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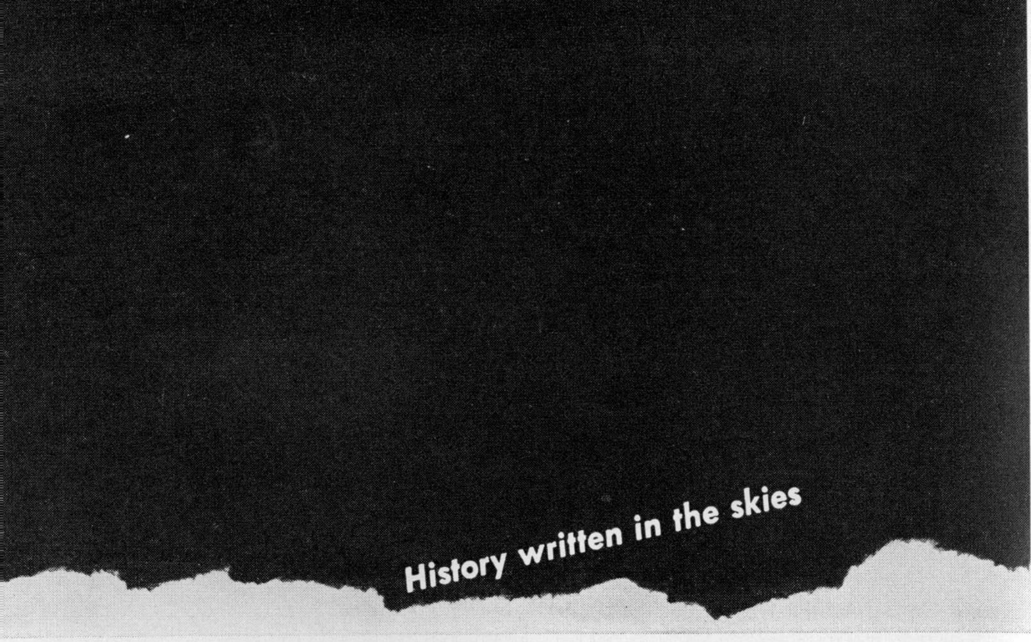
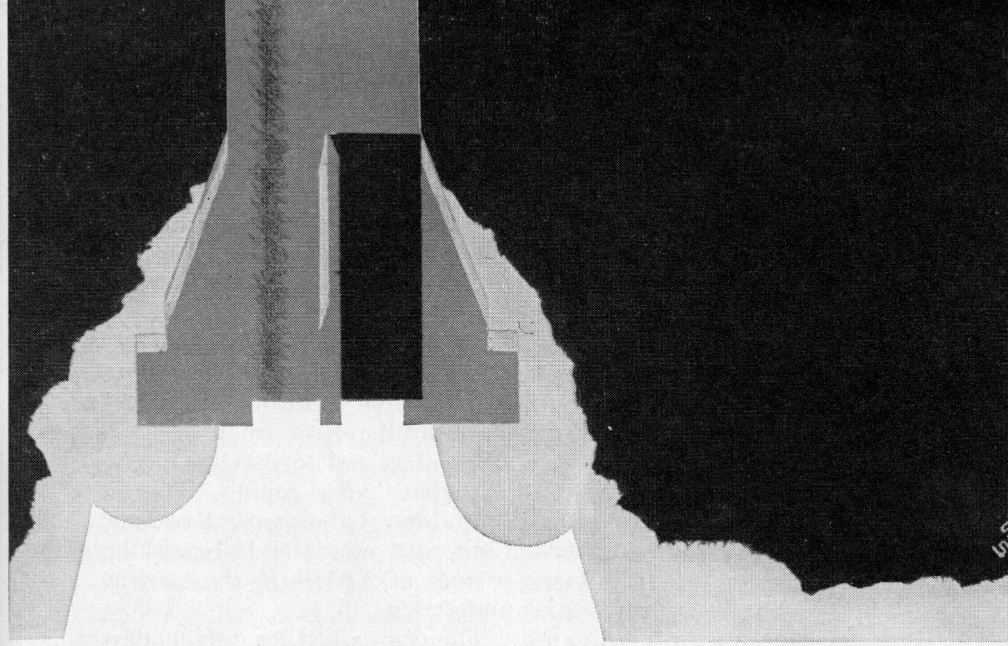
OCTOBER 1958

# ARMY INFORMATION DIGEST

# THE ARMY IN THE SPACE AGE

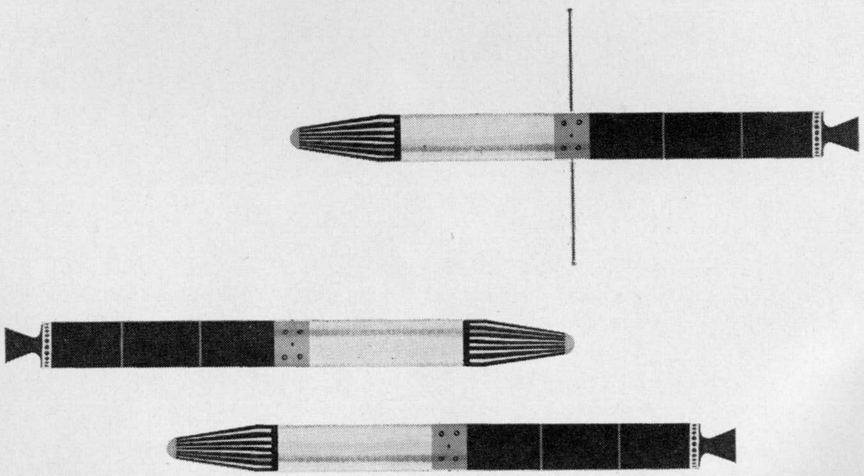
THE OFFICIAL U. S. ARMY MAGAZINE



# THE EXPLORER SATELLITES

## and how we launched them



**Major General J. B. Medaris**

IN MORE than a million years of existence on earth, until the twentieth century, man was limited in his explorations to a thin terrestrial patina that supported his lateral wanderings.

By the middle of this century man had crawled to the peak of the highest mountain, probed the ocean's depths, and survived polar winters. His greatest travel triumphs came when he took to the air in flying machines, and within fifty years could circle half the globe non-stop, and climb nearly twenty miles above the clouds to survey a curving world below.

In this new-found quietness nearer the stars, man could not still an inward clamor to reach further toward infinity.

The first step upward was made by the Soviets, who gathered the fruits of a combined military-scientific research program to launch the earth's first satellite on 4 October 1957.

A startled Free World turned searching eyes from the circling Sputnik to preparations in the

*MAJOR GENERAL J. B. MEDARIS is Commanding General, U. S. Army Ordnance Missile Command, Huntsville, Alabama.*

United States for launching scientific satellites as America's contribution to the International Geophysical Year.

To implement this program, the U. S. Army, which had had pronounced success in long-range ballistic missile development, was given a new mission on 8 November 1957.

On that date the Department of Defense directed the Army Ballistic Missile Agency to prepare for an IGY satellite launching, using the Jupiter-C missile as the carrier.

ABMA was then less than two years old, having been activated 1 February 1956. But it was in an enviable position. Commanded at that time by the writer, with Dr. Wernher von Braun as Director of the Development Operations Division, its personnel comprised the Free World's most experienced missile team.

Its accomplishments were many. While under the leadership of Major General H. N. Toftoy at Redstone Arsenal, it had developed the 200-mile range Redstone.

After the formation of ABMA it had worked under crash procedures to refine the Redstone and place it in the hands of troops as soon as possible, and to develop the intermediate range Jupiter. The Jet Propulsion Laboratory, Pasadena, California, was the full working partner of ABMA in the satellite undertaking.

The team asked for only 90 days before launching.

On the 84th day following the order to prepare, Explorer I was launched from Cape Canaveral, Florida. It left the pad at 10:48

## The Less You Know, The Easier It Looks

**THE big headlines make it look easy when a man-made satellite goes into orbit, but for those who know the story behind the headlines, the putting up of a satellite is perhaps the most delicately complicated task man ever has set for himself. The scientific knowledge of thousands of men, the technical skills of other thousands are necessary to make just one successful shoot.**

**At the Army Ballistic Missile Agency, Huntsville, Alabama, 3,200 dedicated military and civilian scientists and technicians working as a single-minded team with the 2,000 equally competent and dedicated scientists and technicians at the Jet Propulsion Laboratory, Pasadena, California, were needed to put up the Explorers. If only one of these more than 5,000 men and women had made an undetected error, the end-results might have been an anti-climactic flop.**

**Complexity of the satellite itself, apart from the propulsion systems, is suggested by the fact that one of the simpler devices on Explorer III is a miniature tape recorder, developed by the State University of Iowa, that collected data on cosmic radiation encountered during the total orbit, played the information back on a signal from a ground station, after which the tape was automatically erased and reset, to be used again and again.**

**Other larger and more advanced satellites will follow the Explorers, each contributing something to the knowledge of space-searching man. There will be new concepts of peaceful as well as military uses, such as the all-seeing eye, the manned platform in space, world-wide communications relay stations, perfect weather forecasts, possibly weather control, and continuously unfolding knowledge of the universe. No man now can foresee more than a few of the wonders, the surprises to be encountered in investigation of space—the vastest of the frontiers that have challenged and lured man onward in progress.**



p.m., Eastern Standard Time, 31 January 1958.

Seven minutes later, when it was placed in orbit, tense and jubilant workers relaxed for the first time in weeks. Other giant strides, some perhaps more spectacular in themselves, will be taken as man explores the universe. Few will equal Explorer I in public acclaim. It signaled the advent of the Space Age for the United States and friendly nations. The "Open House" observance of ABMA's second birthday at Huntsville the next day was transformed from a birthday party to a jubilant celebration by Huntsville citizens.

WITHIN five weeks after the successful orbiting of Explorer I, on 5 March 1958, the ABMA team was ready to try again. But this shoot was disappointing. After a highly successful launching of the first main stage, Explorer II was pushed rapidly on its course by the solid propellant second and third stages. But the fourth and final stage motor, which would have given the satellite orbital velocity, failed to ignite.

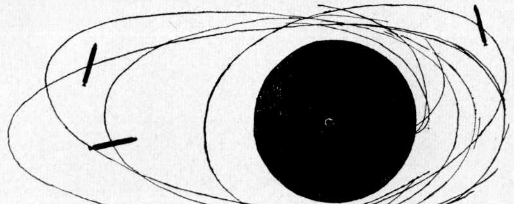
The next day another Jupiter-C missile from ABMA arrived at Cape Canaveral, and the elaborate and careful checkout procedure began. Carrying a satellite with instrumentation for experiments exactly like that in Explorer II, it was successfully launched on 26 March 1958, and Explorer III was placed in orbit.

In a repeat performance, on 26 July, still another Explorer was propelled into orbit by the mighty surge of a Jupiter C missile. Identical in external configuration to its predecessors, Explorer IV carried advanced instrumentation, including four separate radiation counters, which brought its weight to 38.43 pounds. Moving in a highly elliptical orbital band covering most of the earth's surface, Explorer IV was designed to investigate the phenomenon of high corpuscular radiation intensities detected by the earlier Explorers.

IT IS impossible for those not directly connected with the effort to appreciate the tremendous amount of dedicated labor, the variety of skills and ingenuity, painstaking care and high degree of teamwork necessary to erect these milestones. The story is that of a group of military and civilian specialists who had confidence, tenacity, experience and ability.

THE Explorers were placed in orbit by the Jupiter-C rocket, a four-stage vehicle which was originally conceived in 1955. During the Spring of that year, Army missile developers at Redstone Arsenal, under the technical leadership of Dr. Wernher von Braun, submitted a satellite proposal to the Department of Defense entitled Project Orbiter. This was prepared in cooperation with the Navy Bureau of Ordnance and the Jet Propulsion Laboratory.

The main stage for Project Orbiter was to be the Army's Redstone liquid-fuel ballistic missile,



developed at Redstone Arsenal under military direction by Dr. von Braun's group. The Redstone was to be capped by high-speed upper stages consisting of clusters of small solid propellant motors.

Later that year Project Orbiter was abandoned in favor of Project Vanguard, a more sophisticated design submitted by the Naval Research Laboratories.

Early in 1956, after the Army had been assigned the job of developing the Jupiter Intermediate Range Ballistic Missile, it was decided that the staging concept and the work already accomplished on Orbiter could make a great contribution to the Jupiter program.

## RE-ENTRY SOLVED

THE aerodynamic heating problem associated with the re-entry of a ballistic missile had to be solved. This was one of the most challenging aspects of the IRBM program. The Army Ballistic Missile Agency, again joined by JPL, decided to use the Project Orbiter principle in this vital work.

The plan was to modify the proven Redstone workhorse missile for the main stage, and add solid propellant upper stages and a scaled-down Jupiter IRBM nose cone. Experiments on nose cone re-entry could then be made without the expense and added delay of waiting until the Jupiter itself was ready for test launchings.

The experimental missile was named the Jupiter-C because of its role in the Jupiter development. The C is an abbreviation of "Composite Re-entry Test Missile."

THE first launching of the Jupiter C, conducted in September 1956, was a complete success. The inert final stage traveled more than 3,000 miles southeast from Cape Canaveral, Florida, and reached an altitude of more than 680 miles. Other tests followed, and a significant step toward solving the re-entry problem for the Jupiter IRBM was achieved on 8 August 1957. President Eisenhower exhibited a Jupiter-C nose cone in November, announcing that the United States had found a workable solution to the aerodynamic heating problem. That cone was recovered by the Navy.

Attaining a promise of a satisfactory solution so early in the experiments was beyond the Army's fondest expectations. Several other Jupiter-C flights had been scheduled, but these were cancelled after the August success, and the hardware became available for other purposes.

## PREPARING THE SATELLITE

WHEN the satellite launching order was received, much of what was required to do the job was already on hand, as a result of the re-entry experiments. Some preliminary work, dating back to Project Orbiter, had been performed on the satellite proper and orbit calculations. Certain modifications, however, were required on the launching vehicle. These were carried out by ABMA, which was responsible for the main stage, and JPL, which provided the high-speed upper assembly.

For its satellite carrier role, the Redstone was modified as follows:

1. Tanks were lengthened to hold more fuel and oxidizer.

2. A unique fuel mixture known as "hydyne" was employed in place



of the alcohol used in the tactical Redstone.

3. The forward section of the Redstone was modified to support the launcher of the high-speed stages, which consists of a spinning cylindrical "tub," supported on the axle and spun by electric motors in the Redstone nose section.

4. A special attitude control system was designed which positions the forward section of the Redstone booster to fire the high-speed stages in the correct direction at the apex of the booster trajectory.

The second stage of the missile consisted of a cylindrical ring of eleven solid motors, each six inches in diameter and approximately four feet long, each containing about fifty pounds of a solid propellant in a stainless steel case.

Fitting within the ring of eleven motors were three identical motors which compose the third stage. The final stage of one motor, with the satellite payload attached, was then added. The fourth stage motor was made of a slightly more energetic type fuel than that in the other stages.

## LABORATORY CONTRIBUTIONS

THE 84 days prior to the first launching were filled with orderly, careful preparation at the Huntsville, Alabama, installation and the Pasadena Laboratory. Heading the work for the Army was Dr. von Braun, while Dr. J. E. Froehlich was in charge of the project at JPL.

Laboratories at the Missile Agency, staffed by some 3,200 military and civilian scientists, engineers and technicians, contributed specialized knowledge and skills to the Jupiter-C program. Only by examining their total contributions, and those of the 2,000 scientific and technical personnel at JPL,

*Actual size model of satellite is examined by Maj. Gen. J. B. Medaris, Dr. Wernher Von Braun and Dr. Ernst Stuhlinger, at right, as other project officers look on.*

JPL was responsible for the satellite payload and its instrumentation; for the development, construction and operation of certain microlock ground stations which receive and record telemetering signals from the satellite; and for design, construction and operation of the solid propellant units.

The designers paid particular attention to heat control. The metal surface of the satellite shell was striped with a flame-sprayed aluminum oxide coating, which covered 25 per cent of the total surface. The remaining surface was sandblasted to give a dull, satiny finish.

This combination of aluminum oxide and sandblasted stainless steel was chosen by JPL and ABMA to give the correct ratios between the absorptivity to solar and infrared radiation. This controls the average temperature of the satellite and its electronic components.

## INSTRUMENTATION

EXPERIMENTS installed aboard the 80-inch, 29.87-pound Explorer I included:

1. A Gieger-Mueller cosmic ray counting tube and associated circuitry for the counting of primary cosmic radiation. This apparatus was designed and built by Dr. James A. Van Allen of the State University of Iowa, and was initially prepared for Project Vanguard. JPL repackaged the experiment to meet the cylindrical requirements of the Explorer configuration.

2. Two micrometeorite detector experiments developed at the Air Force Cambridge Research Center by Dr. Edward Manring and Maurice Dubin. One of these was a set of 12 wire grids mounted as a parallel resistance network on the aft end of the fourth stage rocket motor. Collision with micrometeorites would erode or fracture the grid, and variance in electrical resistance would denote the change. The second such experiment was a microphone to record impacts of micrometeorites upon the exterior.

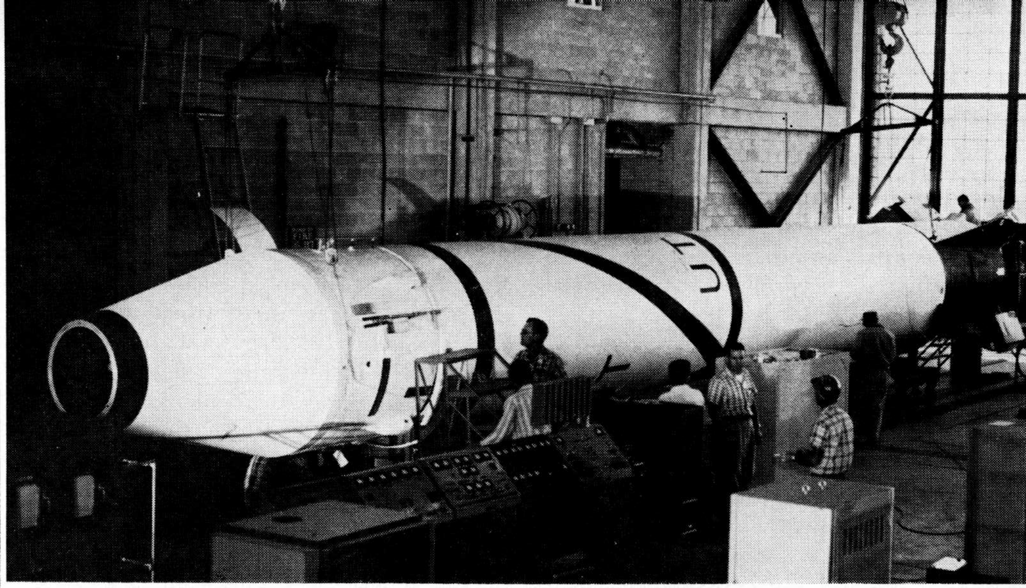
3. Four temperature gauges which read the temperature at three different locations on the outer shell of the satellite and at one location in its interior. These instruments were prepared by JPL.

Data collected by these three experiments would be transmitted to ground receiving stations by two radio beacons.

WHEN the booster left the Missile Agency and the spin launcher and satellite were shipped to Florida from JPL, almost everything humanly possible to assure success had been accomplished. Then came the final series of checks performed at Cape Canaveral jointly by ABMA's Missile Firing Laboratory and JPL technicians.

The power plant and propulsion systems, the pneumatic systems and other functioning assemblies received final scrutiny. The booster, spin launcher and high-speed clusters were assembled on site, employing a specially adapted service tower. Calibration tests of on-missile measuring devices were run off to insure accurate, telemetered data for pre-flight evaluation and flight performance.

Seasoned crews who had launched all of the Army's large ballistic missiles aligned the missile in azimuth and vertical positions. They set up the elaborate electronic gear which would track the missile for immediate presentation of velocity and position, recording this information on film, tape and oscillographs for later study.



*Following exhaustive checkout in an Army hangar at Cape Canaveral, this Jupiter C was reassembled prior to launching Explorer III.*

Many other complex preparations were completed. 29 January, the launching date selected weeks before, arrived. That morning weather reports indicated a maximum jet stream velocity out of the west at 170 miles per hour at altitudes between 36,000 and 40,000 feet. Chances of success were marginal. As a test vehicle, the Jupiter-C was not designed to withstand the abnormal stresses which would not interfere with ballistic missiles such as the Jupiter.

The shoot was postponed 24 hours. Next day the wind velocity had increased to 205 miles per hour, making the launching an even greater risk. By early the next day, 31 January, wind velocity had dropped to a maximum of 157 miles per hour at 7.8 miles altitude, which was deemed tolerable. The wind continued to drop. The order was given to proceed.

## INTO ORBIT

WHEN "Firing Command!" rang out in the tense blockhouse, the missile roared into life and lifted majestically into space. It rose vertically for eight seconds and then began to tilt into its trajectory. Propelling the giant was about 75,000 pounds of thrust. The powered stage of booster flight lasted 150 seconds. Explosive bolts separated the spent booster from the nose section, and the latter started to coast upward with the spin launcher assembly attached to its tip and rotating at 750 rpm.

The assembly coasted for 250 seconds. During this period the top unit was subjected to spatial attitude control by means of a special system developed by Army missile engineers, to establish the proper angle for injection into orbit.

Just as the assembly reached the top of its arc, 225 miles above the earth, a radio signal, flashed from the Army hangar at the Cape, ignited the second stage. The eleven scaled-down Sergeant missile motors burned for 6½ seconds, increasing the velocity. The third stage of three motors was set off and burned for another 6½ seconds. The final stage of one motor was then ignited and pushed the projectile beyond the orbital speed of 18,000 miles per hour.

The job was done. It was necessary to await confirmation, and it was a harrowing wait, for the Army was traveling untrodden paths. But the answer, the affirmative answer, did come—and there was great joy—and relief.

## SCIENTIFIC FINDINGS

EXPLORER I was placed in orbit at a velocity of about 18,500 miles per hour. Its minimum distance from the earth was about 224 miles, with the maximum at 1,573. Lifetime predictions vary from five to ten years.

A great deal of extremely valuable information has been gained from Explorer I's scientific apparatus. The scientific experiments and the radio beacons have done their work well. The high-power transmitter, whose batteries were expected to last about two weeks, ceased transmission about twelve days after the launch. About ten days later it came back on the air but had an insufficiently clear signal to permit interpretation of the data it was supposed to transmit. It continued to send generally weak signals until about one month after launching.

At mid-May the low-power transmitter was still functioning. It was fully meeting its lifetime expectancy of two to three months.

EXPLORER I confirmed man's ability to control temperature within an artificial satellite. JPL scientists have been assured by results that their technique for temperature control is adequate for the successful operation of sensitive electronic equipment. Internal temperature was maintained between 32 and 104 degrees Fahrenheit—well inside the tolerance needed to protect instrumentation from heat or cold failure. Outside temperature, measured at the shell, fluctuated between 14 and 167 degrees Fahrenheit. Inside temperature, of course, is easily within the range of human survival.

JPL scientists pointed out in their initial report of findings that this experiment was designed only to study the problem of instrument environment in a very small enclosure. Success of this simple device indicated that with more elaborate techniques the inner temperature of a larger space vehicle could easily be controlled within a much narrower range.

IN THE cosmic ray experiment, the Explorer revealed that cosmic radiation at extreme altitudes was far greater than had been anticipated. The satellite's reports from the far reaches of its orbit revealed unidentified radiation so intense it overwhelmed the cosmic ray counter. At altitudes beyond 1,000 miles the counts of particle pulses per second soared to ranges hundreds of times greater than had been expected.

While Explorer I counts ran the expected 30 to 40 per second 200 to 300 miles above Southern California, the counts climbed to more than 35,000 per second at the highest altitudes above South America and adjoining waters.



It is assumed that the high rate was produced by protons, or that it was due to X-rays produced in the satellite shell by electrons. In either case it is believed that the particles come from the sun, whereas cosmic rays are believed to hurtle toward earth mostly from interstellar space far beyond the sun.

The results of the experiment are totally inconclusive. Accepted at face value, and assuming that the intense radiation exists at all levels above the earth's atmosphere, this could mean that it would be unsafe for man to remain in space for more than five hours without special protection from dangerous quantities of the invisible light known as X-radiation.

It is also possible that the potentially dangerous radiation is confined to a spatial zone only a few hundred or a thousand miles deep. (It was to measure and define the nature and extent of this high intensity corpuscular radiation that Explorer IV was later launched. Designed by the State University of Iowa Physics Department, the experiment is designed to reveal whether the high corpuscular radiation emanates from the sun or from interstellar space far beyond the sun.)

IN THE third area of Explorer I instrumention, a preliminary review of the data received on the condition of the wire grids indicates that one or two of these grids were fractured during the launching of the last stage. Since that time, no additional fractures have been observed.

The impact microphone whose telemetered signals were carried on the high-power transmitter operated successfully throughout the lifetime of that transmitter. Several records show a change in frequency of this telemetering channel, indicating impact of a small particle on the shell of the satellite.

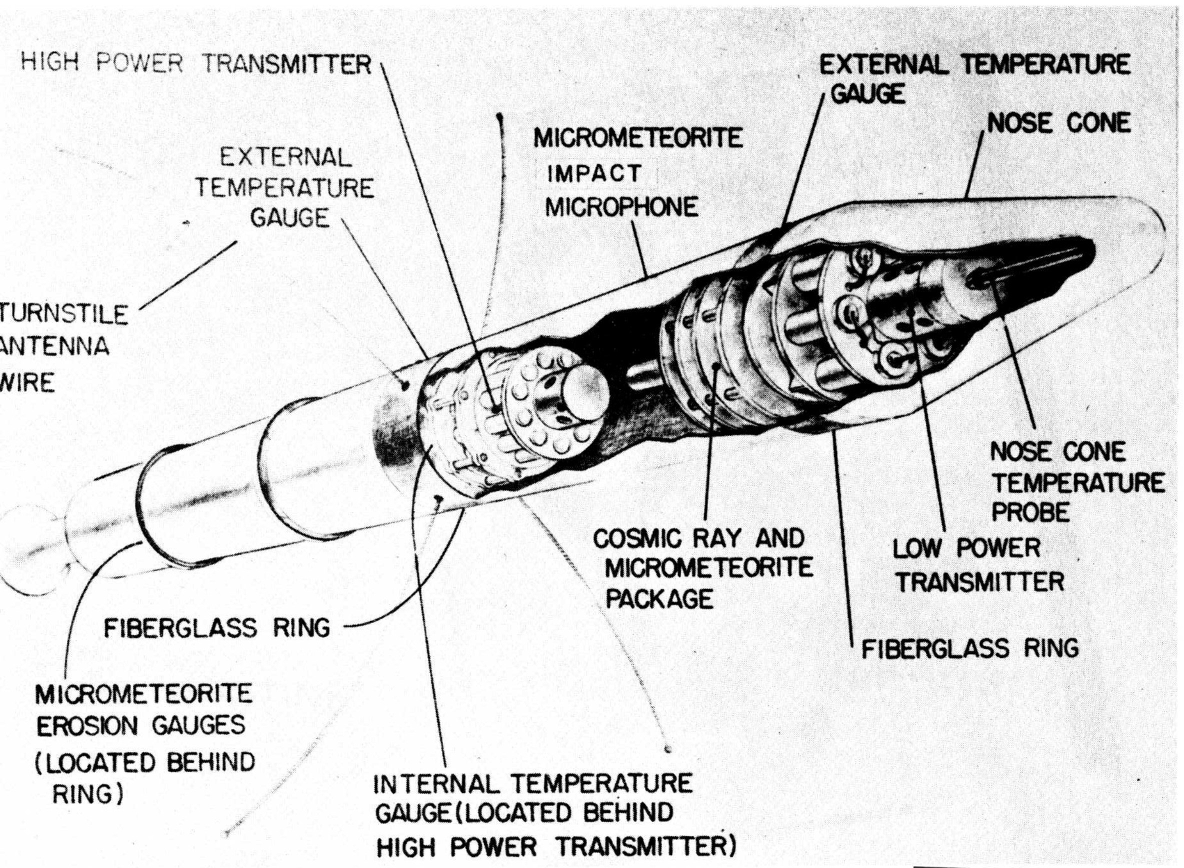
VISUAL and photographic observations of Explorer I are contributing to still another area of science. The Smithsonian Astrophysical Observatory's Moonwatch teams reported more than 100 sightings of the satellite during its first three months of orbiting. The 80-inch projectile has been photographed many times, and these pictures have been used to compute and predict more precise orbital data for other satellites; they are now being analyzed to provide information about the earth's equatorial bulge, and anomalies in the earth's gravity.

## COSMIC RAY STUDIES

EXPLORER III gathered and transmitted three types of information: temperature, cosmic dust erosion, and the intensity of cosmic radiation. The main part of the instrument package is the cosmic ray experiment, which was designed by Dr. James A. Van Allen of the State University of Iowa. Studies based on this experiment are expected to lend further understanding to the first Explorer's puzzling discoveries on radiation.

There were essentially no differences in the carrier vehicle or the launching methods of the satellites. There were, however, several significant changes in the instrumentation in Explorer III.

A major change was the addition of a miniature tape recorder, developed by the State University of


HIGH POWER TRANSMITTER
EXTERNAL TEMPERATURE GAUGE
NOSE CONE
MICROMETEORITE IMPACT MICROPHONE
EXTERNAL TEMPERATURE GAUGE
TURNSTILE ANTENNA WIRE
NOSE CONE TEMPERATURE PROBE
COSMIC RAY AND MICROMETEORITE PACKAGE
LOW POWER TRANSMITTER
FIBERGLASS RING
FIBERGLASS RING
MICROMETEORITE EROSION GAUGES (LOCATED BEHIND RING)
INTERNAL TEMPERATURE GAUGE (LOCATED BEHIND HIGH POWER TRANSMITTER)