NEWS

NASA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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PROJECT: ORBITING FROG OTOLITH (OFO)

contents

8/5/70

NEWS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (202) 962-4155
WASHINGTON, D.C. 20546 TELS: (202) 963-6925

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DOUBLE LAUNCH SCHEDULED

The Orbiting Frog Otolith (OFO) is one of two spacecraft to be launched on a single Scout vehicle by the National Aeronautics and Space Administration no earlier than Aug. 19, from the NASA Wallops Station, Wallops Island, Va.

Also on board the solid-propellant Scout will be the Radiation Meteroid (RM) spacecraft to demonstrate and evaluate improved instrumentation and to gather near-Earth data of scientific interest.

Two male bullfrogs (Rana Catesbiana) will be monitored in OFO for about five days alternately in the weightlessness of space and during periods of partial gravity created by spinning them up to 50 revolutions per minute, producing a one-half g acceleration condition.

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Through microelectrodes surgically implanted in the vestibular (inner ear) nerves leading from sensor cells in the otoliths of the bullfrogs, scientists will be able to study for the first time the electrical response of the otolith sensors during hours of weightlessness.

Data from the five day experiment will provide information about the adaptability of the vestibule in the inner ear (which controls balance) to a sustained weightless environment as well as its response to acceleration.

NASA's Office of Advanced Research and Technology is conducting both basic and applied research to determine how the vestibular organs of man function, both on Earth and in space. A number of disorders have occurred in men and animals during short periods of weightlessness in aircraft and during longer periods in spacecraft, among them disorientation. This is attributed to the vestibular system which in turn influences vision and balance.

A frog was chosen as the space flight specimen because (1) the otolith system of the frog is similar to that in man, (2) its size permits small packaging for spaceflight, and (3) it is amphibious and therefore capable of surviving in both an air environment while pre-launch surgery is performed and in water during flight.

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The Frog Otolith Experiment was developed and tested by Dr. Torquato Gualtierotti of the University of Milan, Italy, while he was in this country as a resident research associate (under the auspices of the National Academy of Sciences) working at the NASA Ames Research Center, Mountain View, Calif. Dr. Gualtierotti is the OFO Program's principal investigator and Ames manages the experiment package.

The flight project is part of the vestibular research program of the Office of Advanced Research and Technology with project management assigned to the Wallops Station.

Since the launch vehicle lifting capability is not entirely utilized by the 293-pound OFO spacecraft, a 46-pound secondary payload, the RM spacecraft, will ride piggyback with the fourth stage of the Scout. The RM program is managed by the NASA Manned Spacecraft Center, Houston.

The OFO and RM spacecraft, both 30 inches in diameter, will separate after achieving Earth orbit. The planned orbit will range from about 195 to 370 miles, or 313 to 590 kilometers, altitude and be inclined 37.7 degrees to the Equator. Time to complete one revolution will be about 1 and 1/2 hours.

The RM spacecraft will remain attached to the Scout fourth stage after separation from the OFO spacecraft. Both spacecraft will go into the same elliptical orbit with orbital lifetimes of approximately 270 days.

The RM spacecraft has two experiments -- the Radiation Experiment and the Meteoroid Experiment. Objectives are to demonstrate the feasibility and accuracy of an advanced radiation dosimetry system and to verify in-flight improved instrumentation to measure meteoroid impact, flux, direction and speed.

The RM instruments will gather data helpful in designing radiation and meteoroid safety measures into future manned missions. The radiation experiment also will help update descriptions of the ever-changing radiation belts that encircle the Earth.

Key element in the radiation experiment is the advanced radiation dosimetry system regarded as a candidate for future manned space vehicles. Instrumentation is designed to measure and determine the type of radiation (electrons or protons) encountered and to convert the data instantly to conventional radiation dose units.

The measurement of dose, or energy absorbed by the body, (expressed in rads per hour) is of more significance as mission durations increase.

For long-term manned space flight missions, it will be necessary to monitor continuously separate radiation components, and independently and collectively assess their biological significance. The general aim of the radiation experiment is to aid in the development of such an advanced system.

The meteoroid experiment employs an improved detector system of thin film capacitors to obtain the number of meteoroid impacts, their direction and speed. The data will be of interest to meteoroid science and helpful in determining damage criteria for spacecraft and in defining a velocity spectrum for small meteoroids in the vicinity of the Earth.

Other NASA installations participating in the OFO and RM programs, in addition to Wallops, Ames, and MSC, are: the Goddard Space Flight Center, Greenbelt, Md., and the Langley Research Center, Hampton, Va.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS)

OFO BACKGROUND AND MISSION OBJECTIVES

The mechanics of orientation and the coordination of body movement have always occurred within a framework which has superimposed upon it the constant one-g environment of Earth, the force of gravity.

Otolith cells, the sensors, or gravitoreceptors, of the vestibular apparatus, develop and operate under this constant one-g presence.

Now spacecraft have made it possible to remove this gravity framework and to learn in detail what the possible biological effects of prolonged weightlessness may be on astronauts.

NASA's Office of Advanced Research and Technology is conducting both basic and applied research to determine the manner in which the vestibular organs of man function, both on Earth and in the space environment.

The Orbiting Frog Otolith (OFO) experiment is part of this OART research program.

Microelectrodes implanted in the vestibular nerves of two bullfrogs will furnish researchers in neurophysiology with the first direct recording of the otolith sensor-cell response made during prolonged periods of weightlessness. From this data, scientists will be able to study how the sensors, long adapted to a constant environment stimulus, will react to such a radical change. Data should reveal any signs of possible disfunction or adaptation of the otolith cells to weightlessness. The results obtained will be a significant step in understanding the physiological mechanism of this and other vestibular organs.

BASIS FOR OFO EXPERIMENT

The vestibule (Figure 1) is in the inner ear. It has three main parts: the semicircular canals (superior, posterior, and lateral) which respond to angular acceleration; the sacculus which responds mainly to vibration; and the utriculus which responds to linear acceleration, therefore, to gravity. Attached to the vestibule, opposite the semicircular canals, is the auditory organ, the cochlea, which looks like a conch shell.

In this experiment, the utriculus is of principal interest since the main objective is to study the effect of changes in gravity.

The sensor organ of the utriculus is the macula. This organ contains several thousand sensor cells, or units, (Figure 2) oriented in different planes to measure acceleration in all directions.

On the upper part of the organ a number of hairs protrude and are immersed in a jelly-like medium. Above the hair, suspended in the jelly substance, are stone-like crystals which are denser than the jelly medium. These are the otolith (from the Greek words <u>oto</u> meaning ear and <u>lith</u> meaning stone) bodies.

The stones, grouped together, are free to move parallel to the surface of the macula, bending the hairs which project from the otolith cells.

The hairs are of two types -- kinocilium (KC) and stereocilium (ST). There is only one kinocilium per cell, but up to 64 stereocilia.

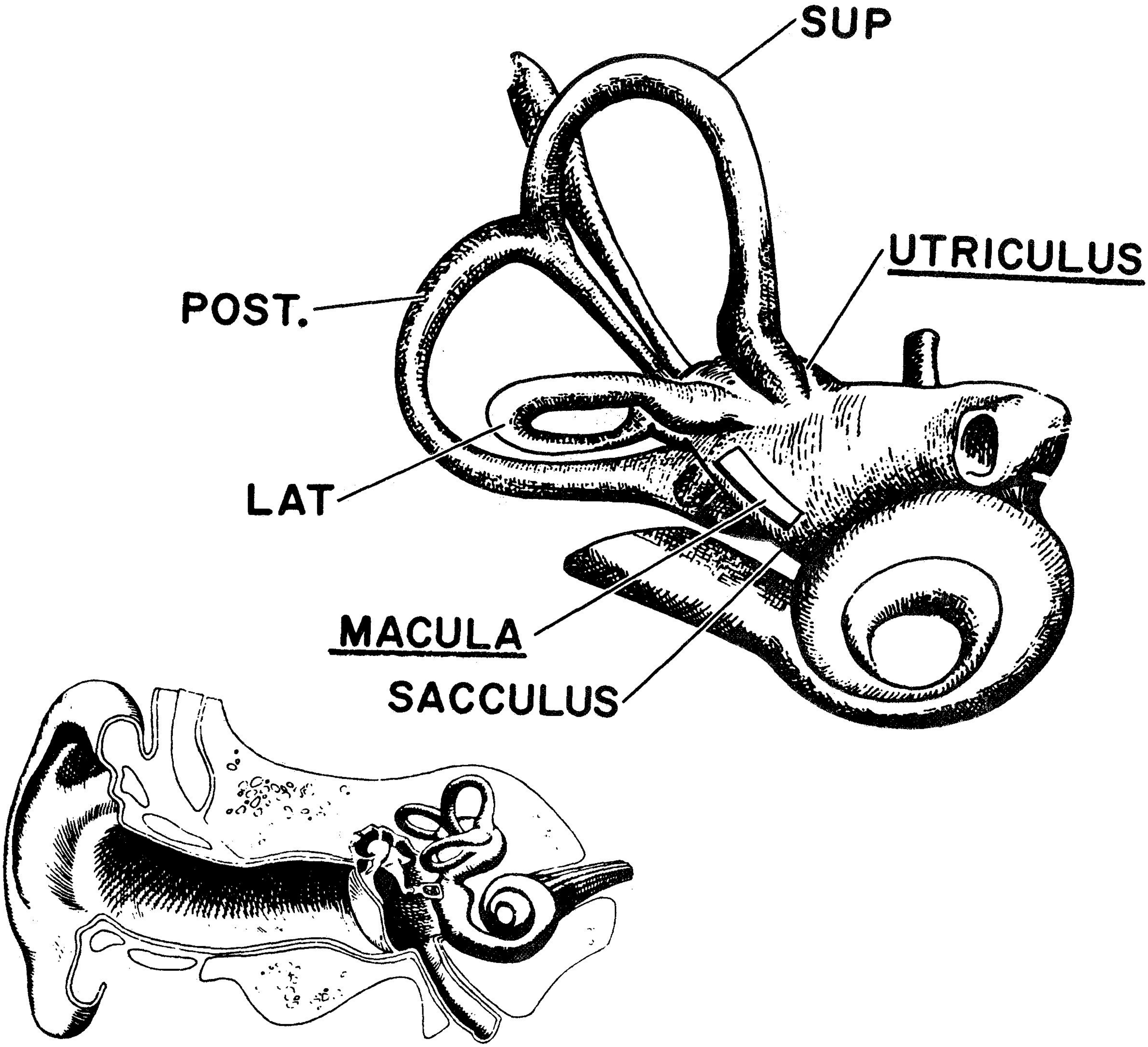
When the otolith bodies shift, bending the stereocilia toward the kinocilium, the sensors are stimulated and issue electrical impulses. When stereocilia are bent in the opposite direction, the sensors are inhibited and no signal is issued. (Figure 3).

Nerves from the bottom of the sensor cells converge into a nerve fiber. The nerve fibers run in bundles, forming one branch of the vestibular nerve. Through this network, information from the vestibular organs is sent to the medulla, a part of the brain, for analysis.

Since the information is carried in the form of electrical activity, it may be picked up by monitoring the nerve with microelectrodes small enough to establish contact with only one fiber. This is the technique used with the frog otoliths in the OFO experiment.

The electrical activity carried along the nerve fiber from the otolith cells consists of pulses of current. The relevant information is the length of the interval between the pulses. Their shape and amplitude are unimportant.

The otolith cells act as accelerometers. When the unit is activated by increasing acceleration, the firing rate increases and the interval between pulses decreases. When the unit is deactivated by opposite movement of the otolith bodies, the sensor is suddenly blocked, and a pause in pulse firing results.



Vestibule situated in the inner part of the Ear

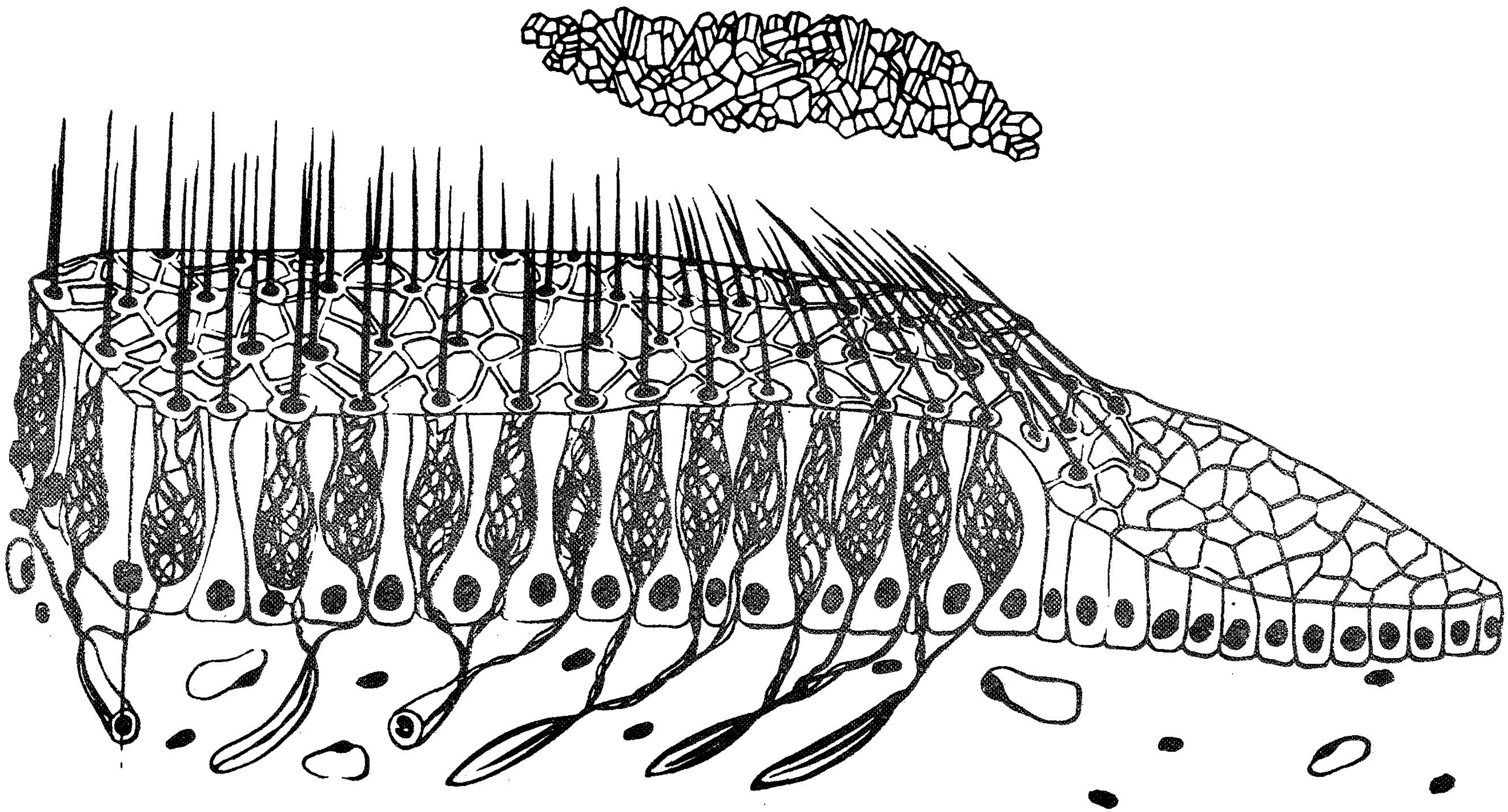


Figure 2

THE MACULA

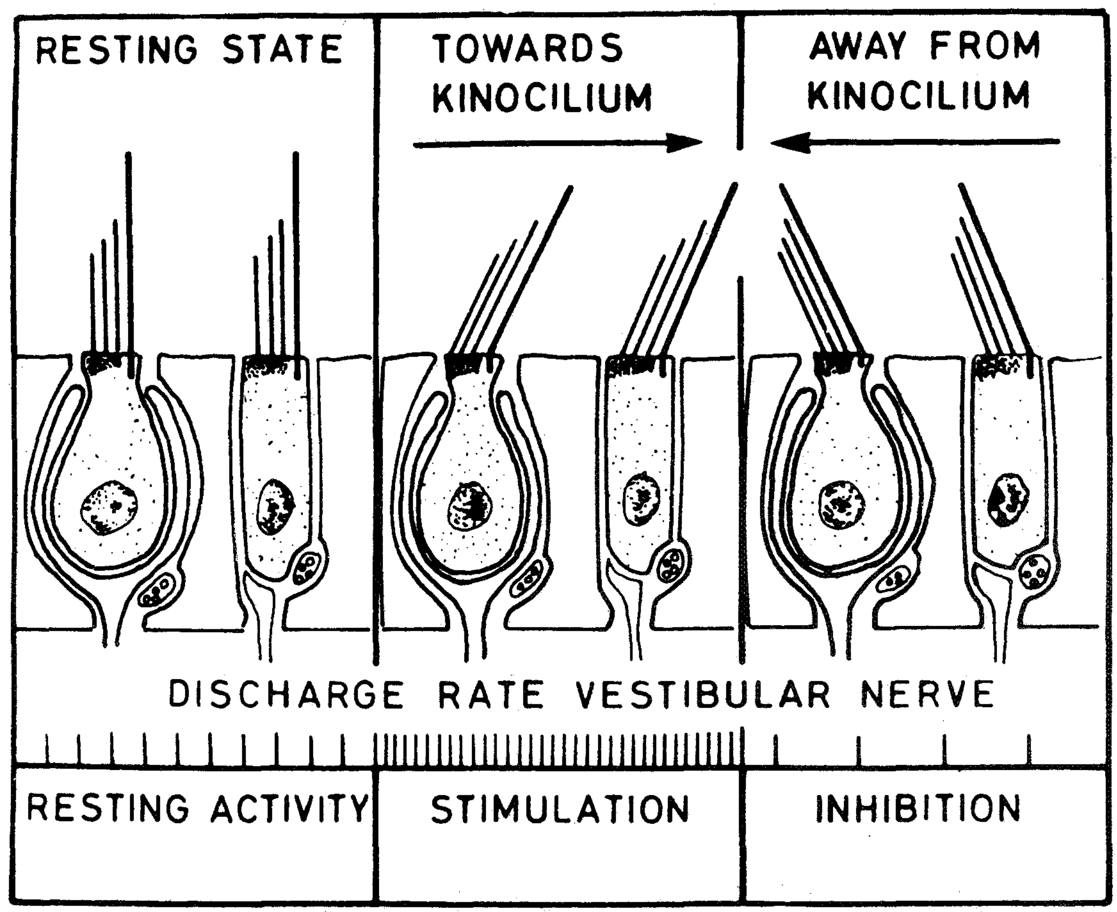


Figure 3

Displacement of Sensory Hair and corresponding Otolith Activity

OFO SPACECRAFT

The OFO spacecraft weighs 293 pounds, is approximately 30 inches in diameter and 47 inches long. Its lower, octagonally-shaped section houses the electronics and, the upper section, with a heat-control shield covering the water-filled centrifuge, houses the two frogs, in a truncated cone with a spherical cap (Figure 4).

The spacecraft mates directly to the standard Scout "E-Section" which protrudes through the Radiation Meteoroid spacecraft. The OFO exterior has a combination of thermal control finishes.

Exterior protuberances include five antennas canted at 45 degrees to support the onboard telemetry, command and beacon subsystems. The yoyo despin assembly is located around the girth of the spacecraft. Four triple-fold booms are located radially around the spacecraft at 90 degree intervals and are folded against the side of the spacecraft.

After separation from the launch vehicle, the spacecraft releases the yoyo despin subsystem and essentially despins to zero rpm, after which the four booms are released and extend 78 inches from the side of the spacecraft.

The resultant increase in the spacecraft's roll movement of inertia caused by the extension of the booms will maintain the g level on the experiment below the 0.001 (10^{-3})-g requirement when the centrifuge is not operating.

The spacecraft for this mission was designed and built by the Space General unit of Aerojet General Corp., El Monte, Calif. The design is an outgrowth of the OV3 satellite concept, developed earlier by Aerojet as a general utility satellite for integration with the Scout launch vehicle.

The spacecraft is unique in that the experiment can be "plugged in" very late in the launch countdown. This capability was required because of the biological nature of the experiment.

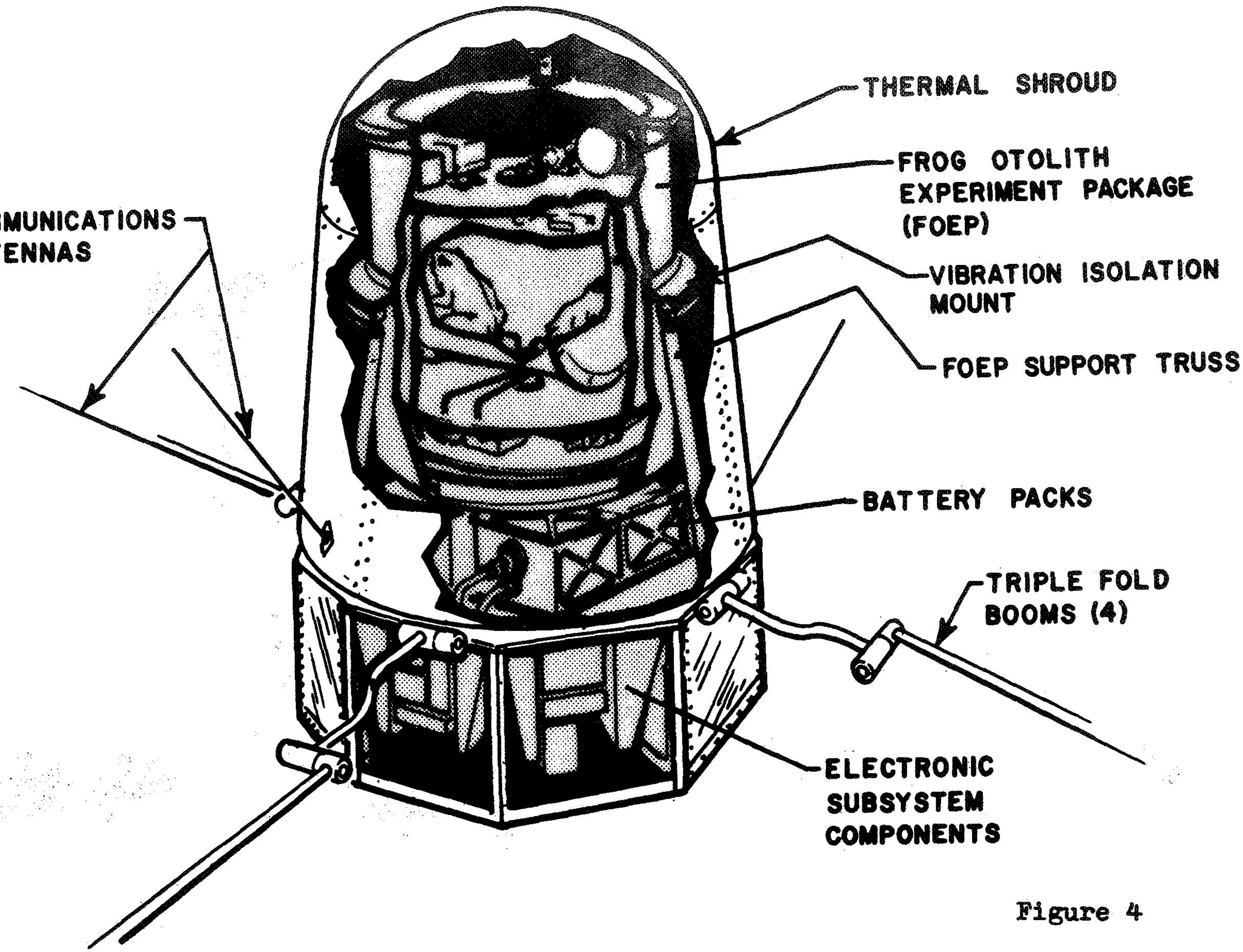


Figure 4

ORBITING FROG OTOLITH SPACECRAFT

FROG OTOLITH EXPERIMENT PACKAGE (FOEP)

All apparatus necessary to assure survival and normal function of the two frogs is contained in the Frog Otolith Experiment Package (FOEP).

The specimens are housed in a water-filled, self-contained centrifuge (Figure 5) which supplies the test acceleration.

Instrumentation to collect and amplify otolith signals, EKG, water temperature and pressure, and general housekeeping data is also in the package.

The FOEP is encased in a pressure-tight container approximately 18 inches in diameter and 18 inches long. Its loaded weight is about 91 pounds. The sealed FOEP will be delivered to the spacecraft-Scout combination five hours before launch. Installation requires about one hour.

The FOEP was designed and fabricated by the Applied Physics Laboratory of Johns Hopkins University under contract to the NASA Ames Research Center. Ames is responsible for the FOEP and has assisted in the engineering and development of the necessary microelectrodes, bio-amplifiers and data-reduction techniques.

FOEP Life Support System

Since survival and normal functioning of the frogs from launch through orbit must be assured, the FOEP contains a life support system (LSS) to maintain a regulated environment for the frogs. The LSS has been designed to meet the physiological requirements of two frogs weighing approximately 350 grams (0.7 pound) each.

The frogs are demotorized (the limb nerves cut) to prevent them from dislodging the implanted electrodes and to reduce their metabolic rates. In this condition, the frogs require no artificial respiration and will remain healthy, without being fed, for as long as a month.

The frogs are completely immersed in water after being installed in the centrifuge. The water serves as the medium which carries oxygen to the frogs' skin and carries away heat and carbon dioxide.

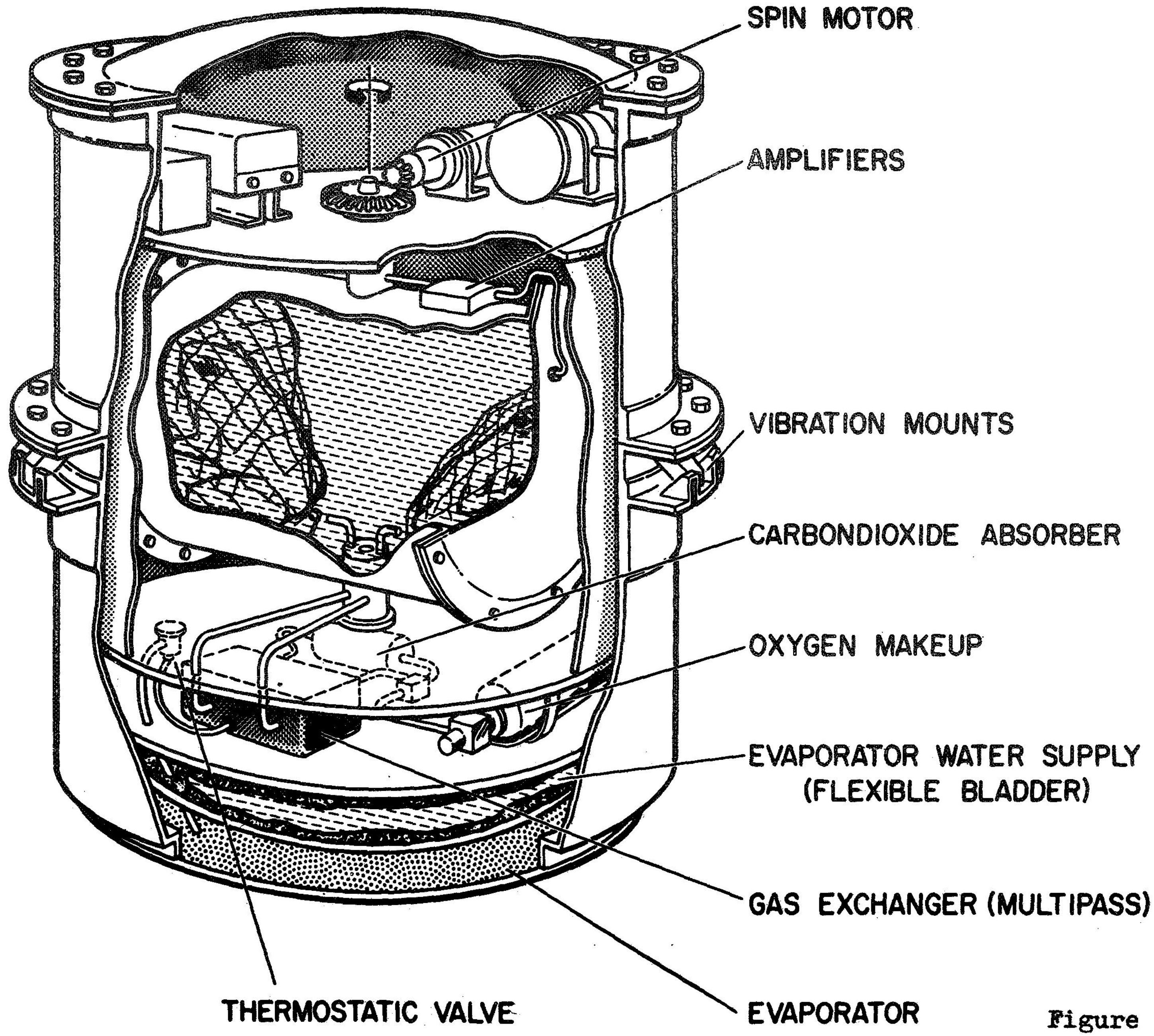


Figure 5

FOEP Cutaway and Interior Views

The LSS consists of two closed loops--one containing liquid and the other containing gas. The interface between loops occurs at a selectively permeable membrane of silicon rubber which separates the liquid and gas. The membrane, called the lung, passes oxygen from the gas to the liquid side and carbon dioxide from the liquid to the gas side. The frogs (in the centrifuge) are in the liquid loop which, from the lung to the frogs, contains water and dissolved oxygen and, from the frogs back to the lung, contains water and free carbon dioxide. The water is circulated by a small pump.

Since the frogs are continually shedding pieces of skin and other matter, it is necessary to provide a fine filtration material around them to prevent fouling of the water circulation system. This is accomplished by lining the interior of the centrifuge with a double layer polyurethane foam, water leaving the centrifuge must first pass through this filter.

The gas loop consists of a circuit through which oxygen is circulated by a small pump. The pump drives pure oxygen to the lung (the permeable membrane) where some of it passes into the liquid loop and the rest of it becomes mixed with carbon dioxide coming from the liquid loop.

From the lung, the oxygen-carbon dioxide mixture is passed through a bed of Baralyme which absorbs carbon dioxide. The pure oxygen is returned from the Baralyme to the pump and recirculated.

As oxygen is used by the frogs, the supply is replenished by gas from the small oxygen tank.

The LSS will be used as well for the gentle and humane asphyxiation of the frogs when the mission objectives are accomplished. Recovery of the OFO experiment is not required. Buildup of carbon dioxide and removal of fresh oxygen will bring on expiration of the specimens.

The LSS provides for limited control over the temperature of the frogs' environment by means of a water evaporator which, augmented by the thermal environment of the spacecraft, will maintain the water temperature at $60° \pm 5°F$.

PRELAUNCH PROCEDURES FOR OFO

The use of live animals and the complexity of the microelectrode implantation technique requires that the experiment package be placed aboard the spacecraft as close to the actual launch time as possible.

Instrumentation, checkout and selection of the frogs requires several days, and a fully equipped neurophysiology laboratory. While EKG electrodes can be fixed under the frog's skin in the general area of the anterior thorax in a few minutes, the implantation of the microelectrodes in the vestibular nerve requires much longer.

Each frog is immersed in a five-percent solution of tricaine methane-sulphonate to assure an anesthetized state while the main motor nerves are cut to provide complete immobilization and a tiny hole is drilled to expose the vestibular nerve. Two silk sutures, to later secure the pre-amplifiers, are passed through each side of the jaw. Two silver wires are conducted through the central bone to fix firmly the microelectrodes' output connections.

Twenty-four frogs will be prepared for installation of electrodes, but the field will be narrowed to 12 by 36 hours before launch.

Thirty-six to 12 hours prior to launch, the microelectrodes are implanted in the nerve of each frog and the four best subjects are selected to go in the prime and backup experiment packages. The backup package will be used as a ground-control unit for comparison of data with that from the flight unit.

After the microelectrode implantation, the frogs will be sealed inside the inner cylinders of the flight and backup packages, immersed in water, and sustained by the package life support systems. Extensive cycling of the centrifuge will provide baseline data for comparison with data obtained later in flight.

After verification of proper experiment operation the Frog Otolith Experiment Package (FOEP) will be sealed and then monitored until delivered to the spacecraft/launch vehicle combination five hours before the launch.

If a malfunction occurs in the package during the prelaunch processing activities, the backup unit can be substituted for the prime FOEP. If the backup unit is flown, the prime package will be prepared for use as a ground control (comparison package) during the flight.

IN-FLIGHT OPERATIONAL PROCEDURES FOR OFO

Real-time transmission of experiment data during launch will furnish valuable information concerning the response of the otolith to vibration, acceleration, and subsequent weightlessness.

As soon as operational activities in orbit permit and the satellite is stabilized at 0.001 "g", the centrifuge cycle will be activated to investigate the otolith's accomodation to gravity stimulus during early periods of weightlessness.

Each cycle lasts about eight minutes and consists of the following:

1. A period of one minute with the absence of acceleratory stimulation.

2. A period of approximately 8 seconds for the slow starting of rotation, furnishing information on the responses to a transient excitation.

3. Fourteen seconds of constant 0.5 "g" acceleration, giving response at a steady excitatory level.

   The main information will be the so-called adaptation profile - the change in the unit activity as a function of time at a fixed level of stimulation.

4. About 8 seconds for slow stopping of rotation.

5. A six-minute period showing after-effects of the stimulation.

One cycle will be performed every 30 minutes during the first 3 hours of the orbital flight, starting as close as possible to orbit injection and satellite stabilization. Cycles for the remaining 21 hours of the first day of the experiment will be carried out every hour.

An interval of 10 hours will follow in which no centrifuge cycles are performed. During this period, a "quick-look" analysis of the available data will provide the basis for choice of the subsequent experimental routine.

After the 72nd hour of flight, another 10-hour quiescent period will allow time for "quick-look" analysis, evaluation, and determination of routine for the remainder of the mission.

THE RM SPACECRAFT

The Radiation Meteoroid spacecraft weighs 46.3 pounds. Its flight configuration, including the fourth stage of the Scout to which it remains attached, is 5 1/2 feet long and 30 inches in diameter.

The spacecraft consists of two cylindrical segments--the 15-inch-deep solar cell array mounted doughnut-like around the fourth stage motor case of the Scout and the electronics package encircling the E-section, the cone-shaped adapter section atop the fourth stage motor case.

The RM spacecraft has a power system, radio system (antennas, command receiver, telemetry transmitter and tracking beacon), radiation instruments and meteoroid instruments, and data-handling units.

Power System: A system of rechargeable batteries and solar cells with automatic charge control provides approximately 25 watts of power at 28 volts.

The cylindrical solar cell array has about seven square feet of solar cells that convert sunlight directly to electrical energy.

The charge control unit will control the battery charge operation automatically but may also be controlled from the ground in case of battery cell failure.

Two nickel-cadmium batteries will supply power to the experiments during dark periods.

Radio System: The antenna subsystem uses two short monopoles attached opposite each other and angled outward from between the solar array and the instrument package.

The command system is a tone-sequential type which commands experiment data runs to the Space Tracking and Data Acquisition Network (STADAN) ground stations.

The telemetry system consists of a transmitter, encoder, timer and magnetic core memory.

The tracking beacon, a 50-milliwatt, unmodulated transmitter, will be on at launch and for the lifetime of the satellite for accurate tracking and definitive orbits for radiation data analysis.

Radiation Instruments: The radiation experiment consists of an Advanced Dosimetry System (ADS) and three standard ionization chambers.

The ADS is composed of a solid state radiation spectrometer and a spectrum-to-dose converter.

The spectrometer has multiple viewing angles and its three solid state detectors are selectively sensitive to electrons and protons. The unit will measure the electrons with energies ranging from 0.6 to 4 million electron volts (MeV) and protons with energies from 10 MeV to several hundred MeV.

The converter applies appropriate weighting factors for real-time dose (energy absorption) determination. The output is accumulated by a counter for each particle type and stored in the memory for each data run. Results are sent by telemetry to the STADAN stations.

Conventional dose measurements will be obtained by three standard ion chambers filled with a mixture of argon and helium gas. Penetrating radiation ionizes the gas, causing a flow of current that is measured and converted to dose rates for relay to the telemetry system.

One ion chamber is unshielded and the other two are shielded. The dose range of the unshielded one is from 0.01 to 100 rads per hour.

Results will be evaluated with regard to possible dosages that could be experienced in prolonged extra-vehicular activities as well as activities inside spacecraft.

Meteoroid Instruments: There are two flat meteoroid detection surfaces, or plates, parallel to each other and spaced three inches apart. Each plate is eight inches square and is made up of a mosaic of one-inch square thin-film capacitors electrically connected in one-by-eight-inch rows. Each individual capacitor, or square, is identified in the electronics for meteoroid impact position information.

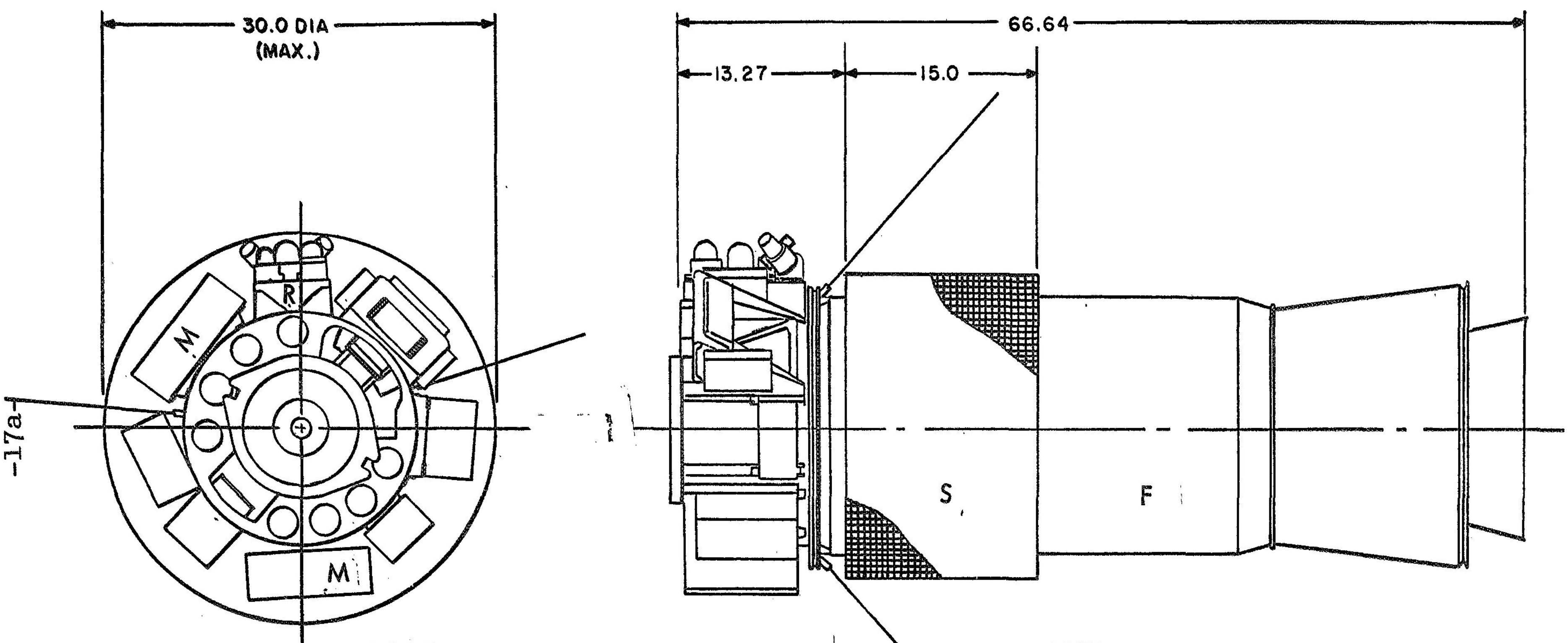
When a meteoroid penetrates a capacitor, it produces a current pulse, or signal.

Signals from the outermost plate will be used to record the meteoroid flux, number of penetrating impacts. Signals from both plates will be used to measure meteoroid speeds and directions.

The thin-film sensors are made of four layers of 1,000 Angstrom (A) thick polysulfone with 200 A of gold on the back and 1,000 A of aluminum on the exposed side. The total thickness of each thin-film capacitor is about 0.00022 of an inch or 5,200 A.

A meteoroid mass of 10^{-14}gram, (0.00000000000001 gram) or larger is required to penetrate the first surface. The mass must be greater than 0.000000000001 gram (10^{-12}grams) to penetrate both surfaces and, thereby, yield speed and direction measurements.

Two independent, but identical, meteoroid detector packages are mounted on the spacecraft.



CODE:

R - Radiation Package
M - Meteoroid Detector (2)
S - Solar Cell Array
F - Fourth Stage of Launch Vehicle

NOTE:
ALL DIMENSIONS ARE IN INCHES.

RADIATION AND METEOROID SPACECRAFT

Figure 6

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RADIATION EXPERIMENT AND BACKGROUND

In 1958, a geiger counter aboard Explorer I detected a radiation region of high count-rate starting at an altitude of about 1,000 kilometers, or 620 miles. This effect was verified later that year when Explorer III showed the same results. The high-count rates came from charged particles, both electrons and protons, trapped in the Earth's magnetic field, the Van Allen radiation belts.

Space radiation dose measurements during Project Mercury established the region of the South Atlantic Magnetic Anomaly as the principal source of ionizing radiation in low altitude non-polar orbits.

The anomaly is a region, between South America and Africa, where the trapped radiation of space stays 400 to 500 miles below that elsewhere around the Earth, ranging down to altitudes as low as 125 miles (200 kilometers). The area covers from the Equator to 40 degrees South latitude and from 90 degrees West to about zero degrees longitude.

Measurements made since 1958 by satellites and sounding rockets have provided additional information on the nature and characteristics of trapped radiation. Of particular interest are findings made during the Mercury, Gemini, and Apollo missions.

The measurements have shown that low-altitude, low-inclination, Earth-orbital flights and limited excursions to altitudes penetrating the trapped radiation belts are possible without overexposing spacecraft crew members.

The spectral data to be measured by the Advanced Dosimetry System on the RM spacecraft will be converted to physical dose in real time and the results will be compared to the dose measured by standard ionization chambers similar to those previously flown on manned flights.

The particle energy spectra data obtained by the Advanced Dosimetry System also will be of scientific value. The charged particle environments are known to be affected by magnetic storms, solar cycle perturbations and high altitude nuclear tests. Any spectral data which can be received and analyzed in a timely manner could be used to update the model environments used in estimating doses for mission planning purposes.

The measurement of dose, is of more significance as mission durations increase.

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METEOROID EXPERIMENT AND BACKGROUND

Uncertainty concerning the meteoroid environment remains and better knowledge is required for the proper design of spacecraft meteoroid protection. The required meteoroid parameters include: mass, speed, trajectory, impact flux, composition, and density. This meteoroid experiment consists of a new detector for measuring meteoroid impact flux, of particles greater than 10^{-14} grams, and speed and trajectory of particles greater than 10^{-12} grams.

The first measurements of meteoroid velocity were based on ground-based observations of meteors in the Earth's atmosphere.

Early flight instruments measured impact momentum with piezoelectric devices. An estimate of the meteoroid mass measured by these devices was determined by assuming the meteoroid velocities were the same as the meteoroid velocity distribution determined from the ground-based meteor observations.

The first flight instruments to directly measure meteoroid velocity were velocity "telescopes" consisting of cylinders, 2.5 cm. in diameter and 10 cm. long. A thin-film plasma sensor was at the front and a thin-film capacitor on a glass substrate was the rear station. Signals resulting from a meteoroid penetration of the films were used to measure time-of-flight (TOF) in the cylinder. This type instrument was used on Orbiting Geophysical Observatory (OGO)-1, 2, and 3.

Only four velocity measurements were obtained with the OGO-1 instrument, possibly two with OGO-2, and three with OGO-3.

The instrument operational today on the sun-orbiting NASA Pioneer 8 and 9 probes is designed to measure the velocity (speed and direction) and momentum of meteoroids in interplanetary space.

It consists of a front film grid sensor array and a rear film grid sensor array spaced 5 cm. apart and an acoustical impact plate upon which the rear film is mounted.

Each film grid sensor is 4 square inches with collection screens on both sides of the thin film.

The sensor and logic are constructed such that the penetration in each plane is located within one square inch for trajectory determination. The time of flight between sensor arrays serves the principal objective of the instrument. Nine velocity measurements have been made on Pioneers 8 and 9.

The meteoroid experiment in the RM spacecraft represents an improvement in providing a larger area (64 square inches) for obtaining useful data.

TRACKING AND DATA ACQUISITION

Monitoring and control of both spacecraft will be by Goddard Space Flight Center Space Tracking and Data Acquisition Network. The STADAN stations that will directly support the OFO mission are in Johannesburg, South Africa; Tananarive, Malagasy Republic; Orroral, Australia; Santiago, Chile; Quito, Ecuador; Fort Myers, Fla.; Kauai, Hawaii; and Rosman, N.C.

Rosman will be the primary OFO station because the data acquired there can be microwaved to Goddard in real-time, or near real-time, for the data processing required to effect control of the experiment. The quick-look data analysis will be performed at Goddard by the principal investigator.

Both the OFO and the RM spacecraft will have almost simultaneous station passes during the first few days after launch. The Orbiting Frog Otolith has priority over the Radiation Meteoroid Satellite for the duration of OFO's mission, normally five days.

The same STADAN stations supporting OFO will be used for RM during its three-month planned lifetime.

SCOUT LAUNCH VEHICLE

Scout is NASA's only solid propellant launch vehicle with orbital capacity. The first developmental Scout was launched July 1, 1960. The OFO and RM mission will be the 68th Scout launch. Since the Scout was recertified in 1963, the launch vehicle has attained a 93 percent success record.

Scout B is a four-stage solid propellant rocket system. Scout No. S-174 and the two spacecraft will be set on an initial launch azimuth of 88.994 degrees to obtain a posigrade orbit of 170 nm perigee and 320 nm apogee with 37.7 degree inclination and 93.5 minutes to complete one revolution.

The four Scout motors, Algol II, Castor II, Antares II, and Altair III, are interlocked with transition sections that contain guidance, control, ignition, and instrumentation systems, separation mechanics and the spin motors needed to stabilize the fourth stage. Control is achieved by aerodynamic surfaces, jet vanes and hydrogen peroxide jets.

The launch vehicle is approximately 73 feet long and weighs about 40,000 pounds at liftoff.

The Scout program is managed by NASA's Langley Research Center, Hampton, Va. The launch vehicle is built by Ling-Temco-Vought, Inc., Dallas.

LAUNCH SEQUENCE

Event	Time (seconds)
Liftoff	-
First Stage Burnout	76.7
Second Stage Ignition	81.0
Second Stage Burnout	123.2
Third Stage Ignition	140.0
Third Stage Burnout	175.0
Spin-up	442.0
Third Stage Separation	443.7
Fourth Stage Ignition	449.0
Fourth Stage Burnout & Orbital Injection	482.3
Spacecraft Separation	528.6

OFO MISSION MANAGEMENT

The NASA Office of Advanced Research and Technology (OART) has overall responsibility for the OFO spacecraft program. The project is part of the program of the OART Biotechnology and Human Resources Division. Program management responsibility is assigned to the OART Special Programs Office. Project management is assigned to the NASA Wallops Station, Wallops Island, Va. The NASA Ames Research Center, Mountain View, Calif., manages the Frog Otolith Experiment Package (FOEP). Tracking and data acquisition support is provided by the NASA Goddard Space Flight Center, Greenbelt, Md.

OFO Contractors

The OFO spacecraft was designed and built by the prime contractor, Space General, a unit of Aerojet-General Corp., a subsidiary of General Tire & Rubber Co. Space General is in El Monte, Calif.

The FOEP was built by the Applied Physics Laboratory of Johns Hopkins University. APL is in Howard County, Md.

OFO Key Personnel

W. A. Guild	OFO Program Manager	NASA-OART
L. C. Rossi	OFO Project Manager	NASA-Wallops
T. Warren	OFO Project Manager	Space General
R. W. Dunning	Exp. Program Manager	NASA-OART
R. W. Magers	Experiment Coordinator	NASA-Ames
E. Marshall	Experiment Coordinator	APL
T. C. Moore	Tracking & Data Manager	NASA-GSFC
Dr. T. Gualtierotti	Principal Investigator	Univ. of Milan

RM MISSION MANAGEMENT

The NASA Office of Advanced Research and Technology (OART) has overall responsibility for the RM spacecraft program. The project is part of the program of the OART Space Vehicles Division. Program management responsibility is assigned to the OART Special Programs Office. Project management is assigned to the NASA Manned Spacecraft Center, Houston, Texas. Tracking and data acquisition support is provided by the NASA Goddard Space Flight Center, Greenbelt, Md.

RM Prime Contractor

Prime contractor for the RM spacecraft is Ling-Temco-Vought, Inc., Dallas, Texas.

RM Key Personnel

W. A. Guild	RM Program Manager	NASA-OART
W. E. McAllum	RM Project Manager	NASA-MSC
Dr. B. J. Farmer	RM Project Manager	LTV
C. T. D'Aiutolo	Meteoroid Exp. Manager	NASA-OART
A. Reetz	Radiation Exp. Manager	NASA-OART
T. C. Moore	Tracking & Data Manager	NASA-GSFC
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W. E. McAllum	Met. Co-investigator	NASA-MSC
R. L. Patterson	Met. Co-investigator	NASA-MSC
Dr. J. H. Johnson	Met. Co-investigator	LTV

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