REMOTE SENSING OF MESOSPHERIC OZONE

by

JOHN EDWARD RUDSKI, JR.

Submitted to the Department of Electrical Engineering on 29 January 1971 in partial fulfillment of the requirements for the Degree of Doctor of Philosophy

ABSTRACT

The photochemistry of ozone in the upper stratosphere and mesosphere is reviewed. Numerical calculations in the literature predict a change in ozone concentration at 70 km altitude from 10^9 cm^{-3} during the day to 10^{11} cm^{-3} at night. The few ozone measurements in the 50 to 80 km region are not consistent, and no valid measurement of the diurnal variation has been made.

Atmospheric ozone should produce an emission line 8°K high with a half-height width of 80 MHz, as viewed from the ground. The line is the $4_{0,4}$ $4_{1,3}$ molecular transition at 101.74 GHz and its intensity and width are due primarily to the stratospheric ozone maximum at 25 km. If the mesospheric ozone concentration increases to 3×10^{10} at 70 km as predicted by Hunt (J.G.R., 71, 5, 1385, 1966), then a line 20°K high and 300 kHz wide at half-height should appear on top of the broader line.

A radiometer was designed and built to observe the mesospheric ozone line. It was a double-conversion, Dicke switched receiver with a system temperature between 4,000 and 5,000°K. When connected to the MIT 20 channel digital synchronous detector, the bandwidth was 48 MHz with 1 MHz resolution.

In a subsidiary effort to develop low loss mixers, diodes were packaged with cutoff frequencies exceeding 10,000 GHz. A 60 GHz balanced mixer was built with a 6 dB conversion loss.

Observations were made from August through October, 1970, about three times a week, at various times during the day and night. The broadband emission line from the stratospheric ozone was detected. Its line strength and shape agree with the predicted values. The narrow mesospheric line was never detected.

On the basis of these measurements, an upper limit can be placed on the nighttime mesospheric ozone concentration. The limit, represented by an exponential distribution between a number density of 5×10^{10} cm^{-3} at 50 km and 10^9 cm^{-3} at 80 km, would have been detected with this instrument.

The diurnal concentrations predicted by the photochemical theory are believed to be in error because the reaction rates are incorrect, dynamic processes are not included, and the water vapor concentration may be slightly higher than calculated.

THESIS SUPERVISOR: David H. Staelin
TITLE: Associate Professor of Electrical Engineering