Popov versus Marconi: the Centenary of Radio

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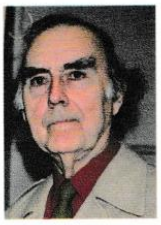
Ralph Barrett is a broadcasting consultant; his career started with Baird Television at the Crystal Palace, and he then studied radio and electronics at many technical colleges and polytechnics in and around London. At the outbreak of war in 1939 he moved to a radio station on the Thames estuary and had an 'exciting' time during the Battle of Britain. The radio station was in direct contact with the USA and was also a radio interception station for secret agents operating in Europe. Shortly after the war, Ralph graduated at the Institution of Electrical Engineers and the Institution of Electronic and Radio Engineers. In later years he was Assistant to the Head of BBC Television Network, and moved around Europe in connection with foreign broadcasts.



This article is based upon a demonstration lecture 'Popov versus Marconi' which was presented in the Telford lecture theatre at the GEC-Marconi Research Centre, Chelmsford, UK, on the 12th November 1996.

The aim of the presentation was to examine the claims of priority of the invention of radio communication, Popov (fig. 1) or Marconi (fig. 2), and – by the construction of working models – to verify the operation and limitations of the apparatus and the early experiments.

Background

After studies at the University of St Petersburg, Alexander Popov (1859–1905) joined the staff of the Navy Torpedo School at Kronstadt, and soon became Head of the Physics Department. The library had foreign journals, which stimulated his interest in the work of Heinrich Hertz and the demonstrations of Oliver Lodge.

Guglielmo Marconi (1874–1937) was a contemporary of Popov, a non-academic who called himself the 'ardent amateur of electricity'. He pursued experiments in his father's mansion, Villa Griffone, near Bologna, and also read of Hertz and Lodge in journals sent from England.

In 1895 both men constructed radio equipment using a 'coherer' as a detector (see Appendix 1).

1 *Alexander Popov c.1895*

2 *Guglielmo Marconi c.1895*

Popov's apparatus was designed for recording atmospherics and was used as a storm detector; Marconi's apparatus was for detecting man-made signals.

Russia and Italy were both to put forward the claims of their nationals as the inventor of radio.

The Demonstration System

The Coherer

Marconi did much work on the coherer and found that metal particles of 96% nickel and 4% silver gave very sensitive operation. Inside a glass tube he made a wedge-shaped gap between two silver electrodes, measuring 1 mm at the closest part. With the gap about half filled with metal particles, rotation of the tube would alter the space occupied by the particles.

Our work on a coherer for the demonstration soon arrived at the use of a coin, which contained a large amount of nickel; the filings produced with a fine-cut file made very satisfactory particles. These were placed in a glass tube of 4 mm inside diameter, between brass plugs creating a wedge-shaped space.

The construction and behaviour of the coherer device are considered further in the paper by Pegram *et al.* elsewhere in this issue.

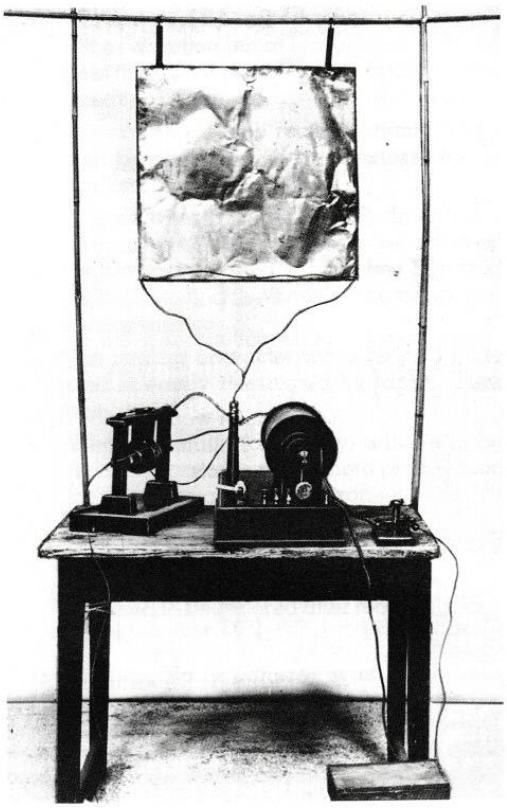
The Aerial

Marconi discovered very quickly the importance of using an elevated aerial, consisting of a metal plate connected to one side of the coherer, and the other side attached to a plate buried in the ground. After tests in the attic at Villa Griffone it was taken to the garden. The transmitter had a similar 'aerial and earth' connected to a Righi-type spark gap (a gap immersed in oil, thought to produce a more vigorous spark), energized by a 10 inch (0.25 m) induction coil. Some years later a replica, shown in fig. 3, was made for the Marconi Company in Chelmsford.

The Transmitter and Receiver

Our transmitter and receiver are shown in fig. 4 and fig. 5, respectively. The transmitter spark gap consisted of two brass spheres set to a separation of 1 cm to produce continuous sparks. A 10 inch (0.25 m) induction coil powered by a 12V car battery, and a Morse key completed the transmitter.

Marconi was satisfied with a working range of 3 km. Our models worked well at about 10 m, which was the maximum distance available within the lecture theatre.

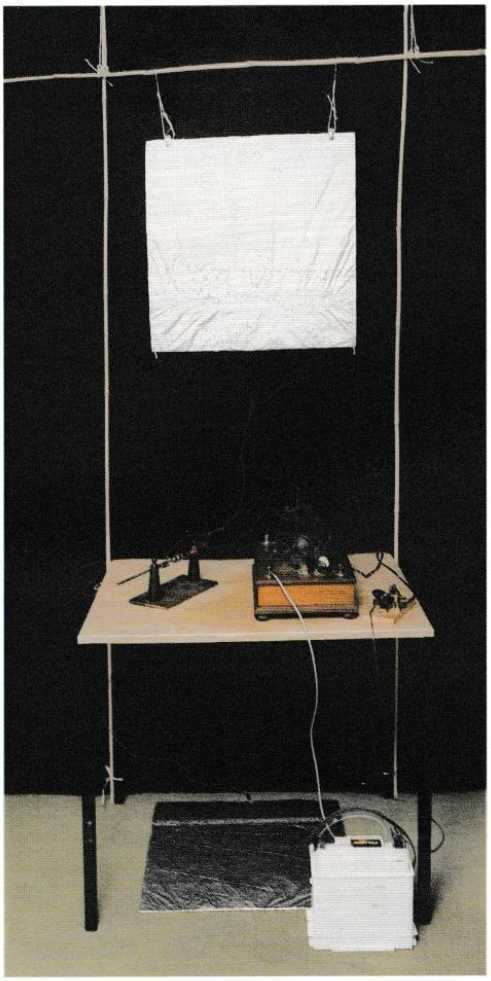


3 ***A replica of Marconi's original transmitter which he used in experiments at the Villa Griffone in 1894***

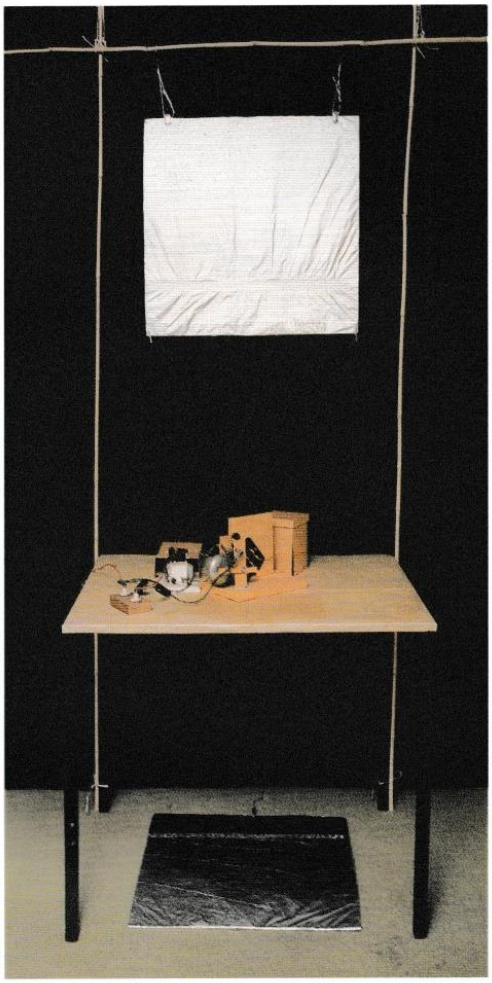
The circuits of the models followed those of the original designs as depicted in fig. 6. The Marconi receiver is on the right (b) and uses a Post Office type relay and Morse printer; resistors are connected to the contacts to avoid spurious sparks, and radio frequency chokes isolate the relay and battery. Popov's circuit (a) on the left shows the bell and bell hammer to jog the coherer into its pristine state of sensitivity, together with the single battery.

Practical Considerations

Marconi found that a separate coherer battery was important, and the voltage was kept low because a large coherer current would cause self coherence. In the model of Popov's receiver with the single battery a delay in decohering was apparent. Had this receiver been intended for the detection of information (which it was not, as Popov was concerned only with the detection of lightning strikes at the time) this would have reduced the speed of Morse operation. In order to keep the coherer current low, a sensitive relay is necessary. Marconi found a Post Office relay could



4 ***Model of the Villa Griffone transmitter. The ground plate is here shown under the table, but in the original apparatus was buried in the ground.***



5 ***Model of the Villa Griffone receiver***

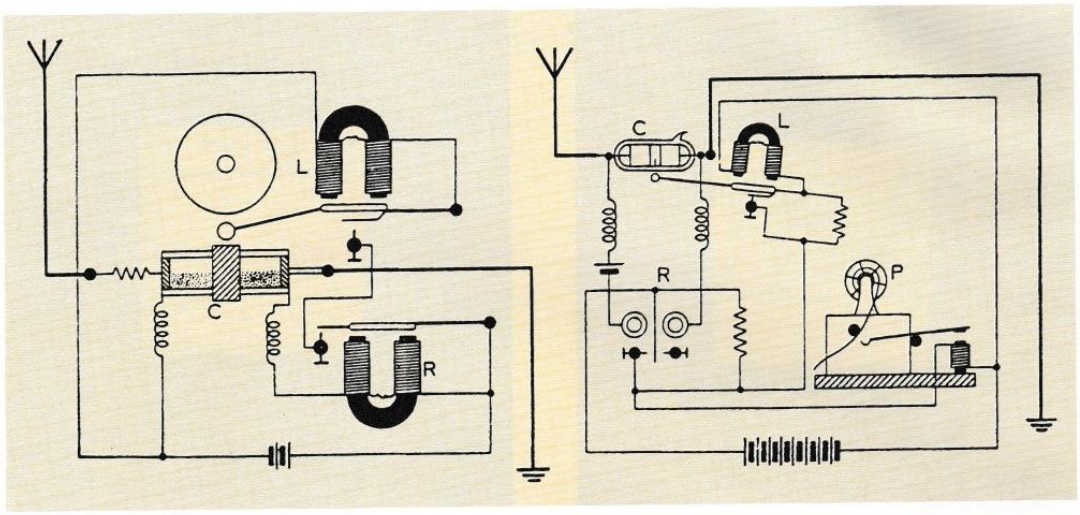
be made to operate at 1 mA, whilst Popov used a Siemens-Halske relay.

For my reconstructions, a relay with a simple horizontal armature was found to be the best and, after replacing the spring by a small balancing weight, the operating current could be reduced to 4 mA.

The Popov receiver (fig. 7), with its 'exploring rod aerial' followed his circuit faithfully, and is contained in a metal box, as described by Victor Gabel in 1926 in the 'Wireless World' journal. A picture of the original apparatus, minus its case (fig. 8), is described as the 'world's first radio'. It is preserved in the Museum of St Petersburg Electro-technical University. Popov demonstrated his receiver on 7th May 1895 to the Physico-Chemical Society in St Petersburg. He used it in conjuction with a Hertz 'vibrator' (radiator). The original Hertz dipole (fig. 9), with the 30 cm spheres can be seen, together with other Hertz relics, in the Deutsches Museum in Munich. Its length is 3 m and its frequency 50 MHz.

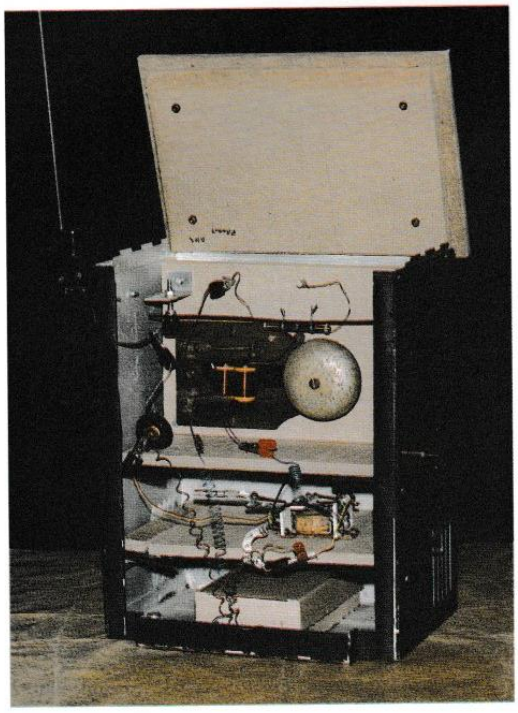
For the sake of portability, our dipole (fig. 10), was 1/4 scale, with a frequency of 200 MHz. In our arrangement it is placed vertically. The dipole is activated by an early motor car spark coil with hammer break trembler, and a Morse key.

After his demonstration, Popov wrote a paper entitled 'Apparatus for the Detection and

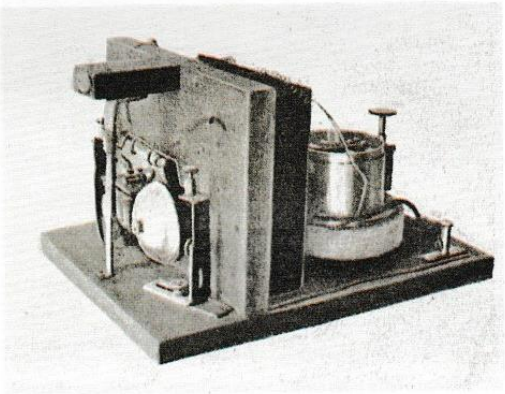


a) b)

6 *Circuit diagrams of a) the Popov receiver and b) the Marconi receiver*
(courtesy Electronics and Power, p.77, The Institution of Electrical Engineers, 1964)



7 *Model of Popov's receiver, with coherer (top), relay (below), and battery (underneath)*

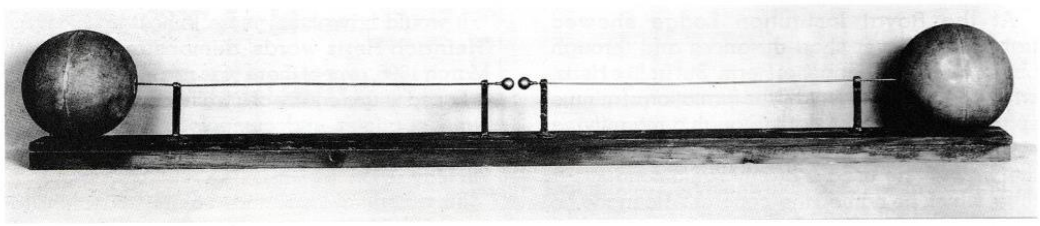


8 *Popov's original receiver with case removed*

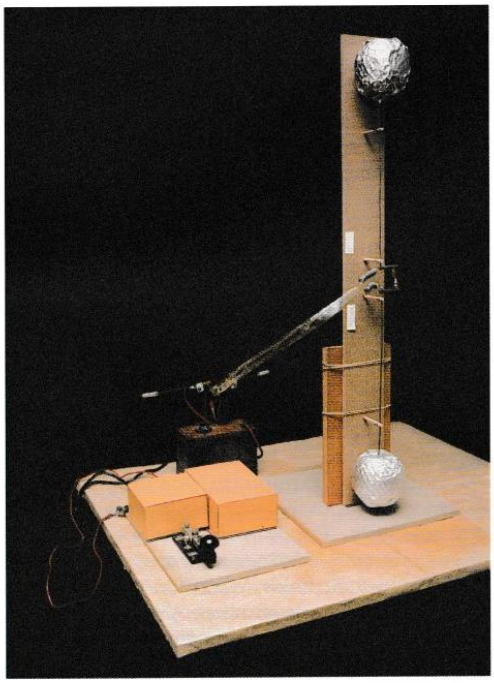
Recording of Electrical Oscillations'. He ends with:

> 'I may express the hope that my apparatus may be used for the transmission of signals over a distance with the help of rapid oscillations as soon as a source of such oscillations with sufficient energy will be discovered'.

However, this idea was misguided and his application to the detection of powerful lightning discharges was to follow, using a 'lightning



9 *Hertz's original transmitting dipole operating at 50 MHz (courtesy of the Deutsches Museum, Munich)*



10 *Model of Hertz's dipole operating at 200 MHz*

conductor' aerial. Marconi nevertheless had realized that what was needed was not a more powerful transmitter but a more sensitive receiver, hence he improved and optimized the coherer.

Our model of Popov's receiver has been tested on a high, long, wire aerial, with a measure of success (the occasional tinkling caused by a distant storm).

The Inventor of Wireless Communication

The question of priority has to be based on printed publications of the contenders, or on researched historical evidence.

We know that Popov demonstrated his apparatus again to the Physico-Chemical Society on 24th March 1896, but no actual records survive. Later, some of those present said the words 'Heinrich Hertz' were received from a Hertzian dipole transmitter. It was one of nine items on the agenda; it must have been very short, and it did not appear in the minutes of the meeting. If we admit this priority claim on the basis of historical research, we must also note Marconi's achievements at Villa Griffone in late 1894 and early 1895.

There is no record in print by Popov before Marconi's patent of 2nd June 1896. There is only indirect evidence that Popov demonstrated transmission of intelligence by means of radio waves on 24th March 1896; but there is comparable evidence of Marconi transmitting intelligence at an even earlier date at Villa Griffone.

According to these criteria I conclude that Marconi can be named as the inventor of radio communication.

Appendix I
Oliver Lodge and the Development of the Coherer

In 1890, Edouard Branly, Professor of Physics in the Catholic Institute of Paris, had found in his laboratory that a spark, producing radio frequency energy, would bring together particles of metal in a tube container. He called it a *'radio conducteur'* tube. This minute closing together, cohesion, caused by electrostatic attraction, produces lower electrical resistance, which can be detected by a current in a secondary circuit.

The world had heard of the death of Heinrich Hertz on the 1st January 1894. It was followed by a commemorative lecture, with demonstrations, by Oliver Lodge, entitled: 'The Work of Hertz and some of his Successors'. It was 1st June 1894 – the Friday evening discourse at the Royal Institution in London. Lodge was Professor of Physics at the University of Liverpool, and was well equipped to give this lecture, because he had tried experiments seeking the theoretical electromagnetic waves of Maxwell.

At the Royal Institution Lodge showed transmission over short distances and through obstacles, in the manner of Hertz. But unlike Hertz, who detected the waves by the formation of minute sparks, viewed in the dark through a magnifying eyepiece, Lodge used a novel method of detecting the waves. He used a Branly *radio conducteur* tube, which he named the 'coherer'. He made no attempt to transmit intelligence; the transmission was simply an oscillation burst in a Hertz dipole radiator. He used an electric bell and, with a battery in series, the bell continued to ring until a tap shook the coherer, producing decohesion of the particles. A later design did this by clockwork.

Lodge presented another lecture on the 14th August 1894, in Oxford, for the British Association for the Advancement of Science, entitled: 'Experiments illustrating Clerk Maxwell's theory of light'. Lodge used various methods of detection: an electroscope proposed by Boltz; a Branly tube coherer, and a coherer of his own design – a spiral of iron wire making a point contact on an aluminium plate. Lodge transmitted through walls, the Hertz radiator being in the Clarendon laboratory, and the receiver being some 60 yards (55 m) distant in the Clarendon lecture theatre. Reception was displayed by a Kelvin marine galvanometer with reflecting mirror. It should be noted that Lodge did not send a message.

Lord Rayleigh said at the time:

'if you follow that up there's a life's work in it'.

In a subsequent comment, Lodge said:

'He was quite right, but I didn't follow it up effectively. I was too busy with teaching work to take up telegraphic work or any other development work'.

It is tempting to suggest that the preceeding is enough to credit Lodge with the invention of radio. If Lodge had been born Russian, **he** would be known as the 'inventor of radio'!

Appendix II
The Day of the Radio – 7th May

The claim of Popov was brought to a head on 7th May 1945 when the Bolshoi Theatre in Moscow was packed by a distinguished audience to celebrate the 50th anniversary of the invention of radio by Popov. On stage were scientists, marshals, admirals, commissars and leaders of the party, and Popov's daughter. It was announced that 7th May – 'The Day of the Radio' – would be celebrated annually.

It would have been more logical to select the 'Heinrich Hertz words' demonstration of 24th March 1896, except there was no printed record of it. Faced with a choice of a well-documented weak claim or a later, undocumented strong claim, the authorities decided on the earlier occasion: 7th May 1895.

If a well-attended lecture featured a demonstration where a message was transmitted (the words 'Heinrich Hertz'), why was there no mention in the minutes? Why did not Georgievsky, Lebedinsky and Rybkin, who were all present at the lecture, not mention it in the 1925 memorial edition of '*Electrichestvo*' to which each contributed an article?

My opinion is that some endeavour was made to transmit intelligence on 24th March 1896 but that, because of imperfect coherer operation, it failed – perhaps because of the single battery in use, causing self coherence and creating a problem in receiving Morse code.

Why did the Soviet authorities so vociverously proclaim, in 1945, that Popov had invented radio? Probably the aftermath of the war, when Stalin's forces had triumphed, won with vast technological assistance from the Americas and Britain. For example, the famous WS19 tank radio: thousands were made in the USA, Canada and Britain, with Russian annotations, for use in Soviet tanks.

A nationwide campaign was undertaken to enhance the reputation and achievements of Russian scientists. Popov was not alone; scientists, physicists and engineers were paraded as pioneers in their fields, television and the aeroplane. In the post-communist era in Russia we can abandon the protestation of priority, after an earlier era, when leaders thought it necessary to put the 'personality cult' of politics into the field of modern invention.

Acknowledgements

The kind permission of the Institution of Electrical Engineers, London, for the reproduction of fig. 6., and of the Deutsches Museum, Munich, for fig. 9, is gratefully acknowledged.

Bibliography

BAKER, W.J., 'A History of The Marconi Company', Methuen & Co. Ltd., 1970.

GOLOVIN, G.I., 'A.S.Popov, Inventor of Radio; Life and Work', Gosudarstvennoe Izdatelstvo Literatury, Moscow, Russia, p. 74, 1945.

LODGE, O., 'Signalling through Space without Wires', 4th edition, Electrician Printing and Publishing, London, 1908.

SUSSKIND, C., *Proc. I.R.E. (USA)*, **50**, p. 2036–2047, 1962.

VYVYAN, R.N., 'Marconi and Wireless', E.P. Publishing Ltd., 1974.