**On a thermal effect observed in reflecting telescopes, by André Couder.**

**Original Summary of Couder’s article: Olivier Ruau, France**

**English translation (December 2013): Pierre Lemay, Canada**

*In the September-October 1949 issue of « L’Astronomie », (bulletin de la Société Astronomique de France), André Couder wrote an article on the thermal effects in reflecting telescopes. This extract of what he wrote applies particularly to spider supports and the analysis of the phenomena. The following document is my translation, from French to English, of French Amateur Astronomer Olivier Ruau’s* [*summary*](http://www.astrosurf.com/altaz/effetthermique.htm) *of Couder’s original article, which I have unfortunately not been able to get my hands on (next time I’m in Paris…). Pierre Lemay.*

…Only a support made up of flat blades under tension (secondary mirror support) can provide the necessary rigidity in a large instrument. In principal it is advantageous to make the blades as thin as the resistance of the materials allows.

Without revisiting the diffraction theory of thin screens inserted in the entrance pupil of an instrument, this reminder: the diffracted energy is smallest and is spread over the largest angle when the screen is narrowest, a double reason to diminish the visible spikes. Take a telescope having a diameter “D”, in which the support blades (vanes) have a thickness “e”; Assume a photographic exposure that records stars down to magnitude “M1”; it is possible to evaluate by calculation from which point “M2”, inferior to “M1”, the stars will appear in the photograph showing diffraction spikes. The M1-M2 difference measures the success with which the secondary mirror support is mounted. Observing in the 80cm telescope (*at the Haute Provence observatory in southern France*)… I found a M1-M2 difference inferior to what I was expecting, of 3 or 4 magnitudes. The spikes formed an unexpectedly bright excess. Second remark: the alternating maxima and minima brightness, characteristic of the diffraction figure of a slot having a width “e”, is not visually perceptible. Thirdly, the brightness of the spikes observed visually in the vicinity of the star Vega, for example, varies widely from night to night, and even during the same night. Finally, an electric wire which happened to cut the light path one day produced a spike less bright than the spikes generated by the vanes even though this wire, round and smooth surfaced, had a diameter almost twice the thickness of the spider vanes. “We are obviously in the presence of the same basic phenomena that produces dew: The spider vanes are loosing heat by radiation; the surrounding air cools when in contact with them… the vanes of the 80 cm telescope being approximately 10 cm in height… correspond to an air temperature drop of 2.7°. A round wire, substituted for the spider blade also surrounds itself with cold air, but the wire’s insulator is cylindrical: the light’s trajectory through one of these chords is very short; this explains one of the remarks made earlier” (Couder follows with a demonstration of the lowering of temperatures). “… The thermal emissivity of the black paint that covers the spider vane is 0.9; explaining the temperature drop of 4.4°, in calm air. When recalculating with a doubling of the convection coefficient, we find -3.1°. These numbers match well with the experimental results of -2.7° obtained earlier: the vane’s surrounding air is obviously warmer than the vane. The regularity of the observed appearances is a consequence of the speed of air circulation being much too small to be accompanied by turbulence: the airflow is laminar.”

The spikes being mainly caused by refraction through a layer of cold air, many remedies can immediately be called upon:

* Reducing the length of the optical trajectory in this cold air by reducing the height of the vanes;
* Removing material in the vanes, where possible, while maintaining sufficient strength to properly hold the secondary mirror;
* Substituting steel wires instead of flat vanes;
* Increasing the coefficient of convection using forced air;
* Adding a tube extension as long as the observatorie’s dome will allow, to reduce the solid angle of sky seen by the instrument;
* Finally, reduce the thermal emissivity of the spider vanes. Here, a few explanations are necessary.

The radiating energy exchanged with objects at ordinary temperatures has its maximum intensity, for a wavelength of λm, near 10m. In this spectral domain paints and varnishes are very absorbent: their power of emissivity is only slightly inferior to that of a black body. Note in passing that this property is almost independent of the nature of the pigment and is a consequence, mainly, of the absorption of the coating product… On the other hand most polished metals have an infrared emissive power inferior to 0.12. Introducing this number in the preceding formula… we find the temperature is reduced by 1.2° or 0.65° (depending on convection rate), almost a quarter or a fifth.

To check these predictions on the 80 cm telescope, I simply covered (glued) a sheet of thin polished aluminum to the vanes as they are currently setup. The operation having been done on only one of the two crossed vanes, we first observed the image with a low power eyepiece. The favorable effect is immediately obvious, although the eye is a poor judge of two linear sources: the spike corresponding to the treated vane appeared (the wind speed being variable) weaker and 2 to 6 times shorter, than the untreated one… Of course the glued aluminum foil was but a crude, temporary setup. On an instrument under construction we will use polished steel vanes, nickel or chrome plated.

Will the polished surfaces not create unwanted reflections? To understand that this fear is unfounded, let’s first consider the observation at the Cassegrain focus: since the vanes are parallel to the optical axis, from a view a short distance from the optical axis, we see a reflected image of the sky very oblique on the vanes. This image has a brightness not much lower than that of the sky itself. It appears under a very small solid angle as compared to the larger opening of the telescope. Consequently, the brightening the focal plane undergoes is insignificant. We can also take comfort in the fact that the reflexion properties of the best paints and varnishes is far from insignificant under such high angles of reflexion. As for Newtonian focus: the eye placed at the focus can see the reflections off the vanes of certain areas at the top of the tube. These areas must be blackened.

The advantages that procure low emissivity coatings can be extended to every component in the upper part of the tube assembly, including the secondary mirror support. I have never observed a cold current effect on the secondary mirror supports on the telescopes at the Haute Provence Observatory (French Alps). The reason, I believe, is this: We can consider constant the air temperature surrounding the secondary mirror vanes, thin and lightweight, which quickly attain their equilibrium temperature. Such is not the case with the secondary mirror supports of large telescopes, the mass of which is higher than 15kg. The speed of cooling of these components for a temperature difference of a few degrees is comparable to the drop in speed of air temperature during the night… … It is the heat accumulated in these massive components during the day which supplies the loss by radiation. The surrounding air around the small mirror appears when it is lightweight. Its existence was noted by M.P.J. Hargreaves, who blames it for the apparent overcorrection of spherical aberration often observed. The cold air column having no more than 1 cm of thickness, this explanation for overcorrection seems true, to me, only for small telescopes. All the same, the remedy I have just described can be applied without difficulty.”