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WILFRED BURCHETT and
ANTHONY PURDY

COSMONAUT YURI GAGARIN

FIRST MAN IN SPACE–

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WILFRED BURCHETT
and ANTHONY PURDY

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With 32 pages of
half-tone illustrations

A PANTHER BOOK

COSMONAUT YURI GAGARIN
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CONTENTS

INTRODUCTION: Interview with Professor Fyodorov, one of the leading scientists in charge of the Soviet Space Programme 7
1 WELCOME HOME 11
2 TAKE-OFF 21
3 U.S. *v.* U.S.S.R. 29
4 THE FIRST RUSSIAN ROCKETEER 34
5 ROCKETS IN WAR AND THE EARLY SPUTNIKS 40
6 TRACKING—NEW CHAIN OF SKY-SPIES 54
7 SPACE-DOGS, THEIR SCHOOL AND TRAINING; THE HISTORIC FLIGHT OF STRELKA AND BELKA 65
8 GAGARIN 87
9 GAGARIN: THE TRAINING OF A COSMONAUT 100
10 "108 MINUTES" 110
11 GAGARIN: THE FIRST INTERVIEW WITH WESTERN JOURNALISTS 118
12 THE MOON NEXT? 124
13 THE ROBOT BRAINS THAT THINK 135
14 MARS? THEORIES AND PROBABILITIES OF LIFE ON THE PLANET 140
15 VENUS PROBE 155
16 SCIENCE FICTION IN RUSSIA 167
17 PROFIT AND LOSS 173
About the Authors 183
Index 185

INTRODUCTION

On April 12, 1961, Yuri Gagarin crashed through a barrier that has kept Man imprisoned since the day when he first learned to walk upright. He is the hero for his courage in risking the unimaginable dangers of the greatest unknown except death itself. But Gagarin's achievement was the climax of stupendous effort by what is perhaps the greatest team of scientists and engineers ever to pursue one purpose. In backing from their government, in time, manpower, money and material, their resources were limitless. But still they could have failed. That they did not is apparent; but why they did not, and how they actually performed the feat of putting a man into space . . . that is a subject to provoke argument for many years to come.

Even with all the facts it would be impossible to give a complete answer. But facts about the Soviet space programme are rare—or, at least, not as abundant as some hard-pressed Western scientists would like. Wilfred Burchett and Anthony Purdy set out to find every fact they could in order to fill in some of the gaps and answer some of the questions. Burchett has travelled thousands of miles through the Soviet Union, visited scores of laboratories, factories, observatories, universities and research stations. Together they interviewed scores of scientists and space-workers, including Gagarin himself, and read hundreds of thousands of words, from rocket-history to science fiction.

The Russians were courteous, interested, and helpful, within their obvious limits. Here is an account of their first interview, with one of the leading scientists in charge of the space programme, Professor Eugene Fyodorov, who contributed as much as any man to the making of Yuri Gagarin's 108 historic minutes.

We climbed a wide, wrought-ironwork staircase laid out with thick-pile red, white and blue carpet to the first-floor office of Academician Fyodorov. His secretary, a trim, attractive, fair-haired girl, dealt with a stream of telephone calls at her crowded desk while the minutes ticked by to three o'clock.

Precisely at three she led us into the Academician's room next door. Fyodorov is a bulky man, with pale blue eyes that are quick to smile, a formidable jaw and forehead and large, capable hands. He looked the picture of an executive scientist; calm, efficient, immensely knowledgeable and cultured. With his interpreter and ours, we sat at a long highly polished table under a huge map of the world, with five red flags pinned in the Atlantic and Pacific Oceans and the Black Sea. "You see," he joked, "our secret rocket stations."

On another wall was a large-scale geophysical map of Russia; on the third, a portrait of Lenin.

"Now," he said, "we can discuss your questions. Firstly, Gagarin; the results of his flight came fully up to our expectations. The chief point, I think, that we established was that in prolonged weightlessness there are no ill effects, no unpleasantness that we did not know about. He worked very well during this period and did everything demanded of him. I am not an engineer, but I know that as a result of the spaceshot we were able to improve and elaborate the cabin."

What was his opinion of the U.S. success in putting a man into a ballistic rocket? He shrugged. "Firstly, we are very pleased that they have been able to do this; it represents a new stage in research and a success for American science. We bypassed it because, frankly, we considered that this up-and-down flight is much simpler than putting a man into orbit, and we were more concerned with such problems as re-entry and descent.

"We carried out these up-and-down flights before—not with a man, but with animals, mice and so on, saving the bigger-sized rockets for bigger experiments. As for the Americans claiming to have produced more scientific data from such a flight, I cannot say. I have not seen their data yet. I don't see the point of the claim concerning the manual control by Commander Shepard; Gagarin was able to control his space-ship himself if necessary, but it was not."

He discussed a claim in the London magazine, *New Scientist*, that "absolutely no scientific purpose had been achieved by the flight of Major Gagarin." With a trace of a smile, he commented: "It is the same with any achievement. Once it has been done, there are always people who say something else should have been done. If Major Gagarin had landed on the Moon, someone would have said: 'There's nothing special about that,' and would have suggested that he should have gone on to some other planet.

"We consider that this first flight was essential. Without this first step, others would not be possible."

What have the Russians learned about cosmic radiation following the recent flights? "Very much. A great deal is known in regard to radiation screening with metal jackets and so on. We know enough, for instance, for a flight to the Moon to be possible with passengers."

For such a flight, which did he consider more important scientifically—a manned or robot landing first? "Much fuller results," he said, "would be achieved by the flight of man. In cosmic research, perhaps in this more than any other field, we can be faced with unexpected circumstances. A man can decide on the spot what to do, whereas with instruments, they perform only a pre-planned programme which cannot take the unexpected into account.

"It is quite clear, however, that a robot flight is much easier, at the technical level we have reached today, and it is possible that a robot goes initially, followed by a man. A few dozen years ago it was the other way round: first the man explored and machines went in later. In space, instruments probe first."

What contribution can countries such as Britain make to space research, without satellites? "It is not necessary to have sputniks. Any country can add to theoretical research. Jodrell Bank is an important case in point. The radio telescope there is of tremendous assistance in discovering the nature of space. We do not have one of such size in Russia, nor will we have one in the foreseeable future. Of a different kind, perhaps, but Professor Lovell has always helped us in the past when we needed his assistance, so such an instrument would be unnecessary here. We do, of course, have much smaller versions, and we have one being planned which will work on a different principle."

Asked about the possibilities of future international co-operation, Professor Fyodorov said: "There are two organizations working along these lines: the International Astronautical Federation and C.O.S.P.A.R. Both of these hold meetings and conferences at which we discuss reports and the results of our research. All of us think that this could and should be developed. Especially we think that disarmament could help bring us closer. We would be pleased to share our knowledge, and to receive the benefit of Western knowledge, if we knew it would be used for peaceful purposes by the whole world."

I

WELCOME HOME

AT midday on April 14, 1961, an *Ilyushin*-18 plane, escorted by seven *MiG* fighters, swept over Vnukovo Airport and on to circle low over Moscow. The Man from Space was about to arrive. Half an hour earlier a similar plane had brought Khruschev from an interrupted Black Sea holiday at Sochi. The airport was decorated with flags and bunting and slogans hailing Yuri Gagarin, Conqueror of the Cosmos. Party and government officials, marshals and generals, leading scientists and engineers who had built the space-ship, ambassadors and the world press, delegates from factories and offices were gathered in a huge, expectant crowd as the silvery plane touched down and taxied up to the end of a long red carpet.

As the single uniformed figure stepped out and tripped nimbly down the gangway, a wave of applause rolled across the expanse of tarmac. A band struck up an old Soviet Air Force song: "Fly higher and higher and higher." Journalists scribbled furiously in their notebooks, TV and cine-film cameramen zoomed in with their longest lenses to get the world's first glimpse of the world's first space traveller.

Yuri Gagarin, deceptively tall at first sight in his long military greatcoat, strode down that eighty yards of red carpet to the beginning of an ordeal that must, at moments, have made him pine for the silence and blissful state of cosmic weightlessness he had known so shortly before.

At the other end of the carpet, the distance closing rapidly, was Nikita Khruschev, a chuckling, happy figure, bubbling over with elation and pride, who, when the young major eventually stood before him, stood to attention to hear the report, now and again gravely nodding his head, but with the twinkle in his eyes never far away.

The speech over, the emotion was released; a full minute's all-embracing bear hug, while the two men exchanged unknown words, all but drowned beneath the roar of shouts, hand-clapping, stamping of feet, whistling and singing that through TV and radio was rippling out to every country in the world. Tears glistened in 80-year-old Voroshilov's eyes; President Brezhnev was speechless with delight. After the Soviet national anthem, Khruschev directed Gagarin into the arms of his wife Valya, his parents, brother and sister, waiting, slightly dazed by it all, in a V.I.P. pen below a battery of cameras and microphones.

Everyone of importance in Russia who could be there, was there, straining to shake the hand, or catch a glimpse of, the man who had seen and done things that no mortal had seen and done before.

The airport scene had all the elements of a great historic event, literally of cosmic proportions. And yet it was also very down-to-earth and human. Fortunately no one had the idea of putting father Alexei or mother Anna into special clothes for the occasion. There they stood, carpenter and peasant, dressed in the rough clothes of the hammer-and-sickle age they represented, he wearing his carpenter's cap, she her peasant's shawl welcoming the son who only fifty hours previously had been unzipped from his astronaut's orange space-suit and helmet. Father, not very comfortable among the great, doffing his cap now and again when someone smiled at him, rubbing his hands over the stubbly, shaven head. Mother fighting a battle with the tears of pride and joy that welled in her eyes and the need for courage and dignity worthy of such a son, such an occasion and such company. Valya, his gentle-faced wife, modestly in the background, her eyes glistening behind the spectacles.

Mother and wife need not have been ashamed of tears for this occasion. Tough President Brezhnev and old Voroshilov brushed away their tears too as the embraces and hugs and warm words of praise and welcome continued on the improvised tribune and the crowd strained forward to catch intimate glimpses of their hero. Then down from the tribune to be presented by Khruschev to the diplomatic corps—and what black-hatted, striped-trousered ambassador was not secretly a little thrilled to shake the hand that two days before had been at the controls of the space-ship.

Into an open, flower-bedecked car together with Khruschev and Valya, his wife, for a triumphal drive into the city. It was "flowers, flowers all the way." None could remember such a welcome and the general jubilation was said by Muscovites to be matched only by that on VE day. Official decorations for May Day had been hastily rushed up a few hours previously with City Council trucks laden with banners and flags and coloured lights racing around the city all night in a fever of activity. But the "unofficial" decorations were provided by a million or so Muscovites who packed the last ten miles of the built-up part of the route from the airport, bouquets of flowers in hands, flags with rocket silhouettes, pictures of Gagarin, slogans and banners and crying: "Now for the Moon," "On to the Planets," "Welcome Hero Yuri Gagarin," "Glory to Columbus of the Cosmos," and so on. Along Leninsky Prospekt and its three solid miles of new houses and shops—each balcony with its red banner—down into the older part of the town. Gagarin with his easy smile, Khruschev happier than anyone remembered seeing him before; Valya with her gentle unwavering smile and moist, bespectacled eyes.

People swept forward, narrowing broad boulevards into tiny rivulets along which the police had difficulty in squeezing the triumphal cavalcade. It was Gagarin's day and the people had taken over the streets. A riotously happy, improvised holiday by public consent.

Red Square, where a meeting was scheduled after the airport reception, was a sea of people and riot of colour. Between a huge portrait of Gagarin at the History Museum end and the 70-ft. high model of a rocket soaring into space at the St. Basil's Church end, the huge square was packed with just enough space for half a million paraders to file through after the speeches.

It was May Day and November 7 rolled into one. Party and government leaders with Gagarin as the focal point gathered on the Mausoleum tribune under which lie the embalmed bodies of Lenin and Stalin. Uniformed marshals and generals jostled for place with scientists, students and diplomatists in the granite stands below.

Nothing in Gagarin's ordeals of space training had prepared him for this. His own speech, to a crowd which madly cheered every sentence, was a brief one, mainly of thanks to party and government for having entrusted the first space flight to his hands; to the scientists, engineers and workers who built the spaceship, to all those who took part in preparing him for the flight. There was prolonged, tumultuous applause when he said: "I am sure that all my fellow space pilots are ready to fly around our planet at any time. We can state confidently that we shall fly our Soviet space-ships on more distant routes."

Then it was Khruschev's turn. He started his oration by listing the "noble moral traits, courage, self-determination and valour"; praised "this first person who for an hour and a half looked at our entire planet . . . viewed its tremendous oceans and continents . . . our pioneer in space flights . . ." Gagarin listened with the solemn, awed look of a man realizing for the first time that he had done something really big. "If the name of Columbus, who crossed the Atlantic Ocean and discovered America, has been living on through the ages," continued Khruschev warming up to his theme, "what is to be said about our wonderful hero, Comrade Gagarin, who penetrated into outer space, circled the entire terrestrial globe and returned safely to Earth. His name will be immortal in the history of mankind." And so on and much more.

Khruschev's words were aimed far beyond the hundreds of thousands in Red Square and the tens of millions elsewhere in the Soviet Union at their TV and radio sets. He was addressing a world audience of hundreds of millions. (For the first time, by a happy coincidence, the Gagarin reception celebrations were carried on direct telecast to the whole of Europe—to England by the B.B.C., to West Europe by Eurovision, to East Europe by Intervision.) It was a great historic occasion of which Khruschev was determined to make the most. And his voice rang with pride as he ran over the background to the Gagarin flight.

"Now when Soviet science and technique have demonstrated the highest achievement of scientific and technical progress, we cannot help looking back to the history of our country. In our mind's eye we cannot help seeing the years that have passed.... We have defended our state in the fire of civil war even though we were often barefooted and half naked. . . . When we stand beside the man who made the first space flight, we cannot help recalling the name of the Russian scientist and revolutionary, Kibalchich, who dreamed of flight to space but who was executed by the Tsarist Government. . . . It is with special respect that we recall the name of Konstantin Eduardovich Tsiolkovsky, scientist, dreamer and theoretician of space flights. . . ."

It was when Khruschev started reading out the awards—"Hero of the Soviet Union"—the first "Pilot Cosmonaut of the Soviet Union"—that the blinks started in Gagarin's eyes. They came faster when Khruschev started to eulogize his parents and the firm lips started to tremble at the warm tribute to his wife. The TV cameramen mercifully turned their camera lenses away for a while. It was a rather comforting moment to realize that a hero of outer space, conditioned to the most fearsome physical and psychological ordeals, can also produce tears; that the vibration stands and centrifuges had not annihilated emotions. "A fine woman, Valentina Ivanovna," said Khruschev. "She knew Yuri Alexeyevich was departing into outer space but she did not dissuade him. On the contrary, she gave her heart's blessing to this noble exploit of her husband, the father of her two little children. Remember that no one could completely guarantee that the parting with Yuri Alexeyevich would not be the last one. Her courage and realization of the tremendous importance of that unparalleled flight show the great soul of Valentina Ivanovna. . . . She demonstrated her fine character, her willpower and her understanding of Soviet patriotism."

There was terrific applause from the crowd when Khruschev referred to "not very clever people on the other side of the ocean" who refused to believe the news of the first Soviet sputnik launching.

"Now," he shouted, with a triumphant, ruddy smile, "we can actually touch a person who has returned from the sky." Khruschev dwelt for a moment on the wider implications of Gagarin's feat, what it meant for the future: "The flight of the 'Vostok' is only the first swallow in outer space. It soared aloft in the wake of our many sputniks and probes. It represents a natural outcome of the titanic scientific and technological work carried out in our country for space conquest. We shall continue this work in the future. More and more Soviet people will fly along unexplored routes into outer space and probe the mysteries of nature still further, placing them at the service of man and his well-being, at the service of peace. We stress," he said, and he became very serious, "at the service of peace. Soviet people do not want these rockets which can fulfil programmes laid down by man with such amazing accuracy, ever to carry lethal cargoes." And he repeated his earlier pleas to "the governments of the world" to take all possible steps towards "general and complete disarmament."

After the speeches—the monster parade. A mighty river of people with flags and flowers in hand and banners floating overhead, surging into Red Square. Every pair of eyes straining towards the trim, uniformed hero on the tribune. Impossible to miss him, wedged in between the beaming, ebullient Khruschev and a radiant Voroshilov. In the background the crenellated red walls of the Kremlin, the green-roofed cream palaces and churches, their golden domes and palace windows sparkling in the evening sun. How much history have those palaces and churches—and especially the noble Spassky Clock Tower that dominates the square—seen in their time!

But never a day like April 14, 1961, because the world itself had never known such a day.

Across the vast cobbled square the molten river poured, dividing up to leave that multi-coloured jewel of St. Basil's an island behind it, before joining up again for a brief descent to the Moscow River where it split up into tributaries carrying the components to their chosen place for continuing the celebrations.

Later that evening, the culmination of the day's rejoicing—a fabulous Kremlin reception. While some two thousand guests feasted and drank inside, the people thronged the streets and squares, and packed the bridges to admire the floodlit Kremlin towers. Etched against a sky exploding with myriad-coloured showers of fireworks and all reflected in the calm waters of the Moscow River. As the salvoes of the salute to Gagarin crashed out, the tips of the Kremlin towers were wreathed in smoke and with the bursting cascades of colour overhead it was one of those fairy-tale pictures that Moscow reserves for the very great occasions.

Inside the Kremlin, guests had gathered in the lofty St. George's Hall of the Grand Palace. Walls and pillars of milk-white marble, enormous gold and crystal chandeliers glittering overhead. Everyone who was anyone in Soviet public life was there. Delicate ballerinas and burly bemedalled marshals;

composers and scientists; circus stars and space technicians; diplomatists and journalists—and of course all the Communist Party and government leaders.

When the scene was set—Khruschev arrived with Yuri and Valya Gagarin, and parents Alexei and Anna.

Khruschev, bubbling over with pleasure as he had been all day, guided the group to the space at the head of the hall, reserved on such occasions for the very honoured guests, with party and government leaders and foreign diplomatists in their wake.

The formal part of the proceedings was soon over. President Leonid Brezhnev, a former engineer with a rugged face dominated by huge shaggy eyebrows, read the decrees of the Supreme Soviet conferring on Major Yuri Gagarin the titles of Hero of the Soviet Union and Pilot-Cosmonaut of the Soviet Union. Amid thunderous "hurrahs" and applause and much clinking of glasses, Brezhnev pinned on Gagarin's breast the Order of Lenin and the Gold Star Medal that go with the "Hero" title, and then embraced him. A brass band struck up a quickstep march which is the signal at Kremlin receptions to down some quick toasts. From that moment, the atmosphere was riotously gay and relaxed. Normally staid, reserved government leaders competed with each other to kiss and hug the hero. Minister of Defence, Marshal Rodion Malinovsky, a massive bear of a man with iron-grey hair and a normally severe expression, swept the cosmonaut high up off his feet in a crushing embrace which must have recalled the boost period at take-off. There were toasts and more toasts, from the Chief of the Air Force, Marshal Vershinin, from Khruschev again, from representatives of workers, peasants and intellectuals.

The whole Gagarin family were there among the leaders, including the wife of one of Yuri's brothers. Khruschev insisted there and then on a group photo of the Gagarin family together with himself, Brezhnev, Voroshilov, Malinovsky and Vice-Premier Frol Kozlov.

By this time with toasts and music and general gaiety, the parents were as relaxed as anyone else. Clad in dark clothes now, more befitting the atmosphere of a Kremlin reception. Father Alexei looked uncomfortable in his more formal clothes, but pride in his son's exploits overcame any uneasiness at this —or perhaps it was suddenly being thrust shoulder-to-shoulder with the most important in the land.

Throughout the Kremlin reception, as at the airport, a balance was struck between the sense of historic importance of what was being celebrated and the human down-to-earth side of things. The space hero was put on a pedestal, it is true —the highest in the land. No Soviet citizen had ever been so fêted and decorated in such a short time. (The pedestal is no literary allusion. Khruschev, from the tribune in Red Square, promised a bronze bust of Gagarin would be set up in Moscow and a special medal issued to commemorate the first manned space flight.) But every effort was also made to portray Yuri Gagarin as a very mortal bit of flesh and blood, a father, husband and son, with wife, parents, brothers and sisters like other ordinary humans. All entitled to a share of reflected glory. It would have been easy to have pushed him up to such cosmic heights that would set a spaceman apart from ordinary humans. As it was, most people, looking at that family group, watching their emotions, knowing their background, felt that Gagarin's feat was a great triumph for mankind itself. Soviet young men and women felt especially that there was nothing supernatural about Yuri Gagarin. Given the same chance and with the same grit to overcome training difficulties, they too could follow along the trail he had blazed.

Gagarin Day closed in Moscow with some of the greatest Soviet artists paying homage to the hero in a concert which followed the speeches and toasts.

Sviatoslav Richter, wearing the Lenin Prize medal awarded him only a few days previously for his great artistry, played Rachmaninov; ballerina Maya Plissetskaya outdid her usual brilliance in a scene from "The Little Hunch-Backed Horse." The best song and dance ensembles in the country danced and sang their legs and heads off while the vodka and champagne flowed among the guests.

Long after the Kremlin reception was over and official celebrations had finished, the crowds danced and sang in Red Square; packed Gorky Street and the Moscow River Embankment. Till the small hours of the morning, the city was alive with laughter and song to complete a day that can never be repeated. A day and night of homage to the first mortal to reach for the stars.

2

TAKE-OFF

A COOL, grey Russian dawn cast its long transparent shadows in the east wing of the Peter and Paul Fortress. The cells were cold and dank. The golden spires of St. Petersburg that rose into view from the square, barred windows were those of another world to the hopeless, listless prisoners inside. The executioners tramped along the long stone corridors, keys jangling, to stop outside the iron door of Nikolai Ivanovich Kibalchich, revolutionary, assassin, and scientist. His time had come; he was 27 years old, and on that April morning in 1881, he died on the scaffold, leaving history's strangest legacy.

Throughout his last night of life, the wild-eyed bearded inventor had scribbled feverishly his plans and theories for a machine that would release man from the bonds of earth and allow him to ride the sky with the Valkyries. It was the culmination of eighteen years of study, but, he told his friends dryly, the final solution had come to him while making the bomb that blew the Tsar to bits.

He sent his plans to the governor of the prison, with a request that he should be allowed to discuss them with some scientists before he died. His request was refused, and the plans were locked up in the secret archives of the Tsarist police.

They remained there until after November, 1917. By incredible chance, one of the by-now-victorious revolutionaries who opened the files for the first time recognized the writings and realized their worth; within a few days excited scientists were discussing the discovery and making mathematical calculations.

Russia was taking its first steps towards the stars.

At dawn on another morning in April, just eighty years later, another 27-year-old Russian was led out of his cell-like room—not to a scaffold, but to a rocket launching ramp. His name was Yuri Alexeyevich Gagarin, son of a carpenter, who was to be the world's first space pilot.

Two incidents, long separated in time, but intimately connected. For Gagarin was about to realize not only Kibalchich's dreams—of a manned space flight—but also to put to the test some of the young revolutionary's practical ideas. Those long-hidden notes had dealt with rocket engines, claiming emphatically that they were the only means by which man would ever leave the Earth—and describing in astonishing detail how they should be built.

His own "flying bombs," such as the one that killed the Tsar, were primitive illustrations of the principles he set down on paper in the last hours of his life. His theories of rocket engines and how they could be used to put man on the track of the stars were to guide generations of Russian rocketeers, and they were used in hurling the first astronaut into space.

When Yuri Gagarin went to bed on the night of April 11, 1961, he did not know that tomorrow was to be his day, the day that would in future generations always be connected with his name, the day when he would be the first man in history to see the whole of the Earth's globe. He was the first on the list of candidates, certainly, but many factors beyond his control stood between him and Vostok, whose take-off time was only twelve hours away.

At the cosmodrome living quarters in East Kazakhstan on the edge of an airstrip and launching site at Baikonur, 200 miles north of the Aral Sea, he slept peacefully, unaware of the anxiety of a handful of doctors and scientists, some of whom crept in occasionally to stare at his unconscious form. He had refused a sleeping pill.

Gagarin said good night at 9.45 p.m. and by 10.15 was asleep. He was the least troubled of the three-man team of astronauts whose fate hung in the balance that night. The doctors knew this from the readings they had taken shortly before, after the final briefing. At 9 o'clock his temperature was normal—36.7° C., pulse 64, blood pressure 115/75. But still they could not be sure of their final decision, for even with such a short time to go, there remained a doubt. The doctor in charge, Yevgeni Anatogevich, did not sleep at all that night. . . .

The other young men in that white stone building were not stand-ins for Gagarin. At midnight on April 11, they stood an equal chance, in this fantastic Russian-roulette-style-situation, of being fired into outer space at dawn. All three were, in some respects, supermen, trained to a pitch of physical and mental fitness that was scarcely conceivable. They were among the fittest men alive.

Yet Gagarin was different, with one factor that had stood out through all the gruelling tests that had led up to this moment. He had, the scientists agreed, a little more than the others; an inner calmness, an equanimity they could not match.

He, surely, was the man. But all that night the doctors watched and waited, even listening to his steady, rhythmic breathing. A draught from under the door, a cough, a scratch of his cheek, an involuntary twitch . . . any of these things would have changed his destiny.

At 5.30 a.m. a white-smocked doctor paused by his bed for a final look. He tapped the sleeping figure lightly on the shoulder. "Time, Yuri," he said softly. The blue eyes opened instantly, and he sat up.

"Did you sleep well?"

Gagarin nodded. There was a question in his eyes behind the one he asked: "Am I to get up?"

The doctor answered both with a smile. The lieutenant swung his legs to the floor, glanced at the framed picture of Valentina, his pretty, dark-haired wife, on the bedside table, and strode to the wash-basin. A shave, some limbering-up exercises, and he was ready for the day. It was a simple beginning to April 12, 1961.

A flock of anxious specialists now surrounded him. Gradually he lost his identity as a man as he was zipped into a series of envelopes that constituted his space-suit; a complex piece of scientific tailoring without which his blood would foam like boiling water when he got beyond the reaches of the atmospheric pressure, without which his body would be crushed to pulp under eight to ten times his own weight during take-off.

He chatted and joked while it was being fitted, and ate his breakfast—a dark-brown paste of concentrated calories and vitamins to which he had grown accustomed. Sensors to record his physiological functions were strapped and taped to his skin. Finally a pale blue fibre suit was pulled on, then a bright orange one. Trailing electrical leads, and surrounded by white-coated men and women, some with gauze mouth-masks, Gagarin moved out into the weak sunlight of dawn, a short, stocky, bizarre figure with a small head—as yet uncovered by the plastic helmet—emerging from a lumpy, ungainly protective cocoon.

He climbed into an Air Force bus, already half full of passengers who were to assist him in his historic ride. He sat next to a woman, Olga Apenchenko, correspondent of a Moscow newspaper, who was never to be able, for security reasons, to write the full story of what she saw.

Much later she did describe that short ride, however:

"A road was winding ahead of the bus beneath high, pale blue skies, but the end of the rocket launching range was not yet in sight. My idea of what this would look like had evidently been too naïve; as elsewhere, there were houses and roads and children scampering about, enjoying the spring sun.

"The river was swollen and by a clearing close to the bank sat a fisherman, an immobile figure of patience, home-made rod in hand. On the opposite side, a flock of wild duck circled. . . ."

She describes, too, a few of the shadowy, anonymous figures who made Gagarin's flight, Kibalchich's dream, a reality: "A dark-complexioned, rather severe looking man with massive features . . . chief designer of the spaceship, he had something more in him than he cared to show. I heard a light rustle around me when he appeared. It was difficult to say what this whisper expressed: awe, respect, a mixture of both, and something else.

"He entered the workshop and everything changed, somehow. The movements of the technicians became more collected and precise. It seemed that even the hum of the machines assumed a new overtone, intense and rhythmic. This man's energy stepped up the motion of shafts and cogs.

"The designer's glance scanned premises and people . . . I wondered what he would say to the cosmonauts. Very simply, with a gesture towards the rocket, he murmured: 'Well, it's time to go,' and added, 'I've already been inside to see how it feels.' "

Gagarin and his colleagues knew this man well; he lived on the base, and was a friend, as well as guide and instructor, to them. Every evening they would visit his home to have long talks which ranged far beyond the immediate future; for he, too, was a dreamer, as well as a practical engineer. He gave each of the three, two small copies of the pennant that already lay in the silent dust of the Moon's surface, fired there by one of his rockets months before. "Perhaps one day you'll pick up the originals," he had said, smiling.

At the foot of the massive, towering silver-and-black rocket, festooned with cables and coloured wire, a brief conference was held. Professor Vladimir Parin, from the Academy of Medical Science embraced him in a bear hug as the last clip in Gagarin's space helmet was pushed home. The professor drew back, laughing, with his hand to his face; the clip had cut his cheek. "A historic wound," he smiled. After cosmonauts Vladimir Mikhailov, 28, Alexei Grachov, 27, Vasilievich

Zavodoski, 27, shook his hand, Nikolai Konstantinovich, parachute expert, called good luck.

A photographer shouted to Gagarin to halt as he stepped on to the gantry hoist that was to take him to the nose-cone of the rocket 100 feet above. He stopped, turned, waved both his arms, and was carried out of sight.

His disappearance was the signal for a flurry of activity. The mesmeric effect of the orange-suited spaceman's presence was gone; now the ground staff seemed to be working against time. They swarmed over the gantry and the rocket hull like busy ants, while inside in the tiny cabin far above them, Gagarin was calmly settling into his seat. . . .

The "seat" is more of a couch, built to the exact contours of a man from head to foot. As he settled in, the loose leads snaking out from his suit were quickly coupled up to a variety of instruments. The cabin that looked so small from outside was in fact roomy, about the size of the flight-deck of a Comet airliner. As the three-foot-square hatch was bolted into place by two engineers, Gagarin's private world came to life; the capsule began humming with noise from all around as a multitude of valves, motors and gauges were switched on.

Ground control communication was tested; amused operators in the concrete and armour-glass bunker a mile away from the launching pad heard the snatch of an army song: "I love you, life . . . I hope the feeling's mutual" coming from inside the space helmet.

The routine that every air force pilot knows, the pre-flight check, began; a long, careful scrutiny on which Gagarin's life might depend. In front and above him, a navigation screen began to move. This carried a map linked to an analogue computer which moves so that the pilot will always have before him the exact position of the ship. Above this, a chronometer and orbital clock; the chronometer as a basis for the mechanical navigation, the clock for showing the time of day, time from zero launching and the time left for switching on retro-rockets for the return to Earth.

The main panel records fuel supply, engine thrust, cabin temperature, engine temperature, humidity and air composition and electrical supply. In the centre is a TV lens. Another one, at the side, is built in to record profile image of the pilot. There are more than one hundred needles and dials. Every device, to the last tiny fuse, has a recording meter to reveal its behaviour. Broadly, the instruments were divided into six groups: flight-control, communications, power-sources, cabin conditions (air, temperature, pressurization), flight navigation and physiological sensors. Every part had a "fail-safe" duplicate, and as a third protection there were complex emergency safety devices; the seat was fitted with an ejector and twin automatically opening parachutes which could be fired at a height of four and a half miles. The seat (for the event of such an emergency) had its own built-in supply of oxygen linked independently of the main supply to Gagarin's suit.

Checking all these took ninety minutes. Then the trolleys and gantries were removed and cables disconnected. At the control panel deep underground green lights one by one winked their confirmation of readiness. Inside the humming capsule, Gagarin reported in a relaxed voice: "Cabin pressure—one. Humidity 65, temperature 19. Compartment pressure comfortable, instruments cleared, feeling fine." An engineer tells him that the rocket motors are about to be started; a bank of television screens show two pictures of him as he nods in reply. Over the hi-fi amplifiers come his last words on Earth: "Let's go on up."

The count-down starts from 20 . . . 19 . . . 18 . . . 17 . . . silence, except for the range controller's voice and the crackling of radio and electronic equipment . . . 11 . . . 10 . . . 9 . . . 8 . . . 7 . . . 6 . . . 5 . . . 4 . . . 3 . . . 2 . . . 1 . . . zero. The huge clock in the control room shows 9.07 a.m. Moscow time as an exploding roar fills the air and the microphones as the giant ship lifts off, so smoothly, in a hurricane of white-hot flames, steam and swirling smoke. Within seconds it is majestically rising above the storm, gathering speed at a fantastic rate, committing the body and soul of Yuri Gagarin to outer space.

At home, Valya is giving the children breakfast....

3

U.S. *v.* U.S.S.R.

How had the Russians succeeded in leaping ahead of Western scientists? What happened? What—and who—lay behind it? Speculation among scientists and laymen has been endless. There were many, of course, who said they knew the answer; the Russians captured most of the German rocket engineers who made the V2s. These Germans, they claimed, were the ones who deserved the credit.

Not unnaturally, the Soviet scientists are indignant. Yevgeni Fyodorov, chief of the space programme, had something to say about this: "It's true," he told Burchett, "that many German rocket experts worked here after the war, but their work was restricted to showing us how the V2 worked, and its principles. We, even at that time, were operating along entirely different lines, and were soon convinced that we had little or nothing to learn from them. The Germans contributed nothing of any significance to our present successes." He continued, earnestly: "No one expects us to give away our secrets, but it must be understood that we had certain ideas which differed in important points of principle from those the Germans were proposing. We turned their schemes down; the Americans accepted them. It is as simple as that."

And he had this criticism to make of the U.S.A.'s early efforts: "They were working along the lines of the V2; their space flights were merely an extension of the scheme the Germans were operating when they bombed London from rocket sites at Peenemünde. That is why the Americans are behind. It is typical that Wernher von Braun, the creator of the V2, should be running their research programme.

"Our scientists," he said, "right from the earliest days of the revolution, have had the stars as their goal. Jules Verne is one of the most popular authors here, his books running into millions. Tsiolkovsky was convinced that man would conquer outer space, and his works are still guiding us in our research. We had done a great deal of work on this subject long before the Second World War and we were well ahead of any other country including America in rocketry. After the war our progress was faster, still with the aim of eventually constructing space-ships that would take us first to the Moon, then to other planets.

"Our American colleagues have been hampered, I believe, in their work by the emphasis on militarization, and the limited tasks set them to develop super V2s."

Asked about the Soviet Union's own I.C.B.M.s, he said: "They are a regrettable by-product of the space programme. They were not an aim in themselves. Our people are working with complete freedom on their main tasks; if there is something in our findings that is needed for defence purposes, then the military can help themselves to it. They take what they need. As scientists we regret the necessity for this, and so do we all. Please don't forget that even when we had a monopoly of I.C.B.M.s we were willing to put them under international control. Military requirements do not interfere with the task of conquering outer space."

Fyodorov's remarks were strangely echoed by a German scientist, now living in Madrid, who revealed details of the Nazis' overall plan for the first time to Purdy. "At the end of the war," he said, "it was every man for himself. We knew that there would be competition for our services between the Americans and the Russians; in fact, several of my colleagues had been counting on that. Oddly enough, perhaps, there were quite a few who preferred to work for the British, but there was a curious snag. The London Home Office, after many enquiries about our background and so on, turned down our applications. They said it would be too expensive to keep us, with our families, in Britain. They were prepared to take the men, but not the women and children. It sounds fantastic, but it was so.

"I believe the correct figure of Germans who went to work for the Russians, in captivity or voluntarily, amounted to a few more than 1500 in 1945. The Americans, however, though they seized fewer people, got the cream of the administrative staff—men such as Wernher von Braun. And it must be understood that von Braun was always considered by us to be more of an administrator than a pure scientist.

"He and his colleagues, I believe, knew the scheme which had been pressured by Hitler—but they did not know how to carry it out." The plan, he said, was a concrete one, one so secret that only a dozen or so scientists were in possession of all the details. "We had," said the German, "a programme which began at the V1 and ended at V12. No one, as far as I know, has ever speculated what was to have gone up after the tried and tested V2. I can tell you.

"V3 was a heavier V2 with a much greater range and weighing about ten tons. This was to have been the first of the two-stage rockets and we hoped that this and V4 and 5 would be capable of hitting with some accuracy New York and Chicago. Hitler was convinced that if only American cities could be devastated in the same way as London and Moscow, U.S. morale would collapse and the way would have been open to some kind of agreement.

"But from V6 onwards—that was a space programme. V6, for instance, was to have been the first manned rocket, and the Redstone missile which took Shepard 113 miles up was, in fact, that V6. I know, because I worked on that specific project. I can recognize many, many details from the information which is being published now. But I also know this: the Russians got many young men who were, so to speak, the hidden brains behind the V1-V12 programme, thinkers, dreamers, rather than engineers. I am sure they influenced Russian thinking, though Fyodorov is probably right in saying they were working on different lines to us. Our intelligence on the subject was quite good, and we knew they were far ahead of us in certain lines of research—but in 1944 they did not have the resources to put their ideas into practice.

"The Americans had the same chance, though today they make many excuses. They muffed it. In my view, they made two serious mistakes. The first was to have been without a policy in 1945, when rocket engineers were ten a penny in Europe and could have been bought virtually for cigarettes.

"The second was to have entrusted the space programme to a number of commercial firms without a central control.

"These firms are more interested in seeing ten or twelve rockets fall into the sea or explode than in seeing a man in orbit. Their money is made out of failures. To succeed first time would be bad for the stockholders. In Russia, as in wartime Germany, there is a plan, and everyone works flat out to fulfil it, without regard to private interests."

The opinion of this ex-Nazi is supported, to some extent, by Mr. Russell Crist, ex-chief of the production policy at the U.S. Defence Department, who reported barely two months after Gagarin's flight: "There are rumblings loud enough to cause us all to ask whether the American free-enterprise system is properly geared to serve the national interest as well as itself. The mere fact that such opinion exists should cause businessmen to sit up and take notice."

And Fyodorov pointed out to Burchett that Helmuth Gottrup, one of von Braun's assistants, had written in the American magazine, *Missiles and Rockets* in January 1960: "Russia's achievements are in a large measure due to the absence of outside pressures on scientists," plus the fact that rivalry and competition between different armed services and contractors—non-existent in Russia—was both extravagant and time-consuming.

"If anyone deserves the credit for our achievements today," said Fyodorov, "it is Konstantin Tsiolkovsky. He was the one who made all this possible."

4

THE FIRST RUSSIAN ROCKETEER

KONSTANTIN TSIOLKOVSKY was a cheerful, eccentric, self-educated genius. Deaf from scarlet fever at childhood, he had no formal schooling. But he was a natural mathematician, a practical inventor who made his own laboratory equipment, a writer of science fiction and a prolific publicist of the one theme that haunted him all his life—outer space, and how to get there.

He was born in 1857. In March, 1883, two years after Kibalchich had put his ideas on rockets down on paper, Tsiolkovsky had completed an extraordinarily accurate work, *Free Space*, on how it was possible to orbit a sputnik around the Earth. This was probably the first use of the word sputnik, incidentally, in space literature. There is no record of whether or not Tsiolkovsky knew of Kibalchich's existence until he came across the latter's notes some thirty years later, but they were working on complementary lines at the same time.

It was not until 1954 that *Free Space* was first published, though he quoted some of the essential parts of it in *Dreams of Heaven and Earth*, published in Moscow in 1895. "A hypothetical Earth sputnik," he wrote, "similar to the Moon, but nearer to our planet, just about 300 versts from the Earth's surface, would represent a very small mass free from the pull of gravitation."

He went on to discuss how such a sputnik could be created, and the speed at which it would have to move in orbit. "Despite the relative nearness of such a sputnik to the Earth, and supposing it were to be built—how is it to be hurled beyond the boundaries of the Earth's atmosphere? How can one impart to a terrestrial body the speed necessary for it to nullify the pull of Earth's gravity, when this speed needs to exceed eight versts a second?" It was a question that few bothered to pose, let alone answer. But sixty-two years later, when the first sputnik *was* launched, it orbited at a height of about 300 versts (roughly 180 miles) and its speed did indeed reach eight versts a second, as the old genius had foreseen.

This self-taught scientist—most of his learning came from library shelves—was not only concerned with the theory of space travel. Back in 1878 he had rigged up primitive centrifuges to test—on chickens and mice—the effect of acceleration and overloading on living organisms. At this time, too, he sketched instruments which would simulate conditions of weightlessness on the ground. Sketches and manuscripts now in his museum-home at Kaluga, about 100 miles west of Moscow, show his preoccupation with interplanetary travel and aeronautics from 1878 onwards.

His first two scientific works, written in 1881 and 1882, both dealt with space research. In one, he revealed the results of his tests in the centrifuge with the unfortunate chickens. He found that they could stand loads of 5 to 6 Gs but inevitably died when the G-load reached 10. This was contained in *The Mechanics of Living Organisms* which was read by a famous Russian physiologist of that time, Sechenov. Sechenov was so impressed by the scientific arguments that he recommended the un-schooled Tsiolkovsky for membership of the Academy of Sciences, a recommendation which was unanimously accepted. In his later work on the effects of speed he developed the principle of space suits and hermetically sealed space capsules similar to the one used by Gagarin. Another theory is still being investigated today: that the take-off stresses on the human body could be overcome by immersing the pilots and passengers in liquid for those brief moments. As an illustration, he gave this example:

"Place a fresh hen's egg in a tin of water," he wrote. "Seal up the tin. You can drop it or give it a good hefty blow. The egg will not break. This could be the principle to adopt to protect future space crews from the harmful effects of acceleration."

In 1903, Tsiolkovsky published a monograph in the Moscow *Scientific Review* on Space Research by Jet Engines, a work which has become widely read today by specialists in this field. In a foreword to his own book, *Beyond the Earth*, he pointed out that he had worked out all the mathematical solutions for rocket or jet engines before the end of the century, and that "by 1896, after a year's fundamental mathematical research, [I] based my future work on jet space-ships as the most feasible means of orbital or interplanetary flight." But after the mathematical solutions—and there were no electronic computers to help in those days—Tsiolkovsky put in another eleven years work on scientific and technical problems. These confirmed his theories, and his reports are read by every science student in every Russian university today. He produced figures showing the required cosmic speeds for reaching the main planets in the solar system. He showed that to leave the Earth's gravitational pull it would be necessary to exceed 11.2 kms. per second, and this enormous velocity, he was confident (and rightly so), could be attained with liquid fuels. After checking and experimenting with a number of combinations, he settled on these as offering the best potential for space power: Liquid oxygen and liquid hydrogen; liquid oxygen and methane; liquid oxygen and alcohol.

Much later, he decided that ozone (tri-atomic oxygen) was a possible and more profitable substitute for oxygen. The result of such scientific audacity was disgrace. His report (in the scientific review) was confiscated, the editor forced to suspend publication. Eight years later the second part of the thesis, together with a résumé of the first, appeared in the St. Petersburg *Aeronautics Bulletin*, this time without reaction.

Tsiolkovsky was part of the amazing intellectual and artistic ferment of the later 19th-century Russia. In no other country at that time was there such an outpouring of literature from pens of the quality of Tolstoy, Turgenev, Chekhov, or music from such composers as Tchaikovsky, Moussorgsky, Borodin, Rimsky-Korsakov, Glinka and Glazunov. It was the period, too, when Pavlov and Mendeleev were making their contributions to world science. If Tsiolkovsky remained in obscurity it was because there was no technical means for translating his blue-prints into experimental models. And there were no established industrialists, as in the West, to give financial backing to an inventor's dream.

In his modest, timbered cottage at Kaluga, and in the time he could spare from teaching mathematics at a local school, he carried out literally in his back room the basic research for such ships as Vostok. In the days when the express train was the fastest means of travel, he was absorbed in the problem of how to reach 18,000 m.p.h., and how to protect the human organism at that speed. He was obsessed also with the possibility of some cosmic catastrophe, when man would want to leave the Earth *en masse* to populate another planet in one great invasion wave. For this he drew up a scheme for a vast space "lifeboat" dirigible to hold 200,000 people. It would be nearly two miles long by 300 yards wide. This was Tsiolkovsky in his more fantastic moods—but the scientists who sneered were also among those who laughed at his ideas for jet engines and rocket ships.

The early years of the twentieth century were bitter ones for him, but he made up for his time in the wilderness when World War I produced a desperate need for what was to be, obviously, the weapon of the future—aircraft. Scientifically, he bloomed, but financially the period was a disaster. His theories and published works were heavily drawn on without any payment to him; creditors closed in, he had no money to finance experiments and the cost of everything shot up. To raise a little money he sold a serialized version of a science-fiction work to a St. Petersburg magazine, but after a few issues the latter closed down.

He was producing ideas as fast as he could put them down on paper, but he could hardly afford the paper. His situation changed with the Revolution; Lenin was not one to let scientists rot in garrets. In 1918 he was awarded a considerable state pension, and practically everything he wrote saw the light of day. In 1929 he wrote a major work, *The Cosmic Rocket Train,* in which he described the principles for multi-stage rockets—very nearly a blue-print for those which twenty years later were putting sputniks into orbit. On his 75th birthday, in 1932, when only a few top specialists in the outside world had even heard Tsiolkovsky's name, meetings were held throughout the Soviet Union to honour him as "the father of astronautics." There was a special session of the Academy of Sciences. The government awarded him the "Red Banner of Labour." He died in 1935, apparently confident that his lifetime's work was about to be realized.

He was clearly a remarkable figure, and it is surprising that his science-fiction books have not become more widely known outside the Soviet Union. Sketches of his space-ships made forty years ago show them not only with the sort of rocket engines we know today, but also with automatic controls, heat-regulators, solar batteries and much that goes into modern space-ships. He laid down plans for interplanetary stations and great multiple wheel-shaped space-ships with hot-house vegetable gardens and everything necessary to sustain life for scores of passengers on cruises lasting the several years necessary to visit the more distant planets.

Indeed, after studying Tsiolkovsky, an obvious question presents itself: why did the Russians take so long to build their big rockets and put sputniks into orbit? Part of the answer, at least, is that it is one thing to know how—and quite another to have the economic and technical capacity to translate the know-how into space hardware. Only the economic and technical giants among countries can do it, as the pioneer industrial countries Britain and France know too well. It was only when Russia emerged with a potential approaching the stature of the U.S.A. that she was able to afford the investment in space. The decision in the early 1950s to push ahead with this research, regardless of cost, can only have been reached after much argument and heart-searching, in view of the enormous demands for post-war reconstruction. Enough influential people were found, however, to agree with Tsiolkovsky's aphorism: "Earth may be the cradle of wisdom, but we can't always live in a cradle."

5

ROCKETS IN WAR AND THE EARLY SPUTNIKS

FROM Kibalchich's scribbled notes and Tsiolkovsky's models to Gagarin's 108 minutes of glory was a long, uphill battle—and not only to solve the technical questions. Kibalchich thought that the essential first step was to blast away at the stars with his rocket bombs. Later, scientists had to mask their ideas in fantasy and fiction because Church and State objected to man meddling with the heavens. Although the Soviet régime from its earliest days encouraged rocket research—as indeed all scientific work, even if it meant rags and hunger to build and equip the laboratories—there was opposition even ten years ago to investing what it took to put Gagarin into space.

A journalist from *Komsomolskaya Pravda*, daily paper of the Young Communist League, made a brief, but significant, mention of this. In a dispatch describing the atmosphere and the personalities present at the Cosmodrome on one of those exciting visits to the big and still largely anonymous names in Soviet space research, he referred to the chief, nicknamed the "Founder" because he had sent dogs for reconnoitring space with the very first rockets. "In all those years," the paper reported, "a small group of scientists had been engaged in this field. Not all of them were present at the range on that day. Some ten years ago they had to stand up for their rights—break down the opposition of those who were sceptical about space research or openly hostile to the idea...."

This is somewhat of an understatement; ten years ago there was, indeed, opposition, but not of a passive scientific nature. Stalin himself, it is said, opposed the spending of huge sums of money on space research, preferring a rocket programme to be restricted to purely military lines, necessary for the needs of the Red Army and Air Force.

Scientists say that in the early 1950s their budget for interplanetary exploration was regarded with great suspicion, then trimmed again and again. The experiments they did carry out, however, produced such astonishing results that restrictions were quickly relaxed. The world generally believes that the present space-race began in 1957, with the launching of the first sputnik; in fact, Russian scientists put up its forerunner as early as 1951. Not in orbit, admittedly, but high enough to convince the sceptics of the potentialities. And backing the scientists at every stage was one important, though then comparatively little-known, politician. Nikita Khruschev . . .

One of the most brilliant scientists in Russia, Mstislav Keldysh, now 60, was also bending all his energies and influence towards space. He was an expert particularly on aerodynamics and hydrodynamics, and this, allied with a tremendous interest in computers, made him one of the most valuable proponents of the controversial space exploration programme. As a holder of several Stalin Prizes and Orders of Lenin, he was a man to be reckoned with.

His perseverance had a great deal to do with the success of the programme, and in May, six weeks after Gagarin's historic flight, his efforts were recognized. He was elected president of the Academy of Sciences in Moscow. Characteristically—and significantly—the first meeting, held immediately after his election, dealt with the next stage of space-flight—the Moon and beyond. Though it has not been discussed in the West, Keldysh's appointment is without doubt the signal for the undertaking of even more dramatic adventures in space.

To detail all the steps from Kibalchich's cell to Gagarin's lift at the Cosmodrome would fill many volumes. There is room for only a few highlights. What set Kibalchich scribbling furiously in those last few days of his life was a revolutionary advance on a very simple principle. Fill a balloon with air—

then take your hand off the outlet. The balloon will move away in the opposite direction of the outlet—propelled by the escaping air. The speed and duration of movement will be proportionate to the mass and pressure of the air in relation to the diameter of the outlet. That is the principle of jet propulsion.

Sir Isaac Newton had suggested using this principle to propel small vehicles and boats. The Frenchman Brisson and the Abbé Bartholon advanced the same idea for the use of guided balloons. But Kibalchich went much further. His scheme was a projectile in which mass and pressure would be provided by charges of chemical explosives, similar to gunpowder. Moreover, he sketched a device whereby multiple charges would be introduced separately into the firing chamber, each blast imparting a speed additional to that of the preceding blast or the total of the preceding blasts. After the initial charges had imparted sufficient thrust to send the rocket straight up to clear the Earth's atmosphere, the engine and its escape jets would swing over on support pins in such a way that it could be propelled horizontally on a planned trajectory. Kibalchich was perhaps the first to commit to paper plans for multiple rocket blasts as the way to project a vehicle beyond the Earth's atmosphere and direct man towards the stars.

Various experiments were made in the Soviet Union and elsewhere to launch rockets with liquid explosives. The first successful attempt was made by an American, Goddard, who in March, 1926, launched a chemical fuel rocket that travelled about sixty yards at an average speed of 60 m.p.h. The Russians had their major breakthrough on August 17th, 1932, when the first liquid fuel rocket took the air. (It seems that the race between U.S. fuelled and Soviet liquid-fuelled rockets has gone on ever since.) The Soviet OR-2, as it was known, was remarkably similar in principle and shape to the one designed by Tsiolkovsky thirty years previously and was built by engineer F. A. Tsander, a member of a group set up to study jet propulsion. It was the first such rocket ever fired and led the way to those which put the first sputniks into orbit a quarter of a century later. A little over 8 feet long by 6½ inches at its widest diameter—excluding the tail fins, it carried an engine weighing 143 pounds and was powered by liquid oxygen and a petrol-paraffin mixture. The liquid oxygen was forced out of its tank under pressure of its own steam and when it entered the combustion chamber with the fuel mix, the whole was ignited by an ordinary spark plug; the escaping gas from the explosion providing the thrust. With only nine pounds of fuel, the rocket rose just under three miles reaching a maximum speed of 650 m.p.h. and parachuted back to Earth. A modest beginning—but a successful one.

Experiments split up from here, one branch continuing with rockets, another developing jet engines for planes. On April 15th, 1932, an Aviavinto plane was flown using tetra-nitromethane—a chemical rocket fuel, but on February 28, 1940, the first real rocket—or jet—plane took the air, piloted by V. P. Fyodorov. The rocket engine was mounted in the tail, powered by nitric acid and kerosene, and weighed 220 pounds.

The "roketoplane" as it was called, was towed by another plane to get altitude—then the planes separated and the rocket engine was switched on. Pressure in the ignition chamber was 18 atmospheres and the plane flew at 125 m.p.h.—a jet of escaping gas streaming from its tail. This was a considerable achievement at the time and the "roketoplane" was the forerunner of a whole family of jets from the first *MiG* fighters to the *Tu*-104.

World War II interrupted work on both pure rocket and jet plane developments. Diverted is a more correct term regarding rockets, because the same principle that sent the OR-2 aloft was used in the famous Katyusha multiple rocket weapons which wreaked such havoc with the Nazi divisions. They played a major role in blunting the German tank attacks and in shattering Wehrmacht defences in Soviet pre-offensive barrages. Not as spectacular as the German V-weapons—

designed for pinpointing military targets rather than hit-and-miss shots at civilian centres—but very effective and devastating proof that the Russians had their own specific line of rocket development. The Katyusha was based on a prototype rocket weapon built in the early 'thirties by an engineer, J. Petropavlovsky.

After the war years Russian rockets started to point skywards again. By 1949, geophysical rockets of the A-2 and A-3 class were carrying dogs aloft. First to 60—then 120 miles, dogs in their containers were being parachuted back from various heights. "Only after these vertical flights," said Science Academician Chernigovsky, "and thanks to the analysis of their results and the performance of the special equipment devised, could we undertake the next stage of cosmic research—the launching of the sputnik carrying the dog Laika."

Laika was carried in the second sputnik—the first having been launched to check arrangements for putting a vehicle into orbit. Up to the Gagarin flight, 160 rockets had been used to pave the way.

"All the researches have one characteristic and extremely important point," continued Chernigovsky. "Ever since the work of cosmic study was started there has been no sensationalism and no record-chasing. All the launchings were elements of one strictly scientific programme. Each vehicle sent up had only a definite set of scientific problems to solve. . . ." The programme entered a new phase with the launching of the first sputnik on October 4, 1957. Chronologically the programme was as follows:

October 4, 1957	Sputnik I, 184 lb., in orbit around Earth.
November 3, 1957	Sputnik II, 1,118 lb., in orbit around Earth with the dog Laika.
May 15, 1958	Sputnik III, almost 2½ tons including nearly one ton of instru-

	ments, orbited around the Earth at 65 deg. to the Equator which was the angle later chosen for orbiting space-ships, including the Gagarin flight.
August 29, 1958	One-stage rocket with dogs Belanka and Pyostraya recovered from height of 280 miles.
January 2, 1959	Lunik I multi-stage rocket, 1½ tons, passed within 4,000 miles of the Moon and went on to become first artificial satellite of the Sun.
July 2, 1959	Single-stage rocket, 2 tons, in vertical shot to "great height" with dogs, Otvazhnaya and Snezhinka, and rabbit Marfusha, recovered in nose cone.
July 13, 1959	Similar recovery of two dogs, one of which was Otvazhnaya again.
September 12, 1959	Lunik II, multi-stage rocket, of which last stage, 1½ tons and 868 lb. of instruments in container, made direct hit on Moon.
October 4, 1959	Lunik III, multi-stage rocket, last stage of which 1½ tons, which photographed the far side of the Moon and telemetered the pictures back to Earth.
May 15, 1960	Space-ship with dummy pilot. Weight 4½ tons, almost circular orbit, 200 miles up. Intended to test re-entry devices but due to

	fault in orientation system, forward-firing retro-rockets kicked it into an elliptical orbit instead of putting it on an Earth-bound trajectory.
August 19, 1960	The first space-ship to solve the re-entry problem, the first living creatures to orbit the Earth and return.
December 1, 1960	Space-ship III. About 4½ tons with two dogs on board was destroyed while re-entering the Earth's atmosphere due to an incorrect trajectory.
February 4, 1961	Space-ship IV. About 6½ tons.
February 12, 1961	Automatic-Interplanetary Station 1, 1,420 lb. Launched from a sputnik orbiting the Earth on a trajectory which was aimed to bring it within 60,000 miles of Venus, on May 19-20.
March 9, 1961	Space-ship V. About 4½ tons with dogs.
March 25, 1961	Space-ship VI. About 4½ tons with dogs.
April 12, 1961	Manned Space-ship Vostok. Over 4½ tons, with pilot Yuri Gagarin. Single orbit around the Earth and safe landing of Vostok and pilot.

It is an impressive list, each launching designed for a specific task, either a seven-league step forward or a patient checking to straighten out problems that had arisen in earlier probes. The aim of each was to bring nearer the day when a

Yuri Gagarin would be put into orbit—and then sent safely on his way to the Moon and Mars and farther.

Russians did not seem to be very space conscious when Sputnik I went up—or perhaps they were merely taken by surprise. Publicity media did little to press home its cosmic importance. The announcement came at about midnight on October 4, 1957, in laconic and undramatic language over Moscow Radio. *Pravda* the next day printed a small-type item about it on the last two columns of the front page with an uninspiring title—just covering the two columns of the front page with "Tass Communiqué." In much bigger type alongside were two columns of telegrams from collective farmers promising to fulfil, or announcing they had fulfilled, their agricultural deliveries. The news that made banner headlines all over the world was probably not even noticed by many *Pravda* readers that first morning. Later in the day—it was a Saturday—hundreds of people flocked to the Moscow Planetarium. But it seemed as if it was only the enormous publicity the event received in the outside world that later caused the stops to be pulled out of the home publicity organs.

It was a nice piece of timing. In America, prophecies had been confidently made for months previously that the first Earth satellite would unquestionably be "Made in U.S.A." A small Soviet announcement a few weeks earlier about the firing of an intercontinental ballistic missile passed almost unnoticed in the West—or was written off as propaganda.

As so often with Soviet space launching, Sputnik I was like a punctuation mark to an important international event. On that day in Washington, an I.G.Y. (International Geophysical Year) conference on rockets and missiles was in progress. What could have been more appropriate! The Soviet delegate was Anatoli Blagonravov, a white-haired, distinguished-looking professor, and one of the Russians' leading space specialists. The weight of the first sputnik astonished the specialists as much as the event itself. At the Washington Conference, Blagonravov says his American colleagues tried to persuade him that the communiqué had been garbled—it must mean 8 and not 80 kilograms. (Eight kgs. was about the weight of the satellite which the Americans were preparing at that time.) The Soviet rocket man assured them that the weight was correct and that at the time he and his colleagues had left Moscow, two launching variants were being discussed, "the simpler of which apparently had been chosen." He described the sputnik as a "baby moon" and said it was the first of several which would be launched during the I.G.Y.

Sputnik I was launched at the first cosmic speed of about 18,000 m.p.h. and ranged up to about 560 miles above the earth; its familiar beep-beep signals and its pinpoint of light streaking across the sky sending radio hams, astronomy amateurs and just plain curious people all over the world into frenzied activity. Significantly, it was launched at an angle of 65 degrees to the Equator—as was the Gagarin space-ship three and a half years later.

It was not only the radio and astronomy hams who were enthusiastic, nor were Soviet leaders as reserved in their appraisal of Sputnik I as the modest press coverage indicated. Burchett recalls a reception at the East German Embassy in Moscow a few days after the launching and a jubilant Khruschev saying: "When we announced we had I.C.B.M.s they didn't believe us; in the West they said it was propaganda. Now we have launched our sputnik. They didn't want to believe that either. But any idiot can look up at the sky and see it: can point a finger at it," and amid roars of laughter and applause, he jabbed his own stubby finger towards the glittering chandeliers. He went on to develop for the first time a theme which he repeated often later. "From now on," he said, "bombers are obsolete—museum pieces only. We're not going to make any more. Navies are good only to satisfy the ego of some admirals dashing here and there in their battleships and aircraft carriers. From now on they're only good for ceremonial parades."

Sputnik I was made of highly polished aluminium alloys and filled with gaseous nitrogen to ensure an even temperature for the instruments. Streaming behind it in flight were four antennae from about 8 feet to 9½ feet long. Its trajectory took it virtually over the entire globe, pouring out information concerning orbital perimeters and flight performance.

The facility with which the Russians were able to announce its itinerary down to a split minute, three days ahead, indicated that they had very efficient tracking and computing equipment. This took many specialists as much by surprise as the fact of the launching itself. But it was only a pilot shot for another much more important successor.

If Sputnik I took the world by surprise, the next one, with the dog Laika aboard, was even more of a sensation. Launched on November 3, a few days before the 40th anniversary of the Bolshevik revolution and within a month of the first sputnik, it staggered American specialists by the huge increase in weight—at half a ton, just six times as heavy, and at 1,000 miles altitude almost twice as high. This really represented the big stuff in rocketry. It was obvious that a very efficient liquid fuel had been developed to lift such a huge weight as this seemed in those first days of sputnikry, smoothly enough for living organisms to survive; also new heat-resistant alloys and efficient insulating materials to prevent overheating on the way up were indicated. It was disclosed for the first time that dogs had been making rocket flights for years previously and that space messenger Laika had made vertical flights several times. She travelled in an air-conditioned, pressurized container, reached for her food at the tinkling of a little bell according to reflexes fixed in a Pavlovian training. Information telemetered to Earth showed that she had withstood the stresses of take-off and trials of weightlessness quite well. And, small satisfaction as it may be for the dog-lovers who protested at

Soviet embassies in England and elsewhere, Laika very specifically paved the way for Yuri Gagarin. Without Laika—and scores of other dogs which were the real pioneers of space flight—Gagarin would never have been projected into the cosmos.

The League against Cruel Sports at the time expressed its "horror, disgust and contempt" at the dispatch of Laika and, calling on the United Nations to "outlaw such foul experiments and those who perpetrate them," declared that such outrages "put scientists, whether Russian or otherwise, outside the pale of decent people." The League could draw little comfort from the knowledge that Laika died a blissful death through lack of oxygen, the body committed to a cosmic crematorium after funeral rites that included 62 million miles of orbiting around the Earth. The ashes were scattered throughout the Earth's atmosphere and Laika's name will remain immortal as the first living creature to penetrate outer space.

British science received some reflected glory from those two sputnik launchings because of the remarkable work done at Jodrell Bank, where the giant radio telescope tracked both of them. Professor Lovell, in charge, had the satisfaction of finding Sputnik I in its final stages—after Soviet stations had lost contact—and accurately predicting its doom. The sputniks in fact helped to project Jodrell Bank and the excellence of its scientists and equipment into the forefront of world attention. No sputnik or space-ship launching was complete after those first sputniks without some appropriate comments from Professor Lovell, and the Russians often called on him for assistance. A lesser contribution was also made by the Australian observatory near Canberra which took the first—and very clear—photographs of Sputnik I, on October 8. One of the interesting features of these first two launchings was the degree of international co-operation in tracking the sputniks. Thousands of messages poured in to "Cosmos-Moscow" from observers and radio hams all over the world, giving data on radio and visual observations which the Russians said was of enormous help—especially in keeping track of movements in the southern hemisphere.

After the first two sputniks were launched, Burchett spoke to Academician Fyodorov, at that time Acting Learned Secretary of the Soviet Academy of Sciences, a very distinguished Soviet geophysicist from a family of scientists. He was then —and still is—the chief adviser to the Soviet Government on space research. His own research work had made banner headlines in the world press a generation earlier.

Just twenty years before Sputniks I and II were orbiting the Earth, Fyodorov and three other Soviet scientists, headed by explorer Ivan Papanin, were adrift on an ice flow near the North Pole. The ice on which they had set up their research station had broken loose, and in an epic of courage and endurance the four men drifted for nine months in the severest weather conditions that exist anywhere in the world. Altogether they covered 3,000 miles, drifting right across the central basin of the Arctic. For weeks all hope was given up for them. But they were found by Russian airmen and, in a final exciting episode, with the eyes of the world on them, they were picked up by a pilot who managed to land on the ice floe. Only the reception given to Gagarin twenty-three years later can be compared to that given to the Papanin expedition when rescued and rescuers arrived in Moscow.

Fyodorov had just graduated from university at the time of the expedition, where he was the geophysicist with a bent for astronomy and geodetics. Throughout the ordeal, he continued his research on gravity, the earth's magnetism, meteorological and astronomical observations—dispatching weather balloons into the lower reaches of the atmosphere—studying the ionosphere for radio communications and the physical properties of the aurora borealis. Also some of the basic work for sputnik launching.

It was the first time a Soviet space scientist had received a foreign correspondent after the sputnik launchings and Fyodorov outlined to Burchett the main principles on which they were working.

Sitting at a long polished desk with a big terrestrial globe in front of him, he referred to the work of Kibalchich and Tsiolkovsky. "Their work was theoretical. The problem then was to have the technical basis for interplanetary flight. Now we have achieved this. The great interest for our scientists now is to solve the remaining problems. We consider the results of the first two sputniks as the first definite stage on the way to interplanetary flight." He mentioned the work of a young scientist, Yegorov, who at that moment was working "on the most suitable trajectory for a Moon flight." As to whether there was any immediate prospect for such a flight, Fyodorov said: "No. But in solving any problems we pay great attention to tackling the main, basic obstacles. We never think it worth while setting some limited aims which are insufficient to solve the whole problems. We like to have plenty of reserves in hand. Although now we have only succeeded in orbiting the Earth, part of our effort must be directed towards the Moon and even further interplanetary flight. Probably we lose a bit of time as far as quick, spectacular results are concerned but we have the advantage of solving basic problems, and this makes it quicker in the long run."

On the question of manned flight—very much in the air then because of the Laika launching and the fact that the vehicle which took Laika into space was big enough to carry a man—Fyodorov was quite specific: "It is out of the question to send up a human being before many more experiments have been made with animals.

"We have solved the problem of putting an animal up. The next to devise a means of bringing one down. And things will not stand still while we are working on that—we shall push ahead with other work and always keep well ahead of the immediately possible."

What Fyodorov had in mind became clear a few months later when—on May 15, 1958—Sputnik III went up. A cone-shaped gleaming monster of almost 2½ tons, nearly twelve feet long by six feet wide at the base of the cone, with a full ton of instruments aboard, and orbiting at well over a thousand miles above the Earth, its tasks were to measure pressure and composition of the upper layers of the atmosphere; the intensity of cosmic and solar radiation; the pull and extent of the Earth's magnetic field. These were all aimed at piling up the reserves necessary to know (a) just where one could put a spaceman and be sure he would be safe while orbiting and (b) which of Yegorov's variants would be the most appropriate for a Moon flight.

The leap from 184 lb. of sputnikry in October, 1957, to two and a half tons in May, 1958—with all that implied in the development of rocket power—is the yardstick of the speed with which the technical problems of launching a man into space were being solved.

It is hardly worth while going into detail of all the space and rocket shots which followed. The time-table speaks for itself, and the main ones which preceded Gagarin's flight, Lunik III, the Belka-Strelka space-ship and the Venus interplanetary station are dealt with separately. They all fitted into a step-by-step programme with a minimum of duplication, each one carrying things further than could be justified by the immediate prospects.

6

TRACKING—
NEW CHAIN OF SKY-SPIES

WATCHING over this vast armada of rockets, space-ships and supersonic aircraft is the Interplanetary Communications Commission headed by President Leonid Sedov, a greying, round-faced physicist and mathematician whose works on aerodynamics are standard for all Soviet rocketeers.

Its members meet in the nerve-centre of the space exploration programme, the Academy of Sciences in Moscow. It is a huge cream-and-gold building with an imposing façade and immaculate gardens.

At the end of a long, straight carriageway, set back off the road, it might well be an opera house or museum. But here some of the world's greatest brains devote themselves to making Tsiolkovsky's dreams come true. "And rather like a rocket on take-off," says one, "we are moving faster and faster every moment." Its growth has been staggering. In 1917, the Academy had one institute, five laboratories, thirteen research stations and seven museums. Today it controls 160 large institutes and more than fifty "special research stations." The Academy directly employs 350,000 people. Official figure for foreign scientists as members of the Academy, incidentally, is fifty-seven. Reports and papers published have now reached the weighty total of 40,000 quires a year, translated into fourteen languages.

The Space Commission is a closely knit team, divided only by their own fields of research. There is no grouping as in the West, of scientists under army, navy, air force and civilian chiefs, no commercial contractors with perhaps conflicting interests. And there is virtually no budget; whatever is needed for the completion of a project is provided.

They guard a million secrets, unknown outside Russia, and not unnaturally their curtain of secrecy is impenetrable to foreigners—and particularly journalists. Nevertheless, within the limits of military security, Russia's scientists are generous in explaining their achievements and methods.

When rocket fuel is mentioned, however, they will blandly change the subject; it is their greatest and most astonishing success—and secret. They were appalled when reports reached them that a Soviet rocket had "leaked" fuel over the Pacific, and that American scientists had been able to take samples. "If they get but the minutest quantity," said one Russian professor, "they will know. Immediately." But the report proved false; Cape Canaveral is still in the dark, working against time with liquid and solid fuels that are one quarter as efficient as the Russians'. Although, while the authors were in Moscow, scientists had heard rumours that the U.S. Aerojet Corps had at last cracked the secret.

As has already been stated, the Russians began experimenting with liquid fuel rockets in 1930. Tsander, a disciple of Tsiolkovsky, had approached Lenin years previously for permission to carry out research into rocket propulsion, with a view to building a space-ship. Lenin agreed, and Tsander presented a paper on the subject to the Moscow Conference of Inventors. He also built his rocket, using a moderately successful liquid fuel of petrol and oxygen. In 1932 he launched a much larger missile, using petrol and liquid oxygen—perhaps the first time this combination had been used for such a purpose.

It was followed by the successful use of nitrogen tetroxide and toluene, then alcohol and liquid oxygen—the "Lox" of U.S. missiles today. The Russians use it as well of course—but their highly prized secret is whether this is the actual fuel for the space rockets. No one outside Russia knows, for they have made great progress, too, in the development of solid fuels.

The huge weight of the satellites hurled into space points to engines of enormous size, with fuel of a higher calorific value than any developed in the West. The other top-secret Russian success: a cooling system to handle the enormously high temperatures engendered by atmospheric friction, particularly during re-entry. Cooling is one of the weakest links of the chain in rocket-building; there have been countless expensive failures in both America and the U.S.S.R., often simply because a small pump or valve failed, and the metal casing was left unprotected against the heat of ultrasonic speed. Steel becomes molten at about 1,300° C.—a temperature that can be doubled and trebled, though, by the use of Russia's new metal alloys and a new coolant.

To take the alloys first: the rocket engineers wanted a metal or metals capable of withstanding between 3,000 and 5,000° C. Further, these materials had to be stable at the other extreme, of close to absolute zero. The tanks for the oxidizers, for instance, could be only one hundredth of an inch thick, and the oxidizers themselves have boiling-points around zero or below. Thus, tissue-thin metal had to be able to withstand the pressure of tons of weight in fuel, and heat ranging from many degrees below freezing (on the launching pad) to 5,000° C. (in flight). The answer was found in alloys of niobium, tungsten and molybdenum. Tungsten, for instance, has a melting-point of around 3,400°—provided it is absolutely free from impurities. It has certain deficiencies, however, which are compensated by alloying it with niobium and molybdenum. These two, though, are normally useless because of their special weakness: rapid corrosion. To counter this, the alloys are covered with wafers of ceramic paint which burn off, one by one, as the temperature rises.

The cooling system helps here, too. Called "penetration" cooling, the system pumps the fluid through millions of tiny pores, less than a thousandth of a millimetre wide, in the metal casing and its protective ceramic paint. The composition of this fluid is almost as important as the fuel itself, and its formula is as closely guarded.

The weight factor is a big one, of course; many of the metals and paints used have to be incredibly thin. Vanadium, for instance, is produced in foil only 100 microns thick, and aluminium alloy has been "drawn" into threads scarcely visible, yet with a strength comparable to iron. Using conventional methods, the wiring of the instruments in Vostok would have run into many miles and several hundreds of pounds weight, but with the miniaturization techniques now being employed, this was cut down almost to nothing. One breakthrough in this field came when Victor Matveyev, an engineer in the Leningrad Research Institute of Electrical Measuring Instruments, suggested that it might be possible to manufacture wire as fine as a spider's web in this way: a tiny piece of metal or alloy is placed inside a glass tube which is then heated and drawn out into the finest-possible bore capillary tube. The metal is stretched along with the tube to a fantastic length. That was the theory, and it worked in practice; by this means one cubic centimetre of manganin alloy became 10 kilometres of wire one-tenth the thickness of human hair.

With this kind of know-how, the Space Committee feel justified in claiming that they are equal to, if not ahead of, the West in instrumentation, as well as in launching methods —a claim that is, however, strongly denied by American scientists.

There is one other branch of their programme which has developed at extraordinary speed: the tracking of satellites. A vast network of observatories from the Siberian Arctic to the borders of India and China keep a night and day watch on Soviet sputniks, and follow the course of I.C.B.M.s, geophysical and meteorological rockets.

When the first sputnik was launched, the giant radio telescope at Jodrell Bank had long been the envy of Russian scientists. It was necessary to enlist its aid for much of the tracking information. This huge space-probe, whose planners were once in difficulties over paying for it, has more than repaid its cost in friendship; it has increased tremendously the flow of information and goodwill between Soviet and British scientists, which continues today even though the sputnik-launchers no longer have the same need for its services (except in such cases as the deep-space probes of the Moon and Venus).

Tracking space-ships is a science that has to keep pace with the development of the ships themselves, and millions of roubles have been poured into a research and construction programme which is reaping a rich reward.

One project at the Crimean Astrophysical Laboratory has just been completed: a telescope that they believe will be the most powerful in Europe. "To explain its power simply: a burning match in Vladivostok would be visible from Moscow through it, if the earth had no atmosphere," an astronomer told Purdy.

The site of this extraordinary sky-spy is on a beautiful, wooded plateau of the Yaila mountains, 600 metres above sea level. The "Science Settlement," as road signs describe it, is a cluster of white stone buildings dominated by slender towers topped with silver cupolas, reminiscent of the Kremlin. Besides optical telescopes, there is also a cosmic ray station and a radio missile tracker here.

The optical system is based on a mirror of 2.6 metres in diameter with a focal distance of 10 metres. The successful casting of the blank of the mirror, which weighed five tons, took five months in special furnaces.

The reflecting surface is a paraboloid which allowed a maximum error of three hundredths of a micron, and the completion of this took a further six months.

The finished mirror weighs four tons; built-in self-adjusters have the effect of taking the weight off the reflector, which would otherwise buckle under the strain of supporting itself, and 160 electric motors drive the mechanism. Its movement is automated almost entirely, and punch-tape computers feed in instructions from a separate control-room.

Once "locked on" to a star or the motion of an artificial satellite, the telescope trails it automatically while cameras record its path across the night sky.

So sensitive is the 62-ton instrument that it was found that the heat of sunlight during the day could affect it considerably. The dome has now been insulated with a double skin, and the inside is air-conditioned. Around the tower on metal rods are huge "umbrellas" to act as sunshades, and tall trees have been transplanted to help absorb heat.

A big solar telescope near by is used to record sun-flares, which affect cosmic radiation dosage in space. Every two or three days in a small cinema on the site, scientists watch hour-long films in which the only "star" is the Sun. Hundreds of miles of film have been shot with the telescope's automatic cameras; the audience's excitement is greatest when tiny splodges appear on the Sun's flaming rim, representing gigantic explosions. The sound track generally is a long, low whistling, but changes to a deep rumble when there are "flare-ups."

A team of astronomers working under V. B. Nikonov, doctor of physics and mathematics, has just completed a study of a star discovered last year. One astonishing fact that emerged: when the star flared up it gave off the equivalent energy that our Sun takes a hundred thousand years to produce. During the flare-up the upper layers of the star's atmosphere expand into space at a speed of about 1,800 km. per second.

It was established too, that the new star is 500 million times further away from the Earth than the Sun—four thousand light years, in fact.

During Gagarin's flight almost the entire optical and radio equipment of the station was used in tracking him; close observation was possible, and the images were channelled through closed-circuit television to watching scientists and astronomers at rocket stations and laboratories.

One of the leading astronomers engaged in this is 73-year-old Alexander Mikhailov, a genial, white-haired professor who directs Leningrad's Pulkovo University. Vice-President of the International Astronomical Union, fluent in six languages and a world traveller, Mikhailov has an immense reputation, and was one of the "back-room" team on the sputnik programme.

"Here at Pulkovo," he told Burchett, "we decipher much of the material telemetered back from the satellites and rockets. One of our chief tasks at present is studying the atmospheres of Venus, Mars and Jupiter, but I hope the day is not far off when we will have a telescope mounted in a satellite, able to do the job without the distortion of the Earth's atmosphere."

The professor co-operated with the Sternberg Astronomical Institute and the Kharkov University in mapping the Moon from the lunik photographs. They listed 252 lunar features, including 150 on the hidden face.

The craters and newly discovered landmarks were named after Thomas Edison, the American inventor; Giordano Bruno, Italian philosopher; Heinrich H. Hertz, German discoverer of radio waves; Igor V. Kurchatov, Russian nuclear scientist; Nikolai Lobachevsky, Russian mathematician of the nineteenth century; James Clerk Maxwell, British pioneer of magnetism; Dmitri Mendeleev, Russian scientist; Sir John Napier, sixteenth-century inventor of logarithms; Louis Pasteur, French bacteriologist; Alexander Popov, Russian pioneer of radio; Madame Curie, Polish-born discoverer of radium; Tsu Ching-Chi, Chinese mathematician and astronomer of the fifth century who calculated the value of *pi* (relation between circumference and diameter of a circle); Jules Verne, French "father" of science fiction; Mikhail Lomonosov, founder of the Russian Academy of Sciences; Joliot-Curie, French scientist; and Konstantin Tsiolkovsky.

To reach the Moon requires more than imagination; new sources of power must be found, for as the distances from Earth increase, so do the problems, by a disproportionate amount.

Professor V. Krasovosky is one of a team investigating long-range super-high speed rockets. "A journey within the solar system using the existing types of rocket engines would last a few years," he says, "and a visit to the nearest star system would last the life-span of several generations. Somehow we have to beat this problem with a new source of power to give photonic speeds. The people working on this believe that intensive light radiation will bring a rocket up to a speed of 10,000,000,000,000 kilometres a year—very nearly the speed of light itself.

"The science-fiction writers always depict this sort of engine as easy to build! Still, their descriptions of how the journey will be made are fairly accurate, I think."

The other obvious source of space-ship power—atomic energy—is discussed by Gilzin, who, unlike many U.S. scientists today, is pessimistic about its capabilities. He writes:

"The tremendous magnitude of atomic energy makes it possible to undertake the most distant flights into space. It is sufficient to point out that the energy given off when 20 kilograms of uranium or plutonium are split up is sufficient to send a body weighing 1,000 tons to the Moon and back. Authors of books on astronautics usually make note of this and proceed to paint fantastic projects of such super-distance flights. However, the case here is not so simple as it seems. Atomic energy, though there has been much written about it, still does not supply the complete solution to interplanetary flight.

"That an atomic cosmic rocket can be built is a fact based on achievement of technique. Such an atomic ship, however, will not differ so greatly in its abilities from the usual ships that use chemical fuel, for the potential possibilities of atomic energy are one thing, the actual technical prospects for using these possibilities, another.

"The almost unimaginable situation," he went on, "would exist of the crews in such rockets being away millions of years. On their return they might discover that their home civilizations had vanished." And what would be the secret of their longevity? "Relativity," says the Professor. "Only the rocket's crew can stand to win; at a speed close to that of light, time slows down, and the human body ages more slowly. The faster the speed, the slower the ageing process.

"It takes light close on ten thousand million years to reach the frontier of space we know about and come back. So if man is to get there he will have to make it at speeds which will slow down time by a hundred million times, so to speak. Ten years on board his space-ship will be equal to a thousand million years on Earth. This also means, of course, that the information he brings back will be that much out of date.

"How is this to be explained?

"The essence of the matter lies in the problem of how to create an atomic motor with a reaction thrust necessary for the ship's flight. To obtain this we have to throw some substance back at a great velocity. In the liquid-fuel rocket motor the products of combustion of the fuel form this matter. But what will this substance be in an atomic reaction motor? There is nothing in it that burns.

"Instead of the combustion of fuel we have the splitting of the atoms of some nuclear combustible, as the metal of uranium. When this takes place the complex, heavy uranium atom disintegrates, or, as we say, splits up into two lighter, simpler atoms or other substances. Both of these new atoms, which result from the splitting of the uranium atom, fly off in opposite directions with a velocity of tens of thousands of kilometres per second. The kinetic energy of the products resulting from the splitting atoms forms the basic part of the atom energy given off when the atoms split.

"How can this tremendous energy be used to create the reaction thrust? The simplest thing would be to force the products of the atomic disintegration, which takes place in the motor, to escape in one direction through some opening.

"Then this stream of substance, escaping at a speeds tens of thousands of times greater than with conventional fuel, would create a correspondingly greater thrust. However, such a solution is impossible in practice.

"The one chief reason is that if the thrust of such an atomic reaction motor is to be sufficiently great, a large enough number of grammes and tons of the substance must escape every second. But this means that grammes and tens of grammes of uranium must be split up every second, from which it follows that the motor must develop colossal power—hundreds of millions and even billions of horsepower. For when a gramme of uranium splits up, as much energy is given off as during the combustion of 1.7 tons of petrol—that is, every gramme split in one second is equivalent to one million horsepower.

"In such a motor a tremendous amount of heat will be given off every second. The temperature of the walls of the motor, as a result of the countless blows against it caused by the particles whirling about at a tremendous velocity will reach many millions of degrees, and the motor will evaporate.

"If the substance which must be thrown off by the atom motor cannot be the product of atom splitting, there must be some other special working substance for this purpose on the ship. Here, indeed, is a substance to be 'thrown off.' Because of this, the main advantage of the atom engine—the practically unlimited duration of its operation—is lost.

"What then, is the need of this work if the entire working substance has already been expended? It becomes necessary to stop the motor.

"This means that the length of time it will operate has to be governed by the possible supply of the working substance on the ship. When, by installing such a motor, we get rid of the supplies of chemical fuel, we, whether we wish it or not, substitute another substance. And as a result we get practically the same situation.

"The atomic reaction motor will differ from the usual liquid fuel rocket only in that, instead of a combustion chamber, it will have an atomic pile. The heat generated will be transmitted to some liquid or gas, the working substance, which will escape as a heated stream from the motor through a jet-pipe, thus creating the reaction. This constitutes practically all the advantages of atomic engines.

"Generally, one can say that the velocity of the gases from an atomic motor will be no more than double the maximum possible velocity escaping from the conventional liquid fuel rocket.

"One of the serious difficulties in the building of an atomic space-ship is the necessity of protecting the crew and those at the launching pad from radiation. It is likely that the first-stage motor—to get the space-ship off the ground—will always be a conventional one, and that the reactor will not be switched on until the Earth's atmosphere is left behind. After the entire working substance of the atomic motor has been consumed, this stage would then be separated and probably return to Earth, leaving the ship to carry on with liquid fuel engines. Such a ship to fly around the Moon would weigh about 1,200 tons."

7

SPACE DOGS, THEIR SCHOOL AND TRAINING; THE HISTORIC FLIGHT OF STRELKA AND BELKA

GAGARIN'S triumph marked the end of phase one of the Russian space programme; and of the thousands who contributed to it, none could boast of playing such a unique part as two mongrels. They preceded him into space by eight months; in fact, they made it possible for him to go, justifying Pavlov's tribute to the dog world: "They have put Man in his place."

Gagarin met Strelka and Belka ("Little Arrow" and "Squirrel") in January, 1960. The lieutenant was one of twenty trainees. The dogs were two of one hundred.

For this final, pre-manned flight, the dress rehearsal, the biologists demanded animals of absolute physical fitness, with sturdy genetic history, aged between eighteen months and three years, agile and well formed. The biologists asked that the dogs should be as small as possible, and the TV technicians fixed the colouring, buff, grey or golden, with contrasting patches. They were finally selected from the research kennels of the Pavlov Institute.

To find out how such animals are found for space flights, Burchett travelled to a little village outside Leningrad, to the headquarters of the institute at Pavlovo-Kultishi.

It was not by accident that the Russians used dogs—not chimpanzees—as the first cosmic passengers. Perhaps no other people know dogs, scientifically speaking, as they do. Ivan Pavlov was the great, unchallenged master of animal psychology; his work on the higher nervous system of animals and his theory of "conditioned reflexes" won him world fame.

Although the anthropoid apes are nearer to man in the evolutionary scale, the dog, as man's oldest friend, is closer to man in many of his emotional and physical reactions. From a biological viewpoint the reaction of blood circulation and breathing in a dog during unexpected circumstances is very similar to human reactions. Dogs are also amenable to prolonged tests which the nervier chimpanzee will reject; in general they are more disciplined and emotionally stable. Fluctuation of canine breathing is a very convenient yardstick to his emotions. A dog will puff away at anything from ten to 300 times a minute according to exertion, temperature, environment and emotions. Variations of pulse in dog and man are almost identical and variations in respiration and pulse occur for much the same reasons—if one allows for questions of taste! "Dogs," said one of the assistants, "are highly organized, steady and easily trained animals. Monkeys, on the other hand, are capricious, highly strung and undisciplined. That is why experiments are best conducted with dogs—and was of course why the founder of this Institute used dogs for all his physiological experiments. We have plenty of chimpanzees here," he explained, "but these are used for experiments where discipline and emotional stability are unimportant factors—and nothing to do with space research."

For the selection and training of the space dogs, Pavlov's pupils apply the principles established by the great physiologist —to a science he could not have dreamed about, and their work produced Laika and the host of other animals who preceded man into space.

Heading the research team at the laboratory is Dr. Victor Fyodorov, who explained the basic points of selection: "The great thing is to get them young. We have found definite age limits within which young animals react most to different situations." Both positive and negative influences, he said, would, if applied at a particular time, alter their behaviour for the rest of their lives.

"For instance," the doctor went on, "we divide a batch of puppies—all born about the same time—into two groups. One group we leave alone. The other is 'processed.' They learned that food would appear at the tinkling of a bell. In time, this knowledge activates the saliva glands in anticipation. Then, one day, we change the pattern; we ring the bell, saliva appears, but no food. The puppies become confused, and lose their appetite for the food even when it is given to them, eventually.

"Now," said Fyodorov, "a new situation arises; we substitute a slight electric shock—nothing painful—under the right foot when the bell tinkles. After a while, this is discontinued, and the old order—a bell, then food—reintroduced. But the puppies continue to lift their right feet. They become cowardly. For two years they are left alone to live a normal life, and an interesting fact emerges: those that were only two months old when the tests began remain cowardly; their reflexes have been fixed for life. But the puppies who were eight months old at that time return to normal soon after the end of the experiments."

The space researchers asked for dogs of a specific type of nervous activity—emotionally stable with a high resistance to external and unusual influences, animals whose reflexes for the specific job in hand could be easily fixed. Through many canine generations of tests at the Pavlov Institute, it was found that mongrels were almost invariably better emotional types.

Laika, Belka, Strelka and the others selected by these methods were among those trained in this manner from two months old. But positive reflexes were fixed, as well as the negative ones. When they began their actual training at the Cosmic Physiological Research Station, they were already disciplined co-operators, not passive victims. "Thus, their specialized space training programme, though completely unfamiliar, was very quickly learned, and they adapted themselves in a very short time," one of the white-coated assistants said. "It is important to note, too, that for all their incredibly tough testing, all their frightful ordeals, they remained remarkably cheerful and unconcerned. Today they are just as friendly, bright-eyed and alert as any dog in the street."

Burchett was shown other animals being trained for space; rats finding their way through a complex maze, responding to different coloured lights by making a right or left turn. "Those lights, by the way, are being switched on and off by a punched-tape computer," a vet explained. "The rats also perform certain manoeuvres on the command of a buzzer. Vary the sound, they vary their actions. But you have to be careful. Rats are extraordinarily sensitive to noise—and at a certain note they drop dead.

"Space rats too," he went on, "are the subject of very careful selection. Their specific type of higher nervous activity has to be carefully studied and certain conditional reflexes have to be fixed. Only then, by comparing their behaviour during prolonged observation, after return from the rocket-trip, can we fill in the picture of the effect of space flights on them."

Dr. Fyodorov made an important point about the length of the tests. Relating the effects of cosmic radiation to genetics is a slow process, he said, and may take months or years, and this is why in a special laboratory of "Radiation Biology" they were trying out the long-range effect of varying dosages of radiation of the type most likely to be encountered on the longer interplanetary flights. For this type of experiment, he said, chimpanzees were adequate.

In another building of the Institute a goldfish was having its reflexes fixed by light tests. Each time it touched a tiny red float with its nose, mosquito larvae dropped into the water, "so later it will get used to eating at a command; food if it touches one float, nothing if it touches another. The floats will be tiny lights, one bright, the other dim, and gradually we shall narrow this difference until they are the same. It will become confused, hesitate, and we shall know to what degree it is sensitive to light."

This, explained an assistant, is important to know if it is planned to change their natural surroundings. This knowledge could help to entice fish into special lifts on the Volga dams and help them to their spawning grounds upstream—or accustom them to month-long voyages as space food.

Outside the tree-enfolded, cream-and-white cluster of laboratories and offices, a huge enclosure was alive with barking, yelping, scampering dogs—leaping into the arms and licking the faces of white-smocked girls who came to carry them off for their daily forty-five minutes' work in the labs. It was Belka and Strelka's old home.

For the first two months of their space-trials, the two animals lived a carefree life, petted and fussed over by the staff of the Laboratory of Cosmic Physiology. Gradually, however, their environment changed; fields and trees and the open air were soon memories, as the scientists accustomed them to unnatural situations. The nightmare life that Gagarin had also undertaken eventually became theirs: hours spent in enclosed spaces, being whirled in the centrifuge in shattering noise and vibration tests, in a series of gravity experiments, first in water tanks, wearing breathing masks, then the real thing in the Air Force planes executing parabolic curves.

They learned to open trap doors, obey commands from radio signals inaudible to the human ear, remain calm in conditions of increasing heat, blinding light, pitch darkness and extremes of acceleration and deceleration. "Above all," said one Moscow scientist, "they learned confidence."

The dogs' progress was, in fact, remarkable. With rare exceptions, their physical or mental distress at all this was quickly forgotten, and they showed no reluctance at repeating a familiar experience. New situations, however, were approached with great wariness, though here again, from pulse and heart beat recordings, it was apparent that the initial agitation grew less, or was of a shorter duration, as their training progressed.

In spite of their almost identical appearance, there was a valuable difference between the two dogs—temperament. Strelka was the more calm, sedate and even-tempered, and became more quickly resigned to the indignities of the task. Belka, at times, could be moody, irritable, even unco-operative, and showed greater nervousness.

In normal health, at the time of acceptance, their statistics were:

Strelka: weight, 5.5 kg., 32 cm. high, 50 cm. from nose to tail; Light-coloured coat with dark spots.

Belka: weight, 4.5 kg., 30 cm. high, 47 cm. from nose to tail; Light-coloured. Both were female.

First for hours, then days, then weeks on end, they lived in a model of the space-ship cabin, or else—wearing their brightly coloured, zipper-fastened nylon suits—were carried or trotted from one laboratory to another for tests on frequency or respiration, body temperature, arterial blood pressure, electro-cardiograms and X-rays.

Step by step they were led along the space road—each reflex fixed leading on to a more complicated one. By the time they were ready for training for a specific flight they had become used to greeting the unexpected with Nordic phlegm. They were trained to remain immobile for up to five hours on end, strapped to a tray on the floor of a sealed cabin, submitted to vibration and ear-shattering noise and G-loads and high temperatures without trying to tear free from their space harness. The official report of the Belka-Strelka flights says: "In preparation for the experiment the dogs underwent lengthy training in a model of the space-ship cabin, with a system of harness allowing them freedom of movement for normal vital activities. The dogs were kept harnessed for steadily increasing periods of time. They grew accustomed to wearing gauges, fixing suits and sanitary devices . . . to take food in the form of specially prepared mixtures from automatic devices."

Specimens of hair, skin, blood, bone, urine, and muscle were surgically taken under anaesthetic for analysis preservation and comparison. Some of these specimens, kept "alive" in test-tubes, were then subjected to exposures of radiation and extreme conditions far beyond those the dogs themselves would have to undergo. From this was set limits of endurance which corresponded roughly with calculations already made. The miracle of the whole series was that neither Belka nor Strelka broke down under the strain of the increasing pressure of training. The enormous number of centrifuge tests necessary was already worrying the planners, who knew that, although "stand-ins" were available, and were in fact sharing the two mongrels' experiences, if either of the principals reached the limit of their psychological endurance, the vast complex of costly experiments would have to begin all over again.

The results justified the training methods—not only for Belka and Strelka but for all the space dogs. In Academician Sisakyan's summing-up of the last two canine flights before Gagarin, he said: "It should be noted that during the period of zero-gravity, the animals did not display any visible signs of alarm, nor did they attempt to free themselves from the straps. The film photographed during the flights shows the animals jerked their heads up only when they entered the state of weightlessness . . . during the first minutes of weightlessness, blood pressure, heart and respiration rates remained increased, but after four to six minutes they gradually returned to normal . . . they were sufficiently calm after landing—actively reacted to environment, responded to the call [of the tinkling bell] and had a hearty appetite. In other words, no noticeable deviations were detected in their behaviour. . . ."

Work on the actual cabin of the rocket was directly linked with the progress of the dogs' training. Though the basic design was accepted, many changes had to be made in equipment details; for instance, automatic valves had to conform to the amount of oxygen consumed by the dogs, releasing more at periods of stress, less during the weightless orbiting period. This amount varied between eight and nine litres of oxygen an hour. Between seven and eight litres of carbonic acid gas—"bad air"—was exhaled, and this gas had, of course, to be neutralized.

This particular problem had been recognized many years before as being a major obstacle to prolonged space flight; the chemical means of absorbing foul air was both bulky and unstable. In the laboratories of the Moscow University biology department, on the hill overlooking the city, researchers found an answer in the slime of a pond's surface.

The treacly, wafer-thin, green mass gives off oxygen at an astonishing rate, and it was discovered that only one and a half kilos of algae—the minute cells that perform this function—would be enough to keep a man alive for twenty-four hours; Belka and Strelka would need only a very small amount in the cabin with them.

But the possibilities of algae did not end there. A very fast-growing plant, it absorbs impurities and converts them into oxygen without, it seemed, becoming poisonous or even obnoxious to a human digestive system. Therefore, the scientists argued, there was a possibility of algae becoming a staple diet for space passengers. It had, at least, the advantage of being in inexhaustible supply, given the right conditions of cultivation.

There was, though, yet another risk, that prolonged exposure to cosmic radiation might destroy or damage the algae cells. The decision of the final conference on the subject of oxygen regeneration was that this would have to be accepted, and, somewhat regretfully, for the extra weight would cut down available payload—the chemical synthesis scheme was given priority. Like everything else, this presented its own unique problems.

In this process, the speed of oxygen conversion would not necesarily correspond with the amount actually needed by the dogs. To maintain the balance between production and consumption, therefore, a sensitive regulator had to be designed, built and linked to the telemetering transmitter. In two weeks, it was ready.

Besides Belka and Strelka, the other animals and plants to make the flight were to be: two white rats, fifteen black and thirteen white mice, several hundred insects, two *Tradescantia* plants, and onion, pea, wheat and maize seeds. The geneticists had chosen them with painstaking care, to represent a cross-section of organic life ranging from the simple to the extremely complex. Radiation exposure would reveal, it was hoped, changes in, and the origin of, harmful mutations. The insects, for example, were two strains of *Drosophila* fruit fly, D-18 and D-32.

It was planned to cross the strains after the space flight to find out the frequency of origin of the most important types of harmful mutations, called, somewhat sinisterly, the "recessive and dominant lethals."

Fifty cartridge cases, the size of fingers, were to contain a variety of bacteria and tiny fragments of preserved human and rabbit skin. One cartridge enclosed a glass slide on which, in a jelly compound, cancer cells grew.

The common form of cancer cell is comparatively easy to study and develops well in artificial nutriment. As with the plants and seeds, the Russian scientists were anxious to study the genetical effects that might arise from prolonged radiation exposure; whether, for instance, the next generation would be monster, freak, stunted or normal. And every seed, cell and plant in the space-ship would have a "twin" on the ground, growing under normal conditions, for comparison later.

All these samples, would, of course, be immovably fixed inside the cabin in their respective containers; all, that is, except one—the dogs' food. Somehow this had to be transferred at the proper place and time, without being affected by zero gravity, to the dogs' mouths. Intravenous feeding was discussed and discarded; the experiment was, after all, to simulate the conditions of a man in space as far as possible.

When the condition of zero gravity occurs, a space-man trying to drink from, say, a bottle of water would find it impossible; the water either remains trapped in the bottle, or else, if shaken out, lazily wraps itself into spheres the size of golf balls and floats gently away, breaking into a thousand smaller ones if touched. Solid food, too, had to be "caught" before eating, if given the chance to escape. The dogs' food, therefore, had to be a combination of both solids and water, and arranged so that it could not break free and hang, suspended and tantalizing, before the animals' eyes. A special jelly-like compound with an agar-agar base, smeared on an aluminium plate, was the answer. The formula and weights were: lean meat, 80 gm.; compound fat, 30 gm.; roled oats, 10 gm.; agar-agar 2 gm.; water, 188 gm.; sausage, 20 gm. This, then, was the space-dogs' dinner—with the addition of vitamins, C, P, A, B_1, B_2, PP and B_6. Total weight was 331 gm., with a calorific content of 453.8.

This paste was fairly sensitive to changes in temperature, going "off" or melting if it became more than warm, so food and container were sterilized in an auto-clave at a temperature of 115° C., ensuring perfect preservation. And to remove temptation from the dogs, a flap covered the paste until lifted by a radio signal from the ground, with a tinkling bell accompaniment.

Strelka, Belka and their companions lived on this semi-artificial food for several weeks without losing weight or suffering undue thirst. The delighted dieticians believed that they had discovered the perfect dog-food; a somewhat bizarre and humble by-product of the space programme, but important to them. And perhaps to dogs, too.

The feeding of the rats and mice was achieved by a different system; each animal, by now a little personality, with its own X-ray picture, electro-cardiogram, temperature and pulse chart, was trained to operate levers at a given signal. Solid food in pipe-like troughs was then exposed. Water was sucked from a wick leading to a sealed tank. The rats and mice, of course, were kept in separate net cages from the two dogs.

"The circus," as it was called by the staff of the Science Academy, was assembled several times in the fast-developing dummy of the space-cabin, which, after sealing, was put through a complete simulation of the actual intended flight. Strelka and Belka, the rats and the mice, had, for most purposes, already been "in orbit" around the earth for hours before they ever left the ground. The cabin was "cooked" and shaken and thrown around in a giant cradle, whirled at fantastic speeds on a machine resembling the chuck of a lathe, which reproduced the forces of acceleration and deceleration exactly as in the space-seeking rocket.

From all these trials the animals emerged unscathed. Their reactions were watched intently by the men who were to follow them, on television screens in the laboratory. The tiny transistorized TV cameras, similar to the smallest industrial cameras used in Britain and America, functioned perfectly throughout —a remarkable feat considering that they were undergoing the same buffeting as the animals they were watching. An extract from a technical report on the difficulties facing the TV engineers states: "A number of conflicting requirements had to be met. On the one hand, it was necessary to ensure the highest image quality; on the other, it was essential to reduce weight, dimensions and, especially, power consumption of the equipment. The task posed—that of transmitting information on the behaviour of the animals and the co-ordination of their movements—made it possible to reduce substantially the parameters of the television image—line and frame frequency—and thereby to narrow sharply the spectrum of the TV signal. Technological considerations were also taken into account; for the first experiment it was expedient to work in as narrow a frequency spectrum as possible so as to safeguard against possible frequency and phase distortions which might appear in transmitting a spectrum of several Mc/s. The selection of such parameters made it possible to establish a highly economical and reliable radio channel with considerable energy reserve and with satisfactory image quality."

Using television was a considerable step forward from the previous recording attempts with cine-cameras, which were much bulkier and less reliable. With film, too, far brighter lighting had to be used to obtain a sharply defined picture. As the lamps were directly in front of the dogs, this also meant less discomfort.

Photography did, however, play a large part in the scientific investigation of cosmic rays, and the space-cabin was combined camera, platform and dark-room. In a scientific paper written by S. Vernov and Professor N. Grigoryev, both of the Academy of Sciences, they describe an experiment that cannot be duplicated on Earth:

"A block of heavy nuclear photographic emulsions records the passage of cosmic rays through it . . . any fast-charged particle, when passing through a suitably prepared emulsion, leaves behind a track of separate grains which show up as dark spots against a light background when the plate has been developed. The greater the charge of a particle, or the slower the speed, the closer are the grains to one another and the track becomes denser and darker. This provides an indication of the basic properties of the microparticle which has left its track in the emulsion: charge, mass, speed and behaviour all along its path . . . this source of information is so vast that its transmission by radio is out of the question.

"Viewing the photographs in a microscope," the report continues, "it is possible to reconstruct the complete picture of how particles are born or vanish in processes which last a few billionths of a second, or even faster. For the vast possibilities of the photographic emulsion method to be fully utilized it is essential that the emulsion comes back from an exposure in space, where 'primary' cosmic rays are found, as opposed to the 'secondary' and diminished cosmic rays in the belt of the earth's atmosphere."

Equipment was installed in the cabin to develop some of the cosmic ray photographs while still in orbit. After a ten-hour exposure a timing device split the emulsion layers in two, like the cutting of a pack of cards. A spongy material containing developer solution was then inserted into the gap, to remain there for ninety minutes. By the same method came the preservative "fix" and within a few moments after this the pictures were ready for inspection—though on the actual flight they were, at this stage, still spinning round the Earth. Three other blocks of emulsion plates were also to be carried aloft, but these were to remain unopened and undeveloped until the return to Earth.

Of all the information which the scientists hoped to obtain from this next flight, that concerning cosmic rays was perhaps the most important, for unquestionably they could be biologically harmful to space-travelling man. Cosmic rays surround the Earth in two zones of high-intensity radiation, the boundary of the outer zone being as far as 55,000 km. from the Earth's surface in places, and as near as 14,000 km. in others. The frontier-line is unknown, though artificial satellites are mapping it all the time. This space-map must, however, be more detailed before man risks interplanetary travel; prolonged exposure to radiation must be avoided even though a high degree of shielding can be provided.

Radiation counters in the cabin were provided with screening of different fibres, alloys and plastics of great complexity, as well as of the more homely strips of brass and iron, to see which would be the most effective as a shield. These were placed in the ejectable part of the cabin which also contained the "Noah's Ark" cradle for the animals, radio transmitters, TV cameras and lighting, ejection and pyrotechnical equipment and the photographic plates.

The parachuted capsule was made of sheet metal alloy, double-skinned and extensively padded. The calculations and preparations were now complete. The circus was assembled for the last time; the rats and mice in their cages, Strelka and Belka in their little space-suits. While the capsule was fitted into the nose-cone of the huge rocket, the control station at the launching-pad was a hive of activity, with more than two hundred technicians checking every electrical circuit by remote control.

A long line of television screens flickered into life showing the faces of the two dogs in profile and full-face. Pulse, heart-beat, respiration, air temperature and humidity were checked, the figures registering on deep banks of illuminated dials. The rocket-launching crew on the pad moved away, the gantry connections were cast off, a red light changed to green on the range-controller's desk, and with a roar the engines burst into life. Slowly the 400-ton giant heaved itself off the ground in a billowing cloud of white gas and smoke and steam from the cooling tanks set into the ground, then rapidly accelerated as it cleared its own height. There were anxious faces in the control room, but few were watching the rocket itself; their eyes were on the agitated needles of the telemeter gauges. Computers were noisily producing a continuous stream of figures, using the radioed data being fed in automatically for calculations on the rocket's estimated behaviour.

The now-invisible ship was entering an orbit inclined to the Equator at 64° 57′. The apogee, chattered the punched-tape, would be 360 km., the perigee 339 km. Speed was 15,000 m.p.h. and would increase to 22,000 m.p.h. The first orbit would be completed in 90.7 minutes. No hitches.

Strelka and Belka had withstood the acceleration load on take-off without excessive overstrain, just as they had done in the centrifuge so many times. Strelka's pulse-meter flickered up to 160, from 90 just before take-off. Belka's rose from 75 to 150, while her breathing frequency shot up from 60 to 240. In pre-flight tests, pulse rates had been up only as high as 150, but there was still no cause for anxiety.

The noise inside the 4½-ton capsule was fantastic. A hi-fi microphone was sending back a scream which hurt the ears of the technicians who wore headphones. For the dogs it was the noise and vibration that were the worst experience. With the shedding of the various stages, however, it would decrease a little.

Liquid-air refrigeration plant was functioning and kept the temperature between 17° and 20° C. Humidity, another dial showed, varied between 37 and 40 per cent. Oxygen content was 21-24 per cent. Barometric pressure was very near that of sea-level, 760 mm. In other words, everything was as near normal as could be, and no safety systems had had to be used yet.

Radiation readings were now coming in, too, from outside the Earth's atmosphere. The rocket was still climbing and was about to go into orbit in free flight. Its height reached 200 miles. Radiation dosage was worked out by computers to be 100 milliröntgens in twenty-four hours—double the permitted amount for a man without shielding. Again, normal, and according to pre-flight calculations.

The orbit itself was interesting, but without surprises. Both Belka and Strelka showed signs of irritation at the prolonged weightlessness, but the sensors attached to them also revealed that nothing untoward was happening to them because of it. Belka's pulse-rate, in fact, calmed down from 200 to between 80 and 100 in this period. Heart-beats were almost back to normal, too.

The next anxiety was re-entry, but this problem was now in the hands (or the valves) of the computers. The mathematical equations had been worked out many months before; every command to the rocket was now being given automatically. But a single failure of a single part of the transmitters or receivers could wreck the result of years of work.

One scientist had worked out a table of errors.

An error of one m/sec in the rocket's velocity at the moment of re-entry would mean a deflection of 50 kilometres on landing.

An error of 100 metres in height at that moment would result in the landing area being missed by 4.5 kilometres.

An error of one angular minute in the direction of vector velocity towards Earth would put the rocket off course by 60 km. An ignition failure in one of the retro-rocket motors would destroy the capsule altogether.

Any errors were likely to be big ones. There were ten thousand moving parts on Earth and in space working to bring the ship down safely, and if the weakest link in the chain broke, the most probable result would be the burning up of the rocket by atmospheric friction miles above the Earth.

After orbiting the earth eighteen times, 200 miles up, the command to return was radioed. The braking rockets fired, fully and on time, the cabin slowed, the descent began. The outer skin glowed white hot as it streaked downward into the denser atmosphere, but layers of tissue-thin ceramic paint, and a newly developed coolant, threw off the heat before it reached danger level. Inside, Strelka and Belka were unaware that only a foot or two away from them the temperature had soared to thousands of degrees, furnace-heat; the air-conditioning plant was functioning untroubled and the interior temperature gauges still showed 20° C. At a height of 7,000 metres a barometric relay set off the ejection device and the Noah's Ark was catapulted in its protective container from the cabin. Parachutes braked the fall and the two objects from space swung gently down, side by side at first, then further and further apart as the heavier cabin plummeted faster than its companion. When the two hit the ground they were still performing their function of recording; the last data sent out was that of the touch-down speed: the cabin at ten metres per second, the "Ark" at six metres per second.

The parachutes had barely hit the earth when a little crowd of astonished farm-workers surrounded the strange containers. No planes were about or had been heard; there was nothing to suggest from where they might have come. Approaching closer, somewhat nervously, they saw a stencilled message in yellow paint: "Please inform Soviet Space Centre by telegram immediately on discovery." The youngest men raced each other to the nearest phone . . . but cars were already bumping their way over rough fields to the spot. . . .

The two mongrels were alive; that was enough to justify the flight. But, from the fantastic complex of instruments in the control room, it was possible to know before the capsule was opened that the achievement had been greater than that. The dogs had suffered no ill-effects at all. The strain of the entire trip had been far less than they had experienced in training. And after a journey of 435,000 miles Strelka and Belka had landed only six miles from the target. Now they were back, licking the hands that patted them as they were unhooked from the cradle.

No one was more pleased to see them than Yuri Gagarin. . . .

Fyodorov, now no longer "Acting," but Chief Learned Secretary of the Academy of Sciences and, by this time, the leading authority on the overall, co-ordinated picture of Soviet space developments, saw Burchett again shortly afterwards. The question of manned flight was clearly much nearer now that Belka and Strelka had demonstrated the safety of re-entry and landing. But Fyodorov was still cautious.

"A man will be sent," he said, "only when we can be absolutely certain, without any possibility of error, that we can bring him back safely. People talk loosely about 'hurling' or 'shooting' a man into space as if he were merely an expendable bit of super-instrumentation. We do not regard man just as the tip of a rocket."

He went on: "There are still many complex problems to be solved of course; not only do we have to bring him back safely but we have to ensure he will continue to live in good health, and his children and grandchildren also.

"The main task of the Strelka and Belka ship was to test the descent and landing gears; the next most important was biological research. To secure the life of the many creatures aboard during take-off, weightlessness and descent, in protection against radiation, in air regeneration, oxygen supply, feeding and many other things, we had to duplicate features that will be necessary for a human in flight. We also had to test the guidance and orientation systems, to ensure that the ship entered the descent orbit at the precise point in time and space so that it would come down exactly at the pre-selected area.

"Of course, the successful flight of this ship and the fact that all the instruments worked well brings the time of a manned flight much nearer. But, in my own opinion, much more research is still needed; the responsibility is too great. There must be further assurances of reliability of instruments, for instance. Probably we will duplicate every key instrument in the manned space-ship."

About one thing he was evidently pleased and highly confident: "Cosmic radiation is still a hazard," he said, "but we are confident now that we can provide adequate protection. We know a great deal about it, what it is and how it is distributed. There was considerable joint work in this field by Soviet and American scientists to locate and study the nature of the radiation belts."

Referring to the number of animals, insects and plants on board with Strelka and Belka, Fyodorov said: "There were many things only remotely connected even with manned flight. The size and weight of the ship enabled us to load it with all sorts of objects and appliances." And he repeated what he had said three years earlier: "We pay great attention to solving basic problems which perhaps have no immediate application. We like to have certain reserves in hand, and this always justifies itself."

Some of the experiments carried out on the Belka-Strelka ship were for the launching of the Venus rocket; others were connected with manned interplanetary travel. Meanwhile, it was clear, and Fyodorov said as much, that the Belka and Strelka space-ship was the prototype for the first trip by a cosmonaut, with such modifications as intervening tests might dictate. The further launchings in December, 1960, and

February and March, 1961, were in fact proving and modification tests.

As expressed in the dry language of the official report after the Gagarin flight: "One of the prime problems among a vast number of scientific and technical issues that confronted Soviet scientists and designers in preparing for, and effecting, the first manned space flight was that of ensuring the requisites for safe flight and safe return to Earth. To solve this . . . elaborate design development had to be conducted and many experimental launchings made." It is interesting that—as Fyodorov told press correspondents on the eve of the Gagarin flight—with Belka, Strelka, Zvezdochka and other space-dogs present at a press conference, the Russians rejected the idea of sending a man up in a rocket as a prelude to orbital flight. The achievement would lie only in the space flight itself, they felt, not in a ballistic trajectory shot.

The required information about radiation, weightlessness, overload and physiological functions could be obtained from animals and instruments without risking a man. When they were completely confident of their equipment and were ready to embark on super-long-distance exploration, then, said Fyodorov, a man would go and look at the world for himself, to encounter and report on experiences that were outside the appreciation of animals and instruments.

Not even the most optimistic space-scientist had expected things to move so quickly; many were still fearing to find great and so far unknown hazards and obstacles in the way, though perhaps none agreed with the British astronomer who declared at the time of the first sputnik: "Space travel is bunk." Journalists were perhaps the most optimistic; a Moscow monthly magazine in 1954 produced an issue with a cover design showing a rocket with stubby, swept-back wings being fired into space. It was a mock-up of a November, 1974 issue, and in it the writers, after quoting scientists, engineers, designers and science-fiction writers, predicted that manned flight might be possible in 1974. On his death-bed, Tsiolkovsky, in 1935, told journalist Max Polyanovsky that although unmanned rockets would soon fly into outer space, it would be another couple of centuries before manned flight would be possible. And, as we shall see, one of these scientists responsible for a key sector of the man-in-space programme did not believe it would take place in his lifetime. Strelka and Belka changed his mind.

When one glances at the list of Soviet space probes, it looks a very smooth, orderly operation. But just as whether to go into outer space at all was the subject of bitter controversy in the immediate post-war years, so was every move, from plotting an orbit to designing a spaceman's suit, hammered out in vigorous and furious arguments among those responsible. Professor Parin, for example, refers to "a great deal of argument" on the question of the cosmonaut's training programme. "Some physiologists insisted without proper justification on training for oxygen deficiency," he said. "Now, oxygen deficiency may originate in a space-ship only in a breakdown or other emergency. The fact is that the oxygen supply system had a double protection; the cabin sealing plus the space-suit. The possibility of both systems being damaged is infinitesimal."

Nevertheless, the trainee cosmonauts were given the oxygen deficiency treatment, as described later. The difficulty was, of course, that much of what lay ahead of Gagarin could not be known despite the impressive lists of experiments with animals. The cardiograms, TV supervision, telemetered and taped information and careful post-flight checks could tell much—but dogs cannot talk and their organisms are not identical with those of humans. An enormous amount of information was amassed, and Gagarin's training was designed to meet every condition that could be anticipated. But much was still unknown, and unknowable, when he went aloft.

"Medical men can already sum up the first results," Parin wrote in a report to colleagues three days after Gagarin's flight. "Even though the radio telemetric data has not yet been processed, the training programme has proved its worth. The actual conditions turned out to be much easier than those of training. There was a large 'safety margin' which may be called upon, however, for more complex space routes . . . now, I think that a man in space is capable of doing a great deal more than was supposed. It had long been believed that in the conditions of G-load during the start and braking, and probably of zero weight, an astronaut would not be capable of controlling a space-ship in an environment changing at truly cosmic speed. Yuri Gagarin's state during the flight warrants the conclusion that trained men are well capable of doing this. . . ." Parin went on to strike a personal note which emphasizes how many of the men intimately associated with the space programme felt at various stages: "When our research in space medicine and physiology was just getting under way, we were all aware of the remarkable prospects ahead. I thought that I would learn a great deal of absorbing interest to me—but I did not think that I would live to see man's space flight. A year ago when the first animals were put into space and returned safely, I realized I was mistaken.

"Now it seems that had there not been a single pleasant event in my lifetime, life would still have been worth living for that day alone."

That one space scientist such as Parin did not believe—even eight months prior to putting a man into space—that it would not happen in his lifetime, emphasizes the speed with which matters moved once the "action" button was pressed. It also reveals the narrow limits in which individuals worked. The overall picture was known only to a few men at the top, such as Fyodorov and the genius of all-round space technique, Keldysh. The biologists did not believe the engineers could solve the problems of re-entry and landing so quickly, and probably the engineers had their doubts as to whether the biologists could keep up with them in preparing a man for a safe flight.

Who are they, these scientific giants who planned this step-by-step advance, who designed and built the space-ships and their precious payloads of instruments, who plotted their orbits and trajectories? Only a handful of men know the names of the executives, and Khruschev intends to maintain this secrecy, he says, while the Cold War lasts. Similarly, the launching-sites (and it is estimated that there are 200 major ones) are top secret, though immense advances in radar and infra-red tracking by the U.S. have created a situation where only the general public of the two countries are in the dark. It is freely admitted on both sides that it was a rocket from the anti-aircraft defences of a launching area that brought down Gary Powers and the U-2, and U.S. officials claim they know exactly where it was fired. An American report on the accuracy of the Russian ballistic rockets, aimed into the Pacific with a target error of only six miles, fixes their launching pads as a little more than 100 miles north-west of the Caspian Sea. Not far, in fact, from Baikonur.

8

GAGARIN

MAMA Gagarin burst into tears when told that Yuri had been chosen as a spaceman. She confesses that she doesn't know whether it was pride or fear that was uppermost; it was certainly a shock.

She is a woman of her time in Russia; solid, reliable, earnest, devoted to her family and conscious of her responsibilities. Her son, Yuri Alexeyevich, was born on March 9, 1934. Valentin, his eldest brother, was then 10, his sister Zoya 7. A fourth child, Boris, came after Yuri. As with Dickensian England, it was the best of times, it was the worst of times. Russia had not yet fully emerged from the chaos of the Revolution; the lot of the peasant was still improved more in theory than in practice. And the Gagarins (no relations of the princely family!) were peasants. Papa Alexei had virtually no schooling, had taught himself to read and write. A leg injury had kept him from an active part in the Revolution, and this was not to improve his farming capabilities. He became, in the tiny village of Gzhatsk, near Smolensk, an odd-job man, but gradually switched full-time to a craft that he mastered as an artist: carpentry. Gagarin's earliest memories are bound up with wood shavings and the feel of smooth carving. "I can still tell the difference between pine and oak, maple and birch, just by the smell," he says.

While mother veered towards indulgence, father was strict with the children. For those days he held perhaps strange but enlightened views on their upbringing, never using physical punishment, never swearing or shouting at them, nor bribing them to behave. On the other hand, he was, says his son, "Never effusive in his tenderness." The children idolized their father, and still do.

War came a few weeks after Yuri started school. The lightning advance of the German armies brought them to within a few miles of their home, and the village became a battlefield over which both German and Russian troops fought furiously and—for the village—disastrously.

The first plane Yuri ever saw, crashed. It was an old bullet-riddled *Yak*, and it came down in a meadow near the farmhouse. Two airmen escaped unhurt, and slept by the wreckage to guard it. In the morning, after an icy night, they found that sleeping between them was another small guard—Yuri.

Planes continued to fascinate him through his childhood. While still learning the alphabet he began memorizing the names and makes of Russian and enemy aircraft, and Air Force men in the district were an immediate attraction for him. With his father's carpenter's tools he built a wooden model and "flew" it out of an upper floor window. It dropped like a stone on the head of a passer-by, who failed to appreciate the child's ambitions.

During the German occupation some of the worst recorded Nazi atrocities were committed in the district, and death became a friend to many of the Gagarin neighbours. The children helped the Resistance in ways they were well-suited for: smashing bottles and scattering the fragments on the road, then waiting behind hedges for the satisfying bang of bursting tyres; starting fires near German huts, and spreading misleading information. Among the Nazis who grew to hate the young Gagarins and their friends was a red-haired Bavarian, known to them as Albert.

One day he lost his temper, grabbed Boris and hung him by his scarf on a tree-branch. While the child was slowly strangling, his mother and Yuri watched helplessly, desperate with fear. Albert made it clear that any rescue attempts would cost more lives. Boris took a long time to die, however; too long, for Albert became bored and walked away. Anna Gagarin and Yuri dragged him down, carried him back to the family dug-out and revived him.

Later Valentin and Zoya were carried off by S.S. men and herded on to a "children's train" for deportation to Germany. No one expected to see them again, but in the chaos of the German retreat that followed Stalingrad the two Gagarin children escaped and joined the Russian army, Zoya as a vet in a cavalry unit, Valentin as an anti-tank gunner. Their father developed ulcers through hunger and spent the rest of the war in a military hospital, first as a patient, then as an orderly.

With the end of the war, the villagers of Gzhatsk set about rebuilding their shattered homes. First to be built was a school. It had one teacher, a pretty young girl named Nina, little furniture, a blackboard but no chalk, and no textbooks. Among its first pupils were Yuri and Boris.

Yuri and Boris learned to read from an Infantry Manual, left behind by Russian troops; their geography was picked up from war maps issued by the Soviet News Agency.

The arrival of Lev Mikhailovich Bespavlov a year later was a milestone in Yuri's life. This was his first physics teacher, a man who came to be regarded with awe by his pupils. His experiments were crude but impressive: filling a bottle with water, tightly corking it and taking the class into the freezing air outside to watch it explode, "with a bang like a grenade" remembers Gagarin. He conjured up electricity by combing his hair, re-enacted Newton's discovery of the laws of gravity with an apple from Yuri's garden, floated pins and needles on water and showed them how to find their way with a compass.

He made a tremendous impression on Yuri, the more so because he always wore a faded air-force tunic. Lev had been a gunner-radio operator. "He was," says Gagarin, "a wizard."

The future spaceman's first uniform was that of a foundryman—a peak cap with a union emblem, baggy tunic and trousers, and a wide belt with a big brass buckle. To him, the image in the mirror was unbelievable. He spent his last few roubles on a photograph to send home. For he was now in Moscow, with six years schooling behind him, training as a metalworker at the Lyubertsy Plant making heavy machinery.

His first boss was a tall, heavily built man with a drooping moustache and iron-bound muscles, whose opening words to Yuri and his fellow apprentices were: "Get used to handling fire. Fire," he said proudly, "is strong, and water is stronger than fire, the earth is stronger than water, but man is the strongest of all."

"We," says Gagarin, "were scared of everything."

At the end of the first day the foreman assigned him to a machine making snap-flask moulds. Gagarin made the moulds, inserted hinge-pins, covered the flasks and put them on a conveyor belt. After the first shift the foreman reappeared, beating his forehead with his fists. He told his young comrades, as only foreman foundrymen can, that they had made a slight error: the pins had been put in the wrong way round. "The next day," says Gagarin dryly, "we made better progress."

His final report as an apprentice was good. He was the only one of his year to graduate with the top rating and was one of three chosen to continue training at a newly built trade school, at Saratov-on-Volga, where the three R's were combined with learning how to build tractors.

During his years there Gagarin became a versatile sportsman—ski-ing, volleyball and basketball were his favourites. After simultaneously completing secondary school and getting his foundryman's certificate, Gagarin and two other outstanding boys were transferred for higher studies to a technical school at Saratov—and here he put his foot on the first rung of the ladder that was to lead him up to the Cosmodrome lift and a further couple of hundred miles up into outer space.

The teacher, Nikiforov, who escorted them to Saratov, says that within a few hours of arrival, immediately after they got their lodgings, the four of them went into town—and Gagarin saw a notice, "Aeroclub." "Ah, my friends, that would be something, to get in there," he said—and promptly did.

At the club, Yuri had his first close-up view of a plane—a whole one and on the ground. This was long after he arrived at the Volga city. The plane was a *Yak*-18, an old biplane trainer that trundled along at about 100 m.p.h. It was the actual plane in which he later learned to fly. An instructor standing by it at the time says he was struck by the "rapturous expression" on the young foundryman's face as he looked at the plane. They struck up a conversation and veteran flyer Dmitri Martyanov drew from Yuri his secret ambition. In his third year at Saratov, Yuri was accepted as a member of the Aeroclub, and Martyanov became his instructor and close friend.

It was to Martyanov that Yuri later gave the traditional gift—a pack of Troika cigarettes—after he made his first solo flight. He was then in his fourth and last year at the Technical School. "You did very well," said Martyanov. "One would think you'd been flying for quite a while."

"You're right," Gagarin replied, "I've been flying since I was a kid."

From the moment he soared off the ground in the old *Yak*-18 and circled around the field at 100 m.p.h., and at an altitude of 4,500 feet to perform a couple of very simple manoeuvres, he knew he was born to fly. But it was still a far cry to 17,500 m.p.h. at 200 miles altitude.

A few months later when Gagarin graduated with an "excellent" from the Technical School, he had wings as well as his foundryman's crossed hammers on his tunic. And it was clear the wings had won. No earth-bound factory for him in future. It was a short hop from the Saratov Aeroclub to the Orenburg Air Force School—much to the dismay of father Alexei and mother Anna.

As an Air Force trainee, Gagarin was good but not exceptional. His marks were more for perseverance and careful preparation for everything he did rather than brilliance. "Don't imagine he was an infallible cadet, a child prodigy. He wasn't. He's an impetuous, enthusiastic young man who made the same slips as any other," says one of his instructors.

His worst marks were for his landings, which, at that time, were of the "just-made-it" or "miracle" variety. This contrasted so much with his complete confidence and assurance in the air that it became a talking-point among the professional pilots, and they voluntarily gave him special coaching. "Once," says instructor Yadkar Akbulatov, "I took him up and watched carefully. On steep banks his performance was not absolutely perfect, but when he went on vertical stunts he put on a show that made me see stars from the G-load." Then came the touch-down. It was faultless. Surprised, the Air Force man asked why he couldn't always land like that. Gagarin grinned. "I've found the solution," he said, "I put a cushion on the seat." He had, too. His lack of inches had always made it difficult for him to orient himself to the ground, but that cushion was to go everywhere with him from then on.

When his fighter unit at the Air Force School had its first practice shooting in flight, all the pilots except Gagarin did excellently. His shots went wide of the target. As with his landing fiascos, he went over and over the technique on the ground before he would have another try. The next time, he riddled the target. When he set his mind on something, he went after it and kept after it till he got it. Despite his size, he became an excellent basketball player and captained the School junior cadets' team. In one key game, in which his team beat the senior cadets to the surprise of the latter and the onlookers, Yuri explained the result to the other captain: "Why did we win? Because we played better? Not at all. We won by sheer determination. We were bent on winning while you hadn't made up your minds." The incident is typical of the single-minded way he went after what he wanted.

It was while he was at the Orenburg Air Force School that Yuri met his black-eyed Valentina—a gentle, madonna-faced trainee at the local medical school. He seems to have handled this matter in the same single-minded way.

Instead of the bachelor Gagarin who arrived at "N" unit in the late autumn of 1957, there were three by the autumn of 1959 when the time came to leave for the space training headquarters. Valentina in the meantime had given birth to a chubby baby daughter, Yelena.

From the callow youth sighing enviously at the Saratov "Aeroclub" sign eight years earlier, Yuri Gagarin had become a first-rate jet fighter pilot, "a born flyer and a brave flyer" as his regimental instructor told him; partly conditioned by complicated aerobatics for the sort of training his new assignment demanded, his obstinate, tenacious character well fitted for the ordeals that he knew lay ahead.

How and why was he chosen? The most authoritative answer is given in the official report on the space flight published first in *Izvestia* on April 24, 1961.

"The first space flight," said the newspaper, "could only be performed by a man who, realizing the tremendous importance of the task set to him, had conscientiously and voluntarily agreed to devote all his forces and knowledge and even perhaps life itself to the accomplishment of this outstanding exploit. Thousands of Soviet citizens of different ages and professions expressed the wish to make the flight into outer space. Soviet scientists were instructed to carry out a scientifically based selection of the first cosmonauts from among the vast number of applicants.

"In the course of a space flight, man is subjected to the influence of a whole complex of environmental factors (acceleration, weightlessness, etc.) and a considerable nervous and emotional strain calling for the mobilization of all his moral and physical abilities. Along with this, the cosmonaut must retain a high degree of working ability and be able to orient himself in the complicated conditions of the flight and, if need be, take part in controlling the space-ship. All this determined the high demands made of the cosmonaut's health, his psychological qualities and the level of his general background and technical proficiency.

"These qualities are most fully combined in pilots. Work as a pilot already determines the stability of a man's nervous and emotional sphere and his strong will-power—of special importance in the first space flights. In the future, however, the range of persons participating in such flights must undoubtedly be broadened considerably.

"In selecting the group of cosmonauts, talks were held with a great number of pilots who expressed the desire to make a space flight. Those of them who were best prepared were subjected to a careful clinical and psychological examination. Its purpose was to determine the state of health, reveal the latent deficiency or reduced resistance of the organism to separate factors characteristic of the future flight and ascertain their reactions to the action of these factors.

"The examination was carried on with the use of a number of modern biochemical, physiological, electro-physiological and psychological methods and special functional tests making it possible to assess the reserve possibilities of the main physiological systems . . . (investigations in the pressure chamber at considerable degrees of rarefaction of the air, abrupt changes in the barometric pressure, breathing of oxygen at increased pressure, investigations in the centrifuge etc.)

"Investigation . . . to find out persons possessing an especially retentive memory, resourcefulness, active attention that can easily be switched, the ability to develop precise, co-ordinated movements. As a result of clinico-physiological examination a group of aspirants was formed which started on a programme of special instruction and training on special stands and devices simulating on the ground and in the air, conditions of space flight . . ."

What all this meant in the near-torture routine for the space candidates is set down later in this book. As a result of the preliminary tests which went a long way along the road of actual space pilot training, including hot boxes, isolation chambers, centrifuges and several dozen parachute drops for each candidate, it was established that ". . . the selected cosmonauts possessed good stability to the influence of the above factors and individuals were singled out who stood the tests better than the others." These—including, of course, Yuri Gagarin—were then given further planned physical culture lessons "based on the individual features of each cosmonaut's physique . . . aimed at improving the stability of the organism to the effects of acceleration, working out and perfecting the easy use of the body in space and stepping up the ability of enduring long physical tension." Setting-up exercises for an hour each day were for general physical training.

After further long periods of training, including actual space-ship conditions complete with space-suit and familiarity with a whole range of life-saving systems there was another culling out and "a group of best men ready for space flight was picked from among the trainees."

In the dry language of the official report—from among the group of best space pilots: "Major Y. A. Gagarin was chosen . . . for carrying out the world's first manned flight into space . . . At his urgent request, he was included in the group of candidates for space flight and passed the tests. Y. A. Gagarin made the best showing during the training period . . . fully justifying the great confidence placed in him of being the world's first space pilot."

It is clear the Russians wanted to have very wide margins of safety, both in selecting the candidate for the first great venture and in his preparation. They wanted someone who could adequately cope with all the known dangers and difficulties and still have plenty up his sleeve for the unknown ones.

The biologist Nikolai Gurovsky, a senior research worker from the Institute of Cosmic Biology who had much to do with training the cosmonauts says that the choice of Gagarin "did not at all mean that it is only for pilots to make space trips. The time will come when the engineer, the astronomer, the biologist and the journalist will be making them. But when the candidates for the first flight were discussed, the scientists decided unanimously that it should be a pilot who, by virtue of his profession, encounters many factors bound to be met with by space travellers; over-loads on take-off and return, rapid change of speed, the need for lightning-fast orientation and the ability to take quick decisions without anyone's advice.

"During his services in aviation," Gurovsky went on, "Yuri Gagarin displayed first-class ability as a flyer. He also demonstrated tremendous will-power and perseverance during general and special training."

The choice of Yuri Gagarin—and the man's character—lent point to a fascinating controversy which had raged in *Komsomolskaya Pravda* some eighteen months previously. It started with a letter by a lovelorn young Leningrad student asking the advice of writer Ilya Ehrenburg regarding her quarrel with her engineer friend. It touched issues so deep that Ehrenburg published the letter and his own comments, discreetly leaving the name of the girl as "Nina," that of the engineer as "Yuri." The essence of the quarrel was Yuri's attitude towards the arts and even ordinary human feelings. There was no place for "old-fashioned stuff," art, music and poetry in the space age. Nina had decided to break with him and sought confirmation from Ehrenburg that she had done the right thing. "Do you think the arts are going to pot and love should be approached more simply, the way Yuri does. Sometimes I begin to wonder . . ." Ehrenburg, as a humanist and vigorous defender of the arts, obviously came down heavily on the side of Nina—to the extent of 2,500 words. Letter and article started off a heated controversy. One would like to record unanimous support for the wise and sensitive arguments of Ehrenburg, but many of the early letters were from people like Yuri—carried away by the relentless advance towards the stars. Thus one Moscow engineer, L. Polestayev . . . "It is science and engineering that shape the profile of our epoch . . . our lives are guided by the creative force of reason and not by emotions; we are moved by the poetry of ideas, by theories, experiments and construction . . . we have no time to dote: Ah, Bach! Ah, Blok! These are outdated. . . . The most fascinating stories spring from science and engineering now, from bold, precise and merciless reason . . ." "How can I admire Bach or Blok?" asked the engineer Petrukhin in his letter. "What did they ever do for Russia or mankind? Leave the arts to the dilettantes." "I can get along beautifully without art," commented still another engineer, Nekrassov. A college student, Levin, maintained that "a decent physicist is twenty times more useful than any poet. . . ."

The controversy raged for four months and the defenders of Yuri became an insignificant minority as the stream of letters swelled into a flood from all over the Soviet Union. One letter from Elvita Popova who described herself as a member of the Young Communist League wrote saying that "notwithstanding the terrific advance of the most exact science, electronics, I am confident that in outer space too, man will struggle, suffer and love. Man will appreciate lilac in outer space too. . . ." The point about lilac and outer space was seized on after this letter to symbolize the harmony that must exist between the arts and the most advanced sciences if man is to continue as a civilized being. The whole question of aesthetics and the humanities and their place in the space age was projected on to the public platform by intensely articulate people.

"I am sure the first space pilot will be a man who knows Bach and Blok, who has read Gorky and Chekhov, who is fond of Pushkin and Gogol," wrote B. Kirrilov from the remote town of Kizil-Arvat in Central Asia, "because they, the great geniuses of music and literature, have helped develop since our childhood our courage and honesty, our love of people, our pride in what we have achieved. The first man to invade the Cosmos will not merely be brave but cultured."

". . . In the Cosmos too, man will need a sprig of lilac," agreed engineer R. Leonidov, "and in the pockets of their space-suits, the astronauts of the future, real men and women of great science, will no doubt carry books of verse on their flights to the Moon, Mars, Venus and the stars." But with a humorous tilt at lovers of art who go to the other extreme and ignore science and technology, he warned that in the "dark and cold of the Cosmos" the sprig of lilac would have to be protected by science. "Shining containers filled with liquid air will enable it to breathe. It will be kept warm by semi-conductors of solar batteries. Artificial gravitation apparatus will secure a normal circulation of the juices in its lustrous leaves. Slabs of lead and graphite will preserve it from the deadly currents of cosmic rays and the super-strong envelope of the space-ship will protect it from the blows of the swiftest meteorites." Leonidov expressed the very reasonable conviction that the arts and science "like two mighty trees, will flourish side by side with branches interwoven."

It was Nina and Ehrenburg and those who supported them that were right—as events proved. Gagarin did not record Man's first, breathless adventure into outer space in terms of statistics, graphs and scientific analysis. His first words when he saw the Earth and its halo were: "How beautiful it is." His more detailed descriptions later revealed a depth of poetic feeling. In his first interview, shortly after he landed, he told *Pravda* and *Izvestia* correspondents that his favourite authors were Chekhov and Tolstoy, Pushkin, Jules Verne, Tsiolkovsky and Polevoi. It is typical that his favourite hero was Meresyev in Polevoi's *Story of a Real Man*—the story of a downed aviator who crawled on his elbows with bullet-ridden, useless legs, crawled for days through snow-covered forest and enemy lines—back to partisan-held territory. Later by sheer guts and endurance he taught himself to use artificial legs to take to the air again. Literature and music in fact are as fresh air and light to Yuri Gagarin.

The last glimpse we have of him at home—an hour before he flew off to spend that last night at the Cosmodrome, he is preparing his things and interrupts reading one of his favourite poems, "Requiem" by Robert Rozhdestvensky, to change the nappies of month-old baby Galya. Waiting for the shattering roar of the rocket engines, he sings "I love you, Life" and when the space-ship plunged into its Earth-bound parabola, with the scientists and biologists anxiously peering at the TV screen, watching those leaping green flashes on the luminous dials of instruments registering his vital physiological functions, straining to catch one word from him in this new untested ordeal of transition from weightlessness to overload, the strong cheerful voice crackles through—singing: "My country hears; My country knows . . ."

Yuri Gagarin carried a sprig of lilac with him.

9

GAGARIN: THE TRAINING OF A COSMONAUT

LONG before Gagarin was chosen as the first space-pilot, his rocket and the capsule were completed. The instruments were designed, if not actually built, before he was even on the short list. It was not the vehicle that had to be tested; it was the man.

The training of a cosmonaut is Inquisition-like in its cruelty; yet competition to undergo this scientific torture, in both Russia and America, was tremendous. Very many of the volunteers were turned down almost immediately, because of a flaw in their health record, or psychiatric instability.

Many were later rejected for a variety of reasons unconnected with physical or mental health; the final few were rare specimens indeed, in both hemispheres.

Press reports for long gave the impression of a race between Russia and America to be the first in space with a manned rocket; the Soviet scientists insist that this was not true; that for many months they had known that they had the great advantage—a fuel that that was reliable and that would propel a far greater weight of instruments in orbital flight, which was the only manned space venture they were interested in as a first step into the unknown. And, loosely speaking, the greater the payload available, the greater the chances of success.

The safety factor depended largely on this. The Russian Vostok rocket was so packed with instruments, shielding, safety devices and so on that the pilot's weight represented only two per cent of the total.

But if the fuel was there, and the rocket was there, and the capsule was there, the human element was certainly unpredictable. No scientist likes working with unknown quantities, and to reduce the margin of error the most extraordinary tests were devised.

The five main stages of a manned space flight are take-off, acceleration, orbiting, re-entry and deceleration, and landing.

The principal physical strain comes from acceleration load, weightlessness, deceleration load and noise.

The experiments with dogs produced a mass of information which satisfied engineers that the vehicle could provide 100 per cent protection for the man. But which man?

Follow the progress of Gagarin, the eventual choice, in his training.

Firstly there were blood, skin, urine and anatomical tests; normal examination of the type anyone might undergo for an insurance company which is underwriting a bigger-than-usual risk.

Next, the pressure-chamber: a double-walled steel canister, the size of a Nissen hut, of the type that divers use to recover from or avoid "the bends," a perhaps-fatal condition which occurs when, brought up from the depths too suddenly, oxygen bubbles form in the bloodstream. While in this compartment, Gagarin had strapped to him pulse and heart meters and a blood pressure gauge. From this comparatively simple and painless test to one which duplicated the acceleration and deceleration loads. A car travelling at 60 m.p.h hits a brick wall. A passenger is thrown forward from rest to almost 60 m.p.h. in a tenth of a second; the damage to him occurs only when he is stopped in the same space of time by the dashboard; if his velocity is unchecked by obstacles, he will come to little harm.

This is the theory, and Gagarin underwent this in practice; for those are roughly the forces at work in a rocket on take-off. The same effect is felt in reverse when braking. The young major came through this again and again, while cine-cameras recorded his movements and expressions, and meters attached to nerve centres revealed his unseen reflexes. The processed cine-film, in slow motion, showed the flattening of the cheeks, sinking of the eyes, and stretching of the skin which occurred; it was as though he had been hit by a sheet of plate glass.

A characteristic of the space-training programme was to go rapidly from one extreme to the other—at 8 a.m., say, after a long night's peaceful sleep, the cosmonauts would be plunged into a noise-bath; an hour-long ear-shattering ordeal of roaring, howling and screeching, recorded on tape and amplified hundreds of times through huge loud-speakers in an enclosed room. It was the kind of noise that could not be shut out, even by blocking the ears; it ran through every nerve and fibre of the body.

This would be followed at 10 a.m. by a spell in absolute silence, in solitary confinement. And this, said Gagarin, was perhaps the worst of all. On entering the darkened room, filled with panels and gauges, pipes and valves, the trainee never knew how long he would remain here. Sometimes it was days before he emerged.

Loneliness, fear, hunger, cramp, cold, heat—all were deliberately inflicted on the hapless men whose only comfort was the softly padded pilot's seat in the centre of the room.

"There was no sound," Gagarin said, "not even the slightest rustle. No movement of the air, nothing. It was uncanny, unnerving."

The only link with the world outside was by telephone—but here again there was a chilling psychological trap. Often the watching scientists, invisible to their "victim," would make this a one-way link; he could speak, but there would be no reply. His reports were at set intervals, sometimes once an hour, sometimes once every three hours. He would have to state how he felt, what he had been thinking about, what he had been doing. Occasionally they chatted to him, played music or cracked jokes. But, perhaps the next time he reported, there would be no reply at all. It was calculated to make the strongest man break down. He would be given no warning of his release, either. He had nothing to look forward to. One Moscow scientist told us: "It was worse for them than being in gaol. They couldn't even write the days on the wall and tick them off."

To occupy them they were given small tasks; mathematical problems, working out navigational courses, memorizing complicated instructions. But the scientists were careful to leave them with long periods of idleness, both mental and physical. One man who showed signs of cracking would be put in this isolation chamber again and again until he either accustomed himself to it or broke.

Gagarin came out of these tests remarkably well. "In there," he said, "I thought about the future, not the past, as one usually does in such circumstances. I imagined myself in the cabin of Vostok. I shut my eyes and would 'see' continents and oceans flowing by beneath me, with a scattering of city lights as I flew over London, Rome, Paris, Peking and my own Gzhatsk." He also tried to recite half-forgotten poetry and ballads. Observers were amazed at his ability to withstand prolonged periods of solitude, but for the others the toll was heavy. By December, 1960, there were only a score or so of competitors for the title of Cosmonaut No. 1.

The launching at that time of the third cosmic ship, containing the dogs Pcholka and Mushka, provided unwittingly a further test of their nerves. For the space-ship's computers went wrong; it slipped out of control and burned up in the atmosphere at re-entry. Some of the training school instructors were anxious about the effect this disaster would have on Gagarin and his colleagues, "But," said Gagarin, "they needn't have worried. We just got on with the job."

There were many other obstacles for those who remained: the thermal chamber, where steam pipes pushed up the temperature to oven-heat, while the cosmonaut, strapped in his chair and bathed in perspiration, continuously operated dummy levers and buttons to a set programme until exhausted. The limits here were high, but Gagarin was used to furnaces and had always been fond of the Russian sauna bath. The centrifuge, too, was a frequent "schoolroom." Soviet Air Force jet pilots are always put through centrifuge tests, but the usual maximum is around 7 to 8 Gs. For the cosmonauts, however, this was not good enough; they had to withstand pressures of more than 10 Gs and for the briefest of moments, of up to 15 Gs. The normal pilot's seat on the centrifuge beam was altered from its upright position to become almost horizontal, extended so that the trainees were lying on their backs, as they would during a rocket-ship take-off. Sensors were taped to the skin and connected to delicate instruments recording a variety of physiological functions as the cosmonauts were whirled round at tremendous speeds. "My eyes wouldn't shut," said Gagarin, "breathing was a great effort, my face muscles were twisted, heart beats speeded up and the blood in my veins felt as heavy as mercury."

It was almost a relief to be sent on the parachuting course. Gagarin made forty jumps, each one a little trickier than the last. His instructor was Nikolai Konstantinovich, Master of Sport and holder of several world parachute records, including one for a free fall of 14.5 kilometres. As neither Gagarin nor his colleagues had much experience, they had to begin learning the rudiments of a jump, and gradually worked up to a more elaborate repertoire, with delayed action drops, tree and water landings and so on. The worst experience, said Gagarin, came with his first "corkscrew" descent—"A very unpleasant phenomenon; the body starts spinning at great speed and it seems you are in the grip of a force that drives you through the air like a screw. Your head feels like lead; there is a sharp, cutting pain in your eyes and your whole body is drained of strength. You lose all sense of direction." Konstantinovich showed him how to get out of the corkscrew—keeping legs and arms outstretched and facing downwards. Gagarin finished the course, not just with a pass, but as a parachute instructor.

Relaxation was strictly limited. In off-duty hours they were told to sleep as much as possible, or read. Exercises were part of the working day: P.T. before breakfast, ball-throwing, horizontal and parallel bars, weight-lifting, and swimming, running and jumping. Gagarin excelled in most, but particularly swimming. His high-diving style was classical, and he won several inter-squadron contests. Celebrations, however, were strictly of the teetotal kind. The trainees were allowed only an occasional beer, and cigarettes were banned altogether. Film shows were frequent, but usually of the educational kind. Light relief came in the wall-newspaper of the base, titled "Moon News." Apart from progress reports on individuals, it devoted columns every day to cartoons and parodies of the training programme. Gagarin was a keen contributor.

Physically and mentally, after six months, he was still unscathed. Then came the curious weightlessness experiments, about which much has been written, but which can never be adequately described, for it is a completely unnatural situation that, on Earth, cannot be reproduced for more than a few seconds. Those who have bathed in a salt-saturated water, such as the Dead Sea, have come nearest to the strange sensation.

In the early experiments, the express lift of Moscow University was used. The scientists loaded instruments in and virtually dropped it like a stone from the twenty-eighth floor. Next, the space volunteers were shot down, one at a time. The little floor indicator strip above the doors scarcely had time to show a streak of light as it plummeted 500 feet, to be slowed and stopped by special air brakes at the bottom.

After the "take-off" from the twenty-eighth floor, the passenger had his feet on the floor for less than a second before the ceiling began to catch up with him. At a certain speed he could be suspended between both without support. This was a less costly and more convenient way of reproducing "zero gravity" than the normal one of flying an aeroplane in a parabolic curve —a difficult manoeuvre which can overstress aircraft and endanger the whole plane.

Even in an aeroplane, the zero gravity effect can be reproduced for only a very short time—between 30 and 90 seconds —and the University lift produced the same results for no cost. Today the students travel in it at the sedate speed of 3½ metres a second, unaware of its unique contribution to the space age.

From the hundreds of zero-G experiments, the biologists built up a picture of what it would be like if the condition was prolonged. And they feared that it would disturb or destroy, temporarily, the power of the pilot to co-ordinate his movements. The tendency was, for example, to overreach when taking hold of an object; legs and arms became "loose" and "floated" unmanageably for a fractional second before coming under control. There were also some none-too-encouraging changes in blood circulation and breathing. Another possibility: that zero-G would induce hypnosis.

However, it became apparent that continued experience brought adaptation of the body to this weird condition. In any case, it was impossible to prolong the tests; only an actual orbital flight could fill in the gaps of knowledge.

Similarly, too, the scientists could only begin to estimate the psychological effect of loneliness in space. During prolonged flights the pilot is deprived of the usual aural and visual stimulants; no one could tell, in spite of the isolation chamber tests, the eerie effect of absolute silence in orbit; nor of the pitch darkness outside the tiny cabin, which takes away perception of depth. On longer flights than the one immediately in hand there would be the question of the interruption of the normal rhythm of life; no day, no night, no physical work, but no rest either. Instruments could never provide the answers.

The key to safety in acceleration and deceleration lies in the position of the space-pilot's seat. Experiments with the dogs had shown that the immense loads during the periods of boost and braking could best be absorbed by the body if the pilot was in a jack-knife position, with knees drawn slightly upwards and his feet on a level with his head. In this way the weight would be spread over the largest area with least harm to the body's internal structure. This could not, however, prevent blackouts. After undergoing forces amounting to 10 Gs loss of consciousness is inevitable; Vostok's cabin was to be hurled upwards at a speed of 25,000 feet per second, which meant up to 17 Gs (20 Gs is about the limit of a man's endurance) and this would have to be for only the smallest fraction of a minute.

The engineers wanted maximum speed in the shortest possible time; the medical scientists wanted the slowest speed for the longest possible period. The compromise was a series of peak thrusts, gigantic bursts of speed which gave a limit of 12 Gs several times.

Gagarin spent hours on a vibration table, being shaken 200 times a minute; he also underwent the controversial oxygen starvation experiment; a simple one, causing some amusement to onlookers, though it had the merit of being painless to the victim.

Gagarin sat in a small sealed room, at a table with a paper and pencil. Instructions came to him through headphones from scientists watching him through a thick glass window, to write his name at the top of the pad. While he did this, a valve opened and began drawing out the air through large-diameter pipes.

Gagarin joked, chatted over the intercom, waved, doodled, and, after a few minutes, wrote his name once more. It was something of an effort. Two more minutes, and his writing became a scrawl, then indecipherable. With his eyes still open and apparently conscious, he would struggle to keep writing, but the pen slipped, he would wave it in huge arcs as if carving his name in the air that was fast diminishing. Finally he blacked out. The flow was reversed and gradually, gradually consciousness returned.

The victims have no recollection of losing consciousness, and usually no memory of writing their names more than two or three times. For a few seconds they can be commanded to perform odd antics for the benefit of observers—and, equally, they know nothing about this, either.

This was a routine test, again to plot endurance; it was never considered likely that the chemical air-regeneration plant that had worked so well in Strelka and Belka's ship would fail. At the beginning of the course, Gagarin was by no means alone. But as the trials progressed, the other volunteers were eliminated, one by one. Until there were six . . .

During the final phases of these preparations, exciting news came which was to remain a closely guarded secret from the world.

An exact duplicate of Vostok had been launched, empty except for instruments, on two dummy runs, and both times successfully recovered without damage. Extra instruments had taken the place of the pilot, and the data they recorded showed nothing to upset calculations.

Besides the space volunteers, there were hundreds of Russian Air Force officers assisting in research. Supersonic fighters took off every day packed with extra instruments to test the behaviour of new metal alloys, plastics and fibres. They wore cosmonaut-type space-suits, far more complex than their own, to test fabrics, insulation and wiring in the toughest of conditions. They made many suggestions for improvement and modifications, and the trials they provided were of the kind that could not be duplicated on test-benches or in unmanned rockets.

One such pilot—and one of Russia's best-known—is stocky, broad-chested Konstantin Kokkinaki, from a famous family of pilots. Three brothers served in the Soviet Air Force with him and another is an aviation engineer; all fought in the war (one was killed). Konstantin being credited with nine German planes shot down in one day.

He added a little information to the vast amount being collected in an unexpected way. In a "flying-laboratory" aircraft on the secret list, he took off for a routine flight at supersonic speed. "Suddenly," he says, "the plane dived and began to go into a spin; I was at about 300 metres. The force of the sudden overload tore the control stick away from me, lifted me out of the seat and cracked my head against the cockpit canopy.

"The next instant the plane turned sharply, nose up, and even greater pressure threw me back on to the seat and held me there as if with a giant hand.

"A twelve-fold overload makes your blood as heavy as lead and stops it going to the brain; everything becomes foggy, your mind swims. Trying desperately to pull myself together, I realized that the aircraft was bucking like a horse; first up, then down, and all the while I was crashing backwards and forwards against the canopy and the seat. It was completely out of control. I managed to grab the control stick and pulled it towards me with what strength I had. Clinging to it I was struck blow after blow by just about everything in the cabin. Then suddenly, just as suddenly as it started, everything was normal.

"My brain was reeling and I didn't know if I could handle a landing. First of all I called up control and asked them to clear the landing strip . . . and to tell them to stop talking to me; my head was buzzing and the voice in the headphones made it worse. My helmet was over to one side, my face was covered in blood, and from the feel of the now-steady controls I knew that the aircraft had been damaged. Anyhow, I got it down, and fortunately the whole sequence had been recorded on the instruments which make these planes like a laboratory.

"It was auto-vibration, and it had lasted seven seconds. It felt like seven years, but the important thing was that from the instruments we traced the cause, and we had a whole lot of data that would have been impossible to get otherwise."

10

"108 MINUTES"

GAGARIN lay strapped down in his seat in a tunnel of instruments, each one humming, clicking, buzzing, flashing. It was zero plus 100 seconds, and the pressure was easing. To his left, without moving his head, which had felt as though it was bursting, he read the altimeter: 7,000 metres. Time for the first stage to burn out. The thrust indicator was slackening perceptibly, and the vibration was less. The rubber-mounted panels all around were still quivering, but even the smallest figures were readable.

Above him a red light, larger than the others, glowed momentarily; the warning for the second stage ignition. Five seconds ticked by on the clock above the TV lens. Acceleration load was almost normal—normal for supersonic flight, normal for those aerobatics he had performed so often above his own countryside in jet fighters, when safe wings stretched out on either side of him and he flew no higher than the next man. Now he was higher than any birds had ever flown, hurtling upwards faster than any man had ever travelled, propelled by twenty-million horsepower. The light went out and switched to green. The giant returned to kneel on his chest. The needles flickered but he could not see them. . . .

In the underground bunker, air conditioning sucked out the cigarette smoke while a hundred anxious eyes watched the duplicate control panels. The air was full of noise; the clacking of teletypes, the chattering, staccato note of computers, the hiss and whine of short-wave receivers. Along one wall shirt-sleeved men with headphones hunched before television screens, watching the two images that showed simultaneously on alternate sets; profile and full face. Illumination was even, reception excellent. Gagarin's voice came through the speaker relays above the continuous roar of engine noise, reverberating through his body to the tiny throat microphones he wore under his helmet . . . Vostok . . . Vostok . . . first stage separated . . . Terse, strained words, followed instantly by a new note in the room as computers linked to the second stage rocket began streaming out coded data; followed, too, by a tiny relaxation of tension.

Gagarin was now being thrust forward with renewed impetus; overload crept toward 10 Gs—past black-out stage for untrained flyers, the point where his body was weighing about half a ton. He was still conscious, however. He could dimly see a glowing orange cross on the panel in front of his wincing eyes.

Several watchful technicians were pacing up and down along the row of computers. Each unit was linked to both Vostok and the central bank of computers by different frequencies. For speech, Gagarin had two short-wave and one ultra-short-wave band. For normal control signals direct to the instruments in the cabin, a frequency of 19.995 M/cycles per second was in operation. Others were 9.019 and 20.006 M/cycles per second for the radio teletype circuit, and 143.625 M/cycles for ultra-short-wave. The transmitters for communication close to the ground—for take-off and landing—were of the normal Soviet Air Force type, but with modifications to extend the area of reception. In fact, Gagarin was able to use these channels for almost the whole of his flight.

Vostok's speed was approaching its peak of 17,500 m.p.h.; he would be out at any second. Cabin temperature was steady at 68° F., humidity correct at 65. Already, the complete orbital statistics had been confirmed: apogee 327 km., perigee 181 km., inclination to the Earth's axis 64° 57′. The reason for this choice of inclination was simple. To use the impetus of the rotation of the Earth, the launching site points eastwards. But the first stage of rockets quickly burns out and falls to the ground. In order to ensure that it falls on Soviet territory, this course—roughly diagonal across Siberia—is followed.

9.11 Moscow time. Gagarin had left the Earth's atmosphere. The second stage had separated and fallen away. Temperature and velocity fell sharply. There were silent handshakes 200 miles below. In the cabin Gagarin felt the sudden release as his trajectory altered and he fell into the huge swinging curve that was to take him around the world. He was in orbit.

Gagarin had counted from the moment of separation. Now his words came through clearly . . . "18 . . . 19 . . . 20 . . . this is Vostok. Last stage gone . . ." He pulled his body towards the cabin window and the dim light beyond. "I can see the Earth in a haze. Feeling fine." He added, after a second look, "How beautiful . . ."

Now he was able to move for the first time, and he loosened his straps. Instantly his body parted from the seat and he was floating, still held down by the straps, but completely relaxed. He loosened the nylon bonds still further and unclipped his face mask. Ground control asked him how he was. "Fine . . ." he repeated.

Already he had been in a state of zero gravity, in flight, longer than any man had ever experienced. To him it meant nothing; there was no unpleasantness, nothing unexpected. He reached down and switched on the globe navigator. This was a space-age instrument straight from science fiction. No man had ever used the whole globe as his chart before now. It was revolving, slowly, as his position altered in relation to the Earth. A cross in the centre indicated the exact spot below him. Another switch, and the spot was pulled up into sharp magnification. He was tracing his own invisible equator around the earth; Siberia, the Pacific . . . into darkness, for he was now moving into the shadowed part of the globe. Through the porthole, though, he could just make out the outline of islands and streamers of white and grey cloud.

He repeated the instrument readings every three or four minutes; after each came a calm confirmation from Earth. He had not expected to be so relaxed, so unhurried in his thinking and movements. He found the telegraph key and slowly tapped out V-O-S-T-O-K . . . V-O-S-T-O-K. Received, said the voice in his earphones, laconically.

Minutes went by, and as he hurtled on towards his second dawn of the day he strained his eyes to watch it; watching it as no one had ever watched a sunrise. Watery rays filtering through a hazy atmosphere, fiery orange near the ground gradually fading into the velvet blackness of night and space. This little porthole was Man's first unclouded window on the Universe.

Outside Vostok there was utter silence, absolute silence, as the ship, now a satellite, fell around the Earth like a stone dropping down a bottomless well. The velocity meter was rock steady, 17,500 m.p.h. Radiation counters clicked busily, telemetering their continuously altering readings back to Earth, mapping the lethal field first probed by the sputniks of two and three years ago.

Another, more tangible blanket of danger was being recorded, too; meteor swarms, almost invisible clouds of dust that held the million-to-one chance of disaster. The odds of hitting a meteorite bigger than a grain of rice were almost uncountable, but there would be no warning and no protection against such an event. The multi-skinned capsule was capable of standing tremendous punishment, and the double layer of pressurization—one in the cabin, another in his suit, both exactly equal and independent of each other—was insurance against all but the biggest catastrophe.

Still, the thousand scientists were not able to alter the course of a single rock hurled by nature with such force as meteors possessed. But Vostok sailed on, and Garagin sang. . . . Through his headphones he heard an appreciative chuckle. "When you're through singing, we've got a professional," and clearly, with only a trace of atmospherics to heighten the effect, came the nostalgia-charged lyrics of "Moscow Nights," a honey-sweet hit tune that throbs with emotion. Gagarin knew it well;

Moscow Radio plays it every day, but it had never been played like this before. . . .

Zero plus forty-five minutes, and South America, Argentina, was below. "Flight normal . . . Feeling well . . ." he called. The south Atlantic slid into view. Just 188 miles down there, heav- on an ice-cold sea, a Russian tracking ship was stationed, its radar antennae probing skywards for its countryman riding the biggest sea of all.

Gagarin was writing on a pad strapped to his knee. He wrote his name, and Vostok. No difficulty. He unclipped the pad and it floated away. He held it firmly with one hand and wrote with the other. It was a conscious effort, but of adaptation, the effort of being in an unfamiliar situation. There was no physical pain, no buzzing of the ears apart from that of radio transmission. He felt for the feeding-tube; he hadn't had breakfast. . . .

The tube was as slim as a fountain pen, and gold-plated along the barrel until it joined a flexible pipe. By squeezing this he forced a little of the salty paste into his mouth. The combined food and drink, like a meat jelly, was an adaptation of Strelka and Belka's diet. The perfect food, scientifically, if not gastronomically.

10.15. He reported: "Over Africa," and then, in reply to a query, "Standing up well to weightlessness." At 10.16, as the minute hand of the chronometer passed zero plus sixty-nine, the red panel light glowed to give notice of descent in ten minutes. He was 8,000 km. from the landing ground. Swiftly he checked his instruments again, reported once more that all was well and that there were no abnormalities. Control confirmed this, asking if he now wanted to make any alteration in the flight plan. He could, at this point, have taken over manual control; there was no risk of committing errors. His every move would be checked electronically and corrected instantly. Had he wished he could have gone around the world again; the scientists had built into Vostok the largest possible margin; there was ten days' supply of food and power in the capsule.

Gagarin replied, however, that he wanted to be brought down as planned; he was busy writing notes, anxious to record every impression of every minute.

In front of him the magic eye globe was still revolving in its socket, and he pushed the switch for magnification. A glass strip, etched with a tiny white triangle, moved slowly towards a thick red line. When the two met, that was the exact moment for the firing of the retro-rockets. The area inside the triangle would be the landing point, Smelovka.

Vostok had to be oriented exactly for that moment, not one degree out of position. The task was being performed by the computers at Baikonur, but had they failed him he would have had to use the control lever, a stubby gear-stick similar to a car's which rolls the ship right or left as required. The movement is registered on a gauge like an aircraft's artificial horizon. This horizon, however, is a circle. When a spot in the middle is correctly positioned, descent is safe. Penalty for error might range from missing the landing-point by a few miles to a too-rapid descent on an incorrect trajectory and a fiery death. Once more, though, confirmation came from master control that the electronic system was functioning satisfactorily.

Gagarin radioed his satisfaction, strapped himself back into the seat, released a catch to let it down into the fully reclining position, and waited....

Tension was mounting; it was inevitable, though so far there had not been a single hitch. The men in the bunker on the launching pad knew that Gagarin was approaching his most difficult moment, a crisis that had taxed the world's greatest scientific brains for many years. Fast coming up was the moment of re-entry.

Gagarin's present speed was far too fast for descent. To come down and hit the atmosphere's dense layers at 17,000 m.p.h. plus would be like falling into a furnace, and just as disastrous. Friction would consume the capsule in ten seconds.

To slow the ship down to less than a quarter of its speed, retro-rockets were to be fired forward to act as giant brakes. As it slowed, so Vostok would fall nearer and nearer the upper fringe of the atmosphere until it was safe to re-enter. There was a wide safety margin, but many factors were still untried, and everything depended on the retro-rockets and the computer that would give the signal for them to fire.

Even firmly strapped in, Gagarin felt the atmosphere around him in the cabin change, almost imperceptibly. The sensation of weightlessness left him. The brakes had fired with a shattering roar and he watched, awed, as white tongues of flames streaked past the porthole. They were racing back from the nose-cone, enveloping the entire shell as the exploding energy grappled with the new pull of gravity. The solar thermometers in the cabin and on Earth shot up to register a fantastic 4,000° C.; the skin was hotter than a bar of molten steel, but the two refrigeration units, the cooling system and the air regeneration equipment pumped steadily on.

Overload was greater than on the way up; the pressure was painful in the extreme. Every muscle and nerve was being hammered by vibration. Instruments began to swim in front of his eyes, but through it all the clock was visible . . . 10.27. There were twenty-eight minutes to go. On the TV screens Gagarin's face retreated in profile until it was almost flat. The nose was pushed in, the eye sockets grew larger, and shadowy. Every bone in his face was sharply outlined by dead-white skin. Speech was impossible, though he could just hear the reassuring voice of the controller through the screeching of the engine, telling him that all was well.

The pressure was slowly lifted. After one and a half minutes he was warned by orange lights and radio to prepare for landing. "Above target, on course, para-brakes," called control, and Gagarin felt a push in the chest as the parachutes, a huge cluster of them, billowed out high above the capsule. His hand had been on the cord he had to pull for emergency ejection; the whole seat would have been fired out of the cabin and parachutes under it would have automatically opened. As he floated down gently, he could see from his window the multi-coloured squares of familiar farmland rushing up to meet him; familiar because this was near Saratov, his old training base. The descent was quite fast, but by far the most sedate part of his historic journey.

From the control room at Baikonur, ninety miles away, even the elderly raced for the exits. A convoy of waiting cars and trucks roared off with a dozen excited passengers. Scientific calmness and detachment were gone, for the moment. . . .

Two women working in the fields were staring at the sky. The dot grew larger, changing from black to white. Parachutists, one whispered. Alarmed but determined, they ran towards the object as it drifted over the trees and hit the earth in the middle of a long, stubbly field. As they ran a hatch opened and a head emerged, followed by a body in a sky-bue suit. Gagarin had wriggled out of his outer covering; it was too bulky for comfort. But thoughts of the U-2 were flashing through the minds of the women until the spaceman grinned and called: "Hallo, give me a hand." At the realization of what they had seen, one woman burst into a fit of giggling, while the other almost collapsed with shock. A man arrived and shook Gagarin's hand. The little party was still standing, looking at each other with mutual delight, when the first car, from a near-by military post which had been alerted for the touch-down, came racing up. . . .

Half an hour later the telephone was ringing in a little house that had the name Gagarin on the door. Valentina answered. . . .

11

GAGARIN: THE FIRST INTERVIEW WITH WESTERN JOURNALISTS

On Friday, June 9, 1961, Gagarin interrupted his leave to see Burchett and Purdy in Moscow. It was his first and only meeting with Western journalists, face to face across a table. His press conferences had been huge, theatrical affairs, highly organized, with questioning restricted by time and security, with the atmosphere as impersonal as at a barrack-room briefing.

The private meeting was in marked contrast. It took place in a big, old-fashioned room of the State Committee for Cultural Foreign Relations, on the fringe of old Moscow.

Outside, it was hot; 80 degrees. In the courtyard Gagarin's official car was parked alongside Burchett's green-and-cream Ford Zodiac. One of the drivers brought out a deck-chair and sunglasses and settled down in the shade of the high green hedge.

Inside, the room was cool and dark, but with a little tension in the air. While Gagarin was downstairs with the chief of the Foreign Press Bureau, the photographer, very slightly nervous, was pacing out distances for every possible situation. A tall, handsome young interpreter, also from the Foreign Press Bureau, said cheerfully: "I never thought this would happen, you know," and went on, "even we don't know how this has been managed. It is difficult enough for our own journalists to talk to the major, and we have had applications for interviews with him from every country in the world. They have all been turned down."

The arrangements for this meeting had, in fact, been fixed only two hours before, but the groundwork had taken weeks. The first request from the authors went to the Soviet authorities (in company with a thousand others!) only hours after the announcement that Vostok was in orbit. Soon scores of letters, telegrams, memorandums and telephone calls were passing; Purdy twice had to fly to Moscow from London at twelve hours' notice. *Izvestia* reported his arrival and the fact that the two men were "working round the clock in two shifts." While one wrote, the other carried out interviews. Sleep was forgotten for long periods. But all the time they were waiting . . . waiting for word that they could see the man who, to Westerners and all but a handful of Russians, is the most inaccessible in the world. One Moscow scientist jokingly told them: "Now, if it was Mr. Khruschev, I'm sure you would be successful. He talks to journalists every day. But Yuri Gagarin . . ." and he shook his head.

Even the photographer was excited. As an official cameraman, he had taken pictures of the cosmonaut at several public functions, but he had never been the only photographer present, had never seen him relaxed, or closer than across a room. Gagarin had always been on a stage, but at 1.15 p.m. on that Friday, there he was, walking, sitting and talking with the audience. . . .

Gagarin entered briskly, alone and smiling. The first impression was of his good-natured personality; big smile—a grin, really—light step and an air of sunny friendliness. He is short, stocky and powerfully built. But the key to his character, perhaps, lay in two other points: his handshake, and his eyes. His hands are incredibly hard; his eyes an almost luminous blue. "Never," said Burchett, "have I seen eyes like that." "And never," said Purdy, "have I felt a grip like his."

With the two writers on either side of him, Gagarin, wearing a well-cut dark blue suit, white shirt and silver tie and holiday sandals, sat down easily on a velvet sofa. He eyed the pile of papers—this manuscript—on the table, and pretended alarm. "The next man to go up," he joked, "should be a writer!"

His attitude to questions was, like the very fact of the interview, unexpected. They had not been submitted, nor even asked for, beforehand. No one except Burchett and Purdy knew what was to be said. Yet in no single case was there hesitation in his reply, and the translations were instantaneous. Words tumbled out, facts and jokes and interjections, with pauses only to refresh his memory. He gestured with his hands constantly, trying to draw pictures in the air. "My worst moment?" His right arm shot up. "The first minute"—the hand swooped down—"and the re-entry." He tapped the table with his finger. "But 'worst' is a comparative word. There wasn't one 'bad' moment. Everything worked, everything was organized properly, nothing went wrong. It was a walk, really."

He talked with simple pride about the instruments and the ship itself, and the ground staff at Baikonur. "The support I had, each man giving of his very best, gave me great confidence," he said.

To whom did he speak on the ground? A scientist, a radio operator, or a fellow cosmonaut? Purdy explained that Shepard had reported during his flight to one man, a friend and colleague, because scientists said it would help him psychologically.

Gagarin thought for a moment. "Well," he said, "I spoke to a lot of people from up there, not just one or two—many people. It made me feel pretty good. I remember them playing that song—'Moscow Nights'—and some Tchaikovsky and ballads and army songs I knew. Somehow it didn't feel lonely at all." He leaned forward, clasping and unclasping his hands. "It's difficult to describe, but I really felt as if I had the whole country with me." He couldn't help remembering at that time, he said, the staggering number of people who had put him into orbit, the scientists who, starting with Tsiolkovsky, had contributed to Vostok's triumph. Gagarin seldom referred to "my flight"; it was always "our flight" or "the country's achievement." Listening to him, watching his eyes, it was easier to understand that his formal speeches at Vnukovo Airport and in Red Square, speeches that were strangely unreal and artificial to Western ears, were in fact completely sincere; Gagarin is an officer, a space-pilot and a party member, not an orator. Examining him closely, Purdy was amused and relieved to see other evidence that he was not completely perfect: a mole on his left cheek (was that taken into account?) and a minute cut where he must have nicked himself that morning, shaving.

Discussing Commander Shepard's trip, Gagarin regretted that he had not read the astronaut's own account of it—"I'm supposed to be on leave, you know," he chuckled. Nonetheless, he had followed the published progress of the American's training with great interest. From the start of their own programme, the Baikonur team had been reading and discussing the American methods in relation to their own. One thing had puzzled them, although it was a matter of no concern to the men themselves: why U.S. doctors preferred chimpanzees to dogs for human "stand-ins." The general opinion: "They make better pictures." And Gagarin laughed again when Burchett, quoting from American newspaper reports, asked why the manual controls of Vostok had not been used. "The American view," said Burchett, "is that Shepard's flight was superior to yours in one way, in that he actually controlled it himself."

"How much driving can you do in five minutes?" the major asked, almost incredulously. "And what was the point of it? I could have guided Vostok had I wanted to; there was a dual control, we knew it worked, and that was enough. It was, after all, a secondary system, and I had many priority jobs in a very crowded schedule; I was busy every second, and I was travelling at eight kilometres per second. The tiniest error, say at the moment the braking system was switched on, just could not be permitted, and my mind was entirely occupied with these things. Manual control was not necessary or important." Ground control did at one point ask him if he wished to "take over" but he was absorbed in writing copious notes on instrument behaviour in zero-gravity, and declined the offer. The pilot-control was an exact duplication of the radio-control, and enabled him to undertake the whole landing and choose his landing spot as well, if he wished.

As with the scientists that the authors interviewed, the American Project Mercury was talked about by Gagarin without a trace of patronage or any jarring note of superiority. There was genuine admiration; though in discussing Shepard further, Gagarin could not resist adding: "Please remember that ours was an entirely different kind of flight, for a different purpose. Vostok was a space-ship, built to go up and stay up. There was ten days' supply of food in that cabin. Shepard's was a ballistic trajectory. Still, it was a great achievement."

He had seen pictures of the American capsule and instrument panel. "But it's difficult to compare the two. Vostok's cabin was very big; the thrust of the engines was much greater. We had to go higher and faster for a much longer time with a much bigger rocket."

Did he experience any sensations he had not undergone in training? "A complicated question to answer. All the time there were different sensations, different feelings, of course. They lasted for seconds only, often, and there was really no time to analyse them. I was so busy; it was just work, work, work. Of course there was discomfort, there were great stresses on the body, but the training programme had been extremely rigorous and thorough, and included just about everything." Weightlessness, he said, was "interesting" but not uncomfortable. He is the only man in the world to have experienced this strange sensation for more than five minutes in flight, and, indeed, one of the objects of the flight was to see how man could stand up to a condition that could not be satisfactorily simulated on Earth. His report: "No real problems."

Gagarin talked earnestly for a few moments about his future. He wanted, he said, to go up again, and would shortly begin another course of training. This time he would know more than his instructors. What would he like to achieve next? "Another flight." Where? "Well, anywhere it is necessary to go." The Moon? "A bit early to talk about that now, but I could fly a bit longer, much farther, in that ship. I have no doubt that there will be a Soviet citizen on the Moon one day, and we are all hoping that the day will not be far off."

He wore only one decoration on his lounge suit—a badge that had just been presented to him, two hours before, by the Young Communist League. He is very proud of the honours that have been showered upon him, but always links them with the team who made it possible. One person is not so modest: his daughter Lena. "At school, and to all her friends," he laughed, "she goes around saying: 'My Daddy's a space man; my Daddy's a Hero of the Soviet Union!' "

Before he left, the young major collected another memento of his historic trip. Burchett's father, at 88 the oldest working journalist in Australia, was on holiday in Moscow at the time. In his luggage was a hunting boomerang, and he walked into the room with it just as Gagarin was leaving. "Please take this," he said, holding it out, "as a symbol of safe return. It always comes back, and I hope you and your colleagues do too." Gagarin, delighted, examined the precision-carved weapon closely, while one of the interpreters rapidly explained its use, and how experts could actually catch it on its return. "I shall treasure it," said Gagarin, swishing it a few inches through the air. "It's a nice sort of symbol to have."

12

THE MOON NEXT?

AFTER Gagarin's flight? What? Certainly it is now possible to put a man on the Moon. This is a claim that many Russian scientists make privately, though the official space programme guardedly says that it will merely be possible "before too long."

The dramatic announcement of the first Earthman to set foot on its legendary, mystical surfaces will no doubt be hailed as man's greatest scientific achievement, though a body of scientific opinion questions its technical value. One view is that what can be done with a manned rocket can be done much more easily with a robot one.

Academician Fyodorov, however, expressed what is probably the official opinion of Soviet space planners when he said: "During wartime, a city was considered captured when the infantry entered it. Outer space will be conquered when Man sets foot there."

Let us examine the background to the energetic attempts being made now to bring this about.

A remarkable piece of scientific forecasting is to be found in the files of the Soviet newspaper *Trud* (Labour) in its July 21, 1957, issue. Six weeks before the first sputnik was launched, and while most Western and many Russian scientists were still convinced that space-flight was not to be in their lifetime, a young technologist, Y. S. Khlebtsevich described with amazing accuracy a Moon-shot which we now know to be both feasible and probable.

"A flight to the Moon," he said boldly, "may be effected in the next five to ten years. The take-off, the flight, manoeuvring and landing of the rocket will be effected and controlled by telemetering radio equipment on the Earth and in the rocket.

"It will land a small 'tank'—a mobile caterpillar laboratory, which will also be guided from the Earth. This laboratory will be equipped with television, operating in the same manner as an ordinary outside broadcast unit here.

"The tankette will not require special conditions necessary for human beings; its equipment will be able to stand higher speeds and higher fluctuations of temperature. There is no need to protect the rocket and its cargo from radiation and meteorites. Lastly, there will be no need for a return trip, and this will reduce the weight of the whole ship to 250 tons.

"How will the moon rocket be guided? The trajectory and time-table of its flight is plotted in a special electronic computer and governing gauge. After its take-off, the rocket's flight will be watched by several automatic radar stations. Working in unison with the rocket's equipment they will determine its co-ordinates with extreme precision, calculating the necessary corrections and transmitting them to the motor controls.

"The tankette-laboratory will later help the scientists to choose the best place for landing a rocket with men on the Moon. Radio-guided rockets will deliver fuel, special equipment, supplies of water, air and food. The rockets will land at places selected through the signals of the tankette, which will act as a landing beacon."

Detailed plans for just such a flight have already been drawn up; the moonship has been designed, and—it is rumoured—tentative dates for its dispatch have been fixed. To all but a handful of Russian scientists, the only unknown factor is: will there be a man on board? Officially: silence. Unofficially, it is said that there will certainly not be until a first-stage mechanical probe has landed—but both will be long before the usual American and British estimates of 1965-70.

One man who has more than an academic interest in seeing this achieved is Alexander Saukov, a tall, grey-haired man, slightly stooping, with a high forehead and ascetic looks, the outward sign of an earnest and dedicated man who devotes himself fifteen hours a day to the more complex problems of geology. Recently Saukov—twice a Stalin Prizewinner—has been one of the growing number of scientists who have been examining the satellite data with increasing impatience and excitement. He belongs to the school that believes that we must already begin preparing for the time when Earth's mineral deposits, or some of them, become exhausted, and he believes that space offers much more than just additional resources of the minerals we already know and use.

"I think there could be deposits of rich new ores there for the taking," he says. "For instance, on the Moon we may find that there are active volcanoes—Professor Krayrev is certain that this is the case in the Alphonsus Crater—and by using what we know about volcanic rock and gases here, we should be able to produce on that 'dead' planet oxygen and water. I need hardly go into the transformation that that might lead to.

"The properties of lunar rock, however, will almost certainly differ in one great respect to that of our own; they will contain a much higher amount of radiation. This is because of the lack of atmosphere up there, allowing the free fall of cosmic rays—which also, of course, allows a greater number of meteorites and meteoric dust to land and settle. These particles and pieces of iron-hard rock seldom reach Earth because of the density of our atmosphere, which burns them up on the way." And he added: "Other scientists talk about the possibility of oil-fields on the Moon; the oil originating inorganically from water and metal carbides at great depths, high pressures and high temperatures. No, I think we shall have to revise our views of the 'dead' planet."

Professor G. V. Petrovich discussed a landing at some length in one report he wrote for the Academy of Sciences:

"In the case of an Earth-to-Moon flight," he says, "with a cushioned landing on the Moon and a return to Earth, it would seem wise to fully automate, not only the rocket's start and its guidance, but also the entire flight including the landing on the Moon, which calls for exceptional accuracy to prevent accidents. This applies not only to unmanned rockets, in which there is no choice, of course, but with electronics as highly developed as they are today there is no need to entrust man with these most critical and difficult manoeuvres. Moreover, with an automatic control system, including a radio altimeter, a computer and other instruments the landing will be safer, better and require less fuel.

"For the same reasons it is advisable to fully automate the rocket's start from the Moon on its return flight and its landing back on Earth, irrespective of its payload.

"One must bear in mind that the system of landing the rocket on the Moon should operate quite independently of the instruments on board, since it takes radio signals 2.6 seconds to each the Earth and back. However, in order to ensure shockless landing the response time of the control system must be of the order of hundredths of a second.

"It is quite possible that even the choice of the site for landing will be made automatically by the equipment which controls the retro-rockets.

"Before any such landing, however, part of our endeavours must be to analyse the surface of the Moon, to find out the best kind of landing-ground. Knowledge of the composition and mechanical properties of lunar ground would make it possible to design rational shock-absorbing gear."

It is believed that the rocket which hit the Moon, and the station which photographed the far side, telemetered back information and pictures of vital importance in selecting a landing ground.

Professor Petrovich went on: "The low-density atmosphere of the Moon is no use for slowing down rockets, and retro-rockets represent the only means to effect soft landings. No doubt this will result in a temporary contamination of the Moon's atmosphere by combustion gases; it must also be borne in mind that in the process of a soft landing the surface of the Moon directly underneath the rocket will be shattered and melted by the jet of hot gases from the nozzle of the retro-engine. So the analysis of the composition and structure of the lunar ground, and micro-relief directly at the landing spot will not give authentic information about the rest of the Moon's 'mantle' of rock.

"For this reason, after the landing, the automatic scientific station should move away a few dozen metres from the rocket. If the surface is covered with dust it should move a few hundred metres away, before making its probes....

"It is extremely difficult," Professor Petrovich continues in his report, "to grasp the entire complexity of the technical problems involved. For instance, the self-propelled automatic scientific station must have electronic equipment which would enable it to take its bearings automatically, steer away from fissures and hollows and move around steep hills. In time there would be developed automatic stations that would wander all over the Moon's surface, investigate every corner and relay to the Earth not only pictures of the Moon but also the results of comprehensive studies of its nature and make-up.

"Power for the rocket system, scientific apparatus, radio transmitters and electric motors to propel the station along could be supplied by solar semi-conductor batteries, with buffer electro-chemical batteries that would take over when the station happens to be in the shade.

"Studies of the Moon will give birth to a number of new sciences. Parallel to the traditional studies of geography, we shall see the development of selenography, selenophysics and selenochemistry.

"The task of recovering the equipment could be solved by a variety of methods. All of them involve, however, a more or less prolonged storing in the severe lunar conditions of fuel needed to send the rockets back to Earth. This will be no easy task, for the Moon has great extremes of temperature—from plus 132° C. at midday to minus 160° C. at midnight. These temperature variations occur in the course of the lunar day (29.53 Earth days) depending on the height of the Sun and the time of night.

"For the storage of fuel it is desirable to find a cooler area with a smaller temperature spread; such areas exist where the Sun's rays strike the ground at a low angle, for instance in the narrow band along the line of the terminator, or in the polar regions. It will be very difficult, however, to use the terminator region for this purpose because of the terminator's displacement along the surface at a rate determined by the Moon's rotation (from zero at the poles to 15.4 km. an hour at the equator).

"During the day surface temperature on the Moon in the polar regions does not rise above 50° C., so here seems to be the most likely choice for landing rockets and starting them on their return journey, as well as for storing fuel containers.

"Burying the fuel containers at a shallow depth will make it possible to keep the temperatures fairly constant.

"In view of the extremely low heat conductivity of the Moon's rock the temperature at a depth of less than one metre is estimated to be minus 110° C. and believed to be constant throughout the day. There is a possibility that the Moon has warmer zones near active or dormant volcanoes.

"Climatic conditions impose limitations on the choice of fuel destined for more or less prolonged storage. The use of low-boiling-point fuels such as liquid oxygen or liquid fluorine is entirely excluded, or at least confined to cases where the rocket will stay there only a very short time—and only on the illuminated part of the Moon at that.

"Other protective devices will be needed, and allowances made for loss by evaporation. High boiling-point fuels seem to be the only choice.

"There have been mentions of using the Moon as a stepping stone for interplanetary flights, but this is an illusion.

"The organization of the interplanetary station on the Moon for servicing interplanetary flights is inexpedient technically because of the amount of power needed to take off and land. It will be necessary to decelerate the rocket when it will approach the Moon at a speed of 3.3 km. per second or approximately half that, depending on the duration of the flight and the trajectory. For the take-off it will be necessary to give the rocket an escape velocity of 2.4 km. per second.

"The Moon's gravitational pull is one-sixth of the Earth's, and take-off will naturally require much less energy. However, even these expenditures of power would be avoided if an interplanetary station is established on an artificial Earth satellite.

"Furthermore, the conditions of man's existence on the Moon will hardly be more favourable than on such artificial satellites. Just as in the case of satellites, it will be necessary to protect the man on the Moon from vacuum, from solar and cosmic radiations, from meteorites and micro-meteorites. Even in the polar regions of the moon the problem of protection from high temperatures during the day and the cold of the night will be a complicated one. It is true that it is possible to create hermetically sealed living quarters beneath the Moon's surface, but that will need power for heating and lighting.

"On artificial satellites of the Earth, the protection problem can be solved only by using materials sent up from the Earth. If the satellite is placed into orbit at a rational distance and its plane of orbit is properly oriented, the quantities of material for crew protection need not be prohibitive.

"Rocket flights to celestial bodies—around the Moon and to the Moon in the first place—and in particular manned rocket flights there, could only be a practical proposition if a number of conditions are satisfied.

"In the first place the choice of launching time and flight trajectory is determined not only by the mutual position of the Earth and the Moon in their movement about their axis and about the Sun, but also by the need of ensuring control of the round-the-Moon flight or the Moon landing from tracking stations on Earth.

"Furthermore, lacking enough experience, one cannot disregard the danger from meteors.

"The chance of a space-ship colliding with a big meteor is so small that one can safely disregard it. Fine meteorite dust presents no danger, and, anyway, interplanetary space is being continually swept of it by the action of solar pressure.

"But medium-sized meteorites do present danger. Micrometeorites are studied by high-altitude rockets and especially by the sputniks and cosmic rockets. It is important to know the abrasive effect of micro-meteorites on such things as optical lenses and equipment, solar batteries and construction material.

"Capsules could be protected from occasional meteors by a sufficiently strong shell or screen. Nevertheless, rocket launchings are contra-indicated on days when the earth is crossing the orbits of great meteoric showers or comets. It is also advisable to avoid launching rockets on trajectories that would cross these paths.

"The degree of hazard from meteor showers depends on the size of the particles, their nature, whether they are made of iron or rock, on their speed in relation to the rocket and the density of the shower. There are several hundred known swarms of meteors pursuing paths around the Sun with periods of revolution ranging from one to 125 years or more. Also known are the dates when the orbits of the Earth and these swarms cross each other. On these days space-ships will be safer on Earth. It is not every year that the Earth goes through the core of these showers, and when it does, the length of time in them varies, as the swarms can be millions of kilometres wide and their orbits are usually slightly inclined.

"Along with the already-charted meteoric swarms there exist other, as yet unknown orbits through which the Earth does not pass. Rocket probes are mapping these now.

"For instance, data collected by Sputnik III has shown that during its period of operation it registered hits from particles with sizes ranging from one eight-billionth to one two-hundred millionth of a gram with energies of from 10,000 to 100,000 ergs. It has also been established that the probability of collision with particles one-billionth of a gram in mass is about one particle every few hours.

"On May 15, 1959, however, the number of collisions rose to between four and eleven impacts per square metre per second; on May 16 and 17 the number of collisions was 4,000 times smaller, then it fell off 50,000 times and finally 600,000 times.

"Sputnik III has been working in orbit, passing on such information, without a failure of any kind. Its hermetic seal is unbroken, temperature control and the solar batteries are functioning properly. No other proof is needed to show that it is possible to build a really reliable space vehicle that will function for years if necessary.

"The level and amount of the Sun's activity must also be taken into account at the time of the launching of a space rocket. At a time of high solar activity there are gigantic explosions and eruptions into space of clots of ionized matter, as well as high-intensity, dangerous radiation. The average time of the cycle of this high danger period is every eleven years. Then there is much more disruption of radio communications, and magnetic storms, sunspots and intensive radiations of radiowaves in the centimetre and metre ranges. It is not yet possible to predict storms on the Sun, but during them it is advisable not to undertake manned flights into space.

"No manned satellites, either, should be placed in orbit within the boundary of the Earth's outer radiation belt, and more remote manned satellites must stay at a height of at least 50,000 km. Most space-ships orbit between 500 and 1,500 km. up.

"The speed of a space-ship or satellite orbiting at a height of 500 km. is 7.62 km. per second and its period of revolution is 1 h. 34.5 min.

"At an altitude of 50,000 km. orbital speed is 2.66 km. per second and the period of revolution, thirty-seven hours. A so-called stationary satellite with a twenty-four hour period of revolution, moving round with the Earth so that it always remains above the same spot, must be located at a distance of 42,190 km. from the centre of the Earth. The first space pioneers will be in a similar position to the earliest sailors in history, facing storms, hidden reefs, shallows, unknown currents, scurvy, sea-sickness and other hazards. But there is no doubt that the new problems will be overcome."

A plan for an observatory on the Moon is nearing completion. It includes the use of instruments impossible or impractical to build here; for instance, a refractor twenty-five metres across. A telescopic mirror of this size would buckle under its own weight on Earth, but the Moon's force of gravity—or lack of it—would reduce this stress to one-sixth. The first astronomical instrument, however, will be a radio-telescope, perhaps with the "new principle" that Fyodorov hinted at to Burchett and Purdy.

The chief hazard will be the constant shower of meteor dust, and a screening system that does not interfere with visibility is, of course, a first essential. Professor Dmitri Martynov, the young astronomer and director of the Sternberg Astronomical Institute, says that the lunar observatories will at first be unmanned, entirely automatic and ground controlled by radio and television links. "The first man to look at the observatories," he says, "will probably be a repair man."

If the landing is made—or, *when* it is made—another set of entirely different problems arise. Whether he is Russian or American, the first man on the Moon will plant a flagpole there. The whole significance of this action will not merely be confined to the celebration of an achievement; the question will be posed: who *owns* the Moon? What terrestrial (or lunar) rights will a man or country possess by making the first 239,000-mile journey across space to conquer another planet?

Already a commission of the United Nations is investigating the position. Called the Committee on the Peaceful Uses of Outer Space, the legal situation has loomed large on every agenda, though few detailed recommendations have been made.

There are three alternatives: that the Moon and other planets can be annexed by the first country to put a man on them; that no one can annex or lay claim to "property" beyond the limits of the Earth and its atmosphere, unless artificially made and placed there; and that all outer space conquered by the physical presence of man should be under international control.

The U.N. *ad hoc* committee is generally in favour of the third proposal, but its feelings are mixed, for political reasons.

The issue is further complicated by the absence of the Soviet Union from its deliberations. Russia refuses to co-operate without a change in the composition of the committee, complaining that the present balance of membership is heavily weighted against the Eastern Bloc.

Neither the U.S.S.R. nor the U.S.A. have made any claims on space above the Earth's atmosphere, and scientists and politicians in both countries say they will not do so. Nevertheless, the arrival of the first man on the Moon, and the planting of his flag, will no doubt speed up the day when lawyers will don space-suits too.

13

THE ROBOT BRAINS THAT THINK

IT is clear that all these problems hinge on one branch of science for their solution—the designing and building of computers. It is worth while to examine the progress made by the Russians in their top-priority programme for computer development.

At a brand-new institute in Tbilisi, Georgia, a team of mathematicians are working on a fantastic project for advanced robots that can "think" for themselves.

The young scientists—average age, 26—are members of the cybernetics division of the Georgian Academy of Sciences. Under the director, Vladimir Chavchanidze, and with colleagues from all over the Soviet Union, they are tackling the problem of giving a space robot the power to make its own decisions. "For instance," one of the team told us, "a robot on the Moon can be guided by ground control quite safely when it is stationary; it can pick up and transmit data about the soil it is 'sitting' on, atmosphere, pressure, humidity, temperature and so on. But when it moves it is bound to run into difficulties. We on Earth would not be able to plan any kind of route predictably, because we don't know all the hazards. There might be gaping fissures near by, and the machine would have to find a quick way round them. But to do so might mean crossing water or a different type of soil or vegetation, even.

"So first that would have to be tested and analysed to see if, for some reason, it didn't present as great a danger as the fissure. Now, we can't help with all this; all we can do is watch what happens via television. Our contribution will already have been fed into the machine before it leaves Earth."

So an intricate, but miniature, computer is being built which will enable the robot to make decisions and act on them. This is the urgent task of cybernetics, a young science barely fifteen years old, which, in outline, means the adaptation of mathematics to automation and computers. This is one task; another, equally important in the space programme, does away with the necessity for test flights of rockets—a remarkable achievement, saving huge sums of money, time, and, most important, lives.

Cybernetics projects a space flight from launching pad to parachute landing in a huge mass of complex theory and calculations which cover every second of the rocket's progress.

The choice of a space-ship's design, the materials for the body and interior working parts, the shape of everything from the pilot's seat to the smallest valve, all are calculated exactly by this new science with its new tools, the computers. It is not infallible, of course; many minute but costly mistakes have been made. One error in working out the trajectory path was responsible for the loss of a sputnik containing two dogs on December 3, 1960. It had been in orbit for two days. When the signal was given for its return to Earth, a miscalculation gave it too fast and too steep a descent, and the 4½-ton satellite was burned up on re-entry.

On February 4, 1961, a 6½-ton Sputnik—the biggest that had been launched so far—also went astray and was destroyed because of a minute mathematical error by a computer. Lunik III and the Venus probe—both of which deviated from their scheduled paths—are other instances of fallibility. However, the possibility of such errors is being reduced all the time by systems of double and triple and even quadruple checking, and the ability to make minor flight changes while in trajectory.

The computers being designed at Tbilisi and other cybernetics institutes handle all the processing data for the launching and control stations. If the destination is the Moon, they work out its speed and direction and orbit in relation to the Earth, the speed of the rocket, its path and how it will be affected by the gravitational pulls of the two planets, and—most important —the precise moment of launching.

Without computers, man would take years to make such calculations which the machines perform in minutes. And their accuracy, in spite of the errors mentioned, can be judged from the vast number of problems they have solved and the number of satellites that have been successfully launched, orbited and recovered. An error of a few tenths per second in the speed of a rocket, for instance, would mean a space-ship missing its target completely by perhaps thousands of miles. Lunik II hit its target on the Moon's surface exactly, and Gagarin returned to Earth only six kilometres away from the selected spot.

The projected manned Moon flight will take approximately thirty-five hours flying time. A computer known as the Ural-2 calculates the trajectory and its possible deviations in a little under thirty seconds, and in this time it has performed more than 300,000 operations. The Ural-2 is probably the most efficient computer in Russia; its huge bulk—it occupies a thirty-foot wall—dominates the scene in the launching control rooms.

Next in size and importance is the controller computer, the "foreman" of the other electronic "brains." The development of this—and its scope has to be extended every time a new satellite is launched—is the problem of the Institute of Automation and Telemechanics in Moscow. Here, two scientists, Dr. Alexander Lerner and Dr. Alexander Cheylustkin, explained its workings: "Imagine," said Dr. Lerner, "a group of machines. Each one has a certain individual sound when it is working perfectly—we all know, for instance, the hum of our own car when it is running well. An experienced ear can detect when something is wrong, even if its cause is unknown. We are using this method of sound analysis by highly sensitive microphones. Faults are traced and, by immediately and automatically playing back a programme of the correct sounds, the listening machines can find the individual fault and signal its failure to master control. This is much better and simpler than keeping a check on individual working parts." For the more or less silent electronic instruments, the doctor added, a similar detector, though far more sensitive, has been produced. This reports failures in any part of the computer system within minutes, and can actually pin-point the spot for repair.

Ground failures may be serious in rocket launching; in space, with manned flights, they can be fatal. But much has been learned from the errors mentioned. The head of the Institute, stocky, 55-year-old Vladimir Trapeznikov, explained the ideal he hopes to achieve:

"We have to discover a principle by which we can build automatic systems which allow for individual elements being damaged without harming the whole. Nature's organisms function on a system of reserves; if a cell cracks up, another is immediately ready to take over its job. The brain goes on continuously like this for scores of years, and somehow the brain has to be duplicated."

He revealed that an immediate project is a key control instrument that contains several thousand elements in one cubic centimetre of space—"Super-miniaturization combined with a complex and high-speed control, made up of mutually interchangeable elements working at 100 per cent efficiency." This system, he says, will be in service in space-ships "very soon," and will represent one of the biggest advances in flight safety yet made.

In an interview with Professor A. Prokhorov, of the Scientific Council for Cybernetics, he discussed yet another problem that is being tackled as a first essential of super-long-distance space exploration:

"Guiding space-ships from Earth is not only difficult but impossible on very long trips," he said, "if only because radio waves would take such a long time to cover the distance between the control-room and ship.

"By the time the instructions arrived at the object of guidance, the instructions would have lost their meaning. And the bigger the distance, the greater the power required to transmit and receive. On Earth we can easily boost the power to the necessary output, but this is not so in the ship. This means that a cosmic rocket will be in contact with Earth only at specific, pre-arranged times—and then only for the briefest few seconds, or split seconds. To get across all the necessary information it will be necessary to condense the automatically collected data into a high-speed transmission that will be unintelligible, and probably inaudible, to ordinary radio receivers on Earth. High-powered unscrambling devices here will have to decode the message. Computers will be vital at every stage; without them we should be lost."

The professor used an interesting analogy. "To get some idea of cosmic speed," he said, "imagine yourself in a cinema. Normally the screen in front of you shows twenty-four pictures a second. Speed it up so that you see twenty or thirty films, one after the other, in a total of seven seconds. Of course, you would see nothing at all; neither the eye nor the brain can work at such speed. But that is the sort of continuous situation, for days, weeks, even years of a cosmic space-ship."

Astronauts would be unable to deal with any problems that arose because of such a speed unless an enormous margin of warning was given. Only computers can do this, hence the experiment at Tbilisi.

14

MARS? THEORIES AND PROBABILITIES OF LIFE ON THE PLANET

THE Russian space programme for the next five years includes close investigations of Mars and Venus; how close depends on data received from the preliminary space-probes such as the Venus satellite launched on February 12, 1961. There are so many imponderables and unknowns about these planets, Moscow scientists say, that it is impossible to make definite plans until a great deal more is revealed by instruments. It may well be that deadly radiation belts will preclude any possibility of a manned investigation such as will shortly take place on the Moon. But within two years it will be certainly known whether such a landing can or cannot be made.

At this moment Soviet scientists are studying closely every kind of theory that has ever been published about Mars and Venus; translations, diagrams and photographs are piled high on many desks.

"Our concrete information is really so scanty that we are approaching this part of the programme with a completely open mind," Burchett and Purdy were told.

Typical of the open-mindedness is the support for what is perhaps the most startling theory about Mars so far—that it has two huge artificial satellites in orbit around it put there by beings who are, or were, far more advanced than us, scientifically.

Professor Dr. I. S. Shklovsky, physics and mathematics expert, is quite certain about this. He bases his belief on new evidence that the two satellites—plainly visible to observatories—were not in existence more than one hundred years ago. Called Phobos and Deimos (Fear and Terror) they were discovered in 1877 by an American astronomer, Hall.

Phobos is in orbit at a distance of about 6,000 km. from Mars and completes one revolution of its mother planet every 7 hours 39 minutes.

Deimos moves in a circular orbit with a radius of 23,500 km., and circuits in 30 hours 18 minutes. Both move in the plane of the Martian equator.

They are thought to be approximately sixteen and eight kilometres across—the smallest satellites of any known planet. "And this is just about all we know of them," says Shklovsky.

What makes them so interesting? "Firstly," he says, "their size and proximity to their planet; an absolutely unique phenomenon in our solar system is that the period of revolution of Phobos is shorter than that of its own parent Mars.

"All our previous theories have failed to explain the origin of these two. If we consider, for instance, that they are asteroids, accidentally 'captured' by Mars, then why are they moving in circular orbits lying precisely on the equatorial plane? That would be too much of a coincidence.

"An American astronomer, Sharples, discovered in 1945 that Phobos had actually changed its position in just a few decades—deviation from its proper orbit was as much as 2.5 degrees; a sensational finding. This conclusion was reached after the most careful observation and comparison of earlier data, in particular that by the Russian astronomer Struve at the beginning of the century.

"Sharples was able to calculate the position of these two satellites at any given moment, and the fact that the true position did not coincide with the mathematical one is of tremendous significance.

"Since Phobos has speeded up its movement during this period it means that it drew nearer to the surface of Mars. This is exactly the behaviour of the artificial satellites of the Earth; atmospheric resistance slows up their movement, they progressively descend and at the same time their speed is accelerated.

"The changes in the nature of movement are so great that we can confidently say that we are witnessing the slow agony of a celestial body. It means that in just a mere 15 million years Phobos will fall on Mars; astronomically speaking, this is a very short period indeed.

"Two possible causes of this slowing down have been advanced," says the professor. "Firstly, it might be the resistance of the medium surrounding the satellites—the same thing that slows down sputniks. If this medium is interplanetary matter (which could be of greater density than it is around the Earth) it is incomprehensible why it does not have a retarding effect on both; for only Phobos is affected. But perhaps it is the Martian atmosphere? Perhaps, but the two American astronomers Whipple and Kell do not agree.

"Another reason for the speed-up might be tidal action. But since Mars lacks large bodies of water, only the tidal movements in the solid crust of the planet should be considered. Jeffries, the British astronomer who is probably the greatest expert on tides, recently checked this theory and found that the crust movement of Mars would account for only one ten-thousandth of a part of the acceleration of Phobos.

"Other explanations? Well, it goes without saying that there could be a powerful magnetic field around Mars which could retard its 'baby,' but my mathematical calculations rule this out, too. Finally, generally speaking, there is the remote possibility that the speed-up occurred because of the attraction of its twin Deimos, the Sun and other planets. We have worked this out and find that, if anything, the reverse would be the case.

"So I arrived at the conclusion that there are no 'natural' ways to explain either the origin of the Martian 'moons' or the oddities in behaviour of one of them. Therefore, I believe this to be the case:

"The atmosphere must be the retarding factor. But the atmosphere of Mars, at that distance away from it, must be highly rarefied. So to slow the satellite down appreciably the satellite must have a very small mass and a density, I reckon, of approximately one-thousandth of the density of water. The form that fits this description would be a cloud of dust particles at a considerable distance from each other. Calculations show that such a cloud would be considerably dispersed along its track of movement, like a comet's tail or Saturn's famous ring. There is only one way of reconciling the requirements of solidity, invariable shape and the extremely insignificant density of Phobos. That is to assume that it is hollow inside—and that is a cosmic impossibility if it is a natural creation. I believe it is not a natural creation; Phobos is an artificial satellite, and so, probably, is Deimos.

"Of course, to say that these satellites are small is to speak comparatively. Their masses may be equivalent to millions of tons, or even more. But the creation of such satellites is not an insurmountable one to intelligent beings; within a few centuries we on Earth will have them in orbit. They will be at such a height as for the atmospheric retardation to be a very slow process, insignificant, and they will stay aloft for hundreds of millions of years, tens of thousands of times more than the entire history of mankind to date. These will be monuments far more durable than the so-called 'permanent' Pyramids, which are subject to the action of the sun and wind, rain and cold. So maybe the Martian satellites are the monuments to a once highly civilized community which exists no longer. Or maybe it does.

"Now how does one go about proving this theory? Well, it can be proved, of course—and the first steps will be a rocket probe of the Venus kind. Observations from Earth can help enormously, too. It is very important, for instance, to make a study of the changes in the satellites' brightness.

"It is known, for example, that asteroids, whose size in some cases is much bigger than Phobos and Deimos, are not as a rule round, for they are mostly odd-shaped fragments of rock. Their revolution in space around a centre of gravity produces changes in appearance to the scientist and astronomer in an observatory; sometimes they are very bright, sometimes very dark, according to which surface is visible. If the brightness of Mars' satellites should prove constant, it would confirm their spherical shape and furnish corroboration of my theory. In any case, I can assure you that the theory will not remain theory for long."

A constant watch is being kept on the strange cosmic twins by some of the most efficient observatories in the Soviet Union, and on Professor Shklovsky's point of the constant (or otherwise) brightness, it is hoped that an important announcement can be made in the not too distant future.

One thing that earth-bound telescopes will never see, however, is whether life exists on Mars itself—that much-loved theory of science-fiction writers and fantasy-weavers.

Perhaps the first to formulate a widely accepted theory about the possibility of life there—the first in Russia, anyway—was Professor Gavril Tikhov, whose studies are classified as astrobiology.

The old man (he was 85 when he died in 1960) aroused furious controversy with his ideas, but respect for his arguments has increased since his death. Tikhov, in lectures and scientific papers, challenged the beliefs of Sir James Jeans, who denied the existence of life anywhere else except on Earth, and dismissed them as a theory based on a false premise: that life could not exist without oxygen. Where there was no oxygen, said Sir James (and a large number of Soviet scientists, besides!) there could not, therefore, be life.

Tikhov showed that, even on earth, there are plants which exist in marshes and swamps that have adapted themselves to a lack of oxygen; some even thrive on ammonia gas, and several species of fungi seem to like nothing better than a strong solution of vitriol!

Burchett collected a large number of the professor's published writings and reports. One stated: "We cannot go on accepting this theory without question. It is said that there is very little moisture and oxygen on Mars . . . but whoever proved that the conditions of life on Earth are the best possible? Imagine some Martian scholars getting together and discussing the possibility of life on Earth. 'How can there be,' one of them might ask, 'when we know from spectral analysis that there is so much oxygen in their atmosphere? Everything living would burn up and suffocate!' "

Tikhov travelled thousands of miles, from the Siberian Arctic to the southern borders of Russia, to collect information about the extreme conditions under which plants and organisms thrived, to show that he could be right. It was a lonely journey.

Most prominent among his critics was a well-known astronomer, Fesenkoff, who claimed that Martian life was an impossibility. He estimated that the physical conditions on the planet would be comparable to those existing on Earth on a plateau twelve miles up, but with the temperature considerably lower and with, of course, no oxygen at all.

Tikhov replied that, even here on earth, vegetation could be encountered (in Tibet) four miles up. And Martian gravity was only half as strong as Earth's pull. Therefore conditions, soils and plant growth were sure to be quite different. As for the temperature being lower, well, that would only make the vegetation more hardy; fungus could be found (and he had found it) in the Arctic.

Just before Gagarin's space-ship left Baikonur, Assistant Professor F. Zigel wrote a paper for the Academy of Sciences which carried Tikhov's theories a step further. He hazarded the supposition of intelligent beings on Mars who will be in contact with us within a year or so of the analysis of the Venus probe data.

"On Mars," it states emphatically at the start, "there is organic life. Tikhov and his pupils convincingly demonstrated that the optical properties of the Martian 'seas' bear a great resemblance to earth plants living in hard, tough climatic surroundings. And in 1956-7 the American astronomer Sinton was able to detect in the spectra of the Martian 'seas' absorption bands characteristic of organic molecules.

"But maybe Martian life has gone no further than lichens or similar plants? If we take this point of view, we shall have to conclude that Mars was able to produce only the most primitive forms of life. And if Mars had, in the past, an intelligent race of beings who died out without trace, wouldn't this clash with our own experience that intelligence can subdue the forces of nature? Do we really accept that one day Man might die out in the same way? Certainly the great scientists and thinkers can't accept this view. Tsiolkovsky, for instance, summed it up by saying: 'The murky views which some scientists advocate as to the inevitable end of every living thing on Earth . . . should not now be regarded as axiomatic. The finer part of mankind will, in all likelihood, never perish . . . they will migrate from sun to sun as they go out. And so there is no end to life, to intellect and the perfection of humanity. Its progress is everlasting.'

"There is no question," Zigel continues in his paper, "that if a race of sentient beings had appeared at one time on Mars it could never have disappeared without trace; the Martians would have opposed their intellect to these forces and they would have won.

"To take the question in detail: suppose a Martian was tackling the problem of whether the Earth is populated or not. The problem would be no simple one, even if they had extremely powerful telescopes. Martians would not be able to see Earth people, of course. They could prove there were intelligent beings here only by circumstantial evidence. But so far there are not so many facts in this category available to them.

"A green splotch of vegetation appears on the orange area of an Earth desert; this is a new zone of afforestation. Or the Martians detect the unfamiliar point of a relatively small body of water; a new artificial lake or sea has been created. That, I think, is all there is to the more noticeable changes visible from Mars, and which the Martians would regard as 'mysterious.'

"Generally speaking they would look upon our oceans and continents as having hard and fast outlines; only the seasonal changes in the Earth's vegetation and the periodic melting of the ice-caps would be relatively easily visible.

"Obviously they would not be able to see the network of roads, cities, railways and the achievements we pride ourselves on. Sputniks are so minute, cosmically, as to be undetectable. Add to this fact that the Earth is surrounded by a cloudy, dense atmosphere, and you would be bound to conclude that the problem of whether the Earth is populated or not would be the subject of interminable argument among Martian scientists.

"Now look at things the other way round. On Mars we can detect far more signs of intelligence. Firstly, there are the famous canals. Many photographs have been taken of Mars: they all record thousands of these canals, interlaced in a curious kind of pattern. Through a telescope they appear as one solid mass, but when atmospheric conditions are unusually good and the telescope is exceptionally powerful we see the canals as separate dots.

"It is worth while noting that this web extends all over Mars. Not a single point of the planet's surface is more than 300 kilometres away from one. None of the canals break off abruptly; they always run into a 'sea' or into another canal.

"They vary in width, from belts 200-300 km. wide to strips not more than a few kilometres wide. The entire network is linked up with the polar caps which seem to be their source.

"The Italian, Schiaparelli, who discovered them in 1877, conjectured that they were irrigation structures. Later his theory was developed and substantiated by the American, Lowell. We still do not have any other theories that would fit the facts. It stands to reason that the word 'canal' is an expediency. No one imagines open streams of water as there are in Holland, for instance. But certainly their principle and their use would be the same; to take moisture to every place that needed it on that parched planet.

"When spring comes, as one of the polar caps melts, the entire system of canals, where it would be Martian spring, turns green. The water from the pole brings life to the vegetation stretching along the waterway and the canals darken, assuming a greenish tinge. This process takes place at a speed of about four kilometres an hour and in the direction of the equator. This must be the speed at which the hidden water flows beneath the ground on Mars.

"On Earth, of course, spring spreads from south to north. On Mars, on the contrary, spring spreads from the poles to the equator, which is a patently artificial process. There isn't and cannot be a single natural reason to explain why on Mars the water should flow from the poles to the equator. We can't even explain this away as being due to moist winds, because the atmosphere there is too dry for such winds.

"It is curious to note, also, that on reaching the equator the darkening does not stop, but crosses over to strike deep into the opposite hemisphere. If it was nature's work she would change the direction, and because this is not so it is possible to believe that Mars has pumping stations which irrigate the whole planet. The equatorial areas of Mars are horrible; unending, arid deserts. But when spring reaches them a startling change occurs. The canals fork. Instead of one, there are two, running parallel like railway lines. And where there are two, there we find the driest part—the equatorial belt.

"These canals intersect not only the Martian desert but also the 'seas,' which are vast open spaces of vegetation. It is quite probable that in the remote past they were really the bottom of seas that by now have dried out, or almost completely so anyway.

"The fact that the canals intersect the present seas proves that they were built at a time when the planet's real seas had dried up and the demand for water had become particularly acute. When they run into the seas many of the canals fork again—a necessity, perhaps, to take more water for the arid areas of the planet from the moist part that the seas represent. At the spot where the canals intersect we can see that there are curious spots, patches of vegetation in the form of a circle which we call, for want of a better word, oases. It seems that they form an important part in the structure of the canals, and it may be here that the Martians have their cities.

"If the canals were not strips of vegetation stretching along defunct rivers or cracks in the ground, they would have a totally different form, disposition and property. The hypothesis by the American astronomer McLaughlin, who considers the seas and canals to be heaps of volcanic ash, is absurd. This theory clashes with evidence we have already, and offers no reasonable explanation for any of the peculiar properties of these features. The canal system unquestionably shows the work of intelligence."

Zigel refers to Phobos and Deimos: "They are amazing. They could not have separated from their mother planet, or they would have a far greater mass. Furthermore, neither could Phobos, in such a case, go round Mars faster than the planet rotates. There are many other points, but they all add up to one: that there is no natural process which could be held responsible for their formation.

"On the other hand we get a very simple explanation if we suppose that the two satellites are Mars-made, by Martians.

This idea was voiced in 1951 by the American astronomer Hard, and later, and in great detail, by Professor Shklovsky. Mars satellites have circular orbits, just as sputniks do. From the point of view of thrust, the alignment of artificial satellites in an orbit that coincides with the planet's equatorial plane is, scientifically, the best one. This is precisely, exactly, remarkably, the case with Phobos and Deimos.

"In its revolution around Mars, Phobos undergoes a queer acceleration which can be explained, as Shklovsky has shown, only if this satellite is a hollow sphere, which would be out of the question if it is a natural body. And, incidentally, if Phobos and Deimos were to have a polished, mirror-like surface, their diameters would be much less than previously indicated, maybe only one or two kilometres, for measurement can only be estimated by relative brightness.

"Given the high technical standards which we now have, such artificial constructions of this size are not impossible, by any means. We are already designing large permanent artificial satellites in the form of wheels, the diameters of which will be tens and even hundreds of metres across.

"Shklovsky thinks that the Mars satellites were made long, long ago—at least tens of millions of years ago—and today are merely monuments to an extinct civilization.

"I believe they appeared quite recently, perhaps 100 years ago. It is the odd circumstances of their discovery which leads me to believe this.

"It was Kepler who conjectured that Mars should have two satellites, and astronomers assiduously hunted for them for about two centuries. The great Herschel and Lassell discovered Uranus satellites with their giant telescope, though these objects are much harder to see than Phobos and Deimos, which none then could detect.

"After 1862 it was universally accepted that Mars had, in fact, two satellites, but it was not until fifteen years later that they were suddenly observed and recorded, not by one astronomer, but by many at the same time. Furthermore, they have been seen since by comparatively low-power telescopes—certainly less powerful than the one used by Herschel and Lassell. So the conclusion can be that Phobos and Deimos were built by the Martians somewhere between 1862 and 1877.

"Naturally," says Zigel, "this idea is disputed. Moscow astronomers Moroz and Shcheglov claim that the satellites were discovered in 1877 only because better telescopes were used then. But it is a fact that they were seen with scores of greatly inferior ones used by professional and amateur astronomers all over the world.

"Again, if the two Martian 'sputniks' had really been in orbit for millions of years, they would have been the subject of an incessant hail of micro-meteorites and radiation, just as ours are, and would have been completely destroyed by now. This is excluding the possibility—remote, but there—that they might have collided with bigger meteorites, any one of which could have wiped them out in a second.

"Now suppose Phobos has a polished metal surface; then on our calculations it should have a diameter of close on two kilometres across and a mass going into millions of tons. In that case, judging from our own experience with the amount of meteor dust that falls on earth, we reckon that the greatest possible age of Phobos would be in the order of tens of thousands of years—a very different matter to the 500-million-year estimate of Shklovsky. And it is much more likely that 'Fear' and 'Terror' are far, far younger.

"In 1952 astronomers suddenly discovered an unfamiliar green patch on Mars—a new 'sea', the size of the Ukraine. It was named the Laocoön Knot. This odd formation darkens every year, though it stays the same shape. Who was it who planted a huge portion of the Martian desert? Why does the vegetation here thicken with every passing year instead of growing sicklier? This extraordinary fact may again be taken as an obvious manifestation that the Martians are undertaking an immense battle with their rigorous conditions. Incidentally, this is not the first time that such vegetation changes have been noticed.

"From time to time, too, curious, dazzlingly brilliant points flash on Mars' surface to be followed by tiny clouds which all resemble the consequences of a terrific explosion. These phenomena occurred in 1937, 1951, 1954 and even quite recently. Moreover, they last a few minutes, even several seconds at times. It is hard to guess what they represent, but there is no question that our celestial neighbour is leading a life of its own. The Martians have certainly not disappeared. They are still alive."

In spite of several breathtaking assumptions, Zigel's conviction is taken seriously by many scientists in the Soviet Union. Such ideas are constantly being discussed, not only in lecture rooms and scientific forums, but in the more practical committee-rooms of the space research programme, where the theoreticians can hear dates being fixed for the launching of fact-finding probes.

Tikhov's pupils, too, are continuing his research at the astro-botanical observatory of Alma Ata in Kazakhstan, which specializes in the study of vegetation on other planets, particularly Mars.

Burchett went to Alma Ata to investigate the Tungus mystery. This was an unexplained, gigantic explosion in Siberia in 1908. Theories were at once put forward that the cause was a visit from another planet by a space-ship. To support this, it was claimed that the soil in the area remained radio-active, though no trace of meteorites had been found and there were no other reasonable possibilities.

Burchett was told by a young Kazakh scientist, however, that an expedition dispatched to the site in the summer of 1960 had 'definitely proved' that the explosion was caused by a comet colliding with the earth—"a unique case; history knows of no other example."

Maybe not; and if only for this reason, there will always be those who are convinced that people from another world did visit us in 1908. Anyway, it is no joke to say that Soviet astronomers are planning to listen for them in the near future. One researcher, Nikolai Kardashev, of the Sternberg State Astronomical Institute, says that his colleagues are suggesting that certain planets should be selected for investigation on the subject of whether intelligent beings exist, and small rockets with tape-recorded messages and radio transmitters powered by solar batteries, sent off to them. These systems, he points out, have already been tried and tested in the sputniks and space probes. "In the neighbourhood of their destination," says Kardashev, 'these automatic Earth envoys will broadcast the information stored on the magnetic tape, and if intelligent beings exist, they should have no difficulty in deciphering it."

The Russians are also working on the slender possibility that these people on other planets are trying to communicate with us. Finding the radio wavelengths they would use is not entirely guesswork. One of the biggest sources of radio interference in outer space are the emissions from the Milky Way constellation, and, to reduce this to a minimum, frequencies below the 30-cm. waveband must be used. Secondly, it is reasonable to assume that a highly developed community would need an atmosphere around its planet—and an atmosphere would bar the use of radio waves less than one centimetre long. Therefore, their signals would be somewhere between the two and probably in the 20-21 cm. region; 21 cm. is the wavelength of emission generated by hydrogen atoms, and hydrogen is the most common element in the Universe. "Obviously," says Kardashev, "if a civilization on another planet has achieved any high degree of scientific and technological progress it is bound to discover the radio emission of interstellar hydrogen, and the 21 cm. wavelength naturally suggests a universal standard."

One of the Soviet Communications Ministry radio transmitters is to instal powerful equipment for beaming simple signals—numbers from one to ten—to the selected stars. "But," laughed an astronomer, "we don't know what we shall do if we get an answer!"

15

VENUS PROBE

VENUS, favourite of the poets, the gods, and of many astronomers too, is as romantic as its neighbour, but much of the fantasy has been stripped away by the cold precision of the probing space-ship launched on February 12, 1961. Three months later, on May 19, having travelled 70 million kilometres, it streaked past the Venusian atmosphere remorselessly to steal secrets that have been kept since the birth of the universe.

The attempt to tear away those vapour veils which till now have protected the secrets of Venus from terrestrial "peeping Toms" and their telescopes, was another of those major breakthroughs for Soviet rocketeers. It represented a superb piece of cosmic precision work which quickened the pulse of space scientists and astronomers the world over. On February 12, 1961, a multiple rocket launched a sputnik, which, while orbiting round the Earth, launched a carrier rocket which in turn launched the Venus space-ship. The Russians called it for short, the A.I.S.—automatic interplanetary station. Weighing about two-thirds of a ton, the A.I.S. had covered 75,000 miles towards its rendezvous with Venus when the launching was announced.

Part of the background to this new development had been provided by those tests in the Pacific about a year previously in which the Russians had dropped nose cones within a few miles of the bull's eye after travelling 8,000 miles. "It would be appropriate to recall," wrote Alexander Ilyushin, engineering specialist of the Academy of Sciences, commenting on the Venus probe, "that roughly a year ago the Soviet Union fired two shots at a pre-designated target area in the Pacific to put the finishing touches on a high-powered, multi-stage ballistic rocket. These tests prove that the techniques employed for governing the flight of these rockets were exceedingly accurate. This closed a major chapter of preparation for space voyages to other planets of the solar system."

The giant sputnik—its weight has never been disclosed—which sent the A.I.S. hurtling off to its rendezvous was fired at the first cosmic speed of 5 m.p.s., "not intended for investigation of circumterrestrial space but for the firing of an automatic interplanetary station at Venus."

Why not aim the A.I.S. at Venus directly from the ground—as had been done with the Moon shots? Why complicate matters by firing it from a body whirling around the Earth at about 18,000 m.p.h.? The answer revealed some new secrets of rocket development. It had been assumed till then that once a rocket left the ground nothing more could be done about it. If angle-minute calculations and timing were incorrect by a fraction of a minute, a metre or a second—too bad. These fractional errors on the ground would be multiplied by tens and hundreds of thousands by the time a sputnik was placed in orbit. The possibility of some very minor corrections by manipulating guidance fins from the ground, had been disclosed for trajectory flight during the Moon shots, but orbital flight around the Earth was regarded as predestined from the moment the starter button was pushed.

In explaining the "piggy-back" Venus launching, Ilyushin repeated what was already known that: "Thanks to observation of sputnik motion and the processing of data from it by a special computer centre on Earth, we can determine a sputnik's trajectory with amazing accuracy. This means we can calculate with great exactness all errors arising in the orbiting of the sputnik itself. It means also we can ascertain at any given moment and with very great accuracy not only the sputnik's position in orbit but also its velocity sector." Then comes the astonishing revelation: "This enables us to remedy all the errors arising while the sputnik is aligned on its round-the-Earth orbit. The importance this has for the shooting of the automatic interplanetary station is obvious." It is as obvious as Tsiolkovsky half a century and more previously had explained that an orbiting space platform, independent of such disturbing factors as the Earth's atmosphere, was a much more satisfactory starting point for interplanetary flight than ground launching pads. "The A.I.S. carrier rocket," continued Ilyushin, "can be launched from the sputnik orbiting the Earth at any time and from any point in its orbit and . . ."—a grim thought in these days of nuclear warheads—"could be fired back at the Earth as well as at any target in the solar system."

In order to make the Venus approach at the most favourable moment, the rocket had to be fired at a very much narrower angle than that needed for the Moon and for that reason alone the possibility of inaccuracies in launching was many times greater. "The method of launching from the sputnik was precisely to overcome such inaccuracies," said Ilyushin and went on to another important advantage. To get a rocket clear away from the Earth's gravitational field and on its way to the planets, the second cosmic speed of about 7 m.p.s. is needed, whereas to orbit the earth 5 m.p.s. is sufficient. The difference in initial rocket thrust between 5 and 7 m.p.s. is enormous. But by launching from an orbiting sputnik "the rocket which the sputnik carries and which in turn carries the A.I.S. has to impart a rather small additional velocity. And the smaller the additional velocity we have to impart, the smaller are the alignment errors which are bound to arise. Consequently this launching method . . . presents a colossal advantage as far as the accuracy with which we align an A.I.S. is concerned. The errors . . . are immeasurably less than if we were to launch it straight from the ground."

In the great excitement of the Gagarin flight, the importance of the launching method of the Venus probe has been somewhat dimmed in the popular mind.

But Ilyushin in his concluding comment made a point about which we are going to hear a great deal more as time goes on.

"This new launching method is remarkable furthermore in that it is the first move towards transforming sputniks into take-off stations for space travel and research. February 12, 1961, will go down in the annals of history as the day when we first began to open up our celestial neighbours, as the beginning of a new era in the history of mankind." Remember Zigel's statement quoted earlier that the Russians are "already designing large, permanent artificial satellites in the form of wheels, the diameters of which will be tens and hundreds of metres across." These are the interplanetary bus stations of a not-at-all distant future. Science fiction is being pinned down on the drawing boards. The petering out of the Venus station's radio signals and the cosmic scale counter-attraction of the Gagarin flight, resulted in the launching method of the Venus ship receiving much less attention than it deserved. It ranks with Sputnik I, the Moon photo probe, the Belka-Strelka return journey and the Gagarin flight as one of the immeasurably great milestones erected by Soviet scientists along the path to the stars.

When the orbiting sputnik discharged the mother carrier rocket, it was orbiting 4,000 miles up from the Earth's centre, in almost a perfect circle. (There was only 35 miles difference between apogee and perigee.) At a pre-computed precise point in time and space, the signal was given to discharge the carrier rocket and when this latter had reached a predetermined point and had accumulated a speed of 661 metres per second more than the escape velocity needed to clear the Earth's gravitational pull (11,200 metres per second) the rockets jaws opened and with a final "bon voyage" flick of its instruments, projected the A.I.S. on its 168-million mile flight to Venus. How many hundreds of tons of original rocketry must have been necessary to hurl such a great weight of space hardware 4,000 miles straight up into the heavens staggers even the space-fiction writers.

By the time the A.I.S. *had* travelled about 600,000 miles and rid itself completely of the Earth's gravitational pull, it had entered an elliptical orbit around the Sun, 95 million miles at its farthest and 66 million miles at its closest to the Sun's centre and travelling at 63,000 m.p.h. in relation to the Sun. During the first part of its flight, Venus was moving towards the Earth, approaching within a mere 25 million miles but then moving away from it again and by the time the A.I.S had reached it after 100 flight days, Venus was about 43 million miles from the Earth. The A.I.S., however, would have covered nearly four times that distance for its midnight rendezvous; on May 19/20. When it got within the 370,000 miles it would fall within the embrace of the veiled planet's gravitational field. It would be drawn in to pass within some 60,000 miles of Venus "without further corrections to the trajectory."

"To have the station move in the immediate vicinity of the planet," states the official report on the Venus probe, "it was necessary to guide it on the calculated trajectory with a great deal of precision. Should there even be small deviations in the velocity, communicated to the station at the end of the boost stage, it will . . . pass at a considerable distance from the planet. Velocity mistakes amounting to one to three metres per second at a total speed exceeding 11,000 metres per second and velocity direction mistakes amounting to 0.1 to 0.3 degrees may lead to the increase of the minimum distance by 60,000 miles. The same result will be produced by a one minute mistake in the time of launching."

Another cause of error could arise from Man's insufficiently exact knowledge of cosmic measurements. "The main source of this inaccuracy," states the report, "is the lack of sufficient precision in measuring the astronomical unit—the average distance between the Earth and Sun—which determines the scale of the solar system. . . . This may lead to mistakes in calculating orbit deviations from Venus which might even be greater than the radius of the planet. Therefore . . . a successful flight . . . calls for exceedingly accurate measurements of the flight trajectory and for a possibility of minor corrections of the station's motion by means of special devices during flight." To make things easier for the future, one of the tasks set the A.I.S. was to check up and report back on the exact measurements of the solar system.

The instrument-packed station was a little over six feet in length by three feet in diameter and weighed 1,396 pounds. Bat-like wings—in fact panels of solar batteries—unfolded immediately the A.I.S. separated from the mother rocket, to power the various instruments. Three radio antennae also unfolded. A fourth umbrella-shaped paraboloid antenna, over six feet in diameter, was scheduled to be lowered from the station only at the approach to Venus. It was designed "to relay a large volume of information within a short period of time at a great distance." This was the one intended to peer behind those dense veils of clouds and relay back to earth at enormous speed and on many channels the Venus secrets that have haunted man since the first telescopes were aimed at the planets. One eight feet long antenna was for short-range communications—to give information on trajectory to ground control stations and special ships at sea in the early stages. Another pair of T-shaped cross antennae were to maintain "medium-range" two-way communications between the time of leaving the Earth's gravitational field and the approach to Venus. Something either went wrong with the latter or the power supplies because radio contact was broken after February 22 when the A.I.S. had covered a little over two million miles from the Earth, although Soviet ground stations continued tracking it and by late March, when it had shortened the distance to Venus to 22 million miles, Academician Topchiyev assured correspondents that it was still on its plotted trajectory; would pass as planned within less than 60,000 miles of the planet and "further news" would be heard from it.

For the Venus probe—and others which will follow it—a special Centre for Long-Distance Cosmic Radio Communications has been set up. Information from the 1,800 monitoring stations in the Soviet Union is continuously and automatically flashed to the Centre's computers in the early stages of the flight—but in later stages the information is telemetered back directly to the Centre. It is as much a command centre as a receiving one. According to commands radioed from there, instruments on the Venus ship were controlled; one bank of solar batteries switched on and another off; the same with the automatic instruments regulating temperature and switching on and off the radio transmitters. This for many millions of flight miles. In the remoter areas of scores and hundreds of millions of miles, instruments worked according to preset programme but were expected to continue relaying the results of their work to the Cosmic Communications Centre.

Everything did not work exactly as planned—with so many unknowns it would have been a miracle if they had—but the Soviet scientists are confident that they will work the next time or the time after next. According to past performances, their confidence is justified.

"Special narrow-band low-noise receivers are employed to pick up long-distance radio signals," continues the official report. "This requires a sufficiently accurate computation of the values of the receivers and emitted frequencies with allowance made for the Doppler shift.* To maintain a steady frequency on the input ends of the narrow-band filters of the receivers aboard the interplanetary station and at the measuring point, an estimate allowance for the Doppler shift is made for the emitted and received frequencies." (Another of those

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* The Doppler principle involves a fairly predictable distortion of radio and light waves. As the source of wave vibration and an observer approach, the observed frequency is higher than the emitted frequency; as source and observer recede, the observed frequency is lower. The distortion is a basis for measuring the velocity of heavenly bodies—*Authors.*

unknown and at present unknowable factors in which a slight error in that inevitable cosmic guesswork could disrupt radio reception.) As to what is involved:

"At distances measuring tens and hundreds of millions of kilometres, the signal reaching the Earth is extremely weak. At 70 million km. (the Earth-Venus distance on May 19/20) only one-tenth—with twenty-two zeros after it—of a watt reach every square metre of the Earth's surface. Antennae covering a large area are required to pick up such small signals, even when super-sensitive receivers are employed. Large antennae have been built at stations of the Cosmic Space Radio Centre which make it possible to pick up radio signals from tremendous distances. These can be trained at any point of the celestial sphere with an accuracy of several angular minutes. Training programmes are introduced automatically into the electronic computer controlling the antennae.

"All measurements are transmitted via automatic line to the Co-ordinating Computer Centre where the trajectory measurements are processed, and high-speed electronic computers forecast the station's movement and compute the antennae training programmes."

The Co-ordinating Computer Centre exercises overall control of all ground measuring services according to a set programme.

This cosmic radio centre and its subsidiary stations were built and equipped "to control the A.I.S., shape its orbit and carry on two-way communications with it at distances of several hundred millions of kilometres."

The A.I.S. itself represented a miniature, highly transistorized automatic factory of which the orientation system was exceptionally interesting. It was called upon to stop any head-over-heels fledgeling capers the A.I.S. might have been tempted to perform after being pushed out to free space from the mother rocket. It had to keep the solar batteries facing the sun throughout the entire flight, no matter what the position of the A.I.S.; to ensure any required turns in space and the immediate stabilization after such turns. Most important, the orientation system had to repeat what the Lunar station did in focusing the TV cameras on the Moon's far side, by ensuring that the umbrella-antenna was orientated towards the Earth at the fatal moment of the approach to Venus: "To secure a high speed transmission to Earth of scientific information and data on the work of the station apparatus." Electronic monitors or sensors at places subject to overheating or overcooling switched back situation reports to a control mechanism.

If the temperature varied from the tolerances fixed in the preset programme, electronic signals switched on a stand-by heating device or opened the ventilation louvres. This provided for normal working temperature for the instruments even when heat from the Sun doubled as the ship approached within 66 million miles.

Apart from the main job of revealing Venus secrets to Man —and checking up on the true dimensions from the encircling atmosphere—the A.I.S. had the following tasks:

To measure the extent of cosmic rays and the intensity of gamma fields; to measure charged particles of interplanetary gas and the corpuscular streams of the Sun; to register the incidence of micrometeors. Knowledge of all this is necessary to chart the traffic lanes for future interplanetary flights and set up the signboards in time and space to mark off the danger zones.

As to Soviet scientific conjectures about Venus, one of the most authoritative accounts was given by N. Barabashov, director of Kharkov University Observatory. After the agreed known fact that it is shrouded in clouds and its size is about the same as the Earth (diameter about 7,500 miles; density and mass about eight-tenths of that of the Earth) there was much controversy about what the mystery planet represents. The duration of rotation around its axis—that is, the length of a Venus day and night—whether it rotates from west to east, or vice versa, were among the unknowns. Estimates of the Venus day ranged from 34½ hours fixed by a Russian astronomer A. A. Belopolsky in the early 1900s to that of 255 days by A. Dolphus of France who concluded with some other astronomers that the length of the day on Venus was the same as that of its year. In other words, it took exactly as long to complete one rotation on its axis as to complete an orbital revolution around the sun. Barabashov was inclined to believe the estimates of the American astronomer R. S. Richardson, who from spectroscope observations at the Mount Wilson Observatory, concluded that if Venus rotates from west to east, the period would be a little more than seven days and if from east to west a little over three and a half days.

Until very recently the surface temperature of Venus was estimated at between 140° F. and 176° F. But recent measurements by Soviet astronomers A. D. Kuzmin and A. E. Salomonovich using radio-telescopes and thermo-elements show an alarming range of from 32° F. at night to between 390° F. and 580° F. when the Sun is at its zenith. "If further observations confirm these results, we will have to recognize the fact that it is extremely hot on Venus and if water reservoirs exist on its surface, they would boil away in the earth's atmospheric pressure. If they do not boil away, it would mean the atmospheric pressure on Venus is considerable."

Nevertheless Barabashov, basing his opinion on many years of observations from the Kharkov Observatory, believes there are large sheets of water on Venus. The surface of the planet is dark, reflecting about twenty-five per cent. of the light that reaches it while the clouds floating in its atmosphere reflect over fifty per cent. "While processing the photometric photographs of Venus," he continues, "it became known to me that Venus reflects light in the same manner as it is reflected by mirror-like surfaces. A similar effect was achieved in the study of polarization of light reflected by Venus. It would be quite natural to surmise that the surface has notable pronounced mirror-qualities, peculiar for instance, to ocean surfaces. . . . The author on the basis of photometric observations of Venus, as early as in 1949 arrived at the supposition that a big water surface—an ocean—may exist on the planet. The same idea was expressed by the American astronomers Menzel and Whipple, who proceeded from totally different assumptions . . ."

It was not until 1960, when an American astronomer, Strong, carried a telescope to the height of fifteen miles in a balloon, that water vapour was discovered in the Venus atmosphere—above cloud level—suggesting at least tiny amounts of life-giving oxygen. Barabashov suggests that under the heavy, enveloping clouds known to contain a considerable quantity of carbon dioxide, there may be layers of oxygen and water vapour. Radio emissions from Venus, monitored on Earth, indicate powerful electric discharges which suggest thunderstorms, "about one thousand times more powerful than those on the Earth."

Another view presented by V. Beloussov, Corresponding Member of the Academy of Sciences—while not completely discounting the possibility of living organisms on Venus—considers that: ". . . it is likely that the close proximity of Venus to the Sun and the high temperature have been prohibitive for life to appear on Venus, and its atmosphere has remained in its primeval state. All the same, if our notions of planet development are correct, the processes that occur in the interior of Venus must be similar to those on Earth. Therefore we may expect to find ridges and volcanoes of the Earth type on Venus.

"What if . . . we fail to find such ridges and volcanoes there? Then we shall have to ponder the causes of their absence and to ask ourselves whether or not our theories of the development of planets in general and of the Earth in particular are correct. We shall have to revise our views on the processes that are supposed to take place inside the Earth!"

Professor Shklovsky, whose views on Mars are mentioned earlier, is even severer in his judgment of Venus: "What a murky world this must be! A world of red-hot rock, no water, a dense atmosphere of carbon dioxide and eternal clouds completely blocking the view of sun and stars . . ." Contrary to his colleague from Kharkov, Professor Shklovsky says that since the surface atmospheric pressure on Venus is five times as high as that on Earth, and the temperature ranges up to 572° F., "or even more, the assumption that Venus has seas is absolutely out of the question." When scientists fall out—let poets rejoice.

It was the job of the A.I.S. to confirm or deny the harsh allegations made by the scientists in their remorseless stripping away of the glamour woven around Venus through the centuries by the poets. If a heavy meteorite put an end to the Venus space-station's activities before it ripped aside those flimsy vapour veils—then it would be one up to the poets. But nothing can take away from the scientists the glory for having created such a superb piece of spacemanship and the wizardry of its launching.

16

SCIENCE FICTION IN RUSSIA

ONLY a year or so ago, those 108 minutes were still in the furthest realms of space fantasy, science fiction straight from the brightly coloured pages of a children's comic.

But Soviet space scientists for the past four years have been pressing hard on the heels of their science fiction writers—the latter having kept themselves fairly within the boundaries of the probable in their space stories.

The ordinary Russian who knows his Jules Verne and Konstantin Tsiolkovsky is today much more pernickety about space stories than his counterpart in Britain, America or France. If the *Daily Express*'s Jeff Hawke were, by some stretch of the imagination, printed in *Pravda* or *Izvestia*, it would be laughed out of print. Worse, it would annoy the customers who could and would pick faults in the size and shape of the space-ships, their engines, their instruments, even the food they eat.

Of these strip-cartoon characters, one Russian science-fiction writer, Professor Ivan Yefremov, says, "I like some of them, but the trend doesn't appeal to me; too many of the authors have a tendency to neglect science altogether. But the trouble doesn't really lie with a fallacious imagination. It's the stereotype plots; you know, the fantastic invention, the mad inventor, the lovely girl detective and so on. The readers should be pretty sick of all that by now.

"Our science fiction is usually based on fact. For instance, I wrote a novel *Diamond Pipe* in 1944 about the terrible journeys and difficulties of prospectors in Siberia. The idea came from the known geological similarity of the East Siberian Plateau and the South American plateau. The heroes found their diamonds, of course, eventually. And so did we in real life—ten years after the book was published!"

The days of having to write such stories with conjecture and supposition are over, says the average Russian—why not use facts? Russian science-fiction films of the "I was a satellite of the Sun" type, in fact run in shots of documentary film from space training, rocket launchings, TV pictures of dogs in orbit and other real meat of space flights.

One Moscow scientist, however, recently worked out a theory which is a form of science fiction in reverse; a piece of whimsical speculation which is not out of place here. His name: Professor M. M. Agrest. His theory: that space-ships landed on Earth many millions of years ago from another planet. His story goes like this:

One of the most mysterious riddles of nature is the origin of tektites, glassy stone found mostly in the Libyan desert. Tektites contain radio-isotopes of aluminium and beryllium. The radio-isotopes are a kind of birth certificate, showing that they were formed at least a million years ago in conditions of intense heat and intense radioactivity. But our planet is billions, not millions, of years old; they therefore somehow arrived on a "ready-made" Earth.

Are they akin to meteorites? No. Meteorites which reach here from time to time are incomparably older, and, besides, they fall indiscriminately on places all over the globe. So this, says Agrest, might have happened: A giant space-ship approached the Earth at the speed of light; a photon-powered job in fact; at a height of about forty thousand kilometres it slowed down to three kilometres per second, and, having cut off its engines, stayed over the planet like an artificial satellite with a transit time of twenty-four hours, thus remaining over one spot. From this position, the cosmic travellers fired down sounding devices to test the nature of the Earth's surface. Finding a satisfactory spot (the Libyan desert) they landed. The tektites are due to the fall of these "sounders."

Once here, they had to build rocket dromes and other special facilities for flying off from the Earth to investigate near-by planets, and also to their own base ship which might have remained aloft outside the Earth's atmosphere. Close to Libya they set up a monument to their arrival: the Baalbeck Terrace.

Today the Baalbeck Terrace is a structure that defies explanation, says Agrest. Erected very many thousands of years ago, it is entirely out of keeping with its estimated time of construction. One block alone, for instance, is twenty metres long and weighs more than 2,000 tons. Even today, he says, such a building would be almost beyond our capabilities. Geologists and archaeologists are still asking: who put them there, and how? Builders from another world? Agrest asks: Why not?

He now comes to the most imaginative part of his theory: the meaning of the Dead Sea Scrolls.

"In the spring of 1947," he writes, "a Bedouin strayed into the Ain Fecha Cave near the Dead Sea looking for missing sheep. In the cave he found fragments and unbroken pitchers, containing leather rolls with unintelligible writing....

"The manuscripts turned out to be the oldest texts of the opening passages of the Bible, written about 2,000 years ago, and representing copies of still older writings. It is common knowledge that ancient Jewish priests, while making up the Bible, inserted in it the oldest written language relics available at the time.

"The legends of the opening chapters of the Bible mention the existence of some creatures which came to the Earth from the heavens, and of men taken from the Earth to the heavens: 'The fallen [men from the heavens] were on the Earth during and even after the days when the [fallen] sons of God came . . .' 'And Enoch walked with God; and he was not; for God took him.'

"Then we come to the account of the destruction of Sodom and Gomorrah. Before that disaster occurred, the Bible says, some messengers told Lot, a local inhabitant: 'Escape for thy life; look not behind thee, neither stay thou in all the plain; escape to the mountain, lest thou be consumed.' Lot answered: '. . . I cannot escape to the mountain, lest some evil take me and I die.' The story goes on: '. . . And lo, the smoke of the country went up as the smoke of a furnace . . . and rained upon Sodom and Gomorrah brimstone and fire . . . and overthrew those cities, and all in the plain, and all the inhabitants of the cities, and that which grew upon the ground . . . but she [Lot's wife] looked back from behind him, and she became a pillar of salt . . . and Lot went up out of Zoär [his temporary place of refuge] and dwelt in the mountain . . . for he feared to dwell in Zoär . . .'

"The situation was, as I see it, that men were told to leave the site of the coming explosion, without so much as stopping in the open country or watching the blast, and to take refuge behind thick earth cover. The blast involved a characteristic nuclear eruption of smoke and rock, wrought great havoc, destroyed all vegetation and killed the human beings who remained where they were. Whoever looked back was blinded or killed. Those who saved themselves by taking refuge in makeshift shelters not far from the blast site had then to go into remote caves in obedience to the warning they had been given.

"Perhaps these space creatures, with their immeasurably higher culture and greater power, were taken by the Earth people for gods, just as the first Spaniards to land in Peru hundreds of years ago were considered by the Indians to be gods.

"Subsequently, these 'people' left the earth and took with them a 'son of the Earth.' Before leaving they blew up their surplus nuclear fuel supply, after cautioning the inhabitants so that they should not suffer from the blast. This was the destruction of Sodom and Gomorrah.

"Another curious thing, unconnected with the Bible: it has long been established that some knowledge of the planets was obtained in a mysterious way at a time when there were no instruments with which to get that knowledge. An example: Jonathan Swift described the basic features of the satellites of Mars 150 years before those satellites were discovered. They are so small and so close to the planet that the only way to observe them is through very powerful telescopes which certainly did not exist in Swift's day.

"Such incongruities puzzled scientists so much that they even speculated on the existence of an ancient people with an incredibly vast knowledge of astronomy. The people disappeared, but their knowledge, or fragments of it, were passed on through the ages. This possibility was mentioned by Gauss, the German mathematician and astronomer. Yet history cannot place these people.

"But it might be supposed that during their stay on Earth the space men tried to educate the Earthlings, but because of the latter's extremely low standards of culture and technical abilities that knowledge was difficult to apply and, therefore, could not come to stay. Some knowledge of astronomy, however, was an exception—as even the humblest shepherd and the primitive nomadic tribes of the Biblical lands had to be able to find their way by the stars.

"Therefore, it is the astronomic information that the space travellers could have given men that would have had the greatest chance of preservation. Isn't Swift's 'discovery' and the scores of other similar facts the remains of the knowledge imparted so long ago?

"All this is pure fantasy, but the facts fit often enough to make it interesting speculation. Of course, one might ask: why, if these space travellers did arrive here all that time ago, why have there been no other visits since?

"To that one might say: to the inhabitants of the distant far reaches of the universe, our Earth is no more than one of a multitude of inhabited planets. And, under the theory of relativity, time on a superfast rocket would pass much more slowly than it does on Earth. Maybe the space-men's home is so far away that, having left Earth thousands upon thousands of years ago (in terrestrial time) they are still on their way. . . ."

17

PROFIT AND LOSS

RETURNING to Earth, and to the mundane economic problem of profit and loss, we find the biggest and one of the most exciting questions: What of the commercial uses of space?

For in analysing the potential goods and services it has to offer, space is brought to everyone's fireside. Its development can affect every man in every nation on Earth.

Even in a Communist state, money and labour cannot be expended without promise of profits for the national economy as a whole. Knowledge is only useful when it can be applied.

Russia's economists have for many years been concerned with the long-range benefits of space exploration, and two of them, N. Varvarov and K. Mikhailov, have published a brief outline of the principles of space economics.

"Though incomplete," they write, "knowledge of nature's mysteries has already had a far-reaching effect on the economic aspect of social life. For the penetration into matter ensures mankind inexhaustible power resources, while the breakthrough into space holds out the promise of new, boundless reserves of materials. Further advance in these directions will lead to a new, unprecedented progress in society.

"However, despite the fact that this is so obvious, we sometimes hear arguments about the inadvisability of large material expenditure on the study and conquest of space—at least at the present time.

"These expenditures are considerable indeed. But results already obtained are no less fruitful for both science and practical activity. If, however, we picture the economic advantages planetary exploration will give in the near future alone, the urgency of further space exploration will become quite evident.

"As we know, the development of any field of the economy involves what is known as feedback. As applied to astronautics, this feedback means that we not only make use of what had already been achieved, but that a powerful impetus is given to improvement.

"Thus, it would have been impossible to build and launch space vehicles without better alloys, precise instruments, electronic components, computers as well as advanced research in chemistry and physics, astronomy, mathematics and many other fields of production and knowledge.

"If we estimate what savings have been made through increased productivity, automation, new metals and metal-working methods, we are safe in saying that space has already, to some extent, repaid the money invested in it.

"But these are side-issues; what is no less important is that the big achievements in space already made serve to solve specifically economic problems—extremely difficult but vital problems.

"The time is coming when an ever greater number of man-made satellites of most diverse forms and purposes will ride the sky outside our atmosphere. They will become larger, heavier and more complex as time goes on.

"First of all, sputniks will be employed to an ever greater extent for studying the upper atmosphere; its density, temperature, composition, their changes with time and geographical latitude, and the dependence of these changes on solar activity which is the only source of energy for atmospheric movement.

"Sputniks will be used for the exploration of minerals and power resources and in defining the shape of the Earth for geodetic purposes.

"The practical importance of all these problems explains why the first studies with the aid of satellites were geophysical.

Figuratively speaking, the first gaze of man outside our planet was turned back towards it. But soon we must look further to seek the commercial resources of other worlds.

"We cannot say that we even know anything about the rocks they consist of. As far as current theory goes, all the planets of the solar system were formed by the accretion of a single protoplanetary dust cloud, and their subsequent history must, in the main, have followed the same law.

"This, however, does not exclude the differences in processes that take place on the various planets, caused by size, mass and chemical composition, existence or absence of plant life, its level and character, temperature pattern, etc. Therefore, the comparison of our planet with the other worlds of the solar system would make it possible to revive the existing cosmogonic, geophysical, biological, geological and other theories.

"This is all very important. When people talk about the natural resources of the Earth—coal, oil, gas, iron ore, chemical, mineral and atomic raw materials, they often refer to their limited supply.

"Sooner or later they will be exhausted, people say. If the future generations are not to be left unprovided for, alternative sources of minerals must be sought in other planets.

"But all the same, there is no ground for talking about the coming crisis of raw materials and power supply on the Earth, just as there is no use guessing about how long the Earth's resources would last.

"After all, we know very little about our planet yet. While he has reached for millions of kilometres into the depths of the universe, Man has penetrated only several thousand metres down into the bowels of his home. Our mines and wells look like pinpricks in the Earth's crust. Even the deepest are less than one-thousandth of the Earth's radius.

"The only conclusion we ought to draw is that we must study our planet and probe its interior before we can say anything about its resources.

"And here, too, man-made satellites can help the explorers.

"As soon as a sputnik is in orbit, the major factor governing its flight is the Earth's pull of gravity. It responds to all variations in the gravitational field caused by different formations in the Earth's crust. Its flight path changes as it flies over deposits of heavy iron ore, ridges of mountains or the lighter water bodies.

"As these features differing in density are distributed uniformly, there will be forces altering the sputnik's trajectory into a wave-shaped one.

"In continuously tracking the satellite it is possible to locate the large-sized 'malformations' in the Earth's surface. So we hope to be able to detect areas of minerals in this way—an especially valuable aid where ocean-beds are concerned.

"This is just one illustration of how the study of the Earth can be assisted by our progress in space exploration, and how probing the universe has a direct commercial application on Earth.

"It may seem premature and unwarranted to plan commercial development of mineral resources on other planets before we have fully explored our own. But the two projects go hand in hand; their joint study is a 'must.'

"One final point: the utilization of mineral resources in space will not be warranted unless we initiate a large-scale development of the planets where they are found. Their environments will have to be remodelled after the fashion of our own life on Earth; shipping costs of such minerals may be prohibitive, depending on large numbers of unknown factors. Then again, it may be that technology on Earth will one day be able to manufacture synthetically anything we find in outer space."

Scientists claim that the first sputniks have reported back valuable information on mineral—especially iron ore—deposits in Siberia and that they will be used more and more frequently for strategic mineral surveys on that vast and largely unprospected territory.

Television allied to astronomy is playing an increasing part in the space programme. Every movement of Gagarin throughout his flight was closely watched, with ground reception being only slightly less sharp than, say, a Eurovision broadcast. One immediate goal this year is the placing outside the Earth's atmosphere of TV cameras linked to phototelescopes: this eliminates the atmospheric distortion unavoidable even in such high-power "ordinary" telescopes as the one at the Crimean observatory. Also, as the sky always appears pitch-black when viewed outside the Earth's atmosphere, satellites, space-ships, and stars will show up much more brightly.

Practical advantages which will follow from TV cameras and stations in the sky include greatly improved weather forecasting (U.S. scientists were able to track the course of typhoons in 1960 with this method) and world-wide domestic TV and wireless communication.

On the subject of weather satellites, Varvarov and Mikhailov say: "If the farmer was able to know what the weather would be like several months ahead, he would be better able to plan his sowing and planting. Rough estimates show that, if this were so, harvests would be boosted by 50 to 100 per cent.

"What prevents reliable long-range forecasting is the extremely intricate 'weather machine.' The great diversity of the meteorological processes taking place in the atmosphere and thousands of other factors, interlace with each other. Not long ago it would have seemed impossible to relate all this material; scientists would simply have been buried in the avalanche of initial data and the computations involved.

"Today, however, data-processing systems can quickly find short cuts through the jungle of causes and effects of weather making.

"But there remains the big difficulty—that of data gathering.

A huge army of meteorologists watches the world's weather ceaselessly. In the U.S.S.R. alone this service incorporates thousands of ground stations, weather ships, planes and helicopters, and the launching sites of meteorological rockets.

"The operating costs of all this are hardly covered by the practical uses for which it has been organized. And yet the problem of long-range weather forecasting has still not been solved. Why? For one thing, the weather is watched regularly only over one-third of the Earth's surface, and this mainly in the lower atmosphere.

"The remaining part where the weather is actually made is left without proper observation. Another unknown is the current lack of information about exactly what takes place in the atmosphere; for instance, there is a strong, but improved, indication that solar activity processes there greatly affect the weather on the ground.

"The continuous sounding of the upper atmosphere with planes, radios and rockets requires both much money and effort, especially on the oceans and other normally inaccessible areas.

"Therefore it is most unlikely that it will be possible to extend these studies to the upper atmosphere by employing the same methods. The cost alone would prohibit it. Much cheaper —very much cheaper—would be the use of sputniks.

"They could be equipped with the necessary photographic television, infra-red, radar and other apparatus, and circle the Earth at various heights and in different directions. They would watch continuously the cloud cover of the Earth, the amount of solar energy coming to the edge of the atmosphere and reaching the Earth's surface, the movement of cold and warm masses of air, the temperature of air and water and radio their data to Earth in a continuous flow.

"This information, processed by computers and meteorologists, would give us a world-wide picture from which could be estimated reliably the main trends. Storms, typhoons, floods and drought could be safely predicted, with the consequent saving of lives, crops and cattle."

This world network involves the use of fundamentally new methods of super-long-distance radio transmission. A satellite orbiting outside the Earth's atmosphere at a speed which keeps it stationary above one spot on Earth would serve as a relay station for an area of almost half the globe's surface. Three such "sky-hook" satellites would cover the world, if placed at a height of 35,800 kilometres. The three would have to be travelling in exactly the same plane, 120° apart. To achieve this, they would be launched from one spot at intervals of eight hours. Power supplies would be from solar reflectors, and their life-time would be an indefinite one, running into thousands of years. They would reveal, for instance, the secrets of the large air masses which are known to move to Siberia in wintertime, forming what is called the "great Siberian anticyclone."

This mass weighs about 14,000 *million* tons. In summer it dissipates, perhaps causing the much-discussed shifting of the Earth's axis which, in turn, influences the world-wide weather pattern.

The points made about reliable, long-range weather forecasting will not be lost on farmers, no matter what nationality. But how far off is such a service? A very strong belief in Moscow is that the Soviet Union will have a combined observatory, television relay station and meteorological station in orbit by the end of 1962; it will be visible only to Russians, for the world's first commercial sputnik will be travelling at the same speed as the Earth's rotation, thus appearing to be stationary over one spot. The spot is obviously likely to be over central Siberia, providing the greatest coverage for all purposes. Eastern cities such as Vladivostok will no doubt be receiving Moscow TV programmes via the sputnik, and perhaps telephone calls too.

The American Telegraph and Telephone Corporation is also, of course, investigating the possibilities. The number of telephone calls between Europe and the U.S.A. is expected to increase by twenty-five times during the next two decades, and the company is prepared to spend £60 million on a telephone satellite project, the rockets being supplied by the N.A.S.A. and the payload by the A.T. & T. Nine other large American companies are working on similar schemes, following an appeal by the Federal Communications Commission for them to draw up plans quickly to make the most of the space programme. Between them, it is hoped to have five sputniks in orbit by mid-1964.

In Britain, eight giant industrial firms have formed British Space Developments Ltd. One of the backers, Sir Robert Renwick, says: "We believe there is more money in space than ever dreamed of. The use of space in the next two decades will be a major key to continued prosperity."

The French and Italian Governments also have their plans; both countries are successfully experimenting with high-altitude rockets, some containing small animals. In a joint European "space club" venture, Britain alone has offered to subscribe £23,000,000. The race is on.

One Moscow scientist told Purdy: "It is exciting to hear of the fast-moving developments by so many countries, but it is a pity that so many of them are duplicated. Progress would be much quicker if there was more international co-operation."

To this end, the International Academy of Astronautics has been set up. It held its first meeting in May, 1960, and is designed as a clearing house for information gleaned from sputniks and space probes. It is publishing an international journal and will award prizes to individual scientists; already funds are pouring in. The Guggenheim Foundation, for instance, has given $75,000, and many more such contributions are expected from private organizations, as well as governments.

"There is great hope for all of us in this kind of co-operation," said Academician Fyodorov, who is one of the Soviet Union's representatives on the I.A.A. "There is room for everybody in space—and nobody need fight over it."

At the beginning of the space age, a reassuring sentiment.

About the authors:

WILFRED BURCHETT

WILFRED BURCHETT was born in Melbourne in 1911. He has worked as a Fleet Street journalist for twenty years. During World War II, was a war correspondent for the *Daily Express*, the Sydney *Telegraph* and Toronto *Star Weekly* in the Far East and Pacific. Burchett was wounded in action in Burma and achieved a memorable scoop at the end of the war by being the first correspondent to enter Hiroshima. The A-Bomb on Hiroshima was virtually the final act of World War II, and Burchett was horrified at this preview of what half the major cities of the world could look like in the first few hours of a World War III. He has had very decided views on questions of war and peace ever since.

In the immediate postwar years, Burchett was *Daily Express* correspondent in Berlin and Central Europe and later correspondent for *The Times* and *Christian Science Monitor* in Budapest.

After the Korean war broke out, Burchett visited China as a freelance writer and when the Panmunjom peace talks started he went to Korea to report the peace talks from the northern side for French and Italian left-wing dailies. He remained in Panmunjom for two and a half years, from the first day of the peace talks until the last P.O.W. was exchanged. Burchett was on the spot at the beginning of the battle for Dien Bien Phu and then reported on the Geneva talks which ended the Indo-China war, spending another two and a half years in South East Asia as a freelance writer.

Since 1957, Burchett has been in Moscow as a contributor to the *Daily Express* and *Financial Times* of London, Fairchild Publications and *National Guardian* of New York, and Express Newspapers of India.

Burchett is the author of a number of books, of which *Wingate's Phantom Army* is probably the best known to English readers.

ANTHONY PURDY

ANTHONY PURDY, 30 years old, is an ex-Fleet Street journalist who has always been interested in science reporting. His articles have often been coloured by experience: he was the first British journalist to be able to describe prolonged weightlessness (the condition lasted for a minute, in a specially stressed aircraft, five years ago) and he tried out for himself pressure suits, catapult ejector seats and the dubious delights of the centrifuge. To test a survival suit for the Navy—and television, for which he was working at the time—he was dropped by helicopter in the North Sea and left to float until its defects became noticeable. He has been shaken on the vibration table and starved of oxygen in a pressure chamber—both described in Gagarin's training for space.

Working for a London Sunday newspaper, TV and radio, being assistant editor of a magazine, and freelancing has taken him to eleven different countries.

INDEX

ACADEMY OF SCIENCES, 54
Acceleration load, 78
Agar-agar, 74
Agrest, Prof. M. M., 168
Akbulatov, Yadkar, 92
Alcohol, 36, 55
Algae, use of, 72
Alloys, 56; aluminium a., 57; manganin a., 57
Aluminium, 49
American Telegraph and Telephone Corporation, 179–80
Ammonia gas, 144

BAALBEK TERRACE, 169
Bach, 97
Baikonur, launching site, 22, 86
Barabashov, N., on Venus, 163
B.B.C., 15
Belopolsky, A. A., 164
Bespavlov, Lev M., 89
Bible, early space hints, 169
Blagonravov, Prof. A., 47
Blok, 97
Brass, 77
Braun, Wernher von, 29
Brezhnev, Pres. L., 12, 18
Bruno, Giordano, 60
Burchett, sees training animals, 68; sees Fyodorov after dog-flight, 81

CANBERRA OBSERVATORY, 50
Cancer cells, 73
Cape Canaveral, 55
Carbonic acid gas, neutralization of, 71
Centrifuge, Tsiolkovsky's, 35; dog tests in, 69; tests with, 103–4
Ceramics, use of, 56
Chavchanidze, V. 135
Chernigovsky, Acad., 44
Cheylustkin, Dr. A., 137
Chimpanzees, unsuitability of, 65–6
Ching-Chi, Tsu, 60
Cine-cameras, TV, 75, 101
Computers, for telescopes, 58; Tbilisi Institute, 135; value of, 137
Cooling, during re-entry, 56; penetration cooling, 56
Cosmic: radiation, Russian knowledge of, 9; speeds, 48, 139; Physiological Research Station, 67; rays, 76; rays in photography, 76; ship (3rd), 103; first cosmic speed, 156; second cosmic speed, 157
Cosmonaut, training of, 23, 100 et seq.
C.O.S.P.A.R., 10
Count-down, 27
Crimean Astrophysical Laboratory, 58
Crist, Russell, 32
Curie, Madame, 60
Cybernetics, new science of, 136; Scientific Council for, 138

DEAD SEA SCROLLS, 169
Dogs, first rocket flights, 44; Pavlov's, 65; compared with man, 65; training of, 66
Dolphus, A., 164
Doppler shift, 161
Drosophila, 73

EDISON, Thomas, 60
Error, margin of, 79; causes of, 159; another factor, 161–2
Eurovision, 15

FUELS, for space flight, 36, 42; secrecy about, 55
Fyodorov, Prof. Y., authors' interview with, 8; opinion of U.S. success, 8; geophysical studies, 51; on space problems, 52; task of Strelka/Belka flight, 81; on co-operation, 181.
Fyodorov, Dr. Victor, 66

GAGARIN, Major Y. A., arrival at Moscow, 11; pre-flight medical, 23; vitamin breakfast, 24; meets Strelka/Belka, 65; childhood, 87; foundryman, 90; Air Force, 91; wife Valentina, 93; in training, 101, 104, 107; parachute training, 104; at take-off, 110; at re-entry, 115, 116; first meets Western journalists, 118
German experts, *see Rockets*
Goldfish, 68
Gottrup, H., 32
Grachov, A., cosmonaut, 25
Grigoryev, Prof. N., 76
Gurovsky, Nikolai, 95–6

HERTZ, Heinrich, 60

ILYUSHIN, A., 155
I.C.B.M.s, international control of, 30
International Academy of Astronautics, 180
International Astronautical Federation, 10
International Astronomical Union, 60
International Geophysical Year, 47
Interplanetary station, 155, 159, 160, 162; tasks of, 163
Intervision, 15
Iron, 77
Izvestia, on space flight, 93

JEANS, Sir James, 144
Jet propulsion, principle of, 41–2; first jet flight, 42
Jodrell Bank, assistance of, 9–10; tracking of Sputnik I, 50, 57
Joliot-Curie, 60
Jupiter, study of, 60

KARDASHEV, N., 153
Keldysh, Mstislav, elected President Academy of Sciences, 41
Kerosene, 43
Kharkov University, 60
Kremlin, reception at, 15–17
Khruschev, N. S., receives Gagarin, 11; Red Square speech, 14; German Embassy speech, 48
Kibalchich, N. I., scientist and revolutionary, 15; execution, 21; space machine, 21; multiple rocket proposal, 42
Kokkinaki, Konstantin, 108
Komsomolskaya Pravda, space controversy in, 96
Konstantinovich, N., 104
Kozlov, Vice-Premier Frol, 18
Krasovosky, Prof. V., 60
Kurchatov, I. V., 60
Kuzmin, A. D., 164

LAUNCHING SITES, 86
League Against Cruel Sports, 50
Lerner, Dr. A., 137
Life on planets, 153
Lobachevsky, N., 60
Lomonosov, Mikhail, 60
Long-Distance Cosmic Radio Communications, Centre for, 161
Lovell, Prof., *see Jodrell Bank*
Lowell, 148

MALINOVSKY, Marshal Rodion, 18

Mars, study of, 60; Russian programme, 140; satellites of, 140, 149–50; theories of, 141, 150–1; atmosphere of, 142–3; life on, 146; "canals" of, 148; new "sea" on, 151; "flashes" on, 152
Martynov, Prof. D., 133
Maxwell, J. Clerk, 60
McLaughlin, American astronomer, 149
Mendeleev, Dmitri, 60
Menzel, 165
Meresyev, hero of *Story of a Real Man*, 98
Meteors, dangers of, 131, meteorites, 168
Methane, 36
Mikhailov, Prof. A., of Pulkovo University, 59
Mikhailov, K., 173
Mikhailov, V., cosmonaut, 25
Molybdenum, 56
Monitoring stations, 161
Moon, new features of, 60; flight to, 124; problems involved, 127, 129–30; legal position, 134

NAPIER, Sir J., 60
New Scientist, 9
Newton, Sir Isaac, 42
Nikonov, V. B., 59
Niobium, 56
Nitric acid, 43
Nitrogen, as filling for sputnik, 49
Noise, problem of, 78

OBSERVATORY ON MOON, 133
Oxygen: cabin supply, 27; liquid fuel, 36; in rocket, 43, 55; deficiency training, 84
Ozone, 36

PARACHUTES: rocket recovery by, 43; training with, 80, 95; Gagarin parachute training, 104
Parin, Prof. V., 25, 84–5
Pasteur, Louis, 60
Pavlov, I. P., dog training, 49; Pavlovo-Kultishi, 65
Peenemünde, 29
Petrol, 55
Petropavlovsky, J., engineer, 44
Petrovich, Prof. G. V., 126
Photonic speeds, 61
Plutonium, 61
Polevoi, B., 98
Polyanovsky, Max, 84
Popov, A., 60
Powers, Gary, 86

Pravda, 47
Pressure chamber, 101
Prokhorov, Prof. A., 138
Propulsion, by light radiation, 61, by atomic energy, 61
Psychological training, 102

RADIATION EXPOSURE, 70–1, 73
Radio, receivers, 161; transmission by space, 179
Rats, sensitivity to noise, 68
Red Square, Gagarin parade, 13
Re-entry, problem of, 79
Refrigeration, 79
Relativity, 62
Renwick, Sir Robert, 180
Richardson, R. S., American astronomer, 164
Robot flight, 9
Rockets: stations, 57; super-high speed, 29; German experts, 29, 31; first successful, 42; first Russian, 42; Katyusha rocket weapon, 43

SALOMONOVICH, A. E. 164
Saukov, A., speaking of Moon, 125
Schiaparelli, 148
Science fiction, 167
Sechenov, Russian physiologist, 35
Sedov, Prof. L., 53
Sharples, American astronomer, 141
Shepard, Com., manual control by, 9, 121
Shklovsky, Prof., 140; on Mars, 165–6
Siberia, anti-cyclone over, 179; Tungus mystery, 152
Sisakyan, Acad. N., 71
Smelovka, landing point, 115
Sochi, 11
Solar batteries, 162
Soviet Space Centre, 80
Space: suit, 24; cabin, 26; equipment of, 26–7; television in, 27; capsule, 77
Space programme: different policies, 31–3; decision, 39; chronology of Russian, 44–6; Russian policy, 52; commercial possibilities, 173
Space shot, result of, 8; main stages of, 101
Sputnik I: first announcement, 47; weight of, 47–8; purposes of, 174; for study of Earth, 174–6
Sputnik II, launching of, 49
Sputnik III, 53
Star, newly discovered, 59
Stalin, opposition by, 40–1
Steel, 56
Sternberg Astronomical Institute, 60, 133
Strelka and Belka, 53; compared, 70
Strong, American astronomer, 165
Struve, Russian astronomer, 141
Swift, Jonathan, description of Mars, 171

TEKTITES, riddle of, 168
Television: in space cabin, 27; transistorized, 75; role of, 177
Tikhov, Prof. G., 144; writings of, 144–5
Topchiyev, Acad., 160
Trapeznikov, V., 138
Trud, 124
Tsander, F. A., 42
Tsiolkovsky, K. E., scientist and space theoretician, 15, 30; space writings, 34; prophecy of cosmic flight, 36; cosmic speed, 36; moon feature, 60, 146
Tungsten, 56

UNITED NATIONS, 50; Committee, 134
Uranium, 62, 63
U.S.A., early work, 29

VANADIUM, 57
Varvarov, N., 173
Venus: study of, 60, rocket to, 82–3; Russian programme, 140, 155; probe of, 155; theories about, 163; water on, 165; life on, 165
Verne, Jules, 30, 60
Vernov, S., 76
Vershinin, Marshal, 18
Voroshilov, 12
"Vostok," 16, 46

WEATHER, satellites for, 177; forecasting, 177
Weightlessness: ill-effects of, 8; dogs and, 49; suitable food for, 73; nature of, 104–5, 112
Whipple, 165

YEFREMOV, Prof. I., 167
Yegorov, 52, 53

ZAVODOSKI, V., cosmonaut, 26
Zero gravity, *see weightlessness*
Zigel, Prof. F., Martian theories of, 145

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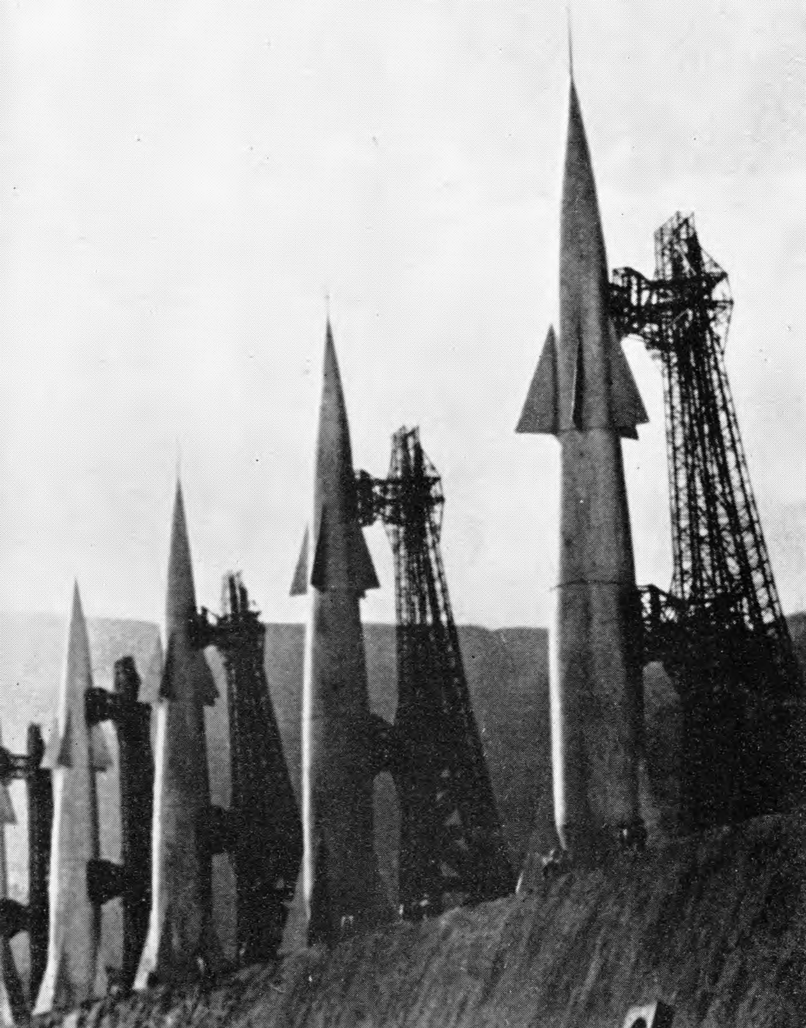
Just before take-off

Peasant women who were first to speak with Gagarin after he landed

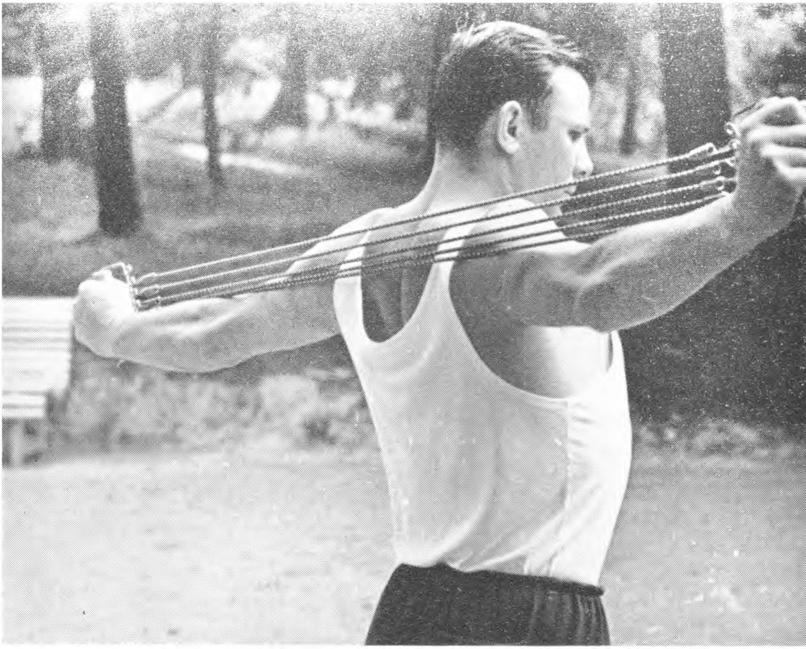
A wooden post marks the spot where Gagarin returned to earth

Alexei Grachov having sensors taped on by Dr Arabova, space physiologist

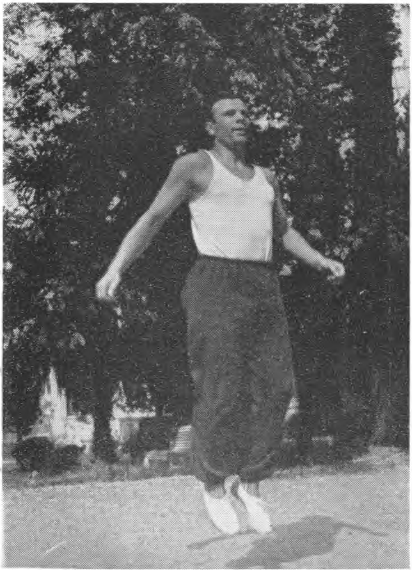
Ilyushin in his library. Trained as an astronaut, Russians say he crashed his car and is still in hospital

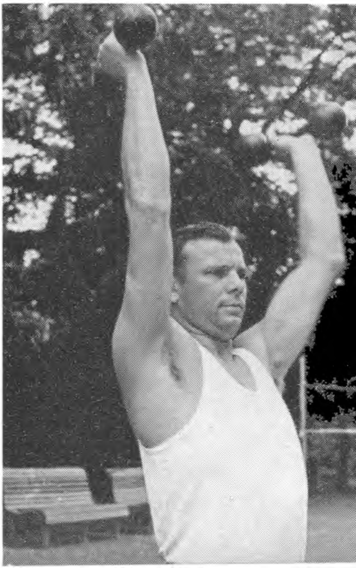


Rockets and launching gantries

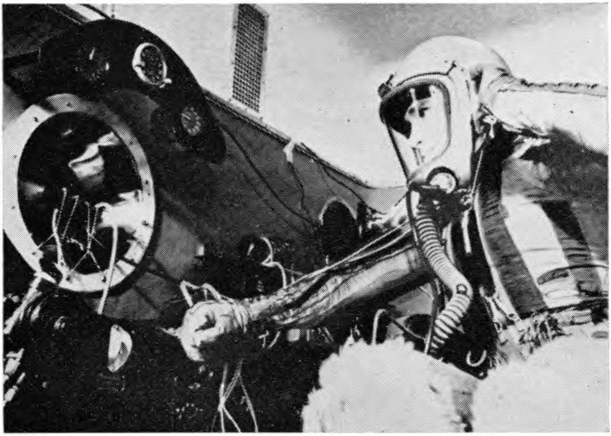


Gagarin: physical exercises





Vladimir Mikhailov, 28, trainee astronaut with Gagarin, in pressure chamber

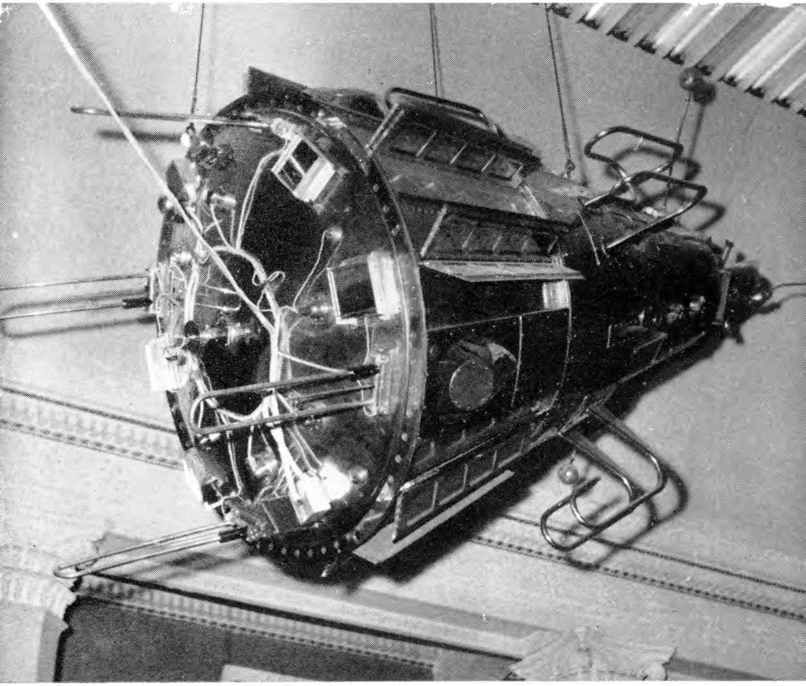


Mikhailov tests space-suit and communications in pressure chamber

Vasilievich Zavodoski, 27, trainee astronaut in Gagarin's team

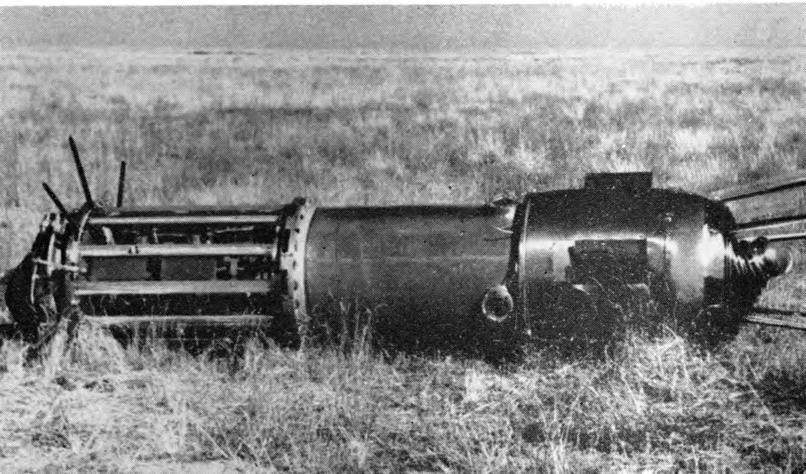
The House of Secrets—Moscow Headquarters of the Academy of Sciences

Top scientist in Soviet space programme is Yevgeni Fyodorov seen here with authors Burchett and Purdy, in the only interview he has given since the Gagarin flight



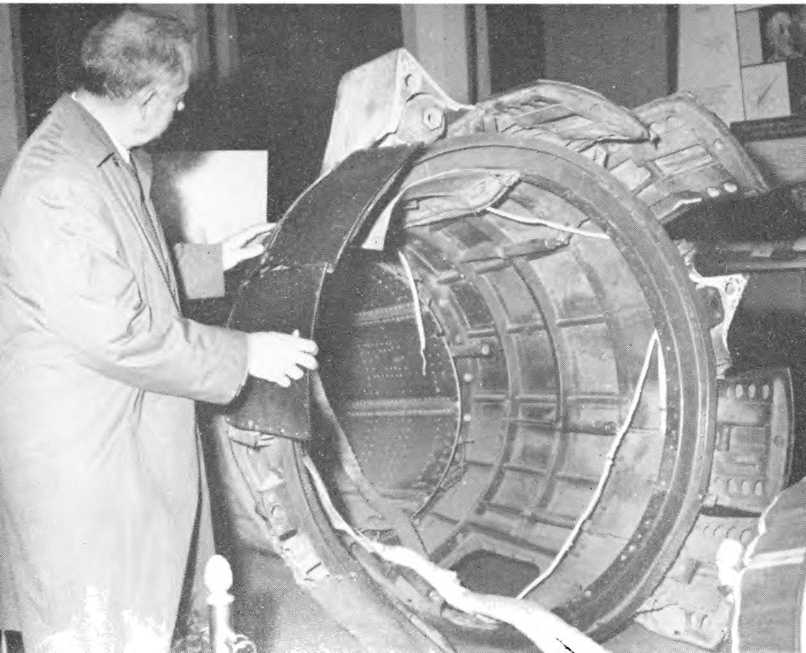
The lunik moon probe

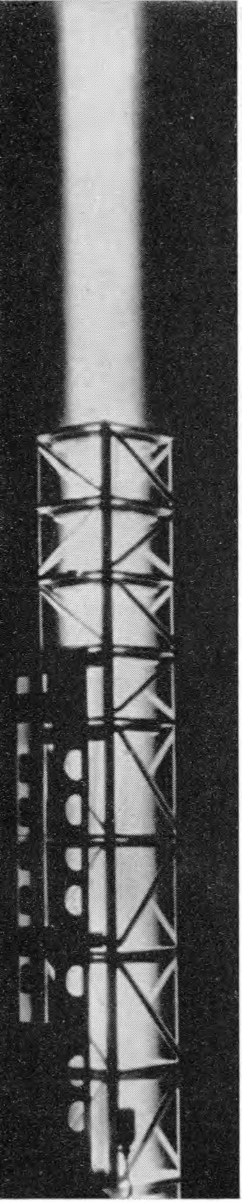
Nose-cone of recovered moon rocket



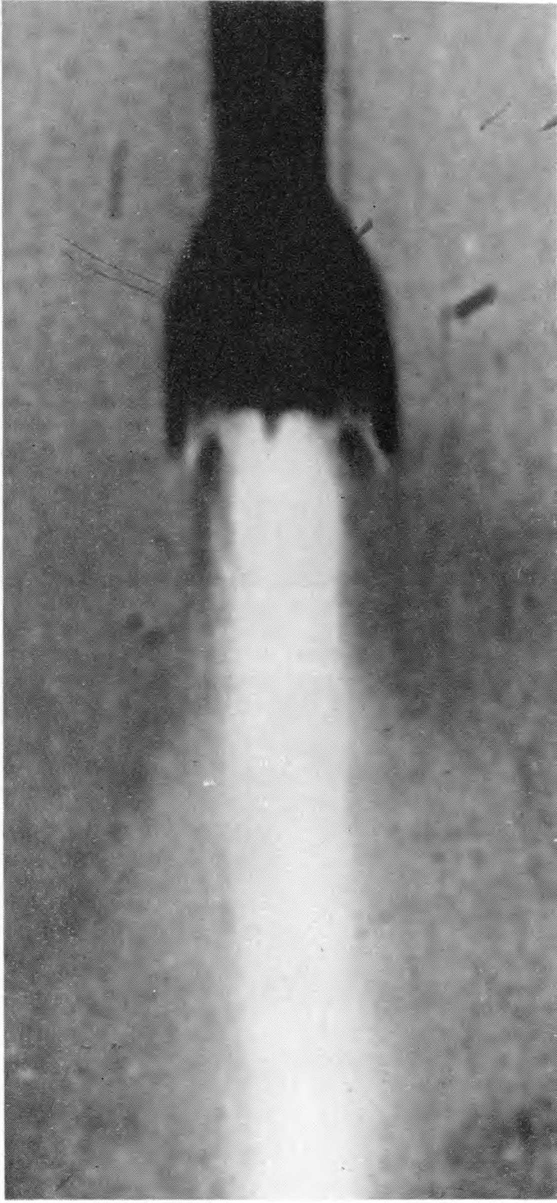
Flight of nose-cone of first sputnik's carrier rocket

Burchett with recovered nose-cone of IGY rocket

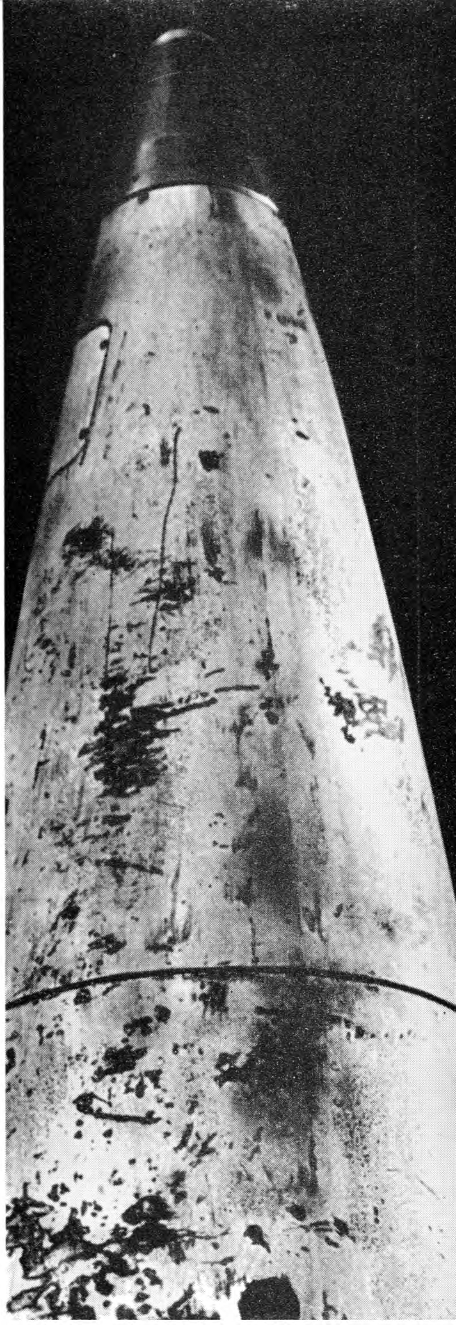




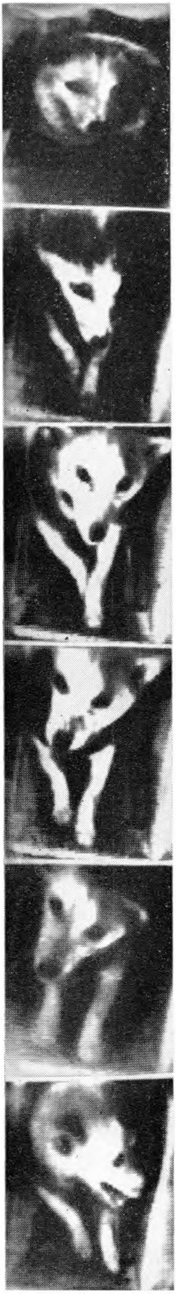
A few seconds after space-ship rocket take-off



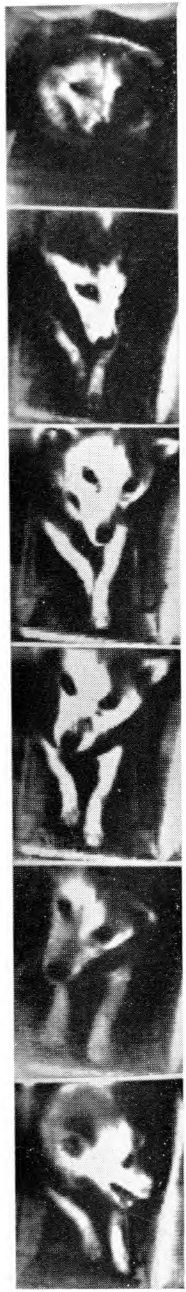
Zero plus 5 seconds

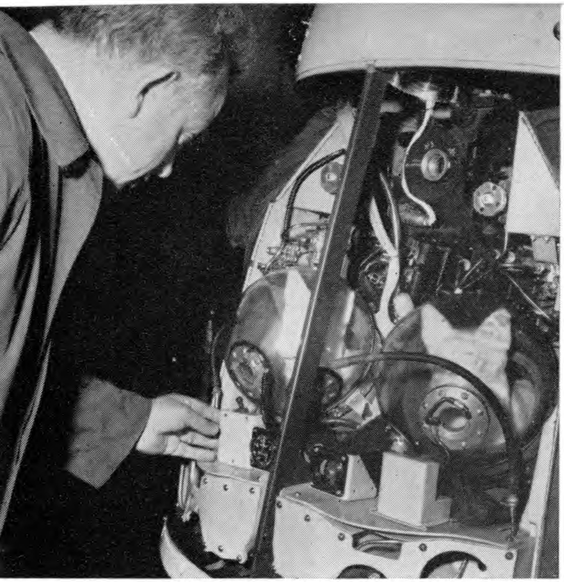


Recovered nose-cone of Vostok-type rocket



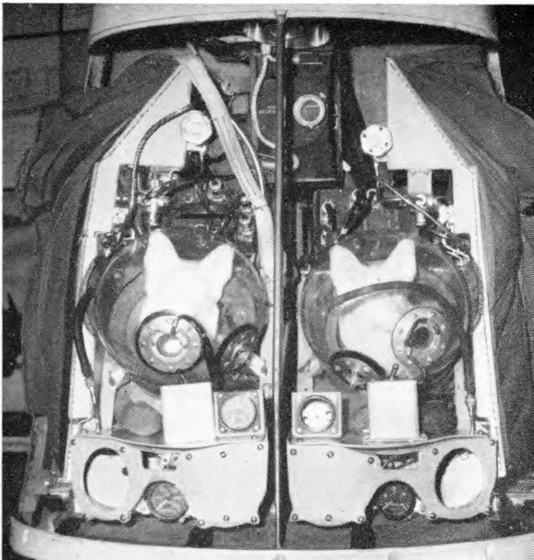
Television film taken during the flight of Strelka and Belka





Burchett and the Strelka/Belka capsule

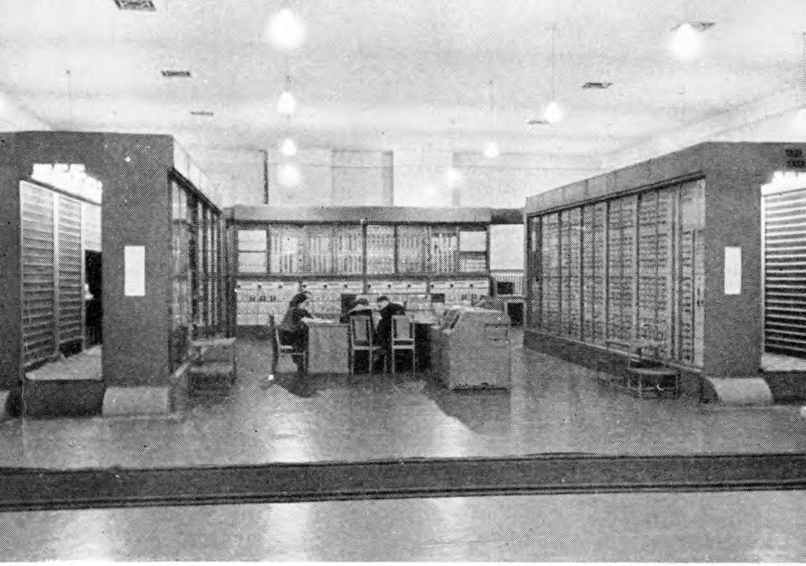
The Strelka/Belka capsule



Nose-cone of an animal-carrying space rocket

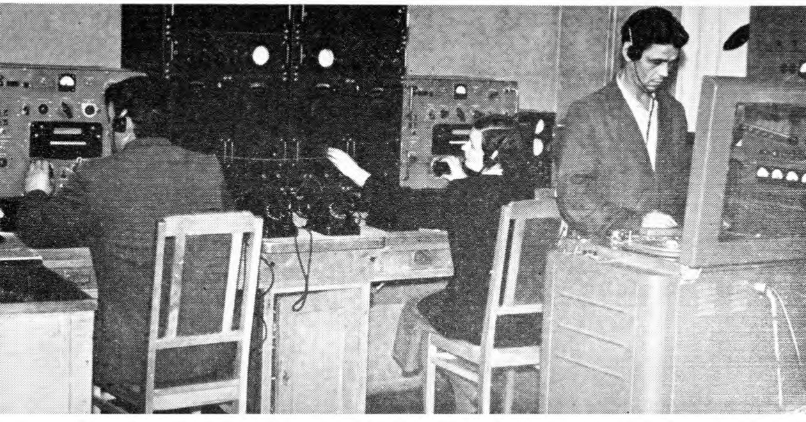
Belka and Strelka

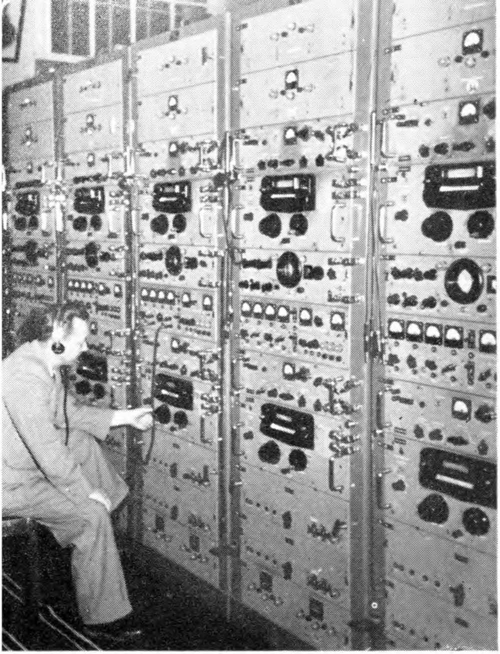
Chernushka (Blackie) and one of Strelka's puppies



"Strelka" computer used for computing trajectories

Part of the tracking and control apparatus at a launching site



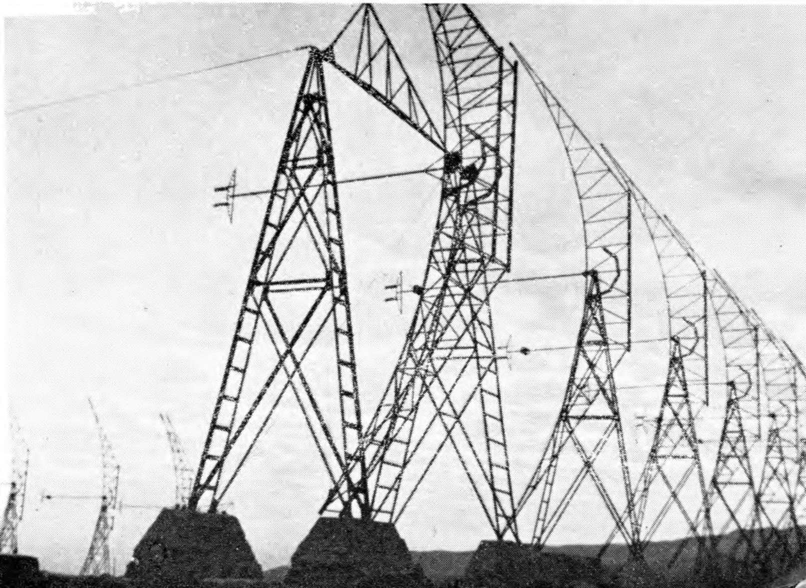


Part of the tracking and control apparatus at a launching site

Moscow University where space experiments were carried out and the lift from the 28th floor was used for zero G tests

Corner of Pulkovo Observatory

Antennae of radio-telescope at Burokane, Armenia



Gagarin gives his first interview to Western journalists.
Left to right: interpreter, Burchett, Gagarin, Purdy

Gagarin with author Purdy

Gagarin with author Burchett

The men behind Gagarin's flight were headed by such men as MSTISLAV KELDYSH, appointed head of the Academy of Sciences within six weeks of the man-in-space triumph

Chief Learned Secretary of the Academy of Sciences, Academician Yevgeni Fyodorov

Academician Sisakyan

Academician Parin

Professor Alexander Mikhailov at Pulkovo Astronomical Observatory

Gagarin at
Press Conference

Valya

Lena, Gagarin's two-year-old daughter, with globe

Lena
and friend

Galya,
Gagarin's
baby

Young foundry
trainee Yuri
Gagarin

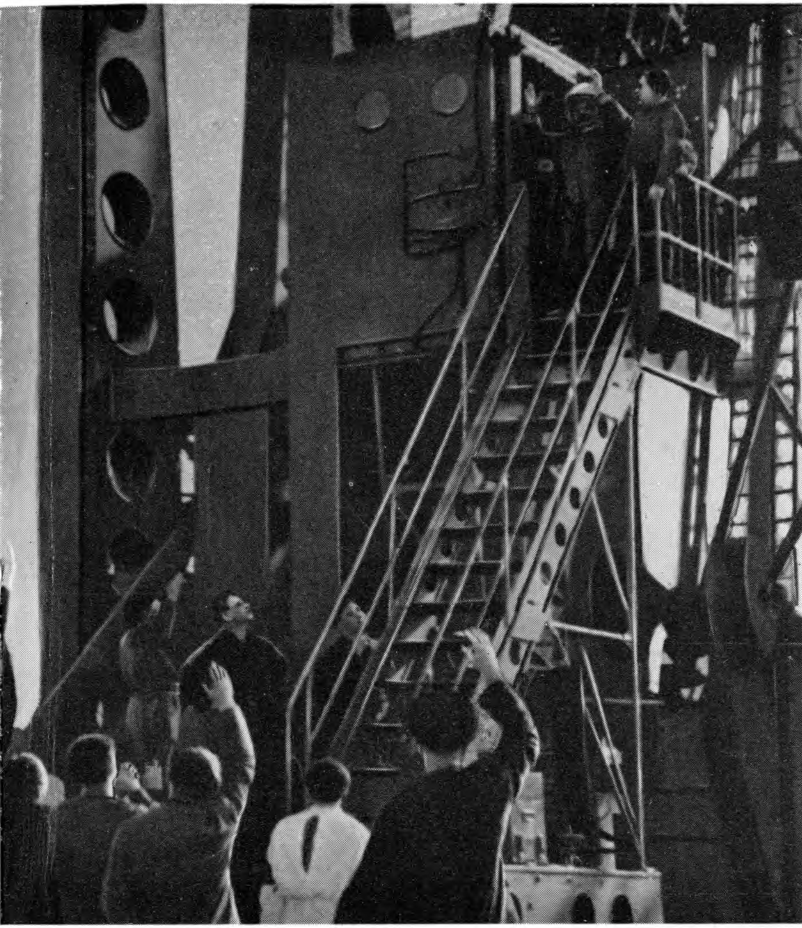
Gagarin and
Valya in the garden

Valya listening to the radio report

Gagarin family with Khruschev and others at Kremlin reception. From left to right: Defence Minister Marshal Malinovsky, ex-president Voroshilov, father Alexei Gagarin, mother Anna, Khruschev, Gagarin and wife, Brezhnev and Kozlov. Front: Elder sister, brother, brother's wife and younger brother

Mr and Mrs Khruschev, Mr and Mrs and Valya Gagarin, at Moscow airport reception

Red Square welcome



Gagarin at the entrance to the hoist

Author
Burchett

Author
Purdy


Valya