Optomechanix

Microscope Design Study:
Olympus CX21

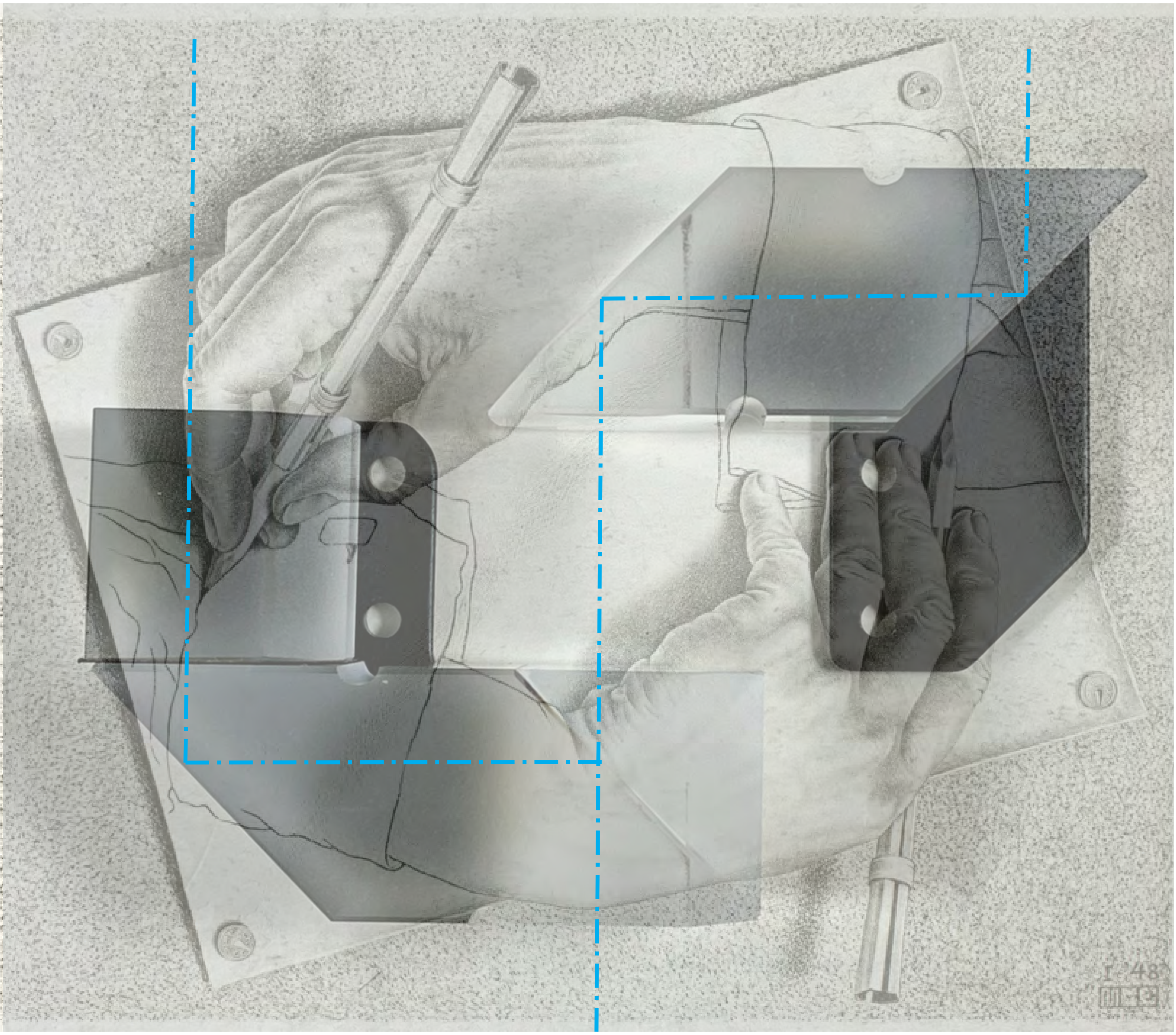
Microscope Manufacturers:
The Big Four

Microscopy Global market
Share

Iran: A Hard Choice Between
Morality, and Modernity

The Opto-mechanical Design of a commercial Microscope

Oct-Dec 2022



Technical journal of OMiD, Opto-Mechanical Institute of Design

Olympus CX21 Back view of the microscope. It was designed by Olympus opto-mechanical design team in late 1990’s.

Contents

OSA 100 The Optical Society Since 1916
Member of OSA
Optical Society of America

OMD Opto Mechanical Institute of Design

SPIE.
Member of SPIE
The international Socierty for
Optical Engineering

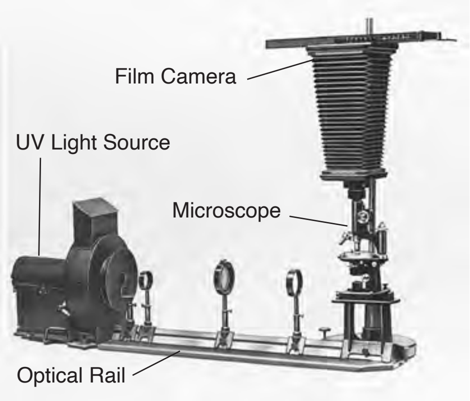
Henry Siedentopf physicist

This issue Dedicated to:

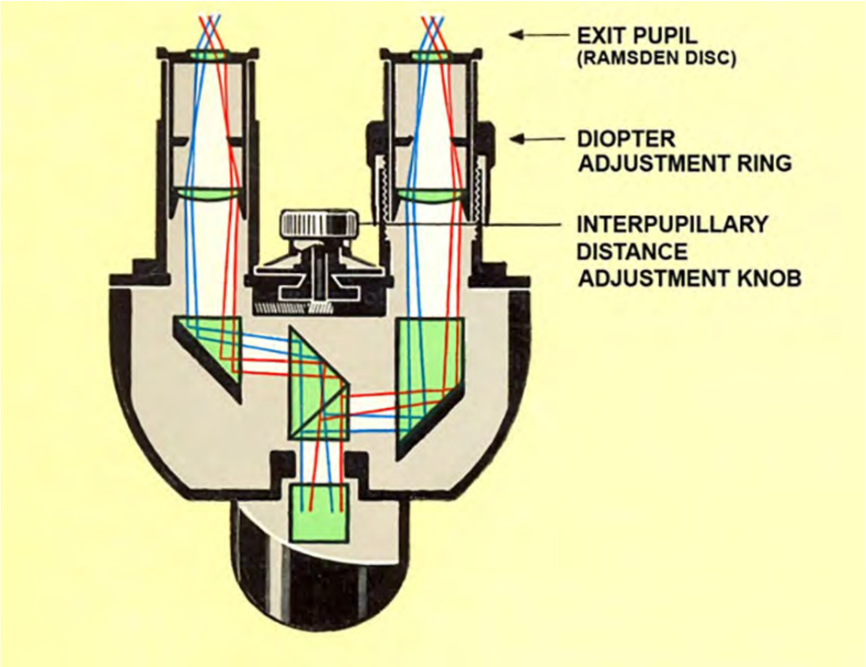
Henry Siedentopf (1872-1940). He was a Professor for microscopy at the University of Jena from 1919 till 1940. He also worked at Carl Zeiss company from 1899 to 1938. In 1907 he was nominated as the head of the microscopy department.

He worked on the development of micro-photography and slow motion and fast motion in the field of cinephoto-micrography. In 1908 he invented together with August Köhler the fluorescence microscope (left).

In 1902 the ultramicroscope was co-developed by Richard Adolf Zsigmondy (1865–1929) and Henry Siedentopf, working for Carl Zeiss AG. In 1925, Zsigmondy received the Nobel Prize for Chemistry. The Siedetopf binocular head (below) was his invention, and bears his name today.



World’s first fluorescence microscope.



Carl Zeiss drawing of the internal schematic of Siedentopf design.

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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.

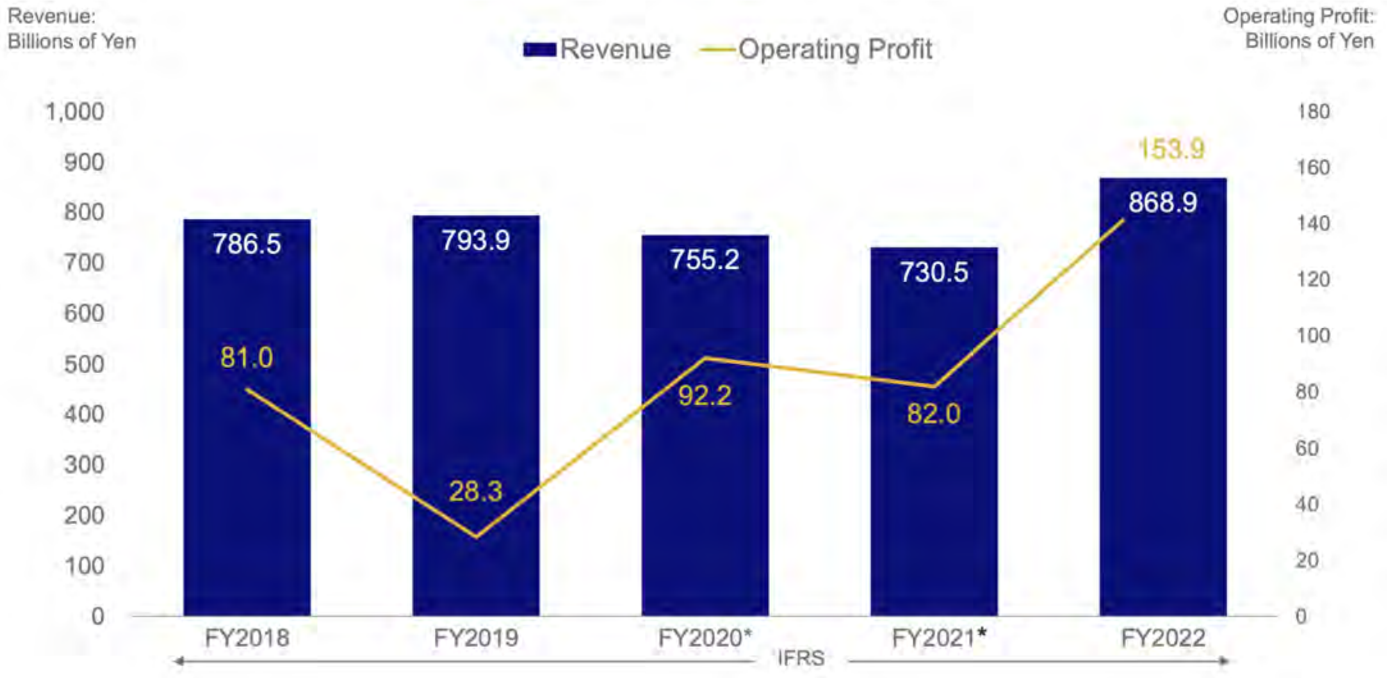
Cover page photo: Combination of Seidendof prisms, and MC Escher’s drawing
Front back: Back view of Olympus CX21 microscope’s die-cast Aluminum housing.

An introduction to Microscope Design, and marketing

In the last issue we covered some camera manufacturing, and marketing history as told by Bob Shell. In this issue, we are going to study microscopy design, and we'll start with an Olympus model because I am more expert on their microscopes than any other brand. I was an OEM designer for at least a decade, integrating their microscopes in my designs for my customers in Silicon Valley. Olympus has a huge market share in biomedical optics, namely, endoscopy, and microscopy.

Microscope design is the most favorite of mine because it is practically a vertically oriented optical bench where you could add, and take off optics to get the image you wish to achieve. Microscopes have always fascinated me because while I visit museums such as the industrial museum in Munich, Germany, I get to see a huge collection of them in beautifully made brass finish aside their finely made wooden boxes filled with accessories. The advancement of opto-mechanics, is like life itself: When you look back in life, you could see as Steve Jobs put it: "connecting the dots", to find yourself where you are now. Microscopes have evolved tremendously through the years, and you could connect the dots with each design staring through the display cases in museums.

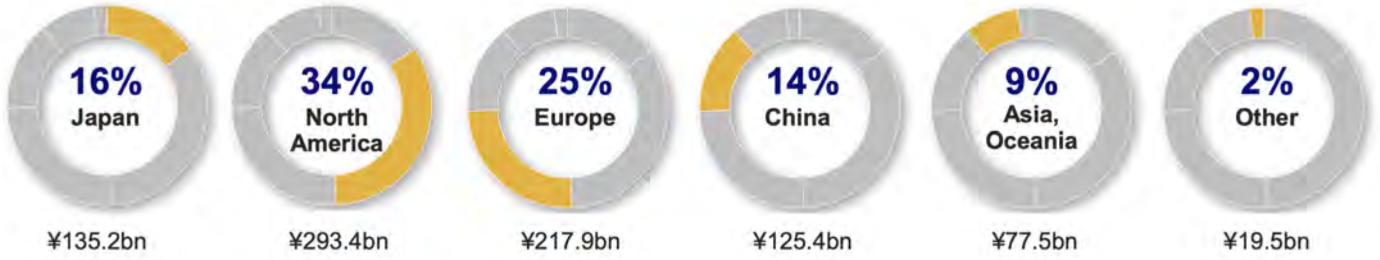
Revenue, and operating profit, Olympus Corp



The main players in microscopy are the big four:

Olympus Corp, Japan:	31, 577 employees world-wide in 39 countries. 868 Billion in global sales, of which 119 Biln is in Scientific solutions, 461 Biln in Endoscopy Owns 70% of the market share, 17, 000 patents, Source: Olympus

Revenue by Region:



Company Name	Number of Employees	Global Sales Volume per Year	Patent Filings
Olympus Corp	32, 491	$ 499.2 Million	67, 624
Nikon Instruments	2,244	$ 129.5 Million	37, 480
Carl Zeiss LLC	12,034	$ 4,127 Million	20, 617
Leica Micro Systems	2,254	$ 697.8 Million	6, 009

There is a huge market out there for microscopy, endoscopes, and therapeutic products, etc.

Almost all microscope parts are sent to Asia for manufacturing, except some critical pieces that requires highly skilled workers or big companies simply won't trust giving away their trade secrets to off shore factories to build them. Incidentally, how do you think the Asian companies grew in their manufacturing know-how? They learned it all from experienced giants. Now they have their own design teams, and are manufacturing their own lines of products. Watchmaking companies in China grew the same way. Today there are over 300 watchmaking factories in Schengen alone. Big companies like Apple, own their own plants there, and so are the big four in microscopy.

Microscope as a product is quite difficult to build. I have seen many small firms approach it without knowing what it really takes to make it a successful product. The robust, swiss-made Wild microscope era is over. Microscopes today are built with an experienced design team whom are aware of so many alternatives to develope a good product. The material selection is crucial to stay competitive. As we'll see in case of Olympus CX-21, the choice of materials, and use of ball bearings are only used where it is absolutely necessary. The microscope we'll study was designed for schools, and small labs that need a reliable microscope at an affordable price. The image quality (optical design, and lens making), plus its opto-mechanical design, and manufacturing are a great buy for the price.

Ali Afshari
Editor in Chief
Optomechanix

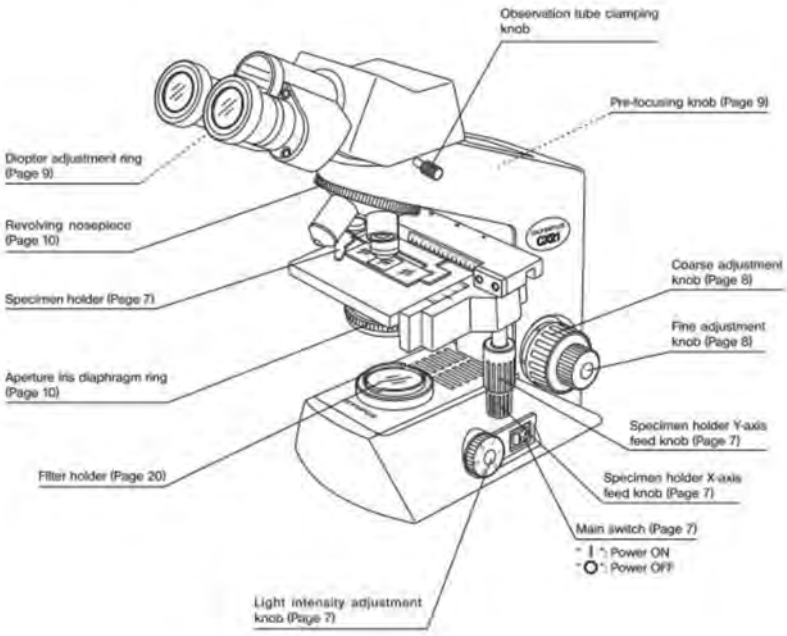
Before giving all my complements throughout my article on Olympus CX-21, let me get over this major design flaw that I have seen many microscope manufacturers make in their choice of this white plastic material as drive gear. If you have a Leica stereo microscope, and the zoom knob is stuck, this is the gear that has split, and it won't turn. This material gets brittle over time, and it would split. It's just a wrong material of choice for the mechanical engineer. Unfortunately, I have seen it used by so many microscope manufacturers.

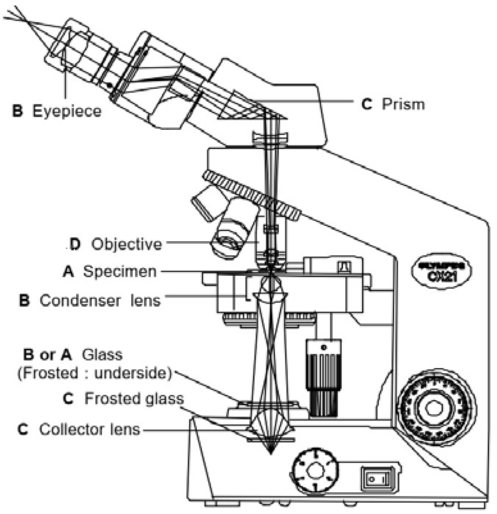
Optomechanics of a Commercial Microscope

By Ali Afshari

In commercial instrument design, it is so essential to keep the costs low, especially when designing a microscope. Most microscopy end users are either biomedical labs with a relatively good budget but also universities, especially in third world countries, schools have very limited budget. So, to create a decent microscope to deliver high quality images, in the late 1990's, Olympus introduced the CX series. I would estimate at least 200,000 of these microscopes have been sold worldwide in the commercial market, and with my estimated manufacturing cost of only $150 each (in Asia), it is marked up to $450 when entering the US by its main distributor in NY. The consumer price for this microscope is marked up to $1,500. This amounts to $300M in global sales, but may be a small fraction of 3 Billion in annual microscopy sales. I am going to cover its optomechanics because I consider it to be such a well-designed instrument optimized to reduce cost while keeping its value at reasonably high quality.

Olympus CX21 (above) with its optical light path shown (right), and its basic components (below).





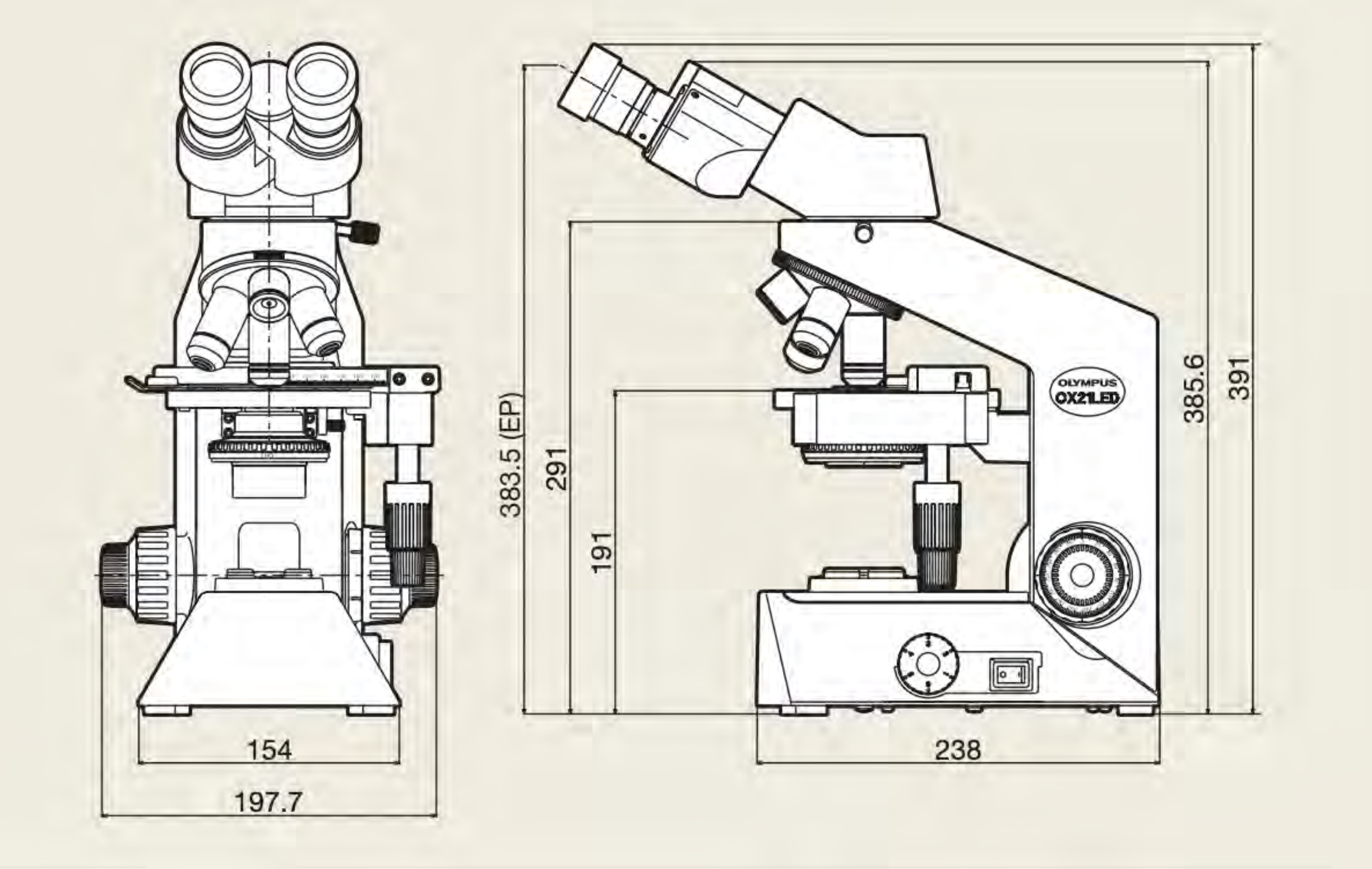
Before we study the inside of this fine instrument, let’s cover its basic design features:

Objectives: 4X, 10X, 50X, 100X Plan Achromatic objectives, 10X Eyepieces, Adjustable height **Abbe Condenser**.

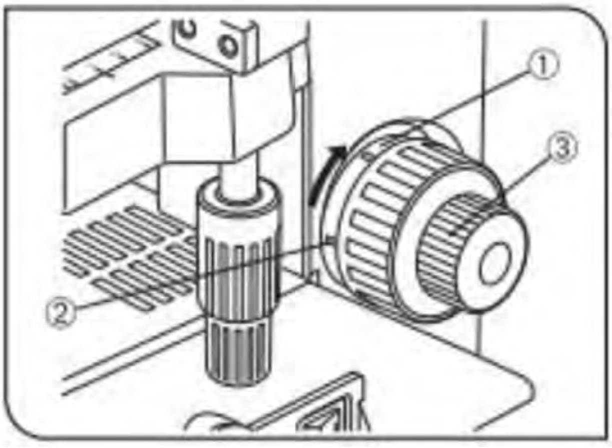
Weight: 6 Kg, **Stage Platform**: 120x132 mm, with 76 X 26 mm Travel, **Viewfinder:** 30° Inclined binocular viewing.

Rated Voltage: 100 ~ 240 V, **Illumination:** LED 1.7 W, or 6V 20W Halogen lamp at 18 W total consumption.

Helical Type **Focusing Stage:** 20 mm, Fine Focusing Graduation: 2.5 Microns



Dimentional data of Olympus CX21

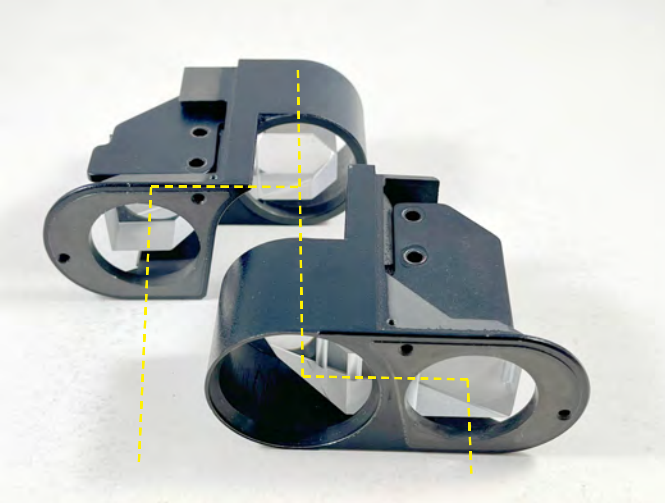


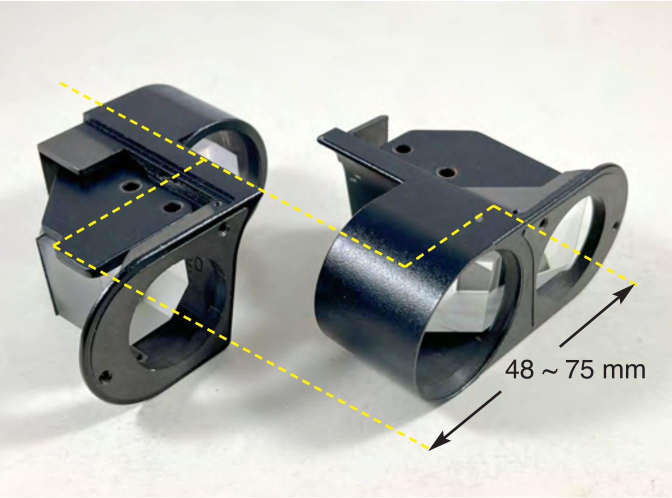
Left, a very useful storage box for the microsocpe. Olympus also offers an optional cord rest that mounts on the back of microscope to secure its power cord. Above, the fine, and course focusing knpbs, and setting ring (1) to adjust the friction of course focusing knob. See page 20 for details.

The Siedentopf Binocular Head

This is an extremely well-designed binocular head that is relatively low cost to build. The main problem in designing a binocular head for microscopy is that in the traditional Jentsch design (see page 29), the focus would change while adjusting the interpupillary distance (IPD) to regulate the two eyepieces according to that between your eyes. In Siedentopf design (below), the optics, and mechanics join hand in hands to eliminate the focus shift. Just like two periscopes, the image orientation would not rotate inside each arm while they pivot around a common central axis.

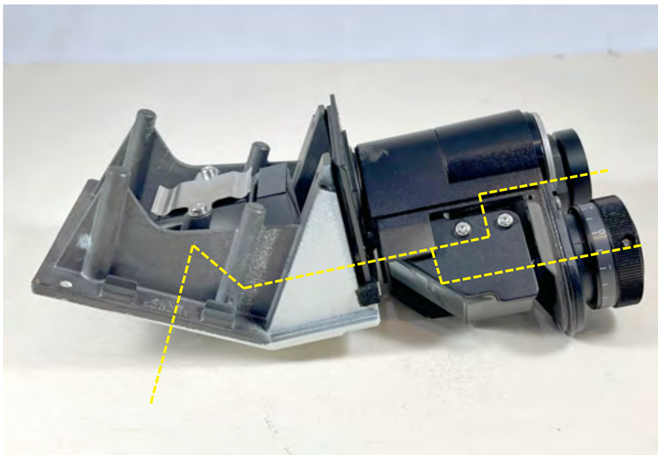
This design is particularly my favorite because of what I have seen in Jentsch-type designs that have two helical mech-

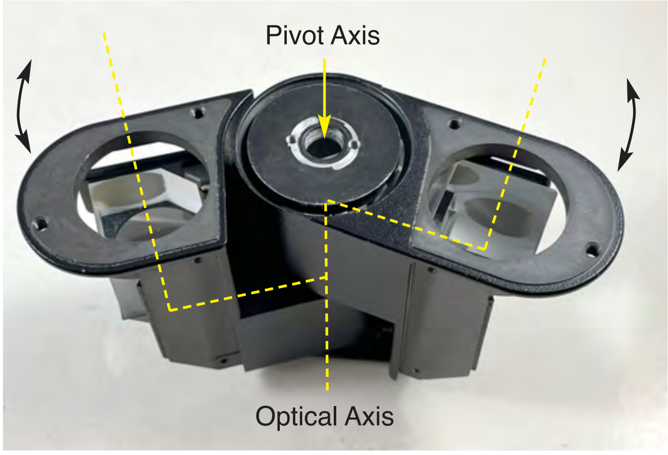

The inner light path of the binocular head



Interpupillary distance


Bottom view of the viewfinder


Side view of the binocular head showing the inclinded



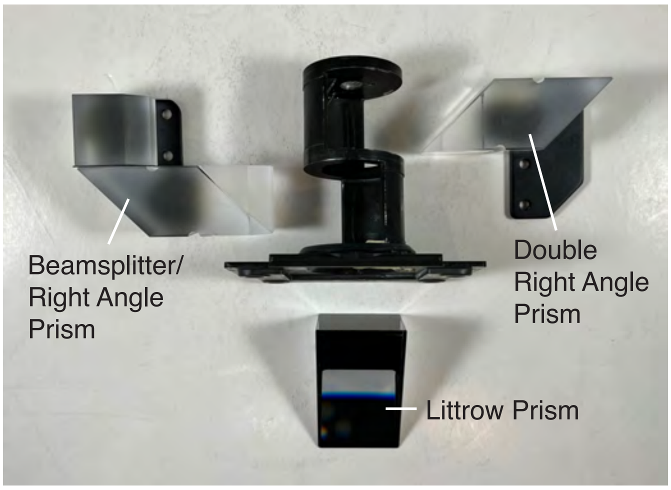
The pivot point to adjust the imterpupillary distance cuincides with the pivot point of the optical axis.

anisms to compensate for focus change in each eye by pushing in and out each eyepiece.

As it could be seen from the exploded view drawing (opposite page), there is a main support frame that secures both periscopic arms carrying each eyepiece. I emphasize so much on understanding this design because it is a perfect example of what is possible in finding a solution to an opto-mechanical task.

Note how each prism is attached to either of the swivel arm: Prisms are epoxied to a mounting plate that secures to each arm via two screws. This simplifies assembly, and alignment in a big way. The main support frame is the heart of this design, allowing two beams at two different levels to enter its central axis of geometry. Its design reminds me of the MC Escher's drawing of two hands drawing each other (front cover).

Top view of prism housing

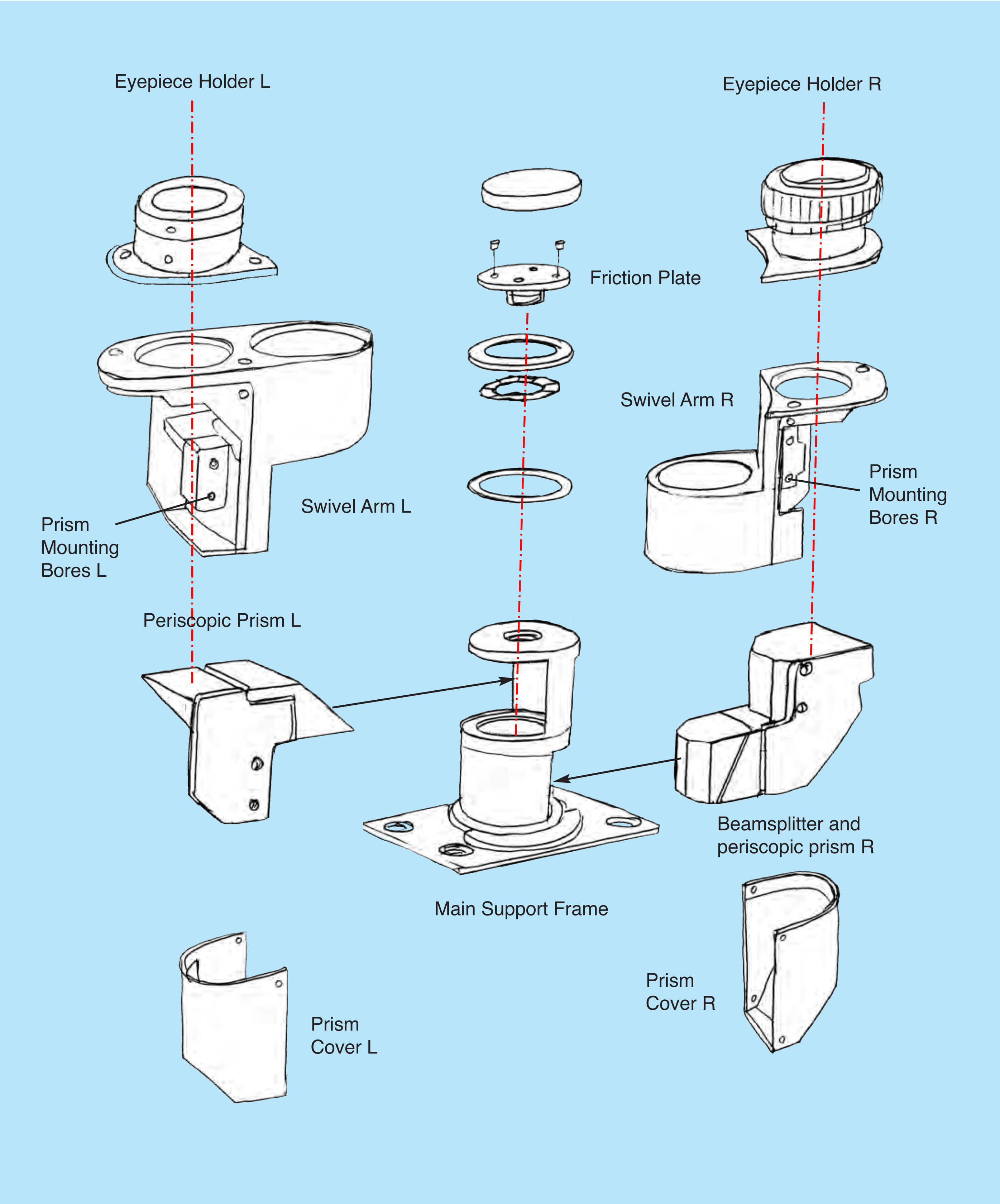


Prisms oriented to insert inside the main frame housing.

Prisms inserted inside the main support frame housing.

Prism housing shown with prism covers

Historically speaking, this design was very common in binocular heads made by Carl Zeiss since 50's but this is certainly a very simplified version of that design. The original Zeiss version was a much more integrated design, made of steel parts, and it was more expensive to build, and required more time to assemble. The Japanese version is much lighter weight, and much more modular. Well 50 years is a long time for improvement, and although Zeiss has displayed tremendous spirit for their innovations in opto-mechanical design, but if it was my choice, I would definitely go with this new scheme.



Exploaded view of Siedentopf binocular head revealing two periscopic prisms pivoting around a central support frame.

Let's take a different look at this assembly, and it's how you could come up with it: IN opto-mechanical design, knowledge of both fields is necessary to combine them together. The traditional design of binocular heads was to adjust the interpupillary distance in a linear fashion. My question is why no one ever looked at binoculars? Binoculars have had this design since before world war I. It would take a curious mind to take that design, and apply it to a different application.

In any case, new microscope designs come along at least once every year. The Etaluma microscope design was a mil-

Binocular head and its subassembly

Viewfinder disassembled to its parts

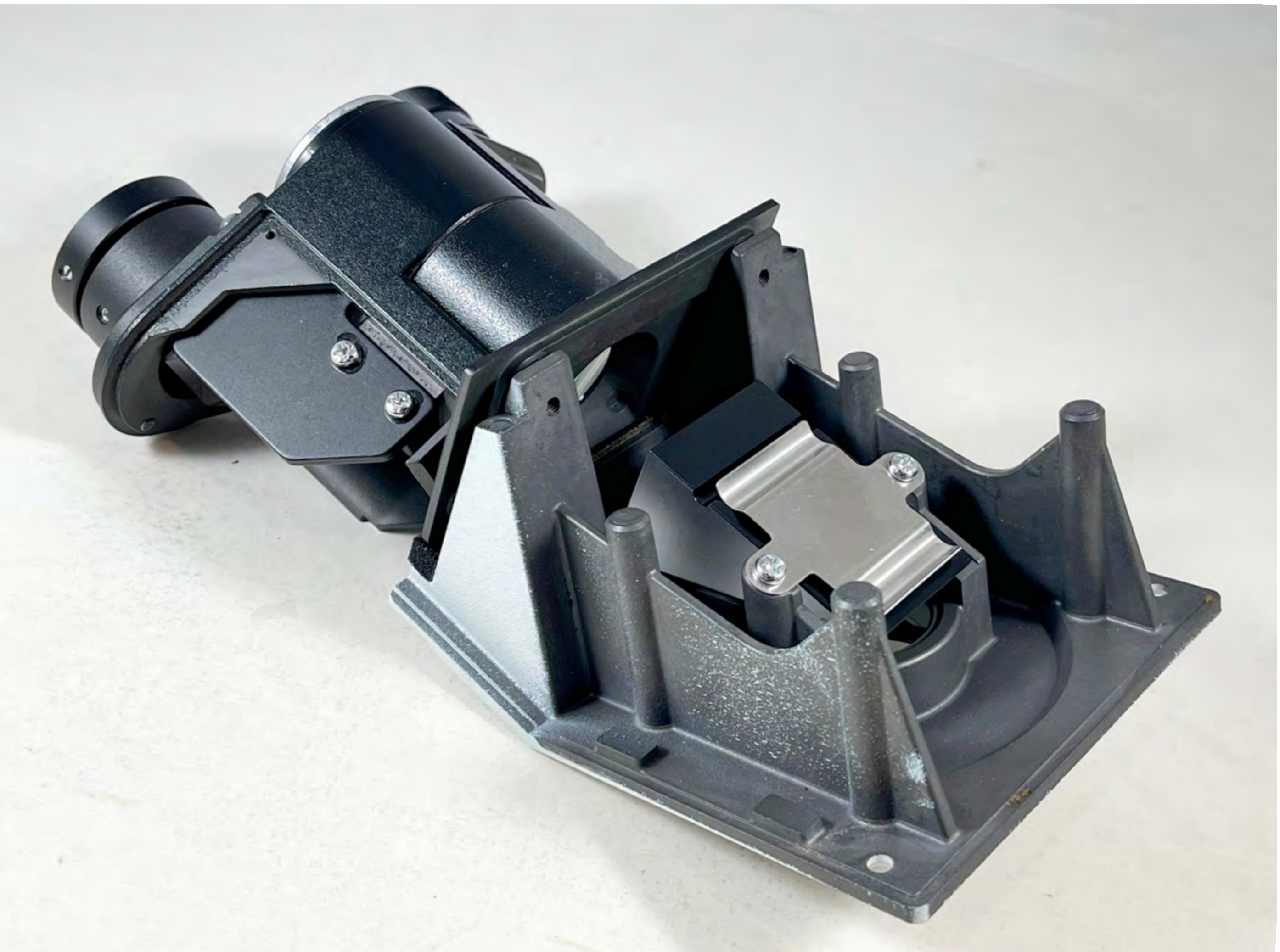
Binocular head with its screws removed

Binocular head revealing its support frame

Viewfinder disassembled to its two main parts lion-dollar project. No one thinks how much it would cost to develope something reliable, and economically wise to produce. I have seen the internals of that microscope, and every piece is as reliably designed as it could possibly be designed. If you think about it, optomechanical design is about paying attention to every detail, because when the time comes to producing a few thousands of them, you'd better be sure your design is far more reliable than a single prototype. It has to be easily assembled during production, and the parts have to be easily fabricated, and the tolerances have to be well specified otherwise the assembly line would halt while putting it together. The opto-mechanical design of this binocular head is so reliably done that I would give it my 10+ in a design contest.

Side view of binocular head's swivel arms.

Top view of prism assemblies with mounting screws.

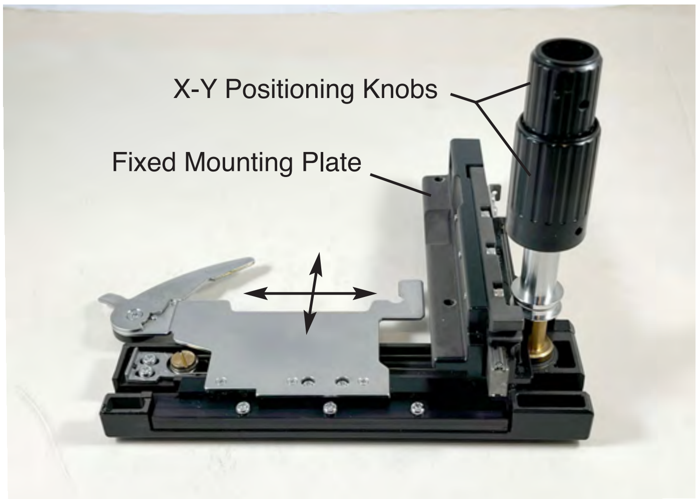


Binocular head assembly with its covers removed to reveal its compact/ low profile design. A trinocular head could easily be achieved by adding an extra glass on top of its Littrow prism to allow a percentage of the light to pass through for the imaging camera.

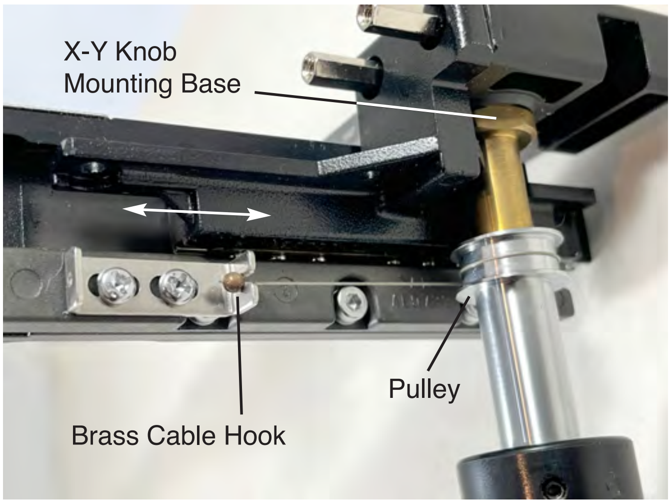
X-Y Stage for Smooth Sample Slide Positioning

The mechanical stage for this microscope has been simplified to bare minimum. Instead of geared carriage, this microscope uses steel strings to translate the sample. The result is a more compact, and less jamming mechanism than most traditional systems. Microscope stages would rarely jam but rack and pinion designs are kind of difficult to build, and align. Utilizing strings is much more simplistic, and much lower in cost. However, the string type stages could more likely be more difficult to assemble.

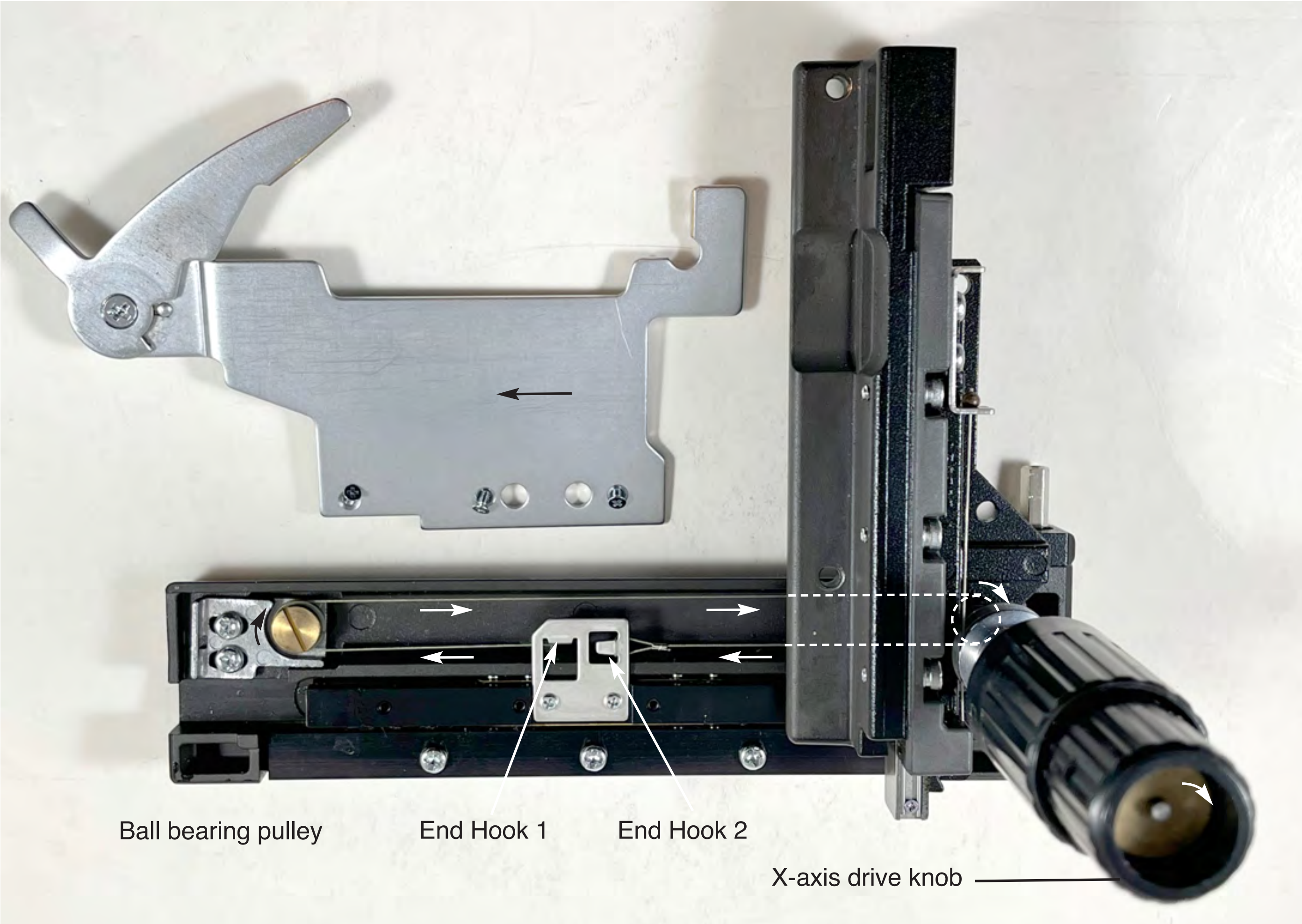
Opposite page, the compact design of this design is illustrated, and explained in detail.



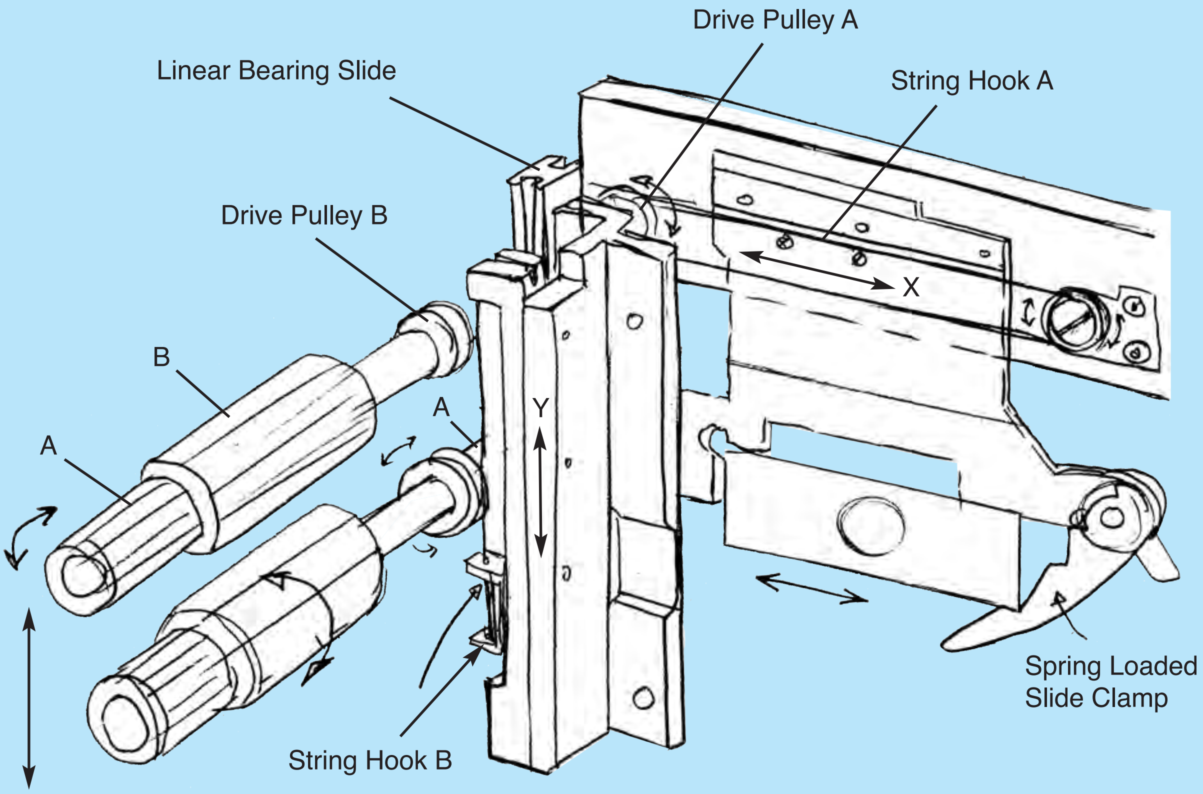
X-Y stage turned over to show its construction.

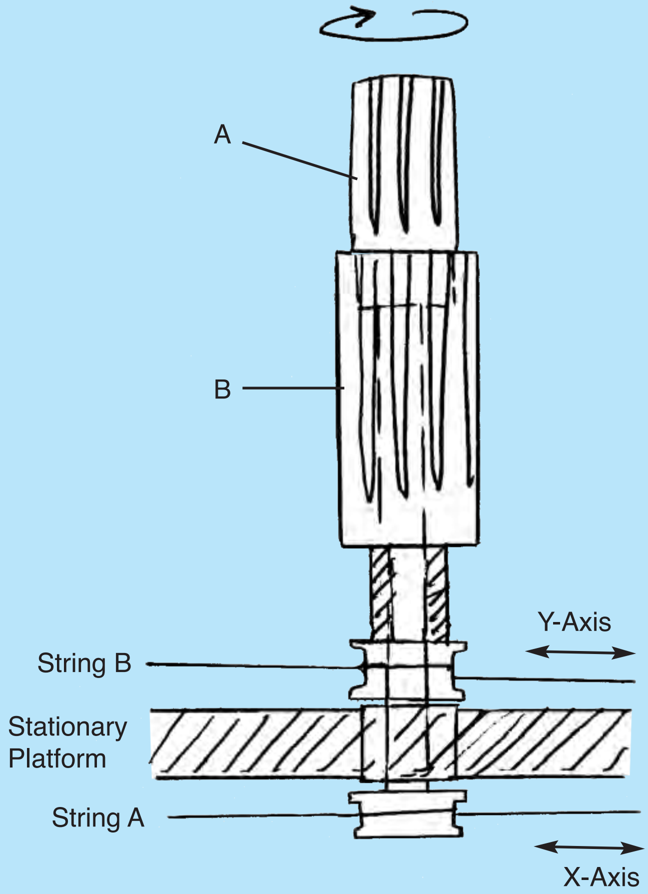


Close up of tring driven pulley, and steel cable.



X-axis string cable exposed to reveal its end hooks, and transfer of rotation X-axis pulley causing axis displacement.





How It Works

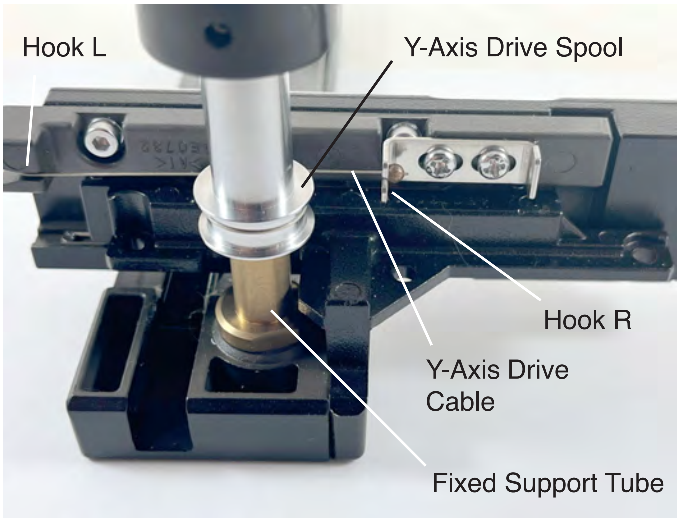
The X, and Y axis are driven by two concentric control knobs A, and B. The two ends of each string are secured to each end of the linear bearing slide for each axis. As the control knob rotates, the pully attached to its other end translates each string, therefore causing each axis to translate in X or Y direction.

In traditional rack and pinion design, the linear bearing slides are longer,a nd they protredue out from the side of the platform. Rackless design such as this, eliminates rack protrusion.

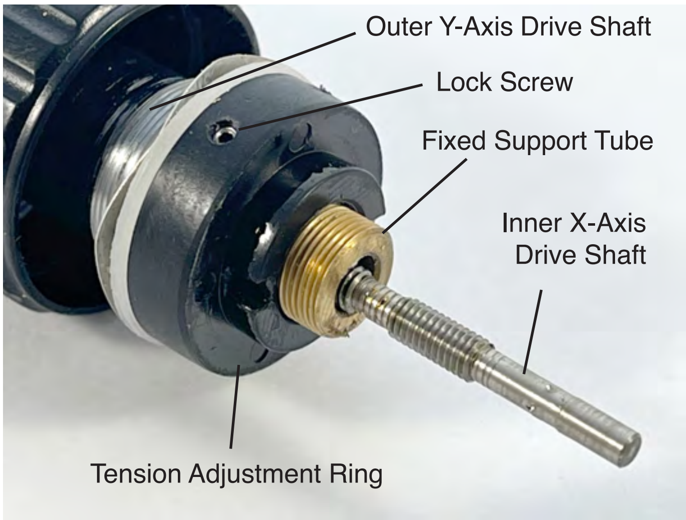
This design provides smooth stage translation, and if motorized, it would simply slip at the end of its travle.

Viewfinder disassembled to its two main parts

I can't use animation here so I'll use as many views as possible to explain how this mechanism works. There is a fixed central support tube securing the coaxial focus knobs perpendicular to the X-Y stage frame. There are two spools that control the X-Y motion on this stage. Both the control knobs for X, and Y axis are well balanced in their friction, and sensitivity. This is not out of pure luck. It is well executed with precision made components, and ball bearings. There are also non-rotating washers that completely isolate the two controls so the rotation of one control knob would not cause any positional change on the other axis whatsoever.

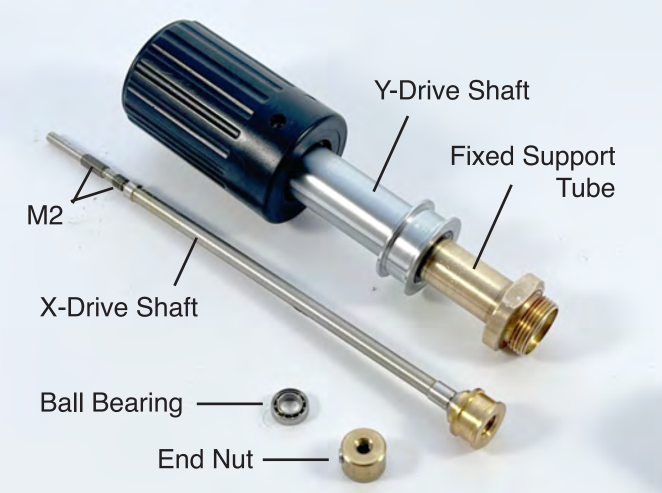


Close-up anatomy of the X-Y assembly

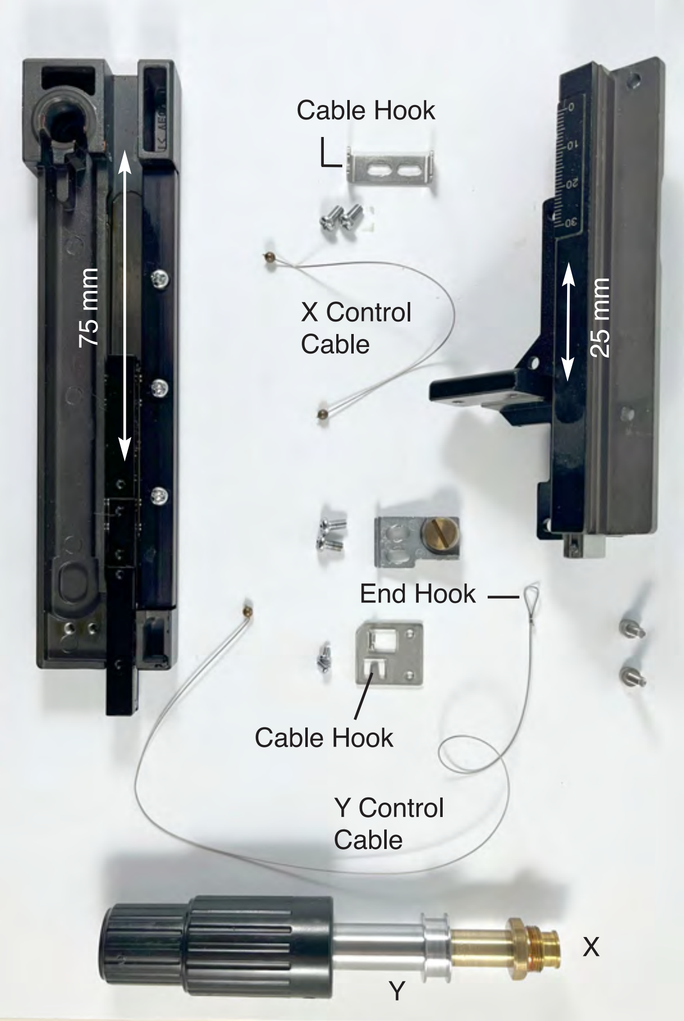


Starting disassembly by removing the X-axis control knob.

Taking apart the X-Y control knobs assembly.

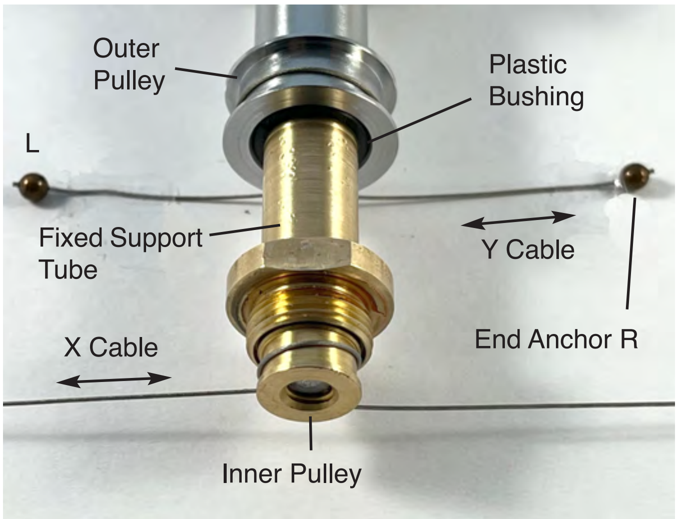


Detail of coaxial control knobs reveals small ball bearing.

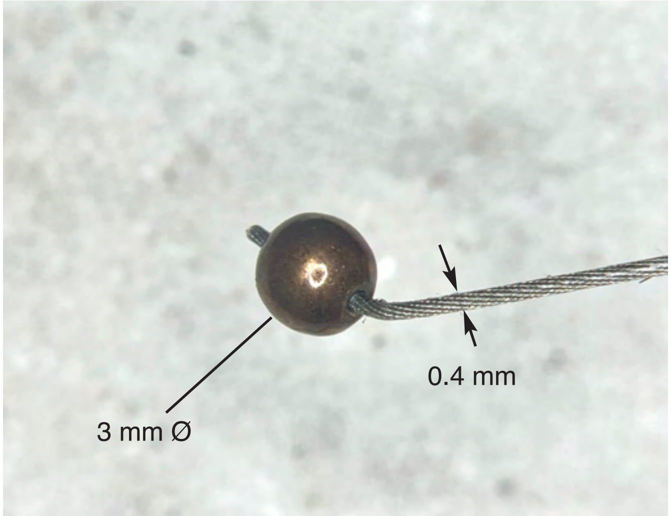


Components of the X-Y table, and coaxial control knobs.

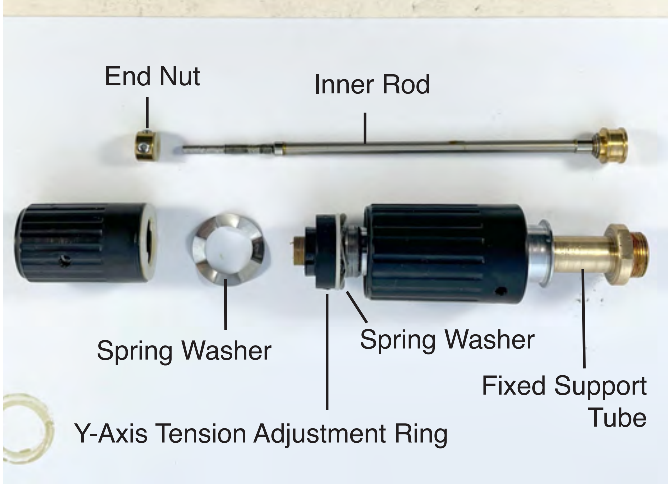
The friction for each axis drive knob could be precisely adjusted by spring washers, and lock nuts that are secured in position via set screws. The X-Y stage is so designed that each knob is being secured to its inner shaft by threaded couplings in addition to utilizing set screws. This not only prevents the knobs from slippage, it would also secure the knobs in precise alignment to their true center. You can't achieve a reliable design by just set screws. The expression Dieter Ram uses for one of his design principles: “A good design is honest.” The choice of materials for this design is also very good because back in the Wild era (1960's) you could only get precise feeling by using polished metals with proper grease.



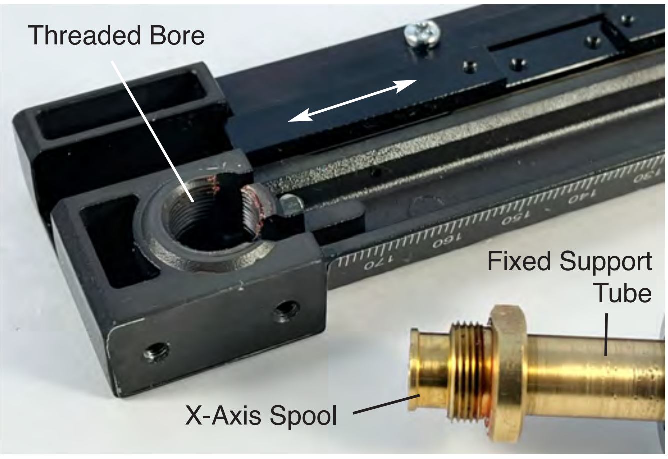
Dual spools and cabling for X and Y axis control.



Brass ball pressed anchors at ends of thin steel cables.



Binocular head with its screws removed

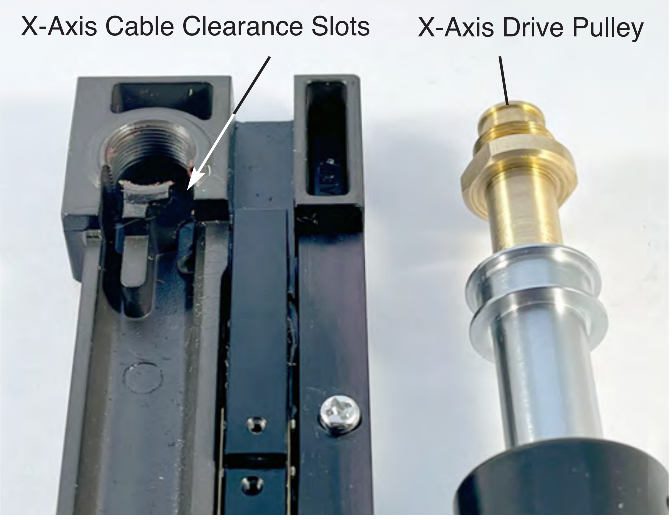


Interrupted threaded bore to secure coaxilal focus column allows passage of X-axis drive cable.

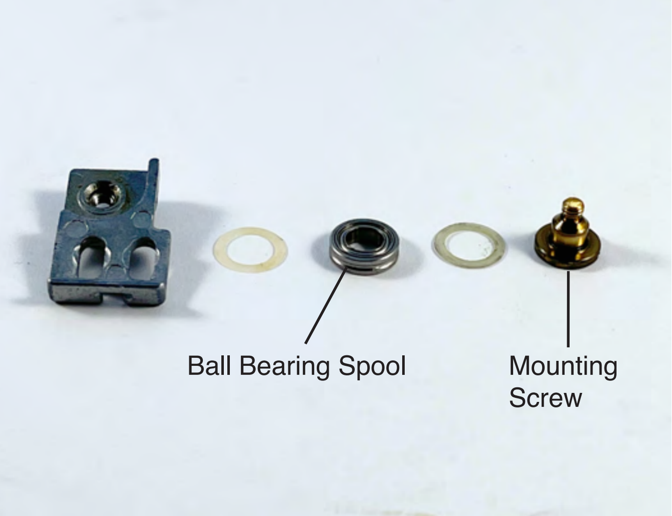
Details of drive shafts for X, and Y axis reveal two sets of threads: One, for securing the plastic knobs; Two, for adjusting their tension (friction) via spring washers.

The coaxial focusing knob mounts on the X axis, and the X-axis drive pully sits deep inside it. For cable clearance, there are two slots cut out to allow the cable to run through (below, left). The return pulley is a specially made ball bearing secured by a large mounting screw (right).

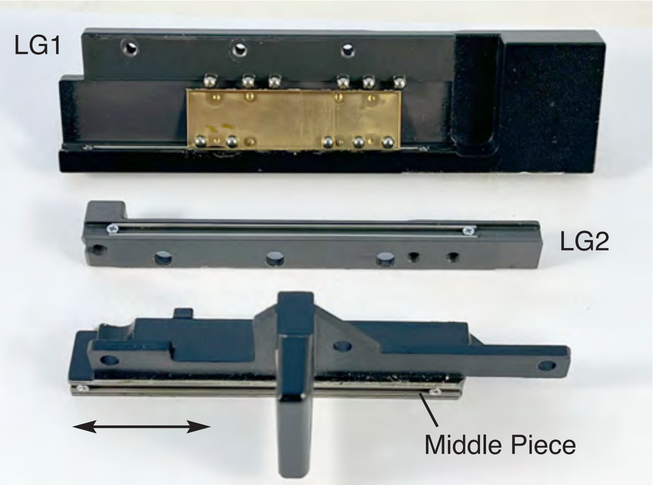
The linear bearings side of the stage is well built with precision rods, and nice Aluminum casting. The design is modular, and easy to disassemble, and put together. Overall, this stage runs smoothly, and it has a nice feel to it like most mechanically driven microscope stages.



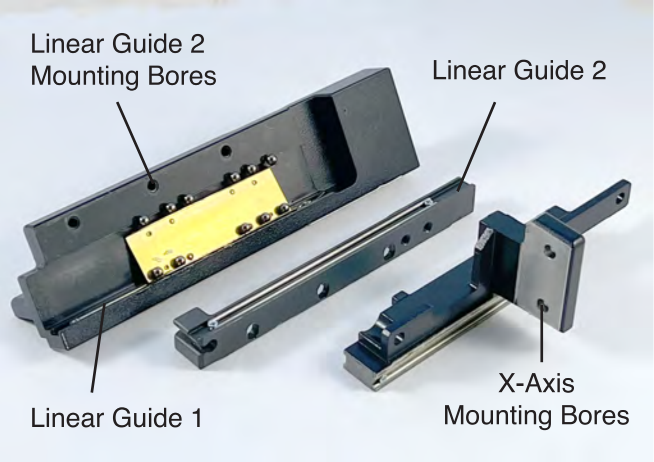
Binocular head and its subassembly



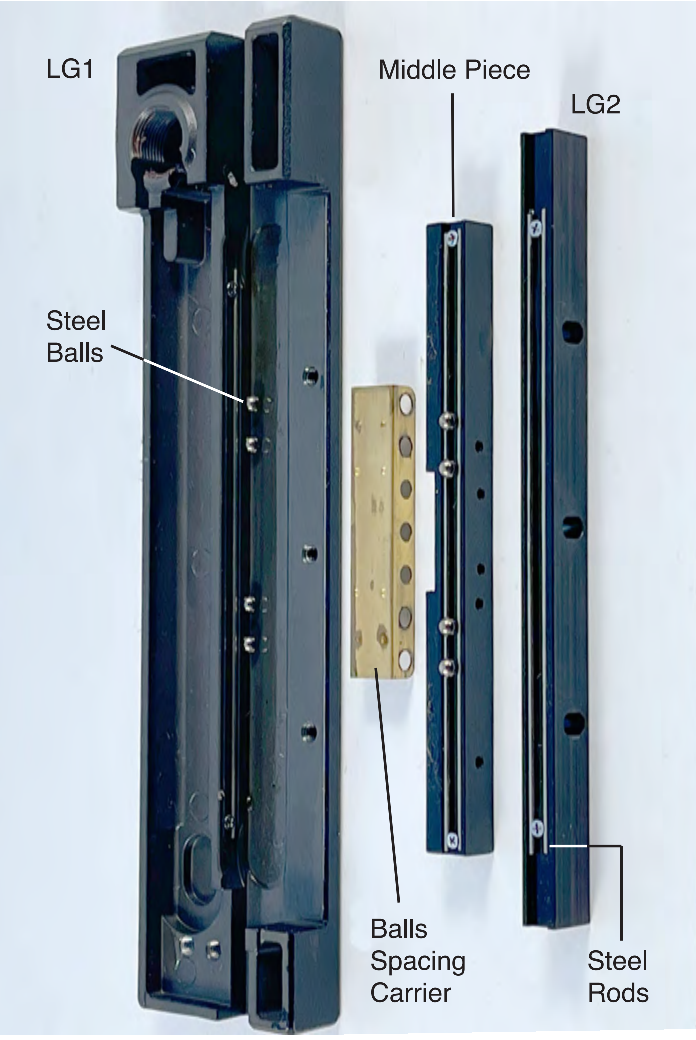
X-axis counter spool for tensioning the cable.



Y-axis linear bearing components



Side view of Y-axis linear bearing components

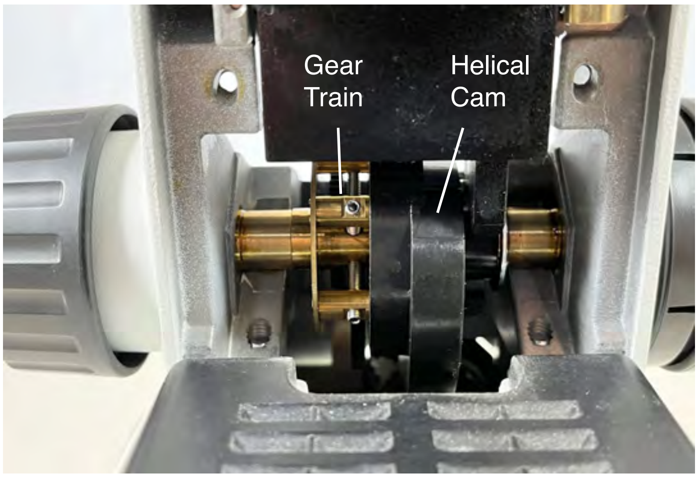


X-axis linear bearing components

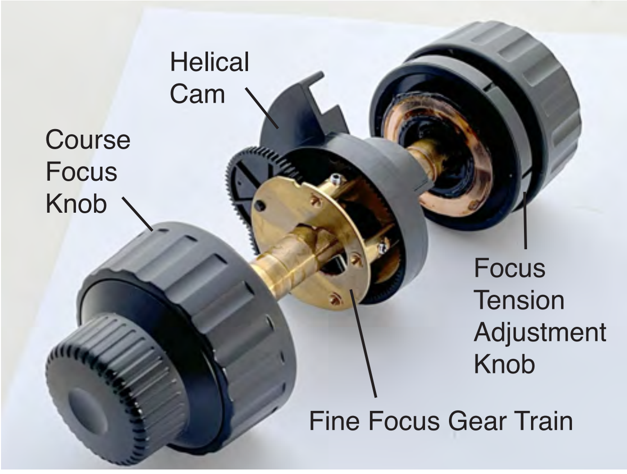
The Focusing Mechanism

Last time I discussed microscope design was back in April 2019 issue of Optomex, which I covered Leitz Diavert microscope. Well, that was Leitz design, with their one-track mind for quality. The Japanese design (which are mostly Chinese-built), we should expect something different: More plastics, more modular design, and cheaper to manufacture.

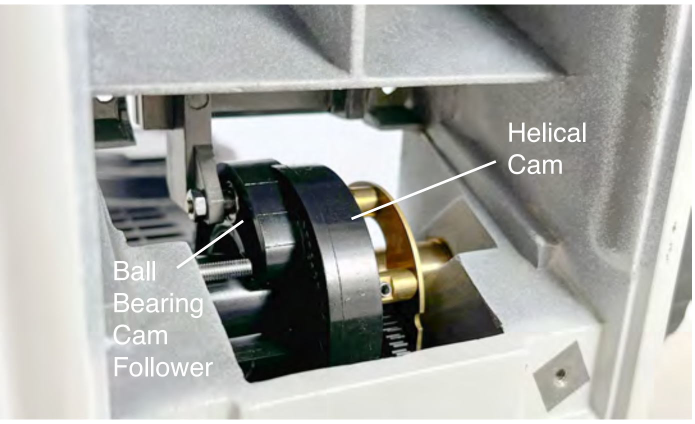
The basic idea is shown on opposite page: The course focusing knob rotates a large cam 5 to raise, and lower the focusing rail 7. The course focusing knob is not directly linked to the focusing cam 5. It is rather linked via a fine focusing gear train (1 through 3) that rotates cam 5 through an internal gear 4. Therefore, by rotating the fine focus knob, cam 5 rotates at a very slow rate, but rotating the course focusing knob will directly rotate the focusing cam, by bypassing that gear train. A side view of this mechanism is shown on the next page. This is not as easy as it looks. The inner gear



Front view of focusing cam and fine focus gear train



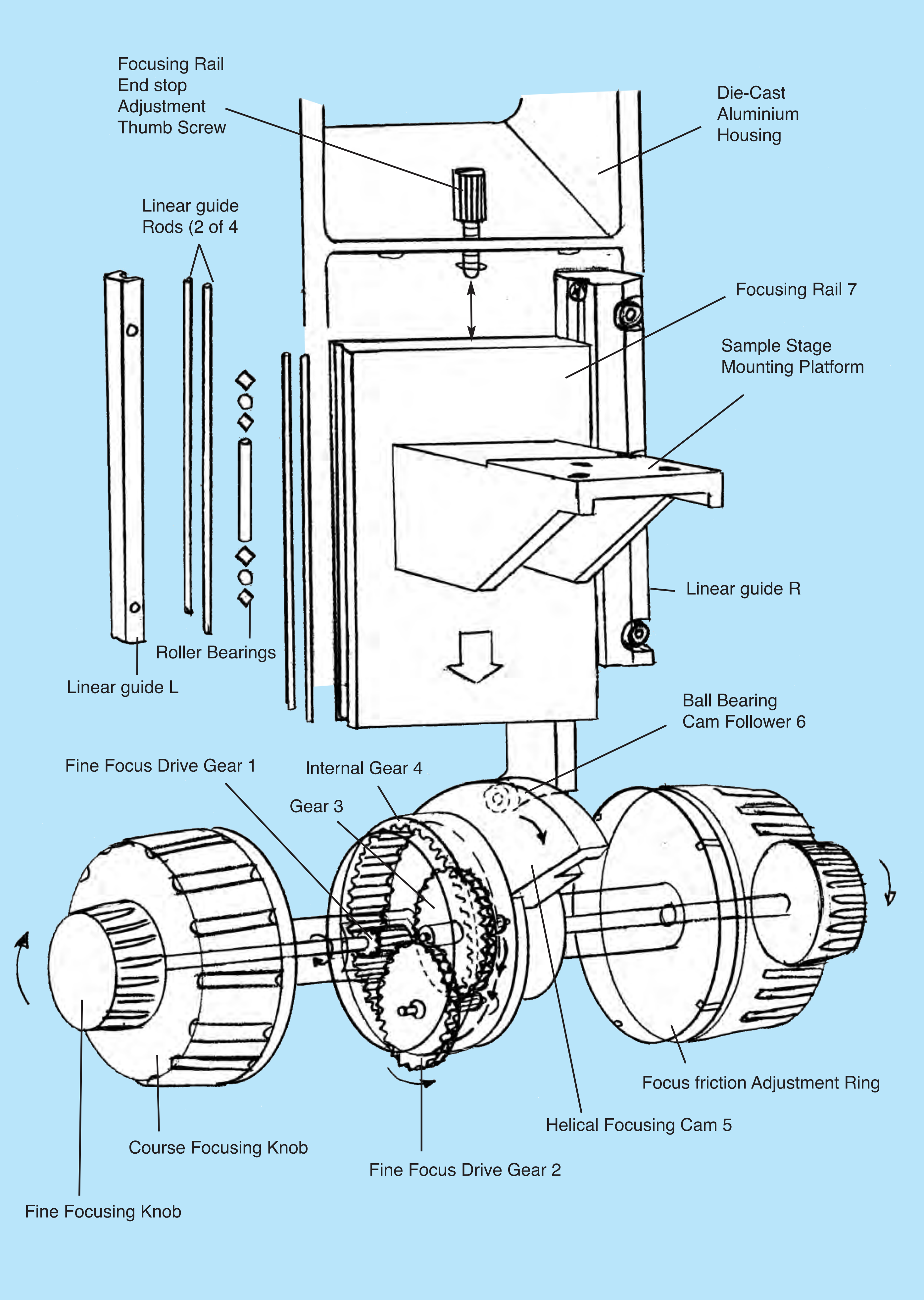
Here's the focus gear removed to reveal its components.



Rear view of Focusing mechanism driven by helical cam.

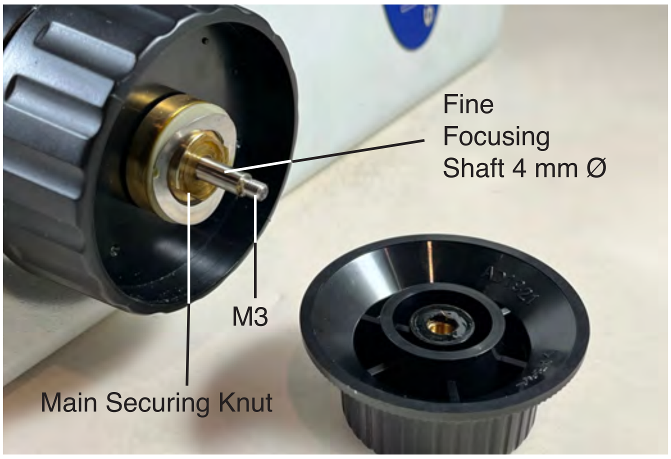
Course focusing knob rotating the helical cam.

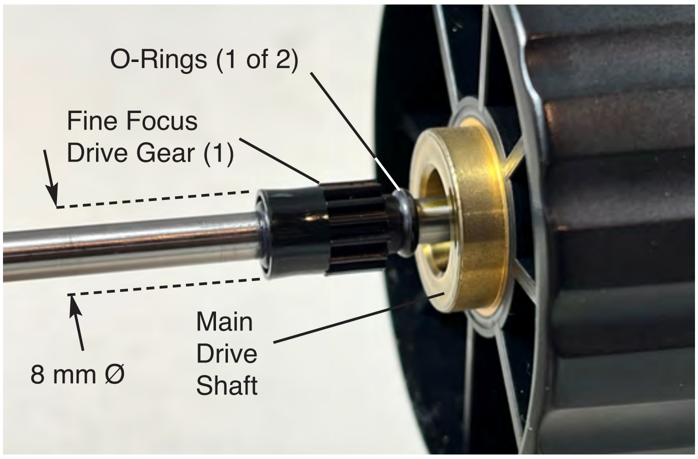
Front view of microscope with sample stage removed.


Focusing Rail
End stop
Adjustment
Thumb Screw
Die-Cast
Aluminium
Housing
Linear guide
Rods (2 of 4
Focusing Rail 7
Sample Stage
Mounting Platform
Linear guide R
Roller Bearings
Linear guide L
Ball Bearing
Cam Follower 6
Fine Focus Drive Gear 1
Internal Gear 4
Gear 3
Focus friction Adjustment Ring
Helical Focusing Cam 5
Course Focusing Knob
Fine Focus Drive Gear 2
Fine Focusing Knob

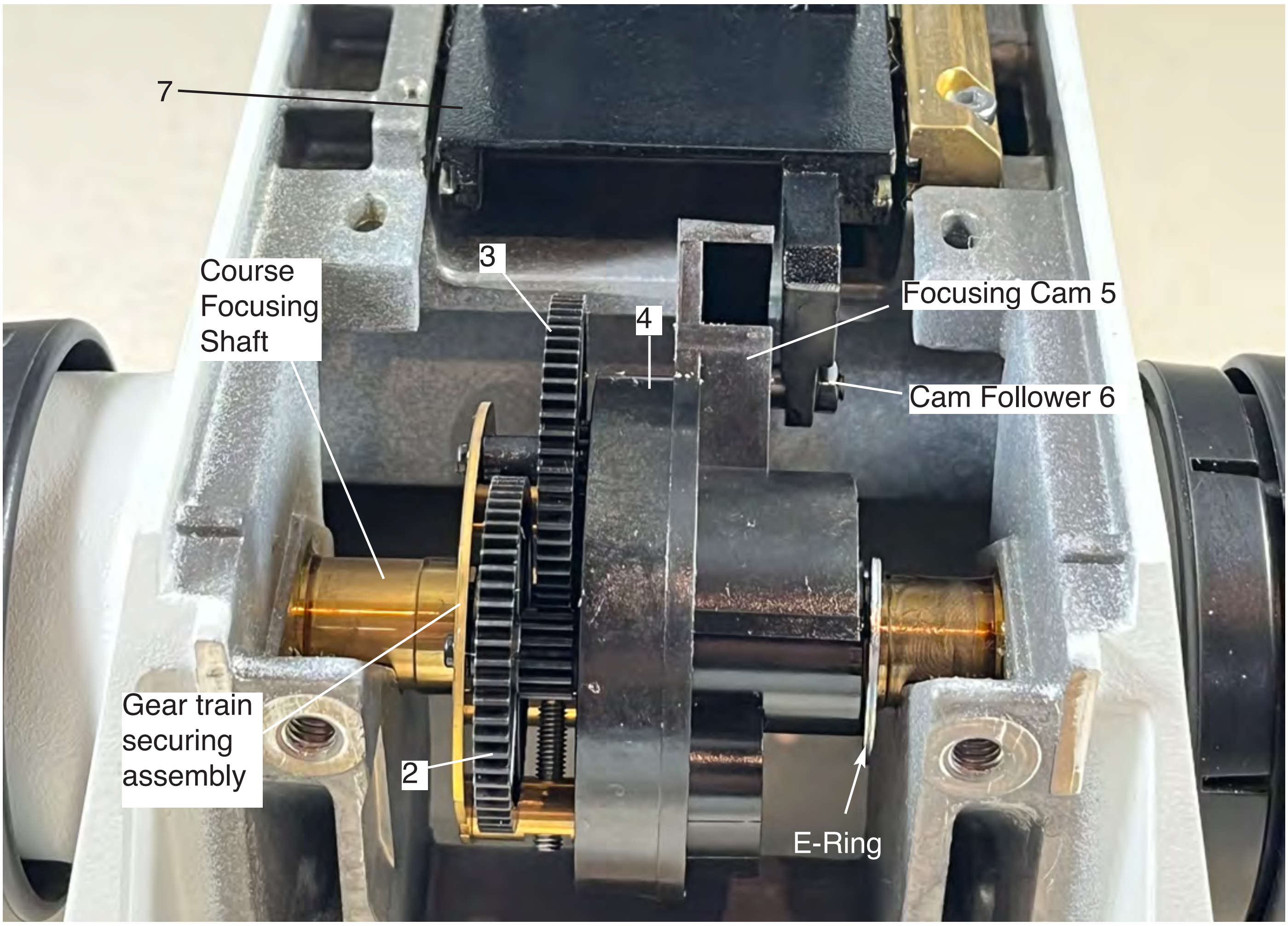
cam, by bypassing the gear train. A side view of this mechanism is shown in opposite page. This is not as easy as it sounds though. The inner gear resides inside the course focusing shaft, so the large shaft has to be cut on its middle side so gear 2 could engage with it to drive the 2nd gear, etc. The gear train assembly is mounted on the course focusing (shown on opposite pgae, below) while the large focusing helical is not.

So another way to understand this design is to large imagine if glue is poured over the gear train, the course focusing mechanism would still work. The focusing cam is actually linked to the main shaft through the gear train. If there were no friction at all between the focusing knobs, and the gears, rotating the course focusing knob would cause the fine focusing knob to spin may be 50 times as fast. But because there is friction, each knob could do its job independently from the other. This is a very smart design because there is a continuous engagement betwenn the two knobs, and basically, the fine focusing mechanism could be operated for the entire 20 mm travel range without stopping.

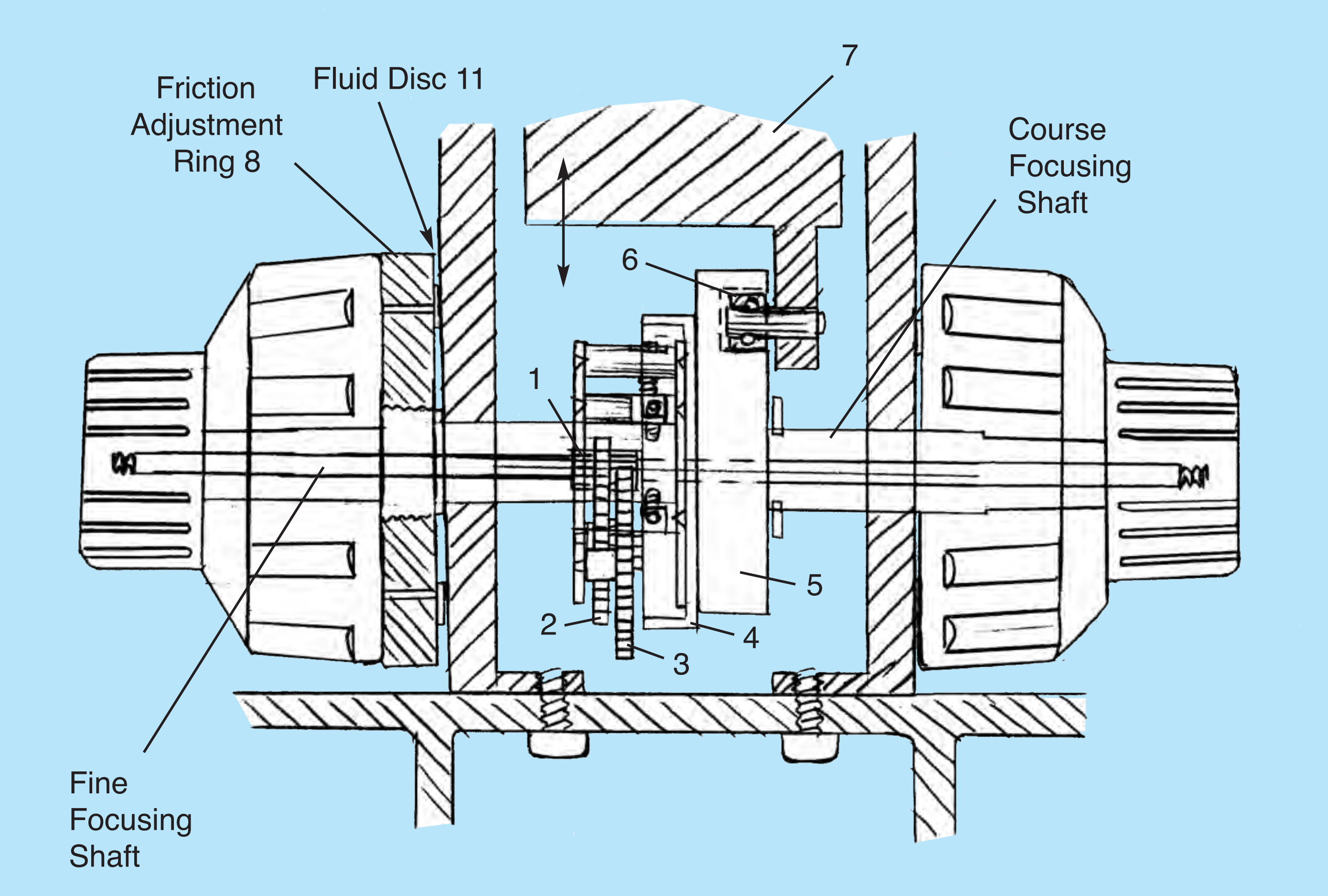




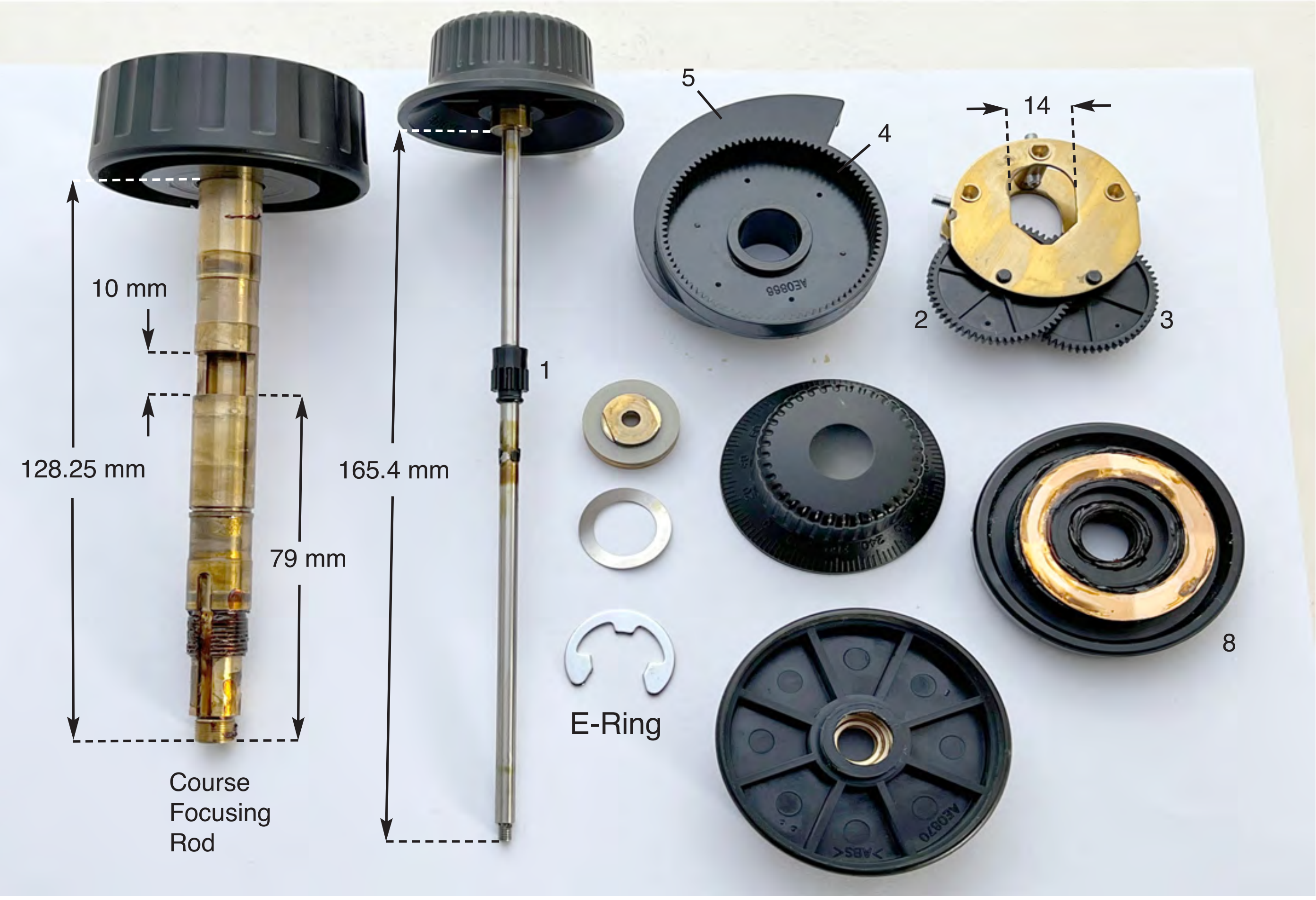
Pulling out the fine focusing gear 1 from the other end: Surprisingly, it is not hard mounted, rather held by two O-rings. As you'll see later, the fine focus mechanism runs so smoothly that a small gear like this one could easily drive it.

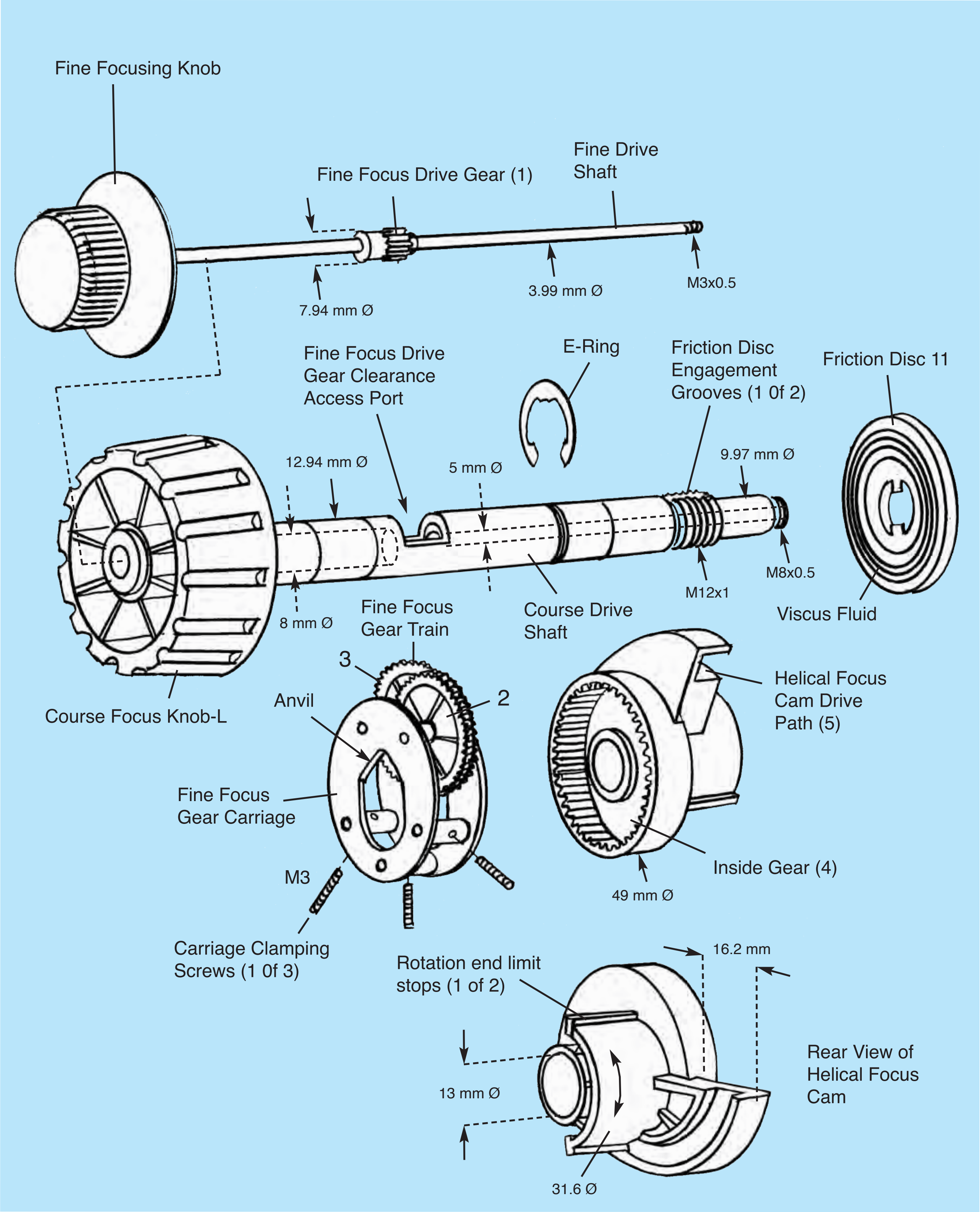


Opposite page, drilling the 79 mm deep, 5 mm bore at the center of focusing rod would probably make this part one of the most challenging parts of the microscope to make.



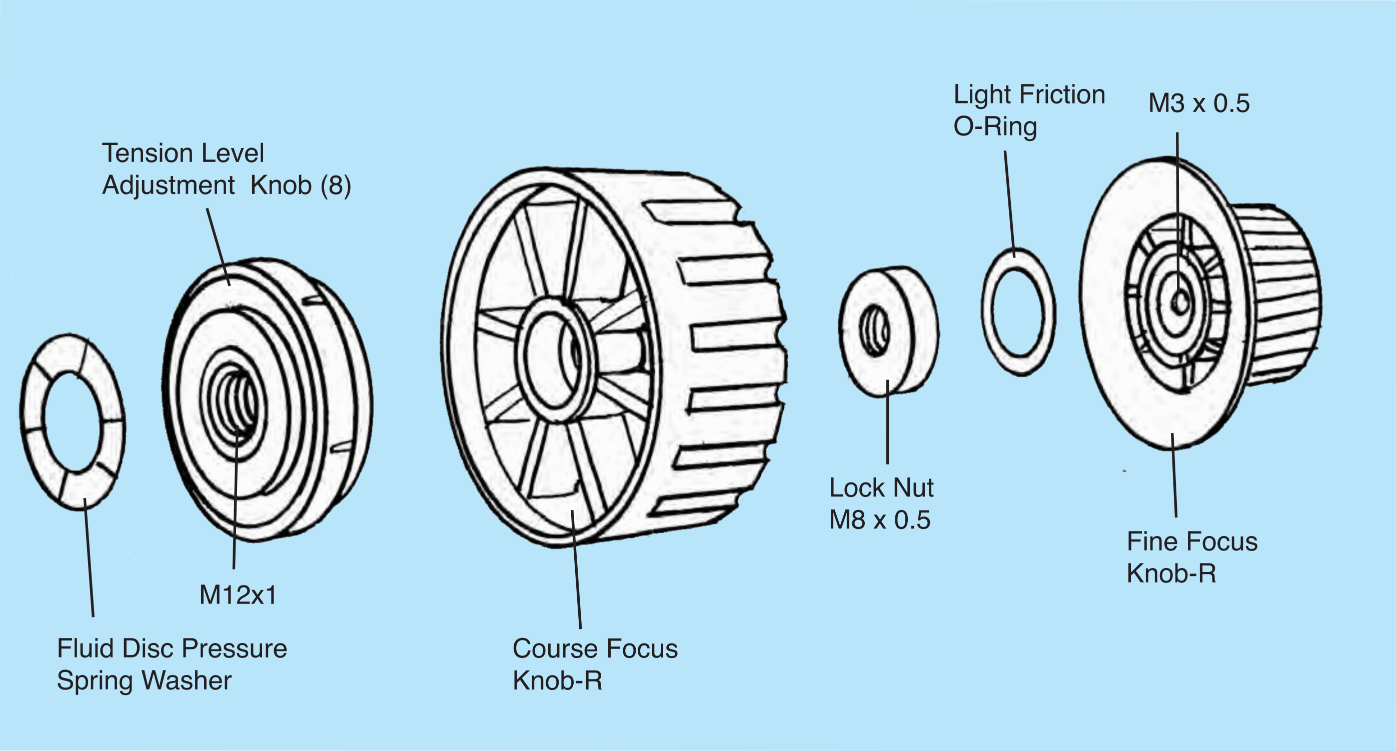
Side view of the focusing mechanism: While fine focusing ring rotates the focusing cam 5 through a reduction gear train, its entire assembly rides on the course focusing mechanism. This gives the course focusing knob to do an override. This mechanism works only because it is backed by a finely tuned friction plate (8) similar to fluid heads on tripods.



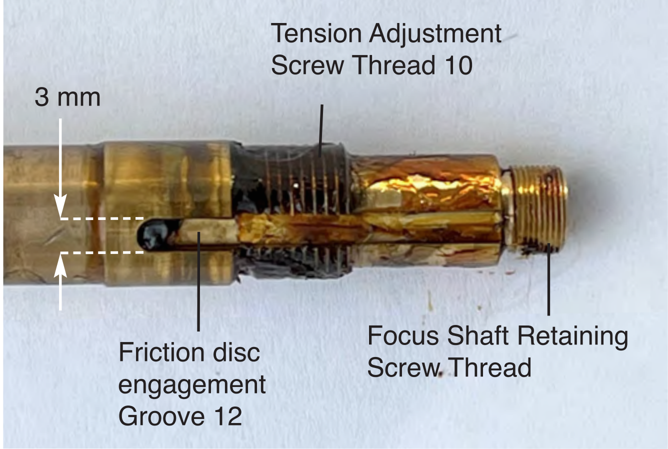


An exploded view of the drive mechanism shows how this design is actually implemented. The entire mechanism is held together is by a central drive shaft which is held from both ends by two large L and R knobs. The inner bore that allows the smaller, fine focus shaft to go through, is 4 mm on one half while 8 mm on the other half (see above). This provides proper resting point for fine focus drive gear (1) to drive gears 2, and 3, and finally the inside gear 4.

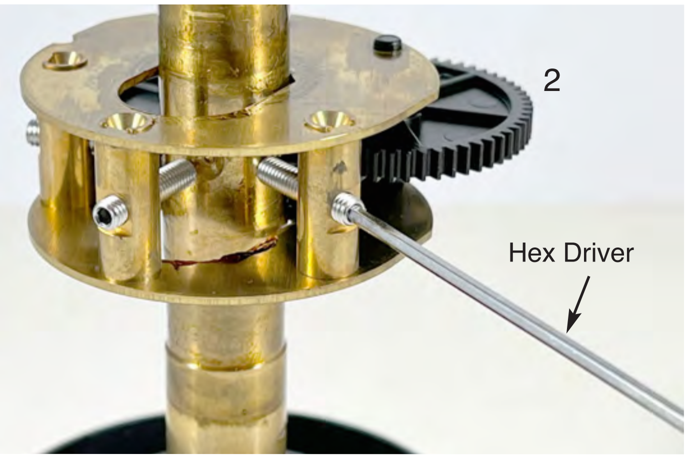
For designers, this mechanism needs to have a positive stop on both ends, and this is provided by two end limit stops that are part of the injection molding design of the cam wheel drive 5 (above).



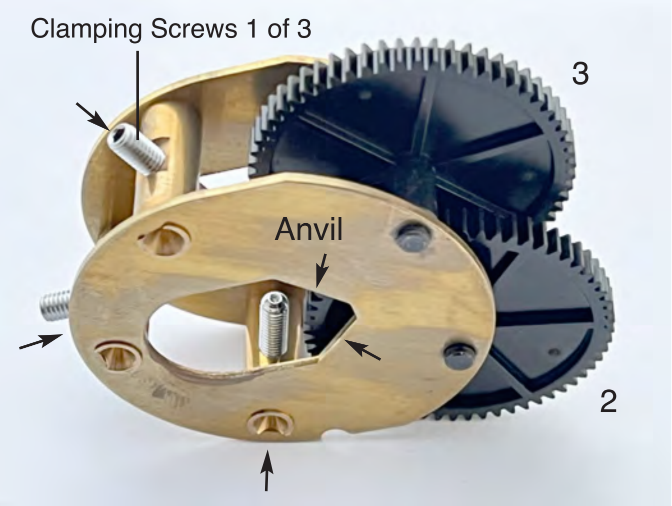
Tension adjustment knob 8 (above), rides on screw thread 10 below, pushing friction disc 11 against the microscope chassis. Groove 12 keeps the friction disc engaged with the main drive shaft for smooth/adjustable friction control.



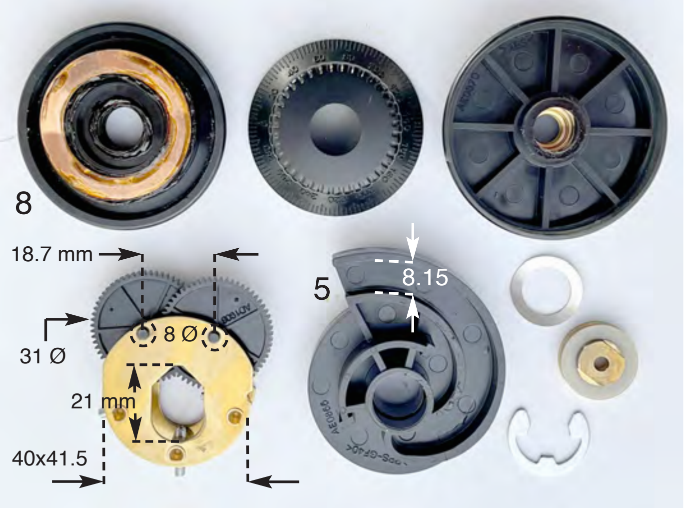
End view of course focus drive shaft



Securing the carriage assembly on focus drive shaft.



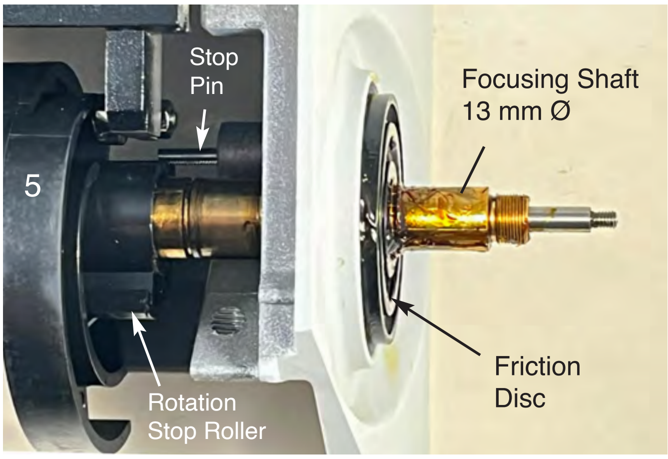
Fine focus gear-train and support Carriage. Three clamping screws secure the carriage to focus drive shaft.

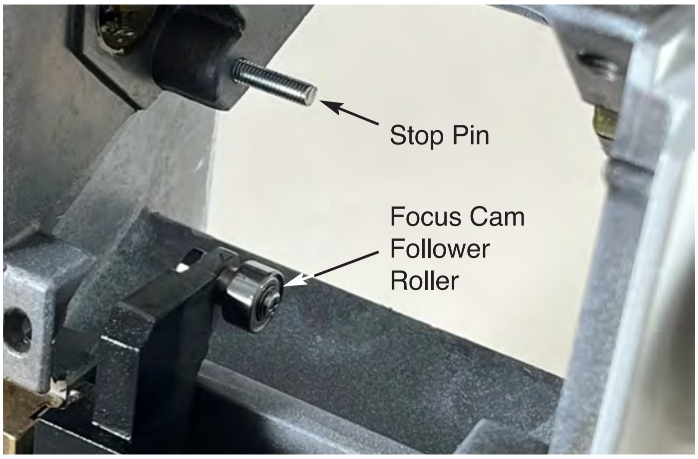


Mechanical dimensions that are useful for designers.

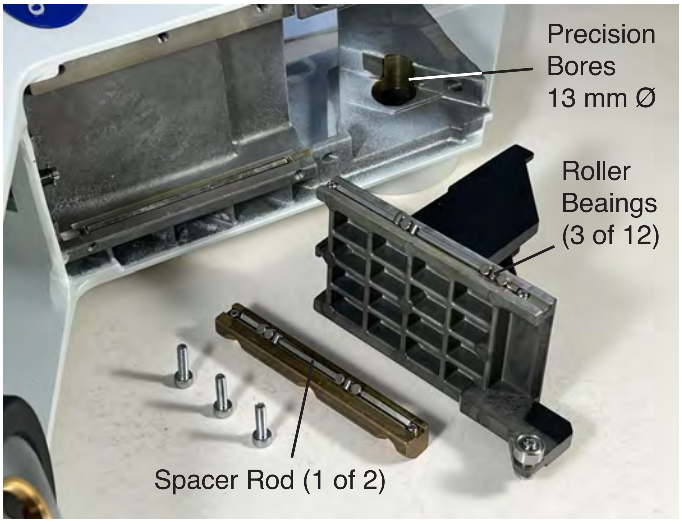
Something has to be also said about the end stop of the focusing cam, and the friction disc providing constant friction for the focus knob. There are two precision reamed bores on the chassis to accept the focusing shaft (below, left). There is viscus fluid in between the friction pad, and the chassis that provides smooth, uniform friction that is adjustable by a ring just behind the course focus knob. The tolerance between the focusing shaft, and the precision bores are 0.6 mm, and this gap is filled with thick grease. Chinese microscopes have had problems with the type of grease they use for decades. The grease utilized in these microscopes are the type utilized in many other precision Japanese instruments.

The roller bearings are divided to two sets of 3 rollers separated by spacer rods on each side of the focusing rail. This is a clever way to reduce the number of rollers. These rods are not tightly fitted, and are only utilized as spacers.

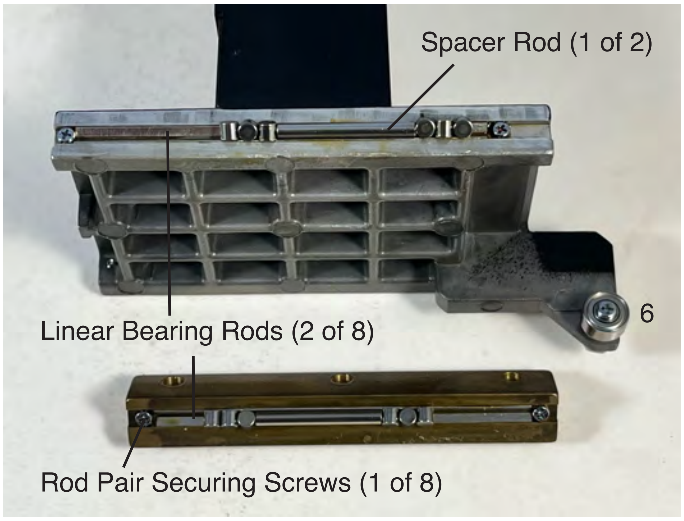




Detail of the stop pin mounted on the main chassis to limit the rotation of focus cam (5). Also shown is the friction disc that is sandwiched between course focus knob, and microscope chassis.



The roller bearings arrangement in focus mechanism.

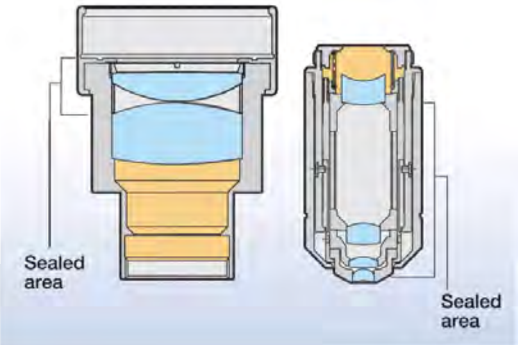


Close up of the roller bearings arrangement.

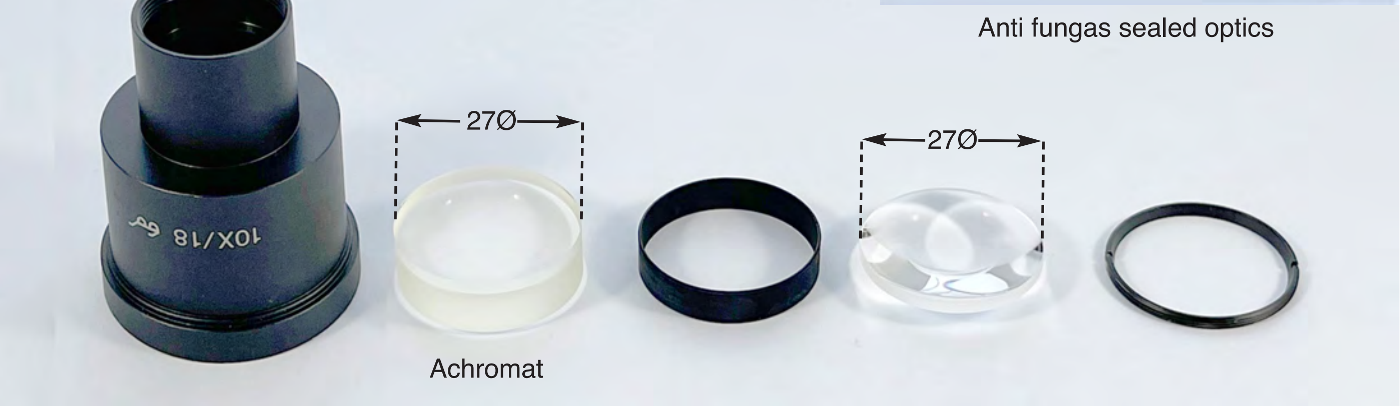
Length of each objective in millimeters, and the length of RMS thread for their mounting on the nosepiece turret.

Imaging Optics

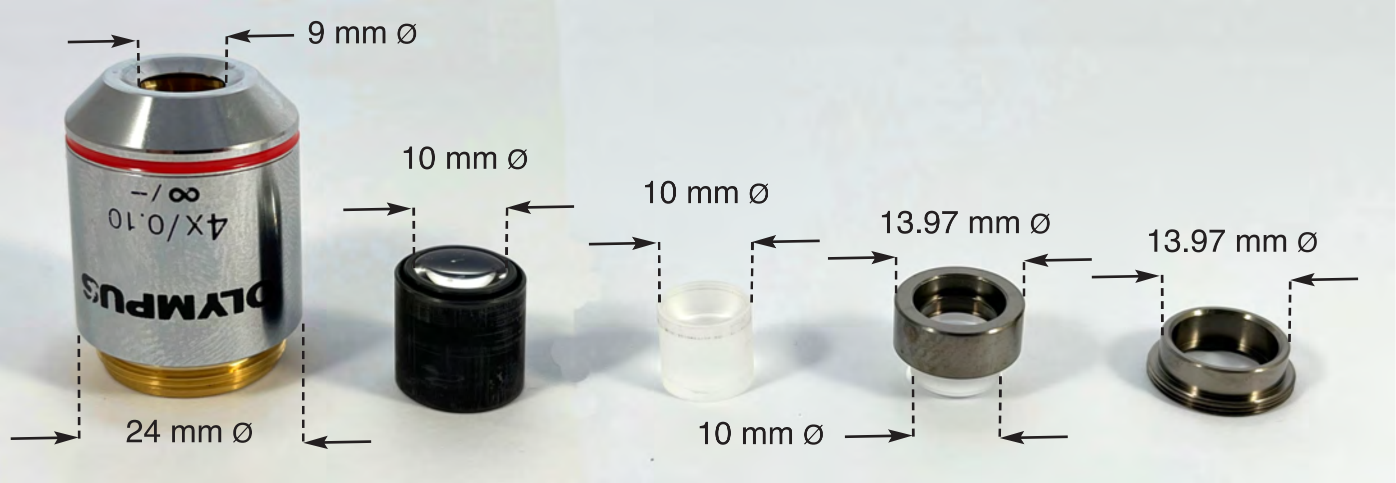
I will disassemble the eyepiece, and at least one objective to show you what's inside them. As it could be seen from the actual dimensions, the tolerance of the optics inside lens cells are around 0.3 mm inside the objectives. I am using this wording to make it sound less technical. Tolerance would actually be as small as +/- 0.1 for each piece. The smaller the element, the tighter it could be fitted inside each other.



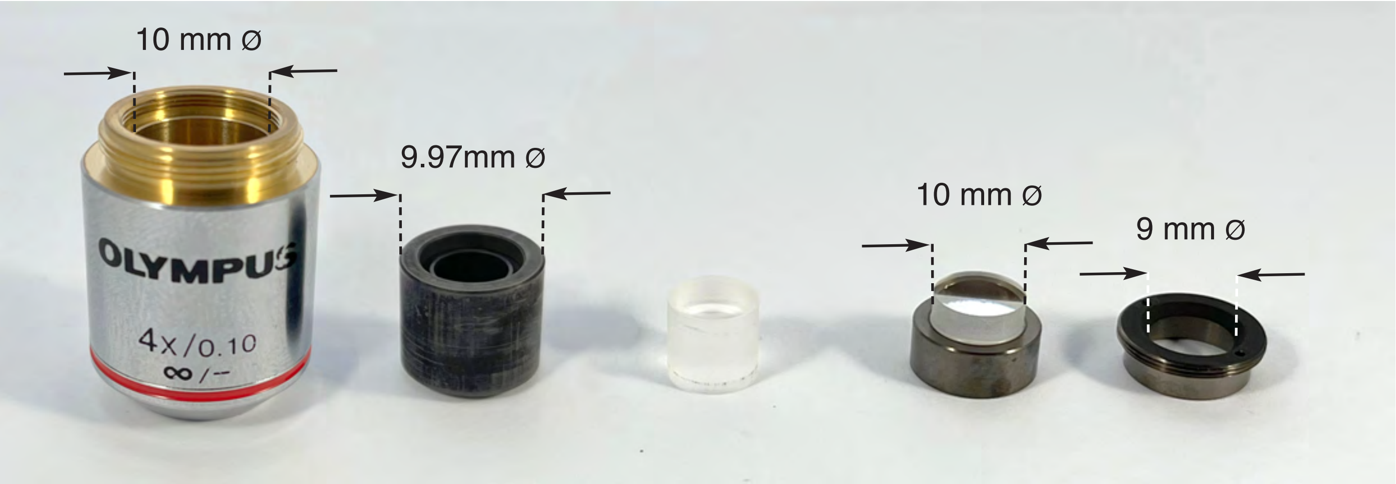
Anti fungas sealed optics



Olympus has been making this eyepiece for many years, and it has its typical fat body using three elements in 2 groups.

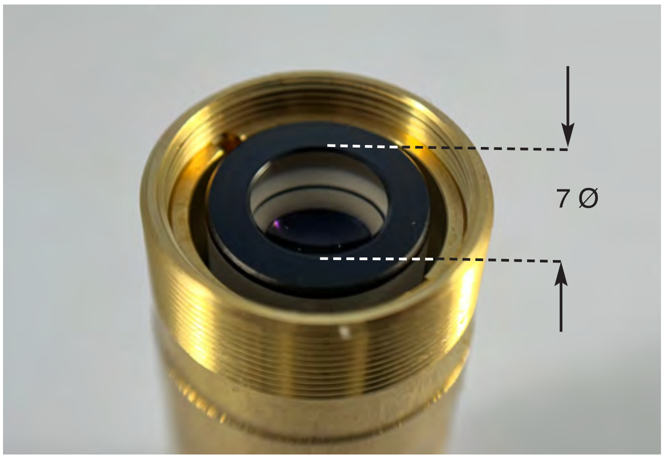


A close look at the 5X objective. It consists of three lenses, and 4-piece housing and spacers.



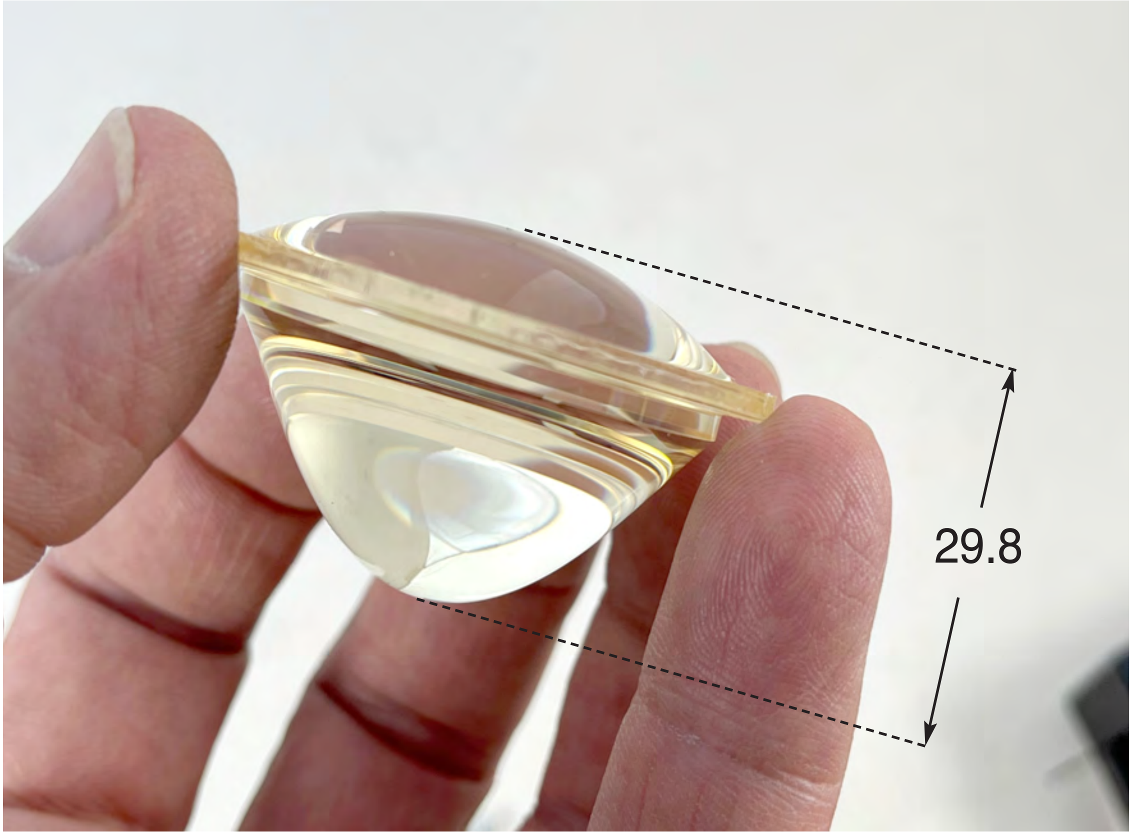
Back view of the elements inside the 5x objective reveals the tight tolerance fitting of the elements inside the barrel.

40X objective disassembled to show spring loaded obj.



Back end of spring loaded 40X objective barrel.

Two critical dimensions of 40X lens barrel are 17 Ø mm sections that slide inside the lens casing.

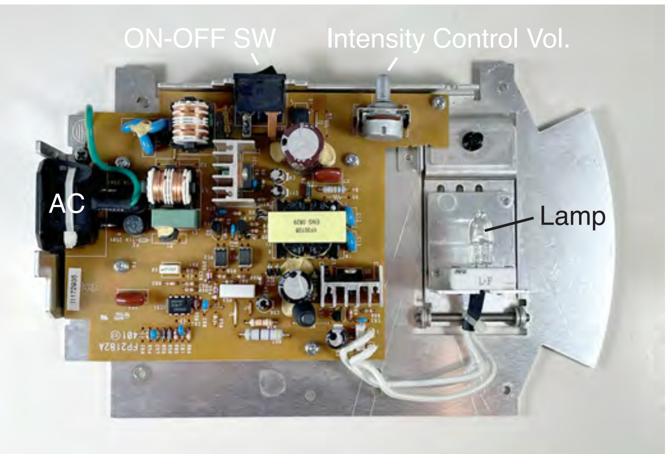


The condenser is made of flexible gelatin type material, yellowish in color. This lens is 42 mm in diameter, with an outer 49.5 x 2 mm mounting surface. The lens sits above a KG-1 filter, with a protective clear glass on top.

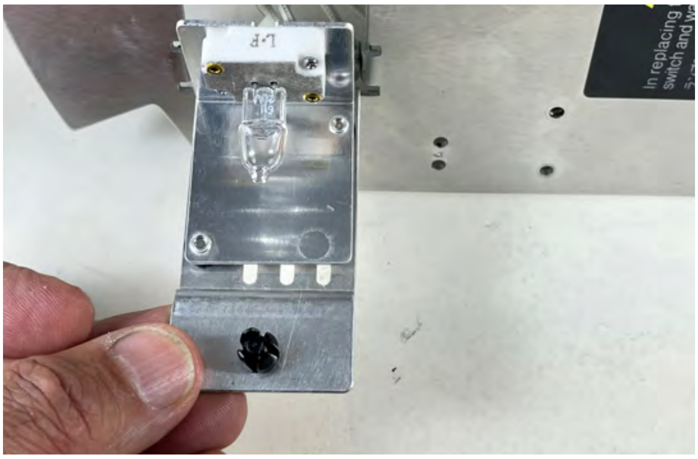
Power Supply, and Illumination Optics

Modern microscopes utilize switching power supplies that are compatible to foreign voltage outlets. I have had an earlier model Olympus burned by one of my students by plugging it into a 220v AC outlet. The funny thig is he called me before plugging it in, and I said it's for 110V but he still plugged it in, thinking it would work for a while!

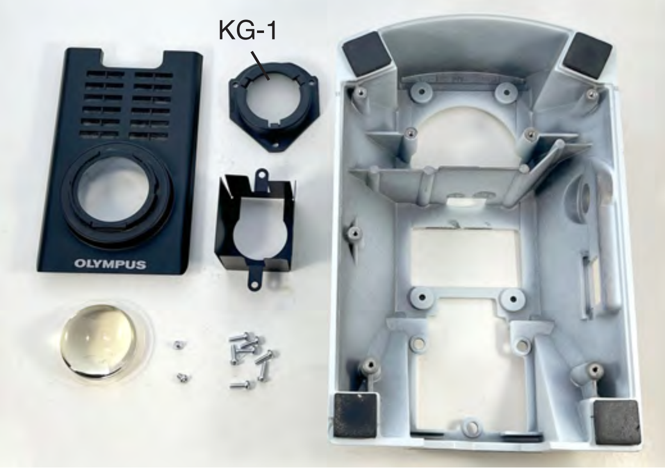
In any case, Olympus has been using this design for many years, and with each model offering an improved version of it.



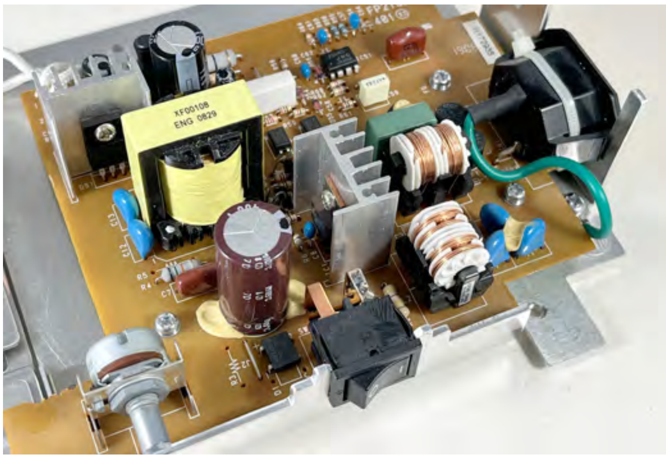
Top view of switching power supply.



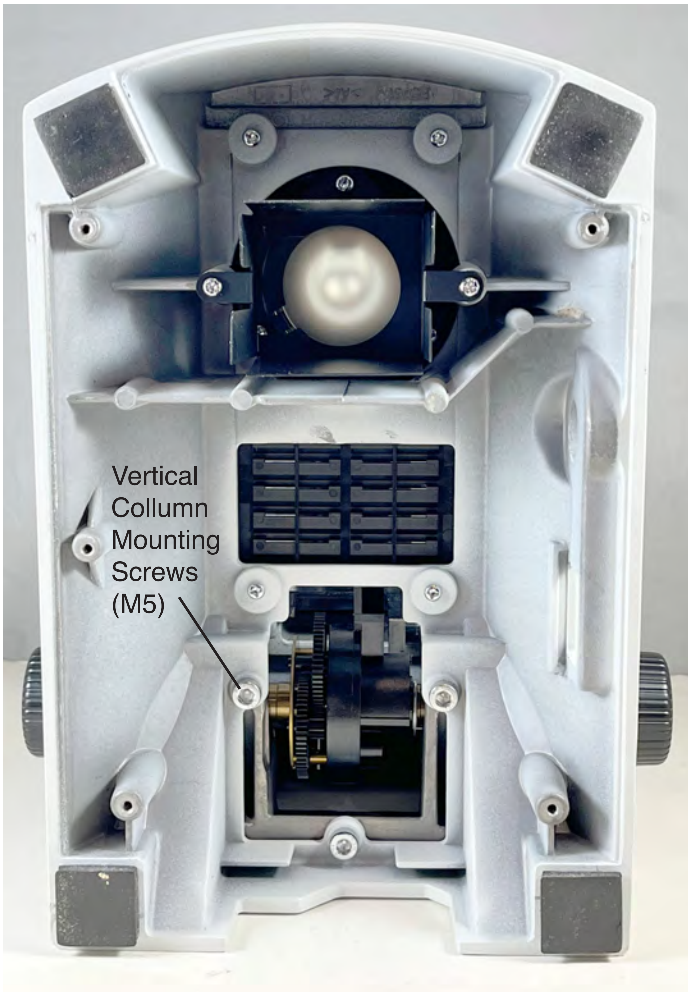
6V 20W Halogen lamp door for easy replacement



Disassembly of the lamp housing inside the base (right).



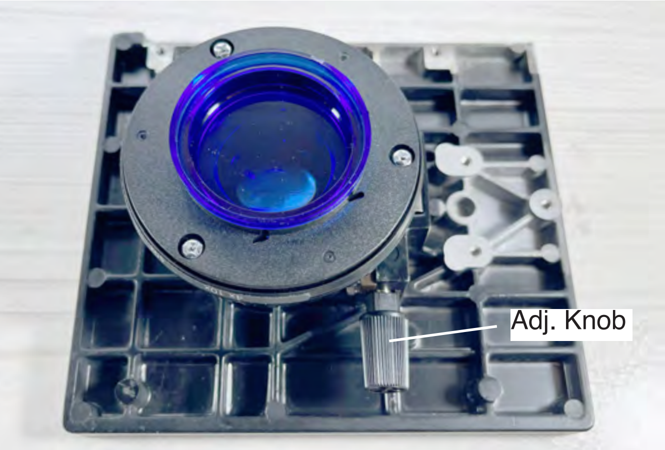
The intensity control pot, and the on/off switch stay with the electronics board during removal. This a Japanese style design reducing cost drastically during production.



4 support legs land directly on the floor through power supply board. Olympus has been using this design for many years. Focus mechanism visible from the base.

The optics supplied with this microscope are infinity corrected Plan Achromatic objectives which are nice considering its medium price range. Overall, I consider this model to be so well designed, and economically advantageous, and offering value engineering.

Plastics are used anywhere possible but Aluminum/steel material are rightly chosen when needed. The Aluminum housing is so easy to transport weighing only 6 kg, and having an easy to grab hollow handle on its top.



Low cost design to interchange filters

Rack and pinion drive below the stage

Condeser carrier removed to show rack gear.

Detail of pinon drive gear, and two-piece rack guides.

6-Blade iris diaphragm, and the three cover support columns. The diaphragm unit has minimalist design with least number of parts. It consists of three injection molded rings. The center control ring rotates 120 °.

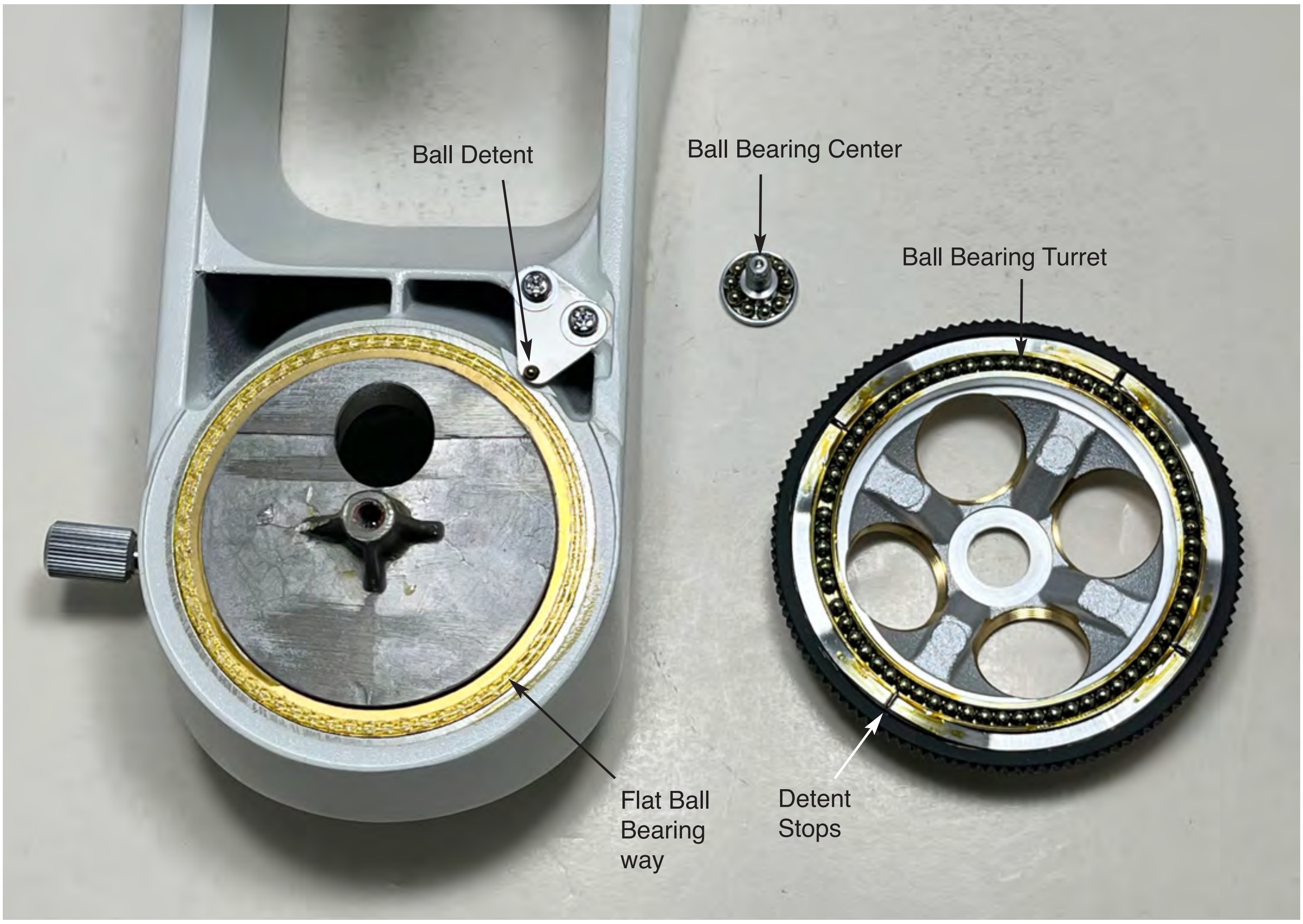
The Abbe condenser focusing stage is well intended but there is the wrong choice of material for its pinion gear. Over time, this material would split in half, and lip over its center shaft, and cause the mechanism to jam.

The Nosepiece

Did you say you wanted quality? Well, every detail counts in that chain, and the construction of this nosepiece is no exception. The Nosepiece turret plays an important role in microscopes because its job is to center each objective, and to provide accurate parfocal distance to the specimen. It is said that Olympus machines the objective seating bores after the assembly. I find that hard to be implemented but it would be the best way to thread bore each objective position after the final mechanical assembly. There are so many factors that would make sense for this procedure.

The M5 screw is tightly machined to prevent slippage.

Rubberized 4 position 82 mm Ø nosepiece turret.



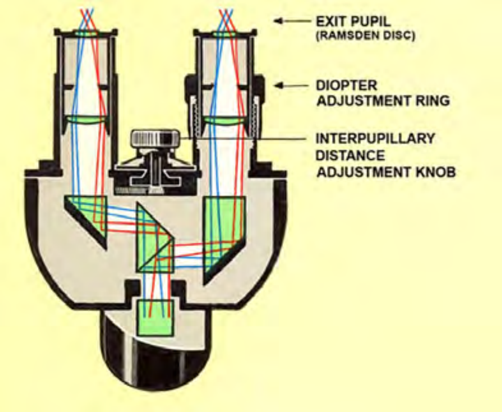
A fully supported ball bearing is surprising for a microscope in this price range. The result is a solidly switchable, and an as good as it gets opo-mechanical alignment of optical axis for each objective.

Parts Count

Microscope summary of parts:

Viewfinder Assembly: 32 parts including 5 prisms, 2 element Tube Lens, 21 mechanical parts, 4 Plastic Covers. 31 Screws	32
The X-Y Stage: 64 pieces, 62 screws, 20 steel balls	64
Illumination Optics: 23 parts including 6 optical elements, 17 mechanical parts, 9 screws, 1 thumb screw	23
Focus Mechanism: 52 parts including 3 Gears 1 Thumb Screw, 2 E-Clips, 2 O-Rings, 13 Screws	52
Objective Lenses: 4~6 Lens elements each	44
Eyepieces: 6 parts including 2 Lens Elements each	12
Nosepiece: 5 piece Rubberized Turret Assembly 3 screws, 2 washers, 80 Steel Balls	5
Die-Cast Aluminum Body: 2 Piece Main housing, including 1 Logo, 4 Rubber Legs.1 thumb Screw, 19 Screws	12
Switching Power Supply: 84 Electronics, and Mechanical Parts, 1 Lamp. 15 Screws	85
Total Number of Parts:	330
Number of Screws:	153
Steel Balls	100

Viewfinder consists of 32 parts, and 31 screws



Old versus New

Good old Zeiss binocular head (left) designed by Henry Siedentopf (1872-1940) was a much more integrated design, made of steel parts. It was more expensive to build, requiring more skilled workers to assemble. The Japanese version (above) is much lighter weight, and much more modular. The new Zeiss assembly for Axioplan microscopces (discussed in the last issue) is designed much similar to the Japanese version by Olympus.

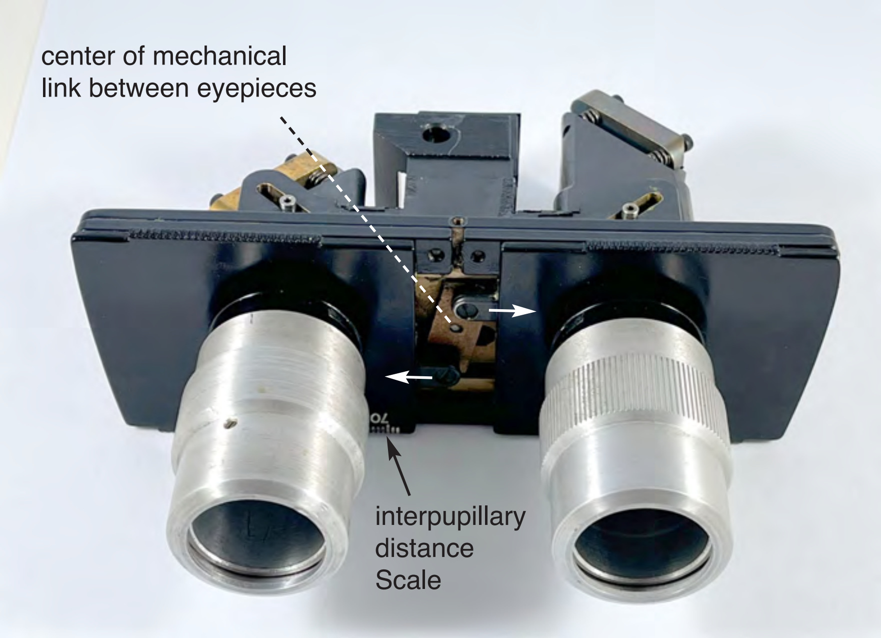
The Jentsch Design

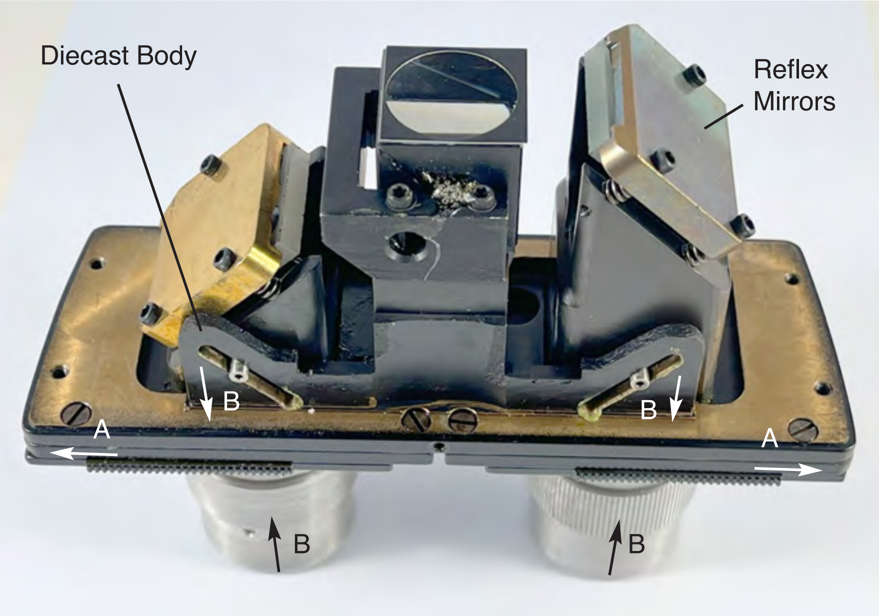
It wouldn't be fair not to cover the Jentsch design now that we have praised so much the Siedentopf. There are lots of microscopes at OMiD museum that I could take apart, and explain their inner workings. This binocular head by the good old Bausch & Lumb (below) looks to be interesting to discuss.

As you could tell from the figures, there is only one prism in this assembly, and the rest is done with mirrors. Another obvious feature of this 60-year-old design is it's an all-metal construction, preferably brass. There are several design features that are shown in the figures: Above, right, illustrates how the right, and left eyepieces are linked together to move in symmetrical directions.

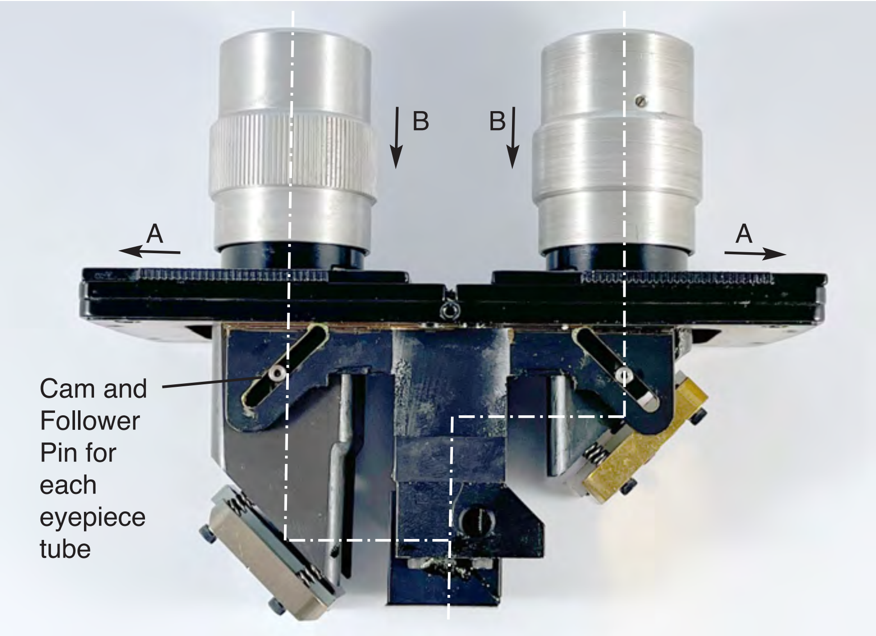
Middle, right, adjusting the interpupillary distance between the two eyepieces in direction A, would cause them to move in direction B. This is necessary to keep the image in focus by maintaining the optical path length. Bottom, right, there are two cam, and follower pins that drive each eyepiece tube in and out as they are pushed closer, and further apart.

The only advantage of this design might be the interpupillary distance could be set by a more accurate scale engraved above the eyepieces. Zeiss binocular heads for Axioplan have an equally accurate scale on a rotary disc.





Pulling apart the eyepieces in direction A would cause them move in direction B to keep the image in focus by maintaining the optical path length.



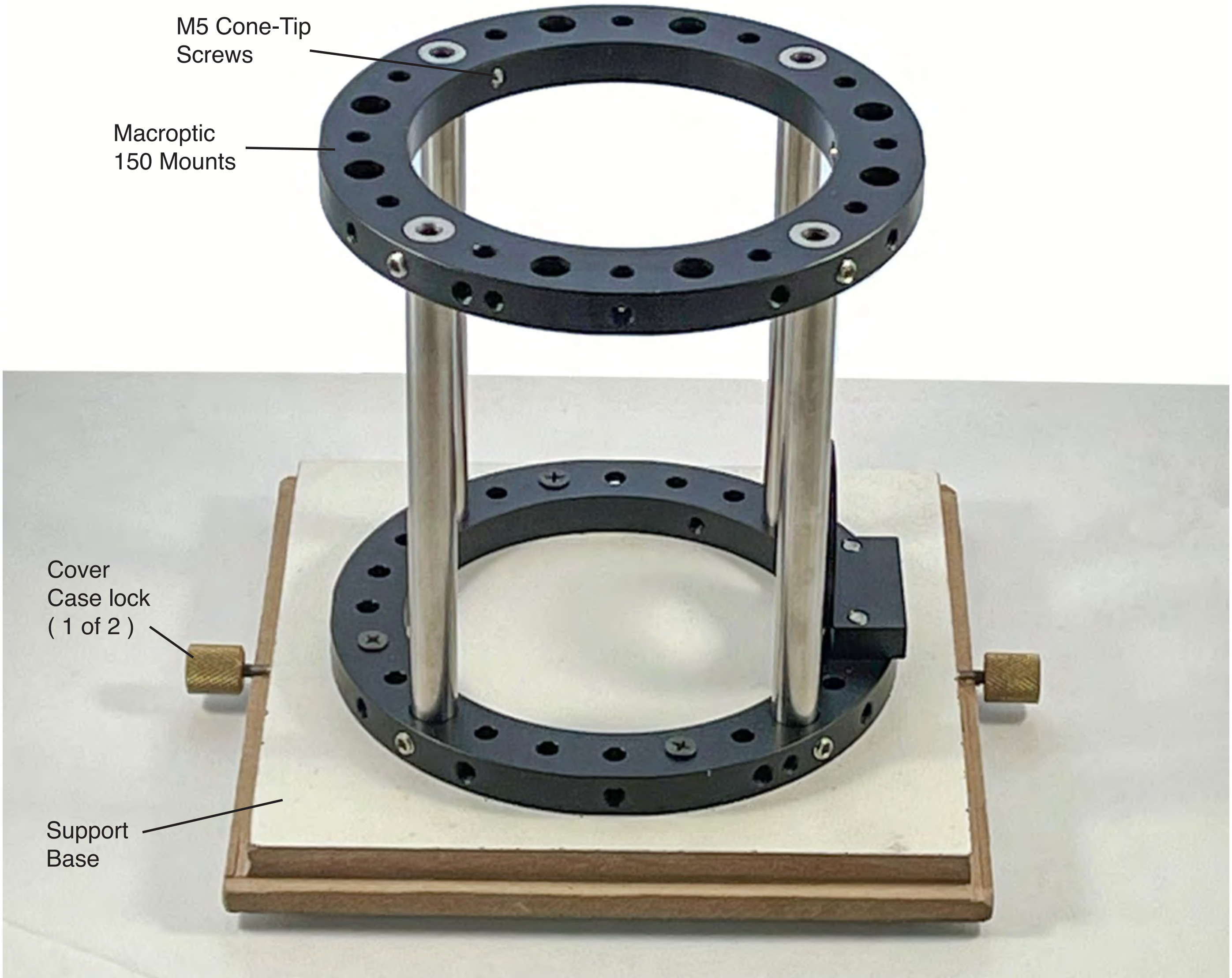
Constructing an Optical CMM machine with Optoform

In the past several issues we have shown many types of microscopes being built with Optoform II. In this issue, we'll look at one application built with the classical Optoform mounts, namely, Macroptic 150, and Minioptic 100. These mounts are circular, and they lend themselves to various applications demanding a rigid construction. The optical CMM is really a low mag microscope, usually consisting of a Telecentric lens, a CMOS camera, and measurement software. There are two types of Optical CMM designs; One; With a fixed camera that will measure anything placed within its field of view; Two; With a traveling camera (utilizing a X-Y-Z stage) that could measure objects much larger than its field of view. We'll be discussing the first type.

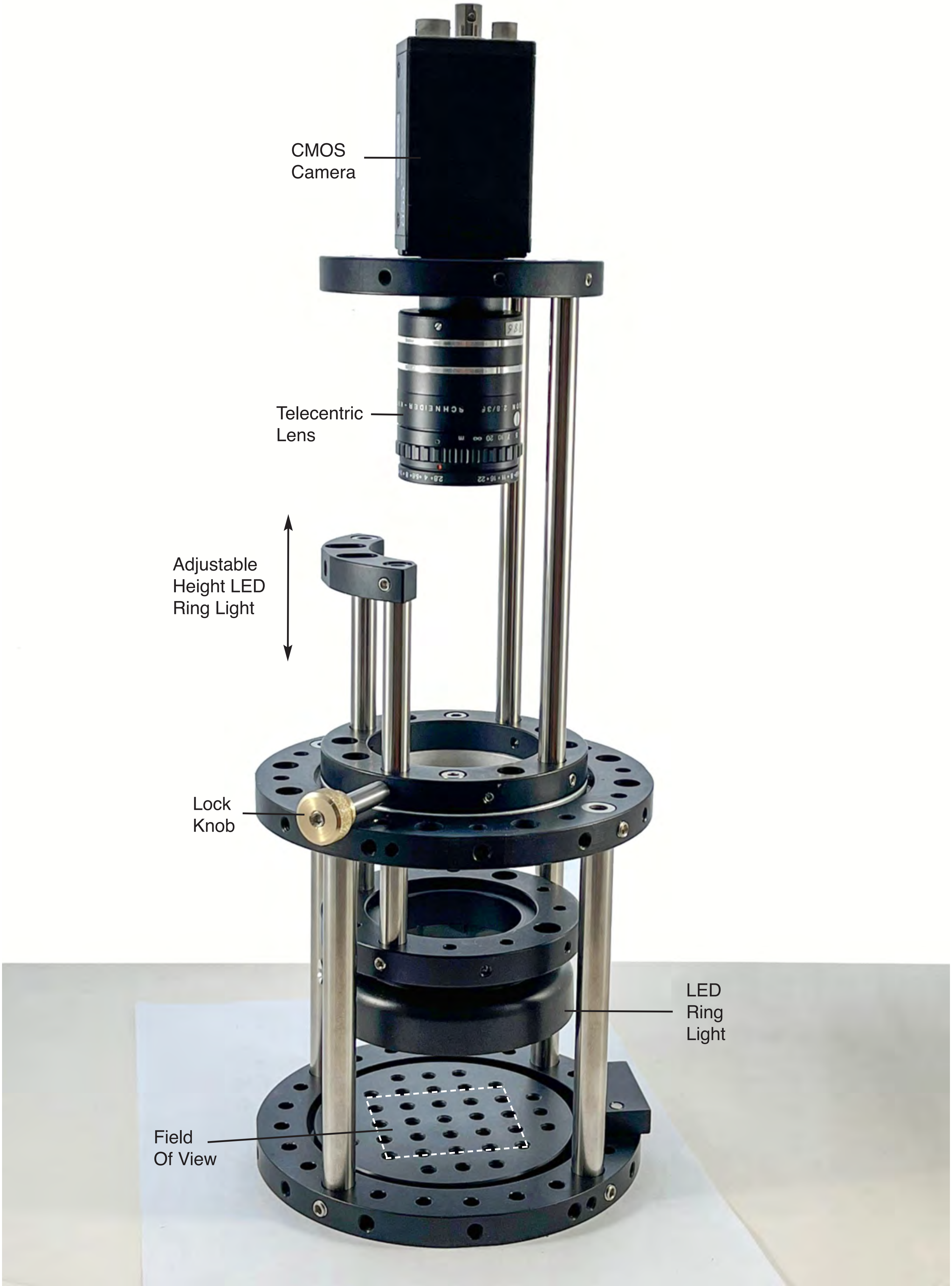
To build the structural foundation for this instrument with Optoform, we would start with a wooden platform (below) securing the support legs made of Macroptic 150 mounts. The rest of the structure could be built with Minioptic 100 (next page). Mioptic mount 100 (100 mm in diameter) is ideal for imaging applications because it could easily secure a C-Mount camera, the lens, and the ring light in a closely fit frame. The illumination is the most crucial part of this design.

Measurement softwares are sensitive to side reflections on screw threads, Several methods may be utilized to achieve desired illumination such as collimated rear illumination. Other measurements, may require the LED ring light to be raised up or lowered to measure countersunk bores. The idea is to position the ring light so its reflection off of the countersunk bore would not be seen by the camera lens so the internal bore diameter could be measured. If the countersunk bore is to be measured, then the light should be positioned such that the countersunk area would be visible to the camera.

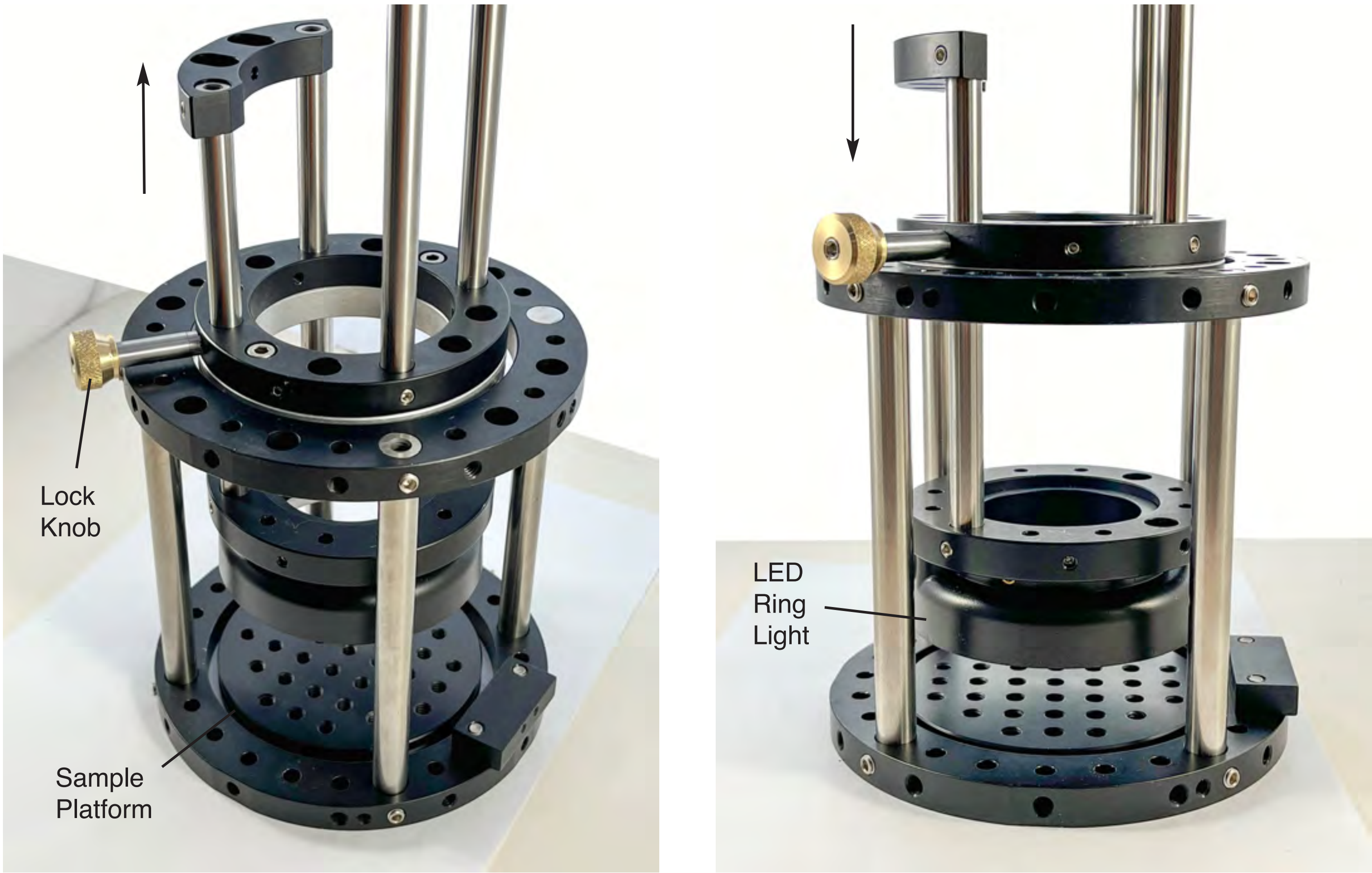
Optoform needs an enclosure to be a portable, storable instrument. This example serves as both a practical hint on how to build one, and it illustrates how an optomechanical instrument can be housed to perform reliably, and accurately.



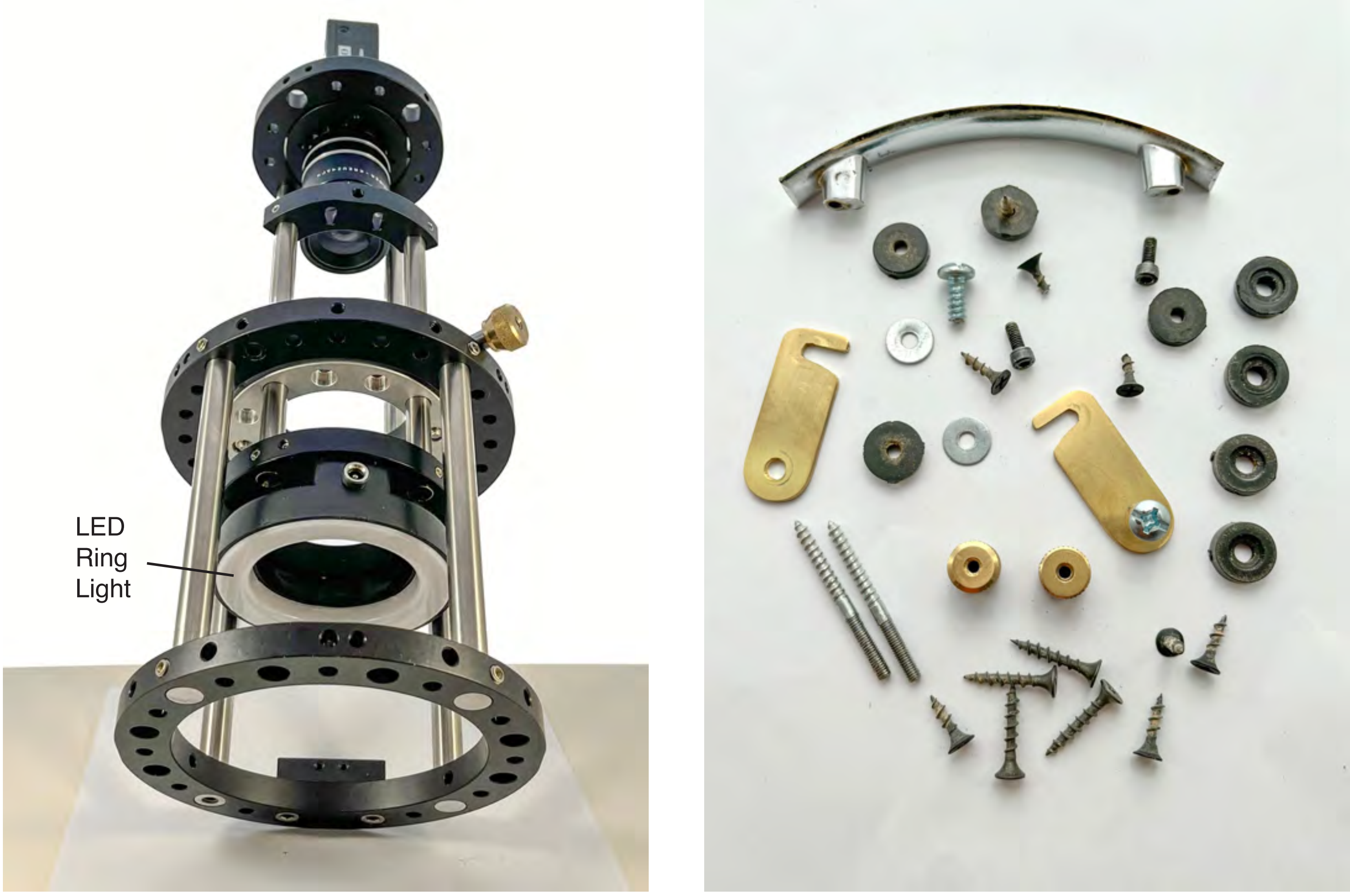
Wooden platform with four rubber legs acts as the instrument base the Optoform inspection assembly, and accepts a fitted cover case for storage or transport.



The object is placed on the sample platform for measurement. The object could also be back illuminated (see P. 34).

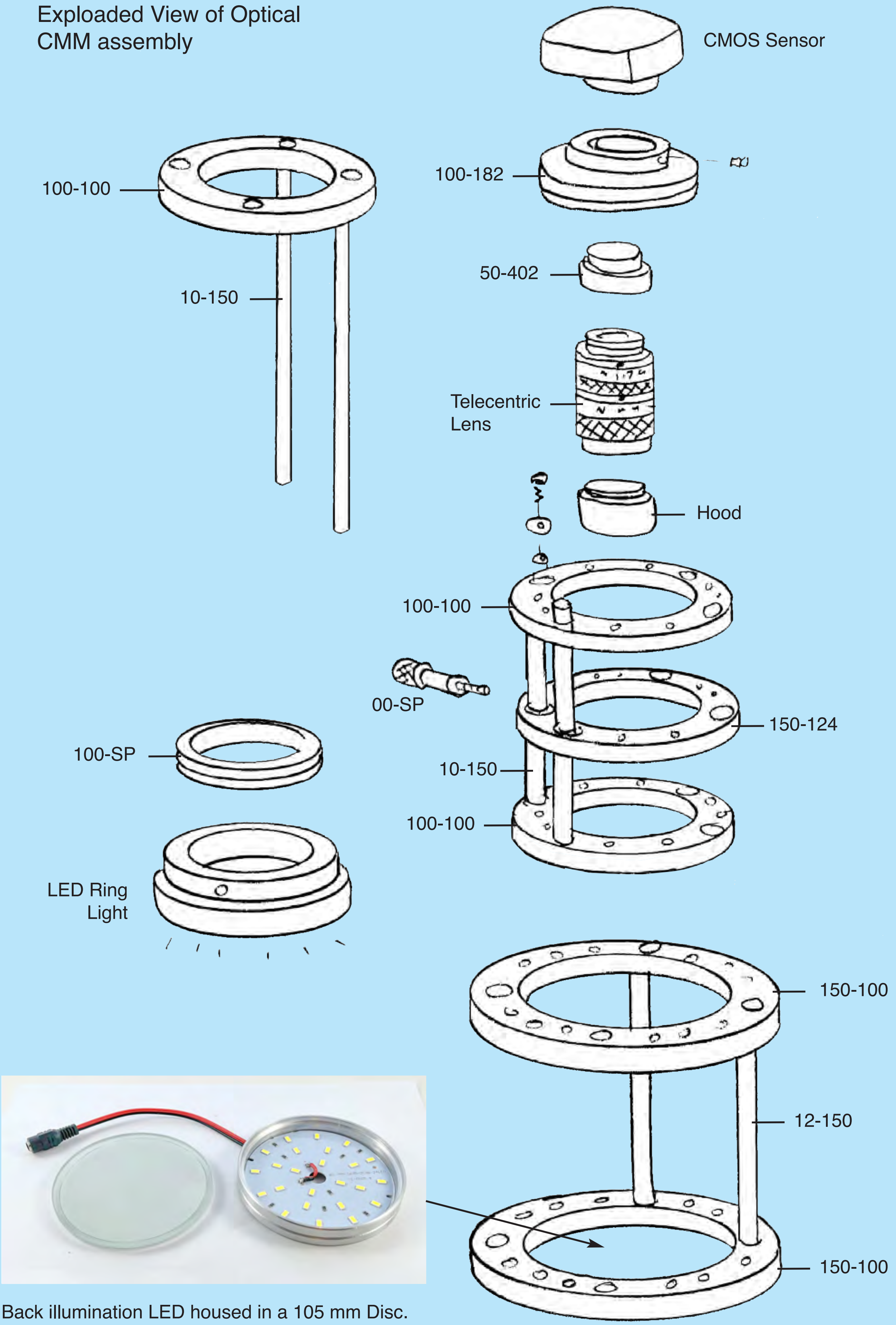


The LED ring light could be lowered (right), or raised up (left) to highlight the correct shadows for measurement.

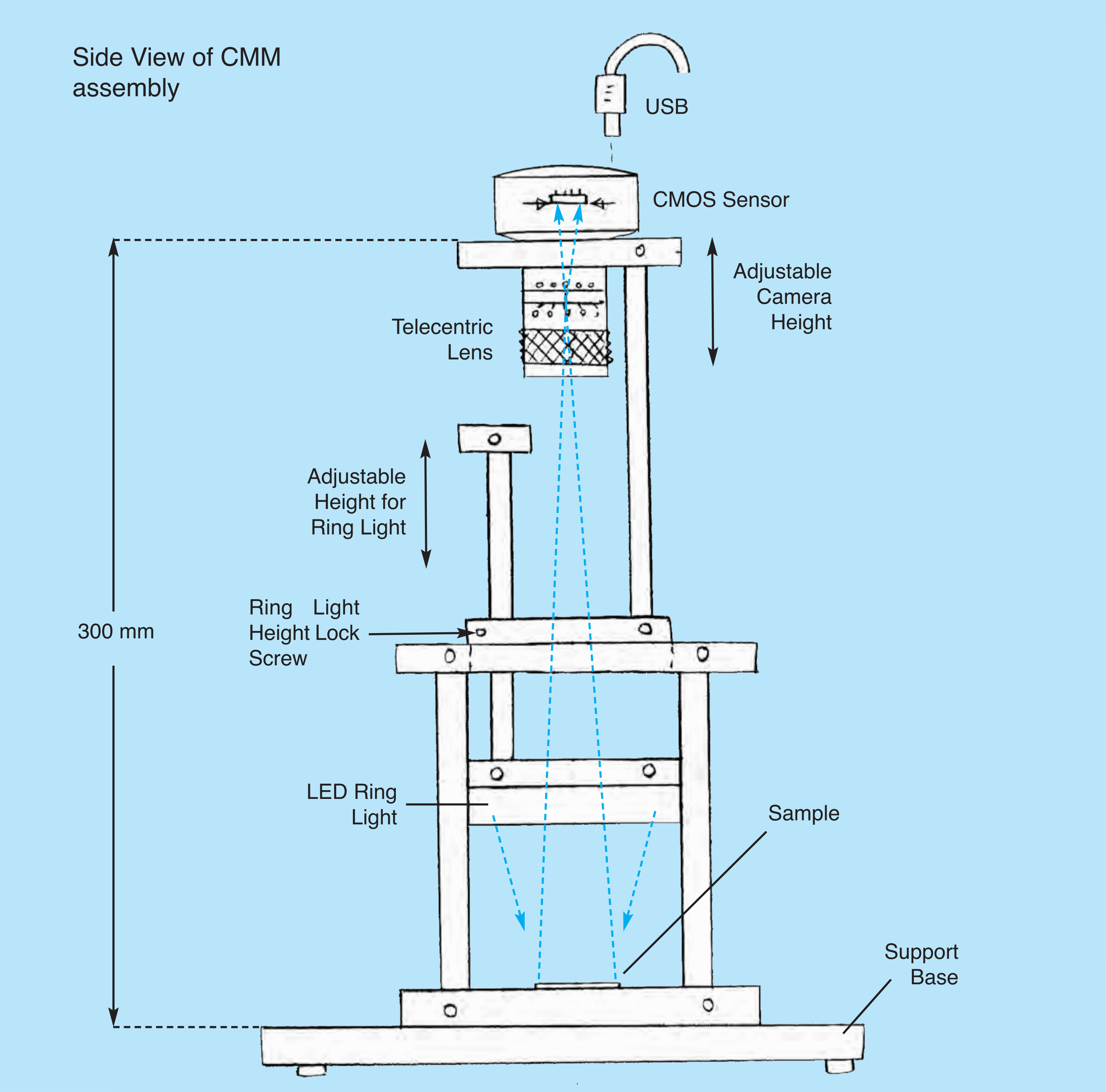


Bottom view of optical inspection tool showing the ring light (left). Right, custom parts built for the hard case (see P. 35)

Exploaded View of Optical CMM assembly



Back illumination LED housed in a 105 mm Disc.



Carrying case with lock, and carrying handle

Swing-Open lock design

Iran: A Hard Choice Between Morality, and Modernity

By Ali Afshari

In the last issue of Optomex, I discussed the alternate option of losing which is very unusual. Many of us always struggle to win in life no matter what. So why lose? I gave a few examples of when it would be a better option. For movie buffs, it would be like the ending of Casablanca. I'd like to follow up on that article with another unusual subject, perhaps to reduce some of the islamophobia that exists in the west. When I arrived in America back in 1978, Iran was going through a revolution led by Ayatollah Khomeini (1900-1989). Putting religion aside, he was a charismatic figure like Mao Zedung (1893-1976), the founder of people's republic of China. Before Iranian revolution, the Chinese had already been throwing their fists on the air for 30 years, with communist slogans like: "Down with capitalism". Chinese leaders saw a Neo-Capitalism emerging in the World, and they chose to join its bandwagon in 1978. This was during Jimi Carter's administration, just a year before Iran took the exact opposite stance, with anti-American slogans, which has continued to this day. In this article, I will put the two options in parallel with one another. The question I always ask is why every struggle for freedom, and democracy in middle east is received with so much dislike? How is it that Iran became an isolated state under heavy sanctions, while China flourished?

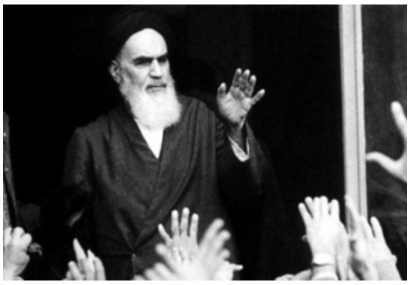
Sanctions have even influenced the consciousness of Iranians living abroad. Take the Medical field, for example: Medical doctors have gained a certain celebrity status when visiting Iran. Because of this, Iran has been most up-to-date in medical sciences in past 40 years. But in other fields like engineering, Iranians would say: "No, we're just going there to visit family", so Iran has been placed in isolation by its own engineering minds. Although in contributing papers in scientific journals, Iran has pulled itself up. Paradoxically, that's how so many bright engineering graduates from Iran's top universities have managed to find work abroad.

There is yet another cultural barrier for advancement in science, and technology under the slogan: "We do want your advancement in science, but minus western culture". This has caused countries in Middle East to fall behind because they have been pulling modernity by one hand, while pushing back western culture by the other. As we know, it's impossible to get one without the other. China also played this game while opening its doors during the 80's but finally gave up. Chinese had the teachings of Confucius, while the Japanese had Shinto. These doctrines were practically obsolete. What China actually did in mainland was to allow small entities make their own decisions, and it all began with small local farmers. Den's new policy allowed them to cultivate their land without intervention by government under communist doctrine [1]. The objective was for people to come out of starvation, and didn't matter how (Den's famous cat catching mice analogy). In Malcolm X terms it meant: "By any means necessary".

Leading a nation always faces conflicting interests because there are diverse views: The youth want freedom of expression, and freedom of choice while elders want to have more security by keeping the old values. This is like a young boy and girl wanting to get married. The girl's parents would immediately ask the young boy how he's planning to support her. The youth usually care about the feel of the moment, and worry much less about future. The elderly would most likely make a wiser decision for them, no matter how unpopular. This is how prime minister Lee Kuan Yew (1923-2015), justified his method for modernizing Singapore. Deng Xiaoping (1904-1997) had the same philosophy for China: "Let us run the country, and we'll make you prosperous."

Leaders of religious states like Iran insist on preserving moral values than fast forwarding to progress. Why are those values so important, and where do they come from? It all has to do with the history of that region. After the death of prophet Muhammad (570-632), free elections were established. Ali Ibn Abi Talib (600-661) had been appointed as the spiritual leader by Muhamad during his last Hajj pilgrimage, but the first president was chosen to be Abubakr. Ali was an adviser to the first 3 caliphs, till he became the fourth elect president. Muawiya ibn

Imam Ali, appointed Islamic spiritual leader by prophet Muhammad. Collection of his speeches during his rule, and his letters are in the book: "Nahj al-Balaghah".



Ruhollah Khomeini founder of the Islamic Rebublic of Iran in 1979

Deng Xiaoping founder of modern China, with Jimmy Carter in 1978

Chaiman Mao Zedung founder of People's republic of China 1948

Abi Sufyan employed dirty political tricks to put himself in power. Ali was assassinated during a morning prayer. The trouble began after Muawiya's Son Yazid (646-683) appointed himself as the next khalif by inheritance. This is where Imam Hossein (Ali's son) refused to give his pledge of allegiance to him, and there was a battle in Karbala between Hossein, and his 71 followers, against over 10,000 well-armed Yazid's soldiers. One of the most beautiful stories about that war was when a high ranking General of Yazid's army joined Imam Hossein's followers. Shiites commemorate their martyrdom (Sep 4th of this year) for their efforts to establish democracy. Unfortunately, ever since then, most countries in middle east have been ruled by dictators rather than people-elect leaders.

Lee Quan Yew founder, and prime minister of modern Singapore

This philosophy of Imam Hossein turning his back to riches, and his uncompromised struggle to establish free elections, along with Imam Ali's 5-year pious ruling has established the doctrine that democracy can only be achieved through a morally obliged leader. As we know, the western world has been ambivalent to that doctrine as a prerequisite. The western world believes, it is the democratic establishment that sustains democracy, not a person: "This is like asking big corporations to be fair to small folks because they don't have the same resources. We legislate laws to protect the rights of small entities. Take president Trump, for example. In a democratic society, we would know how to deal with him, so he wouldn't stay in power".

Although, this doctrine sounds good in theory, it has not been so effective when dealing with the lobbying power of special interest groups, and especially when applying it to global policy. In fact, it is for lack of good morals and justice that has made our world unsafe. An easy to grab example would be the demolishing of some 260,000 Palestinian homes (last time I heard) in last 50 years by Caterpillar bulldozers. Well, that's not so assuring for a safe world to live in for the rest of us. The world we live in can be more simplified to a number of small families who compete for better living conditions. Before modernization, China, Japan, and Singapore were fascinated with the power of western world, so they were quick to join it. Oil rich countries like Iran didn't have strong economic motives. They were more fascinated with the concept of freedom in the west, so they chose moral leaders rather than economic minds. As a result, they fell behind economically. As Imam Ali stated: "Under poor economics, moral values leave the house".

A friend of mine shared his story, while he was studying as a dental student in Sweden during the Iranian revolution. He said: "I was so overwhelmed by Khomeini's charisma, and believed everything he said, and so openly expressed it to everyone around me. The dean of our school was trying so hard to make me a liberal, till he finally gave up! One day, while he was walking with me on campus." He said: "We in Sweden, have reached the peak of our financial goals, and today, Sweden is enjoying great prosperity because of the good planning set in place by our elders. But have you seen our youth? Some 40 years ago, we gave them all the freedoms they wished for, but look at them now; Some of them have turned homosexual, or they are committing suicide. I am glad you in Iran have started a moral revolution, and have taken the spiritual path, but you must not lose sight of your economic development."

With over 43 years passed their revolution, there is no turning back for Iranian people in search of their own form of government. Iranians have a certain devotion to Islam through the teachings of Rumi, Hafiz, and Omar Khayyam. Rumi poems are specially known for love of God than fear. With this interpretation, you can't enforce any religion. The Taliban regime in Afghanistan won't dare to challenge the resilience of Iranian women. Women also had a key role in realizing the Iranian revolution. Today Iran is stirring towards a more secular society but it will remain an Islamic nation. Teachings of Confucius didn't survive the test of time. On the contrary, many of the laws running the western world to this day, are based on Islamic teachings [2]. Without moral leadership, those laws will not be applied at a global level. It would be to our own good to join hands for achieving both prosperity, and morality. This was Imam Ali's vision of government. In spite of his widely known war heroism, Imam Ali did not become an expansionist like Pres. Bush's: "I'm a war president".

I'll use this Joe Cossman's joke that I heard from him in class to perhaps make some sense of it. He said there was once a huge fire in a city that their most well-equipped firemen couldn't put it out. The fire was so big that any fireman drove close to it, would turn back to escape the heat. The mayor plead to all neighboring villages for help. No one succeeded except this rusty old fire truck that drove near the fire, and put it all out. The city was so overwhelmed by their courage that they ran a reception for them, and the mayor personally gave them a check for $5,000 as reward. Then he asked: "Here's your check, now what are going to do with the money?" The driver replied: "The first thing we're going to do is to fix the brakes for this damn truck".

Revolutions happen! It forces a nation that would have otherwise been asleep, to get up and do something. It takes numbers to have a revolution, but later, it's not their number but the quality of its individuals in their hearts and minds.

[1] Book by Zhao Yong: "Who's afraid of the big bad dragon? Why China has the best (and the worst) educational system in the world?"

[2] For instance, the definition of "Circumstantial evidence" is taken right out of chapter "Yousuf" in Quran, Verse 26.

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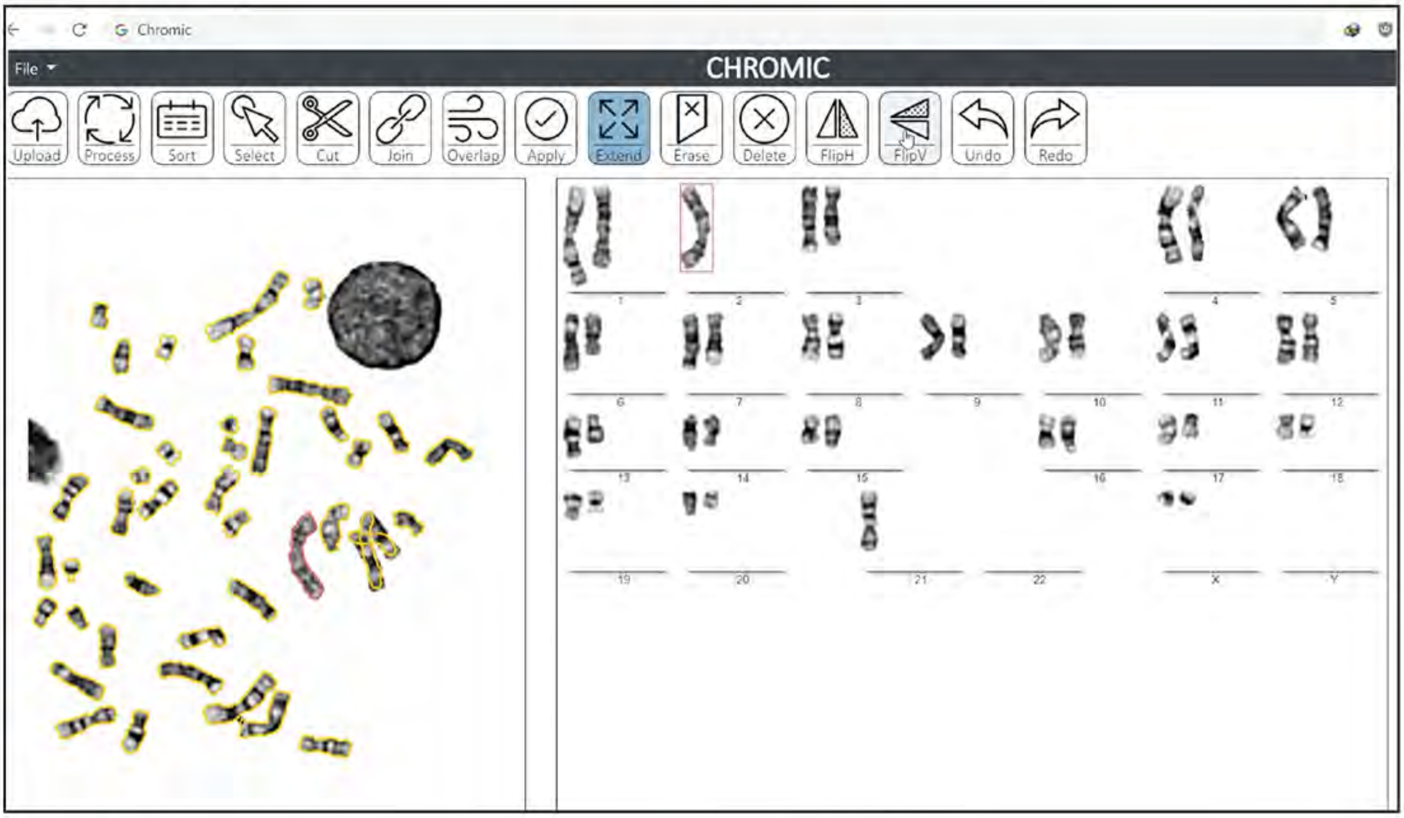

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