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# Chapter 18

# DEVELOPMENT OF THE FIRST AUTOMATIC STATIONS FOR LUNAR FLIGHT IN THE USSR*

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The first successes of Soviet cosmonautics are inseparably bound with the study of the Moon. And this is not by chance, for the nature and structure of our celestial satellite, despite numerous investigations, is still hidden in riddles. One of these riddles, which has long attracted attention and has been the reason for many, sometimes quite fantastic, hypotheses, was bound with the structure of the invisible far side of the lunar surface. The final elucidation of this question became possible only with the realization of space flight, the dreams of which were transformed into reality at the turn of our century due to the work of the great K.E. Tsiolkovsky and other founders of cosmonautics.

The idea of rocket flight around the Moon and photographing its other side was expressed as far back as the 1920s. The possibility of carrying out this experiment was mentioned by R. Goddard [4, p. 415; 7], F. Tsander [2, p. 57], F. von Hoefft [6], H. Hein [8], and others. They suggested the launching around the Moon of small rockets, equipped with cameras, with subsequent return of the rockets to the Earth.

According to the projections of these pioneering scientists, the angular orientation and flight control of these rockets were to be implemented by means of a gyroscopic control system supplemented, according to Goddard, with correction devices in the form of inertial and optical appliances. However, the above projects were received with skepticism by their contemporaries, including specialists [5, pp. 170-171], who realized that the state of development of rockets and automatic control systems did not, at that time, permit one to consider seriously the reality of circumlunar flight.

For a successful accomplishment of such flight around the Moon and of photographing its surface it was necessary to solve the following problems:

1. Select an optimum flight path and then launch the rocket at a calculated time.

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2. Impart escape velocity to the spacecraft, required for reaching the general vicinity of the Moon.
3. Ensure the required spacecraft orientation and optical axis of the photographic equipment during flight.
4. Develop the necessary reserves of power aboard the spacecraft.
5. Photograph the lunar surface.
6. Transmit to the Earth the results of photography.

Beginning in the middle 1940s, rocket developments in the Soviet Union were developing at a swift rate. In 1948, the first Soviet controllable ballistic rocket R-1 was launched; it was developed in the Design Bureau under S.P. Korolev's supervision [3]. In 1957 the USSR had constructed a multistage intercontinental ballistic missile, capable of reaching any area of the globe. Having constructed this rocket, on 4 October 1957, the Soviet Union was able, for the first time in the history of mankind, to launch an artificial Earth satellite. The subsequent launchings of the second and third Earth satellites in 1957-58 clearly demonstrated the power of Soviet rocket technology and its ability to ensure space launchings.

The next stage in the development of the Soviet space program was accompanied by a series of Moon missions undertaken by the automatic space stations. The first such station, Luna 1, was launched on 2 January 1959. After the flight in the vicinity of the Moon it became an artificial planet of the solar system. Luna-2, launched a few months later (on 14 September 1959) for the first time, reached our celestial satellite and delivered to its surface a pennant with the State Emblem of the Soviet Union.

The construction of Luna 1 and Luna 2 involved spherical hermetically sealed containers 0.8 m in diameter. Arranged inside each container were the radiotelemetry system, power supply accessories, electronic blocks of scientific instruments, a fan for gas mixing and heat removal from transmitter to container machines. Outside the container antennas, scientific instrument sensors and a special pole, were set up. At the end of the pole a magnetometer sensor was located.

In contrast to the first two Soviet Lunas, the third automatic station Luna 3, was somewhat different in construction. It was launched on 4 October 1959, exactly 2 years after the launching of the first artificial Earth satellite by the USSR. On 7 October 1959, photographs were taken of the other side of the Moon by Luna 3, resulting in the enrichment of science by most valuable information for all mankind. The successful carrying out of such an outstanding experiment, a triumph of Soviet space science, became possible due to creative coordination of scientists and engineers of various specialties who managed to construct, within quite a short time, a unique automatic control system of the station's orientation during flight, to develop a single power supply system for the instruments aboard, to solve the problem of selecting an optimum flight path, photographing the other side of the Moon, and transmitting the survey results to the Earth.

The flight path of Luna 3 is shown in Figure 1. The specific feature of this trajectory was the fact that the lunar gravity field was used for its accomplishment.

The return of the station to the Earth after the flight around the Moon took place from the side of the northern hemisphere. As a result of the gravity maneuver, the orbit was close to elliptical with an apogee of about 480,000 km and a perigee of about 47,500 km.

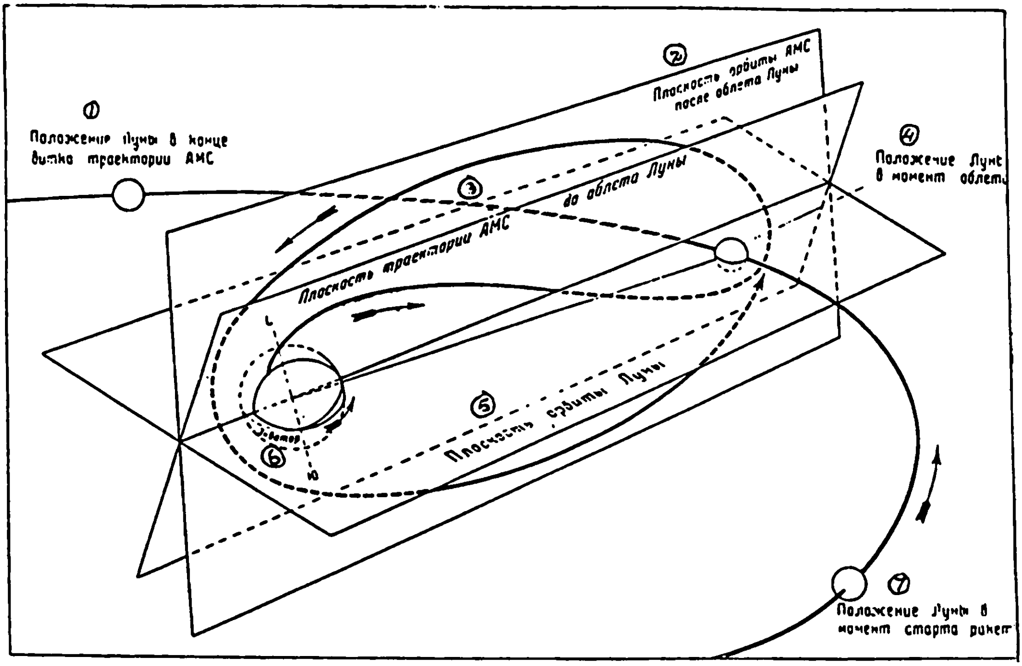

**Figure 1** Diagram of flight path of the automatic interplanetary system. (1) Position of Moon at end of trajectory loop of automatic interplanetary station (AMS); (2) Plane of AMS orbit after circumlunar flight; (3) AMS trajectory plane prior to circumlunar flight; (4) Position of Moon during flight around it; (5) Plane of Moon's orbit; (6) Equator; (7) Position of Moon at moment of launch of AMS from Earth.

The solution of such problems as the photographing of the lunar surface and transmission of results to the Earth was predetermined by the vigorous development of the radio-technology and radio transmissions to great distances. The photographing of the Moon from the automatic space station required solving a multiplicity of technical problems connected with selection of exposure conditions, automatic processing of the film, construction of an illuminator of required clarity and strength, etc. All this involved difficulties.

Of these, the most complex and important was the development of the automatic control system to assure the station's orientation during the flight. This system, which was the beginning of the development of spacecraft control systems in the USSR, was devised under the supervision of B.V. Raushenbakh, a member of the USSR Academy of Sciences. Academicians M.V. Keldysh and S.P. Korolev were highly interested, due to the importance and the novelty of the problems, and participated in the construction of the orientation system for Luna 3. In evaluating the results of the work done in this sphere, the fact should be kept in mind that Luna 3's orientation control system was the world's first automatic control system housed in a spacecraft. There was no previous experience whatsoever, in constructing this type of system so everything had to start practically from zero. Nevertheless, Soviet specialists brilliantly resolved this problem.

Luna 3's orientation control system operated on the basis of a two-stage procedure, with the orientation control of the station's movement around the Moon consisting of several stages. Initially, on command from the Earth, the station was oriented toward the Sun. The command was given at the moment, when the Earth, the Moon, the station and the Sun were approximately on the same straight line. In this case, the station was naturally on the other side of the Moon.

For orienting toward the Sun, four optical Sun pickups were arranged at the bottom of the station. With the appearance of a signal at the output of any one of these there was automatic cessation of the station's search rotation, which prior to this was provided by feeding minor displacement to one of the angular movement pickups set up on three reciprocally perpendicular axes and designed for dampening the station's oscillations about its center of mass. The command for search rotation was given also by getting the Sun into the vision field of any of the four pickups (arranged around the illuminator in the nose cone of the station). At the moment of opening the lid of the illuminator the Moon was in the vision field of the lunar pickup. Thereafter, the power supply from the solar pickups was automatically cut off and the station operated in the regimen of lunar orientation.

At a certain precalculated moment the lunar surface was photographed from aboard the station, oriented in this way was by means of a camera. The direction of the optical axis of this camera coincided with the orientation axis of the lunar pickup, which was rigidly fixed to the station's body.

The specific feature of this orientation system was the fact that it operated on a relay principle: the controlling signals, formed by the position and angular movement pickups, were changed in steps, and the orientation jets operated only in conditions of constant thrust. These initial premises were dictated, on one hand, by rigid limitations for the consumption of working fuel in the process of orientation, and on the other by the specifics of space flight. It was economically expedient to expand to some extent the nonsensitivity zone of the pickups (but only up to certain limits, determined by the requirements of the orientation accuracy) and to implement the station's orientation within a certain tolerance zone of the station's angular deviations.

For the same reason, in order to ensure the highest efficiency of the controlling devices with a minimum consumption of fuel, it was decided to assemble discrete logic elements of the computing and transforming block in Luna 3's orientation control system. The orientation jets were estimated to operate in three sets of conditions: (1) in continuous thrust condition, (2) in impulse condition with invariable frequency and duration, and (3) in non-thrust condition. The cut-in of each of these sets of conditions corresponded to certain combinations in the reading of angle and angular movement pickups. Moreover, the direction of correction impulses depended on the sign of deviations arising in the systems.

The fact that the world's first automatic control system of spacecraft orientation, set up in Luna 3 was of a relay type with logic and transforming arrangement, indicates that the development of the cosmic automatic control systems (SAU) was from the start developed in its own way, on the basis of principles, which were not extensively used in aviation and rocketry where use was mainly made of analog automatic control systems, which reduce nonlinearity and auto-oscillations to a minimum.

The fuel for the orientation jets of Luna 3 was compressed gaseous nitrogen, which was contained in a special cylinder.

There were two ways to ensure the required amount of power on board the station:

1. Use storage batteries of high capacity, capable of generating, without recharging, electric energy throughout the flight.
2. Supplement the power reserves on board during flight, which could be obtained by means of solar batteries.

The last variant seemed to be preferable as it enabled the total weight of the station to be reduced. However, for the practical realization of a supply system on the basis of solar batteries the way had to be found for arranging these batteries on the spacecraft. As pointed out above, the time of the oriented flight of the station was less than one hour, which was a lot less than the time planned for its functioning. A certain amount of torsion after the completion of orientation could not guarantee that the station would keep its prescribed position in relation to the Sun throughout the whole flight. Therefore, the designers of the station had to construct the so-called omni-directional solar battery, which at random position of the station in relation to the Sun would ensure sufficient charge of the storage batteries and continuous operation of radio receivers and scientific instruments.

Prior to the launching of Luna 3, it was necessary to make a final checkout of all calculations. To enhance the reliability of the orientation system, the main stages of the station's flight were reconstructed under laboratory conditions. For this purpose, a special test bed was constructed on which the orientation control system with actual Sun and Moon pickups and photo-camera was being perfected. The platform, imitating the controllable object (i.e. the station), was suspended on a multistrand suspension with considerable length of strands. The bed also included a follow-up system, which turned the top point of the strand's suspension in accordance with the course of the platform. The strands were never twisted, thus making visible the absence of moments of external forces.

The last stage of the tests was the playback of all operations logic of the control system during the circumlunar flight, including the photographing of the lunar surface with the orientation of the station at the Moon simulator. The photographs, obtained during this test by multiple working of the camera shutter with the cutoff winding of the film, indicated high precision in performance of the orientation control system.

In conclusion, it is noted that further development of space technology has confirmed the correctness of the main principles employed in the construction of the Luna 3 automatic station. In particular, attention is drawn to solar batteries, which as power generators have found a firm place among the spacecraft's on-board equipment for various purposes; the relay systems of orientation control, now more widely used in the investigation of space; and the two-stage operational procedure of Luna 3's orientation control system, which was subsequently adopted for later space flight endeavors.

## BIBLIOGRAPHY

1. Kosmonavtika. Malen'kaya entsiklopediya (Astronautics. A small encyclopedia). Moskva, 1970.
2. F.A. Tsander. Iz nauchnogo naslediya (From the scientific legacy). Moskva, 1967,
3. "Iz istorii aviatsii i kosmonavtiki" (From the history of aviation and astronautics), vyp. 19, Moskva, 1973, pp. 89-93.
4. R.H. Goddard. Report to Smithsonian Institution concerning further developments of the rocket method of investigating space. -- In the book "The papers of Robert H. Goddard", N.-Y., vol. 1, 1970, pp. 413-430.
5. R. Esnault-Pelterie. L'astronautique. Paris, 1930.
6. F. von Hoefft. Die Eroberung des Weltalls. -- "Die Rakete", 1928.
7. "Scientific American", 26 February 1921.
8. H. Hein. Der Schuss in den Weltraum. -- *Kosmos*, Stuttgart, 1925, 22 Jahrgang, H. 5, SS. 145-150.