THE WORKING OF THE ROENTGEN RAY IN WARFARE

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PERHAPS the most interesting addition to surgical science of late years is that which has endowed us with the power of investigating, by ocular demonstration, the condition of the interior of the body, whereby we are enabled to determine the position, size, etc., of foreign bodies which may have been adventitiously introduced into the tissues, and also observe the condition of injured bones, joints, and internal organs. Doubtless you are all by this more or less acquainted with the effects of that truly astonishing element, the X ray, a name modestly applied by its illustrious demonstrator, Professor Roentgen, to whom surgeons in particular, and the world at large, owe an inestimable debt.

The object of this lecture is to give my experience in the working of this curious element, the X ray, in military surgery, and through the universal kindness of many official friends I shall be able to give you the results of its employment on the recent Frontier Expedition in India, and then to lay before you some modifications in the construction of the appliances for generating the X ray, which have suggested themselves to me after working amongst the wounded on the field of battle and its adjacent hospitals; and I humbly beg your criticism of them, in the hope that some useful advance in the science may be originated, and additions made to our efforts towards alleviating human suffering, thus showing our craft to be still striding onwards and making laudable efforts at deserving the kindly praise bestowed upon it by the Secretary of State for War, Lord Lansdowne, in a recent speech in the Senate, and proving that we surgeons of the present day are aiming—as our illustrious forefathers ever aimed—at placing at least one more niche in the Temple of Æsculapius.

It is not within the province of this lecture to attempt a description of our knowledge of the nature of this wonderful element; I merely beg

to lay before you some of the most interesting results of its powers as applied to military surgery; and as I see both non-professional and professional friends have kindly come to give the subject their attention, I will make my best endeavours to describe the cases with as few technicalities as are conducive to clearness of demonstration.

As many may not care to go into the details of construction of apparatus, I will first exhibit some of the pictures taken during the recent Frontier Campaign, and give a short description of each, in the hope of entertaining those who would rather not wait for the consideration of what one may call the engineering or mechanical section of the subject.

I propose to show you, by means of the magic lantern, a few cases of interest which were taken during the Frontier Campaign. Amongst the first was the following one.

Case I.—This is a representation of the knee-joint. It shows the lower end of the thigh bone, and the upper ends of the two bones of the leg; also a piece of the knee-cap, the whole of which did not get into the area of the photographic plate. This patient was shot up in the thigh, the bullet apparently struck the lower end of the thigh bone and rebounded in a new channel made by itself; the interest attached to this case is that a probe passed easily down to the bone, but no evidence of a bullet could be got, the X rays however showed it to be about half an inch beneath the skin of the hollow of the knee. The case is also of interest in proving how a bullet made of soft lead can be flattened when striking a bone; for here you see a soft lead missile having struck the bone, been defeated by it, and lying with its flattened face towards its conqueror. Imagine our disgust when we discovered this long-sought-for trouble had been smiling at us within half an inch of our fingers!

Case II.—Here is a case where a bullet had travelled down from the middle of the thigh to about 2 inches below the knee-joint. This is a representation of the upper part of the leg—the bullet had entered the thigh about its middle-third, and simply been lost. It had evidently wound its way round the thigh, behind the knee-joint, to the point where you see it in the picture. You will notice its irregular outline, it was in fact a ricochet; another point of interest regarding this case is, that the patient at first would not consent to an operation for its removal; he was a native soldier of the Gourkha Regiment; he was sent to the base hospital at Rawal Pindi, where I saw him in January last; he had been in bed from October 20th, 1897, having been shot at Dargai. We examined him again at Pindi, and found the bullet had moved about an inch; he could not walk on account of the sharp edges of the bullet causing great pain and irritation in the tendons or sinews with which it was surrounded; after removal, however, he rapidly recovered.

Case III.—Here is a bullet lodged in front of the elbow-joint—the picture shows the lower part of the bone of the upper-arm, and the upper ends of the two bones of the fore-arm. This man was shot about the middle of the inner face of the upper-arm; no trace of the bullet could be made out; the wound healed well; the man was sent on two months' sick

leave; on return he applied for a pension, being a native soldier; his complaint was that he could not extend the arm to its full extent, it seemed to lock suddenly, when the joint had got at the angle shown in the picture. It was by mere chance that I saw the case, as he was suspected of what we call "piling on the agony" a bit to get a pension and go home and be married; however, here was the whole of a Martini-Henry bullet lying on the face of the joint; we could not feel it even when we knew its exact position. The round tendon, which you can all feel on the front of your elbow joints, overlapped the bullet, and the latter had by this time become so closely embedded within some muscular fibres beneath that it was impossible to feel it. The medical officer who removed it next day told me it took him nearly half an hour to separate this bullet from the fibrous material with which it was so tightly entwined; suffice it to say that the man was not "humbugging" and soon recovered.

Case IV.—Here is a representation of the foot. The chief point of interest attached to this case is that it demonstrates how small a foreign body will sometimes render a soldier incapable of performing his duty. Now the small body I refer to is that little angular black spot situated just under that prominence of the heel-bone, it was not more than a quarter of an inch in diameter, in shape triangular, and embedded in the sensitive covering of the bone, professionally called the periosteum; this membrane is full of nerves and blood-vessels; the case was that of a sergeant, a valuable and good non-commissioned officer; he had been shot on the upper aspect of the instep, four small pieces of metal, probably telegraph wire, had been extracted; the wound healed rapidly, but on attempting to walk he experienced a sharp stinging pain running up the back of the leg—for about six weeks he had tried to walk without success; the X rays showed the cause of his disability, and after its removal next day I believe he made a rapid recovery. I must explain to those who are not conversant with the anatomy of the heel, that the tissues covering this part are composed of very dense cellular material, within which it would be almost impossible to find so small a body without accurate localisation.

Case V.—This is rather a difficult case to demonstrate, yet it is one of intense interest. The soldier was a Sikh, one of two who were shot when bravely defending their regimental transport mules at the point of the bayonet; night had overtaken them, and they were rushed at close quarters when in a river bed, they had put on their warm coats, which are composed of badly cured goat-skin, the long hair covers one face, the tanned skin forms the other; one man was shot in the thigh, the other in the elbow; on the third day both showed symptoms of rapid blood-poisoning; several attempts had been made to extract the offensive bodies, but the limbs had become so much swollen and so many pieces of sloughing tissue had formed, that numberless tracks led from the wounds; it soon became evident that the cases would die from septicæmia or blood-poisoning, unless the limbs were removed, and even with this drastic treatment the issue was doubtful, on account of the flaps being composed of poisoned mortifying tissues. The X rays, however, localised the

offending bodies. Here is the one from the thigh, you will see how closely the bullet was wrapped within this covering of skin and hair; both were very offensive when removed, but by dint of careful antiseptic treatment the cases recovered rapidly, and three months afterwards I had the pleasure of hearing from their illustrious commanding officer, Colonel Des Vœux, of Fort Gulistan fame, of their restoration to duty; he was particularly pleased with their recovery, as they had distinguished themselves at the noble defence of that Fort, one being the sergeant who led sixteen men against overwhelming odds, and captured three of the enemy's standards at the point of the bayonet.

Case VI.—This case is one chiefly of surgical interest, at the same time, however, it has a romantic touch of reality, being the leg of a general, the very brave and able General Wodehouse. Its surgical interest consists in demonstrating the fact that not only bones, but fibrous tissue, commonly called gristle, will sometimes split a bullet, or chip pieces from its surface. The bullet entered the leg in its upper third, passed obliquely downwards, and was cut out on the opposite side of the leg in its lower third, having in its course passed through the space which you see exists between the two bones; this space is filled in by a tough fibrous membrane, and as the bullet pierced it, you see the membrane cut four pieces off its surface; there they are lying on the same plane, sticking in the membrane. The other point of interest in this case is the proof it gives us that even a jagged wound, such as this, does not of necessity cause intense pain, for General Wodehouse would not be laid up for long, and shortly after the injury was received he rode into Peshawar at the head of his brigade with the wound still unhealed. What you see in the upper part of the picture is a safety pin, for I may as well explain that it is not necessary to remove dressings or splints when taking pictures with the X rays, for they will pierce all such material.

Case VII.—Here is a case of intense interest, and one of great surgical value. It is that of a Gordon Highlander, who was shot at Dargai. The bullet entered the groin from the front, passed backwards, and was flattened out against the wing-like portion of the hip-bone, which spreads outwards from the spine; in that situation you see it represented in the photograph (picture A), and, as this picture was taken with the photographic plate lying against the spinal aspect, you see the bullet through the bone. A point of great surgical value in this case is, that for some reason or other the man thought the bullet had come out after hitting him. Many times was it searched for with probes, but to no purpose; a probe could be passed directly backwards for about 6½ inches. When I first saw this case in the base hospital at Rawal Pindi, about three months after receipt of injury, the man looked wasted, and there was a constant discharge of matter from the wound, also signs of an abscess in the hollow of what we call the pelvic cavity; this was gradually contracting the muscles which pass from the cavity to the thigh, and, consequently, the latter had become flexed on the body. I suppose that on account of his weak condition an operation for the removal of this offending body was not performed at once, and the next time I heard of the case was from Dr.

Mackenzie Davidson, who had been down to Netley on a visit to his friend Professor Stevenson; they had taken a picture of the case from the front aspect, and I show it to you now (picture B). You will see it is our old friend of the first picture, not altered in shape, but having changed its position. Evidently portions of bone had been killed by the blow of this bullet, and, subsequently, by its irritating presence, had become loosened and fallen away, thus letting loose the bullet, for it had fallen forward into the position you see it in picture B. One proof of this fact is that a probe would reach it at about 3 inches from the surface, whereas when seen at Rawal Pindi the probe passed 6½ inches backwards. Dr. Mackenzie Davidson heard from Professor Stevenson that when he cut down upon this bullet it was found lying loose in the cavity, and I surmise that an abscess had been formed out of the *débris* of the dead bone, and had gravitated downwards, and that the bullet, when loosened, had fallen down into the abscess cavity.

Cases VIII. and IX.—Here is a curious "splutter," I dare say you may call it. I have chosen it to show you how a bullet can be split up into many pieces by even small bones, for it is the hand of a Sikh soldier; he was shot through both hands when in the act of firing his own rifle. Some sporting shot amongst the Afridis evidently saw the Sikh "drawing a bead" on him, so he must have done the same and got first pull, as the bullet passed straight along the line of the Sikh's rifle-barrel, passed through both hands, entering each exactly in the position of the middle finger—here is the right one—there were seven bits of lead at first in this hand; some were removed after our first photograph, and this is a subsequent one, taken to discover the state of affairs. You will see how the supporting bone of the middle finger has wasted away almost entirely, and that the finger has fallen back, becoming the shortest in place of being the longest digit. Thus this case is one of the many which illustrates the value of the X rays in showing us how matters are progressing in wounds, and guiding us in treatment.

Case X.—This curious object shows what a smash-up a bullet may make in some parts of the body; it is the hip-bone of a native soldier. He had been wounded some time before I saw him, and an enormous lump of calloused bone had formed. Some of it was not fully developed bone, and consequently does not show so deep a shadow as other parts, so that the point of interest here is the representation of growing bone. On the inner and lower side you see this round object, which is the bullet.

Case XI.—In this picture you see what, in all probability, would have caused permanent disability to the man affected. It is a knee-joint, and between the bone of the thigh and that of the leg, and beneath the knee-cap, you perceive some irregular pieces of lead. Now when the joint is extended to the full, these three bones approach one another so as to come almost entirely in apposition. You can see that the joint in the picture is somewhat flexed or bent, and that when extended, and the bones approximated, they would squeeze these pieces of lead between

them; in so doing, the sharp edges of the metal would be pressed against the sensitive surfaces of the bones forming the joint, thus giving rise to much pain and irritation. This is precisely what was taking place; the patient could get the leg extended to the position shown in the picture, but when beyond that point he experienced a sharp pain in the joint, which prevented movement. No amount of probing could have localised these bits of metal, situated as they were within the fibrous material covering the joint—and the observation of their size, number and position, as you have demonstrated here, is the only method of research that could have enabled a surgeon to remove them.

Case XII.—I show this not as representing anything of surgical interest, but to let you see a somewhat curious result of X rays' work. It is the hand of an officer who was shot whilst wearing a pair of leather gloves; some portions of glove were carried by the bullet into the hand, and gave rise to local blood-poisoning; much swelling took place, and you see this represented in the picture; but what I want to call particular attention to is the distinct image of the plaster which encircles some of the fingers; at the time the skiagraph was taken there were several running sores due to blood-poisoning; these being painful, it was necessary to leave all dressings on the hand, even a flat wooden splint, and thus this case shows you how the X rays enable us to examine the condition of the interior of limbs when the patient cannot bear to have the part unsupported; the reason you see those rolls of plaster so distinctly marked out from the rest of the dressings is that lead forms part of their composition, and consequently renders their substance much less porous than wood, etc.; hence the X ray has cast a deeper shadow in passing through them. A point of surgical interest attached to this case is, that we feared some of the bones had become involved in the destructive processes taking place, but by this picture we were re-assured, for their condition is shown to be healthy; at one time it was quite a question whether it was not the most advisable proceeding to amputate this hand, and the satisfactory condition of the bones added greatly to the resolution in favour of conservative treatment.

Case XIII. A and B.—A question of much surgical importance was decided in the investigation of this case. I show you two pictures, the first taken a few weeks after the receipt of injury, the second about six weeks later. It is the hand and wrist of an officer who was shot through the lower part of the fore-arm and wrist; great destruction of the bones and joints occurred; in the first picture you will see that there appears to be three long bones in the lower part of the fore-arm, but the two on the thumb side are really portions of one bone that had been split by the bullet, and the joint between this bone and the wrist was fissured; now examine the picture B, and here you will see how completely these two portions have come together, new bone being thrown out, the joint surface levelled, and in all probability a useful joint will result from what former surgical precepts considered a hopeless case. In picture A you will also notice a good deal of spotting in various situations; this spotting represents portions of dead bone that have been thrown off from the injured and

dying surfaces; in picture B you will see these have disappeared, the dead bone having been cast out of various openings, and as Nature renovated the dying surfaces these spiculæ were no longer detached; thus this case demonstrates the great recuperative power of bony tissue in an otherwise healthy subject; a few dark blotches can be seen encased in the lower end of the fore-arm bone, these are splashes of the bullet, and since the new bone seems to be growing satisfactorily they are being gradually encysted and will probably not cause any further trouble. When I last saw this officer he was begining to recover some movement in that joint which had been so completely fissured, thus giving us sound hopes of recovery and the pleasure of watching its progress, in what at first appeared a hopeless state of affairs.

Case XIV.—Here is another instance where I think we may fairly claim success for the X rays. It is that of an officer of the 3rd Sikhs, who was shot in the chest at the attack on Dargai. The bullet is supposed to have struck the breast-bone at an angle and to have been split by the dense bony tissue. To all appearances the bullet had passed out a short distance from where it had entered. But in spite of a magnificent constitution and brilliant health this officer did not progress so well as the medical officer in charge could have wished; there was some rise of temperature, cough, etc., which symptoms always give rise to anxiety when connected with the chest. I was asked to examine the case with the X ray, and found what you see here. Just beneath the second rib on the left side you perceive a round dot. Now to a professional eye it was evident that some foreign body of a non-porous, probably metallic, nature was situated there. I had to proceed further to the front early next morning, so I was dependent on the report of Surgeon-Captain Bates, A.M.S., his able medical officer, for the further history of this black dot. In effect it was that he cut down on it at once, finding what was evidently one end of an irregular piece of metal. It was extracted with some little difficulty, being about 1¼ inches long and twisted on its own axis, with some sharp points protruding from its edges. There was also some pus or "matter" surrounding this foreign body. After removal the patient progressed very satisfactorily, and returned to duty with his regiment. Now to anyone conversant with the anatomy of this region it is evident that had this foreign body not been discovered and removed there must have existed great danger of an abscess being formed, and in its development have caused complications of a very serious nature, for matter will travel very rapidly in this situation, either by gravitation into the sac surrounding the lung, or by a destructive process, eating its way into the lung substance. By so doing it might have lighted up a purulent inflammation of the lung and other serious complications, which it is needless for me to enumerate here. Doubtless several attempts had been made to discover whether any portion of the bullet was present near the seat of injury, and without success. This can be readily understood if you examine the picture, for to pass a probe along an irregular channel is always difficult, but to succeed in hitting off the pointed end of a foreign body like this, when wedged between two ribs, is practically impossible,

and you might grovel about for several times without hitting it off, most probably never attaining this end; besides there existed only the probability of a foreign body, so no one would have been justified in trying several times, hence the danger of the complications above mentioned. In all probability some portion of this bullet had passed outwards, and this remaining bit had travelled backwards between the first and second ribs.

Case XV.—In spite of my time being up, and the eye of our august Secretary on me, I must show you this triumph of what we call a powerful X ray; the case is also one of great anatomical and surgical interest. A bullet entered the right side of the chest at a point in the lower end of the arm-pit; it had penetrated the substance of the liver, but where it had gone afterwards was a mystery. The man had suffered a good deal from shock at first, and all the disagreeable conditions attending a wound of the liver, but he was regaining strength when I saw him; there was, however, a large open channel passing far into the liver substance, but no bullet could be discovered by probing. I tried to find it in the liver with the X rays, but failed, and in desperation had a peep at the other side of the body, finding what this picture shows you. Just in the centre you see a round black object; that is an ordinary round bullet, such as the Afridi fires from his native-made gun. It is perfect in shape, so evidently did not strike a bone, but the great interest attached to this case is that one would regard it as impossible for such a body to pass from one side to the other in this part of the abdomen without causing some fatal injury. I may tell you that in its track it must have passed between many vital organs, enormous blood-vessels, crowded together in a small space, and several nerves endowed with vital functions, any one of which would, if wounded, have caused a fatal issue. The picture is taken in the centre of the left loin, the bullet having entered on the right side of the chest.

When organising any apparatus or materials for use in warfare, one has to consider many details peculiar to the special work the apparatus may be engaged in, so for convenience of description I propose to divide this portion of the lecture into the following headings:—

1. The best form of apparatus for military work.
2. The safest means of transport.
3. The difficulties met with on and near the field of battle, and the means of overcoming them.

Now I think you will agree that one great desideratum in the construction of all apparatus for military work is, that they should be what one may call "get-at-able," thus enabling us to renovate the inevitable defects of wear and tear; every portion of our apparatus should undoubtedly be easy of access, the coil, the condenser, connections, etc., should all be packed in cases that can be opened and inspected at a moment's notice, without the necessity of special instruments; there should be no looking about or sending for particular screwdrivers, wrenches, etc., no hurrying or flurrying of attendants; the operator should be independent of help; and with a view to obtaining this desirable condition the Medical Department of our Army has spared no expense

or trouble, having after due consideration ordered the apparatus which I now place before you.

This is the apparatus: I hoped to have shown you one of greater dimensions, but the manufacturer has been unable to complete it in time. This is an exact representation of the apparatus which the Medical Department forwarded some time ago to Egypt, and I may as well tell you that even after all the consideration, and all the trouble which has been taken, there are many details which the manufacturer acknowledges can be improved even in this apparatus. The fact of the matter is of course that this science is only in its infancy, and the more we go on learning the less we find we know. However, there is no doubt that this is an apparatus which, if carefully managed, should work successfully. You see it is not a very bulky one; the whole thing is enclosed in this box. It is made by Mr. Dean, of Hatton Garden, and he has shown a great deal of ingenuity in its construction, and a great deal of care and trouble in its manufacture. I do not think it is necessary for me to go into the details of the ordinary construction of this apparatus. Suffice it to say that beneath here we have an apparatus for the generation of the secondary current of electricity which is essential for producing this X ray. Here you will see a most ingenious stand which, when taken to pieces, will fold up and can be carried in this drawer. This stand will bend in any direction downwards on any side, and so on, and you can also bend this tube in any direction.

[Apparatus described.]

Mr. Cossar, of Farringdon Road, supplied me with only three tubes. He said he thought that they would work, and work they did. They were used in more than 200 cases in Tirah; they went through all the rough transport country, and they landed back at Rawal Pindi, in January, in as good working order as when I took them out, with one exception, and that was that we found a tremendous difficulty in working with the delicate electrical connections of these tubes. Here is a broken one, I unfortunately let the box lid fall on it; it was a folding box, and the lid fell on the tube. Here you will see what sort of make-shifts people have to design when they are facing the difficulties of military work. This tube was my best; it had taken that chest case, the hip case, and four or five other very interesting ones. This was a case which this tube had taken with extraordinary intensity, and with wonderful purity of X ray; and to my utter disgust, one day I was trying it in a difficult case in a tent, and the wind blew the flap of the tent in and broke the connection away, and there was my best tube gone! However I am much indebted to a most excellent and kindly scientific man, Mr. Dalby, of the Indian Telegraph Department. He and I rubbed our heads together, and scratched them in various ways, to see if we could not renew this little tube. He said:—"I think if we were to make a sort of cap of some material, we might do it." Well, I set to work, and he got what is called Chatterton's Compound, which sticks to glass, from the Telegraph Department of the Engineers, and put a spiral coil of wire, connected it with the broken ends of that terminal, covered them over with Chatterton's Compound, and that over

with sealing-wax, and to our great joy we found our tube worked just as well as ever. There are many difficulties which, anybody who works with military apparatus, will have to encounter. I was going to describe them in a little more detail, but time will not allow.

Yet there is one very important subject, that is, the most desirable means of transport for our apparatus.

Whilst introducing this subject I beg to point out that it is not only possible but quite easy to have an X ray apparatus working at the front; further, also that the cases already exhibited contain indisputable proof that even in savage warfare, where the Geneva Convention is unknown, the X ray can be brought under control, and an immensity of human suffering obviated; it is not necessary that every field hospital or bearer company should be supplied with an apparatus, as it can be readily transported from one part to another of the field of operations. I feel sure you will see what an advantage it is to be able to localise bullets, and other foreign bodies, without the painful process of searching with probes, and that a threefold advantage is gained in the treatment of our patients by this means: first, the absenceof any pain or physical injury; from which arises the second advantage, in cases where there has been much loss of blood or injury to bone, we are enabled to ascertain the exact condition of affairs without the risk of increasing the depression of our patient by operation, and we thus give him the best chance of re-action, upon which depends his recovery. Who indeed has not seen on active service many a case where the vital powers have held out to their last flicker, and are probably being supported by a cheerful and magnificent heroism on the part of a brave man, where, with proper means at hand, the surgeon has been enabled to fan that last flicker into restoring flame, which he would have been powerless to accomplish without scientific aid—and who with much experience of active service has not gone through the indescribable chagrin and sorrow of witnessing the converse! Therefore, ladies and gentlemen, I maintain it is now the duty of every civilised nation to supply its wounded in war with an X ray apparatus, amongst other surgical aids, not only at base hospitals, but close at hand, wherever they may be fighting and exposing themselves to injury in the performance of their hazardous duty. After trying every kind of transport in India—mules, camels, wheeled vehicles, etc.—I came to the conclusion that by far the safest and most satisfactory in every respect is human transport. Coolie labour can be obtained in most places, and where not, any European could be employed. As the portable apparatus should not weigh more than from 80 to 100 lbs. two men are all that is required for the moment and a reserve of two more, with reserve equipment, complete the transport I beg to exhibit for your consideration; a bamboo pole or hollow steel bar of about 6 feet in length, is what I found the best construction from which to suspend the boxes; each end of the pole is carried on the heads or shoulders of the bearers, and the boxes are slung from the pole. In Tirah I employed a disused Dhoolie pole and Dhoolie bearers to convey my apparatus; they willingly volunteered for the service, and carried the whole apparatus from Bagh Camp in Tirah, down the defile

to Dwatoi, and down the Bara Valley to Peshawar, without injury; parts of this march were beset with difficulties seldom experienced in any kind of warfare, and yet these faithful followers landed their charge in good working order, at a time when it was sorely needed. It may interest you to see a few photographs I took during this march, as they will serve to show the difficulties of transport in such a country; yet photography cannot adequately exhibit the conditions, for rocks, icy-cold water, rapid torrents, frost, and snow do not come entirely within the grip of our photographic lenses. Mules, camels, and wheeled transport are too uncertain conveyances for delicate materials, except of course where we have good roads and plenty of room; but our military apparatus should be independent of these luxuries, and it seems to me that this transport fulfils the necessary conditions.

[Magic lantern slides were here shown illustrating the difficulty of transport.]

In the third part of this section I will give you what appeared to be the difficulties specially involved in working the apparatus at the front. The generation of our primary current of electricity is at present a very serious consideration. The only means I had in Tirah was a heavy and cumbersome primary battery, worked by a mixture of bichromate of potash and sulphuric acid; the latter is too dangerous an article for military transport, unless accompanied by someone who will look specially after it. I ran out of the supply in Tirah, the railway company refused to forward more, and I had to gather together the few ounces carried in the equipment of the various field hospitals. I, therefore, condemn this form of battery for field work, and beg to recommend the employment of a hand dynamo and portable accumulator. This combination has many advantages; in the first place, it will stand rough transport, and should one get out of order the other can be substituted. Thus, if the accumulator is run out or injured, the dynamo can be used to give sufficient current for most cases; with an army in the field there is always plenty of hand labour for this purpose; and again, if the dynamo is out of order, the accumulator can be charged at the field telegraph station.

We shall often experience a good deal of difficulty in examining cases in the open air or in tents from conditions of climate; hot sun, rain, frost, snow, and wind, all militate against a good result; the baneful effects of hot sun are chiefly seen in the condition of the wax which insulates the wire of the secondary coil; should this melt, the coil becomes useless. We have experimented and found that the mixture of paraffin wax and resin in which this coil is embedded [exhibit] will not melt until the temperature is raised above about 150° Fahr. which should be enough for all practical purposes; this covering of felt [exhibit] also protects it from sun, rain, snow, and frost.

I experienced much annoyance from high winds when working in the open or in tents—the delicate platinum terminals of our ordinary Crooks tubes were constantly breaking from the strain of the shaking

wires, and I had to strengthen them by embedding them in this cap of sealing-wax [exhibit]; but Mr. Dean has devised this vulcanite case [exhibit] for each tube, which seems to get over the difficulty.

Another matter requiring special study for military operations is the quality of our "connecting" and "lead" wires; I tried several patterns, and found they all leaked at times, especially in damp, hot weather, and the one which gave the best results is this common thick telegraph wire —its insulating material of rubber, wax, and hemp, is far more serviceable than any of the fancy silk varieties.

Regarding the use of the fluorescent screen at the front, I must say it seems to me to be the most important part of the apparatus for urgent cases; by its means we can explore without delay the whole body, and its condition is therefore a matter of much importance. I am indebted to Mr. Le Couteur, of the London Photographic Association, for the suggestion of protecting its surface with a layer of celanite, and having the whole enclosed in an aluminium case [exhibit]; this protecting layer of celanite is most important, for no matter how careful one is the surface is liable to be scratched, and you will find that in military surgery your operations have frequently to be conducted under conditions of temperature where perspiration, like the babbling brook, flows on for ever, and soaks through everything porous; besides the danger of the enthusiastic onlooker, who in his laudable delight at discovering the shadow of a bullet on the screen, seems quite unable to resist the temptation of diving his finger at the inoffensive shadow of the offending bullet, and from climatic as well as preventable causes the military finger is not always chemically inert.

Regarding the employment of glass photographic plates for taking radiographs, there is of course the danger of breakage in transport. I broke many, but after trying films, bromide papers, and Messrs. Eastman's X ray papers, I came to the conclusion that we have not yet arrived at a satisfactory substitute for glass—the gelatine on films is very apt to deteriorate in hot damp weather, and I was not successful in obtaining good pictures with Messrs. Eastman's X ray papers, though it was probably due to my want of practice in their development. It would undoubtedly be a great advantage to discover an unbreakable basis for our sensitive photographic film, but I must confess I have not seen one yet, though we are working diligently to discover the much-needed element, and hope soon to succeed. I cannot let this matter pass without paying a tribute of high appreciation to Messrs. Paget's XXXXX plates—I had three dozen at the commencement of my venture in Tirah, and through all the adverse conditions they worked admirably, giving at the end of four months' rough travel as good results as at the beginning.

In conclusion, ladies and gentlemen, I beg to thank you for the honour you have done me by your patronage, and ask you to overlook the many defects incidental to the exposition of a scientific subject which is only in its infancy, and in the knowledge of which I am but a humble tyro, though I trust we shall now get the benefit of older and more experienced heads than mine, and thus gain some useful hints in what I venture to assert is a most interesting subject.

Lieutenant H. O. MANCE (R.E):—Anyone who has attempted to travel about in England with a complete X ray equipment will appreciate the difficulties of transport which must have occurred in the Frontier Campaign. I am inclined to think the author is rather sanguine when he says the weight of the complete portable apparatus will be from 80 to 100 lbs., especially if an accumulator battery is included. I entirely agree with the author in his condemnation of primary batteries except on an emergency, and I would go even further and be inclined to trust to the hand dynamo alone as a source of electrical energy on service. It would be interesting to know what maximum power the author found it necessary to provide for. Allowing 10 per cent. loss in the gearing and 40 per cent. in the dynamo, one-man power would generate about 37 watts. A dynamo capable of being worked by two men would probably provide ample power. The above estimate assumes that the power is applied to a winch handle. If leg power is used, probably about 30 per cent. more power would be obtained. With regard to accumulators, those of the ordinary liquid types are objectionable on account of:—1. The acid contained by them. 2. The excessive weight. For instance, the traction cells by well-known makers of Faure-type cells have a capacity of 7·5 watt-hours per lb. of gross weight of cells in ebonite boxes. A battery capable of giving an output of two-men power for five hours as estimated above (370 watt-hours), would weigh about 50 lbs. When a teak case is included and allowance is made for the diminished efficiency of small cells, the weight would probably be found to be over 80 lbs. Even if a second set of cells were not considered necessary for use, while the first set were being charged, a few reserve cells would also have to be taken to provide for the deterioration of the plates. This latter is a most uncertain factor, especially in the Faure type of accumulator, if the cells are worked beyond their rated maximum output or allowed to run down, a by no means improbable contingency during an important examination. The Planté type seems to be best for large output and small capacity batteries. Of dry storage cells very little is at present known, but it is somewhat doubtful whether any reliable and mechanically strong battery exists under 50 lbs. weight, which would furnish the above output. To be able to dispense with this weight might be an important consideration. There would be a great deal of trouble occasioned and time and energy wasted in charging the cells from the hand dynamo or at the field telegraph station. It seems to me that secondary batteries are only advisable where there is some ample continuous current supply available for charging purposes, and even then only when the supply itself is not available for direct use. A hand dynamo, on the other hand, if well made cannot be overworked owing to lack of power, and could be constructed to stand almost any amount of rough usage and to facilitate porterage. To use the available power to the best advantage the resistance of the armature windings and series field coil of the dynamo should be as low as possible. There must be a shunt field winding to maintain the field during the break in the main circuit. A magneto-machine would be simplest, but probably too heavy. A hand dynamo might possibly furnish a current not sufficiently steady for screen work, but I think a little practice would get over this difficulty if it exists. In the unlikely event of a failure, batteries might possibly be temporarily borrowed from the R.E. and used direct without the loss of power which would be occasioned by charging accumulators. The employment of someone on the staff skilled in instrument repairing would minimise any delay due to breakdowns of apparatus. With regard to the use of Eastman's paper, besides being less liable to damage it would have the following advantages over plates:—1. It is lighter. 2. It requires less operations to get a finished print. 3. More than one print can be taken, if required, at the same time. 4. The result is a positive and consequently represents the object in the right position. The ordinary prints from a plate are negative prints and show the image reversed. However, though some good skiagraphs have been taken on this paper, my experience bears out that of the

author that they are not so good as plates, given equally favourable or unfavourable conditions. Films possess all the advantages of paper over plates, for positive prints can be obtained from them by printing through the films the wrong way. They will most probably supersede plates in warfare. I have always used Cadett's "Lightning" plates with "Velox" developer, and find they give very satisfactory results. Though a 6 to 8-inch spark is quite sufficient for all purposes, experience has, I believe, universally shown that, for screen work especially, it is better to use a coil of higher capacity so as to maintain a regular discharge under all conditions. An App's 10-inch coil weighs about 60 lbs., but could be made in two separate parts of about 30 lbs. each. With regard to the difficulty experienced by the patients moving,—following a suggestion of Surgeon-Major Perry, A.M.S., I have found small half-filled sandbags suitably disposed about the part to be examined to ensure perfect freedom from involuntary movement. For long exposures it might be advisable to put the patient under chloroform. It would be interesting to hear what precautions are considered necessary to keep the stock of plates from the action of wandering X rays. Also the quantity of stores considered necessary for a campaign such as that on the Indian Frontier, and the most suitable size of plates or films, etc. In conclusion, I must congratulate the Medical Staff on the excellent results obtained. As an amateur, I find that there are so many points to be attended to in X ray working at home before satisfactory results are assured, that such successes as we have seen attained by this pioneer field equipment under overwhelming difficulties plainly show what great care and perseverance must have been exercised by the operators.

Mr. JOHN LE COUTEUR:—I have often wished to hear the results of the X ray in actual warfare, because it has been a matter of very great interest to me, and I have therefore followed the proceedings with very great interest. At the present moment I am experimenting with a view of making an apparatus—or having it made rather, because I do not make apparatus—so that a damage can be repaired on the actual field of battle. If a coil is damaged it is very often thrown quite out of gear, and rendered useless, whereas if you could repair the damage easily you might start an 8-inch coil, and come back with one perfectly useful, working at 6 inches. I have brought here to-day one or two sections to illustrate that point. This is a section of a coil. Supposing we made a coil in what we call the junk fashion, so that the engine junk can be taken out and a fresh one put in its place. Any lady or gentleman who is interested in the matter may see these specimens of the inside of the coil which are here for inspection. The great difficulty that we have found at the present moment has been that the coil has been so screwed up and embedded in wax and all that kind of thing that when damage was done it requires an experienced man and quite an elaborate tool shop to put it right. What I should like to see would be a coil which would be at once, within three or four minutes repaired and put into position for work. With regard to the latest developments in tubes, I must pay a little tribute to Dr. Mackenzie Davidson's tube. On Saturday last I was able to take a very fine photograph of a spine, under five minutes. The time before it had taken much longer than that, but apart from the actual photograph of the spine, the definition was beautiful, and certainly it is the finest tube that I have met with yet. Of course, a tube of this pattern would be rather difficult to carry in such a case as has been described by Surgeon-Major Beevor, but at the same time it is a tube which can be used whenever the X rays are used. Another matter which I do not think Dr. Beevor touched upon very well was that of taking a storage battery. That has been a point of extreme difficulty, and I should be glad if some person present could give us his opinion with regard to an idea which has been discussed between Dr. Beevor and myself about having a battery something in this fashion filled with gelatine, which can be easily charged up by a hand motor. I have been speaking to an experienced electrician about the matter, and he thinks it is quite possible that a hand motor could be taken on the field service to weigh about 50 lbs. A couple of men could

charge up the cells in from two to three hours, or for an emergency case they could get sufficient electricity to drive a 6-inch coil in about twenty minutes. If that is possible it does away with a great deal of the difficulty. These are the various forms of tubes for various classes of work. There is a tube here which is used for the inside of the face. This was made by my friend Mr. Cosser, and he also made me one for internal symptomatic photography, which is useful for special occasions and for rare cases. There is another difficulty. I am referring to difficulties, because I hope that by thought being directed to this matter we may arrive at something approaching perfection. The brake which I found most useful has been the Vril brake, but even that has its disadvantages and takes some time to adjust. The nearest approach to the brake which I have yet put in actual use is a modification of the Vril brake. The mercurial brake is altogether out of the question, and need not be even discussed. On the field you have not a dark room, and there has been a device made in Paris during the last few days for developing a plate in the daylight. A chemist in Paris has been consulting me as to the best means of getting over a little difficulty; that is, the action of the alkalies on the surface of what we call a developing box. I fancy we can get over that difficulty, and I hope in the course of the next few days to have a sample over of what we call the developing box, so that therefore the Roentgen photograph can be taken on the field and developed in the open air without the use of a dark room. As Surgeon-Major Beevor remarked, very often there is no time for taking an actual photograph, and you want to see by means of the fluorescent screen what is happening and where the bullet is, or the injury, and we have devised a screen for that purpose. There is a fluorescent screen here which has been made for me. It is one on a modified scale. I have not the screen in this, but it is merely a box which can be opened and the screen is put in here, and then the surgeon looks through the back of the bag, and he has an impervious dark room.[1]

Surgeon-Major-General T. F. O'DWYER, M.D.—I did not come here to make a speech but simply to learn something, and I have learnt something to-day. There was one matter which the lecturer has referred to with regard to which I should like to ask for a little more detail, and that is, the system and the means of obtaining the electricity. He says he was not satisfied with the apparatus he had on the frontier, and he points to a hand dynamo which was the best means of obtaining the electricity. Then he says an accumulator can, if necessary, be charged at the field telegraph station. I have no doubt it can if you teach the people there how to do it; but my practical experience of the matter is this, that at present field telegraph stations are not competent to take charge of these apparatus; I think they damage them. I believe they require more instruction. That is a matter of detail which can be very easily got over. We should ask the assistance of the Royal Engineers in a matter of that kind. I should like to have the lecturer's experience as to how many Roentgen ray apparatus he thinks necessary. He says he does not desire every field hospital to have one, or needs one, but we must remember what a field hospital is intended for. It is attached to a brigade; and in a brigade there are four regiments, and that is a tolerably large unit. I think it would be better—of course it is presumption on my part to offer an opinion upon a matter in which I have no practical experience—if every field hospital had an apparatus of the kind. On active service the apparatus would be very often required, and one might replace the other. Therefore, speaking in a reasonable way, I do not consider we can have too many of them. It does not do to be hunting over the field of battle to get an apparatus to deal with the wounded men, and I suppose no one will dispute but that it is of

[1] Since the above the experiments have proved a success, and a hand-motor has been devised by the Photographic Association, so that the difficulties of taking accumulators, etc., has been overcome.—J. Le C.

very great importance that bullets and projectiles should be removed from the limb as soon as possible, and before inflammation is set up, and before dangerous symptoms are set up (although I am well aware that a movable field hospital would not always be the best place to use the Roentgen rays). That can only be done by having plenty of these apparatus by you and having trained instructors who can make use of them. In every base hospital I take it there would be one of those apparatus, and I believe they should be in all the field hospitals. I merely would like to have the lecturer's opinion upon that.

Dr. J. MACKENZIE DAVIDSON:—I am a non-combatant, and therefore I must approach the subject purely from a scientific aspect. In the first place, I should like to congratulate Surgeon-Major Beevor upon being a pioneer, especially under such very difficult circumstances. I think the work he has done confers great credit upon himself and also upon the apparatus provided for him. I think in addition to the ordinary X ray apparatus supplied, there should be supplied some apparatus to enable the precise localisation of the bullet to be carried out. I think it is very important to know the exact position. That can be obtained by very simple means, which I need not go into at present, but I simply draw attention to the point, because if the exact position of a fragment or fragments is known, they may be removed, of course, not only with much greater precision, but the searching about which is necessary with the present skiagraphs which are obtained, is avoided. A skiagraph produced by even the very best tubes, and with the best definition, is really a picture on the flat; it is a projection. It gives no idea as to the exact position or level of the bullet, and therefore some apparatus should accompany the coil and tubes to enable localisation to be carried out precisely. As to the means of best providing a current, that certainly is a very difficult question. Primary batteries are always very unsatisfactory. Accumulators of course have to be charged, and no doubt some form of dynamo worked either by hand-power to charge the accumulators, or even in the case of emergency to work the coil direct, would probably be the best. As to the tubes, I must say from my experience of tubes, Surgeon-Major Beevor showed great courage in only taking three with him, because I not uncommonly destroy three in a short time working with a strong current. Therefore, in the matter of tubes, there should always be a very considerable number supplied. Of course if the tube fails the rest of the apparatus is absolutely useless. Therefore I think a large number of tubes should always be supplied with any apparatus in the field.

Surgeon-Major W. C. BEEVOR, in reply, said:—These are the tubes which Mr. Le Couteur mentioned as being the best, the osmium-focus tubes. Dr. Mackenzie Davidson has given us his opinion in the matter, and I may say I am in entire accord with him. There is no tube to equal this pattern; there is no doubt about that. Dr. Mackenzie Davidson showed me yesterday when I had the great pleasure of first making his acquaintance, a method by which he tests these tubes. It is quite unnecessary for me to go into technicalities, but those who have worked some time with this X ray will very readily appreciate the value of these osmium-focus tubes. They really show you the bullet in its proper position and of its proper shape. With regard to the question of the storage battery, I am very glad that Surgeon-General O'Dwyer and Dr. Mackenzie Davidson and Mr. Le Couteur have drawn attention to it. If you will excuse me, I will just read my opinion on the matter:—"I will give you what appeared to be the difficulties specially involved in working the apparatus at the front. The generation of our primary current of electricity is at present a very serious consideration. The only means I had in Tirah was a heavy and cumbersome primary battery, worked by a mixture of bichromate of potash and sulphuric acid; the latter is too dangerous an article for military transport, unless accompanied by someone who will look specially after it. I ran out of the supply in Tirah, the railway company refused to forward more, and I had to gather together the few ounces carried in the equipment of the various field hospitals. I, therefore, condemn this form of battery for field work, and beg to

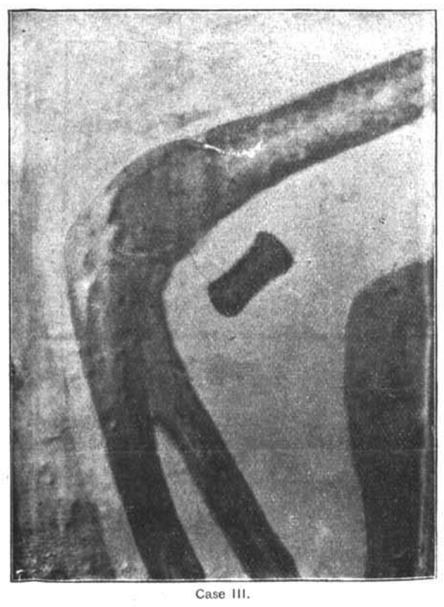
recommend the employment of a hand dynamo and portable accumulator. This combination has many advantages; in the first place, it will stand rough transport, and should one get out of order the other can be substituted. Thus, if the accumulator is run out or injured, the dynamo can be used to give sufficient current for most cases; with an amy in the field there is always plenty of hand labour for this purpose; and again, if the dynamo is out of order, the accumulator can be charged at the field telegraph station." Surgeon-General O'Dwyer has very kindly raised a question of much interest. He very truly remarks that at field telegraph stations you cannot expect—and if you do you will be disappointed—to find men who will charge your accumulator successfully and properly. But here again I maintain, as I have maintained all through, that the operator who undertakes the responsibilities of an X-ray apparatus should be independent of help. He should charge his own accumulators. You will find I am quite sure that the Royal Engineers and the Telegraph Department will help you in any way they possibly can—at all events that was my experience in Tirah, and I have greatly to thank them for their help and assistance. If it had not been for their help I should have lost many good cases. You will always find that the Royal Engineers are very hard-worked in a campaign, and therefore you cannot expect them—either officers, non-commissioned officers, or men—to work what one may call overtime for the benefit of the X ray apparatus; much as they probably would be willing to do it, they have not the time. Therefore, I maintain we ought to take out one of these dry batteries. I have been trying several lately, and I have feared to bring them here, because we have not found a satisfactory one yet, though in a few days I think we shall succeed. I have tried three kinds in India, but none of them were successful. There was one successful kind of cell—some people might know it here—the dry electric cell, and that is the Obach. They use it a great deal in telephone companies, and so on. I got hold of some in India, and gathered them together, and I must say they worked admirably. Of course the difficulty in all these questions is great. It is very difficult to explain to a mixed audience of people who cannot be expected to understand about the force and strength and pace of an electric current, and therefore it will be unnecessary for me to go into details; but I must say that a primary battery will, I fear, always give us trouble at the front. I wish it was not so, but I am afraid it is. There is one thing I will say now whilst we are talking about trouble in the protection of tubes. I must say, with all due deference to other opinions, that if we had a small reostat attached to our apparatus it would be undoubtedly of great benefit. The man working the apparatus may have the fever, or he may get shot, or wounded, and if an unskilled hand begins to handle these tubes he is likely to do some damage. Even a skilled hand like that of Dr. Mackenzie Davidson's when he is playing with them breaks them, sometimes as many as three in a day; and if an unskilled hand takes them—unskilled in the regulation of the current that he drives through them—he will ruin the whole thing undoubtedly. But if you give him one of these reostats, you certainly do fit him up, I maintain, with a distinct advantage in the treatment of his tubes. With regard to the number of the apparatus which are necessary for the force, I quite agree, of course, with Surgeon-General O'Dwyer, that it would be a distinct advantage if we had one attached to each brigade, because, as he truly says, brigades and even units of brigades are sometimes separated many miles from one another, and may be attacked simultaneously; and so if you have one apparatus for a division, of course you must be able to travel from one brigade to another. Therefore it would be an advantage undoubtedly if we had one attached to every field hospital as a part of the equipment of a brigade. That is his opinion, and I should say it would be the opinion of everybody else who has studied the matter. With regard to the question of localising apparatus, which Dr. Mackenzie Davidson has very wisely brought up, there is no doubt if we could have a portable apparatus for the localisation of bullets it would be an

immense advantage There are various ways of localising bullets which one has thought out more or less at times, and often failed; but still the rotation of a limb for showing the distance of a bullet from the bone is a most helpful procedure. You can put it under the screen, but you cannot localise it with perfect accuracy. The best example I had was in the case of the foot which you saw where there was a small piece of lead a quarter-of-an-inch in diameter, and where the tissues over that portion of the foot are very dense and it is difficult to find foreign bodies in them. A very clever young surgeon—Surgeon-Lieutenant Fleury, A.M.S.—cut it out the next day. I give him all due honour for his skill, not only in that case but in others. He made a cross on the skin, and said:—"I think that is about where we shall get it," and he cut right down on the actual spot; that was luck, there is no doubt about it. I hope some day we shall be able, with Dr. Mackenzie Davidson's assistance, to design a localising apparatus which will put the question of our power of exact localisation beyond the chances of luck. I thank you very much for your attention.

The CHAIRMAN (Surgeon-Major-General J. Jameson):—Ladies and gentlemen, any remarks that I have to offer in concluding the debate must necessarily be practical, rather than mechanical or scientific. Every day we find more and more use for this kind of photography. For example, Dr. Stechow, a surgeon of the Prussian Army, lately found that a certain condition of the swelling of the foot occurring in soldiers after prolonged marches, and at field manœuvres, and which the French and Germans have described under the head of various names, such as footœdema, pied forcé, and such like, is really due to a fracture of the second metatarsal bone of the foot. This was quite unsuspected until it was demonstrated by the instrument. Of course this involves the question of treatment if we are to avoid the permanent injury following such an accident. I must say I have heard very little of that kind of accident in our own Army, although it is spoken of so frequently elsewhere, and I wonder if it is that perhaps our race have got larger or stronger feet than those of our neighbours—but that is another story. No doubt one of the most important things to be attained by this photography, is the possibility of forming an opinion of the nature of the fracture without removing the splints. This opens up another question as to supply and equipment, because it is manifest that our old iron splints, or even plaster of Paris apparatus, would be a very wrong thing to use under these circumstances interfering very much with the photography. Fortunately in the new equipment we have a different apparatus with open wire and wood, which will work admirably. Reference has been made to the necessity of supplying these various apparatus, very freely I thought, to the hospitals in the front, but the difficulties of transport must really be considered. It seems to me that from our present knowledge the advantages are not so very great after all in that part. The place, I think, for them is the line of communication, or at the base hospitals, because after all nothing except very urgent operations are advised to be performed in advanced places. What the photography really determines is more the position of a bullet, or the kind of fracture, but the urgency of an operation is determined by other considerations. There is one thing I was very much interested in, namely in the picture of General Wodehouse. I take a personal interest in it, having known that distinguished officer in Egypt, and also his father, Admiral Wodehouse, at Southsea. There is one circumstance that was not shown in the photograph, and it is this. While the operation was going on for the removal of the bullets, the Afridis crawled up, and suddenly blazed into the operating tent, and put thirteen shots through the canvas. That might have been a very disturbing element, interfering with aseptic surgery; but what happened? Nothing! The operation went on as if there was not an Afridi within 100 miles. In the Army we have taken very much interest in this subject of the X rays, and for 18 months we have had an apparatus at work at Netley, and the professor of surgery, Professor Stevenson, has done very good work indeed. I think he is more in

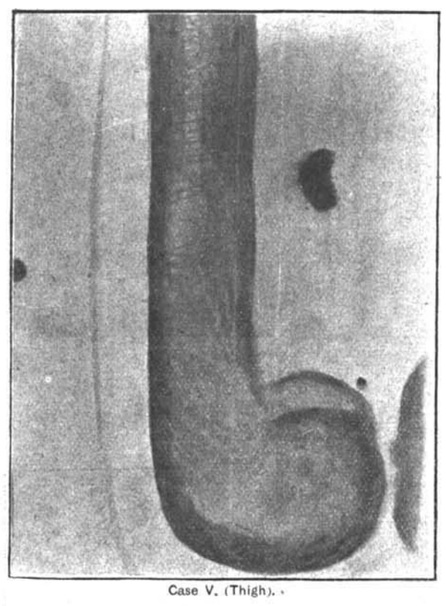
love with the apparatus which has been invented by Dr. Mackenzie Davidson than by any other. He speaks in the very highest terms of praise of the way in which by it any foreign body can be localised. We have also an X ray apparatus at Aldershot, and there the young surgeons undergo instruction in the art. I was very much pleased to see that five or six of them have become very good performers, and as a result of that three of them are at the present moment under orders for Egypt. We have also sent out two instruments to Egypt, one for use in the front and the other for the base at Cairo, and another is being perfected, and we have had the advantage of Surgeon-Major Beevor's experience in trying to introduce all the new improvements. We hope in a few weeks to have an apparatus at the Royal Hospital at Dublin, and another in the Herbert Hospital at Woolwich, and one at Gibraltar; and elsewhere as we can afford the funds. I think I may take this opportunity of expressing our gratitude to Surgeon-Major Beevor for the most excellent lecture he has given us—a lecture not only interesting but most eloquent. Personally I have received the very greatest pleasure in hearing it

Case II

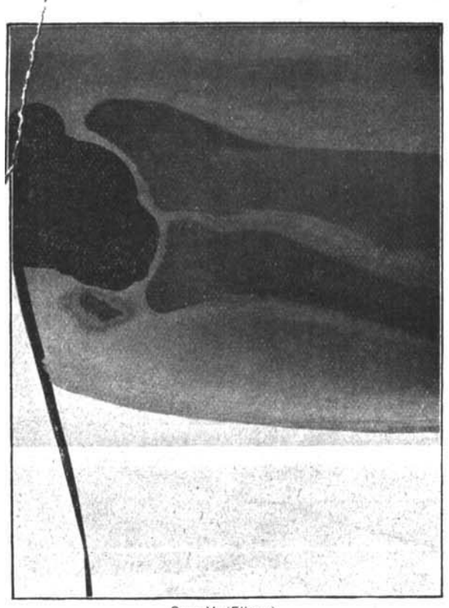


Case III.

Case IV.



Case V. (Thigh).



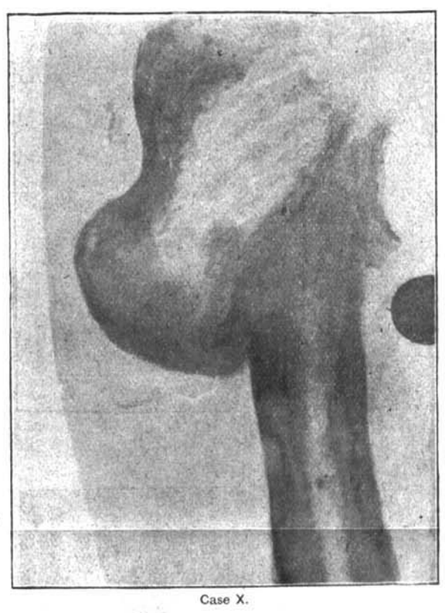
Case V. (Elbow)

Case VI.

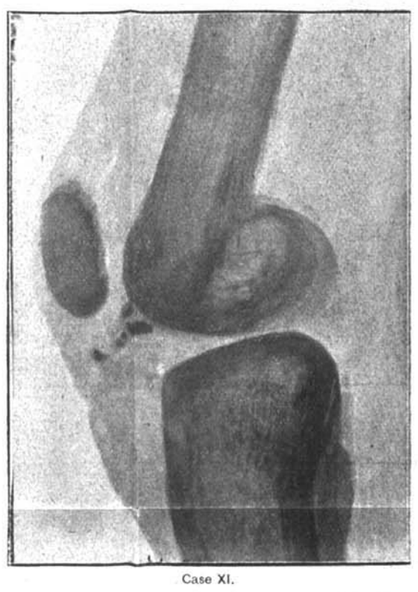
Case VII. A.

Case VII. B.

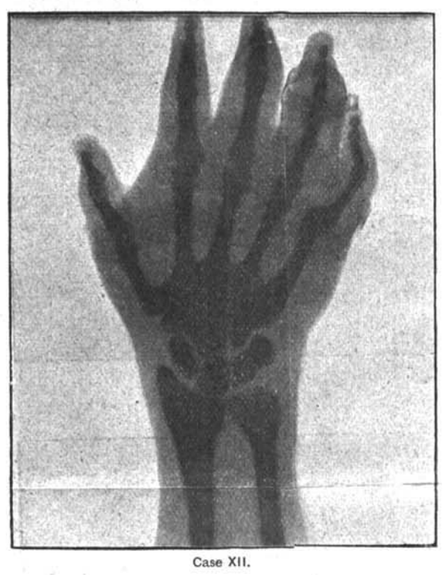
Case VIII (Case IX. mislaid).



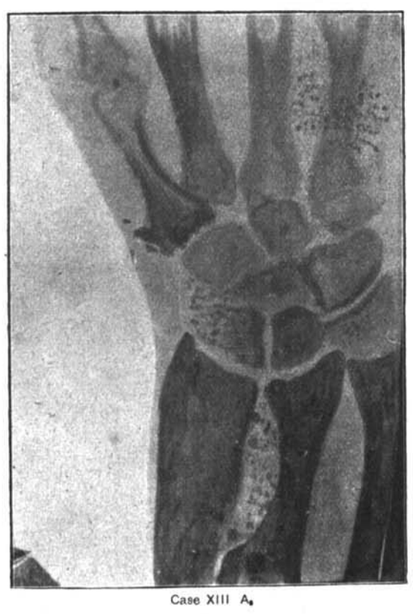
Case X.



Case XI.

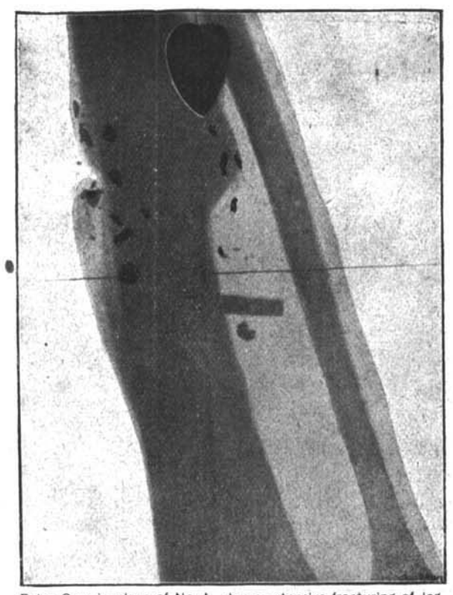


Case XII.

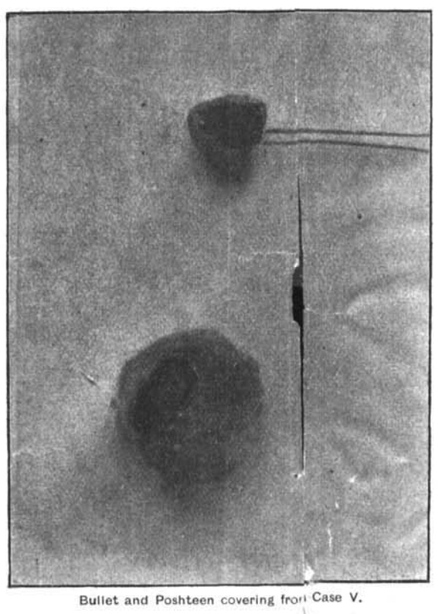


Case XIII A.

Case XIII. B.



Extra Case in place of No. I., shows extensive fracturing of leg bone and splitting up of a Snider Bullet.



Bullet and Poshteen covering from Case V.

J. J. K. & Co., London.

The Photographs illustrating Cases I., XIV., and XV., have unfortunately been mislaid.