
# De begintijd van de radio

## *deel 1: van Funk tot CW*

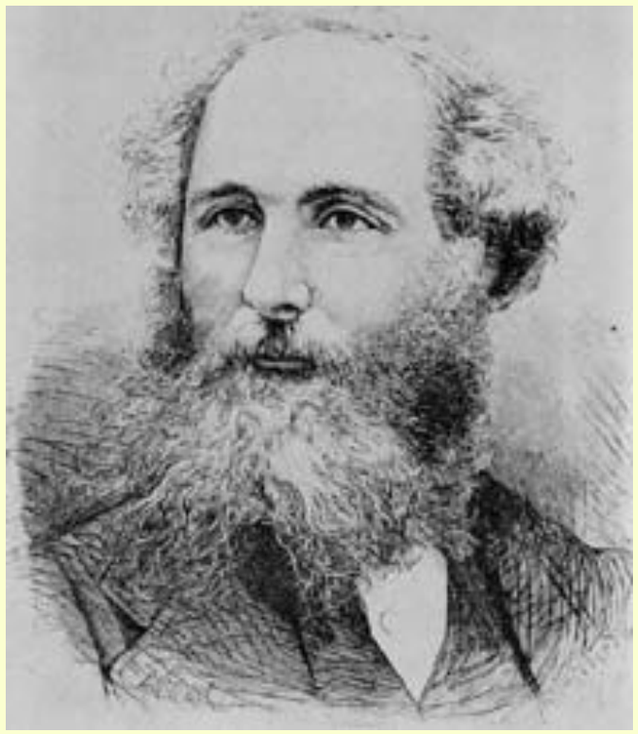
Edo Dooijes  2007  /2016

- wegbereiders van de radio
- vonkzenders
- detectors
- eerste stappen naar Continous Wave:
  boogzender, machinezender

Charles Coulomb, 1736-1806

André Ampère, 1775-1836

Michael Faraday, 1791-1867



# James Clerk Maxwell, 1831-1897

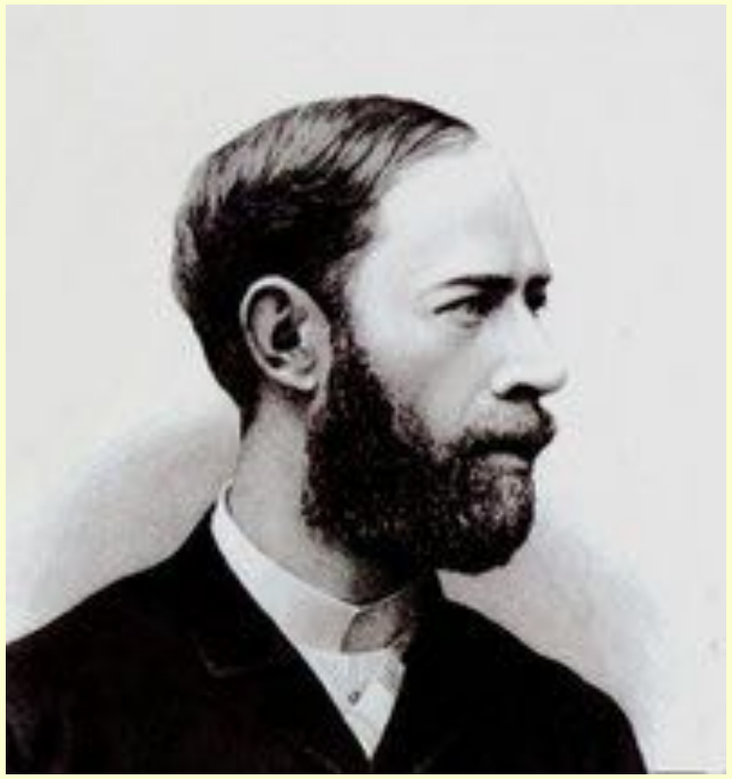
$$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}$$

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

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

$$\nabla \times \mathbf{B} = \mu_0\mathbf{J} + \epsilon_0\mu_0\frac{\partial \mathbf{E}}{\partial t}$$

De Maxwellvergelijkingen (1873)



# Heinrich Rudolf Hertz, 1857-1894

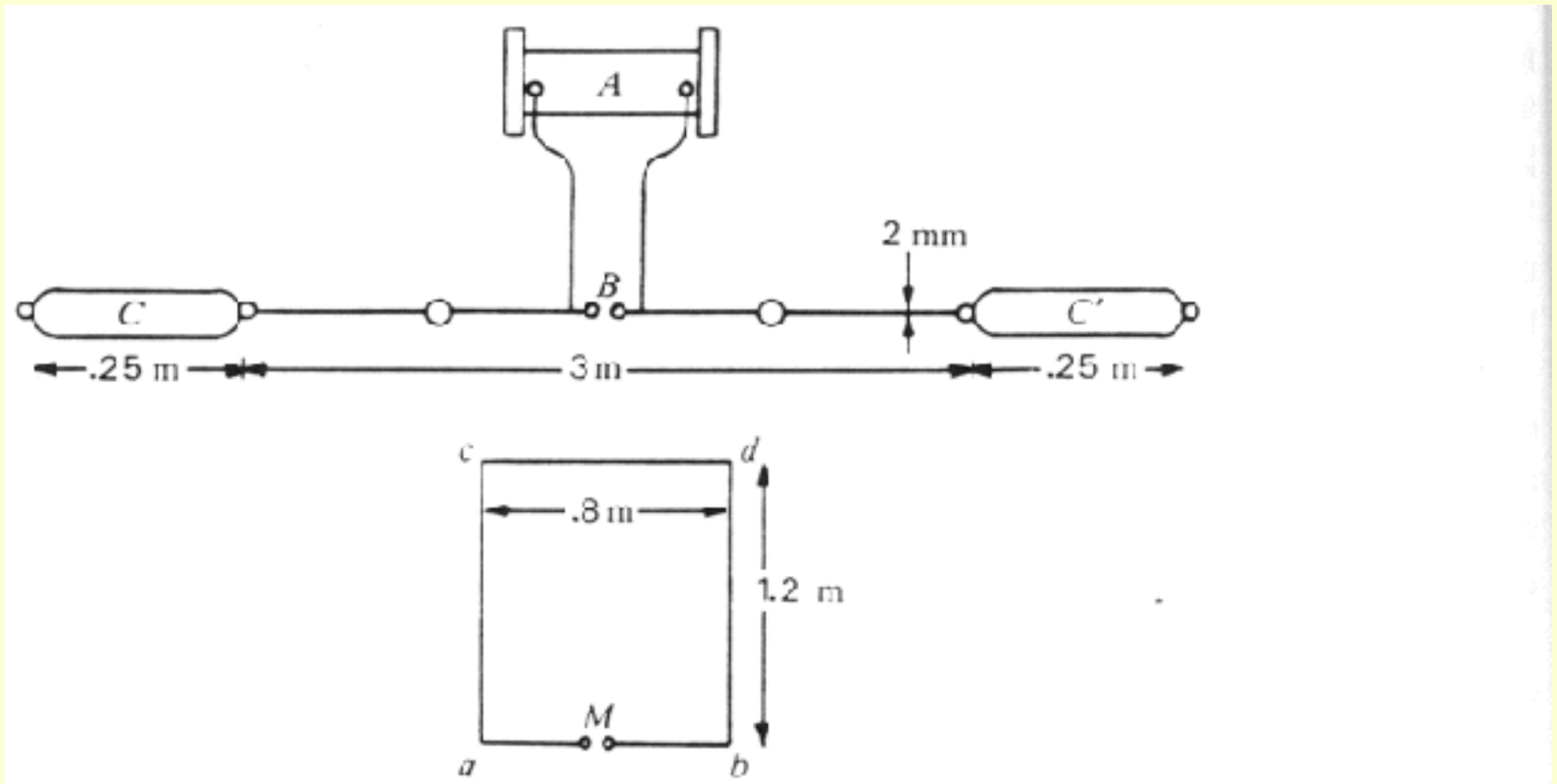
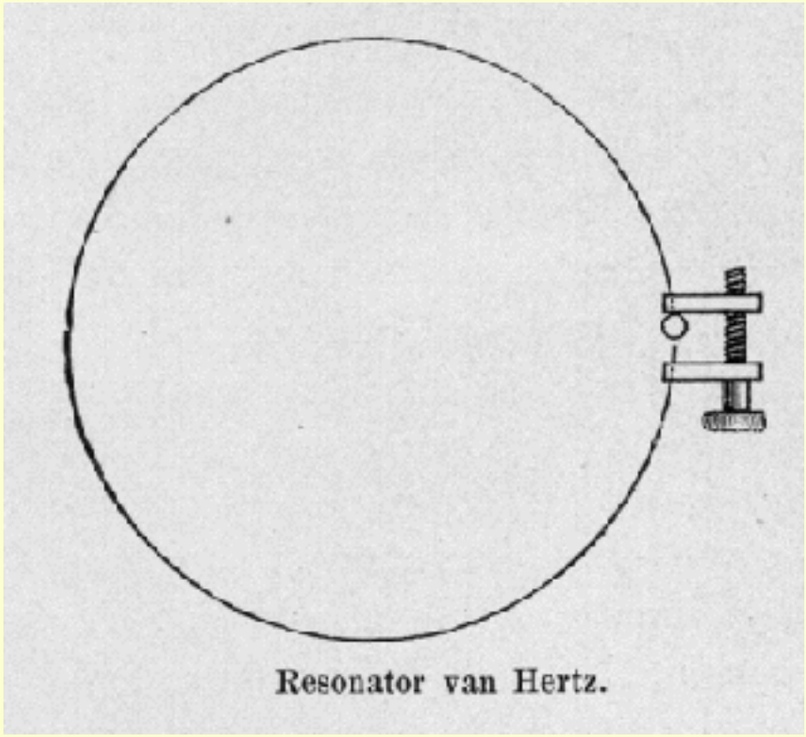
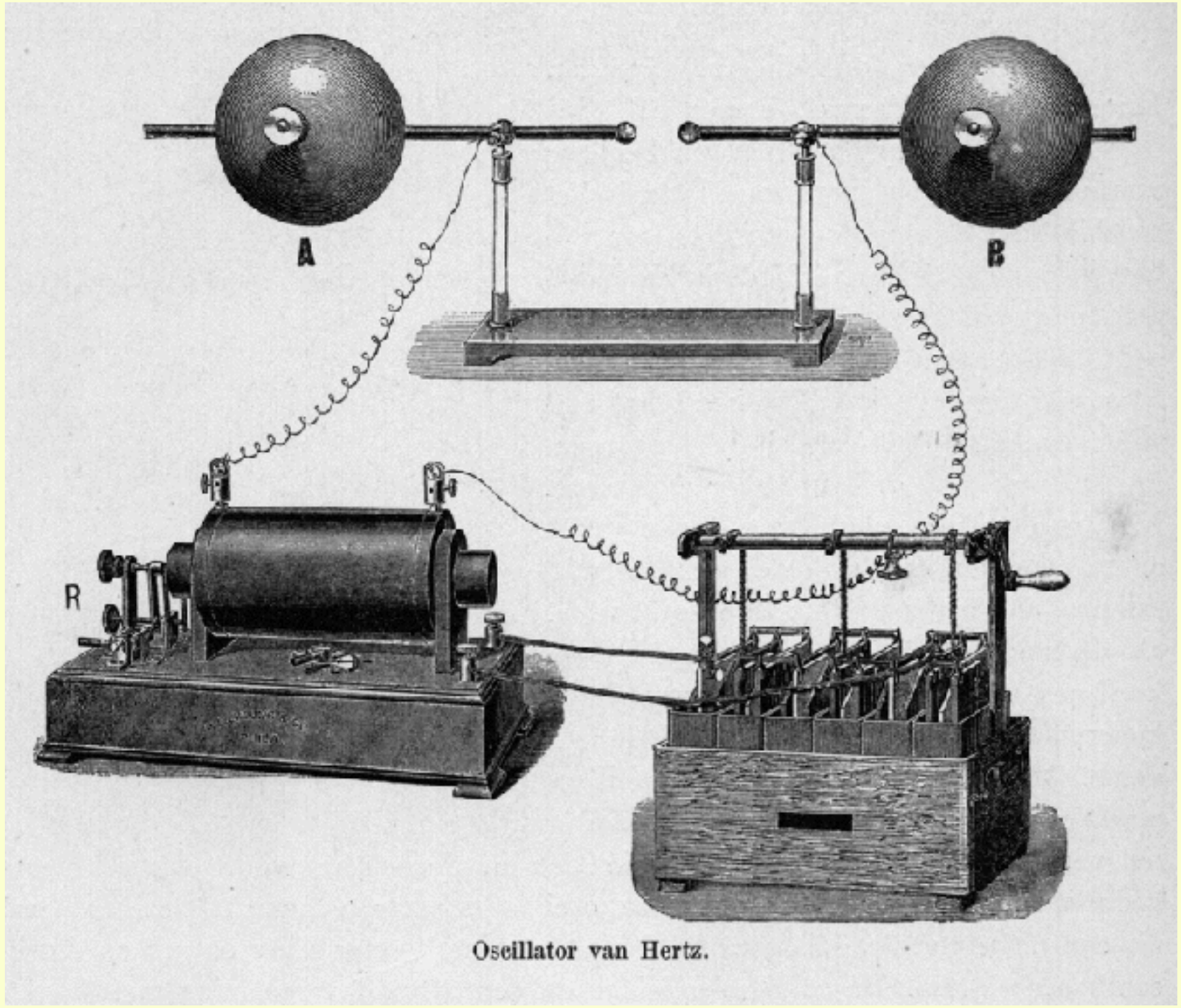



**Figure 1-1** Heinrich Hertz's complete radio system of 1886 with end-loaded dipole transmitting antenna ($CC'$) and resonant loop receiving antenna ($abcd$) for $\lambda \simeq 8$ m. With induction coil ($A$) turned on, sparks at gap $B$ induced sparks at $M$ in the loop receiving antenna. (*From Heinrich Hertz's book Electric Waves, Macmillan, 1893; redrawn with dimensions added.*)

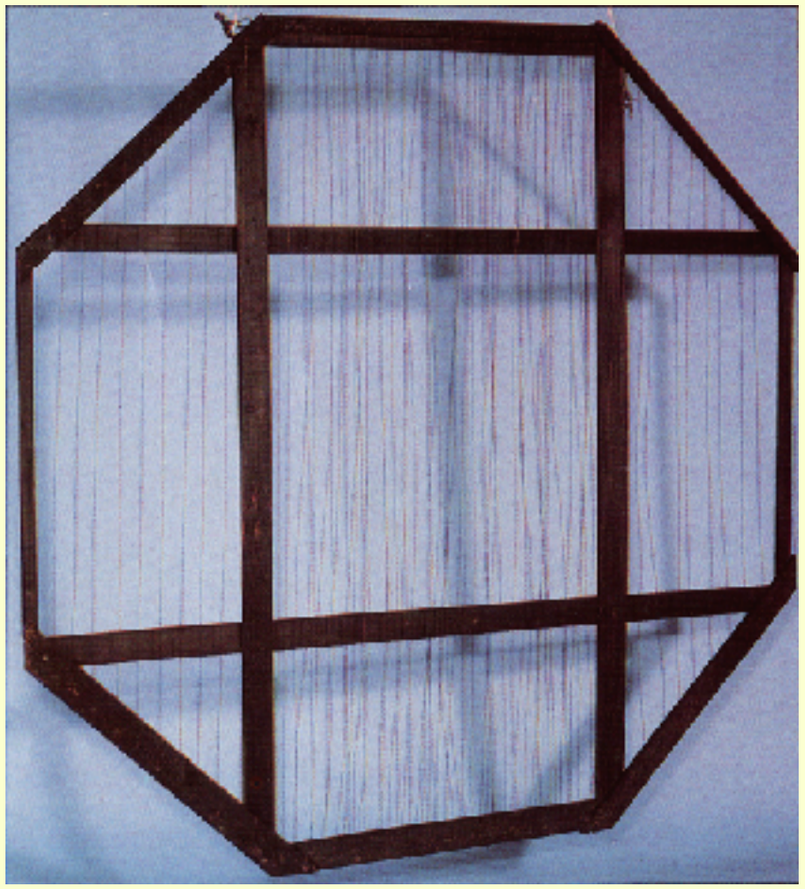
Test
Maxwellvergelijkingen
1885-1889

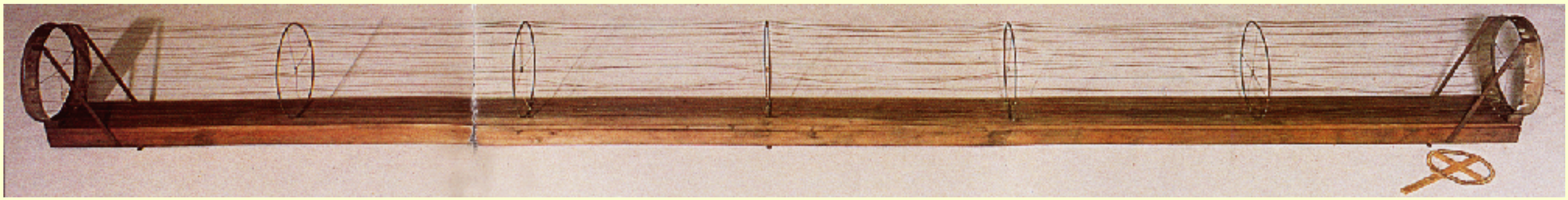


Resonator van Hertz.




Oscillator van Hertz.





# Aleksandr Stepanowitsj Popov
# 1859-1906

1895 verbinding over 500 meter

1900 redding van de Apraksin in de Finse golf

# Karl Ferdinand Braun, 1815-1918

puntcontact gelijkrichter 1874

'Braunse buis' 1897

tankkring ('jigger') 1897

raamantenne 1913

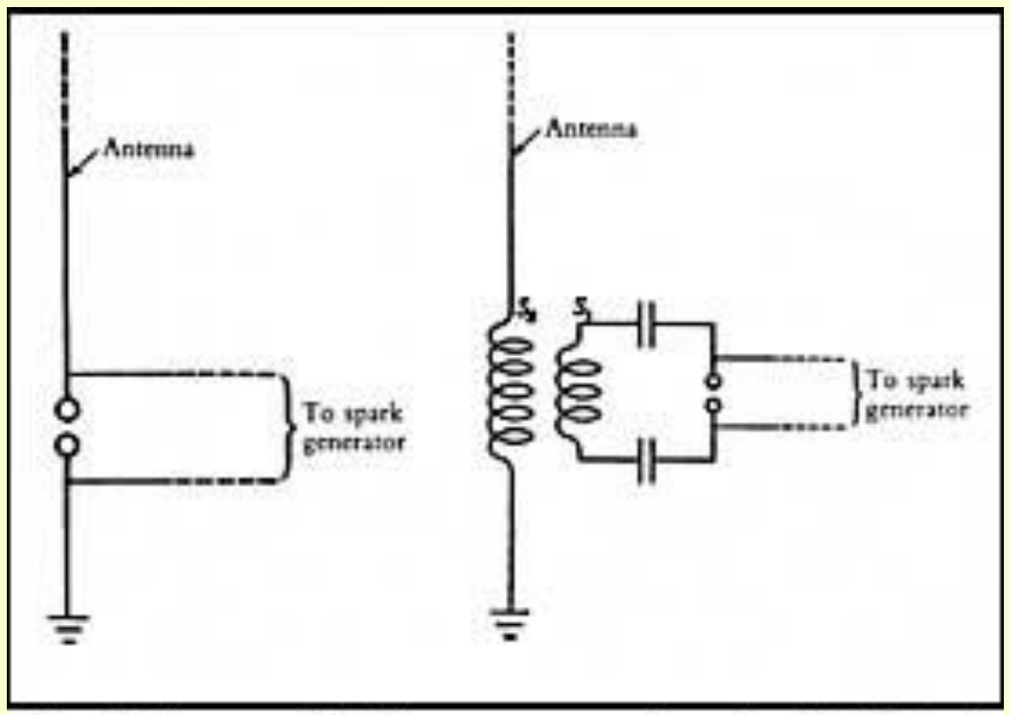



Fig.2. Direct or "tight" antenna coupling circuit (left) and Braun's "loose" coupling circuit (right).

# Guglielmo Marconi  1874-1937

1895 draadloos over 2 km in Italië

1900 British Patent 7777 (syntonic communication)

1901 Cornwall - Newfoundland,  3425 km

1909 Nobelprijs natuurkunde, gedeeld met Braun

1922 herwaardering korte golf

To the Dutch Radio Society
with all best wishes.
Guglielmo Marconi
1926

Marconi ontvangt op Signal Hill
(Newfoundland)

…

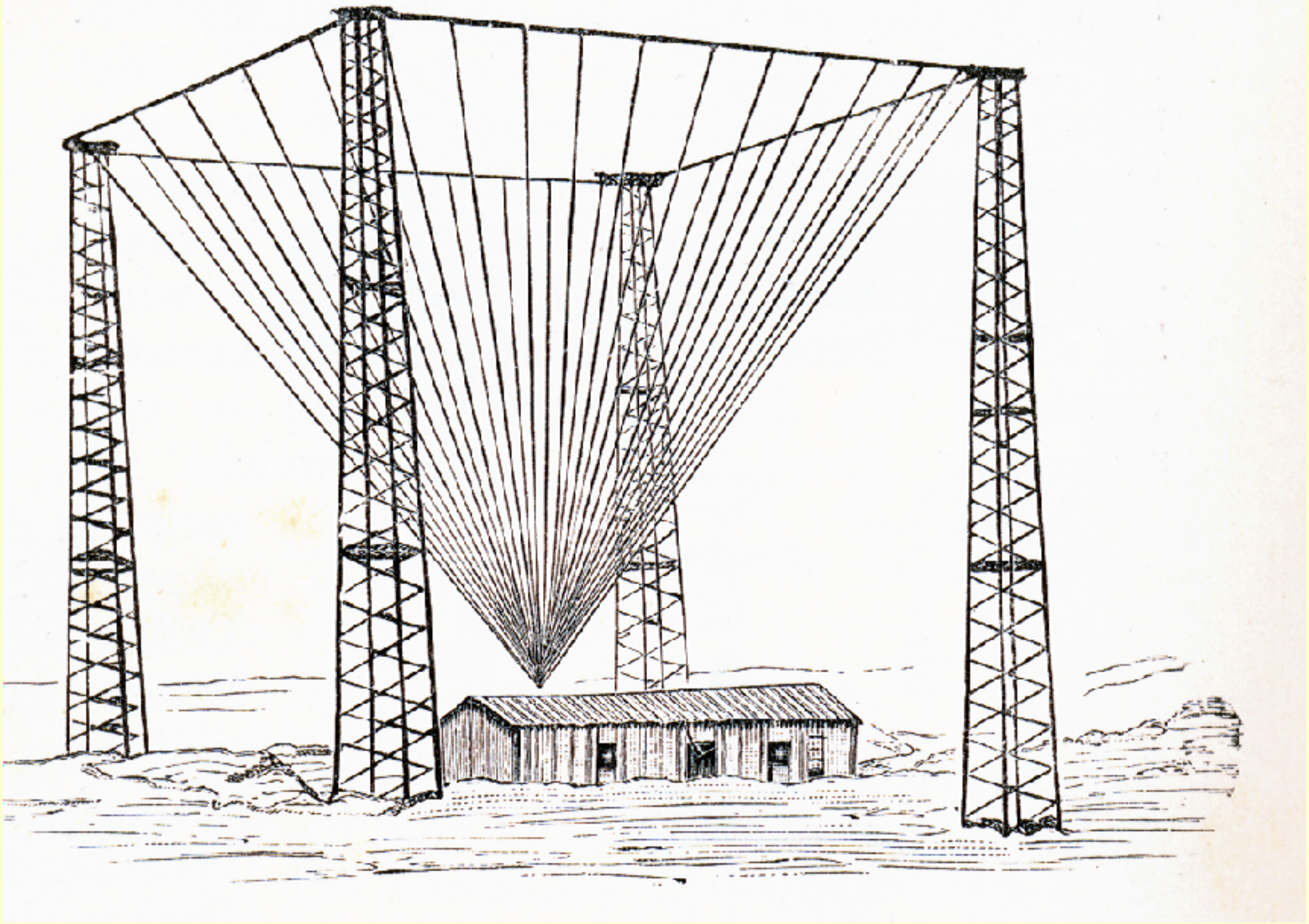
vanuit Poldhu (Cornwall)

Verbinding alleen mogelijk via F-reflectie (toen nog niet bekend!) op > 10 MHz

Reconstructies van de zender+antenne in Poldhu wijzen op output op 166 kHz (1875 m)
en/of 9.4 MHz (32m), 12 MHz (25m).
Misschien heeft Marconi de eerste transatlantische kortegolfverbinding gemaakt!

Maar voorlopig (tot 1924!) gaat men er van uit: bereikbare afstand = 500 * golflengte.

Fig. 661.



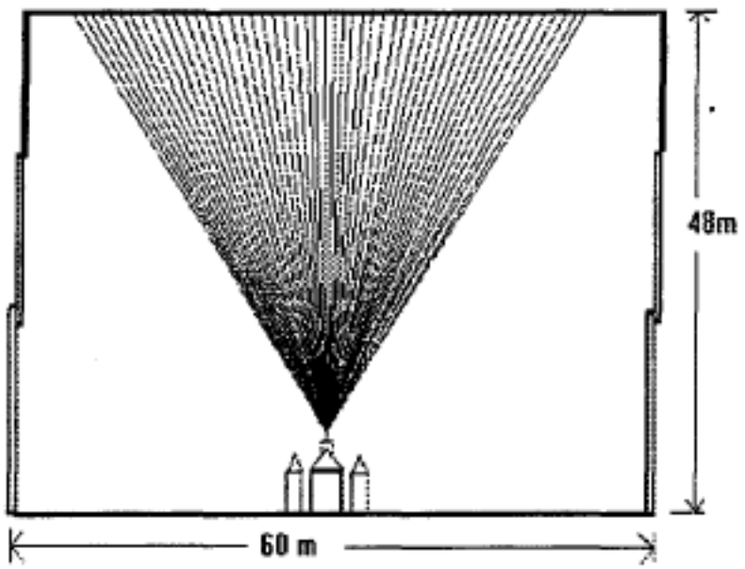
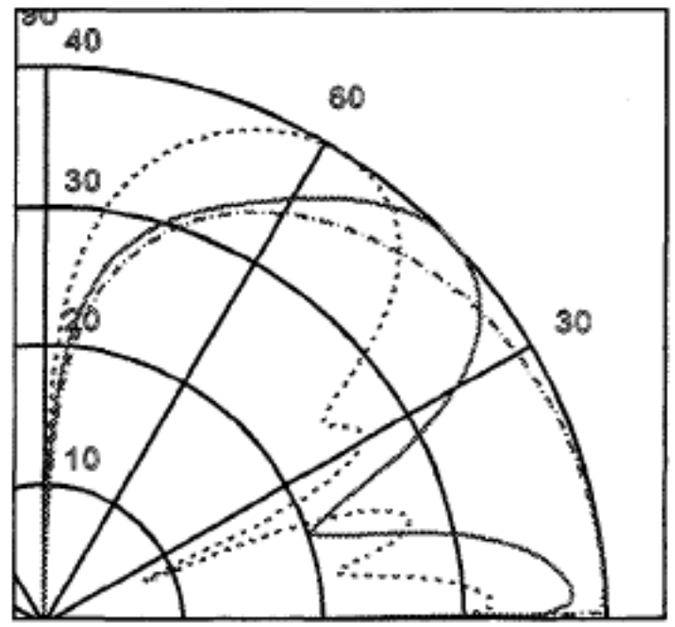



**Fig. 1 Antenna used by Marconi during the first transatlantic experiment**

We base our analysis on the conditions that prevailed during the 12th of December 1901.




| SYMBOLS USED | FREQ (MHz) | Gmax (dB) | Pin (Watts) |
|---|---|---|---|
| -.-.- | 0.166 | -14.7 | 8.31E-07 |
| ... | 9.37 | 7.62 | 4.24E-04 |
| — | 12.50 | 9.05 | 1.81E-03 |

**Fig. 2 Far Field pattern of Marconi's antenna over ocean at three different frequencies**

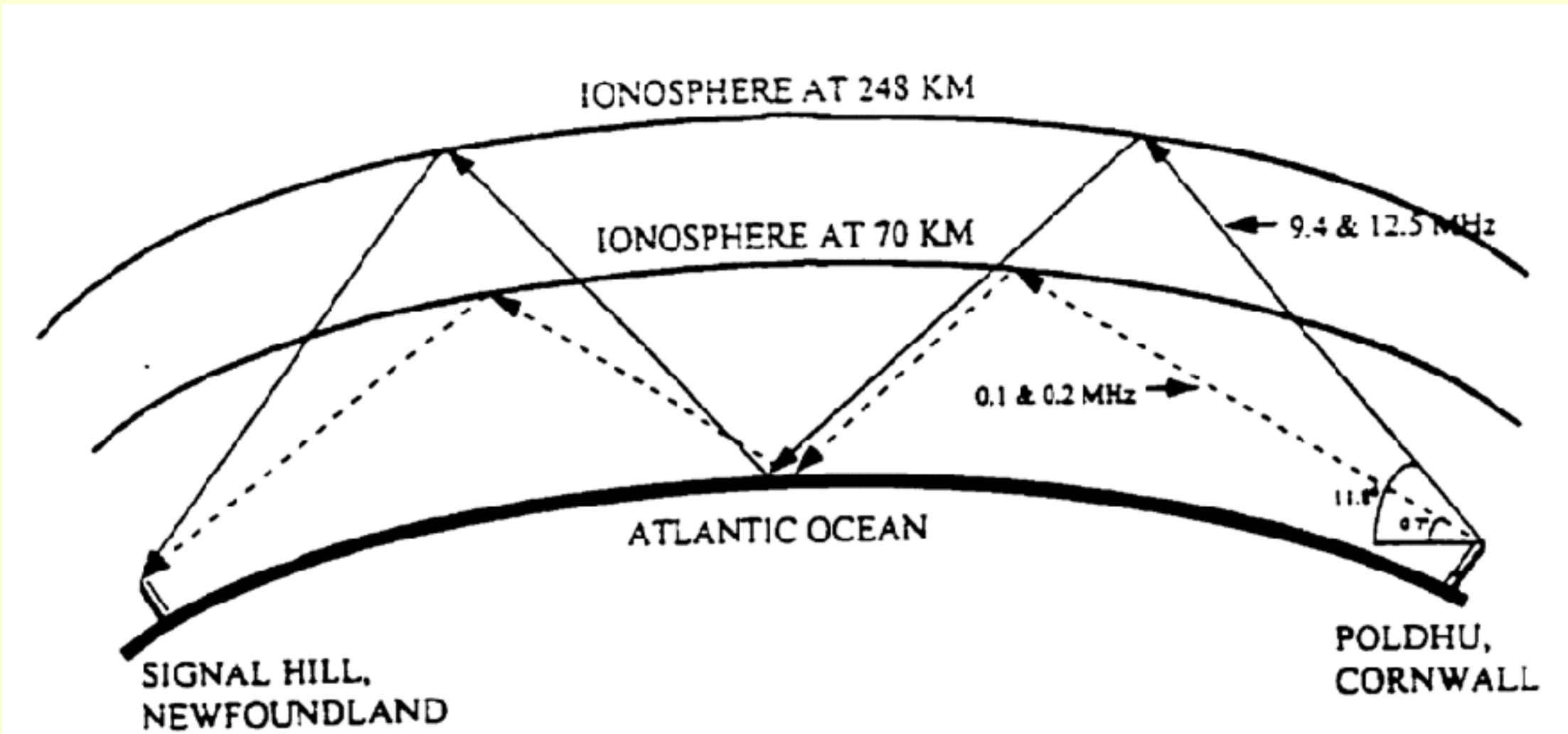



Figure 3.2: Ionospheric propagation path for December 1901

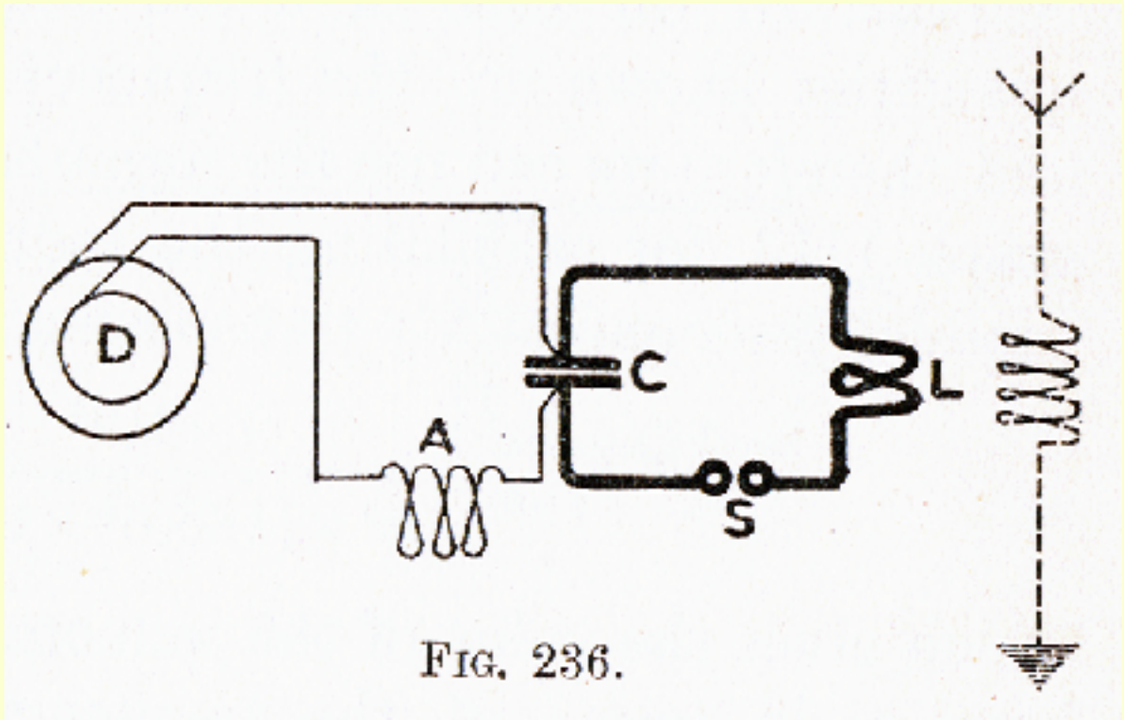



FIG. 236.

zenden op 300 m (1 MHz) met P = 500 W, alternator 200 Hz, C = 5000 pF

L = 5 μH voor resonantie in rechter circuit,
D+A = 127 H voor resonantie in linker circuit.
Een reële waarde voor D is 0.01 H, aan te vullen met A.

met S vonken/sec is $P = CV^2/2 * S$
dus hier (met S = 400) moet V = 23 kV zijn.

max spanning aan C (in eerste periode) is 2.3 maal $V_{eff}$ van de alternator,
dus $V_{eff}$ moet 10 kV zijn.

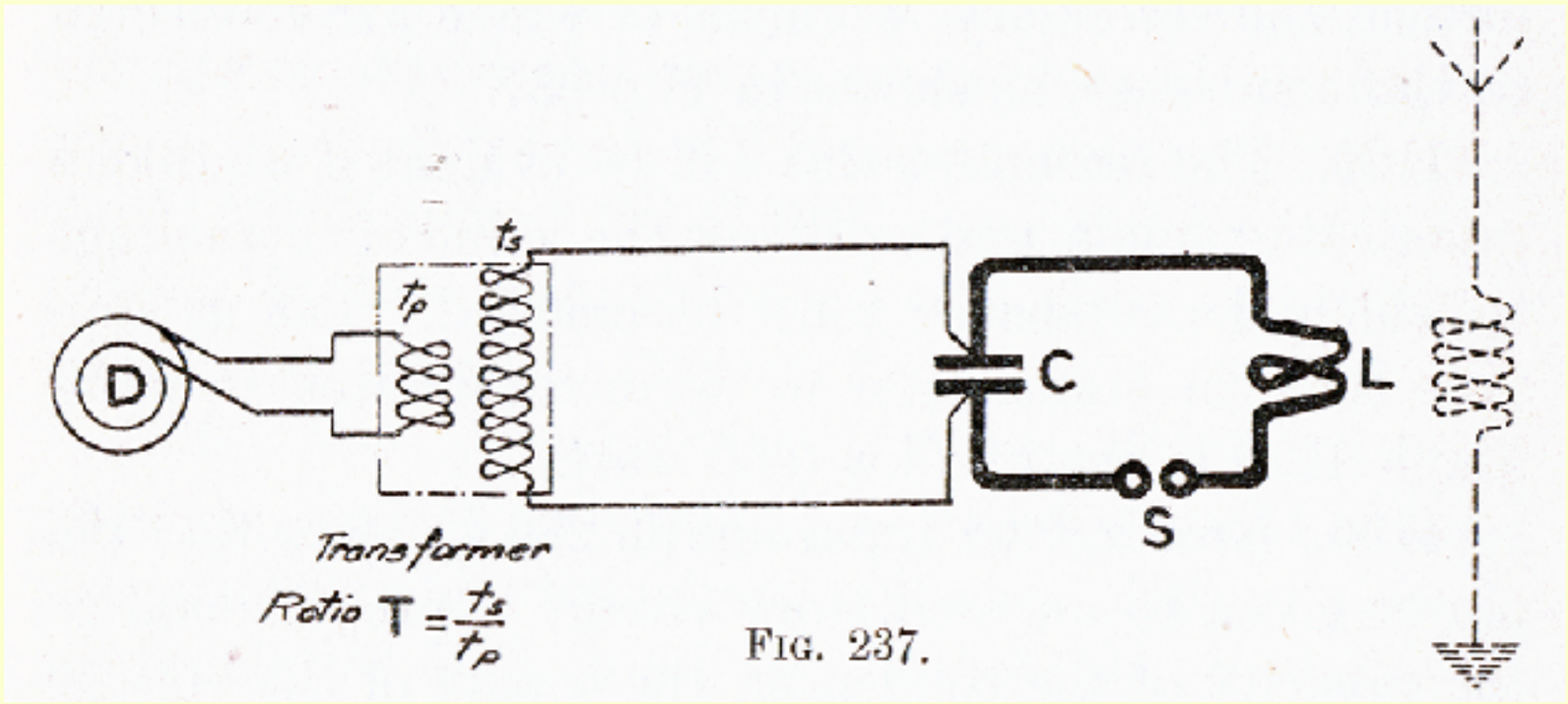



FIG. 237.

Bij gebruik van trafo lijkt C in het alternator circuit $T^2$ maal zo groot.

Met T = 100 kan $V_{eff}$ = 100 V zijn, en er is maar 2.7 mH extra nodig (niet getekend).

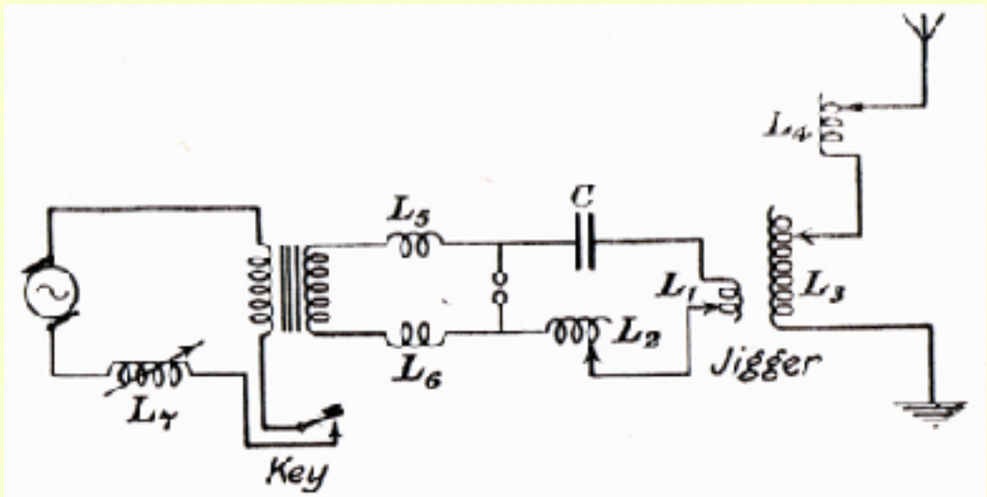
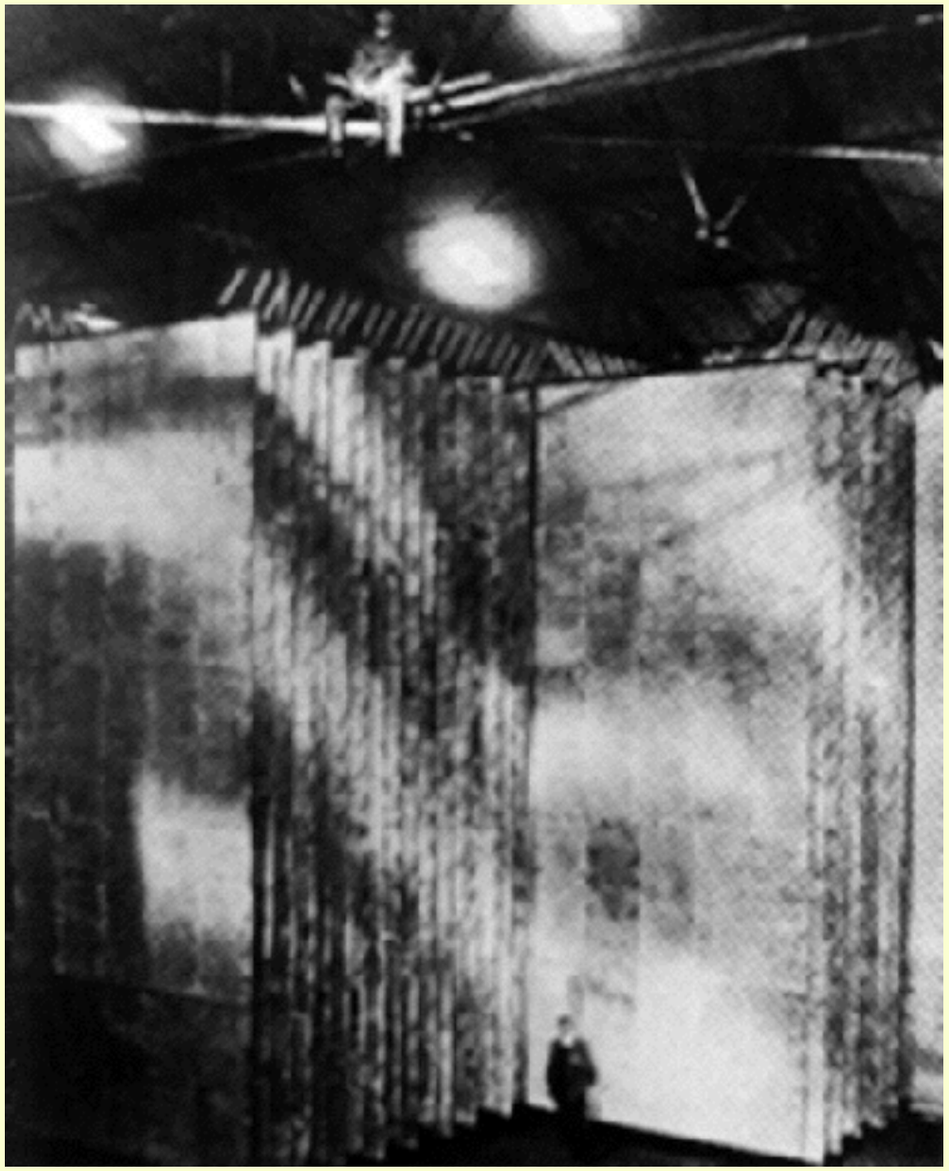
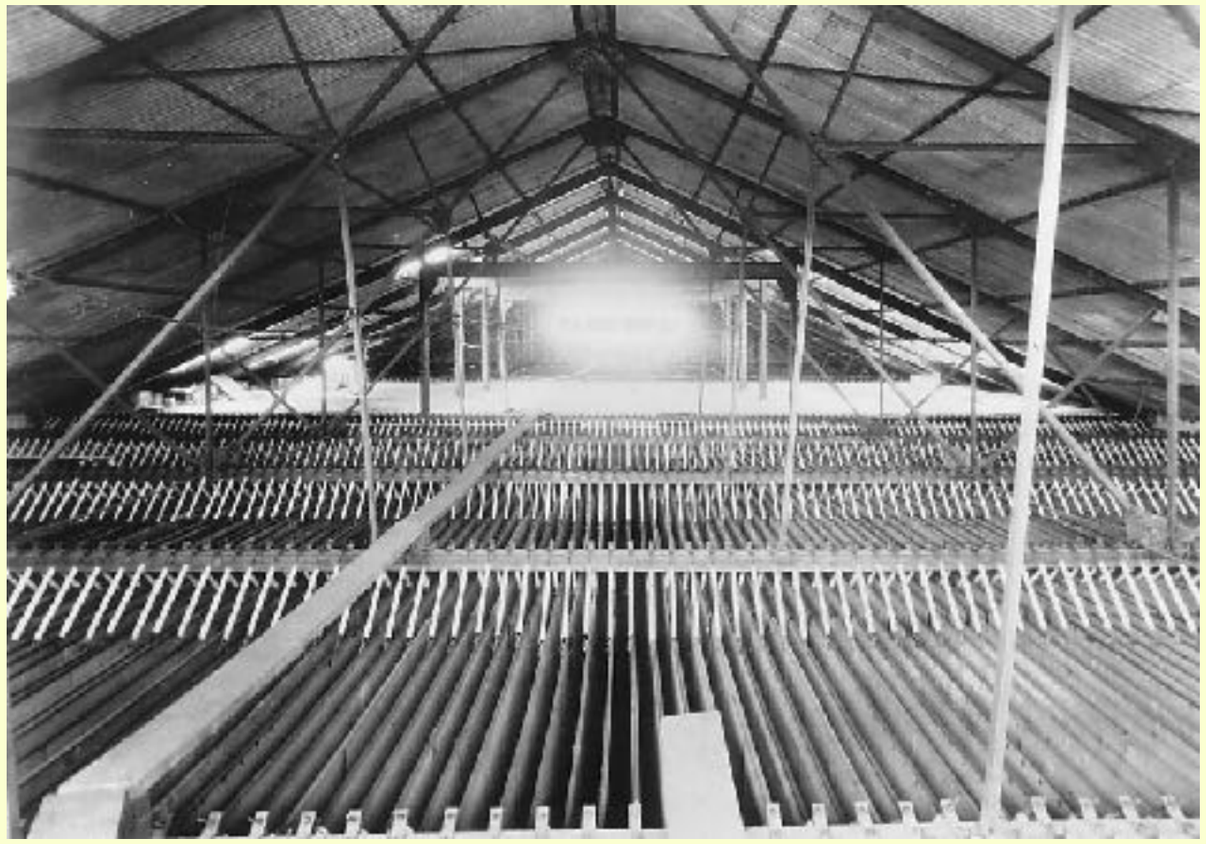
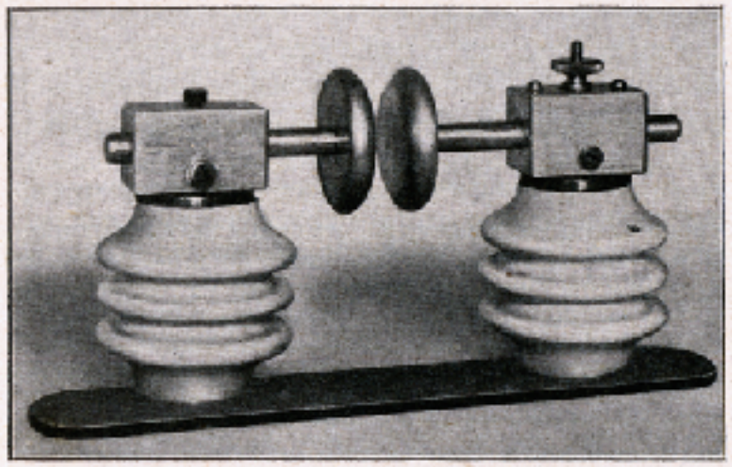


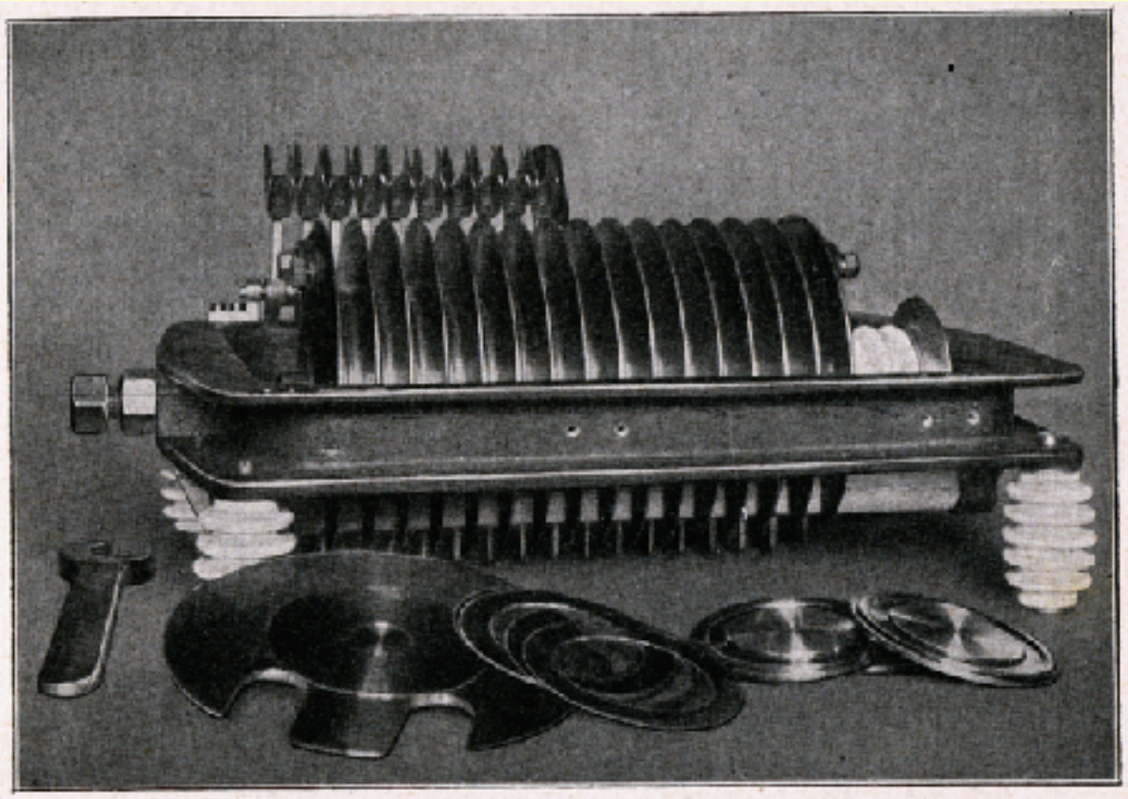

FIG. 143.—CIRCUIT OF SPARK TRANSMITTER.



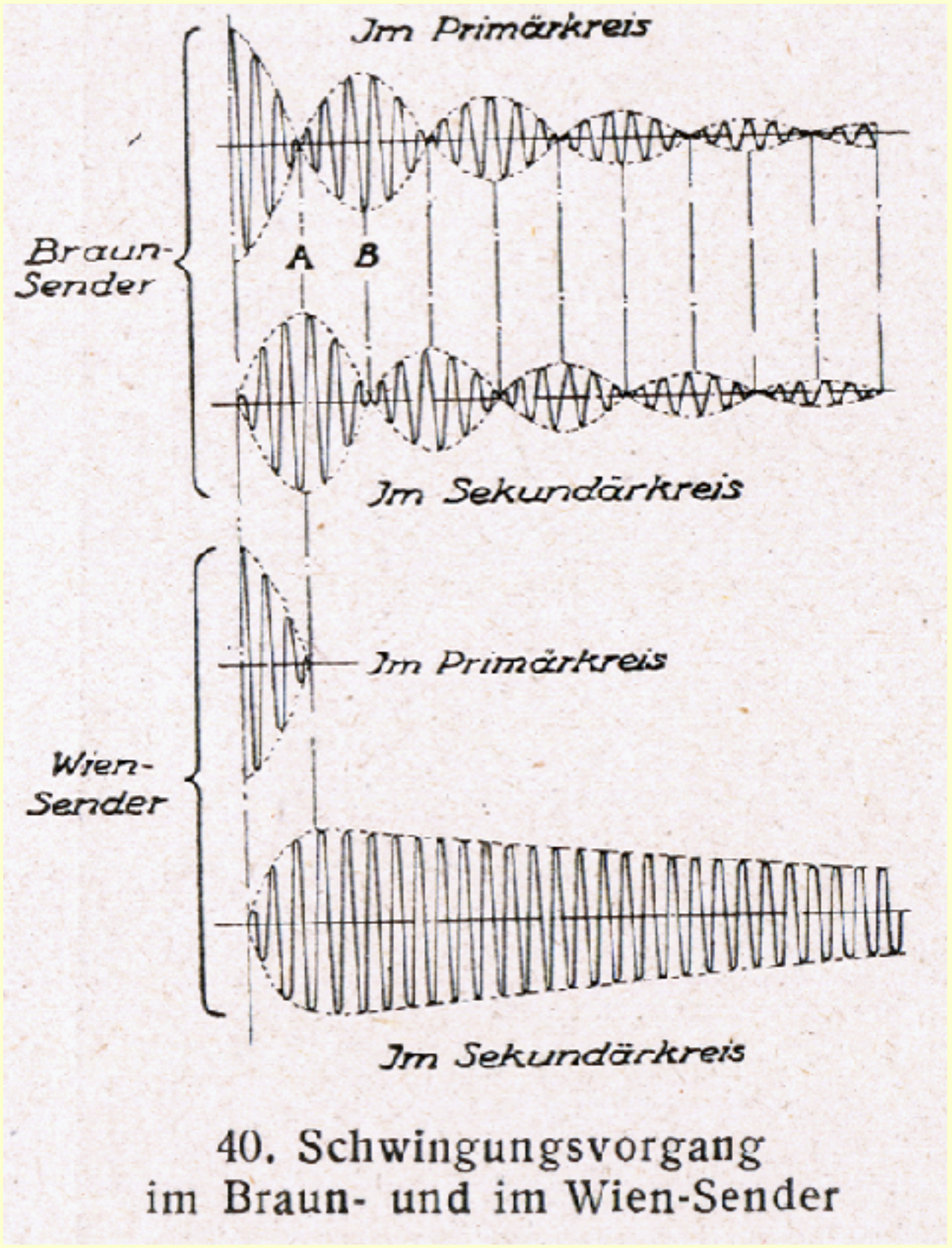




38. Pilz-Funkenstrecke



39. Funkenstrecken nach Wien
Unten rechts Elektroden, in der Mitte Glimmerringe, links Kühlplatte




40. Schwingungsvorgang
im Braun- und im Wien-Sender

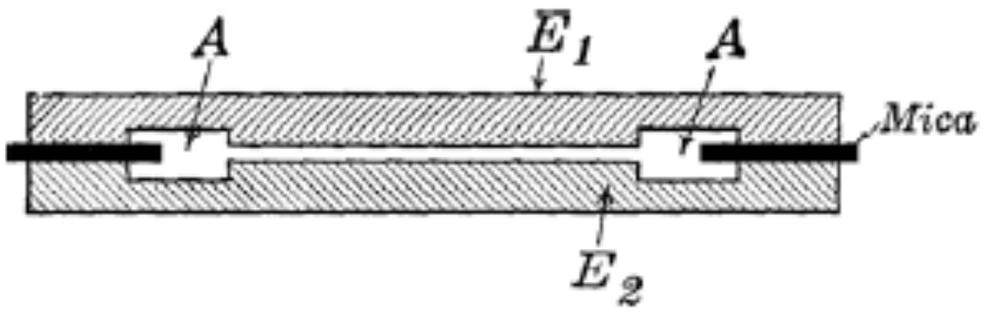



**Fig. 3.** Basic diagram of quenched spark gaps used by the Telefunken Company. The gap between the electrodes of silver plated copper E1 and E2, is about 0.2 mm (from: J. Zenneck, *Wireless Telegraphy*, New York: McGraw-Hill, 1915).

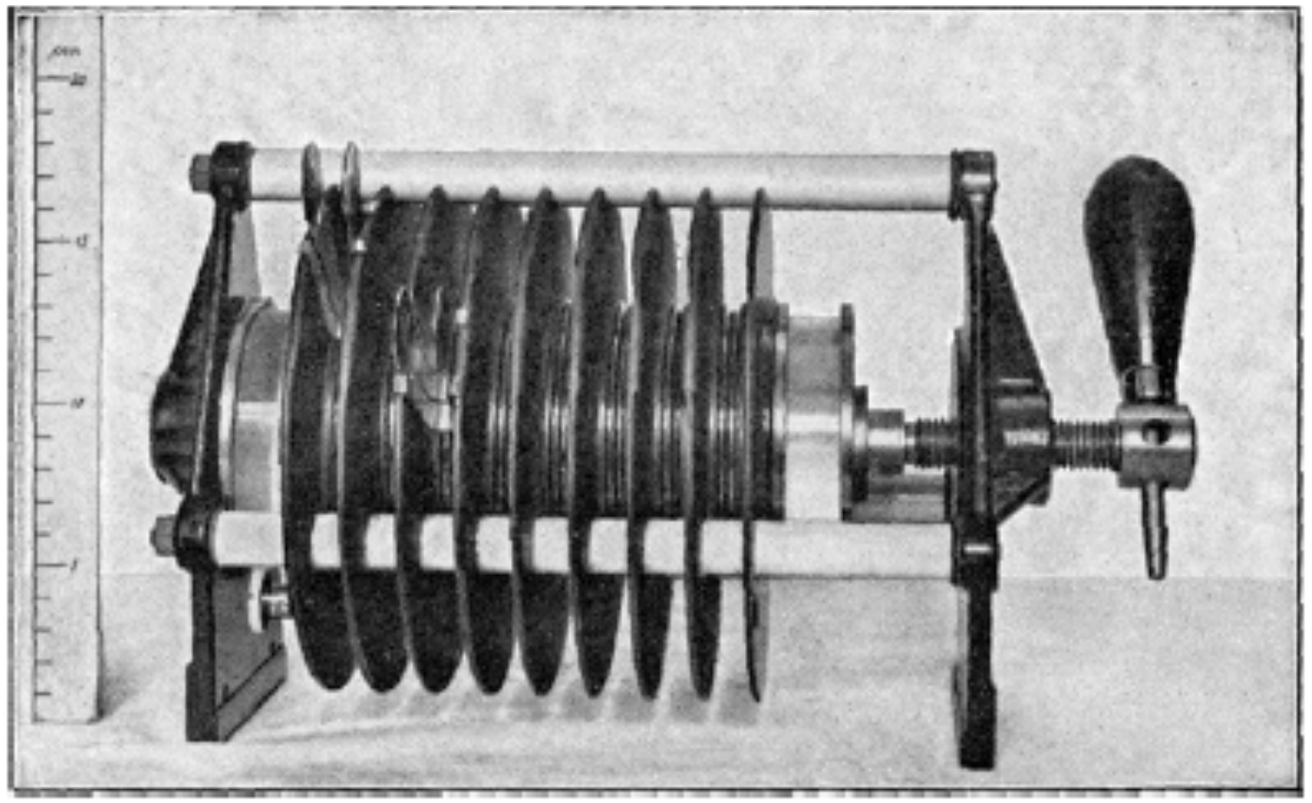
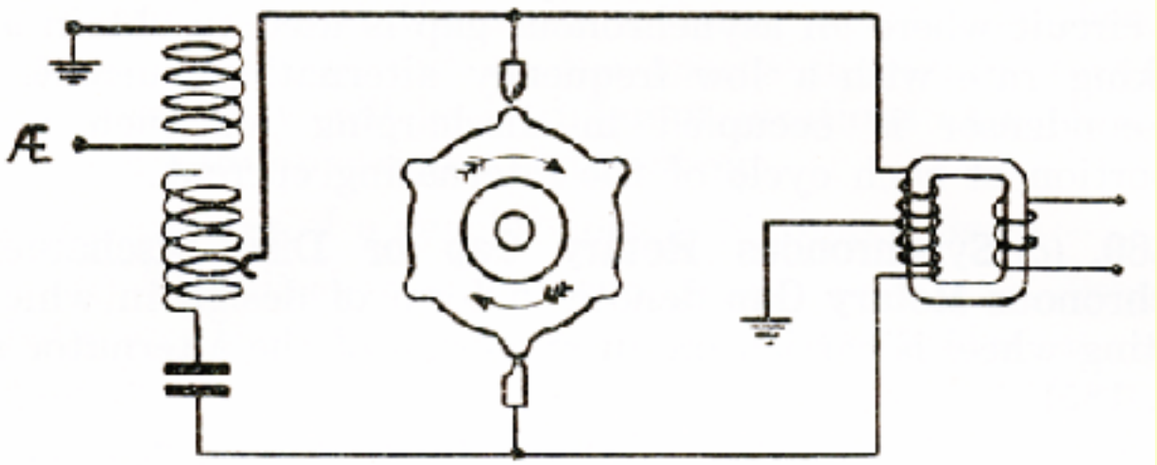


**Fig. 4.** Photograph of a series of spark gaps used by the Telefunken Company (from: J. Zenneck, *Wireless Telegraphy*, New York: McGraw-Hill, 1915).




*Asynchronous Rotary Gap.*

FIG. 184.

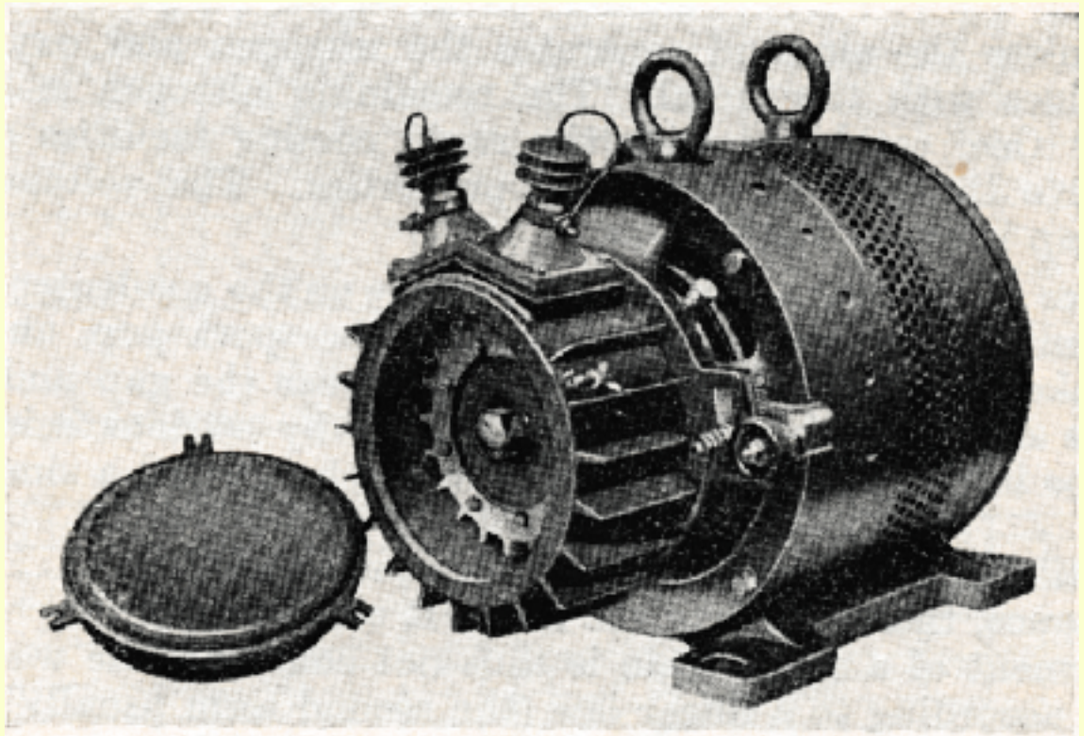
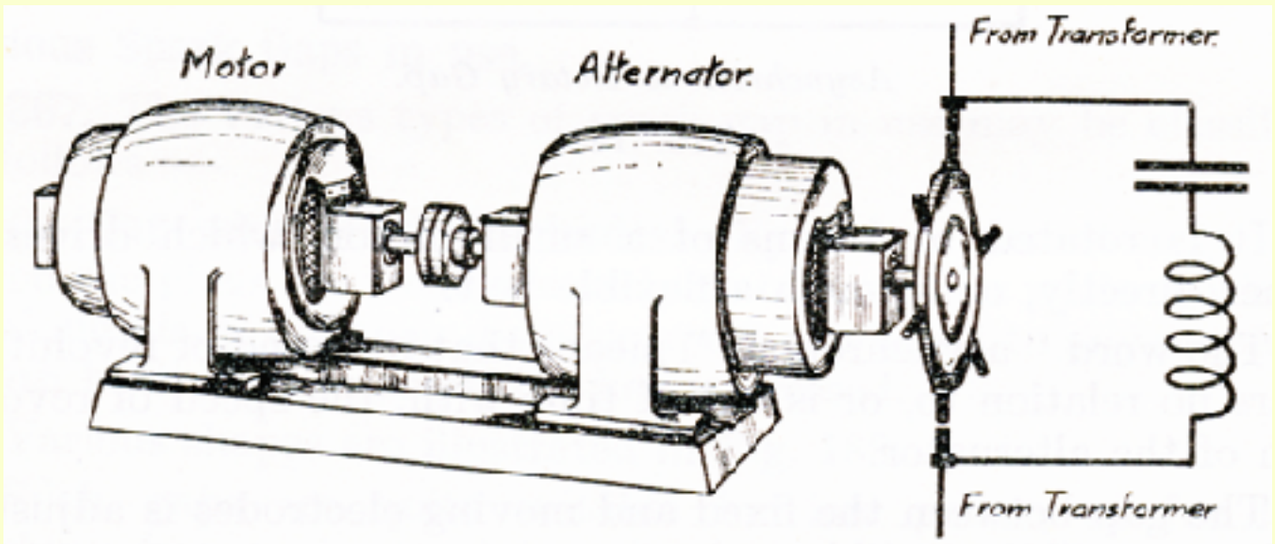


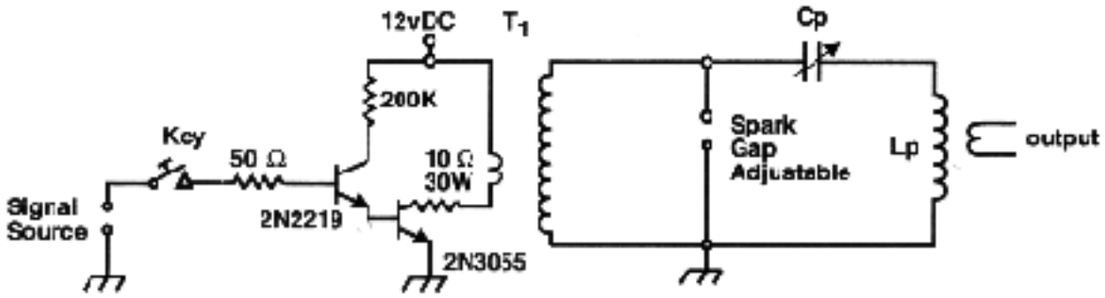
FIG. 139.—1½-KILOWATT DISC DISCHARGER.
(By courtesy of Radio Communication Company.)



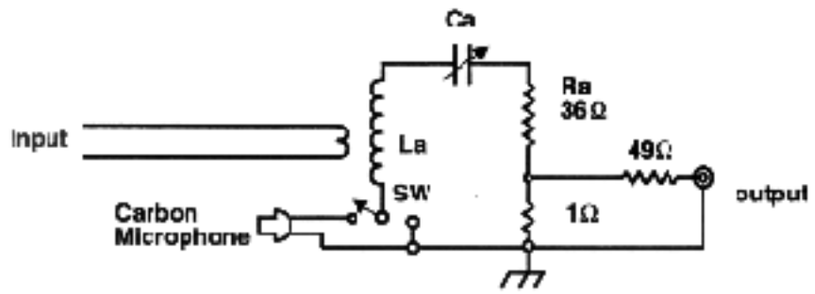

*Motor Alternator with Synchronous Rotary Gap.*

FIG. 185.

## SPARK TRANSMITTER

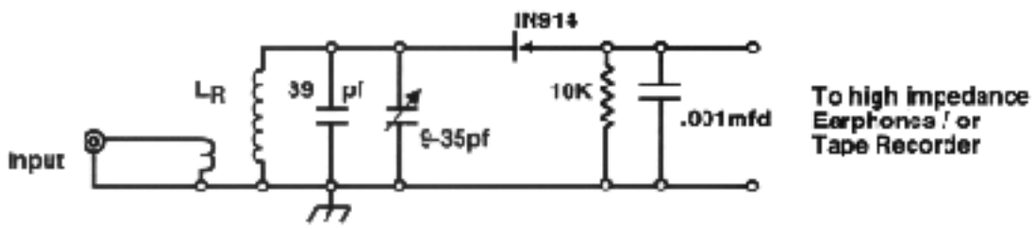


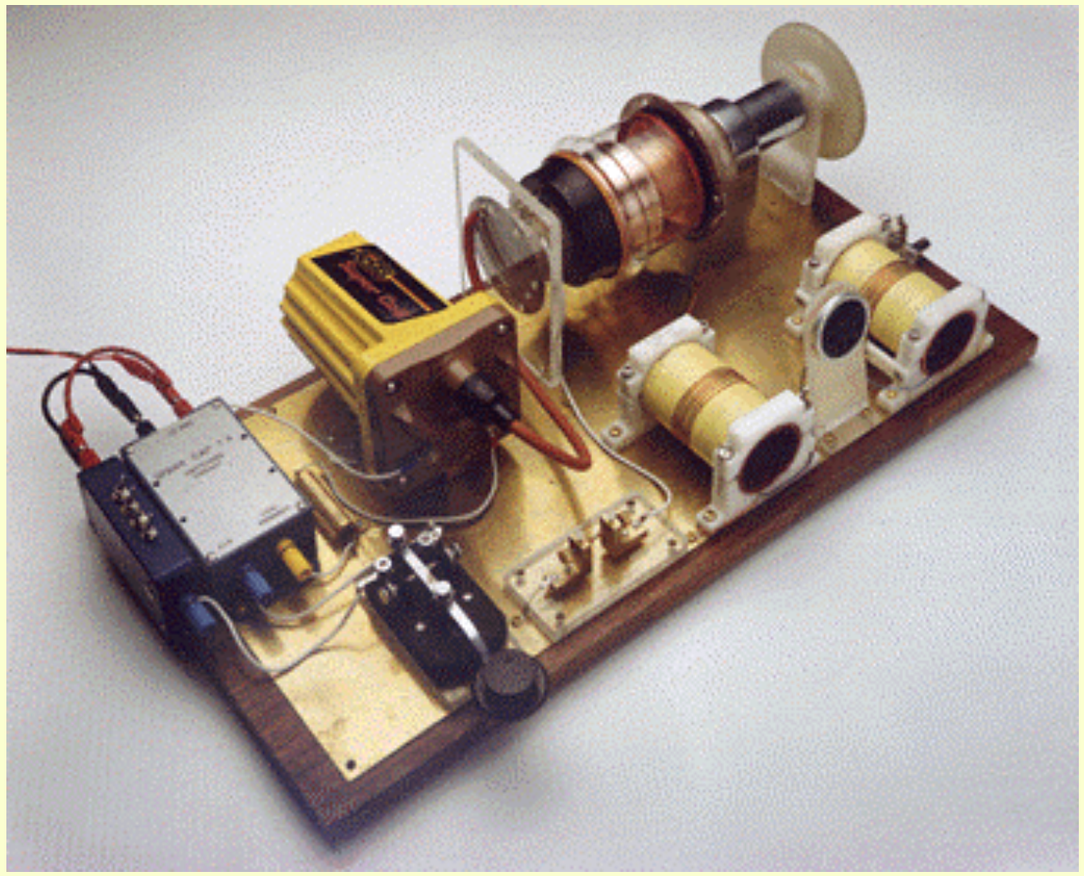

## TRANSMITTER ANTENNA




| | |
|---|---|
| Ca | 100pf |
| Cp | 100pf High Voltage Vacuum Capacitor |
| Lo, La, $L_R$ | $22_{\mu H}$ |
| T1 | High Performance Automotive Ignition Coil |
| SW | SPDT Switch Phone/ CW |
| Signal Source | RC Oscillator 60-, 120-, 800Hz and 10 kHz |
| Power Supply | 12vdc Gel-Cell Battery |

## RECEIVER



60 v/s asynchroon

750 v/s synchroon

John Belrose's 5 MHz vonkzender en kristalontvanger

Marconi vonkzender 1917 (geen CW dus!!)

Morse-voorbeeld uit de verzameling instructie-gramofoonplaten

van Norman Field <www.normanfield.com/morse.htm>

na 1913

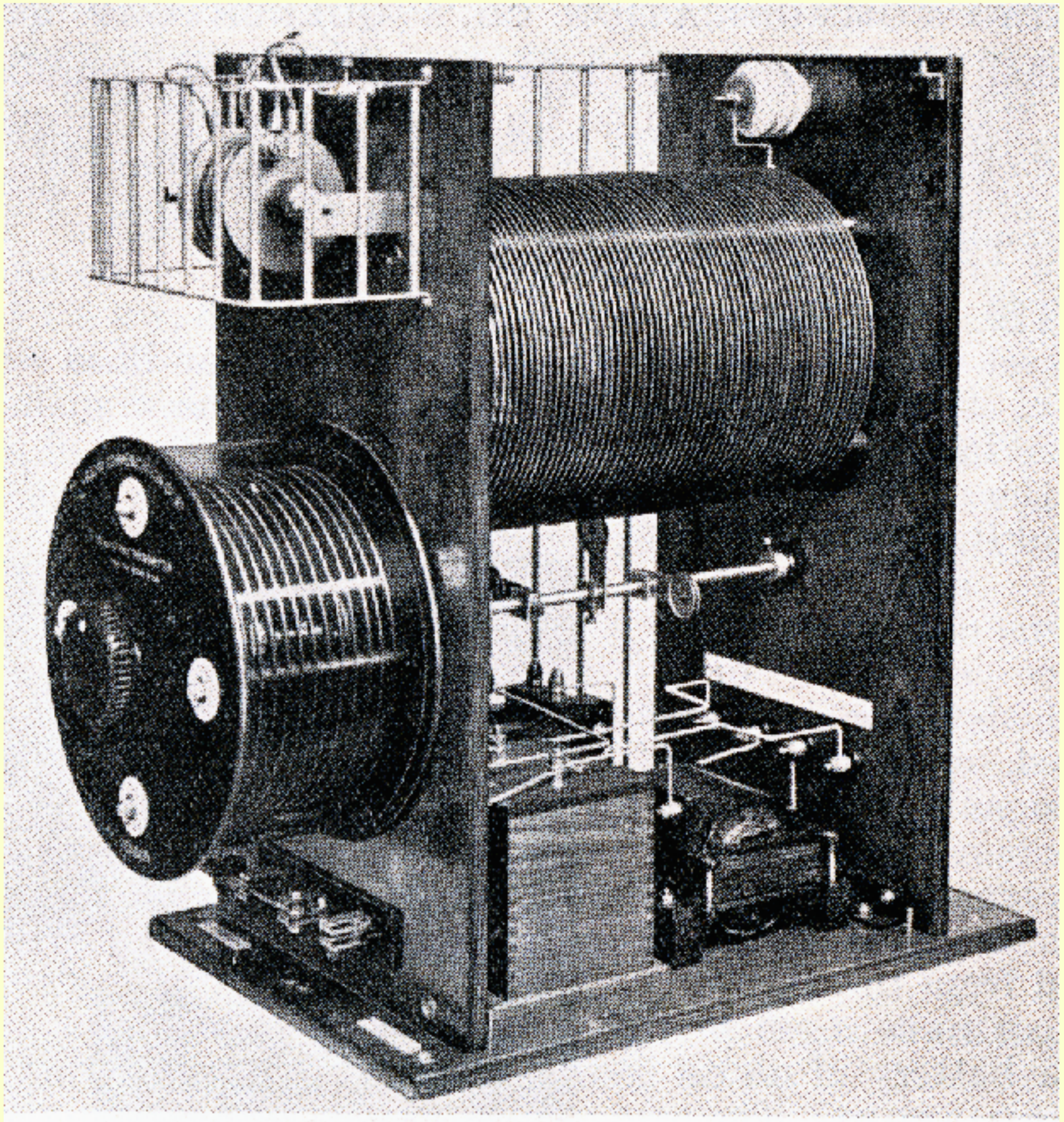
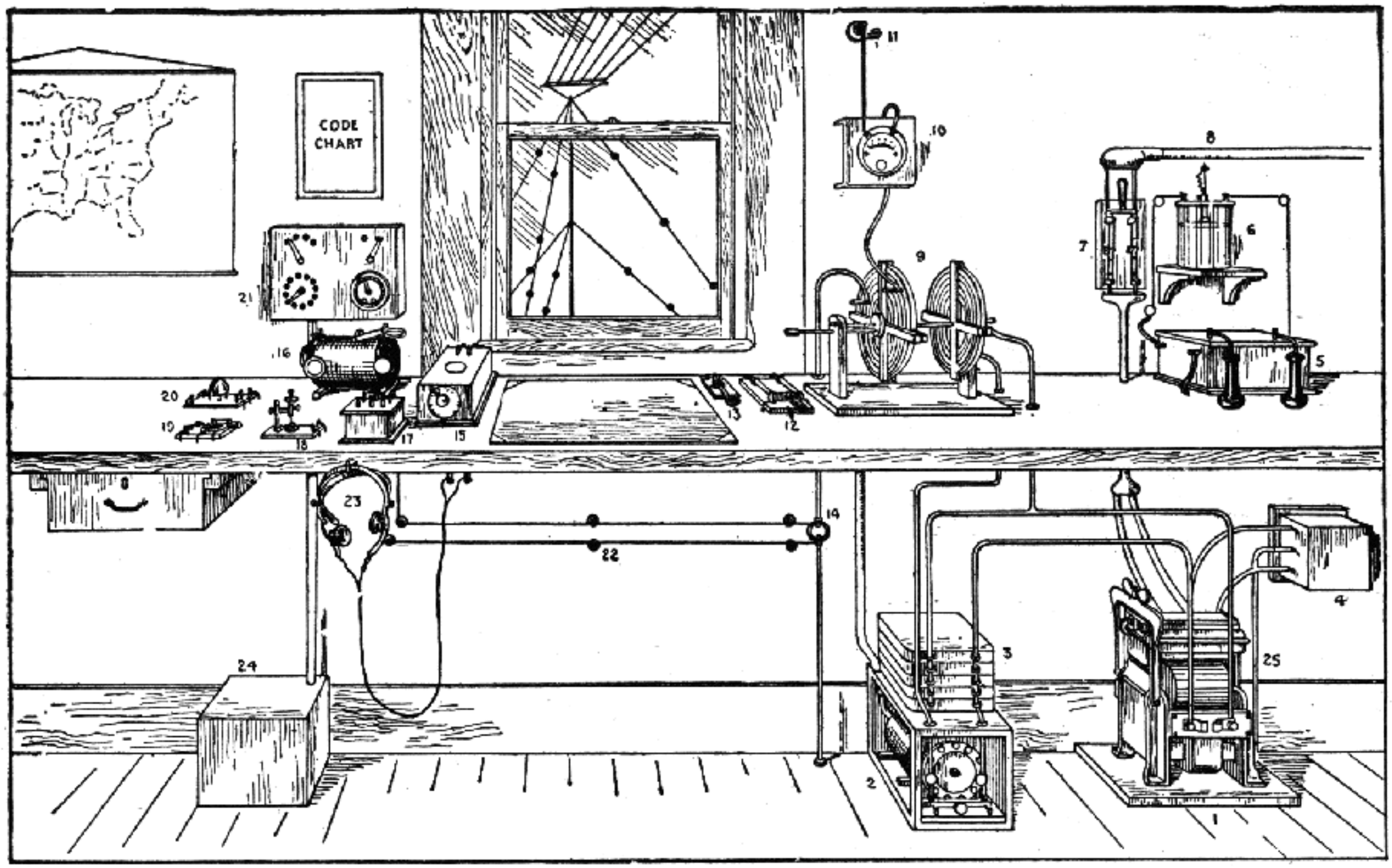


Fig. 241. Radio Communication Co., Type T24, ¼ kw. Q.G. Transmitter.

1917




Modern amateur wireless station.

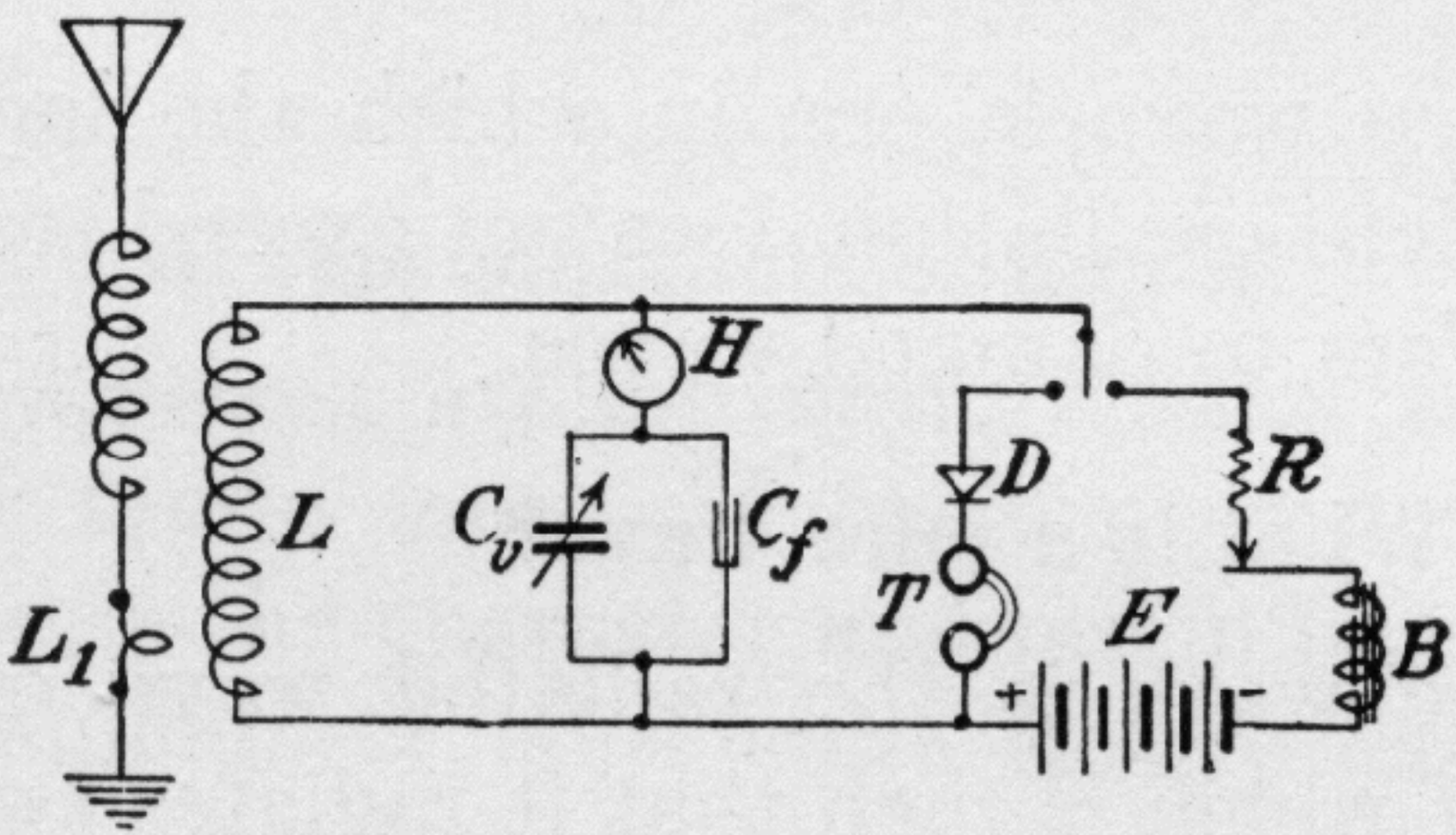



FIG. 70.—Wiring diagram of Kolster decremeter.

Ontvangers / detectors

- vonkenbrug
- coherer
- electrolytische detector
- magnetische detector
- kristaldetector
- Fleming-diode
- heterodyne ('directe conversie')

directe registratie *of* via het gehoor van de operator

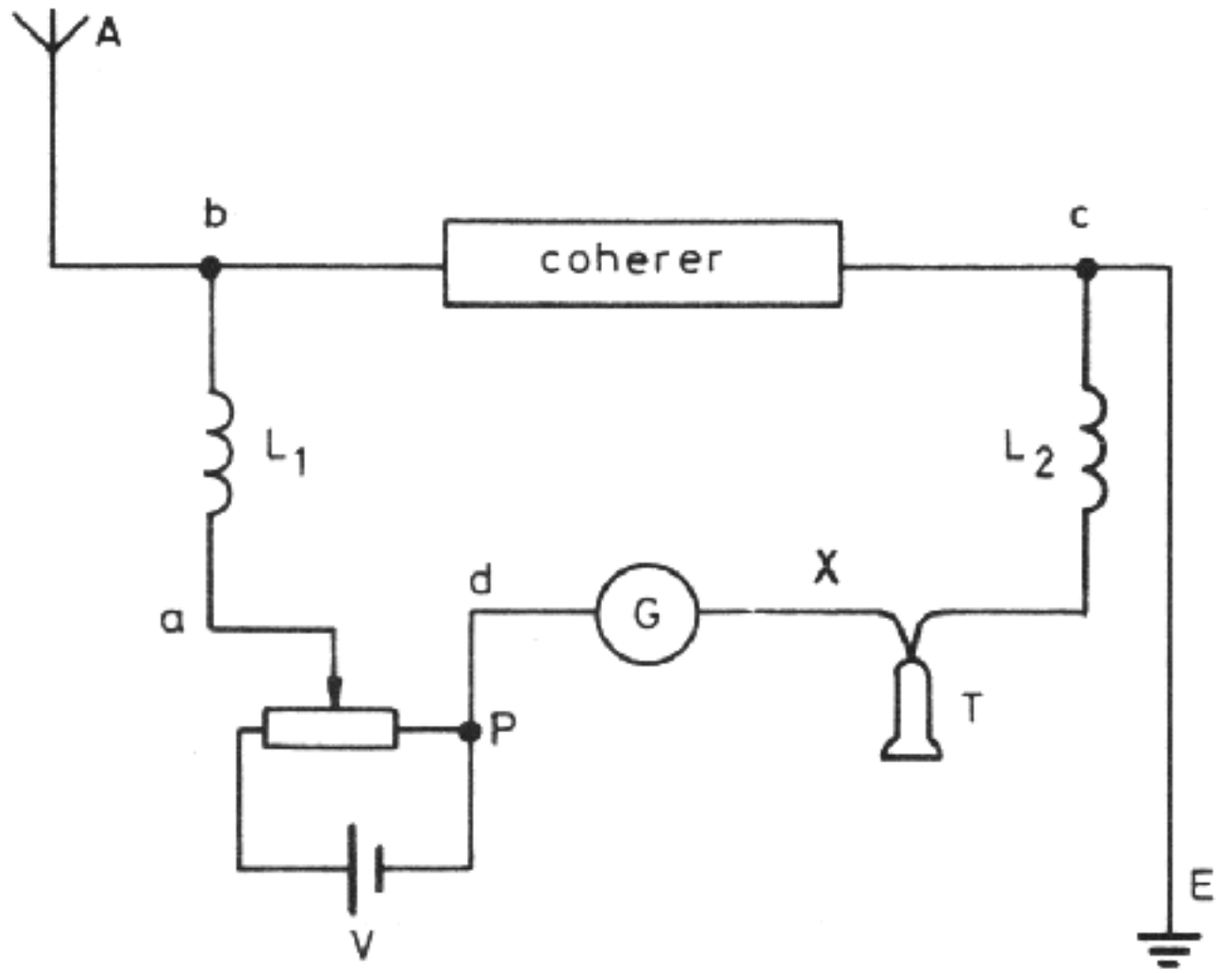
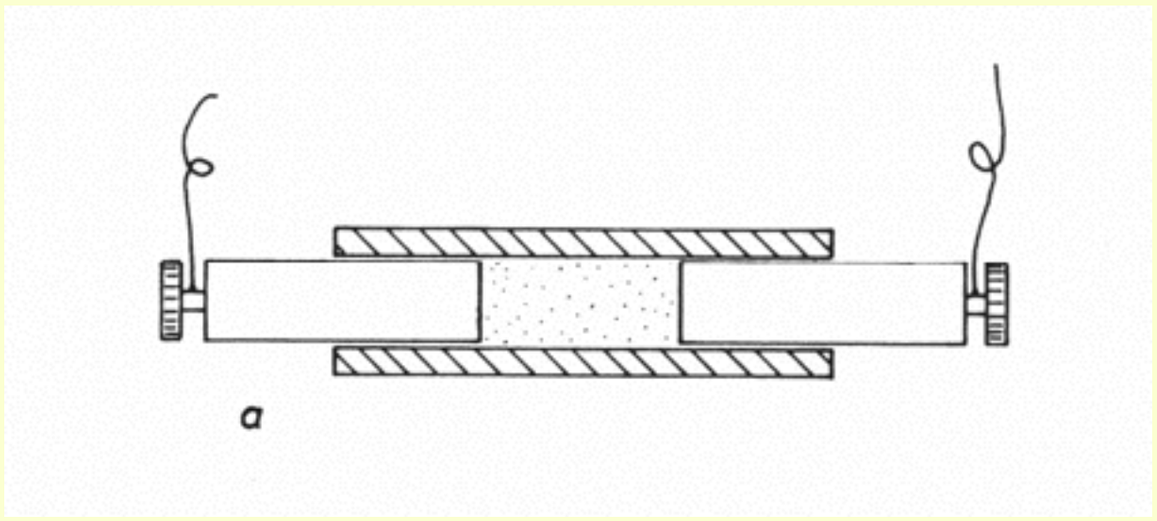



**Fig. 3.2** *Basic coherer operating circuit*
A = aerial, E = earth, G = galvanometer, T = telephone receiver, V = battery



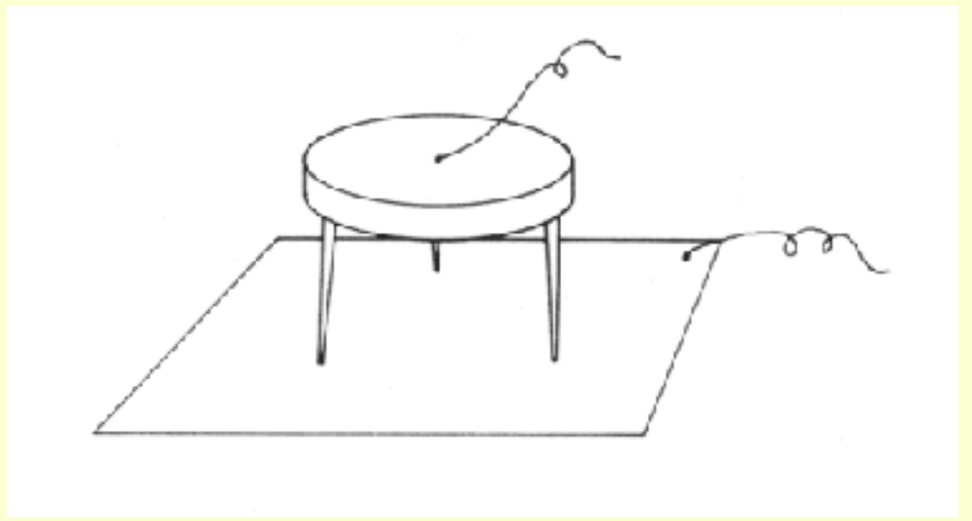
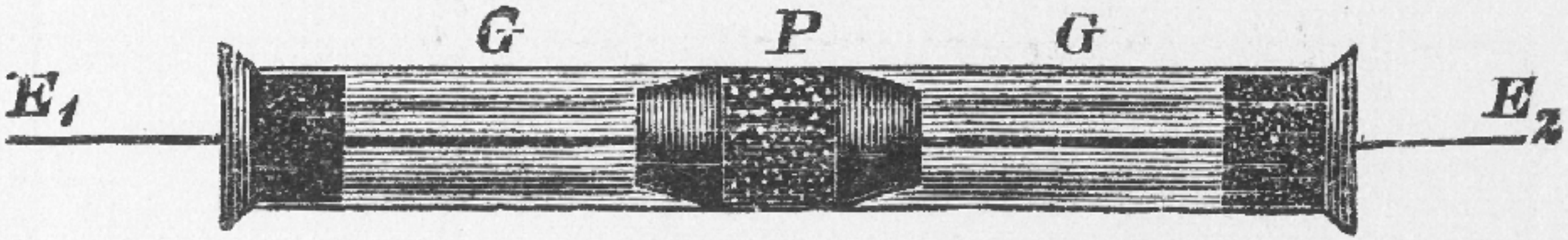



Fig. 273.




coherer

.....,Branly (radiotoepassing), Lodge (naamgever),.....

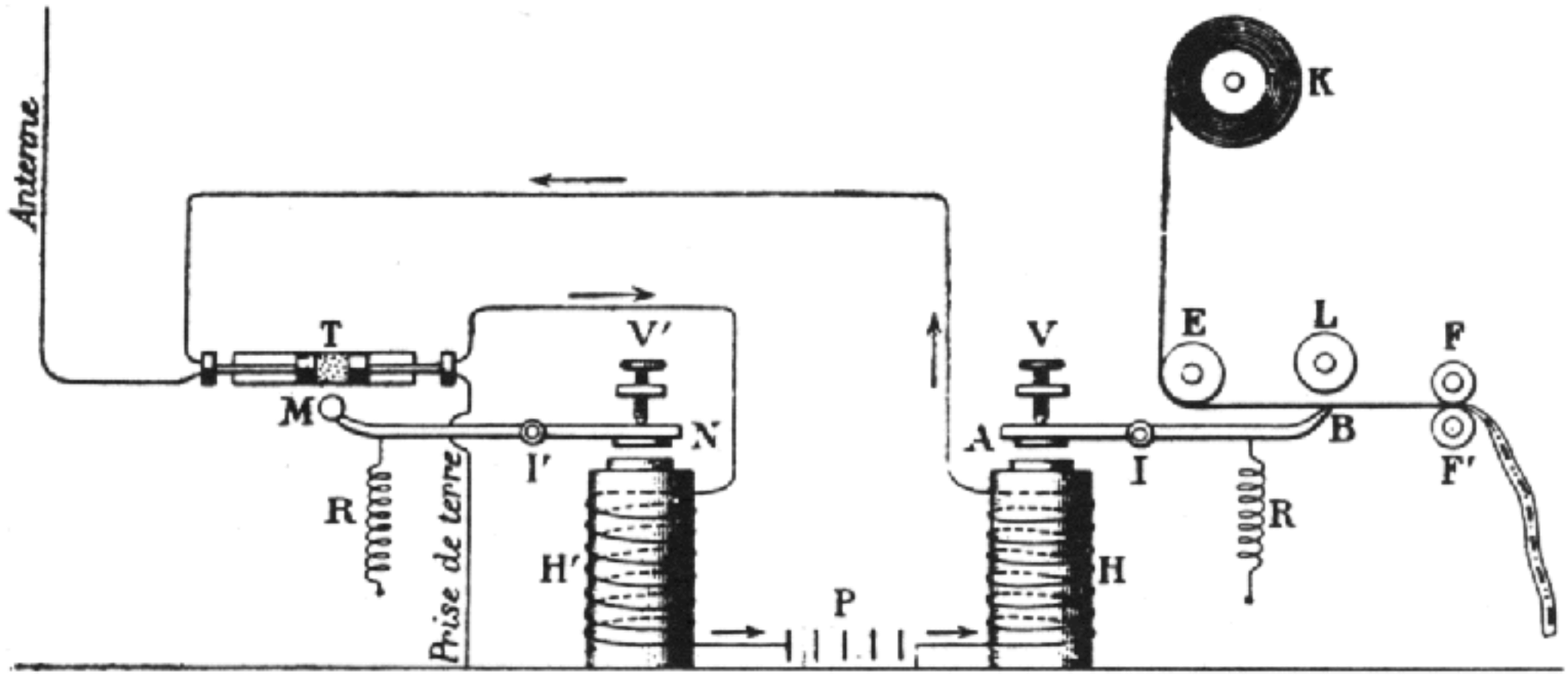
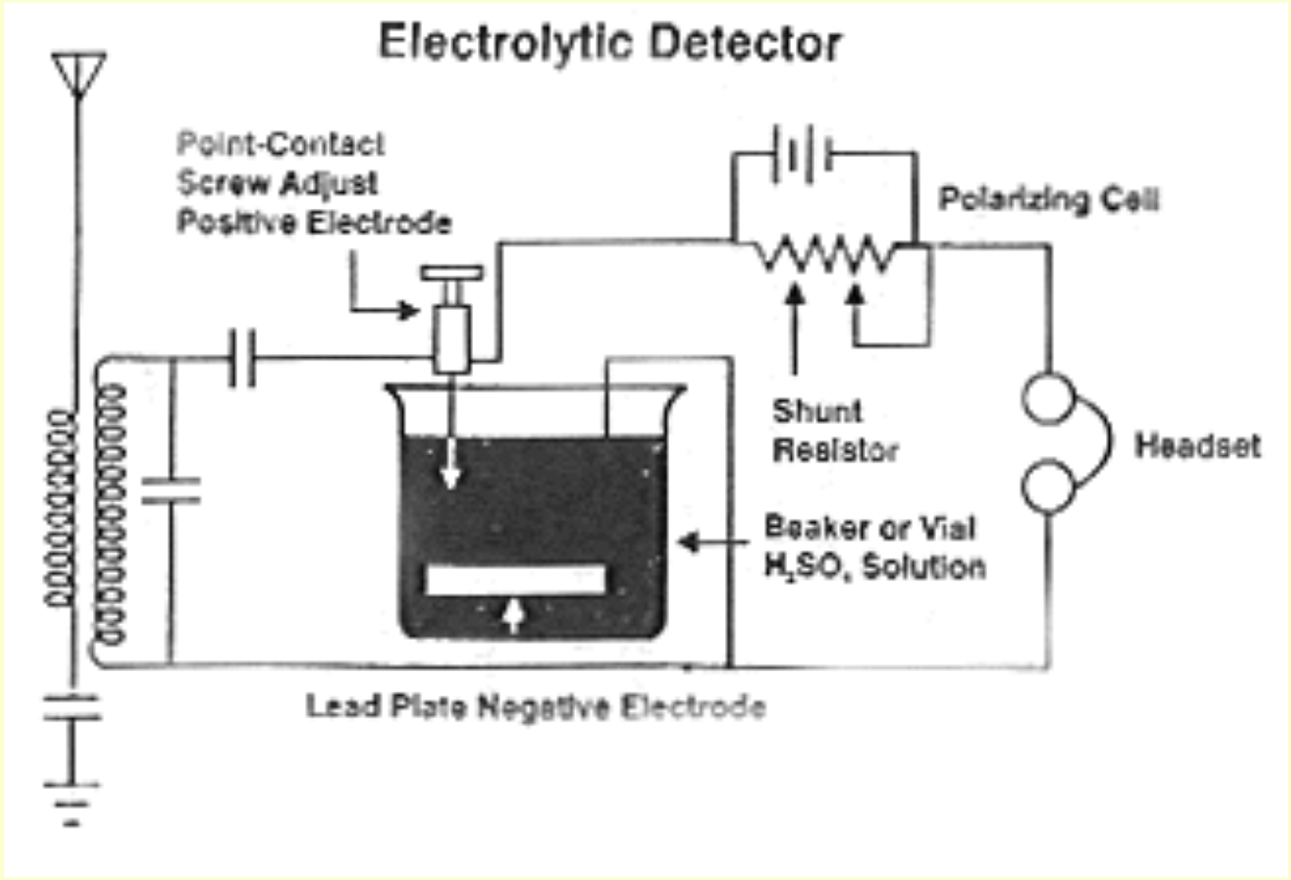



**Fig. 3.27** *Branly coherer with tapper (M) and inker (B)*
[Monier, E.: *La Télégraphie sans fil* (Dunod et Pinat, 1913), p. 24]




De 'Anti-Coherer'

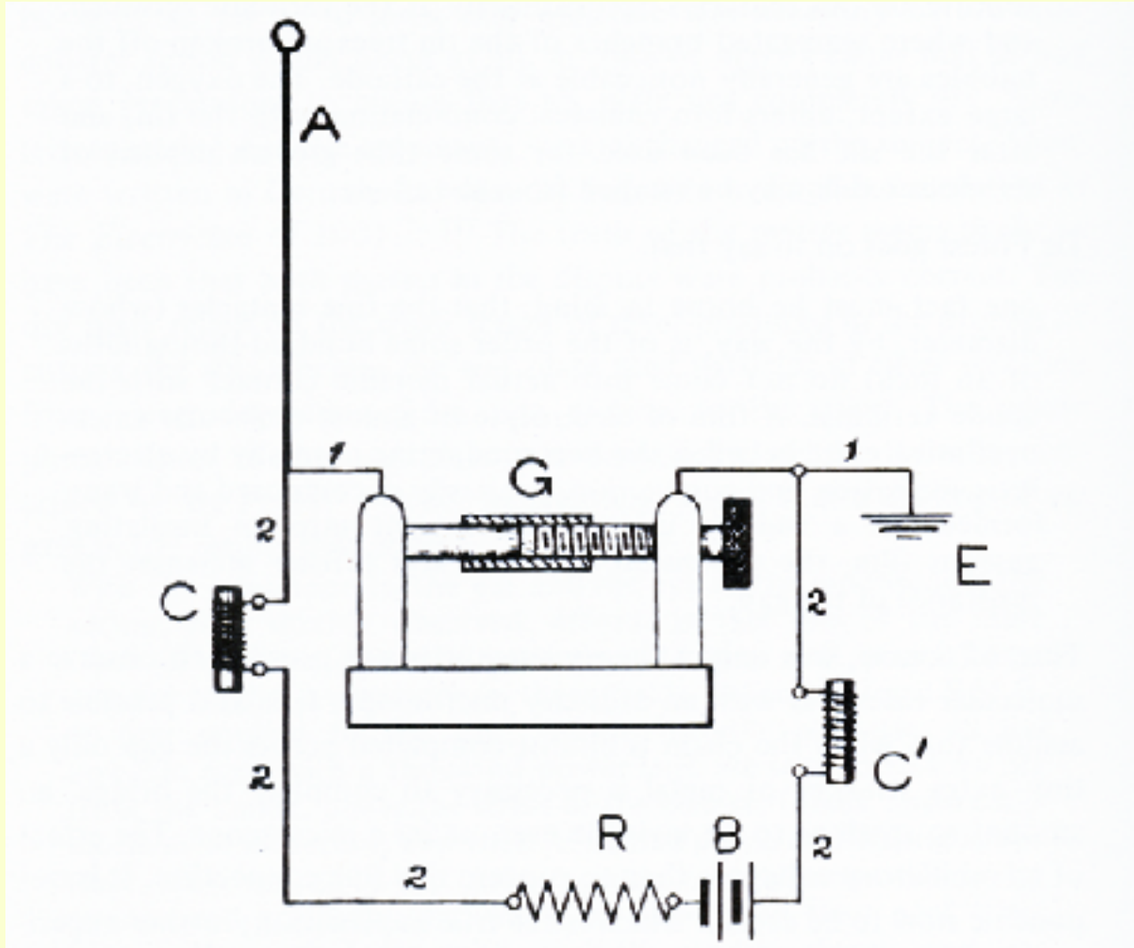
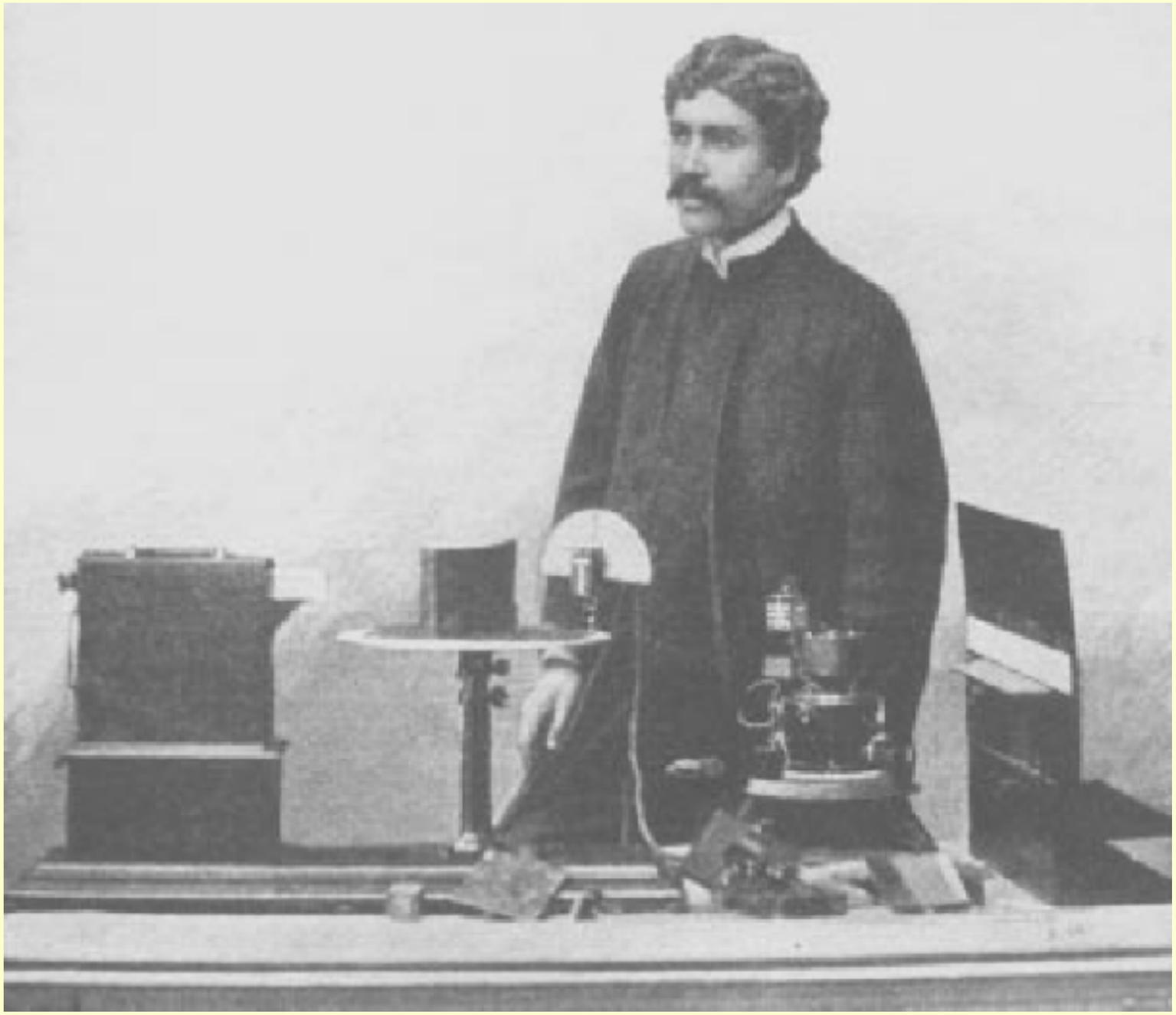



**Fig. 4.1** *De Forest's 'responder'*
The active paste was contained in the gap (G)
[Fleming, J.A.: *Principles of electric wave telegraphy and telephony* (Longmans, 3rd edn., 1916), p.508]

J.C. Bose, 1858-1937



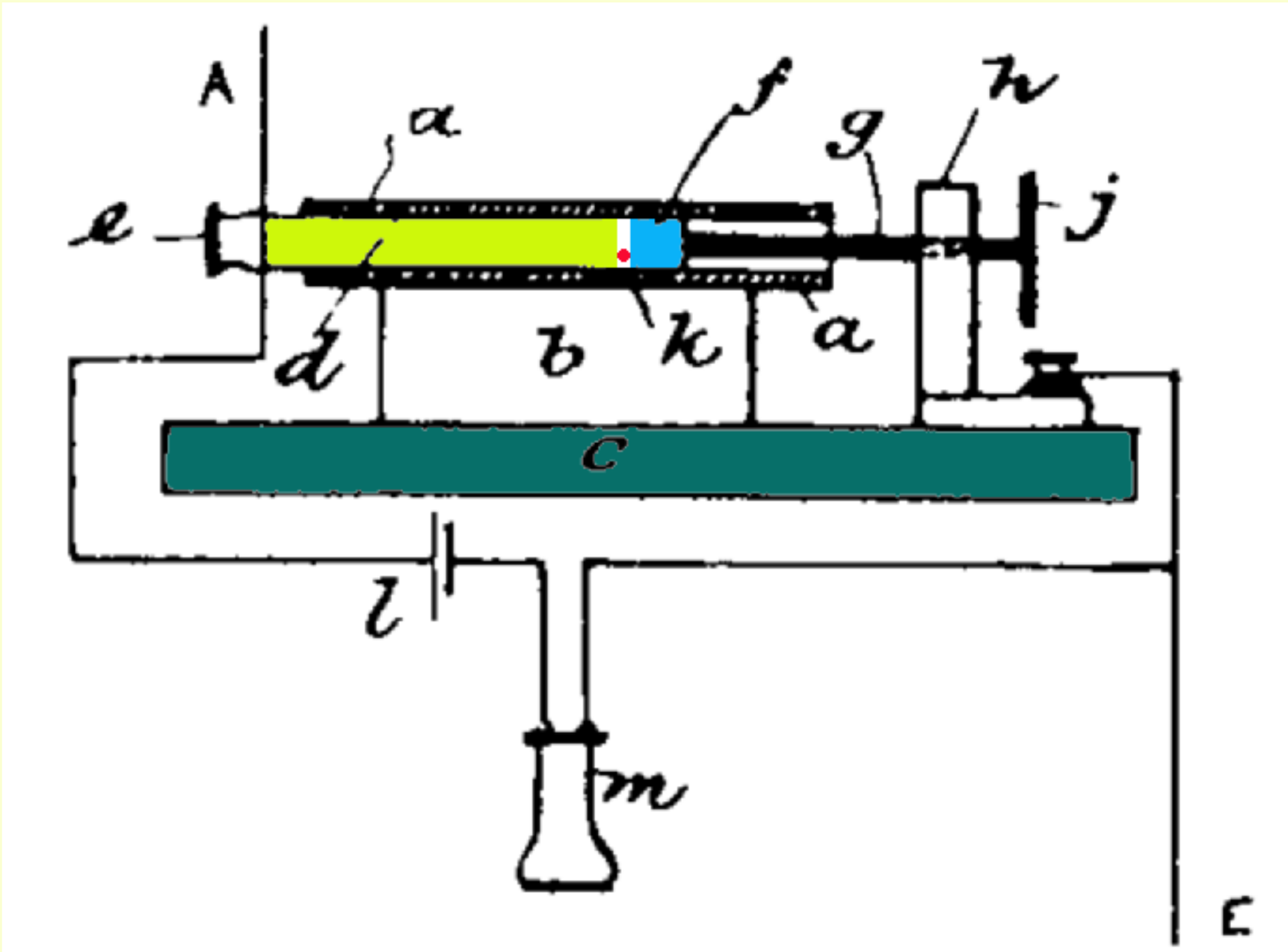
experimenten met mm-golven (60 GHz) rond 1885 (!)

' coherer with a telephone (self restoring coherer)'

galena (PbS) kristal detector

# The Italian Navy Coherer (Het 'Coherer Schandaal')

Marconi's
British Patent 18105 (1901)




$k$ = kwikdruppel
$d$ = koolstof electrode
$f$ = verstelbare ijzer electrode

carborundum (SiC) detector

Dunwoody 1906

advertentie uit
Radio News (USA) 1928

No. 836,531. PATENTED NOV. 20, 1906.

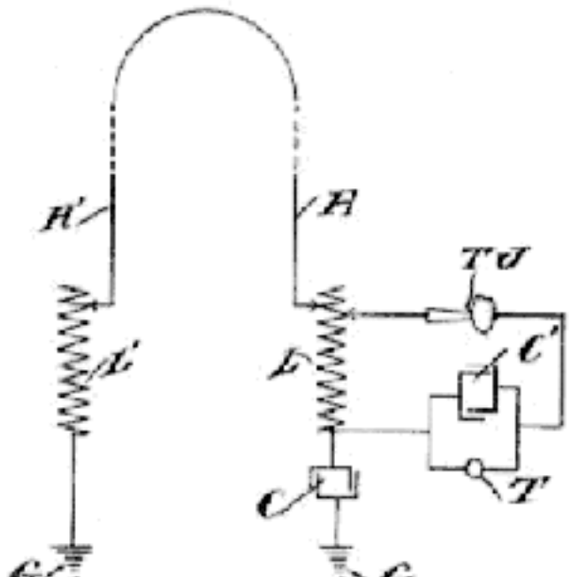
G. W. PICKARD.

MEANS FOR RECEIVING INTELLIGENCE COMMUNICATED BY ELECTRIC WAVES.

APPLICATION FILED AUG. 30, 1906.

1906

Fig. 1.



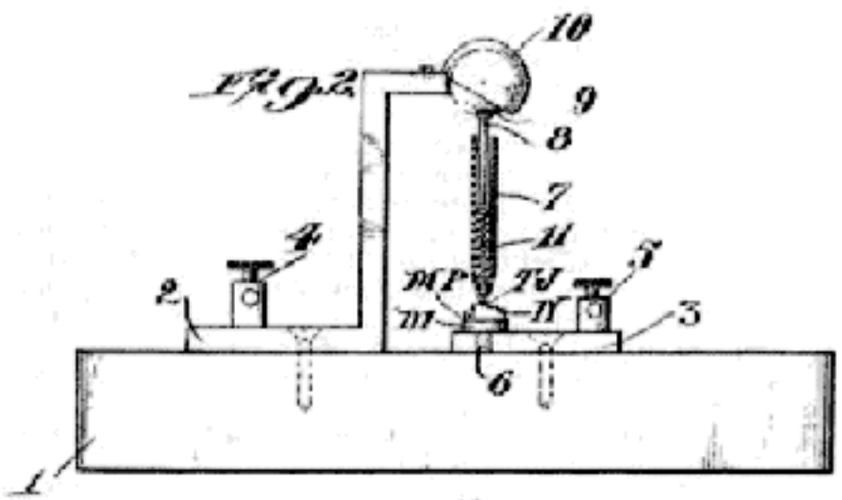
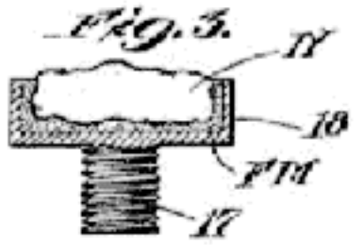




Fig. 3.




Attest:
Thomas C. Edwards
J. Francis Regan

Inventor:
Greenleaf Whittier Pickard
by Philip Farnsworth Atty

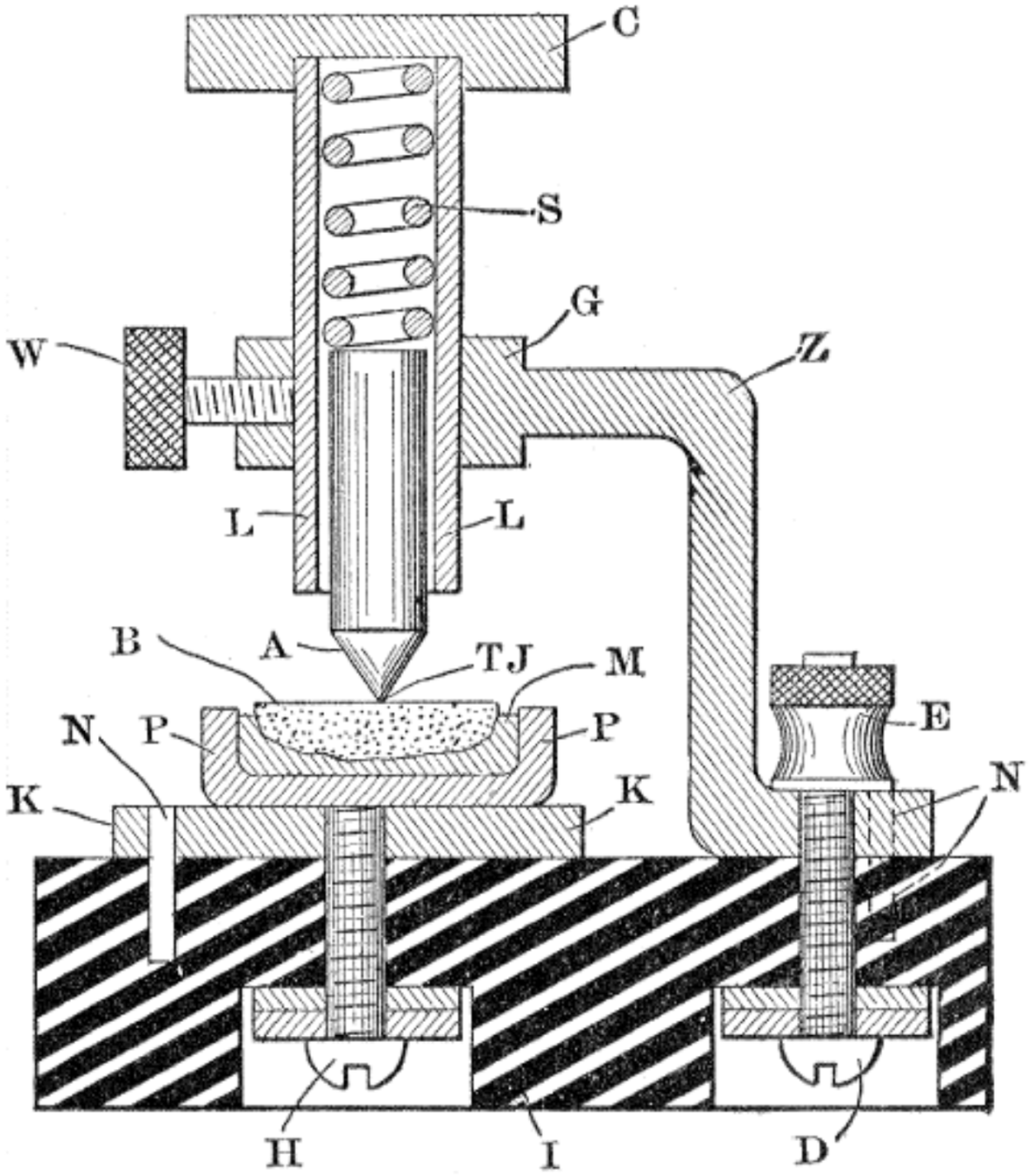



**Fig. 2.** Pickard's Silicon Detector is composed of (A) a brass rod, (B) the silicon, (M) solder, and (P) the metallic cup, as well as various supporting and adjustment parts [from G. W. Pierce, *Principles of Wireless Telephony* (New York: McGraw-Hill, 1910)].

1904

# J.A. Fleming's 'oscillation valve'

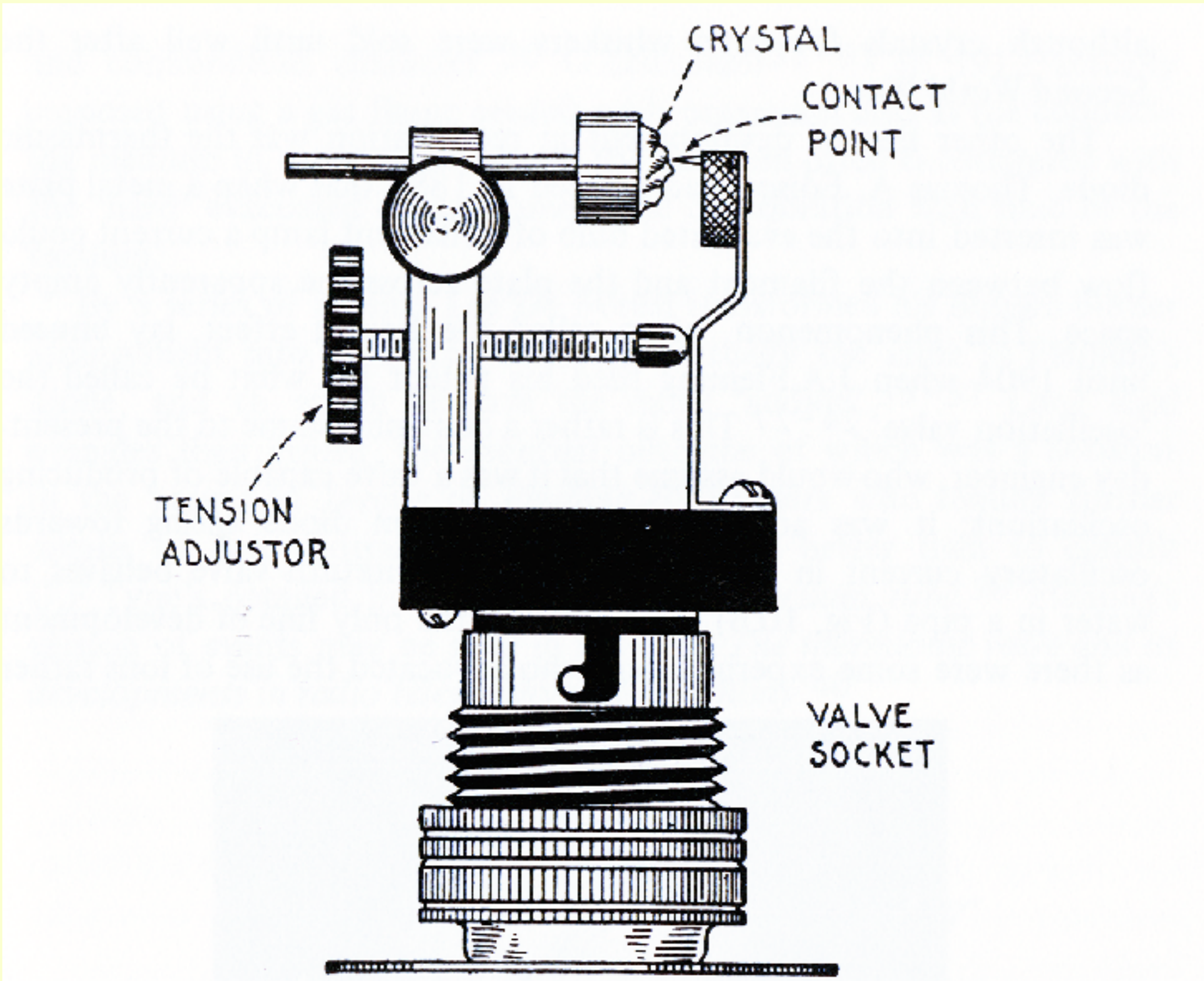
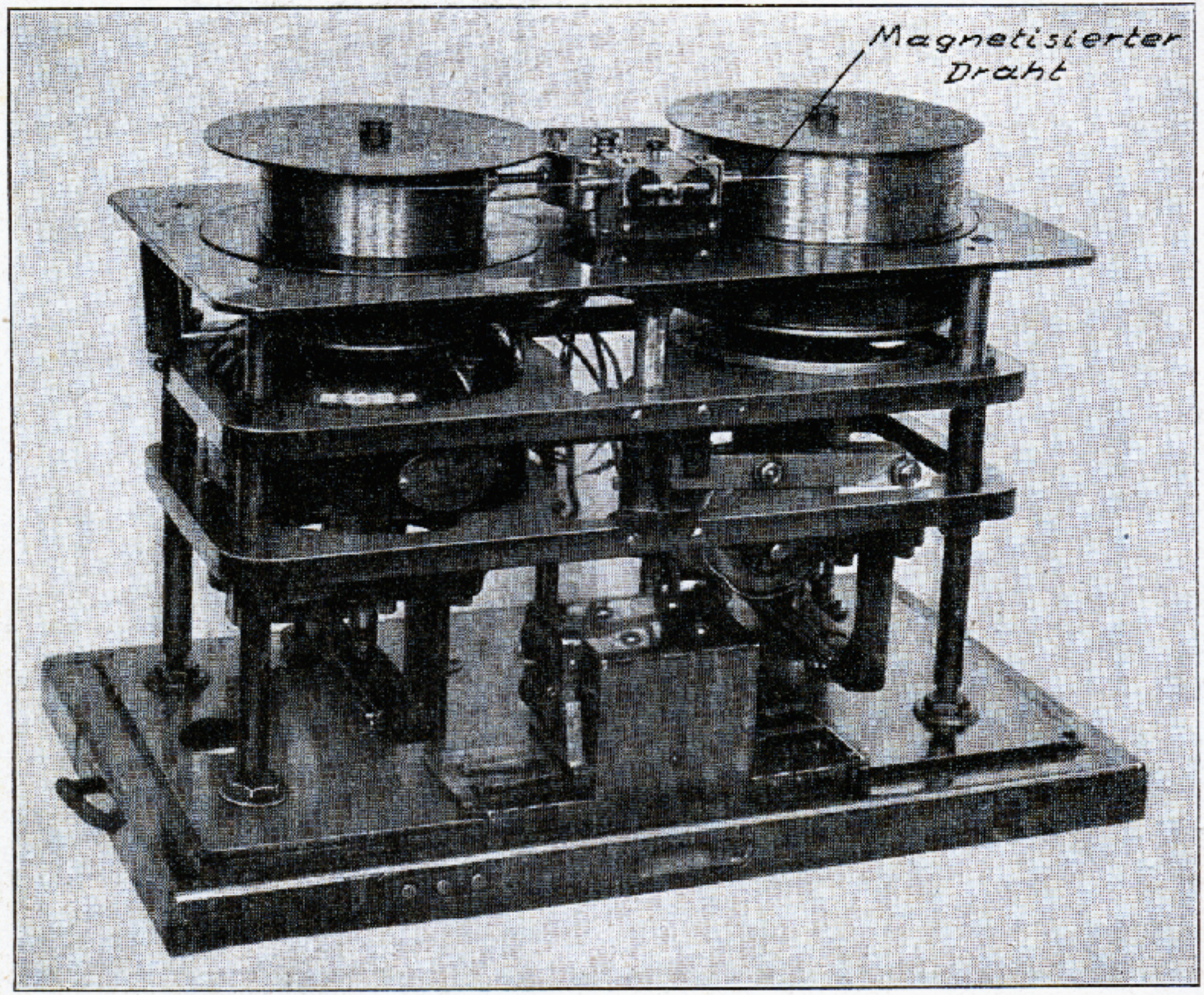



**Fig. 10.4** *Crystal holder designed as a plug-in replacement for a Fleming diode valve*
[Bucher, E.E.: *Practical wireless telegraphy* (Wireless Press, New York, 1917), p.143]

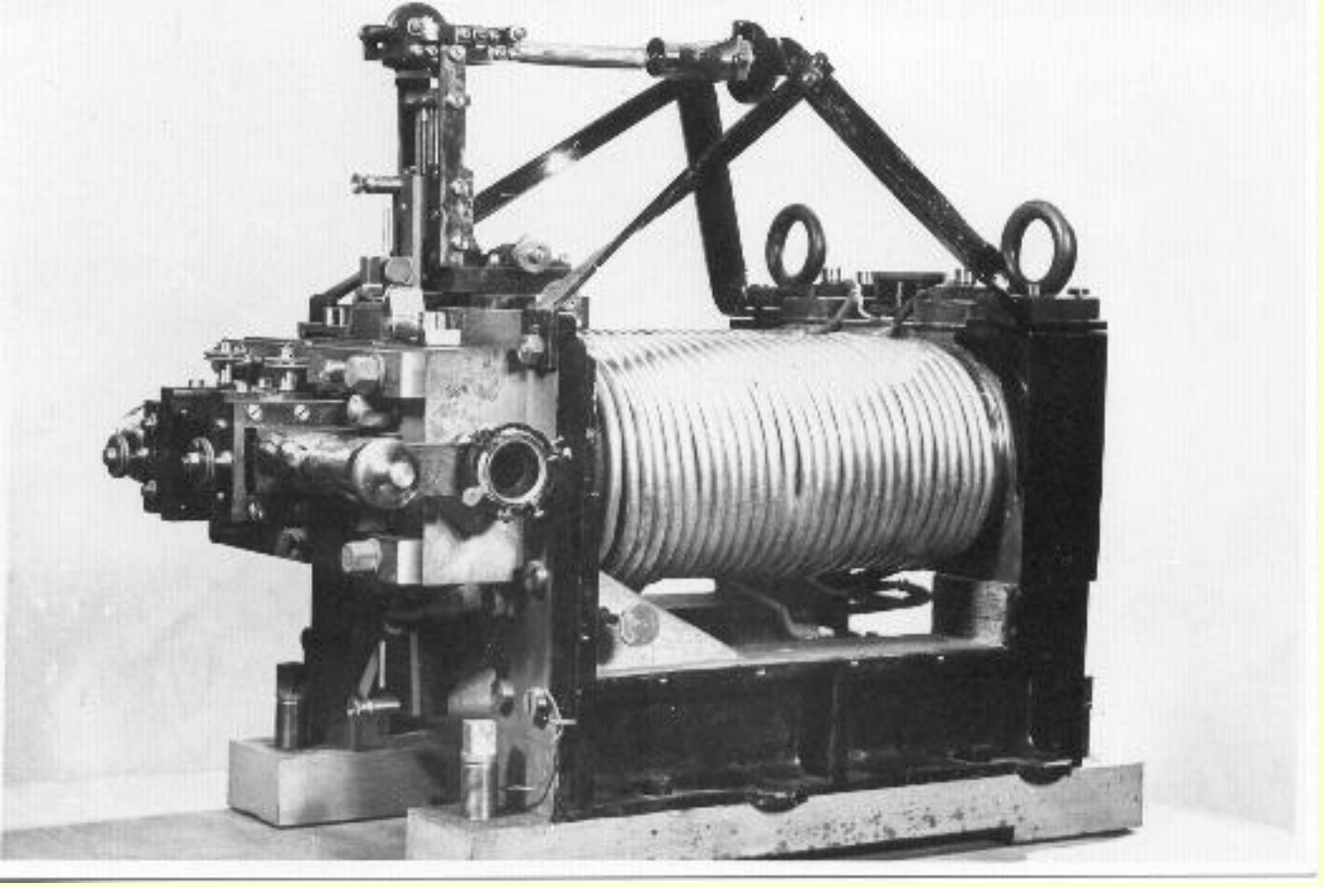
1899




119. Das Telegraphon von Poulsen

1947

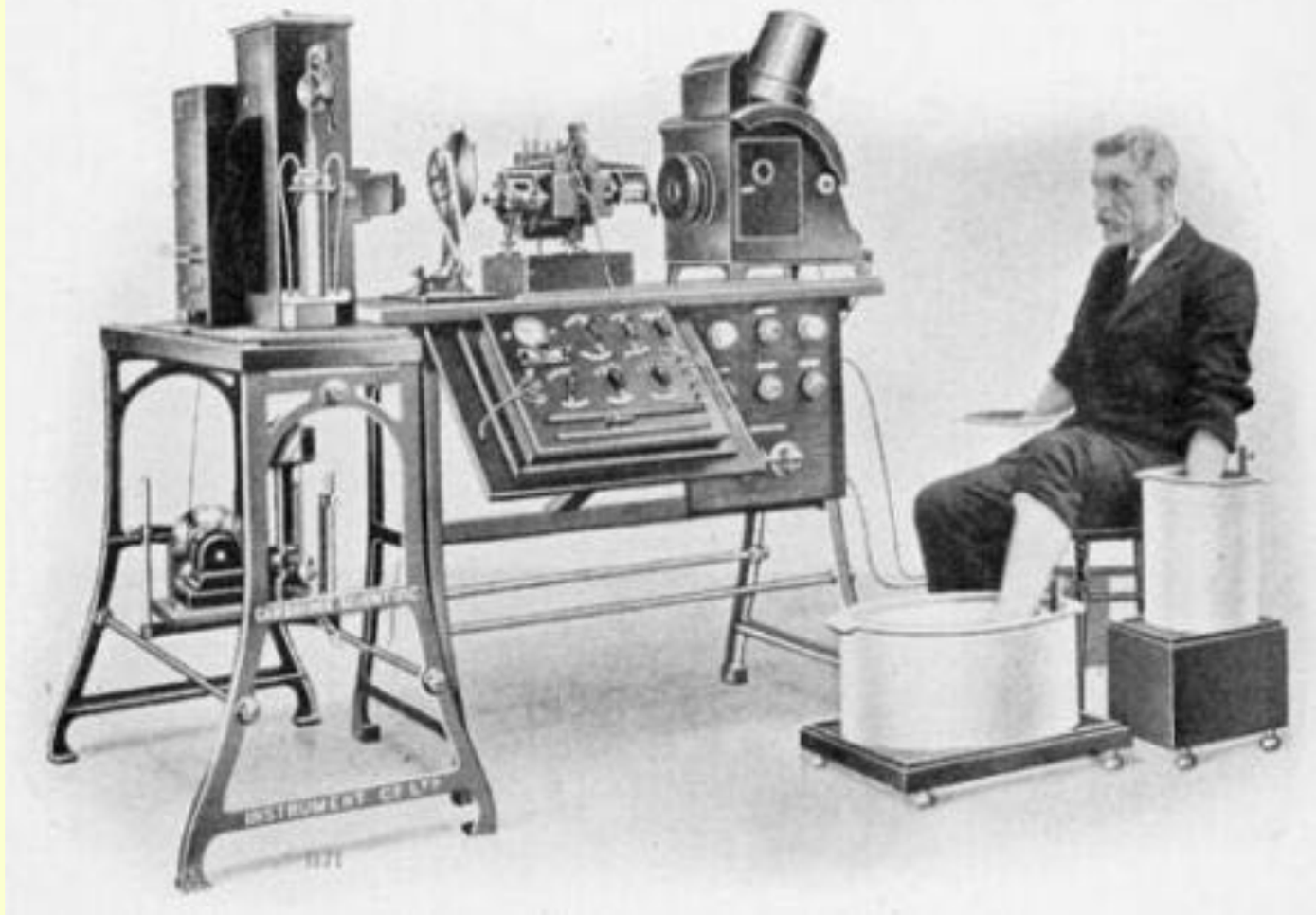

Webster Model 80



Willem Einthoven 1860-1927

Cardiograaf, snaargalvanometer 1903

Nobelprijs Geneeskunde 1924



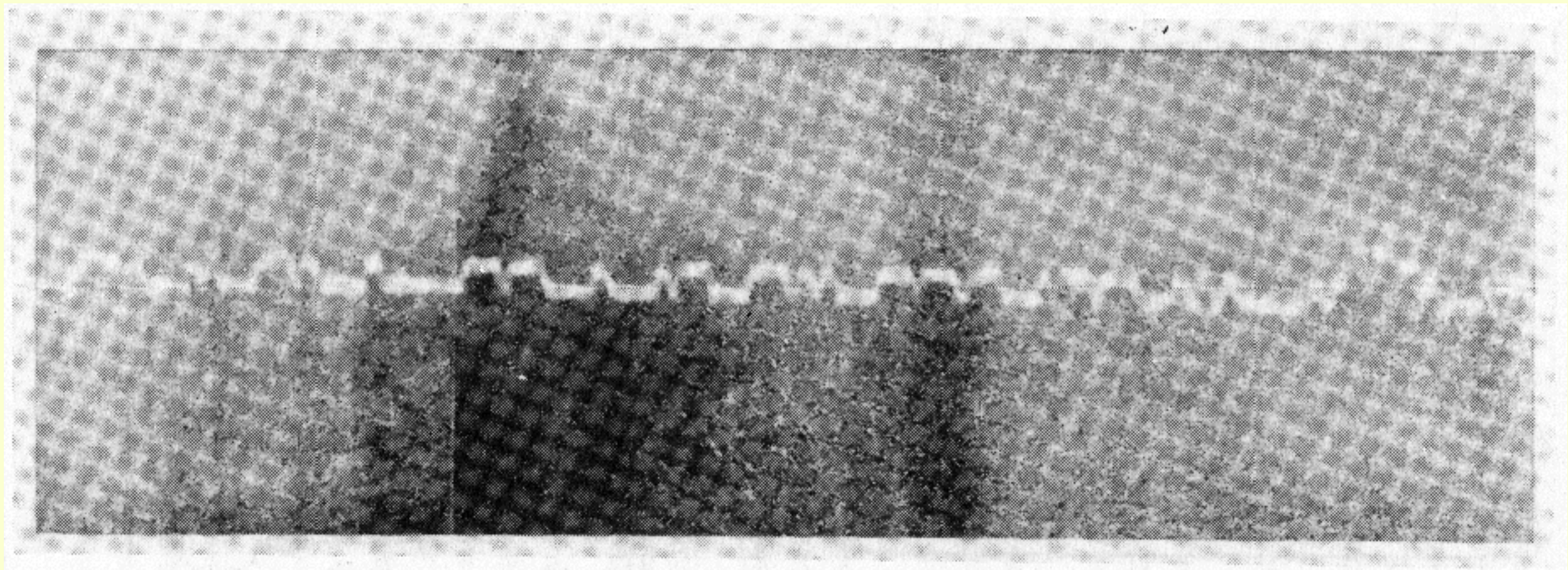


**Fig. 5.1** *First published photographic record of a transatlantic message*
This message was transmitted from Glace Bay, Nova Scotia, and received at the Marconi station, Clifden, Ireland. The record was made by an Einthoven galvanometer actuated by the detector current
[Erskine–Murray, J.: *Handbook of wireless telegraphy* (Crosby–Lockwood, 4th edn., 1913)]

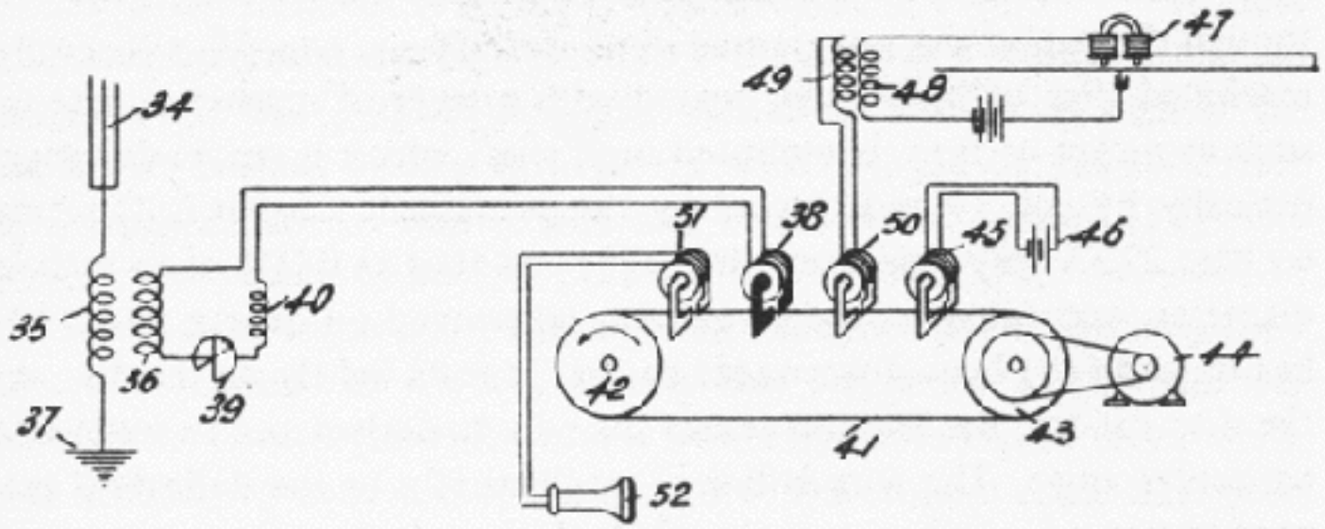



**Fig. 5.11** *Fessenden's demagnetisation detector – a forerunner of modern tape recorder erase systems*
[British Patent 20 466, 1908]

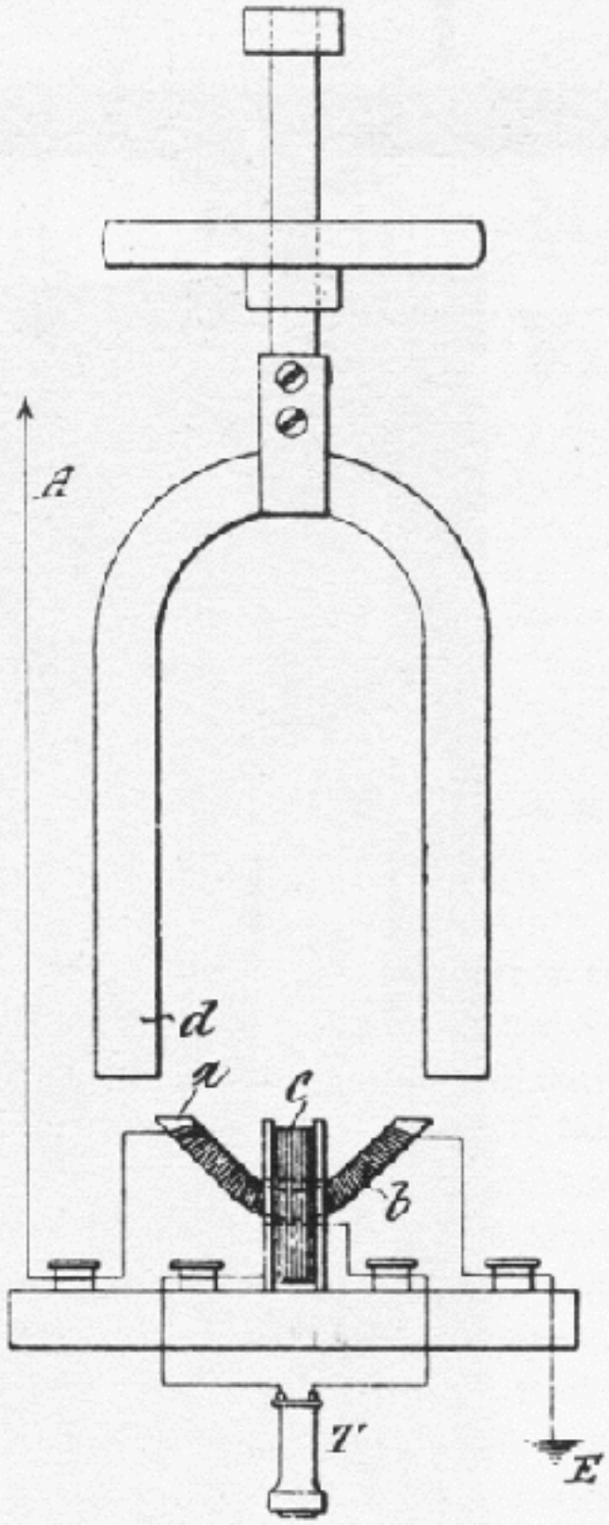
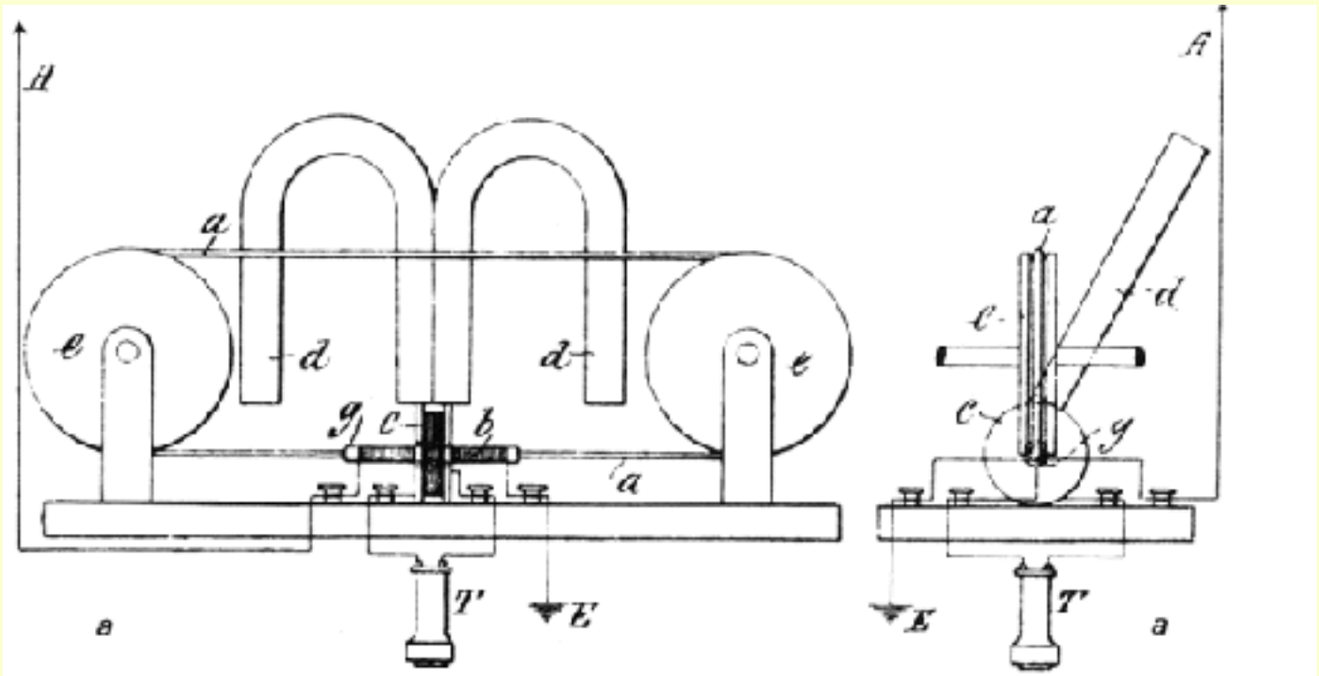



**Fig. 5.15** *Marconi's first hysteresis detector*
[British Patent 10 245, 1902]




*Marconi's second hysteresis detector*
(a) Two views of the detector

Hysterese detector voor telegrafie
(Marconi)
in gebruik tot ca 1920

**Fig. 5.22** *A Marconi hysteresis detector in use*
[Collins, A.F. 'Manual of Wireless telegraphy', (Wiley/Chapman & Hall, 1906) p.165]

Waarom Continuous Wave?

- beperkte bandbreedte -> minder onderlinge storing
- effectiever gebruik van antenne
- minder atmosferische demping
- morse beter neembaar door
    operator controle over de 'beat note'
    - later: mogelijkheid van audio modulatie

Nadeel:
    niet zonder meer 'neembaar' via de koptelefoon

Veel deskundigen meenden dat CW theoretisch onmogelijk was.

CW met behulp van

- Poulsen boog oscillator (sinds 1902)
- Alexanderson alternator (sinds 1906)
- Meissner 'lampzender' (sinds 1913)

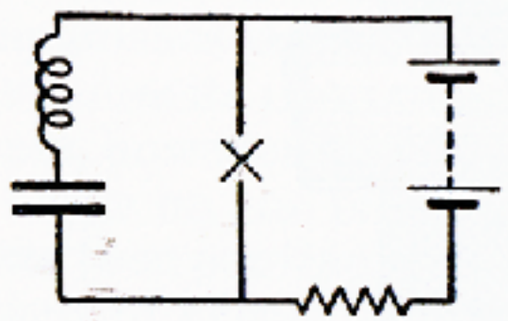


FIG. 155.—SIMPLE ARC-MAINTAINED OSCILLATORY CIRCUIT.

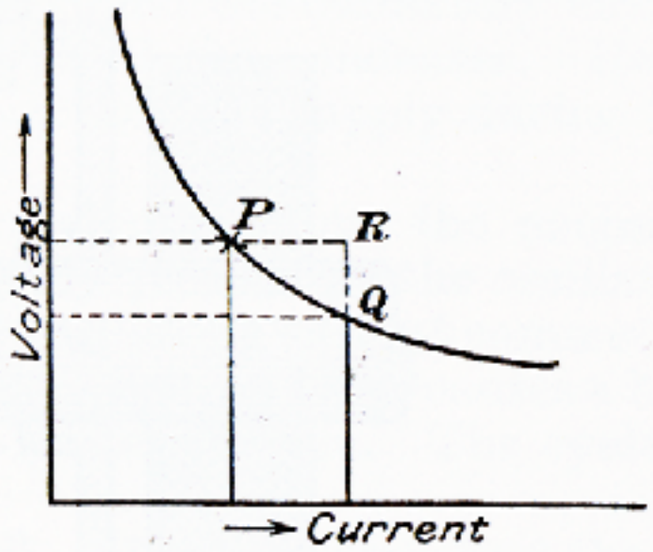



FIG. 156.—CHARACTERISTIC OF CARBON ARC.

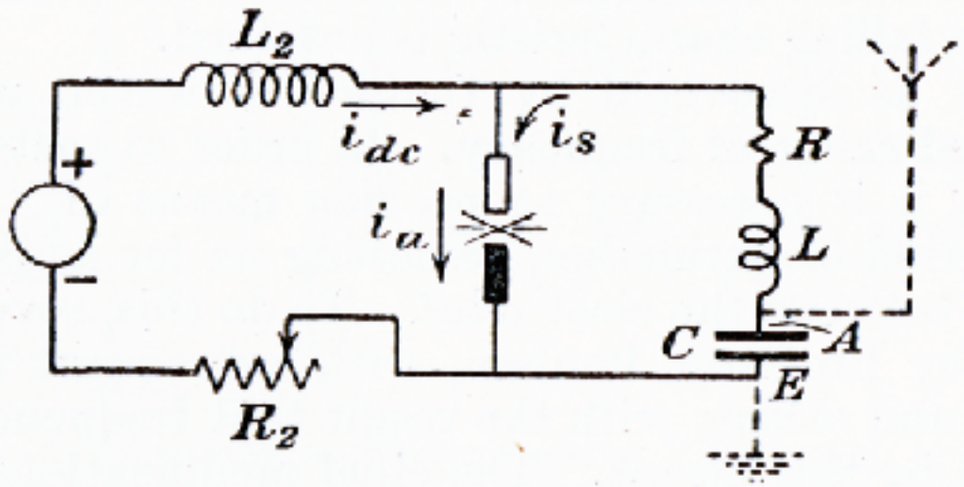



FIG. 158.—CIRCUIT DIAGRAM OF RADIO-FREQUENCY ARC GENERATOR.

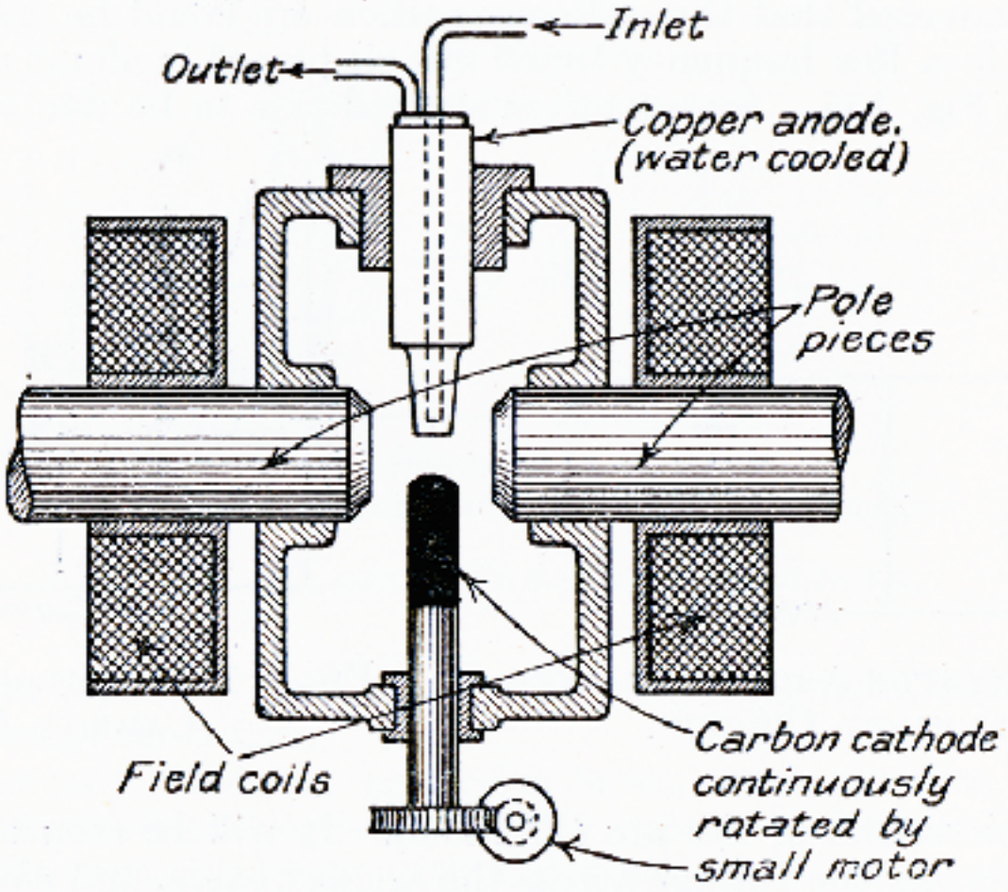
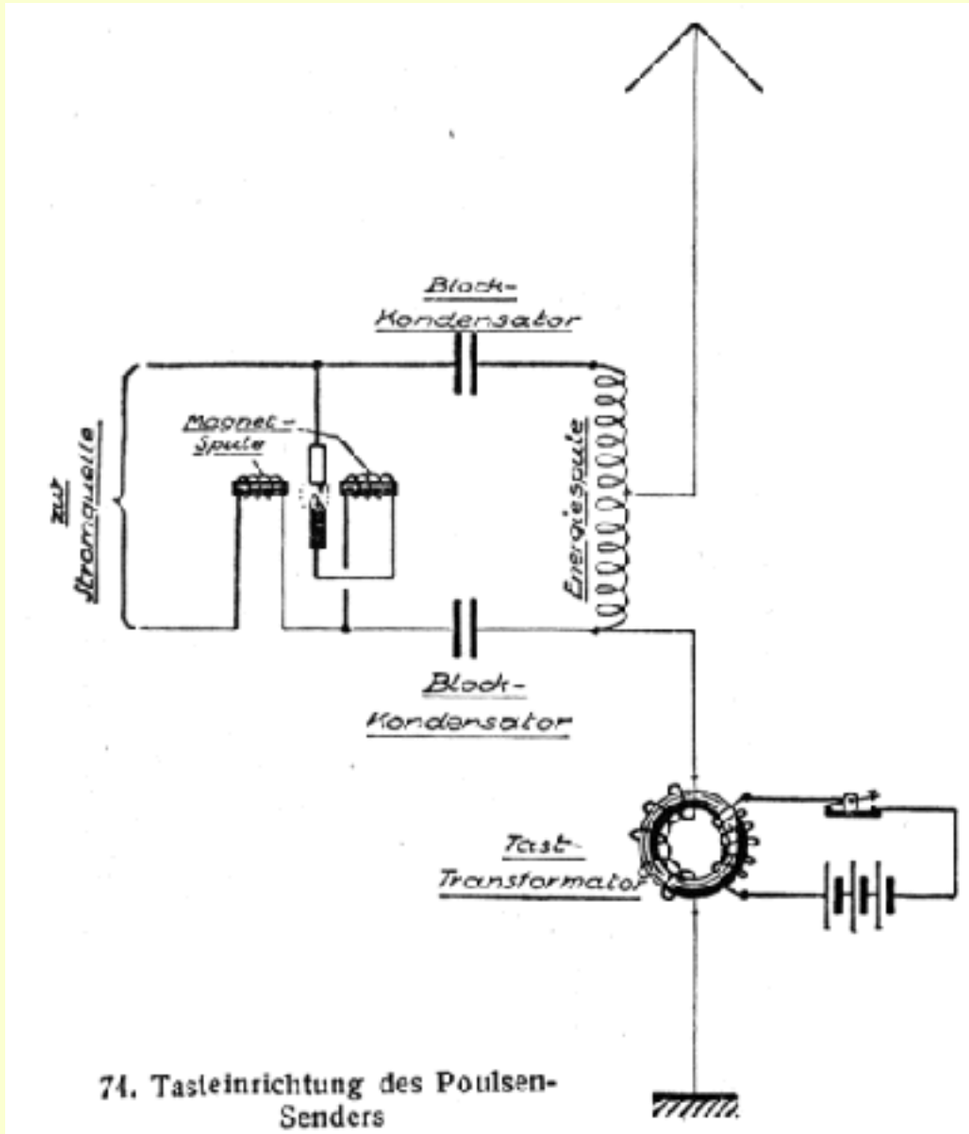
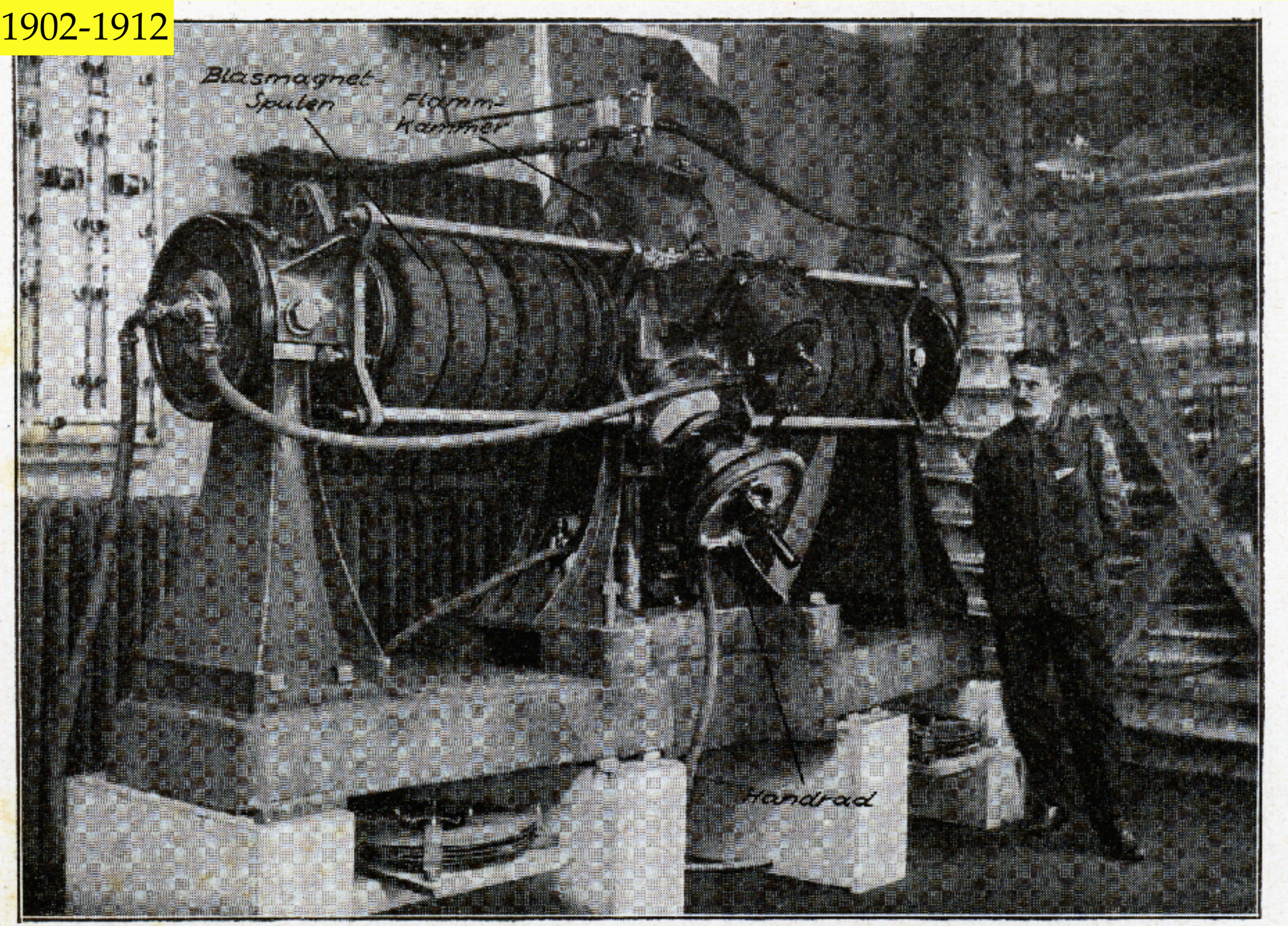



FIG. 157.—DIAGRAM OF RADIO-FREQUENCY ARC GENERATOR.




74. Tasteinrichtung des Poulsen-Senders

1902-1912




73. Poulsen-Sender in der Bauart der Firma C. Lorenz

# Reginald Fessenden (1866-1932)

propageerde CW vanaf 1900 ,
tegengewerkt door Marconi

1900 draadloze spraakoverdracht met vonkzender
1902 uitvinding van het heterodyne-principe
1906 eerste 'omroepprogramma' met machinezender

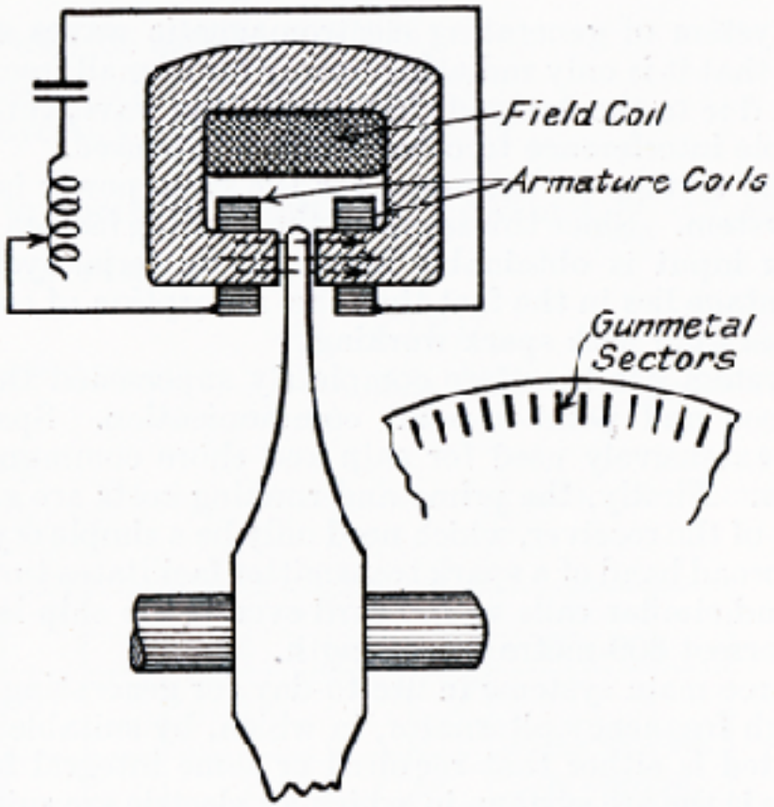



FIG. 148.—SECTION OF ALEXANDERSON ALTERNATOR.

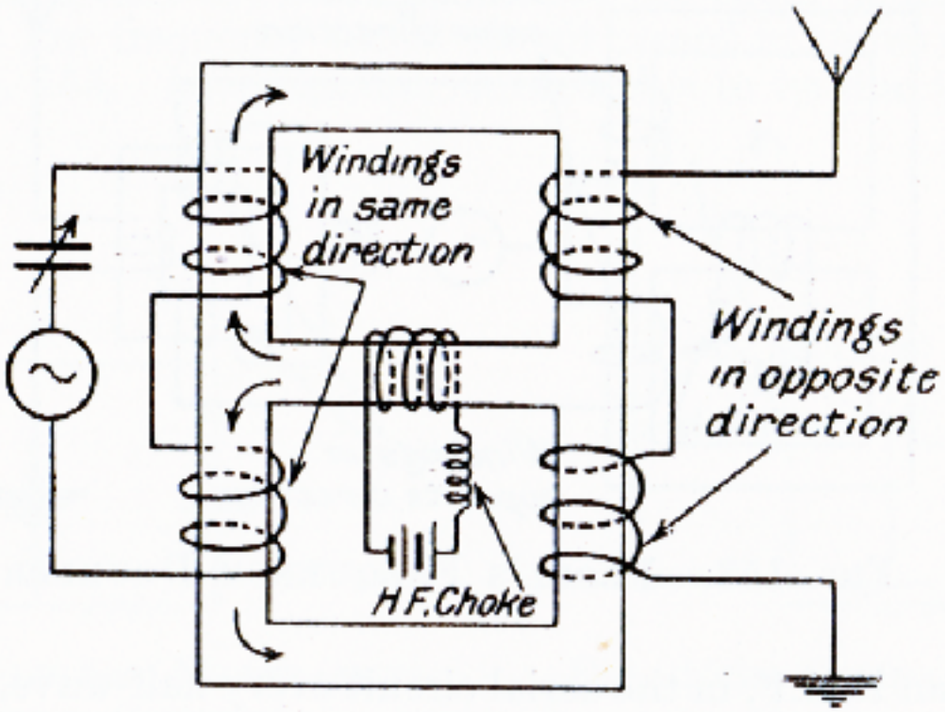
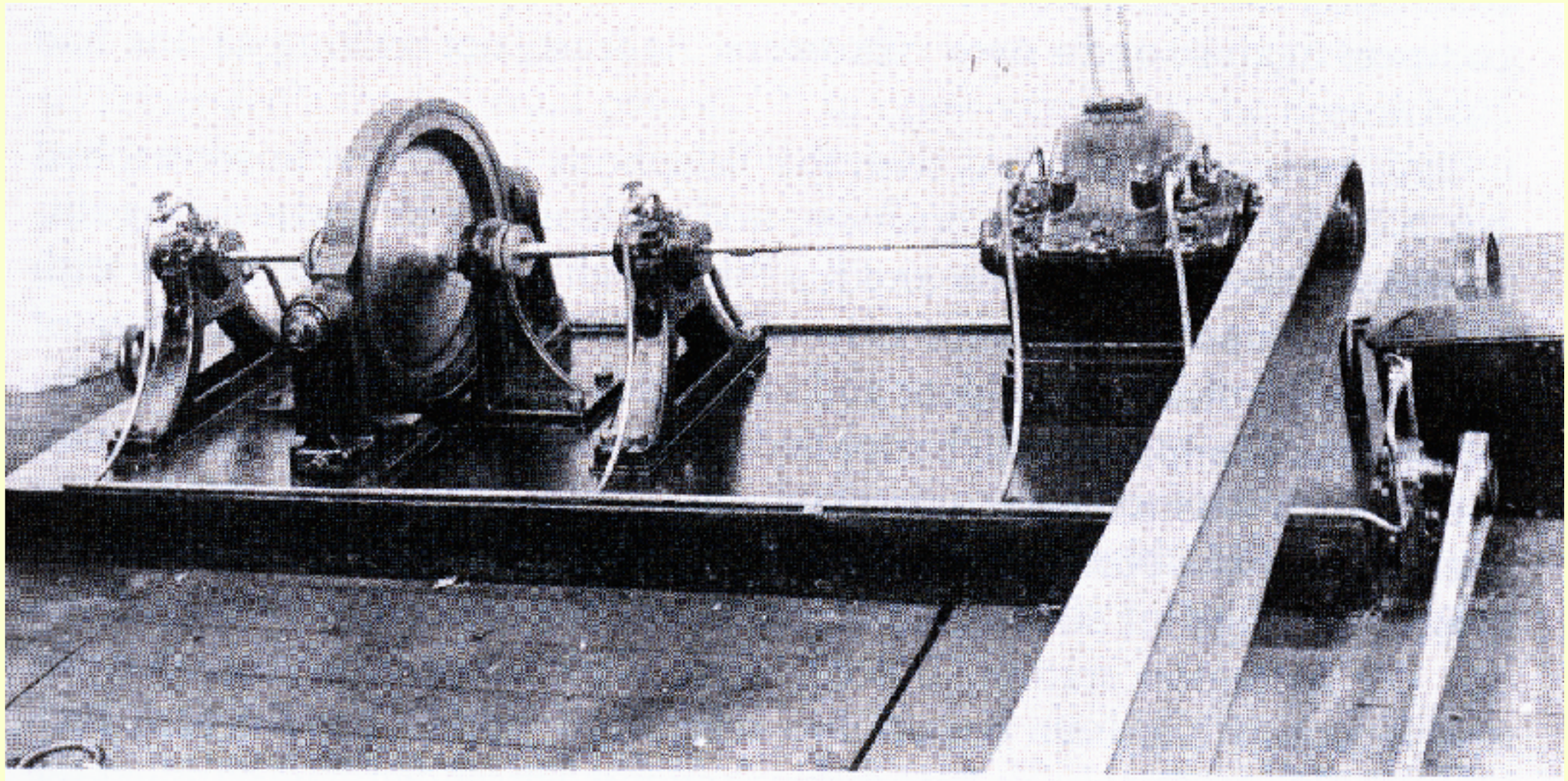
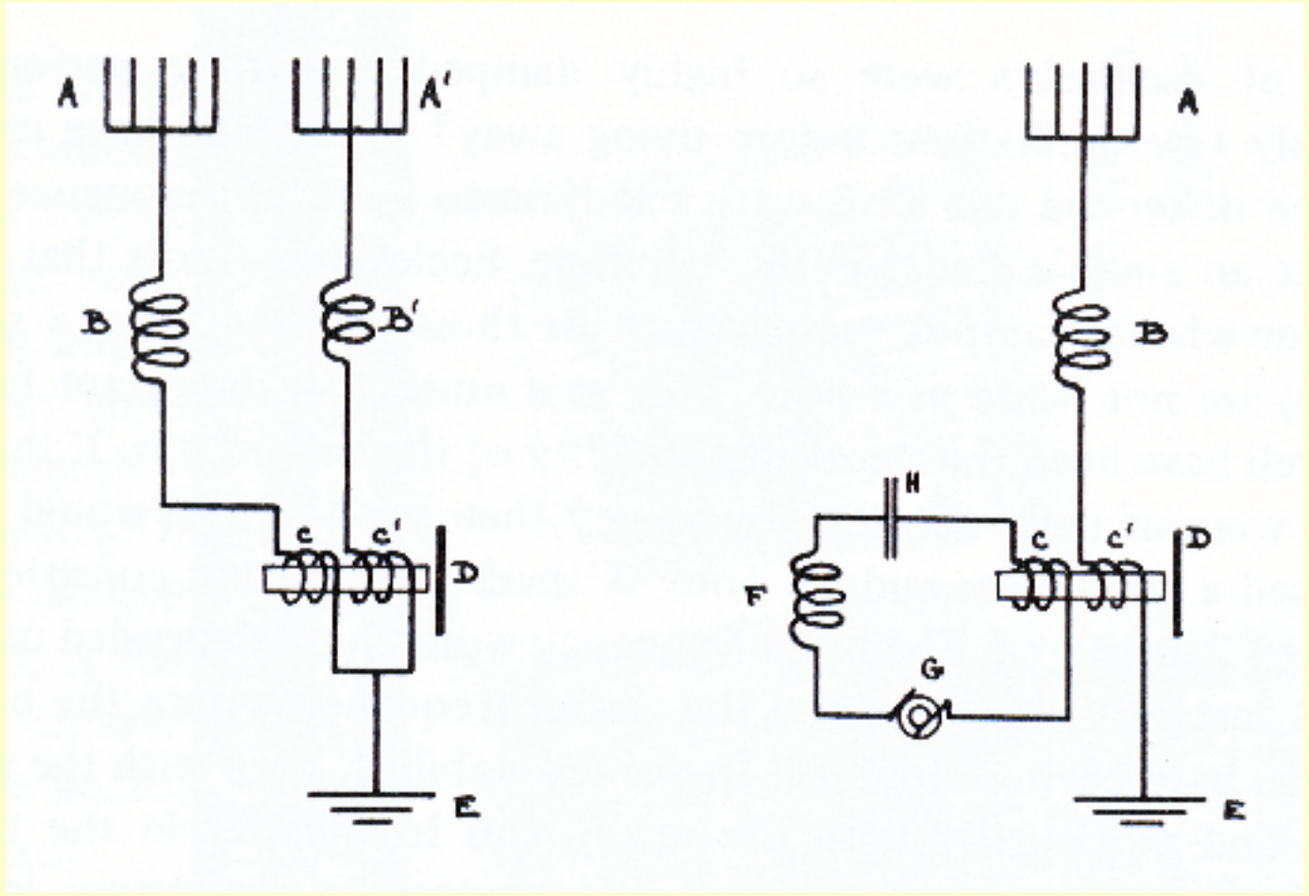



FIG. 151.—JOLY'S FREQUENCY DOUBLER.

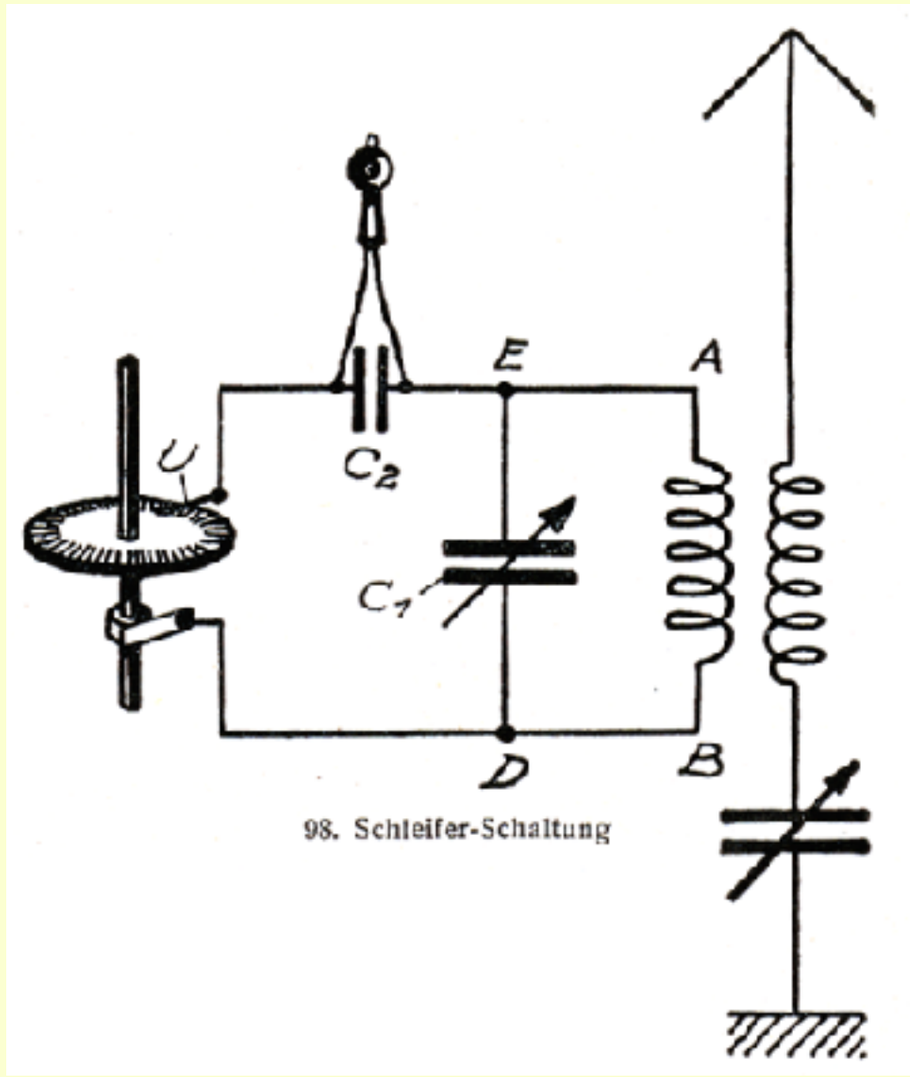


Pl. 1: Alexanderson's 2 kilowatt alternator.
Source: General Electric Company




<-- Fessenden heterodynes

Schleifer (Eng. tikker) -->




98. Schleifer-Schaltung

# Lee de Forest
# 1873 - 1961

## His Inventions Changed the World

werd vervolgd...