30860

2 C
5

OTS: 60-11,536

JPRS: 2553

25 April 1960

FIRST FLIGHT TO THE MOON

- USSR -

Distributed by

OFFICE OF TECHNICAL SERVICES
U. S. DEPARTMENT OF COMMERCD
WASHINGTON 25, D. C.
~~Price: $0.50~~

U. S. JOINT PUBLICATIONS RESEARCH SERVICE
205 EAST 42nd STREET, SUITE 300
NEW YORK 17, N. Y.

JPRS: 2553

CSO: 3558-N

FIRST FLIGHT TO THE MOON

/This is a translation of an unsigned article appearing in Priroda (Nature), No 10, 1959, pages I-VII./

On 12 September 1959 the second Soviet space rocket was launched, and on 14 September at two minutes and 24 seconds after midnight Moscow time it struck the surface of the moon. Mankind had for the first time succeeded in executing flight from the earth to another celestial body, thereby confirming the leading role of the Soviet Union in such vital branches of science and technology as are associated in the conquest of interplanetary space. The large numbers of responses elicited from scientists and the many congratulatory messages received by the USSR Academy of Sciences from abroad in connection with the launching demonstrate that the world scientific community justifiably views this achievement of the Soviet people as a fresh contribution to the furtherance of world science.

The weight of Soviet devices being sent aloft is steadily increasing. While Sputnik III weighed 1,327 kg, and the first space rocket (final stage exclusive of fuel) weighed 1,472 kg, the weight of the second space rocket totalled 1,511 kg. Equally important is the fact that the rocket's final stage was guided, thus permitting the automatic introduction of corrections in the rocket's basic flight characteristics before entry into free flight.

The over-all weight of the payload instruments with their power supplies and container amounted to 390.2 kg. All the information from the rocket was transmitted back to earth on five frequencies: 20.003, 19.997, 39.986 and 183.6 megacycles. The radio equipment on board insured dependable tracking of the rocket from the ground, from launching to the moment when the container hit the moon.

The rocket delivered to the moon three pendants bearing the emblem of the Soviet Union and the inscription "Union of Soviet Socialist Republics. September 1959." Two of the pendants were housed in the container holding the scientific instruments and the third was placed in the final stage. Construction measures were taken to insure that the pendants would not be destroyed upon impact with the moon.

Optical tracking of the second rocket, as in the case of the first, was facilitated by special equipment producing a sodium cloud -- an artificial comet. The latter was formed exactly on time, at a distance of approximately 150,00 km from the earth; in the first rocket the sodium comet had been produced at 113,000 km. Observation of these artificial comets not only enables determination of the rocket's position at the time of the cloud's appearance but also makes it possible to judge, by the speed of its diffusion, the density of interplanetary gas.

Like its predecessor, the second Soviet space rocket was tracked not only from the USSR but also from abroad. The British astronomer Professor Lowell reported locating the second rocket with the aid of a radiotelescope shortly before the sodium cloud was formed. Reports were also received from many institutions and individuals stating that the radio signals from the Soviet rockets had been clearly received.

The container and final stage were thoroughly sterilized to insure that terrestrial microorganisms would not be carried to the moon. It cannot be said categorically at this stage that conditions on or beneath the surface of the moon absolutely preclude the possibility of some highly simple forms of life there and hence the possibility that microorganisms and spores deposited on the moon might adapt themselves to the existing conditions. In the not-too-distant future we will be able either to study the forms of life there or to convince ourselves that no such forms exist. In either case we will learn things about the evolution and origin of life that we could not learn on the earth. If, however, microorganisms and spores were to be deposited there, and particularly if they succeeded in adapting themselves to the new conditions, an undesirable element of uncertainty would be introduced into our studies. The sterility of objects sent to bodies in space is therefore extremely important, at least until their thorough biological investigation has been completed.

Nine days after its launching it became possible to communicate the first results on the flight of the second moon shot. The sorted data showed that the container fell to the moon's surface east of the Sea of Serenity, in the area of the craters Aristillus, Archimedes and Autolycus. The distance between the container's point of impact and the center of the visible side of the moon was approximately 800 km.

It is of very great interest to know whether the moon has a magnetic field and, if so, of what magnitude. A fully reliable theory of terrestrial magnetism does not yet exist, and information obtained through a moon shot might lend support to various of the existing hypotheses or, alternatively, detract from them.

The preliminary data enable us to assert that:

(a) no magnetic field close to the moon has been revealed, according to the magnetometer readings, i.e., within the limits of its sensitivity and deviational error (or the order of 60 gammas);

(b) the measurements of radiation intensity close to the moon have not revealed a radiation belt of charged particles; this fact accords with the results of the magnetic measurements.

It is of vital importance for future space flight and for an understanding of certain processes occuring on the sun, in the upper layers of the atmosphere and in the space surrounding the earth, to have information on the matter comprising interplanetary space, a region which we can now no longer regard as absolutely empty. During the journey of the second space rocket from earth to moon, measurements were made inside the earth's radiation belt, the very existence of which was established only a short time ago on the basis of information from the artificial earth satellites and space rockets. In addition, a record was made of the currents produced by particles of ionized gas captured from the surroundings by four positive particle traps installed in the container. The size of the measured currents varies along the rocket's path. The first findings show that there are areas between the earth and the moon where the concentration of ionized particles is less than 100 particles per cubic centimeter; on approaching the moon, at about 10,000 kilometers, the measured currents grow. This may be due either to the presence of a shell of ionized gases around the moon -- a kind of lunar ionosphere -- or to the existence of a region containing an elevated concentration of corpuscles having energies on the order of tens of electron volts.

Questions which only a few years ago seemed within the exclusive domain of science fiction are now being studied by prominent scientists and engineers in many parts of the world. We can no longer call unreal such problems as the establishment of automatic or controlled research laboratories and astronomical observatories on the moon, the designing and building of a permanent earth satellite serving for research and as an aid in the solution of technical problems, rocket flights to our neighboring planets in the solar system, Mars and Venus, and, the most important problem of all, achieving return flight to the earth.

In the course of another few years or decades all these problems will have been solved, and we can be certain that Soviet men and women will make a contribution worthy of their country to the grand cause of conquering space.

So that our readers might become better acquainted with the problems involved in sending a rocket to the moon, we present below a communique which appeared in Pravda on 21 September 1959.

* * *

The entire world has learned the exciting news of the launching by the Soviet Union of its second space rocket, which on 14 September at two minutes and 24 seconds after midnight struck the surface of the moon. For the first time in man's history, flight has been executed to another celestial body.

The earth-to-moon flight was made possible by the advanced state of Soviet science and technology. It was the product of the efforts of Soviet scientists, designers, engineers, technicians and workers, the result of the inspired work carred out by the large collectives engaged in the creation and launching of the second Soviet space rocket.

Sending a rocket to the moon poses an exceedingly intricate scientific and technical problem. It was necessary to produce a highly advanced multistage rocket, powerful rocket engines consuming "hot" fuel, a highly accurate flight guidance system, surface launching equipment and an automatic observation complex to track the flight.

To give an indication of the demands made on the guidance system, the automatic launching system and the observation network for the success of a moon shot, we outline below some facts about the moon's motion and describe some of the problems involved in designing an appropriate flight path.

Let us first recall some of the basic facts about the moon's motion that astronomy has taught us. The moon, a satellite of the earth, travels around the earth in a nearly circular orbit. The plane of the moon's orbit is at the present time inclined to the plane of the earth's equator at an angle of about 18 degrees. As a result in travelling on its orbit the moon's inclination, i.e., the angle formed by the line joining the center of the earth with the moon and the plane of the earth's equator, varies between +18 and -18 degrees, It takes the moon approximately 27.3 days to circle the earth. The distance between the two bodies is 384,386 km on an average and varies between 356,400 at the perigee of the lunar orbit and 406,670 km at the apogee. The moon's orbital velocity is roughly one km per second; this means that it describes an arc of about 13 degrees daily.

The flight of a moon shot consists of two parts: the power phase, during which the thrust of the rocket's engines raise the rocket to a given point in space, imparting the requisite velocity to it, and the free-flight phase, which begins after burnout of the final stage engines and separation of the nose-cone. The nose-cone is disconnected from the final stage mechanically and through the application of a small but distinct additional velocity to the nose-cone.

Conforming to the laws of celestial mechanics, the rocket's free-flight trajectory after burnout was for the most part, i.e., where the moon's gravitational force was relatively weak, close to the hyperbolic, with the center of the earth acting as one of the hyperbola's focal points.

Moving away from the earth, the rocket's velocity gradually decreased to approximately 2 km per second. Subsequently, owing to the steadily increasing attraction of the moon, the decrease stopped, the speed began to increase and continued to grow until impact with the moon. The speed at impact was 3.3 km per second.

The rocket launching was preceded by theoretical research and technical computations to ascertain the trajectory and firing time which would result in encounter with the moon under the most advantageous conditions. This matter warrants closer examination.

In principle, a rocket to the moon may be sent up on any day, i.e., with the moon in any orbital position in relation to the earth. But we find from computations that when firing a rocket from points situated in the latitudes of Soviet territory, it is advantageous from the power standpoint to execute the launching when the moon lies close to its orbital point of minimal inclination, i.e., when the moon's inclination is close to -18 degrees. Under such conditions, the rocket will leave the launching area at the smallest angle to the earth's surface, and the velocity losses due to the earth's attraction will be minimal, thus allowing for a greater payload. For earlier or later takeoffis, the payload must be correspondingly lighter. Within the space of a few days before or after the optimum, however, these losses are relatively small, and in each lunar month there is approximately one week during which rocket flight to the moon is feasible. Greater deviations from the optimum period force sharp reductions on the size of payload.

During the optimum time period, the rocket's encounter with the moon should occur when the moon lies above the horizon. In planning the space rocket's flight, the encounter time was selected so that the approach would take place when the moon lay, as far as the tracking points were concerned, near its upper culmination point, i.e., where its height above the horizon is nearly maximal. This situation is the most favorable for radio communication.

Based on the computations, the most advantageous angle between the trajectory plane and the earth's equatorial plane was chosen and this determined for the given launching point the rocket's course during the initial phase of the flight. The launching angle has a direct effect on the rocket's velocity during the power phase and on the losses to terrestrial gravitation. The choice of launching angle was made with a view to minimizing the losses and consequently allowing for the largest possible payload. Other factors involved were the proper placement of the flight control instrumentation and the transmission of information both during the power phase and in the first phase of free flight after burnout.

As found from the computations, when effecting flight to the moon from Soviet territory, the moon should, at firing, lie above the horizon near its lower culmination point. This means that there should be a difference of about half a day between firing and the moon's upper culmination. Bearing in mind that impact with the moon should occur at the upper culmination, it is clear that the flight should last either half a day, one-and-a-half days, two-and-a-half days, and so on.

The choice made for the space rocket was a flight of approximately one and a half days, a half-day flight requiring excessively fast initial velocities and a two-and-a-half day flight (or longer) to put the rocket on the moon at an observable time requiring the observace of far more rigorous accuracy than otherwise in the final moments of the power phase. The choice of flight time determined the rocket's velocity at the end of the power phase; it was, as already indicated, slightly above parabolic.

The rocket's trajectory, both in the power phase and after burnout, was arrived at with the aid of modern digital computers. The principal factors in the problem were the gravitational forces of the earth and moon, but it was also necessary to takeinto account the displacement of the earth's gravitational field from center due to the earth's oblateness and the disturbing effects of solar gravitation.

To insure that the rocket's flight characteristics at the end of the power phase would be sufficiently close to those computed beforehand, the vehicle carried a control system that operated throughout the power phase, i.e., for several minutes. The subsequent day-and-a-half flight was uncontrolled, proceeding solely under the influence of the gravitational fields of the arth, moon and other celestial bodies.

If a space vehicle is to strike the moon without adjustments in its course during the free-flight phase, the flight pattern calculated for the end of the power phase must be very closely matched in actual practice. An error in velocity of only one meter per second, i.e., 0.01 percent of the total speed, would result in a shift in the impact point with the moon of 250 km. Deviation of the velocity vector from the computed direction by one angular minute produces a 200 km shift in the point of encounter. Another factor heavily influencing the accuracy of the shot is the point of engine burnout. All these factors, along with that of exact firing time, operate cumulatively and tend to produce more sizable inaccuracies than would result from each factor acting separately.

Since the moon has a radius of 1,740 km, a successful moon shot requires that the error in velocity be no more than a few meters per second and that the deviation in the velocity vector from the predetermined direction be no more than one tenth of a degree. Achieving this order of accuracy in a rocket's course poses a highly intricate problem. It should also be mentioned tha a lunar launching from Soviet territory imposes higher accuracy demands on the control system than a launching from points closer to the equator.

The need to comply rigorously with the assigned firing time is bound up with the fact that the rocket's plane of motion turns together with the earth as the latter goes through its daily rotation, A 10 second deviation in firing time produces a shift in lunar encounter of 200 km. In turn, firing that is punctual within several seconds makes heavy demands on the organization and preparation of the flight, as well as on the automatic firing system. The second Soviet space rocket, which was launched with just this accuracy, demonstrates the degree of perfection of the launching system and the dependability of the automatic firing devices. The rocket's launching deviated by about one second from the preassigned time.

Another major task associated with the flight was that of establishing a tracking and computing system, a complex network of units designed to determine the rocket's characteristics while in flight. The need for the quickest possible supply of information on the rocket's flight was the prime factor determining the whole system. Such information was necessary to prepare target instructions for the tracking and measuring units, so that the rocket's course and point of impact on the moon might be accurately predicted. It is understandable from what we said before about the effect of flight errors on the eventual point of impact that the flight characteristics must be determined with the accuracy of the finest astronomical computations. However, the traditional ways of determining the patterns of motion of bodies in space, evolved over the centuries of astronomical observation, cannot be used in this instance. The basic technique of astronomical observation - optical measurement - is inapplicable here, the rocket being too small a target, angular measurements alone being too inaccurate for limited observation times and, finally, such measurements being at times impracticable since they depend on suitable visibility and a suitable condition of the earth's atmosphere. Consequently, the observation system for space rockets relies basically on radio devices, which measure slant range, angles and radial velocities.

These special features and requirements of space rocket flight analysis have been met to a maximum degree by the automatic complex, which provides a highly accurate measure of current slant range and two rocket angles, the azimuth and angle of location. The information received at the tracking point is put into binary code, undergoes preliminary processing and is labeled with an astronomical time. All these operations are performed by special digital information machines. These machines also handle the automatic output of the data into communication lines, for both the measurement and the memory output systems. In the computing center, special electronic machines decode the incoming information and record it on punched cards which then go to the computers. From the data arriving from different tracking points, the computers calculate the rocket's initial flight conditions, target instructions and the coordinates of the rocket's impact point with the moon.

So as to obtain the completest possible information on the rocket's motion up to the very last moment of the flight, continuous measurements were made of the rocket's distance, its radial velocity (the speed of its movement away from the point of measuring) and the coordinates of its angle of location and azimuth. These measurements were effected on a frequency of 183.6 megacycles.

The observation data gathered by the rocket itself, together with information on the state of its measuring and radio equipment (temperature and pressure conditions) were received and recorded by telemetering stations on the ground. The rocket's transmitters housed in the container operated on 183.6, 39.986 and 19.993 megacycles.

Tracking of the rocket's final stage was assisted by a transmitter operating on two frequencies, 19.997 and 20.003 megacycles. These wavelengths were also used to transmit additional data on cosmic radiation intensity via a device installed in the final stage.

Thus the tracking and measuring work involved in the flight of the second Soviet space rocket was carried out by a large complex of radio facilities set up at special points in different parts of the country.

All these points were joined by a special system of communication insuring the effective transmission of measured data to the computing center and of target instructions to the tracking points.

To make certain that the tracking and measuring devices would be coordinated in time and would attach a standard time unit to the tracking results, a standard time system was worked out specially for the purpose.

The preliminary results compiled from the tracking information converging on the computing center over automatic lines from all tracking points in the Soviet Union in the course of 20 to 30 minutes made it possible, during the first hour of the rocket's flight, to compute its subsequent trajectory, to ascertain that it was sufficiently on course to hit the moon, and to calculate target instructions for subsequent detection by Soviet and foreign tracking stations. It was predicted from this information that the rocket would probably hit hit the moon in the northern part of the visible hemisphere.

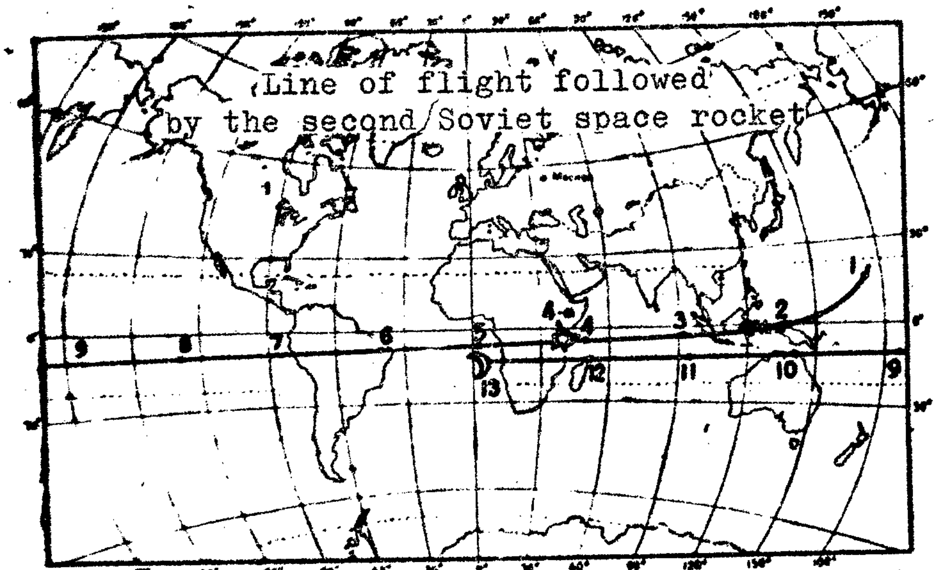
Subsequent sorting of the data and the reception of considerable additional information on the rocket's range and radial velocity made it possible to state the place and time of encounter more exactly. It was ascertained that the point of impact lay in the area of the Sea of Serenity, 800 kilometers from the center of "our side" of the moon.

The successful flight of the second Soviet moon probe represents an extremely important step forward in the investigation of outer space and of the bodies in it.

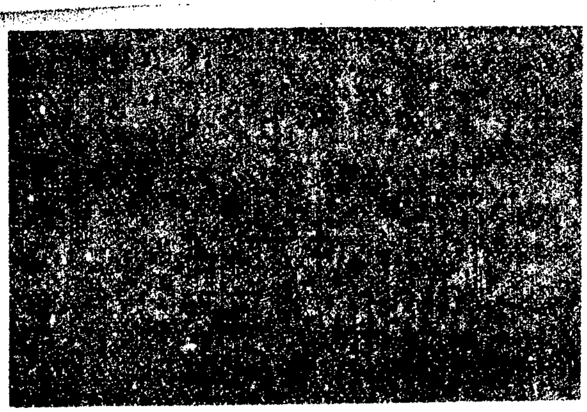
* * *

On 4 October 1959 the third Soviet space rocket carrying an automatic interplanetary station was launched. The interplanetary station will circle the moon and then pass near to the earth. Information on the station's subsequent course and on the results of the studies it will help to carry out will appear in forthcoming issues.

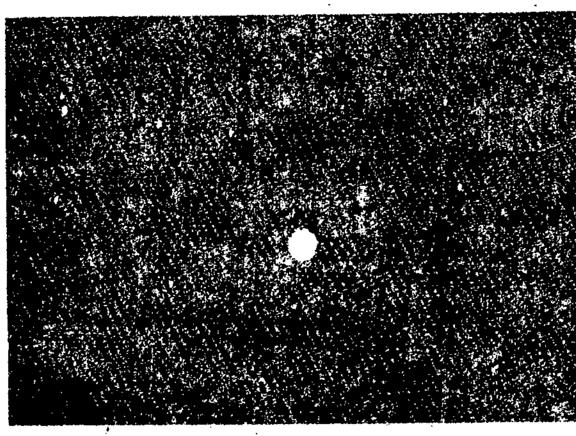
Ribbon and pentagonal elements of spherical pendants.



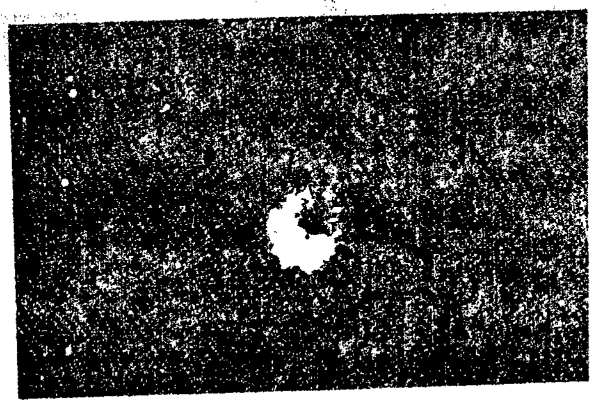
The numbers indicate the successive positions of the rocket projected on the surface of the earth. (1) 12 September, 12:00; (2) 15:00, 78,500 km from the earth: (3) 18:00, 112,00 km; (4) 21:00, 142,400 km: (4a) formation of artificial comet; (5) 13 September, 00:00, 171,000 km; (6) 3:00, 198,000 km; (7) 6:00, 224,00 km; (8) 9:00, 250,000 km; (9) 12:00, 274,000 km; (10) 15:00, 298,000 km; (11) 18:00, 322,000 km; (12) 21:00, 346,000 km; (13) 14 September, 00:02:24, 371 km, encounter with moon.



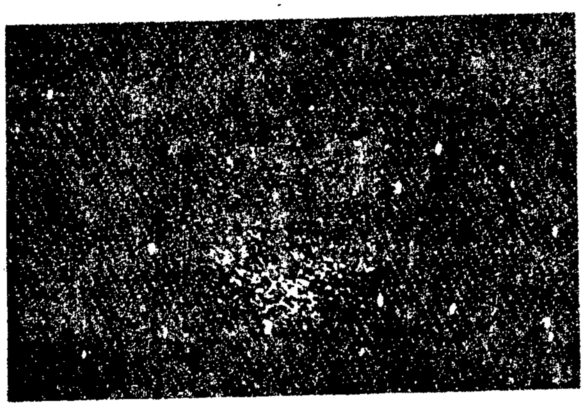
Segment of sky before formation of artificial comet.



Initial phase in development of artificial
sodium comet.



One of intermediate phases of artificial
sodium comet.



Final phase in development of artificial
sodium comet.

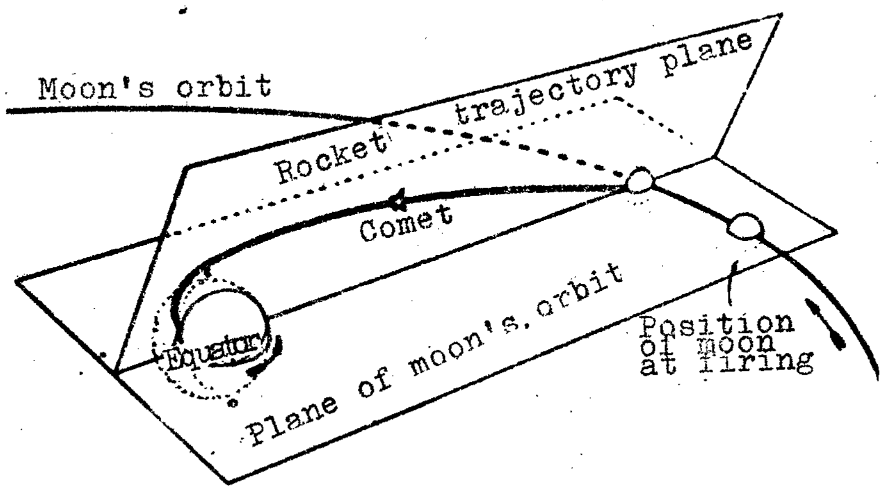
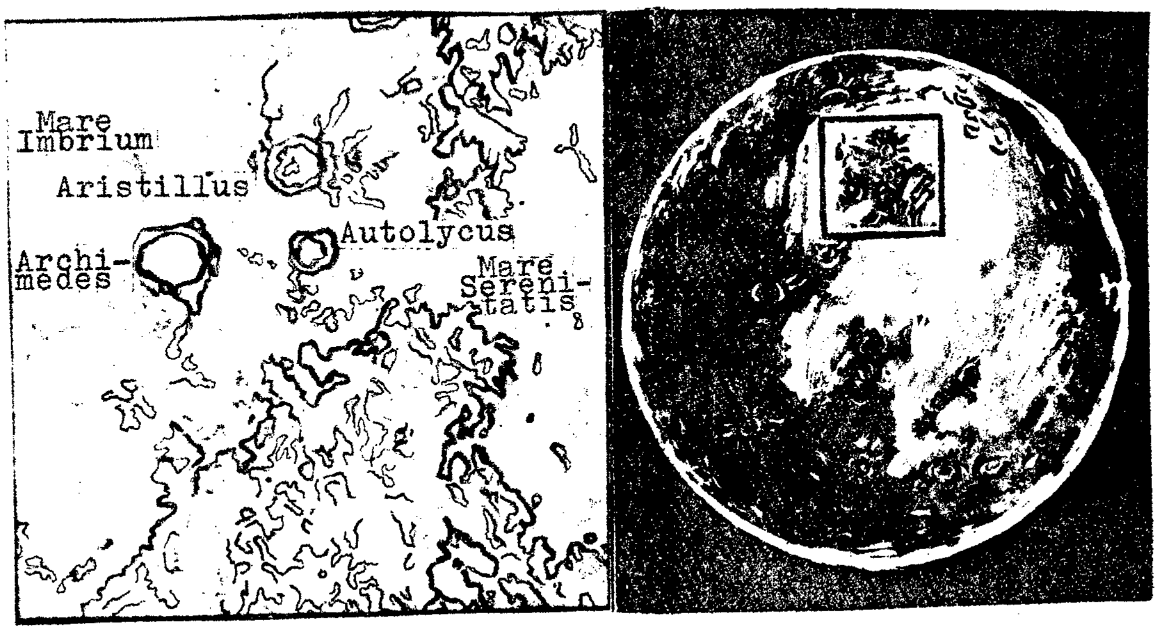


Diagram of lunar rocket's flight trajectory.



Zone of rocket encounter with Moon.
Reinverted image.

END

µ

FOR REASONS OF SPEED AND ECONOMY
THIS REPORT HAS BEEN REPRODUCED
ELECTRONICALLY DIRECTLY FROM OUR
CONTRACTOR'S TYPESCRIPT

This publication was prepared under contract to the
UNITED STATES JOINT PUBLICATIONS RESEARCH SERVICE
a federal government organization established
to service the translation and research needs
of the various government departments.