2014 ISHRAD lecture
8 March 2014: Vienna

Medical Physics: Setting the Scene for Medical Radiology

Francis Duck

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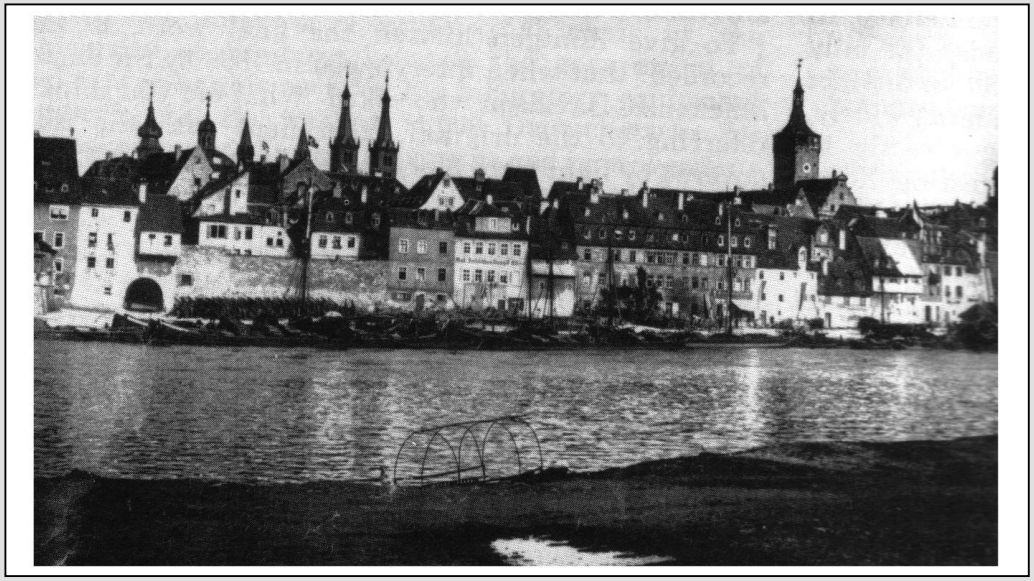
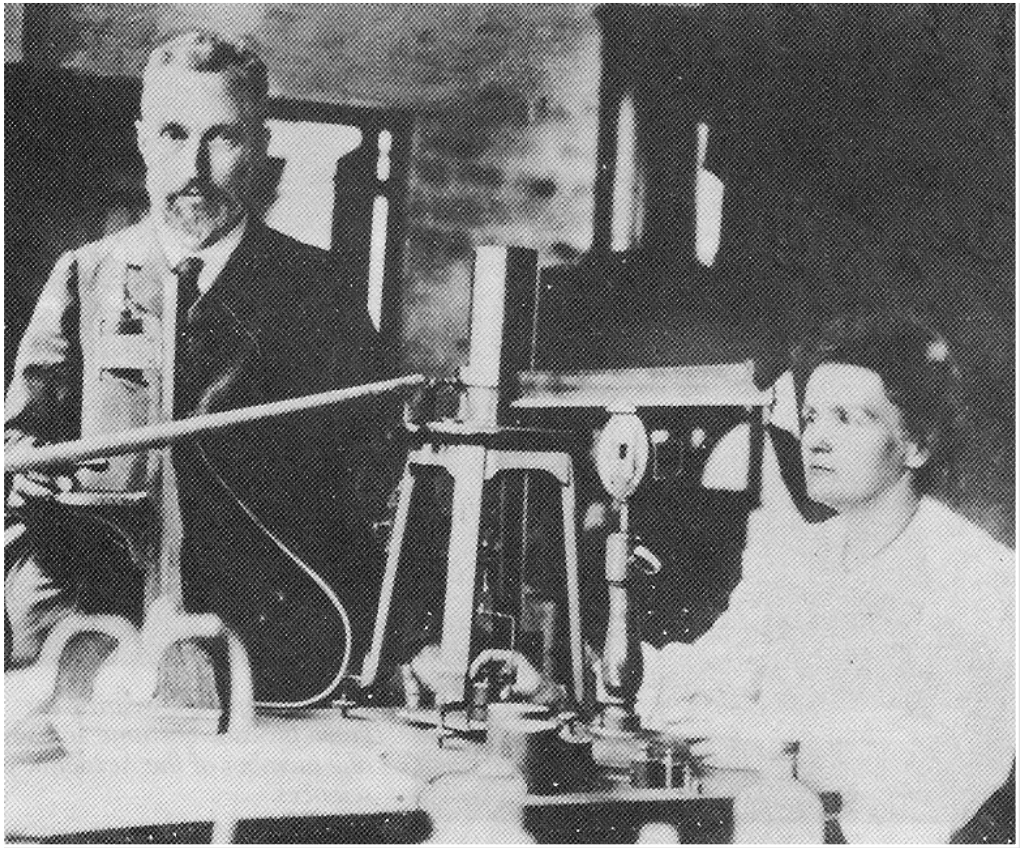
Medical physics is much older than radiology

Professors of Würzburg University

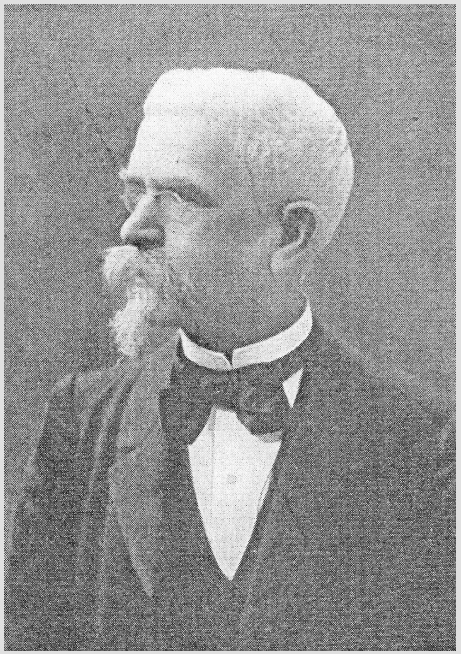


Adolf Fick 1829-1901, professor of physiology, publishes *Die medizinische Physik* in 1865

Wilhelm Röntgen, 1845-1923, professor of physics, discovers X-rays in 1895



Paris 1898



Charles-Marie Gariel (1841-1924) was the 4th professor of medical physics at the faculty of medicine in Paris, at the time of Marie and Pierre Curie's discovery of radium

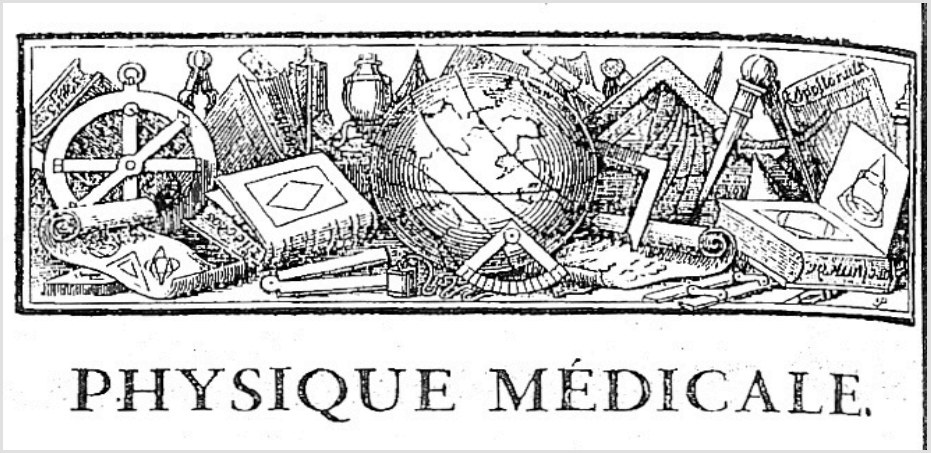
La Société royale de médecine: 1776-1793

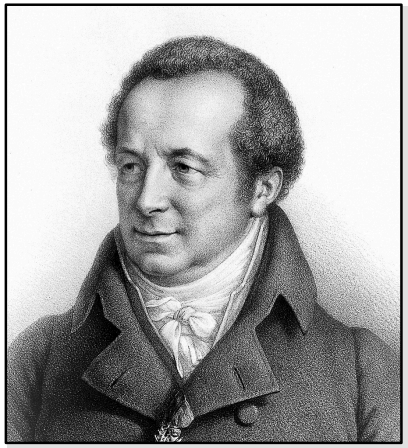
- Established by decree of the council of Louis XVI
- Félix Vicq d'Azyr was the prime mover and permanent secretary
- Composed of about 30 members with 150 international associates, including Benjamin Franklin
- The work was published in *Histoire de la société royale de médecine:* and *Mémoires de médecine et de physique médicale.*

Headings from the medical physics section of l'*Histoire de la société (royale) de médecine, before and after the French Revolution*

Vol I 1779

Vol 10 1798





Jean Noel Hallé (1754-1822)

Professor of Medical Physics and Hygiene in Paris

1795 to 1822

Hallé's definition of medical physics:

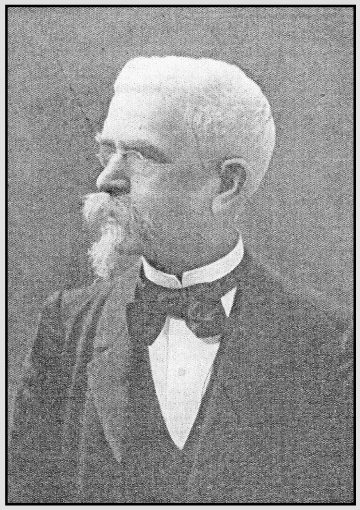
"Physique appliquée à la connaisance du corps humain, à son conservasion et à la guerison de ses maladies"

Physics applied to

- *knowledge of the human body …,*
- *to its conservation …*
- *and to the cure of its illnesses.*

Medical physics professors in the Faculty of Medicine in Paris in the 19th century

Pierre Pelletan 1823-1843



Charles-Marie Gariel 1886-1906

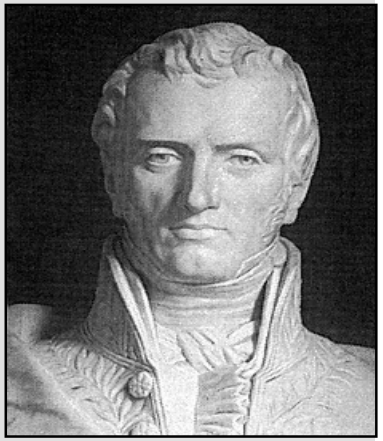
1795-1822 Jean Noël Hallé

1843-1886 Jules Gavarret

Jules Gavarret (1840)

Principes generaux de statistique medicale

Jules Gavarret



Claude-Louis Navier

- C-A Louis had studied the outcomes of blood-letting in treating typhoid.
- *"Navier's discourse made clear his grasp of the subject and the judgements one could draw from the use of the principles of probability calculation in therapeutic research"*
- Gavarret applied Poisson's probability calculations to Louis' study.
- With only 140 patients, the predicted mortality rate was between 26% to 49%, at a 99% confidence level

Charles-Alexandre Louis

Siméon Poisson

Gavarret's "Law of Large Numbers" applied to Therapeutic Research.

- The patients must be drawn from the same locality and class.
- The illness must have a precise diagnosis and perfect definition.
- The number of cases in each class must be noted.
- The therapy must be clearly formulated.
- The medical statistician must be competent.

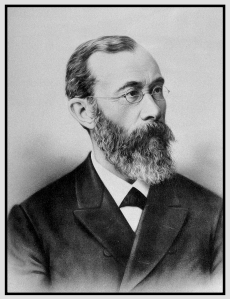
A selection of 19th century medical physics books

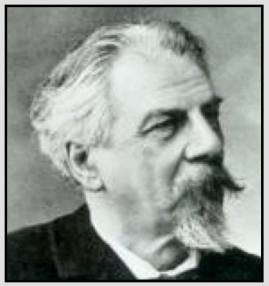
Matteucci (1844) *Lezioni sui fenomeni fisico-chimici dei corpi viventi*.

Fick (1856) *Die medizinische Physik.*

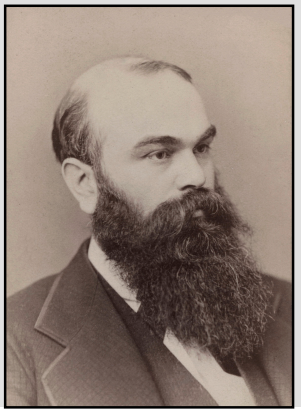
Gavarret (1869) *Physique biologique. Les Phenomenes physiques de la vie*.

Wundt and Monoyer (1871) *Traité élémentaire de physique médicale*.



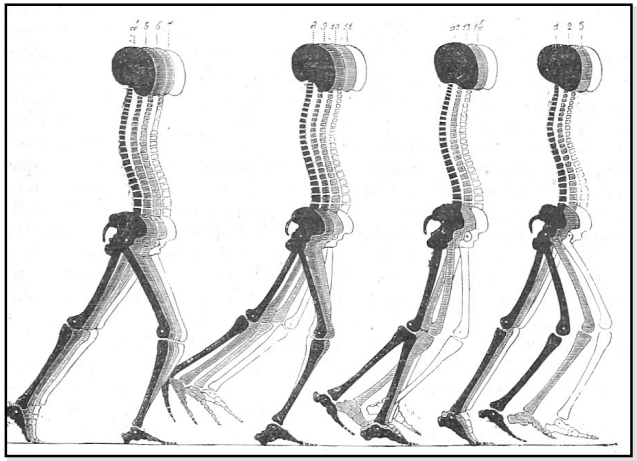


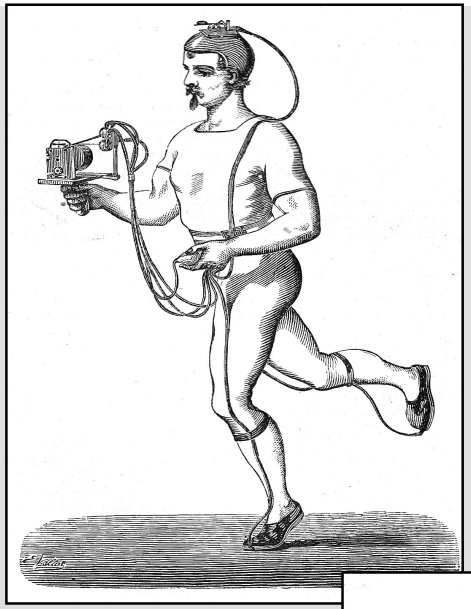
Draper (1885) *A Text-Book of Medical Physics for the use of Students and Practitioners of Medicine.*

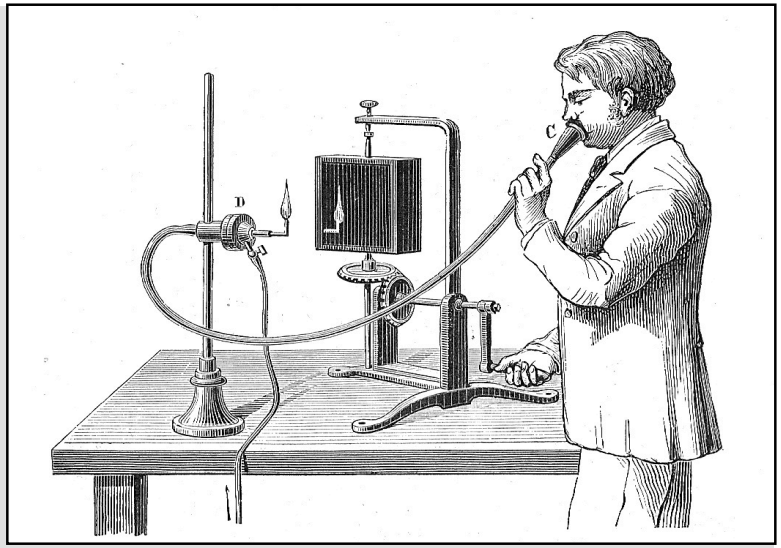


Physics and Physiology

- fluid mechanics and the circulation
- pneumatics and respiration
- optics and vision
- acoustics and speech and hearing
- heat and body temperature
- dynamics and animal mechanics
- electricity and bio-electrics
- energy and metabolism







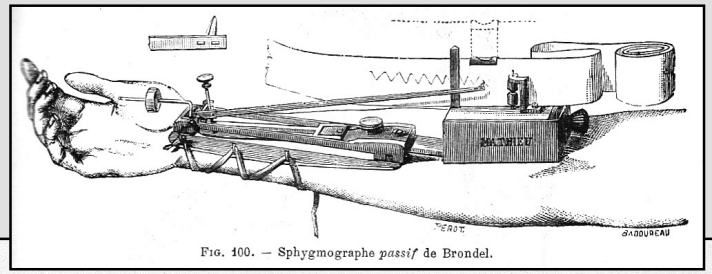
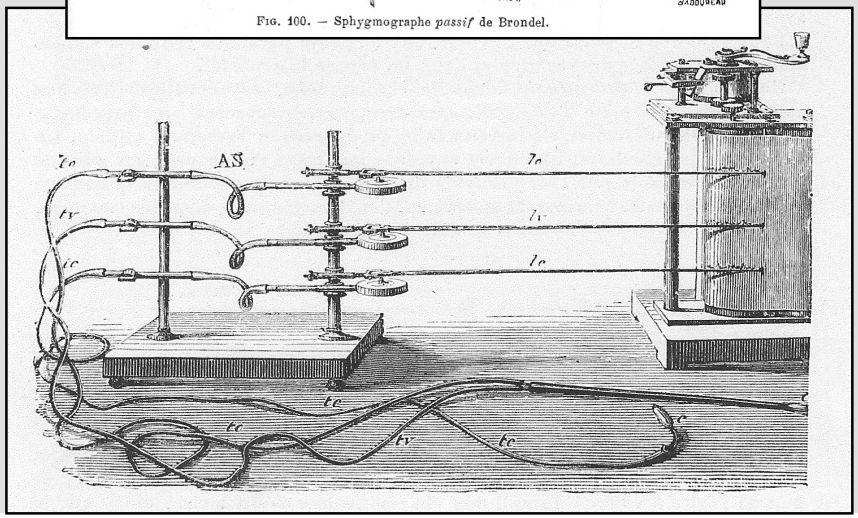


Fig. 100. — Sphygmographe *passif* de Brondel.



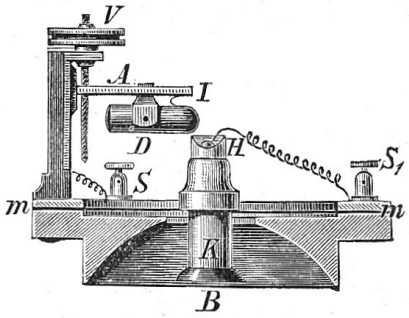


Fig. 849.—The Miophone.

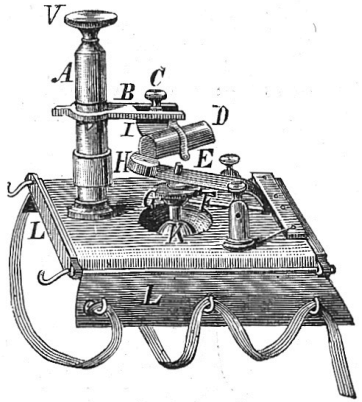


Fig. 850. —Sphygmophone.

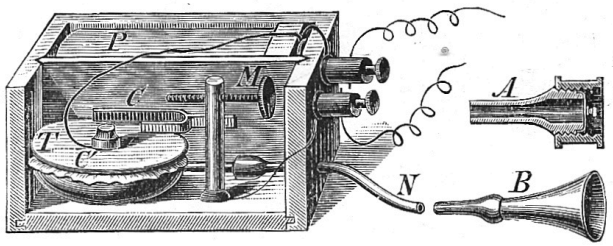
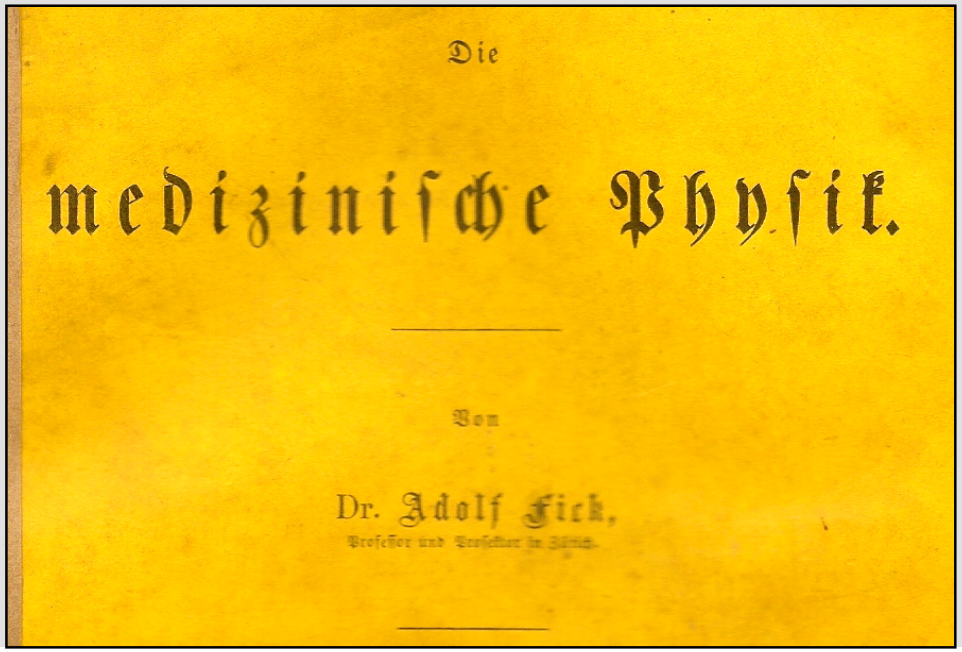
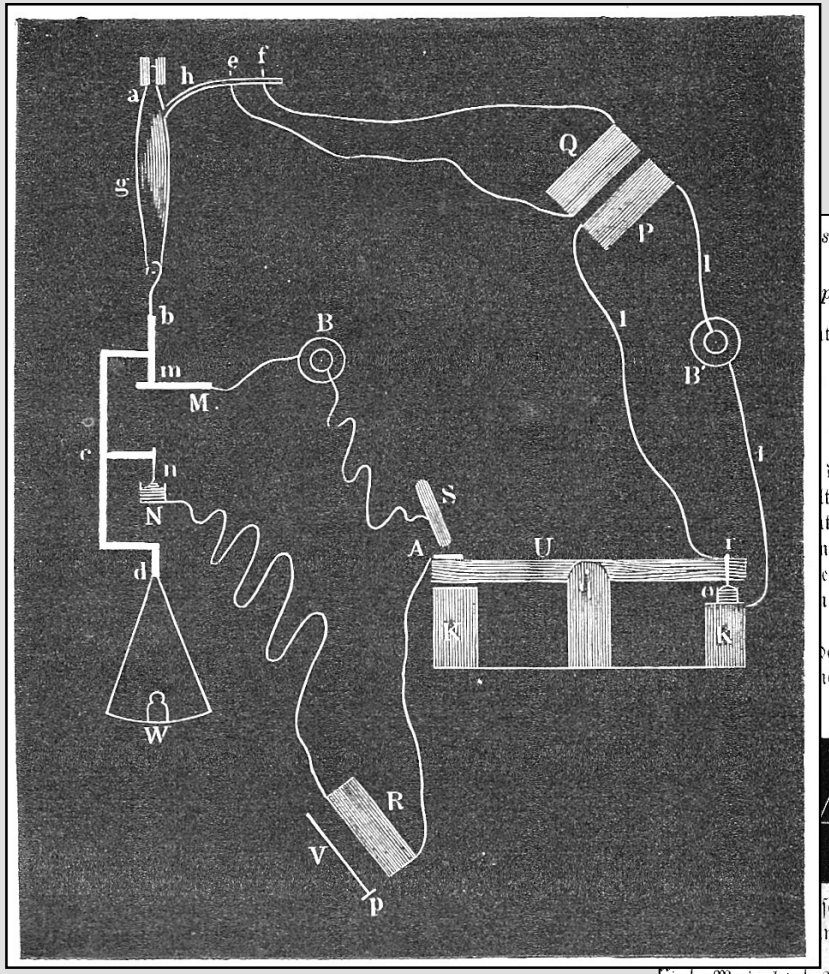


Fig. 851.—A Medical Microphone.

Adolf Fick (1829-1901)
Mathematician and Physiologist

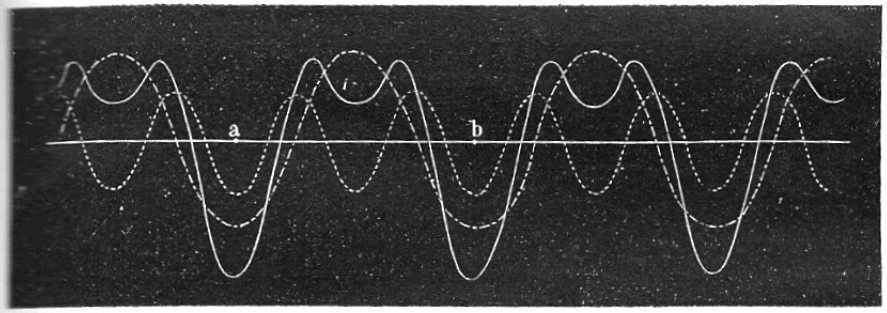


Figures from Fick's *Die medizinische Physik*



der Curve, Fig. 57, variiren, und ist der Abstand von a nach b (die Dauer

Fig. 57.



der Periode) $= \frac{2\pi}{n}$, so hört man gleichzeitig den Ton n und seine Octave

oder $2n$; die Gleichung der Curve ist aber $v = a_1 \cos nt + a_2 \cos 2nt$;

τ_1 und τ_2 sind hier beide Null. Jede Ordinate der Curve kann angesehen

$\sin. kt + \mathfrak{N} \cos. kt$

$p \cos. kt\, dt - \cos. kt \int p \sin. kt\, dt\Big]$;

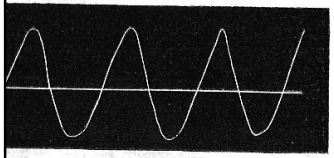
ten der Integration bedeuten und der Kürze wegen

$+ \mathfrak{M} \sin. kt + \mathfrak{N} \cos. kt$ stellen diejenigen

durch die Trägheit der Flüssigkeit vorhanden sind;
tene Ausdruck bestimmt die Modificationen, welche
ttfindenden Schwingungen vermöge der Einwirkung
ung entstehen.
e das Gesetz der Pulsbewegung nur dann richtig
und dasselbe Gesetz befolgten, was aber nicht der

das wahre Gesetz des Pulsganges wäre $p = \mathfrak{J} \sin. mt$
ntare Schwingung, die durch Fig. 179 dargestellt

Fig. 179.

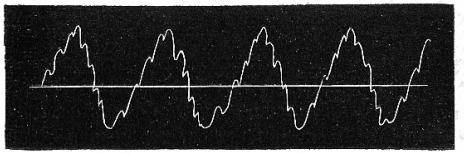


setzung findet man aus (2) für das Gesetz, nach
ngt, folgenden Ausdruck:

$+ \mathfrak{M} \sin. kt + \mathfrak{N} \cos. kt + \frac{g}{\gamma lk} \cdot \frac{k}{m^2 - k} (\mathfrak{J} \sin. mt + \mathfrak{K} \cos. mt).$

Schwingung, die durch die Trägheit der Masse entsteht, übereinstimm

Fig. 180.



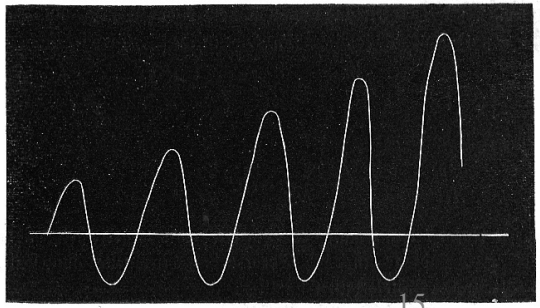
also der Pulsgang durch $p = \mathfrak{J} \sin. kt + \mathfrak{K} \cos. kt$ ausgedrückt
findet man:

$$x = \frac{\gamma l - \mathfrak{A}}{2\gamma} + \mathfrak{M} \sin. kt + \mathfrak{N} \cos. kt$$

$$+ \frac{g}{\gamma lk} \left[\frac{1}{4} k (\mathfrak{J} \sin. kt + \mathfrak{K} \cos. kt) + \frac{t}{2} (\mathfrak{K} \sin. kt + \mathfrak{J} \cos.\right.$$

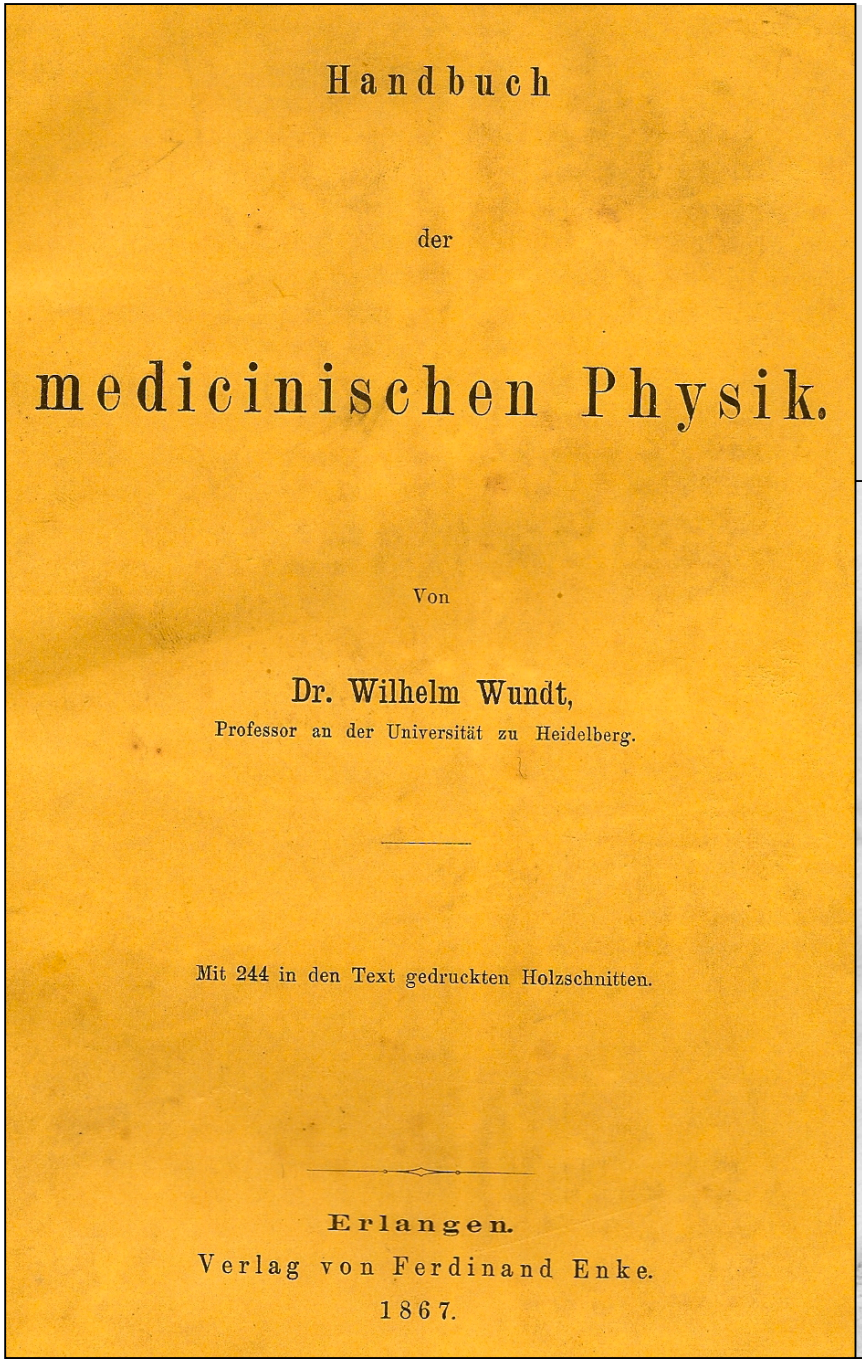
die graphische Darstellung dieser Schwingung zeigt Fig. 181.

Fig. 181.



Dies letzte Beispiel zeigt nun schon aufs Schlagendste, daß für d
trachtungen die Vernachlässigung der Widerstände, die sich Redter

Wilhelm Wundt (1832-1920). Experimental physiologist and psychologist



Handbuch

der

medicinischen Physik.

Von

Dr. Wilhelm Wundt,

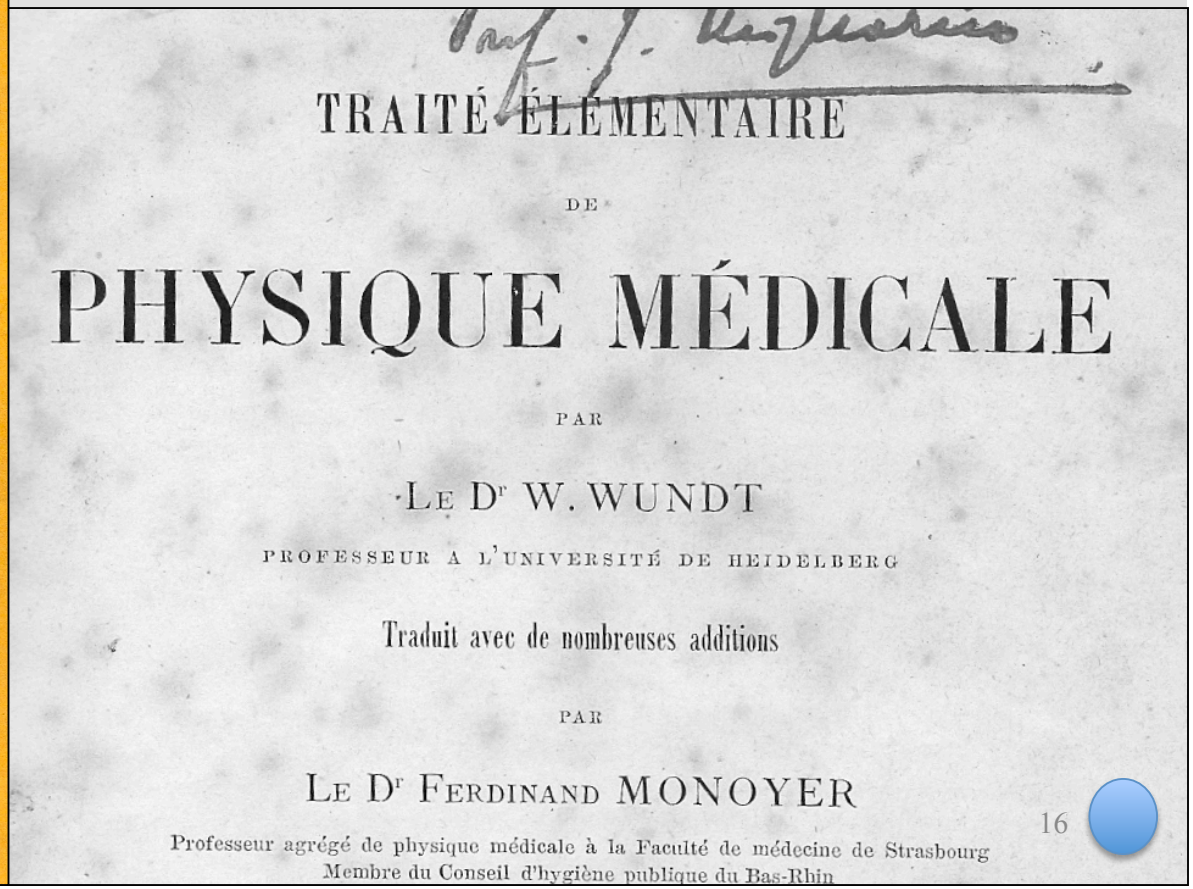
Professor an der Universität zu Heidelberg.

Mit 244 in den Text gedruckten Holzschnitten.

Erlangen.

Verlag von Ferdinand Enke.

1867.



TRAITÉ ÉLÉMENTAIRE

DE

PHYSIQUE MÉDICALE

PAR

LE Dr W. WUNDT

PROFESSEUR A L'UNIVERSITÉ DE HEIDELBERG

Traduit avec de nombreuses additions

PAR

LE Dr FERDINAND MONOYER

Professeur agrégé de physique médicale à la Faculté de médecine de Strasbourg

Membre du Conseil d'hygiène publique du Bas-Rhin

The moment I finished this work, begun in the calm of peacetime, the cannon's voice was heard. Shells whistled through the air and shot their murderous splinters onto my desk (24 August 1870).

Events have moved on, deeply painful events whose fatal outcome has deeply affected our hearts. We hope for calmer times, more favourable to the development of scientific study than the terrible days and nights that have passed. This translation has been made and will be published in France. It will remain as a memory that binds the capital of Alsace to our well-beloved homeland.

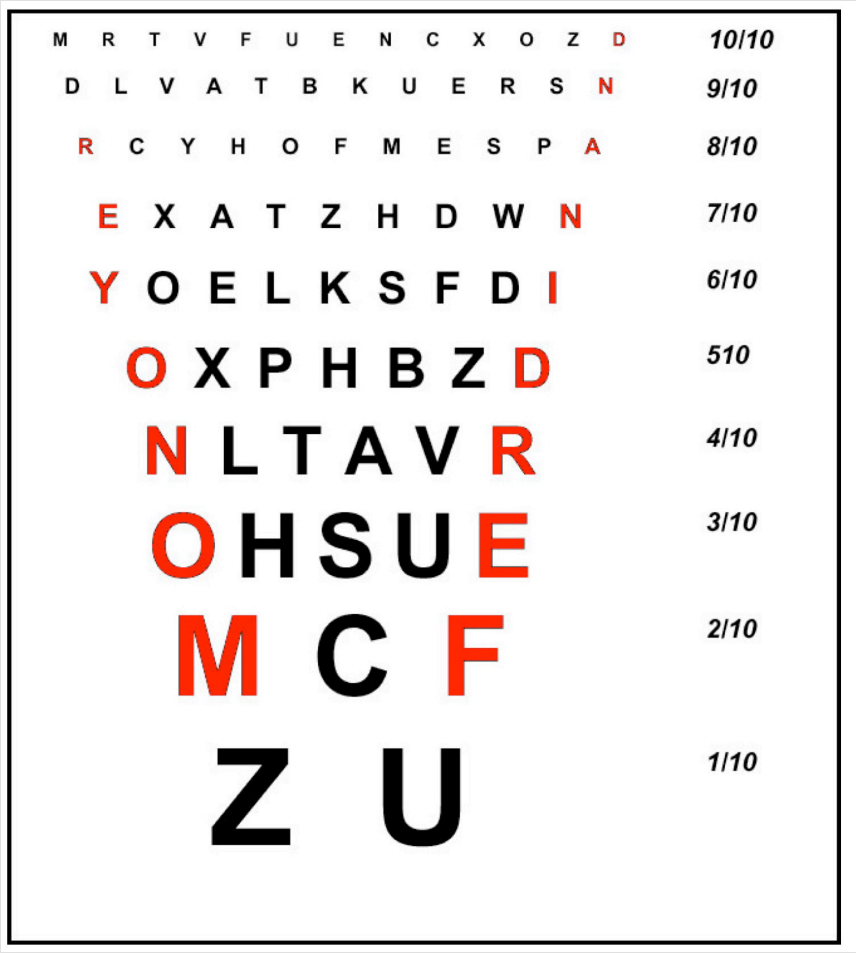
Que Dieu protége la France!

Strasbourg, 28 février 1871

From Monoyer's preface to his 1st French translation of Wundt's Der medicinishen Physik. *Traité élementaire de physique médicale. 1871. Paris Balliére.* p VIII

Ferdinand Monoyer (1836-1912)
Faculty of Medicine: Strasbourg, Nancy and Lyon

L'échelle Monoyer,
showing the embedded letters of his name



What was going on in Britain?

Advertisement for a medical physics course in Edinburgh in 1836

NATURAL PHILOSOPHY,
AND
MEDICAL PHYSICS,
Qualifying for Surgeons' Hall, &c.

MR LEES having found more spacious and convenient accommodation in the Premises of ARGYLE SQUARE MEDICAL SCHOOL, will conduct his CLASSES there during the ensuing Winter Session, commencing on Thursday the 10th of November at Twelve o'clock.

The LECTURES on NATURAL PHILOSOPHY and MEDICAL PHYSICS, embracing the construction of SURGICAL, PHILOSOPHICAL and MECHANICAL INSTRUMENTS, will be delivered every day at Twelve.

PRACTICAL MECHANICS

The Rooms for PRACTICAL MECHANICS, which are furnished with all the requisite INSTRUMENTS, will be open from One to Three. In this Class, the Students practise under Mr LEES' immediate personal direction .....

Fee, for each Course separately, L.3 5s. For both Courses taken together, L.5 5s.

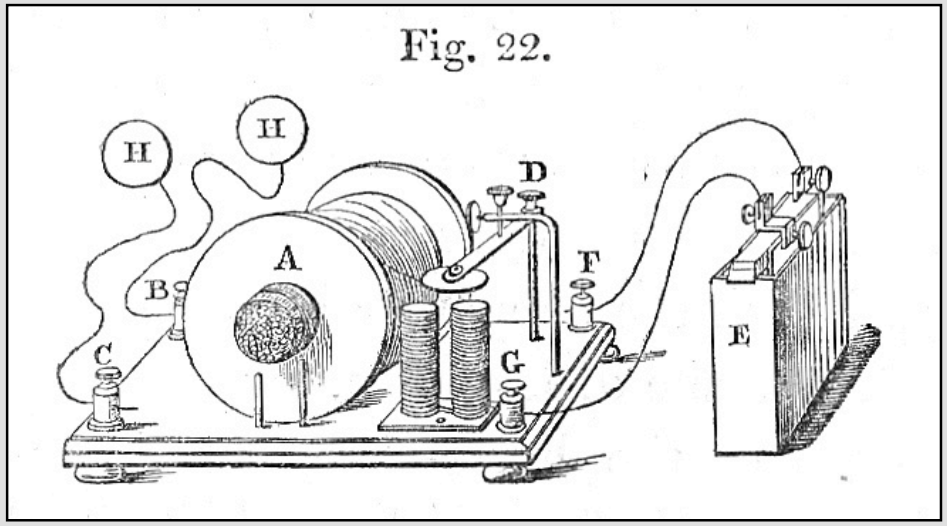
8. REGENT TERRACE,
October 1836

Golding Bird (1814-1854)
Guy's Hospital, London

Started electro-therapy at Guy's Hospital in 1836

Established England's first electrical therapy department in 1840.

- *Elements of Natural Philosophy*, 1839
- *Lectures on Electricity and Galvanism in their Physiological and Therapeutical Relations*, 1849



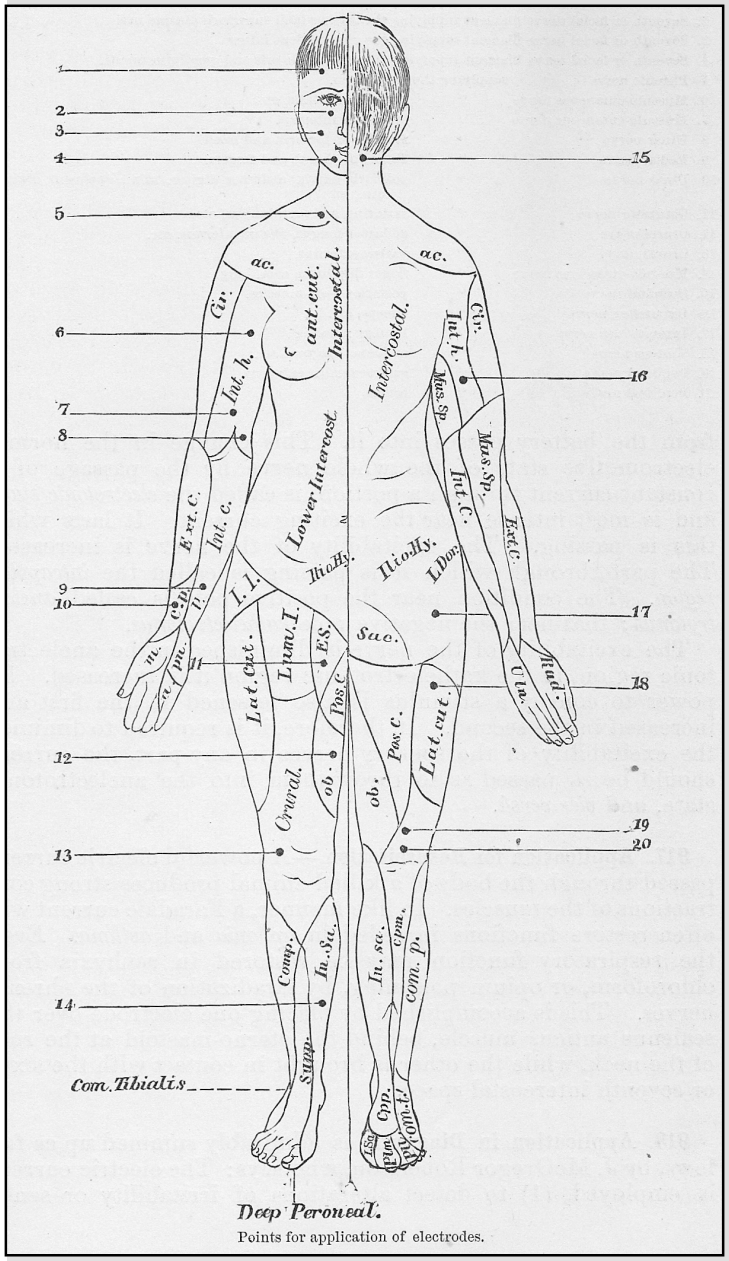
Physics lecturers in British medical schools in the late 1800s

Liverpool	O Lodge
Manchester	A Schuster
Glasgow	W Thomson (Lord Kelvin)
Aberdeen	J Clerk Maxwell
Dublin	G FitzGerald
Galway	J Larmor
Edinburgh	PG Tait
Cambridge	JJ Thomson

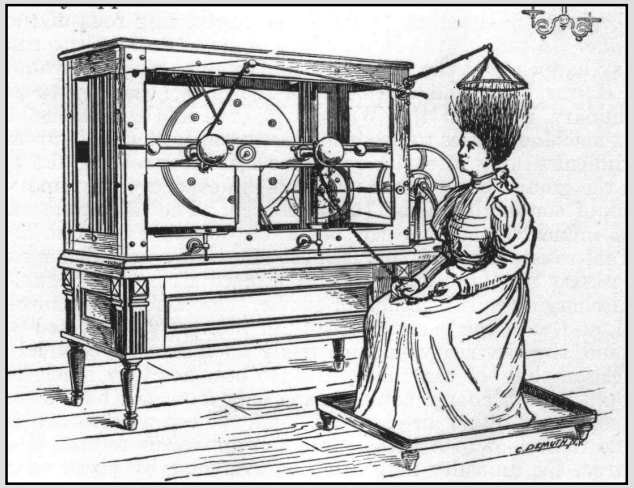
"Pure physicists know nothing and probably care little for the problems which interest us as medical men". William Stone, 1887.

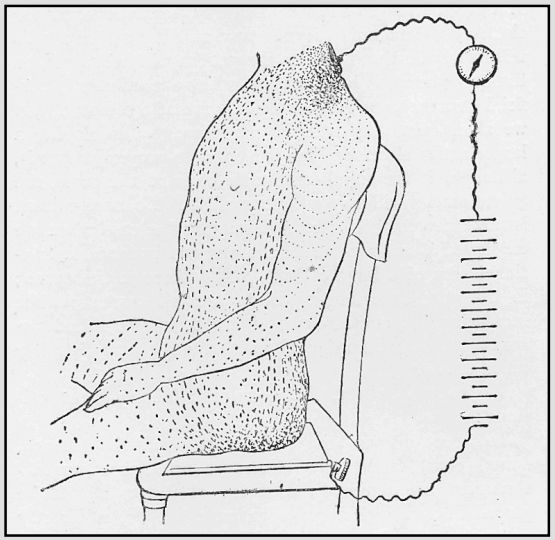
Setting the Scene for Medical Radiology

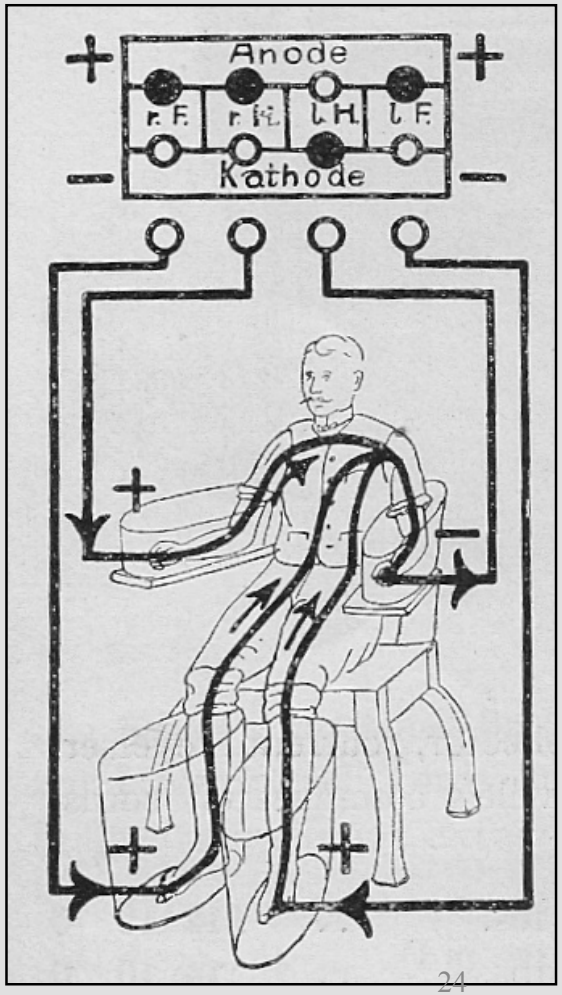
Medical Electricity



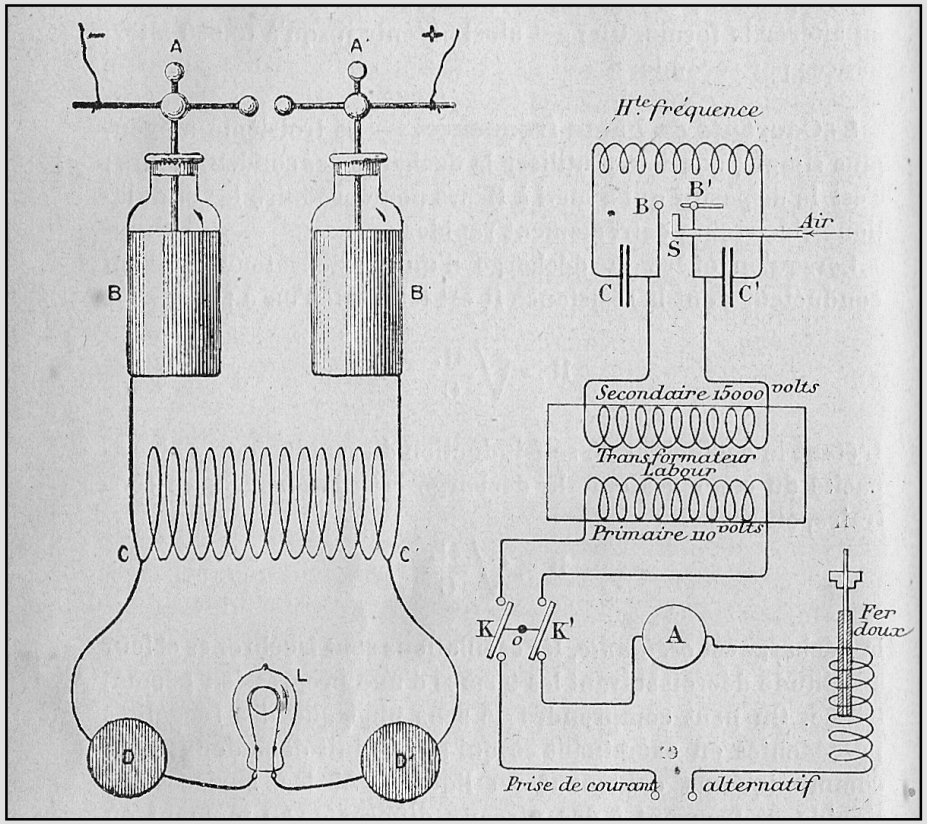
Points for application of electrodes.

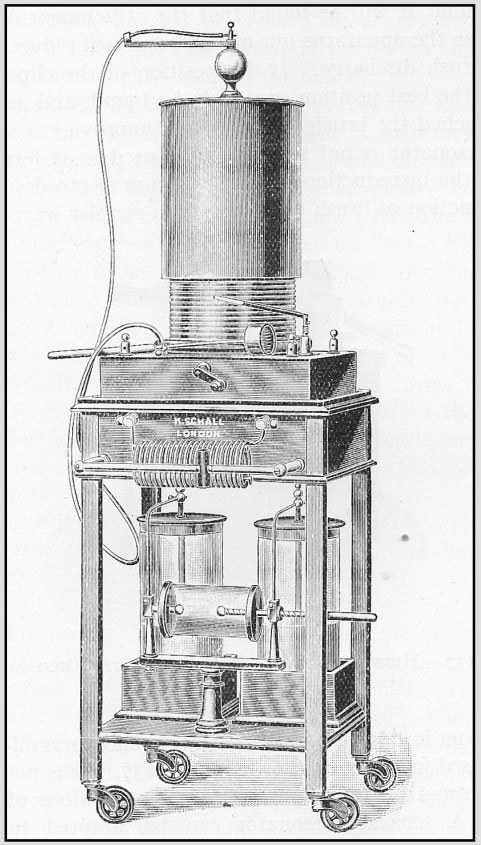


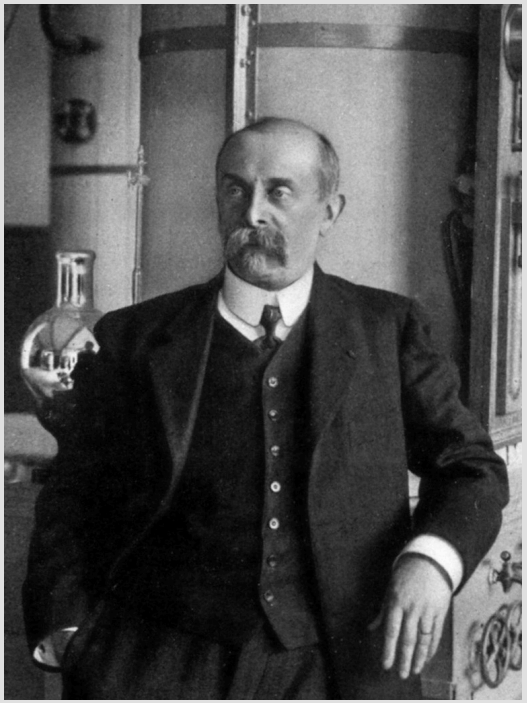




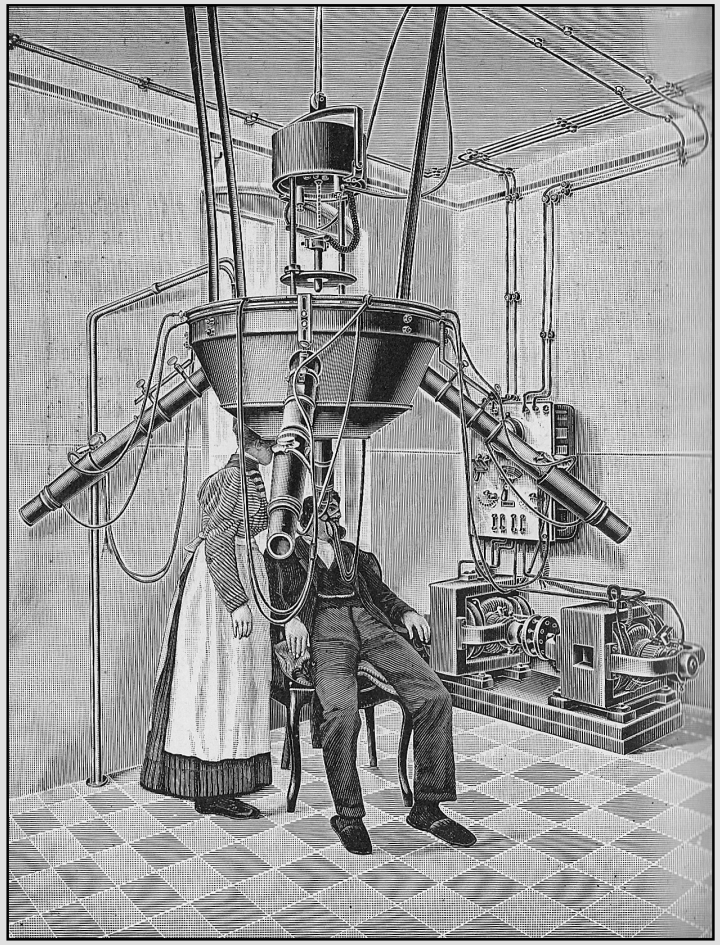
1895
Arsène d'Arsonval introduces radio-frequency electrotherapy







1895
Niels Finsen introduces ultraviolet radiation for the treatment of lupus



Seeing within the body

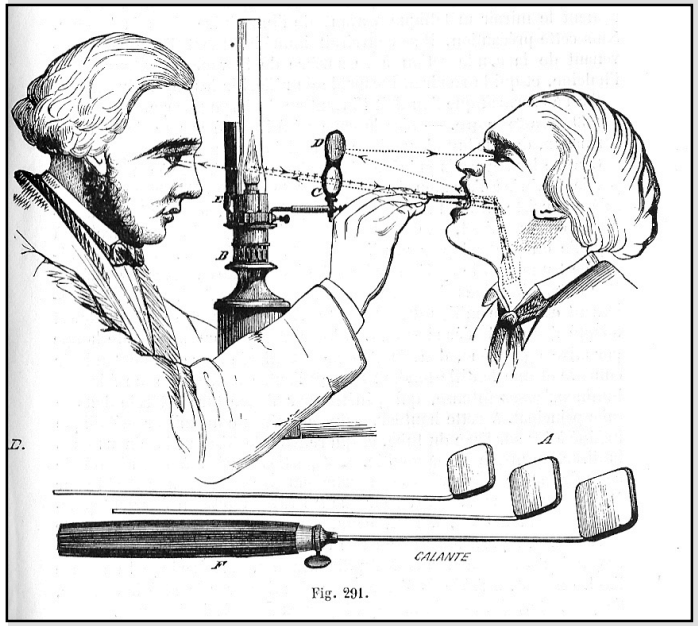
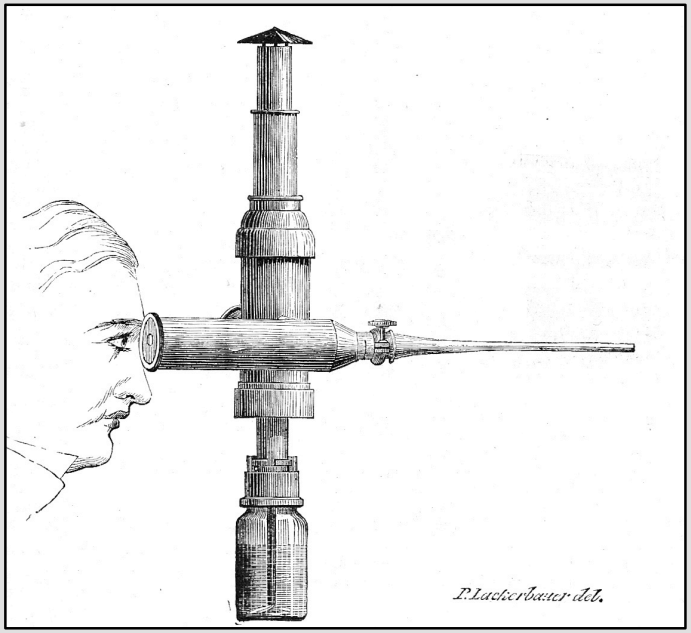


Fig. 291.



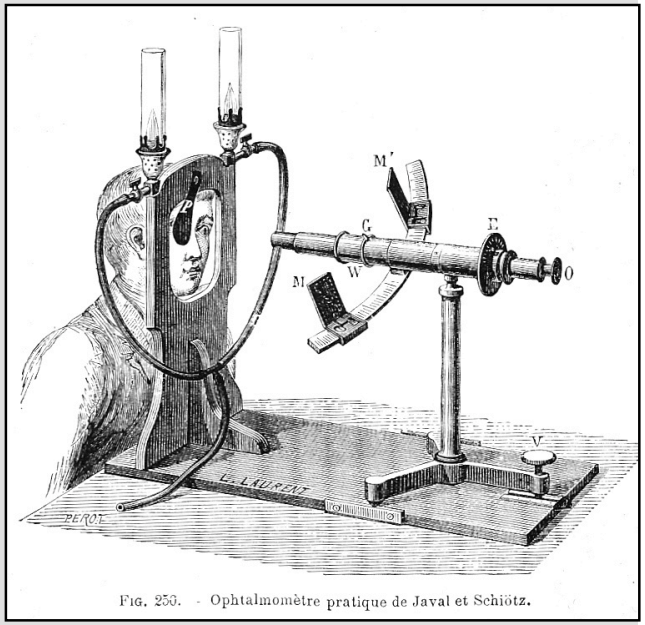
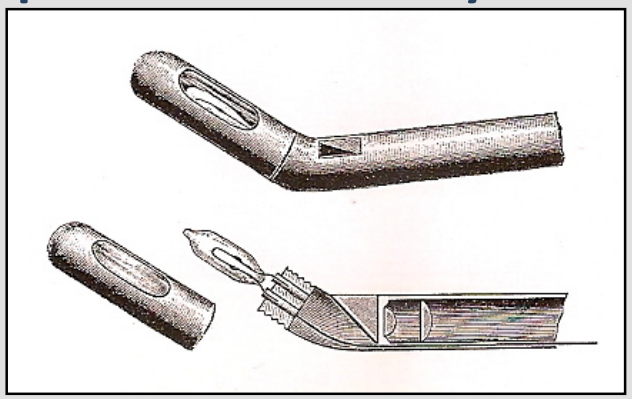
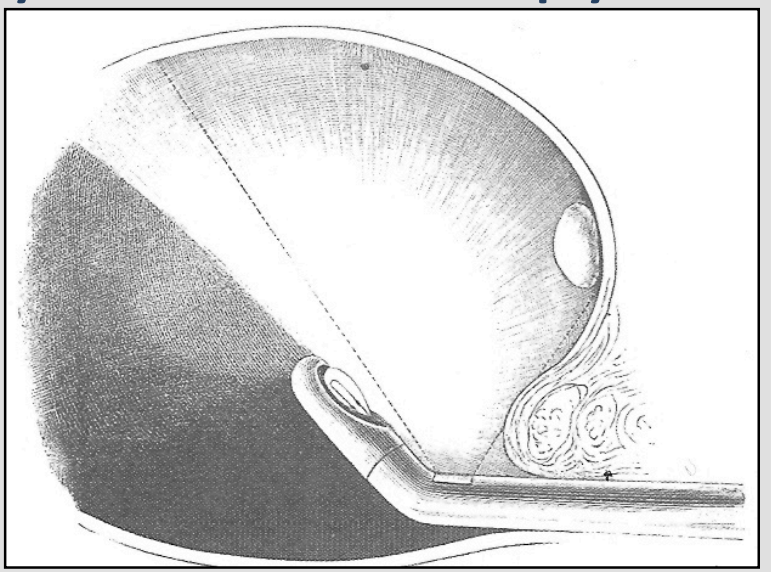
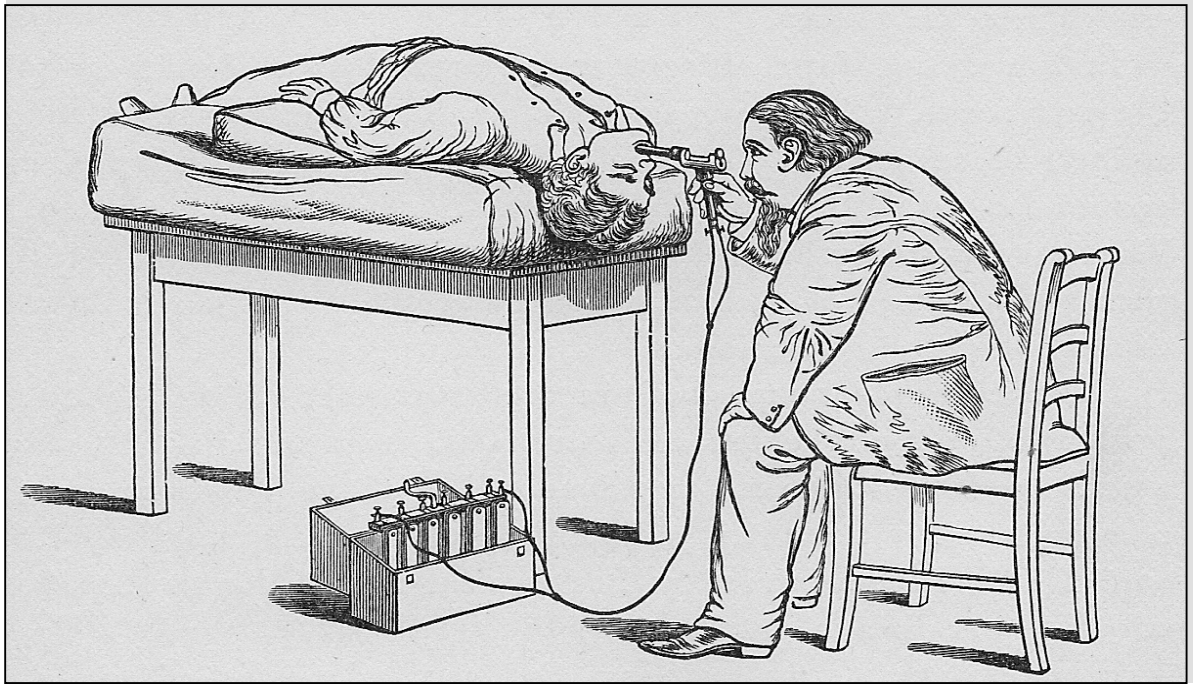


Fig. 250. - Ophtalmomètre pratique de Javal et Schiötz.

1879 Edison's carbon filament incandescent lamp opens the way for cystoscopy and endoscopy







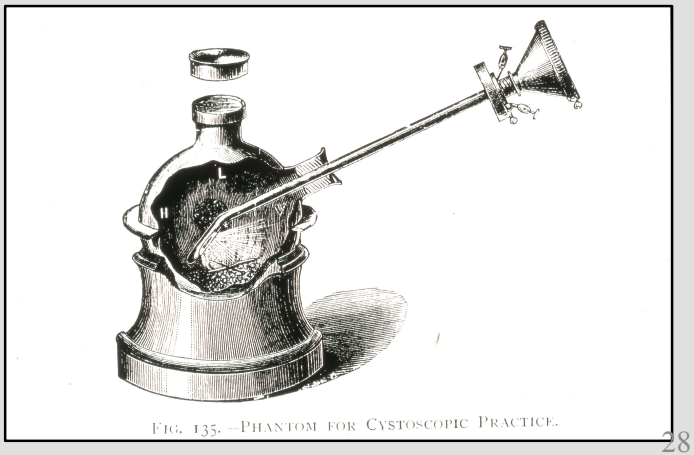
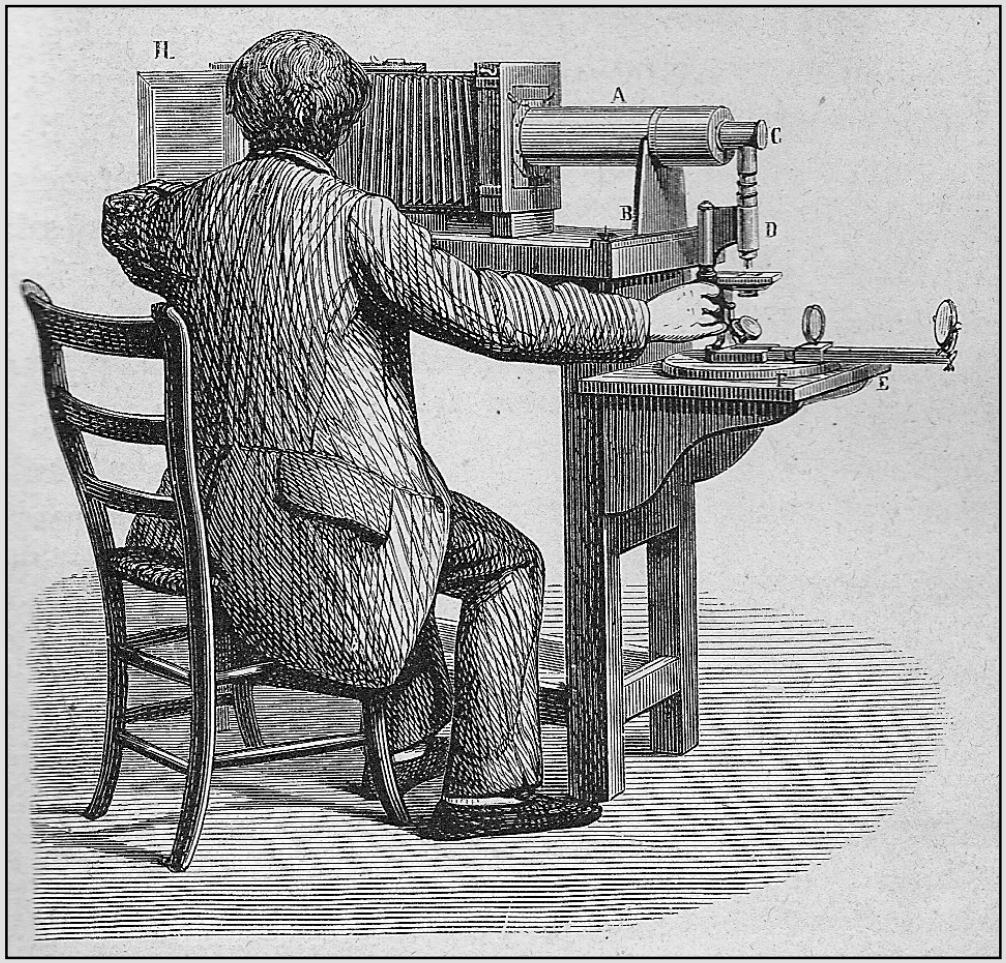
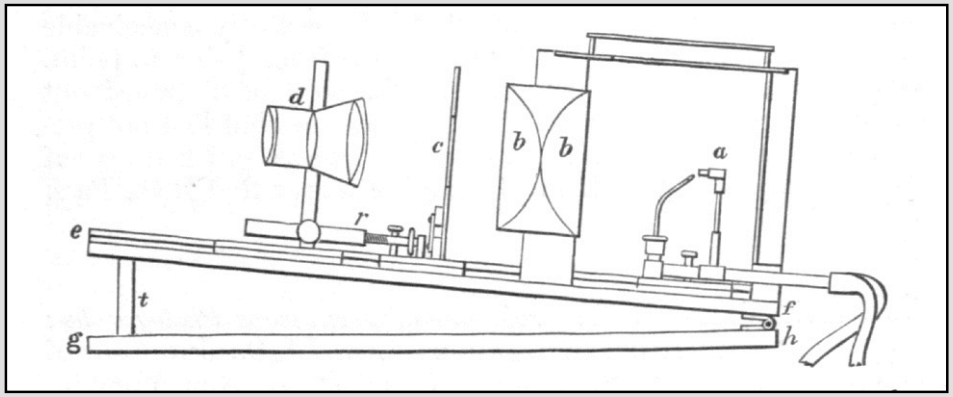


FIG. 135.—PHANTOM FOR CYSTOSCOPIC PRACTICE.

Image recording and projection



Nachet's photographic microscope



Draper's projector

Projection microscope

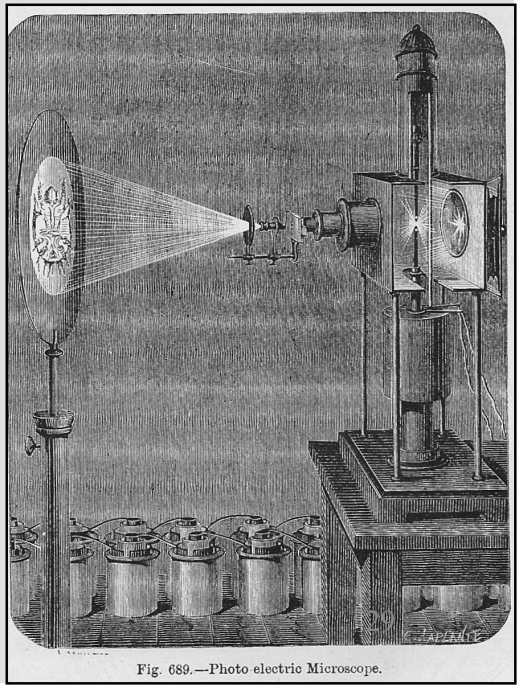
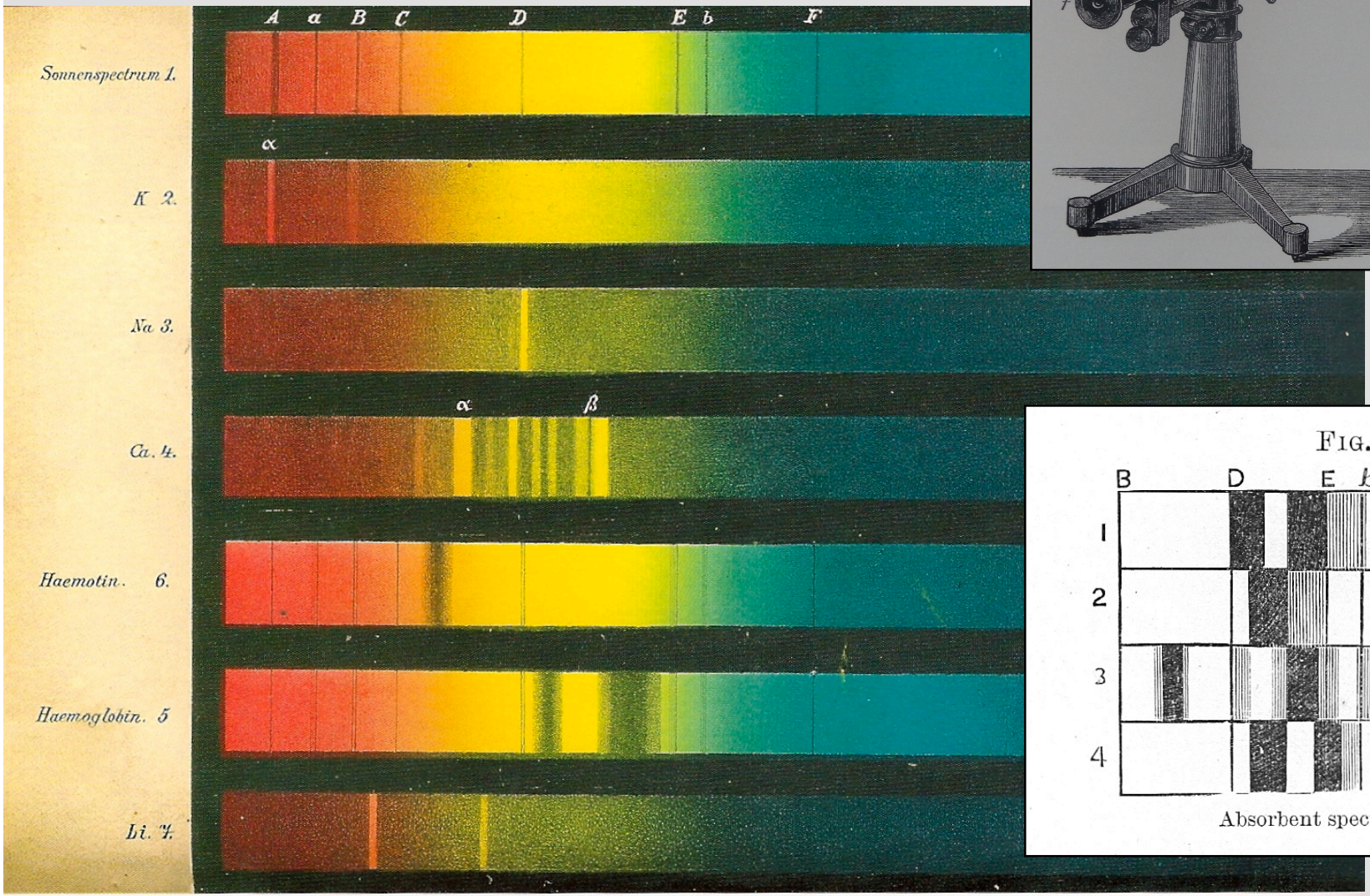
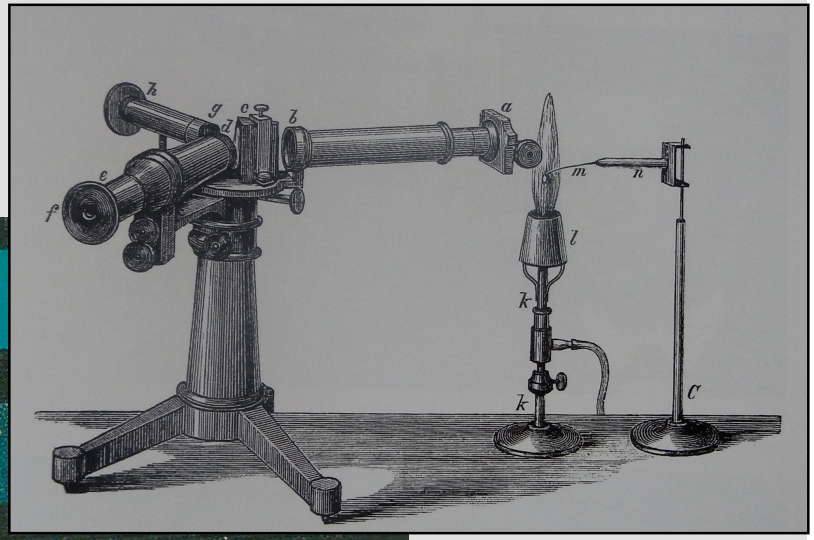


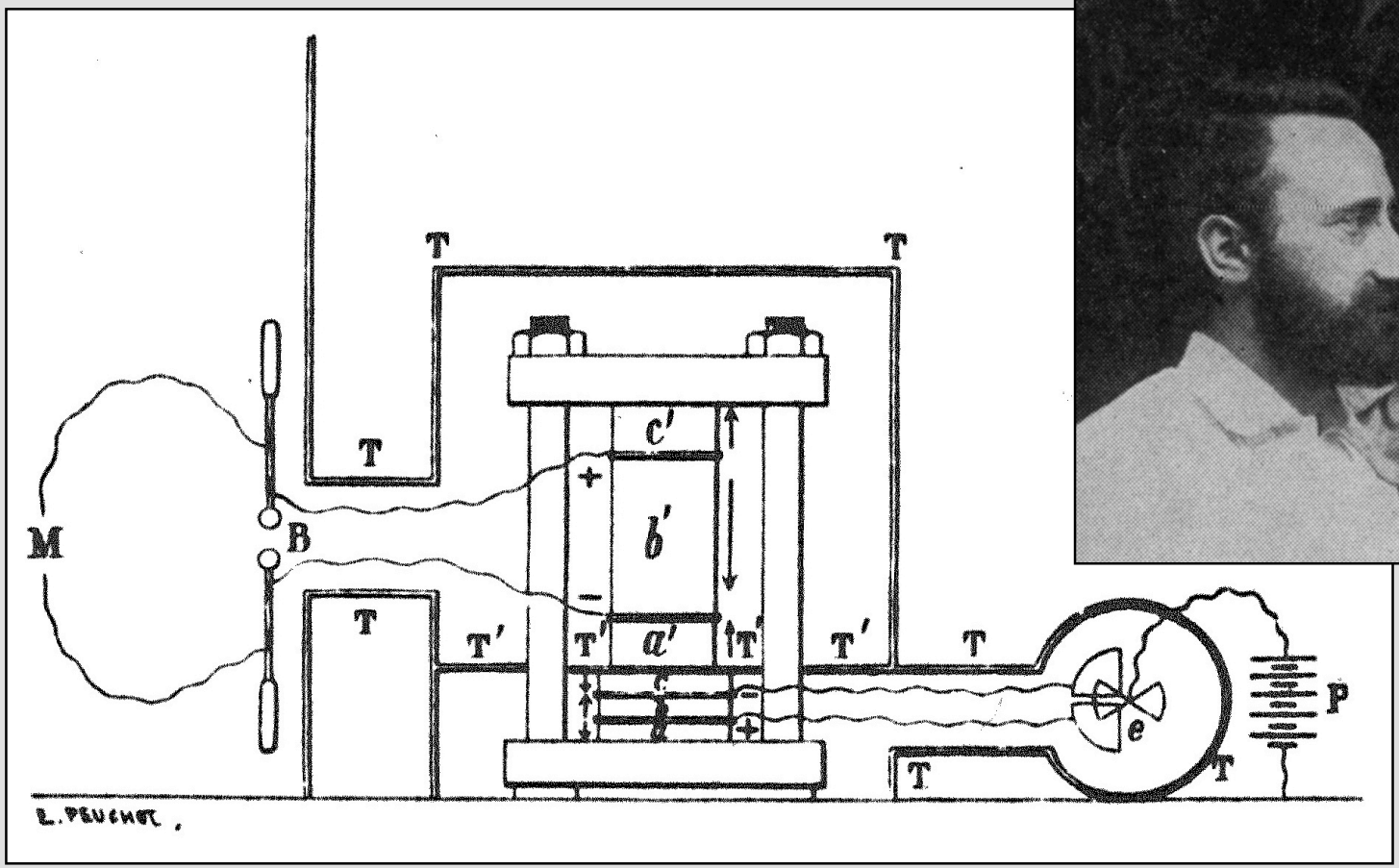
Fig. 689.—Photo-electric Microscope.

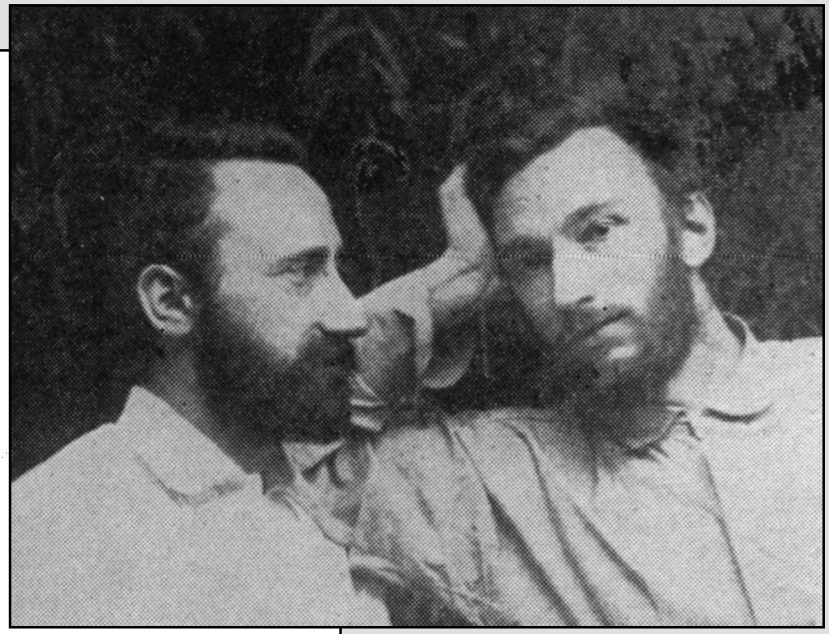
Spectroscopy



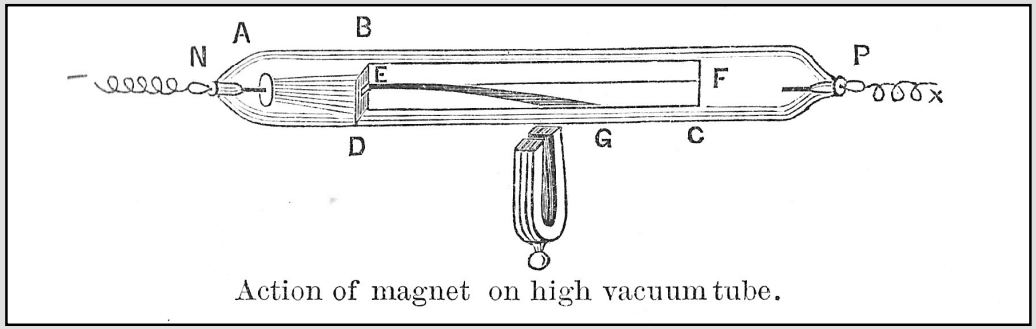


1880-81
Jacques and Pierre Curie discover piezoelectricity in several crystals, including quartz.





Vacuum Tubes and Radiant Matter



Action of magnet on high vacuum tube.

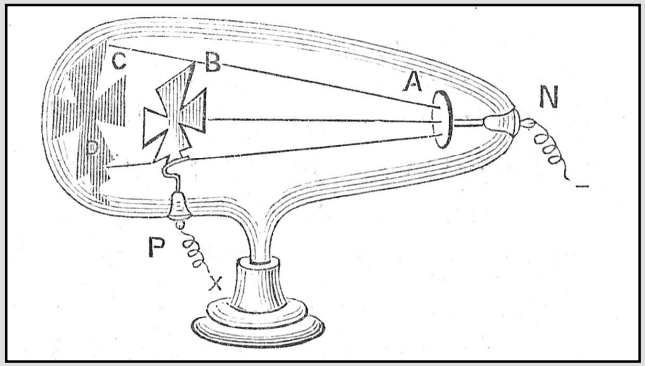
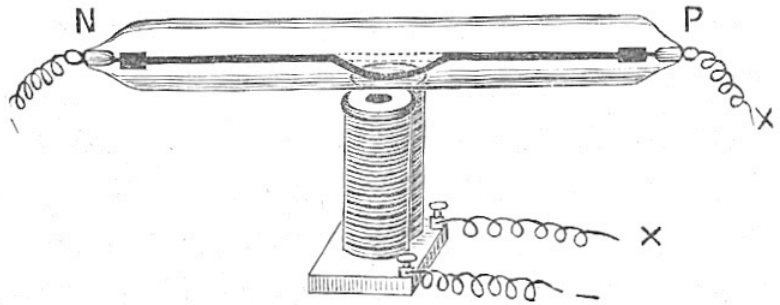
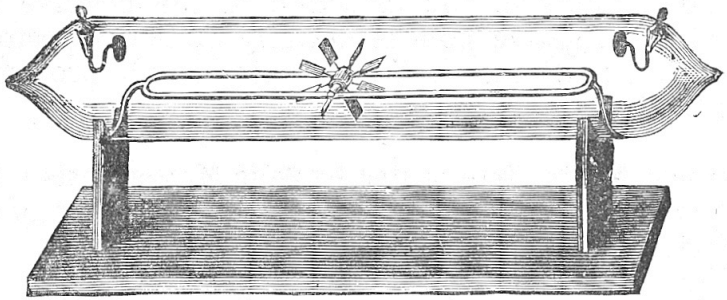


FIG. 99.



Action of magnet on low vacuum tube.

FIG. 98.


Railway tube.

Included in Draper's lectures to medical students in New York

John C Draper (1885) *A Textbook of Medical Physics*

Medical Physics before Radiology

- Medical physics was defined and introduced into medical training in revolutionary France by Jean Hallé
- Faraday's discoveries gave renewed impetus to medical electricity in the 1830's
- Physics was applied to all aspects of physiology, especially in the German universities
- Advances in optics gave rise to further developments in microscopy, spectroscopy, endoscopy, image recording and projection
- High frequency electrotherapy and UV phototherapy were both introduced in 1895, the year of Röntgen's discovery of X-rays

If you want to read more….

- Duck FA. *Physicists and Physicians: A History of Medical Physics from the Renaissance to Röntgen*. IPEM. 2013. 310pp.
- www.ipem.ac.uk/Publications/SCOPE/ESCOPE.aspx
- Duck FA. The Origins of Medical Physics. *Physica Medica*. 2014;30:397-402.