



URSI: perspectives into the past and present of Radio Science

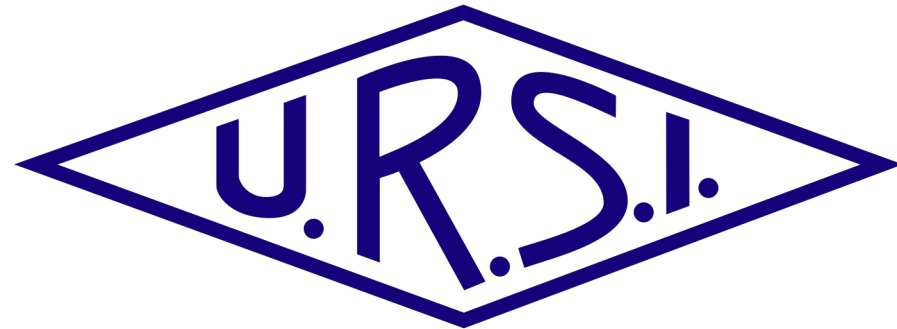
Ari Sihvola

President of the International Union of Radio Science

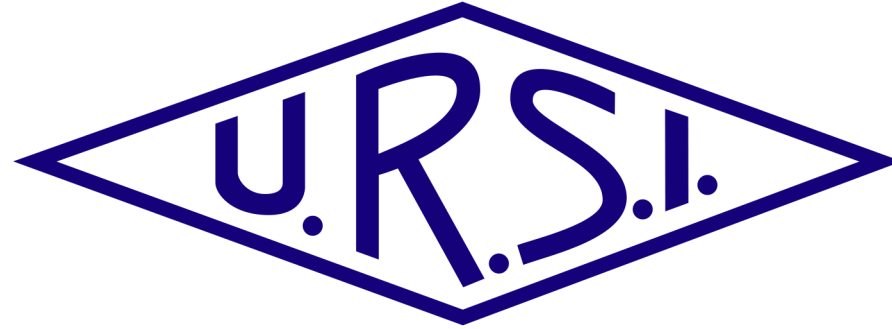
Aalto University, Finland



Union Radio-Scientifique Internationale



International Union of Radio Science



is a non-governmental and non-profit organisation under the International Council for Science, responsible for stimulating and co-ordinating, on an international basis, studies, research, applications, scientific exchange, and communication in the fields of radio science

The 3000-year road to modern radio science

Historical milestones:

Amber and lodestone

Static electricity and magnetism

Electromagnetics

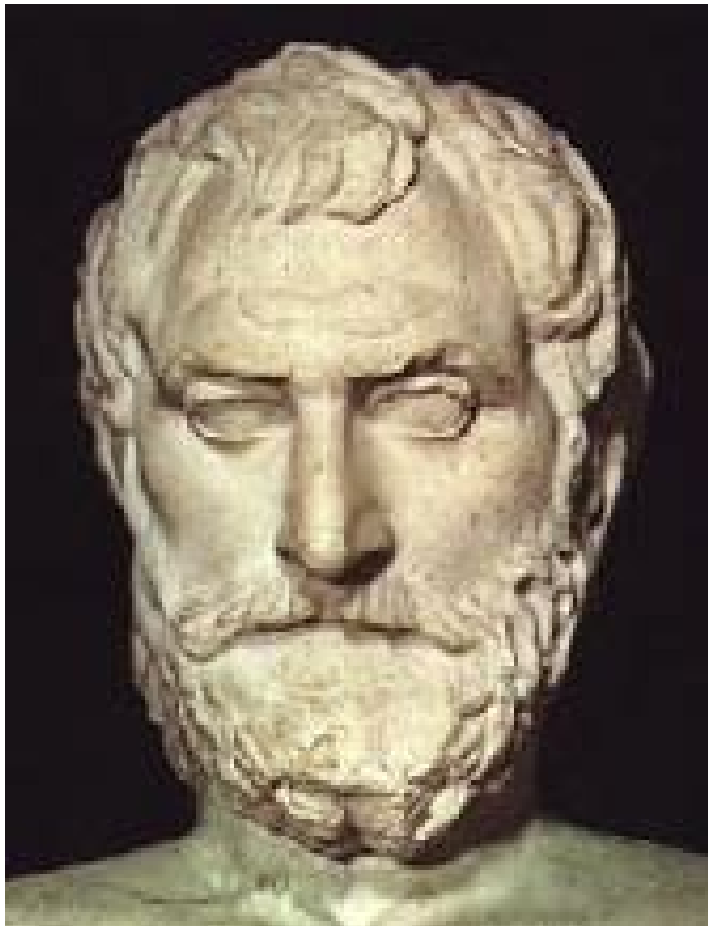
Wireless communications

International collaboration: URSI

- Thales and Lucretius
- Peregrinus and Gilbert
- Franklin and Coulomb
- Volta, Ørsted, Ampère
- Faraday and Maxwell
- Hertz, Popov, Marconi



Thales (624–546 BC)



ηλεκτρον

electron

electricitas

elettricità



electricidad



électricité



electricity



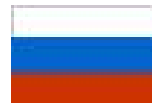
elektricitet



Elektrizität



электричество



elekter



ηλεκτρον

eletricidade



sähkö

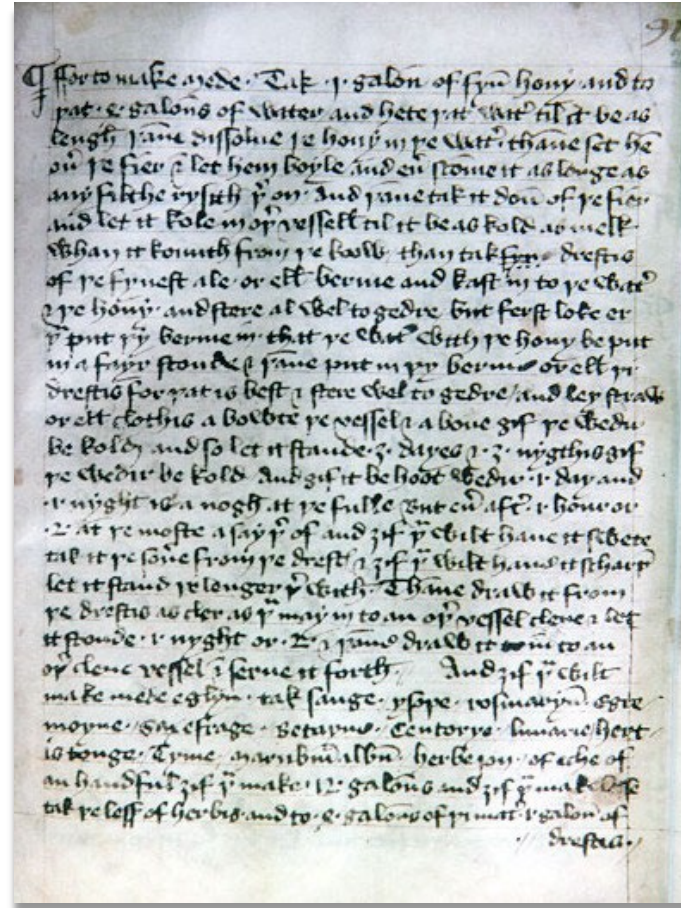


Petrus Peregrinus (Pierre de Maricourt)

Part 1: 10 chapters (magnets)
Part 2: 3 chapters (compass and
perpetuum mobile)

*Epistola
Petri Peregrini
de Maricourt
ad Sygerum
de Foucaucourt*

(1269)



William Gilbert (1544–1603)



Tractatus, sive Physiologia Nova
DE
MAGNETE,
Magneticisq; corporibus & magno
Magnete tellure, sex libris comprehensus.

a **GUILIELMO GILBERTO** Colce-
strensi, Medico Londinensi.

*In quibus ea, quae ad hanc materiam spectant, plurimis
& Argumentis & experimentis exactissime absolutissi-
meq; tractantur & explicantur.*

Omnia nunc diligenter recognita, & emendatius quam ante
in lucem edita, aucta & figuris illustrata, opera & studio D.
WOLFGANGI LOCHMANS, I. U. D.
& Mathematici.

*Ad calcem libri adiunctus est Index capitum, Rerum & Verborum
locupletissimus, qui in prioribus editionibus desiderabatur.*



SEDINI,
Typis GOTZIANIS:
ANNO M. DC. XXXIII.

FAC-SIMILE TITLE PAGE OF GILBERT'S "DE MAGNETE," THIRD EDITION.

Tractatus sive Physiologia Nova de Magnete, magneticisque Corporibus, et de magno Magnete Tellure; sex libris comprehensus; plurimis & argumentis & experimentis demonstrata



- Book I: Ancient and modern writings on the Loadstone
- Book II: On Magnetick Motions
- Book III: On Direction (turning towards magnetic poles)
- Book IIII: On Variation (declination)
- Book V: On Declination (inclination)
- Book VI: On the Globe of the earth, the great magnet (Earth rotation caused by magnetic force)
- Of electricity only one chapter in Book II

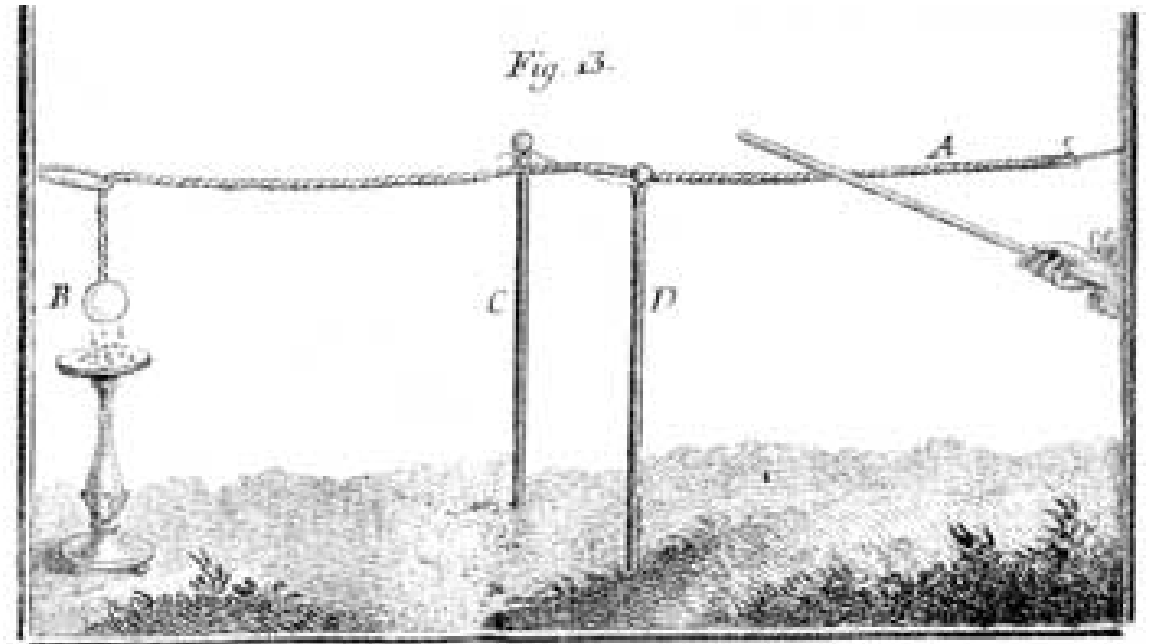
Stephen Gray

(1666–1736)

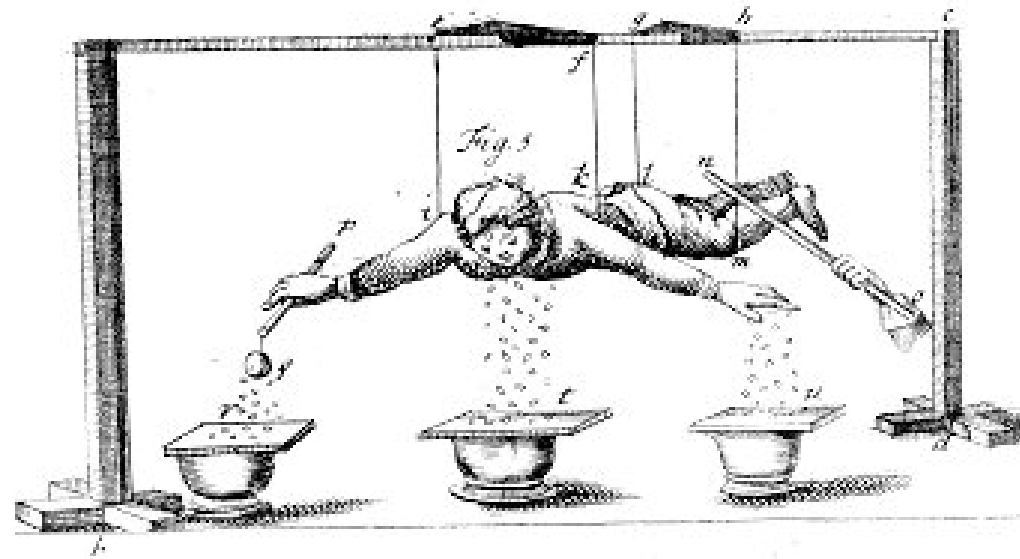
Conduction of electricity



The first Experiment was made in the matted Gallery July 2, 1729, about Ten in the Morning. About four Feet from the End of the Gallery there was a cross Line that was fixed by its Ends to each Side of the Gallery by two Nails; the middle Part of the Line was Silk, the rest at each End Packthread; then the Line to which the Ivory Ball was hung, and by which the Electric Vertue was to be conveyed to it from the Tube, being eighty Feet and a half in Length, was laid on the cross Silk Line, so as that the Ball hung about nine Feet below it: Then the other End of the Line was by a Loop suspended on the Glass Cane, and the Leaf-Brass held under the Ball on a Piece of white Paper; when the Tube being rubbed, the Ball attracted the Leaf-Brass, and kept it suspended on it for some Time.



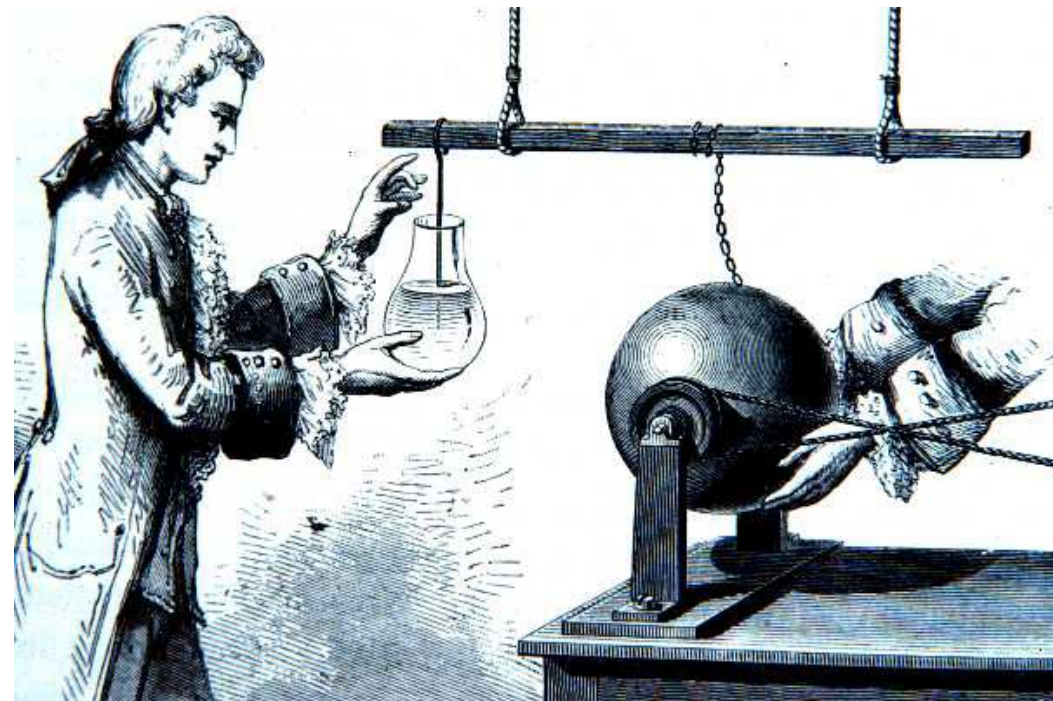
Electricity in the 18th century

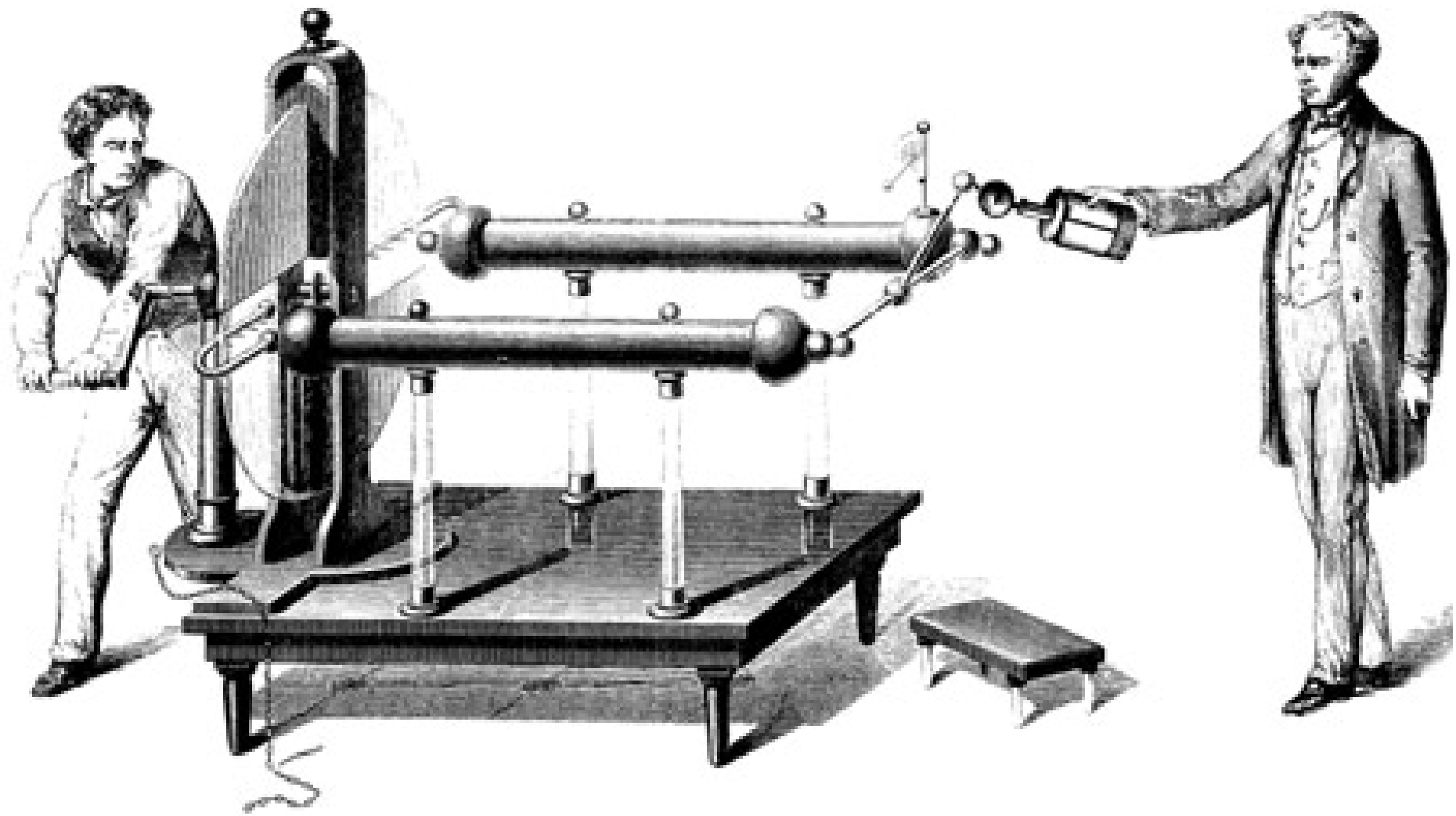


Leyden jar

Ewald Jürgen von Kleist (Pommer 1745)

Pieter van Musschenbroek (Leyden 1746)





Leyden jar ... excellent capacitor



PENGUIN CLASSICS

BENJAMIN FRANKLIN

The Autobiography and Other Writings



Benjamin Franklin
(1706–1790)



Alessandro Volta (1745–1827)

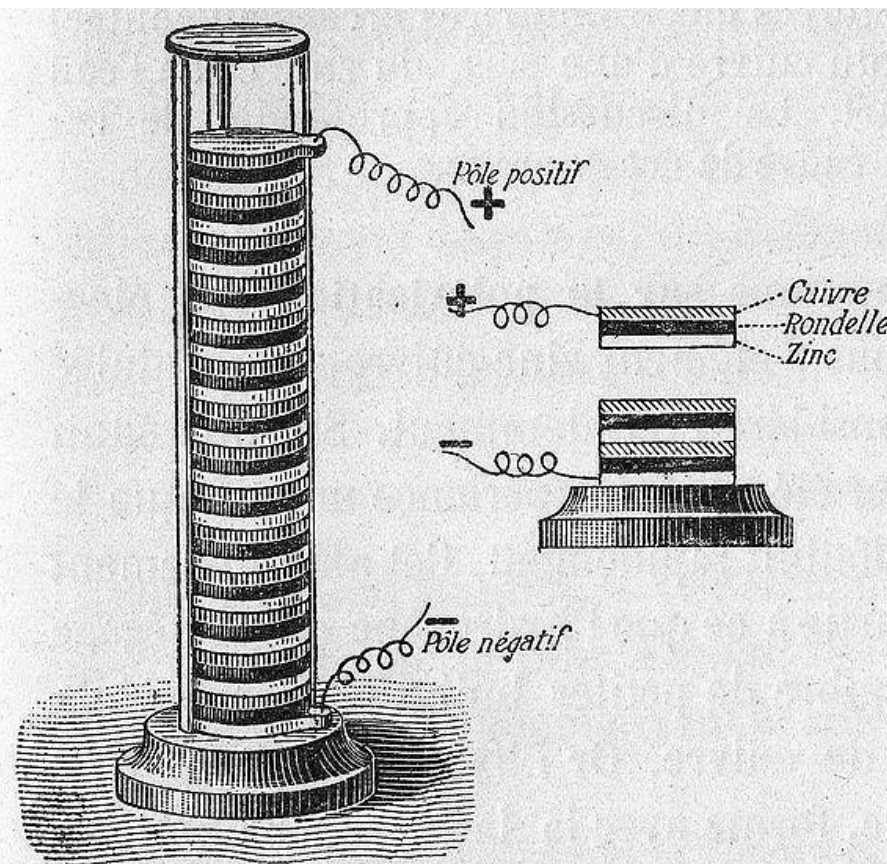
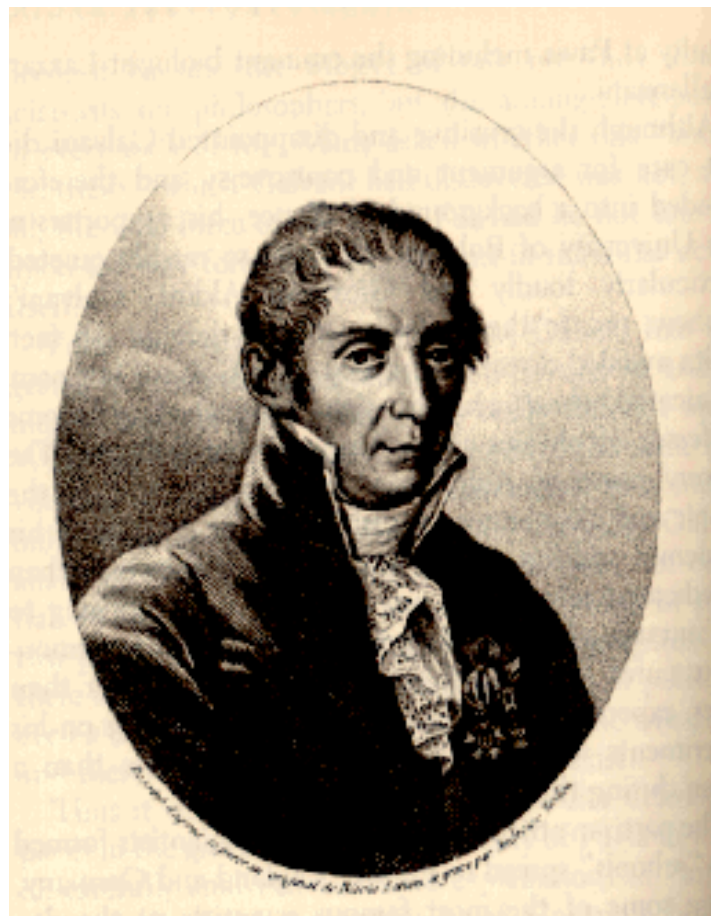


Fig. 283. — Pile de Volta.

THE
PHILOSOPHICAL MAGAZINE.

SEPTEMBER 1800.

I. *On the Electricity excited by the mere Contact of conducting Substances of different Kinds. In a Letter from Mr. ALEXANDER VOLTA, F.R.S. Professor of Natural Philosophy in the University of Pavia, to the Right Hon. Sir JOSEPH BANKS, Bart. K.B. P.R.S.**

Como in the Milanese, March 20, 1800.
AFTER a long silence, for which I shall offer no apology, I have the pleasure of communicating to you, and through you to the Royal Society, some striking results I have obtained in pursuing my experiments on electricity excited by the mere mutual contact of different kinds of metal, and even by that of other conductors, also different from each other, either liquid or containing some liquid, to which they are properly indebted for their conducting power. The principal of these results, which comprehends nearly all the rest, is the construction of an apparatus having a resemblance in its effects (that is to say, in the shock it is capable of making the arms, &c. experience) to the Leyden flask, or, rather, to an electric battery weakly charged acting incessantly, which should charge itself after each explosion; and, in a word, which should have an inexhaustible charge, a perpetual action or impulse on the electric fluid; but which differs from it essentially both by this continual action, which is peculiar

* Translated from the author's paper published in French in the Philosophical Transactions for 1800, part 2.



Hans Christian Ørsted (1777–1851)



July 1820



EXPERIMENTA

CIRCA EFFECTUM

CONFLICTUS ELECTRICI IN ACUM

MAGNETICAM.

Prima experimenta circa rem, quam illustrare aggredior, in scholis de Electricitate, Galvanismo et Magnetismo proxime-superiori hieme a me habitis instituta sunt. His experimentis monstrari videbatur, acum magneticam ope apparatus galvanici e situ moveri; idque circulo galvanico cluso, non aperto, ut frustra tentaverunt aliquot

Dabam Hafniæ d. 21de Julii 1820.

Johannis Christianus Ørsted.

Eques auratus Ordinis Dannebrogici, in Universitate Haf
niensi Prof. Physices Ord. Secretarius Societatis
Regiæ Scientiarum Hafniensis.

André-Marie Ampère (1775–1836)



THÉORIE
DES
PHÉNOMÈNES ÉLECTRO-DYNAMIQUES,
UNIQUEMENT DÉDUITE DE L'EXPÉRIENCE,

PAR ANDRÉ-MARIE AMPÈRE,

DE L'ACADÉMIE ROYALE DES SCIENCES, DE LA SOCIÉTÉ PHILOMATIQUE, DE LA SOCIÉTÉ ROYALE D'ÉDIMBOURG, DE LA SOCIÉTÉ HELVÉTIENNE DES SCRUTATEURS DE LA NATURE, DE LA SOCIÉTÉ PHILOSOPHIQUE DE CAMBRIDGE, DE CELLE DE PHYSIQUE ET D'HISTOIRE NATURELLE DE GENÈVE, DE L'ACADÉMIE ROYALE DES SCIENCES ET BELLES-LETTRES DE BRUXELLES ET DE L'ACADÉMIE ROYALE DE LISBONNE, CHEVALIER DE LA LÉGION-D'HONNEUR, PROFESSEUR A L'ÉCOLE POLYTECHNIQUE ET AU COLLÈGE DE FRANCE.



A PARIS,

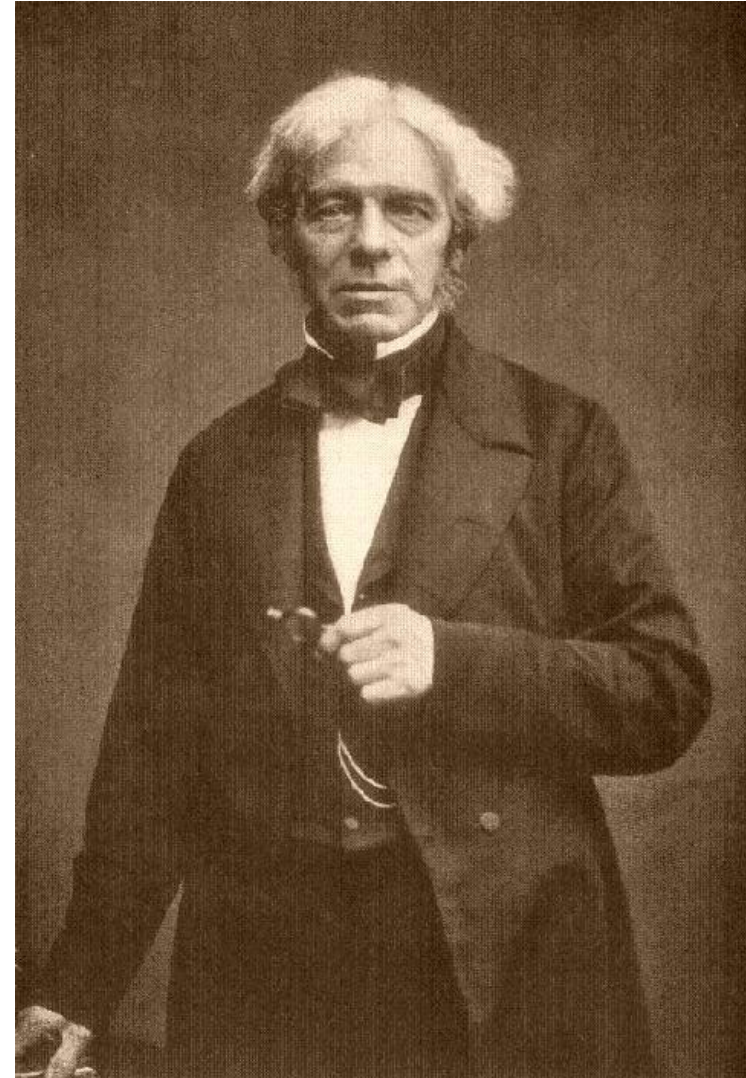
CHEZ MÉQUIGNON-MARVIS, LIBRAIRE-ÉDITEUR, RUE DU JARDINET, N° 13.
ET A BRUXELLES, AU DÉPÔT GÉNÉRAL DE LIBRAIRIE MÉDICALE FRANÇAISE.

NOVEMBRE 1826.



Michael Faraday (1791–1867)

- electromagnetic induction (1831)
 - Faraday law, Faraday cage, Faraday rotation, generator, rotator, permittivity, electrochemistry, diamagnetism, concept of field



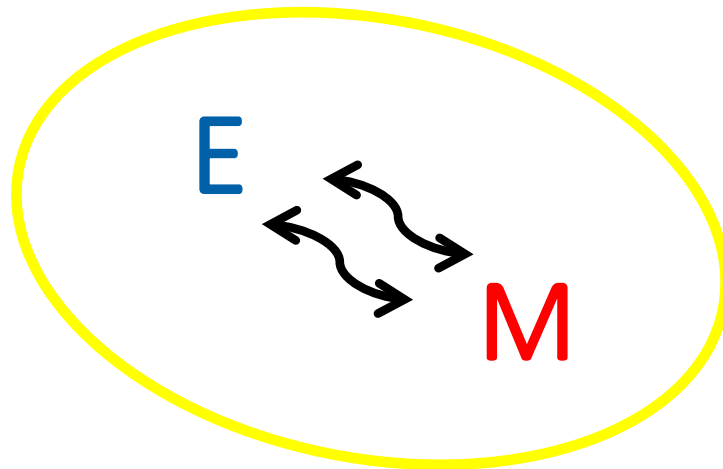
$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\text{EMF} = -\frac{\partial \Phi}{\partial t}$$

— full interaction of electricity and magnetism—

$E \rightarrow M$

$M \rightarrow E$



James Clerk Maxwell (1831–1879)



$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$$

$$\nabla \cdot \mathbf{D} = \rho$$

$$\nabla \cdot \mathbf{B} = 0$$



Heinrich Hertz (1857–1894)

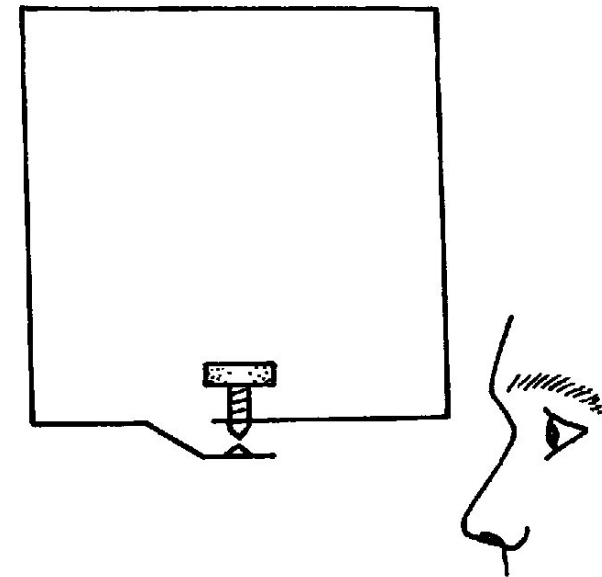
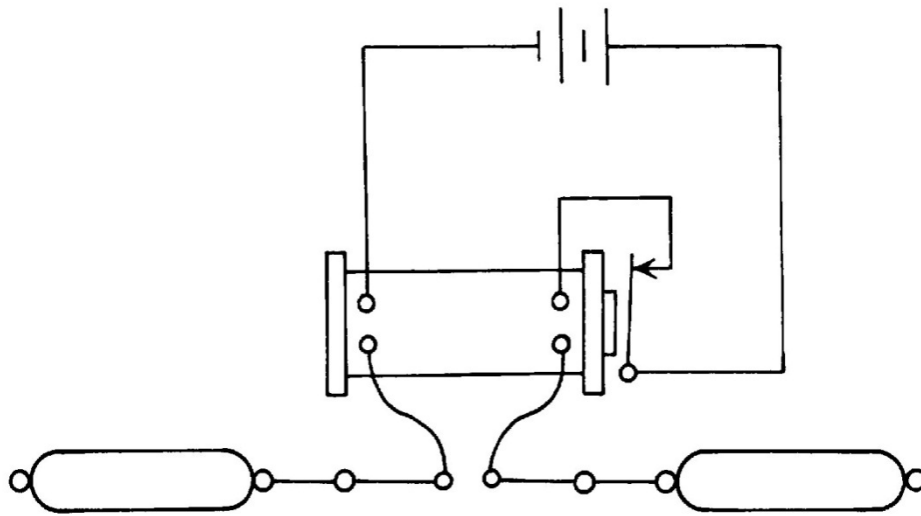


- experiments 1888: electromagnetic waves as light
- except: through walls and past corners
- a dipole radiates well, especially when half-wave
- fast current variations? oscillating spark!



Hertz' experiments 1887–88

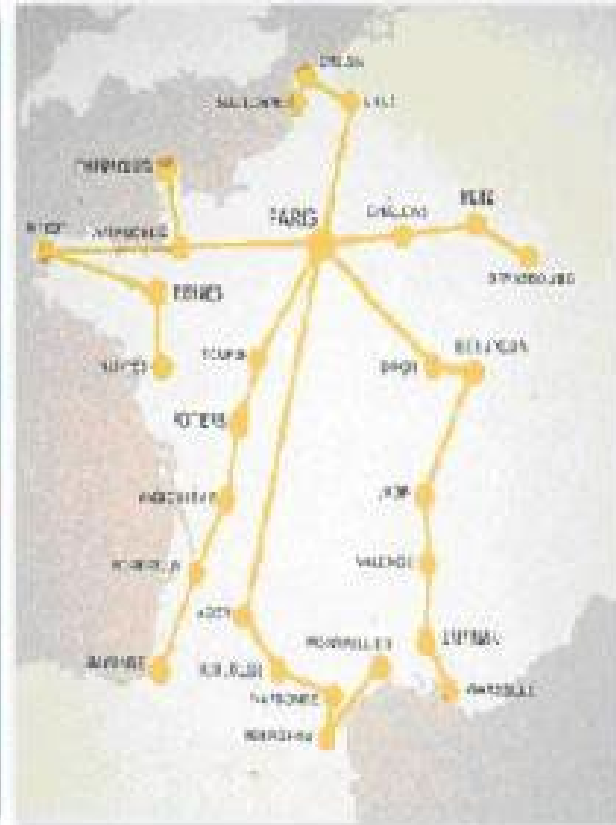
50 MHz (inductor + "dipole antenna")



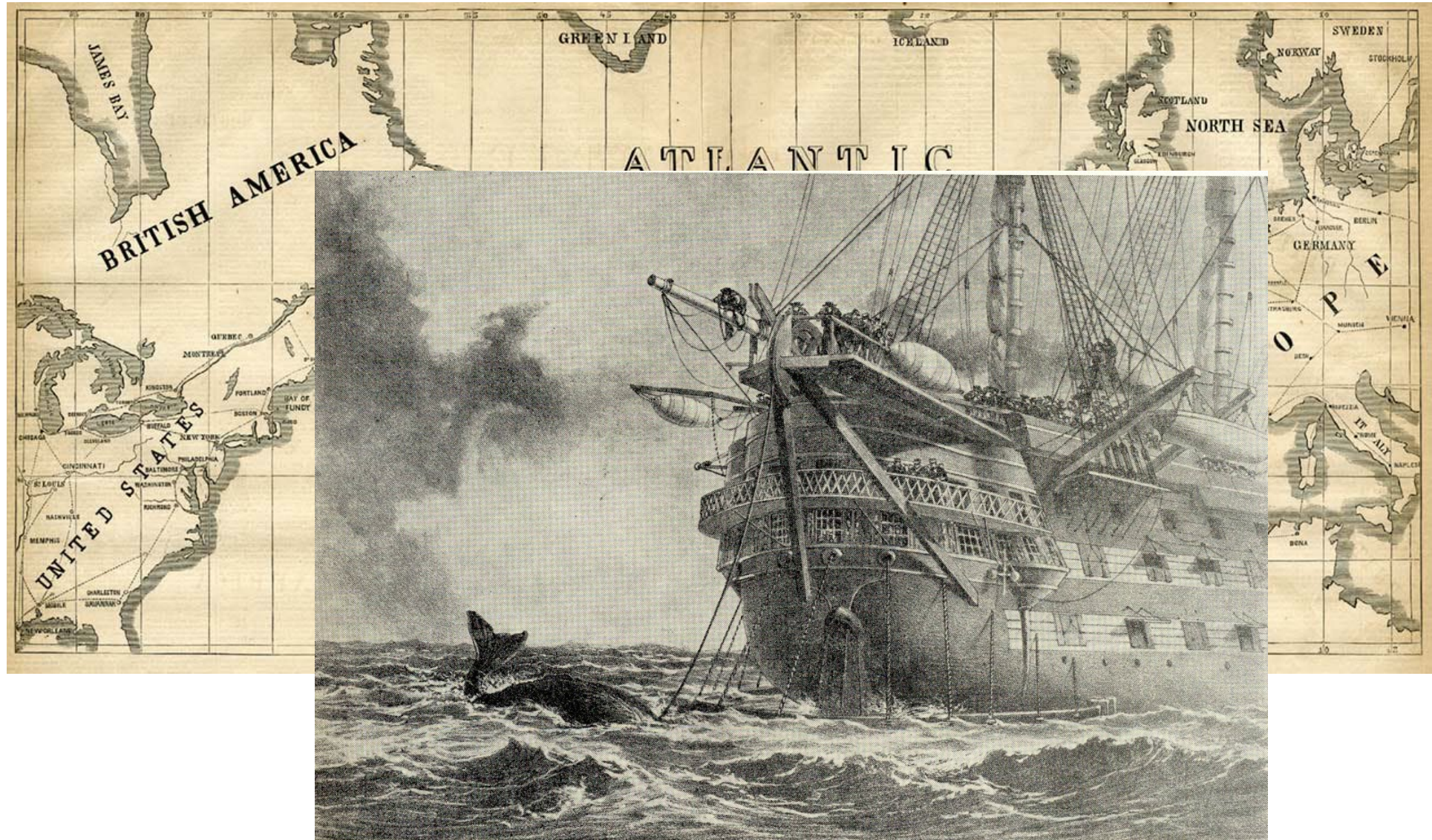
Towards wireless:

- Optical telegraph
- Resistive telegraph
 - conduction of electricity
- Inductive telegraph
 - induction (electro/magnetostatic)
- Electromagnetic telegraph
 - radio waves

Claude Chappe (1763–1805)



Wired telegraph



William Henry Preece (1834–1913)

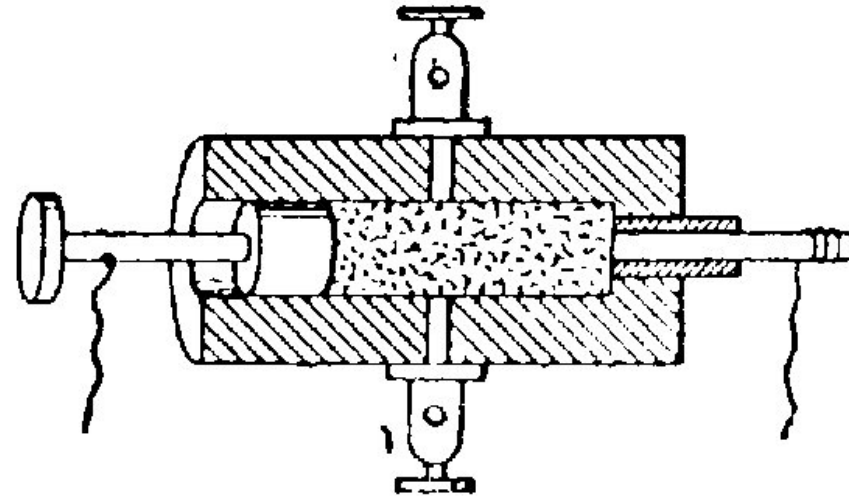
Chief Electrician of British Post Office



The Americans have need of the telephone, but we do not. We have plenty of messenger boys.

Detector of radio waves, **coherer**

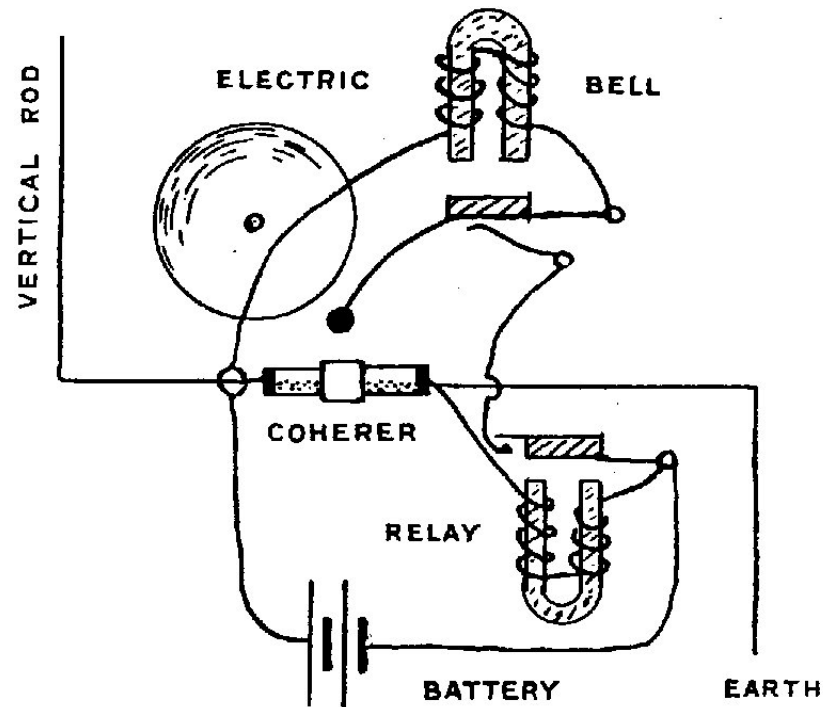
- galvanometer
 - not sensitive to AC
- loudspeaker
 - not sensitive to fast variations
- Hertz spark gap
 - weak sensitivity



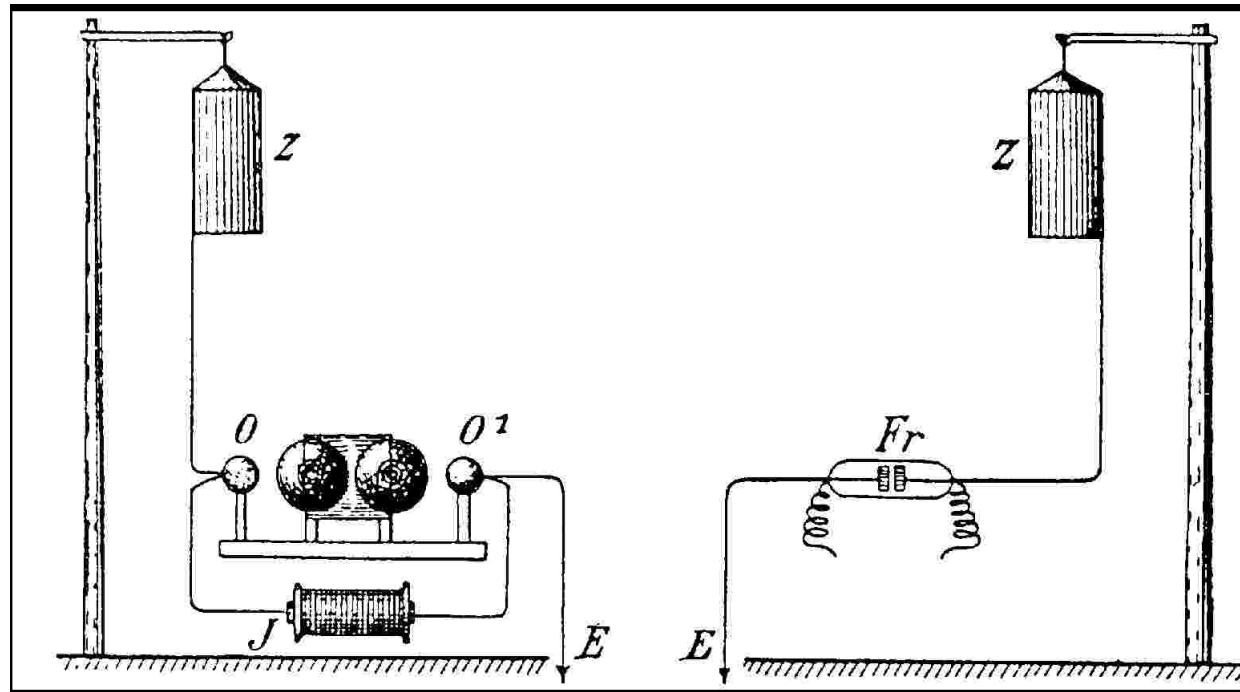
- 1890 Eduard Branly
 - discharging Leyden jar reduces greatly the resistance of metal powder; shaking restores the resistance
- 1892 Oliver Lodge
 - (electric cohesion), (Branly: "radioconductor")

Aleksandr Stepanovich Popov (1859–1906)

- was aware of the experiments by Lodge
- 1895: receiver for thunderstorm detection

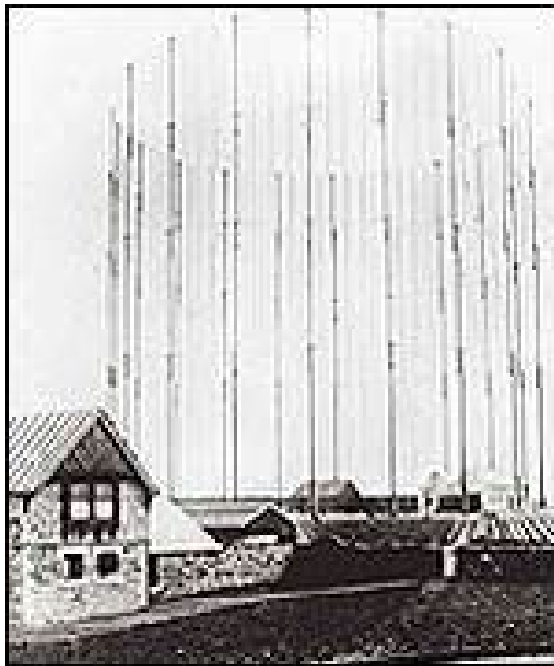


Guglielmo Marconi (1859–1905)

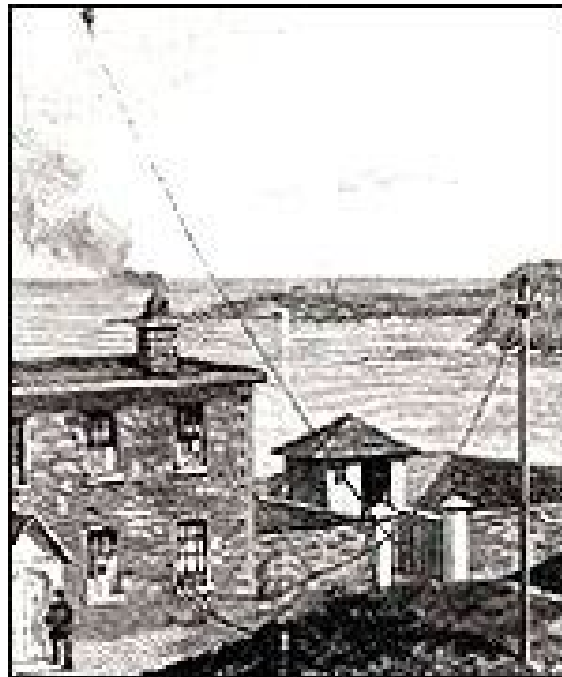


Over the Atlantic

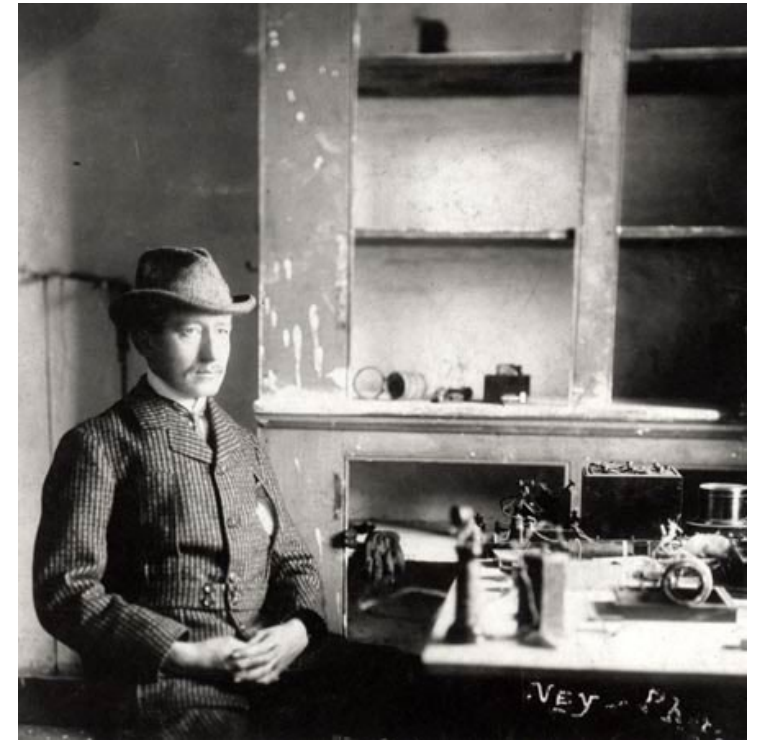
- 12 December 1901
- Poldhu (Cornwall) – Signal Hill (Newfoundland)
2900 km !



Poldhu



Signal Hill



Towards international co-operation

- Maritime radio (Titanic 1912)
- Companies (de Forest, Telefunken, Marconi)
- Competition, interference
 - need for administration and frequency allocation
- Belgium: King Leopold II and King Albert I
 - communications in Congo with radio links
 - Dr. Robert Goldschmidt
- International Research Council 1919

- 1914: *Commission provisoire international de télégraphie sans fil scientifique*
- 1919: *Union internationale de radiotélégraphie scientifique*
- 1st General Assembly: July 1922 Brussels
 - Belgium
 - France
 - United Kingdom
 - USA
- Commissions in 1922:
 - Measurement Methods and Standardization
 - Radio Propagation
 - Electromagnetic Field
 - Radio Goniometry
 - Atmospheric Disturbances
 - Liaison with Operators, Practitioners, and Amateurs
- 2nd General Assembly: Washington D.C., 1927
 - 11 Member Committees
 - Wave propagation, ionosphere

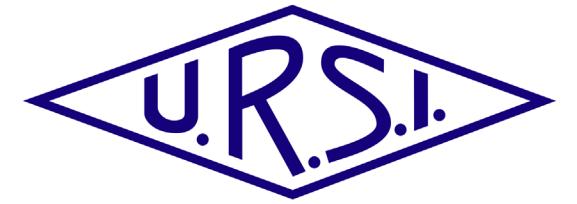




URSI Union Radio Scientifique Internationale
International Union of Radio Science

- **Commission A** Electromagnetic Metrology
- **Commission B** Fields and Waves
- **Commission C** Radiocommunication Systems and Signal Processing
- **Commission D** Electronics and Photonics
- **Commission E** Electromagnetic Environment and Interference
- **Commission F** Wave Propagation and Remote Sensing
- **Commission G** Ionospheric Radio and Propagation
- **Commission H** Waves in Plasmas
- **Commission J** Radio Astronomy
- **Commission K** Electromagnetics in Biology and Medicine

General Assembly (and Scientific Symposium)



- Scientific Programme: Progress + state of the art
- Science vs. technology ?
- Community
 - Global coverage, relations to sister Unions and ICS, ITU, publications
- Awards
- Young Scientists Programme & Student Paper Competitions
- Membership issues (free, benefits, reduced fees, correspondence, discounted page charges)

- 1st GA: Brussels (1922)
- 2nd GA: Washington D.C. (1927)
- 3rd GA: Brussels (1928)
- 4th GA: Copenhagen (1931)
- 5th GA: London, UK (1934)
- 5th GA: Venice and Rome (1938)
-
- 33rd GASS: Montréal (2017)
- 34th GASS: Rome (2021)
- 35th GASS: Sapporo (2023)
- 36th GASS: Krakow (2026)

Member Committees Worldwide

44 Member committees



100 Years of the International Union of Radio Science



Editors

Philip Wilkinson | Paul S. Cannon | W. Ross Stone

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