UDC 629.7:930.1 **doi: 10.20998/2074-272X.2019.5.01**

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AN ANTHOLOGY OF THE DISTINGUISHED ACHIEVEMENTS IN SCIENCE AND TECHNIQUE. PART 51: ROCKET-SPACE TECHNOLOGY DESIGNER SERGEY KOROLEV AND HIS ACCOMPLISHMENTS IN MISSILE DESIGN

Purpose. ***Preparation of short scientifically-historical essay about one of founders of domestic rocket production and practical cosmonautics, distinguished Soviet designer of space-rocket technology Sergey Pavlovich Korolev. Methodology. Known scientific methods of collection, analysis and analytical treatment of scientific and technical information, touching becoming and development in the world of space-rocket technique and resulted in scientific monographs, journals and internet-reports. Results. A short scientifically-historical essay is presented about the distinguished Soviet designer of space-rocket technique S.P. Korolev, becoming one of founders of domestic rocket production and practical cosmonautics. The important deposit of former German people, creating rockets, workings in the USSR after completion of the World War II is marked, in development of the first Soviet ballistic rockets. Basic scientific and technical achievements of talented and purposeful scientist and practical worker, becoming in 1950 a Chief Designer of the Special Design Bureau No. 1 (SDB-1), S.P. Korolev in area of creation of Soviet strategic rocket weapon (rocket-nuclear «shield») and modern space-rocket technique for mastering of near and distant space tellurians. It is pointed out that under the direction of the Chief Designer of SDB-1 S.P. Korolev in the USSR was developed and accepted on the armament of Soviet Army consisting of two stages intercontinental ballistic rocket (ICBR) of type P-7 (1956, military index 8K71, by power of thermonuclear war-head in 5 Mt and distance of its flight in 8 thousands km) with the liquid rocket engines (LRE) of type РД-107 and РД-108 of design of distinguished Soviet designer in area of rocket engines V.P. Glushko. It is indicated that the Chief Designer S.P. Korolev is the «father» of domestic space-rocket technique, providing by powerful launch vehicles, created in the USSR on the basis of ICBR with LRE of РД-7 type (military index 8K71), start of first in the world of Soviet space satellite (on Octobers, 4, 1957) and start on the circumterrestrial space orbit of the first in history humanity of Soviet cosmonaut Yu.A. Gagarin (on April, 12, 1961). Originality. Certain systematization is executed of known from mass medias of scientific and technical materials, touching becoming and development in the USSR of rocket production, at the sources of which the talented scientist-practical worker and distinguished Soviet designer of space-rocket technique S.P. Korolev. Practical value. Scientific popularization and deepening for the students of higher school, engineer and technical and scientific workers of physical and technical knowledge in area of history of becoming and development in the former USSR of modern rocket production, extending their scientific and technical range of interests and further development of scientific and technical progress in society.*** References 25, figures 10.

Key words: **space-rocket technology, distinguished Soviet designer of space-rocket technology Sergey Korolev, achievements in modern rocket production, cosmonautics, scientifically-historical essay.**

Наведено короткий науково-історичний нарис про видатного радянського конструктора ракетно-космічної техніки Сергія Павловича Корольова, що став одним з основоположників вітчизняного ракетобудування і практичної космонавтики. Відмічений важливий внесок колишніх німецьких ракетників, що працювали в СРСР після закінчення Другої світової війни, в розробку перших радянських балістичних ракет. Описані основні науково-технічні досягнення С.П. Корольова в галузі створення радянської стратегічної ракетної зброї і сучасної ракетно-космічної техніки для освоєння землянами ближнього і дальнього космічного простору. Показано, що головний конструктор С.П. Корольов є «батьком» вітчизняної ракетно-космічної техніки, що забезпечила запуск першого в світі радянського штучного супутника Землі (1957 р.) і перебування на навколоземній космічній орбіті першого в історії людства радянського космонавта Ю.О. Гагаріна (1961 р.). Бібл. 25, рис. 10.

Ключові слова: **ракетно-космічна техніка, видатний радянський конструктор ракетно-космічної техніки Сергій Корольов, досягнення у сучасному ракетобудуванні, космонавтика, науково-історичний нарис.**

Приведен краткий научно-исторический очерк о выдающемся советском конструкторе ракетно-космической техники Сергее Павловиче Королеве, ставшем одним из основоположников отечественного ракетостроения и практической космонавтики. Отмечен важный вклад бывших немецких ракетчиков, работавших в СССР после окончания Второй мировой войны, в разработку первых советских баллистических ракет. Описаны основные научно-технические достижения С.П. Королева в области создания советского стратегического ракетного оружия и современной ракетно-космической техники для освоения землянами ближнего и дальнего космического пространства. Показано, что главный конструктор С.П. Королев является «отцом» отечественной ракетно-космической техники, обеспечившей запуск первого в мире советского искусственного спутника Земли (1957 г.) и пребывание на околоземной космической орбите первого в истории человечества советского космонавта Ю.А. Гагарина (1961 г.). Библ. 25, рис. 10.

Ключевые слова: **ракетно-космическая техника, выдающийся советский конструктор ракетно-космической техники Сергей Королев, достижения в современном ракетостроении, космонавтика, научно-исторический очерк.**

Introduction. When you get acquainted with biographies of prominent scientists and engineers of the world from various fields of knowledge, you often «catch» yourself thinking that what an often difficult fate these people had for the great deeds, the mysterious cosmos of people for us. By their years of suffering and conscious goals, they had to «get through» incredible life difficulties, including betrayal of cruel and selfish colleagues, far-fetched accusations of wrecking in the service, arrests, court sentences and imprisonment in harsh conditions in prisons and camps. This is especially true of such people who were the best representatives of

the true intelligentsia, whose life fell on the period of revolutions and rampant political dogmas and repressions in their homeland. Often, the objective laws of the development of human society, and sometimes fateful cases, led these spiritually strong people from life's «dead ends» to the main paths for the development of scientific and technological progress in it. Such stoic people include the outstanding Soviet designer of rocket and space technology, twice Hero of Labor (1956; 1961), Academician of the Academy of Sciences of the USSR (since 1958) Sergey Pavlovich Korolev [1] (Fig. 1), to whom this essay is dedicated.

The goal of the paper is preparation of a brief scientific and historical essay about one of the founders of domestic rocket science and practical cosmonautics, an outstanding Soviet designer of rocket and space technology S.P. Korolev.

1. The beginning of the life and career of S.P. Korolev. He was born on January 12, 1907 in the city of Zhitomir in the family of Pavel Yakovlevich Korolev, a teacher of Russian literature [1]. His mother, Maria Nikolayevna Moskalenko, soon broke up with his father (because of which Sergey was brought up from his mother's parents in the city of Nizhyn, now Chernihiv Oblast, from two to ten years old) and in 1916 moved to Odessa to the place of work of the new husband – mechanical engineer Grigory Mikhailovich Balanin (Sergey's stepfather). In September 1917, he begins to study in the first class of the 3rd Odessa Men's Gymnasium [1]. The turbulent events of the civil war made adjustments to his studies.

Fig. 1. Outstanding Soviet designer of Space-rocket technology, twice Hero of Labor, Lenin Prize Laureate, Academician of the Academy of Sciences of the USSR Sergey Pavlovich Korolev (12.01.1907-14.01.1966) [1]

Young Sergey had to take a seven-year school program at his parents' home. Further, in the period 1922-1924 his studies at the construction school No. 1 of Odessa followed, after which he received secondary education and a mason specialty [2]. At this time, he «fell ill» with aviation. In 1924, Sergey entered the Kyiv Polytechnic Institute in the field of aviation technology. Here he became a glider athlete. In 1926, he transferred to the N.E. Bauman Moscow Higher Technical School (MHTS) at the Aeromechanical Faculty. In February 1930, S.P. Korolev successfully defended his graduation project at MHTS related to the design of a light aircraft of the CK-4 type (the diploma project supervisor is a future outstanding Soviet aircraft designer, three times Hero of Labor, Academician of the Academy of Sciences the USSR A.N. Tupolev [3]) [4]. So under the «wing» of A.N. Tupolev he became an aeromechanical engineer. As it turned out in the future, this person will fulfill in his life an even larger and actually fateful role – he will «pull» him into the design world in the winter of 1939 to develop new military aircrafts (even of prison character, but with clean bed and enhanced nutrition) from the prison camp, which was murderous in harsh conditions at the distant gold mine «Maldyak» of the Soviet Kolyma and thereby actually will save him from the cold and starvation death of a prisoner [4, 5].

2. The main events of the pre-war and military periods of the work of S.P. Korolev in rocket and aviation technology (1930-1945). In September 1931, S.P. Korolev and talented rocket engine enthusiast F.A. Zander achieved with the help of the Soviet Osoaviahim the creation in Moscow of a new public organization – the Jet Propulsion Research Group (JPRG) [6]. In August 1933, the JPRG successfully launched the first in the USSR small ballistic missile with a liquid rocket engine (LRE) [6]. In the same 1933, on the basis of the Moscow JPRG and the Leningrad Gas-Dynamic Laboratory, the Reactive Scientific Research Institute (RSRI) was created under the leadership of I.T. Kleimenov, whose deputy became S.P. Korolev (Fig. 2) [6].

Fig. 2. Young S.P. Korolev while working at the RSRI (1933, Moscow) [6]

In the years 1934-1935, he was the Head of the Departments of cruise missiles and rocket aircrafts at the RSRI. By 1938, projects of liquid cruise missiles and long-range ballistic missiles, as well as aviation missiles for firing at air (ground) targets and anti-aircraft solid-fuel missiles were developed in these Departments of the RSRI. We indicate that for the period 1937-1938 there were arrests of prominent specialists of the RSRI, which since 1937 became known as SRI-3 [7, 8]: I.T. Kleimenov, G.E. Langemak (the Deputy Director of the Institute for science, the main co-author of the development of a new type of weapon in the world – the Soviet «Katyusha» multiple rocket launcher (MRL) [8]), S.P. Korolev, V.P. Glushko, and other. At present, it is

believed that these arrests, which caused great harm to domestic science and rocketry, were directly related to the Head of the Rocket Engine Development Department (since 1936) A.G. Kostikov (30.10.1899 – 05.12.1950), who became on September 15, 1938 (after the arrest of these employees of the SRI-3) the Chief Engineer of the leading Institute in the USSR, engaged in the development and testing of missile shells, and installations for launching them from the ground and from airplanes [7-9]. It is known that A.G. Kostikov on June 20, 1938 headed the expert commission of SRI-3, which gave an opinion to the bodies of the People's Commissariat of Internal Affairs of the USSR on the harmful character of the activities of engineers V.P. Glushko (in the future, an outstanding Soviet specialist in the field of rocket engine technology, twice Hero of Labor, Academician of the Academy of Sciences of the USSR [10]) and S.P. Korolev [7]. Note that A.G. Kostikov, taking advantage of his official position, actually appropriated co-authorship (to mask his thieves' plans, he filed it together with the Institute's designer I.I. Gvay, and the Deputy Head of the Main Artillery Directorate of the Red Army of the country V.V. Aborenkov) of the development at the SRI-3 of the «Katyusha» guards rocket mortar (БМ-13 combat vehicle), which they presented in the USSR Copyright Certificate No. 3338 of February 19, 1940 for the invention «*Mechanized installation for firing rocket shells of various calibers*» [7]. It is also interesting that on June 17, 1941 (literally on the eve of the beginning of World War II in the USSR [3]) A.G. Kostikov demonstrated the firepower of the «Katyusha» MRL based on the domestic three-axle ЗИС-6 car to the leadership of the CPSU and the USSR Government [7, 8]. The success of the «Katyusha» demonstration was overwhelming! Immediately, on June 21, 1941, personally I.V. Stalin, as the Head of the Government of the USSR, made an urgent decision to deploy mass production of M-13 rocket missiles and БМ-13 launchers for them developed by the SRI-3, and also to begin the formation of the corresponding military units in the Red Army [7]. Despite the terrible military events for the USSR at the beginning of the war, on July 28, 1941, two Decrees of the Supreme Soviet of the USSR on awarding «*For outstanding services in the invention and design of one of the types of weapons that enhance the combat power of the Red Army*» were issued: Chief Engineer of SRI-3 A.G. Kostikov was awarded the title of Hero of Labor by the first of the Decrees) and 12 employees of this Institute were awarded by orders by the second Decree [7]. In addition, the «false father» of the legendary «Katyusha» was soon awarded the military rank of Major General of the Engineering and Aviation Service. Career «starfall» for A.G. Kostikov continued further: from the beginning of 1942 to February 18, 1944, having a degree of Candidate of Technical Sciences, was the Director of the SRI-3, and on September 29, 1943 he was elected a Corresponding Member of the Academy of Sciences of the USSR (Department of Mechanics). But, as they say among our people, «God marks the witchcraft». For «deceiving the Soviet Government and disrupting its important task» A.G. Kostikov was dismissed on February 18, 1944 and arrested on March 15, 1944 (he was in prison till February 28, 1945) [7]. Suspicions of his espionage and betrayal were not confirmed. After his release, he was restored to his rights and from August 1, 1945 until the end of his life he worked as the Head of the Bureau of the SRI-24, engaged in the development of missile shells [7, 8].

The true role of the employees of the RSRI (SRI-3) illegally repressed in the 1930s in the creation of the domestic jet weapon of the «Katyusha» MRL (БМ-13 combat vehicle) was nevertheless restored [7]: by Decree of the President of the USSR of June 21, 1991 I.T. Kleimenov, G.E. Langemak, V.N. Luzhin, B.S. Petropavlovsky, B.M. Slonimer and N.I. Tikhomirov were awarded the high title of Hero of Labor (posthumous), and their names were rehabilitated.

After such quite large in volume, but important for completeness of the representation of the history of the creation of rocketry in the USSR by the example of the legendary» Katyusha» (БМ-13 combat rocket launcher, which did so much for our Victory during the war) retreat, we return to the pre-war events directly related with the specified SRI-3 and the person of S.P. Korolev. On June 27, 1938, on the basis of the above conclusion of the SRI-3 expert commission headed by the notorious A.G. Kostikov, he was arrested as a member of the Trotskyist counter-revolutionary organization [5]. Then, on September 27, 1938, he was sentenced to 10 years of imprisonment in labor camps by the Military College of the Supreme Court of the USSR. He spent a year in Butyrka prison (Moscow), where he was brutally tortured and beaten during interrogations [11]. In April 1939, S.P. Korolev found himself in the distant Kolyma in a prison camp mining gold at the Maldyak mine. In the first year of his camp in Kolyma, he miraculously survived scurvy and half-starved existence. From the «paws» of death, former Director of the Moscow Aviation Plant No. 156 M.A. Usachev (by the way, a master of sports in boxing, who had a strong physique), who personally knew S.P. Korolev and undeservedly sentenced to 15 years for the death on December 15, 1938 of the legendary pilot V.P. Chkalov, the new И-180 fighter designed by N.N. Polikarpov which was being prepared for flight tests just at the said plant, saved him [12]. M.A. Usachev, as a «guardian angel», ended up in the camp hut of the Maldyak mine at a critical moment for the life of S.P. Korolev near him. It was he who provided him with the urgently needed camp medical assistance and an additional food ration, which put the inmate-goner S.P. Korolev «on his feet» [11].

In December 1939, the prisoner S.P. Korolev as a military specialist, included in the list of 100 people needed by the aircraft designer A.N. Tupolev, who was arrested in 1938 to work in prison on a new Soviet bomber, and was sent from the Kolyma mine «Maldyak» to Moscow [1, 4]. An interesting fact is that, upon the arrival of the stage in Magadan (the capital of the Kolyma region), he was late for the «Indigirka» steamer, bound to Vladivostok and sunk (as it became known later) during a storm in the Okhotsk Sea [4]. Well, it's a sign of fate for our hero! Apparently, he was needed on Earth to do something important in the near future. Upon arrival on

March 2, 1940 in Moscow, a camp prisoner S.P. Korolev by a special meeting was convicted a second time and sentenced to eight years in prison [11]. After which he was transferred to a new place of detention – Central Design Bureau No. 29 (CDB-29) of the People's Commissariat of Internal Affairs of the USSR, where in the conditions of the prison «sharashka» under the guidance of aircraft designer A.N. Tupolev he took an active part in the creation and production of one of the best during the period of the Second World War front-line bomber of the Ty-2 type [3] and at the same time proactively developed projects of guided aerial torpedo and a new version of the missile interceptor [4, 6]. The latter, probably, was the reason for his transfer in 1942 to another prison-type design bureau – Special Design Bureau No. 16 (SDB-16) at the Kazan Aircraft Plant No. 16, where work was carried out on new types of rocket engines with a view to their use in aviation [1]. In this institution, he, with his characteristic enthusiasm, devotes himself to the idea of using jet engines in practice to improve the aircrafts: reducing the take-off run of the aircraft during take-off and increasing the dynamic characteristics of the aircraft during air combat. In early 1943, S.P. Korolev in the framework of SDB-16 was appointed the Chief designer of the group of rocket installations used on aircraft [1]. According to the results of work on the development of an aircraft rocket installation, in July 1944 he was prematurely released from prison with release a criminal record, but without rehabilitation. In 1945, S.P. Korolev S.P. awarded for valiant work by the Order of the Badge of Honor [5]. Until the end of the Second World War, he actively worked as a civilian in SDB-16 at the Kazan Aircraft Plant.

3. On the contribution of former German rocket experts to the creation of the first Soviet ballistic missiles. For many years, the work of German rocket experts in the USSR, invited, as we say, by the voluntary-forced order by the security services of the victorious country of World War II to transfer their experience in creating rocket technology to Soviet specialists, was hushed up. As for the United States, the Americans never hid the fact that their initial successes in creating ballistic missiles and in space missions included a «German rocket foundation» which included 765 leading German rocket engineers who had been working for the United States Army from September 1945 [10, 13]. As we know, in September 1944, Germany created the first-ever combat ballistic single-stage medium-range missile with a liquid-propellant rocket engine of the V-2 type (the Chief Designer of the rocket is the outstanding German designer of rocket technology Wernher von Braun [10]), capable of delivering by air at speed of up to 1.5 km/s ordinary chemical explosives (for example, trinitrotoluene) weighing up to 1 ton at distance of up to 300 km [10, 14]. In September 1945, S.P. Korolev was sent to Germany, where he was acquainted with German captured missile technology as part of the Soviet Technical Commission for almost a year [13]. It should be noted that due to the restoration of one of the underground plants for the production of the V-2 rocket near the city of Nordhausen [10] in post-war Germany, which ended up in the Soviet zone of occupation, 10 sets of this rocket were sent to the USSR [13]. A great contribution to this work was made by the long-lived missile engineer B.E. Chertok (1912 - 2011), who stood at the «source» of rocket science in the USSR and later became Deputy to the Chief Designer of rocket and space technology S.P. Korolev and who left behind invaluable memoirs of the development of rocketry in the USSR [14-17]. The wise B.E. Chertok, while still in Germany as part of the mentioned Technical Commission, managed to attract the talented assistant and ally of Wernher von Braun Helmut Gröttrup (1916 - 1981) to work in the field of the formation of Soviet rocket science. In turn, H. Gröttrup, thanks to his vast knowledge, talent as a leader, decency, wide views on technical problems and a benevolent character, managed to interest many German rocket experts in work on rocketry in the interests of the USSR. As a result, in the summer of 1946, about 500 German experts, headed by H. Gröttrup, were sent to the USSR to raise the Soviet missile industry [13]. Some of them (up to 150 people) were placed in complete isolation from people on Gorodomlya Island in the middle of the picturesque Seliger Lake (Tver Region) [13].

In the USSR, on May 16, 1946, to manage rocket development, on the basis of the Artillery Plant No. 88, the lead SRI-88 (Podlipki station, Moscow Region) was created under the guidance of a major Soviet military production organizer, Major General L.R. Honor [18, 19]. In the structure of the Soviet SRI-88, which had 25 Departments, the German rocket experts have the modest role of Branch No. 1. It should be noted that those who worked in the USSR in excellent living conditions with high salaries became «Soviet» German rocket engineers, ahead of the number of achievements of «American» German experts (Wernher von Braun group [10]), in the projects of ballistic missiles developed they became world pioneers. It was they who first proposed for these missiles [13]: detachable warheads, bearing tanks, intermediate bottoms, hot pressurization of fuel tanks, flat nozzle heads of rocket engines, rocket thrust vector control using engines, etc. They included rocket scientists with world-famous [13]: Hoh (control systems), Magnus (gyroscopes), Umpfenbah, Albring, Müller and Rudolf (Rudolf). They, as part of the creation of the USSR missile «shield», completed ballistic missile projects for 600, 800, 2500 and 3000 km. They also proposed a project for an intercontinental ballistic missile (an analogue of the future famous Soviet strategic missile P-7) [13]. In 1953, the «exodus» of Russified German rocket experts from the USSR began. As the saying goes, «the Moor has done his job, the Moor may retire». As befits a leader, H. Gröttrup was the last to leave the USSR. Famous Soviet rocket engineer B.E. Chertok in his memoirs notes that at the station at farewell of this German rocket expert «*he couldn't look H. Gröttrup in the eyes with shame*» [13, 14].

4. Key achievements of S.P. Korolev in space and rocket technology in the post-war period of his work (1946-1966). To begin with, on May 13, 1946, a secret Resolution of the Council of Ministers of the USSR No. 1017-419 cc «Issues of Jet Arms» (now declassified) was issued, aimed at creating a new military industry in the

USSR for the development and production of strategic missiles [6]. In accordance with this directive document in August 1946 S.P. Korolev was appointed Head of Department No. 3 of the Special Design Bureau (SDB) at the SRI-88 for the development of medium and long-range ballistic missiles. The initial task for S.P. Korolev, set for SRI-88 personally by I.V. Stalin, was the development and creation of a domestic analogue of the German ballistic missile V-2, called «Product No. 1» (P-1 rocket) [6]. In October 1948, S.P. Korolev (Fig. 3) begins flight design tests of the Soviet single-stage ballistic missile P-1 (analogue of V-2) and in 1950 it was successfully put into service in the Soviet Army [20].

Fig. 3. Soviet designer of rocket technology S.P. Korolev in field tests of a ballistic missile created under his command (1948, Kapustin Yar training ground) [4]

This missile with a range of 300 km in comparison with the German V-2 missile was significantly more reliable in storage and operation [20]. Further, under the leadership of S.P. Korolev a ballistic missile P-2 was created with flight range of 600 km [20]. The P-2 rocket with a liquid-propellant rocket engine had a carrying fuel tank, a more convenient layout for operation in military units and a warhead detaching in flight. The new autonomous control system for the P-2 missile had twice the accuracy of firing at targets as compared to the P-1 missile [20].

By the beginning of 1950, the framework of Department No. 3 at the SRI-88 had become tight for the rapidly growing team of rocket designers led by S.P. Korolev. On April 30, 1950, an order was issued by the Minister of Arms of the USSR, Colonel General D.F. Ustinov on the transformation of the SDB of the SRI-88 into the Special Design Bureau No. 1 (SDB-1) at the SRI-88 for the development of ballistic long-range missiles with LRE, which since 1956 has become an independent enterprise, and S.P. Korolev was appointed its Head and Chief Designer (Kaliningrad, Moscow region, now the city of Korolev) [6]. Then, in 1953, the implementation of the P-3A ballistic missile project of an unstabilizing scheme with a flight range of 1200 km followed [6]. During 1954, SDB-1 of S.P. Korolev on the basis of this missile completed work on the development of the P-5M missile with a range of up to 1200 km carrying a nuclear warhead [6]. Successful flight tests at the Semipalatinsk test site of the USSR (South-East Kazakhstan) of this missile gave the foundation of the Ministry of Defense of the USSR to take it into service in 1956. This was the first domestic strategic missile, which became the basis of the nuclear missile «shield» of our country [5]. Based on the P-11 rocket S.P. Korolev in 1957 developed and put into service in the Soviet Army a strategic ballistic missile P-11M with a nuclear warhead, transported in the refueling form on a tank chassis [20]. After a certain modification of this missile to the marine conditions of combat alert of Soviet atomic submarines in SDB-1 of S.P. Korolev a sea-based ballistic missile P-11ФМ was created [20]. This missile was equipped with a new control and aiming system, which makes it possible to fire when the sea is quite rough from the surface position of the atomic submarine. To finalize this combat vehicle, the documentation for it was transferred to SDB-385 (Miass, Chelyabinsk Region). Together with the P-11ФМ missile, the talented designer V.P. Makeev, who later became its Chief Designer [20, 21], was sent to this now world-famous Russian Center for the development of sea-based ballistic missiles. In this regard, we can say that S.P. Korolev laid the foundations for the establishment in the Urals of this unique in the USSR rocket science center. Soviet liquid ballistic missiles lost a number of parameters to American solid-fuel rockets. Therefore, in SDB-1 under the leadership of S.P. Korolev experimental solid-fuel ballistic missiles PT-1 and PT-2 were developed [5]. Note that modern missile systems are mainly equipped with solid-fuel intercontinental ballistic missiles (ICBMs), which are based on the PT-2 ICBM, created by the Chief Designer of SDB-1 S.P. Korolev [5, 6].

The main direction in the scientific and technical activities of the Academician of the Academy of Sciences of the USSR S.P. Korolev in the field of rocketry was the development and creation of ICBMs operating on LRE [1]. A special place among the achievements of SDB-1 and its Chief Designer S.P. Korolev takes the development and creation of a two-stage ICBM type P-7 (8K71) with LRE. In 1956, this strategic ICBM was developed. It had a detachable warhead (5 Mt warhead) weighing up to 5.5 tons and a flight range of 8,000 km (Fig. 4) [1, 20].

This rocket was successfully tested in 1957 at the specially built missile training ground No. 5 (Southwest Kazakhstan), better known to the general reader as the southern Baikonur Cosmodrome (near city of Leninsk) [1, 15]. We also point out that for combat duty of these ICBMs in the USSR, a launch station was built (the «Angara» facility) in the area of the village Plesetsk (Arkhangelsk region), currently known as the northern Plesetsk Cosmodrome (Russia) [1, 16]. Note that the modification of this ICBM called P-7A (8K74) had a 3 Mt warhead with a mass of 3 tons and a flight range of 12,000 km [1, 22]. The P-7A ICBM was in service with the Strategic Missile Forces of the USSR in the period 1960-1968 [1, 15]. Later on, SDB-1 developed a more advanced design of a two-stage ICBM with a LRE of the P-9 type, launched from an open starting position (Chief Designer – S.P. Korolev) [20]. In this rocket, supercooled liquid oxygen began to be used as an oxidizing agent. In 1962, the Strategic Missile Forces of the USSR started service of a modification of this P-9A missile launched from a closed launch position (a mine version of ICBM)

[20]. On this, SDB-1, led by S.P. Korolev, ceased to engage in combat missile-related topics and concentrated its design forces and creative capabilities on the development and creation of launch vehicles and systems designed for the peaceful development of near and deep space.

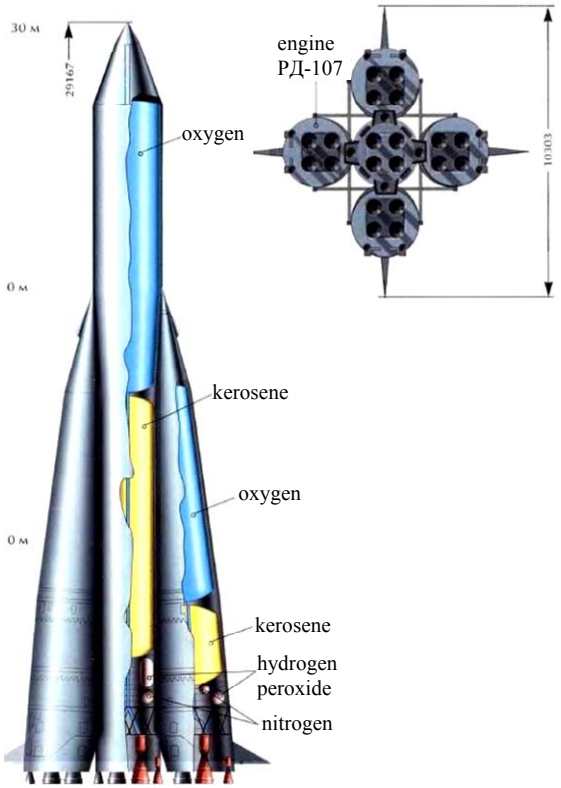

Fig. 4. Soviet ICBM P-7 and its main elements [22]

Figures 5, 6 show the general views of liquid propellant rocket engines of the types РД-107 and РД 108, respectively (Chief Designer – Academician of the Academy of Sciences of the USSR V.P. Glushko [23]), installed in an amount of 4 at the first stage (side blocks, see Fig. 4) and in the amount of 1 (in the center of ICBM) at the second stage of the Soviet P-7 ICBM (with index 8K71) [20, 22].

Note that the P-7 rocket was made with parallel division of stages. It consisted of one central and four side rocket blocks. At its start, propulsion systems – LREs of all five rocket blocks were launched simultaneously. Such a scheme was characteristic of the first ICBMs of the USSR. To control the movement of the P-7 ICBM (launch weight 280 tons), its design used for the first time not gas rudders, but rudder rocket engines (RREs). On each of the four lateral blocks of P-7, two single-chamber RREs were installed, and on a single central block – four similar RREs (see Fig. 5, 6) [20, 22].

In 1955, long before the development and flight tests of the ICBM P-7, Corresponding Member of the Academy of Sciences of the USSR (since 1953) S.P. Korolev, Academician of the Academy of Sciences of the USSR M.V. Keldysh and Doctor of Technical Sciences M.K. Tikhonravov «came out» with an offer to the Council of Ministers of the USSR about the launch into space using ICBM of the Soviet artificial Earth satellite (AES) [20].

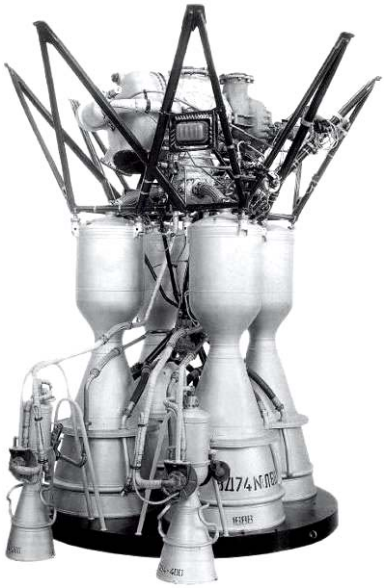

Fig. 5. Four-chamber LRE of РД-107 type used at the first stage of the Soviet P-7 (8K71) ICBM [22]

Fig. 6. Four-chamber LRE of РД-108 type used at the second stage of the Soviet P-7 (8K71) ICBM [22]

The Soviet Government, headed by N.S. Khrushchev, supported this proposal, which promised the USSR, if successful, large political dividends. After the creation in 1956 of a reliable nuclear missile «shield» in the USSR (a thermonuclear bomb of the РДС-6с type [24] and a means of delivering it anywhere in the world in the form of P-7 ICBM), capable of teaching wise American wisdom «hawks», it was possible to do space for a demonstration of Soviet missile power. To implement these important peaceful plans, at the SDB-1 in the period 1957-1966 under the leadership of the Chief Designer S.P. Korolev a whole family of new missile carriers based on the P-7 ICBMs was developed (Fig. 7) [22].

On October 4, 1957, the USSR, using a modified P-7 ICBM with an index of 8K71PS (see Fig. 7), launched from the Baikonur Cosmodrome, launched the first in the world AES with a mass of 83.6 kg to the near-Earth orbit [20, 25]. The first Soviet AES, flying over the

planet Earth, continuously emitted electromagnetic signals into the surrounding space, received by radio amateurs of all countries of the world. Figure 8 shows a general view of the Soviet P-7 (8K71PS) ICBM, which launched the world's first AES in space during its prelaunch training at the Baikonur Cosmodrome [22].

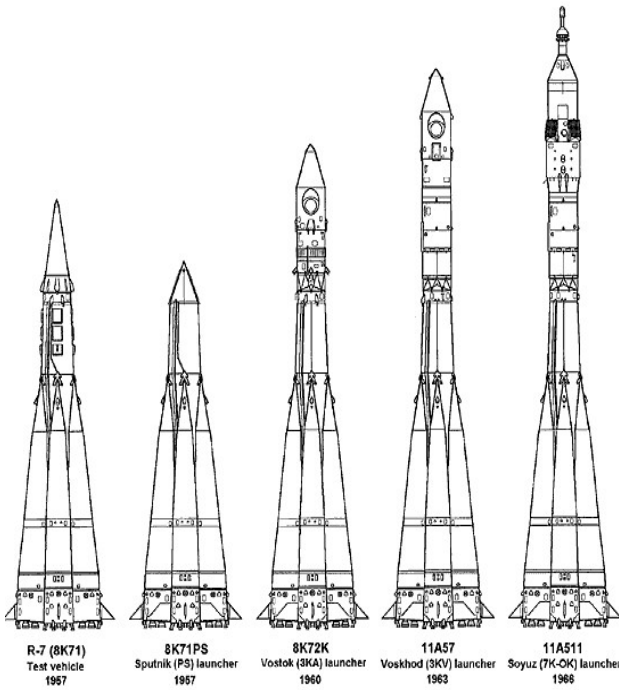

Fig. 7. The family of launch vehicles created at SDB-1 under the leadership of S.P. Korolev based on the ICBM P-7 (8K71) [22]

Fig. 8. The Soviet ICBM P-7 (8K71PS), which launched the world's first AES to the Earth's orbit in 1957, on the launch pad of the Baikonur Cosmodrome during its preparation for launch (Chief Designer – S.P. Korolev, 1957) [22]

The launch and flight of the first Soviet AES have a stunning success in the world. American rocket experts and the US leadership were in real shock. The whole world community was delighted with this breakthrough of the USSR into space. Later, S.P. Korolev, who directed all the work in the USSR to launch this satellite, said [1]: «*...It was small, this the very first artificial satellite of our old planet, but its sonorous callsigns spread across all continents and among all peoples as the embodiment of the bold dream of mankind*». In SDB-1 under the leadership of S.P. Korolev in parallel with the preparation of rocket technology for manned spaceflight, work on satellites of scientific, economic and defense purposes was actively continued during this period. In 1958, Soviet geophysical satellites were designed and launched into space intended to study the Earth's radiation belts.

In 1959, in the USSR under the leadership of S.P. Korolev three automatic stations (AS) are created and launched to the Moon. Here [1]: AS Luna-1 flew near the surface of the Moon; AS Luna-2 symbolically delivered the pennant of the USSR to the Earth's satellite, turning into a plasma upon impact on its surface; AS Luna-3 was the first in the world to photograph the back (invisible from the Earth) side of the Moon. Since 1960, the Soviet SDB-1 began to develop a new spacecraft designed for soft landing on the lunar surface and transmitting the lunar panorama to Earth using it.

On April 12, 1961 S.P. Korolev and the large team of Soviet rocket designers headed by him again amazes the world community [1]: in the USSR, using the first manned spacecraft Vostok-1 and the P-7 (8K72K) launch vehicle (see Fig. 7), the world's first flight of man in outer space around the Earth is carried out (the Vostok-1 ship completed in 108 minutes one revolution around our planet and returned to Earth). This legendary man-cosmonaut was a citizen of the USSR Yuriy Alekseevich Gagarin (Fig. 9).

Fig. 9. Chief Designer of SDB-1 Academician of the Academy of Sciences of the USSR S.P Korolev and the world's first cosmonaut Yu.A. Gagarin [4]

In 1962, S.P. Korolev completed training and conducted a group flight around the Earth of the manned spacecrafts Vostok-3 and Vostok-4. In the same year, he and his SDB-1 participated in the launch of the Mars-1 interplanetary station [2]. In 1963, a design of the P-7

(11A57) type rocket carrier (see Fig. 7) for the Voskhod manned spacecraft was developed at SDB-1. In 1965, he directed the space flight of the Voskhod-2 spacecraft, during which the Soviet cosmonaut A.A. Leonov for the first time in the history of world cosmonautics went into open space (for about 12 minutes) [2]. He participated with his team of scientists and specialists in the rocket launches of the Soviet ASs Luna-5, Luna-6, Luna-7, Luna-8, Venus-2, Venus-3, and the spacecraft «Probe-3» as well as the communications satellite «Lightning-1» [2]. In 1966, at the SDB-1 under the leadership of S.P. Korolev a project of the P-7 (11A511) type rocket carrier was developed (see Fig. 7) for the Soyuz new-generation manned spacecraft [2]. Academician of the Academy of Sciences of the USSR S.P. Korolev took a direct part not only in the design developments of Soviet rocket and space technology. He was the author and co-author of more than 250 scientific papers and inventions [4]. S.P. Korolev was married twice. The first time he married in 1931, his wife was his classmate Ksenia Vincentini. In 1935, his only daughter Natalia was born in this marriage, who later became a medical doctor, MD and Professor. In 1948, the S.P. Korolev's family broke up [5]. His second wife (since 1949) was Nina Ivanovna Kotenkova (1920 – 1999), she worked as a translator in the indicated above secret RSI-88 [5].

Designer S.P. Korolev since the 1950s «nurtured» the idea of launching man on the Moon. The corresponding space program of the USSR was developed with the support of the Head of the Soviet Government N.S. Khrushchev [1]. Initially, the USSR's program for the development of the Moon was carried out using unmanned spacecrafts. The first attempts of S.P. Korolev to create of a new powerful rocket carrier (the H-1 rocket project) for delivering a manned spacecraft to the Moon proved unsuccessful [17, 20]. Premature death of the Chief Designer of the SDB-1 S.P. Korolev interrupted the creative flight of his thoughts in the implementation of the Soviet Lunar Program. His successor V.P. Mishin in a short time to create a lunar space complex also failed. In this regard, the Government of the USSR decided to close this program. As we know, the United States achieved success in landing on the Moon in 1969 thanks to the creation of the powerful Saturn-5 rocket carrier under the leadership of the prominent German-American designer of rocketry Wernher von Braun [10].

Famous scientist-mathematician and mechanic, President and Academician of the Academy of Sciences of the USSR M.V. Keldysh characterizes the «father» of domestic rocket science and practical cosmonautics, Academician of the Academy of Sciences of the USSR S.P. Korolev as follows [5]: «... *Dedication, unusual talent of a scientist and designer, ardent faith in his ideas, vigorous energy and outstanding organizational skills. He possessed a tremendous gift and courage of scientific and technical foresight, and this contributed to the implementation of the most complicated scientific and technical ideas*». On January 14, 1966 S.P. Korolev died during a complicated surgical operation on the intestine (rectal sarcoma was found during the operation). The urn with its ashes is located in the Kremlin wall on the Red Square of Moscow (Russia) [4]. After his death, the pace of development of space programs in the USSR decreased [5]. And to this day, neither in Russia nor in the USA, as the most developed «space» countries of the world, the equal S.P. Korolev has appeared, on the scale of personality and talent, a person capable of breakthrough success in space exploration.

5. Awards, distinctions and recognition of merits of S.P. Korolev. This great designer in the field of rocket science of the USSR and a practical scientist was awarded the following Soviet state awards and such honorary titles [1]:

- two gold medals of the Hero of Labor «Hammer and Sickle» (1956, 1961);
- three orders of Lenin and the Order of the Badge of Honor (1956, 1961, 1965, 1945);
- Laureate of the Lenin Prize (1957);
- Academician of the Academy of Sciences of the USSR (1958);
- K.E. Tsiolkovsky gold medal of the Academy of Sciences of the USSR (1958);
- medals «For Labor Valor» and «Valiant Labor in the Great Patriotic War of 1941-1945» (1945);
- Honorary Citizen of city of Korolev (city of Kaliningrad near Moscow renamed in 1996 at the initiative of the Russian public) and city of Kaluga.

In 1966, the Academy of Sciences of the USSR instituted S.P. Korolev gold medal «For outstanding services in the field of rocket and space technology». Monuments were erected for him in Zhitomir and Moscow, and memorial plaques-reliefs (Fig. 10) on the building of JSC KMPO (former Aircraft Plant No. 16 and SDB-16) at the Baikonur Cosmodrome and in Kazan.

Fig. 10. A memorial plaque in honor of the outstanding Soviet designer of rocket and space technology S.P. Korolev installed on SDB-16 building of the former Kazan Aircraft Plant No. 16 at which he was in the period 1942-1945 worked on improving the aircrafts (Kazan, Russia) [11]

His name is «carried» by Samara Aerospace University (formerly Kuybyshev Aviation Institute), the research ship of Russia, the Russian rocket and space corporation Energia (successor to the legendary SDB-1), streets of the cities of the former USSR, including the

cities of Ukraine: Odessa, Kyiv, Dnipro, Cherkasy, Uzhgorod [20]. His name is given to the high mountain peak in the Pamirs («Roof of the World») and the mountain pass on the transcendent Tien Shan.

Conclusions. The name of the outstanding designer of space and rocket technology S.P. Korolev is connected with the creation in the USSR in the late 1950s of strategic missile weapons, which became the basis of the Soviet nuclear missile «shield», the launch of the world's first artificial Earth satellite and the launch of the first human cosmonaut to Earth orbit. He was a pioneer in the USSR in the field of many areas of the creation and development of domestic nuclear missile weapons and rocket and space technology for the peaceful exploration of outer space. He, as the Chairman of the Council of Chief Designers of the USSR (1950-1966), coordinated all the most important Soviet work in the field of development and creation of military and civil missile equipment. He was inherent in the design talent and the talent of the organizer of scientific and technical works of large scale.

REFERENCES

1. Available at: http://odesskiy.com/k/korolyov-sergej-pavlovich.html (accessed 07 May 2018). (Rus).

2. Available at: https://kpi.ua/ru/node/11087 (accessed 22 July 2018). (Rus).

3. Baranov M.I. An anthology of the distinguished achievements in science and technique. Part 48: Aircraft designer Andrey Tupolev and his accomplishments in airplane design. *Electrical engineering & electromechanics*, 2019, no.2, pp. 3-8. **doi: 10.20998/2074-272X.2019.2.01.**

4. Available at: http://ptiburdukov.ru/Справочник/Биографии/Королев_Сергей_Павлович (accessed 11 October 2018). (Rus).

5. Available at: https://24smi.org/celebrity/3744-sergei-korolev.html (accessed 26 August 2018). (Rus).

6. Available at: http://stuki-druki.com/authors/Korolev.php (accessed 04 May 2018). (Rus).

7. Available at: https://ru.wikipedia.org/wiki/Костиков,_Андрей_Григорьевич (accessed 20 June 2018). (Rus).

8. Golovanov Ya.K. Korolev: *Fakty i mify* [Korolev: Facts and myths]. Moscow, Nauka Publ., 1994. 800 p. (Rus).

9. Available at: http://epizodsspace.airbase.ru/bibl/ogonek/1988/ljeotets.html (accessed 14 December 2018). (Rus).

10. Baranov M.I. An anthology of the distinguished achievements in science and technique. Part 50: Rocket-space technology designer Wernher von Braun and his accomplishments in missile design. *Electrical engineering & electromechanics*, 2019, no.4, pp. 3-11. **doi: 10.20998/2074-272X.2019.4.01.**

11. Available at: https://histrf.ru/lichnosti/biografii/p/koroliev-sierghiei-pavlovich (accessed 20 November 2018). (Rus).

12. Available at: https://pravo.ru/process/view/12232 (accessed 06 March 2018). (Rus).

13. Available at: https://zn.ua/SOCIETY/samaya_bolshaya_tayna_sovetskoy_raketnoy_tehniki.html (accessed 16 April 2018). (Rus).

14. Chertok B.E. *Rakety i liudi. V 4-kh tomakh. Tom 1* [Rockets and people. In 4-th volumes. Vol. 1]. Moscow, Mashinostroenie Publ., 1999. 416 p. (Rus).

15. Chertok B.E. *Rakety i liudi. Fili–Podlipki–Tiuratam. V 4-kh tomakh. Tom 2* [Rockets and people. Fili–Podlipki–Tyuratam. In 4-th volumes. Vol. 2]. Moscow, Mashinostroenie Publ., 1999. 448 p. (Rus).

16. Chertok B.E. *Rakety i liudi. Goriachie dni kholodnoi voiny. V 4-kh tomakh. Tom 3* [Rockets and people. Hot days of cold war. In 4-th volumes. Vol. 3]. Moscow, Mashinostroenie Publ., 1999. 448 p. (Rus).

17. Chertok B.E. *Rakety i liudi. Lunnaia gonka. V 4-kh tomakh. Tom 4* [Rockets and people. Lunar race. In 4-th volumes. Vol. 4]. Moscow, Mashinostroenie Publ., 1999. 538 p. (Rus).

18. Available at: https://history.wikireading.ru/81266 (accessed 21 November 2018). (Rus).

19. Available at: http://www.astronaut.ru/bookcase/books/chert1/text/20.htm?reload_coolmenus (accessed 01 May 2018). (Rus).

20. Available at: http://space.hobby.ru/korolev.html (accessed 11 April 2018). (Rus).

21. Available at: http://www.makeyev.ru/about/history/makeev (accessed 19 February 2018). (Rus).

22. Available at: http://oruzhie.info/raketi/335-r-7 (accessed 08 March 2018). (Rus).

23. Available at: http://space.hobby.ru/glushko.html (accessed 18 June 2018). (Rus).

24. Baranov M.I. An anthology of outstanding achievements in science and technology. Part 7: Nuclear and thermonuclear weapon creation. *Electrical engineering & electromechanics*, 2012, no.2, pp. 3-15. **doi: 10.20998/2074-272X.2012.2.01.**

25. Baranov M.I. *Antologiia vydaiushchikhsia dostizhenii v nauke i tekhnike: Monografiia v 2-kh tomakh. Tom 2.* [An anthology of outstanding achievements in science and technology: Monographs in 2 vols. Vol.2]. Kharkov, NTMT Publ., 2013. 333 p. (Rus).

Received 23.04.2019

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How to cite this article:
Baranov M.I. An anthology of the distinguished achievements in science and technique. Part 51: Rocket-space technology designer Sergey Korolev and his accomplishments in missile design. *Electrical engineering & electromechanics*, 2019, no.5, pp. 3-11. **doi: 10.20998/2074-272X.2019.5.01.**