NATIONAL RADIO ASTRONOMY OBSERVATORY

February 23, 1981

25 METER MILLIMETER WAVE TELESCOPE
MEMO No. 138

TO: W. G. Horne and 25-m Group

FROM: S. von Hoerner

SUBJECT: Reflective Surface Paint

This is a response to Bill Horne's Memo No. 137 of February 10. The reported loss of reflectivity at shorter wavelengths looks indeed rather disturbing, and I wanted to visualize how bad it actually is.

The design goal of the 25-m telescope is a surface rms deviation of $\sigma = 0.075$ mm, for a nominal shortest wavelength of $\lambda = 16\ \sigma = 1.20$ mm. This wavelength is at one of the atmospheric windows; the next one up is at $\lambda = 2.0$ mm, the next one down at $\lambda = 0.87$ mm (values from 25-m proposal).

Fig. 1 shows superimposed the reflectivity of white-painted plates of four different layer thickness, light to medium heavy. It may be possible to limit the range of paint thickness between 100 and 150 μm ($4 - 6 \times 10^{-3}$ inch). If so, we may use from Fig. 1 only cases b and c, which are practically the same and not so bad as the extremes.

Fig. 2. thus uses the reflectivity $R = \frac{1}{2}(b + c)$ and shows the comparison between blank and painted plates, regarding the efficiency and the gain of the 25-m telescope. We now may draw different conclusions. My own conclusion is: Yes, we should try hard to find a better paint, if that is possible; but if not, we still have a rather good telescope with paint, even at $\lambda = 0.87$ mm, but especially so at the design value of $\lambda = 1.20$ mm.

Why not blank? The unpainted aluminum surface goes in sunshine easily up to 70 °C at an air temperature of 30 °C, or $\Delta T = 40$ °C above air; whereas the white-painted surface goes only to $\Delta T = 5$ °C above air. Thus, the thermal deformations from sunshine (or heat radiation from dome) will be increased by as much as a factor of <u>eight</u> if the paint is omitted. This excludes daytime with open dome

observations in most pointing angles. And regarding the closed dome in daytime, we certainly would need repeated measurements of a "Plate in Tent" with a blank plate.

Does anyone understand the measured reflectivities of NPL, shown in Memo 137? I tried to but couldn't, see Fig. 3. Interference between two reflected rays seems the easiest explanation for well-pronounced wavelength-dependent minima. In this case we would expect

$$\Delta p = 2t = \frac{1}{2}\lambda, \quad \frac{3}{2}\lambda, \quad \frac{5}{2}\lambda, \quad \ldots.$$

where Δp = path length difference and t = paint thickness. I asked Bill Horne about the paint thickness of the five measured cases and he gave me the approximate values of Table 1. There is not much agreement between the expected minima at 4t or 4t/3, and the measured minima at λ_o. Maybe the fairly constant λ_o for thinner paint means selective absorption, and maybe a combination of both absorption and interference would explain the data?

Table 1. Paint thickness, expected and observed minima.

case	thickness		expected	observed
	10^{-3} inch	μm	4t, 4t/3	λ_o
a. light	3	75	0.30 mm	0.79 mm
b. standard	4.5	115	.46	.77
c. medium	6	150	.60	.76
d. medium heavy	7.5	190	.76	.84
e. heavy	9	230	.92, .31	1.45, .46

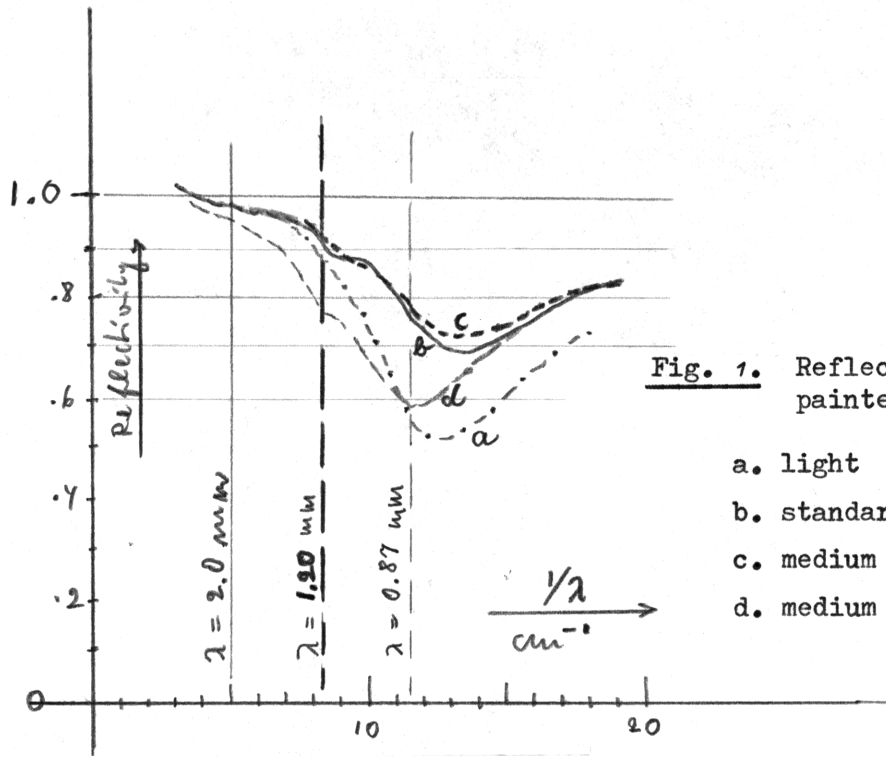


Fig. 1. Reflectivity of painted plates.

a. light

b. standard } average used

c. medium }

d. medium heavy

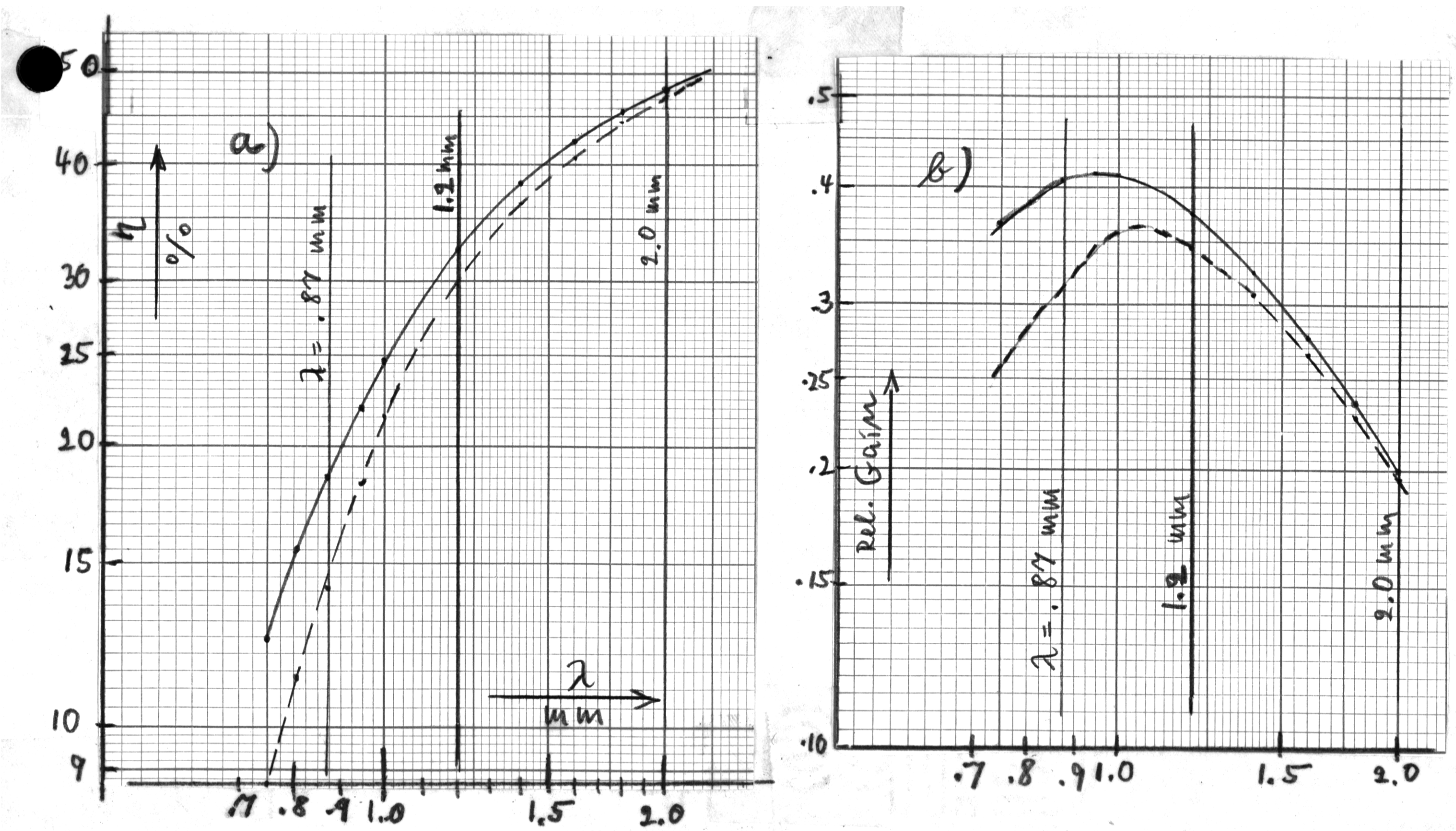
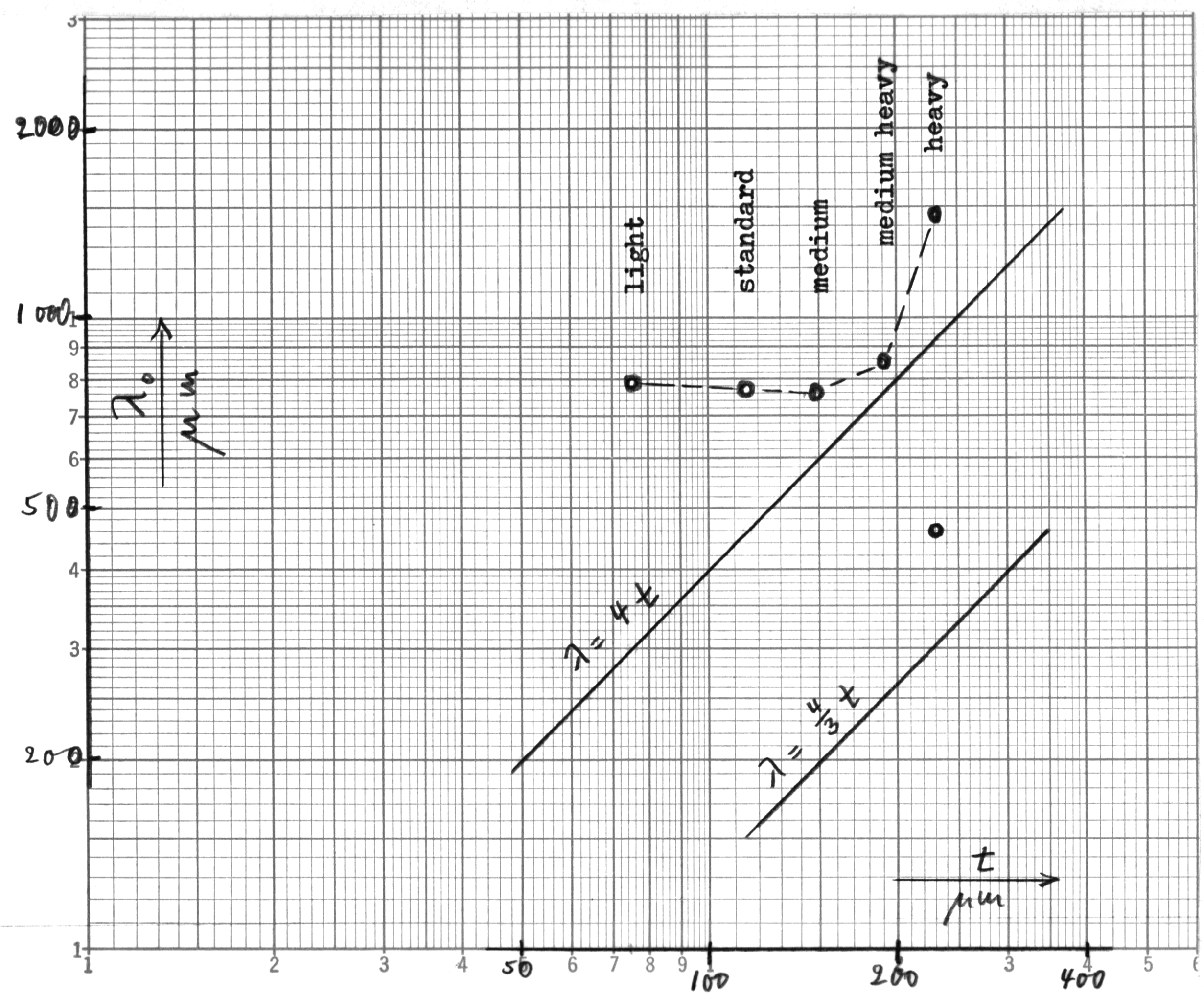


Fig. 2. Comparison of blanc (———) and painted (– – –) plates.

a) Efficiency, with $\eta_o = 60\%$, and $\sigma = 75\ \mu m$.

b) Gain $= \eta/\lambda^2$.



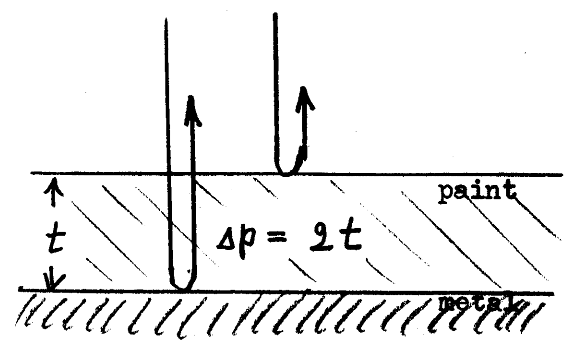


Fig. 3. Trying to understand the minima of the measured reflectivity.

They could be caused by interference between the rays reflected at the metal surface and at the paint surface.

But then the path difference Δp should be equal to $\lambda/2$ for the main minimum, $3\lambda/2$ for the secondary one.

No good agreement.