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WHO ARE THE MEN AND FORMULAS THAT LAUNCHED SPUTNIK

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WHO ARE THE MEN AND FORMULAS THAT LAUNCHED SPUTNIK

G. Sourine and J. Marmain

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Where there is smoke there must be fire... Theoretically, the problem of an artificial satellite was long known to have been solved. It was also known that the tremendous scientific progress of the last ten years had made this development technically possible. Numerous articles have appeared in the last few months in the Soviet press announcing the firing of sputnik, the first of its name. The magazine Radio even advised radio hams last June that the satellite's signals would be broadcast on 20 and 40 Mc. In August 1955, academician L. Sedov stated at the Astronautic Congress of Copenhagen that the Russian satellite "could be launched within the next 2 years..."

And then, suddenly, in the night of 4 October, the Soviet radio and the crackling flashes on the teletypes of the news agencies and newspapers announced the great news to the world, a world somewhat astonished to learn that the first artificial moon was a Russian moon! After the first moment of dumbness had passed, a race was on to get information and unpublished material and one only needs to take another look at the world press output of the last three weeks to realize how many thousands of lines of copy were devoted to this subject. To be sure, it was this avalanche of sensational information and revelations which led Georges Sourine and myself to undertake this investigation. As a matter of fact, it was our common interest in Soviet problems which led us to make a very detailed search of everything that had been written on this subject. In so doing, we discovered that even very serious authors had written articles that were replete with contradictions and technical implausibilities. Everybody was able to notice that while the Russians remained silent, all great physicist, astronauts, astronomers, rocket specialists, admirals, and generals of world renown enthusiastically began making all sorts of sensational but entirely contradictory statements.

At that point we decided to start our investigation from scratch and, in order to get it off our chest, to examine the "guilty parties," in other words, the Russians themselves! Although the Russians do not talk much, they do write a lot and it exclusively is through their writings that we are able today to disclose today a great number of unpublished details about sputnik and the men responsible for its existence. Georges Sourine, a great expert in the Russian language and its dialects, was of valuable assistance for in a few days and nights we had to decipher accurately an increasing quantity of books, dictionaries, magazines, and Russian newspapers. Here is how we did it.

First of all, we plunged back into the works of Konstantin Siardovitch Tsiolkovskiy, whom the Russians consider the spiritual father of sputnik and whose writings have been reported at length by Aviation Magazine in Nos 182 and 183. There we found a prophetic phrase: "The first big step of humanity consists of crossing the atmosphere by creating an earth satellite" (sputnik zemlya).

Undoubtedly, this was the first time that an artificial satellite had been mentioned in Soviet literature. Let us recall that Tsiolkovskiy died in 1935 and that the USSR celebrated the centenary of his birth (17 September 1857) with unusual glitter this year.

Cosmic Speeds

Next we consulted the Great Soviet Encyclopedia under "Interplanetary Flights." There, we found a very interesting article by M. Tikhonravov, a specialist in rocket motors (Vol 27, page 51, ff, edition of June 1954). In a section entitled "Tsiolkovskiy's Formula" Tikhonravov writes (and we quote, leaving him the responsibility for his statement):

"The final speed of the rocket (Vk) — as shown in the accompanying chart — is a function of both the exhaust speed of the combustion products (C) and the relation $\frac{Mt}{Mk}$, where Mt is the mass of the fuel and Mk the mass of the empty rocket after combustion.

"When the force of terrestrial attraction and the centrifugal force are in equilibrium, then the orbit of the interplanetary ship will assume the form of a perimeter. The speed of this motion is called circular speed; it is expressed by $Vk = \sqrt{gr}$, where g represents the acceleration of gravity at a distance r from the center of the planet. If r equals the radius of the earth and g = 9.8 m per second per second, then Vk = 7,912 m per second. A body fired into space at that speed cannot fall back to earth. As the rocket leaves the earth, Vk diminishes but the launching into a circular orbit requires the use of more energy than that required to attain a speed of 7,912 m per second.

"Disregarding air resistance, the necessary speed to escape from terrestrial attraction equals $Vn = \sqrt{2\,gr}$. The trajectory of the body (rocket) will then be parabolic, and this is the reason why Vn is called the parabolic speed. For the earth this speed Vn equals to 11, 200 m per second, on the average.

"The necessary speed for total liberation of the interplanetary ship from terrestrial attraction, exerted jointly by earth and sun, can be obtained by launching the vessel at a certain angle; it is 16,662 m per second. The maximum speed of big liquid-fuel rockets is now more than 2,000 m per second, the exhaust speed being C = 2,000 m per second and $\frac{Mt}{Mk} = 3$. Our chart shows that for an exhaust speed of 4,000 m per second the circular speed is reached when $\frac{Mt}{Mk} = 7$. For a velocity of 11, 200 m per second $\frac{Mt}{Mk}$ must be 15. For a velocity of 16,600 m per second $\frac{Mt}{Mk} = 30+$.

"It is not very probable that [single-stage] rockets answering these requirements can be built. Several means can be considered to overcome the difficulties. The relative quantity of fuel necessary to attain cosmic speed can be diminished by applying the principle of a rocket in stages. All the elements of such a rocket would serve as accelerators and detach themselves after accomplishing their function with the exception of the last one, which attains cosmic speed... It is also possible to utilise certain parts of the rocket as fuel. The maximum speed can be increased by increasing the exhaust speed. Atomic energy can be used to achieve this. But the creation of an atomic rocket requires the solution of a number of complicated technical problems. In the future, the use of atomic energy will make it possible to reduce the relative weight of the fuel (perhaps without having recourse to the stage rocket), increase the payload, decrease the time required for interplanetary voyages, and even to consider an incursion of space beyond the solar system. It will also make the return to our own planet safer."

There follows a paragraph on the works of Tsander and Kondratiuk, as well as a summary of studies undertaken outside the frontiers of the USSR by such well-known scholars as Oberth, Goumm, Esnault-Pelterie, Goddard, etc.

The Rocket and Its Formula

Now, we have seen what the necessary conditions are to escape terrestrial attraction. We have also noted that a multiple-stage rocket is required to achieve this result. This, indeed, is the salient point. As artillery general, A. Blagonravov, recently said in New York, "Sputnik itself is nothing; we could just as well have sent up a chair!" The important element of the success being the rocket itself, we looked up this word in the Great Soviet Encyclopedia. And here is what we have found over the signature of N. Tikhonravov (again the same one!) and B. Lapounov (another rocket expert) in vol 55, page 665-668, edition of July 1953:

"The basic formula (Tsiolkovskiy's formula) of rocket flight theory is as follows: $V = C \ln \frac{M1 + M2}{M1 + H}$, where V represents the speed of the rocket at the time T, C — the exhaust speed of the combustion products, M1 — the rocket mass at the time T, M2 — the mass of the fuel burnt before the time T, and H — the mass of the remaining fuel. When the motor has finished its work: H = 0 and M1 = Mk, from which $V = V_{max} + C \ln \frac{M1 + M2}{M1} = C \ln \left(1 + \frac{M2}{Mk}\right)$. This formula is valid for free space where there is no field of attraction and atmospheric resistance. It is approximately valid for flights under actual conditions.

"For a liquid rocket $V_{max} = P_y \cdot g \ln \frac{M_0}{M_k}$ where P_y represents the relative thrust of the motor, $g = 9.81$ m per second per second, and M_0 is the initial weight (mass) of the rocket. In order to increase the maximum speed (and the range), the principle of a rocket consisting of stages is used. Each element carries a rocket and detaches itself after exhausting its fuel supply. The last element contains the payload.

"For such a rocket,

$V_k = C \left(\ln \frac{1}{1 - X_1} + \ln \frac{1 - X_1 X_1}{1 - X_1 X_1 - X_2} + n \frac{1 - X_{n-1} X_{n-1}}{1 - X_{n-1} X_{n-1} - X_n}\right)$ where V_k is the final speed, $X_1 = \frac{G_{t1}}{G_0}$ and $X_1 = \frac{G_{ti}}{G_{ti}}$ where G_{t1} is the weight of the fuel burned by each rocket element, G_{ti} — the total weight of each element, and G_0 — the initial weight of the whole rocket.

"When $X_1 = X$ we have:

$X_n = X_1 (1 - X X_1)$ $n = 1$ and $V_k = nC \ln \frac{1}{1 - X_1}$. The terminal speed of a stage rocket is proportional to the number of its elements. With the help of such a rocket it is possible to attain a speed of the order of magnitude of 8,000 m per second, which is sufficient for the creation of space stations and artificial earth satellites.

It will be noticed, however, that in the long formula above, the author of this study did not elaborate on the meaning of the parameter ln and it is a pity he did not.

This is how sputnik was launched. What were the properties of the launching rocket? How many stages did it have? The Russians are extremely reticent on this point: M. Varvarov, president of the astronautical section of the Central Aero Club of the USSR and L. Sedov, the great coordinator of the "baby-moon" have replied: "Several." Pobedonostsev, another scientist, and great expert on rocket propulsion, said over Radio Moscow: "It is known that our technology permits us to launch an artificial satellite with the help of a 3-stage rocket," without ever specifying that this was actually the manner in which sputnik was launched. Pravda of October 9 specifies (sic) in a long bulletin that the rocket had been extremely powerful and had been guided with the greatest precision so as to place sputnik into the selected orbit, that it had risen vertically, only to deviate 'a little later' from that course, owing to an electronic brain set before the firing, that at the end of its course it had reached a height of several hundred kilometers and was traveling parallel to the surface of the earth at an average speed of 8,000 m per second. It added that after the last stage had burned out, the protecting head was ejected and sputnik took off.

A question arises here, the whole importance of which will be understood: At what altitude was sputnik released?

Altitude of Release

From the first day on it was announced that sputnik revolved at an altitude of 900 km and all newspapers immediately concluded that it had been launched precisely at that altitude. This is utterly illogical and here is the reason why:

(1) Let us first note that the Russians have later specified that sputnik reached 900 km (and, according to Pravda, even nearly 1,000 km) at its apogee and that its perigee was "considerably smaller." It follows, in effect, an elliptical orbit. Mrs. Lydia Kournossova has since revealed that this perigee amounted to 300 km. Thus, it is quite unlikely that sputnik was launched at a point constituting its apogee.

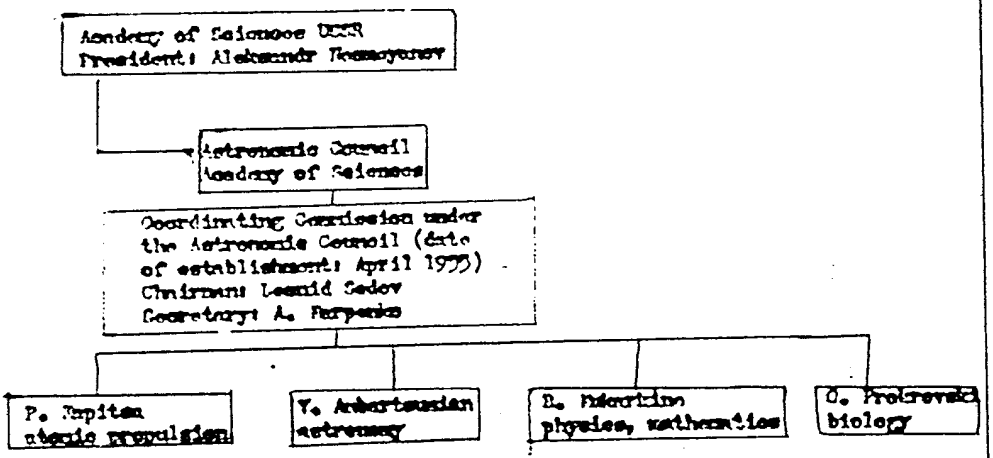
(2) What do the laws of celestial mechanics say, in effect? A body launched near the earth with a speed of 8,000 m per second will not return. In fact, at that speed the centrifugal force and the force of gravity cancel each other out, as we have seen above. The body will thus be transformed into a satellite moving in a circular orbit like all heavenly bodies. This orbit obviously approximates a circle which, for that matter, is nothing but a special form of ellipse. We saw that a body launched a a speed of 11,200 m per second escapes the gravitational attraction of the earth and heads for some place in the solar system. If, then, we launchethis body, for example an artificial satellite, with a speed lying between the first and second cosmic speed, i. e., between 8,000 and 11,200 m per second, it will go off sufficiently far and will thus rise to a higher altitude than that of its launching. The greater this speed, the further it will travel and the more elongated will be its orbit. The force of gravity will then compel it to return and to pass fairly near to the earth, more or less at the point of its release. It will then begin its second trip and so on. For this reason it is not rash to conclude that sputnik 1 was released at an altitude of 300 - 400 km, i.e., obviously, at its perigee. This checks perfectly well with what the Russians have published and what we have reported above, namely, that the carrier rocket had reached a height of "several hundred kilometers" and that the initial launching speed of sputnik exceeded 8,000 m per second.

Reasons for the US lag

Another question disturbing all western nations: why was the United States beaten in the race to launch an artificial satellite? Are the Russians so strong? Are the American technicians blundering? Let us not get panicky. Instead, let us try to reason this out in the light of the controversies which developed in the US. after the Soviet success. There can be no doubt that the scientists of free American are quite as capable as their Russian colleagues and that they have powerful

resources permitting them to complete such a tremendous project. What they lack is a "coordinator," a Leonid Sedov. One does not have to be a great scientist to understand that all branches of industry and scientific research must work closely together in order to achieve an accomplishment of such scope. This includes chemical propulsion, aerodynamics, mechanics of liquids and special metals, mathematicians, electronic brains, radio, atomic propulsion, chemistry, biology, ballistics, etc.) It is now known that the American researchers have worked along parallel lines, sometimes without communicating to each other the results of their work on a common problem, involved as they were in the rivalries between Navy, Army, and Air Force, each of which was pulling its weight to obtain the highest appropriations from Congress. These are the deep-seated reasons why the Americans have not yet been able to solve completely certain problems posed by the carrier rocket, particularly the separation of the different elements, which has to be accomplished with "gentleness" so as not to change the precise course leading the satellite into its orbit within a few meters.

The Russians themselves began by centralizing all their research on Project Sputnik by creating a coordinating commission under the Astronomic Council of the Academy of Sciences USSR. Leonid Sedov was appointed its chairman. We were able to reconstruct the organizational chart of this commission as follows:



We should also mention the Astronautic Section of the Central Aero Club of the USSR imeni V. P. Chkalov, whose chairman is K. Narvarov with A. Shternfeld as his assistant.

Apart from the achievement itself, of what possible use can sputnik be? We have asked Aleksandr Nesmeyanov, president of the Academy of Sciences USSR to answer this question.

WHAT IS THE USE OF THE FIRST ARTIFICIAL SATELLITE

Launched on the occasion of the International Geophysical Year, the first artificial Soviet earth satellite will permit the study of numerous phenomena of the atmosphere.

The important role which the ionosphere plays in all questions of celestial physics is well known. It is a mysterious laboratory where so many phenomena of the upper atmosphere are born.

Scientists need to collect a great number of experimental data to explain the nature of solar particle radiation as well as of other phenomena. In this respect, many attempted explanations of the role of ultraviolet rays and other analogous solar radiation in the formation of the ionosphere, have remained hypotheses.

We already know the structure of the atmosphere at high altitudes, its temperature, pressure, and density. A knowledge of these parameters is important not only for scientists but also for engineers, for example in calculating the movement of planes flying at high altitude.

In the light of the latest research, particularly studies concerned with rockets, the insufficiency of our knowledge of ionosphere physics has become clearly apparent. This research has demonstrated the need to find ways and means to study the upper layers of the atmosphere from the point of view of theory as well as of experimentation.

Interesting suppositions and hypotheses have been formulated on the origin of cosmic rays, the aurora borealis, and other phenomena taking place in the upper layers of the atmosphere with the help of a new branch of physics, magneto-hydrodynamics. However, there is as yet no theory which explains the formation of the ionosphere in a manner which is in agreement with experimental data. The firing of rockets to high altitudes opens up new possibilities in this field because they enable us to measure directly certain parameters of the atmosphere.

With the help of these engines the electronic concentration of the ionosphere, pressure, and density of the atmosphere, etc., were measured in the USSR.

These measurements have yielded interesting results. Their principal defect lies in the brevity of the observation time. It has become necessary to elaborate scientific research methods which would permit the conducting of experiments in the upper layers of the atmosphere during a prolonged period of time. The artificial earth satellite has given us this opportunity.

What is the Nature of the Ionosphere

Among a number of studies to be undertaken by means of the artificial satellite, research on primary cosmic radiation ranks first. This phenomenon is caused essentially by hydrogen nuclei (protons) and helium nuclei (alpha particles) and by a much smaller number of heavy nuclei (carbon, nitrogen, oxygen, etc). One of the characteristics studied in primary cosmic radiation is the similarity which exists between the curve of element propagation in the universe and the distribution curve of primary cosmic radiation components according to their charges. Such elements as lithium, beryllium, and boron are very rare in nature and the question has not yet been theoretically resolved as to how many of these nuclei enter into the composition of primary cosmic radiation. In this respect, a study of the characteristics of this radiation could clarify questions on the duration of cosmic particle circulation in universal space as well as the origin of the cosmic rays themselves.

It is fitting to include in this series of questions also the study of the variations in the intensity of cosmic rays at the different altitudes and divers regions traversed by the artificial earth satellite. The study of these phenomena assumes essential importance for the solution of question regarding the origin of cosmic rays and problems of astrophysics. Particular examples include an explanation of the connection between solar eruptions and disturbances at the magnetic pole of the earth.

Among the questions concerning the study of the structure of the ionospheric layers appears also the determination of ion concentration. It has been experimentally established that this concentration varies with altitude. From this fact it can be seen that the receipt of further information regarding the ionization of the atmosphere along the orbit of the satellite will be of unusual interest.

While on the subject of ionospheric measurements, we should mention those that will be undertaken by spectrographic means in order to determine the ion composition of the ionosphere so as to learn about and define its chemical structure.

Why Is the Magnetic Pole Fluctuating?

The fluctuations, or oscillations, of the magnetic pole of the earth is one of the most astonishing geophysical phenomena. Measurements undertaken partly on the surface of the earth and partly with the help of rockets have shown that the magnetic pole of the earth is not constant in time but, rather subject to so-called secular and short variations. The nature of the secular variations remains largely an enigma. As regards the variations of short duration, their origin is at this time being related to the existence of systems of electrical current of the order of magnitude of hundreds of thousands of amperes in the upper

layers of the atmosphere. For example, it has been assumed that such systems which cause variations of the magnetic pole of the order of a solar day are situated at an altitude of 100 to 120 k.

It follows that a study of the changes of intensity of the magnetic pole at high altitudes should be of special interest. It will provide scientists with new data on the existence of short variations of various types and on the resulting variations of atmospheric currents.

This interest will be increased by the fact that magnetic variations are linked to other physical phenomena by virtue of certain laws: aurora borealis, propagation of radioelectric waves, cosmic ray variations, etc. The connection is particularly strong between magnetic perturbations and auroras borealis. It is assumed that both phenomena are caused by particle radiation from the sun. However, the nature and intensity of this particle radiation has not yet been adequately studied. Now, the theory of auroras borealis is based to a great extent on assumptions regarding the nature of particles emitted by the sun. For this reason the question of the nature and intensity of particle radiation remains extremely important and on its solution depend in large measure our ideas about the appearance of the auroras borealis and other phenomena taking place in the upper layers of the atmosphere.

Meeting With Meteorites

Among the studies made possible with the help of the artificial earth satellite, the study of micrometeors and meteors takes up an important place. These solid particles, which move, for example, at a speed of 50 to 70 km per second in relation to the earth, are of great interest not only to geophysicists and astronomers but also to the builders of rockets and satellites. Computations show that even small particles are able to pierce the exterior skin of the satellite. It thus becomes necessary to learn the number and energy of micrometeors over a given distance and their energy. The procurement of spectrographic pictures of micrometeors and of meteors would allow us to draw precise conclusions regarding the "meteoritic danger," an extremely important problem for future interplanetary communications.

We have mentioned only a few of the experiments which will be carried out by Soviet scientists with the help of artificial earth satellites. But it can be seen that the results which these engines will allow us to obtain will add considerably to the scientific data collected by other means during the course of the International Geophysical Year.

A. Kosmeyanov.

We shall close this first detailed report by answering one last question: What is the future Soviet program for the firing of satellites? Here is what we know about it:

(1) The firing of a great number of satellites carrying various measurement instruments in the course of the International Geophysical Year;

(2) Within a short time, the firing of a nonrecoverable satellite with dogs as occupants;

(3) The firing of a recoverable satellite with a human occupant;

(4) The firing of a moon satellite to "inspect its [illegible] side."

This whole program is aimed at one single goal: The firing of a projectile to the moon.

In a coming study we shall learn about the different Soviet projects for a landing on that planet.

In a coming issue we shall study the biological studies by Pokrovskiy of conditions of animal life at high altitudes, carried out up to now by means of rockets having reached altitudes of 100 and 200 km.

Sources: Pravda, since 5 October; Great Soviet Encyclopedia; Rasskazi o Raketakh, by B. Liapounov, 1955 Moscow; Soviet Studies August 1957; Radio, June 1957; and the collected works of K. E. Tsiolkovskiy.

FIGURE CAPTIONS

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Appearance: Sputnik is a sphere composed of 2 hemispheres of aluminum alloys (we emphasize the plural of the Russian word). The surface is highly polished and specially treated to facilitate thermal exchanges. The color is yellowish, which undoubtedly means that sputnik is gilded, like the future American satellite.

Features: Diameter: 580 mm. Fitted weight: 83,600 kg. This weight was so surprising that in the beginning it was thought that the figure had been distorted through errors of transmission. To this question, the Russians answered: "If sputnik is so heavy, it is because we have incorporated a very heavy chemical battery to supply the transmitters as long as possible; furthermore, the greater the mass the less the initial speed is slowed down."

Radio equipment: "Sputnik" contains 2 transmitters which broadcast continuously on wave frequencies of 20,005 and 40.002 Mc, corresponding to wavelengths of about 15 and 7.5 m. The power of the beam is nearly one watt. The signals are telegraphic signals lasting 0.3 seconds. They are followed by a pause of the same length. The pause of one transmitter corresponds with the sending period

of the other. The 2 transmitters operate through 5 antennas of different length (2 of 2.40 m and 2 of 2.90 m). These antennas are mounted on exterior sockets permitting their being folded back (as in the ribs of an umbrella) at the time of the ejection from the last rocket stage.

Sputnik is filled with nitrogen stirred into circular motion by an unexplained process. This inert gas is used for the thermal regulation of the internal parts. The transmitters, in fact, emit heat and this heating problem must have been one of the most difficult to solve.

Orbit: The initial orbit is an ellipse, one of whose foci is the center of the earth; the apogee, given as 900 km on the first day, according to Pravda, is "in the magnitude of 1,000 km;" the perigee, according to Mrs. Lydia Kournossova, cosmic ray specialist and delegate to the Barcelona Congress, is 300 km. The apogee is situated above the southern hemisphere of the earth, the perigee above the northern hemisphere. The total initial trajectory was about 44,400 km long and was covered in 1 hour 36 minutes 2 seconds. The last stage of the carrier rocket gave sputnik at the time of its release an initial speed of "a little more than 8,000 m per second." An article signed by K. Saveliev in Pravda of October 15, stated that sputnik had been fired "with a slightly higher speed than necessary."

[Photo page 12 of original]

WHO ARE YOU, LEONID SEDOV?

At last we were successful in penetrating the secret of the mysterious Mr. Sedov, who was so adept at eluding the indiscrete questions of the band of journalists pursuing him! Leonid Ivanovich Sedov was born in 1907. A specialist in mechanics, he was elected corresponding member of the Academy of Sciences USSR in 1946, becoming a member in 1953. He received the Stalin prize in 1952. He completed his studies at the University of Moscow in 1931 and became a professor there in 1937. In 1931 he went to work at TsAGI (Central Institute for Hydrodynamics) and in 1947 at TsIAM (Central Institute for the Construction of Aircraft Engines). All his scientific output was devoted to mechanics problems. In the field of the mechanics of liquids, he established formulas for the aerodynamic forces operating on nonstabilized wing movement, especially vibrations. He discovered a new method of calculating problems arising from profile aerodynamics. He applied this method to the theory of thin wings. Later, he largely adapted it for use in the theory waves, elasticity, etc. In his book "The Problems of Hydrodynamics and Plan Aerodynamics," (Chapter 7, Section 2: "Slipping on the Surface of Heavy Liquid") he states and completely solves the problem

of slipping. The results of these labors were incorporated in naval construction and the construction of hydroplanes. Sedov also solved the problem of the impact of a body on water, of ricochet, and a series of other problems concerning the hydrodynamics of heavy liquids. Sedov is supposed to have been the first discoverer of a method permitting the study of the flow of gases around a grate. He also refined the method permitting the study of potential gas currents, considerably enlarging the field of application of the method of approximations of S. A. Chapliguine. In the theory of similarities, Sedov stated and solved the problems constituting the scientific basis of this branch science. He elaborated on the theory of the nonstabilized motion of gases — in particular the theory of the propagation of shock waves — he obtained interesting results in the theory of surface waves, and established the law of pulsations in isotopic turbulence. His work "The Propagation of Strong Explosive Waves" (1946) laid the foundations for shock wave theory. For this accomplishment, the Academy of Sciences USSR awarded him the Chapliguine Prize. Sedov also studied several astrophysical problems. He was awarded the Order of Lenin and received many decorations. In April 1955 L. Sedov was named chairman of the Coordinating Commission under the Astronomics Council of the Academy of Sciences USSR — Project Sputnik.

When Leon Zitrone of the French television system interviewed L. Sedov, he asked him: "Do you believe you are ahead of the Americans?" he was answered: "The facts speak for themselves!"

(Quotation from the Great Soviet Encyclopedia, Vol 38, pages 372-373, edition December 1955).

/Photo page 13 of original/

WHO ARE YOU, PETR KAPITSA?

The presence of P. Kapitsa on the coordinating commission, of which L. Sedov is chairman, is an entire program. Kapitsa is considered to be the father of the Russian A and H bombs. On the other hand, it is known that the Soviets are working feverishly to develop atomic propulsion intended for use in future space rockets. The relationship between this name and this work is evident.

Petr Leonidovich Kapitsa was born in 1894 as the son of a general in the former government. He completed his studies at the Polytechnic Institute of Petrograd in 1918. His first works were devoted to a study of the inertia of electrons and the characteristics of radioactive radiations. He perfected an installation which made it possible for man to work with very powerful magnetic fields. This enabled him to observe the fission of spectral lines in field of up to 320 kilogauss, discover the linear increase of electric

bodies in these fields. He perfected a large-output hydrogen liquefier and constructed an original installation for the industrial liquefaction of helium. We should mention that Soviet sources always fail to mention one important episode in the life of Kapitsa. In 1921 he emigrated to Great Britain. Lord Rutherford, the famous English physicist, welcomed him in his institute and, some years later, made him its director. Nevertheless, Kapitsa did not succeed in obtaining British citizenship. In 1934 he joined a group of scientists invited to an international congress in Moscow and did not return. He even succeeded in repurchasing his laboratory and in having it shipped to the USSR. From 1935 to 1946 Kapitsa was director of the Institute of Physical Sciences of the Academy of Sciences USSR. He perfected a new process for the manufacture of liquid air by using a low-pressure cycle and a turbo-expander. With the same turboexpander method he created an installation by means of which large quantities of liquid oxygen could be obtained through rectification. For his thesis "A Turboexpander to Obtain Low Temperatures and its Application in the Liquefaction of Air" (1939) he received his first Stalin Prize in 1941. He also studied the properties of liquid helium and discovered the phenomenon of super fluidity. In 1943 he received his second Stalin Prize for his work, the results of which were published in "Heat Transmission and Superfluidity of Helium II" (1941) and "Research on the Mechanism of Heat Transmission of Helium II" (1941).

Kapitsa became a member of the Physics and Mathematics Section of the Academy of Sciences in 1939, was named Hero of Socialist Labor in 1945, and received 2 more Stalin prizes in 1943 and 1949. Holder of 3 orders of Lenin, he also holds honorary doctor's degrees from various universities (4 British, 3 American, 2 French, 3 Chinese, etc). Other special distinctions: University of Liege, medal (1934); prize of honor of the Academy of Sciences (1937); Franklin Medal (1941); Faraday Medal (1942).

[Figure top right page 12 of original] These two sketches, which represent the orbit of the sputnik, explain why the satellite travels in northeasterly direction over one half of the earth and in southeasterly direction over the other half.

[Left Figure page 12 of original] [No caption. See text.]

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