

1. STATUS REPORT ON BIOSCIENCE ON GEMINI

SIEGFRIED J. GERATHEWOHL
Manager, Life Science Projects
Manned Space Science Division, NASA

BEEM: I would now like to turn the program back to Dr. Gerathewohl, who will give us a status report on the bioscience in the Gemini program.

GERATHEWOHL: In organizing this meeting, I thought it would be of benefit to all of us if we would give a little history and review very briefly what has been done so far in the ongoing research. I did not want to go too far back, but at least in the ongoing life sciences or biosciences research within NASA.

The various types of experiments, which were assigned to flights GT-3 through GT-7, are shown in table I. They are grouped in accordance with the areas of responsibility, which I pointed out in my introductory remarks, or the organization which proposed them—as is the case with the engineering experiments which originated at the Manned Spacecraft Center, in Houston, Tex., and the experiments which were proposed by agencies pertaining to the Department of Defense. We are particularly interested in the S-experiments, among which we find the ones dealing with life sciences problems. They are:

- S-2 Sea urchin egg growth
- S-4 Radiation and O-G effects on blood
- S-8 Visual acuity
- S-12 Micrometeorite collection, and
- S-3 Frog egg growth, which is not included in table I because it is scheduled for a later flight.

I would like to say now a few words about the state of each of these experiments. The list below gives the objective and a short description of an experiment to evaluate the effects of weightlessness on the processes of fertilization, cell division, and development of sea urchin eggs (S-2).

Purpose: Evaluate effects of weightlessness on growth of simple cells
 Equipment: Cylinder having eight growth chambers and temperature recorder
 Weight: 10 ounces
 Volume: 0.02 cu ft
 Procedure: Operate fixing and fertilizing knobs at prearranged times
 Location: Pressurized cabin

Figure 1 shows the interior of the experimental package with the various chambers for eggs, sperm, and fixative to arrest the growth at certain times during the flight. The assembled package is shown in figure 2. The astronaut had to initiate fertilization and fixation of the eggs by turning the handle. Unfortunately, the experiment failed for mechanical reasons, but we learned a lot about technical requirements and human errors in conducting experiments under rather difficult conditions. The experiment may be repeated in one of the later Apollo flights.

Table I. —Gemini Experiments—Flights GT-3 Through GT-7

Type	No.	Title	GT-3	GT-4	GT-5	GT-6	GT-7
Medical	M-1	Cardiovascular Reflex	—	—	X	X	X
	M-2	Cardiovascular Effects	X	X	X	X	X
	M-3	In-Flight Exerciser	—	X	X	X	X
	M-4	In-Flight Phonocardiogram	—	X	X	X	X
	M-5	Biochemical Analysis of Body Fluids	—	—	—	X	X
	M-6	Bone Demineralization	—	X	X	X	X
	M-7	Gemini Calcium Balance Study	—	—	—	—	X
	M-8	In-Flight Electroencephalogram	—	—	X	—	X
	M-9	Vestibular Effects	—	—	—	—	X
Engi- neering	MSC-1	Electrostatic Charge	—	X	—	—	—
	MSC-2	Proton Electron Spectrometer	—	X	X	X	X
	MSC-3	Tri-Axis Magnetometer	—	X	X	X	X
Technical Defense	T-1	Reentry Communication	X	—	—	—	—
	D-1	Visual Definition of Objects in Space	—	—	X	X	—
	D-2	Visual Definition of Nearby Objects in Space	—	—	X	X	—
	D-3	Mass Determination	—	—	—	X	—
	D-4	Radiometric Measurements	—	—	X	—	X
	D-6	Visual Definition of Terrestrial Features	—	X	X	—	—
	D-7	Radiometric Observation of Objects in Space	—	—	X	—	X
	D-8	Radiation	—	X	—	X	—
	D-9	Simple Navigation	—	—	—	X	X
Scientific	D-13	Astronaut Visibility	—	—	X	—	X
	S-1	Zodiacal Light Photography	—	—	X	—	—
	S-2	Sea Urchin Egg Growth	X	—	—	—	—
	S-4	Radiation and Zero-G Effects on Blood	X	—	—	—	—
	S-5	Synoptic Terrain Photography	—	X	X	X	X
	S-6	Synoptic Weather Photography	—	X	X	X	X
	S-7	Cloud Top Altitude Spectrometer	—	—	X	—	—
	S-8	Visual Acuity	—	—	X	—	X
	S-9	Nuclear Emulsion	—	—	—	—	X
	S-11	Airglow Horizon Photography	—	—	X	—	—
	S-12	Micrometeorite Collection	—	—	—	X	—

Dr. Richard Young from Ames Research Center is also preparing a parallel experiment using frog eggs. The rationale of this study is given in the following:

Purpose: Evaluate effects of prolonged weightlessness on cell tissue

Equipment: Eight chambered cylinder, frog eggs

Weight: 15 ounces

Volume: 0.02 cu ft

Procedure: Preflight: Briefing

In-flight: Operate fixing knob

Postflight: None

Location: Pressurized cabin

Whereas Dr. Young does not expect noticeable effects of weightlessness on the developing sea urchin egg, he expects to detect such effects on the frog egg, the dependency of which on

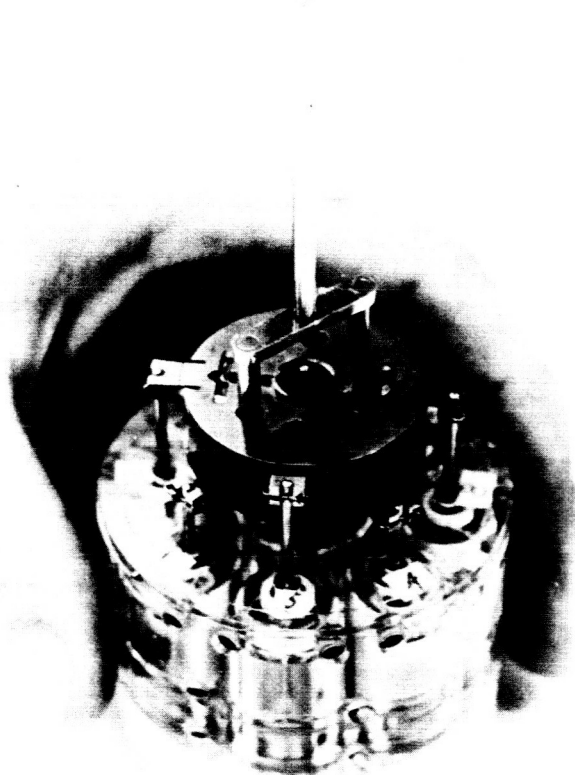


Figure 1.—Interior of experimental package.

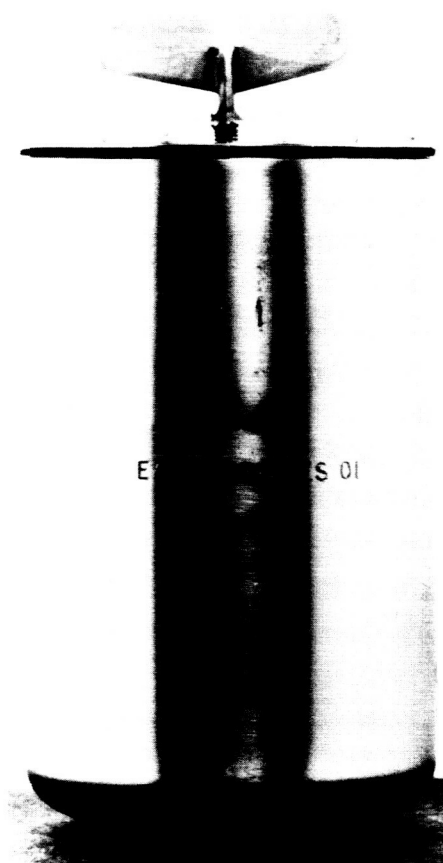


Figure 2.—Assembled experimental package.

gravity factors seems well established. The flight units, which are being built by General Electric Co.'s Missile and Space Division, have been delivered to the McDonnell Aircraft Corp. (See fig. 3.) The experiment is scheduled for GT-8, which is to fly in spring of this year. Since the biosatellite cannot accommodate the sea urchin egg experiment, frog and sea urchin eggs may be flown together in Apollo.

Extremely interesting results were obtained in an experiment on the effects of radiation and 0 G on human white blood cells, which is conducted by Dr. Bender from the Oak Ridge National Laboratories:

Purpose:	Weightlessness and radiation relationship on white blood cells
Equipment:	Apparatus containing cells and radioactive source
Weight:	6 ounces
Volume:	0.03 cu ft
Procedure:	Actuate slide mechanism
Location:	Pressurized cabin

The experiment was more or less stimulated by Russian reports of chromosomal disruptions as a result of space flight. Dr. Bender's flight package is shown in figure 4. Since the experiment and its results are published in the "Manned Space Flight Experiments Symposium

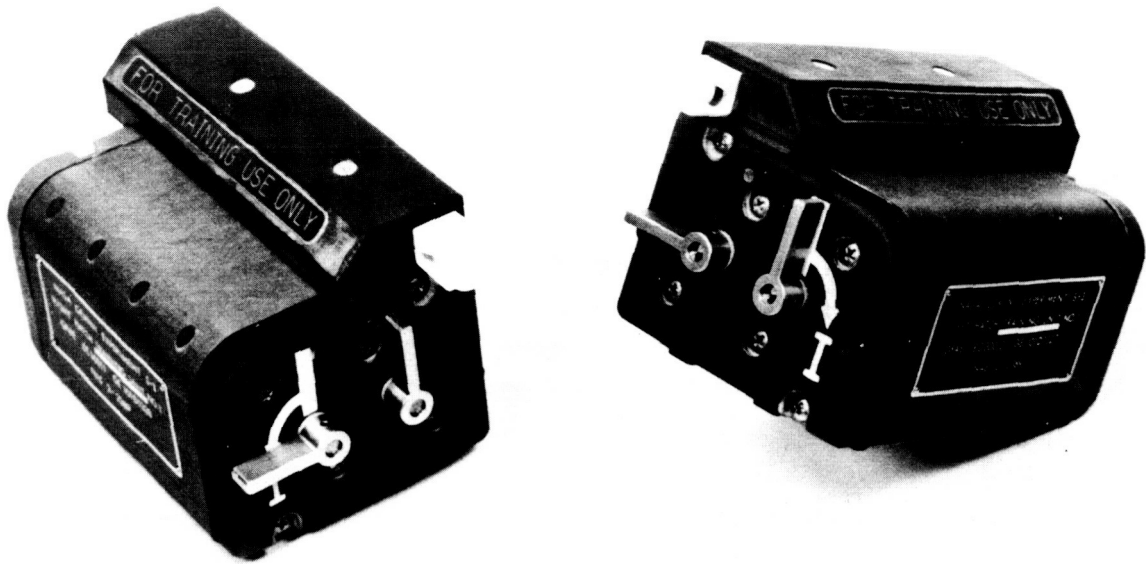


Figure 3.—Flight units.

Gemini Missions Nos. 3 and 4," I will show only two of Dr. Bender's tables. Table II shows the increase of chromosome aberration with increasing radiation dose and, furthermore, the persistent increase of chromosome deletions in the flight samples. A synergism between radiation and some flight parameter—apparently weightlessness—seems to exist for human chromosome single breaks in white blood cells. That the space flight by itself—one thinks in particular of acceleration, vibration, and pure oxygen—induces these aberrations is ruled out by the nonradiated flight samples and also by the preflight and postflight blood samples obtained from the flight crew (see table III). I am sorry that Dr. Bender is not with us to interpret the slight increase noticeable at the bottom of the table.

An experiment, which is not in a sense basic biologic in nature but was assigned to this Office, is being conducted by Dr. Duntley and Dr. John Taylor from the Visibility Laboratory, Scripps Institution of Oceanography, University of California, to measure visual functions in flight and visual acuity from orbital altitudes:

- | | |
|------------|---|
| Purpose: | Investigate astronaut's visual performance in seeing objects on Earth's surface |
| Equipment: | Vision tester and photometer |
| Weight: | 5 lb + D-6 |
| Volume: | 0.02 cu ft + D-6 |



Figure 4.—Flight package.

Procedure: Preflight: Laboratory experiments and plane flight over target area
 In-flight: Use vision tester, view, and photograph targets
 Postflight: Visual acuity test
 Location: Pressurized cabin

Table II.—Results of Experiment S-4 Chromosome Aberration Analyses

Subject	Sample	Cells scored	Estimated dose (rad)	Chromatid deletions	Chromosome deletions	Ring and dicentric chromosomes
Crew						
Grissom	Preflight	100	—	3	0	0
	Postflight	200	—	2	0	0
Young	Preflight	100	—	0	1	a ₁
	Postflight	200	—	0	1	a ₁
Experiment						
	Ground	400	2	3	3	1
	Flight	400	2	1	3	0
	Ground	400	47	1	6	5
	Flight	400	47	3	14	1
	Ground	400	94	5	13	13
	Flight	400	94	6	28	16
	Ground	400	138	6	32	43
	Flight	400	138	6	48	34
	Ground	400	189	6	45	36
	Flight	400	189	2	88	48

^aThese 2 dicentric chromosomes appear identical; both lacked acentric fragments.

The GT-5 astronauts used an in-flight vision tester once a day in order to determine the effects of space flight—in particular, weightlessness—on near-vision acuity. (See fig. 5.) Moreover, the astronauts tried to identify bright rectangles, which were placed on dark squares as background, which were laid out like a big eye chart at the Gates Ranch near Laredo, Tex. Figure 6 shows the orientation of the Gemini spacecraft over the observation site, which actually consisted of three rows of four markings each. An in-flight photometer was used to measure the brightness of light scattered by the Gemini window, as shown in figure 7. The values obtained varied very markedly during the GT-5 overflights. Due to the difficulties with the fuel cells during the first part of the flight, and due to shortage of control fuel at the end, the experiment had to be shortened and the markings were ascertained only

Table III.—GT-5 Astronaut Chromosome Analysis

<u>Preflight</u>	Cells scored	Chromosome-type aberrations				
		Chromatid deletions	Chromatid exchanges	Deletions	Dicentric	Exchanges
T-11:						
Cooper	300	7	0	7	1	1
Conrad	225	10	0	2	0	0
T-8:						
Cooper:						
a ₁	150	2	0	1	0	0
b ₂	150	5	0	1	0	1
Conrad:						
a ₁	49	0	0	1	0	0
b ₂	150	3	0	1	0	0
T-4:						
Cooper	150	3	0	0	0	0
Conrad	150	0	0	1	0	0
<u>Postflight</u>						
Cooper	150	5	0	5	0	3
Conrad	150	6	0	2	1	2

^aAfter 125 I RISA injection.

^bAfter Cr⁵¹ and RISA injection.

two times. Figure 8 shows the observation site photographed from orbit. The results of the GT-5 mission indicate that the visual performance of the astronauts was not degraded during the 8-day flight, and that the ground observations were within the predicted statistical probability. However, the individual identifications of the test markings were not reliable enough, and the experiment will be repeated—using a modified pattern as shown in figure 9—during the GT-7 flight.

Finally, the micrometeorite experiment (S-12) is as follows:

Purpose: Collect and study nature of interplanetary dust
 Equipment: Collection apparatus with isolated compartments
 Weight: 8 pounds
 Volume: 0.045 cu ft
 Procedure: Position collection apparatus on outside of spacecraft, open and close apparatus remotely, recover apparatus and stow
 Location: Pressurized cabin and outside spacecraft

Hemenway's experiment has three objectives, of which the first is successful sampling of nanometeorites, and estimation of the percentage of these which originate by ablation from meteorites. Second, the flux will be measured from examination of the density of holes which

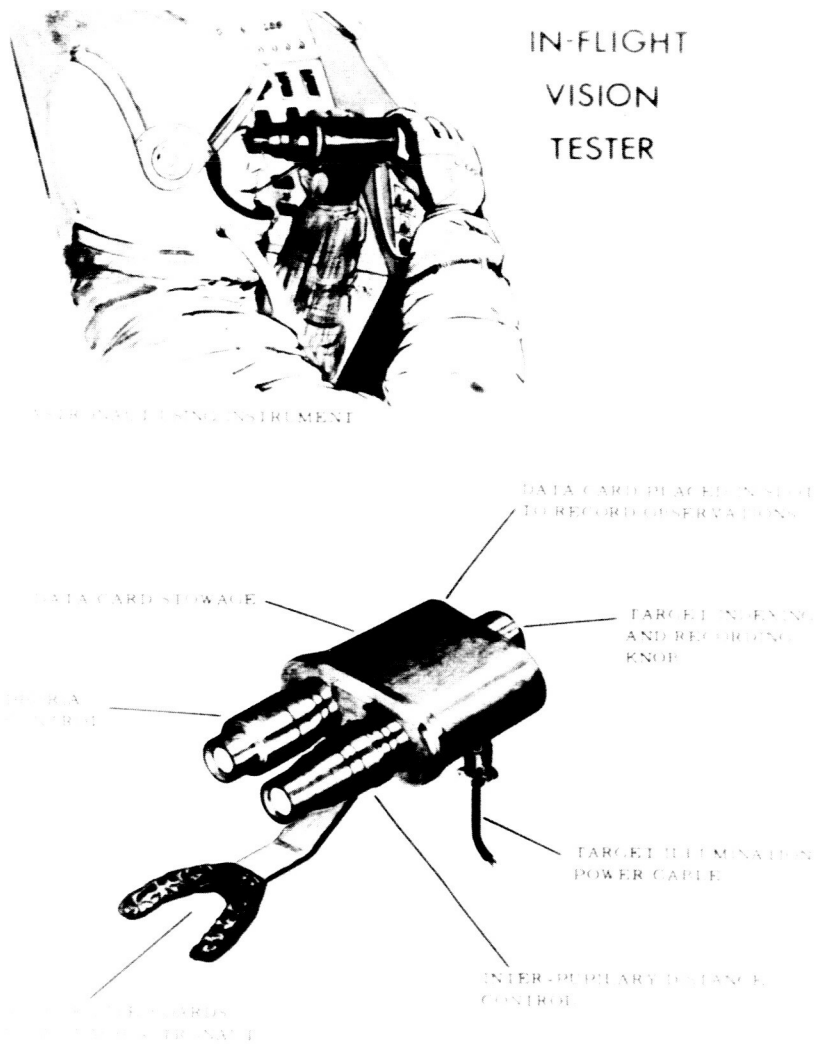


Figure 5.—In-flight vision tester.

occur in a series of thin films. Following Mercury flights, a study of the outer surfaces of the windows and periscope lenses used during those missions has already indicated such impact sites.

And finally, for biological purposes, sterile collection surfaces will be located within a discrete sterile compartment included to find out whether micro-organisms are present or absent in the space environment. An attempt to answer the further question of survival of micro-organisms will be made through incorporation of a nonsterile compartment (fig. 10) which will house various micro-organisms including bacteria, molds, spores, and viruses to be exposed to the space environment. After flight, the survival rate of these micro-organisms will be assayed. Also, the microbiological collection surfaces will be treated to a wide variety of culture techniques, including those to be used in search for extraterrestrial life. The equipment to be used is shown in figures 10 and 11.

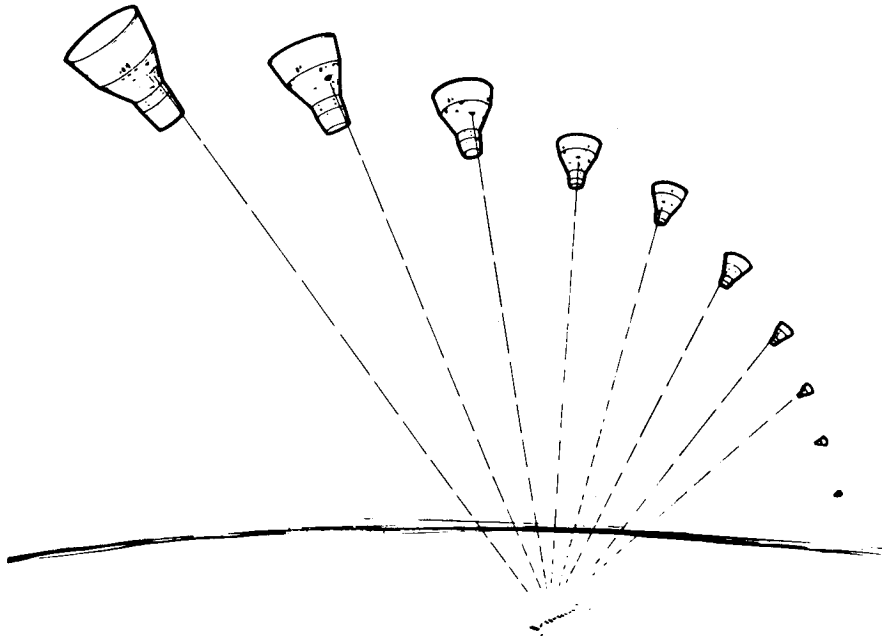


Figure 6.—Orientation of Gemini capsule over prepared ground targets.

Dr. Hemenway has invited interested scientists to participate in his study. For example, guest experimenters selected for S-12 on GT-9 are:

Robert Soberman	-----	Air Force Cambridge Research Laboratories Cambridge, Mass.
Hugo Fechtig	-----	Max Planck Institute for Nuclear Physics Heidelberg, West Germany
Uri Shafrir	-----	University of Tel Aviv Tel Aviv, Israel
Michael Carr	-----	U.S. Geological Survey Menlo Park, Calif.
Donald Gault	-----	Ames Research Laboratory NASA-Moffett Field, Calif.
Paige Burbank	-----	Meteoroid Technology Branch NASA-MSC, Houston, Tex.
Otto Berg	-----	Goddard Space Flight Center Greenbelt, Md.

This is one of the first attempts where an experimenter has opened the door to let other scientists in as coinvestigators. I am pointing this out because this approach may be applicable to experiments under consideration for the Apollo Applications Program.

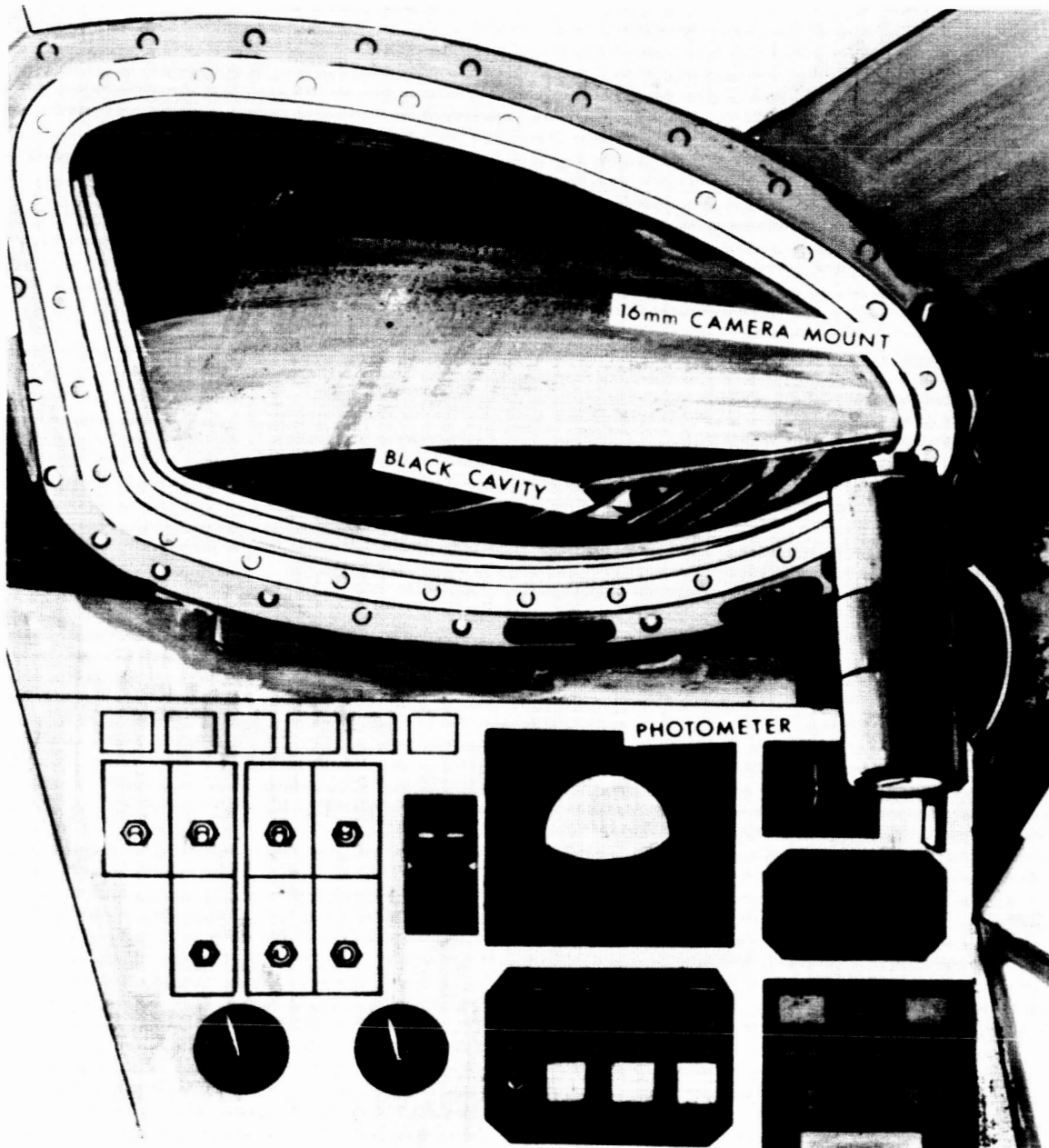


Figure 7.—In-flight photometer.

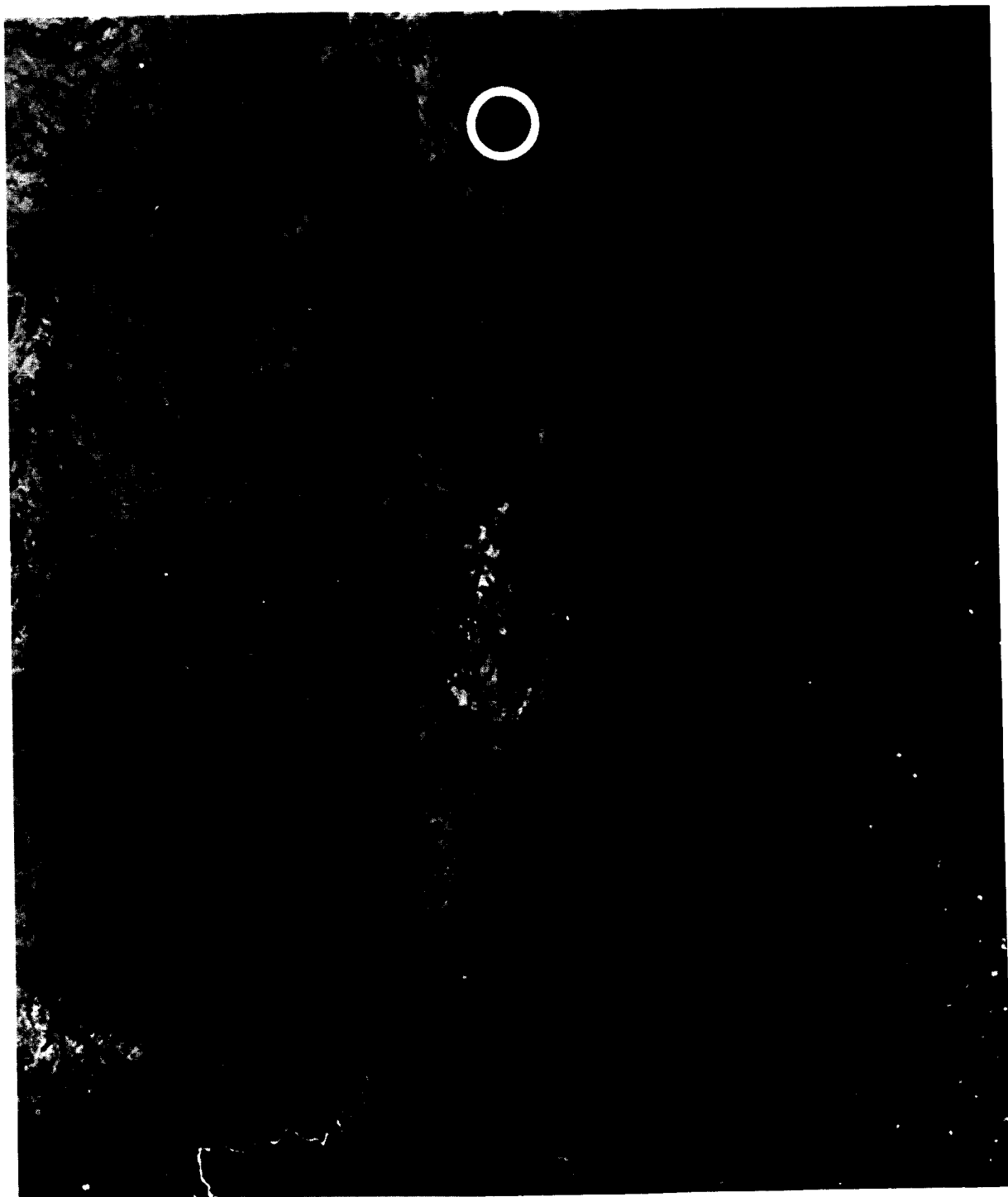


Figure 8.—Observation site photographed from orbit.

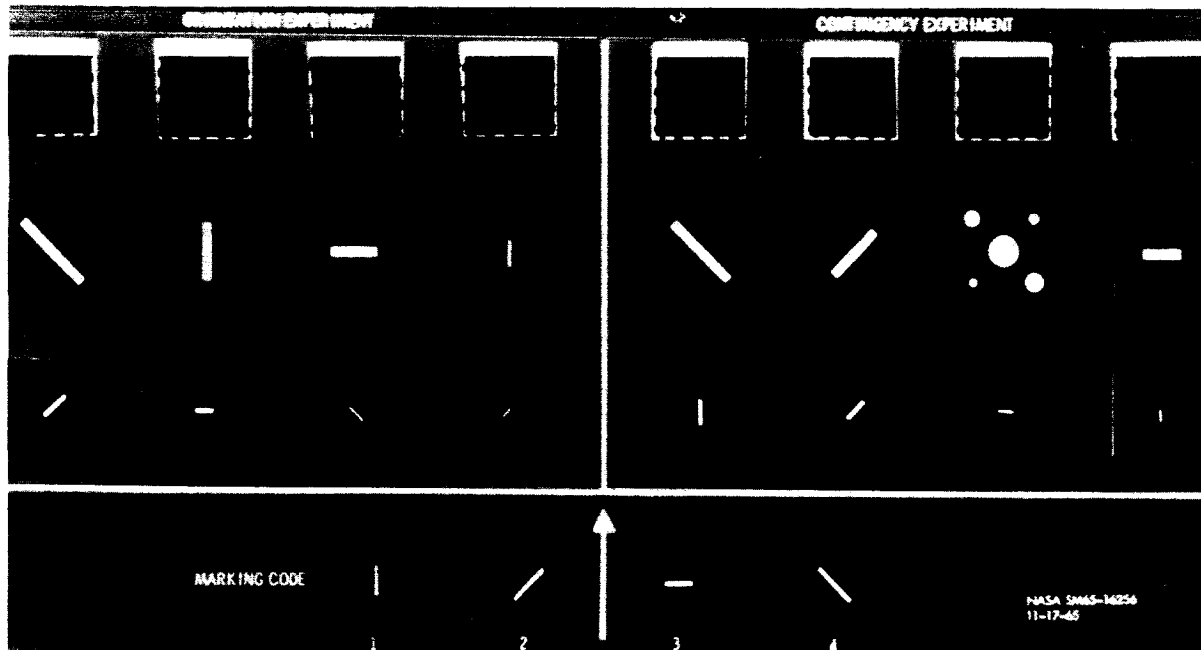


Figure 9.—Ground markings at Laredo.

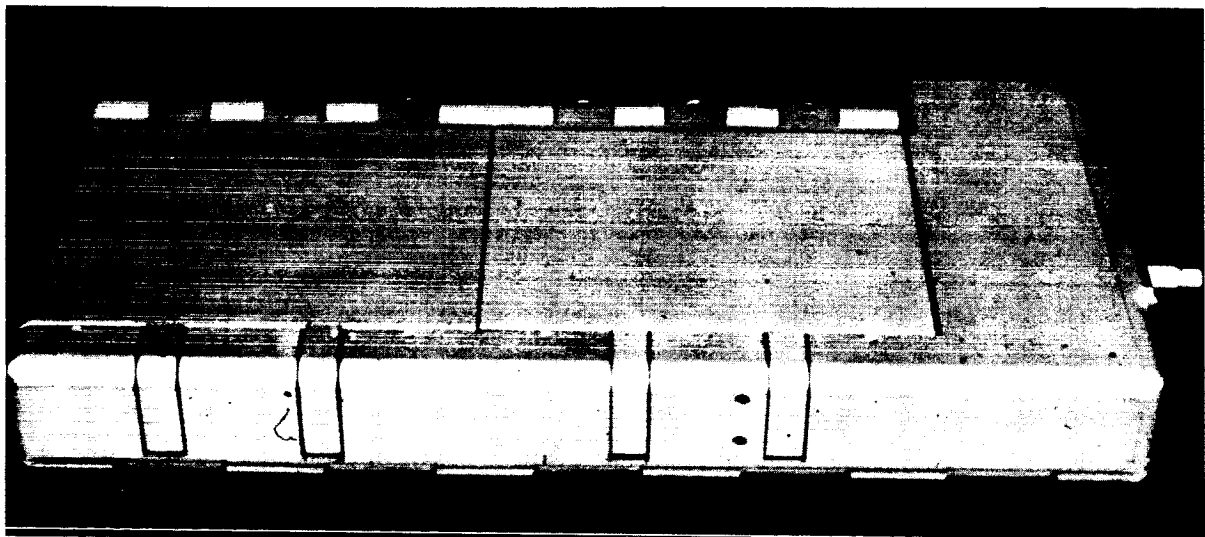


Figure 10.—Apparatus for microorganism survival experiment (closed).

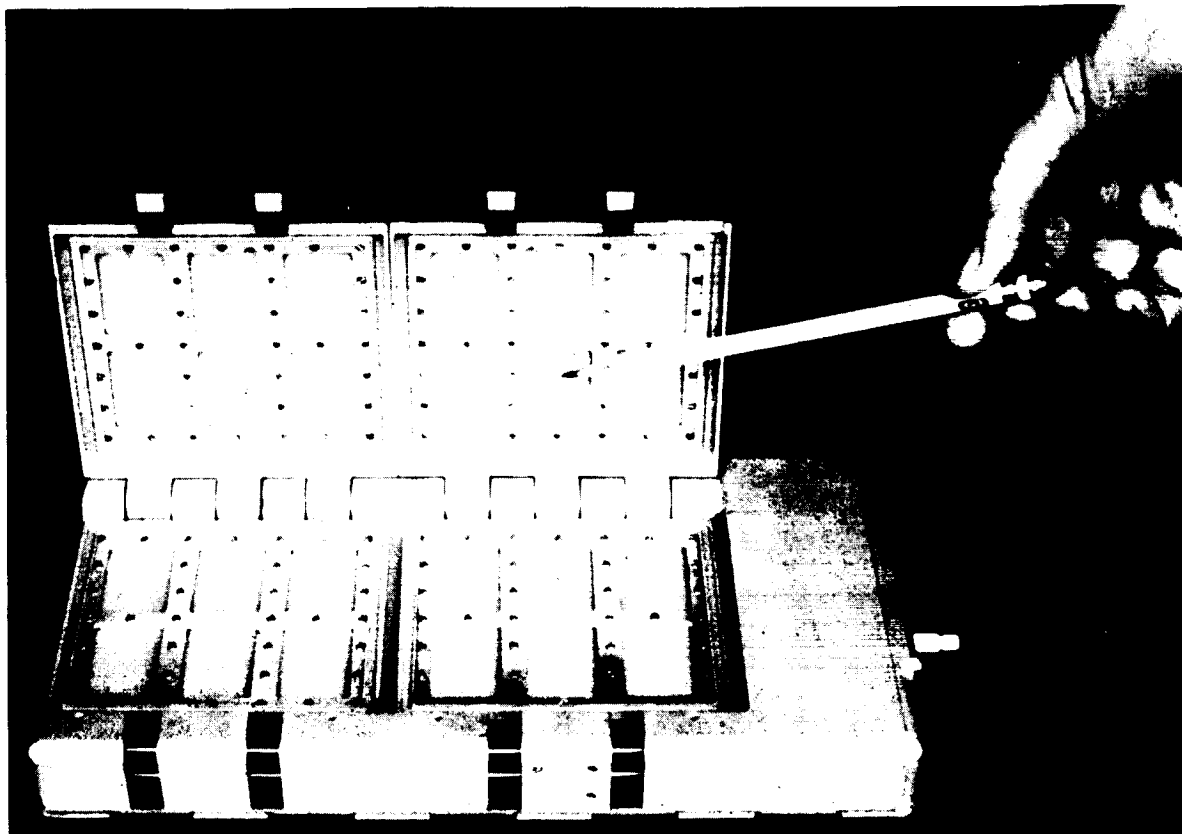


Figure 11. —Apparatus for microorganism survival experiment (open).