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SIXTH QUARTERLY PROGRESS REPORT

FOR THE PERIOD

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INFRARED RADIATION MEASUREMENTS OF COMBUSTION GASES

University of California at Davis

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INTRODUCTION

Knowledge of the infrared radiative properties of rocket exhaust gases is required in many applications. Examples include the prediction of radiative heating to the base regions of multi-engine vehicles and the long-range detection of ballistic missiles. The magnitude and characteristics of this infrared radiation depends on the flame composition and temperature.

Analytical studies of the radiative heating from rocket exhaust plumes indicated the need for complete and accurate spectral absorption data. Although numerous investigations of CO_2 and H_2O have been reported recently, the results are for a maximum temperature of 1200° K or are restricted to a narrow wavelength region. Furthermore, existing theories for predicting infrared radiation from high temperature gases are based on highly idealized physical models. The validity and applicability of the results based on these theories require experimental confirmation.

The objective of the present study is to obtain the spectral characteristics of a number of common combustion products under a variety of accurately known thermodynamic and optical conditions. An experimental apparatus for this purpose has been designed and constructed. The key element is a graphite resistance furnace with an inert ceramic tube liner for the containment of high-temperature gases. A beam of radiation from a high-temperature source is directed through a known length of test gas in the center region of the furnace. A monochrometer on the opposite end of the furnace is used to measure the amount of energy absorbed as a function of wave length.

Measurements of the spectral absorptivities of carbon monoxide were reported during the previous quarter. These included data for the 4.67 micron fundamental band at path lengths of 1, 5, 10 and 20 cm and temperatures of 300, 600, 900, 1200, and 1500° K over the pressure range of 1/4 to 3 atmospheres. For the first overtone band absorption was found to be significant only for a path length of 20 cm at pressures of 1, 2, and 3 atmospheres for the same temperatures.

TRANSFER OF PROJECT TO DAVIS CAMPUS

As a result of the move of the principal investigator from the Berkeley Campus to the Davis Campus of the University of California the project was transferred to the Davis Campus during the present quarter. Since it was necessary to disassemble the high-temperature spectral absorption apparatus for moving, it was decided to review the original design before reassembly. The particular objective of this was to see if modifications could be made to permit absorption measurements at higher temperatures.

REASSEMBLY OF INFRARED SPECTRAL ABSORPTION SYSTEM

Two possible arrangements are being considered. The first is similar to the original and is pictured in Figure 1. Greater flexibility will be achieved by mounting the source, furnace and monochrometer on an optical bench.

The second arrangement is to mount the tube furnace so that its axis is vertical rather than horizontal. The major advantage of this is that the stress in the ceramic liner will be compression only. This is very important at the higher temperatures of operation desired (1800 to 2400° K). A possible disadvantage is the amount of free convection which may result. Previous testing, however, has indicated definite convection currents even when the furnace axis is horizontal. Vertical operation, may, therefore, be satisfactory.

A second major change will be made in the type of window holder used to define the test path length. This component of the apparatus has been the factor which determined the upper temperature. In order to make measurements above 1500° K the type of window holder shown in Figure 2 is being designed. It will consist of three ceramic tubes. The center tube will act as a spacer and span the test section. External pressure on the two outer tubes will hold two sapphire windows in place. A platinum ring will be used to provide a seal between the test section and the inside of the two outer tubes. Since some temperature drop across the test section can be tolerated, gas cooling of the sapphire windows will also be included.

Initial testing of the reassembled apparatus with new window holders will be made with carbon monoxide. Effort will then be directed to carbon dioxide and water vapor.

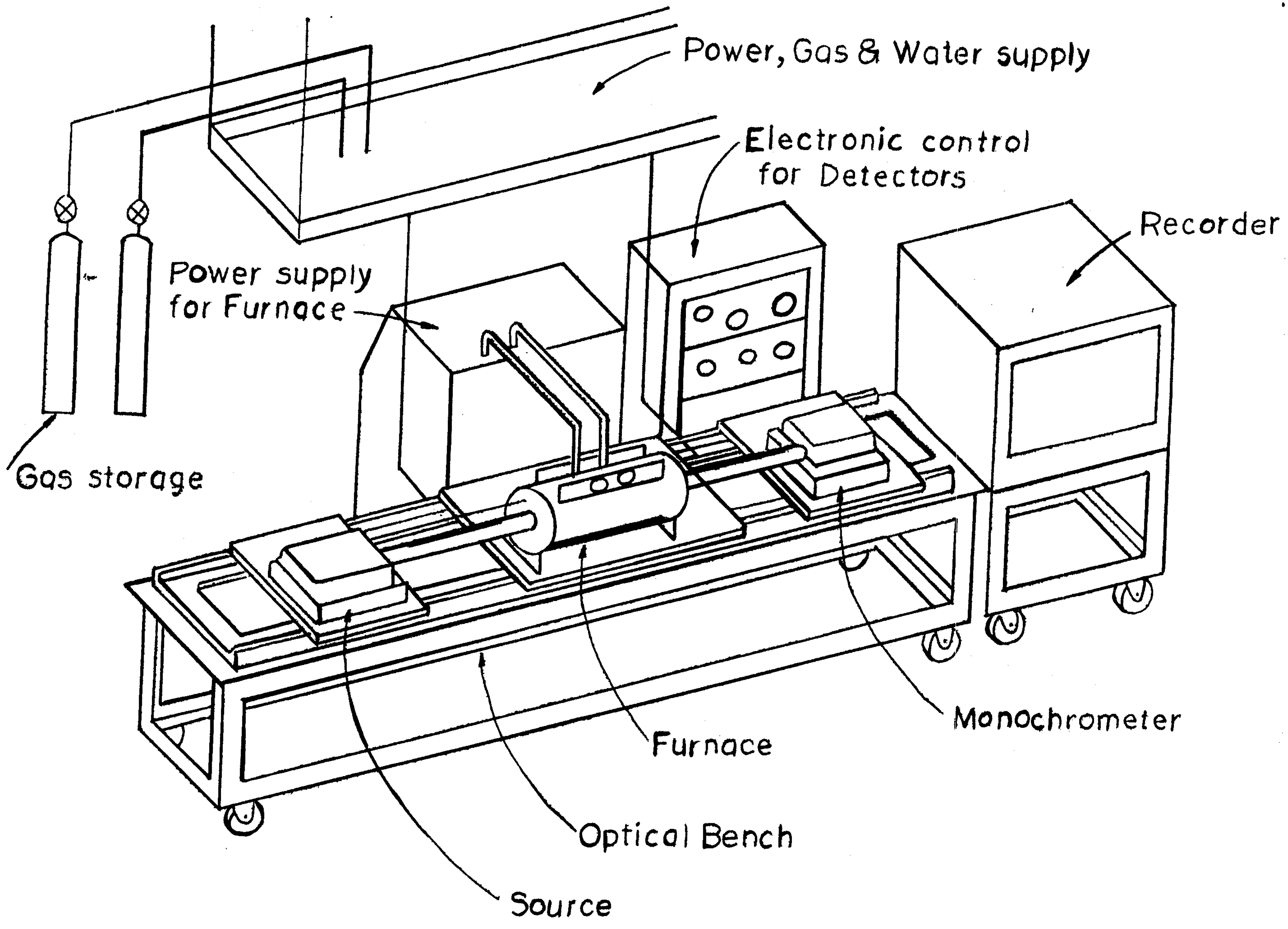

Fig. 1 INFRARED SPUTROL ABSORPTION SYSTEM

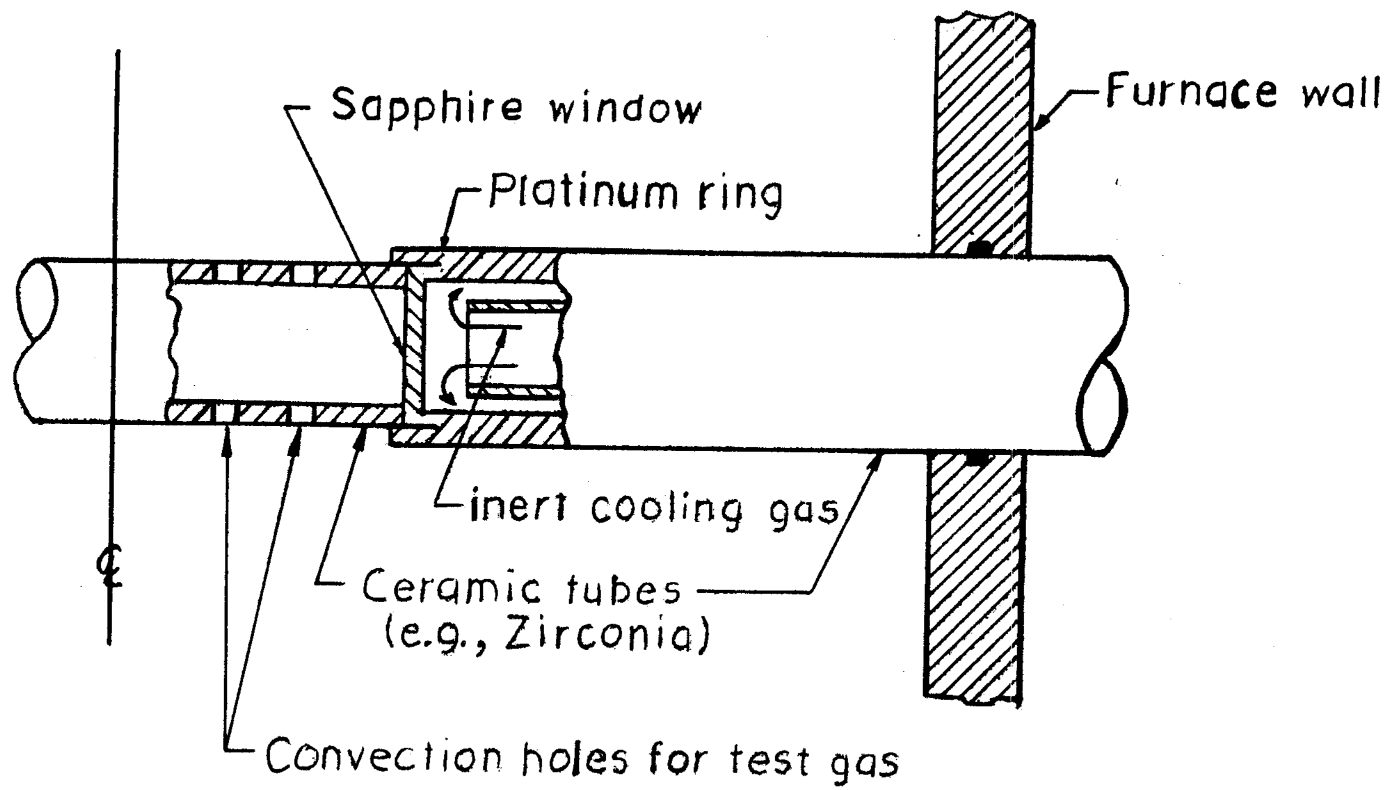

FIG. 2 PROPOSED CERAMIC TUBE WINDOW HOLDER DESIGN