

Who was the Real Inventor of Marconi's Wireless Detector?

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ABSTRACT

Marconi attributed the success of his 1901 transatlantic experiment to the Italian Navy Coherer, a novel detector gifted to him by Lt. Luigi Solari of the Italian Navy. A controversy over the real identity of the inventor has been reopened recently with claims that it was Jagadish Chandra Bose. Based on those claims, it has been asserted that *"the invention of radio should not be attributed to Guglielmo Marconi alone, but Guglielmo Marconi and Jagadish Chandra Bose."*

There are a number of problems with the arguments offered in favor of Bose as the inventor, and the purpose of this article is to present an opposing view. We make a strong case that Bose is actually the least likely of several possible candidates for which a valid claim of precedence can be made for the invention of this device.

Marconi excited the imagination of the world in December of 1901 when he announced receiving the first transatlantic wireless signal in an experiment at Signal Hill in St. Johns, Newfoundland. Marconi attributed the success of his experiment to a novel detector gifted to him by Lt. Luigi Solari of the Italian Navy, which Solari had named the Italian Navy Coherer. This detector used a small drop of mercury between iron and carbon electrodes to make it a very sensitive and self-recovering coherer that did not require "tapping-back" after the reception of each pulse to restore sensitivity, as did the metal-filing coherers that Marconi had used prior to the transatlantic experiment.

Shortly after the experiment, a controversy arose regarding the identity of the inventor of this novel detector. The controversy intensified when Marconi filed a patent on the receiver, which he clearly did not invent. The true identity of the inventor was never fully resolved in Marconi's day, and has been the subject of various articles from time to time ever since. The identity of the inventor is of some historical importance because the success of the experiment and the resulting rapid advance in communications in the decade that followed—leading to Marconi's Nobel Prize in Physics in 1909—was due, in part, to that detector.

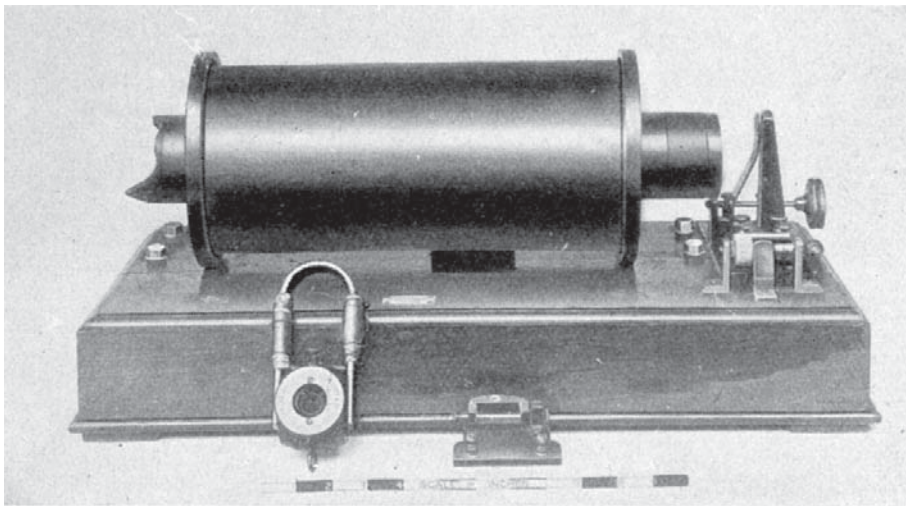
In a recent article appearing in the July 2006 issue of the *AWA Journal* entitled "Jagadish Chandra Bose – The Real Inventor of Marconi's Wireless Detector," Varun Aggarwal made a claim that Jagadish Chandra Bose¹ was the real inventor of the Italian Navy Coherer used by Marconi in his 1901 transatlantic transmission experiment.² Based on that claim, he went even further to claim *"the invention of radio should not be attributed to Guglielmo Marconi alone, but Guglielmo Marconi and Jagadish Chandra Bose."* The claims in the Aggarwal article echo similar claims first made by P. K. Bondyopadhyay in an earlier article appearing in the *Proceedings of the IEEE* in 1998.³ The claims

by both authors are based on work reported by Bose in the *Proceedings of the Royal Society of London* dated April 27, 1899 entitled "On a Self-Recovering Coherer and the Study of the Cohering Action of Different Metals."⁴

Jagadish Chandra Bose (1858 – 1937), born in Mymensingh, India (now Bangladesh), was a brilliant experimental physicist who, during the period 1894-1900, pioneered instruments for generating, transmitting and receiving radio waves at millimeter wavelengths to study properties of matter such as reflection, refraction, polarization. Later in life he developed instruments for studying the interaction of electromagnetic radiation with plants, at which time he demonstrated that plants and metals show similar responses to electromagnetic stimuli. He spent considerable time searching for a self-recovering coherer to measure the electromagnetic radiation in his experiments, a search culminating in the discovery that

crystalline galena formed a virtually perfect self-restoring coherer—for which he received a patent in 1904. He was knighted in 1917 for his work with electromagnetic radiation, and in 1920 he became the first Indian to be elected a fellow of the Royal Society.

Bose is now often cited as the inventor of the Italian Navy Coherer, primarily on the basis of the two papers by Bondyopadhyay and Aggarwal cited above. Apparently, there have been no opposing views, even though there are a number of problems with the arguments offered in favor of Bose as the inventor in their papers. The purpose of this article is to present an opposing view to those of both Bondyopadhyay and Aggarwal by making a strong case that Bose is actually the least likely of all possible candidates for which a valid claim of precedence can be made for the invention of the Italian Navy Coherer.



28. - Coherer a mercurio, telefono e rocchetto usati da Marconi a San Giovanni di Terranova.

Fig. 1. The receiver equipment used by Marconi in the 1901 transatlantic experiment included the self-restoring mercury coherer made under the direction of Lieutenant Luigi Solari of the Royal Italian Navy, a telephone used as the detection device, and an induction coil. (Luigi Solari, *Storia della Radio*, 1939)

BACKGROUND

Shortly after Marconi's transatlantic experiment in December of 1901, it became generally known that Marconi had used a self-restoring coherer gifted to him in the summer of 1901 by Luigi Solari, a lieutenant in the Royal Italian Navy who named it the "Italian Navy Coherer" (see Figures 1 and 2). The controversy over who actually invented the Italian Navy Coherer arose almost immediately, beginning with a letter to *The Times* of London by Sir Oliver Lodge who, several weeks after the experiment, wrote: "*He probably has been using as a detector the very simple device depicted in my little book on the subject published by the Electrician, page 27; and I know how sensitive this plan is...*"⁵ Lodge's claim was followed by a barrage of articles in the public press over the following year and a half making various claims and counterclaims about the identity of the inventor and the circumstances of the invention.

The real excitement began when Prof. Angelo Banti, director of *l'Elettricista*, published an article in May 1902 entitled "The Castelli Coherer" in which he stated that Corporal Paolo Castelli—an assistant signalman in the Italian Navy at Livorno, Italy—had invented the coherer used by Marconi in his first transatlantic experiment.⁶ Banti was clearly unaware of Solari's claim that he and his group at Spezia, Italy had developed the Italian Navy Coherer gifted to Marconi. Banti's article "*brought down on [him] certain courteous observations*" to the effect that

it was not Castelli's coherer that was given to Marconi but instead, a different coherer developed independently by personnel under Solari's command.

Banti wrote a second article to emend the first, faithfully relating what he was told by unnamed sources, presumably Solari and/or other Italian Navy representatives.⁷ He related a story that personnel under Solari's command had developed the Italian Navy Coherer independently of Castelli, which quite by coincidence just happened to be virtually indistinguishable from one of two Castelli coherers. The only difference between the Castelli coherer—which Banti referred to as Type I in his illustration reproduced here as Figure 3—and the Italian Navy coherer referred to as Type II was that the Italian Navy Coherer had one carbon electrode and one iron electrode rather than two iron or two carbon electrodes. Both used a small drop of mercury between the two electrodes which made it both sensitive and self-restoring—and a telephone as a sensitive sounding device which

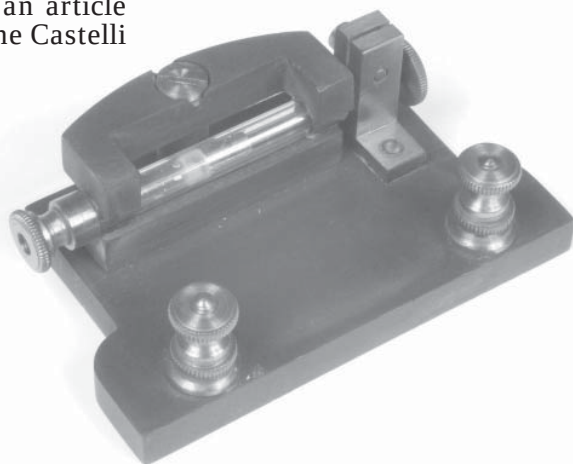


Fig. 2. The Italian Navy Coherer used by Marconi in his transatlantic experiment consisted of a small drop of mercury situated between one iron electrode and one carbon electrode. (Museum of History of Science, University of Oxford)

was not shown in the figure.

Clearly, Banti did not believe the story he was told because in recounting the story he obviously took great delight in pointing out that Castelli began his experiments in September of 1900 which yielded his best results by February 20, 1901, while Solari initiated his experiments in January of 1901 and completed them in the summer of the same year. The striking similarity of the two coherers and the close timing of the two inventions made it difficult for Banti—and apparently his readers, for that matter—to believe the story that the two coherers were invented independently. Banti closed his article with the following statement, making it clear that he believed something was being concealed: “but let us, nevertheless, honestly avow that we have not published any false thing, but that instead there has been raised a question of ‘soup and sops’ for the purpose of concealing some manoeuvres to which we are strangers. And this suggests that . . . ?”

Almost a year later in June of

1903, eminent author Emile Guarini asserted that the Italian Navy Coherer was actually invented by one Professor T. Tommasina from Geneva.⁸ He made a strong case by citing several papers Tommasina had published—the earliest on May 1, 1899—describing a coherer made “by means of a drop of mercury placed in a glass tube between two brass electrodes of cylindrical shape.”⁹ Shortly thereafter, Solari published a response claiming among other things, that “the ‘Royal Italian Navy Coherer’ is constructed in an entirely different manner from those suggested by Wilson and Tommasina...”

There was no rebuttal from Guarini, and so the controversy became dormant until it was revived in a paper published in the *Proceedings of the IEEE* in May of 1993 by author and historian V. J. Phillips 90 years later.¹⁰ Phillips, author of *Early Radio Wave Detectors*,¹¹ was eminently qualified to review the controversy, which he did in great detail—and in the process he provided a roadmap to the controversy, complete with

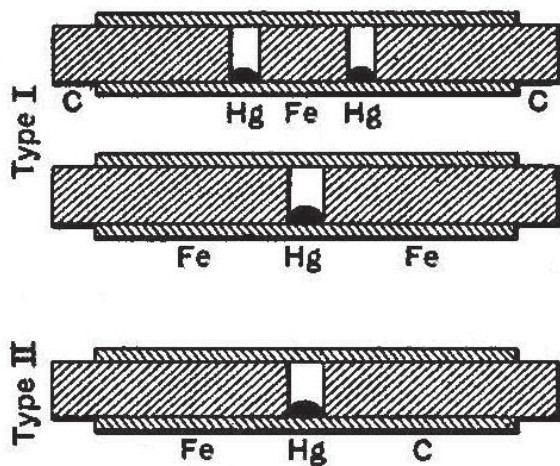


Fig. 3. The Italian Navy Coherer (Type II) made by Lieutenant Luigi Solari at Spezia, Italy was virtually identical to the two coherers (Type I) made by Corporal Paolo Castelli at Livorno, Italy. (The Electrician, Vol. XLIX, No. 12, July 11, 1902, p. 477)

a list of references to the writings of the key participants. Phillips concluded in his paper that it could not be determined who actually invented the Italian Navy Coherer. His concluding statement was short and to the point: “*What then, are we to make of the controversy [including who invented the coherer] after the lapse of nearly one hundred years? One thing, of course, is quite clear: we shall probably never know for certain the full truth of the matter unless by some lucky chance some relevant, but hitherto unknown, personal correspondence should happen to come to light.*”

Bondyopadhyay revisited this controversy again in 1998, a scant five years after Phillips, using essentially the same information available to Phillips, but he came to a very different and startling conclusion which was captured by his introductory statement: “*Incontrovertible evidence is presented to show that this novel wireless detection device [the Italian Navy Coherer] was invented by Sir J. C. Bose of Presidency College, Calcutta, India.*”¹² In this regard, it should be noted that when Phillips wrote his article in 1993, he was fully aware of Bose’s work—specifically his work on a self-restoring coherer¹³—and yet he never considered Bose to be a candidate. Apparently Bondyopadhyay’s 1998 claims have gone unchallenged because Aggarwal now makes similar claims without reference to any opposing view.

THE CASE AGAINST BOSE AS THE INVENTOR OF THE ITALIAN NAVY COHERER

The case made by Aggarwal and Bondyopadhyay in support of Bose as the inventor of the Italian Navy Coherer and the opposing view are summarized as follows:

1. Bondyopadhyay asserted that the Italian Navy Coherer is “*a trivially modified version of Bose’s invention.*”¹⁴ However, this is not true. Most significantly, the Italian Navy Coherer was by all accounts self-restoring while Bose never claimed his so-called “iron-mercury” coherer was self-restoring. In fact, he never claimed any of his metal coherers with a mercury electrode was self-restoring—with the notable exception of potassium, which was self-restoring even without the use of a mercury electrode.

2. Absent any direct proof that Bose invented Marconi’s receiving device, Aggarwal states: “*The primary evidence is the precedence of Bose’s invention to all recorded/claimed inventions of the device.*”¹⁵ By device, Aggarwal was referring to “*an autocoherer which used a mercury-metal interface and a telephone receiver to hear the signal.*” (Aggarwal’s use of the term “autocoherer” here—meaning an auto-restoring coherer—is somewhat of a misnomer.) However, it turns out that Bose does not have any such precedence. Despite claims by Aggarwal, Bondyopadhyay and even Phillips to the contrary—Professor David Edward Hughes, an English scientist working in America, experimented with an iron-mercury coherer and a telephone receiver to receive electromagnetic signal transmissions through the air as early as 1879-80—long before Bose’s experiments with iron coherers using mercury electrodes.

3. Aggarwal states: “*There is also powerful circumstantial evidence supporting Bose’s precedence as the inventor of this device.*”¹⁶ However, the “*powerful circumstantial evidence*” promised by Aggarwal is more speculation than fact.

4. Tommasina—the most likely contributor to the Italian Navy Coherer design—has been rejected as a potential inventor by Bose supporters based primarily on a single ambiguous statement made by Solari that “the ‘Royal Italian Navy Coherer’ is constructed in an entirely different manner from those suggested by Wilson or Tommasina...”¹⁷ Despite this half truth, there is very convincing evidence to support the claim for Tommasina—not the least of which comes from Solari himself, who specifically stated in his book *Storia della Radio* published in 1939 that the Italian Navy Coherer was based on the phenomena observed by Tommasina.”¹⁸

These points are detailed in the four sections that follow.

BOSE’S “IRON-MERCURY” COHERERS WERE NOT SELF-RESTORING

It has been asserted that the Italian Navy Coherer is a “trivially modified version of Bose’s invention” even though it used a small drop of mercury in a linear glass tube as opposed to Bose’s U-tube filled with a large amount of mercury. A close examination of both designs clearly shows that the seemingly minor differences in physical characteristics makes a major difference in their electrical characteristics, particularly the self-restoring characteristic of the coherer.

The use of mercury in the self-restoring Castelli coherers was described as follows:¹⁹

“In the mercury tubes the self-decoherence is more or less perfect according to the purity and freedom from amalgam of the mercury used, to the dryness and cleanliness of the interior of the tube, and to the smallness of the drops of mercury. The most suit-

able diameters of the drops are comprised between the extreme limits of 1.5mm and 3mm. Drops less than 1.5mm. in diameter give insensitive tubes; those greater than 3mm. diminish the completeness of the decoherence.”

It is clear that mercury was not used as an electrode in the Castelli coherers, but was placed between two other electrodes specifically to produce self-decoherence—and further, that very small drops were necessary to perform that function. While Solari never explained the purpose of a single drop of mercury in his coherer, it can be safely assumed that it served the same purpose.

In sharp contrast, Bose used mercury in his coherers as an electrode for the sole purpose of adjusting the pressure of the coherer contacts, a parameter known to affect coherer performance. Further, Bose used a large amount of mercury sufficient to fill a U-tube cited by Aggarwal as being similar to the one pictured in Figure 4,²⁰ which according to Castelli’s findings, would have produced a coherer with minimal or no self-recovery properties.²¹ In fact, Bose never claimed his “iron-mercury” coherer was self-restoring. He restricted the claim of self-restoration for his potassium-mercury coherer only,²² and it was clear that even in that case, the mercury electrode was not responsible for the self-restoring properties of potassium.

Here is what Bose had to say about his coherers using alkaline-earth metals: “The tendency towards self-recovery was, however, very slight...” and about coherers using magnesium: “The tendency towards automatic recovery is almost wanting [i.e., almost lacking].” More to the point, here is all that Bose had to

say about his iron coherer:

“Iron.—The action of this metal is well known. In one of my experiments I used it in connection with mercury. When the contact is very lightly made, there is a tendency towards an increase of resistance by the action of radiation. But after a time the action becomes normal, that is to say there is a diminution of resistance.”

The action of iron was indeed well known, and by all accounts coherers consisting of iron (as well as copper and steel) electrodes were not self-restoring.²³ In fact, in a subsequent paper, Bose experimented with a single-point iron electrode on an iron plate and demonstrated that the resulting coherer was not self-restoring.²⁴ Clearly, if mercury had special properties that made self-restoring coherers out of two metal electrodes that were otherwise not self-restoring, Bose surely would have reported it.

The real clincher is Bose’s sum-

mary at the end of his article on self-restoring coherers:

“It will be seen from the above that all metals exhibit contact-sensitiveness to electric radiation, the general tendency being toward a diminution of resistance. The most interesting and typically exceptional case, however, is the receiver made with potassium, which not only exhibits an increase of resistance by the action of radiation, but also a remarkable power of self-recovery.”

Bose made it very clear that of all the metals he tested, he found that only potassium had the power of self-recovery. Even with potassium, it is important to point out that self-recovery was not a result of the mercury electrode because in some of his experiments one piece of potassium was partially flattened against another without mercury. In fact, it is likely that none of the potassium experiments were performed with mercury as an electrode because Bose stated

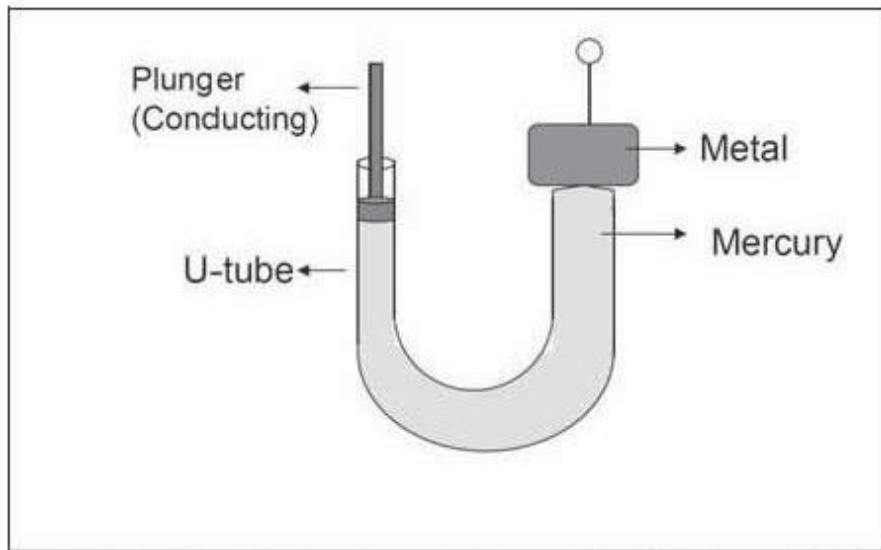


Fig. 4. A U-tube configuration filled with mercury was used by Bose to adjust the pressure of the mercury contact on the metal to the right by adjusting the conducting plunger electrode on the left. (AWA Journal, Vol. 47, No. 3, July 2006, p. 51)

that his potassium receiver was kept immersed in kerosene to prevent oxidation, and so immersion of the entire U-tube configuration would have contaminated the mercury and/or the potassium-mercury interface.

With regard to the purported use of a telephone in Bose's iron coherer, often referred to by Bose supporters (but never by Bose himself) as the "*iron-mercury-iron with telephone*" coherer, it is quite apparent that he did not use a telephone with iron. Bose specifically stated he did only *one* experiment with mercury and iron—and in that experiment he reported that: "*When the contact is very lightly made, there is a tendency towards an increase in resistance by the action of radiation. But after a time the action becomes normal, that is to say there is a diminution of resistance.*" Since the direction of the change in resistance cannot be determined with a telephone, it is clear that he must have used a galvanometer for this experiment. Further, since the change in resistance was a major parameter reported in most of his experiments, it is safe to conclude that as a matter of course he used a galvanometer and not a telephone as the detection device. Bose mentioned the use of a telephone only once in passing, and only in conjunction with an unspecified *self-restoring* coherer—which, given his concluding statement about potassium being the exceptional case, had to be potassium and not iron, as inferred by Bose supporters.

With regard to Bose's so-called "C-Hg-Fe coherer" referred to by Bondyopadhyay, Bose also mentioned in passing that he had performed experiments with carbon but he never reported any results. He did not state whether the coherer configuration was C-C

or C-Fe or C-Hg-C or C-Hg-Fe, whether the coherer resistance increased or decreased with electrical stress, whether a telephone or galvanometer was used—and more to the point, whether or not it was self-restoring. Based on Bose's summary statement that potassium was the exceptional case for self-recovery, one could conclude that if Bose did experiment with a carbon-mercury coherer it was not self-restoring. Bose—who never reported any results with a carbon-electrode coherer (with or without mercury)—cannot possibly be accorded precedence for the use of a carbon-mercury-iron coherer, and certainly not the discovery of a *self-recovering* coherer using a carbon electrode.

BOSE DOES NOT HAVE PRIORITY FOR THE INVENTION OF MERCURY COHERERS

Contrary to claims by Bose supporters, Bose was not the first to invent or even experiment with a mercury coherer—much less an "*autocoherer which used a metal-mercury interface*" as claimed by Aggarwal. Professor David Hughes experimented with an iron-mercury coherer with a telephone as early as 1879-80—long before Bose. Hughes disclosed his experiments to no less than eight distinguished British scientists in 1879 and 1880, a summary of which was later published in *The Electrical Review* on June 2, 1899.²⁵ Hughes provided an overview of his early work in an 1899 edition of *The Electrician*,²⁶ which included an explanation of why he did not publish his work immediately following his disclosures in 1879-80. Oddly, neither Aggarwal nor Bondyopadhyay referenced Hughes' work published in these two preeminent British journals for electrical engineering and wireless telegraphy in 1899—the

same two journals that published much of the Italian Navy Coherer controversy. Aggarwal was clearly unaware of Hughes' work with mercury coherers because he shows a table with the first column entitled "Time" with an entry in the first row of: "1879-1880," and the second column entitled "Invention/Claim" with the corresponding entry in the first row of: "David Edward Hughes uses some kind of a coherer. No use of mercury."²⁷

Pertinent passages from the June 1899 issue of *The Electrician* describing Hughes' use of an iron-mercury coherer in the 1879-1880 time frame are reproduced here:²⁸

"Of course it was highly important to find the most sensitive form of microphone [the term used by Hughes for coherer] to receive the rays, as we may call them. Contacts of metal are apt to 'cohere,' or stick together, apparently by the electrical waves welding them. A microphone [i.e., coherer] which is

both sensitive and self-restoring, that is to say, does not cohere, is made with a carbon contact resting lightly on bright steel. Such a receiver is shown in fig. 3.... (see Figure 5). *Contacts of iron and mercury are sensitive, but very troublesome. Iron and steel cohere, but are sensitive, and keep well when immersed in a mixture of petroleum and vaseline, which, though is an insulator, does not bar the electric waves from them.*"

While the description of Hughes' mercury coherer is short, it is no shorter—nor does it contain any less information—than the descriptions published by either Bose or Tommasina. In fact, the disclosures by Bose in his paper are very similar to those of Hughes: 1) both mentioned their respective iron-mercury coherers were sensitive, 2) both articulated the importance of a self-restoring coherer but neither specifically claimed

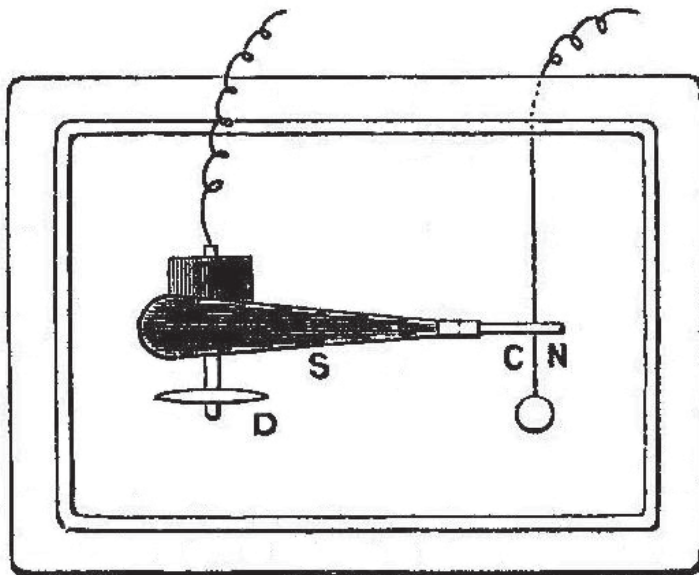


Fig. 5. The heart of Hughes' receiver was a sensitive and self-restoring "microphone" which consisted of a carbon contact resting on bright steel; Hughes' "microphone" was actually the first known semiconductor junction used in a wireless receiver. (*The Electrical Review*, June 30, 1899, p. 884)

their respective iron-mercury coherers were self-restoring, 3) both used mercury as an electrode but neither restricted the mercury to a single small drop situated between two electrodes, 4) both mentioned the use of telephone as a sensitive detector although Bose never specifically stated that he used one with his iron-mercury coherer while Hughes used one in most—if not all—his experiments, and 5) both reported the discovery of a self-restoring coherer (Bose with a potassium coherer and Hughes with a carbon-steel coherer) but neither depended on mercury for self-restoration. About the only difference in their respective descriptions was that Hughes stated his iron-mercury coherer was “troublesome”—as did other experimenters who followed him²⁹—while Bose stated when “the contact is very lightly made, there is a tendency towards an increase in resistance.”

That Hughes used a telephone to receive radiated waves in conjunction with a microphone (i.e.,

a self-restoring coherer) is evident from Figure 6 which is reproduced from the June 1899 article appearing in *The Electrical Review*. The article clearly states that the first experiments using a telephone to receive radiated waves at distances between transmitter and receiver of six feet to 200 yards were performed during the period October 15th and 24th, 1879, which predates any known use of the telephone for that purpose. Artifacts used by Hughes circa 1880, which are preserved in the science Museum in London, testify to his early wireless experiments (Figure 7).

Since Hughes performed his experiments years before Bose, he clearly has precedence for the use of an iron-mercury coherer and the use of a telephone as a detection device. Precedence has been already given to Hughes for much of his early work by a number of authors—for example, by both Fleming and Phillips for his use of the telephone as an indicating device with coherers for wireless telegraphy, and also for

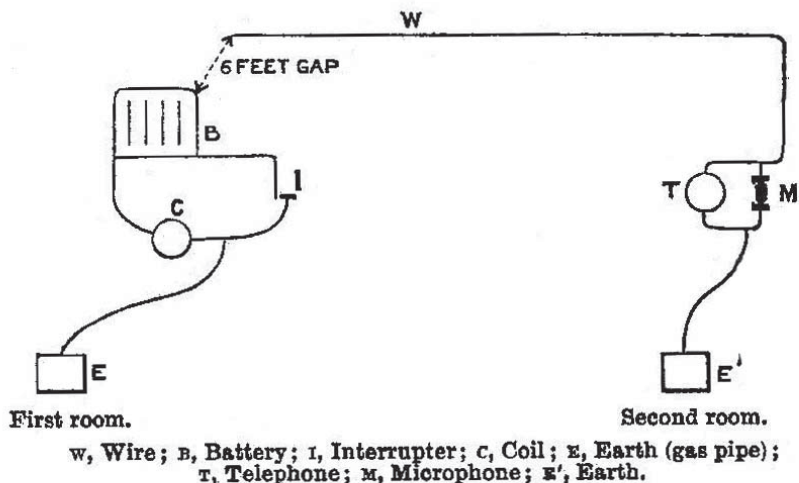


Fig. 6. The first experiments using a telephone to receive radiated waves at distances between transmitter and receiver of six feet to 200 yards were performed by Hughes during the period October 15th and 24th, 1879, which predates any known use of the telephone for that purpose. (*The Electrical Review*, June 30, 1899, p. 884)

his discovery of the self-restoring coherer formed with carbon-steel electrodes.³⁰ Apparently, no one has yet cited Hughes' early work on iron-mercury coherers, but that is no reason to deny him the precedence he deserves.

AGGARWAL'S "POWERFUL CIRCUMSTANTIAL EVIDENCE" IS SHEER SPECULATION

Lacking any direct evidence connecting Bose to Castelli, Solari or even Marconi, Aggarwal promised certain "powerful circumstantial evidence" to support the case for Bose as the inventor. Three examples were offered including a possible mention of Bose by Solari, a purported contact with Bose by Marconi's managing director Major Stephen Flood Page, and an implied tribute to Bose by Marconi.

Solari's Possible Mention of Bose: Aggarwal suggests there "might" be a connection between Solari and Bose based on a statement by Solari: "He [Solari] might be referring to the work of Bose

*when he says 'the idea of the employment of mercury had been suggested to me [Solari] by something which I had read in some English publication which I found myself unable to trace....'"*³¹

The full statement by Solari in its appropriate context is reproduced below with Aggarwal's excerpt underlined;³² the reader can decide whether Solari might be referring to the work of Bose, as Aggarwal suggests:

"And if anyone should wonder what can be the explanation of my delay in taking out patents for this invention of my own, I may say that I have always been dissuaded from such a course by my recollection that the idea of the employment of mercury had been suggested to me by something which I had read in some English publication which I found myself unable to trace, as well as by certain researches of Ridberg. I have now, however, succeeded in tracing the former to Fahie's 'History of Wireless Telegraphy,' published in September 1899 which



Fig. 7. Hughes' microphones and apparatus constructed c. 1880s from left to right are: an experimental microphone consisting of a carbon pencil resting in a carbon cup; a rectangular cell; a clockwork driven spark transmitter (the first radio transmitter in the world); a variable resistor; two experimental microphones consisting of needles suspended in contact with blocks of gas carbon; a microphone detector (the first radio receiver in the world); another cell; and a Bell telephone receiver. (photo and caption courtesy of Science Museum, London)

shows (see page 320, par. 10) that so early as March 2, 1897 (i.e., about three years prior to any employment by me of mercury for purposes of wireless telegraphy). Mr. Marconi himself had already patented, 'The use of mercury in sensitive imperfect electrical contacts.'"

It was Phillips who first questioned Solari's reference to Marconi's patent in this statement on the basis that Marconi's patented mercury coherer was not self-restoring whereas Solari's was.³³ Bondyopadhyay took this one step further and stated that Solari's reference to Marconi "is clearly fraudulent," presumably on the basis that Marconi's non-self-restoring mercury coherer would not have precluded Solari from patenting his self-restoring mercury coherer.³⁴ Aggarwal took it yet another step further by assuming the story was true except for the reference to Marconi, and suggested that Solari's reference might be to someone else—namely Bose.³⁵ However, substituting Bose for Marconi makes the story even more illogical. First, Bose did not have any patents at that time that would have forestalled a Solari patent, whereas Marconi had a patent with a sensitive iron-mercury coherer, albeit not self-restoring. Second, like Marconi, Bose never made any claims that his mercury coherers with iron or carbon were self-restoring—only potassium—and so the same objection to a Marconi reference also applies equally to the Bose reference. Last but not least, Bose never made any reference or claims for applications of his mercury coherers to wireless telegraphy, hence it would not have precluded Solari from patenting the Italian Navy Coherer for wireless applications—a fact that is rather obvious because Marconi

applied for and received a patent for the Italian Navy Coherer a short time later!³⁶

It is much more likely that Solari's entire story was fabricated in an attempt to explain why he did not file a patent for the Italian Navy Coherer—something he would not have wanted to do if, indeed, his work was based on another inventor such as Castelli or Tommasina. His story has a "ring of fabrication" because he first claimed that the "idea of the employment of mercury had been suggested to me by something which I had read in some English publication which I found myself unable to trace," and then he remembered it was actually in Marconi's patent—hardly something any inventor would forget—particularly Solari, who had been a friend and confidant of Marconi since childhood. Solari later clearly stated that he did not invent the Italian Navy Coherer, giving even more credence to this theory.³⁷

Regardless of the veracity of Solari's statement, Aggarwal provides no basis whatsoever for suggesting that Solari was referring to Bose. If one were to assume that the story was true with the exception of the reference to Marconi, it would have been just as logical to suggest that Solari was alluding to the work of Hughes, whose work was reported in *The Electrician* and also reproduced in Appendix D of Fahie's *History of Wireless*, the very book to which Solari was referring in his statement.³⁸ After all, Hughes did experiment with an iron-mercury coherer, a self-restoring carbon-iron coherer, and a telephone as a detector in a wireless communication configuration. Further, Marconi (and likely Solari) was well aware of Hughes' early work, as evidenced by this statement he made during a lecture to the Royal

Institution on June 13th, 1902.³⁹

"In all these self-decohering coherers a telephone which is affected by the variations of the electric current, caused by the changes in conductivity of the coherer is used in place of the recording instrument. It has not yet been found possible, so far as I am aware, to actuate a recording instrument or a relay by means of a self-restoring coherer. The late Prof. Hughes was the first, I believe, to experiment with and receive signals on one of these coherers associated with a telephone. His experiments were carried out as early as 1879, and I regret that this pioneer work of his is not more generally known."

Major Stephen Flood Page's purported contact with Bose: According to Aggarwal, Bose wrote a letter to his good friend and poet Rabindranath Tagore stating in part: *"A short time before my lecture, a multi-millionaire proprietor of a very famous telegraph company telegraphed me with an urgent request to meet me."* Bose continued to write: *"...and within a short time he himself arrived with patent forms in hand. He made an earnest request to me not to divulge all valuable research results in today's lecture: There is money in it—let me take out a patent for you."* While Bose never identified the proprietor, Aggarwal states that the proprietor *"is believed to be Major Stephen Flood Page, the Managing Director of the Marconi's Wireless and Telegraph Company"*—a speculation obviously cited in an attempt to establish a relationship between Marconi and Bose, which is asserted in some unspecified way to support their position that Bose invented the Italian Navy Coherer.

First of all, Major Flood Page was neither a *"multi-millionaire"*

nor the *"proprietor"* of the Marconi Company, and Aggarwal gives no explanation of the discrepancy between Bose's description of a *"multi-millionaire proprietor"* and the fact that Major Flood Page was neither. Further, he provides no evidence or rationale to support his speculation that Major Flood Page was involved. Major Flood Page became the managing director of the Marconi Company on March 24, 1900, almost a year after Bose's first and only paper on mercury coherers given in April of 1899—and so the subject of the urgent request *"not to divulge all valuable research in today's lecture"* could not have been about mercury coherers if Flood Page had been involved.

Bondyopadhyay reported that the lecture in question was given to the Royal Institution on May 17, 1901,⁴⁰ but by that time, Bose's disclosure of a self-restoring coherer with mercury had already been in the public domain for two years. The only device of interest to wireless telegraphy that Bose was working on at that time was the galena detector,⁴¹ and while the patent rights for this device would have indeed been valuable, it has no bearing whatsoever on who discovered the Italian Navy Coherer with mercury.

A So-Called Tribute to Bose by Marconi: Aggarwal attempts to establish a relationship between Marconi and Bose by citing passages from a book by Orrin E. Dunlap on Marconi, which Aggarwal claims were intended *"to tribute Bose for providing crucial support at a critical juncture when Marconi needed it the most."*⁴² The so-called *"tribute to Bose"* was taken from an article written for McClure's magazine in 1887 by H. J. W. Dam who was reporting on interviews with Bose and Marconi

made at separate times.⁴³ Dunlap manipulated Dam's original text by adding the names of Bose and Marconi here and there to give it the appearance that Bose was praising Marconi—and inserting quotation marks which give the false impression that Dam's passages were being quoted. For example, text on page 35 in Dunlap's book referencing Dam's article reads in part:

"Marconi, himself, was credited with 'opening new doors in the electric wing of the temple of truth.' Dr. Jagadis Chunder Bose, the Hindoo, Professor of Physics in the Presidency College at Calcutta, and distinguished student of electrical radiation, foresaw, 'all the special sciences marching abreast along the old Roman road of science which leads no one knows wither.'"

The above text was taken verbatim from Dam's article; the rest of the text was added by Dunlap to give the appearance that Dam's article referenced Marconi and Bose. The actual text from Dam's article in which these phrases appear makes no reference to either Bose or Marconi, and contains no quotes or attributions:

"But the electrical advance in the last twenty years has been most extraordinary. Invention and experiment have daily, if not hourly, thrown open new doors in the electrical wing of the temple of truth. And now, at the close of the nineteenth century, the great mass of new facts concerning light, electricity, inaudible sound, invisible light, and the Lenard and Röntgen rays; the eager inquiry, based upon new discoveries, into the properties of living matter, crystallization, the transference of thought, and the endeavor to establish scientifically the truth of certain great religious concepts—all the special sciences thus

represented, marching abreast of one another along the old Roman road of science, which leads no one knows wither, have come upon a great high wall blocking the way completely in all directions."

Dunlap implies that Dam was referring to Marconi who *"opened the doors in the electrical wing of science,"* whereas it is clear from the original text that Dam made no such reference to Marconi. Even more egregious, Dunlap clearly misrepresented Bose as foreseeing *"all the special sciences marching abreast along the old Roman road of science which leads no one knows wither,"* when, in fact, Dam did not ascribe that quote to Bose or anyone else.

Aggarwal gives this passage Marconi's imprimatur by stating that *"Marconi personally edited"* Dunlap's book. However, there is no evidence that he personally edited the book—only a statement in the "Appreciation" at the front of the book for Marconi's *"kindness in thoroughly reading the final proofs [such] that the book would be accurate in facts..."* There is a big difference between "editing the text" and "reading the final proof"—the final proof not being the time and place where any substantive changes are made—particularly in the days before computerized manuscripts. It is very unlikely that Marconi would have taken the time to check the accuracy of quotes such as those cited above while reading the final proof. Whether or not Marconi edited the final proofs, it is clear that the book was not completely *"accurate in facts."* If these passages with false attributions constitute a tribute to either Bose or Marconi, it is Dunlap's tribute written circa 1937 and not Marconi's, Bose's, or even Dam's.

There is also a suggestion that

this passage was intended as “a tribute to Bose for providing crucial support to Marconi at the critical juncture when Marconi needed it the most.”⁴⁴ Bose, if anything was Marconi’s competitor, not his supporter. It was Sir William Preece, Chief Electrical Engineer of the British Post Office who gave Marconi support when he needed it the most. Preece introduced Marconi to the British public at a speech at Toynbee hall on December 12, 1896 at time when only a handful of people in London had heard of Marconi. At that meeting, it was said that Preece “pledged the Post Office’s support for the development of Marconi’s invention, and dismissed as irrelevant the claims made for an Indian Professor Jagadish Chandra Bose,⁴⁵ as the true discoverer of wireless telegraphy.”⁴⁶

Bondyopadhyay made a slightly different claim than Aggarwal by stating that Dam’s original magazine article itself was actually a tribute to Marconi: “Marconi, who was more than 17 years younger than Bose, received high praise, confidence, and support from Bose [34] publicly, which Marconi desperately needed at that time to establish credibility...”⁴⁷ The reference [34] in this quote is to the Dam article, but nowhere in Dam’s entire article was it ever said that Bose mentioned or alluded to Marconi—much less gave him high praise. In fact, Marconi’s name does not even appear in the section of the article devoted to the Bose interview, and Bose’s name does not appear in the section devoted to the Marconi interview.

The first two examples are unsupported speculation, and the third is based on a false attribution written circa 1937—none of which constitute “powerful circumstantial evidence”. Further, Aggarwal

does not explain how any of this circumstantial evidence, even if true, supports the contention that Bose invented the Italian Navy Coherer.

TOMMASINA DISCOVERED THE “MERCURY-DROP” SELF-RESTORING COHERER

If ever there was an individual other than Castelli and Solari who contributed to the invention of the Italian Navy Coherer, it was surely Professor Tommasina. He was first credited with the invention by Emile Guarini in the June 19, 1903 *Electrician* where he detailed the rationale for naming Tommasina as the inventor.⁴⁸ He began with a quote from “*Telegrafia Senza Fili*,” an Italian Navy publication by Castelli’s superior, Captain Quintino Bonomo (Rome, 1902), which clearly showed that Castelli was aware of Tommasina’s work, and intended to experiment with it between September 1, 1900 and May 18, 1901:

“It was our intention to carry out a complete set of studies with Marconi’s apparatus before experimenting with the methods proposed by Popoff and Tommasina, when a desire expressed by Semiphorist Castelli induced us to carry out an experiment—independent of those already commenced—with telephonic reception by means of a little tube of his construction.”⁴⁹

Guarini went on to point out that Prof. Tommasina had communicated his first note on coherers to *Comptes Rendus* dated May 1, 1889 which began with the words: “In my researches relating to coherers with single contact, after having obtained very sensitive ones by means of a drop of mercury placed in a glass tube between two brass electrodes of cylindrical shape...”⁵⁰ He further stated that

Tommasina followed this note with a communication to "*Archives de la Societe de Physique et des Sciences Naturelles*" of Geneva dated May 3, 1900, "*wherein he claims priority to Popoff in connection with the use of the telephone, and he mentions, amongst the different decohering coherers, a coherer consisting of a drop of mercury between two carbon electrodes.*" This work was also detailed in the July 7, 1900 issue of *l'Elettricista*, an Italian journal which Guarini asserted that Castelli would have certainly read, and one from which he would have certainly profited.

Castelli may have gotten the idea for using a telephone and/or carbon electrodes from Tommasina in *l'Elettricista*, or from any number of other publications available at the time describing the use of telephones for wireless telegraphy—including *The Electrical Review* in which Hughes' experiments with a telephone were detailed. Exactly where Castelli got the idea for a telephone is not known nor is it particularly relevant because Hughes clearly has priority in the use of telephone as a sensitive listening device with a coherer. However, there is no question that Tommasina has priority in the use of "*a small drop of mercury between two electrodes*" for the purpose of making a self-restoring coherer. Bose never reported using a small drop of mercury between two electrodes of any type in any of his experiments—nor did he ever claim that mercury was the secret to making a sensitive self-restoring coherer.

Aggarawal's objection to Tommasina being the inventor of the Italian Navy Coherer is that he believed Bose had preference over Tommasina in both the use of a telephone and a self-restoring iron-mercury coherer. In fact,

Hughes had preference over both Bose and Tommasina for the use of a telephone with a self-restoring coherer, and also for the use of an iron-mercury coherer. Bose and Tommasina disclosed their respective mercury coherers at virtually the same time in early 1899, but neither claimed their respective coherer was self-recovering at the time of their disclosures. However, according to Guarini, Tommasina did make such a claim for his coherer with a small drop of mercury on May 1, 1900.

The fact that Tommasina did not disclose the self-restoring capability of his small-mercury-drop coherer in 1899 is not particularly relevant, because he—like all inventors—is entitled to precedence for all functions of his device, whether or not realized or mentioned at the time of disclosure. Recall that De Forest is credited with the invention of the audion amplifier with a grid as a result of his 1907 patent application for a *sensitive detector*—even though he made no claims for an amplifier because he did not realize his invention could amplify until years later. So, even if Bose had claimed his iron-mercury detector was self-restoring in 1899, at best they would have had equal preference. However, it was Tommasina who disclosed the small-mercury-drop coherer configuration virtually identical to the one used in the Italian Navy Coherer—not Bose.

Bondyopadhyay's objection to Tommasina as the inventor is based primarily on Solari's ambiguous statement which seems to indicate Tommasina was not involved: "*In any case, however, the coherer called the 'Royal Italian Navy Coherer' is constructed in an entirely different manner from those suggested by Wilson and by Tommasina...*"⁵¹ According

to Phillips, Prof. Ernest Wilson of King's College, London described a mercury device in a patent taken out in 1897, which was an entirely different type of device using two drops of mercury separated by a thin oil film which ruptured under the application of an applied voltage. So, it is true that the Italian Navy Coherer was constructed in "an entirely different manner" from that of Wilson, but certainly not from that of Tommasina, who clearly stated: "*In my researches into contact coherers, after obtaining some very sensitive ones by means of a drop of mercury placed between two cylindrical brass electrodes...*" The Italian Navy Coherer was indeed constructed differently from Tommasina's in that it used one carbon and one iron electrode whereas Tommasina's used two brass electrodes, but clearly, both used a small drop of mercury between two electrodes, which Castelli pointed out was the secret to making the iron-mercury and carbon-mercury coherers both sensitive and self-restoring.

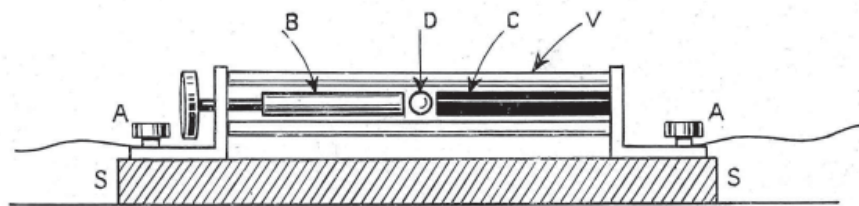
Solari was certainly not forthcoming about how he developed his Italian Navy Coherer, and his written comments about the relationship between his coherer and those of Castelli were both evasive and ambiguous, indicating that he had something to hide. Given the similarity of the coherers and the close timing of the discoveries, it is clear that either Solari got his ideas from Castelli, or they both got their respective ideas from Tommasina. It is difficult to believe that Solari was not somehow made aware of Castelli's results, and used them as a basis for designing a coherer with carbon-iron electrodes.

Solari's ambiguous statements about Castelli's involvement were not inconsistent with this thesis,

and he never actually denied he had a priori knowledge of Castelli's work. For example, he seemed to distance himself from Castelli by stating: "*It was I who suggested to him [Marconi] that it should be called the 'Italian Navy Coherer,' although the model brought over to England by me had, in fact, been devised in the station under my own immediate supervision, with which stations the above-mentioned naval signalman Castelli had nothing whatsoever to do.*"⁵² However, all Solari actually said here was the model he gave to Marconi was made at his station, and that Castelli had nothing whatever to do with the station under his command. Neither assertion taken individually or together constitutes a denial that Castelli was somehow involved.

The ambiguity of Solari's statements about Tommasina's coherer and the mystery of Tommasina's involvement in the Italian Navy Coherer design is cleared up in Solari's book *Storia della Radio*, published in 1939—two years after Marconi's death. In his book there is a line drawing of the Italian Navy Coherer he gave to Marconi with the caption translated as follows: "*Outline of the Italian Navy mercury coherer (Solari's model) based on phenomena observed by Tommasina*" (see Figure 8).⁵³ In the text, Solari stated his coherer was based on technology from a report written by Prof. Tommasina in Geneva in 1899.⁵⁴ Solari also mentioned the design of a similar mercury coherer developed by Castelli, and stated that Castelli's coherer was also based on the work of Tommasina.

The reason for Solari's half-truth to the effect his coherer was "*constructed in an entirely different manner from those suggested by Wilson and by Tomma-*



24. - Schema del coherer a mercurio R. Marina (modello Solari)
basato sul fenomeno scoperto dal Tommasina.
A-A: Serrafili di ottone; B: Elettrodo (regolabile) di ferro; C: Elettrodo
(fisso) di carbone di storta; D: Goccia di mercurio; V: Tubetto di vetro;
SS: Base di ebanite.

Fig. 8. The caption to this line drawing of Solari's Italian Navy coherer appearing in his book *Storia della Radio* published in 1939 provides convincing evidence that its design originated with Tommasina: Outline of the Italian Navy mercury coherer (Solari's model) based on phenomena observed by Tommasina. (Luigi Solari, *Storia della Radio*, 1939, p. 41)

sina" now seems quite clear.⁵⁵ A subplot to the larger controversy surrounding the invention of the Italian Navy Coherer consisted of numerous accusations that Marconi was an intellectual thief for patenting inventions of others. No less than six articles to that effect were published in 1902 alone.⁵⁶ If Solari had admitted that he gifted a coherer based on Tommasina's ideas to Marconi, who subsequently applied for a patent in his name and later added Solari as the one who communicated the invention to him,⁵⁷ it would have been a major embarrassment for both, and would have provided substantial ammunition to Marconi's critics—possibly resulting in a significant adverse impact on the then-struggling Marconi company. This supposition is suggested by the timing of Solari's book which was published just two years after Marconi's death in 1937, a time when there was no longer any reason for Solari to obscure the fact that Tommasina's work was indeed the basis for the design of both the Italian Navy and Castelli coherers.

Bondyopadhyay also objected to Tommasina as the inventor on the basis that "*Solari never*

claimed that his work of 1901, which leads to his giving the mercury coherer to Marconi in the summer of 1901, originated from Tommasina's work."⁵⁸ Clearly, Bondyopadhyay must not have been aware of Solari's book.

CONCLUSION

It would appear that the question of who invented the Italian Navy Coherer can be best answered as follows. Hughes has already been credited for the first to use a telephone as a sensitive detection device with a coherer, and for numerous demonstrations that reception of remote electrical transmissions was possible with a variety of self-restoring coherer configurations with a telephone as a detector. Hughes must now be accorded precedence for the first to experiment with an iron-mercury coherer, but Tommasina must be credited for the first to use a single small drop of mercury placed between two metal electrodes to make a sensitive and self-restoring coherer. Castelli can be credited for combining Tommasina's "mercury-drop" coherer with Hughes' telephone detector to demonstrate the efficacy of a self-

restoring coherer in the reception of radio transmissions at long distance—although it may well be that Tommasina conceived of using the telephone with the mercury-drop coherer before Castelli. At best, Solari can be accorded precedence only for the asymmetric carbon-iron electrodes because Castelli's work clearly predated Solari's. Therefore, it was Tommasina that added the one missing ingredient that made the Italian Navy Coherer self-restoring—the single small drop of mercury—but it cannot be said that he invented the Italian Navy Coherer complete with the carbon and iron electrodes using a telephone as a listening device.

Given the fact there is no direct or indirect evidence that Bose was involved in the design of the Italian coherer, and further, that he has no precedence in any of the key technologies involved in its function, it is difficult to see how any credible claim can be made that Bose invented the Italian Navy Coherer. Even more troubling, however, is Aggarwal's view that as a result of whatever contribution Bose might have made to the Italian Navy Coherer, "*the invention of radio should not be attributed to Guglielmo Marconi alone, but Guglielmo Marconi and Jagadish Chandra Bose.*" To put this view in its proper perspective, the coherer itself is only one part of the detector circuit, which is only one part of the receiver, which in turn is only half of the radio system—the transmitter being the other half. There were a very large number of people who contributed to all the required technologies for a radio communication system—not just the coherer. Furthermore, there is also much more to making a commercially successful wireless communication system than a single coherer experiment: the selection

and integration of multiple technologies, the reduction to practice, and the marshalling of financial resources and staffing to demonstrate and subsequently construct an operational system. To seriously suggest that Bose should be accorded equal billing with Marconi for Marconi's contributions to radio—even assuming that Bose did invent the Italian Navy Coherer that, after all, was used only in one experiment and was found to be unsuitable for use in a practical wireless communication system—is myopic at best. However, such a suggestion—combined with the lack of any credible evidence that Bose contributed to the coherer design used in the transatlantic experiment—becomes a stretch of epic proportion.

ENDNOTES

- 1 The anglicized form of Bose's name, Jagadis Chunder Bose, was used in most publications in English.
- 2 Varun Aggarwal, "Jagadish Chandra Bose: The Real Inventor of Marconi's Wireless Detector," *AWA Journal*, Vol. 47, No. 3, July 2006, pp. 50-54.
- 3 P. K. Bondyopadhyay, "Sir J. C. Bose's Diode Detector Received Marconi's First Transatlantic Wireless Signal of December 1901 (The 'Italian Navy Coherer' Scandal Revisited)," *Proc. of IEEE*, Vol. 86, No. 1, Jan. 1998, pp. 259-285.
- 4 J. C. Bose, "On a Self-Recovering Coherer and the Study of the Cohering Action of Different Metals," *Proc. Roy. Soc. (London)*, Vol. LXV, No. 416, Apr. 27, 1899, pp. 166-172; reproduced in *Proc. IEEE*, Vol. 86, No. 1, Jan 1998, pp. 244-247; also reproduced in *Collected Physical Paper of Sir Jagadis Chunder Bose*, (Longmans, Green and Co., London, New York, Toronto, Bombay, Calcutta, and Madras, 1927) Chapter XII, pp. 116-126.
- 5 Sir Oliver Lodge, "Letter," *The Times* (London), Dec. 20, 1901;

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- 6 Angelo Banti, "La Telegrafia Senza Fili e la R. Marina Italiana," *l'Elettricista*, Series II, Vol. 1, May 1902, pp. 113-119. Reproduced in: Angelo Banti, "The Castelli Coherer," *The Electrician*, Vol. XLIX, No. 10, June 27, 1902, pp. 387-388.
 - 7 Angelo Banti, "The 'Castelli' Coherer and the 'Royal Italian Navy' Coherer: The End of a Scandal," *The Electrician*, Vol. XLIX, No. 12, July 11, 1902, pp. 476-477.
 - 8 Emile Guarini, "The Real Inventor of the Mercury Coherer," *The Electrician*, Vol. LI, No. 9, June 19, 1903, p. 360.
 - 9 Thomas Tommasina, "Sur la Production de Chaînes de Dépôts Électrolytiques, et...Fréquence," *Comptes Rendus*, May 1, 1899, pp. 1092-1095.
 - 10 V. J. Phillips, "The 'Italian Navy Coherer' Affair: A Turn-of-the-Century Scandal," *Proc. IEEE*, Series A, Vol. 140, No. 3, May 1993, pp. 175-185.
 - 11 V. J. Phillips, "Early Radio Wave Detectors," (Peregrinus, London, 1980).
 - 12 P. K. Bondyopadhyay, *Proc. of IEEE*, Jan. 1998, p. 259.
 - 13 V. J. Phillips, *Early Radio Wave Detectors*, 1980. Phillips referenced Bose no less than six times, including Bose's key paper on self-restoring coherers: J. C. Bose, *Proc. Roy. Soc. (London)*, Apr. 27, 1899, pp. 166-172.
 - 14 P. K. Bondyopadhyay, *Proc. of IEEE*, Jan. 1998, p. 269.
 - 15 Varun Aggarwal, *AWA Journal*, July 2006, p. 52.
 - 16 Ibid.
 - 17 Luigi Solari, "The Real Inventor of the Mercury Coherer," *The Electrician*, Vol. LI, No. 12, July 10, 1903, p. 502.
 - 18 Luigi Solari, *Storia della Radio*, (S. A. Fratelli Treves Editori, Milan, 1939) p. 41, 50.
 - 19 Angelo Banti, *The Electrician*, June 27, 1902, pp. 387-388.
 - 20 Varun Aggarwal, *AWA Journal*, July 2006, pp. 51. The original sketch of this U-tube configuration appears in A. K. Sen, "Sir J. C. Bose and Millimeter Waves," *TENCON '98, 1998 IEEE Region 10 International Conference on Global Connectivity in Energy, Computer, Communication and Control*, Vol. 2, Dec. 1998, p. 289.
 - 21 Angelo Banti, *The Electrician*, June 27, 1902, p. 388.
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 - 23 E. Branley, "Variations of Conductivity Under Electrical Influence," *The Electrician*, Vol. XXVII, No. 684, June 26, 1891 pp. 221-222; E. Branley, "Variations of Conductivity Under Electrical Influence," *The Electrician*, Vol. XXIX, August 21, 1891, pp. 448-489; K. E. Guthe and A. Trowbridge, "On the Theory of the Coherer," *Phys. Rev.*, Vol. 11, July 1900, pp. 22-39.
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 - 25 J. Munro, *The Electrical Review*, June 2, 1889, pp. 883-885.
 - 26 D. E. Hughes, *The Electrician*, May 5, 1899, pp. 40-41.
 - 27 Varun Aggarwal, *AWA Journal*, July 2006, p. 53 (Table 1).
 - 28 J. Munro, *The Electrical Review*, June 2, 1889, p. 884.
 - 29 See for example: V. J. Phillips, *Proc. IEEE*, 3, May 1993.
 - 30 J. A. Fleming, *The Principles of Electric Wave Telegraphy and Telephony*, (Longmans, Green, and Co. London, 1916) 468, 573; V. J. Phillips, *Proc. IEEE*, May 1993, p. 255; V. J. Phillips, *Early Radio Wave Detectors*, 1980, p. 5.
 - 31 Varun Aggarwal, *AWA Journal*,

- July 2006, p. 52.
- 32 Solari, "Mr. Marconi and the Italian Government," *The Times* (London), July 3, 1902, p.6 cols. b and c.
- 33 V. J. Phillips, "The 'Italian Navy Coherer' Affair: A Turn-of-the-Century Scandal," *Proc. IEEE*, Vol. 86, No. 1, Jan. 1998, p. 253. [Reprinted from V. J. Phillips, "The 'Italian Navy Coherer' Affair: A Turn-of-the-Century Scandal," *Proc. IEEE*, Series A, Vol. 140, No. 3, May 1993, pp. 175-185.]
- 34 P. K. Bondyopadhyay, *Proc. of IEEE*, Jan. 1998, p. 272.
- 35 Varun Aggarwal, *AWA Journal*, July 2006, p. 52.
- 36 G. Marconi, "Improvements in Coherers or Detectors for Electrical Waves," British patent No. 18,105, applied for on September 10, 1901 and accepted on October 2, 1902.
- 37 Luigi Solari, *The Electrician*, July 10, 1903, p. 502.
- 38 J. J. Fahie, *A History of Wireless Telegraphy 1839-1899*, (William Blackwood & Sons, Edinburgh and London, 1st ed., 1899) Appendix D.
- 39 G. Marconi, "The Progress of Electric Space Telegraphy," *The Electrician*, Vol. XLIX, No. 10, June 27, 1902, p. 390.
- 40 P. K. Bondyopadhyay, "Marconi's 1901 Transatlantic Wireless Communication Experiment," Mahand Communications, Inc., web article: <http://home.online.no/~kgroenha/bondy.pdf>, p. 6-7.
- 41 J. C. Bose, *Collected Physical Paper of Sir Jagadis Chunder Bose*, (Longmans, Green and Co., London, New York, Toronto, Bombay, Calcutta, and Madras, 1927), p. 187. Chapter XIV of this book on pages 163-191 constitutes the lecture given to the Royal Society in June 1901.
- 42 Orrin E. Dunlap, *Marconi - The Man and His Wireless*, (MacMillan Company, New York, 1937), pp. 31-32. Aggarwal incorrectly cited page 91 for the tribute passages.
- 43 H. J. W. Dam, "Telegraphing without Wires. A Possibility of Electrical Science," *McClure's Magazine*, Vol. VIII. No. 5, March 1897, pp. 383-392.
- 44 Aggarwal actually has it backwards—the false quote is an apparent tribute to Marconi by Bose, not visa versa.
- 45 A footnote appearing in the quoted text reads: "In 1895, Professor Bose, of the Presidency College, Calcutta, had succeeded in ringing a bell and exploding a mine with electro-magnetic waves while working along the same lines as Marconi."
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- 47 P. K. Bondyopadhyay, *Proc. of IEEE*, Jan. 1998, p. 276.
- 48 Emile Guarini, "The Real Inventor of the Mercury Coherer," *The Electrician*, Vol. LI, No. 9, June 19, 1903, p. 360.
- 49 Quintino Bonomo, *Telegrafia senza fili*, Chapter: "Summary of Experiments Carried out between September 1, 1900 and May 18, 1901," Rome, 1902, p. 11.
- 50 Thomas Tommasina, *Comptes Rendus*, May 1, 1899, pp. 1092-1095.
- 51 Luigi Solari, *The Electrician*, July 10, 1903, p. 502.
- 52 Luigi Solari, *The Times* (London), July 3, 1902, p. 6.
- 53 Luigi Solari, *Storia della Radio*, 1939, p. 41, 50.
- 54 Ibid, p. 50.
- 55 Half of Solari's statement was true—Wilson's coherer was indeed constructed an entirely different manner than Solari's, but Tommasina's coherer was not.
- 56 S. P. Thompson, "The Inventor of Wireless Telegraphy," *Saturday Review*, Vol. 93, April 5, 1902, pp. 424-425; ___, "Wireless Telegraphy: A Rejoinder," *Saturday Review*, Vol. 93, May 10, 1902, pp. 598-599; ___, "The Inventor of Wireless Telegraphy," *Saturday Review*, Vol. 93, May 31, 1902, p. 697; ___, "The Inventor of Wireless Telegraphy," *Saturday Review*, Vol. 93, June 21, 1902, p. 805; ___, *The Times* (London), p. 12, col. F, July 5, 1902; ___, *The Times* (London), p. 8, col. c, July 21,

Marconi's Detector

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ABOUT THE AUTHOR

Eric P. Wenaas has had a life-long passion for antique radios beginning with his first Radiola and crystal set given to him as a young man growing up in Chicago by family friends. He experimented with radio devices and repaired radios and televisions as a hobby while in high school, and went on to study electrical engineering at Purdue University, graduating with B.S. and M.S. degrees in Electrical Engineering. He then went to the State University of New York at Buffalo where he earned a Ph.D. degree in Interdisciplinary Studies in the School of Engineering. After graduating, he moved to Southern California where he first worked at Gulf General Atomic for several years, and then moved to Jaycor, a defense company in Southern California, where he spent most of his career, first as an engineer and later as the President and Chief Executive Officer.

Upon his retirement in 2002, he set out to research the early days of wireless and document interesting historical vignettes based on original documents of the era. He has written articles for the *AWA Review* and the *Antique Radio Classified*, and has recently published a critically acclaimed

book, *Radiola: The Golden Age of RCA - 1919-1929*, covering the early history of RCA—including the formative years of the Marconi Telegraph Company of America. For this work he received the AWA Houck Award for Documentation in 2007. He is a member of the IEEE and the Antique Wireless Association, and is a past member of the American Physical Society. Dr. Wenaas resides in Southern California and continues to enjoy collecting and displaying radios, and researching the early days of wireless.

