# Man's First Orbit in Space

by K. W. Gatland

MAJOR YURI ALEXEYEVITCH GAGARIN'S space journey will be long remembered as marking the beginning of an entirely new era of human conquest and discovery. Many manned flights will be made in the future, but this first "quantum jump" will certainly be the most durable in human memory.

When it comes to the first reconnaissance mission around the Moon, and even when its ancient dust receives the first imprint of man, these events will emerge as the result of experience building up over the years, involving flights of longer duration and at greater distances from Earth, and even the achievement of the first Lunar landing will come about almost as an anti-climax—as the inevitable result of what has gone before.

First news that a man was orbiting the Earth came from Moscow radio at 07.00 G.M.T. on Apr. 12 when listeners were asked to stand by for an important statement. This ran:—

"The World's first space-ship Vostok with a man on board was launched into orbit from the Soviet Union on Apr. 12, 1961.

"The pilot space navigator on the satellite space-ship Vostok is a citizen of the U.S.S.R., Flight-Major Yuri Alexeyevitch Gagarin.

"The launching of the multi-stage space rocket was successful and after attaining the first cosmic velocity and the separation of the last stage of the carrier-rocket, the spaceship went into free flight on a round-the-Earth orbit.

"According to preliminary data, the period of the revolution of the satellite-spaceship around the Earth is 89.1 minutes. The minimum distance from the Earth (at perigee) is 175 kilometres (109 miles) and the maximum (at apogee) is 302 kilometres (187 miles); the angle of inclination of the orbit plane to the Equator is 65 degrees 4 minutes.

"The spaceship with the navigator weighs 4.725 kilograms (10,395 lb.) excluding the weight of the final stage of the carrier-rocket."

### Inclined Orbit

A reconstruction of the orbit is shown in Fig. 1, which shows the operation in three phases. The first drawing indicates the launching site in the Soviet Union, tracing the departure trajectory eastward; the second indicates the passage of the spacecraft around the back of the Earth, and the third indicates the path of re-entry some hundreds of miles westward of the point of departure. Fig. 2 shows the orbit as a flat projection.

The entire operation lasted just 108 minutes. It began at 7.07 B.S.T.; by 8.15 Major Gagarin had reported that he was over Africa, at 8.25 the retro-rocket fired to start the descent, and at 8.55 the spacecraft was back on the ground with its occupant safe and well. The discrepancy involved in the statement that the spacecraft was over S. America at 7.15 B.S.T. has not yet been explained.

Why did the spacecraft make only one orbit before returning? The answer is not difficult to find. Apart from minimizing the chances of things going wrong, the single orbit was necessary to ensure descent in the desired recovery area within the Soviet Union. Because of the Earth's rotation about its axis, the launching point is displaced to the east to the extent that if recovery were attempted, say after four or five orbits, the vehicle would descend outside the borders of the Soviet Union. To bring the recovery area back into correct alignment with the spacecraft's orbit, the vehicle would have to spend much more time in space. This was, in fact, the case with the two dogs Strelka and Belka, launched in Spacecraft II on Aug. 19 last year, which made about 18 orbits before being returned after a period of some 24 hours. As it happened, the dogs were successfully recovered the next day a few miles from the designated landing point in the U.S.S.R., but an orbital flight of this duration was obviously too much to expect for an initial manned experiment.

The journey of these two dogs, with smaller test animals, insects and plants, etc., was preceded on May 15 by the launching of a spacecraft said to contain a "dummy astronaut." The Russians made it clear that this vehicle would not be recovered but would be allowed to burn up in the atmosphere. However, when the re-entry signal was given, the retro-rocket which should have started the spacecraft on its descent trajectory, fired in the wrong direction because of an orientation fault, and instead sent the vehicle into a higher orbit. At the same time it separated into two parts.

After the successful return of Strelka and Belka on Aug. 20 the Russians released the first technical information concerning the nature of their experiments (Ref. 1). It seems worth while to recall what they disclosed, as the manned vehicle must owe much to the successful outcome of these earlier experiments.

The spacecraft containing the dogs, they said, was orientated in orbit so that its retro-rocket acted to slow down the vehicle and start it on its descent path. To minimize the effects of deceleration on the animal occupants, the retro-rocket was fired when the space-vehicle was still some 7,000 miles from the

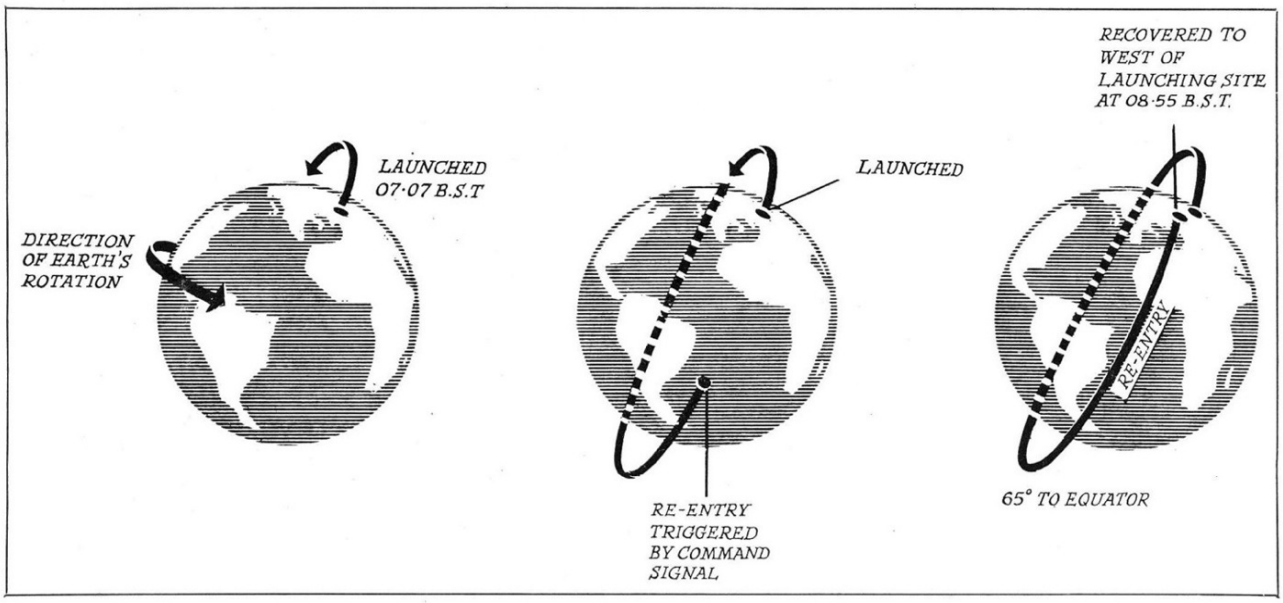



Fig. 1. The 108 minute space-journey seen in three stages, according to information supplied by Soviet news sources. Because of the Earth's eastward rotation, the landing in the Soviet Union would have been made west of the launching point.

A colleague of Major Gagarin's, Gennady Mikhailov, prepares for a simulated high-altitude test at a space-medical research centre.

appointed landing area in Russia. Maximum deceleration during this period was stated to be about 10*g*.

After the retro-rocket had fired, an "instrument compartment" containing devices which had already operated during orbital flight was jettisoned to reduce the mass of the re-entering spacecraft and allowed to burn up in the atmosphere. These included telemetry apparatus, equipment for guiding the vehicle while in orbit, part of the scientific equipment for studying cosmic rays and short waves emitted from the Sun; temperature control apparatus, and "a powered deceleration unit."

Of the spacecraft's total weight of 10,008 lb., the pressure cabin has been said to have accounted for 5,512 lb., and the instrument compartment 3,250 lb., which would leave only 1,246 lb. for the spacecraft casing, including the protective heat shield (!)

At an altitude of between 23,000 and 26,000 ft., the "cap of the ejection trap" was jettisoned by barometric relays and the pressure cabin containing the animals was ejected from the ship. The cabin, it was stated, touched down at a speed of 20-26 ft./sec., while the spaceship itself landed at nearly 33 ft./sec.

The Russians explained that separation of the two components was an emergency procedure, used on this occasion to test the escape system before manned flights were attempted. They also stressed that the animals would have landed safely if the pressure cabin had not separated from the spaceship.

### Re-entry accuracy

The statement that the two components landed only 6¼ miles from the pre-arranged launching centre represents a very high order of guidance accuracy. "The ship," the Russians explained, "was guided automatically as well as by command from Earth. It was equipped with a high-precision orbit control system." The orientation system was active both during orbital flight and throughout the descent. An error of only 3 ft./sec. in speed, would have deflected the vehicle over 30 miles. And an error of about 300 ft. in estimating the vehicle's height above the Earth would have resulted in a deflection of nearly three miles. Finally, an error of one minute of arc in attitude would have meant a deviation of 30-40 miles.

Concerning the spacecraft itself, we still do not have all the details. On the exterior of the vehicle were control jets and the "orientation system's reserve high-pressure gas containers." Also on the exterior "were the transducers of the scientific apparatus, the radio aerials and the experimental solar batteries, and also a system of heat insulation to prevent the ship from burning up during the descent."

Apart from receiving command signals from the Earth, the vehicle "was guided automatically by means of a precision orbit-control system." Apparatus aboard the craft was powered by both chemical and solar batteries, the latter being "placed on two half-discs one metre in diameter" which remained locked on the sun irrespective of the vehicle's attitude or position.

Within the pressurized cabin, air pressure had to be maintained close to the sea level value, with an oxygen concentration of from a fifth to a quarter and not more than 1% of carbon dioxide. Air temperature had to be kept between 60° and 80° F., and its relative humidity content between 30% and 70%.

In order to maintain the correct oxygen balance in the cabin, it was said that "special devices were devised which automatically regulated the speed of absorption of carbon dioxide

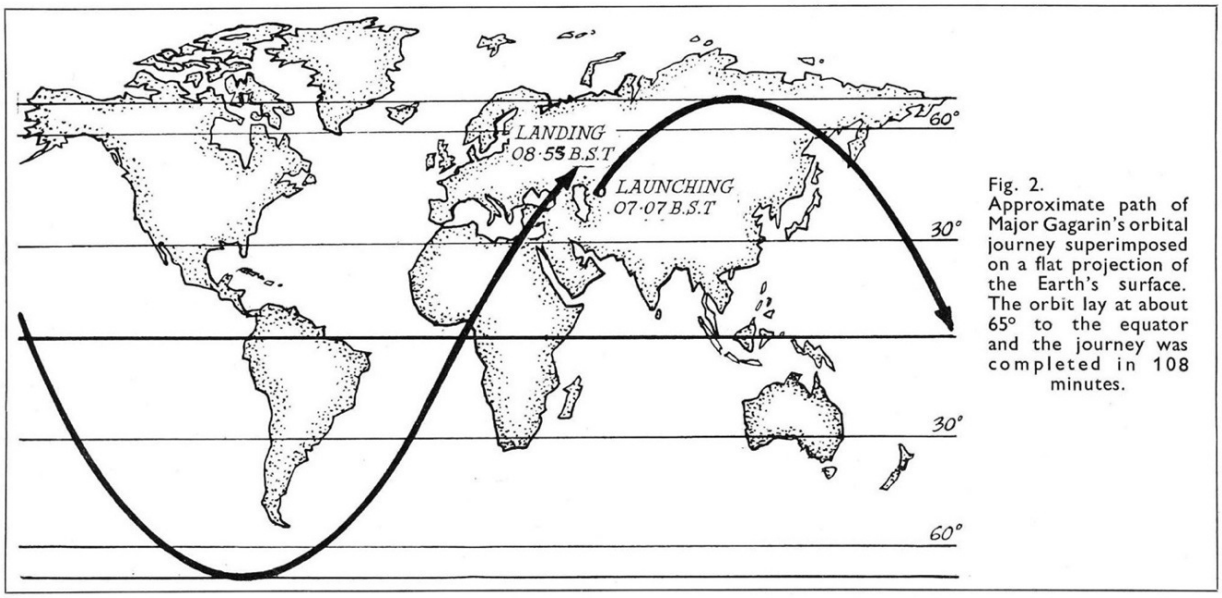
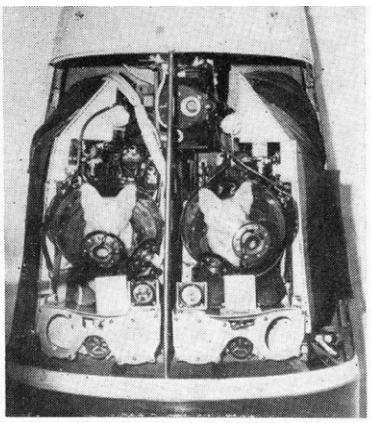
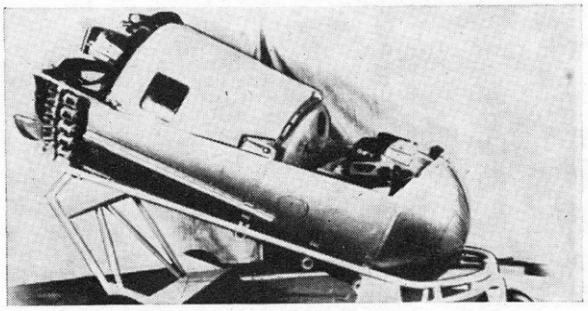



Fig. 2. Approximate path of Major Gagarin's orbital journey superimposed on a flat projection of the Earth's surface. The orbit lay at about 65° to the equator and the journey was completed in 108 minutes.



Method of housing two dogs in ejectable chassis in the payload section of a Russian geophysical rocket.



Below, the capsule in which Strelka and Belka were recovered from orbit on Aug. 20, 1960.

and water vapour with the emission of appropriate quantities of oxygen." Any decrease in oxygen and increase in carbon dioxide concentration was registered by gauges which fed signals into the telemetering equipment and a control unit. A liquid-air radiator was employed to remove heat from the cabin. Temperature of the instrument compartment, and the stable temperature of the refrigerant, were maintained by means of a heat exchanger and a louvre system.

So much for Spacecraft II. As our table of the Soviet space programme shows, there were three further animal experiments prior to Major Gagarin's epic mission. In fact, on the third occasion, the spacecraft, re-entering along an incorrect descent trajectory, burned up in the atmosphere carrying its two canine passengers, Pchelka and Mushka, to destruction; smaller animals and insects were also aboard.

The third and fourth experiments involving, it is believed, just one orbit and not 18, appear to have been eminently successful and, according to the Russians, Gagarin's flight came next. "There was no earlier attempt," said Academician Nesmeyanov, president of the Soviet Academy of Sciences.

### On Entering Orbit

At a Press conference in Moscow on Apr. 15, Major Gagarin addressed a large gathering of correspondents and diplomatic observers, and later answered their written questions.

He said it had been his one ambition to become a pilot, and on his urgent request he was accepted as a candidate for space-training. The night before his orbital mission he had slept soundly and was wakened one hour before take-off.

Within the space-vehicle, he heard the command being given to start the rockets. Acceleration, vibration and noise did not depress him, and he was able to perform all the work that he had to do in accordance with the flight programme.

Once the final stage of the carrier rocket had separated in orbit, Gagarin said he became accustomed to the condition of weightlessness and was able to continue his work. He had become familiar with weightlessness in preliminary tests. (Presumably this was in aircraft flown for short periods on powered parabolic trajectories, so that drag and weight are counter-balanced by centrifugal force.) These conditions, he contended, "do not adversely affect the capacity of an organism to work or its physiological functions."

Gagarin said he ate and drank under weightlessness, and maintained constant radio communication with Earth, using a Morse key and a radio-telephone. He also continued his observations of the environment, taking instrument readings and recording his observations on tape. He even wrote in a notebook.

Concerning his "space-food," Gagarin said he consumed a special jelly-like substance which he was previously trained to eat while weightless. "I squeezed it into my mouth and was able to drink water by the same method."

The interesting point here is that the feeding technique was similar to that employed with the dogs Strelka and Belka in Spacecraft II (Ref. 1). Provided with a glutinous "jelly" containing quantities of nutritious substances and water, the dogs were trained before their orbital mission to take this food from an automatic feeder "in conditions as far as possible simulating those of space-flight."

### Re-entry and Landing

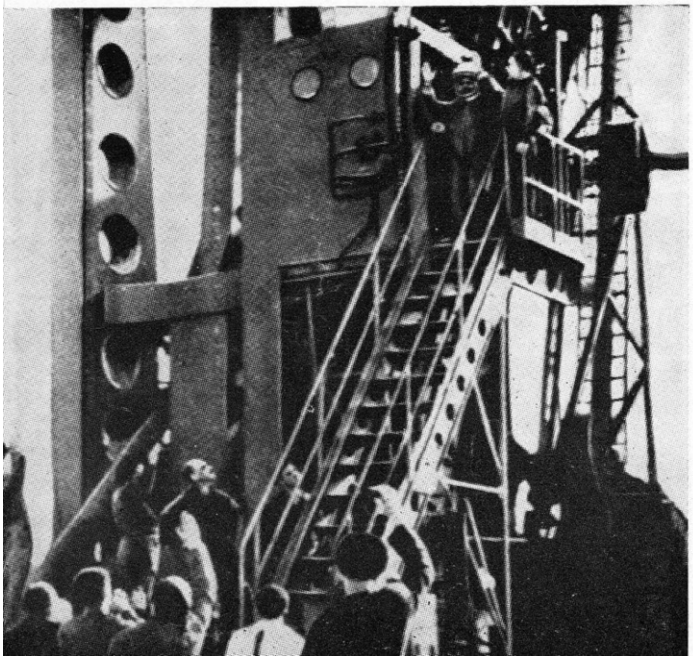
All the while he was in orbit, Gagarin said he felt in excellent spirits and was able to perform all the work he had to do. After a certain period, the command was given to descend. The spacecraft was orientated in space, the retro-rocket switched on, and the velocity was reduced to enable the vehicle to come out of orbit. The re-entry proceeded according to programme and the landing was made in the pre-arranged area. Gagarin said he was pleased to greet the people "who happened to be there."

Clad in his space-suit, Major Gagarin is seen in the bus that took him to the launching base prior to the historic orbital flight.

The question period which followed the astronaut's statement failed to elicit much technical information. Many techniques for landing have been developed in our country, said Gagarin, one of which is the parachute technique.

"In this flight we employed the following system. The pilot was in the cabin of the spaceship," he began; and then changing the drift of his words, he continued, "the landing proceeded successfully and demonstrated the efficiency of all systems developed for this." That was all. No hint of the re-entry technique or the precise method by which his vehicle had landed.

The landing party appeared almost simultaneously with his arrival, he remarked. His weight before the flight was 69.5 kg., and still about the same. There had been no preliminary flights in ballistic rockets. On the question of visual observation of the ground, he had "looked out through a port-hole;"



Major Gagarin stands at the top of a stairway alongside the first stage of the powerful booster before ascending, by lift, to his "Vostok" spacecraft mounted in the rocket's nose.

**SOVIET SPACE PROGRAMME IN BRIEF**

| VEHICLE | DATE | PAYLOAD | ORBIT | REMARKS |
|---|---|---|---|---|
| Sputnik I | Oct. 4, 1957 | 184 lb. | Apogee 588 miles, perigee 142 miles, period 96.2 min. | Carried radio equipment, etc. |
| *Sputnik II | Nov. 3, 1957 | 1,120 lb. | Apogee 1,038 miles, perigee 140 miles, period 103.7 min. | Carried the dog "Laika." No attempt at recovery. |
| Sputnik III | Nov. 15, 1958 | 2,925 lb. | Apogee 1,167 miles, perigee 135 miles, period 106 min. | Carried wide range of scientific research instruments. |
| Lunik I | Jan. 2, 1959 | 796.5 lb. | Aphelion 123.1 m. miles, perihelion 91.2 m. miles (solar orbit), period 443 days. | Passed Moon to orbit Sun. |
| Lunik II | Sept. 12, 1959 | 858.4 lb. | Collision course to coincide with Moon. Distance covered 236,875 miles. | Destroyed on impact with Moon. |
| Lunik III | Oct. 4, 1959 | 613 lb. | Apogee 298,000 miles, perigee 29,500 miles, period 15 days. | Photographed Moon's hidden face. |
| *Spacecraft I (Sputnik IV) | May 15, 1960 | 10,008 lb. | Apogee 228.7 miles, perigee 188.5 miles, period 91.1 min. | Contained "dummy astronaut." Orientation fault in orbit—did not re-enter. |
| *Spacecraft II (Sputnik V) | Aug. 19, 1960 | 10,140 lb. | Apogee 211 miles, perigee 190 miles, period 90.72 min. | Successful recovery of dogs "Strelka" and "Belka," etc., during 18th orbit. |
| *Spacecraft III (Sputnik VI) | Dec. 1, 1960 | 10,221 lb. | Apogee 165 miles, perigee 117 miles, period 88.6 min. | Carried two dogs "Pchelka" and "Mushka." Burned up on re-entry during 18th orbit. |
| Sputnik VII | Feb. 4, 1961 | 14,293 lb. | Apogee 204 miles, perigee 139 miles, period 89.8 min. | Test vehicle for Sputnik VIII? |
| Sputnik VIII | Feb. 12, 1961 | 1,419 lb. (Venus probe) That of Sputnik launcher not disclosed. | Aphelion 94.6 million miles, perihelion 66.7 million miles, period 300 days. | Aimed to rendezvous with Venus between May 19–20. |
| *Spacecraft IV (Sputnik IX) | Mar. 9, 1961 | 10,360 lb. | Apogee 154 miles, perigee 114 miles, period 88.3 min. | Carried the dog "Chernushka," etc. Successful recovery during first orbit. |
| *Spacecraft V (Sputnik X) | Mar. 25, 1961 | 10,350 lb. | Apogee 153 miles, perigee 111 miles, period 88.4 min. | Carried the dog "Zvesdochka," etc. Successful recovery during first orbit. |
| *Spacecraft VI "Vostok" (Sputnik XI) | Apr. 12, 1961 | 10,395 lb. | Apogee 187 miles, perigee 109 miles, period 89.1 min. (est.) | Carried first human astronaut. Successful recovery during first orbit. |

* Part of Soviet Man-in-Space programme.

there was no television. Would photographs taken during the flight be published? "The spacecraft did not have a single camera and hence there were no pictures to publish."

Asked whether the spaceship could be used again, Gagarin said this matter was best decided by the scientists and engineers, but he personally considered that the entire spaceship and its parts could be launched again. On the question of how many astronauts were in training in the Soviet Union, he replied, amid laughter, that there were enough to perform the assigned tasks. When would another such flight be made? "Our scientists and space-pilots will effect such a flight when it is needed."

When finally Gagarin was asked if the "Vostok" could have carried a man to the Moon(!), he said it could not. "Special spaceships are being created in our country for that purpose."

Thus, the Press conference came to an end, leaving a vast number of technical questions unanswered.

### Air-brakes and Parachutes

What precisely are "the many landing techniques" that Gagarin began to describe? If we go back to the early experiments with dogs launched in Soviet geophysical rockets on "up-and-down" trajectories, we find there were two basic recovery methods.

In one, the dogs were carried within the detachable nose-section of a rocket, which was fitted for recovery with a system of extensible petal-like drag-brakes and a parachute (see sectional drawing in THE AEROPLANE AND ASTRONAUTICS, Aug. 12, 1960, p. 185).

In the second, dogs were provided with individual pressure-suits and transparent helmets, enabling them to be catapulted out of the rocket's payload section as it descended into the lower atmosphere. This system was originally described by A. V. Pokrovskii, director of the Institute of Experimental Aviation Medicine, U.S.S.R. Academy of Sciences (Ref. 2).

"Conditions necessary for life and rescue of the animals (two in each rocket) were ensured by means of special space-suits equipped with removable helmets, without oxygen masks, and by means of an ejection chassis equipped with an oxygen supply and a system of parachutes. Special attachments for securing the animals during flight were provided in the space-suit. The ejection chassis was so constructed that the oxygen supply system, the parachute system, and all the equipment for recording physiological functions of flight, could be fastened to it.

The weight of the ejection chassis was given as 70 kg. (154 lb.), the parachute ensuring a vertical landing speed of about 6 metres/sec. The two dogs were accommodated in right- and left-hand ejection chambers in the nose-section of the rocket. Conclusions reached following the experiments were given by Pokrovskii as follows: "The method of ejecting the animals from the rocket compartment at altitudes of 75 to 85 km. (47 to 53 miles) at a speed of about 700 metres/sec. (1,568 m.p.h.), and at altitudes of 35 to 50 km. (22 to 31 miles) at a speed of 1,000 to 1,150 metres/sec. (2,240 to 2,576 m.p.h.) ensures the recovery of the animals, the maintenance of their vital activity, and the absence of substantial changes in their various physiological functions."

Relating this early work of the late 1950s with the information on Spacecraft II given at the beginning of this article, it is tempting to speculate that Gagarin was landed in a similar manner.

The capsule which contained Strelka and Belka was catapulted away from the spacecraft after it had dropped to a height of some 23,000 ft. Twin sets of wheels can be seen at the base of its chassis which presumably run on guide rails in the body of the spacecraft; centrally disposed between them is the ejection device.

At the same time, we have the information that Strelka and Belka could have been recovered within the spacecraft without the capsule separating.

The question has been raised whether the Soviet re-entry vehicles have minimum lifting surfaces to aid their control in the lower atmosphere, before final separation and recovery occurs. Here one can only reiterate a statement contained in an earlier article (Ref. 3). Prof. V. Dobronravov remarked that the use of parachute re-entry methods alone, as was the case in certain Soviet geophysical rockets, will not suffice to return a satellite, "especially one containing a man." "We need a satellite," he said, "which can also be a unique type of glider—one that has devices to prevent the rocket from revolving around its horizontal and vertical axes."

On Apr. 13, the day after Gagarin's flight, the following comment appeared under the name of Igor Merkulov in *Soviet Weekly*. He writes: "It has been found that the best results can be achieved by combining power deceleration with atmospheric drag, where parachutes or wings can be used."

A correspondent in Moscow provides some additional comments by individual Soviet scientists. It is considered by many that human piloting of a lifting vehicle is more effective than completely automatic control monitored from the ground. It is possible to provide the pilot with visual indicators and a screen on which a map is projected to assist in checking the flight co-ordinates. A map of the heavens can be similarly projected. One report describes the pilot as being placed within a capsule which rotates through 360° within the ship to assume an optimum attitude under all conditions of flight.

Sooner or later the facts will be published, but until they are speculation is bound to continue. However, it was done, the spacecraft itself appears to have made a separate descent. And, by any token, it *was* a memorable achievement.

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