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Strategic Missiles

1. There is nothing unusual about Soviet ICBM's. Both they and the space vehicle rockets are constructed in exactly the same way as the short-range tactical missiles, that is to say, they are two-stage (dvukhstupenchatyy), liquid-fuel missiles with a length

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varying between 18 and 24 meters. The V-2 was the origin from which all Soviet missile development sprang. The same pattern has been followed throughout, and the ICBM is exactly the same type of two-stage missile as the tactical weapon, except that everything is on a massive scale and the fuel has an admixture of boron, in order to develop a higher calorie mixture for increasing the specific impulse. The primary goal is to achieve a high-calorie fuel to give greater thrust, to have all the circuits and control mechanisms working properly with respect to each other, and to reduce the errors in deviation from the planned trajectory, or to correct the errors to a zero deviation position, and then the missile can travel from one continent to another.

2. Thus, strategic missiles are constructed on exactly the same principles as the tactical missiles, with, of course, all dimensions greater. Although they may have the same horizontal and vertical gyroscopes, the strategic missiles have powerful rudder-steering mechanisms, compared with the smaller steering mechanisms on, say, the R-11. In addition, tremendous auxiliary equipment must be used to handle the strategic missiles, because of their enormous size. They have not only a launching pad peculiar to them, but also protective breastworks, and are held in place by rails and supporting towers, in contrast to the way in which a tactical missile is held against excessive wind pressure. The basic mechanisms are the same, but everything is designed to handle a much more massive missile. The tower must support even the connections to the control panels used for making final checks. Hoisting mechanisms must be used to place the missile on the pad.

#### Space Vehicles

3. An exception to the above ICBM staging pattern was the first earth satellite, which was launched by means of a package (paketa) of missiles, consisting of the R-11 and R-2 joined together, three below and one above. The overall weight, including fuel, was about 100 tons, of which 68 tons was liquid fuel, the balance of 32 tons comprising the airframe, the satellite itself, and various instruments. A basic component of the fuel was boron. Subsequent satellites including Gagarin's capsule, were launched by two-stage liquid propellant rockets.

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4. Control of the Venus satellite was lost, and before Gagarin's launching, a number of unsuccessful attempts to put a man into orbit had been made, which had ended in death or failure but source could not provide details such as dates, names, etc.

Trend of Development

5. With the original V-2 as a foundation, the R-1 was developed. From the R-1 evolved the R-11, which is a very successful engineering design and is being used as a basis for the development of other types. All that is required, in principle, is to increase the capacity and size; the principle of the assemblies and fuel remain the same, but trouble has been encountered with the fuel. The R-5 is based on the R-11, but it is very much larger. The Soviets have now gone back to the R-5 and will continue to use it as a basis for development, which consists of proportionately increasing the amount of fuel, the diameter of the nozzle, and the size of the combustion chamber, and testing the assemblies under new conditions. There is no question of trying a radically different design, and no work is being done on types entirely different from the R-5/R-11 basic model. The electronic and control systems remain the same, and the only developments concern the fuel. The objective is to decrease the volume of the fuel, which would, of course, be revolutionary - to decrease the space required for fuel and increase the warhead size, range, and velocity.

Propellants: Nuclear, Liquid, Solid

6. Considerable efforts have been made to develop a new type of fuel which would achieve a very high specific impulse and occupy a small storage space, thus eliminating the large tanks required for liquid propellant and oxidizer and possibly permitting a larger warhead which could carry a conventional charge as an alternative to an atomic weapon. One method proposed was nuclear propulsion, and on Khrushchev's orders this line was intensively pursued. A special effort was made to achieve success as a "gift" for the 43rd Anniversary of the October Revolution [7 November 1960]. Representatives of government committees, Marshal Nedelin, and many specialists in missile technology were present for the testing of the new engine. After the command "Launch" had been given, the missile failed to lift off; after about fifteen minutes had passed, Nedelin was told that there had been a malfunction. He therefore came out of the

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deep reinforced-concrete shelter, but at that moment the fuel system of the second stage ignited prematurely and broke through the lower (first) stage, resulting in an explosion.

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7. Up to 300 persons, including military personnel and scientists, were killed; a few were saved, by a miracle, receiving severe injuries, but some of these have since died. There was widespread mourning in many towns, including Dnepropetrovsk, since many of the personnel working at the launch site who perished in the explosion came from that city. Not all the specialists who took part in this program died, and developmental work was still in hand in mid-1961, though experiments had not so far been successful. The Nedelin disaster occurred because the specialists were under pressure and tried to hurry. ✓

8. The only successful propellant developments so far have been achieved in liquid fuels. Fruitful experiments have been carried out with high-calorie fuels for long-range missiles. All the basic fuels currently used for missiles, such as kerosene, various combinations of its equivalents, and certain additives such as boron, which turn them into high-calorie fuel (vysokoye komponentnoye toplivo), with a smaller rate of consumption and greater power have been worked on with some success. In particular, an advance was made sometime during the summer of 1961, when a knowledgeable Soviet officer stated: "The matter of high-calorie fuel has taken a great step forward".

9. So far, no solid (porokhovoy) propellant has been developed which can propel a large missile to a great range. The only solid type perfected is used in the free rockets, which look like pencils. Great care is required in the handling of these rockets, especially when they are being loaded. There was at least one incident when the frame of a rocket was slightly bent during loading, with the result that when it was placed in the launcher the friction ignited it, causing casualties. Efforts continue to be made to develop solid propellants, notably atomic fission, as described above.

10. Temperature is a big factor, and the limits have been scientifically calculated to range from  $-40^{\circ}$  to  $+40^{\circ}$  C. In some climatic conditions, parts have to be heated, and in the Far North it is either very difficult or impossible to handle liquid-fuel missiles. There the missiles have to use solid fuel (tverdoye toplivo). The components cannot be heated, and if (gun) powder is used it will ignite.

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Metallurgy

11. In addition to the problems outlined above, other difficulties have been met in the fields of metallurgy and electronics. In theory, one can enlarge a missile out of proportion in length and in width, but then it is necessary to adapt and develop corresponding electronic equipment so that the missile can be brought through the active (powered) phase with the necessary speed and direction. Recalculations begin and these lead to the conception of new electronic equipment. This is where the bottleneck occurs. It is necessary to assemble the housing and allocate all the spaces to the fuel feed devices, turbo-connections and so on. This presents no problem, nor does the technical recalculation required to make a larger combustion chamber - the development of combustion chambers has progressed well - the problem is that the metal does not yet meet requirements.

12. The Soviets are working on high-heat-resistant steels; some have been developed but they do not respond sufficiently to the demands made of them. Thus, when there is an increase proportionally of the diameter of the nozzle of the combustion chamber and the flow of fuel, the metal cannot stand up to the additional heat. Hence there is keen Soviet interest in Western developments in hard steels, such as the nimonics. As an experienced Soviet officer explained, it is not possible to increase the propulsion force still further by mechanical means, as the metal cannot support this increase when the fuel consumption rate remains unchanged, since it would result in the metal burning through, and this, in turn, if the fuel injector (forsunka) also burned out, would result in an immediate fuel leak, which would inevitably cause an outbreak of fire or the missile would cease traveling after the first 150-200 meters. The essential scientific balance would be disturbed.

Electronics

13. Electronics development is still lagging. More than one senior Soviet officer has stated on several occasions that electronic equipment is in short supply and of poor quality. The control system (apparatura upravleniya) is still unreliable; the actual assemblies and control elements are faulty; there are defects in construction; ~~components do not function exactly as designed.~~ There is also a lack of personnel trained in electronics. The fact that there are

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very few people with practical experience has an appalling effect on the efficiency of electronic techniques. Missiles used for training purposes do not land as planned; there have been many cases on the Kapustin Yar range in which they have landed on populated areas or railroads. There are still large lateral deviations at long ranges, and these have not yet been reduced to an acceptable minimum. In war, the Soviets plan to compensate for this by the use of nuclear warheads.

Testing Concepts

14. When a missile is prepared for testing and is actually fired, the data are taken down and form the basis for establishing the firing table. All deviations in impact are registered. Only after hundreds of missiles are fired, and they fall within allowable deviations, are the firing tables established exactly. Dozens and dozens are fired before a missile is accepted for production. This is also done under varying conditions, particularly at different temperatures. The main point is that firing tables are established only on the basis of actual firings, not on theoretical data.

Headquarters Comment: In previous reports, source used the word powder (porokhovoy) throughout to describe the solid propellant of the free rockets and the booster of the V-75 surface-to-air missile.

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