12 METER MILLIMETER WAVE TELESCOPE
MEMO No. 156

NATIONAL RADIO ASTRONOMY OBSERVATORY
Tucson, Arizona

May 3, 1982

12-m Telescope Memorandum

To: H. Hvatum

From: M. A. Gordon

Subject: A Sunshield for the 12-m Telescope

An advantage of the Kitt Peak millimeter-wave telescope over many of its competitors has been its ability to operate effectively during the day as well as during the night. The astrodome shields the telescope structure from the heating effects of direct sunlight. A removable sunshield shields the surface and feedlegs from sunlight during observations of sources near to the sun. The Caltech 10-m telescopes are reported to degrade substantially during the daytime because they are unprotected from sunlight. The UMASS telescope, while protected from direct sunlight by its radome, is restricted by the transmission characteristics inherent in the membrane and space frame of its radome.

Only the millimeter-wave telescope of the University of Texas is able to work well in direct sunlight, thanks to its gold-plated Invar surface and its astrodome. But, its 4.9-m diameter provides significantly less collecting area than will our forthcoming 12-m telescope.

The result is that the 36-ft telescope continues to be an useful research instrument in spite of its 1960's antenna technology. We want the 12-m telescope to perform even better.

The teepee for the 36-ft telescope is made of Griffolyn T55. This material is a sandwich of white and black polyethylenes, with a coarse nylon netting bonded in the middle for strength. Radiowise, it acts as a single homogeneous membrane with a dielectric constant of 2.7 relative to air and a loss tangent of 0.006.

The heavy curve (marked "Characteristic") of Figure 1 shows the transmissivity of T55 as a function of frequency, for normal incidence. The small loss tangent gives it negligible absorption for frequencies up to 1000 GHz. For frequencies of importance to the 12-m telescope, the loss is due entirely to multiple reflections within the membrane. The 0.1-mm thickness of T55 gives the first resonance at about 450 GHz. (For the theory of the radio transmission of a membrane, see pages 259ff of Volume 26 of the MIT Radiation Laboratory series.)

Figure 2 sketches three possible configurations in which the Griffolyn T55 can be used as a sunshield for the 12-m telescope. The corresponding transmissivities of these schemes are plotted in Figure 1.

For the 12-m telescope, a teepee will have the fabric inclined 52° to the direction of incoming radiation. The path length through the fabric will increase by the factor secant(38°), giving the transmission curve marked "Teepee" in Figure 1. While the transmission of this kind of design is excellent up to the probable 400-GHz limit to the telescope's operation, the teepee acts as a sail to the wind coming through the astrodome slit. For the 36-ft telescope, this wind torque can easily overcome the torque capacity of the telescope's drive motors. The resulting pointing errors can offset the sun-shielding advantages of the teepee.

Another possibility is to stretch the membrane across the telescope's surface. This configuration would eliminate the extra wind torque. Unfortunately, the incoming radiation (1) would pass once through the membrane to the surface, the reflected radiation (2) would pass again through the membrane on the way to the subreflector, and the radiation reflected from the subreflector (3) would pass through the membrane a third time on its way to the receiver feed. The effective transmission of this sunshield, marked "3-pass", shows substantial absorption in the 200-plus GHz range where we expect to use the telescope heavily.

A third possibility is to use a system recently adopted at Hat Creek by the University of California at Berkeley. Through the use of a tunnel in the central section of the membrane, the incoming radiation passes through the membrane only twice. This transmission curve is marked "2-pass" in Figure 1. The transmission at high frequencies is still substantially less than for the Teepee design.

Which design do we choose? The Teepee would be the best choice if the wind torque could be lessened. Fortunately, this sail effect should be considerably less for the 12-m than for the 36-ft telescope because of its shorter focal length. Because the wind torques should roughly vary as the square of the focal length, the wind torques should be about a factor of 3 smaller for the 12-m surface. Also, the 12-m's greater setback from the open slit may further reduce the amount of wind blowing normal to its optic axis. I therefore choose the teepee over the other designs.

Bill Horne tells me that the new surface may be more tolerant to solar heating than the 36-ft. The ESSCO plates will float over the steel back structure, and the steel quadrupod legs can be kept at the same temperature by means of heating tapes. While I hope that Bill is correct, I still worry about the specular reflection of sunlight. The shiny ESSCO plates will not be painted. It seems prudent to be prepared for a solar problem by having a sunshield on hand.

Here are some questions to consider:

1. Should the telescope backstructure be provided with a tie-down ring at the edge of the surface plates? There must be a way to attach the teepee's bottom edge so that the surface plates won't be bent by the tension of the teepee.

2. Can we tape the cracks between adjoining surface plates to confine the air needed to inflate the teepee? The usual airflow pattern is to enter the teepee volume through a hole in the telescope surface and to exit near the Stirling mount.

3. Should we plan to cushion the outer (not the sides or bottom) of the feed legs with styrofoam to minimize abrasion of the teepee membrane and to thermally isolate the feedlegs from solar heating?

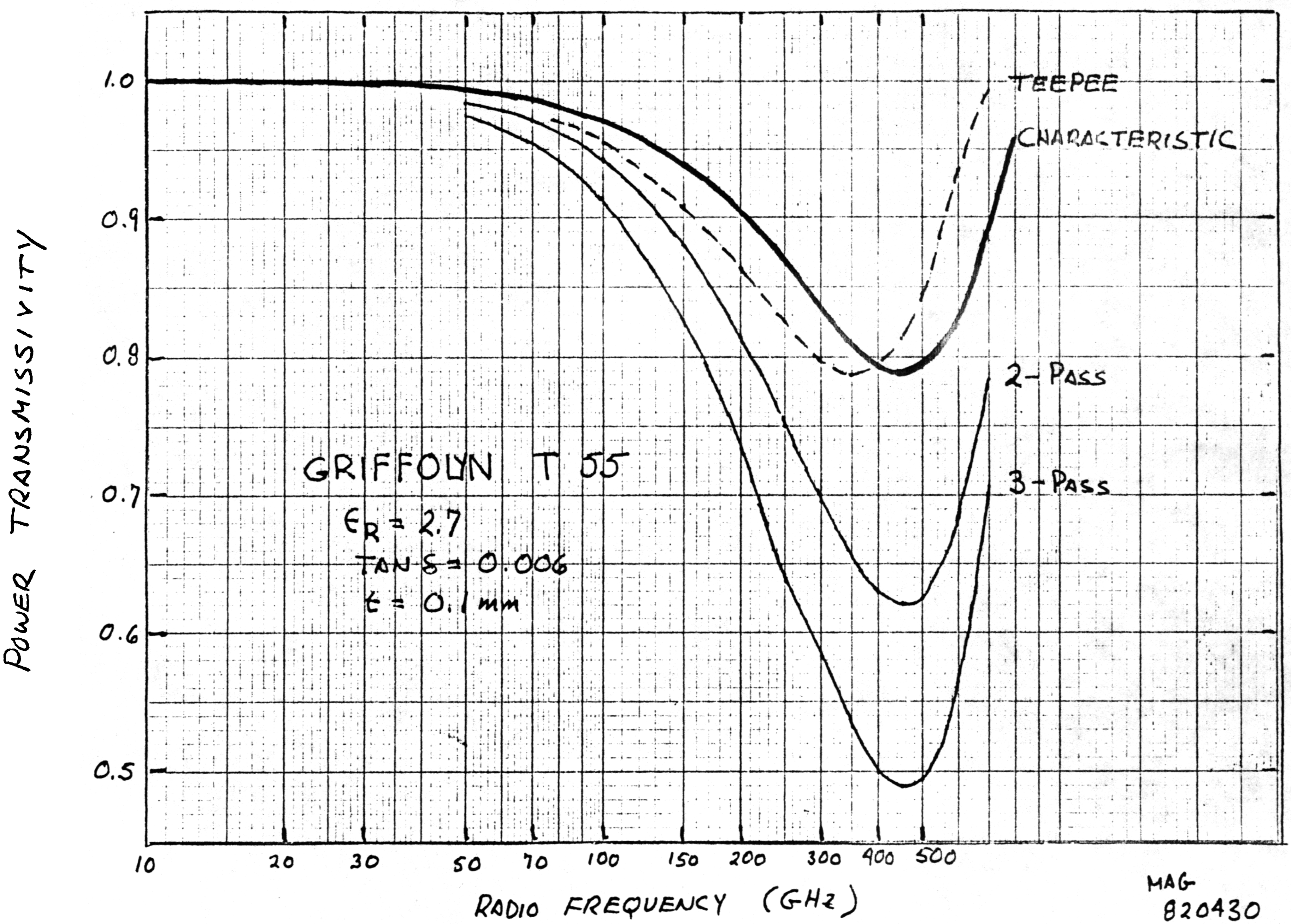
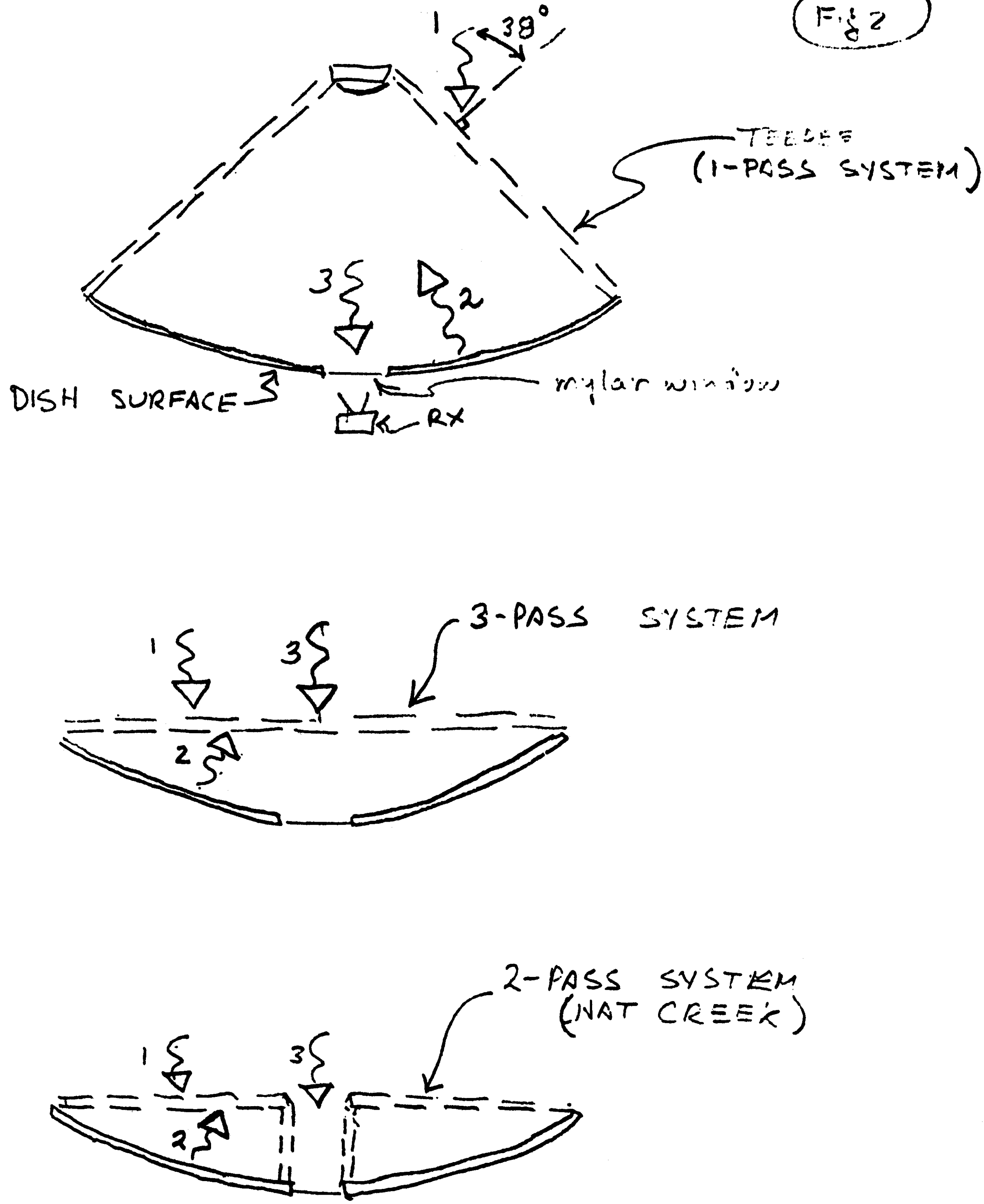

POWER TRANSMISSIVITY
1.0
0.9
0.8
0.7
0.6
0.5
TEEPEE
CHARACTERISTIC
2-PASS
3-PASS
GRIFFOLYN T 55
ε_R = 2.7
TAN δ = 0.006
t = 0.1mm
10
20
30
50
70
100
150
200
300
400
500
RADIO FREQUENCY (GHz)
MAG
820430

Fig 1

Fig 2



SUNSHIELD SCHEMES

MAG
920503