AN UPDATE OF UTAH STATE UNIVERSITY'S GAS ACTIVITIES

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INTRODUCTION

In Oct. 1976 NASA announced the GAS program, a concept which allowed the non specialist access to space. This was an event which may well have ushered a new era into space activities. We have all paid lip service to the concept of the availability of space to all people rather than just to the "professionals". This program is one small step along that lengthy path. In the creation of the GAS program NASA has created a mechanism which is rare indeed for any bureaucracy. It has created a program which is designed to be responsive to the needs of those outside the system to institute change. In my interaction with the personnel of the GAS program I have met many individuals who have grasped the concept of change and encouraged it. In this paper I wish to present my version of the impact this program has had on Utah State University, the institution at which I am a professor.

USU SPACE INVOLVEMENT

Utah State University has had a fairly long involvement in the space program. The program as it now exists had it's initial roots in a small atmospheric research program, which grew into a rocket program in the early 1960's.

Table 1 shows some of the highlights of the space program at USU.

TABLE 1

1960--1970	ELECTRO-DYNAMICS LAB ROCKETRY---AURORAL AND IONOSPHERIC PHYSICS
1970--1980	CENTER FOR ATMOSPHERIC AND SPACE SCIENCES THEORETICAL PLASMAS--IONOSPHERIC PHYSICS MIDDLE ATMOSPHERE CHEMISTRY AND PHYSICS ROCKETRY--BALLOONS--AIRCRAFT--SATELLITES--RADARS
1970--1980	SPACE DYNAMICS LABORATORY CRYOGENIC IR TECHNOLOGY--INTERFEROMETRY INTERFEROMETERS--CRYOGENICS--ROCKETS
1980--1984	CASS, SDL & SHUTTLE VCAP------------------STS-3 & 51F VEHICLE CHARGING AND POTENTIAL ISO-------------------STS-9 & 20 IMAGING SPECTROMETRIC OBSERVATORY FACILITIES CLASS INSTRUMENT CIRRIS----------------STS-C & ? CRYOGENIC INTERFEROMETER(S) DOD INSTRUMENTATION UARS------------------1989-90 UPPER ATMOSPHERE RESEARCH SATELLITE

Given the existence of a vigorous space program at the university, it was fairly natural that USU should get involved in the GAS program at an early stage. My own involvement began when Gil Moore, whom I had known for several years prior to that time, called me, after having committed to the first of the GAS payloads and said, after describing the program briefly, "What are you going to do with this if I give you half of it?" At that time I was concerned by the lack of hands-on opportunities in space for undergraduate students, and out of Gil's offer and my concerns at the time came the present USU GAS program.

ORGANIZATIONAL CONFIGURATION OF A STUDENT GAS PROGRAM

The program at USU is centered around a scholarship program. In this program, seniors in high school are encouraged to write a proposal to do an experiment in space. As you may imagine this requirement in itself represents a considerable selection in the student. Only those students who have been interested in science and space will have very much to propose. We choose three students per year. Each will have a four year tuition scholarship provided he or she maintains an adequate grade point average. Where possible we help them find part time jobs in some of the space related research areas at the university. The success of these students has been such that it is not difficult to find work for them. The vice president for research supplies $500.00 per year per student for supplies and other costs associated with their experiments. It is a source of pride to me that we have a significant number of "walk-ons" in this program. Students fairly often come and say that they want to be involved. After explaining that there are no direct resources for them and that there is an enormous amount of extracurricular work involved, they are encouraged to participate in the program in a variety of ways. To date several of these students have flown experiments.

The essence of the program as it is designed at USU is that it is a "hands-on" program. Each student is required to do a large amount of the construction of the experiment. Certain items, to be discussed later are supplied but most items flown to date have been constructed by the students themselves. In many cases trades are made between the students for services in which one or the other of the students is particularly skilled.

Some resources must be made available to the students if one wishes to develop an effective team of students. Perhaps the most important of these is interaction with each other and suitable faculty members. To encourage this interaction one needs several items:

Space must be made available where the students can see each other frequently. This is probably the single most difficult item to supply in a university environment. We have been able to make available to the students, several rather spartan offices and a small amount of laboratory space.

A weekly meeting of the students and faculty is held during the school year and on occasion during the summer. The weeks before delivery, these meetings often occur every night.

A design philosophy must be established. If this is not done an inordinate amount of time is spent in negotiating for resources. The philosophy should be flexible enough to accommodate many students, but must represent the constraints of the GAS environment.

Certain of the major hurdles which any experiment presents should be either eliminated or minimized for the students. The student should be made aware that this is being done however. The hurdles which are minimized at USU are the physical configuration, the controllers and the power supply choices. A moderate amount of faculty help is supplied and modest resources are supplied.

WHAT HAVE WE DONE?

Given this philosophy, what has been accomplished? Table 2 shows what has been done so far in the program.

TABLE 2

STS-4 ONE PAYLOAD G-001 TEN EXPERIMENTS
This was the first GAS payload. See Fig. 1 for a picture of the payload and the participants.

41-B (STS-11) TWO PAYLOADS G-004&8 EIGHT EXPERIMENTS
These two payloads represented our first use of the 60 lb canister. The best bargain in space! Three of the eight experiments represented opportunities extended to other institutions including another university in the state, a high school and a foreign university. See Fig 2.

41-G (STS-17) ONE PAYLOAD G-518 FOUR EXPERIMENTS
This payload may represent the fastest turn-around in history. The payload was delivered six weeks after recovery of the payloads from the previous flight.

51-B Participation in the NUSAT program. Langmuir probe, orientation sensor, and flasher units were all USU student experiments. Assembly at USU.

Participation in a canister being flown by personnel from University of Mexico. One USU student experiment on board.

DESIGN PHILOSOPHIES

For the type of operation we are running, in which several individuals or groups are flying in a single GAS can it is important to keep each experiment as isolated from the rest of the pack as possible. In order to accomplish this we have designed a standardized "spacepak" for use by each experimenter. These will be described later.

A standardized controller is supplied for each spacepak. This controller was the only item not developed by an undergraduate. A masters degree candidate designed and built our controller and at present programs the ROM which contains the program for each of the students. This design incorporates a 16 channel multiplexer connected to an eight bit A/D converter, up to 16K bytes of program space and the ability to "go to sleep" during times when no action is required. This is required because of the need to conserve power. Data are stored in ROM using an on-board ROM burner. Up to 32K Bytes are available for storage. Control is accomplished through eight output lines, each capable of supplying three amperes.

Power sources are an ever present problem. We have found that lead acid batteries in the 2.5 and 5 ampere-hour sizes are adequate for most of our experiments. Because weight is seldom the most severe constraint in a GAS can, the weight penalty for using the lead acid technology is tolerable. It should be noted that the lead acid batteries, while quite good, do not satisfy ones needs in all cases. Alkaline batteries, can supply more energy in some cases, but since the batteries can be used only once, there is no chance for test of the individual cells.

One should always maximize the thermal isolation of the experiments from each other to the extent possible. For this reason we have encouraged the use of foam and epoxy structures for containers. Care should also be taken to eliminate radiative coupling between various experiments and the walls of the can. At some temperatures radiative energy transfer can dominate over conductive transfer unless care is taken.

We try to minimize inter-pak communication. On most of our experiments we are able to keep the interaction limited to that necessary to turn the paks on and off.

OUR CURRENT CONFIGURATION

After our first attempt to build a large number of experiments onto a single frame, it was clear that the tri-wall construction, while a very good, stiff framework, presented substantial difficulty when several experiments were to be flown together. Our aim in the program is to enable as many students as possible to fly experiments and the ability to incorporate as many experiments into a GAS can as possible. An analysis of the experiments which were flown on G-001 and a look at the experiments proposed for G-004 and G-008, showed that a large percentage of the experiments really required a fairly small volume. As a consequence a standard "spacepak" was designed. This pak, which is shown in Fig 3, is based on a hexagon which will fit inside the 19 inch circle allowed for the GAS canister. The length allowed can easily be varied for different experiments, but it has been found that a four inch height (outside dimensions) will fit almost all experiments, especially if the allotted shape is known in advance of the initial design.

IMMEDIATE PLANS

At the present time there are a total of 12 experiments under development at USU. We anticipate that at least six of these, or one five cubic canisters worth will be ready for integration by Dec. I and that the remainder will be ready in by late spring.

The proposed experiments include:

A study of the velocity of a bubble in water under the influence of a temperature gradient.

A reflight of the Scott Thomas's experiment on surface tension driven convective flow. (Marongoni flow)

The study of surface waves in zero-G. (Capillary waves)

Crystallization in Zero-G. (Vapor phase and liquid phase)

Bio gas generation.

Penicillum growth.

A study of undamped oscillations in a vacuum and Zero-G.

Several other experiments still being formed.

SPIN OFFS

The GAS program has had several spin off effects at USU. One of the most recent of these is the creation of a new program in space engineering which has created a Center for Space Engineering. For this program we have created several new courses and combined them with course work currently been given and created a degree specialty in space engineering. This specialty can be obtained at the masters degree level in the departments of Mechanical, Civil and Electrical engineering. The program has created considerable interest among students and there are already enough students for our first class, even though we have not formally announced the program. Experimentally the program will be based on having each Masters degree student involved in some activity in which a space experiment is flown. Some of these will be free flyers ejected from GAS canisters. A variety of experiments have been designed which include structural damping in zero-G and vacuum, environmental studies and reentry vehicles to study the lower atmosphere. In Figures 4 & 5 we show some of the structures in which the experiments will be housed and a proposed additional "boosted" version of the satellite. Fig 6 shows a computer created for control and housekeeping functions. This computer and up to 30 megabytes of battery backed RAM can be housed in less than one third of the satellite structure.

You will hear today from two of the groups that have taken advantage of the USU expertise to start their own programs, which will hopefully continue into the future. These are the Weber State College group that was involved in NUSAT and the group from the University of Mexico which is currently building a payload at USU. The activities of these groups makes it clear that the GAS philosophy of space science is spreading.

LONG RANGE PLANS

Every enterprise needs goals. This is especially true of a program like the USU GAS program. In addition to planning the continuance of the existing and expanded programs, we feel the need for a major central effort. We have therefore created a five year goal, which has many hurdles in front of it before it can become a reality. If we accomplish this goal, we will construct a small radio controlled satellite with enough aerodynamic control and enough propulsion on board that we can command partial re-entry into the atmosphere, control the space craft to execute a plane change using aerodynamic forces, and then recircularize the orbit. This program will teach the students who participate in it not only the ordinary structural and environmental material, but will require knowledge of aerodynamics, orbital mechanics and control theory as well. Each us luck.

Figure 1. First USU Payload with Participants

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Figure 2. Second Payloads

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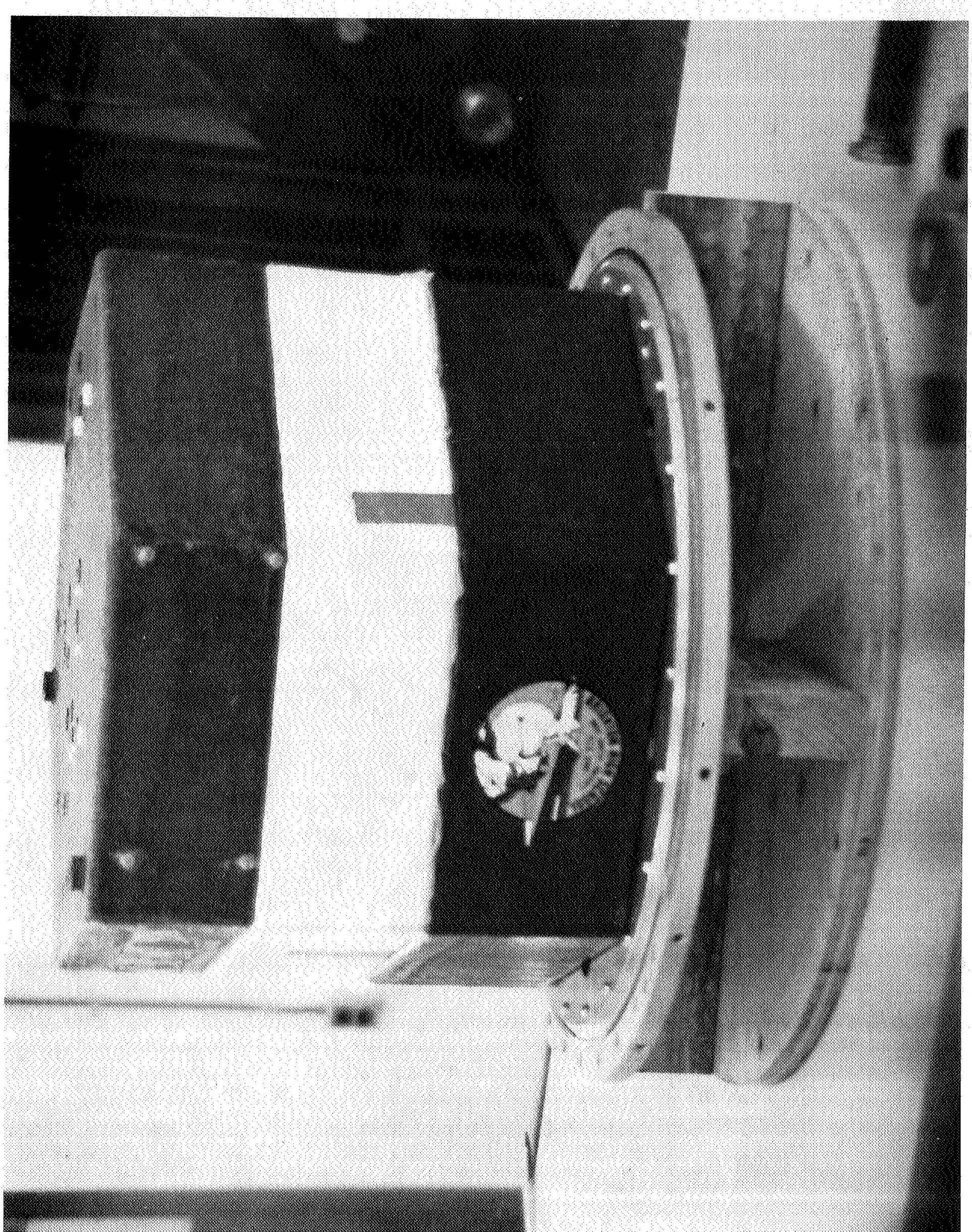

Figure 3. Space Pak Configurations

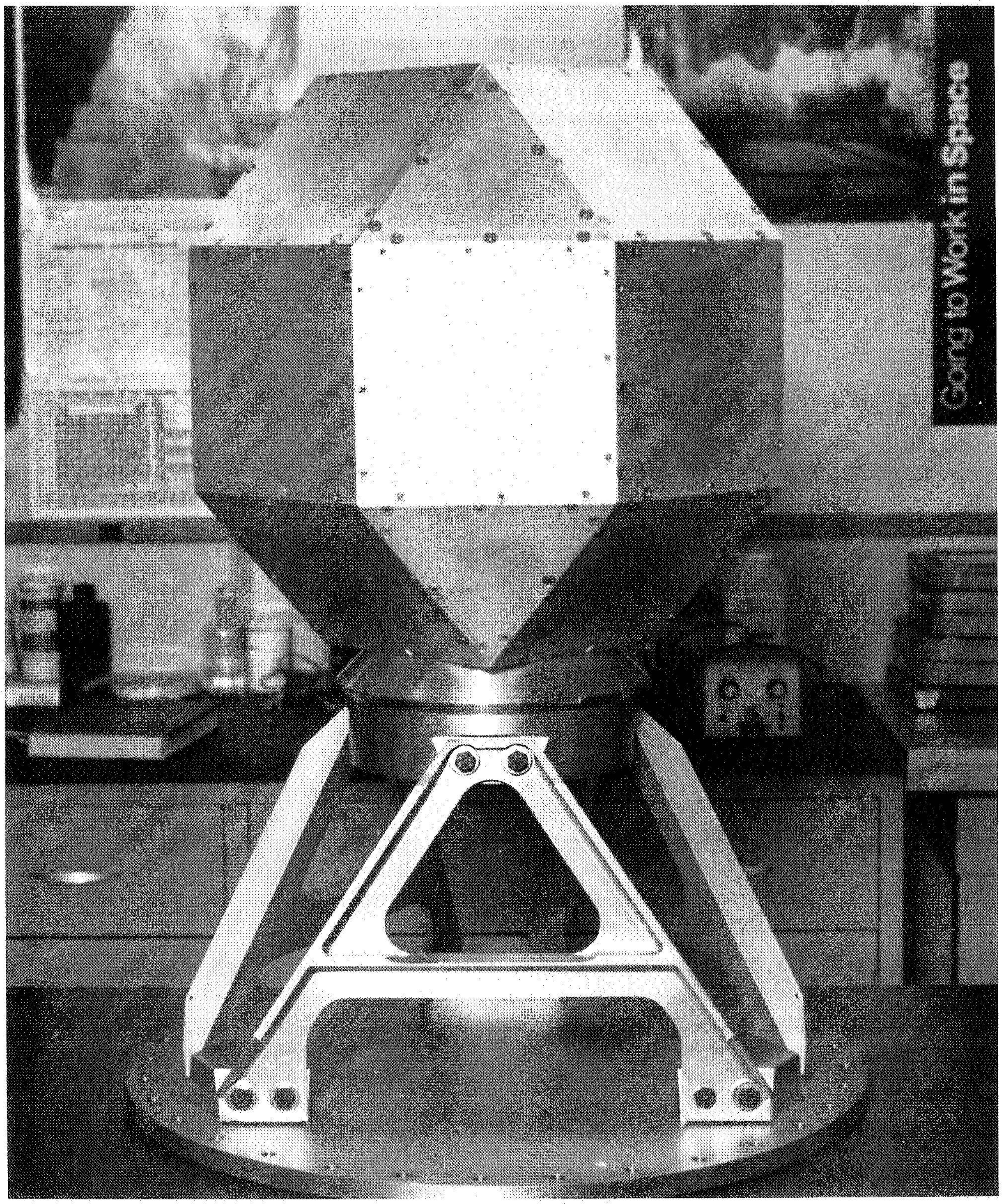

Figure 4. Satellite Structure

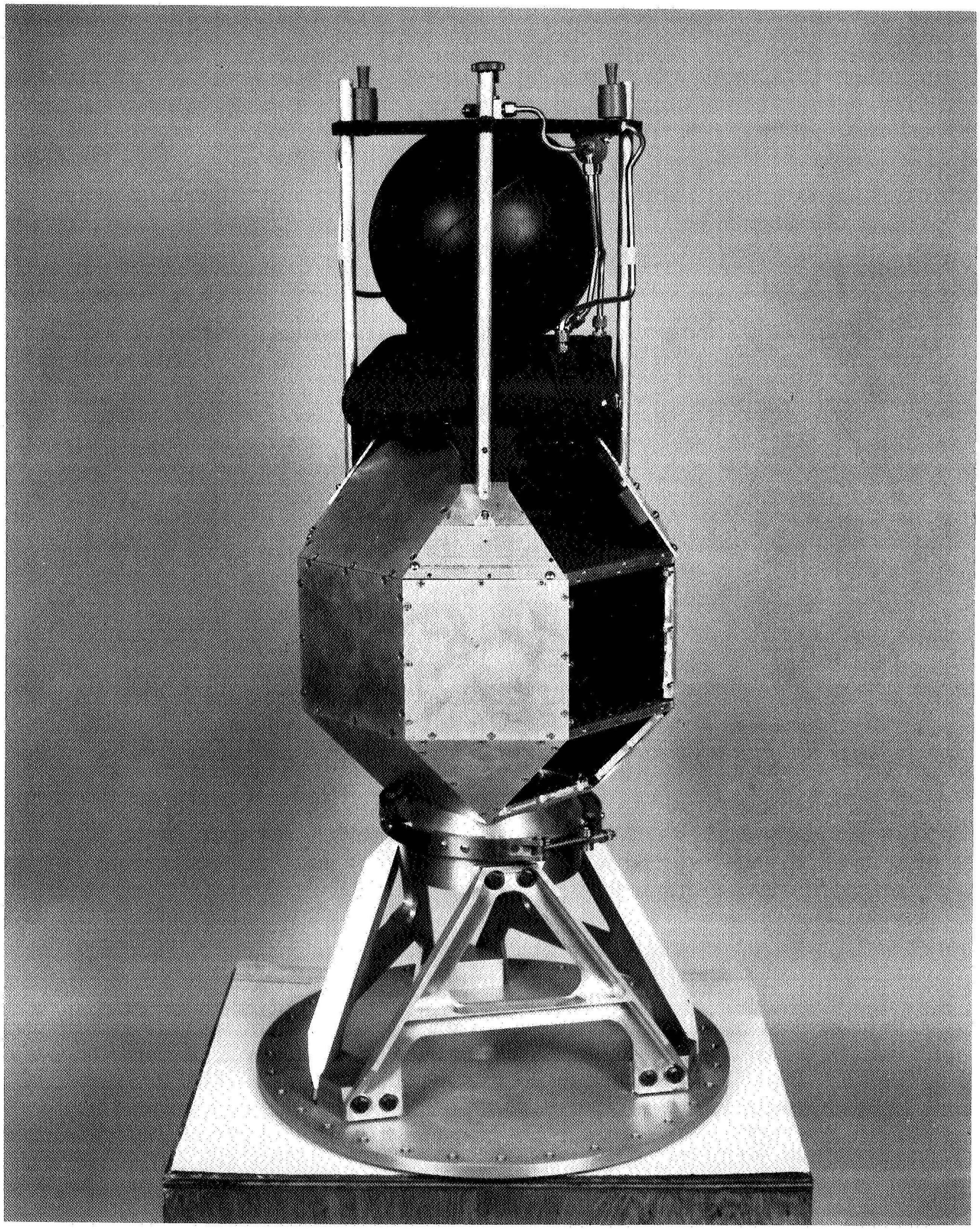

Figure 5. Boosted Satellite

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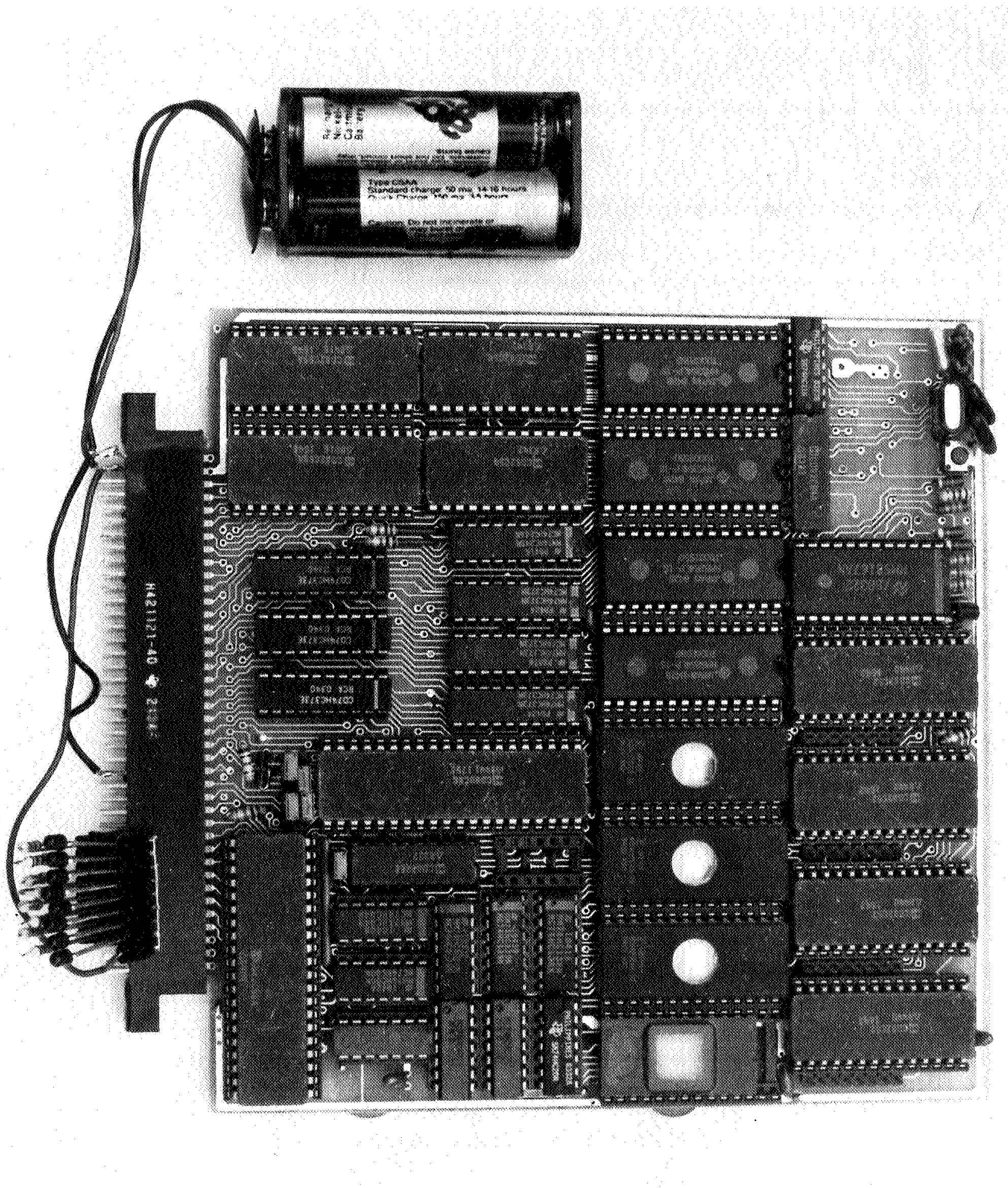

Figure 6. Computer