Making a Peltier Cooler for Your Camera (2010 Version)

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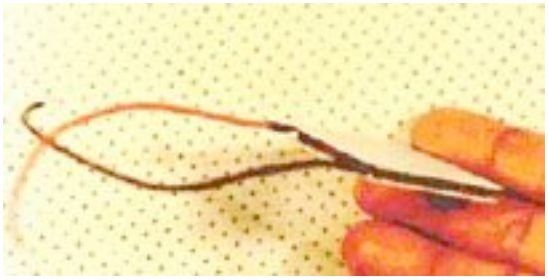
This document describes how to construct a cheap peltier cooler utilizing off the shelf parts and a few simple tools for less than $60 USD. It's a mix of my originall instructions from 2006 and my modifications since then.It isn't pretty, but it's functional and very easy to maintain, repair or modify. Please review the "Warnings and Cautions" section at the end of this document for potential problems.

Note that you accept all liability and responsibility for constructing and use of the peltier cooler. You use the information contained in this document at your own risk.

Things You Need..

A) Peltier Cooler (about $13 USD for the QK66 model) :



Dimensions of the QK 66 model Peltier Cooler are 40 x 40 x 4 mm with 2 power Leads. It uses a maximum of 15.4 volts and draws up to 6 amps of power. The 2006 model was $23 USD, had a max of 12 volts and 4.4 amps. The bimetallic cooler metal core is sandwiched between two white ceramic plates. The plates are physically delicate, so be careful with them especially on the edges where it is easy (from personal experience) to break or chip them them. The model I used can be ordered at:

https://store.qkits.com/moreinfo.cfm/QK66

B) Heavy Duty CPU Cooler and Fan either aluminum or preferably Copper.

Any CPU Heat Sink and Fan module should work, so a trip to most Computer stores will likely get you what you need. Make sure it has at least a 50 x 50 mm surface area and run on up to 12 volts of power. The model I used is this one originally (2006)

http://startech.com/Product/ItemSpecs.aspx?productid=FANP100&c=CA

However the copper ones are preferred as it will dissipate heat at about 200% better.

http://www.startech.com/item/FAN3701U-6cm-Copper-CPU-HeatsinkFan-for-1U-Servers.aspx

The copper ones may be difficult to find at your local computer store though.

C) Heat Sink Conductive Grease ($5 to $15 per tube):

You only need a few little "dabs". You should definitely place a little grease on the heat sink and hot side of the Peltier Cooler. You can likely get grease at a Computer store or by ordering it from:

http://startech.com/Product/ItemDetail.aspx?productid=HEATGREASE&c=CA

You may also want to apply a thin coating on the camera bottom, which improves cooling by an additional 5 to 10 °C. This is especially important if the camera case is not perfectly smooth, as you want an efficent transfer of cold to (or removal of heat from) the camera .

D) Power Supply:

I recommend the power supply (i.e. an AC to DC "Wall Wart" power converter) you use delivers between 9 to 12 DC volts and current output of at least 1.0 amps (ideally 1.5 to 3 amps). An adjustable power supply (say 3 to 12 volts) is also recommended as you can then vary the voltage which then regulates how much cooling is applied. What temperature decrease you can expect for how many volts and amps that the AC to DC converter is described in the “Using it and What to Expect..” section at the end of this document.

E) Other Materials You Need:

- Three 2 to 3 mm diameter by 7 to 10 mm long screws with larger (maximum 5 mm diameter and less than 2.5 mm thick) flat or round heads. The heads can not be counter sunk and should be the round dome type.

- Two or more Rubber Bands of approximately 7+ cm's un-streched length for a Flea FireWire (30 mm x 30 mm x 40 mm dimensions) camera. The actual length will depend on the dimensions. In later revision, I went to a permanent version that uses metal springs to secure the camera to the cooler.

- Electricians Tape.

- (Optional) Sheets of thin flexible foam insulation (packing material works great). The amount of material needed will depend on the size of your Camera and for a Flea (30 mm x 30 mm x 45 mm dimensions) camera, i used approximately a 400 mm x 130 mm sheet folded over several times.

- (Optional) 3.5 mm diameter Male positive tip plug / socket that fits to your power supply. You can also hard-wire the wires together.

- (Optional) Indoor / outdoor digital thermometer with an external plug in temperature probe. I found a cheap (<20$ CDN) one at Home Hardware in their gardening department which is accurate to +/- 0.5°C.

- (Optional though recommended) a copper plate (about 1/8” or 3 mm thick) that sits between the cold side ceramic plate and the camera, especially for larger cameras like the Grasshopper.

F) Tools You May Need:

Power Drill.
Screw Driver
Needle Nose Pliers
Metal File.
Sharp Knife.
Scissors
Duct Tape (As a Canadian, duct tape is an important part of every Handy Man’s kit).

Assembly..

A) Preparations..

1) First we need to determine which side of the Peltier Cooler is the hot side. The easiest way to determine which is "hot" is to apply 3 to 12 volts BRIEFLY to the leads of it and holding your finger on one side or the other will easily indicate which is which. Then mark the hot side by placing a small "dot" with felt marker or pencil or pen in one corner. Do not leave it plugged in for very long as without a heat sink and forced air cooling, you can basically cook it and get a melt down. Also by plugging in the Peltier Cooler now, you verify it was all in working order before you try an attach it or cover it with thermal paste.

2) Remove the Fan from the CPU Cooler Heat Sink. Make note of which side of the fan was "up". We want to make sure that it is blowing air down through the metal fins of the CPU Cooler Heat Sink after we reassemble it.

3) The CPU Cooler Heat Sink may have raised areas on the CPU attachment side and we do not want that at all. The Heat Sink surface should be flat so that the Peltier and Heat Sink make good contact to transfer the heat away efficiently. So you may need to file down any ridges or raised edges.

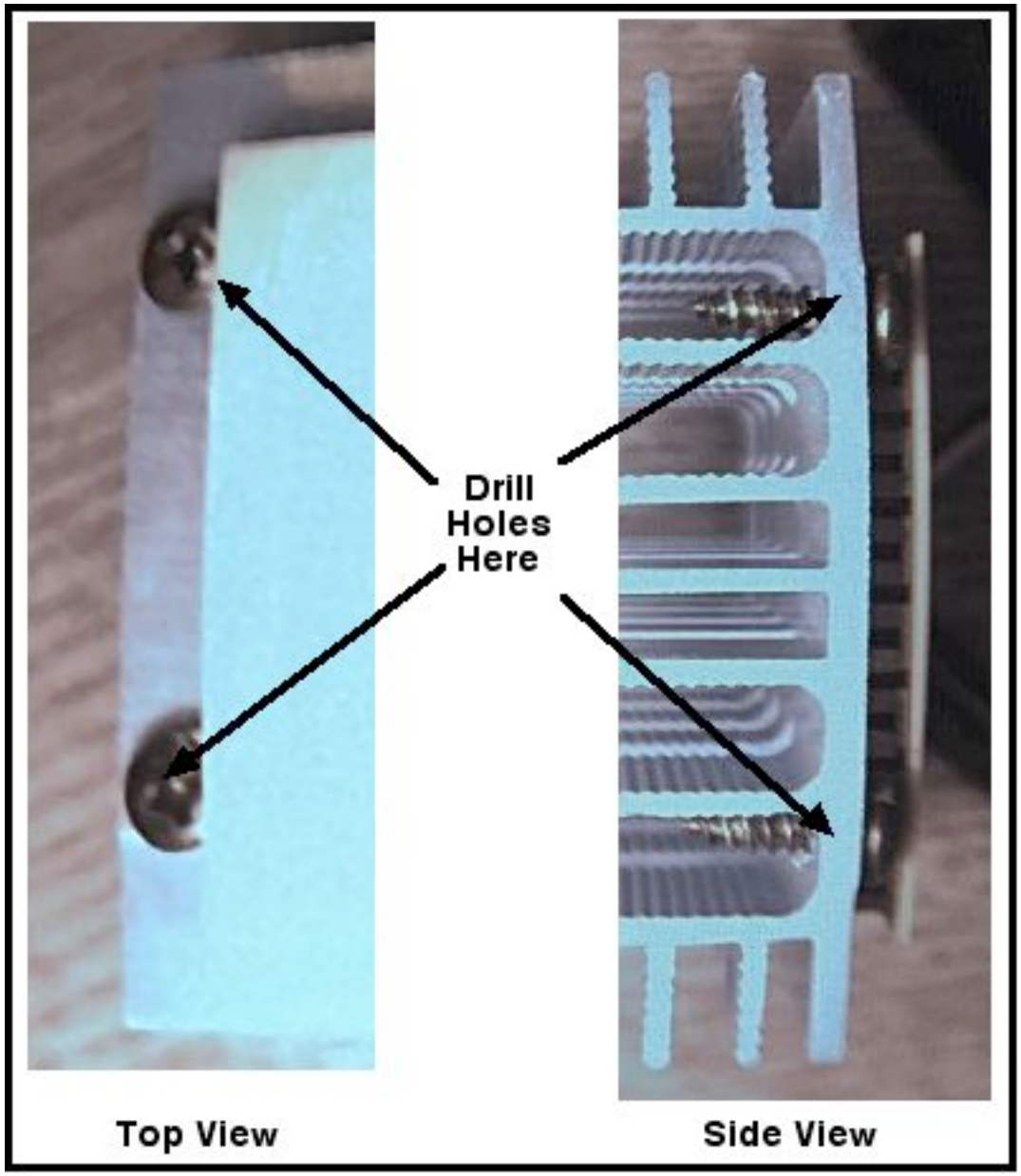
4) Cut the white plug off the CPU Cooler Fan so that you now have 2 bare power leads. You will later merge these leads with the leads on the Peltier Cooler so that both have power and are the same polarity.

B) Mounting the CPU Heat Sink to the hot side of the Peltier Cooler...

What we will do next is drill three holes in the CPU heat sink and then use the three flat head screws to hold the Peltier Ceramic Plate to it.

1) Set the CPU Cooler so that the CPU mounting face is up.

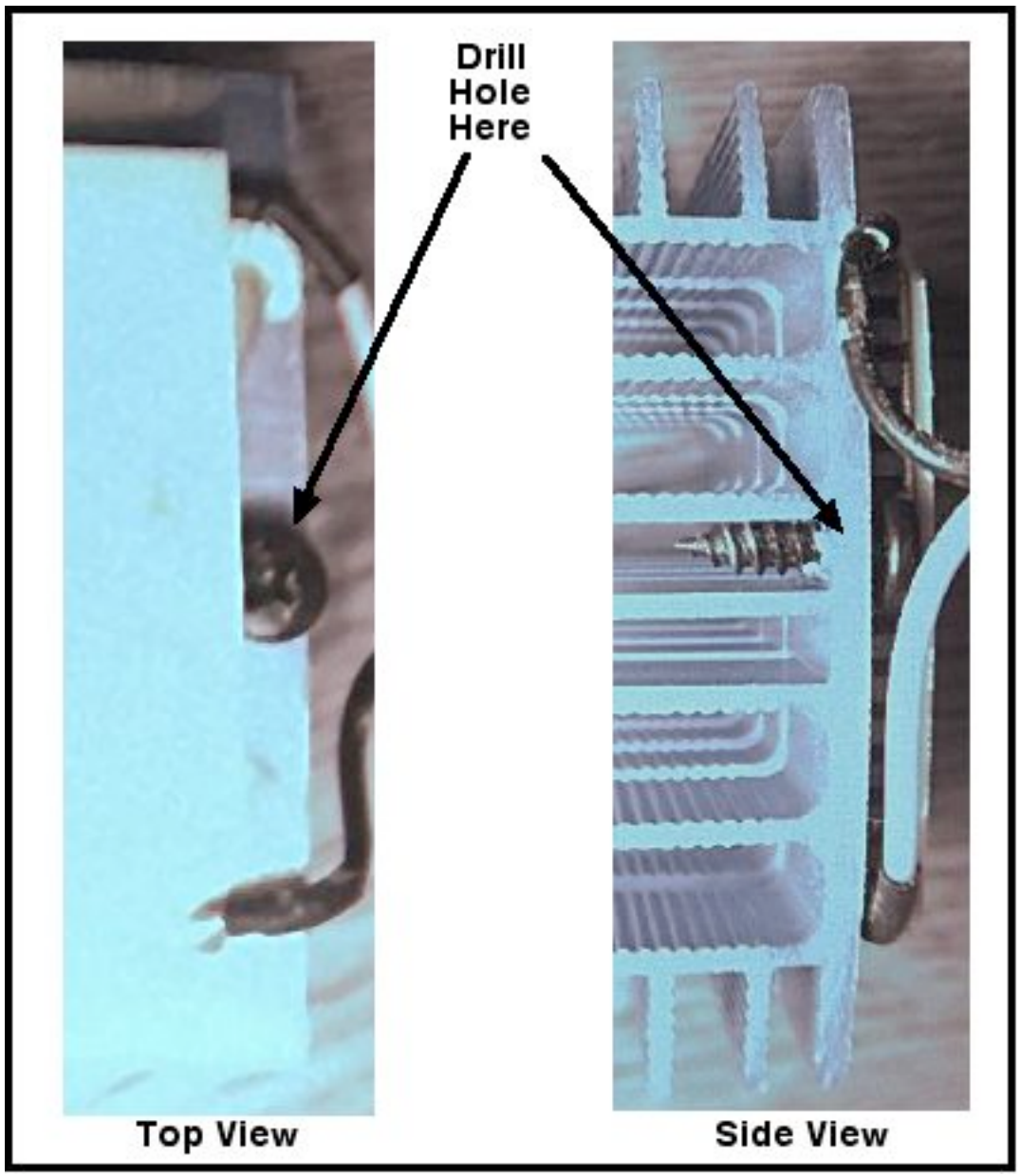
2) Drill two 1.5 to 2 mm diameter pilot holes at approximately 5 mm from the edge of the heat sink and approximately 30 mm apart, which will fit between the last two gaps on the heat sink underside, as shown below (screws are where the hole should be).



3) Now screw in the 2 to 3 mm big headed screws into pilot holes until they are flat. Then unscrew the screws until there is approximately 1.0 to 1.5 mm gap between the head and the Heat Sink surface.

4) Place the Peltier Cooler on the heat sink and move it back until the bottom ceramic plates slides under the raised screw heads. The screw heads will overlap the Peltier Ceramic Plate and will eventually be used hold it in place.

5) Now we need to mark where the 3rd pilot hole and screw should go. This will be approximately 2 to 3 mm from edge of the Peltier Ceramic Plate and centered so that the hole lies over the central gap in the underside of the heat sink, as shown below (the screw is where the pilot hole should go).



6) Remove the Peltier Ceramic Plate from the CPU Heat Sink and then drill the 1.5 to 2 mm diameter pilot hole. Next screw the 3rd screw all the way into the pilot hole until it's flush against the surface. Now unscrew the third screw and remove it.

7) Put a thin coating of Heat Sink Conductive Grease on the "hot" side of the Peltier Ceramic Plate.

8) Place the greased side of the Peltier Ceramic Plate on the heat sink so that it is against the back 2 screws. Now move it back and forth / side to side a little bit so that the grease spreads evenly between both surfaces. Now slide the ceramic plate back so it's under the two raised screw heads and now against the screw body.

9) Now carefully screw in the third screw until it's snug against the ceramic plate. **DO NOT over tighten** or you'll break the ceramic plate.

10) Now carefully tighten the back two screw heads so that they are snug down against the ceramic plate. Again **DO NOT over tighten** or you'll break the ceramic plate.

11) Reattach the Fan to the CPU Heat Sink with the original screws. Make sure it is the correct side up and is blowing air down onto the heat sink fins. If you use more than a 9 volt power supply, you may need to use rubber stand offs to remove fan vibration (see the Vibration Removal.. section at the end of document).

12) Remove some of the insulation on the Cooling Fan's two leads to expose the wires.

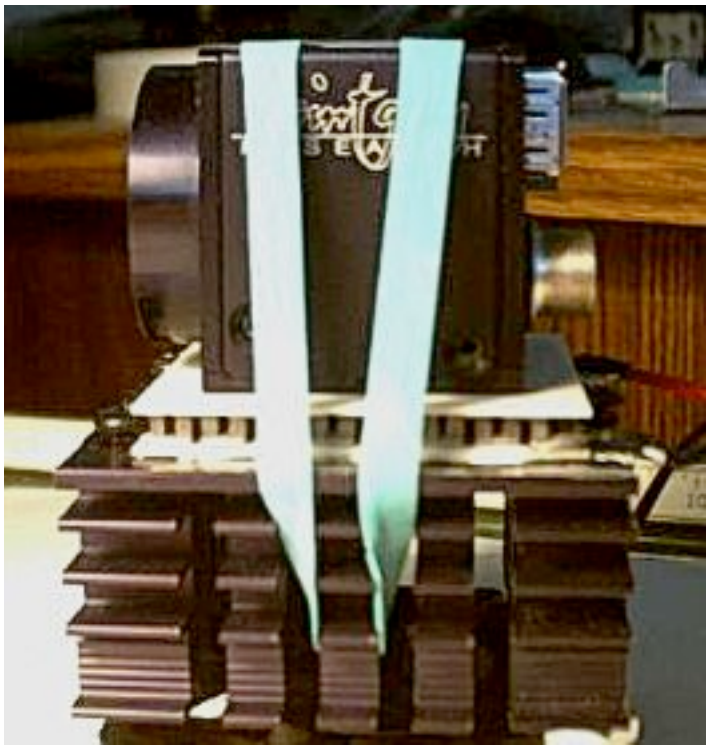
13) Remove some of the insulation on the 3.5 mm Male Power Plug two leads to expose the wires.

14) Twist attach or solder the Red leads together for the Male Power Plug, the Peltier Cooler and the Fan and then wrap them with black electricians tape.

15) Twist attach or solder the Black leads together for the Male Power Plug, the Peltier Cooler and the Fan and then wrap them with black electricians tape.

C) Attaching the Camera (2006 version)

1) Place two or more rubber bands over the arms / fins on one side of the heat sink and pull it upwards until it's snug. I am recommending rubber bands because they are cheap, easy to manipulate and will not over tighten the camera against the Peltier Ceramic Plate. The main drawback with rubber bands is that exposure to sunlight will degrade the rubber and they will eventually break, which is why I recommend 2 or more rubber bands. You will eventually stretch the rubber band(s) over top of the camera and then attach them to arms / fins on the other side of the heat sink, similar to what shown below.



2) You may optionally want to cover the base of the camera (or top of the ceramic plate, which ever is smaller) with a thin coating of Heat Sink Conductive Grease which increases heat transfer. However this potentially could mar the finnish of the camera and is difficult to remove, so it's up to you whether you do this step or not. It will help transfer heat away from the camera.

3) You may also want to optionally create an insulating tent or blanket for the camera. This helps the camera retain it's cold state and can drop the temperature by up to 10°C more. Basically cut a sheet of insulating foam (packaging material) large enough to cover the top and sides of the camera and then wrap it on the three exposed sides of the camera, forming a blanket or tent. Leave more material on the open ends where the telescope attaches and where the FireWire cable plugs in, so you can wrap those areas up too. Folding the material several times to create a multi layer wad and closing off the rear end can make a significant difference. Use twist ties to wrap around both ends and close the blanket material off as best you can.

4) Now place the camera on the cold side of the Peltier Ceramic Plate so that the it is attached either to the top or the bottom of the camera.

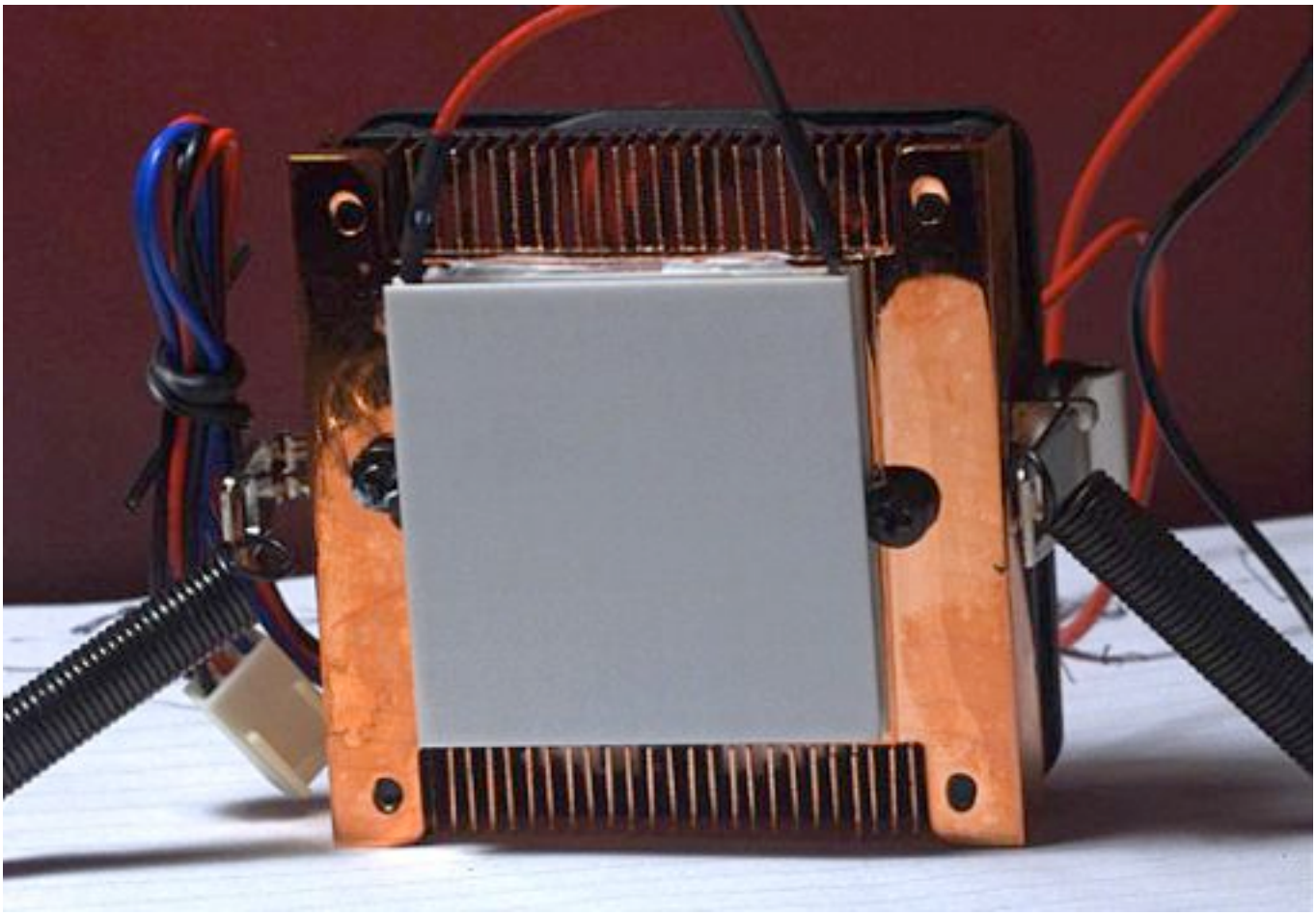
5) Next gently stretch the rubber bands over top of the camera and then attach the rubber band ends over the

arms / fins on the opposite side of the heat sink.

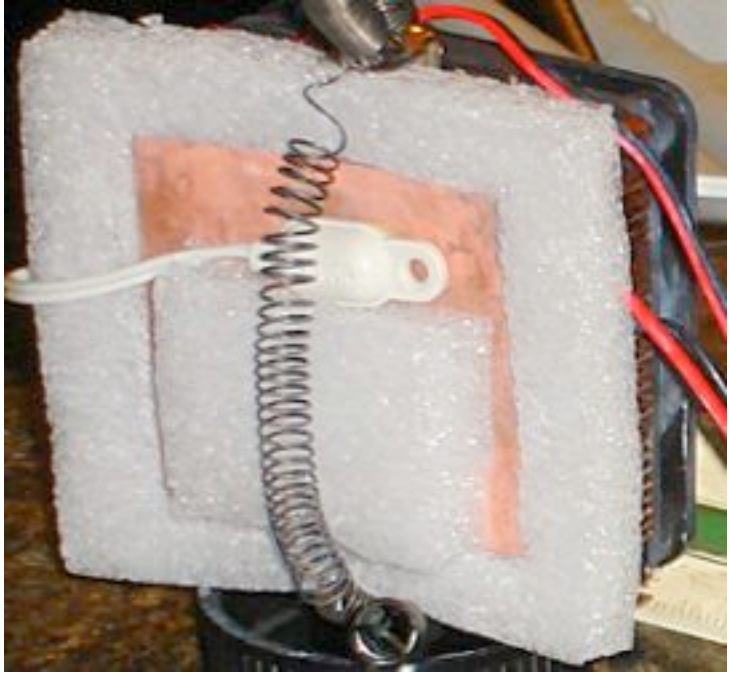
D) Attaching the Camera (2010 version)

The 2010 version has some additional refinements which improve the cooling ability, reliability and stability. The major differences are summarized below.

1) I now use a Copper heat sink which dissipates the heat twice as fast as aluminum, as shown below. Note that I used 2 screws to hold the peltier cooler to the heat sink. This is a mistake as after a while the screws loosened (likely due to vibration and movement) and the peltier plates slid slightly off the heat sink. This caused a huge drop in cooling ability, to the point where it was barely keeping the Grasshopper camera at ambient temperature.



2) To improve the transfer of cold between the camera base and the cold ceramic peltier, I added a ~ 3 mm (0.125 inch) thick copper plate between them as shown in the left image below. This is primarily because the Grasshopper camera has a larger base than the Flea series do and I wanted to increase the surface area that makes contact with the Peltier cooler. It also improves the ability of heat transfer too, as I applied a copious amount of thermal paste between them.



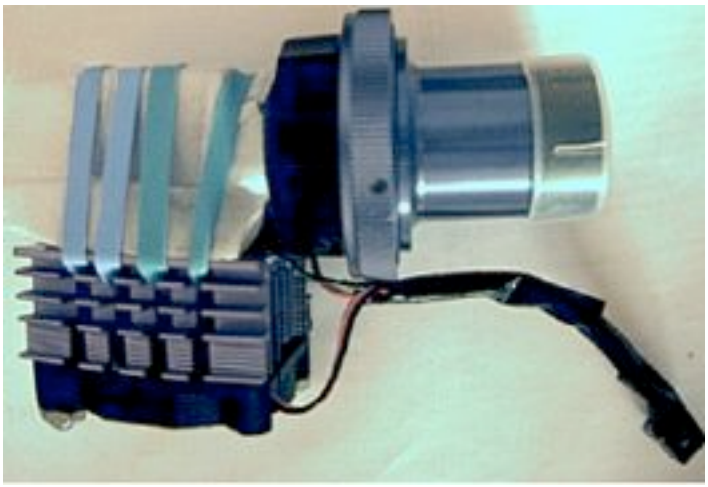
3) Because of the larger sized Grasshopper, I also added a insulating sheet below the camera and around the copper plate, as shown in the right image above (I was testing the temperature drop, which is why the white sensor is on the copper plate) Basically, I cut a hole though the center of the 10 mm thick sheet which is just big enough for the 40x40 mm ceramic peltier cooler. Then using an exacto knife I cut an inset depression that fits around the copper plate. This allows the copper plate to make good contact with the cold ceramic plate and be insulated from the hotter heat sink below.

4) The bracket on the heat sink, which was originally designed to secure it to the CPU, makes for a convenient attachment point for the springs. Basically I wrapped the camera in multiple folds the insulating sheet material and then draw the springs across the camera body. The springs hold the insulation tight to the camera and the camera tight to the heat sink. The thicker springs hold the camera other thinner springs help stabilize it.

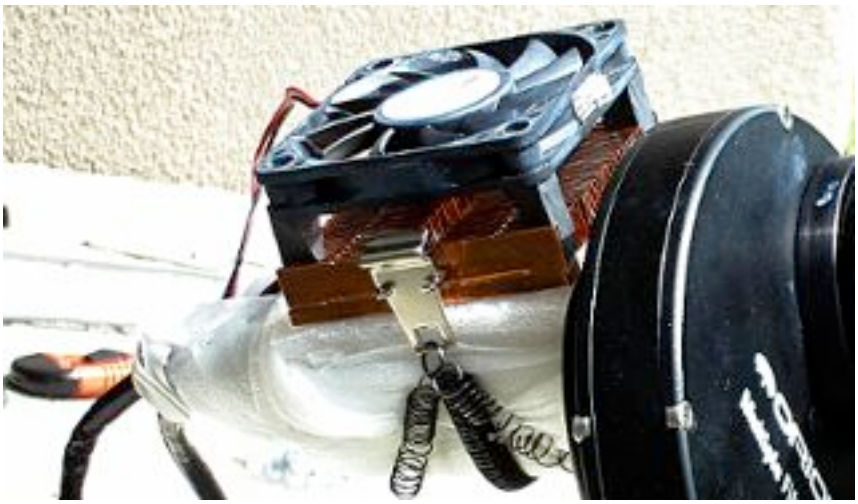
A future improvement will likely be to add 4 small screws at the corners of the Copper heat sink to attach the springs too. This gives some lateral stability and keeps the camera centered better on the cooler. It also allow me to rotate the heat sink 90 degree, so that the air flow is directd out the sides instead of down the telescope axis.

E) Final Product (nearly)..

The assembled product may look something like the following examples (2006 “Mark I”version).



The current “Mark III” 2010 design with the copper heat sink looks like this when in use.



Warning and Cautions...

- Always make sure that the fan is running when your using the cooler. Without the fan, the heat sink will not dissipate heat fast enough and it will over heat the cold side. This could “cook” and cause damage to the camera.

- Using a Peltier Cooler in humid environments and cooling the camera below the dew point can result in water condensing on the outside or inside the camera. Water and electronics are a bad combination, so you need to be very careful with how far you cool the camera down. Most weather web sites that have forecasts for your area will generally indicate what the current dew point temperature is.

- Unless the camera has a metal external case it is unlikely the peltier will help much. Most plastics are an insulator not a conductor, so cooling them will likely not yield much benefit.

- The Rubber Bands will eventually “break” so inspect them before using the cooler if your going that route. Always use 2 or more bands just in case one fails or just switch to non breakable springs and be done with it.

Temperature Change Results..

The most effective way of using the cooler is to power it up for approximately 20 minutes of time before you power up or plug in the camera. It will cool down faster if it the camera is no powered up before you start cooling too.

What drop in temperature you can achieve depends on how much energy you pump into the Peltier Cooler and how fast the heat sink can dissipate the heat. Here are my 2006 test results using the 12 volt 4.4 amp maximum Peltier cooler and aluminum heat sink summarized in the table below.

Time	12V / 1.7A Temp°C	9.0V / 1.7A Temp°C	7.5V / 1.7A Temp°C	6.0V / 1.7A Temp°C	3.0V / 1.7A Temp°C	9.0V / 2.0A Temp°C	12V / 1.25 A Temp°C	12V / 3.3 A Temp°C	9.0V / 0.4A Temp°C
Zero	24	24	24	24	24	24	24	24	24
5 Min	11.8	12.5	13.5	13.7	18.7	13.8	19.2	11.9	17.1
10 Min	10	10	12.3	11.7	16.7	9.8	17.9	11	15.4
15 Min	10.1	10	11.2	11.9	16.3	9.3	17.1	11.8	15.2
20 Min	8.5	10.7	10.4	12.3	16	9.9	17.4	11.2	15.3
25 Min	8.5	10.5	10.7	12	16	9.3	16	11	15.5
30 Min	9.7	10.1	11.9	11.5	16.4	10	15.7	11.5	15.4

Each column represents the temperature drop in degrees centigrade recorded for each AC to DC converter over 30 minutes of time. A converter marked as 12V / 1.7A means it supplied 12 Volts and delivers a maximum 1.7 Amps.

Note that supplying high amps does not necessarily mean you get the best cooling, which is shown in the "12V / 3.3A" case. The problem is that the Heat Sink / Fan combination can not dissipate the heat fast enough and the heat is spilling over into the cold size. A more efficient cooling method such as a copper CPU heat sink does compensate for it.

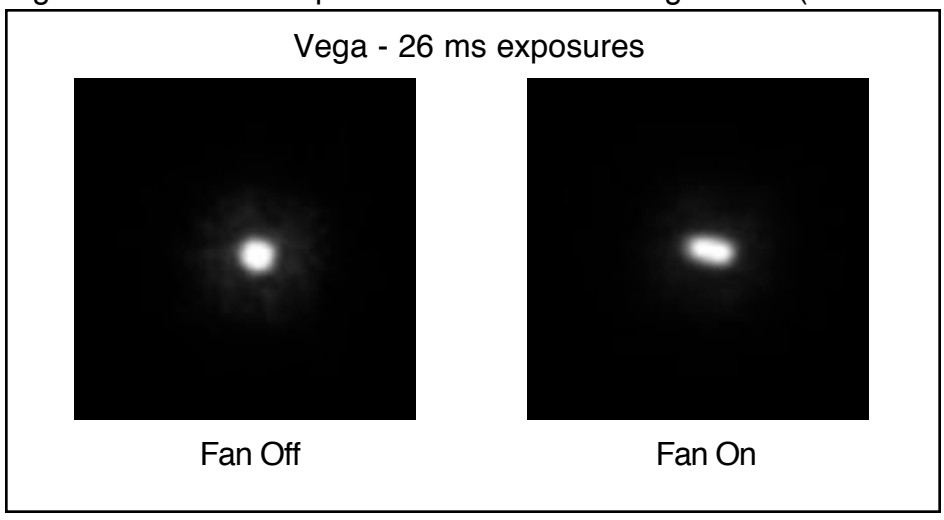
The "sweet spot" for a power supply with the 2006 model Cooler was one delivering a voltage of 9 to 12 and amperage of 1.5 to 2.5. With that you can expect a temperature drop of approximately 14 to 15° Centigrade below ambient temperature.

With the improved thermal transfer in the 2010 Copper heat sink model, I now use a 12 volt / 3.3 amp power source to cool the camera. In testing, this has provide a further 10 degrees centigrade drop, and if the camera starts at +24°C, after 20 minutes it's at 0°C. When running, the Grasshopper EXHAD View cameras add about 6°C of heat due to the CCD and circuitry, so my total temperature drop is from +24°C ambient down to +6°C after 20 minutes with the camera running.

Vibration Reduction..

My original 9 volt 2 amp power supply finally died and I replaced it with a 12 volt 3.3 amp model I have on hand. Although this works very well for deeper cooling with the 2010 Copper Cooler, it created a vibration issues. Note that I have a Carbon Fiber tube on the C8, and the cell that holds the mirror does not vibrate. There is also no vibration on the mount. either However the far end of the tube where the corrector plate attaches has a steady "hum" vibration.

Even when running the camera at high frame rates and short exposures, there is a noticeable elongation of bright stars. Here is Vega shot at 26 ms exposures and 200 % enlarged view (0.6 arc seconds per pixel).



The stars are stretched out by 3 arc seconds and turning the fan off returned the stars to perfect ~ 1 arc seconds dots.. So I decided to to isolate the fan from the mount to try and solve this.

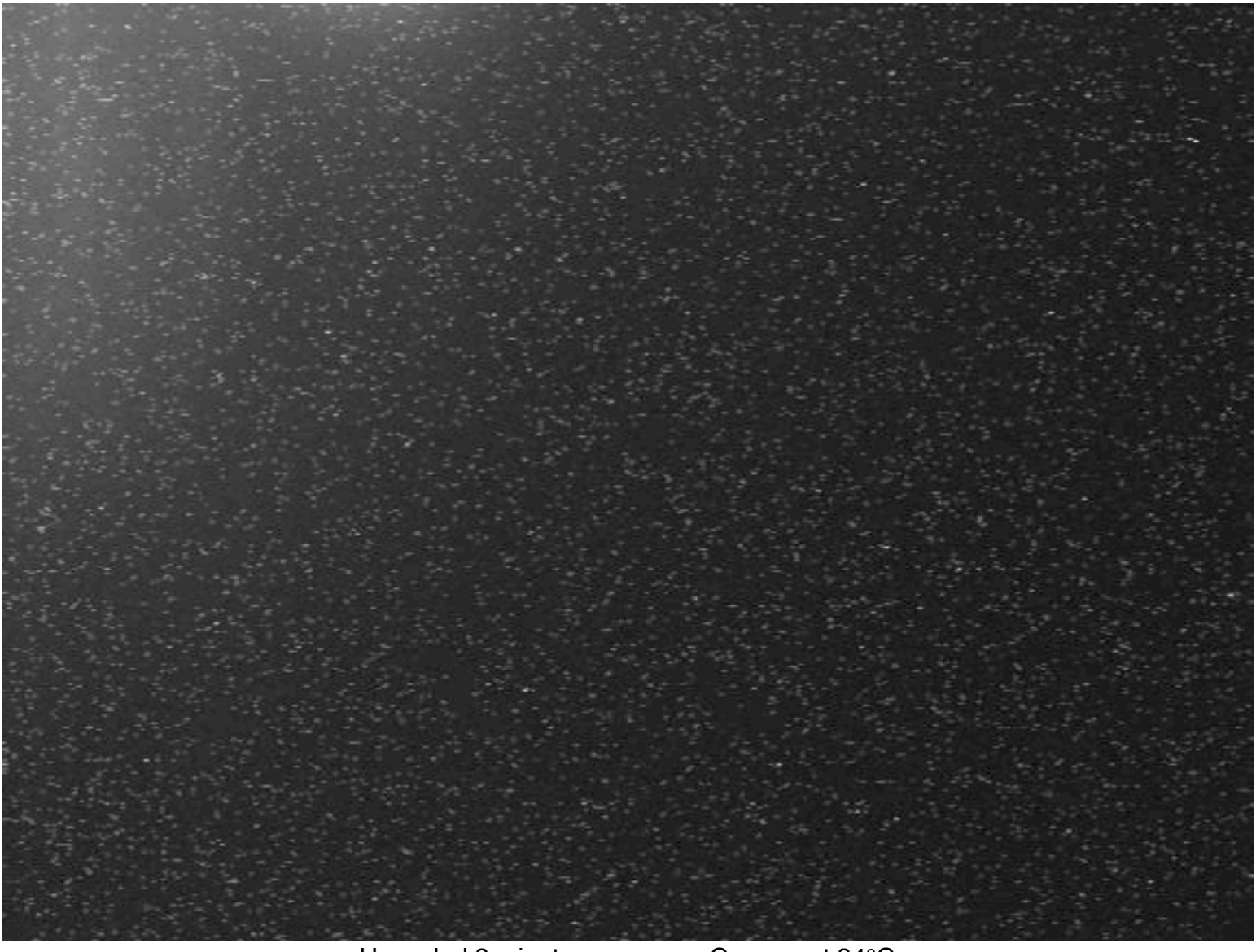
My first attempt was to make some thin rubber washers and insert them between the fan and heat sink. However the heat sink is threaded and the screws solidly attach the fan to it, so the vibration is passed right through. My next attempt was to create some rubber stand offs (6 mm x 6 mm by 25 mm tall) from old rubber plumbing pipe connectors to isolate the fan. These are just large enough to fit tightly into the space between the fins where the original screws went. I used some small short wood screws to attach the fan securely to the top of the four rubber stand offs. Initlaly my tests showed it reduced it somewhat, but there is enough vibration that stars are slightly elongated. Secondly I'm not sure what would happens when the temperature drops below 0°C ambient and the originally pliable rubber becomes as hard as iron.

As it turns out the issue is the fan that shipped with CPU Cooler, which spins at a much higher rate than my previous fans do and does vibrates (perhaps bad or just poor quality bearings). Replacing the fan with another CPU fan (somewhat smaller with fewer blades) I had lying around solved the issue completely.

Note that you may not have the issues I did, which appear to be a combination of Carbon Fiber tube and the harmonic of the fan. So try it out before you go through the things I did above to get a solution.

Example Image Results..

As an example of what cooling can do, compare the following three monochrome images taken with the same FireWire camera and the 2006 mode cooler with a 9 volt 2 amp power source. The images were taken with the same 3 minute exposures and gain levels of 600 out of 1024 maximum. The ambient room temperature was 26.2°C. The first is uncooled (34.0° Centigrade when operating), the second is cooled (12.9°C) and the third is cooled to 9.0°C. The noise drop off from cooling is substantial.



Uncooled 3 minute exposure - Camera at 34°C

Cooled 3 minute exposure - Camera at 12.9°C

Cooled 3 minute exposure using Astro IIDC Auto replace Hot Pixels - Camera at 9°C