# Guglielmo Marconi and Early Systems of Wireless Communication

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This paper is based on a lecture given in 1984 by the author when Chairman of the South East Centre of the Institution of Electrical Engineers. It has been revised and is published here as a contribution to the Marconi Centenary celebrations currently taking place.

The description of Marconi as 'the Father of Wireless' is attributed to Aleksandr Popov (1859–1906), the contemporary Russian Scientist, who was one of the many people studying the work of Hertz in the latter part of the last century.

Having spent over forty years in the Marconi Company, I came to realise that I did not know very much about Marconi himself (fig. 1), or the origins of the technique of wireless communication. I soon discovered that I was not alone in my lack of knowledge about the man, and also that the modern Electronic Engineer has never heard of 'syntony', or of a 'coherer', or of a 'jigger'. Names and words that have passed out of the technical vocabulary. This paper describes some of the work carried out during the pioneering days of wireless communication with particular reference to Marconi and the Company that subsequently carried his name. In addition to the technical aspects of this work there is some insight into the commercial difficulties that Marconi had to face, as well as quotations from many of his contemporaries.

**1 Guglielmo Marconi, 1874–1937**

## Archive Material

I have had the privilege of access to the archives of the Marconi Company, which are carefully preserved at Great Baddow, Chelmsford, and which give a relatively complete and formal record of the early progress of the Company. Some of the archives are very frustrating, as often only one side of a series of letters has been retained and it is necessary to guess the other part.

One of the largest parts of this store of information is the 150 or so large volumes of press cuttings. These were started in 1897 when the daily national and local newspapers and technical journals, both in the UK and overseas, were read and extracts taken. More recently (and they are still maintained), because of the impossibility of dealing with the vast amount of technical material currently being generated, the extracts are much more mundane.

Because of the completeness of these records of press material, it is possible to read the daily interchange that was vigorously fought on the claims of various protagonists, about who did – and who did not – originate a particular improvement.

There are hundreds of photographs of people, places and equipment, regrettably some of these will never be properly identified and catalogued.

As the archives are not only of Marconi, but of the Marconi Company, there are Company records from the earliest days, including, for example, the first staff book, which contains some very well-known names, and the manufacturing drawings of the earliest production equipment. One should realise that, because there were no copying machines, each 'copy' is an original drawing.

There are also copies of handbooks, catalogues and even of advertisements – Marconi's used to advertise in those days!

There is plenty of technical library material, including a full set of the 'Marconigraph' which was published by the Company and became the 'Wireless World' in 1913. The American Marconi Company also produced the 'Marconigram' from 1903 on a weekly basis. Many of Marconi's own lectures are available.

Patents formed – and still form – an important part of the Company's activity. There were many cases brought before the courts in the period up to the First World War, by companies that had been set up to compete with the Marconi Company, and the evidence is all retained. Some of this material forms the best record that we have for the very early work of Marconi and his contemporaries. The Company continued challenging the infringement of the early Marconi patents as recently as 1943. Not always with success.

Among the unpublished papers is a large biography of Marconi, written by his secretary, De Sousa, in about 1921. It is in the first person, as if dictated by Marconi.

In addition to all the paper there are many artefacts. Of the earliest, a few only are original, but an attempt has been made to construct replicas and display these in a properly organized manner in a special building at Great Baddow. Together, these records and items form a fascinating wealth of material covering the progress of wireless from 1897 until the present day.

Another feature that quickly comes to light when comparing the material written on the subject at the turn of the century and the papers that were read to learned societies at that time with further papers by the same people, ten, twenty or thirty years later, is that the detail has changed and there is some evidence of time and events modifying the recollection of history. That is why I use the word attributed, when referring to Popov's comment about Marconi.

Many people have studied Marconi's contribution to wireless communication over the years. Many books and articles have been written, and papers presented, on the life and work of Marconi and of the history of the Marconi Company. However, one aspect that emerges quite early in a study of some of the published work, is that the majority are written around the particular person, without bringing out the contemporary work of other people in the same field. It is fascinating to discover the friendships and exchanges of information that occurred between people with aims similar to those of Marconi, and how mutually complimentary they were in their public comments.

Some of these early personal friendships persisted for years, despite the competition that rapidly arose as soon as businesses were set up and it became important to be recognized by potential customers as a leader in the field. Others, such as Silvanus P. Thompson, continued to object for years that Marconi had never invented anything.

Looking briefly at the history of wireless telegraphy before and after Hertz (fig. 2), one should realise that, in 1865, Maxwell had predicted the existence of electromagnetic waves in the æther, and that these waves would have the same characteristics as light. However, Maxwell died in 1879, aged 48, ten years before Hertz was able to confirm

**2** ***Heinrich Hertz (1857–1894)***

his theories. Hertz showed that it was the presence of a spark that allowed waves to pass to a suitable arrangement which operated as a detector and which was placed at a greater distance than would be possible by induction. He also showed that these 'electric waves' were capable of reflection and refraction and that an interference pattern of maxima and minima could be produced, allowing the measurement of wavelength. Hertz worked at about 30cm wavelength in 1887; he was just 37 when he died.

It is necessary to refer to D.E. Hughes (1831–1900) – the inventor of the microphone – who, in 1879, within a few weeks of the death of Maxwell, noted that a spark produced a current in a telephone receiver. He showed this work to William Spottiswood (the President of the Royal Society), to Prof. Huxley, and to Sir George Gabriel Stokes, demonstrating transmission and reception from 60 yards (55m) to over 500 yards (460m) and noting the variation in signal strength with range. Stokes said that all the results could be explained by known electromagnetic effects and he therefore could not accept the suggestion that electric waves existed. Hughes was so discouraged at not being able to convince them that he refused to write up his work in a paper until he had better proof. In fact he did no further work and the record of his discouragement only came to light in a letter to J.J. Fahie in 1899.

I am sure that had Hughes received encouragement he would have followed up his clues and it is likely that he could have anticipated Hertz, Edouard Branly and Marconi, finding himself amongst the foremost names of all time. He did, however, make a large fortune out of his electromechanical telegraph. He was ingenious, but with limited electrical knowledge. Hughes was a Professor of Music and there is a picture of his apparatus in the Oxford Companion to Music by Percy Scholes.

## Early Telegraphy Systems

Telegraphy, as distinct from signalling by flags or beacon fires, probably dates from the patents for the electric telegraph in 1837 by Cooke, Wheatstone and Morse. In 1838, Steinheil proposed the use of the earth return as part of the circuit – a form of wireless. The earth also became used in several other ways, sometimes with less-than-obvious advantages.

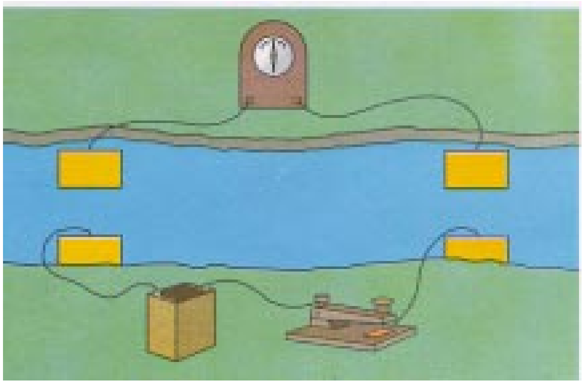
Prior to the use of Hertzian waves, three possible wireless systems were explored: by conduction, by induction, and by electrostatic means.

Little progress was made using electrostatic means, but both conduction and induction systems of wireless telegraphy were being demonstrated from 1842 onwards and both types had some practical use. They were installed in situations where it was particularly difficult to run a cable, or where a cable had failed.

### The Morse Experiment

It was Samuel Morse, in 1842, who showed that wireless communication was possible across a river by using separated plates on each bank, opposite one other (fig. 3). He established a relationship between the current flowing in the circuit, the size of the plates, and the width of the river.

Many people continued to experiment with this system and it was made to operate over distances of several miles. It was not long before someone, using a 'rule-of-thumb' derived from experimental results, suggested that it would be possible to set up a system to communicate across the Atlantic, if the batteries, immersed sheets, and plate separation were large enough†.



**3** ***The general arrangement of Morse's experiment***

### Conduction Systems

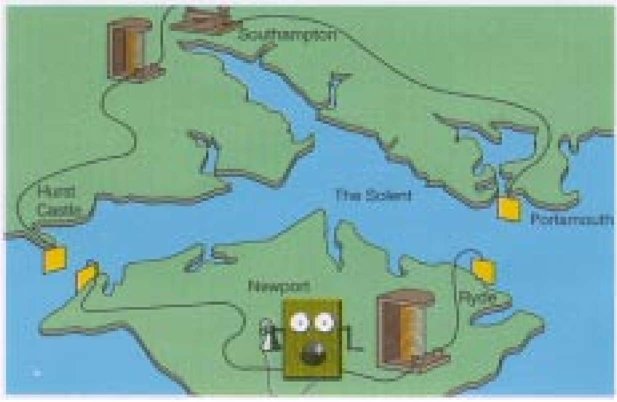
As an illustration, the following two conduction signalling systems had considerable use.

#### *The Isle of Wight System*

In 1882 W.H. Preece, the Chief Engineer of the British Post Office, installed a conduction system across the Solent, between the UK mainland and the Isle of Wight, when the submarine cable failed at Hurst Castle.

Fig. 4 shows the land lines that existed between Portsmouth (Southsea), Southampton and Hurst

† The proposer, J. B. Lindsay (1799-1862), did say that 'further work was necessary to determine the accuracy of the prediction', but considered that, if the length of Gt. Britain was used as the baseline, the immersed sheets would each be 3000 sq. ft. (279m$^2$) and the area of the zinc plates to give enough battery power would be 130 sq. ft. (12m$^2$).




4 ***The Isle of Wight system***

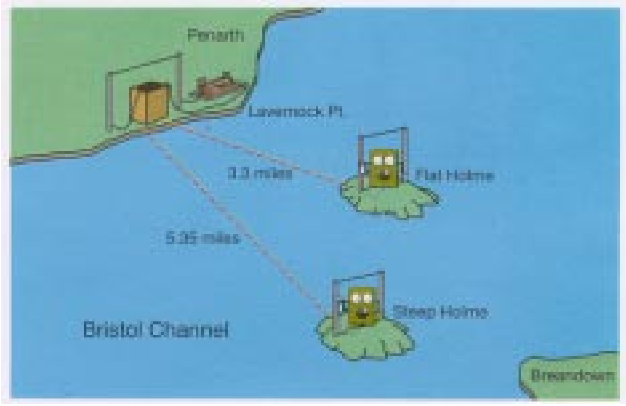
Castle, and also those between Sconce Point, Newport and Ryde. Morse signals were transmitted and received between Southampton and Newport with considerable success, using a telephone receiver, there not being enough current to operate a paper tape inker. When the cable was repaired and this method discontinued, some commented that the iron sheath of the broken cable had probably helped the results.

### *Fastnet*

The second example is the installation at Fastnet Rock (fig. 5), where it had been found impossible to maintain a cable connection, because of the constant battering of the sea, causing the cable to be worn through by chafing on the rock face.

Fastnet Rock is eight miles from the SW corner of Ireland. It is 360 ft (110m) by 150 ft (46m) and stands 80 feet (24m) above mean sea level. An insulated cable was laid to within 100 feet (30m) of the rock where the end was laid bare and connected to a copper anchor. Across the rock, on the north and south faces, copper rods were fixed into the rock face to a depth of 20 feet (6m) below the surface. The system, which worked well and reliably, was devised by Willoughby-Smith in 1895.


5 ***The Fastnet Rock system***




6 ***W.H. Preece's Bristol Channel system***

## Inductive Systems

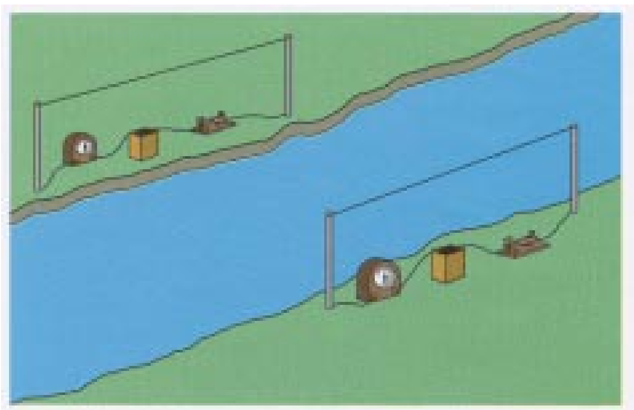
### *Bristol Channel*

W.H. Preece was active in experimenting with inductive systems, notably a system in the Bristol Channel between the mainland and the two islands, Flat Holme and Steep Holme, set up in 1892 (fig. 6). He also used this installation for direct comparison with Marconi's system a few years later.

### *Arran*

In 1894, he (Preece) also set up an arrangement between the Isle of Arran and the Mull of Kintyre, across the Killrannan Sound, which is about four miles (6.4km) wide, using two parallel lines of six miles (9.6km) in length along each side, both 500 feet (150m) high, and an ordinary land line at sea level. In other words, two wire rectangles facing each other, of dimensions 6 miles by 500 feet (fig. 7).

The system worked well, but it was found that if the ground level return wires were removed and replaced by earth plates at each end the performance was much better. When using the earth between the separated plates, the current flow takes place along a hemispherical surface and the calculated mean depth of the equivalent



7 ***The general arrangement of the Isle of Arran system***

wire was 900 feet (275m), giving nearly twice the effective area to the loops, allowing communication over a larger distance. This system was also used at Frodsham, with an equivalent depth of 300 feet (90m), and at Conway with 350 feet (107m).

So much for some of the alternative **wireless** telegraphy systems of the time, but it must not be forgotten that, at this time (say 1895), telegraphy and telephony by wire and cable were well-established world-wide. Those with an investment in these systems did not welcome any new system that might intrude and diminish their market share, expansion and profitability.

## Guglielmo Marconi

In order to put his work into its proper place, it is necessary to mention not only his activities, but those of Lodge and Jackson in this country, of Popov in Russia, and Slaby† in Germany. There were many more people than this, too numerous to mention, actively experimenting at that time. In the United States, for instance, De Forest, Fessenden, Stone and Shoemaker took out hundreds of wireless telegraphy patents, shortly after the original idea had been demonstrated by Marconi.

Marconi was born in Bologna, Italy, on 25 April 1874. He was the second son of the runaway marriage between Giuseppe Marconi, the son of a wealthy landowner, and Annie Jameson, daughter of Andrew Jameson of the Irish Whiskey Company (this whiskey connection could be regarded as a crucial component in determining the eventual success of Marconi in business).

Marconi was initially educated, between the ages of five and seven, at a private school in Bedford. He went to school in Florence up to the age of fourteen and then for two years at the Leghorn Lyceum (Livorno). He also received extra private instruction in science from a tutor named Professor Rosa. Despite this, however, he did not gain the qualifications needed to enter either the University at Bologna, or the Naval Academy.

At the age of eighteen, after he had passed the examination that allowed him to delay his compulsory military service until the age of 26, he attended lectures at Bologna University by Righi and Dessau, by special arrangement.

During 1894 (aged 20) he studied the works of Hertz (who had died that year). This interest was probably prompted by a commemorative article written by Righi, having previously become familiar with the mathematical conclusions of Maxwell and Kelvin. He had also read a description of the results obtained by Branly and Onesti, with detectors consisting of imperfect electrical contacts.

### Early Experiments

Marconi started his experiments on the application of Hertzian waves to the transmission and reception of messages over a distance, without wires, in the early summer of 1895 at the Villa Grifone at Pontecchio Bologna (fig. 8).

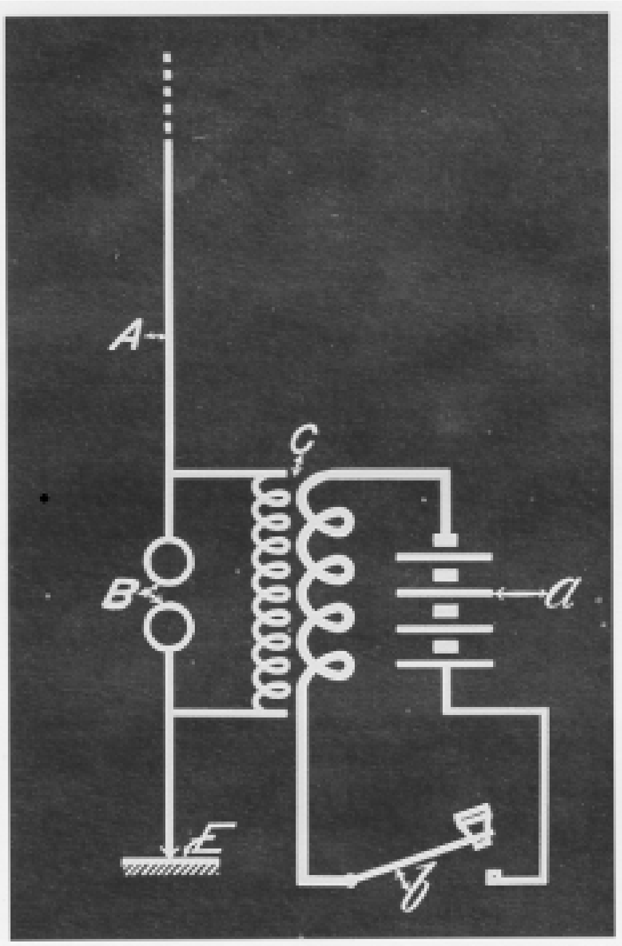
He clearly began by repeating the experiments of Hertz, but unfortunately there are no detailed records or notes of the steps that he took to improve the performance of his apparatus, so that transmission and reception of signals was progressively possible across a room, down the length of a corridor, and from the house into the fields. Success was signalled initially by the waving of a handkerchief, and progressed to the need to fire a gun in order to indicate reception at a distance of about two kilometres, out of sight over an adjacent hill, in September of that year.

Although no notes exist, many anecdotes refer extensively to his intense dedication to achieving a successful and improved system. He was clearly a great experimenter, who, if he lacked a scientific means of pointing the way forward, would, by a great many iterations, obtain an optimum solution. For example, if we take these earliest days. He started transmitting with the short dipoles and sheet reflectors of Hertz, connected to a battery powered induction coil (fig. 9).

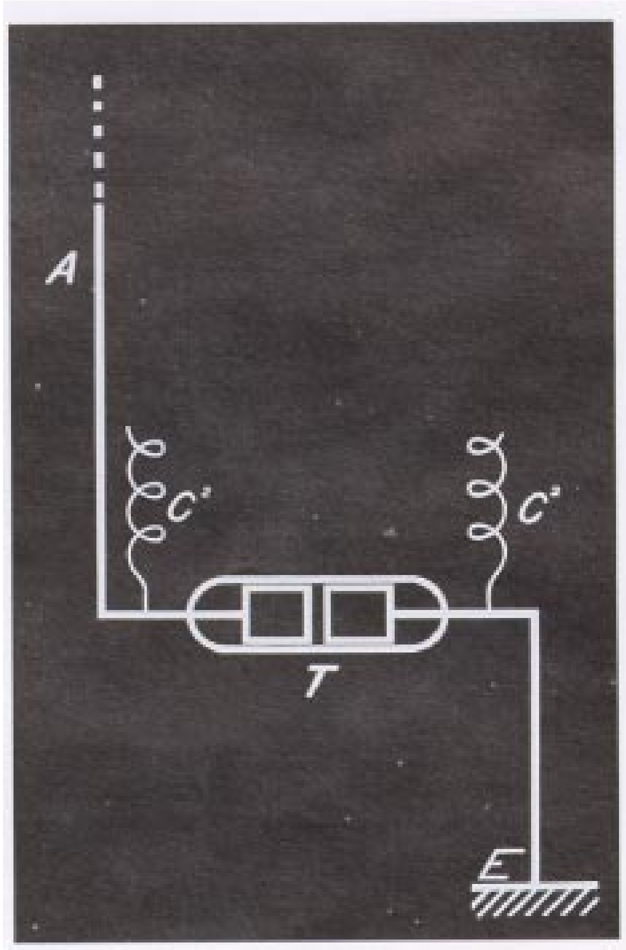
A next step was to leave the spark gap at ground level and to raise the arms of the dipole above ground or alternatively one arm to a plate on (or in) the ground and the other to a plate on a pole. Both methods were used in subsequent demonstrations. He had made a modified Hertz oscillator, but one with much greater capacitance and hence greater radiating power.

**8** ***Villa Grifone***

† Professor Adolf Slaby was the German Emperor's Scientific Advisor.



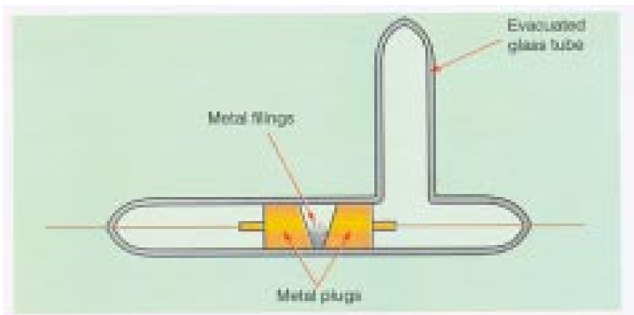

9 ***Early transmitter***




10 ***Early receiver***

## The Coherer

Similarly, his inventive and intuitive ability was applied to the receiver (fig. 10)†, which consisted essentially of a coherer connected to a similar aerial arrangement to that used by the transmitter and then to a conventional relay and inker system, borrowed from telegraphy equipment. Marconi's coherer seems to have been derived from Branly, but Popov had used a very similar type for the recording of lightning strikes in 1893. There were many versions of basically the same design, where filings of metal were held in between metal plugs in a tube (fig. 11).

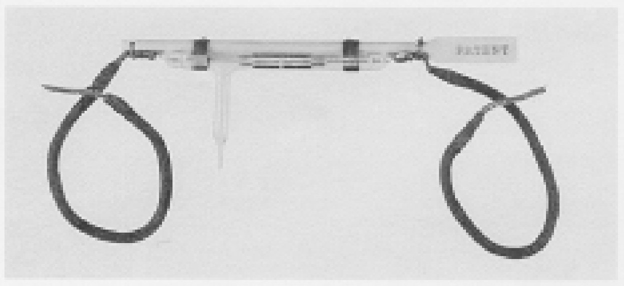



11 ***Coherer***

The coherer was perhaps the most important of the very early detectors. The precise theory of operation has never been determined, but it can be regarded as a device with a specially-constructed 'dry joint' which has two states: one of high resistance and the other of very low resistance. It has the characteristic that the application of an RF signal will change it from the high to low resistance state, where it will stay until mechanically shaken.

It is said that Marconi tried several hundred combinations of metal filings of various sizes between metal plugs of different shapes and spacings before settling on undoubtedly a very refined version. Marconi's tube (which was evacuated) was much smaller, (about 2 inches [50mm] long), the gap between the slightly tapered silver plugs was small (0.025 inches [0.635mm]) and the

† Figs. 9 and 10 are copies of the slides used in Marconi's lecture to the Royal Society of Arts in 1901. He continued to use them for several years himself and they were also used by Prof. Sir Ambrose Fleming in his commemorative lecture in November 1937.



**12 *Marconi coherer***

faces had been treated with mercury. He used 95% nickel mixed with 5% silver (fig. 12).

There is an apocryphal story about the experience of H.M. Dowsett (who was to become the Technical General Manager of The Marconi Company in 1931) on his first day in 1899. Marconi gave him an old smooth file and a small piece of metal and told him to make some filings. After half an hour he had made a very small heap and was convinced that as the 'new boy', he was having his leg pulled. However, Marconi subsequently told him that he had produced one coherer's-worth of filings and that only a clogged-up file would produce small enough particles!

## Improvements and Patents

Even at this early stage, Marconi had showed that he was very capable of developing his concepts and apparatus to a high level of performance and reliability, and he started to relate the performance to the parameters of his equipment. He discovered, as a result of many iterations, that the distance over which signals could be transmitted and received, varied in proportion to the square of the length of the vertical wires attached to the transmitter and receiver. Furthermore he found that when plates were attached to the top of the wires, the range varied in proportion to the square of the height of these plates from the earth. Probably the plates were not themselves so important, but the increase in capacitance was. Marconi referred to this relationship with height in his Nobel Prize Speech in 1909. A 2m pole gave a range of 30m, a 4m pole 100m and an 8m pole a range of 400m.

He also showed at that time and many times later, as is evident from his numerous patents, that 'improvements to design' was a continuous process – for example, putting the receiver in a metal box to avoid spurious interference to the recording equipment caused by the transmitter, a means that would be obvious today.

Similarly, automatically disconnecting the receiver aerial by using a back contact on the sending Morse key was another improvement, known as the 'Grasshopper' key.

In January 1896, less than a year after he had started experimenting seriously, he was considering applying for a patent for his invention. But prior to so doing, he offered to make the information available to the Italian Government. He did so via a family friend, General Ferrero, who was the Italian Ambassador in London. Marconi came to London in the middle of February 1896 with his mother and called on the Ambassador. Unfortunately, Marconi's 'Black Box' (fig. 13) had been broken by the Customs in the course of their examination of this unfamiliar apparatus.

After many months of consideration, the Italian Government advised Marconi to make his

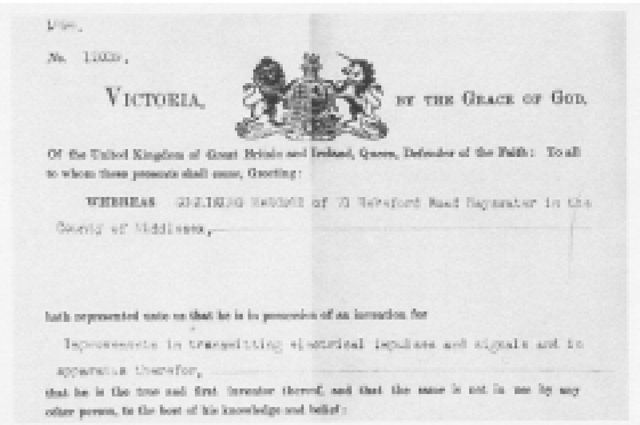
**13 *Marconi soon after arriving in England in 1896***

inventions available world-wide and British Patent 12039 was filed on June 2 1896, the first wireless telegraphy patent (fig. 14).

This patent includes the words:

> 'I believe that I am the first to discover and use any practical means for effective telegraphic transmission and intelligible reception of signals produced by artificially-formed Hertz oscillations.'

The description in the patent papers is a very complete practical disclosure, with layout diagrams. The claims cover the use of a keyed induction coil producing sparks across a gap, one (fig. 15) or both sides (fig. 16) of which may be connected to elevated plates or wires, or placed in a parabolic reflector (fig. 17). One rather unusual item to find in the patent is the use of a rotating contact driven by an electric motor to keep the trembler contacts smooth and without a tendency to stick – just another improvement. Alternatively one side of the transmitter (fig. 18) may be earthed and the other side connected to a plate or wire. Similarly for the receiver, with the spark gap replaced by a coherer (fig. 19). There are many claims for the coherer and the tapper and the method of connection using chokes.


No. 12039,

VICTORIA, BY THE GRACE OF GOD,

Of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith: To all to whom these presents shall come, Greeting:

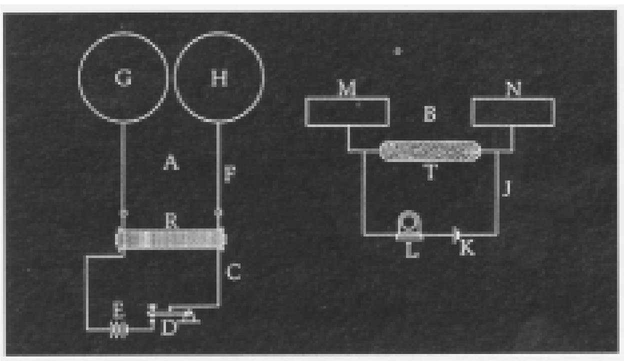
WHEREAS Guglielmo Marconi of 71 Hereford Road Bayswater in the County of Middlesex,

hath represented unto us that he is in possession of an invention for

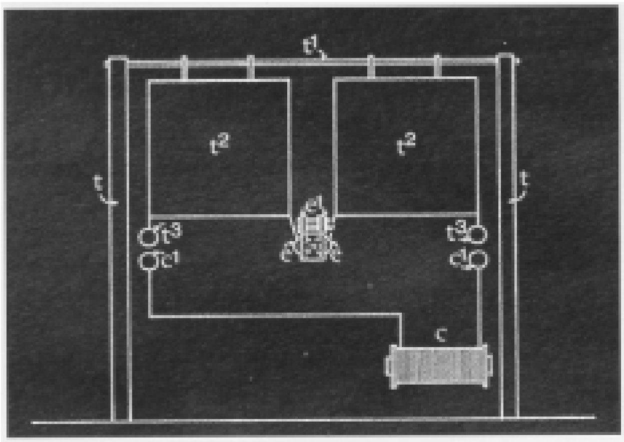
Improvements in transmitting electrical impulses and signals and in apparatus therefor,

that he is the true and first inventor thereof, and that the same is not in use by any other person, to the best of his knowledge and belief:

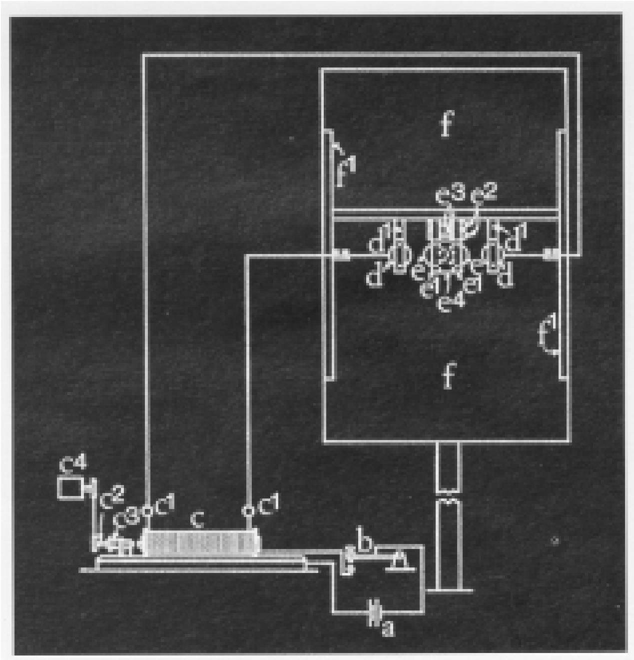
**14** ***Patent 12039***




**15** ***Keyed coil with single gap***



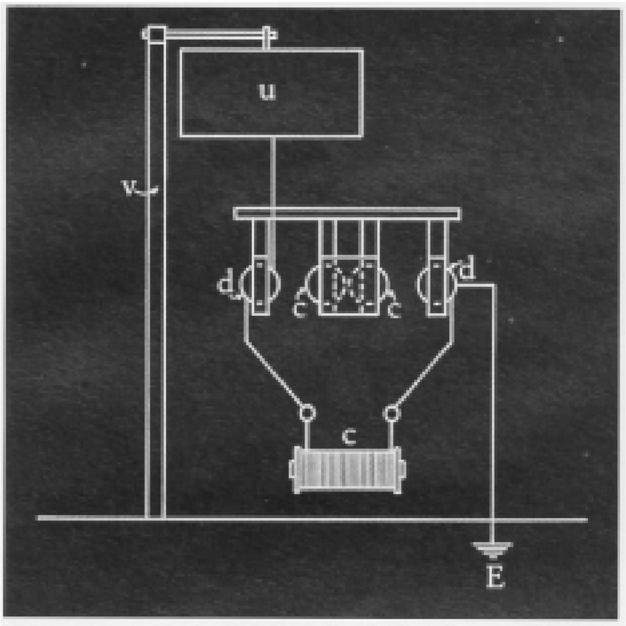

**16** ***Keyed coil with two gaps***



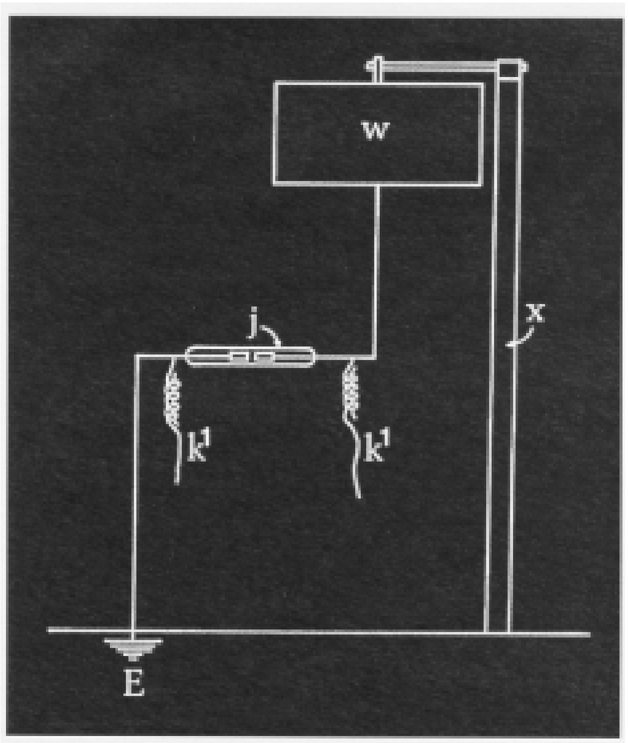

**17** ***Parabolic reflector***

## Wireless Demonstrations in England

It was Marconi's cousin, Henry Jameson-Davis, who met the Marconi family when they arrived in London and it was Jameson-Davis who introduced Marconi to A.A. Campbell-Swinton who, having seen a demonstration, gave him a Letter of Introduction to W.H. Preece in June 1896. In July of that year he demonstrated his apparatus to both the Post Office and the War Office, and there was a further historic demonstration at Three Mile Hill on Salisbury Plain on 2nd September, with the GPO, the Navy and the Army present (fig. 20). This demonstration worked at 2m wavelength. The service representatives were, even at this time, concerned with the security of communication.




**18** ***Transmitter with one side earthed***




**19** ***Receiver with one side earthed***

The Naval observer on Salisbury Plain was Capt. H. Jackson, who, in that same year, had succeeded in communicating between ships, using equipment similar to Marconi's, but totally independently. The Army observer, Major Carr, was impressed and, as a result, Marconi was asked to develop apparatus that would activate a receiver in a steel box immersed in the sea, a mile

**20** ***Impression of Marconi's demonstration on Salisbury Plain in 1896 by the artist Steven Spurrier***

off shore, to detonate mines remotely. This was not followed up!

William Preece, assisted by Marconi, gave an important lecture at Toynbee Hall on 12 December 1896. The Press who attended, headlined Marconi as 'the **inventor** of wireless'. This description prompted a strong reaction from scientific circles and Oliver Lodge, who also had made valuable contributions, was outraged.

Lodge had shown to a meeting of the Royal Institution on June 1 1894, and in the same year at Oxford, that his form of a Branly detector could detect signals at 150 yards (138m). He did not however appear to have grasped the significance of this demonstration and had not extrapolated from his experiments to a form of practical long-distance telegraphy.

Lodge said later (1897):

'stupidly enough, no attempt was made to apply any but the feeblest power so as to test how far the disturbance could really be detected.'

Rutherford, using a magnetic detector, had also signalled across a half mile (800m) of streets in Cambridge, in June 1896.

In 1895–1896, Popov, Minchin, Rutherford and others, used these methods applied to the study of atmospheric electricity, using vertical rods similar to those used by Marconi. Popov's use of an aerial was only as part of a receiver, with no transmission. Popov, in December 1895, said:

'I hope that when my apparatus is perfected, it will be applicable to the transmission of signals to a distance ...... when a sufficiently powerful generator of these vibrations is discovered.'

He did not really need more power, but a more sensitive detector.

One comment made by Preece during his lecture, which was not borne out, was that the Post Office had decided to spare **no expense** in experimenting with the apparatus, and one of the first trials would be from Penarth to an island in the (Bristol) Channel. This was the path used by Preece for his induction experiments (fig. 6). The trials took place, but no money came from the Post Office.

Preece went on to say that he had the greatest faith in the apparatus:

'The curious thing about it is that there is no new principle introduced. The first man who taught us how to generate these waves was Hertz, and they have been developed by others, but in making practical use of these waves, Mr. Marconi has invented devices which are highly novel and very beautiful, and when they are patented and can be made public, I think they will be admired by everybody.'

Marconi did not claim novelty, only improvements, these improvements were the subject of the 12039 patent.

'My invention relates in great measure to the manner in which the above apparatus is made and connected together.'

Nothing false was ever claimed by either Marconi or Preece.

More experiments continued in the following year (1897) with the assistance of Preece, with whom Marconi remained a great friend for years, although Preece sometimes had to take a formal position because of his Post Office appointment.

Although Marconi did not like public speaking, he gave lectures at the Royal Institution, The Royal Society of Arts, the Institution of Electrical Engineers and many other venues, on the progress of his work, any or all of which could have been done by Preece, or many others, but none of them did.

In March he was back on Salisbury Plain and achieved a range of 7 miles (11.2km).

The reports of Captain Jackson to the Commander-in-Chief, Devonport, on both of the Salisbury Plain demonstrations are complete and contain considerable detail of Marconi's equipment. Capt. Jackson acknowledged that there was little difference between his and Marconi's apparatus and that the results were similar, although Jackson's were slightly inferior because he had a less powerful transmitter and a less sensitive receiving apparatus.

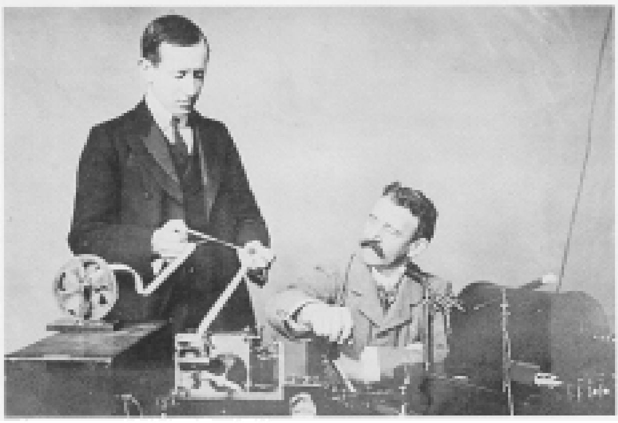
He commented that the Marconi apparatus consumed 13W to transmit over 2 miles (3.2km), whilst the power required for a ship's mast-head lamp was 260W.

He was, however, the recorder of the reported remark that:

'there is no possible market for the instrument, except for naval and military purposes.'

Who **actually** said this is not clear.

## George Kemp



**21** ***George Kemp (seated) with Marconi***

George Kemp was very active as Marconi's assistant (fig. 21). He was an ex-Petty Officer and had been one of Preece's laboratory assistants. He joined Marconi from the Post Office, becoming his assistant and technician for more than thirty years. He kept notebooks of his work and, in the 1930s, prepared further, more complete records. These latter documents are in the Marconi archives. Unfortunately, although his copperplate handwriting gives a general description, there is more detail about the travelling arrangements and times of trains, than of the exact equipment used in the experiments!

## The Bristol Channel Trials

There is much more detail available about the trials across the Bristol Channel in May, as Preece presented a lecture on the results at the Royal Institution on June 4 1897. These tests were conducted, as usual, in the normal bad weather conditions and the record speaks of people huddled in huts on the beach to get out of the storm. No success was achieved on the first two days with the aerial at 150 feet (46m), but on the fourth day, with the aerial at 300 feet (92m) and using a 20 inch

(0.5m) spark coil, a new record range of 8.7 miles (14km) was achieved. The Morse message that was sent was 'let it be so' (at a wavelength of 1.25m).

During this period, Preece repeated his electromagnetic experiment on May 10th with perfect results.

Among the people who witnessed these tests was Prof. Slaby from Germany. He commented:

> 'What I saw was something new; Marconi had made a discovery; he worked with means, the full importance of which had not been recognized and which alone explained the secret of his success. He has thus, first shown, how by connecting the apparatus with the earth on the one side and by using long-extended vertical wires on the other side, telegraphy was possible.'

Slaby suggested therefore that wireless telegraphy was a misnomer and proposed 'spark telegraphy'. 'Die Funkentelegraphie' was the term adopted in Germany.

Slaby proposed that there should be a commercial arrangement between Marconi and AEG, but there was failure to agree on terms. Later Slaby, Arco of AEG and Braun of Siemens & Halske amalgamated to form a new company in 1903, called Gesellschaft für Drahtlose Telegraphie, and who marketed the Telefunken system, becoming a formidable rival to Marconi.

## The Formation of the Marconi Company

There were many approaches to buy Marconi's patents and there were rumours that the taxpayer 'was funding him to the detriment of British scientists'.

Once again this was where the whiskey connection was significant because Jameson Davis, his cousin, became the first Managing Director of the Wireless Telegraph and Signal Co. on 20 July 1897. Col. Jameson Davis was a corn-milling engineer and seven of the eight other first subscribers were corn factors, or corn merchants.

The new Company purchased all Marconi's patent rights. Marconi received £15,000 cash, less the legal fees of forming the Company; he also received 60,000 shares of £1, the remaining 40,000 shares were put on the market. Marconi was one of five directors.

The Marconi's Wireless Telegraph Company of America was formed on November 22nd 1899 and became the Radio Corporation of America in 1919.

The UK Company name was changed to Marconi's Wireless Telegraph Co. Ltd on 24 March 1900 when Samuel Flood Page became Managing Director. The Marconi International Marine Co. was created on April 25 1900, Marconi's 26th birthday.

## Further Demonstrations

With the setting-up of the Company, the number of demonstrations increased significantly. Marconi was in Italy when the Company was being formed and, as a result of this visit, it was announced shortly afterwards that the Italian Navy would adopt Marconi's apparatus.

Later that year, in October 1900, Marconi was back on Salisbury Plain, now communicating with Bath at a distance of 34 miles (54km).

The new Company created a separation with the Post Office, which carried out experiments of its own at Dover, but without much success. The report by Preece to the Post Office on this work, said to be for the purpose of 'determining the laws which govern this method of transmission' includes the comment: 'the results at Dover are distinctly unfavourable when compared with those we had between Lavernock and Brean Down in the Bristol Channel'.

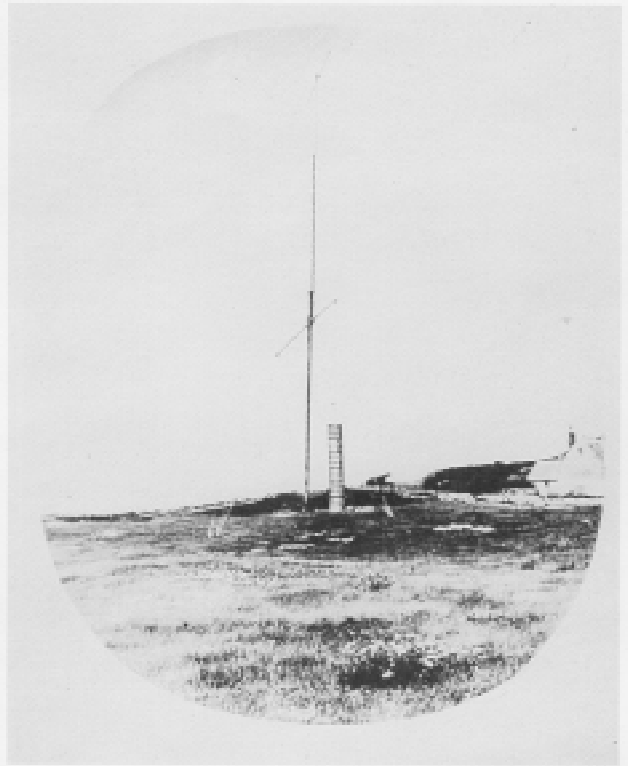
Marconi then concentrated on his original idea of communication with, and between ships at sea. He established a coastal station at the Needles Hotel, Alum Bay, Isle of Wight (fig. 22), and carried out tests with two steamers, achieving ranges of up to 18 miles (29km) – always, it seems, in bad weather. Bad weather and the results of gales, continually appear in the records of Marconi's work.

A second station was set up at the Madeira Hotel, Bournemouth. Lord Kelvin sent the first **paid** message (he insisted on paying), the first wireless telegram (fig. 23), from the Isle of Wight to Bournemouth in early 1898, thus creating a problem with the Post Office, whose monopoly covered all messages within the three mile limit.

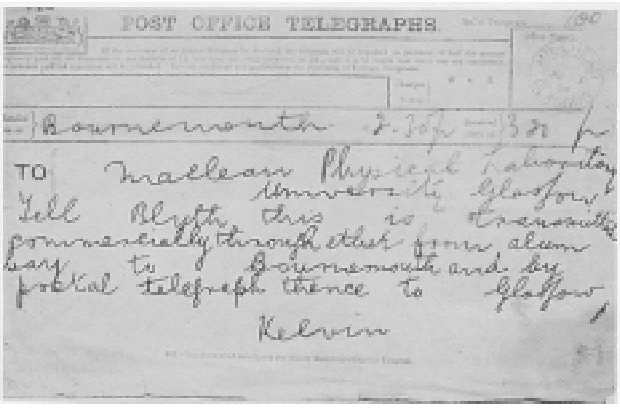
Towards the end of September 1898, Marconi left the Madeira Hotel because of a dispute with the management over the cost of accommodating the aerial (115 feet (35m) high) in the front garden. He moved to the Haven Hotel at Poole, where he worked and lived from time to time until 1926 (fig. 24).

Further demonstrations were given at many places including:

- from the House of Commons to St. Thomas' Hospital;
- from the Lighthouse at Ruthlin Island to Ballycastle NI;



22 ***The 115′ (35m) aerial at the Needles on the Isle of Wight***



POST OFFICE TELEGRAPHS

Bournemouth

TO Maclean Physical Laboratory
University Glasgow
Tell Blyth this is transmitted
commercially through ether from Alum
bay to Bournemouth and by
postal telegraph thence to Glasgow
Kelvin

23 ***Lord Kelvin's telegram, sent from the Isle of Wight to Bournemouth in 1898 – the first paid message***

- at the Kingstown Regatta – sponsored by the Dublin Daily Express (SS 'Flying Huntress');
- at the Cowes Regatta. From Queen Victoria at Osborne House to the Prince of Wales on the Royal Yacht 'Osborne' – 150 messages were passed;
- from the East Goodwin Lightship to the N. Foreland Lighthouse at a range of 12 miles (19.2km). This link was maintained by the Company for 14 months at its own expense;
- from South Foreland to Wimereux on the 27th March 1899; and

24 ***The Haven Hotel, Poole***

- at the America Cup races 1899, at the request of the New York Herald and Evening Telegram (Editor – Gordon Bennett).

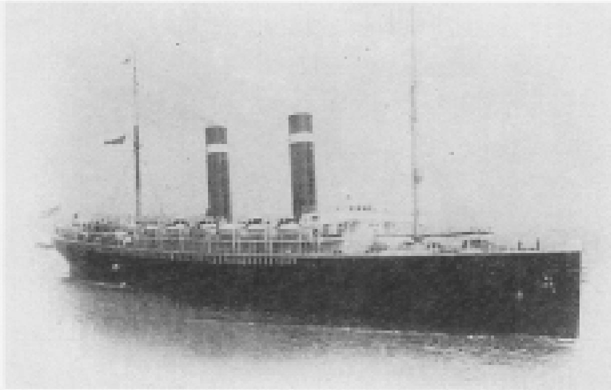
Most of these events are well documented and each could be the subject of a complete paper.

The Naval Manœuvres of 1899 gave the opportunity for communication over a distance of 95 miles (152km) using an intermediate ship as a repeater (HMS 'Europa' to HMS 'Juno' to HMS 'Alexandra'), giving that section of the fleet an advantage of about three hours.

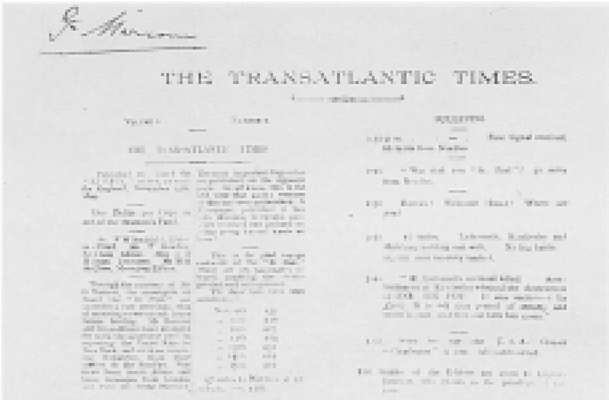
Capt. Jackson (HMS 'Juno') noted that the distance of the horizon from the height of the aerials (150 feet) was 31 miles (50km) and that communication between 'Juno' and 'Europa' had been achieved over 60 miles (96km). He says:

> 'the induction must have passed through or over a mass of sea water about 500 feet high and 30 miles thick.'

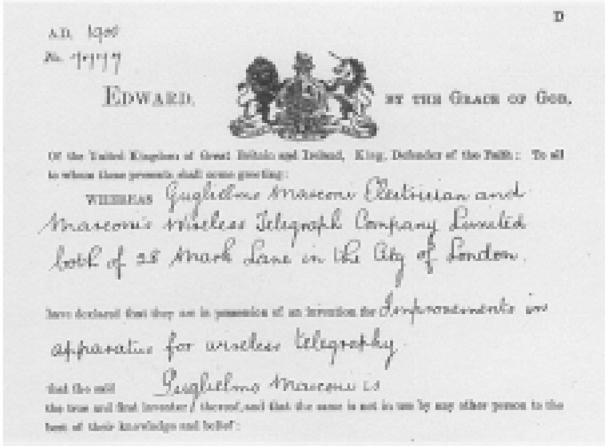
On his return from the USA in the SS 'St. Paul' (fig.25) in 1899, Marconi established contact with the Needles at 60 miles, receiving the latest news of



**25 *SS 'St. Paul'***


THE TRANSATLANTIC TIMES

**26 *The first issue of the 'Transatlantic Times'***


A.D. 1900
No. 7777
EDWARD, BY THE GRACE OF GOD,
Of the United Kingdom of Great Britain and Ireland, King, Defender of the Faith: To all to whom these presents shall come greeting:
WHEREAS Guglielmo Marconi Electrician and Marconi's Wireless Telegraph Company Limited both of 28 Mark Lane in the City of London
have declared that they are in possession of an invention for Improvements in apparatus for wireless telegraphy
that the said Guglielmo Marconi is the true and first inventor thereof, and that the same is not in use by any other person to the best of their knowledge and belief:

**27 *Patent 7777***

the South African war. The 'Transatlantic Times', Vol.1., No.1. was produced, dated November 15 1899, at $1 a copy (fig. 26).

As a result of these and many other trials, Marconi obtained the initial orders for his new Company. However the Company did not show a profit for several years and if it had not been for the continued financial support from his fellow directors, he would not have been able to continue his experiments and the Company would have failed.

Marconi engaged technical staff, Dr. J. Erskine-Murray in 1898, and Dr. W. H. Eccles in 1900. This support gave him a significant advantage over both Oliver Lodge, who had to run a department at Liverpool University, and Capt. Jackson, who had to carry out his Naval duties, in addition to their studies of wireless.

## The 7777 Patent

In April 1900, the famous 'Four Sevens' patent was granted for 'Syntonic Transmission and Reception' (fig. 27). As with the first patent, the novelty consisted not in a new discovery of scientific principle, but in its method of application to the purposes of wireless telegraphy.

## Two Tuned Circuits

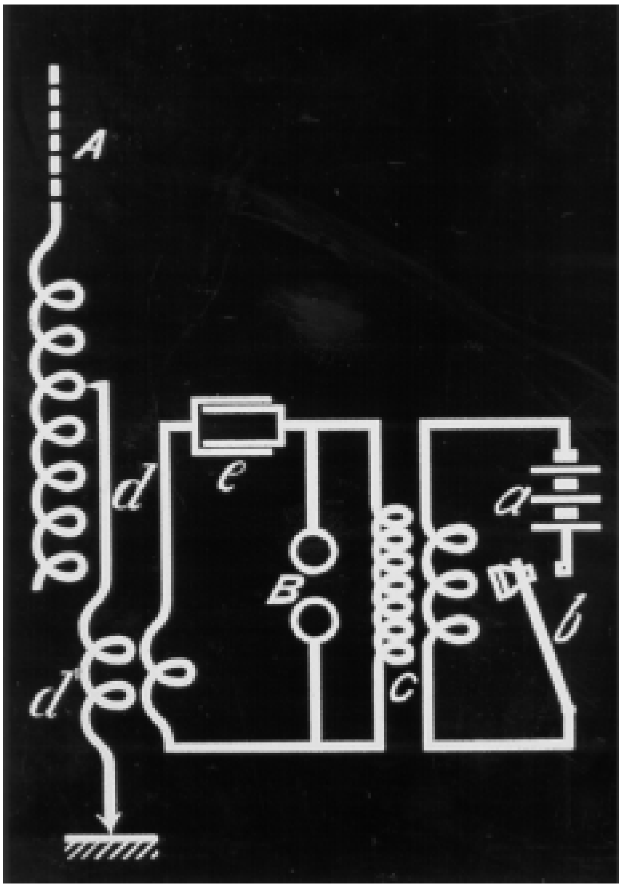
The method by which the natural frequency of oscillation of a circuit could be controlled was already known. If a circuit were constructed to be a good radiator of energy, (for example an open aerial), the oscillations set up therein by a spark discharge would quickly die away as the energy was dissipated in radiation. Ideally the circuit would maintain the oscillation between each discharge by resonating. Such a circuit could be constructed, but the two requirements of being a good radiator and for sustained resonance were recognized as being mutually conflicting.

By combining within his apparatus two tuned circuits, one being a highly resonant closed circuit and the other an aerial circuit of good radiating characteristics, and weakly coupling the two together, a successful result was obtained, with greater range and selectivity (fig. 28).

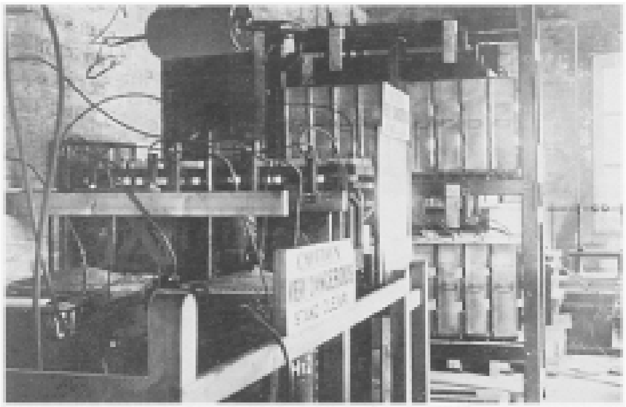
The radio frequency transformers were called 'jiggers'. Marconi had effected the practical compromise that allowed control of the rate at which energy was transferred to the aerial.

## Poldhu

It would be a serious oversight to omit reference to the transatlantic experiments, although these were only possible by virtue of enormous investment by the Board of the Company. Ambrose Fleming designed the apparatus at Poldhu, having been appointed Scientific Adviser to the Company. Work started in October 1900 and tests started in the beginning of 1901. The input power was 20–25kW from an alternator giving 2000V at 50Hz, this was stepped up to 20kV into a closed oscillating circuit. The keying was achieved by shorting out chokes in the output of the alternator.



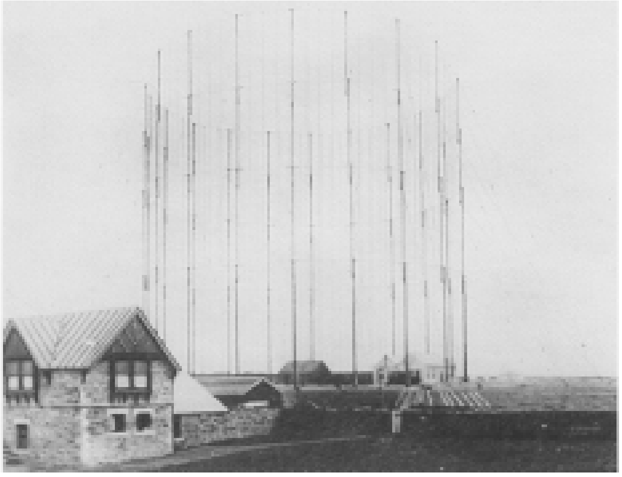

28 *Two tuned circuits*



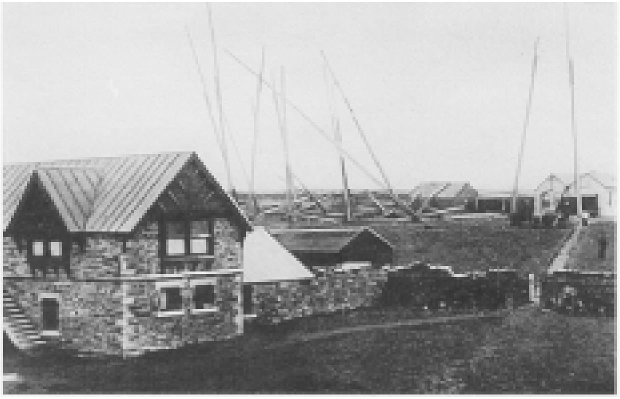
29 *The Poldhu transmitter*

In the photograph (fig. 29) the rack contains many capacitor boxes, each 0.05mF, made of twenty glass plates 16 inches square (0.4m square).

It was decided to build a second similar station at Cape Cod but, once again, the weather took an active part and the large inverted cone aerials at both sites were wrecked (figs. 30 and 31). Poldhu replaced this with a 60 wire fan between two 150 foot (46m) masts (fig. 32).



30 *The first inverted-cone aerial at Poldhu*

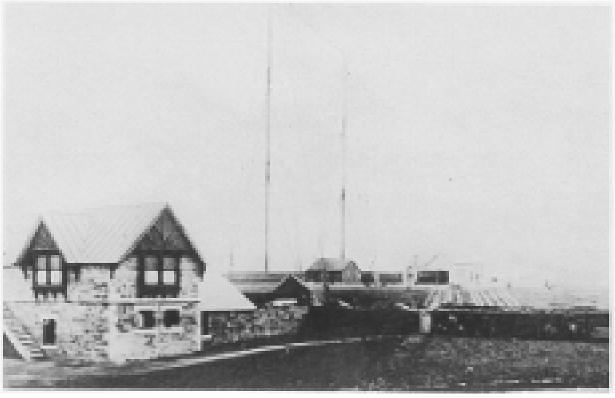


31 *The effect of bad weather on the first Poldhu aerial*

Marconi decided to do a one-way test, by taking a receiver to Signal Hill at St. Johns', Newfoundland. He gave the wavelength of operation as 366m.

At St. Johns', Marconi and Kemp used a kite to lift the aerial wire to 400 feet (122m) (fig. 33), but because of the wind the system would not stay in tune and hence the new syntonic receiver was abandoned for a plain aerial-to-earth circuit, coupled by a jigger to a circuit containing a mercury coherer (probably operating as a rectifier) with a telephone earpiece in series. The dots were received at 12.30 p.m. on December 12$^{th}$ 1901 local time and recorded in his diary (fig. 34). The weather got worse and the tests could not be continued, preventing confirmation by an independent person.

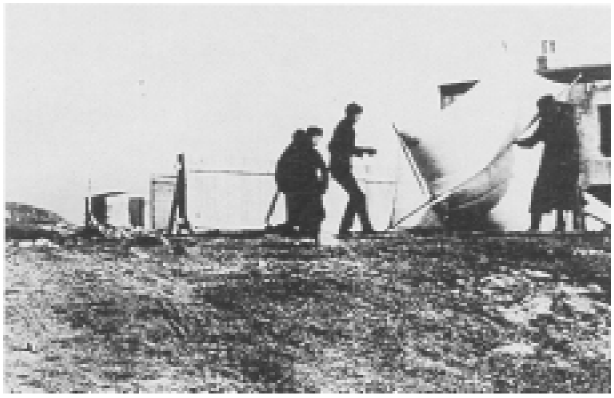
Immediately after this success and in order to ensure the presence of Marconi, the American Institute of Electrical Engineers brought forward, at very short notice, the date of their Annual Dinner at the Waldorf Hotel and held it in honour of



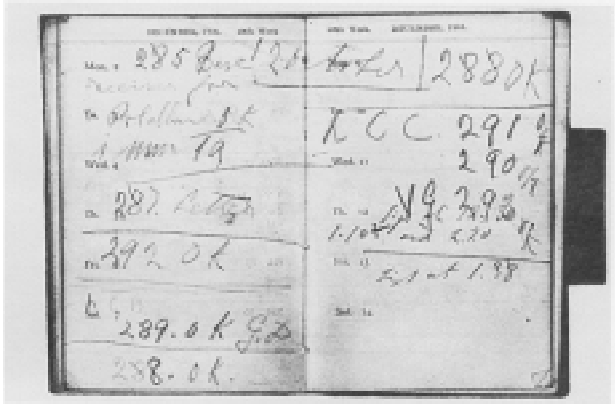
a)

b)

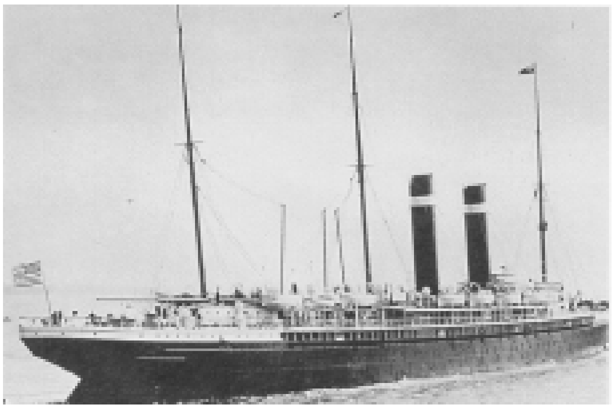
**32 a)** ***The replacement fan aerial at Poldhu, and*** **b)** ***the site as it appears today***



**33** ***Raising the kite at Signal Hill***



**34** ***Marconi's diary recording the events at St Johns'***



**35** ***SS 'Philadelphia', showing her 150-foot (45m) masts***

Marconi on January 13th 1902. The room was decorated with lamps flashing the Morse 'S', and the menu (signed by many, including Alexander Graham Bell) had a cover that reflected the transatlantic achievement (one item on the menu was 'Potage Electrolytique').

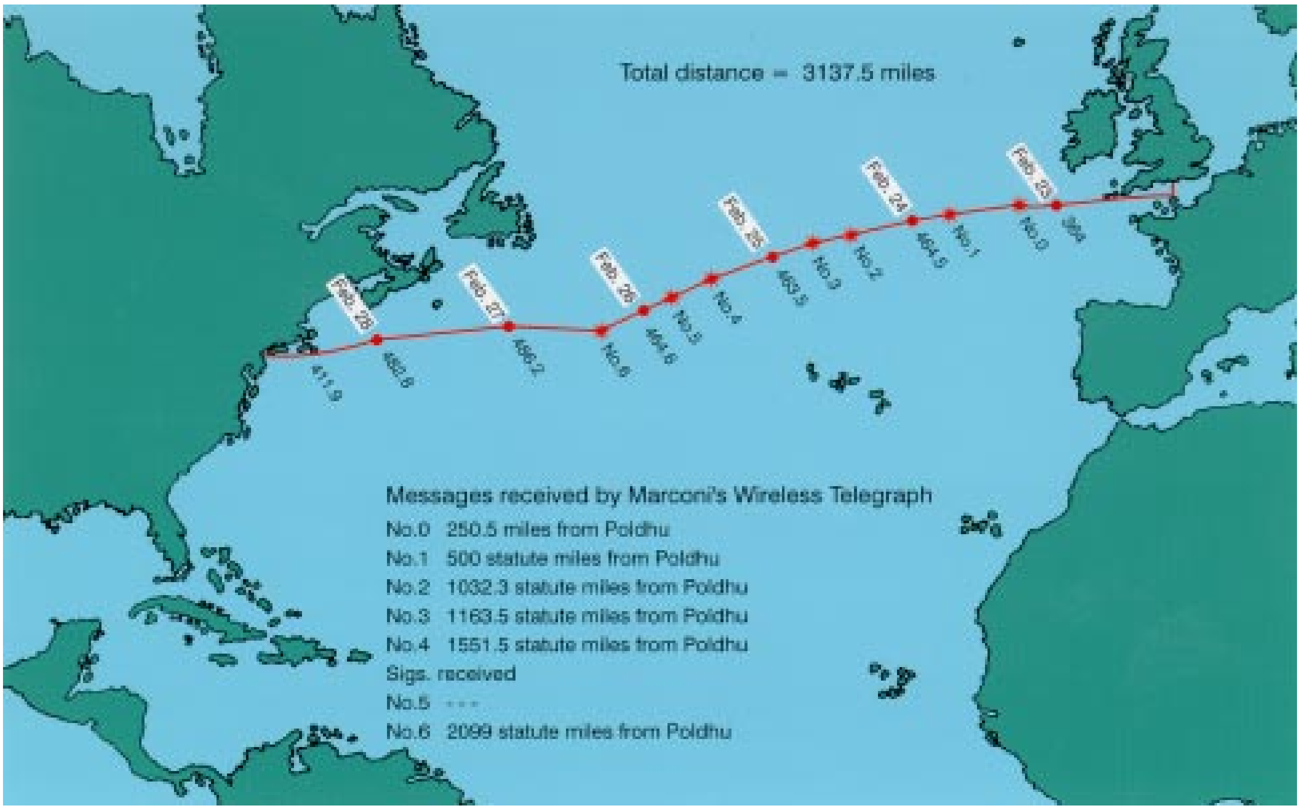
Subsequent work in the SS 'Philadelphia' (fig. 35), in February 1902, revealed that the range obtainable at night was much greater than at day, achieving 2099 miles (3358km) (fig. 36). I am intrigued that the certified tapes of the messages that we have, do not contain any recognizable plain language, or code, unlike the earlier records of experiments.

### 'Carlo Alberto'

The King of Italy placed the new warship 'Carlo Alberto' (fig. 37), with a crew of 800, at Marconi's disposal enabling him to carry out more experiments, over a period of six months, from Finland, Prussia, the Mediterranean and the North Atlantic coast of America.

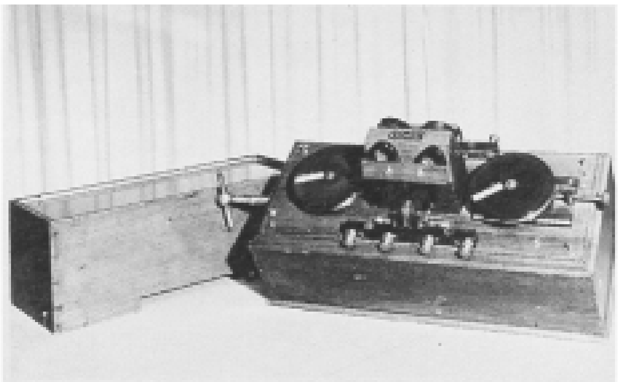
## The Magnetic Detector

A most significant invention of Marconi was the Magnetic Detector (fig. 38), which became the standard system for reception for many years, superseding the coherer. Again, Marconi applied a phenomenon, discovered by Rutherford in 1895, which was based upon the effect of high frequencies on the magnetic characteristics of iron. The rigorous explanation of the actual operation of the detector was not understood until research into the theory of magnetic materials produced the explanation in 1931.




**36** ***The route diagram for the experiments aboard the SS 'Philadelphia'***

**37** ***The 'Carlo Alberto'***



**38** ***The magnetic detector***

## A Summary of Early Events

For reference, the following lists some of the progress in the wireless communications business, that took place in the first few years of the 20th century.

The Marconi Company had been formed in 1897 with Wireless Telegraphy in a very rudimentary state. By 1903, as a consequence of Marconi's efforts, there had been the following achievements.

- There was a daily service of news between Glace Bay, Nova Scotia, and Poldhu at a range of 2400 miles (3840km).
- The Italians were building a station to communicate with Buenos Aires – a range of 5000 miles (8000km).

- The Marconi System had been adopted by British and Italian Navies.
- There were 32 installations on British warships and 20 installations on Italian warships.
- Lloyds had a contract to use only the Marconi system.
- There were ten coastal stations in England.
- The Dover-Calais and Ostend-Boulogne ships were fitted.
- The Slaby-Arco installations in Germany were replaced by a Marconi system.
- Italy was building several coastal stations.
- There were ten coastal stations in the U S A, and also at Chicago, in Cuba, Hawaii (4), Alaska and Milwaukee.
- Eighteen transatlantic liners had been fitted by 1901, and thirty by 1903.

This rate of progress in just six years was certainly impressive. On the other hand, Marconi experienced the problems with Government contracts, which are still all too familiar today.

There were difficulties in agreeing terms with both the Post Office and the Admiralty. Neither of these organizations wishing to be the first to set a pattern. The Admiralty wanted to use Marconi equipment, as there had been very successful results during the naval manœuvres in July 1899, when three warships were fitted. However, they could not wait for the contract to be agreed, particularly as Marconi wanted a royalty of £100 per annum for each ship fitted. A royalty of this amount would have produced an income of £10,000 if all the relevant ships of the fleet were fitted. This was the sum being offered by the Post Office for all the Marconi patents.

A complete receiver and transmitter with batteries, key and inker was sold at £93 16s 6d. The breakdown of prices was as follows:

| | | | |
|---|---|---|---|
| Receiver | £13 | 16s | 0d |
| Inker | £15 | 0s | 0d |
| Bell | | 3s | 6d |
| Coil attachments and Key | £4 | 5s | 6d |
| 10-inch Coil | £38 | 11s | 6d |
| 100 'M' Cells | £22 | 0s | 0d |

Several sets to the design of Capt. Jackson were made at HMS 'Vernon', but these were of inferior performance to that achievable by Marconi sets. The Admiralty used their Crown Rights to employ inventions and to manufacture, under the terms of the Patents, Design and Trade Marks Act of 1883, and had fifty copies of the Marconi sets made by Ediswan (also a root of GEC), having in the end bought just thirty-two sets, but paying the required royalty for only these.

Eventually, most of the Jackson sets were modified to Marconi standard and became of equal performance and represented the ultimate development of untuned spark gap systems.

## Marconi – the Man

What sort of a person was Marconi? The comments of contemporaries are many:

'Always the clear leader, but somewhat aloof, even at 23, when his Company was formed.'

'Not a cordial man, a human loveable man.'

'His manner is of chilly reserve, charm and distinctly scientific.'

'English in dress, unduly serious for his age.'

'English in speech, trustworthy.'

'Not the fastest spark of southern fire. A cool calculating man of the North.'

'For a successful inventor, Marconi appears the least joyous of men.'

'His features are melancholy in expression. They are of a man fast approaching forty, not those of a man of twenty-eight. His face is impassive, his eye almost cold.'

'When he smiles he half shuts his eyes, wrinkles the muscles of his cheek. It is not a pleasant smile.'

'If you visit Marconi with the expectation that he will do most of the talking, you find that you must do the talking yourself. To be sure, he answers questions frankly and fully; but he will not converse voluntarily.'

'You discover quickly enough that his reticence is the reticence of modesty. When he discusses the Marconi system of wireless telegraphy, he refers to it as 'our system' not as 'my system'. He praises, where praise is due, he acknowledges fully how important to him has been the work of his predecessors.'

'As he himself recognized the merit of the labours of those who went before him, it is fitting that others should recognize the fact that his organizing talents have brought together a hundred contributory speculations and detached discoveries into harmonious relation, and have given us a system of wireless telegraphy, still susceptible of improvement in many respects, no doubt, but practical in the attainment of results scarcely deemed possible by present agencies.'

'He insisted on a clear order of rank, which was evident when his party sat down to a meal.'

'The greatest thing about him is his capacity for labour.'

'A determined worker from the earliest times.'

'Said to have locked himself in his laboratory in the attic for days on end ceaselessly without food or rest.'

'Very adroit with his hands and a good pianist. A great traveller, almost constantly on the move.'

'A great persuader of his business friends to put up more and more money, to enable more demonstrations to be staged and to build new and higher-powered stations, at a time when virtually no orders had been received by the Company.'

'He clearly enjoyed the large number of events, discussions and awards given to honour him. It seemed that every new success was followed by some public celebration, and the newspapers of the period carried daily reports of his activities.'

'He was a great developer.'

Solari of the Italian Navy and a lifelong friend said:

'In intimate circles and with trusted friends he displayed a simple and youthful joy which was very surprising to people who had only met him at official meetings.'

If we remember that the first person to notice that the lid of the kettle lifted when the water boiled did not himself design the steam engine, then we can identify the qualities that marked Marconi as the pioneer of wireless. He was not primarily interested in the purely scientific aspects, but in the practical application for useful purposes.

He was also a great predictor. At a joint meeting of the IRE and the American Institute of Electrical Engineers on June 20 1922, he concluded with the following remarks:

'As was first shown by Hertz, electric waves can be completely reflected by conducting bodies. In some of my tests, I have noticed the effects of reflection and deflection of these waves by metallic objects miles away. It seems to me, that it should be possible to design apparatus by means of which a ship could radiate or project a divergent beam of these rays in any desired direction, which rays, if coming across a metallic object, such as another steamer or ship, would be reflected back to a receiver screened from the local transmitter on the sending ship, and thereby immediately reveal the presence and bearing of the other ship in fog or thick weather.

One further great advantage of such an arrangement would be that it would be able to give warning of the presence and bearing of ships, even should these ships be unprovided with any kind of radio.

I have brought these results and ideas to your notice as I feel and perhaps you will agree with me that the study of short electric waves, although sadly neglected practically all through the history of wireless, is still likely to develop in many unexpected directions, and open up new fields of profitable research.'

He felt that it was his initiative in using longer and longer wavelengths that was responsible for this neglect as everyone followed his preoccupation with increasingly greater wavelengths (Poldhu/Clifden: 1100m (1901), 2000m (1903), 3660m (1904), 6660m (1907)).

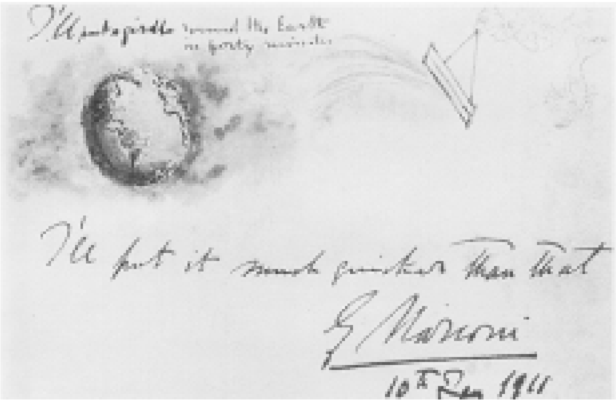
And in 1927 he said:

'I am known as a man who deals in cold scientific facts and practicalities, not in Utopian fantasies,......As to talk of a saturation point, a limit to radio progress, there is no limit to distance, hence there can be no limit to wireless development.'

The picture shown in fig. 39 (note the slight misquotation) emphasises the reason for Marconi being regarded as justifiably as the Father of Wireless in the simplest of terms. No challenge was too great.

## Acknowledgements

I must, in particular, mention the help of Mr. Roy Rodwell, who is responsible for the Marconi Archives, also Keith Geddes lately of the Science Museum, and the late Gerald Garrett who made available some of his unpublished work for study.



**39** ***A girdle round the Earth***

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