EEE 163 | REPORT

Section A (*The Product)*

Manufacturer:	SANYO, Japan
Product Line:	Conference Series
Model Number:	XG-V10XE

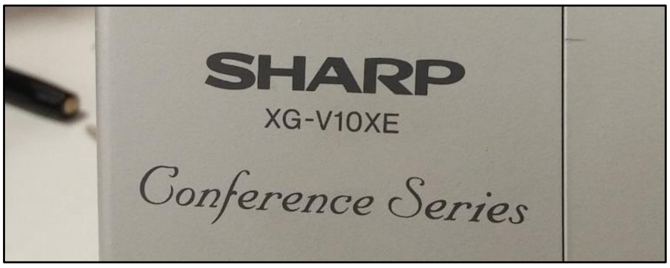

Figure 1a: Projector model number.

Figure 1b: Projector front+side view.

Section B *(Primary Function of Product)*

The product in question is an industrial projector (*figure 1)* and its main function is to take a computer monitor display signal as an input and transfer it to a larger screen using light as a means of transmission. The use of such a product enables users to display images that would initially only be large enough for individual viewing on a personal computer monitor and enlarge it to the point where an entire audience can view it from a distance.

Section C *(Physical Principles)*

The main operating principle that allows this product to work is the conversion of a digital or analogue video signal into a light array that is capable of recreating the input image through the emission of light. Firstly, the incoming video signals from the analogue or digital cables are initially separated into different colour groups, with each colour signal containing the data for that colours specific intensity at a certain time and position in the image. For example, video signals are commonly split up into RED, GREEN & BLUE (RGB), in which any colour in the colour space can be represented with different intensity combinations of each signal, with white being produced when all 3 colour channels are at full intensity.

However, for video electronics and this projector as seen in *figure 2*, a 'YP_RP_B' (analogue) or a 'YC_RC_B' (digital) colour space is used, which is converted from RGB and uses colour formats based on luminance (Y) and chrominance (P_B & P_R). Technically the 3 signals in 'YP_RP_B' still represent RGB with 'Y', 'P_R' and 'P_B' being converted from RED, GREEN & BLUE respectively. [1]

Figure 2a: I/O panel.

Figure 2b: Composite video input close-up.

The process of converting these video signals into a controlled light emission starts with 2x Zenon UHP (ultra high performance) bulbs shown in *figure 3a* (not installed) which output high intensity white light through a sealed chamber of various mirrors and lenses as shown in *figure 3b.*

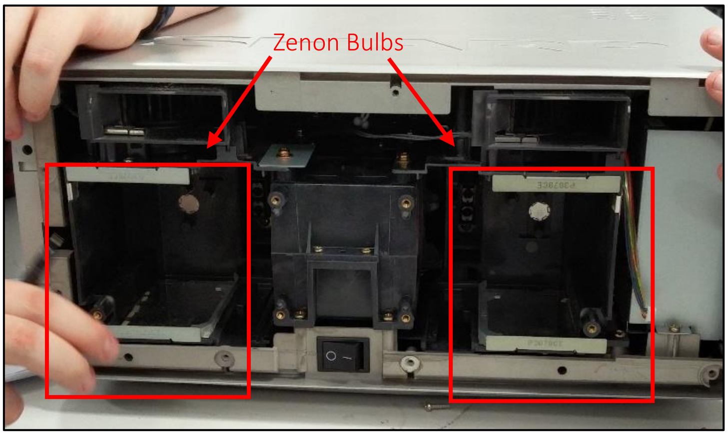

Figure 3a: Zenon bulb sockets.

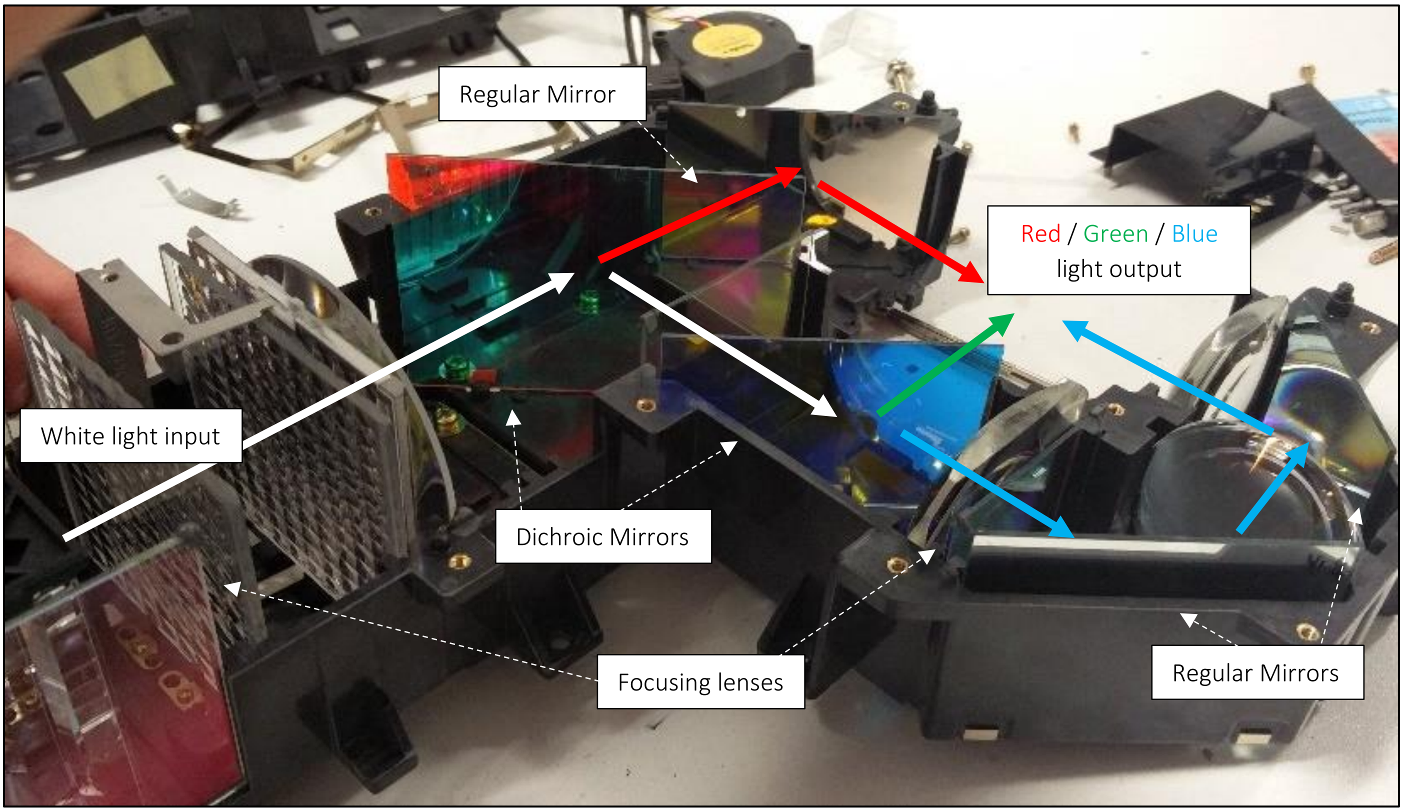

Figure 3b: Sealed mirror and lens chamber.

These various mirrors and lenses function to guide the light efficiently through the chamber and to split the white light up into its red, green and blue components. Also, various focusing lenses are used to achieve a uniform light intensity over the whole frame.

This is achieved using dichroic mirrors, which only reflect light of a specific wavelength while letting the rest of the light shine straight through. This is illustrated in figure 3b, with the combination of regular and dichroic mirrors directing the red, green and blue components of the white light in different directions.

These 3 light components pass through individual liquid crystal display filters (LCD), which are digitally controlled sheets of glass/plastic that contains many separate pixels. These separate pixels can be digitally controlled to be transparent, opaque or anywhere in-between. This is what controls the actual image, as for any of the pixels, the output colour will be a combination of the intensities of the red, green and blue light components. These LCD screens can be seen for each colour component in *figure 4b.*

Figure 4a: Dichroic prism

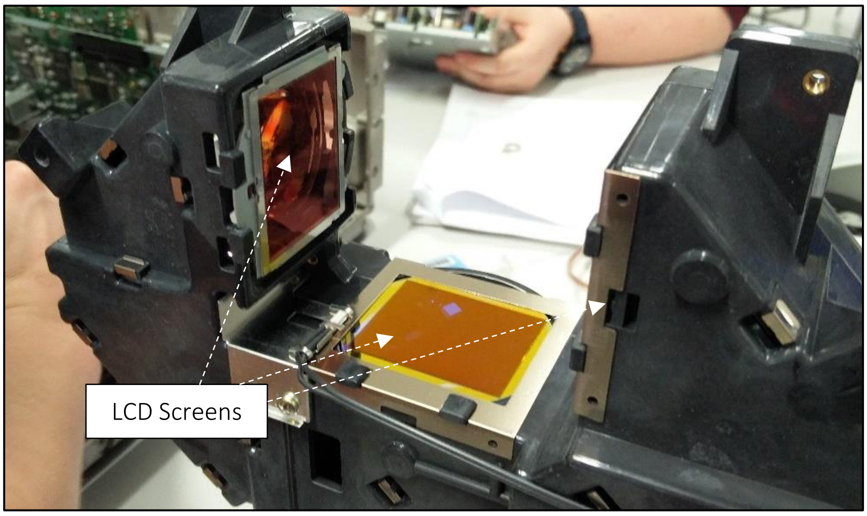

Figure 4b: LCD screens.

After the 3 components of light are filtered through the LCD screens, they pass into a dichroic prism, which combines and merges the 3 sources of light into 1 output source. Out of the 4 used sides on the dichroic prism as shown in *figure 4a*, 3 are used to receive light from the 3 LCDs with the 4th side being the combined output light source. [2]

Finally, the light from the output of the dichroic prism is fed into a lens seen in *figure 5* which projects the image onto a screen. The lens has focus and zoom adjustments so that the image can be enlarged by a certain amount and focused to depending on the size of the screen and its distance from the projector.

An annotated diagram of the operation of this projector can be seen in *figure 6.*

Section D *(Assembly Methods)*

Numerous manufacturing and assembly methods/techniques are used to produce a piece of electronic equipment of this complexity.

The outer casing of the projector appears to be injection moulded plastic due to the complexity of its structure as seen in *figure 7.* The reason plastic was used is because it is relatively cheap and easy to manufacture compared to other materials.

The metal housing that secures the lens in place as seen *figure 8* in manufactured by CNC milling (computer numerical control) out of a block of aluminium which enables its complicated shape to be relatively easily achieved with accuracy.

The mirror tunnel seen previously in *figure 3b* would have to be constructed in a clean room environment to avoid dust particles contaminating the mirrors finish. The plastic casing for this would have probably been constructed in several parts using injection moulding, with final construction of the tunnel along with putting the mirrors into position being done manually.

The electronic circuitry is formed of several printed circuit boards (PCB), which are fibreglass sheets with copper tracked that allow a high number of electrical connection in a small area. Most of the components are placed by robots and are soldered using wave soldering or infrared laser soldering for surface mount components (SMD). The boards are then connected together using plastic connectors or ribbon cables. In a few cases, evidence of manual soldering was found, such as in *figure 9.*

Due to the complexity of the system as a whole, each subsystem would have been manually put together to produce the final product, using various interconnecting tabs and many screws. This can be assumed due to the product not being mass produced, so the set-up costs for a fully automated manufacturing process would not be economically viable.

Section E *(Inputs & Outputs of System)*

The full set of video and audio inputs can be seen in *figure 2a*,

Inputs:	Outputs:
Infrared signals from remote control	Analogue video outputs x3 (pass through VGA)
Physical buttons x20 *(figure 10)*	Analogue audio output X1
Power input x1 (IEC socket)	Light - indication LED's x4 *(figure 11)*
Analogue Video inputs x6 (VGA, S-video, component)	Light – Projection image x1
Digital Video input x1 (DVI)	Sound from internal loud-speakers *(figure 12)*
Analogue audio inputs x5 (stereo R/L phono)	Heat output through fans from bulbs
Wired Remote input/output (mini-jack style socket) x1	

Section F *(Parts List)*

Thermal Fuse	Various transistors	Dust filter	Blower style fans
Resistors	Bearings	Heatsinks	Conventional fans
Capacitors	Servos	Lens	Dichroic/regular Mirrors
Inductors	Motors	Various connectors/sockets	Gear sprockets/worm gear
Transformers	IR receiver/transmitter	Op amps	EMI shielding
Switches	LCD screen	Dichroic Prism	Various IC/microprocessors
Plastic casing	Zenon bulbs	Screws/Bolts	Carrying Handle

Section G *(System Diagram)*

A basic system diagram showing the key subsystems of the projector and how they interact with other subsystems is shown below in *figure 13.*

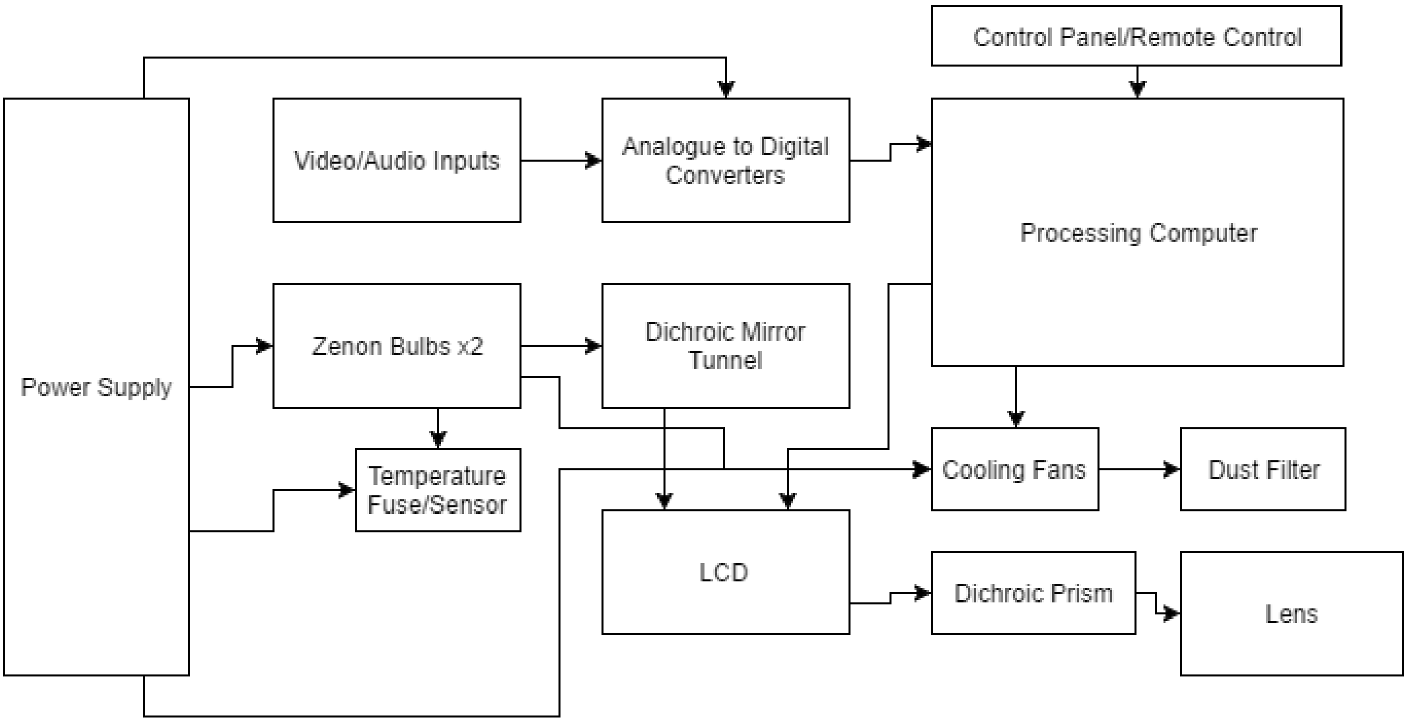

Figure 13: System Diagram.

Section H *(Failure Mechanisms)*

Heat:
As seen in *figure 14,* temperature fuses/sensors are placed against the bulbs so that the bulbs are shutoff in the event of reaching temperatures that could damage other components or damage the bulbs itself. Also, as seen in *figure 15*, heatsinks are placed on the transistors in the power supply units to help dissipate heat to avoid damaging the components. To get this heat out of the projector, a total of 9 fans pull in fresh air from the outside and push out hot air from the projector as seen in *figure 16.*

Dust:
Dust particles can contaminate the lenses within the projectors and cause image quality defects as well as clogging up the air paths - restricting the flow of air, hence limiting the transfer of heat and causing overheating.
To overcome with problem, the lens and mirror tunnel is completely sealed as seen in *figure 17*, and is manufactured in a clean environment so that no dust can enter. Furthermore, as seen in *figure 18*, a dust filter is placed before the intake fan so catch any dust before it enters the projector.

Section I *(Individual Electronic Component – Packaging & Function)*

Component: Zoom & Focus Motors + Len casing motors

Packaging: Two high gear ratio motors are fixed on a metal bracket surrounding the lenses focal and zoom adjustment rings as seen in *figure 19,* the wires connect to a motor driver which is controlled by the projectors computer.

Function: These are controlled by the projectors computer from user input via the physical control panel buttons or through the remote control and they physically rotate the lenses focussing and zoom components to adjust the image for different conditions. Furthermore, as seen in *figure 20,* a worm gear system is used for lens tilt adjustment, where a motor connected to a worm drive controls upwards of downwards movement of a metal bracket within the lens housing. Attached to this worm drive is a sliding potentiometer and 2 pressure switches, this is used as feedback to that the projectors computer knows the current position, because as the worm drive moves, the sliding potentiometer is moved there changing its resistance (see *figure 21)*.

Section J *(Comparison Equivalent)*
Compared to a modern equivalent projector, some features of this projector are still relevant, and the physical principles to how the projector operates are still the same today, but many features and technologies have also progressed. For example, the resolution of a similar costing projector has increased, with compatibility for 4K video compared to standard 1080 resolution that this projector is capable of. Furthermore, this projectors main input form is analogue, which is susceptible to noise and imperfections, so modern projectors have adopted digital standard connections such as HDMI and display port.

The physical size for industrial grade projectors haven't dramatically changed in comparison to this projector in question, however, the light output has managed to be achieved in a smaller projector package. This is due to advancements in thermal efficiencies of the bulbs used as well as the internal mirror/lens structure. For example, some projectors use separate LED style bulbs for the red, green and blue components, which avoids needing a dichroic mirror chamber to split the white light, saving space and maximising light efficiency.

References:
[1] equasys. (Unknown Date of publication). *Colour Formats* [Online]. Available: http://www.equasys.de/colorformat.html

[2] SeeBigTV. (Unknown Date of publication). *How do projectors work* [Online]. Available: http://www.seebigtv.com/how-home-theater-projectors-work.html

Appendix:

Figure 5: Projector Lens.

Figure 7: Injection Moulded plastic casing

Figure 9: Evidence of manual soldering.

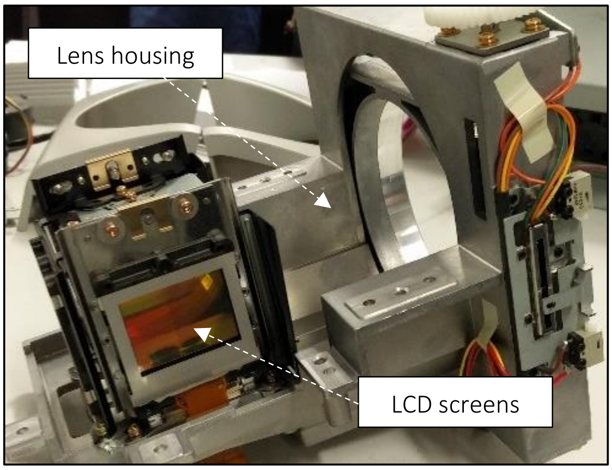

Figure 8: CNC'd aluminium lens housing.

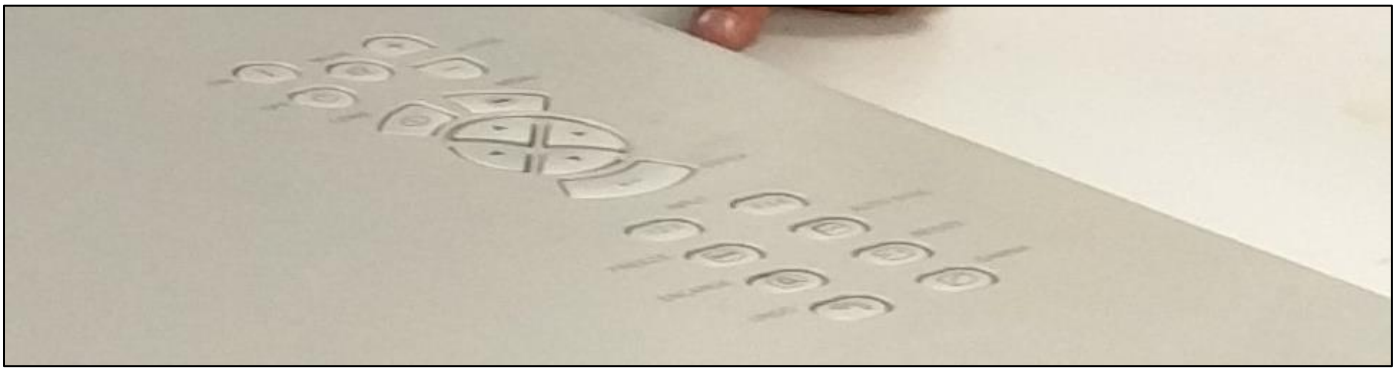

Figure 10: Physical buttons

Figure 11: Indication LED's.

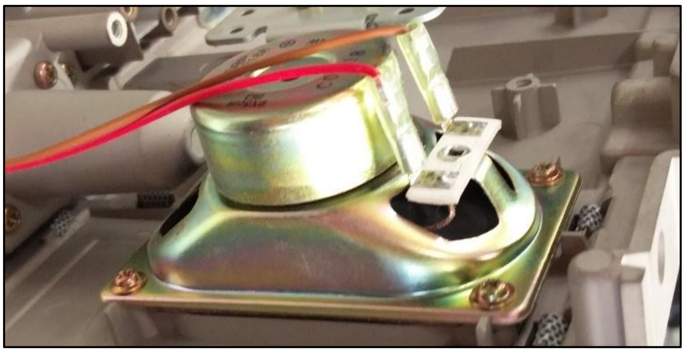

Figure 12: Internal loud-speakers.

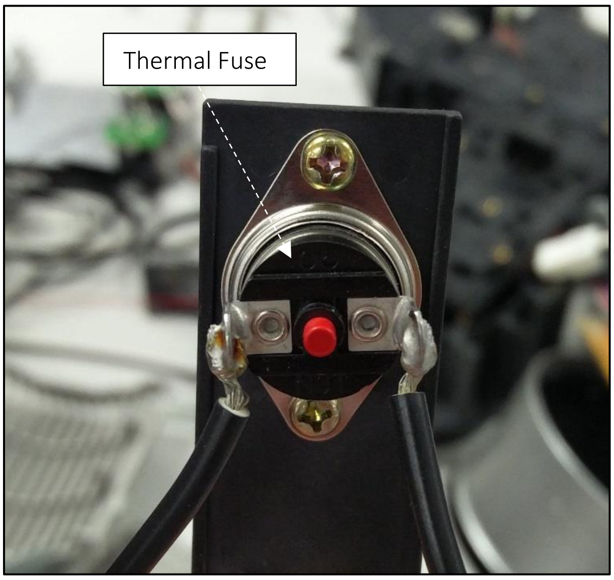

Figure 14: Thermal Fuse.

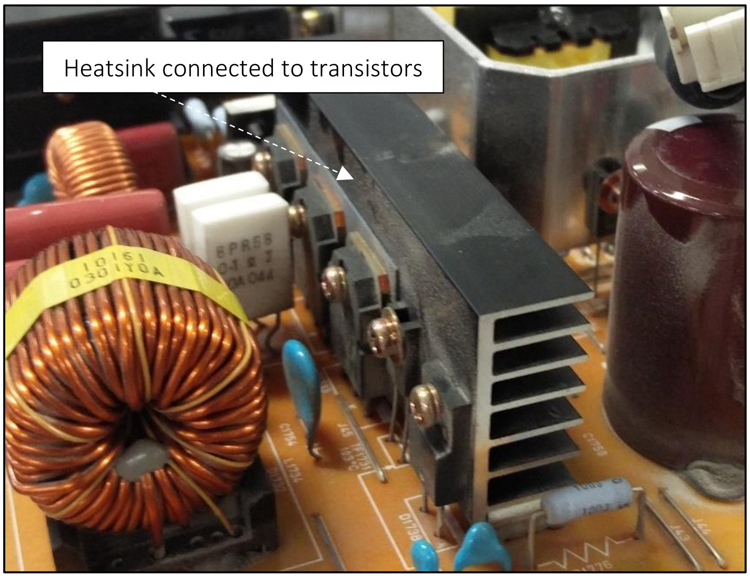

Figure 15: Heat sink.

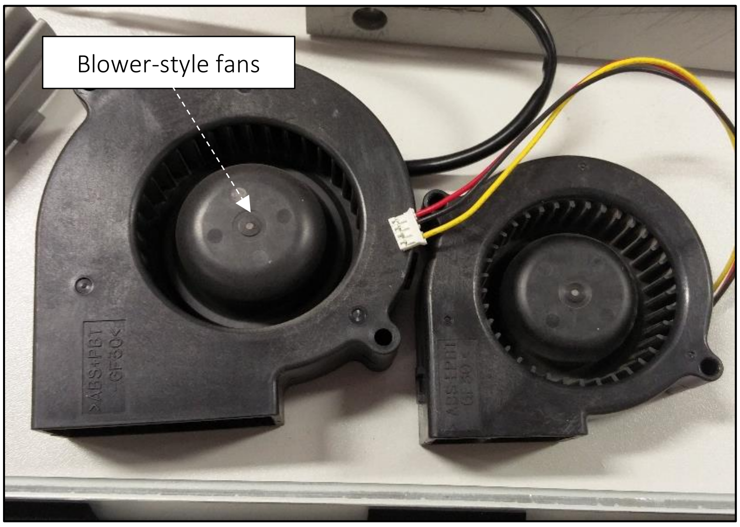

Figure 16: Fans.

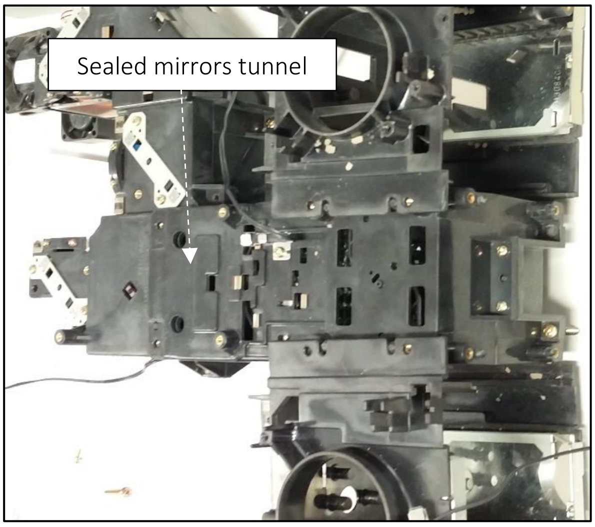

Figure 17: Sealed Mirror Tunnel.

Figure 18: Dust Filter.

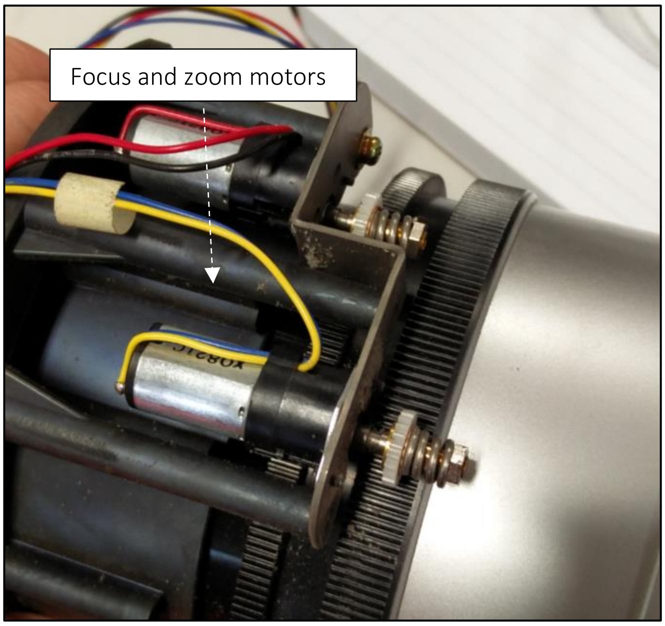

Figure 19: Focus and zoom adjustments.

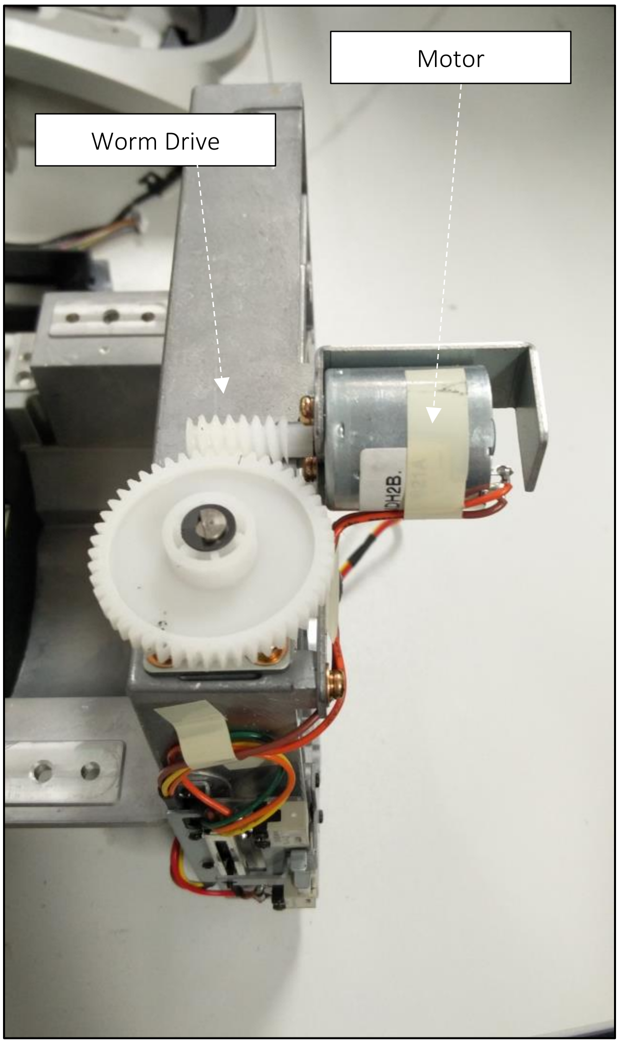

Figure 20: Worm drive motor.

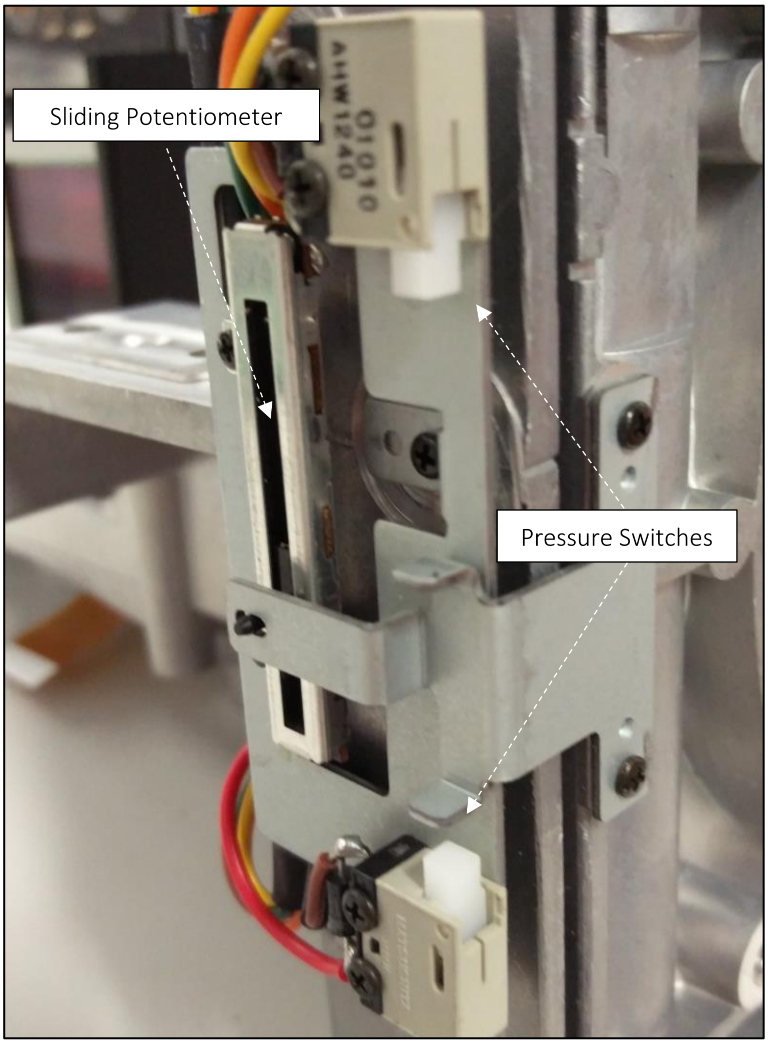

Figure 21: Worm drive sliding potentiometer.

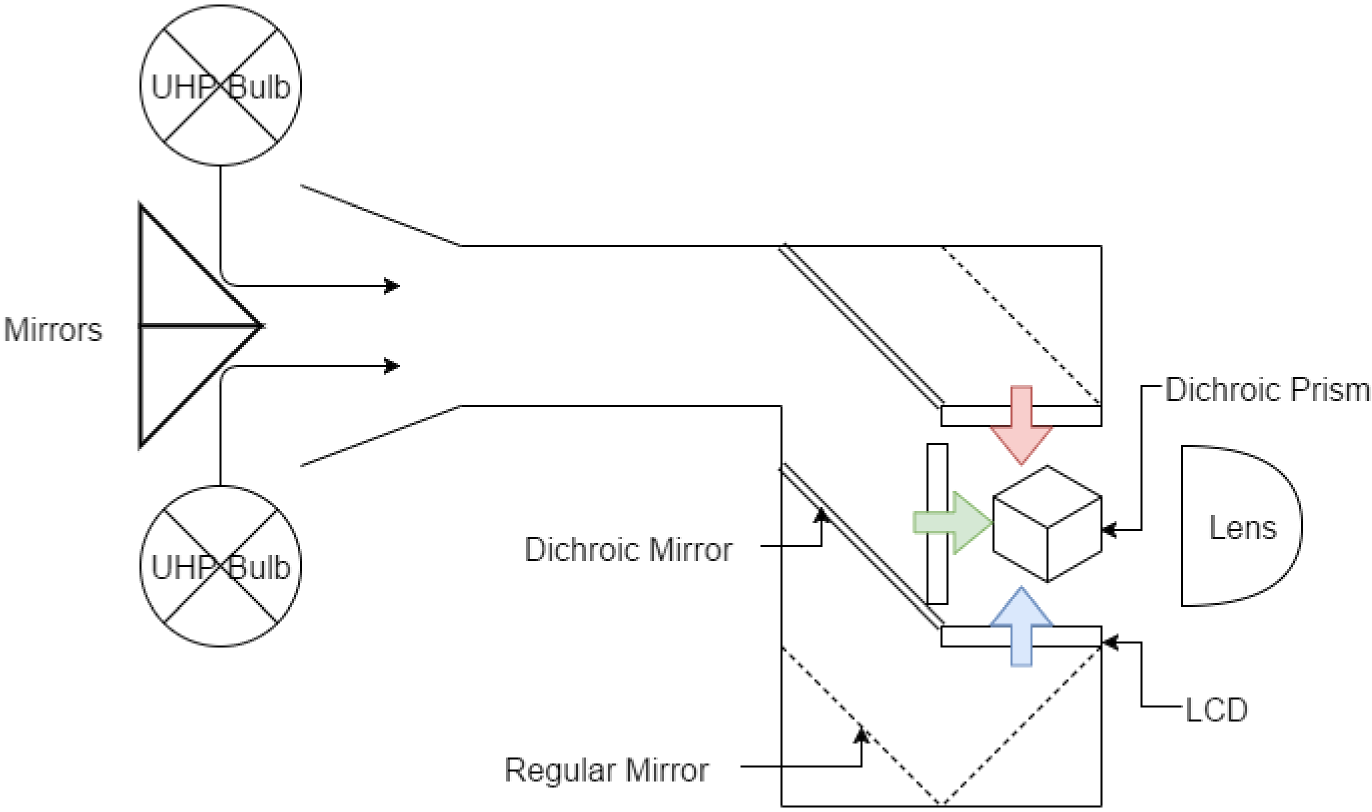

Figure 6: Annotated Sketch of operation.