The Marconi Wireless Telegraph Apparatus in R.M.S. *Titanic* Confirmed by Observations of the Wreck

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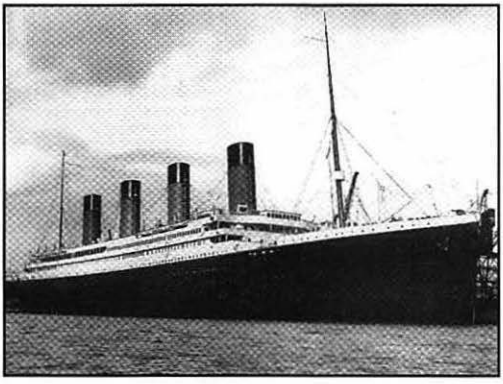


Figure 1. *Titanic alongside in Southampton. Note the spacing between the two inner antenna wires, as opposed to that of the outer wires, at the forward spreader and the strop insulators between the third and fourth funnels. (Harland & Wolff archives)*

Introduction

A system-level description of the Marconi apparatus on board the White Star liner Titanic was previously presented in a two-part article published in the AWA quarterly newsletter, the Old Timer's Bulletin in November 2001 and February 2002. For this article, that description will be expanded to include component-level detail.

In September 2001, film director James Cameron explored the remains of the Marconi suite during his expedition to film the wreck of the Titanic for his upcoming documentary Ghosts of the Abyss. One of Cameron's uniquely-designed remotely operated vehicles (ROVs) was able to penetrate farther than any previous attempt into the portion of the Officers' Quarters that housed the Marconi suite, where it disclosed the remains of the transmitting apparatus. Based on Cameron's discovery, it appears that, although the Marconi Room was completely destroyed by hydrodynamic forces acting inside the superstructure as the ship plunged to the ocean floor, the more substantial walls of the adjacent room that housed the transmitting apparatus provided a measure of protection for the equipment therein. This room was called the "Silent Room," because its walls were heavily insulated with asbestos to prevent the loud noise of the electric motors and spark generating equipment of the transmitting set from distracting the operator while he attempted to receive faint signals through his headphones. Organisms that have taken residence within the wreck have eaten

Figure 2. Olympic's *Marconi Room, as seen during her maiden voyage in June 1911. (Marconi plc archives)*

away most of the remaining interior walls over the past 90 years with the result that the Silent Room is now open to view.

Cameron's thorough exploration of the Silent Room yielded a gold mine of information. Although pictures of operating rooms or Marconi rooms are relatively common (Figs. 2 and 3), contemporary pictures of the interiors of Silent Cabins aboard ships during the spark era are rare. Of the three Olympic-class liners, of which Titanic was the second, the only known photograph of the interior of a Silent Room was taken around 1924 and shows Continuous Wave equipment. Therefore, even though the configuration of a Marconi transmitter could be postulated by studying contemporary literature concerning the subject, there was little direct evidence prior to Cameron's expedition to corroborate such speculation. But there, illuminated in the lights of Cameron's ROV, was an almost-complete 5-kW Marconi transmitting set, arguably the most famous one in the history of marine wireless telegraphy, still connected together by the original circuit wiring. A study of this apparatus is therefore illuminating for students of both Titanic and Marconi history.

Background

Marconi's Wireless Telegraph Company, Ltd. (hereafter referred to as the Marconi Co.), had an exclusive financial arrangement with the major British-flagged shipping lines among which was the White Star Line. These companies paid the Marconi Co. for the use of their equipment and for the salaries of the operators who manned the shipboard installations. The Marconi Company was responsible for the training of the operators as well as the installation and maintenance of the leased equipment.

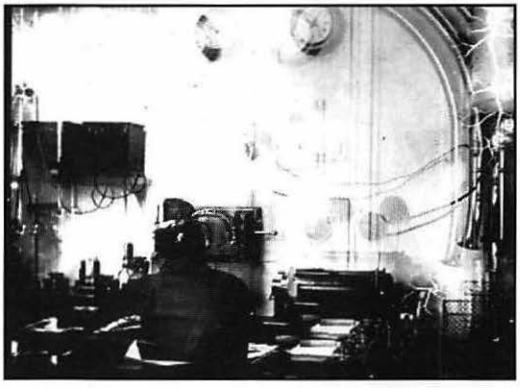


Figure 3. Titanic's *Marconi Room, as seen during her maiden voyage in April 1912. Double-image photo, the only surviving photograph of* Titanic's *Marconi Room. (Fr. F. Browne collection)*

The major incentive to the steamship lines for installing a wireless telegraph apparatus was revenue generated by passenger traffic. Use of the apparatus for navigational purposes was also understood, but not fully appreciated, across the industry. Not all ships plying the North Atlantic were equipped with wireless, and of those that were, only a relatively few were manned around the clock. This changed as an immediate result of the *Titanic* disaster, but the signals for change were already in the air just prior to 1912. The differences in the physical placement of the wireless controls between the White Star sisters *Olympic* (1911) and *Titanic* (1912) demonstrate an increasing dependence on having more than one operator man the station. On board *Olympic*, it only took one operator to control the entire apparatus from the Marconi Room should the occasion require it (*Olympic* was nonetheless staffed with two operators, because of the expected passenger traffic load). On board *Titanic*, the controls for the transmitting equipment were moved into the Silent Room, which meant that two operators were required to work in tandem to adjust the equipment.

The wireless apparatus was housed on board *Titanic* in a series of interconnecting rooms — the sound-proof "Silent Room," in which noisy transmitting equipment was located; the Marconi Room, an office which contained the operators' work stations, manipulation keys, and receiving equipment; and the Bed Room, which contained the operators' spartan berthing. This suite was located inboard on the centreline of the Boat Deck within the Officers' Quarters deckhouse. A six-pane skylight overhead in the Marconi Room provided natural light to the space.

As mentioned above, the wireless apparatus was operated and cared for by Marconi Co. employees, who were by routine assigned to *Titanic* for the duration of one voyage and, therefore, not considered part of the normal White Star Line crew. The uniforms worn by the two Marconi operators aboard *Titanic* were made distinguishable by Marconi emblems on the buttons, sleeves, and cap. Marconi employees were not directly responsible to any of the ship's crew, except the ship's Master, and even then, only in certain instances. Most of their time was spent within the Marconi suite, with the exception of meals, which were taken in the dining saloon reserved jointly for Marconi and postal employees on C Deck.

Originally, the standard 1.5-kW marine wireless apparatus was intended for the two newest additions to White Star's transatlantic service, the sister ships *Olympic* and *Titanic*. As events happened, though, wireless technology progressed so rapidly between 1909 and 1911 that a 5-kW plain spark apparatus was now available to be installed on board *Olympic* just prior to her maiden voyage in June, 1911. *Titanic* would receive the additional benefit of a synchronous rotary spark discharger the following year.

Titanic's wireless apparatus had a nominal working range of 250 nautical miles, but signalling more distant stations was possible. At night, ranges of up to 2,000 miles were attained with sets of similar architecture. The use of the "T" type aerial afforded greater power and sensitivity in both fore and aft directions so optimised performance could be expected when the ship was pointed either toward or away from a distant station.

Details of the Wireless Installation

The Marconi wireless apparatus consisted of both transmitting and receiving equipment sets. The transmitting set consisted of five distinct circuits that

converted direct current from the ship's electrical mains into regulated, high-power, radio-frequent oscillations that were then transmitted into the atmosphere by way of the ship's aerial. Much of this equipment was located in the Silent Room, the walls of which were heavily insulated with asbestos to quench the noise and reduce interference generated by the transmitting apparatus. The receiving set, located on or adjacent to the aft-facing operators' desk in the Marconi Room, was connected into a single circuit that converted radio-frequent oscillations collected by the aerial into audible signals that could be heard by the operator. An emergency transmitting set, also located in the Marconi Room and capable of producing a plain spark in the event of a casualty to the main transmitting set, was also provided.

Transmitting Set

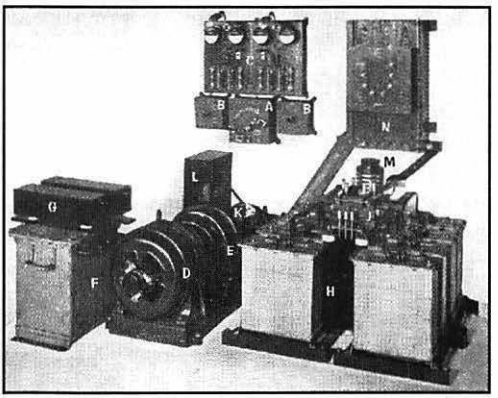


Figure 4. *5-kW transmitting set of the type installed on board* Titanic. *A—Starter. B—Field Regulators. C—Double Panel Switchboard. D—Alternator. E—Motor. F—Transformer. G—Choke Coils. H—Main Condenser* (Titanic *had 4 cells, not 8 as depicted here). J—Swiss Commutator* (Titanic's *commutator was arranged for 4 cells). K—Disc Discharger. L—Discharger Box. M—H.F. Tuning Inductance. N—Jigger (variant of the type used aboard* Titanic*).* (The Year Book of Wireless Telegraphy and Telephony 1914, *modified*)

The Direct Current transmitting circuit carried the 100-volt direct current (D.C.) from the ship's lighting circuit via a local electrical distribution box to the main switch for the Marconi equipment. This circuit included the main switch, a starter, two field regulators, the D.C. switchboard, four protecting shunts and the motor. The function of each of these components is described below.

Main Switch — The Main Switch was used to allow D.C. from the ship's mains to flow to the motor. To start up the motor, the operator first had to close the double pole (D.P.) knife main switch, then place the starter handle over the first or second contact.

Starter — (see A, Fig. 4) The full and sudden application of direct current to the motor could burn out the armature windings, so a series of resistance coils was used to slowly bring the motor up to operating speed. The manual motor starter consisted of a series of brass contact studs on a slate face. Each stud was connected to a resistance coil within the starter's cast-iron casing. The starter incorporated an overload release electro-magnet, which caused the electrical flow to the motor to be cut out whenever the current exceeded a pre-determined value. As the handle of the starter was slowly moved across the contact studs, resistance was taken out of the circuit and current was thereby admitted to the motor armature in small increments. The motor's speed steadily increased as the handle was moved toward the final or full running position.

The handle was held in the full running position by a no-volt release, which was essentially another electro-magnet. Upon loss of power, a break in the current flowing through the motor windings or the activation of the overload release, the handle was released and brought back to the full open position by a spring held in tension.

Field Regulators (see B, Fig. 4) - Two field regulators - one to regulate the frequency of the alternator, another to regulate the voltage of the armature - connected in series with the motor generator allowed the operator the means to adjust the discharged spark. Each field regulator consisted of a number of turns of resistance wire wound on a slate base, in much the same fashion as the starter. As the operator moved the starter handle across each sequential tap to bring the motor up to its steady operating speed, resistance in the motor's armature circuit was steadily decreased until it reached a minimum value. As resistance was being cut out of the armature circuit, it was introduced in proportional quantities into the field-magnet circuit. This was designed to keep the motor armature from overheating during the starting process. When the starting handle was brought to rest on the final contact stud and the armature was running at a constant speed, this protection was no longer necessary and all resistance was then cut out of the field circuit. If a greater speed was desired after the motor had been brought to its constant steady speed, then an application of extra field resistance would decrease resistance in the armature circuit, thereby allowing the motor armature to rotate at a faster rate. In the alternator, the part that revolved was the field, so an increase in the resistance of the exciting field (alternator) regulator reduced the current flowing through the alternator field and the voltage across the alternator terminals subsequently dropped. The difference in the effect of applied resistance by the two field regulators was due to the fact that in the motor, the armature rotated; in the alternator, it was the field that rotated. Close regulation of the voltage and frequency produced by the motor generator was necessary to achieve a properly quenched spark. No spring return was fitted on the handle of the regulators, as the handle had to be capable of being left on any selected contact stud.

The settings observed for the field regulators in the wreck of the Titanic show that an extra amount of field resistance had been applied to increase the speed of the motor and thereby raise the alternating voltage, while the alternator had a bit more resistance than normal applied to lower the frequency of the transmitted spark to compensate for the increased speed of the motor without affecting the voltage output. Basically, the observed positions of the settings support the supposition that the Marconi operators were trying to wring more power for the transmitted spark from the fading shipboard power supply moments before the ship foundered.

Double Panel Switchboard (see C, Fig. 4) — The switchboard had a slate panel for direct current (DC), and another for alternating current (AC), both of which were mounted on a common cast-iron frame. Each panel included a double pole (D.P.) knife switch that allowed for control of current flow into the working circuits and cartridge fuses to provide for circuit protection against sudden differences in potential. A shaded pilot lamp on each panel illuminated when power was being supplied to that particular panel, no matter if the respective D.P. switch was open or closed. An illuminated pilot lamp on the DC panel indicated that ship's direct current was being supplied to the switchboard

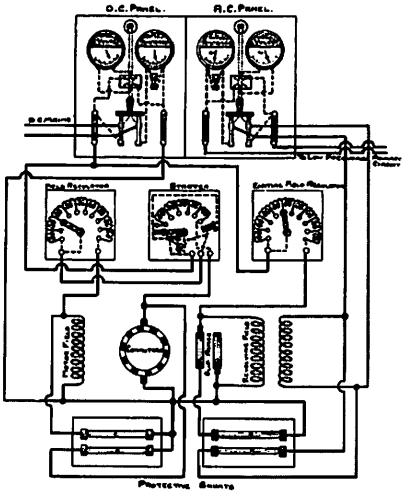


Figure 5. *Motor Generator Connections (5 kW).* (Handbook of Technical Instruction for Wireless Telegraphists)

from the mains, while an illuminated lamp on the AC panel indicated that alternating current was being supplied to the switchboard by the alternator. The DC circuit was protected by 100-ampère cartridge fuses; the AC, by 30-ampère fuses. Each fuse consisted of a fuse wire surrounded by asbestos or sand, the whole of which was contained within a cardboard cylinder capped with brass terminal lugs at either end. The strength of the voltage or electro-motive force (E.M.F.) in either circuit could be measured by pressing the voltmeter key momentarily and observing the needle deflection in the voltmeter on the respective panel. The operator could also monitor the performance of the motor generator by observing the values measured by the ammeter on each panel, which measured the current flowing inductively through the stationary windings of the motor field (DC) or armature (AC).

Protecting Shunts — Four graphite sticks, in tubular form, were connected in shunt (parallel) across the alternator and motor terminals for the purpose of preventing spikes created by the oscillating discharges in the transmitting circuit from damaging the windings of the motor and alternator. The resistance supplied by these sticks absorbed excessive oscillations in voltage. Each of the two sets of protective shunts was mounted between two pairs of brass springs, fixed on a baseboard supplied with electrical terminals.

Motor Generator (Fig. 5) — A source of alternating current was required for the generation of radio-frequent oscillations. The Motor Generator supplied 300-volt, 60-cycle AC from the 100-volt DC ship's supply. Radio transmission required that the generator provide constant speed and AC voltage under variable load. For this reason, the motor was rated at a larger output than the alternator so as to provide a suitable margin of power to compensate for the load placed on the alternator each time the transmitter key was depressed. The set (see D-E, Fig. 4) consisted of a drum-wound motor and a simple alternator coupled together on a common cast iron base. The motor armature was on the same shaft as the alternator rotor field, separated by a coupling. Rotation of the motor armature caused rotation of the drum-wound alternator armature by way of the common shaft. As the alternator field revolved past stationary coils situated around the interior of the framework, alternating current was induced in the windings. Mechanical power was thus converted to electrical current. The AC taken from the stationary windings at the alternator end of the shaft was sent to the AC panel of the switchboard.

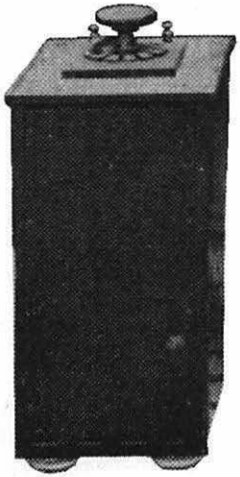


Figure 6. *Low Frequency Inductance.* (Handbook of Technical Instruction for Wireless Telegraphists, *modified*)

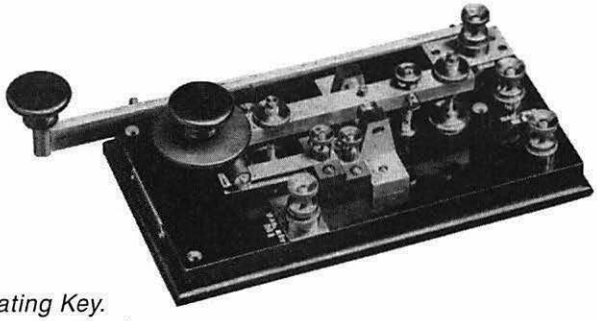


Figure 7. (right) *Manipulating Key.* (Handbook of Technical Instruction for Wireless Telegraphists, *modified*)

Low Frequency Primary Circuit

The Low Frequency primary circuit carried the low potential alternating current generated by the alternator to the primary winding of the transformer. This circuit included the AC switchboard, a regulating inductance, a manipulating key, a magnetic key and the primary winding of the transformer.

Low Frequency Inductance (Fig. 6) — In the DC circuit, self-inductance effects were only produced at times of switching the circuit on or off, or when the current was increased or decreased. With alternating current, self-inductance effects continually rose and fell as the current switched direction. In order to establish a state of resonance (i.e., where the potentials across the inductance and the capacity balanced one another) in the low frequency primary circuit so that the condenser could be efficiently charged, a variable inductance was provided. The low frequency inductance consisted of a coil of insulated copper wire wound on a laminated iron core. Adjustment of the inductance value was performed by moving a brass spring brush over a series of brass stops. Both the speed of the motor and the amount of inductance were adjusted to achieve the state of resonance. When both current and voltages were in phase, the alternator delivered energy to the transformer at maximum efficiency.

Manipulating Key (Fig. 7) — The Manipulating Key was connected to the low potential side of the transformer by way of a magnetic relay key. The function of the key was to form the dots and dashes of the Morse code by allowing the alternating current to flow from the alternator to the transformer whenever the operator depressed the key. The Marconi Morse transmitter key had platinum contacts to resist the corrosive effects of switching the circuit to the magnetic key. An ebonite knob and protecting disc on the end of the brass bar of the key protected the operator from electric shock. Because there was

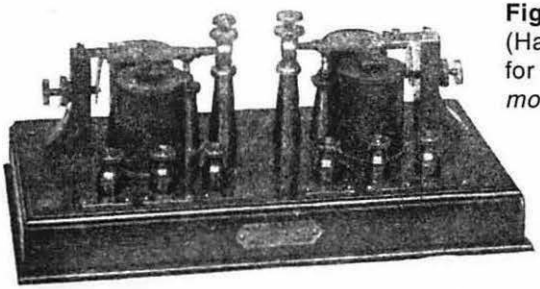


Figure 8. *Double Magnetic Key.* (Handbook of Technical Instruction for Wireless Telegraphists, *modified*)

no aerial change-over switch to protect the receiving headphones from the sending spark, the Marconi key had small auxiliary spring contacts on the side, which were pressed together by a small ebonite bar projecting from the side of the brass bar each time the key was depressed. These contacts were joined across the receiver headphones, short-circuiting them whenever the key closed the circuit. In this manner, the ears of the operator were protected from the loud discharge of his own transmitter. A brass lever with an ebonite knob at the left side of the base broke the circuit completely if required in an emergency situation, effectively isolating the transmitter key.

Double Magnetic Key (Fig. 8) — The relay key utilised electro-magnetically operated switches to interrupt the 100-300-volt primary circuit, in order to protect the expensive platinum contacts of the manipulating key from the corrosive effects of a high voltage spark. Use of a double magnetic key relay also allowed the manipulating key to be worked on a lower voltage. As the name implies, two electro-magnets of similar construction were utilised, one in the DC circuit, the other in the AC low-frequency primary circuit. Each one consisted of two coils of wire wound on boxwood bobbins, which were then mounted in parallel on two slotted soft iron cores fixed to an iron yoke in the wood base. The windings on the D.C. coils were of much finer wire and of greater numbers of turns than those of the AC coils as the current used was much smaller. A soft-iron armature was mounted above each set of coils on a brass arm by means of a flexible spring. Each armature carried a platinum contact stud on its under side, directly across a small air gap from a like contact mounted atop a brass support pillar extending upwards from the base. The first electro-magnet was energised from the DC mains whenever the manipulating key was closed, attracting the armature and thereby closing the contacts. This in turn closed the circuit from the alternator through the AC coils. The flow of current through the coils created a magnetic field that attracted the armature in the AC electro-magnet, closing the low-frequency primary circuit which allowed current to flow from the alternator through the primary winding of the spark transformer. When the key was released, the transformer circuit was opened and the armature was released and forced back to its original position by the spring. The current had an alternate path to follow along the brass strip of the manipulating key and through the pillars of the DC electro-magnet in order to rejoin the original circuit; therefore, very little sparking occurred at the breaking of the manipulating key contacts. As alternating current comes to a zero value 100 to 120 times per second, it follows that a zero value would be reached shortly after the release of the manipulating key, which resulted in very little sparking at the magnetic key contacts. In this manner, the circuit could be interrupted without dirtying

or burning out the contacts. This ensured that the operator would be able to use the key to send the Morse code as fast as the hand can work without worrying about developing intermittent contact operation.

Transformer (see F, Fig. 4) — A high voltage step-up transformer raised the voltage of the AC supplied by the alternator for charging the main condenser. The transformer was an iron-core type. Two transformer windings were superposed on a middle limb, with the entire limb assembly immersed in high-flash insulating oil within a galvanised steel tank to prevent arcing. The primary consisted of thick copper wire wound over a soft iron core, with two ends of the winding brought through heavy ebonite bushes to standard lugs on the outboard side of the galvanised container. The secondary was in two parts, each part consisting of fine wire wound in a great number of turns over the primary (which was separated by a stout ebonite tube), thereby forming a continuous circuit. The greater number of turns in the secondary winding ensured that the voltage tapped off the secondary would be greater than what was introduced into the primary. The four ends of the secondary windings were connected to plug sockets on the inboard side of the galvanised container. The secondary terminals were fitted with two brass strips which allowed the two windings to be arranged in either series or parallel. The output voltage from the secondary could thus be adjusted to provide 5 kilo-volt-ampères at either 10,000 (parallel) or 20,000 (series) volts to charge the condenser. The necessary changes of wavelength were obtained by variation of the capacity of the condenser in the closed circuit and the amount of inductance in the aerial circuit.

High Tension Circuit

The High Tension circuit carried the high voltage current stepped up by induction through the secondary winding of the transformer to the condenser. This circuit included the transformer secondary windings, two choking coils, the main condenser and the condenser commutator.

High Frequency Air Core Choke Coils (see G, Fig. 4) — The flow of current through the AC transformer was regulated by two "choking" coils of potentially high impedance. The coils consisted of a few turns of heavily insulated copper wire wound over an air-filled porcelain cylinder contained in a teak box. Being without an iron core, these coils had practically no effect on the low-frequency current from the transformer to the condenser. The frequency of the transformer charging current was so low that the current passed through the coils to the condenser with minimal resistance. However, owing to the fact that impedance effects increase as the frequency increases, high frequency oscillations were prevented from flowing back through the chokes. In this manner, the choking coils prevented the condenser discharge currents from flowing back into the secondary of the high voltage

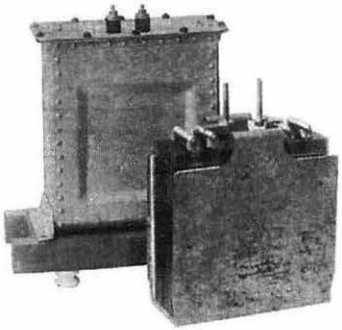


Figure 9. *Condenser Cell and Cradle.* (Handbook of Technical Instruction for Wireless Telegraphists, *modified*)

transformer, where they could have caused a difference in potential in the winding strong enough to puncture the insulation and short-circuit adjacent layers.

Main Condenser (Fig. 9) — The purpose of the condenser was to store the high-voltage charge until it built up to the point where it reached the break-down voltage of the spark gap. Upon discharge, the condenser charged again. This cycle would repeat itself numerous times as long as the key was down, completing the circuit. The main condenser used in Titanic was of the "double plate, whole plate" type and consisted of four cells, each mounted on a teak stand. Each cell contained 17 sheets of zinc - acting as conductors - interspaced with 36 flint glass plates - acting as dielectrics - supported by a galvanised iron cradle. Each cradle was suspended within a galvanised iron tank, which was packed with sheet and block cork and then filled with transformer oil to prevent direct arcing. The terminal bolts, which were fitted through the lid of each tank had heavy ebonite bushings where they passed through to the exterior. The whole system of zinc and glass plates could be lifted easily out of the case for the purpose of renewing any glass plate that had broken down. The condenser was protected from heavy loads by a pair of spark points of flat brass fitted to the terminals. The noise made by any discharge at these points served as notice to the operator to adjust his circuit. Due to the effect of dielectric hysteresis in the glass plates, the condensers could become very hot during operation.

Swiss Commutator (Fig. 10) — A controlling device was mounted on top of a wooden framework around the condenser tanks and used to vary the configuration of condenser cells in the circuit according to the length of the wave desired for transmission. The four condenser cells were connected to five hollow copper bars of square cross-section mounted on a baseboard and arranged in two parts of two cells each. Two additional hollow copper bars were mounted on ebonite standards such that they lay two inches above, and perpendicular to, the five bars on the baseboard. Electrical terminals on the upper bars were connected to the leads from the choking coils and the closed oscillatory circuit. Split brass plugs were inserted in various holes in the bars, depending on the configuration desired, to connect the upper bars to the lower. For the normal 600-meter (500-kHz) wavelength, the two parts of the condenser were connected in parallel; for the 300-meter (1000-kHz) wavelength, they were placed in series. Thick copper strips were used to connect the condensers to the terminals mounted on the lower commutator bars.

High Frequency Primary or Closed Oscillating Circuit (Fig. 11)

The High Frequency Primary or Closed Oscillating circuit set up an oscillating current of high potential for transmission. This circuit included the main condenser, rotary spark discharger, a variable inductance and the primary of the oscillation transformer, or "jigger."

Rotary Spark Discharger (Fig. 12) — The function of the spark gap was to keep the closed oscillation circuit idle until the condenser was fully charged; to discharge the energy stored up in the condenser in the form of radio-frequent oscillations; and to restore the gap to its non-conductive state (known as "quenching the spark") when the energy had been transferred to the aerial. A 10-inch circular steel disc was mounted on an independent shaft running in ball bearings, which was then directly coupled to the aft end of the motor-generator shaft through an insulating rubber coupling. This arrangement permitted the discharge of the condenser to be accurately timed with the alterations of the charging

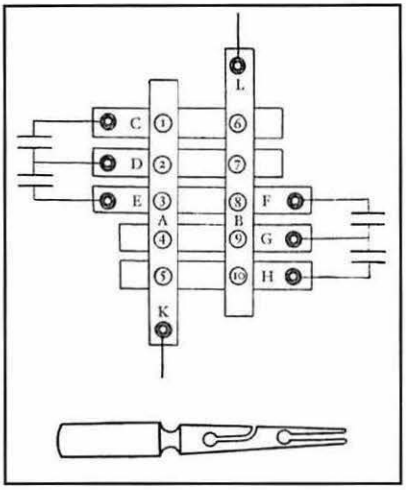


Figure 10. (left) *Swiss Commutator. To place the condenser cells in parallel, the brass plugs would be placed through the holes marked 1, 7, 3, 9, and 5, or through 6, 2, 8, 4, and 10. To place all four cells in series, two plugs would be inserted in the holes marked 1 and 10.* (Handbook of Technical Instruction for Wireless Telegraphists, *modified*)

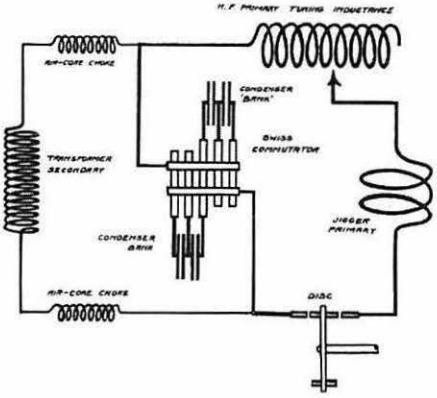
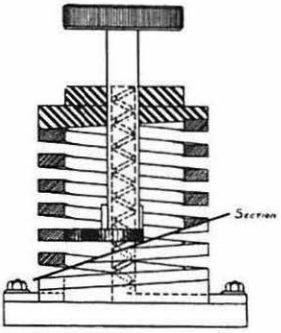


Figure 11. (right) *High Tension and Closed Oscillatory Ciruits.* (Handbook of Technical Instruction for Wireless Telegraphists)

Figure 12. (left) *Disc Discharger. This disc has holes for 8 contact studs,* Titanic's *had 16. In addition,* Titanic's *discharger shared an extended bed plate with the motor generator. (Courtesy of Louise Weymouth, Marconi plc Archivist)*



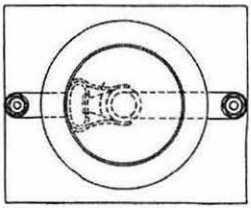


Figure 13. (right) *High Frequency Tuning Inductance.* (Handbook of Technical Instruction for Wireless Telegraphists, *modified*)

current; hence, this system was also known as a Disc Discharger. The disc was fitted with 16 transversely-mounted copper discharge studs, each of which protruded 1 inch from either face. The discharge studs revolved between two stationary electrodes on ebonite pillars, which could then be adjusted in order to maintain the shortest possible discharge gap without actually touching the revolving disc.

When the stationary electrodes were connected in series with the closed oscillation circuit of the transmitter, the spark would discharge whenever an electrode on the disc came opposite the stationary electrodes. At the charging current of 60 cycles, the condenser was charged and discharged 120 times a second. In actuality, the spark discharge began long before the electrodes were directly opposite, which was a consideration when adjusting the discharge gap. In order to muffle to sound of the spark discharge, a heavy teak box was positioned and hinged so that it could be lowered over the disc and the two stationary electrodes. This discharger box contained a semi-circular cut-out on the side closest to the motor to allow the box to be lowered over the shaft. When lowered, the discharger box enclosed only the upper portion of the discharger apparatus. The lower half was left open to the atmosphere so that noxious gases resulting from the spark discharges could be dissipated by the spinning disc.

The operator adjusted the spark primarily by adjusting the speed of the motor until the discharges were synchronous (i.e., regular sparking without misses), resulting in a clear, musical spark note. The note of the spark was dependent on the speed of the disc; therefore, the speed of the motor was adjusted to obtain a spark frequency of between 400 and 700 sparks per second. This range had been determined through practice to give best results, as operators complained of fatigue brought on by having to listen continuously to notes of too high a pitch. Ultimately, the adjustment obtained depended on the ear of the operator, so the discharge box was lifted in order to clearly hear the spark during adjustments. The desired spark produced a high-pitched note that was crisp and clear in order to make it easier to discern over the interference of atmospherics at the receiver than the "Shhhh" sound emitted by plain spark dischargers.

The discharger box was found locked open in the remains of *Titanic*'s Silent Room. This would seem to reinforce the scenario wherein one of the Marconi operators, most likely junior operator Harold Bride, took station in the Silent Room towards the end to adjust the spark in response to the failing ship's power. The reason for lifting the box would have been to hear the spark clearly as the motor was adjusted to provide more output from less power.

High Frequency Tuning Inductance (Fig. 13) — The condenser was only capable of adjustment for two values of capacitance. An additional inductance in the closed circuit was required to provide a final adjustment to tune the oscillation frequency to the wavelength of the aerial circuit. A heavy brass spindle with ebonite handle allowed the operator to move a spring brush up or down the inner surface of a heavy copper spiral. The length of the spiral in the circuit affected the amount of H.F. inductance inserted into the circuit. The busbar connectors from the condenser bank were bent around the spiral in order to increase the effective value of inductance.

High Frequency Variable Coupling Jigger (See N, Fig. 4) — In the Marconi system, coupling transformers were termed "jiggers". A variable jigger was

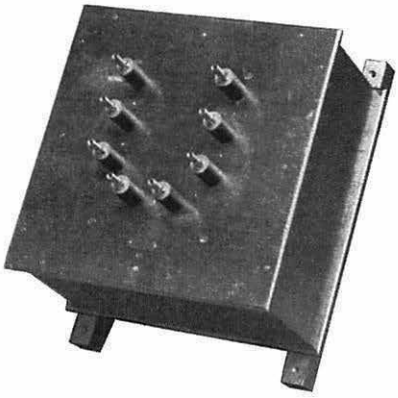


Figure 14. *Aerial Tuning Inductance.* Titanic *had two of these units, operating in tandem.* (Handbook of Technical Instruction for Wireless Telegraphists, *modified*)

used to roughly couple the wave-generating and wave-radiating circuits together. When the condenser discharged, the resultant oscillations set up in the jigger primary coil were transferred by induction to the jigger secondary coil. The primary of the jigger consisted of four turns of a heavy insulated copper-stranded cable wound on edge as a square-shaped spiral and mounted on an ebonite support which was held in a wooden frame with metal supporting legs. The ebonite end plate of the primary supported five solid brass lugs which were connected to taps on the coil. Behind them ran an insulated horizontal copper bar onto which either one or other of the lugs could be plug connected. One terminal was connected to the high frequency tuning inductance, the other to the main condenser.

The secondary consisted of an insulated copper-stranded cable which was wound seven times around a square teak box with an ebonite top. Eight tappings were brought from the secondary winding to brass sockets mounted on the ebonite top. One end of the secondary was joined to the earth-lead, the other to the aerial by way of the aerial tuning inductance; the number of turns (i.e., amount of inductance effect) of the secondary in use could be altered, depending on which socket the lead plug was inserted into. For the purpose of adjusting the coupling between the wave-generating and wave-radiating circuits, the secondary was made to slide laterally over the primary by means of a handle and screw fitting. When the primary coil was positioned almost directly over the secondary coil, the two circuits were considered to be closely coupled, and if the distance between them was relatively large, they were said then to be loosely coupled. Two closely coupled circuits resulted in the maximum amount of radiating signal strength, but the oscillations set up in each circuit could interfere with one another. By loosening the coupling, greater selectivity could be gained to reduce interference, at some cost to radiating strength. The degree of coupling was usually determined by the station erecting engineer, with the optimum position marked on the primary casing. The operator seldom was required to change this setting.

Radiating or Open Oscillating Circuit

The oscillating current set up in the closed circuit was inductively transferred to a circuit open to the aerial. The Radiating, or Open, Oscillating circuit included the secondary winding of the jigger, an aerial tuning inductance, an earth-arrester spark gap and a tuning lamp.

Aerial Tuning Inductance (Fig. 14) — For maximum efficiency, the effective length of the aerial had to be adjusted to match the exact frequency required; however, practical shipboard considerations precluded having a separate aerial of the exact physical wavelength required for each of the international frequencies. The variable jigger, while providing for the proper degree of coupling between the radiating and aerial circuits, was unable to tune the aerial to a specific wavelength. An additional inductance was therefore provided to adjust the wavelength of the aerial circuit to the desired frequency and bring it into resonance with the oscillating circuit. The Aerial Tuning Inductance consisted of two similar units, each made of stranded cable well insulated and braided, wound twenty times in one layer on a wooden form contained in a square teak box, in a manner similar to that of the jigger secondary. Tappings were brought from various points through ebonite bushings to eight brass plug-sockets arranged on the face of each containing-box. Because of the length of Titanic's aerial, two separate units, providing a total inductance of 300 microhenrys, were required to produce the long wave.

Tuning Lamp (Fig. 15) — The tuning lamp was a small, 4-volt carbon filament lamp which was wired in series with an adjustable inductance coil of wound copper wire and mounted on a teak base. The lamp was shunted between the jigger secondary and earth so that it could take a small fraction of the oscillating current induced in the earth-lead of the transmitter. The amount of glow produced in this lamp acted as an indicator of the total amount of current in the earth-lead, and as this depended upon the accuracy of syntonisation between the jigger primary and secondary, the lamp could be used for tuning these circuits (i.e., the lamp was most brightly lit when the two circuits were in tune). The operator could add an additional amount of inductance into the circuit by moving a pivoted brass arm across the inductance coil.

Earth Arrester (Fig. 16) — A terminal was needed to protect the receiving apparatus from the high potential of the transmitting apparatus while also providing protection for the aerial against lightning. The earth arrester was actually two round brass plates separated by thin discs of mica. The wires to the ship's earth connected with the bottom plate. The top plate was connected to the earth of the oscillation transformer and the aerial terminal of the tuner. A circular groove was cut in each brass disc, coinciding with the edge of the mica, to ensure that no sparking would take place at the mica edge and thereby burn it; the sparking then took place across the outer edge of the upper plate. The gap was short, so that transmitting currents (and lightning) would flow in sparks across it, but wide enough to act as an insulator to the tiny received currents which found their way to earth through the tuner. Use of this protective spark gap was unique to apparatus manufactured by the Marconi Co. and alleviated the requirement for a change-over switch.

Extra Condenser and Earth Arrester — Titanic used an extraordinarily long aerial, the natural frequency of which was such that an unacceptable number of turns would have to have been taken out of the jigger secondary in order to obtain the 300-meter, or "short," wave. Therefore, an extra, or Short Wave, condenser was supplied to reduce the total capacity of the aerial and thereby render it suitable for the production of the shorter wave. A separate arrester was also provided so that received currents of the same frequency as was being transmitted would pass through to earth, rather than oscillate in the closed oscillating circuit.

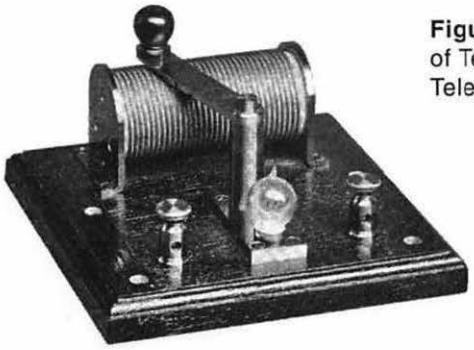


Figure 15. (left) *Tuning Lamp.* (Handbook of Technical Instruction for Wireless Telegraphists, *modified*)

Figure 16. *(*right*) Earth Arrestor.* (Handbook of Technical Instruction for Wireless Telegraphists, *modified*)

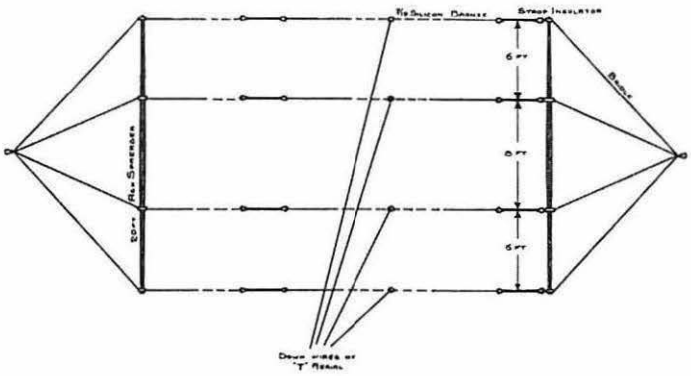


Figure 17. (above) *Four-wire Aerial 5-kW type.* (Handbook of Technical Instruction for Wireless Telegraphists, *modified*)

Aerial

Aerial (Fig. 17) — Titanic was fitted with a Marconi twin "T" type aerial, rising vertically from the roof of the Marconi Silent Room and connecting with four horizontal wires strung between the ship's two masts, which were stepped approximately 600 feet apart. Positive electrical connection was made between each vertical lead-in and its corresponding wire in the horizontal flat top by means of a "T" Joint that was designed in such a manner that strain was not collected at the junction. Two 20-foot spreaders at either end of the flat top portion spaced the two inner wires 8 feet apart and the two outer wires 6 feet from the inner wires. The aerial spreaders were supported by bridles of tarred hemp rope (ratline), which in turn could be raised or lowered by rope halyards run through reef blocks attached to the top of their respective masts. The

forward spreader had four eyebolts, each of which took a 5-ft. flexible strop insulator with a working strain of 30 cwt, from which an individual aerial wire was run.

The fundamental wavelength of the aerial was 325 meters, which provided a good value of aerial current at the 600-meter adjustment and a fair value at the 300-meter wave adjustment. Because the natural wavelength of an aerial was aproximately four or five times its physical length, the working length of Titanic's aerial had to be much shorter than the distance between the two masts. The length of the horizontal wires was therefore limited to keep both standard radiated waves within limits. This resulted in the strain insulators for the after portion of the aerial being suspended over the space between the 3rd and 4th funnels, instead of attached directly to the aft spreader. The remaining wire aft of the insulators served only as support. Also note that the lead-ins had to be taken from the exact centre of the flat top; otherwise, each branch of the "T" would have a different wavelength, making accurate tuning impossible.

Leading-in Insulator (Fig. 18) — A Bradfield type deck insulator, rated for the 5-kW marine generator set and able to withstand a minimum of 30,000 volts, was used to insulate the aerial from the steel structure of the ship. The insulator was elevated on an approximately 6-foot-high wooden trunk, square in cross-section, to keep it clear of a canvas awning that was part of the design for the roof of the Officers' Quarters but never utilised during the ship's short career. In order to protect the Bradfield insulator from the strain of the aerial being pulled by the wind, the lead-ins were firmly attached to a screw eye in the roof of the Officers' Quarters and electrically isolated by a single strop insulator. Electromagnetic energy was transferred between the aerial and the Bradfield insulator by way of two flexible wires that ran from the terminus of the lead-in wires to the insulator's shackle head. The brass terminal socket on the lower end of the insulator rod inside the Silent Room secured the wire connection to the Aerial Tuning Inductance as well as to the two plug sockets mounted on the aft bulkhead of the Marconi Room.

Partition Insulators (Fig. 19) — Two partition insulators were provided to feed the high voltage aerial wires through the soundproofed wall of the Silent Room. Each consisted of a steel rod encased in an ebonite tube, with brass terminals on both ends.

Aerial Plug Sockets — Two plug sockets were provided to feed high voltage through the wall of the Marconi Room to the aerial. One socket was connected to the earth arrester terminal in the aerial circuit; the other, to the induction coil secondary in the emergency set. Each socket consisted of a large electrose insulator, moulded over a 27-in. brass rod. Connecting lugs on either end were used to connect the leads. The outside of the insulator was threaded, so that a collar could be used to draw the socket up tight in the hole through the cabin wall. The plug sockets were designed to withstand a minimum of 30,000 volts.

Receiving Set (Fig. 20)

The Receiving circuit was considered a secondary circuit in a loosely coupled oscillation transformer, of which the transmitting circuit was the primary. This circuit included the magnetic detector, multiple tuner, a pair of headphones and a headphone condenser. A stand-by receiver, with associated power supply, could be inserted into the circuit by means of a two-way switch, when required.

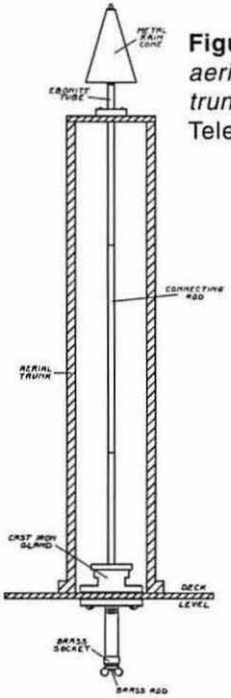


Figure 18. (left) *Bradfield Leading-in Insulator, mounted atop an aerial trunk. (Author's modification of the illustration for an aerial trunk in* Handbook of Technical Instruction for Wireless Telegraphists)

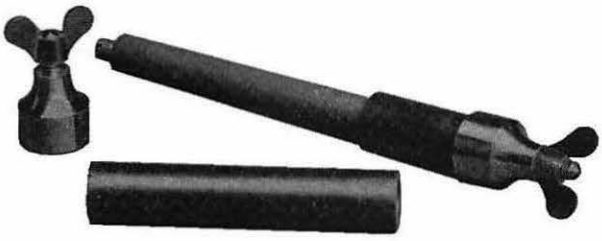


Figure 19. (above) *Partition Insulator.* (Handbook of Technical Instruction for Wireless Telegraphists, *modified*)

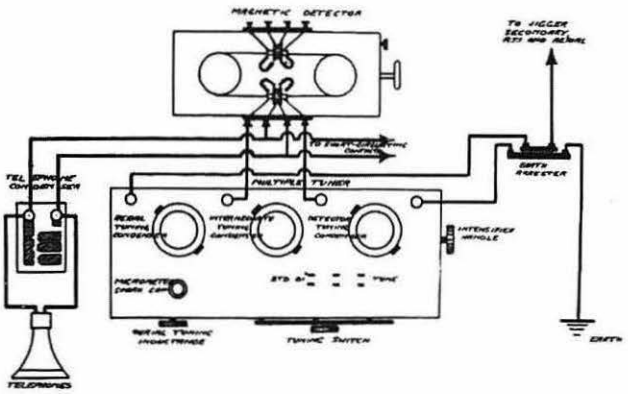


Figure 20. (right) *Receiving Circuit Connections.* (Handbook of Technical Instruction for Wireless Telegraphists)

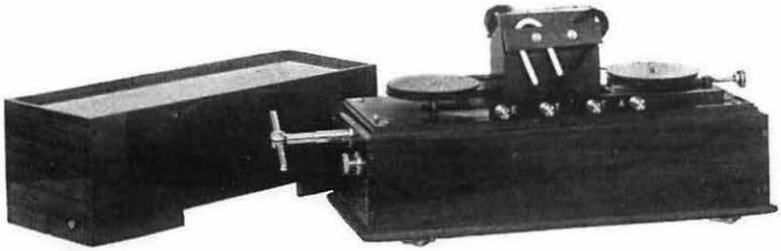


Figure 21. (above) *Magnetic Detector.* (Marconi: Receiving and Measuring Instruments)

Magnetic Detector (Fig. 21) — This instrument, colloquially known as "Maggie," was used to convert the received electro-magnetic waves into a form of energy that could be heard by the operator. A continuous band of soft iron wire revolved on ebony grooved wheels, which were turned by clockwork. The band passed through a glass tube that was wound with a fine wire, through which radio-frequent oscillations flowed on their way from aerial to earth. Two horseshoe-shaped permanent magnets were mounted above the tube. When the iron band passed underneath the two magnets, it underwent a cyclic change in magnetism and became extremely sensitive to the magnetic field generated by the current flowing through the primary coil wound around the glass tube. It may be mentioned that for the greatest intensity of received signals, the two permanent magnets could be placed with like poles together over the coils. This arrangement, however, introduced a low noise in the telephone termed "breathing". Adjustment of the position of the magnets could reduce the unwanted noise effect, but at a slight decrease in the intensity of the received signals. A wire bobbin inserted in the path of the magnetic flux was acted upon inductively by the magnetized regions of the iron band, sending a current to the receiving headphone diaphragms via a secondary circuit. In this way, a single sound was generated for each group of incoming oscillations. A brass key was provided on the side of the instrument's base to allow the operator to wind the internal clockwork. The primary terminals of the detector were connected to the tuner, the secondary terminals to the receiving headphones via the phone condenser.

Marconi Multiple Tuner (Fig. 22) — The Multiple Tuner was used in conjunction with the Magnetic Detector to provide a reliable receiving apparatus that required no adjustments when once set. A means of tuning it to the incoming signals of one given wavelength, and eliminating the signals of all other wavelengths, was provided by three inductively-coupled adjustable circuits. The full range of 100 to 2,500 metres was obtained in four steps by a triple four-way Tuning Switch located on the front of the instrument case. This switch simultaneously altered the amount of fixed inductance and capacity in the primary, intermediate and secondary circuits for a progressive increase or decrease in wavelength. The intermediate circuit was used to filter the received signals, so that the detector circuit would be actuated only by signals of the desired wavelength. This decreased the effect of atmospheric discharges (known colloquially as "Xs") on the detector circuit. Finer adjustments of tuning were made by means of the variable condensers located on top of the case.

A small double-pole, double-break detector switch on the top of the case could be placed in either the "Std. Bi" or "Tune" position. In the "Std. Bi" (Stand-by) position, the Magnetic Detector was connected directly into the aerial circuit and the necessary tuning adjustments could be made with the Aerial Tuning Inductance multiple-contact switch (located on the left front of the case) and a variable adjustment of the Aerial Tuning Condenser (AK). The "Std. Bi" position was often used for reception, as it was specifically devised to pick up incoming signals of widely different wavelengths. A high induction coil across AK prevented static charges from accumulating in the aerial circuit. When it was desired to operate the tuner in a highly-tuned condition, the detector switch was thrown over to the "Tune" position, which removed the Magnetic Detector from the aerial circuit and coupled the detector circuit to the intermediate circuit, where accurate tuning could be accomplished. A multiple-contact switch on the side of the instrument case allowed for a simultaneous adjustment of the

Figure 22. (right) *Marconi Multiple Tuner.* (Marconi: Receiving and Measuring Instruments)

Figure 23. (above) *Head Telephones.* (Marconi: Receiving and Measuring Instruments)

Figure 24. (left) *Headphone Condenser.* (Marconi: Receiving and Measuring Instruments)

inductance couplings in the primary and secondary circuits. The particular wavelength adjustment corresponding to any position of the Tuning Switch was clearly marked on the face of the operating handle. For the normal operating wavelengths of 300 and 600 meters, Switch S-1 was placed in the second position, which placed AK in series with the aerial, shunted the Intermediate Condenser (IK) to the intermediate circuit and placed the Detector Tuning Condenser (DK) in series with the Magnetic Detector. As the Marconi system did not use an aerial change-over switch, injury to the receiving equipment from the heavy inductive effects of transmitter oscillations was prevented by the micrometer spark gap, which automatically shunted the aerial terminal to earth during transmission.

Head Telephones or Headphones (Fig. 23) — The operator received the incoming train of signals through head telephone receivers, which converted the feeble electrical current impulses to a discernible sound. As the action in the headphones was electro-magnetic, and therefore unable to keep pace with extremely rapid changes in direction of an oscillating current, the current had to first be converted by the detector into an intermittent uni-directional current.

This current effect acted on the diaphragm, which was a thin disc of special iron, causing it to vibrate in and out in response to the impulses of the current flowing through the coils. The vibration of the diaphragm created the sounds in the operator's ear. The working parts of the headphones were enclosed in ebonite casings, so as to isolate the interior components from dust and dampness. Two sets of headphones were provided, each wound to a resistance that equalled the resistance in the secondary of the associated detector. The headphones connected to the Magnetic Detector were wound to a relatively low resistance (150 ohms); those connected to the valve receiver, relatively high (8000 ohms).

Headphone Condenser (Fig. 24) — The train of oscillations set up by the magnetic detector included not only the fundamental note, but also the associated harmonics. In order to prohibit the harmonic oscillations from creating their own sounds in the telephone receivers, a condenser was shunted across the telephones to suppress some harmonics while strengthening others. It did this by compressing the small irregular currents with the main impulses before charging the condenser; once the current flowed from the condenser to the telephone receivers, the "note frequency" was clarified, which made the sounds heard in the telephones clearer and stronger.

Marconi Valve Receiver (Fig. 25) — The valve receiver was used as a stand-by detector/tuner even though it had been already proven to be more sensitive than the Magnetic Detector. The valve receiver took its name from the Fleming Oscillation Valve, which was used to convert alternating electric current oscillations created by spark gap discharges into direct current. The two 4-volt "valves" were essentially tungsten filament lamps with a cylinder of copper gauze surrounding the filament. These cylinders were capable of adjusting the current flow, hence the name "valves". Received radio-frequency oscillations induced oscillating voltages in the secondary circuit so that the copper cylinder gauze around the filament alternated between positive and negative potentials. The heated filament released electrons, which flowed through the vacuum to the copper gauze. At positive potential, electrons flowed across the cylinder and therefore through the entire circuit; at negative potential, the electrons were repelled and no current ensued. The rectified current continued through the circuit to the head telephones, where it was converted into audible sounds. This provided for increased sensitivity without impairment by strong atmospherics or interfering signals.

The aerial and intermediate circuits operated in a similar fashion to those described for the Multiple Tuner. The "Std. Bi" position on the small D.P.D.B. detector switch magnetically coupled the valve circuit to the aerial circuit, while the "Tune" position coupled both circuits through an intermediate circuit. The potentiometer and series resistance were located on the left side of the case and were used to vary the amount of voltage impressed on the valve filaments, which in turn affected the strength of the rectified current. The intermediate circuit coupling coil adjustment was on the right side and was used to decouple the intermediate circuit, which had the effect of cutting out interfering signals. After such adjustment of coupling, fine-tuning could be accomplished by manipulating the adjustable condensers (high-capacity ebonite disc condensers for the Aerial and Intermediate circuits and a sliding variable condenser of very small capacity ("Billi" type) for the valve circuit). The aerial tuning inductance adjustment, located on the front of the case, operated in the usual Marconi pattern. A platinum wire around the glass bulbs of the

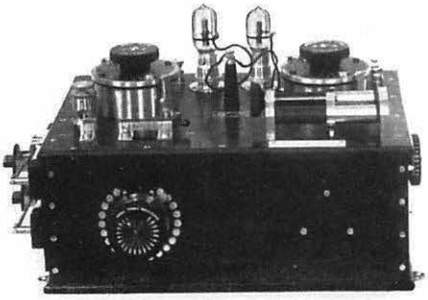


Figure 25. *Marconi Valve Detector.* (Marconi: Receiving and Measuring Instruments)

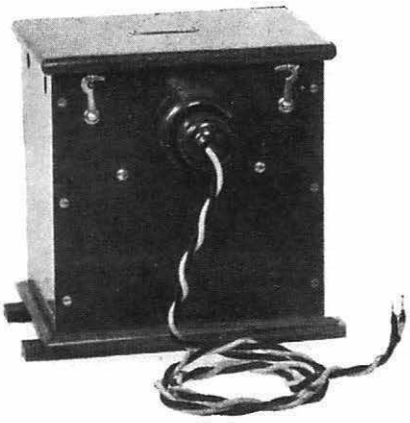


Figure 26. *Valve Accumulator Battery Box.* (Marconi: Receiving and Measuring Instruments)

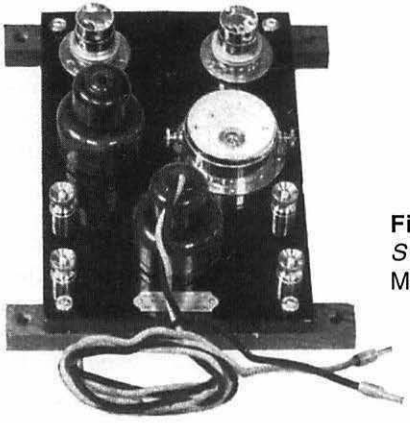


Figure 27. *Valve Accumulator Charging Switchboard.* (Marconi: Receiving and Measuring Instruments)

valves was connected to the positive terminal of the battery in order to prevent the glass from becoming statically charged and thereby interfering with the sensitivity of the detector. The operator could select between the two valves as he saw fit. As there was some variance in the manufactured quality of the Fleming valves, the potentiometer and series resistance had to be readjusted for maximum sensitivity whenever a new valve was selected or replaced. Each valve had an average life of 1,000 hours.

Valve Accumulator Battery Box (Fig. 26) — The Marconi Valve Receiver required a 6-volt source in series with a voltage regulating resistance to raise the filaments to incandescence. This was provided by a dedicated battery-accumulator, which was charged by the ship's mains. Two battery boxes were provided, so that one could be charged while the other was in use. Each battery was rated at a 40 ampère-hour capacity and consisted of three cells in celluloid containers, all fitted in a polished teak box.

Valve Accumulator Charging Switchboard (Fig. 27) — A small switchboard was used to facilitate the charging of the valve accumulators off the ship's mains. Two 50 c.p. lamps were provided to regulate the normal charging current of 2.5 ampères. To power the receiver, the charging plug was removed from the accumulator socket and a plug from the receiver inserted in its place.

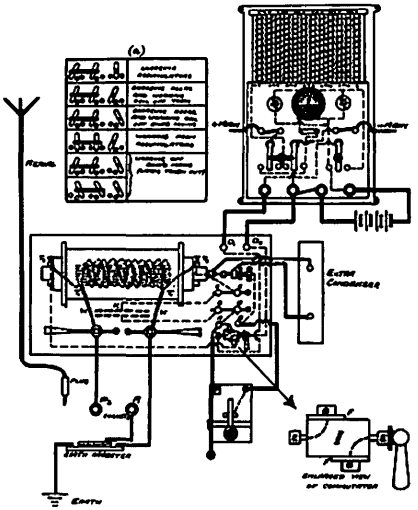


Figure 28. *Plain Aerial Emergency Transmitting Gear Connections.* (Handbook of Technical Instruction for Wireless Telegraphists)

A voltmeter, activated by a push button, indicated to the operator when the accumulators are charged.

Two-way Switch — A standard two-way toggle switch, linked at the switch lever, allowed the operator to select either the Magnetic Detector/Multiple Tuner or the Valve Receiver for use as a receiver.

Emergency Set (Fig. 28)

In the event of a loss of power to, or a breakdown of, the main transmitting set, a Plain Aerial Coil Set, capable of producing a plain spark and operating continuously for at least 6 hours, was provided. It was not capable of producing the power or pleasing tones of the main set but it was kept ready for emergency use. The Plain Aerial Coil Set could be quickly connected to the aerial for the production of a plain aerial spark. It had the additional advantage of producing highly damped waves, which would affect receiving circuits of stations within a normal working range of at least 80 nautical miles, even if they were not strictly in tune. The set included an accumulator battery, a suitable charging switchboard, a 10" induction coil and a separate manipulating key.

Accumulators — A battery of 8 chloride accumulators stored direct current from the ship's mains for use by the wireless set in the event of a shipboard electrical casualty. During normal operation, the accumulators were charged by the ship's dynamos and required little attention. Upon loss of power from the ship's mains, the operator could discharge the accumulators through a 10" induction coil by using the Emergency Key. Eight accumulators were provided in order to provide the necessary E.M.F. to work the emergency spark coil. The cells in each battery were arranged in series, with positive connected to negative, leaving a positive terminal at one end and a negative at the other. Cells were deep enough to allow the lead plates to be covered with dilute sulphuric acid at all ordinary angles of heel. Iron shelving, covered with paraffined hardwood as an insulator, was used to accommodate the accumulators. Hardwood fittings held the batteries secure within the shelving to prevent shifting due to the movement of the ship. The movement of the ship actually helped the accumulators keep the electrolyte at a uniform specific gravity, as it kept the acid from settling in layers of varying densities. The acid would boil toward the ends of

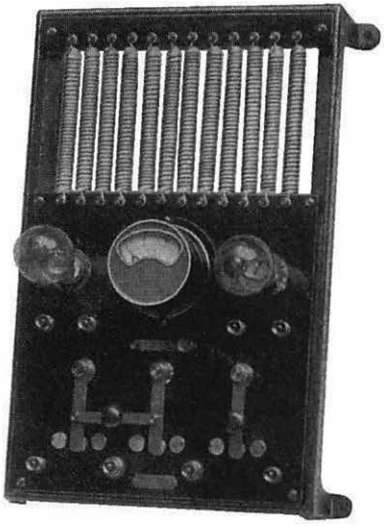


Figure 29. *Charging Switchboard.* (Handbook of Technical Instruction for Wireless Telegraphists, *modified*)

charging, but spraying was prevented by covers. The operator had to ensure that no naked-flame lights were used near the cells when the accumulators were fully charged, because the amount of hydrogen released during the process could be ignited by contact with a light source. The operator monitored the voltmeter mounted on the Charging Switchboard during operation of the emergency set to guard against the occurrence of sulphating in the accumulator cells, a condition where the lead plates were coated with a white insulating skin of sulphate of lead which rendered the plates electrolytically inert and gave the cell a high resistance and low capacity. Normal (non-emergency) discharging of the cells had to be terminated when a reading of 14.5-15 volts was indicated; otherwise, permanent sulphating of the cells would occur.

Charging Switchboard (Fig. 29) — The switchboard used for the emergency set was a Marine Type Switchboard, No. 1. The operator could control the discharging and charging of the accumulators through use of multi-point switches on the switchboard. The position of the double pole three-way switch connected the ship's dynamos to the accumulators and determined the direction of the charging current through the battery. Two 50 c.p. carbon filament lamps provided a visual indication that the proper connection had been made for charging the batteries. The position of the D.P. switch that provided proper charging would cause the lamps to glow least brightly. The single pole three-way switch was used to connect the induction coil into the circuit. A 15-ampère fuse inserted between the coil and accumulator terminals along the bottom of the switchboard protected the coil when working off the accumulators; the two connected to the fuse terminals protected the coil from the main charging and working circuits. Because the accumulators were not used in normal operation, a series of twelve 4-ohm charging resistance coils were inserted into the charging circuit to slow the charging rate. The filament lamps were wired in series with the charging circuit and allowed a charging current

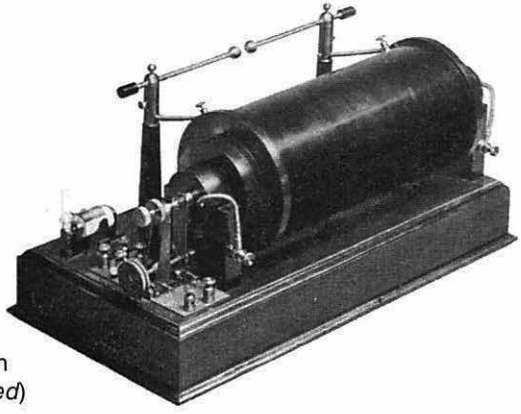


Figure 30. *10" Induction Coil.* (Handbook of Technical Instruction for Wireless Telegraphists, *modified*)

of 4-ampères to pass. Since the charging rate of the battery was nominally 12-ampères, long charges were required to fully refresh a depleted battery. When the battery of accumulators was fully charged and charging current still passing, the operator would read approximately 20.8 volts on the supplied voltmeter. At that point, gas would be freely bubbling from both positive and negative plates. With the charging current removed, the reading fell to around 17-volts, or 2.1-volts per cell. Because permanent sulphating would occur when the voltage in any individual cell in the battery fell below 1.85, the operator took care not to allow the total voltage as shown on the voltmeter to fall below 14.5-15 volts, which equated to 1.17 specific gravity of the acid.

10" Induction Coil (Fig. 30) — To power the emergency spark transmitter key, 16-volt, 8-ampère direct current supplied by the accumulators was changed to a high-voltage alternating current by the Induction Coil. The primary winding consisted of 360 turns of No. 12 insulated copper wire wound over a core of stranded soft iron wire. An ebonite tube covered this winding and supported the secondary winding, which consisted of 54,000 turns of No. 34 silk-covered wire wound in 116 sections, which were connected in series. The size of the coil was predicated on the number of turns in the secondary winding, and gave an indication as to the magnitude of increase in the output voltage. The direct current in the primary winding was interrupted by a "hammer break", which was effectively an armature on a spring that alternately created and collapsed the magnetic fields around the windings at about 25 interruptions a second. In so doing, a rapid change in flux affected the secondary winding, inducing an alternating current. The voltage was stepped up high enough to jump the air gap between two discharge rods connected to the secondary terminals, thus forming an electric spark.

Coil Condenser — In order to prevent unwanted sparking at the induction coil hammer break contacts, an extra coil condenser was provided. This condenser, which had a capacity of 2-microfarads, consisted of alternate layers of tin foil and varnished paper. Because the tin sheets and dielectric paper were very thin, a fairly large capacity could be realised in a relatively small container. In all, 140 sheets of foil were utilised. The condenser was charged by counter E.M.F. created by the breaking of the primary circuit, thereby absorbing the current that would otherwise discharge at the hammer break contacts. The condenser subsequently discharged back into the primary circuit through the accumulators, increasing their effect in the coil secondary. In summary, the coil condenser helped to eliminate sparking at the induction coil hammer break contacts, accelerate the "break" of the primary circuit, and retard the current at the "make."

Emergency Key — This key was similar in function to the main transmitter key, with the exception that it was wired to the induction coil primary, rather than to the magnetic relay key which keyed the main transformer. This separate key was required in Marconi installations because of the lack of a changeover switch.

Ancillary Equipment

Other equipment was supplied by the Marconi Company for the purposes of fault isolation, circuit tuning and system maintenance by shipboard operators. This equipment included a shunted buzzer, portable wavemeter and a tool box.

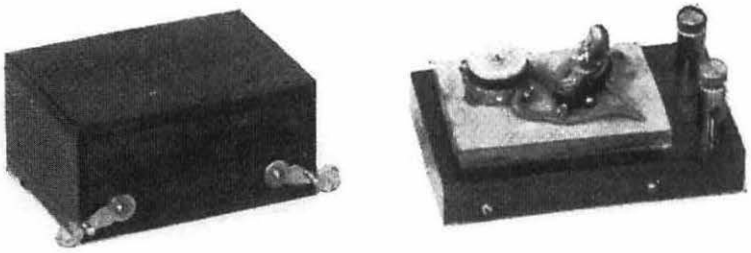


Figure 31. *Shunted Buzzer.* (Marconi: Receiving and Measuring Instruments)

Shunted Buzzer (Fig. 31) — To test the receiving circuit or allow for short-range transmissions, a battery-powered high-note buzzer was placed in series with the tuner in the transmitting aerial circuit. The buzzer itself operated under the principle that a current, provided by a dry cell, passing through two coils would attract an armature, which normally was at rest against an adjustable contact where it closed the aerial circuit. Once the armature was attracted away from the adjustable contact, the circuit was opened and the current flow through the buzzer coils ceased. The spring contact was released and the circuit closed once again, repeating the process. The intermittent spark thus created generated a "buzzing" sound, hence the name. The buzzer utilised in Titanic had a non-inductive resistance shunted across the coils, so that the buzzer could be used to tune the radiating circuit. During normal operation, this device was switched out of the circuit and isolated. However, the normal discharge output of the transmitter prohibited clear transmission with stations located within a few miles of the sending station. In order to communicate over a short distance, then, the buzzer could be connected to the aerial and earth; the necessary capacity and inductive effects being in the wires, the wavelength being that of the aerial circuit, while a simple spark key functioned as the make and break for the buzzer. The multiple tuner could then be calibrated using the buzzer by first setting the intermediate circuit to a certain value, then adjusting the aerial and detector circuits until they were in tune with the oscillations produced by the buzzer. The musical frequency of the buzzer could be varied from 200 to 1,000 cycles per second.

Pneumatic Conveyor — A pneumatic conveyor system was provided to transport Marconigram forms between the Enquiry office, located on C Deck, and the Marconi Room. The suction in the brass conveyor tubes was created by an air pump rated at 1/2 B.H.P.

Figure 32. *Wavemeter.* (Marconi: Receiving and Measuring Instruments)

Clocks — Two clocks were provided for time-of-receipt reference. One clock was driven by an electric pulse transmitted from a master clock on the bridge and continually displayed local ship's time. The other was mechanical and set to the time at destination; during Titanic's maden voyage, the clock was set to New York time.

Wavemeter (Fig. 32) — A portable wavemeter was provided to allow the Marconi operator to measure the natural wavelength in a given circuit. The Marconi Wavemeter consisted of a square wooden frame wound with 25 turns of silk-covered wire, with this coil connected across a variable condenser. A high-resistance carborundum crystal detector in series with a pair of headphone receivers was shunted across the terminals of the condenser. The entire apparatus was mounted in a wooden box 9"x 6"x 4 1/2" deep. The operator measured a circuit by holding the coil of the wavemeter near enough to the circuit to be loosely coupled. The variable condenser was adjusted until signals were loudest in the headphones. The condenser reading was compared to a card affixed to the lid of the wavemeter, which translated the reading into wavelength.

Tool Box — A complete electrician's repair kit was provided. It included special tools, a galvanometer with dry cell and spare parts required to service Marconi marine sets.

Summary

Prior to James Cameron's 2001 exploration of the wreck of Titanic, there didn't appear to be much remaining of the liner's wireless apparatus. The aerial was swept away when the ship's two masts were dislodged during the sinking. A bent aerial insulator connecting rod protruding from the roof over the Silent Room was the only apparent equipment remaining until that too was trampled by submersibles touching down on that part of the deckhouse. The first probe inside the Marconi Room revealed only an electrical distribution box, incorrectly identified at the time as the Marconi tuner, that was mounted on the forward wall, still hanging by the heavy wires that carried power from the ship's lighting circuit to the Marconi switchboard. The interior of the Marconi Room, briefly glimpsed during that 1993 expedition sponsored by RMS Titanic, Inc., appeared to be nothing more than a featureless wasteland. As far as anyone knew, any surviving equipment was either buried underneath piles of debris or torn loose and scattered by the destructive forces acting upon the liner as she plunged to the bottom of the ocean.

That assumption was dispelled when Cameron sent one of his ROVs into the after portion of the Officer's Quarters in 2001. Evidently shielded from the brunt of the hydrodynamic forces by its thick insulated walls, the Silent Room lay undisturbed for close to a century. The transmitting set was still intact with each of its components located in or near its original location. Switches and plugs could even be seen in their final settings. The preserved contents of the Silent Room provided a sharp contrast to the almost total lack of artefacts in the adjacent Marconi Room.

Cameron's find sheds new light on our understanding of the Marconi apparatus aboard Titanic. Prior to this, archival photographs taken aboard Olympic were used as the ultimate reference when reconstructing Titanic's configuration. It was therefore a surprise to find the double-panel switchboard, field regulators, tuning lamp, and earth arrester – all of which appear in photographs of Olympic's Marconi Room – in Titanic's Silent Room. Evidently, the Marconi equipment

layout in *Titanic* was radically different from *Olympic*'s. Similar differences with the elder sister ship were found elsewhere in the ship, which came as a surprise to historians who have always used the extensively-photographed *Olympic* as a template for understanding how *Titanic* appeared internally.

The discovery of the transmitting set is even more significant when considered in context of the history of the disaster. Had there been no wireless telegraph apparatus to send distress calls across the æther, *Titanic*'s lifeboats might have drifted for days before being spotted. Because of *Carpathia*'s rapid response to *Titanic*'s CQD, the majority of survivors who found their way into (or onto) a lifeboat were saved. Cameron discovered in the wreck the very instrument that *Titanic* used to alert the world to her plight. It is fitting that the transmitting portion of the apparatus that was directly responsible for saving the lives of over 700 souls has itself survived the sinking and subsequent decay of the ship. Hopefully, the equipment can someday be recovered and restored to operating condition. Failing that, though, at least we can now tell the complete story of this vital apparatus.

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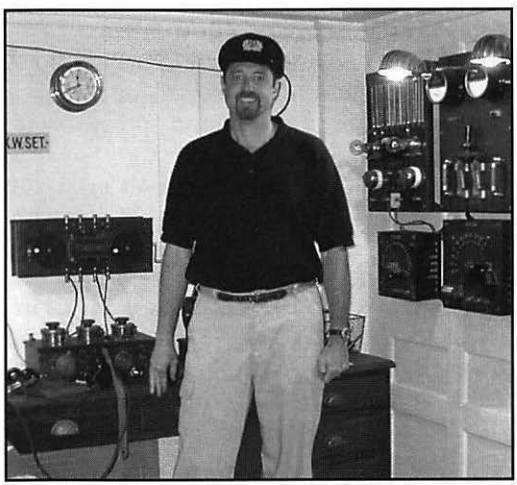
material on Marconi marine sets; **Barbara Goldberg**, who searched the New York Public Library for copies of relevant Marconigraph articles; **Louise Weymouth**, the Company Archivist at Marconi plc, who graciously took pictures of Marconi wireless equipment for my use; **Gordon Bussey,** historian for Marconi plc, with whom I had a most productive conversation about both Marconi and his equipment; and **Neal McEwen**, webmaster for The Telegraph Office website, who provided additional technical comment. Above all, it was **James Cameron** who explored the Marconi spaces in the Titanic wreck, discovered the transmitting apparatus and provided copies of the relevant unedited footage through his documentarian, **Ed Marsh** of Earthship Productions, to me for analysis. Without their contributions, I could never have come close to understanding Titanic's true Marconi configuration.

Parks E. Stephenson

Parks E. Stephenson was born in Richmond, Virginia in 1957. A graduate of the U.S. Naval Academy and retired naval officer, Parks has spent a career at sea, much of it dealing with marine communications and data links. He works today as a Principal Systems Engineer at Raytheon (previously Hughes Aircraft) Naval & Maritime Integrated Systems in San Diego, California. With his background in communications, a modest tube-radio collection and an active interest in the history of the Titanic disaster, it seemed only natural for him to turn his attention toward the famous liner's Marconi apparatus.



Today, Parks is a contributing member of the Marine Forensic Panel (SD-7), chartered by the Society of Naval Architects and Marine Engineers (SNAME) to evaluate the forensic evidence from shipwrecks, like Titanic, in order to learn lessons that might be applied to improve modern shipbuilding techniques. Most recently, Parks was an advisor to director James Cameron for his documentary, Ghosts of the Abyss. Cameron's exploration of the Marconi spaces inside the Titanic wreck provides the first public glimpse into those rooms since the ship sailed from Southampton on her maiden voyage. Parks was fortunate enough to be the first to analyse Cameron's findings and will never forget the sense of being one of the first to visit the room where so much drama took place some 90 years ago.

Parks and his wife Tamara have two children, Connor and Zoe. Connor has already picked up a bit of Morse Code, which helped earn him the Cub Scout Communications badge. Now that Zoe has learned the letters that spell her name, it won't be long before she learns the Morse equivalent.