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DIRECTORATE OF
SCIENCE & TECHNOLOGY

Space Event Report

LUNA-13 -- 21 DECEMBER 1966

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4 October 1967

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MISSILE EVENT REPORT

LUNA-13 -- 21 DECEMBER 1966

SUMMARY

Luna-13, the second Soviet vehicle to be successfully soft-landed on the moon, was launched from the Tyuratam Missile Test Range [redacted] on 21 December 1966. [redacted] According to TASS, the vehicle landed at a point with the following selenographic coordinates: 18°52'N 62°03'W. After landing photofacsimile panoramic pictures of the lunar surface were transmitted back to earth, together with data on the composition of the moon's surface.

[redacted]

CONTENTS

[redacted]

[redacted]

DATA

Soviet Press

Announcements released by the official Soviet news agency TASS on the launch and completion of mission are presented below. For a detailed description of the lunar craft and results published by the Soviets, see the Appendix.

"Luna-13," TASS Announcement; Moscow, Pravda, 22 December 1966, page 2.

(Translation) In accordance with the program for space research, the Soviet Union launched a space rocket in the direction of the moon on 21 December 1966 at 13 hours 17 minutes Moscow time.

The rocket carried the Luna-13 automatic station.

The main purpose of the station is the continuation of scientific investigations of the moon and circumlunar space.

Preliminary results of the processing of measurements show that the station is moving on a trajectory close to the calculated one.

At 17 hours Moscow time on 21 December 1966 the Luna-13 station was at a distance of 44,000 kilometers from earth above a point on the earth's surface with the coordinates: 44 degrees 31 minutes north latitude and 80 degrees 11 minutes east longitude.

Two radio communication sessions have been conducted with the station. On the basis of telemetry data it was established that the equipment on the station is functioning normally.

A special ground measurement complex is observing the flight of the station. The coordination-computation center is processing incoming data.

"Automatic Station Luna-13 Has Successfully Completed Its Program for Investigation of the Moon," TASS Announcement, Moscow, Krasnaya Zvezda, 31 December 1966, page 1

(Translation) The program for investigation of the moon by means of the Luna-13 automatic station, which made a soft landing on the surface of the moon on 24 December 1966, has been fully completed.

As a result of the investigations which were carried out, unique data of great scientific importance were obtained on the physicomechanical properties of the surface layer of the moon. Television pictures were received of a panorama of the lunar surface in the landing area of the station which were taken with the sun at different elevations.

The scientific information received from the Luna-13 automatic station is being processed.

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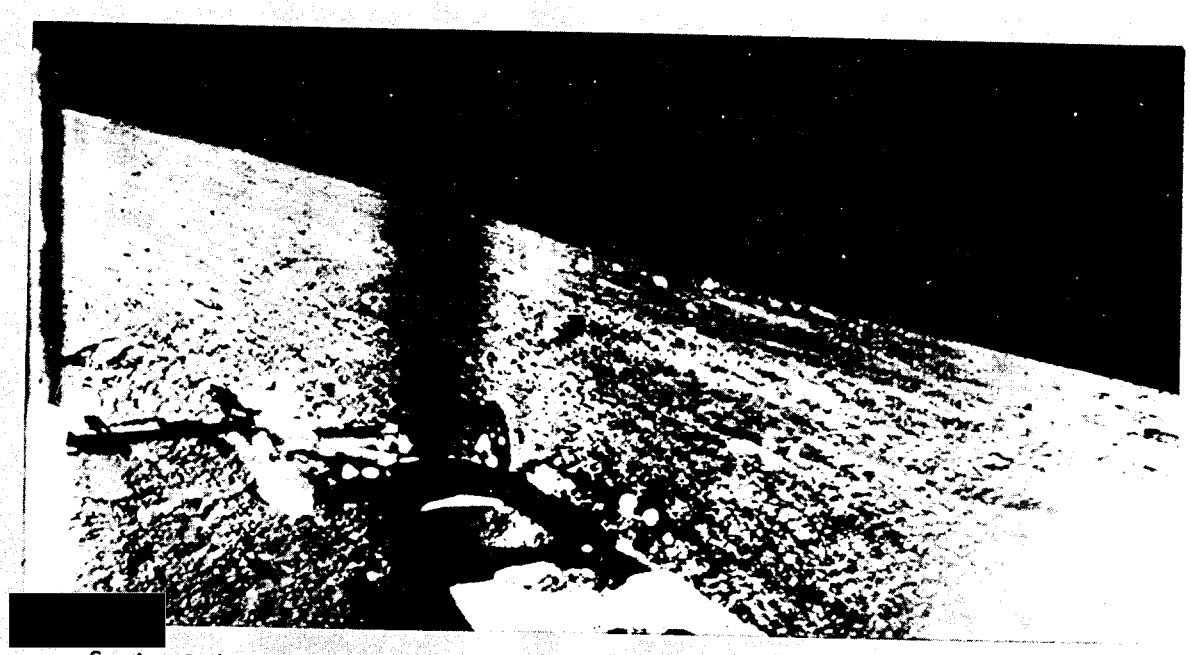
[redacted]

[redacted]

Figure 1



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Soviet Release of Lunar Surface and Spacecraft Photographed by Luna-13

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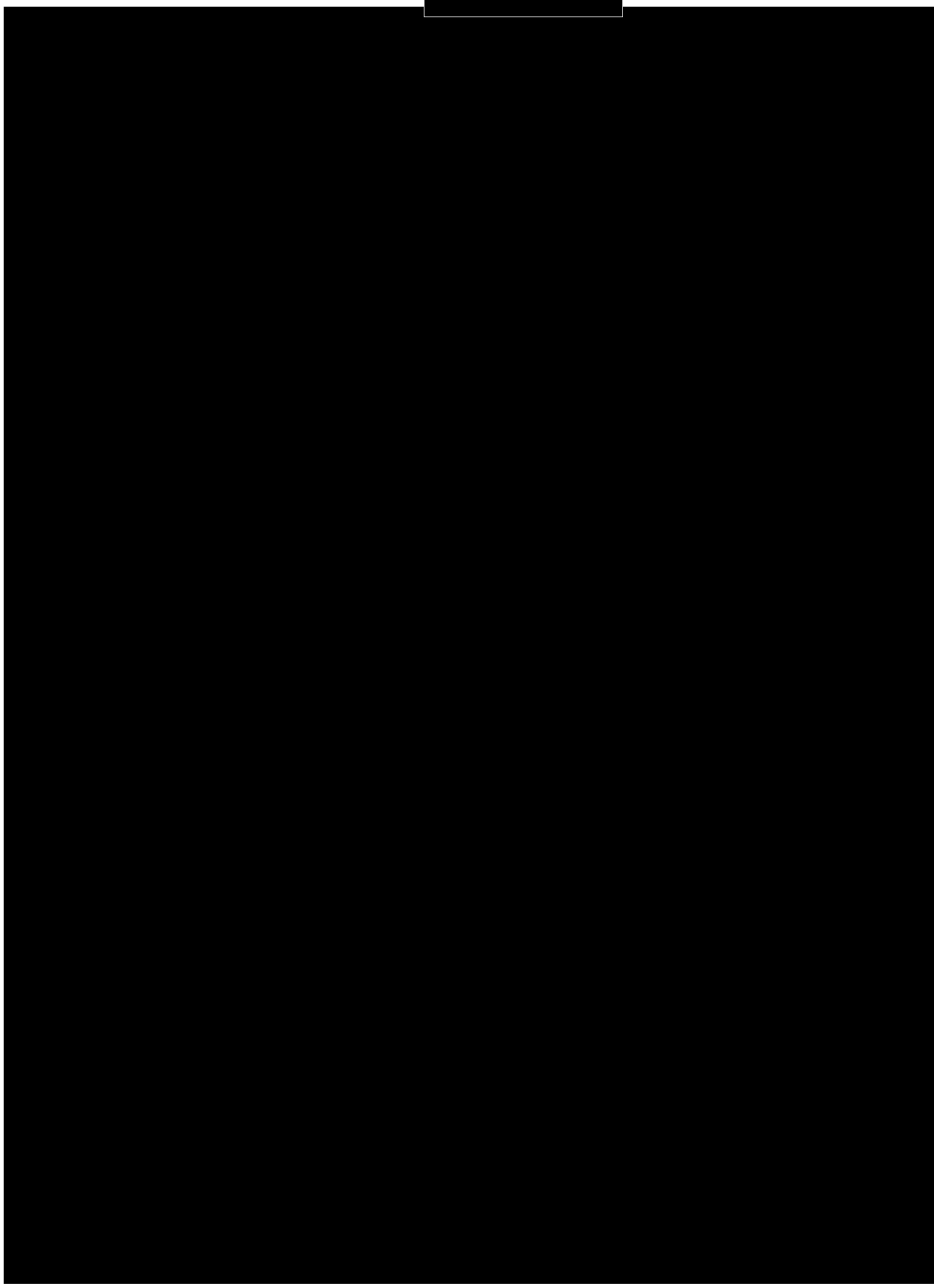

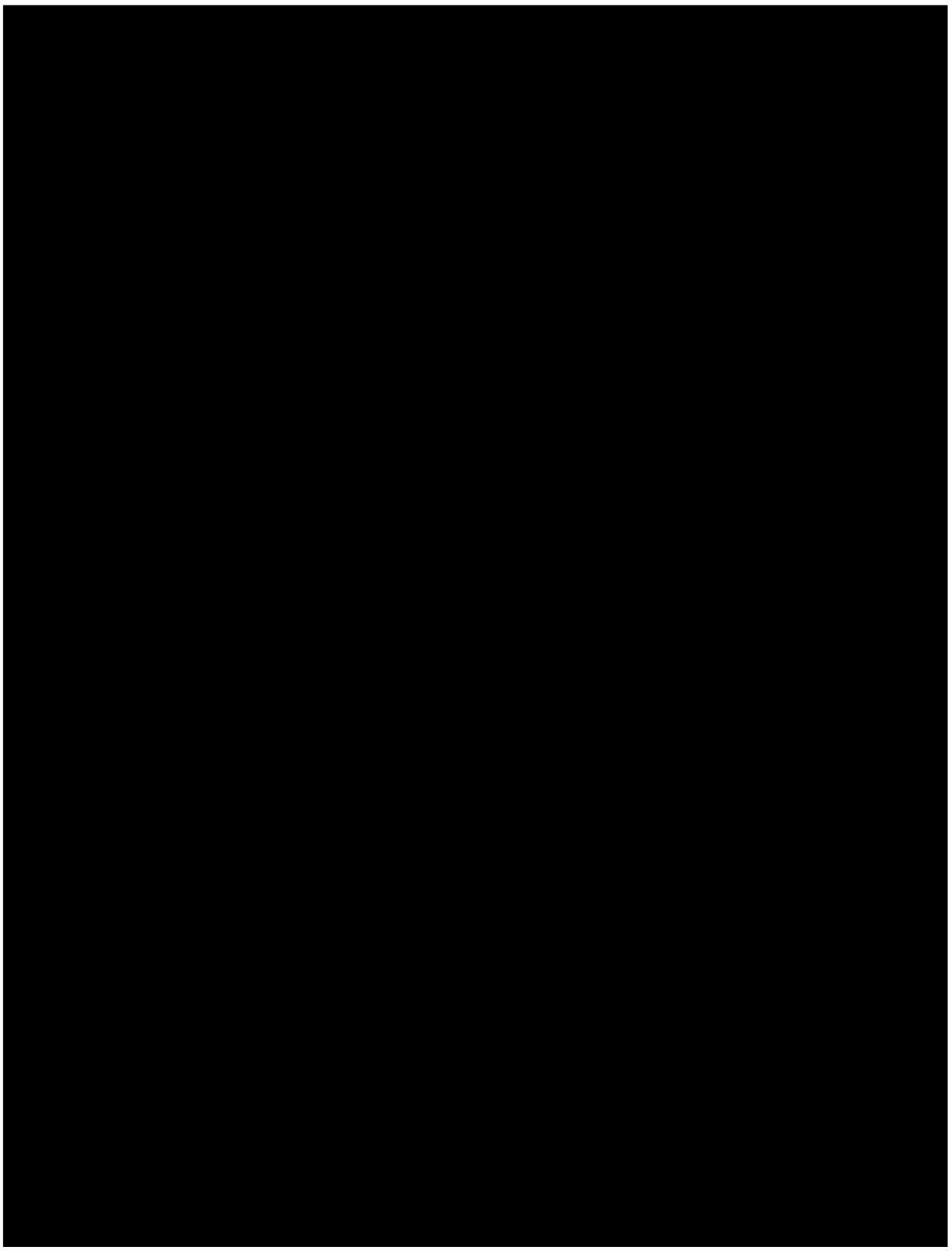

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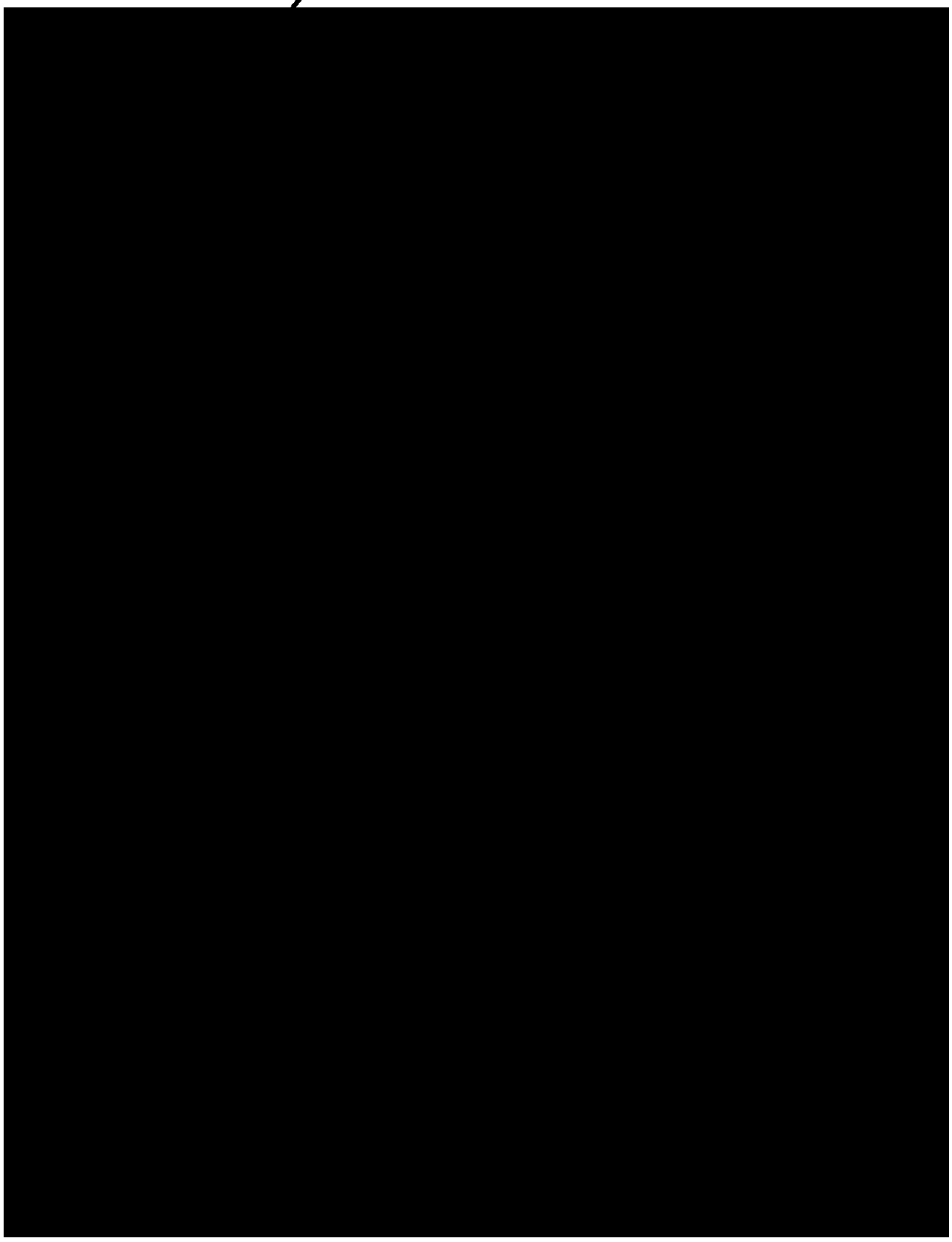

Pre-Midcourse

Tracking data for the pre-midcourse trajectory were available [redacted] a TASS-announced position point were also available [redacted] the TASS-announced position as follows:

	TASS
Time	21 December, 1400Z
Distance	44,000 km
Latitude	44°31'N
Longitude	80°11'E

[redacted]

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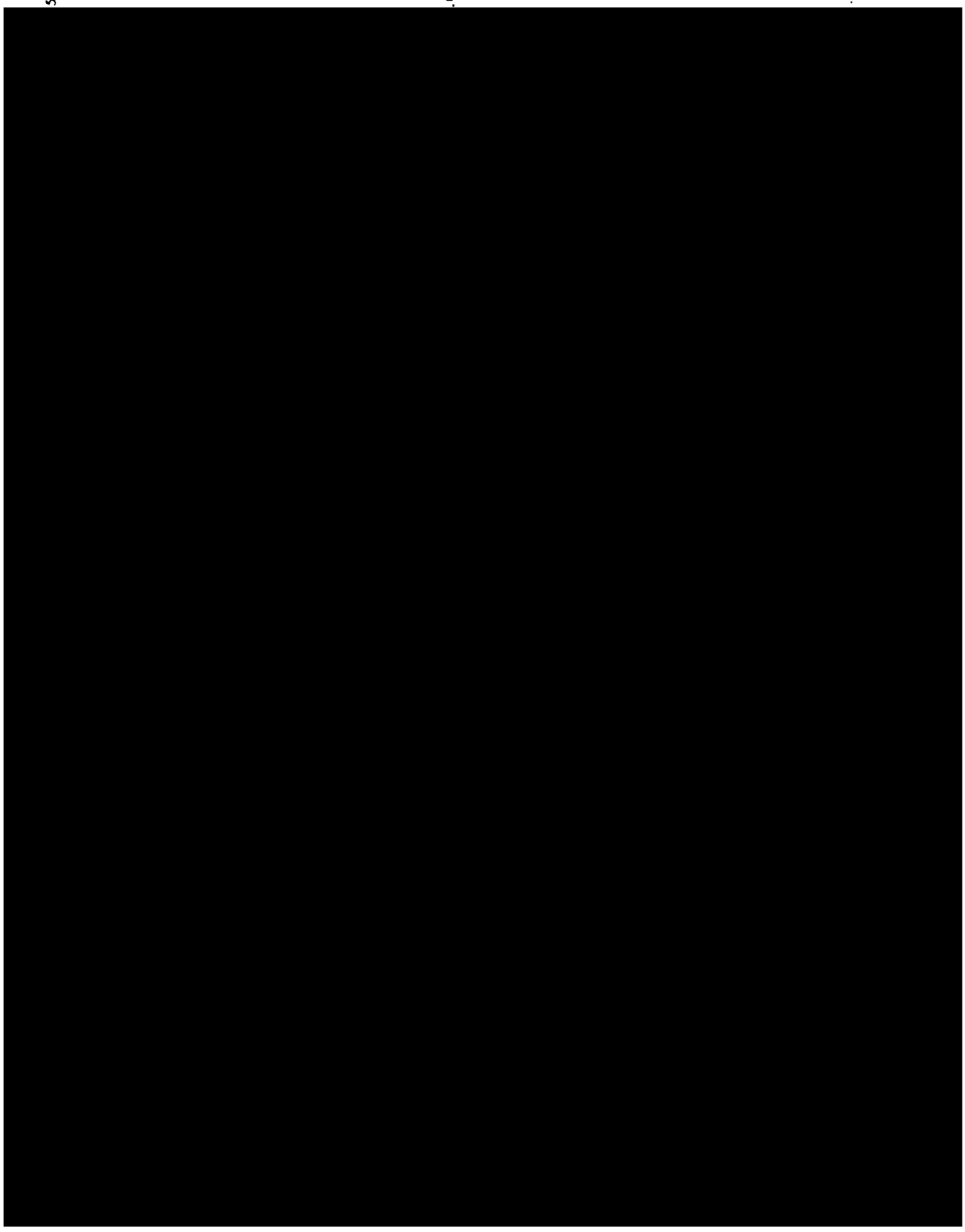
The Soviets announced that Luna-13 soft-landed at 1810Z on 24 December at 18.867°N 62.050°W. [redacted]

[redacted]



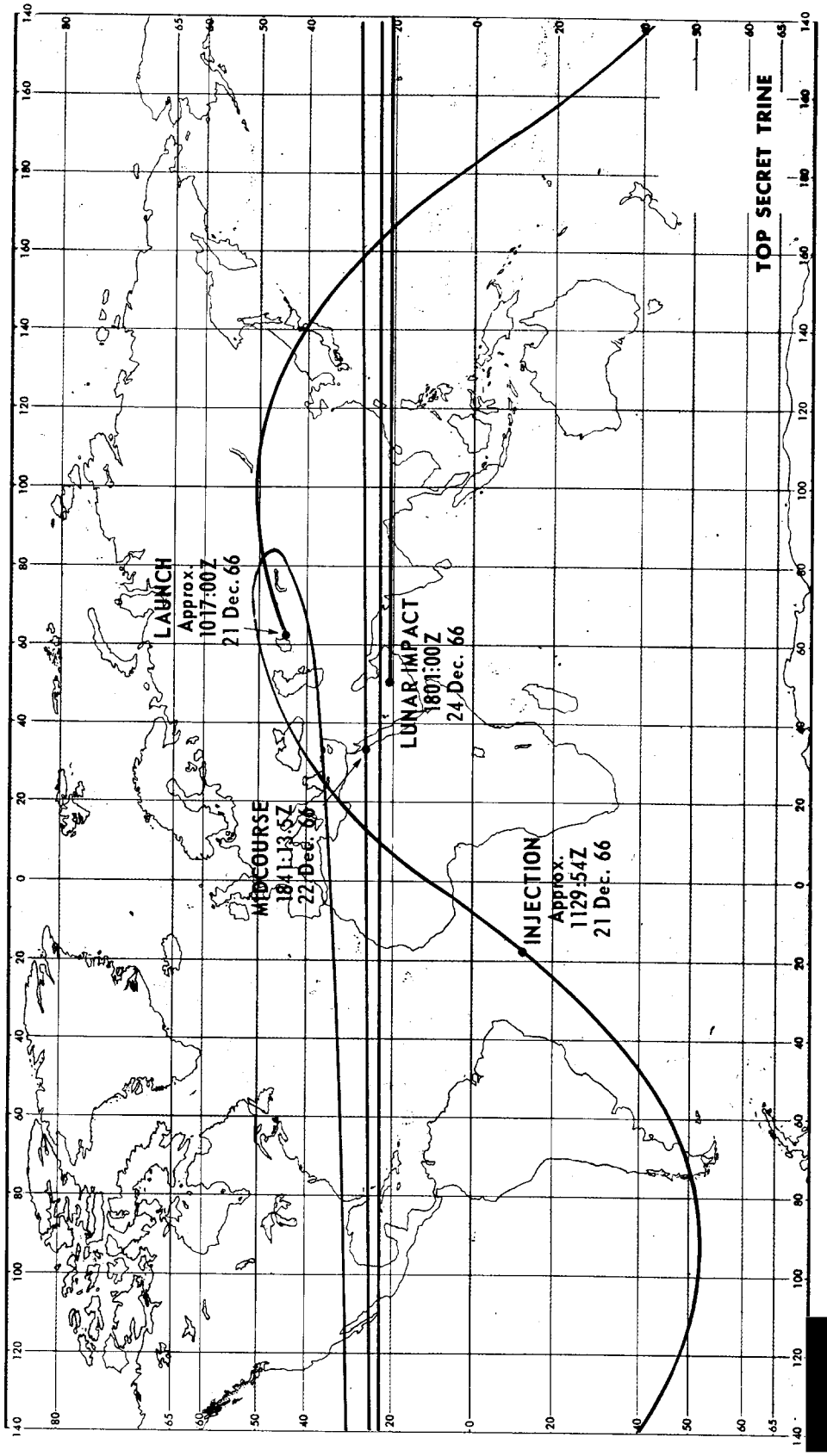


Figure 3. Luna-13 Earth Trace

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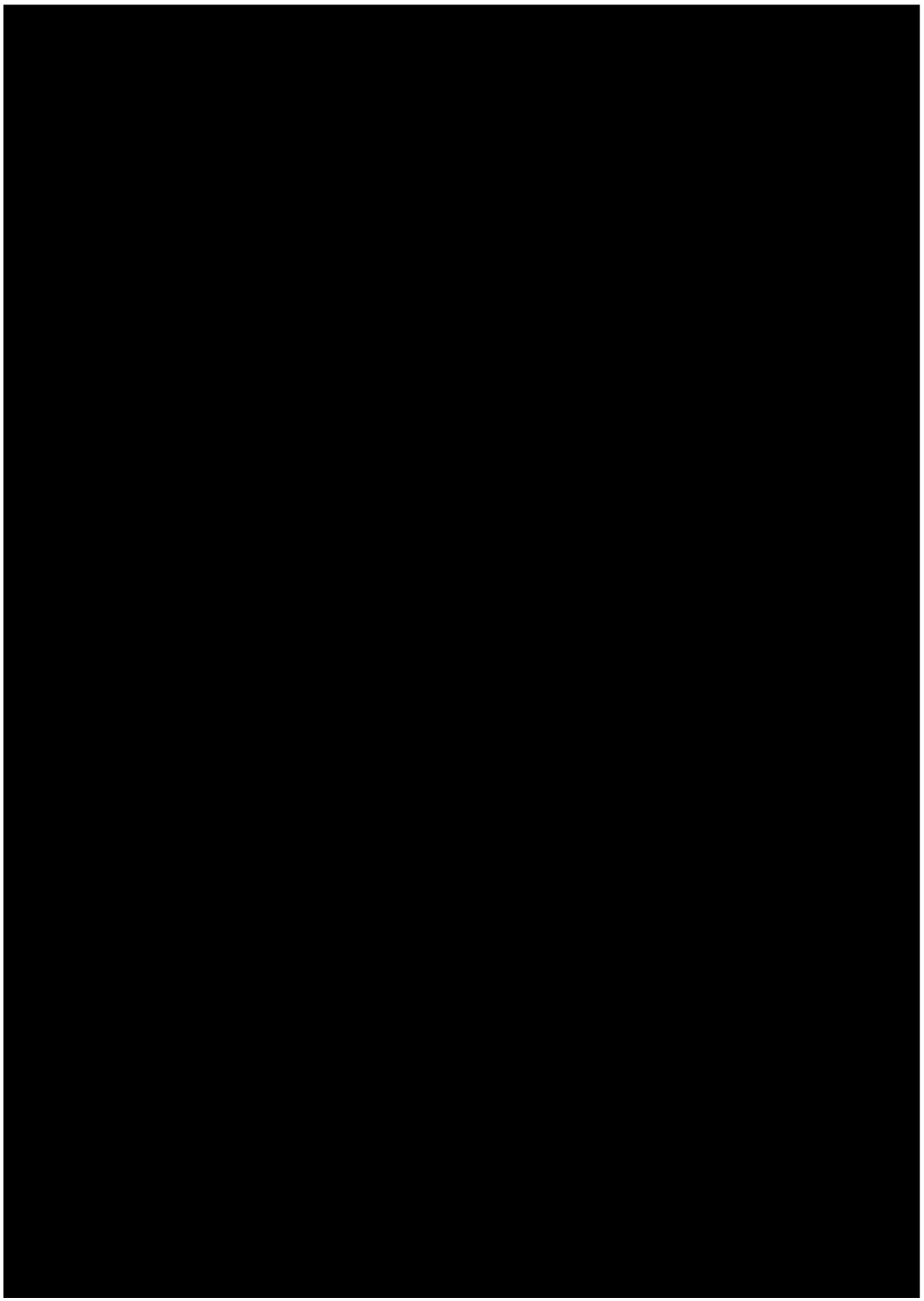

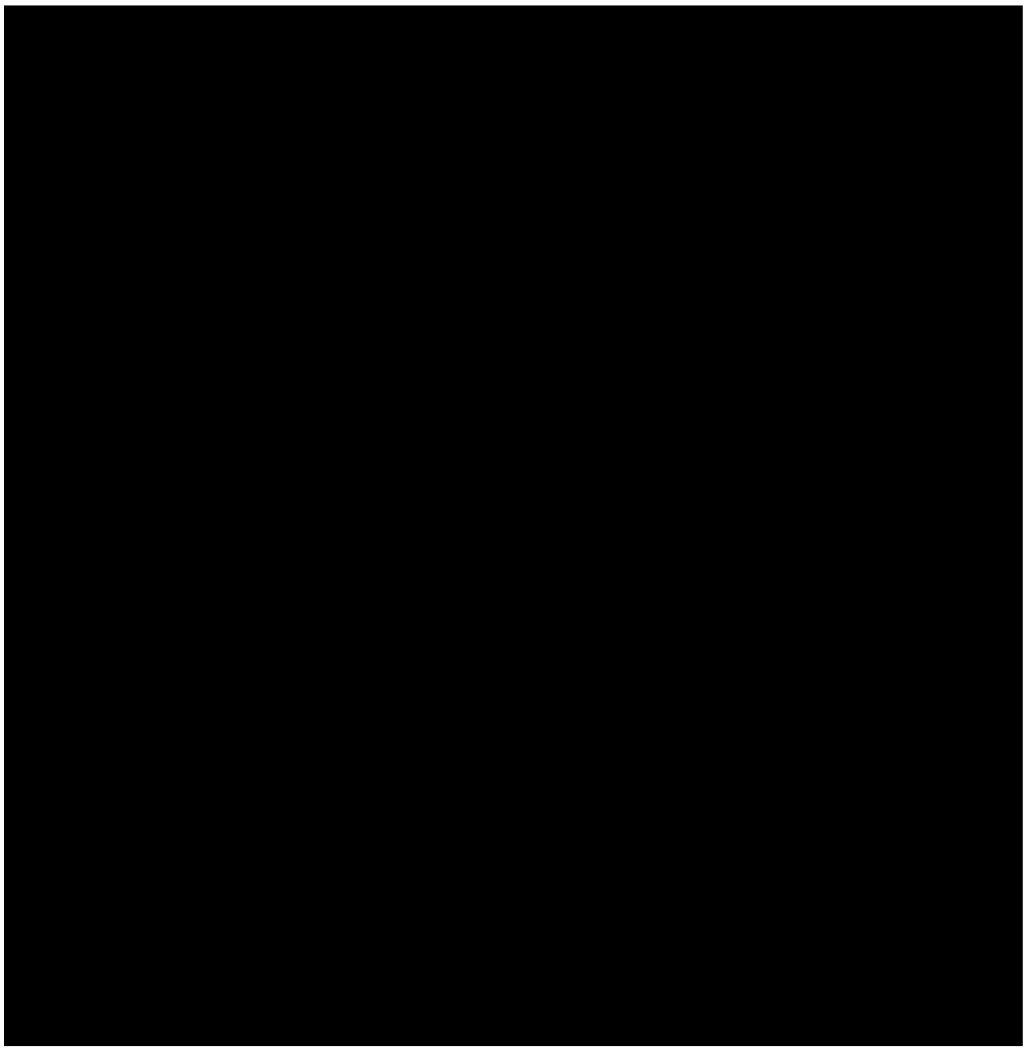

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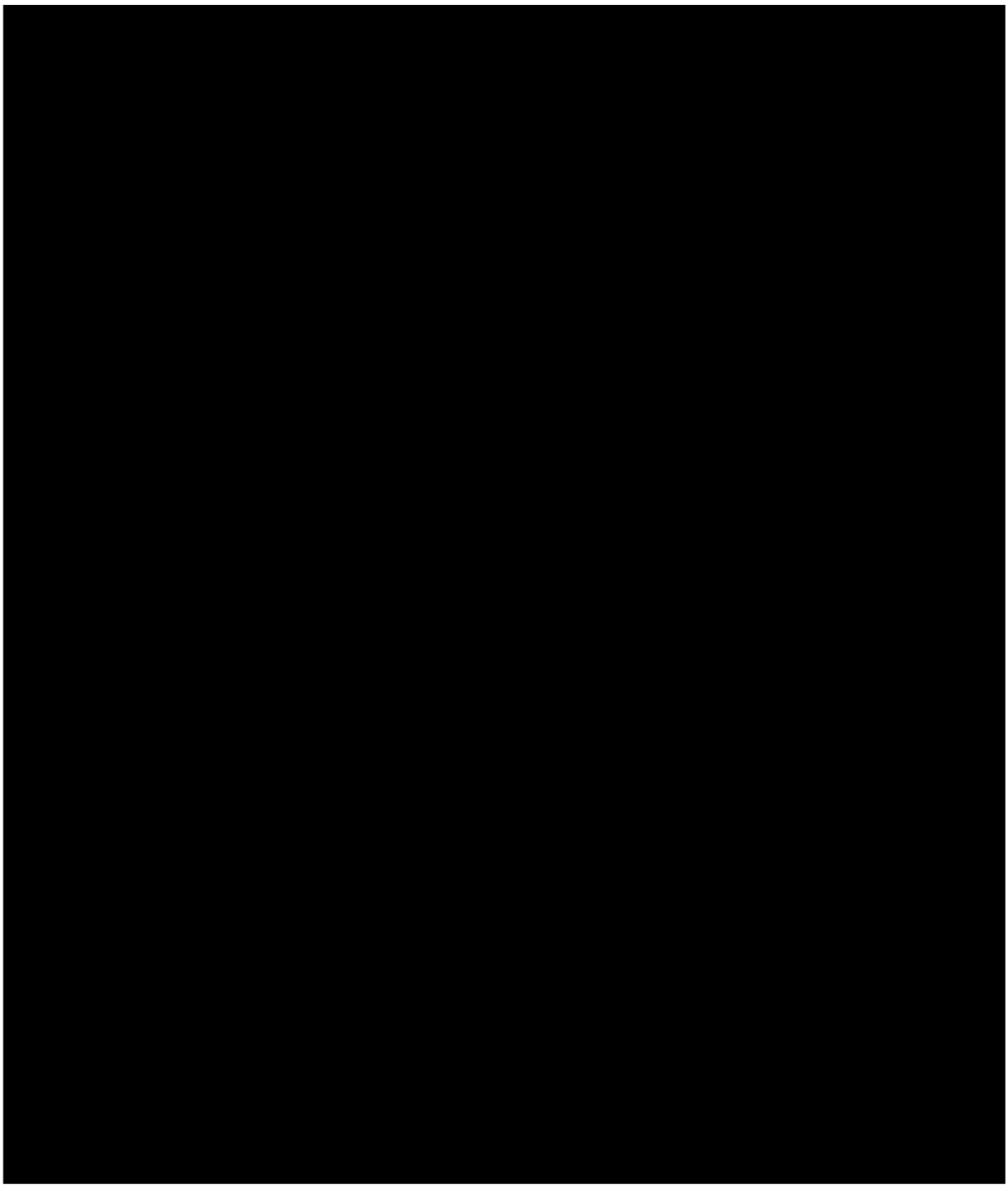

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APPENDIX

TASS Describes Luna-13 Station and Experiments

There were a number of structural differences between the Luna-13 automatic station and its predecessor, the Luna-9 station. Experience in working with the first station, which soft-landed on the surface of the moon, made it possible to introduce improvements in the design of the Luna-13 station, and the solution of a number of scientific problems required that the station be equipped with new scientific apparatus.

Within the hermetically sealed housing of the Luna-13 station was a rack with radio receiving and transmitting equipment, electronic time-programmed devices, chemical batteries, automatic and scientific instruments and telemetry equipment, as well as a system of heat regulation.

On the outside of the Luna-13 housing were mounted four petal-shaped antennas and four rod antennas, a television device, and two instrument extension mechanisms. Before the automatic lunar station was placed in its working position, the petal and rod antennas as well as the extension mechanisms were in a folded position and were held in this position by a special lock. The station was converted to the working position upon command from the on-board time-programmed device; then the lock opened and permitted the antennas and extension mechanisms to unfold. At the end of one of the extension mechanisms is a mechanical punch-penetrometer, and at the end of the other mechanism is a radiation densimeter. The extension mechanisms made it possible to place the penetrometer and densimeter on the surface of the moon at a distance of 1.5 meters from the station.

The Luna-13 television device is an optico-mechanical scanner whose design resembles mechanical television or phototelegraphy instruments. It should be noted that the optico-mechanical system meets the rigid demands of weight, size, power consumption and reliability of operation which are placed upon the instruments of the automatic lunar station.

The time required for a complete circular scan of the television camera (approximately 100 minutes) and the depth of field (from 1.5 meters to infinity) made it possible to distinguish details having dimensions of 1.5-2 millimeters at a distance of 1.5 meters.

The television equipment has automatic contrast adjustment responsive to the illumination of the lunar surface. The axis of the television device on a sufficiently flat horizontal surface was inclined approximately 16 degrees to the local vertical. This created favorable conditions for the transmission of microrelief pictures of both regions near the camera as well as those lying at greater distances, including the line of the horizon.

In order to insure the necessary temperature conditions on the Luna-13 station, a system of heat regulation of the active type is used in conjunction with special outer thermal insulation. The active system of heat regulation was activated immediately after the station landed on the moon. As a result of the effect of gas pressure within the station, water passed from a flexible tank into an evaporator valve which served simultaneously as a heat exchanger. As water evaporates in the valve, the heat given off by instruments during their operation is absorbed. Adjustment of the evaporator valve made it possible to maintain a temperature in the station within limits of 19-30 degrees Centigrade.

The telemetry information received from the Luna-13 station showed that the operation of all systems was reliable and stable.

The rocket booster launched on 21 December 1966 at 13 hours 17 minutes Moscow time placed the Luna-13 automatic station and the rocket stage into a parking orbit as an artificial earth satellite. At a precisely calculated time, the rocket stage imparted the velocity to the station necessary for its flight trajectory toward the moon. On the basis of data calculated by the coordination-computation center, a mid-flight correction was made on 22 December, as a result of which the new flight trajectory passed practically through the calculated lunar impact point.

At two hours prior to landing on the moon preparations were begun for braking the station. The station was oriented and stabilized in space, and at 20 hours 59 minutes the braking engine was actuated; at 21 hours 01 minutes Moscow time on 24 December 1966 the Luna-13 station made a soft landing in the region of the Ocean of Storms.

Within approximately 4 minutes after landing and upon command of the on-board time-programmed device, the station was converted to the operating position and the first radio communications session was held with the station. Telemetry data indicated that all systems of the station were operating normally, and the temperature and pressure on board the station were within the prescribed limits.

The Luna-13 station made a soft landing in a region located at a distance of approximately 400 kilometers from the landing area of the Luna-9 automatic lunar station. It is essential to note the morphological differences in the landing regions of both stations. While Luna-9 landed in the immediate vicinity of the eastern boundary of a continental shield extending over the entire far side of the moon, the landing area of the Luna-13 automatic station is located on a broad plain of the "sea" type.

The closest lunar formations are the craters Seleucus (with a diameter of 43 kilometers) and Schiappareli (with a diameter of 24 kilometers). Around the landing zone, in an area with a radius of approximately 100 kilometers, formations larger than 3.5 kilometers in size are not observed. In addition, one should emphasize the absence of rather large formations rising above the surrounding area. This may be seen in the accompanying photograph, which shows that the line of the horizon is smooth. A more interesting feature of the landing region, which was known on the basis of observations from earth, is the abundance of so-called crevices (extensive depressions having a length of tens of kilometers). They are arranged in the form of a divergent beam and run in a direction from the southwest to the northeast. The great number of bright spots noted in this region is evidence of the presence of local accumulations of different types of depressions.

In some respects the landing region of the Luna-13 station resembles the Mare Orientalis located on the far side of the moon, photographs of which are obtained by the Zond-3 automatic interplanetary station in the summar of 1965.

The Luna-13 station landed before sunrise over this area. The sun rose on 25 December at 3 hours 30 minutes Moscow time. Since the landing region was located close to the equator, the sun rose to an almost vertical position with respect to the line of the horizon, and its height increased by 0.5 degree each hour. Before the sun passed through the zenith, that is, before local lunar midday, the shadows of objects, running from east to west (after midday--from west to east), changed their direction very slightly. Consequently it was possible to orient the fragments of the panorama on the basis of directions of sunlight. The photograph published shows the lunar landscape in the direction to the south of the station. It was obtained during the third picture transmission session. At the moment of transmission of the first pictures of the area, the elevation of the sun was six degrees. During the second transmission session

it was 19 degrees and, finally, the published fragment of the panorama was obtained when the sun was at an elevation of approximately 32 degrees above the horizon. The visibility of parts of the lunar landscape depends to a great extent on conditions of illumination. This characteristic of the reflective ability of the lunar surface has long been known from observations made on earth. The greatest amount of light is scattered by the lunar soil in the direction of the sun. Hence, the lower the sun the more sharply pronounced will be this property. That is, the brightness of the landscape increases sharply if observations are made from the direction of the sun. As a result, a bright halo appears around the shadow of the station in the panorama transmitted during the second session.

Preliminary analysis of photographs shows that the structure of the soil in the landing area of Luna-13 is very similar to that of the landing zones of the Luna-9 station and the American Surveyor-1 station, which made a soft landing in the summer of this year in the region of the crater Flamstead. Upon closer examination the surface appears to be heavily pitted, with individual grains having a size of several millimeters. Again the absence of a layer of dust on the moon has been verified.

In the area surrounding the station may be observed a number of crater-like formations as well as a considerable number of rocks several centimeters and more in size. A study of the arrangement of these formations verifies the conclusion that the rocks fell on the surface at low velocity. Their origin could be either a volcanic eruption or the formation of a primary crater as a result of a meteorite impact. Moreover, the trajectory of their fall was rather steep; otherwise (with a slanting trajectory) there would have remained tracks on the surface directed toward the source of ejection of the rocks. Consequently, the mineralogical composition of the rocks is analogous to that of the soil. It is certain that they are not meteorites: the velocity at which meteorites collide with the lunar surface cannot be less than 2.4 kilometers per second, which would unavoidably lead to an explosion with the formation of a crater-like depression in the surface.

In the published photograph one may easily see a group of rocks (in the upper left-hand corner) formed apparently by the fall of a monolithic fragment. In the bottom left part of the photograph is a long shadow cast by a rock with a remarkably flat shape, as if it protrudes from the surface. In addition, parts of the station which were discarded in landing may be seen in the photograph. A careful investigation of the photograph will require a long time.

In order to carry out the program of scientific investigations, the following instruments were installed on the Luna-13 automatic station:

--a measuring punch-penetrometer for determining the properties of the very outer layer of lunar matter (within limits of several centimeters);

--a dynamograph for recording the duration and magnitude of the dynamic overload pulse developed in the landing of the station on the lunar surface;

--a radiation densimeter for determining the specific gravity (density) of lunar matter.

The combined measurements taken with the aid of these instruments made it possible to receive a variety of data on the physico-mechanical properties of the lunar surface at the point of landing.

The station was also equipped with an instrument for recording cosmic radiation which was intended to continue investigations of radiation conditions at the surface of the moon begun with the Luna-9 station.

The punch-penetrometer had a conical point made of titanium. The point was connected to a small, solid-propellant thruster which developed, for a period of one second, a force on the order of seven kilograms, as a result of which the punch was implanted in the soil surface.

The dynamograph consisted of piezoelectric load sensors and an electronic circuit for storing the duration and amplitude values of the acceleration pulse produced during landing.

On the basis of these parameters an evaluation was made of the mechanical properties of the lunar surface in the landing zone, since a short load pulse of high amplitude corresponds to a hard surface, while a longer pulse with a correspondingly smaller amplitude corresponds to a soft surface.

A preliminary comparison of the received acceleration pulse with results of modeling experiments made under earth conditions provides the basis for assuming that the mechanical properties of the moon's surface layer to a depth of 20-30 centimeters are close to the properties of earth soil of average density.

Together with measurements of the mechanical properties of lunar matter interest was also devoted to data on its density (specific gravity). It is known that the average specific gravity of lunar matter (for the moon as a whole), determined from data of astronomical observations, is less than the average specific gravity of matter on earth (3.34 grams per cubic centimeter against 5.51 grams per cubic

centimeter for earth). Until now the density of the outer layer of the moon has been studied also only by astronomical methods; the first direct measurements of the specific gravity of the surface layer were made with the aid of the Luna-13 station.

The device for measuring the density of lunar matter ("radiation densimeter") contains:

--a small source of gamma radiation;

--three gas discharge counter units for measuring gamma quanta;

--a screen for shielding the gas discharge counters against gamme radiation from the source.

As the densimeter comes into contact with the lunar surface, the latter is exposed to photons from the source and scatters them in all directions. A certain part of the scattered photons reaches the gas discharge counters, which measure the intensity of the scattered flow. It is known that this intensity is proportional to the density (specific gravity) of lunar matter. According to preliminary data, the intensity of gamma quanta scattered by the moon's surface corresponds to a density not exceeding one gram per cubic centimeter, that is, considerably less than the density of earth soils and the average density of the moon. The measured value is close to the density of porous or granular loosely-bonded rock.

The instrument installed on the Luna-13 station for recording cosmic corpuscular radiation consisted of gas discharge counters connected in a coincidence circuit. This instrument, unlike the equipment on the Luna-9 station, recorded not gamma radiation but only the charged particles contained in cosmic radiation; this made it possible to determine the reflectivity (albedo) of the lunar surface for cosmic rays. It was determined that the lunar surface "reflects" approximately 25 percent of the particles falling on it from outer space. This occurs for the reason that there are particles comprising cosmic radiation which have considerable energy. As such particles pass through lunar matter secondary particles are formed which receive part of the energy of the primary particles. Some of these secondary particles move in directions forming a noticeable angle with the direction of the primary particles. Thus, under the effect of cosmic rays the moon "shines," radiating particles having a significant amount of energy. However, measurements have shown that the total intensity of high-energy particles on the moon during a quiet sun is not great. This instrument on the Luna-13 station verifies the conclusion regarding the low level of radioactivity on the lunar surface which was made by a similar instrument on the Luna-9 station....

"Luna-13--New Success of Soviet Science," TASS Report, Moscow, Krasnaya Zvezda, 31 December 1966, pages 1,4.

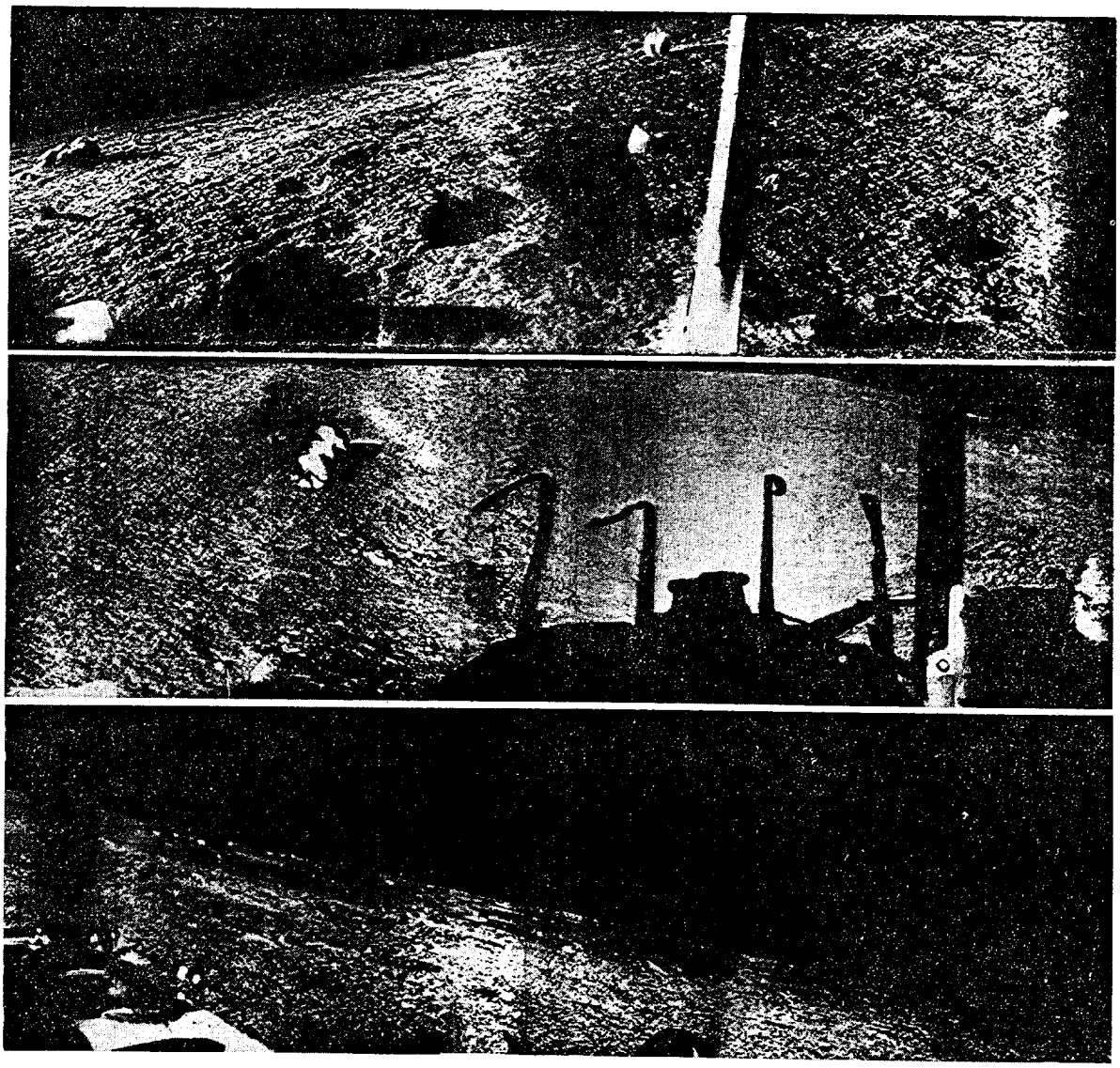

Figure a. Lunar Panorama Transmitted by Luna-13

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