In 1909 in Italy, a franciscan monk was the first to discover electromagnetic seismic precursors

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Abstract

We present to the international scientific community three important works by Father Maccioni adapted into English with several parts literally translated. The investigation into the existence of an electromagnetic seismic precursor was carried on in Italy in the beginning of the XXth century and exploited the capabilities of a specifically designed coherer. For several reasons both the work and the author are widely unknown even in Italy. We think this is likely to be the very first historical case of a study of a seismic precursor of the electromagnetic type.

Introduction

The title of this work sounds deliberately provocative. Our aim is simply to stimulate focus on the Italian contribution on seminal research about earthquakes. We do not want to speculate about the existence and/or effectiveness of electromagnetic seismic precursors nor that their existence has been definitely assessed starting in 1909. We just want to show univocal evidence that, since 1909, in Italy this phenomenon was being unequivocally assessed.

In modern seismology, an earthquake precursor is defined as the observation of some physical phenomenon that originated from the hypocentral region of a large earthquake at a time before the initiation of the rupture of the large earthquake. Father Maccioni was studying the electromagnetic (EM) waves, or natural radio signals, associated with earthquakes. At the time of Father Maccioni, the origin times of the earthquakes were not well established, and thus to Father Maccioni an EM precursor was simply the observation of EM energy before the arrival of the seismic waves at the observing station. It is not clear whether or not Father Maccioni's EM observations would be considered earthquake precursors in the modern sense or whether he

was observing EM waves that were generated at the time or after the initiation of a fault rupture. Even so, in this paper the term “earthquake precursor” will be used for the EM observations of Father Maccioni.

Earlier literature has identified the work *Earthquake in connection with electric and magnetic phenomena* by John Milne [Milne, 1890] as the first investigation of “electromagnetic” precursors. Some examples of this identification are [Hobara et al., 2005], [Parrot et al., 2006], [Nemec et al., 2009], [Freund et al., 2018]. This claim could be true if by “electromagnetic phenomena” we mean the entirety of distinct electric and magnetic phenomena, as was commonly done in Milne’s time. Instead, if we mean electromagnetic signals in the modern sense, we must make a sharp differentiation between the archaic term “electro-magnetic” and the modern one “electomagnetic”. Milne [1890] refers to electric precursors and magnetic precursors as two separated kinds of phenomena. He never refers to precursors or to any other signal of true electromagnetic nature [Nardi, 2020].

After literally translating several specific parts of the Italian papers (one major limitation with early 1900 Italian researchers was that they basically wrote in Italian in national journals), we will show how a little-known Franciscan monk spoke of “electromagnetic” phenomenon in the modern sense and planned the investigation of an electromagnetic precursor by ingeniously exploiting technology available at that time.

Historical setting

Natural EM signals associated with earthquakes have been reported for many decades, although not all strong earthquakes have observations of EM signals before or at the time of the

earthquake. Nevertheless, presently it is not known who was the first to suggest, investigate or at least to incidentally observe this phenomenon. Below we report a simple chronology following the publication in 1865 of the seminal *A dynamical theory of the electromagnetic field* by James Clerk Maxwell.

1879. Michele Stefano De Rossi from Italy published *La meteorologia endogena* (*Endogenous meteorology*; the original work was written in Italian). In that work we find the explicit term "electro-magnetic precursors" but as usual at that time, this term referred to the whole of distinct electric and magnetic phenomena though these two distinct classes were linked by intercorrelated events like inductive currents evidenced by galvanometers.

1888. Heinrich Rudolf Hertz from Germany experimentally confirmed the existence of the waves predicted by Maxwell theory. At that time, In Italy they were called "Hertzian waves" or "Electric waves".

1890. John Milne from England published the book *Earthquake in connection with electric and magnetic phenomena* [Milne, 1890]. In this work, the author never used the term "electromagnetic" nor "electro-magnetic". Moreover, Milne did not report or face unknown phenomena nowadays ascribable to the electromagnetic class with the possible exception of "the Mount Sonnblick episode" (page 148) that, however, is not related to earthquakes at all. In the bibliography section we report a link to the original text.

1895. Guglielmo Marconi from Italy broadcasted a radio telegraphic signal using a coherer as a detector. For the present investigation, the relevance of this event is connected to the subsequent diffusion of the knowledge about electromagnetic waves and coherer use.

1909. Father Atto Maccioni in Siena (Italy) announced the discovery of an earthquake precursor phenomenon of electromagnetic nature detectable using a modified coherer [Maccioni, 1909]. This discovery, which is actually the object of this work, will be totally forgotten after his death. The reasons for this will be thorougly discussed in the following.

Modern studies of EM precursors of earthquakes can be traced at least back to Warwick et al. (1982), who reported on unusual radio signals that preceded the occurrence of the Mw 9.5 earthquake in Chile in 1960. Some earlier studies, such as Gokhberg et al. (1979), also address the topic of EM earthquake precursors. Since then, numerous studies have reported EM earthquake precursors, although the topic is very controversial even today within the seismological community. What is not controversial is that a priest in Italy in 1909 reported on observations of EM signals that might have been EM earthquake precursors. Indeed, it is this story that we are telling, starring a 34-year-old monk, director of the Seismic Observatory of Siena, set up in the convent of the “Friars Minor of the Observance”.

The contribution of Father Atto Maccioni

We will now present the translation from Italian of important parts of three papers by Father Atto Maccioni (see Data and Resources). Sentences quoted like «*this*» are a literal translation. The rest of the English text is a paraphrase and often a synthesis made necessary by the archaic, slow and sometimes rhetorical language of the time. Our comments are reported by the use an "edit" expression and some footnotes. The format «*quoted text* (##)» can be directly compared with the original text referenced by the line number. Indeed we have made available, in the

Electronic Supplement to this article, the original textual form of the referenced papers in a numbered and completely exact version (including typographical errors).

NEW DISCOVERY IN THE FIELD OF SEISMOLOGY [Maccioni, 1909a] (see Data and Resources and the original text “Maccioni_1909a.pdf” in the Electronic Supplement).

Father Maccioni is in the Hallin the Hall of the Academy of Physiocritics in Siena. This is the very first official announcement of his discovery. The news already «*leaked*» by the press made this announcement necessary. Maccioni points out that (despite what the press says) the utmost importance should be attributed to the discovery of the underlying physical phenomenon, not to the invention of the device itself: «*Journalism, always inclined to exaggeration, has taken over the news. I therefore had to publicly play down these exaggerations and present the facts under their essence* (22-24). *It is just the discovery of waves that are not mechanical and, nonetheless, play a role in the phenomenon of the earthquake that is the real news deserving serious consideration by scholars* (27-29)».

At that time, the foreboding of an earthquake by animals was considered certain. Maccioni explains that this effect was initially attributed to an amplified sensitivity to the mechanical wave. However, the introduction of *tromometers* now seems to have disproved it (edit: instrument sensitive to the oscillations of the ground that today we call "instrumental", spreaded in Italy from 1873). His starting idea is that the advanced warning of earthquakes by animals was due to «*oscillatory discharges*» generating electromagnetic waves which can act on muscles and nerves «*like induction currents*» (edit: think to Galvani’s experiences on 1781). Verbatim he says: «*Breaking away almost completely from the theories advanced up to now, I believed that only an*

electromagnetic emission from the seismic focus during the earthquake preparation phase could explain a physiological disturbance on the nervous system of animals. As a matter of fact, it is now established by recent studies that oscillatory electric currents, emitting electromagnetic waves, can act on muscles and nerves of animals in the same way as induction currents do (70-75)». Maccioni explains at this point with evident awareness that the earthquake is only the final manifestation of a complex and multi-phase preparation process: «*I thought it reasonable to believe that the earthquake, as it is usually detected and recorded by standard seismographs, is nothing more than the last phase of a bigger and more complex phenomenon and that its preparation is connected to a series of different phenomena that have to do with the generation of oscillatory electric currents* (75-79)».

Maccioni's device has been therefore expressly designed for EM waves: «*This is the reasoning that inspired my experiments: if before the mechanical manifestation of an earthquake there was the development of oscillatory electricity, then this would be necessarily visible using a suitable detection instrument (92-95)*» and the technical solution is the coherer: «*Well, I used a simple coherer in the experiences I am going to present* (102-103)».

However, Maccioni believes that Marconi's coherer is «*not sensitive enough*». The monk then experiments with other solutions including the coherer «*by Tommasina*» which he considers much more sensitive (edit: Tommaso Tommasina (1855-1935) was an Italian theoretical and experimental physicist who actually designed some versions of choerer that were more sensitive and simpler than Marconi's ones [eg. Tommasina, 1899b]). Unfortunately, the failure of these experiments disappoint him to the point of thinking of giving up; during the «*seismic period*» that occurred in January 1909 east of Siena, seismographs record many events but the coherer never

reacts. He finally decides to try a very last attempt with a coherer «*built my way* (121-122)». The technical solution comes from an experimental observation. To be more «*sensitive*» a classic coherer (edit: see fig. 1) had to be longer: «*During the numerous experiments initially carried out with Branly-Marconi tubes I noticed a detail that was useful to verify its correct functioning. In order for the coherer to be sensitive, to varying distance between the coherer and the spark gap or to varying length of the sparks, I also had to vary the distance between the terminal cylinders of the rheophores together with the amount of filing interposed between them. I then thought of building a new coherer able to be sensitive to any length of the spark, and I succeeded. By producing sparks with the same machine, it was now evident that simply moving the disks of the machine, provided it was energized, was enough to cause the current of the pile to pass through the filings* (edit: it was a Wimsursth machine, that produces high voltage by rotating elements that need to be pre-charged with static electricity. That is why he says he had to be "energized"). *That is to say, the action of the very small sparks discharging inside the machine during the initial rotation of the discs alone was sufficient to make the coherer react. So I believed to have reached the goal being sure that, if the earthquakes had been accompanied by electromagnetic waves, these would have been no longer unnoticed* (123-135)».

At this point, Father Maccioni and his assistant Father Lombardini (edit: Ildefonso Lombardini) simply waited until April 11, 1909, when two modest tremors occurred with an epicenter 22 km away. This is how the friar recounts the incident: «*Finally, on the morning of April 11, two modest earthquakes wanted to give us the pleasant surprise of warning us of their arrival, sending, four minutes before the shock, the suspected electromagnetic waves to impress my new Avvisatore* (edit: "Avvisatore" is the name that Maccioni usually uses for his alarm device

and more generally it is the name that at the time was given to the instruments that could give a warning of the earthquake, such as tromometer [Ferrari, 2000; Calzecchi-Onesti, 1886]. Literally it could be translated as "Alarm" or "Warner" but we prefer to refer to it in the text by the Italian name Avvisatore). *I do not hide the fact that at the first alarm I could not believe myself and the device. However, at the reply at 5:59 am there was a new alarm from the Avvisatore, always four minutes before the mechanical shock and right under my eyes and my assistant. At this point we necessarily had to accept the evidence!* (142-148)».

Maccioni's report continues with the detailed description of of the device that detected these events (edit: see fig. 1): «*My device is made up of a small model Italian battery element connected* (edit: in series) *to a galvanometer acting as a small relay and then to the particular model of coherer mentioned above* (edit: and presumably this is connected to the battery again). *A cable connects one of the coherer's clamps with a metal bar vertically sinking into the ground. This bar must absolutely not emerge from the ground. This is to prevent the Avvisatore from reacting under the action of atmospheric discharges, although for the moment I cannot guarantee that, on a few occasions, the device will not react to an extraordinary atmospheric discharge. But even if this happens, it will not cause misunderstandings* (edit: given the exceptional nature of the lightning). *The relay is intended to close the circuit of a strong battery powering a recording device, a clock fixed at 12 position and an alarm bell. The difference between the arrival of electromagnetic and mechanical waves is given by the comparison between the time marked by the Avvisatore and that indicated by a very sensitive seismoscope chosen among the best available in major observatories* (151-161)».

After this, Maccioni speculates about two questions: does the delay of the seismic wave with respect to the EM waves vary with the distance from the epicenter? Is it possible to use the EM wave to estimate the magnitude/intensity of the earthquake? He can only say that it will take time to answer these questions, only after the necessary experimentation. The friar, however, can already assess that the device is not sensitive to distant earthquakes, since (being in Tuscany) it has not detected the recent earthquakes that occurred in Calabria and Sicily. But the limitation of the instrument only to local seismicity is not so much a shortcoming as it is an advantage.

To investigate the possibility of assessing the intensity of the earthquake, Maccioni planned to implement a series of coherers characterized by different ranges of sensitivity in partial overlap between them. In this way he wanted to estimate the strength of the received signal based on how many of them would react. The monk points out that his guidelines for further development of the equipment should be considered only indications of how the problem could be faced. It cannot be excluded that even a Branly-Marconi coherer, suitably modified, could achieve the same results. As a matter of fact, in the next experiments he intends to test a tube coherer like Marconi's but without the vacuum inside. Finally, Maccioni concludes with the following sentence: «*The discovery of electromagnetic waves, as a phenomenon preceding and concomitant to the earthquake of volcanic origin, opens up a new unexpected field of research for modern seismology, and I hope that by continuing on this new path we can achieve, sooner than one might believe, the complete solution to the arduous problem of earthquake prediction* (199-202)». (Edit: Maccioni distinguished between "volcanic" and "tectonic" earthquakes. We have to pay attention to the fact that he did not mean the modern interpretation of these terms,

195 but, as was used at the time, he followed the ancient electrician theory on the origin of volcanoes
196 and earthquakes).
197
198 MACCIONI SEISMIC "AVVISATORE" (ALERT SYSTEM). DESCRIPTIVE NOTES [Maccioni,
199 1909b] (see Data and Resources and the original text "Maccioni_1909b.pdf" in the Electronic
200 Supplement).
201 The construction and technical features of the *Seismic Avvisatore*, which could not be
202 detailed during the oral presentation on May 2 at the Accademia dei Fisiocritici (edit: reported **in**
203 previous section), are described in this technical note. This is the exact description of Maccioni's
204 coherer (see fig. 2): «*A disk with a hole in the center protrudes from a wooden base with a*
205 *diameter of about 4 cm. This contains a glass disc which acts as a movable bottom. A layer of*
206 *metal filings (silver aluminum) about 2 mm thick is deposited on the glass. A silver disc cut in half*
207 *rests on this layer. The distance between the two parts* (edit: the space within) *can vary depending*
208 *on the sensitivity you want to give to the device. Generally, 5 mm is enough. The two half discs*
209 *compress the filings thanks to the adjustment of two screws and the resulting pressure too has a*
210 *great influence on the sensitivity of the coherer. The same screws serve as clamps for the cables*
211 *that will be connected one to a single element of an Italian copper sulphate pile and the other to*
212 *a very sensitive relay* (7-16)».
213 Maccioni's note continues with a description of the relay (see again Fig. 1) which at that
214 time was an object derived from a galvanomer: «*The relay consists of a common frame*
215 *galvanometer of the type called Schweizer multiplier. The winding is built with 200 turns of 0.4*
216 *mm section wire. The needle has been silvered and is free to move thanks to its single-wire metal*

suspension. A string of platinum or silver is placed near the needle in order to close a circuit when the needle is deflected (17-22)». This circuit closes on a series of 4 or 5 elements of a powerful Leclanché pile. The battery powers the recording, alarm and decoherization device. The aerial of the device, which had to pick up the EM signal only from the subsoil and not from the atmosphere, according to Father Maccioni, was a metal bar stuck in the ground: «*A large copper cable (3 mm section) connects* one of the coherer wire clamp *with a shaft sunk vertically into moist soil. This cable should not pass alongside the external walls of the building. It is also advisable to drill the hole for the bar immediately next to the Avvisatore itself. This layout was effcient in eliminating disturbances caused by electrical discharges from the atmosphere even during local thunderstorms* (24-29)». In the photo (of the original text) you can see two clocks stopped at 12 o'clock. They are activated respectively by the alarm and by a seismoscope in order to show the time difference between the arrival of the EM wave and the seismic wave. Beyond lightning occurrence, Maccioni also encounters other problems: «*It is absolutely necessary that there are no electrical appliances generating sparks near the Avvisatore like doorbells, switches etc. The simple spark arising from the interruption of the bell circuit is enough to make the coherer react* (33-37)».

The note continues with a description of the device functioning. It conforms to that already presented to the Academy of Physiocritics, although a little more detailed. In order not to repeat again his first results of April 11th, the friar presents the case observed by Prof. Gentile, director of the Porto Maurizio Observatory. With several letters the Professor informed Maccioni of some observations of telluric currents made by means of a galvanometer and of one specific episode is detected with equipment of the Maccioni type: «*On June 13* (edit: 1909) *he wrote to me: "At*

the observatory, at 8 am of the 11th I found the needle of the galvanometer shaken. Over the span of two hours, I observed the arrival of electric waves 6 times. A similar phenomenon had never occurred to me. The same evening, after the earthquake, I went to the observatory and discovered that his electro-magnetic waves had crossed the cohérer before and during the earthquake, letting the current pass through the cohérer. This quake was recorded here as a III Mercalli degree from a distance of about 250 km from the epicenter." (100-106)».

The friar concludes the article hoping that other scholars will continue with passion this new kind of observations and announces with satisfaction that he has already been asked for 11 devices to be housed in as many seismic stations.

ELECTRO-MAGNETIC WAVES AND SEISMIC PHENOMENA [Maccioni, 1910] (see Data and Resources and the original text "Maccioni_1910.pdf" in the Electronic Supplement).

Almost a year after the official announcement (edit: the speech at the Academy of Fisiocritici [Maccioni 1909]), the first results of the experimentation with the Maccioni *Avvisatore* are now presented.

Maccioni once again points out the real extent of his discovery: «*We have to admit that this advance will never be great* (19)*».* However, as he has already widely discussed, beyond the exaggerations made by the press, the real importance of the discovery is not the *Avvisatore* itself but just the association of electromagnetic waves with the earthquake. This is his real discovery. The application for the purpose of forecasting is only a possibility derived from the discovery: «*The anticipation of the earthquake is nothing but an application of what I am trying to prove, that is to say the discovery of electric waves* (37-39)».

Regarding the real existence of these waves (edit: at the time indifferently called «electromagnetic», «electro-magnetic», «electric waves» and also, in the exclusive case of Maccioni, «electro-seismic»), according to the monk there does not exist any doubt. Professor Guzzanti, director of the Geodynamic Observatory of Mineo (Catania, Sicily region), was the first to be interested in studying Maccioni's device, although he openly declared that he had always fought the theory of electricity in relation to seismic phenomena. Several days after the instrument was installed, Guzzanti informed the friar that he had had clear evidence of the existence of "*electric waves*" on occasion of an earthquake with an epicenter close to his Observatory. «*An evident confirmation can be retrieved from the telegraphic communication from the Morabito di Mileto observatory* (edit: near Vibo Valentia, in the Calabria region) *about a month after the Avvisatore was installed. The Director, prof. Labozzetta, thus telegraphed: "Pleased to inform you the Avvisatore anticipated local third degree shock".* (57-59)». Further confirmation can be found in the bulletin of the Moris Observatory in Massa Marittima, where there is an activation of the *Avvisatore* in relation to the earthquake in October 1909, just a month after installation.

«Summarizing the many observations carried out in these months of extraordinary seismicity, the following satisfactory results can be noted. (71-72)». (Edit: Here, for reasons of space, we had to omit the entire verbal description of the events detected by the Avvisatore in the period August-November 1909 at the Siena “Osservanza” observatory. These data can be found in the original document attached in the Electronic Supplement. The available dataset concerns 27 seismic events recorded at the "Osservanza" plus 4 other cases involving other observers who had Maccioni's Avisatore. It seems that the Avvisatore and the tromometer could

anticipate the earthquake by a few minutes but the Avvisatore could often anticipate the tromometer widely).

A very short worldwide fame

As we have seen, Maccioni had to give a lecture at the Academy of Siena before obtaining definitive results because the newspapers were already spreading news about his discovery. We have collected several articles from the Italian and foreign press of the time. The news literally reached the antipodes of the world in New Zealand. In fig. 3 we find evidence for this spreading. Despite this, after the monk's premature death (at the age of 45, probably) everything was forgotten. Actually, a mystery surrounds the monk's life in the period following the publications we have examined. It seems that an indiscretion by Fr. Maccioni led to his abandoning the cassock and leaving the observatory in 1916. Apparently, Fr. Maccioni “observed a woman through the window of the palace in front of the monastery.” At this time in Italy this offense was considered a major indiscretion that merited severe punishment. Following the discovery of his action, Fr. Maccioni was banished from the Franciscans, and his Franciscan superiors acted to obliterate all information about Fr. Maccioni’s time in the order. Up to now, there has been no official biography of Maccioni, and it was extremely difficult to construct the one we attach in the Electronis Supplement (see the file Maccioni_Biography.pdf).

After Maccioni left the observatory and the Franciscan order, a kind of looting of his scientific ideas took place within the scientific community. There were at the time a series of emulations, commercial achievements and even a patent that are not attributable to Father Maccioni. In these years also there was the outbreak of the First World War and most of all the decline of the

coherer with the birth of radio that contributed to throwing into oblivion the work of Father Maccioni. Indeed, he did not have enough time to obtain further results besides the preliminary ones published in Italian in "Electro-magnetic waves and seismic phenomena". For these reasons his work remains almost unknown today, and even in Italy we found very few traces of it and only in contemporary literature: [Martinelli, 1997, p. 200; Fidani, 2006; Nardi, 2020].

Discussion

From all the documents we have examined it is evident that Father Maccioni intentionally sought an electromagnetic precursor of the earthquake. This probably happened for the first time in history and precisely in the historical period allowing for the conception of this idea to be possible. The motivation for his research appears to us today a bit naive, particularly the *electrician* theory on which it was based that is today totally superseded by the tectonic theory, which at the time was beginning its evolution. Today, the search for EM precursors is motivated by the experimental observation of EM emissions associated with the micro-fracturing of rock [eg. Warwick et al., 1982; Nardi & Caputo, 2009]. Nonetheless, Maccioni's idea that the earthquake was only the final product of a preparation process that included the emission of EM waves is remarkably sharp and modern. This is the principle on which all the precursors theories are based today.

From a purely technological point of view, Maccioni's work was nothing more than an extreme specialization of the coherer. The coherer is a detector capable of reacting "mechanically" to EM waves by varying the cohesion of some metal filings. Cohesion creates conductivity. This property was discovered by the Italian physicist Temistocle Calzecchi Onesti.

He, publishing his results in Italian, called this object *coesore* [Calzecchi, 1884 and 1911]. The "coesore" was improved by Sir Oliver Lodge, who translated the same name into the English "coherer", and was later further refined by the French Édouard Branly, who in his language gave it the new name of "radioconducteur". Since 1890 the improved version of Branly has represented the standard model of this EM detector, which, however, kept the English name. The coherer was initially used to predict lightning storms (to preserve telegraph and then telephone lines) but in 1895 it was made famous by the radiotelegraphic experience of Guglielmo Marconi. Marconi's coherer, however, was a further improvement that was recognized at the time as the most suitable for radio communications. Anyway, even this version was not sufficient for Maccioni's purpose. The monk had to adopt a different configuration that had been developed by the Italian Tommaso Tommasina (a brilliant researcher, about whom very little known today) to investigate the phenomenon of cohesion of metal filings [Tommasina, 1899a]. Subsequently, Maccioni developed his own version of a coherer that, as we learned from his own words (document “New discovery”, lines 123-135), reached the goal of achieving maximum sensitivity to long sparks. Maccioni had intended to increase the overall sensitivity of the coherer but seems to have actually unknowingly extended the sensitivity spectrum towards the lower frequencies. In our opinion this may have accidentally given him an advantage over other radio coherers, such as Marconi's. Indeed, the portion of the spectrum at very low frequency, between the ELF band and the VLF, is precisely where today the greatest number of potential EM precursors are observed nowadays and the one in which the maximum EM emission produced by the micro-fracturing of the rock is observed experimentally [Nardi & Caputo, 2009]. Despite the extreme specialization achieved by Maccioni, he adopted the coherer in 1909, when *radio*

telegraphy was turning into *radio broadcasting* and radio technology was developing towards resonant circuits with electrolytic and crystal detectors much more sensitive than a coherer. The first transmission of the human voice had already occurred in 1906 thanks to the *amplitude modulation* (AM) of *continuous* waves (no longer *damped)* implemented by the Canadian Reginald Aubrey Fessenden. Just in the year of Maccioni's premature death, 1922, BBC radio broadcasts began and the coherer was by now an obsolete technology doomed to oblivion.

We mentioned that at the time of Maccioni there were other studies on earthquake warning devices in Italy. Indeed, for over forty years there was also been an instrument commonly used in seismology that could be used as "micro-seismic warning device": the *tromometer* [Ferrari et. al., 2000, Calzecchi, 1886]. It was designed by the Barnabite friar Timoteo Bertelli (1868) and, for the first time it detected "instrumental" shocks not perceived by the population and that could anticipate a sensitive shock by a few moments. A little known curiosity is that the inventor of the coherer himself, Calzecchi Onesti, used his sensor to create a tromometer which for the time was extremely sensitive [Calzecchi, 1886]. The idea of a coherer anticipating the earthquake can give us the illusion of an electromagnetic precursor observed even before Maccioni. On the other hand, in Calzecchi's warning device, the coherer was employed in the inverse of the radiotelegraph use. In fact, it usually worked as a conductor, previously activated by a special inductor. The occurrence of the seismic shock caused the decoherization (as a consequence of a purely mechanical action) and this triggered an alarm. It seems that singing was enough to activate it. In Italy, however, it was Bertelli's *tromometro normale* (normal tromometer) that was appreciated and used widely. Indeed, it was even used by Maccioni during his experiments with the "*Avvisatore*" to confirm the occurrence of an

earthquake. What emerges from the limited case history collected by the friar (Maccioni, 1910) is that the “Maccioni Avvisatore” could anticipate the Bertelli tromometer by many seconds. From this point of view, we can affirm that the monk's instrument was successful: it seems to work at least as much as a tromometer, despite being an electromagnetic sensor. Basically, Maccioni looked for an EM precursor, perhaps he found an EM phenomenon associated with the earthquake, but his device more than a forecast, seems to have produced something that can be at best (roughly) compared with what we call today early warning even if there was no way that the “warning” could be given to anyone other than a seismologist who was near the instrument. Maccioni's intellectual honesty should therefore be appreciated when at the Accademia dei Fisiocritici (Maccioni, 1909a) he began his introductory speech by emphasizing the fact that, despite what the press wrote, the greatest importance had to be attributed not to his instrument but to the discovery of electromagnetic waves associated with the earthquake.

Conclusions

We hope to have provided enough evidence that in 1909 Father Maccioni had already consciously sought, and maybe even found, precursory phenomenon of the "electromagnetic" type in the modern sense of this term. Unfortunately, Maccioni's troubled history did not allow his work to have a significant impact on the science of seismology. What we have done here is to present some important samples of his literary production translated into English, so that the international community will be now able to make its own opinion on the matter. We hope that from now on, as far as EM precursors in the sense of electromagnetic waves associated with the

earthquake are concerned, the fundamental contribution of a modest Italian monk named Atto Maccioni will be recognized.

Data and Resources

We presented a translation (partly literal and partly paraphrased and summarized) of three papers by Father Maccioni originally published in Italian and, probably, never translated into English before. In the Electronic Supplement we attach the full text version in the original language in digital format: Maccioni_1909a.pdf; Maccioni_1909b.pdf; Maccioni_1910.pdf. In these digital reproductions the lines of text have been numbered in such a way that our complete translation of the most significant passages can directly refer to the corresponding Italian text in order to allow readers to promptly verify the translation. These reference texts are reported in the bibliography respectively as: [Maccioni, 1909a]; [Maccioni, 1909b]; [Maccioni, 1910].

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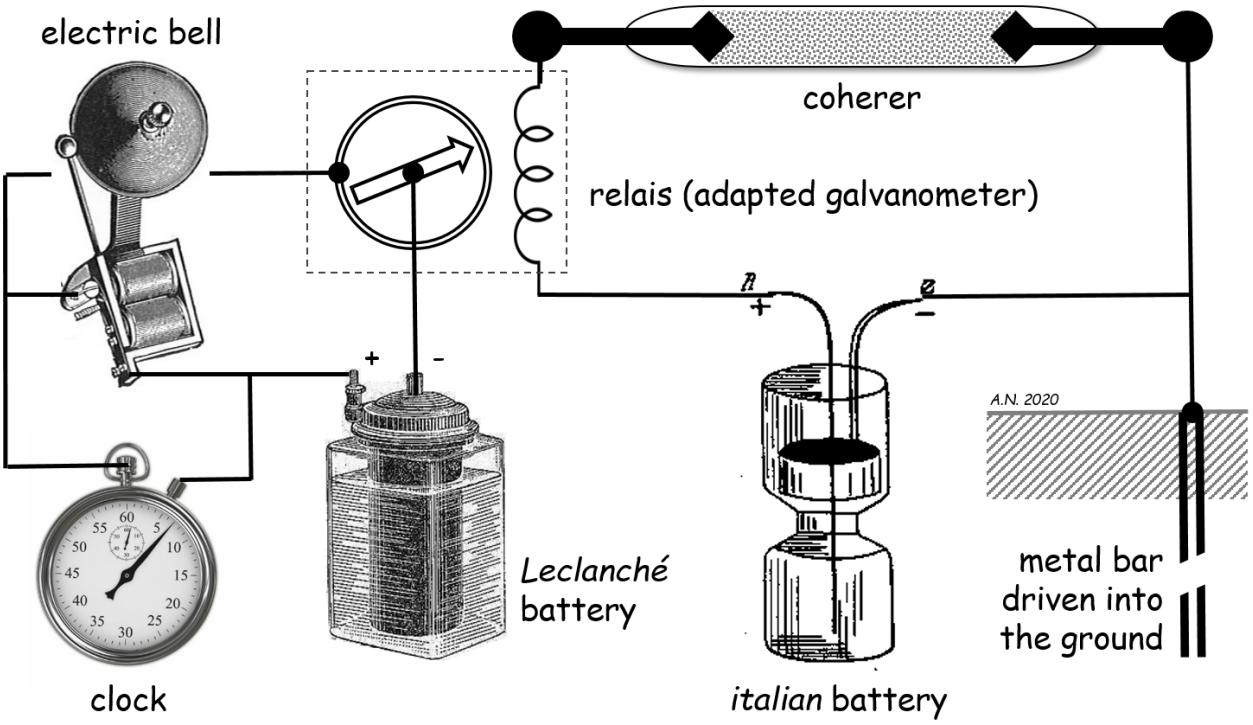
List of Figure Captions

Figure 1. Father Maccioni's *Avvisatore* in our idealized graphic reproduction. The scheme is inspired by the description given during the talk at the Academy of Fisiocritici [Maccioni, 1909]. A galvanometer acts as a relay and separates two main circuits: a coherer-based EM wave sensor (right) and a clock-based alarm-recorder that activates when the relay is energized by coherization (left). In this figure a coherer of the classical form has been represented.

Figure 2. Maccioni's "special" coherer in an exploded view inspired by the description included in the technical note published in the Franciscan magazine *Luce e Amore* [Maccioni, 1909b]. In a cylindrical cavity in the wood there is a glass base where some metal filings are deposited and pressed by two silver semi-discs integral with the leads. The original document only showed a photo with an overall view of the assembled device.

Figure 3. Maccioni's discovery immediately achieved worldwide fame thanks to the press. Here are some examples (* = page shown in the photo). May 1909: *La tribuna illustrata**, Italy; *L'illustrazione italiana**, Italy; *Corriere della sera*, Italy; *La Domenica del Corriere**, Italy. February 1910: *Diario do Açores* (Azores Daily), Portugal. September 1911: *La lectura Dominical**, Madrid. August 1911: *The Oamaru Mail**, New Zealand. May 1926: La Revista Blanca, Madrid.



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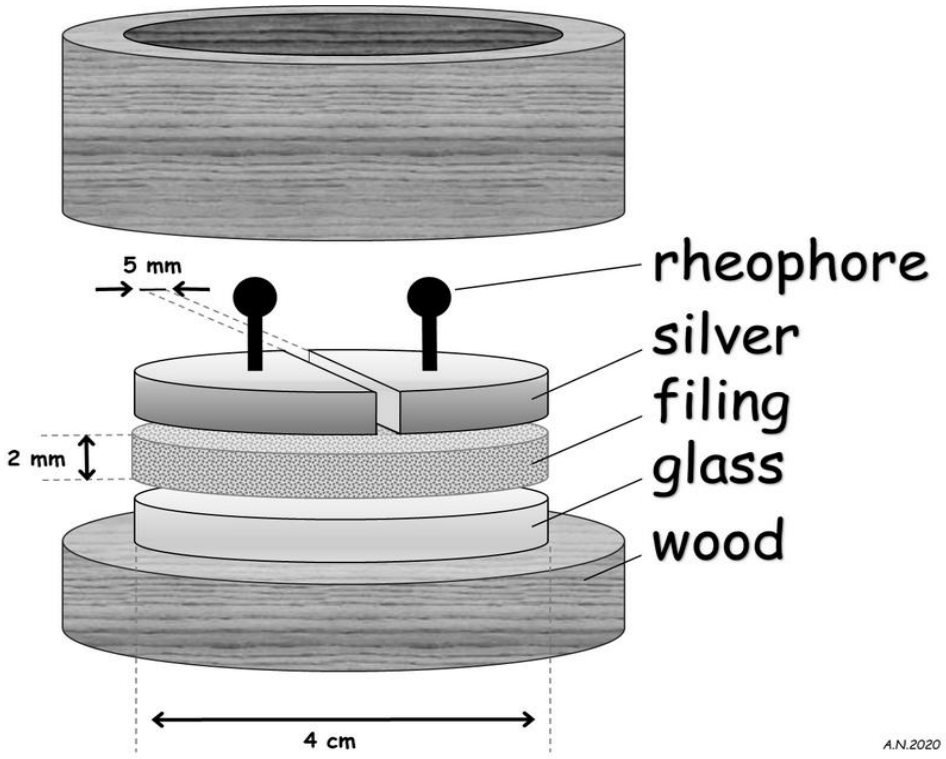

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