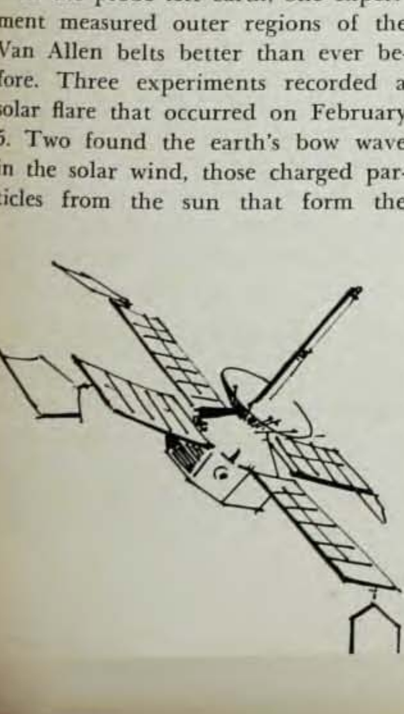
involved, etc.). Present plans indicate that the first compound used for acceleration will be lithium fluoride, which has a conveniently high permanent dipole moment. It will collide, at a ninety-degree angle, with a target beam of argon, chosen for its mass and its great resistance to forming compounds.

### *Mariner fly-by*

As June ended, the world's farthest-out physics laboratory was fast approaching its moment of truth. On July 14, after 240 days and more than 300 million miles of travel, Mariner IV would have its encounter with Mars. Eight experiments aboard, six of which have been observing fields and particles since the time of launching, were awaiting their opportunities to measure many qualities of Mars and its environment: magnetic moment, trapped radiation, surface pressure, density and height of atmosphere, surface texture and configuration. Responsibility for the eight experiments is assigned to 29 physicists from eleven institutions.

The space probe already holds many records. Long ago it exceeded the previous one for long-distance communication, 66 million miles, established by a Russian Mars probe in 1962. The encounter-to-earth distance is 134 million miles, and before the probe concludes transmission of pictures and data gathered at encounter, its makers expect to receive messages from 150 million miles away.

As the probe left earth, one experiment measured outer regions of the Van Allen belts better than ever before. Three experiments recorded a solar flare that occurred on February 5. Two found the earth's bow wave in the solar wind, those charged particles from the sun that form the



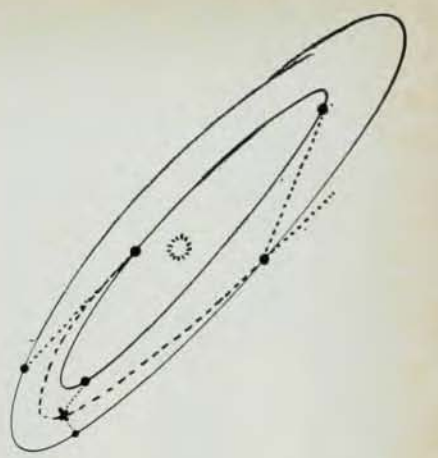
solar plasma. Three, observing fields and particles around the earth, got negative results in searches for the earth's wake as the probe crossed regions where one might expect to find it. A strange ratio of protons to alpha particles in the solar wind, a refinement of a Mariner II estimate, started speculation on acceleration mechanisms operating in the sun. Cosmic dust was found, surprisingly, to increase in density with increasing sun-probe distance.

Two identical probes, Mariners C and D, were prepared for launching during the month following November 4. Mariner C failed shortly after its November 6 launching, apparently because a Fiberglas fairing did not eject properly and prevented opening of power-providing solar panels. After a new metal fairing had been substituted, Mariner D was successfully launched (and renamed Mariner IV) on November 28. From a briefly occupied, 100-mile-high parking orbit it was injected into an orbit about the sun designed to take it from earth to Mars while earth, moving faster in a smaller orbit, passes Mars. A mid-course correction on December 5 assured passage within 5600 miles of Mars.

The encounter, as seen from earth, has Mars passing in front of the slower-moving probe. Thus one can perform an occultation experiment in which receivers on earth study disappearance and reappearance of the communications signal. From the resulting effect on signal, investigators will look for qualities of the Mars atmosphere (height, density, density gradient) and an ionosphere, if one exists.

Another encounter experiment was designed to record up to 21 TV pictures (a 1/5-sec exposure every 48 sec). Because they are tape-recorded at 10 700 bits/sec and transmitted at 8.33 bits/sec and because other data are being transmitted between pictures, more than a week is required to get all pictures from probe to earth. Conditions permitting, picture transmission will go on well into August with the hope that second and later transmissions can be used to improve the first.

Some time afterward communica-



tion with the probe will be lost, but it may be possible to reestablish it in 1967 after Mariner IV and earth, pursuing their separate orbits, come close together again, say within a mere 50 or 60 million miles. By that time it will most probably be impossible to point the high-gain antenna toward earth, and thus the two sun satellites, Mariner IV and earth, may have to be close enough to permit use of Mariner's omnidirectional antenna instead of the high-gain antenna that now points toward earth.

Occultation and photography can occur only at encounter, but the remaining six experiments, all dealing with particles and fields, have been delivering data from the first day of the trip. They deal, respectively, with trapped radiation, solar plasma, magnetic fields, cosmic rays (solar and galactic) and cosmic dust.

In the trapped-radiation experiment, three G-M tubes and one solid-state detector have observed several increases of radiation, one of which is known to be associated with the February 5 solar flare. As compared with similar measurements in 1962, results (from both this experiment and the ion chamber) show less radiation but more high-energy particles as one would expect from the quiet-sun period. The trapped-radiation experiment failed to detect the wake of the earth in the solar wind at 12 million miles, and its observations of outer-fringe Van Allen radiation, the best yet, show an outermost limit for earth influence at 104 000 miles.

A collector, a power supply, and output circuitry make up the solar-plasma probe. A collector voltage, rapidly alternating between limits which are, in turn, cycled through 32 steps, produces signals that show numbers of positive ions in 32 energy bands from 30 to 10 000 eV. With it, experimenters have been able for the first time to make observations all the way through the earth's bow wave at a distance of 34-35 earth radii.

Although this instrument has been able to resolve hydrogen and helium plasma components more accurately than predecessors and to produce reasonably accurate values of solar-wind velocity, a recalibration was required so that data recorded after the first week would be meaningful. The cause was a resistor failure, which, for a time, left experimenters uncertain of the manner in which the energy sweep was occurring.

Another negative result from an attempt to find the earth's wake came from a helium magnetometer especially designed for space probes. It observes the amount of circularly polarized light passing through ionized helium, a quantity affected by direction and intensity of magnetic field. Among its positive results are significant field changes at 48-60, 84-100, and 140-152 thousand miles from earth. All three transitions separate different regions of interaction between earth's field and solar wind and are consistent with expansion of the earth's field as the sun became quiet and solar wind decreased. Strong disorderings found in the interplanetary field are associated with irregularities in plasma emission from the sun, interactions between slow and fast moving plasma and plasma instabilities. The magnetometer has also revealed some periodic variations that can be associated with the sun's 27-day rotation.

A time-of-flight spectrometer with 20 million miles between two detectors observed the February 5 flare. The event could be seen at the sun and detected by arrival of energetic protons at the IMP II satellite circling earth and later by protons turned back into a Mariner IV cosmic-ray telescope looking away from the sun. Observers concluded that extensive irregularities in the magnetic field beyond the earth's orbit scatter charged particles back into the Mariner telescope. A puzzle arises from an unusually low, essentially zero helium-to-hydrogen ratio in the particles detected. Some of the acceleration mechanisms one would expect to find at the sun apparently aren't there.

The Mariner IV cosmic-dust detector has been recording micrometeorites at an average of one every 1.5-2 days and at a rate that is increasing as the vehicle moves outward from the sun. The instrument is an aluminum plate acting as a microphone diaphragm. On its surfaces is a layer of insulation covered by evaporated aluminum, and by recognizing which surface is penetrated it can record which way a given particle comes in. The system responds to any particle bigger than $10^{-11}$ gm. Records of particles by size show that about once every 40 days a particle big enough to crack the glass ($10^{-5}$ gm) would be expected to hit the solar panels powering the probe.

Whatever Mariner IV learned at encounter and whatever information it sent back in subsequent weeks would embroider a record that is already substantial. As for the future, the probe has confirmed an earlier conclusion: radiation encountered is no serious hazard for astronauts and manned space flight. (A large solar proton event might be an exception if one occurred.) Moreover, one can assume that Mariner IV data will encourage pursuit of recommendations that came from last year's study by the Space Science Board of the National Academy of Sciences: vigorous exploration of Mars between 1969 and 1973, landing of an automated laboratory by 1973 (perhaps by 1971), study of Mars physics, chemistry, geology, and biology (if there is any). For the physicist, this will mean a new, big laboratory in which the radiation fields may hold clues to relations between relativity and the quantum. And somewhere in this laboratory he may catch his first graviton.

### *Mars experiments solicited*

The National Aeronautics and Space Administration has set August 1 as the deadline for preliminary proposals of experiments to be carried on its 1971 Voyager mission to Mars. The program will use the Saturn-