Final Report

Spectrographic Coverage and Data Reduction of NASA Chemical Release Studies Directed Toward Design and Development of New Spectrographic Instrumentation.

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I. ABSTRACT

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A slitless spectrograph was designed and constructed using an 1800 groove/mm reflection grating and an F/0.87 camera lens of 76mm focal length to provide a dispersion of 70 A/mm. This instrument gave excellent spectra for upper atmosphere chemical releases during the Firefly III series. The slitless spectrograph is being used by Georgia Tech at the present time under Contract NASI-1671.

Author

II. INTRODUCTION

The search for means to measure winds of the upper atmosphere led quite naturally to the study of chemical releases that could tap energy stored in the ionosphere and thereby produce visible clouds which could be tracked at night. Spectral information from these clouds can be used to determine the presence of various atomic or molecular species which are present in the upper atmosphere. The task assigned under this contract was to provide spectrographic coverage for these chemical releases during the extent of the contract. High resolution spectral coverage was to be provided with an auroral slit-type spectrograph which was the property of the Air Force Cambridge Research Center. However, a slit-type spectrograph is rather strongly limited in application where the spectral source is a very weak luminescent distant cloud. One of the objectives of the program was to develop a fast slitless type spectrograph that would record spectral information from the luminescent clouds that were expected.

III. ACCOMPLISHMENTS

A. Slitless Spectrograph

A study of slitless spectrographs which use transmission gratings showed that 600 was the maximum number of grooves per mm that could be used on a blazed transmission grating. A blazed reflection grating was readily available with 1800 grooves per mm.

A grating with 1800 grooves/mm will give three times the spectral dispersion which can be obtained with a 600 groove/mm grating. A slitless spectrograph produces a separate image of the light source for each of the wavelengths present. For a distance light source, one cannot increase the spectral resolution by using a longer focal length camera lens since this increases the size of the image. This increase in image size prevents one from obtaining greater spectral resolution even though greater dispersion can be obtained by increasing the focal length.

The above factors were considered and a slitless spectrograph was designed using the following components:

Bausch and Lomb reflection grating with 1800 grooves/mm, Super Farrand F/0.87 lens with a 76 mm focal length, and a 70 mm Beattie Coleman film magazine with data chamber.

The spectrograph was constructed so that the zero spectral order of the grating could be superimposed just above the spectral images. This provided a method of determining wavelengths. A photograph of the spectrograph is shown in Fig. 1.

The slitless spectrograph proved to be very effective in recording faintly chemi-luminescent clouds in the upper atmosphere. Representative spectra obtained with our spectrograph of chemical releases which were observed during the Firefly III program sponsored by Air Force Cambridge Research Laboratory are included in Fig. 2. In these spectrograms the spectra are spread horizontally and the zero order image appears above the spectra. The spectrogram labeled Dana shows a continuum which is produced by an aluminum release. The two images at 3962A and 3944A have been identified as the resonant lines of aluminum. The spectrogram labeled Netty was produced by an acetylene release. Here again a continuum is present but strong CH and the Swan bands of C_2 are easily identified even though the clouds size is very large. The spectrogram labeled Ruby shows the resolution which is possible for point like clouds. This chemical release contained cesium and sodium. On the original film the following atomic lines were identified: 6213A Cs, 6010A Cs, 5845A Cs, 5896A Na, 5890A Na, 5670A Na, 5688A Na and 5683A Na. The two sodium yellow lines which are only 6A apart are actually resolved on the spectrogram. These spectrograms show that the slitless spectrograph is a well designed instrument which performs well in recording the spectra of chemi-luminescent clouds in the upper atmosphere.

B. Spectrographic coverage for NASA Wallops Station releases of CS_2 and $Pb(CH_3)_4$ on 1 June 1962 and 24 Sept. 1963.

a. Equipment used.

1. The auroral slit-type spectrograph which used an F/0.87 camera lens and provided a dispersion of 100 A/mm was in operation for these launches.

2. The slitless spectrograph described in Part A above was in operation for these launches.

b. Data obtained

No luminescent clouds were observed for the CS releases. The $Pb(CH_3)_4$ release was scheduled for release at 113 seconds after launch at about 115 km altitude. Photographs by Prof. Edwards of Ga. Tech indicate that the release occurred near 80 seconds after launch at an altitude of approximately 82 km. Our spectrographs were not opened at this time and it is very doubtful if spectra could have been recorded because the release was not visible to the observers at the spectrographic site.

C. Future Spectrographic Coverage.

The slitless spectrograph developed under this contract proved to be a valuable instrument for recording spectra from chemical releases in the upper atmosphere. At our request, the spectrographic work under this contract was transferred to Contract NASI-1671 with Georgia Tech. They can best provide the technical services needed for operating the spectrograph in the field.

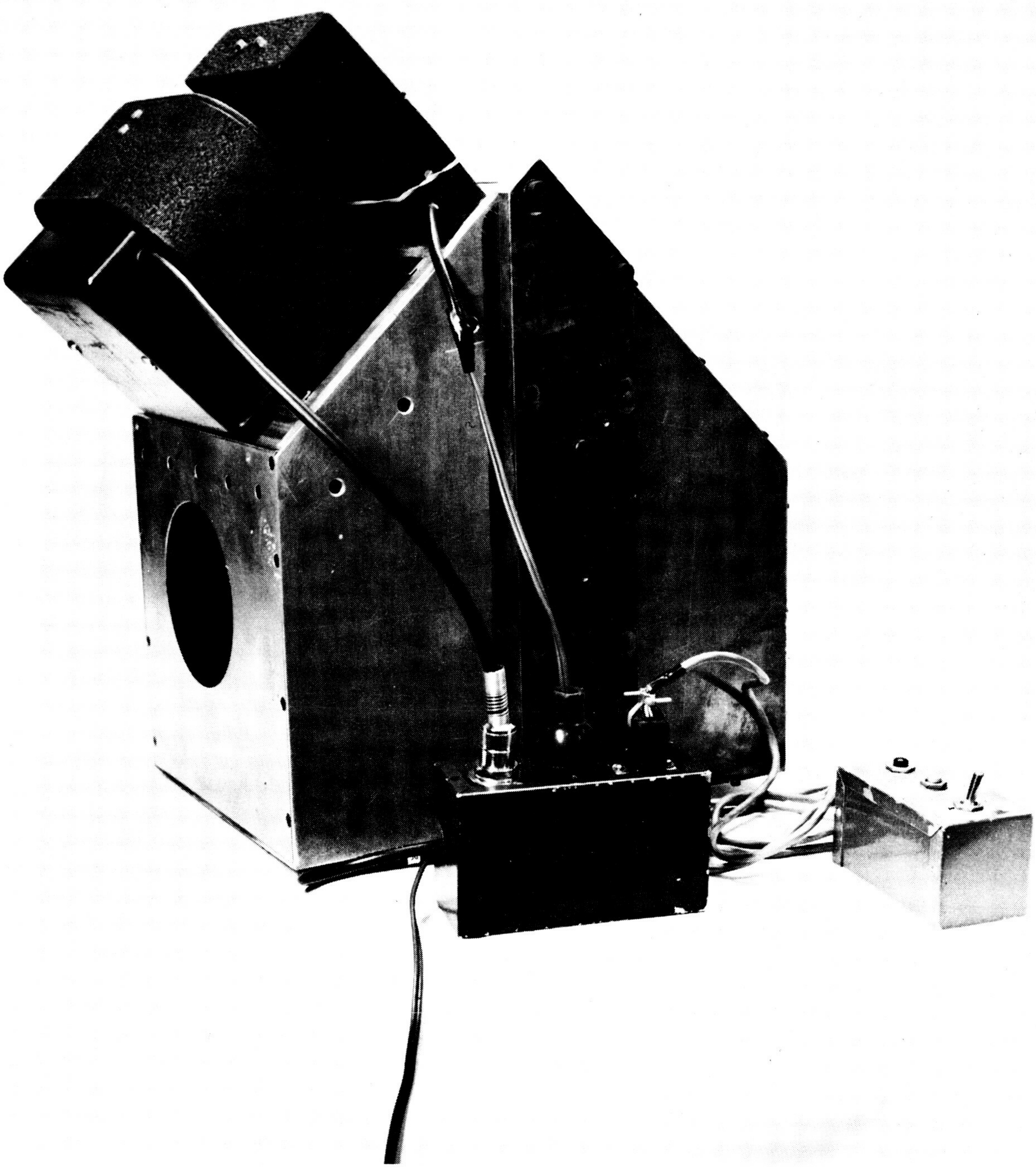
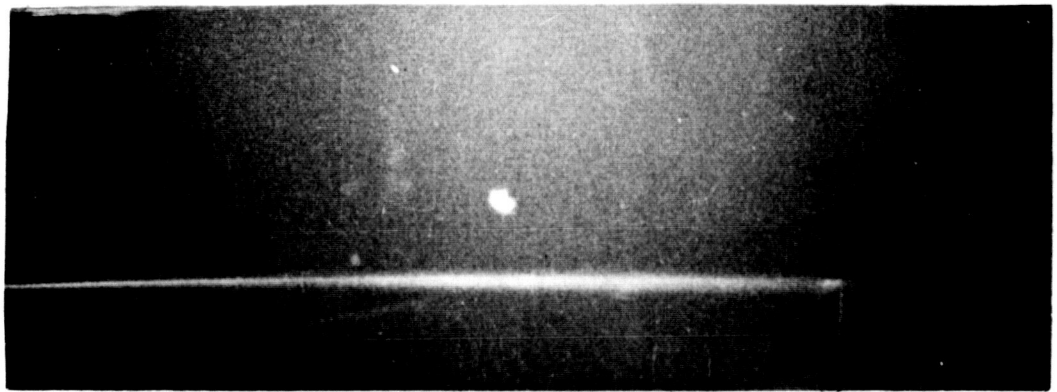


Fig. 1



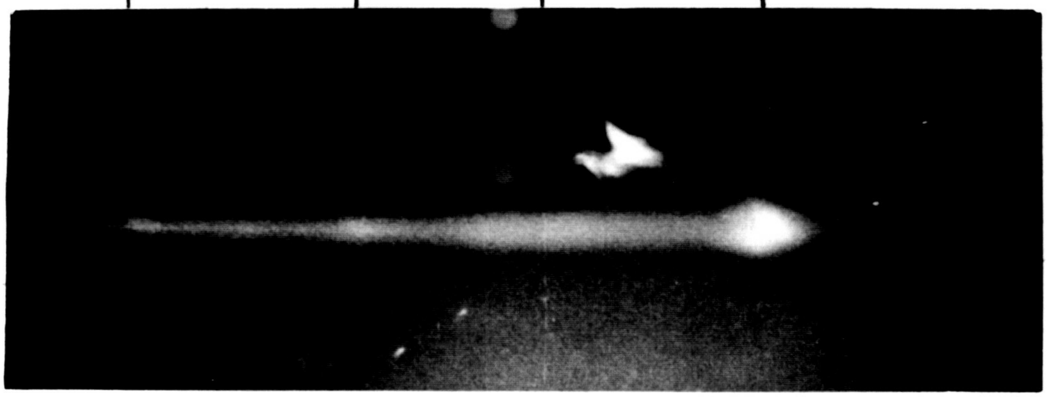
3962A
3944A

Dana - Aℓ

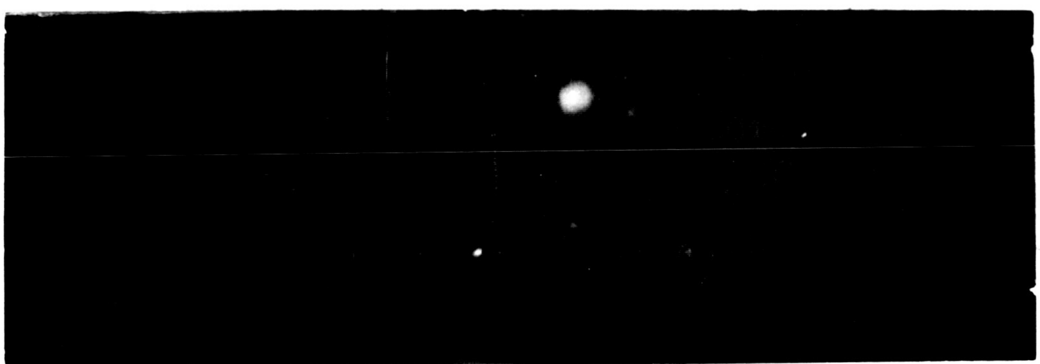
C_2 Swan Bands

CH

5585A 5156A 4737A 4315A



Netty - Acetylene



5893A

Ruby - MPEC

Fig. 2