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16. Abstract

Author B. P. Vladimirov describes the "Baykonur" cosmodrome, its functions, operations, and services in considerable detail. The description includes the launch complex, launching pads, launch structures, launchers with cable masts and propellant-loading towers, and pre-launch laboratory, including service trusses and towers. The paper is illustrated with 7 photographs and a diagram, which describes the sequence of all phases of rocket assembly and preparations for launch. The paper concludes with a description of all pre-launch procedures and the launch itself.

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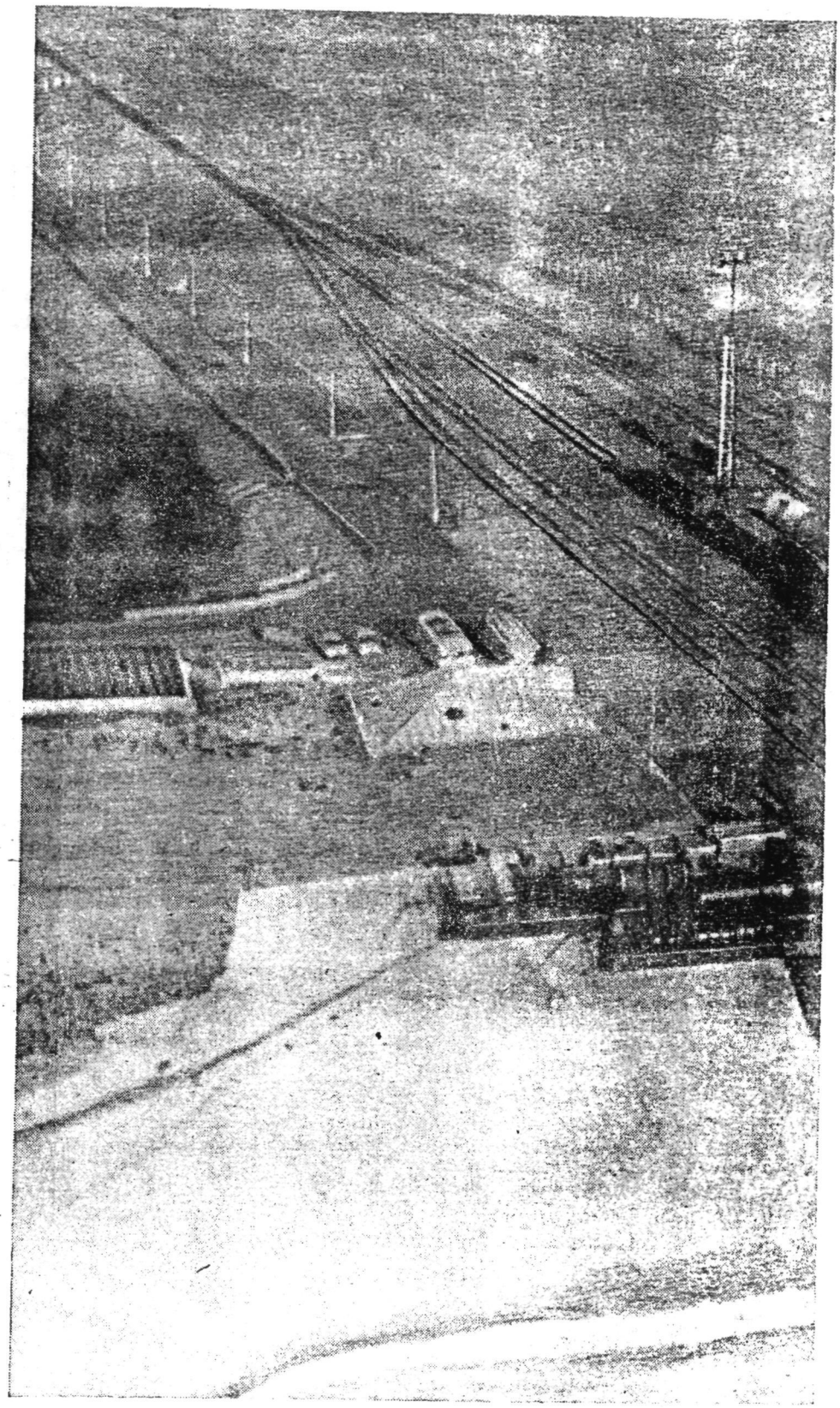

Figure 1: View looking towards the launch site.

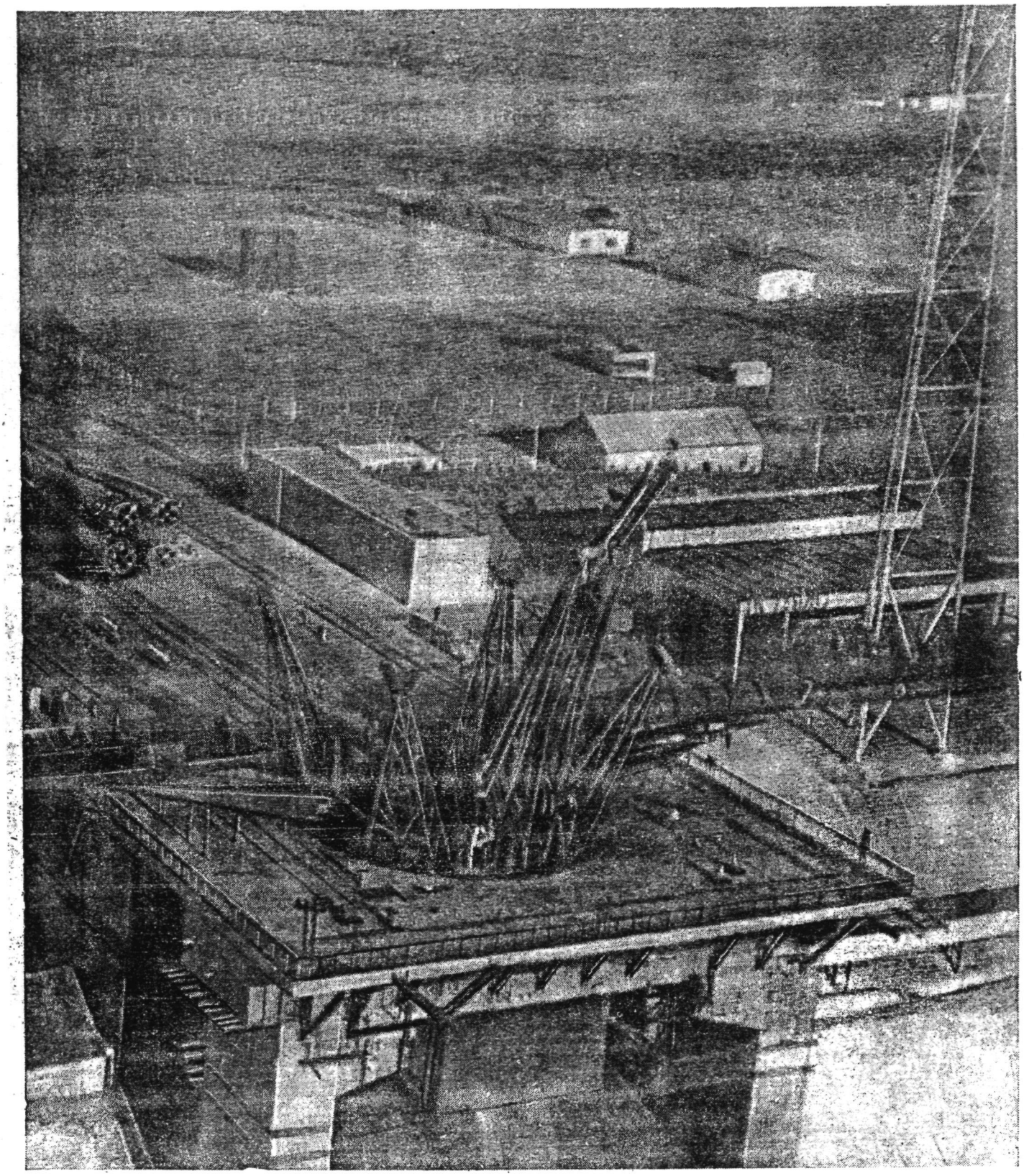

Figure 2

rocket. Below it there is the gas-efflux channel, to carry away the combustion products of the rocket engines. On the baffle plate the launch system is concentrated around the aperture. In the launch and other structures there are systems for charging and temperature control of fuel, compressors, and storage vessels for compressed gases, containers for storing fuel, and the control system equipment for preparing the rocket for launch and for the launch itself.

Behind the inclined gas-efflux channel, there is the command point bunker. It is connected by cables with all the cosmodrome operational services, the observational and command and measurement points. A short distance away there is the assembly and test structure. A railway track connects the assembly and test structure with the launch area. Along this track the space vehicles move to their final point, from which to begin their journey into the universe.

The main structure of the launch complex is the launch system. In appearance it is quite original because of the unusual shape of the launch vehicle. The construction of a rocket, which takes the form of a package with transverse division into stages, is reminiscent of the famous Russian troika. A group of five units is in "harness" as the first and second stages. The central unit, the core, is the first and simultaneously the second stage, and on two sides symmetrically attached there are four lateral units of the first stage.

These lateral units are cone-shaped and are attached to the central unit roughly at a distance of 20 m from the base of the rocket (the total length of the launch vehicle with the spacecraft is about 50 m). At the apex of the lateral units the rocket is suspended on the launch system, and penetrates roughly 7 m into the aperture in the launch structure. Its entire weight is supported on four support points.

This rocket shape is radically different from the traditional idea of a rocket launch. Usually, a rocket is supported on its base on the launch structure and, in ascending, immediately leaves all elements of the launch structure on the pad. In this arrangement, the launch system must support the rocket until its engines come up to the basic thrust condition and as soon as the rocket tries to ascend, it is set free in a few seconds.

As a rule, in the first period of motion the rocket does not acquire sufficient stability and a strong wind or a nonuniform motor thrust

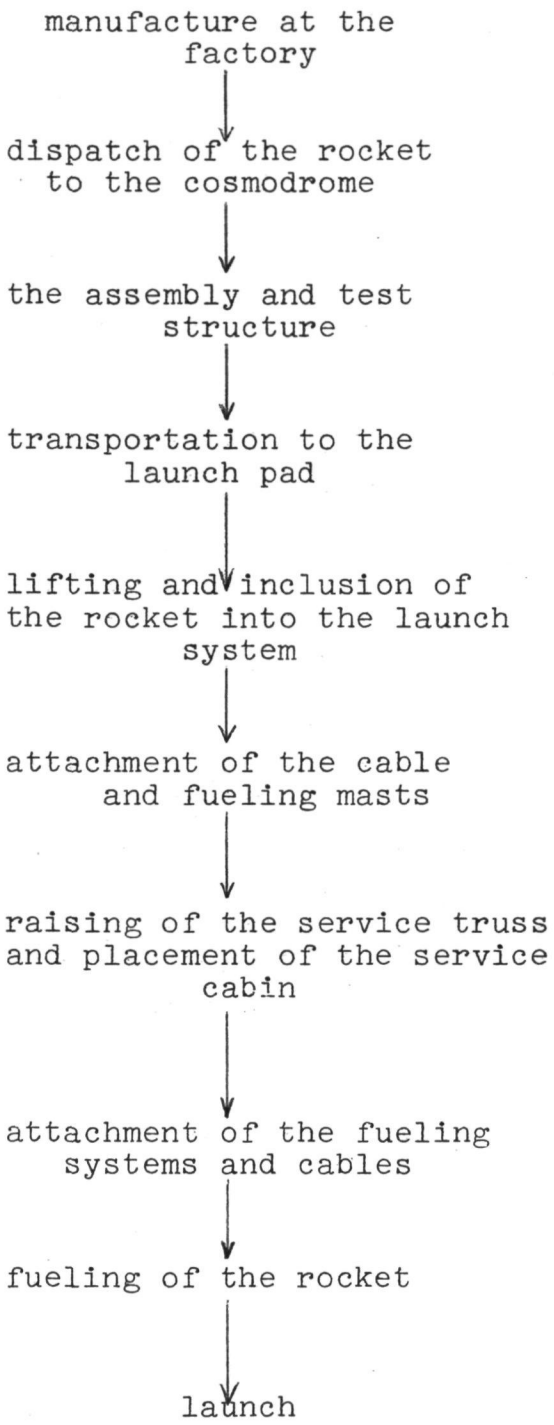

Figure 3: Schematic diagram showing the movement and preparation of a rocket for launch, from the moment of manufacture to launch.

can deflect it from a strictly vertical ascent. Therefore, for each type of rocket there are safety limits for the launch area. The rocket must have a "corridor" through which it can be safely launched. This /67

means that all elements of the launch equipment can only be located outside this corridor, and the supports on which the rocket is suspended prior to launch must be withdrawn, when the rocket base passes by. Similar limits determine the diameter of the aperture in the launch structure for the base of the rocket and the internal diameter of the annular base of the launch system.

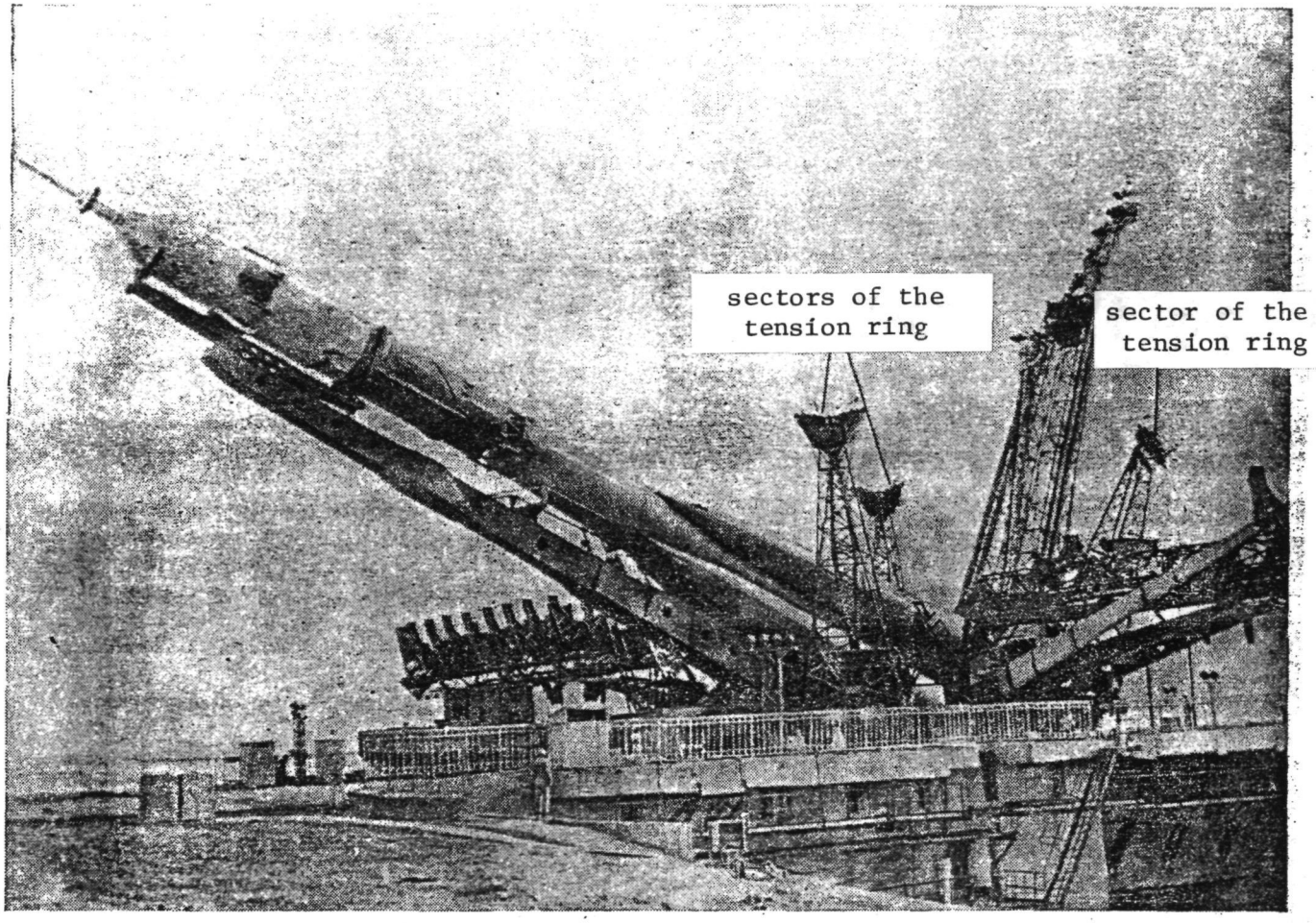

Figure 4: Mounting of a rocket in a vertical position. The support elements of the launch system, the mast, and the service trusses are withdrawn.

The support structure of the support system may be described in this way: in the plane of the suspension supports, the body of the rocket is freely contained by the tension ring, consisting of four support trusses, attached via hinges to the base of the launch system. When the tension ring is closed, these separate four parts form a rigid structure which holds the multi-ton rocket safely. Outwardly, the

structure looks like a truncated pyramid, within which the rocket hangs. The structure holds the pyramid in the closed position, because of its own weight. The rocket, which hangs freely in the launch system, can sway, like a mast, under the influence of the wind or non-uniform thrust of the engine. Therefore, inadmissible loads may rise in the support element of the rocket, and its initial orientation in space may be disturbed. To avoid this, the rocket is fixed externally by stabilizers at four points of the base. Hinged attachments, to which the rocket is fastened, like the support elements of a pyramid, are separated from the rocket as it starts to move, and fall away to the side under the action of their own weight. The pyramid supports the rocket until its engines generate sufficient thrust, capable of raising the rocket and imparting the correct initial motion to it. As soon as the rocket begins to move, the pyramid opens and the four support trusses of which it is comprised fall away in a few seconds beyond the launch corridor, free of the rocket path.

At the launch of space rockets, one can easily see how the support trusses fall away from the rocket, and how it slowly leaves the ground in a cloud of flame and smoke. When first tests were made on the opening of the pyramid at the cosmodrome, the pyramid received the name "tulip".

There is a saying that the simpler a structure is, the more reliable it is. The launch system has exactly these qualities. In the two decades of the space age, many different space vehicles and space craft have been built, but the "tulip" has functioned reliably and has set them all initially on the correct start to their space journey. /68

The launch system is equipped with cable and fueling masts. Their names define their purpose. Along one of these pass the cables for supplying electrical energy to the launch vehicle prior to launch, and the other carries lines for supplying fuel and telemetry cables to items on the spacecraft. When movie frames of a rocket launch were shown, the viewers observed how the masts fall away to the side from the body of the rocket, a few seconds prior to launch.

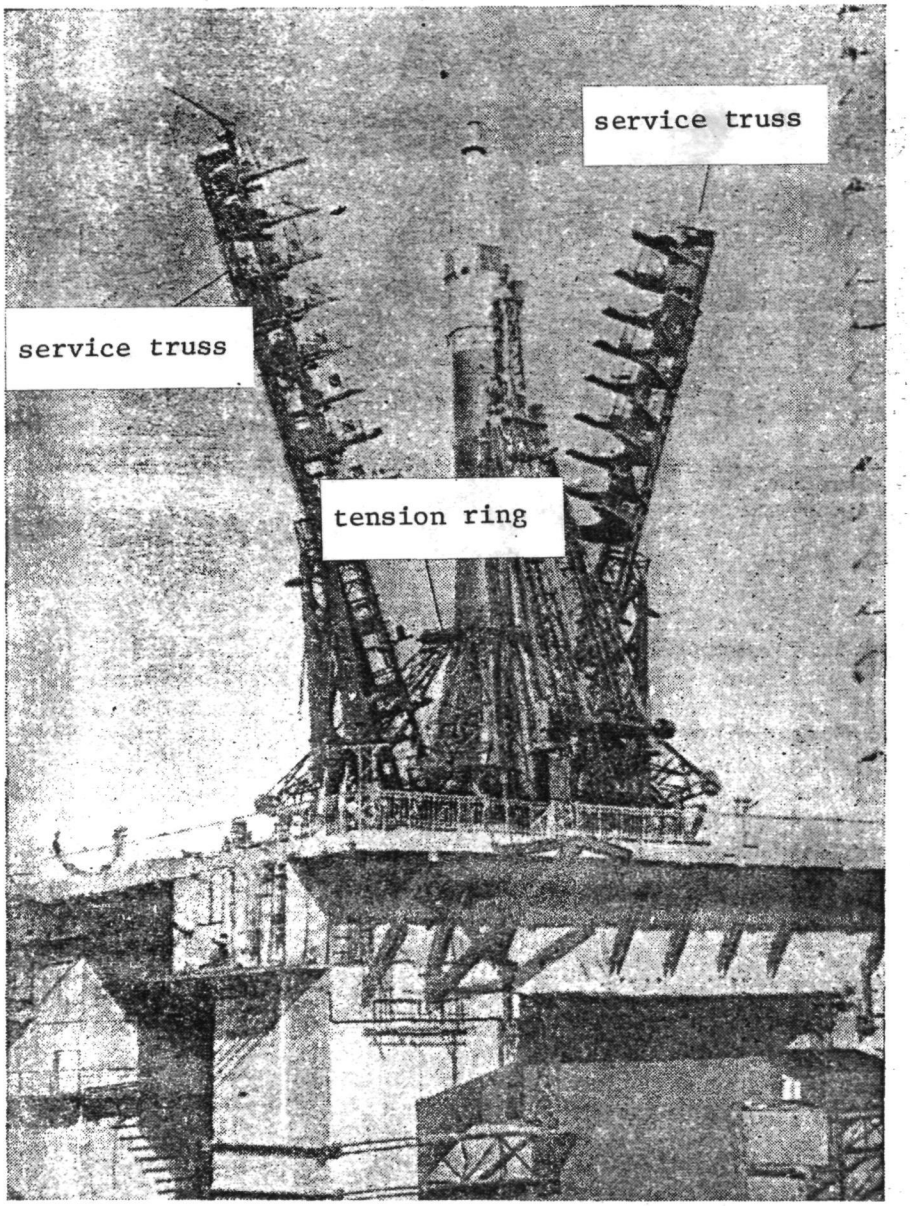

Figure 5: A rocket is set up on the launch system. The cable and fueling masts are withdrawn. The service masts are withdrawn. In the lower part of the photograph one can see the deflection plate of the launch structure.

The Cosmodrome Pre-Launch Laboratory

The service facilities are particularly important in the launch complex. These provide access for the service personnel to locations

close to the fueling systems, the electrical and pneumatic joints, to the rocket, and are also used to bring in equipment and instruments /69 to different heights. The service facilities (the service trusses and the service cabins) are used to make the last checkout of the rocket prior to launch.

The Service Truss: This takes the form of two columns of height almost as great as the rocket, which are attached via hinges to the base of the launch system. In the operating position, these form a distinctive gantry with floors at various levels, within which the rocket is located. These floors freely span the rocket, and make it possible to service it from all sides. Some of the floors are closed in, where micro-climate zones can be set up for operation with large temperature drops. The cosmonauts embark from the topmost floor. Before launch, the gantry is opened and each half of the truss falls away to a horizontal position, one on each side.

The Service Cabin: This is a huge platform which covers the entire aperture in the launch structure beneath the rocket. It forms a suspended working area below the rocket for servicing. Multi-level extensible floors of the cabin provide free access to numerous service locations at the base of the rocket.

Final Preparations

Preparation of the rocket for launch begins with the transportation of its units and parts of the space vehicle and spacecraft in special railway wagons from the manufacturing factories. At the cosmodrome, they are set up in the test and assembly building. Here, cleanliness rules. This is underlined by the white clothing of the workers.

The assembly and test building of the cosmodrome, where the rocket takes its final shape, is well known to us from our television screens, photographs, and movie-news pictures, and is furnished with various equipment, monitoring and testing apparatus and instruments, to provide a last-minute check of the life-activity of the rocket and the space vehicle in the forthcoming flight.

Finally, all the units of the rocket are assembled. The final operations are conducted; the space vehicle is mated to the rocket. Thereafter, the rocket-spacecraft system is tested as a whole, and the rocket and space vehicle are made ready for their journey to the launch

pad.

Powerful bridge cranes lift them onto the transport-assembly complex, the transporter. The aperture in the assembly and test structure is opened, and the transporter slowly moves to the launch pad. It seems to the onlooker that a fantastic ship is floating in wide-open space. On the launch pad, everything is ready to receive the rocket and spacecraft. The launch system is in its original configuration, the support trusses swing open, the cable and fueling masts are withdrawn, and the columns of the service trusses are withdrawn.

Over the last few meters, the transporter proceeds on a calibrated track. Self-propelled carriages pull it with millimeter accuracy. The frame, the base of the transporter, is suspended on jacks and rigidly attached to bedrock. Then the ascent begins. At the transporter control desk they press a button to bring on the pumping station for the hydraulic system. And the huge silver-white body of the rocket floats upwards. In a period of a few minutes it reaches the vertical position /70 in the aperture of the launch installation. The transporter requires very great structural strength to hold its load in this position with an accuracy of a millimeter. The enormous bulk of the transporter carries out this operation with precision accuracy.

The voltages are supplied to the launch system. The pumping facilities for raising the support trusses are switched on. And the four trusses ascend simultaneously, each bringing its sectors up to the rocket. The tracking systems accurately synchronize their motion. The tension ring envelops the rocket body, and the "tulip petals" close. Now, one can transfer the rocket and the space vehicle from the transporter to the launch system. The links from the rocket to the transporter boom are opened. The boom is withdrawn to its original position, and the transporter returns to the assembly and test building.

After the rocket is finally fastened to the launch system, the columns of the service trusses are raised. The cable and fueling masts are brought up alongside the rocket, and the hoses for the fueling system, the pneumatic fixtures of the gas communication lines, and the cable circuit plug joints are hooked up.

A check is made that the rocket is vertical. If deviations are observed, the stabilization system is switched on, and holds the almost 1000-ton load in the required position to an accuracy of several seconds of arc. This is made easier by the fact that the launch system floats

on a hydraulic suspension.

A very important stage in the launch preparation of the rocket is charging it with fuel and compressed gases. From this moment, all

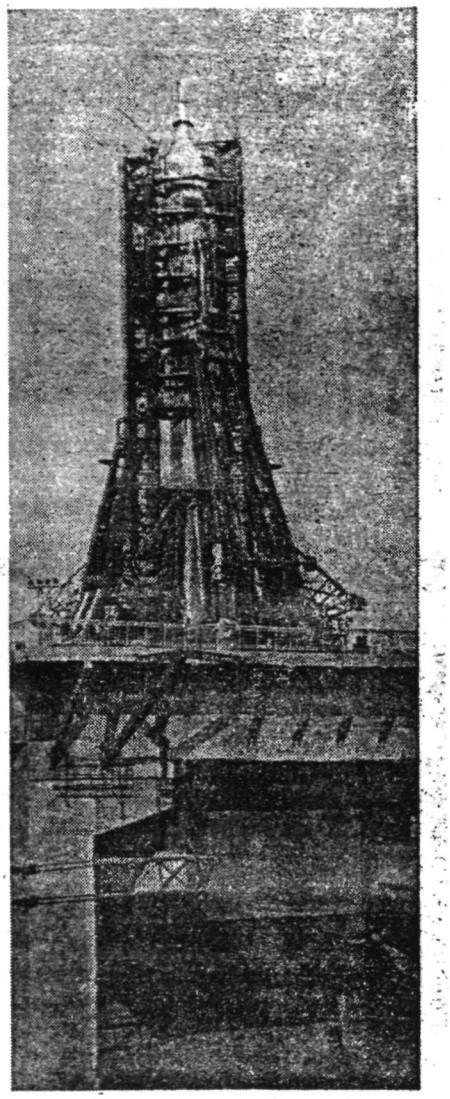

Figure 6: Rocket in the last period of launch preparation. One can see the deflector plate of the launch structure and the beginning of the gas-efflux channel.

is accomplished in a strict engineering sequence. The main role is played by a logic scheme on which the fueling control system is based. Its function is to check that each machine, unit, mechanism, and instrument accurately fulfills its function.

The fueling control center is concentrated in the bunker, which holds the panels for control, monitoring, and signalling. The blinking

control lights signal that the fueling systems are operating correctly. The fueling process is mapped in a lighted mnemonic scheme. The high-power pumping facilities supply fuel along the trunk lines at high speed from storage to the launch facility. From here, the fuel goes to the tanks via individual hoses attached to the side of the rocket. Simultaneously, the rocket is furnished with compressed gases.

Measuring devices, located at different places in the fuel lines, rigorously monitor parameters of the components supplied: the temperature and pressure at various points of the fuel lines, the supply rate, the level, and the volume.

Before the Launch

The rocket fueling is complete. The final operations to prepare the rocket for launch are being conducted on the launch pad. The fuel lines are separated from the rocket, the service cabin is withdrawn into a recess, and the columns of the service truss are dropped down to a horizontal position.

We are now fifteen minutes from readiness. The service personnel leave the launch pad. Approximately five minutes prior to launch, the first command is given, which is repeated on the public address system throughout the cosmodrome, like an echo:

"Switch to launch!"

In the bunker at the central control desk, the control switch is set to the launch position. An automatic cycle of pre-launch and launch operations begins. The second command is given:

"One minute!"

The telemetry system interrogates thousands of sensors located in all corners of the rocket.

"Purge!"

The channels of the fuel supply system and the motors are purged with nitrogen. Approximately one minute prior to launch the command is given:

"Switch to drain!"

All the drain facilities onboard the rocket are opened. The supply to the fuel tanks from the ground fuel system is stopped.

"Launch!"

But still this is not blast-off of the rocket, but only total readiness for that. From this instant, the onboard rocket control systems

are switched on.

"Withdraw the towers!"

The state of all the onboard systems is recorded in the autonomous mode, the last monitoring.

"Ground to rocket contact!"

On the screens of the television sets one can see that the fueling and then the cable masts are withdrawn. The onboard system of the spacecraft and rocket are transferred to autonomous control and onboard supply. In the microphones and reproduction systems, signals counting down the time are heard. The final seconds before launch!

The time mechanism of the control desk is switched on. From this /71 moment the launch time corresponds to the design value with an accuracy up to hundredths of a second.

"Ignition!" is given over the intercom.

A huge flame flares up at the base of the rocket. An avalanche of fire fills the aperture of the launch structure. With a roar it falls back into the gas efflux channel. The noise level grows to an incredible level; the engines have begun to function.

And finally the most nerve-wracking command: "Blastoff!" The instant has come, and the launch system, which senses that the rocket has acquired enough thrust to leave on its journey, smoothly opens its embrace, freeing the rocket.

Blanketed by clouds of smoke, the rocket departs from Earth. Its twenty-million horsepower thrust carries it into space. It moves faster and faster. The rumble of the engines dies down. The glowing spot vanishes in the sky.

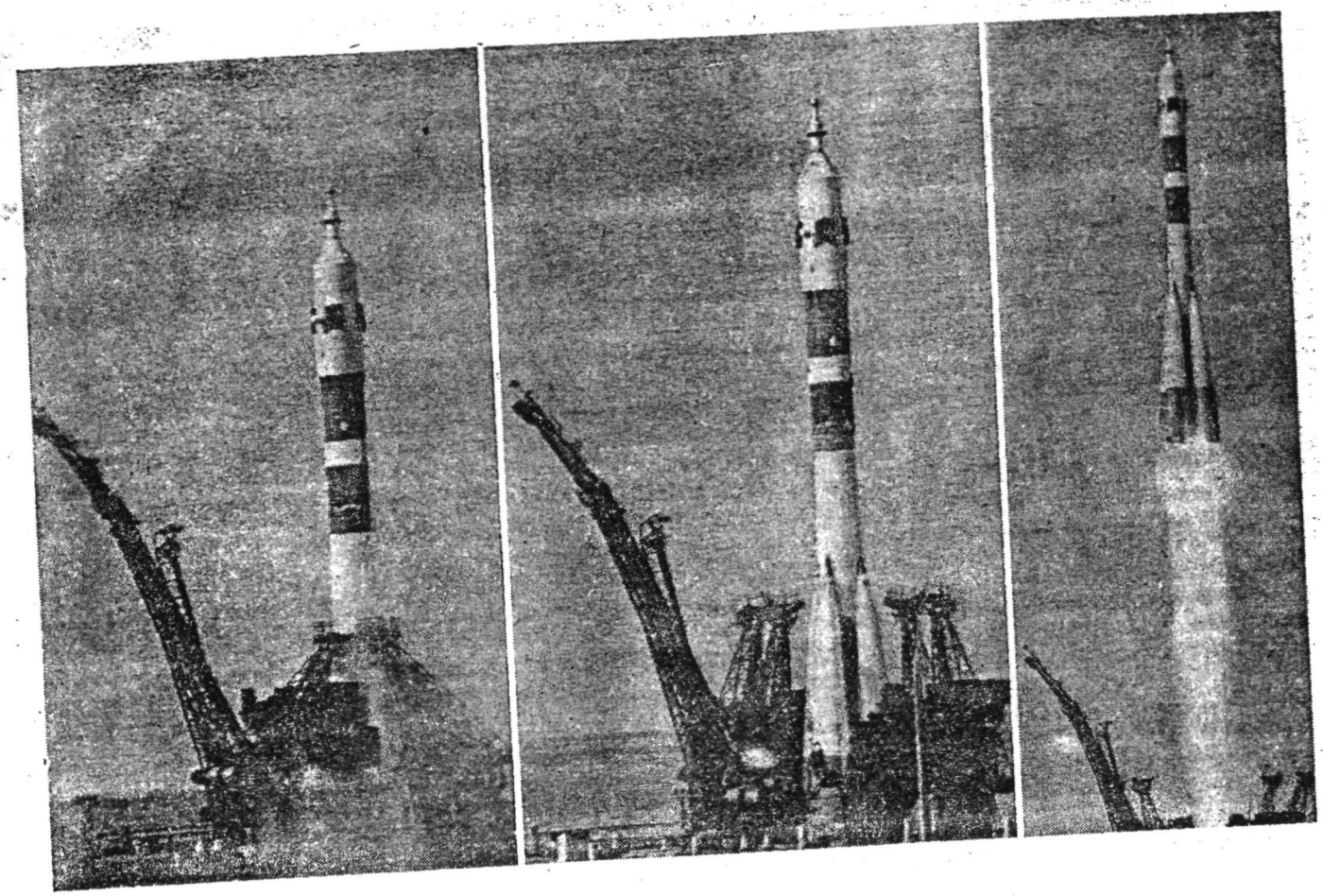

Figure 7: Blast-off and commencement of the rocket flight.