ACOUSTIC MODAL PATTERNS AND STRIATIONS (AMPS) EXPERIMENT G-325, NORFOLK PUBLIC SCHOOLS

Joy W. Young
NORSTAR Project
Norfolk Public Schools Science and Technology Advanced Research Project

ABSTRACT

This paper will describe how high school students with the guidance of volunteer mentors were able to successfully complete an acoustics space experiment. Some of the NORSTAR program strategies used to effectively accomplish this goal will be discussed. The experiment and present status of results will be explained.

INTRODUCTION

The Norfolk Public Schools Science Technology Advanced Research (NORSTAR) experiment flew aboard Discovery, STS-64, during September of 1994. Several years ago a group of 9-12 graders in an extended day program for gifted students was awarded a GAS canister (G-325) by NASA Langley Research Center (NASA LaRC). NASA scientists, under the direction of Dr. Joseph Heyman, volunteered to act as mentors to the student group. This NASA commitment stimulated the formation of the NORSTAR project in Norfolk Public Schools and gave the impetus for development of this hands-on, real time, highly motivational, alternate model to the normal high school science program.

The main goal of the NORSTAR program includes both science objectives and broader educational objectives. The main science objective of G-325 was to explore the interaction of sound with particles in a closed microgravity environment. The educational objectives of the NORSTAR project include development of skills such as leadership, teamwork, oral and written communication, and critical and creative thinking. With the G-325 payload we wanted to involve and stimulate the students in a space investigation that had scientific significance and to educate the students in all aspects of carrying out scientific experiments (funding, design, manufacturing, testing, analysis). These objectives have been supported consistently by the skilled mentoring techniques of the NASA LaRC mentors and various other mentors from businesses, industries and universities nationwide. The primary G-325 experiment, Acoustic Modal Patterns and Striations (AMPS) was developed over a four year period by NORSTAR students. The idea for the experiment was initiated from students' studies of the Kundt tube and the recent work in acoustic modal visualization of Dr. Robert Apfel, Yale University. Also included in the G- 325 payload were 50 small passive experiments from elementary and middle school students.

PROGRAM DESIGN

The NORSTAR GAS-325 program was jointly designed by Norfolk Public Schools Gifted Program and volunteer mentors from NASA Langley Research Center. NORSTAR students are selected by standardized test scores, grades, teacher recommendations and interviews, and are bused each school day to the Norfolk Technical Vocational Center. Students also put in extra volunteer time on Saturdays and during school vacations. Students receive a 1/2 credit for every 75 hours of participation in the program with a semester limit of 1 1/2 credits.

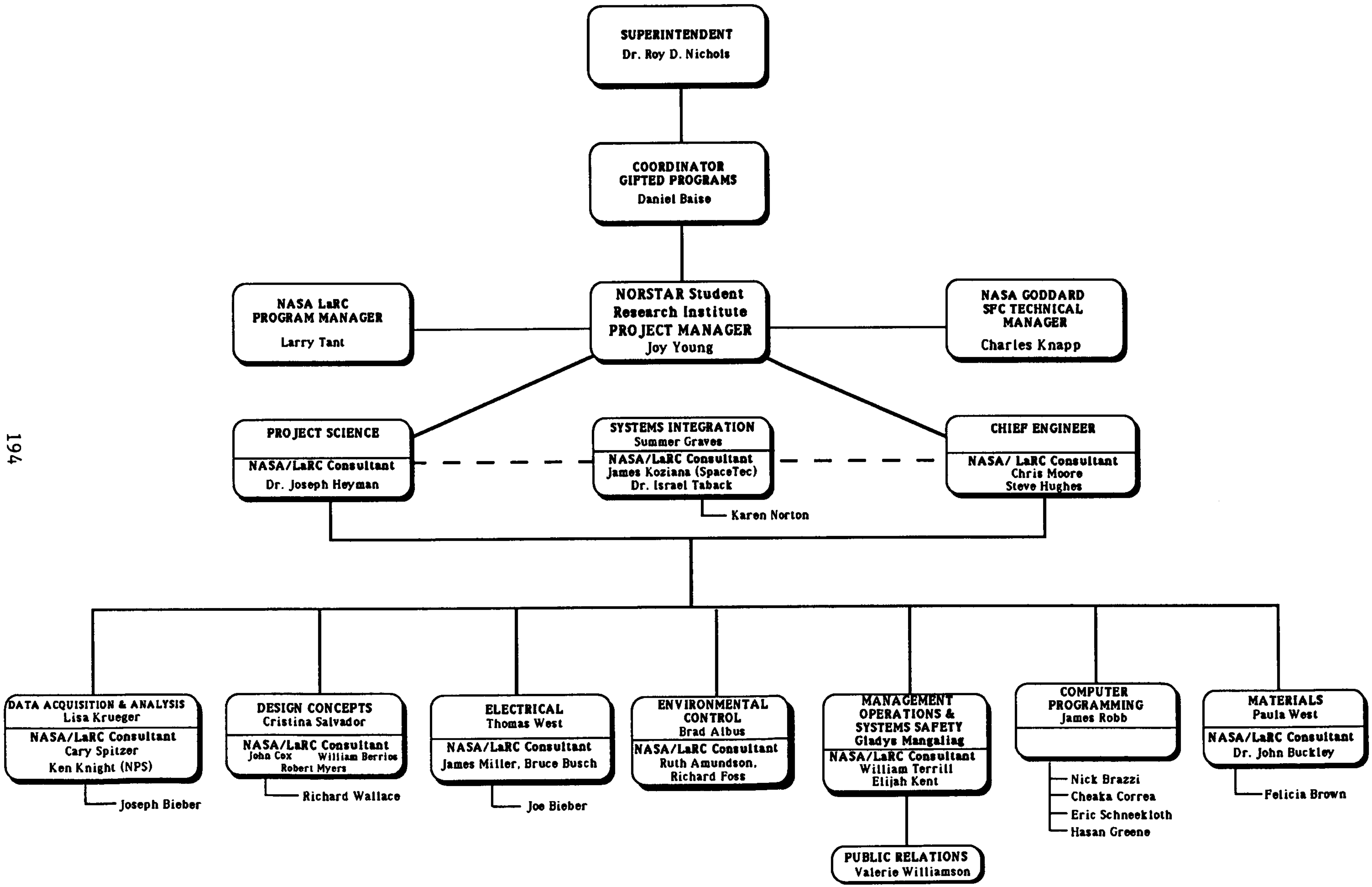

FIGURE 1. NORSTAR SUBSYSTEMS ORGANIZATIONAL CHART

Learning through 'real work' projects is the main objective of the NORSTAR program with teacher and mentors used as facilitators and guides. The students are allowed considerable freedom to design and carry out their ideas and develop projects in a small team setting. Each team is responsible to other teams and for the success of the main space experiment. Teams give regular status reports which detail projected weekly workloads and accomplishments made during the previous week. The student teams and their responsibilities in their subsystems are as follows:

- **Project Scientist:** leadership of the overall scientific validity of the project
- **Chief Engineer:** leadership of all the structural details of the space experiment
- **Systems Integration:** leadership of integration of all systems for the success of the project
- **Management Operations and System Safety:** documentation of the main experiment and safety data to NASA Goddard and NASA LaRC
- **Materials:** selection and assessment of all materials and documentation of materials for the main project
- **Electrical:** design and construction of the electrical circuits and power supply for the main experiment
- **Thermal:** monitoring of the thermal limits of all experimental apparatus and preparation of the Thermal Analysis and thermal safety of the main project
- **Data Acquisition:** design of the data acquisition apparatus and analysis of data obtained.

These teams approximate NASA guidelines for project teams each with its own volunteer mentor. The students and mentors communicate regularly by telephone, fax, and in face to face meetings either in the school or at the mentor's workplace.

The NORSTAR teacher and mentors focus on training students to be knowledgeable enough in science/technology/engineering to produce a project of real scientific significance. They encourage team work, individual learning, responsibility in self-directed learning and interactive and communication skills. To these ends the NORSTAR teachers and mentors encourage, design, and direct activities which will improve and give maximum opportunity to practice the following skills.

- knowledge of scientific principles and practices
- reading and comprehension
- writing papers to communicate facts and persuade points of view
- oral communication - one on one and presentation to groups
- computer literacy
- design of experiments and projects
- analysis of results of research and experiments
- planning of workload to achieve success - time management
- brainstorming and original thinking
- integration of 'think' time and 'production' time to produce results
- listening and questioning skills
- self confidence and self esteem
- intergroup and interpersonal working skills
- ability to work, despite frustration, to completion of a project deadline

These skills are encouraged and developed at slightly different rates for each student depending on the number of hours of experience in the NORSTAR setting and the cognitive level of the student. The student is viewed in a holistic manner and encouraged to develop skills and knowledge independent of team/group setting as well as in a team/group setting. Specific methods to achieve these objectives are as follows:

- students are expected to read for research and write daily logs of their work
- students present Weekly Status Reports both written and oral to the group (stating progress made and projected work)
- students who are not currently engaged in work on the main project are assigned computer literacy, research, experiment or design tasks
- students are assigned peer seminar oral presentations
- students present status reports in the form of Design Reviews to a board of mentors at NASA Langley Research Center
- students work individually or as a team towards completion of the main experiment
- student/instructor interaction consists of questioning the student and leading the student to resources such as books, phone contacts, mentors, to discover answers
- students work in teams to achieve the success of the main experiment
- students are encouraged to ask questions, seek answers and be accountable for their progress at Weekly Status Report sessions, in conferences with their mentors and other 'outside the classroom' experts
- students are encouraged to seek many sources for information
- if the student becomes discouraged the teacher/mentor acts as an encouraging factor by giving direction
- outside speakers visit on a regular basis to extend student learning
- students give presentations on their ongoing work to interested adult and student groups which have included in state, out of state and visiting groups from other countries - Japan, England, South Africa

The NORSTAR program has evolved over the years, with NASA mentor guidance, into a student centered science/engineering experience which has produced highly motivated students in a cross section of Norfolk Public Schools population. On average, forty nine percent of the students are minorities, ninety percent of the NORSTAR graduates enter college programs in the science/technology fields. Whether in the areas of space, aeronautics, or other science, business and industrial fields, we feel that similar programs could only serve to enhance the understanding of science in the United States. This model could be adapted by business and industry to encourage learning and produce a scientifically literate, motivated core of leaders for future exploration of space, creative engineering, and problem solving in the twenty first Century.

Parent involvement has been a crucial part of the NORSTAR endeavor. Parents with technical skills have helped at every stage of the G-325 project. Our parent organization raised the money for all of our students to travel from Norfolk to Kennedy Space Center to watch the launch of the project.

Local and national businesses and industries were contacted by the parents and students, first by telephone and then follow up letters. All hardware and manufacturing used in the G-325 were donated by these businesses and industries who supported and were willing to mentor our project.

SCIENCE DESIGN

Amps Experiment

The G-325 acoustical experiment was conducted in a five cubic foot Get Away Special (GAS) canister. Two twenty-one inch clear acrylic tubes were suspended from a box containing two titanium tweeters. A separate function generator was connected to each tweeter to supply the sound and an amplifier amplified the sound. Inside each test chamber four grams of cork dust acted as a medium to visualize the modal patterns created by acoustic standing waves at resonances of the test chambers. Different patterns were expected to be formed as the frequency range was ramped up in each tube. Frequencies from 6000 to 7499 Hz ran through Test Chamber 1. A frequency range from 7500 to 9000 Hz was run through Test Chamber 2.

In the ground experiments, modal patterns formed at 45 of the ramped frequencies. Striations were evident in the cork particles at each node (see fig.2). We hoped to see if these striations would also occur in microgravity or if they were a phenomenon caused by gravity. In the microgravity environment of space, the cork particles should have been free to move without the constraints of gravity and form floating discs at the nodes of the standing waves.

The modal patterns at different frequencies were videotaped. The videotape data gathered is being used to determine:

1. The number of nodes and antinodes.
2. The types of modal patterns.
3. The effect microgravity has on striations seen in nodes on Earth

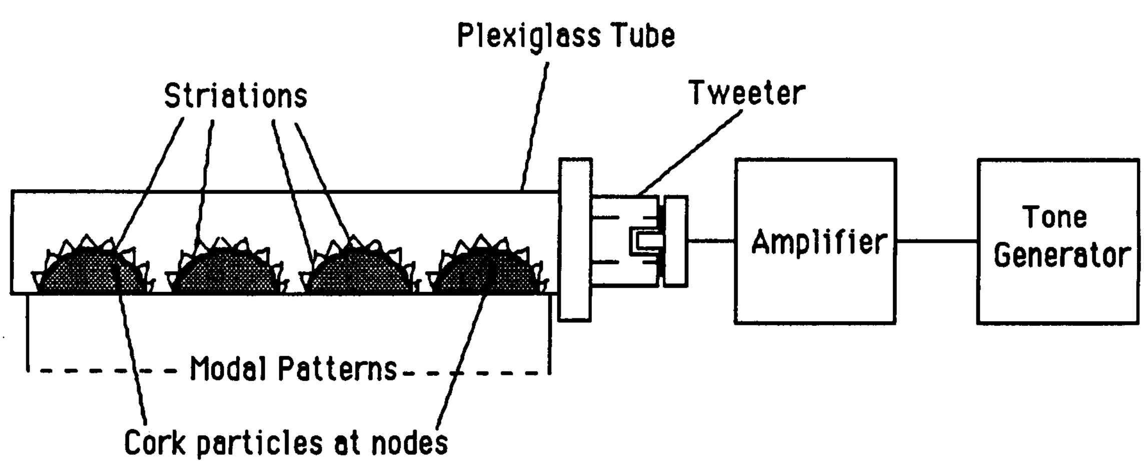

FIGURE 2. AMPS EXPERIMENT

Passive Experiments

Although the primary objective of the NORSTAR GAS-325 project was to study acoustical standing wave modal patterns, on a space available basis, we included small, passive, benign, experiments placed in a sealed container in the GAS canister. These were contributed by middle and elementary school classes in an effort to more widely share the excitement of space experimentation. The passive experiments fell primarily into the biological/physical sciences categories, and sought to discover and/or measure the effects of space and microgravity on prepared samples. Some examples are popcorn, marigold seeds, ink, paint, chalk, cooking oil, yeast, alum, and brine shrimp eggs.

EXPERIMENTAL RESULTS AND LESSONS LEARNED

Science

AMPS Experiment

All systems worked as projected. The videotapes show that lights, amplifier, tweeters and videocameras performed as expected. Sonograms from sound recordings showed the ramped frequencies in test chamber 2 (7500 - 9000 Hz) were completed but those in test chamber 1 (6000 - 7499 Hz) ceased at 57 minutes. The video footage on chamber 2 shows some promising visible activity from 17 minutes to 27 minutes. We do not at present have the technical expertise or equipment to sufficiently enhance the tapes for analysis but we are, at this time, seeking help from NASA, universities and industries to assist us in this final stage.

We learned that although ground experiments with four grams of cork dust showed definite patterns when the dust was dispersed in a microgravity environment the volume may not have been enough to produce results that were visible on video. We have since considered using greater amounts of cork dust or changing to larger or brighter particles as our medium to study acoustic modal patterns. We have also considered that we might have included a dispersal system for the cork dust after launch. There is some evidence of static cling inside the tube and a large deposit of cork dust on the end of the tube which may have resulted in fewer dust particles in free flow in the tubes and less resolution of modal patterns for the video recording. These are problems students will have to consider and resolve in their after flight analysis

Passive Experiments

Results of many of the seed experiments are not available at this time because students are awaiting seasonal growth of their plants. We are in the process of gathering all the student papers together and hope to have a list of results available for the September 1995 symposium.

Educational

AMPS Experiment

The 9th - 12th grade NORSTAR students learned much from the process of developing the G-325 payload. We hope that they learned the skills that were previously listed and feel that their portfolios, presentations and the successful integration and flight of an experiment which was entirely accomplished by these students show the success of this educational project. When questioned about what they learned, the students expressed that the main lessons they learned were as follows:

- perserverence: the knowledge that all projects are not achieved without expenditure of time and personal involvement.
- science: the students felt that they had learned a considerable amount of physics.
- group working skills: all students felt that the NORSTAR experience had prepared them well for the teamwork situations found in most research labs, industry and businesses today. They stated that they have found these interpersonal skills of great value in other classes and in their daily lives.
- responsibility: seeing a project through to the end and being personally responsible for your part in the whole project.

Students said that this project has given them their first insight in to the real processes of the science/ engineering workplace. In one student's words " The NORSTAR experience educated me about science facts but more important, to me, is the way the program functions. It has given me independence to make decisions and then to learn to live with the consequences. In a normal textbook science experiment, if I got the wrong result I could modify or doctor data to satisfy what I knew would be the correct answer. At NORSTAR with the G-325 payload I learned that there was no fudging of results. I had to be responsible, it is a real project. I had to be honest, meet deadlines and really care about my work because my small part could affect the overall success of a 'real' experiment. This was exciting and tiring. I spent many extra hours repeating, revising and rethinking ideas. I was not working for a grade I was working for the project, the experiment, to discover. What I did was important and this was what meant most to me." This student is presently working a summer internship program at NASA LaRC.

Suffice it to say that the NORSTAR team believes that this 'real work' experience is beneficial to students beyond the normal high school experience. We feel that research and industry is looking for such prepared graduates.

Passive Experiments

Teachers and students (2nd - 7th grades) were enthusiastic about the chance to participate in a space experiment. Five of these students and their parents were present at the launch of the project. We found that NORSTAR students benefited from activity as mentors to younger students. Although the experiments were at elementary levels, the students were enthused about space and sending up 'real' experiments whose result they could not exactly predict. We noticed that the younger students were more confident in their predictions than those who were older. Teachers told us that the process of developing the passive experiments taught students the importance of the scientific processes including: proposing a problem, research in books, hypothesizing, and planning the experiment with appropriate variables, The enthusiasm of these young students, both the initial contact and through later weeks of planning, resulted in increased parental and teacher interest in their learning as noted by parental and teacher calls asking for information about the NORSTAR project. The main problem has been that these young students have gone on to the next grade. We have learned that such projects should involve teachers in several grade levels so that youngsters can be monitored and mentored through these grades for the extended time it may take to complete the initial experiment and analysis of results. We must find some way to promote continuity. These young students began their space experiments in September of one year but the experiments did not fly until the following September and were returned to site in December. There must be some link between grade levels and teachers in a school system to ensure follow through and results. We are working on this problem to reach solution before our next attempted GAS project. Several ideas have been proposed, including:

- city wide training of teacher groups who will work together through several grade levels to provide follow up and closure
- selection of already existing cadres of teachers who are working in several grade levels
- working through guidance departments and elective programs particularly set up for such integrated experiments
- maintaining regular weekly contact with teachers and students

We encourage future GAS users to meet frequently with elementary and middle school students who are piggy backing on a main experiment. Enthusiasm generated during initial contact must be maintained (sometimes for a year or more through several grades) so that closure can produce meaningful results for these students.

FOLLOW UP

The NORSTAR program is still, and probably always will be, changing and progressing. As new ideas and problems emerge and new contacts are made in business, industry and research, our ideas will continue to expand as they need to do in our rapidly changing technologic society. Flexibility, tempered by solid science processes, allows NORSTAR students to prepare for a future that will often present problems, that will call for both creative thinking and a solid grounding in reality. We hope in the future the NORSTAR program will present students with other real life challenges. We envision, after analysis of our first payload, a second GAS payload that will perfect our G-325 project, and present more tangible experimental results that will contribute significantly to the field of acoustic resonance research. We plan to include several other experiments in our payload of equal scientific significance in order to utilize the 5.00 cubic foot canister to its utmost efficiency.

In conclusion, the experience has been an exciting adventure for many K-12 graders. It has been a real working experience for students and teachers. Students have reacted positively and have stayed with the project through moments of deep despair, frustration and aggravation. They have, through mentor support and NASA commitment come through to an understanding of science principles and the knowledge that hard work, intuition, cooperation and vision can produce a tangible, fulfilling, life experience. We hope that this type of program will help many students to experience the freedom to touch the trail of a comet and be so lifted from the regular that they will want to persevere to significantly contribute to mankind's exciting and constantly changing future.

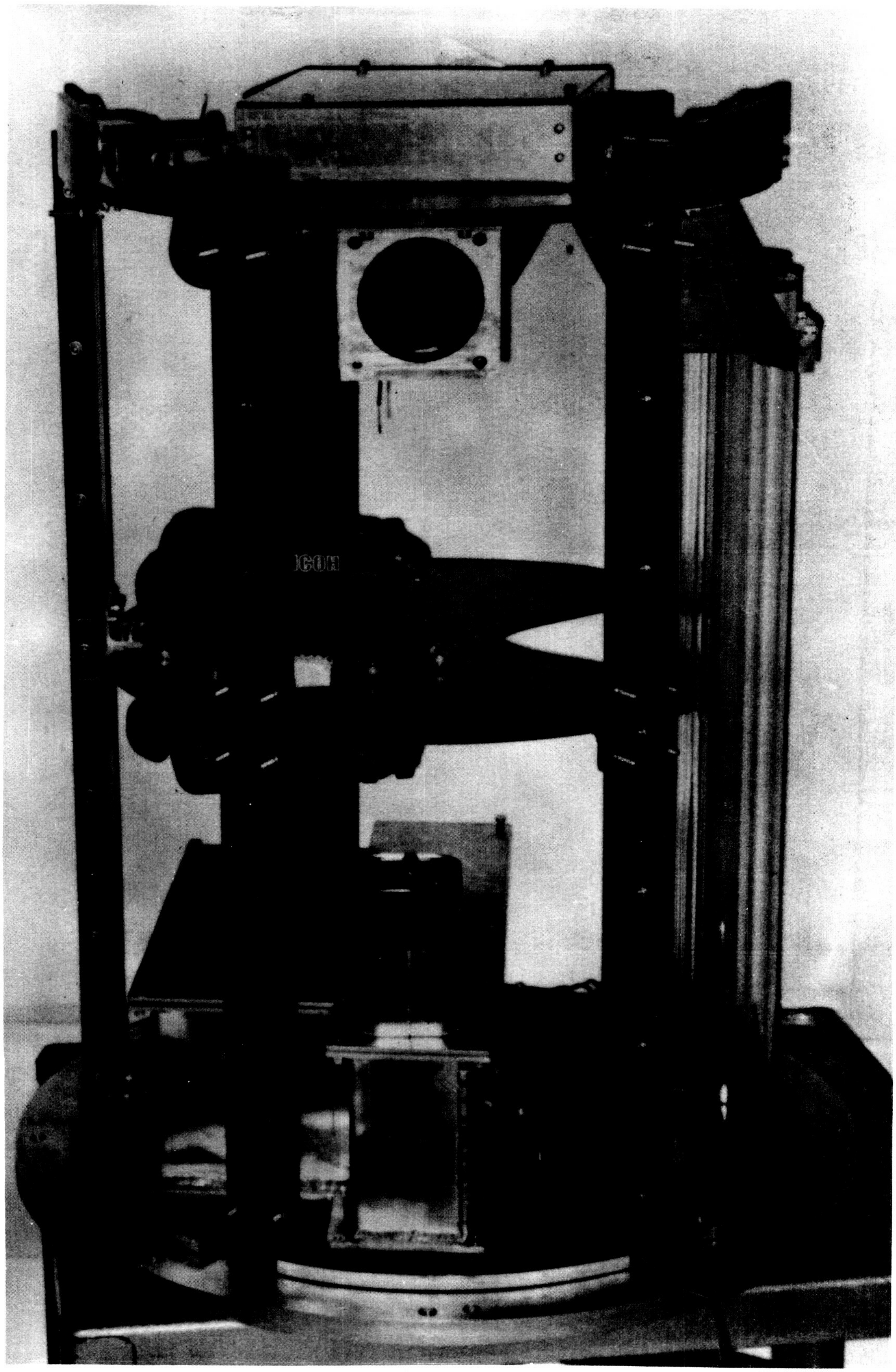

FIGURE 3. NORSTAR G-325 AMPS PAYLOAD