Medical and Biological Engineering

From Ideas to Successful Medical Products

Content

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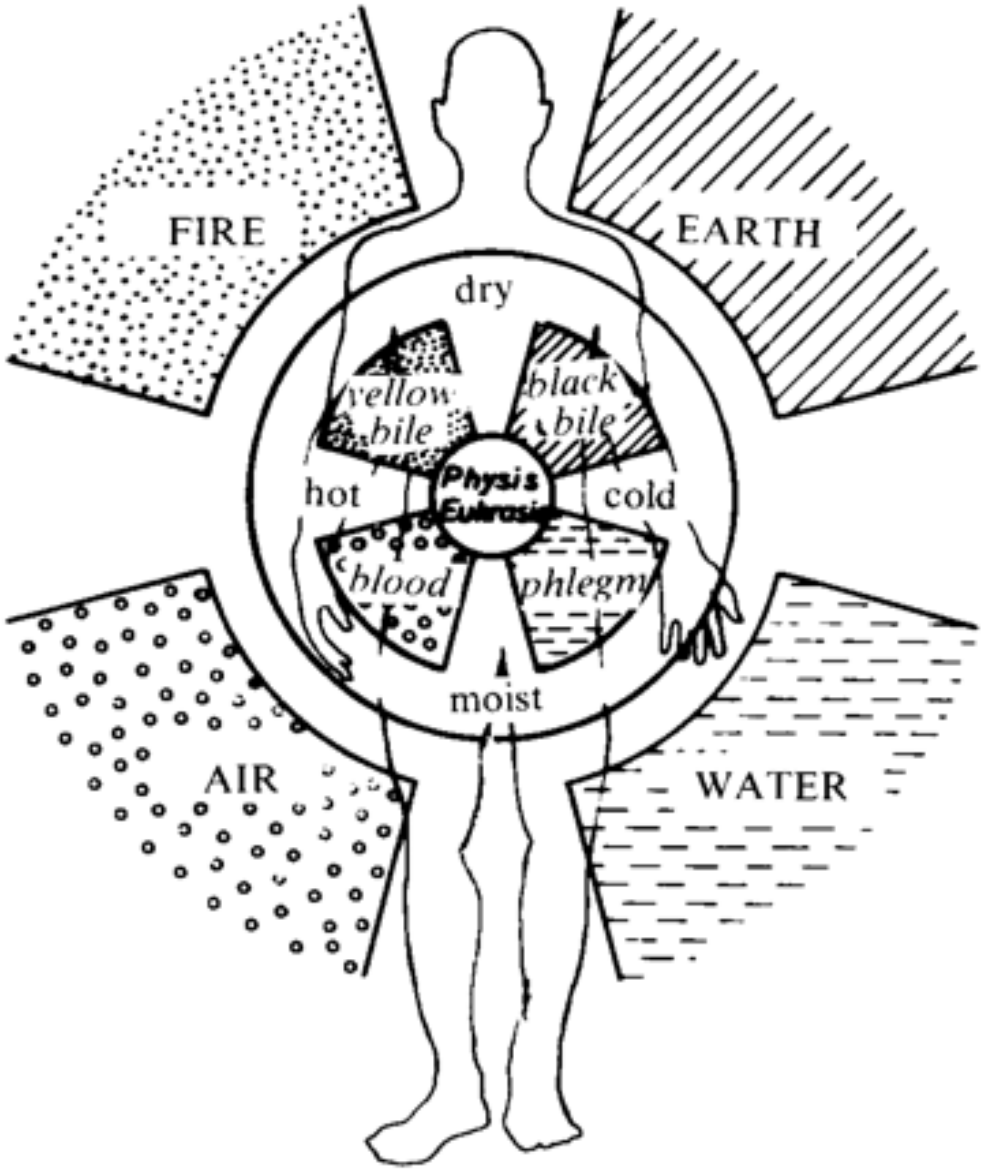
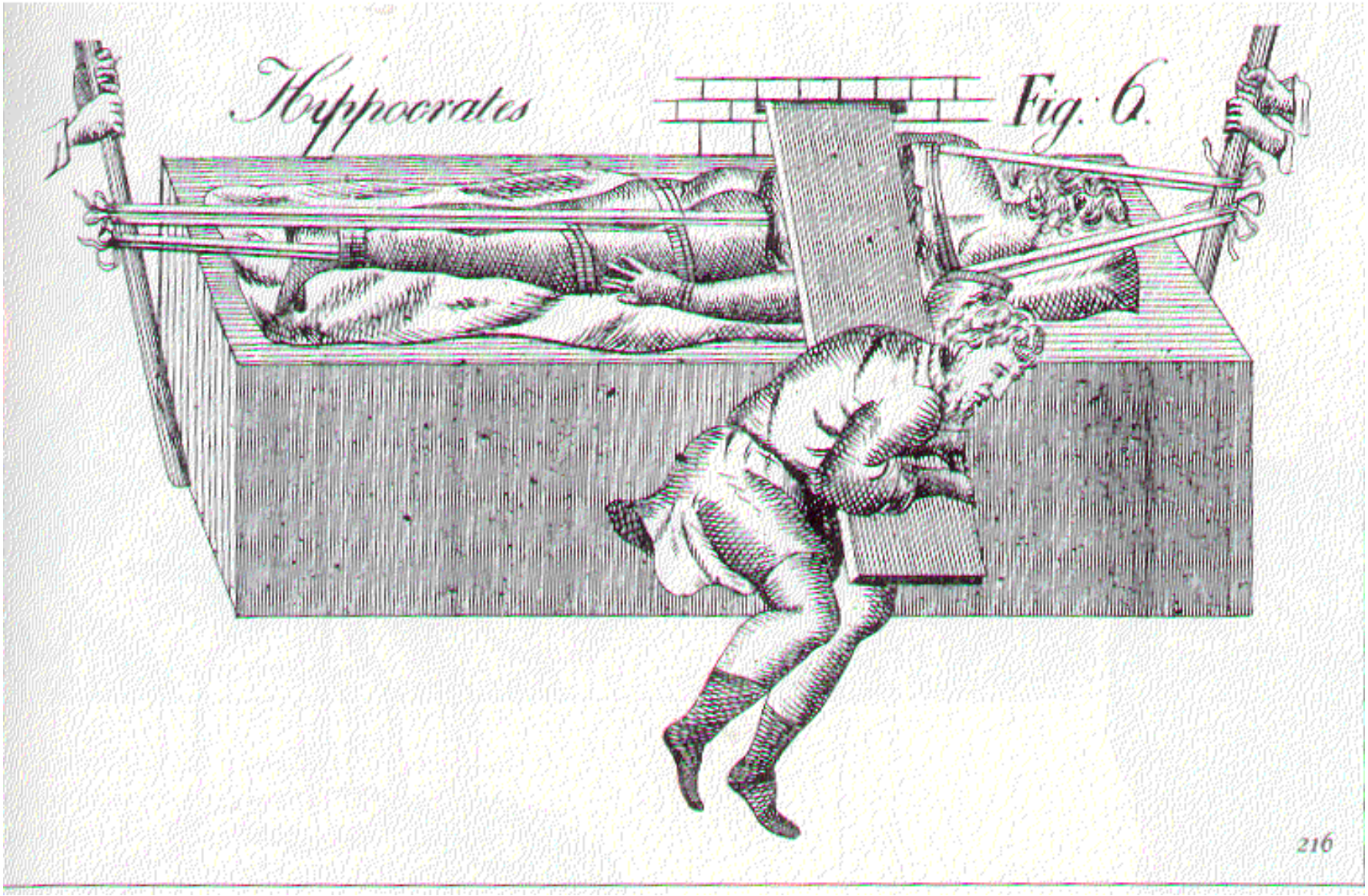


Hippokrates (about 400 B.C.)

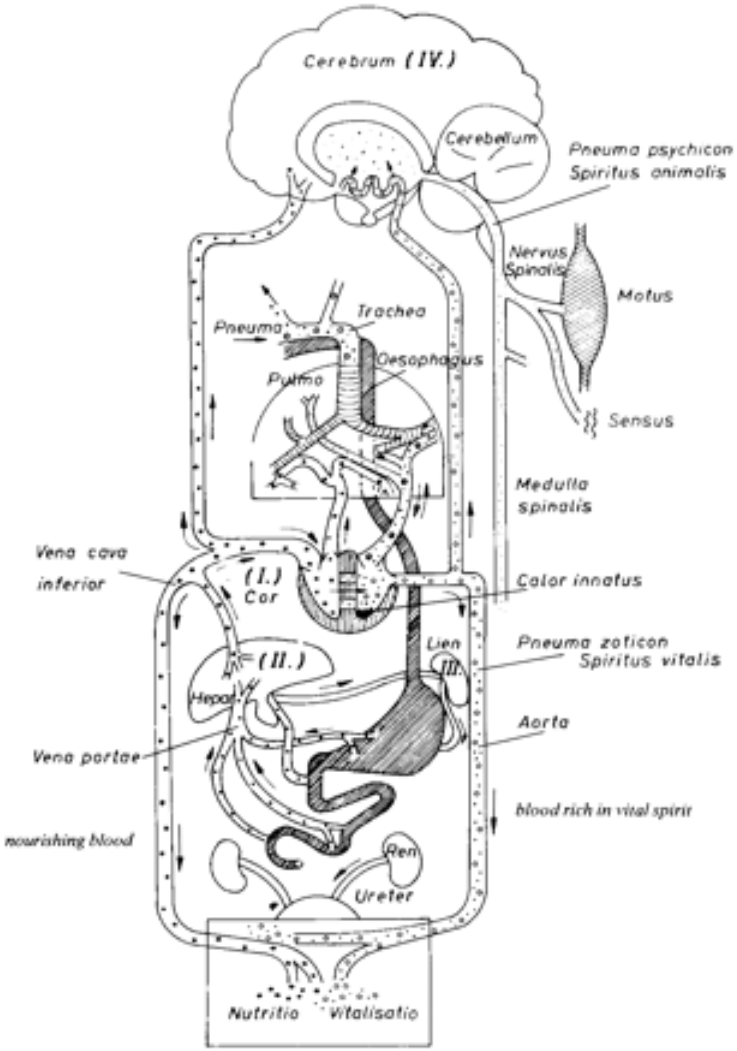
The relations among the elements that comprise comprise the universe (earth, fire, air, water), their qualities (dry, hot, moist, cold), and the humors present in the human (black bile, yellow bile, blood, phlegma) according to the ancient model.

Model of the human individual as it is embedded in the universe



Treatment of fracture of spinal column

recommended by Hippocrates and applied until the middle of the 19th century



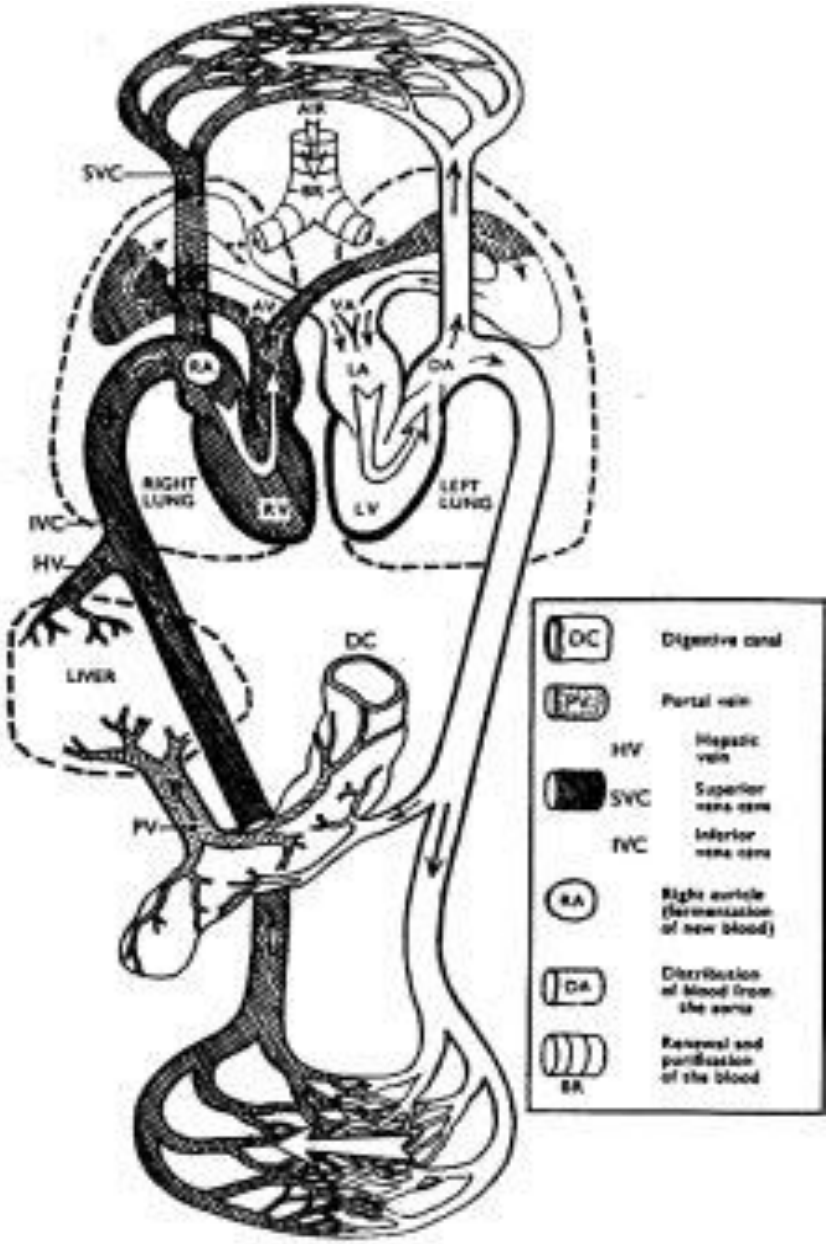
Galen (129 – 199 A.C.)

Model of anatomical and physiological systems

1. The peripheral circulation is not closed.

2. The physiological systems are:
   * Brain and nerves for sensation and thoughts
   * Heart and arteries for live-giving energy
   * Liver and veins for nutrition and growth

Model of anatomical and physiological systems



William Harvey (1578 – 1657)

1616 / 1628

Harvey has postulated (or hypothesized) that there must be a connection between the arterial and the venous branches of the circulatory system.

The existence of capillaries had been proven experimentally by Marcellus Malpighi (1661)

The model of closed circulation

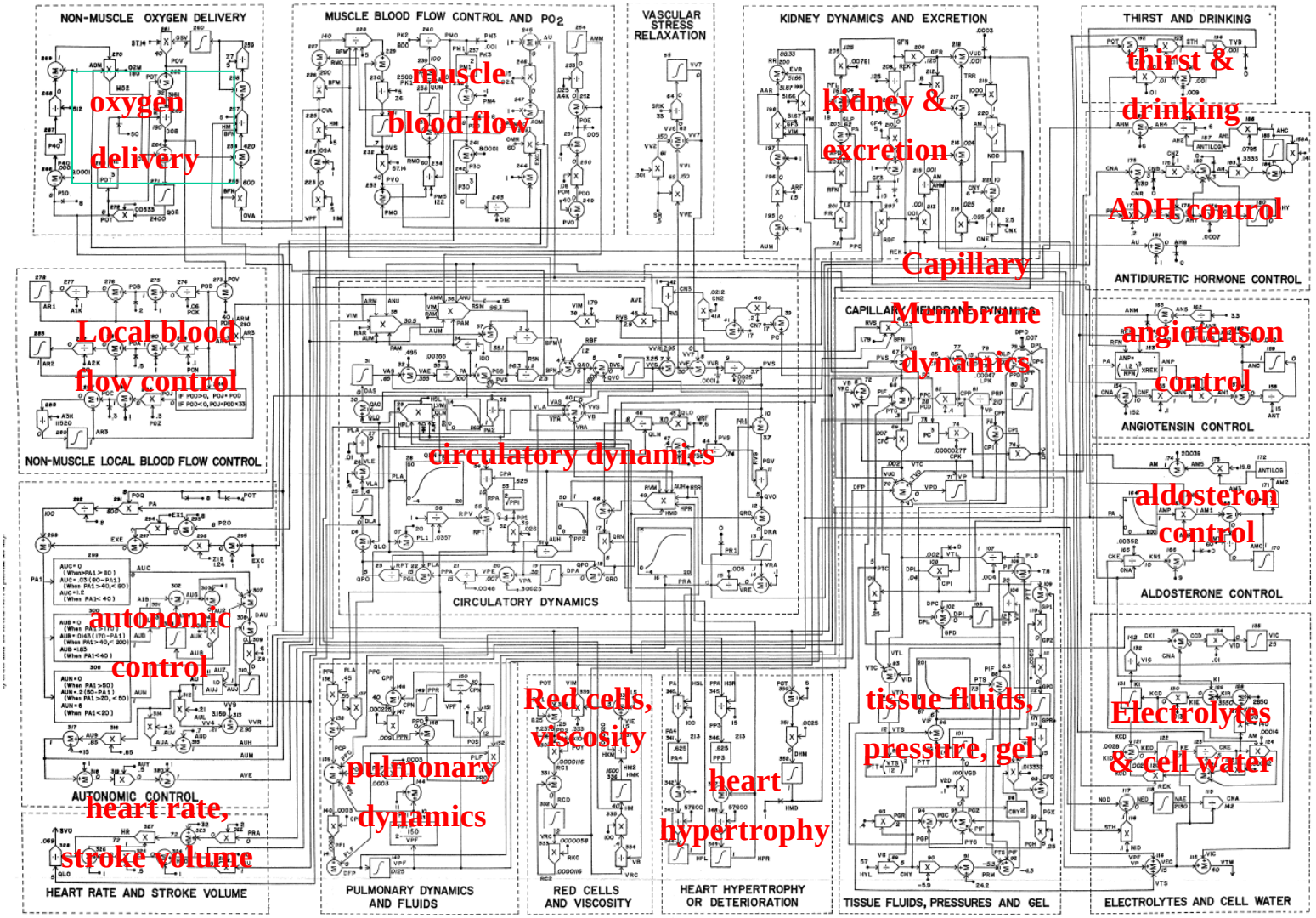
René Descartes (1596 – 1650)

For Descartes the human was functioning like a mechanical machine. This is demonstrated by the model for sensation conduction from the foot (heat, pain) to the brain via a tube filled with liquid.

This model was developed in 1632, but published only after Descartes's death in 1662.

The mechanical model of sensation conduction

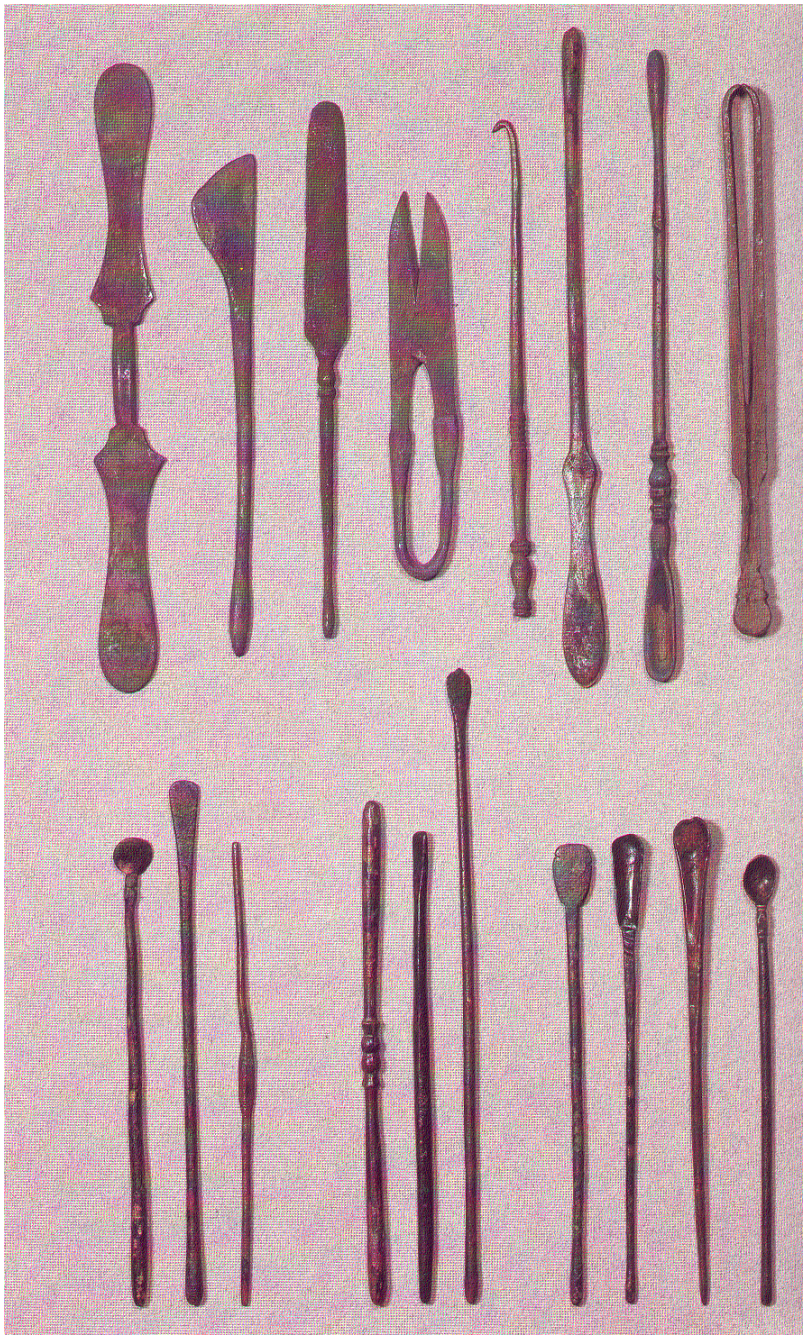
Guyton AC, Coleman TG & Granger HJ 1972



Model for circulatory overall regulation (without ANS control)

Mobility aid – Walking stick (Egypt, 2nd century B. C.)

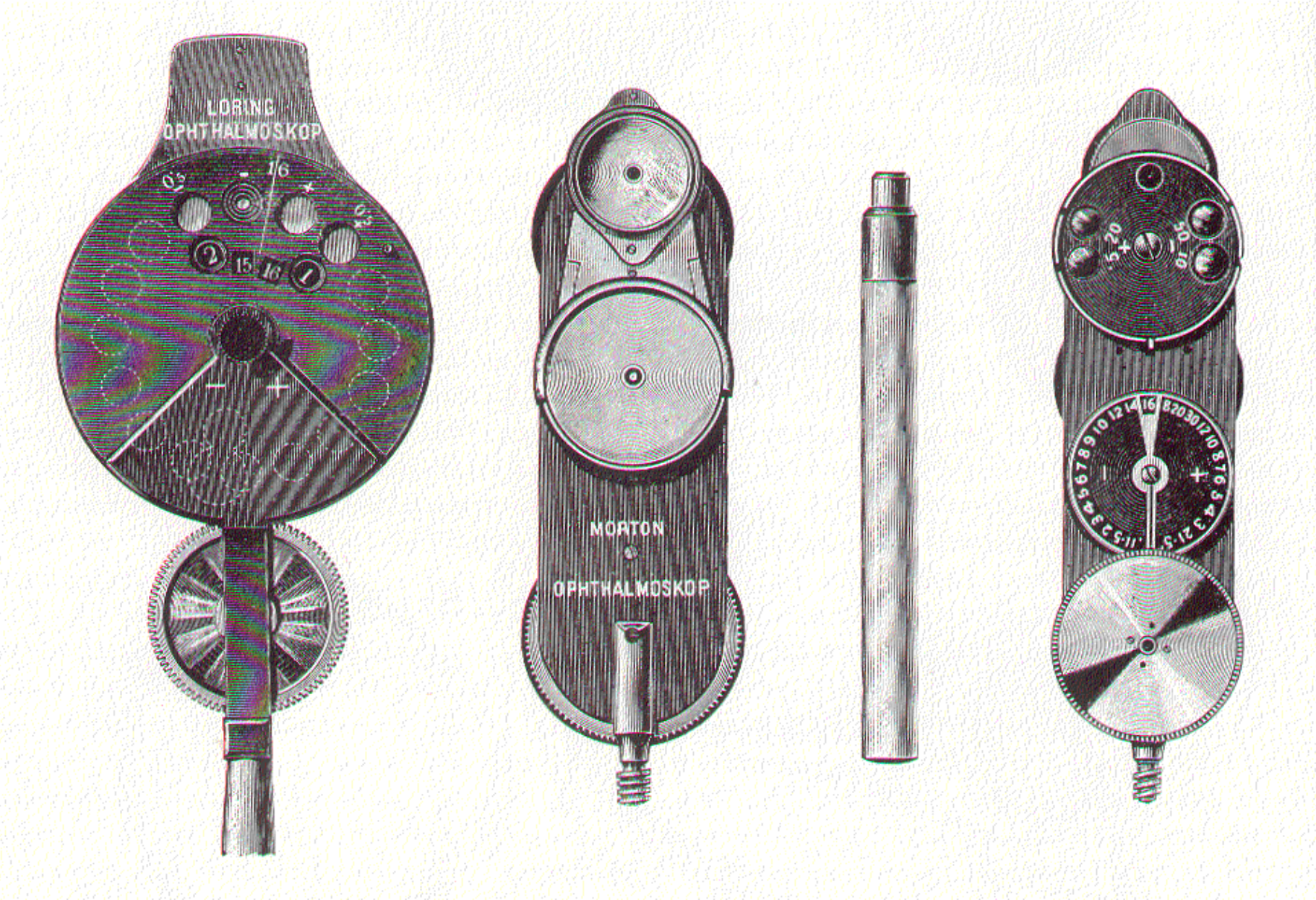
Mobility aids (painter: Brueghel the Older, 1559)



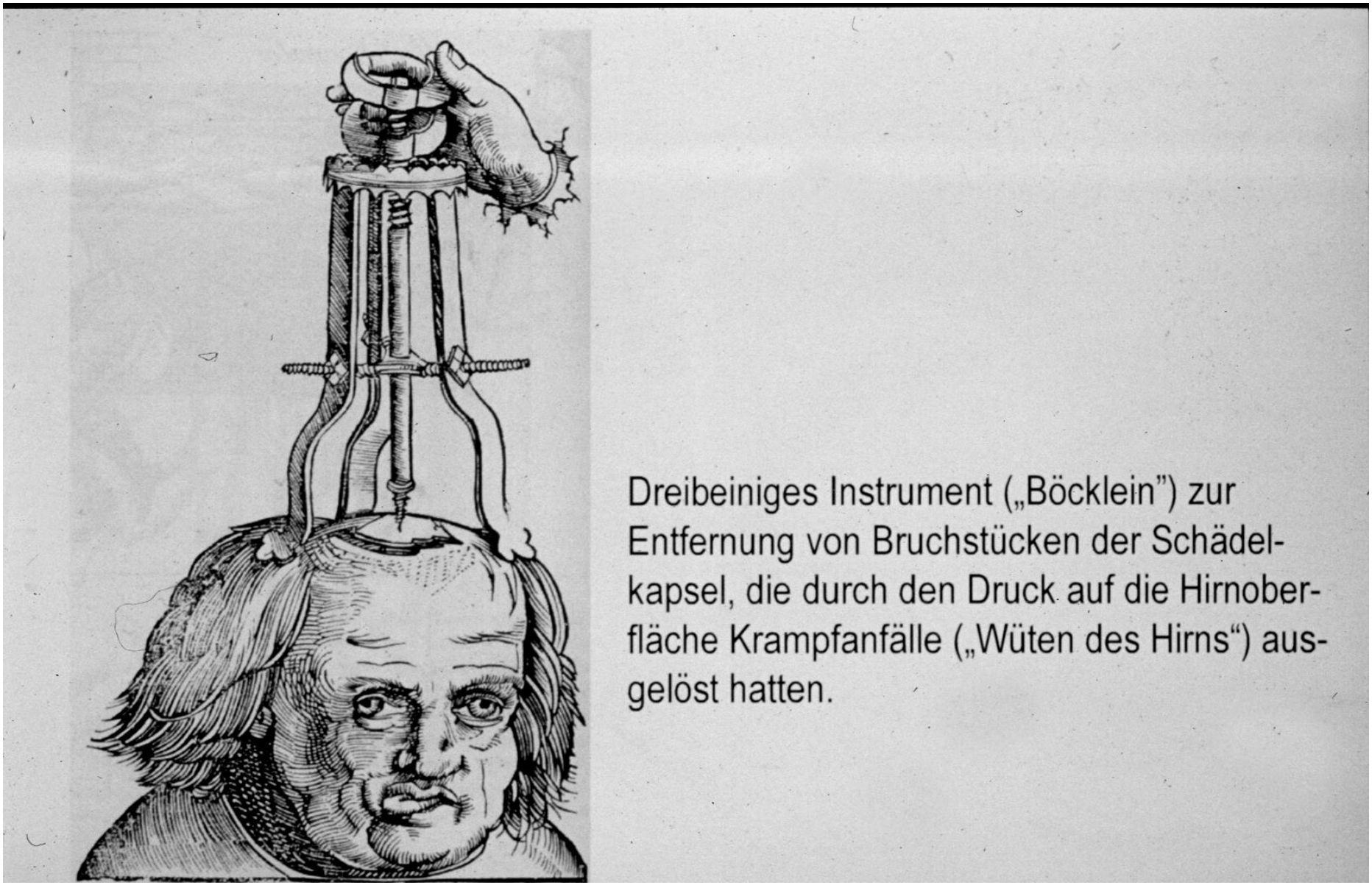
Tools for surgery (1st century A.C.)

Device for measuring the blood lost during phlebotomy (Al-Jazari, 1206, device reconstructed 1977)

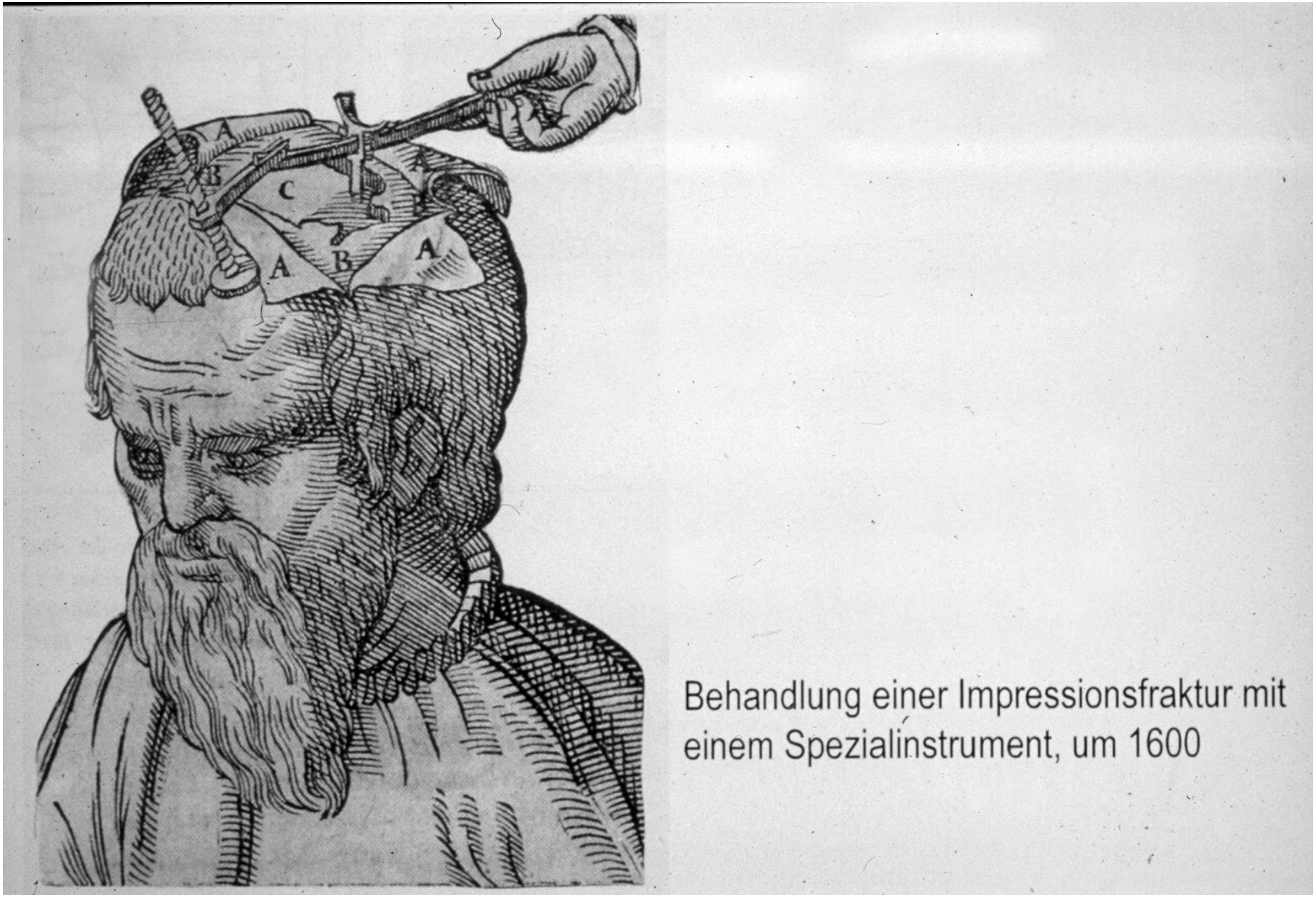
Reading glasses (1466)



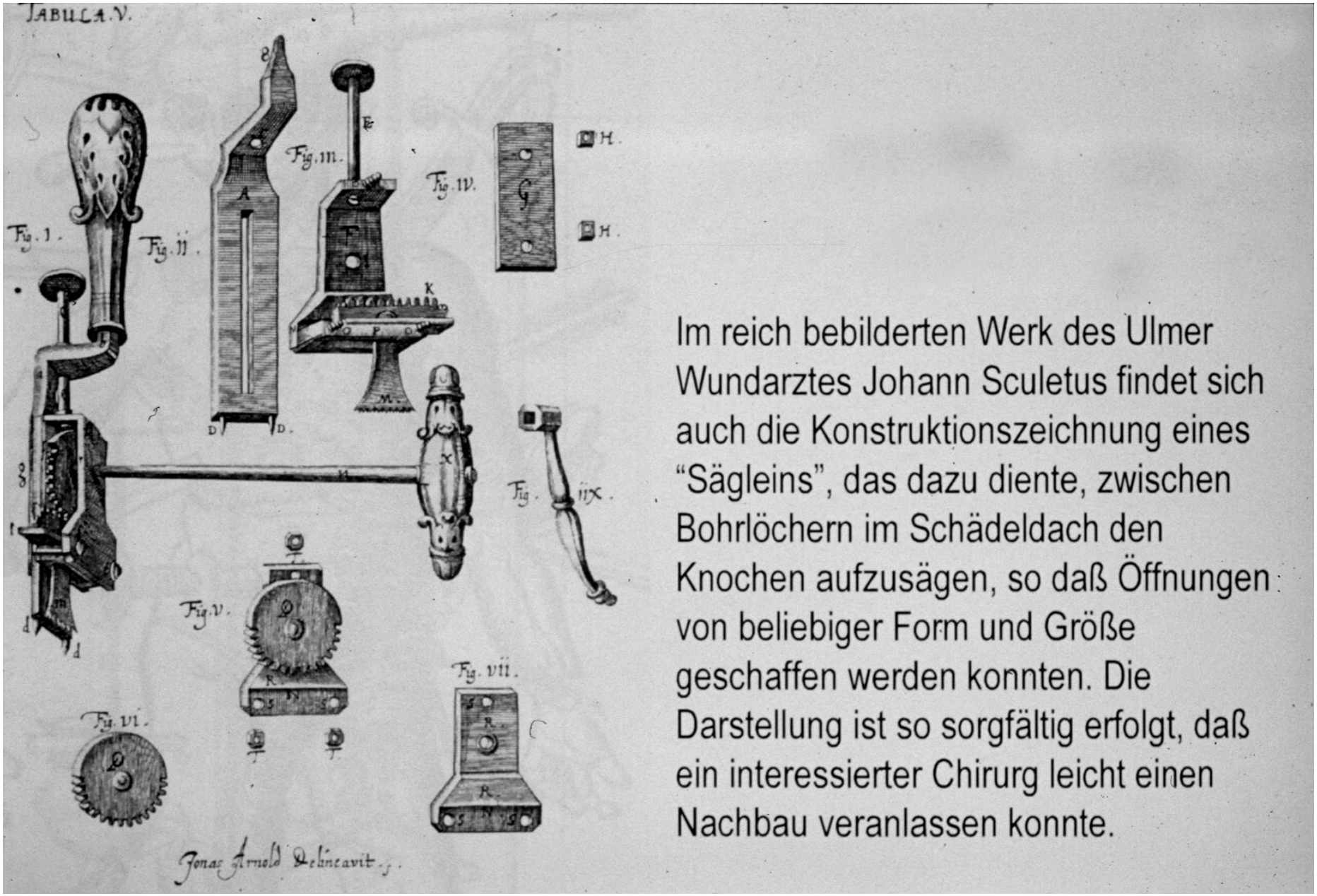
Ophthalmic instruments for the measurement of refractory anomalies (1900)



Special tool for the removal of skull bone fragments and the lowering of elevated intracranial pressure (published 1517)



Special device for the treatment of skull fracture (used about 1600)



Special saw and saw blade for skull surgery (published 1666)

Ablassen von Bauchwasser (Ascites) durch eine in die Bauchwand eingeführte Röhre. Die Verwendung von Spezialinstrumenten vom Typ des Troicarts (Trocar) kam erst Ende des 17. Jahrhunderts in Gebrauch.

Removal of ascites (about 1672)

Operating theater and surgery (about 1495): Transplantation of a leg

FARBTAFEL 69
Unbekannter Künstler, *Beinamputation,* Mitte 18. Jahrhundert. Farbe auf Holz. Reproduced by permission of the President and Council of the Royal College of Surgeons of England, London. *Der Farbige im Auditorium ist gewiß kein Sklave oder Diener. Ein Forscher glaubt ihn als Omai identifizieren zu können, »ein berühmter Mann aus Polynesien«, der von 1774 bis 1776 in London lebte und mit Captain Cook wieder in seine Heimat zurückkehrte. Britische philanthropische Gesellschaften übernahmen für viele Schwarzafrikaner die Finanzierung einer Arztausbildung.*

Operating theater and surgery (about 1774): Amputation of a leg

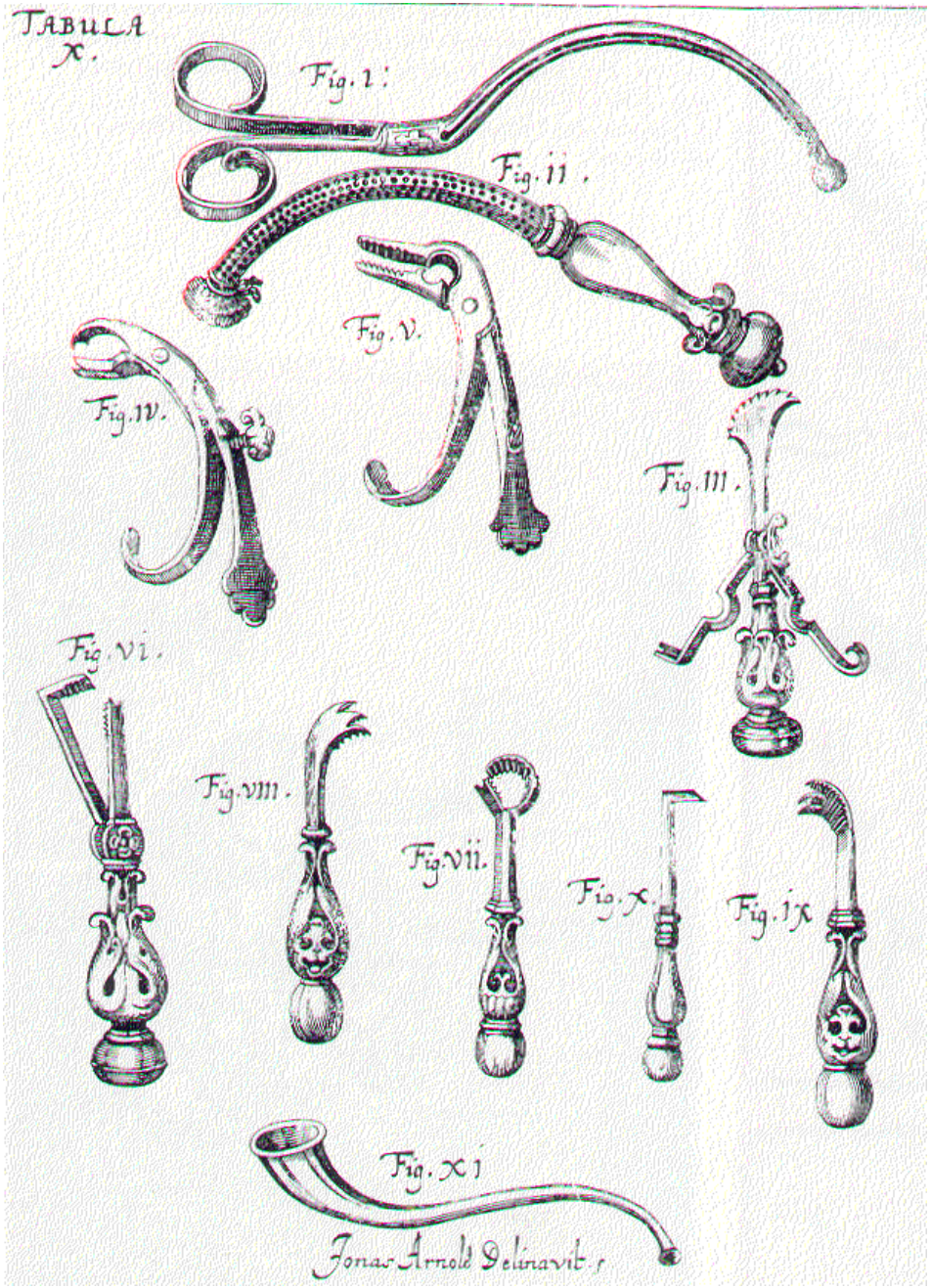
(a)

Teeth are made from ivory with springs for coupling the two parts

(b)

Tooth of hippopotamus as carrier and supplied with some human teeth

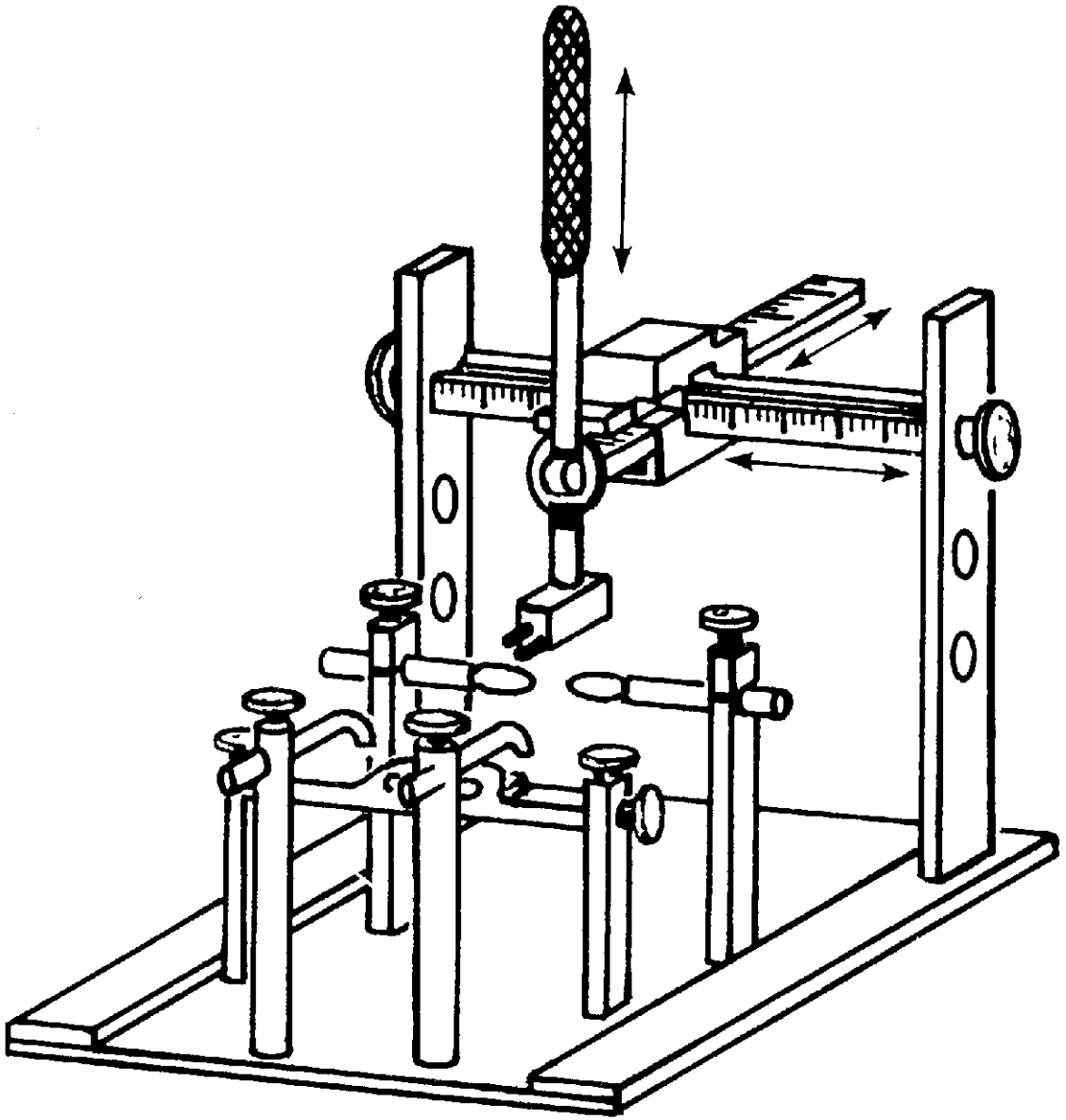
Dentures of the former US president George Washington (1789)



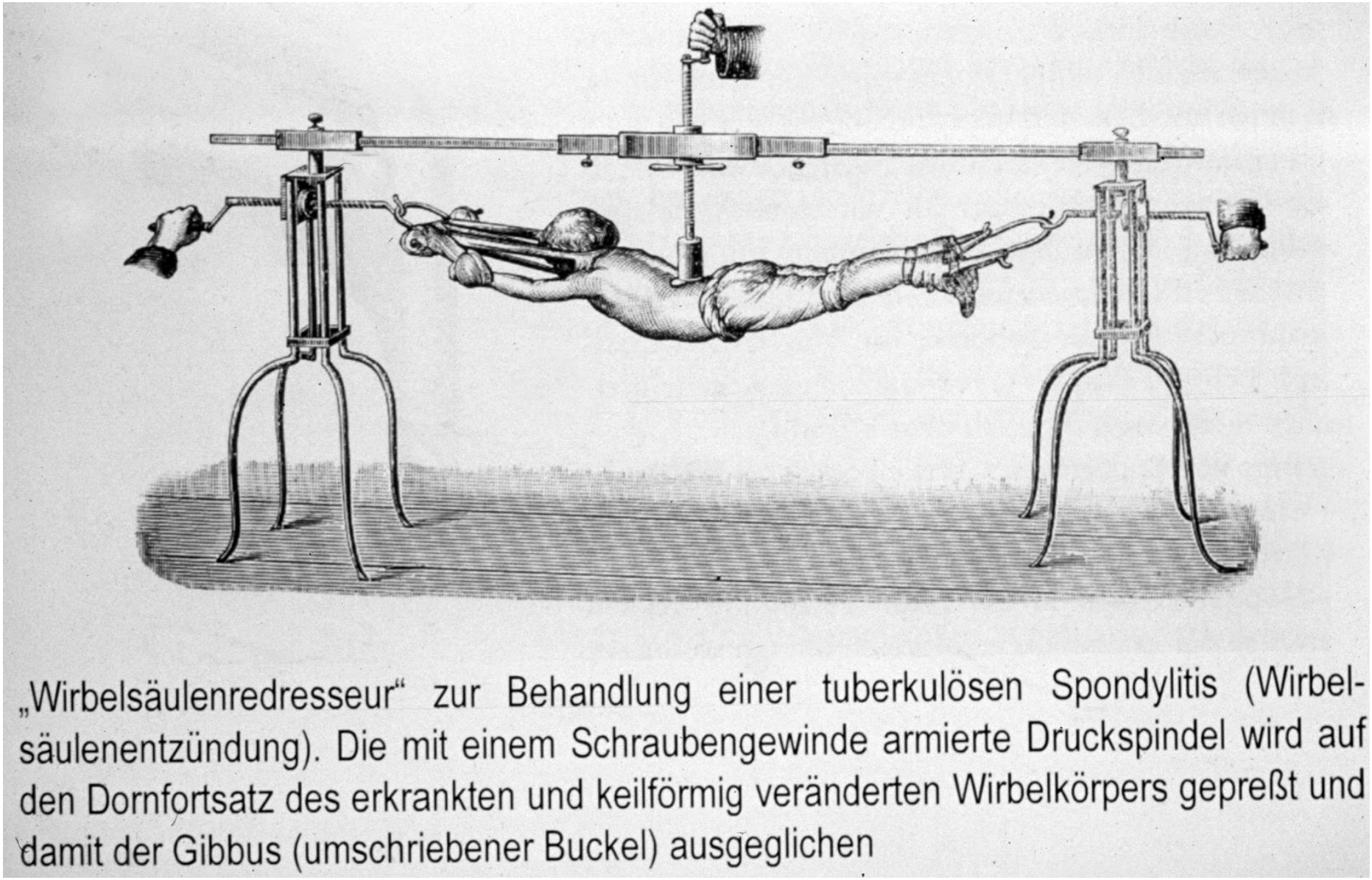
Instruments for dentistry (1666)

Dentist‘s chair (about 1850)

Pedal-driven drill for dentistry by JB Morrison (patented 1871)



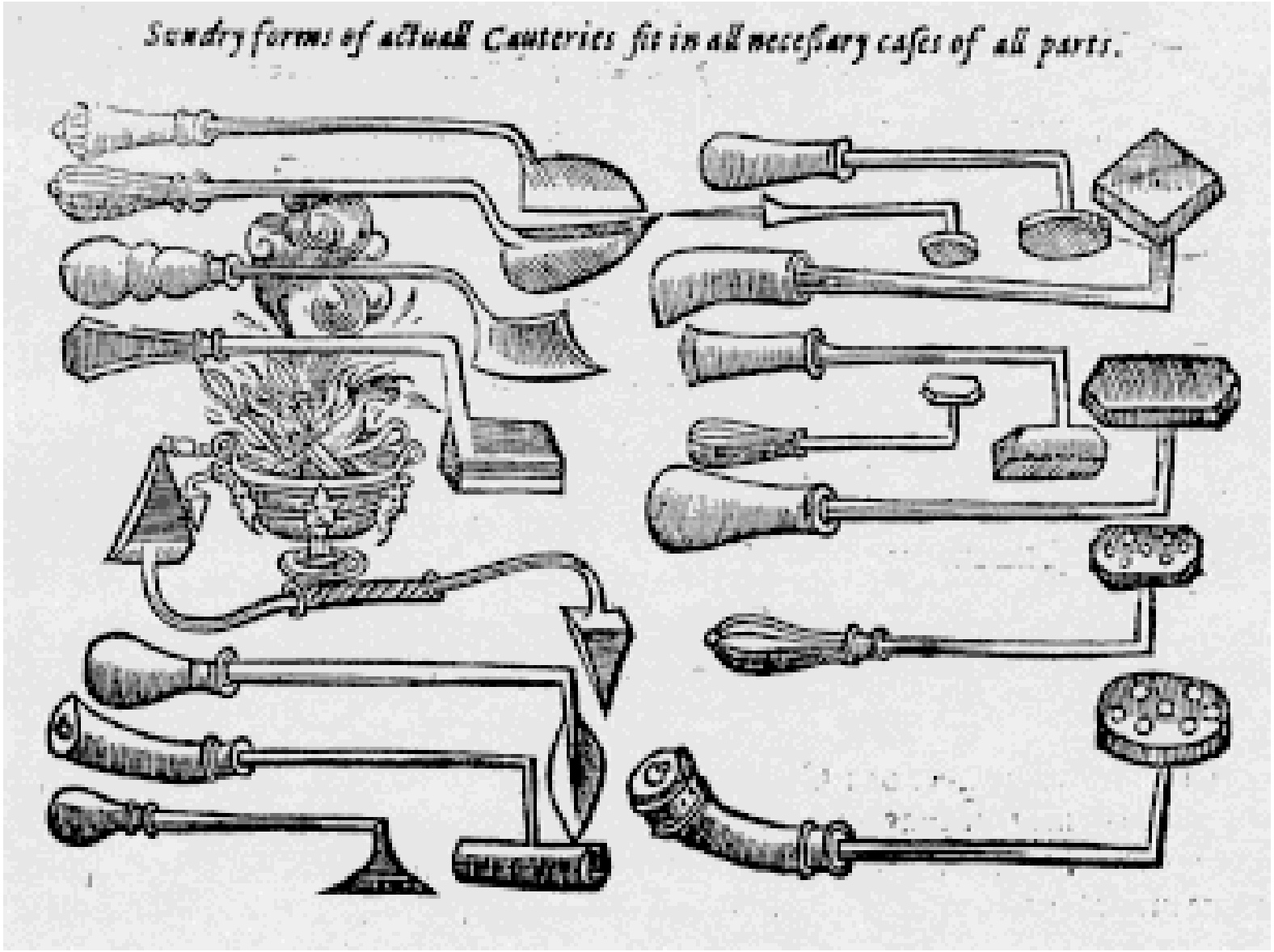
Stereotaxic instrument for the introduction of electrodes into the brain (1902)



„Wirbelsäulenredresseur“ zur Behandlung einer tuberkulösen Spondylitis (Wirbelsäulenentzündung). Die mit einem Schraubengewinde armierte Druckspindel wird auf den Dornfortsatz des erkrankten und keilförmig veränderten Wirbelkörpers gepreßt und damit der Gibbus (umschriebener Buckel) ausgeglichen

Orthopaedic stretching apparatus for the treatment of spondylitis

(published 1900)

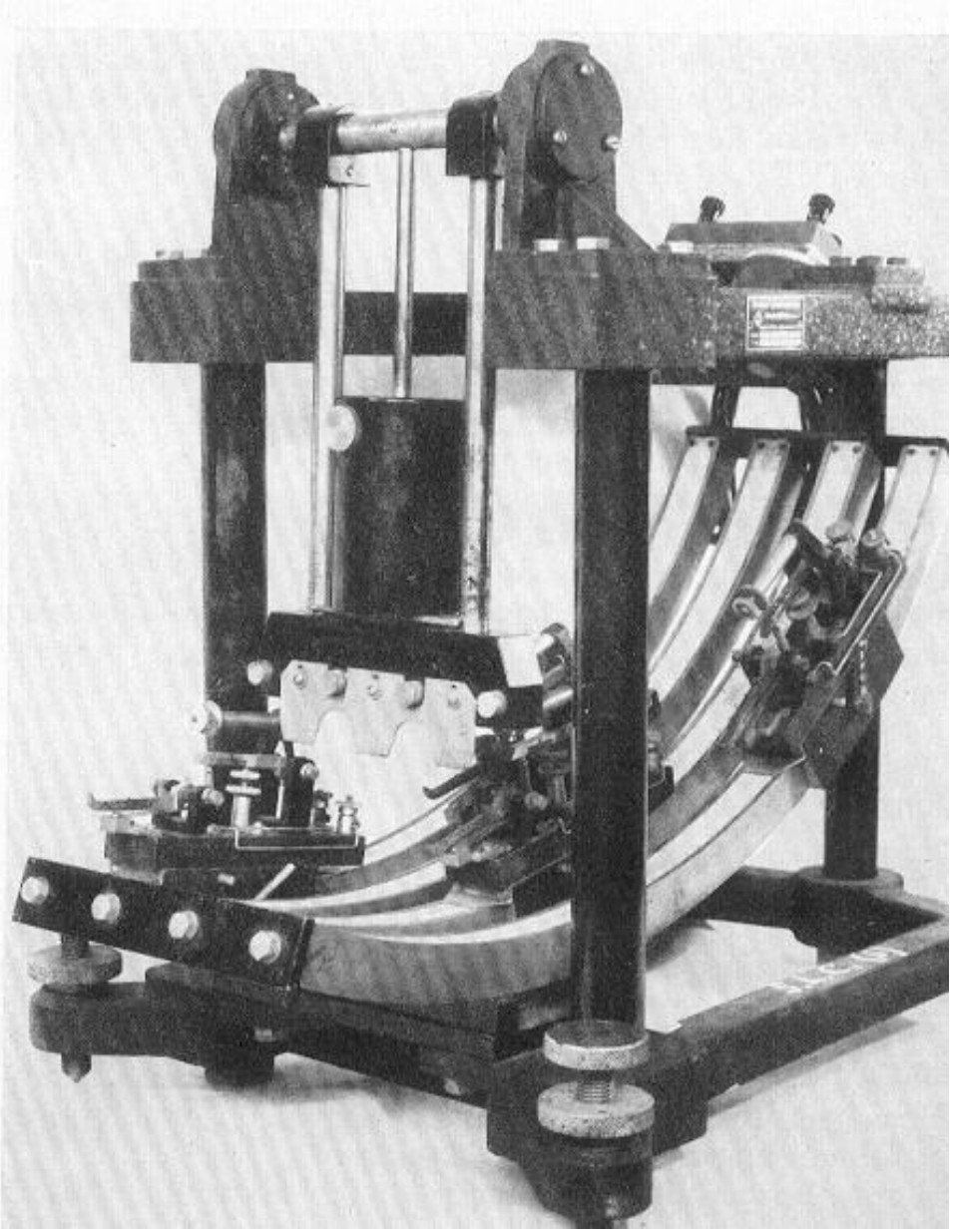


Instruments for cauterization, developed by Ambroise Paré

(Father of modern surgery about 1550)

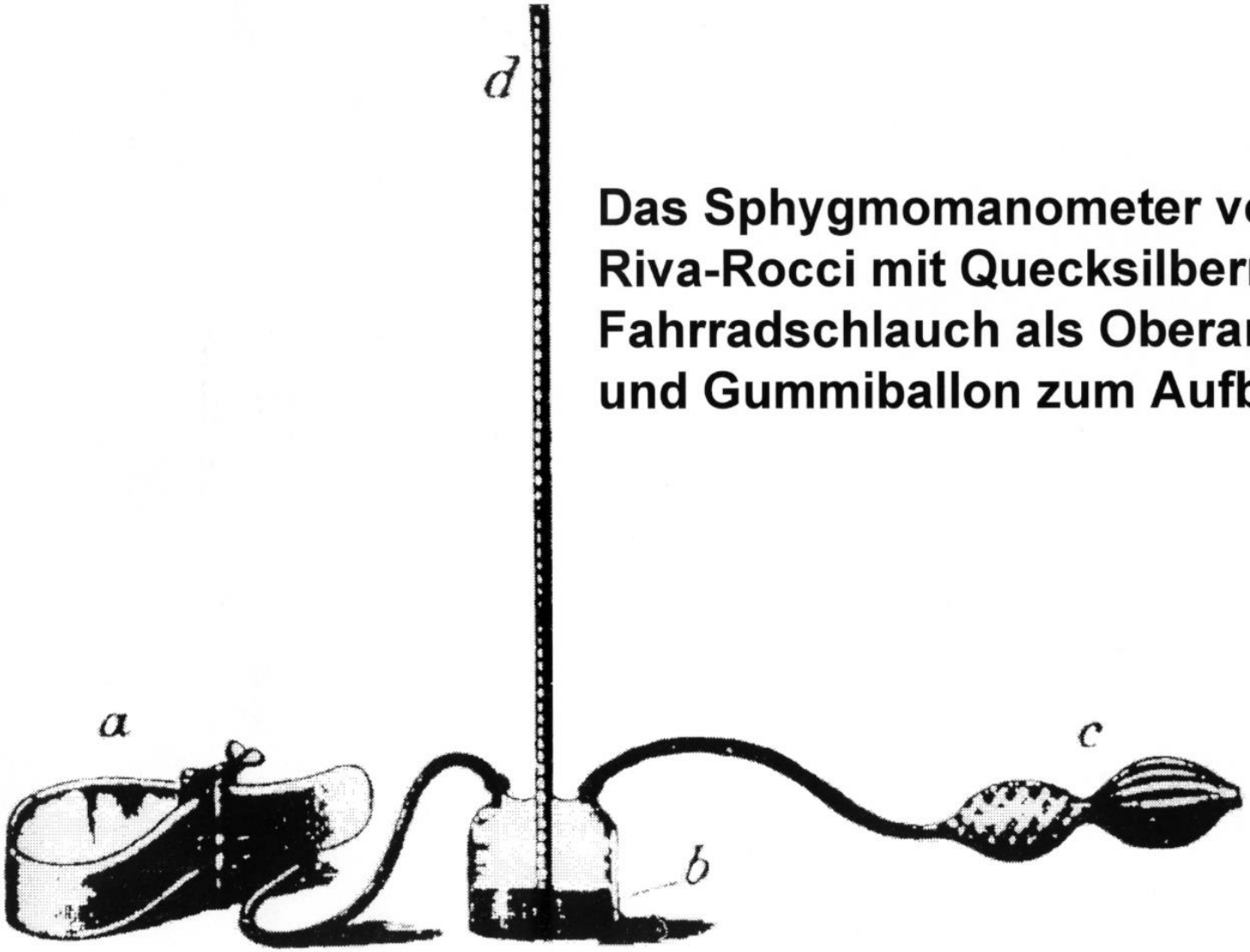
Thermokauter, angegeben 1876 von Claude André Paquelin (1836-1905). Es handelt sich um einen Platinbrenner, der durch ein über ein Gebläse zugeführtes Benzin-Luftgemisch glühend gehalten werden kann. Dieses Gerät, das vorwiegend zur Stillung kapillarer Blutungen benutzt wurde, war bis zur Mitte des 20. Jahrhunderts in Gebrauch.

Tool for the thermal cutting of tissue or the stopping of bleeding (described 1876 and used until about 1950). The heat is generated by the burning of petrol.



Apparatus (pendulum) for the determination of the speed of nerve impulses by H. Helmholtz (1850)

Direct measurement of the arterial blood pressure by St. Hales (1726)

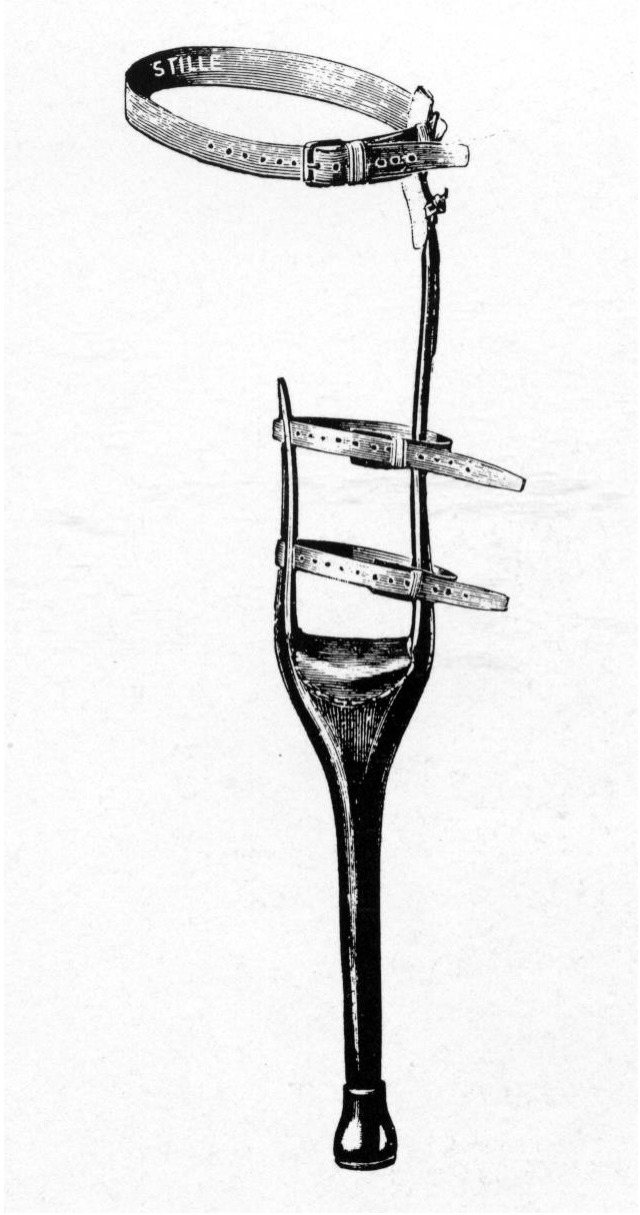


Das Sphygmomanometer von Riva-Rocci mit Quecksilbermanometer, Fahrradschlauch als Oberarmmanschette und Gummiballon zum Aufblasen.

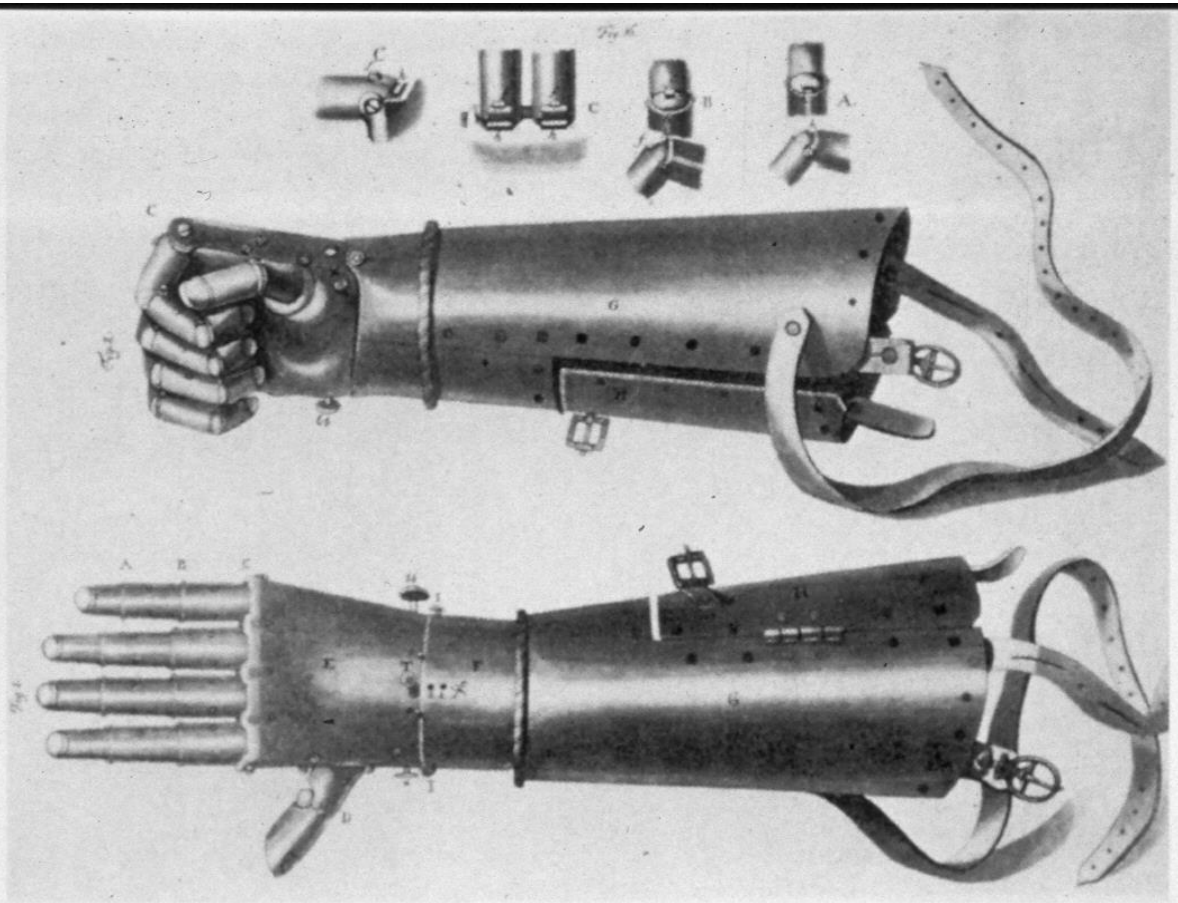
Original device developed by S. Riva-Rocci for blood-pressure measurement in 1896

Design of a total leg prothesis by Ambroise Paré

and manufactured by a French smith (1552)

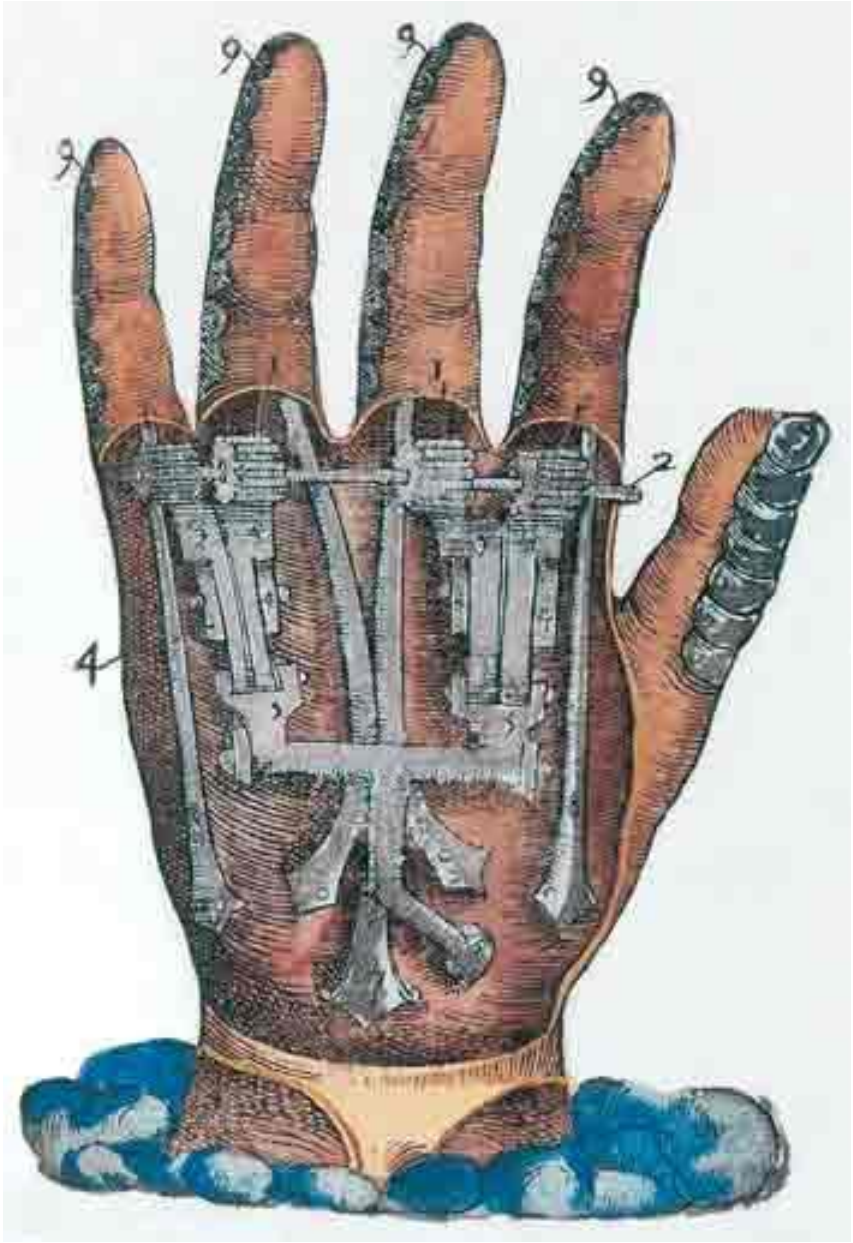


Prothesis for lower-leg amputees (1901, left, and 1920, right: a mass product for first world war victims)



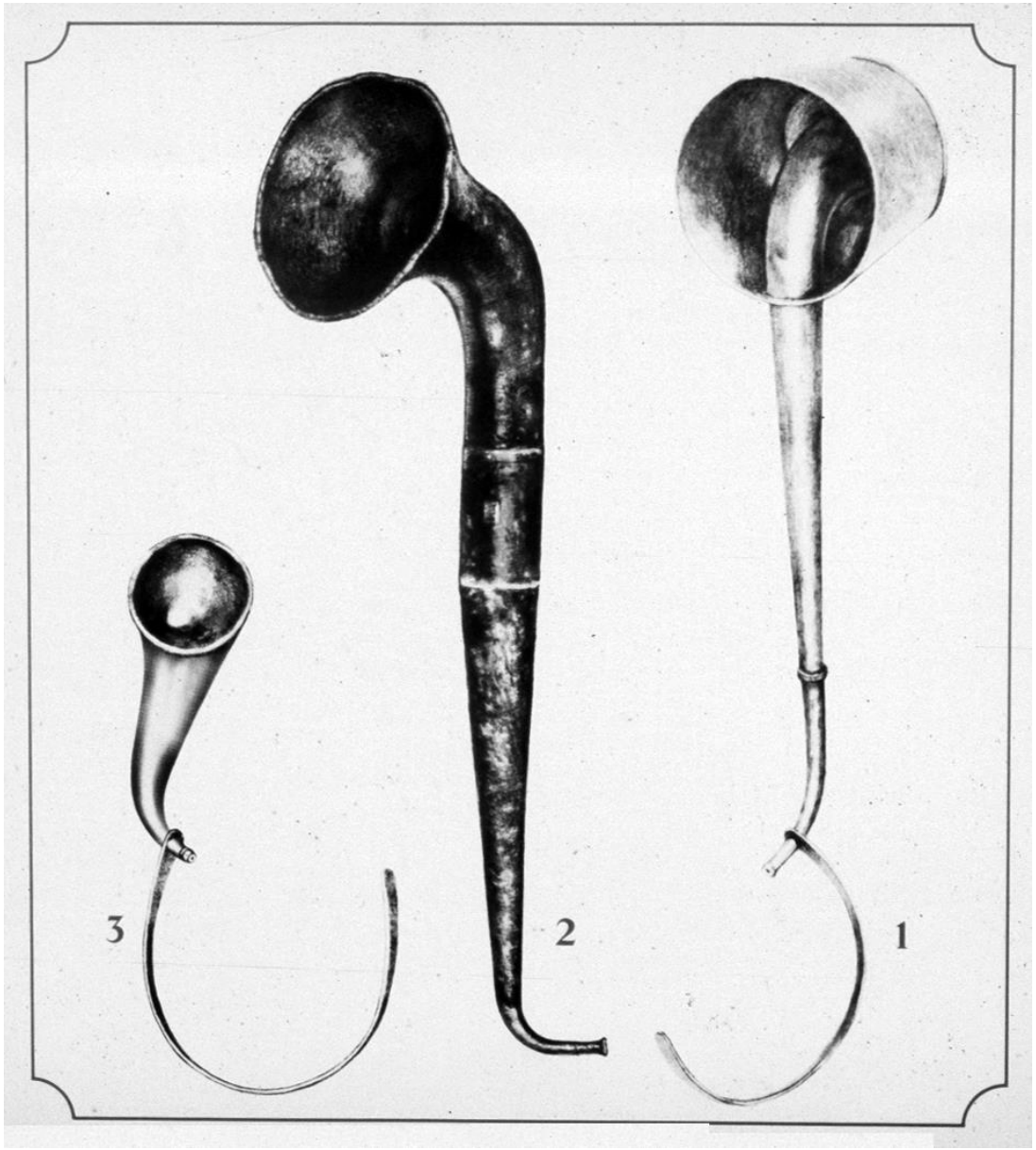
Die „eiserne Hand“ des Reichsritters Götz von Berlichingen (1480-1562), deren Original noch heute im Schloßmuseum der Götzenburg in Jagsthausen erhalten ist, gilt als Musterbeispiel einer mit einem Greifmechanismus ausgestatteten, funktionsfähigen Prothese.

Arm prothesis, rendering possible gripping functions (about 1500)

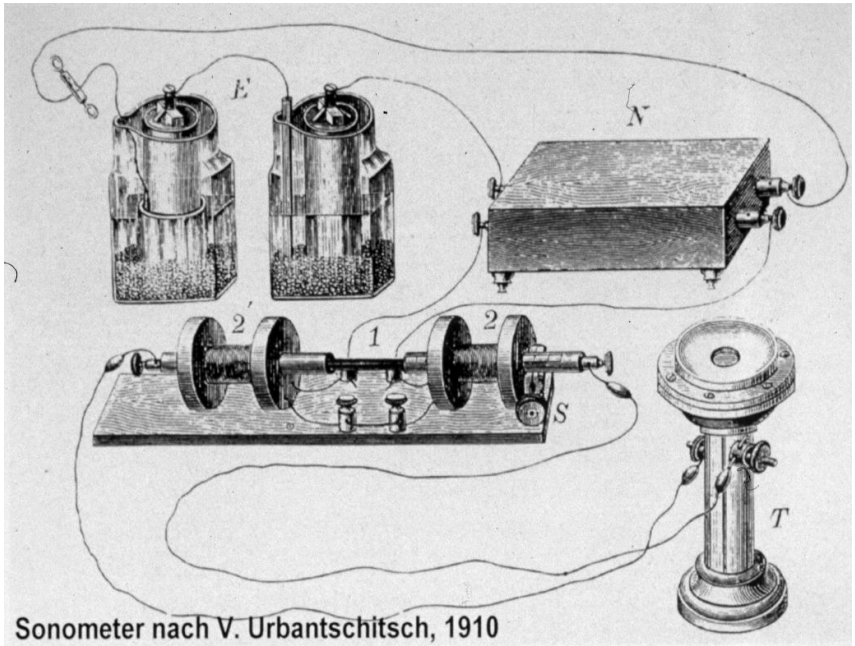


Construction draft for a movable hand prothesis (Ambroise Paré, about 1550)

Basic metabolic research (Santorio Santorino, 1614). The test person was sitting for months on a balanced scale.



Hearing aids (No 3 was used by the German composer Ludwig van Beethoven, about 1800)

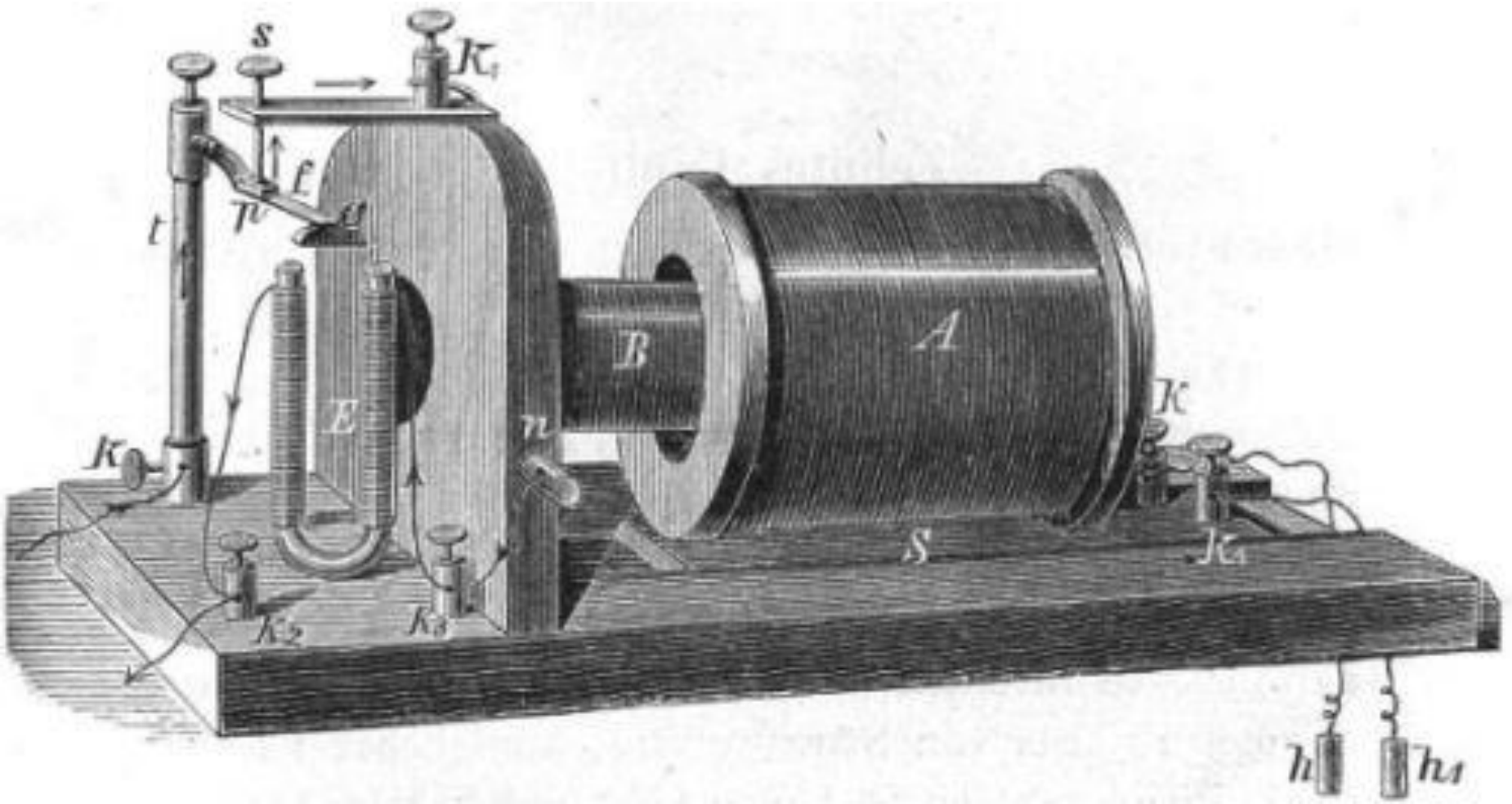


Sonometer nach V. Urbantschitsch, 1910

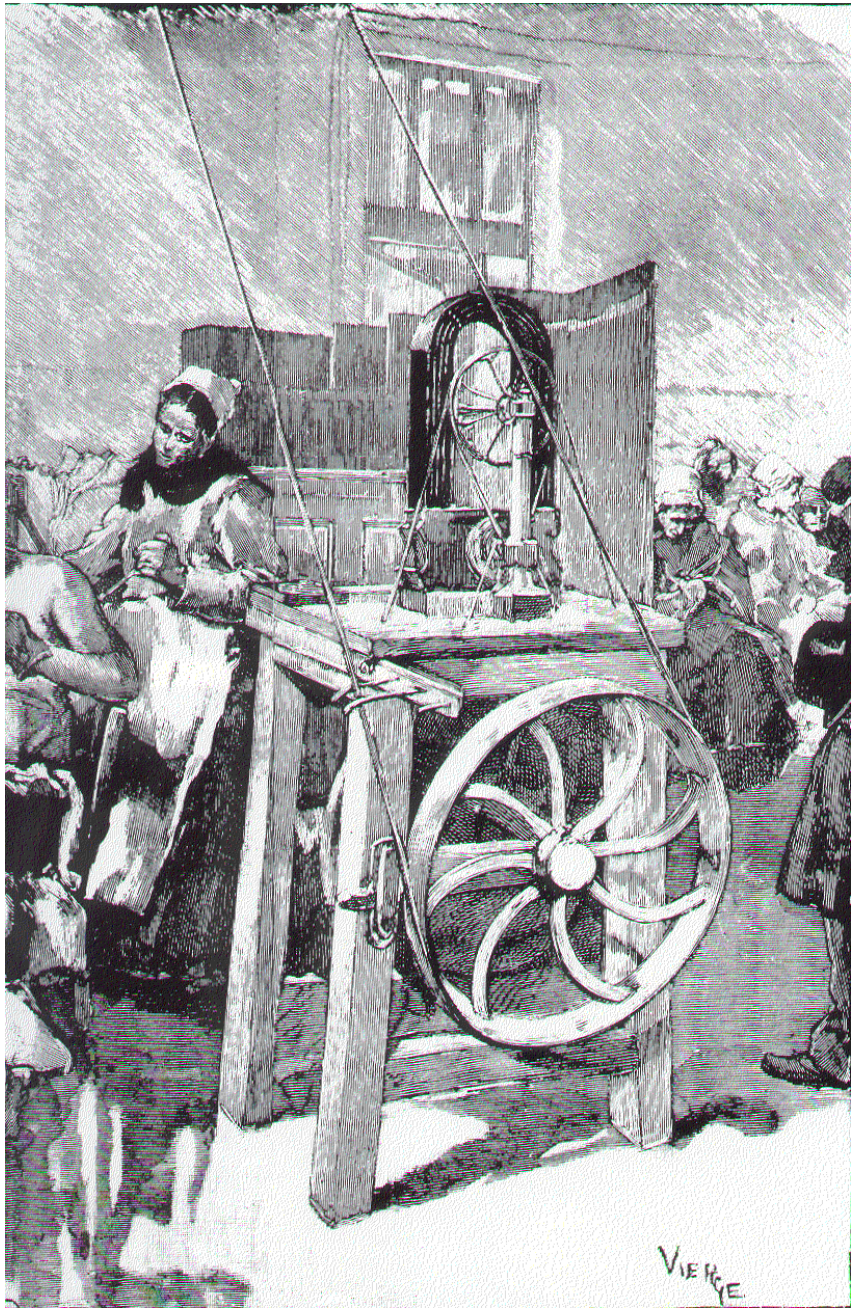
Hörprüfgerät, Vorläufer der heutigen Apparate.
E = Stromquelle, in diesem Fall Leclanché-Elemente
N = Stromunterbrecher, Neefscher Hammer zur Geräuschdämpfung in einem Kasten untergebracht
T = Telefonhörer
2 = feststehende Spule
1 = verschiebbare Spule
S = Stellschraube zur Verschiebung der Spule1 gegenüber Spule2

Dadurch ausgelöste Induktionsströme werden über das Telefon in Geräusche umgesetzt, deren Intensität somit meßbar ist.

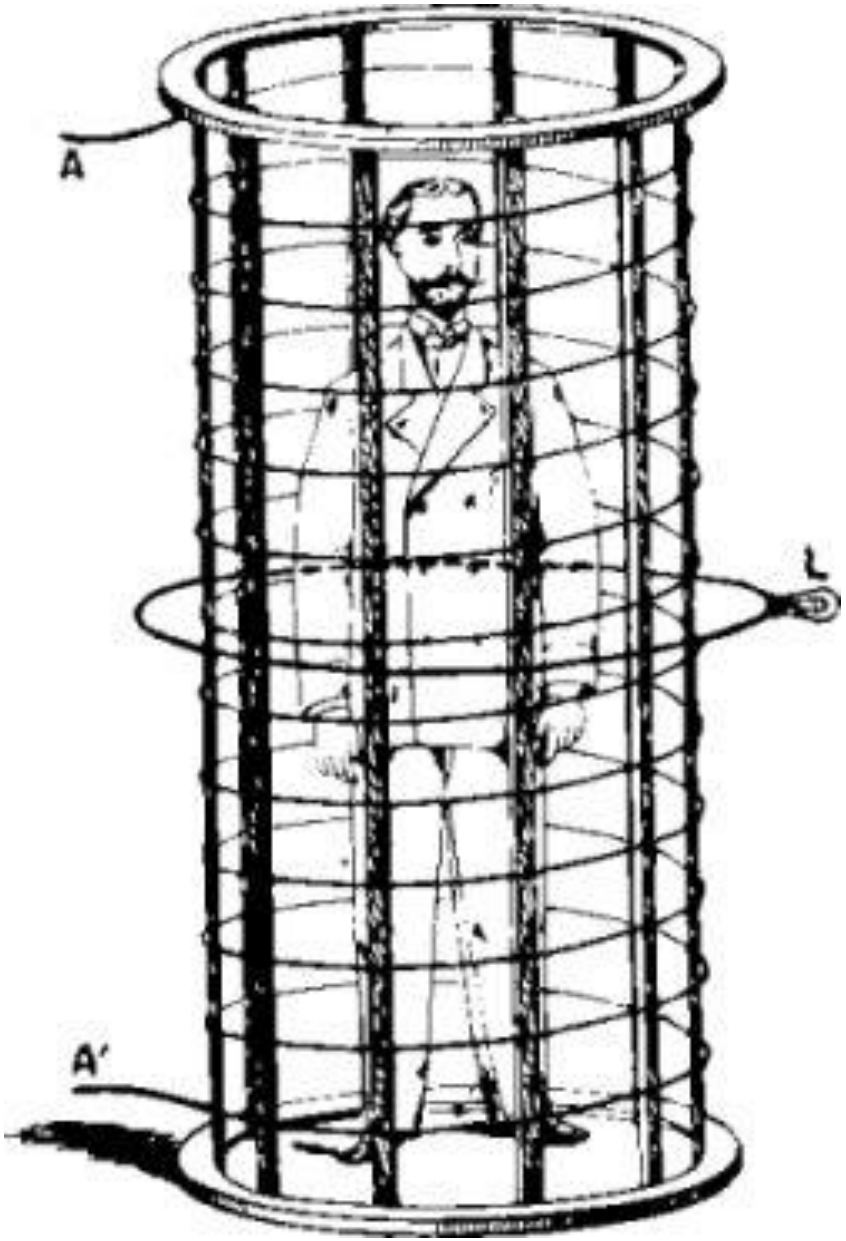
Sonometer (audiometer), i.e. measuring device for hearing defects, battery-powered and provided with a telephone loudspeaker (1910)

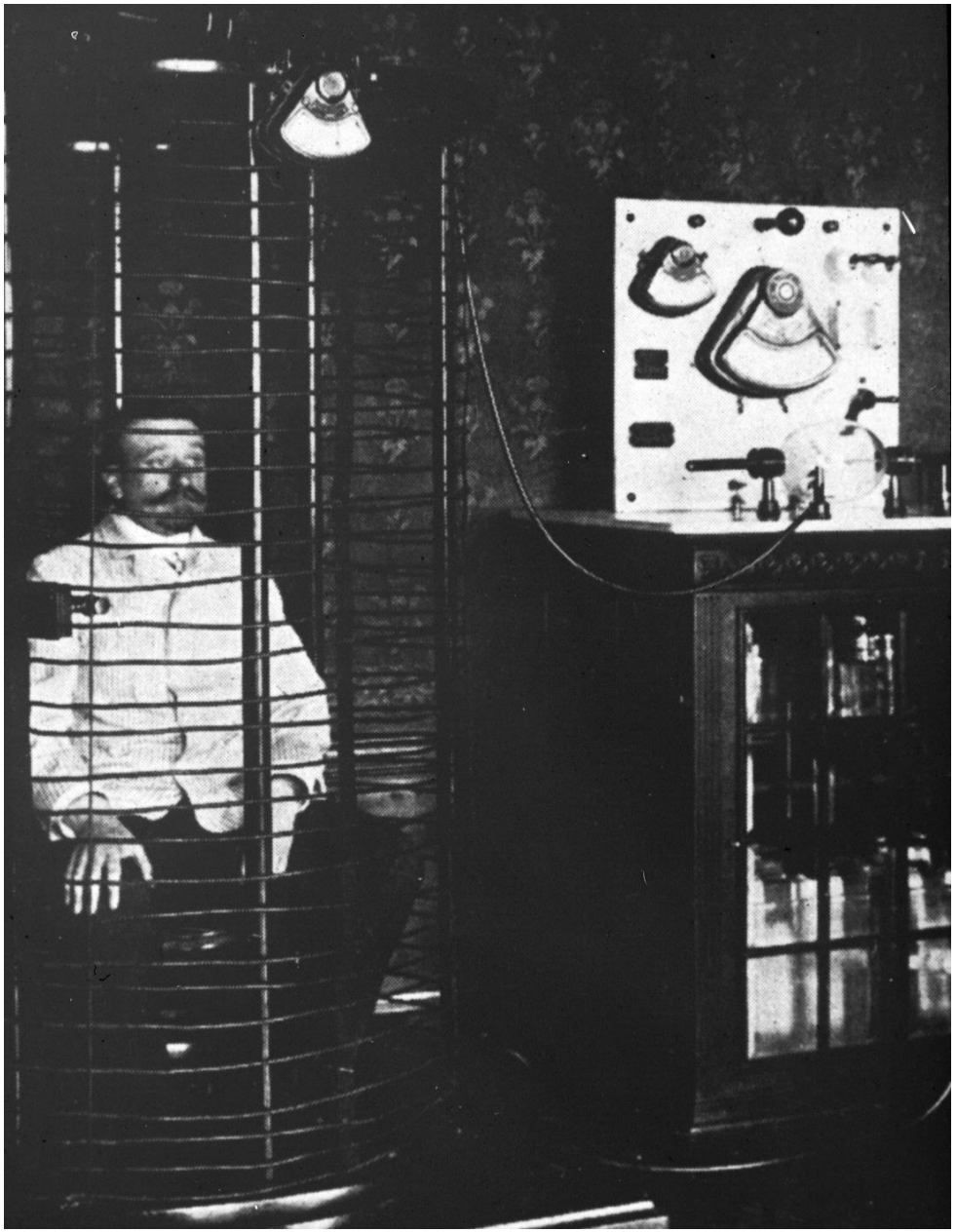


Induction Coil Stimulator by Emil du Bois-Reymond (1848). This regularly repeating stimulator may be the first electro-medical device, later on produced by Werner von Siemens (and used by him for tooth pain-suppression in his brother).

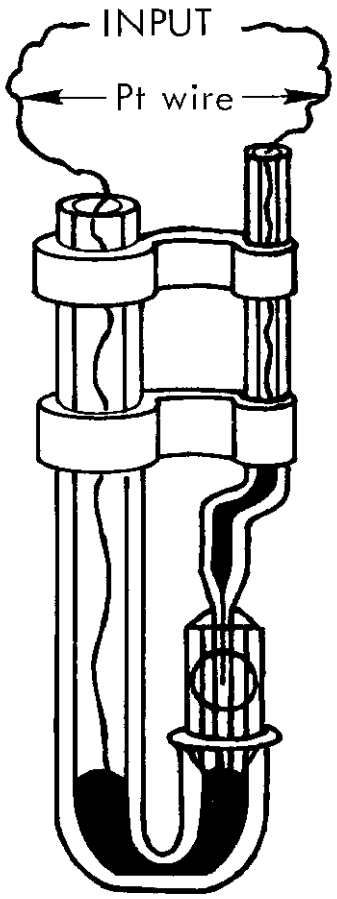


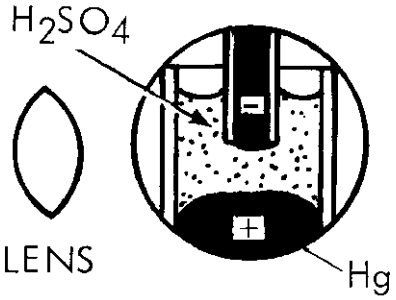
Induction generator for electrotherapy (1880)





Solenoid for magnetic stimulation: Schematic and experimental arrangement (J-A. D'Arsonval himself?, 1893, based on research work by N. Tesla)



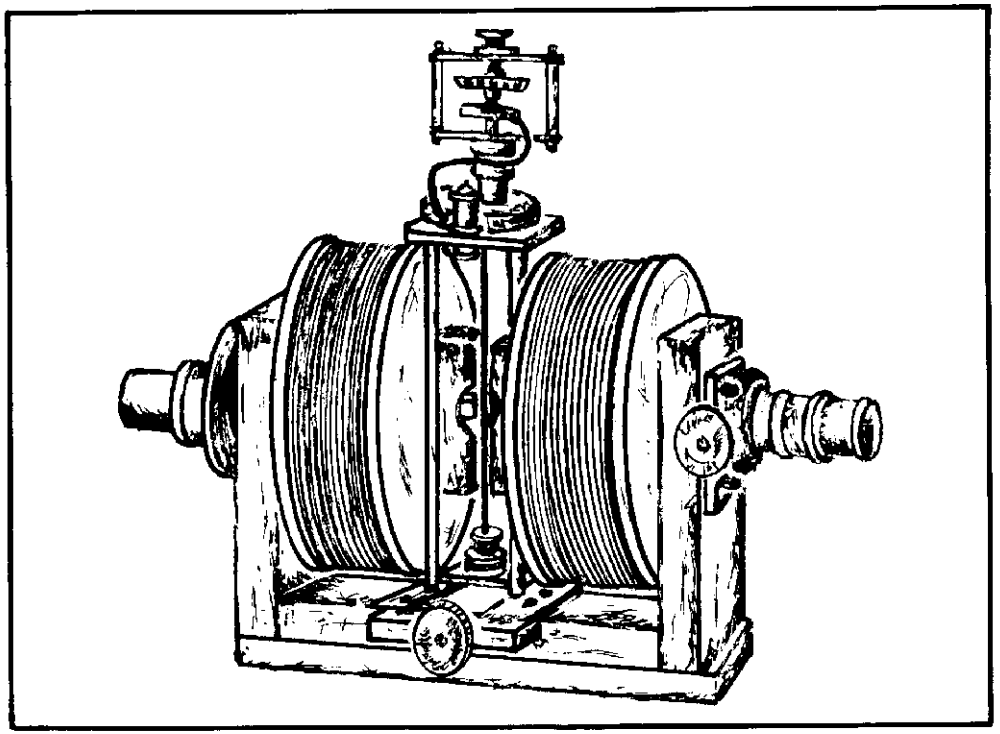


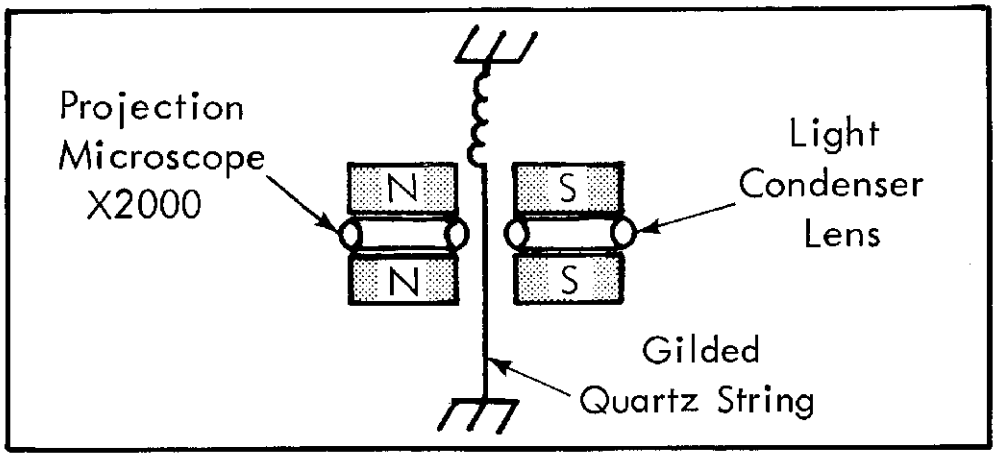
Capillary electrometer invented by

G. Lippmann (about 1875)

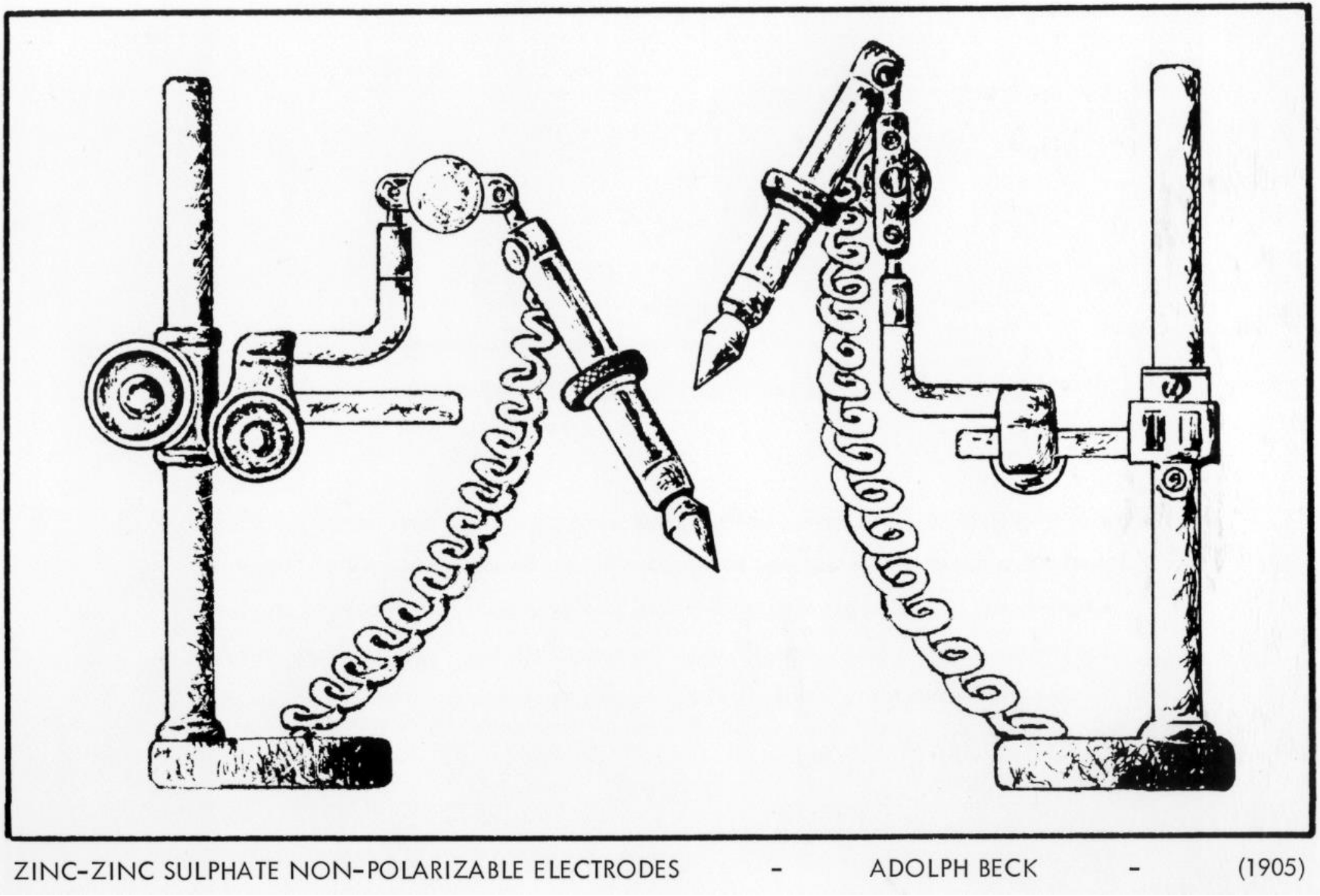
Acquisition and monitoring of the electrocardiogram with a capillary electrometer (filled with mercury) before W. Einthoven by A.D. Waller (1887)

Abb. 3c: Elektrokardiogramm vom 18.11.1902 nach EINTHOVEN

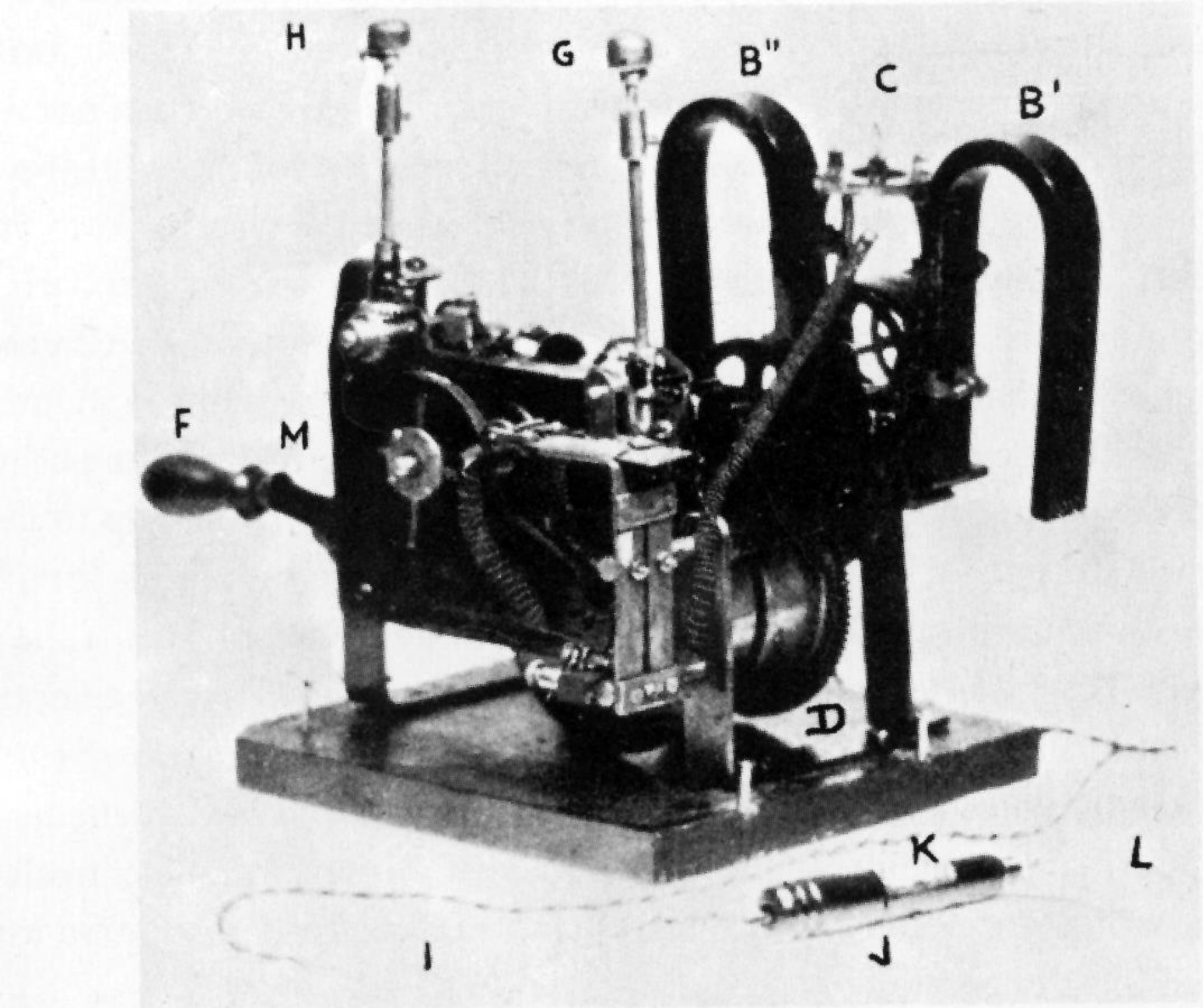




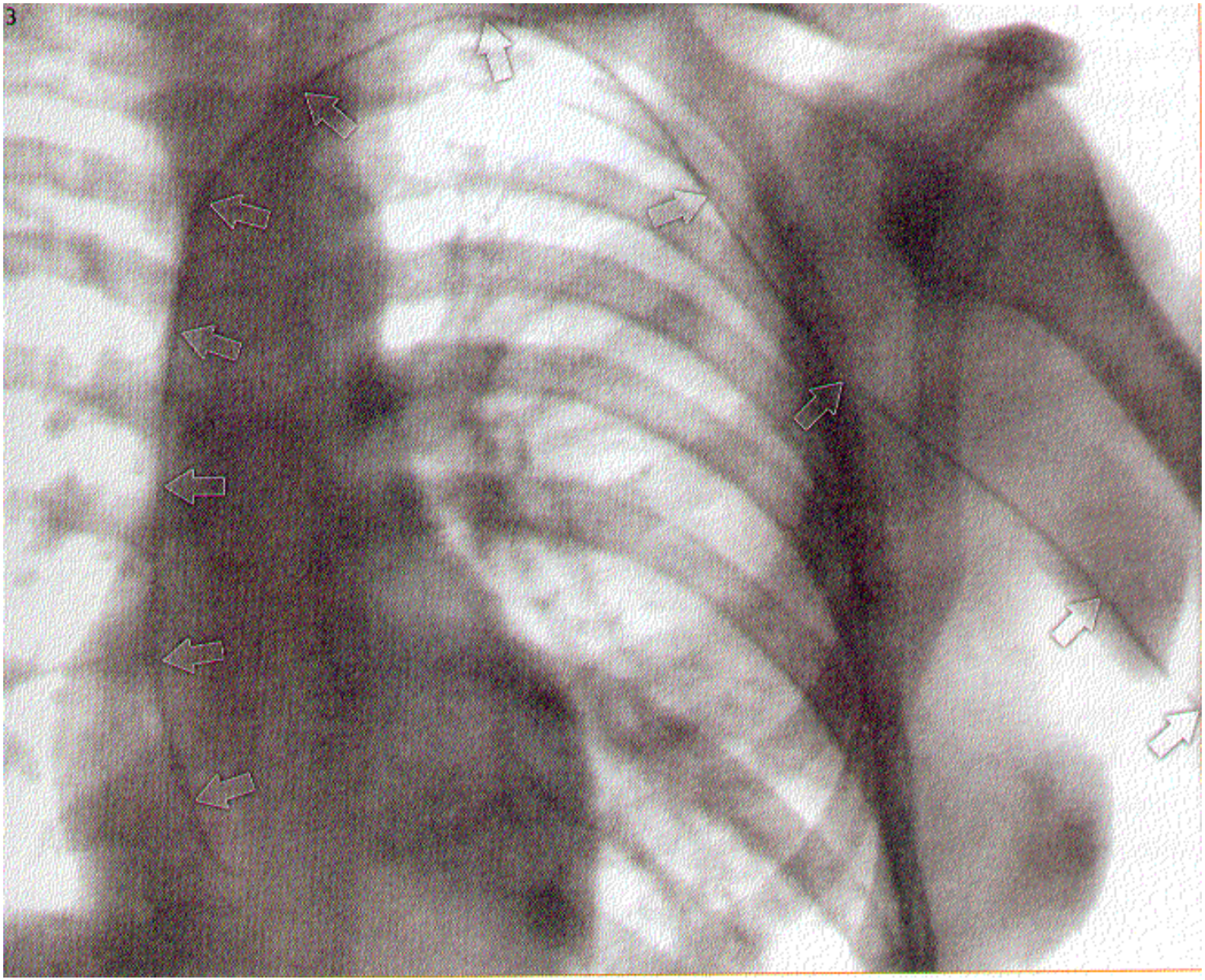
Recording of the electrocardiogram with the string galvanometer developed by W. Einthoven (1903, Nobelprize 1924), used by H. Berger for the EEG (1920s)



Zinc-Zinc Sulphate non-polarizable electrodes (1905)

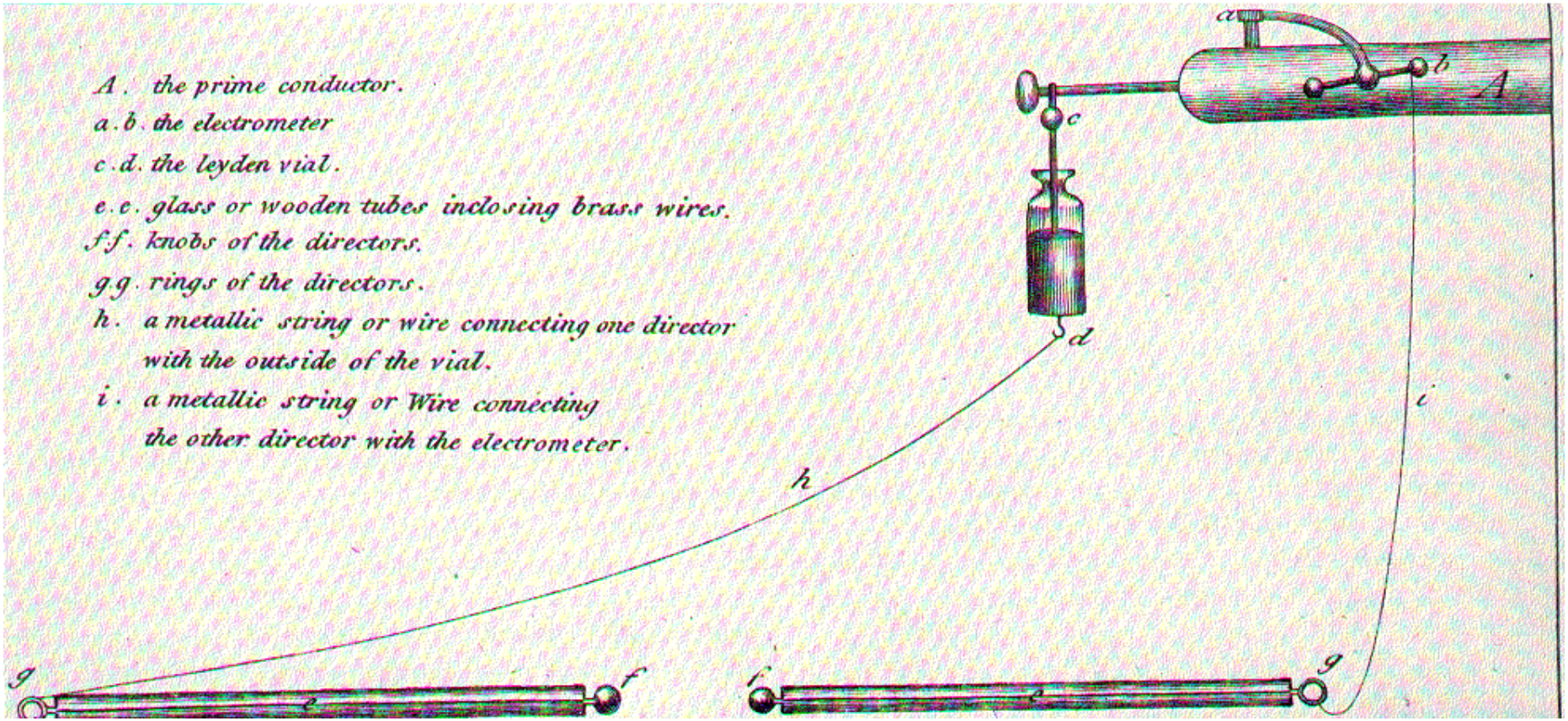


First „artificial“ pacemaker with spring-driven pulse generation and with 3 different pacing rates (30 min^{-1}, 60 min^{-1}, 120 min^{-1}) by A.S. Hyman (1932)



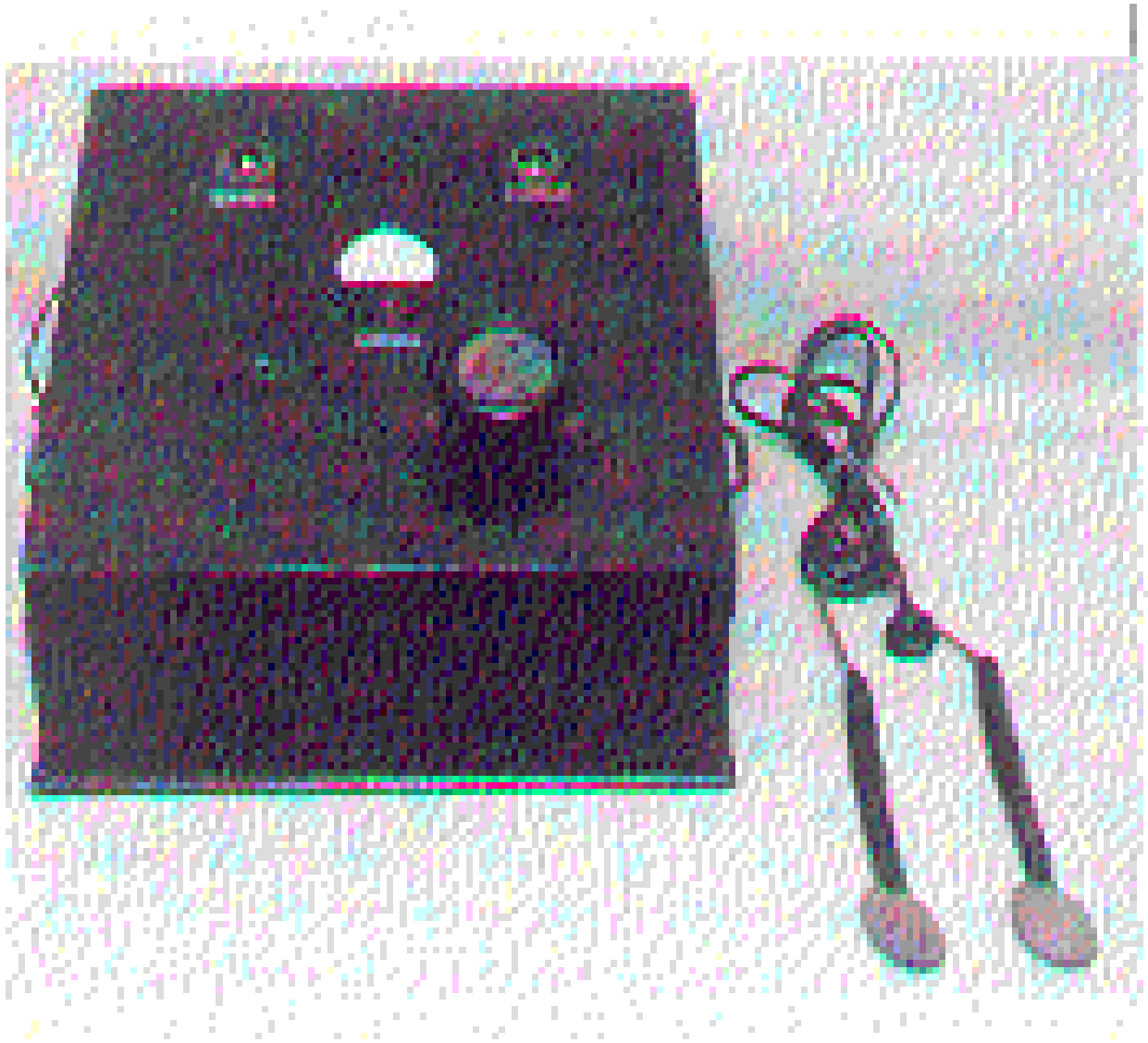
Historical X-ray image depicting the chest of W.T.O. Forssmann (Nobel Prize 1956). The first catherization of the living human heart. The catheter is running through the antecubital vein of his left arm to the heart (1929)

Two „early“ programming devices for implanted cardiac pacemaker with the nicknames (a) „coffee grinder“ (manually operated, only stimulus intensity) and (b) „iron“ (stimulus intensity, stimulus rate)

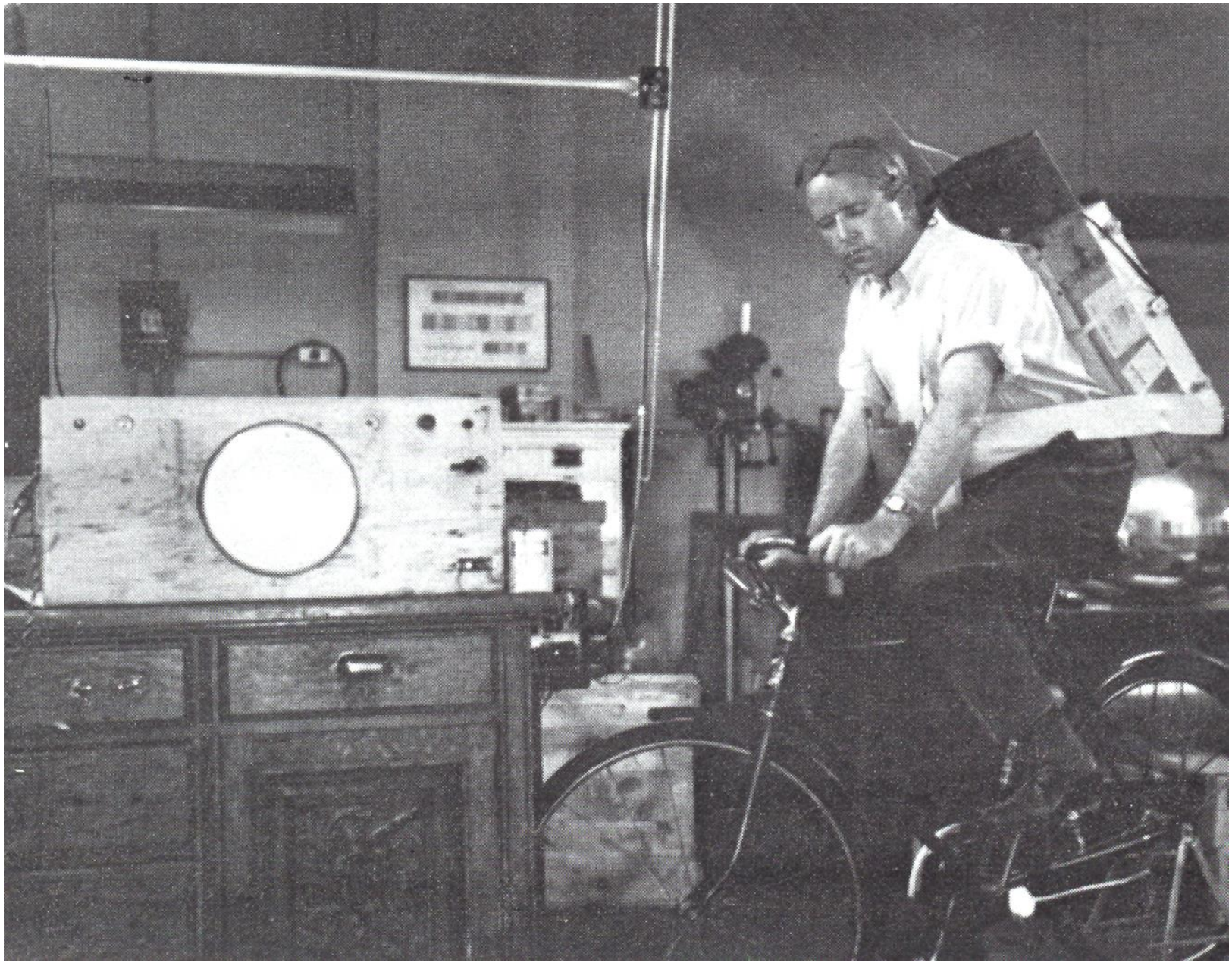


Apparatus for the recovery of apparently dead persons (i.e. by „defibrillation),

Ch. Kite (1788)

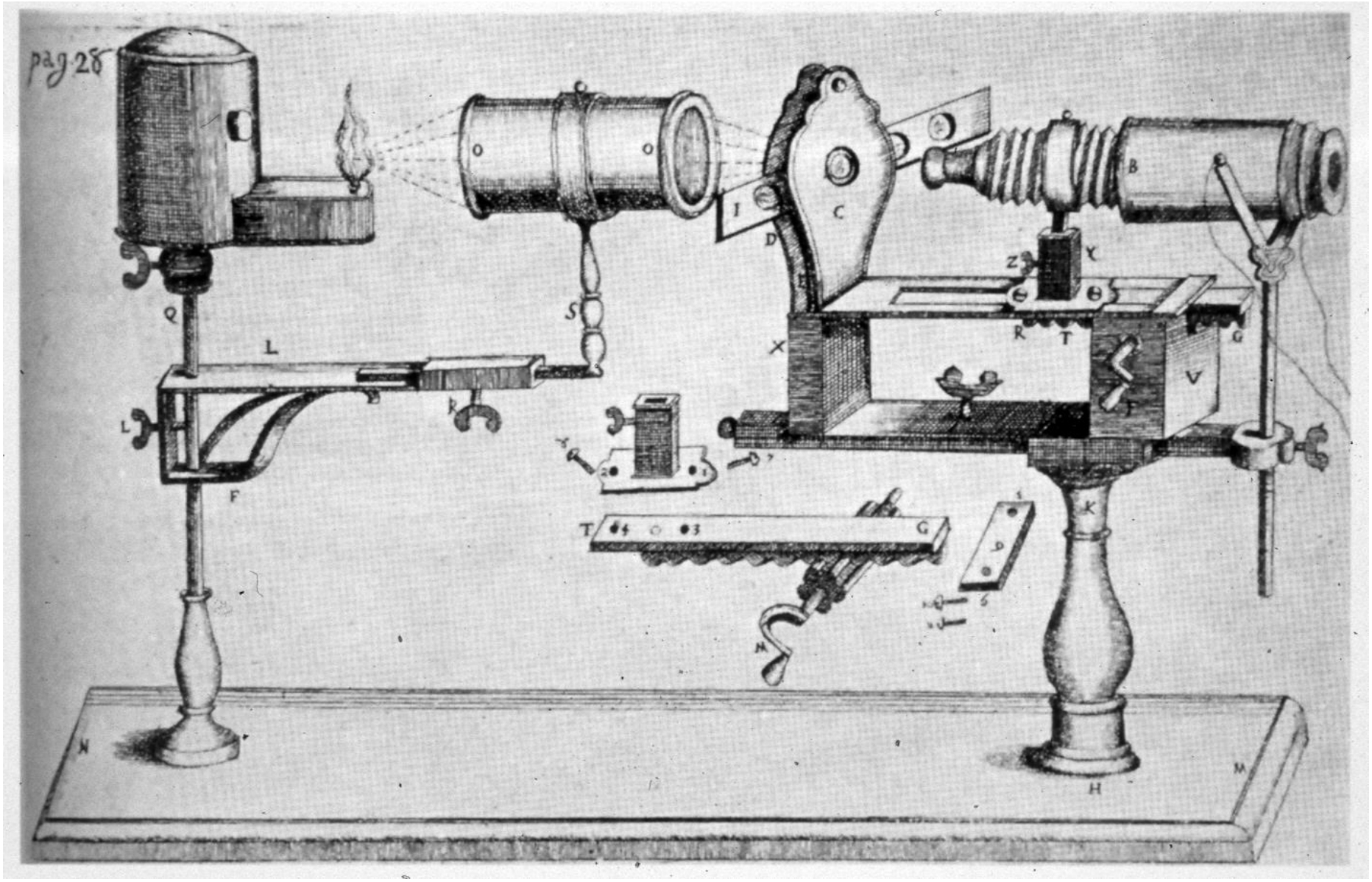


First extracorporeal defibrillator applied (1947)

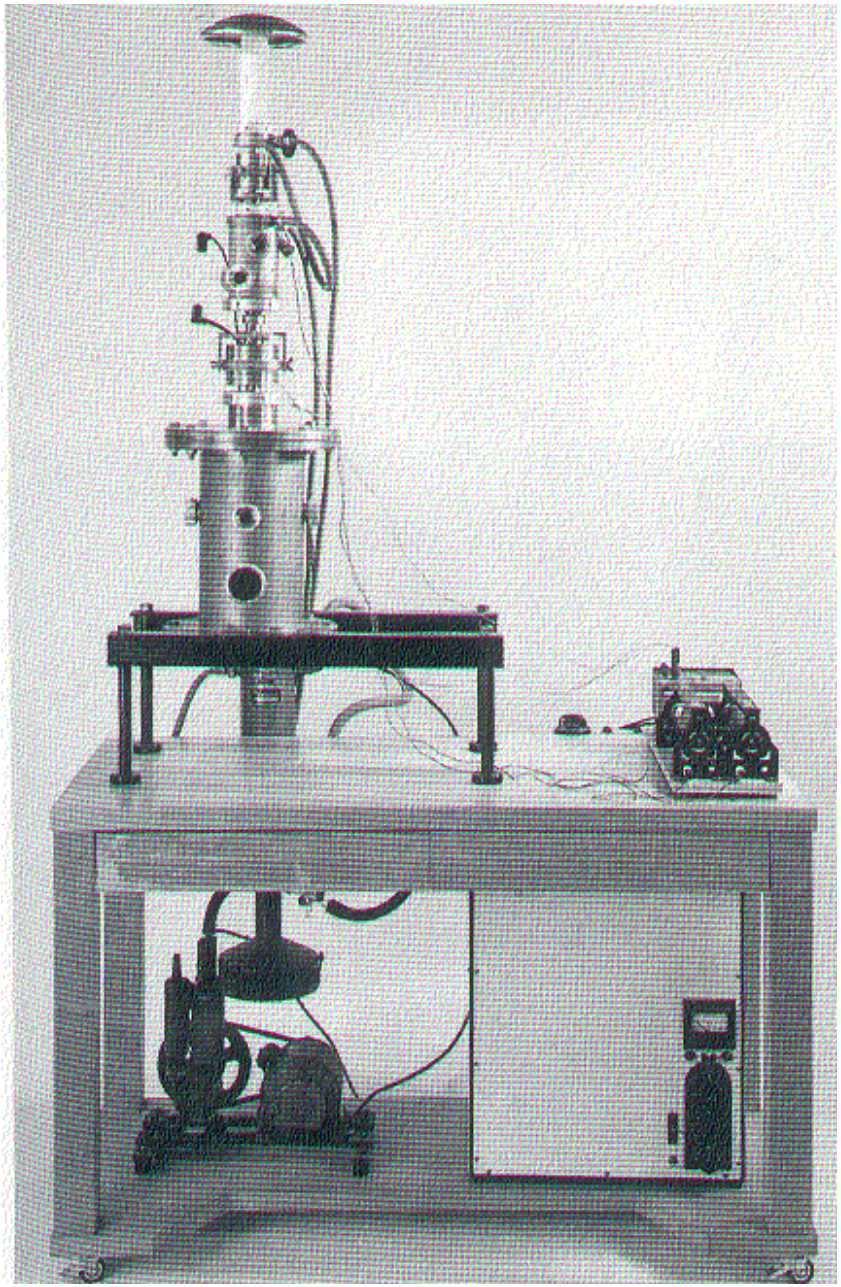


Portable Holter-recorder with 80 lbs (1947, with N.J. Holter himself?), using audiotapes and FM-modulated sub-carrier for analogue recording

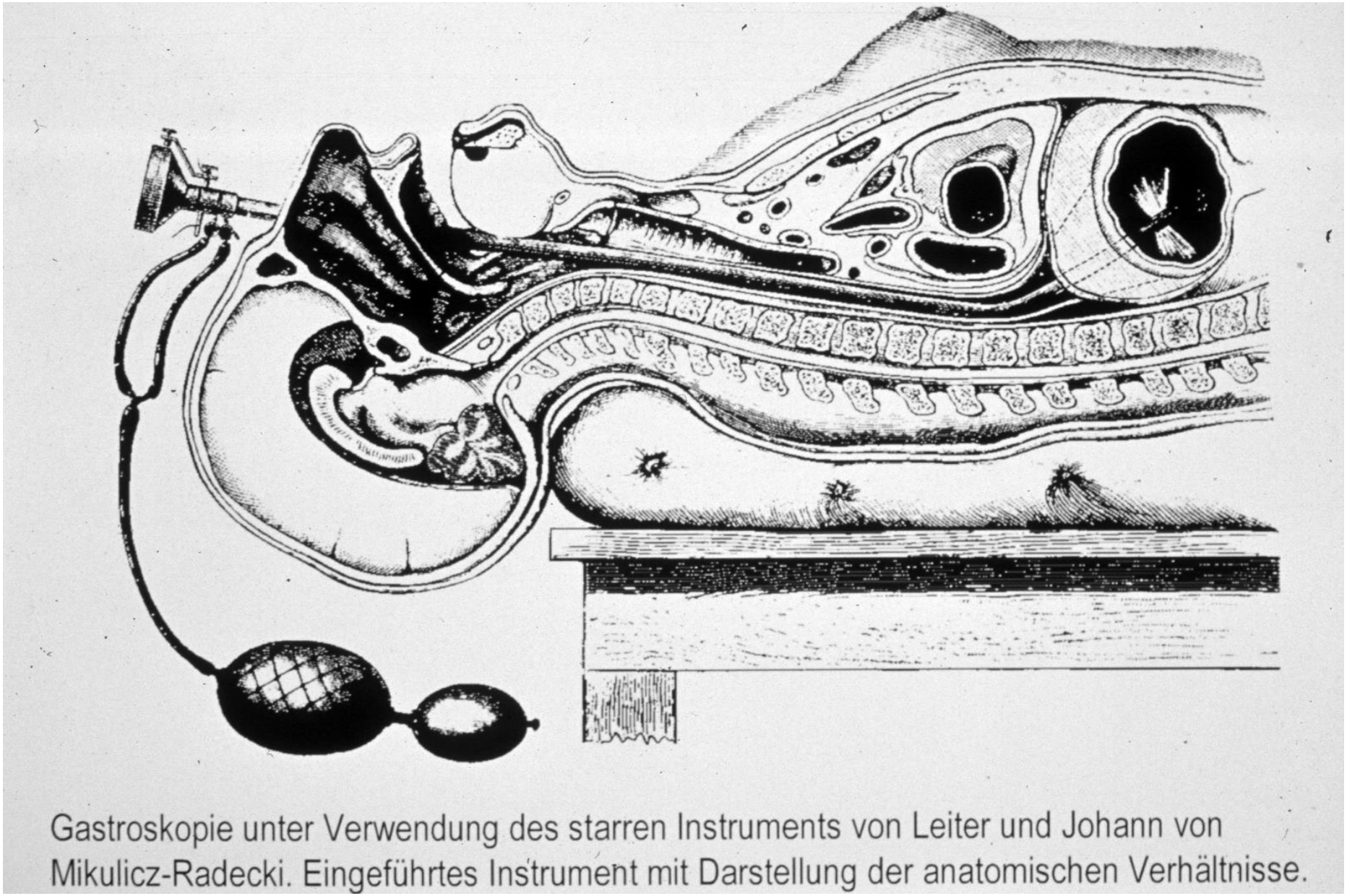
Drum kidney 1943 (William Kolff, died Feb. 14, 2009)



Microsope with horizontal beam path and burning candle as „light source“ (1691)



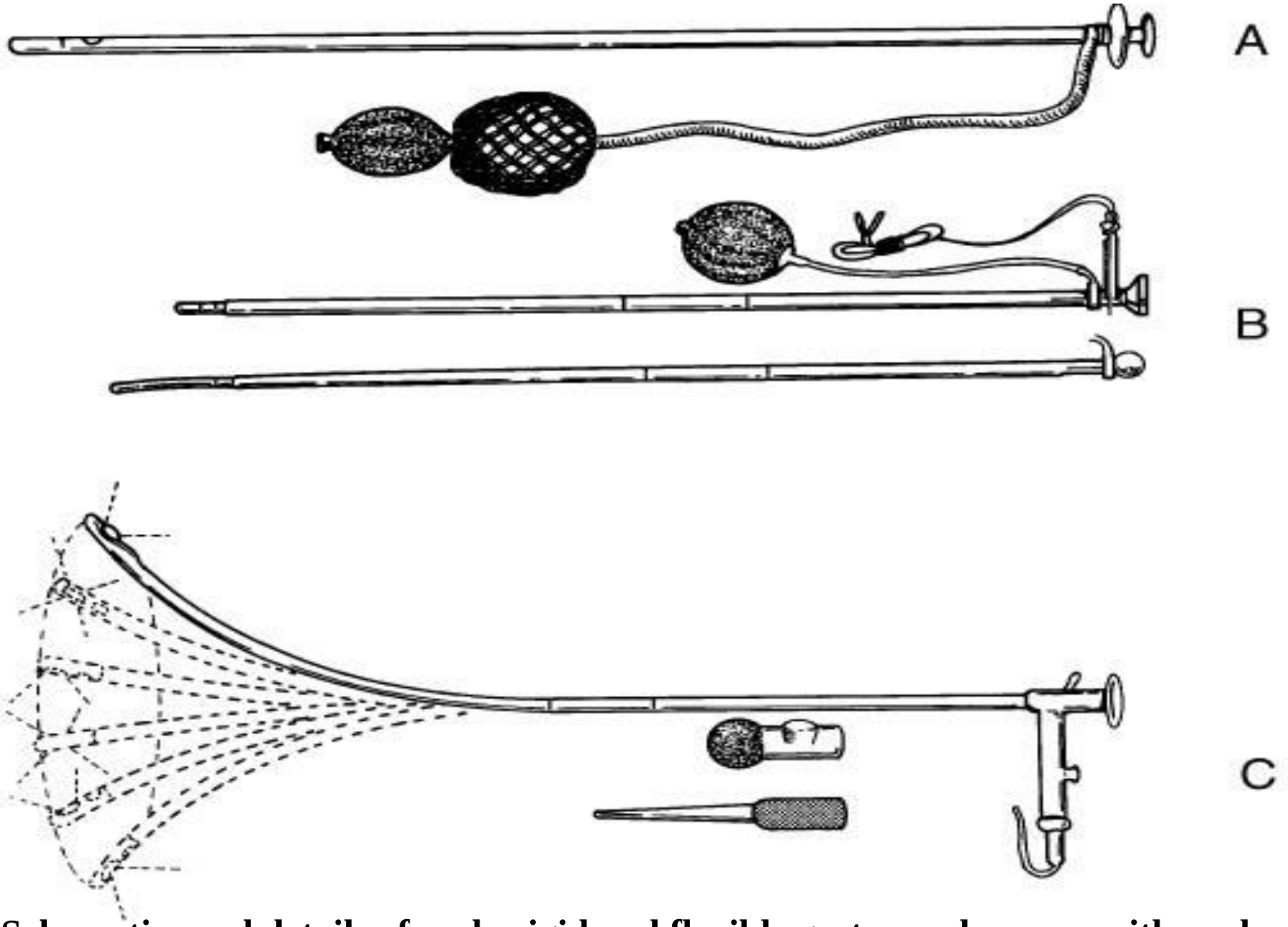
Electron microscope by Ernst Ruska, Nobel Prize winner in physics 1986 (1931)



Gastroskopie unter Verwendung des starren Instruments von Leiter und Johann von Mikulicz-Radecki. Eingeführtes Instrument mit Darstellung der anatomischen Verhältnisse.

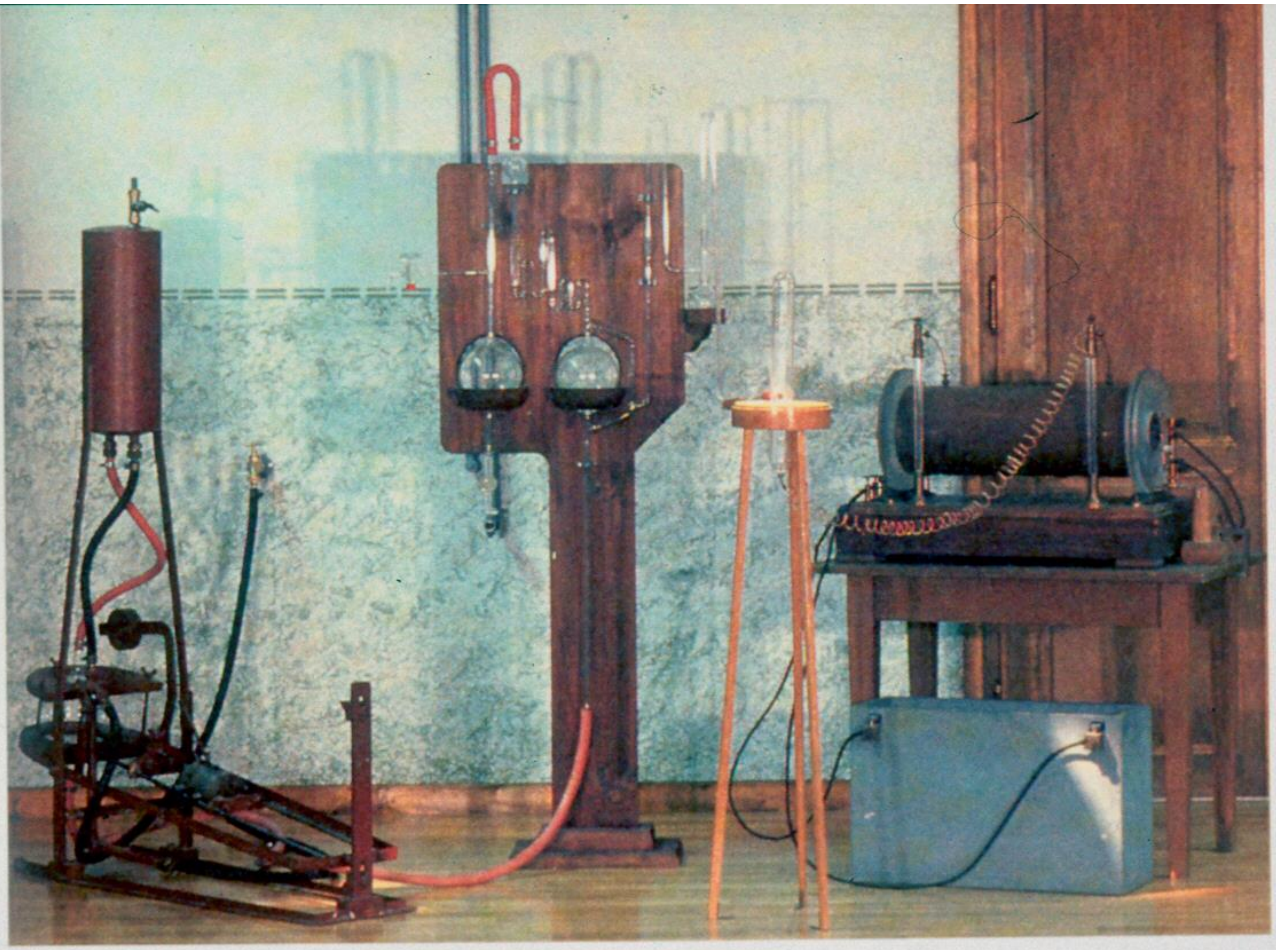
Rigid gastro-endoscope for introduction into the stomach (1890)

The first endoscope has been invented by Ph. Bozzini, a medical doctor, 1806 in Frankfurt



Schematics and details of early rigid and flexible gastro-endoscopes with ocular

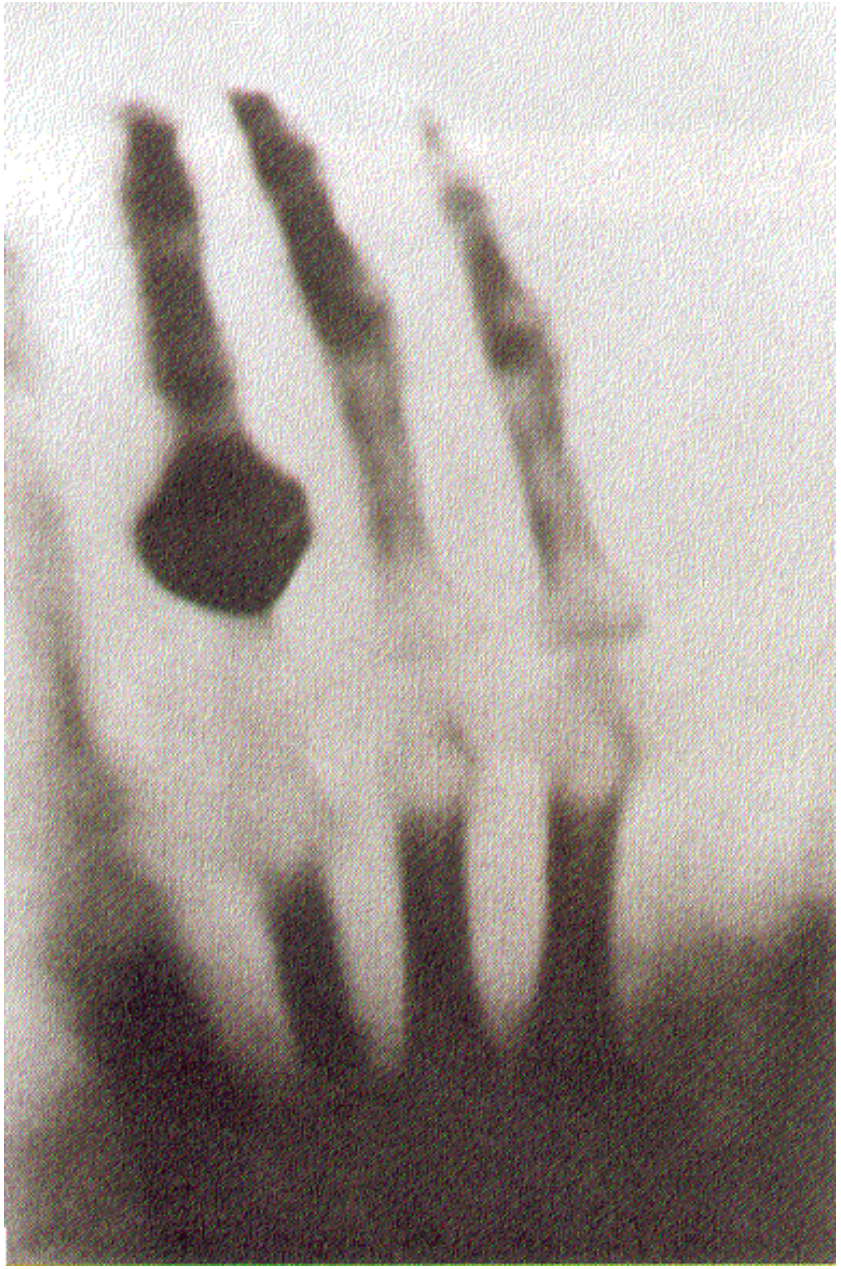
First photographed image taken with a flexible endoscope (1957)



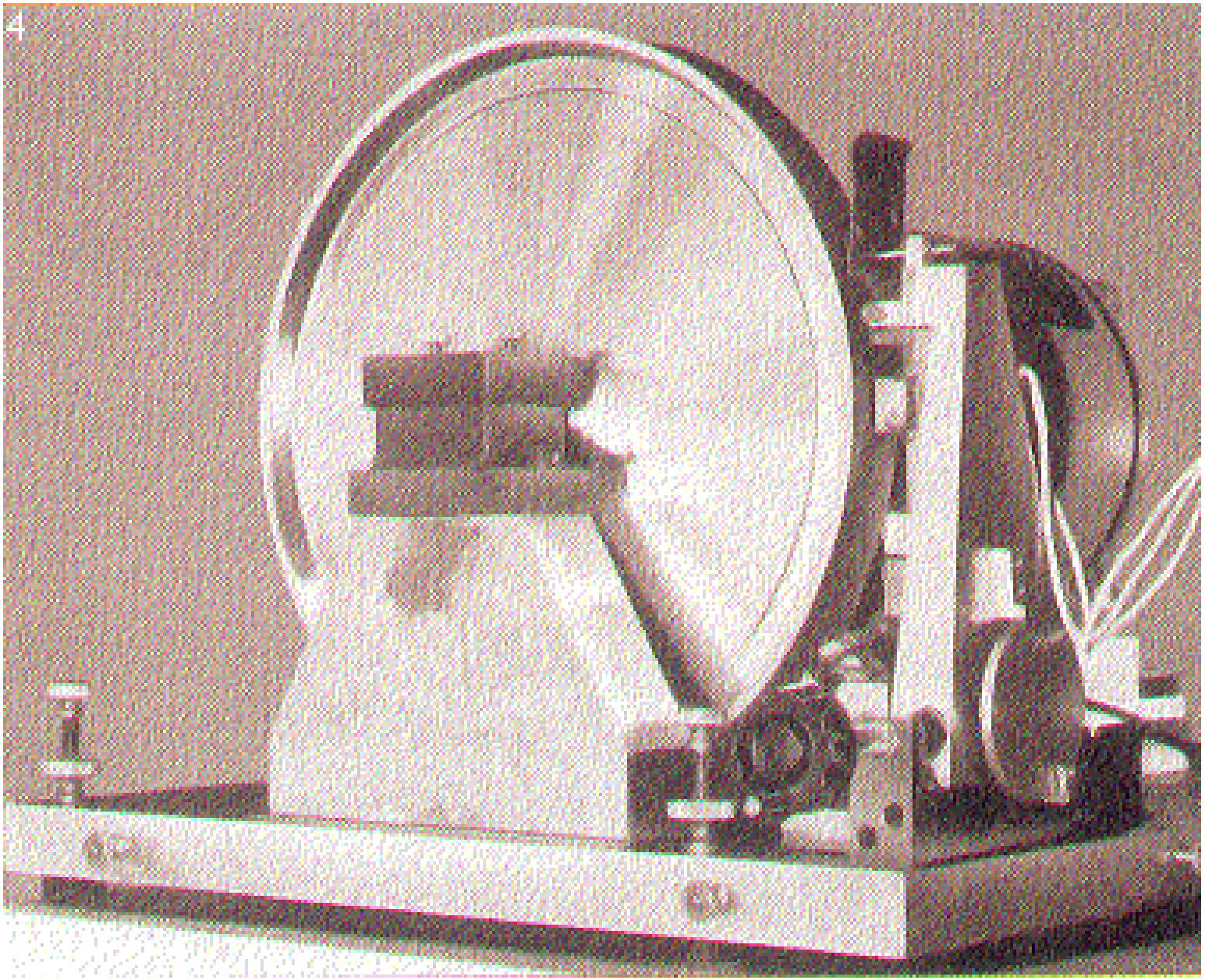
Die von Röntgen bei seinen Experimenten benutzte Versuchsanordnung ist rechts im Bild rekonstruiert worden. Auf dem Tisch erkennt man den Rühmkorffschen Funkeninduktor.

Deutsches Röntgenmuseum, Remscheid

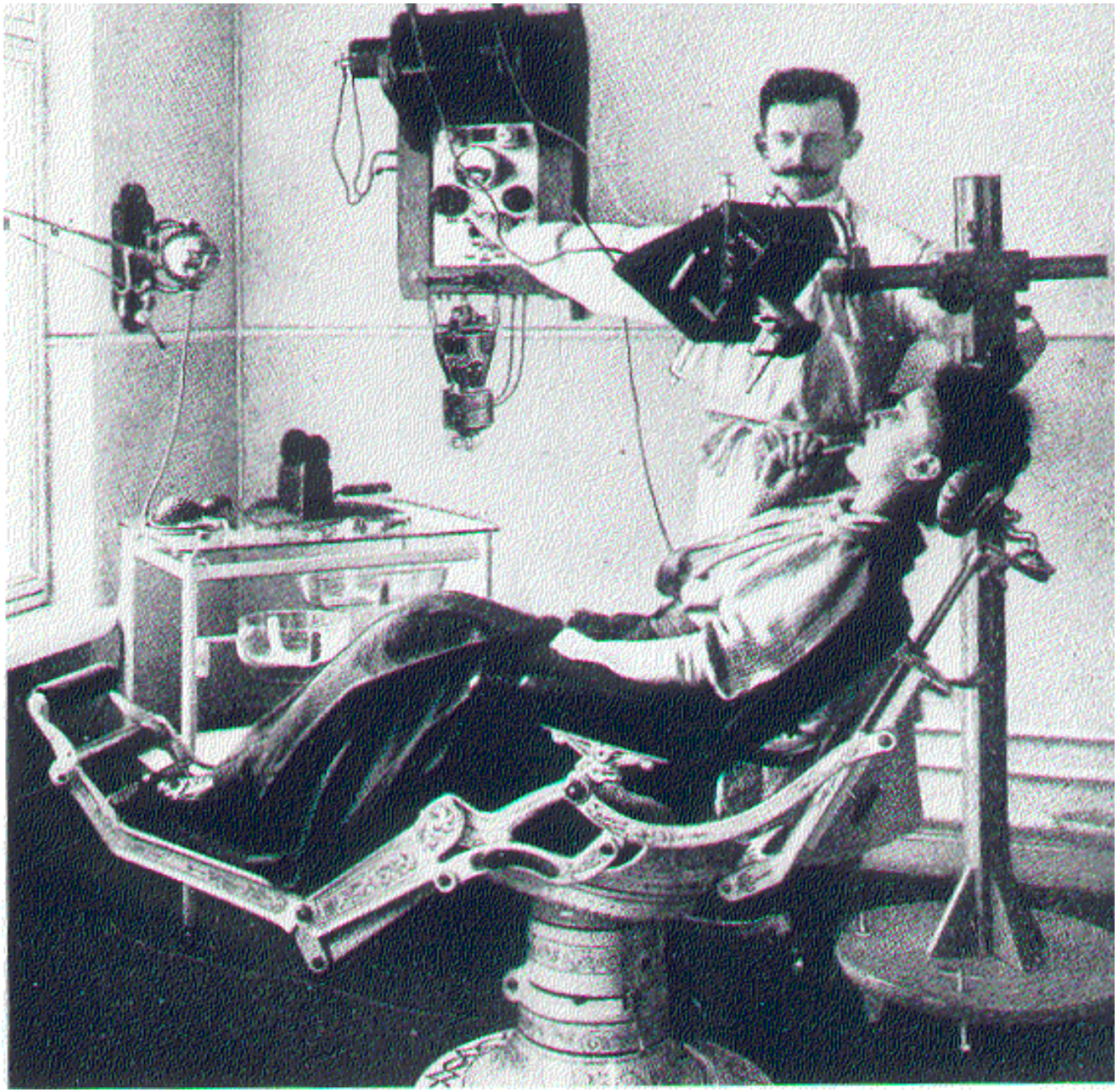
W.C. Roentgen's workplace (reconstruction) for the detection of X-rays (1893)



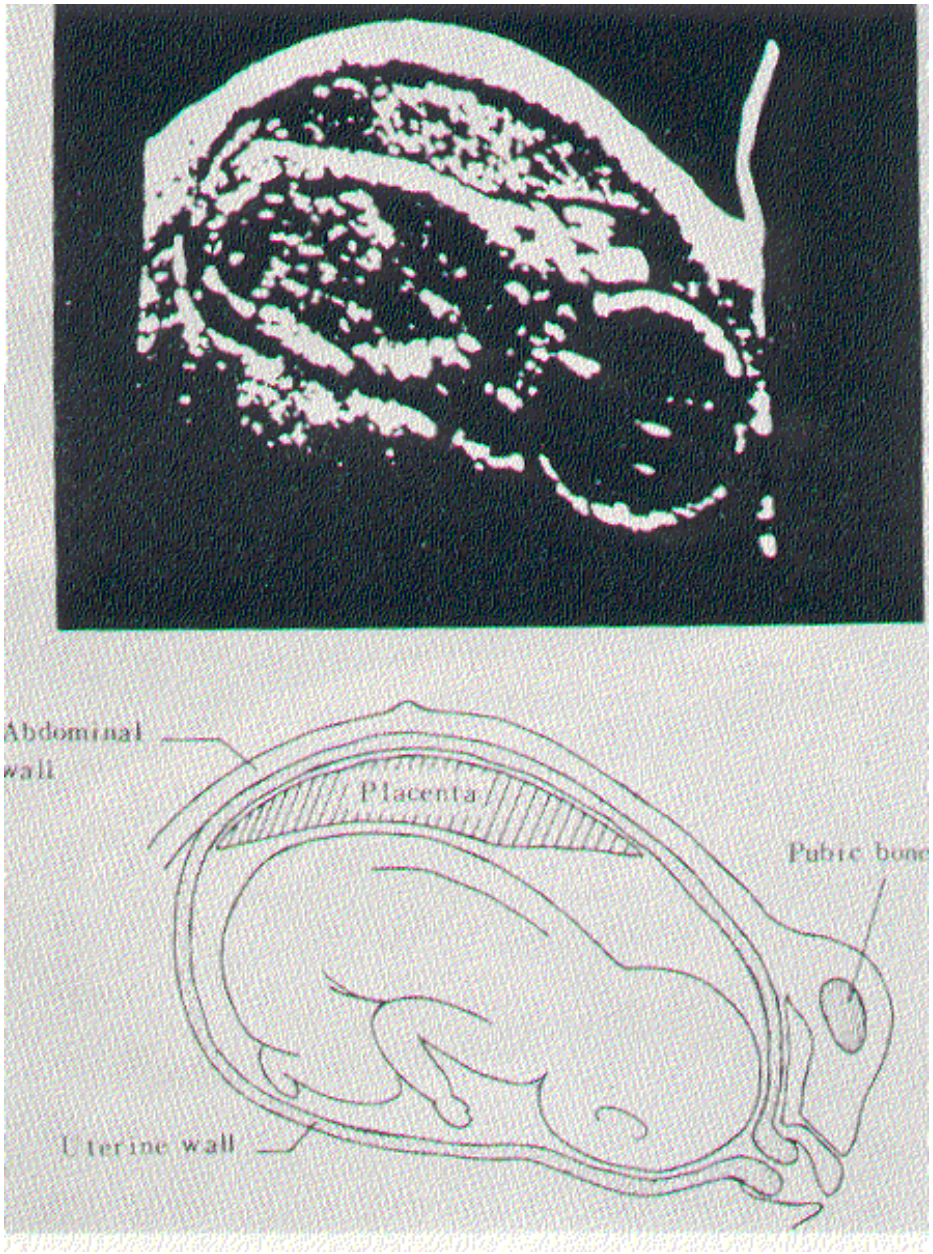
First X-ray image, taken by W.C. Roentgen (Nobel Prize 1901) from the left hand of his wife with an exposure time of 15 minutes (1895)



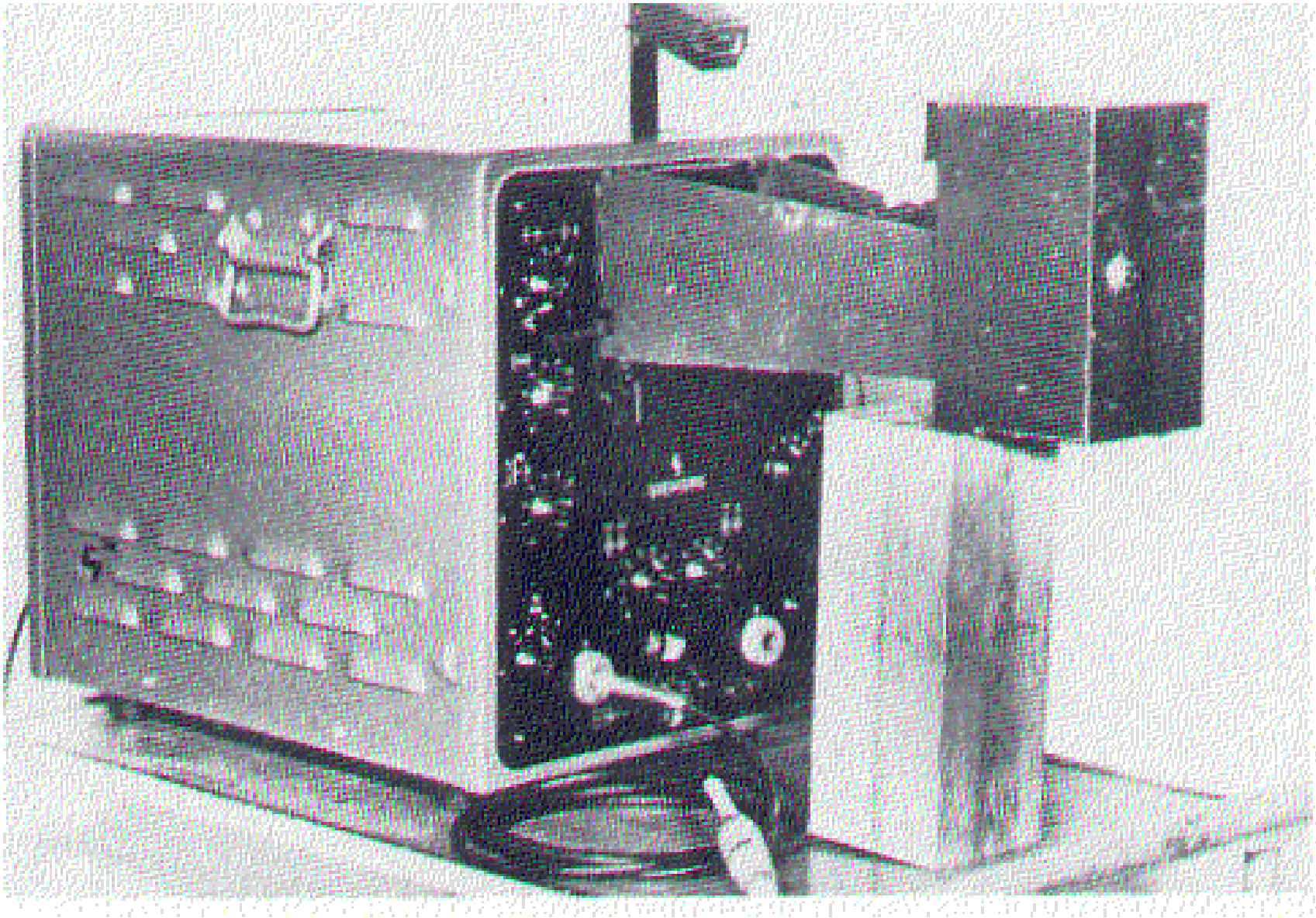
Memory wheel (diameter 40 cm, 50 revolutions per second) for video recording, Philips (1957)



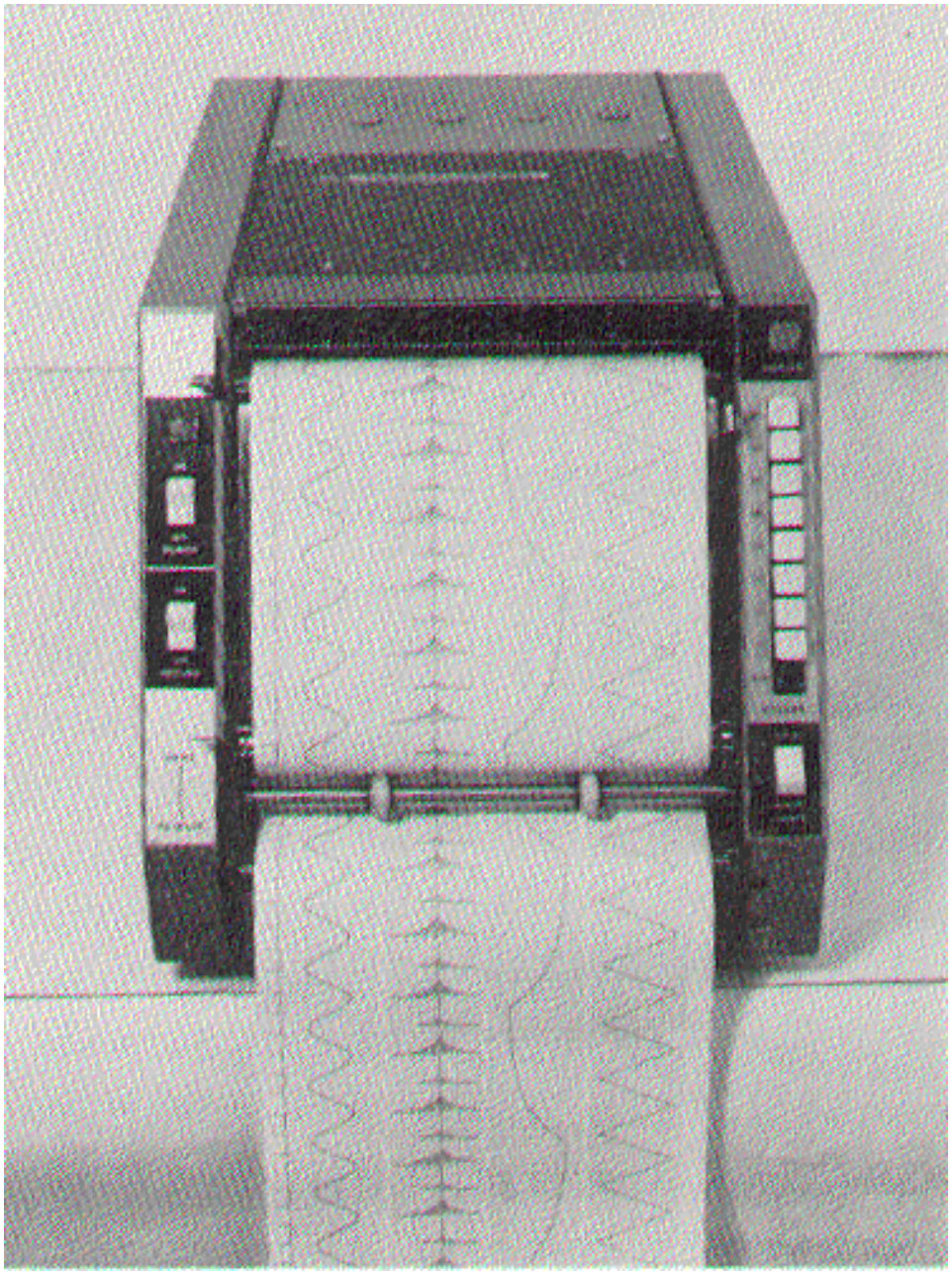
X-ray testing of jaw and teeth with free running cables (Siemens 1911)



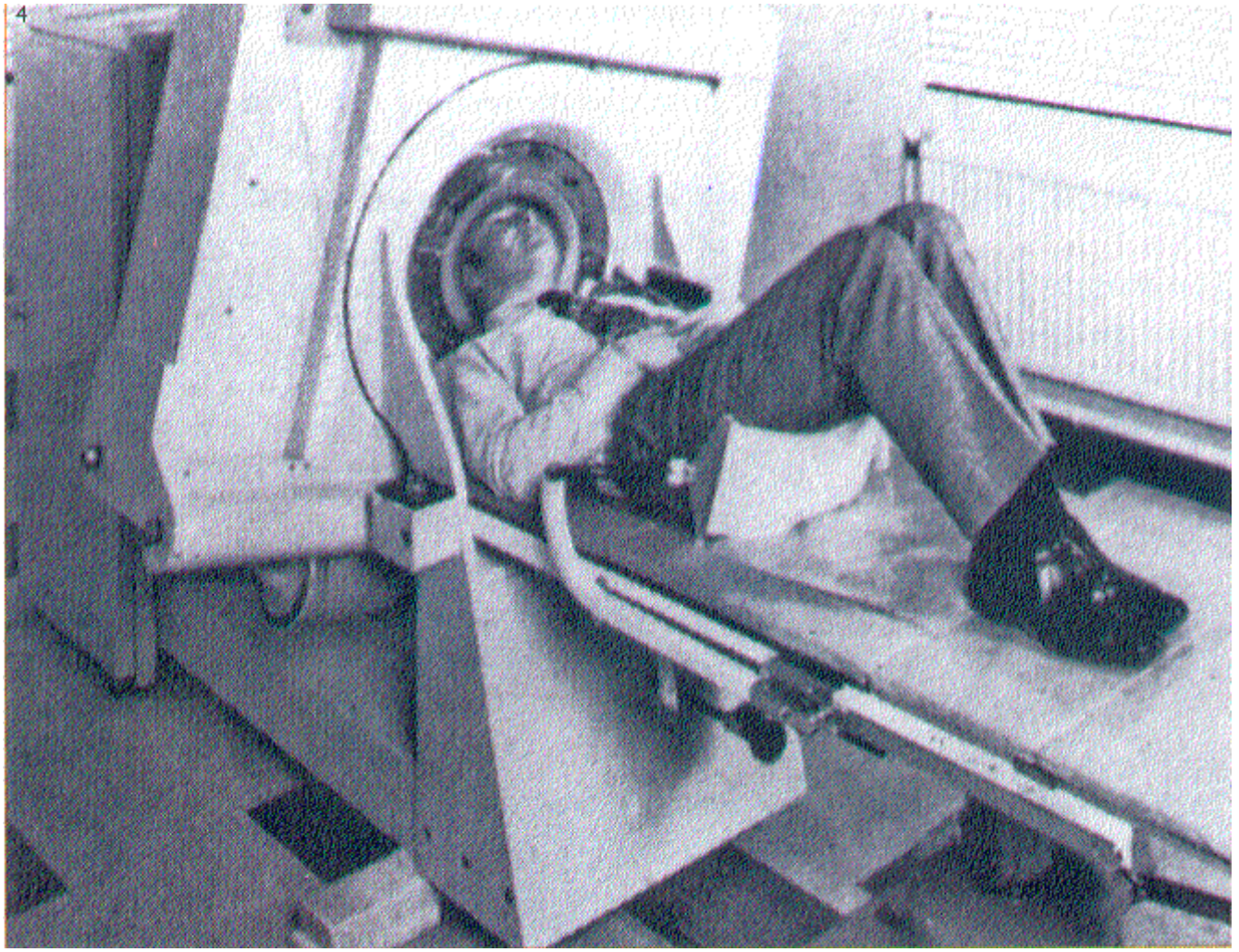
Ultrasound B-mode image of a foetus in the 38th week (1973)



First echocardiograph (Siemens-Reiniger, 1953)



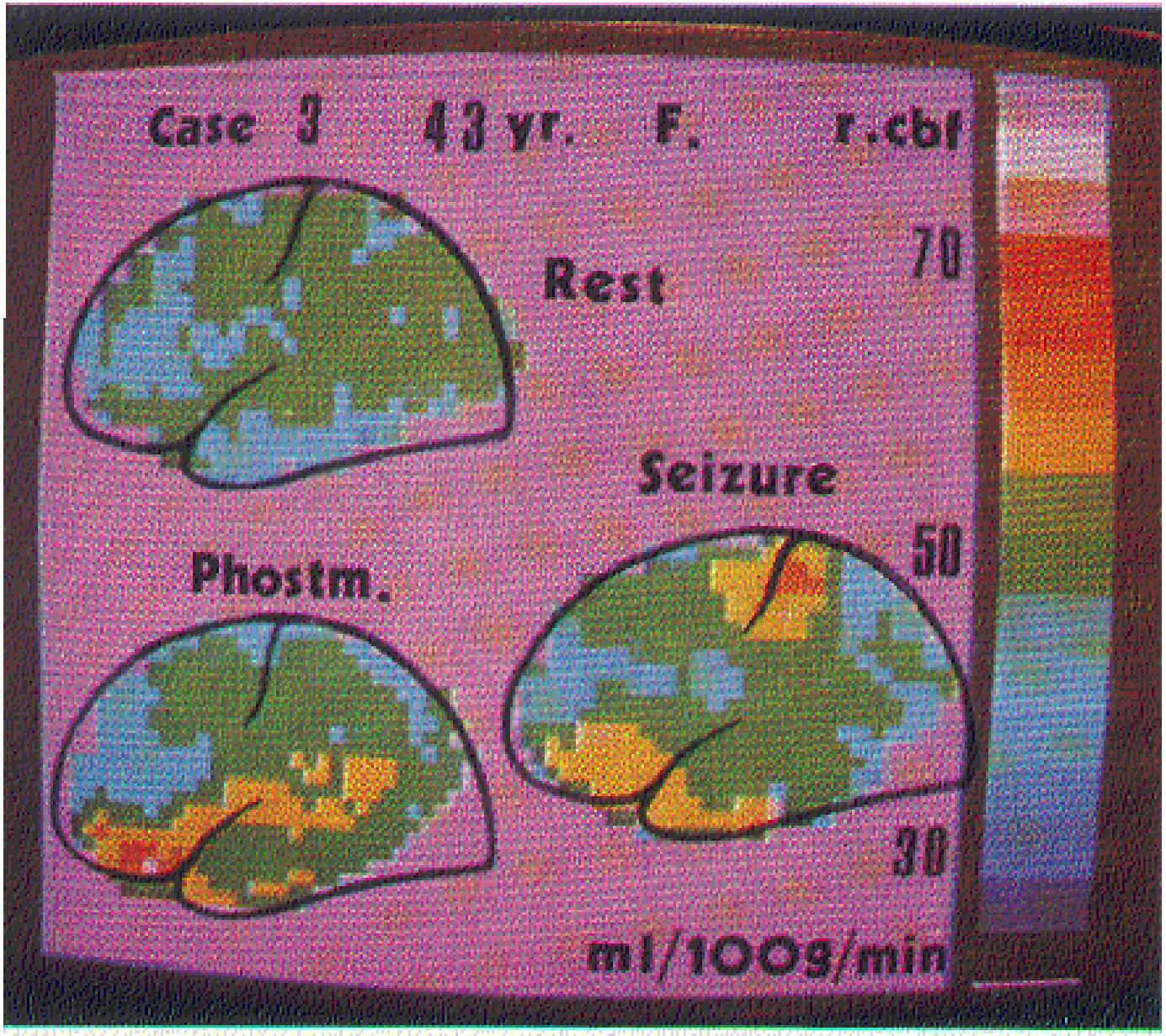
Ink-writing 4-channel recorder (Siemens, 1973)



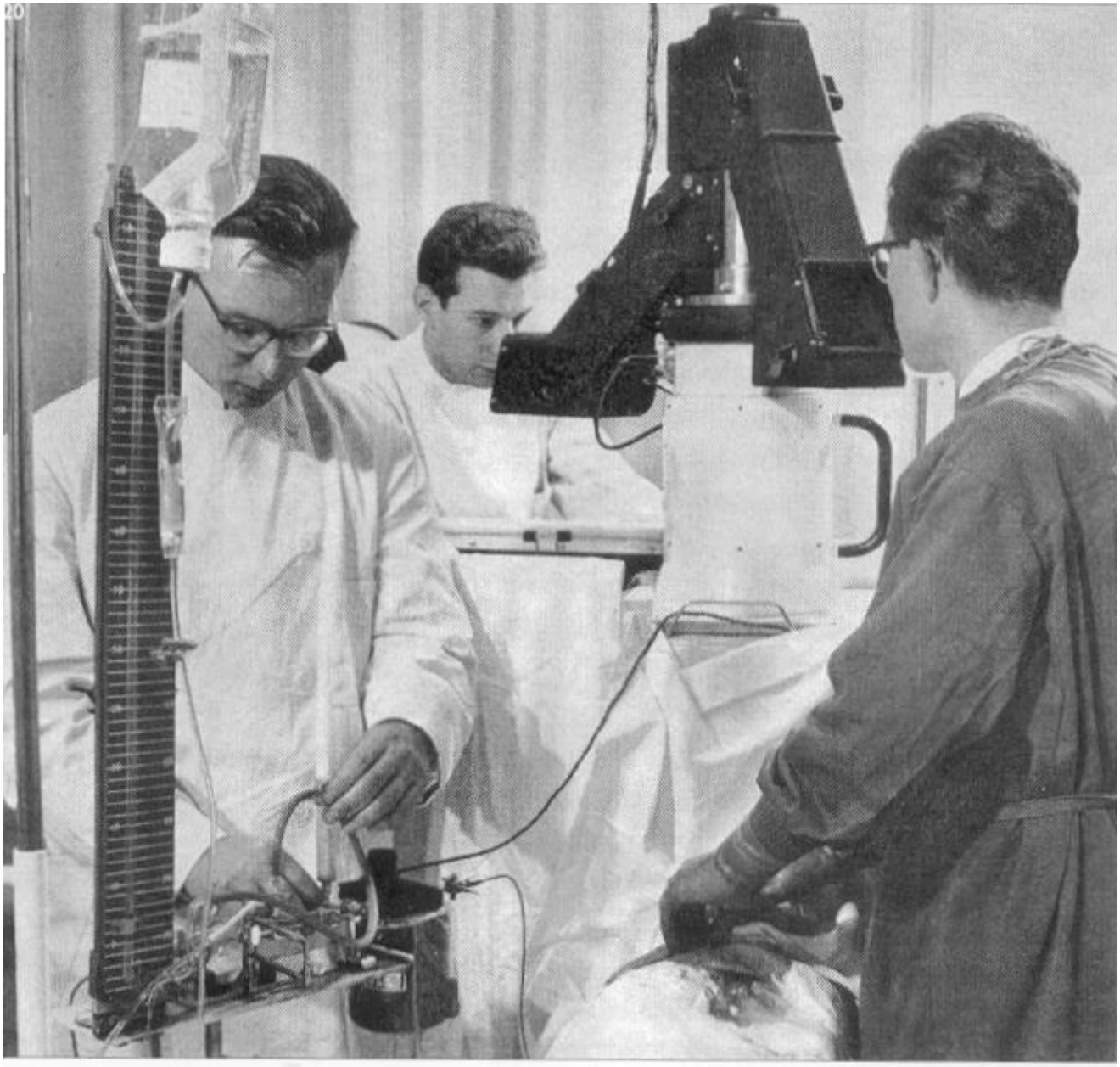
G. Hounsfield (Nobel Prize 1979) with the first EMI-CT-prototype (water-bag around the head) and the first brain scan of Hounsfield himself? (1972)

First MR-image from the brain (1980)

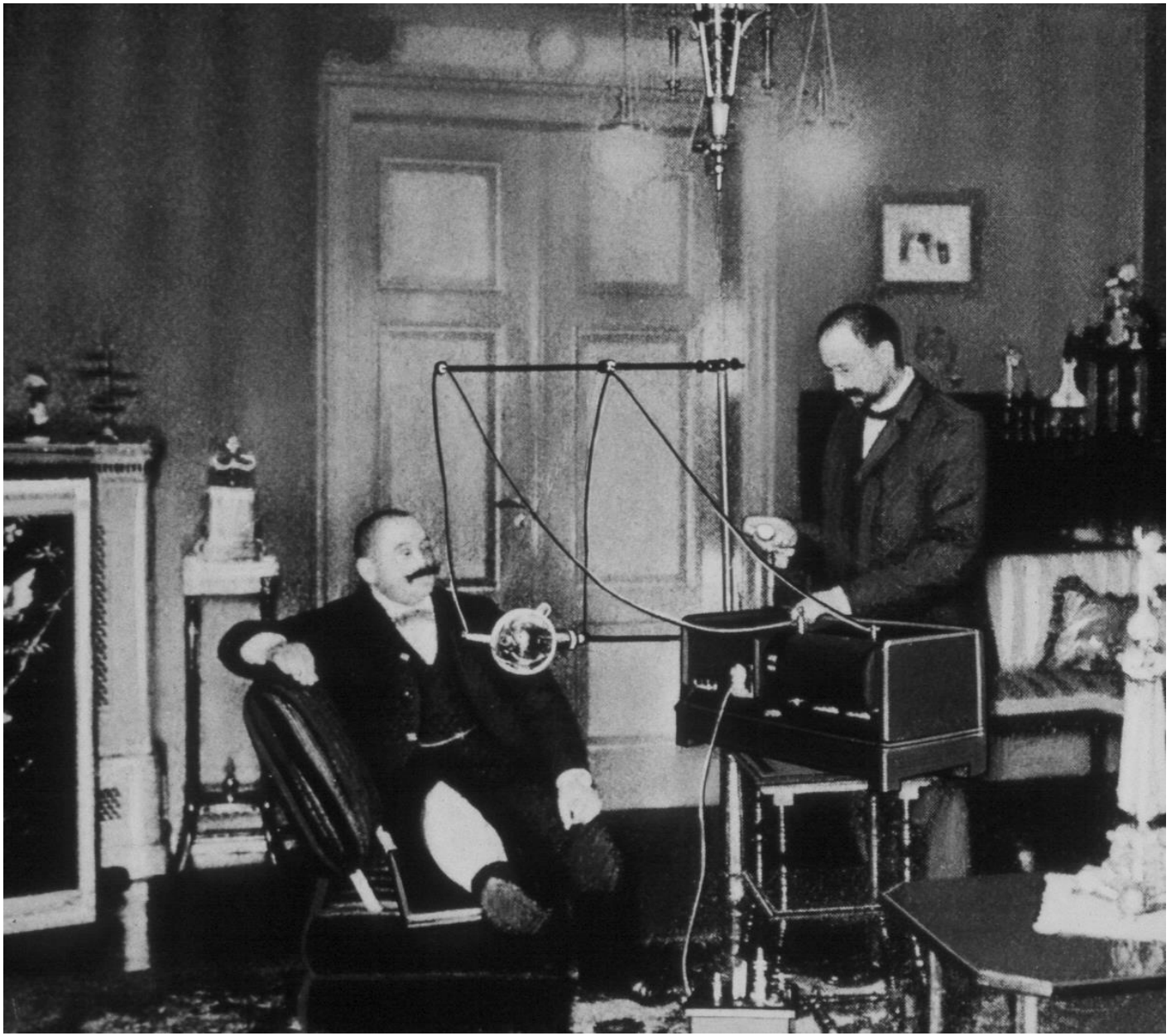
Whole body Gamma scan: dark spots (e.g. in the ribs) show the metastases (1988)



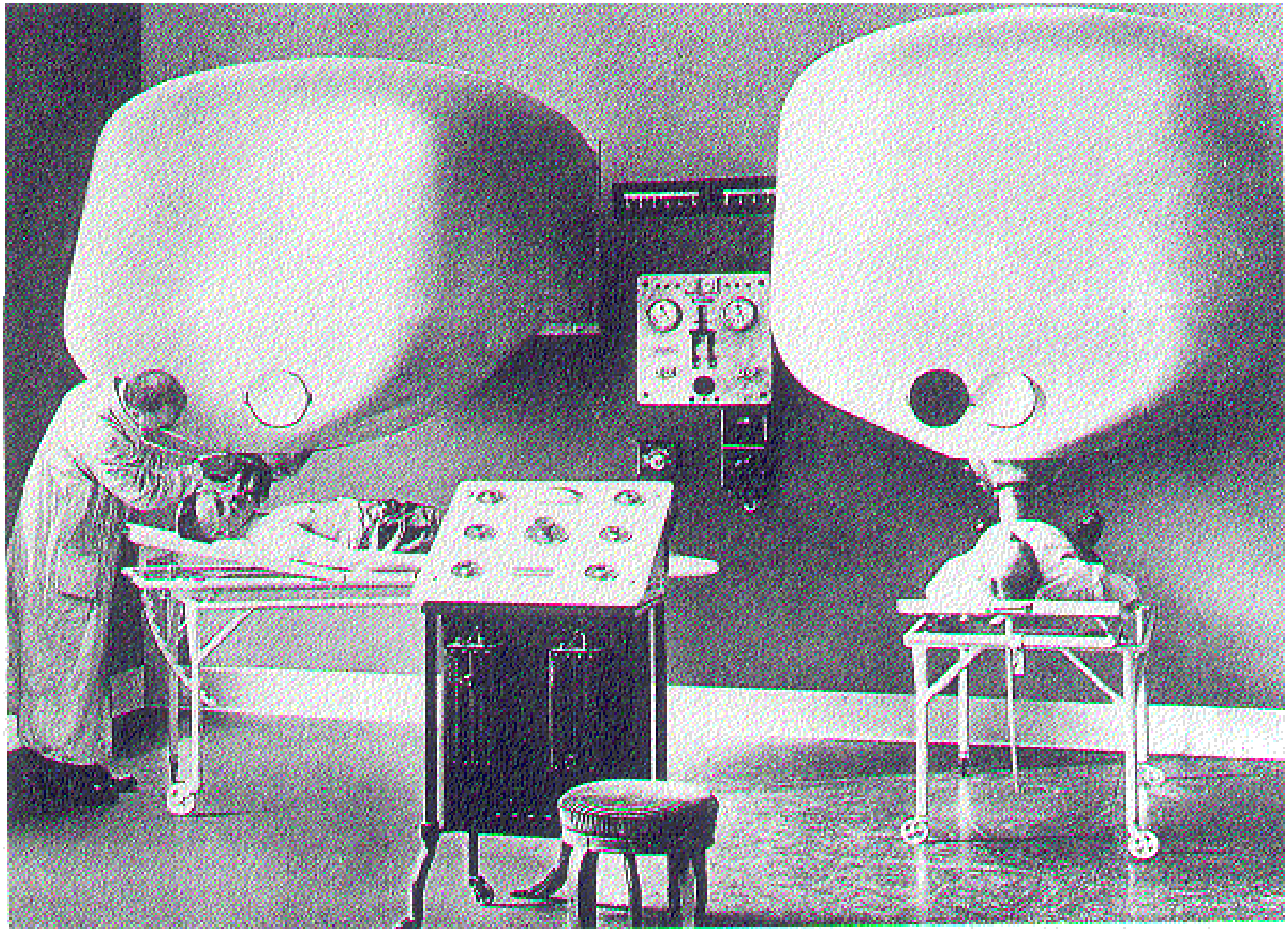
Regional cerebral blood flow (rCBF) determined from 133-Xenon washout curves Acquired with a 254 channel multidetector scintillation camera, N.A. Lassen (1976)



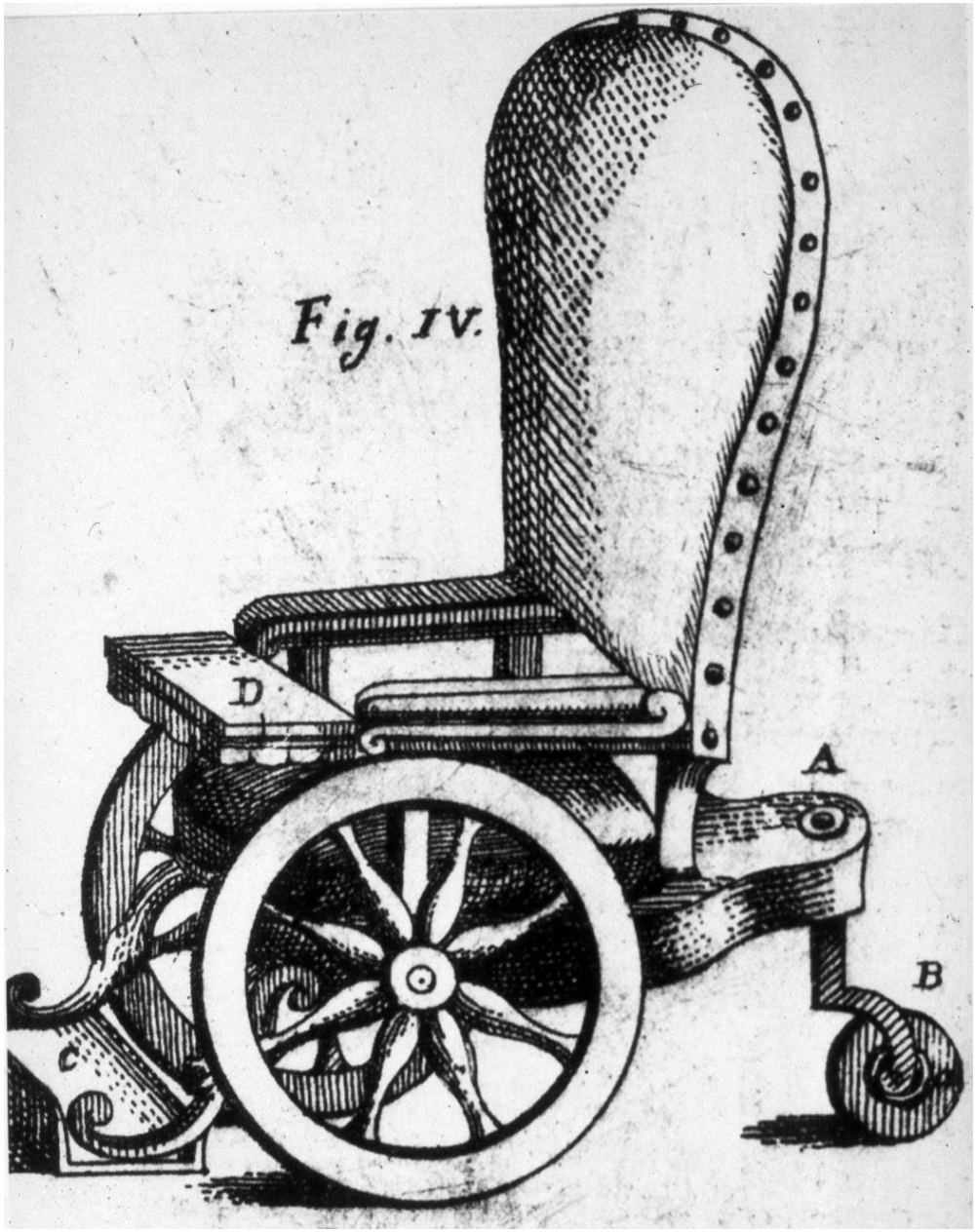
Heart catherization workplace with two-way image intensifier, Philips (1956)



Radiation therapy (about 1905)



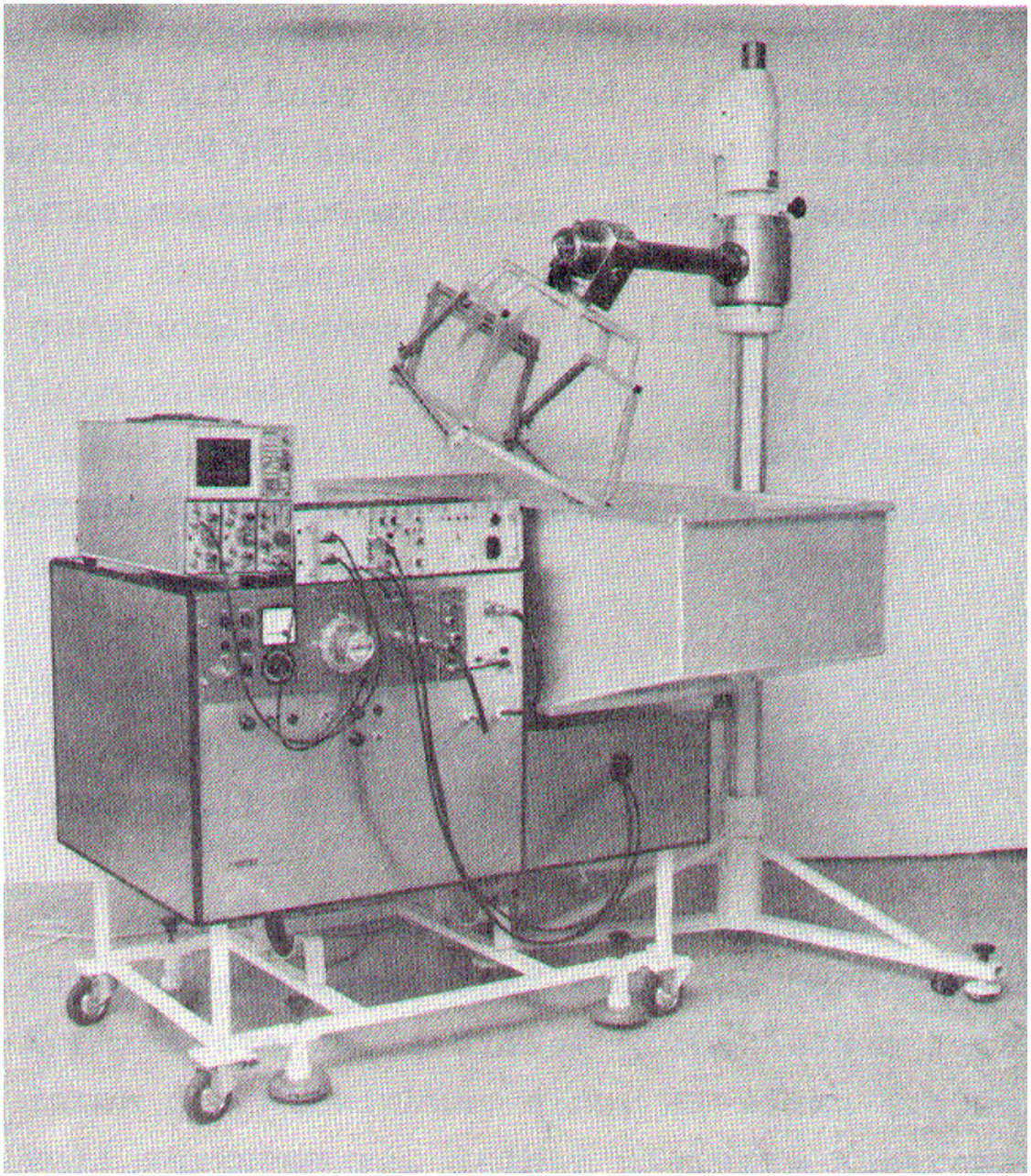
HV-based X-ray generator (Siemens 1919)



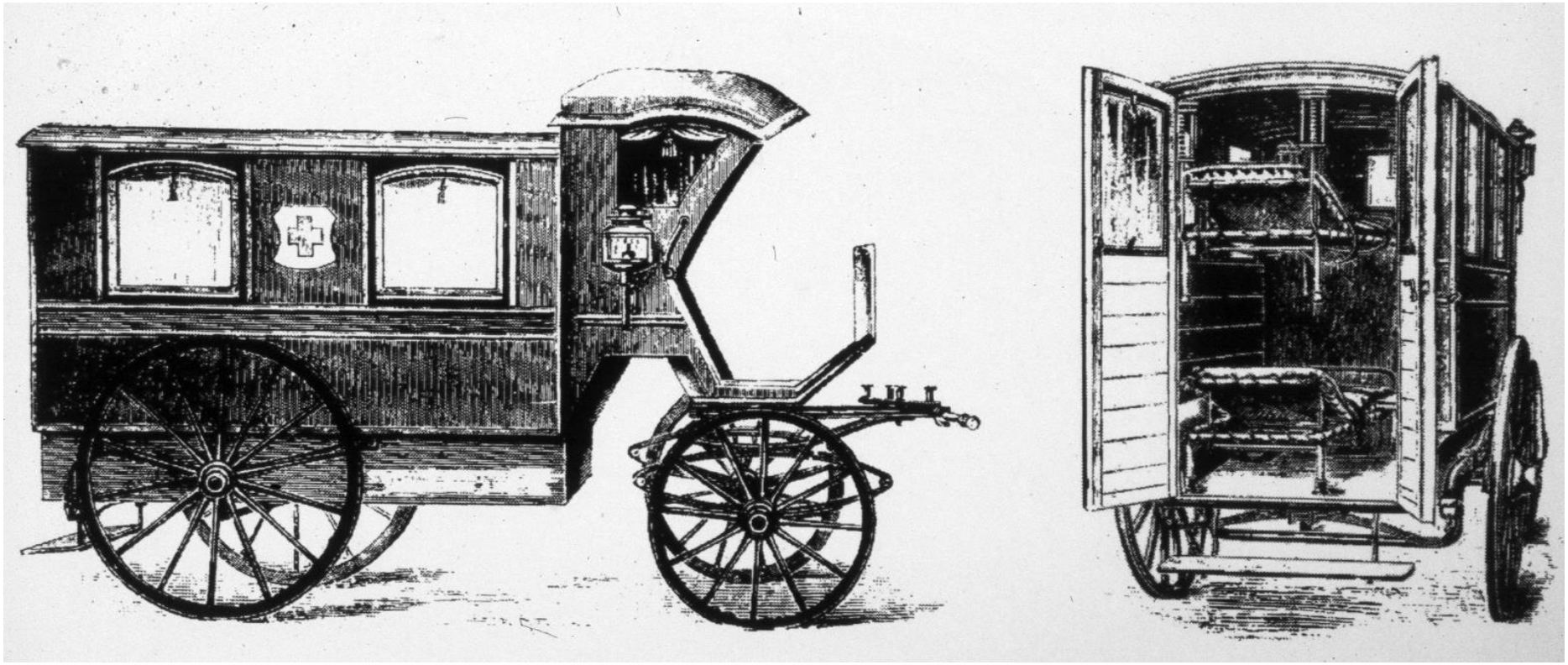
Wheelchair for rich people (18th century)

Extracorporeal disintegration of kidney stones – schematics (1975)

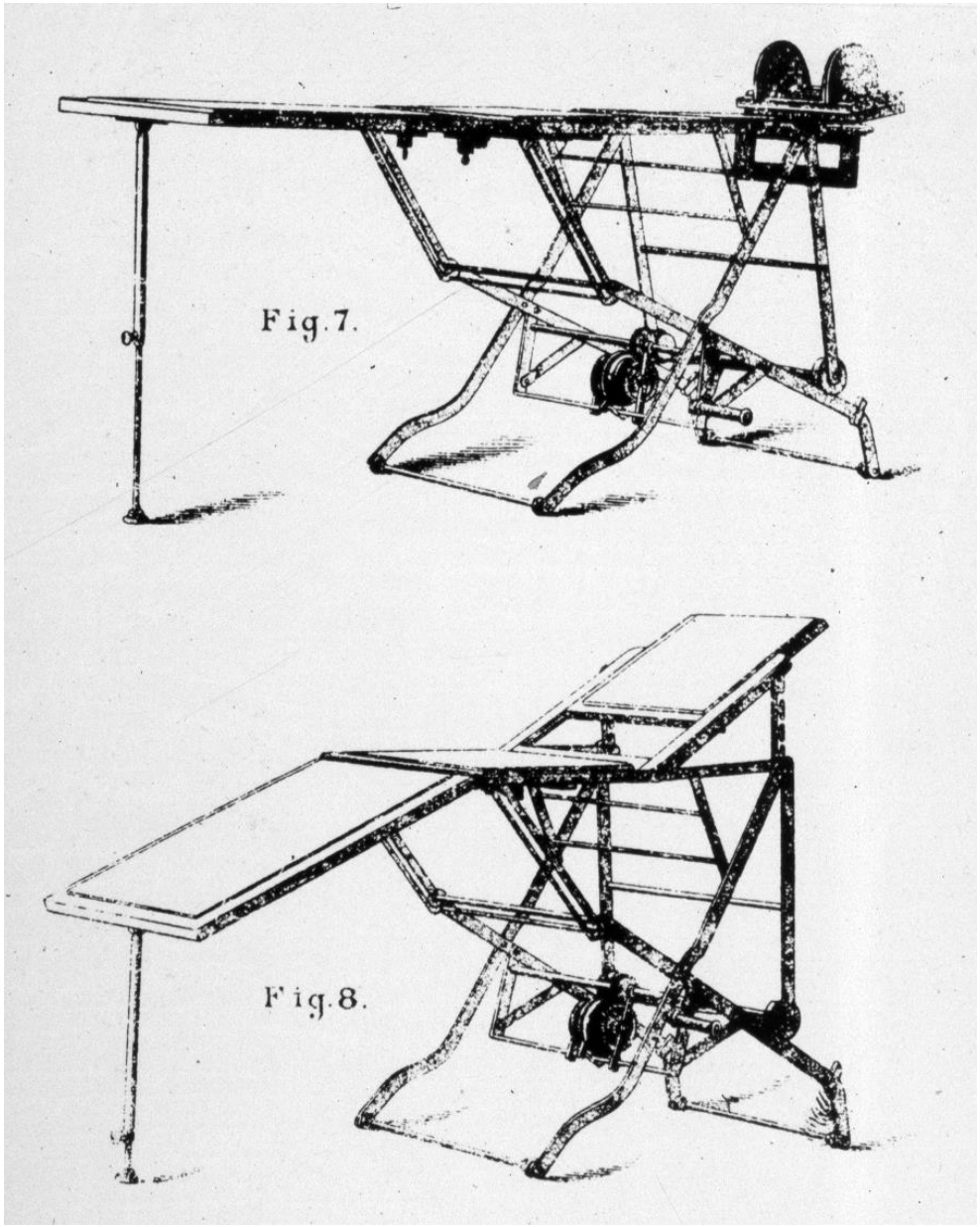
The patient is positioned in a water-filled bathtub („the most expensive bathtub ever built“)



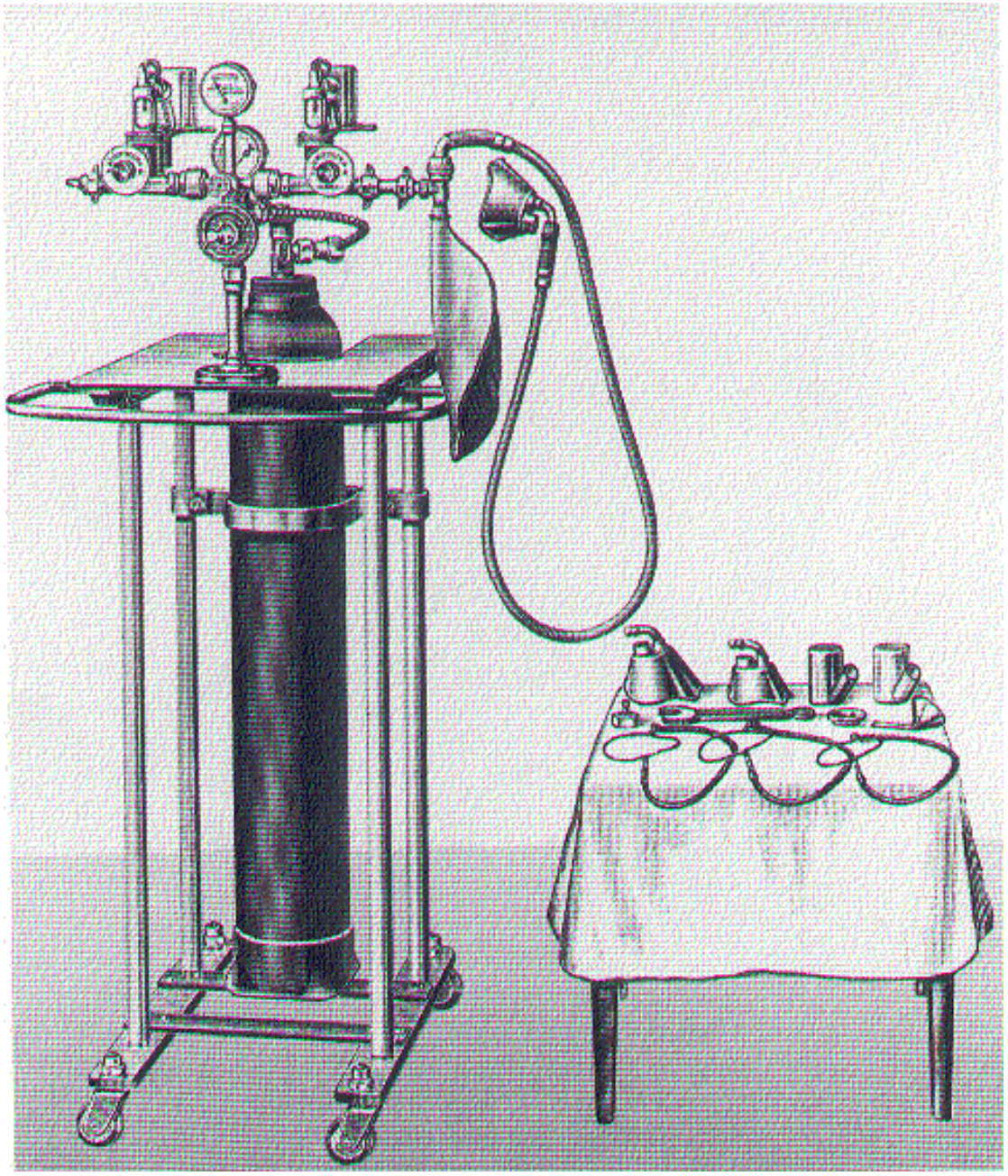
Shockwave generator for animal experiments (Dornier, 1977)



Patient transport vehicles pulled by horses (used until 1920s)

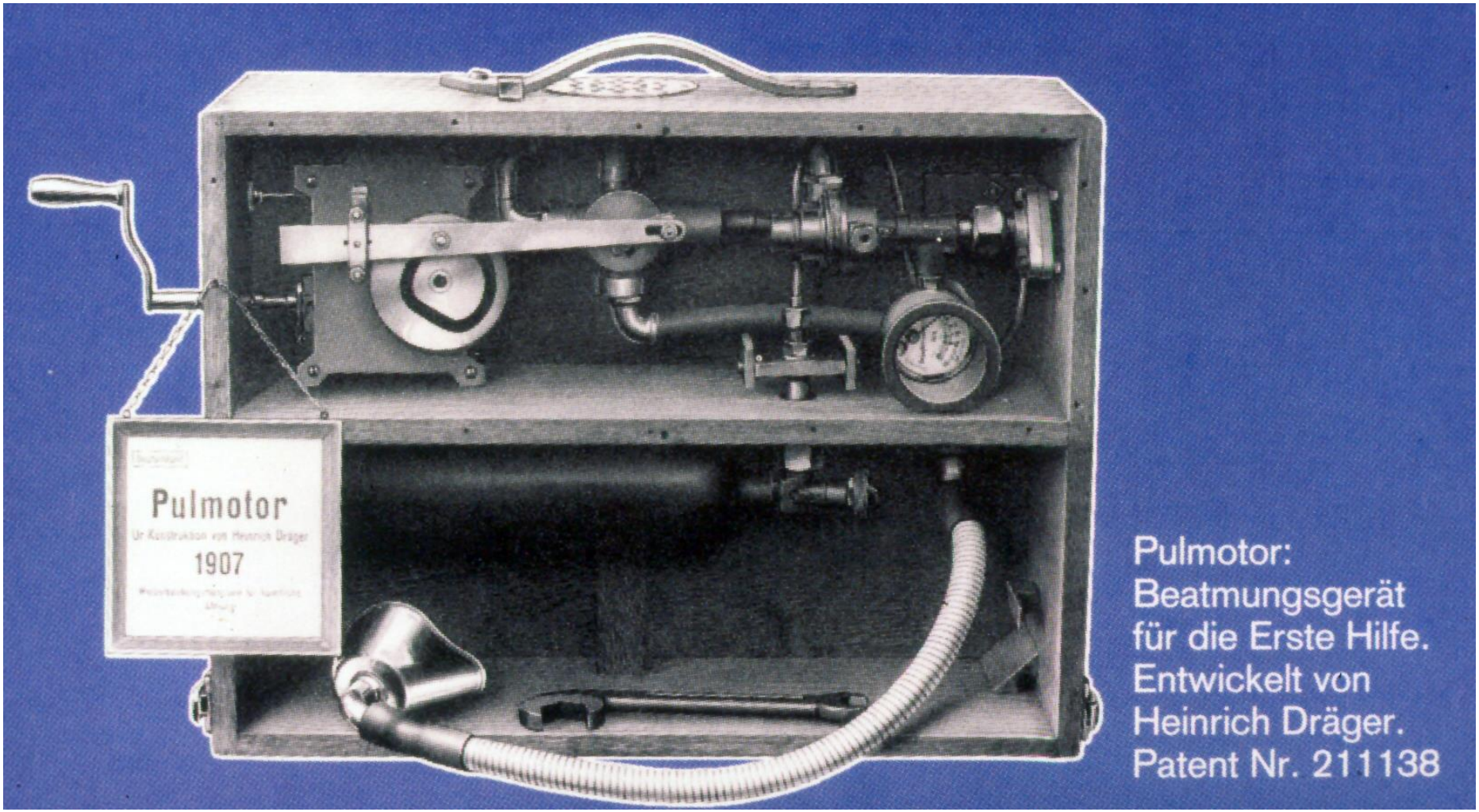


Manually adjustable operating table with flexible joints (about 1890)



First machine for anesthesia by vaporized ether (Draeger, 1903)

Two different types of iron lungs or cabinet respirators (1920 – 1970)

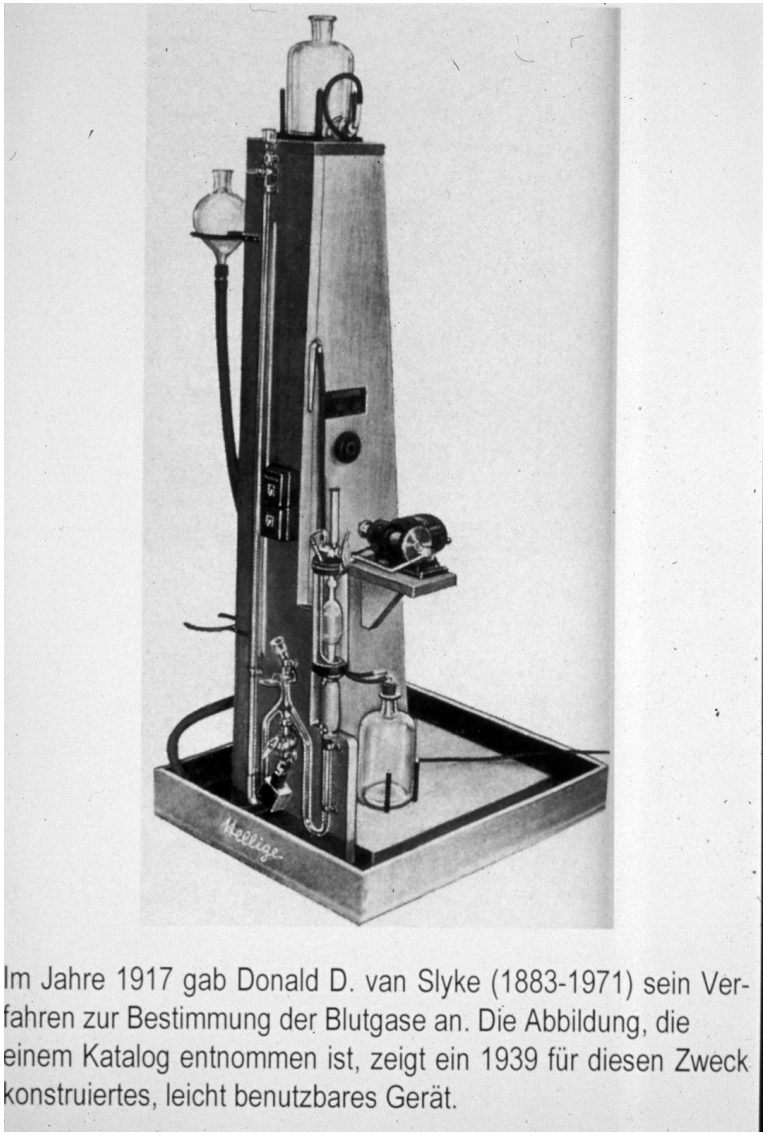


Ventilator driven manually with a crank working on a rotating plate

(H. Draeger, 1907)

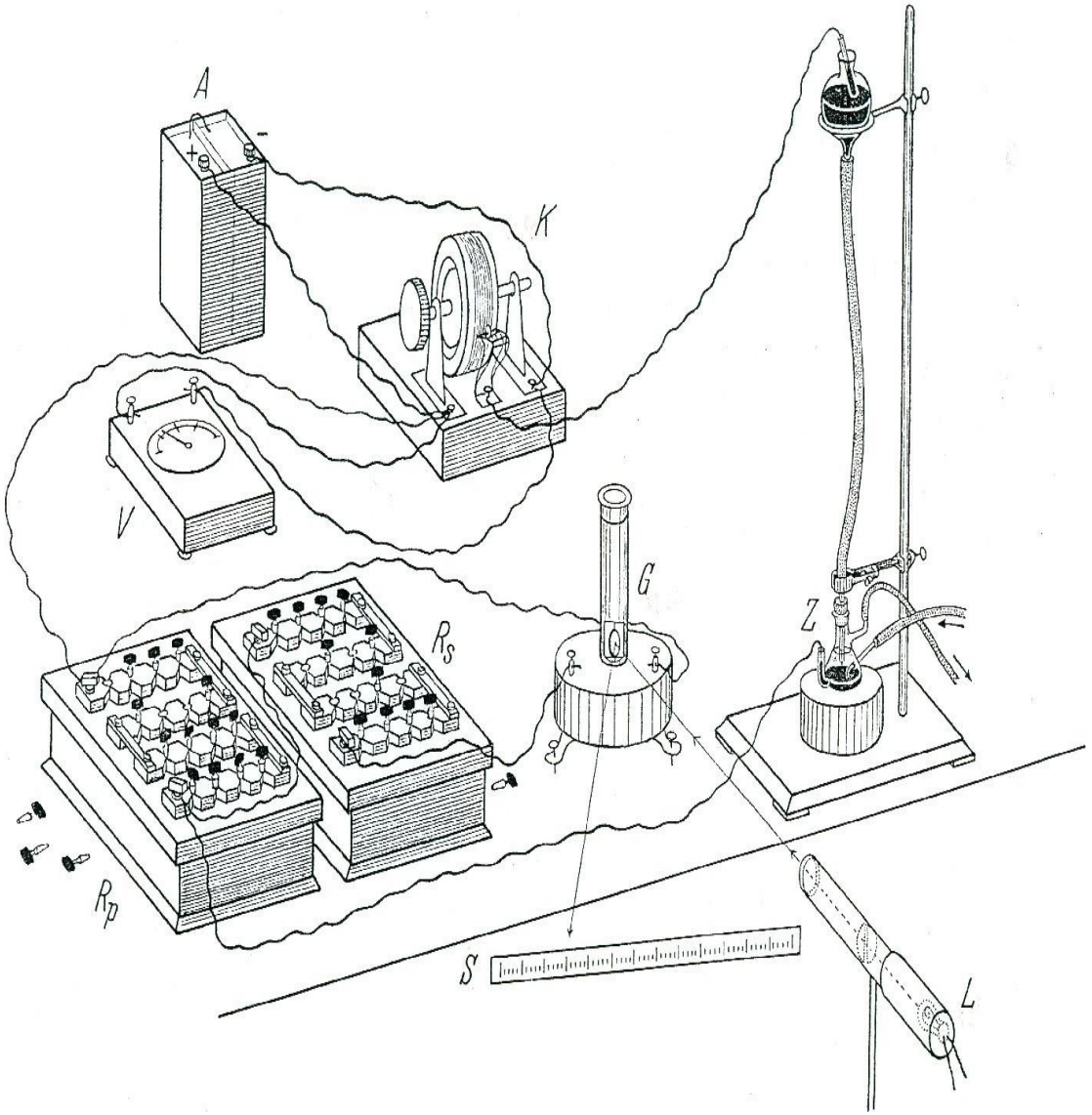
Low pressure generator for the treatment of tuberculosis by pneumothorax

(invented by C. Forlanini in 1892 and employed until 1950)

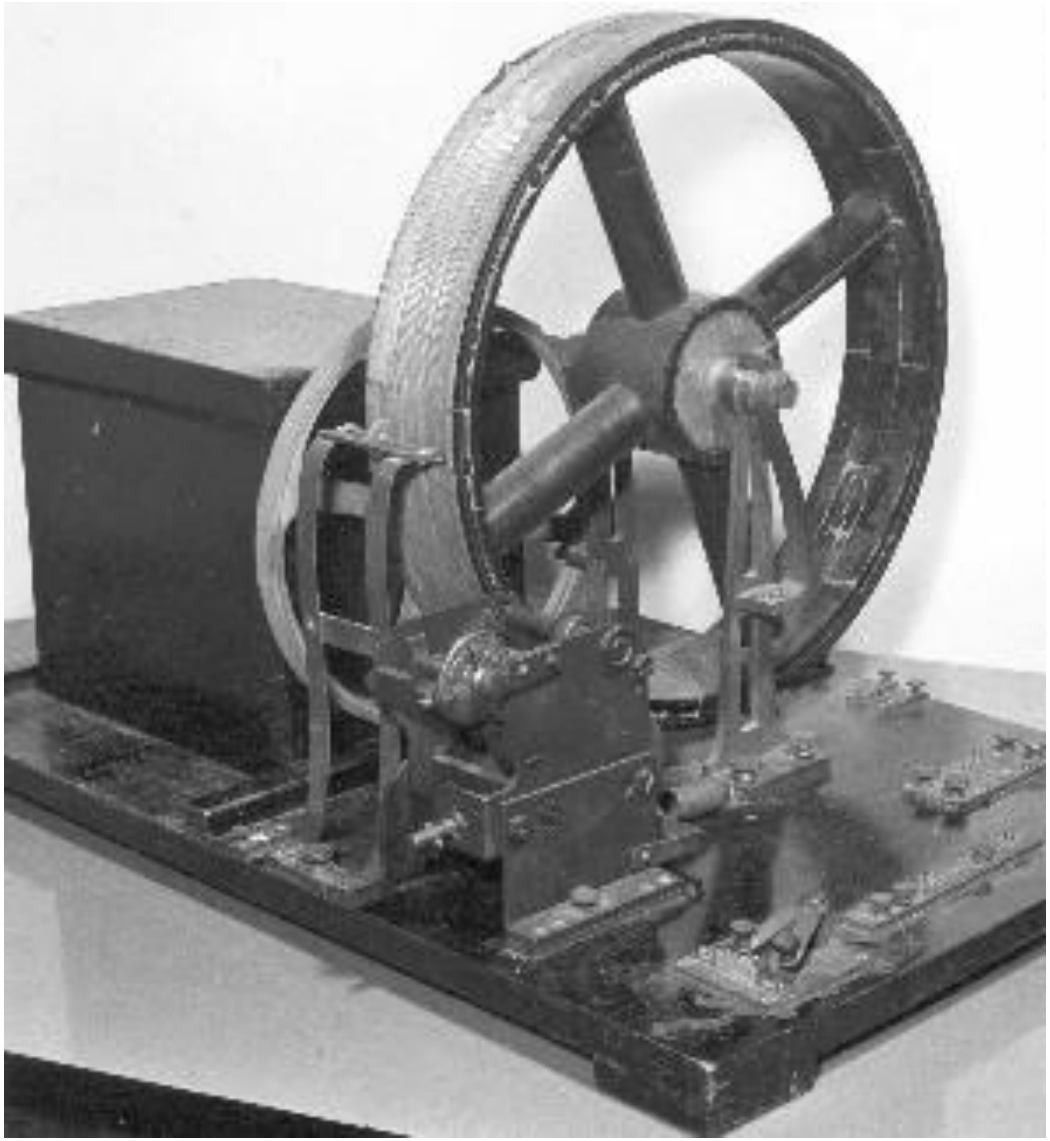


Im Jahre 1917 gab Donald D. van Slyke (1883-1971) sein Verfahren zur Bestimmung der Blutgase an. Die Abbildung, die einem Katalog entnommen ist, zeigt ein 1939 für diesen Zweck konstruiertes, leicht benutzbares Gerät.

Blood gas measurement (D.D. van Slyke, 1917). The shown device was built 1939. The measurement procedure (gas elimination and chemical binding) was employed until the 1960s.



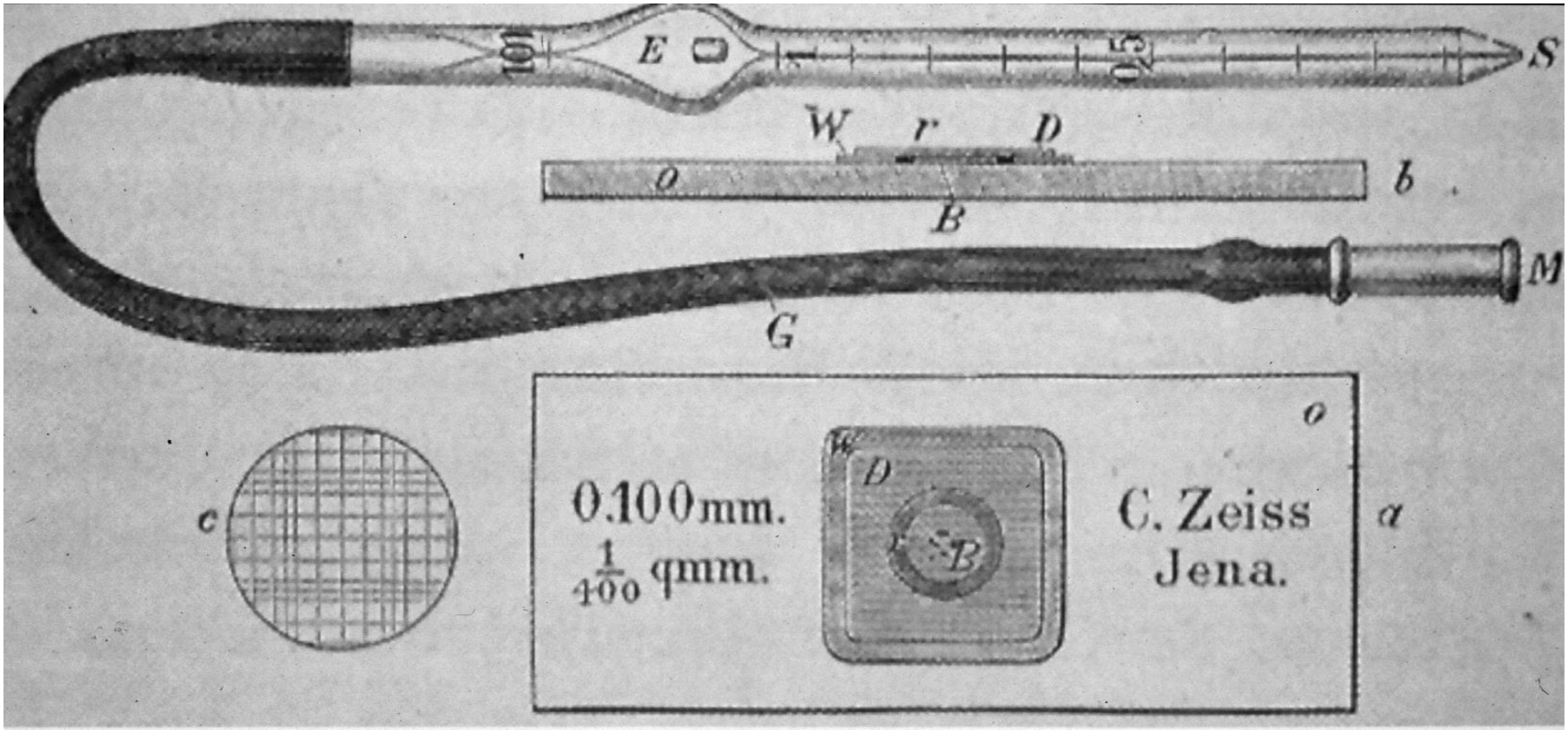
Polarography with the dropping mercury electrode by J. Heyrovsky (Nobel Prize 1959): Principle and measurement schematics



Polarography with the dropping mercury electrode by J. Heyrovsky

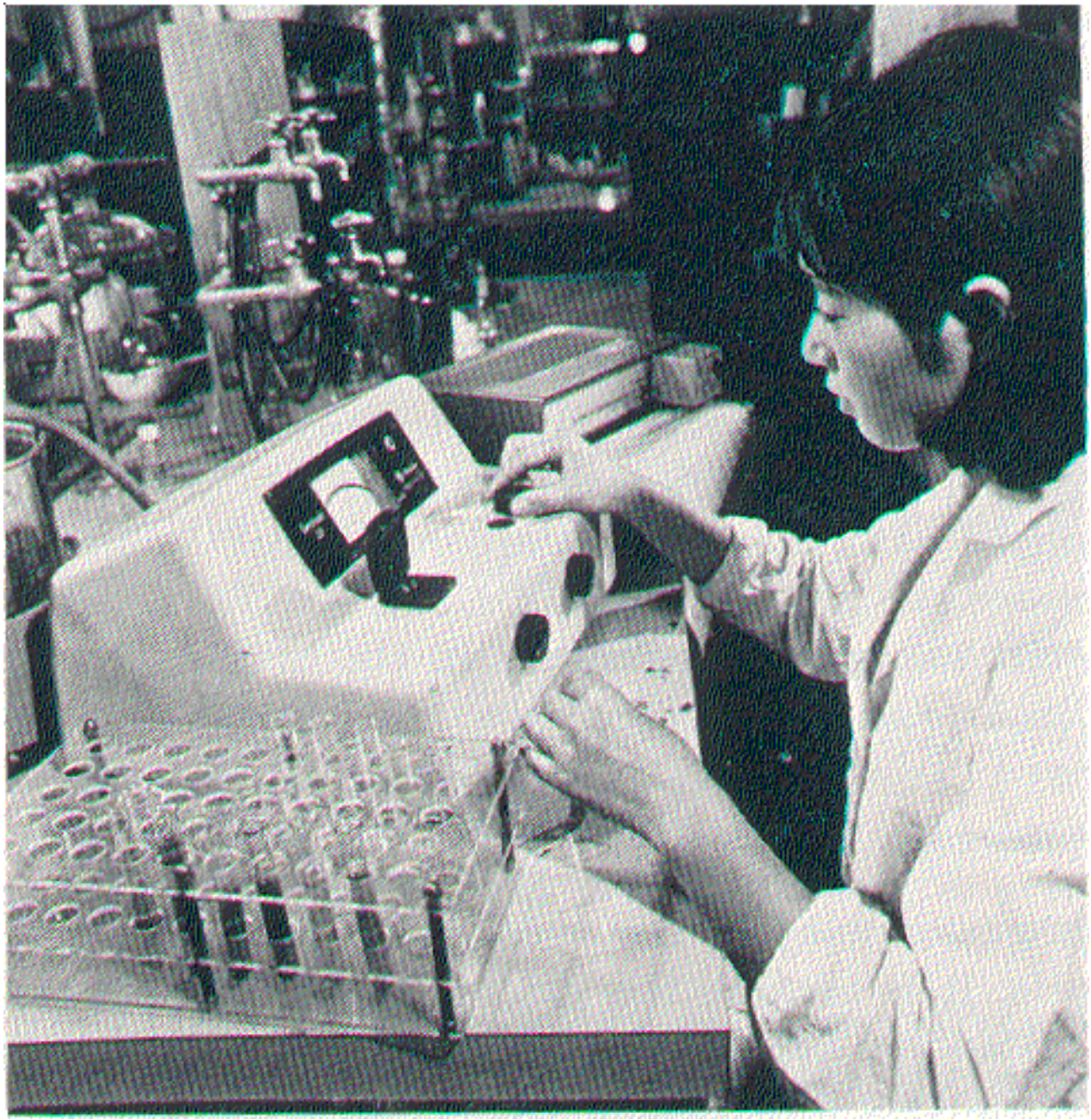
(Nobel Prize 1959): First polarograph

The first appliance for the measurement of the pH-value in blood (Radiometer, 1952)

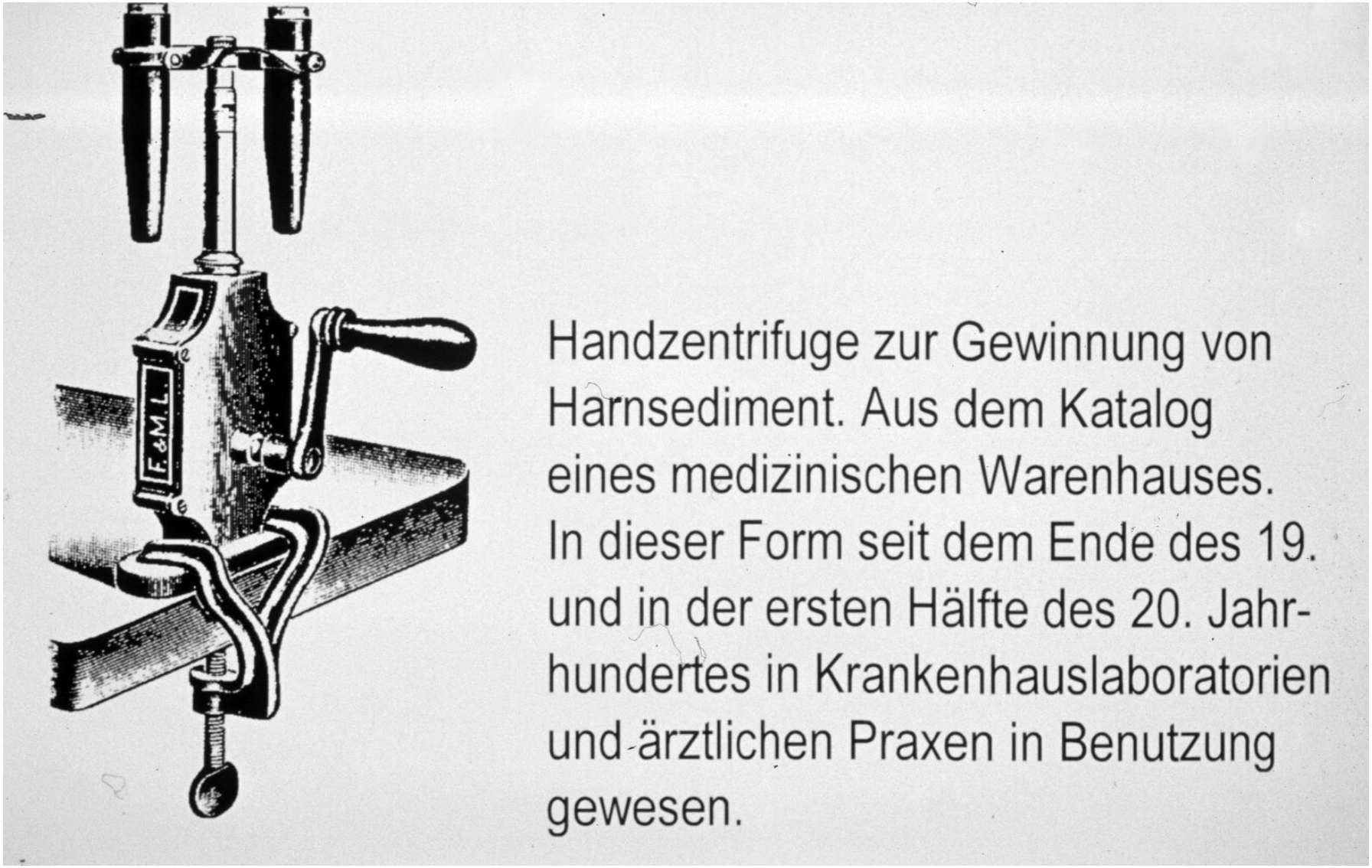


Zählkammer nach Thoma zur Bestimmung der Zahl der Blutkörperchen unter dem Mikroskop mit Mischpipette zur Verdünnung des Blutes. Nach Einführung automatisch arbeitender Zählgeräte in den sechziger Jahren des 20. Jahrhunderts wurde dieses 1878 von dem Pathologen Richard Thoma (1847-1923) eingeführte Verfahren mehr und mehr verlassen.

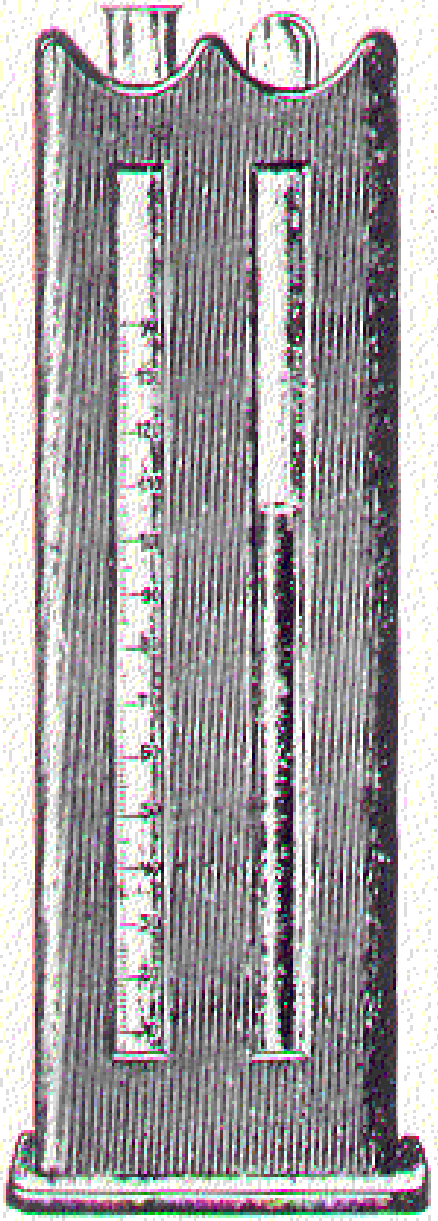
Blood cell counting using the Thoma-plate and a microscope. Invented and introduced 1878 by R. Thoma and used until the 1960s. Required time about 10 minutes.



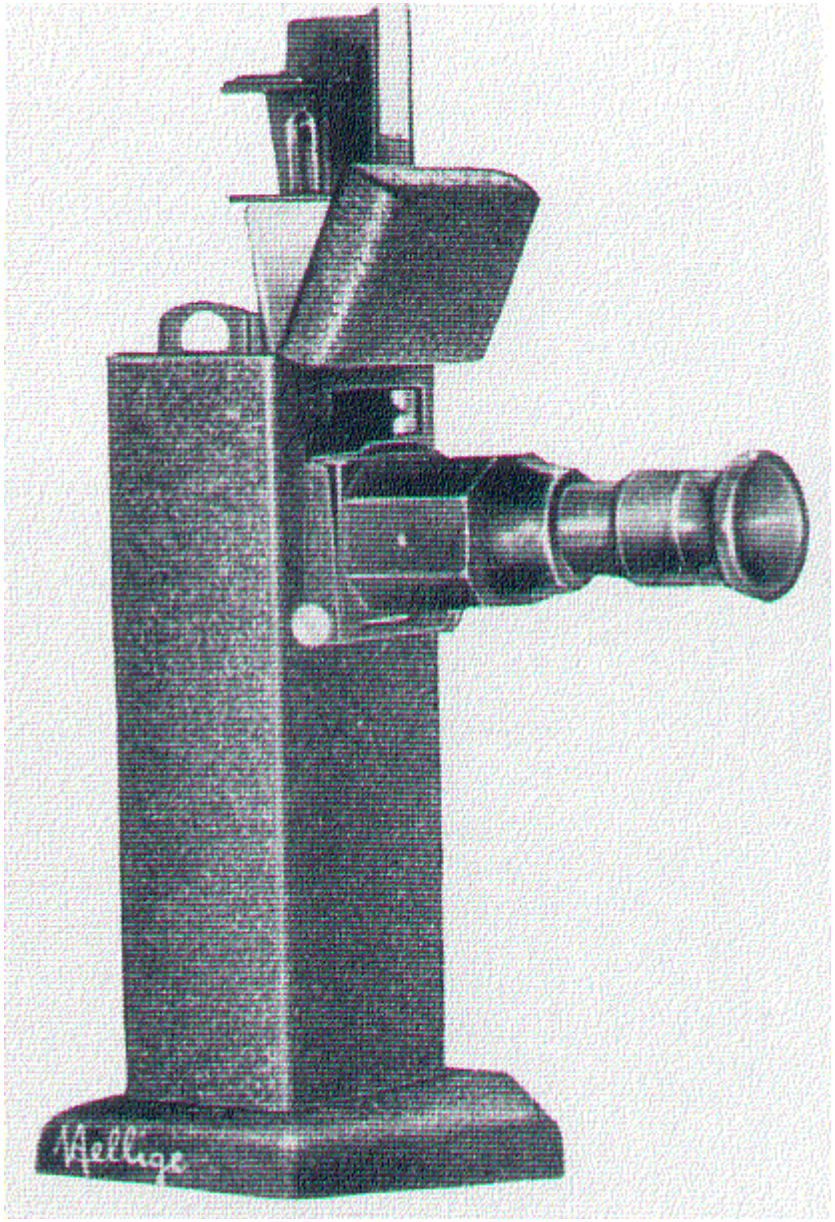
Electric photometer for in-vitro diagnostic testing (1973)



Manually operated centrifuge for two containers and samples, introduced 1890s and used until 1940s

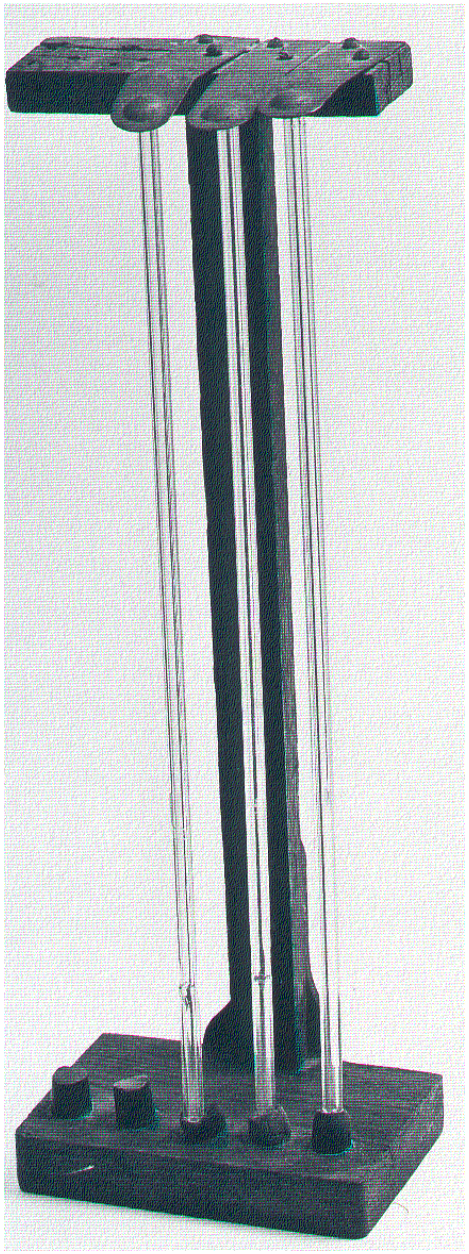


a. Sahli (1905)

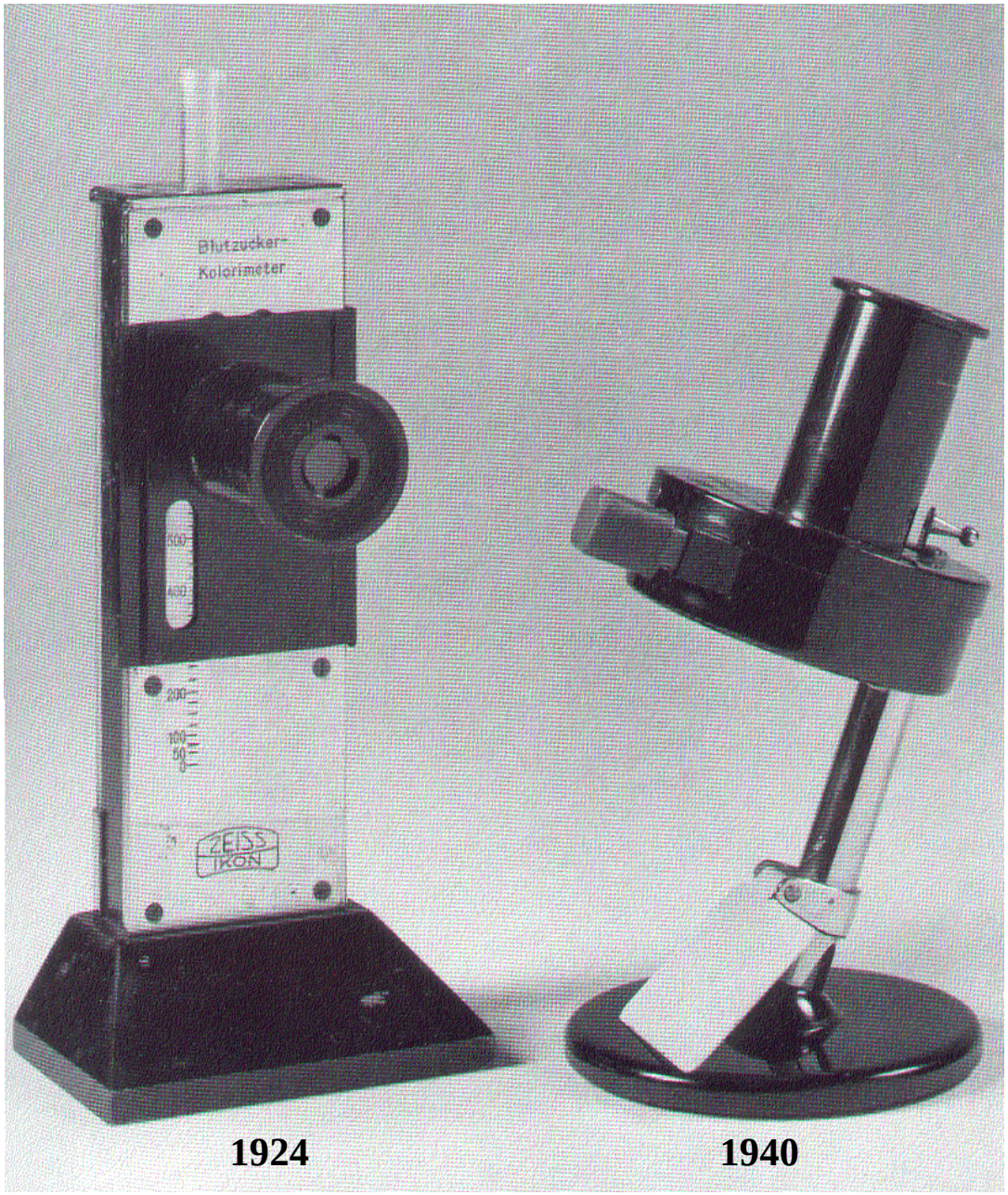


b. Autenrieth (about 1925)

Measurement of hemoglobin concentration, based on colour assessment



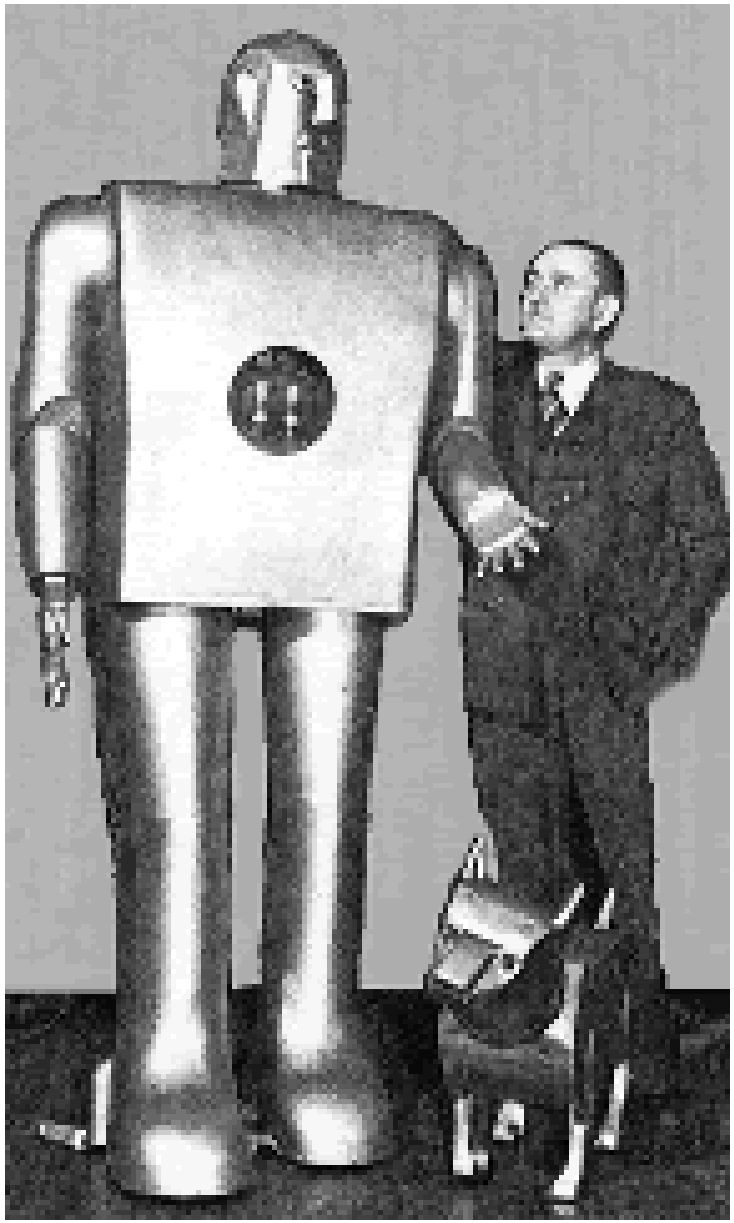
Measurement of the erythrocyte sedimentation rate, proposed by R. Fåhraeus (1918), device built by A. Westergren (about 1950)



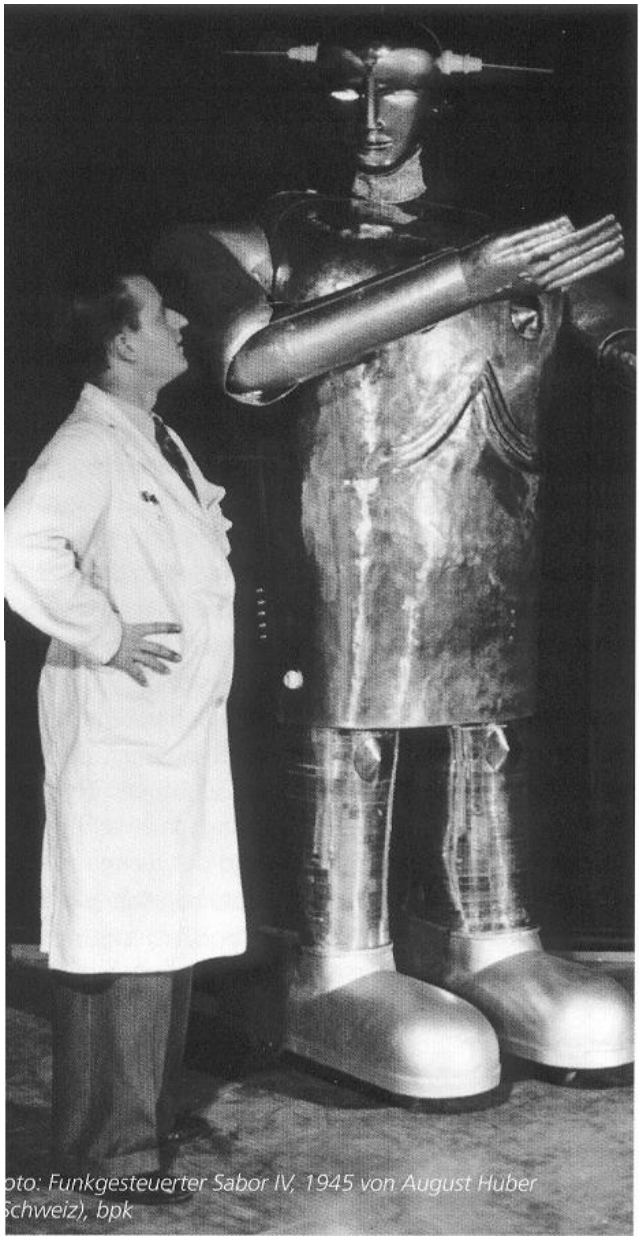
1924 1940

Blood glucose measurement by colorimetry

First programmable automaton (Al-Jazari 1206): Four automatic musicians sitting in a boat that floated on a lake to entertain guests at royal drinking parties: Two drummers, a harpist and a flautist.



Elektro and his dog Sparko (Westinghouse, 1939)



„Humanoid“ remotely controlled roboter (Switzerland, 1945)

First right coronary angiogram acquired by injection of a contrast agent via a right aortic root catheter by Sones (1958)