MEDICAL PHYSICS
For the Use of Students and Practitioners of Medicine
(Textbook Published in 1885)
John C. Draper, M.D., L.L.D.
Author
Selection of Illustrations and Discussion
Provided By
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Introduction

Medical Physics, especially as we know it today, is heavily based on ionizing radiation, both x-radiation and from radioactive materials that are used for both diagnostic and therapeutic clinical procedures. This began with Roentgen's discovery and extensive research on the properties of x-ray/Roentgen radiation in 1885 quickly followed by the discovery of radioactivity and the development of medical applications.

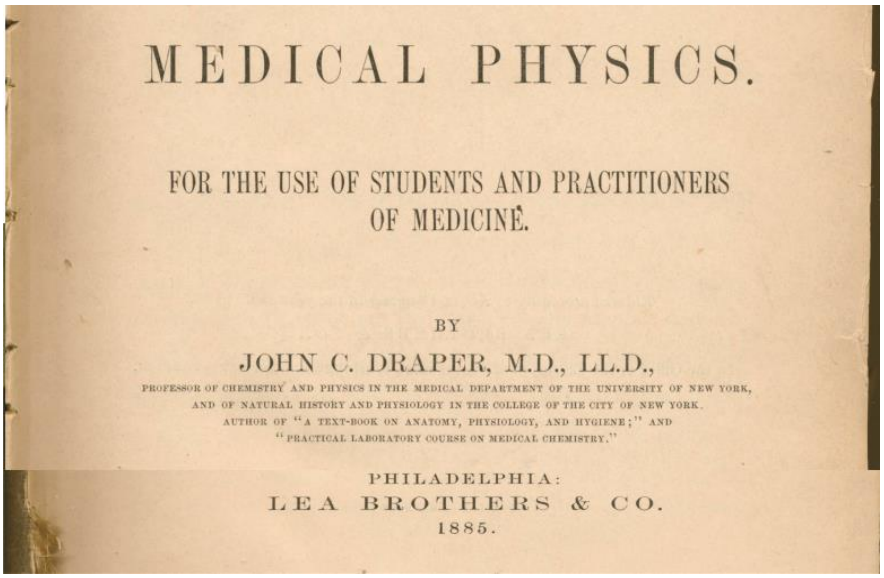
Before that time (1885) *medical physics* was a significant science that applied a wide range of physics phenomena to a better understanding of the living human body, conditions that affect health within a community, and to a variety of medical procedures. This early (before ionizing radiation) field of medical physics is extensively described in the book, Medical Physics by Dr. John Draper published in 1885.

This book of 733 pages provides a comprehensive coverage of virtually all fields of physics known at that time and describes applications related to health and medicine. A major feature is its 377 high-quality illustrations. These enhance conceptual learning and understanding that support/ the application of physics to a wide range of medical and heath related activities. It provides a visual representation of the physical universe rather than a symbolic representation with mathematical symbols and equations. This is the type of knowledge that contributes to the practice of medicine.

Although the title of the book is *Medical Physics*, it provides a comprehensive coverage of all areas of physics supporting the belief that medical practitioners should have a broad knowledge of the physical sciences.

A feature of the book that is of historical significance is that that many of the experiments and apparatus described along with developments and discoveries are identified with the names of the physicists who were the creators.

The images from the book selected for this article are for a few topics to illustrate the state of knowledge at that time and what was being taught. The Figure reference numbers are as they are in the book and not altered for this publication.


MEDICAL PHYSICS.

FOR THE USE OF STUDENTS AND PRACTITIONERS OF MEDICINE.

BY

JOHN C. DRAPER, M.D., LL.D.,

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PHILADELPHIA:
LEA BROTHERS & CO.
1885.

Ultimate Composition of Matter

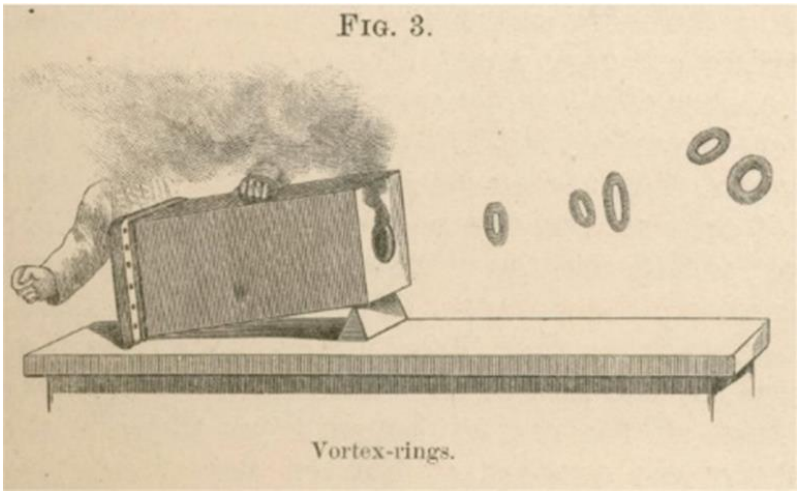
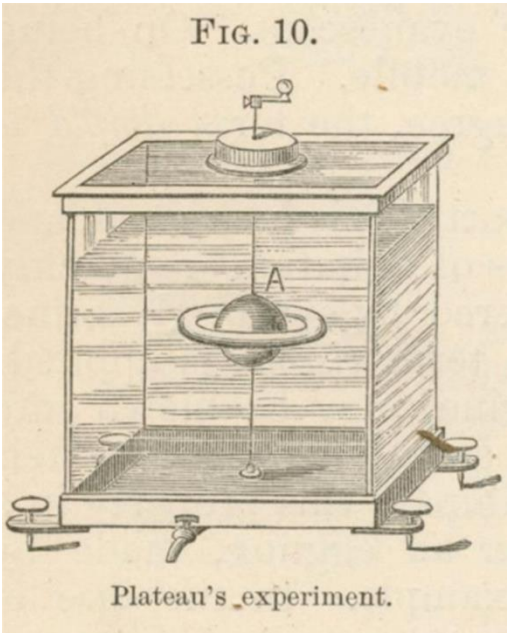


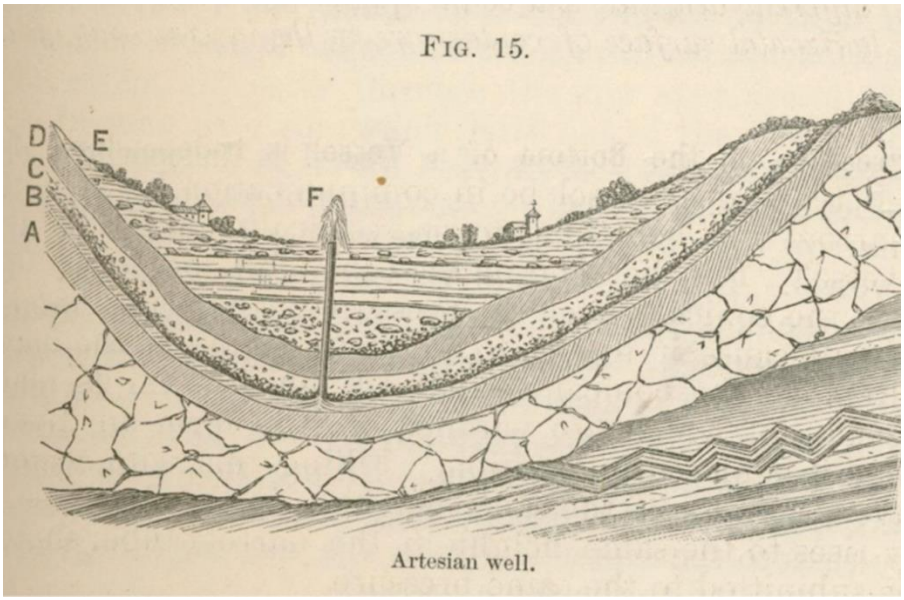
Fig. 3 illustrates a device used to show the formation of a simple circular vortex-ring demonstrating some of its important properties. To set up for a demonstration, ammonia, salt, and sulfuric acid is placed in the box and the combination forms solid sal ammoniac particles that are like smoke. They are visible and suspended in air by fluid-friction. This was used to demonstrate that a vortex had the characteristics and behaved as individual particles. This was especially obvious when two vortexes collided.

Properties of Liquids



The experiment shown in Fig. 10 uses a quantity of olive oil suspended in a mixture of water and alcohol that had the same density as the oil. This eliminated any influence of gravity. The oil assumes a spherical shape as show. When it is spun by hand with the handle a satellite ring is formed. This is similar in form to the satellite ring around Saturn.

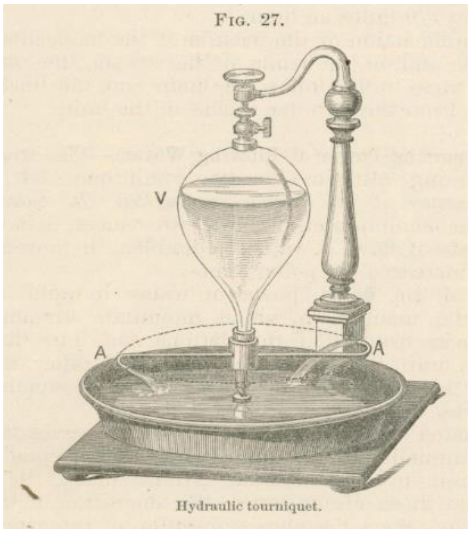
Hydrostatics



The sources of water for so-called Artesian wells are often distances away and always at higher elevations as illustrated in Fig. 15. The community health issue is the water is coming and filtered through channels and generally not contaminated as water from shallow wells might be.

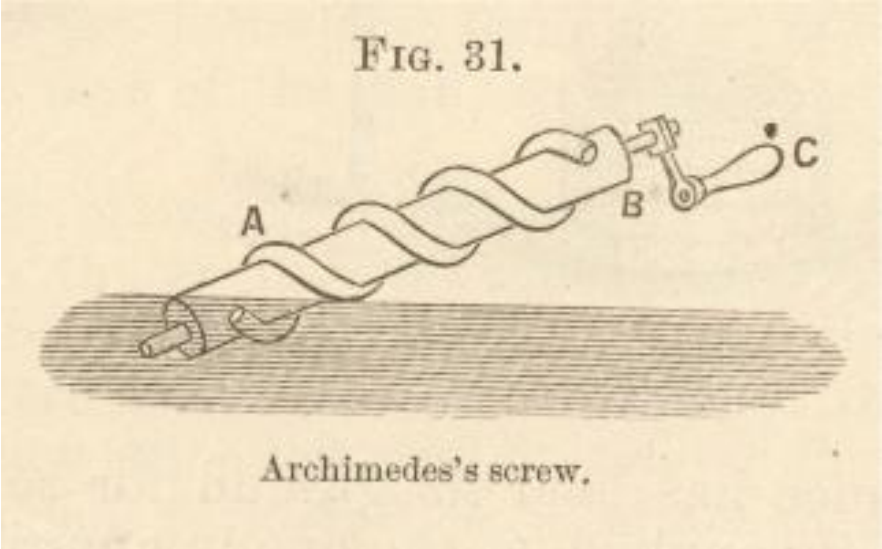
A concern at that time was sewerage from toilets was discharged on or near the ground surface and could contaminate water in shallow wells.

Hydrodynamics



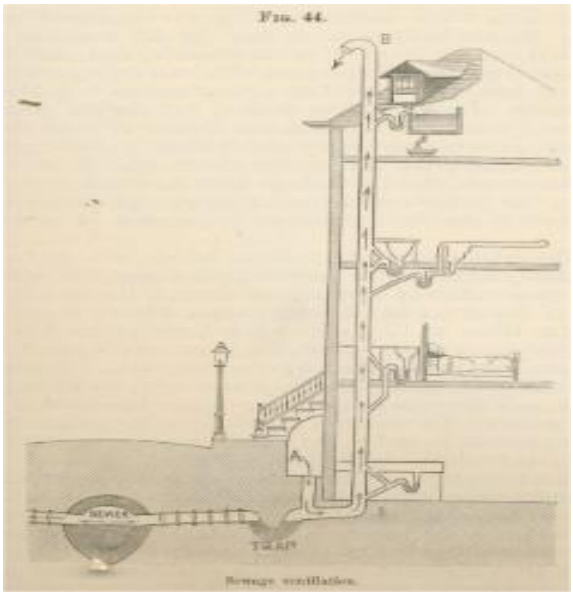
One of the principles of hydrodynamics, or fluid in motion, is demonstrated in Fig. 27. Specifically, that forces are created by moving fluid. The hydrostatic pressure in the glass container forces water out through the small openings at the end of the tubes.
The acceleration of the water to pass through the small openings creates a force that rotates the apparatus.

Hydraulics



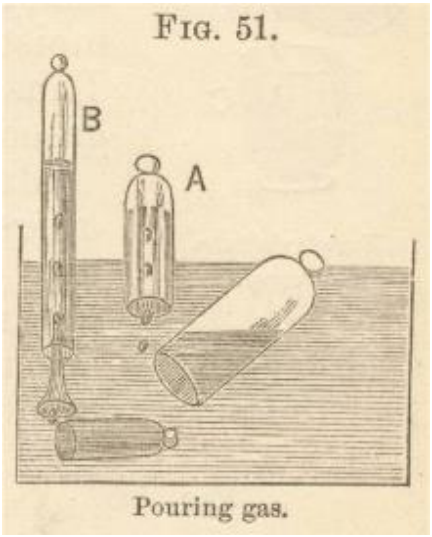
Hydraulics, the movement of fluids, is achieved with many different devices, including pumps, turbines, etc. One method uses an Archimedes's screw illustrated in Fig. 31. It was used extensively, especially in Europe, to pump water, drain flooded areas, and to move sewage.

It is relatively simple in design and economical to use, often powered by windmills.



The significance of properly designed and constructed sewer systems is emphasized here in Fig. 44. A specific Health issue illustrated here is proper venting to protect against the buildup of gases in the living areas.

Pneumatic Apparatus

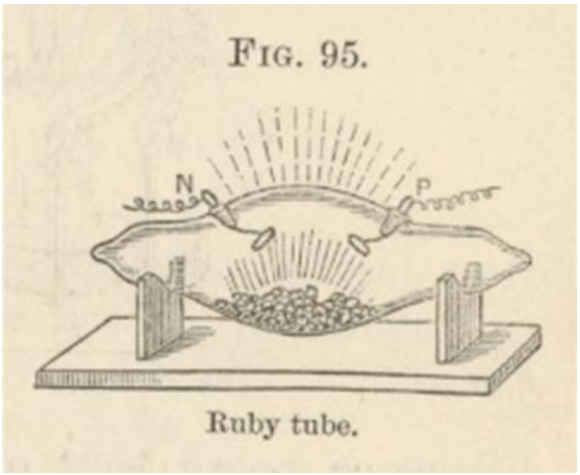


It is generally easy to pour a liquid from one container to another with the help of gravity. How do you pour a gas? One method used in the physics laboratory is illustrated here. It is done in a large container of water. An empty container, with respect to gas, is filled with water and with the opening down in the larger water container.
When a gas is poured from another container it displaces the water as it bubbles up into the receiving container.

Properties of Radiant Matter

In a lecture by Faraday in 1816, we find the first use of the term *radiant matter*. In 1819, Faraday says, "matter may be classed into four states, solid, liquid, gaseous, and radiant. Crookes contributed to the concept of radiant matter by demonstrating the passage of a form of matter through tubes in which the gas molecules had been removed down to approximately one millionth of an atmosphere. A major issue was to show that radiant matter was very different from gas molecules and had different properties.

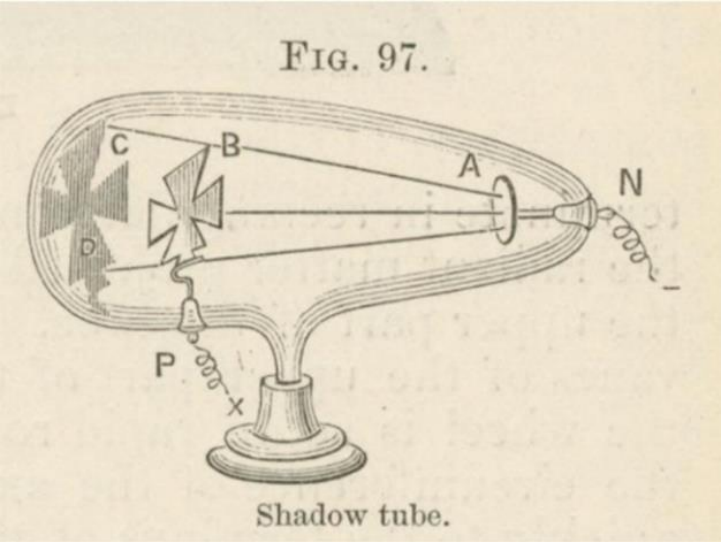
Added Note: The electron (a form of radiant matter) was discovered by the English physicist J.J. Thomson in 1897.
It had been observed that some substances, including several precious stones would emit visible light when submitted to the action of an electric discharge.



Shown here in Fig. 95 is the Ruby Tube developed by Professor Crookes. Various substances are placed in the highly evacuated (about one millionth of an atmosphere). When the electrodes are connected to a coil providing a high voltage the

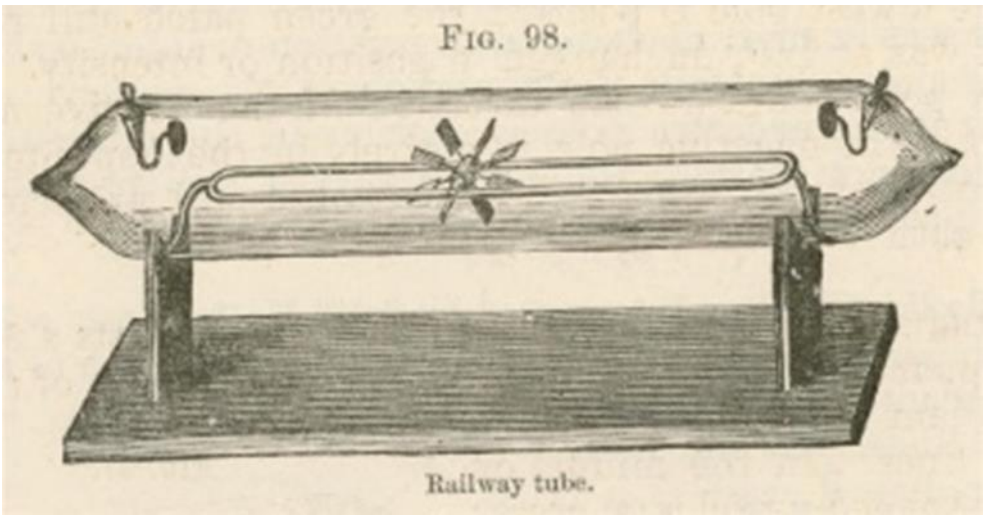
substances glow with colors that are characteristic of each material. Rubies emit a red color and diamonds emit a variety of colors.

The glass tube itself also emits light with the color depending on the source of the glass. English glass emits a blue light and the German glass that was most frequently used for tubes emitted a bright apple-green color.



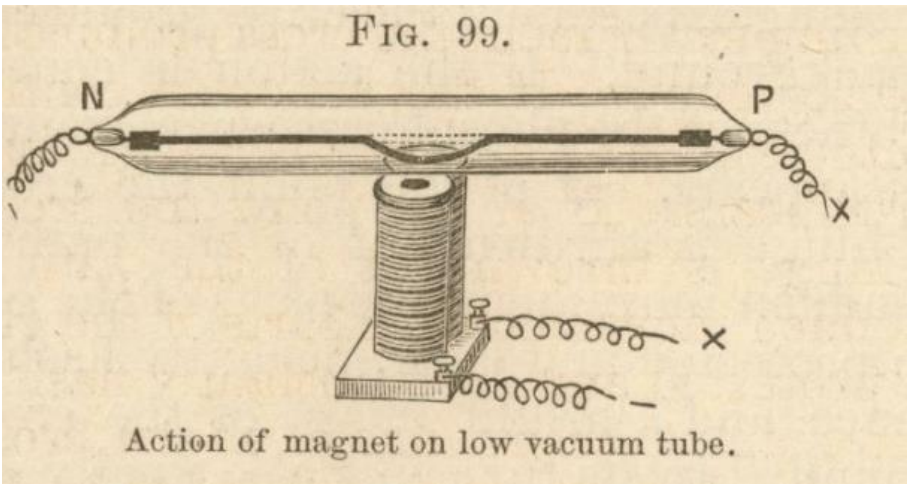
The tube shown in Fig. 97 was used to demonstrate that radiant matter traveled in straight lines and could cast a shadow. When the two electrodes in the tube were connected to a coil providing a high voltage the large end of the tube glowed where it was exposed to the radiant matter. The metal star mounted in the tube intercepted the radiant matter and cast a shadow.

Added Note: It would be discovered many years later that this type of tube connected to a high-voltage source was producing x-radiation.

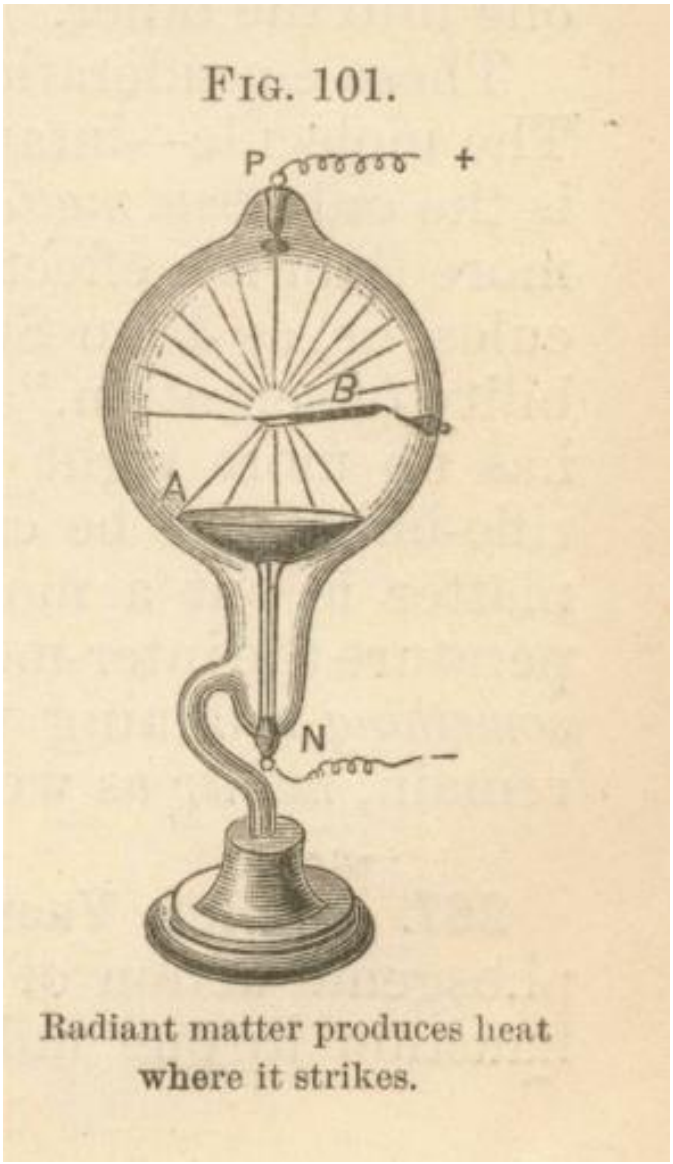


The apparatus shown in Fig. 98 was used by Professor Crookes to demonstrate that radiant matter could exert forces and names this the Railway Tube. It consists of a track running between the two electrodes at the ends of the tube.

A small lite-weight paddle wheel is placed on the track so that the paddles in the upper position are inline between the two electrodes. When the electrodes are connected to an electrical source the paddle wheel rotates and moves along the track away from the negative terminal. Demonstrating that a beam of radiant matter is flowing from the negative to the positive electrode.

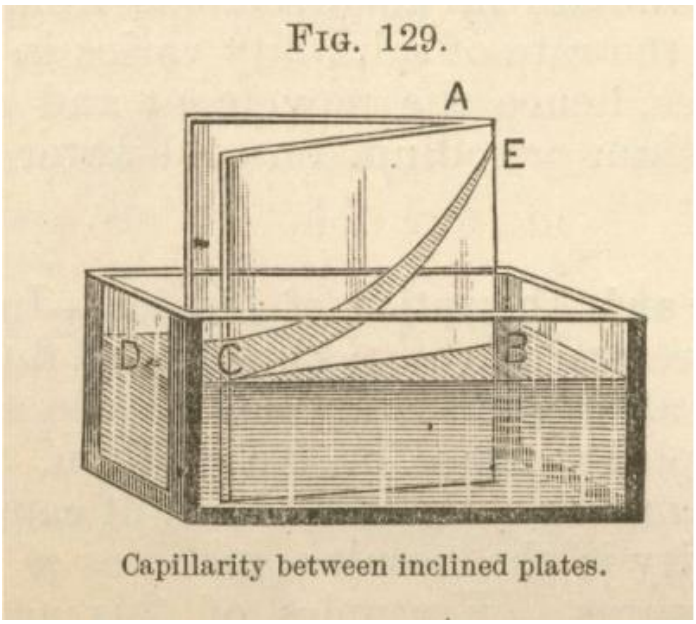


The tube shown in Fig. 99 was used to demonstrate that radiant matter could be deflected with a magnet. Within the tube there was a partial vacuum leaving sufficient gas to ionize and glow along the path of radiant matter between the two electrodes.



The tube shown in Fig. 101 was used to demonstrate that radiant matter produced heat when it was absorbed in a material. It contained a small platinum plate at the positive terminal (B) and a focused cup at the negative terminal as shown. When it is connected to an electrical source radiant matter is focused on the platinum plate heating which becomes red-hot. The heat radiates to the glass tube causing it to become warm.

Molecules Of Two Media, One Set Moving



The apparatus shown in Fig. 129 was used to demonstrate capillary action that occurs between the surfaces of a solid and a liquid. Two glass plates are separated with a wedge shape as shown and placed in a tank of water. The water is pulled up by capillary action between the solid and liquid media. It is pulled to the greatest height where the glass plates are the closest.

General Properties of Sound

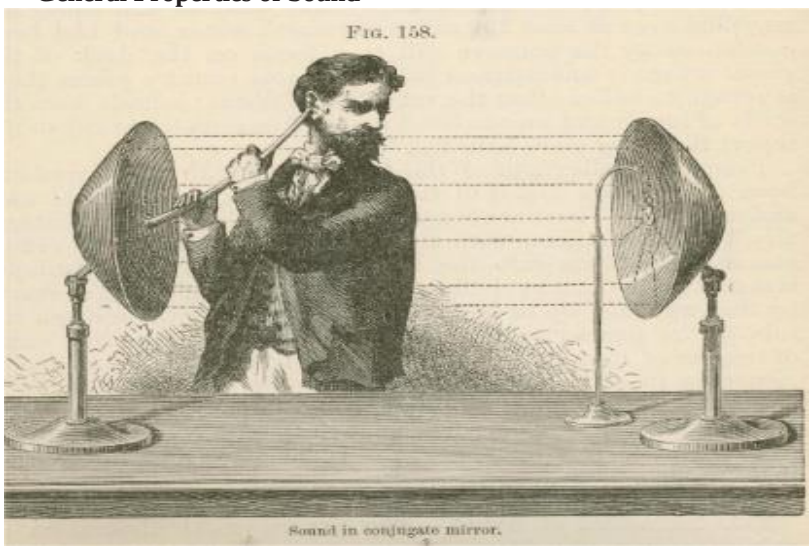
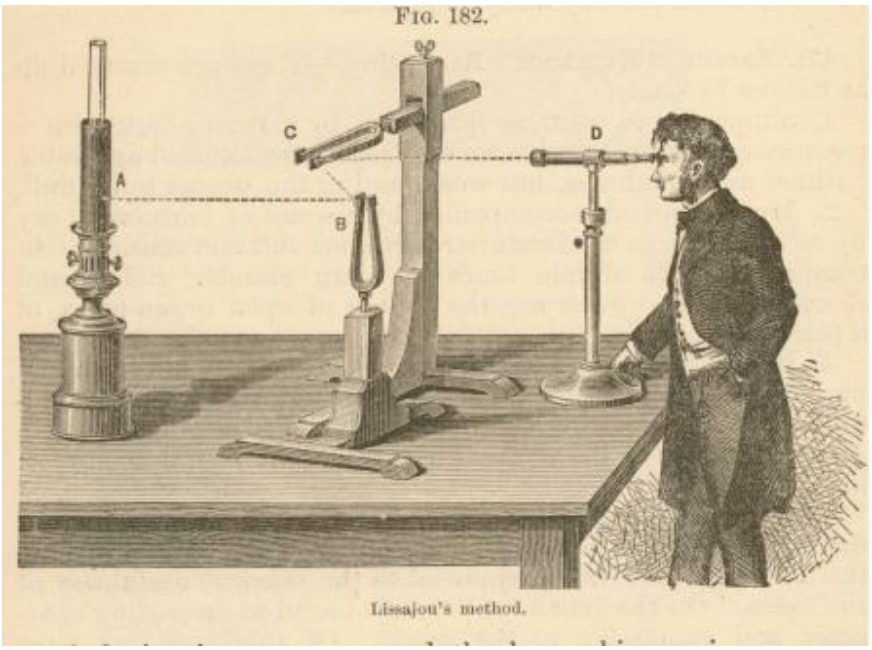
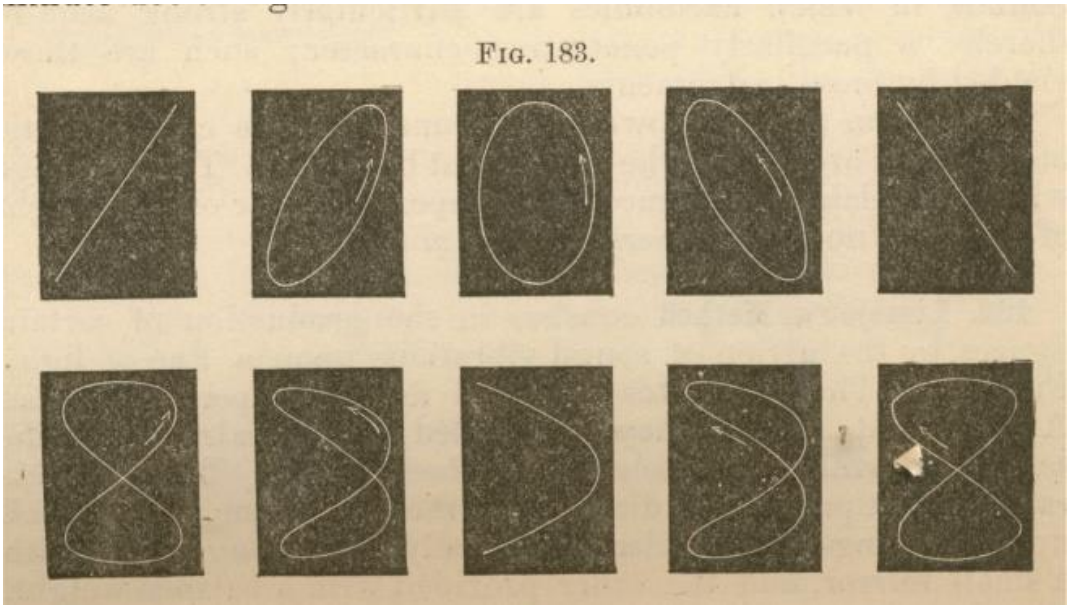


Figure 158 is a demonstration of the reflection of sound between two parabolic mirrors. A watch is placed at the focus of the mirror on the right. The sound is then reflected in parallel lines to the mirror on the left. It is then re-focused where it can be conducted to the ear as illustrated.

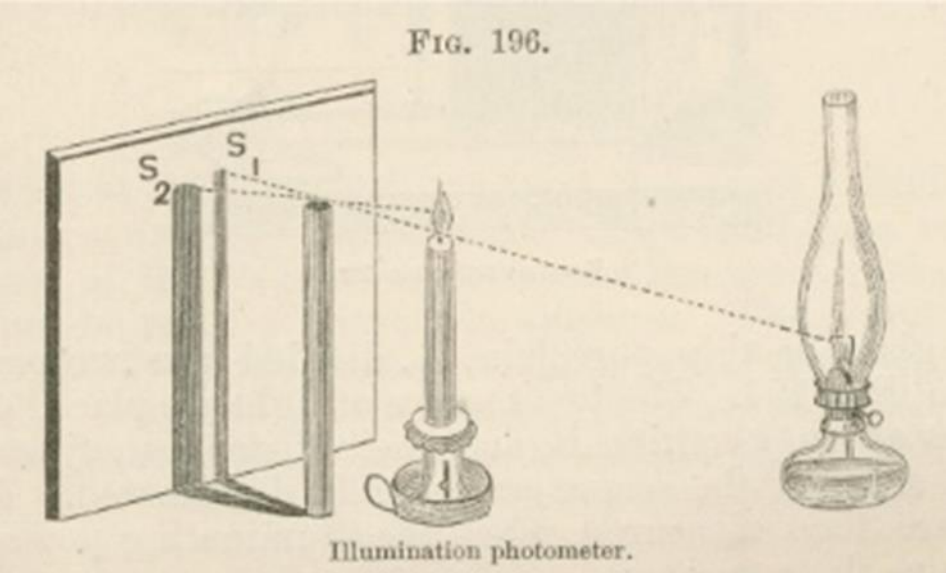
Analysis And Synthesis of Sound



The apparatus shown in Fig. 182 was used to demonstrate the combined effect of resonant vibrations in different directions and the formation of Lissajou's curves. Small mirrors are mounted on the two tuning forks. A small point source of light is viewed with a telescope along a path through the two mirrors. When the tuning forks are not vibrating, a small point of light is observed. When the forks are vibrating various patterns are formed and recorded on photographic paper as illustrated in Figure 183 below. The shapes depend on the frequency and phase relationships between the two vibrating forks.

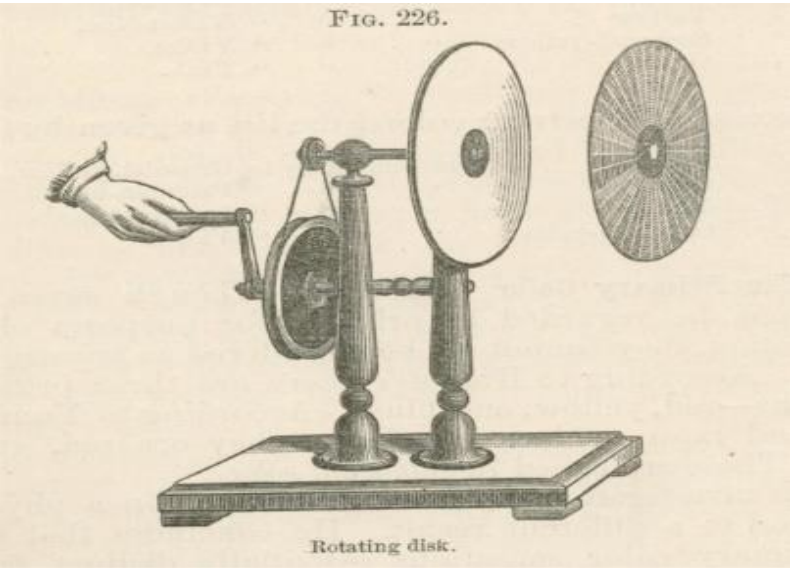


Transmission, Absorption, And Intensity of Light



Rumford's photometer illustrated in Fig. 196 was one method used to measure the intensity of a light source. An opaque rod is located a short distance in front of a screen as shown. The two light sources that are to be compared are moved until their shadows appear with the same intensity. The intensity of each is proportional to the square of the distance between the light source and screen.

Chromatics



Newton's rotating disk shown in Fig. 226 is one method used to demonstrate the composition of light as a mixture of different colors. Disks divided into segments of various colors are mounted on the spinning apparatus. When they are spun at a high speed the composite color is observed. This would be white when the segments of the disk contain the spectrum of colors that are in white light.

Faradaic or Induced Currents

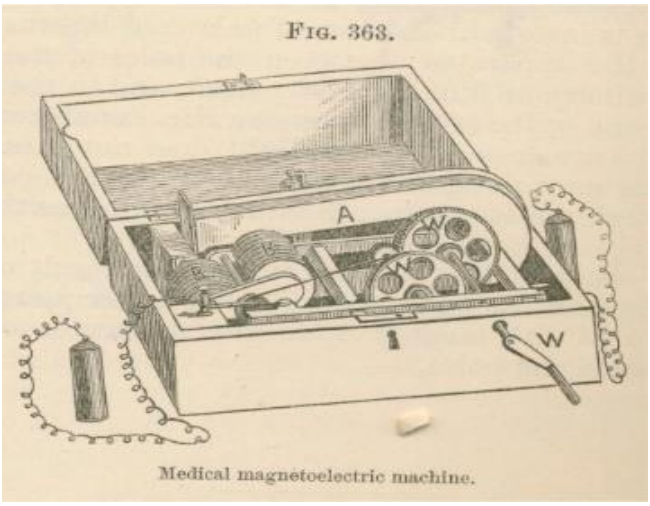
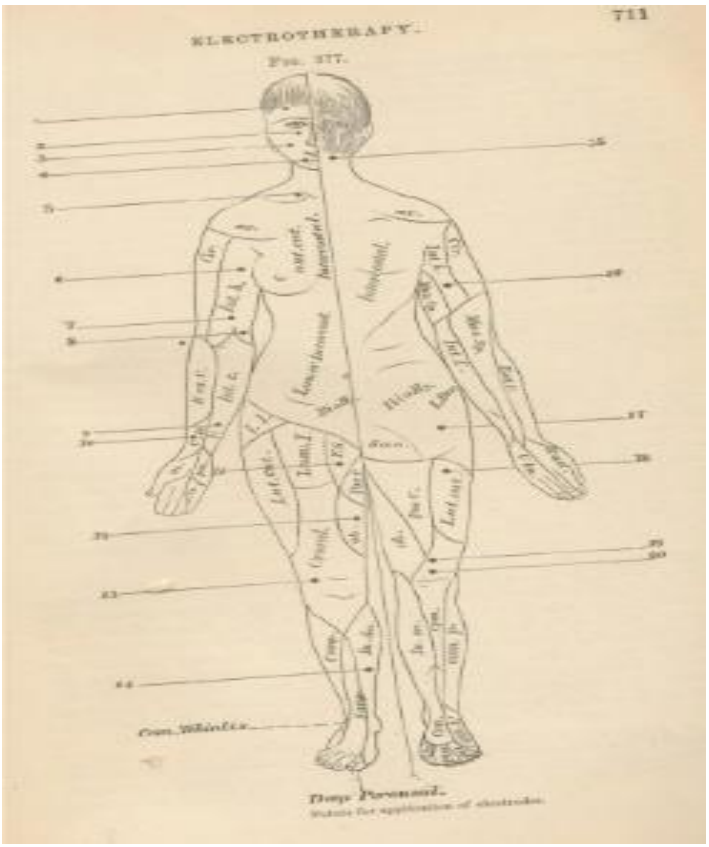


FIG. 363.

Medical magnetoelectric machine.

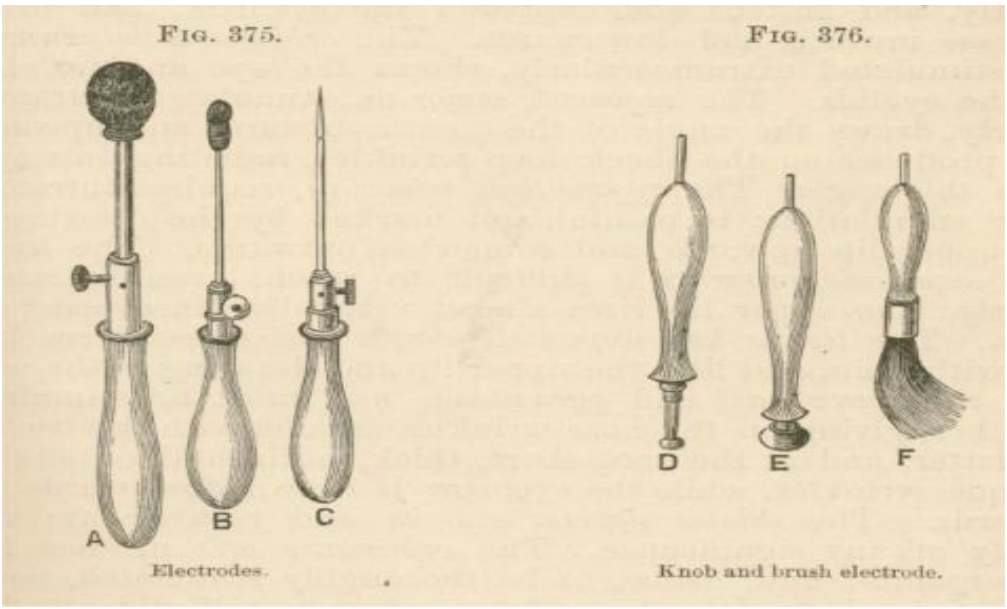
The principle of magnetic induced currents was used to explain the operation of the "magnetoelectric" machine shown in Fig. 363. It contains a large horse-shoe magnet (A) and a mechanism for rotating a small metal object between the magnetic poles. As the magnetism in the object fluctuates with the rotation, an electric current is induced in a coil around the rotating object. The machine was used to pass electrical currents through the human body for medical purposes.

Electrobiology; Elecrophysioloy And Elecrotherapy



Electrobiology, the interaction of electricity with living organisms, was a major field of interest within the scope of medical physics. It generally consisted of two areas of specialization, electrophysiology, the study of natural electricity within living organisms, and electrotherapy, the application of electricity to the human body for medical purposes. Fig. 377 is a detailed diagram showing where to apply electrodes to treat specific conditions.

A variety of electrodes for different medical applications are shown in Figs. 375 and 376 below.

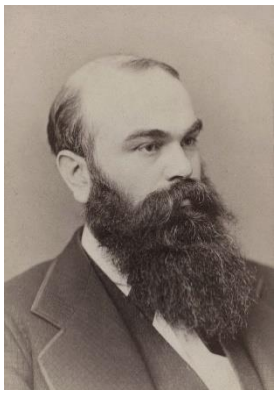


Summary and Looking Back in Time

The textbook, *Medical Physics*, authored by John C. Draper, M.D., L.L.D. and published in 1885, provides a comprehensive description of the field of physics as it was known and practiced at that time in history. The purpose of the book was to provide medical professionals and students with an understanding and knowledge of all physical principles with an emphasis on physics that applied to the living human body and function (vision, hearing, etc.), public health, and treatment methods. With its many high-quality illustrations, it visually connects readers with a variety of experiments and demonstrations that enhanced the learning process.

The illustrations selected and discussed here give emphasis on some of the classic experiments and demonstrations from the past, the great interest among physicists in "radiant matter", and physics based therapeutic methods at that time in history.

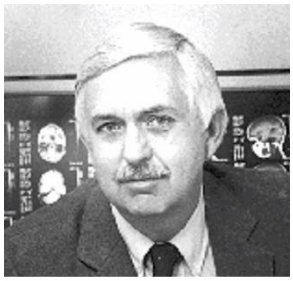
The interest and experiments with "radiant matter" is especially significant. This was to be the foundation for the discovery of x-radiation by Roentgen in 1885 that was to "give birth" to the field of medical physics as we know and practice it today



Book Author

John Christopher Draper, M.D.,L.L.D. (March 31, 1835 – December 20, 1885), https://en.wikipedia.org/wiki/John_Christopher_Draper, was an American chemist and surgeon and author of several major textbooks of the time. His book, *Medical Physics*, published in 1885 was a major contribution to the naming, defining, and establishing of the field of *Medical Physics*.
It emphasized the value of a comprehensive understanding and knowledge of physics for medical practitioners and students.

Article Author



Dr. Perry Sprawls

Perry Sprawls, Ph.D., is a clinical medical physicist and educator,, with a major interest in the preservation of the history and heritage of medical physics and related medical applications. Links to his other historical publications are on the website www.sprawls.org . Contact: sprawls@emory.edu

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