# The Invisible Light


The Journal
of
The British Society for the History of Radiology

Number 39, October 2014
ISSN 1479-6945 (Print)
ISSN 1479-6953 (Online)
www.bshr.org.uk

**Contents:**



**Editorial.**

Apologies for the delay in sending out this issue of The Invisible Light, however life has been more frantic than usual! This year has been very successful as regards radiology history.
We had an excellent conference at UKRC in Manchester. The stand in the technical exhibition was well received, and I was pleased that the historical session is now part of the main scientific programme rather than being held in the exhibition centre. The session was well attended.
I attended the meeting of the International Society for the History of Medicine meeting that was held into Tbilisi in Georgia. This was an excellent meeting and I'm now the official UK representative to the ISHM. The next meeting of the ISHM is being held in Argentina in September 2016, and also in that year the International Congress of Radiology will also be held in Argentina from the 21st 24th of September. There is to be a historical session at ICR and I hope that many of us will be able to attend, and present papers at both of these meetings.
As always I am interested in receiving papers on the history of radiology, so do please send them for The Invisible Light.
Best wishes
Adrian


Chairman, The International Society for the History of Radiology.

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**BSHM Annual Lecture: 2014 James Le Fanu.**

Our 2014 lecture was given by James Le Fanu. James Le Fanu is a doctor, social commentator and historian of science and medicine.
He writes a regular column for both the Daily Telegraph and the Sunday Telegraph and is the author of the highly acclaimed books *The Rise and Fall of Modern Medicine* and *Why Us?: How Science Rediscovered the Mysteries of Ourselves*
He gave the lecture on 24 February 2014 in the Roben's Suite in Guy's Hospital, London on the 29th floor of the tower.

The talk was entitled *Neuroscience and the five cardinal mysteries of the mind.*

Our speaker discussed the under appreciated contribution of functional imaging to understanding of the mind.
He raised the fundamental question as to what does the brain actually do? The talk was beautifully illustrated with functional MRI images.

**Aunt Minnie Europe Articles.**

Charles Dotter's attack on arteriosclerotic obstructions (January 15, 2014)
http://www.auntminnieeurope.com/index.aspx?sec=sup&sub=car&pag=dis&ItemID=609191
Austrian pioneer Guido Holzknecht leaves remarkable legacy (May 14, 2014)
http://www.auntminnieeurope.com/index.aspx?sec=sup&sub=cto&pag=dis&ItemID=609872
Marie Curie and the Great War (June 23, 2014)
http://www.auntminnieeurope.com/index.aspx?sec=sup&sub=xra&pag=dis&ItemID=610041
What lies beneath the wrappings of an ancient mummy? (16 September 2014)
http://www.auntminnieeurope.com/index.aspx?sec=sup&sub=xra&pag=dis&ItemID=610400

**Mayneord-Phillips book collection.**

A small collection of books of historical importance in medical physics has been made secure in a library archive in Bath. They were previously owned by two pioneers of medical physics, Major Charles Phillips and Professor Val Mayneord, of the Cancer Hospital in London, which later became the Royal Marsden Hospital. They will be housed in the Bath Royal Literary and Scientific Institution (BRLSI) library, and will be listed on the BRLSI library catalogue (www.brlsi.org/library-archives). The 9 volumes are by Faraday, Joule, Clerk Maxwell and JJ Thomson.

**Old and Recent Books.**

**Review of Annotated X-ray Bibliography 1896-1945 by Richard Mould. P333**
**Published by Polish Oncological Society, Warsaw 2014**

The Nowotory journal of oncology is Poland's premier oncology journal and is the official journal of the Polish Oncological Society and the Maria Curie Cancer Centre. Supplements to the journal are published in a book form from time to time and Richard Mould's Radium History is an example of a monograph published by Nowotory in 2007 and was a well-received addition to the literature in this area. Dr Mould has now produced a companion volume to the previous work to cover the early years of radiology, medical physics and radioactivity till the Second World War. This is an ambitious undertaking and the information and detail is truly encyclopaedic. A bibliography of all the references has required perusing through numerous archives and journals and has been over 5 years in the making. In addition to the extensive bibliographies there are excellent annotations and descriptive summaries of events with interesting

illustrations. There is an excellent index. The work is a superb example of scholarship and a herculean effort to bring all this information together in one source. It will be of interest to a wide range of people from radiologists, oncologists, and medical physicists to medical historians and other researchers. In addition it would be a valuable asset for all medical libraries. Dr Mould deserves to be congratulated for his herculean efforts and has done the medical and scientific communities a great service by compiling this volume of encyclopaedic information.
Reviewed By Dr Arpan K Banerjee
Chair Brit Soc History of Radiology

**Radiology in a Trench Coat**
**[Military Radiology on the Western Front during the Great War]**
**Author: Col. Dr. René van Tiggelen, Curator of the Belgian Museum of Radiology**

[Translated into English by Jan Dirckx]
Published by Academia Press, Ghent, Belgium [2013]
Cost: euro 30.00 from Academia Press, Eekhout 2 – 9000 Ghent, Belgium.

Published for the centenary of the start of the First World War [1914] this 19-chapter 220 page hardback, extremely well illustrated [265 figures] book with 219 references and an Index of Names is an excellent addition to the historical literature of radiology. The 19 chapters include The onset of radiology; Belgian army radiologists among the pioneers; Vehicles for radiology; Localization of projectiles and their extraction; Dangers of X-rays; Problems and solutions in radiology; Radiology described by those who have undergone it; Imperial German military radiology; French military radiology; Radiology in the British Expeditionary Force. The author must have turned himself into a real-life Sherlock Holmes detective to have located some of the early references and illustrations. For example we have a photograph of the equipment [German manufacture] used by the Japanese in the Russo-Japanese war of 1905-1906. From the same war there is a photograph of the famous Russian battlecruiser, the Aurora, also showing the installation of X-ray apparatus manufactured by Siemens & Halske. It was the Aurora which shelled the Winter Palace in St. Petersburg on 24 October 1917, which signaled the Bolshevik takeover of the provisional government. Van Tiggelen's book probably contains the most photographs of X-ray ambulances in any book available to historians. These photographs include the usual X-ray Renault wagon with Marie Curie at the wheel, but there are other photographs of Marie Curie which are less well known, and also some of Irène Curie. The most unusual mobile apparatus must be the Aérochir of 1918. This was a biplane carrying all necessary X-ray equipment together with a surgeon. It was based on a Voisin bomber but was never deployed. After the war development continued based on a Breguet bomber and it was finally used operationally during the French colonial wars of the 1920s. This most interesting book is recommended to all historians of World War I, and of radiology. It would also make a useful Christmas of birthday present for a current working radiologist.
Reviewed by Richard F. Mould
**Interesting Web Sites.**

**The Oak Ridge Associated Universities online museum of health physics.**
http://www.orau.org/ptp/museumdirectory.htm

This is a database of radiological equipment. There are any interesting images and links to books – either to PDFs or to Google books. Worth having a look at. The purpose of the Oak Ridge Associated Universities (ORAU) Health Physics Historical Instrumentation Museum Collection is to chronicle the scientific and commercial history of radioactivity and radiation. It has been deemed the official repository for historical radiological instruments by the Health Physics Society, and the Society has been generous in its financial support for the purchase of items.
The collection is the property of the not-for-profit ORAU Foundation, and it is located at the Professional Training Programs (PTP) training facility in Oak Ridge, Tennessee. Unless noted otherwise, this website only features items actually in the collection. If you have any technical or historically-related questions about the collection, or if you are interested in making a donation, contact Dr. Paul Frame via E-mail (paul.frame@orau.org) or by phone (865)-576-3388. Please do not ask about an appraisal - they do not attribute monetary values to items.

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**Military Radiology Before & During the First World War 1896-1918**

by
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**Abstract.** The centenary of the First World War is now upon us and with this in mind a brief review of military radiology before and during WWI is given. In early 1896, very soon after the discovery of X-rays by Wilhelm Conrad Röntgen in Würzburg on 8 November 1895, many radiographs were published in books and journals showing bony fractures, and also foreign bodies embedded in skulls, hands, arms, legs and feet. Several of these cases related to injuries caused during warfare and the earliest textbooks always made some mention of the applications of the *new rays* in warfare. Descriptions are given of some of the early X-ray apparatus used in warfare and practical experiences such as the difficulty of setting up facilities for developing X-ray films and the difficulty of obtaining electrical power for the apparatus. Military radiology in the Boer War in South Africa, 1899-1902, was the first to be very well documented in medical journals. By the time of WWI motor vehicles specially designed for deployment just behind the battle front so that radiology services would be available as quickly as possible. These were used by most of the combatant countries, including Belgium, France, Germany, Japan, the United Kingdom and the USA. These mobile X-ray ambulances included the so-called *Little Curies* used by Marie Sklodowska Curie, who with her daughter Irène acting as her assistant also taught military radiology to technicians in the American army.

## Introduction

The first recorded consideration of the possible use X-rays in warfare for sick and wounded soldiers, was by the Prussian War Ministry in Berlin, early as 4 February 1896 [1]. Three months later in May 1896, the world's earliest textbook on X-rays, written by the London photographer Henry Snowden Ward [1865-1911] [2] did not mention warfare explicitly but in his final chapter on *Applications and Probable Advances* suggested 'A plan and elevation are necessary to locate exactly any foreign body. For instance, if a bullet is embedded in the thigh, it is necessary to make one radiogram (or radioscopic examination) from the front or back, and one from the side. Measurement on two such observations will locate the shot exactly.' Radiogram and radioscopy were early terminology for radiograph and for fluoroscopy. Ward continued to say that 'A triangulation method may also be adopted'. The value of X-rays in military surgery were also recorded early in 1896 in the *British Medical Journal* [3] and in the *Archives of Clinical Skiagraphy* [4] by Sidney Rowland [1872-1917] who was the Editor of the *Archives* and the *BMJ*'s Special Commissioner tasked with writing a *Report on the Application of the New Photography to Medicine and Surgery* [5]. **Table I** lists the pre-1914 wars in which X-ray equipment was used, and which are briefly summarised and illustrated below.

**Table I**. Military conflicts pre-1914 in which X-rays were used.

| | |
|---|---|
| 1896 | Italian-Ethiopian war |
| 1897 | Graeco-Turkish war |
| 1897-1898 | British army Tirah campaign on the NW frontier between India & Afghanistan |
| 1898 | Nile river war in the Sudan |
| 1898 | Spanish-American war |
| 1899-1902 | Boer war, South Africa |
| 1905 | Russian-Japanese war |

## X-Rays in Warfare 1896-1898

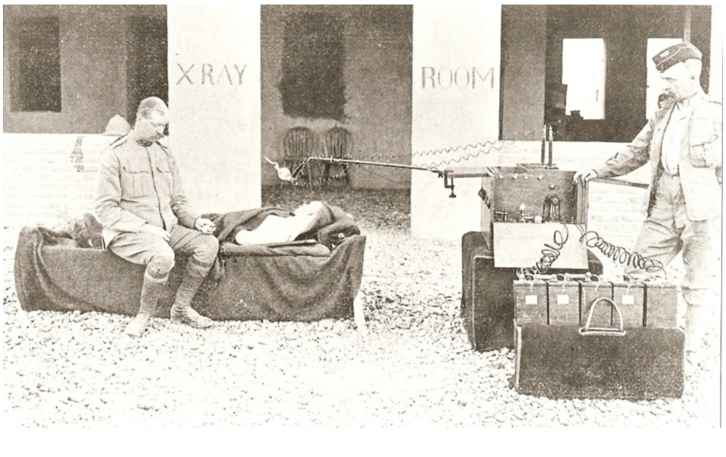
The first practical use of military radiography was in March 1896 by an Italian, Lieutenant-Colonel Giuseppe Alvaro of the Military Hospital, Naples, [6]. The Italian army had suffered a crushing defeat by the Ethiopians at the battle of Adowa and two of the Italian soldiers wounded in the forearm were radiographed to locate the bullets. Alvaro described his technique as follows. 'One takes a prepared photographic plate, places it in several layers of black paper, then puts it in a cardboard or wooden cassette, or on a small taboret in such a way that the impressed gelatinous surface is toward and underneath that part of the body of which the shadow is to be taken, it being fixed in this position with gauze. Above is placed the Crookes tube at a distance of 20 to 30 cm, the current being generated by a Ruhmkorff coil. After 20 minutes, or a good half-hour or longer, according to the potential of the current and the nature, thickness and density of the part, one obtains a negative with a relative white shadow on a black base.'

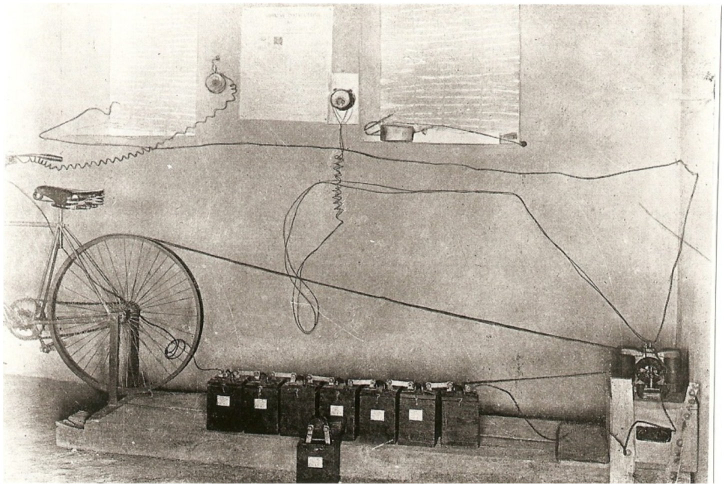
The next military campaign after that in Ethiopia, to use X-rays was the Graeco-Turkish war of 1897 [7, 8]. Germany supported the Turks with the German Red Cross providing a hospital unit in Constantinople, while England, France and Russia sided with the Greeks. The contribution by the British Red Cross was described in the *Daily Chronicle* newspaper of 4 May 1897. 'The apparatus forwarded will consist of an absolutely complete outfit in itself similar in every detail to the apparatus in daily use at St. Thomas' Hospital, London. The secondary winding of the induction coil is over 13 miles in length and will give a heavy discharge over 10" of air. It is hoped that it will be possible to use the fluorescent screen to the exclusion of the photographic method, as the position of the bullet or the seat of the injury may be viewed in many positions rapidly, and the time required to develop a dry plate (although much shortened by the use of Eastman's new X-ray paper) constitutes a serious delay to a busy surgeon.' The apparatus was sent to Greece in the charge of Francis Charles Abbott, a surgeon from St. Thomas' Hospital. It was reported from this war that a serious obstacle to battlefield radiography was a lack of a reliable source of electrical power. Reliance had to be placed on the Royal Navy's warship, *HMS Rodney*, which was used to recharge the wet batteries of the X-ray apparatus.

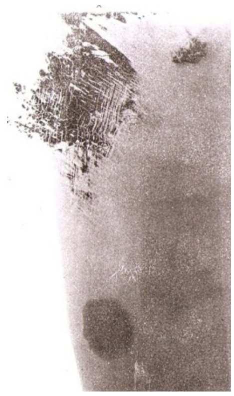
The 1897-1898 Tirah campaign took place on the North-West Frontier which is between India and Afghanistan, near the Khyber Pass and was the first large scale conflict involving the British Army (8,000 British and 30,000 Indian troops) to which was attached Surgeon-Major Walter Beevor [1858-1927] with an X-ray apparatus [9, 10]. The X-ray apparatus was manufactured by A.E. Dean of London and was supplied with three X-ray tubes by A.C. Cossor. All tubes survived unbroken! It was, though, only after the next major military operation by the British Army, the River War in the Sudan, in 1898, culminating in the battle of Omdurman, that the military use of X-rays became well publicised. The Tirah campaign was the first in which the X-ray facilities were actually sited on the field of battle. This was necessary because the base hospitals were at Rawalpindi over 100 miles distant, over roadless plateau, valleys and mountains. Following Tirah, the introduction of field X-ray units in to the British army became standard policy.

The Nile River War of 1898 is famous for the battle of Omdurman following General Gordon's fight to the finish at Khartoum against the Mahdi and his death in 1885. It took many years to mount the expedition, led by General Herbert Kitchener (later to be Minister for War in 1914) and in which Winston Churchill participated [11]. After this battle '121 British wounded were conveyed to the surgical hospital at Abadieh. Of this numbers there were 21 cases in which we could not find the bullet by ordinary methods. In 20 of these an accurate diagnosis was arrived at with the help of the rays. The remaining case, a bullet in the lung, was too ill to examine.' Developing work in the Sudan was taken at 3 o'clock in the morning when the temperature in war the mud brick X-ray dark room varied from 90°F to 110°F. This was the coolest time available! Constant dust storms also proved to be a problem and one night the roof of the mud hut blew off and 11 X-ray plates were destroyed. Sudanese dust was often visible on the radiographs [12].

**Figures 1-3**.







**Figures 1-3** [*Top*] Surgeon-Major John Battersby [1879-1919] and his orderly taking a radiograph in 1898. The X-ray tube was described as a 'modified Crookes tube suspended by means of an ingenious holder'. They used a 10" induction coil made by A.E. Dean of London. [*Centre*] Method by which electricity was generated for charging storage batteries at the base hospital by the Nile at Abadieh: which was 1,250 miles upstream from Cairo. The bicycle is mounted on a wooden railway sleeper. [*Bottom*] Bullet wound in a soldier's thigh. The Sudanese dust is clearly visible on the X-ray plate, as is the bullet. [12]

American experience in military radiology commenced with the Spanish-American war of 1898, which resulted in the annexation of Puerto Rico and the Philippines and the setting up of Cuba as an independent republic. Relatively few soldiers were wounded in this conflict and the principal cause of war deaths was typhoid fever. In the report written for the United States House of Representatives a series of case histories were included together with details of X-ray apparatus and technique. The section *Lodged Missiles* was divided into {1} Mauser bullets deformed by ricochet. {2} Undeformed Mauser bullets. {3} Shrapnel bullets. {4} Brass-jacketed bullets. The X-ray facilities were not on land in this war but in the hospital ship the USS *Relief*. [13]

**Figure 4.** Radiograph of a bullet lodged in the left occipital lobe of the brain of the American soldier Private John Gretzer. This was taken in August 1899 on his return to San Francisco, having been injured at long range in the Philippines in March of that year. He entered the U.S. Mail Service afterwards and returned to Manila on duty. [13]

### Boer War 1899-1902

Radiographic experience was very well documented for the Boer war of 1899-1902 when compared to earlier conflicts [14-28]. During this war, British army X-ray apparatus was provided as standard issue for all general military hospitals and the *British Medical Journal* of 1899 lists the standard X-ray kit as follows. '10" Apps-Newton induction coil [**Figure 5**] with condenser, spring-hammer interrupter, rods and electrical cables; 2 six-cell lithanode accumulators; 6 Cox 'Record' focus tube with tube stand [**Figure 6**]; 1 Mackenzie cross-thread localiser with stand [**Figure 7**]; 108 Edwards cathodal XXX plates, photographic paper and chemicals.' **Figure 5** shows Cox's Record tube from a 1901 advertisement in Isenthal & Ward's *Practical Radiography* [2]. Later, a 2.5 horse-power motorcycle engine was added to the kit and this was used in practice by fixing the engine and the dynamo to an army bed frame. [24].

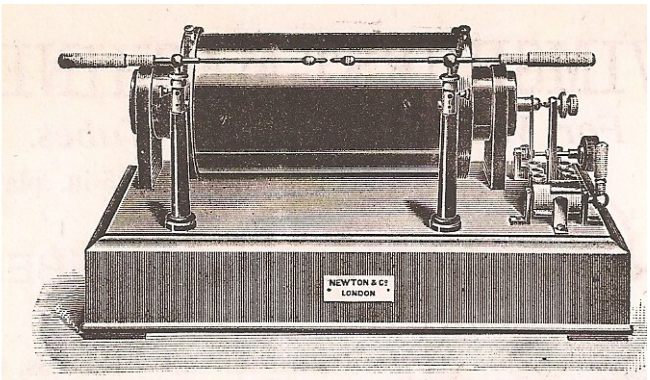



**Figure 5**. Newton & Co., 1898 advertisement [2] for a Newton Apps induction coil. For many years until the early 1920s the induction coil [also called a spark coil] was the only form of high tension generating plant available for operating X-ray tubes [other than influence machines such as the Wimshurst machine]. The distance between the two points [*see centre of diagram*] is the spark gap. By 1901 [2] there were many coils available with spark gap ranges such as 4-6", 6-8" and 8-10".

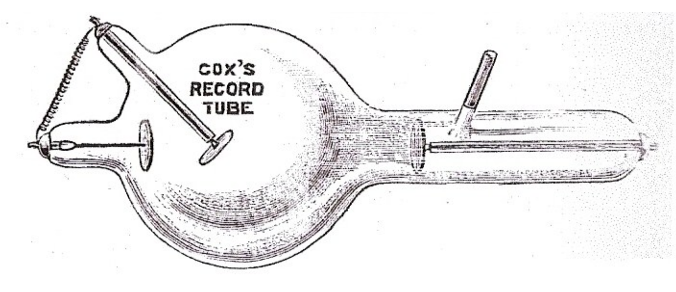



**Figure 6**. 1901 Harry W. Cox Ltd. advertisement [2] which stated 'Our **Record Focus Tube** has been awarded the **Gold Medal** (only award) in the **Röntgen Society's Tube Competition** for the best tube for both Photographic and Screen Work. The Competition was open to the World, and 25 tubes were submitted by various makers.'

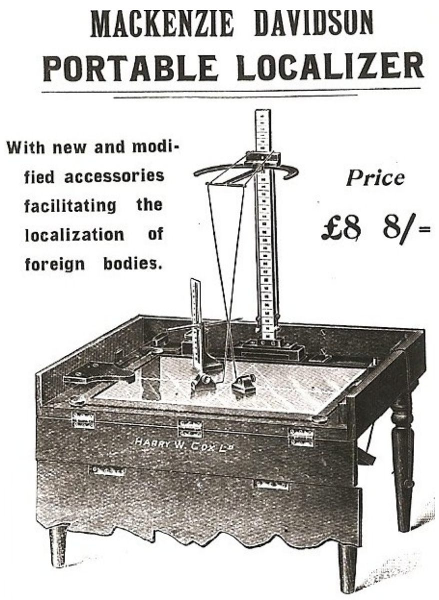



**Figure 7**. The [Sir James] Mackenzie Davidson [1857-1919] cross-thread localiser was based on the principle of triangulation and was the most popular of several techniques for determining the position, including depth below the skin surface, of foreign bodies such as pieces of shrapnel or bullets. It was developed in 1897 and was the first method to use mathematics for the localisation process. [29-31] Full description of the theory is given by Walsh. [32]

Several field hospitals were equipped with the latest X-ray apparatus one of which was the Imperial Yeomanry Hospitals in Deelfontein where the chief radiologist was Dr John Hall-Edwards [1858-1926] from Birmingham and who was to become famous in the United Kingdom, not least due to his X-ray injuries, which by the time of his return from South Africa had become irreversible radiation dermatitis. He had to suffer amputation of the left forearm and all the fingers of his right hand. His name is inscribed as one of the British X-ray martyrs on the Hamburg Memorial.

Burrows in his book on the history of British radiology [33] states that the Deelfontein hospital complex was about 36 hours from Cape Town by train and was said to be the largest military hospital in South Africa, measuring a half-mile by a quarter-mile in area. It was staffed by 30 doctors, 60 nursing sisters and could treat 1,100 patients. The hospital had piped drinking water and sewage, a steam laundry and electric lights. The X-ray department contained a large dark room with running water and electricity, linked by telephone to the operating theatre.

Hall-Edwards arrived in Deelfontein in March 1900 with two complete X-ray kits and was to spend 14 months in South Africa. The major problem he initially experienced with the equipment was the lack of a reliable source of generating power: the pedal bicycle although suitable in theory was a practical failure because of the great efforts required to operate it. Hall-Edwards attempts to have the accumulators recharged in Cape Town or Kimberley were also a failure as they arrived back in Deelfontein discharged. His solution was to obtain a second-hand oil engine, which was overhauled and after the laying of cables supplied not only power for the X-ray kit but also electric light. He was then able to work his induction coil direct from the dynamo and to therefore dispense altogether with the accumulators. In the 14 months in the hospital a total of 280 patients were referred for X-ray examination, many on several occasions. [14, 17, 20, 22-24]

### Russo-Japanese War 1905-1906

The Russo-Japanese war started in 1905 and after the May battle of the Tshushima Straits there were 83 wounded sailors on the Russian cruiser *Aurora*, 40 of whom were radiographed in the ship's infirmary. The Japanese also used radiography, employing German apparatus, and the range of examinations was described by a French physician J.J. Matignon in 1907 who had also described the equipment in 1906. [34, 35] A rare photograph of the equipment used by the Japanese has only been reproduced recently, by René Van Tiggelen [36], having remained only in the original reference for almost a century [**Figure 8**].

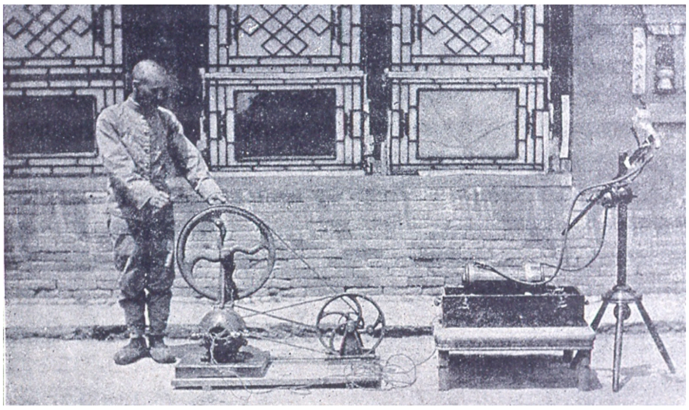


**Figure 8.** Japanese soldier using German X-ray equipment, 1905. [35, 36]

The cruiser *Aurora* has a special place in history .... unrelated to X-rays! It was this cruiser which shelled the Winter Palace in St. Petersburg on 24 October 1917, which signalled the fall of Alexander Kerensky's provisional government and the Bolshevik takeover. The *Aurora* is still in 2014 to be seen in the river Neva, as a tourist attraction. **Figure 9** shows the X-ray apparatus installed in the *Aurora* [36, 37].

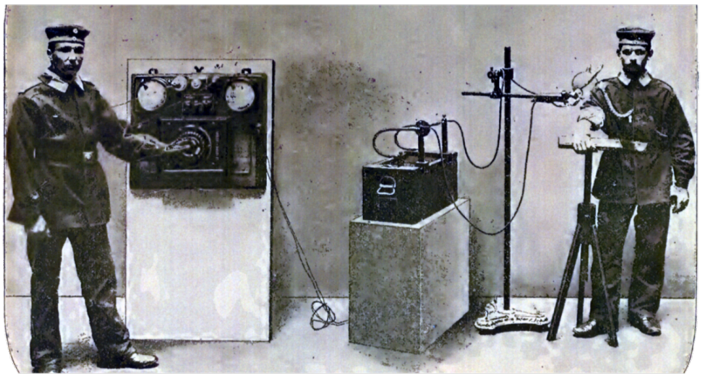


**Figure 9**. Portable X-ray equipment manufactured by Siemens & Halske in Germany. This was installed in the *Aurora*. [36, 37]

### X-Ray Ambulances 1914-1918

*Pedal power* from a tandem bicycle as used in the Sudan war and *hand-operated Röntgen cabinets* used in Manchuria during the Russo-Japanese war were replaced by horse-drawn mobile X-ray ambulances. These in turn were replaced by ambulances driven by using a petrol engine, making horses redundant for military radiology. Several photographs from different countries of these motor driven X-ray wagons were published in the medical literature [38-51]. **Figures 10-11** are examples of X-ray wagons and **Figure 12** is the front cover of a manual. The apparatus in **Figure 10** had a generator specification of 20 amps at 150 volts; the accumulators were 30 amps at 150 volts; and the generator and accumulators could be used in parallel. The car was 20 horsepower and had an Austin chassis.

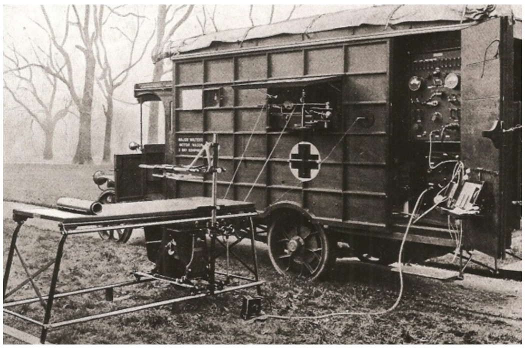


**Figure 10**. A British army X-ray wagon. The view was described as 'the table arranged for use but without operating tent erected'. Built by Siemens of London who claimed that radiography, radioscopy and therapeutic treatment could be under taken in the wagon. [45]

**Figure 11.** Marie Curie reserved for her own use one of the 20 X-ray ambulances in the French military medical service. It was an old Renault *crocodile hood* vehicle. This photograph was taken in October 1917. [Courtesy: Musée Curie]


**Figure 12.** Operating manual published as a textbook. [42]

## Maria Sklodowska Curie

Marie Curie [1867-1934] is of course best known for her discovery with Pierre Curie [1859-1906] of radium and polonium, and the foundation of the Institut du Radium [now Institut Curie]. She is though, associated with X-rays through her work during World War I, when development of her Institut, virtually completed in 1913, was deferred for the duration of the war. She created an auxiliary radiology department in the French military medical service, raising large sums of money to provide so-called *little Curies*, **Figure 11**, as well as X-ray equipment for fixed hospitals. Together with her daughter Irène [1897-1956] she visited the battle front many times. For example, together they visited Hoogstade in September 1915 [meeting with King Albert I of Belgium] and an English hospital, the Belgian field hospital, housed on St. Joseph's secondary school, Veurne, **Figure 13**. When she travelled on her own she always sent postcards to her two daughters Irène and Eve: one example is in **Figure 14**, which is postmarked Dunkirk on 23 January 1915. In addition Marie and Irène trained both French and American army personnel to operate the equipment. The classes were taught at the Hospital School Edith Cavell at 40 rue Amyot and at the Institut du Radium in Paris. She also published a textbook in 1921 entitled *Radiology and War*. [52, 53]

**Figure 13**. Marie and Irène Curie in Veune. The man on the far left is Sir Henry Souttar [1875-1964] of the London Hospital, who would later publish widely on the subject of radium and cancer [54-57]

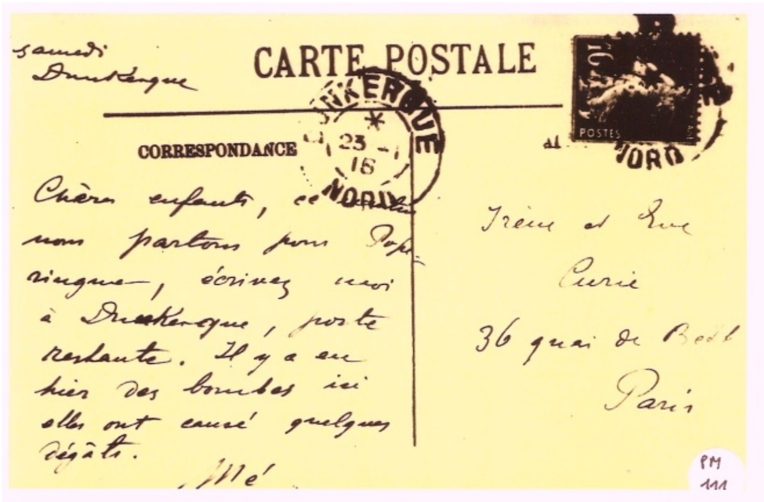



**Figure 14**. Postcard from Marie Curie to her daughters. [Courtesy: Ecole Supérieure de Physique et de Chimie Industrielles de la Ville de Paris]

## Non-Destructive Testing 1896-1918

The first example of non-destructive testing using X-rays would have been in 1896 by Röntgen when he radiographed his hunting rifle [**Figure 15**]. A copy of the image was given by Röntgen to Adolf Isenthal who used it as the frontispiece for his 1901 textbook [3rd edn] written with Henry Snowden Ward [2]. The caption is 'Radiogram through a double-barreled gun, showing penetration and differentiation of rays.' In the 2nd edn of this book, published in 1898 [2] is a 'radiogram of steel-joint showing extent of brazing', which was taken by Hall-Edwards.

**Figure 15**. Part of a 1995 exhibition in the Physics Department of Würzburg University. The gun and its radiograph are shown *left* and *centre* is Röntgen's Nobel Prize certificate.

There are also other early examples of X-rays in 1896 being used to detect flaws in metals and alloys. These included Arthur Wright of Yale who radiographed a piece of welded metal and showed the welding seam which could not be seen by the naked eye. The Carnegie Steel Works in Pittsburgh used the same method [58]. Items radiographed during the First World War years included aeroplane hollow box struts, welds, pistons [59], and as illustrated in the *Journal of the Röntgen Society* [60] fuses of 75mm shells, aluminium gear cases and faulty welding in a metal tank.  Aeroplane propellers were also tested for flaws using X-rays [**Figure 16**] [61].

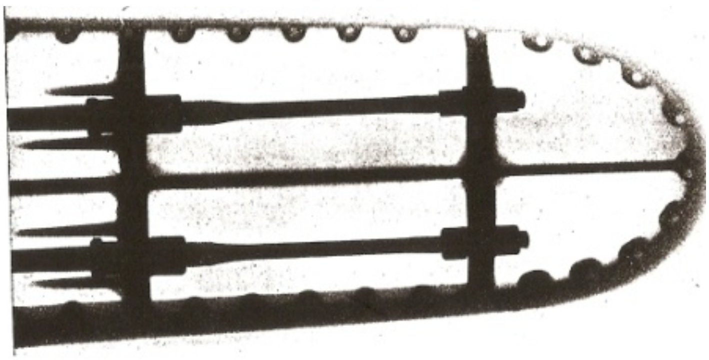
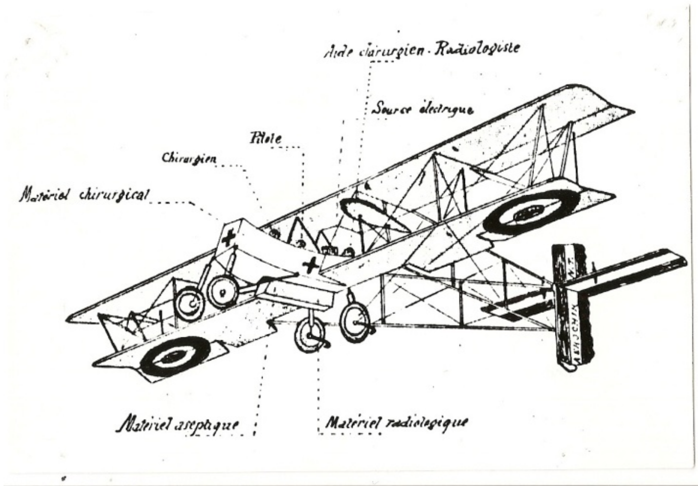


**Figure 16**. Non-destructive testing of an aeroplane propeller [61].

### Escadrille Pozzi "Aérochir" 1918

The most unusual mobile X-ray apparatus was surely the one involving the use of a biplane [62-65] intended for the French combat squadron *Pozzi*. The project was developed in September 1918 by an engineer [Nemirovsky] and a doctor [Tilmant] working in the United States Army. Their proposal  was to convert a *Voisin* bomber into an ambulance, with all the necessary equipment necessary for radiography. The radio-surgical room was set up in a tent, transported as part of the equipment.  It was not used during World War I, but was modified after the end of the war, using a Breguet bomber and was used in the French colonial wars of the 1920s [66].

**Figure 17**. The "Aérochir" of 1918.



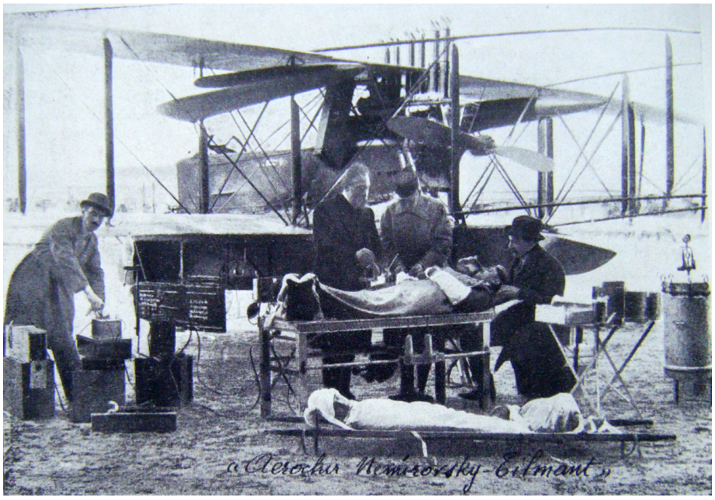




**Figure 18**. Deployment of the X-ray apparatus.

## United States Military Radiography 1917-1919

The United States Army Manual of 1918 includes much advice and information on military radiography [67] and several papers, mainly in 1918, appeared in the *American Journal of Roentgenology* to describe the experiences with X-rays in World War I [47, 68-76]. An extensive review for 1917-1919 also appeared in the journal *Radiology* [77]. **Figures 19-20** are two examples from the Manual [67]. X-ray ambulances have already been mentioned [38-51] and Colonel Christie who was in charge of the American X-ray equipment on the western front compared the different X-ray ambulances [47]. 'The advantage of the English and French camions over the American is that the two former have the body of the car arranged as a dark room, while the latter is not. Experience in this war has shown that the greater part of the Roentgen ray work in hospitals in the forward areas, including evacuation hospitals, is fluoroscopic. The few plates which will be made can conveniently be developed in the small portable dark room furnished with the American apparatus.' Christie also commented on the automobile engines. The engine of the American camion is not used to generate power for the Roentgen rays or lights, and can therefore be overhauled and placed in order between trips.' He saw this as one advantage of the US design, others being its much lighter weight, a demountable apparatus and the availability of spare parts.

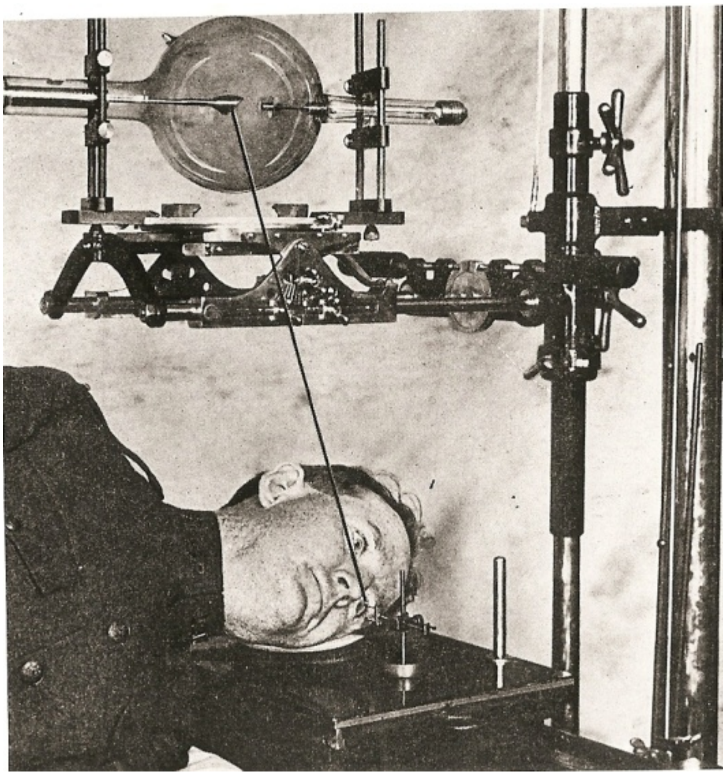


**Figure 19**. Part of the technique for the localisation of 'projectiles in the eye'. A tube shift method was used with two radiographs taken.

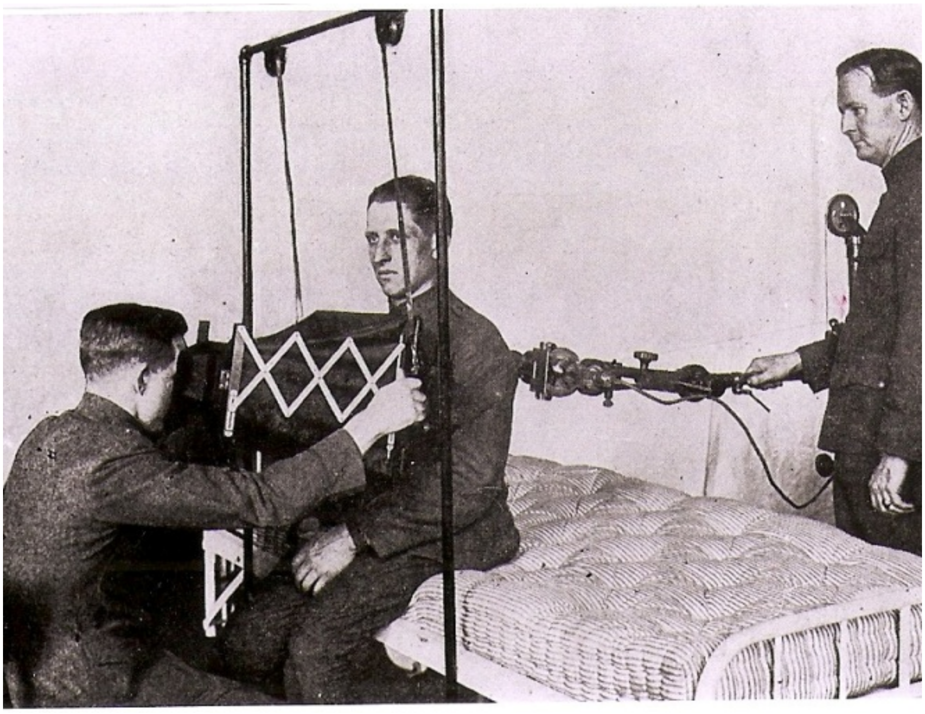
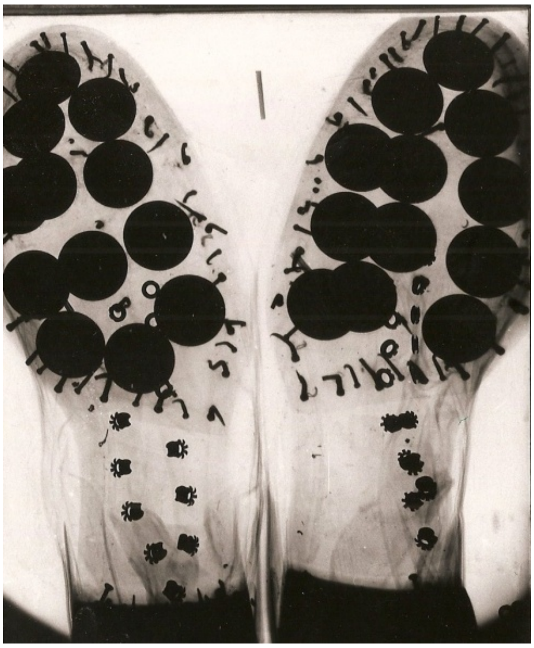


**Figure 20.** 'A bedside unit with a simple vertical fluoroscope for chest examination at the bedside'. It was stated to give 'good average results when two conditions are met: (**1**) a tube current of 5 mA; (**2**) a proper low tension voltage supplied to the transformer terminals.'

**End Note**

To conclude this brief review are two unusual items. The 9 cm x 12 cm advertisement which was inserted in all issues of the *Journals of the Röntgen Society* in the year 1917 and a radiograph taken in 1920 of the boots of a Polish soldier who smuggled gold coins into England.

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**BRITISH DOCTORS IN ARGENTINA: Sir James Mackenzie Davidson, by by Dr. John D. C. Emery**
**Buenos Aires British Hospital**
http://www.abcc.org.ar/health-issues---our-hospital/british-doctors-in-argentina---dr-sir-james-mackenzie-davidson

Sir James Mackenzie Davidson

Strictly speaking, this eminent personality should not be included in these biographies, as he was born in Argentina, but pursued his studies in Aberdeen, and practiced later in Scotland and England all his life. Never-the-less, his successes were such, that he is worthy of being remembered.

He was born in the Santo Domingo Monastery located on the Estancia Santo Domingo, in Quilmes, in 1856. His father was John Davidson, whose Estancia was next to William H. Hudson's family's farm: their properties were separated by a river called Conchitas. Whilst the Davidson's enterprise prospered, the Hudson's steadily declined, and the latter was eventually bought over by John Davidson. William Hudson was 15 years senior to James Mackenzie Davidson and they had little contact in their youth, though some of Hudson's later letters mention correspondence between them in England, pertaining to his book "Far away and long ago".

James Mackenzie Davidson was educated at the Buenos Aires Scottish School, and his medical studies were undertaken in Edinburgh, London and Aberdeen, from which school he graduated in 1882. He then specialized in ophthalmology and became Assistant Professor of Surgery at the Aberdeen University, under Professor Sir Alexander Ogston. As from 1886 he was ophthalmic surgeon at the Aberdeen Royal Infirmary and at the Royal Hospital for Sick Children. He was a successful and well liked teacher, and began employing the new methods of aseptic surgery. His hobby of studying electricity and optical physical phenomena, led him to read the novel work of Roëntgen in developing X-rays in 1886, and subsequently visiting him in Wuerzburg, Germany. There he spent some time learning about this extraordinary development.

The following year he was the first to publish an X-ray of a bladder stone. He then moved to London, and pursued these subjects intensely. In 1900 he published a paper in the "Roëntgen Society" on a new rotational mercury interruptor, which was adopted in X-ray machines universally, and known by his name. He also studied fluoroscopy as applied to the diagnosis in human beings. His first contribution in this line was its application to localizing foreign bodies, mainly in the eye, and later in war wounds. He was also one of the earliest physicians to utilize radioactive radium, and identified some skin conditions which improved with its use.

In 1912 he was knighted by the King for his extraordinary contribution in the fields of ophthalmology and radiology. He was also named Consultant Surgeon to the X-ray departments of the London Royal Eye Hospital and of the Charing Cross Hospital. In 1912 he was elected to a two year tenure as President of the London Roëntgen Society, and also of the Radiological Chapter of the International Medical Congress which was held in London that year. He was also one of the very few foreigners to become an Honorary Member of the American Roëntgen Ray Society.

After his death in 1919, the British Radiological Society instituted the Sir James Mackenzie Davidson Lecture as one of its main yearly features, and the British Institute of Radiology awards yearly The Mackenzie Davidson Medal for outstanding work in this field.

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**Mackenzie Davidson Medal, officially inscribed on bottom of rim: "JAMES CHADWICK, Phd., F.R.S., 7th DECEMBER 1932."**

**Bronze medal is 2 3/16 inches diameter; diced goat-skin case, w/ velvet & satin interior, is 2 15/16 " square**

**Electro-Diagnosis in the First World War**

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This article is not about diagnostic radiology, but about its close sibling, electro-diagnosis. Both technologies were spawned from rapid developments in nineteenth century medical physics and medical electricity. By the beginning of WWI each was semi-autonomous as an independent clinical discipline, yet still retained strong links to its origins.

**Origins of electro-diagnosis**

Techniques for electro-diagnosis had been established decades before the outbreak of the war in 1914. Duchenne de Boulogne, who pioneered these techniques during the middle years of the 19th century, died in 1875 at the age of 69. By the early part of the 1880s, several books on the subject were available in English, including Tibbits' 1871 translation of the first part of Duchenne's *L'Électrisation localisée*, Poore's *Selections from the Clinical Works of Dr Duchenne* (1883) and Putzel's translation of Erb's *Handbook of Electrotherapeutics* (1883). Hughes Bennett, physician to the Hospital for Epilepsy and Paralysis in London, published *A Practical Treatise on Electro-Diagnosis* in 1882, probably the first monograph by an English author specifically devoted to this subject. Maps of motor points for the placement of the stimulating electrodes were widely published (Fig 1), identifying the locations where, under normal conditions, the nerve or muscle to be examined is sufficiently superficial to be stimulated by an electric voltage applied to the skin. I have given more details of this background in my book *Physicists and Physicians: A History of Medical Physics from the Renaissance to Röntgen*.

Hughes Bennett subtitled his book "*In Diseases of the Nervous System*". Specifically he reported the use of electro-diagnosis in paralysis, whether caused by diseases of the brain, spinal chord or peripheral nerves. However, paralysis from traumatic injury is mentioned only in passing. Up to the outbreak of war, those involved with electro-diagnosis had very little experience with the investigation of the widespread and varied traumatic effects of modern warfare on those exposed to high explosives and high velocity arms. And these effects were as unexpected as were the realities of modern trench warfare. Jules Tinel, the head of neurology of the 4th French Military Hospital at Le Mans wrote, in 1916, *"The frequency of peripheral nerve injuries in this war is considerable. This has been a surprise."* Radiology had little or nothing to offer to the diagnosis of such injuries.

**Links with radiology**

By the late nineteenth century, most reputable hospitals had a department of therapeutic medical electricity, some of which carried out electrical diagnostic tests as well. They also became the primary home for radiology during its formative years. Books from this period reflected these developments. As one example, the pioneer radiologist Dawson Turner published the first edition of his *Manual of Practical Medical Electricity* in 1893, shortly before the discovery of x-rays. He was, at that time, lecturer on medical physics and electro-therapeutics at Surgeon's Hall, Edinburgh. This book included, in Part III, chapters on electro-diagnosis. For the 3rd Edition (1902), by which time Turner was the medical officer in charge of the Electrical Department of the Royal Infirmary, Edinburgh, the title of the book had been extended to add "*The Röntgen Rays and Finsen Light*" to reflect the addition of this new material. Several other texts at that time included a similar spread of topics, grouped under the general title of Medical Electricity, and this pattern, reflecting practice as much as convenience, lasted well into the beginning of the 20th century.

It should not be surprising, therefore, to find the same association between radiology and medical electricity in the organization of military hospitals during WWI. Table 1 lists the heads of some combined departments of radiography and electrotherapy in French military hospitals. What is notable about this list is the wide range of knowledge and expertise of the heads of these departments. Many had made important contributions in medical electricity, even though their names would later become associated specifically with radiology. Three, Imbert, Cluzet and Bergonié were professors of medical physics. This structure in French military hospitals gave a robust environment, therefore, for the more subtle discipline of electro-diagnosis to take its place during WWI.

**Adolphe Zimmern**

Adolphe Zimmern (1871-1935), Figure 2, was yet another example of a technically-competent French doctor whose contributions spanned medical electricity and radiology. The following details of the use of electro-diagnosis in the war are largely taken from his book *Electrodiagnostic de guerre* (1917), co-authored by Pierre Perol, from which most of the figures that accompany this article are taken. An English version, edited by Elvin Cumberbach, Medical Officer of the Electrical Department at St Bartholomew's Hospital, was published the following year in the Military Medical Manuals series, edited by Sir Alfred Keogh.

Zimmern was born in Paris, became an intern of the Paris hospitals in 1897 and obtained his MD in 1901. In 1907 he was appointed to the academic post of *agrégé* in the physics department of the Faculty of Medicine under Charles-Marie Gariel. This laboratory, together with the biophysics laboratory of Arsène d'Arsonval at the *College de France*, were the two powerhouses for the applications of physics to medicine in Paris at this time. Zimmern was appointed as head of the department of electro-radiology at *la Charité*, and then, in 1911, became head of the *Institut municipal d'électro-radiologie* at *la Salpetrière*, where he remained for the rest of his career. During the pre-war years he worked at the cutting edge of medical electricity. He extended Leduc's observations on the induction of coma by electricity, which he considered was comparable to that following an epileptic seizure. He investigated fulgaration, a method of cauterization using diathermy, publishing a little book on the subject in 1909. He studied the effects of x-rays on the thyroid gland in rabbits. His *Radiothérapie: Rœntgenthérapie – Radiumthérapie Photothérapie,* published in 1913, was widely recognized as a substantial contribution. For this book, his co-author was his friend and colleague Paul Oudin, who had developed the widely-used resonant "Oudin coil", and had carried out the very first x-ray studies in Paris in January 1896.

**Electrodiagnostic de guerre**

The electro-diagnostic techniques that Zimmern described in *Electrodiagnostic de guerre* were straightforward and were not original. A faradic (ac) or a galvanic (dc) electric voltage was applied to the skin, either using a local sponge electrode of about 1 cm diameter and a large ground electrode, or between two small local metal electrodes (Figure 3). For dc application, standard sequences of polarity switching were used (Figure 4). The applied voltage could be controlled with a rheostat or, for faradic stimulation, by the distance between the primary and secondary coil (Figure 5). The threshold of electrical current was recorded at which a muscle contraction was first observed, this measurement being of primary diagnostic importance. Qualitative observations included a reduced speed of contraction, and the inversion of the normal response to altered polarity. The voltages available were sufficient to reach conditions of tetanic contraction and unbearable pain with normal sensation. The cost of installing the equipment was not great. Nor were the overheads high in running the service in comparison with similar costs for a radiological service, with its need for x-ray plates, chemicals and replacement x-ray tubes.

**Medical applications of electro-diagnosis**

Zimmern listed and discussed a variety of conditions of traumatic injury for which electrodiagnosis could be of value. These were:

- Traumatic compression of nerves
- Lesions of the cord
- Combined hysterical and organic disorders
- Reflex paralyses and contractures
- Ischaemic paralyses
- Paralysis of toxic and infective origin
- Severance of muscles and tendons

The injury may have caused division, compression or irritation of the nerves and in each case he explains how the site and character of the traumatic injury may be examined. Gunshot wounds frequently involve the severance of muscles and tendons, and Zimmern describes how these injuries may be investigated also. Under some situations, electrical stimulation during surgery was used. Whatever the situation, he stressed the importance of repeat investigation, recognizing that nerve damage was susceptible of spontaneous recovery, even though this may take several months to take effect. He reminded the reader of other possible traumatic causes of paralysis such as gassing and frostbite, and of disease causes such as poliomyelitis and diphtheria.

**Military applications of electro-diagnosis**

Such studies had a clear medical purpose. The value to the surgeon was set out. Guidance in therapeutic management during recovery could be quantified. There was, however, another agenda, and this was a military one. Zimmern describes how electrodiagnosis could be used to evaluate disorders of cutaneous sensation. He says "The faradic coil is a valuable means of testing sensibility, both from the point of view of affections of the sensory system, *and for the purpose of exposing malingers* (my italics)". He goes on " when the secondary coil is moved slowly up towards the primary, a point is reached … at which the patient begins to experience a slight tickling sensation, which is at first disagreeable, and gradually becomes definitely painful". The ratio of the current at threshold to that at pain is a measure of sensation, variable with the site of measurement, but equivalent on opposite sides of the body under normal conditions. The use of such a method to identify soldiers who simply desired to remove themselves from the front line is obvious.

**The galvano-psychical reflex and voltaic vertigo**

Zimmern had himself studied the physiological response to external emotional or physical stimulation in the context of military experience. He uses the term "galvano-psychical reflex" for the phenomenon that we now associate with evoked responses and, perhaps, lie detection, for which there may be a small change in skin resistance in response to an applied stress. His preferred stimulus was heat. The presence of normal or exaggerated response (associated with "hysterics") implied the absence of any organic lesion. In "voltaic vertigo", arising from the electrical stimulation of the ear, a threshold for vertigo of over 4 mA was considered diagnostic of injury (Figure 6).

**Army pensions**

It would be easy to dismiss these electro-diagnostic studies as being on the fringes of serious medicine. But that would be an incorrect judgement. The test for voltaic vertigo became compulsory following a meeting of the *Société de Neurologie* in April 1916. According to Zimmern, reports of electrical diagnosis were of considerable importance alongside radiological examinations in French Medical Board papers. This Board had the authority to advise on pension awards, and an electrical examination was the only diagnostic test that would offer explicit evidence on the underlying cause of an observed paralysis, with a prediction of a possible partial or total recovery. A pension was awarded only if a disability was both severe and incurable. Since it was for life and could never be revoked even following a diagnostic error, this goes some way to explain the emphasis that was being placed on these tests that might otherwise only indirectly affect medical management. Of equal importance, the electrical tests helped to differentiate between simulated, hysterical or functional paralysis. This would have helped in resolving the tension between the military, who wished to return soldiers to the front line, and the doctors who were concerned with their medical care.

**Summary**

Electrodiagnosis complemented radiodiagnosis during WWI. Both arose from technological innovations that had emerged at the end of the previous century. Pioneers in one often contributed to the other. The specific challenges that arose in the medical care of injured soldiers, and particularly the use of scientific diagnostic tests to illuminate and guide treatment and surgery, acted as a launch-pad for the separate development of radiology and electro-diagnosis after the war ended.

| **Head** | **Hospital** |
|---|---|
| Antoine Béclère | Val de Grâce Paris |
| Jean Bergonié | Bordeaux |
| Stéphane Leduc | Nantes (civil) |
| Louis Delherm | Toulouse |
| Albert Laquerrière | Rennes |
| Hyacinthe Guilleminot | Bourges |
| Armand Imbert | Montpellier (civil) |
| Joseph Cluzet | Lyon |
| Charles Livon | Marseille |
| Théodore Guilloz | Nancy |

Table 1: From Anne Rasnussen. L'Electrothérapie en Guerre: practiques et débats en France (1914-1920). *Annales historiques de l'électricité;* Déc 2010;8:73-89.

**Figures.**

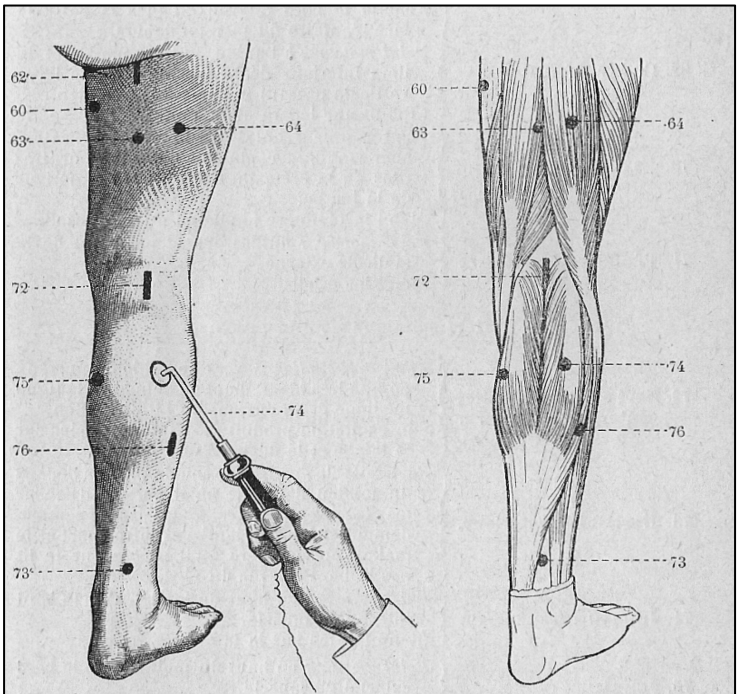


Fig. 33 et 34. — Points moteurs du membre inférieur (région postérieure).

Figure 1. Motor points for the leg. From Zimmern, *Electrodiagnostic de guerre.*

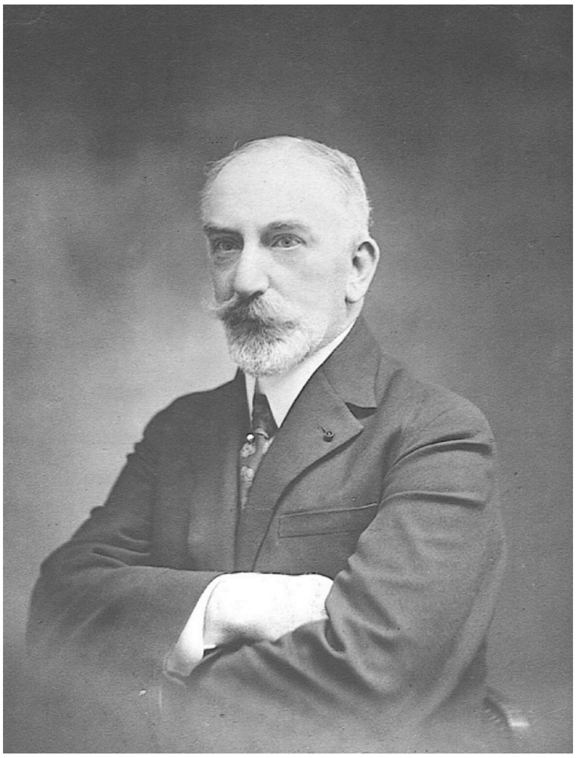

Figure 2 Adolphe Zimmern, as president of the *Société de radiologie médicale de France*, 1925. BIU Santé Paris.

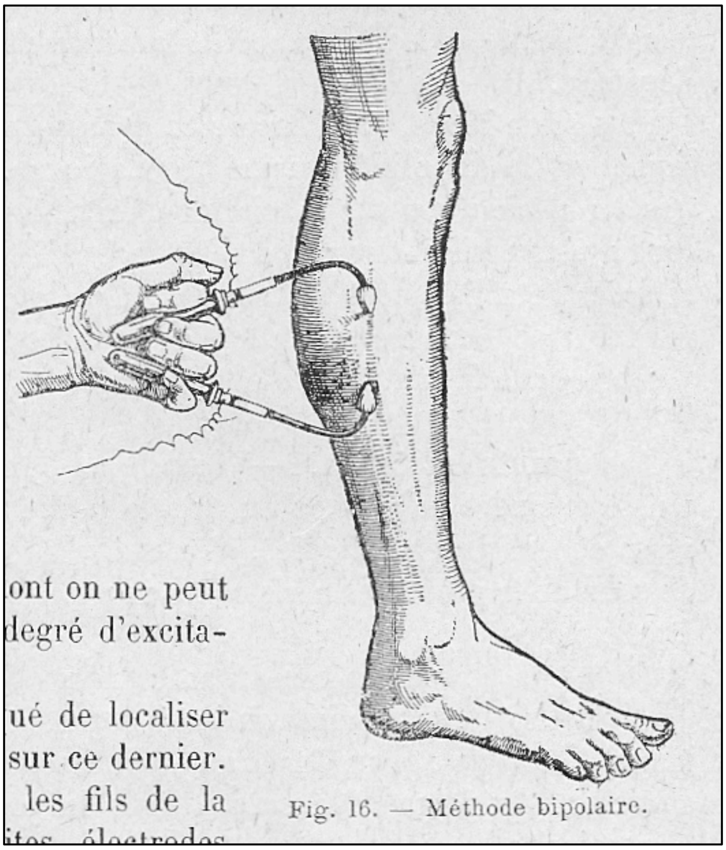


Figure 3 Bipolar electrode placement.

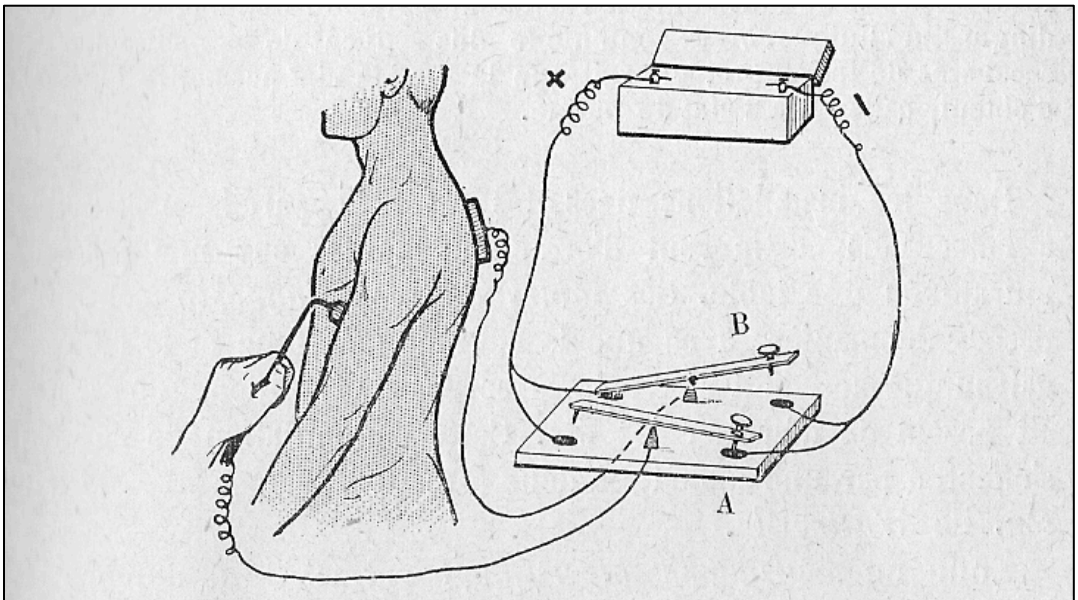


Fig. 6. — Manœuvre de la double clef. (La clef A est abaissée : dans ces conditions l'électrode exploratrice est reliée au pôle négatif.)

Figure 4 Switching allowed the polarity of galvanic stimulation to be altered in specified sequences.

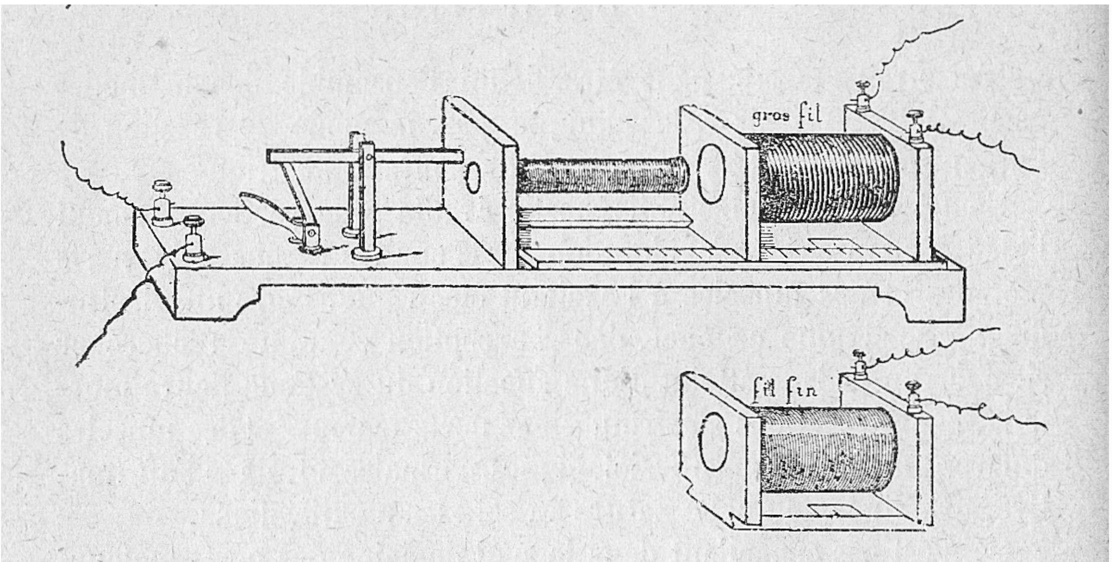


Fig. 1. — Appareil faradique à chariot.

Figure 5 Faradic coils, showing slider to alter the secondary induced voltage.

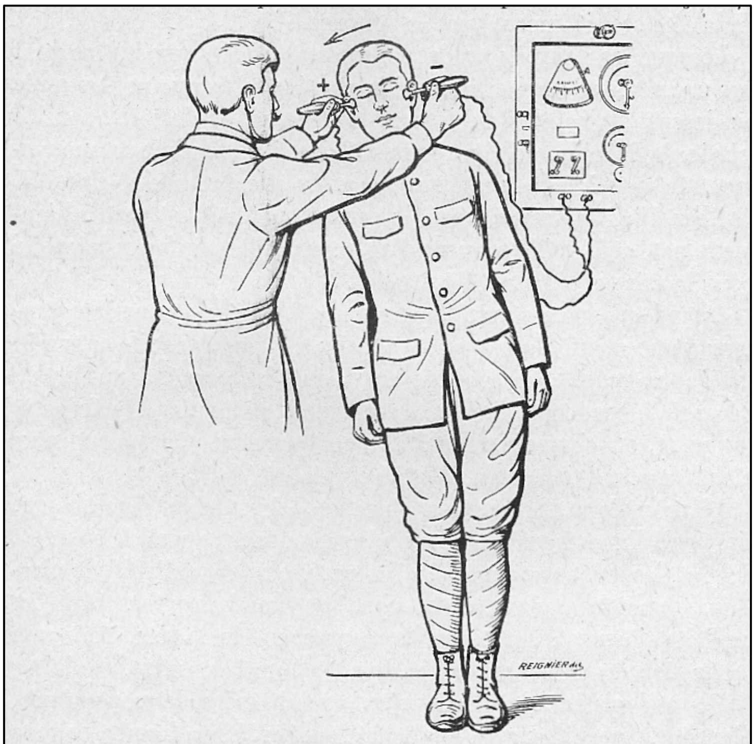


Fig. 44. — Le vertige voltaïque normal. Le sujet s'incline vers le pôle +.

Figure 6 Voltaic vertigo.

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