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Chapter 4

The Contribution of Fridrikh Tsander: A Memoir*

Marsha Freeman†

Introduction

Soviet space pioneer Fridrikh Tsander (1887-1933) is a seminal figure in the earliest history of the theory and development of spaceflight. He saw himself as taking the theoretical groundwork laid at the turn of this century by Konstantin Tsiolkovsky, and extending it to the practical reality of taking man into space.

Tsander combined the ability to generate creative concepts for accomplishing his goals, and the tenacity to perform numerous experiments, with a dedication to organizing public support, particularly among youth, for his dream to go "Forward to Mars." Those young men he inspired and trained went on to make significant contributions to the Soviet space effort.

The lack of knowledge today about his work is not due to any shortcomings on his part. Tsander died in 1933, at the age of 46, just at the moment that government support for large-scale rocket experiments was being realized, and dramatic breakthroughs could be made. Lacking such support throughout his life limited what Tsander was able to practically realize, but visionary concepts he

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† 21st Century Science & Technology, Washington, D.C. USA.

originated are still being worked on today, such as the "combining" of aircraft and rockets for spaceflight. Those who worked with Tsander, and continued after him, including S. P. Korolev, readily acknowledge Fridrikh Tsander's central place in the history of astronautics.

Figure 1: Soviet space pioneer Fridrikh A. Tsander (1887-1933).

Mars in 1909

Fridrikh Arturovich Tsander was born in Riga, Latvia on August 23, 1887, into a German family. His father, a medical doctor who worked at the Zoological Museum in Riga, often took his son to see the exotic animals there. His mother died when Fridrikh was two years old. Tsander wrote that his father's stories of "life in unknown forms that might be found on other planets, as well as meteorites like those kept in the museum, aroused in me, at a very early age, the wish to fly to the stars."

During high school, Tsander was introduced to the recently-published 1903 article by Tsiolkovsky, *Space Research with the Aid of Jet Propulsion Machines.* According to his former co-worker and biographer, Leonid K. Korneev, this article "created a great impression on the young dreamer" and the idea of space travel "was the source of his inexhaustible and endless enthusiasm throughout his life."

After high school, Tsander studied first at the Technical College of Danzig, Germany, and in 1907 returned to Riga to attend the Polytechnical Institute. In an autobiographical article written in March 1927, for inclusion in Nikolai Rynin's voluminous *Interplanetary Flight and Communication*, Tsander wrote: "In 1908, I was twenty-one years old, officially an adult. I obtained a substantial sum of money and the first thing I bought was an astronomical telescope with an objective diameter of 10 cm and a length of approximately 1.5 meters."

At that time, Tsander organized the "First Student Association for Aeronautics and Flight Technology," at Riga Polytechnical Institute. "I often mentioned to my friends that we should work on problems of flight to other planets. During the famous opposition of Mars in 1909, I often showed the planets and star clusters to my friends with the aid of my telescope," Tsander said.

By that time, Tsander had already been working on concepts for space propulsion and space flight. Space historian Viktor Sokolsky (who has researched Tsander's hand-written material in the archives of the then-Soviet Academy of Sciences) reports that on June 23, 1907, Tsander made an entry in his notebook on the motion of a body propelled by the reaction of issuing particles. In November of that year, he made brief mention of problems associated with the creation of a spacecraft.

Figure 2: Fridrikh Tsander as a student, in 1913.

In 1914, Tsander received an honors degree in "Technological Engineering" and obtained employment at the rubber plant, "Provodnik" to familiarize himself with a material that could be used as an insulating material in the vacuum of space. When the plant moved to Moscow in 1915, Tsander left Riga. Two years later, the factory closed down, and Tsander devoted himself to study and theoretical calculations of interplanetary flight.

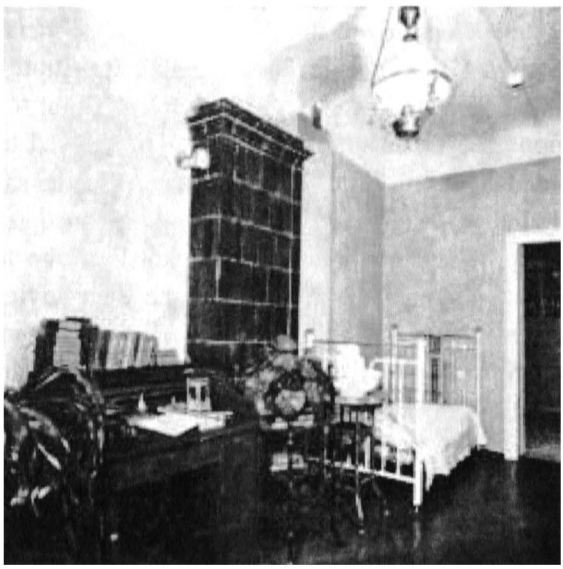

Figure 3: This modest bedroom in his home in Riga, is where Tsander lived and worked until leaving for Moscow in 1915.

Figure 4: Fridrikh Tsander's home in Riga, Latvia opened as a museum in 1987.

Airplanes Combined with Rockets

Tsander had carefully studied the writings of Tsiolkovky but had concluded that staged rockets were neither safe for manned flight, nor efficient. Between 1917 and 1919, Tsander started his work on combining airplanes that could fly at a high altitude, with an attached rocket that could take a spaceship to space.

In February 1919, Tsander began work at Aviation Plant No. 4 ("Motor"), using all of his spare time to study the construction of an airplane fitted with a rocket engine. The following year, he presented a detailed speech about his spaceship and the possibility of flights to other planets, at the Provincial Conference on Inventors in Moscow. V. I. Lenin was in the audience, which, Tsander relates, made him very nervous.

He reported to his friend and biographer Korneev later: "After the speech, I was invited to meet Lenin... Lenin was greatly interested in my work and my plans for the future; he spoke with such simplicity and cordiality that I am afraid I took advantage of his time by relating to him in great detail my work and my determination to build a rocket spaceship. I also told Lenin I was working on the problems of man's flight to Mars... Lenin asked me: 'Will you be the first to fly?' I answered that I had to set an example, and that I never thought possible to do otherwise. At the end of our conversation, Lenin shook my hand strongly, wished me success in my work, and promised support."

On December 30, 1921, Tsander presented his concept of a high-pressure aircraft motor to a governor's conference of inventors, "and they wished me further success and expressed a desire that I continue my work in this direction."

But the Soviet Union, in the midst of the ravages of civil war, was in no position to support rocket research. In the middle of 1922, Tsander was laid off from his job at the Aviation Plant, and used the time to intensify his studies. In April of the following year, the workers at the plant awarded Tsander one percent of one month's wages in order for him to be able to continue his researches, and in return, he presented a report to a general plant meeting at the factory.

Tsander proposed that "it can be affirmed with almost total certainty that intelligent life exists on Mars," to explain why that planet must be the ultimate object of space exploration. He reported that in the previous 10-15 years there had been important successes in the Soviet aviation industry, which led him to his "independent design of a rocket and its usage in combination with an airplane."

"My spaceship consists of an airplane filled out with a high-pressure aviation engine," Tsander reported. "The engine would use liquid oxygen, and gasoline or ethylene, or hydrogen... The engine would start the propellers and the

plane would leave Earth... At a height of 28 km the aviation engine would be cut off and the rocket engine would take over, with a force of 1500 kg."

In his April 1923 report to the factory workers, and in another report prepared the following month, Tsander outlined the advantages to this design. One would be that "the rocket will have permissible stresses, not the tremendous pressures [thrust] and dimensions which Tsiolkovsky calculated." Another grew from his concern that in Tsiolkovsky's design, "in case the rocket motor should fail, the entire apparatus would fall to the Earth." In Tsander's design, should the rocket fail, the winged spaceship would glide back to a safe landing.

In addition, an aircraft-like landing, Tsander proposed, would greatly increase the safety of spaceflight, as compared to the parachute method proposed particularly by German space pioneer Hermann Oberth. Tsander proposed to place a small airplane inside the large aircraft, which, with wings, would be the spaceship and the return vehicle.

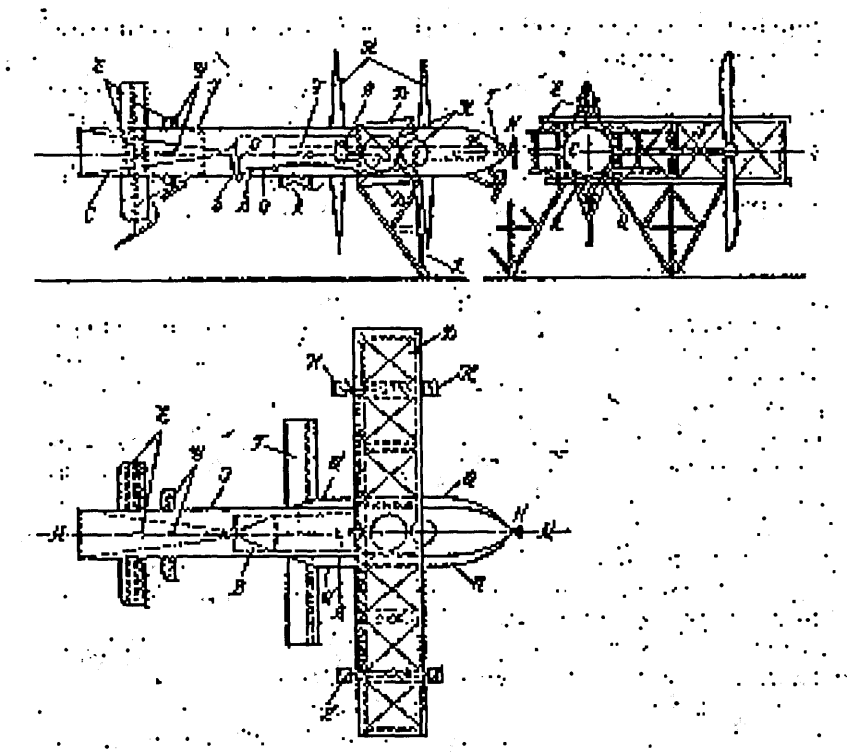

Figure 5: Tsander design for a winged rocket, made up of a propeller biplane, with a small monoplane for return to Earth, in the center.

When the aircraft engines were stopped, and the rocket started, at speed of about 400 m/sec and an altitude of about 28 km, "with the aid of a special

mechanism, we would transfer parts of the airplane to the boiler. We would then get liquid aluminum, which combined with hydrogen and oxygen, furnishes us with an excellent fuel." Tsander concludes that from his calculations, "we would have attained sufficient speed to leave the Earth and to fly over to other planets." Throughout his life, Tsander continued to develop this unique idea of using metal parts of the aircraft as a fuel for the rocket engine.

Alternatively, Tsander proposed, the aircraft could store and use liquid oxygen and other gases in liquid form, which would increase the efficiency of the rocket, to where "it would be possible to burn the liquid fuel exclusively, without dismantling the aircraft itself." Certainly, he pointed out, one would want to use this design, and reuse the aircraft, during the test program.

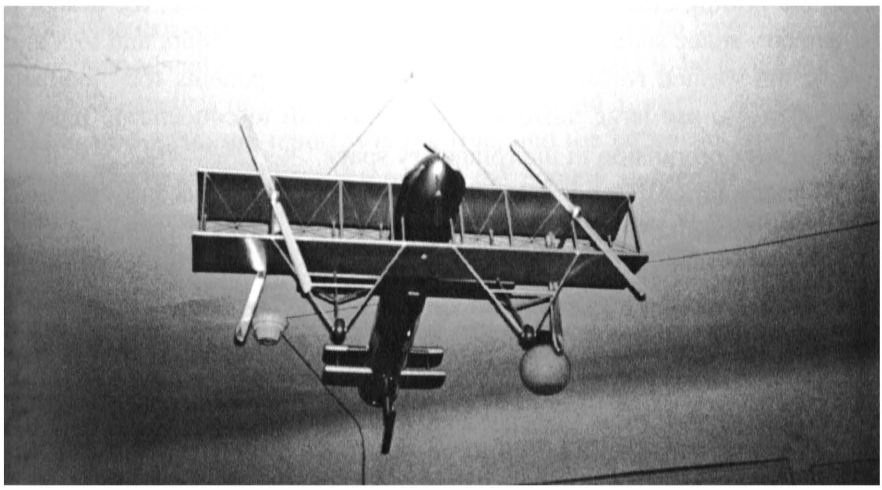

Figure 6: This model of Tsander's winged rocket design hangs in the Tsander Museum in Riga, Latvia.

Throughout this period, in addition to performing design work and calculations, Tsander continued conducting small-scale experiments. Korneev reports that as early as 1909, Tsander had mentioned in his notebooks the possibility of using metal fuels, and in 1917, he designed and had constructed a crucible for use in experiments in burning molten metals.

In January 1916, he had begun construction of a greenhouse, light enough in weight to be used in interplanetary voyages. This, he explained, was necessary both to provide sustenance, and to provide the oxygen necessary for the crew. "I did achieve certain results," he reported in 1923. "I grew peas, some cabbage, giving lovely roots."

In the fall of 1923, Tsander married A. F. Milyukova, and later had two children, Astra and Mercury.

But experiments on rocket motors and high-pressure aircraft engines required substantial support. For this, Tsander turned to a public lecture program, to try to raise the interest, and the funds, needed for his space research.

Organizing Support for Space Research

On January 20, 1924, Tsander was a featured speaker at the meeting of the Theoretical Section of the Moscow Society of Astronomy Enthusiasts (or Amateur Astronomers) (MOLA). During his presentation, he included, for the first time in public, his calculations of the required period of acceleration for his spacecraft, the gliding descent to Earth from interplanetary space, the design for an interplanetary space station, trajectories from the Earth to Mars and to Venus, drawings of his winged rocket, the use of aircraft components for propulsion, and a new idea—to use large mirrors on the spacecraft to concentrate light and replace rockets for propulsion in interplanetary space.

In his presentation, Tsander also made reference to the "recently published book of G.[sic] Oberth [1923]," and the experiments of Robert Goddard, which confirmed the calculations Tsander himself had made. In his outline of his lecture, Tsander indicates that at the end of his report, he would conclude that "comprehensive investigation of constructions is required, and the formation of a society of investigators and interplanetary voyage enthusiasts is desirable."

Korneev reports that at this meeting, the section approved a proposal by Tsander to organize within the USSR a "Society for the Study of Interplanetary Travel," which was created shortly thereafter; the first amateur "rocket" society in the world. For a time, it was part of the Zhukovsky Air Force Academy in Moscow.

On July 15, 1924, Tsander presented a proposal for the work the Society should be conducting. This should include "theoretical scientific work, drawing work, and laboratory work." Tsander's program for the Society included the testing of small rockets with various fuels, including an investigation of gas pressures, smoothness of walls, transmission of heat through the walls, various fuels including metals, rocket materials, an injector rocket operating with atmospheric air, complex joined rockets, and liquid fuel containers.

Then, he proposed, there should follow the construction of airplane models driven by rockets and motors, or rockets alone; testing of the effects of large accelerations; construction and testing of motors with liquid oxygen or solar heat; testing of diving suits for use in spacecraft at high altitudes, and in space; testing of apparatus to regenerate exhaled air; greenhouse investigations; testing in wind

tunnels; testing of television for rockets; investigation of the upper layers of the atmosphere with rockets; and other experiments.

In a July 31 presentation, Tsander announced that the Society would be sponsoring a contest for a high altitude rocket, and that they intended to publish a journal, titled *Rockets*. Tsander, who could read German, also reported that they would be undertaking the translation of Hermann Oberth's 1923 book into Russian. Tsander reports that "approximately 150 persons registered within a short time," as members of the Society.

Then, on August 4, a report was received that Professor Goddard in America had sent a rocket to the Moon. The Society for the Study of Interplanetary Travel organized a debate on this news, which took place on October 1, 1924 in the auditorium of the Physical Institute of Moscow State University. The number of people who came to hear about this remarkable feat was so large they could not all be accommodated in the hall, and the horse militia had to be called out to keep order! The debate was repeated again on October 4 and 5.

But, of course, the report was not true, and the suggestion has been made that giving the report credence discredited the Society and led to its demise. But the outline of Tsander's statement at the debates, contained in the archives of his papers, indicates his presentation encompassed the broadest range of topics, including flights to Mars and Venus, the military significance of interplanetary flights, the importance of such flights for astronomy, and the fact that this technology could provide flights from Moscow to New York in two hours.

Tsander reported that the "lack of published material, and of space and time, did not permit us to work intensively. After existing for approximately one year, the Association became inactive. The files and the library were handed over to the Military Scientific Organization in Moscow."

In 1924, Tsander's article, *Flights to Other Planets* was finally published, and he embarked on a vigorous organizing tour to garner support and manpower for his research. Throughout 1924 and 1925, Tsander presented lectures and reports on interplanetary voyages, not only in Moscow, but also Kharkov, Leningrad, Saratov, Ryazan, and Tula.

After the demise of the Society for the Study of Interplanetary Travel, Tsander brought his lectures and vision to other organizations hoping to engage them in the research. Tsander has been described as having the drive and conviction of a crusader.

An Interregnum

For the next few years, Tsander submitted application after application to various institutions, to try to secure funding to continue his work, and continued his hectic schedule of public lectures. In 1927, the Air Force Academy in Moscow finally invited Tsander to deliver a series of lectures, the summary of which he had submitted to them in 1924. A model of Tsander's spaceship was shown at the Exhibition of Interplanetary Machines held in Moscow in February 1927, sponsored by the Interplanetary Section of the Association of Inventors, with a sign indicating he had built it in 1922.

On October 8, 1926, Tsander submitted materials to the Science Department of Glavnauka, the main administration for scientific, museum, and scientific-artistic institutions, to seek their support for his research. Glavnauka passed the material on to Professor V. P. Vetchinkin for evaluation, and the professor recommended that the book Tsander proposed to write be published.

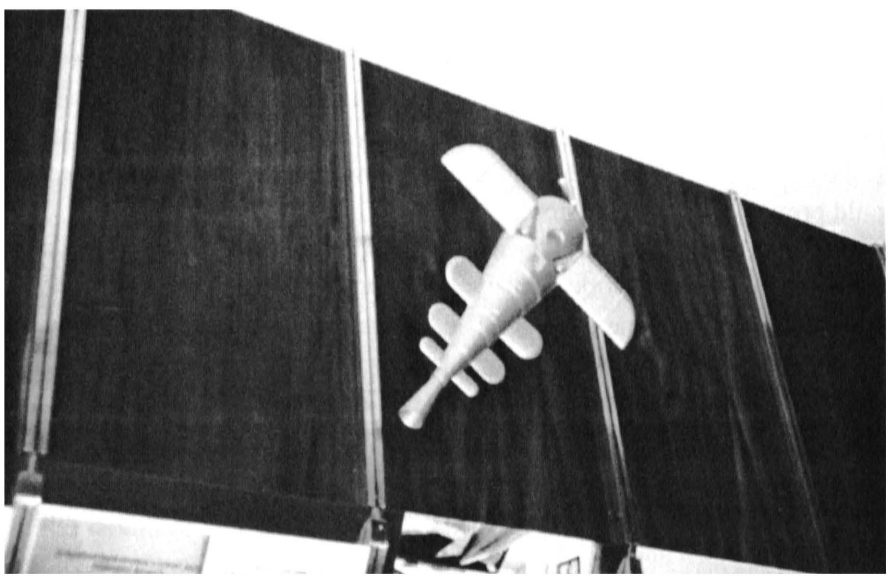

Figure 7: This model of Tsander's rocket plane, which was designed in 1922, was shown at the 1927 Exhibition of Interplanetary Machines in Moscow.

Thereafter, Tsander submitted his formal application to Glavnauka requesting that he be allowed to work at TsAGI (the Central Aero-hydrodynamics Institute), or in the "aviation trust, exclusively in the area of interplanetary voyages," and to make it possible for him to prepare his book. Tsander pointed out that "approximately 5,000-6,000 men are working in the area of aviation in the

USSR. If even one man can be given the possibility to work in the area of special high altitude and high-speed flights and flights to other planets, this research will occupy only one five-thousandth the volume of the work in the area of ordinary aviation, which can be considered quite permissible."

The Scientific Department of Glavnauka replied on July 7, 1927, that "it will not be possible to satisfy your request...". How they came to that conclusion is revealed by the evaluation of Tsander's work given by one reviewer, Prof. V. I. Yakovlev, who stated, "Many of Tsander's works have no scientific significance." Hermann Oberth would have understood the situation perfectly.

In the meantime, Tsander had also requested, "desiring to improve the arms of the Red Air Force," permission to work at TsAGI. Tsander asked for 3,000 rubles for his salary, and 7,000 rubles for experiments.

In March of 1927, Tsander wrote that his children, "although much loved, (I had given them astronomical names, the daughter being called Astra and the son, Merkur), considerably slowed down the work." In a letter in early December 1929, he mentions that because he was working on his research "at every free moment at home, I became quite ill with a sore throat, and had the misfortune to lose my three-year-old son due to complications from scarletina; then I myself became ill with scarletina and almost died also. After this, I was some time in recuperation."

In 1930, after having received no support from existing scientific or military institutions, Tsander engaged in discussions with colleagues and co-thinkers about the possibility of establishing a society "similar to that which existed in 1924." In December of that year, N. K. Fedorenkov wrote to Tsander asking if he would like to become chairman of a Society for the Study of Interplanetary Voyages. He reported that in response to material he had published earlier, he received many letters, perhaps over one hundred, and there was increased public interest in Moscow.

Fedorenkov suggested to Tsander that he contact the Moscow Aviation Institute and others, and invite them to join. He should also get in contact with Osoaviakhim, the Society for the Creation of Weapons and Aviation-Chemical Construction, (also translated Association for Promoting Aerochemical Defense).

At long last, Fridrikh Tsander would obtain some support for the research he had been carrying out on his own for more than twenty years.

Finally, a Rocket Program

By 1929, Tsander had designed his first experimental rocket engine, the OR-1 (experimental rocket-1, from the Russian transliteration).

In notes dated September 30, 1929, he wrote that "because of the shortage of funds, I unexpectedly conceived the idea of transforming a blowtorch into the first jet engine. I made this idea a reality... The gasoline tank was of one-liter capacity, the air pump diameter including piston was 15 mm, the piston stroke was 107 mm, the inner outlet diameter of the torch nozzle was 22 mm... There was a combustion chamber inside the jacket arranged with the aid of a special pipe. A disposable conic nozzle was attached to the end of the pipe; this ensured exhaust velocities exceeding the speed of sound," and so on. Korneev relates that the total fuel and oxidizer (gasoline and air) consumption per second was only 1.69 g.

On December 20, 1930, Tsander began work at the Central Institute for Aircraft Motor Construction, where he embarked on a series of experiments on OR-1. The following year, a jet engine section was established within the Central Council of Osoaviakhim, and Tsander was appointed its director. In the second half of the year, the section was reorganized and Tsander was made the chairman of the technical council that was in charge of the group.

As Korneev relates, Tsander placed great hope in the youth, and made an effort to involve as many students as possible from the Moscow Aviation Institute. Tsander gave lectures, conducted group study courses, and "entrusted them with certain technical calculations and with the construction of various rocket components."

During this period, a group of rocket enthusiasts had formed, which also had the intention of conducting experiments on rocket engines. In April 1932, Osoaviakhim, therefore, established the Group for the Study of Jet Propulsion (GIRD). Korneev related that it did not have a smooth beginning. The sums allocated for research were very limited, and skeptics referred to the rocket enthusiasts as "lunatics."

Finally, they found an unoccupied basement in Moscow, and "Tsander's exultation at finding these quarters cannot be described," Korneev relates. Not unlike the youthful space enthusiasts in Germany in the same period, the GIRD members were faced with inventing a new technology, including the machine tools and measuring devices for their research.

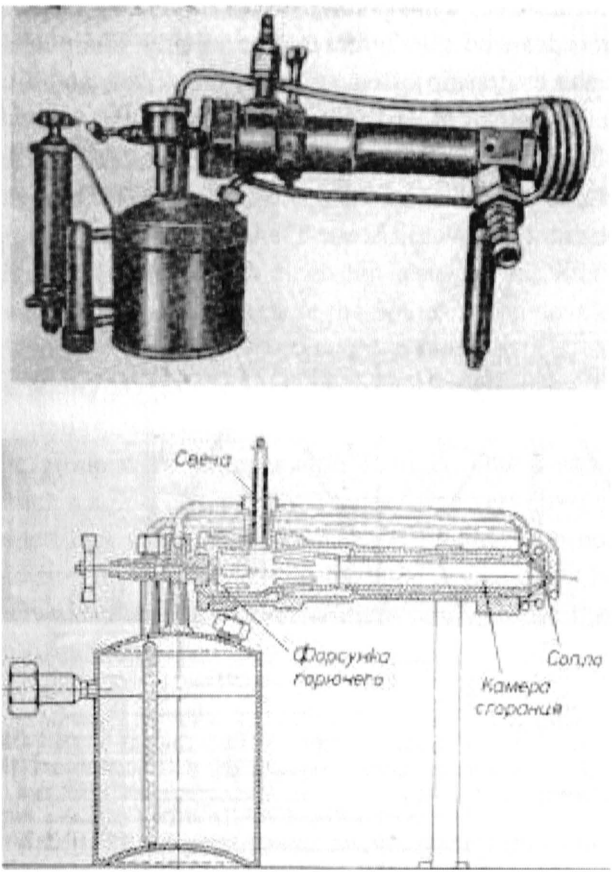

Figure 8: Tsander's schematic of the OR-1 experimental rocket engine, which he designed.

Korneev, who participated in this work, states: "Many were the sleepless nights they spent, often on an empty stomach, in search of solutions of rocket technology problems." He relates that the members of GIRD were humorously referred to as the "Group of Engineers Working Gratis," which has the same acronym in Russian.

In April 1932, Tsander went over to full-time work for GIRD. He continued experiments with the OR-1 rocket engine and, by July 1932, Tsander had conducted more than 50 combustion experiments.

Tsander had lectured extensively at TsAGI starting in March 1931, and soon met S. P. Korolev, who had come there in 1930. According to Tsander's daughter, Astra Tsander, her father's activities interested Korolev, and he joined the group at GIRD. On October 7, 1931, Korolev along with aircraft designer B. I. Cheranovsky, were present at the 32nd testing of the OR-1 engine.

A new idea emerged, which was to construct a rocket glider, the RG-1, using Tsander's more advanced OR-2 rocket engine, and Cheranovsky's glider. Korolev undertook the leadership of constructing the glider, and a contract was concluded between the Bureau of Airflight Technology of the Central Council of Osoaviakhim, and Tsander at GIRD, reportedly for 1000 rubles. Korolev, Astra Tsander reports, became the chief of the 4th brigade of GIRD, engaged in constructing the rocket glider that would house Tsander's OR-2 engine.

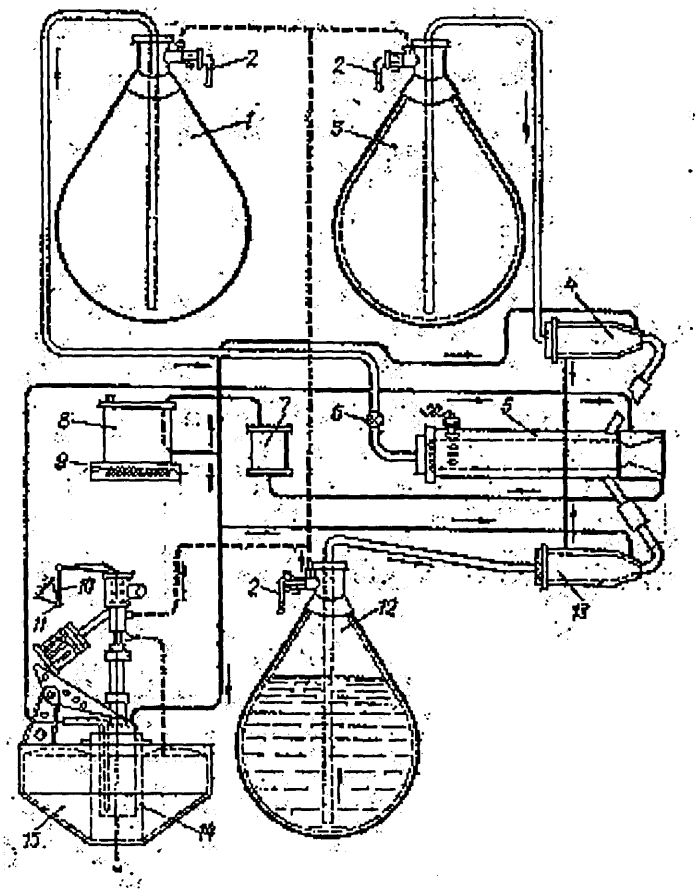

Figure 9: The assembly diagram of the liquid-fueled OR-2 rocket engine.

Tsander had begun design work on his next-generation, OR-2, engine in the fall of 1931. It was the first design in the USSR of a liquid jet engine. Gasoline was chosen as the fuel, and the oxidizer was liquid oxygen. The engine system consisted of one tank for the fuel and two tanks for the oxygen, all pear-

shaped, equipped with a device allowing them to be discarded through openings in the wing of the glider. The first combustion tests with the new engine started on March 18, 1933, but Tsander had already left for a rest at the mineral spa in Kislovodsk.

At the end of 1932, upon completing his design of the OR-2, Tsander began to design a new, more powerful liquid engine with a thrust of 600 kg, and also three versions of an engine with a 5-ton thrust. Astra Tsander makes the case that these designs of her father, although not tested in his lifetime, became the heritage from which the future rockets of the Soviet Union developed.

Tsander's intense and total commitment to making the dream of taking man to the planets a reality is described by his co-worker Korneev. "I remember that for three days running, we couldn't get a vital test [of the OR-1] ready. All the members of the group were younger than Tsander, and it was much easier for them to stand such a strain. Seeing that Tsander was very tired and asleep on his feet, we presented him with an 'ultimatum': if he didn't go home immediately everyone would stop work... Tsander disappeared ... five or six hours passed, and one of the mechanics shouted... 'Everything's ready. Raise the pressure, we're off to Mars!' And suddenly everyone was stupefied. A couch that stood at the far end of the basement toppled with a crash, and from behind it appeared Tsander."

Overwork finally led, after much persuasion, to Tsander's agreement to go to Kislovodsk for a rest. When he arrived at the sanitarium, he was running a high fever, having apparently contracted typhoid fever during his journey on the train. At 6 AM on March 28, 1933, Tsander succumbed to his illness. As Korneev writes, "This extraordinary and brilliant man's life came to an abrupt end in his 46th year." After Tsander's death, Korneev was appointed the chief of the team of GIRD researchers.

Summary

Tsander summarized his own contributions to the new science of astronautics, in the autobiographical piece he wrote in March 1927 for inclusion in Rynin's volumes. They speak for themselves:

1. To provide rockets with wings for flight in the atmosphere, for attainment of cosmic speeds of approximately 8 km/sec in the upper layers of the atmosphere, and also for landing in a glide upon return from interplanetary space to the Earth or some other planet possessing an atmosphere.

2. To equip such an airplane rocket with engines for flight in the lower layers of the atmosphere, where the efficiency of rockets is very small due to the low flight speed. The engines should be of special design, it being best if they are designed to operate for half an hour without breakdown.

3. To simultaneously use rocket propellants giving solid and gaseous products of combustion. The first kind of propellant (particularly because methods, proposed by others, of assembling rockets involve enormous initial weights and are therefore not cheaper but more dangerous than my airplane rockets, since the design of pure lifting rockets has not yet been studied) may consist of parts of the interplanetary spaceships, e.g., girders, surfaces, etc. made of alloys of aluminum, magnesium, lithium, etc. These parts become superfluous because of the weight reduction due to the consumption of part of the propellant. It is thus an advantage that we can build a very strong spaceship capable of carrying a sufficient amount of propellant.

4. To use combinations of rockets and concave mirrors, concentrating the sunlight inside the spaceship in order to increase the gas-outlet velocity, i.e. the power of the rocket during light in interplanetary space.

5. To use a ring (solenoid) in which an electric current flows, and the pressure of the solar radiation on a cloud of iron filings maintained inside the ring by the electric current, for propulsion in interplanetary space. It is an advantage that meteors passing through this cloud will scarcely affect the light.

6. To concentrate the sunlight in parallel beams by means of huge convex and concave mirrors designed as described under point 4, in order to obtain high speeds and permit flights to other solar systems (at present this is the only possible method which offers hope for such flights).

7. To use a sphere made of very thin metal sheets, charged by the Earth's electricity and repelled from it by electrostatic forces, for the purpose of interplanetary flight. This is possible if the Earth carries an electric charge.

8. To circle around a planet, in or outside its atmosphere, in order to increase the flight speed (obtaining energy gratuitously during flight to other planets); to accelerate the interplanetary spaceship when its flight speed is high (for the same purpose).

9. To deflect meteors by means of electrostatic energy emitted by the spaceship as cathode rays in the direction of the meteors, the spaceship being located inside an electrically charged sphere.

"I have several other suggestions to make on the design of interplanetary spaceships, their engines, rockets, etc., as well as other proposals which I have not yet worked out sufficiency," Tsander concluded.

When a monument was erected to Tsander in Kislovodsk, Korolev sent a telegram writing that he would "forever remember Fridrikh Arturovich Tsander as his teacher and chief." Korolev also wrote of Tsander, "Due to his work during the past ten years, prototypes of the first Soviet rocket motors have been created. F. A. Tsander died in 1933, but was able to create a team of workers, his students and successors."

Acknowledgment

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