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Chemical Release and Radiation Effects Experiment (CRRES) Educational Planning and Coordination

5-32586/5-32588

Final Technical Report for the Period
February 14, 1991 through September 30, 1991

(September 1991)

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16. ABSTRACT

This report summarizes the efforts conducted to provide educational planning and development support for the Chemical Release and Radiation Experiment (CRRES). Included are activities regarding scientific working group and workshop development including the preparation of descriptive information on the CRRES Project.

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PREFACE

This technical report was prepared by the staff of the Research Institute, The University of Alabama in Huntsville. It summarizes the key aspects of the research performed under NAS8-36955, Delivery Order 112. Dr. William-W. Vaughan was Principal Investigator. Technical work was accomplished under the direction of Ms. Melanie Alzmann.

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be constructed as an official National Aeronautics and Space Administration, Marshall Space Flight Center position, policy, or decision unless so designated by other official documentation.

I have reviewed this report, dated ______________ and the report contains no classified information.

____
Dr. William W. Vaughan
Principal Investigator

Approval:

____
Research Institute

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I. Scope of Work

TASK: CHEMICAL RELEASE AND RADIATION EFFECTS EXPERIMENTS EDUCATIONAL PLANNING AND DEVELOPMENT

(1) The contractor shall provide the assessment and production of educational materials for the Chemical Release and Radiation Effects Satellite (CRRES) project experiments using video and still-photography documentation and technical writing.

(2) The contractor shall perform reviews and critiques to broaden the definition and benefits of the educational aspects of the CRRES project.

(3) The contractor will collaborate with the Project Scientist, Principal Investigators, and other related persons, and participate in a working conference at a Caribbean site location prior to the Caribbean Rocket Campaign.

(4) The contractor will document using video and still-photography the CRRES Caribbean Rocket Campaign from design review stage to launch and release.

(5) The contractor will provide special emphasis consultant personnel, where required, for assessments of concepts and approaches which may cause significant improvements and revisions in the project deliverables.

II. Summary of Meetings, Workshops, and Special Documentation

During the contract period, assessment and coordination of the CRRES project work was undertaken and accomplished and also documented. A scientific workshop was held, as well as engineering and administrative meetings. The contractor coordinated and participated in all events listed below.

(1) February, 1991 — EDUCATIONAL BRIEF

The contractor assisted in the writing and production of a NASA Educational Brief on the CRRES Project. (See Appendix)

(2) March 18-20, 1991 — INVESTIGATORS WORKING GROUP
Aguadilla, Puerto Rico

Documentation and coordination of the meeting activities was accomplished by the contractor and distributed to the COTR and CRRES Project Office. A copy is on permanent file in the University of Alabama, Research Institute Office. An Agenda of the meeting is included in Section III for the purposes of this final report.

(3) June 18, 1991
July 18, 1991 — BRIEFINGS
Wallops Flight Facility, VA

Briefing sessions were held between the payload managers and engineers to develop a time-line for video documentation of the CRRES Sounding Rocket Campaign and launch schedule.

(4) April 16-August 6, 1991 — VIDEOTAPING/STILL PHOTOGRAPHY

CRRES Sounding Rocket integration and testing documentation was accomplished by the contractor. A listing of documented rocket tests is included in Section IV for the purposes of this final report.

III. Detail Agendas of Meetings and Workshops

CRRES IWG 14
AGUADILLA, PUERTO RICO
MARCH 18-20, 1991
PRELIMINARY AGENDA

MONDAY, MARCH 18, 1991

CRRES RESULTS DATA EXCHANGE MEETING

A. AA-5, AA-6 Equatorial Seeding Experiments

1.	Rocket, Altair Radar, Optical Results	Mendillo
2.	VHF Radar Results	Kelley

B. South Pacific Critical Velocity

1.	Experiment Results	Wescott
2.	CIV Models	Papadopolous

C. G2, G3, G4 Diamagnetic Cavity and Momentum Coupling

1.	Modelling Studies	Huba
2.	Optical Results	Hoffman/Mende
3.	CRRES Satellite Data	Anderson/Singer

D. G-7 Lithium Ion Tracing — Peterson

E. G5, G6 Lithium Cold Plasma Injection

1.	Optical Data - Li and Eu	Haerendel/Mende
2.	CRRES Satellite Data	Mende/Anderson/Singer
3.	Aircraft Optical Data	Wescott/Weber
4.	Ancillary Data - Goes, SMSP	Fritz
5.	Millstone Hill Radar Data	Foster

F. G8, G10 Barium Releases - Aurora Triggering

1.	Optical Data	Mende/Wolcott/Simons
2.	CRRES Satellite Data	Fritz/Anderson/Singer/ Mende/Wygant
3.	Aircraft Optical Data	Wescott/Webers
4.	Ancillary Data and Field Models	Fritz
5.	Millstone Hill Radar Data	Foster

TUESDAY, MARCH 19, 1991

Introductions and Welcomes

Review of Past Campaigns

Satellite Release Opportunities

Repeater Orbit Determination

Sounding Rocket Schedule - Confirmation

Ground Site Configurations and Changes

Aircraft Configuration

Arecibo Radar and HF Heater Configuration

Operations Network Configuration

Archiving CRRES Data at the NSSDC

Introducing CRRES to our Puerto Rican Hosts

WEDNESDAY, MARCH 20, 1991

Splinters Meetings:

A. Aircraft Operations

B. Sounding Rocket Operations

C. Ground Site Configurations

Reconvene and Review of Actions

Assignment of Action Items

Adjourn

IV. Sounding Rocket Program Event Summary

1. Payload electrical wiring and modifications
2. Payload wiring checks
3. Payload Sequence test and interrogate radar transponder
4. Apply potting compound to connectors and overnight set
5. Build-up payload for environmental testing
6. Obtain initial weight and C.G.
7. Static and Dynamic balance payload
8. Obtain Flight weight and C.G.
9. Measure mass moments of inertia in Pitch and Roll axis
10. Payload vibration tests: A) 3-axis Flight level sine
    B) 3-axis Ramdom
11. Post-Vibration Sequence test and interrogate Radar Transponder

Items 1-11 were successfully accomplished and documented. Another remote site was included with video documentation to replace Puerto Rico.

V. Monthly Summaries of Research Activities Performed

1. February and March 1991

   - Provided support for Project Initiation Conference activities
   - Made arrangements and provided support for planning to NASA personnel and scientific working group of CRRES for the CRRES Results Data Exchange Meeting
   - Participated in the CRRES Results Data Exchange Meeting (IWG 14) Aguadilla, Puerto Rico
   - Coordinated with NASA Technical Monitor on project development activities
   - Assisted in development of middle and secondary level classroom NASA educational brief

2. April 1991

   - A slide presentation was produced and distributed to the NASA Centers which depicts a CRRES-related series of chemical release.
   - A set of formal notes was drafted and prepared for review and sent to the CRRES Project Scientist pertaining to the IWG 14 held in March.
   - Videotaping of the CRRES Puerto Rico Sounding Rocket Campaign began. Design and development of different sized sounding rockets has been documented in the following areas:

     - Nosecone spin balance
     - Telemetry check
     - Electrical wiring
     - Cannister design

3. May 1991

   - Videotaping of the CRRES Puerto Rico Sounding Rocket Campaign(s) continued and was updated in the following areas:

     - Telemetry skin fit
     - Rocket-to-station electrical/instrumentational checks
     - Vibration testing
     - ACS (Attitude Control System) check

   - Coordination of developments continues between the contractor and scientists
   - A three-week postponement of first sounding rocket launch from the Northern site in Puerto Rico is now confirmed and all documentation is on schedule.

- Formal notes of the IWG 14 were finalized and documentation of the January - February 1991 High Altitude Release Campaign(s) has been collected and drafted into brief text.

4. June 1991

- Rocket boom development and nosecone development were documented by video camera. Still photography was used to produce a collection of pictures depicting Sounding Rocket hardware and instrumentation in a variety of shapes and sizes.
- A two-month postponement of first sounding rocket launch from the Northern site in Puerto Rico has been confirmed. Time has, therefore, allotted to complete additional documentation of Potting and Boom Tests.

5. July 1991

- Completion of the CRRES Sounding Rocket documentations was accomplished, edited, and script drafted for video. Due to the postponement of the Puerto Rico Sounding Rocket Campaign, other remote site locations were documented to complete the project work of this task.

6. August 1991

- Preparation of Final Report.

APPENDIX

EDUCATIONAL BRIEF ON CRRES PROGRAM

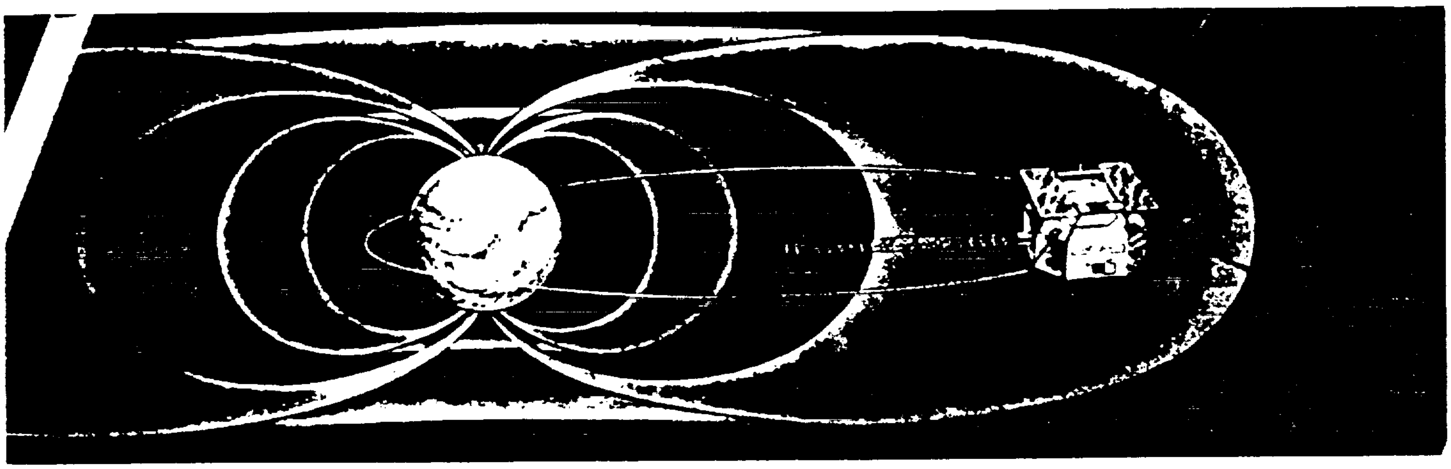
NASA Educational Briefs

An Educational Publication of the National Aeronautics and Space Administration

For the Middle School Classroom

NASA Headquarters
Washington, D.C.

EB-103/1-91



An artist's conception shows the Combined Release and Radiation Effects Satellite (CRRES) as it flies a highly elliptical orbit of 22,231 by 215 miles through the inner and outer Van Allen Radiation Belts of the Earth's magnetosphere.

The Combined Release and Radiation Effects Satellite Program

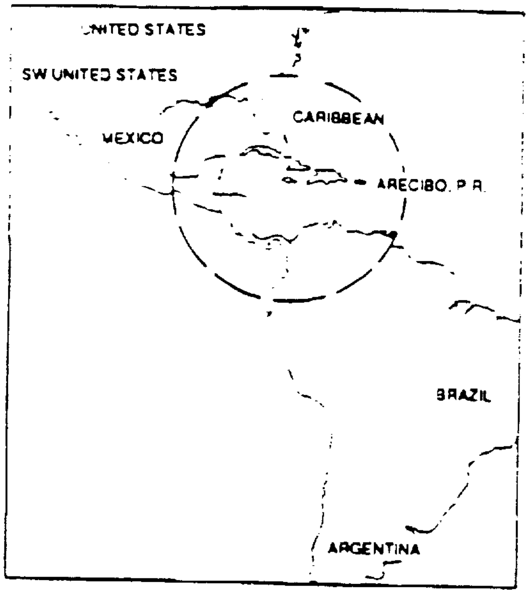
The Combined Release and Radiation Effects Satellite (CRRES) Program is designed to study the space environment around Earth and the effects of space on modern satellite electronic systems. In the summer of 1991, in a series of high-altitude chemical releases from the CRRES satellite and from suborbital rockets launched from sites on the island of Puerto Rico, common chemicals such as sodium, barium, calcium, and lithium will be used as tracers, to "paint" the magnetic and electric fields that surround Earth. Careful study of these effects with optical, radio, and radar observatories will reveal significant new information about the interactions of solar radiation, atoms and ions, and electromagnetic fields in space, and how the ionosphere reacts to high levels of energy input, as happens (on a much greater scale) with a solar flare.

The Arecibo Observatory, part of the National Astronomy and Ionosphere Center, and the world's largest and most sensitive radio telescope and radar, will play a crucial role in the CRRES experiments. In addition, staff and graduate students from the University of Puerto Rico at Mayaguez, on a joint program with Cornell University, will take part in the investigations.

The summer 1991 chemical release experiments are part of an 18-month international program to study the ***ionosphere*** through satellite and rocket experiments. The CRRES program began in April 1990 with the launch of the Pegsat spacecraft on the Pegasus rocket. Chemical releases made over Northern Canada from Pegsat were used to study the electric structure of the space regions in the ***aurora***. Sounding rocket releases in July and August 1990 over the Marshall Islands studied the formation of ionospheric irregularities.

The CRRES satellite itself was launched on July 25, 1990. Its first releases in September over the South Pacific were designed to investigate Nobel Laureate Hannes Alfvén's ***hypothesis*** that there is a critical ***velocity*** at which neutral gases ionize in space. Results to date appear to confirm his hypothesis. High-altitude satellite releases are also being made over North America early in 1991, followed in summer of 1991 by the Puerto Rican campaign.

The CRRES program includes scientists from the United States, Puerto Rico, Canada, Germany, Argentina, and the Soviet Union. Optical and radio observations are being made from locations in the



Approximate viewing area for the Caribbean sounding rocket experiments.

South Pacific, Canada, throughout the Caribbean, and in Argentina, Chile, and Equador. Radar sites such as the Arecibo Observatory, Kwajalein in the Marshall Islands, and Millstone Hill in Massachusetts are also participating.

Background

Above Earth's atmosphere lies not empty space but an environment of magnetic fields, electric fields, waves, and charged particles, a fourth state of matter known as a ***plasma***. A layer of positively charged (and therefore electrically conducting) ions - the ionosphere - surrounds Earth at an altitude of about 60 to 400 km. Earth itself sits in a huge magnetic field - known as the ***magnetosphere*** - that shields the planet from the most harmful effects of ***cosmic radiation***.

This space environment is extremely changeable and unstable. Electrically charged atoms flowing outward from the Sun—*the **solar wind***—collide with the magnetosphere and generate intense phenomena such as the Northern and Southern Lights, known as the aurora, and huge geomagnetic storms that can disrupt communications systems on Earth.

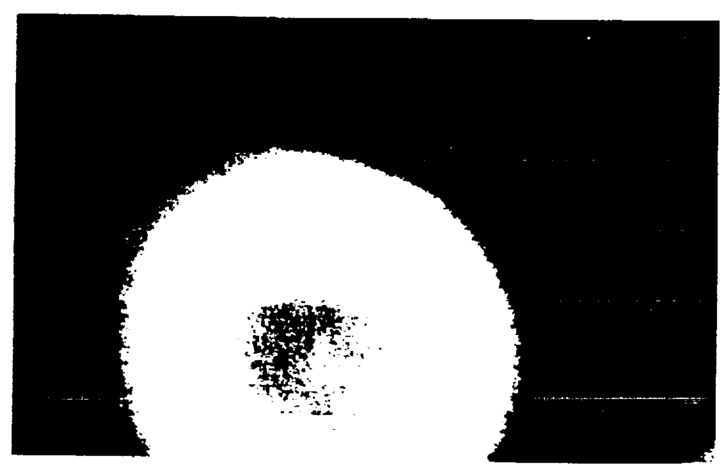
The Explorer 1 satellite, launched during the International Geophysical Year 1958, led to the discovery of the Van Allen Radiation Belts, regions of high radiation that can be very harmful both to humans and space systems. Since then, data from scientific instruments on satellites, sounding rockets, and scientific balloons have led to the development of a model of the essential features of Earth's ionosphere and magnetosphere. The CRRES Program will help further refine the details of that model.

The CRRES Science Program

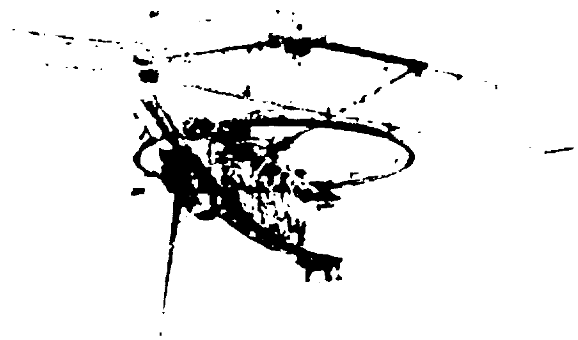
In the CRRES Program of experiments, small amounts of specific chemical substances with special properties are injected into the ionosphere to produce a controlled perturbation, to make a trace of the medium, or to simulate a natural phenomenon.

One of the most common CRRES experiments involves injection into space of barium vapor. Sunlight converts ***neutral atoms*** of barium into positively ***charged ions*** by stripping electrons from its atoms by photo-ionization. The artificially produced ions behave identically to the naturally occurring ions, mimicking their behavior. However, the artificially produced ions have the additional advantage that, unlike the natural ions (hydrogen, helium, and oxygen), they glow in sunlight and so can be seen easily. Therefore, barium releases can be used as tracers, illuminating the electric and ***magnetic fields.*** This is analogous to using smoke in a wind tunnel to demonstrate the airflow patterns over a test model. With larger releases, the environment can be modified with artificial clouds of charged particles in order to study the response of space to such an artificial perturbation.

The CRRES Caribbean experiments will answer some very fundamental questions in the physics of the



In this release in April, 1990 over Canada from the Pegasus rocket a bright spherical cloud occurs as neutral barium atoms glow and a darker "tail" forms as atoms are ionized. The neutral barium cloud continues to move at the speed of the satellite. However, when an atom becomes ionized it becomes "stuck" to the magnetic field line of the earth and its forward motion stops. The ions are then seen moving tightly around and down the magnetic field line in striations.



The Arecibo Observatory

ionosphere and magnetosphere: What are the electric fields that control energy flow? How do rapidly moving clouds of ions lose their ***kinetic*** energy and come to rest? How do the various layers of the ionosphere influence each other? And can an artificial chemical injection in the ionosphere create a "lens" to focus radio waves? The experiment will also investigate Nobel Laureate Hannes Alfvén's hypothesis on critical ionization velocity. *[The hypothesis states that if the relative velocity of an electrically charged neutral gas and a magnetized plasma is large enough, the neutral gas will ionize even though less energy is available than is nominally required for ionization.]*

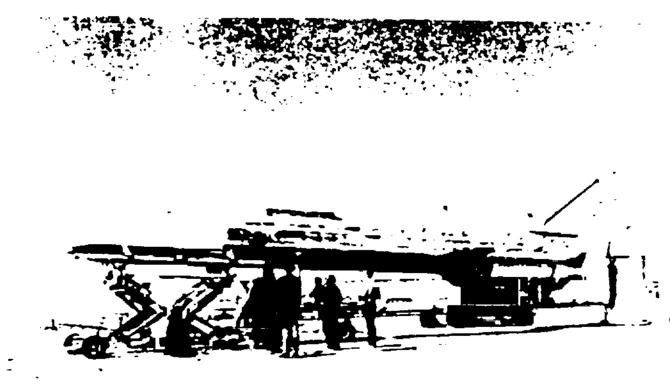
The Arecibo Observatory

The effects of the CRRES releases will be studied with an extensive network of ground- and aircraft-based instruments. Central to the diagnostic effort will be the Arecibo Observatory operating as an ionospheric radar, mapping the chemical release effects with high precision. The observatory, administered by Cornell University for the National Science Foundation, is credited with many major discoveries, including ***pulsars*** at radio frequencies, ***quasars***, and other phenomena involving concepts such as the "Big Bang" theory, gravitational effects, ***black holes*** and molecules in cosmic dust.

Arecibo is also uniquely able to probe the upper atmosphere and ionosphere with radar beams. Pulses of radio waves are directed upward so as to interact with free electrons in the ionosphere, in a process known as ***incoherent scatter.*** Each electron acts alone in scattering a tiny fraction of the radio waves it encounters. By analyzing the weak return radar echoes, and dividing the return signal into time slices called range gates, scientists can obtain vertical profiles of the characteristics of the ionosphere, and especially of its irregularities.

HF and VHF Radio Propagation

The CRRES chemical releases will also be of interest both to radio amateurs and professionals studying HF and VHF propagation. A barium chemical release increases the local ionospheric density, and hence acts like a meteor trail of enhanced ionization. However, it lasts much longer—minutes instead of seconds. Scientists will be studying the effects of the releases with high-frequency radio bi-static paths, and



A two-stage sounding rocket with payload (at tip) on a mobile launcher.

VHF ***coherent scatter*** radars similar to those used to study auroral ***backscatter*** and will analyze the effects upon satellite signals passing through the artificial barium ion clouds.

Photographing CRRES Releases

Most of the CRRES releases from the summer campaign will be visible throughout the Caribbean. They will occur at dusk, about one hour after sunset, or near dawn, one hour before sunrise. While the releases must occur in sunlight to allow ***photo-ionization*** of the barium atoms, a dark sky is needed to best observe the resulting glow of the neutral atoms and ions. The releases will be very bright, easily visible, and can be photographed.

High-altitude satellite and low-altitide rocket releases require different equipment for successful photography. Satellite releases require fast, long focal length systems, and clock drives to compensate for Earth's rotation are desirable. Either fast telephoto or astronomical telescopes can be used. Near-Earth releases from sounding rockets are easier to photograph. Only standard equipment is required including a 35mm camera with a fast 50mm lens and adjustable shutter with a T or B setting for taking time exposures; ASA 1600 film; a 2-second exposure; a tripod; and a cable release, can be used. For both types of photography the speed of the system is very important and should not be slower than f4. For best results, a dark sky site is required. If light pollution is a problem, filters may be used to isolate the color of the chemical release being photographed. The value of a chemical release photograph to a scientific study is significantly enhanced with a few simple measurements:

- an accurate log of the time of the photograph
- latitude and longitude of the observing location (USC & GS topographic maps or sectional aeronautical charts)
- approximate values of the elevation and azimuth (relative to true, or magnetic north). Exact pointing information comes from the star field in the photograph.

NASA will make the time and coordinates (latitude, longitude, altitude) of all releases available through NASA Spacelink: An Electronic Information System for Educators, and through a telephone hotline to be established.

For the Classroom

1. Concepts indicated in bold italics are important in understanding the CRRES Program. Have your students list as many facts about each of the following as they can:

plasma	photo-ionization
ionosphere	magnetic field
aurora	kinetic energy
hypothesis	pulsars
velocity	quasars
magnetosphere	black holes
cosmic radiation	solar wind

incoherent, coherent, and backscatter

2. What are ions? What role do they play in the space environment around Earth? What is the difference between neutral atoms and charged ions in the CRRES experiments?

3. Give 3 physical or chemical characteristics each of barium, lithium, sodium, calcium. Name one chemical compound that can be made with each of these elements.

4. Have your students research Nobel Laureate Hannes Alfven and James Van Allen, the founding father of the American space physics program.

5. What are some of the processes that take place in an aurora? How do they show themselves?

6. Demonstrate an electrical charge by generating static electricity. Demonstrate the action of a dynamo. Use a bar magnet and iron filings to demonstrate dipolarity. Compare the shape of the magnetic field around a bar magnet with the diagram of Earth's magnetic field. List as many differences as possible. Why is the shape of Earth's magnetic field different?

7. Demonstrate high- and low-frequency sound. How does the ionosphere make possible the transmission of radio waves?

8. What orbits can satellites be launched into? Why might a satellite be put into geosynchronous orbit? What is one characteristic of a polar orbit?

9. Locate on a world map as many sites and countries as you know are involved in the CRRES program.

Resources for Educators

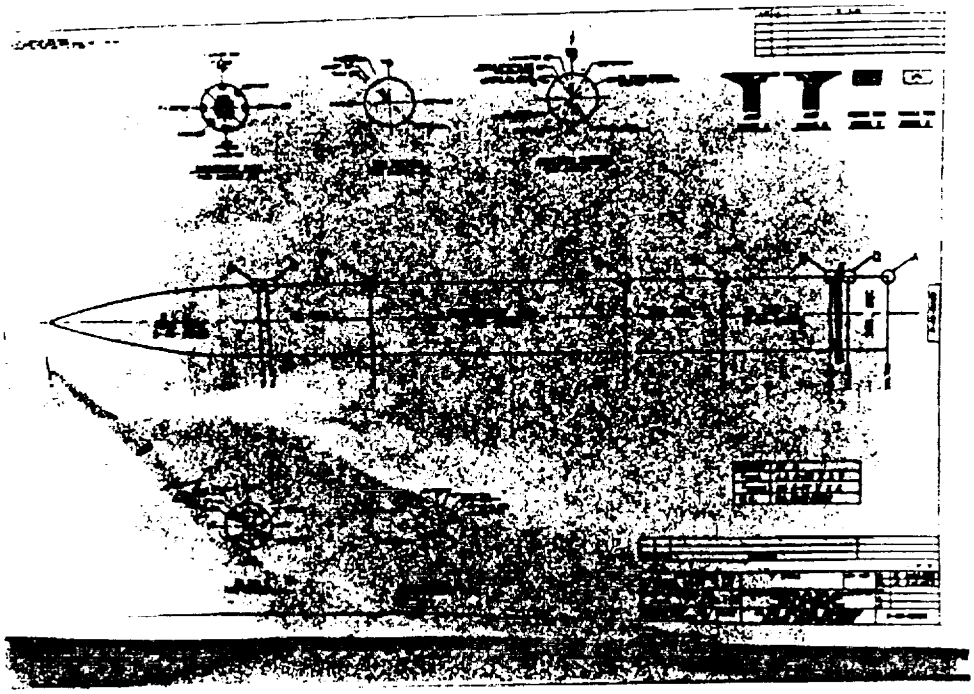
For information on NASA Educational Services, contact:

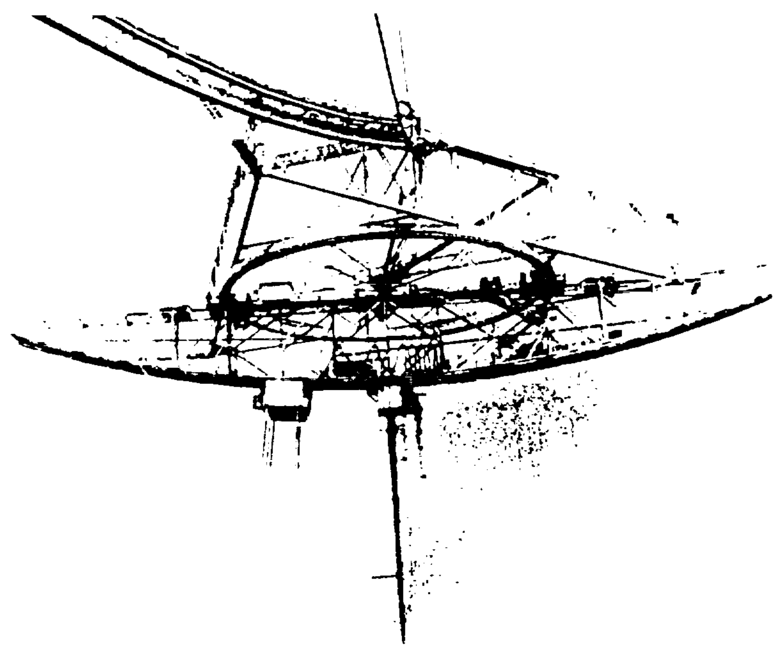
a) **NASA Spacelink:** an electronic space information system for educators. Details from Spacelink Administrator, Marshall Space Flight Center, Mail Code CA-20, Huntsville, AL 35807. Telephone (205) 544-6527.

b) **Educators Resources Laboratory:** NASA John F. Kennedy Space Center, Mail Code ERL, Kennedy Space Center, FL 32899. Telephone (407) 867-4090 (Serves Puerto Rico, Florida, and Georgia)

Further Reading

James A. Van Allen: *Origins of Magnetospheric Physics*, Smithsonian institution Press, Washington, DC, 1983





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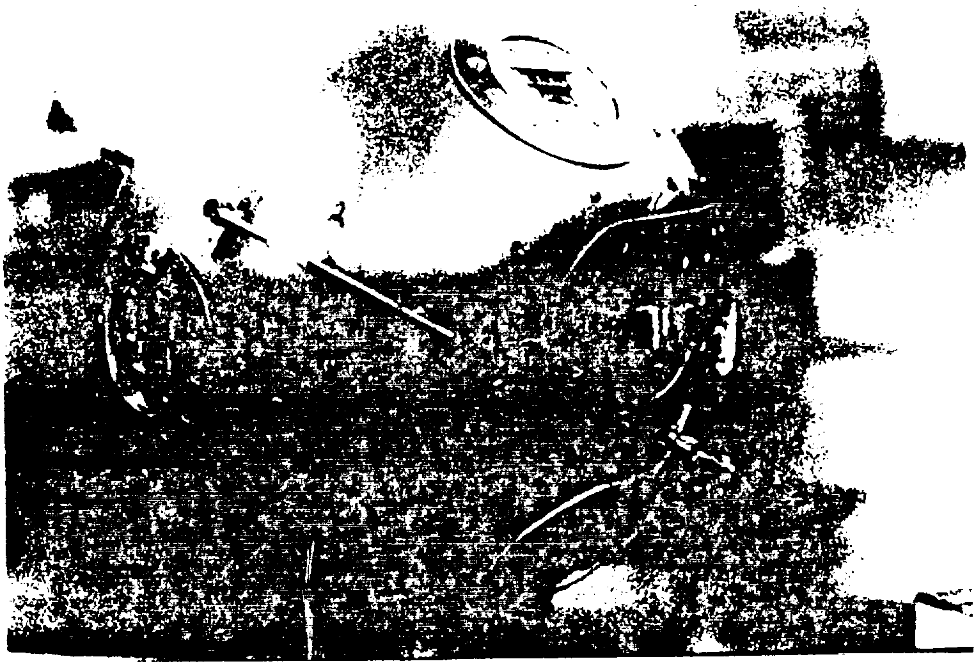

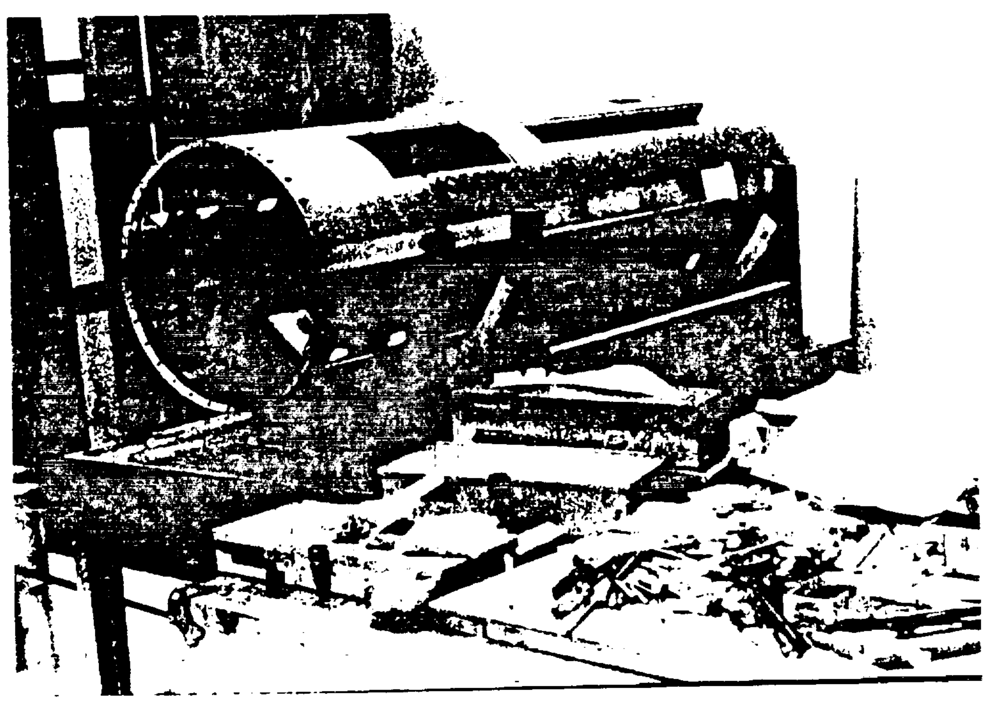

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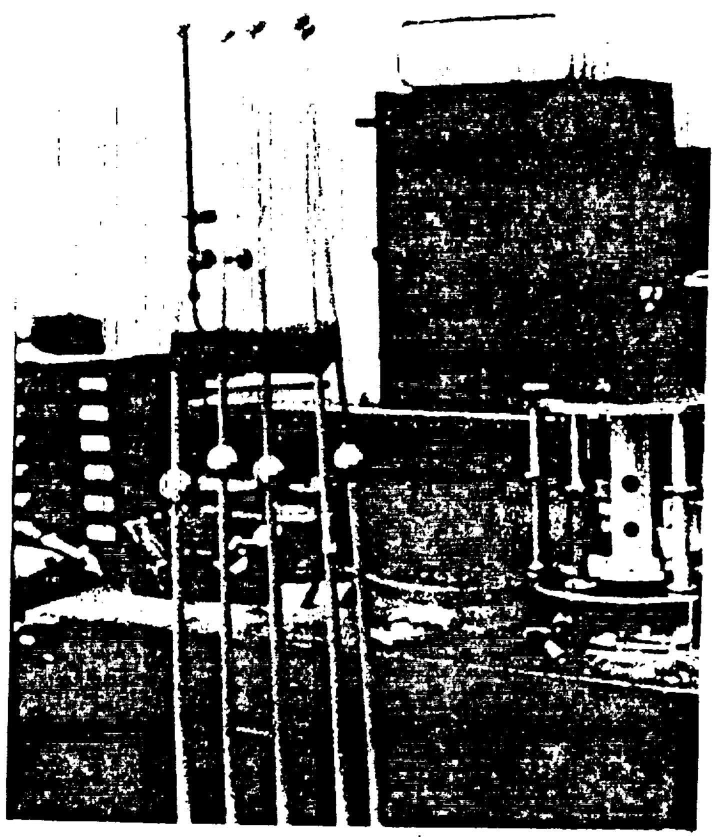

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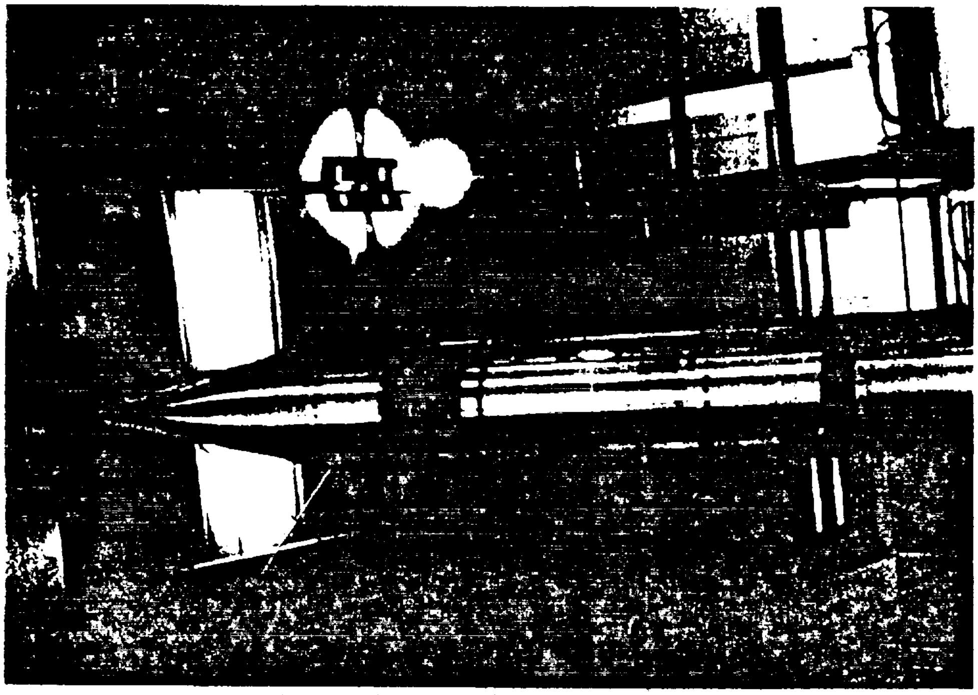

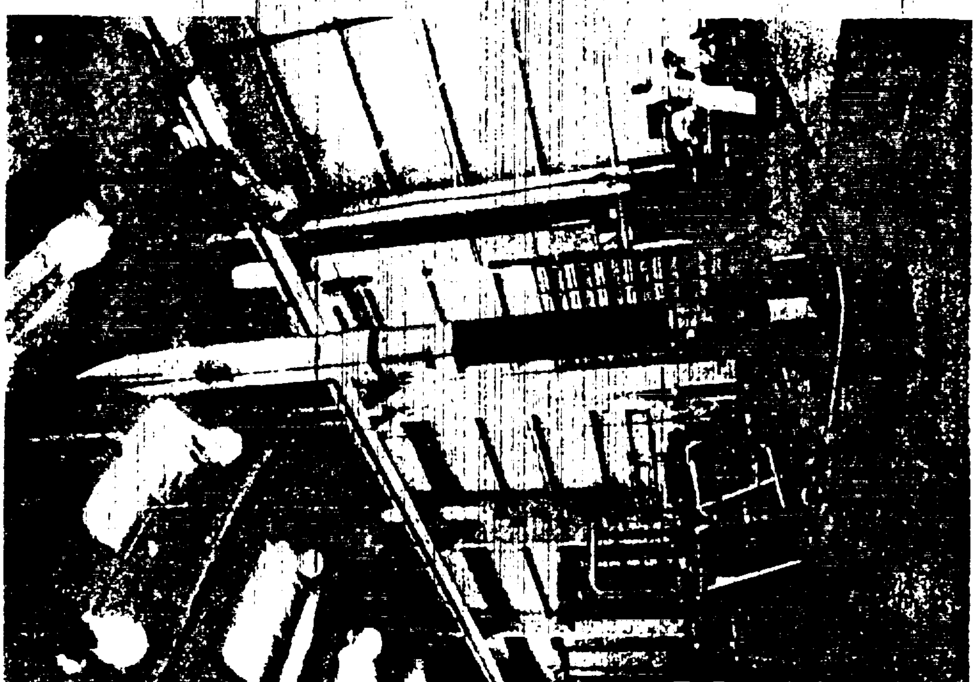

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