Stereomicroscopes: Part 1

Understanding Stereoscopic Vision and the Evolution of Stereoscopic Devices (5th Edition)

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Figure 1. Some stereomicroscopes

Introduction

Although not as widely recognized as standard biological compound microscopes, stereomicroscopes are widely used.

Stereomicroscopes and Entertainment Media

In addition to their real world uses, some discussed in this paper, they are often seen in television shows and movies, particularly those containing elements of forensic science. For example, the American Optical (AO) Cycloptic® microscope with its unique appearance (discussed in more detail in the CMO section), and its distinctive Galilean (discussed later) drum markings has been used in several US TV shows. This includes, possibly the most popular TV drama series of its time, *CSI (Crime Scene Investigation)*, (2000 -), where it was used by Supervisor Dr. Gil Grissom, Ph.D. Olympus SZ series stereomicroscopes are seen on *CSI:NY (Crime Scene Investigation: New York)*, (2004 – 2013). On *Bones*, (2005 -), an Olympus SZX7 is used by one of the show's continuing characters, entomologist Dr. Jack Hodgins, Ph.D. On *Body of Proof*, (2011–2013), the American TV series that starred Dana Delaney as Dr. Megan Hunt, M.D., Dr. Hunt is seen using a stereomicroscope. Reference to the stereomicroscope is made in *Crossing Jordan*, (2001–2007), where the lead character is Dr. Jordan Cavanaugh, M.D., and in *Rizzoli & Isles* (2010 -), titled from its main characters Homicide Detective Jane Rizzoli and Chief Medical Examiner of the Commonwealth of Massachusetts Dr. Marua Isles, M.D.

A Leica MZ series stereomicroscope appears on the BBC's series *Sherlock* (2010 -). *Sherlock* is a modern dramatization of Sir Arthur Conan Doyle's famous detective, and a Leica stereomicroscope is often used by the title character, Sherlock Holmes. In this series the images, which appear to be seen through the Leica MZ series stereomicroscope, are often created using 'artistic license' and can be computer simulations or scanning electron microscope (SEM) photographs. A trinocular Zeiss Stemi stereomicroscope appears in the British TV series, *Rosemary & Thyme* (2003 - 2006), where it is used by named series co-star Rosemary Boxer.

It is likely camera distributors pay for product placement and display, as camera names are often prominently visible in movies and on TV. However, although they are relatively ubiquitous in forensic dramas, these rarely display the names of the stereomicroscopes used, and if they are present, the names and logos are often blurred or otherwise obscured.

Coverage and Balance

In this paper, I have tried to be comprehensive and balanced as regards the history of stereo vision, instruments, stereomicroscopes and stereomicroscopy. This coverage has depended upon:

(1) The help of technical staff still employed or retired from microscope manufacturers. However, some stereomicroscope manufacturers are no longer in business. For many of these companies, only limited information is now available. In addition, some makers merged with others, after these mergers some business contracts, manuals, instructions, and other information was "tossed out".

(2) Available printed resources e.g., manufacturer or reseller brochures, manuals, and books contemporary to the time many of these instruments were made, and more modern texts, journals, and on-line resources, are the sources I have relied upon where companies no longer exist or have merged, and manufacturer personnel are no longer available.

(3) Many fellow microscopists and microscopy enthusiasts were kind enough to share information about their instruments and stereomicroscopy, and this knowledge has helped make this paper more accurate and comprehensive. These individuals, where anonymity was not requested, are identified in the "Combined References and End Notes" section of the paper.

Background: The Compound Microscope

In this paper, the term "compound microscope" is restricted to mean a standard "non-stereoscopic" monocular or binocular microscope, although most stereomicroscopes are also compound microscopes

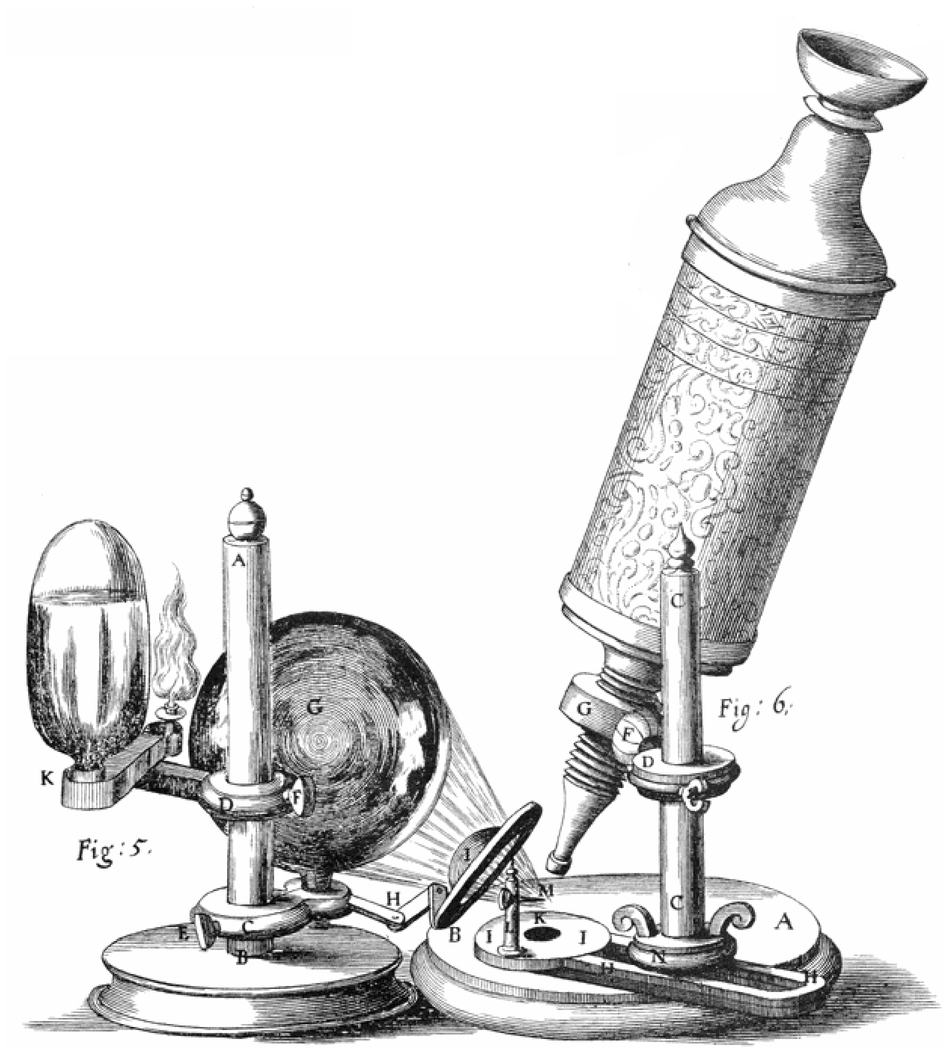


Figure 2. Robert Hooke Microscope c. 1665 used reflected rather than transmitted light

Most compound microscopes, metallurgical microscopes being an exception, use objectives designed for specimens mounted on slides and enclosed under cover slips. Objects are commonly flattened by cutting into thin sections, so they can be viewed with transmitted light. This light passes through the subject before it enters the objective. In contrast, stereomicroscopes view most objects using incident light. That is, light is reflected from an object before it enters the lens. Early compound microscopes were an exception. For example, Hooke's microscope of 1665 used reflected light, Fig. 2.

Figure 3. AO high N.A. 0.95 APO Objective

Later compound microscopes usually used transmitted light. For high-resolution imaging, it is critical to correct for coverslip thickness. In the recent past, top quality, and expensive, apochromatic (APO) lenses, e.g., Fig. 3, had correction collars. This allowed for the optical adjustments required on high quality, high numerical aperture lenses to account for variations in coverslip thickness. The Royal Microscopical Society (RMS) standardized coverslip thickness at 0.17mm (the current standard for No. 1.5 coverslips). This standardization significantly diminished the need for correction collars on objectives.

However, owing to coverslip manufacturing variations, high magnification, and high N.A. objectives can still benefit from the presence of correction collars, which can adjust for potential optical aberrations.

Many stereomicroscopes, and comparison microscopes (described in the section to follow), have dual objectives designed for viewing without cover slips. They are designed to view objects at relatively low magnifications, typically 10x - 40x. Some of the more expensive stereomicroscope use APO optics to reduce image degradation.

For most stereomicroscopes, working distance (the distance from the bottom of an objective to the in-focus area of an object) and depth of field are relatively large. Resolution and working distance typically have an inverse relationship. Stereomicroscopes provide microscopic views of the world without the need for complex object preparation. Because of their large field of view they can give us "in context" views of objects that would otherwise be impossible to obtain.

As M.C. Cooke said, " ... we may be permitted to recommend the novice always commence the examination with the lowest power of his microscope ... the greatest satisfaction will always be derived from a great practical use of low powers". Although this was said for compound microscopes, it is clearly applicable to stereomicroscopes.

The Comparison Microscope

In 1911 W. & H. Seibert marketed the first comparison microscope, designed by chemist W. Thörner for food quality control. This was followed shortly by comparison microscope models from other German makers, such as Leitz, and U.S. manufacturers (Mappes, 2005). Pictures of a Seibert comparison microscope can be seen on-line at the *Museum optischer Instrumente* (Mappes, 2005-2006).

Seibert's comparison microscope used two substage mirrors. Similar dual mirrors had already been used by Riddell (discussed later in this paper) c. 1853. (Author's note: dual mirrors can be found on some relatively modern stereomicroscopes, e.g., by British manufacturers Vickers, and Watson.

Figure 4. Bausch and Lomb Comparison microscope. c. 1929 front View

Although neither a stereo nor a standard compound microscope, the comparison microscope can be considered an intermediate instrument between the typical biological compound microscope and Greenough stereomicroscopes (Greenough's design is discussed in later).

Similar to a compound monocular microscope, a comparison microscope provides a single image of each object viewed.

Like the Greenough stereomicroscope, to be discussed later, it has two objectives. However, unlike either of these microscopes, it looks at two different objects at the same time. As its name implies, it is used to compare objects.

Figure 5. Bausch and Lomb Comparison microscope right-side view

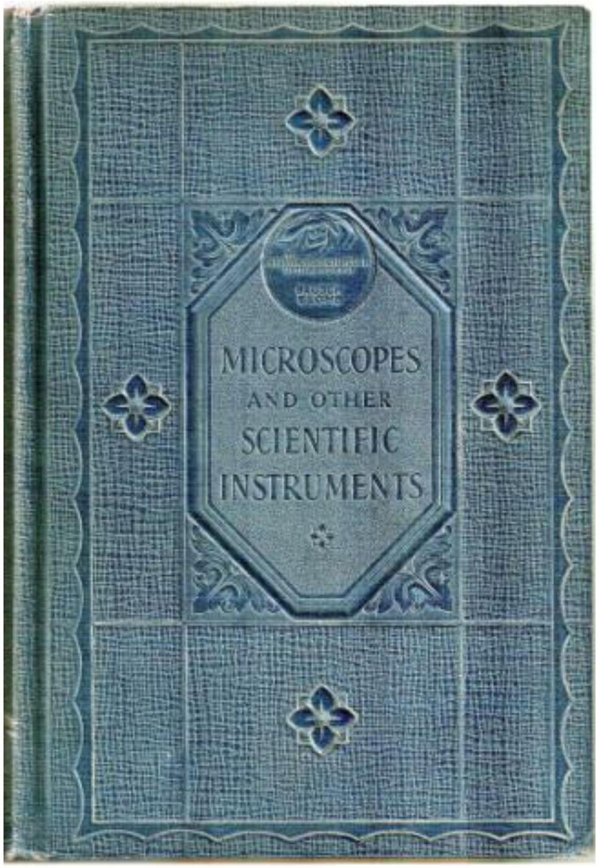


Figure 6. Bausch & Lomb's 1929 hardcover catalog

Perhaps this extract from Bausch & Lomb's (B&L's) 1929 *Microscopes and Other Scientific Instruments* book, Fig. 6, best describes this instrument.

> *The Comparison Microscope makes possible the comparison of any two objects that can be brought within its field, which are seen in juxtaposition through a single eyepiece. It is particularly useful to the technical expert who seeks to compare under the microscope substances, surfaces or colors. Affording, as it does, a means of accurate investigation and of ocular demonstration before courts or jury, it is of great assistance to the examiner of disputed or suspect documents.*
>
> *It is especially adapted for the examination of inks, colors, erasures, changes, interlineations, and overwriting, and for the comparison of disturbed and undisturbed paper surfaces, pen, and pencil points, the tint, texture, and condition of paper surfaces, the texture and quality of typewriter ribbons, written and printed characters, and type faces.*
>
> -- (Bausch and Lomb, 1929)

In 1929 the comparison microscope shown in Figs. 4 and 5, with 2x objectives and 10x Ramsden eyepieces sold for USD $80.00. Other paired objectives were available for $11 and $17 respectively.

Many modern examples of comparison microscopes are often purpose-built for specific functions. A modern example is shown, in Fig. 7.

The Yuken Hydraulics "Microscopic Inspection Device" (Hagan, 2011) is a comparison microscope used to measure "pollution" of hydraulic fluids. Hydraulic fluid samples are soaked up and dispersed by a membrane filter under one of the lenses. The contamination of the dispersed fluid is compared to a standard contamination disc placed under the other objective. This device has built in illumination useable with either an AC or DC power source. It can be used on the bench top of in the field. This is a relatively heavy instrument weighing about 10 pounds.

Figure 7. A Modern Comparison Microscope

History of the Stereomicroscope

One can be excused for believing that the first stereomicroscope was designed quite recently. This is true for the first practical instruments for scientific purposes. However, over three hundred years ago, the first "stereo" microscope, was designed by a monk in the Orders of Capuchin Friars Minor (O.F.M. Cap), also known as the Capuchin Franciscans, a Catholic Order deriving from the Franciscans.

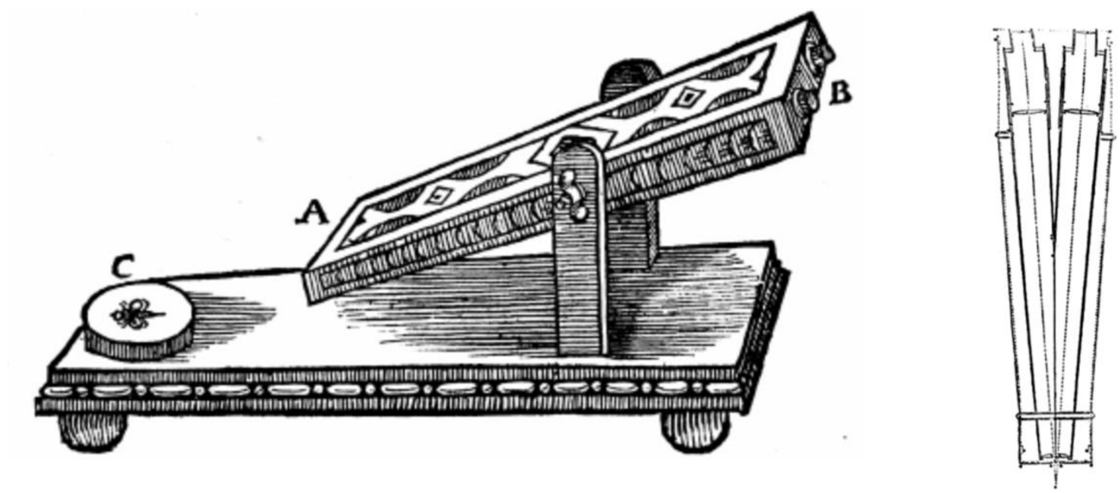


Figure 8. Père d'Orleans binocular microscope (pseudoscope) [Ref. Journal of the Society of Arts 1886]

Father (Père) Cherubin d'Orléans (Francois Lassere) designed his binocular "stereo" microscope, Fig. 8, c. 1670s, (Journal, Nov. 1886), (Cherbun, 1677). This microscope was constructed not only with dual eyepieces, but also with dual objectives, with the images to each eye reversed.

Stereo above is in quotes as this is a pseudoscopic rather than a true stereoscopic microscope (Wade, 1998), (Encyclopaedia Britannica, 1910). In a pseudoscope images appear inverted in the vertical direction, that is high points appear low and low points high. So that object points closest to the objective appear farther away and points farthest from the objective appear closer. Thus, a toothpick viewed through Père d'Orleans microscope would appear as a mold to make copies of the toothpick.

From Fig. 8, it is hard to get a sense of size. Thus, Fig. 9 is presented below. It includes a slightly later Anianus stereomicroscope built on the Père d'Orleans design. As this later version is shown in use, it gives us an appropriate sense of size.

Figure 9. Anianus microscope built on a Père d'Orleans design. Photo courtesy, and with permission of Thomas Serfling and Carl Zeiss Microscopy GmbH .

Normally right images go to the right eye and left images to the left eye to provide stereoscopic images. However, if the images sent to each eye are reversed this is no longer true. As Dr. Kurt Schwidefsky, former head of the Photogrammetry Department of Carl Zeiss Oberkochen, notes in his book (Schwidefksy, 1950), " ... if left and right images are exchanged the orthoscopic *[author: stereoscopic]* effect changes into a pseudoscopic one.

The same effect occurs if the two images seen are rotated by 180 degrees. This 180-degree image rotation is the typical case for both standard compound monocular and binocular microscopes. This can be easily seen by writing "abc" in very small letters, and looking at these letters under a standard compound microscope using the lowest magnification available. The original and its view through a compound microscope are shown below.

abc	Original text
ɔqɐ	As seen through a compound microscope

This reversal is always seen using a standard compound microscope. It is the reason when we move a slide right the image moves left, and when we move a slide downward the image moves upward. Compound microscope images are not seen in three dimensions, spatial orientation is usually unimportant, so this effect is not normally detrimental to subject investigations.

The instrument shown in Fig. 8 was not the only stereo microscope designed by Père d'Orléans. He also designed a stereo microscope made of two monocular-style microscopes and held in housing similar to a cylindrical Withering microscope. [Author aside: Dr. William Withering was famous for his use of the Foxglove plant extract, current day terminology digitalis, and its benefit to heart patients (Withering, 1765)]. Fig. 10 shows an example of the housing design of a cylindrical Withering simple monocular microscope.

As Wise, Ockenden, and Sartory (Wise, 1950) note, although the

> *... principles of stereoscopic vision were not fully understood at the time. Nevertheless, the remarkable fact remains that the author [Père d'Orleans], in his books, had expressly recommended systems giving erect images for the monocular compound microscope. Had he used [author: any of these] his ... instrument would have rendered [author: stereoscopic images].*
>
> -- (Wise, 1950)

D'Orleans' microscope was developed before the invention of achromatic microscope lenses, and at a time when simple single lens microscopes provided better images than their compound relatives.

Perhaps, because of the negative implications of this for serious scientific use, only modest development of the stereomicroscope took place over the next 150 years. The next major advance was achieved by Prof. Riddell in the U.S., c. 1850s, see below, who used prisms above the objective to divide the circle of rays coming from an objective into binocular eyepieces (Ferraglio, 2008).

However, that 1850s development would first require a greater understanding of 3D vision.

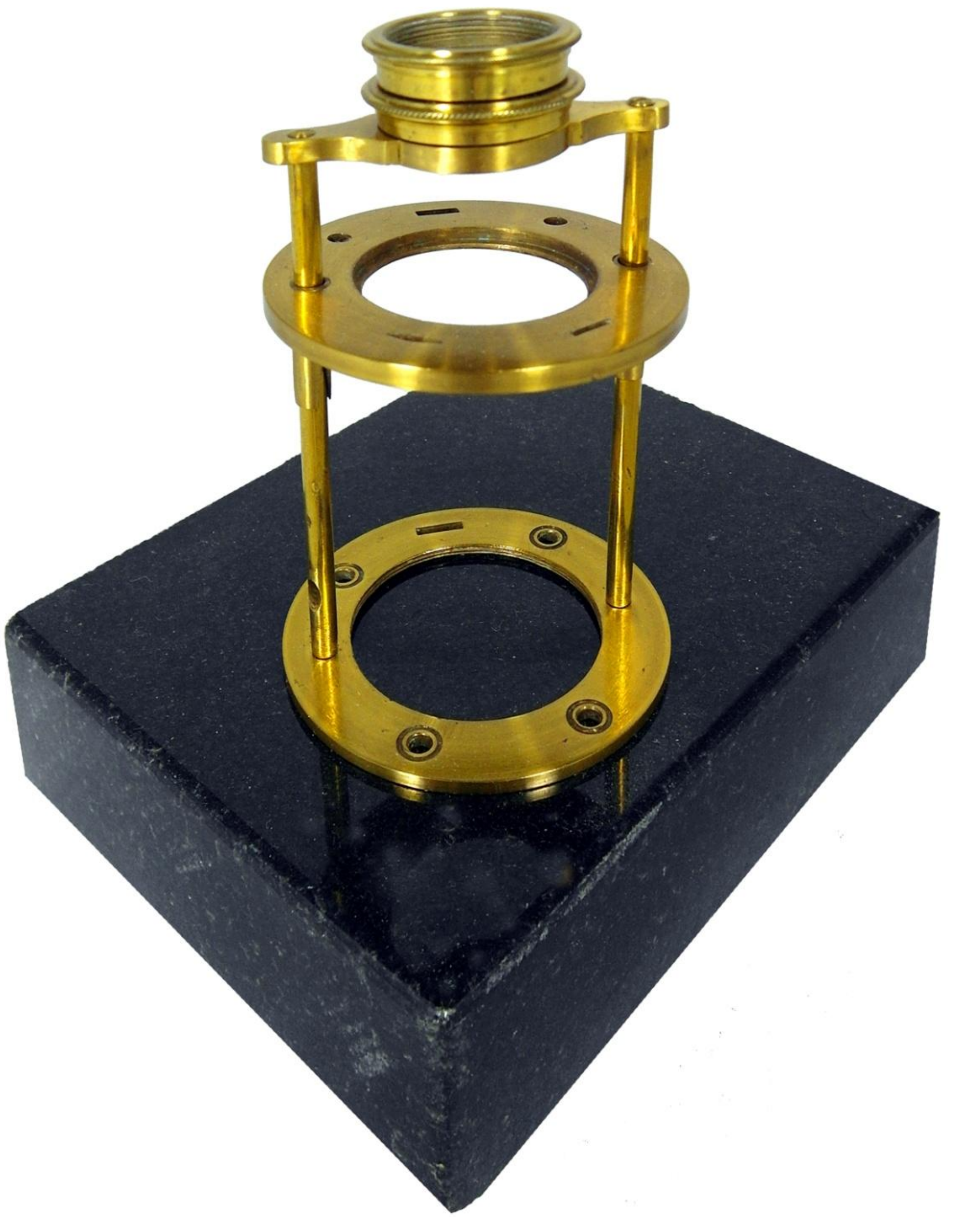


Figure 10. Cylindrical Withering microscope shown w/o accessories

Understanding Stereoscopic Vision:

Wheatstone, Brewster, and Follow-ons

As mentioned earlier, the first "stereo" microscopes were pseudoscopes, e.g., the microscope built by Cherubin d'Orleans, rather than true stereoscopic instruments. An understanding of optical principles gradually evolved. Initial work was done by the English scientist Sir Charles Wheatstone, who constructed his first stereoscope c. 1832 (Wing, 1996). He documented his findings in *Contributions to the Physiology of Vision,* (Wheatstone, 1838*).* Wheatstone is perhaps best known to electrical engineers for the Wheatstone bridge (which was not his invention), to communications engineers for his work on the telegraph, to muscians for his invention of the concertina, and to cryptographers for his Playfair cipher. He was, in the best Victorian tradition, a "man for all seasons". However, he is rarely identified for his invention of the stereoscope.

It is perhaps usual to think of the development of scientific devices as moving in a straight direction to instruments that are ever more capable and sophisticated. However, this is usually not the case. The design of scientific instruments is frequently influenced by external surrounding and public attitudes at the time of their development. That is development usually does not occur in a "straight line". The stereomicroscope definitely falls into this category. Its technology grew at a time of great public excitement, and relatively widespread distribution, of the "new" Brewster stereo viewer. This arose because of the Great 1851 Exhibition (see below). This stereo excitement was likely the stimulus, at least the environment, in which the Greenough stereomicroscope was developed (the Greenough stereomicroscope is discussed later).

The understanding of stereoscopic vision, and the subsequent history of stereo devices, derives from Wheatstone's work. This work was critically important for the development of the stereomicroscope. Wheatstone's basic "discovery" was that the images of an object seen close-up were different as compared to images seen at a distance. The closer an object was the greater the differences in the image as seen by each eye. Images seen at, what is for practical purposes, infinity were identical to both eyes and gave the same impression as if seen by a single eye.

While the stereo viewers, discussed here, may initially seem only marginally related to stereomicroscopes, they were the devices that brought significant public and scientific attention to the wonders of 3D vision. They were critical to the thinking, wonderment, and understanding about what was possible. They helped shape the development of the stereomicroscope. Without their existence and the excitement they generated, the development of the Greenough-style stereomicroscope, widely used today and discussed later in this paper, would likely have been significantly delayed.

Figure 11. Brewster-style stereoscope. Courtesy, and with permission of Rainer Maertin, www.photoarsenal.com

Wheatstone's original interest in stereoscopic vision related to the development of the stereoscope. Wheatstone's stereoscope was an enormous instrument, used on a desk.

However, his optical investigations were important for their understanding and explanation of 3D.

Wheatstone's stereoscope was first developed before the widespread use of chemical photography. Thus, it was necessary for him to commission artists to draw separate, slightly different, pictures that would be perceived as three dimensional, when seen simultaneously with each eye. His papers were a major factor for the evolution of the modern stereomicroscope.

Wheatstone's original stereoscopes used mirrors and were relatively large, heavy, cumbersome, and expensive. Fortunately, his designs were shortly modified, enabling stereoscopes to be produced at a lower cost, and used with relative ease. This redesign was initially done by Scottish Scientist Sir David Brewster c. 1849. Brewster's design would likely have been ignored, as had Wheatstone's, if he had not gone to Paris and met M. Dubosoq who immediately saw the advantages of Brewster's viewer and began manufacturing it.

Dubosoq quickly realized that photographs for Brewster's viewer should be taken at the general distance that the eyes were apart. (Pellerin, 2000). [Author's aside: The process of Louis-Jacques-Mandé Daguerre, see below, had just become available. The French government acquired the Daguerre process and in 1839 gave it as a gift, "free to the world". Daguerre is considered so important in France, that his is one of the less than one-hundred names inscribed on the Eiffel Tower].

Brewster documented his work c. 1840s in two technical papers. The second paper was presented to the Royal Society of Edinburgh in 1844 (Wing, 1996). Brewster, following on the work of Wheatstone, realized that the eyes are approximately 2-1/2" inches apart, so any dual images produced and then seen with that separation would produce stereo vision. In the course of his investigations, Sir David Brewster found the mirrored viewers of Wheatstone were difficult to build and use, so he developed stereo viewers of his own design. Wheatstone's and Brewster's stereoscopes, were devices for viewing two not quite identical images to produce a 3D view.

Brewster-style viewers were made from a variety of woods, from exotic burled and bird's eye maple, Fig. 11, to more traditional woods, Figs. 13 and 14. They were popular at the time of their original manufacture, and thus made in large quantities. Many of those made in the 19th and early 20th century are still commonly available for sale today, at relatively low prices. As a major contributor to the Encyclopaedia Britannica editions of 1842 and 1860, Brewster was able to document his work for a larger audience. However, it was Queen Victoria's and Prince Albert's interest in the Brewster stereoscope at the London Exhibition of 1851 [(Fox, 2003), (Blake, 1995)] held at Hyde Park, in the Crystal Palace Fig. 12. This combined with the rise of chemical photography, c. 1834-39 by William Henry Fox Talbot, in England and in c. 1839 by Louis-Jacques-Mandé Daguerre, in France, that generated widespread public awareness, interest, and acceptance of stereo viewers and stereo photography. Photographs made using the processes of Daguerre and Talbot are known respectively as daguerreotypes, and talbotypes or calotypes. It is likely that Talbot's techniques were developed before Daguerre's.

The London Exhibition was open almost six months, and it has been estimated that 33% of the British population attended. The Great Exhibition was a way for Britain to display their achievements, many scientific, to the rest of the world. Invitations were extended to other countries to participate. It was also a way for Prince Albert and Queen Victoria to highlight the progress that occurred under her rule. The Exhibition's longer name was the "Great Exhibition of Works of Industry of All Nations", and fifty nations participated. The Exhibition is alternately referred to as the "Crystal Palace Exhibition", the "Great Exhibition", or the "Exhibition of 1851". During this time Queen Victoria called Brewster's stereo viewer (Author's aside: The Brewster viewer was made by a Paris maker, mentioned below, under the guidance of Sir David) "a marvel of the highest order" (Dinkins, 2009-2). The Exhibition was, perhaps, the single most important event in the recognition and future progress of stereoscopic activity. [Author's aside, profits from the Great Exhibition were used, following Prince Albert's direction, to fund museums in England, including London's Natural History Museum. (Shuter, 2003)]

After the Great Exhibition, many versions of the stereoscope could be found in England and across the channel in France. In the US, Holmes later designed a less expensive stereo viewer in 1861, (see below). However, until the Holmes-Bates device's introduction in the US, stereo viewers of the Brewster type were made by manufacturers, primarily, in Europe and England.

Figure 12. Exterior view of the Crystal Palace used for the Great Exhibition of 1851, as shown on early English post card, after it was moved, flags of participating nations removed, and rebuilt somewhat enlarged at Sydenham, after 1854.

For example, the three Brewster-style viewers shown in, Fig. 13, were all made in France, by *Unis France, Stereoscopes Paris*.

On the left is a less common large viewer, with its back partially tilted to show a portion of its frosted glass rear window, approximate size: 140mm deep (with focusing extended away from the body) x 160mm wide x 105mm tall). In the middle of the Fig. is a more flexible stereoscope. It contains a mirror on the underside of the lid (raised slightly here) to reflect light into the viewer. It can be used to see opaque as well as transparent images. On the right is a less expensive 3D viewer, absent the capability to view opaque images. The knobs, seen on the right and left viewers, allow the eyepieces to be moved in or away from the body for focusing.

Fig. 14 shows a Brewster-style viewer, and one of the slides used with it. This viewer is designed exclusively for 10 cm x 4.5 cm glass slides, and does not have the capability to view opaque images.

It was also made by *Unis France*, who at the time was possibly the leading European maker of Brewster-style viewers.

Figure 13. Three Brewster-style stereo viewers

Figure 14. Brewster-style dedicated glass slide viewer, and a glass 3D slide

Fig. 15 shows a turn-of-the-century microscope-styled viewer developed by Moritz von Rohr of Zeiss, Germany. It was designed using concepts of Swedish ophthalmologist (and Nobel Prize winner, 1911) Allvar Gullstrand (Zeiss, 2006). The similarity in design of this viewer to a stereomicroscope is obvious.

Figure 15. Verant Magnifier, c. Late 19th century. Courtesy and with permission, Carl Zeiss AG, (Zeiss, 2006)

The Holmes-Bates Viewer

Dr. Oliver Wendell Holmes (USA) was a frequent contributor to the Atlantic Monthly (and father of the Associate Justice of the Supreme Court of the United States, whose life is documented in the 1950 movie *The Magnificent Yankee*). He was an ardent hobbyist and enthusiast for the then recently developed viewers and views yielding three-dimensional images. (Hankins & Silverman, 1995)

He felt there was a need for a less expensive and lighter version of a stereoscope than the Brewster models available at the time. He developed a prototype for a less expensive stereo viewer, deliberately left it unpatented, and showed it to a number of Massachusetts acquaintances. The viewers he designed were, as were most of its descendants, very low power simple binocular microscopes.

One of his acquaintances, a small-scale seller of photographic items and stereo view devices, was Joseph L. Bates, who had a Boston business. Fig. 16 shows Bates' added "inventions and improvements" to Holmes' stereo viewer. This figure is from the back of one of Bates' stereo view cards, and the picture of his Boston store is from the front of another. Mr. Bates was intrigued by Holmes' work. Bates' improvements included adding a sliding focusing mechanism with wire holder, see photo. From that joint work, the popular open, covered eye hood, stereo viewer was developed.

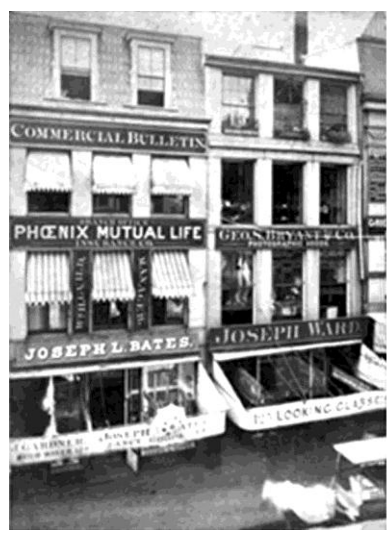


Figure 16. Bates' viewer and his Boston store from back and front of stereo view cards

After some modifications and simplifications, the Wheatstone, then Brewster stereoscopes evolved to become the Holmes-Bates parlor stereo viewers popular in the late 19th and early 20th century. This open stereo viewer, with wood or metal eye hood, is still often called a Holmes-Bates stereo viewer after its two developers. The newly designed viewers were made in large numbers, and were quite popular, possibly owing to their relatively low cost. This helped stereo viewing gain broad public acceptance (Waldsmith, 1991 and 2002).

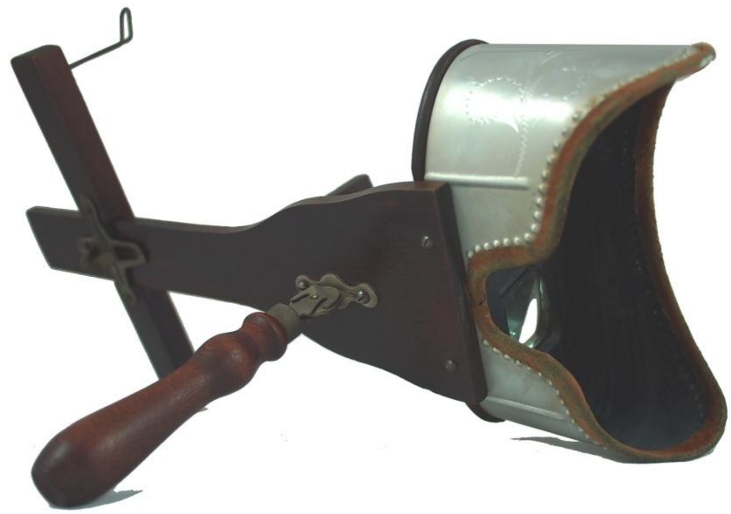
These viewers were made in both hand-held and table models, with the hand-held models being both less expensive and more popular. Fig. 17 shows a Walnut tabletop stereo viewer and a handheld stereo viewer, both were made by Bates. The topmost viewer holds a Bates stereo view card. Both viewers were made in the latter half of the 19th century**.**

Viewers sold by Bates can be identified by:

(1) a large bulbous handle to provide support when viewing, and simultaneously
(2) a Bates blind stamp, or
(3) a gilt border design with alternating icons between dual gilt bordering lines.

Figure 17. Bates (1) Walnut tabletop stereo viewer holding Bates stereo view and, (2) handheld stereo viewer

Second-hand Holmes-Bates viewers are still commonly seen for sale at relatively low prices. These viewers were popular in America for about 60 years, which explains their ubiquity.



Inexpensive stereoscopes made of wood and metal were common sights in middle and upper class households in the 20th century, their popularity gradually diminished with the rise of radio and movies.

Figure 18. 20th century (Holmes-Bates style) hand-held stereoscope. The "Monarch" model, Keystone, Meadville, PA.

The most widespread viewers and views, at the start of the 20th century, were those made by the USA's Keystone View Company of Pennsylvania. Other companies, e.g., Underwood and Underwood, and H.C. White, also produced these instruments in large quantities. However, by about 1905 Keystone was probably the world's largest provider of stereo viewers and views, and their aluminum and fabric hooded Monarch stereo viewers, Fig. 18, had the largest market share after about 1910.

Stereo viewers were in their time the primary devices that brought the distant world to local living rooms. They were the televisions and internet of their day. They allowed people to learn about the world in a way that was not possible with the two dimensional printed images in magazines. Waldsmith (Waldsmith, 1991 and 2002) provides a somewhat more extended discussion of the evolution of stereo viewers, and a detailed discussion of stereo views.

The Stereographoscope

The *graphoscope* (*infrequently spelled graphiscope*) started life as a simple low power microscope with a single large lens. It could be used to view photographs, printed text, hand writing, etc. in more detail. It was commonly made to collapse into a rectangular configuration. There are numerous examples of single lens graphoscopes made in France before the 1860s.

With the growing popularity of stereo viewers, Charles J. Rowsell of England decided to incorporate a stereo viewer with the earlier graphoscope, and he received a British patent in 1864. This combination of large lens simple microscope, i.e., graphoscope, combined with a stereo viewer eventually became known as a stereographoscope (stereo + graphoscope).

[Author's aside. There seem to be more examples of stereographoscopes that come to market from France, than anywhere else.]

Figure 19. Stereographoscope

The stereographoscope were the earliest examples of a simple, albeit very low power, monocular and binocular microscope combined in the same instrument. While Wenham's prism binocular microscope discussed below represents one of the earliest compound microscopes designed with this same capability, but for higher magnifications.

Fig. 19 shows a stereographoscope containing both the large lens, and a stereo viewer on the same front plate. Graphoscopes and stereographoscopes are still commonly available on the used market at prices similar to, or only slightly greater than, those of stereoscopic only viewers.

Although stereographoscopes may look substantial, they are typically relatively lightweight and delicate devices. They are usually inexpensively made, and easily damaged. As they do not have the eyeshade of the standard stereo viewer, they are not as easy to use, and often optically inferior. However, they were quite popular, as they display nicely, and many were made.

Some of the more expensive models were designed for impressive appearance and were built from specialty woods. They often had attractive engravings and added ornamentation. Fig. 20 shows a larger stereographoscope with engraved designs.

Figure 20. A slightly larger and more ornate stereographoscope

The terms graphoscope and stereographoscope were later used by various manufacturers, sometimes with only slight punctuation variations, e.g., grapho-scope, or stereo-graphoscope, for devices that differed considerably from the original stereographoscopes.

Figure 21. Stereo-graphoscope c. 1889

As one example, a unit identified as a stereo-graphoscope is shown in Fig. 21, It was patented in the US c. late 1880s. It is more similar to a conventional stereo viewer, as can be seen from the photograph, than the stereographoscopes discussed above. It main feature was the presence of brass mounted lenses that could be rotated to view non-stereo images.

Stereo viewers were the most ubiquitous simple stereo binocular microscopes ever made. As with the modern Greenough stereo compound microscope, see later in this paper, they view two slightly dissimilar images, which are then merged by the brain to form a 3D object.

The discussion of "Stereoscopic Vision and the Evolution of Stereoscopic Devices" is continued in Part 2.

Combined References and End Notes

(This list includes references/notes for the full paper. However, additional references may be added in later Parts)

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