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Through A Cracked Lens: Alternate Views Of Optical Microscopy Part III: Galilean Microscopes.

Mark W. Lund, PhD, MOXTEK, Inc.

The first man-made optical instruments were the looking glass, the magnifying glass and the burning glass. These were known by the fifth century BC. The next advance was eighteen centuries later when similar positive lenses were used to correct presbyopia. As lens making technology advanced to fulfill this demand, negative lenses were invented and used to improve the vision of near sighted people. Soon there were spectacle shops dotting Europe, and it was inevitable that people would start to play with combinations of lenses. This all came together at the end of the sixteenth century when the microscope and the telescope were invented in several places independently.

Since the glass components necessary to make microscopes and telescopes had spread to a wide range of places in a short time it is not surprising that the history of invention is uncertain. Even experts disagree about the story but it was something like this:

> Spectacles were invented about 1280 AD. This was a money making technology and, as a result, the technology was closely held. For about 250 years the art of making spectacles gradually spread and improved. The first book on the art and science was published in 1521, and accelerated the spread of optical technology.
>
> In 1535 Fracastoro of Verona wrote "If anyone should look through two spectacle lenses, one being superimposed on the other, he will see everything much larger and nearer," and goes on to describe what could be the view through a telescope.

In 1609 Galileo heard of a telescope invented in Holland and within a day had perceived the nature of the invention and built his own. Soon he also made a microscope. Galileo did not invent the microscope or the telescope, but did put their design on a scientific footing and was responsible for the telescope's popularization.

The great discovery was more than putting two lenses together. It also required recognizing the potential of each instrument, and then persisting until the potential was realized. Remember that Galileo's successful telescopes were very long and had small lenses. One of his existing telescopes is four feet long and has objective lens of one inch clear aperture. This telescope has a virtual exit pupil two millimeters in diameter four inches away from the eye. Since the exit pupil is in front of the eyepiece the view through it would be a large black field with a small bright spot in the middle about one degree wide. This telescope had about 14 power, and had such a small field of view that a man's head would fill it at 700 feet (200 meters).

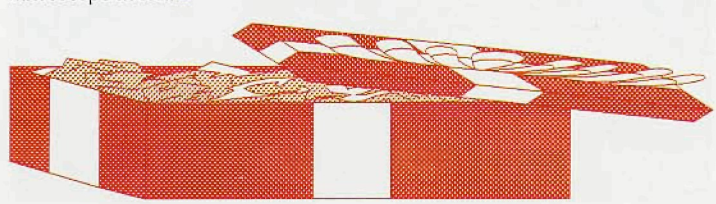
I can imagine that early experimenters could easily get two or three power by holding the lenses in their hands, but it was just a curiosity. To get a useful telescope with a power of 10 or 30 with their crude lenses actually pushed the optical technology of the time. It also required both insight from careful experimentation and persistence in making such a system work.

The Galilean telescope consists of two lenses--the objective lens of positive power, and an eyepiece of negative power. This type of telescope was probably invented in the Netherlands. It was popularized by Galileo, who built one soon after hearing of its discovery in Holland. This type of optical system is still in use. It is still used in inexpensive "field glasses," and (reversed) in camera viewfinders. Because the eyepiece is a negative lens the exit pupil is virtual, and is located between the objective and eyepiece.

Not many people realize that this same optical system can be used as a microscope. In fact the same lenses used in a Galilean telescope can be used to form a microscope by increasing the distance between them. To reduce aberrations, Galileo's telescope objectives had long focal lengths. The minimum length for a Galilean microscope was about four times the objective focal length, so it is not surprising to find mention of a microscope built by Galileo that was six feet long and one inch in diameter. The first practical compound microscopes used the short focal length magnifying glasses of the day with a negative eyepiece. Soon the advantage of a positive power eyepiece was discovered by Fontana, which Galileo and others quickly adopted.

For a period of sixty years compound microscopes were made and used mostly as a curiosity, mostly because their owners did not know how to use them effectively. High power was not necessarily needed in those days, since there was much to be discovered at low powers. It is hard in modern times to imagine what vistas magnifications of ten or twenty times opened up. No one had ever seen the hairs on a fly's leg, or the hooks on a bee's foot. Robert Hooke in about 1665 solved the question of why cork was so light and spongy by seeing the closed but empty cells (in fact he named them "cells"). Just as in astronomy it only required 10-30 power to discover the mountains on the moon and the moons of Jupiter, many important discoveries were just outside the resolution of the naked eye. Just a slight increase in the natural resolution of the eye was required, and as people learned to use them, the Galilean and Fontana microscopes made significant advances in scientific endeavors.

Now, as well as then, the instrument is necessary, but not sufficient. It is still necessary to learn how to use the instrument, have faith in its potential, and to develop techniques to use it effectively. Galileo was the one who took the telescope, developed its theory, and proved it practical. He also used his theory to make microscopes, but it fell to Hooke and Leeuwenhoek to prove the microscope useful.



COMING EVENTS

✓ Jan 3/5 '96: College Park, Md
Jan 10/12 '96: New Haven, CT
Jan 25/27 '96: San Diego, CA
March 5/7 '96: St. Louis, MO
July 1/3 '96: Hmilton, MT
Aug 7/9 '96: Madison, WI
Microwave Workshop - Tissue Processing for TEM. (Ted Pella, Inc.) Kathy Stangenberg: (800)237-3526 (not CA), (800)637-3526 (CA only).

✓ Jan 3/6 '96: **Winter Workshop on Electron Diffraction and Imaging of Surfaces.** (AZ State Univ). Scottsdale, AZ. Sharon Willison, Arizona State Univ, Ctr for Solid State Sci, Box 871704, Tempe AZ 85287.

✓ Feb 5/9 '96: **14th Australian Conference on Electron Microscopy (ACEM-14) & 1st Meeting of the International Union of Microbream Analysis Societies (IUMAS).** Sydney, Australia. Maret Vesk: 61-2-351-2351, Fax: 61-2-552-1967, eMail: maret@emu.su.oz.au

✓ March 3/8 '96: **Pittcon '96.** Chicago, IL (412)825-3220, Fax: (412)825-3224.

✓ March 18/22 & March 25/29 "96: **Practical Aspects of Scanning Electron Microscopy (PASEM 96).** (Univ of MD). Tim Maugel: (301)405-6896, Fax: (301)314-9358.

✓ April 8/12 '96: **MRA Spring Meeting** (Material Research Society). San Francisco, CA. (412)367-3003, Fax: (412)367-4373.

✓ April 9/12 '96: **SCANNING '96.** (Foundation for Advances in Medicine and Science, Inc.) Monterey, CA. Mary K. Sullivan: ((201)818-1010, Fax: (201)818-0086, eMail: fams@holonet.net

✓ April 21/25 '96: **18th International Conference on Cement Microscopy.** (ICMA) Houston, TX. Louis A. Jany: (610)926-1024, Fax: (610)926-1906/

✓ May 11/16 '96: **Scanning Microscopy, Cells and Materials, and food Structure 1996 Meeting** (Scanning Microscopy International). Bethesda, MD. (708)529-6677, Fax: (708)980-6698.

✓ June 4/7 '96: **Protocols in Microscopic Imaging, Immunocytochemistry and Image Analysis.** (Geo. Washington Univ.) Washington, D.C. Fred G. Lightfoot: (202)994-2881, Fax: (202)994-8885.

✓ ***Lehigh University Microscopy Short Copurses.*** Bethlehem, PA. Prof. David Williams: (610)758-5133, Fax: (610)758-4244, eMail: inter-SEM@lehigh.edu

June 10/14 '96: **Scanning Electron Microscopy and X-ray Microanalysis.**

June 17/20 '96:

Advanced Scanning Electron Microscopy with Digital Image Processing.

Quantitative X-ray Microanalysis of Bulk Specimens and Particles.

Analytical Electron Microscopy, Analysis of TEM Specimens.

June 18/20 '96: **Atomic Force Microscopy and Other Scanned Probe Microscopies.**

✓ June 24/28 '96: **12th Annual Short Course on Molecular Microspectroscopy.** (Miami Universtiy). Miami University: (513)529-2874, Fax: (513)529-7284

✓ July 1/5 '96: **6th Asia-Pacific Conference on Electron Microscopy.** (Chinese Univ. of Hong Kong). Ms. Karina Ng: (852)28666733, Fax: (852)25286045.

✓ July 2/4 '96: **MICRO '96** (RMS), London, U.K. 44 1865 248768, Fax: 44 1865 791237

✓ July 4/19 '96: **43rd International Field Emission Symposium.** Moscow, Russia. Prof. Alesander L. Suvorov: (095)125 96 91/(095)125 34 39, Fax: (095)34 39, eMail: surorov@cl.itep.ru

✓ July 22/25 '96: **INTER/MICRO-96.** (McCrone Research Institute) Chicago, IL. Nancy Daerr: (312)842-7100, Fax: (312)842-1078

✓ July 27/August 4 '96: **3D Microscopy of Living Cells** (Univ. of British Columbia). Vancouver, BC, Canada. Dr. James Pawley: *(608)263-3147, Fax: (608)265-5315, eMail:* JPAWLEY@macc.wisc.edu

✓ 8/17 August '96: **17th Congress and General Assembly of the International Union for Crystallography.** Seattle, WA. Prof. R.F. Bryan, Univ of VA.

✓ 11/15 August '96: **MSA/MAS/MSC Joint Annual Meeting.** Minneapolis, MN MSA Business Office: (508)540-5594/(800)538-3672, Fax: (508)548-9053.

✓ 26/30 August '96: **EUREM '96.** University College, Dublin, Ireland. Prof. Martin Steer: 353-1-7062254

✓ 26 Sept/2 Oct. '98: **14th International EM Congress.** Cancun, Mexico. Miguel Jose Yacaman: Tel./Fax: 525-570-85-03

Sixth Asia-Pacific Conference on Electron Microscopy

Concerning this conference, it appears that erroneous information has been published by this newsletter, and other publications, concerning both the date and contact information. The conference will be held in Hong Kong on July 1-5, 1996 and information may be obtained from the Conference Secretariat, Ms. Karina Ng: Tel.: (852)28666733, Fax: (852)25296045.

As of 30 November 1995, more than 20 major microscopy manufacturers have reserved exhibit space in order to present their latest instrumentation, equipment, supplies and services.