



Stargate helmet animatronics

by **Honus** on August 9, 2016

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Author: Honus **DIY Animatronics**

I'm a former bicycle industry designer turned professional jeweler. I like working with my hands and am happiest when I'm in the shop building my creations. If you need help with your project just let me know!

Intro: Stargate helmet animatronics

I made a Stargate Horus helmet before and while I was happy with the **finished project** (especially considering the budget) I always had it in the back of my mind to make a really good, screen accurate replica. As luck would have it a friend who builds and collects movie props just so happened to see my project and asked for my help in doing just that!

This instructable isn't about how to make the complete helmet but rather how to build all of the animatronics to make it move. This was much more complicated than my previous version and needed to be more robust and as such required new construction techniques. The methods presented here can be applied to any animatronic costume project and the entire head mechanism could be easily reproduced for use in other costumes that have a moving head. Although the finished helmet was to be a display piece it is wearable just like the movie helmets. The helmet has moving head, light up eyes (dimnable), opening eye iris and properly moving fans. Everything is radio control just like the original movie helmets. It was a really challenging and exciting project and I was thrilled to have the opportunity to work on it.

Here you can see the head mechanism moving-

Test video of the fan mechanism-

Here's the video of the finished animatronics-

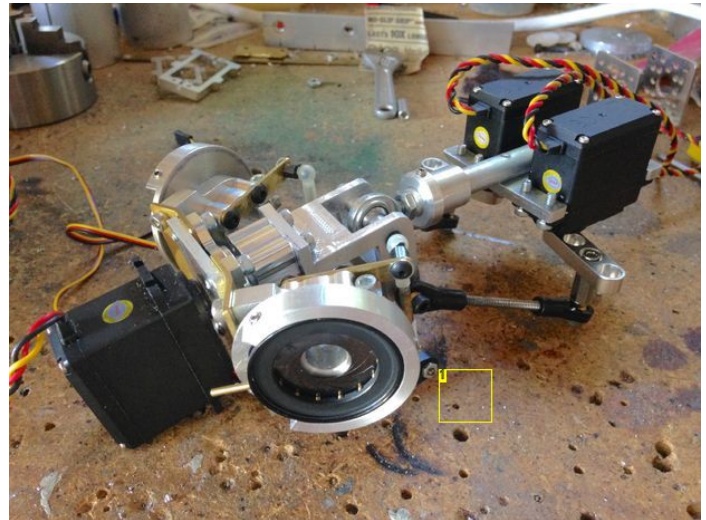


Image Notes

1. Animatronic head mechanism made from Aluminum for durability

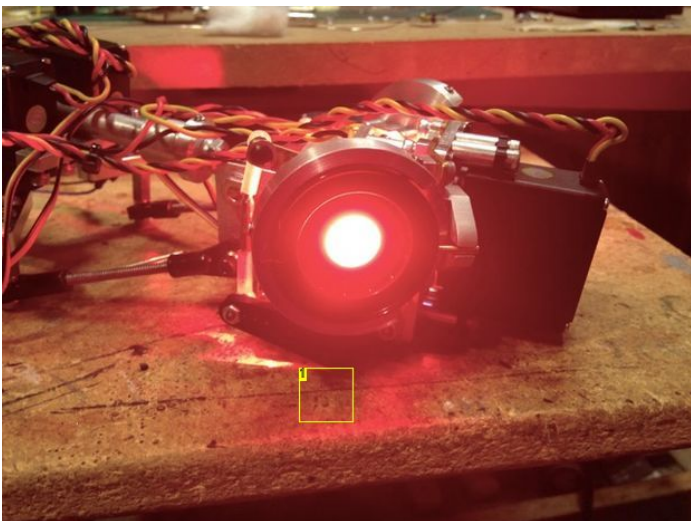


Image Notes

1. Super bright eyes!

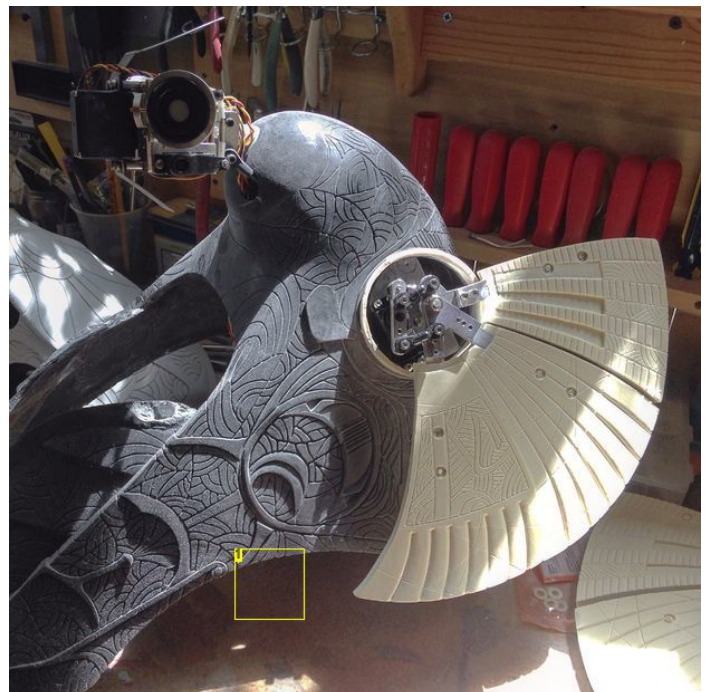


Image Notes

1. Test assembly of animatronics

Step 1: Tools and materials

Tools

The main tools used to make this were my small Taig benchtop lathe with a milling attachment, benchtop drill press and a bandsaw.

The bandsaw I use is a DeWalt portable saw- I made a vertical stand for it so I could use it as a benchtop saw. I love this saw and it will cut through 1" thick Aluminum plate no problem.

For cleaning up fiberglass and resin castings I use a Makita mini belt sander- an absolutely wonderful tool that saves hours of work compared to hand sanding and grinding.

I also used a soldering iron for the wiring and to make battery packs and various sizes of drills and a 6/32 threading tap.

Materials

I usually purchase metals from an Aluminum recycling center near my home but Online Metals is a great supplier.

I buy fasteners in bulk from Bolt Depot. It's unbelievably less expensive than buying them in small quantity at my local hardware store.

For servos and Actobotics mechanical parts I used the following from Servocity-

2xHitec HS-5085MG servos- Servos used to open and close eye iris

3xHitec HS-645MG servos- Servos used for main head movements

2xHitec HS-5585MH servos- Servos used for fan mechanisms on sides of helmet

2xActobotics 1/2" bore pillow block- Bearing mounts used for eye iris cups

1xActobotics 1/2" bore ball bearing hub mount- Bearing mount used to support head rotation servo

1xActobotics 1/2" servo shaft attachment- Hitec servo shaft extension for head rotation servo

1xActobotics 1/2" bore clamping hub- Clamping hub to mount onto 1/2" servo shaft extension

2xActobotics 1/2" clamping hub- Clamping hubs to hold iris eye cups

1xActobotics 6-32 x 1/4" ball links (12 ea/pkg)- Ball links for head and fan servo linkages

1x6-32 stainless steel threaded rod- 12" long threaded rod for making servo linkages

2xActobotics Aluminum servo arms (single)- Heavy duty servo arms for head movement servos

2xActobotics Aluminum servo arms (dual)- Heavy duty servo arms for fan movement servos

1x2-56 ball and socket linkage (pkg 6)- Ball links used to make eye iris servo linkages

1x 10-32 thread male rod end bearing- Bearing for the head neck joint

2x iris apertures measuring 37mm OD x 5mm thick- found them on eBay

Electronics

For the radio I used a FlySky FS-t6 6 channel radio. For under \$60 it's pretty hard to beat for a computer radio. If you wanted to make controlled using an Arduino while wearing it you could do that too!

For the eyes I used a Sparkfun FemtoBuck LED driver to power 2 super bright 3W high power red LEDs.

I used an Arduino Pro Mini to alter the radio signal into something the FemtoBuck could recognize.

Other materials used included lightweight fiberglass cloth, fiberglass resin, ProPoxy20 epoxy putty and a few small high strength magnets (purchased from a local hardware store.)

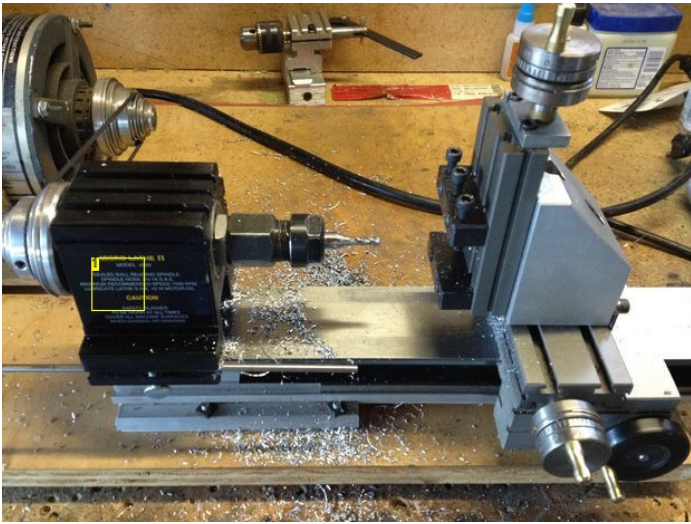


Image Notes

1. Taig mini benchtop lathe with milling attachment

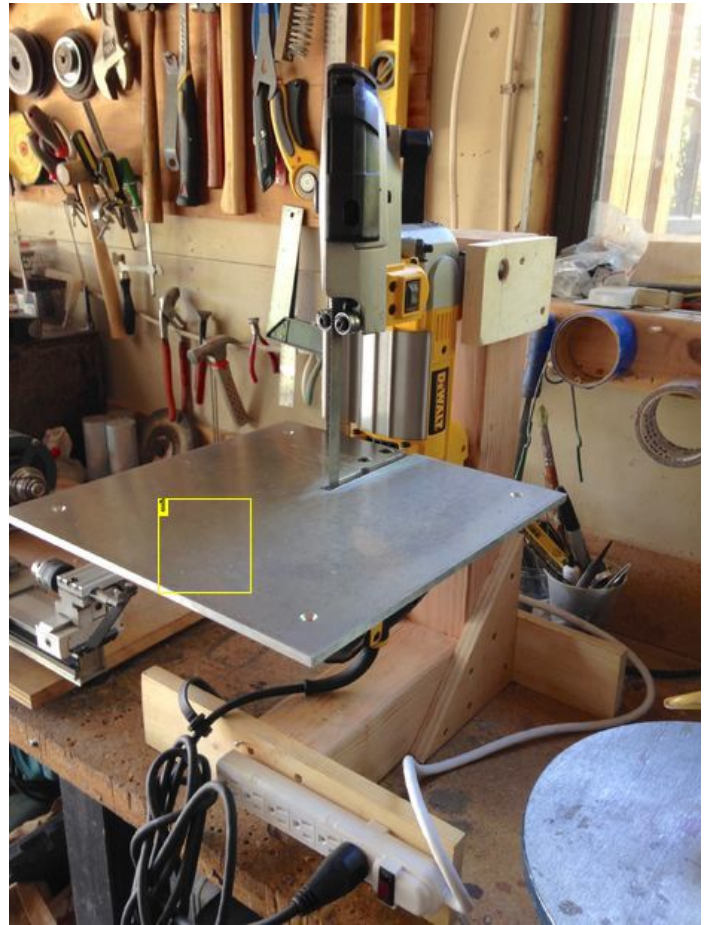


Image Notes

1. Band saw in home made vertical stand



Image Notes

1. Makita mini belt sander



Image Notes

1. 6 Channel programmable computer radio

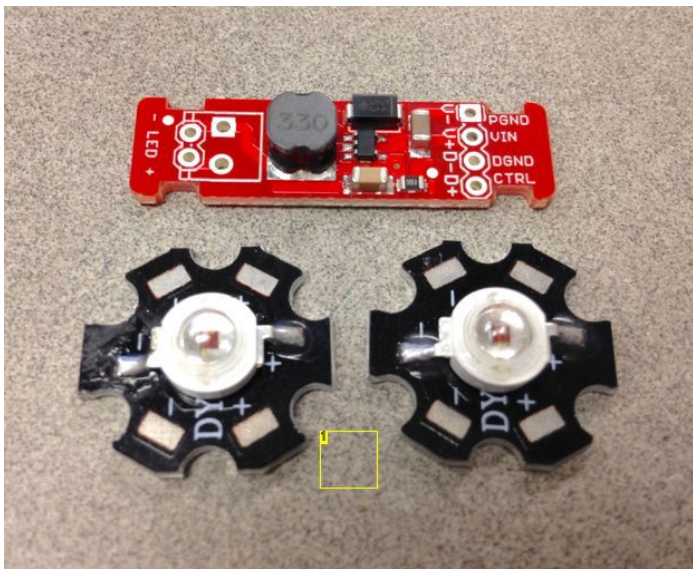


Image Notes

1. FemtoBuck and eye LEDs

Step 2: Helmet castings

When I opened the box containing the helmet castings my jaw almost hit the floor.

My friend owns many screen used Stargate pieces but was missing a few key items in order to make a complete set of screen accurate helmet castings. As luck would have it he hit pay dirt when he was commissioned to restore an original screen used piece and was given permission to pull molds for the few missing items.

Some of these parts were cast from the original movie molds and some were cast from molds pulled from movie production pieces. Some of the molds made for these new castings were even made by the same person that made the original movie helmet molds. Everything was extensively researched and verified- having this set of castings was like walking into the movie production shop in the early 90's and leaving with them in hand!

The last three photos show a mockup of the helmet and a static version with the test paint finish. This mockup has the fixed fans to show placement but the finished version needed to have moving fans. The previous helmet I made had moving fans but the movement was incorrect- I had the center fan fixed and the upper and lower fans moved in opposite directions. On the movie helmets all of the fans moved in the same direction while expanding and collapsing.

The movie helmets are a lot more complex than you would believe. I always thought the movie helmets were a single piece construction but they're actually made of several pieces that are hinged together. While these castings aren't available to purchase I thought I'd share photos of them here for anyone that wants to use them as a reference for making their own helmet.

The quality of the castings sent to me is just phenomenal- easily one of the most beautiful prop replicas I have ever seen. I was definitely a bit nervous cutting into them in order to fit the animatronics!

But before I could cut them up I had a whole lot of metal work to do....



Image Notes

1. Fiberglass head casting



Image Notes
1. Back side of the upper helmet casting



Image Notes
1. Side view of the upper head casting

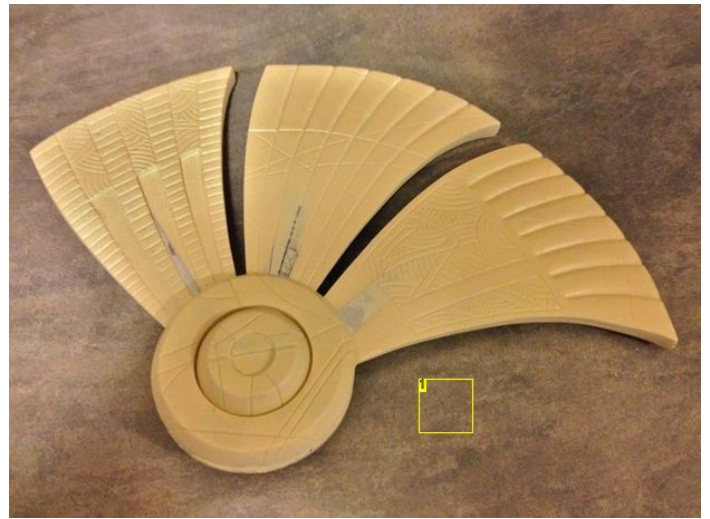


Image Notes
1. Resin casting of the fan blades



Image Notes

1. Mockup of the helmet castings showing final positioning



Image Notes

1. Test paint of a finished casting



Image Notes

1. Test paint of the lower back of the helmet

Step 3: Forward head mechanism

First step- design and build the head mechanism.

The design of this is somewhat similar to the previous one I had made except I needed to add a functioning iris for the eyes, which would take up a lot of space in the head. At the same time I also wanted to improve the range of motion for the head.

The first three photos show the forward head mounting plate. The servo behind the plate allows the head to roll from side to side. The plate is cut from 1/8" thick Aluminum sheet and is bolted to the servo using 6-32 threaded screws and Aluminum spacers. A 1/2" diameter servo shaft extension sticks through the mounting plate.

Attached to the opposite side of the mounting plate is a 1/2" bore bearing support- this takes the bending load off the servo as the head tilts. A 1/2" clamping hub holds the servo shaft to the bearing. There are two bent brass plates that fit underneath the bearing support and these hold the 1/2" bore iris bearing mounts. I cut the brass plates using a bandsaw and bent them to shape in a vise.

At this point the iris cups have not yet been installed. This is a lot more complex than the previous version I made. Even though this screen accurate head is much larger than my previous low budget version there really isn't much room in it and getting everything to fit properly was pretty tricky.

I generally try to use as many off the shelf parts as possible as it makes the build easier and makes repairs simpler/faster since I don't need to re machine pieces if something is damaged. In this regard I use a lot of Actobotics parts from Servocity, in this case the iris bearing mounts, 1/2" servo shaft extension, 1/2" bearing support and 1/2" shaft clamp. The servo is a Hitec HS-645MG.

Next I machined the mount for the eye iris servos. I machined this from a block of Aluminum using a milling attachment on my benchtop Taig lathe. The servo mount is attached to the forward mounting plate using two 6-32 screws. The servos are a pair of Hitec HS-5085MG digital servos. In order to get the proper movement from the servos I installed longer heavy duty servo arms.

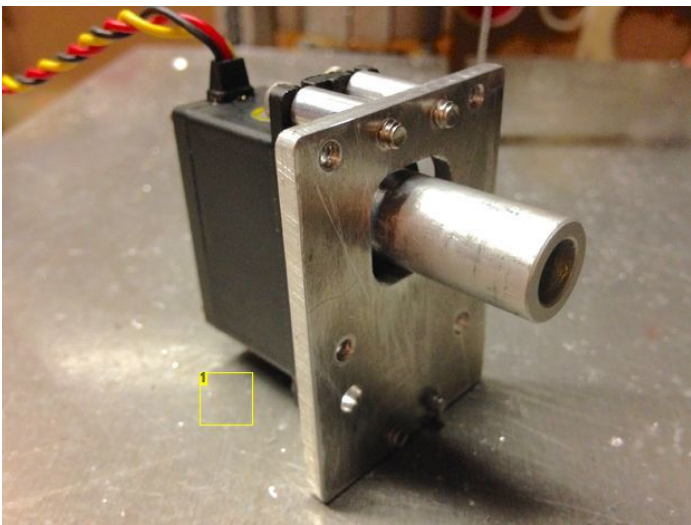


Image Notes

1. Forward head mounting plate cut from 1/8" Aluminum and 1/2" servo shaft extension installed

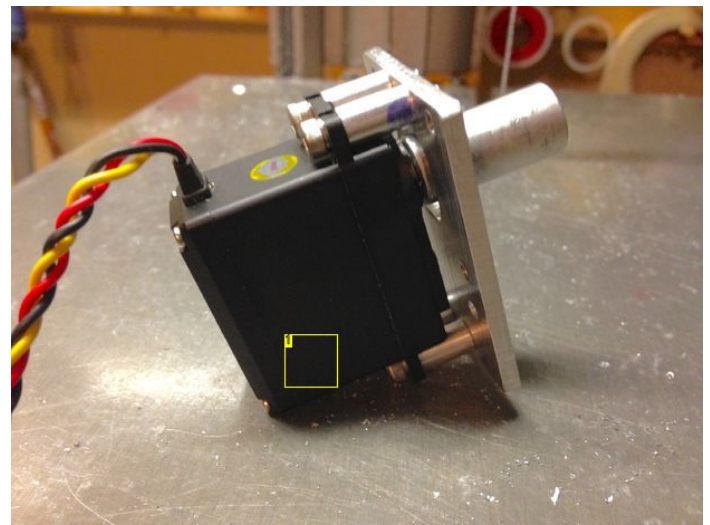


Image Notes

1. Servo is held to the plate with 6-32 bolts and spacers

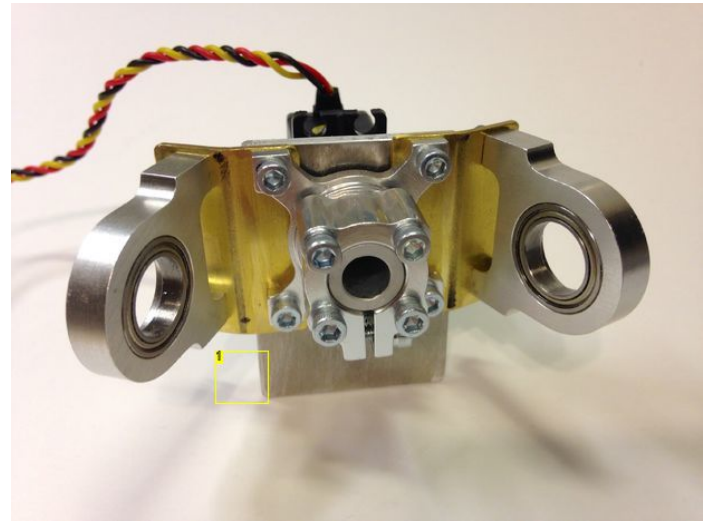
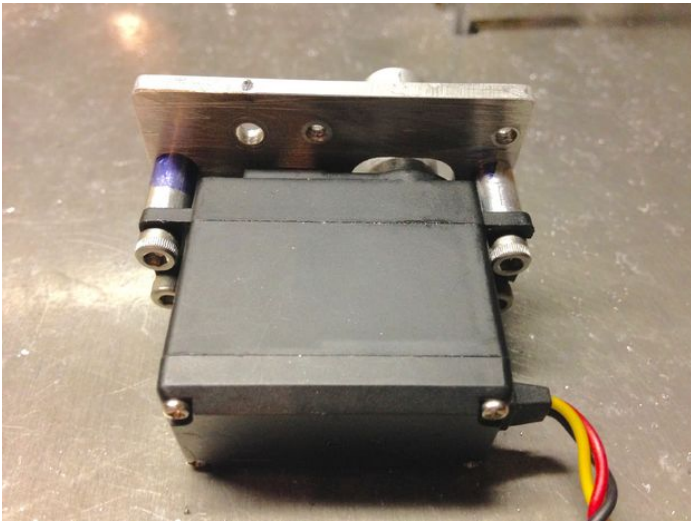


Image Notes

1. Brass plates hold the eye bearing mounts to the forward mounting plate- a 1/2" bore bearing plate supports the servo output shaft and is held in place with a 1/2" clamping hub

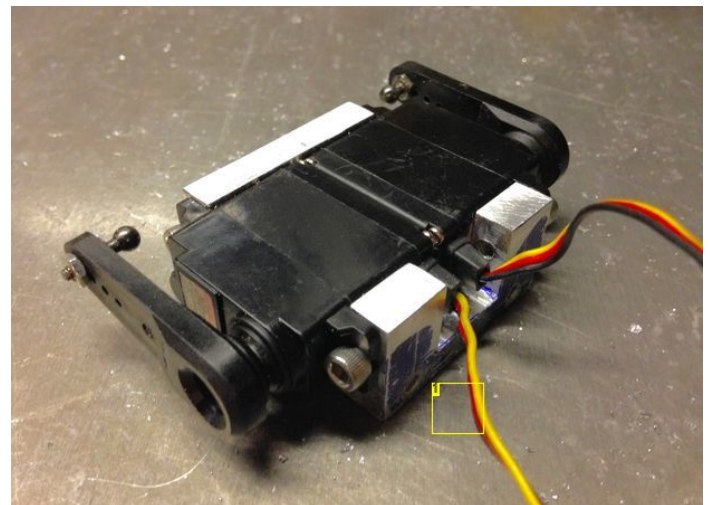
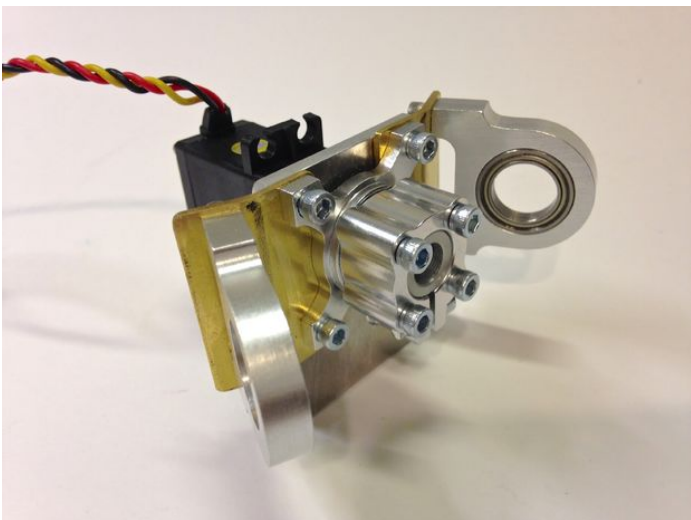


Image Notes

1. Iris servo mount was machined from a block of Aluminum

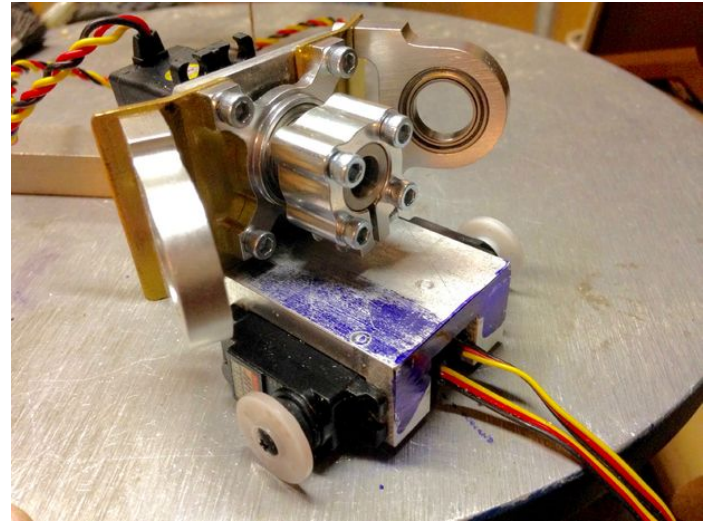
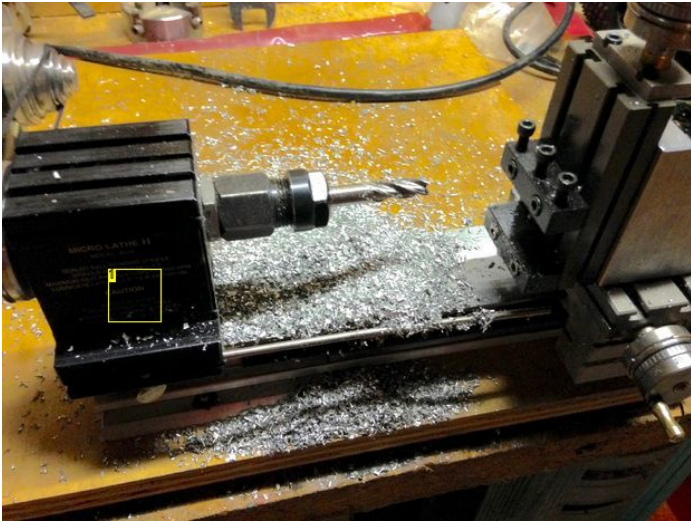


Image Notes

1. Lathe with milling attachment- this was used to machine all of the Aluminum parts

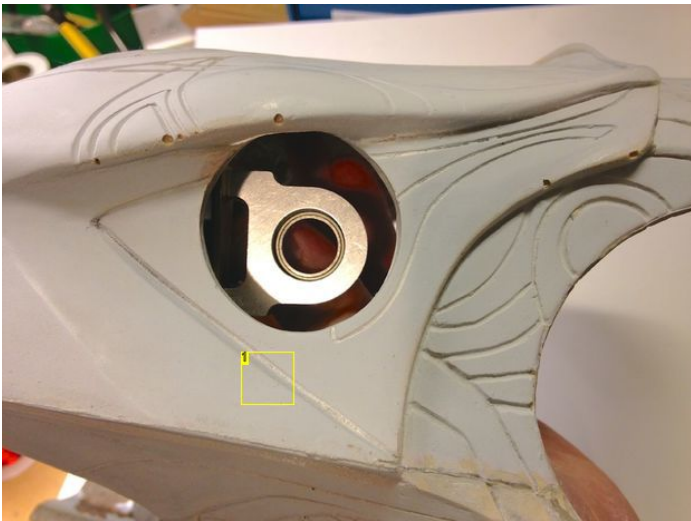


Image Notes

1. Checking the location of the eye pivot bearing in the head casting

Step 4: Eye iris mounts

The original movie helmets had an iris so they had to be in there!

The first pics shows the eye iris apertures. They measure 37mm OD x 5mm thick- perfect size! The iris apertures are available from China via eBay but you can find them in the U.S. from companies like OptoSigma and Thorlabs. The trick is finding one with the correct dimensions and I lucked out with an eBay find as they were a lot less expensive than sourcing stateside.

Full open to full close requires rotating the pin lever 90 degrees. The way I've designed it the pin lever is fixed and the iris body rotates- it's housed in a machined cup that rotates in the bearing mount. I machined the eye cups from solid Aluminum 2" OD round bar stock using the lathe. Each iris is held in place in the cup with three 6-32 set screws. The cup has a shoulder that sits against the 1/2" bearing mount and it's held in the bearing with a 1/2" Actobotics clamp. A small brass arm is attached to each clamp and a short 2-56 ball linkage allows the servo to rotate the iris cup.

Next I made the iris pin retainers. These hold the lever pins in place so as the iris cup assembly is rotated the iris opens and closes. I machined the retainers from Aluminum plate and they are held onto the iris bearing assembly brass plates with 6-32 screws.



Image Notes

1. The eye iris- fully opened and closed

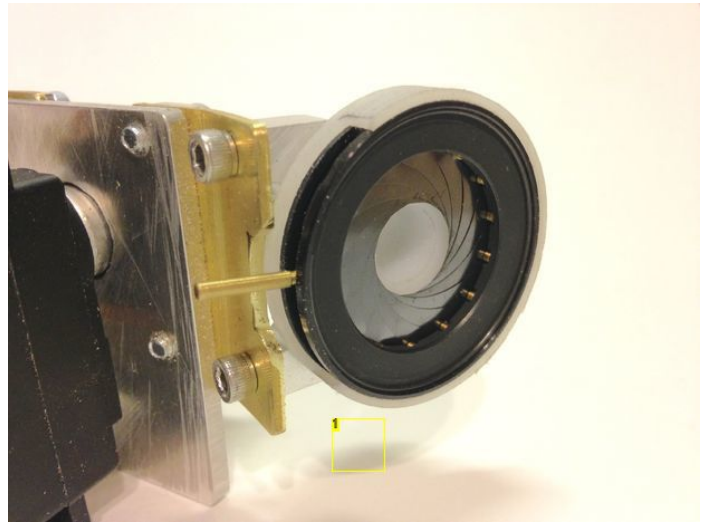


Image Notes

1. Eye iris brass mounting plate- a test iris cup was machined from plastic to check fit

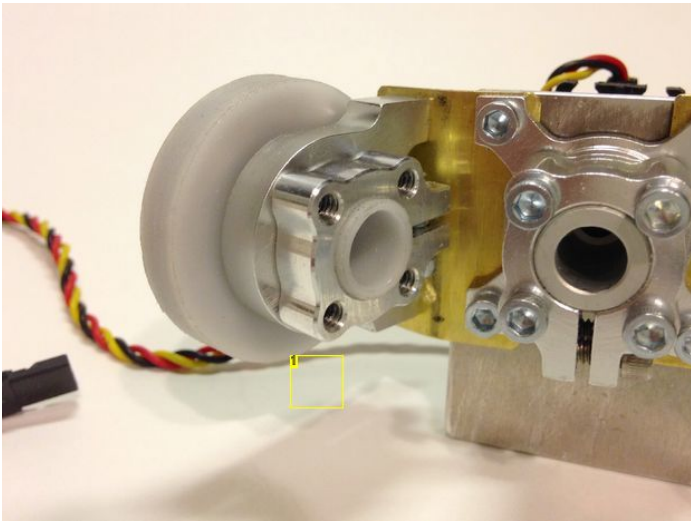


Image Notes

1. 1/2" clamp that holds the iris cup to the bearing mount



Image Notes

1. Turning the outer diameter of the iris cup from 2" Aluminum round stock

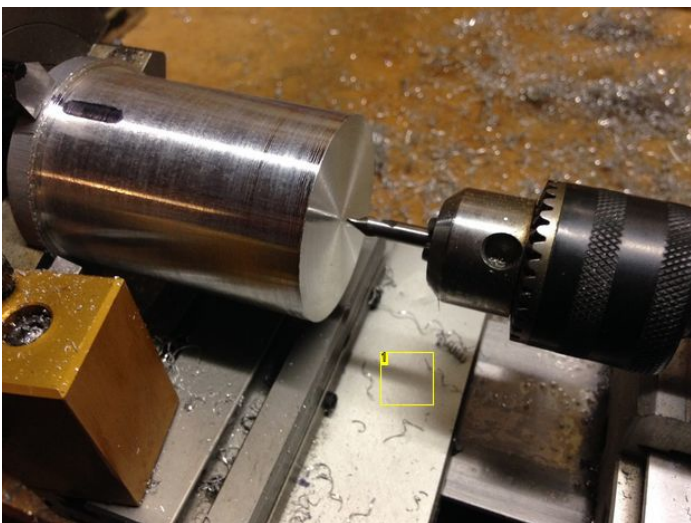


Image Notes

1. Using a center drill to locate the center of the round stock

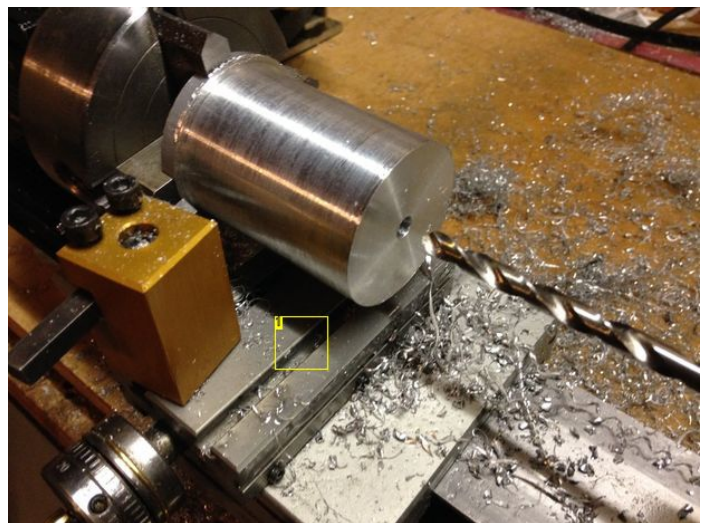


Image Notes

1. Drilling the center of the iris cup

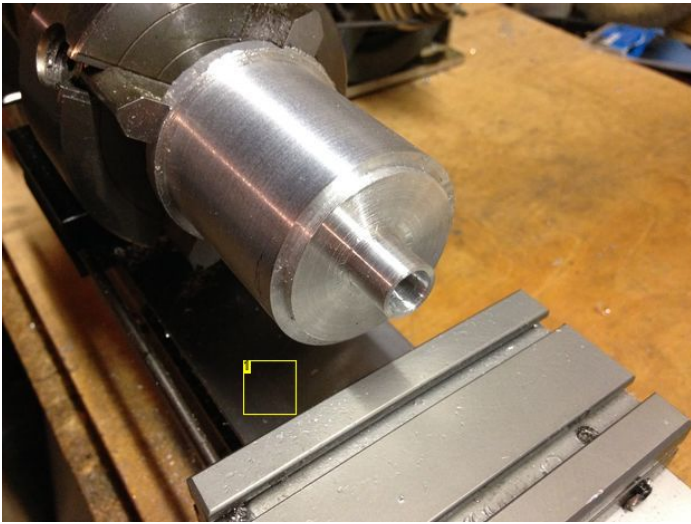


Image Notes

1. Machining the iris cups- this shows the side that fits through the mounting bearing- the LED shines through the hole

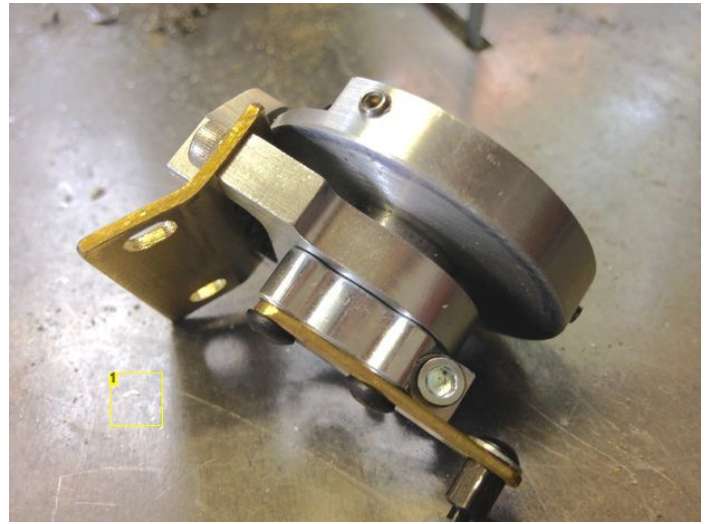


Image Notes

1. Eye iris assembly- 6-32 set screws hold the iris in the cup

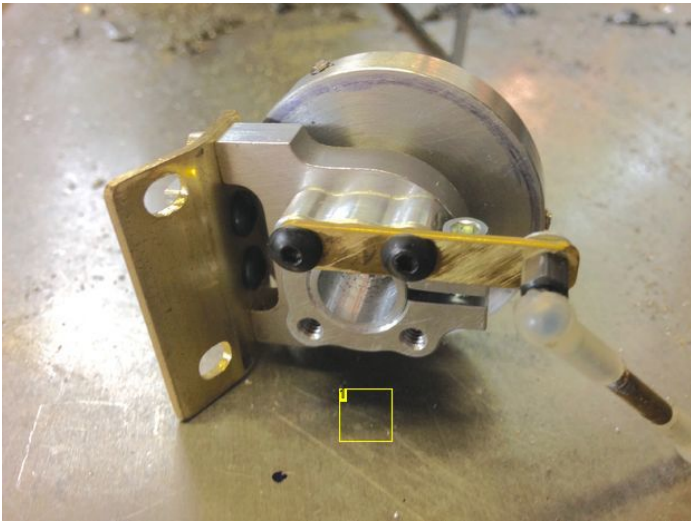


Image Notes

1. Brass arm is bolted to the clamping hub

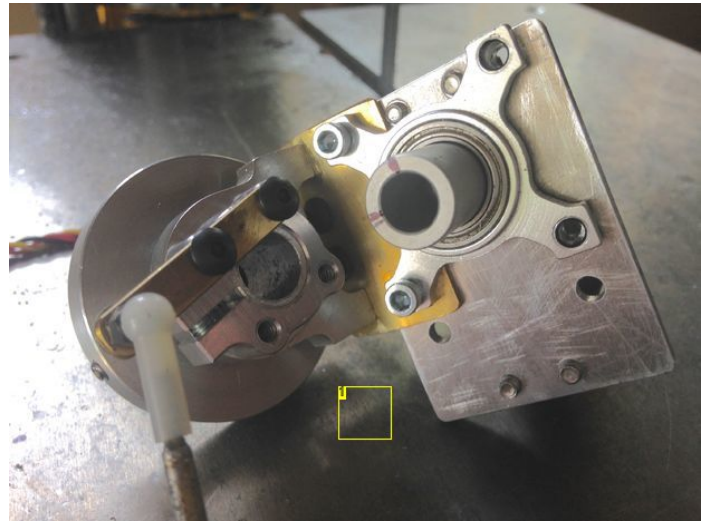


Image Notes

1. Eye assembly attached to the forward mounting plate

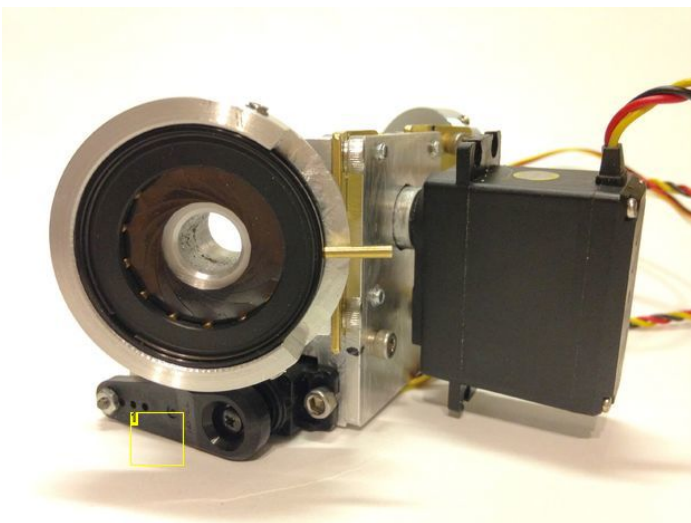


Image Notes

1. Eye iris and servo arm

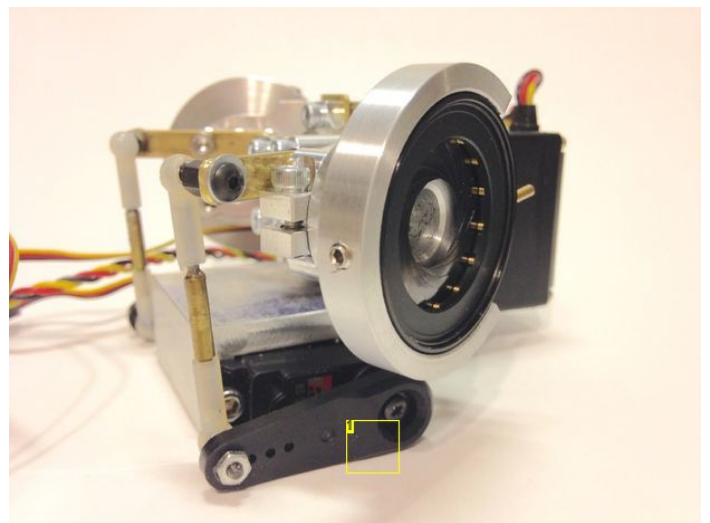


Image Notes

1. Servo arm connected to the eye iris with a ball link

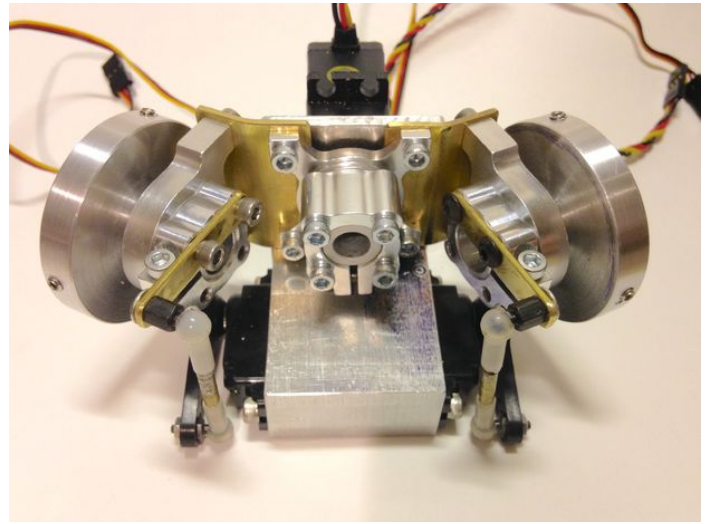
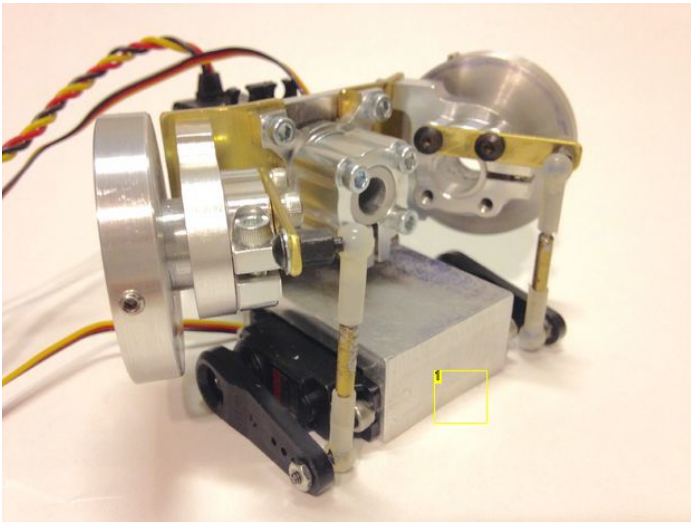


Image Notes

1. Head mechanism with eyes and servos installed

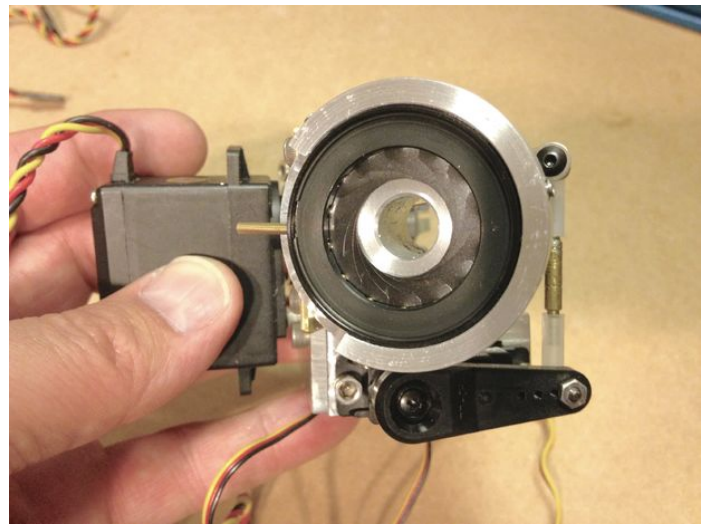
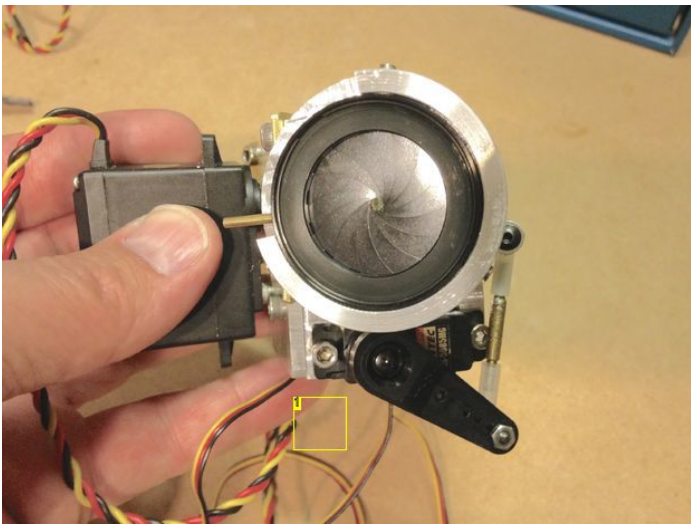


Image Notes

1. Testing the iris movement- fully closed

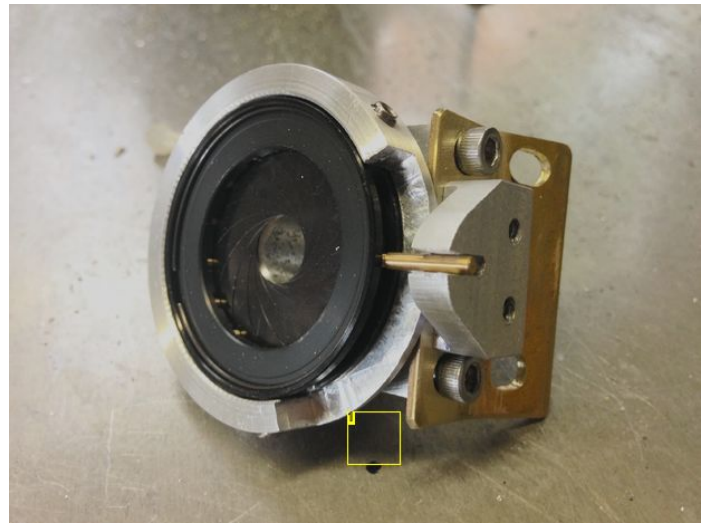


Image Notes

1. Iris pin retainer machined from Aluminum plate

Image Notes

1. Iris pin retainer installed- as the iris cup rotates the iris opens and closes

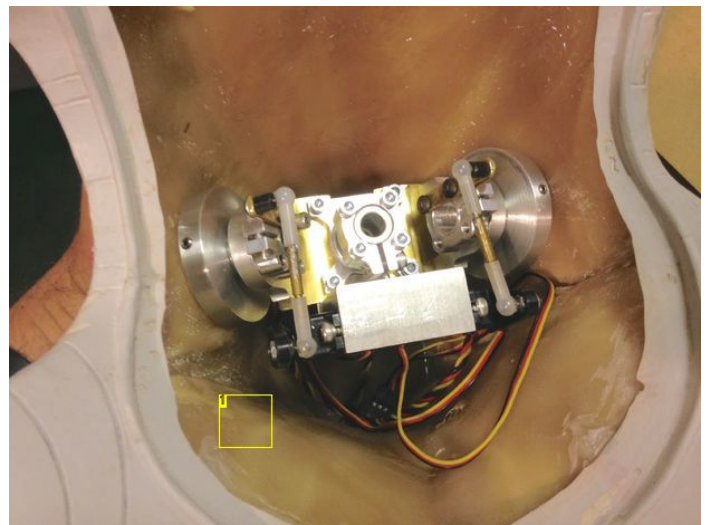
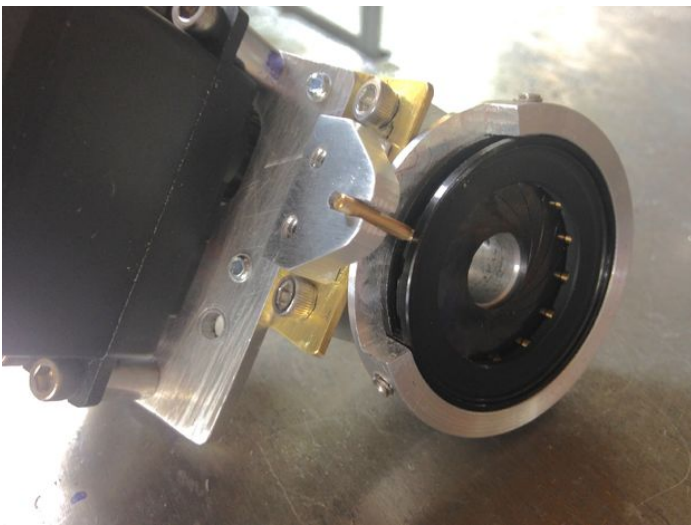


Image Notes

1. Test fitting the head mechanism- perfect fit!

Step 5: Neck pivot and head servo mount

Now I needed to make the head move.

I machined the head swivel (neck joint) joint mount from 1" thick Aluminum plate. This mount is attached to the forward servo 1/2" extension clamp with four 6-32 screws. The swivel joint is a 10-32 rod end and it's attached to the mount with a long 6-32 bolt with machined spacers. The swivel joint allows the head to move up/down and left/right. The 6-32 ball links on the bottom of the mount attach to the servos that make the head assembly move.

The 10-32 rod end is threaded into a 3/8" Aluminum rod and the rod has a machined collar with a 6-32 set screw that holds it in place. The collar is positioned at the top of the main helmet body and moving the rod in the collar allows you to adjust the distance between the body and head castings to get the spacing just right.

The servos that make the head move were mounted to an Aluminum plate using Actobotics servo mounts. The 6-32 ball links are threaded onto Actobotics Aluminum servo arms which are fitted to Hitec HS-645MG servos.

Once I got this assembly together it turned out the servo mounting plate assembly I made was a tiny bit too wide. I could use the current setup if I changed the servo arms and used smaller end links as it would allow me to position the servos closer together but the smaller 4-40 nylon end links have a tendency to break under higher loads. I hate it when things break so a quick re design was necessary.

The last photo shows the redesigned servo mount assembly. I had to flip the servos 90 degrees in order to make it fit properly in the main helmet section- once I did that it was good to go. There is a machined flat area where the servo plate bolts to the 3/8" round rod and the plate is held in place with two 6-32 screws. At this point I still needed to trim the servo arms but that could wait until the final assembly.

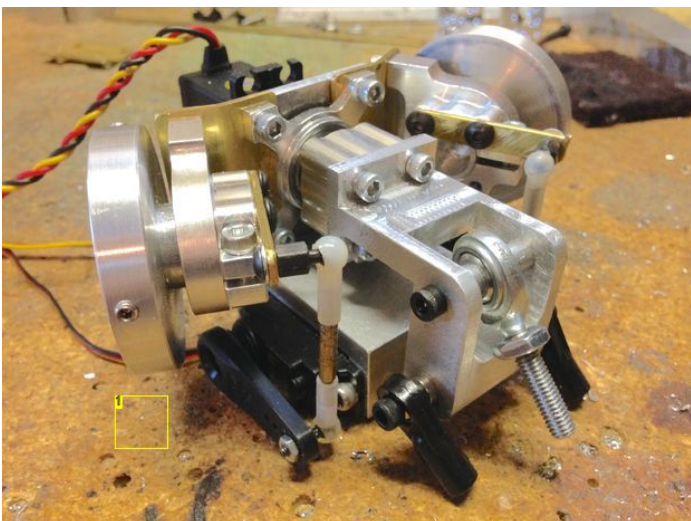


Image Notes

1. Head mechanism with neck pivot mount installed

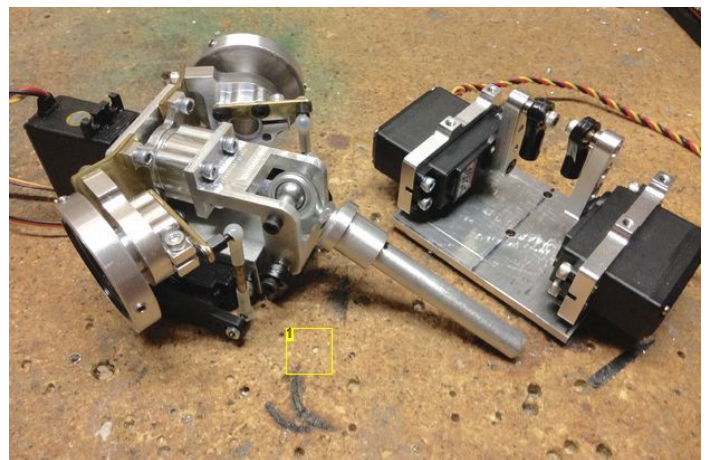


Image Notes

1. Head mechanism with Aluminum rod and collar for mounting in the head casting- this servo mount setup was too wide

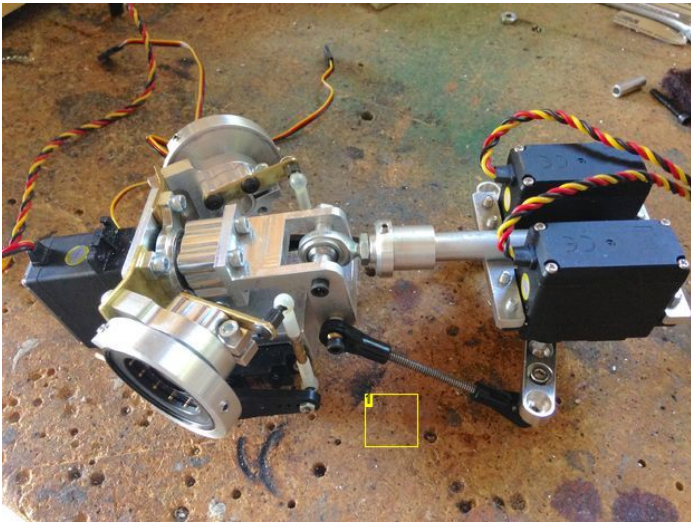


Image Notes

1. The new narrow servo mount showing the servos connected to the neck joint

Step 6: Eye LEDs and electronics

I wanted really bright eyes to shine through the iris.

The LEDs are rated at 3 Watts each (silly bright) and the driver board is a Sparkfun FemtoBuck. The FemtoBuck is a constant current LED driver board that can accept a PWM signal to dim the LEDs -there's a great simple hookup guide on the product page.

Next I made a clear sheet plastic lens, scuffed it with a scotchbrite pad and added some polyfill behind the lens to help diffuse the light and then I placed the lens behind the iris. The LEDs were simply screwed to the 1/2" hub clamps that hold the iris cups in place. I was really happy with how it looked. The pics show the full range of iris motion.

I set up the radio to dim the eyes and poof! Yep- I let out the magic smoke. I accidentally reversed the power wires to the FemtoBuck and smoked the driver chip. I ordered a replacement AL8805W5 chip, removed the blown one using a hot air tool and soldered the new one in. Note to self- **ALWAYS** use polarized connectors!

As soon as I was back in business I set about making the RC radio receiver signal work with the FemtoBuck. The FemtoBuck is able to dim the LEDs by applying a voltage range of .5V to 2.5V to its control pin. The problem is that the RC receiver doesn't output a compatible signal so a fix is needed.

Arduino (Pro Mini) to the rescue! At the beginning of this project I thought I'd finally build something animatronic without an Arduino in it but the little buggar managed to work its way in there...

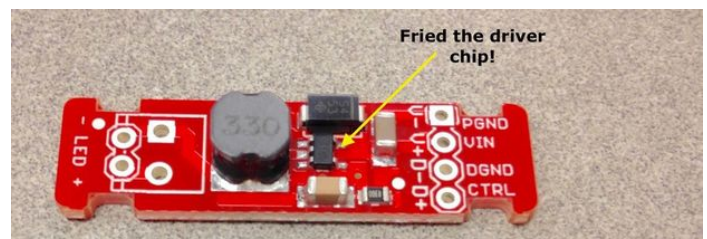
The Arduino takes power and input signal from one channel of the RC receiver. The Arduino output then is connected to the input control pin on the FemtoBuck- simple!

Using this code the Arduino was able to take the output of the RC receiver and turn it into something useful-

```
const int inputPinA = 2; // The pin connected to the RC receiver's servo output A
const int outputPinA = 3; // Output PWM pin A
void setup() {pinMode(inputPinA, INPUT);}
void loop() {unsigned long pulseLength;
pulseLength = constrain(pulseIn(inputPinA, HIGH), 1000, 3000);
analogWrite(outputPinA, map(pulseLength, 1000, 3000, 0, 255));
}
```

And with that I was able to get a full range dimmer for the eye LEDs using the RC transmitter. I also made two battery packs using AA NiMH cells- one 6V pack for the radio receiver, Arduino, head and eye servos and a 7.2V pack for the fan servos and eyes. The reason for this is the fan servos are rated for higher voltage and draw more current and the eye LEDs also want 7V + input power. In order to do this the fan servos are still connected to the radio receiver, but only using the signal and GND wires. The output from channel 6 on the receiver provides +6V, GND and the signal to input pin #2 on the Arduino. The output from the Arduino pin #3 provides the signal to the FemtoBuck to dim the eye LEDs (have a look at the wiring diagram.)

The radio is set up as follows



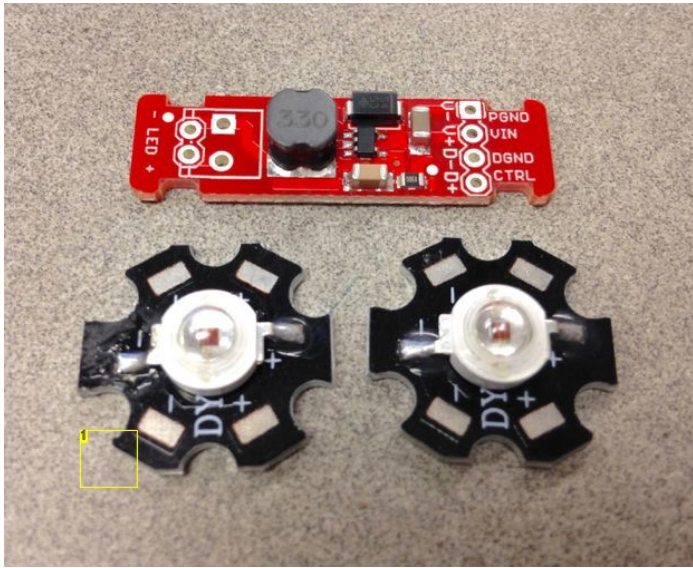


Image Notes

1. Sparkfun FEMTOBUCK and 3W LEDs

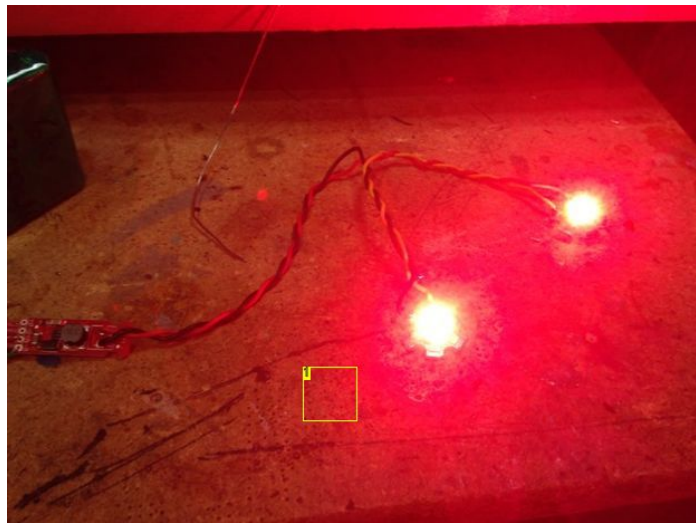
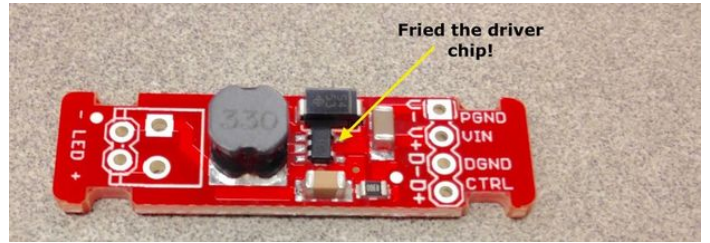


Image Notes

1. Now those are bright!

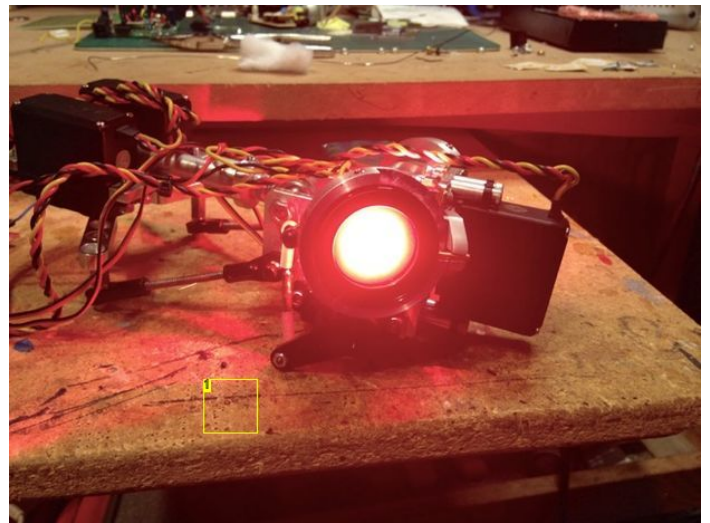


Image Notes

1. Installed LEDs with the iris fully open

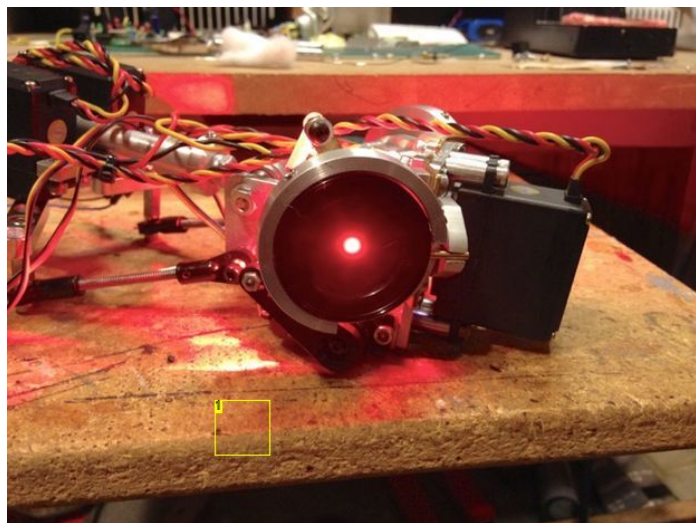


Image Notes

1. Eye LEDs with the iris fully closed

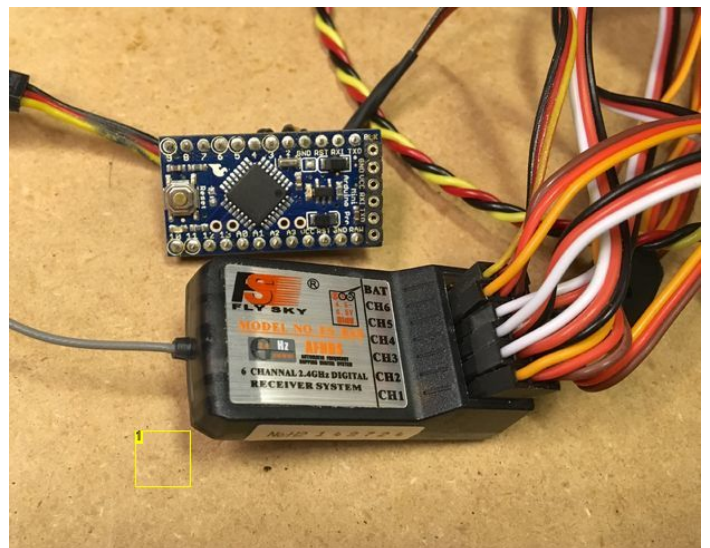


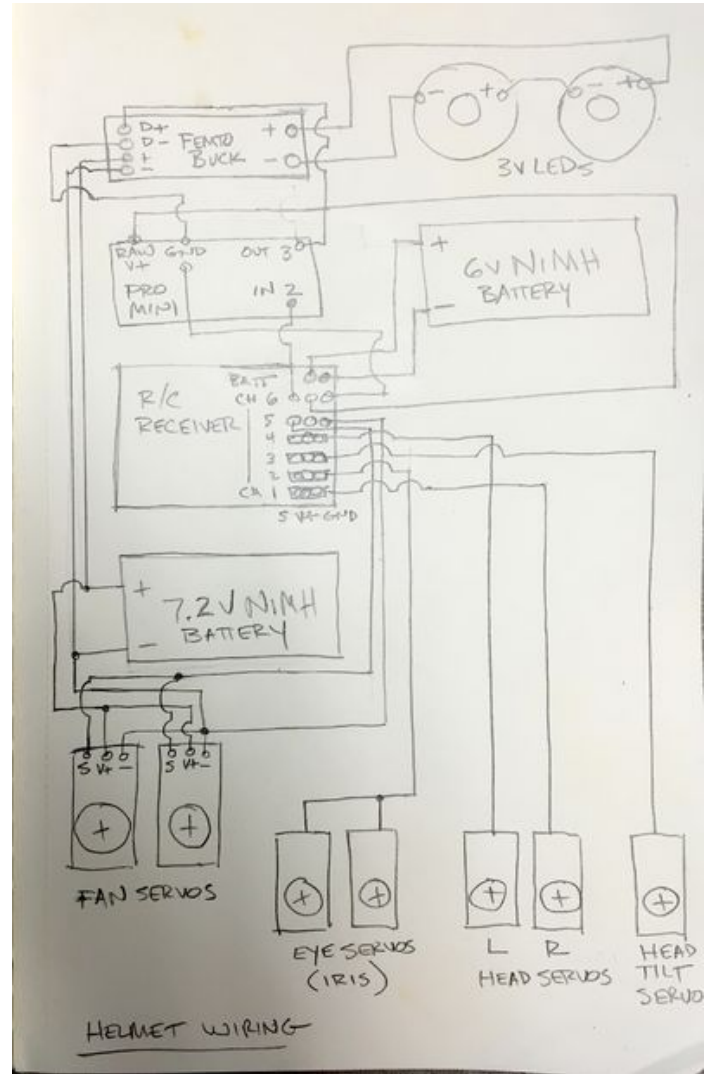
Image Notes

1. RC radio receiver with Arduino Pro Mini



Image Notes

1. NiMH battery packs



Step 7: Fan mechanics

Thanks to some awesome software I got the fan motion just right.

In several scenes in the movie Stargate you can see how the fans on the sides of the Horus and Anubis helmets rotate in a progressive manner, with the upper fan moving the greatest amount and the lower fan moving the least. It's a really cool effect and the set of three fans on either side of the helmet was made to move using a single servo. It's a really compact mechanism.

In order to replicate this I created a kinematic model of the mechanism using a free program from Autodesk called ForceEffect. This is an awesome bit of free software that allows you to plot motions of all kinds of linkage mechanisms. I would have killed for software like this back in the day (20+ years ago) when designing suspension mountain bikes as I used to plot kinematics manually. With ForceEffect I was able to quickly go through several iterations of linkage designs until I was able to get the motion just right. If you want to build any kind of linkage or something like mechanical wings then this program is a real life saver!

The original helmet mechanics used helper springs to overcome the high leverage ratios- I have the benefit of modern digital servos that are much more powerful than the analog servos used when the film was made so I didn't need them and cleaned up the mechanism a fair bit and made it easier to assemble.

Once I figured out the necessary linkage lengths and pivot locations in ForceEffect I began building the fan mechanisms. First I cut the fan arms from Aluminum using a bandsaw, drilled the pivot holes and tapped the holes for the linkage screws using a 6-32 thread tap. Next I cut the servo mounting plates from 1/8" Aluminum sheet. The five holes in the center of the mounting plate are for the Actobotics 1/4" mounting hub that holds the fan pivot shaft. The arms were slid over the shaft with brass bushings in between each arm and a locking collar holds the Aluminum arms on the shaft. Small linkages were made using 6-32 threaded rod and ball link ends.

Once I was sure I liked the range of motion (and nothing was binding!) I mounted the fan blades to the individual arms with two bolts holding each fan blade. At this time I also made the mounting arms that bolted to the servo mounting plate.

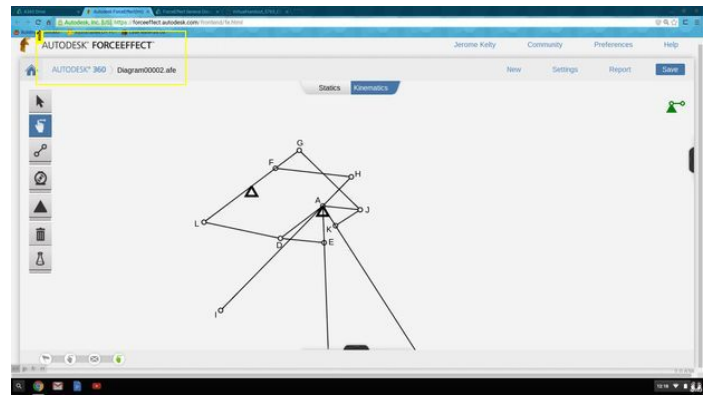
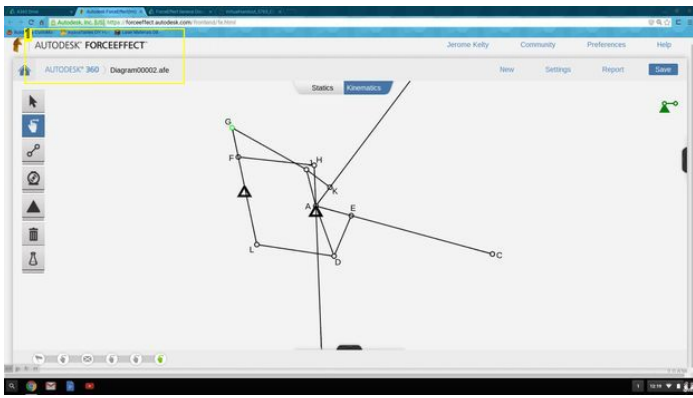


Image Notes

1. Modeling the fan mechanism linkages using ForceEffect- this shows the fans fully open

Image Notes

1. Fan mechanism linkage design showing the fans collapsed



Image Notes

1. Arms for the fan mechanisms- these rotate around the main pivot and are bolted to the fan blades

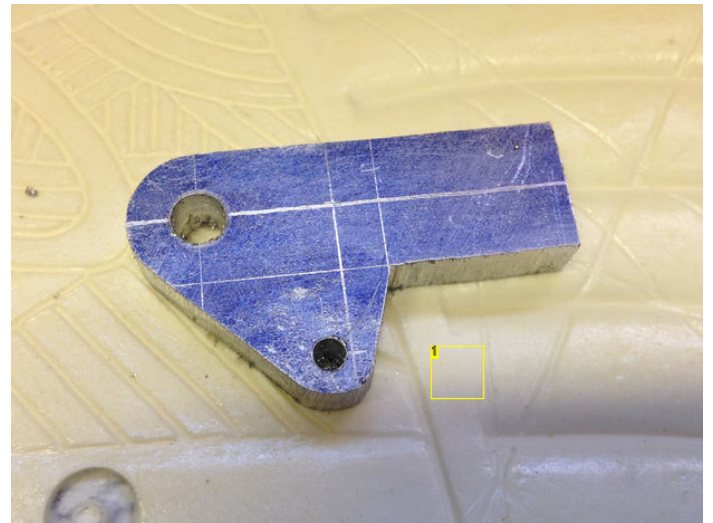


Image Notes

1. Closeup of one of the fan mechanism arms- the blue dye helps when marking out the pattern on Aluminum sheet

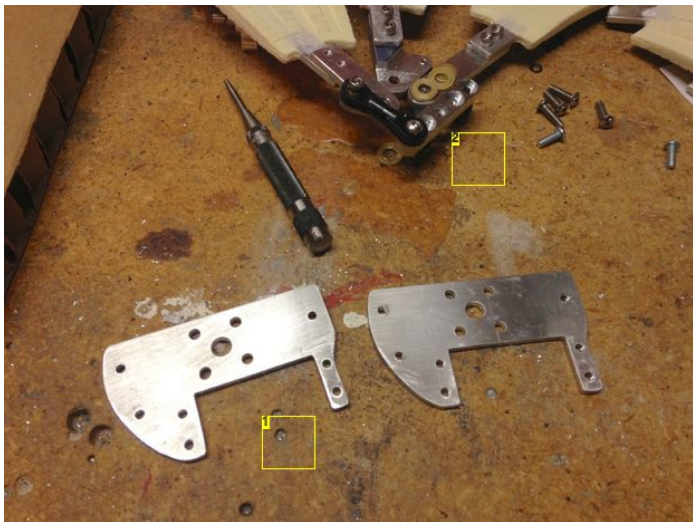


Image Notes

1. Servo mounting plates for the fan mechanisms
2. Fan mechanism arms with brass washers

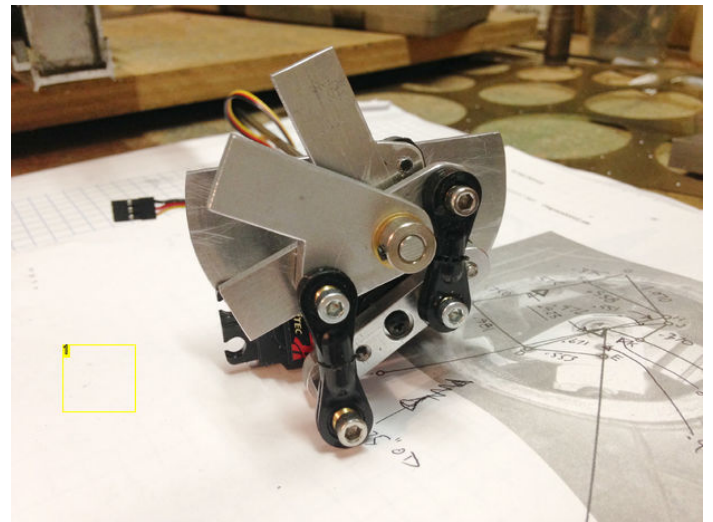


Image Notes

1. Finished fan mechanism in the collapsed position

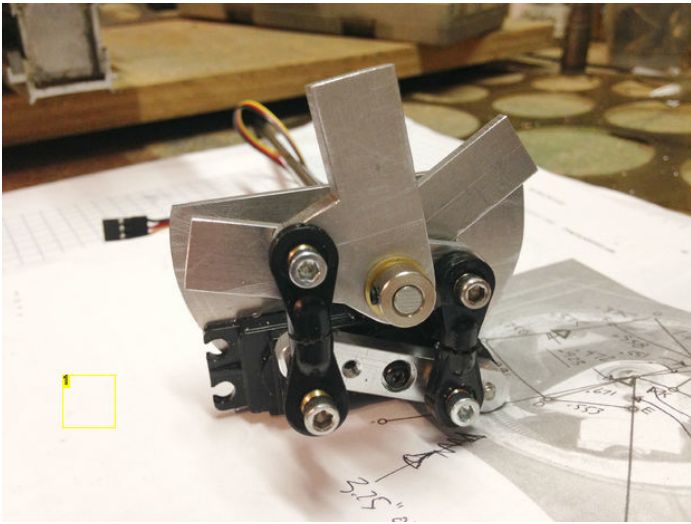


Image Notes

1. Finished fan mechanism in the fully open position



Image Notes

1. Cat resin fan blade with Aluminum arm insert



Image Notes

1. Finished mechanism with fans mounted

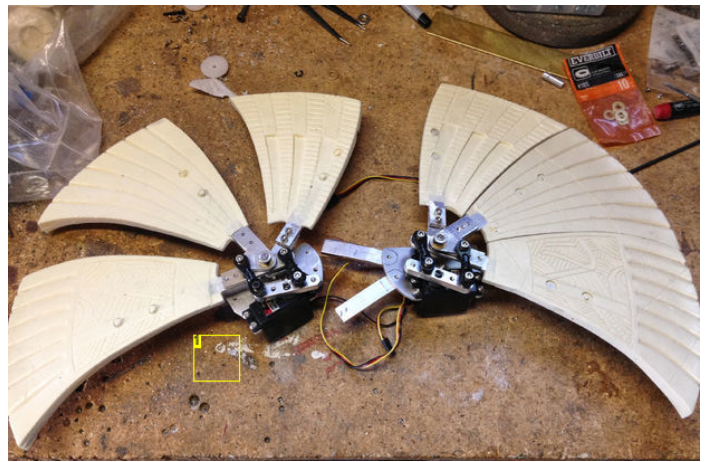


Image Notes

1. Finished fan mechanisms with mounted fans- making the Aluminum arms for mounting in the helmet

Step 8: Fan assembly

Mounting the fans to the helmet was tricky.

Once I got the fan mechanics finished I had to install them in the helmet, which was really hard because they needed to be perfectly aligned with each other and there is a separate angled piece that fits in between the fan blades and the side of the helmet that also had to be aligned correctly. In order for the fans to work and look right the fit needed to be perfect.

I secured the Aluminum fan mounts to the inside of the helmet. I found the best way to do this was to use some ProPoxy20 epoxy putty (great stuff!) to hold the mounting arms in place and then once the putty set I reinforced the joint using some fiberglass cloth and resin.

To fit the fan mechanism caps I had to hollow out the solid resin castings and then reassemble them with magnets and also a locating tube epoxied in. The tube inside the fan cap slides over the fan mechanism retaining collar and the magnets touch the two locating screws, holding the cap in place. I also had to fit some brass trim strips that cover the gaps underneath the caps. Once I got all of this done I realized the linkages that drive the fan blades were too large so I had to make new lower profile links from brass sheet in order for the caps to fit correctly.

I also made some brass "fingers" from sheet stock that covered the open gap that was present as the fans moved up and down- just like the original movie helmets.

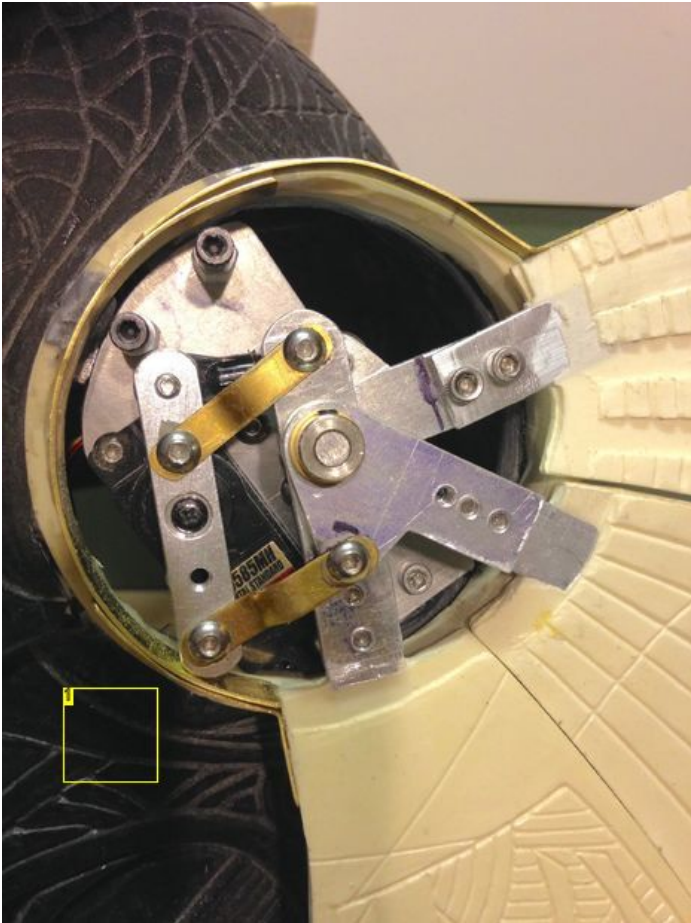


Image Notes

1. Left side fan mechanism with new brass linkages installed- note the button head screws to save space

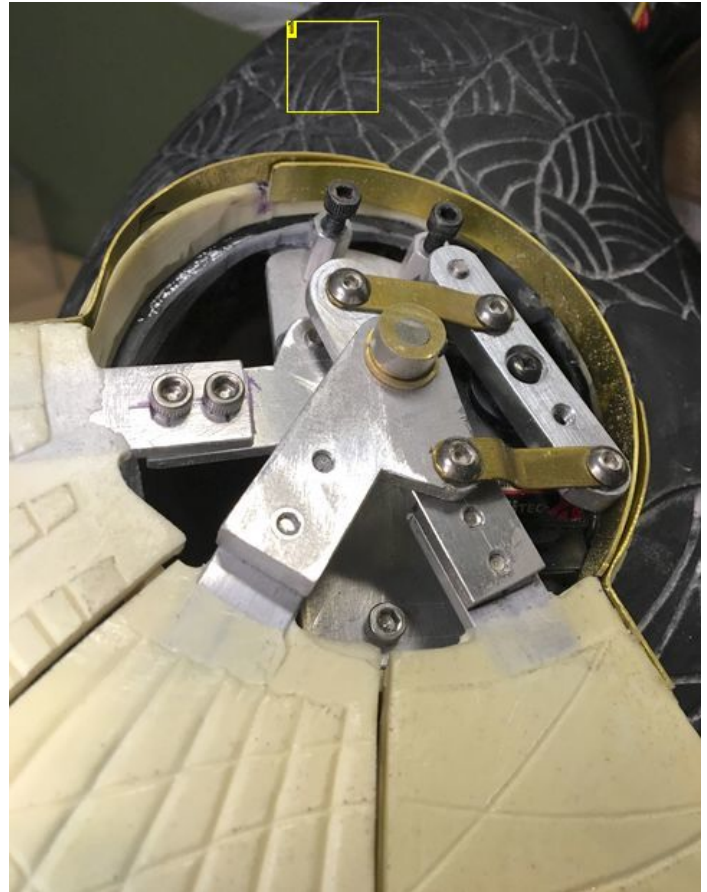


Image Notes

1. Brass strips and sliding fingers and the two screws that the magnets attach to



Image Notes

1. Fan mechanism arms attached to the inside of helmet with epoxy putty and reinforced with fiberglass cloth

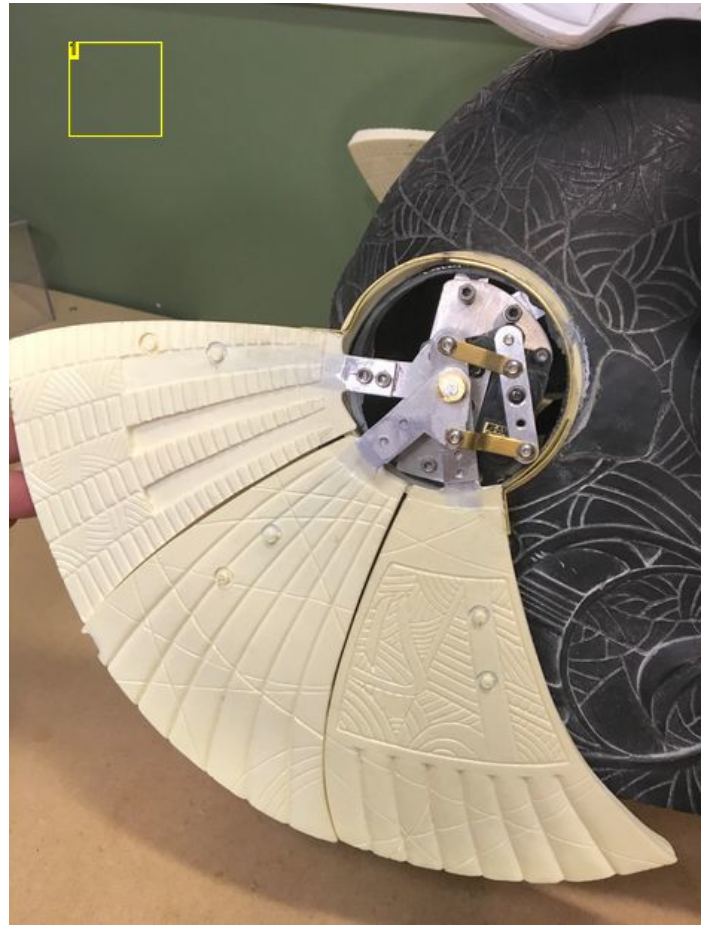


Image Notes

1. Installed fan mechanism with fans in lower position



Image Notes

1. Solid resin fan cap casting

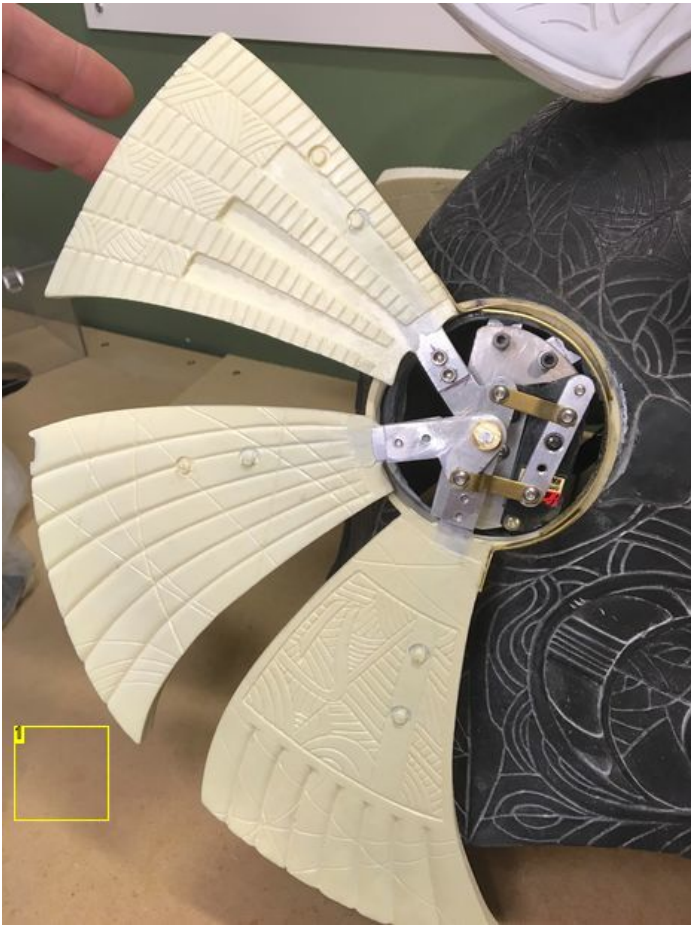


Image Notes

1. Fans in fully extended position



Image Notes

1. Fan mechanism cap needed to be hollowed out using the mini belt sander and taken apart for proper clearance

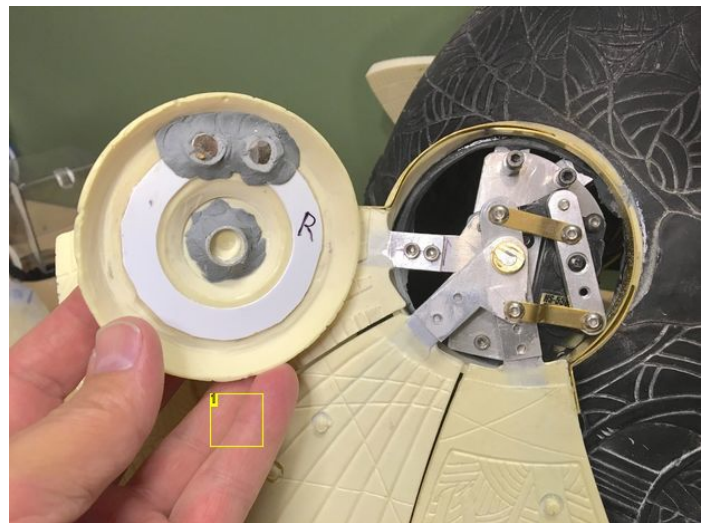


Image Notes

1. Back of the fan mechanism cap showing the centering tube and magnets



Image Notes

1. Installed fan caps

Image Notes

1. Backside of the fan mechanism and caps showing the brass fingers

Step 9: Head assembly

Final assembly!

With the fans installed and moving correctly I mounted the head mechanism by drilling a large hole at the nose of the helmet casting and using epoxy to secure the machined Aluminum collar I had made. I attached a stainless steel mounting plate to the forward head mechanism to hold the head casting but it proved to be too flimsy so I replaced it with a much thicker piece cut from brass sheet.

I drilled two holes in the brass sheet that mated up with two screws mounted to an Aluminum plate inside the head. The Aluminum plate was first attached inside the head with some ProPoxy20 and then reinforced with fiberglass cloth and epoxy resin. With this system the head could be removed by simply unscrewing two thumbscrews.

Unfortunately once I got the head mounted I realized the head now sat too low and too far forward! I had to machine a new Aluminum neck joint mount that raised the head up and moved it back a bit. Once I got this done the head sit just right.

And with that final bit the project was finished! This was one of those projects that took a really long time to do but it was so worth it in the end and my friend was overjoyed with the results. I also learned a lot doing it.

I hope you liked reading this and are able to apply some of this to your own costume or animatronic project. If there are any questions please don't hesitate to ask!

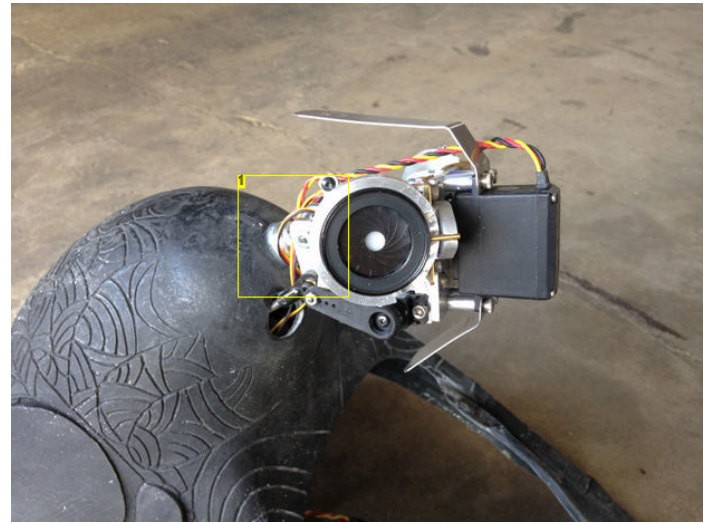
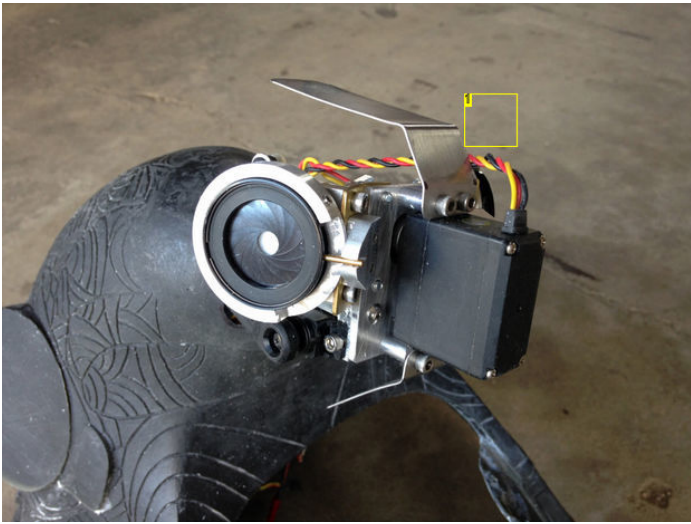


Image Notes

1. Fitting the head mechanism- the upper steel plate was later replaced

Image Notes

1. Here you can just see the collar epoxied into the helmet casting



Image Notes

1. These two servos move the head up/down and left/right

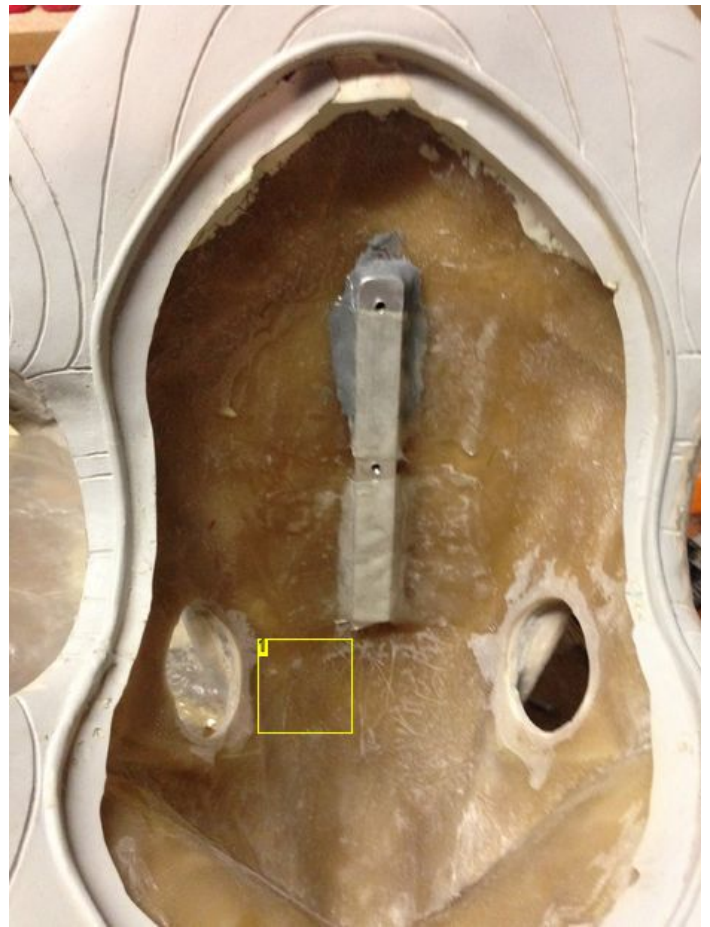


Image Notes

1. Aluminum mounting plate inside the head is held in place with epoxy putty and fiberglass cloth

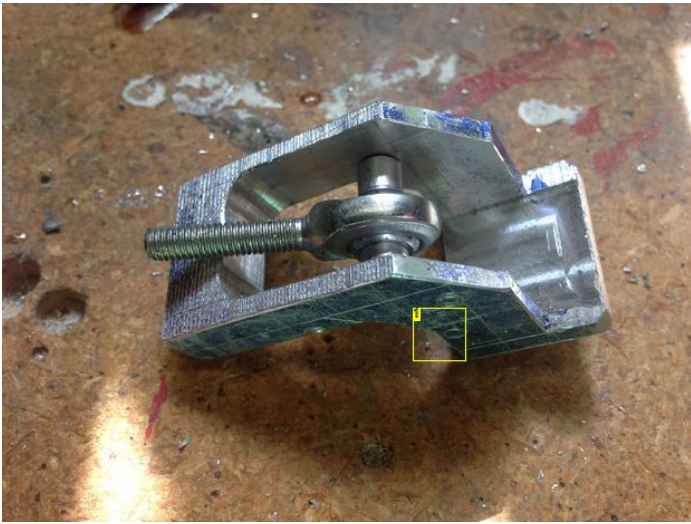


Image Notes

1. The new neck mechanism joint machined from a single piece of 1" thick Aluminum on the lathe using the milling attachment

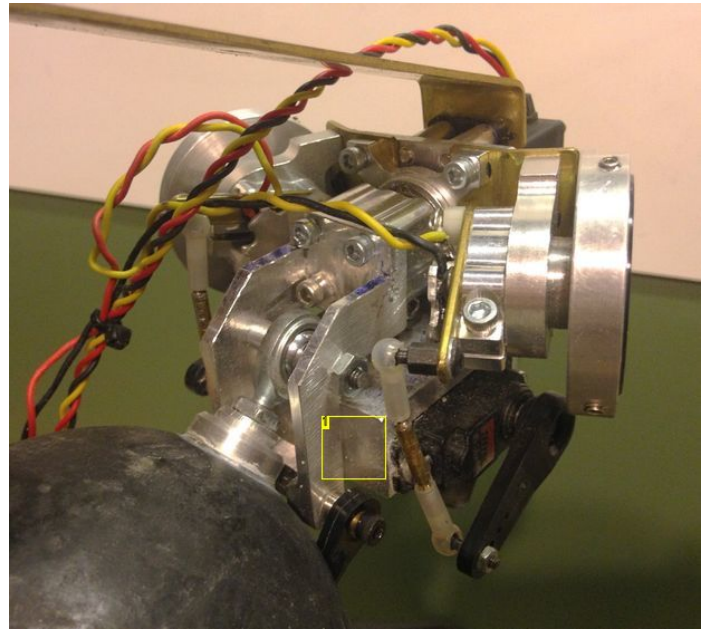


Image Notes

1. The new neck joint mounted in place and the upper brass mounting plate installed

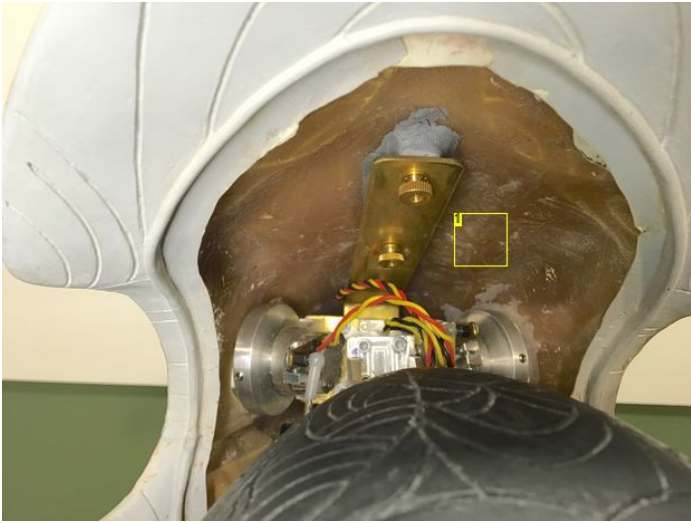


Image Notes

1. Two thumbscrews hold the head in place



Image Notes

1. The helmet after everything was installed



Image Notes

1. The helmet with finished animatronics

Related Instructables



Animatronic Stargate helmet
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How to create simple animatronics-part one: using the MAKE
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Spolovinkin says:

Thank you very much. Great idea and perfect solution. This is awesome

Aug 12, 2016. 9:38 AM [REPLY](#)