References

1. F. Scherb, private communication.
2. A. Bonetti, H. S. Bridge, A. J. Lazarus, E. F. Lyon, B. Rossi, F. Scherb, "Explorer X plasma measurements," paper presented at COSPAR meeting, Washington, May 1962.
3. K. I. Gringauz, V. V. Bezrukikh, V. D. Ozerov, R. E. Rybchinskii, *Soviet Phys. "Doklady" English Transl.* **5**, 361 (1960).
4. E. N. Parker, *Astrophys. J.* **132**, 175, 832 (1960).
5. J. C. Brandt, *Icarus* **1**, 1 (1962).
6. J. W. Chamberlain, *Astrophys. J.* **131**, 47 (1960); *ibid.* **133**, 675 (1961).
7. W. I. Axford, *J. Geophys. Res.* **67**, 3791 (1962); P. J. Kellogg, *ibid.* **67**, 3805 (1962).

23 November 1962

The Iowa Radiation Experiment

The primary purposes of the Iowa experiment in Mariner II are to search for charged particles magnetically trapped in the vicinity of the planet Venus and, if such particles are found, to obtain preliminary measurements of their spatial distribution and intensity. These measurements, when taken together with measurements by the magnetometer equipment on the same vehicle, should advance knowledge of the planet's internal constitution and its magnetosphere. The radiation equipment is also useful in monitoring the intensity of low-energy particles in interplanetary space during the 3½-month flight from the earth to the planet.

At present only the planets Earth and Jupiter are known to have extended belts of magnetically trapped particles. The belts of Earth have been studied by a comprehensive series of *in situ* observations with satellite and space probe equipment, those of Jupiter by radio-astronomical observations with ground-based equipment.

Current radar-astronomical evidence, obtained independently from the Millstone and Goldstone observatories, indicates that the angular rotational rate of Venus is of the same order of magnitude as the angular rate of its orbital motion around the Sun. Hence it is widely believed that Venus, by virtue of tidal friction during the evolution of the solar system, is now revolving about the Sun with its same hemisphere continuously facing the Sun. If this is indeed true, and if, despite such a low rotational rate of the planet, Mariner II finds a substantial intensity of trapped particles and a substantial magnetic field intensity (say, of the order of 100 gammas) at the expected miss distance of some 6.5 planetary radii from the center of the planet, then it would seem that profound revisions of general theories of planetary magnetism will be necessary. The implications of other combinations of conceivable outcomes of current work may be considered.

In planning the experiment it was thought most likely that the radiation belt of Venus, if any, would have a much lower intensity of particles than that of Earth and that the energy of these particles would also be lower. Other general considerations were the very limited weight, power, and telemetry allocations for this experiment and the necessity for the highest possible reliability. Our final choice of detector was an Anton type 213 Geiger-Mueller tube, which is a miniature tube having a 1.2 mg/cm^2 mica window about 0.3 cm in diameter. A number of such tubes have operated successfully in orbital flight for over 16 months in Injun I, throughout Explorer XII's lifetime of 4 months, and (as of the date of writing) for over 6 weeks in Explorer XIV. Some properties of the Mariner II detector are given in Table 1.

The tube also detects soft x-rays efficiently ($\sim$ 0.1 for 2-kev x-rays) and ultraviolet quite inefficiently ($\sim$ a few counts per second from a laboratory mercury arc whose ultraviolet intensity simulates that of the Sun). Although the x-ray sensitivity of this detector has valuable applications for studying x-ray bursts from the Sun and has been so used in Injun I, in the Mariner II apparatus special care was taken to shield it from both direct and reflected sunlight. The physical arrangement is shown in Fig. 1. No portions of the spacecraft lie within or near the conical aperture of the collimator. The axis of the spacecraft is stabilized to within less than 1 degree from the probe-sun line. (This angle is also measured and telemetered.) The sunshade of the tube's collimator prevents any sunlight from falling on any part of the collimator if the error in this angle is less than 10° in any plane; and the collimator itself prevents sunlight from falling on the window of the detector unless the axis of the detector is tilted toward the sun-probe line by more than 25 degrees, a situation which would correspond to a gross failure of the stabilization of the spacecraft. During flight to Venus, the spacecraft is gradually rolled around the probe-sun line in a systematic and known way in order to keep the directional telemetry antenna pointed toward the earth. The slow sweep of the axis of our detector across the celestial sphere may conceivably provide a significant search for sources of soft x-rays, but no analysis of the data from this point of view has yet been made.

Table 1. Properties of the Iowa detector.

Type: Anton 213 Geiger-Mueller tube
Weight of assembly: 60 g
Window thickness: 1.2 mg/cm^2 mica
Full angle of collimator: 90°
Directional geometric factor: 0.2 cm^2 sterad
Efficiency for electrons:
- 1.0 for $E > 70$ kev
- 0.35 for $E = 40$ kev
- 0.1 for $E = 34$ kev
- 0.01 for $E = 29$ kev
- 10^{-3} for $E = 27$ kev
- 10^{-6} for $E = 5$ kev (nonpenetrating)

Efficiency for protons: 1.0 for $E > 500$ kev
Side shielding: 0.35 g/cm^2 of stainless steel and magnesium
Omnidirectional geometric factor: 0.2 cm^2
Maximum apparent counting rate: 50,000 count/sec
Maximum observable true counting rate by use of laboratory calibration curve: 10^7 count/sec

The basic telemetry frame for the Iowa detector is 887.04 seconds in length. During each such frame the counting rate of the detector is sampled twice, at intervals separated by 37 seconds, as follows:

1) The number of counts during an interval of 9.60 seconds ("long gate") is accumulated on a shift register of seven binary stages. This register "overflows" on the 256th count.

2) The number of counts during an interval of 0.827 second ("short gate") is accumulated on a shift register of 15 binary stages. This register overflows on the 65,536th count.

Since the maximum apparent counting rate of the 213 detector is 50,000 per second the "short gate" system always gives a unique reading. At counting rates less than 26.6 per second the "long gate" reading is unique and has, of course, much better statistical accuracy than the "short gate" read-

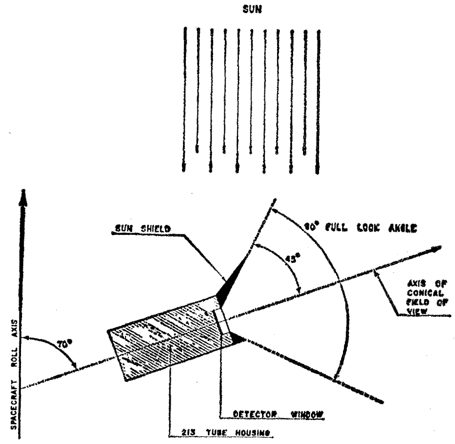

Fig. 1. Schematic diagram of the detector on Mariner II.

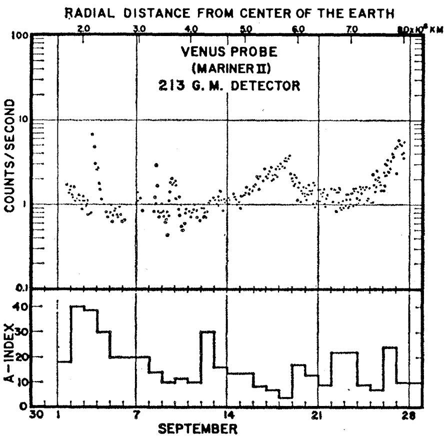

Fig. 2. Data reported in September 1962. (Top) Counting rate. (Bottom) Magnetic A indices.

ing. At rates in the range 26.6 per second to about 60 per second the "short gate" system gives the approximate rate, indicates the number of times (one, two, or three) which the "long gate" register has overflowed, and, with some reservation, makes it possible to use the "long gate" reading for obtaining a more accurate rate, if it appears that one is entitled to assume substantial constancy of counting rate over a time period of some 47 seconds.

The upper portions of Figs. 2 and 3 show data observed in interplanetary flight during September and October 1962. Each point corresponds to an average over five sampling periods. The expected minimum counting rate is about 0.6 count/sec because of galactic cosmic rays, whose interplanetary intensity in the general vicinity of Earth's orbit is about 3 particles cm^{-2} sec^{-1} during the present period of reduced solar activity. Such a minimum

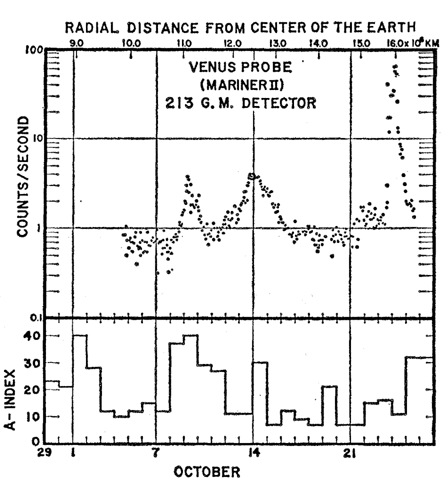

Fig. 3. Data reported in October 1962. (Top) Counting rate. (Bottom) Magnetic A indices.

counting rate is indeed seen to have been approached during portions of the period covered by Figs. 2 and 3. In general, the data attest to a remarkable "cleanliness" of interplanetary space in respect to the types of radiations to which this detector is sensitive (see *1*). Marked increases of counting rate are noted on the following dates: 3, 8, 9–10, 15–19, and 25–28 (?) September, and 8–9, 12–15, and 23–24 October 1962.

No proper interpretation of these peaks has yet been made. The following general lines of interpretation are being investigated: (i) changes in directionality or intensity and/or energy spectrum of particles in the solar wind; (ii) solar cosmic rays; (iii) galactic x-rays (see above). It is expected that the following other lines of evidence will contribute to an understanding of the significance of these peaks:

1) Mariner II magnetometer measurements.

2) Mariner II plasma probe data.

3) Data from the ionization chamber and two other (thick-walled) Geiger-Mueller tubes in Mariner II.

4) Data from a set of thin-window 213 detectors in the Iowa equipment in Explorer XIV, particularly near apogee (which is at 16.4 earth radii).

5) Data from the magnetometer in Explorer XIV.

6) Terrestrial data on geomagnetic and auroral activity.

7) Data from rocket, balloon, and low-altitude satellite equipment near Earth.

8) Radio and optical observations of the Sun.

Pending completion of a thoroughgoing study, we have plotted the daily average Fort Belvoir magnetic A indices from the weekly Boulder reports (*2*) in the lower portions of Figs. 2 and 3 with the idea of testing whether or not our counting rate peaks have any correspondence to geomagnetic effects which are presumably caused by changes in the solar wind. There is some indication of correspondence, but the relationship to this crude index of geomagnetic activity does not appear to be intimate, and no conclusions are proposed at this time.

The planetary encounter, now expected on 14 December, continues to represent the observing period of greatest interest for this experiment (*3*).

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References and Notes

1. J. A. Van Allen and L. A. Frank, *Nature* **184**, 219 (1959).
2. Billings, Trotter, LaVelle, "Preliminary reports of solar activity" (High Altitude Observatory, Boulder, Colo.).
3. We are grateful to Hugh R. Anderson and Leonard A. Parker of the Jet Propulsion Laboratory, California Institute of Technology, for continuing cooperation on all aspects of payload integration and data handling. Substantial experimental and data analyses have been provided by H. K. Hills and C.-S. Wang of our laboratory. Our work has been supported in large part by a contract with the Jet Propulsion Laboratory.

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Cosmic Dust

The objective of the cosmic dust experiment on Mariner II is to make a determination of the flux of dust particles in interplanetary space by direct measurement techniques similar to those used in recent satellite experiments. Prior information concerning distributions of dust particles in interplanetary space has been obtained from analyses of photometric studies of the zodiacal light and the solar corona. Dubin and McCracken (*1*) have compared the measurements from the satellite experiments with these photometric observations and have demonstrated that the spatial density of cosmic dust may be greater near the earth than in interplanetary space by at least three orders of magnitude. The cosmic dust detector on the Mariner II spacecraft is at present extending the direct measurements to interplanetary space.

The experiment consists of one metallic sensor plate (3.5×10^{-2} m^2) with an acoustical transducer bonded to it (*2*). The electrical signal from the detector is proportional to the mechanical impulse received by the sensor plate from an object impacting on its surface. The electronic instrumentation is capable of differentiating two momentum ranges differing in magnitude by a factor of 10. The minimum threshold sensitivity, as determined by low-velocity calibration techniques (*3*), is $7.4 \pm 1.7 \times 10^{-4}$ dyne-sec.

At both momentum levels the system is capable of counting and storing three events until they are telemetered to earth, whereupon the system is reset for more data. An in-flight calibration signal occurs after each telemetry readout and thus repeatedly demonstrates the operation of the electronic section of the experiment. The solid viewing angle of the system is approximately π steradians.