Building a Floating Binocular Mount

Version 1.0

This document describes how you can build a floating binocular mount.

What is a floating binocular mount? It's a device that helps you use very large, heavy binoculars as if they were much lighter. Unlike other binocular mounts, which restrict the binoculars' movement, the floating mount allows complete freedom of movement in three dimensions plus vertical and horizontal aiming. It's as if the binoculars were made weightless.

The floating mount employs a parallelogram frame, but in a different way from other parallelogram mounts. Other parallelogram mounts allow motion in only two dimensions, up/down and around the central pivot. The floating mount also allows motion towards and away from the central pivot. This is possible because the binoculars and counterweight are not mounted directly on the parallelogram, but on separate bars connected pivotally to the ends of the parallelogram. The binoculars and counterweight move in opposite directions as the frame is opened and closed. The dimensions of the frame are carefully designed so that the binoculars and counterweight remain perfectly balanced around the central pivot.

With other parallelogram mounts, you balance the binoculars by sliding the counterweight along a bar. This is not possible with the floating mount because there is only one point on the frame where the counterweight will properly balance the binoculars in all positions. Instead, you balance the binoculars by adjusting the size of the counterweight. The counterweight is comprised of multiple small weights on a bar that is at right angles to the frame. It works just like an adjustable barbell (in fact, small barbell weights make an excellent counterweight system).

You can think of the letter Z as a model for the frame. The diagonal of the Z is doubled, and is the parallelogram. The binoculars are at one end of the Z, the counterweight at the opposite end. The frame is supported at the center of the diagonal. In order for the frame to balance, the binoculars, counterweight, and center support must always be in a straight line.

There is a second, smaller frame attached to one end of the main Z frame that holds the binoculars. This smaller frame allows the binoculars to be pivoted horizontally and vertically. It is designed so that both the horizontal and vertical pivot points coincide with the balance point of the main frame. The entire structure remains perfectly balanced no matter where the binoculars are pointed. The binoculars need to have a tripod attachment, ideally a sliding central bar attachment or else a well balanced L bracket.

The main parallelogram is supported by a pier-like mount. In earlier versions, I tried to use a camera tripod, but there was a constant problem with the parallelogram bumping into the tripod legs. The pier has inner and outer sections allowing the height to be adjustable. Three legs at the bottom of the pier fold out providing a wide base of support.

The best way to use the floating binocular mount for astronomy is to sit in a reclining chair with the mount directly behind you. This gives you maximum freedom of movement in all directions. You can scan from horizon to zenith, and pan 180 degrees left to right. The central support should be at about the same height as your head and about one foot behind it.

If you have carefully balanced the mount, you can let go of the binoculars and they will stay in position. There are knobs on all the axes that let you lock the binos in position, but it is best to leave all the knobs loose. The mount is not intended to be rigid like a telescope mount. Instead, the idea is to leave everything loose so that if the binoculars are bumped, they will jump to a new position without vibrating.

Materials and Tools

I highly recommend using aluminum for most of the components. Aluminum is strong and lightweight, practically indestructible, free of defects, reasonably easy to cut and drill, can be bent, and is available in a huge variety of shapes and sizes. With redesign, it could be made of wood, but would not be as compact, lightweight and durable. Metal bars, tubes, and plates can be found at yards in major cities or online from Coremark, Online Metals, and others. Fasteners and other small parts that cannot be found at local hardware stores can be ordered from McMaster-Carr.

Besides hand tools, the one power tool that is indispensable is a drill press, ideally a floor mounted drill press with a vise on the table. For cutting aluminum, a bandsaw is very helpful, particularly a small horizontal bandsaw like those sold by Harbor Freight, Northern Tool, and others. Some parts require bending aluminum bars. This can be done by brute force around cylinders of suitable diameter, but is much easier if you have a metal bending tool like those sold by the same vendors.

These plans are based on simple operations on off-the-shelf parts and do not require any elaborate machining using a lathe or milling machine or 3D printing, casting, welding or brazing. You don’t need to be a machinist to build this, but you should have enough skill working with metal to cut and drill accurately. To avoid problems, please proceed with construction in the order described here.

You will notice some extra holes in the photos which are not used for anything. This is because there was a lot of experimentation during the construction of the mount.

Construction Overview

These plans are designed to support binoculars of any size up to 100 mm diameter and weighing up to 10 lbs. If overloaded, the mount will flex and not balance as well, and the bolts at the corners of the parallelogram might bend.

The mount consists of 3 main parts: the parallelogram, the binocular frame, and the pier. I suggest constructing the binocular frame first, then the pier, and finally the parallelogram. With any project, it’s a good idea to do the most difficult part first, so that if it fails, you won’t have wasted a lot of time on the other parts. I think the binocular frame is the most difficult part since it involves bending aluminum which can be tricky. The parallelogram comes last since it is easier to precisely balance it if the other parts are finished.

Binocular Frame

The binocular frame is designed to provide unrestricted movement for at least 90 degrees horizontally and vertically for large (up to 100 mm diameter) binoculars. It includes a vertical balance adjustment and relies on the binoculars' sliding center post or L bracket for balance in the horizontal direction. There are knobs to adjust the friction in both directions. The binocular frame can be separated quickly from the front end of the parallelogram.

The binocular frame consists of an upper part and a lower part. The upper part is connected to the parallelogram. The lower part supports the binoculars. The upper and lower parts are connected by pivots at the sides. These pivots provide the vertical aiming of the binoculars.

To keep the mount perfectly balanced, it's important that the binocular frame not flex under the weight of heavy binoculars. For this reason I built the main horizontal parts of the frame using square tubes instead of flat bars. The sides of the frame are not under twisting stress and it was easier to make them out of flat bars. This also made it easy to bend the corners which avoids bumping into a sharp corner in the dark.

The side pivots joining the upper and lower parts of the binocular frame are important balance points. The binoculars should be positioned so that they can be tilted vertically and stay in place without added friction. Also, the side pivots need to be in a straight line with the counterweight and the central frame support in order for the entire mount to balance.

In order for the binoculars to balance within the frame, there needs to be easy adjustments vertically and horizontally. For horizontal adjustment, I rely on the sliding center post that is incorporated into most binoculars of 80 mm or larger. If the binoculars have only an L bracket, it needs to be well balanced, if necessary by drilling another hole or making a new bracket or extension or adding a counterweight.

Designing a vertical adjustment that was quick and easy and not too difficult to build was one of my biggest challenges. I solved it by relying on the natural "springiness" of aluminum. There is a long curved section of aluminum bar that extends forward under the binoculars. This acts as a spring, and needs to be large enough so that the binoculars can be adjusted up and down without permanently distorting the bar. The vertical adjustment is made by turning a small bar knob that runs along a long bolt at the back end of the bar. A second, tighter curve in the bar connects it to the bottom part of the frame. A bolt and knob through this tighter curved part make it possible to adjust the friction for side-to-side binocular movement.

Let’s start with the spring bar that supports the binoculars. This is likely to be the most difficult part of the entire mount to make. That’s because it can be difficult to get the bends in just the right position, even when using a metal bending tool as mentioned above. The sequence of steps described below should maximize your chance of success.

If you are using the Compact Bender as sold by Harbor Freight, you should use one of the round dies on the bending arm, not just the pin. If you try to bend using only a pin, it can drag the workpiece away from the square block causing an inaccurate bend.

Cut a 24” long piece of 1.5” by 1/8” aluminum bar. Bend one end around a 1.25” diameter cylinder. Start the bend 3” from the end, and bend it a full 180 degrees. Since aluminum springs back after you bend it, the finished bend will be slightly larger than 1.25”. Drill two ¼” holes through both sides of the 180-degree bend at once so the holes match up exactly. One hole should be ½” from the end of the bar, the other 2-1/4” from the end. Enlarge only the two holes on the shorter side of the bend. The hole nearest the end of the bar should be enlarged to 19/64” so the head of a carriage bolt will jam into it. The other should be enlarged to 3/8” so a long carriage bolt will fit loosely.

In the straight unbent end of the bar, drill a 13/64” hole 2-1/2” from the end. Thread this hole for a ¼-20 screw thread.

Bend the straight end in the same direction as the bent end around a 3” diameter cylinder. Start this bend 7” from the end. Stop this bend at about 150 degrees or when the gap inside the bend is about 7 inches after the force on the bar is released. We are not bending a full 180 degrees because we want some spring left in the bar when the sides are parallel.

Now comes the crucial final hole, which holds the head of the long carriage bolt that makes the height adjustment. We want this hole to be in a straight line with the two holes already drilled nearest the sharp bend when the sides of the bar are parallel. Bend the bar by hand until the sides are parallel, then clamp it in this position. Mark the position on the long end of the bar that is in line with the two holes. You can do this by sighting through the two holes or by sticking a long bolt or rod through the holes. Ideally, this third hole position will be about ½” from the end of the bar, though the exact position doesn’t matter. Drill a 19/64” hole at this position.

To complete the height adjustment mechanism, insert a 5” long ¼” carriage bolt into the 19/64” hole near the longest straight end of the bar while the bar is clamped with the sides parallel. Thread a nut and lock washer most of the way onto the bolt. Push the long bolt through the 3/8” hole and ¼” hole near the other end of the bar. The carriage bolt should protrude about an inch from the ¼” hole near the sharp bend. Spin a ¼” threaded female “through” knob onto this end. If everything works right, you should have about 2 inches of vertical adjustment by turning the knob. Finally, tighten the nut and lock washer on the head end of the carriage bolt to jam the head into the 19/64” hole.

The shape of the clamping knobs is up to you, but I like to have knobs of different shapes to avoid confusion. For example, the knob for the vertical adjustment is right next to the knob for friction in azimuth, so I used a small bar knob for the first and a 5-star knob for the second.

Now that the height adjustment is made, you can make a captive knob that attaches to the binocular base. You can make a captive knob from any male knob with a ¼-20 post by filing off the bottom part of the threads (nearest the knob handle). Then screw the knob into the threaded hole in the height adjustment bar until the smooth bottom part of the post emerges.

Now we’re ready to make the outer part of the binocular frame. The frame consists of an upper section and a lower section. The upper section connects to the parallelogram, and the lower section supports the height adjustment that we just finished. The lower section is 5/8” narrower than the upper section so it can pivot inside the upper section.

Both upper and lower sections contain a part that might be difficult to make, so let’s tackle that part first. To make strong rounded corners, I used 1” by ¼” aluminum bar, bent around a 2” diameter cylinder. This bend might be difficult to make if you don’t have a metal bending tool as mentioned above. To avoid this difficulty, you might make square corners using steel corner braces. Square corners introduce a possible safety problem. If the user detaches the binoculars without first removing the counterweight, the binocular frame will jerk upward possibly causing injury.

To make the rounded corners, cut two pieces of the aluminum bar 10” long for the lower section, and two pieces 9-1/2” long for the upper section. Bend all four pieces to a 90 degree angle starting 2-1/4” from the end. In each piece, drill ¼” holes ½” and 1-1/2” from the shorter end. In the two shorter pieces, drill a ¼” hole ½” from the longer end. In the two longer pieces, drill ¼” holes ½”, 1-

1/4”, 2”, and 2-3/4” from the longer end. These multiple holes provide extra vertical adjustment for the binoculars, in addition to the approximately 2 inch adjustment range of the aluminum bar. This extra adjustment might be needed because there is a wide variation in balance point between different sizes and models of binoculars.

In one of the longer corner pieces, drill a 3/16” hole 4” from the longer end. Then cut a small aluminum bar, ¾” by 1/8” or 1/16” and 4-1/2” long. Drill a 3/16” hole ½” from one end. Drill ¼” holes ½”, 1-1/4”, 2”, and 2-3/4” from the other end. These holes should exactly match the holes in the corner piece. You can use the corner piece as a template for drilling the holes in the small bar so they match exactly. Then enlarge the three holes in the corner bar to 19/64”. Attach the small bar to the corner piece using a #10 machine screw, nylon spacer or washers, and nut. The purpose of this small bar is to prevent the side knob from working loose as the binoculars are scanned vertically.

To avoid the safety problem mentioned above, you should round off the longer ends of these curved bars.

Now let’s make the cross tubes that mate with the parallelogram and height adjustment. These should be cut from 1” square radius corner tube with 1/16” (.062) wall. I cut the tubes at a 45 degree angle, which is easy to do if you have a horizontal bandsaw, but if this is difficult you could just cut them at a right angle. The diagonal cut is really just an unnecessary complication that adds nothing to the strength of the mount. The tube for the upper section should measure 16-1/2” along the longer edge of the diagonal cut. The tube for the lower section should measure 15-7/8”. The exact length isn’t important as long as one tube is 5/8” longer than the other. If you are cutting the tubes at a right angle, subtract 2” from these measurements.

In the lower tube, drill a ¼” hole at the center. If you cut the ends diagonally, the hole should be across the ends of the diagonal, in other words one hole in the long side and the other in the short side. (Ignore the oval hole in the lower tube in the photo. It has no purpose in this version of the mount. Apparently I needed it in a previous version and I can’t remember why.)

Now connect the curved corners to the cross tubes. The main challenge is to get the holes between the two to match up accurately so the resulting structure is neat and strong. Clamp a corner to a cross tube. Starting in one of the holes already drilled in the corner, drill through the cross tube and temporarily fasten the corner and tube with a hex bolt. Then drill the other hole. Separate the corner from the tube. Enlarge the holes in the corner to 19/64” and insert carriage bolts for the permanent connection.

Next, connect the height adjustment to the lower frame section. Position the center of the lower frame tube inside the tightly curved end of the height adjustment. Run a carriage bolt through the holes in the adjustment mechanism and lower frame tube, adding 1.25” fender washers as necessary for spacing. For smoothest movement, use a nylon washer on either side of the lower frame tube. Spin a female knob onto the end of the bolt. This knob will adjust friction in the horizontal movement of the binoculars. Depending on the height of the female knob, you might need to add a spacer under the knob to give a comfortable amount of room between the knob and the lower frame tube.

There is one task remaining for the upper frame section. We need a strong and quick connection between it and the parallelogram. Ideally, something strongly attached to the upper frame tube that would fit snugly into the front end of the parallelogram. A custom T joint made by machining, casting, or 3D printing would be ideal. Looking for a solution using simple operations on off-the-shelf parts, I came up with the following.

Start with a piece of aluminum bar 1” by 2” by 3”. Cut away two corners leaving a T shape. The fat center of the T is 1” wide or slightly more so it fits snugly inside the parallelogram tube. Do not try to jam it forcefully into the tube; aluminum can seize up and refuse to come apart. The sides of the T are about ¼” thick. Drill ¼” holes in the sides for connecting with the binocular frame upper tube.

If the original aluminum bar is 1” thick, this may leave a loose fit inside the parallelogram tube. To tighten up the fit, I drilled ¼” holes in the top and bottom of the T and inserted ¼” plastic hole plugs.

Now insert the T into the parallelogram tube and drill a ¼” hole all the way through the tube and T near the bottom of the T. Into this hole fit a ring-grip quick-release pin. This pin provides a fast, strong connection between the parallelogram and binocular frame.

When the T is finished, connect it to the binocular frame upper tube with carriage bolts through the tube and the holes in the sides of the T.

If you have a bandsaw, it’s not too hard to make this T connector. If you have trouble cutting thick aluminum, an alternative is to use a piece of square aluminum bar. If you use 1” square bar inside 1-1/4” thin walled square tube, the fit will be very loose. 1-1/8” square bar fits perfectly inside 1/16” wall 1-¼” tube (you might have to file the bar down slightly). 1-1/8” bar is a very unusual size but I found some at Metals Depot. Another alternative is to cut a piece off a 1” by 2” bar, making it just wide enough to fit inside the tube.

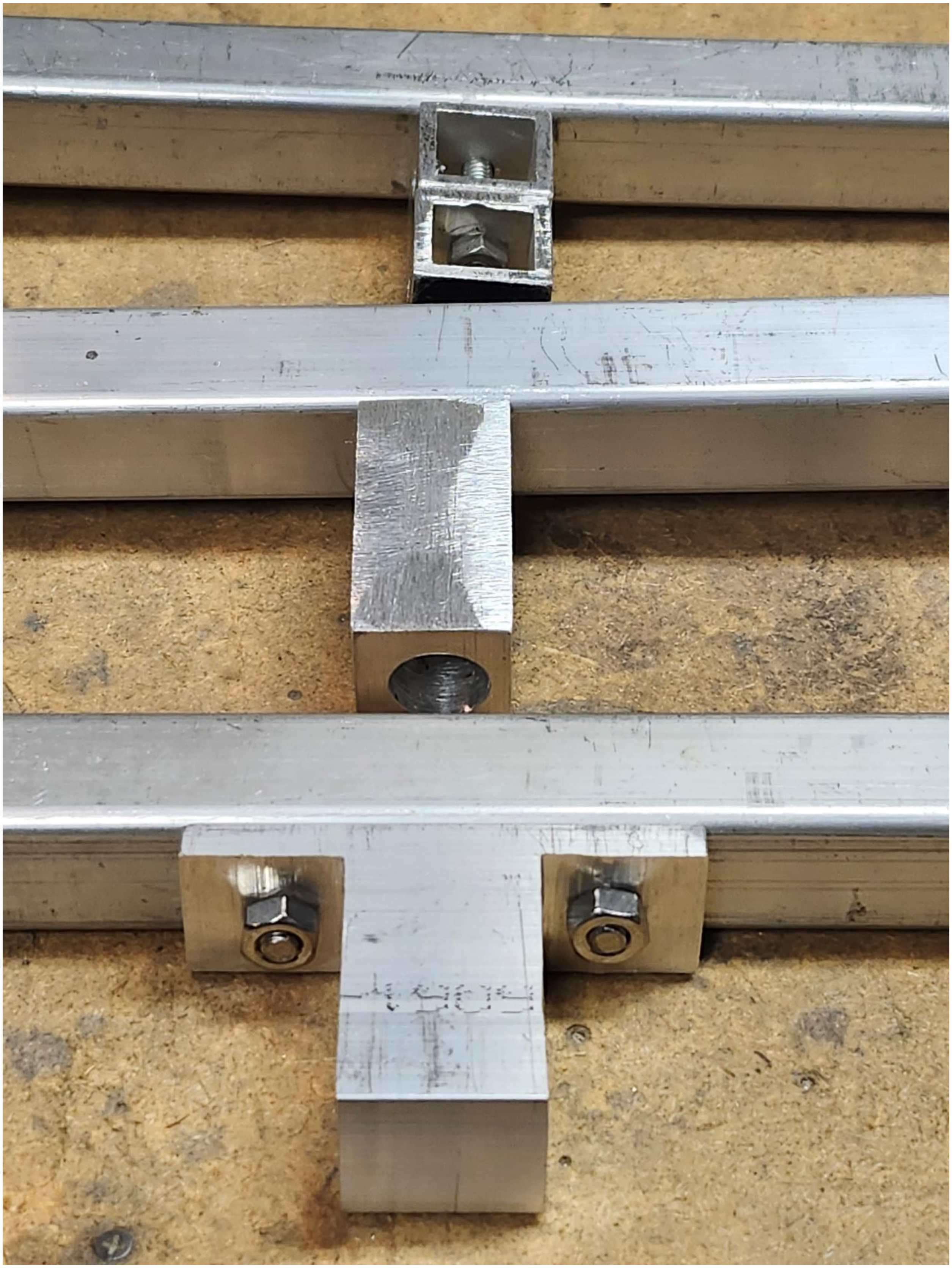
Once your 2” long square bar is cut, drill a 1/4” hole lengthwise all the way through. Then enlarge one end of the hole to 5/8” or 11/16”, depending on how much room you need to get a socket into the hole. This enlarged section should be 1-1/4” deep. Drop a hex bolt into the hole, drill a hole in the center of the binocular frame upper tube, and use a socket wrench to connect the bar with the tube. It might be easier to use a socket head bolt instead of the hex bolt.

This square bar connector is acceptably strong, though it does not resist rotation of the binocular frame as well as the T connector.

Finally, if your ability to cut and drill aluminum is limited, you could do what I did in my original construction. Cut two pieces of 1” square 1/8” wall tube, slightly more than 1” long to fit snugly into the parallelogram tube when turned sideways. Drill ¼” holes through opposite walls of one tube and one wall of the other. The holes need to match up exactly, so use the holes in the first piece as a guide to the second piece while the two are clamped together. Bolt the two tubes together making an approximation of a 1” square bar. This assembly is strong enough to do the job.

Run a carriage bolt through the hole in the middle of the upper frame tube, then the 1” square tube with two holes, and finally the 1” square tube with one hole, and fasten them together tightly with a nut. You should be able to get a 7/16” box wrench inside the second square tube. Fasten the 1” tubes so that the open sides are perpendicular to the length of the upper frame tube. This assembly should slide easily but snugly inside the 1.25” square tube that you will use for the front tube of the parallelogram. You might need to file down the corners.

The picture below shows the completed connection in my three prototypes.



Now that the upper and lower sections of the binocular frame are complete, the only step remaining is to join them together. To provide easy altitude adjustment with variable friction, the sections are joined by a clevis pin on the left side and a carriage bolt and knob on the right. I drilled four holes in the lower section to extend the range of possible balance adjustment in case the main height adjustment isn't adequate. For my Oberwerk 22x100 binoculars weighing 7 lbs, the middle of the range using the center holes is about right.

On the left side, simply insert a clevis pin through holes in the upper and lower sections, with a washer between the upper and lower sections. On the right side, position the upper frame section between the lower frame section and the small bar, and run a carriage bolt through the holes, with washers (preferably nylon) separating the aluminum bars. Spin a knob onto the end of the carriage bolt. You now have a friction adjustment for altitude motion.

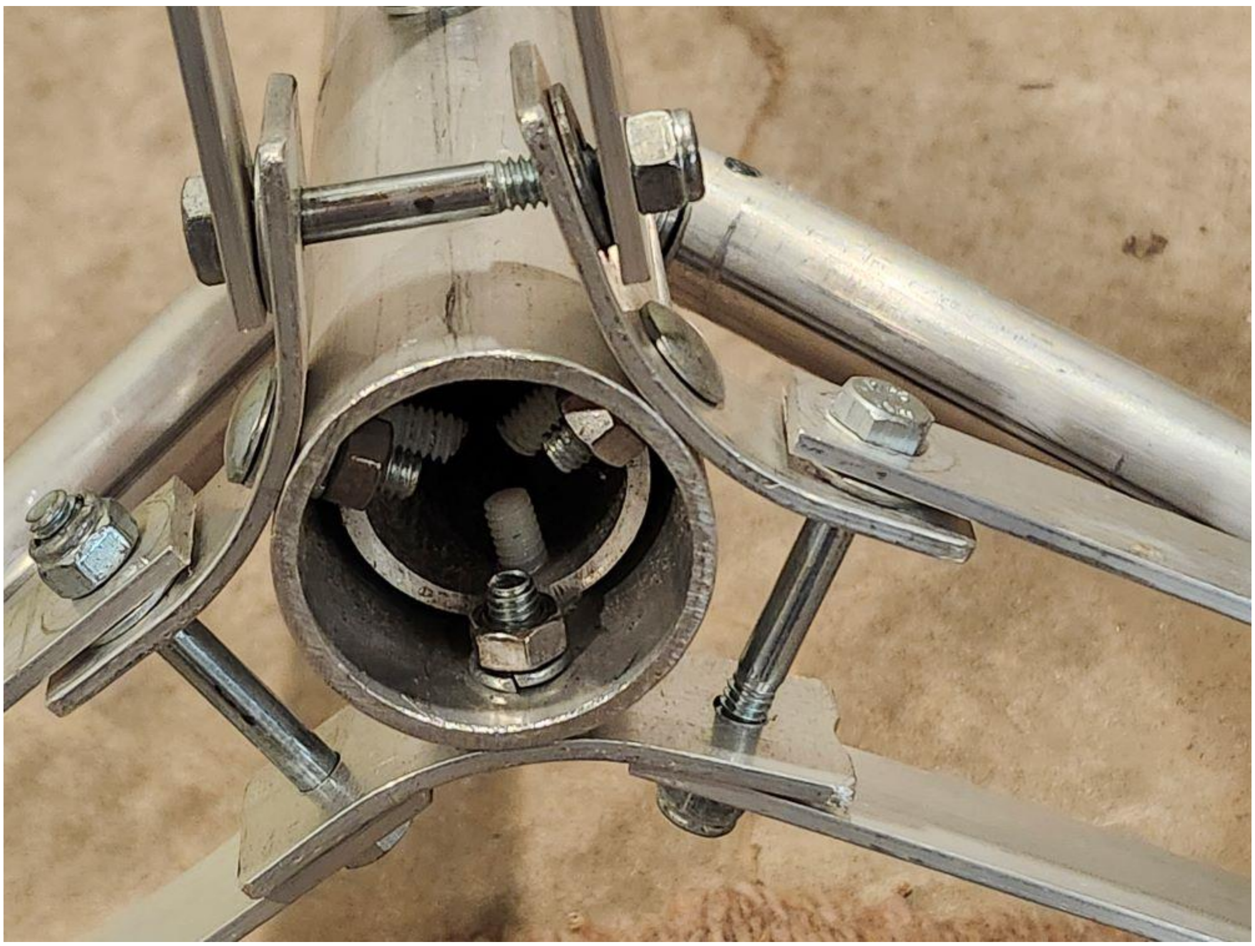
Pier

In early versions of the floating binocular mount, I tried to mount the parallelogram on a camera tripod. This worked poorly because the parallelogram was constantly bumping into the tripod legs. For maximum range of motion, the parallelogram should be free to move to a vertical position and beyond. I can think of two ways to accomplish this. The center of the parallelogram could be mounted on an extremely tall fork, or hanging off the side of a pier. The pier seemed like a simpler solution, so that's what I adopted.

In addition, it should be possible to adjust the height of the top of the pier, since the parallelogram has the greatest range of motion if its center support is at about the same height as the observer's head. The pier doesn't need to be very strong, since the amount of weight it supports and the magnification are modest, but it does need a wide base to resist tipping over when the binoculars are pulled away or pushed towards it.

To fulfill these requirements, the pier consists of two concentric aluminum tubes. When the inside tube, which supports the parallelogram, is raised above its lowest position, it is held there by a pin or bolt extending through holes in the tube. At first I tried to build a clamp to hold the inside tube at any height, but it was hard to build and didn't work reliably. A pin through holes is guaranteed not to slip!

Three legs fold out from the bottom of the outer tube and provide a wide base of support. Actually, the legs are not directly attached to the tube. Instead, they are attached to struts which in turn are attached to the bottom of the tube. The strut and upper half of the leg form a triangle with the lower part of the tube, making a rigid support that can fold compactly with the entire leg against the tube. The top end of the leg rests against the head of a small bolt, holding it in place.



Let's start again with the most complicated part, the attachment of the struts to the bottom of the tube. This is another case where a custom made part, by machining or casting or 3D printing, would be useful. Instead, there are a couple of ways to make it by simple operations on off-the-shelf parts.

As illustrated here, I used curved aluminum bars to attach the struts to the tube. Bend three pieces of 1” by 1/8” aluminum around a 3” diameter bar, through an angle of 60 degrees. The bars should be 3 inches long. Depending on your bending method, you might need to start with longer bars and cut the ends off. After bending, drill a 19/64” hole in the center and ¼” holes ½” from each end. (Never drill holes before bending since this will produce an uneven bend.)

Instead of the 60 degree curved bend, it is easier to make two sharp 30 degree bends, one inch from each end of the bar. If using the metal bender, make the bends directly around the 5/8” center pin of the bender. Alternatively, you could just clamp the bar in a vise and bend using a hammer.

The pier itself consists of a 1.5” OD aluminum tube inside a 2” OD tube. Each tube has a 1/8” wall, leaving 1/8” space between the tubes. The outer tube is 24” long, the inner tube 26”.

The outer tube needs some ¼” holes near the bottom to attach the legs, and a pair of holes near the top for the height adjustment. Try to make the bottom holes at 3 equal spacings around the tube. The spacing between holes along the outside of the tube works out to 2/3*pi = 2.09” or 2-3/32”. To attach the curved bars, the holes should be ½” above the bottom. Do not attach the bars permanently at this time, because you will need to leave the bottom of the tube open while completing work on the inner tube.

You will also need three holes farther up. These are to attach the three short bolts that hold the top ends of the legs in position. They should be 5-1/2 inches from the bottom, and 60 degrees away from the bottom holes. Use a 13/64” drill and thread them for ¼-20 bolts.

The pair of holes at the top for the height adjustment pin should be ¼” diameter, ¼” from the top. For maximum convenience, these should be made into U-shaped slots using a hacksaw, file, or whatever. The holes should be positioned so that they are 90 degrees away from one of the leg holes at the bottom. This minimizes the chance of a collision between the head of the height adjustment pin and the parallelogram.

Preparing the inner tube includes another tricky step. Inside the top of the tube is a nylon insert that supports the parallelogram. This insert is a piece of round nylon rod 1.25” diameter and 3” long. At the center you have to drill a ½” hole. Drilling nylon can be very tricky since it tends to suddenly grab the drill bit. To do it successfully, the nylon needs to be securely clamped to the drill press table and you should make a series of brief “pecks” to gradually deepen the hole. Cool the bit frequently with a water spray. There are special drill bits for drilling plastic, though I have successfully used standard bits. You might want to enlist the help of a machinist for this step.

The hole should be large enough so a ½” bolt can slide freely into it. There seems to be enough variation in the diameter of drill bits and bolts so the bolt might be too tight. If so, you can enlarge the hole with a 33/64” or 13mm bit or a round file.

Once the nylon insert is drilled, slide it into one end of the inner tube until it is even with the end. Then drill a 5/16” hole into the side of the tube and nylon, 2” from the end. Drill only to the center, then tap the hole for a 3/8-16 thread. Insert a 3/8" threaded male knob or bolt into this hole now, to ensure that the nylon doesn't move out of position.

At the other end of the inner tube, you will need three holes to accept nylon bolts. These bolts take up the 1/8" space between the tubes providing smooth vertical motion and eliminating looseness. The position of these holes is important, since the nylon bolt heads must not collide with the short bolts near the bottom of the outer tube. One of the holes should be 90 degrees counterclockwise (as seen from above) from the 3/8" hole at the top of the tube. The others should be evenly spaced 120 degrees away from this first hole. The holes should be near the bottom of the tube, say ½". Use a 13/64" bit and tap for ¼-20 thread. Do not insert the nylon bolts until after the inner tube has been inserted into the outer.

The final step in preparing the inner tube is to drill a series of holes for the height adjustment. I spaced the holes 1.5 inches apart. Be careful to get the holes at the exact center of the tube so the pin holes match up between the inner and outer tubes. These holes should be parallel to the 3/8" hole at the top. The diameter should equal the diameter of the pin (1/4"). They can be slightly larger to allow for misalignment, but this might cause looseness in azimuth motion. The top hole should be 3.5" from the top of the tube to avoid colliding with the nylon.

Before inserting the inner tube, apply pieces of Velcro to the top inside of the outer tube. Pull the hook and loop sides apart. First stick the hook (harder) side onto the inside of the outer tube. Then stick the loop (fuzzy) side onto the hook side with the adhesive against the hooks and the fuzzy side towards the inside (not the way Velcro is usually used.) Together, the Velcro fuzz at the top and nylon at the bottom provide nice smooth vertical motion with no looseness.

Remove the 3/8" knob or bolt from the inner tube. Slip the inner tube into the top of the outer tube making sure the felt stays in position. Push the inner tube all the way down until the tops of the tubes are even. The bottom of the inner tube will extend 2 inches from the bottom of the outer tube.

Shorten the nylon bolts to 1/2" if necessary and drive them all the way into the holes at the bottom of the inner tube. You might need to file or grind down the heads to get them to fit into the outer tube. Push the inner tube back up so the 3/8" hole emerges from the top, and re-insert the knob or bolt. Pull the inner tube up and verify that the height adjustment pin fits through all the holes.

Now attach three ¼” by ½” long round head bolts that will hold the tops of the legs in position. Extend the bolt heads out from the outer tube using stacks of washers or nuts or nylon spacers. Also attach the curved bars to the bottom of the outer tube.

Now that the center post is complete, the next step is to make and attach the legs. The legs are 1” OD aluminum tubes with 1/8” wall, 24 inches long. The struts are ¾” by 1/8” aluminum bar, 12 inches long. The top ends of the legs should be cut at a 64 degree angle so they will be flush with the post. Drill a ¼” hole 13 inches from the angled end of each leg, taking care that its position matches the angled cut at the top of the leg. In other words, if you hold the top of the leg against the pier, the hole should be perpendicular to the pier. Drill ¼” holes 3/8 inch from each end of the struts.

Put end caps on the legs. Attach two struts to each leg. Attach the other end of the struts to the curved bars on the pier. Use nylon stop nuts so the bolts attaching the legs don’t work loose. Tighten them so the legs unfold with a reasonable amount of force and stay in place when folded in against the pier.

Now the pier is complete. When the legs are unfolded and the top ends rest against the small round head bolts on the pier, the pier should feel very solid.

Parallelogram

With the binocular frame and pier complete, we're ready to build the heart of the floating binocular mount. The goal is to make the entire assembly – binoculars, counterweight, and frame – balance perfectly in all positions as the frame is opened, closed, and rotated. Inevitably, there will be a slight imbalance caused by flexing of the frame under the weight of heavy binoculars. But if you have built it carefully, only a slight amount of friction will be needed to hold the binoculars in place.

At first I tried to make the frame balance by making it perfectly symmetrical, supported at the center by an extra third bar across the center of the parallelogram. But eventually I realized that I could make it simpler and more compact by eliminating the center bar and supporting it directly on one of the long sides of the parallelogram. I made the asymmetrical frame balance by attaching a couple of small permanent counterweights to the frame.

The parallelogram frame is constructed primarily from thin-walled aluminum tubes. For the center tube that supports the entire frame, I used 1" square tube of 1/16" (.062) wall with radius corners. For the end tubes that attach the binoculars and counterweight, I used 1.25" square tube with .09" wall and radius corners. The other center tube is ¾" round tube with 1/16" wall.

It might seem odd to use smaller tube at the center, which bears twice as much weight. But since the force on the center tube is at the center, versus at the end on the other tubes, the stress is actually half as much. Other reasons to use 1.25” tubes at the ends are that this size is more convenient for connecting the binocular frame and counterweight, and makes extra space between the end plates and center tube at the four pivot points.

Thin-walled 1.25” square tube is very hard to find at the retail level. Radius corner is even harder. Eagle Aluminum of Loretto, Minnesota is the only supplier that I have found, and you might need to buy 24 feet. I have found the following suppliers for square corner 1/16” wall 1.25” tube: McMaster-Carr, MetalsDepot, Shapiro Metal Supply, Metals4U, Eastern Metal. I don’t remember where I found the .09 radius corner, but most likely at a local yard (Garelick in Minneapolis) that happened to have some.

If you can’t find any thin-walled tube, you could use the standard 1/8” wall, it would just be heavier than necessary.

I used a small round tube for the other center tube since it is under tension in all binocular positions and has no bending stress. A small square tube would probably have been easier for accurate drilling.

The 1.25” tubes are 28 inches long. The center tubes are 24 inches long.

In one of the 1.25” tubes, drill a 1” hole one inch from the end for the counterweight bar. First, clamp the tube securely to the drill press table. To get this hole accurately at the center of the tube, it helps to drill a small pilot hole (about 5/16). Then I enlarged the hole very slowly with a twist drill. I believe you could also use a hole saw.

Drill 3/8” holes ½ inch from the ends of the two center tubes. These will form the corners of the parallelogram, so be careful to get them the same distance apart between the square and round tubes. Also take care that the holes in the round tube are parallel. This is where a drill press vise is really helpful. Drill the holes at one end of each tube. Then bolt this end together and drill the other end to get a perfect match.

The tubes will need some additional holes, but these should wait until later for most accurate results.

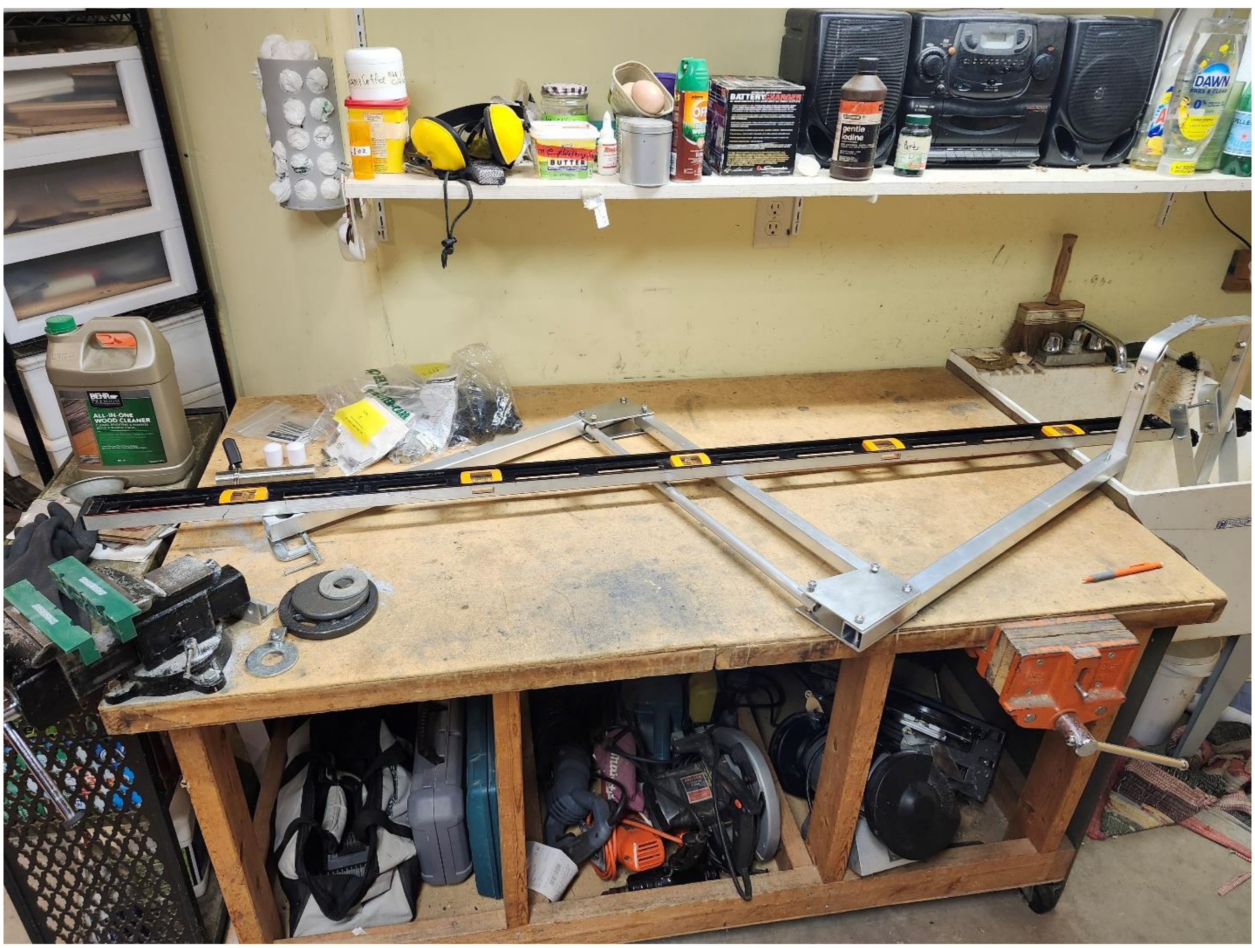
The short sides of the parallelogram consist of 1/8” aluminum plates bolted on the ends of the 1.25” square tubes. The plates are trapezoid shaped. The plates on the tube that holds the binoculars are 5” by 5” by 3-5/8”. The plates on the tube that holds the counterweight are 5” by 3-5/8” by 2-1/4”. An easy way to cut them is to first make 5” by 7-3/8” rectangles, then cut the rectangles at an angle of about 74 degrees. This rectangle length includes a 1/8” saw kerf between the plates. Aluminum can be cut on a table saw or miter saw using a special metal cutting blade or fine tooth carbide blade. File down the corners and edges of the plates.

Now drill ¼” holes near the corners of the plates, about ½” from each edge. For most accurate results, drill two plates at once. The holes on the slanted side are the corners of the parallelogram, so the spacing between them should be identical in all four plates. To ensure this, drill all four at once or use one plate as a template for the others.

Next the plates need to be bolted to the 1.25” tubes. For most accurate results, clamp one plate so it is even with the end of a tube. The square corner nearest the longer side of the plate should be even with the end of the tube. Use the existing hole in the plate at that corner as a template to drill only through one wall of the tube. Then do the same on the opposite side of the tube. This should produce four perfectly matching holes. Temporarily bolt the tube and plates together, then follow the same drilling procedure at the other square corner of the plates. If you are using carriage bolts, remove the plates and enlarge the two holes at the square corners of one plate to 19/64. Then permanently bolt the plates to the tube.

Now that the sides of the parallelogram are complete, we can assemble it. The goal is for the frame to open and close with as little friction as possible. To achieve this, I used Grade 8 hex bolts in sintered bronze (Oilite) bearings. This combination is easy to construct and has less friction than anything else I've tried. When the frame is extended all the way, the force on the pivots increases rapidly and can make it hard to move the binoculars back towards the pier. In previous versions with weaker bolts, I've often bent the bolts.

Put 3/8" OD, ¼" ID, 3/8" long flange bearings into the 3/8" holes at the ends of the 1" center square tube. Put 3/8" OD, ¼" ID, 1-1/4" long sleeve bearings into the holes at the ends of the round center tube. Position the tubes in between the plates at the ends of the 1.25" square tubes as shown in the photos. Run 2" long Grade 8 hex bolts through the holes in the plates and tubes. There will be some looseness between the center tubes and the plates, but this doesn't matter. We want to avoid any rubbing between the plates and tubes. Put nylon stop nuts on the ends of the bolts. The resulting assembly should open and close with very little friction. When fully extended open, the two center tubes should be parallel. When closed, all four tubes should be parallel.



With the binocular frame attached to the parallelogram, you can drill the center hole where the entire frame will be supported. Since the frame is not perfectly symmetrical, the center hole will probably not be at the exact center of the 1" square center tube. On the mount that I built, the center hole is 13 inches from the end of the tube nearest the binoculars. Since the dimensions and materials of your mount might be slightly different from mine, for best balance you should determine the support point by making your own measurement. Lay the parallelogram with the binocular frame attached on a table or other support where the binocular frame can hang over the edge. Open the parallelogram about half way. Lay a straight edge on top of the parallelogram so the ends are even with two points. One point is the center of the 1" hole you drilled for the counterweight bar. The other point is the binocular balance point in the middle of the binocular frame. This is on the line between the center pivot points of the binocular frame. With the straight edge aligned with these points, make a pencil mark on the 1" square center tube where the straight edge crosses it. To double check your work, try opening and closing the parallelogram. The three points should remain in a straight line.

The center hole should not be drilled at the pencil mark, but ½ inch closer to the end of the tube closest to the counterweight. This compensates for a slight sag when the frame is in a vertical position bearing heavy binoculars. The sag is caused by looseness in the bearings and bending of the tubes. If you wanted to be an ultra-perfectionist, you might reduce the sag by using heavier tubes or wider plates or some other type of bearings (maybe roller skate ball bearings). In my opinion this is unnecessary, the balance will be nearly perfect even with heavy binoculars.

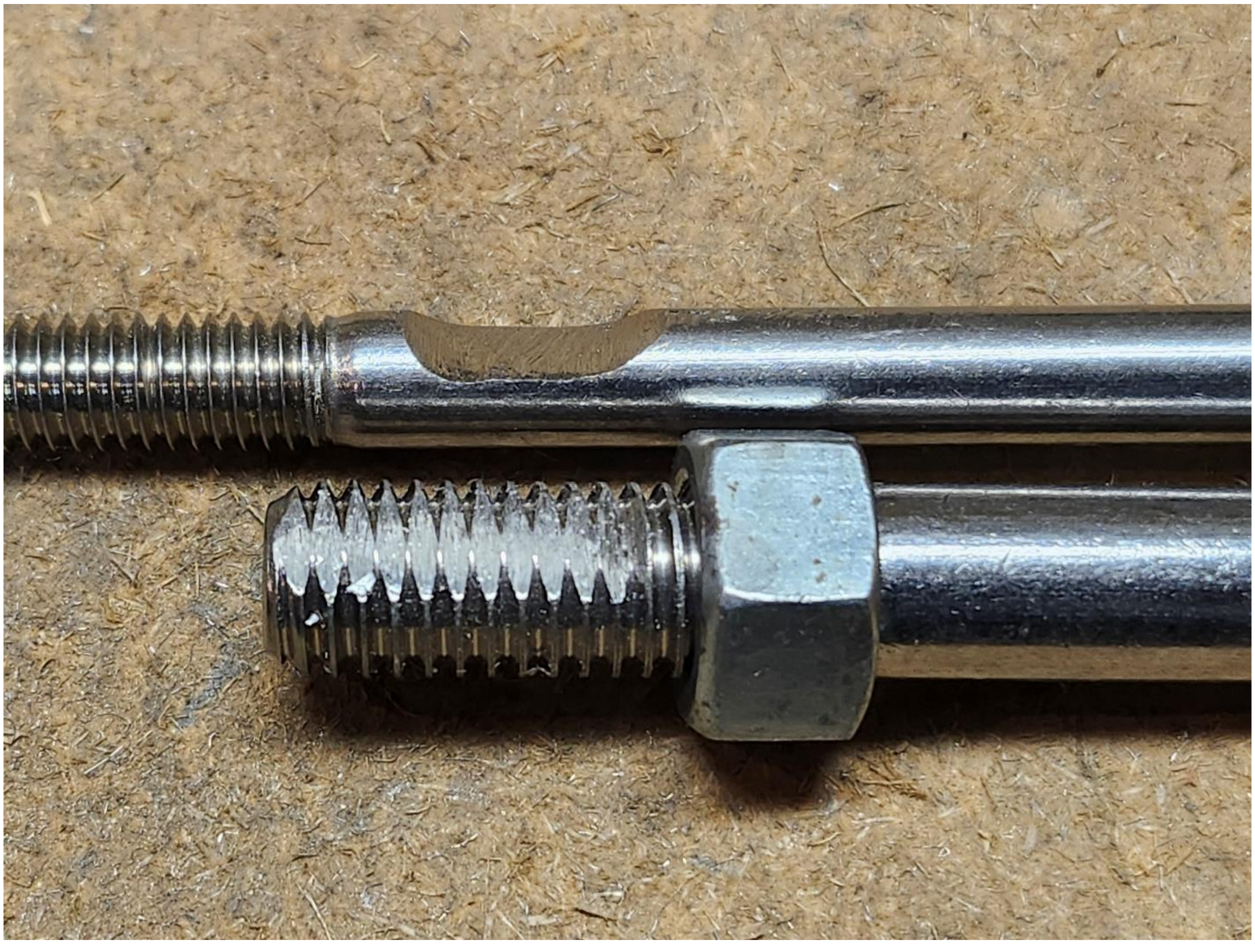
Now drill a ½" hole through the 1" square center tube at the point you determined. Also drill a ¼" hole in one side of the round center tube, at the same position along its length as the one in the square center tube. This hole will accept the pin in the small center bar (next paragraph). This hole should be in the left side of the frame as seen from behind. It doesn't matter if the hole is all the way through except that it weakens the tube slightly. Put 3/8" ID, ½" OD, ½" long bronze flange bearings in the center hole of the square center tube.

There is an additional small bar near the center of the parallelogram. The purpose of this bar is to provide adjustable friction when opening and closing the frame. It is parallel to the short ends of the parallelogram. Cut a piece of 1" by 1/8" aluminum bar 5 inches long. Drill a 3/8" hole about ½" from one end, a 1/4" hole about ½" from the other end. The spacing between the holes should be exactly the same as the spacing between the holes on the slanted sides of the parallelogram end plates. Cut the head off a 1.5" long hex bolt and fasten it in the ¼" hole with a pair of nuts and a lock washer. Cut off the tip of the bolt so it is even with the nut. This forms a pin that will fit into the hole near the center of the round tube.

The next step is to construct the pier head assembly that connects the parallelogram to the top of the pier. This needs to strongly hold the parallelogram at an offset of about 2 inches to the left of the pier as seen from behind. It also provides friction adjustments in three axes.

The heart of the pier head is an aluminum bar ¾" thick by 1-1/4" wide by 2-1/2" long. Two holes are drilled through this bar. First drill a 3/8" hole through the length of the bar, centered 7/16 inch from one edge and 3/8 inch from each side. Then drill a ½" hole through the thickness of the bar, centered ½ inch from one of the corners opposite the previous hole.

If you have done the math, you will notice that these holes overlap by 1/8 inch. There is a reason for this. Two specially prepared bolts go through these holes. Each bolt is flattened by 1/16 inch along part of its length. The flattened sides face each other in the holes and lock each other against rotation as the parallelogram is rotated horizontally and vertically.



For the ½” bolt, start with a standard 4” long partially threaded hex bolt. Use a file or grinder to flatten the threaded end for about 7/8 inch of its length. Do a little bit at a time. To start with, just flatten until the threads are gone. Then flatten the other bolt and try to fit them both into the bar. If you’re using stainless steel like I did, this is a lot of grunt work. I’m not sure that stainless is really needed here, although I generally use stainless fasteners for anything that is used outdoors.

The 3/8” bolt is a partially threaded hex bolt 5” long. Flatten a 1/2” long area centered 1-1/2” from the tip. I used a 3/8” round file for this. Start out 1/16” deep. Then put the 3/8” bolt in the hole with one inch of the threaded end sticking out, and then try to slide the ½” bolt into its hole. Gradually file or grind off enough of both bolts until you can get them both to fit in their holes snugly. There should be just enough looseness to allow the 3/8” bolt to slide lengthwise to tighten or loosen the motion of the parallelogram frame.

Finally, cut the head off the ½” bolt. Spin a nut down to the bottom of the threads.

Now we can assemble the central support of the parallelogram. Take the modified 3/8” bolt and put a nylon washer and the short bar on it. Then push it through the two bronze bearings in the square tube. At the same time insert the pin on the other end of the short bar into the hole at the center of the round tube. Put a large nylon washer on next, one that is large enough to fit around the flange of the bronze bearing. Then push the 3/8” bolt through the long hole in the aluminum bar of the pier head. Finally spin a star knob onto the end of the bolt. Depending on the height of the knob, you might need to add a nylon spacer under the knob. If you can’t get the assembly to grip the tube tightly, you’ll have to extend the filed-down area of the 3/8” bolt towards its head.

The 3/8” bolt assembly is now complete, but to complete the pier head we still need to attach the ½” bolt that forms the central pivot. Loosen the 3/8” bolt so it can easily be turned by the head. Insert the ½” bolt into the aluminum bar so its flat side faces the flat side of the 3/8” bolt. The tip of the ½” bolt should extend 1/4 inch from the top of the bar. Thread a nut onto the end and tighten the nuts on both sides of the bar.

This completes the assembly of the pier head. By tightening the star knob, you can put friction on the opening and closing of the parallelogram, and at the same time add friction to the vertical rotation of the entire frame when it is on the pier.

Now we can complete assembly of the three main parts of the mount. Insert the ½” bolt of the pier head into the ½” hole at the top of the pier. You should be able to rotate the parallelogram freely around its central pivot without hitting the pier.

Balancing

When you put everything together, you will notice that the frame is nowhere near balanced. The front end with the binocular frame is much heavier. The next step is to add the counterweight.

As mentioned before, the floating binocular mount does not have a counterweight that slides on a shaft. Instead, there is a counterweight bar at right angles to the frame where different combinations of weights can be hung. The counterweight bar is at the only point on the frame where it can balance the binoculars in two dimensions as the parallelogram is opened, closed, and rotated.

I used a 1” diameter stainless steel bar 6” long to hold the counterweights. For the weights I used barbell weights of 5, 2.5, and 1.25 pounds. For more precise balancing I added 1” steel washers. The weights are held in place by a pair of barbell end spring collars. For binoculars weighing more than about 7 pounds, you’ll need to add a second 5-pound weight.

Note that the counterweights are not necessarily equal to the weight of the binoculars. The weight of the counterweight bar and unbalanced frame must also be taken into account. Also, the binoculars are slightly farther from the balance point than the counterweight. You need to add and remove weights until balance is achieved.

There is another balance problem. Even if you precisely balance your binoculars in one frame position, the frame will become unbalanced as you open or close it. That’s because the frame is not perfectly symmetrical. To make the frame balance in all positions, you need to add small permanent counterweights according to the following procedure.

Set up the parallelogram with the binocular frame attached on the pier. Insert the counterweight bar. Hold the center square tube in a vertical position and the end tubes in a horizontal position. While holding the center tube vertical, add enough weight to the counterweight bar to make the end tubes balance. It will probably take about 1.5 pounds.

Without changing the counterweight, rotate the center tube 90 degrees so it is horizontal and the other tubes are vertical. Then rotate the center (altitude) pivot of the binocular frame so the parallelogram end tubes balance. Tighten the side clamping knob of the binocular frame. The parallelogram center tube will be badly out of balance. It will probably need about 1.5 pounds of weight on the back end (farthest from the binocular frame) to bring it into balance. Experiment with whatever you have handy, perhaps C clamps and small pieces of steel, until you find the amount of weight that makes the frame balance. Cut a pair of steel bars to make a counterweight that you can permanently attach to the back end of the center tube, one on either side. One-inch wide bars fit nicely onto the tube. For my frame, a pair of stainless steel bars ½" by 1" by 4" long gave perfect balance.

There is one more small but very important detail. The parallelogram should be prevented from opening too far. If it opens completely, to where the two center tubes bump into each other, the forces on the corner pivots increase rapidly. This increases the friction making it difficult to move the binoculars back towards the pier. With heavy binoculars, the force can be enough to bend the bolts at the corners. There is also the possibility of fingers getting pinched between the center tubes.

The bolt fastening the permanent counterweight to the square center bar does double duty in limiting the opening of the parallelogram. I designed it to maintain a space of 3/4 inch between the center tubes.

If all the dimensions are correct and the counterweights are sized properly, the empty frame should remain perfectly balanced in two dimensions as it is opened, closed, and rotated. You should be able to attach binoculars of any size and with the appropriate counterweight, the mount will remain balanced. It works well with binoculars of any size up to 100 mm weighing 10 pounds. I haven't tested it with anything larger. Ultimately the friction will increase and slight bending will degrade the balance.

Using

The goal of the floating binocular mount is to give you complete freedom of movement, just as if the heavy binoculars magically became weightless. To achieve this, it is important to set the mount up correctly.

For astronomy, to see the sky in maximum comfort you should use a reclining lawn chair. You can use a straight chair or stool or lie on the ground if you prefer.

First, set up the pier behind the chair. The legs should be oriented so that one leg extends straight back away from the chair, and the knob at the top of the pier points to the right as you face towards the back of the chair. The pier should be about one foot behind your head for maximum movement horizon to zenith. Adjust the top of the pier so it is about level with the top of your head.

Next, open the parallelogram frame and insert the ½" bolt into the hole in the top of the pier. Rotate the frame so it is to the left of the pier when facing the back of the chair. Set the front end of the frame (where the binocular frame will be attached) onto the back of the chair.

Then attach the binocular frame to the front end of the parallelogram. Remove the ring-grip quick-release pin from the hole at the front of the parallelogram. Insert the 1" square attachment at the top center of the binocular frame into the 1.25" square tube and re-insert the pin. Rest the binocular frame on the chair.

Attach the binoculars to the binocular frame. Open the frame 180 degrees at the pivots. Move the binoculars into the center of the frame. While holding the binoculars with one hand, screw the captive knob into the ¼" hole at the bottom of the binoculars. The large curved bar of the binocular height adjustment should be between and parallel to the front tubes of the binoculars. Let the binoculars rest on the chair.

Attach the counterweight. Insert the counterweight bar into the 1" hole at the back end of the parallelogram. Add and remove barbell plates, washers, or whatever else you are using for counterweight until the whole frame balances. Add the spring clips to the ends of the counterweight bar, adjusting the counterweights as necessary.

Balance the binoculars in the binocular frame. Raise the binoculars from the chair. Point the binoculars vertically and turn the knob on the balance adjustment mechanism until the binoculars are balanced. If you cannot get the binoculars to balance by adjusting the knob, you might be able to achieve balance by moving the side pivots to a different hole among the four choices. Remove the binoculars, remove the knob, bolt, and washers on the right side pivot, and remove the clevis pin and washer on the left side pivot. Re-install all this hardware in a different hole. In general, larger binoculars balance better using the holes nearer the ends of the curved bars.

When you have achieved balance with the binoculars pointed vertically, point the binoculars horizontally and adjust the position of the support post along the center bar of the binoculars until they are balanced.

After balancing the binocular frame, you might need to make a slight adjustment to the main counterweight.

Once the mount is perfectly balanced, you can easily move the binoculars about five axes: left and right around the pier, up and down, towards and away from the pier, and altitude and azimuth pointing of the binoculars. Clamping knobs on all the axes let you apply friction to hold the binoculars in place against wind or imbalance. You should try to avoid tightening the knobs because the idea of this mount is to let the binoculars “float” as freely as possible. This prevents vibration when the binoculars are bumped.

If you want to show something to another person, an easy way to do this is as follows. Tighten all the knobs except for the one at the top of the post that controls rotation to the left and right. Swing the binoculars to one side so you can easily get out of the chair. Then the other person can get into the chair and swing the binoculars back into position.

CAUTION: When you’re done observing, first set the binoculars down on the chair, then remove the counterweight. DO NOT disconnect the binoculars before you have removed the counterweight, because doing so will cause the binocular frame to suddenly jerk upward, possibly causing injury.

Parts list

Aluminum tubes	**Dimensions (inches)**	**Count**
Square tube radius corner	**1.25 x 1.25 x .062 x 28**	**2**
Square tube radius corner	**1 x 1 x .062 x 24**	**1**
Square tube radius corner	**1 x 1 x .062 x 15.5**	**1**
Square tube radius corner	**1 x 1 x .062 x 14.875**	**1**
Round tube	**.75 x .062 x 24**	**1**
Round tube	**2 x .125 x 24**	**1**
Round tube	**1.5 x .125 x 26**	**1**
Round tube	**1 x .125 x 24**	**3**
Aluminum bars		
Flat bar	**1.5 x .125 x 24**	**1**
Flat bar	**1 x .25 x 10**	**2**
Flat bar	**1 x .25 x 9.5**	**2**
Flat bar	**.75 x .125 x 12**	**6**
Flat bar	**.75 x .125 x 4.5**	**1**
Flat bar	**1 x .125 x 3**	**3**
Flat bar	**1.25 x .75 x 2.5**	**1**
Flat bar	**1 x .125 x 5**	**1**

Flat bar	2 x 1 x 3	1
Aluminum plates		
Plate	7.5 x 5 x .125	2
Steel bars		
Round bar, stainless	1 x 6	1
Flat bar, stainless	1 x .5 x 4	2
Nylon round bar	1.25 x 3	1
Barbell plate 5 lb	6.25 x .75	2
Barbell plate 2.5 lb	5 x .625	1
Barbell plate 1.25 lb	3.75 x .5	1
Small parts		
Carriage bolt	1/4 x 5	1
Carriage bolt	1/4 x 3/4	3
Carriage bolt	1/4 x 1.75	8
Carriage bolt	1/4 x 1.5	11
Carriage bolt	1/4 x 3	1
Hex bolt	1/4 x 2.5	1
Hex bolt	1/4 x 1.75	3
Hex bolt	1/4 x 2.25	3
Hex bolt	1/4 x 1.5	1
Hex bolt	1/2 x 4	1
Hex bolt	3/8 x 5	1
Grade 8 hex bolt	1/4 x 2	4
Round head screw	1/4 x 1/2	3
Hex nut	1/4"	20
Hex nut	1/2"	2
Nylon stop nut	1/4"	10
Flat washer	1/4"	16
Flat washer	1"	6
Lock washer	1/4"	4
Fender washer	1/4 x 1.25	4
Machine screw	#10 x 1	1
Hex nut	#10	1
Lock washer	#10	1
Nylon spacer	#10 x .375	1
Nylon spacer	1/4 x 1/4	3
Nylon washer	1/4 x 1	2
Nylon washer	1/4 x 1.25	2
Nylon washer	3/8 x 1	1
Nylon washer	3/4 x 1.375	1
Quick-release pin	1/4 x 1	1
Nylon bolt	1/4 x .75	3
Velcro	3/4 x 2	2
Tube end cap	1"	3
Bronze flange bearing	1/4 x 3/8 x 3/8	4

Bronze flange bearing	3/8 x 1/2 x 1/2	2
Bronze sleeve bearing	1/4 x 3/8 x 1.25	2
Ring-grip quick-release pin	1/4 x 1-5/16	1
Clamping knob, male	1/4"	1
Clamping knob, female	1/4"	2
Clamping knob, thru	1/4"	1
Clamping knob, male	3/8"	1
Clamping knob, female	3/8"	1
Barbell end clips, pair	1"	1