

Optics history as effective instrument for education in optics and photonics

S.K. Stafeef and M.G. Tomilin

St.-Petersburg University of Information Technologies, Mechanics and Optics, St.-Petersburg, 197101, Kronverksky Pr. 49, Russia

ABSTRACT

The education problem in optics and photonics is to draw young generation on the side of light, optical science and technology. The main goal is to prove the slogan that "physics is a small part of optics": during the thousand years optics formulated the clear worldview for humanity. In fact optics is itself presents multidisciplinary collection of independent scientific arias from one hand and was a generator of new fields of knowledge from the other hand. Optics and photonics are the regions where the fundamental problems of our reality have to be solved. The mentioned functions belonged to optics during the period of civilizations development. This is a basic idea of books serial by S. Stafeev and M. Tomilin "Five Millennium of Optics" including 3 volumes. The first volume devoted to optics prehistory was edit in 2006 in Russian. Its main chapters devoted to relations between Sun and Life, the beginnings of human intelligence, megalithic viewfinders, gnomons and ancient temples orientation, archaic optical materials and elements. It also consist the optical riddles of that period. The volume II is devoted to Greek and Roman antiquity and is in the process of publishing. It consist the chapters on the beginning of optics, mathematical fundaments and applied optics evolution. Volume III would be devoted to Medieval and Renaissance optics history. The materials are used at our university in a course "The Modern Natural Science Conceptions" for students and graduate students. In our paper the possibilities of optics history as effective instrument for education in optics and photonics are discussed.

Keywords: optics prehistory; medieval and renaissance optics; ancient images, megalithic viewfinders, gnomons and temples orientation; optical theory, materials and elements; eye and vision.

1. INTRODUCTION

Optics and photonics have exciting history closely tied with modern science. For receiving the harmonious education in this field it is necessary to trace the development of optics from early beginning up to current state. Such panorama of optics development arise deep interest of pupils to the subject of investigation and give fundamental knowledge. Sun light as main source of energy and basis of life was the most important object of investigation during the whole period of civilization evolution. Vision as the main source of information about the surrounded world determined the evolution of human intellect. The direct sky objects observation during thousand years helped to predict nature cycle changes and to fix man in time and space. Control of Sun, Moon and planets trajectories gave the calendar to many nations. Many megalithic facilities and observatories were built for this and religious purposes. Viewfinder as one of the first optical instrument was created as the result of ancient visual observations. Other ancient optical elements such as mirrors, lenses and magic spheres were the result of handicraft activity in metallurgy and jeweler's art. Transparent crystals processing and glass-making create the basis of ancient optical materials.

During the prehistoric period optics had a syncretic stage with ancient philosophy and religion and had a magic context. Greek and Roman antiquity was characterized by serious interest to nature of light and mechanisms of vision. The famous Greek thinkers founded the basis of geometric optics, catoptrics, dioptrics and meteors. The contribution of outstanding scientists Euclid, Archimedes and Ptolemy to optics produced a strong influence on following ages. The main achievement of middle ages was the invention of glasses, while

the main achievement of Renaissance was the development of perspective theory, demonstrating the optical knowledge penetration into fine arts technology.

In our paper the general context with selected illustrations of two our books is presented to give the common impression of collected information on civilizations history seen by optician eyes.

2. FIVE MILLENIUM OF OPTICS: PREHISTORY

Introduction	12
Chapter 1. Sun and Life	17
1.1. Sun messenger	17
1.2. Beginnings of life	19
1.3. Light, eye and brain	25
1.4. Sun-earth interconnections	35
Chapter 2. The cradle of intellect	44
2.1. Myths, legends and symbols (fig.1)	46

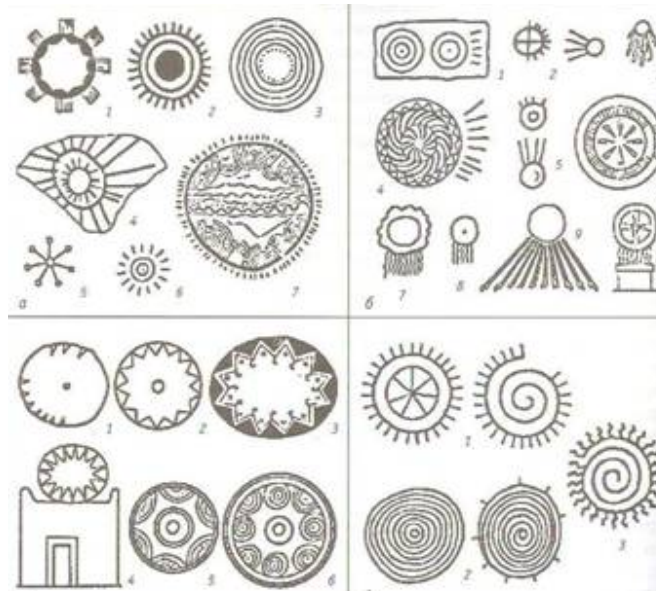


Fig.1. Sun symbols of different nations and times

2.2. Horr eye (fig.2)

59

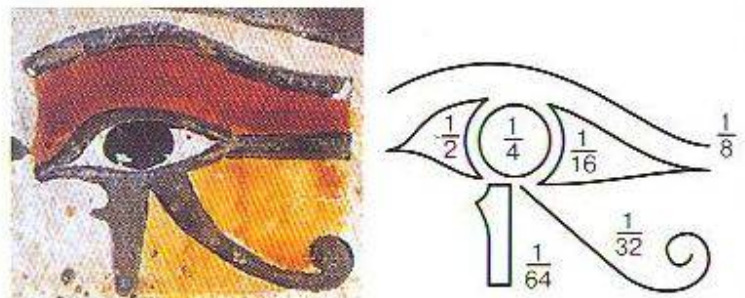


Fig.2. Horr eye and its interpretation as fractions

2.3. Images and letters

63

2.4. Sky cycles and calendars (fig.3)

78



Fig.3. Calendar marks on bones from pal eolith.

Fig.4. Stone menhir with secularized viewfinder aperture

Chapter 3. Megalithic viewfinders

100

3.1. Megalithic civilization and stone viewfinders (fig.4)

100

3.2. Linear backing. Menhirs, leis and stone ranges

109

3.3. Viewfinders with secularized aperture. Dolmen and dromoses

121

3.4. Cromlechs and horizon observatories

141

Chapter 4. Gnomons and ancient temples orientation

164

4.1. Gnomons as elements of reversal backing (fig.5)

165

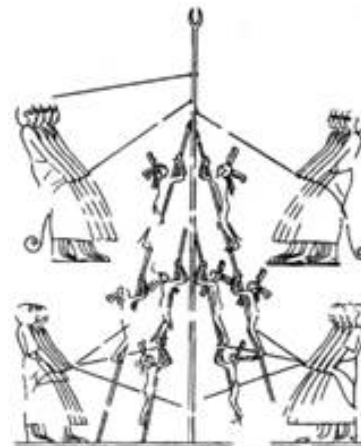
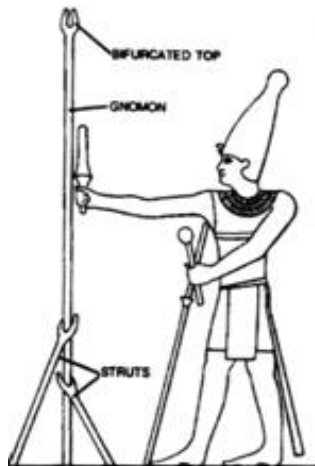


Fig.5. Gnomons in ancient Egypt

4.2. Sacred symbols of ancient viewfinders

176

4.3. Temple complexes orientation in Europe and Asia

191

4.4. Temples and complexes of New World

216

Chapter 5. Archaic optics: materials and elements

231

5.1. Bronze mirrors (fig.6)

231

5.2. Magic mirrors of China and Japan (fig.7)

241



Fig.6. Ancient Egyptian mirror



Fig.7. China magic mirror

5.3. Natural crystals and its processing

252

5.3. Lenses and spheres (fig.8)

262



Fig.8. Ancient crystalline lens from Ninevia, VIII BC.

5.4. First glass

273

Application. Ancient optical mysteries

282

1. Mystery of megaliths

282

2. Pyramids, Orion constellation and Zodiac cycles

284

3. Myths of ancient Egypt and Arcaim

286

4. Viewfinders for skies

289

5. Ancient telescope (fig.9)

290



Fig.9. Ancient telescope? Fig.10. Quartz skull illustrate HT handling

6. Quartz skulls (fig 10).

Conclusion

294

Literature (295 pos.)

296

3. FIVE MILLENIUM OF OPTICS: ANTIQUITY

Introduction

7

Part I. Principles of antique optics

26

Chapter 1. Antique mythology and light metaphysics

27

1.1. Light and vision in mythology (fig1)

29



Fig.1. Narcissus and his reflex.

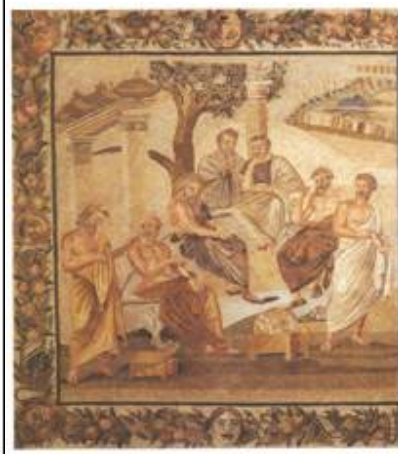


Fig.2. Plato Academy.

1.2. Metaphysics and natural philosophy of light

34

1.3. Color symbolism and antique chromatism

41

Chapter 2. Main stages of scientific knowledge evolution

52

2.1. Classification of scientific disciplines

54

2.2. Main stages of antique science (fig.2)

59

2.3. Optics among antique disciplines

92

2.4. Structure of antique optics

96

Chapter 3. Physical theories of visual perception

104

3.1. Extramission (fig.3)

111

3.2. Intramission

114



Fig.3.Ocular beams

3.3. Sinaugogja and sinestasis	121
3.4. Accidensia	132
3.5. Color's nature and color perception	136
Chapter 4. Vision physiology and psychology	148
4.1. Vision physiology. Eye models (fig.4)	150

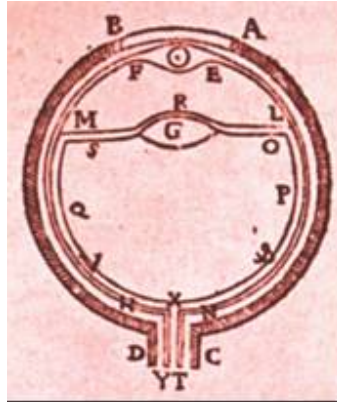


Fig.4. Galen's model of eye

4.2. Vision psychology. Optical illusions	165
4.3. Vision and cognition	173
Part II. Mathematical principles of optics	190
Chapter 5. Studies of direct vision	191
5.1. Optics of vision	194
5.2. Direct vision in Euclid "Optics"	201
5.3. Direct vision in Archimedes and Hero "Catoptrics"	206
5.4. Direct vision in Ptolemy "Optics"	209
5.5. Illusions of direct vision	216
Chapter 6. Catoptrics	220
6.1. Euclid's catoptrics	222
6.2 Archimedes' and Hero's catoptrics	227
6.3. Catoptrics theorems in Ptolemy "Optics"	230
6.4. Multiple mirror systems and burning mirrors	241
6.5 Archimedes' burning mirrors (fig.5)	248



Fig.5. Antique mosaic with the scene of Archimedes death

Chapter 7. Dioptrics	257
7.1. Ptolemy's theoretical analysis of refraction	260
7.2. Ptolemy experiments with light refraction	262
7.3 Atmosphere refraction	268
7.4. Localization of refractive images and their distortion	270
Chapter 8. Meteors	276
8.1. Aristotle's Meteorologica	279
8.2. Theory of humid meteors	283
8.3. Theory of circular meteors (fig.6)	286



Fig.6. Antique mosaic with rainbow

8.4 Theory of visual rays for study meteors	291
Part III. The beginning of applied optics	297
Chapter 9. Optical materials, elements and technologies	298
9.1. Bronze and mirrors (fig.7)	299



Fig.7. Fragment of vase decoration



Fig.8. Intalia

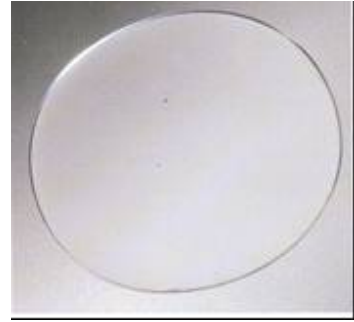


Fig.9. Antique crystal lens

9.2 Optical crystals and jewelry produces (Fig.8)	304
9.3. Crystal lenses (fig.9)	308
9.4. Schliemann lenses and Nero monocle	313
9.5. Crystal spheres. Antique telescope	317
9.6. Glasses and decoration produces	322
9.7 Mosaics from smalt	331
Chapter 10. First optical instruments	341
10.1. Gnomonic	344

10.2 Evolution of viewfinders	356
10.3. Lamps	364
10.4. Lighthouses and light telegraph	369
10.5. Imaging optical systems: myth or reality?	375
Chapter 11. Optics and arts	382
11.1. Paintings (fig.10)	385



Fig.10 Fragment of antique vase decoration

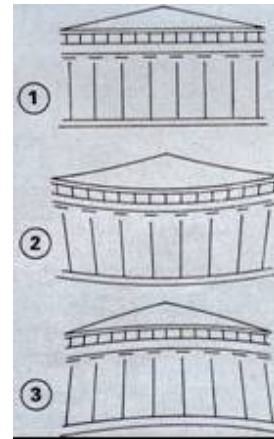


Fig.11. Optics in architecture

11.2. Scenography	391
11.3 Sculpture	396
11.4 Architecture (fig.11)	398
11.5. Theatre	404
Conclusion	413
Applications	440
Archit and optics	440
Lucretius and vision	444
Theophrast	458
Literature (393 pos.)	464

We hope that brief review will give the common impression about the context of our books. The conference on education and training in optics and photonics at Technium OpTIC at St. Asaph is a good opportunity to discuss possible profit of translating two volumes of "FIVE MILLENIUM OF OPTICS" into English. The authors use the study of optics history for education in optics and photonics themselves and recommend other specialist to follow their practice.