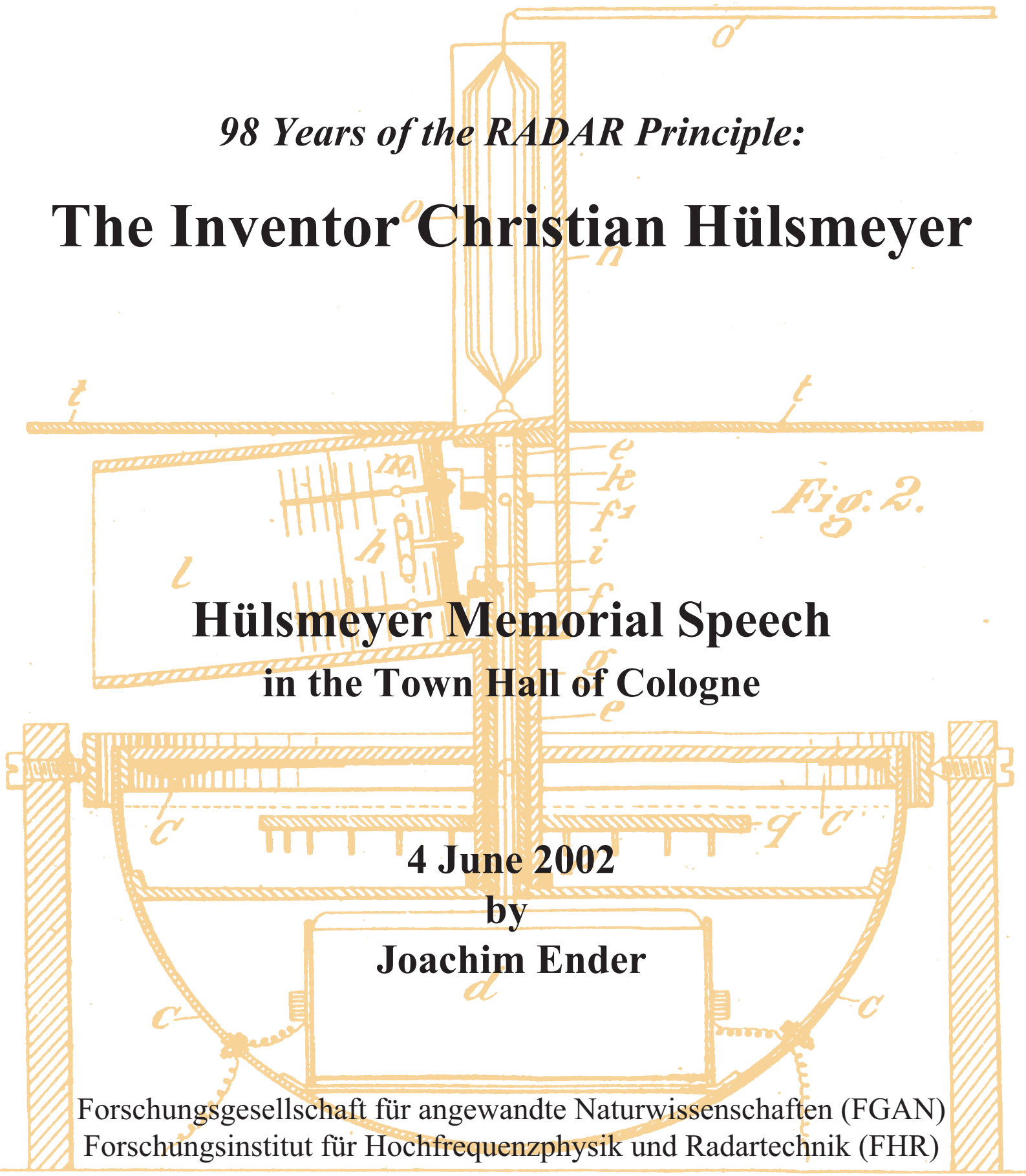
EUSAR 2002

98 Years of the RADAR Principle:

The Inventor Christian Hülsmeyer



Hülsmeyer Memorial Speech
in the Town Hall of Cologne

4 June 2002

by

Joachim Ender

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98 Years of the RADAR Principle: The Inventor Christian Hülsmeyer

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Cologne, 4 June 2002, Town-Hall

1. Introduction

HONOURED MAYOR OF COLOGNE, DEAR HERR EDGAR HÜLSMEYER, DEAR ATTENDEES OF THE EUSAR CONFERENCE, DEAR GUESTS,

Christian Hülsmeyer 1904

it is an honour and pleasure for me to have in this remarkable town the opportunity to remind of a very resourcefull spirit – some people also say unlucky fellow - named Christian Hülsmeyer, who was the father of this gentleman *(pointing to Edgar Hülsmeyer)*. Why 'unlucky fellow'? Because sometimes it is said, that he has invented the radar *too early!*

Yes, it was too early, and perhaps his invention was no radar in the strict sense; but meanwile it is internationally undisputable, that the cradle of the radar principle stood here in the heart of the Rhineland, in Cologne and Düsseldorf, thanks to Christian Hülsmeyer. 98 years ago he gave a demonstration in the closest neighbourhood to our conference location.

And that's why we thought it may be a good opportunity to pay homage to that splendid inventor at the EUSAR conference in Cologne.

Before I start, a warning: I'm no historian, so I only can reproduce what I have read or seen, or what has been told to me. Thanks to the Hülsmeyer family and to the friend of the family – Herrn Heinz Kassel, our institute came to the ownership of many valuable documents, which provided a rather solid fundament for our intention.

2. Historical Environment

Kaiser Wilhelm II

Now let's go back in time for nearly a century! It was the year 1904, Kaiser Wilhelm II ruled in Germany, the Brothers Wright performed their first flight with succeeded return to the starting place, the third Olympic games introduced the discipline "ton jumping" and the legendary Russian-Japanese sea war was waged.

First motor flight of brothers Wrigth with return

Russian - Japanese war

The electronic techniques were absolutely at the beginning, no amplifying devices like triode tubes, transistors or MMICs had been invented, no radio, no television, no computer existed and the ether was nearly free from electromagnetical waves – perhaps apart from some spurious signals generated by the first Marconi's communication links.

In the May of this year – probably at the 17 or 18 May – a young inventor aged 22 gave a demonstration here in Cologne to representatives of the navigation as well as reporters from local and newspapers from afar. He presented an enigmatic wooden box, from which several wires stuck out. The young man claimed that this device – he called it "*telemobiloscope*" – could detect remote metallic objects like ships, also in darkness, fog and rain, and could so prevent terrible ship disasters.

Three weeks before this invention was filed as a patent at the German patent office in Munich. One of the demonstations took place at the yard of the Domhotel , another must have been performed on the Hohenzollern bridge, which is certainly well known to you.

Städtische Nachrichten.

s Köln, 18. Mai.

Das Telemobiloskop, eine Erfindung des Ingenieurs Chr. Hülsmeyer in Düsseldorf, wurde gestern vormittag um 11 Uhr im Domhotel vor Vertretern des Norddeutschen Lloyds, der Seedampfschiffahrts-Gesellschaft Argo in Bremen und andern geladenen Herren vorgeführt. Die Erfindung beruht auf dem Grundsatz der drahtlosen Telegraphie und bezweckt, Schiffe sowie sonstige metallische Gegenstände auf dem Meere zu sichten. Der Unterschied zwischen der bereits bestehenden Anwendung der drahtlosen Telegraphie und dieser Erfindung beruht neben den konstruktiven Neuerungen lediglich darin, daß, während man bei der drahtlosen Telegraphie Geber und Empfänger auf verschiedenen Schiffen getrennt verwendet, man beim Telemobiloskop Geber und Empfänger auf einem und demselben Schiffe anordnet. Die vom Geber ausgesandten elektrischen Wellen können den Empfänger nicht direkt erreichen, sondern müssen von einem metallischen Gegenstand auf dem Meere (also von Schiffen) zurückgeworfen werden und so auf gebrochenem Wege zum Empfänger gelangen. Der große Vorteil, den die Erfindung bietet, liegt vor allem darin, daß Schiffe, die mit Geber und Empfänger nach diesem System ausgerüstet sind, jedes andere Schiff ohne diese Apparate sichten können, ja, dem Kapitän auf der Kommandobrücke wird sogar auf 3 bis 5km Entfernung die Richtung gemeldet, in der sich das entgegenfahrende Schiff befindet, so daß er, selbst wo Licht- und Nebelsignale versagen, noch Zeit genug hat, seinem Fahrzeug den richtigen Kurs zu geben und so schweres Unheil rechtzeitig zu verhüten. Der Versuch mit den kleinen Apparaten, die nur für kleinere Entfernungen berechnet sind, gelang vollkommen. Zur Ausnutzung der Erfindung hat sich eine Gesellschaft unter dem Namen Telemobiloskop-Gesellschaft Hülsmeyer u. Mannheim, gebildet.

In several books it is reported that the telemobiloscope managed to ring a bell whenever a Rhine ship passed the bridge and the receiver picked up echo signals.

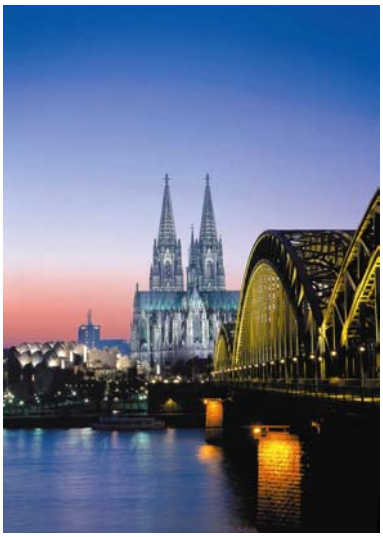
The idea of radar was born!

A report of this event is printed even in the New York Times of the 19 May 1904.

3. Curriculum vitae I

Let's have a look at the previous life of Christian Hülsmeyer. He was born at the Christmas Day of the year 1881 in Eydelstadt, Northern Germany, as a son of a carpenter. After the visit of the elementary school he got a further education at the so called "Lehrerseminar" (teacher's seminar) in Bremen. In the science lab of this institution he experimented with electromagnetic waves for the first time.

To become a teacher seemed too boring to him, so after the completion of the Lehrerseminar he changed to the Siemens-Schuckert company in Bremen, where he, amongst other things, was concerned with the electrical equipment of ships.



Hohenzollern Brigdge in Cologne

After two years he underwent a radical change in his life: With his brain full of ideas and his pockets empty of money he moved to the Rhineland where the ambiance was filled with new inventions and technological revolutions.

It was in Düsseldorf, where he developed the telemobiloscope. He could find a partner, Herrn Mannheim, who invested 5000 Goldmarks in the project; they founded the "Telemobiloscop-Gesellschaft Hülsmeyer & Mannheim" at Cologne.

Now let me go back a little in the technological history: In 1865 James Clarke Maxwell had developed his theory claiming the existence of electromagnetical waves. Not until 23 years later their existence was proofed by Heinrich Rudolph Hertz – professor at Bonn and Karlsruhe. Hertz also noticed that electromagnetic waves are reflected by metallic objects, but he did not apply this cognition in a practical engineering sense like Hülsmeyer did. In Italy, Gulielmo Marconi was the first to show, that these waves can be used for communication, and Hülsmeyers invention came only seven years later. He could revert to the first progresses of the communication technology.

4. The technical details of his invention

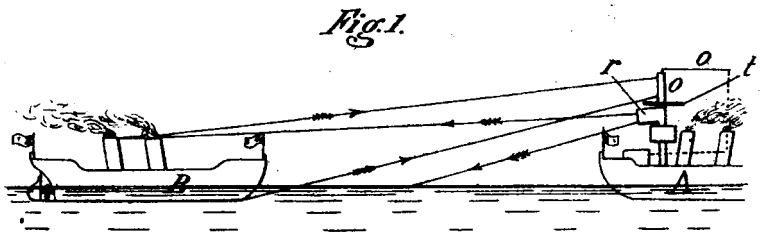
1.1 First patent - Telemobiloscope

N° 13,170 **A.D. 1904**

Date of Application, 10th June, 1904—Accepted, 22nd Sept., 1904

COMPLETE SPECIFICATION.

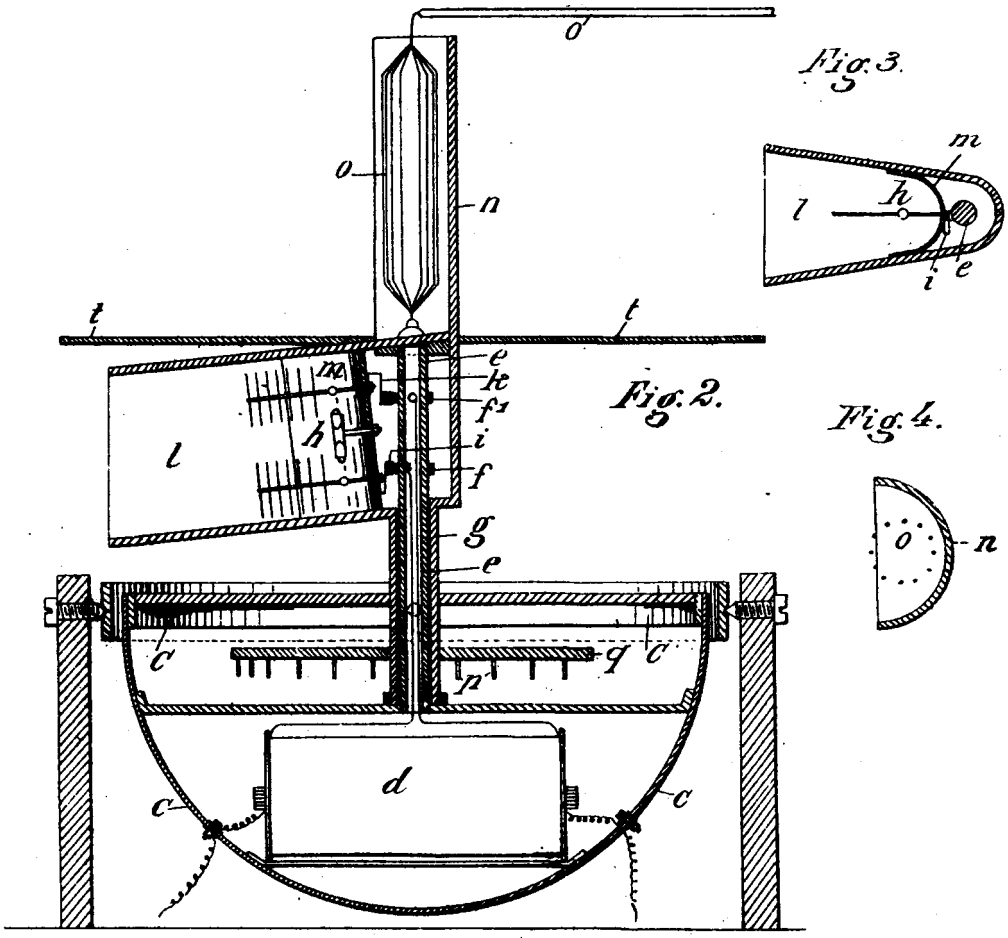
"Hertzian-wave Projecting and Receiving Apparatus Adapted to Indicate or Give Warning of the Presence of a Metallic Body, such as a Ship or a Train, in the Line of Projection of such Waves".—



Hülsmeyer filed his patent with the German title “Verfahren, um entfernte metallische Gegenstände mittels elektrischer Wellen einem Beobachter zu melden”, in the succeeding english patent called: „Hertzian-wave Projecting and Receiving Apparatus Adapted to Indicate or Give Warning of the Presence of a Metallic Body, such as a Ship or a Train, in the Line of Projection of such Waves“.

1.1.1 Functionality

It was intended to use the apparatus on ships. Transmitter and receiver should be mounted on a movable platform in such a way, that gravity brings them always into a vertical orientation independent of the pitch and roll motions of the ship. The RF frontend consisted of the transmit and receive antenna and the wave exciter.

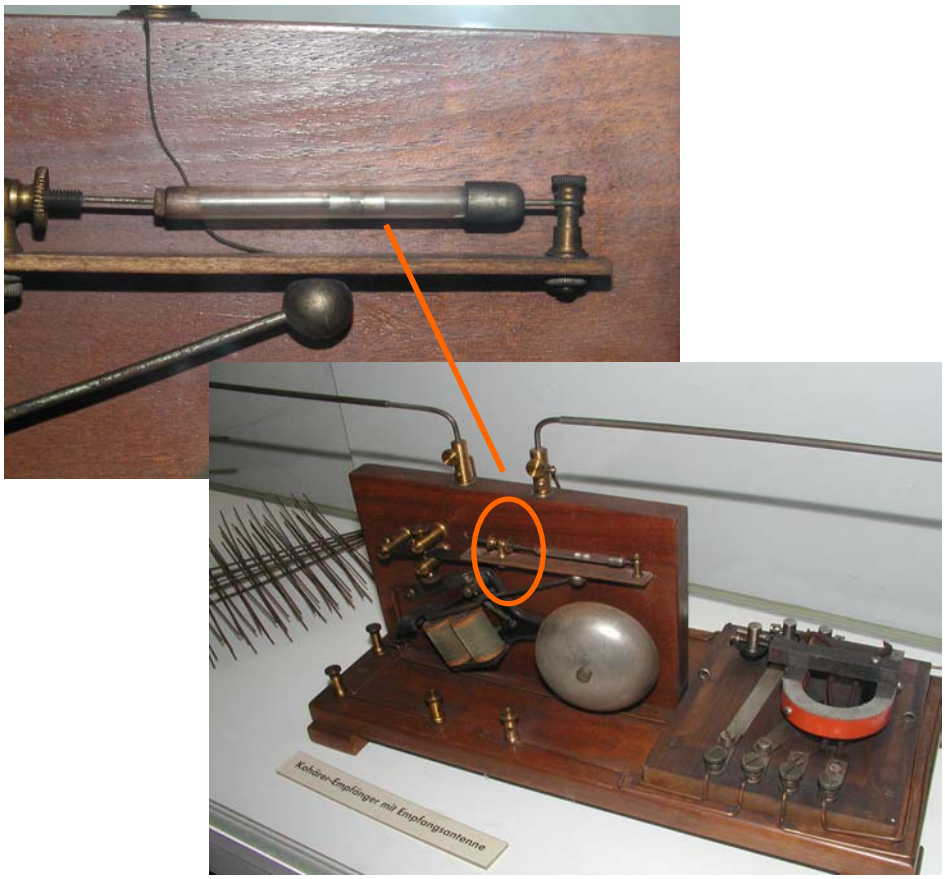


The radio frequency was generated by a double spark gap driven by an induction coil and radiated by an antenna consisting in an array of wires. The directivity of the transmitted wave was increased by a so called “projector screen”, that is simply a single-edge opened metal case. Hülsmeyer called the focusing to a narrow beam “projection of the electric waves”.

Since the frontend could be rotated in azimuth by 360 degrees, the power had to be supplied by a rotary joint working with insolated rings and brushes.

The receive antenna was a circular array of vertically spanned wires with a semi-cylindrical reflector behind it. We recognise that the receiving unit was shielded from the RF power parts by a metallic plate.

The received signals were transferred to the target detector in the bottom part of the telemobiloscope. Since no low noise amplifier was available at that time, Hülsmeyer used a device well known at those days, called “Coherer”.



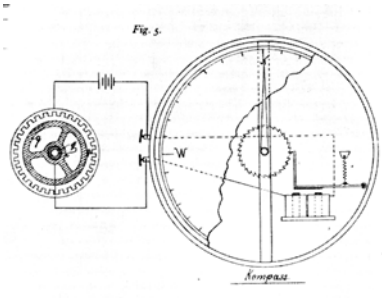
Exhibits at the “Deutsche Museum” Munich

A coherer consists of a glass tube containing metal filings. When a high frequency current passes through the filings they tend to stick together, so reducing their electrical resistance. That could be used to close a local circuit over a relay and to alarm the operating officer by an optical or acoustical signal.

In his experimental setup he used an electric bell. But this bell had to serve also for another purpose: When the filings of the coherer had stuck together the tube had to be tapped to separate them again. This was done automatically by the hammer of the bell in a closed loop operation.

1.1.2 Plan position indicator

Since it was too uncomfortable to read off the azimuth direction of a detected target on deck, Hülsmeyer invented an electro-mechanical device to transmit the azimuth angle to the pontoon bridge: A pointer was rotating synchronously to the antenna by means of an electromagnetically driven toothed wheel mechanism. Un-



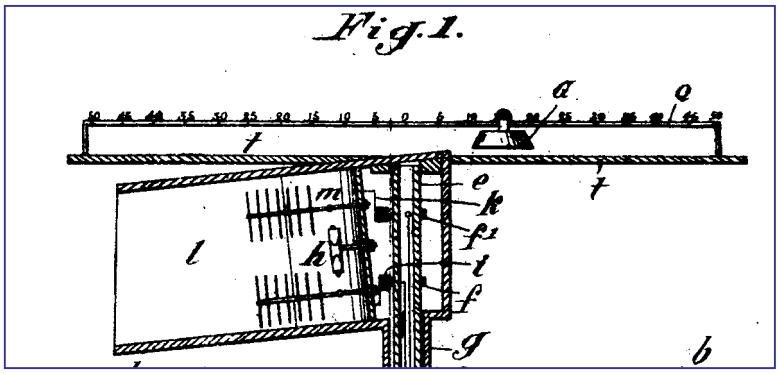
In der Patentschrift
№ 165546.

doubtedly, what he called “Kompass” was a predecessor of the later PPI, the plan position indicator.

1.2 Additional patent: ranging

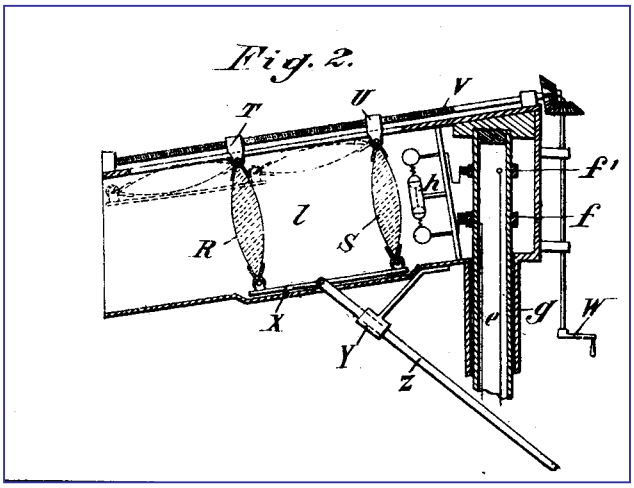
Unfortunately, the telemobiloscope worked with a continuos induction of sparks with no possibility to measure the travelling time of the wave indicating the distance of the reflecting object.

But Hülsmeyer soon recognised that it would be of great interest to determine not only the direction to the target but also the distance, later called “ranging” in the abbreviation “RADAR”. In the same year he filed an additional patent called “Improvement in Hertzian-wave Projecting and Receiving Apparatus for Locating the Position of Distant Metal Objects” . His solution to the ranging problem was to measure the elevation angle from the mast of the telemobiloscope carrier ship to the detected target. He proposed two methods.



The first consisted in a mechanical elevation scan by means of a weight which could be shifted forward or backward changing the inclination of the RF device.

The second is more complicated. It uses two lenses in front of the transmit aperture – I don’t know from which material – which could be bent by a mechanical device so changing the direction of the transmitted wave.



He did not explain clearly how the measurement of the elevation angle should be performed, I guess the angle should be varied until the strength of the received signal was maximum – so providing a *maximum likelihood estimator*.

1.2.1 Supplements

Some supplements should make the operation of the telemobiloscope on board the ship more robust and comfortable: Hülsmeyer proposed to use two units at the fore deck and the after deck to cover all directions uniformly. To shelter the precious apparatus from storm and water, he suggested to provide a *radom* made of wood.

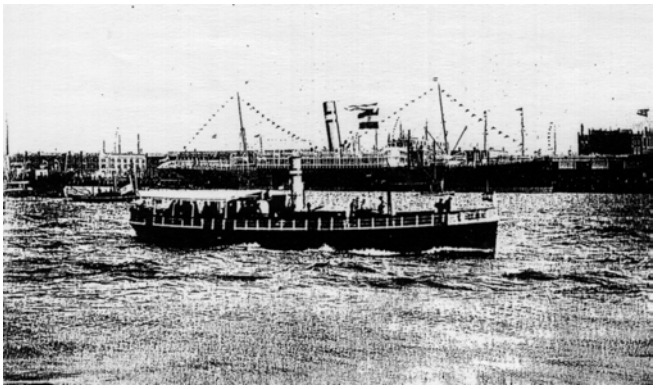
5. Further Experiments

Additional to the events in Cologne, Hülsmeyer shall have demonstrated his invention also at the bank of the Rhine in Düsseldorf to representatives of the German Navy. You certainly guess what was the reaction: His idea did not rouse any interest. The experts argued: Since the steam pipes can be heard over a longer range than Herrn Hülsmeyer’s device can detect, this invention is absolutely useless.

TECHNICAL NAUTICAL MEETING

at SCHEVENINGEN

on JUNE 8th, 9th and 10th 1904.



More interest was excited during the "TECHNICAL NAUTICAL MEETING" in Scheveningen, Holland, in June 1904. In the proceedings of this civilian meeting one can read, that the telemobiloscope was operated successfully on board the tender ship "Columbus". From further sources we know that a maximum detection range of 3 km was verified.

6. Assessment of his work

Now it's the right moment to summarise the work of Hülsmeyer and to give a rating of the usefulness of his singular invention.

GESELLSCHAFT FÜR DRAHTLOSE TELEGRAPHIE
m. b. H.

Telegr.-Adr.: TELEFUNKEN.
Telephon: Amt IV. 4685-4688.
Codes: A. B. C. 4th EDITION WESTERN-UNION LIEBER.

BERLIN S.W. 68, den 21. August 1905.
LINDEN-STRASSE 3
Industrie-Palast „Berlin".

Li/Dr.N.

Herrn
H e i n r i c h M a n n h e i m,

C ö l n a/Rh.
Hohestr. 77.

Anliegend geben wir Ihnen die uns vor einiger Zeit freundlichst zur Verfügung gestellten Patentbeschreibungen von " Verfahren um entfernte metallische Gegenstände mittels electrischer Wellen einem Beobachter zu melden " und " Telemobiloskop" Zusatz zu No. 32910 VIII/74 d. von Chr. Hülsemeyer, Düsseldorf, mit bestem Dank zurück, da wir für die genannten Erfindungen keine Verwendung haben.

Hochachtungsvoll
Gesellschaft für drahtlose Telegraphie
m. b. H.

(Koplert.)

1 Anlage.

A letter of the Telefunken Company, stating that they don't see any application of his invention

At that time, no transmitting tube, no amplifiers and no matched filters were available. Since Radar is a continuing fight against the noise, the range of the telemobiloscope was naturally limited. It was a very wideband device, I suppose the spectrum was spread along some hundred Megahertz similar to our imaging radars today. This sounds phantastic, but it is a disadvantage. To recognise this, let me interlace a short remark:

At the beginning of our Hülsmeyer plans, we thought about reconstructing the telemobiloscope and to demonstrate it at the EUSAR conference. But, in our days, this invention would have no chance to operate because of the expected gigantic number of false alarms. The coherer detects every incoming wave over some hundred Megahertz, that means a lot of radio and television stations, communication links and whatever runs through the ether today. We made some trials with

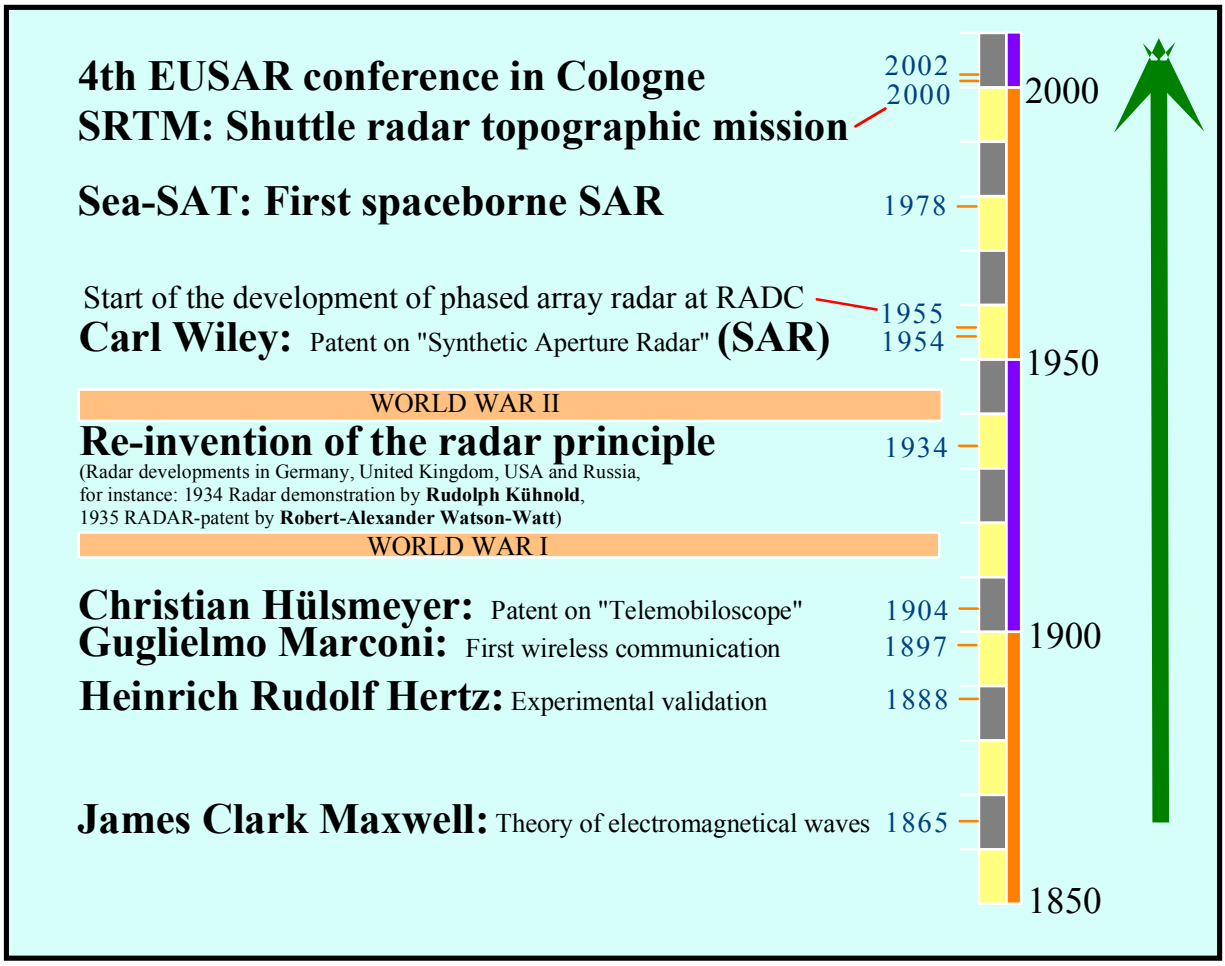
a coherer built at our labratory, it even reacted on the Neon lights. So we cancelled our original plan.

A further problem of Hülsmeyer's invention: There was no real frequency separation. Two ships equipped with telemobiloscopes certainly would interfere to each other.

So, the original device would not have been used as an operational ship equipment on a large number of ships. Nevertheless, today we cannot understand, why this invention was not further developed.

7. Further history of radar

But in the same year, 1904, the diode tube was invented and three years later the triode. This was the first unit for real signal amplification.



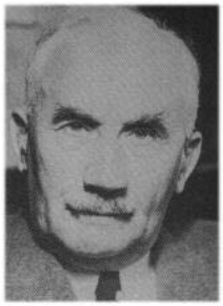
In 1924 wave traveling time measurements were successful, and in 1929 antennas with directional patterns were developed by Yagi. So, in the thirties the time was mature for a re-invention of radar. The further development of radar certainly is known to you, it is an infinite story, so I indicate only some milestones ....

In Germany, UK. , USA. and Russia operational radar systems were developed independently. In a way as a repetition of Hülsmeyer's experiments, Rudolf Kühnold demonstrated his radar in October 1934 to the German navy. But this time the success of this device lead to a series production of the system FREYA.

You know that world war II had pushed the further development of radar. 1954 the patent on "Synthetic Aperture Radar" (SAR) was filed, in 1978 the first SAR satellite SEASAT was launched and the progression runs further and further so that we are witness of many new ideas and results at this EUSAR conference.

8. Curriculum vitae II

Let's come back to Christian Hülsmeyer! After he had demonstrated his invention to a world wide public, he earned much approval. His invention was patented in many countries. But as far as we know, nobody has bought any of the telemobiloscope patents. As an example I show to you a letter of the Telefunken company dated 21.8.1905. This letter states, that the company doesn't see any application of this invention ...


Christian Hülsmeyer 1955

In 1905 Hülsmeyer terminated his radar activities, 1907 he founded the company "Kessel- und Apparatebau Christian Hülsmeyer, Düsseldorf". During the further years he developed and patented 180 inventions at home and abroad related to other fields than radar.

For the invention of the telemobiloscope he was honoured by many leading personalities of Germany, e.g. by Bundeskanzler Konrad Adenauer.

After a rich life full of ideas and projects he died at the 31.1.1957 during a residence at Ahrweiler – not far from here – and was buried at the northern cemetery of Düsseldorf at the Rhine.

9. Concluding remarks

Now let me give some concluding remarks. Many people have argued about the question: Was the telemobiloscope a radar or was it not? That the abbreviation RADAR was invented 30 years later, cannot be the answer. Also the claim, that radar includes ranging as a indispensable part, does not solve the problem, since he *had* a kind of distance measurement.

So let us carefully summerise:

1) Hülsmeyer has demonstrated that he could use the reflection of distant ships to detect them. His apparatus had a range of about 3 km.
2) He could not measure the distance due to travel time of the waves, instead of this he intended to use an angular measurement method for this purpose.
3) The device made use of a large part of the spectrum and would never have got the license from the todays offices for telecommunication.
4) The electrical parts available at 1904 were not usable for real operating radar systems, there was no tube, no amplifier, no reliable electronic detector.

So, again: Was it a radar or not? I think we can go contentedly into the evening with the following compromise formula:

"Christian Hülsmeyer was the first who demonstrated and patented the core of the radar principle, namely to detect distant objects by the reflection of electromagnetic waves".

And that's the end of my presentation, I hope you have enjoyed it a little. I wish you a pleasant further evening.