can only accelerate particles with a charge-to-mass ratio greater than 0.125. Since a conventional cold-cathode, pulse-discharge (Philips-ion-gauge or PIG) ion source can only remove electrons with ionization potentials less than around 120 V, significant beams of ions with mass numbers about 240 would be produced with a charge-to-mass ratio of approximately 0.05. A synchrotron can easily accelerate ions of this charge-to-mass ratio although the energies reached would not be very high.

This limitation is overcome by a second stage of acceleration made possible by a storage ring. For example, uranium, the most difficult case, can be injected into the synchrotron with a charge-to-mass ratio of about 0.05 and accelerated to about 7 MeV/nucleon. At this energy the ion can be transferred to the storage ring, an almost identical dc, alternating-gradient ring concentric with the accelerating ring. The first acceleration gives the ions a velocity of about 0.15*c*, sufficient to ensure complete stripping of a reasonable percentage of the ions. The stripping is accomplished by passing the ions through a thin foil on their way into the storage ring. During storage the field of the accelerating ring is returned to its minimum of 300 G; then the particles, with their greatly increased charge-to-mass ratio, are reinjected into the inner ring and accelerated again. By this "bootstrap" acceleration, it should be possible to obtain 70-GeV uranium ions.

Intensities are estimated at 10^{12}–10^{13} particles/sec for ions with mass number less than 128. For larger masses estimates are unreliable because it is not known what heavy ion yields to expect from a PIG source. The principal losses after injection will probably arise from charge exchange with residual gases in the accelerator chamber during the first stage of acceleration. Rough predictions indicate that beam attenuation will go as $\exp(-10^{10}\,Pt)$ where P is pressure in Torr and t is time in sec.

To minimize pressure the designers presently favor cryopumping at 4–5 °K using high-pressure helium circulating around the guide rings. The entire system would be backed with turbomolecular pumps, which would handle light gases and roughing.

To keep t small the synchrotron magnet is pulsed at 60 Hz. This cycling rate also enhances the synchrotron's duty factor; the addition of the storage ring makes the Omnitron's duty factor essentially 100%. —CHH

Lunar Orbiter Answers How High the Moon

The earth-to-moon distance is now known to less than 15 m as a result of combining theoretical calculations of a couple of years ago with new determinations of the moon's mass calculated from observations of Lunar Orbiters 1 and 2. The new accuracy represents about one part in two million. It is incorporated in a new 50-year lunar ephemeris calculated by J. Derral Mulholland and William L. Sjogren of the Jet Propulsion Laboratory of California Institute of Technology. Wallace J. Eckert and H. F. Smith Jr of the IBM Watson Laboratory did the theoretical calculations on which the ephemeris is based (PHYSICS TODAY, June 1965, page 73).

... also of Interest: Space and Cryogenics

Union Carbide has made a micrometeroid detector so delicate that it will record velocity and direction without changing either. Aluminum films on both sides of a plastic sheet produce signals that tell where and when a particle ruptured each of them. . . If you want to see a satellite better, illuminate it with a laser and make a hologram with the reflection. You should beat atmospheric distortion say Stanford engineers Joseph Goodman, Wright Huntley, David Jackson and Matt Lehmann. . . Mohave Desert dust devils, those frequent summer cyclonic systems, may be a clue to yellow clouds on Mars say Jack Ryan and Ferol Fish of Douglas Aircraft, who are watching them to find out whether Martian clouds might have 350-mile/hr velocities and be dangerous to man. . . . NBS runs a Cryogenic Data Center that evaluates and compiles data on thermophysical properties of low-temperature fluids. □