cord. The patient made good progress, and when I heard of him last he was walking about with the aid of sticks.

Although the exposures in this case were not unduly long, the skin over the chest and upper part of the abdomen showed distinct signs of X-ray dermatitis two days afterwards; this disappeared in two days' treatment with an evaporating lead lotion. This is the only case in which anything of the kind has occurred in my hands, and I attribute it to the extreme debility of the patient, consequent upon his lowered vitality.

I will now show you a few of the more interesting cases which came under my notice:

Mauser Bullet in Right Foot Plate CXXIV. (*a*).—Sergt. G. B——, 2nd Grenadier Guards, was shot at Bidulpsberg, on May 29, 1900. The bullet entered the ankle through the upper and outer edge of his ammunition-boot, passed out again through a fold in the leather, and re-entered 2 inches lower down; it then entered the foot and was retained. At the time the man was struck he was lying down in the firing-line, with the enemy in front of him. It was removed by Mr. William Turner, and the patient made a rapid and complete recovery.

Mauser Bullet in Neck.—Private M. C——, Royal Irish. Shot at the Waterworks, near Bloemfontein, March 31, 1900. The bullet entered the left side of the face through the malar bone, 1 inch below and outside the external angle of the orbit. At the time I saw him the entrance-wound was completely healed, but he complained of headache, pain on moving his head, and he could not open his mouth more than 1 inch. The bullet was localized at a depth of $1\frac{1}{4}$ inches from the skin. It was removed by Mr. Raymond Johnson. The wound healed by first intention, and the patient made a good recovery.

Fragments of splintered Mauser in Calf. Plate CXXV. (*b*).—An officer of Imperial Yeomanry. Shot at Kheis, May 28, 1900. Was helping a wounded man out of the river, when a bullet struck the stones and entered his calf. Five fragments were localized and removed by Mr. A. D. Fripp, C.B., C.V.O. The upper piece was situated 3 inches from the entrance-wound. Little difficulty was experienced in finding any of the localized pieces, and several small bits were found in addition.

Shrapnel Bullet in Left Knee. Plate CXXIV. (*c*).—Private J. T——, 2nd Black Watch. Shot at Retieffs Nek, July 24, 1900. Was helping to move the guns, when a shrapnel burst over him, and a bullet passed through his knee 1 inch below the lower border of the patella. The bullet entered on the outer side, and, having passed through the head of the tibia, could be felt on the inner side beneath the skin. It was radiographed for the purpose of ascertaining the amount of injury sustained in the bone. As far as can be seen the bone is uninjured and the bullet is intact. I have already drawn attention to this case, as proving that a soft leaden bullet can pass through soft bone without being injured.

Soft-nosed Mauser in Finger. Plate CXXIV. (*d*).—Sergt. W. S. R——, Shropshire Imperial Yeomanry. Wounded at Zerust, October 20, 1900. Was lying in a corn-field within 400 yards of the enemy. His rifle was resting upon the ground, and his hand was upon it, when a bullet struck his right index-finger, smashing the bone. He was sent to me to ascertain the amount of injury to the bone, when I discovered a whole bullet in his finger. I may state that he had been in a field-hospital and a general hospital before being sent to us. His finger was, of course, much swollen, but one would have thought it impossible for a whole bullet to have been overlooked.

Mauser Bullet in Chest. Plate CXXV. (*a*).—The officer whose chest is shown here presented himself at the hospital with two retained Mauser bullets, both of which were localized, and subsequently were removed by Mr. J. B. Christopherson. From the radiograph it would be quite impossible to tell where the bullet was situated. Its distance from the skin was found to be

1¼ inches, and it was found lying against the ribs beneath the scapula.

In summing up my experiences in South Africa, I must admit that my anticipations were more than fulfilled, and that the results of my work were all that I could wish. I learned many valuable lessons for future guidance, not the least important being that he who puts his trust in accumulators without having at hand the means of charging them is leaning upon a broken reed. Primary batteries are useless, static electric machines are fragile and difficult to move about, and the bicycle-driven dynamo is impossible. To what, therefore, are we to resort to in the future? I have no hesitation in recommending that each base and general hospital be furnished with an oil-engine and dynamo, capable of giving enough current to work an electrolytic interruptor. The whole of the available current need not necessarily be used, as resistance is easily placed in circuit, and any form of interruptor can be used at will. The oil-engine must be capable of working with the heavy oil, the light oil being exceedingly dangerous in hot climates. There is not the slightest difficulty in designing such a piece of apparatus, and its weight need not be excessive. In South Africa most of the large base and general hospitals were lighted with the electric light, so that there was no difficulty in obtaining the necessary current; and when engaged in fitting up the X-ray department at the Imperial Yeomany Hospital at Pretoria, I found the electrical engineers most obliging in offering me every help in their power. This hospital was lighted by a plant which was formerly used for lighting the prisoners' camp on the "Racecourse," and on my notifying to the Engineers that I required their services, I had a man placed at my disposal within twelve hours, who willingly carried out all my instructions.

I would further recommend that all the apparatus used by the War Department should be made by one firm (or, better still, by themselves), and that all parts should be interchangeable, and as far as possible separate —that is to say, that the coil, condenser, and interruptor should be each separate and self-contained, so that, in the event of anything going wrong, any part could be replaced from the base stores.

The X-ray apparatus sent out by the War Office was, as far as I was able to judge, all that could be desired. It consisted of a 12-inch coil, with separate condenser and platinum contact-breaker; two "lithanode" accumulators, a Mackenzie-Davidson localizing couch, cross-thread localizer, and a fluorescent screen. A supply of plates and chemicals also accompanied each set. The platinum breaks were the most serviceable I have seen, and the apparatus was capable of turning out any amount of good work if placed in skilled hands. As I have said before, however, the sets were frequently placed in the hands of men untrained in radiographic work, and as a consequence they were rarely used. At a large general hospital, situated twenty miles north of us, I was informed by the principal medical officer that the X-ray apparatus in his charge had never been used. At another hospital near the (then) front the officer in charge of the department had but a very rudimentary idea of the work, and had never seen a localization made. At this hospital wounded men were being constantly brought in, and there was any amount of work. I spent several hours in making localizations for the instruction of the officer, and heard subsequently that his efforts were not marked with success. Months afterwards I heard from another officer in charge of the same department, asking me to go up and give him some elementary lessons. My commandant refused to allow me to go, and how the officer in charge of the X-ray department got on I am unable to say. At a large civil hospital at Pretoria, I found that the cross-thread localizer had been used as a developing-table, and that the officer in charge kept his stock of plates in the same room in which he worked his X-ray apparatus. My object in mentioning these facts is to prepare you to accept *cum grano salis* the report which some day may be issued by the War Office regarding the usefulness of the X rays in the campaign.

It has already been admitted that if an officer in charge of an X-ray department is to be a success, he must devote the whole, or, at any rate, the greater part, of his time to the work, and that, in addition, he must have undergone a special course of training to fit him for the duties allotted to him. I think also that, for many reasons, the office of radiographer should be only filled by a medical man. These facts being admitted, it strikes one as curious that the ruling powers at Victoria Street have not yet grasped the truth, and that at the present time there is no supervision over the X-ray departments in South Africa, and that the bulk of the work is in the hands of non-medical assistants. It may be urged that I overestimate the benefits to be derived from the systematic application of the X rays to military surgery.

I think not; and, moreover, I am absolutely certain that a more extended use of them throughout the campaign would have greatly benefited our patients, and would have added greatly to our store of knowledge.

There can be little doubt but that a systematic radiographic survey of gunshot injuries to bone would have been of immense service in helping to clear up many disputed points in the behaviour of small-bore projectiles. Much good work has undoubtedly been done, but the possibilities were great, and they have not been taken full advantage of.

The question of the desirability of removing localized bullets is not one which can be argued here; but there can be no two opinions that, having a means of knowing the exact whereabouts of a bullet, it is our duty to our patient that we should make sure of its locale, independently of any idea of operation. Indeed, no sound opinion of the desirability, or otherwise, of operating can be formed until such knowledge has been gained.

Actual experience at the front has proved to me that in the X rays military surgeons have a helpmate of inestimable value, and no stone should be left unturned to render the Royal Army Medical X-ray Department as perfect as possible.

In a short discussion which followed the paper, Mr. SHENTON noticed that Mr. Hall-Edwards did not mention the use of the fluorescent screen for purposes of localization. During the past year at Guy's Hospital all the cases of localization of foreign bodies had been done with the fluorescent screen without one failure, the foreign bodies being mostly pieces of needles and fragments of broken glass.

Mr. VEZEY drew attention to the excellence of the radiographs, and asked what plates were used.

Dr. BATTEN, referring to Mr. Hall-Edwards' remarks on the want of a stereoscope, said he had constructed a rough one from two pieces of glass and two bandboxes.

Mr. COLLINGWOOD said he should not only be glad to know what plates had been used, but what precautions were taken to preserve them from injury and risks of accident; also whether any films had been employed.

Dr. CLARK recommended the "monobloc" accumulator as most suitable where portable apparatus was required, which would stand rough usage.

Mr. WILSON NOBLE asked what form of electrolytic break was used.

Mr. PAYNE said he was sorry to hear that Mr. Hall-Edwards had had the same unfortunate experience with his bicycle-dynamo as Lieutenant Bruce had in Ladysmith. It was obvious that the dynamo was too large, and required more power than two men could give. Perhaps a machine requiring one-fifth, or even one-eighth, of that used by Mr. Edwards would have worked quite well. It should be remembered that a horse-power (in terms of which the power of a dynamo was often stated) was the maximum rate at which a horse could work for a few minutes, and not the rate at which it could work for a long time.

Mr. VALLANCE said he had worked with Mr. Hall-Edwards in South Africa for twelve months, and could recall a very interesting time which they had spent together. He agreed with the author's remarks as to the accuracy of the cross-line method of localization and the use of the telephone-probe, though he thought that in certain cases of deep wounds it might be of considerable use.

Mr. HALL-EDWARDS, in reply, said, with regard to the use of the screen, it was difficult to see clearly when working in broad daylight, and he found it difficult to arrange to do the X-ray work at night. The plates used were the "Castle" plates, made by Messrs. Mawson and Swan. No special precautions were taken to preserve the plates beyond using the usual waxed paper in which plates were packed for export. Only one negative had been broken out of a total of 4,000 which had been brought home. Films were only employed on one occasion. The electrolytic breaks were the pattern composed of a piece of platinum wire sealed into the end of a glass tube. When they got out of order it was difficult to put them right again, which was no doubt a disadvantage.

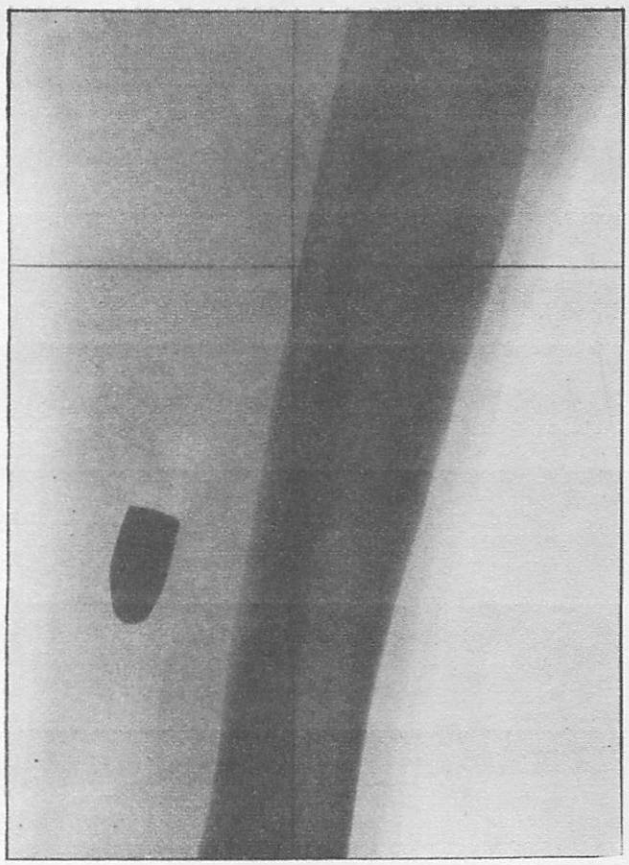
The PRESIDENT agreed with Mr. Hall-Edwards as to the difficulty of using the screen in the daytime and of accustoming the eyes to the darkness. It was most interesting to hear the experiences of a man fresh from the war, and they had had a most interesting evening, thanks to Mr. Hall-Edwards' enthusiasm for his work.

A hearty vote of thanks was then given to Mr. Hall-Edwards for his interesting paper.

After the paper Mr. Rebman showed the specimen of staurolite crystals in mica-schist, illustrated and described in the last number of the ARCHIVES.

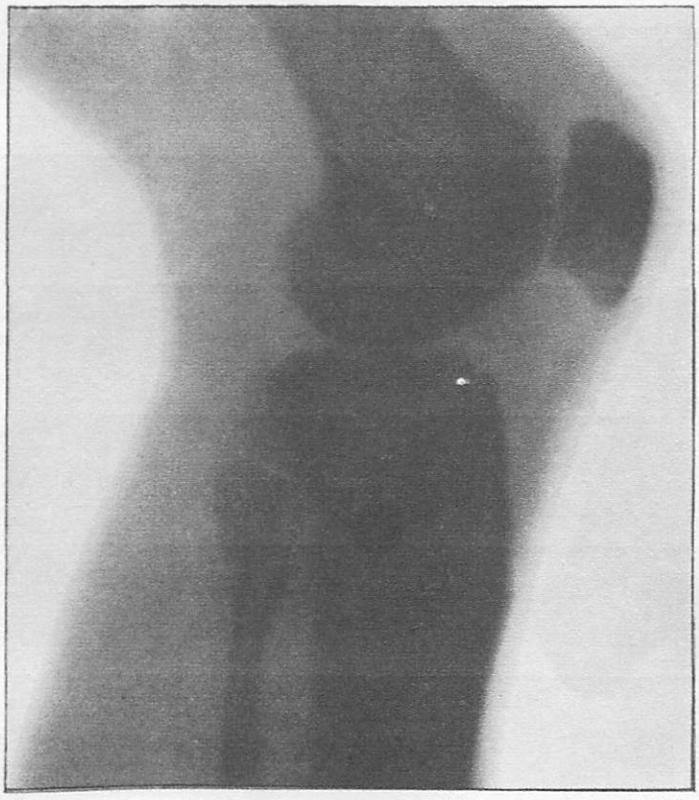
MAUSER BULLET IN FOOT.

PLATE CXXIV. (*a*).
("*Archives of the Roentgen Ray.*"—*Copyright.*)



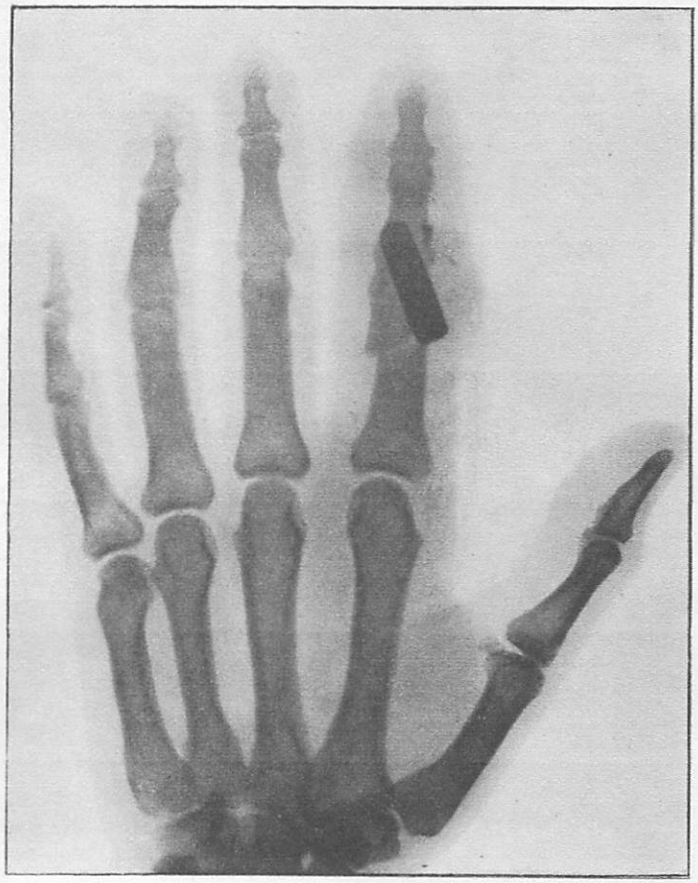
SERVICE-REVOLVER BULLET IN CALF.

PLATE CXXIV. (*b*).
("*Archives of the Roentgen Ray.*"—*Copyright.*)



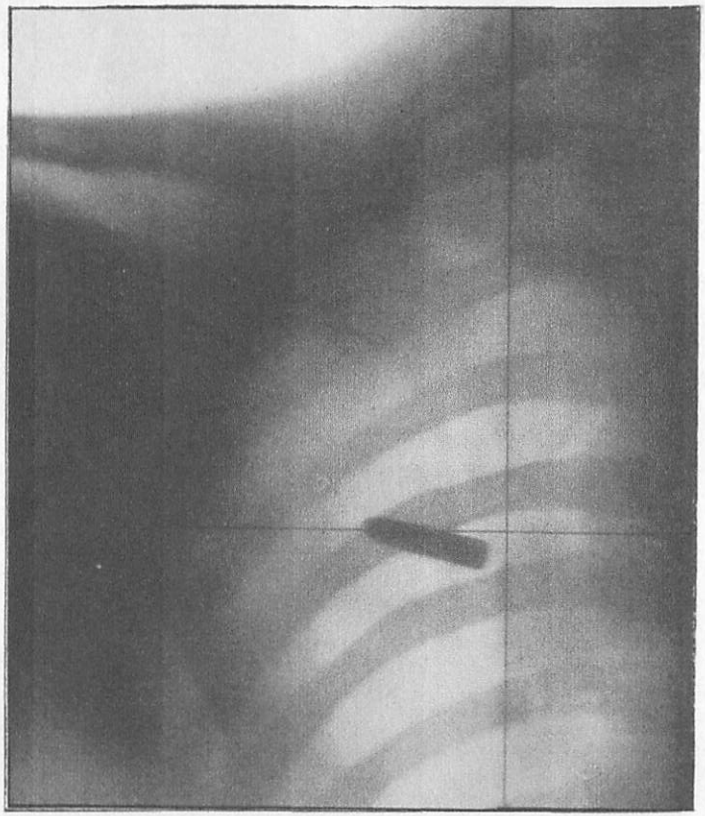
SHRAPNEL BULLET IN LEG.

PLATE CXXIV. (*c*).
("*Archives of the Roentgen Ray.*"—*Copyright.*)



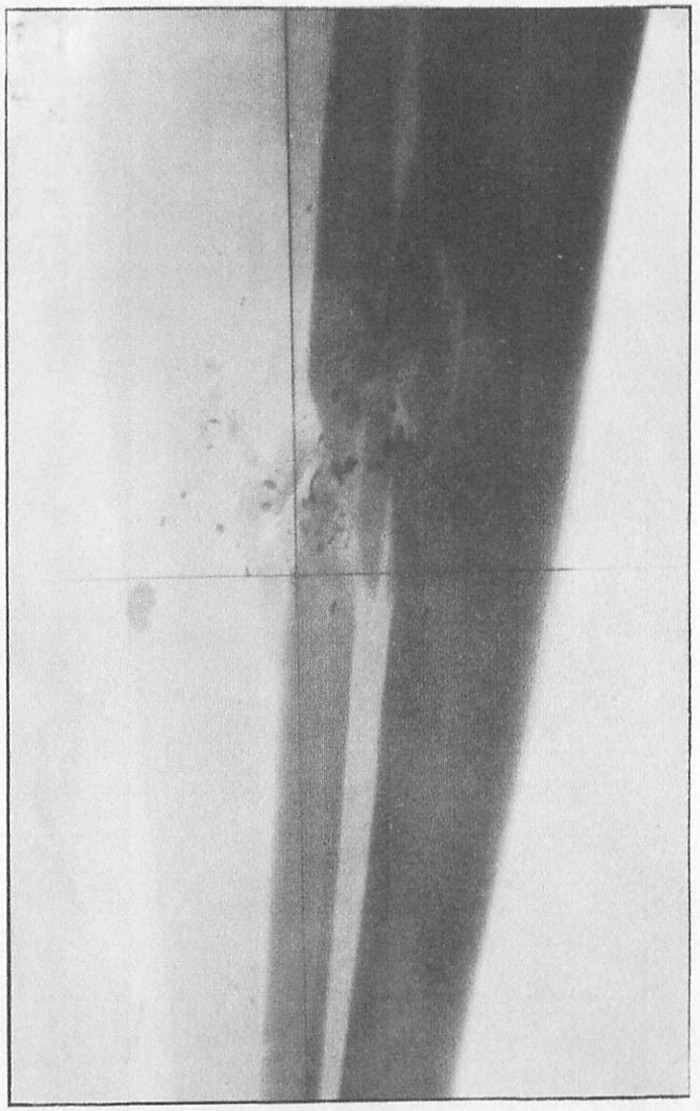
SOFT-NOSED MAUSER BULLET IN FINGER.

PLATE CXXIV. (*d*).
("*Archives of the Roentgen Ray.*"—*Copyright.*)



MAUSER BULLET IN CHEST.

PLATE CXXV. (*a*).
(*"Archives of the Roentgen Ray."—Copyright.*)



GUNSHOT INJURY TO LEG.

PLATE CXXV. (*b*).
(*"Archives of the Roentgen Ray."—Copyright.*)