The Soviets, so far, have launched four moderately successful lunar spacecraft. The first merely flew by the moon. The second impacted the moon but performed no close-in experiments. The third flew past the moon and took some photographs of its back side which were later transmitted to the earth. Figure 7: These photos were taken from a distance of 40,000 miles, and the signal to noise ratio on the communication system was very poor, so that the resulting pictures produced only a very crude impression of the side of the moon not visible from the earth.

The last Soviet attempt, Lunik IV, was launched on 2 April 1963. It apparently missed the moon by a large distance and failed in its mission.

The Soviets have made no positive announcement about an Apollo-type programme, but their current interest in manned space flight, and in rendezvous techniques, suggest that they also expect to send a man to the moon.

THE FLIGHT OF RANGER VII

Ranger VII was launched 28 July 1964. Figure 8: The launch sequence required the spacecraft to be accelerated to satellite speed and placed in a 120-mile altitude circular orbit. It coasted for 20 minutes, then was accelerated to the lunar trajectory velocity of 10.949 km/sec, or 24,500 m.p.h.

Figure 9: The required accuracy of this manoeuvre and the complication arising from the fact that the earth is rotating is illustrated in this figure. The path to the moon remains reasonably constant over any one day, hence the trajectory from the launch in Florida to injection on to the lunar path must change with time as the earth rotates. On any one day, launch constraints restrict the permissible launch period to about two hours. The duration of the flight from earth to moon is selected so that the arrival at the moon will be visible from the Goldstone tracking station in California. Figure 10: The trajectory is illustrated in this figure.

After injection on to the correct lunar trajectory, Ranger VII was separated from the final stage rocket and was then ready to perform its operations in space. Figure 11: The first operation was to unfold its solar panels and stabilize itself with the long axis pointed at the sun. The roll angle of the vehicle was then turned so that the high-gain antenna was pointed at the earth. Photoelectric sensors were used to detect sun and earth. The spacecraft was moved by small gas jets exerting forces of the order of 4 grams. The gas is supplied from vessels containing 4 pounds of air at a pressure of 3,500 psi. Sun and earth acquisition were completed in 6–1/2 and 23 minutes respectively. After being stabilized, the craft oscillated through a 1/2° limit cycle within a period of 15 minutes.

The spacecraft communication system, operating in the region of 2,300 mc, was phase-locked from an earth-based transmitter. Two antennas were used, an onmidirectional and a four-foot parabola. The switch over to the parabola, by command from the earth, was done about 20 minutes after the spacecraft had stabilized on the earth. The transmitter power was 3 watts.

For the next 12 hours the spacecraft reported its operating conditions through a telemetry system which measured 110 quantities such as temperatures, voltages, etc.

Figure 13: The tracking stations at Goldstone, California, Johannesburg, South Africa, and Woomera, Australia, collected these data and also measured the spacecraft position and velocity. Position measurements were made by measuring the pointing angles of the 85-foot parabolic antenna. Radial velocity relative to the tracking station was obtained by measuring the doppler shift in the phase-locked loop from ground to spacecraft to ground.