Radar Innovation and Proofs from C.Hülsmeyer.

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Abstract: The Telemobiloskop technical description is given in C.Hülsmeyer patents. Some apparatus and photos are available in Bremerhaven and Münich museums. This two information sources are difficult to correlate. The known tests results only show very short range plate detection. So C.Hülsmeyer can be granted as radio location inventor, but he did not succeed in demonstrating its value.

Keywords: Radar History, Telemobiloskop, Hülsmeyer

1. Introduction

We have some different sources of information about Hülsmeyer ideas and tests, but mostly uncorrelated, so that we have only been able to pursue hypothesis on how demonstrations were performed. We analyse first the patent implementation, then the apparatus on show at the Bremerhaven and Münich museums and publications about the Köln and Rotterdam presentations.

2. The patent [1]

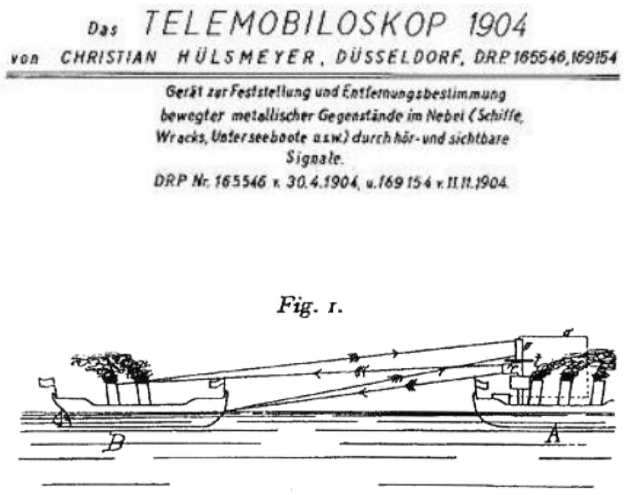
Das TELEMOBILOSKOP 1904
von CHRISTIAN HÜLSMEYER, DÜSSELDORF, DRP 165546,169154
Gerät zur Feststellung und Entfernungsbestimmung bewegter metallischer Gegenstände im Nebel (Schiffe, Wracks, Unterseeboote usw.) durch hör- und sichtbare Signale.
DRP Nr. 165546 v. 30.4.1904, u. 169 154 v. 11.11.1904

Figure 1 describes the echo location and detection process. Azimuth is given by the directive antenna. Range will be later related [2] to the target measured elevation angle and the known transmitter height above the sea surface. But the description shows neither a workable elevation estimation process nor the required accuracy.

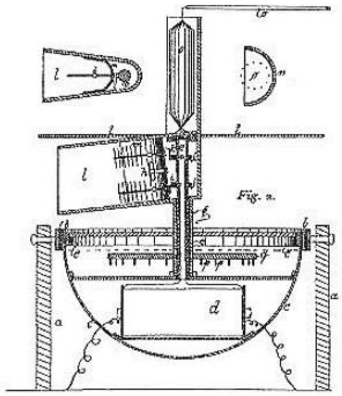

Figure 2 is related to the transmitter and its associated antenna.

The transmitter is said to be a Righi spark-gap. From Bologna Institute documents:

"It was invented by Augustus Righi, who was a professor at University of Bologna and an expert on Hertzian waves. Righi, who was a friend of the family first made Marconi aware of Hertzian waves.

When a high voltage is applied to the oscillator, a discharge takes place across the two outer spark-gaps, but then transfers to the central spark-gap which causes very short Hertzian waves to be radiated."

Fig. 3 - Righi's transmitter spark type oscillator made at the institute, 1903, Inv.No: VIII - 161/162

From V.J.Phillips [3], “two rods, with cross-pieces, are fixed to the outer balls. The capacitor formed by the gap and the rods is charged by the coil and when the voltage is sufficiently large a spark occurs….the associated electric and magnetic fields causing the emission of a RF pulse”. Taking into account the dimensions, that leads to expect a wavelength around 50 cm, radiated by the cross-pieces in the funnel. The directivity of such an antenna seems poor, the aperture being around one to two wavelength.

The Bologna Institute description gives the radiation as issued from the spark between the two central balls, and resulting in a very short wavelength, some centimetres according to an hypothetic scale deduced from the dimensions of the rod on show at the Münich Museum. The Righi oscillator being centered at the parabolic reflector focal line, some directivity might be achieved at centimetre wavelength, leading to a rather good estimation of the target azimuth.

Unfortunately, we don’t have enough information about the Righi spark-gap radiation to ascertain decimetric or centimetric wavelength. Only the smallest might have given azimuth estimation.

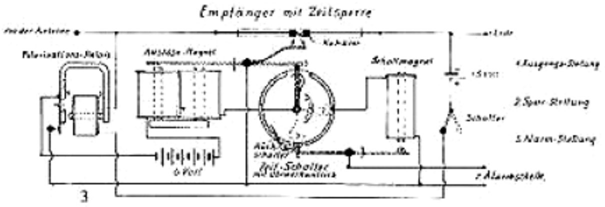

Fig.4 – Hülsmeyer’s receiver patent

Figure 4 shows a Branly “radioconductor” as receiver, with a mechanical “time synchroniser” to avoid parasitic signals. This synchroniser seems to be an addition from the October 1904 patent, but inertia prevents any efficiency against direct transmitter coupled signals.

A lot has been written about this “coherer”, used by Marconi, Ferrié and several at the early days of radio-communications. From personal tests I conducted with a coherer, I might infer that:

- as written by C.Hülsmeyer, the sensitivity depends on the applied DC voltage.
- the coherer detects frequencies up, at least, 300 MHz.
- “decohering” action doesn’t require a mechanical shock. Zeroing the applied DC voltage seems to act as well.

From these points, the radio-conductor appears to behave like a Tunnel diode, resulting from a isolator molecular gap between the iron filings, one of R. Gabillard hypothesis [4]. But we don’t know if the one used by C.Hülsmeyer was efficient at centimeter wavelength.

Last, but not least, the receiving antenna is, as described in the patent, an equivalent thick conductor, very close to the spherical reflector. Rotating the reflector simultaneously with the transmitter parabola, is a good idea to ascertain the same bearing, but the directivity of that receiving antenna is doubtful.

From the now known “radar equation”, decoupling between transmission and reception must exceed several tens of decibels to insure that the detected signal comes from an echo some miles apart. The patent describes a *t* plate, whose dimensions are two to three times the funnel aperture. The achievable decoupling factor don’t exceed 10 to 20 dB. From what we know, it’s difficult to ascertain that echoes were detected. A later patent [3] from C.Hülsmeyer describes a “tube around the conductor *d* ” to increase the Transmitter-Receiver isolation. Did he invented the coaxial transmission line? Nevertheless, it would have been insufficient.

A newspaper article [5] entitled “Aus Köln und dem LandKreiss”, dated 18 Mai 1904, describes some Telemobiloskop tests, in the Hall from Köln Domhotels, similar to Hertz demonstration about electromagnetic waves reflection on metallic plates, but at greater ranges. Later on [6], in may 1904, some possible applications are described from a bridge “am Rhein” with maximum range up to 5 km, not explicitly referred to real tests.

3. The implementation

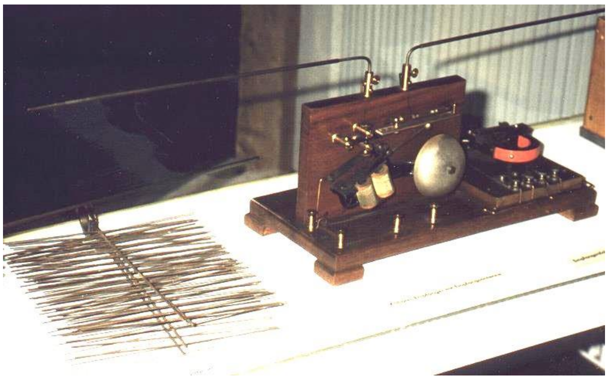

Fig. 5: Rod and Branly radio-conductor receiver, on show at Münich Museum.

That implementation shows a dipole as receiver antenna, whose dimensions suggest a metric wavelength. The rod refers to the telemobiloskop patent, but the receiver doesn’t cope with.

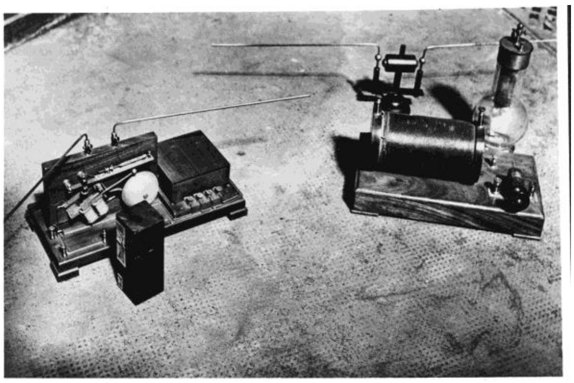

Fig. 6: Transmitter and receiver (Münich Museum photo).

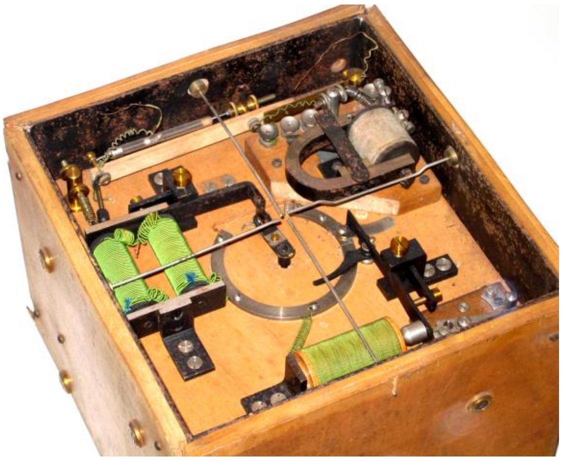

Fig. 7: Synchronised receiver on show at Bremmerhaven Museum.

Figure 6 shows a Righi spark-gap transmitter and the same receiver. As the patent rods, the dipole parts are connected to the outer balls, with length suggesting metric wavelength. If the inner element is truly balls immersed in oil, that differs from the short wavelength described by Righi.

Figure 7 shows a receiver without antenna, but the length of the outer connections seems incompatible with centimeter wavelength. Its use for Telemobiloskop demonstrations is doubtful.

Those implementations may be either the ones of telecommand transceivers C.Hülsmeyer had worked with, or the telemobiloskop without the required antenna directivity for azimuth estimation. On the other hand, the working frequency is closer to the band used for telecommunications.

Saved implementations and patents are uncorrelated, unless the patent drawing scale be many times larger that the one deduced from the rod seen in Münich, i.e. some meters for the funnel height and half meter for the cross-pieces on the rods.

The best bet is then metric wavelength, with a rather large apparatus without gimbals, using dipole and parabolic reflector on transmit and a monopole above the isolating plate, possibly with a reflector, on receive.

4. The tests

Unfortunately, we did not found precise description of the tests, either in Köln or Rotterdam. The only documents we discovered are extracts from newspapers which describe expected performances rather than proven ones. Only the Köln DomHotel test is documented, describing the detection of metallic plates, roughly ten meters apart. For that demonstration, the plate, with an optimum orientation, acts as a mirror and thus reflects a high level signal, tens of decibels above simple diffraction such as the one of a boat bow, but similar to the one of the hull at normal incidence. If the plate is laterally moved, its reflected rays directivity may be a substitution to the one of the Telemobiloskop antenna, leading to an apparent azimuth resolution.

As concerns the transmitter-receiver isolation, it would have been proven if the ship detection appeared in a given azimuth up to a maximum range, repetitively. Even ship detection seems to have been inferred from close range plate detection, at ranges estimated as minimum to enable collision avoidance.

The first Rotterdam demonstration might have been a repetition of the one in Köln, at close ranges. The telemobiloskop was on-board the ship-tender *Columbus*. If detection of close ships was performed, it was probably on normal hull aspects.

The second one, in 1905, was probably the first attempt to really detect ships at some kilometers range, but failed. The technology was probably short in T/R isolation and/or in transmitted power/receiver sensitivity, and the target radar-cross-sections were too low (diffraction rather than reflection).

5. Conclusion

- Hülsmeyer has been the first to describe ***radio detection and location***, even if its apparatus had not the required accuracy to estimate range from the elevation measure.
- He has shown the requirement for a directive illumination, together with an antenna rotation to survey the area, and for sender/receiver decoupling. Detection of the "echo" from a metallic plate had been demonstrated earlier by Heinrich Hertz.

He invented the Radio Location but

its implementation was poor, behind the state of the art from Righi, Braun, Marconi, etc.. So the experimental proof was not entirely successful. The decoupling between direct signal and echo, and the precise description of the experimental apparatus are not enough documented today to conclude if he made an experimental proof of a "some miles" maximum range.

6. References

[1] Das Telemobiloskop von Christian Hülsmeyer, Düsseldorf. Deutsche Patentschrift Nr. 165546, 30.04.1904.

[2] Telemobiloscope, de C.Hülsmeyer, brevet français n°343.846 demandé le 10 juin 1904.

[3] The Telemobiloscope. An Edwardian radar, by V.J.Phillips, Wireless World, july 1978, p.68.

[4] The Branly coherer and the first radiodetectors, by R.Gabillard. L'Onde Electrique, Mai-juin 1991, p.7.

[5] Kölner Tageblatt, May 18th, 1904, by Gustav Rudolph: "Er nennt denselben Telemobiloskop"

[6] Unpublished paper on Christian Hülsmeyer by Arthur O. Bauer, 2004.