John Battersby was born in Dublin on May 19, 1856. He was educated at Trinity College, Dublin, where he graduated M.B. and B.Ch. in 1879. He entered the army a surgeon in 1881, became surgeon-major in 1893, and lieutenant-colonel in 1901. He retired in 1911. He served in the Egyptian war of 1882, when he was present at the battle of Tel-el-Kebir, and received the medal with a clasp, and the Khedive's bronze star; in the Chitral expedition of 1895 (medal with clasp); and in the Nile expedition of 1898, when he took part in the battle of Khartoum, and received the medal with a clasp, and the Egyptian medal; Lieutenant-Colonel Battersby died at Knockamoe, Omagh, Tyrone, on April 8, 1919. (From an obituary in the *British Medical Journal*, p. 533, April 26, 1919.)

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The Present Position of the Roentgen Rays in Military Surgery

J. Battersby, M.B., Major R.A.M.C.

(*Arch. Roentg. Ray, 3:*74-80, 1899.)

MR. PRESIDENT AND GENTLEMEN,

In the first place, I desire to thank you for your kindness in inviting me here to-night, and also to acknowledge the great honour your Society has conferred upon me by asking me to read this paper before an audience so eminently critical.

Before proceeding to the subject of my address, I wish to take this opportunity of expressing my gratitude to Mr. Mackenzie Davidson for the great assistance he gave me, prior to my departure for service in the Soudan, as by his kindness I brought a modification of his apparatus with me which enabled me to localize some deep-seated bullets with mathematical accuracy, and rendered their extraction simple and easy.

To Dr. Haughton, of Trinity College, Dublin, I am also much indebted, as under his kindly guidance I owe my first practical introduction to X rays.

Having recently had the pleasure of listening to his presidential address, on Roentgen ray work, at the opening meeting of the Biological Association in Trinity College, Dublin, and as part of my experience in the application of X rays to the practical needs of military surgery is so closely allied to his own, I am permitted to adopt his

arrangement in the primary part of my paper.

To your honorary secretary, Dr. David Walsh, I am also indebted for much valuable information, abstracted from his excellent treatise on this subject. I wish to avail myself of this opportunity of stating that wherever modern writers have suggested to me important views or practical information, I trust I have fully acknowledged my obligations.

To your telegram inviting me here tonight I confess I replied with probably too much haste, and, having answered in the affirmative, I found the task of selecting a suitable subject upon which to address you not too easy. However, I concluded you could not expect me to tell you anything about X ray work you do not already know, and consequently resolved to crave your indulgence, and ask you to permit me to dwell upon matters rather of a practical than scientific nature, which might probably be of use hereafter to junior officers of the royal corps to which I have the honour to belong.

I am in a position to state that most of our large military hospitals at home and abroad are now provided with a most efficient X ray outfit, and every inducement and encouragement are offered to officers by the Director-General of the Army Medical Service to acquire a thorough practical knowledge of this most important adjunct to our professional knowledge. Much doubt existed as to whether the process was applicable to the arduous and ofttimes difficult requirements of field-service. Surgeon-Major Beevor, however, has demonstrated that successful results can be obtained in the cold and mountainous regions of Northern India, and only those who have a knowledge of that country can thoroughly appreciate the difficulties encountered, and the manner in which they were overcome. More recently it was my good fortune to be selected for service in charge of the Roentgen ray apparatus with the Nile Expeditionary Force in the Soudan, where the temperature varied from 100° to 122° F. in the shade. "Remember," wrote the principal medical officer of the Egyptian army, in answer to some information I asked for, "Beevor worked chiefly in cold regions: your efforts will be carried out in intense heat, where the temperature in tents is frequently over 120° F." I would like to state that whatever success attended my labours in the Soudan is largely due to the great care and attention bestowed upon the construction of the coils before they left London, and also the ready and able assistance I got from the warrant-officer of my own corps who was selected to help me.

Before leaving Cairo I took the precaution of having very thick felt covers made to surround the outer boxes containing the coils and storage batteries, and by keeping these constantly wet, the internal temperature was considerably reduced, as evaporation in the Soudan is very rapid. Between Wady Halfa and Abadieh all my apparatus had to travel for two days and a night in an open truck, exposed during the day-time to the fierce heat of a blazing sun. By keeping the felt wet every two hours, we reached our journey's end without mishap; thermometric observations later on proved that when the felt coverings were kept damp the temperature in the centre of the coil did not exceed 85 degrees.

With regard to Roentgen ray work, my experience has taught me that public, private, and official opinion is divided upon the results obtainable. Some I have met so confident of invariable success that they regarded the process equivalent to, and as easy as, putting a penny in the slot, when out comes a skiagram accurately demonstrating some abstruse problem in surgery, anatomy, physiology, or perchance psychology. Another and more difficult class to deal with are those who tell you decidedly that "they do not believe in the Roentgen rays," but even such I have succeeded in winning round to the same view I held, and finally heard them acknowledge "that the Roentgen

rays are of invaluable assistance in localizing the exact position of bullets, and in many cases rendered probing of wounds unnecessary." A middle course is probably the safest for the critic to adopt, as undoubtedly there are many cases in which success is assured, and others in which much valuable information may be obtained, while at the same time a note of warning should be given not to expect too much in the more obscure regions of the body, or finer shades of pathological change. If it is permissible to draw conjectures of the future from observation of the past, we may almost prognosticate that the Roentgen rays will some day render to medicine services not less conspicuous than those already conferred upon surgery. Calcification of arteries can be demonstrated in the limbs; possibly with improved methods atheromatous changes may be shown in the heart and larger bloodvessels. Many difficulties have already been cleared up, by means of the fluorescent screen, regarding aneurism of the heart and of the first part of the aorta. Nor should it be impossible to detect the irregular outline of the upper and convex surface of the liver, when an abscess is pointing in that direction, towards the pleural cavity; many of us, too, will know how difficult it is to accurately localize, for operative purposes, such an abscess.

Radiography can boast its most brilliant results in obscure injuries to bone, especially when the injured parts are too swollen to admit of careful examination by ordinary methods, or when such examination cannot be borne by the patient. Instead of long and painful manipulations by the surgeon, often ending in nothing better than a suspended judgment, he can, with the help of the rays, give a definite diagnosis and prognosis, and also gain in many cases much useful assistance as to his future treatment.

For our own reputation, and the welfare of our patients, many important conclusions would be arrived at if we invariably made it a routine practice to examine with the Roentgen rays every case, or suspected case, of fracture that came under our observation. Oberst of Halle, and Dr. Richardson of Boston, found as the result of such a systematic course of examination that, under ordinary treatment,

(1) Perfect union is rare;

(2) Oblique fractures generally have some overriding;

(3) In deep-seated bones there may be much bony deformity unrecognised;

(4) If fractional disturbance continues after treatment, overriding is the rule.

Nowhere has skiagraphy proved of greater practical value and assistance to the surgeon than in the detection and localization of foreign bodies. One condition alone is necessary—the foreign body must offer a resistance to the rays greater than that of the tissues in which it lies. Thus, a bullet buried in muscle or lodged in the lung casts a clear-cut shadow on the fluorescent screen, the image being somewhat obscure when lodged in more opaque structures, such as bone. Glass can be readily photographed, its opacity to the rays being due to lead and other materials necessary for its manufacture. The exact size, shape, and position of a needle in the hand or foot can now be readily demonstrated, when formerly it might have eluded not only the vigilance of careful manipulation, but even an extensive probing and cutting operation. Pins have been accurately localized in the larynx, and false teeth, buckles, and coins found in the oesophagus.

In military surgery the Roentgen rays have proved of great value, as lead is very opaque to the rays. The erratic course often taken by bullets after entering the body renders their discovery by ordinary means exceedingly difficult, if not in some cases quite impossible. After the Battle of Omdurman, 121 British wounded were conveyed

to the surgical hospital at Abadieh. Of this number there were twenty-one cases in which we could not find the bullet or prove its absence by ordinary methods. In twenty out of these twenty-one cases an accurate diagnosis was arrived at with the help of the rays, the odd case, a severe bullet wound of the lung, being too ill at the time to examine. To confirm the beneficial results obtained by means of the Roentgen rays on field-service, it is satisfactory to quote the opinion of the senior medical officer in charge of the hospital, when he stated "The Roentgen rays proved of invaluable assistance in localizing the exact position of bullets, and in many cases rendered probing of wounds unnecessary;" and, again, "the X ray apparatus has been found of inestimable value in this hospital in the treatment of the wounded. It has been applied to every case of gunshot wound in which the bullet was presumed to be lodged. Twenty-one cases in all were examined from the arrival of the wounded up to the present date. In many cases the X rays prevented much suffering to the patient which would have been caused by probing, the use of the finger, or enlarging the wound in the ordinary search for the bullet, as the skiagraph at once indicated the exact position of the bullet."

"In other more complicated cases the Mackenzie-Davidson method localized the exact position of the bullet, so that the surgeon was at once able to come to the conclusion if operative interference was judicious or otherwise. If considered advisable, the removal of the bullet was much facilitated by the diagram previously indicating exactly where the projectile was to be found."

I would like to augment this most satisfactory statement by a quotation from Dr. Haughton's address to the University of Dublin Biological Society, which testifies that "the X rays have furnished the army surgeon with a probe which is painless; which is exact; and, most important of all, which is aseptic—qualities not possessed by the older, though ingenious, instrument bearing Nelaton's name."

A bullet lodged in the right lung was beautifully seen with the screen in one of our patients at Abadieh, the shadow being equally visible whether examined from the front or back of the chest. So far as the abdomen is concerned, the results of skiagraphy in adults are, I think, uncertain or negative; but coins and other foreign bodies have been located in children.

That in certain cases a short exposure may give a better result than a long one has been my own experience, but my conclusions were deducted as the result of chance. Skiagraphing a skull for supposed bullet lodged about orbital region, I gave a fifteen minutes' exposure with a 10-inch Dean's coil. Not being satisfied with the result, I repeated my observation, when after seven and a half minutes the patient's head began to shake, and the coil was immediately stopped. To my satisfaction, I obtained an excellent plate.

In the Soudan some sixty observations were made by means of the screens and photographic plates, resulting in this conclusion: that each case had to be studied as a special problem with regard to the intelligent adaptation of detail and method.

The accurate localization (for practical surgical purposes) of foreign bodies in the tissues is, I think, the consummation of skiagraphic art. A bullet, for instance, in a loaf of bread can be localized with the fluorescent screen by means of acupuncture needles, but such a procedure is scarcely applicable to patients suffering more or less from shock and in a depressed and nervous condition. With a bullet situated in the upper or lower extremity, it is difficult from a single skiagraphic observation to say whether the projectile lies in front or back of the bone. A cross-skiagram, at right angles to the first, will at once solve the problem; and by this method most of our cases were localized in the Soudan. But for

deeper structures my best results were obtained by the aid of a modification of Mr. Mackenzie-Davidson's localizing apparatus, which I brought out specially with me.

I shall now briefly deal with the application of the process to the requirements of field-service.

It is essential that our outfit should be made as light as possible, in order to be portable and suitable for mule, camel, or human transport, as often narrow defiles and mountainous passes have to be traversed. Another important item is that the constituent parts of our apparatus should be small enough to fit in paniers, to hook on either side of a pack-saddle on a mule's back. Our most serious difficulty at present is the best method of generating the primary electrical current for charging the storage batteries or working the coil direct. Primary batteries for many reasons are unsuitable, and not to be recommended. In the Soudan a small dynamo driven by means of a tandem bicycle answered admirably, and was readily transported by rail and river to our destination at Abadieh; but as at present constructed it is unsuited for mule, camel or human transport.

An ideal apparatus would consist in a statical or friction machine—some modification, for instance, of Mr. Wimshurst's—by which the focus-tube could be excited direct. In such a design I am aware that many physical difficulties confront us, but are not insurmountable; I would therefore humbly ask your criticism and kind assistance concerning its attainment, as such an achievement would enable us to reduce our present apparatus very considerably, by dispensing with primary and storage batteries, dynamos, bicycles, and our induction coils.

The Roentgen ray outfit which was sent out to the Soudan consisted of a 10-inch coil, made by Mr. Dean, of Hatton Garden. This coil was specially insulated, and, with the condenser, commutator, interruptor, ammeter, voltmeter, small electric lamp, fluorescent screen, and two focus-tubes, was enclosed in a strong oak box. It was most complete and satisfactory, but for the requirements of field-service too heavy for camel or mule transport. Consequently I had a special arrangement of ropes made, by which means, and by the aid of a long pole, it could be carried on the shoulder of four men like an Indian dhoolie.

Another 10-inch coil, designed by Mr. Apps, also accompanied me. At my suggestion, this coil consisted of two separate parts, the coil proper being enclosed in a teak case, and the condenser, commutator, contact-breaker, etc., in another. By this method the weight was evenly divided, and the two boxes could be readily carried on either side of a mule or camel, or by coolies over very mountainous districts.

It is scarcely necessary for me to say that this coil gave entire satisfaction, as Mr. Apps' work is too well known to this Society to need any commendation from me. In addition, a small 6-inch Dean's coil accompanied me to Omdurman from Abadieh, the headquarters of our apparatus and base surgical hospital. I have already drawn attention to the thick felt covers I procured at Cairo, by which the internal temperature of the coils was much reduced by the process of evaporation, as these covers were constantly kept damp, and no doubt helped to perserve the insulating material of the coils.

The method by which we generated electricity I shall presently describe and illustrate by means of a photograph.

The storage battery consisted of eight separate E.P.S. cells, which proved more useful than having them permanently fixed in a wooden case, as the voltage could be regulated, increased, or diminished as the case required; and also, should a cell become injured or a plate buckled, it could be taken out of the circuit at once and a spare one substituted. These cells when put in series answered admirably, but owing to the excessive heat the water evaporated rapidly from the acid solution, and general lowering of

the specific gravity of the electrolyte was noticed, presumably owing to the unusually high temperature at which the cells had to be worked.

In no case when the cells were fully charged did the hydrometer register a specific gravity of 1.22. This is an observation upon which I wish to lay stress, as in the absence of a voltmeter the exact condition of the cells when in use can only be judged by a hydrometer, the discharge being stopped when a specific gravity of 1.15 is recorded at 60° F.

A table of revised specific gravities for each increase of temperature above 60° F. for reference in warm climates is urgently required.

I brought four 10-inch ordinary bianodic focus-tubes with me. They were obtained from Mr. Dean, and personally tested by me before leaving. The platinum-wire terminals fused through the glass ends of the tube were protected by a ferrule of thick indiarubber, and each tube wrapped in cotton-wool and carefully packed in a small wooden box, which did not leave my personal supervision until I returned to Cairo in October. Two of these tubes did most excellent and extensive work, one being better for screen-work, while the other gave more satisfactory photographic results.

The fluorescent screen I found most useful at night, but unsatisfactory to work during the day owing to the intense sunlight, which, do what we could, seemed to penetrate the hood, no dark-room being available. The surface of the screen was protected by a layer of celluloid, which in a warm and dusty climate is a matter of no mean importance. The great advantage of screen-work in military surgery depends upon the fact that under suitable conditions we can explore any part of the body without delay. The greater perfecting, therefore, of our screen apparatus for daily work is a matter of much importance.

With regard to photographic materials and developers we had a good deal to learn. I may at the commencement state that glass plates alone gave satisfactory results, of which I had a variety of different sizes —Wratten and Wainwright's, Paget's, Lumière, and a small supply of Cadett Lightning. Those with the thinnest film appeared most suitable for the intense heat, but thick or thin, without the aid of an alum-bath I do not think we could have saved our plates, as the water for developing was comparatively hot, no ice being procurable, consequently the more delicate shades of development had to be sacrified (sic—A.J.B.). Of developers we used Rodinal, Hydroquinone, Metol, and Pyro. There was a marked tendency for development to proceed at a very rapid pace, often making the picture flash up at once, when the greatest precautions were necessary to preserve the result. As a rule, our developing work was performed at three o'clock a.m., and even then (the coolest time) the temperature in our mud-bricked dark-room varied from over 90° to 110°. An atmosphere laden with dust and constant dust-storms was most trying, eleven plates being destroyed one night by a fierce storm which blew off our improvised mud roof. I found "Tyler's dark bags" which I brought out with me most useful, as the wooden plate-holders are apt to shrink, and consequently light to gain admission.

Before leaving Cairo for the front, I fortunately discovered that the July heat, about 95° in the shade, was affecting the guttapercha insulated wire I brought out from home, the insulating material of which commenced to crack in different places. It was my good fortune during some of my rambles in the city of Cairo to make the acquintance of a Monsieur Maroni, electrical engineer of Cairo, and through his kind assistance I obtained from the Telephone Company some Italian-made insulated wire of different grades, similar to that used throughout Cairo. This wire answered admirably, and withstood the heat splendidly.

The PRESIDENT congratulated the Society on the excellent results that had been brought about by the use of the Roentgen rays, which showed that it was possible to obtain these even under the most difficult circumstances. It would be possible in future to get rid of many difficulties of diagnosis in the field, such as distinguishing between dislocations and fractures, localization of bullets, etc., which in former days could not be settled so readily. Warfare under these circumstances would perhaps become less severe than in former days. He thanked Major Battersby in the name of the Society for the communication.

Surgeon-Major BEEVOR congratulated Major Battersby on the successful work which he had carried out with the X rays. Having been in three campaigns, he was acquainted with some of the difficulties met with in military surgery. In the recent Frontier War in India, where they had several hundred wounded men, he had been able to test the practical value of the X rays. One case in particular might be mentioned, that of a man who was wounded in the right side; the bullet had entered between the ninth and tenth ribs, and had apparently penetrated partly through the liver and was lost. A long probe had been passed into the wound, but the position of the bullet could not be determined. But when the patient was brought to the base-hospital, by the aid of the X rays they found it lodged on the left side. The results obtained by Major Battersby showed that the X ray apparatus could be worked successfully in hot climates. In the Indian Frontier War most of the work was done during very cold weather among the mountains. They had one accident with the induction coil at starting, when the paraffin-wax was melted during transit in the railway train, and wet blankets were resorted to to keep the coil cool. Major Battersby was to be congratulated on the successful application of the "bicycle" to the driving of the dynamo. Soldiers were always willing to help in any way with the X ray apparatus; and if men were found to do the charging, there would not be any difficulty in the use of this method of obtaining current. There were some points connected with the practical working of the X ray apparatus concerning which the the opinions of the members of the Society would be valuable. As to the length of spark, it seemed that the best penetration was obtained with a long, slow spark, while for screen-work a quick, short spark was better. As regards photographic apparatus, what was the most portable and convenient arrangement, also what were the best plates, or papers, or films for very hot or very moist climates? The films which he had tried seemed to absorb moisture.

Surgeon-Major KILKELLY, Grenadier Guards, said he had employed a small dynamo direct for working a 6-inch coil, driven by hand, and suggested that for developing plates a portable "dark-room" might be used, with a suitable aperture fitting round the operator's eyes so as to avoid some of the difficulties connected with developing tents and huts. He would be glad to know whether Major Battersby had had any experience with these, and whether he had also worked the coil direct from the dynamo when driven by the "bicycle" arrangement.

Professor S. P. THOMPSON said Major Battersby's experiences raised several points that were of interest to the physicist and to the instrument makers. Would it be possible to use the influence machine instead of the induction coil? and, if so, what would be the most convenient size and shape for the machine so that it might be portable. As to the materials for the plates, would ebonite be more suitable than glass? Would it stand the climate? Would the cylindrical form be better than the one usually used with plates? As to the films for the photographs, would it be possible to use mica for these instead of celluloid?

Mr. WILSON NOBLE said, with reference to Major Beevor's question as to the length of the spark, he found that a battery might be employed of double the E.M.F. usually recommended, and that this would give the best results; in this way a quick spark and a thick one was obtained. The tube should show no blue cloud when working, and should have a low resistance. He had recently obtained a radiograph of a shoulder showing bones and tendons by using a tube which took a heavy spark 3 inches long. As to films, they would not give the same density as plates. He had obtained the best results with Lumière plates; and these might be recommended if the long time required for developing them were no objection.

Mr. WEBSTER recommended the heating of the tube with a spirit-lamp when it could be obtained. The tube should be heated behind the cathode; it ought not to show any blue cloud when the anode was red-hot; a red-brown phosphorescence would appear behind the anode. For developing in a hot room of 90°, he had found amidol the best developer, and suggested this for use in hot climates.

Mr. E. PAYNE congratulated Major Battersby on the successful application of the "bicycle" method of driving the dynamo; some months back he had suggested in a note in the ARCHIVES that such a method might be possible. He was very pleased to see that someone else had not only thought of the same idea, but had really carried it out, and shown it to be used as a practical method of working the dynamo. With regard to the difficulty of using warm water in very hot climates, might it be possible to work a small freezing-machine with the aid of the "bicycle", not necessarily for the production of ice, but for reducing the temperature of the fluids used for developing, etc. With reference to influence machines, it ought to be possible to make the machine portable by having the plates packed separately from the case and other working parts.

Mr. LESLIE MILLER said, with reference to the questions that concerned the manufacture of apparatus, special methods would often be employed by makers if they knew exactly the kind of work that was required. It was not necessary to use paraffin-wax, for instance, if the coil was to be used in hot climates. With reference to the accumulators and the evaporation of the liquid, they might be more covered in and prepared especially if their destination were known. With regard to the sensitized papers for taking radiographs, the Eastman paper had been used successfully during the recent Greek War.

Mr. GAIRDNER said that from his experience of different spark-lengths, he did not think the latter made very much difference. He thought it better to have a set of three or four tubes of different vacua, and not to resort to heating the tube. The suggestion of Professor Thompson that mica might be employed instead of celluloid for the photographic films was a very good one; there was a want of adhesion between the celluloid and the sensitive film.

Major BATTERSBY, in reply, said that he had not as yet tried to work the coil from the dynamo. With regard to the use of black material for a dark tent or bag, it would require a material that was proof against the very brilliant sunlight—perhaps two or three layers of black velvet would keep out the light. As to the size and portability of an influence machine, since guns could be carried, he did not see any reason why it should not be possible to carry an influence machine equally well. He thanked the different members for the information they had given with reference to the practical working of the tubes, and expressed his gratitude to the meeting for the reception that had been accorded to him.

A vote of thanks to Major Battersby, proposed by the PRESIDENT, was then carried unanimously.

DESCRIPTION OF PLATES

Before demonstrating some of my achievements in the Soudan I would crave your indulgence, and ask you, an eminently critical audience, to review my efforts with a friendly criticism, as it was not contemplated that my work (which was performed under great climatic difficulties, and solely and purely for practical surgical purposes) should ever aspire to the coveted position of public demonstration.

As the result of my practical experience in the Soudan, I think I may safely counsel any of my friends who are anxious to visit that country either for pleasure or scientific pursuits, not to do so, of their own free will and accord, during the months of July, August, and September, when the temperature varies from 100° to over 120° F. in the shade, and dust-storms almost cyclonic in their character are of daily or nightly occurrence.

My headquarters were at Abadieh, a small village on the Nile, about 1,250 miles from Cairo and 9 miles north of Berber. Here the Egyptian troops had constructed a number of large, well-ventilated and mud-bricked buildings, which admirably suited all the requirements of a large surgical hospital in the field.

After the battle at Omdurman we brought back wounded to Abadieh 121 British officers, non-commissioned officers, and men. Of this number there were 21 cases that could not be diagnosed accurately by ordinary surgical means. By the help of the Roentgen rays, which were used about sixty times, we found the bullet, or proved its absence, in 20 out of these 21 cases—the odd case being so ill with a severe bullet wound of the lung that it was not considered justifiable to examine him at the time.

In order to avoid unnecessary pain and disturbance to the patient, suffering a good deal from shock, my skiagrams were invariably taken without interfering with any of

Plate LVII (a):890. The Nile at Abadieh.

the dressings. Consequently, such substances as iodoform and the perchloride of mercury preparations interfered materially with our skiagraphic effects, but not with our practical diagnosis and surgical results.

PLATE LVII*(a)*

My first picture will show you the Nile at Abadieh, and is interesting, being probably the first photograph ever taken and developed in this part of the world, as, shortly before our arrival, the whole district was more or less in the hands of the Dervishes. The river here is about three-quarters of a mile broad, and in colour not unlike the Thames as it flows under Westminster Bridge. Such was the water for cooking and drinking purposes, and the development of photographic plates—not an easy matter, when the temperature in the shade was 110°, and no ice to cool the water procurable. A gyassa, or native boat, is seen fighting its way against the current towards Atbara, most probably conveying commissariat stores for use on the march to Khartoum, for by similar boats were most of our stores brought to the advanced depot at the front.

PLATE LVII*(b)*

This photograph shows you the method by which we generated electricity for charging the storage batteries which worked our induction coils, and illuminated the lonely desert for the first time with electric light, after our "specially prepared candles" had been resolved by the excessive heat into their oily constituents. You can see that the pulley of a small dynamo is connected by means of a leather strap with the back wheel of a specially-constructed tandem bicycle. The required velocity for the dynamo was thus obtained, and our procedure was as follows: Having carefully adjusted the circuit with the storage battery, and also with the voltmeter and ammeter, my warrant-officer took his position

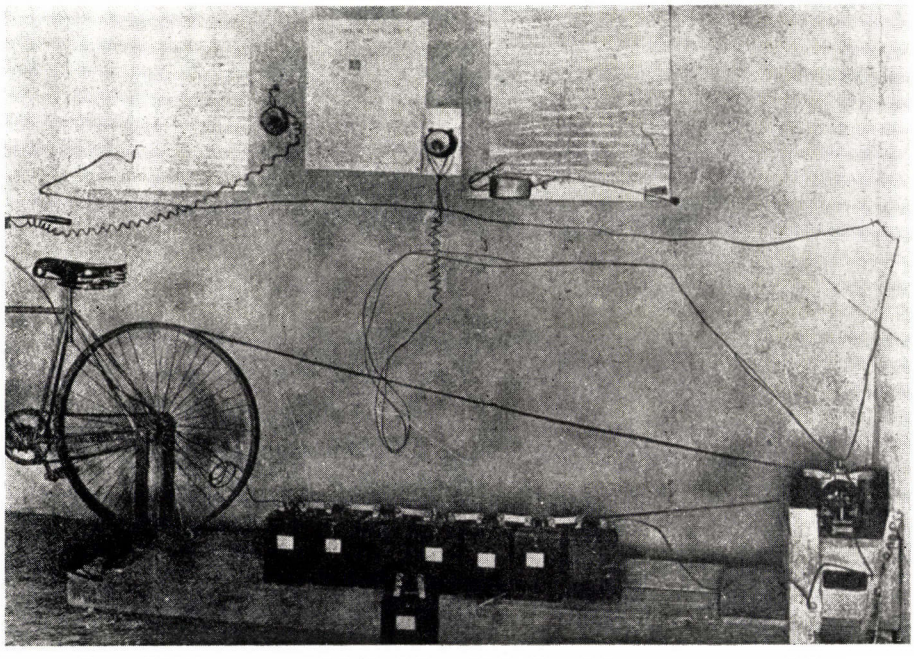


Plate LVII (b):891. Method by which electricity was generated for charging storage batteries.

on the seat of the bicycle which you see in the picture and commenced pedalling. When 15 volts and 4 ampères were registered, the switch close to the handle of the bicycle was opened, and charging of battery commenced. As the resistance became greater a sensation of riding uphill was experienced, and the services of an additional orderly requisitioned for the front seat. This bicycle practice was generally carried out in a shade temperature of 110° F. So that at the end of half an hour we unanimously agreed that some other form of scientific amusement was desirable. Then, the switch having been turned off before pedalling ceased, in order to avoid any discharge from the battery, the machine was brought to a standstill.

Our cells were the ordinary E.P.S. cells, 40 ampère hour type, with a voltage of 2 volts per cell, and a discharge of 4·5 to 6 ampères. The cells while being charged required the dynamo to give a current of 15 volts and 6 ampères; this multiplied together gives an electromotive force of 90 Watts, and as 760 Watts equal 1 electric horse-power, 1/8 horse-power was necessary to drive the dynamo for charging. It was also necessary to have an extra 1/8 horse-power to overcome the resistance of the working parts and the opposing force contained in the full batteries; hence the necessity of tandem-seat for extra man.

A happy hint for further development is here given to the many possessors of bicycles in this electrical age, that, with a little mechanical ingenuity and by removing the tyre from the back wheel, one and all may at any time and in any place start a small installation on his own account.

Never was the old adage as to "necessity being the mother of invention" more fully exemplied than at Abadieh, where nothing but sand and dirty water could be obtained. And whether the Egyptian Government will ever call upon me officially to return the few purloined wooden railway sleepers upon which you see my bicycle and dynamo are fixed is a matter that does not much concern me now. A far greater personal loss was the dedication of a new flannel-shirt for the protection of my dynamo from dust, from a field-service kit necessarily not too large.

PLATE LVIII*(a)*

Here you see our 10-inch coil at work, which has been specially insulated and enclosed in a strong oak box; the storage battery is connected with the coil, and a modification of Crook's (sic) tube suspended by means of an ingenious tube-holder over the shoulder-joint beneath, which is a photographic plate encased for greater protection in wooden light-tight plate-holder.

PLATE LVIII*(b)*

This illustrates a modification of Mr. Mackenzie Davidson's localizing apparatus, by means of which I was enabled, with mathematical accuracy, to localize two bullets which had entered through the shoulder, and lodged in each case near the shoulder-blade. Another bullet was localized with similar precision in the pelvic cavity. The patient, a private in the Seaforth Highlanders, while standing half-right firing at Omdurman, was hit about 1 inch behind and 1 inch below the anterior superior spine of his left ilium. When examined at night with the screen, the lateral view distinctly showed the bullet, which next day was localized. The vertical depth from the surface to the centre of the tip of the bullet was 1¾ inches, and centre of base of bullet 2 inches, so that the depth, direction, and exact position of the bullet were told to the operating surgeon.

PLATE LIX*(a)*

Private H., 2nd Rifle Brigade, bullet-wounds through outer and inner side of left arm, and a third wound near inferior angle of left scapula. Three pieces of bullet found at outer side of humerus. No bullet seen in chest, consequently no necessity to probe for it.

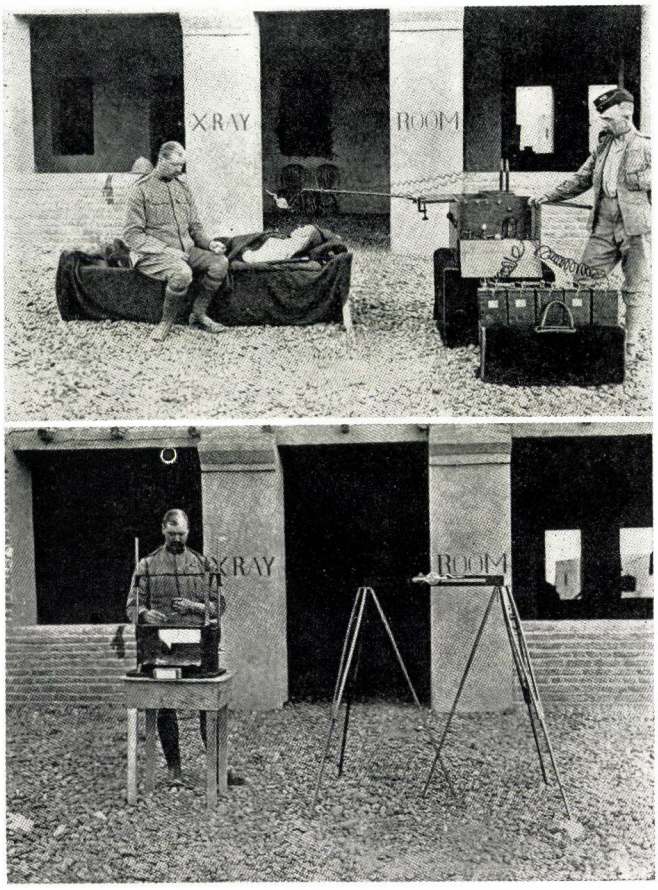


Plate LVIII (a):892. Major Battersby and his orderly taking a radiograph.
Plate LVIII (b):893. Localizing apparatus.

PLATE LIX*(b)*

This faint skiagram, taken through the chest without removing the dressings and bandages, illustrates one of the cases I have already referred to. Private J. B., Royal Warwickshire Regiment, received a bullet-wound near the tip of right shoulder, behind the acromial end of his clavicle. Front view revealed the bullet at right angles to axillary border of scapula, about 2 inches below glenoid cavity, outer tip of bullet just touching axillary edge, probably in subscapular space. This case was localized by Mr. Mackenzie Davidson's method with the following result: The depth from skin on back to the centre of tip of bullet was 2 inches, and centre of base of bullet 1¼ inches from surface. The bullet was easily extracted in the presence of the principal medical officer, who stated that the result was "highly satisfactory."

PLATE LX*(a)*

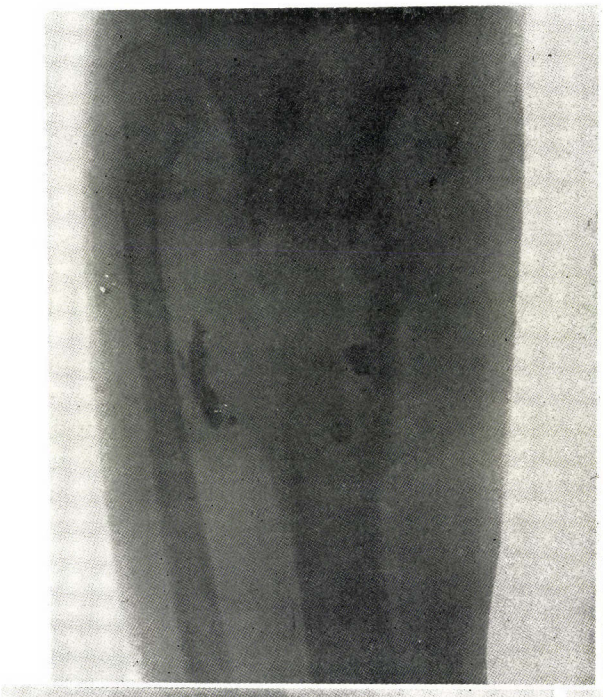
Sergeant S., Lincolnshire Regiment, received a bullet-wound at inner part of left supra-orbital ridge. The projectile was supposed to be lodged at the back of the orbit, as the eyeball was protruding and the sight destroyed when studied closely. The skiagram shows outlines of the bones of upper part of face, including orbital cavity, as well as fleshy parts of forehead and nose, but no trace of bullet. The eyeball was enucleated a few days afterwards, but

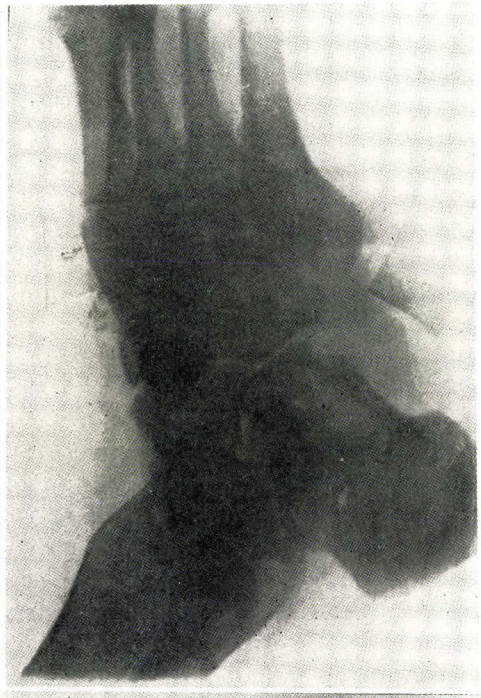
Plate LIX (a):894. Wounds of arm, showing fragments of bullet.

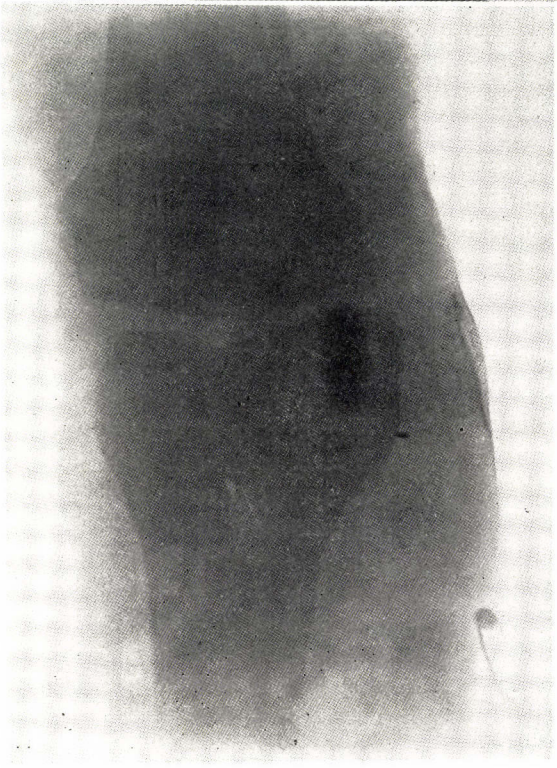
Plate LX (a):896. Splinter of bone in eye.

Plate LIX (b):895. Bullet in right shoulder (taken through dressings).

Plate LX (b):897. Bullet in thigh. "X" Soudan dust on plate.







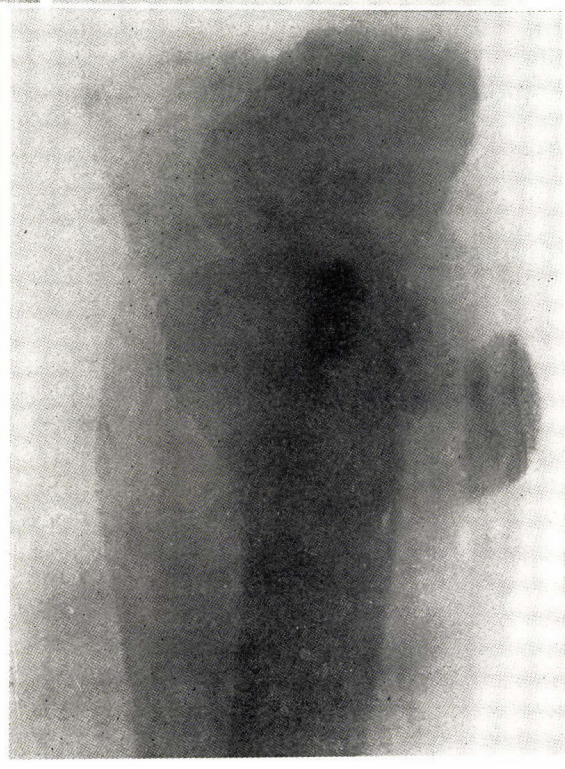


Plate LXI (a): 898. Fracture of both bones of leg by a bullet.
Plate LXII (a): 900. Bullet in knee (front view).

Plate LXI (b): 899. Bullet in left ankle.
Plate LXII (b): 901. Bullet in knee (side view).

no foreign body was found. Injury evidently produced by spent bullet, which drove a splinter of bone into the eye.

PLATE LX*(b)*

Private L., Lincolnshire Regiment, bullet-wound left thigh. Front view shows bullet projecting from outer side of femur about the middle of the shaft. Side view reveals projectile lying parallel with shaft on upper side. The bullet was thus localized by these two photographs, and easily removed.

PLATE LXI*(a)*

This shows the result of a bullet-wound of the left leg in a private of the Cameron Highlanders. The skiagram was taken some time after the injury, and shows clearly the fracture of both bones, the tibia especially being very severely damaged and suffering from necrosis. Several splashes of lead are also seen in the wound.

PLATE LXI*(b)*

Private L., Seaforth Highlanders, bullet-wound left ankle. Front view showed bullet with broad end towards inner side. In the side view the bullet is seen in the joint between the astragalus and scaphoid. The bands of lead plaster are also visible. Incision over place indicated revealed bullet, which was readily extracted.

PLATE LXII*(a)* AND *(b)*

Private H., Seaforth Highlanders, bullet-wound on inner side of right knee, over inner condyle of femur, about 2 inches from inner border of patella; knee-joint much swollen and inflamed.

Front view (*a*) revealed bullet in inner condyle of femur, long axis parallel to leg, lower end reaching to articular surface of condyle, upper end about two-thirds up condyle; bullet about ¼ of an inch from inner margin of condyle.

Side view (*b*) showed bullet about midway between anterior and posterior border of internal condyle of femur, lower end touching articular surface, and long axis nearly parallel to limb. The patella is widely separated from front of femur, and the front part of condyle appears to be much comminuted. Operation revealed bullet embedded in inner condyle, and was easily extracted.

I think the facts I have mentioned, together with the few cases I have shown you, must convince the most sceptical that the Roentgen rays are of the vastest importance and a great help to our diagnosis in military surgery.

I am convinced that the wounded soldier is often saved much mental worry and not unfrequently bodily pain by the help given to us by the X rays.

I have shown you how probing for an uncertain bullet, with its subsequent pain, is now a thing of the past in military surgery; how bullets can be localized with mathematical precision in the deeper parts of the body on field service; and also demonstrated the great help gained by aid of the rays in uncertain fractures.