National Radio Astronomy Observatory
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MEMORANDUM

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From : James Lamb JWL

Subject : 12-m Antenna noise pickup

I. Introduction

Part of the radiation from feeds on the 12m antenna falls on surroundings at ambient temperature with the consequence that the antenna noise temperature is increased and the system sensitivity is reduced. This is normally quantified by a quantity called the rearward spillover efficiency, η_{rss}, which is the fractional power which is not terminated at ambient temperature. The increase in antenna noise temperature referred to the input to the feed is then

$$T_{ant} = (1-\eta_{rss})T_{amb}$$

On the 12m antenna the value of η_{rss} is typically around 85% so that the excess noise picked up is about 45K. This may be compared with receiver temperatures which may be as low as 55K at 90GHz.

Another more subtle problem with pickup is noise which enters the system synchronously with the beam switching cycle. This could be, for example, spillover from the diffraction by the secondary which nutates to beam switch. Although this should be cancelled out to first order because of the symmetrical switching cycle, and possibly to second order by position switching, there may still be a residual which is significant for long integration continuum observations.

This memo gives the results of some crude estimations of the noise temperature seen by the system from the ambient surroundings and proposes some partial remedies.

II. Summary Of Noise Pickup Mechanisms

Most of the possible mechanisms whereby noise from the surroundings may enter the receiver beam are shown in Fig. 1. Table I lists these mechanisms and assigns a guesstimate for the magnitude. It also indicates whether or not the noise could be modulated synchronously with beam switching.

Mechanism	Magnitude (K)	Synchronous Pickup ?
Spillover round secondary	15 - 30	yes (small)
Reflection from feed legs	<8	no
Spillover round primary due to diffraction by secondary	4 - 8	yes
Radiation through hole in primary	2	yes (small)
Losses through gaps between panels	1.5	no
Ohmic losses	3 - 4.5	no
Diffracted rays from edge of primary	<<1	yes

A. **Spillover round secondary :** Most of the power from the feed which spills round the secondary mirror falls on the mounting structure which holds the secondary and various rotation, translation mechanisms etc. It is difficult to estimate just how much of this power eventually goes on to the sky and how much to ambient, but it seems likely that a significant amount may be terminated at 300K. This will be only slightly modulated by the nutation of the secondary.

B. **Reflection from feed legs :** The present feed legs have a flat surface facing radially inwards. Rays reflected by the legs will therefore tend to be reflected towards the opposing leg (possibly via the primary). Since the legs are probably not particularly good conductors there will be a certain amount of pickup at each reflection due to dissipation. In addition it is probable that a good fraction of the energy which passes by the feed legs after the first reflection (either by diffraction or because of the slightly divergent nature of the wave) will also be terminated at ambient temperature.

C. **Spillover round primary due to diffraction at secondary :** This component should vary approximately as the inverse square root of the wavelength, so will be most significant at the longest wavelengths. It falls almost entirely on the surroundings at ambient temperature, and it could be significantly modulated by the nutation of the secondary.

D. **Radiation through hole in primary :** If the vertex of the secondary were a continuous surface the rays reflected by the central portion would pass through the centre of the primary mirror. In practice there is a hole in the secondary so that only some of the rays are reflected through the primary (and there will also be some rays diffracted by the edge of the hole which will pass through). Usually there is a feedhorn connected to a noise tube which protrudes through the hole in the secondary and since it should couple reasonably well to the incident wave it will also contribute an ambient temperature component. There will probably be only a small modulation component.

E. **Losses through gaps between panels :** A small fraction of the primary surface is lost because of gaps between panels. Some ambient radiation will leak through and there will be a wavelength dependence since the gap size is on the order of one wavelength.

F. **Ohmic losses :** For the standard receiver configuration there are four reflections including the primary and secondary mirrors and the two plane mirrors which direct the beams from the off-axis receivers. The ambient contribution may be as high as 4.5K at a wavelength of 1mm.

G. **Diffracted rays from edge of primary :** The diffraction at the edge of the primary should be quite small because of its large size in terms of wavelength. Although the absolute contribution should be quite small the modulation component could be significant since the diffracted field strength at the edge of the primary will vary a lot as the secondary is nutated. Some of the diffracted rays will fall on the edges of the slit in the dome and, depending on the tracking of the dome, could clearly give a time varying pickup.

The total noise temperature for these sources is therefore predicted to be in the region of 35 - 55K, in reasonable agreement with the experimentally determined value of about 45K.

III. Proposed (Partial) Remedies

Some of the above sources of noise can be reduced by the following measures.

A. **Collar on secondary :** Fig. 2 shows a proposal for a collar to go round the secondary. This would be conical and direct rays from the feed on to the sky via the primary. It would therefore reduce the ground pickup component. The radius of the hole in the cone would be slightly less than the radius of the secondary, and it would be placed just in front of it. This would mean that the edge diffraction would be brought in slightly from the edge of the primary, and also would give a diffraction pattern which was not shifted as the secondary was nutated. Hence problems A, C, and G would be reduced.

B. **Collar round hole in primary :** A conical reflector at the centre of the primary (Fig. 3) would minimise the number of rays passing through, and redirect the remainder on to the sky. This would help problem D.

C. **Slanted surface on feed legs :** In order to redirect more of the energy incident on the feed legs on to the sky the inner surfaces could be slanted by a few degrees so that the reflected field would not fall on the opposing feed leg, thus reducing problem B.

IV. Conclusions

The ambient temperature pickup of the telescope is becoming significant compared to receiver noise temperatures. In addition noise picked up synchronously with the beam switching cycle can result in sensitivities for long continuum observations which are much worse than expected for the given system temperatures. The measures proposed in this memo should go some way towards reducing these problems.

Any comments or suggestions on this topic would be greatly welcomed.

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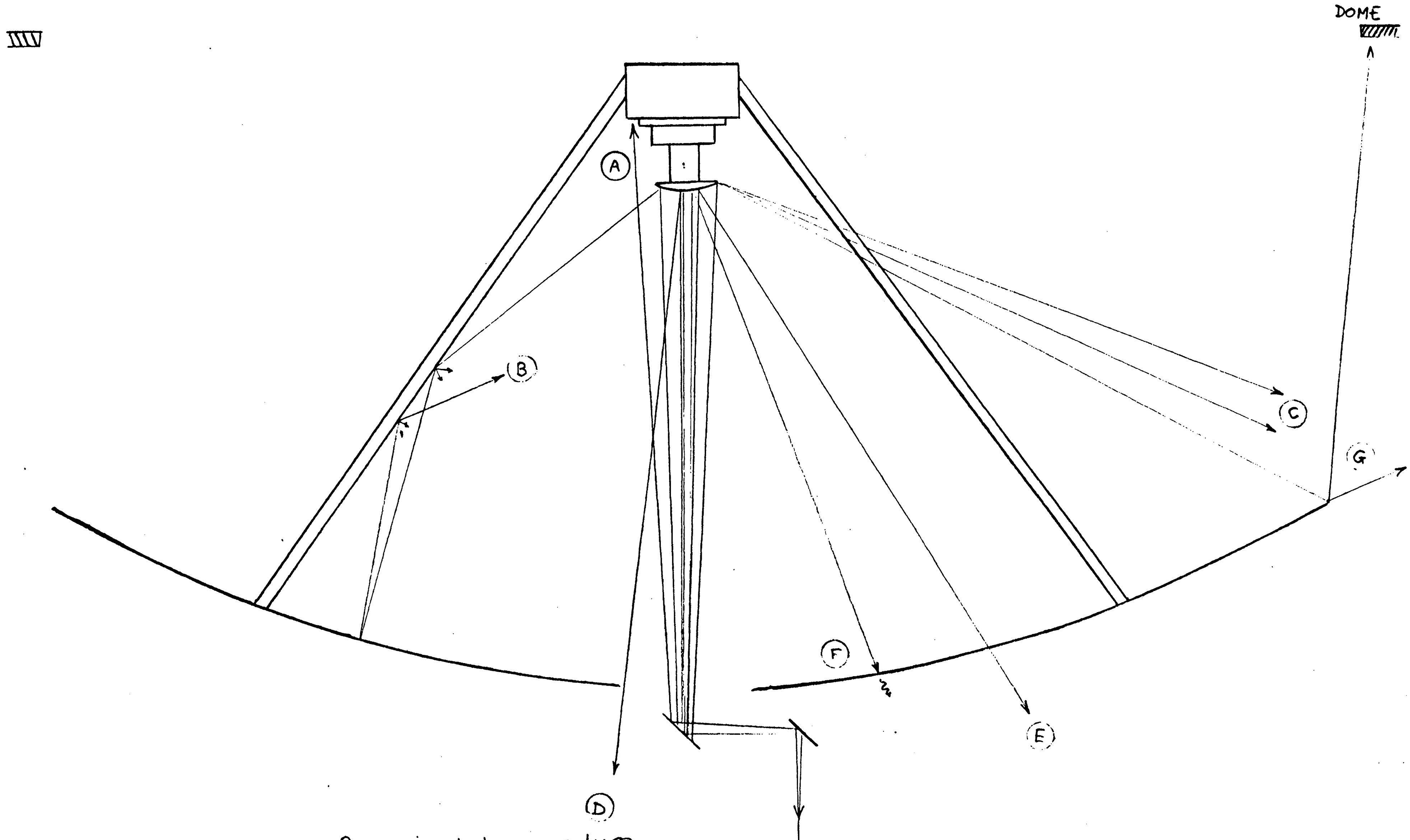

Figure 1. Sources of ambient temperature noise pickup.

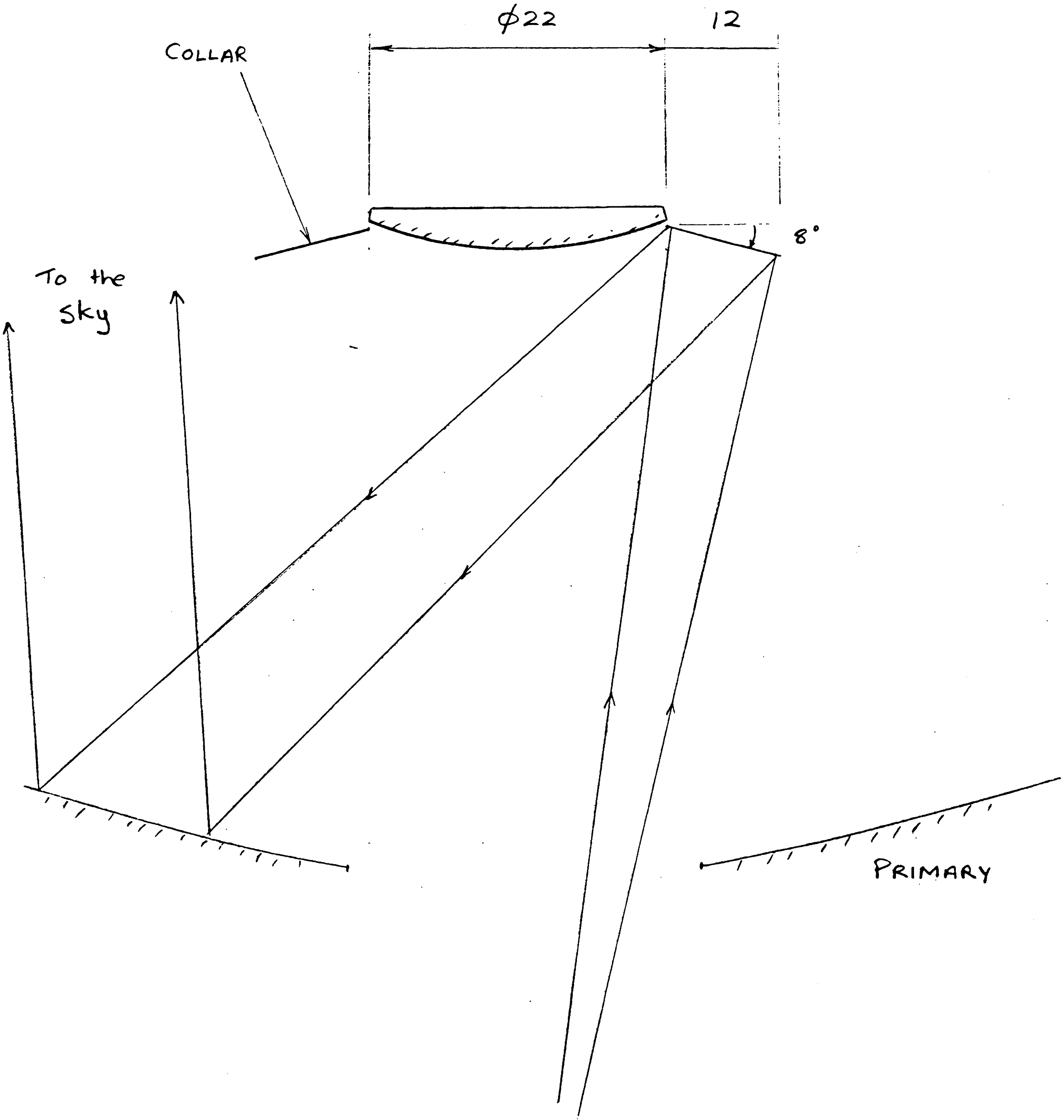

Figure 2. Proposed collar for secondary.

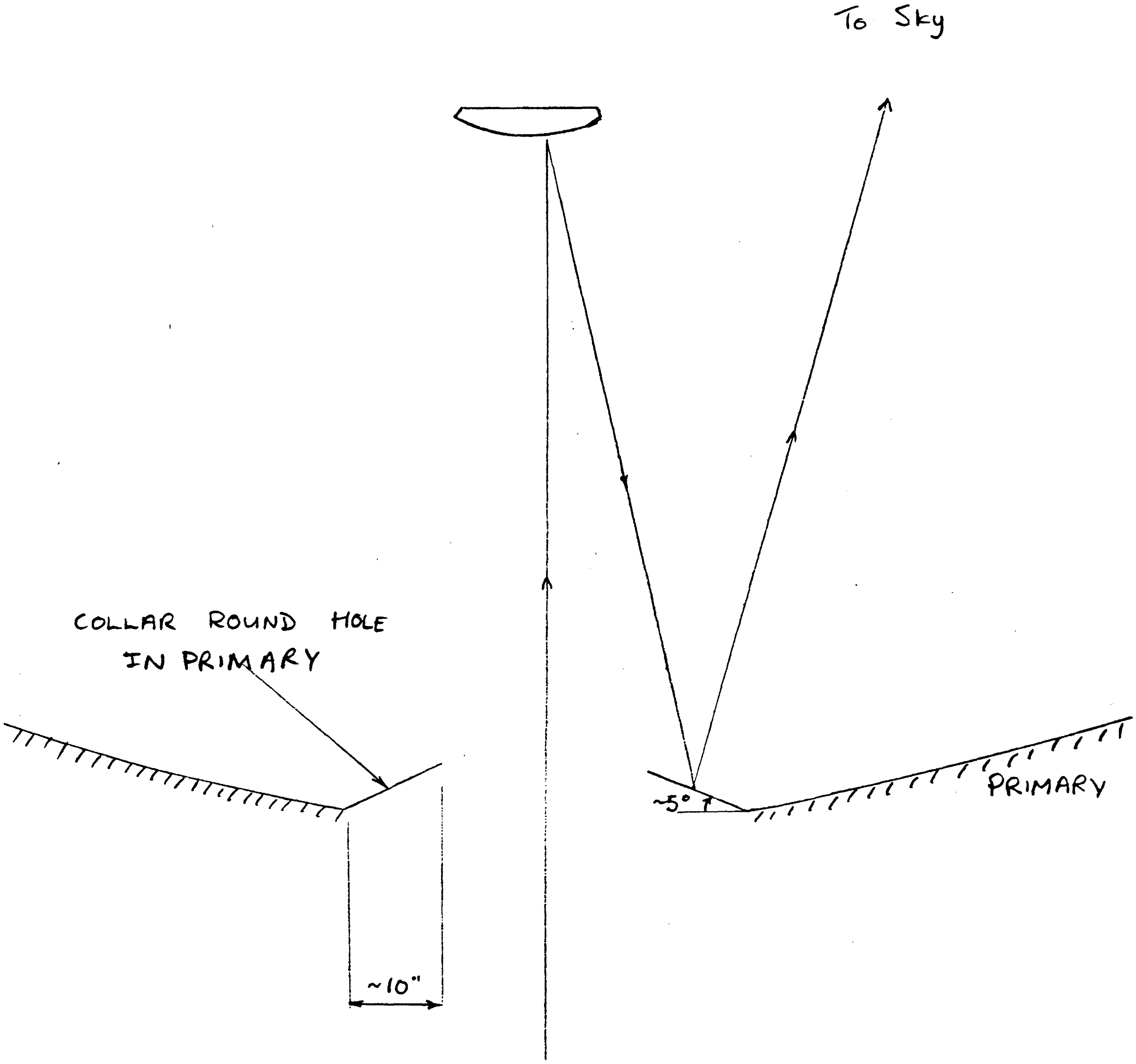

Figure 3. Collar round hole in primary to redirect radiation on to sky.