yield clues to how to predict solar flares and the outbursts of particulate radiation associated with them. If the flares turn out to be predictable, moon landings and other manned interplanetary flights can then be scheduled for flare-free periods. If not, the patrol system can still give warnings when it notices flares. Since the radiation takes more than half an hour to get to the earth-moon region, people on the moon will have time to take shelter and those who happen to be caught in flight can take evasive action, such as turning heavily shielded tails foward the sun.

Future of space research

A review of the United States space-research program and recommendations for the future by the members of the National Academy of Sciences Space Science Board have been published in three volumes entitled *Space Research: Directions for the Future.* The study began in the fall of 1964 when discussions between members of the Board and members of the National Aeronautics and Space administration suggested that the time was appropriate for it. Plans were made accordingly, and in the summer of 1965 panels of experts in various subdivisions of the topic met for two months of intensive study at Woods Hole, Mass. Their deliberations and recommendations are divided among the three volumes of the report according to the following scheme: volume 1, planetary and lunar exploration; volume 2, optical astronomy, solar astronomy, radio and radar astronomy, x-ray and gamma-ray astronomy, physics and geophysics; volume 3, rocket-satellite research, space research and the university, biology, medicine and physiology, role of man in space research.

With "a surprising degree of unanimity" the report recommends Mars as the first-priority target in planetary research. The planet rates so high because it is a field for the study of all three of what the Board calls "central problems" of planetary research: biology, geophysics and meteorology, and (Mars rates "mildly" on this one) origin of the solar system. Remaining members of the system are ranked as follows: moon and Venus, two and three; major planets, four; comets and asteroids, five; Mercury, six; Pluto, seven; and dust, eight. The report qualifies the priorities with a remark that they are preliminary and subject to modification by further debate among scientists and the application of new data as acquired. The Board recommended that during the next ten years a shift of emphasis toward the planets and away from the moon begin and progress toward a roughly equal expenditure on lunar and on planetary exploration in the period 1970-85.

In about ten years a large telescope (about 300-cm diameter) should be put in orbit around the earth. The Board recommended that the instrument be capable of detecting radiation between 80 millimicrons and one mm. Further recommendations for general optical astronomy include two or more orbiting telescopes of 100-cm or larger diameter and the development of various ancillary equipment for telescopes. Specific proposals were also made regarding special equipment for solar astronomy.

If space astronomy is to fulfill its potential, large and systematic support should be given to ground-based astronomy. Equipment should be extended to the limit of its observational capabilities and provided in sufficient amounts to attract enough people to the science.

For long-wave radio astronomy the report proposes a space radio telescope with an aperture about 20 km. Work should be started now, and such an instrument (with a range from 10 MHz to a few hundred kHz) should be in use in about ten years. Continued use of satellites, rockets, balloons, and ground-based equipment was endorsed. Millimeter and far-infrared telescopes with apertures of about 30 m will be needed for future studies; they should be put in space where they are free of terrestrial gravity. Radar studies from the ground, Voyager space probes and lunar orbiters should be continued and extended.

In further recommendations the Board supported continued engineering development of satellites and rockets, endorsed medical and biological investigation of space and planetary environments and their effect on human physiology, and proposed sending scientist-passengers into space along with trained astronauts on certain future missions.

Rf beam separator at Brookhaven

A new radio-frequency beam separator at Brookhaven National Laboratory has produced exposures of negative and positive K mesons at a momentum of 12.8 GeV/*c*, the largest momentum obtained to date with separated kaon beams. The separator, a joint project of the Brookhaven Accelerator Department and Yale University, was completed at the end of 1965. A similar instrument is in operation at CERN, producing kaon beams of 10 GeV/*c*. Before completion of the rf separator, Brookhaven used an electrostatic separator that produced kaon beams up to 5.5 GeV/*c*. The new facility will make possible studies of interactions of antiprotons, kaons, and pions at selected momenta between 7 and 18 GeV/*c*.

Both electrostatic and rf separators depend on the mass-dependent velocity differences among particles in a beam of well defined momentum. In an electrostatic separator, a static electric field is applied transversely to the flight of the beam. Particles of different velocities traverse the field in different times, and, in consequence, are deflected sideways by different amounts. An rf separator uses two short rf deflectors separated by a drift space. Here transit time determines the relative phase of the deflection, and the system has the advantage that the resultant deflection can be made twice the individual deflection for one type of particle at the same time as it is made to cancel for another. Furthermore, at high frequencies a small transit-time difference can correspond to a large phase difference.

In the Brookhaven separator, deflections are imparted to the particles by two iris-loaded waveguides, each 3 meters long, set 40 meters apart. The waveguides resemble electron linacs in their mechanical structure, but the power propagates as a hybrid backward wave. The travelling waves are synchronous with the particle and have a field configuration that pro-