HISTORY

This part devoted to History of Radio. During a long time, many people contributed their effort to radio. Also we know that radio tried lots path in time its development. So, you will find stuff about the people and about the ways. For this issue of ANTENTOP, I used two articles, which are written by known scientists. I believe that these articles show radio history very well. I include several additional pictures in these articles and I hope, the pictures can help you to know the great world of the Radio in most full way.

73!, Igor Grigorov, RK3ZK

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Recognizing some of the many contributions to the early development of wireless telegraphy

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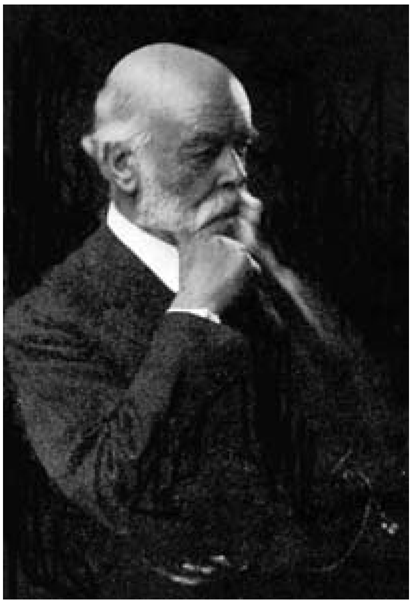
The concept of invention as a "point event," i.e., one person's momentary creative act, is erroneous. Instead, invention should be considered as a process involving time-dependent facts subject to re-evaluation **[1]**. This is exactly the case of the "invention" of wireless telegraphy. It is not possible to identify a single date for the "invention" of wireless or even to name all who contributed to its development. The intended purpose of this paper is to demonstrate this point by summarizing the achievements, motivations, and distractions of but several whose work led to the development of wireless telegraphy.

Guglielmo Marconi (1874- 1937)

As the 100th anniversary of Marconi's journey to England to demonstrate his wireless telegraphy equipment nears, it is appropriate to reflect not only on his early wireless achievements but also on those of several of his contemporaries. In addition, it is valuable to consider possible reasons why Marconi succeeded in developing a workable wireless telegraphy system while the others did not. Heinrich Hertz. In 1887 and 1888, Heinrich Hertz (1857-1894) conducted a series of experiments in Germanywhich convincingly demonstrated the existence of the electromagnetic waves predicted in 1864 by James Clerk Maxwell (1831-1894). Hertz conducted only indoor experiments with electromagnetic waves. These experiments clearly showed the similarities between electromagnetic waves and light which Maxwell had postulated. Hertz never tried to use electromagnetic waves for signalling and even denied the practicability of such an undertaking **[2]**. Hertz died at the age of 36 before he could reconsider that contention. Oliver Lodge. In Britain, independently of but concurrently with Hertz, Oliver Lodge (1851-1940) also experimentally verified the existence of electromagnetic waves. Hertz, however, published the results of his work prior to Lodge. In 1894, Lodge improved Hertz's experimental apparatus by using, as the wave detector, a filings tube coherer based on that developed in 1890 by Edouard Branly (1846-1940)[3].

Clerk Maxwell (1831-1894).

Oliver Lodge (1851-1940)



Perhaps Lodge's most important improvements to the filings tube coherer were the evacuation of the air from the filings tube and the development of an automatic "tapping back" device which utilised a rotating spoke wheel driven by a clockwork mechanism. The mechanical impulses provided by the tapping back device thereby restored the filings tube coherer to its non-conducting state at regular intervals, independent of the detection of electromagnetic waves. This filings tube coherer detector was considerably more sensitive than the wire loop "resonator" with a spark gap used by Hertz and was more convenient to use than was the spherical knob coherer detector Lodge had previously developed **[4]**.

Lodge used his improved coherer together with a Hertzian oscillator as part of a demonstration for a commemorative lecture entitled "The Work of Hertz" given in London at a meeting of the Royal Institution in June of 1894. A sensitive mirror galvanometer was connected to the coherer so that the detection of the electromagnetic waves was visible to the audience **[5,6].** Later that same month, Lodge used a small portable receiver connected to a mirror galvanometer to demonstrate the detection of electromagnetic waves at the annual "Ladies' Conversazione" of the Royal Society in London **[6,7]**.

Oliver Lodge demonstrated essentially the same apparatus at a meeting of the British Association held at Oxford in August of 1894. For that demonstration, however, he replaced the mirror galvanometer with a marine galvanometer of the type normally used for the detection of submarine cable telegraphy signals.

Lodge's source of electromagnetic waves, located in another building some 55 metres away, consisted of a Hertzian oscillator energized by an induction coil. A telegraph key connected to the primary winding of the induction coil was used by Lodge's assistant to send both long and short duration trains of waves corresponding to Morse code dots and dashes **[8]**.

Lodge clearly had all the necessary elements of an elementary wireless telegraphy system. While it can be argued successfully that Lodge did indeed achieve signalling of a sort, there is no indication that the sending of any "messages" was accomplished or even attempted with this apparatus. It was not his intent to do so. Oliver Lodge never considered using his equipment for communicating, although the idea of wireless telegraphy had been suggested two years earlier by William Crookes **[9]**. The purpose of Lodge's demonstration at Oxford was to propose that perhaps there exists an analogy between the way a coherer responds to electromagnetic waves and the way the eye responds to light **[10].**

Lodge later admitted that, at the time, he had not seen any dvantage in using the relatively difficult process of telegraphing across space without wires to replace the well developed and comparatively easy process of telegraphing with the use of connecting wires **[11].** He, like virtually all of his contemporaries, believed at the time that electromagnetic waves travel only in straight lines as does light. (Maxwell, after all, had shown that light is nothing more than electromagnetic waves with very short wavelengths.) Consequently, Lodge assumed that the maximum possible range attainable using wireless signalling would be very limited.

These reasons help to explain why, in Lodge's own words, ". . . 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" **[12]**. In fairness to Lodge, however, one should never think that he was lacking in either insight or in astuteness. His exceptional perceptiveness and keenness of mind when conducting experiments had been demonstrated time and time again. What likely is the principal reason he failed to investigate any practical possibilities for wireless signalling is that Lodge, first and foremost, was a scientist and a teacher. He was interested in advancing science and teaching others about science, not in the development of commercial applications of science **[13]**.

Alexander Popov. Highly respected as an outstanding lecturer and experimentalist in virtually all aspects of electricity, Alexander Popov (1859-1906) taught at the Russian Navy's Torpedo School at Kronstadt. After having repeated Hertz's and Lodge's experiments, Popov demonstrated on May 7, 1895 his "instrument for the detection and recording of electrical oscillations."

The sensitivity of the filings coherer Popov used in this instrument had been improved substantially by him in early 1895 after considerable experimentation. Popov's detection instrument featured a coherer tapping- back mechanism which functioned automatically after the detection of each pulse of electromagnetic waves **[14]**. Since Popov used neither earth connections nor a transmitting aerial nor resonance, he could not successfully employ his equipment for long distance signalling, although his signals did span distances of 60 to 70 metres. Nevertheless, Popov's receiving instrument, when connected to a vertical wire or to a lightning rod which functioned as an aerial, was successfully used as a recorder of lightning discharges receiving what one now could call "Marconigrams" from the sky from distances as great as 30 kilometres.

The concept that a filings coherer could be used to detect thunderstorms did not originate with Popov, however.

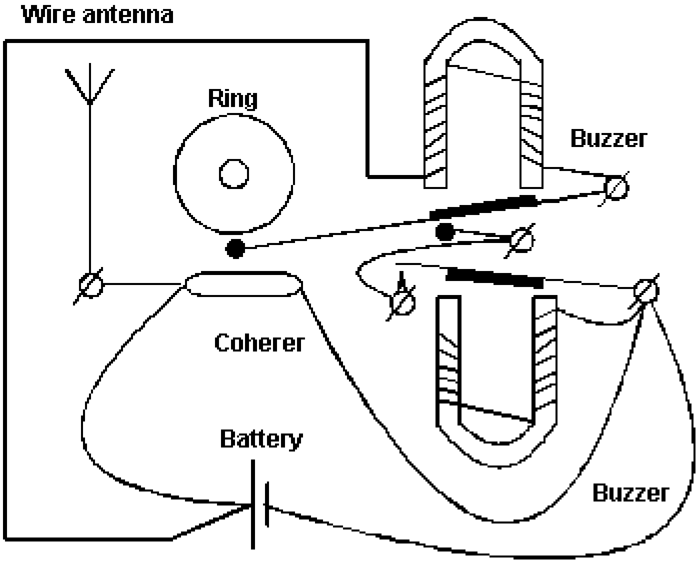
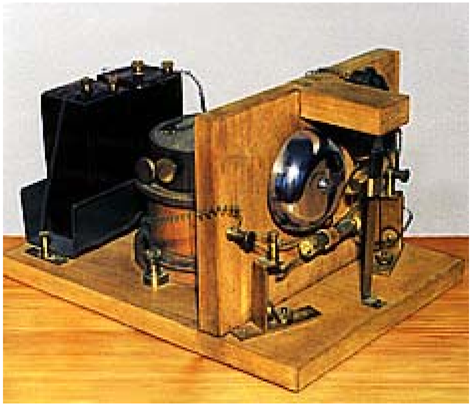


Figure 1

The fact that a substantial decrease in the resistance of a filings tube occurs during a thunderstorm had been recognized since the 1850s **[15]** and the use of a coherer for investigating the waves arising from a thunderstorm had been suggested in 1894 **[16]**. In the January-March 1896 issue of the Journal of the Russian Physico-Chemical Society, a highly respected Russian scientific quarterly, a detailed description of Popov's receiving instrument appeared (**Fig. 1**). Popov concluded his paper by writing: "With further improvements in my apparatus, it can be applied to signalling at a distance using fast electrical oscillations as soon as a source of such vibrations is found possessing sufficient power" **[17].** Clearly, Popov believed that increased transmitter power, rather than increased receiver sensitivity, was the key to long distance wireless communications.

First Popov's Receiver



Like Lodge, Popov believed that electromagnetic waves propagate only in straight lines as does light. Scientists did not abandon this belief until Marconi had repeatedly demonstrated that transmission far beyond the horizon was possible. Again like Lodge and in contrast to Marconi, Popov could not focus his efforts exclusively on wireless. His teaching duties, regular summer work at the power station supplying electricity to the Nizhni Novgorod Annual Fair, and broad scientific interests (e.g., in 1896 Popov was one of the first to repeat Roentgen's x- ray experiments) did not allow Popov to focus his efforts on the development of a wireless telegraphy system. Regrettably, in his efforts to increase the communication range of his equipment, Popov increased the power of his transmitter but did not attempt to increase the effectiveness of his transmitting and receiving aerials or the sensitivity of his receiver through the use any form of resonance **[18].**

Guglielmo Marconi. It is reported that Guglielmo Marconi (1874- 1937) first read about electromagnetic waves in an 1894 eulogy to Hertz written by the Italian physicist Augusto Righi (1850-1920). Marconi immediately began work at his family's estate in Italy to determine if these waves could be used to communicate at a distance. In the spring of 1895, he took his wireless experiments outdoors and soon discovered that an intervening hill was no barrier to the reception of electromagnetic waves. Being intent on developing wireless telegraphy, Marconi used a Morse telegraph key to produce the dots and dashes generated by his transmitter. By using earthed vertical aerials of proper dimensions for both transmitting and receiving (these provided a very simple form of tuning or resonance), Guglielmo Marconi increased the distance at which his signals could be received reliably to about 2 kilometres by the autumn of 1895 **[19].**

In February of 1896, Marconi brought his wireless equipment to England. Guglielmo hoped that his mother's English relatives could provide introductions to important people in positions to help him get support for the further development of his equipment. On June 2 of that year, Marconi filed a preliminary patent application for his wireless telegraphy system. Because of the need to protect his patent interests, the specific details of Marconi's equipment were not disclosed publicly until June 4, 1897 when William Preece (1834-1913), Engineer-in-Chief for the Post Office gave a public lecture at The Royal Institution in London. (The relatives of Marconi's mother had provided him with an introduction to Preece.) The lecture was published in the next issue of The Electrician **[20].** Marconi was granted a patent on July 2, 1897 (the complete patent specification had been filed on March 2, 1897). This was the world's first patent related to wireless telegraphy. Marconi's receiver **(Fig. 2)** turned out to be quite similar to Popov's instrument. However, unlike Popov's design, Marconi employed two separate batteries. The smaller of the two batteries was used power the coherer circuit; i.e., it was used to establish the optimum quiescent point of the coherer and to provide the current which flowed when a pulse of electromagnetic waves made the coherer tube conduct. The second battery was used to power the tapping-back and recording instruments **[20]**.

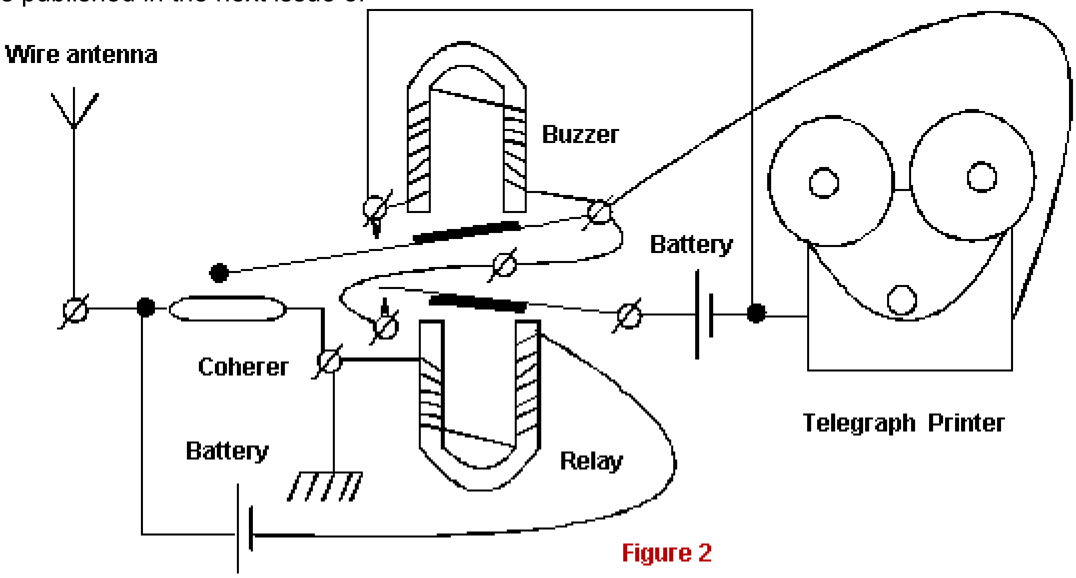


Figure 2

Marconi with his First Transmitter and Receiver

The tapping-back mechanisms developed by Popov and by Marconi warrant further discussion. A relatively simple method for automatic tapping-back had been suggested much earlier by Lodge in conjunction with his original metal spherical knob coherer. Lodge had positioned the electric bell he used to announce the detection of a pulse of electromagnetic waves so that the bell's mechanical vibrations were conducted to the coherer.These vibrations broke the cohesion which occurred between the metal spheres **[21]**. It is generally assumed that both Popov and Marconi were aware of this tapping-back mechanism used by Lodge.

Popov and Marconi, independently of each other, developed and utilised an improved tapping-back device also based on the use of an electric bell mechanism. In each of these tapping-back mechanisms, the coherer, upon the arrival of a pulse of electromagnetic waves, activated a relay which in turn activated the tapping-back devices. The actual tapping-back device employed by both Popov and Marconi to tap the coherer tube directly was the "hammer" or "trembler" from an electric bell. Other similarities between Popov's and Marconi's receivers are evident. Inductance was placed in the coherer leads by Popov to eliminate false operation of the coherer due to sparks produced at the relay contacts **[22].** Marconi similarly used inductance in the coherer leads. In addition to keeping unwanted high frequency currents from reaching the coherer, these inductances kept the desired high frequency currents supplied by the aerial from being shunted around the coherer through the battery. Marconi also used capacitance, high resistance, and inductance at various other locations in his receiving circuit to eliminate false operation of the coherer due to sparks produced at the relay contacts and elsewhere in the circuit **[23].**

In addition to advantages over Popov's design such as the use of transmitting aerial and earth connections on both the transmitter and receiver, Marconi's equipment featured a sophisticated, sensitive and stable coherer he had developed which used a mixture of fine nickel and silver particles between tapered silver plugs in an evacuated glass tube. The volume of particles could be varied by rotating the tapered plugs. This technique was used to obtain the maximum coherer sensitivity. Popov's improvements to the Branly filings coherer, although numerous and important, were less extensive than were Marconi's. Although Marconi's receiver was similar to Popov's, it seems unlikely that Marconi knew of Popov's work. Popov wrote at the turn of the century: "Whether my instrument had been known to Marconi or not, which seems more probable, it was, in any event, my combination of a relay, tube and electromagnetic tapper-back that served as the basis for his first patent for a new combination of already known devices. It is beyond all question that the first practical results in wireless telegraphy over considerable distances have been attained by Marconi before others" **[24].**

At an earlier date, Popov had written: "The credit for the discovery of the phenomena which have been taken advantage of by Marconi is due to Hertz and Branly; then go a number of applications initiated by Minchin, Lodge and many others after them, including myself; and Marconi was the first to have the courage to take his stand on a practical ground and reached large distances in his experiments" **[25]**.

In contrast to Popov and Lodge, Marconi immediately decided to pursue commercial applications of his achievements in wireless experiments. Marconi's achievements, indeed, had impressed his contemporaries. As early as September of 1896, he had transmitted and detected signals over a distance of 2.8 kilometres. In comparison, it was April of 1897 before Popov had succeeded in signaling over a distance of 1 kilometre **[26]**. (Some sources report the distance as 1.5 kilometres **[27]**.) By March of 1897, Marconi had succeeded in transmitting and detecting signals over a distance of 7.5 kilometres and by May of that year he had increased the distance to 14 kilometres. Intent on pursuing the commercial applications of wireless telegraphy, Marconi established "The Wireless Telegraph and Signal Co., Ltd." (later to become "The Marconi Wireless Telegraph Co., Ltd.") in July of 1897 **[28]**.

Marconi's goal was to demonstrate that wireless telegraphy could be used to communicate with ships. He returned home to Italy in 1897 where he demonstrated very convincingly that wireless could be used to communicate between a land station and ships as far away as 18 kilometres, even when the ships were below the horizon. By the end of that year, he also demonstrated that a wireless station located on the Isle of Wight in the English Channel could communicate reliably with ships to a distance of 30 kilometres **[29].**

On March 27, 1899, Marconi showed that wireless could be used to establish a communications link between England and the European Continent when he sent a message from a station he had built at Wimereux in France to his English station at South Foreland. The distance between the two stations was 50 kilometres **[30]**. In the summer of that year, the British Navy invited Marconi to install and operate wireless stations on three warships engaged in naval maneuvers. Signals from a land based station were received to a distance of 160 kilometres while signals between two ships were exchanged reliably to a distance of 110 kilometres and occasionally to 136 kilometres. Not only did these tests show that wireless telegraphy was vital to modern fleets, it now was unquestionably clear that wireless signals could be received at great distances beyond the horizon [31].

The transmitters and receivers used by Marconi at that time lacked any sort of effective tuning. What was needed was some way to enable the transmitters to generate only one frequency and to enable the receiving stations to respond only to the signals desired. Otherwise, hopeless interference occurred when two or more transmitters were operating simultaneously. Marconi was aware of and refined some of the tuning or "syntony" principles which Oliver Lodge had demonstrated as early as 1889 and which Lodge had improved and patented in 1897. Lodge's tuning system, like Marconi's early attempts, provided only a moderate amount of selectivity [32].

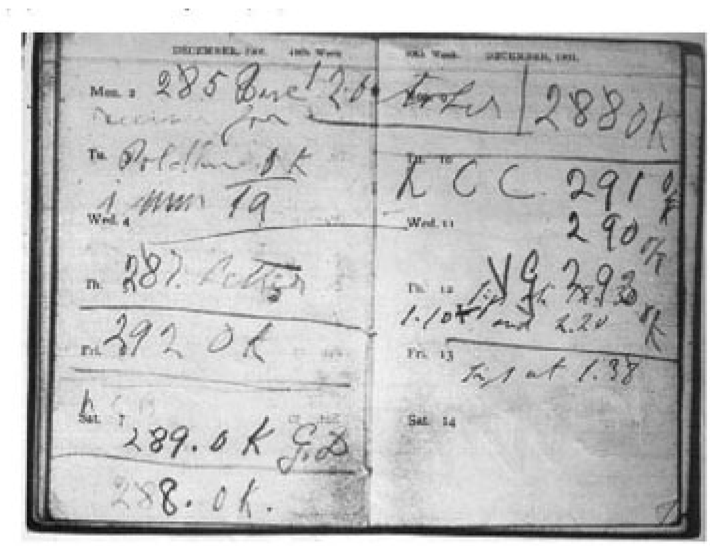
John Ambrose Fleming

Experimentation by Marconi directed toward achieving increased tuning continued. By 1900, Marconi had developed an effective aerial coupling circuit which featured a tapped inductor together with a capacitor which could be varied. Marconi's system provided for tuning both the oscillator circuit in the transmitter and the coherer circuit in the receiver [33].

Marconi still believed that the shipping industry would provide the first significant commercial market for wireless telegraphy. In 1900, he told the directors of his newly formed "Marconi International Marine Communication Company" that he wanted to build two high power wireless stations with the goal of having signals span the Atlantic Ocean [34]. Marconi was convinced that trans-Atlantic signalling would be possible if sufficient transmitter power were used [35]. Before long, Marconi altered his plans and settled on attempting one way trans-Atlantic signalling between a transmitting station he was building at Poldhu, on the southwestern tip of England, and a receiving station in Newfoundland, the closest North American land mass. He employed John Ambrose Fleming to design the high power transmitter needed [36].

Marconi and two assistants sailed for Newfoundland in November of 1901 to locate a suitable reception site and to set up the necessary receiving equipment. The Poldhu station was instructed by cable message to have its 25 kilowatt transmitter which Fleming had designed send the letter "S" in Morse Code continuously for several hours each day beginning on December 11. On the afternoon of December 12, 1901, Marconi heard the faint but unmistakable repetitive sound of three clicks followed by a pause on three separate occasions. It

Marconi's Notebook with First Transatlantic



was clear to Marconi that his goal of establishing a worldwide system of wireless communications now was attainable [37]. However, it would require six additional years of experimentation and development until the first reliable commercial trans-Atlantic communications system was established between Clifden, Ireland and Glace Bay, Nova Scotia in Canada [38].

It should be noted that Marconi, himself, "invented" or "discovered" relatively few things in his early work. Basically, he early on had used Righi's transmitter, Branly's coherer, Lodge's resonant circuits, as well as the earthed vertical aerial suggested by Nikola Tesla (1856-1943) and others. Marconi did, however, make numerous very important improvements to each of these elements of his wireless system. He had the necessary ability to "make things work" thanks not only to his talent but also to his single-purposed devotion to the idea of using Hertzian waves for long distance communication. To the general public, however, Marconi's name soon became associated with all aspects of the "invention" of wireless. The reason for this is simple. The "world" typically gives its acclaim to those who produce exciting results which it (the "world") can understand. The "world" did not understand what Maxwell, Hertz, Lodge, Popov, and others had done because most of their achievements were of interest largely to scientists and these achievements had not been widely publicized in the non-scientific press. The "world" could easily understand what Marconi had accomplished because the basic concept (signalling at a distance) was simple and Marconi had made sure that his achievements were well publicized. Consequently, Marconi received virtually all of the popular acclaim for having "invented" wireless telegraphy.

Additional Reasons for Marconi's Successes. Both Marconi and Popov wanted to use electromagnetic waves for wireless signalling. What reasons, in addition to those already mentioned, likely were responsible for the differences in their levels of success? Thanks to his successful demonstrations for officials of the British Post Office and Admiralty which had been arranged by Preece, Marconi had obtained financial and engineering support from British authorities in 1896 (later on, he also obtained support from the Italian government) whereas the Russian Ministry of Navy did not support Popov until the summer of 1897. If one wishes to compare Popov's and Marconi's achievements, one must also take into account the socio-economic background in both Russia and England at that time. The development of a new technology such as radio did not, and could not, take place as rapidly in Russia as it did in England, an industrial leader. Giving Credit Where Credit is Due. Lodge was the first to demonstrate a receiver which could have been used as part of a wireless signalling system. At the time, Lodge did not publish the technical details of his equipment. The publication priority for a workable receiver which was used not only for limited distance wireless

Nikola Tesla (1856-1943)

signalling experiments but also for meteorologic purposes belongs to Popov. In addition, Popov's lightning recorder may be regarded as the world's earliest applied radio-engineering apparatus designed for practical applications resulting from the detection of electromagnetic waves (but used for purposes other than wireless communication, however). Marconi, of course, received the first patent for wireless equipment and achieved the first truly practical long distance wireless telegraphy system.

There have been controversies concerning the priority of the "invention" of radio for almost a century. Such an attempt to identify only one to whom all the credit should be given is incorrect, however, as pointed out in the beginning of this paper. It also should be noted that the "struggle" for establishing the priority of invention for propaganda purposes typically is characteristic of totalitarian states. Thus, Mussolini's regime presented radio as an "Italian invention," and concurrently with exalting Marconi's accomplishments, the "invention" of the coherer was attributed by that regime to the Italian physicist T.Calzecchi-Onesti (1853-1922) [39].

Similarly, in Russia (and later the U.S.S.R.) since the turn of the century, Popov became known as the "inventor" of wireless telegraphy (in more recent times, he has been called the "inventor" of radio or of radio communication). Interestingly, even in the early days of this century, not everyone in Russia shared this viewpoint of Popov's achievements. It is also important to note that Popov himself never claimed that title. In 1908 D. Sokoltsov, an instructor at the Military Electrotechnical School, called the popular Russian version of the invention of wireless (by Popov) an "old patriotic tale" [40]. Under Stalin's rule, however, the popular Russian version of events became canonical.

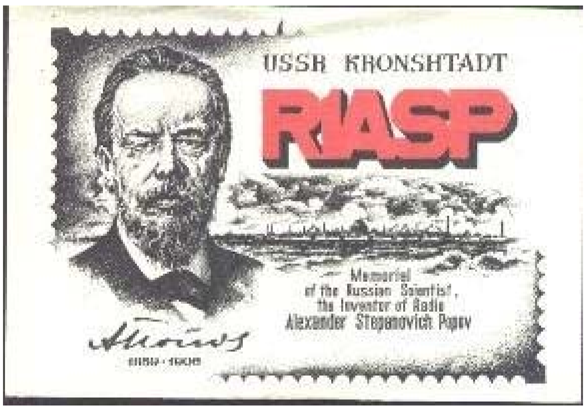
Everyone in the U.S.S.R. writing or speaking on the history of wireless was expected to adhere to the official version of "history." Any deviations from it were dangerous in the Soviet era. Thus, when Matvey Bronstein (1906-1938), a young Leningrad scientist and science writer, refused to "correct" his brochure entitled The Inventors of Wireless Telegraphy, he was asking for serious trouble. Even the title of his work ran counter to the official version, i.e., the single-handed invention of wireless by Popov. Eventually, Bronstein's book ready for publication and Bronstein himself were destroyed (he was shot down in the basement of a Leningrad prison) [41].

Alexander Popov (1859-1906)

The risks associated with deviating from the official Soviet version of history did not end with Stalin, however. There also was a case known to one of the authors where the editor-in-chief of an engineering journal in which had been published an allegedly "biased" article favourable to Marconi was dismissed from his position and the author of the article was deprived of the right to defend his D.Sc. dissertation. The year was 1974, the centennial of Marconi's birth. No matter what Popov's overall international importance in the development of wireless was, he must be given credit for his outstanding contributions to the development of wireless telegraphy in Russia.

Popov truly was Russia's wireless pioneer. In addition to his achievements already mentioned, Popov set up Russia's first manufacture of wireless equipment, organised the training of wireless personnel, and established relations with European specialists in wireless equipment. Of special significance was Popov's cooperation with the French scientist, engineer and businessman Eugene Ducretet (1844-1915). Ducretet manufactured and sold wireless receiving equipment based on Popov's design. This cooperation coincided with the Russo-French rapprochement which occurred at the turn of the century. From 1899 until 1904, the Ducretet Company supplied electrical equipment, including wireless apparatus, to the Russian Navy.

There were many throughout the world who contributed to the development of wireless. Marconi gets, and deserves, the lion's share of the credit for the development of practical long distance wireless telegraphy systems but it must be remembered that many others also made important contributions. Alexander Popov's name and achievements are not well known in the West. Nonetheless, the significance of Popov's work, like that of Lodge and others, must never be underestimated in the annals of communication technology history. "We see here scientists' disinterested work and engineers' and technicians' more purposeful efforts come together just as brooks born in different countries flow together to form a big river, scientific discoveries and industrial inventions have joined to bring about great accomplishments in radio." Louis de Broglie (1892-1987) [42].



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The article has been published in the American magazine "Popular Electronics" in 1993

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