Gennadi Chernenko

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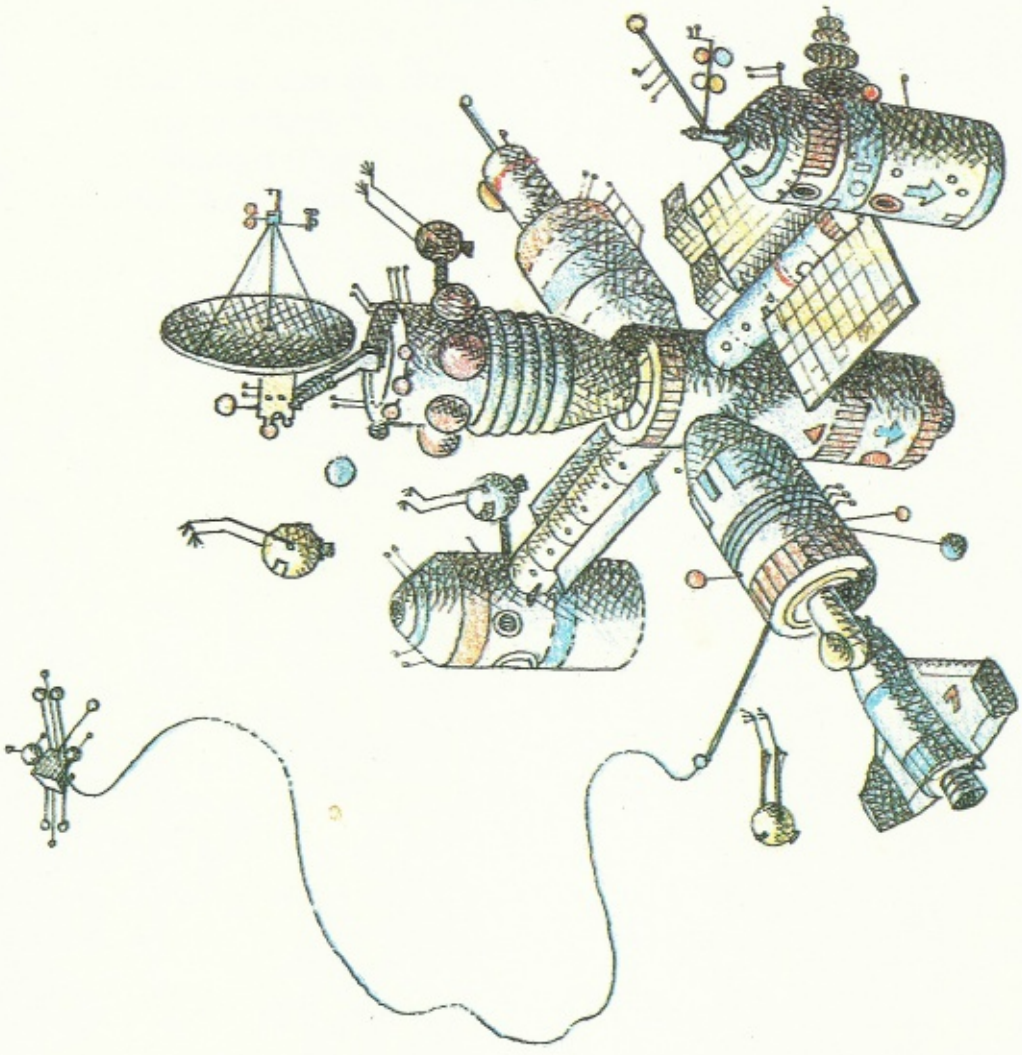

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HOW DOES ONE GO ABOUT FLYING INTO OUTER SPACE?

"I BELIEVE IN MY IDEA"

On fairy tales, legends and science fiction people have flown to the Moon, the Sun and the stars on chariots, a magic arrow, bats, a hunchbacked little horse, comets and meteorites. Today it is obvious to every one that flying into outer space astride an eagle is an absurd idea. But in ancient times it seemed quite probable.

Or flying into outer space by means of a magnet. One daydreamer proposed the following method. Get into a lightweight iron cage, take a big magnetized ball and throw it upwards. The cage will be attracted to the ball. Then throw it upwards again, and the cage will move up again. The man thought that if one were to do this a sufficient number of times, eventually one would reach even Mars.

Another inventor proposed to link the Earth and the Moon by an iron tube and travel back and forth through.

There were even more remarkable projects. The British author Herbert Wells, for example, suggested a way of overcoming the Earth's gravity. Once that mighty force no longer acted on the spaceship, one could fly anywhere. The scientist Mr. Cavor in Wells' novel *The First Men on the Moon* coated his spaceship with cavorite, a substance he had invented which could not be penetrated by the force of gravity, and easily flew to the Moon.

It's a fine method, but, unfortunately, there's no way to make it work. Cavorite is pure imagination. It is possible to overcome the Earth's gravity only by tremendous speed. A spaceship must fly ten times faster than a bullet! At eight kilometers a second a spaceship overcomes the gravitational field and becomes an artificial satellite of the Earth. If the speed is slightly more than eleven kilometers a second, the spacecraft will orbit the Sun, turning into a small planet. At a speed over sixteen kilometers a second, it will fly away from the Sun into other solar systems.

How is it possible, however, to attain such high speeds? One French engineer devised the following machine. Imagine a wheel as high as a ten-story building. A spacecraft is fastened to the rim of this superwheel. If the wheel is whirled faster and faster and then the spacecraft released, it could fly into interplanetary space.

It could, but... When engineers calculated the forces involved, it

turned out that even the strongest wheel would not stand up against the enormous pressure and would break into pieces long before reaching the necessary speed.

What if we were to use a gigantic cannon with the spacecraft the shape of a shell. The cannon would then fire the spacecraft into outer space. That is how three brave voyagers — Nicholl, Ardan and Barbicane — fly to the Moon in a novel by Jules Verne *From the Earth to the Moon*. The trip ends safely in the book. Actually a terrible accident would have happened. The velocity of a shell increases so fast that the passengers of the spacecraft would have been crushed by the pressure in the very first seconds of the flight. It is too bad, but Jules Verne's cannon will not do for flying into the Universe either.

In the winter of 1881 a new cheese store was opened in the center of Russia's capital, St Petersburg. Selling cheese was only a cover-up. Both the owner of the store and his wife were Russian Populists. They and their associates were preparing to assassinate Czar Alexander II. On Sundays the Czar's coach passed along the street where the cheese store was located. The plotters dug an underground passage from the store under the street and laid a dynamite mine in it. In addition they decided to post bomb-throwers along the route.

The decisive day came on March 1. The Czar's coach appeared but turned into a different street. Now it was up to the bomb-throwers. They were waiting for the Czar's coach at one of the city's canals. When the coach and the Cossack escort reached a young man in a sheepskin coat, he raised a white bundle over his head and threw it. There was an explosion, a cloud of smoke, and pieces of the coach and bits of clothing flew on all sides. The Czar had miraculously escaped. He climbed out of the smashed coach, but only managed to take a few steps before a second bomb landed at his feet.

Both the mine in the underground passage and the bomb which killed the Czar were made by Nikolai Kibalchich. The secret police soon learned this and arrested Kibalchich. He was to be executed. In the prison cell he asked for pen, ink and paper. Everything was brought to him. The authorities expected him to write a petition requesting that his life be spared. But Kibalchich was occupied by quite different thoughts. He was thinking about a plan for a flying machine.

"I am working on this project in detention a few days before my death. I believe in my idea, and that belief sustains me in my terrible situation." Such was the beginning of his last letter. There were no airplanes yet, the first airships could fly only in calm weather, and only balloons were more or less safe in the air, yet Kibalchich wrote about a jet-powered machine, a rocket intended to carry people. He knew the

power of explosives. They were to propel his flying machine.

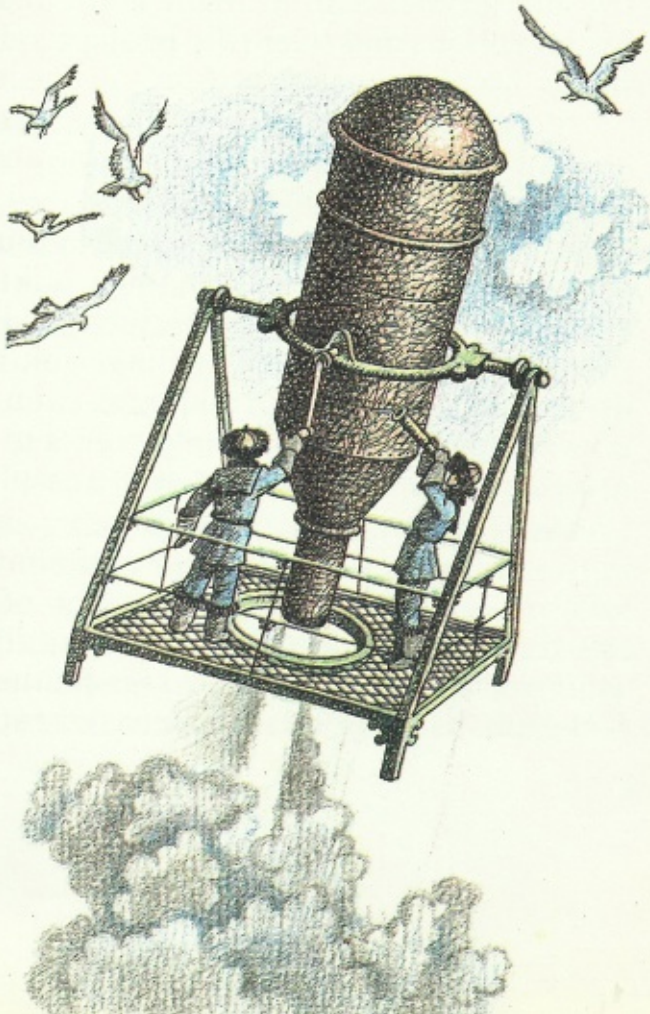
Kibalchich called his project an aeronautic machine. There was nothing in the project about outer space or interplanetary flights, and it is not known whether Kibalchich thought about voyages into outer space. The manuscript contained only one request: that the project be shown to scientists as soon as possible. Kibalchich wrote: "If after detailed consideration by scientists my idea is found feasible, I will be happy to know that I have rendered a great service to my country and humanity. Then I would face death calmly knowing that my idea will not perish with me but will live on among mankind for whom I am prepared to sacrifice my life."

An answer was not received: Kibalchich was executed. Czarist officials buried the project of a rocket machine in the secret archives, and only after the Revolution, in 1917, were the papers found.

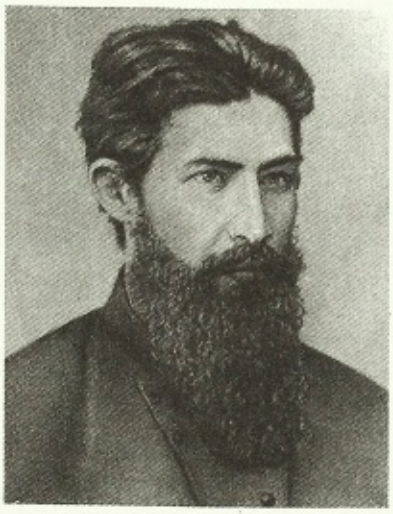
THE ROAD TO THE STARS

Although Kibalchich wrote nothing about space flights, he was on the right track. And if his project were made public at the time, who

This is how Kibalchich imagined his rocket machine



Nikolai Kibalchich



knows, perhaps scientists would have been able to find the road to the stars sooner.

Kibalchich was born in 1853, only four years before the birth of Konstantin Tsiolkovsky, the future great scientist who is quite justly attributed with opening the road to the stars.

Until the age of ten Konstantin lived like all boys of his age: he was playful and curious. He liked to daydream and, occasionally, he gave his younger brother all the kopecks he had saved in exchange for having him listen to his fantasies.

He dreamed of becoming a strong man, saw himself jumping higher than a fence, over trees and houses, climbing up poles and ropes. Or he would imagine that gravity had disappeared: he'd just push away from the ground, spread out his arms, and soar up into the air.

Then, at the age of ten, the boy fell ill with scarlet fever and became deaf. He was not totally deaf but could hear very little. His brothers went to school, but Konstantin could not.

Books were his teachers. The boy liked to work with his hands and invented all sorts of things. He would make a toy carriage with a spring, a musical instrument, or a little windmill. He built physical apparatus and a lathe. Tsiolkovsky never graduated from any school or college, but devoted all his life to self-education. On his own, he studied physics, chemistry, astronomy and higher mathematics.

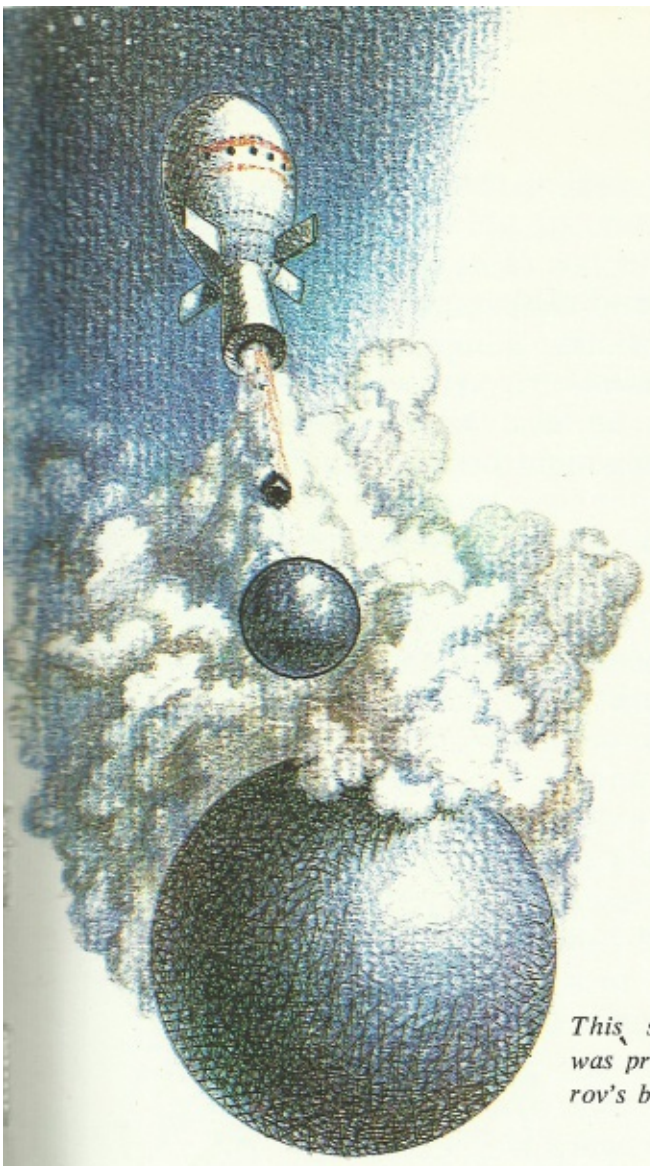
Konstantin became a teacher. He taught children arithmetic, geometry and physics. But at night and on Sundays and holidays, he worked on his inventions and scientific projects, wrote books and papers, and was busy in his home laboratory.

Tsiolkovsky had a big family. His small teacher's wage was hardly enough to make ends meet. Failing to find any support, a person who lacked faith would have given up, but Tsiolkovsky continued his research believing that it would bring humanity immense benefits.

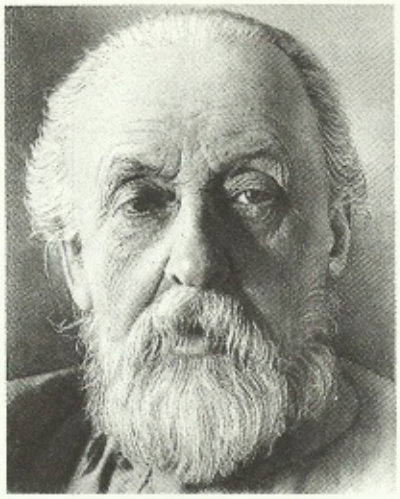
He was still fascinated by a world without gravity, an unusual and strange world where things, people and animals had no weight, where there was no floor or ceiling, no up or down. Konstantin's favorite dream, in his earliest childhood even before books, was a vague feeling of weightlessness, completely free and unrestricted movement like that of a bird in the sky. He did not know where the dream had come from.

As a very young man Tsiolkovsky had started to think about life in outer space, in an environment without air and gravity. He was fully aware of the importance of high speeds for space flights but at the time had no idea how they could be attained.

Tsiolkovsky lived then in the small town of Borovsk in Kaluga Gubernia. Getting up at the crack of dawn, he always managed to do some



This simple drawing was printed in Fyodorov's book



Konstantin Tsiolkovsky

work on his inventions and manuscripts before leaving for the school. In Borovsk he began to write a work entitled *Free Space*, a scientific diary containing the thoughts of a traveller who had been in outer space. "It is a frightening, lifeless dark sky whose brilliant stars are completely immobile," wrote the young scientist. "It is terrifying in this abyss, endless and lacking the usual objects that surround us: no earth under your feet and no terrestrial sky!"

But how does one move in space where there is nothing to push against, not even air? Tsiolkovsky proposed using a jet engine, a peaceful gun, to be more precise, which fires spheres. After the shot the sphere flies in one direction, and the gun with the spacecraft, according to the laws of mechanics, moves in the opposite direction. It is possible to do it differently, the scientist reasoned, by installing a gas cylinder on the spacecraft. The jet of gas would replace the spheres. But that

was in outer space. But how could it be reached? Tsiolkovsky could find no answer.

For a long time he viewed the rocket in the same way as everyone did then recognizing only its minor uses and entertainment value. He had seen holiday firework displays many times, admiring the brilliant lights in the dark sky. The flight of the firework rockets evoked nothing but admiration in Tsiolkovsky. Of course he also knew that military gunpowder rockets had been invented a long time before. But this also failed to ring a bell.

One day in 1896, in Kaluga, Tsiolkovsky came across a small book with a long, very precise, scientific title: *A New Principle of Aeronautics Excluding the Atmosphere as a Supporting Medium.* Tsiolkovsky had not previously heard of the author, Alexander Fyodorov, an inventor from St Petersburg. The scientist read the first lines — an appeal to readers — and realized that the inventor from the capital did not have it easy either — poverty, ridicule and lack of recognition were his lot. Fyodorov asked for support of any kind, even just sympathy and a kind word. That was why he was publishing the work.

What was the book about? Fyodorov described the flying machine he had invented. A simple sketch explained how it worked. The engine consisted of tubes: compressed gas was fed into one end of a tube and it escaped out the other. In other words, the machine was really a rocket.

Fyodorov had not intended his machine for flying into space, only for travelling above the Earth. But Tsiolkovsky saw something quite different in this invention. It was the answer: a rocket! The rocket had no need for air. Air only got in its way. A rocket could fly very well in a vacuum. It could reach tremendous speeds. A rocket would take earthlings into interplanetary space, to the Moon, Mars and Venus!

There were no calculations in the book, and Tsiolkovsky began to figure, laying the foundations of the science of space rocket flights and the theory of astronautics. Shortly he finished his principal work, *Exploration of Space by Means of Jet Machines.* "I propose a jet device, a kind of rocket, an enormous rocket of a specific design. It is not a new idea, but the computations it involves yield such remarkable results that it would be inadmissible not to report them," the scientist wrote.

Five years later this important work was published in the St Petersburg *Science Review.* It had all started with Fyodorov's thin book. As Konstantin Tsiolkovsky put it: the book prompted him to begin serious work just as Newton's falling apple led him to discover the law of gravity.

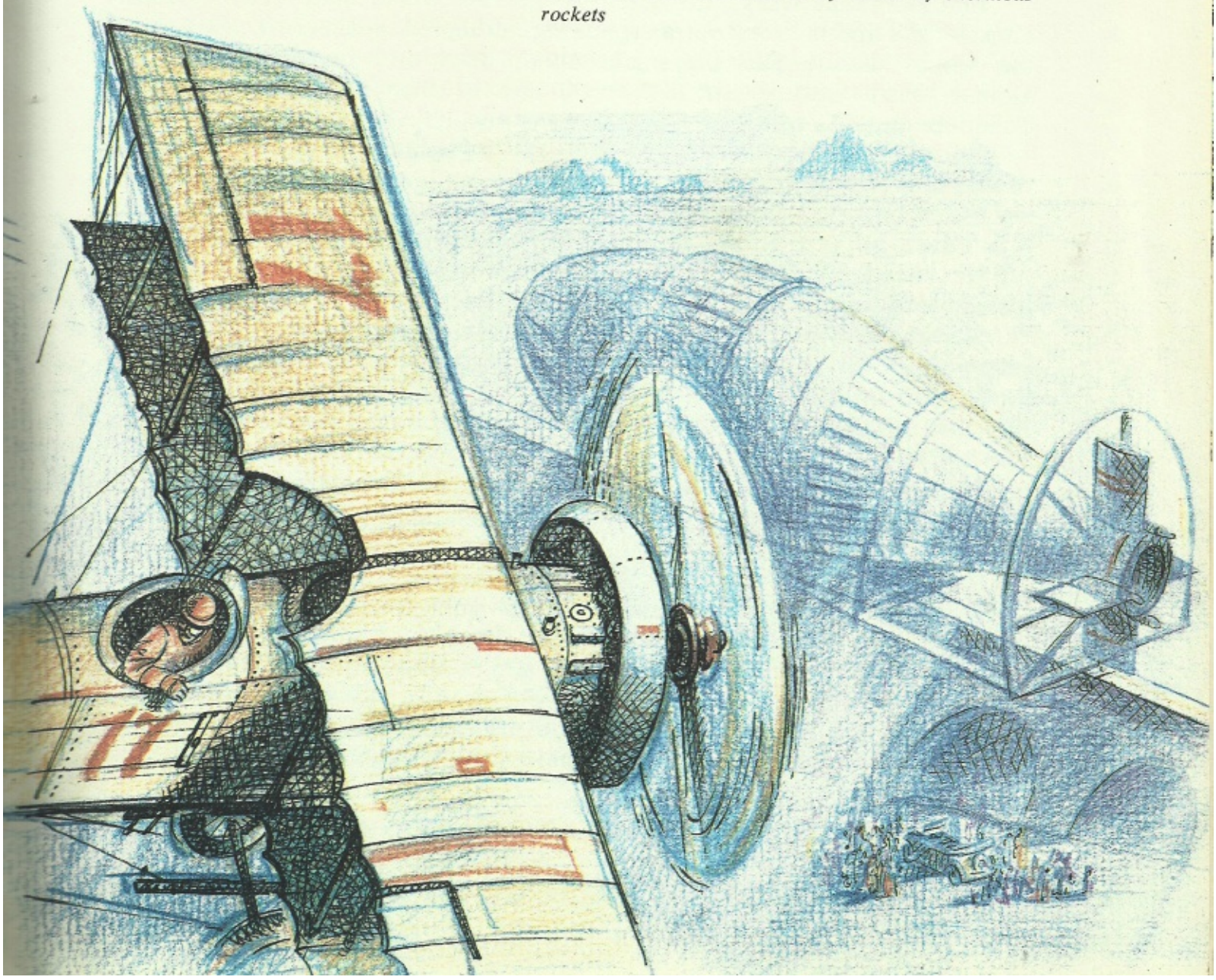
What was Tsiolkovsky's interplanetary rocket like? It resembled an

enormous drop of water. The front contained the crew compartment, air supply and everything for normal living. The back held the fuel tanks and engine.

The scientist concluded that gunpowder was unsuitable for a space rocket. A gunpowder rocket could not attain the required speed. Liquid fuel produces much more energy when it burns. Tsiolkovsky suggested a mixture of liquid hydrogen and liquid oxygen. The fuel burns, and the resulting gases escape through a conic nozzle at a tremendous speed. This produces an equal and opposite reaction that thrusts the rocket forward.

The scientist designed many important things for his interplanetary spacecraft: rudders to direct the flight, equipment providing oxygen for the travellers, and apparatus for conducting research in outer space. Nevertheless, it was only an approximate picture of a space rocket.

In Tsiolkovsky's view man could overcome the force of gravity, and would do so by means of enormous rockets



Tsiolkovsky admitted that. He wrote that hundreds of years would pass before the ideas he expounded would be applied and people would take advantage of them.

He was quite rightly called a great scientist. He was the first to develop the theory of rocket propulsion. He predicted the development of spacecraft for decades to come. There were no real planes yet, carriages still drove through city streets yet Tsiolkovsky wrote about artificial Earth satellites, and space settlements flying around the planet at enormous speeds.

Tsiolkovsky was way ahead of his time, as a true scientist should be. The more time passed, the more widespread his ideas became in the countries of the world.

SPACE ENGINEER

Before Tsiolkovsky, no scientist in the world had ever seriously considered flights into outer space or designed spacecraft. But when the works of the Russian scientist appeared and became known, he gained many enthusiastic followers, one of the first being Frederick Tsander.

Tsander was born in the Latvian city of Riga. His father, a doctor, often told little Frederick about the sky and the possibility of living creatures on other planets. Once Frederick asked his father:

"Can I go to the far-off planets?"

He recalled having cried when his father answered: "No, my son, it's impossible to fly there as yet."

Since then the dream of interplanetary travel never left him. He firmly resolved to study to become an engineer and design interplanetary spacecraft.

One day, in the winter of 1904, the astronomy teacher brought a journal to Frederick's class.

"Today I will read you a remarkable paper," he told the children. "The paper proves that it is possible for man to fly into space."

"Who wrote the paper, Sir?" asked Frederick excitedly.

"Tsiolkovsky," the teacher replied.

It was the paper *Exploration of Space by Means of Jet Machines.* Tsander bit his lip as he listened to the teacher. Tsiolkovsky's idea of an enormous rocket and flights to the planets excited him and was easy to understand. He had dreamed of the same things for a long time.

Later, Frederick Tsander would say that he began serious study of astronautics in 1906, when he became a student of the Riga Polytechnic.

He had a notebook with the word "Spacecraft" on the cover. His first cosmic calculations were written in the notebook.

He bought a small telescope which he had always dreamed of, and observed the sky every night from the roof of his house. Sometimes Frederick took along his sister Margaret and told her about the Moon's craters, Saturn's rings, Mars and the giant Jupiter.

Tsander moved to Moscow. He lived in a tiny room with the barest essentials — a bed, two stools, a book shelf and a desk with heaps of drawings. Tsander worked at an aviation plant, and devoted all his free time to the study of interplanetary travel. He was the first Soviet engineer who devoted himself to astronautics. Whoever he talked to, the conversation would inevitably turn to interplanetary flights. He even gave his children cosmic names: he called his daughter Astraea (a star) and his son after the planet closest to the Sun, Mercury.

In the spring of 1923 Frederick Tsander wrote a letter to Tsiolkovsky saying that he had been working on a project for spaceship for some years.

Tsander's spaceship resembled an airplane — it had wings and propellers. The designer himself expected that it would take off like a usual airplane and at a high altitude, in the stratosphere where the air is very rarefied, the rocket engine would be fired. The metal parts that were no longer needed — wings, propellers and parts of the body— would be pulled inside and melted and the liquid metal used as excellent fuel for the engine. Finally, only a small space glider would be left which needed wings for the re-entry. It would return to the Earth as a glider.

Tsander was in a hurry. He was always short of time. Not only every hour but every minute was precious. To save time, Frederick learned shorthand. This enabled him to work four to five times faster. He knew German as well as he knew Russian and sometimes even wrote in both languages on one page. He had no way of knowing what a difficult task it would be for historians to decypher his shorthand.

The flight to distant planets would take many months and even years. It was impossible to take along enough oxygen, water and food for the crew. Tsander knew that Tsiolkovsky had found a solution: matter would have to be recycled in the spacecraft. Food would have to be produced on board at least partly, the air and the water purified and used again. Nothing was to be wasted or discarded. Tsiolkovsky believed that it was possible to live indefinitely on the available supply of materials in outer space in the same way as everything existing on the Earth lives on the same amount of gases, liquids and solids which do not increase or decrease.

A greenhouse would have to be built in the spacecraft. The plants

would absorb carbon dioxide the people exhaled and supply oxygen. The plants would also serve as food for the cosmocrew. Tsander decided to realize Tsiolkovsky's idea at least in part under terrestrial conditions. He set up a "space garden", an extremely lightweight greenhouse, at home on the porch. There was no soil in the garden. The roots of the plants were suspended in the air and sprayed from time to time with a nutrient. The scientist tried to grow peas, cabbage, radishes, lettuce, carrots and even a watermelon.

As busy as Tsander was in the daytime, at night he would always return to his plant experiments, making additional computations for the greenhouse and creating new designs.

Experiments in the space garden were still underway when Tsander began to consider another tremendous project. Twenty-five years had passed since Russian physicist Pyotr Lebedev had proved that rays of light exert pressure like a stream of gas or liquid. While light pressure is extremely weak, by using very sensitive apparatus Lebedev managed to measure this tiny force.

Tsander proposed to use light pressure to accelerate spacecraft by furnishing them with enormous "sails" or screens which shone like mirrors. The better the screen would reflect sunlight, the stronger the pressure. But the force per square meter would be less than one thousandth off a gram even on the best screen.

It goes without saying that the "solar sail" would be unable to carry the spacecraft into orbit in space. But in outer space, in a vacuum in absence of gravity, even such a negligible force is capable of gradually lending the spacecraft enormous speed.

Frederick Tsander was interested in everything concerning interplanetary travel. He was the first to calculate flights to the planets, and invented a way of preventing spacecraft from colliding with meteorites by means of electricity. It was his proposal to accelerate spacecraft using gravitational forces of planets they were approaching. He was one of the first in the Soviet Union to develop a rocket engine using liquid fuel and a liquid-fuel rocket. And the most important thing was that the advocates of astronautics rallied round Frederick Tsander. Work forged ahead.

A REMARKABLE PREDICTION

At the end of the last century, in the green Ukrainian town of Poltava a man was born who would go down in history as a pioneer of space exploration. At school he read scientific books, and sat for hours on end drawing and inventing things, deep in thought.

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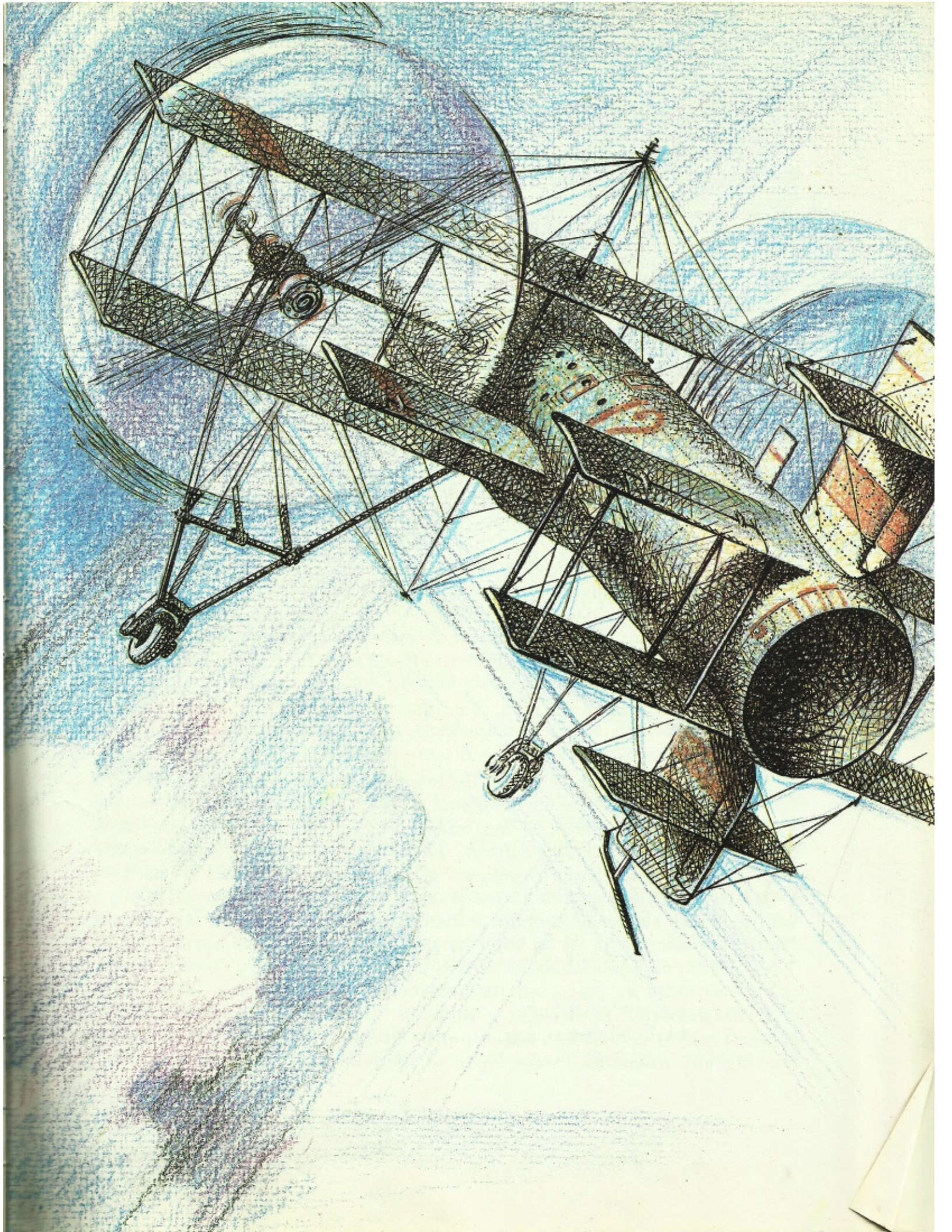
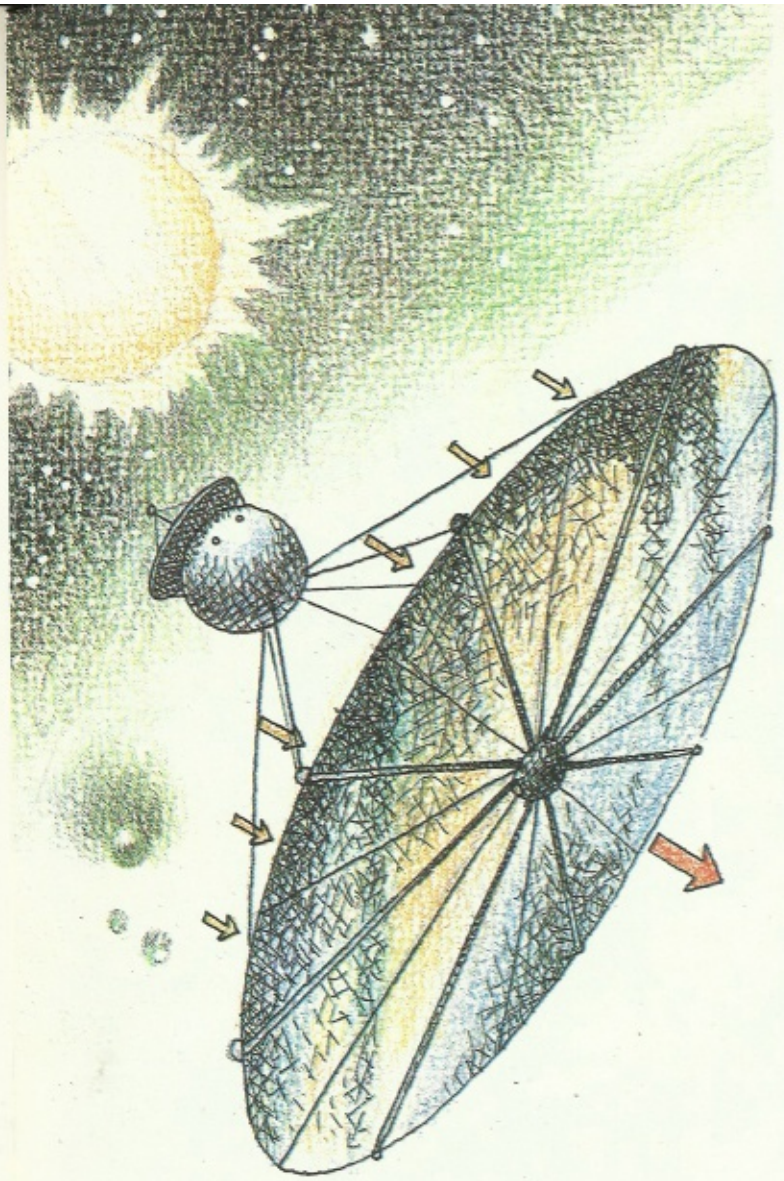
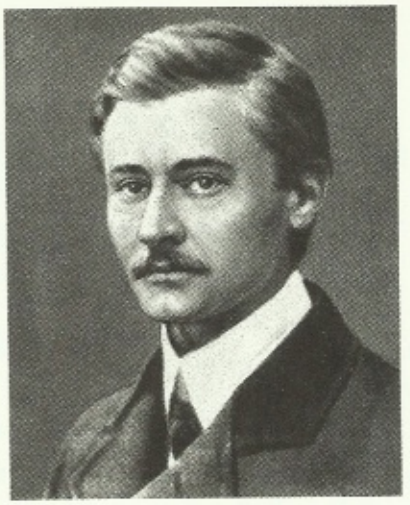




The time would come when space-ships with solar "sails" would fly into the Universe



Frederick Tsander

The man's name was Yuri Kondratyuk. As a youth he had read a science fiction novel by the German author Bernhard Kellerman, *The Tunnel*. The book described the building of an underwater road linking the shores of America and Europe. The idea of a 5,000-kilometer tunnel under the Atlantic Ocean fascinated Kondratyuk. He wanted to work on a tremendous project of his own. Was it possible, for example, to dig a well into the center of the Earth to tap the heat inside it? Or an even greater challenge: to fly to the planets, into outer space?

Kondratyuk soon abandoned the idea of the well but was absorbed more and more by interplanetary travel and astronautics.

After finishing school Yuri entered the Petrograd (previously St Petersburg) Polytechnic but studied there for only two months. The First World War was raging and Kondratyuk left Petrograd. But wherever

he was destined to go, his rucksack always held papers full of calculations. Yuri knew nothing about Tsiolkovsky's works. Neither did he know Tsander. He had to do everything on his own. There were no books or technical manuals, and often even ink was unavailable. He wrote in pencil in school notebooks.

The first artificial Earth satellite would be launched only in forty years, yet Kondratyuk was writing about space flights in great detail and with a high degree of precision. His calculations proved that the interplanetary rocket had to be a "space train", consisting of several rockets or stages linked together in the same way as cars in a train. Once the first stage has done its part and its fuel tanks are empty, it is discarded. The space train becomes lighter in weight and its velocity increases. When the second stage has burnt out, it also separates. Velocity becomes even higher. Finally, the last "car" reaches the necessary speed and goes into orbit. If a rocket did not consist of stages it would be unable to rise into outer space. Kondratyuk clearly demonstrated this.

He also considered the most economical way for a spacecraft to fly into outer space. It turned out that there was a big difference depending on how the rocket rose: straight up or at an angle along an arc. When would more fuel be used up? Kondratyuk concluded that it was best to combine both ways. For a while the rocket should fly straight up to overcome the dense atmosphere quickly and then it should turn and go into orbit along an arc.

The most economical way for the space rocket to move was Kondratyuk's second major discovery. And the third, and perhaps, most important, concerned intermediate interplanetary bases. What was the purpose of these bases?

Imagine a spacecraft flying to a distant planet for several months. It is quite close to its destination now. It would have to land on the planet's surface. Kondratyuk argued that there was no sense in landing the entire spacecraft on the planet. Indeed, to make a soft landing the enormous speed of the spacecraft would have to be reduced almost to zero. At take-off the velocity would have to be regained using up a lot of precious fuel in the process.

Kondratyuk suggested a different way. Only a special vehicle with the cosmocrew would land, while the basic spacecraft would remain in orbit flying round the planet. Having done all the work, the cosmonauts would return to the re-entry vehicle, take off, dock with the basic spacecraft, enter it and fly home to the Earth.

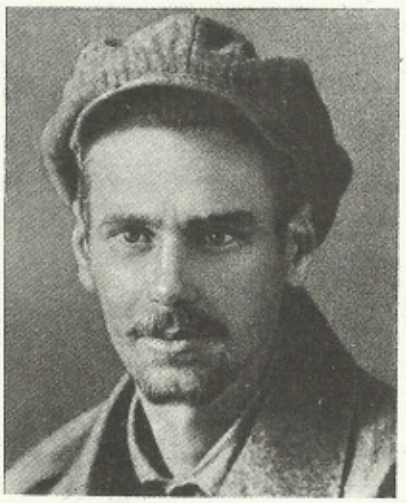
Moreover, he proposed to set up a permanent orbiting base near the Moon, a big lunar satellite. Automatic rockets would deliver fuel and various supplies to the base. Then the interplanetary ship would not have

to take off from the Earth heavily loaded and with a full supply of fuel. Having docked with the lunar base, the ship would replenish its tanks with fuel, load everything it needed on board and fly on to Mars, Mercury or Venus.

Kondratyuk called his work on astronautics *For Those Who Will Read in Order to Build*. He was addressing the scientists, engineers and workers fortunate enough to realize the great dream, to overcome the Earth's gravity and burst into outer space.

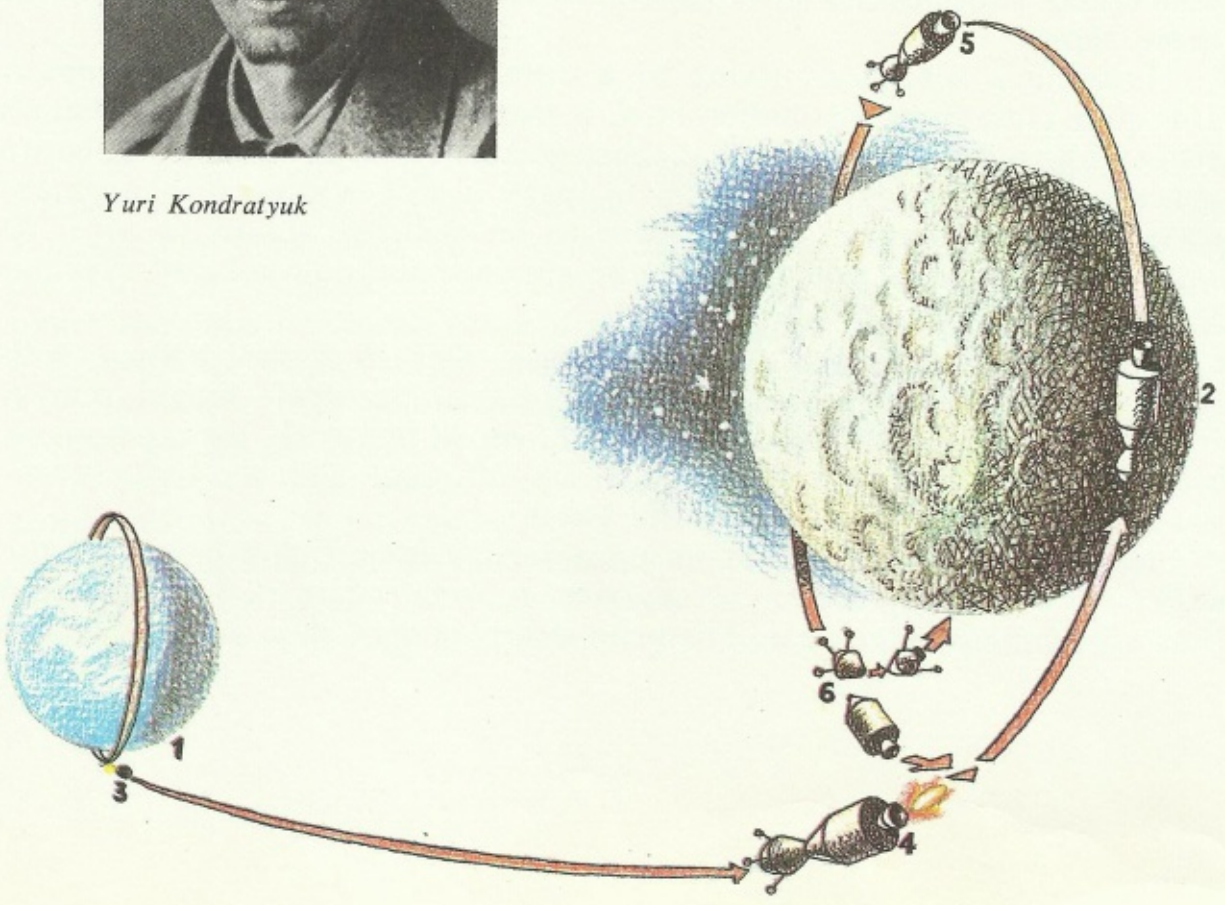
It was a difficult time. The Civil War raged in Russia. Kondratyuk had a hard life. He did all sorts of odd jobs to earn a living, chopping wood, working as a lubricator on the railway, a stoker in a boiler room of a sugar factory, and a mechanic at a flour mill. In the evenings he worked on his calculations.

In 1918 Kondratyuk chanced upon a short item about Tsiolkovsky



Yuri Kondratyuk

This way of flying to the Moon was first proposed by Kondratyuk. 1 — the Earth; 2 — the Moon; 3 — having circled the Earth several times the spacecraft flies off to the Moon; 4, 5 — the spacecraft approaches the target and begins to circle the Moon; 6 — a landing cabin separates from the spacecraft and softly lands on the lunar surface



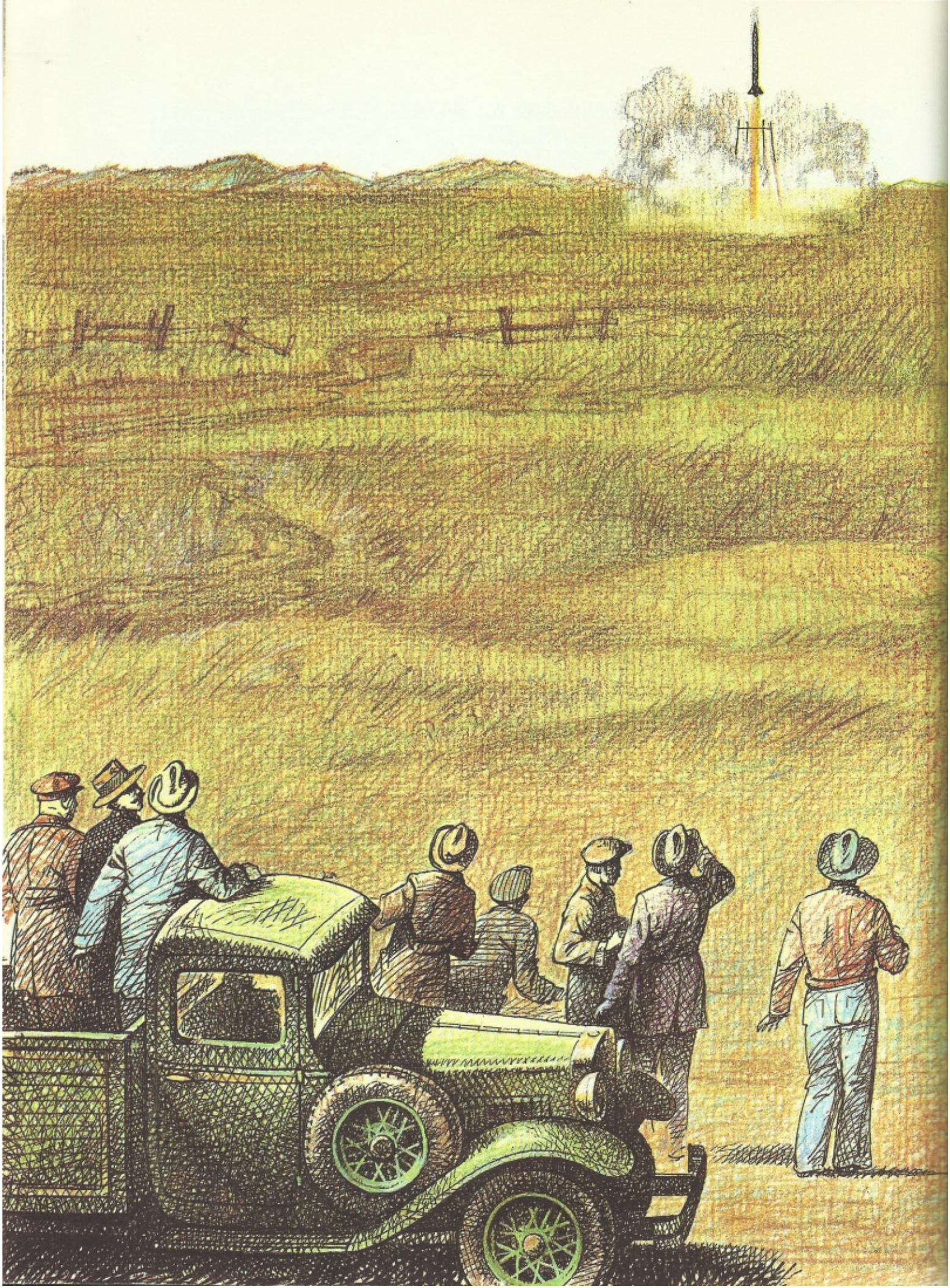
in an old journal. Later he read about foreign scientists working on rocket technology in newspapers. Thus he learned that he was not alone and space travel interested many people.

Kondratyuk went south and worked as a mechanic at a grain elevator and bread warehouse. He knew no respite there either. In the house where he rented a room there lived a little girl, Varya. She remembered the unusual boarder: tall, lank, with a small beard and dark shining eyes. Many years later, when she had grown up, she described how at lunch or supper Yuri would rise impulsively from his chair and begin to pace back and forth snapping his fingers. He would frown and screw up his eyes. Then he would sit down again and hastily scribble or draw something on paper.

At the time he was awaiting a letter from Moscow. Several months had passed since he had sent a manuscript of his work on space flights to Professor Vetchinkin in the summer of 1925. Kondratyuk worried about the professor's reply. Finally, the letter arrived. Yuri recalled that he was amazed by the scientist's answer. Vetchinkin wrote that Kondratyuk should by all means publish the work as a separate book.

The light in the windows of his room would burn late into the night: Kondratyuk was preparing the principal work of his life for the press. Shortly the book *Conquering Interplanetary Space* appeared: it was a slim volume but of immense importance.

As Kondratyuk saw it, the main goal of space flights was not to settle on other planets. The Earth itself needed the flights. He declared that astronautics would make man the real master of the planet and enable him to live a full and happy life.



FORGING AHEAD!

TO THE STARS

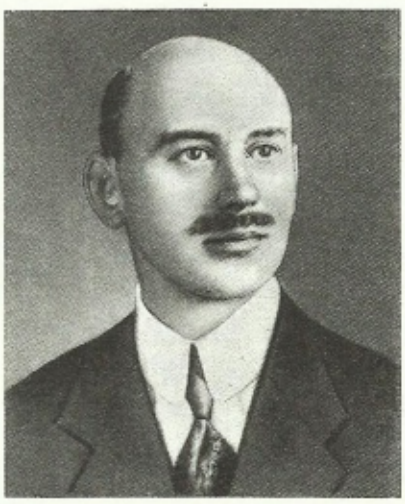
In the 1920s people in other countries were also working on rockets and the most success was achieved by Professor Robert Goddard from the small American town of Worcester. He was the first to begin experiments on liquid-fuel rocket engines.

Goddard kept the results of his experiments secret, hiding them even from his compatriots. Scientists from Germany and France attempted to establish scientific contacts with the American professor and exchange information. But he avoided meeting them. And when a scientist managed to come to Worcester, Goddard showed the shop and laboratory he worked in, and a rocket launcher, but not the rockets themselves.

The professor was a gifted inventor. His work moved forward, only very slowly. New experiments required more money. It was very difficult for him to get the necessary funds. And the secrecy complicated things.

In the summer of 1924, there were rumors that Goddard had built a rocket and would send it to the Moon on July 4. Newspapers and magazines in all countries wrote about it. Some scientists even believed the report.

Sergei Korolyov



Robert Goddard

But on July 4 the launch did not take place, nor did it on July 10 and July 20. A rocket to the Moon was a very remote possibility at the time. The report had been false.

It was only five years after the beginning of his experiments, in the spring of 1926, that Goddard's rocket first left the ground: it was very primitive, weighing only a few kilograms. The rocket reached an altitude of only twelve meters, flew along an arc for about sixty meters and fell in a field covered with ice and snow. The second and third rockets were not much better. It proved to be an incredibly complex task to develop a liquid-fuel rocket.

At the time Robert Goddard was doing his experiments, suffering failures and starting from scratch again, the future Soviet designer of space technology, Sergei Korolyov, was only finishing school. But he had already firmly decided to become an aviation engineer.

He saw an aircraft flying for the first time in 1911, at the dawn of aviation, and he remembered the sight all his life. It happened in the Ukraine, in the town of Nezhin, where six-year-old Sergei lived with his grandparents.

Aeroplanes did not fly very often at the time. Like circus performers pilots toured different towns and exhibited their skills for money. One warm April day Grandfather took his little grandson out of town. Crowds of local people hurried with them to see the miracle of the 20th century with their own eyes: the first flight of an aeroplane in Nezhin. The visiting pilot was the prominent Russian sportsman Utochkin. Virtually the whole town had assembled to watch the event.

On the even field Sergei saw a white plane which looked like a box kite. Mechanics were busy checking it and tightening the wires holding it together.

The pilot appeared, followed by photographers.

Utochkin jumped deftly into the seat and tried the rudders. The motor sputtered and the propeller began to turn. The plane ran over the fresh spring grass, bounced up on a couple of hillocks and ... was suddenly in the air! Everyone clapped.

"Grandpa, look, it's flying!" Sergei cried out, unable to take his eyes off the remarkable white bird. The plane was flying very low over the ground, only a few meters above, but even that seemed amazing.

The second time Sergei Korolyov saw a plane was under quite

different circumstances, when he was at school in another town.

The Korolyov family lived in Odessa on the Black Sea at the time. They had a view of the sea from the balcony of their house. Sergei studied at a technical school. As all the kids in Odessa, he was an excellent swimmer. He swam so far out into the water that he could hardly be seen from the shore.

It was the sea that led him to aviation.

There was a seaplane base in a nearby bay. The hydroplanes would plough through the water from the dock to the open sea, take off leaving a long foamy trace behind, and disappear on the horizon.

For quite a while Sergei had been spending a lot of time at the seaplane base, and knew all the pilots and mechanics.

"Sergei, hold this for a sec!"

"Sergei, give me a hand!"

He was often asked to help at the base. And he was willing to clean and assemble motors, and drag and push the green flying boats into the water from morning to night.

Occasionally the pilots took him along on flights, and this was the greatest of joys for Sergei.

At home, however, his parents frowned on his passion fearing that it would interfere with his studies. But more and more often Sergei told his family and friends that he would become an aviation engineer. And he would fly himself testing his own planes!

And he did, graduating from the famous Moscow Higher Technical School which produced many brilliant Soviet engineers and scientists including aircraft designers Andrei Tupolev and Semyon Lavochkin. From the lectures at the school Korolyov hurried to the local flying school. From the airport he rushed to a lecture. He became an engineer and a pilot almost at the same time.

His dream came true.

In the fall of 1929 a glider meet was held in the village of Koktebel. A score of wood-and-canvas gliders were assembled under the hot Crimean sun on the slope of a hill. Some of them immediately caught the eye because of their beautiful shape. Others were unusual like the *Parabola* glider, a flying wing.

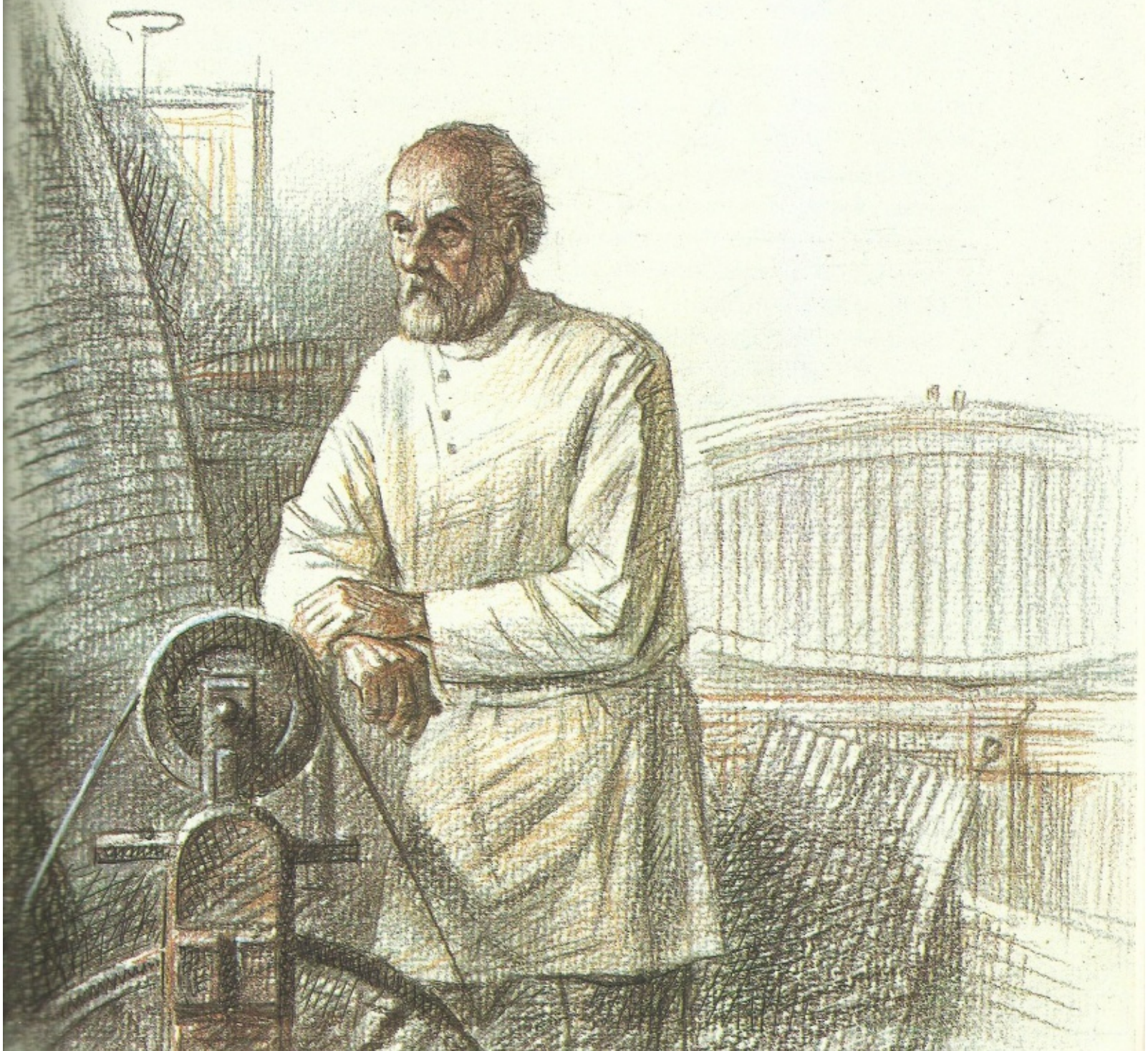
It was acknowledged right away that the most attractive glider was the red-winged *Koktebel* designed by the young engineer Sergei Korolyov.

The designer often got into the cockpit and soared over the blue valley for hours.

Koktebel flew very well, but the only thing that Korolyov regretted was that aerobatic figures could not be performed on it.

He was particularly keen about teaching the glider to loop. It did not matter that no one had made such a glider before, his glider would be the first.

And Korolyov designed an aerobatic glider. As usual he wanted to test fly his brain-child himself but unexpectedly fell ill and was confined



to a hospital bed for a long time. He did not see the remarkable flight of his glider at the next meet in the Crimea.

The glider was test flown by Vassily Stepanchyonok, a real daredevil. He reached an altitude of about one kilometer and put the glider into a dive. It gained speed and then the pilot maneuvered it up again, turned it on its back, then down again. The glider made a loop in the air. Having made two more loops, the pilot landed the glider. Since then aerobatics on gliders have become common.

Many people thought this was Korolyov's main calling in life. Perhaps he was of the same opinion, until, one day, he read Tsiolkovsky's book about astronautics.

"Astronautics cannot be compared to flying in the air. The latter is child's play compared to the former. If they knew the difficulties involved, many of the people working so enthusiastically would be horrified. Yet how wonderful the eventual accomplishment will be!"

Tsiolkovsky abruptly changed Korolyov's life. Things would not be easy for Sergei Korolyov, but he was not afraid of difficulties. He read Tsiolkovsky's works over and over again. The scientist's books never left Korolyov's desk. Now he said the word *rocket* much more often than the word *glider*.

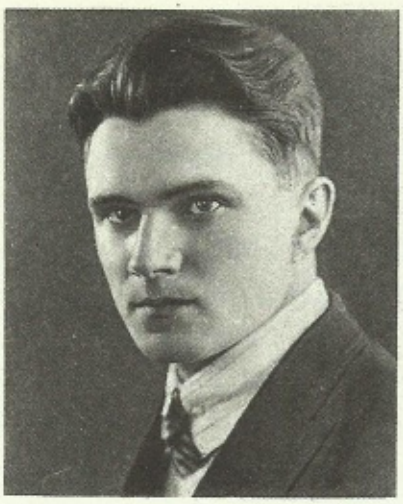
Korolyov was twenty-three. He still did not know that rockets would become the center of his life. He did not know that he would do what Tsiolkovsky had dreamed about. The time would come when Korolyov would direct the development of rockets which would carry the first artificial satellite, the first manned spacecraft and the automatic lunar stations into space.

This would happen many years later. Ahead lay a long and thorny road.

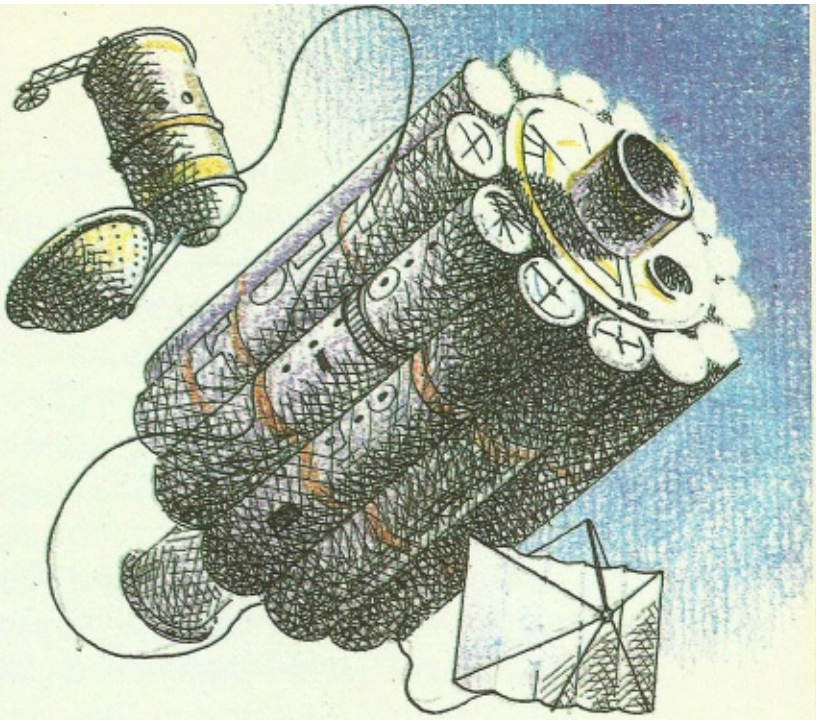
WE FACED THE UNKNOWN

Perhaps they had even met on the streets of Odessa — Sergei Korolyov and Valentin Glushko. Perhaps they had been a stone's throw from one another when they were swimming in the sea or sunbathing. Sergei was only two years older than Valentin.

When Valentin was in school he, like all boys, avidly read Jules



Valentin Glushko



Verne's novels. He was particularly thrilled by his space novels *From the Earth to the Moon* and *Round the Moon*. He wondered whether the day would indeed come when man would reach the Moon and would be able to fly to Mars and Venus. He read the books with bated breath. It was at the age of thirteen that the boy decided to devote himself to astronautics. To begin with he resolved to study astronomy, the science about stars and planets, properly.

On his way to school every day Valentin saw a house with a tower — an amateur observatory. Astronomy lovers observed the sky there. Valentin began to spend his evenings at the observatory. He watched the Moon, Venus, Mars and Jupiter through a telescope. Astronomical observations became his hobby. Thrilled, he watched celestial bodies and different colored planets which seemed to be very close and dreamed of reaching these mysterious expanses.

"Have you heard of Tsiolkovsky?" the head of the astronomy club asked Valentin one evening.

Valentin had never heard the name before.

"No, I haven't" he replied at a loss.

"Then I would strongly advise you to read Perelman's *Interplanetary Travel*. An excellent book. The second edition has recently come out."

The book proved to be remarkable. It was written by a person who knew how to write about science in a way that everyone could understand, the

author of *Entertaining Physics,* Yakov Perelman. He drew the following conclusion: only Tsiolkovsky's rocket would enable space flights to be made, and the day would come when spaceships would fly into the Universe taking people to the Moon and the planets and, perhaps, even to other solar systems and distant stars.

Perelman wrote about Konstantin Tsiolkovsky with deep respect calling him an outstanding scientist and listing his principal works. Now Valentin knew what to do: he had to find Tsiolkovsky's works on interplanetary travel and read them.

He set out for the largest library in Odessa and, to his joy, found the journal with Tsiolkovsky's paper. He learned what the space rocket would have to be like and how the engine would have to be designed, and also how to calculate the velocity of the flight.

Questions arose and Valentin wrote to the scientist saying that he had read the paper *Exploration of Space by Means of Jet Machines* and asked Tsiolkovsky to send him another more detailed paper on the space rocket. He also wrote that he had many questions he would like to ask on another occasion.

The reply arrived very soon. A neat home-made envelope of white paper contained books and a letter. Tsiolkovsky promised to send Valentin his new works. And he kept his promise.

Valentin's letters grew more and more candid. In one he wrote that interplanetary travel was his goal in life.

Valentin's favorite subject was physics. After finishing school he went to Leningrad and enrolled at the physics and mathematics department of the University. It was 1924. His entire life, all his daily actions, were concentrated on making his dream come true. He dreamed of developing rocket engines, building them and testing them.

Valentin Glushko published an article "Stations Beyond the Earth" in a Leningrad journal. In it he wrote that the time was not so far off when stations would be set up to fly around the Earth. Scientists would begin to study their own planet from space. This would provide a better vantage point.

An unusual Gas Dynamics Laboratory, GDL for short, was functioning at the time in Leningrad. When the young engineer Glushko came to the laboratory, it was working on gunpowder rockets. But he began a new project which required many years of persistent work on his part:

the development of liquid-fuel rocket engines. This was in 1930.

Everything had to be started from scratch. Before him were blank pages and the unknown, in the full sense of the word.

There were many unanswered questions. For example, liquid rocket fuel consists of two parts, the fuel and the oxidizer. These substances only become fuel when they are mixed. Each of the parts alone cannot burn. Only the mixture burns.

What substances were more appropriate? Tsiolkovsky had suggested liquid hydrogen and liquid oxygen. But perhaps there were more suitable chemicals?

And how were the parts to be fed into the chamber of the rocket engine: separately or after being mixed? In what way? How was the fuel to be ignited?

The first rocket test ended in a large explosion. Pieces of the rocket hailed down on the engineers. It was a miracle that no one was hurt. After the incident, they became more careful, always observing the test from a shelter. Failures were followed by new tests. The first experiments lasted for split seconds. The engines could not withstand the high temperatures and the walls burned through. But gradually the time they functioned was extended to a second, ten seconds, finally half a minute!

It was not easy to find a fuel which would emit enough heat, take up relatively little space, not spoil during long storage, not explode and, if possible, cheap. Many fuels were tried.

It was dangerous work to say the least. One day Glushko and engineer Yukov were testing a rocket. As they approached the rocket exploded. They were wearing fur caps and that saved them. The shock wave tore the deerskin caps to shreds. An ambulance raced them to a hospital but fortunately, there were no serious injuries.

Little by little major difficulties were left behind. The engines could be fired several times. Now they could be launched.

WE'LL FLY ANYWAY!

When rockets and interplanetary flights were no longer the dream of isolated individuals but the life's work of hundreds of people, it became obvious that the efforts of engineers, designers, scientists and

pilots must be combined. It was then that the Group for the Study of Jet Propulsion (GSJP) was set up in Moscow in the fall of 1931. Frederick Tsander was its first head, but he was soon replaced by Sergei Korolyov.

People came to the GSJP in different ways, but all of them were carried away by rocket technology, knew the works of Tsiolkovsky, Tsander and Kondratyuk. "Having read Tsiolkovsky I began to think about flights to other planets," one of them recalled. "One day I heard that an organization had formed in Moscow to fly to Mars. I got a job there without hesitating, although I knew the wages were low. I was not going to be stopped by such considerations."

For a long time the GSJP looked for a place to do its noisy and dangerous work. The search was carried on throughout Moscow. Finally an empty cellar was found in a multi-storey building. The cellar was dark and grim but very big, and most importantly, capable of withstanding the strongest explosions. The cellar was cleaned and repaired, walls and doors painted, machine tools installed, and work forged ahead.

It should be noted that the "extraterrestrials" were met with distrust and occasionally even ridicule. They were called lunatics and Martians. When they requested funds or materials, they often heard good-natured advice to fly off to the Moon as soon as possible and stop interfering with the work of serious and busy people.

There were not enough tools and instruments, but most importantly, the people lacked experience. It was no easier for the GSJP than it had been for the Gas Dynamics Laboratory. The first rocket engines' walls also burned through in a matter of seconds. "Sometimes it seemed there was no way out. There were weeks and months when one setback followed another," a veteran of the GSJP, engineer Leonid Korneyev, recalled.

But the pioneers had no intention of giving up, and the most persistent among them was Tsander, of course. When setbacks and failures occurred he would repeat his favorite phrase: "We'll fly to Mars anyway!" And everyone felt better right away. They were sure they would succeed sooner or later.

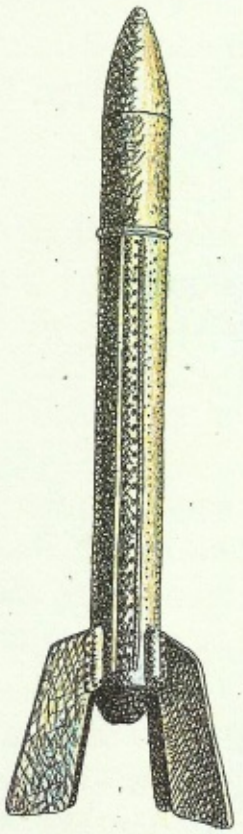
One employee of the GSJP, Krasnukhin, recalled that they worked in the cellar with electric lights, and Frederick Tsander would remain far into the night, absorbed in his work. He was led away from work almost

by force. Many people in the GSJP worked as he did. When the first rocket was being prepared for flight, work continued throughout the night. There were some extremely dangerous situations. After all, the technicians had to deal with explosives, poisonous substances and liquid, and therefore very cold, oxygen.

Once a test engine exploded on the launching site. Fortunately no one was hurt, but a fire broke out. And there were oxygen cylinders nearby.

Mechanics Frolov and Avdonin rushed towards the cylinders. They chopped the hoses off with an axe. Their hair began to burn from the heat, but they managed to drag the heavy cylinder further away. Their legs shook as they worked. The second cylinder also had to be removed, and they got it too. Totally exhausted, they sat down next to the cylinders and lit cigarettes. Korolyov appeared all of a sudden and yelled at the men for smoking near the oxygen! But afterwards he commended them for their bravery.

The GSJP people worked as fast as they could, often risking their lives, to launch the first liquid-fuel rocket as soon as possible. The rocket was developed by the second task force headed by Mikhail Tikhonravov,



The first liquid-fuel rocket built by Korolyov's group in 1933

a scientist who would make a major contribution to Soviet astronautics. The rocket he designed was called GSJP 09.

Finally the shining, eighteen kilogram "cigar" was ready. It was a lovely sight for the GSJP personnel who could admire it for hours. Although the rocket was ready, they did not manage to launch it right away. Three times it was taken out to the testing site, a quiet, deserted wood not far from Moscow, and three times, they returned empty-handed. Minor troubles developed each time. Some people even began to doubt that the rocket would ever fly.

Only the most patient men assembled at the launching pad on August 17, 1933. Everything was ready. It was quiet and the minute of the count-down seemed like an eternity. All of a sudden, there was a roar and fire, the rocket seemed to grow longer, then smoothly and slowly began to rise above the launching pad.

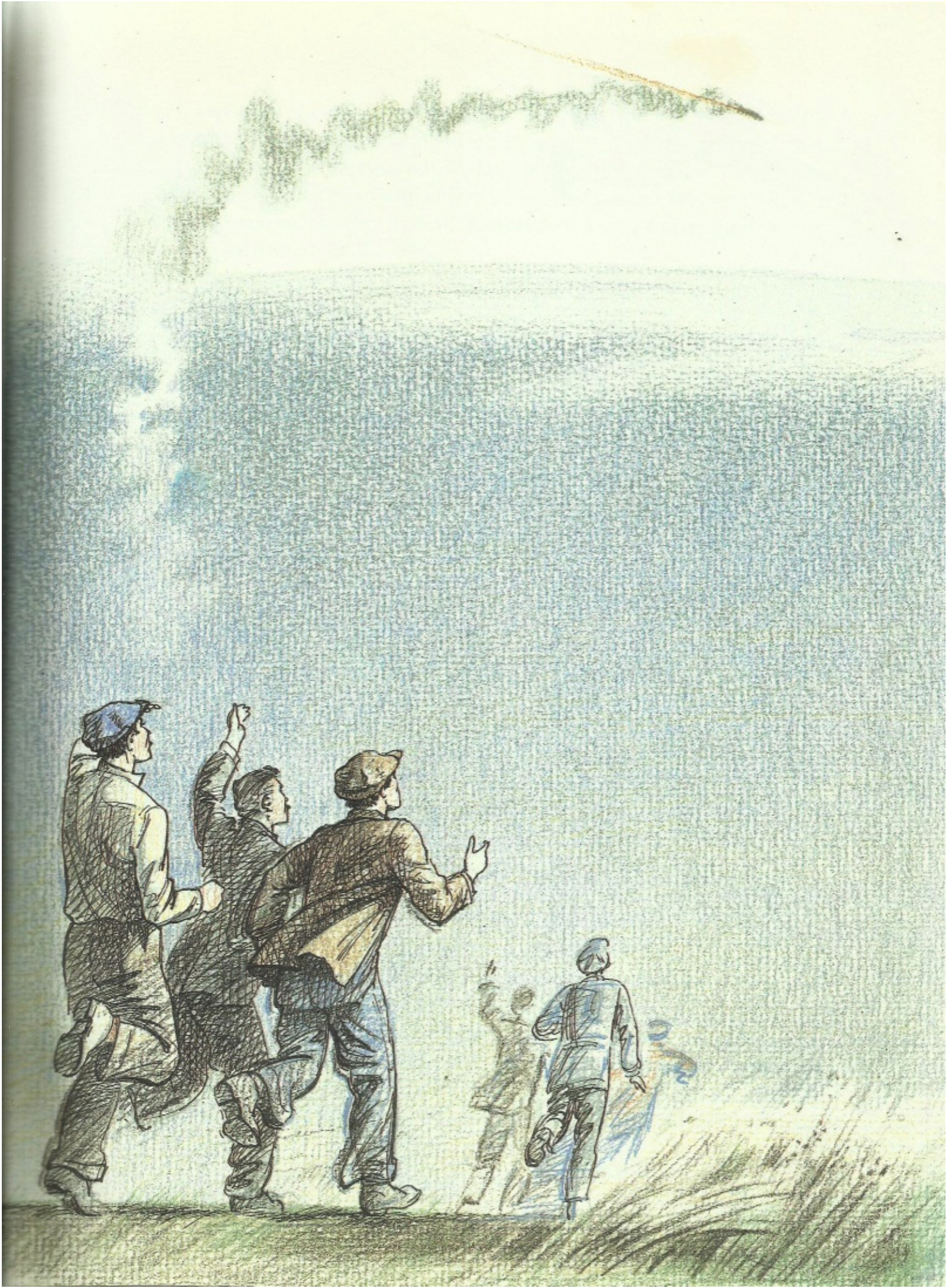
"It's flying!" the people shouted.

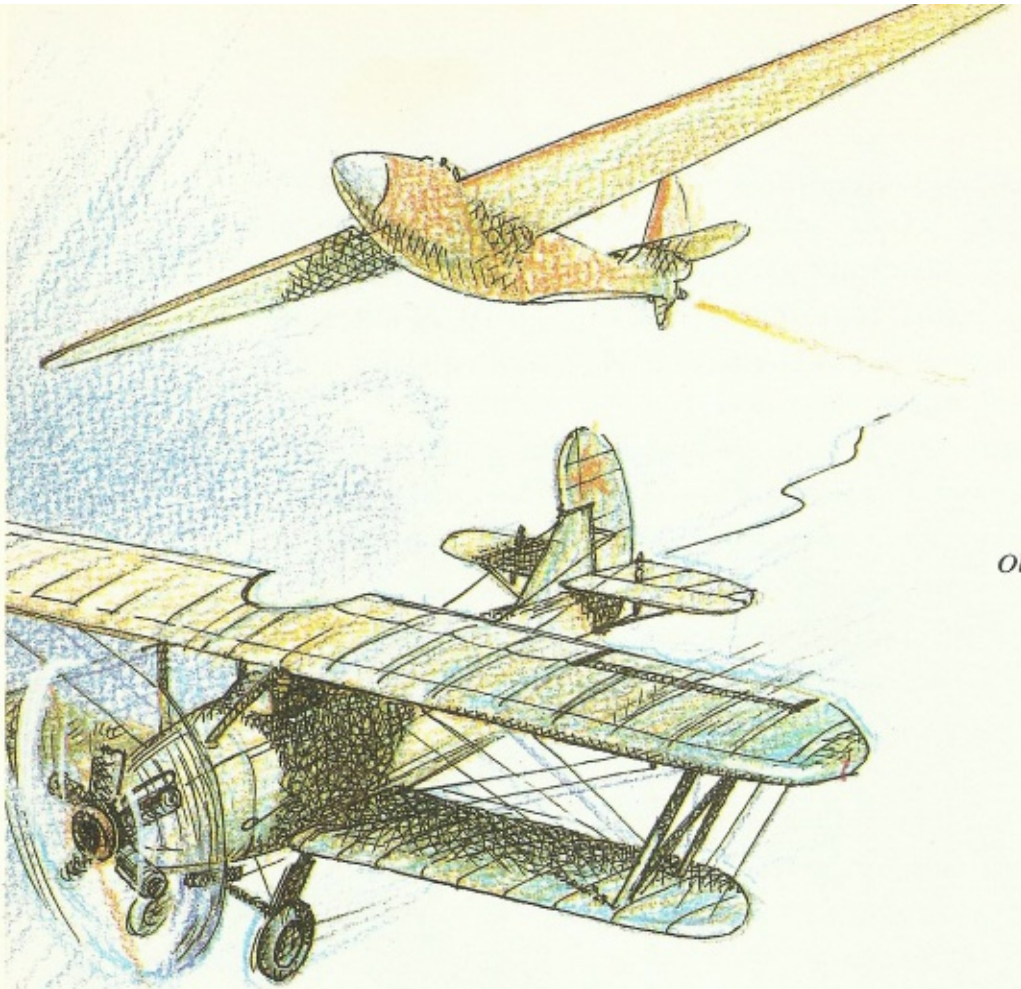
The rocket gained speed rapidly, flying straight up. At an altitude of a half kilometer, it turned and hurtling along an arc, disappeared in the forest. The flight lasted only eighteen seconds. But how the GSJP personnel cherished these seconds! Just think: the first Soviet liquid-fuelled rocket had been launched! The first ever! Everyone rushed towards the place where the rocket had landed trying to outrun one another like children. They returned to Moscow late at night happy and excited.

The people at GSJP were sorry that the flight of the first Soviet liquid-fuel rocket had not been seen by Frederick Tsander. A few months before the launching he went on vacation to the South. Along the way he fell ill and died soon after.

Three months later a second rocket rose into the sky, then a third and a fourth.

Engineers at the Gas Dynamics Laboratory were working hard on rocket engines and rockets. The GSJP also built and launched rockets. And although they had no secrets from each other and Korolyov went to Leningrad to learn about the work being done by the GDL, nevertheless, there was a scattering of forces. It was necessary to unite the rocket experts and set up a Jet Propulsion Research Institute where engineers and scientists would have everything they needed for work. The institute was organized in Moscow, the first in the world! Glushko and Korolyov





Object 318 or Korolyov's rocket glider

began to work together. The flying machines were developed under the direction of Korolyov, while Glushko designed the engines.

It was Korolyov's favorite dream to develop a rocket-propelled aircraft. Such a machine would resemble a space rocket, and its flight would be of major importance.

Work on the rocket-propelled aircraft had started in the GSJP. At the time it had been decided to adapt a flying wing glider designed by Cheranovsky, a gifted aircraft designer who built unusual flying machines, tailless aircraft and ornithopters. It was his *Parabola* glider which had flown at the meet in the Crimea.

It was easier to instal a rocket engine on a tailless glider, but first they decided to test it with a conventional engine. Korolyov himself occupied the pilot's seat. The aircraft took off quite normally but as it turned the pilot lost control, and the aircraft nearly fell to the ground. Only Korolyov's experience and presence of mind saved him from certain death. The GSJP failed to develop a rocket-propelled aircraft.

In the institute Korolyov set about to create a rocket aircraft in

a different way. He chose one of his gliders, well tested in the air, sturdy and reliable. Designers had developed quite a good rocket engine by that time. A strange aircraft appeared on the snowed-in field of an airport outside Moscow (it was late February). It was designated Object 318, but the airport personnel knew it was Korolyov's rocket-propelled glider which was to be tested in the air.

It was unusual to see the nozzle of a jet engine in back. The aircraft was tested on the ground for a long time. The engine was very carefully tested. But even after the most careful tests the first flight involved great risks.

The aircraft was to be flown by experienced glider and aircraft pilot Vladimir Fyodorov. The experimental plane was linked by a cable to an ordinary aircraft. The propellers of the towing aircraft began to turn causing a small blizzard. The aircraft ran along the landing strip followed by the rocket plane. The light rocket plane took off first. Within seconds both planes were in the air.

Linked by the cable they soared above the airport gaining altitude. The pilots could no longer see those on the ground. When they reached an altitude of three kilometers, Fyodorov pulled a lever and the rocket glider was uncoupled.

The silence was suddenly shattered by the roar of the rocket engine. An orange flame burst out of the tail. The speed increased nearly two-fold in some five or six seconds. The plane was left far behind. The rocket-propelled glider gained altitude. And it was manned. Even though the flight lasted for less than two minutes and the speed was far from that necessary to fly into space, those who observed the event realized that it was the first step towards future flights into outer space.

SECRETS OF THE ROCKET ENGINE

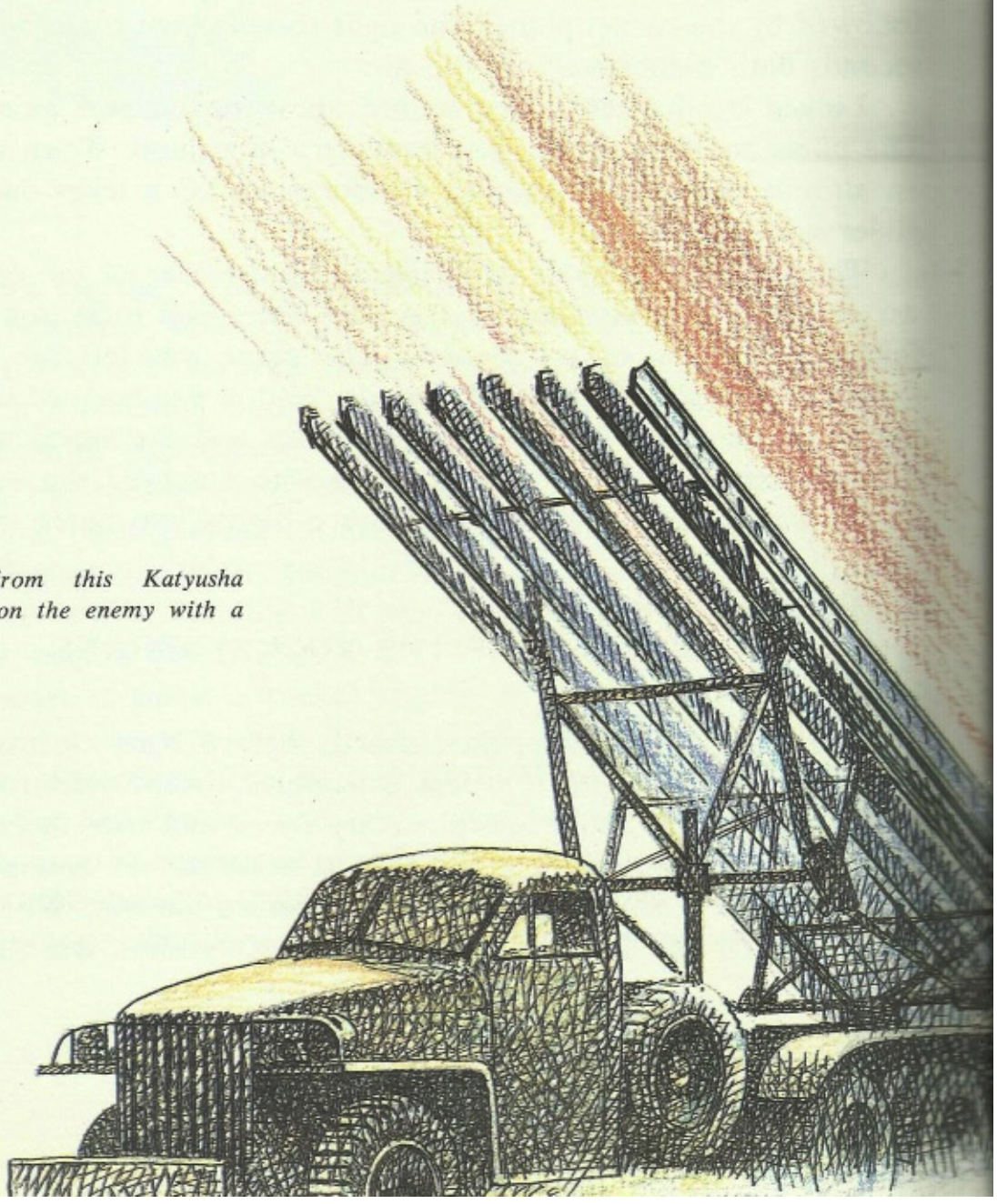
The above events happened shortly before Nazi Germany attacked the Soviet Union in 1941. It was a troubled time. Soviet rocket experts spoke less and less about interplanetary travel and trips to the Moon and more and more about how to use rockets to defend the country. Designers had developed a deadly rocket launcher before the war. When war broke out the Nazis felt the full strength of the Katyushas. But the Katyushas

were not the only rocket weapon developed by Soviet engineers.

Once, during the war, a pilot arrived at a military airport. He had a few free hours and as he observed life at this ordinary airfield, he suddenly noticed something quite extraordinary. A bomber was flying over the field at an unusually high speed. It looked like an ordinary plane, but had a long train of fire behind it. The pilot looked around in concern, but no one expressed any alarm or even interest.

"What was that?" he asked.

It was explained to him that this was not the first test of a booster rocket, a small rocket engine suspended from an ordinary propeller-driven aircraft. The booster abruptly increased speed for a short while



The rockets from this Katyusha launcher fell upon the enemy with a deafening roar

and helped heavily loaded aircrafts to take off. In an air battle the booster enabled the plane to attack the enemy unexpectedly or, on the contrary, avoid his fire. The innovation interested the pilot.

"And who made the thing?" he inquired.

"Why, there's the engineer who's responsible for it," the attendant pointed to a thick-set man. The pilot recognized Sergei Korolyov whom he had met before the war.

They struck up a conversation. It turned out that Korolyov was in charge of the boosters and often tested them in the air. During one of the flights the booster exploded. Korolyov was injured but managed to land the aircraft safely.

Aircraft designer Lavochkin whose fighter plane was adapted with a booster joked that when he agreed to have the booster installed on his plane he thought it would be a cat in a bag but it had turned out to be a real tiger.

One day test pilot Shiyanov was assigned to fire the booster in flight. The pilot later described how he heard a tremendous explosion in back when he pulled the booster handle. The aircraft survived, but it was a sorry sight indeed! A wing was crumpled, the fuselage damaged and there was practically nothing left of the tail.

At the height of the war Germany began to test its new secret weapon, the V-2. The rocket weighed a good deal, about thirteen tons, and could travel several hundred kilometers. The Nazis developed it under the strictest secrecy. The world learned about the terrible weapon when the V-2s began to hit the houses, streets and squares of London. People died and buildings collapsed. Enormous craters remained on the site of the explosions.

The V-2 was a remarkable achievement of German engineers, but because they hurried (the Nazis wanted to use the new weapon as soon as possible), it had a heavy and unreliable engine. Engineers both in the Soviet Union and other countries already knew a great deal about the design of rocket engines. Moreover, their design remains basically the same to this day. Designers have only perfected the heart of the rocket.

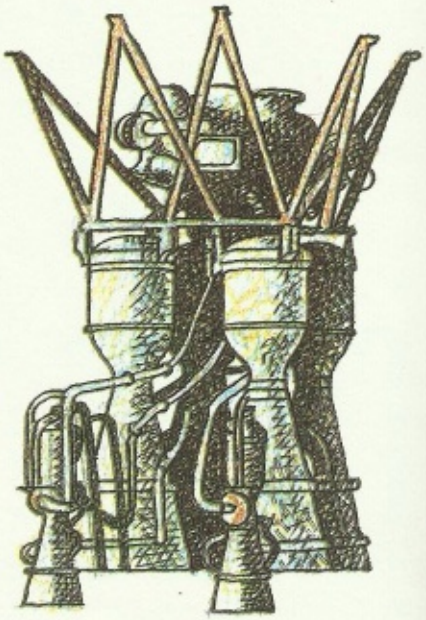
The most important part of the rocket engine is the chamber in which the fuel burns. The chamber resembles a bottle in shape. Fire rages there. Its walls must obviously withstand temperatures of several thousand degrees. There are holes in the bottom part of the chamber

known as nozzles. It is through these that the fuel and the oxidizer are fed into the chamber.

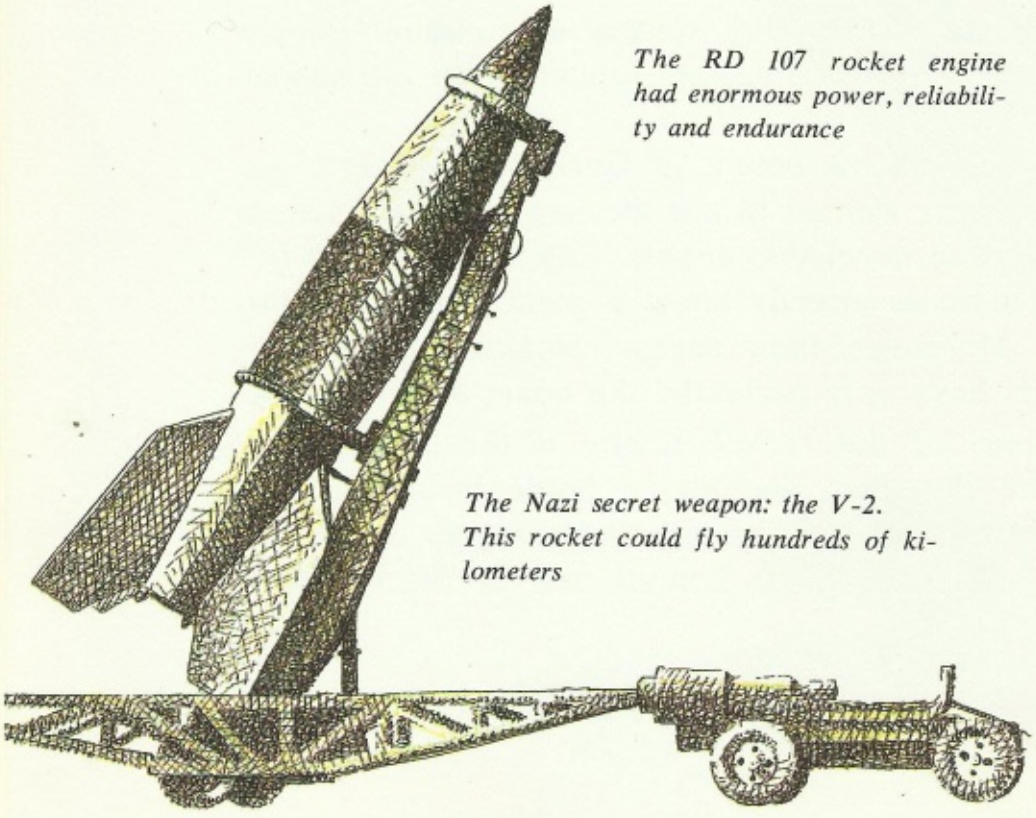
There are not only high temperatures in the chamber but tremendous pressure as well. Obviously a strong force is necessary to feed the fuel into the chamber. There are several ways of doing this. For example, it is possible to push the fuel from the tank by compressed air as tooth paste is squeezed out of a tube. That is how it is done on medium or small size rockets. But on large rockets this will not work. The fuel tanks would have to be too strong, and therefore, too heavy to withstand the enormous pressure. Besides the air cylinders in the rocket would also weigh a great deal. It is much better to use special pumps in large rockets to fill the chamber with fuel, the pumps driven by means of a gas turbine.

But where would the gas to drive the pump come from? Engineers found a solution. There is a chemical substance known as hydrogen peroxide. It is sold in any drugstore. The substance possesses a remarkable property: it rapidly decomposes into oxygen and ordinary water. A lot of heat is emitted in the process, and the peroxide heats to a temperature of 500-700 degrees. The water naturally becomes steam right away. The steam mixes with oxygen and a steam-gas mixture is formed. That mixture turns the turbo-pumps.

Engineers knew how to design the rocket engine but that did not mean



The RD 107 rocket engine had enormous power, reliability and endurance



The Nazi secret weapon: the V-2. This rocket could fly hundreds of kilometers

that their worries were over. Every time the designers set about developing a new rocket, they wondered again and again how to make the engine more reliable and more powerful so the rocket would fly faster and further.

The rockets now could fly thousands of kilometers and reach an altitude of hundreds of kilometers. In the summer of 1957, Soviet newspapers reported that a powerful rocket capable of crossing any ocean had been tested successfully.

Reaching a speed of eight kilometers a second no longer seemed fantastic.

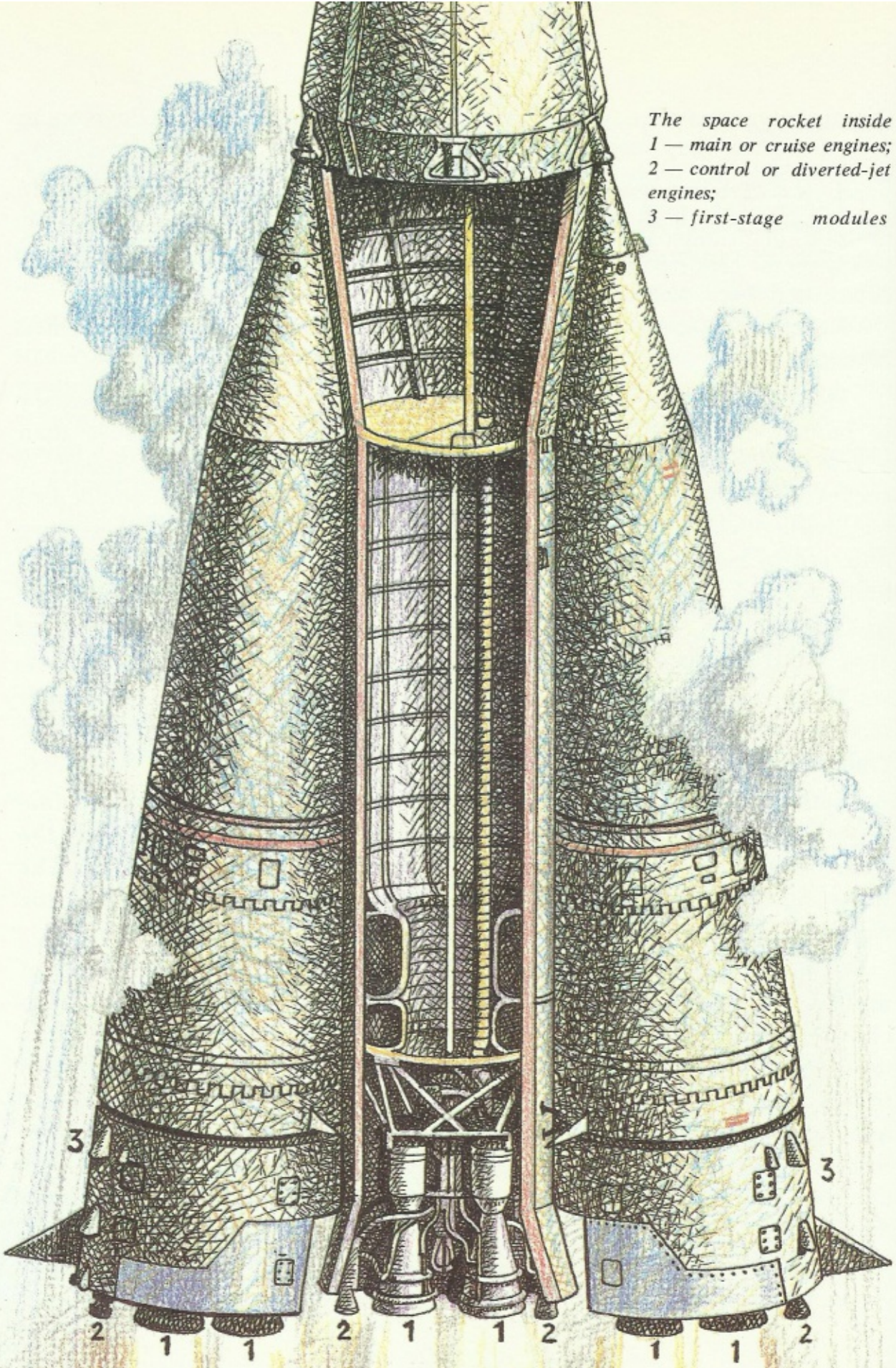
However, a several million horsepower rocket engine was necessary to launch even the smallest artificial satellite weighing no more than a few kilograms. Such engines had to be designed, built and tested. A rocket was helpless without a control system with the most complicated automatic devices. It needed a brain and sense organs. Radio systems were required to maintain communications with it. Finally, it was necessary to build a space port from which the rockets would be launched. And that was no easy job. Construction would have to be carried on in a deserted area far from towns and villages.

The creation of such a super powerful rocket was possible only through the combined efforts of many scientists, engineers and workers. Hundreds of institutes, plants and research labs were working for space.

Setting to work on the powerful rocket engines, the engineers knew that as yet, there were no machines in the world capable of withstanding the tremendous stress to which space rocket engines would be subjected. The stress, however, lasted only a few minutes while the rocket reached the required speed.

Designers thought very hard. In order to increase the power of the engine considerably there has to be much higher pressure in its chamber. It was a vicious circle. The walls of the chamber had to be as thin as possible so they would heat evenly (otherwise they would burn through quickly). But then they would not withstand the high pressure and the chamber would explode. Yet a solution was found: a double-walled chamber with space in between the walls. Before passing into the chamber the fuel went through this space, cooling the inner wall. Thus there would be no overheating. The chamber was lightweight but strong and durable.

It was decided to furnish the new engine with not one but with



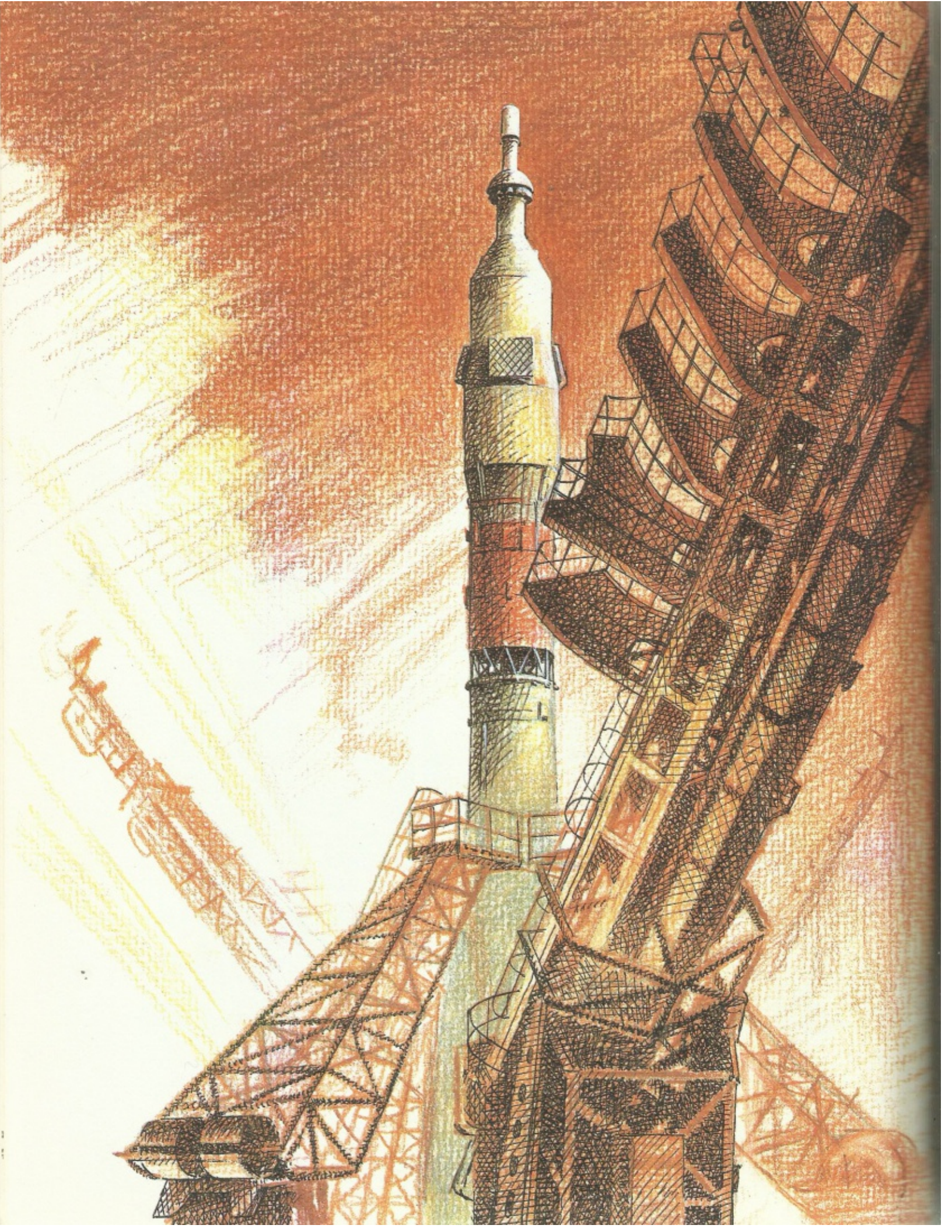
The space rocket inside
1 — main or cruise engines;
2 — control or diverted-jet engines;
3 — first-stage modules

four chambers. The engine came out powerful but small in size and lightweight. In space technology every kilogram matters.

It was also necessary to think of a way to control the rocket's flight by providing it with rudders. The solution was to instal a control or diverted jet engine next to the main cruise engine. If the control jet is turned during the flight, the direction of its thrust changes. This, in turn, changes the course of the rocket. Of course, the firing, operating and shutting off of the rockets at the pre-set time is all automatically controlled.

It is not enough to develop the engine however. Test facilities— strong reinforced concrete structures — must be built far from populated areas. It is impossible to endure the tremendous noise produced by a rocket engine.

It was in the course of intense research that the RD 107 rocket engine was born. It contained about three million horsepower and had a thrust of more than a hundred tons. The RD 108 also had tremendous power, but was more durable. These engines were developed at the design department headed by Valentin Glushko. Everything was leading to the opening of a new age in the history of mankind: the Space Age!



A MANNED FLIGHT

THE FIRST SATELLITE

Scientists wanted to pack the first artificial Earth satellite with instruments, turning it into an orbiting laboratory. It was easy to understand them: this was the first opportunity they had of sending research instruments beyond the planet's atmosphere into outer space, the world of zero gravity. But it proved to be difficult to honor the scientists' request. A lot was unknown or unclear because a satellite was being launched for the first time. It could not become a research laboratory right away.

The instruments required a power source. Was it better to obtain the energy in space or take it along? How was the satellite's air-tightness to be secured? The tiniest leak would be enough for the gas filling the satellite and cooling the instruments to instantly disappear into outer space. How was the temperature to be regulated in the satellite? Instruments emit heat but should not overheat. How were communications to be maintained? Would there be surprises?

All this had to be learned, checked and tested during the first satellite launching. So it was decided first to launch an elementary satellite with a radio and electric battery. Only the temperature and pressure in the satellite would be relayed to the Earth. It would have the simplest shape, a sphere.

A special room was equipped in the shop where the satellite was laid out on a velvet upholstered stand to prevent the slightest damage. The satellite body and many other parts were polished to a shine. This was not simply for the sake of appearance. The assembly work required perfection and the greatest care. These factors would, to a considerable extent, determine the satellite's reliability and the success of the entire experiment.

The booster rocket was being assembled in the next section which was enormous and noisy. The rocket was to carry into outer space the first artificial satellite. The satellite was not very large. It was the size of a big watermelon and weighed eighty-three kilograms. The shining mirror-like sphere had four long antennae sticking out.

When everything was ready parts of the rocket were loaded on

railway cars and the satellite was carefully packed in a crate and sent to the space port in far-off Baikonur.

One building at the space port is much larger than all the others. It is the assembly and test center. There the rocket parts are put together, checked and adjusted.

The satellite seemed tiny and the antennae fragile next to the enormous rocket. The sphere was put under a nose cone and the antennae lay along the rocket body. The radio transmitter was switched on for the last time on Earth. It was a thrilling moment: there was complete silence. Then the satellite's voice was heard clearly: beep, beep, beep.

A powerful diesel locomotive came up to the platform on which the rocket was lying. The command was given and the platform moved slowly towards the launching installation. It was still dark and bright southern stars shone in the sky. The locomotive's wheels clacked on the rails.

The launch was set for October 4, 1957. The rocket was looming on the launching pad. Many truckloads of fuel (liquid oxygen and kerosene) were pumped into the rocket's tanks. All five of the rocket's engines were to be fired at take-off. Their total capacity was mind-boggling — twenty million horsepower!

The count-down began. Finally there was a burst of flames followed by a rumbling. The rocket was engulfed in dense smoke. It seemed that the rocket would disappear completely. But at that moment the long white body rose slowly and majestically. It steadily gained speed. The light was blinding! The flames shot out from the launching installation. The engines rumbled and it was no longer night. A brilliant light shone on everything around. The rocket went faster and faster, higher and higher!

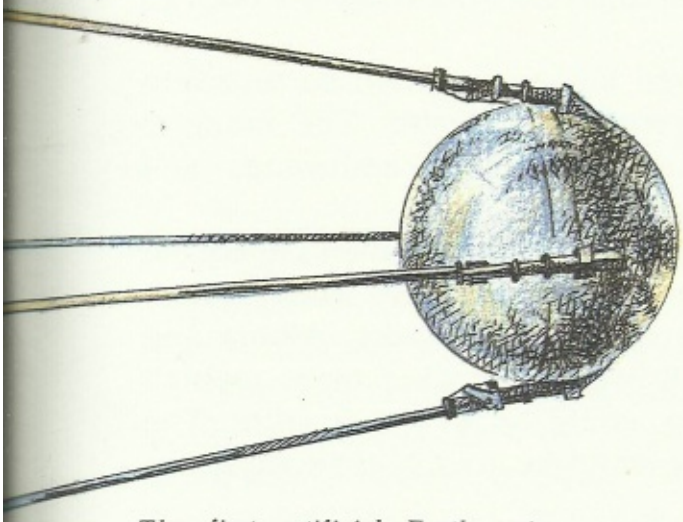
The rocket turned gradually, entering the planned orbit and soon became a distant burning star. A few minutes later it was known at the space port that everything was fine, the necessary speed had been reached, the satellite had separated successfully from the rocket's last stage and was flying in space at an altitude of several hundred kilometers. The first artificial satellite of the Earth was in orbit!

Pandemonium broke loose on the ground: people were hugging each other and shouting. A practical joker brought a huge watermelon and wrote "Sputnik No 1" on it. Then he cut the watermelon and distributed the slices.

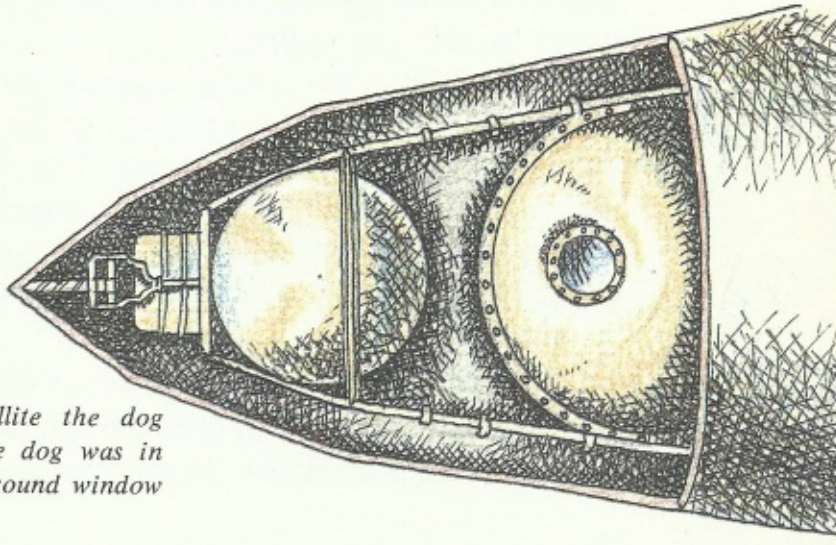
The satellite's beep, beep, beep signals came from outer space. They sounded like the sweatest music. As the satellite disappeared behind the horizon, its voice grew softer and then ceased altogether. The signals would resume twenty minutes later when the satellite would reappear after circling the Earth. The people in the assembly and test center were listening attentively to the radio sets. They were eager to hear the satellite again to be sure that it was safe and sound in orbit.

Time dragged on. Finally the long-awaited beep, beep, beep sounded in the earphones, growing louder, and finally reaching full volume. Now they could see the bright little firefly — the world's first Sputnik.

The first satellite was circling the Earth in outer space, but on the ground engineers and doctors were preparing the second satellite for flight and this time it was far more complicated. The second satellite weighed six times more than the first—about half a ton!



The first artificial Earth satellite (Sputnik)



This was the satellite the dog Laika flew on. The dog was in the cabin with the round window

Doctors taking part in developing the satellite had their hands full. An extraordinary experiment was being prepared: a living creature, a dog, would fly into orbit. Before sending a person into outer space it was necessary to see how an animal would react to the launch, zero gravity, the influence of cosmic rays and whether it could eat, drink and breathe normally.

The new satellite was "three-storeyed" and shaped like a pyramid. A device to study solar radiation was located at the very top. A sphere with a radio and electric batteries was in the middle. Still lower was the most interesting thing of all: an air-tight cabin for the animal. The engineers and doctors had provided the cabin with everything the canine cosmonaut would need. There was an automatic feeder, and special devices maintaining room temperature and normal pressure, and recycling the air.

It was not enough to put the animal into orbit and provide it with everything it needed. The scientists on the ground needed to know the dog's blood pressure, pulse and activity. Medical sensors were placed on the satellite to keep watch over the animal and relay radio signals back to earth.

Only a small dog weighing six or seven kilograms could be sent into space. And not a purebred dog, which was too delicate. The mongrel was most suitable for a space flight because of its endurance and hardiness.

The appearance of a "barking device", as the rocket men called the dog, made an already complicated experiment even more complicated. Three dogs were being prepared for the experiment: Laika, Albina and Mukha. The cute little dog Albina had flown in a rocket twice at high altitudes. It had to be decided which dog would fly in the satellite. The doctors chose Laika. Albina was to be the stand-by, and Mukha would be used to test the cabin.

A few days before the launch Mukha was put in a space "dog house" exactly like the one Laika was to fly in. Everything would have been fine except the dog refused to eat. The dog food had been chosen according to all the rules of science, but something was missing. One of the people hit upon a good idea: to add some ordinary *sausage to the space* food. The idea was tried, and the dog loved it. So that was what was missing!

Laika had smooth white fur with dark spots, and the tips of its black ears drooped. It had sparkling intelligent eyes. The dog was put in the cabin long before the flight. It was necessary to check how the instruments,

devices and the automatic feeder were functioning once again. Meanwhile, rocket preparations were nearing completion in the assembly and test center.

Laika was launched the morning of November 3, 1957. It was a clear day. Accompanied by the rumbling of the engines and flames, the white rocket rose into the brilliant blue autumn sky.

The doctors kept a close eye on the instruments. They were eager to know how Laika had stood up to the extreme pressure at lift-off. The dog was doing fine in zero gravity! Its appetite was good, and its breathing and pulse were back to normal. This meant that a person could also survive the stress involved in space flight.

There were many remarkable achievements in space following the launch of the first Sputnik and Laika's glorious flight. The dreams of scientists had come true: satellites had become research laboratories. Automatic stations began to fly to the Moon. And work was underway on a spacecraft for manned flights.

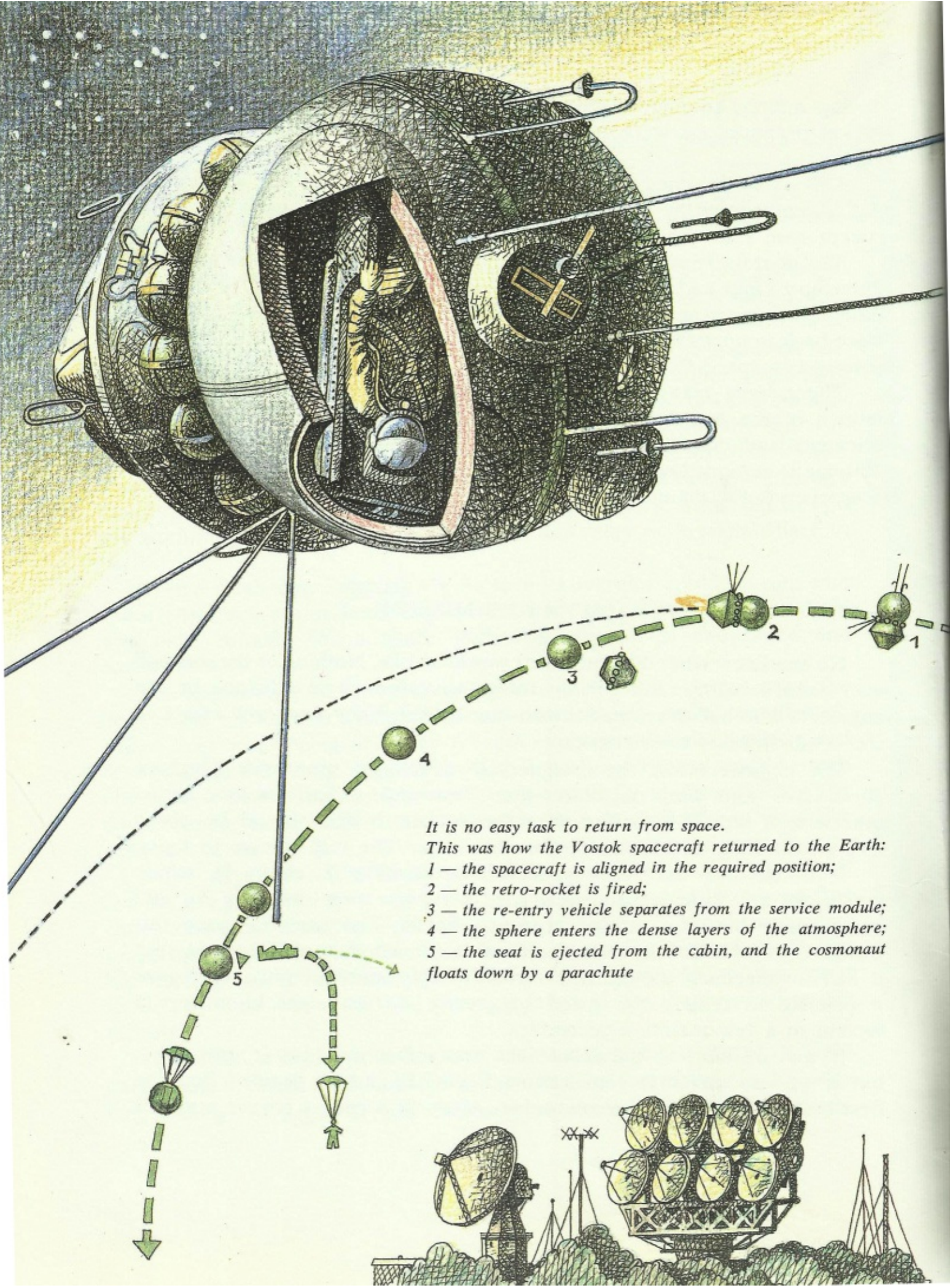
A DIFFICULT MISSION

No one knew what the spacecraft would be like. Nothing of the sort had ever existed before. But certain things were known in advance by the engineers who had developed the booster rocket. They were well aware of the possibilities of their rocket.

The engineers told the designers to develop a spacecraft weighing about five tons and no more than two and a half meters across otherwise it would be wider than the rocket. It also should be about five meters long and fit under the nose cone. The rest was up to them.

It is obvious that the spacecraft must have a cabin in which conditions are suitable to sustain life. A person must not only fly into outer space but also safely return to Earth. The satellite spacecraft would orbit the Earth at a speed of eight kilometers a second, but it had to approach the Earth's surface slowly and smoothly. How was it possible to reduce the speed so greatly — from eight kilometers a second to a few meters a second?

It was difficult to accelerate the spacecraft and put it into orbit, but it was no easier to return it to Earth. Engineers decided that the first brake would be the retro-rocket. After all a rocket engine may not



It is no easy task to return from space.
This was how the Vostok spacecraft returned to the Earth:
1 — the spacecraft is aligned in the required position;
2 — the retro-rocket is fired;
3 — the re-entry vehicle separates from the service module;
4 — the sphere enters the dense layers of the atmosphere;
5 — the seat is ejected from the cabin, and the cosmonaut floats down by a parachute

only accelerate the spacecraft but also slow it down if the thrust is aimed in the opposite direction. Once the speed is reduced the spacecraft will leave its orbit and fall towards the Earth.

The second, most important brake would be the air, the atmosphere surrounding the globe. A fast-moving spacecraft would experience atmospheric pressure of several dozen tons. It was an excellent brake, but would the cosmonaut withstand such braking? Even if car brakes suddenly the passenger experiences unpleasant sensations. Everyone knows that. But things are much more serious and frightening in returning from outer space. For the G-force to remain within permissible limits and the cosmonaut to survive, the spacecraft must fall to the Earth along a definite course.

Designers decided that a parachute would be the third brake. The spacecraft would land safely on the Earth's surface suspended from an enormous, strong canopy.

It was not only a matter of braking, however. There were other equally difficult problems. On a dark night many have seen how a meteorite flies by, leaving a brilliant trace behind it. When the rock is big, it seems as if a fireball with a flaming tail were racing through the sky. They say that a bolide has fallen. The meteor becomes red-hot due to air friction and is often consumed before reaching the Earth. The same thing might happen to the spacecraft which also becomes red-hot. The spacecraft could disintegrate if special measures are not taken. The terrible heat on re-entry must not be allowed to penetrate the cosmonaut's cabin. But how can such a disaster be prevented?

It is possible to instal something like a refrigerator in the spacecraft. But this is complicated and not very practical. Designers decided to do something different: to coat the cabin with a heat-shield. Engineers realized that it would make the spacecraft heavier but this would have to be put up with.

Heated arguments flared up when the shape of the spacecraft was considered. Some designers believed that it should be shaped like a cone and they had good reasons. Others maintained that it should be cylindrical. Still others that it must have wings. And last of all, there were those who wanted a sphere.

Scientist and cosmonaut Konstantin Feoktistov recalled that they had finished preliminary calculations by early June 1958, and reported their results to Korolyov. Quite unexpectedly, the idea of a spherical spacecraft was approved by Korolyov — he generally liked simple

solutions. Indeed, the properties of a falling ball were well studied, so it would be easier to calculate how the spacecraft would move. It was also easier to manufacture a sphere. And there would be enough room in it, which was very important since the cosmonaut's seat and many different devices had to fit inside.

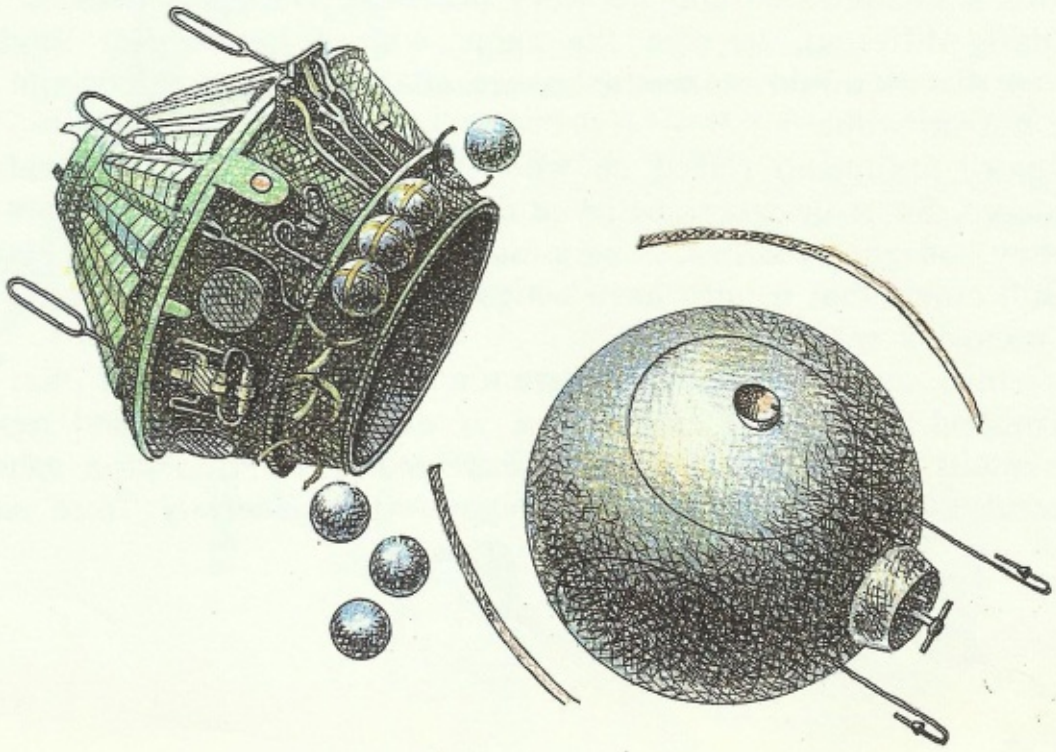
Many devices but not all of them. Some of the instruments and mechanisms could and should be located outside the spacecraft, because they would be needed only in outer space. In returning to the Earth, the things that were no longer needed should be discarded. The lighter the cabin, the easier it would be to return. They decided that the spacecraft should consist of two main parts: the cabin (which the designers called the re-entry vehicle) and the service module with various equipment and the retro-rocket. In space orbit both parts were to be firmly linked together, but before the re-entry they were to be separated.

At difficult moments Korolyov would assemble the designers.

"My dear friends, let's see what your differences are," he would say. "Do you think we can argue till kingdom come? Time's a-wasting! We have to take a decision. I have a general idea of your proposals. Let's have them."

A matter-of-fact discussion would begin, and an hour or so later the decision would be taken and arguments subside.

This was the case when they considered how to separate the spacecraft's parts before re-entry. The cabin and the service module were linked by



no less than eight hundred and fifty electric wires and several tubes. How was it possible to have the wires and tubes pass into the cabin and keep it air-tight and heat-resistant? Moreover, when the parts separated all eight hundred fifty wires would have to be disconnected instantly. And the designers developed a unique space plug.

The cabin was fastened to the service module by means of four metal strips. They held the sphere fast against the module and were locked by special quick-release latches. At the required time they opened, the metal strips flew apart and the cabin was released.

The deadline was approaching but the designers still had endless unanswered questions to deal with. The instruments had to be situated so they would not heat each other, yet there was little space. The two dozen antennae must be arranged so they would not interfere with each other. The interior of the spacecraft contained about six thousand radio tubes and transistors, nearly a thousand electrical switches and more than fifty electrical motors. Fifteen kilometers of wiring proved necessary to link all the spacecraft's instruments and mechanisms together. Many instruments were duplicated, that is two or even three installed instead of one, to assure the spacecraft's safety. If one instrument failed, another would take over.

The compartment with the parachute had a round lid. It was to open and release the parachute into the air. Were the lid not to open the cabin would fall swiftly to the Earth. It was a very important part! Korolyov ordered it to be checked exactly one hundred times. The quick release latches exploded and the heavy lid was swept aside. Then the lid was replaced, its tightness checked again, and the operation repeated one hundred times until the engineers were certain the lid was reliable.

The cosmonaut was provided with a rocket ejection seat. Another lid would be thrown off at an altitude of seven kilometers, the rocket engine under the seat fired, and the seat with the cosmonaut ejected from the cabin. Then the seat would be discarded and the cosmonaut's parachute would open.

The personnel came to work in the morning when everyone else did, but left only when the night shift workers poured out of the neighboring factory. Work never stopped with the bell.

The spacecraft was nearly ready, and was already undergoing tests when someone suddenly realized that it had no name. People began to think of a name, and a contest was even announced, but nothing

appropriate was proposed. Then one of the designers suggested that the spacecraft be called Vostok (East).

Everyone liked the name. And so, the first spacecraft was called Vostok.

CHIEF DESIGNER

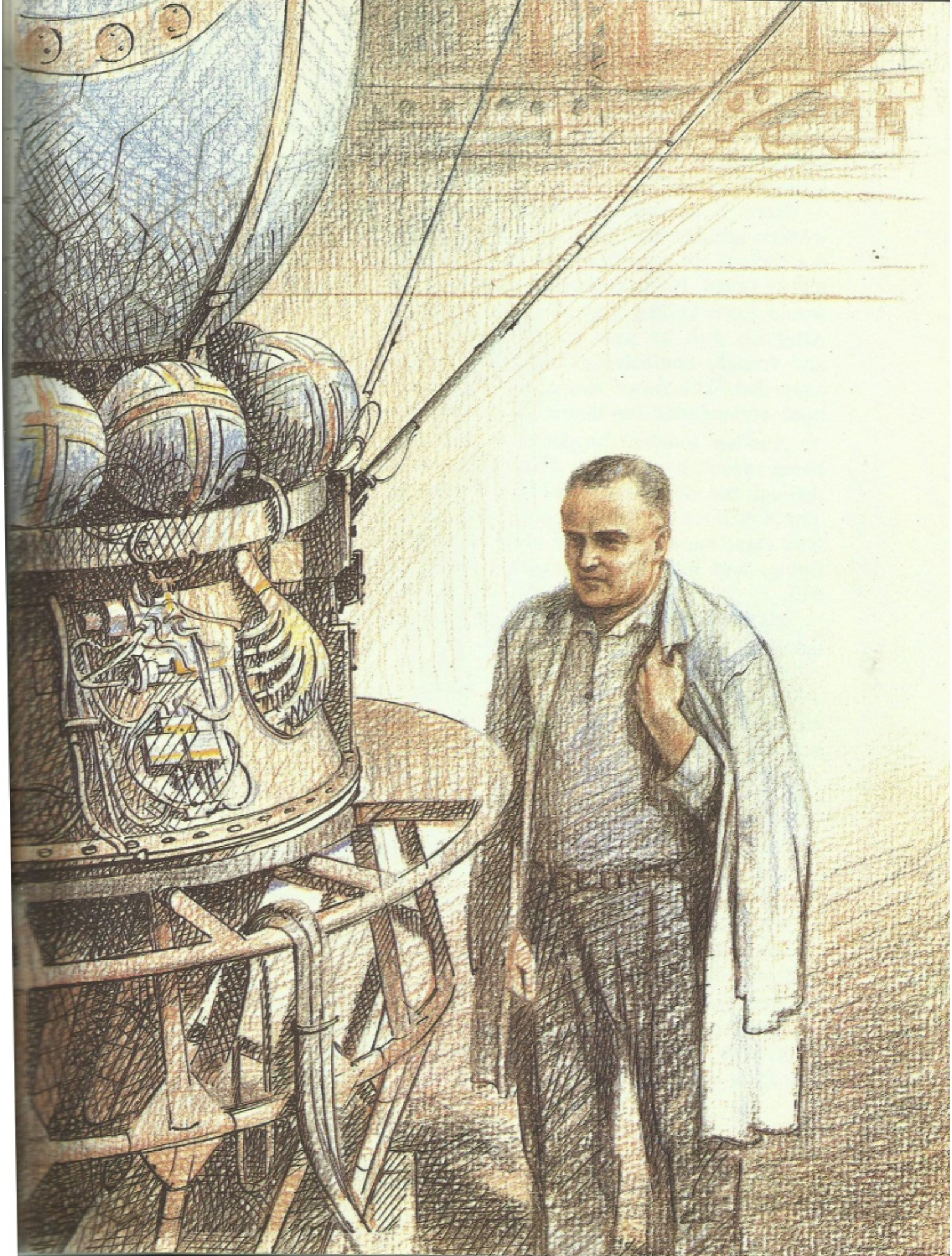
Every morning Sergei Korolyov discussed how things were going with the engineers in the assembly section of the plant where the spacecraft were being made (a dozen had been produced, for tests). Daily and even hourly assignments were checked meticulously. People worked forgetting about breaks, and someone from outside might have exclaimed: "What a rush, what confusion!" Actually everything was guided by the energy and will of the Chief Designer. Events went according to plan.

Occasionally, Korolyov would come into the production areas, dismiss the designers and plant managers accompanying him, sit down in a corner and thoughtfully observe the giant rocket lying on the building cradles. What was he thinking about? Perhaps he was wondering how to make the rocket still better, about the spacecraft and the coming manned flight into mysterious outer space. Perhaps something else.

His entire life was devoted to one great purpose. Some called him possessed. He did not know how to rest. He concentrated all his energy on his work and demanded the same of his subordinates. He always tried to save time. Slow-flying piston aircraft flew to the space port at the time. Korolyov always made reservations on the night flight so as not to waste the day. After a night in the plane he would be ready to work in the morning. Korolyov always said he had slept well on the plane. He dressed modestly. He could not stand neckties and only put them on when absolutely necessary on special occasions. In the space port he wore an old-fashioned coat, which as he saw it, was comfortable and practical.

It was not easy to work with Korolyov. His behavior was very inconsistent. He could be strict and gentle, worried and joyful, tired and vigorous. He was seen in different states but never confused or depressed. He knew how to deal with those who were negligent or uninterested in their work, he valued loyalty, and could not tolerate indifference.

Among themselves designers referred to Korolyov as SK. He was



feared and loved. Korolyov enjoyed immense prestige. When people learned about an upcoming visit, they prepared for it extensively. Nevertheless, everyone remembered Korolyov as a just, considerate and easily accessible man.

Here is an interesting story. During preparations for a launch a worker accidentally dropped a nut into a very intricate mechanism of the rocket. He spent a whole day trying to get the unfortunate nut out, but he failed. If the rocket were launched, it would explode. And no one would have known why. But the worker did not conceal his blunder. After his shift he went to see Korolyov at the hotel in the space port and frankly confessed. The Chief Designer ordered the launch to be cancelled. The delay was a long one and Korolyov could hardly have been commended for it, but he did not punish the worker.

Another incident happened in 1962. A unit of the space rocket was being moved by a crane. The enormous heavy load was floating slowly through the air. The young crane operator was diverted for just a second. The unit hit a reinforced concrete pillar and was badly damaged. Korolyov came running into the plant ten minutes later. His white smock was flying, and his face distorted in anger. Everything came to a standstill.

"Who's to blame for this outrage?" the chief designer loudly demanded.

A thin young worker, almost a boy, stepped forward.

"Do you realize what you've done?" Korolyov shouted. "Do you know how much work went into that rocket, how much public money you have wasted? Aren't you ashamed of yourself?"

The young man hung his head and stood still. What could he say?

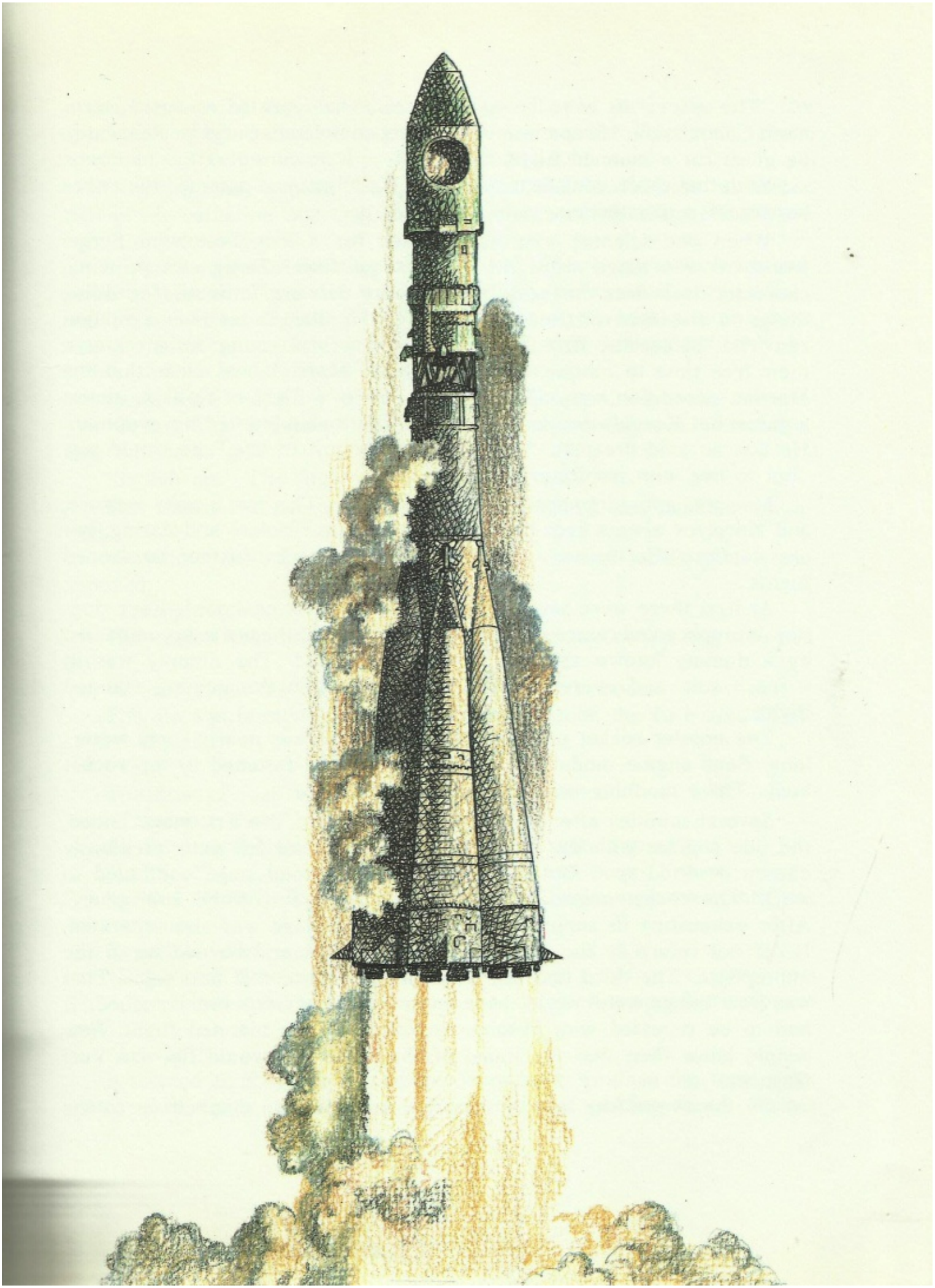
"What's your name?"

"Korolyov," the young man said quietly.

Sergei smiled.

"Why, you've disgraced our name!" he said calmly, took the young man by the shoulders, led him aside and had a long talk with him. When the worker was going away Sergei Korolyov asked him whether he now understood everything.

Korolyov could assume immense responsibility and was not afraid of accepting the consequences. Everyone knew the hour of manned flight was approaching, but who could vouch that the time had come? Korolyov was the first.



"The spacecraft is at the space center," he reported to the Government Commission. "Preparations are being completed. I urge permission to be given for a manned flight."

With that short, confident statement, Korolyov had assumed the entire burden of responsibility.

When one scientist who had worked for a long time with Sergei Korolyov was asked what he thought the Chief Designer's principal character trait was, he said: "An affinity for the unusual, for doing things no one has ever tried to do before." He liked to let his imagination run wild. Before the first flight into space several young designers used their free time to outline an expedition to Mars. It was clear that the Martian expedition was still far in the future, a flight of fantasy, almost a game, but Korolyov eagerly took part in it and submitted his proposals. He was an avid dreamer. "The point is not just to live," he would say, "but to live with inspiration."

Man was going into space for the first time. This was a risky venture, and Korolyov always kept that in mind. He was resolute and daring, but also cautious. He insisted on more and more checks, further unmanned flights.

At first there were several flights with animals on board. Four dogs flew into space and returned safely to Earth. One of them was accompanied by a dummy known as Ivan at the launch site. The dummy was in a space suit, and everything was the same as in the coming manned flight.

The booster rocket of the Vostok spacecraft was nearly forty meters long. Four engine modules with fuel tanks were fastened to the rocket body. These modules were the rocket's first stage.

Several minutes after the launch the work of the first stage ended, the side engines with the tanks were separated and fell on a previously chosen deserted spot. But the engine of the second stage continued to work. The rocket passed through the dense layers of the atmosphere. After exhausting its supply of fuel the second stage was also separated. It did not return to the Earth but grew red-hot and burned up in the atmosphere. The third and last stage put the spacecraft into orbit. That was how things went when the unmanned spacecraft were launched. It had to be repeated with absolute precision in the manned flight. Few people knew then that the name of the man who would fly was Yuri Gagarin.

On the eve of the launch Korolyov and Gagarin climbed up to the

upper platform of the service tower. They stopped at the hatch of the spacecraft. The endless Kazakh steppe covered by the spring grass, stretched out below them.

"Anything may happen, Yuri," Korolyov said, "but always remember that in any situation our engineers and scientists would immediately do everything to help you."

It was a gorgeous morning on April 12, 1961. Gagarin took his seat in the spacecraft. The hatch was closed. Everyone who had been preparing the rocket for flight left it. The platforms of the service tower were empty. Now communications with Gagarin were maintained only by radio from an underground command bunker.

There were ten, five, three minutes left before the launch.

"Cedar! This is Dawn One," Korolyov radioed Gagarin. "Attention. One minute to go."

"Switch on!" The flight commander ordered.

This meant that the automatic launching system was put into operation.

"Switched on!" the ground pilot at the control panel quickly responded.

"Transport One!"

This meant that the instruments monitoring the rocket were turned on.

"Blow!" came the next order from the control room.

The air was blasted from the pipes along which the fuel would flow to the engine.

"Vent!"

The flow of fuel to the rocket tanks was cut off.

"Transport Two!"

All the instruments controlling the launch were turned on.

"Ignition!"

"Cedar! This is Dawn One! Ignition," Korolyov shouted into the microphone.

Gagarin's voice replied:

"Roger, we have ignition."

A few more short commands and then came Korolyov's triumphant cry:

"Lift-off!"

It seemed as if dozens of cannons were being fired at the same time. The rocket slowly rose from the launching pad, gaining speed. Flames

gushed out of the rocket. Through the roar they heard Gagarin's voice: "We're off!"

In the last seconds Korolyov remained glued to the periscope which enabled him to watch the launch from the bunker. It seems incredible, but apparently Korolyov never saw a live launch of a space rocket except from the bunker. Then he left the periscope and watched the flight by means of instruments which told him much more than the visual picture.

ENGINEER ISAYEV'S ENGINES

The personnel were to meet the new chief designer. Different rumors circulated about him: "Stubborn and mean." "Very considerate." One engineer recalled: "The phone rang and a voice said: 'Isayev speaking, please come to my office.'

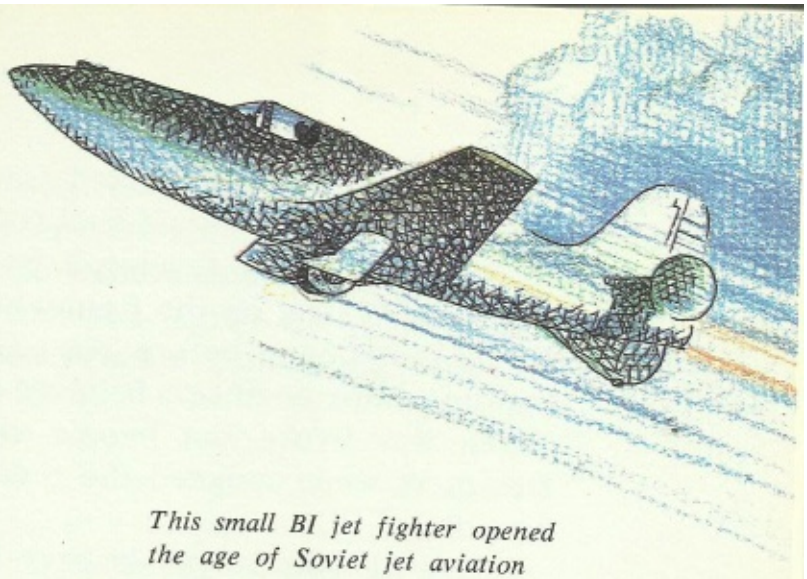
"I went expecting to see a stubborn, hard-headed person. I entered the office which was filled with people chatting among themselves. Where was the Chief Designer, Isayev? Then I saw him, not at his desk but in the midst of the crowd, sitting astride a chair with his chest leaning on its back. He spoke calmly and humorously. Could a man talking in such a friendly manner with his subordinates be hard-headed? Who had spoken badly about him? It turned out to be a designer who had not handed in his work on time and had been reprimanded by Isayev. Then we knew everything would be all right and we'd work successfully with the man."

Alexei Isayev knew all his staff by name, behaved modestly and was sociable. He could relieve tension by a timely joke. He would work at a drawing board himself if need be. And he was not afraid to take a risk.

When the first satellites were launched Alexei Isayev was already an acknowledged designer of rocket engines. He immediately found a common language with Korolyov, because they both were devoted to their respective fields. But Isayev had come to his field in a different, more round-about way. At first he had no idea that he would become an expert on rocket engines.

He had been trained to become a mining engineer. But mining did not inspire him. He left to get a construction job at a steel mill but also failed to stay on. Then he worked at building a plant on the Dnieper. He lived in Moscow, then Magnitogorsk (the Urals), later in the Ukraine,

Alexei Isayev



This small BI jet fighter opened the age of Soviet jet aviation

and finally returned to Moscow. At one point he even wanted to go to a remote island in the Arctic.

Some people might have thought that Alexei was not a very serious young man. But Isayev was searching for a job that would absorb him completely. He wrote to a friend: "I can't stay in one place. The only thing that could stop me would be a job I could get my teeth into."

Everyone was talking about aviation when Isayev was a boy. The names of pilots were known by old and young alike as are the names of cosmonauts today. Alexei Isayev was also thrilled by aviation. All of a sudden, he felt that he could find his place there, and stop running.

Since he was a mining engineer, however, it was very difficult to get a job at an aviation plant in the designers' department. His applications were rejected: what kind of an aviation designer would he make? Then Isayev wrote a letter to the plant manager. He asked the manager to trust in him: one year would be enough to make him an aviation designer.

The manager ordered Isayev to be taken on. And, indeed, before the year was up mining engineer Isayev had become an aviation designer.

He did very complicated work and was highly successful. Aircraft at the time had propellers and piston engines like cars. But one day Bereznyak, a young designer, came up to him.

"Alexei, let's make a fighter with an LRE," he proposed.

"What's an LRE?" asked Isayev.

LRE stands for liquid-fuel rocket engine. The designer had suggested to Isayev that they develop a jet fighter.

They worked on the fighter mostly at night or on Sundays. This was in 1941, not long before Nazi Germany attacked the Soviet Union. At the time many engineers believed that jet planes were not really necessary. When war broke out people viewed the jet fighter quite differently. Designers were assigned the task of developing such a plane as soon as possible.

The BI (Bereznyak-Isayev) fighter was built far from Moscow, in a remote area in the strictest secrecy. It was to be an interceptor. If you remember, Korolyov's rocket glider could not take off itself and was towed by another plane. The jet fighter was to take off after a short run and then soar up into the sky to intercept enemy planes.

Yet it turned out to be much more difficult to build a jet aircraft than designers had thought, the engine being the most difficult nut to crack.

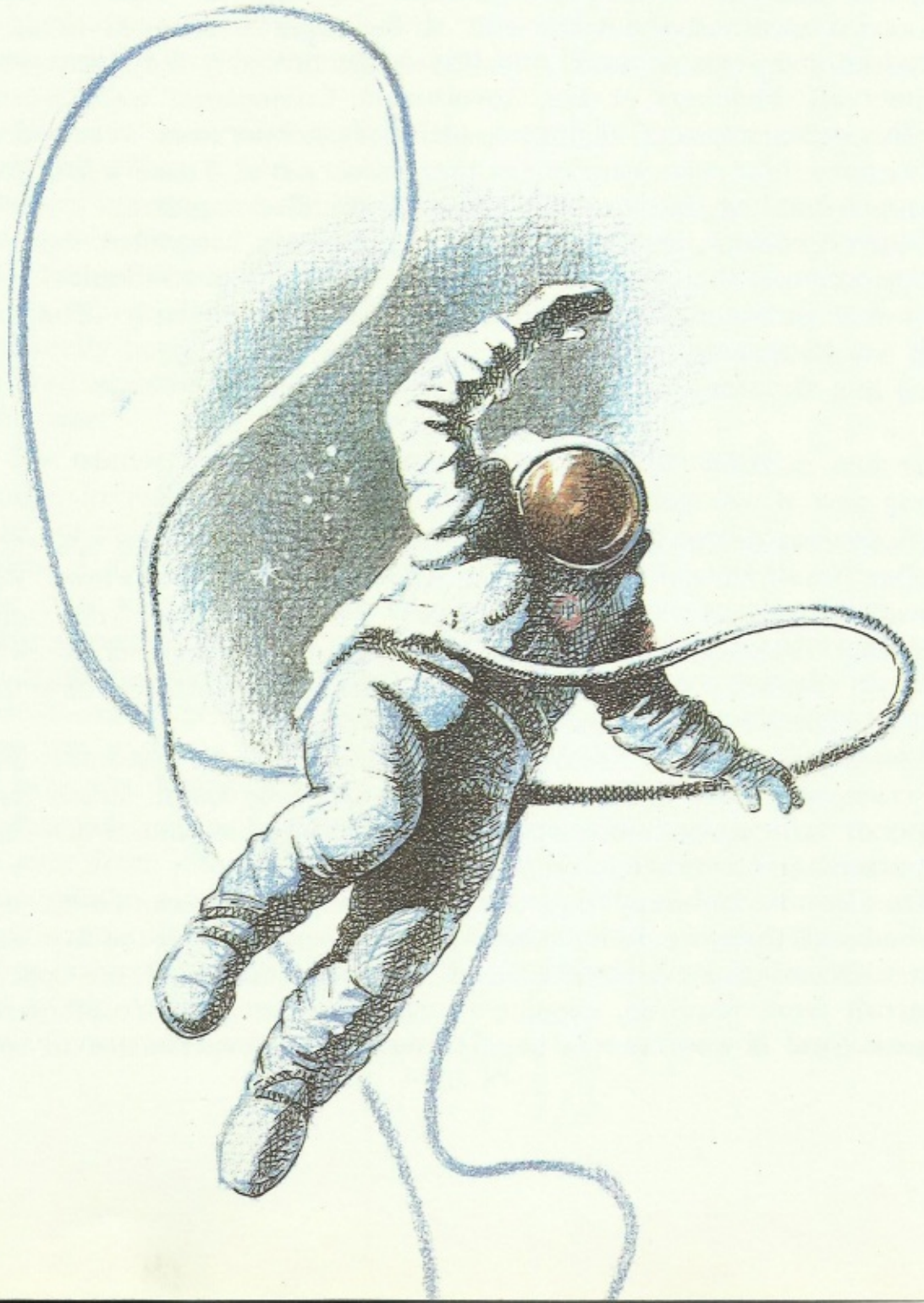
The unusual fighter was tested by pilot Grigory Bakhchivanji. He flew the jet six times, and the fighter responded very well. But the seventh flight ended in disaster. The jet went into a dive and crashed with a huge explosion. It was at that point that Alexei Isayev began to work on rocket engines.

Every spacecraft must return to Earth sooner or later and to do this a retro-rocket which would slow the enormous speed of the spacecraft and force it to leave orbit was needed. But if the engine failed to work then the cosmonaut would be trapped in space and would perish.

The job of designing a retro-rocket for the Vostok was assigned to Isayev's designers' department. It was an enormous responsibility for the head of the department. The situation was particularly difficult since there was no place on the spacecraft to install a second retro-rocket. In other words, the designers had to create a rocket.

Isayev was perfectly aware of all this. He also knew that an engine which worked very well on Earth would not necessarily operate as well in space. The reason was zero gravity. The fuel would flow into the engine in quite a different way than on Earth. This could result in failures or a reduction in power. It was impossible to check everything ahead of time, because it was impossible to simulate zero gravity on earth for long periods of time. The designers in Isayev's department racked their brains before they found a way of compensating for zero gravity.

The importance of the retro-rocket was clearly demonstrated during a flight in the spring of 1960. It was an unmanned flight with only drosophila flies on board for biological experiments. The spacecraft circled the planet sixty-four times. When the signal for descent was transmitted, the troubles began: the retro-rocket functioned properly,



but the spacecraft failed to assume the correct position. Something had gone wrong in the automatic control. As a result the speed of the spacecraft failed to reduce and, on the contrary, increased, and instead of moving towards the Earth the spacecraft rose even higher.

Some of the rocket men became depressed.

"No reason to be upset," Korolyov said. "Our spacecraft will return to Earth! They had better!"

In the same year a spacecraft with two dogs safely landed in the scheduled area.

Alexei Isayev was at the launch site during Gagarin's flight. Everyone was very concerned about the end of the flight which had lasted for a hundred and eight minutes. And Isayev was probably the most worried of them all. Members of the Government Commission were worried, scientists were worried, engineers, technicians, operators were worried and so were those who were not at the control panel. There was a crowd of people standing outside the window all huddled together.

When it became clear that the descent had been completed, there was pandemonium in the control room. Adults behaved like children, skipping about and screaming in delight, and talking incoherently. The same thing was happening outside.

NEW TIMES AND NEW SPACECRAFT

Soviet cosmonauts flew into space six times on the Vostok spacecraft. German Titov followed Yuri Gagarin. Andrian Nikolayev was third. Pavel Popovich was fourth. Valery Bykovsky was fifth. The first woman cosmonaut, Valentina Tereshkova, was sixth. The cosmonauts circled the world two hundred fifty-nine times in that spacecraft, spending three hundred eighty hours, or sixteen days, in orbit.

You can now see the Vostok spacecraft in a museum. It seems so small and cramped inside! It has since been replaced by other, much larger spacecraft which are more roomy and comfortable and much more complicated and improved compared to the first one.

The Vostok had only one seat. If someone had wanted to instal a second seat, there would have been no room anyway. But the time came when a second and even a third seat became necessary. More spacious spacecraft were required, capable of carrying out complex maneuvers in space. And it was time to begin research and experiments in space

and this was impossible in the cramped cabin of the Vostok spacecraft.

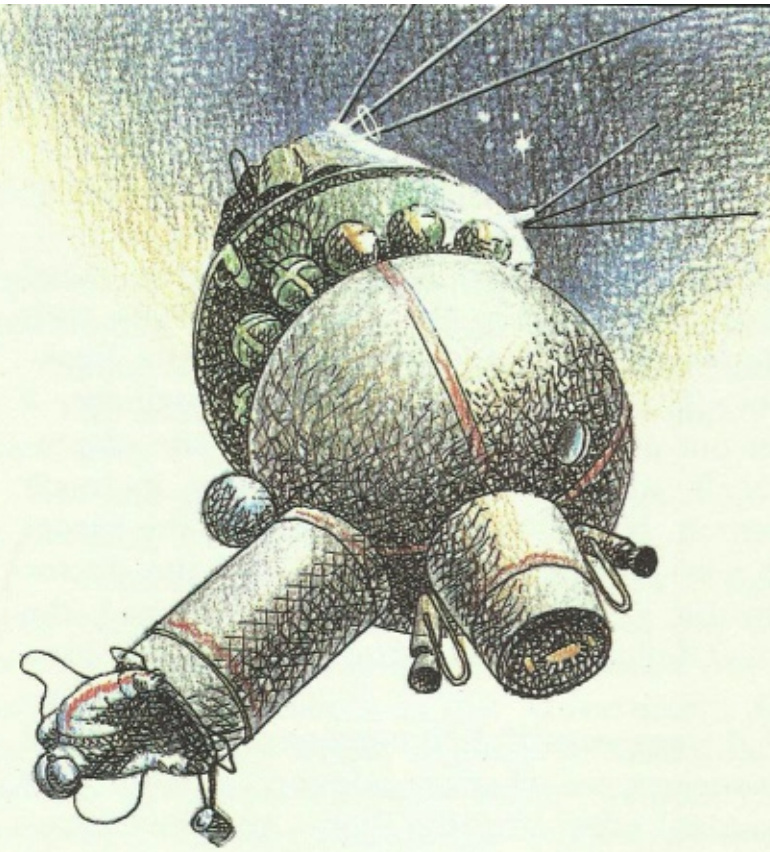
At first designers developed a spacecraft for three people called Voskhod (Sunrise). It made its first flight in the autumn of 1964 with three men — commander Vladimir Komarov, scientist Konstantin Feoktistov and Dr. Boris Yegorov. This was the first time an engineer, a scientist and a doctor had set out on a space trip. Formerly, the cosmonaut had to pilot the spacecraft, watch the instruments, keep in touch with Earth and carry on research. Now the engineer checked the spacecraft's controls, the scientist was busy with his studies, and the doctor watched over the crew's health. The latter could have treated the cosmonauts if one of them had fallen ill. Fortunately this did not happen.

"What is your opinion of the spacecraft? Is it comfortable to live and work in? What would you suggest we change, add or correct?" the designers interrogated the Voskhod crew after the flight. And the cosmonauts gave detailed answers, suggestions and advice. They knew that the Voskhod 2 was being prepared for flight and its crew was to carry out an unprecedented and highly necessary experiment. Only then would man really begin to feel free in outer space, and besides, future flights required it. Man was to open the "door" of the spacecraft and go out into space!

But outside the spacecraft was vacuum, lethal radiation and abrupt changes in temperature involving hundreds of degrees. It was possible to go out into space only in a special, very complicated space suit. Soviet engineers devised such a space suit. The outer white layer reflected solar rays and protected the cosmonaut from overheating. Then came a whole series of layers made of the thinnest shining film protecting him from the extremes of heat and cold. Then there was the abrasion-resistant suit guarding the cosmonaut from the tiny meteorites. Finally, there was a strong air-tight envelope, actually two, the second in case the first was damaged.

The helmet was furnished with a special dark glass visor to protect the eyes from the bright sunlight. The cosmonaut was linked to the spacecraft by a long cord. It was a strong cable and line for monitoring the cosmonaut's physical condition during the space walk. The space suit had to be perfectly reliable. Were the smallest leak to appear, the cosmonaut would perish instantly.

Cosmonauts Pavel Belyaev and Alexei Leonov were in the Voskhod 2



Man first went out into open space from the Voskhod spacecraft

The Soyuz spacecraft replaced the Vostok and the Voskhod

cabin. As they flew over the Soviet Union, Leonov opened the hatch and "floated" outside. He remained there for twelve minutes, linked to the spacecraft by a five-meter cord, moving away and then returning again to the hatch. Leonov saw the surface of the Earth and the bright stars against the dark sky. He felt fine, and found time to talk with the spacecraft commander and even with far-off Earth. So man could live and work in space without experiencing fear or losing control.

The Voskhod spacecraft was a fine ship, but Soyuz (Union) was better still. It enabled the cosmonauts to remain in space for a whole month, by carrying the necessary supplies. Soyuz could change the altitude of its orbit, approach other spacecraft and dock with them.

The Vostok and the Voskhod cabins were in the shape of a sphere. The Soyuz cabin resembles an old-fashioned car headlight. It is more complicated to make such a cabin, but it is more spacious and much easier to fit the seats in. When the spacecraft returns to Earth, it moves with the wider part forward and slightly inclined. It is held up by the air creating an aerodynamic lift. As a result the G-force acting on the cosmonauts is much weaker, and the precision of the landing is increased.

The Soyuz cabin has two seats. One in the center for the commander, and the other on the right for the flight engineer. But this spacecraft may be turned into a three-seater. Then another seat is put in on the left for the scientist.

The space seat is not just a place to sit. And the cosmonaut lies on it with his legs bent rather than sits. In this position it is easier to withstand the G-force at the launch and during re-entry. In addition, the strength of the impact is reduced if the spacecraft hits the ground hard. Each seat is custom-made for each cosmonaut according to the exact shape of his body. A cast is first made and from it the seat.

The Soyuz spacecraft may be called a two-room ship. If the first room is the cabin or re-entry vehicle, the second room is the orbital module firmly locked to the re-entry vehicle. The cosmonauts are in the cabin during the launch of the rocket and the re-entry. The controls are in the cabin. The orbital module is the living area and research laboratory. It is linked to the cabin by a passage with a strong, tight hatch. The cosmonauts work and rest in the orbital module without their space suits wearing light clothes. Space walks are made from here. Then the hatch into the cabin is shut tight, the space suit put on and the cosmonaut goes out the exit hatch.

It is spacious and comfortable in the orbital module. Even a tall person may stand upright. The walls are upholstered by attractive matting. The sunlight comes streaming through the round windows. There is a sofa to lie on, but to do this in zero gravity the cosmonaut has to strap himself down. There is a "cupboard" with a supply of food in tubes and slabs, and water. Eating utensils and napkins are also found there. The designers have provided a special pull-out table for eating and an electrical stove to heat the food.

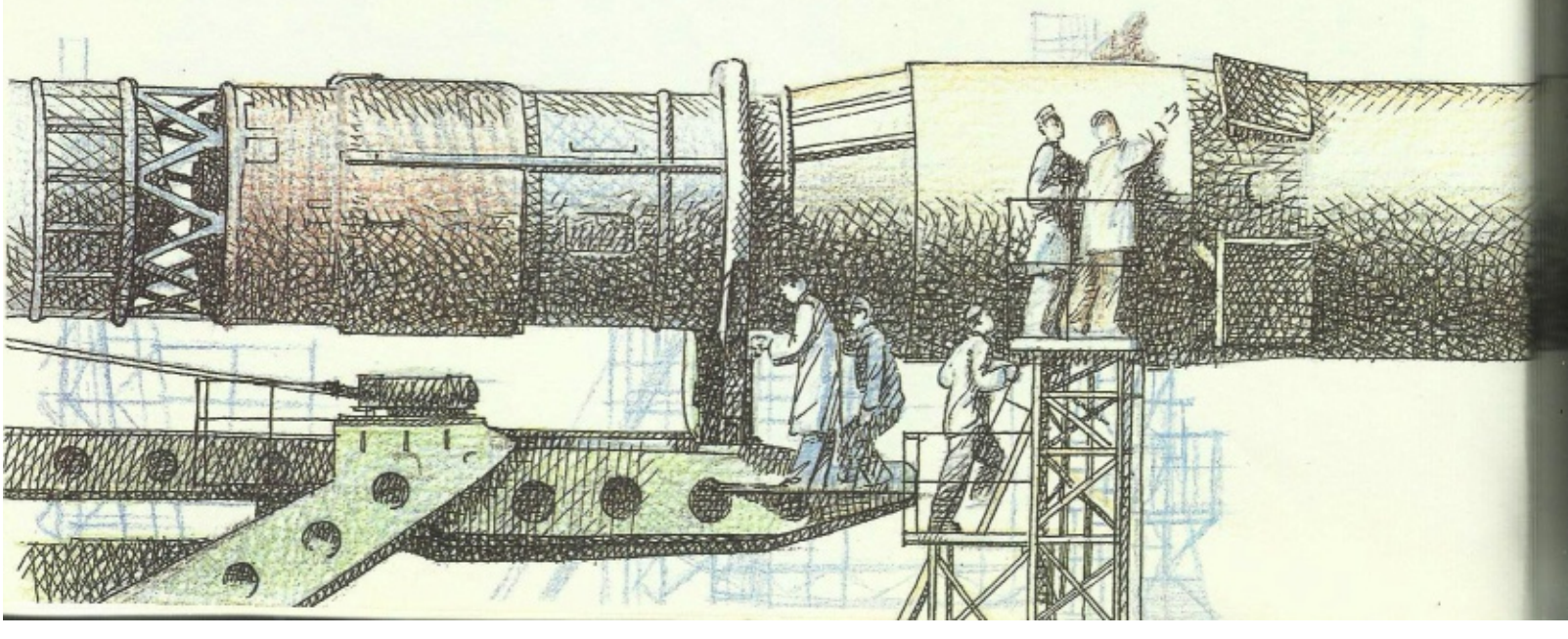
Why is it called an orbital module? Because it is made only for orbit and never returns to Earth. As opposed to the cabin the orbital module is not coated with heat-resistant material and is incinerated before reaching the Earth.

Besides the two "rooms" in the Soyuz spacecraft, there is an uninhabited area. This is the service module. It is of cylindrical shape and attached to the wider end of the re-entry vehicle. It contains various instruments and equipment and the engines. Soyuz has a total of twenty-four rocket engines!

The engines are very different. The two most powerful thruster rockets are for maneuvering in space. Fourteen are for docking to other spacecraft and for altitude control. The rest have very small thrust for finer adjustments of the spacecraft's position.

Soyuz resembles a mythical bird in flight. This is due to the solar battery panels stretching on the sides like wings. The panels are covered by shining dark-bluish cells which convert the radiant energy of sunlight into electric power.

Of course, this is only a very rough idea of the Soyuz spacecraft. No technology is more complex than space technology. But the more



complex a machine, the more difficult it is to make it reliable. The spacecraft is prepared for flight long before the launch. All stages of the flight are rehearsed many days before the real flight: the launch, flight into orbit, flight in space and return to Earth. The rocket and spacecraft undergo continual checks until the last minute before the lift-off. Nevertheless, accidents can happen. How can the cosmonauts be saved if an accident occurs at lift-off or during the rocket's flight?

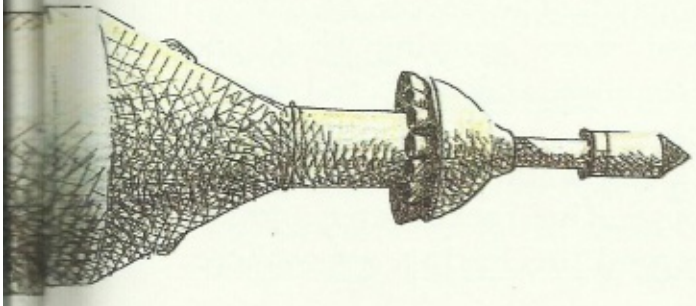
When you watch the launch of a Soviet space rocket on TV, take a closer look at the very top. You will notice something that looks like a mushroom's cap. It is the emergency escape system. Powder-rocket engines are located under the cap. In case of an accident the spacecraft separates automatically and the powder-rocket engines carry it up and away from the rocket. Then the parachute will open and the cabin with the cosmonauts will land safely on Earth.

All this is intended for an emergency: and once it occurred. In early April 1975, preparations were being made at the Baikonur space center for the launching of another rocket with the Soyuz spacecraft. The crew, commander Vassily Lazarev and flight engineer Oleg Makarov, were in the spacecraft. Preparations were going according to schedule. The countdown began.

"Forty minutes to go," the cosmonauts heard over the radio. Shortly another report followed: emergency escape system set!

When there were five minutes left until lift-off, the cosmonauts closed the glass visors of their space suits.

Launch! The rocket rose higher and higher: 120 seconds. The modules, the rocket's first stage, separated: 150 seconds. The nose cone protecting the spacecraft was discarded: 180 seconds.



The space rocket is crowned by a device resembling a mushroom cap. It is the emergency escape system

"Flight proceeding normally," a voice from Earth stated.

The second stage was to fall away at the two hundred sixtieth second, but suddenly the cosmonauts felt the rocket swinging. The commander lifted his arm and it swayed. Then the siren sounded and the warning indicator Booster Failure flickered ominously. The rocket began to revolve.

Something had gone wrong. But what? Now everything depended on the proper functioning of the emergency escape system. And the system did not let the cosmonauts down. The spacecraft began to fall. The G-force increased abruptly, pressing the cosmonauts into their seats. Why was the parachute not opening? Finally, there was a click and the hatch came off. The cabin jolted. This meant everything was normal and the parachute had opened.

The spacecraft landed in the Altai Mountains, in a forest, on the very edge of an abyss. Thus the flight ended. The rocket rose to an altitude of nearly two hundred kilometers and flew one and a half thousand kilometers from the launch site. The entire flight had taken twenty-one minutes twenty-seven seconds.

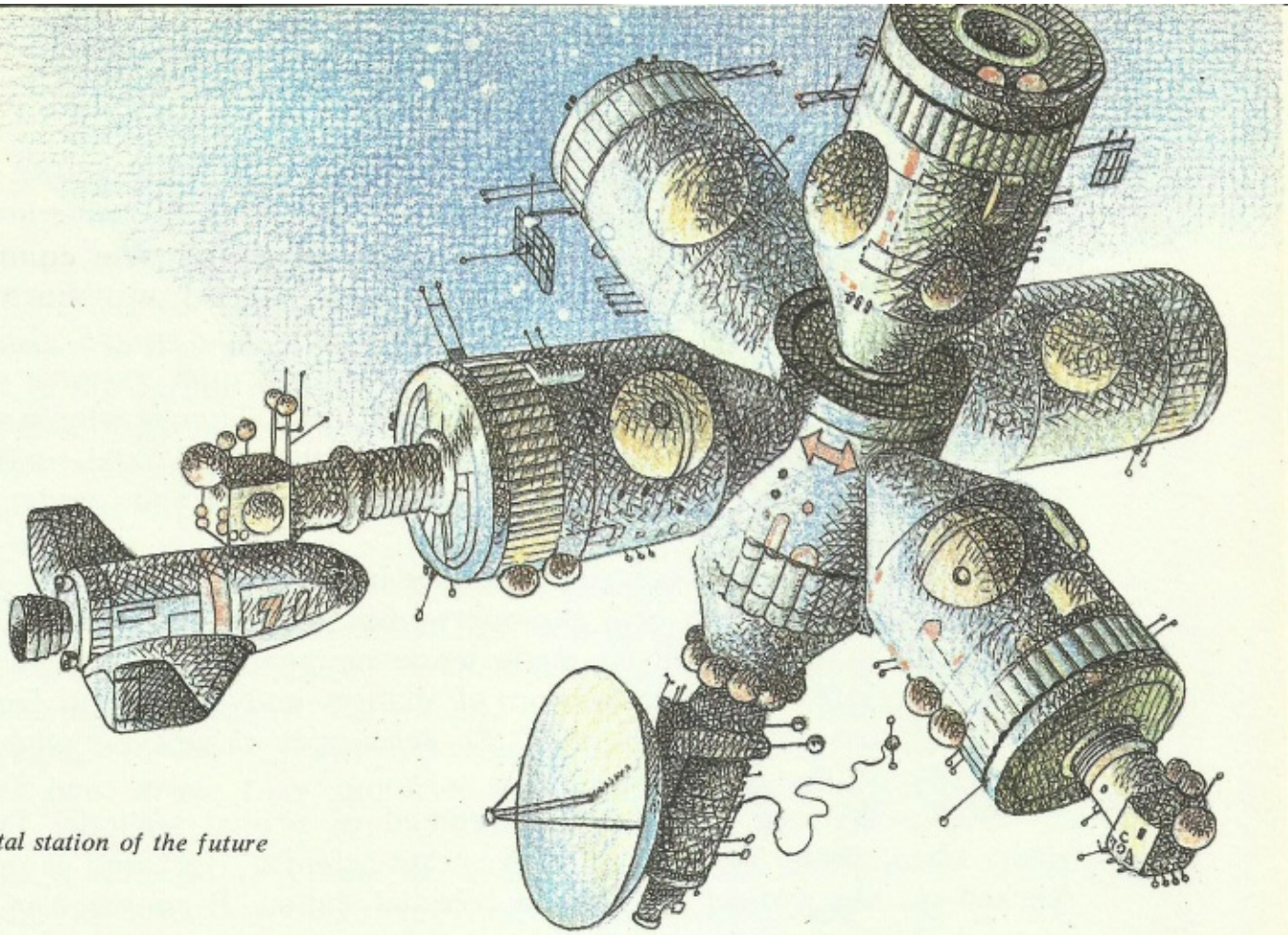
The unknown always involves risk. The path leading into space is difficult and dangerous. After studying this unfortunate accident engineers and scientists did everything so that subsequent flights were successful.

Many outstanding achievements in space are associated with Soyuz. But its most important flights began when the permanent orbital station was put into space. The station was a real "house in orbit".

CELESTIAL CITIES

A remarkable event, was described in Konstantin Tsiolkovsky's science fiction story, "Beyond the Earth". On April 10, 2017, an unusual telegram was received in many countries of the world. Four scientists reported that they had left the Earth with sixteen assistants and were now orbiting it at an altitude of a thousand kilometers. The people had set up a greenhouse in interplanetary space and were growing fruit and vegetables there. They said that they were alive and well and eating properly, and invited others to settle in space.

The telegram thrilled terrestrials. Quite a few wanted to fly into space. People began to build rockets with greenhouses. One rocket after another flew off into space. The first settlement beyond the Earth's atmosphere,



An orbital station of the future

an ethereal city, appeared high up in the sky, thirty thousand kilometers from the surface of the Earth. Living quarters were located inside enormous tubes. It was always summer there, the temperature was constant, and harvests were much better than on Earth. And most importantly, people were not held down by the force of gravity and enjoyed unlimited space.

Such was Tsiolkovsky's view of a city in outer space. The scientist believed that many ethereal cities would appear with time and thousands upon thousands of terrestrials would settle there. "The planet was the cradle of humanity, but should one always live in a cradle?" wondered Tsiolkovsky. Most probably, by the year 2017, settlements if not whole cities will appear beyond the atmosphere. These will be orbital stations with hundreds of people.

The first settlements will appear not because the Earth is overcrowded. And these structures will be research laboratories in orbit rather than residential areas. So many things can be done in outer space, that it is impossible even to list them! How does zero gravity influence the human body? The question can be answered only by living for a long time in

outer space and observing the physical condition of many people there. The orbital station is just the place to conduct such experiments. Only from outer space can we see how cyclones, typhoons and hurricanes arise, rage and subside, and understand how the natural elements operate.

However hard one tries, the complete vacuum existing outside the orbital station cannot be simulated on Earth. That is why materials with new properties — lightweight and strong steel and enormous crystals — can be made only in airfree space and under zero gravity.

It is convenient to observe the weather in different parts of the planet, study the ocean and sea bed, and survey for minerals from outer space. Important discoveries will be made by astronomers. The Earth's atmosphere interferes with observation of planets and stars. The force of gravity distorts telescope mirrors. So telescopes should be taken into space, beyond the atmosphere.

Tsiolkovsky and Kondratyuk dreamed of orbital stations. Tsander wrote about them. Back in 1929 Austrian scientist Hermann Noordung worked out the project for a large celestial station. It consisted of three parts: a thirty-meter revolving wheel, a laboratory and an engine compartment. The parts were linked by electric wires and air hoses. The inventor proposed that the living quarters be located in the wheel's rim. There would be artificial gravity here, a centrifugal force like the one acting on a merry-go-round. Thus people in the living quarters would not experience zero gravity.

Later scientists of different countries invented many orbital stations of various designs and shapes including a set of tubes and spheres, rings, flowers and polygons. But how could such enormous structures be put into orbit? Scientists have been thinking about this for a long time. Small orbital laboratories could be carried into space already assembled. Tsiolkovsky proposed to take large stations into space in parts and assemble them on the spot. Cosmonaut assembly workers could weld the parts together in orbit.

There already exist projects for near-Earth stations for two hundred, three hundred and more people. Scientists have proposed a plan for an enormous station housing twenty thousand inhabitants! This is a real space city including not only astronomical observatories and living quarters but also movie theaters, sports facilities, cafes and even shops. The time will come when space plants will manufacture unique materials. Solar

batteries outside the atmosphere will supply the planet with electric power. But that is all in the future.

You have, of course, heard of Soviet Salyut (Salute) orbital stations. They have not got space ports or plants, and the number of inhabitants is from two to five people, but it was from these stations that everything started in the spring of 1971. That spring marked the tenth anniversary of the first flight by Yuri Gagarin. Who could have believed that only ten years later such a giant would be put into orbit? Next to Salyut 1 the Vostok spacecraft would have seemed very small indeed. You remember that it weighed about five tons. Well, Salyut 1 weighed nearly twenty tons. The station was a spacious "house" intended for people who would live there a long time. It was known as a long-term space station. Cosmonaut Georgy Dobrovolsky recalled: "When we opened the hatch and peeked in, it seemed as if there was no end to our station." Cosmonauts lived and worked for twenty days on board the first Salyut. Then stations number two, three, four and five were sent into orbit replacing each other.

Was it difficult to create an orbital station? It was indeed. Many hundreds of scientists, engineers and workers took part. One of the designers of the remarkable station is well known: he is Konstantin Feoktistov, cosmonaut and scientist. When newsmen asked him what was the most difficult thing in developing the Salyut, Konstantin answered: "It was the testing. At first we had to test each part and system separately. Then the whole thing together. We had tests in laboratories, at the plant and at the space center. The chief aim was to make the station as reliable as possible."

Salyut 6 is a second-generation station. It has been improved and made more comfortable. A powerful rocket carried it into orbit in the fall of 1977 and for four years it served as reliable shelter for space explorers. Five long-term expeditions worked at the station. The first expedition lasted more than three months. The second one even longer — one hundred forty days and nights. The third one hundred seventy-five. And during the fourth expedition Soviet cosmonauts Leonid Popov and Valery Ryumin spent half a year in orbit! It was a world record.

The main crews who remained in orbit for a long time were joined by visiting expeditions for short periods of a few days. Soviet cosmonauts at orbital stations played host to envoys from eight socialist countries: Czechoslovakia, Poland, the German Democratic Republic, Hungary, Vietnam, Cuba, Mongolia and Romania. Unmanned transport spaceships

Progress carried fuel, food, equipment, letters and funny surprises to Salyut 6 many times. It was a special treat to receive a gift in orbit.

Let's imagine that we are also in outer space on an orbital station, and explore it.

If we look at it from outside the Salyut seems to be made of several large tanks. These are the station's modules or "rooms". The largest and most spacious module is the work compartment. It includes work facilities and living quarters.

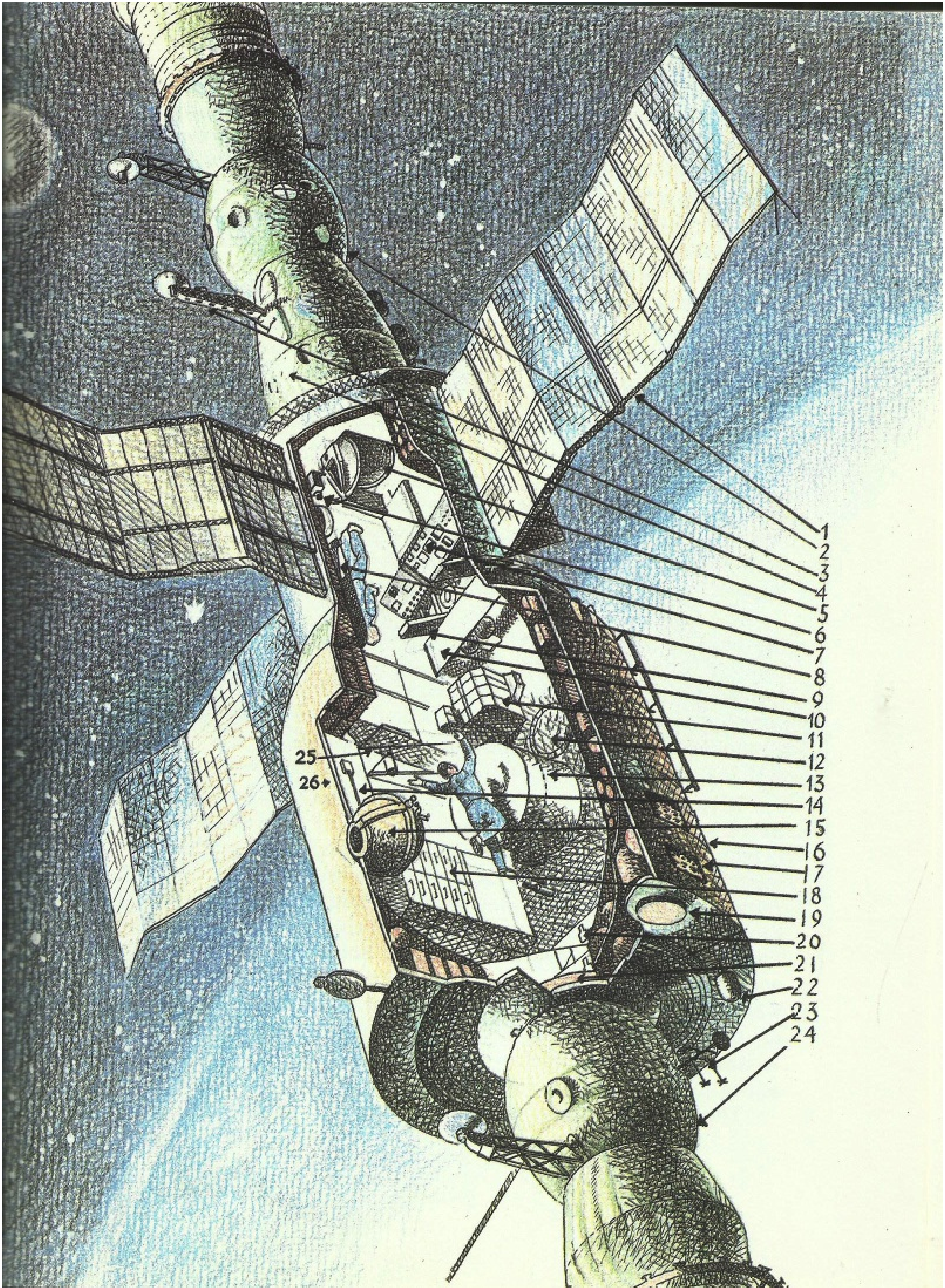
The second "room" is the transition section adjacent to the work compartment. It is here that other ships dock. The cosmonauts open the door and pass into the transition section first. Then they open the second hatch and float (it is zero gravity) into the work compartment. There is another "room" at the other end of the station, but smaller than the first. It is known as the transition chamber. Another ship can dock here.

This makes three "rooms". But since there is always at least one spacecraft docked to the station, and it also has two rooms the inhabitants of Salyut always have five "rooms" at their disposal.

The cosmonauts work in light suits inside the station. That means that the compartments must be absolutely air-tight. The walls, windows and hatches must not have even the tiniest leak. This is no easy task. The station has several hatches and more than twenty windows. Besides, hundreds of wires and pipes pass through the walls of the station to outside instruments. Just try and make the station air-tight! The designers joked: "Our station is like a sieve with all its holes carefully sealed."

There is no up or down when it's zero gravity. But since people are used to it on Earth, they find it easier to live and work when they know where the floor and ceiling are. So designers decided to paint the work compartment different colors. The floor was painted a dark color, the right wall a beige color and the left a light-green. The ceiling was white.

Salyut 6 was a very complicated space station with many different devices, instruments and assemblies
1 — solar batteries;
2 — transport ship;
3 — antenna; 4 — transition section; 5 — hatch;
6 — TV camera;
7 — central control panel;
8 — exercise bicycle;
9 — seat; 10 — table;
11 — camera;
12 — shower; 13 — instrument bay;
14 — sleeping bunk;
15 — air lock for waste disposal;
16 — accessories bay;
17 — altitude control engines;
18 — food containers;
19 — rocket engine; 20 — toilet facilities;
21 — transition chamber;
22 — antenna; 23 — target for docking;
24 — transport ship;
25 — a running stand;
26 — work compartment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Another problem is that the instruments emit so much heat, that it would become as hot as a steambath. To prevent this the air in the compartment is constantly pumped through a cooler.

The air-condition devices perform another important job. They collect the humidity in the air which is expelled by the cosmonauts when breathing and exercising. The humidity is condensed and purified and sent into the drinking water tanks.

The cosmonauts must exercise a great deal at the station. They must fight against zero gravity which weakens a person's heart, muscles and bones. It is necessary to constantly wear a special suit with rubber cords to keep the body under constant strain compensating for the absence of gravity.

The cosmonauts wash in a shower like the showers on Earth. But they have to put on goggles and breathe through a snorkel so as not to get the weightless water and soap into their eyes and mouth. Even experienced cosmonauts were amazed by the shower in space. Georgi Grechko recalled: "Romanenko was taking a shower. And I suddenly thought: here we were flying at an enormous altitude and tremendous speed while he was relaxing in a shower. Unbelievable!"

The Soyuz spacecraft finished its term of service. The last flights to the Salyut 6 station were made on another, newer ship, Soyuz T. The letter T stood for transport ship. Outwardly it looked much like the former Soyuz. The main difference was inside. The new ship had a complex electronic brain, its own computer, a reliable assistant for the cosmonauts. Now it was easier to control the flight and docking. It was said that now the spacecraft had one more cosmonaut.

Then the Salyut 7 appeared in the sky, and its first crew — Anatoly Berezovoi and Valentin Lebedev — broke all the former records. They lived in orbit for 211 days! They took off in springtime when the gardens were in bloom and landed in winter and were met by freezing temperatures. In seven months they flew one hundred fifty million kilometers round the Earth. But shortly even this record was shattered. Commander Leonid Kizim, flight engineer Vladimir Solovyov and doctor Oleg Atkov worked 237 days on the same Salyut 7! The commander and flight engineer went out into open space six times and worked there for long periods of time. Every corner of the spacecraft became familiar to them. It was a remarkable feeling! The long-awaited day of the return came, but instead of joy they felt sadness.

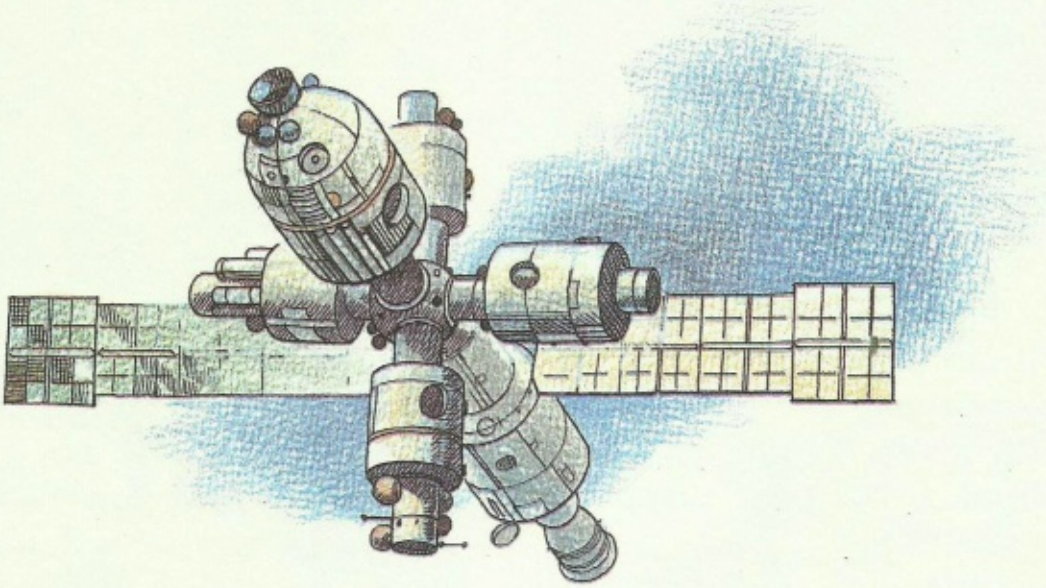
The Salyut 7 station was an excellent one, but the Mir (Peace) sta-

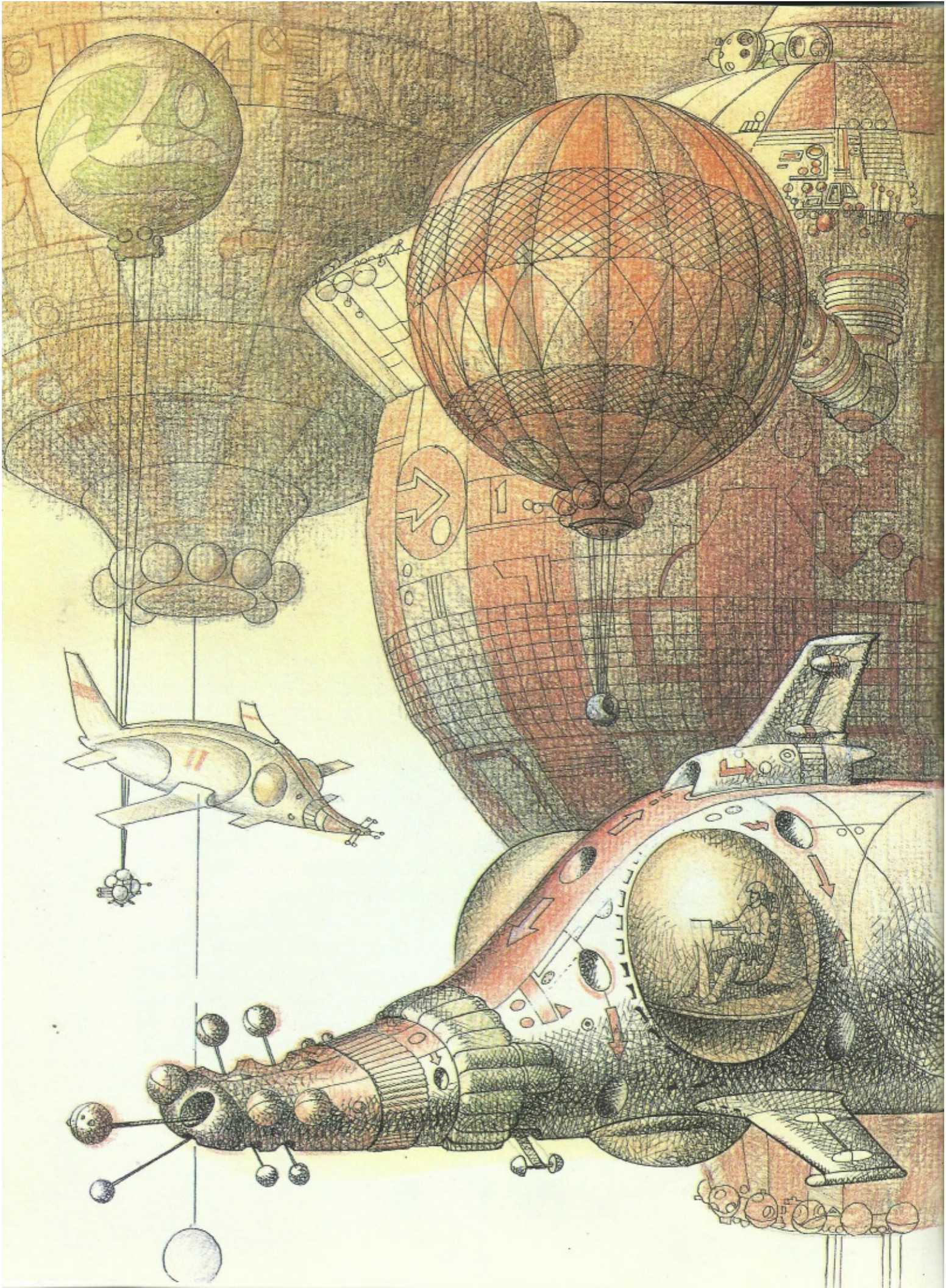
tion is still better. It was put into orbit in February 1986. It has more devices and automatic instruments on board than any previous station.

Mir station has several computers to help it fly. Six spacecraft or modules may dock to it. The result is a real research institute flying at an altitude of several hundred kilometers.

Mir is a much more spacious and comfortable station. This was noted right away by its first inhabitants, cosmonauts Kizim and Solovyov. "It's a pleasure to work here," added the flight engineer.

Tsiolkovsky had once urged: "Always onward without stopping. The Universe belongs to man." That is the way astronautics develop. For the benefit of all people on Earth.





INTO DEEP SPACE

SOFT LANDING

A cloud of brown dust rose from the surface of the Moon in mid-September 1959. It was the first time that an envoy of the Earth fell on its deserted and uneven surface instead of a meteorite, a chance visitor from outer space. A Soviet rocket had reached the Moon. Incredible precision was needed to hit the target. The slightest delay in the launch, the smallest mistake in calculating the speed, and the rocket would have gone astray.

The Moon is the Earth's nearest neighbor. It is only four hundred thousand kilometers away. Very close if we recall that the distance to Mars and Venus is millions of kilometers. Other planets are further still. Before flying to the planets man had to reach the surface of the Moon.

Easier said than done! British scientist Gold believed that a terrible danger awaited people on the Moon. He warned that the Moon was covered by a thick layer of dust that had been accumulating there for centuries. Cosmonauts and spacecraft would immediately sink. Was the frightening picture drawn by the British scientist true?

The rocket reaching the Moon crashed on the surface, but it delivered metal replicas of the emblem of the Soviet Union. The Earth-Moon route had been opened.

Shortly a space photographer set out for the Moon. The automatic camera transmitted pictures of the dark side of the Moon which had never been seen by man. Astronomers could finally see what the Earth's natural satellite was like on the other side.

The road to the Moon was open. And these first flights showed what a great future was in store for space robots and not only lunar ones. It became clear that robots should be sent to Venus, Mars and the more distant planets. They would be able to transmit information as yet unknown to science.

Sergei Korolyov contributed a lot of effort and attention to each interplanetary station, and space automatons were becoming more and

more complicated. Korolyov liked to keep abreast of all the developments in the work. But by that time the scope of the space effort was so great, it was difficult even for Korolyov to do so. He decided to assign deep space to another designers' department led by Georgi Babakin.

Korolyov had known Babakin for many years, was familiar with his work, and regarded him as a gifted engineer. Georgi was fifty at the time and was well aware of the responsibility the assignment involved.

Babakin's life was not an ordinary one for an engineer. He only had seven years of schooling since he lost his father at an early age and had to help support the family. He had shown an interest in radio from childhood. One day he learned that radio electronics courses were being offered in Moscow, where he lived. After the six-month course Georgi studied all his life only independently, learning from books and on the job, and many years later he became a top-notch engineer and scientist and outstanding designer of interplanetary stations.

This, however, did not happen right away, and at first the young electronics man had to do quite different work. He had to drag heavy equipment to Moscow's clubs and theaters, and set it up to transmit lectures and concerts over the radio. He also broadcast from Red Square during meetings and parades. It was not easy, but he gained an in-depth knowledge of electronics. He could repair a transmitter or receiver with his eyes closed or make a new one which did not resemble any of the existing models. His real work began, however, when he got a job at a research institute.

He was assigned the task of developing a complicated automatic device for an aircraft. The device transmitted the readings of an instrument in the tail of the plane to the cockpit. From that time on whatever Babakin did involved transmitting orders or signals over some distance. At first the distance was measured in meters, then dozens of kilometers, and then hundreds of thousands, and finally millions.

A strong will, a love of learning, an extraordinary capacity for work (Georgi could work for days on end without resting), an immense store of knowledge, daring, kindness and a sensitive heart were some of the qualities he possessed. No wonder Korolyov (a fine judge of people) believed in Babakin right away.

To land an automatic station on the Moon softly without ruining the lunar robot was the first assignment of Babakin's designers' depart-

ment. The station, shaped like a flattened sphere, was light and fragile. How was it possible to land it without damaging the delicate parts? Designers proposed to put the station between two gas-filled balloons. It was as if, say, a watermelon, were firmly fastened between two big balls. This contraption could be dropped from a twelve-story building. The balls would absorb the shock and the watermelon would be undamaged.

The balloons were to lie on the station during the flight in outer space and be inflated only before the landing. The balloons were made by another organization. Babakin's department was to study how to attach them and to test them. Unexpectedly, it proved to be difficult to fasten the deflated balloon on the station. They refused to remain in place. Finally a solution was found.

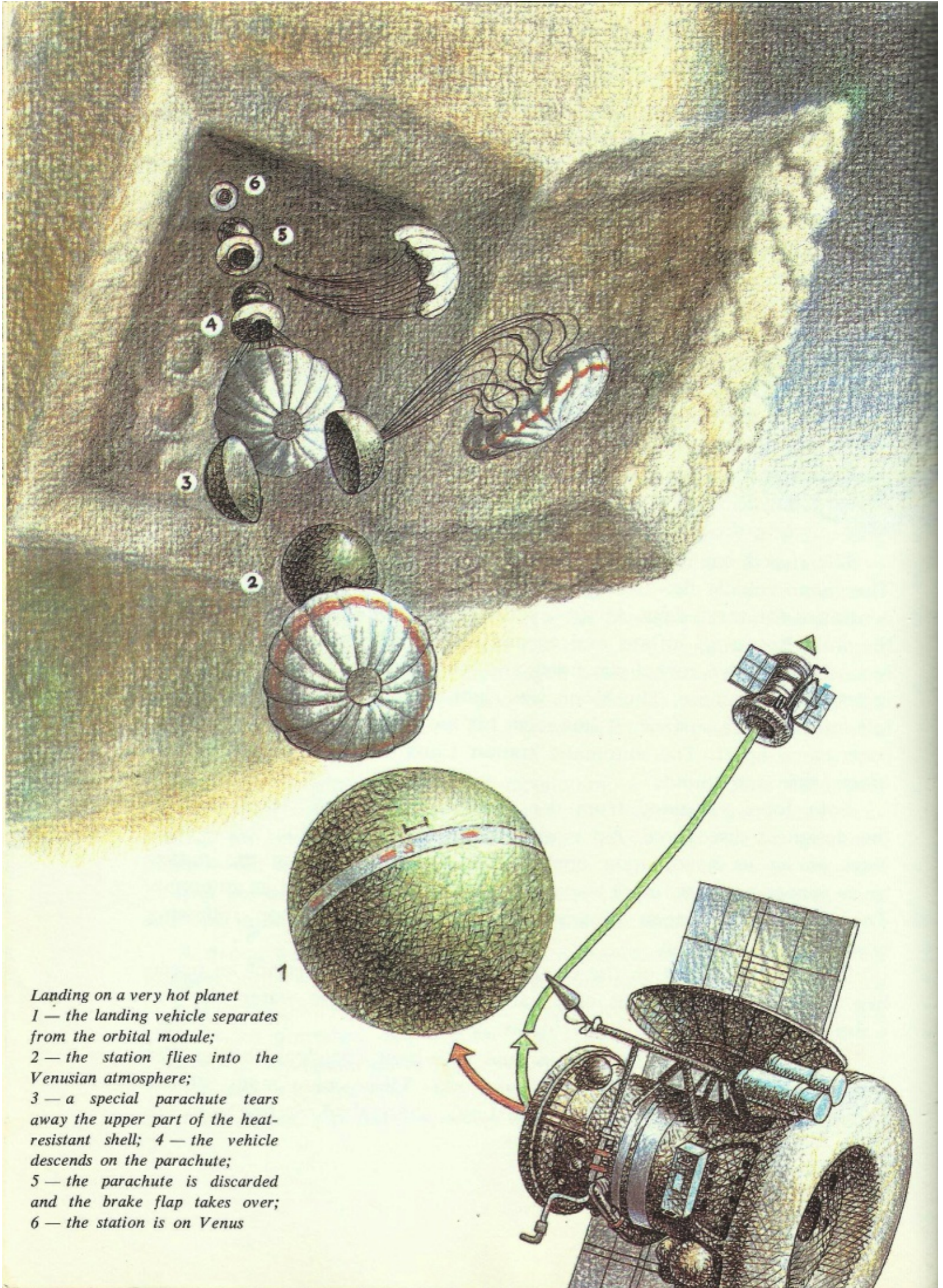
The rocket with the automatic lunar vehicle was launched on a cold January day in 1966. It was called Luna 9, because it was the ninth. After circling the Earth the vehicle headed for the Moon.

The rocket engine was at one end, a strange grey bulb at the other. The lunar vehicle flew along a familiar, well-charted route. The flight continued for three days. About seventy kilometers away from the Moon the bulb began to inflate and turned into a big ball in a matter of seconds. The retro-rocket was fired, and the enormous speed was reduced in less than a minute. The Moon was right there. The ball detached and fell on the lunar surface. It bounced, hit the ground again, and balloon parts came apart. The automatic station Luna 9 was left lying on the Moon, safe and sound.

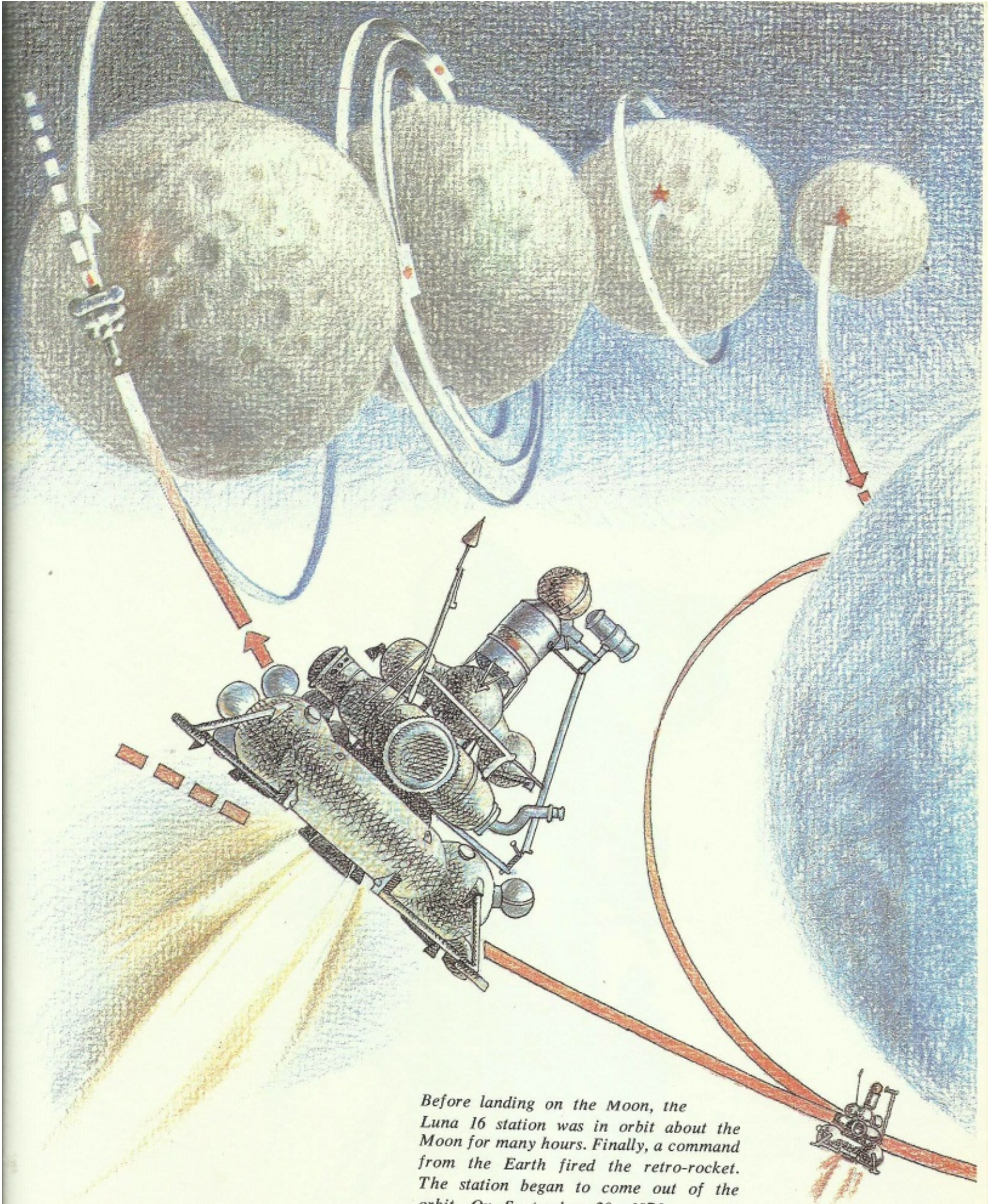
Four lobes extended from the station. This was a clever solution the designers discovered. No matter which way the station fell — sideways or on its head, upon opening the lobes would turn the station to its proper position, the TV eye up. The lobes also served as antennae. The space robot began to scan the surface of the Moon following orders from the Earth.

The station landed on the Ocean of Storms. But it was not an ocean like ours on Earth, it was only called that. It had no water but was a dry plain. There is no water in the lunar seas.

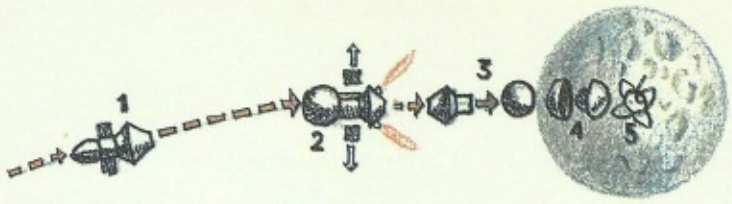
It was morning when the unusual television broadcast began. On Earth people could see the dark lunar sky. There were many stones, mounds and holes around the station. Long, sharp shadows fell from the



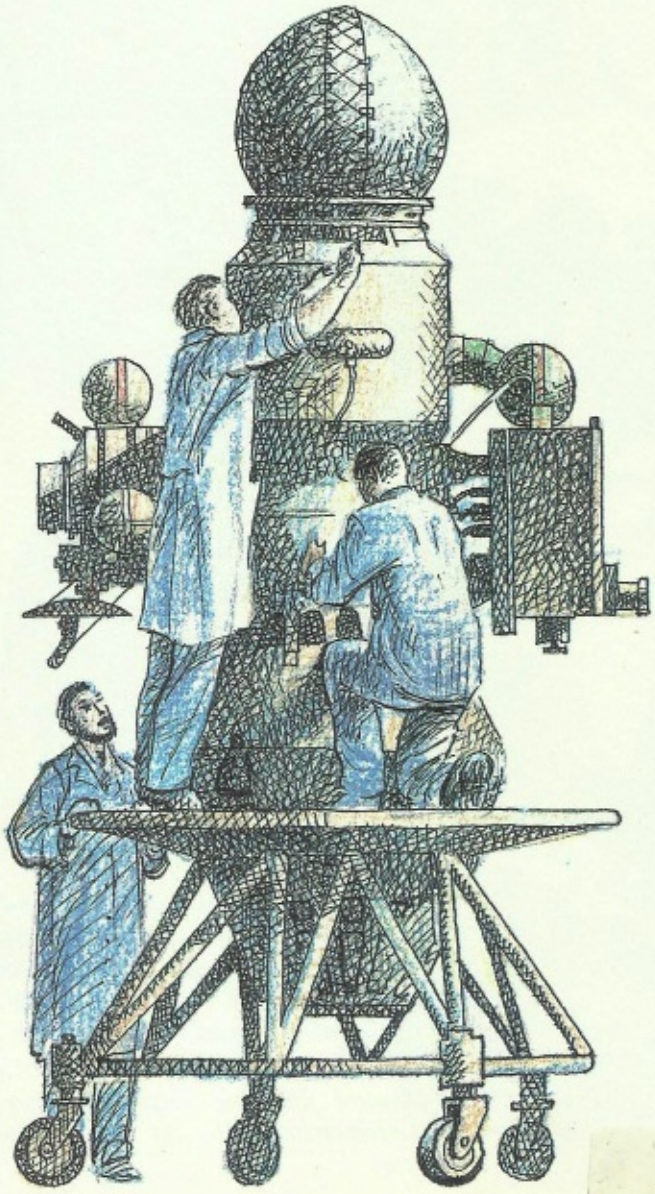
Landing on a very hot planet
1 — the landing vehicle separates from the orbital module;
2 — the station flies into the Venusian atmosphere;
3 — a special parachute tears away the upper part of the heat-resistant shell; 4 — the vehicle descends on the parachute;
5 — the parachute is discarded and the brake flap takes over;
6 — the station is on Venus



Before landing on the Moon, the Luna 16 station was in orbit about the Moon for many hours. Finally, a command from the Earth fired the retro-rocket. The station began to come out of the orbit. On September 20, 1970, at 8:18 Moscow time the automatic lunar probe landed successfully in the Sea of Fertility



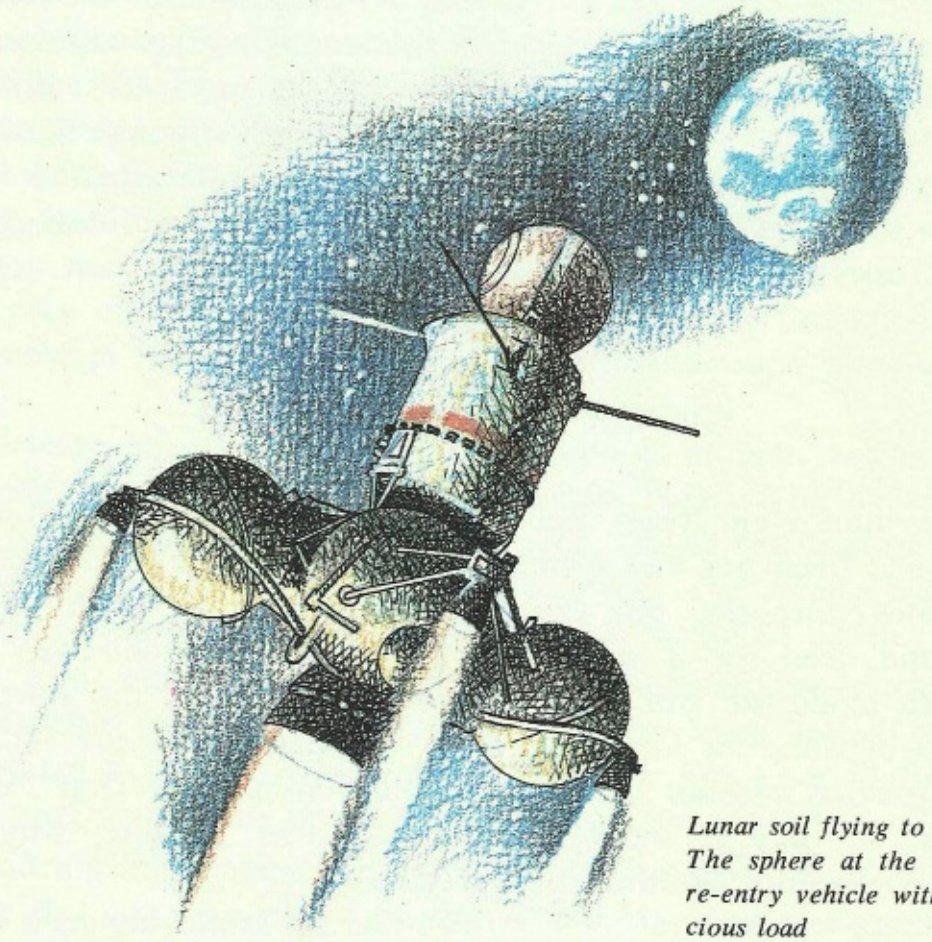
The first soft landing on the Moon
1 — Luna 9 approaches the target; 2 — braking; 3 — the station separates from the retro-rocket; 4 — it lands on the Moon;
5 — TV broadcast begins from the Moon



antennae and other parts. The lobe of one antenna was clearly visible. It was completely clean. And the stones were clean. Where was the terrible dust the British astronomer had written about? It turned out that the surface of the Moon was as firm as the Earth's. Not only a small, lightweight station but a heavy spacecraft with cosmonauts could land safely on such a surface. The Moon was firm!

The station that landed on the Moon was the ninth attempt. A soft landing was not achieved right away. It was a very difficult assignment. Preparations for a soft landing began in Korolyov's department with Luna 4. But even Luna 5 failed.

Only the ninth station was successful. A short time later another Soviet robot landed softly on the Moon and not only transmitted a picture but also measured the density of the lunar soil. Now it was absolutely clear that any vehicle could land on the Moon.



Lunar soil flying to the Earth. The sphere at the top is the re-entry vehicle with the precious load

It is easier for designers of aircraft, cars, turbines and the like. Before undertaking a new project they can study everything that has already been built and draw on existing know-how. Designers of space machines have no one to advise them and no prior experience to rely on. Almost everything was being done for the first time here. Babakin thought that if a person did not believe in the possibility of developing the vehicle, if he was not carried away by the idea, he would not make a good space designer. He himself was certain that a great deal could be done in outer space, on the Moon, and on the planets by means of automatic devices, and the most important and complicated jobs could be done by automatic stations.

Georgi Babakin was chief designer of automatic interplanetary stations, but if the deadline required it he would take a soldering-iron or screwdriver and get down to work. Despite the protests of workers he helped pull a heavy cable to the launching pad at the space center.

An interplanetary station was being prepared for flight. The schedule was tight. All of a sudden, a defect was discovered inside the vehicle. The station had to be taken apart, but it was late and everyone was exhausted. Someone suggested that they leave it until the next shift. But what of the schedule? Babakin decided to repair the defect although he was just as tired as everyone else. He removed his jacket, rolled up the sleeves of his white shirt, threw on a smock and got down to business. When the next shift arrived in the morning, everything was in order.

GETTING THE LUNAR SOIL

More than eight years had lapsed since the first artificial Earth satellite had been put into orbit. Our planet now had man-made moons for various purposes. But the real Moon had no artificial satellite, though the need for it was acute. Although the Moon was close by, there was much we still did not know about it. As the Earth, it was made up of different kinds of rock. For that reason the force of the Moon's gravity was not the same in different places. That force could be measured only by instruments on a lunar satellite, which would help determine the structure of the Moon.

But there was another important reason for launching such a satellite.

The Luna 9 space station flew directly to the Moon and landed. It was not possible to land a station on all parts of the Moon in that way. Scientists were pleading with designers to make it possible to land anywhere on the Moon, on any of its seas. This required the lunar satellite to approach the Moon first, circle it and then land in the specified place.

The flight of Luna 10 resembled the trip of Luna 9, but the final stage was quite different. Near the Moon an instrument container separated from the station. Its speed had been precisely calculated, and it began to circle the Moon, becoming its first artificial satellite. This occurred on April 3, 1966.

The lunar satellite transmitted scientific data for nearly two months. Scientists learned a great deal. For example, powerful volcanoes had erupted at one time on the Moon. This was a real discovery.

In the summer of 1969 American astronauts Neil Armstrong and Edwin Aldrin were the first people to walk on the lunar surface. Man had reached the Moon. Did that mean automatic stations had nothing left to do on the Moon? Of course not. There were still quite a few unsolved mysteries. The astronauts brought back stones from four areas, but the Moon is a big place. It was important for scientists to obtain soil samples from many of its seas.

Babakin understood this well. The idea of an automatic geological device haunted him. Even some of the staff thought the idea outlandish. The station would have to make a soft landing on the Moon, take soil samples, take off and return safely to Earth. No one had tried to solve such a problem before. But Babakin believed that such a station could be made.

He already imagined the station in general outline. It resembled a tall pyramid standing on four widely spaced "legs". The pyramid consisted of fuel tanks, engines and instrument bays linked together. At the top was a rocket with a brown sphere in front. The sphere was a container for the lunar soil to be carried by the rocket to Earth.

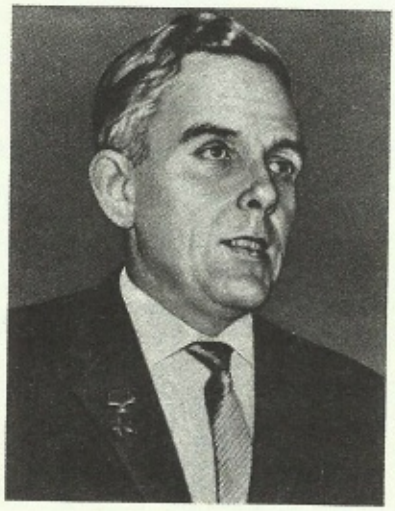
But first the soil sample had to be taken. That meant the station needed a bore. Babakin imagined the bore breaking the lunar soil. It would be able to obtain a sample from the firmest rock. But what if there were sand? It must be able to obtain loose soil samples as well.

It could not be assumed that the lunar station would land on an even place. On the contrary, it would most probably land at the edge of a

crater or put one of its "legs" on a stone. The station must remain upright. But even if it landed on an even site, the station would hit the soil and bounce up. The force of gravity on the Moon is six times less than on Earth, and the bounce is much higher and therefore more dangerous. The station could turn over. That meant the "legs" should be furnished with shock absorbers to prevent any bounce in landing: the station should stick to the soil like a blob of dough falling on the floor.

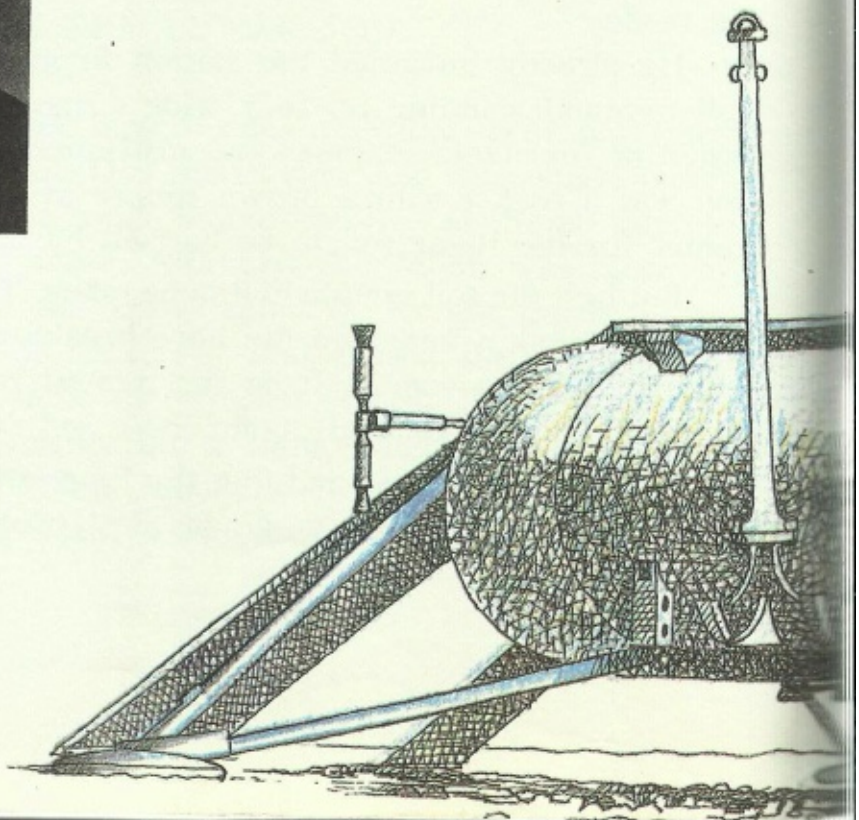
The container for the lunar soil was slightly larger than a soccer ball. Inside it was very complicated. The middle consisted of a capsule to store the lunar soil surrounded by tightly packed radio transmitters, batteries, antennae and a parachute. The sphere had two hatches. One to load the soil and the other for the parachute to open. In flight both hatches must be tightly closed by caps.

Designers knew that the sphere would take quite a battering on the return to the Earth. It would fly faster than Gagarin's spacecraft: more than eleven kilometers a second! It would be overheated and be subject



Georgi Babakin

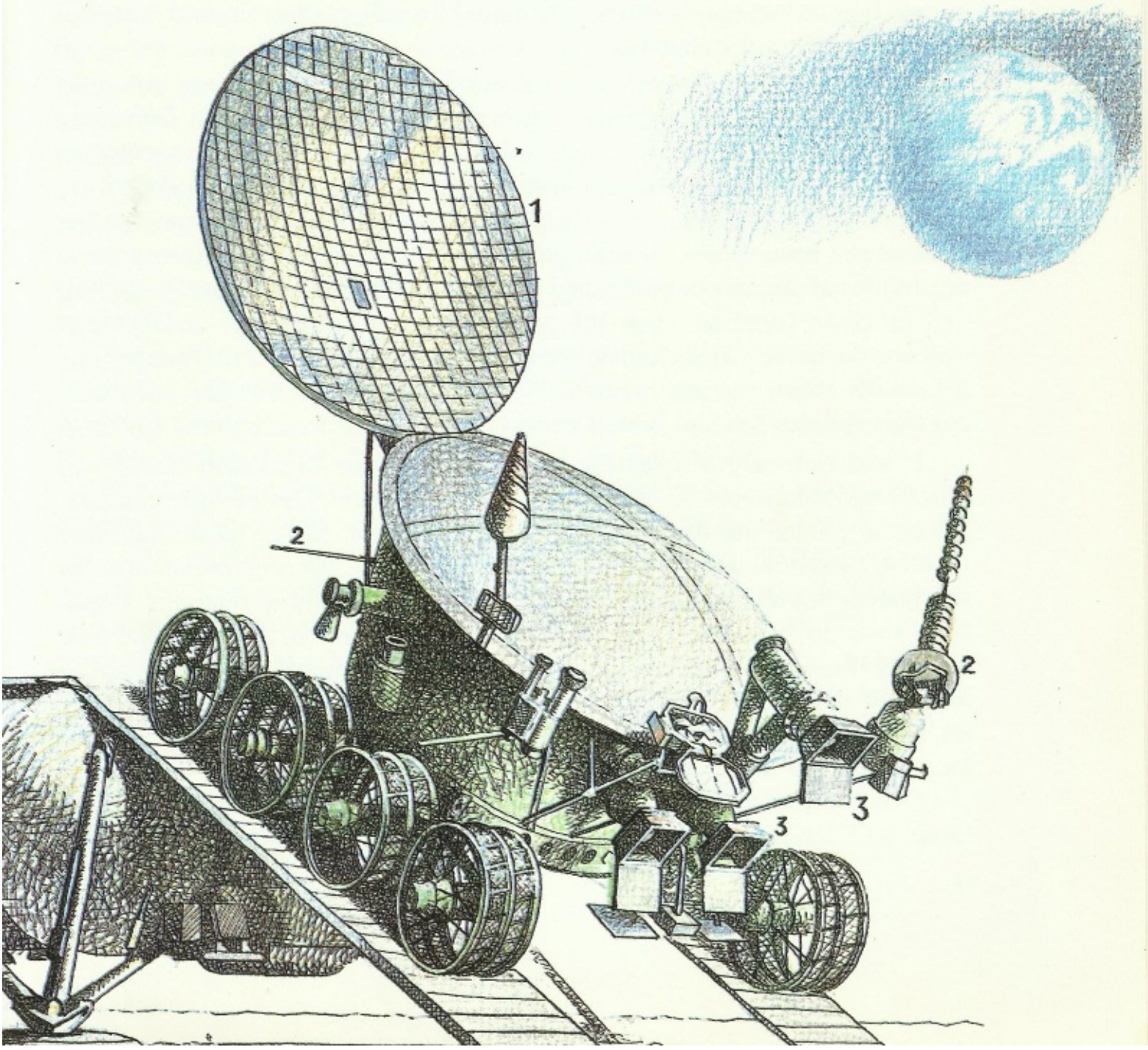
Lunokhod rolling off the landing stage
1 — solar battery panel;
2 — antennae;
3 — TV cameras



to the strongest G-force. But it must withstand everything and bring the soil to the Earth.

The lunar probe landed on the Moon in the fall of 1970. The four metal legs stood firmly on the rough surface of the Sea of Fertility.

Now it had to take the soil sample. On a command from Earth the manipulator arm with the bore moved down. The mechanism began to work. The soil turned out to be loose and the bore broke it easily. A thirty-centimeter sample was obtained. The arm moved up to the container



and put its catch into the sphere. A powder explosion tightly sealed the container cap. The engine of the recovery rocket was fired, the station rose into the sky and headed for Earth. The sphere with the precious load was flying home.

Babakin remembered that when the rocket took off from the Moon men at the control center hugged each other and laughed. It was the first time an automatic rocket had taken off from the surface of the Moon. But the station still faced the flight back and all the difficulties of re-entry. As it approached its planet the station began to signal its position. Then the aerials of the powerful radars on Earth began to probe the atmosphere for electrical traces of the container. When the parachute opened the radio transmitters of the sphere began to work again. It was located by these signals while still in the air and watched from copters until it landed.

"Of course we were glad to have achieved such a precise re-entry. It was the first time in history that the Moon-Earth flight was made without corrections! But still the few seconds from the time the station entered the atmosphere to the first report that it had been spotted were tense. Everything depended on automatic control. As soon as the station entered the atmosphere communications were lost with it. There was no possibility of intervening during these seconds. Perhaps the petal cap had failed to function, then the parachute would not open and the station would be smashed, and nothing could be done about it. You're like a helpless child, terribly worried," recalled Babakin. But the automatic controls did not let him down: everything worked precisely and on time!

It was not easy to create a good machine for the Earth but it was much more difficult to make one for the Moon. Judge for yourself. There is no air on the Moon, and in a vacuum metal parts may fuse together, particularly those that should revolve. Moving parts must be lubricated, but the usual oil immediately evaporates in a vacuum. A special lubricant was necessary. Then there were the extremes of heat and cold. In the daytime the temperature on the surface of the Moon rose to plus 120 degrees and in the night it fell to minus 150 degrees. Under all these conditions the lunar machine must work reliably and over a long period of time.

Two months had not passed since the day the container with the lunar soil landed when the whole world began to talk about a new

miracle of space technology. A Soviet lunar vehicle, Lunokhod, had landed on the Moon. Science fiction writers had often depicted space vehicles. Most often these moved on legs like spiders. The Lunokhod moved on wheels but special, very light ones. This mobile automatic station was also designed in Babakin's department. The designers of the Lunokhod were particularly worried about how to control the unusual vehicle from the Earth four hundred thousand kilometers away. The radio signal takes more than a second to get to the Moon. This meant that the Lunokhod would not immediately carry out commands from Earth. There were craters, crevices and stones all round. Anything could happen.

TV cameras served as the eyes of the Lunokhod. The driver could see part of the lunar surface on the screen. The picture would appear for a few seconds and then would be replaced by a new picture. It was very strenuous work to drive the Lunokhod. That was why it was controlled not by one person but a whole crew — commander, driver, navigator, engineer and operator.

People for the Lunokhod crew were selected almost as rigorously as cosmonauts. A Lunokhod driver also needed a strong heart, excellent vision, good memory and nerves of iron. Those who passed the special medical check-ups learned to drive the Lunokhod on a special track built on Earth.

The vehicle worked during the Lunar day (which lasts two weeks). At night it stopped and waited for the Sun to appear again. With the first rays of the Sun the convex lid with the solar batteries slowly opened. It supplied the motors and instruments with electric power.

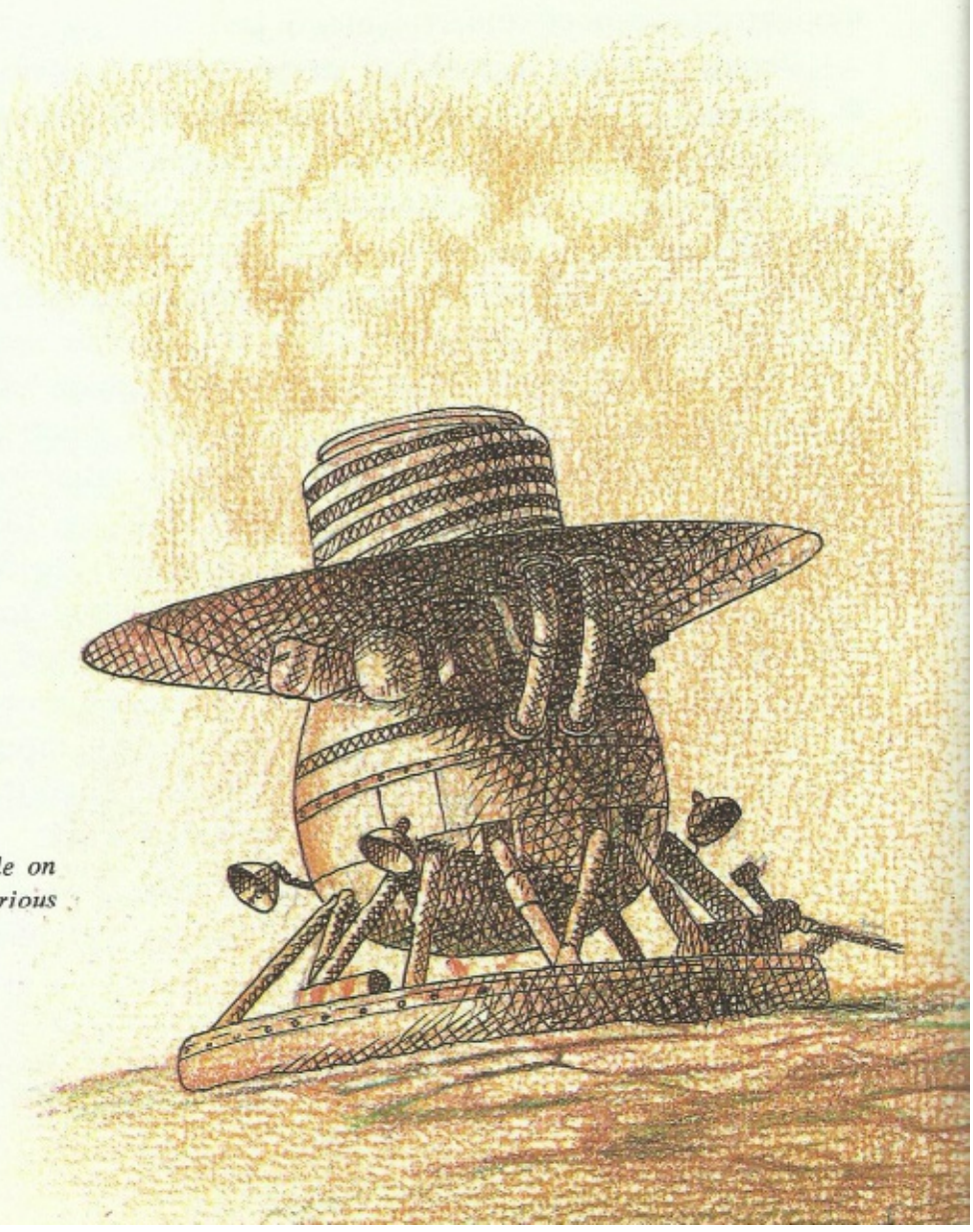
The Lunokhod was a mobile research laboratory. It measured the density and composition of the lunar soil in different places. Space rays were studied. And of course pictures of the Sea of Rains through which the Lunokhod travelled were transmitted to Earth. Although its intended term of service was over, the Lunokhod continued its trip. It worked for ten and a half months and travelled more than ten kilometers on the Moon. Its TV eyes transmitted twenty thousand pictures of the plain surrounded by mountains to the Earth. Then the relay was taken up by Lunokhod 2 which also did remarkable work.

HEADED FOR VENUS

Every planet has its mysteries. Red Mars is filled with secrets. The giant Jupiter is an enigma. Very little is known about distant Pluto. But probably the most enigmatic of all is Venus.

Venus becomes visible as a bright star in the east before sunset. In the evening it shines in the west. Some people thought that the morning star and the evening star were different planets.

It is the closest planet to Earth. The smallest distance between the Earth and Venus is about forty million kilometers. In size and weight Venus is almost the same as the Earth. Like the Earth it is surrounded by an atmosphere. And it gets about as much solar heat as our planet. It would seem that natural conditions on the sister planets must be similar.



The Venus 14 landing vehicle on the surface of the mysterious planet

Observing Venus through a telescope astronomers always felt frustrated. They saw a little yellow circle, with strips and spots, and nothing else. A dense layer of clouds constantly screened the surface of Venus. Only recently, when radio waves began to be used to study the planets, scientists managed to learn something about Venus.

It turned out to be a very hot planet. Its surface is like a frying pan with a temperature of several hundred degrees. There is a lot of carbon dioxide and almost no oxygen in the atmosphere. Venus revolves in the opposite direction as compared to the Earth and all the other planets. A day lasts almost two months, and a night as long. There are no seasons. It is always a very hot summer.

Astronomers learned some facts about Venus, but arguments did not abate. Scientists continued to have a very vague idea of the composition and density of its "air", what the clouds consisted of and the pressure on the surface. It remained only to wait for space vehicles with instruments to land on the mysterious planet and transmit everything they would see, measure and study. Such probes had to be designed.

There were heated arguments in Babakin's office. The scientists had reason to argue. Data concerning Venus, particularly its atmospheric pressure, were extremely varied. Some insisted that it was less than on Earth. Others warned that it was a hundred times greater! The body of the probe would have to be very strong. But this would make it very heavy, and in space technology every nut, every lid and every instrument had to be as light as possible.

One of the first Venus probes was built to withstand a pressure of ten atmospheres. Such is the pressure in the sea at a depth of a hundred meters. But the vehicle was crushed by the atmosphere long before it was to land. Then a Venus probe intended for twenty-five atmospheres was made. It was also a failure. Only the Venus 7, made to withstand an enormous pressure of a hundred atmospheres, successfully reached the surface of the hot planet.

It is possible to fly to Venus only on certain days. Every nineteen months there comes a moment when the relative position of the Earth and Venus is most favourable for the interplanetary trip. Still, it's more than three hundred million kilometers or four months of continuous flight.

The designers of the Venus robot had to solve an unusual problem.

Previously all spaceships and lunar stations were intended to work in a vacuum. Now the task was even more complicated. Designers of the Venus probe felt as if they were making a vehicle for the study of the sea depths. Only even worse. In the sea at least there was no heat like on Venus. The station would fly into the atmosphere of Venus at an enormous speed and turn red-hot, each part and instrument becoming four to five hundred times heavier! Yet the station must survive all this, reach the surface and then work for a given time span.

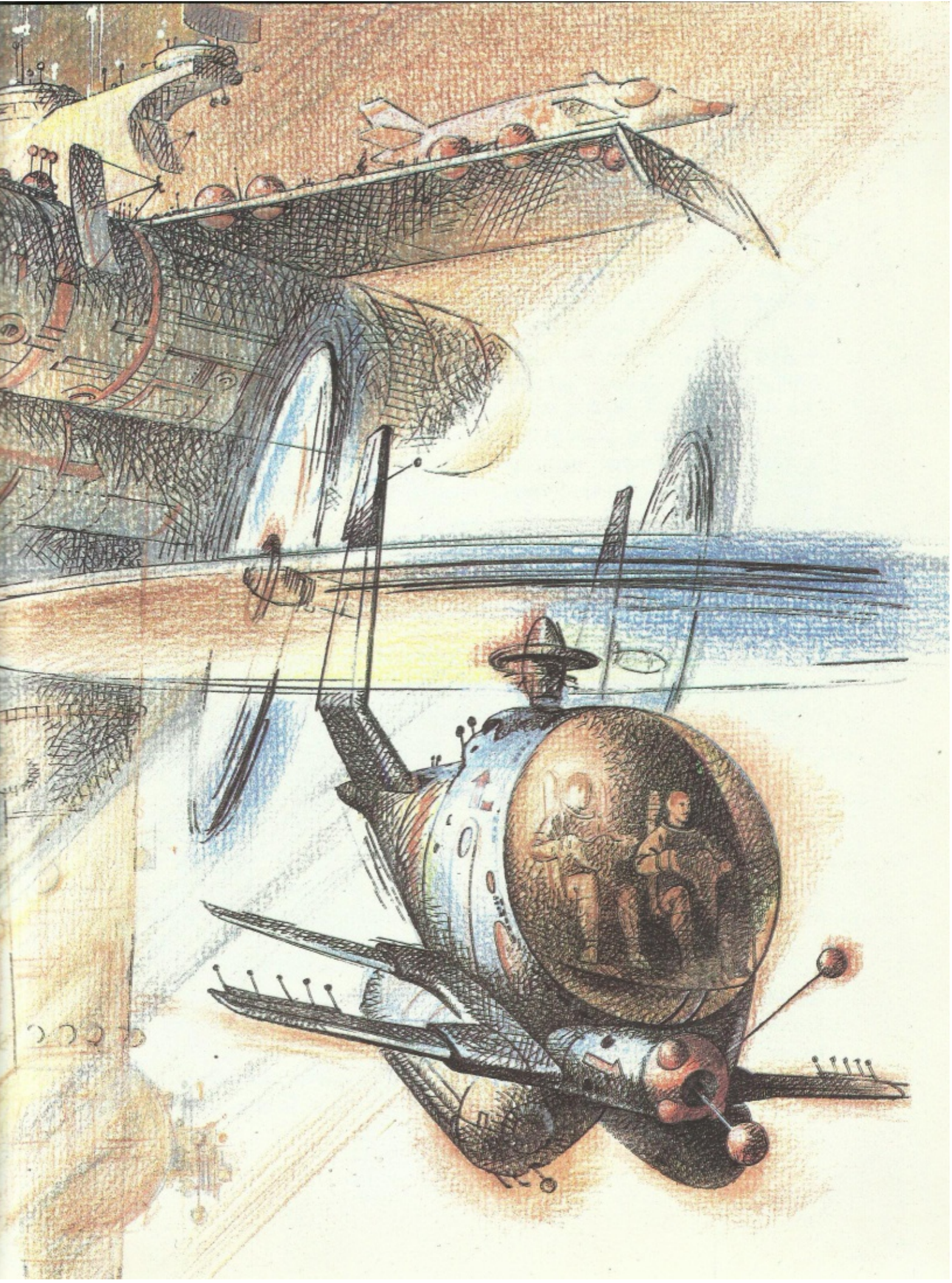
Every station must have an orbital module and a landing vehicle. The module contained instruments and rocket engines. It either flew past Venus or was burned up in its atmosphere. The surface could be reached only by a landing vehicle, a large sphere protected by a heat-resistant shell.

Before the station set out for the long trip, exact replicas passed the most difficult tests on Earth. They were spun on a centrifuge, a special merry-go-round, and tested under rapid acceleration. They were tested in high-pressure chambers and shaken on vibration tables. They were subject to heat and cold. Scientists were particularly hard on the landing vehicle. It was heated to a temperature of several thousand degrees to see whether it protected the instruments inside from overheating.

The first station flew into outer space in the fall of 1981. A second set out five days later. They flew along an enormous arc for more than one hundred twenty days until they finally came close to the target. The landing module separated from station number thirteen. It burst into the atmosphere of Venus. Its speed sharply reduced, and then the parachute opened. Instruments began to study the clouds and the atmosphere.

When there were several dozen kilometers left to the surface of the planet the parachute was automatically discarded. The module picked up speed, but then a special brake flap played the part of the parachute. The landing vehicle with the flap resembled a broad-brimmed hat. The density of the Venusian atmosphere was so great the flap was quite sufficient to assure a soft landing.

The module stood on the hot surface. It had landed on a plain. Conditions were terrible. The temperature was four hundred fifty degrees! The pressure was ninety atmospheres, similar to that in the ocean on Earth at a depth of nearly a kilometer. Not a minute was to be wasted. The module's "eyes" opened and TV cameras began to film the area. For the first time scientists saw the surface of Venus in color.



It was brownish and in some places dark brown. There was almost no blue color. And even the Venusian sky was reddish-orange. While the transmission was under way a manipulator arm took a sample of the soil and fed it into the station's automatic laboratory for study. This was also a first.

The Venus 13 landing vehicle operated for about two hours, much longer than expected. And the Venus 14 station following it did just as well, although it landed on an even hotter place.

The Venus 15 and Venus 16 interplanetary stations set out for space a year and a half later. They were intended to become Venusian satellites and create a map of Venus. But how could they peer through the thick clouds? Both stations had special radars for the purpose. The radio waves easily passed through the clouds, reached the surface of Venus, were reflected, returned to the station and were relayed back to Earth. The radio rays explored the planet's surface and drew a detailed and clear map of Venus.

Scientists believed that the surface of Venus was equally hot in all places. But the station discovered mysterious spots in which the temperature reached 700 degrees. Were they erupting volcanoes? Scientists tend to think so.

However, this is only a theory. Research is being continued, and the most interesting and extraordinary experiment thus far was the flight of the Soviet Vega 1 and Vega 2 automatic stations.

The Vegas were launched from the Baikonur space center on cold December days in 1984. Everything happened according to schedule. The stations flew to Venus six months later, their modules made soft landings on the surface and launched balloons with instruments.

Venusian clouds proved to be frightening: they were filled with dangerous sulphuric acid. The clouds moved at the speed of a hurricane. Imagine how durable and reliable the stations' instruments had to be not to fail during the long and difficult flight!

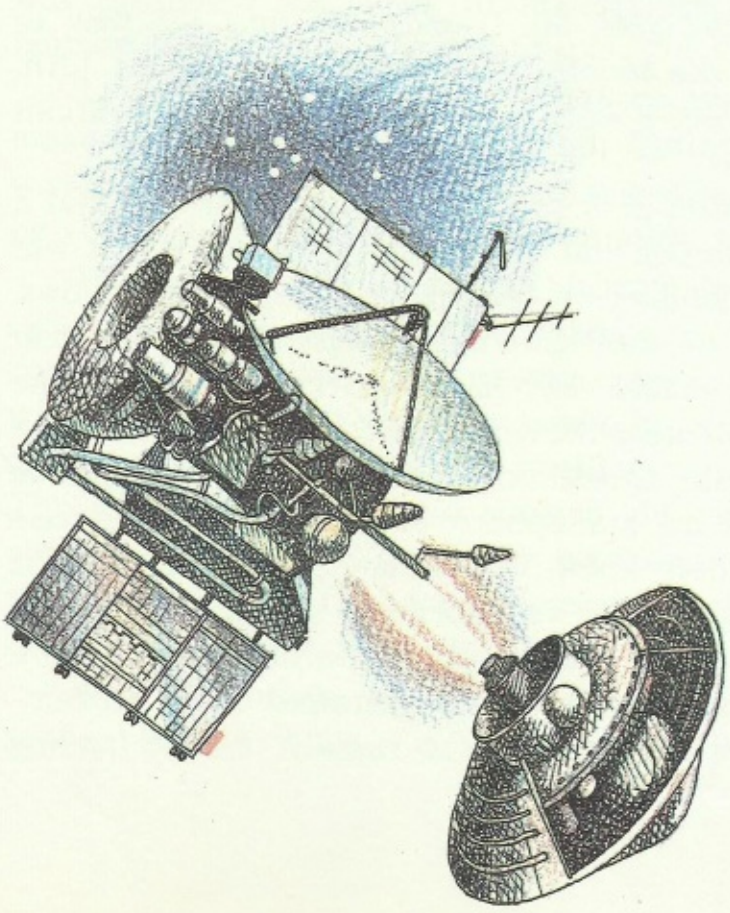
The wonderful instruments were developed with the participation of scientists from many countries — Austria, Bulgaria, Hungary, and Czechoslovakia. They helped Soviet scientists prepare for this remarkable expedition.

But let's take another look at Venus. Why is it so hot? Why is the atmosphere so different from the Earth's? What is the planet's inner

structure like? These questions remain to be answered. In order to study Venus fully we need vehicles capable of working there for weeks, months and even years and moving on the surface and above the planet. Can such vehicles be created to resemble balloons, airships and planes? Engineers decided they could.

Their calculations also showed that three kinds of vehicles were needed. One to fly at high altitudes where it was cool and the pressure low. Another to travel above the hot surface. Finally, a third, to link the high-altitude vehicles with the low-altitude ones.

The first resembled balloons and airships. Filled with a light-weight gas they would float in the atmosphere. But the Venusian balloons did not have to be round. Scientists believe that it would be better to shape them like doughnuts. The atomic engine would be installed in the hole. Rockets returning to Earth could easily take off from such a balloon. And the Venusian airships could be furnished with wings to add lift. The result would be part plane part airship. The doughnut balloon would have a long cable with instruments suspended on it. Then the high-altitude vehicle could be used to study the hottest layers of the atmosphere.



The interplanetary station fell into two parts over the red planet Mars. One part became a Martian satellite, the other, the landing vehicle which flew down to the surface

Small balloons had already flown in the Venusian sky. But it has still not been possible to build low-altitude Venusian vehicles. The most difficult thing is to make vehicles to link the high-altitude and low-altitude vehicles. These would have to fly at all altitudes. Projects already exist. Some resemble sharp-snouted winged fish. Others are like copters.

Terrestrials will begin to colonize Venus with time. At an altitude of about fifty kilometers the temperature and pressure is the same as on the surface of the Earth. It is at this altitude that people will settle on large balloons.

Eventually, people will probably change the atmosphere to make it like the Earth's. To achieve this scientists propose to bring quickly-reproducing plants, seaweeds, to Venus. They would be nourished by carbon dioxide. Absorbing the gas, the seaweeds would give off oxygen. It has been estimated that it would take only about a hundred years to completely change the Venusian atmosphere.

THE RED PLANET

One day Georgi Babakin assembled the designers and said:

"This is what I want to tell you, my friends. It's time we flew to Mars. We've learned to fly to the Moon and Venus, now it's Mars' turn. It's a most interesting planet! But I warn you, it's an extremely difficult mission! We won't have it easy."

Indeed, there was no question of it being easy. It was hard to land a space vehicle on the Moon, harder still to land it on Venus. But it was hardest of all to make a soft landing on Mars. The reason is as follows.

On the Moon, which has no atmosphere, the station does not heat up when it descends. Only a reliable retro-rocket is required there. The dense Venusian atmosphere threatens the spacecraft, but at the same time it serves as an excellent brake. Conditions are quite different on the red planet, Mars. It also has an atmosphere but a very rarefied one and that is its danger. Designers knew that when the landing vehicle would hit the Martian atmosphere at an enormous speed, the braking force would be tremendous. The vehicle would be burned up if it were not protected. But once it had lost speed, the rarefied Martian "air" would be unable to prevent it from falling too rapidly. A safe landing

on Mars required the station to have a parachute the size of a city square which would not fit in the landing vehicle. That was why it was necessary to use all three kinds of brakes on this planet. First, the vehicle would be slowed down by the atmosphere. Then a parachute would be opened. And finally, a quite powerful retro-rocket would be fired.

One of the Soviet Mars stations was launched in the spring of 1971. It was to travel four hundred seventy million kilometers, much farther than the flights to Venus. Of course much more time would be required for the flight: six months. Moving towards Venus the stations came closer and closer to the Sun. Designers were afraid that the Venus stations would be overheated. The Mars station, on the contrary, moved further away from the Sun, and now there arose the danger of freezing the instruments.

Like the Venus stations the Mars probe had an orbital module and a landing vehicle. But the latter was quite different. It resembled the automatic lunar station which made the first soft landing. It had the same round body and extended lobes of the antennae. Only the size was bigger. And it was put into a sphere which was to separate into two parts after the descent to Mars and release the vehicle. The sphere, in turn, was protected by a cone resembling a mushroom cap. The cone was to absorb the shock of the Martian atmosphere and prevent the landing vehicle from overheating.

Soviet scientists and engineers were preparing a vehicle which would make the first soft landing on Mars. During tests on the Earth the sphere was to be dropped to see whether it would come apart, the station would be released and stabilized, and the lobes would open.

The sphere was suspended at a height of twenty meters. It was swinging slightly. Everyone left the site and entered the shelter. The command was given to drop the sphere and it fell on concrete slabs with a crash. Only cameras could be heard whirring in the ensuing silence. A minute passed and nothing happened. What was the matter? The sphere lay there and showed no intention of coming apart. To approach the sphere, check the mechanisms and switch them off meant risking one's life. If the quick-release locks were to explode a person could be torn in half.

All of a sudden, a man ran towards the sphere. Everyone was aghast. It was Yevgeni Maslyayev, the test engineer. He was usually

slow and relaxed, and no one expected him to act like that. After running about ten meters, Maslyayev began to approach the sphere very carefully. He tread softly step by step. Finally he was at the vehicle. Everyone waited with bated breath. Maslyayev put his ear to the sphere: it was quiet. The programmed mechanism operating the release was not working. Carefully, like a mine expert, he screwed open the lid and turned off the mechanism. Now the quick-release locks were no longer dangerous. The reason for the failure was quickly discovered, and it never happened again.

Later Maslyayev was asked how he had the courage to do it. He replied: "I was in charge of the tests. And I imagined the rocket in outer space, flying millions of kilometers, approaching Mars, landing and all for nothing! We just had to find out what the trouble was! There was no other way."

The station flew to Mars six months. But it only took three minutes to reach the surface of the planet. Yet what difficult minutes they were! The vehicle was flying protected by the cone. The speed was decreasing. The parachute could be opened, but not completely so as to prevent too strong a shock. The parachute trailed along shaped like a pear. A few more seconds passed. Now the canopy of the parachute could be opened completely. And the protective cone was no longer needed: it was discarded. A retro-rocket was automatically fired about thirty meters above the reddish Martian surface. The parachute was released and carried away by another rocket.

It was in this way that an automatic station landed on Mars for the first time. At the same time another part, the orbital module became an artificial satellite of the red planet. The satellite photographed Mars and studied its atmosphere. How many thrilling ideas had been proposed about the nature of Mars and the enormous network of irrigation canals dug by Martians to save themselves from dying of thirst. The pictures and instruments showed that there were no canals or other artificial structures on Mars. The climate was very cold. Even on the equator the temperature never rose above plus twenty-five degrees. At night it plunged to minus ninety degrees. And this was in the summertime! The atmosphere was so rarefied that a person could not live there for even a minute without a space suit.

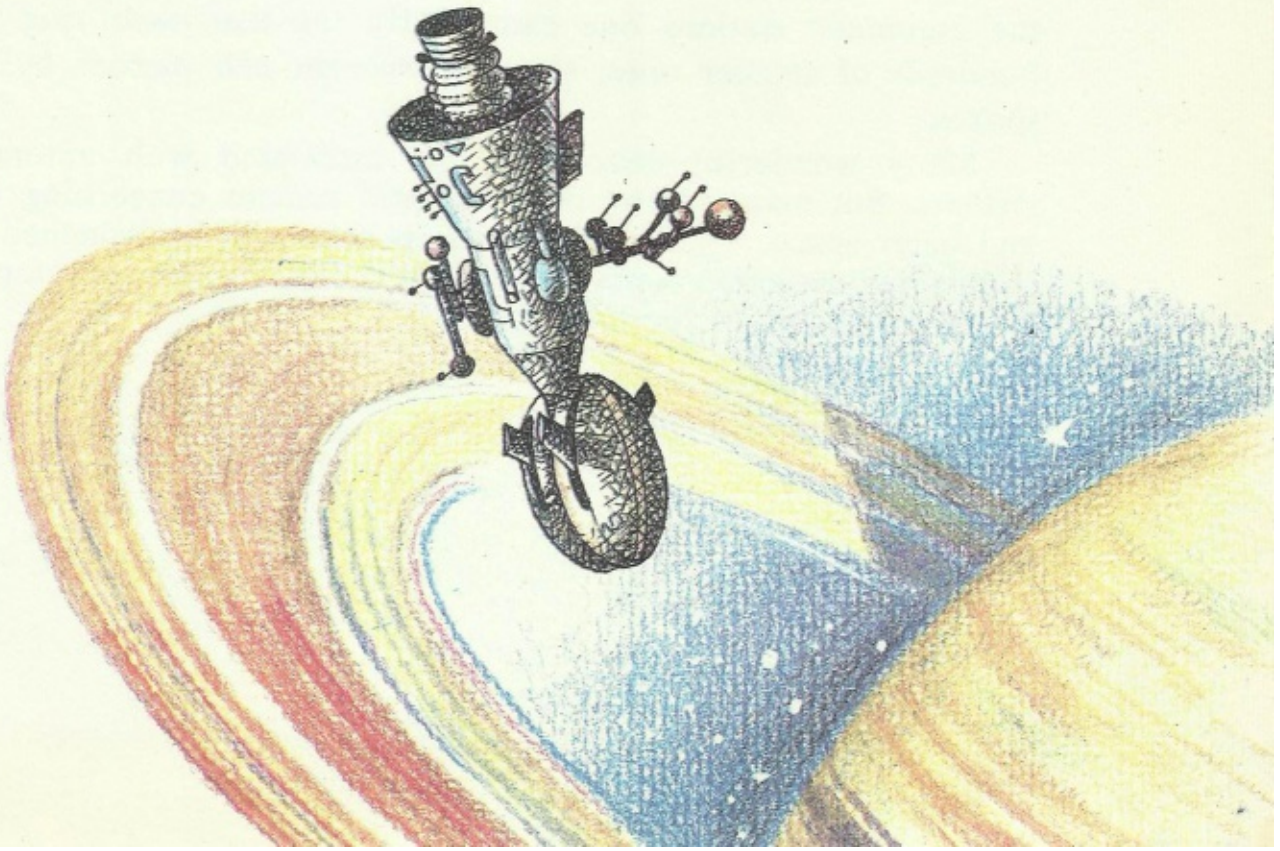
The legends about the canals and intelligent Martians had to be

rejected for good. On the other hand, volcanoes of enormous height were discovered. The Martian volcano known as Olympus is twenty-four kilometers high. The Arsia volcano is still higher — twenty-seven kilometers. The crater of Olympus is sixty kilometers across, Arsia — a hundred. There are no mountains or volcanoes like that on the Earth. Gorges discovered on Mars are several kilometers deep, several dozen kilometers wide and many thousands of kilometers long. The gorges are separated from each other by remarkable flat-topped mountains.

American probes landed on Mars after the Soviet stations. Pictures were taken of two Martian satellites — Phobos and Deimos. It had been thought that perhaps the satellites had been put into orbit by Martians, but they proved to be giant rocks.

It was learned that there were no intelligent creatures on Mars. But perhaps there were animals, plants or microbes? The chief purpose of the American probes was to find out. First they began to photograph the surface. The high-quality color pictures showed a reddish desert and rosy sky. Not a single tree, bush or blade of grass.

Then a robot began to search for microbes. The three-meter long manipulator arm picked up some soil and poured it into a biological laboratory. The soil was put into a nutrient solution. If the Martian microorganisms liked the nourishment they would begin to eat it and



emit gases. Gases did appear in the laboratory. Did that mean microbes exist? It is still impossible to give a definite answer. Other experiments yielded negative results. Scientists are still arguing on the subject. Apparently, to provide a final answer to the question of life on Mars, more complicated, improved automatic stations must be sent there or we must wait for cosmonauts to land on the planet. Scientists believe that rivers flow "underground" on Mars and large seas are hidden there. Perhaps there could be living creatures?

Mars is far away from us. But there are even more distant planets: Jupiter, Saturn and Uranus. Jupiter is the largest planet orbiting the Sun. It is one thousand three hundred times larger than the Earth. The world of the giant planet is extraordinary. The Earth has one natural satellite, the Moon, Jupiter has sixteen. American scientists have sent two automatic stations to this giant planet. Jupiter's pictures were transmitted back to Earth. But the most interesting were the pictures of its satellites. It turned out that the small satellite Io is a land of fire-breathing volcanoes which throw stones and gases two hundred kilometers up! It is all yellow, red and black fire. But the satellite Europa is covered by ice. Its smooth icy surface is crisscrossed by crevices. Ganymede has a network of troughs. Callisto is entirely made up of craters. Each satellite has its own remarkable feature.

The stations flew past Jupiter on to Saturn. That planet is surrounded by remarkable rings. It was impossible to see what they were made of through a telescope from the Earth. Yet on the pictures transmitted from the automatic stations one can clearly see that each ring consists of hundreds of smaller ones, some interwoven and pierced by mysterious spokes.

Many wonderful discoveries are associated with automatic space stations. But many, many mysteries still remain concerning the planets and outer space. This means that new ships will be launched and space technology designers continue to work at full strength, developing unique interplanetary ships for the future.

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