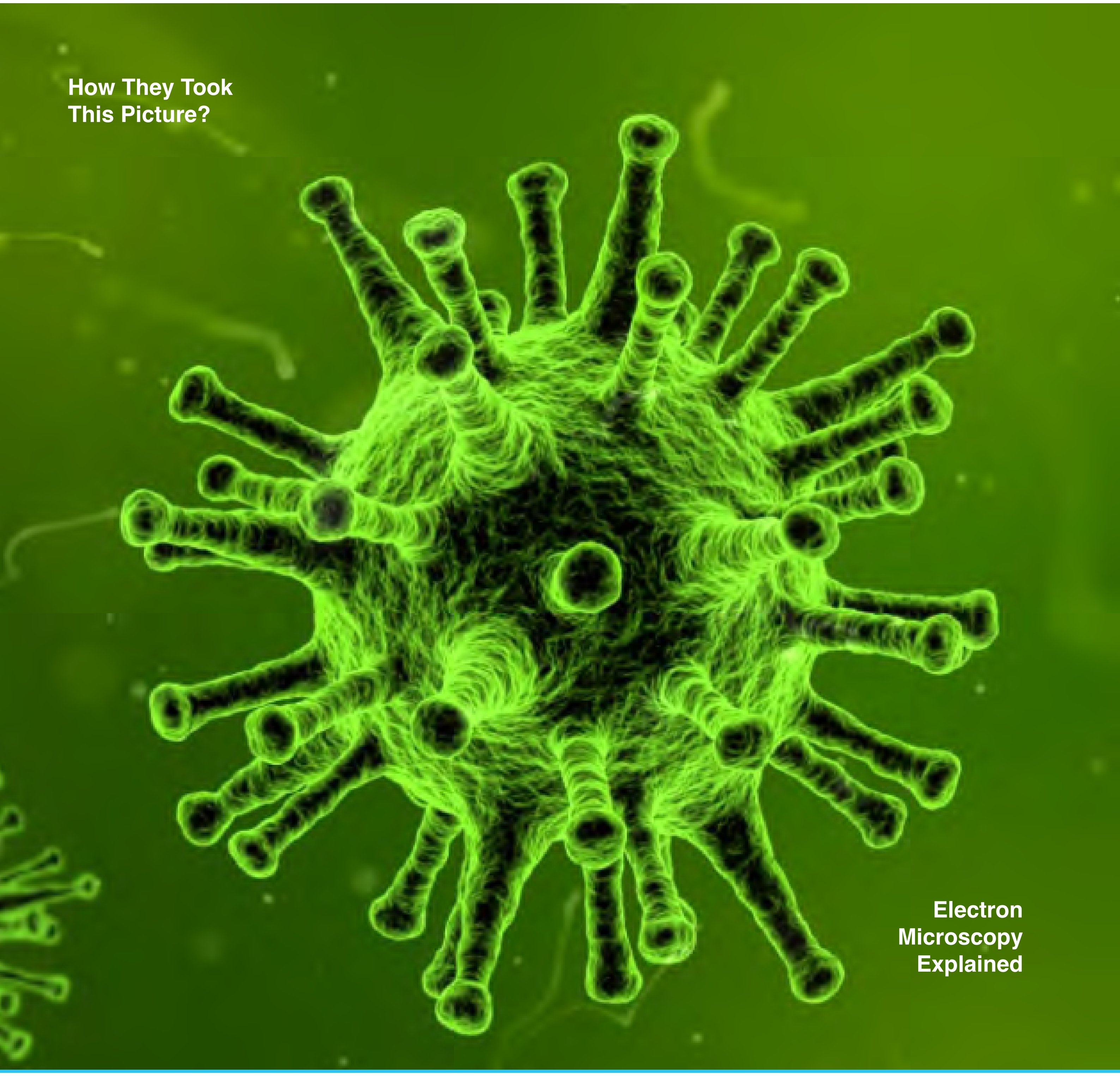
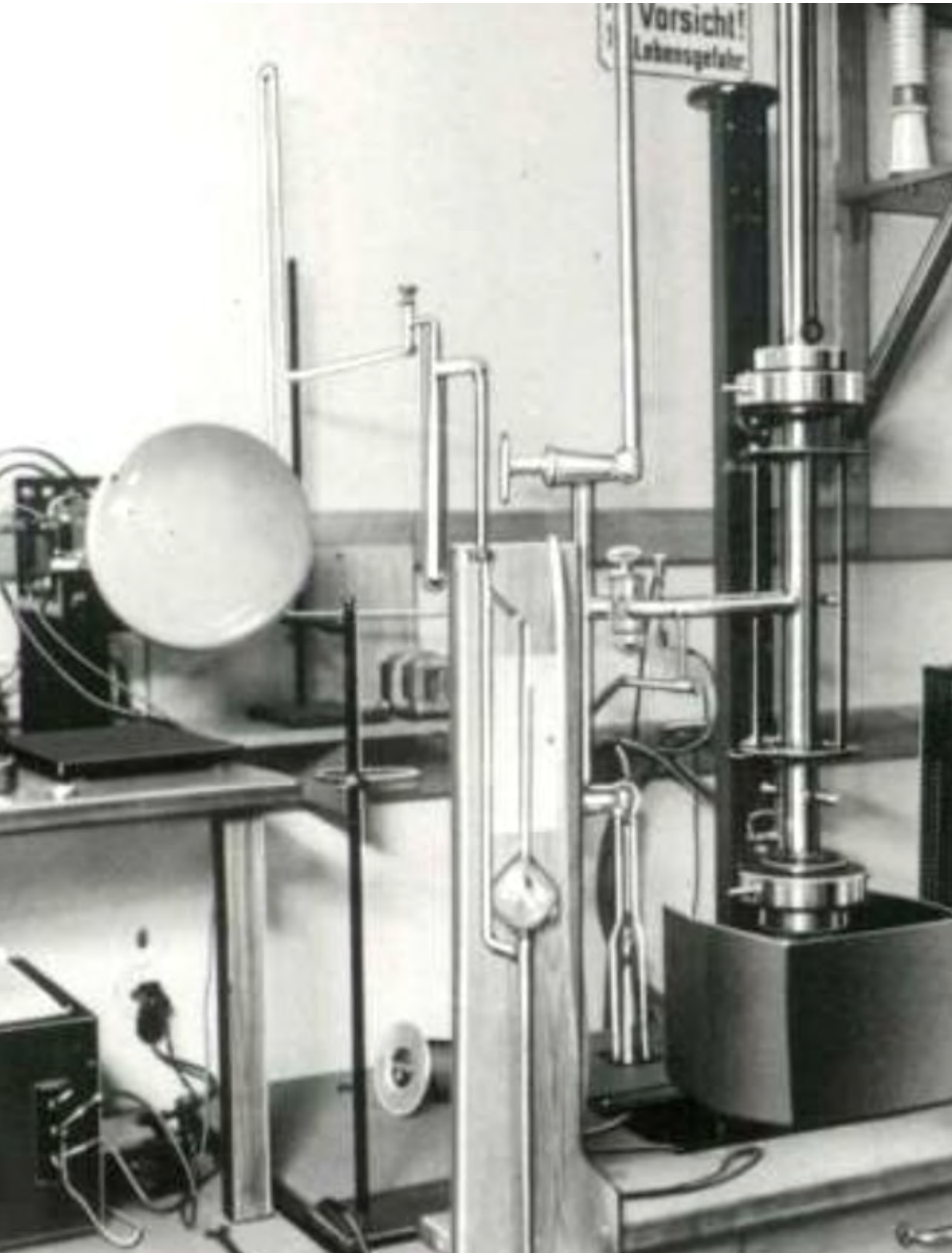
Optomechanix

April-June 2020



Technical journal of OMiD, Opto-Mechanical Institute of Design



The first Scanning Electron Microscope (SEM) built by Dr. Manfred von Ardenne in 1937

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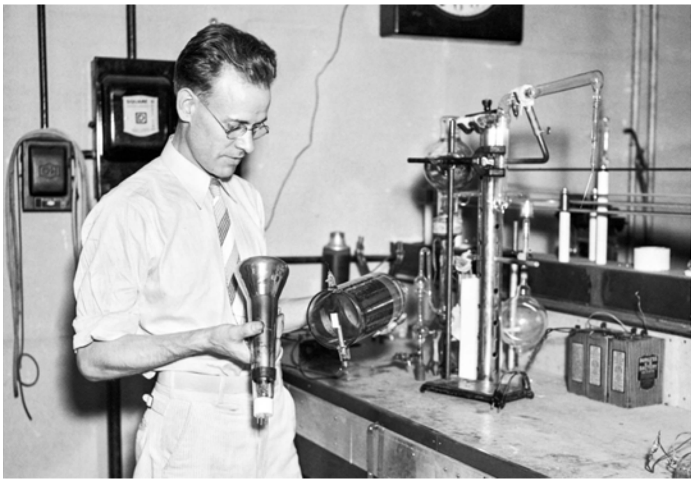
This issue Dedicated to:

Philo T Farnsworth (1906-1971) the inventor of television, was born in the state of Utah. Before him, John Logi Beard had developed a mechanical television, by using a spinning nipkow disc with spiral hole pattern to scan the image. Farnsworth said in order for television to work, it had to have no moving parts, and it was his genious idea to do it electronically. RCA claimed Fransworth's invention as their own, and he spent many years batling it in courts over the ownership of his invention and he eventually won the case.

In 1939 there was a contract signed between Fransworth and president of RCA David Sarnof for about a million dollars plus royalties. But America went to war II and by the time the war was over in 1946, his patent had expired. So Farnsworth didn't get paid much for his invention. That's when real television as we call it took off, and began broadcasting. There is a video of Farnsworth remaining: https://youtu.be/3cspYZyGp1A

He spent his last years developing 2000 line resolution TV (HD), and neuclear power as a cheap alternative for energy source.



Philo Taylor Farnsworth with his early commercial television set (left), at his lab developing his vidicons (right).

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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.

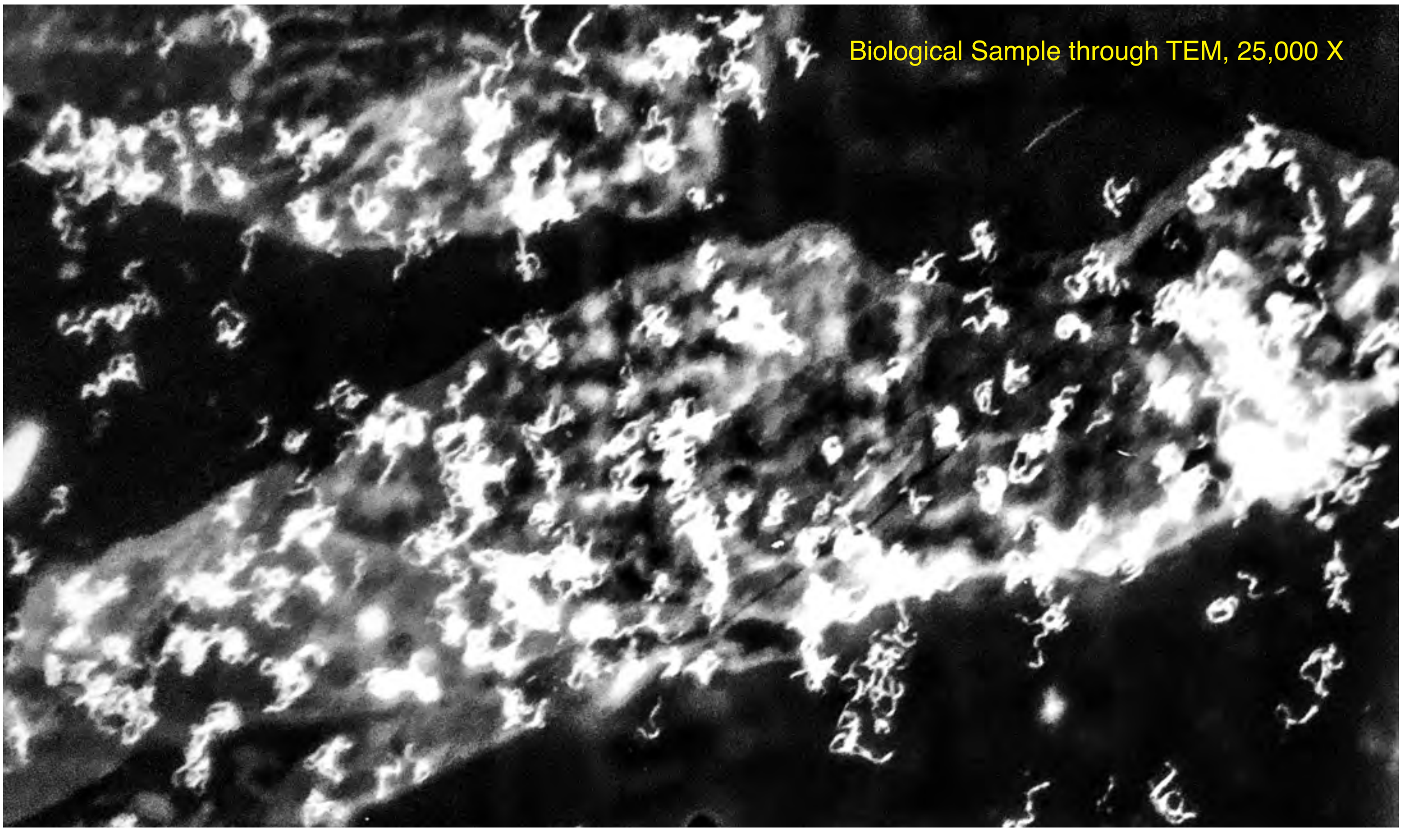
Cover page photo: SEM photo of Covid-19 virus, Courtesy, University of Huston
Inside page photo: The first Scanning Electron Microscope (SEM) in 1937

Transmission Electron Microscope

All nations are working together against this vicious killer virus (current total death toll is 142,000), and I thought what could I contribute? Well the fact that we could see, and identify this virus, and know how it looks like owes much of its credit to the scientists, and engineers who invented the Electron microscope. If you still want to see an informal video on Corona virus: https://youtu.be/aerq4byr7ps

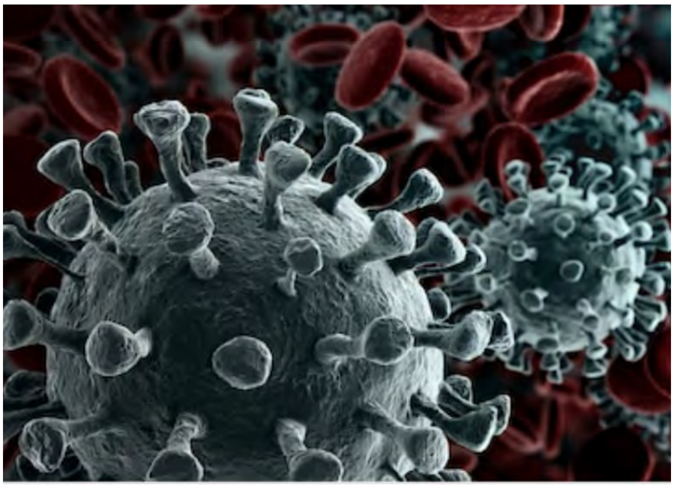
I loved Electron microscopy so much that after I completed my bachelor degree in EE, I went straight to my university

Working with RCA Transmission Electron Microscope EMU-3G built in 1962



Biological Sample through TEM, 25,000 X

Coronavirus with Influenza background

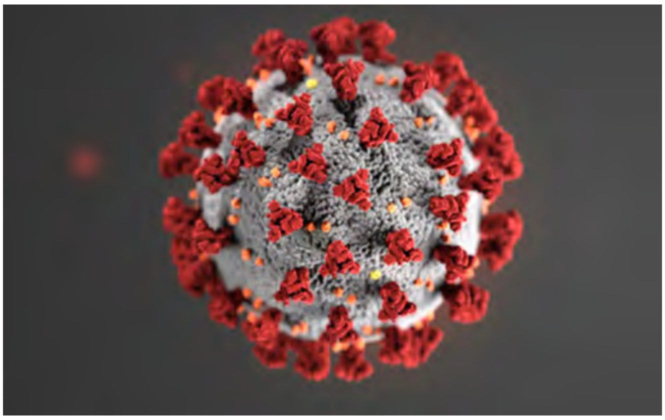


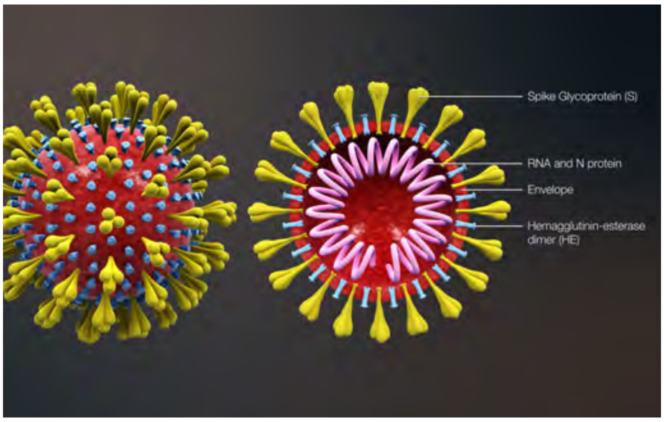
Images courtesy, Shutterstock

library, and checked out as many books I could carry on electron microscopy, and started reading them. I also took a course they offered on the subject at our Chemistry department. The first part of the course covered Transmission Electron Microscope, including sample sectioning, using a microtone machine, and sample preparations, staining, which were boring to me because my main interest was the Scanning Electron Microscope. In Transmission Electron Microscope, a small circular mesh-grid is carried on the tip of a small tweezers, and is utilized to pick a thin layer of a biological sample, floating on water at a sectioning machine. The small grid is then transferred to a specimen holder (opposite Page), and it's inserted into the microscope like an engine oil dip stick. The microscope simply projects a shadow of the Electrons produced by the electron gun situated on top of a tall column, passing through the sample, so the image is formed at the bottom on a photographic sheet of film.

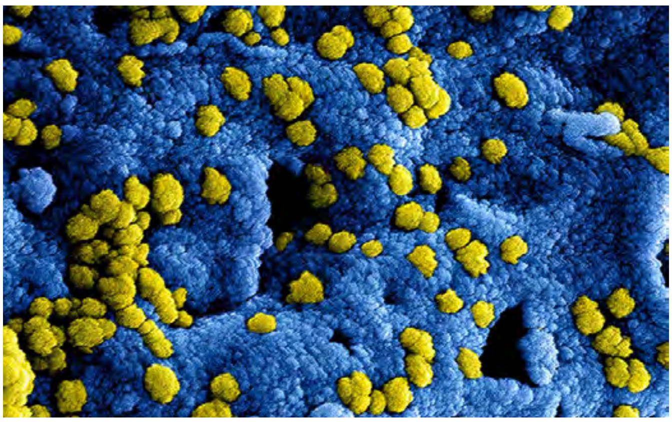
The Scanning Electron Microscope (SEM) on the other hand works differently, and its design is far more interesting to learn. We'll cover the SEM design to show how it works, but we'll start with how the CRT in television works first.

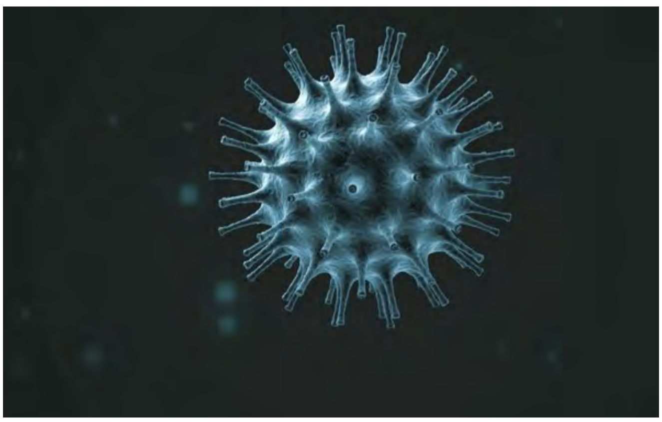
Ali Afshari
Optomechanix editor, and contributor





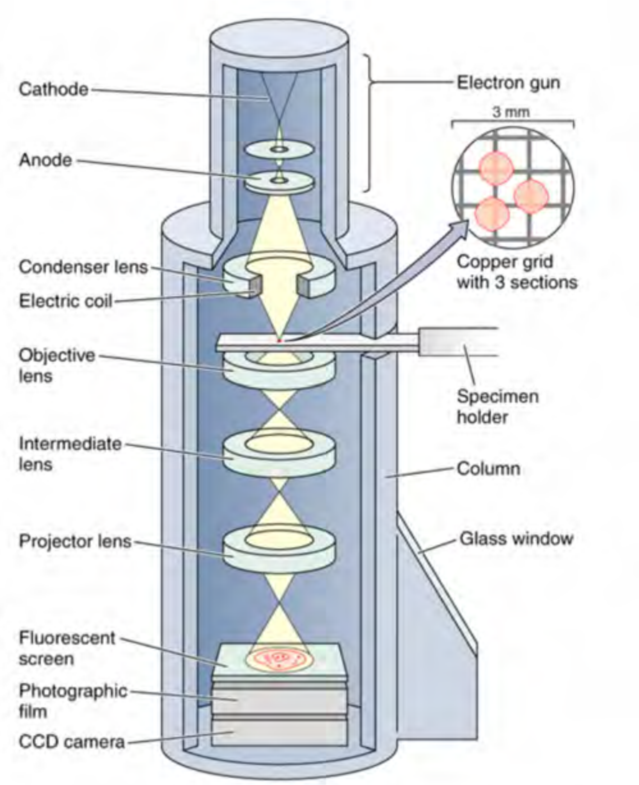
Various false Color Coronavirus images on this page have been taken by SEM. Above, courtesy, scientific Animations



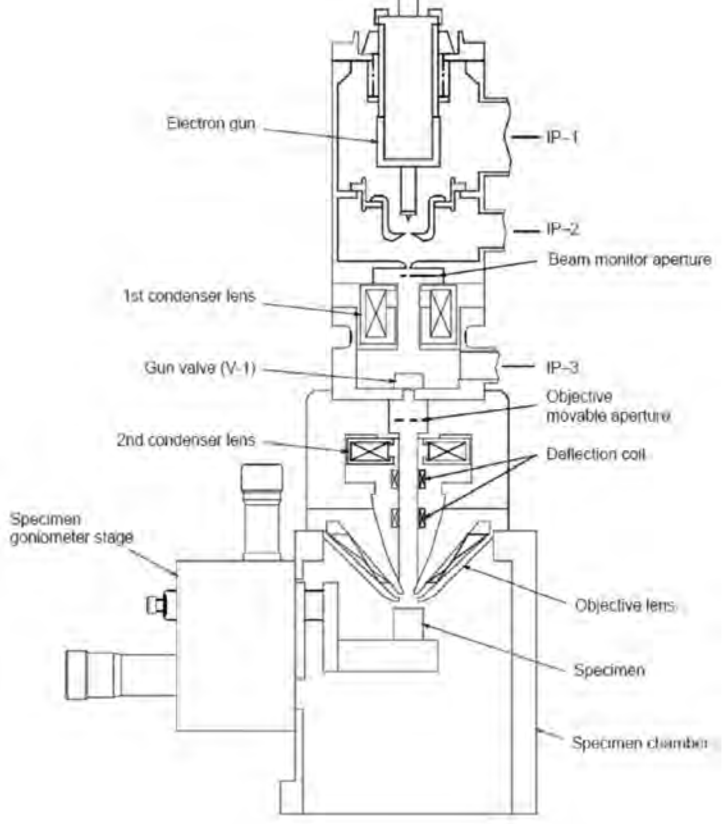


Above, Image courtesy, US National Institute of Alergy and infection diseases. Right, image courtesy, Tewksbury

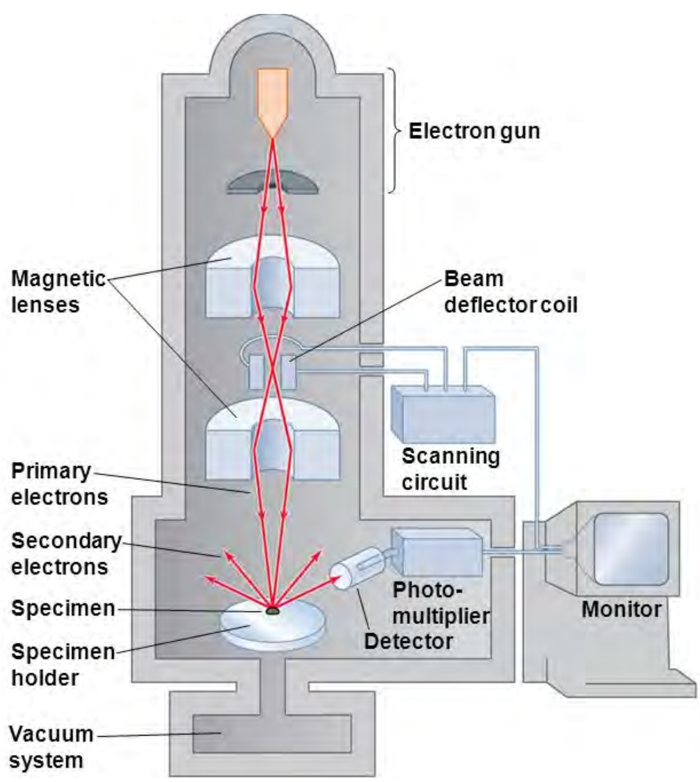
An Overview and Introduction



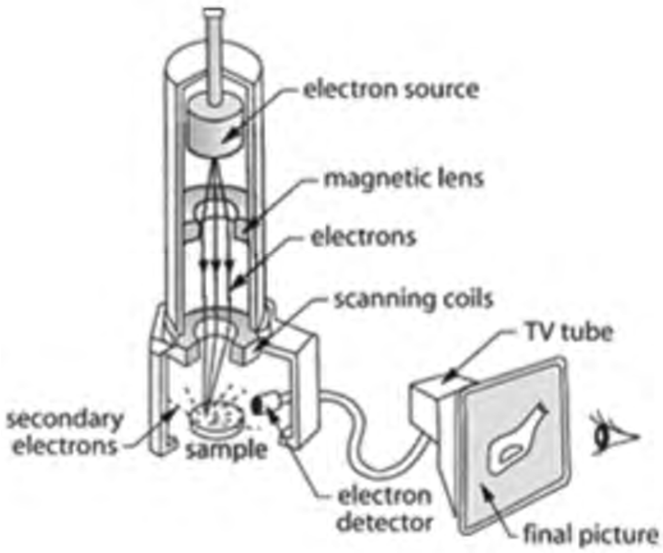
Transmission **E**lectron **M**icroscope
Courtesy, Pearson Educational Inc.



Section View of **Hitachi S-4700** SEM



Scanning **E**lectron **M**icroscope



Various online diagrams I found on Transmission Electron Microscope (TEM), and Scanning Electron Microscope (SEM), showing how it works.
I will explain how the concept evolved, and how it works. The invention of television contributed so much to SEM.

The Invention of Television, and Raster Scan

The invention of Scanning Electron Microscope and television are so related that if you understand one, you'll understand the other. Designers, and inventors have amazing conviction on what they are passionate about. I remember back in the JPL years, my colleague, Perry Fatehi, who was an Iranian designer on Cassini's camera head electronics, showed me what he had designed. I was intrigued by how his circuitry serially read the pixels from the CCD, and wrote them onto a dual port ram while the spacecraft's main frame computer asynchronously read the image line by line from the other side. I said: "That's brilliant, how did you come up with that idea?" He said: "While I was driving! It came to me right on the intersection of highways 118, and 405".

The idea of television was conceived by Philo T Farnsworth (1906-1971), born in the state of Utah. At age 14, while he was working on the field, in his father's farm in Idaho, pushing a horse drawn cutter back and forth, his mind was thinking about an idea he had read in a science magazine about television. When he got to the end, he looked back at this newly plowed field, and he saw evenly parallel lines row after row. It occurred to him that an image could be sliced into such rows back and forth, and then each row transmitted in a continuous sequence, thus raster image was born.

He set up his lab at age 20 in San Francisco, CA, and managed to make a working prototype of his invention by producing a straight line on a cathode tube on Sept 7, 1927 (Fig.3), and that was the breakthrough he had been waiting for. The scan line was produced by deflecting an electron beam using two coils placed on two opposite sides of the beam path. When one coil was energized with a positive charge, the electron beam, having a negative charge, would be deflected towards it, and vice versa. This demonstration had been done by Thompson many years ago, but it wasn't utilized to produce a TV line. A phosphor coating was applied on the front glass screen to convert the electron wavelength to visible green.

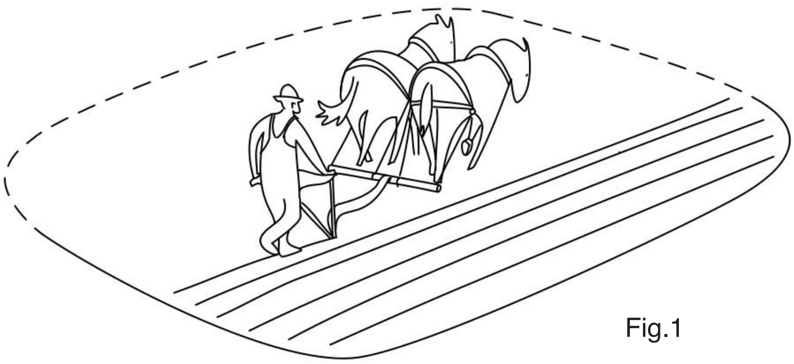


Fig.1

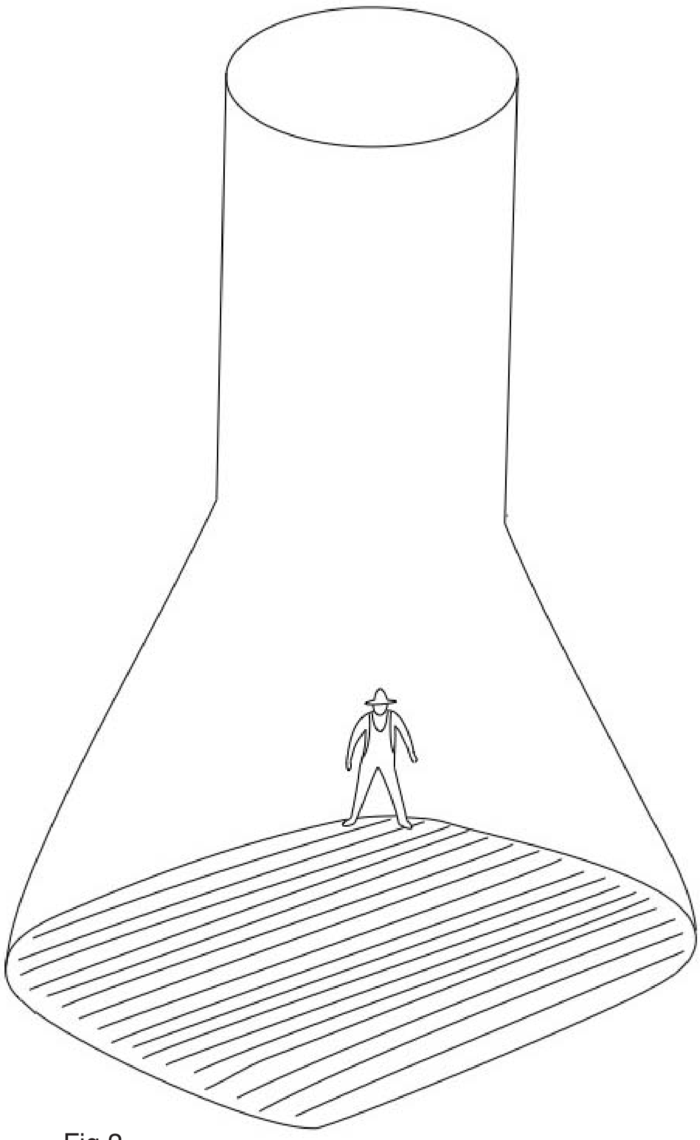
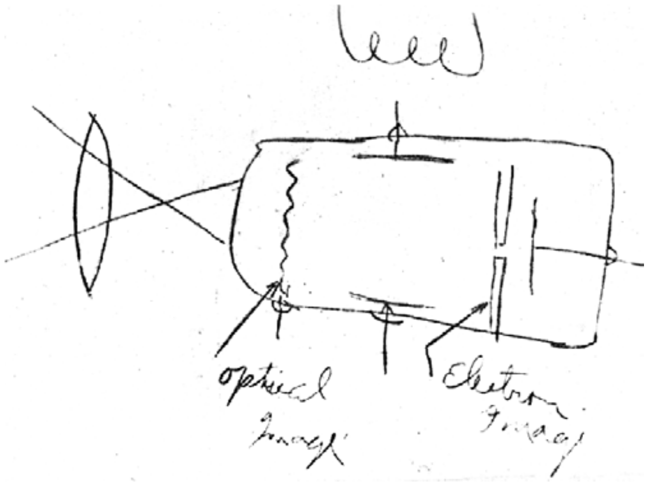


Fig.2


Philio Farmsworth Developing the vacuum tube (left), a television receiver prototype (right).




Farnsworth's first hand sketch of his electron raster scan, and Vidicon tube to show the idea to his teacher, later helped him to get the rights to his invention in courts.


The Vidicon onboard Voyager spacecraft is based on the same television camera image readout scheme invented by Farnsworth in 1914. All the planetary images taken by Voyager that we still enjoy today has been taken by this 1.25" diameter device. Courtesy, OMiD museum.

The Cathode Ray Tube (CRT)

The CRT works on the same principle shown in **Fig.3**. In addition to the two coils sweeping the electron beam to make a horizontal line, there are two more coils (**Fig.4**) to deflect the entire line up and down to fill the entire screen. The straight path of Electrons having a negative charge, bends towards the positive coil. The saw- tooth waveform generated by horizontal, and vertical generators (**Fig.4**) are timed to accomplish this task line by line to produce the a full screen raster scan. The first commercially available television was introduced in 1927, called Model B Televiser. It had only 30 lines of vertical resolution.

On Nov 2nd 1936 BBC Television was born. In 1940's, the cathode ray tube that was developed for television gave radar the visual tool to play an important role in ending world war II.

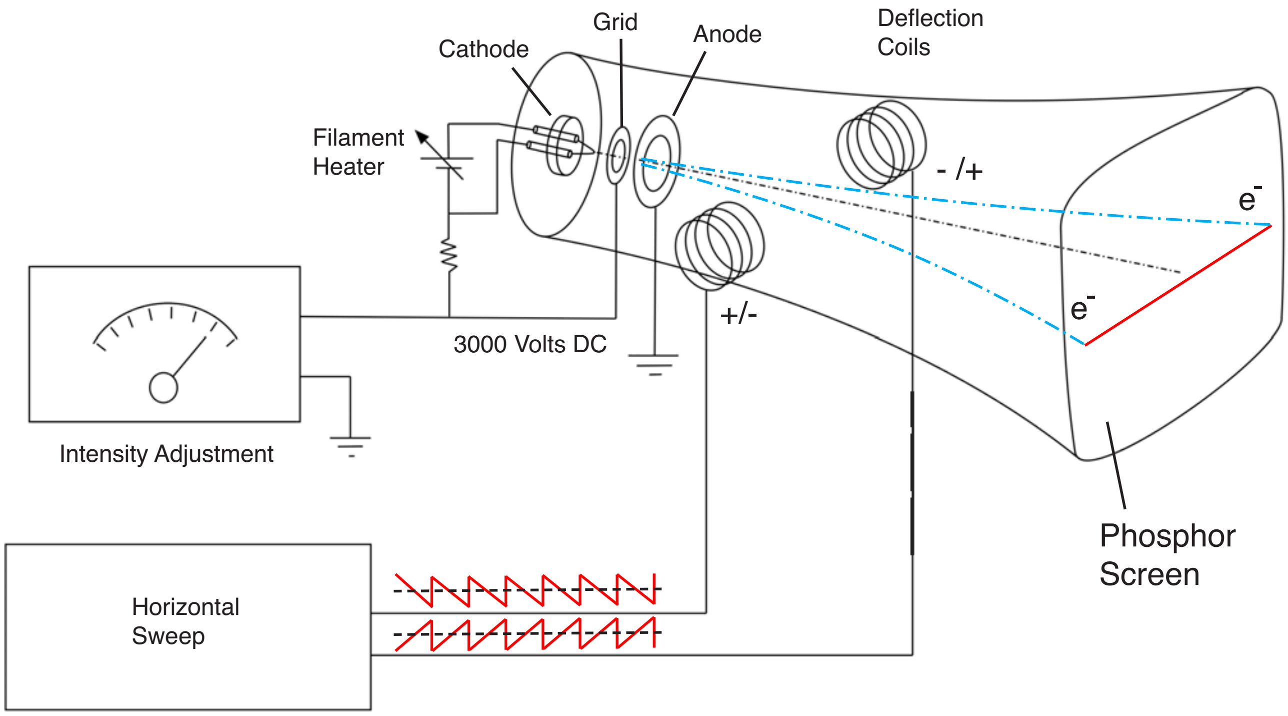


Fig.3 Schematic of single line Cathode Ray Tube (CRT). The horizontal sweep signal driving the deflection coils are 180 degrees out of phase. In other words, when one goes negative in voltage, the other goes positive, and vice versa. This is simply accomplished by connecting the coils in opposite polarities. You could see the affect of magnetic field on an old television set by touching the screen with a magnet.

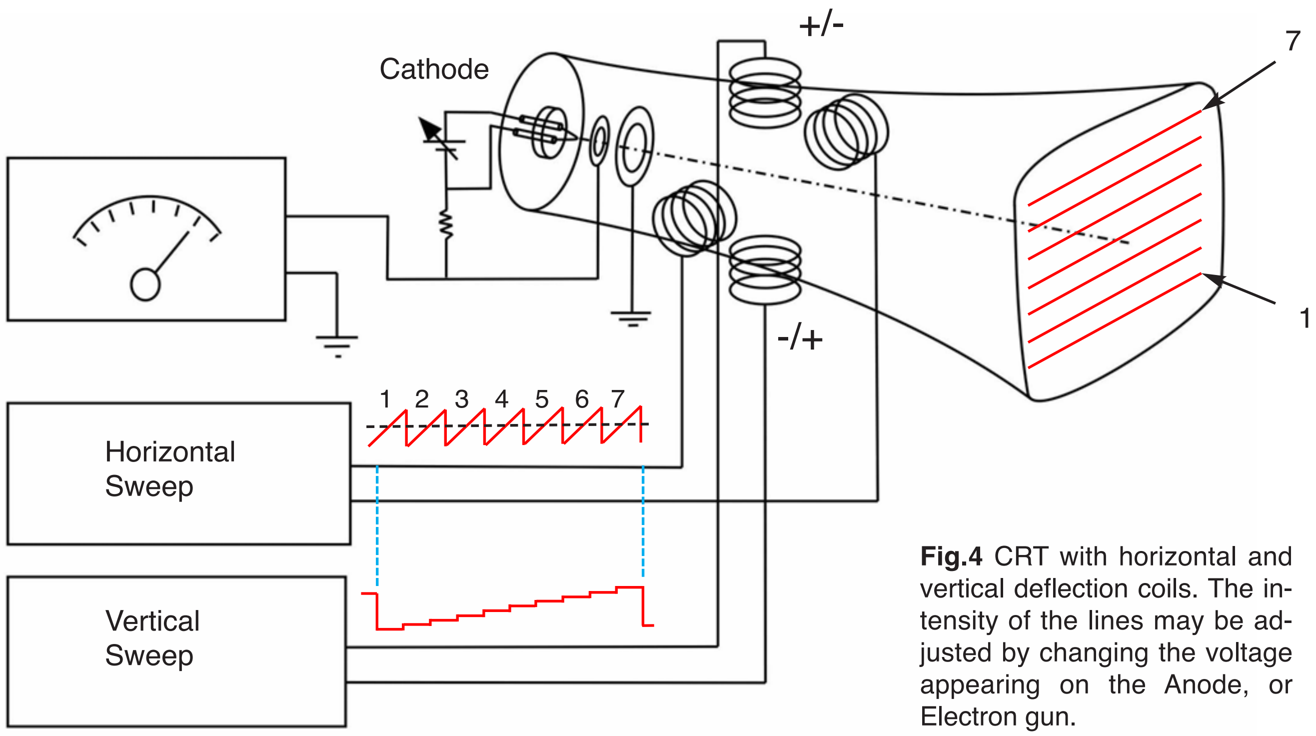


Fig.4 CRT with horizontal and vertical deflection coils. The intensity of the lines may be adjusted by changing the voltage appearing on the Anode, or Electron gun.

The Scanning Electron Microscope (SEM)

Referring to **Fig.5**, the same principle applies in Electron microscopy. There is an electron gun (like a thin Tungsten filament inside a light bulb) on top of the microscope column that produces the electron beam. This beam is focused to a sharp point at the sample plane by several magnetic lenses. There is a similar pair of coils producing a line across the sample as in the CRT. Now here's the idea: **The scan coils on the microscope column, and on CRT are fed by the same source, so these two lines (scan line d, and display line D) run exactly in sync, therefore every point scanned on the sample, is displayed at an identical location on the CRT screen**. When electrons collide on the sample surface, they release what is called secondary electrons from the surface. These electrons are collected by a detector, and amplified, then fed to the electron gun of CRT to display its intensity. Small "d" represents the length of the Electron scan line on the sample, while capital "D" represents the length of the line produced on the CRT. The two saw-tooth signals d1, and D1 are proportinally identical in this example.

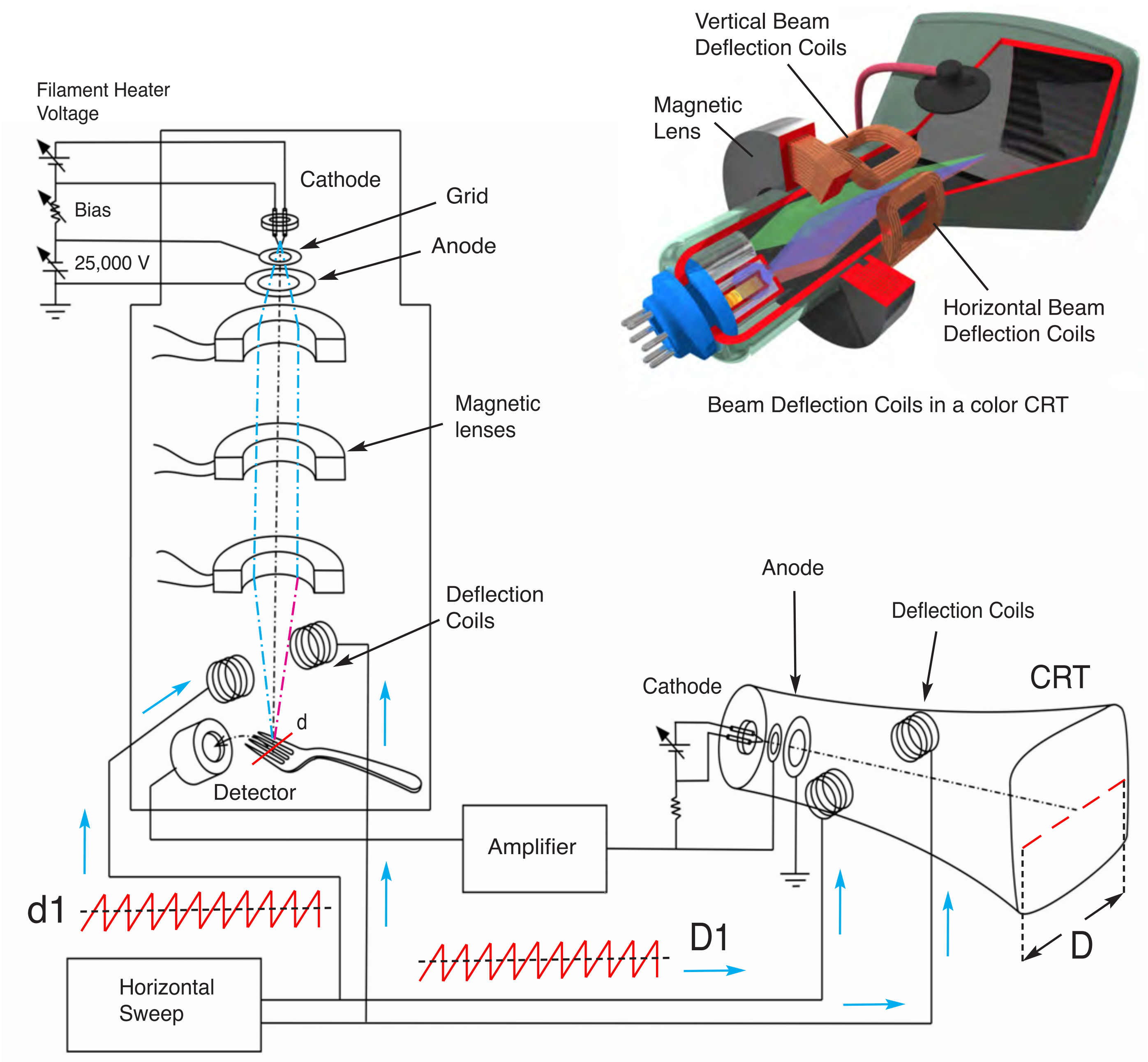


Fig.5 Scanning a sample under a single line SEM

Magnification, and Zoom Function

Now that we have understood how SEM works, the question to ask is how we could magnify with this thing? The answer makes it a lot more interesting. To test our microscope, we'll place a fork on the sample holder, and view its image on the screen (**Fig.5**). The result is as we would expect: The image of fork blades, would be shown on the CRT as bright lines. The detector receives secondary electrons released from the surface of the fork. The secondary electrons are produced by scanning electrons bombarding the sample at a very fine point on the surface of the sample. The secondary electrons have a negative charge, so they are collected by the detector having a positive charge. This is the basic principle how the Electron microscope operates.

It would be easy to see the magnification of the SEM is **M = D/d**, or Monitor Scanning Area / Specimen Scanning area. For example, when the scan line is reduced to 10 mm, and we have an 8" monitor, M = 20 cm / 10 mm = 20X. To change the magnification, we'll add a variable resistor to the lines feeding the deflection coils in the microscope column (**Fig. 6**). By increasing the resistance R, the amplitude of the saw-tooth waveform d2 will be reduced, causing less deflection of the electron beam on the sample (reduced d). This would result a smaller portion of the fork to appear on the same distance D on the CRT tube. So if the scan line is reduced to 0.01 mm, the magnification is M = 20 cm / 10 μm = 2,000 X. This is how in SEM, it is possible to zoom into the sample continuously from 35X to several thousand by turning a variable resistor knob. In real world, many other factors are controlled such as the magnetic lenses inside the SEM column to reduce image aberrations.

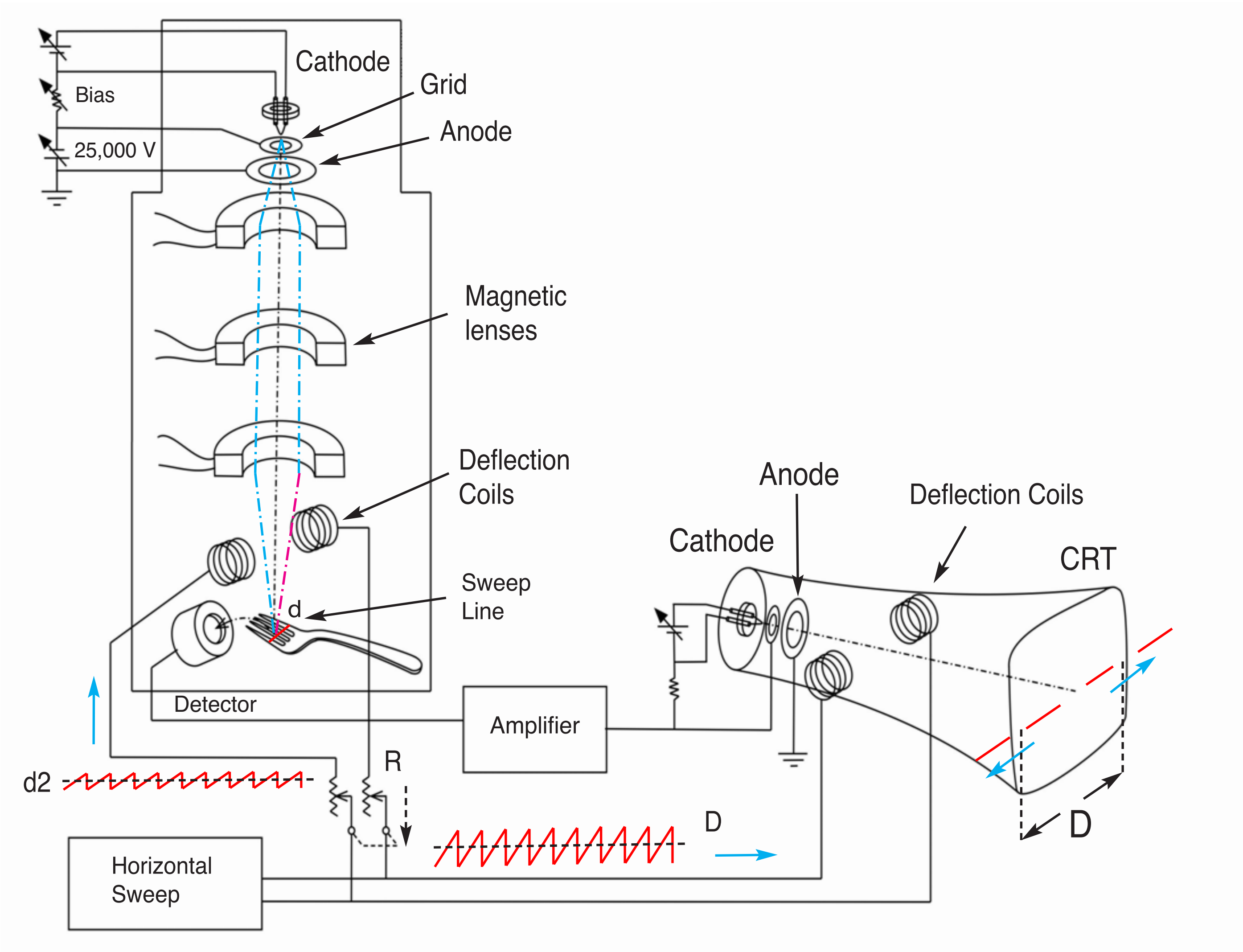


Fig.6 How the zoom function works on the Scanning Electron Microscope: The scan area is reduced by applying less voltage to deflection coils in the microscope column, so the line scan d is reduced. The single detector inside the chamber doesn't know the difference. It transfers the signal to the CRT gun. The resultant image on the CRT screen is now the central portion of the sample, as a result, the observer sees a higher magnification of the sample. The zoom function is the most fascinating features of the raster scan scheme image formation. It all began with the invention of Cathode Ray Tube for television.

SEM full screen imaging

Now that we have a clear understanding of the single line scan, let's add the vertical deflection coils to see a full screen image display. This is illustrated in Fig.7 with 10 vertical scan lines. In the real world, the SEM could have scan lines between 100 to 1,000 lines. The Electron beams are focused by magnetic lenses to a scanning spot of about 100 nanometers. Although the scan rate could be increased to a visual 30 fps rate, for higher resolution imaging, the images take longer time to form. This is because the Electrons need to have enough dwell time at the sample to produce secondary electrons. Now that we are familiar with the concept, I will discuss the electron optics behind Electron microscopy.

Development of Scanning Electron Microscope began in 1930's in Germany, then at RCA in early 1940's. Through late 1940's the design was significantly improved at Cambridge university by improving its detector. SEMs were made commercially available after 1963. Technically speaking, the Transmission Electron Microscope (discussed in the first part of the journal) has a resolution 1,000 times better than light microscopes or a few nano-meters, or a million times magnification on certain samples. In the scanning Electron Microscope, the image starts suffering at about 10,000X magnification, and begins to loose high contrast beyond 25,000X.

Electron Microscopes have elaborate pumping systems to make sure the microscope is operating under high vacuum. It takes about two minutes for the air to be vacuumed out of the chamber. There is first a rapid pumping of air by a motor driven pump, then a diffusion pump takes over to bring the pressure to 10^{-4} Pa.

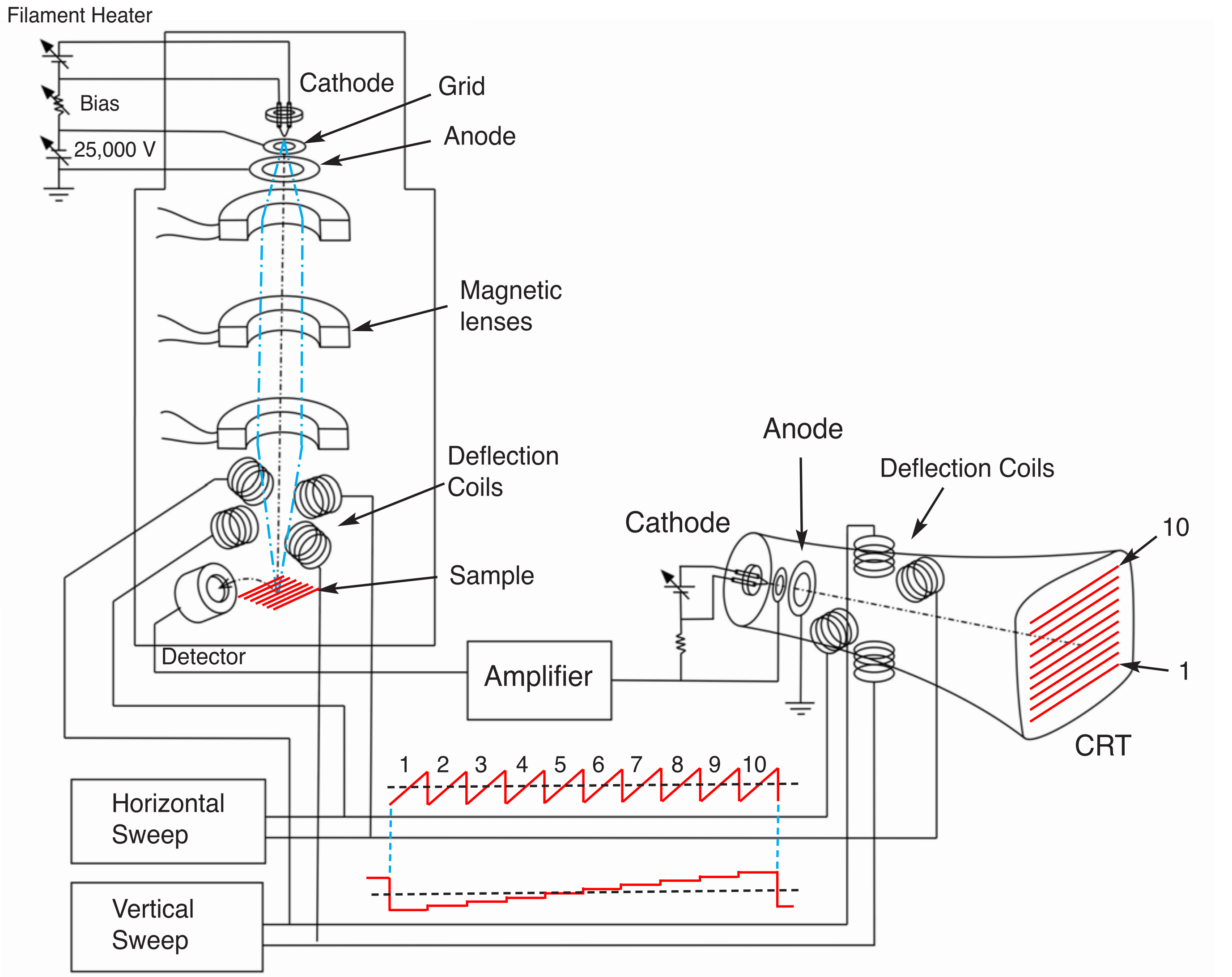
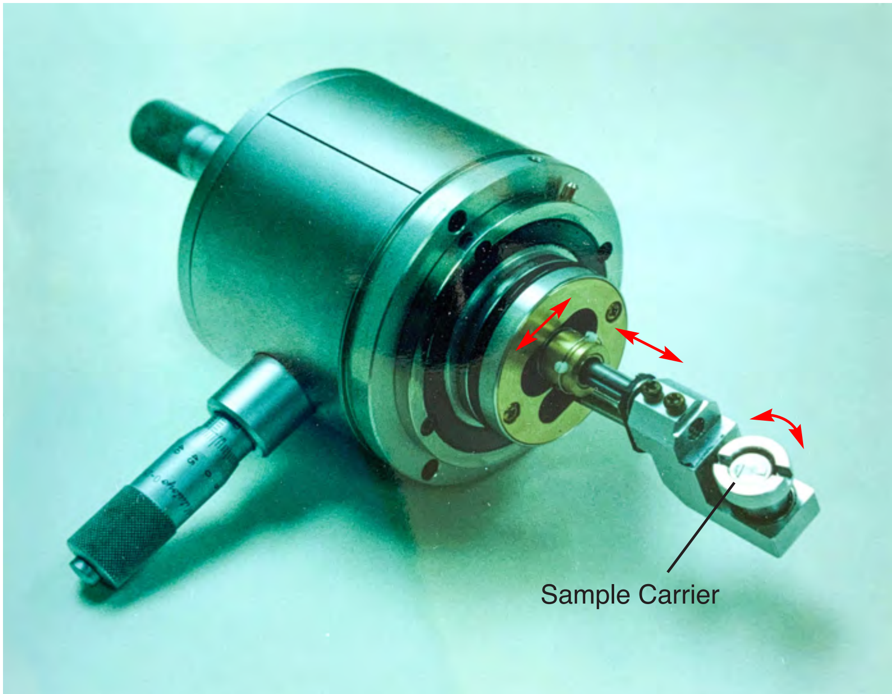


Fig.7 Adding the vertical sweep to our setup would produce 10 horizontal lines on the CRT screen, each corresponding to 10 scan lines on the sample. Note for each 10 saw-tooth signals going to the horizontal deflection coils, there is only one saw tooth signal applied to the vertical deflection coils. The more saw-tooth signals going to the horizontal deflection coils, and the CRT, the higher the resolution. Today's SEMs use the same technique except the CRT tube is replaced by a computer screen. Using a computer, the image could be captured without having to use a camera, and various image analysis be performed.

I studied Electron microscopy in my youth, and I was so excited when I understood how it works that I ran out of the lab, and grabbed someone by the arm, and I asked him: “Excuse me, do you like science?! He said yes, then I literally dragged him behind the Electron microscope and I said then you’d better see this, it’s really interesting how this thing works. To my amusement, he sat next to me for the next half an hour, and forgot how time passed him, and I think he missed a part of his class.

That was in California State University at Los Angeles back in late 80’s. Today, I have the same excitement in explaining to you how this instrument works. The most fascinating object I ever viewed under that microscope was a mechanical ladies watch I secured on the sample holder. The high depth of field in SEM revealed the moving watch parts in amazing detail, and for someone who knew how watches worked this was a new world to explore. Time really didn’t pass for me.

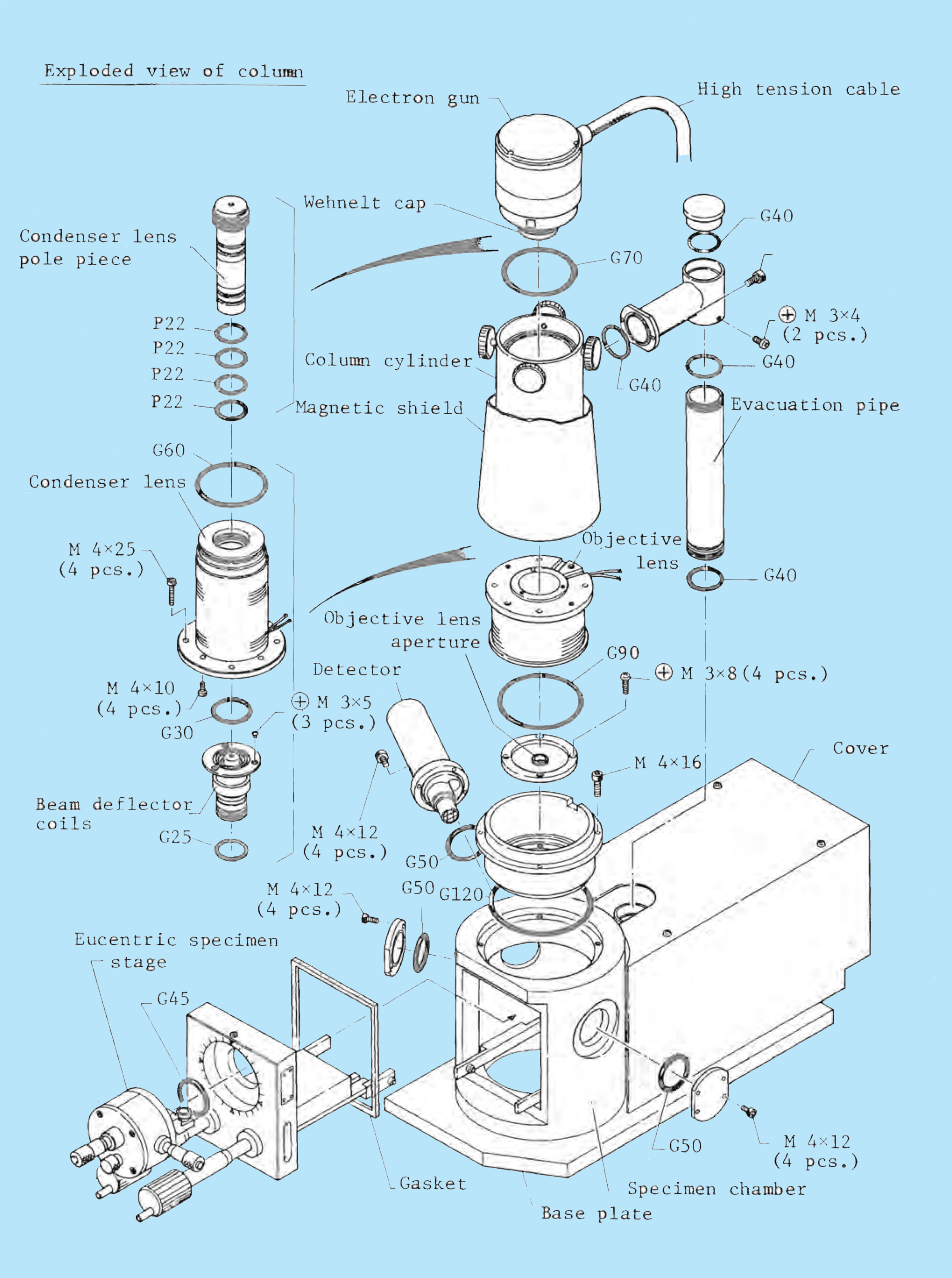


The sample holder of Joel SEM, taken out to dislay its positioning controls

Working with Jeol JSM-T200 Electron microscope back in 1989, It was in this lab, at CSULA that I learned how an Electron microscope works for the first time, and I’ll never forget the generosity, and trust of my teacher who allowed me to stay there after class for as long as I wanted.

At the time, the microscope cost our school $100,000. A few years ago, my friend Coung Dang, bought one for $1,400, and fixed it himself at his home garage to a fully operational SEM.

Left, the sample is first fixed on an Aluminum Stub by a special non-outgassing cement. The Stub is then inserted into the sample carrier, and secured via two set screws.

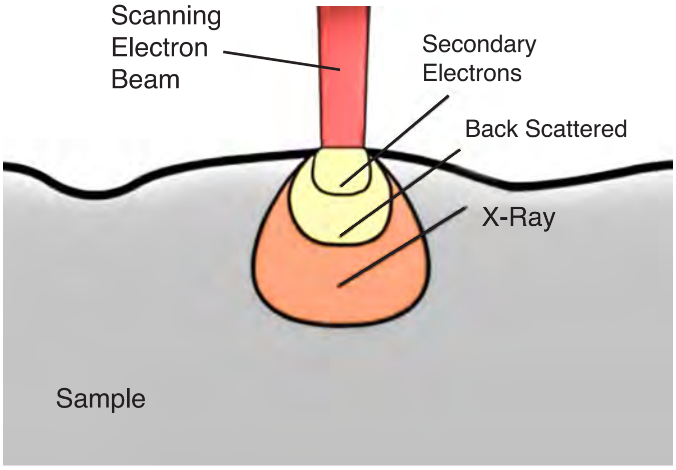


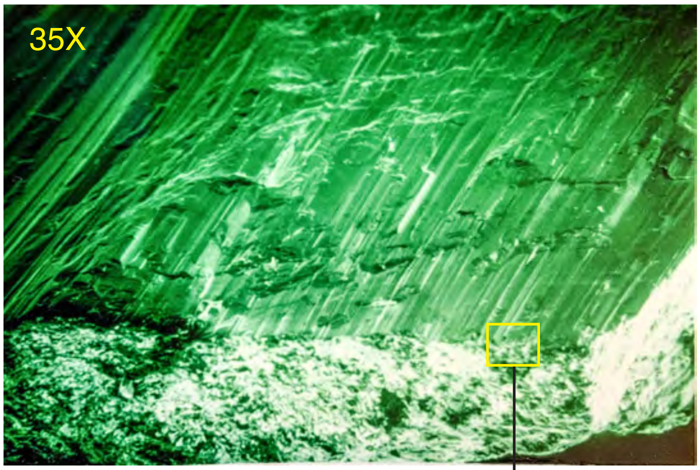
Exploded view of JEOL JSM-T200 SEM reveals the vacuum chamber, X-Y/Rotary stage, Electron gun, Detector, the Condenser, and Objective lenses, and Evacuation pipe, etc. This 1980's design has in most part remained the same.

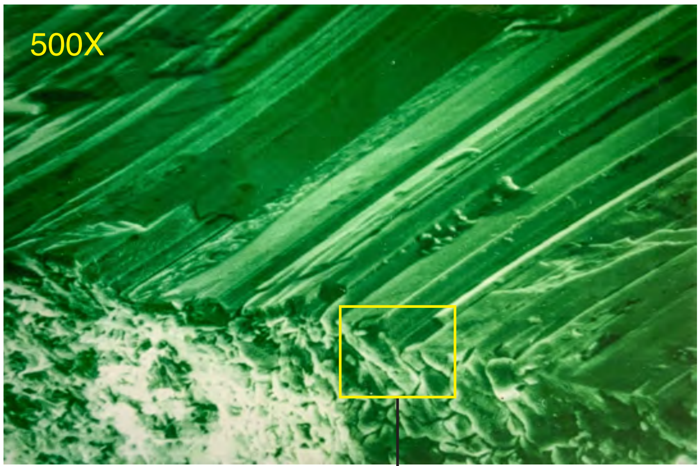
SEM imaging of 3D samples

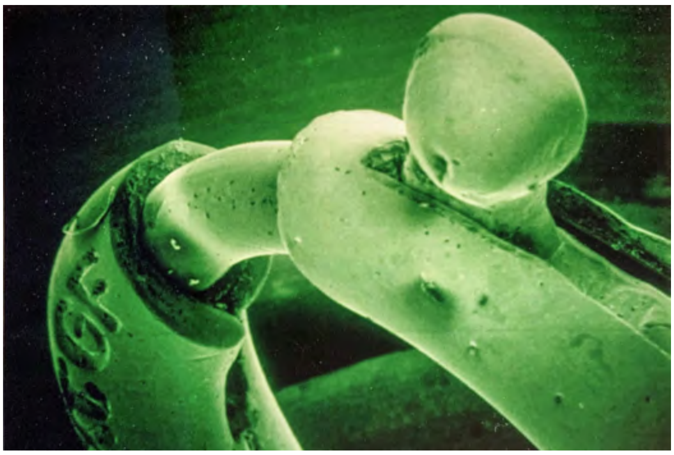
Those who have seen the image degradations in long range optical zooms, are usually impressed with typical 100X zoom rations of a sample through SEM (right).

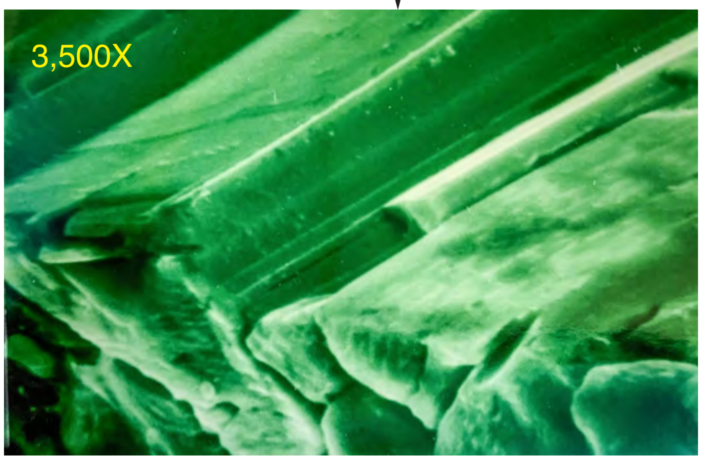
Biological samples have to be coated with a thin layer of Gold to avoid pile up of secondary electrons on the sample. I have only discussed Secondary Electrons (emitted from the surface). There are also Back Scattered Electrons (beneath the surface), and X-Ray emitted from much deeper in the sample (below).



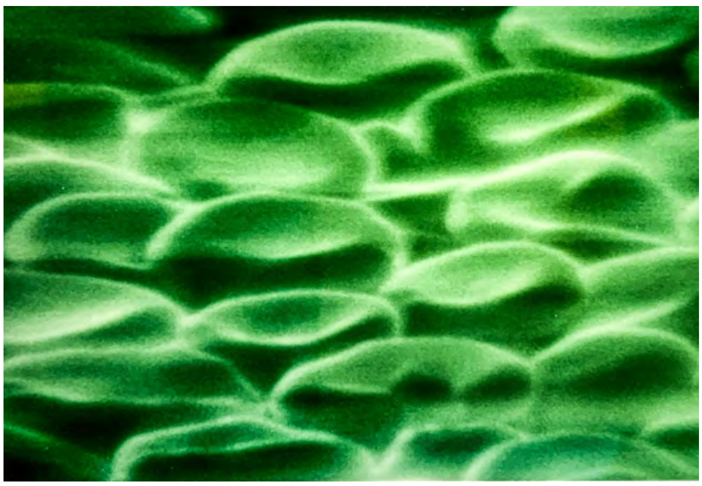








Sputtering Machine lays a thin metal coating on Biological samples.

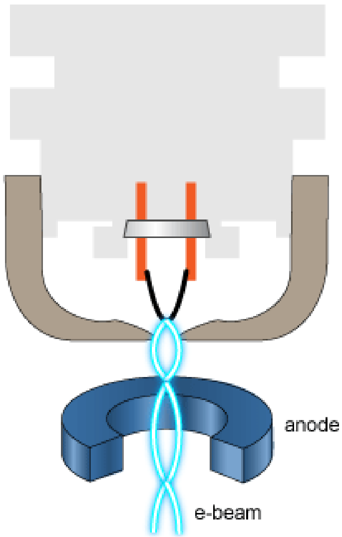


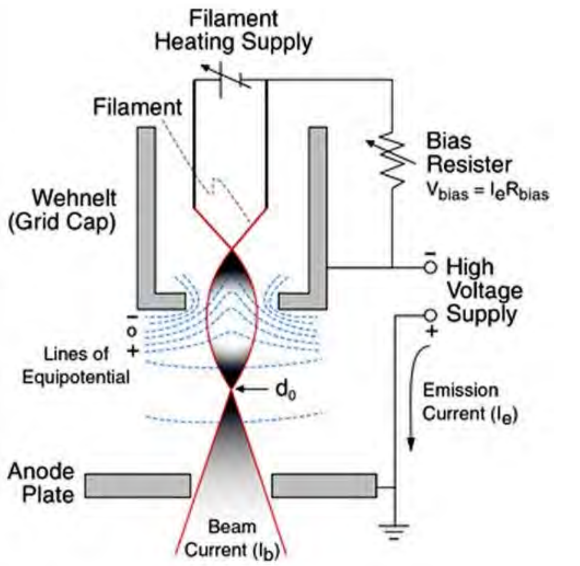
Uncoated blood Cells under SEM lack contrast

Electron Optics

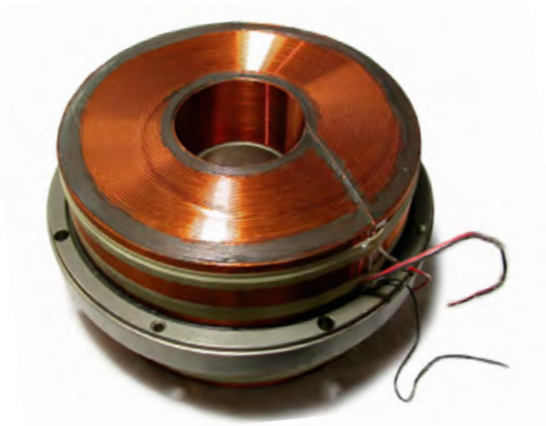
I encourage you to access the huge online resources there are to follow up on your understanding of Electron Microscopy. I would show some examples here just so you could see their more detailed or alternate explanation.

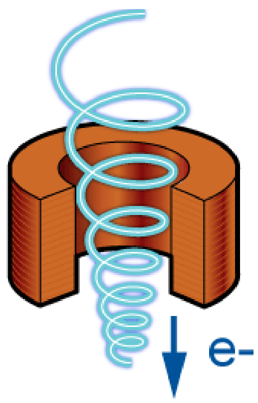
The first one I would like to show is the Electron Gun, and how similar it looks like to an ordinary light bulb.

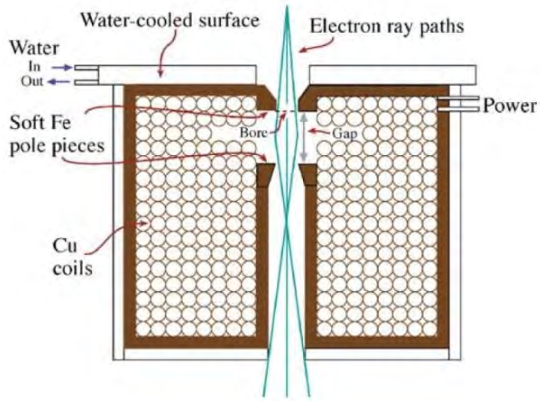




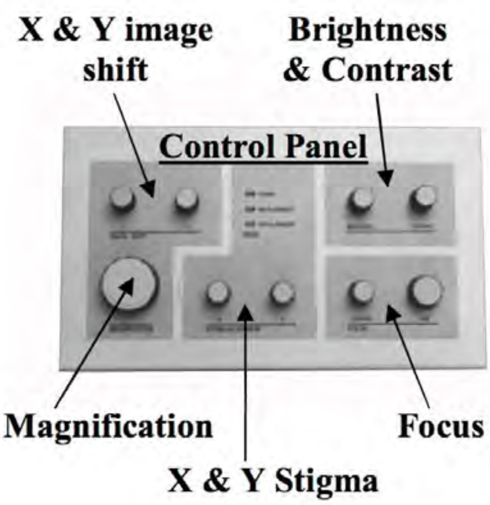
Magnetic Lensing is a sophisticated technique that I showed it by simple coils but in reality there is a lot more to it. Just like optical design in visible light microscopy, to reduce image aberrations, the same is true in Electron microscopy. There are many controls on SEM control panel (see next section) to adjust the filament current, and the current feeding the magnetic lenses to improve image sharpness, and to reduce image aberrations.



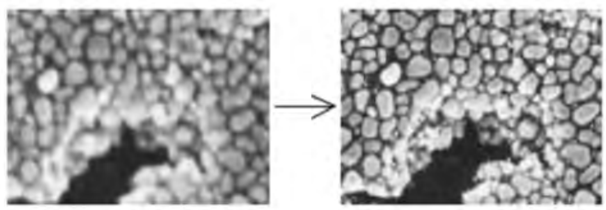




Focus, and Astigmatism Adjustments While you sit behind the SEM controls, there are many controls that has to do with image sharpness and contrast. As you could see on Hitachi S-4700 (below, left) there is a magnification knob to zoom into the sample, but the rest are contrast, and other electronic adjustments to get a sharp image. Images on the right are from of its instructions manual showing how to correct for Astigmatism, and improve image sharpness. Like photography, SEM imaging is really an art, and it takes hands on experience to master it.



(b) Adjust the X and Y stigmators alternately for the sharpest image.



(c) Focus again and check image drift and sharpness.

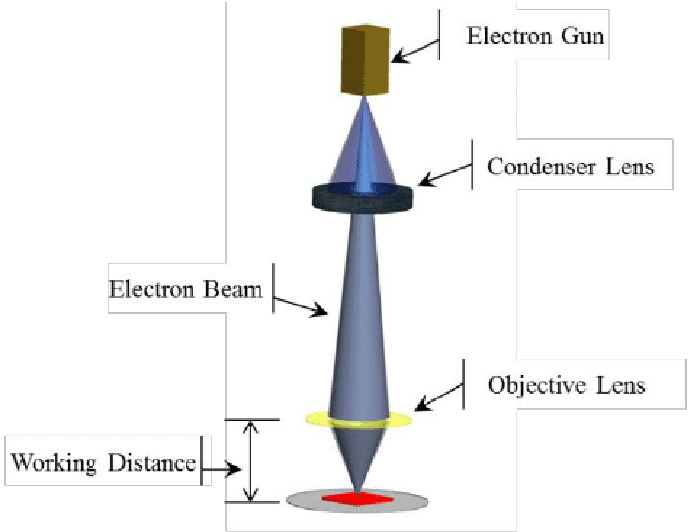
Typical Image adjustments in Hitachi S-4700

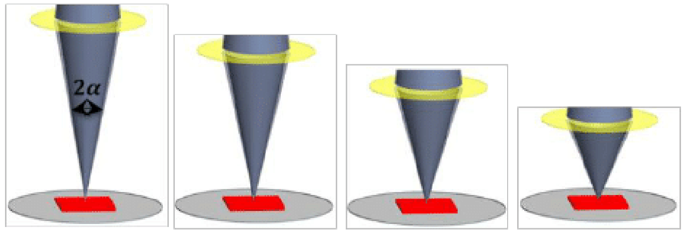
More on Electron Optics

The high vacuum inside the SEM column prevents high voltage sparks between the Cathode, and Anode. It would also maintain the integrity of Electron beam as any interaction with gas atoms would cause the beam to scatter. This is why the Electron microscope is set to automatically shut off the high voltage before high vacuum is reached.

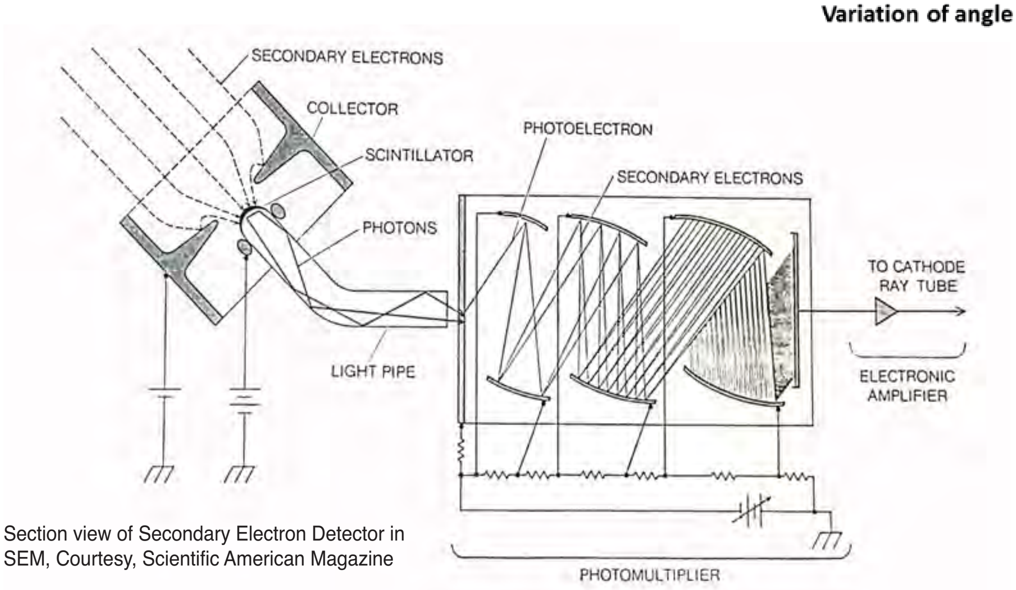
Right, reducing the beam spot on the sample increases the resolution in SEM. A narrow beam angle is also desirable to increase the depth of field. An interesting feature of working with SEM, is when you zoom into a crack of an egg shell, it's initially dark, but as you continue zooming into the crack, there is light again! Where does this light come from?

The answer lies on how the electrons reach the PMT (Photo Multiplier Tube) detector. The detector in SEM is positively charged to +200 volts, so when the scanning beam enters a deep crack, the secondary electrons will still exit the crack, and migrate to the detector.

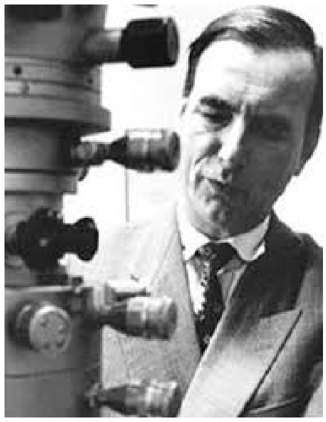




Variation of angle with working distance



Section view of Secondary Electron Detector in SEM, Courtesy, Scientific American Magazine

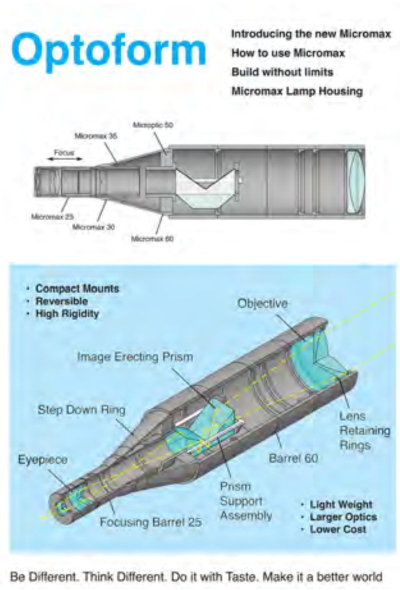


Dr. Ernst Ruska

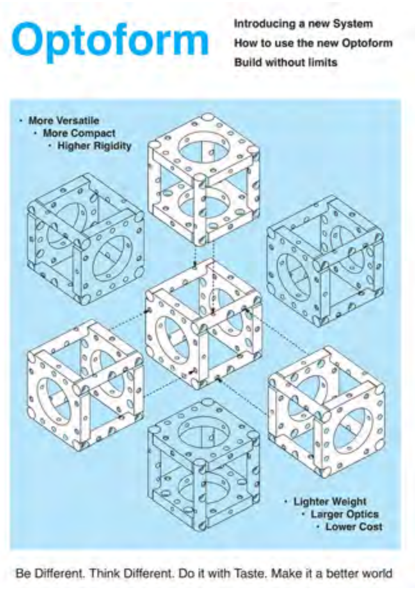
Above, the secondary electrons are accelerated before they strike the scintilator, where each electron produces many photons. The photons are guided through a photomultiplier where photoelectrons are excited. Then each photoelectron triggers a cascade yielding millions of electrons at the output. It's amazing how a farm boy from Idaho conceived a vacuum tube to be reading an image projected on its front face, to convert to an electronic signal. Those days, by the way, were vacuum tube days until Schottky invented the transistor.

The Electron Microscope was invented in 1932 by Dr. Ernst Ruska (1906-1988), born in Heidelberg, Germany. He was a professor at technical university of Munich, and won the Nobel prize in 1986 in physics for his work on Electron Optics. SEM was invented by Dr. Manfred v Ardenne (1907-1997) born in Hamburg, Germany. In 1931 he was the first to broadcast television pictures using a CRT (Utilizing a mechanical pinhole disc to generate the image source, not a Vidicon), and in 1937 he invented the SEM, and also did some work in developing radar.

Dr. Manfred von Ardenne



Micromax 25, 30, 60



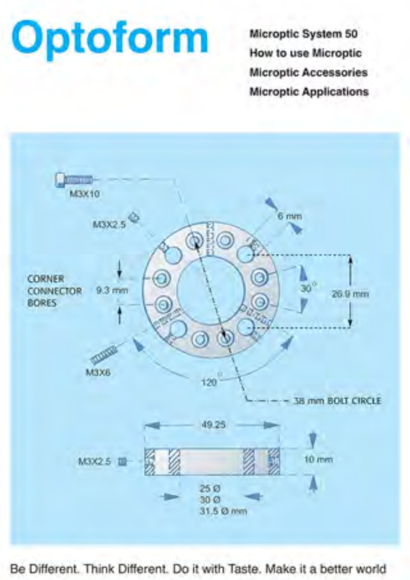
Microptic 40

A Review of New Optofom Catalogs

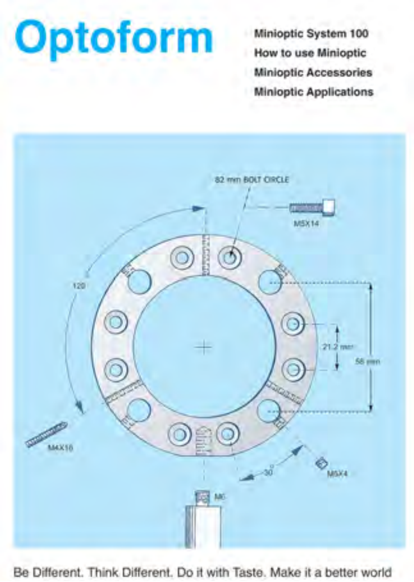
We introduced a new concept this year called Microptic 40. We soon realized the new system much relies on the accessories of classic Optoform, introduced 25 years ago. So here they are: The classic Optoform system re explained in a much simpler way.

Why Optoform?

Opto-Mechanical design has always been in the hands of graphic designers because there has never been the right tool to design optical packaging of products. This gap is being crossed over now with 3D printers. People are starting to realize that design is not only the inner optics, and in many cases, its the usability of a product that dictates its optical design.



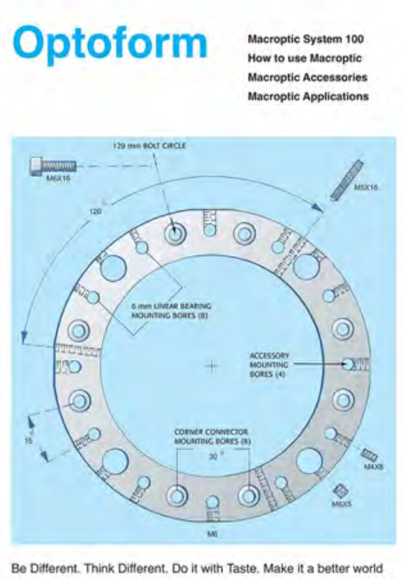
Microptic 50



Minioptic 100

So what's being made inside the lab can completely change course by learning how it will be used outside of the lab. That's where Optoform plays its niche role in product development. It is the only product that allows you to take your experiment outside of the lab without having to machine anything. Your experiment is your product.

You can download new Optoform catalogs from www.Optoform.com



Macroptic 150

Mounted Optics

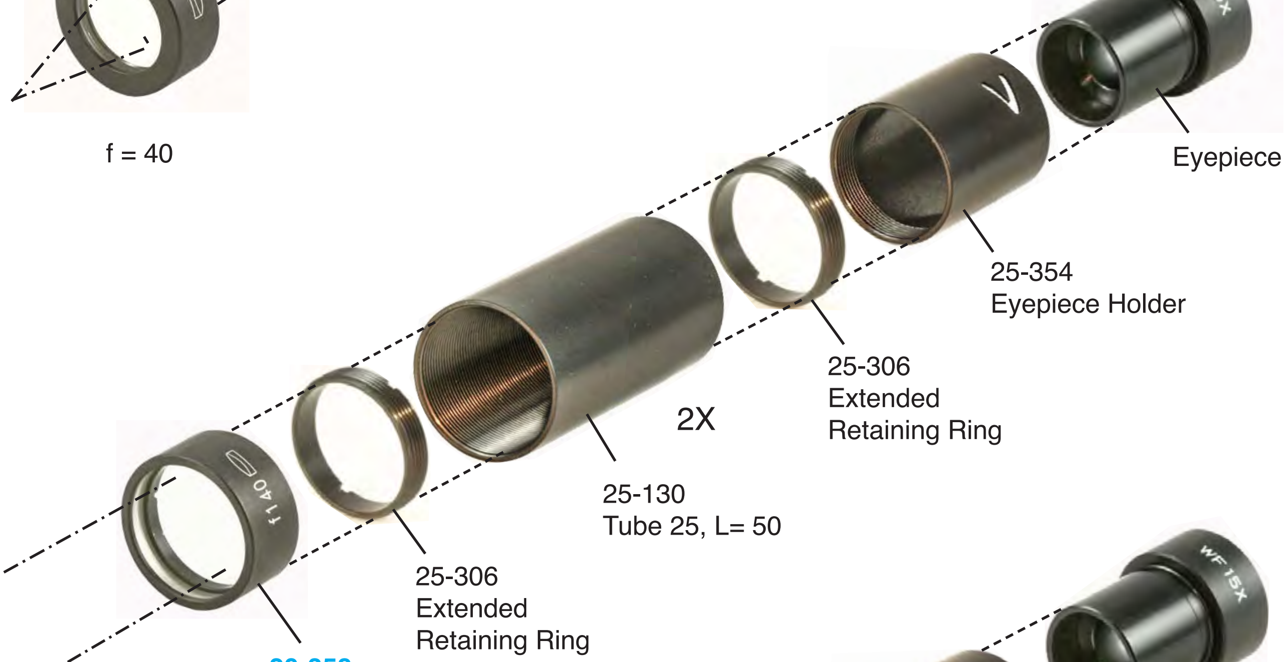
Mounted Optics

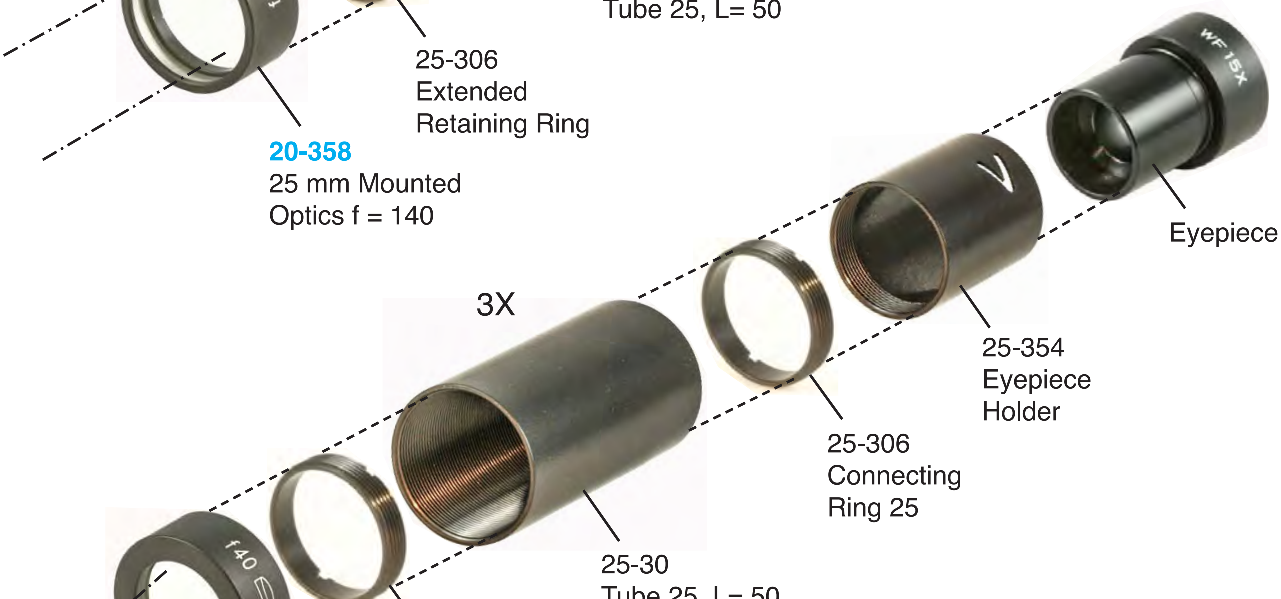
Our mounted optics has direct connection with Micromax mounts, and support tubes. We employ the M23.2X0.75 thread in all our 25 mm lens cells which is the standard Micromax thread (Same as Microbench). That's not all. The mounting direction of the optics depends on how it is utilized with Micromax tubing.

To build a small telescope, for example, tubes, eyepiece holder, and mounted objective lens cells are directly screwed together. The eyepiece holder in this case allows focusing adjustment for the eyepiece. Note the orientation of achromats in their 25 mm lens cells: The threaded mount for longer lens (i.e., f = 140) is oriented towards the eyepiece, allowing its direct mounting to 25 mm tubes for constructing telescopes. The threaded end for shorter achromats (i.e., f = 40) are oriented away from the eyepiece, more suitable for close focus applications. So what if the 40 mm needs to be utilized in reverse orientation? See next page for answer!

f = 140

f = 40



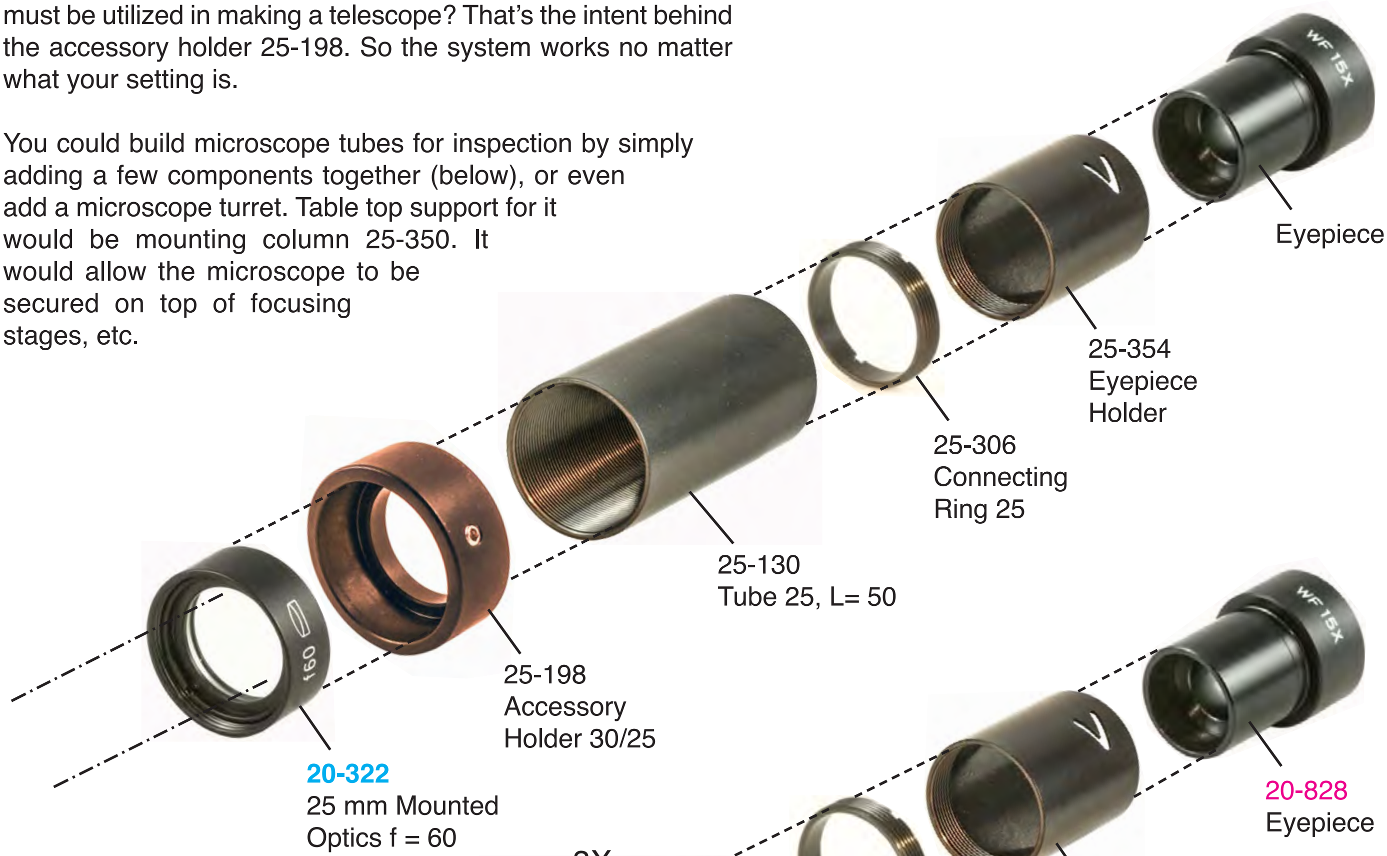


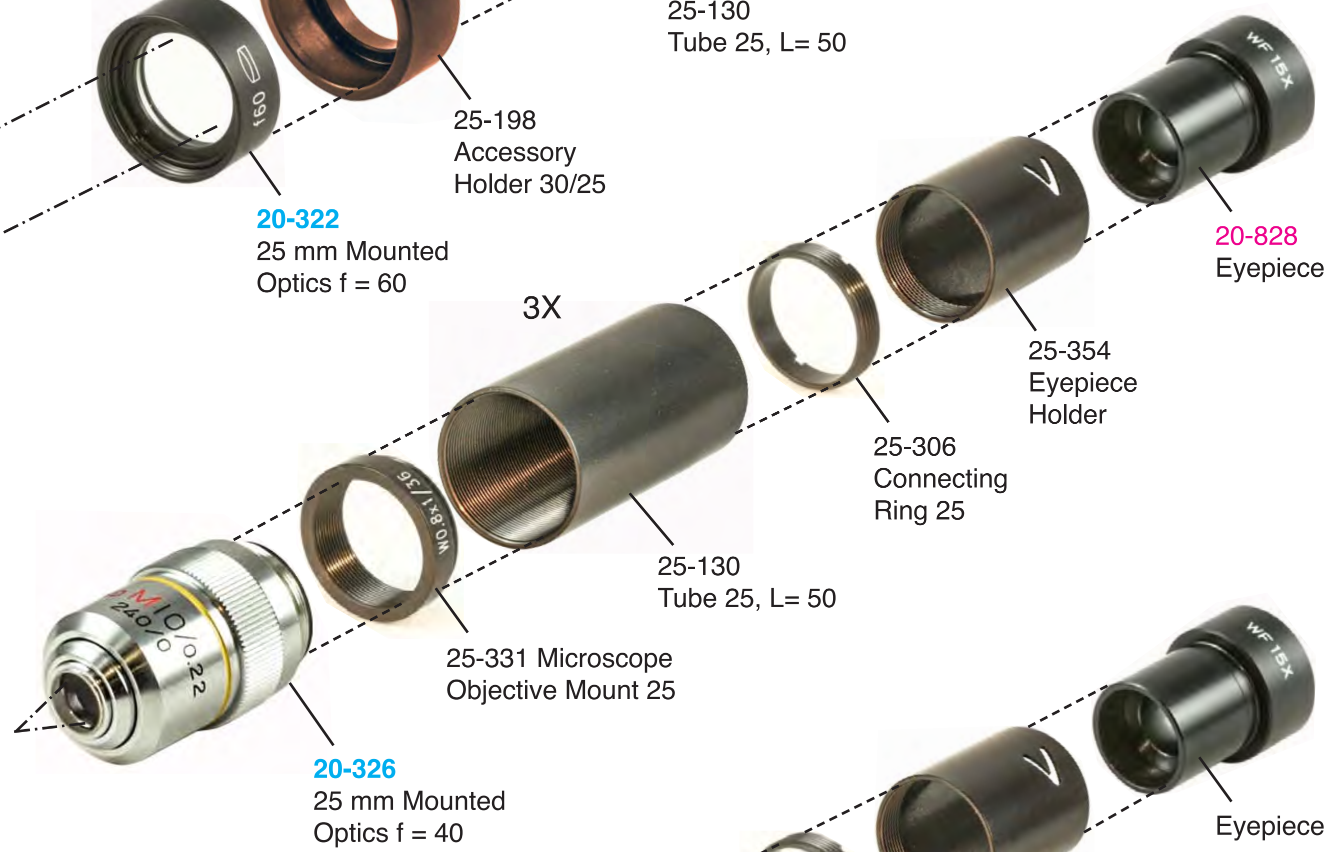
Above, building a telescope with long focal length f = 140 mm objective by direct mounting of lenses to Micromax tubing.

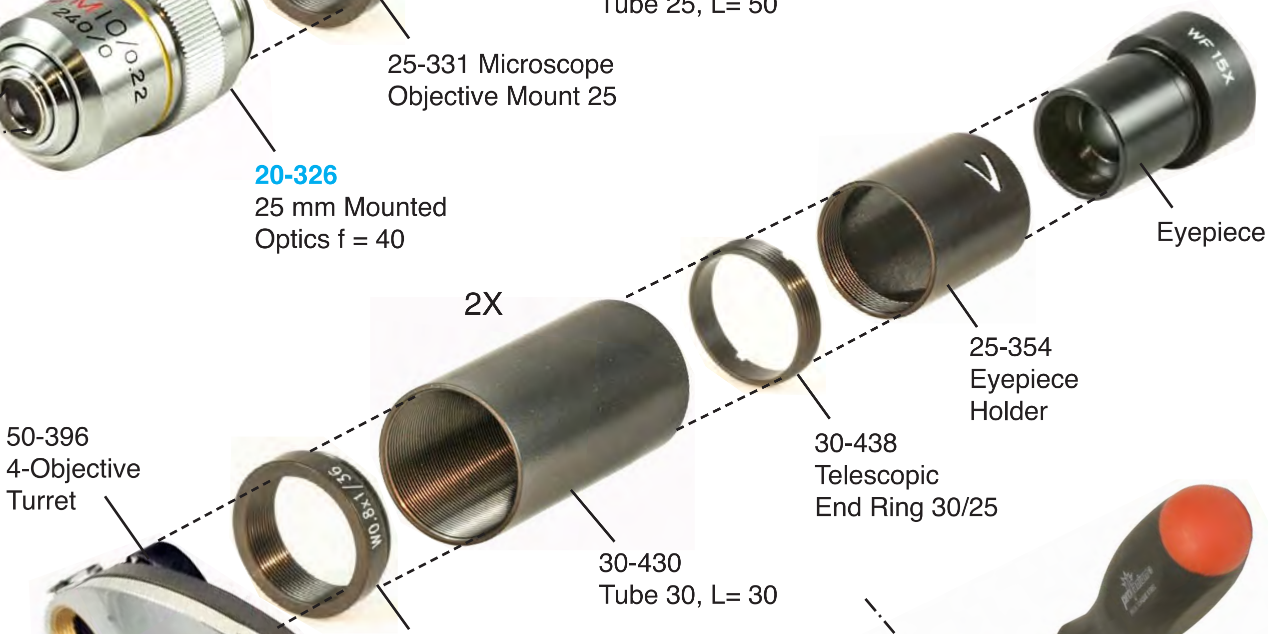
Lower assembly, Building a microscope with short focal length f = 40 mm objective lens with direct mounting of lenses to Micromax tubing.

What if a mounted lens with focal length shorter than 100 mm must be utilized in making a telescope? That's the intent behind the accessory holder 25-198. So the system works no matter what your setting is.

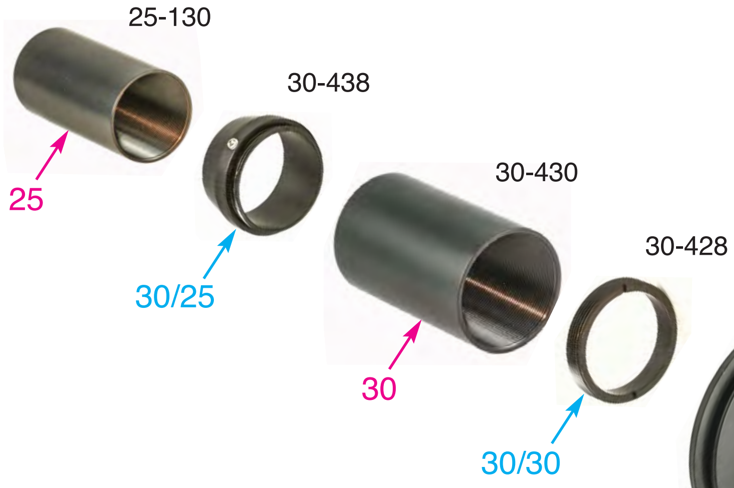
You could build microscope tubes for inspection by simply adding a few components together (below), or even add a microscope turret. Table top support for it would be mounting column 25-350. It would allow the microscope to be secured on top of focusing stages, etc.

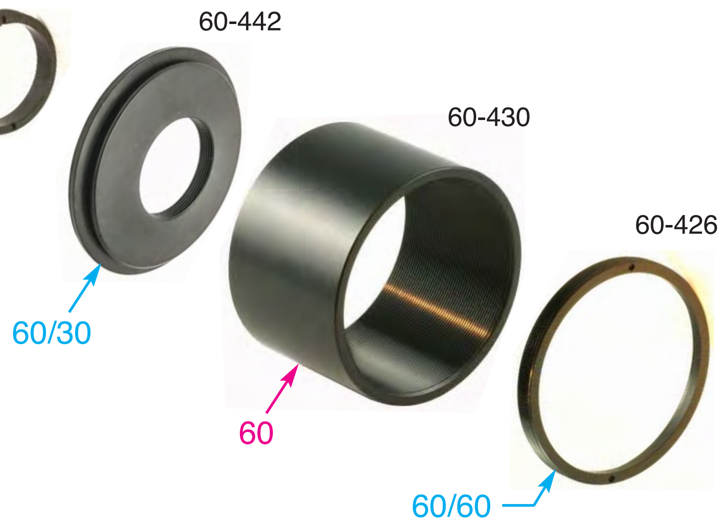






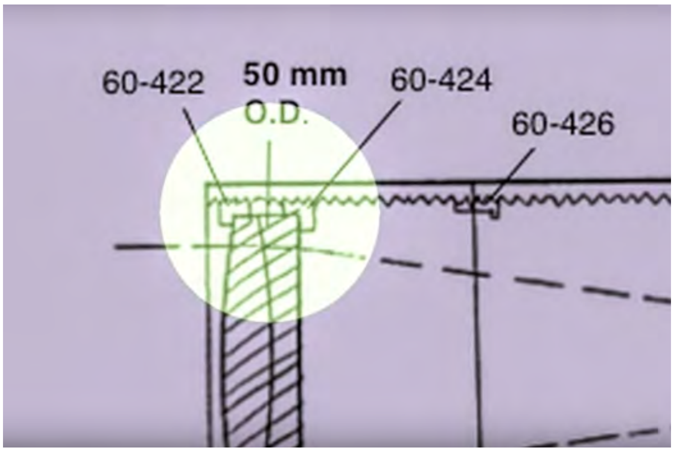
Micromax 25, 30, and 60





Building a Finder Scope

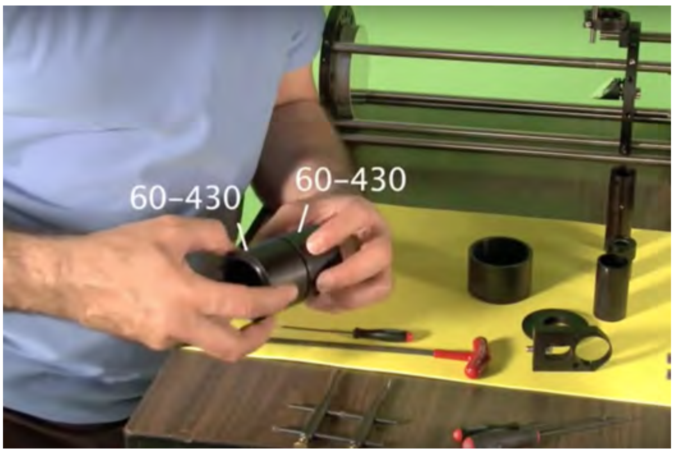
In a finder scope, the 50 mm objective lens-may be held by tube 60 while the focusing barrel is constructed with 30/25 tubes. In this illustration, the tube diameters are shown in red while the interface adapters are shown in blue.



50 Ø mm front lens is held by two retaining rings 60-422

A spanner wrench is needed to secure the rings

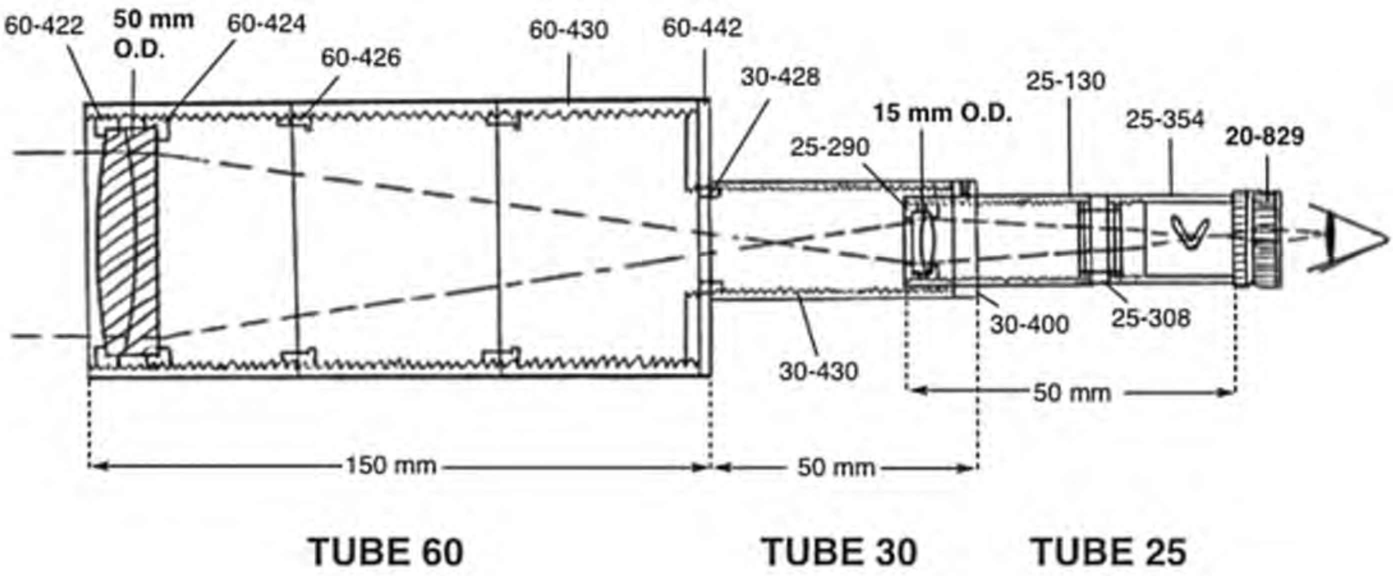
60-430 tubes are added together for the main barrel



To secure the tubes, the connecting ring is held by nails

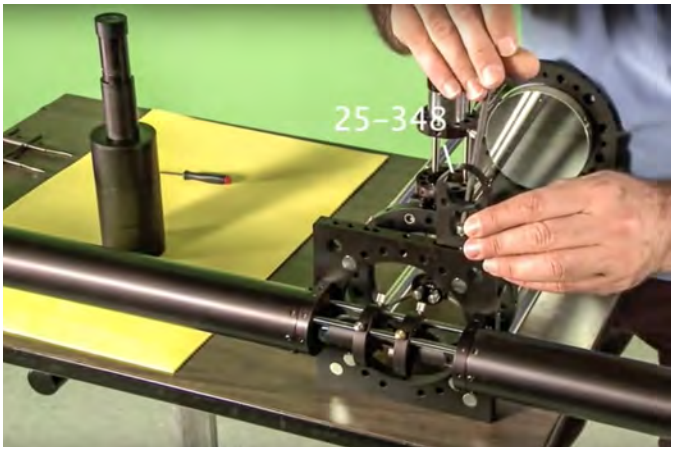
This assembly shows the finder scope built for an astronomical telescope. It is made by direct mounting of Micromax tubes from 25 mm to 60 mm in diameter. While putting this together, the designer might wish to add an LED illumination for a reticule, etc. During the assembly, and testing of a prototype, the usability, and ergonomics of a product is tested. Design through play is far more creative, and practical than just staring at a computer screen.

There is an instructional video on YouTube for how this is put together: https://youtu.be/gsAN2fM_VS0



End plate 60-422 is added to one end

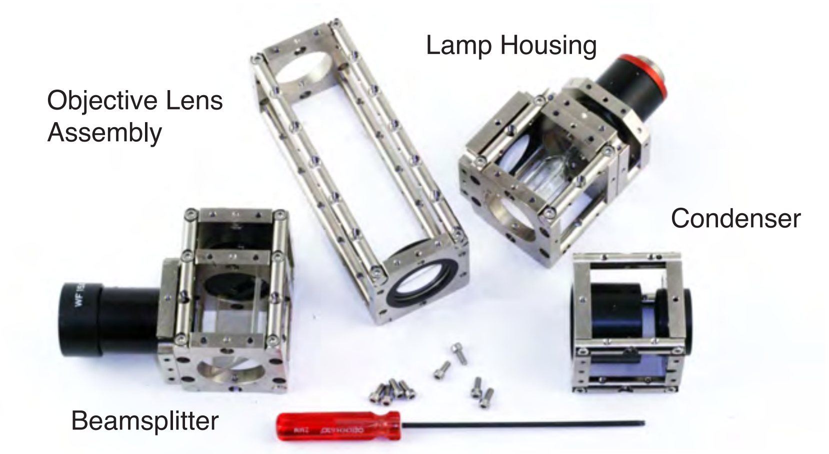
Tubes 30, and 25 are then added to 60-442



The finder scope could be secured in place via 25-348

The finder scope is inserted into the mounting column

Microptic 40

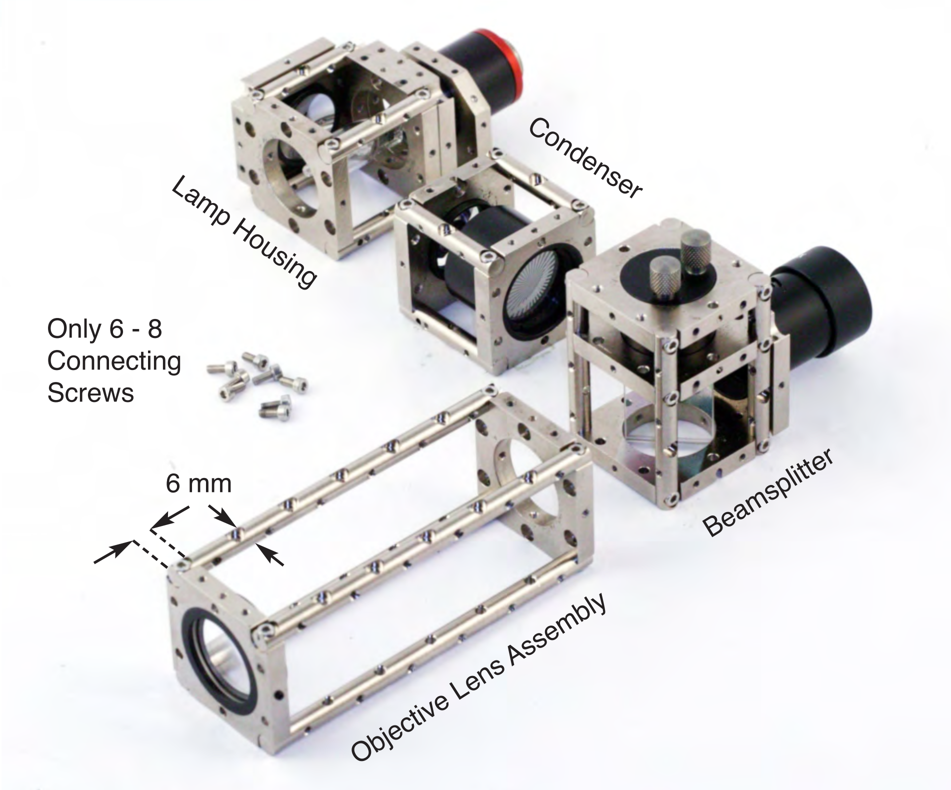


New Modular Concept

Optoform 40 is assembled with tiny M2.5 screws. Don't take apart your subassemblies. Leave ten aside for later use.

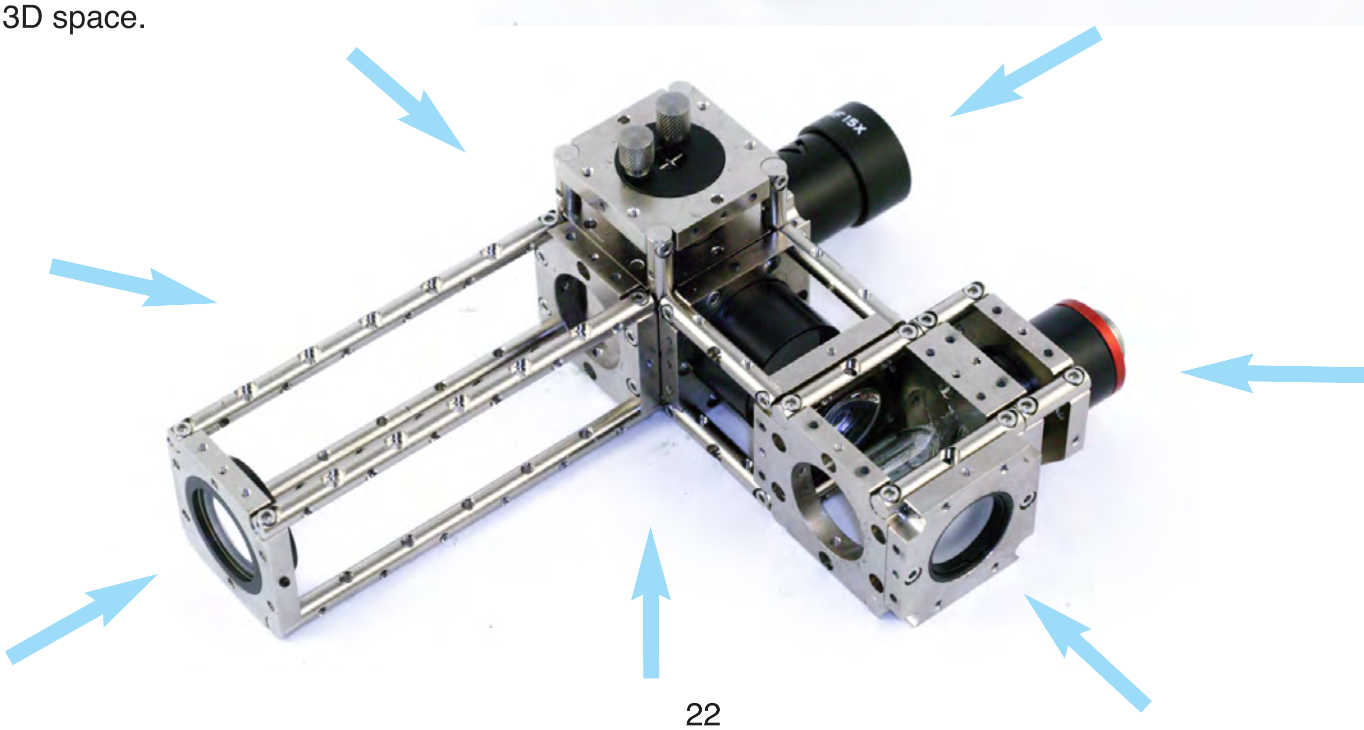
Modules instead of parts

You could build the next setups with your already assembled modules.



3D Construction

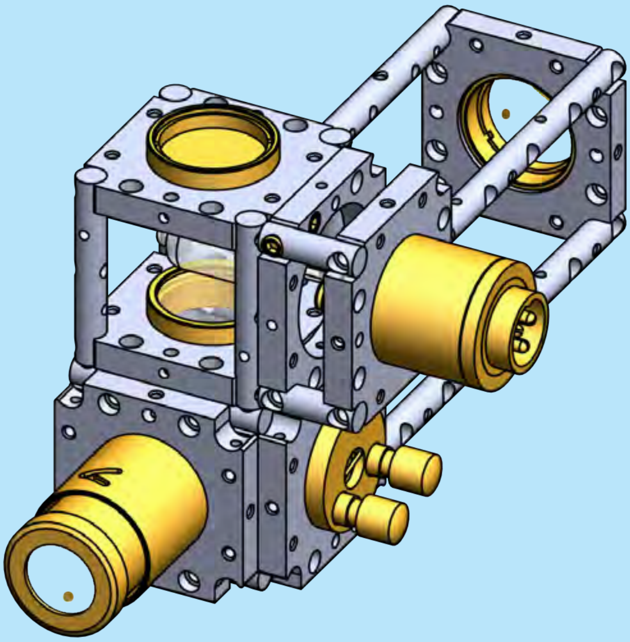
With Optoform, you deal with cubic or swivel modules that can be interconnected at any orientation in 3D space.



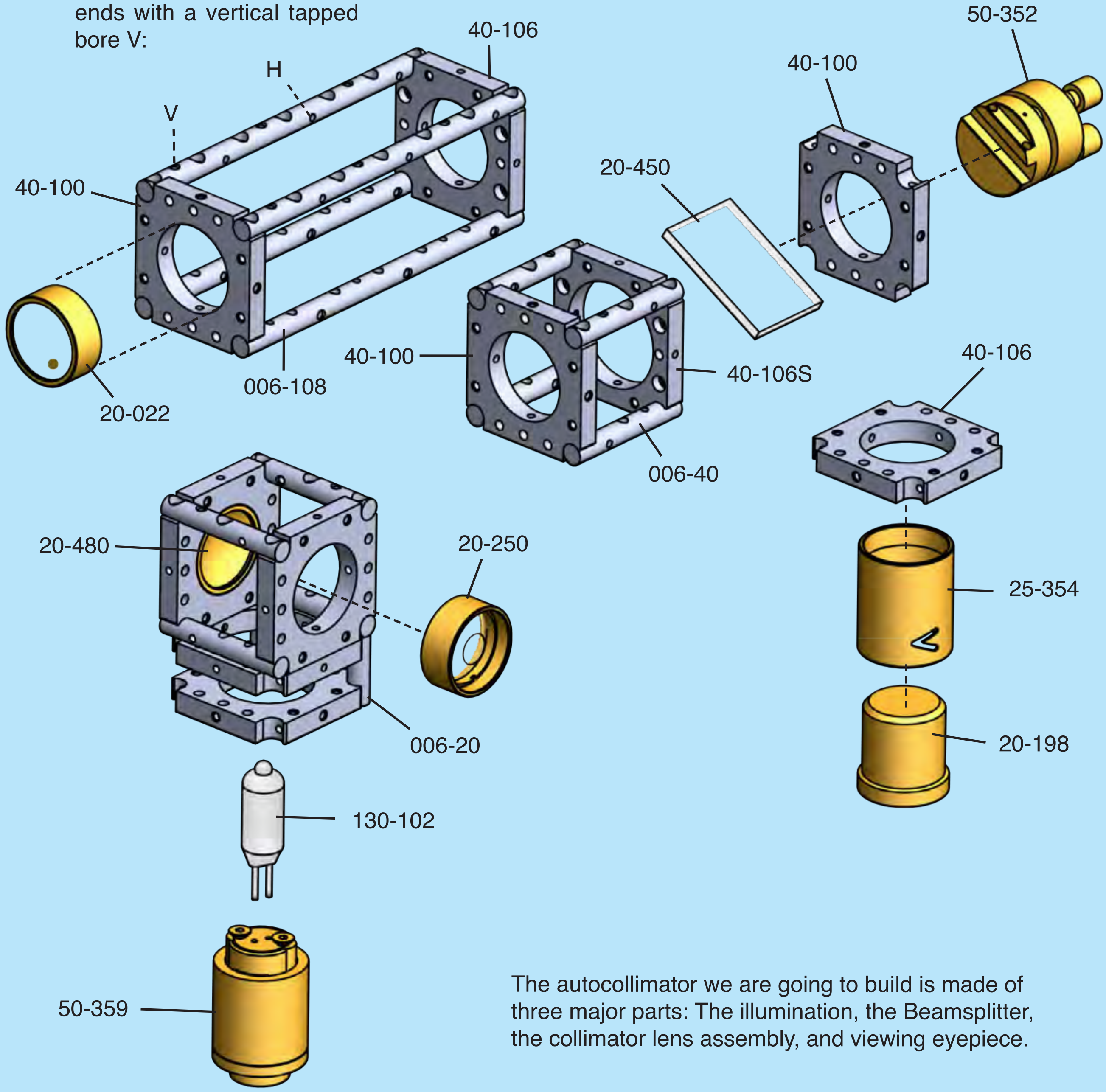
Building an Autocollimator

If you visit Optoform.com, and click on "Built with Optoform" you'll see many examples of Optoform instruments. To build an autocollimator, here are two devices that would need stand-off: One is the lamp which uses 006-20 as stand-off rods, and the other is 50-352 which uses a combination stack of 40-100, and 40-106S to center the beamsplitter 20-450 on the optical path.

Objective lens 20-022 may be replaced with an achromatic lens 20-358 (f = 140 mm) for better image quality.



Every rod starts with a horizontal tapped bore H, and ends with a vertical tapped bore V:



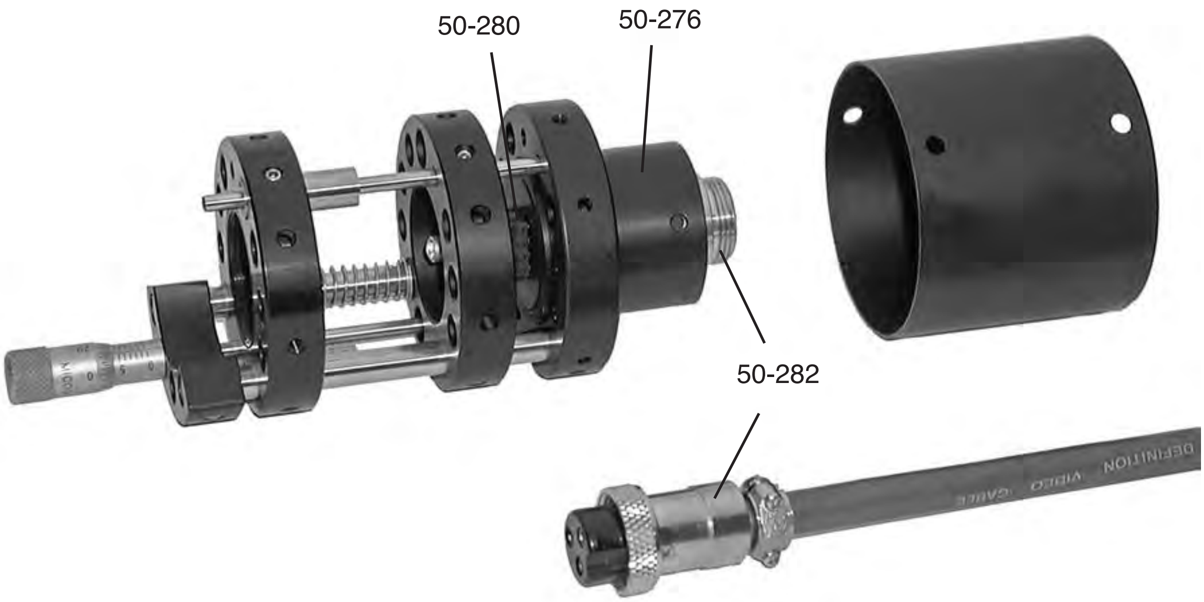
The autocollimator we are going to build is made of three major parts: The illumination, the Beamsplitter, the collimator lens assembly, and viewing eyepiece.

Microptic 50

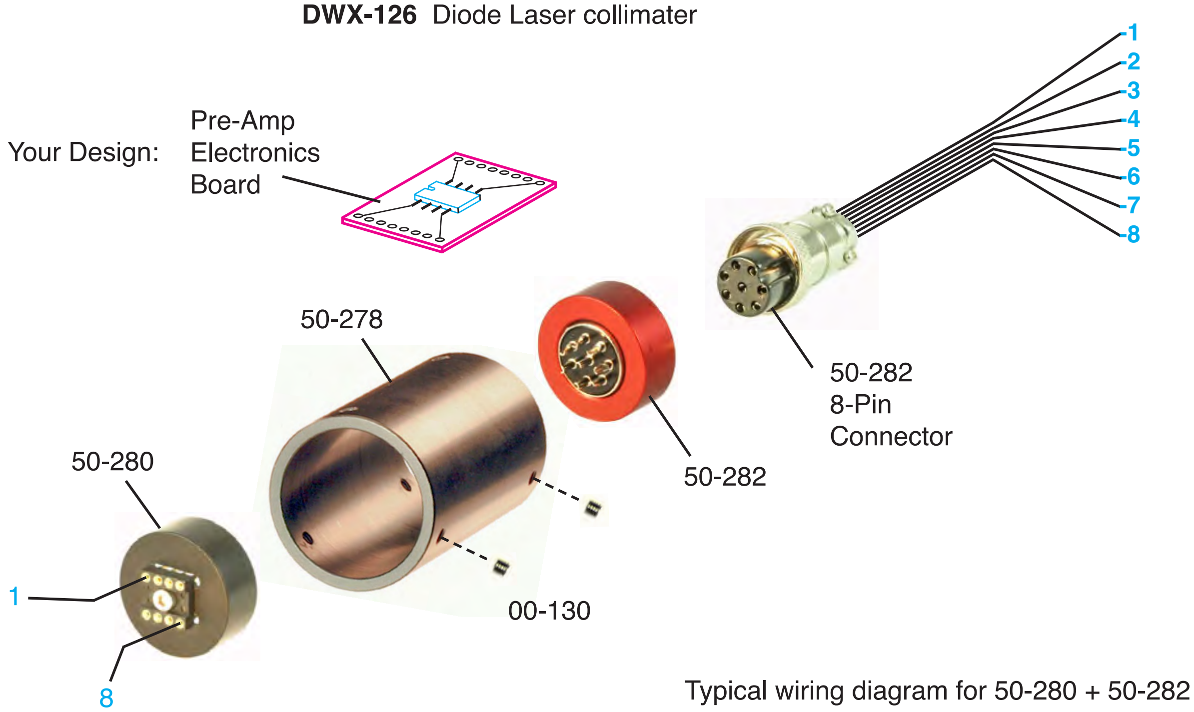
Just a few things to know about Microptic 50 concept: Rods are secured via M3x2.5 screws (00-130) to clear the outside diameter to allow sliding cover tubing (T50-30). Tubes are secured in place via Button Head screws (00-160) arount the mount, on the same threaded bore that optics securing screw (00-136) is inserted securing the optics.

Mounting plates are secured to other pieces in the system, sphere 50 in this example, via 10 mm Allen screws (00-162). If a stack of Belleville washers (00-270) are inserted in between, then a tilt platform can be created. To construct setups, rods, or tubing may be utilized. A setup can first be created, and alighned, then cover tubing may be added to light seal the system.

DWX-126 Diode Laser collimater

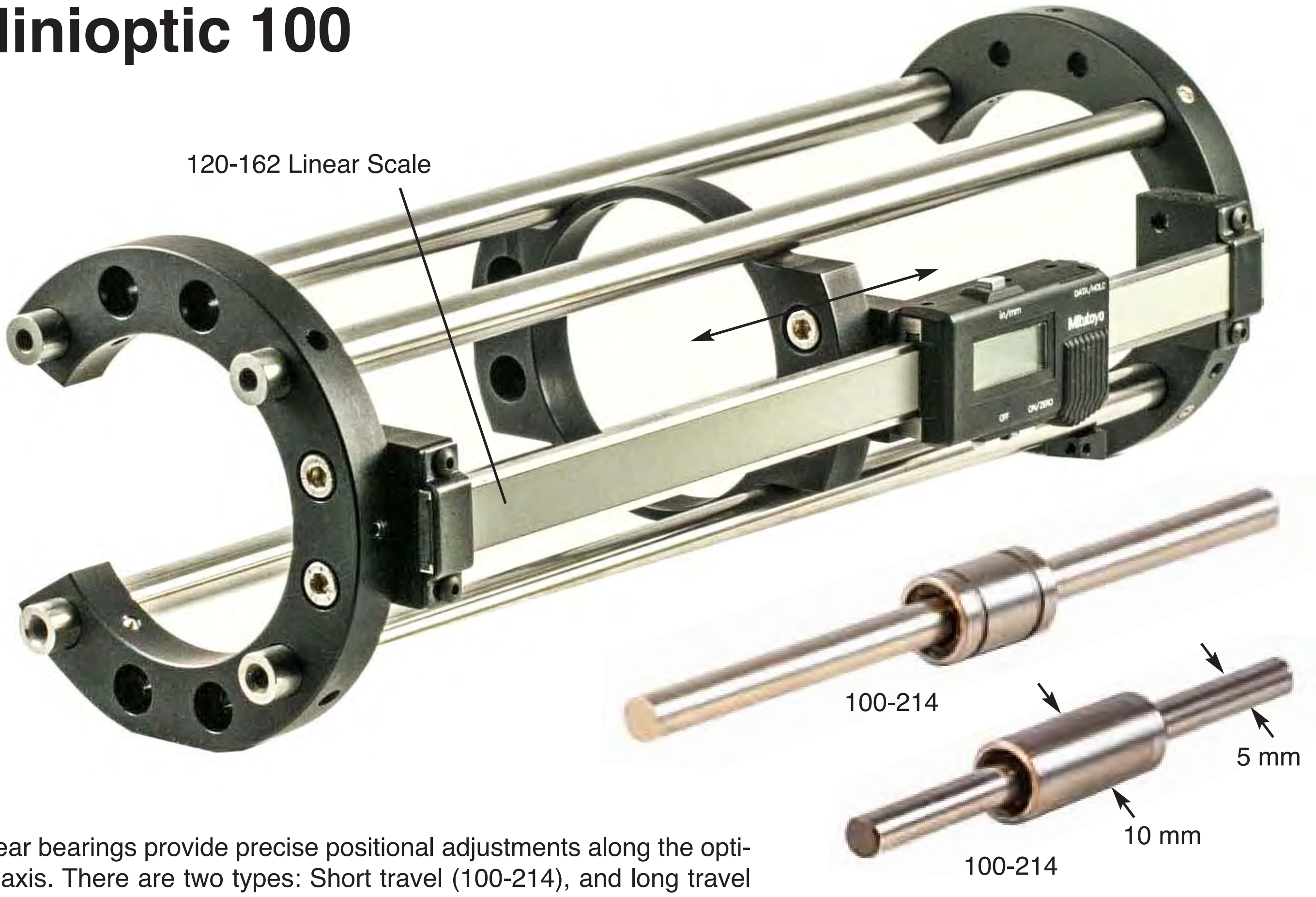


DWX-126 Diode Laser collimater



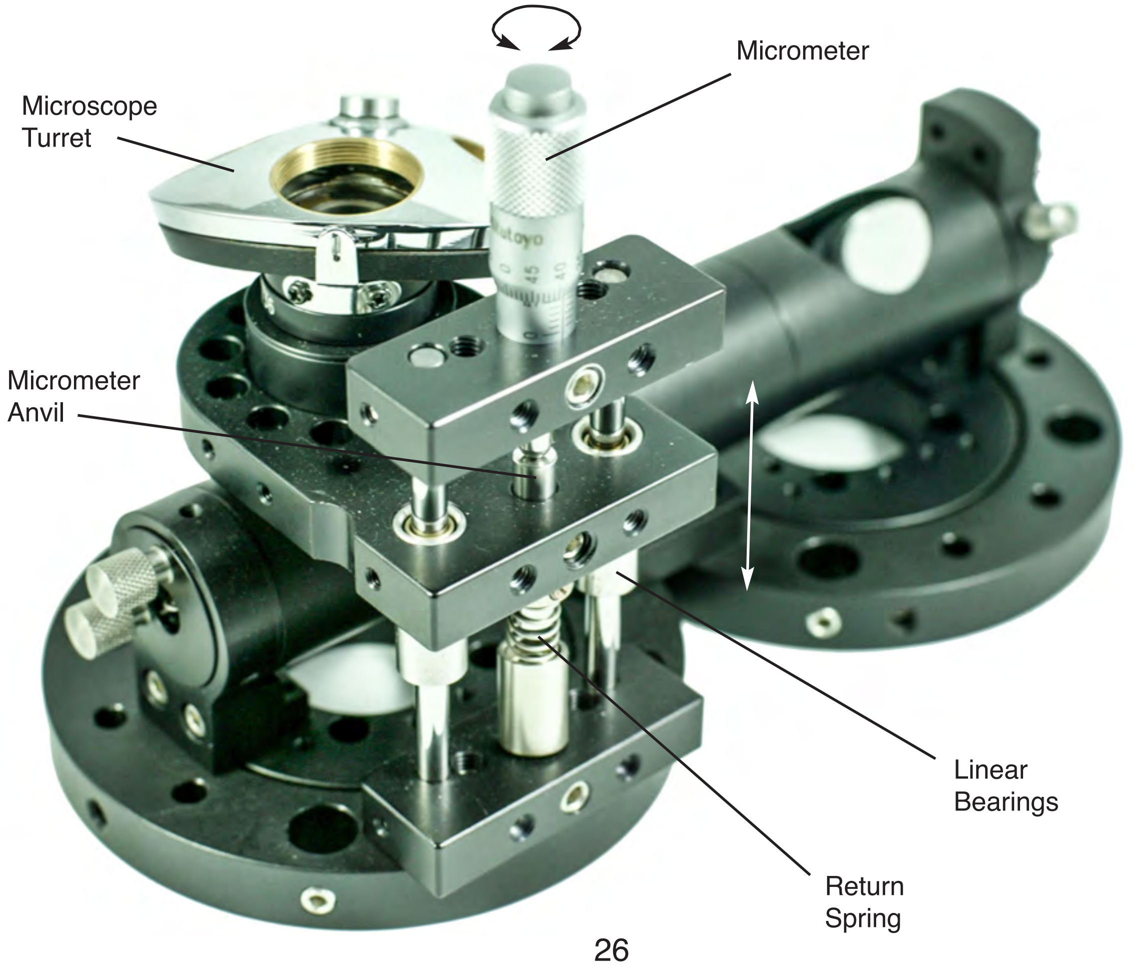
Typical wiring diagram for 50-280 + 50-282

Minioptic 100



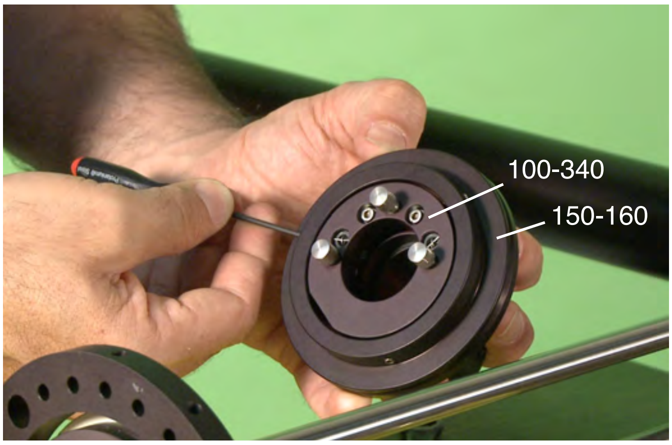
Linear Bearings

Linear bearings provide precise positional adjustments along the optical axis. There are two types: Short travel (100-214), and long travel (100-216).The short travel is intended for precise short focusing motion, i.e., in microscopy (below). The long travel linear bearing allows long travel positional adjustments, i.e., in constructing a delay line (above), combined with a digital linear scale for positional read out or feedback.

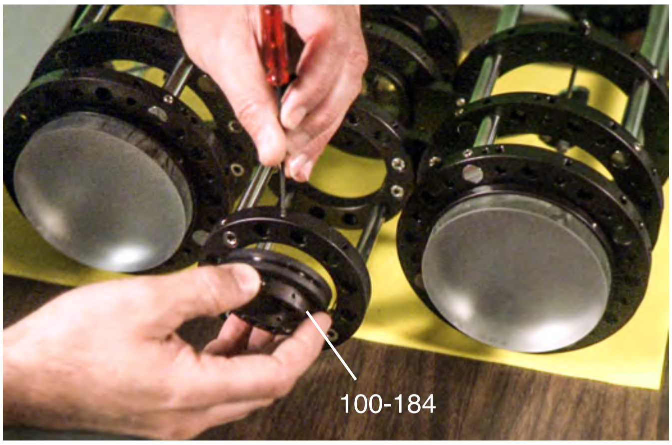


Using Minoptic 100 Accessories

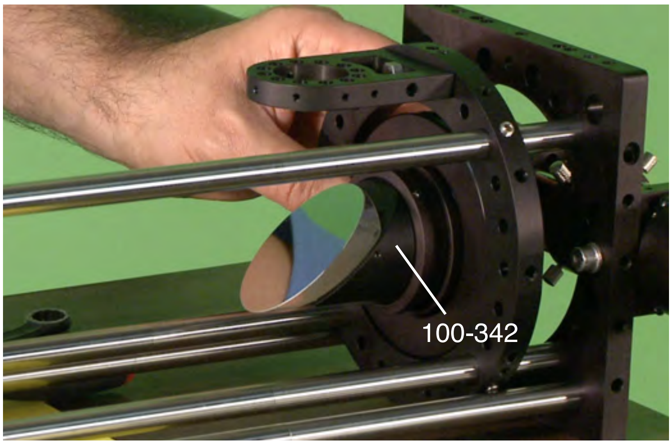
In addition to be designed specificly for Minioptic system, many Minioptic 100 accessories are designed to be compatible with both Microptic 50, and Macroptic 150 mounting plates. To integrate with Macroptic mounts, simply use centering ring 150-160. There is an online video covering the assembly on this page: https://youtu.be/gsAN2fM_VS0



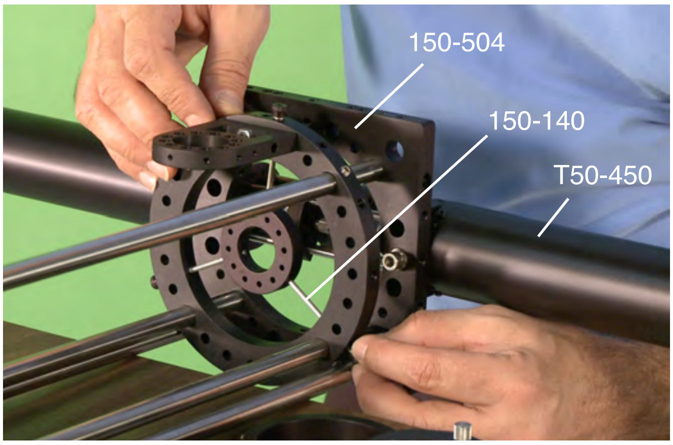
Stepping up Minioptic 100 accessories to fit inside Macroptic 150 mounts via Macroptic center ring 150-160

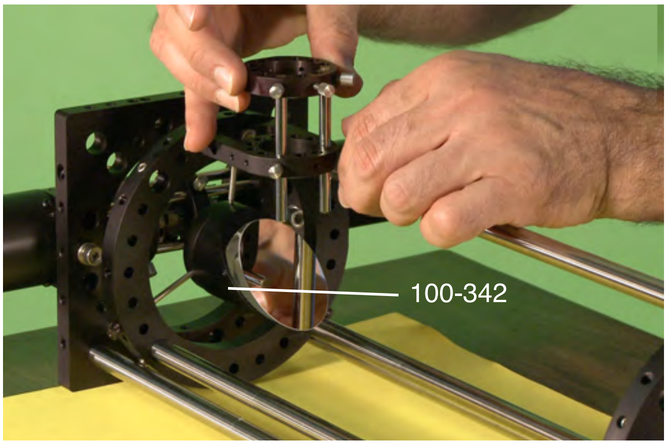


Side mounting of Minioptic 100 with Macroptic 150 via side connector 150-216.



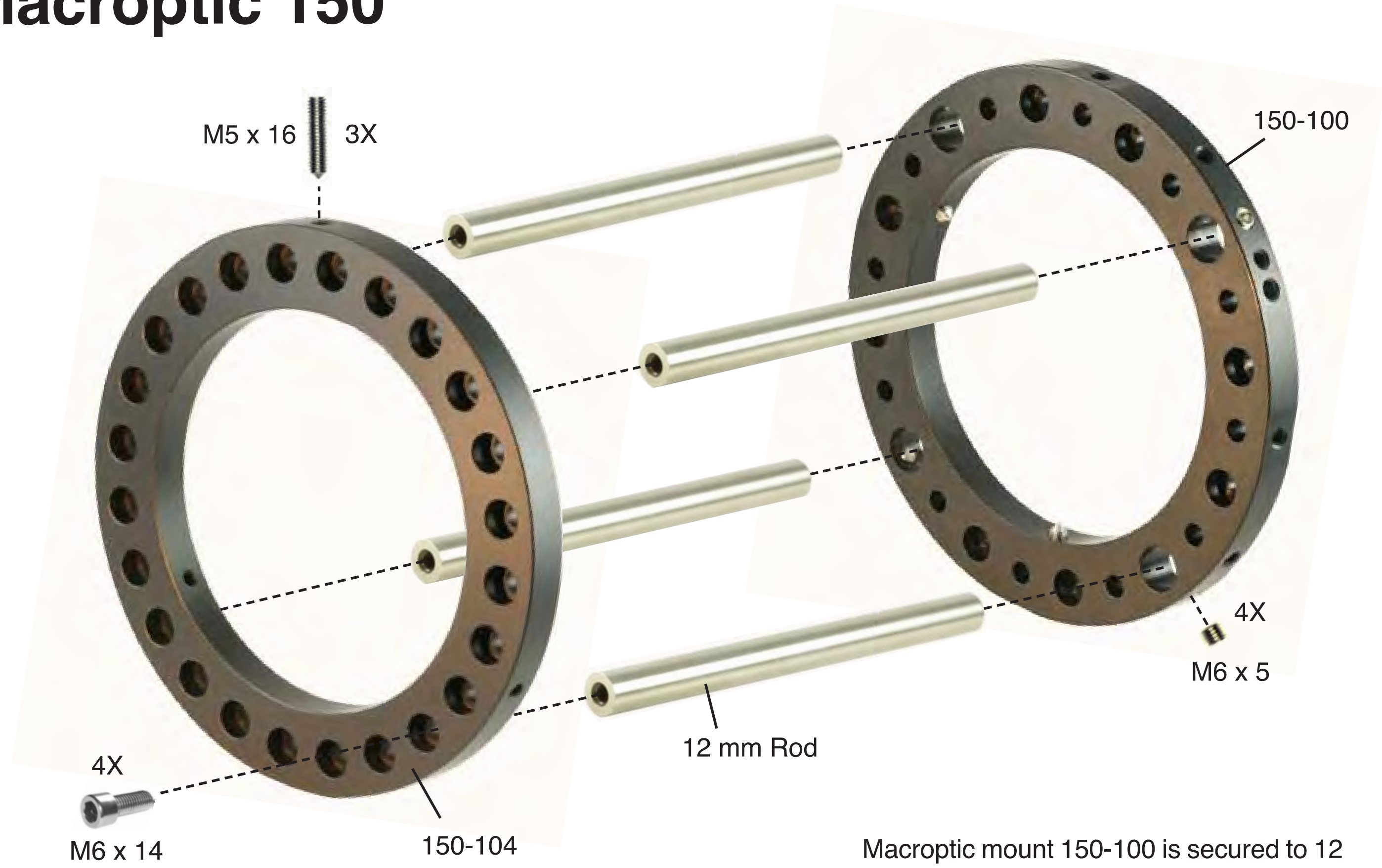
Stepping up Minioptic 100 accessories, i.e., **100-340** to fit inside Macroptic 150 mounts via centering ring 150-160. Mirror mount 100-342 has a threaded hole pattern for direct mounting to Microptic 50 mounts such as 50-100/50-104.



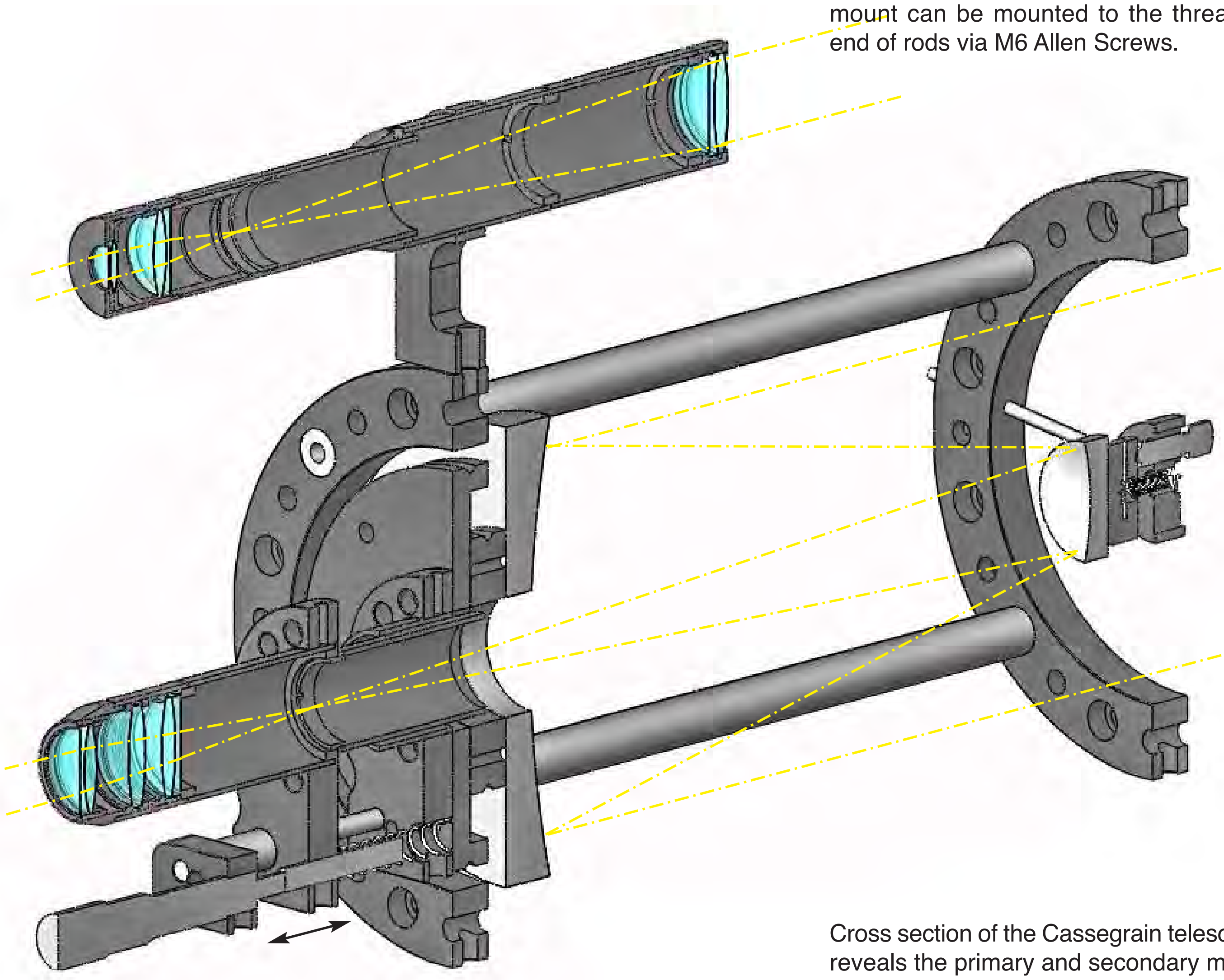


Securing 45 Deg. mirror mount **100-432** inside Macroptic 150-100 via spider assembly 150-140. There is a 38 mm dia. threaded bore pattern on the back of this mirror mount that can be secured directly on Microptic 50 mounts.

Macroptic 150



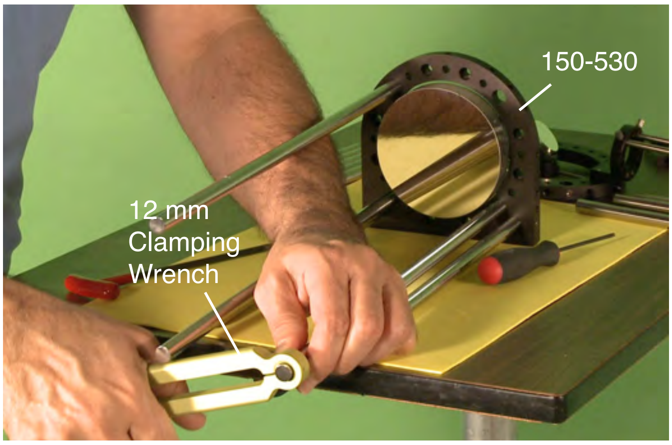
Macroptic mount 150-100 is secured to 12 mm rods via M6 set screws. 150-104 mount can be mounted to the threaded end of rods via M6 Allen Screws.



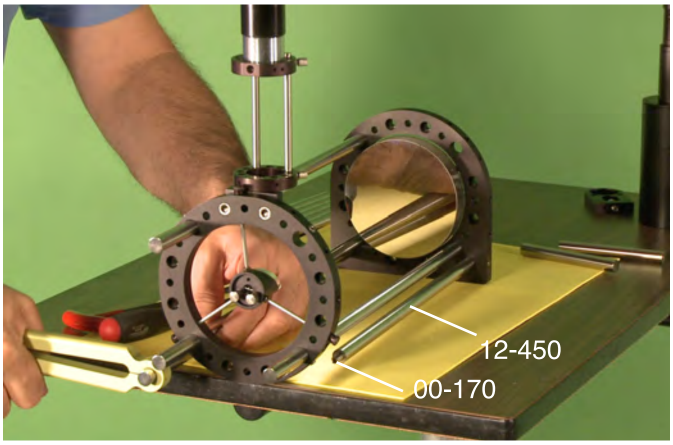
Cross section of the Cassegrain telescope reveals the primary and secondary mirror mounts, and its erect image optical path.

Planetary Interferometery with Macroptic 150

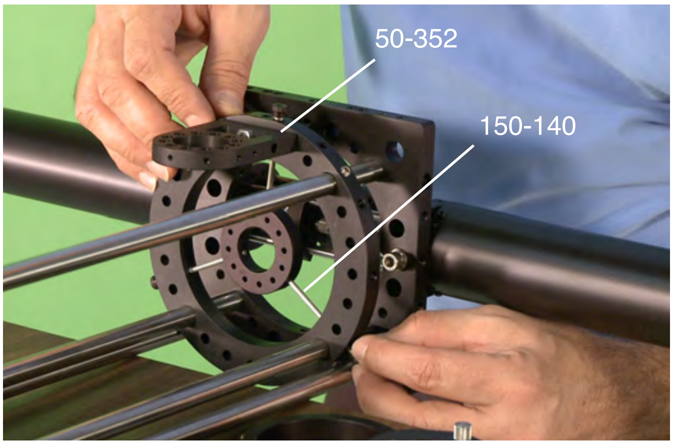
Utilizing Macroptic 150, in this stellar interfrometer setup is a good example of how each Optoform piece is designed to work with every other part in the system. There is an instructional video on Youtube for how this is put together: https://youtu.be/gsAN2fM_VS0

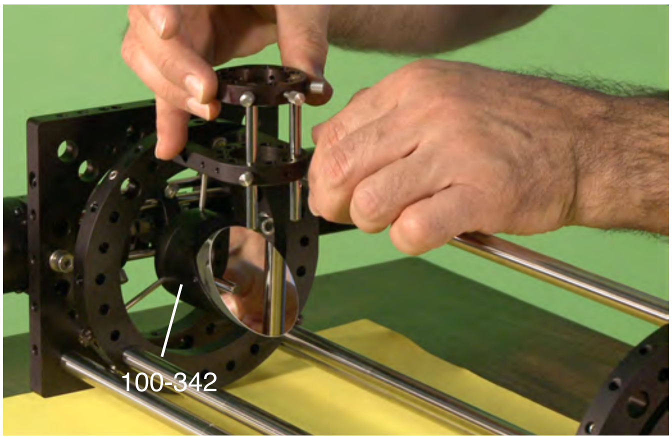


Any two 12 mm rods can be added together by screwing them together via 20 mm long M6 set screws.

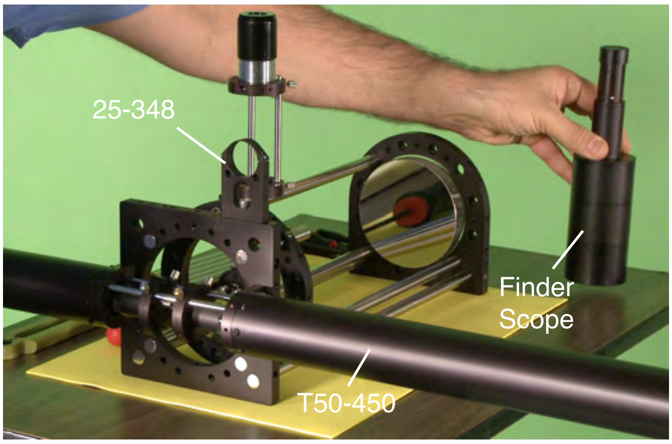


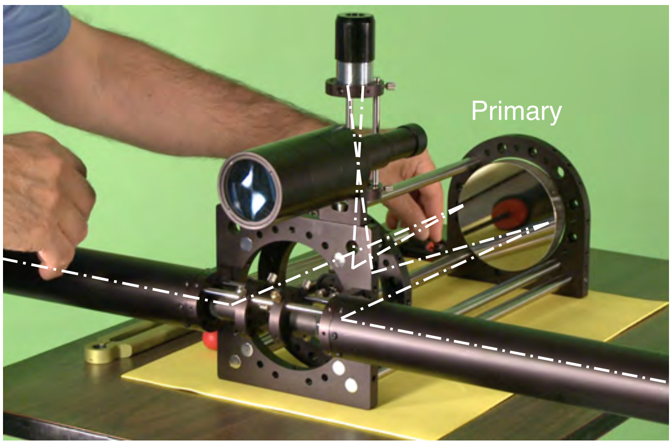
Extending support rods 12-450 (L = 450 mm) with 12-100 rods, for longer telescope housing (L = 550 mm).





A large elliptical mirror is installed in this Newtonian telescope arrangement by utilizing spider assembly 150-140.

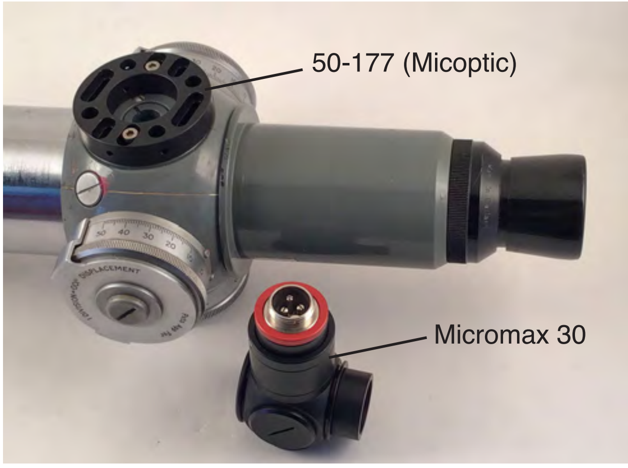




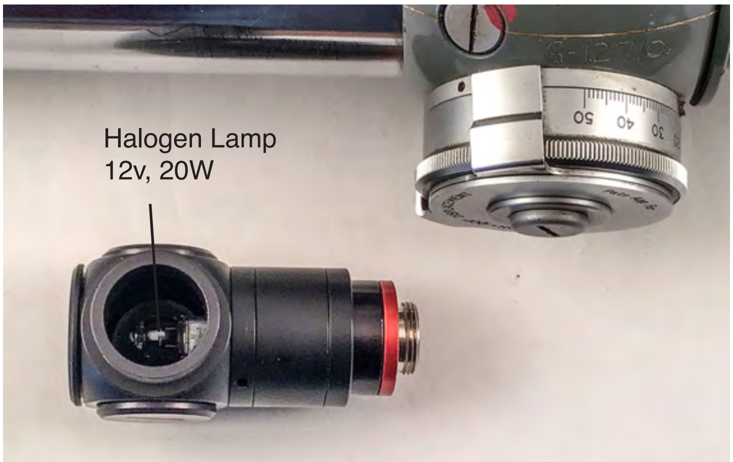
The light is brought in from two views of the planet, 1 meter apart to the fold mirrors in front of the spider assembly (right) then the two beams are brought into focus by the primary mirror, and to the eyepiece by a third fold mirror. This is a scaled down version of Michelson interferometer installed on 100 inch Mount Wilson telescope by Michelson in 1914.

Repairing Vintage Optics with Optoform

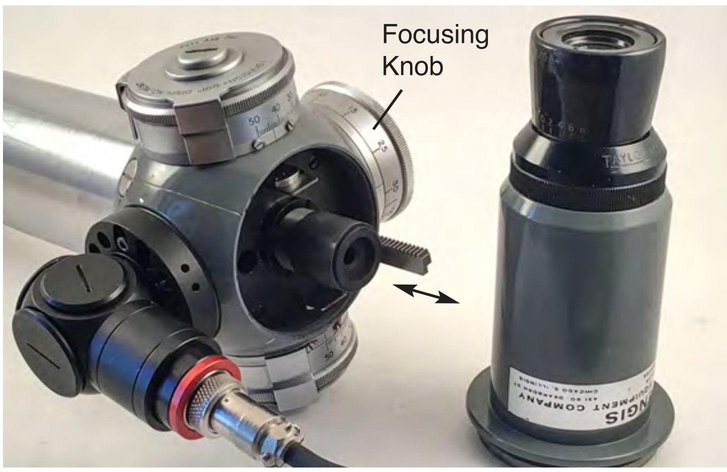
Optoform is so useful in repairing vintage optical instruments by upgrading their missing parts with new off the shelf components. One of the most common applications of Optoform is its readiness to provide compact illumination for instrumentation that are missing parts. Three examples are given here to show how Micromax 25, and 30 can be utilized in constructing a compact, self contained attachment to provide flexible illumination with various lamp types to choose from.



Tailor Hubson alignment telescope equipped with Micromax illumination module for reticule illumination. Micromax's compact design blends so well with the alignment telescope as it were the original light source by the manufacturer.



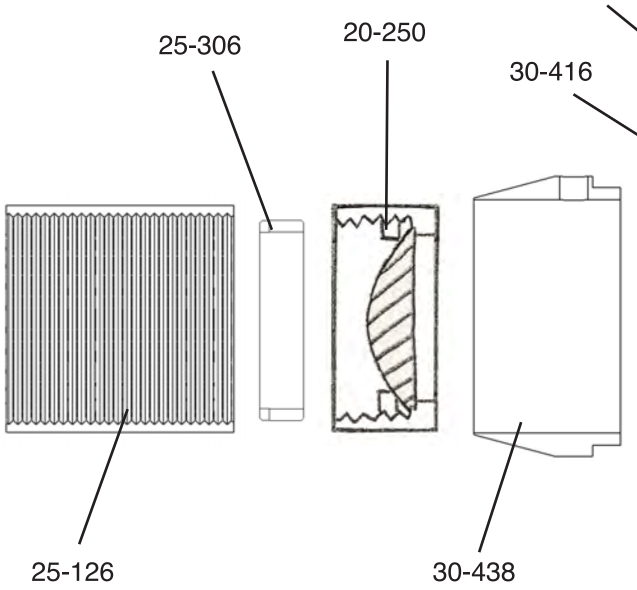
Above, details of Micromax attachment to the telescope are shown. The most commonly utilized adapter plate is Microptic shift mount 50-177. The horizontal bore pattern in this mount allows its mounting to various bolt patterns.

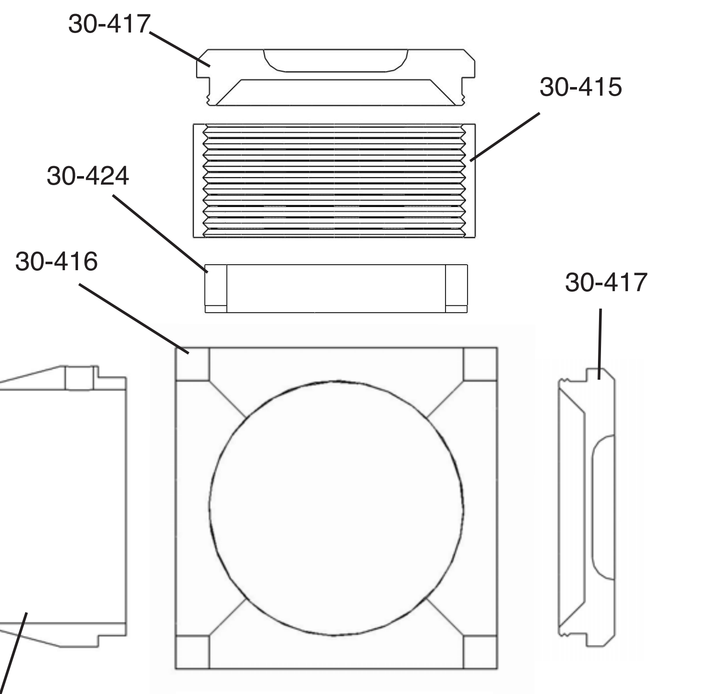


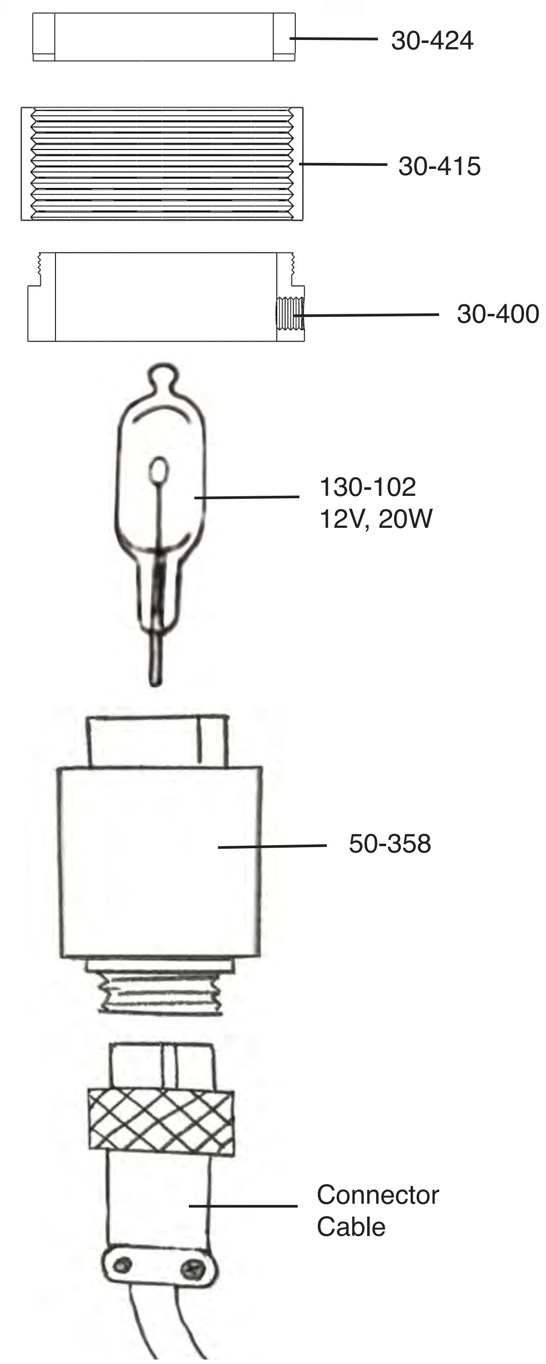
Tailor Hubson alignment telescope goes back over 70 years in its use in optical alignment. The internal focusing mechanism, (left) allows focusing from infinity down to its front window to perform opto-mechanical alignments in a system.

Design Works 400/402

Compact Lamp Housing with Micromax
25/30 components







DWX-400 10W/20W Light Source (please specify)

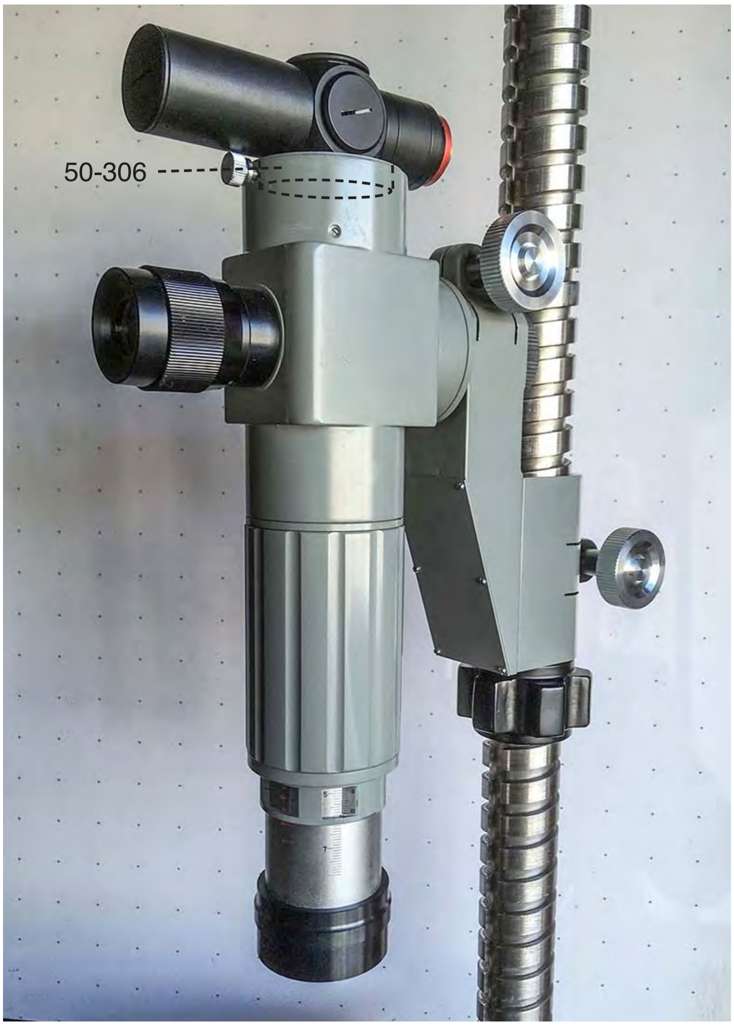
Part No	Description	Qntty	Price
25-126	Tube 25, L =25	1	21
25-117	End Cap 25	2	42
25-306	Retaining Ring, thick	2	18
30-415	Tube 30, L = 15	2	36
30-417	End Cap 30	2	44
30-416	Cube 30	1	60
30-424	Retaining Ring, thick	1	10
30-438	Reducing RIng 30/25	1	25
30-400	Standard Mount 30	1	22
30-416	Tube 30, l = 15	1	18
50-358	Lamp Housing	1	105
20-250	Condenser f = 18	1	65
130-100	Halogen Lamp 6V, 10W Small Lamp OR	1	11
130-102	Halogen Lamp 6V, 10W Small Lamp	1	14
		Total	$480

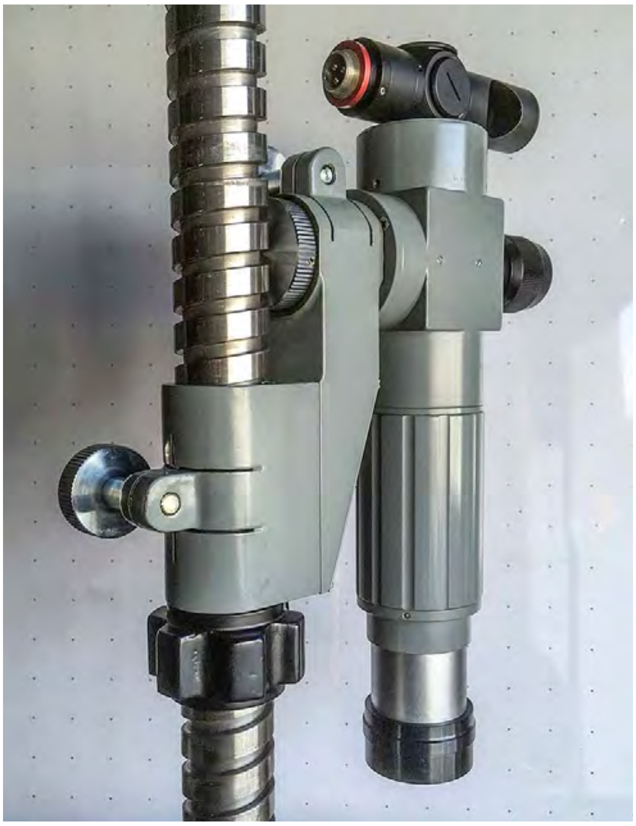
DWX-402 50W Light Source

Identical to DWX-130 but with the following parts:

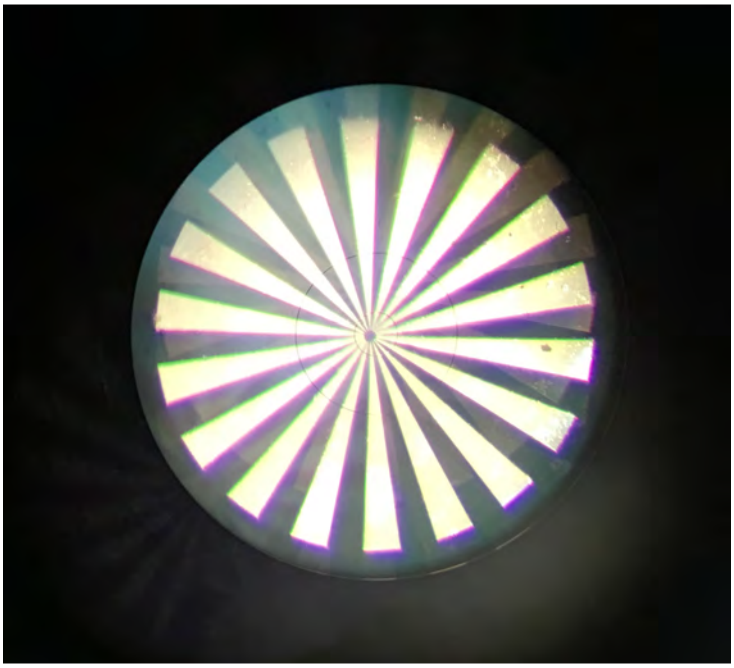
20/25/30/50-Parts listed above		16	272
50-359	Lamp Housing	1	105
130-108	Halogen Lamp 12V, 50W Large Lamp	1	15
		Total	$481

Pearl Autocollimator is another vintage instrument that in this case was missing a light source. A compact Micromax illumination housing was constructed for this instrument, and was secured on top of the collimator using its own lamp securing thumb screw. The interface plate in this case was Microptic End Plate 306. The outside diameter of this mount can easily be machined down in a lathe to exactly match the seating bore of the original lamp housing.

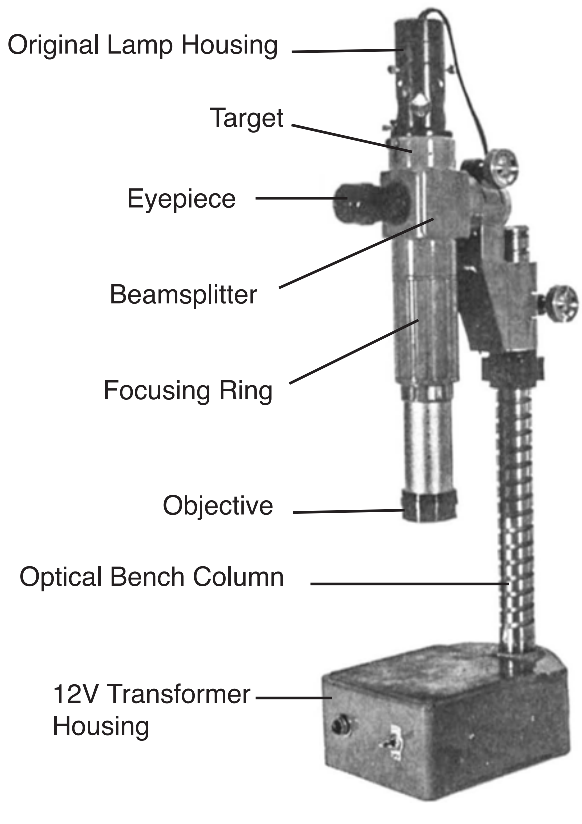




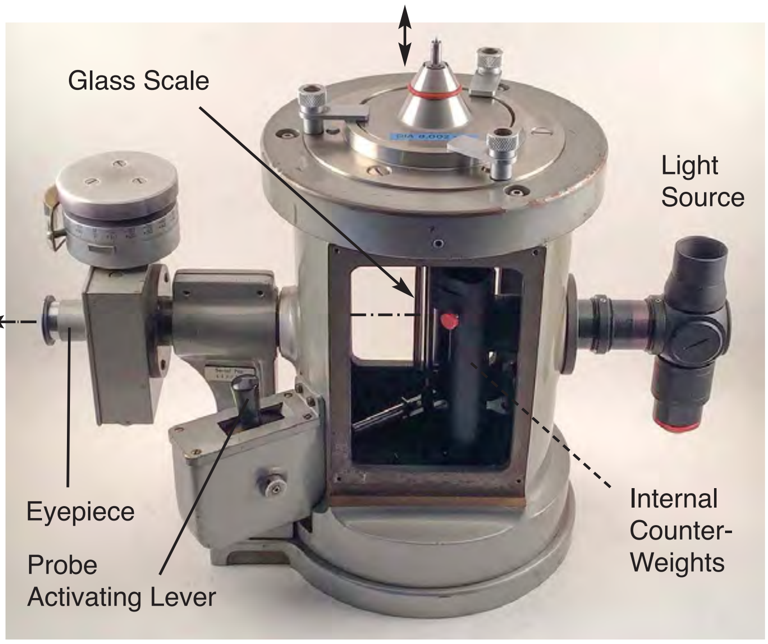
The illumination source for Pearl autocollimator is constructed with Micromax 30. The longer lamp enclosure is achieved by utilizing longer Micromax tubing 25-136 with side access hole for high heat dissipation from Halogen lamp.



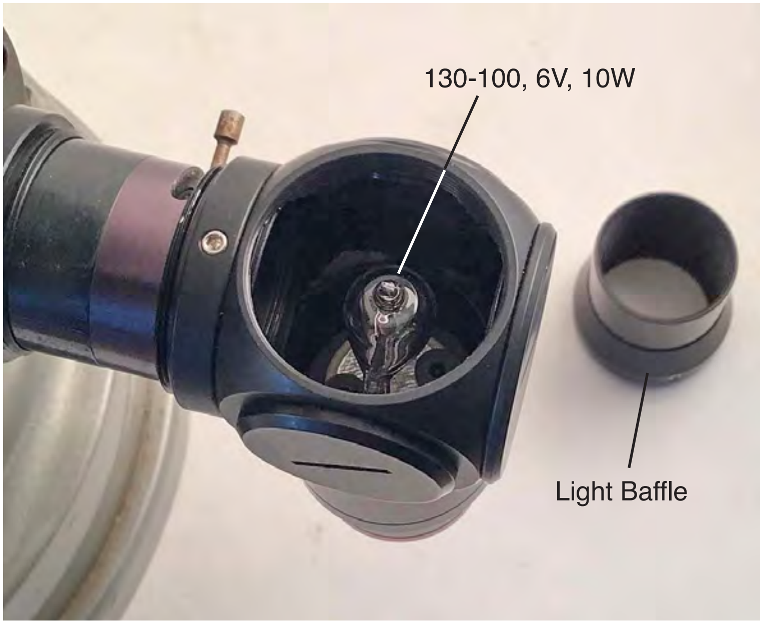
Star target in Pearl autocollimator is utilized to check both infinity focus in SLR lenses, and to check for paralellism between the sensor plane, and the lens seating flange. Right, the 12V power supply transofrmer is fitted inside the base.



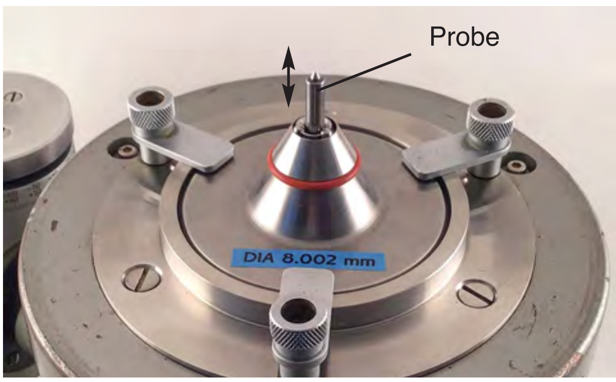
Gaertner Spherometer utilizes two internal weights to counter-balance its central probe's weight to land on the lens surface with virtually zero force. It accepts interchangeable lens measuring adapters (bottom of page) for performing measurements on various diameter lenses. An illuminated 0.01 mm graduated scale is viewed by its optical microscope for precise measurements. The central probe has a 50 mm travel range, and the lower portion of the probe exits the housing during measurements, and the instrument will not function without its support legs (not shown).

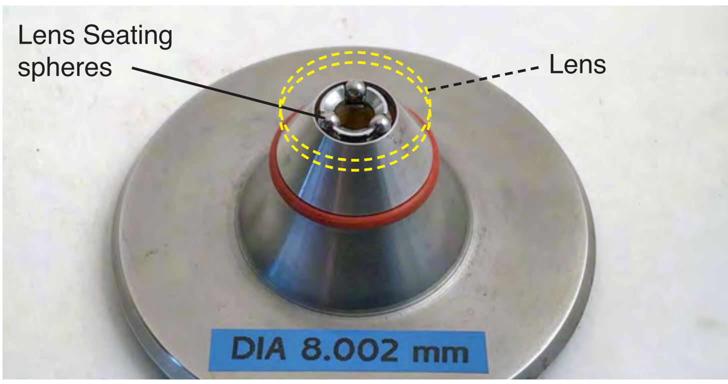


Micromax illumination attachment saves the day because this unit was originally missing a light source. This measurement scheme is still in use today but the scale has been replaced with a linear scale.



Micromax assembly naturally fits the metric flange of this instrument. A 10W Halogen lamp supplies ample illumination behind the vertical traveling transparent scale. Above right, both cover panels removed to reveal internal light path.





The Ambiguity of Spiritual Path: Into the Woods

By Ali Afshari

Back in my NASA years, I had an atheist Italian neutrino physicist officemate named Neil, that every once in a while, we argued about the spiritual realm. Heaven, and hell don't satisfy the resilient nature of those who are searching for higher meanings in life. I am familiar with the works of poets like Rumi, Shakespeare, Omar Khayyam, and contemporary thinkers like Allen Watts, and Eckhart Tolle. They all ask the same question: "What do we dwell here for?" Last month, I was on a plane going to Colorado, and someone was sitting next to me, reading Paulo Coelho's book: "Alchemist". I said wow, you are also into that stuff. He said no, I just read these books that my friends recommend me to read. I Asked what do you think of them yourself? He said: "Nothing, I don't have any thoughts of my own.

I said that what it's all about, to have thoughts of your own. He asked where would one start? What I suggested was to try not go back to sleep when he woke up in the middle of the night. That's when inspirations come to us, and we'd start feeling our individual self as an inspired being. Dr. Wayne Dyer has so much to say about this in his book; "Inspiration". I am not a big book reader. I just get familiar with ideas, and try to re discover them on my own. You could learn your Math, and physics by reading, and memorizing, but you can't walk the spiritual path that way.

In Colorado, there are trees, and rivers that speak to the spiritual self. There is a pathway that I walked into one evening, and many more evenings after that, and I really think it's a sacred path. I still have numb fingers as I write this for falling on them while climbing down a rocky path, to sit next to a river. Deep into the forest, with all the stars above, you see a different you out there. All the knowledge of the stars, and all the other things you might know, won't be useful there. It's just you and the strong presence of something so beautiful that one could not describe in words. You can't be in your own mindful thoughts either. This is meditation in its true meaning. You realize this is not about what you are seeing in the outer world. As Rumi puts it: "Don't be staring at the burning bush that Moses saw. Look into his heart."

I often imagine myself as Moses, walking with his stick in the woods. All prophets had those moments alone. I saw a young girl one evening! I wondered what she was doing there. Did her boyfriend leave her or was she like me, looking for her inner self? When you are not looking for a soul mate, you won't look into people's eyes. You are afraid you'll be distracted. It's your inner eyes you are looking to find. I was once meditating next to the ocean, and there were boys and girls playing on the shore. I closed my eyes to have less distraction. When I re opened my eyes, they were all gone, with all their foot prints washed away. It was as if I was being told: "Now let's see your foot prints." Life is really about your own foot prints. In Middle East, we have sand, and wind to clear the foot prints. You'll have to find your own path.

O Mistress mine where are you roaming?
O stay and hear, your true love's coming,
That can sing both high and low.

Trip no further pretty sweeting.
Journeys end in lovers' meeting,
Every wise man's son doth know.

What is love, 'tis not hereafter,
Present mirth, hath present laughter:
What's to come, is still unsure.

William Shakespeare (from Twelfth Night)

The spiritual realm has a calling voice that invites you to come to sacred places. I don't know if this is a call from within or it's from mother earth. But you could only hear it if you listen closely. Answering to that call will take you to where that young girl was foolish enough to go. I don't recommend women to go to the woods on their own. It's not so easy to explain. The simplest explanation I have is while I am in the woods, I have no fear of anything, but if I do it would be of humans. But it's much deeper than that. Fear is what keeps us in our safe apartment or nice bed in a hotel room. Fear blocks us from exploring, and finding who we really are. Once we break that fear, and explore our inner self, all our fears would be dissolved. At that moment, we would only worry about being alienated again by what Buddha calls Samsara: Our daily routine in the city. But that inner calling will remind us when it's time to liberate ourselves from it.

So while we are entangled in our forgetful daily life, it is a waking call from another realm. Rumi says: "The reed flute is a friend to all who want the fabric torn, and drawn away", and; "It is not given us to see the soul". We could just watch the clothing this world wears and try to feel what's hidden behind it. One of the ways to hear this calling during our daily routines, is to have our ears open to its voice. When the priest gave the candle sticks to Jean Valjean (in Les Miserables), he was aware of that voice. When Farnsworth was pushing a horse drawn cutter back and forth on his father's farm he was listening to it too. All kindness, and all inventiveness, and all design come to us by tuning our ears to the source. What Tarega says a bout Sorcery is: "The sorcerer is the one who keeps his connection with the source". Most prophets were farmers, or Sheppards at one time.

It is so sad our elderlies are dying today. This is a virus designed to get rid of the vulnerable teachers of old school. The old are our most valuable teachers. They are our roots, our best connections to the source. Robert Bly says when I was a little boy, I loved growing my hair long. One day, at school, they forced me to cut my hair, and I was so sad after that, and no one could understand how I felt. My grandfather saw that, and he took me to the ocean. He raised both his hands into the air and said: "Do you see this beautiful ocean? This is all yours to watch, whether you have short hair or long hair, this will always be yours!" "That simple gesture made me happy again ... only a grandfather could do that".

I once was heart broken from all the miseries of life until I came across a Rumi poem: "The strike of the stick is not meant for the rug. It is meant to hit the dust." I remember my spiritual teacher was telling me about his own teacher during his youth. He said: "He was an old man, so ill, laying in his bed in great pain. Me, and other boys would go find him drugs, so he could smoke it, and be in less pain"! The old man would say to us jokingly: "Oh Lord, look at me become a drug dealer at the end!" He said: "He taught me everything I know". Some old men are bigger than life. Old men are so sweet even when they are angry. When I went to my voice teacher, and he heard my voice for the first time, he said: "Ali, you have no voice, and no talent. So please leave it at that, and don't waste my time!" I said so when could I come so you could teach me? He said every Sunday afternoon after 1:00 P.M.

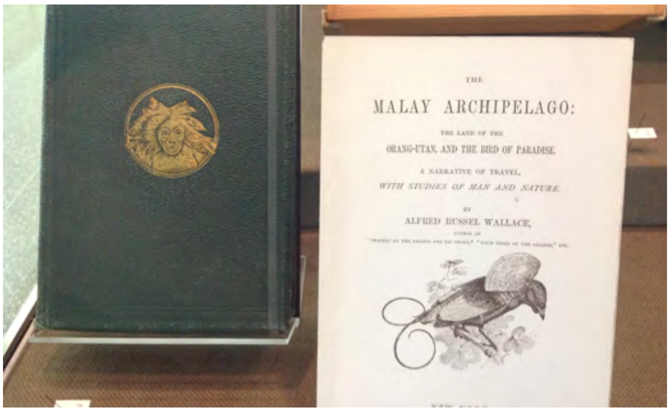
Every session I went there, he made me sweet lemon juice, and offered it to me with such kindness. There were times I took him to a drug store, to get his meds. He soon realized I wasn't going to him to learn how to sing. I just wanted to be his friend. On the last days of his life, he took me to his house to help him clean up. He picked a Swiss watch that someone had given him as a gift, and said give this to my son in law, and he left everything else as if they meant nothing to him. Robert Bly recalled an old man once said: "If you are a man, and you have not been admired by an old man, then you are being hurt". This is really true. Men are not taught what it takes to be a man. That's also how one learns the ways of doing science, through the apprenticeship of a much older research professor.

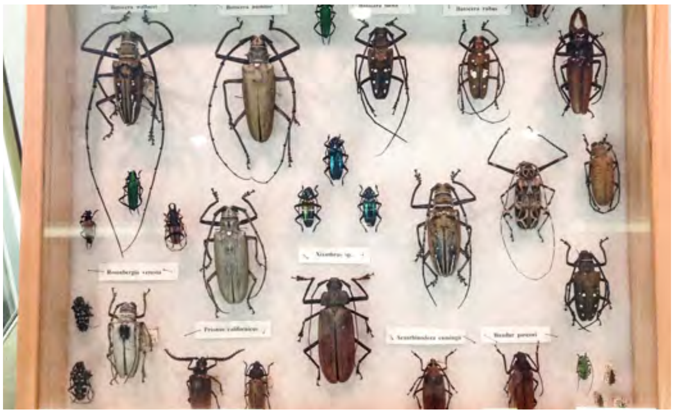
Scientists always want to undress God to see what they might find! Sufis don't want to undress God because without clothing, there is nothing to see. Spiritual path is an extra curriculum course. There are first graders in school (like Harry Potter story!). As one attends the school, he/she gets prepared to go to the next. One has to unlearn everything they already learned to join the school, and this is so essential that most of the time, fools do better! Knowledge would block you from going further on the path. Consider it as a school of silence, or school of contemplation. You could stay as long as you want to stare at almighty's fashion parade.

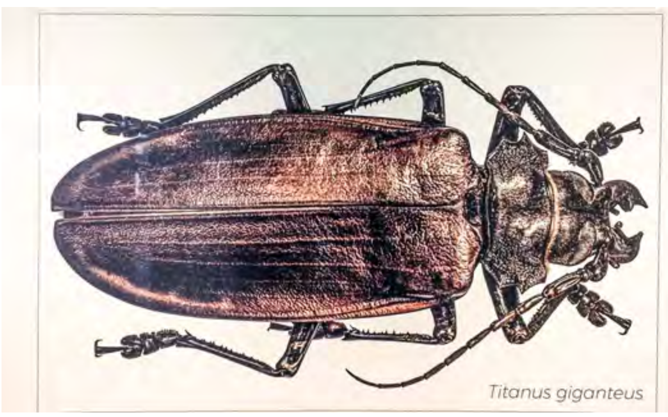
San Fransisco Airport Museum

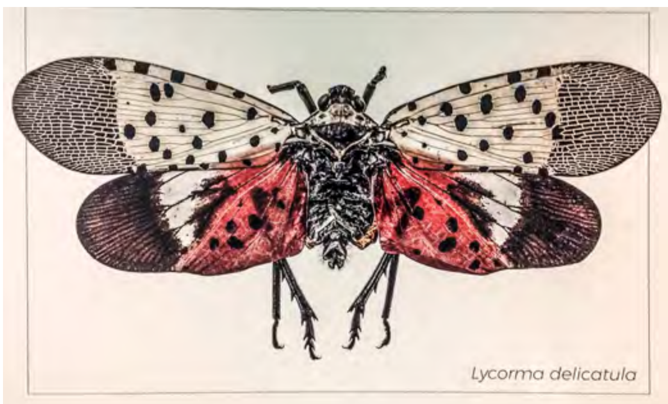
A fantastic collection of insects, and vintage books were on display at SF museum in the month of February, 2020. I really appreciate the work that goes into creating these displays. My friend Bob Shell used to work at Smithsonian, and he said there were thousands of these insects kept at their library all pinned to display boards. He said I always thought what would possibly be the use of all these insects already destroyed by a pin through their stomach? He said: “In the late 1960s I worked on something called The Southeast Asia Mosquito Research Project at the Walter Reed Army Medical Center. I was "loaned" to that project by Smithsonian. I didn't know until years later that I was actually working for the CIA. The hidden purpose of the project was to determine if mosquitoes could be used as vectors for biological warfare agents. The Washington Post "ousted" the project as a secret CIA operation. That's when I learned who I had really worked for.”

Early drawings of insects were done by hand, through rather crude microscopes. Today’s stereo microscopes do an amazing job of identifying insects and allowing their physical shape to be examined. If you want to see the most horrifying creatures you have not even seen in science fiction movies, just search SEM images of insects. You’ll be glad they are so tiny, and we are big!

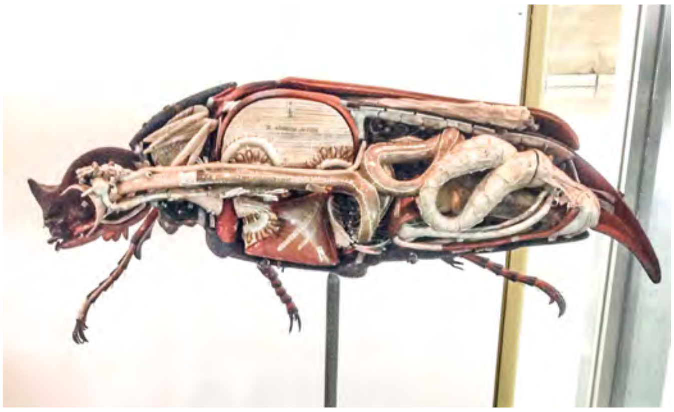









Coccinella septempunctata




Sphex ichneumonius


Phyllium pulchrifolium

Chromic

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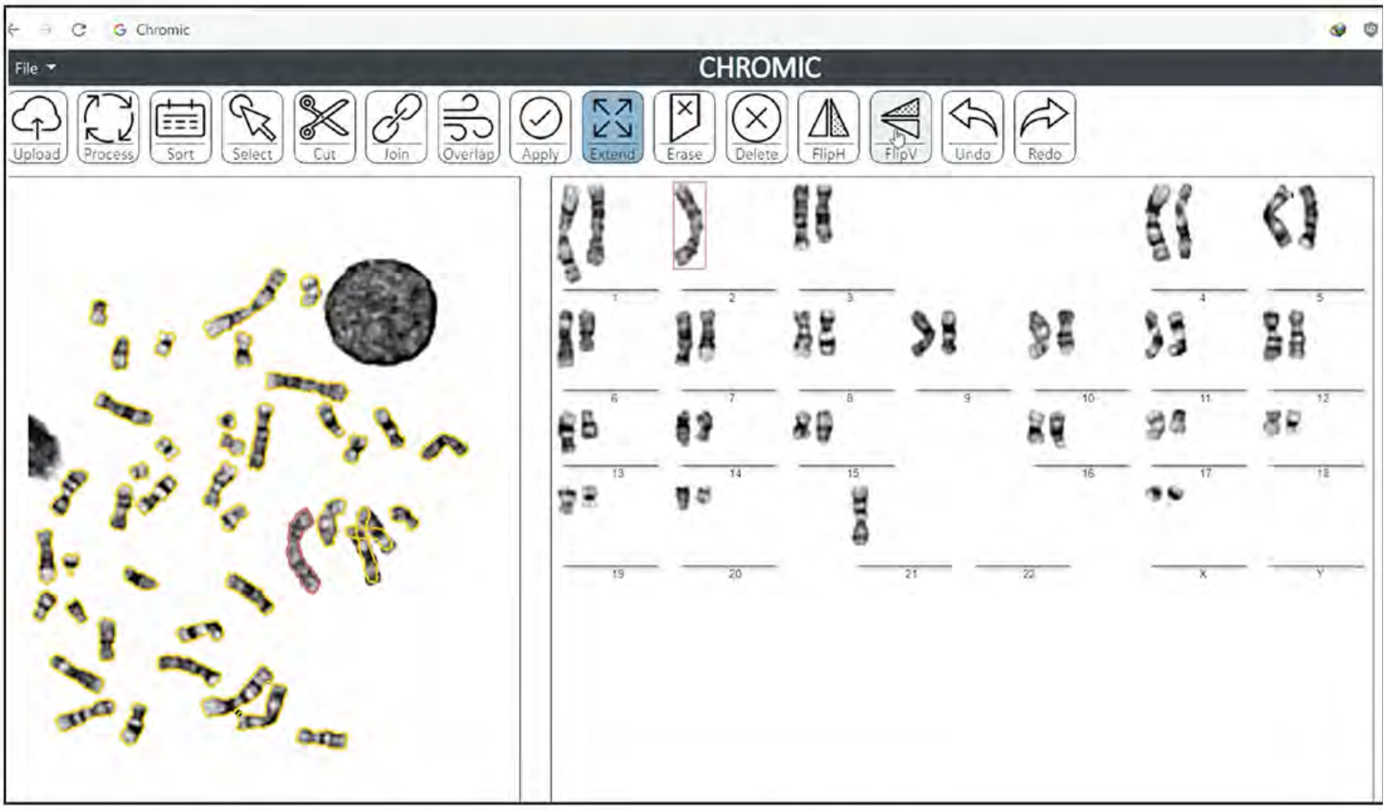

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