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Measurement of Ozone Transmissivity at Low Temperatures

Final Report
March 1, 1974 - May 31, 1975

F.L. Bartman
L.T. Loh
W.R. Kuhn

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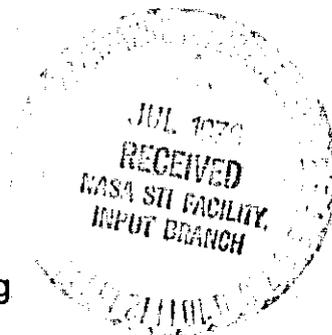
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High Altitude Engineering Laboratory
Departments of Aerospace Engineering
Atmospheric and Oceanic Science



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MEASUREMENT OF OZONE TRANSMISSIVITY
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F.L. Bartman

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ORA Project 012627

under contract with:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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OFFICE OF RESEARCH ADMINISTRATION ANN ARBOR

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ABSTRACT

Low temperature medium resolution ($.02\mu\text{m}$) measurements of the transmissivity of the $9.6\mu\text{m}$ (ν_3) ozone band have been made in the laboratory. The range of conditions under which the measurements were made are:

$$-48 < T < -22^\circ\text{C}$$

$$.0029 < U < .71 \text{ atm}\cdot\text{cm.}$$

$$680 < p < 742 \text{ mmHg}$$

The apparatus used is described briefly, measurement conditions are summarized and the resulting spectra are shown.

These data have not been analyzed as yet, since funds for the analysis have not been available.

1. INTRODUCTION

The purpose of this research is to improve our knowledge of the infrared transmission properties of ozone in the $9.6\mu\text{m}$ region of the spectrum.

Ozone, although a minor constituent of the earth's atmosphere, is an important one for several reasons. It shields the earth's surface from harmful solar ultraviolet radiation, in large part it determines the positive stratospheric lapse rate which strongly influences both the large and small scale dynamics of this region, and it interacts with other minor atmospheric constituents such as the nitrogen oxides and water vapor which is an important contributor to energy balance studies.

At the present time many satellite experiments are being carried out (or are being planned) to measure the altitude distribution of ozone on a world-wide basis. Slant path solar occultation and emission experiments appear to be very promising techniques for this purpose. Nadir emission experiments have already been made.

Analysis of these remote sensing experiments requires a knowledge of ozone transmissivities under the complete range of temperatures, pressures and concentrations to be expected in the atmosphere, and so we have begun to carry out such measurements in the laboratory.

Initially, under a contract with NASA Goddard Space Flight Center, measurements were made¹ of the transmissivity of the $9.6\mu\text{m}$ (ν_3) ozone band for the following conditions.

a) Mass paths from 0.0025 to 0.0866 atmo cm, with total pressure in the range of 728-732 mmHg and room temperatures

b) Mass paths from 0.0022 to 0.966 atmo cm, with total pressure in the range of 1.5-47.8 mmHg and room temperatures

c) Mass paths from 0.0085 to 0.35 atmo cm, with total pressure in the range of 5.7-37.5 mmHg and temperatures in the range of -7 to -12°C .

The measurements reported herein are for mass paths of 0.0032 to 0.0714 atmo cm. with total pressures of about 700-750 mmHg and temperatures in the range of -22 to -48°C . The analysis of this data remains to be completed, since funds which were requested for this purpose have not yet been approved by NASA.

2. APPARATUS

The experimental apparatus, operating procedures and data processing technique used in the measurements of ozone transmissivities at room temperatures and at slightly reduced temperatures (a,b, and c above) are

described in detail in the final report of the contract with NASA Goddard Space Flight Center¹.

In this report we will describe only the modifications made to enable the taking of data at low temperatures.

The measurement system previously used is shown schematically in Figure 1. In this arrangement the ultraviolet spectrometer and mercury vapor source used to measure ozone amounts were mounted on the sample cell with a light beam path crosswise in the cell

The modified system used in these low temperature measurements is shown schematically in Figure 2. The significant change is that the ultraviolet measurements of ozone amounts were made in a 1 meter cell which was separate from the infrared sample cell and the ozone mixture was continuously circulated between the two cells by a peristaltic pump.

Other changes made for the low temperature measurements are:

1. Heat insulating gaskets made of silicone rubber were installed between the infrared sample cell and the frame of the spectrometer.
2. A plywood cell, surrounding the infrared sample cell, was filled with dry ice for cooling.

3. RESULTS

Table I is a summary of operating conditions for the 18 runs of low temperature data taken. The transmission spectra are shown in Figures 3 to 20. These figures are computer plots of the digitized data. The data analysis has not been continued beyond this point because of lack of funds.

The need for ozone low temperature transmissivity data has been documented in previous reports¹ and in our proposal for the additional funds needed for data analysis². The details of the manner in which the data analysis will be carried out are also described in the latter document.

An improved measurement system for low temperature and low pressure data is discussed in a technical report which was published on this grant³.

TABLE 1

Operating Conditions for Low Temperature Data

<u>Run #</u>	<u>p, mmHg</u>	<u>U, atmo cm</u>	<u>\bar{T}, °C</u>	<u>U.V. Line Used, Å°</u>
276	717.8	.0072	-38.3	2536
277	740.3	.0256	-30.6	2894
278	723.8	.0234	-42.2	2894
279	741.8	.0175	-30.0	2894
280	714.0	.0110	-29.4	2894
281	740.3	.0365	-25.0	2894
282	722.3	.0354	-33.3	2894
283	741.8	.0448	-27.8	2894
284	720.0	.0041	-31.1	2536
285	738.0	.0081	-25.0	2536
286	761.3	.0097	-22.2	2536
287	680.3	.0218	-48.3	2894
288	710.3	.0506	-45.6	2894
289	740.3	.0714	-40.0	2894
290	702.0	.0024	-39.4	2536
291	711.8	.0032	-37.2	2536
292	699.8	.0029	-41.1	2536
293	723.8	.0063	-37.2	2536

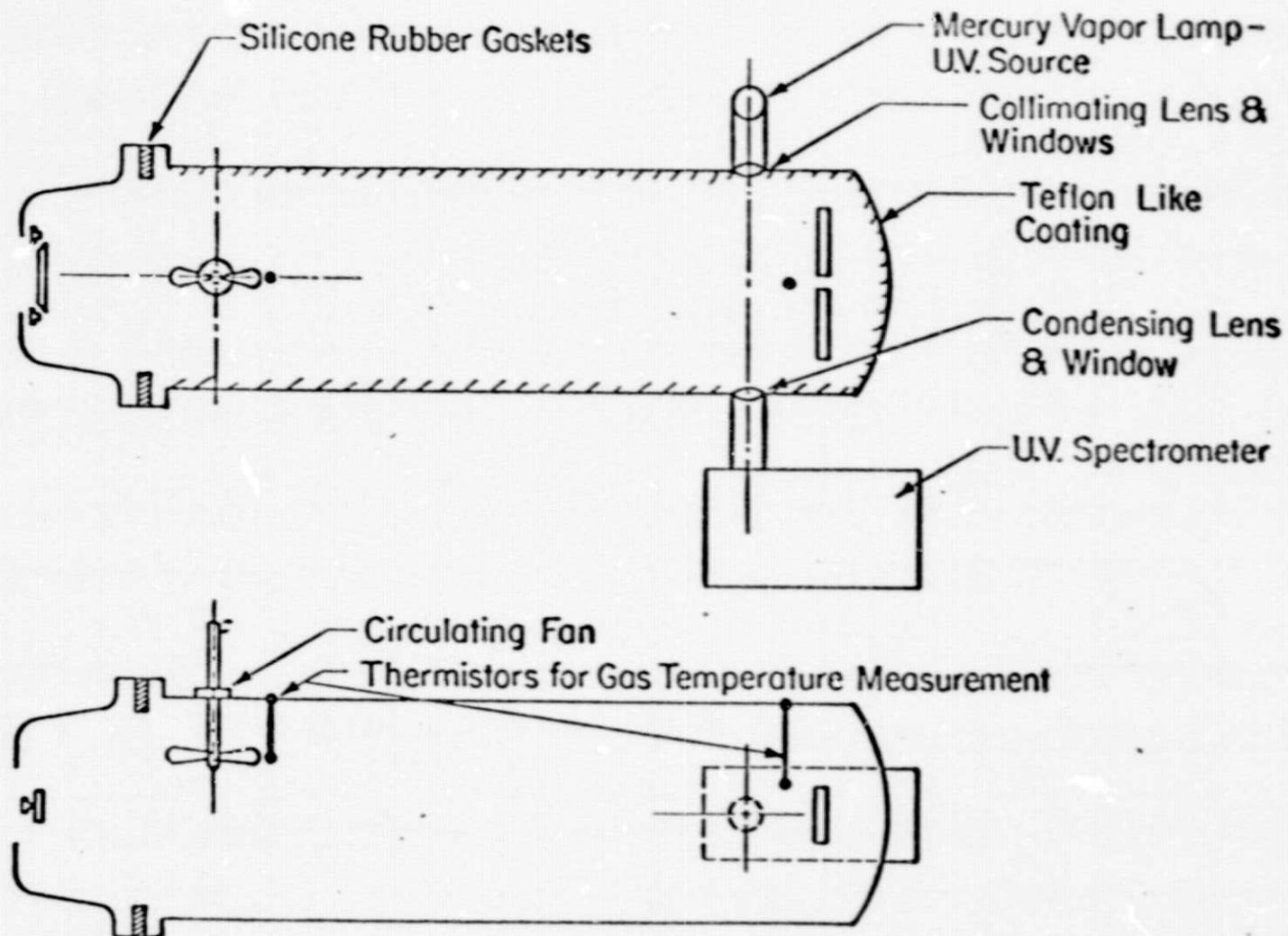


Figure 1. Schematic diagram of spectrometer configuration used for ozone transmissivity measurements (at or near room temperature).

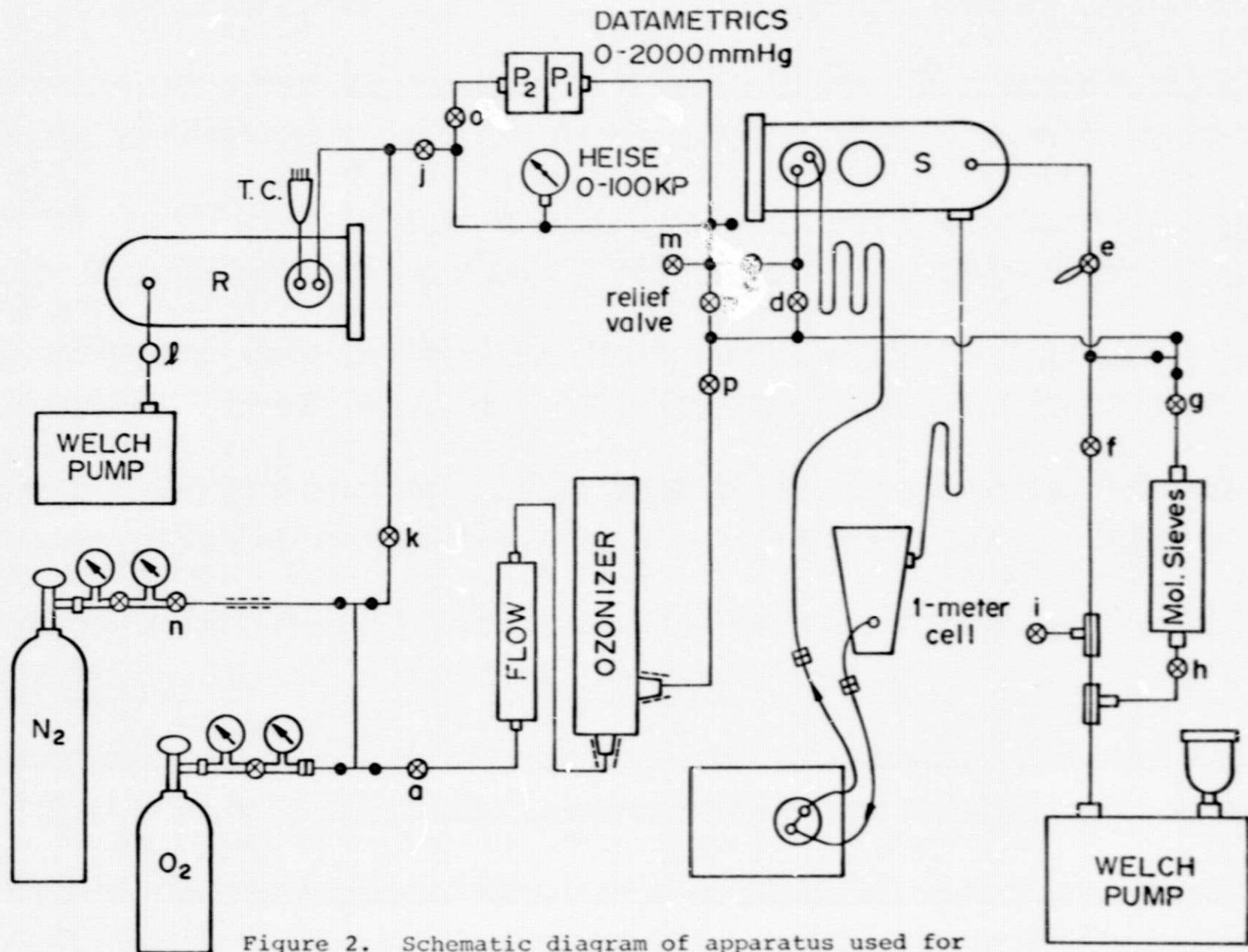


Figure 2. Schematic diagram of apparatus used for low temperature ozone transmissivity measurements.

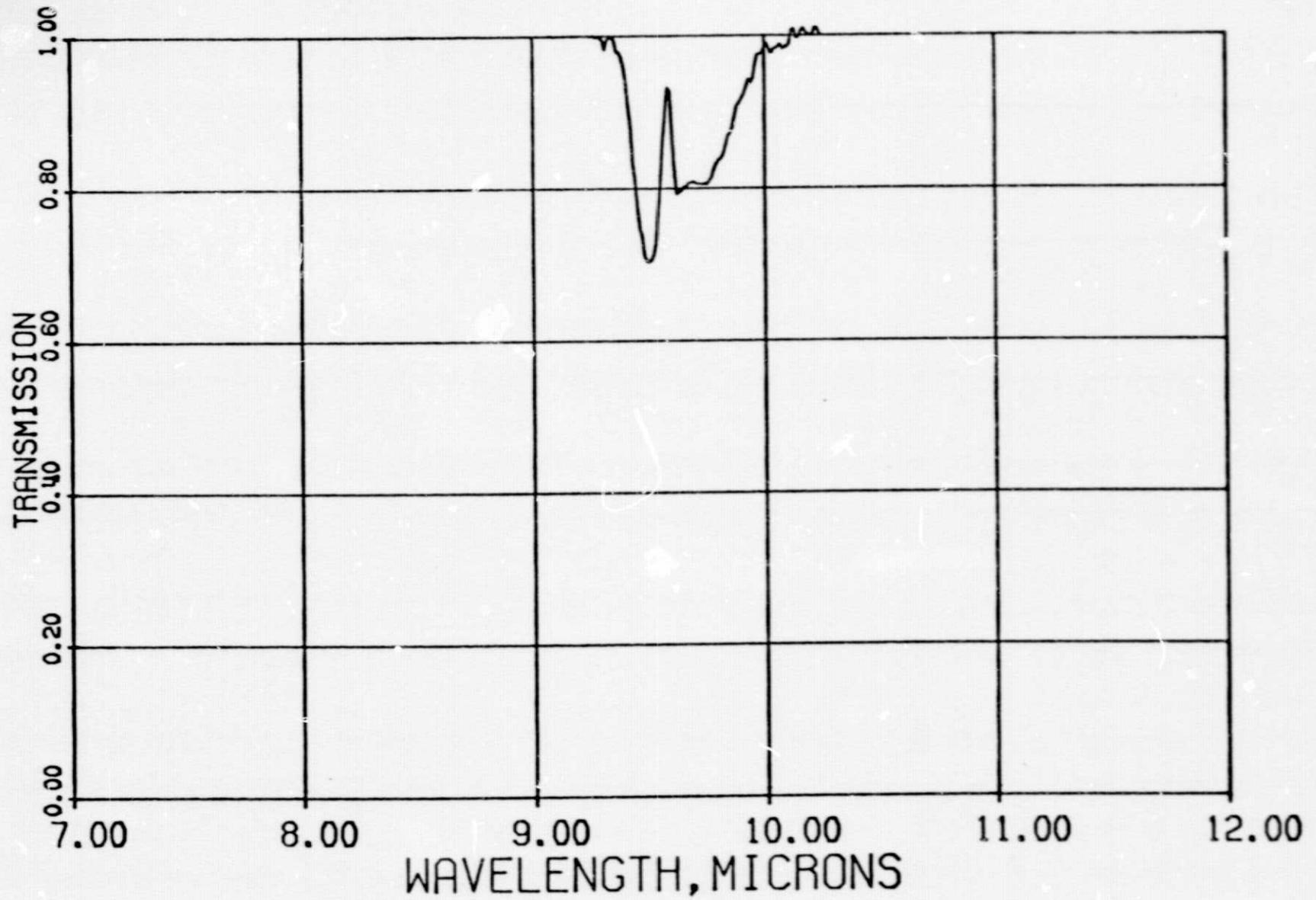


Figure 3. Ozone transmissivity spectrum, Run #276,
 $p=717.8$ mmHg, $U=.0072$ atmo cm, $\bar{T}=-38.3^{\circ}\text{C}$.

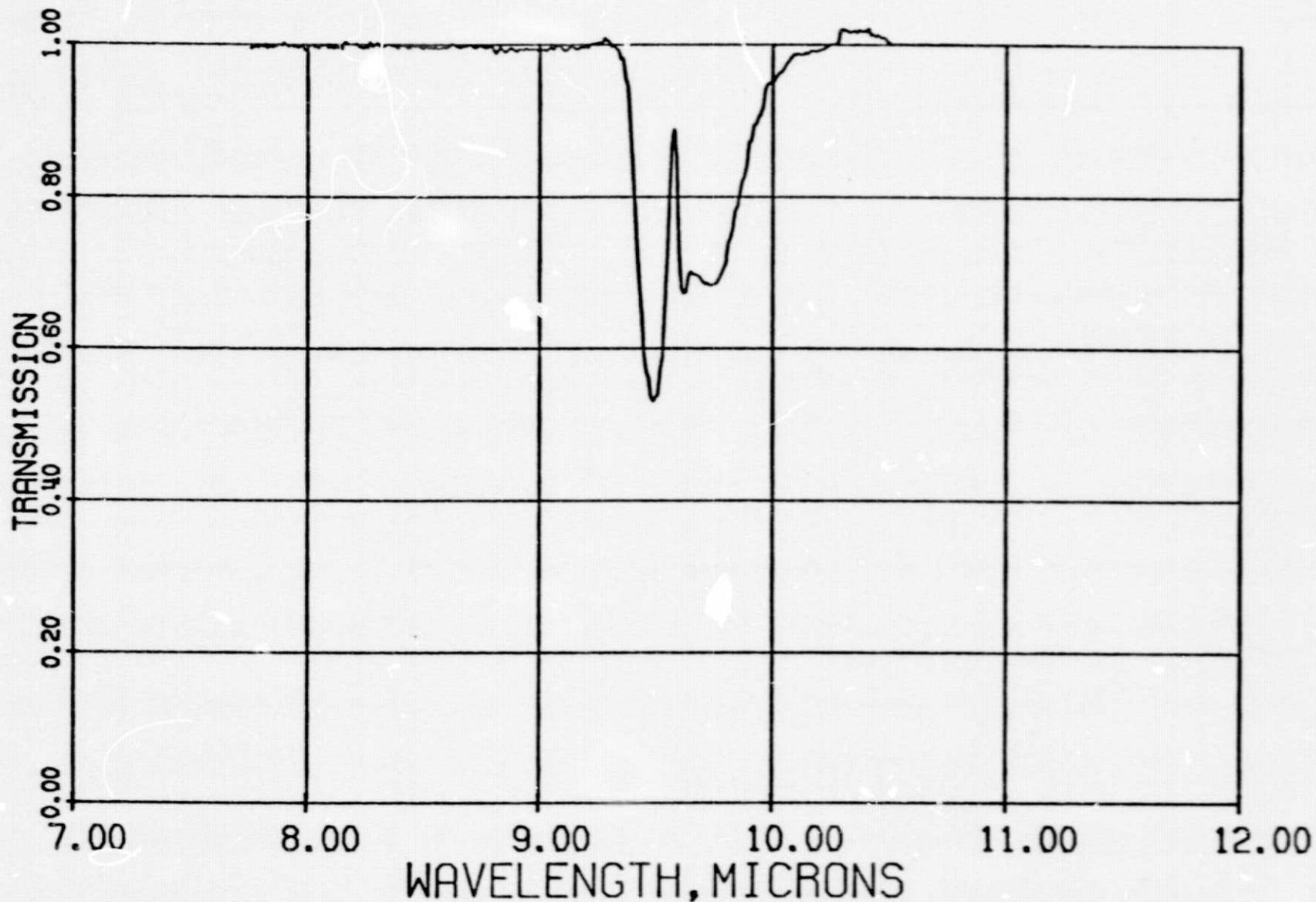


Figure 4. Ozone transmissivity spectrum, Run #277,
 $p=740.3$ mmHg, $U=.0256$ atmo cm, $\bar{T}=-30.6^{\circ}\text{C}$.

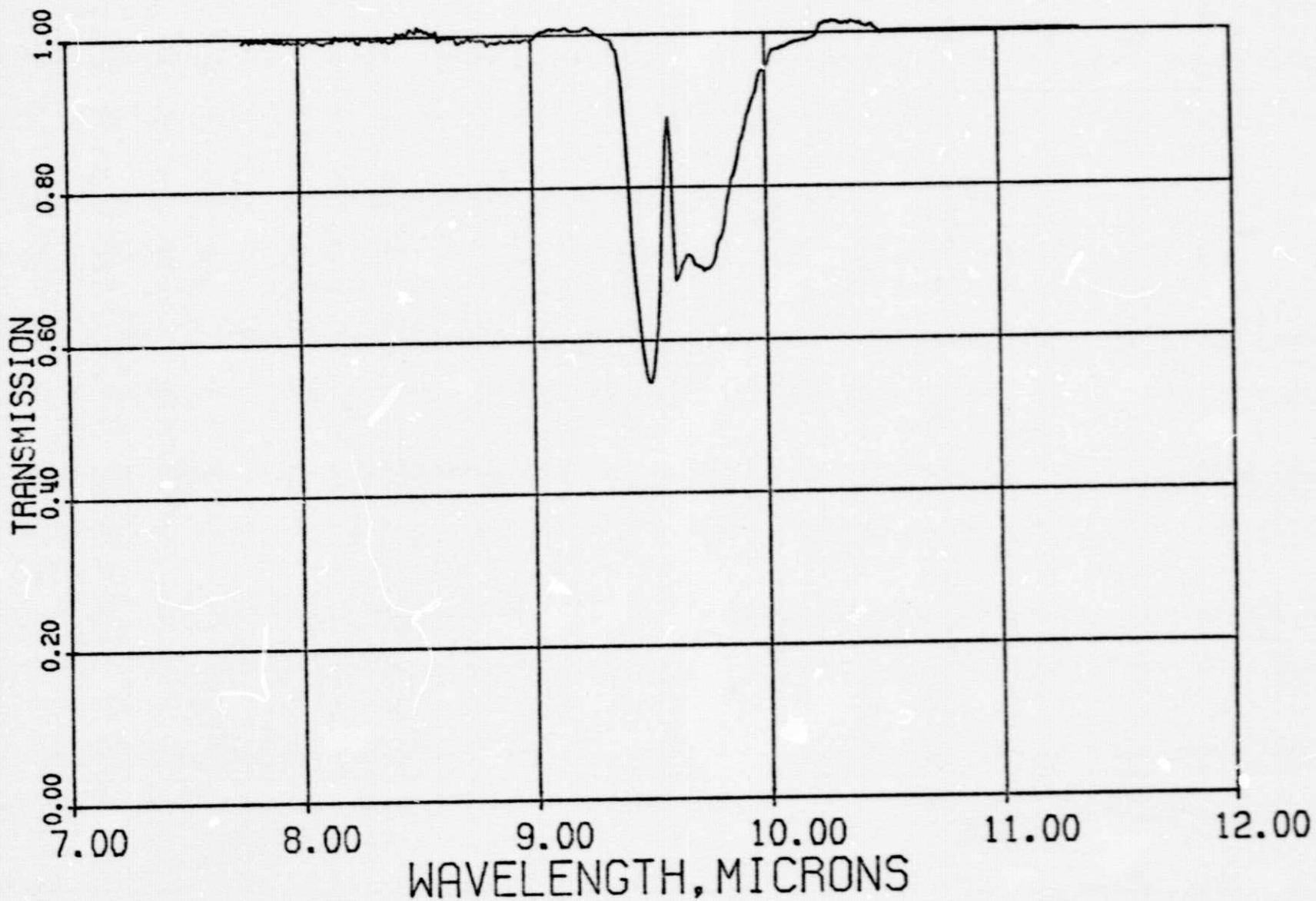


Figure 5. Ozone transmissivity spectrum, Run #278,
 $p=723.8$ mmHg, $U=.0234$ atmo cm, $T=-42.2^{\circ}\text{C}$.

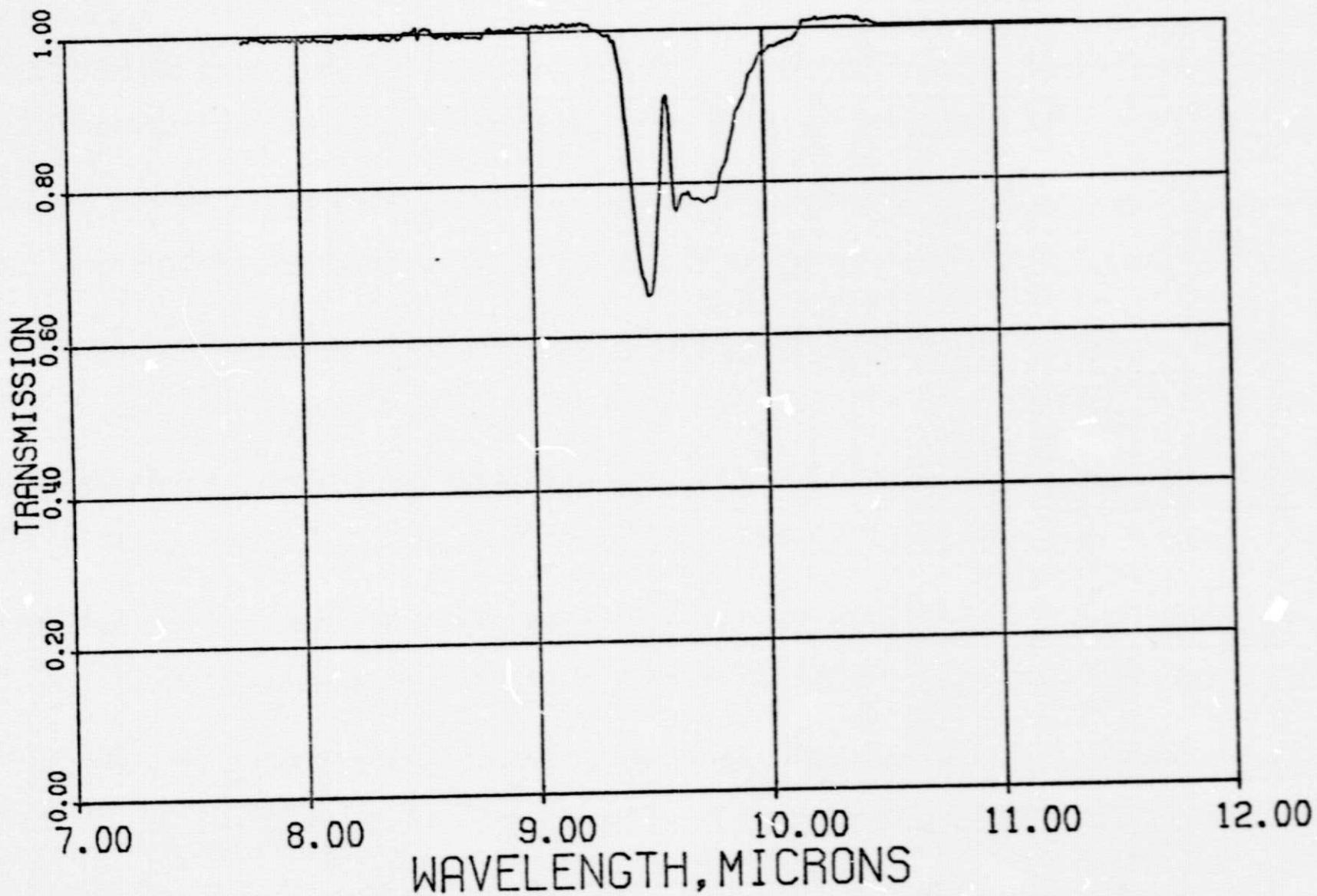


Figure 6. Ozone transmissivity spectrum, Run #279,
 $p=741.8$ mmHg, $U=.0175$ atmo cm, $\bar{T}=-30.0^{\circ}\text{C}$.

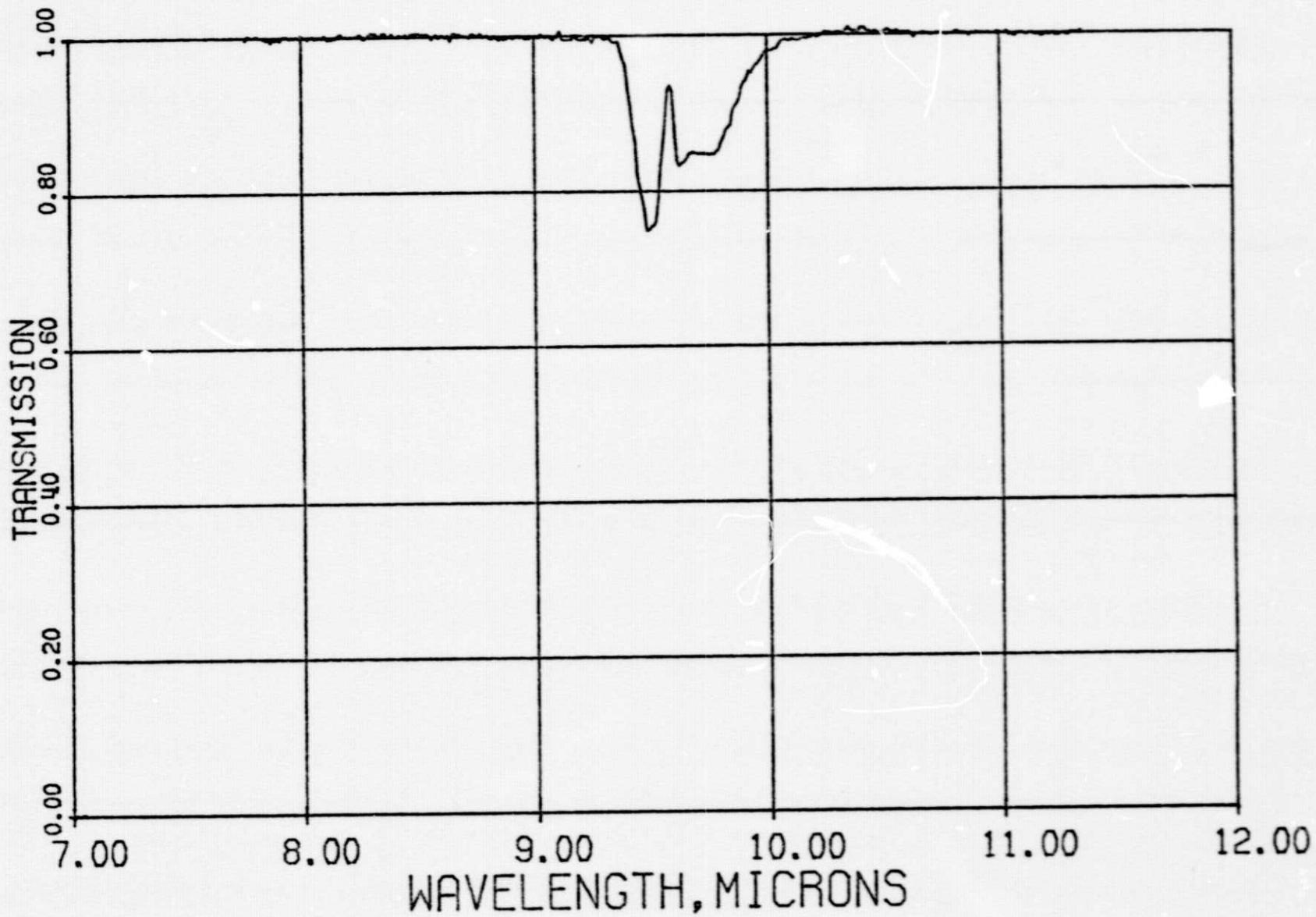


Figure 7. Ozone transmissivity spectrum, Run #280,
 $p=714.0$ mmHg, $U=.0110$ atmo cm, $\bar{T}=-29.4^{\circ}\text{C}$.

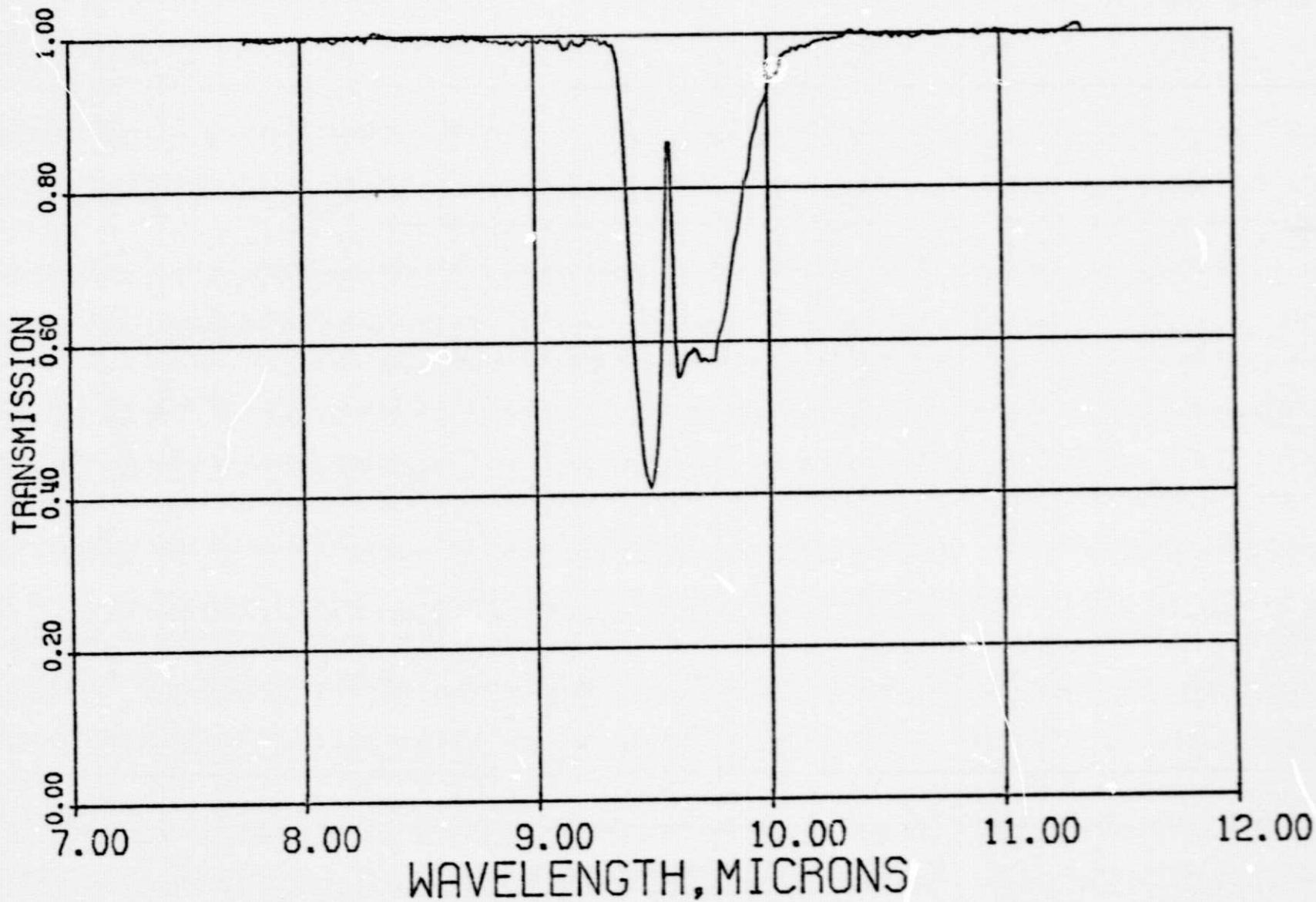


Figure 8. Ozone transmissivity spectrum, Run #281,
 $p=740.3$ mmHg, $U=.0365$ atmo cm, $\bar{T}=-25.0^{\circ}\text{C}$.

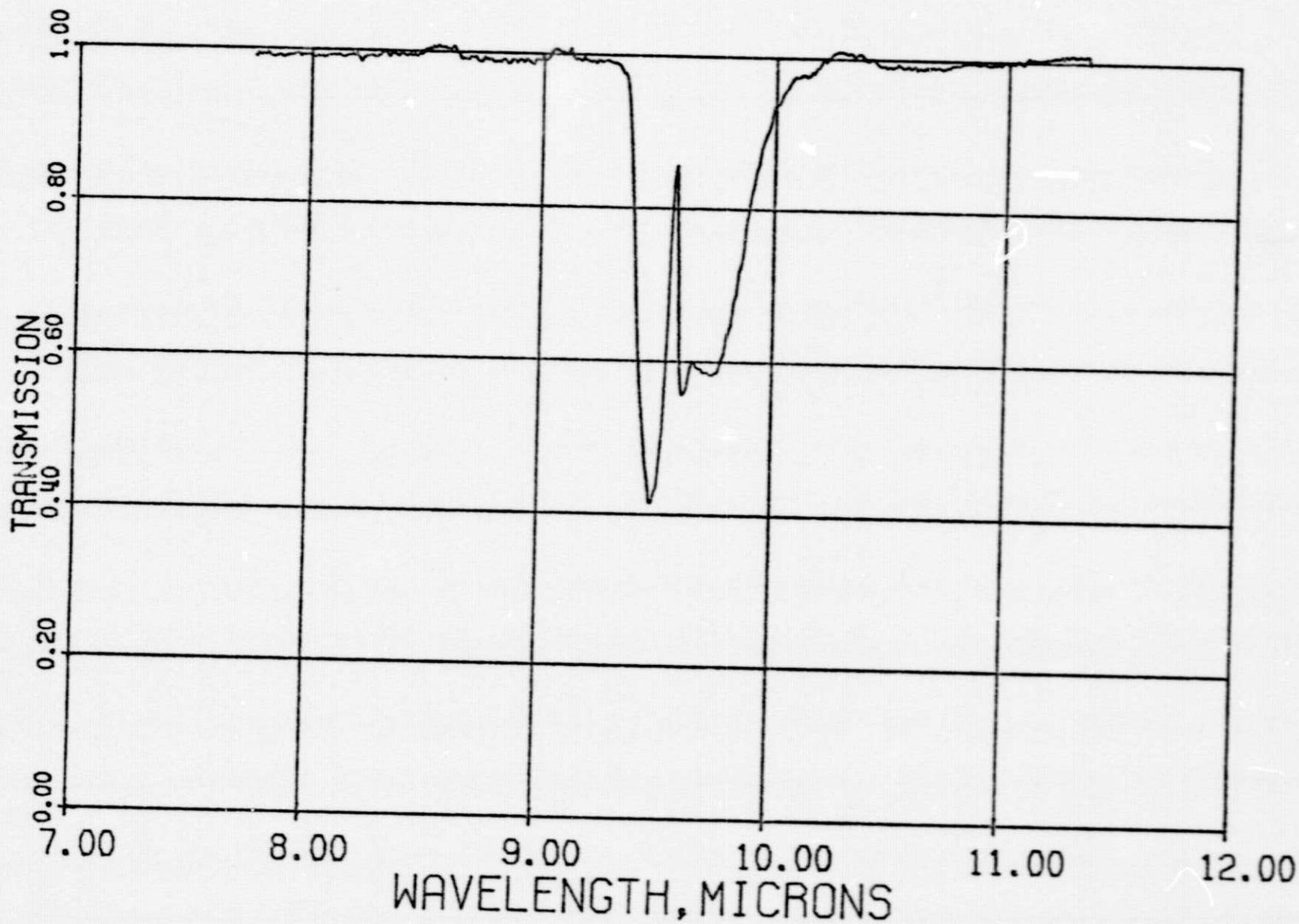


Figure 9. Ozone transmissivity spectrum, Run #282,
 $p=722.3$ mmHg, $U=.0354$ atmo cm, $\bar{T}=-33.3^{\circ}\text{C}$.

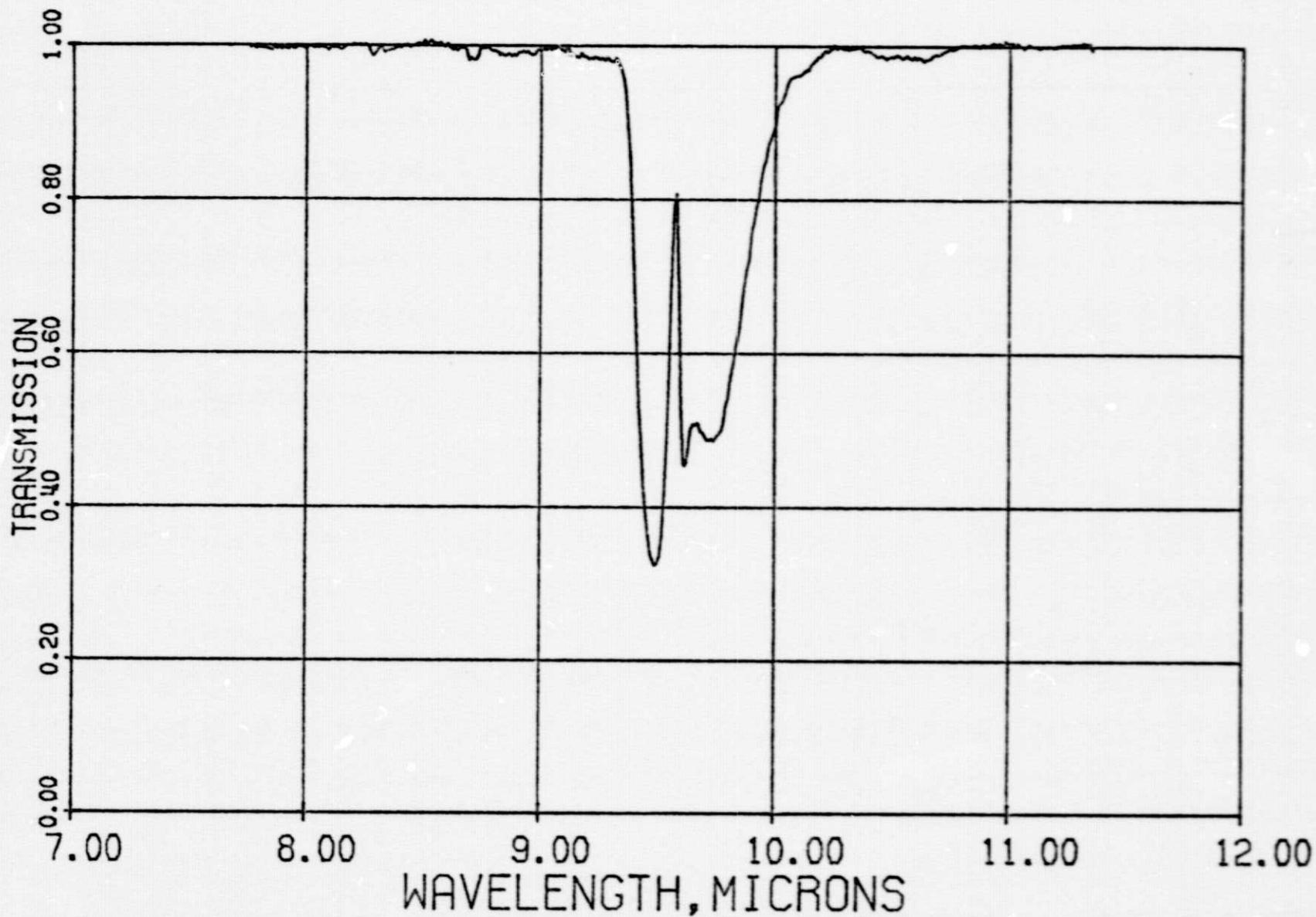


Figure 10. Ozone transmissivity spectrum, Run #283,
 $p=741.8$ mmHg, $U=.0448$ atmo cm, $\bar{T}=-27.8^{\circ}\text{C}$.

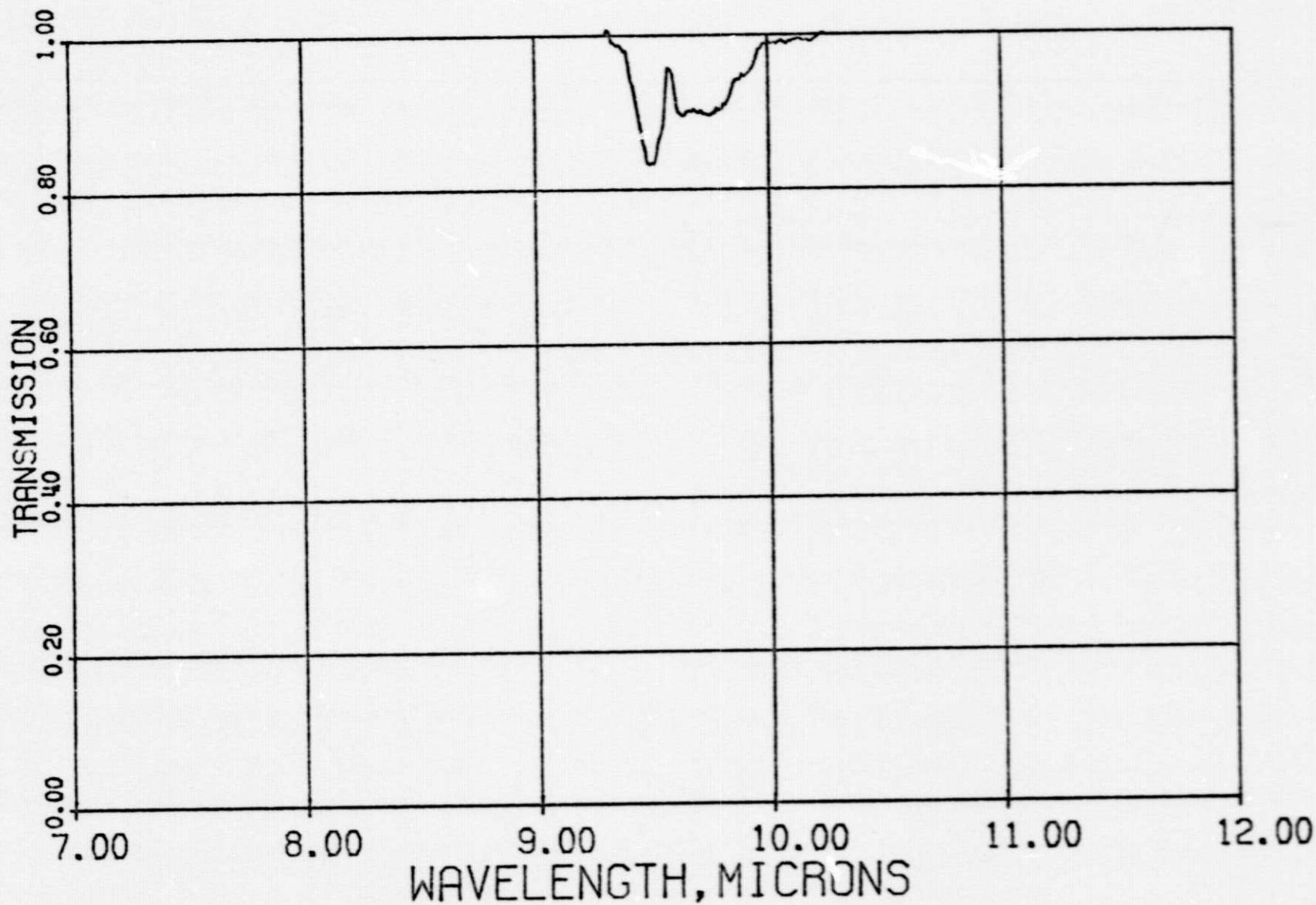


Figure 11. Ozone transmissivity spectrum, Run #284,
 $p=720.0$ mmHg, $U=.0041$ atmo cm, $\bar{T}=-31.1^{\circ}\text{C}$.

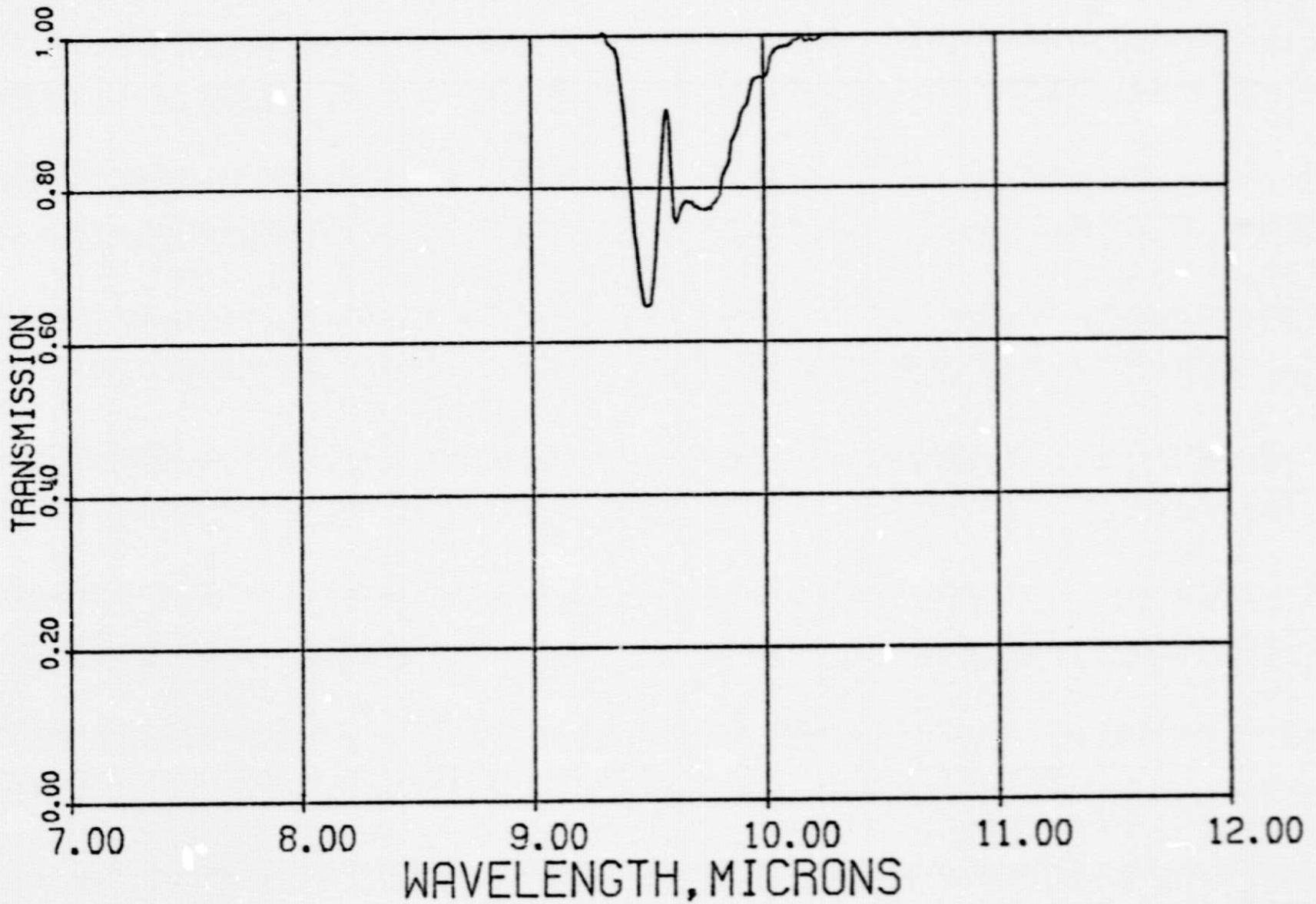


Figure 12. Ozone transmissivity spectrum, Run #285,
 $p=738.0$ mmHg, $U=.0081$ atmo cm, $\bar{T}=-25.0^{\circ}\text{C}$.

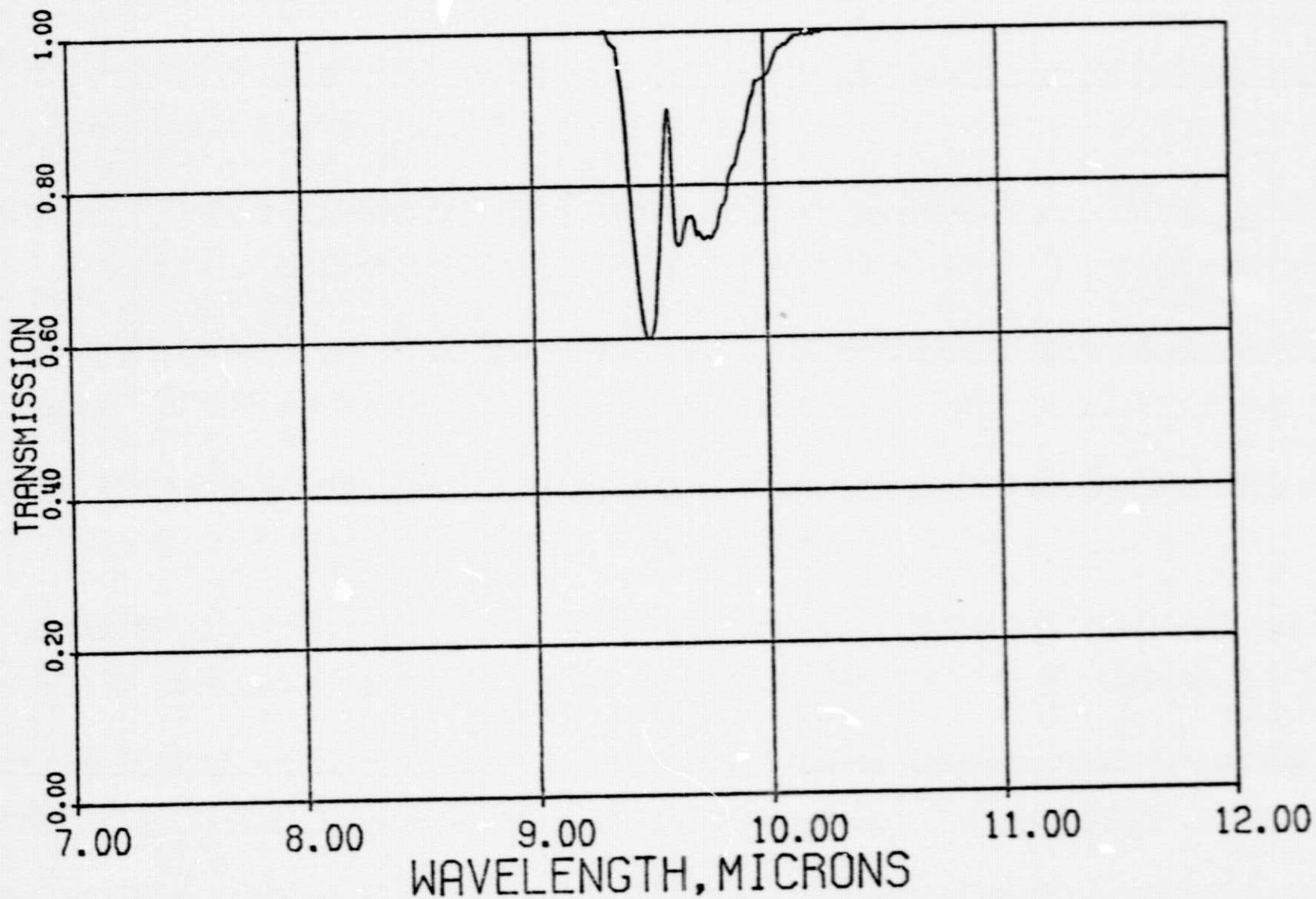


Figure 13. Ozone transmissivity spectrum, Run #286,
 $p=761.3$ mmHg, $U=.0097$ atmo cm, $\bar{T}=-22.2^{\circ}\text{C}$.

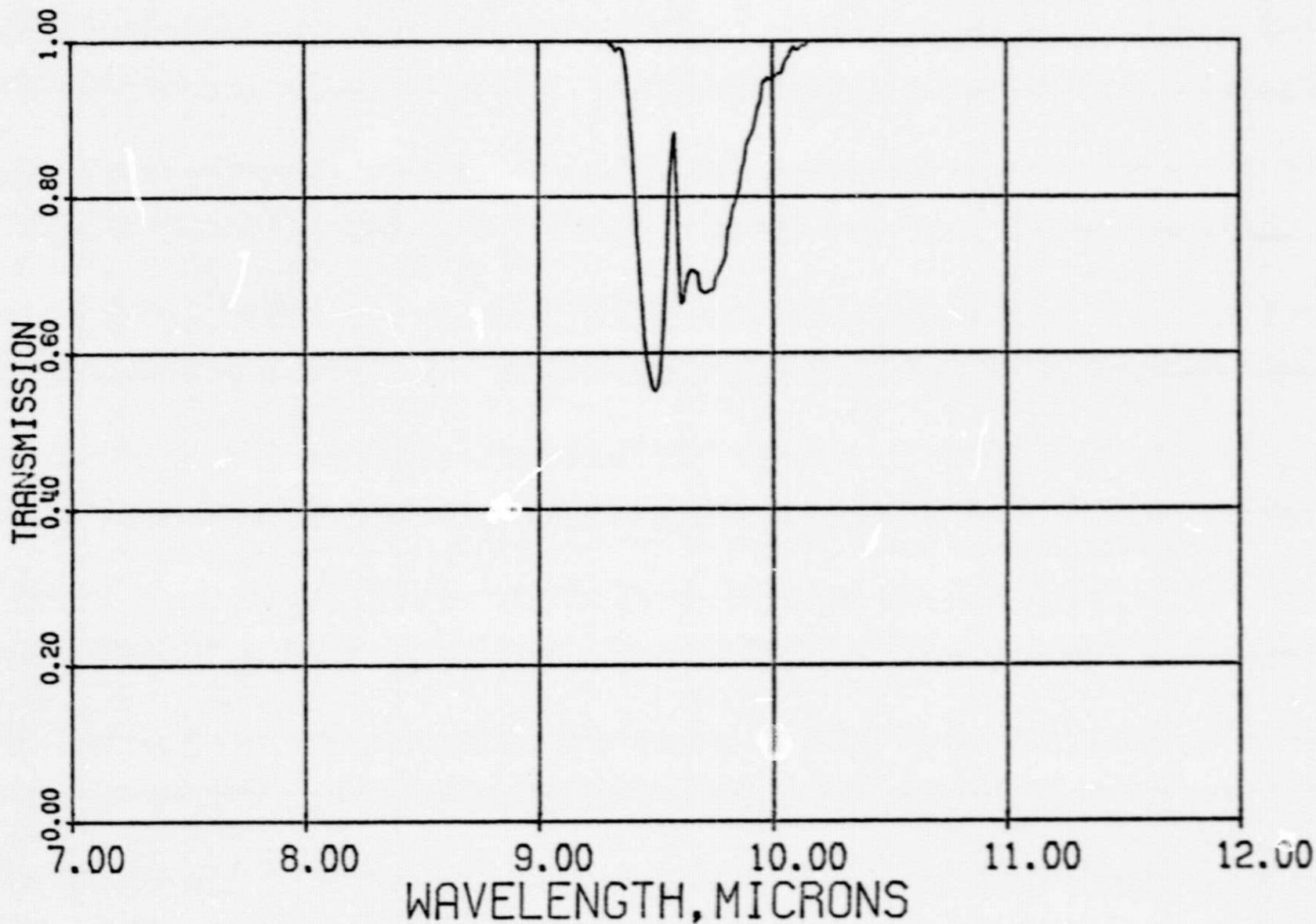


Figure 14. Ozone transmissivity spectrum, Run #287,
 $p=680.3$ mmHg, $U=.0218$ atmo cm, $\bar{T}=-48.3^{\circ}\text{C}$.

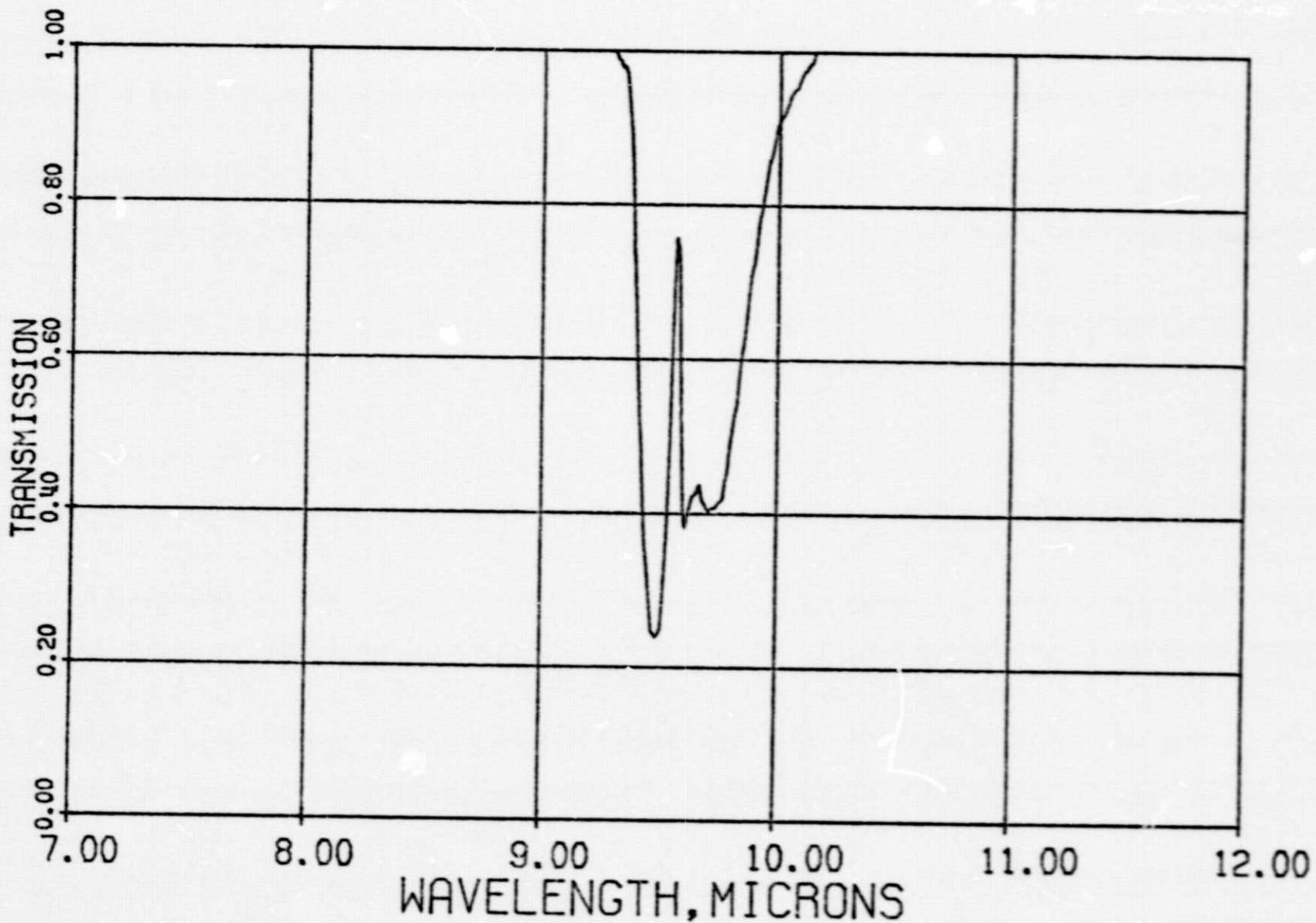


Figure 15. Ozone transmissivity spectrum, Run #288,
 $p=710.3$ mmHg, $U=.0506$ atmo cm, $\bar{T}=-45.6^{\circ}\text{C}$.

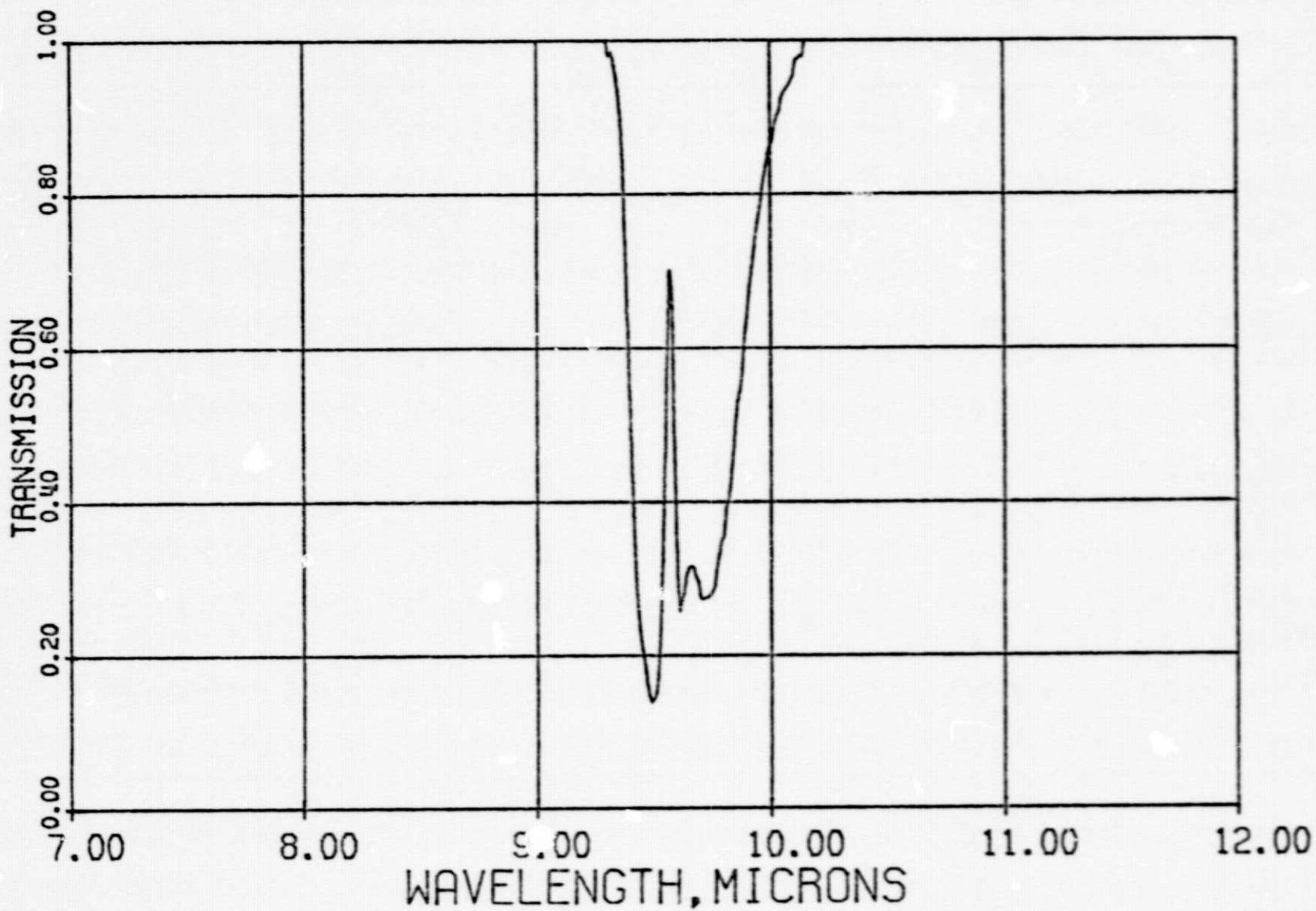


Figure 16. Ozone transmissivity spectrum, Run #289,
 $p=740.3$ mmHg, $U=.0714$ atmo cm, $\bar{T}=-40.0^{\circ}\text{C}$.

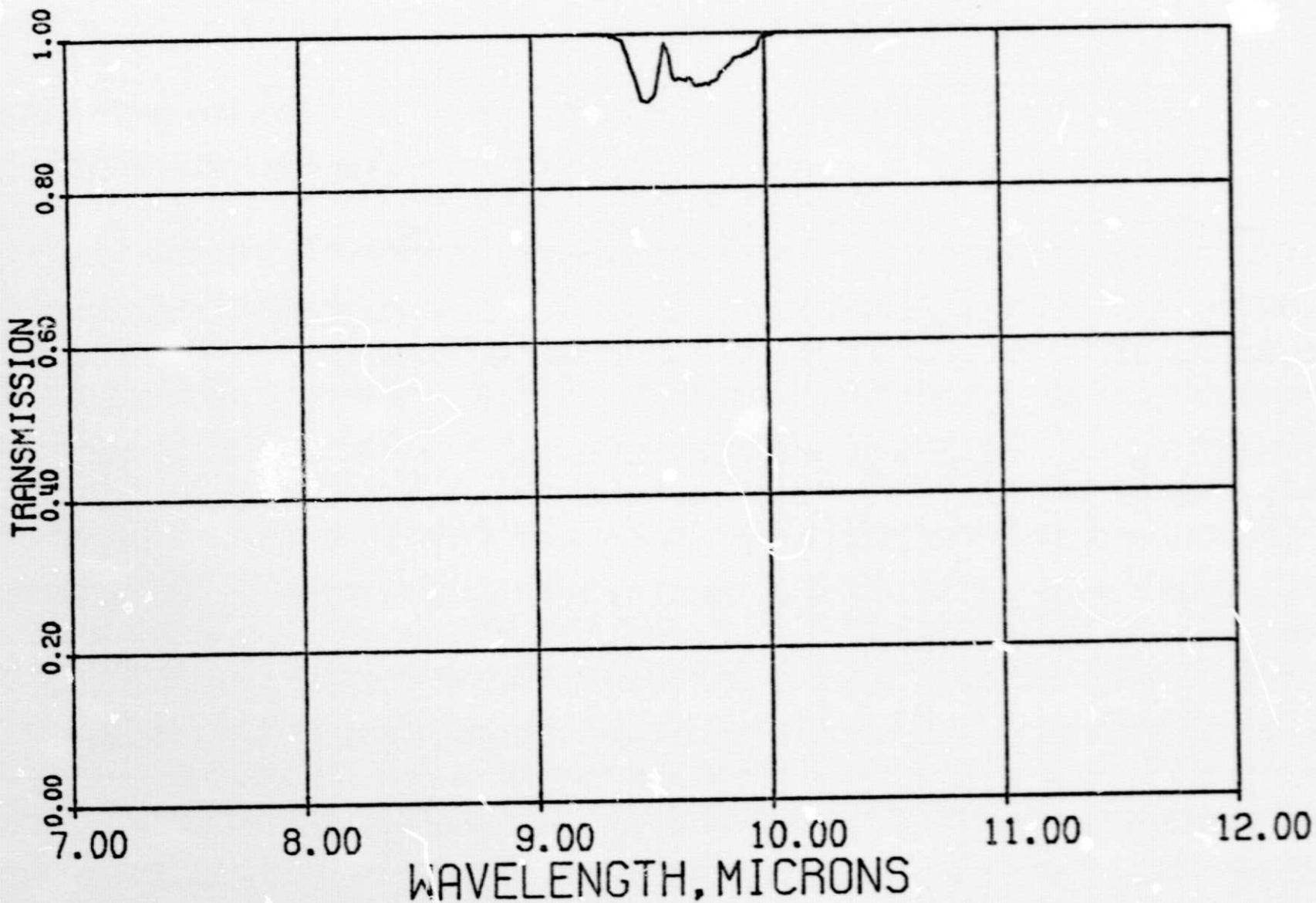


Figure 17. Ozone transmissivity spectrum, Run #290,
 $p=702.0$ mmHg, $U=.0024$ atmo cm, $\bar{T}=-39.4^{\circ}\text{C}$.

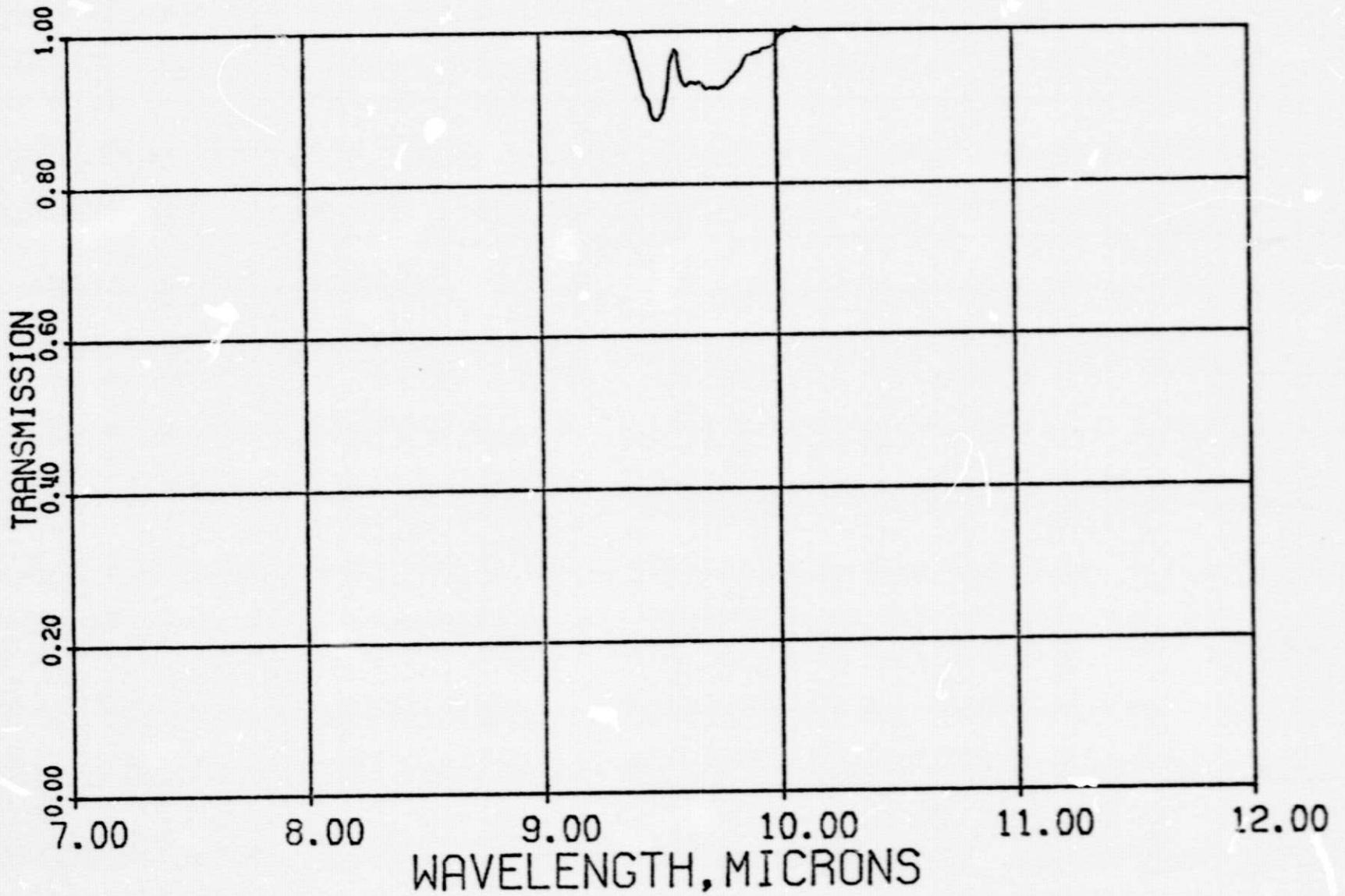


Figure 18. Ozone transmissivity spectrum, Run #291,
p=711.8 mmHg, U=.0032 atmo cm, $\bar{T}=-37.2^{\circ}\text{C}$.

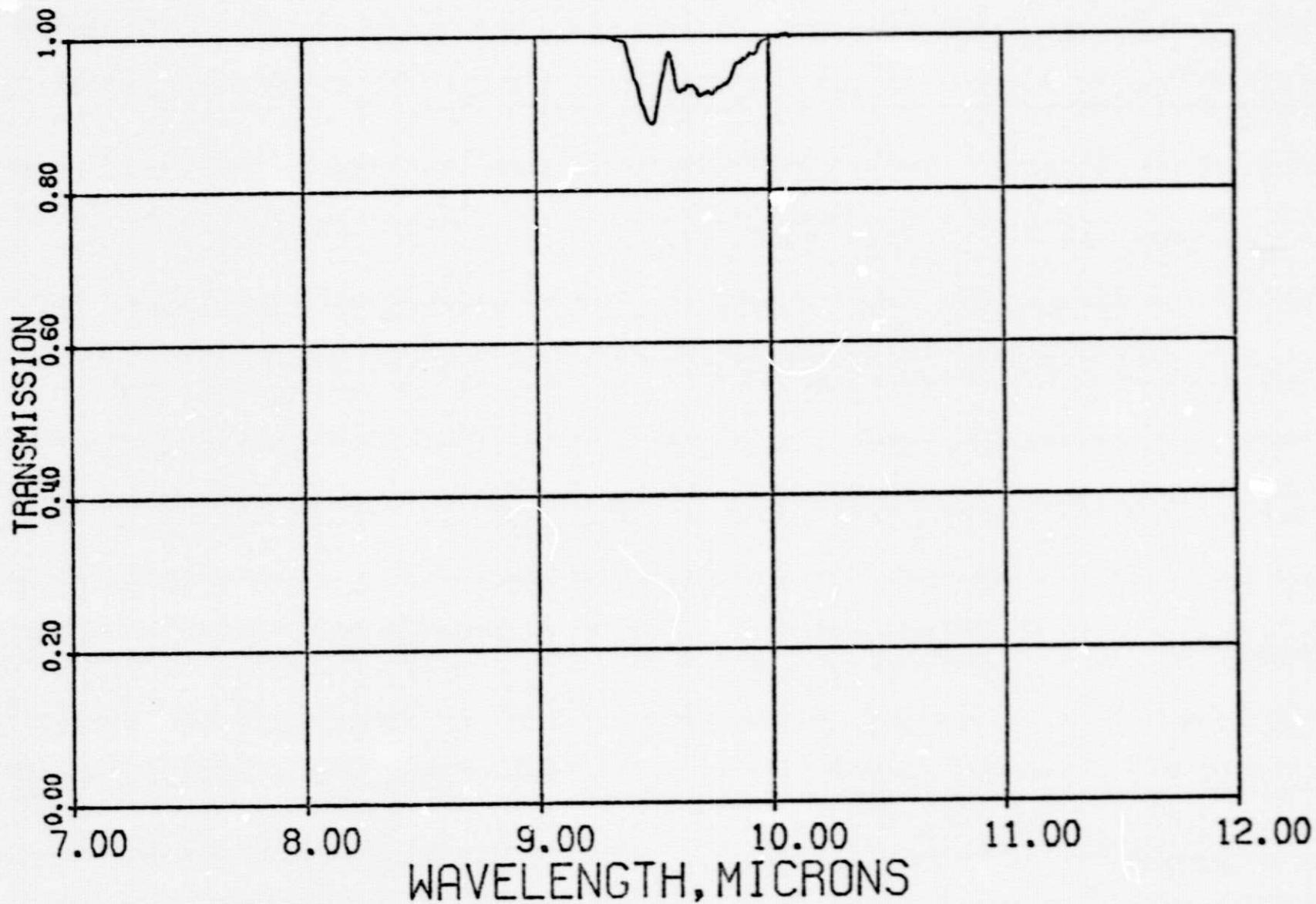


Figure 19. Ozone transmissivity spectrum, Run #292,
 $p=699.8$ mmHg, $U=.0029$ atmo cm, $\bar{T}=-41.1^{\circ}\text{C}$.

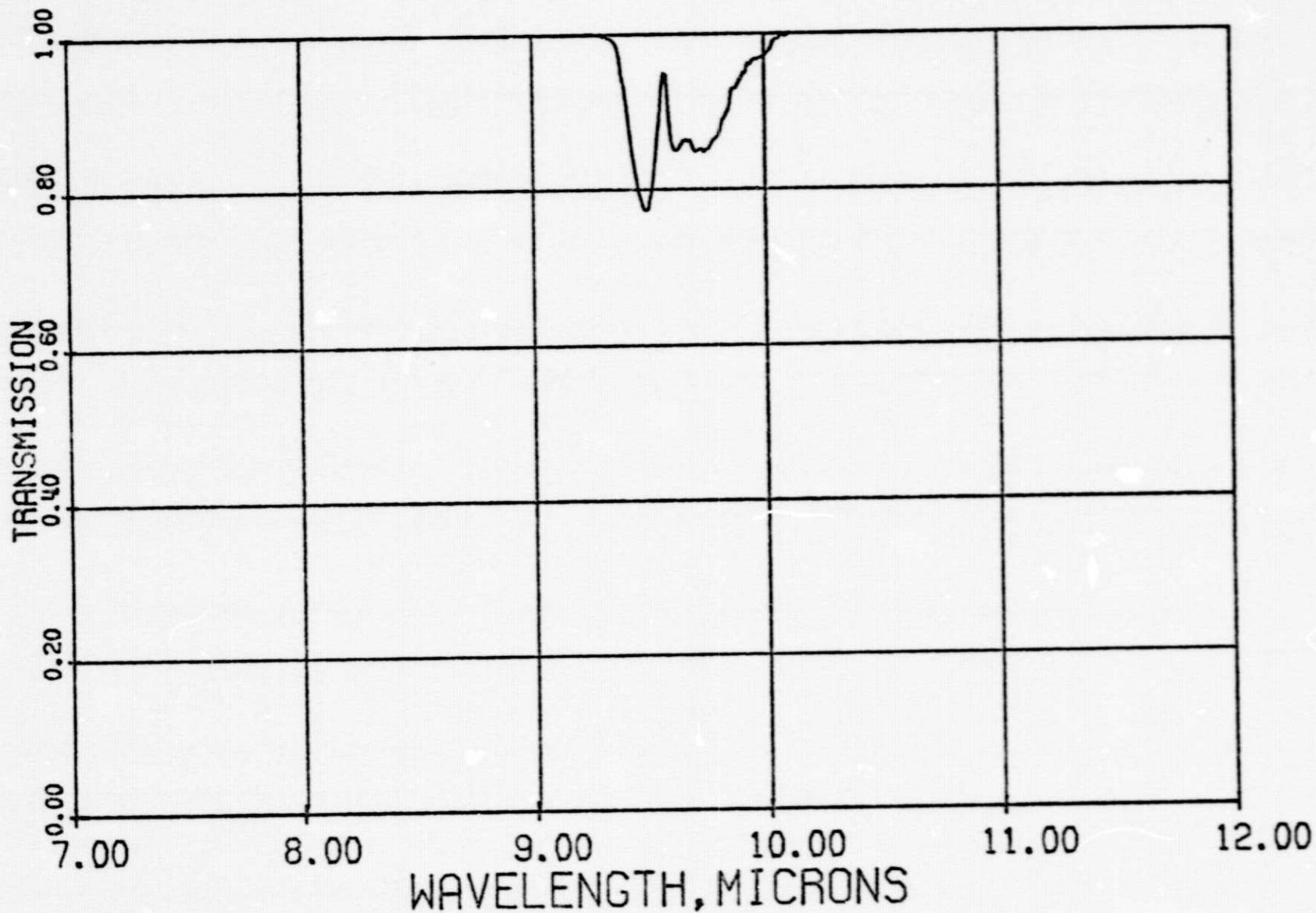


Figure 20. Ozone transmissivity spectrum, Run #293,
 $p=723.8$ mmHg, $U=.0063$ atmo cm, $\bar{T}=-37.2^{\circ}\text{C}$.

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1. Bartman, F.L., W.R. Kuhn, and L.T. Loh, Low Resolution Measurements of Ozone Absorptivity in the 9.6 μ m Region. The University of Michigan, High Altitude Engineering Laboratory, Final Report 036350-1-F, February, 1975.
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