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# OPHTHALMIC INSTRUMENTS IN A MUSEUM OF SCIENCE

Marisa Monteiro[1]; M. João Carvalhal[1]

**ABSTRACT**

Medical studies in Porto began with the creation of the Medical-Surgical School, in 1836; the attendance of a preparatory course taught at the Polytechnic Academy (1837-1911) was required beforehand. On February 1911, it was elevated to a Faculty of Medicine. The creation decree listed subjects such as Physics and Chemistry for Biology, with a one semester duration, which were taught in the Physics and Chemistry Laboratories of the Polytechnic Academy [which, in March, would become the Faculty of Science (FS) of the University of Porto]. These subjects would be replaced on July 1914 by the "FQN" course (from Physics, Chemistry, and Natural Sciences), preparatory to the study of Medicine, also to be taught at the FS, and contemplating an annual chair of Physics. When the FS was established, syllabuses were changed, foreseeing the attendance of free magisterial and demonstration lessons and mandatory practical lessons. Though there were, in the building of the Polytechnic Academy, several rooms assigned to the Cabinet – later Laboratory – of Physics, these were devoid of resources for experimental work, which imposed the purchase of instruments for demonstration and practice. In September 1912, the FS acquired, from the *Maison Charrière Collin*, a set of instruments for Medical Physics. Among others, a Landolt perimeter (for graphical description of the visual field), a Landolt ophthalmoscope (for fundus observation), a Perrin artificial eye (for practice with the ophthalmoscope) and a set of ophthalmologic lenses, all of them now in the Museum of Science of the University of Porto. We will present some of these instruments, as an initial approach to the study of the physics of vision, and understanding of eye defects and diseases.

**KEYWORDS** Physics of vision; Museum; Ophthalmoscope; Landolt perimeter; Artificial eye

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## Introduction

Medical studies in Porto began, in an organized fashion, with the creation of the Medical-Surgical School (FIG. 1), in 1836 (Diário do Governo, 1837, p.9); the attendance of a preparatory course taught at the Polytechnic Academy (1837-1911) was required beforehand, in order to gain access to this school. The discipline of physics was integrated in this course in 1844 (Diário do Governo, 1844, p.326), in obedience to a decree that increased the list of subjects in the preparatory course, known as the «ancillary sciences» (Ferraz, 2013, p.89), following a proposal by some professors of the Medical-Surgical School.

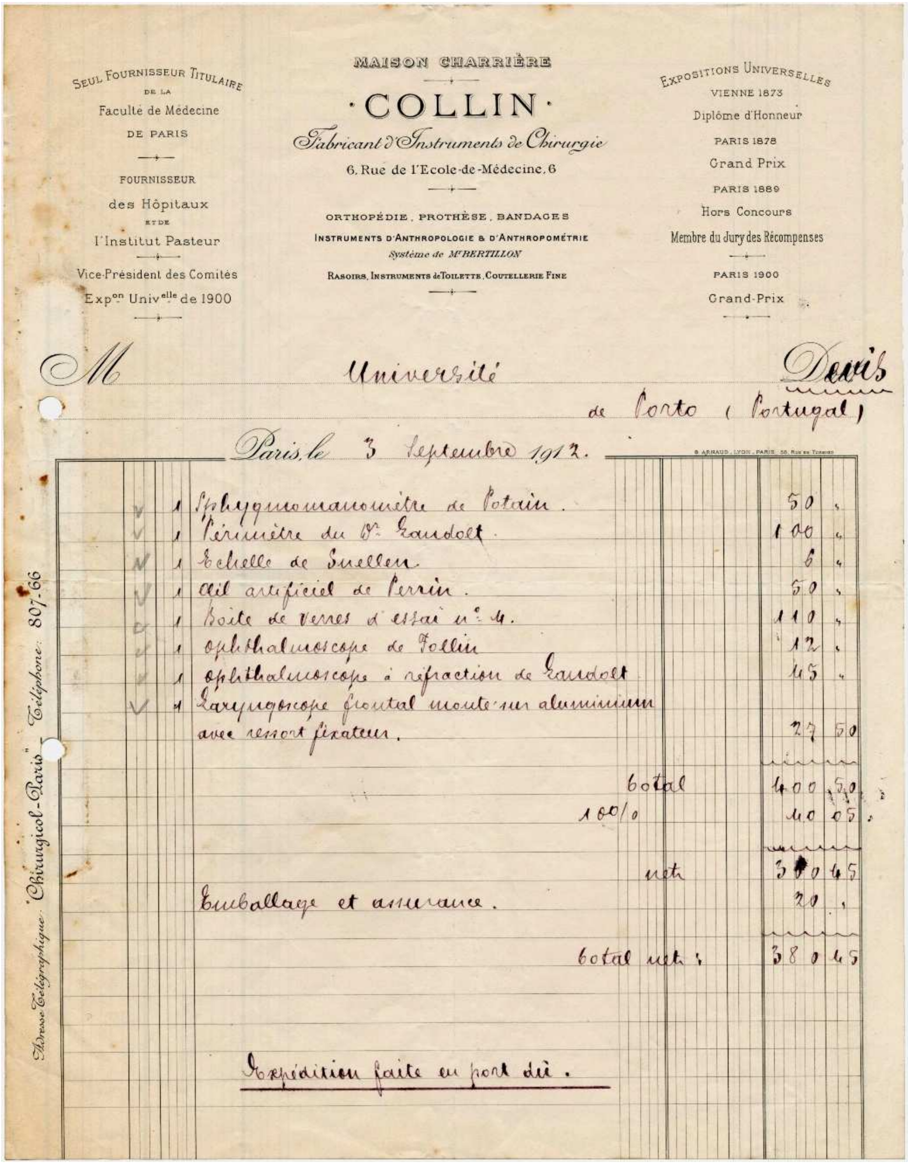
FIG. 1 - Medical-Surgical School (c. 1900) and, after 1911, Faculty of Medicine (Emílio Biel & Cª, Porto, "nº36 – Hospital de Sto Antonio e Escola Medica", stereoscopic pair, c. 1900, detail, Photography Archive of the Museum of Science, Inv. 000482).

On February 1911, within months of the establishment of the Republic in Portugal, the Medical-Surgical School of Porto was elevated to a Faculty of Medicine (Diário do Governo, 1911, p.742). The creation decree listed, among other subjects, Physics for Biology, with duration of one semester, to be taught at the Polytechnic Academy (itself to become the Faculty of Science of the University of Porto shortly after, in March), by the appointed lecturers under guiding lines of the Council of the Faculty of Medicine. The course was first taught by Tomaz Dias da Silva, who would be replaced in 1912/13 by Álvaro R. Machado (Araújo, 2000, p.52); Machado suggested a new program in a report dated June 1913, which he implemented the following academic year. This program introduced some complements of Physics and their connections to Medicine; it included an experimental component, to develop students' skills in this area (Machado, 1913, p.8).

In the same report, that professor proposed the establishment of a group of FQN studies similar to PCN (from Physics, Chemistry, and Natural Sciences) created in French universities in 1893. On July 1914, Physics for Biology, with duration of one semester, would be replaced by an annual chair of Physics – known as Medical Physics – included in the "FQN" course, preparatory to the study of Medicine, also to be taught at the Laboratory of Physics of the Faculty of Science (Diário do Governo, 1914, p.500).

When the Faculty of Science was established, syllabuses were significantly changed, foreseeing the attendance of free magisterial and demonstration lessons, and of mandatory practical lessons. The Laboratory of Physics was by then devoid of resources for experimental work. This would impose the purchase of a variety of instruments for demonstration and practice.

In September 1912, the Faculty of Science acquired from the *Maison Charrière Collin*, based in Paris, a set of instruments for ophthalmology (FIG. 2), intended for practical work in "Radiations", as required by Medical Physics. Some of them are now in the Museum of Science.



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Paris, le 3 Septembre 1912.

| | | |
|---|---|---|
| 1 | Sphygmomanomètre de Potain. | 50 " |
| 1 | Périmètre du Dr Landolt. | 100 " |
| 1 | Echelle de Snellen. | 6 " |
| 1 | Œil artificiel de Perrin. | 50 " |
| 1 | Boite de verres d'essai n° 4. | 110 " |
| 1 | ophthalmoscope de Follin | 12 " |
| 1 | ophthalmoscope à réfraction de Landolt | 45 " |
| 1 | Laryngoscope frontal monté sur aluminium avec ressort fixateur. | 27 50 |
| | total | 400 50 |
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| | Emballage et assurance. | 20 " |
| | total net : | 380 45 |

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FIG. 2 - Invoice for purchase of medical instruments from *Maison Charrière Collin*, Paris, including some ophthalmology instruments (Document Archive of the Museum of Science).

## 1. Landolt ophthalmoscope

Ophthalmoscopy is one of the most commonly used ophthalmological tests; it allows probing inside the fundus of the eye (retina, blind spot and macula) and other eye structures, with the use of an ophthalmoscope (FIG. 3).

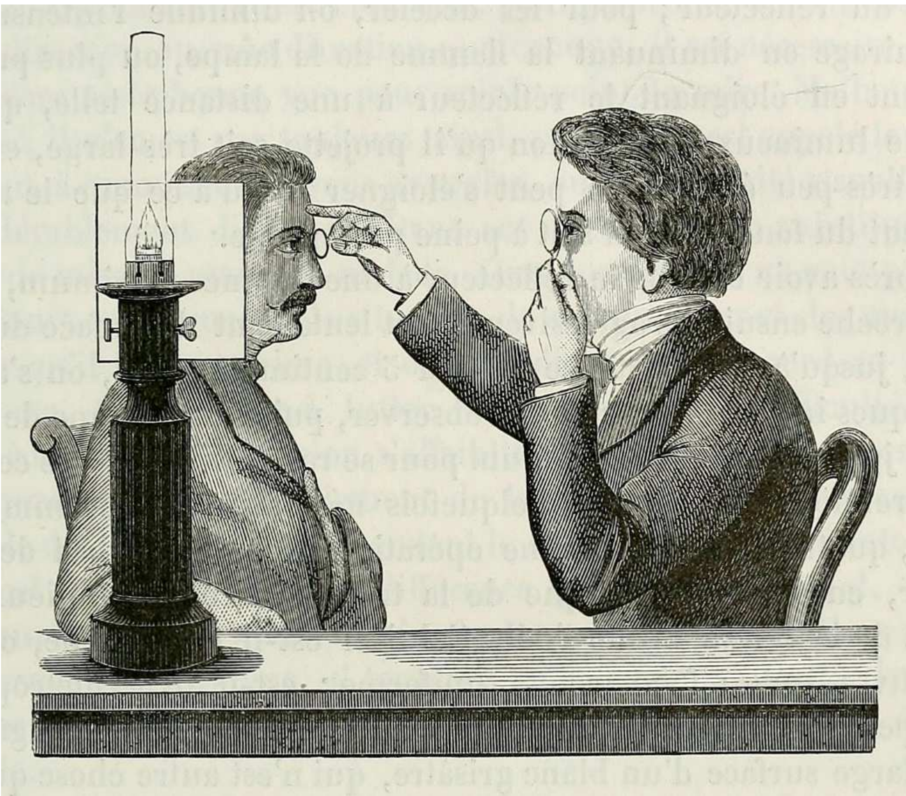

FIG. 3 - Use of an ophthalmoscope (Perrin, 1870, p.57; Duplay et al., 1898, p.17).

The first ophthalmoscope was developed in 1851 by Hermann von Helmholtz (1821-1894). Over the years, it turned out that there was no ophthalmologist who did not have an ophthalmoscope named after him. António Plácido da Costa (1849-1916), professor at the Medical-Surgical School of Porto, seems to have been, among us, the first ophthalmologist to devise an ophthalmoscope (1880); produced in Portugal, this instrument is now on display in the Museum Maximiano Lemos of the University of Porto (Ferraz, 2013, p.516).

Edmund Landolt (1846-1926) was a Swiss ophthalmologist working in Paris, known for his research in the field of ophthalmology. He also developed a new type of ophthalmoscope, based on refraction (FIG. 4), as a result of his pursuit to gather the best characteristics of the different ophthalmoscopes then available (Landolt, 1878, p.86).


FIG. 4 - Landolt ophthalmoscope and accessories in case (Physics collection of the Museum of Science, Inv. 000372).

To look inside the eyeball, light has to be projected through the pupil of the patient, reflecting back on to the eye of the observer, where it must form a clear image. Therefore, this ophthalmoscope is equipped with a concave mirror with a focal distance of twenty centimeters and a diameter of twenty-eight millimeters. It is pierced with a central hole at least three millimeters in diameter; the handle, in ivory and brass, is about twelve centimeters long, making the instrument very handy to use (FIG. 5).

For evaluating the eye refractive condition, the ophthalmoscope contains two discs (FIG. 6): one with six positive lenses and the other with six negative lenses. They are superimposed on the instrument and rotate around the same center, thereby bringing all lenses, subject to all possible combinations, behind the opening of the ophthalmoscopic mirror. Such arrangement allows us to obtain twenty converging systems and twenty-one diverging systems (giving every half diopter from 0 to plus 10 and from 0 to minus 10.5).

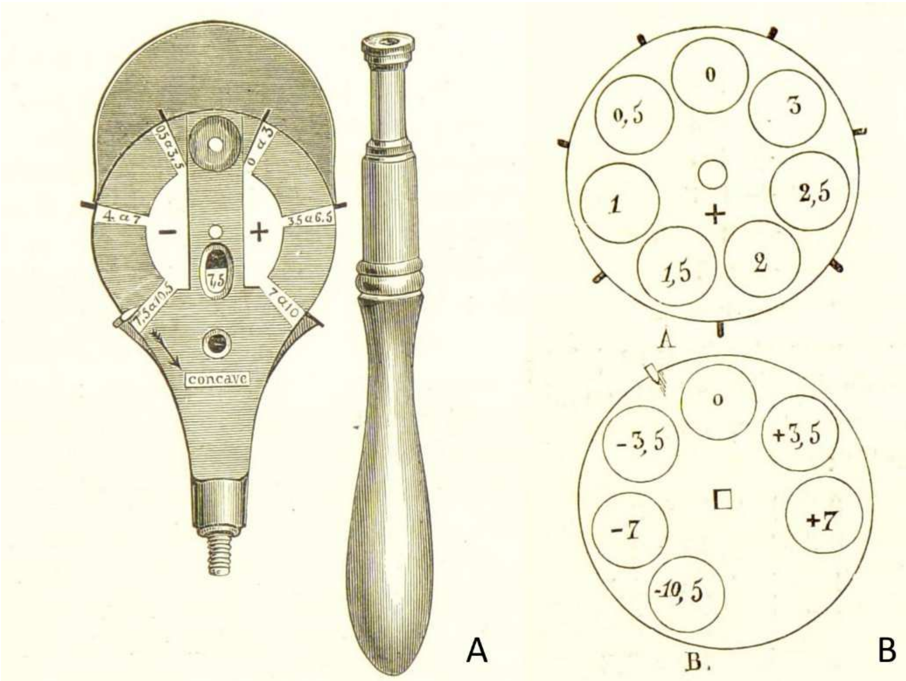


FIG. 5 - Landolt ophthalmoscope, drawing:

A – view of the ophthalmoscope; B – discs with lenses (Landolt, 1878, pp.87-91).

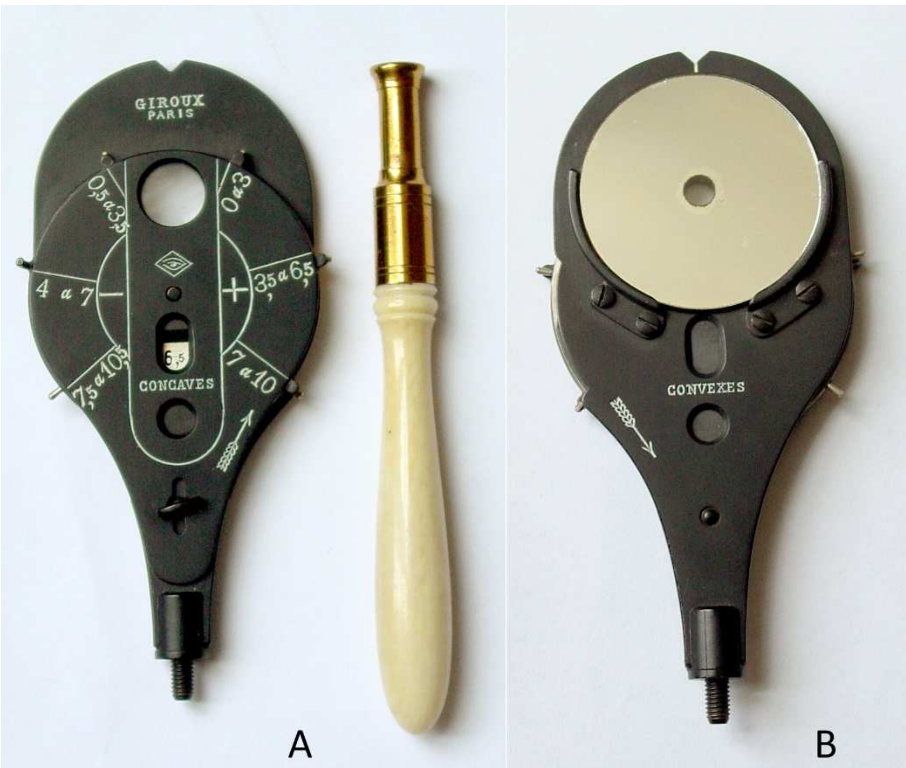


FIG. 6 - Landolt ophthalmoscope: A – view from the observer's side; ivory and brass handle; B – on the other side, the concave mirror with a central hole.

An additional plus 10 diopter lens may be slipped into the groove for the mirror, further extending the working range from plus 20 to minus 20.5 diopters (FIG. 7). There existed probably a second minus 10 diopter lens, to increase the range of powers available. When trying to see the fundus of the eye with different combinations of lenses, the observer will find one that allows him to see clearly; the resulting power should rightly be the one that corrects the eye refractive ailment.

The stenopaeic disk - an opaque disk punctured with a narrow slit – is an accessory for measuring astigmatism (FIG. 8): with edge graduated in degrees, it is placed in the mirror groove, helping determining the power required to correct the refractive error along each major eye meridian.

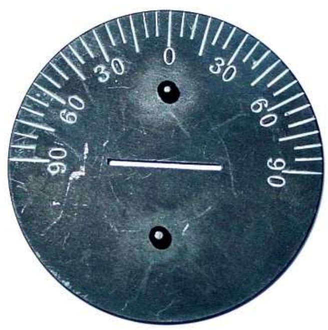


FIG. 7 - The plus 10 diopter lens.

FIG. 8 - The stenopaeic disk.

## 2. Perrin artificial eye

Handling the ophthalmoscope requires manual skills; however, in order to acquire practice, it is necessary to resort to prolonged exercises, difficult to accomplish with a keen eye, since the strong light source may be dangerous in inexperienced hands. For this reason, trainee physicians used to practice the exam of the retina with an ophthalmoscope by resorting to an artificial eye model.

Artificial eyes with fundus drawings, like this particular model (FIG. 9), were first introduced in 1866 by Maurice Perrin (1826-1889), a French physician and professor of surgery, and first made by *Nachet et Fils*, Paris (Perrin, 1866, p.2). Such models can endure light shining for hours on end, contrary to the real eye.

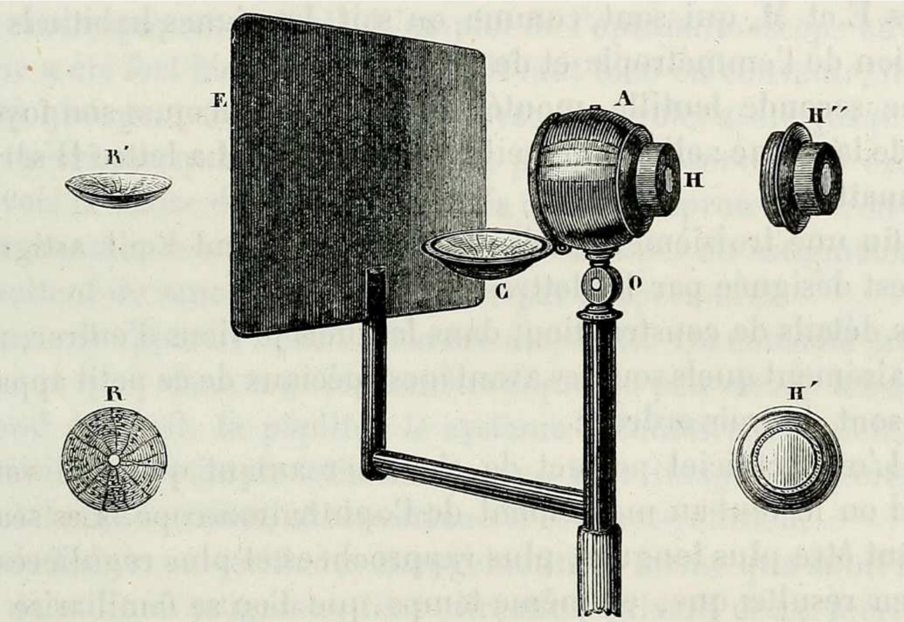

*Fig.* 22. — Œil artificiel pour les exercices ophthalmoscopiques.

FIG. 9 - The Perrin artificial eye, drawing (Perrin, 1870, p.65).

Opportunity for training would be provided by this model (FIG. 10), in the identification of the blind spot and macula, in the observation of the larger blood vessels entering the eye at the blind spot, or in the analysis of some retina pathologies as illustrated by drawings that lecturers would provide.

It has the optical proportions of the real eye. The central part, representing the intraocular cavity, is a hollow sphere, in copper, blackened internally and with a volume similar to the eyeball's (FIG. 11). It is supported by a variable height stand. A black screen mounted behind helps guiding the light beam.

FIG. 10 - The Perrin artificial eye and accessories, in case (Physics collection of the Museum of Science, Inv. 000373).

FIG. 11 - The central part of the artificial eye, with the black screen.

A lens, which simulates the optical system of the eye, is screwed onto the front. There are three powers available to simulate the normal or emmetropic eye (E), the hyperopic eye (H) and the astigmatic eye (A); the myopic eye is simulated also by the E lens. Different degrees of ametropic eyes are produced by screwing these lenses further or nearer, thus varying the distance from the lens to the cup representing the fundus. Diverse pupillary dilatations may be simulated by caps screwed in front: 7 mm or 3 mm diameters are available (FIG. 12).


FIG. 12 - Lenses and caps.

On a posterior ring mounted on a hinge (FIG. 13 A), different copper cups can be placed, in which different ophthalmoscopic images of the eye fundus have been painted, either normal or pathological.

By 1866, the *Nachet et Fils* house was offering twelve different cups, one representing the normal eye, and the others, different pathologies (FIG. 13 B); they also provided cups prepared with a red background or with no preparation whatsoever. These could be painted with images of different retinal pathologies copied from the *Atlas d'Ophthalmoscopie*, authored by Perrin (FIG. 14).

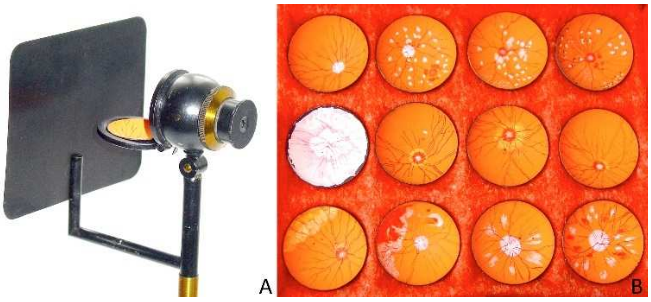


FIG. 13 - A – The artificial eye with the cup simulating the normal fundus fitting the ring; B – Collection of 12 fundi: the top left depicts the normal eye; others reproduce different pathologies listed on a card inside the case.

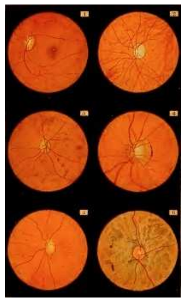

FIG. 14 - Physiological varieties of the fundus of the eye – chromolithograph (Perrin, 1872, plate nº 7).

This eye model also provided the opportunity for studying the dioptrics of the human eye, one of the subjects listed in the program of Physics for Biology.

### 3. Landolt perimeter

A perimeter, or arc perimeter, is used to determine the visual field, that is, the extent of the outer world which is seen by both eyes. Careful exploration of the visual field can be used to diagnose many ocular or neurological disorders, including glaucoma.

In 1858, Hermann Aubert (1826-1892), a German physiologist, constructed the first dedicated investigational perimeter. Edmund Landolt gave the perimeter the following form (FIG. 15):

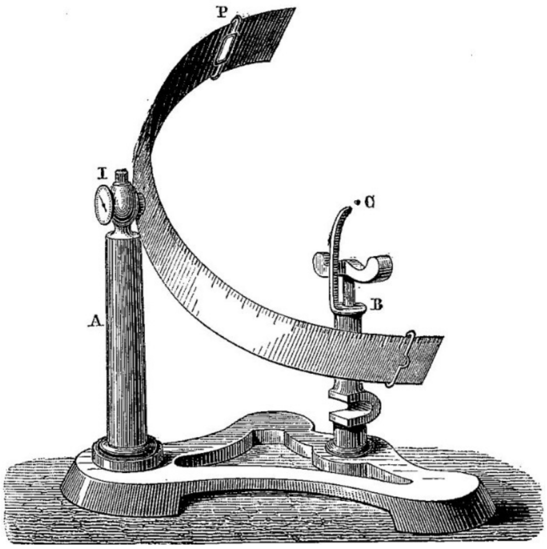


FIG. 15 - Landolt perimeter, drawing (Landolt, 1877, p.175).

To determine the visual field, we must place one eye at a time in the center of a sphere. The most convenient way to obtain such a sphere is given by the perimeter: it consists essentially of a semicircular arc, which, by rotation, describes a hemisphere in the center of which is the eye under examination.

The arc is divided into degrees, on the outer side, from 0° to 90°, starting from the rotation axis, towards the ends. The slope of the arc is read off on a small vertical dial associated to that axis. A piece of wood at variable height works as a chin rest so that the optical center of the eye is placed at the center of the hemisphere described by the arc. The interior of the arc is blackened except for the central fixation point. A grid in the vicinity of the perimeter's center, spaced in half degrees, allows for sensitive measurements around the macula (FIG. 16).

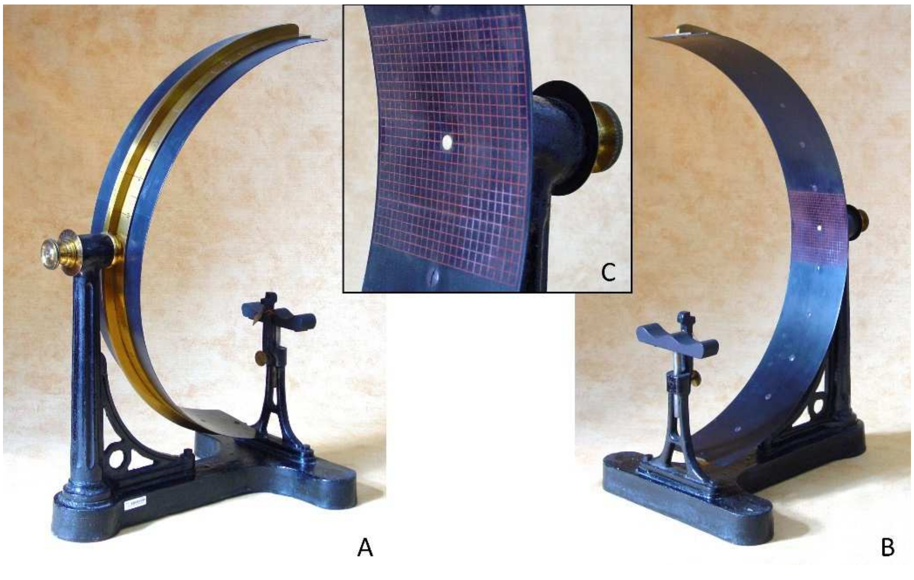


FIG. 16 - Landolt perimeter (Physics collection of the Museum of Science, Inv. 000375): A – The outer side, divided into degrees; B – The blackened inner side of the arc; C – The grid spaced in half degrees.

With the arc of the perimeter maintained at a specific orientation, as the subject stares at the small white dot in the center of the arc, the operator slides a target along the arc and records the angle from which this target is spotted in the subject's visual field. The process is repeated for different orientations of the arc. The results are plotted on a diagram showing a projection of the sphere (polar equidistant projection); the points obtained are joined by segments, thus characterizing the visual field (FIG. 17).

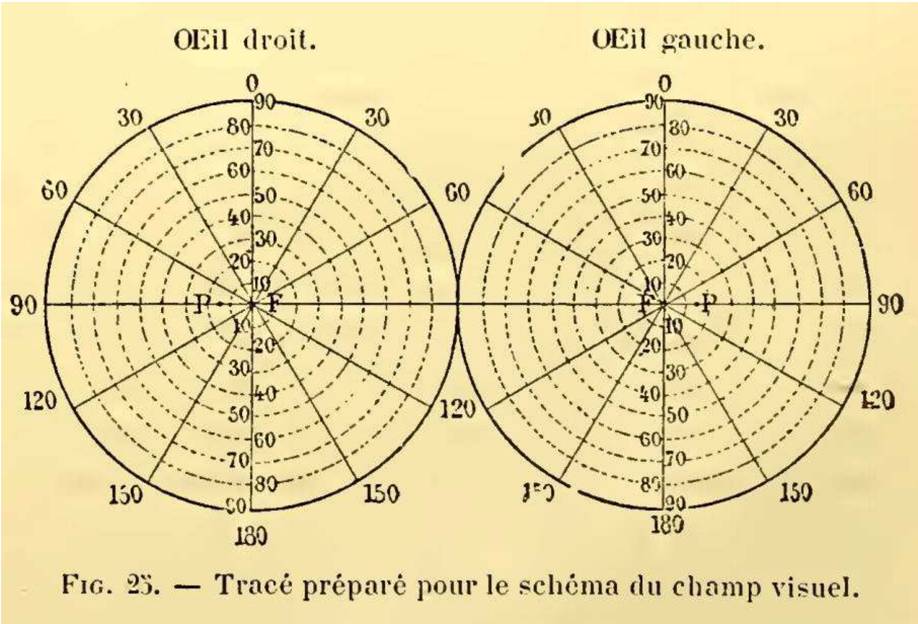


FIG. 17 - Diagram for recording the visual field (Duplay et al., 1898, p.25).

The Landolt perimeter can also be used to determine visual acuity and for the study of the perception of colour. To do this, all it takes is to measure the visual fields associated to red, green and blue colours independently (FIG. 18).

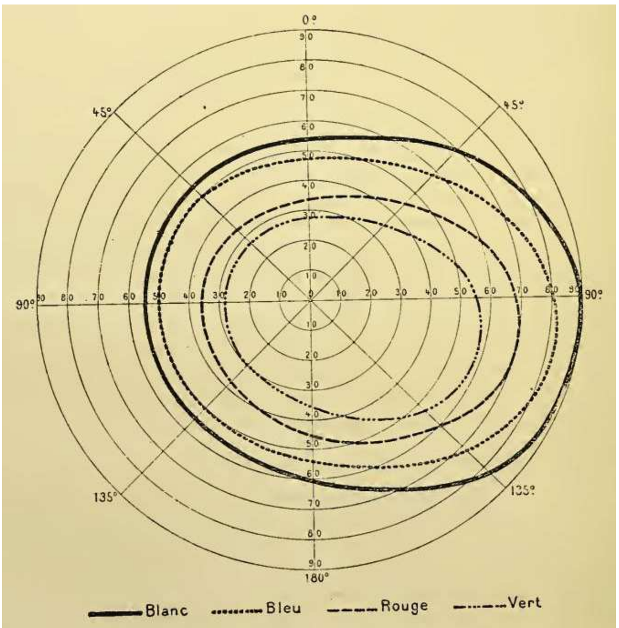


FIG. 18 - Charts which indicate the limits of the medium visual field of different colours: white, blue, red and green (Duplay et al., 1898, p.24).

## 4. Optician's trial set of lenses

Trial sets of lenses are among the apparatus employed in ophthalmic work. They are used in testing vision for detecting the refractive defects of human eyes and prescription of eyeglasses. It is an array of trial lenses to be mounted on a metal spectacle frame, with different magnifying numbers, expressed in diopters; each one has a flap in which we can read this number (FIG. 19).


FIG. 19 - Optician's trial set of lenses (Physics collection of the Museum of Science, Inv. 000374).

There are pairs of spherical convex and concave lenses, for correction of myopia or hyperopia; pairs of cylindrical concave and convex lenses, for correction of astigmatism; and prismatic lenses, for correction of strabismus. The lenses are stored in a velvet lined case, in grooves, and are classified by their kind of prescription. Flat glasses, colored or opaque, and a stenopaeic hole, are also included. Some lenses and accessories are missing.

## Conclusion

With the creation of the Faculty of Science of the University of Porto, in March 1911, the teaching of physics, until then of a markedly theoretical and speculative nature, started demanding practical work and training in the laboratory; such approach asked for laboratories duly equipped for experimental practice (Araújo, 2000, p.51). The acquisition of the instruments we have been describing gave students the opportunity to engage in practical work related to Medicine, though in the context of a Physics course, as a practical assignment was planned for each one (Machado, 1913, pp.20-21).

These instruments are a testimony of the concern for selecting the Physics contents with direct application in Medicine, and for addressing these contents by confronting students with the experimental manipulation of medical instruments.

## References

Araújo, J. M. (2000), A Física na Faculdade de Ciências da Universidade do Porto. In: FCUP. *Faculdade de Ciências da Universidade do Porto: os primeiros 75 anos: 1911-1986*. Porto: FCUP, pp. XXX-XXX [1º e última página do artigo].

Direcção Geral da Instrução Secundária, Superior e Especial (1911), *Reforma do Ensino Médico* [online]. Available from: https://dre.pt/application/dir/pdfgratis/1911/02/04500.pdf [Accessed 15th June 2015].

Duplay, S., Reclus, P. (1898), *Traité de Chirurgie*, IV, 2nd ed. Paris: Masson et Cie, Editeurs

Ferraz, A. (2013), *A Real Escola e a Escola Médico-Cirúrgica do Porto – Contributo para a História da Faculdade de Medicina da Universidade do Porto*. Porto: U.Porto Editorial.

Landolt, E. (1877), *Leçons sur le diagnostic des maladies des yeux*. Paris, Ve A. Delahaye et Cie, Librairies Éditeur.

Landolt, E. (1878), *Manuel d'ophthalmoscopie*. Paris: Octave Doin, Éditeur.

Machado, A. R. (1913), Estudo de física médica na actual organização universitária, Separata do *Jornal dos Médicos e Farmacêuticos*. Porto: [s.n.].

Ministério da Instrução Pública (1914), *Lei nº 239* [online]. Available from: https://dre.pt/application/file/478905 [Accessed 15th June 2015].

Ministério do Reino (1836), *Das Escolas Medico-Cirurgicas de Lisboa e Porto* [online]. Available from: http://legislacaoregia.parlamento.pt/V/1/18/15/p30 [Accessed 15th June 2015].

Ministério do Reino (1844), *Decreto acerca da instrução pública*, artºs 147º a 150º [online]. Available from: http://legislacaoregia.parlamento.pt/V/1/22/76/p319 [Accessed 15th June 2015].

Perrin, M. (1866), *Description d'un Oeil Artificiel destiné a faciliter les études ophthalmoscopiques*, Compte Rendu de la Société de Chirurgie [online]. Available from: http://gallica.bnf.fr/ark:/12148/bpt6k54703977.r=Compte%20Rendu

%20de%20la%20Soci%C3%A9t%C3%A9%20de%20Chirurgie

[Accessed 15th June 2015].

Perrin, M. (1870), *Traité Pratique d'Ophthalmoscopie et d'Optométrie.* Paris: Victor Masson et Fils.

Perrin, M. (1872), *Atlas d'Ophthalmoscopie et d'Optométrie*. Paris: Victor Masson et Fils.