THE INTERACTION OF OXYGEN ATOMS WITH SOLID SURFACES AT eV ENERGIES

Semi-Annual Status Report
1 June, 1967 to 30 November, 1967
NASA Grant NGR-47-005-077

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Submitted to:

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Washington, D. C. 20546

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Report No. EP-4011-101-67U
December 1967

Copy No. 4

I. INTRODUCTION

This report covers the research performed under NASA Grant NGR-47-005-077 during the period June 1, 1967 through November 30, 1967.

In order to understand in detail the behavior of space vehicles in rarefied atmospheres it is necessary to have specific knowledge concerning the interaction of the atoms and molecules of the atmosphere with surfaces of the vehicle, particularly for particle energies corresponding to space vehicle oribtal and escape velocities. The goal of the present research program is to investigate the mass spectrum resulting when oxygen atoms, moving with satellite velocities, strike a solid surface. In addition to adding to the small amount of information presently available concerning particle-surface interactions at energies corresponding to satellite velocities, the results will be of particular value in providing information that will aid in the interpretation of mass spectrometric studies of the neutral constituents of the earth's upper atmosphere.

II. SYSTEM CONSTRUCTION

Efforts during this initial six month period have been devoted to design and construction of the vacuum system, ion source, focusing electrodes, etc., and purchase of necessary equipment. The ion source and magnetic mass analysis chamber are now complete and operating. O^- ion beams have been generated and transported through the neutralization chamber.

The neutralizing cell has also been completed and positioned in the neutralization chamber. Pressure in the cell will be monitored by an ionization gauge located directly on the cell. Slow ion collection plates are mounted in the cell to permit electron detachment cross sections to be measured.

By suitably employing the helium refrigerator cryo-pump it will be possible to eliminate the buffer chamber originally designed to be located between the neutralization chamber and the target chamber. In the new design a long cylindrical tube, cooled to $20^{\circ}K$ with the cryo-pump, will be positioned in the target chamber immediately down stream of the entrance aperture to the target chamber. Calculations show that this arrangement will permit us to maintain the desired target chamber pressure of 10^{-10} Torr, while eliminating the buffer chamber and reducing the distance between the neutralizing cell and the target. The cryo-pump has been ordered and drawings of the bakeable, stainless steel target chamber are being prepared. In addition to the cryo-pump the target chamber will also be pumped by a liquid nitrogen trapped six inch oil diffusion pump.

We have purchased a Granville-Phillips Spectra-Scan 750 quadrupole mass analyzer for mass analysis of the particles emerging from the surface. The quadrupole mass analyzer will be suspended in the target chamber so as to intercept the maximum number of emerging particles. The Granville-Phillips instrument satisfies our requirements of high sensitivity and ability to withstand baking at high temperatures.

To date construction of the system has proceeded satisfactorily and on schedule. The entire system, barring unforeseen difficulties, should be completed and in operation by the end of the contract period.

III. PRELIMINARY DATA

The ion source and mass analysis section of the system has not been completed for a sufficient length of time to permit detailed measurements of ion beam intensity, energy spread, electron detachment cross sections, etc. However, we have begun some preliminary investigations of the operating characteristics of the source when used for the production of negative ions.

The ion source we are using has proved to be an efficient source of positive ions and has been thoroughly investigated.[1] However, relatively little experience has been gained using the source to produce negative ions. Hence, our initial efforts have been directed to investigating source operation for the production of negative ions, in particular O^- ions. Figure 1 shows the negative ion spectrum resulting when pure O_2(99.9%) is used as the source gas. As can be seen, the only impurity ions present are O_2^- and CO_2^-. This surprisingly small quantity of O_2^-(3.4%) is probably a consequence of the high bombarding electron energy (100eV) used in the source, most likely resulting in a high degree of dissociation of the O_2 source gas. The CO_2^- ion is actually the largest impurity ion peak (6.0%) and is probably formed from carbon impurities present in the tungsten filament.

Figure 2 is the output ion spectrum when pure CO_2(99.95%) is used as the source gas. Impurity ions C^-, O_2^- and CO_2^- are present in amounts 1.1%, 1.8%, and 25% respectively, as well as two unidentified ion peaks corresponding to masses 35.5(5.1%) and 37.4(2.7%). The small amount of OH^- ions (2.7%) is due to the fact that this spectrum was taken soon after pump down when a slight amount of water vapor was still present in the system. This was done deliberately to illustrate the mass resolution of the system. With further pumping this OH^- ion peak disappears (see Fig. 1). Since the OH^- impurity ion is completely negligible the higher mass resolution ($\Delta M/M \simeq 1/28$) used to obtain the spectra in Figs. 1 and 2 will not be needed for the experiment.

[1] "High Efficiency Low-Pressure Ion Source," C. E. Carlston and G. D. Magnuson, Rev. Sci. Instr. 33, 905 (1962).

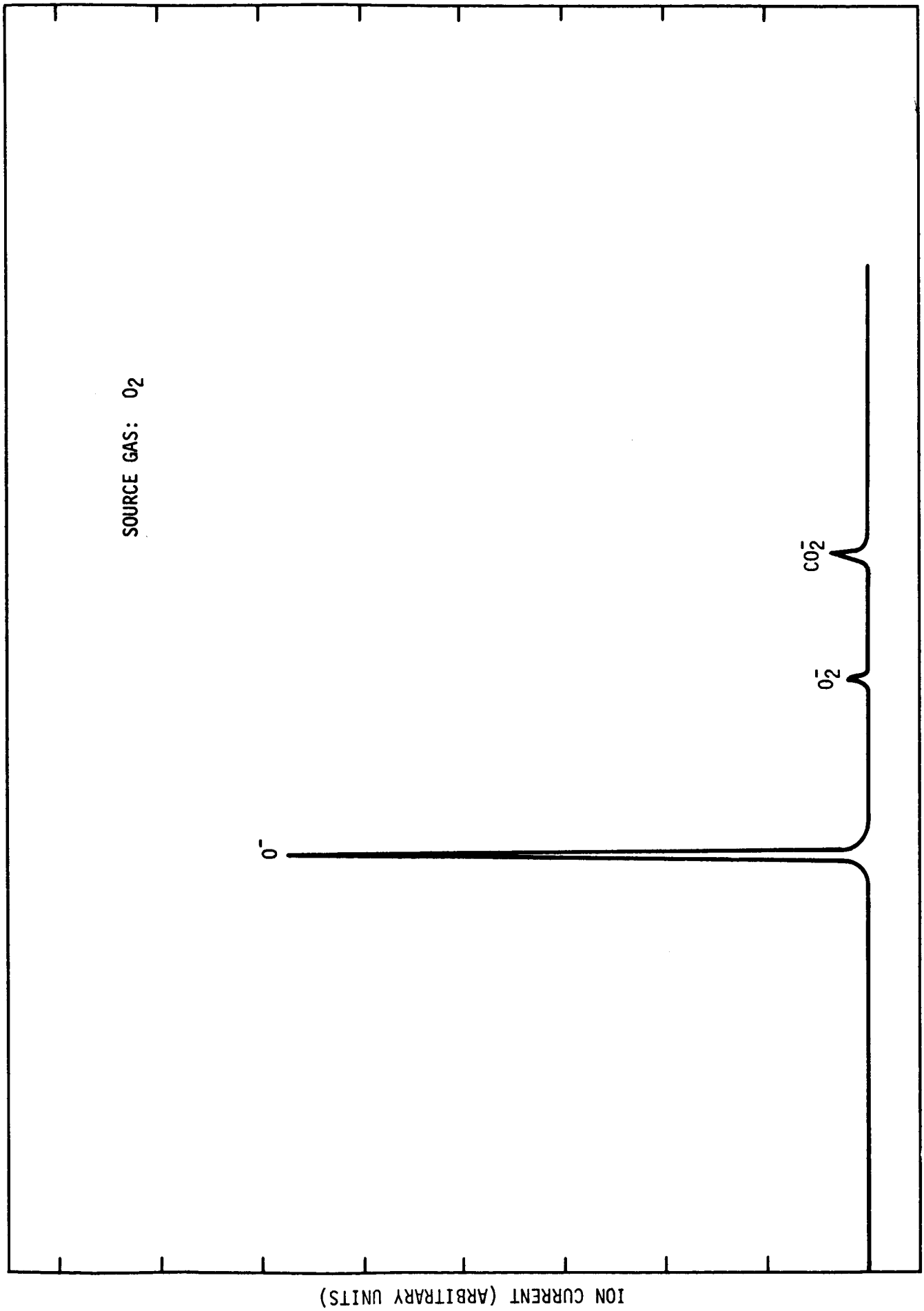

FIGURE 1

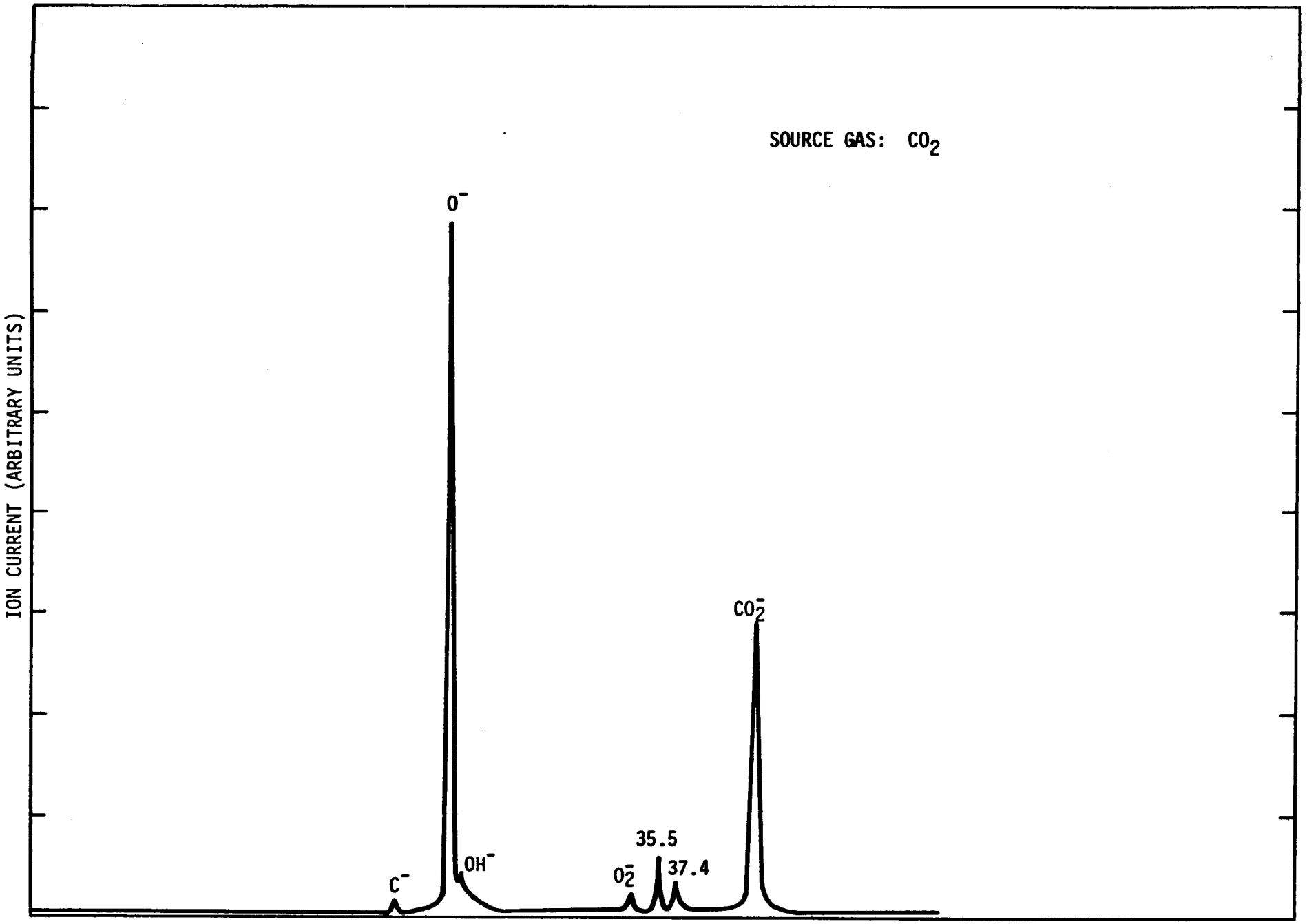
SOURCE GAS: CO_2
ION CURRENT (ARBITRARY UNITS)
O^-
C^-
OH^-
O_2^-
35.5
37.4
CO_2^-

FIGURE 2

At the present time, working only with the higher mass resolution configuration, we have been able to transport O^- ion beams of 400eV energy through the neutralizing cell with an intensity of 10^{-10}A. Much larger currents will be realized when the defining slits are widened.

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