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NASA FACTS

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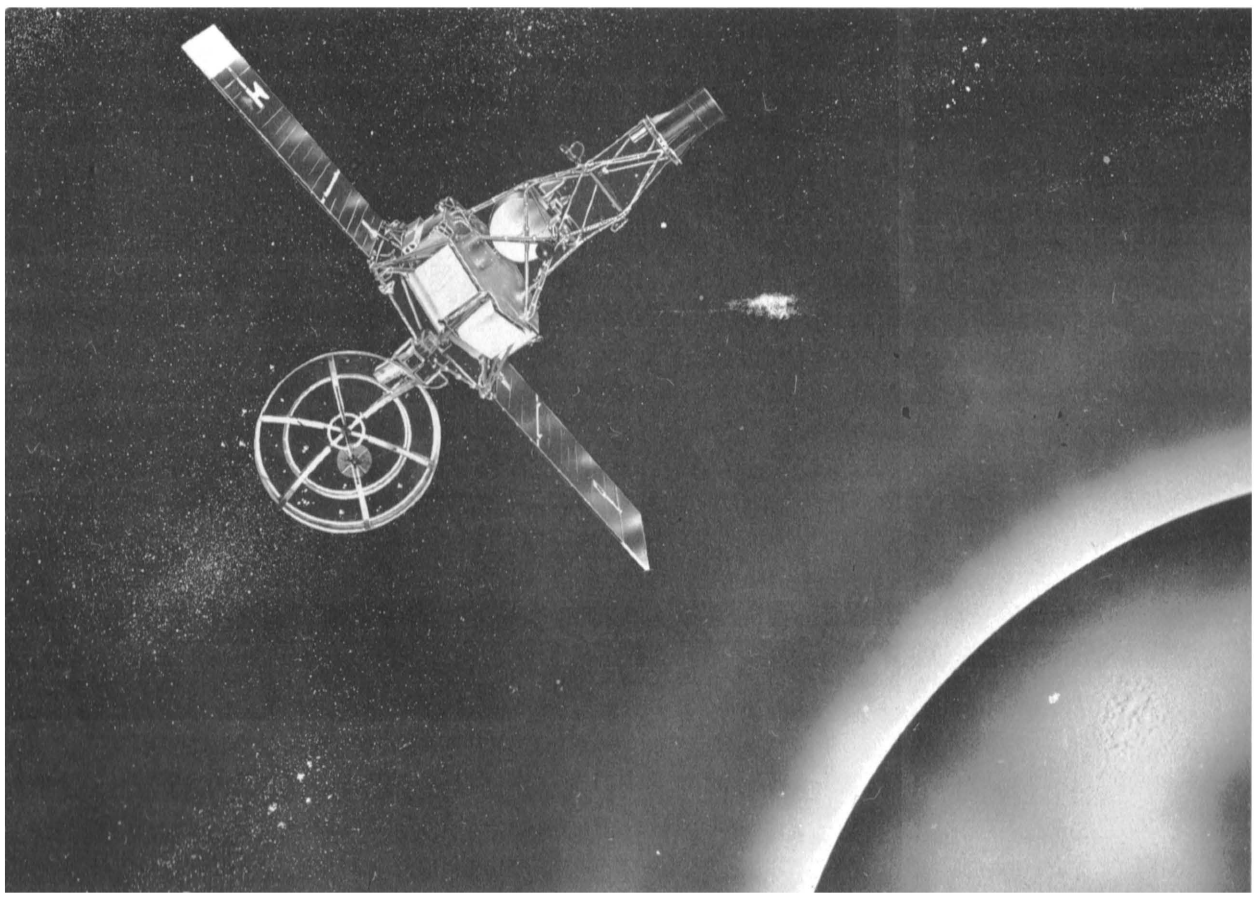
MARINER II REPORTS



Mariner II scans Venus (artist's concept—not in scale).

On December 14, 1962, NASA's Mariner II spacecraft flew past Venus at a distance of 21,648 miles, giving man his first relatively close-up observation of earth's mysterious planetary neighbor. This Venus fly-by climaxed an epic space flight experiment that has significantly advanced the world's knowledge about Venus and about interplanetary space and contributed to planning for man's eventual journeys to the moon and to other planets.

After passing Venus, the 449-pound Mariner continued for some additional time to transmit data about interplanetary space, adding to the abundance of information it had sent while en-route to the planet. On January 3, 1963, when radio contact was lost, Mariner was nearly six million miles beyond Venus and almost 54 million miles from earth. Since launch on August 27, 1962, Mariner sent about 90 million bits (from binary digit, meaning a unit of information) to earth.

This issue of NASA FACTS presents highlights of the new scientific knowledge gained through analyses of the voluminous quantities of data received from Mariner and from earth-based experiments carried out in conjunction with the spacecraft's activities.

VENUS, A GLOOMY LIFELESS DESERT

The Mariner observations, together with radar and optical studies made from earth, have relegated to discard any romantic conception that may have persisted of Venus as a place with earth-like qualities. Mariner found that the temperature of Venus may be as hot as 800° Fahrenheit. This temperature is hot enough to melt lead and precludes the possibility of life like that on earth.

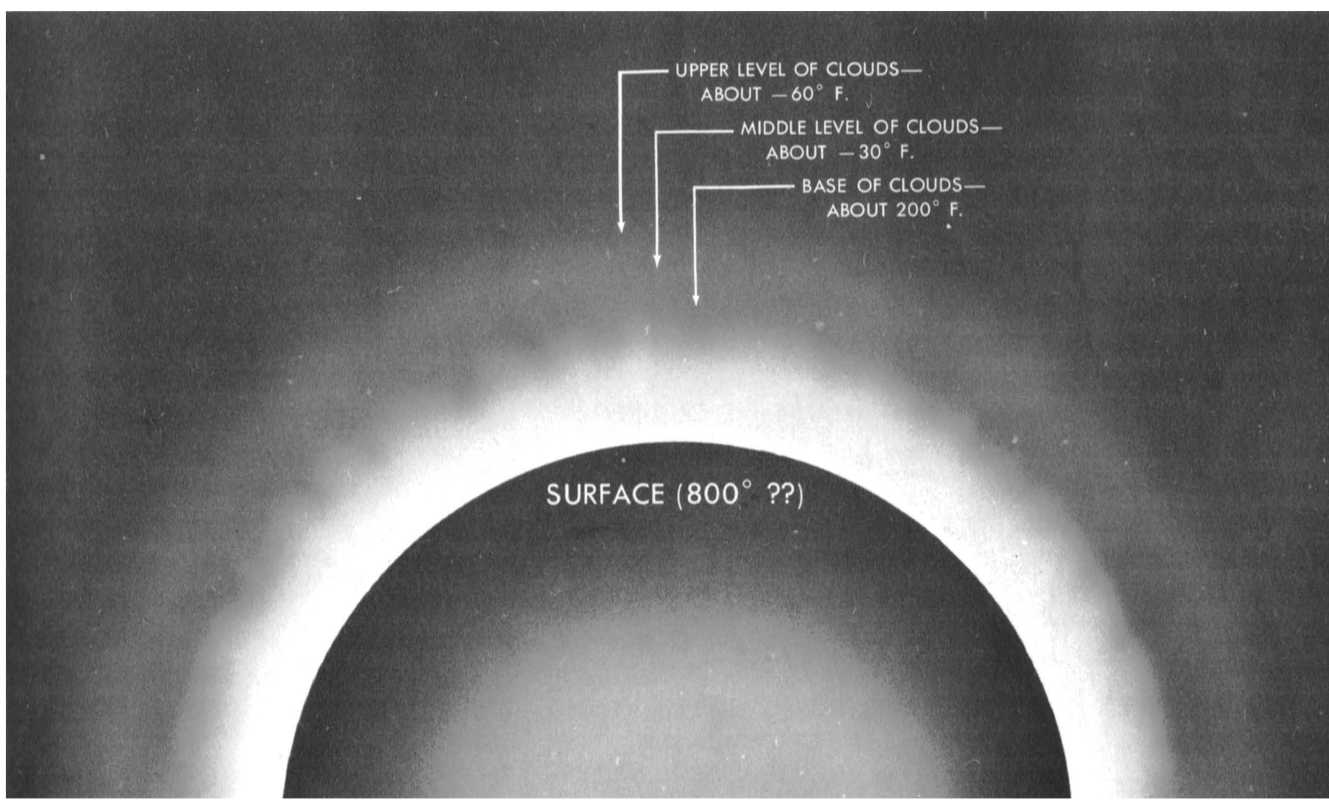
Mariner detected no openings in the dense cloud mass that starts about 45 miles above the Venusian surface and reaches an altitude as high as 60 miles. The spacecraft reported that cloud temperatures were 200° F. at the base; —30° (30° below zero) F. at the middle level; and —60° F. at the upper level. There is speculation that the clouds are composed of condensed hydrocarbons like those found in the smog of some of our world's cities. Mariner detected no carbon dioxide gas above the Venus clouds, indicating a negligible quantity, if any, at this altitude.

Mariner's information on temperature, carbon dioxide, and the unbroken nature of the clouds is based on data from the spacecraft's infrared and microwave radiometers. The radiometers made three scans of the planet: one across the night side; one across the terminator, or line, separating the dark from the sunlit side; and one across the sunlit side. The scans were carried out as Mariner flew closest to Venus on December 14, 1962, and lasted from 1:59 p.m. EST to 2:34 p.m. EST.

Radiometers operate by measuring energy in the form of infrared rays (heat) and of radio microwaves. The sensitive radiometers can pick up these emissions, even from great distances; and scientists can convert them to indicate temperature as well as certain other features.

Earth-based microwave scans of Venus, made before the Mariner experiment, suggested a sur-

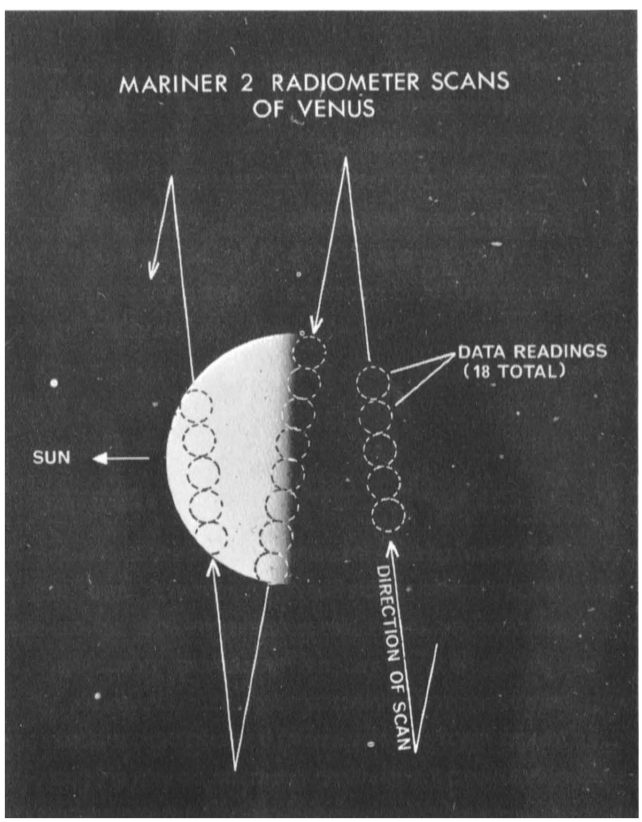
Venus surface an cloud temperatures as indicated by Mariner data (artist's concept).



face temperature of 600° F. Because of the distance at which these measurements were made, scientists debated whether they showed temperature at the surface or were reflections from ionized particles in an ionosphere many times as dense as earth's. (Earth's ionosphere is formed by break-up of neutral atmospheric molecules into negatively charged electrons and positively charged ions.) While flying close to Venus, Mariner made detailed observations that ruled out the postulated super-ionosphere.

Analysis of spectroscopic data obtained by means of earth-based telescopic observations indicates that carbon dioxide is a constituent of the Venusian atmosphere. These results coupled with other assumptions lead to the conclusion that the Venusian atmosphere is 10 to 30 times denser than earth's. Presumably, these atmospheric conditions contribute to the planet's high temperature by creating a greenhouse effect in which the sun's heat reaches the planet's surface but is hindered in rising.

Radiometer scanning of Venus consisted of 18 data readings covering the night and day sides of the planet and the terminator which separates them (artist's concept).



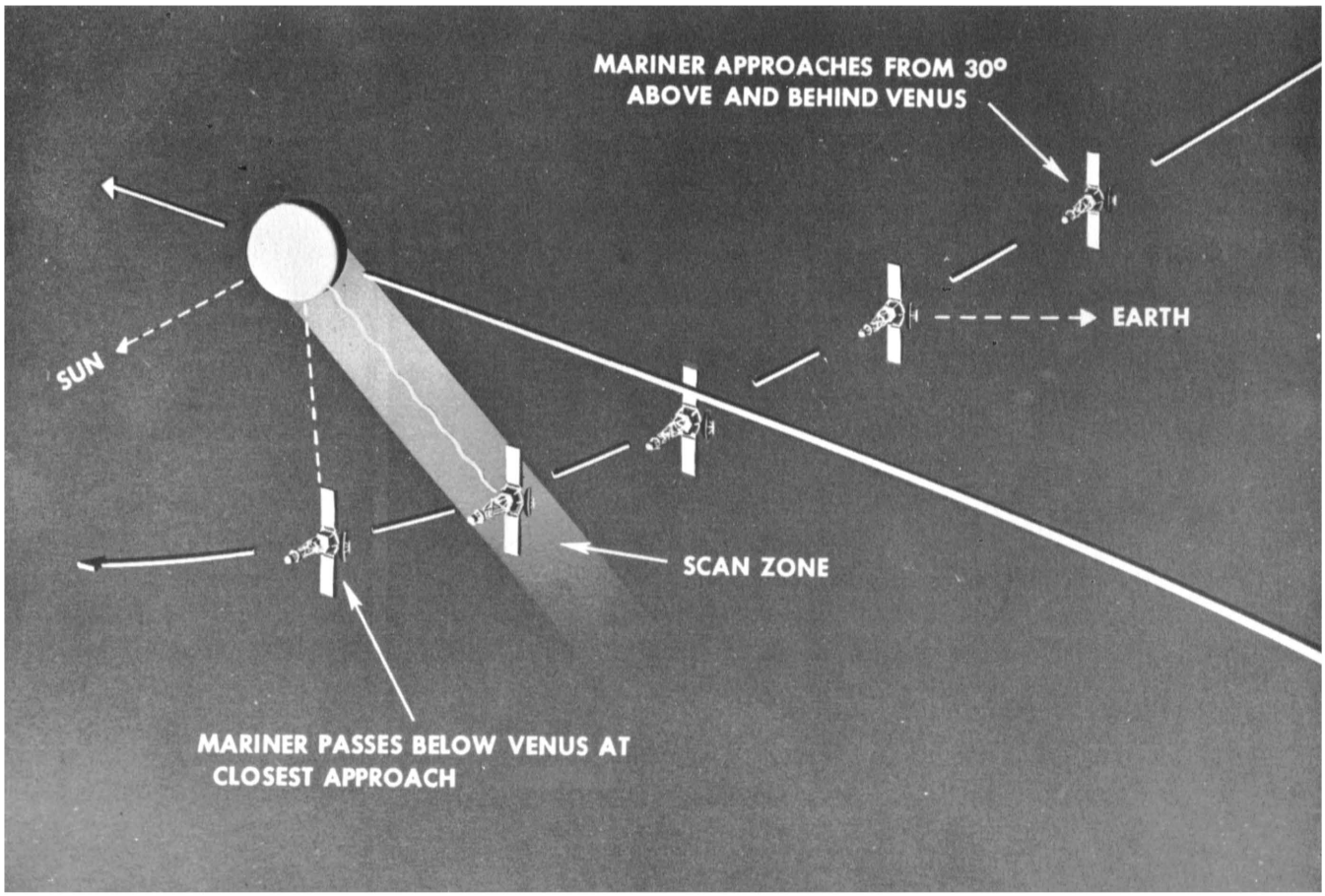
Radar studies, carried out by NASA's Goldstone, California, radar station, provide evidence that Venus rotates once each 225 earth days while orbiting the sun in the same time period. Thus, each day or night on Venus lasts about 112½ earth days, or half the planet's rotational period. Presumably, the Venusian clouds screen out most of the sunlight that would otherwise illuminate the day side, keeping that hemisphere in twilight.

The long Venusian day and night would be expected to result in the side facing the sun becoming quite hot and the other becoming cold. Mariner, however, did not find any appreciable difference in temperature. This indicates that the dense atmosphere must be circulating vast quantities of heat from the day to the night side. Such a massive heat transfer could generate searing winds that lash the planet's scorching surface.

Radar reflections from the Venusian surface are those characteristically made by sand or dirt-like material. If sand covers the ground, the high winds could create sand storms of tremendous proportions.

Radar studies also suggest that Venus rotates backwards with respect to earth and to all other planets of the solar system except Uranus, and perhaps Pluto. (Pluto's direction of rotation is unknown.) Thus, on Venus, the sun rises in the west and sets in the east.

Mariner's instruments also detected a mysterious spot in the clouds that was about 20° F. cooler than the surrounding clouds. Scientists attribute this phenomenon either to higher or more opaque clouds or to a hidden surface feature. In this connection, earth-based radar studies of Venus have indicated existence of a prominent surface feature. However, its relationship to the cool spot in the clouds is uncertain.



Mariner II pass of Venus as would be seen from a point between Venus and the sun (artist's concept).

NO VENUS MAGNETIC FIELD OR RADIATION BELT DETECTED

If Venus has a magnetic field, it does not extend to the altitudes and locations at which Mariner passed the planet. While flying near Venus, Mariner detected no increase in magnetic forces over those observed in interplanetary space. The spacecraft's instruments were set to pick up magnetic fluctuations as low as five gamma. (A gamma is about $\frac{1}{30,000}$ of the earth's magnetic force at the equator.)

The absence of a magnetic field accords with the fact that Mariner reported no increase in radiation as it soared near Venus. A comparable spacecraft approaching earth would have recorded the high-intensity radiation of earth's Van Allen Radiation Region. This region is created by the earth's magnetic field that captures many energetic particles (particles of atoms such as electrons and protons).

There is a possibility that the solar wind (see below) is pushing Venus' magnetic field close to the surface on the sunlit side where Mariner passed. Scientific satellites have provided evidence that the solar wind compresses earth's magnetic field to a 40,000-mile altitude on the sunny side and that it stretches to at least 80,000 miles on the night side.

SOLAR WIND IN INTERPLANETARY SPACE

Analysis of Mariner II data on interplanetary space produced evidence that solar wind, also called the solar plasma, is a predominant feature of interplanetary space. The wind, consisting principally of electrically charged protons and electrons (atomic particles, mostly from hydrogen atoms), was shown as rushing outward constantly from the turbulent surface of the sun.

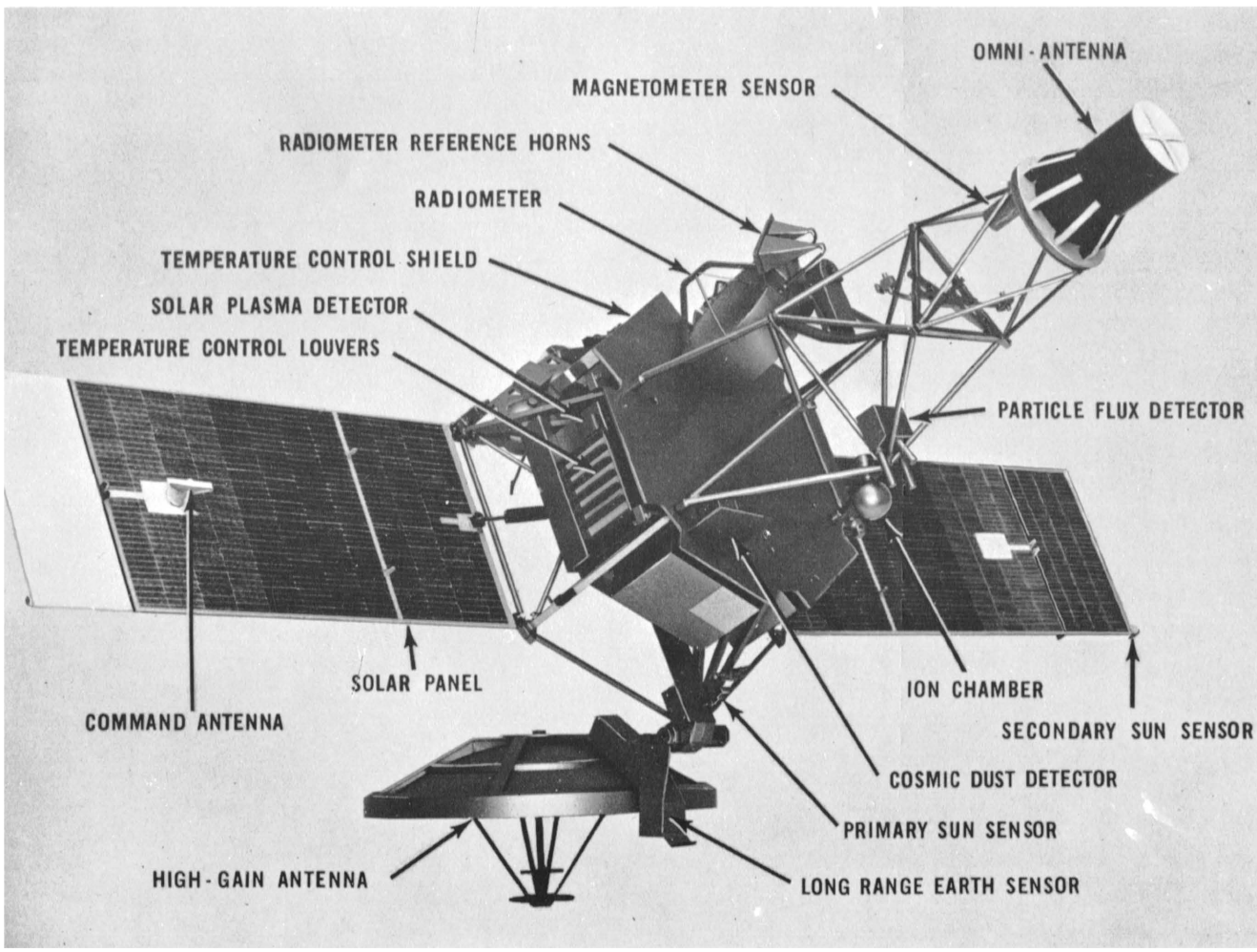
Indicated speeds were from 250 to 450 miles per second, and temperature was about a million degrees Fahrenheit. Although called a wind, this stream of hot electrified gas is more comparable to a rocket's blast than to any other thing known here on earth. The matter constituting the wind is scant, however, consisting of 10 to 20 particles per cubic inch.

It is theorized that the solar wind pulls away parts of the sun's magnetic field and distributes them throughout the solar system. These magnetic fields deflect from the solar system many lower-energy cosmic rays (see below) streaking from interstellar space.

Sudden solar eruptions such as flares appear to increase temporarily the density, velocity, and temperature of the solar wind. This is said to enable it to carry more magnetic fields out into space, with the result that more cosmic rays are deflected.

It has been observed that a decrease in cosmic radiation around earth and disturbances in the earth's magnetic field often follow solar eruptions. It is believed that the augmented solar wind caused by the eruptions produces these effects by sending strengthened magnetic fields into space and by interacting with the earth's magnetic field. Disturbances in the earth's magnetic field are associated with radio interference, or black-out, and with aurorae such as the Northern and Southern Lights in the polar regions.

Principal instrumentation of Mariner II. The radiometers were employed during the Venus pass. The other experiments were used during most of the flight to acquire information on both Venus and the interplanetary environment.



MAGNETIC FIELDS FOUND EVERYWHERE IN SPACE

Data from Mariner's magnetometer, an instrument that detects and gauges the force and direction of magnetic fields, were remarkable in their great number and continuity. Mariner reported that magnetic fields were nearly always present as it raced through interplanetary space.

Scientists believe that the interplanetary magnetic fields are parts of the sun's magnetic field that the solar wind has distributed throughout space. Typically, the interplanetary magnetic fields were found to be weak compared to earth's. Generally, they ranged from five to ten gamma, with precipitous increases to 25 or more gamma following sudden solar disturbances.

COSMIC RADIATION IN INTERPLANETARY SPACE

During its entire flight, Mariner reported about the same amount and intensity of cosmic radiation. This constancy is considered a significant addition to scientific knowledge; but its implications will have to be clarified by additional experiments.

Cosmic rays are made up of protons (nuclei of hydrogen atoms), alpha particles (nuclei of helium atoms), nuclei of atoms heavier than hydrogen and helium, and electrons. They have velocities almost as great as the speed of light (about 186,000 miles per second) and energies in the millions, billions, and trillions of electron volts. (The electron volt is a scientific measurement unit for energies of atomic particles.)

Cosmic rays are the most penetrating kind of radiation, theoretically being able to pass through lead walls as thick as a thousand feet. Most cosmic rays come from outside of the solar system, usually from within our vast Milky Way galaxy but sometimes from other galaxies. Our own sun produces some cosmic rays, particularly during solar flares and other disturbances.

Both cosmic rays and the matter in the solar wind are atomic particles. However, solar wind particles have comparatively low energies, in the hundreds and thousands of electron volts. Despite the great disparity in individual energies, the aggregate energy of the solar wind is far greater than that of all cosmic rays in the region of the solar system studied by scientific spacecraft. This is because, in this region at least, solar wind particles outnumber cosmic ray particles by about a billion to one.

Mariner reported a scarcity of cosmic ray protons below the level of 800 million electron volts. This scarcity is attributed to interplanetary magnetic fields that permeate the solar system and deflect lower-energy cosmic rays.

If a space traveler had journeyed to Venus at the time of the Mariner flight, he would have absorbed a total of 3 roentgens of radiation. This dosage is well within the tolerable limits for man during a four-month period.

MICROMETEOROID IMPACTS FEW

In 1700 hours of recorded data, Mariner registered only two impacts with micrometeoroids—tiny bits of matter in space. Comparison of these data with information from earth satellites would indicate that micrometeoroids are 10,000 times more abundant near earth than along Mariner's trajectory in interplanetary space. Moreover, no concentration of micrometeoroids was detected around Venus such as occurs around earth.

Information about micrometeoroids is of practical importance in design of spacecraft and is believed essential to study of the origin and evolution of the solar system.

TRACKING DATA ADDING TO KNOWLEDGE

The precise tracking data acquired through the Mariner II experiment have provided basic information that is contributing to refinement of important measurements. Among them: the mass of the moon; the mass of Venus; the Astronomical Unit (AU) which is the mean distance from earth to sun and the yardstick for measuring distance in the solar system; and the exact locations of spacecraft tracking stations on earth.

These figures not only will increase scientific knowledge but also are vital to planning of manned lunar and interplanetary voyages.

MARINER ESTABLISHED NEW COMMUNICATIONS RECORD

Contact was maintained with Mariner II until it was 53.9 million miles from earth. This shattered the previous long-distance communications

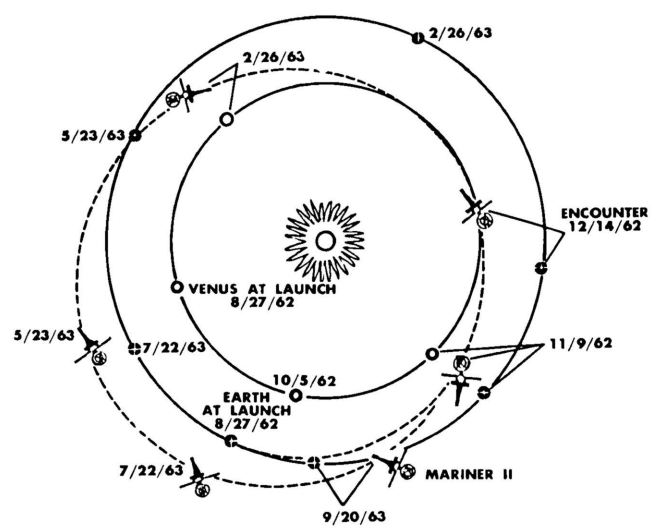
The 85-foot diameter antenna at Woomera, Australia, one of three that tracked and communicated with Mariner II. Others are located near Johannesburg, Republic of South Africa, and at Goldstone, California.

record of 22.5 million miles set with NASA's Pioneer V spacecraft on June 26, 1960.

The Mariner II experiment has demonstrated that reliable communications can be kept up over interplanetary distances. Mariner's transmitter, incidentally, had an output of about three watts, a power level lower than the standard "nite lite" (7½ watts).

WHITHER MARINER II?

The loss of radio contact with Mariner on January 3, 1963, raises the question of Mariner's fate. Mariner II is now a planetoid sailing in a never-ending orbit around the sun (see illustration). It joins such other man-made planetoids as Lunik I; Pioneers IV and V; a Soviet Venus probe whose radio died before it supplied useful



The solar orbits of Venus, Mariner, and earth (artist's concept).

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information; a Soviet Mars spacecraft; and Rangers III and V, lunar spacecraft that went into orbit around the sun. Calculations indicate that thousands of years will pass before Mariner again comes as close to Venus as it did on December 14, 1962.

MARINER MARS MISSION NEXT

NASA plans to launch a fly-by of Mars in 1964. The experiment will be aimed at obtaining television pictures of the planet's surface and gaining information on possible magnetic fields, trapped particle regions, and micrometeoroids.

Plans for a mission to Venus duplicating the Mariner II experiment were cancelled because of the success of Mariner II. The next Venus observation will await development of advanced spacecraft and launch vehicles.

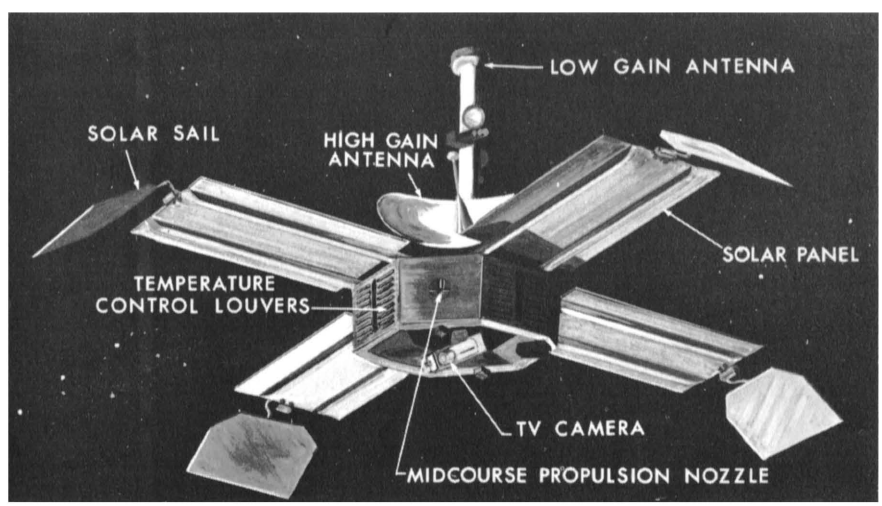
NASA FACTS D-62 described the Mariner II spacecraft, its experiments, and its planned mission to Venus.

MARINER MID-COURSE MANEUVER

On September 4, 1962, ground controllers commanded Mariner to execute a complex mid-course maneuver that changed its trajectory from one that would have reached no closer than 230,000 miles to Venus to one that passed as close as 21,648 miles from the planet. At the time, Mariner was more than a million miles from earth and moving at 60,117 miles per hour relative to the sun. The correction added 51 miles per hour to this speed. Such a relatively minute adjustment to an enormous velocity is considered a tremendous engineering achievement.

The planned increase was 49 miles per hour, and this would have brought Mariner within 10,000 miles of Venus. Although initial computations indicated this plan had been fulfilled, continued tracking showed that the actual velocity increment was 51 miles per hour. The two miles per hour difference, magnified by the great distances in space, more than doubled the planned distance at which Mariner passed Venus.

One of the designs under consideration for Mariner spacecraft to be used on Mars mission.



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