MEMO7588.tex

FROM: R. Weiss July 5, 1988

CONCERNING: Elementary geometric considerations of light baffles in a tube

A classical technique to reduce the illumination of the exit aperature of an enclosed optical system due to scattering from a primary source is to employ baffles. In many optical instruments, including the LIGO beam tubes, the dominant source of difficulties with scattering are ray paths that leave the primary scatterer, in our case the mirrors, then hit the walls of the enclosure and there by either Lambert law or specular scattering are directed to the exit aperature. A means to prevent this is to use baffles that are arranged so that no point on the enclosure wall can "see" both the mirror *and* the exit aperature.

The calculation in this memo applies to purely geometric propagation and does not take into account the much harder problem of the diffraction and reflections by the baffle edges which are being worked on separately. It is clear that in the special circumstances of the LIGO where the light has coherence lengths larger than the beam tube lengths, the geometric approach is a poor approximation since the important consideration is the degree of spatial coherence of the scattered light at the exit aperature. The specific baffle design, the overall shape, the character of the edge and the baffle spacing will be guided more definitively by the diffraction calculations than by the geometric constraints given in this memo. The geometry does serve to give a crude scale to the problem as the baffles are needed in the LIGO to reduce the almost specular reflection from the tube walls at the extremely small glancing angles we expect in the tubes. I don't believe there is a surface black or rough enough (that we can use both from the standpoint of the outgassing and the cost) to keep the walls from looking like perfect mirrors at the small glancing angles.

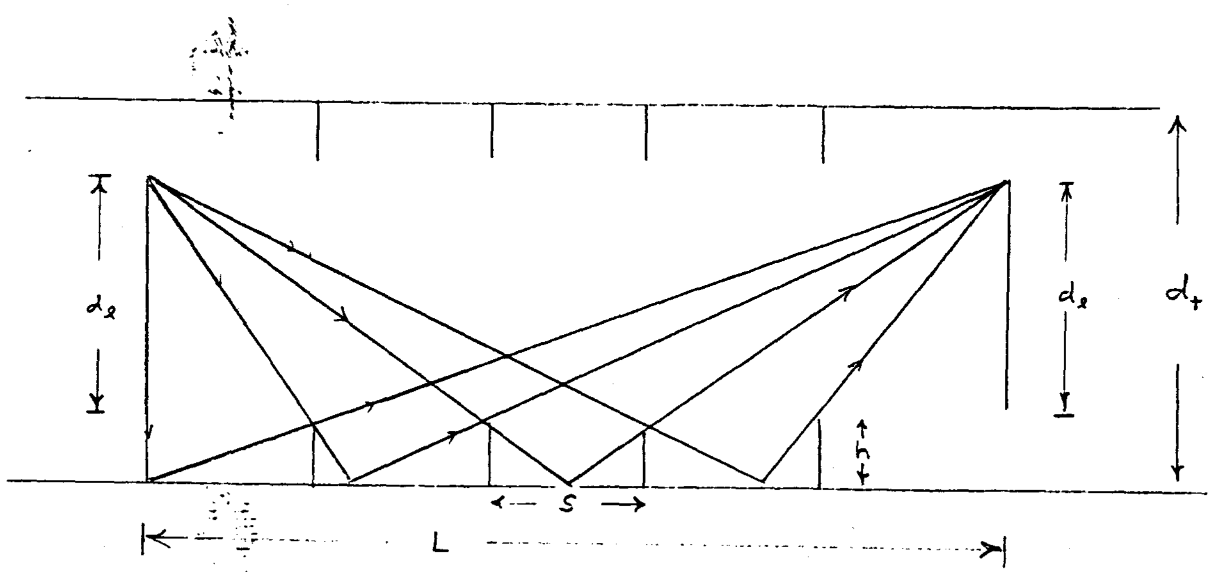

FIGURE 1

Figure 1 shows the geometry. L is the length of the tube and d_t is the tube diameter. d_e is the diameter within which the exit aperature and the mirrors are located. The baffles are assumed to have a circular projection on planes perpendicular to the tube axis. In these planes they have a projected height from the tube wall of h. The projected diameter is

$$d_b = d_t - 2h.$$

The baffle spacing, assumed uniform, is s. It is worth noting that the geometry is symmetric about the half length point of the tube since one is free to interchange the exit aperature and the mirror in the process of thinking about blocking the paths with the baffles. The baffle height required to obstruct the paths hitting the half way point of the tube is determined by similar triangles as

$$\frac{2h}{s} = \frac{d_t + d_e}{L}.$$

The total number of baffles is $N = \frac{L}{s}$ and if $d_e \approx d_t$, then

$$hN = d_t$$

Even though the calculation is done at the mid point of the tube, the result is true for any point along the tube since both specular and Lambert scattering contribute.

Figure 2 shows the relation between the number of baffles and their height as well as the obstructed area as a function of the number of baffles for a tube diameter of 48 inches (122 cm).

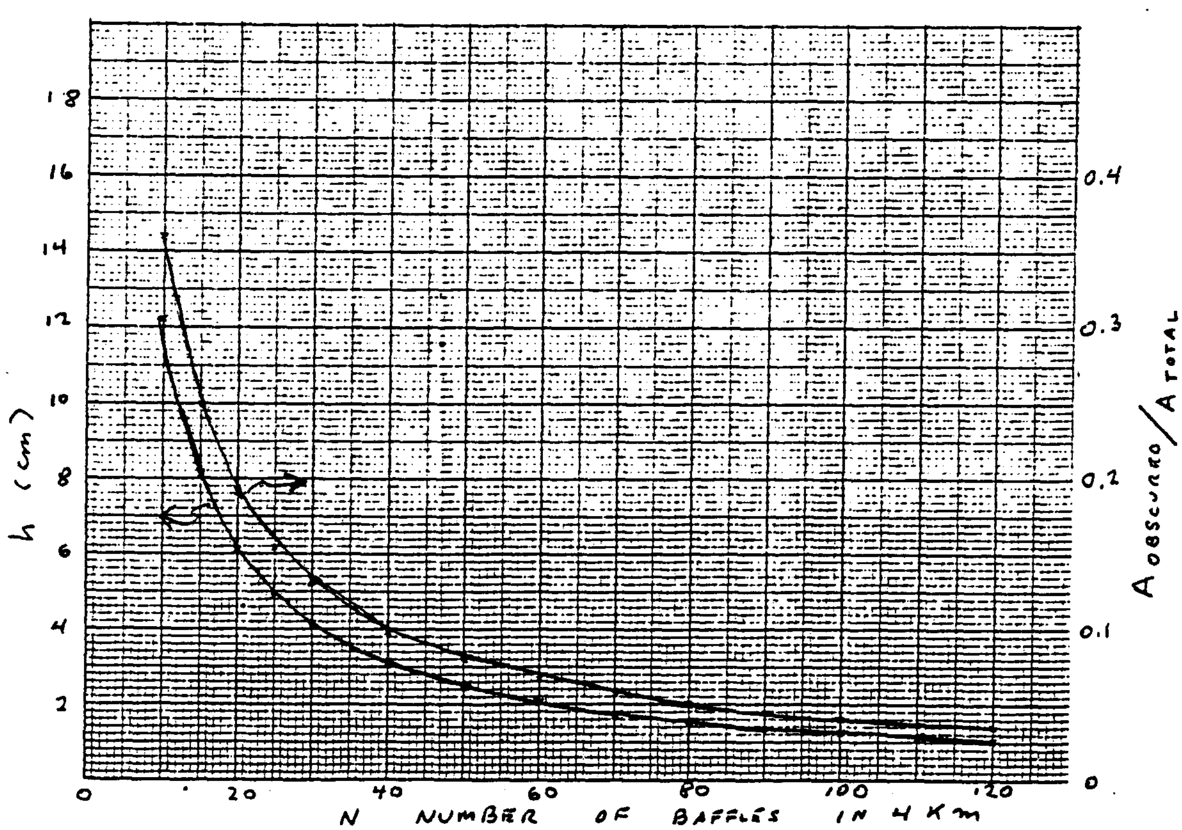

FIGURE 2