GBT Memo No. 46

Painting the Surface of the Green Bank Telescope

D. Hogg

March 22,1990

I have reviewed some of the earlier work on the subject of painting telscope surfaces. The studies were made for the 25 M Telescope project, so it emphasized shorter wavelengths than we are concerned with. However, the results are quite helpful to us.

The basic memo is that by Bill Horne (25 M Memo No. 137) which summarizes some rf tests that John Payne had run at the National Physical Laboratory in Britain. I append the memo to this note. In summary, the results are that the paint we normally use (Triangle No. 6) has essentially no loss up to frequencies near 100 GHz. From the RF standpoint there is no objection to painting the surface.

There are two additional memos (Numbers 138 and 139) by von Hoerner and by Payne,respectively. Sebastian points out that the surface must be painted, since an unpainted surface illuminated by sunlight can rise to a temperature 40 C higher than ambient, whereas a painted surface will probably stay within 5 C of ambient. John notes that the paint is a mixed blessing, since it radiates so effectively in the infrared. Thus at night that the surface can develop a temperature difference of 5 C between the front and the back.

I conclude that the telescope should be painted, and that the rf loss arising in the paint will not be great. However, the temperature differential of 1 C envisioned for the precision operating condition will probably not occur as often as I at least had thought.

Interoffice

National Radio Astronomy Observatory

Very Large Array
February 10, 1980

25 METER MILLIMETER WAVE TELESCOPE
MEMO No. 137

To: Addressees

From: W. G. Horne

Subject: Reflective Surface Painting of the 25 Meter Antenna

In a memo of July 10, 1980 commenting on J. W. Findlays report on thermally induced surface plate distortions I raised some questions relative to the surface painting of the 25 meter which disturbed me. The basic (and most important) question concerned the exact mechanism by which the presently used surface paint reflects radiation at radio wave lengths and diffuses radiation at infra-red and optical wave lengths. I particularly directed the questions to John Payne since I thought he might have some information or opinions on the subject and received an immediate reply from John to the effect that indeed the same questions had disturbed him, and that he had in the past sought answers to them. John and I have had several discussions on the subject and John has provided me with an investigation into the problem which leads to a decision which I think that John and I concur in but which I believe others involved in the 25 meter should be aware of.

A. The Investigation

Several years ago John Payne provided the British National Physical Laboratory with 5 painted aluminum samples of the paint (Triangle No. 6) used by NRAO on telescope reflecting surfaces. These 5 specimens varied by paint thicknesses. The NPL performed power reflectivity test on these specimens along with other specimens being considered for a millimeter wave antenna. Attached are figures 8, 9, 10, 11 and 12 from that report which cover the NRAO paint. If anyone desires to read the complete report they can contact me and I will zerox a copy for them.

The NPL found that the power reflectivity of the aluminum specimens coated with the NRAO paint was essentially 1 at 3^{-1} cm (90 GHz) but that the reflectivity dropped on 4 of the specimens starting at about 3.3 mm with a minimum reflectivity reached around 12.5^{-1} cm, the reflectivity then showed a moderate rise to a peak of around 80% at around 0.5 mm wavelength and then reflectivity started dropping again.

The tests seem to answer conclusively the first question I have had which is that in our normal observing ranges (3mm to 21 cm) the signal is being reflected from the metal surface of the panels and not the paint surface which is why our repainting of the surfaces at Green Bank and Socorro have no apparent impact on the observing efficiency. The decrease in reflectivity which apparently starts in the vicinity of 3.3 mm wavelength is attributed to be due to beam interference within the paint with the maximum loss of reflectivity due to this cause being a function at the paint thickness. Note particularly Fig. 12 which shows 2 minima and is for a very heavy thickness of paint. Note also that for this thickness the first minimum occurs at about 1.4 mm wavelength.

B. Conclusions and Decisions

It is therefore concluded that we should not plan on painting the reflecting surface of the 25 meter antenna with the Triangle No. 6 paint presently used by NRAO since we plan on observing in the frequency range in which reflected losses through this paint run in the 30 to 40% range for reasonable thicknesses and if a heavy thickness might inadvertently get applied in certain areas, loss is much more. For the present we must plan to use the surface panels of the 25 meter antenna unpainted on the reflecting surface. I will continue discussions with Triangle Paint Co. to see if they have any hope of formulating a paint which might be satisfactory at our frequencies.

An additional point which can be made here is that this NPL report does seem to confirm the reports which John Payne received from observers who used the 36 foot at 1 mm following our painting of the surface some years ago. These reports indicated that efficiency at 1 mm was reduced some 20 to 30%. It would seem that we should certainly not consider recoating the 36 ft. and might want to consider removing the existing paint if observations are planned below 3 mm wavelength.

C. Implications of the Decision

A decision not to paint the reflecting surface of the 25 meter has a number of adverse implications which should be called to the attention of those responsible for planning the use of the instrument and also those responsible for certain engineering facets of the instrument.

1. The surface will be more vulnerable to mechanical damage, ie. scratching due to surface travel, corrosion, discoloration etc.
2. The surface will be subject to greater thermal distortion due to direct radiation when the dome doors are open since thermal reflection will be less.
3. Since there will be no diffuse reflection of infra-red and optical radiation it will not be possible to observe the sun with the dome door open and telescope operators must be careful not to traverse the sun when slewing with the dome door open. It will be possible to observe the sun with the dome door closed but the shortest wavelength will be limited.

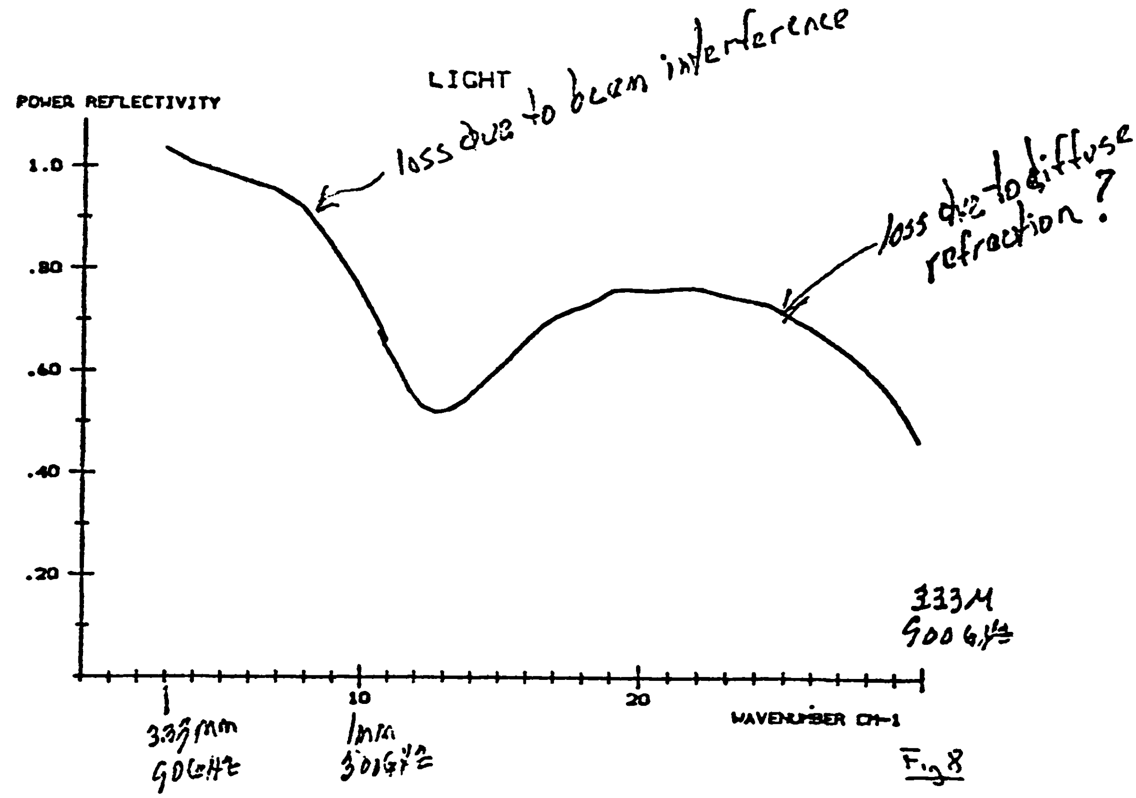


Fig 8

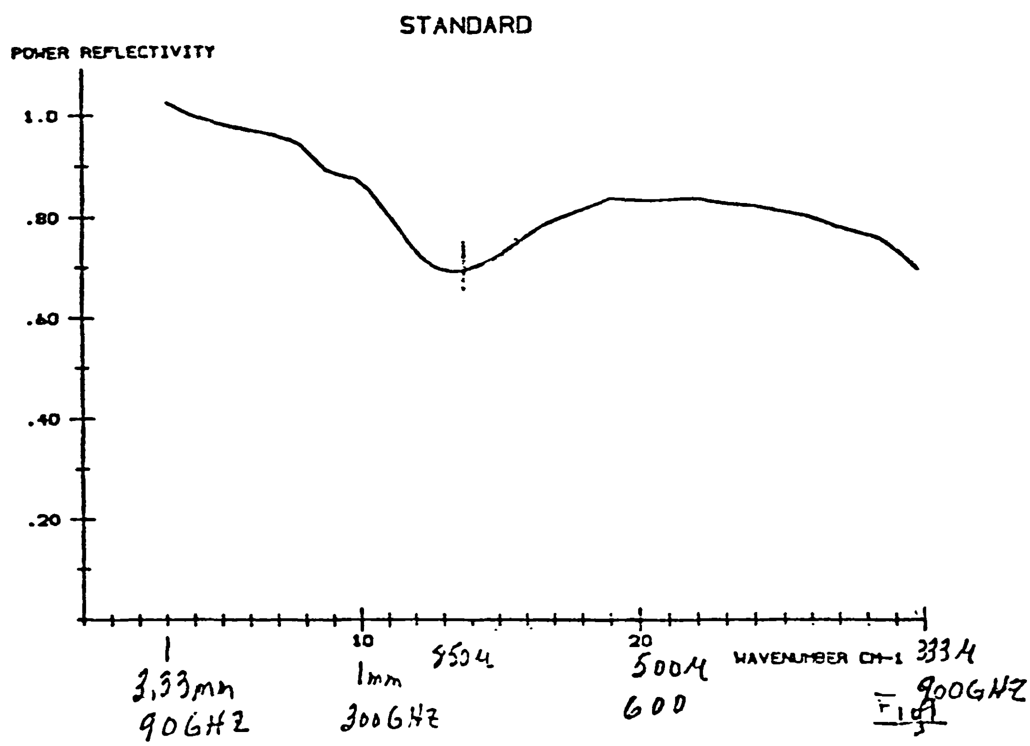


Fig 9

800 μ = .8 mm = 12.5^{-1} cm

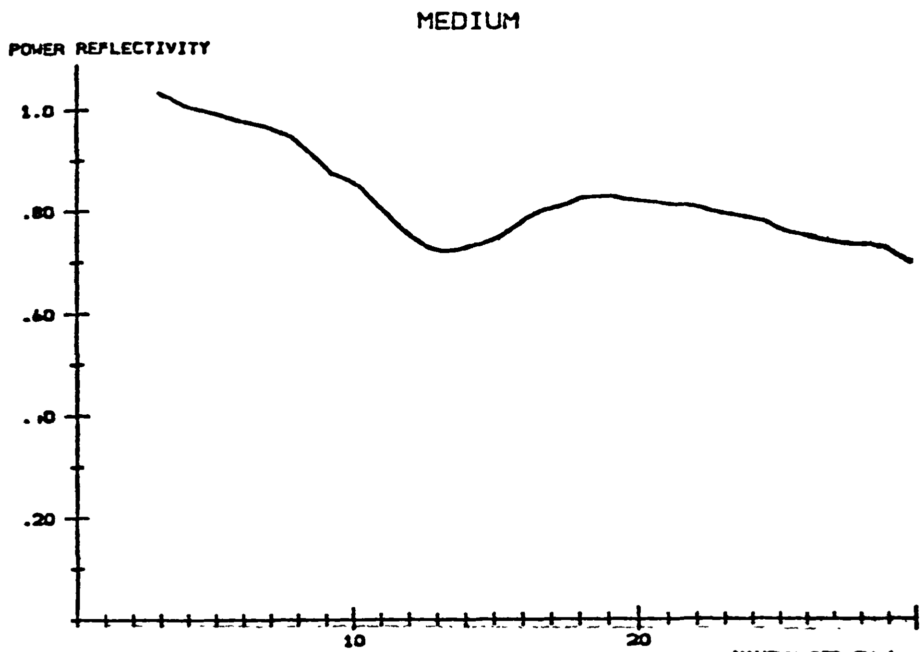

MEDIUM
POWER REFLECTIVITY
1.0
.80
.60
.40
.20
10
20
WAVENUMBER CM-1

Fig 10

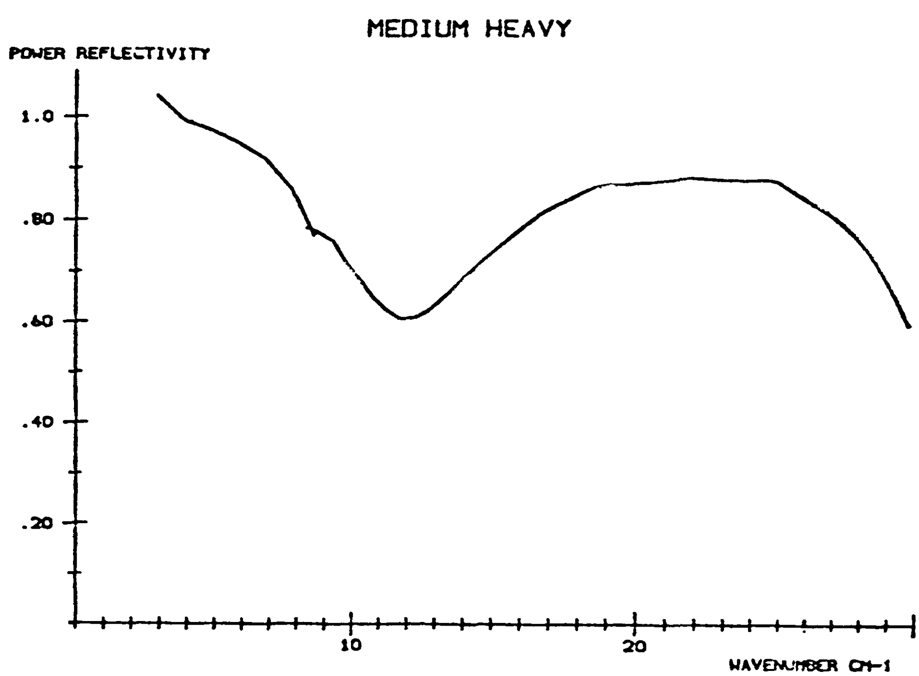

MEDIUM HEAVY
POWER REFLECTIVITY
1.0
.80
.60
.40
.20
10
20
WAVENUMBER CM-1

Fig 11

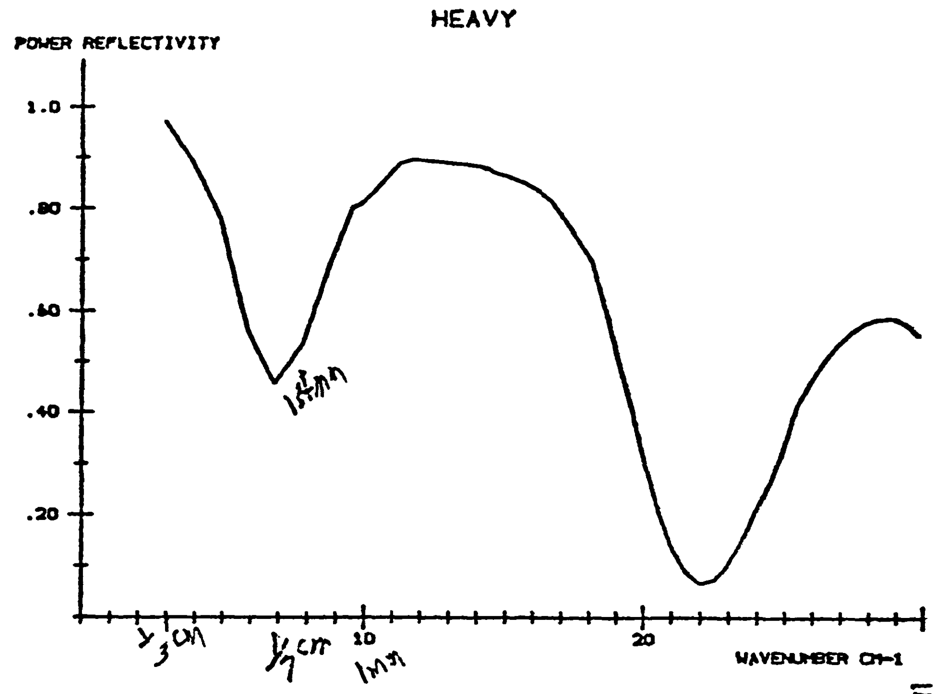
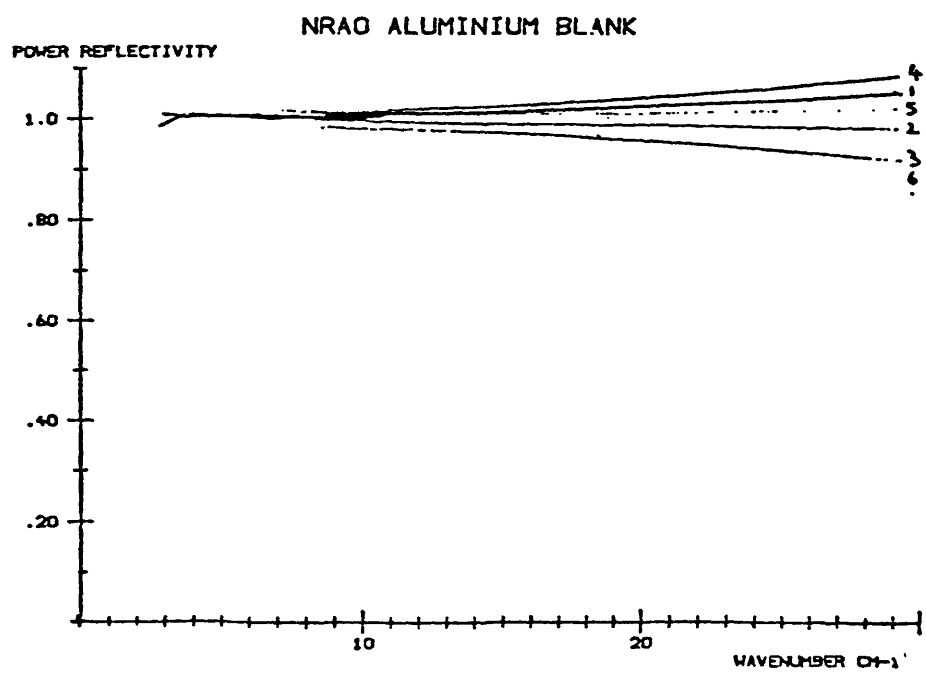

HEAVY
POWER REFLECTIVITY
1.0
.80
.60
.40
.20
10
20
WAVENUMBER CM-1

Fig 12.


NRAO ALUMINIUM BLANK
POWER REFLECTIVITY
1.0
.80
.60
.40
.20
10
20
WAVENUMBER CM-1
4
1
5
2
3
6

F[illegible]