(4) The Tunable 2-18 GHz Radiometer

Figure 4 illustrates the geometry of the tunable radiometer. The radiometer is enclosed in a metal housing insulated by a styrofoam lined cover which helps maintain thermal control. The metal housing helps to protect against RF interference and provides rigidity to the radiometer. The central part of the housing is a thick aluminum pipe in which two very broadband antennas are mounted pointing in opposite directions. Attached to this pipe on either end are two aluminum cones. These cones act as extensions of the antennas and help to define the beams. The radiometer assembly is mounted on a cart through two bearings that allow the radiometer to rotate in a vertical plane aligned north-south. When the radiometer is horizontal, each antenna faces a tiltable reflector. Each reflector has additional ground shields and a shield which fits between the lower part of the reflector and the bottom of the radiometer. When the radiometer is vertical, a nested pair of large aluminum cones can be lowered into position above the upper antenna to further define the beam and act as a ground shield. The lower antenna points downward and observes whatever target is placed there - e.g. the liquid-helium cold load, an ambient temperature load, a liquid-nitrogen-cooled load.

The tunable radiometer consists of two separate Dicke-switched radiometers contained within the single housing, and sharing the opposing antennas. The two radiometers receive orthogonal polarizations and are alternately connected to each antenna. In this way each radiometer is always receiving radiation from the antenna not connected to the other radiometer.

The radiometers operate over the frequency ranges 2-8 GHz (15 to 4 cm wavelength) and 7.5-18 GHz (4 to 1.7 cm). Each radiometer has an electronically controlled bandpass filter. A computer controls the filter frequency and records the radiometer output and various housekeeping information.

Figure 5 is a block diagram of the tunable receivers. Microwave radiation entering the antennas goes to the PIN-diode Dicke switch. The switch alternately connects the input of the first GaAs FET amplifier to the output port of each antenna. The signal, amplified by about 40 dB, passes through the YIG (Ytterium Iron Garnet) bandpass filter. The filtered signal is then amplified by another GaAs FET amplifier. The detector diode produces an output voltage proportional to the input power. A lock-in amplifier detects and amplifies the signal synchronous with the switching from one antenna to the other. The lock-in output is a noisy DC signal proportional to the difference in power received by the two antennas. After integration for 0.1 second, the signal is digitized and sent to the computer. The computer averages ten 0.1-second signals and records the average and rms.

The bandpass of the YIG filter is determined by the magnetic field in which the YIG spheres are suspended. This field is produced by a fixed coil and is thus proportional to the drive current. An analog driver circuit converts voltage to drive current. It corrects for the slight non-linearity of frequency versus drive current so that the frequency selected is very nearly proportional to the input voltage. The computer sets the frequency determining voltages by using two 8-bit digital-to-analog converters (DAC). There are thus 256 separate frequency settings in each of the two frequency ranges - 2-8 and 7.5-18 GHz. This represents an over sampling of about a factor of two in the 2-8 GHz range and five in the 8-18 GHz range.

In normal operation, a computer program sweeps each of the two filters through its tuning range, recording the radiometer output. It then informs the operator to rotate the radiometer so that the antennas are interchanged. Once the interchange is completed the computer sweeps through the frequency range again recording the data. This process is repeated until there are four runs with antenna A looking at the liquid-helium-cooled target interleaved with four runs with antenna A looking at the zenith. Since antenna B opposes antenna A it observes the same targets but out of phase. Atmospheric scans are accomplished in the same manner and with the same program except that the radiometer is fixed horizontally and the north and south reflectors are alternately raised and lowered. Gain calibrations are accomplished with an ambient temperature load in a similar manner but with fewer runs.

The 2-8 GHz radiometer has a representative system temperature of 1000 K and a bandwidth of 70 MHz for an rms sensitivity of 0.2 K for one second of integration. The 7.5-18 GHz radiometer has a representative system temperature of 1500 K and a bandwidth of 150 MHz for a one second integration time rms sensitivity of 0.2 K.

In order to check the performance of each radiometer several tests were made,some of which were periodically repeated. These tests include magnetic sensitivity tests, flip-offset tests, integration