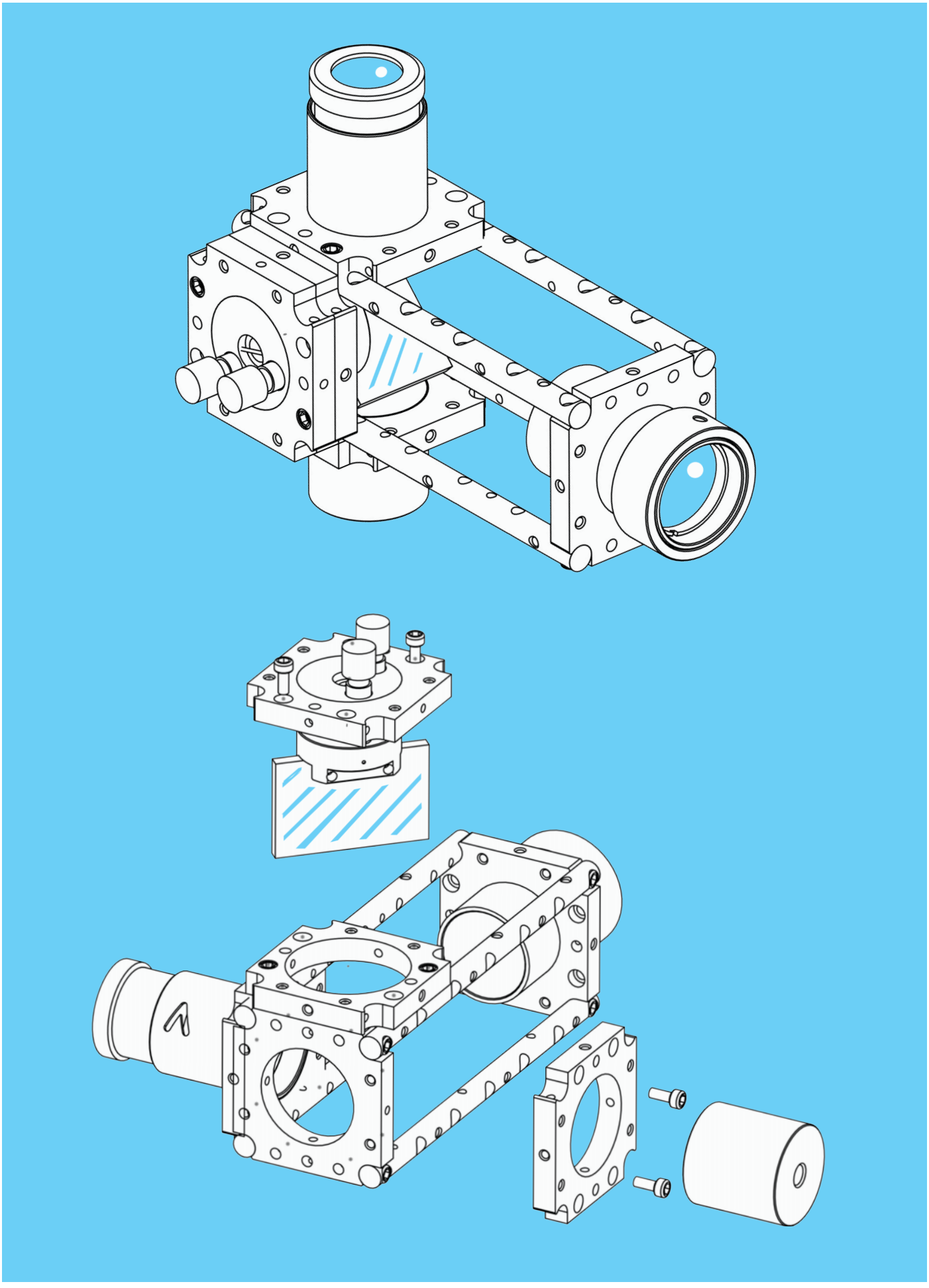
Optomechanix

Understanding Binocular Design

Jan-Mar 2021

Technical journal of OMiD, Opto-Mechanical Institute of Design



Constructing a basic telescope with Optoform 40. Building protorypes from discrete parts has been the dilema of all tinker toy inventors. With new Optoform 40, you can keep what you build as modules to construct your future projects.

Contents

OSA The Optical Society | 100 Since 1916

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Optical Society of America

OMD Opto Mechanical Institute of Design

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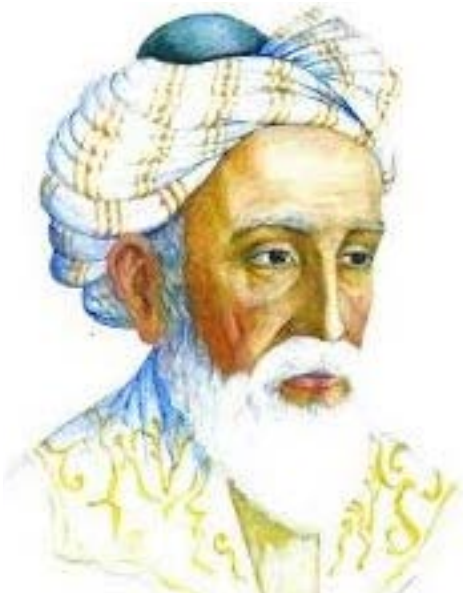


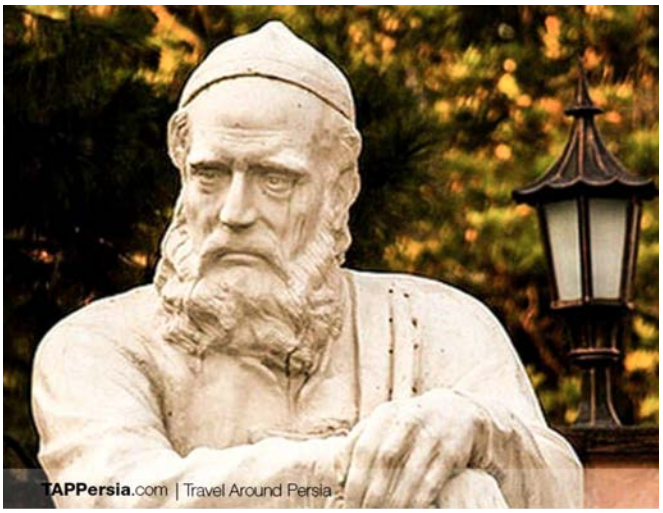
Omar Khayam, Perisan Mathematician

This issue Dedicated to:

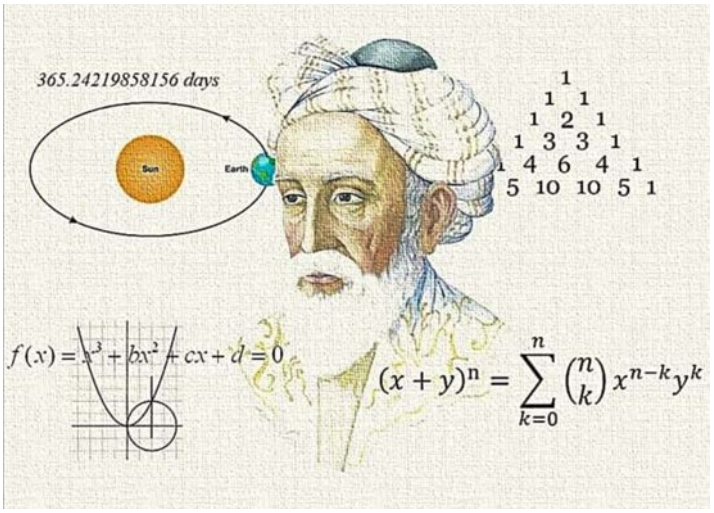
Omur Khayyam (1048, 1131), was a mathematician known in Persian history as the inventor of Lunar Jalali Calendar, the most accurate in the world. Although he was renowned as a mathematician, astronomer, and philosopher, Omar Khayyam may be best known today for his poetry. Born in Nishabur, Persia (located in modern-day Iran).

During the Seljuk dynasty, Khayyam was invited to the city of Isfahan to build a new observatory under the sponsorship of sultan Malik-Shah. For 8 years he led a team of scientists that built a star map and Khayyam measured the length of the solar year so precisely that it loses only one day every 5,000 years—more accurate than the Gregorian calendar, which loses a day every 3,330 years.Using these calculations he helped to develop the Jalali calendar, a forerunner of Iran's modern calendar.

As a mathematician, he is most notable for his work on the classification and solution of cubic equations, where he provided geometric solutions by the intersection of conics. Khayyam also contributed to the understanding of the parallel axiom.



Statute of Omar Khayam at his memorial park



Omar Khayam, and his calculation of solar calender with 11 gigits accuracy: One Solar year = 365.24219858156 days

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Optomechanix is a quarterly journal of Opto-Mechanical Institute of Design (OMiD), with technical articles for practical, hands-on opto-mechanical engineers. This magazine is privately founded.

Cover page photo: Cut section of a Zeiss binocular
Front back: Constructing a basic telescope with Optoform 40

OMiD Museum Launched: www.omidmuseum.com

Thanks to this unfortunate global slowdown in all entertainment activities, it gave us an opportunity to compile, and upload the website for OMiD museum. This was relatively easy for us because our museum is to put it plainly, all shut down! The purpose of this website is to expose our collection to the rest of the world, and to show other museums their vision could continue in this way. I hope this Covid situation will change museum's policies to allow everyone to get in virtually, and still be able to visit.

For us this was so easy because my wife, and I have been studying these artifacts, and have photographed, and documented everything in great detail. We also have this policy to take apart whatever I want to explain their inner workings. I think what Dan Meinwald, the curator of museum at California Museum of photography in Riverside did for me was so

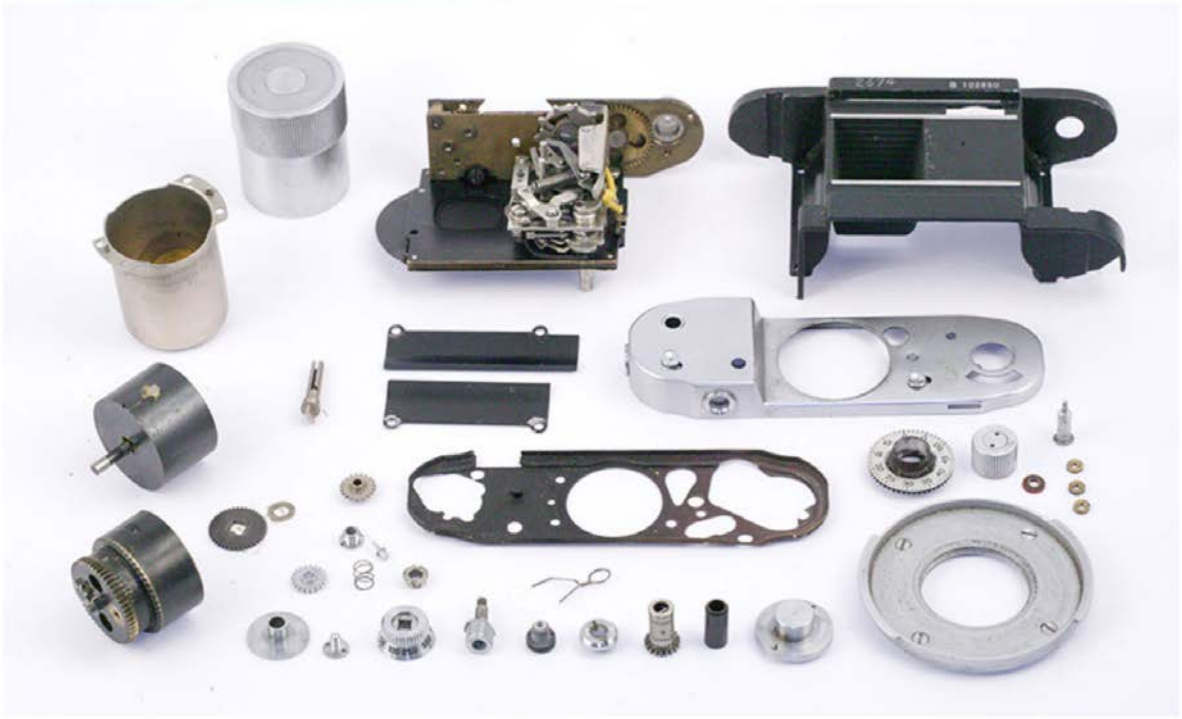
generous: They allowed me to take apart one of their most expensive Leica cameras (an original Leica 0) so I could do my article on it. I learned to do the same for whomever was interested in learning. I let anyone with proper skills to take apart what they liked to study if they were willing to publish their work. The value of these artifacts isn't really that much to us to lock them up in a cage. We need to allow learning, and spread the knowledge among our youth if we hope to produce future inventors. This reminds me that every time I visited CMP, there were always a group of elderly people, sitting around a large table, documenting each piece as volunteers. They actually did all that work for folks like me.

You'll have to reach your 60's to begin looking back and realizing what all that was about. During this public ban that everything is shut down, what could be a better time to archive everything nicely on a website? There are in fact a few advantages to this, and one is somebody from another museum may notice a piece, and a conversation might start, and an exchange of information to know more about the history, and background of some of the pieces.

Another good reason for a virtual museum is a lot of the artifacts stay behind glass displays, and no one really sees them, let alone to study them. By picking up, and photographing each artifact, the curator gets to know a little more about each piece, and gets more educated about them. I know this not true about most museums, but what I say is true about most museums having poor management. You could tell this by how disconnected many museums have generally been to the public.

I wish omidmuseum.com sets a good example for being an accessible center for learning, and being a good trustee for preserving the valuable objects of vintage era in optomechanics.

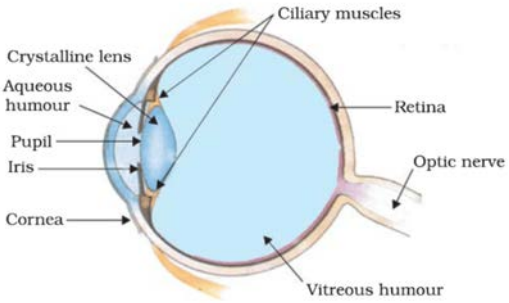
Ali Afshari
Contributing Editor,
Optomechanix



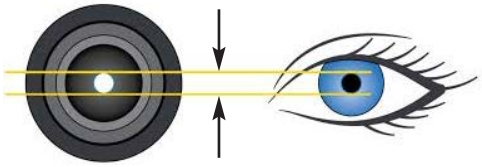
Robot camera page on the website

Cover Article: Understanding Binocular Design

Binoculars are so appealing in their optomechanical design. We discussed the disassembly of a Leitz binocular in the last issue, and in this special issue, we'll cover their prism works. The first thing to know about binoculars is they are designed to work with the human eye, and this often limits their performance. For example, it is assumed that the bigger the front objective, the better they are to look through but as it will be shown here, that's not necessarily true. It will all makes sense when we study the exit pupil of their eyepiece.



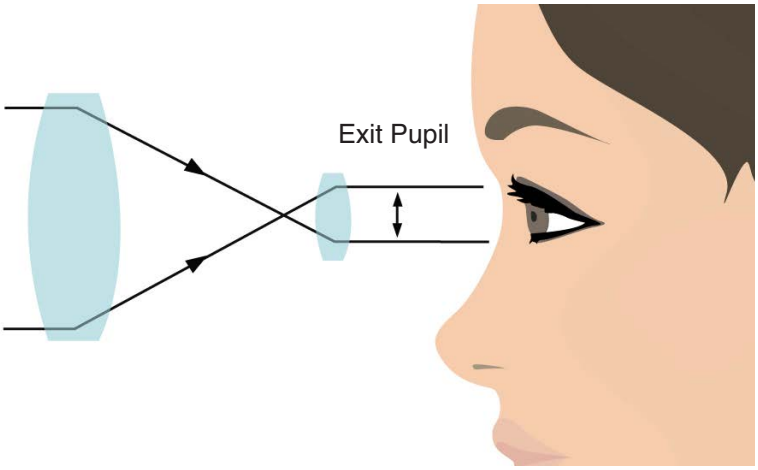
The exit pupil of binoculars is the bright circle you'd see when you hold them at a 30 cm distance from the eyes, looking through their eyepiece at bright light (right). The bigger the objective lens, and the less the magnification, the larger is the exit pupil, calculated by:

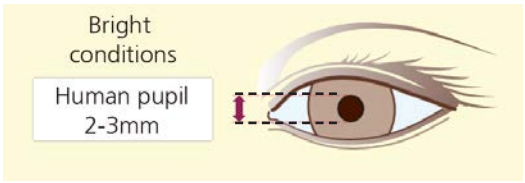


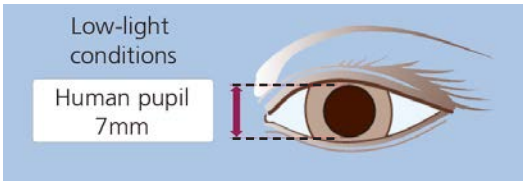
Eyepiece

Exit pupil = The effective diameter of the objective lens ÷ Magnification
With 8x50 binoculars, the formula is 50 ÷ 8 = 6.25
Therefore, the diameter of the exit pupil is 6.25 mm

However, what actually enters the eye is limited to its pupil diameter.







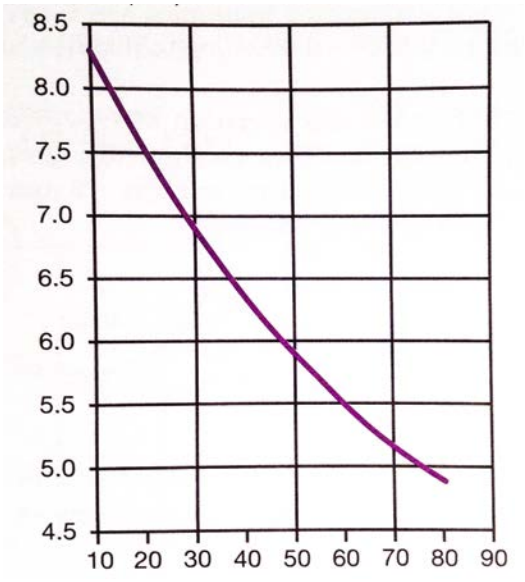
There are several parameters that would influence how much of the light through the eyepiece actually enters each eye. In bright light conditions, the diameter of the eye pupil only 2-3 mm, and by working the above formula backwards:

The effective diameter of the objective lens = Exit Pupil x Magnification
3 mm x 8 = 24 mm is the effective diameter of the objective lens.

This means during day time, the brightness of 8x50 binoculars would be equivalent to a compact 8 x 24. Larger objective binoculars like the 8x50 would only be useful when the eye's pupil are much larger in low light conditions.

To make this worse, the diameter of human eye deteriorates by age (right graph, and weakening of Ciliary muscles above, right). So at night time, your pupil is not really 7 mm in diameter. If you are 60 years old, it's only 5.5 mm, so a large portion of the system exit pupil is then unused. Read the article by Omid Jahromi on page 13 to see what actually happens in twilight.

Dark Adapted Pupil Diameter (mm)

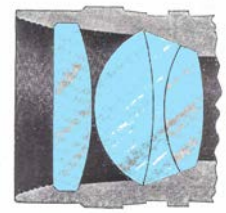


Now let's cover the fun part of binocular design, and it's their prism work. The prism work in binoculars starts very creative, and fun but then gets complicated when polarization, and wave optics are considered.

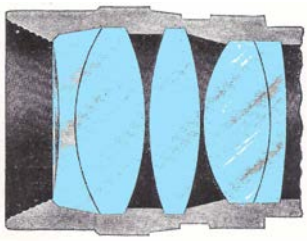
Prism Binocular Designs

1 The Classic Porro Prism

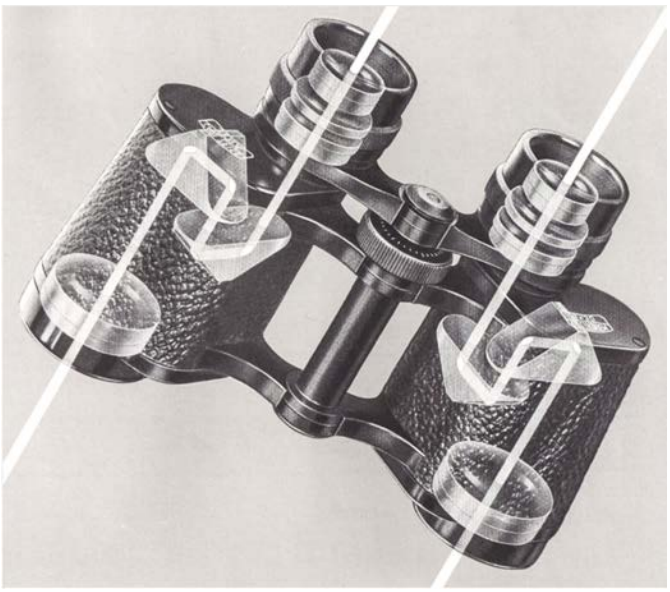
Prism binocular design have evolved since early 1920's with various image erecting designs (opposite page). The most common design is the porro prism design (right) that Carl Zeiss developed through the 1950's. The advantage of the classic design was it increased the eye distance, hence increasing the stereoscopic effect in viewing, which is also multiplied by magnification.



Zeiss Koenig Eyepice



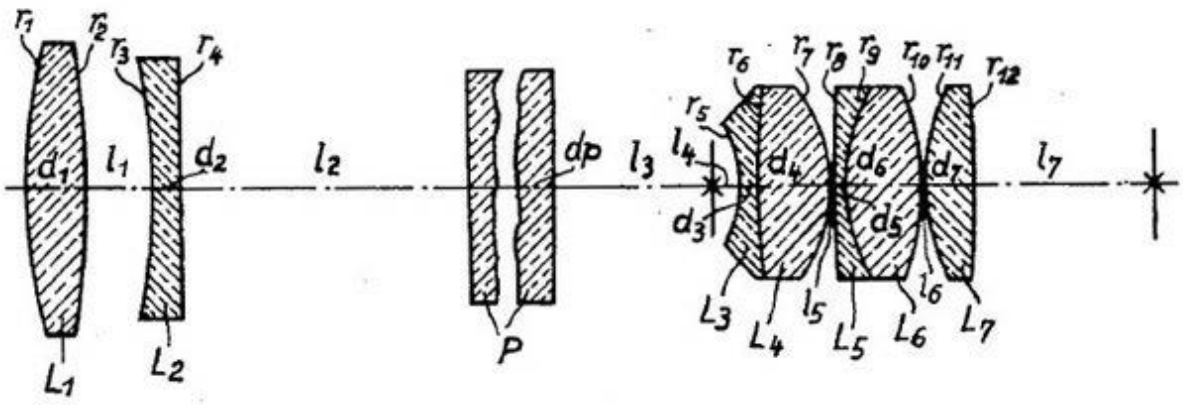
Zeiss Erfle Eyepice



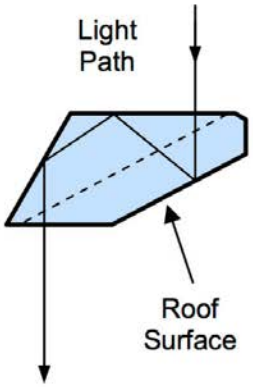
July 10, 1962 H. KÖHLER ET AL 3,043,194

BINOCULARS

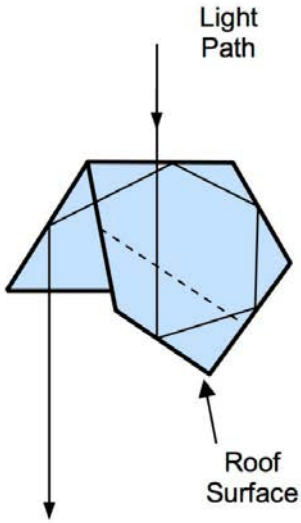
Filed March 6, 1958



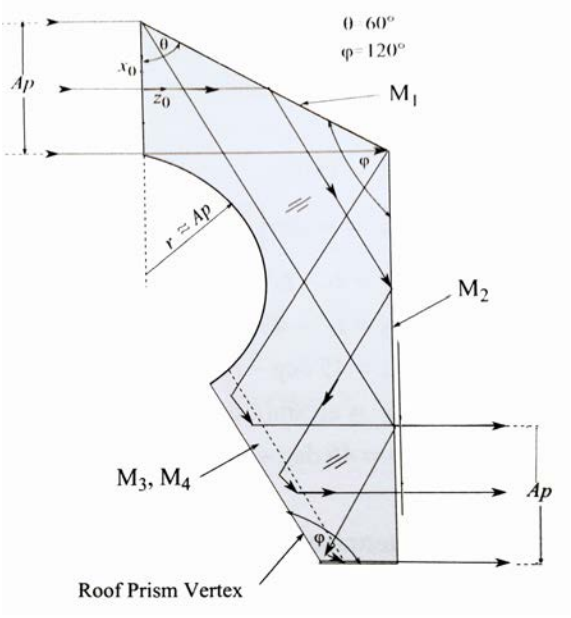
The beam from the objective lens (above, left) passes through an equivalent volume of glass with parallel faces (center) to reach the eyepiece (right). Although prisms are composed of flat surfaces, they exhibit many of the abberations, usually assosiated with lenses. The optical designer corrects for chromatic, astigmatism, image anomorphism, constant coma, and quadratic distortions.

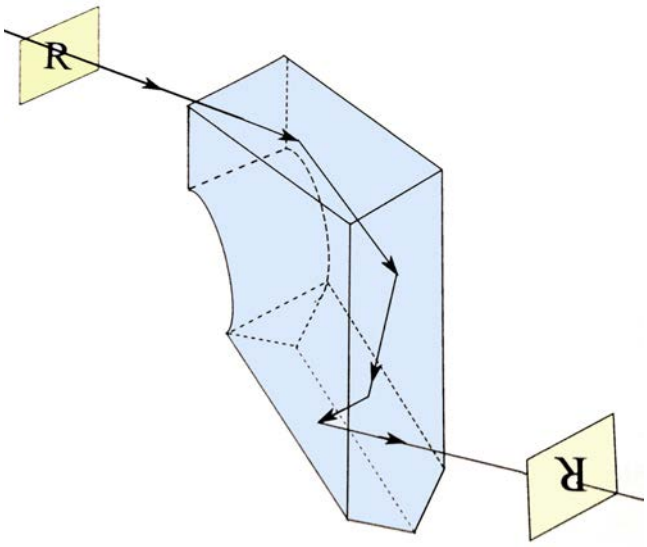


Leman prism binoculars (theatis 3.5X; J.D. Moller, Wedel, Germany in late 1920's). Four reflections are obtained with this compact image-errection prism (see below for details). Source: College of Optical Sciences, University of Arizona



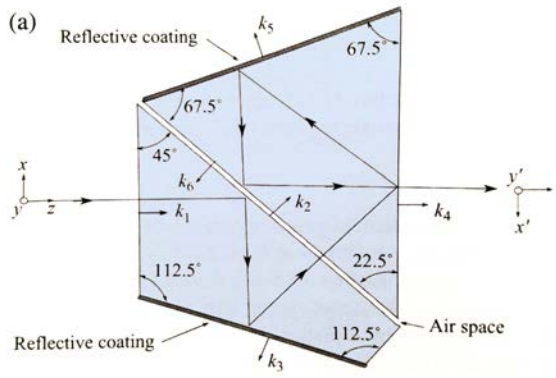
Moller prism binoculars (Tourox 8X; J.D. Moller Wedel, Germany, mid-1920's). This image erection prism system consists of two prisms that are bounded together (right) and held in place by a spring clip. A total of six reflections are obtained. Source: College of Optical Sciences, University of Arizona



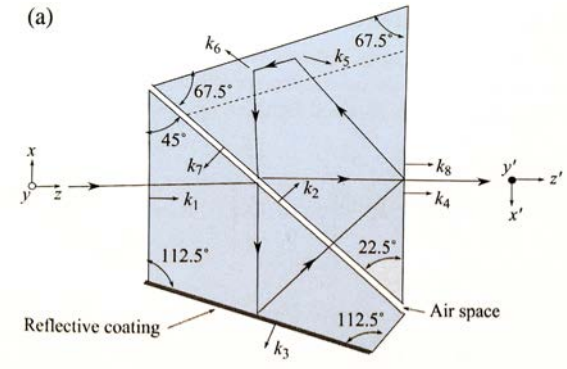


A four-mirror reflecting prism similar to the one used in Leman binocular by Moller Wedel (above). Source: Applied Prismatic and Reflective Optics.

2 Zeiss 8x35 B



(a) Pechan prism design layout, and edge angles, (B) Pechan prism perspective view with image orientation.

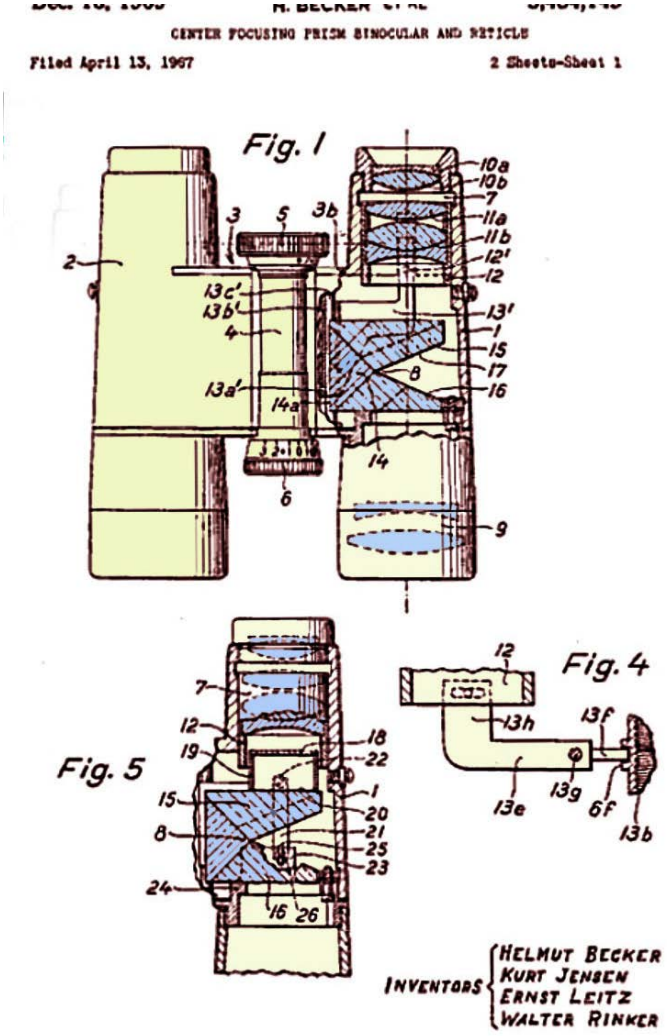


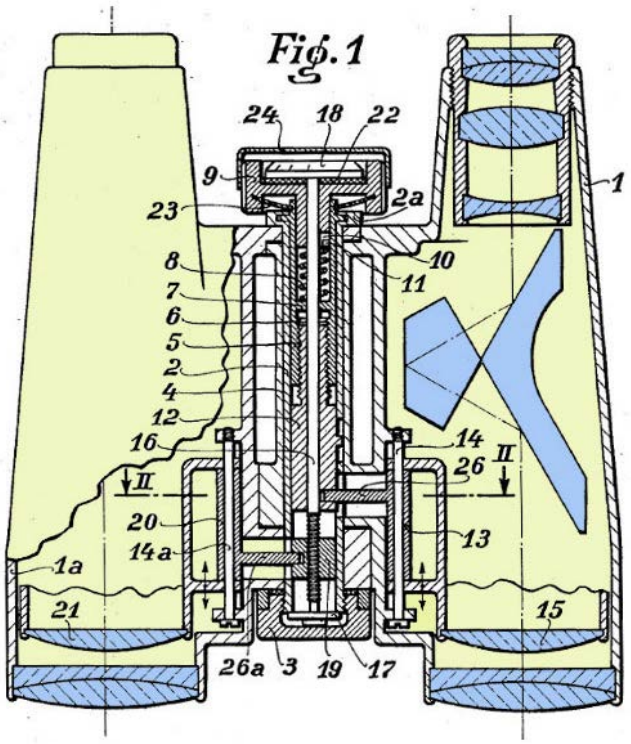
(a) Schmidt-Pechan prism design layout, and edge angles, (B) Schmidt-Pechan prism perspective view with image orientation. Source: Applied Prismatic and Reflective Optics.

The invention of the Schmidt Pechan, and Schmidt-Pecan prisms, allowed binoculars to take a much slimmer form. The body size benefited a drastic reduction in overall size. This Zeiss 8x35B is one of the most calming binoculars ever designed for bird watching.

3 Leica Trinovid 10x40

Leica design of Leica Trinovid binoculars, and Zeiss (previous page) are timeless in their optomechanical design. Both binoculars are extremely compact, and are so convenient to use because the body shape lays flat against the body when hung on the neck. The newer internal focusing mechanism also gives these binoculars a more robust/water sealed body compared to prior art.





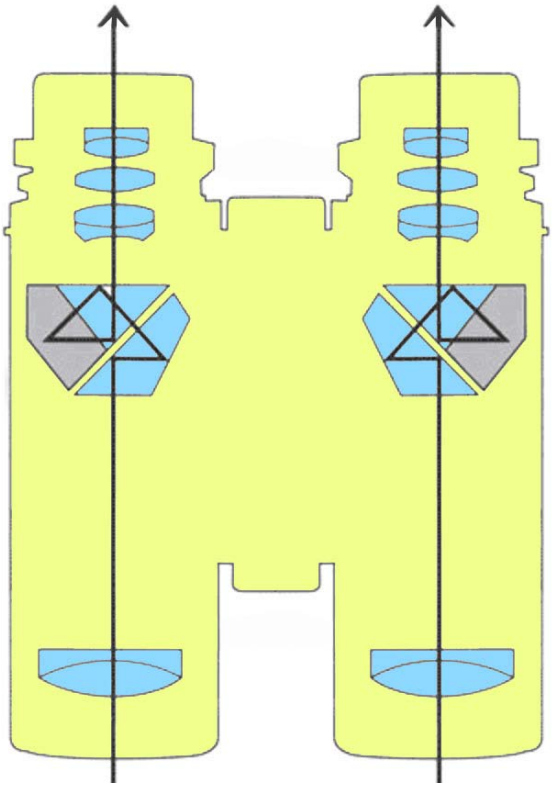
Two binocular prism patents by Leitz reveals strange looking prism work. The prisms in newer binoculars are assembled as a stand alone module compared with the Porro prism design that the prisms had to be mounted directly on the main chassis.

4 Zeiss 10x25 B

These are extremely light/compact binoculars perhaps designed to fit inside a woman's purse. The design is unique in that the eye distance is achieved by double hinge design. A single hinge can not extend far enough form a compact to wide open to the human eye distance. This makes the design challenging but as optomechanics dictates a variety of options, the most user friendly Zeiss has come up with is to place the diopter adjustment behind one hinge, and the focusing knob on the other. in front, and one on the back.

5 Leica 8x50 BA

This binocular is and example of waterproof design, down to 5 meters deep, and Leica guarantees them for 30 years. Note how the 50 mm objectives are fit so tightly together in this design, and it's probably the largest objectives the Schmidt-Pechan prism scheme allows to be implemented.



Dec. 3, 1957 H. KÖHLER 2,814,9

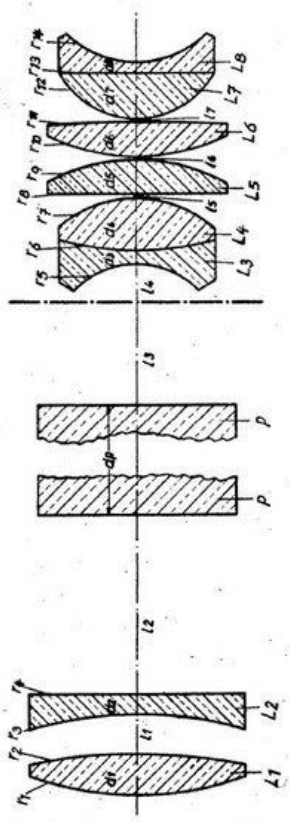
PRISM FIELD GLASS

Filed March 15, 1955

The Eyepiece

Prism Block

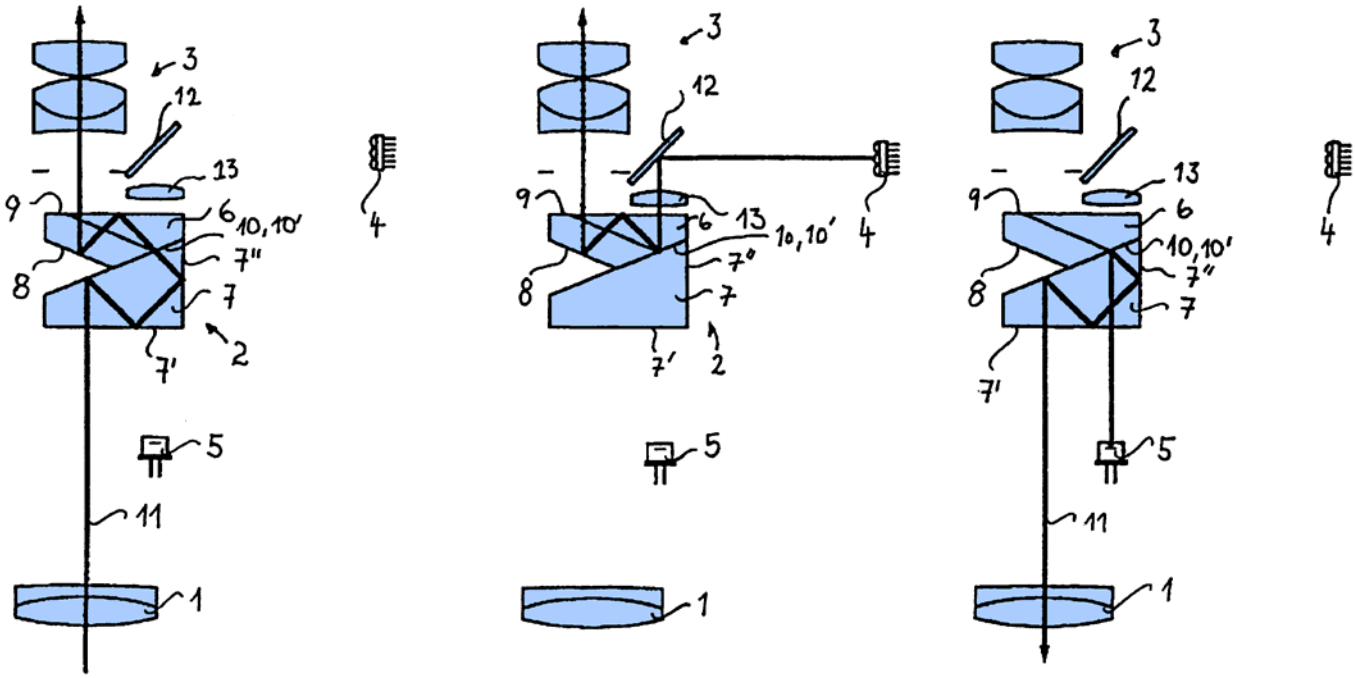
Objective Lens



6 The Rangefinder

How it works

Rangefinder binoculars are a convenient tool for hunters to determine instantaneous distance measurements, displayed through one of the eyepieces. There is usually a bright circle at the center to point to the area of interest.



A rangefinder binocular patent reveals three optical paths: Left, for normal viewing; Right, Laser diode 5 turns on for distance measurement; Center, Alpha-numeric LED display 4 displays the measured distance through the eyepiece. Note the harmful Laser diode beam does not reach the eye during distance measurements.

Binoculars for Twilight Viewing

By: Omid Jahromi, Ph.D.

Binoculars can be used to enhance our vision in twilight. Binoculars with large objective lens (more than 42mm) and relatively low power (7X or 8X) are particularly suited for low-light and night viewing. An outstanding example of such specialized binoculars is the Zeiss Night Owl 7X45 shown above.

In this article, we will review some lesser-known facts related to using binoculars in low light. We limit ourselves to viewing a natural scene (such as an owl sitting on a distant tree) under low-light conditions. In other words, we are not concerned observing stars or moon which are self-luminous high-contrast objects.

Limitations of human night vision

In a very dark night, the human eye switches to the scotopic mode of vision where rods in the retina are the functional photo receptors. This means:

• No color vision (color vision is provided by cone receptors which are not functional at night)

• No foveal vision (there are no rods in the fovea which is a small part of retina responsible for the high-resolution central portion of our field of view)

Seeing color might not be a primary issue for a hunter but lack of foveal vision at night has very significant consequences: The very center of the field of view becomes a blind spot! When a hunter "looks" at a precise direction at night, he sees nothing in that direction. His brain fills in this central hole using the information from the surrounding retinal regions (which do contain rods). That is, the

visual system infers the content that might be present in our direction of gaze by interpolation not by actually seeing anything there.

So, if a hunter looks directly at the owl on the tree using the outstanding Zeiss 7X45 "Night Owl" binoculars shown above, he will not be able to see it. He might see a vague form resembling a bird if he deliberately deviates his line of sight a few degrees to the side so that the owl will be positioned in his peripheral vision.

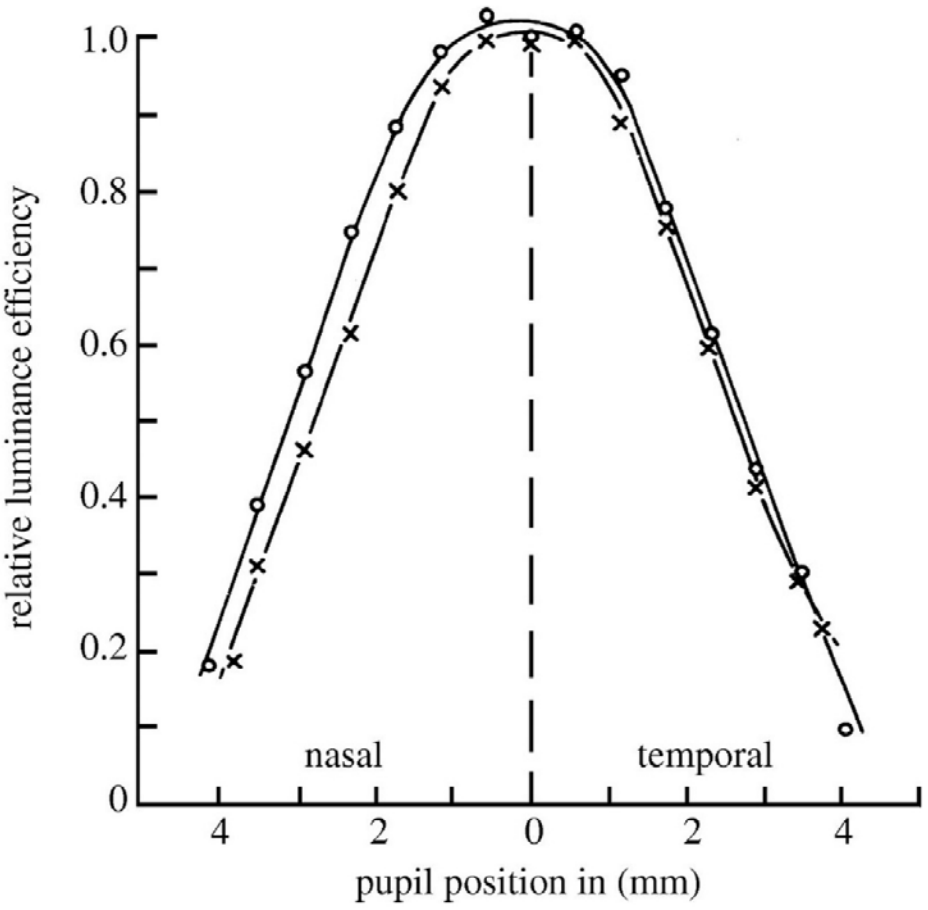
Another tiny significant fact which manufacturers never advertise is that a hunter will not be able to focus his binoculars at night! He can keep playing with the focus knob but that only turns one vague form into another. Focusing requires foveal vision which is not available at night. Night or “scotopic vision” is primarily a proprioceptive sense for human beings. The purpose of night vision is to help maintain our upright body posture and allow us to walk. Human eyes have not evolved to "focus" on anything at night.

Using binoculars in twilight

When a hunter picks up his binoculars to view an owl sitting on a three in twilight, his vision is primarily mediated by the cone photo-receptors of his retina. The cone receptors will receive more light energy as the eye pupil enlarges but the perceived brightness is not proportional to the area of the pupil. This is due to a physiological effect known as Stiles–Crawford effect of the first kind. The graph below shows the relative sensitivity of the cone receptors of human eye as the pencil of light entering the pupil gets larger. As shown in this graph, the portion of light that enters near the edges of eye pupil is much less effective in creating perceived brightness:

Due to the Stiles–Crawford effect increasing a binocular's aperture will not lead to a proportional gain in the light energy absorbed by the cone receptors.

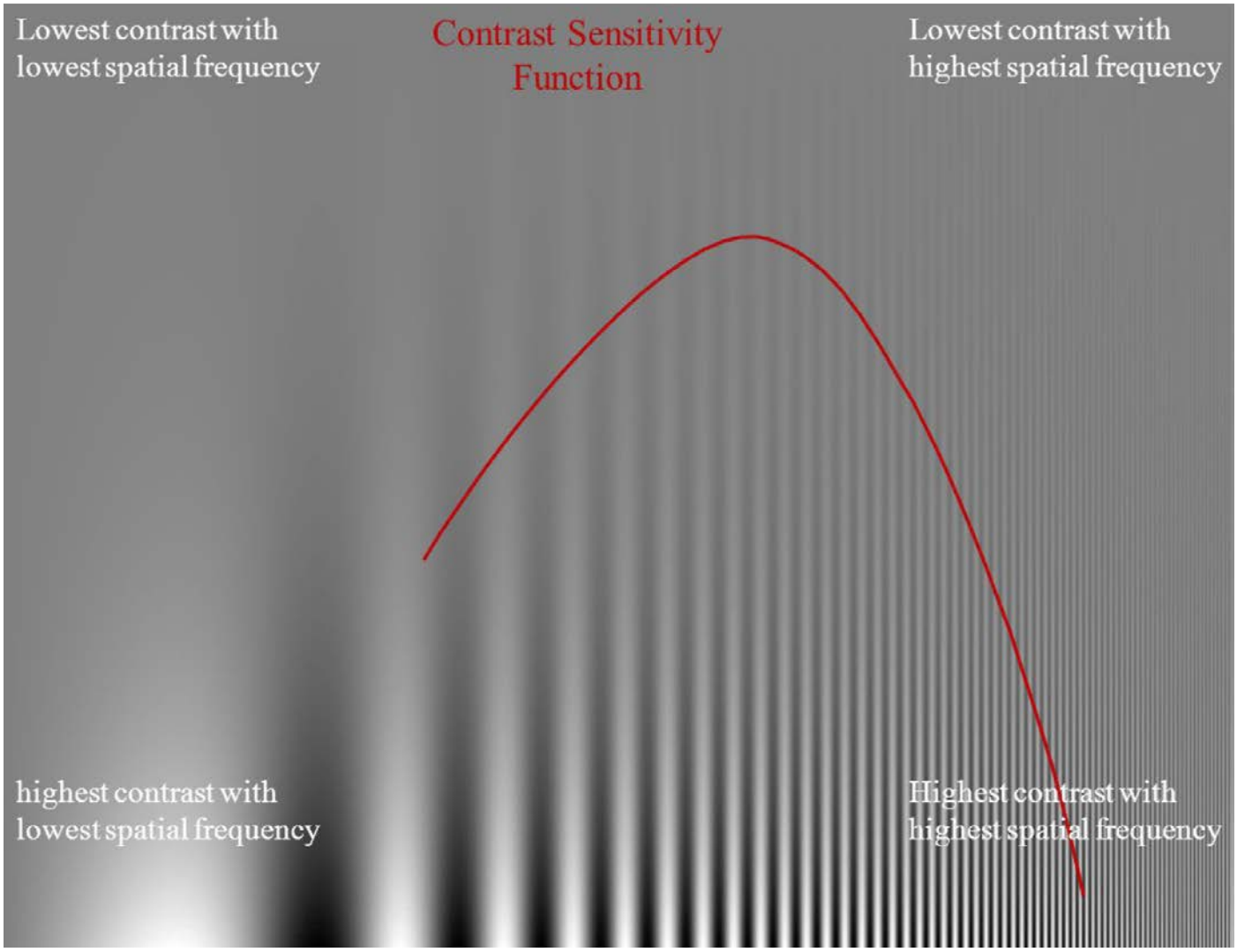
The large objective lens of binoculars such as Zeiss 7X45 Night Owl provide advantages other than increased brightness which makes them effective for hunting or birdwatching at twilight. In general, the human eye is not designed to measure brightness. Brightness is not a characteristic of objects that we encounter in nature. Oranges, flowers and snakes don't have a characteristic brightness. They have a characteristic reflectance that defines their apparent color and texture. The human visual system automatically perceives this reflectance and ignores changes in brightness.



According to Weber's law, human perceptual threshold for detecting a change in brightness is about 8%. This means, on average, humans cannot perceive a change in brightness less than 8% of a base level. This law implies that an increase of less than 8% in light transmission would be barely perceptible to most people, even those with young healthy eyes. Again, this is not the eye's fault. It is exactly what human eye is designed to do: ignore brightness (a highly variable and uncertain feature) and perceive reflectance (a stable feature of objects and environment).

The eye's pupil diameter enlarges to 6mm or more in twilight. But this is not helpful for resolving details. A wide-open pupil increases the eye's intrinsic aberrations so visual acuity decreases. Human eye achieves maximum visual acuity at pupil dimeters about 2-4mm (see Campbell and Gregory, Nature, Sept. 24, 1960, page 1122).

Magnification can somewhat help increase visual acuity in twilight: we can enlarge targets such as a sitting owl such that its spatial frequencies fall within the mid-range frequencies where our eyes can still perceive and resolve details. That's why 10X50 binoculars could be better than 7X50 binoculars in some cases. Picture below shows how the eye's contrast sensitivity changes with spatial frequency. Spatial frequency is measured as number of black and white stripes (cycles) per visual angle (degree). Looking at a low contrast target, the eye can best discriminate spatial detail in the range of about 1 to 5 cycles per degree. Looking at high-contrast targets, the eye can resolve up to 60 cycles/degree.

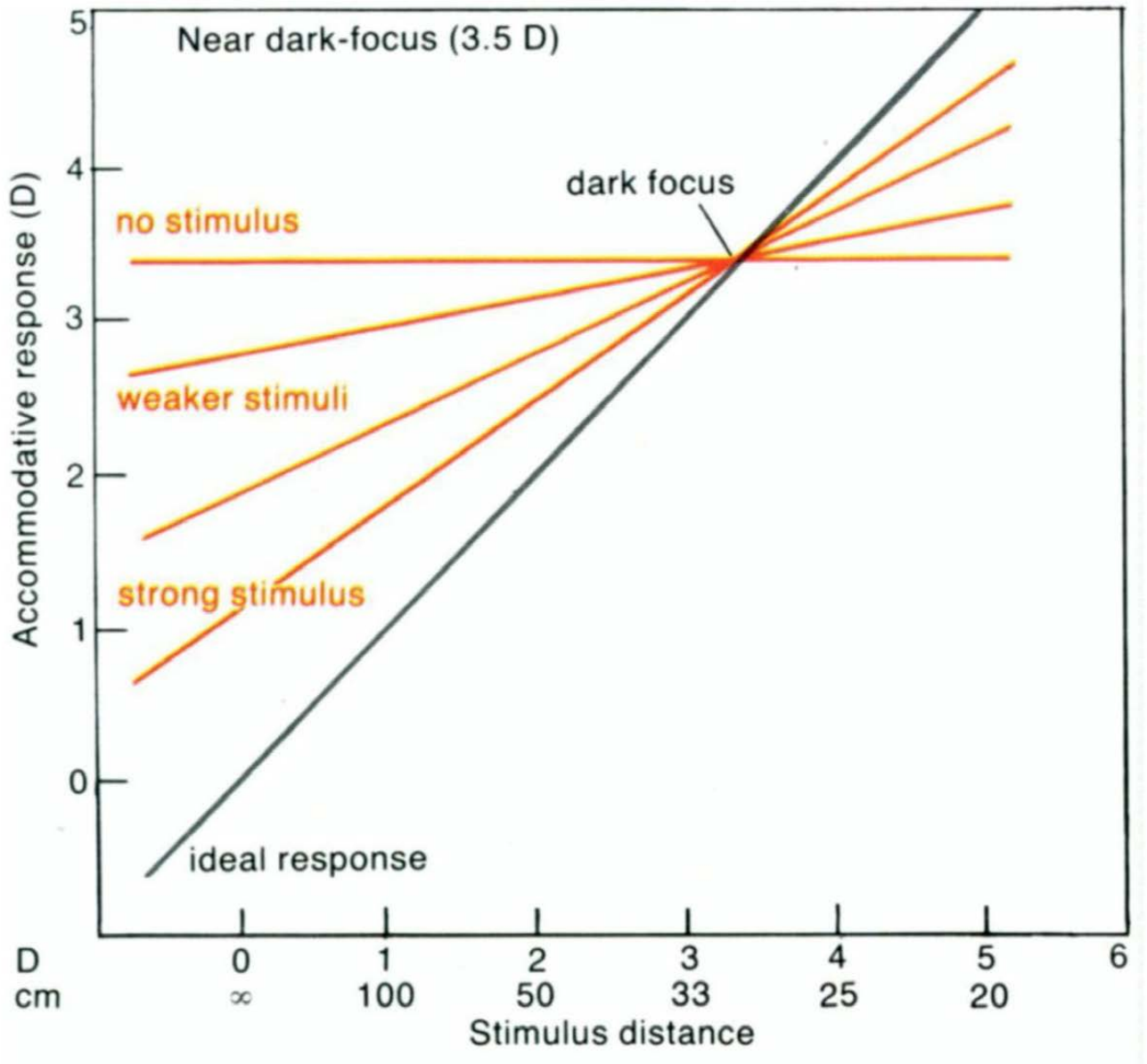


Focusing is a serious problem in twilight

The author believes that he most serious obstacle in using binoculars under low light is the difficulty of focusing: As luminance fades, so does contrast of objects against their background. Under these conditions, human eye loses a significant portion of its accommodation power. At very low luminance, the eye simply ceases to accommodate and stays at a constant focus state known as "dark focus" state. At the same time, the retina does not provide sufficient blur feedback to allow manual focusing of the binoculars by turning the focus wheel. Lack of precise focus causes more blur in the image which in turn causes lower perceived contrast, resulting in a vicious cycle.

The focusing difficulty is further exasperated by the slow response time of the visual nervous system in twilight. The delay in providing visual response to the brain causes the hunter's fingers to overshoot or undershoot the binocular's focus adjustment. In technical terms, the feedback loop oscillates instead of settling on a fixed value. This is similar to our experience when taking a shower: It is difficult to adjust the hot/cold mixing valve due to the time lag between the time you adjust the valve and the time water pours down from the shower head.

As a result of these physiological factors, a hunter or bird watcher will find it nearly impossible to focus his binoculars during twilight.



Conclusion

Our vision is mediated by rod and cone receptors in our retina. Our focused vision is mediated by a small portion of the retina called the fovea. The fovea has cone receptors only. Due to this unique distribution of cones and rods, under night conditions the ability to focus on an object is lost but the ability to maintain posture and walk in the dark is maintained.

At night we are literally blind in the center of our gaze. Our visual system fills this gap with information from the surrounding retinal regions (which do contain rods) so we "think" we see things at the center of our vision while, in truth, we don't. Stated simply, we can still "see our environment" at night but we cannot "look at specific objects".

In twilight, our vision is mediated by the cones. We can still see some color and are able to see details when we fixate our gaze on an object. However, our eye's acuity diminishes and our eye lens loses most of its ability to accommodate (focus).

In this article, we reviewed the implications of human eye physiology on using binoculars for night and twilight viewing. A large objective lens and high light transmission could improve twilight performance of binoculars in theory. However, the perceptual gain obtained is not proportional to these physical or geometric quantities. Twilight viewing should be considered in the context of fundamental physiological features of the human eye. Simply stated, binoculars are not helpful for viewing nature at night. However, they can help us see better in twilight.

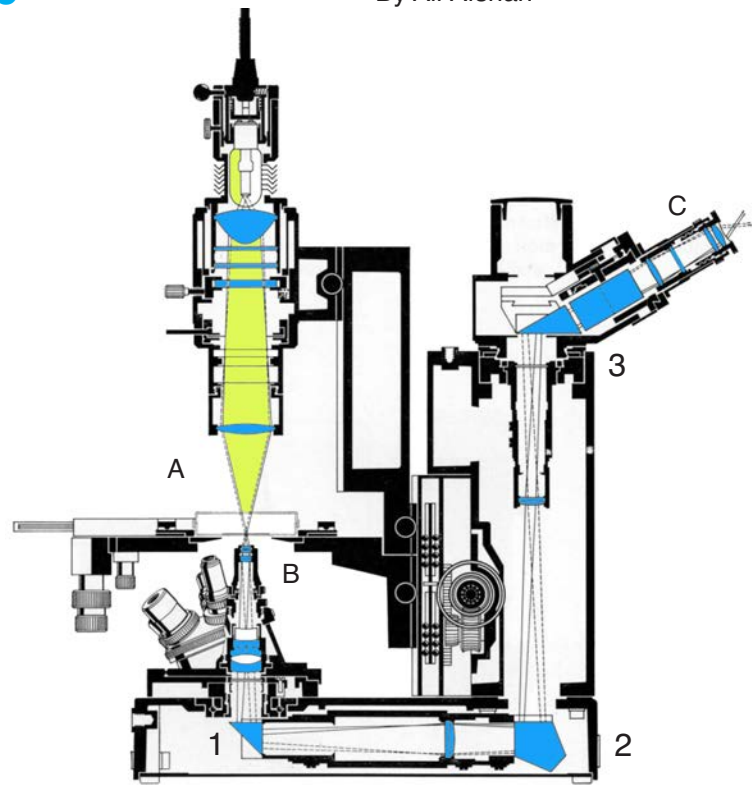
Making of an Inverted Microsocpe

By Ali Afshari

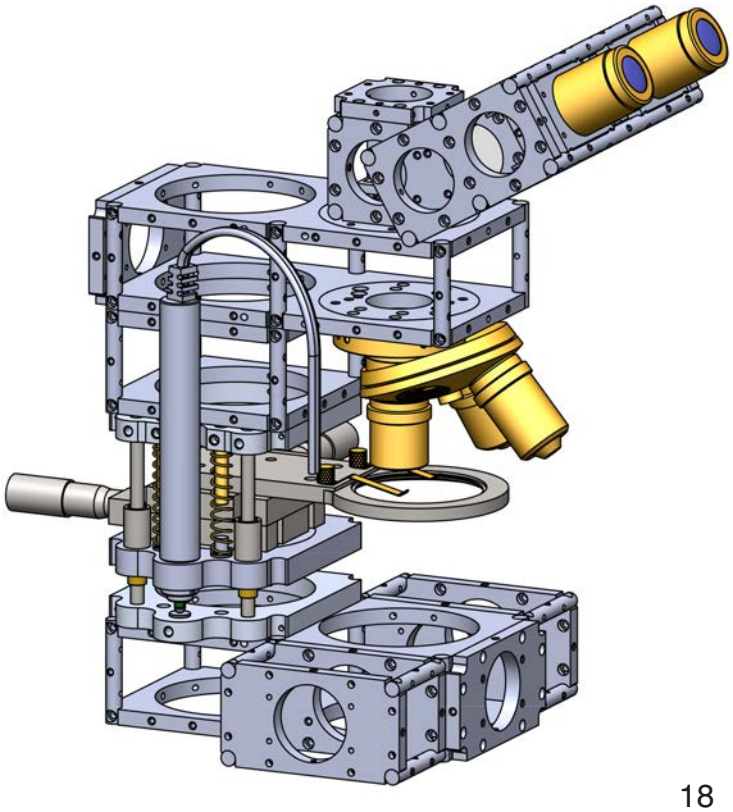
In the last issue, we covered the basics of constructing a biological microscope with new Optoform 40, and 74. The dimensional size of Optoform 40 is to match with Microbench mounts, and Thorlabs' cage system to make switching between them easily. Larger mounts like Optoform 74 follow a geometrical scheme to allow maximum compatibility between the mounts. So in its early days, the basic concept was developed to allow three dimensional beam paths, but it grew both in size, and number of parts to allow construction of 3D structures like microscopes, and various OptoMechaTronics instrumentation. Larger mounts like 142, and 278 are being designed primarily for biomed applications, and will be made available. Now let's construct an inverted microscope.

Let's take a look at what we built last time (below, left), and see what would now be different. To convert that to an inverted microscope, lets look at what modules we could reuse: The Nosepiece turret, the focusing stage, the binocular head, he illumination head, and same raiser plates we built last time. Leitz DIAVERT (right) is an example of a typical inverted microscope. The light source is above the sample platform, usually at a large distance to allow a petri dish to be viewed from below.

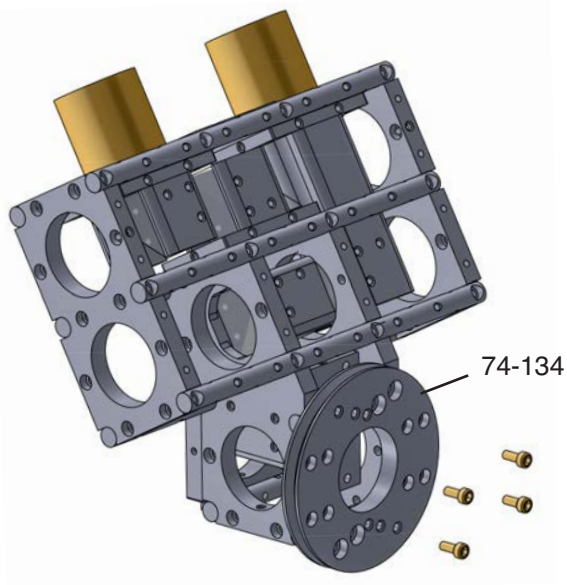
The objective lens in this case goes through three prisms to reach the observation head. There are several relay lenses to transfer the image from the objectives through an elongated beam path to reach the eye. We have a complete description of Leitz DIAVERT in Optomex No 8, Jan-April 2019.



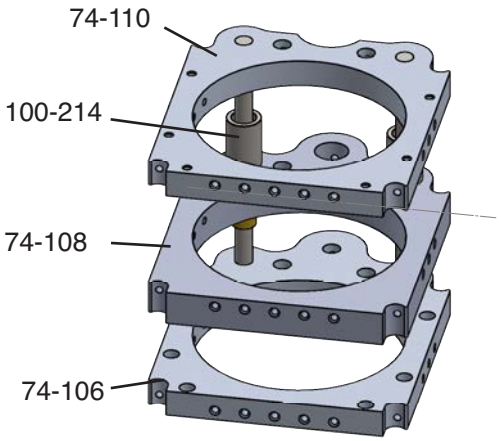
Illimination, and imaging path in Leitz Diavert inverted microscope: A) The light from halogen lap is focused on the sample. B) The objective lens focuses on the sample from below. C) Light from the sample is reflected through prisms 1,2, and 3 to reach the eyepiece. Additional prisms inside the viewfinder are not shown.



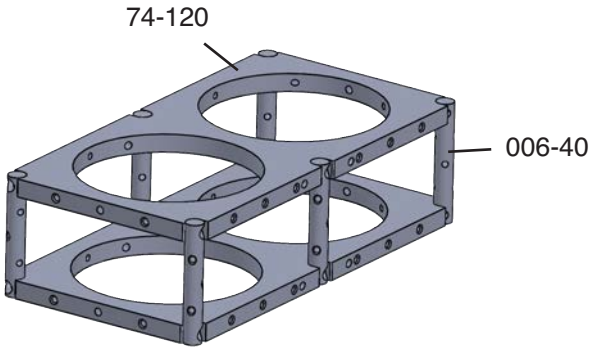
Leitz DIAVERT



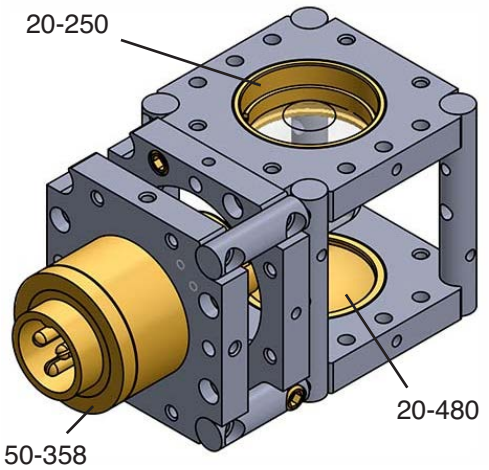
Taking off the mounting ring 74-134 from binocular head to utilize it as the viewing head in inverted microsocpe.



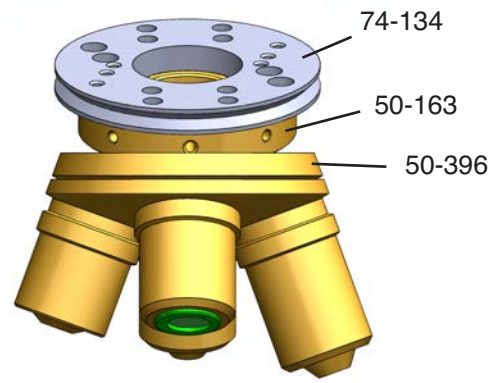
Same focusing Module we built for the biological microscope could be used for the inverted microsocpe.



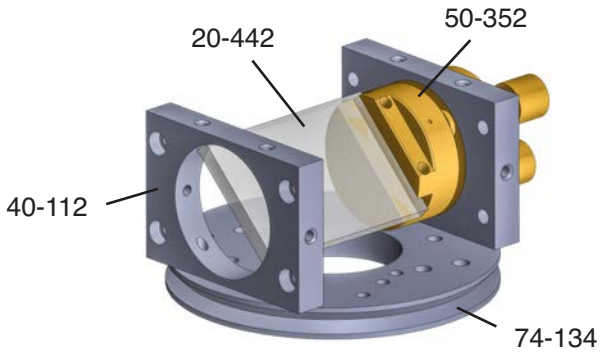
Raiser Platforms could be utilized to build the inverted microsopce.



Same Halogen source that was built for the biological microsocpe could be utilized for the inverted.



Nosepiece Turret that was utiized for biological microscope could be utilized for the inverted microsocpe.

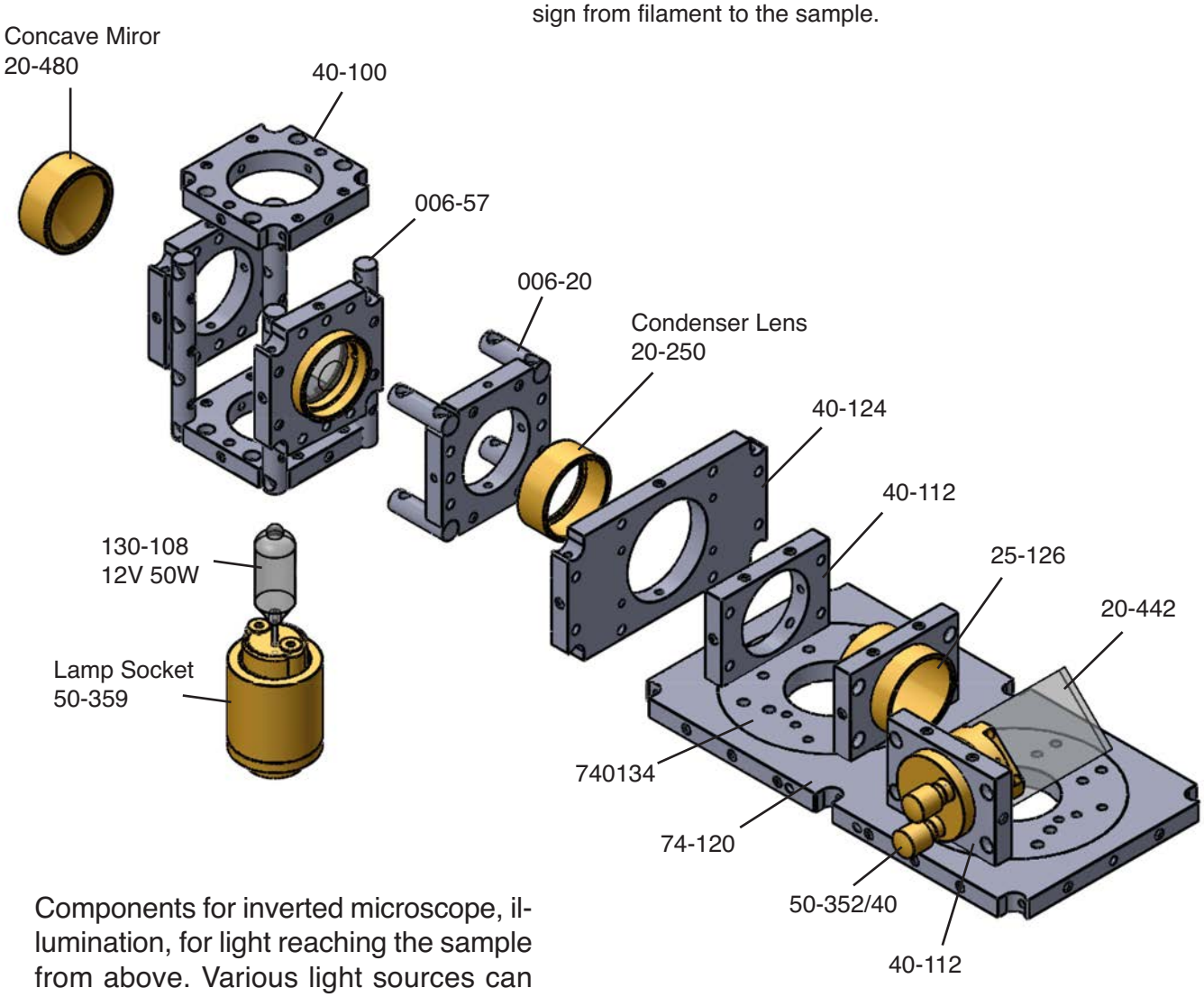


Mirror Holder with tip/tilt mount adjustment can be utilized to construct the illumination, and observation head for the inverted.

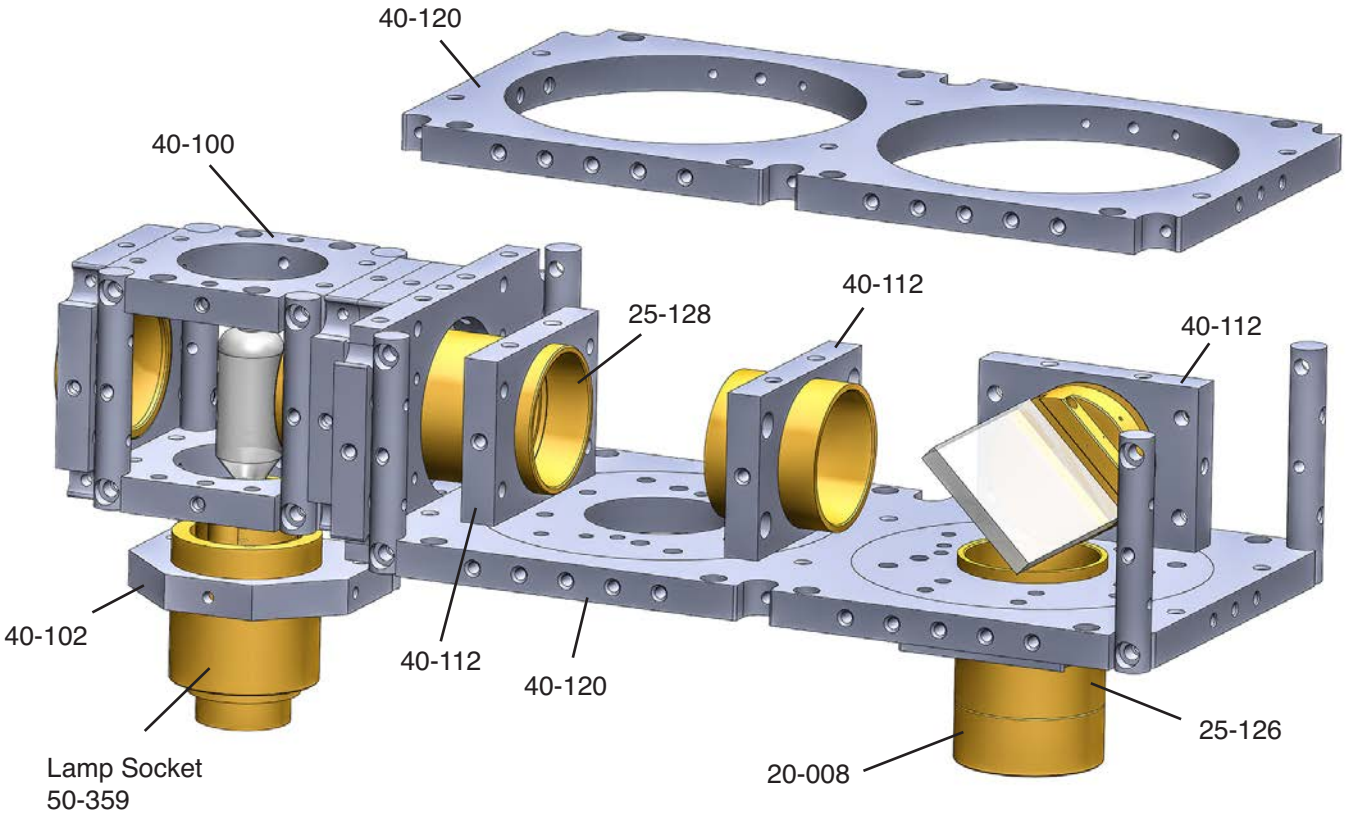
The illumination system

We suggested this illumination system last time as an optional configuration to convert the biological microscope to an epiluminescent or metallurgical system. We could now utilize it for inverted the microscope. The core of the illumination system is the Halogen lamp, and as a module, there are several ways to build it (below). The condenser optics for inverted microscopy (right) has a large diameter to match the numerical aperture of the objectives. This is not so obvious in upright microscopes because it is hidden beneath the stage.

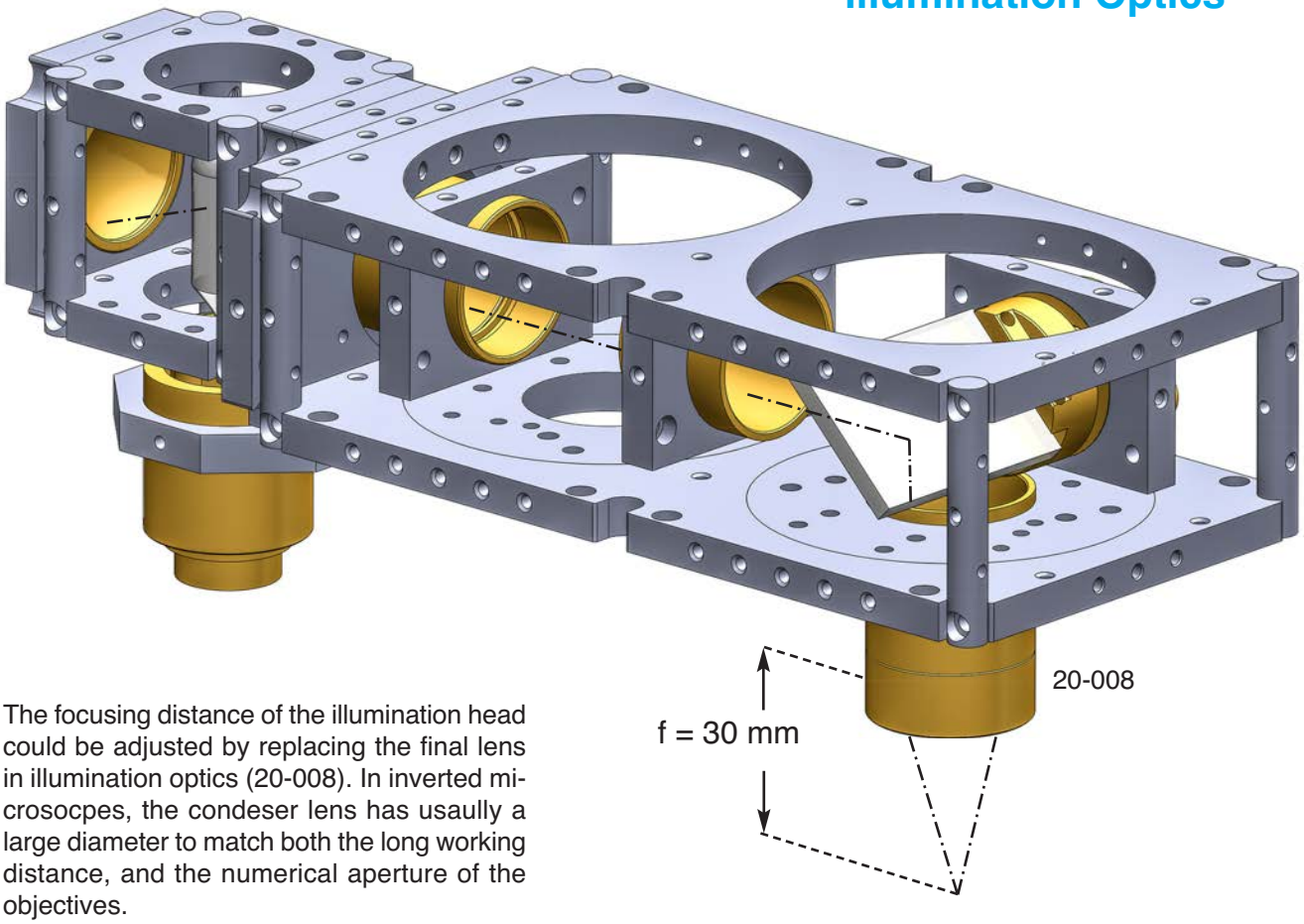
Leitz DIAVERT microscope illumination source with 12V, 20W Halogen lamp (above). DIAVERT uses a srtaight line optical design from filament to the sample.



Components for inverted microscope, illumination, for light reaching the sample from above. Various light sources can be integrated inside optoform, including this 12V, 50W Halogen lamp.



illumination Optics



The focusing distance of the illumination head could be adjusted by replacing the final lens in illumination optics (20-008). In inverted microsocpes, the condeser lens has usaully a large diameter to match both the long working distance, and the numerical aperture of the objectives.

Adding Modules Together

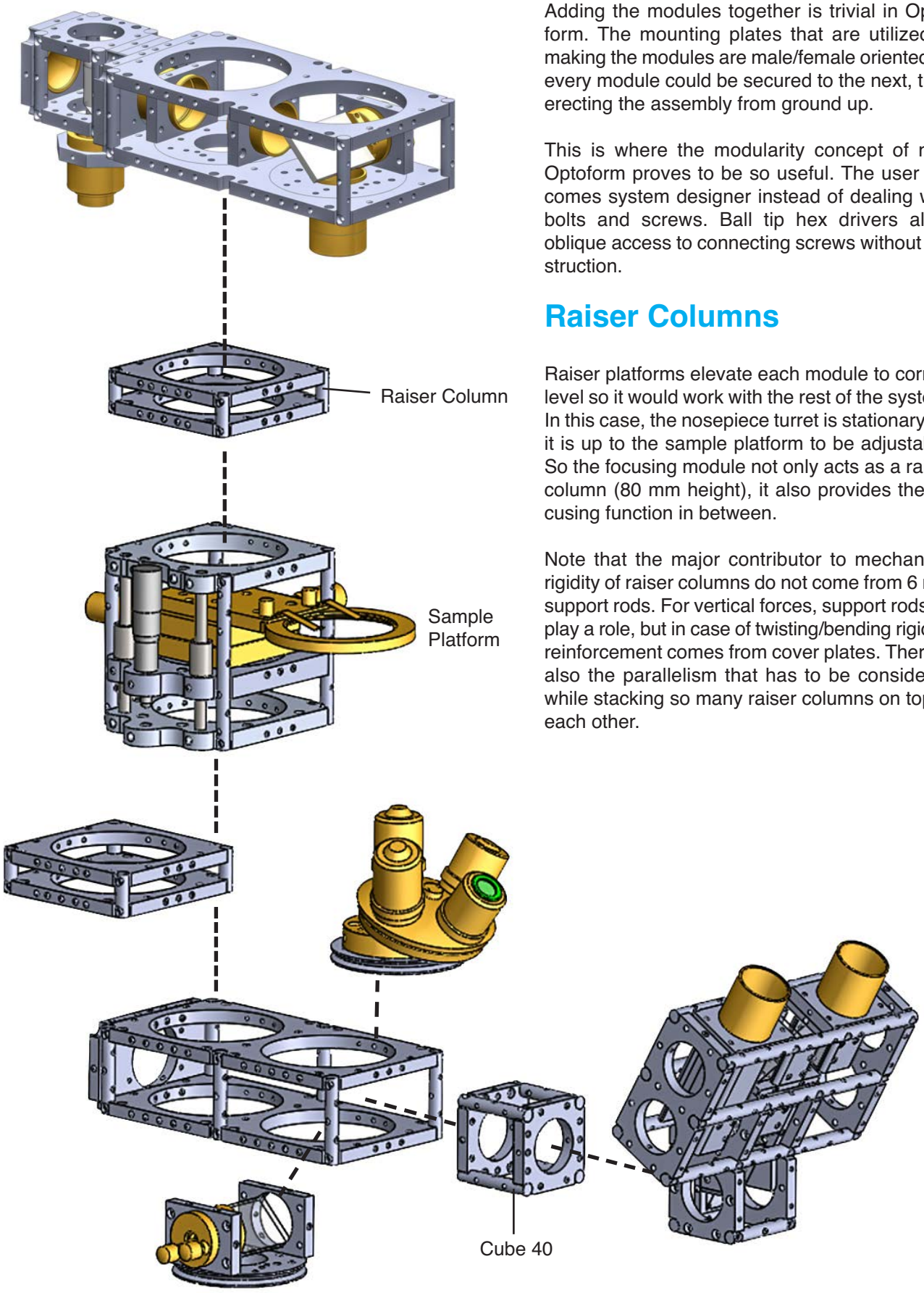
Adding the modules together is trivial in Optoform. The mounting plates that are utilized in making the modules are male/female oriented so every module could be secured to the next, thus erecting the assembly from ground up.

This is where the modularity concept of new Optoform proves to be so useful. The user becomes system designer instead of dealing with bolts and screws. Ball tip hex drivers allow oblique access to connecting screws without obstruction.

Raiser Columns

Raiser platforms elevate each module to correct level so it would work with the rest of the system. In this case, the nosepiece turret is stationary, so it is up to the sample platform to be adjustable. So the focusing module not only acts as a raiser column (80 mm height), it also provides the focusing function in between.

Note that the major contributor to mechanical rigidity of raiser columns do not come from 6 mm support rods. For vertical forces, support rods do play a role, but in case of twisting/bending rigidity, reinforcement comes from cover plates. There is also the parallelism that has to be considered while stacking so many raiser columns on top of each other.

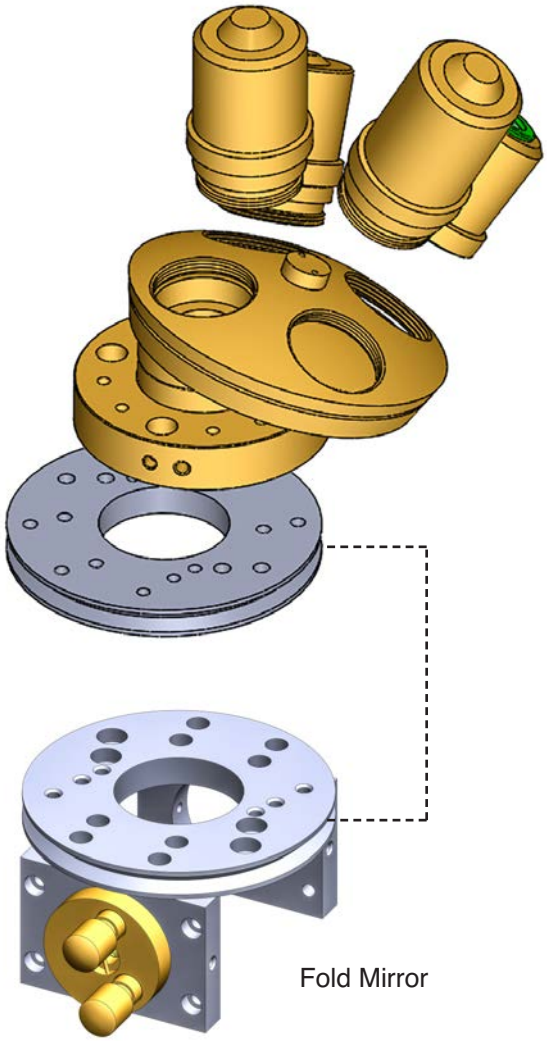


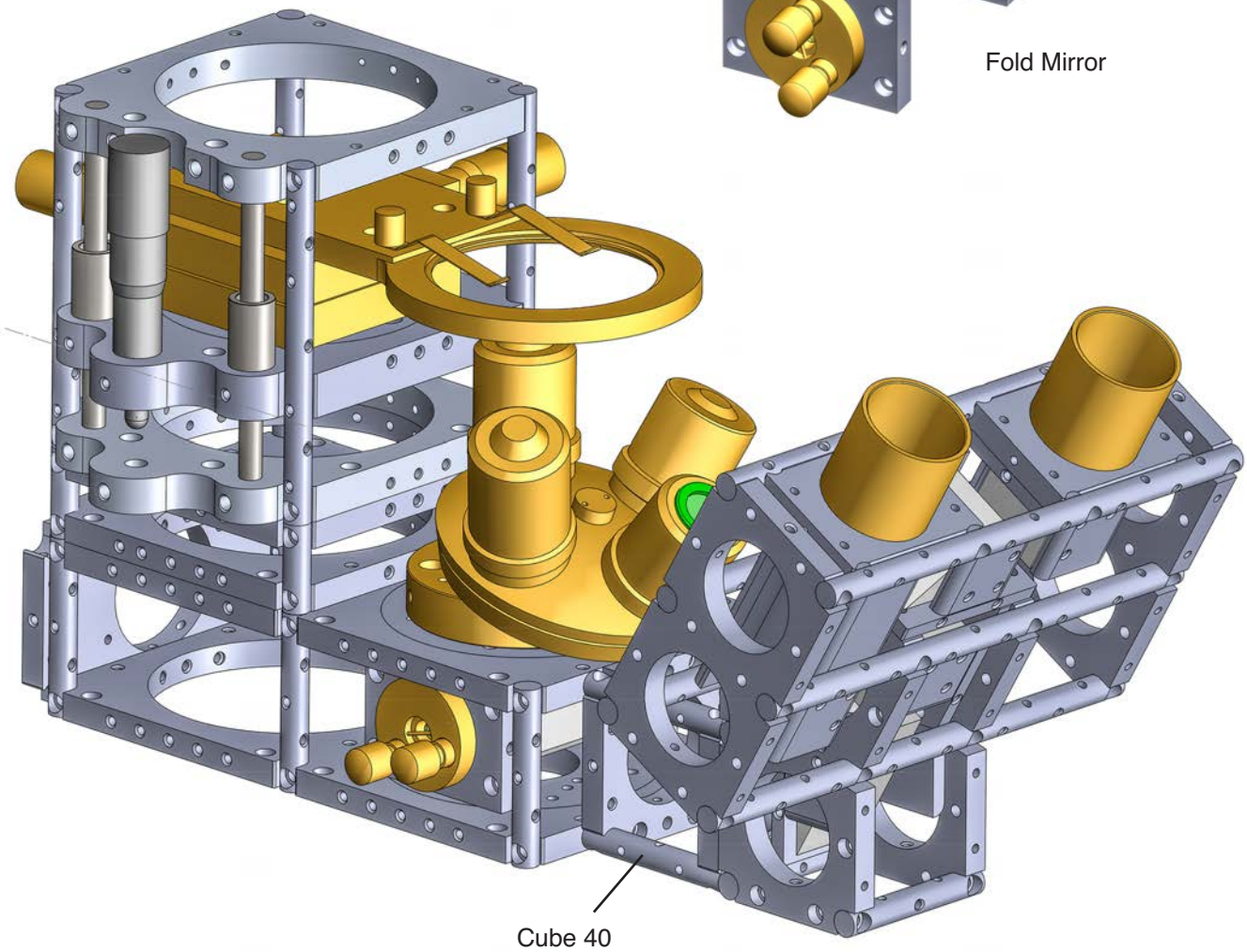
Finishing up the optics Layout

The optical layout of the inverted microscope is pretty much done at this point, and what remains is the illumination system. The binocular observation provides 60 degree inclined viewing, with reasonable height to provide good ergonomics. If higher viewing level is required, raiser platforms, are available in both Optoform 40, and 74 to accomplish it.

An inverted microscope lets you pay more attention to your objective lenses, and the illumination optics because they are more visible, and easier to see. The tilted nosepiece turret is facing toward the operator (to prevent its collision with focusing module on the back wall). A cube 40 is utilized to extend the position n of binocular head, allowing the nosepiece turret to rotate without obstruction.

Note how the modularity scheme of new Optoform has liberated it from the “through the rods” optical path to “outside of the rods” optical path. The nosepiece turret has always been a dilemma for the cage system construction but as you see in this assembly, it’s out of the cage, enjoying some fresh air.



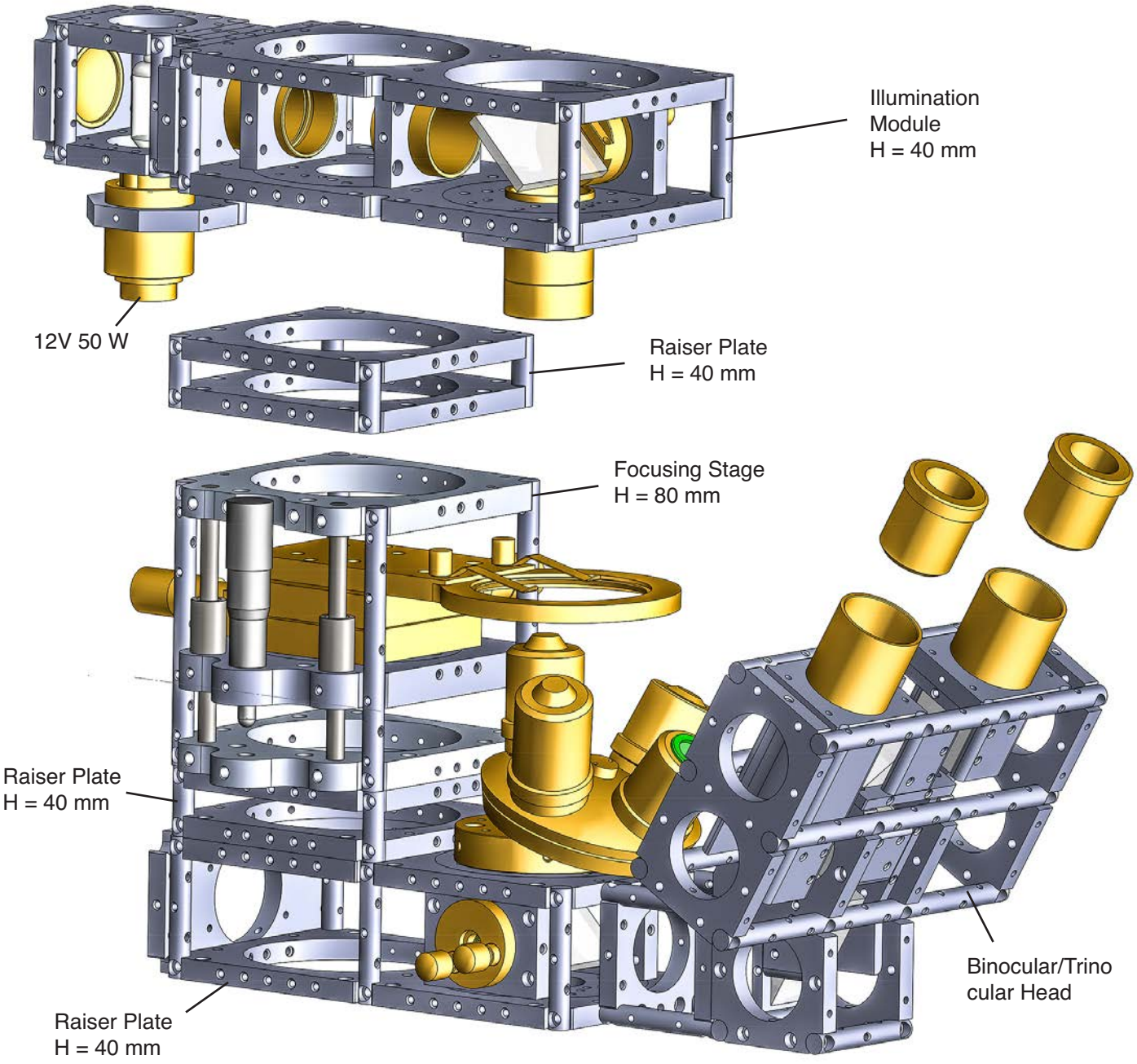


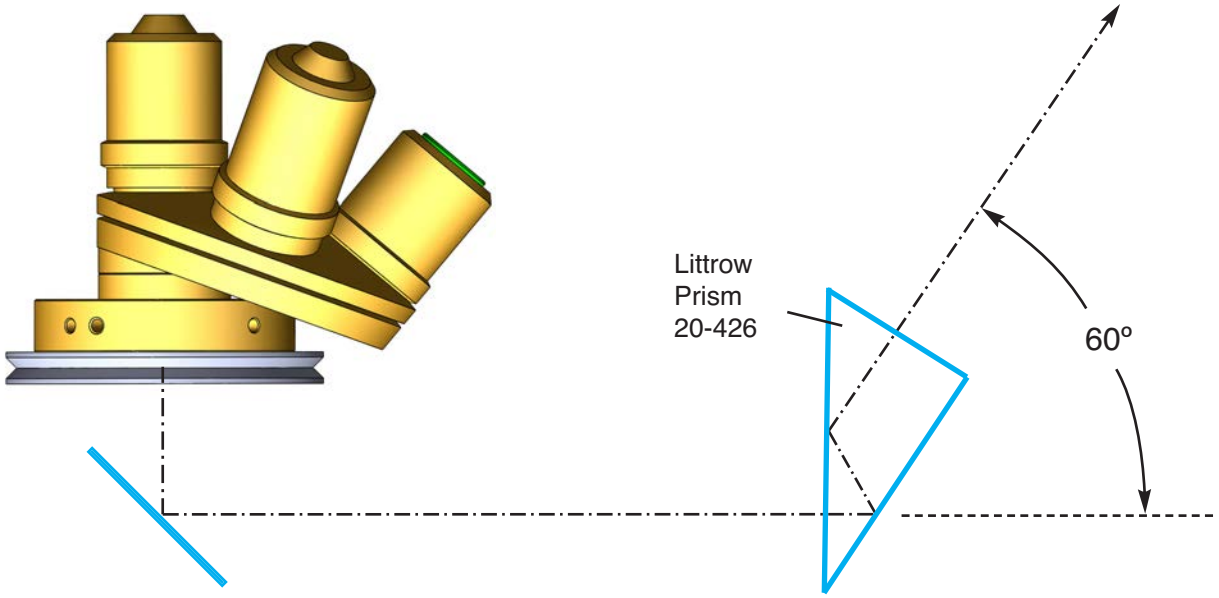
Final Assembly

well, here is the entire system we built, and it measures only 200 mm in height. I just received an email from an optics student, asking me if I had a DIY guide to make this sytem so everybody could use. My answer was unfortunately no. The reality is only grownups could afford these optical kits, and its mechanical components to experiment with. Optical toys for children did have reasonable quality back in the 30's but with the introduction of plastics, children toys, telescopes, and microscopes have become so cheap, that they don't play a great role model for optical engineering. Owning this system was my own dream when I was a child. The price difference is approximately 100 to 1 ($75 to $7,500).

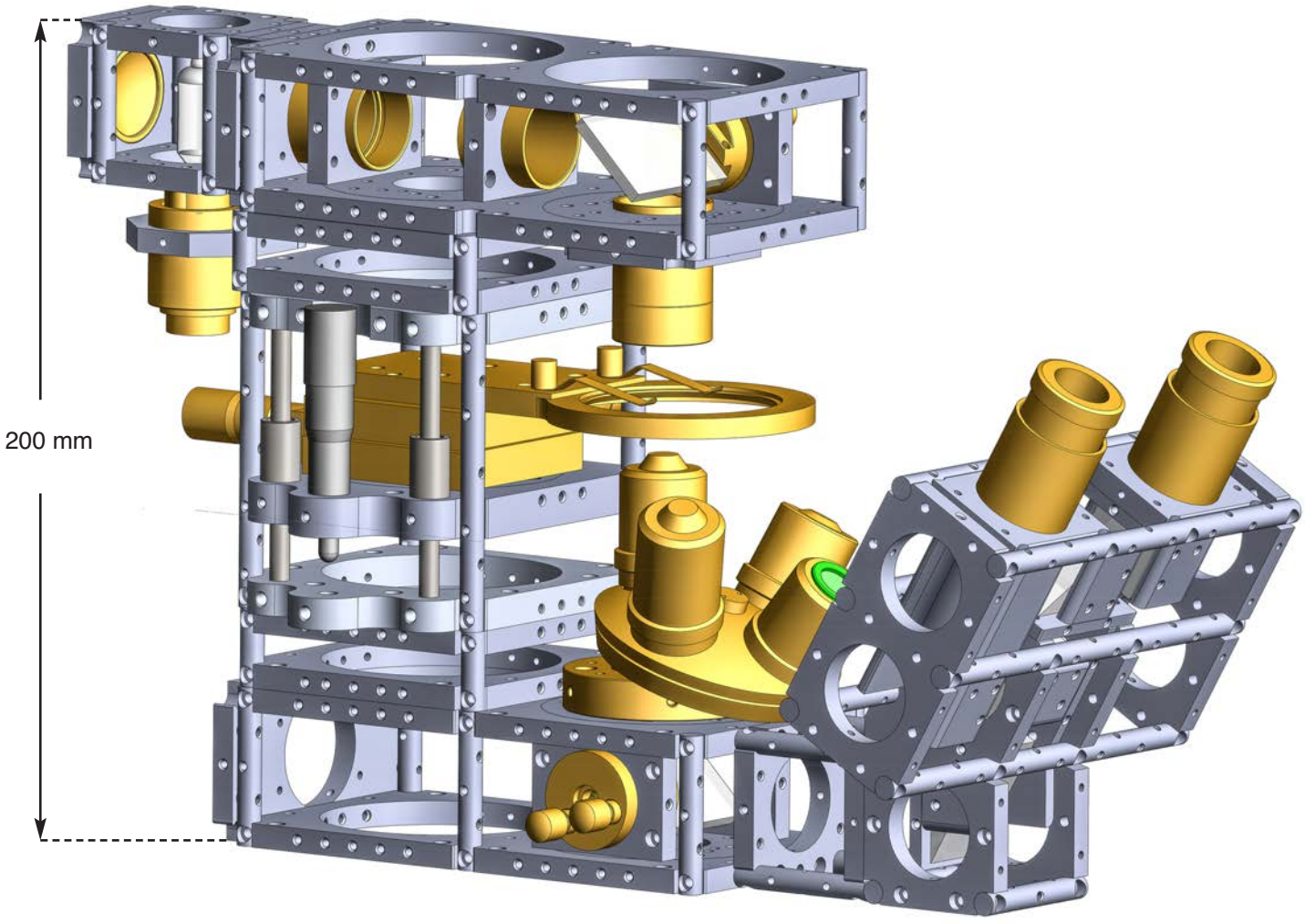
The reason Optoform works so well is because of so many man hours in designing, manufacturing, and putting together its inventory of parts. The end user grabs a lens from a lens kit, and inserts it into the mount, and it's ready to go. You have to be a manufacturer to realize how tight the tolerances are for each, and every piece, and how many parameters, and mounting possibilities are considered before a new piece is added to the system.

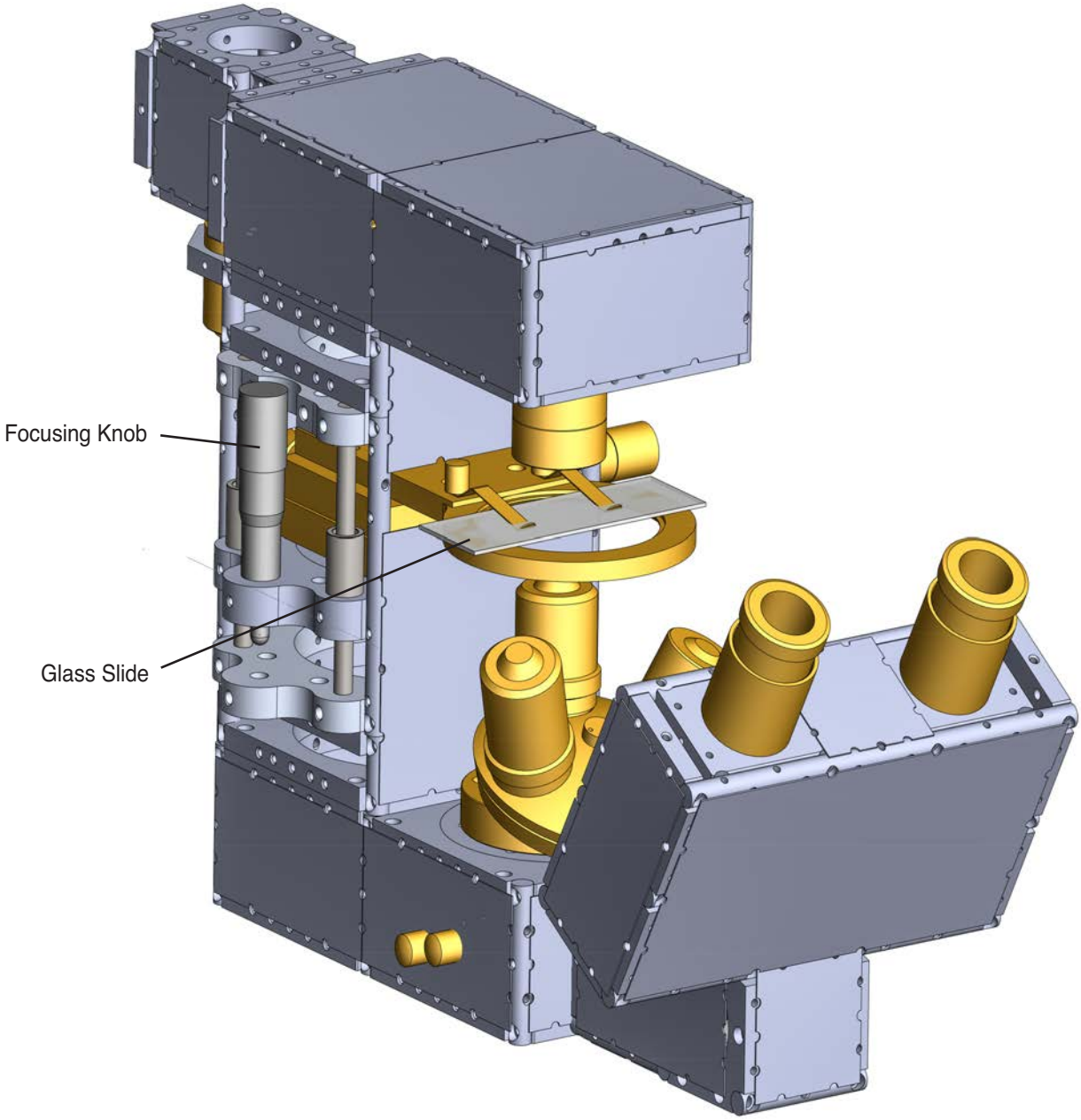
By using, and evaluating this microsocpe, we can prepare it for the next step of construction: To finish it up with pre-cut sheet metal covers for added rigidity, and stability. Sheet metal coverings have a notch pattern to allow securing them on the side of mounting lates via M2.5 button-head mounting screws. Not all the open threaded bores has to be utilized, but just enough to secure the cover plates at critical points.





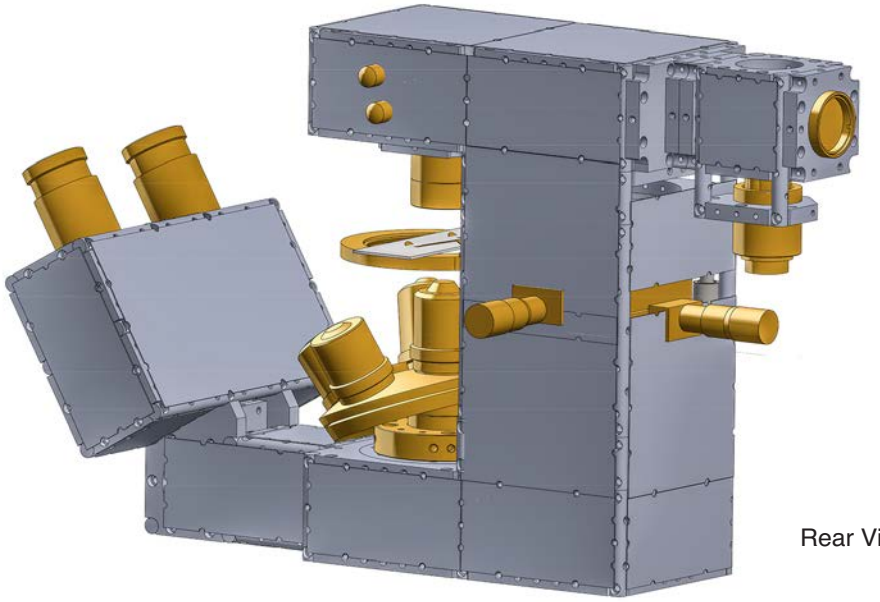
Above, utilizing the Littrow prism is not so trivial. In this case, the angle gets complex, if you have doubt about it, try constructing it in your lab. In optics, always have your feet on the ground, meaning to always use a line of reference. The nature of the cage system mechanics, with its 4 rod system, looks to be an impediment in optomechanical design because one would have a tough time with angles. Once that is resolved, the cage system becomes far more practical in doing prism work than table top experimentation. The reason is once you construct a self holding assembly like Optoform, you could easily rotate it but you can't do that with breadboards, and optical tables. In this case, all you have to do is build the binocular head assembly, and rotate it by 90 degrees.



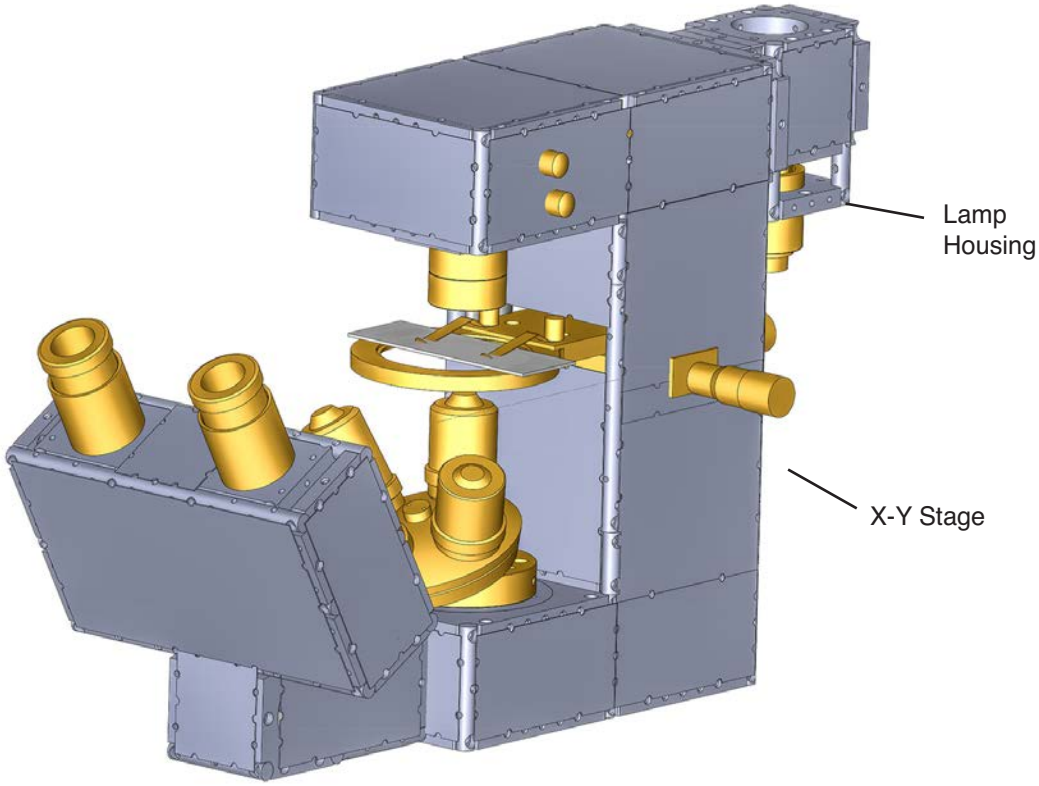


Sheet Metal Covering

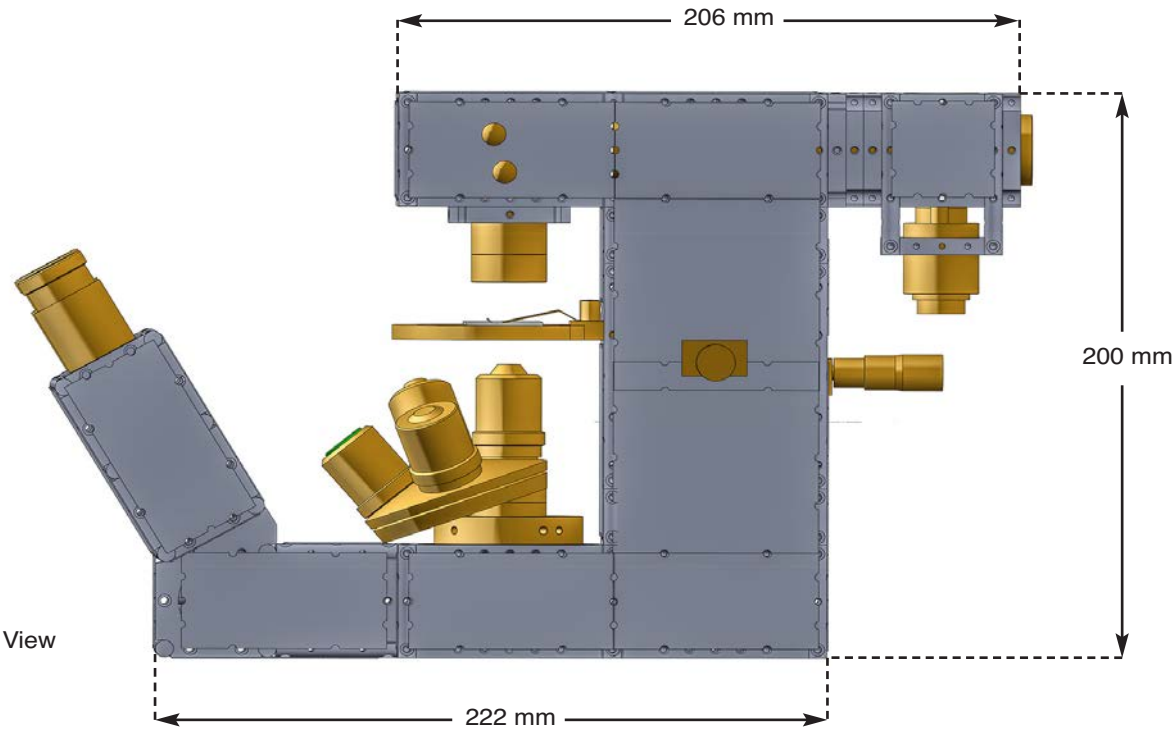
Cover sheets has been added to light seal, and dust seal the optics. The microscope is quite compact, and when the entire assembly is packed inside cover sheets, then the end user would think that it would also needs to add rubber legs. When you deal with a complete instrument, then usability, and durability becomes a concern. Issues like strain belief for cabling, and availability to use by others come to play that would change the outlook of the microscope.



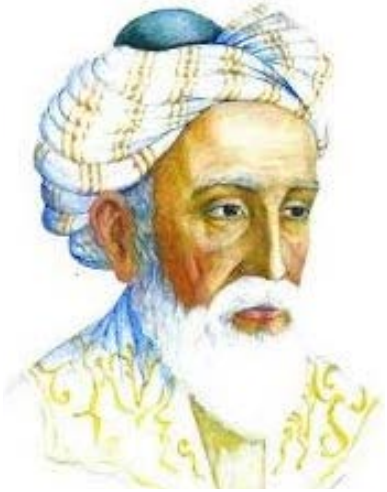
Rear View



For more on the sheet metal covering please refer to two past issues. An imaging microscope with trinocular head may be easily constructed identical to biological microscope shown in our last issue. In that arrangement, the CCD camera would be situated in front of the microscope.



Side View

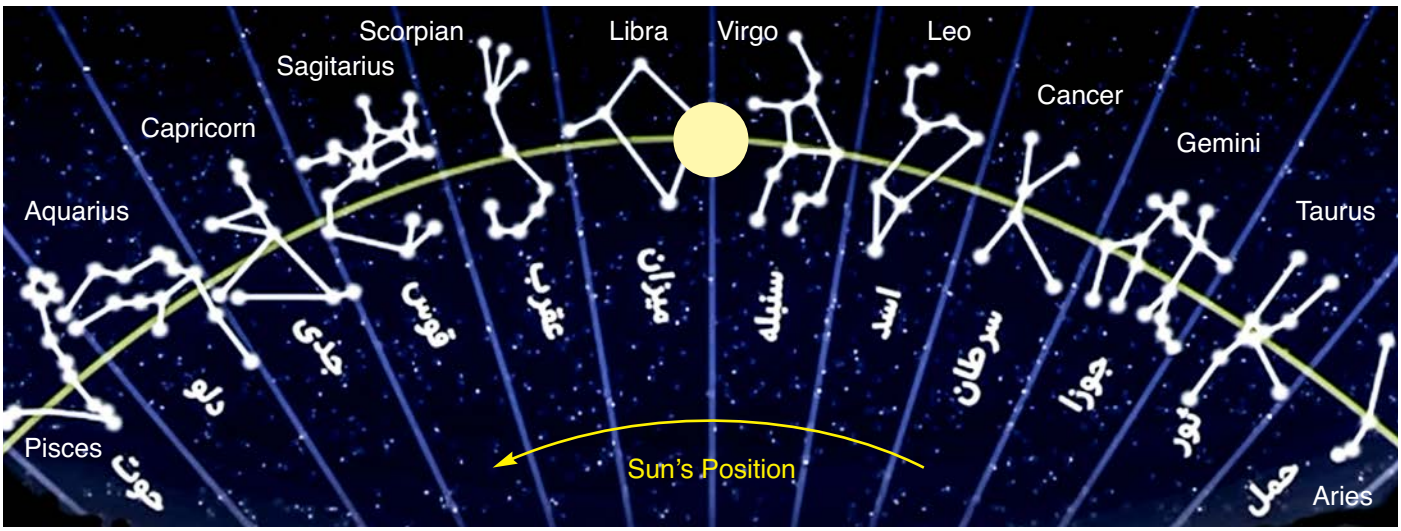


Omur Khayyam and Jalali Calendar

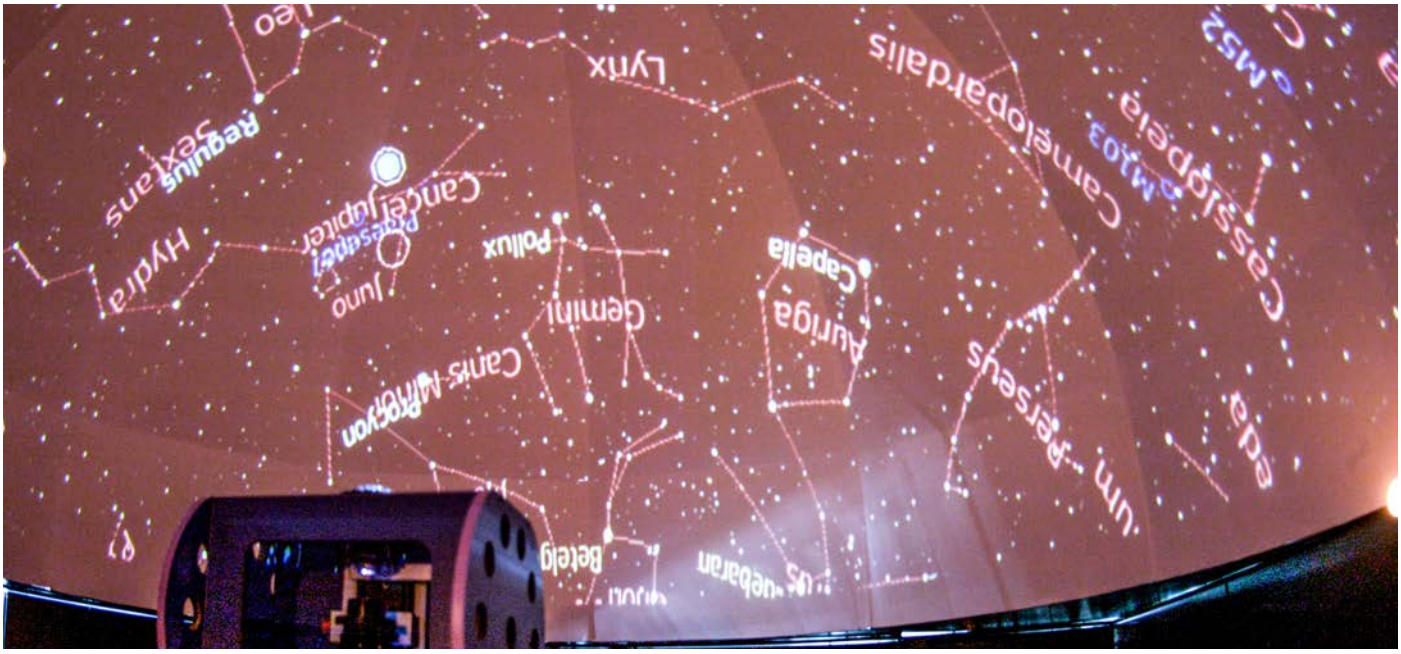
Omur Khayyam (1048-1131) is well known for his poetry in the west but he was also a philosopher, mathematician, and astronomer. He spent eight years studying, and accurately mapping the position of the sun, stars, and constellations, and eventually came up with Jalali calendar, one of the most accurate calendars to date.

During the Seljuk dynasty, Khayyam was invited to the city of Isfahan to build a new observatory under the sponsorship of sultan Malik-Shah. He was asked to solve the inaccuracy of the lunar calendar. For 8 years he led a team of scientists that built a star map and he measured the length of the solar year so precisely that it loses only one day every 5,000 years—more accurate than the Gregorian calendar, which loses a day every 3,330 years. Using these calculations, he helped to develop the Jalali calendar, a forerunner of Iran's modern calendar.

If the earth's rotation around the sun is considered as the basis to construct an annual calendar, the earth rotates around the sun every 360.25 days. So every 4 years, the calendar has to be brought back a day to correct for its error. What Omur Khayyam based his Jalali calendar on the position of the sun along its path in front of the background stars.

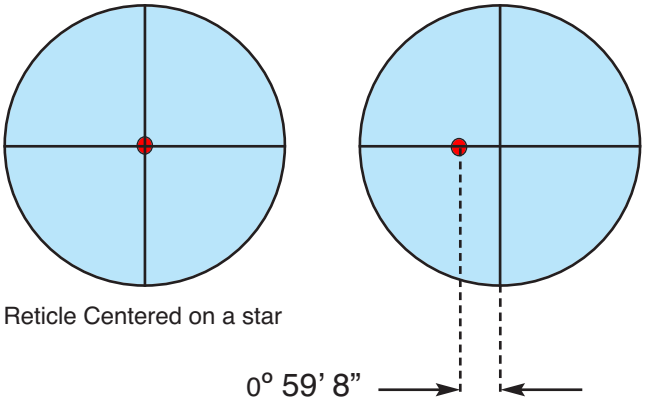


These are the constellations Omur Khayyam recorded to track the sun's position across the northern hemisphere.



The inside of planetarium dome at OMiD museum: When you observe the movements of the sun, and planets in the solar system in the planetarium, you'd understand their dynamics so easily. The first thing you would notice is the back and forth motion of Venus around the sun. You'd realize it's because they are on the inner orbits of our solar system.

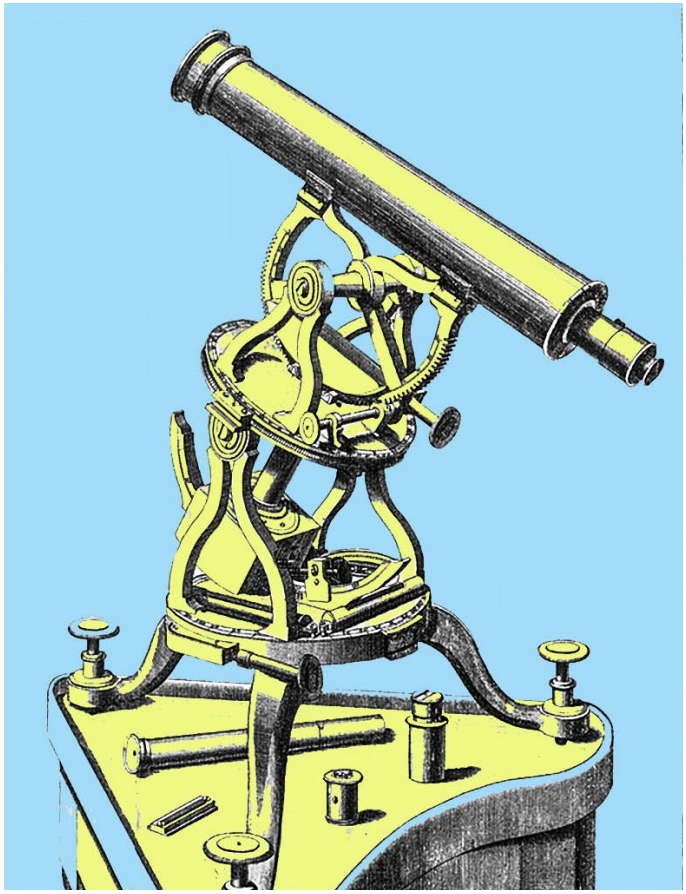
Equatorial Telescope

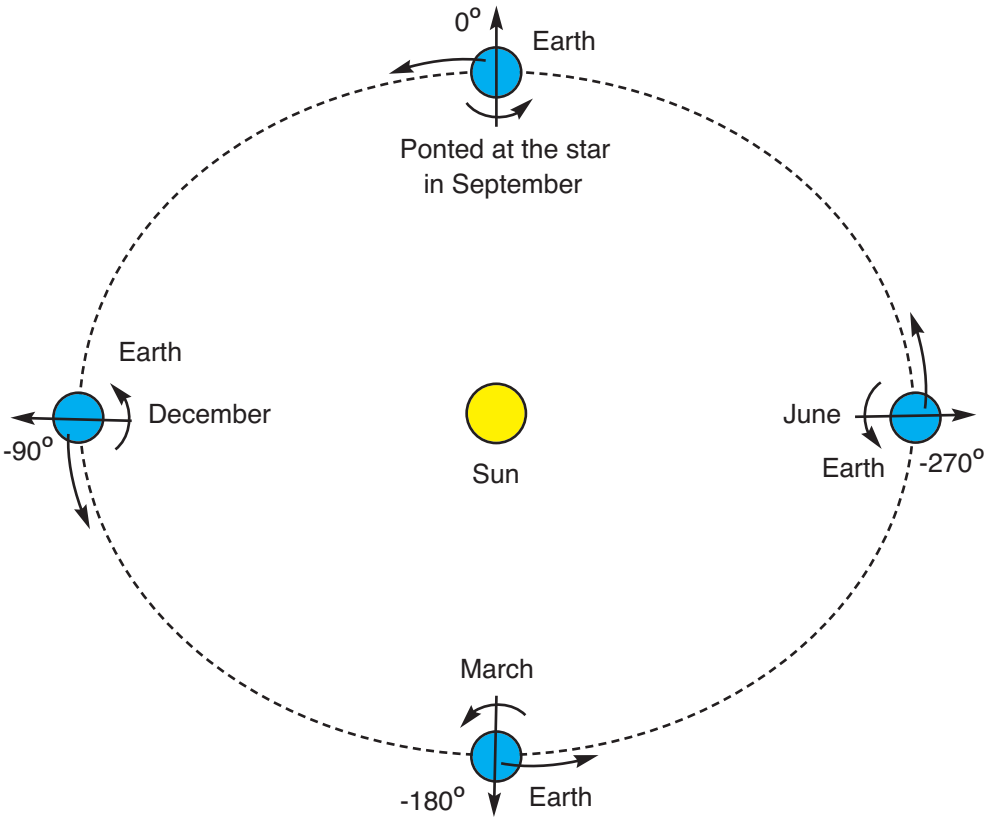


Position of the star falls behindat exactly 24 hours later

The earth rotates around the sun every 365.25 days. The earth also rotates around its every 24 hours.

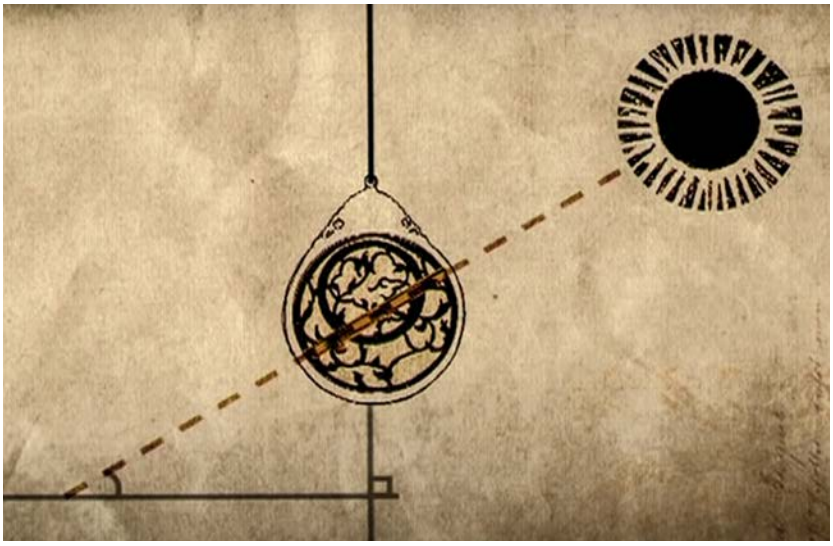
If an equatorial telescope (right) was centered on a distant star (above left), and the star's position was checked exactly 24 hours later (above right) it showed a shift calculated by 360 / 365.25 = 0° 59' 8" degrees/minutes/seconds. The star would fall on the reticule exactly a year later. Astronomers figured out this shift was due to rotation of the earth around itself and around the sun.



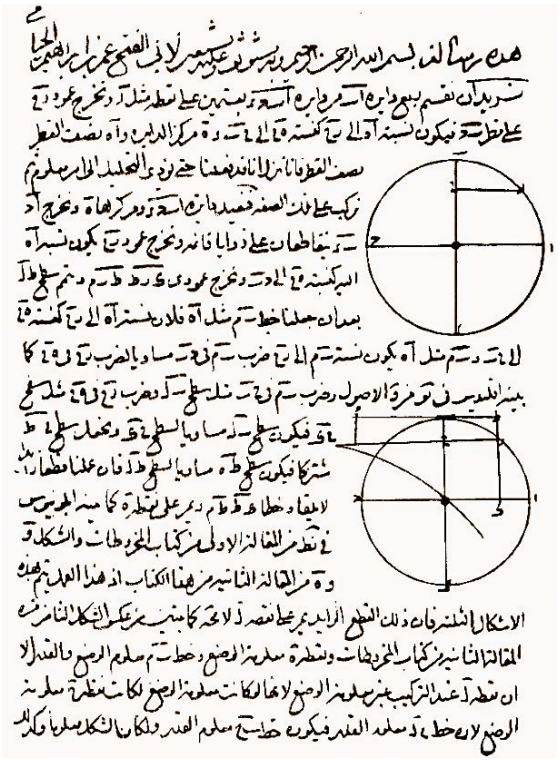


Above, diagram showing the mechanism of an equatorial mount for a telescope built in the 1800's. An equatorial mount is used to track an astronomical object across the sky. Compared with other mounts, an equatorial mount is aligned with the Earth's axis of rotation, ensuring that adjustments only need be made around one axis and can be done at a constant speed rather than a variable speed. The first equatorial mount was invented by the British astronomer William Lassell (1799-1880). This artwork is the frontispiece to a book by the English opticians John and Peter Dollond, Descriptions and Uses of the Newly Invented Universal Equatorial Instrument.

Above, earth's rotation around the sun is shown with a telescope (shown with the straight arrow) mounted on a fixed tripod. The position of a distant star centered through the telescope shifts -0° 59' 8" every 24 hours due to earth's rotation, and -90 degrees every 4 months, and a full 360 degrees in the course of an entire year. Total earth's rotation in a year around the sun takes 365.25 days.



Omur Khayyam's measurement of the solar year with 12 digit accuracy was astounding. How did his team of astronomers come up with such precise measurements? Their calculation (a Solar year = 365.24219858156 days) was accurate to the first 5 digits. The error in the remaining digits weren't His, it was the earth itself. The most advanced measurement of his time was the Astrolabe (left). Using its rotating sight, (similar to how rifles are pointed at targets without a scope) they were able to measure the angle of celestial objects (right). There were engravings on this instrument that allowed them to calculate exact time, the day, and month of the year, as well as many other astronomical calculations.



Left, an Astrolabe disassembled to reveal its pieces. It had interchangeable plates with graduations to indicate the orbit of planets, and constellations. Rigth, Omur Khayyam's most important contribution to mathematics was his work involving cubic equations. A cubic equation is an equation whose highest degree variable is three, like x3 + 3x2 - 2x + 5 = 0.

Although Khayyam did not contribute significant original methods of solution, he did write one of the first treatises that enumerated the different types of cubic equations and attempted to find the general solution of each different type of cubic equation. The question of solving cubic equations by the use of conic sections was one that interested many Islamic mathematicians of the Middle Ages. These solutions involved a mixture of the geometric techniques inherited from the Greeks and the new algebraic techniques developed in the Islamic Empire.

Mathematicians such as Ibn al-Haytham, al-Biruni, al-Mahani, and al-Khazin all contributed solutions to certain types of cubic equations. But it was Omar Khayyam who wrote the first dissertation that set out the complete theory of cubic equations. Source, Wikipedia

Be happy for this moment. This moment is your life.

“To wisely live your life, you don't need to know much
Just remember two main rules for the beginning:
You better starve, than eat whatever
And better be alone, than with whoever.”

“Oh threats of Hell and Hopes of Paradise!
One thing at least is certain - This Life flies;
One thing is certain and the rest is Lies -
The Flower that once has blown forever dies.”

“As far as you can avoid it,
do not give grief to anyone.
Never inflict your rage on another.
If you hope for eternal rest, feel the pain yourself;
but don’t hurt others.”

“It’s too bad if a heart lacks fire,
and is deprived of the light
of a heart ablaze.
The day on which you are
without passionate love
is the most wasted day of your life.”

“Beyond the earth,
beyond the farthest skies
I try to find Heaven and Hell.
Then I hear a solemn voice that says:
"Heaven and hell are inside.”

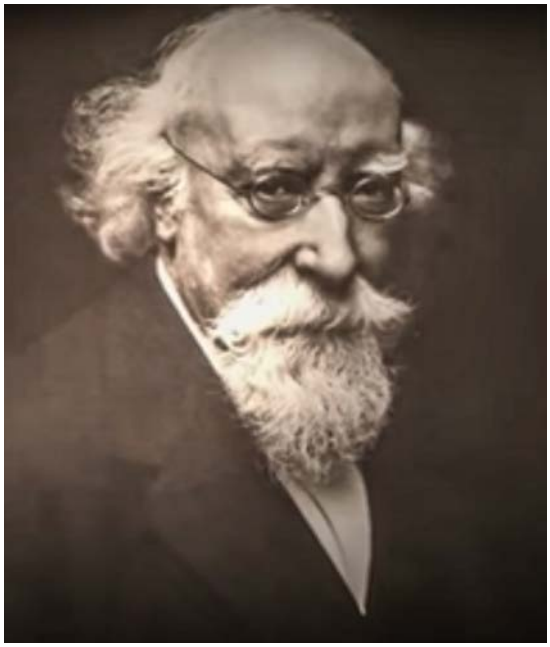
“Realise this: one day your soul
will depart from your body and you will
be drawn behind the curtain
that floats between us and the unknown.
While you wait for that moment, be happy,
because you don't know where you came from and
you don't know where you will be going.”

Alike for those who for To-day prepare,
And those that after some To-morrow stare,
A Muezzin from the Tower of Darkness cries
"Fools! your Reward is neither Here nor There.”

Omur Khayyam

Edward FitzGeraled (1809-1883) studied Persian poetry at university of Oxford. He was friends with great poets of his time like Alfred Lord Tennyson. He came across a small poetry book by Omur Khayyam, and decided to translate it to English. In spite of his extensive work, and determination, it attracted no attention, and ended up being sold for a penny on the bookstalls.

The book was picked up by Whitely Stokes, an Irish lawyer and Celtic scholar. He said to himself: “Oh God, these are fantastic!” He bought as many of those books he could, and sent them to his friends. The Rubaiyat slowly became famous, but it was not until 1868 that FitzGerald was encouraged to print a second, greatly revised edition of it.

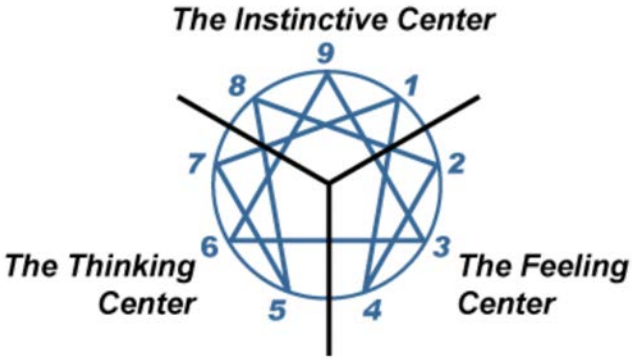


Whitley Stokes (1830-1909)

Psychology of Achievement: Facing Our Dark Side

By Ali Afshari

In the last issue, I opened the discussion on Enneagram, and in this issue and next issue, we'll continue with Advanced Enneagram. We'll go into more detail about how each personality type could pick the right direction towards the more successful tendencies in their personality type. If you are feeling good about yourself, you have been heading at the right direction.



Brain Tendencies

Lets first talk a little about who we are, and how our personalities are formed in childhood. Personality types aren't born, we learn, and pick it ourselves in childhood. When children go along with their parents to different places, they keep observing, and learn about their environment. They are told to be nice, and not to touch anything. Children play the roles they hear grownups talk about, and admire. When they go to school, they'd start forming their ideas about what they like, and their dislikes. At around age 10, they'd start telling their parents: "What's so fun about going to that place?"

While playing, some children wish they would be picked in a particular group with others. Some kids would start their own group. When other kids come over, they are told to be nice, and share their toys, even if their guest would break them. When children receive admiration in handling those situations, they might decide to pick type 2 for their personality. Some children are constantly told to get good grades, even if it means to lie or cheat, that's commonly the start of type 3 personality. Parents don't realize when they tell children to take a music class because he/she'll fall behind another sibling in their age, they are teaching them life is a race. These are some of the things that forms our personality types. At around age 14, we have picked our personality type, and we could not change it in the course of our entire lives. We could have wings or direction to acquire our healthy or unhealthy behavior.

As we hit 18, we realize life isn't a recreation park that we thought, and we'll have to work to get what we want. We also discover we aren't that perfect either: There is this dark side of us who wants to do bad things. So the never ending battle between the good, and bad begins in our hearts. Whatever bad is, it lowers our self worthiness because we start thinking that we aren't authentic. "We are fake, just pretending to be good", that's the voice we constantly hear in our mind. How could anyone win this battle? Is it a hopeless cause? How could anyone deal with the dark side?

Life of Pi, Courtesy of 20th Century Fox

The Dark Side

To discuss the dark side, let's first look at Rumi's personality model (opposite page). His model of the mind, the Soul, ego, super ego, the body, and the ID works somewhat like this: The passenger behind the carriage (the Soul), tells the driver (the Mind) where to go. The mind is the decision maker but there is also ego self, and super ego that filters, or influences it. The carriage is our body, and the horses are our ID, pulling the wagon forward. It is up to our mind whether to: 1) Listen to the passenger; 2) Let it be influenced by ego self, or super ego; or 3) Follow the ID. The thinking/feeling/instinctive cycle in us are the horses (from Enneagram Circle, above). That's really what pulls the wagon forward. The ID

Rumi's Model of the Self:

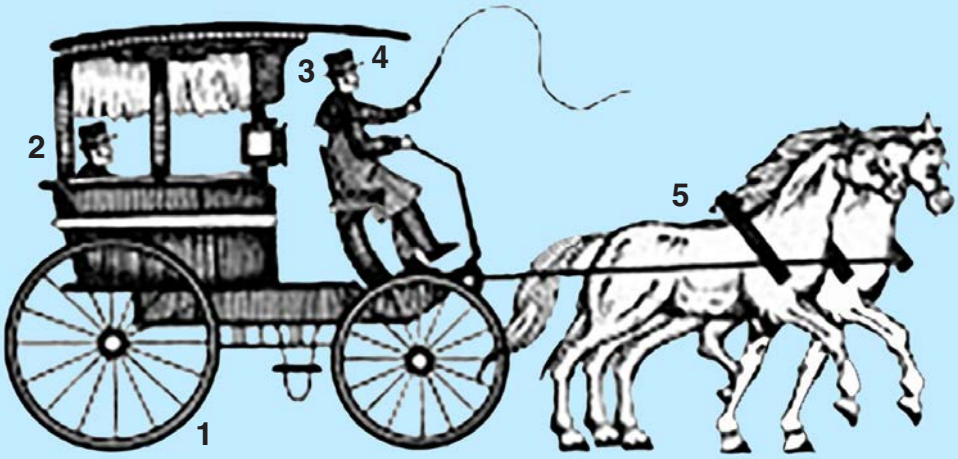
1) **Body**

2) **Soul**

3) **Ego, Super Ego**

4) **The Mind**

5) **The ID**



knows no rules, and without the driver's control, it would keep changing directions. I met someone who had lost 200 Lbs. He said when he went to a theater, he couldn't fit on any of the seats, and he was laughed at. That became his drive (the horses) to lose all his weight.

The ID says go have fun, or do anything you like, and take the most comfortable route. The Super ego, on the other hand tells us to behave, tells us to be honest, don't do bad things, and to forgive. Our mind (Ego self) is in the middle, listening to all this, and has to decide where to go. Well, the first thing we should know is the super ego isn't a prophet of God. It could be a mom, or dad, or a priest or clergy or a rabbi we met at a holy place that taught us those values. Some values may be wrong, or obsolete but super-ego keeps saying them. We don't necessarily have to do exactly as he/she says. We need to make the right decision, and even educate our super ego. If the soul, and the driver don't have a common language, it's because there is a conflict between what we know it's right or wrong, and the ego keeps telling us otherwise. The ego self says I want to have this, or I want to go that way. The ego wants to keep its self image. It doesn't want to get embarrassed by admitting: "I don't know", and wants to prove: "I'm good, successful, lovable, and interesting". At early 20's, we have all the confidence in the world, but before we reach 30, we have lost it all. We are constantly hustling for our worthiness with the ego self in our minds.

I said so little about the soul, as there is so little we know about it. "We are not given to see the soul", Rumi says. It's our very inner self. As people get really old, and start advising younger people how to live life, it's usually their soul speaking. It's our most silent voice, and the most hidden. Where does this voice come from? Rumi says this voice is from the creator. In his reed flute story, Rumi says human being is made in the form of a reed flute.

Hear the story as told by this reed
for being separated.
Ever since I was cut from the reed bed,
I've made this crying sound.

Anyone pulled from a source,
longs to go back.
Anyone separated from someone he loves,
understands what I say

At any gathering I am there,
mingling in the laughing, and grieving,
a friend to each, but only few could hear
secrets hidden within the notes,
no ears for that.

The reed flute is a friend to all
who want the fabric torn, and drawn away.

The reed flute has two ends, the air enters through one end, and goes out from the other end. Rumi says it's the breath of God that is blown into the reed flute, and the voice you hear whispering in our ears is the soul. Our soul wishes to go back to its source, but our mind is tempted to go a different path. If you understood the first 50 poems of Masnavi, you've

read his book, entire. Those 50 poems are said to have been written by him.

He has a poem about Laila, and Majnun (Romeo and Juliet). Majnun had a female camel who just had a newly born calf. He longed to be with Laila, so he left the baby calf behind at his stable so the calf won't slow them down. While he was riding the camel to see Laila, he became so inattentive, that he let go of camel's reins, soon finding himself back to the stable. This goes on a few times until eventually he learns there are two conflicting wishes: His own wish to be with Laila, and his camel's wish to be with her new born. Rumi illustrates through this metaphor where our soul, and our mind longs to go.

So we now know a little bit about the soul. It wasn't that difficult, was it?

What about our dark side? The dark side is in us all, but we need to learn to use it for its real purpose. Have you ever thought what's the use of darkness? It shows light. That's what it's for. We can't have happiness without sadness, or good health if we never got sick. We can't win if we can't lose. We learn with our dark side as much as with our bright side. If we realize this, we could live with it, and sympathize with it. We are just like everyone else. We shouldn't judge people as much as we shouldn't judge our own self by our dark side. In areas that people have faults, they really have no choice. We could have the same attitude towards our dark side, to sympathized with, instead of hate, and despise.

One way to deal with our dark side is if we could imagine all our faults, all our nagging/blaming/finger pointing voices to be riding with us in a tour bus. Anyone you might be angry with, would be one of the passengers. You could take this journey in a peaceful day, riding the bus in beautiful nature, watching the trees go by under the blue sky or your favorite colors. When you reach the right spot, you might wish the driver to stop, so you could get off the bus to enjoy the beautiful scenery. While there, you could also ask any of your dark sides to get off the bus, to join you.

There is a nice comfortable bench nearby that you could both sit on, to have a little chat. That's it. That's how you could chat with your dark side, and start hearing them. In a while, you could make the journey back to the bus, and decide whether you'd like that person to get back in or not. As shown in the movie: "Life of PI", the main character couldn't kill the tiger when he was given the chance. What eventually happens when you sit, and listen to your dark side, your subconscious begins to see you could sympathize with that person. If you could sympathize with your dark sides, and learn to remove their pain, you'll live much happier as a person. It would take a while but it really works.

You could have this mind travel quite easily once you learn how to self hypnose. People think hypnosis is such an unfamiliar territory. Most of us get hypnosed while watching TV, and we don't even know it. I don't want to go to that area too much but the first thing you'd learn when you master hypnosis is not to let anyone hypnotize you. Hypnosis is like the yoga for the mind. You'll learn to be in full control of your mind. Many speakers hypnotize their audience, and many TV commercials hypnotize viewers. Every time you watch a commercial on TV or on the web that tells you to use a certain shampoo, undo it in your mind by saying: "You mean if I use my own shampoo, my hair won't be cleaned?" In self hypnosis, you could easily sit in a bus and ride with those people within your dark side. If you look at your inside, it's just a projection of what's out there.

The "Theater Technique" allows you to exit from your inner feelings, and get an objective view about your surrounding.

Here's an interesting twist to this: What you could do next is to exit from your state of mind, and fly above the bus. You'll be able see it at a distance, and if you get far above, all your dark side becomes a small dot, or a speckle of dust as Carl Sagan said about the earth itself, seen from outside of our solar system. I call it the theater technique: You could always see yourself in the front seat of a theater, watching a moment of your life that you have trouble with. It could be a short clip or a picture of a moment in your past. You could imagine yourself sitting in a back seat, watching yourself watching that scene. You could imagine yourself on a far back seat, or flying above the theatre, knowing someone like you is sitting in that theater, watching that movie, and knowing exactly how he/she feels. These are the things you could do with your mind to exit what you feel, and be less affected by it. Our dark side will not be demolished. It could be sympathized with. When you sympathize with it, you could easily forgive your parent, or whomever did what to you.

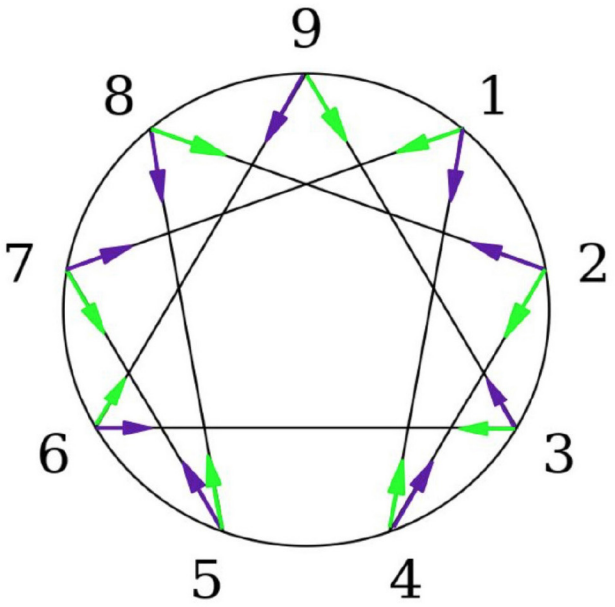
There is nothing to be scared about your dark side, and it's the safest place you could go so long as you don't take any drugs for it. Another way to get rid of all your anger towards someone is to take a white sheet of paper, and to write their name on top. Then write whatever you could say about that person, and whatever they did to you, and keep writing until you run out of words. Then take it to a sink or fireplace, and burn it. Do it once in every 3 days, until you are finished with that person, then go to the next person until your mind is free from them. It is said people may not deserve your forgiveness but you deserve to live in peace. You must let it all go.

You could go anywhere you like with your dark side, don't ever be afraid of facing it. It's not a comfortable feeling but life is about learning to be feeling comfortable by feeling uncomfortable. When you go on a journey in the spiritual path, feel safe. It won't be worse than being an astronaut in outer space. There is still something holding you there! It's the wire that hooks you to the spacecraft, and you could always pull on it to go back to safety. In hypnosis, and in spiritual journeys, your feet remain on the material world. You could go anywhere you'd like in the spiritual world, and you could come back to where you started from. In the works of Carlos Castaneda, it first appeared that he was given Hallucinogens to travel to the spirit world but he later found it had nothing to do with it.

I highly recommend watching: "The Monster Calls". It's about a boy who is losing her mom to cancer, and is struggling with this tragedy on his own. A monster in form of a tree emerges to help him. The monster's transformation to become his best friend is so beautifully illustrated in this film. I wish all scary movies had this theme, to open our hearts rather

than closing it to the unknown. Human being himself/herself is so unknown, and it would remain that way until we break from the shackles of labeling others. This is what happens in the so beloved film: "Good Will Hunting" played by Matt Damon, and Robin Williams. He is so missed.

Advanced Enneagram



Wings, and Directions

Now that we put that behind, we'll continue with our discussion on Enneagram chart (right), and go over each type. In our introduction in the last issue, it was easy to distinguish between each type but of course, you'd like to know where it goes from here. The first thing we should know is no type has seniority over the other, but it is from their energy levels that shows whether a person has become successful in their type or is moving towards their unsuccessful tendencies. Let's first see how different personality types would perform at their work place:

Personality wise, types 1, 3, and 8 would make good managers. Type 6 will make good accountants. They are so detail oriented, and patient. Type 5 is good at doing research but has to be left alone to do their job. They don't like to work in crowds. Type 2 works better at the presence of other people. They'll get depressed if they are left alone. Type 4 works at vibrant environments so they could be involved with art, and creativity. They like to display their creativity to others. Type 9's like to do their work at their own pace. They'll get agitated by set deadlines. Type 8, and 9 don't like to be micro-managed. Type 1 likes to pay attention to details, and they'll usually end up micro-managing. Type 3's are better in allocating work to others. More on the type's directions, and wings on the next issue.

What will be the worse, and best match between different types in a relationship? Let's consider a couple, both being type 6: They'll both be suspicious, and will acknowledge each other to be more, and more suspicious. It will isolate them from social interaction, and it will be a disastrous relationship. You realize the benefit of knowing who you are getting married to, but just know there are: 9+8+7+6+5+4+3+2+1= 45 distinct combinations to cover. Just read what applies to you, or the person you care about. There are a lot of people who don't pay much attention to this, and they realize later how difficult their marriage life gets. We'll also discuss that in more detail on the next issue.

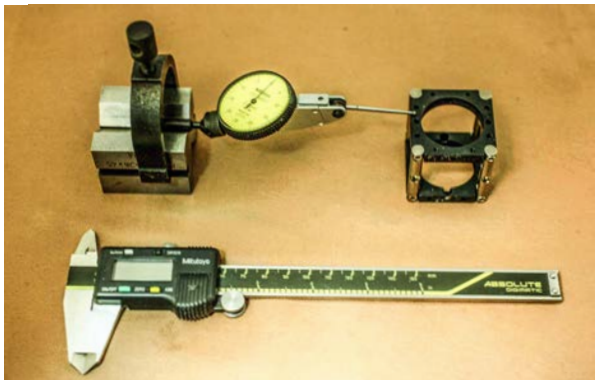
Knowledge is power. Even courage without knowledge ends up in hopelessness. I don't intend to change anyone but myself. I obligate myself to teach what I have learned so I also receive in the process. It works like a mirror: If you like to learn, teach. If you want to be loved, then love yourself. If you'd like to be listened to, listen. Men learn this at a young age while they learn how to do their tie in front of a mirror, but they forget to apply it elsewhere. Anyone could do hypnosis as taught by **Milton Erickson** at least to level 1 or 2. The subconscious opens on the first level, and you could remove what you don't like from your past. Not knowing techniques is like trying to lift yourself up by pulling on your shoe straps.

An Interview with Carl Jung (1875-1961) born in Kesswil, Switzerland, founded analytic psychology

"We need more understanding of human nature because the real danger that exists is man himself. We are pitifully unaware of it. We know nothing of man. Far too little. His psyche should be studied because we are the origin of all coming evil. Man can not stand a meaningless life. "

Watch his interview on Youtube: http://youtu.be/2AMu-G51yTY

Utilizing Optoform pieces for other projects around the lab!

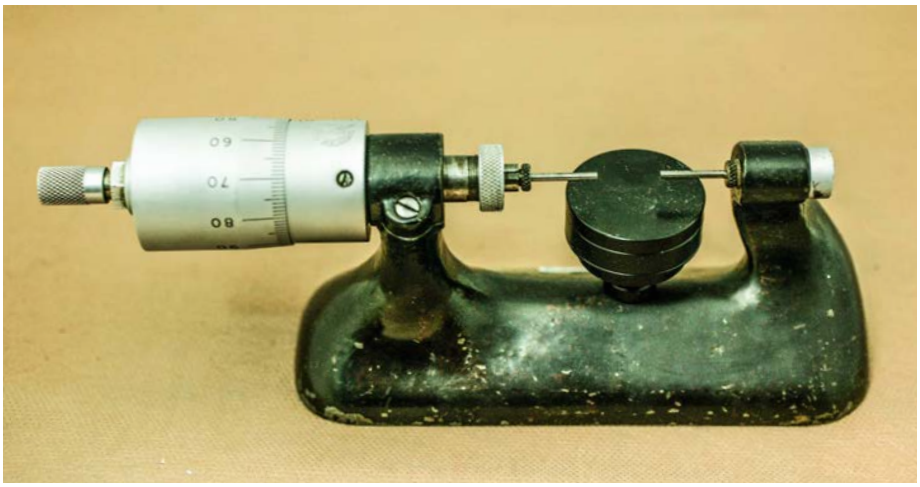


Utilizing Optoform for something else other than optics is the topic of these articles.

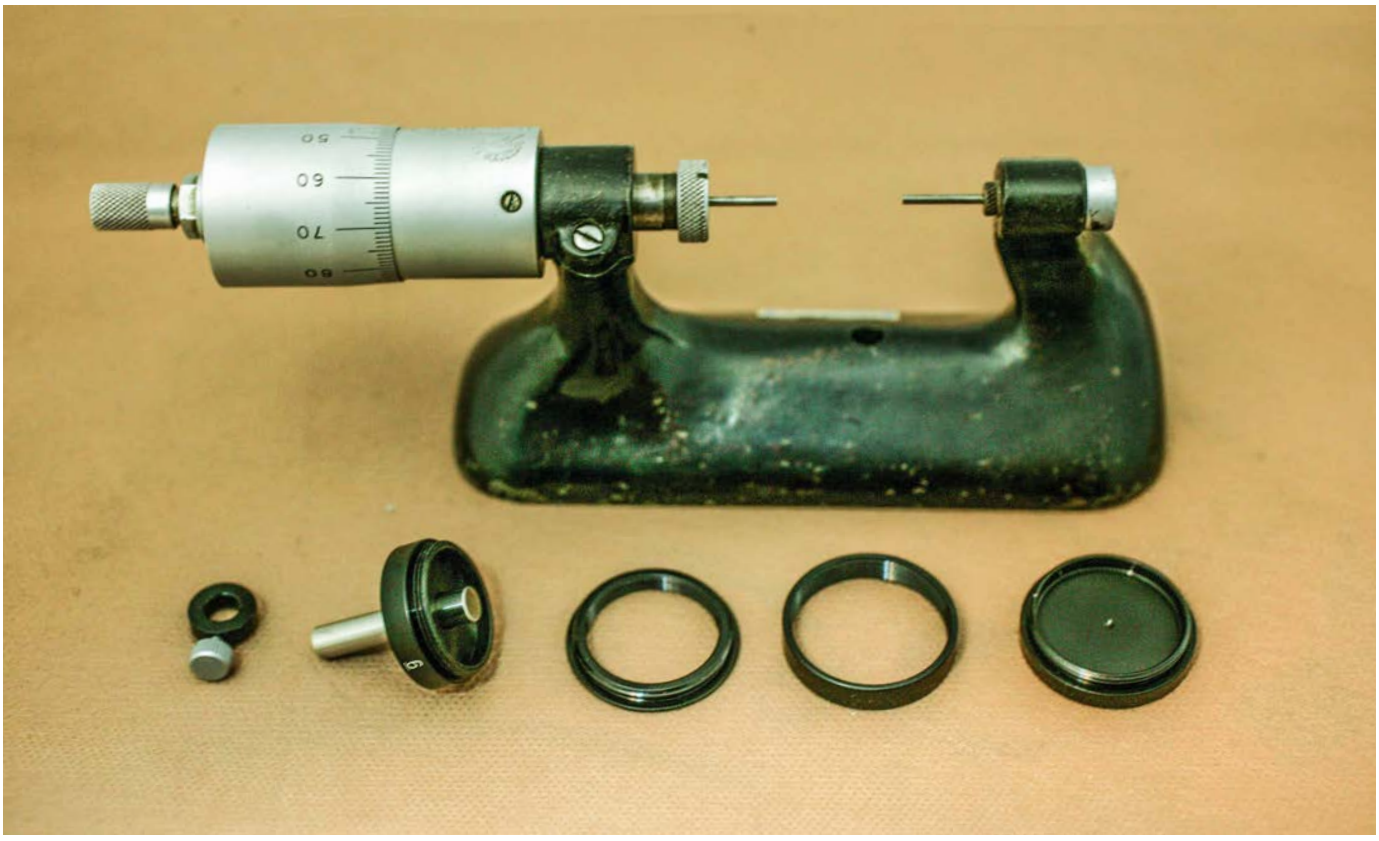
While during my consulting years, I have done mostly optics, I have occasionally done something else, or in my own experimentation, I have needed tooling that weren't available, and I found Optoform the perfect companion to implement them.

The new Optoform mouting plates bring in measurment devices into the optical lab like never before. The height measurement setup (right) would be needed to make high precision assemblies. A digital caliper would also be so helpful in your lab.

Making measurement stages with Optoform



The most useful application of Optoform other than optics is in measurement labs. Optoform's 6 mm rod based system not only connects mounts together, it can also secure measurement platforms when combined with Micromax mounts. In a watchmaking shop, they utilize table top micrometers for measuring small parts. In here, a miniature platform is built with Micomax for retaining small parts during measurement. The platform is fully adjustable, and can accommodate various part sizes.



Chromic

Automatic Chromozome sorting software

Software features:

Costs under $5k, compatible to most cameras

Online image capture and visualization

Convenient tools for editing metaphase images

One of the best image processing algorithms for enhancement of microscopic images

Last generation Artificial intelligence algorithms for classification of chromosomes

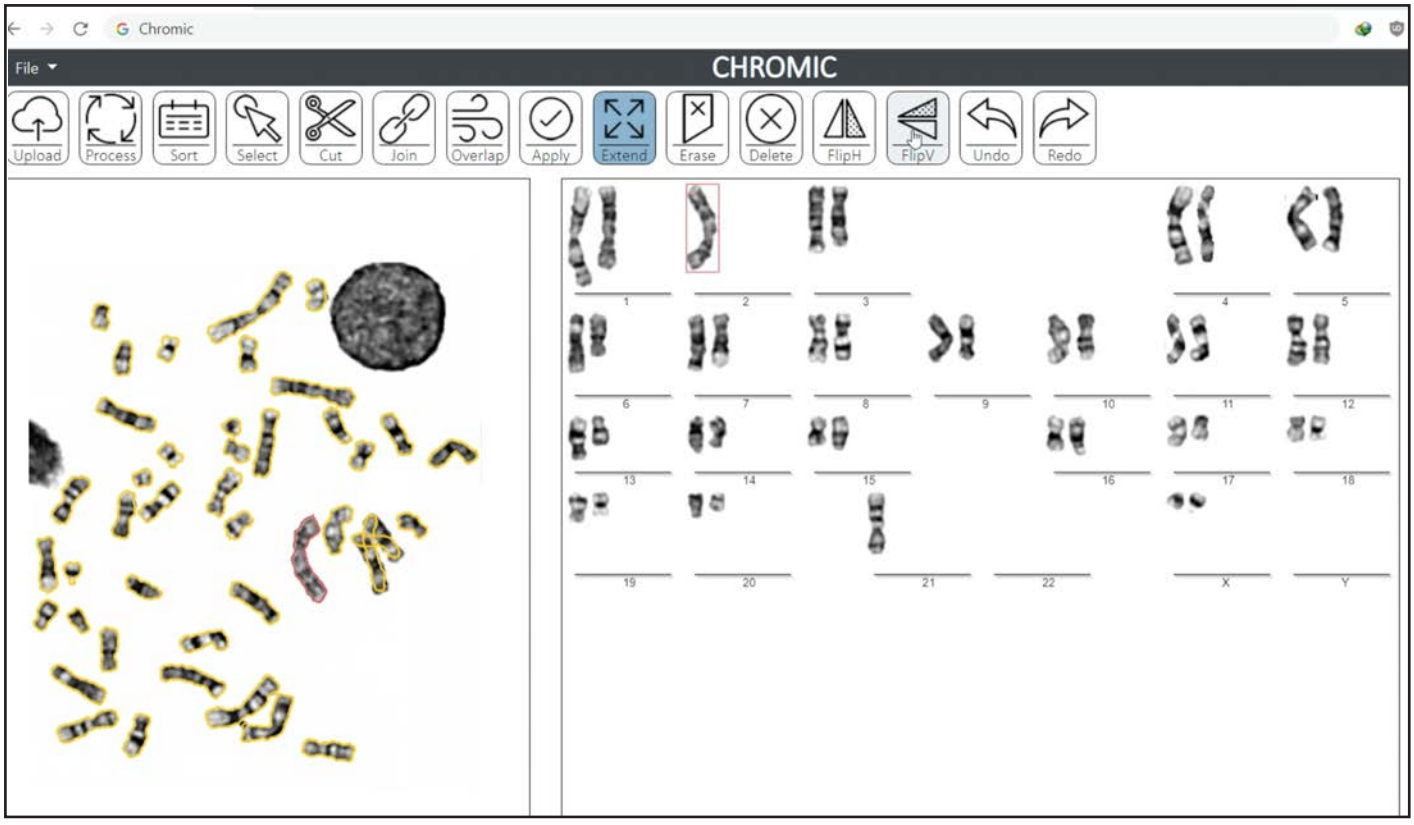
Provides powerful tools for separation of overlapping chromosomes

Exports a report based on examiner's comments on the test results

Optional motorized stage control for metaphase search, and image capture

Competitive advantages of the software:

- ☐ One-year free access to latest software upgrades
- ☐ Personalization options for labs and users
- ☐ High quality and lower cost
- ☐ Technical support



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