STAT

Page Denied

POPULAR SCIENCE LIBRARY

B.V.LYAPUNOV

THE ROCKET

68

NATIONAL CULTURE

B.LYAPUNOV

THE ROCKET

translated from Russian

by Branimir Kirkov

Co-Operative Publishers

NATIONAL CULTURE

PREFACE

This volume deals with one of the most interesting achievements of modern mechanics: jet-propelled engines.

Jet-propelled aircraft and jet-propelled artillery did not become a reality all at once, however, since a great deal of effort had to be expended before the rocket became a powerful engine and a terrible weapon. The noteworthy contributions of Russian scientists and inventors like Konstantinov, Tsiolovskiy and many others mentioned in this book, gave much impetus to its development invoking, at the same time, a real sense of pride in our national science and mechanics. It is the work of these men that has done much to secure the growth of rocket mechanics which developed rather rapidly as time went by during the second World War, when jet-propelled weapons were used extensively and when jet-propelled aircraft first appeared.

We are proud of our success in the field of rocket mechanics. The dreaded projectile-hurling "katiushas" with which the Red Army had spread havoc during the Great War for the defense of our fatherland, and the more recent jet aircraft in our Stalinite Air Force, demonstrated our success to the entire world.

Engines are now on the threshold of far greater possibilities. High-speed aviation, flights at extreme altitudes, and interplanetary travel of tomorrow, these are the greater possibilities. Engines still do not help us to surmount tremendous altitudes and to discover new secrets of nature. They do not yet permit flying extremely high, far, or fast. It is precisely in all this that the future contributions of our own science will be again of priceless merit, since we are going to be the first to give the world the scientific theory of flying, a theory which stems from the principles of aviation and the theory of jet propulsion and which will be based on rocket mechanics and interplanetary travel of tomorrow. This book discusses the rocket, - its past, its present, and its future - with the hope that a vast majority of the readers will become at first interested in the rocket itself only to engage

353

later actively in its further development with the aim of making our own rocket the best in the world.

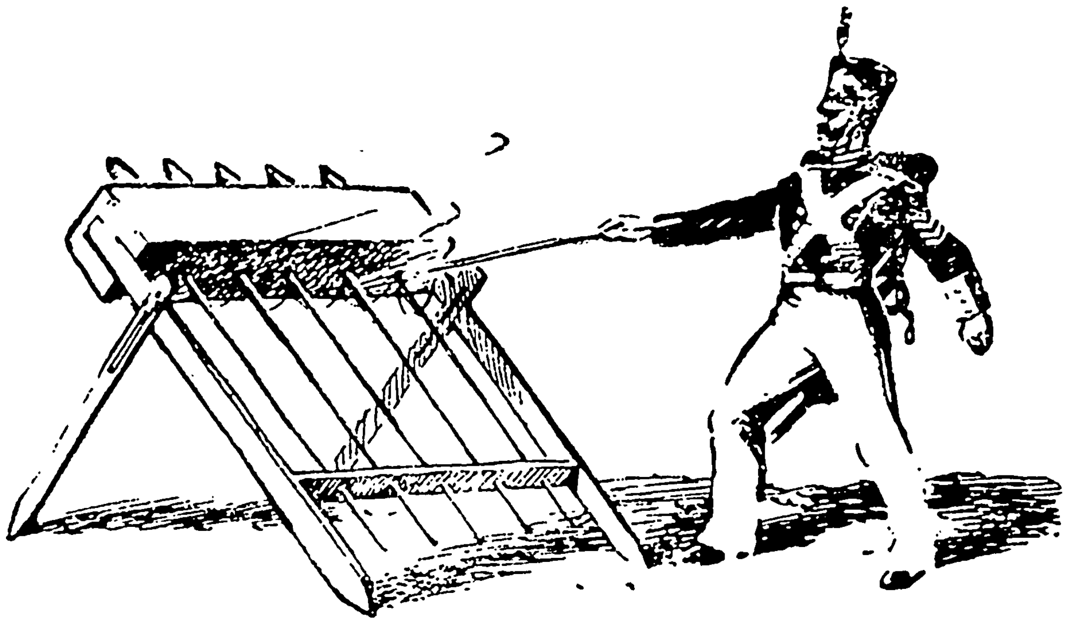
The author of this book expresses his heartfelt gratitude to academician and lieutenant general of Aviation Engineering Service, B.N.Yurev, to professor V.I.Dudakov and to the test pilot and lieutenant colonel, M.L.Gallay, all of whom helped immensely in the preparation of this book.

"Our task consists in utilizing the advantages of the Soviet social system for the purpose of securing a speedy and uninterrupted development of mechanical progress in our country... .

"It is imperative that we get to work at once on the implementation of newly introduced concepts in the fields of mechanics and production. I am referring specifically to this:... work on the development of rocket technology, applying it to new model engines which will in turn create new speeds and new power."

From the report by N.A.Voznesenskiy, chairman of the State Planning Commission of the USSR under the Five-Year Plan for the establishment and development of the people's economy of the USSR, years 1946 to 1950.

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3



ROCKET WEAPONS

History does not record the name of the first missile inventor. Its birth is traceable to the days when gunpowder first appeared.

Great achievements are often the result of very modest beginnings. Thus, the soap bubble led to the balloon and the paper kite led to gliders and engine-powered aircraft. The predecessor of the rocket was substantially a toy used for fireworks and ceased being one only when first used in warfare.

The missile was known among different peoples even in the most remote past. The Chinese named it the "fire arrow" and used it during the siege of enemy strongholds. When the ignited tail and the noise of the "fire arrow" no longer were able to scare the enemy, the Chinese converted it into a bow-catapulted incendiary missile which set fires in the enemy camps.

The missile was also known in Europe. The medieval science books describe various types of missiles, with instructions on how to construct them.

Many years were to pass, however, before rocketed weapons were to gain recognition.

It was not until the end of the Nineteenth Century that rockets were first used as an appreciable military weapon in India. They were made from the hollow stalk of lightweight bamboo, filled with gunpowder and provided with a long wooden tail. While these were their only structural features, the rockets were to become a rather terrible weapon in due course of time.

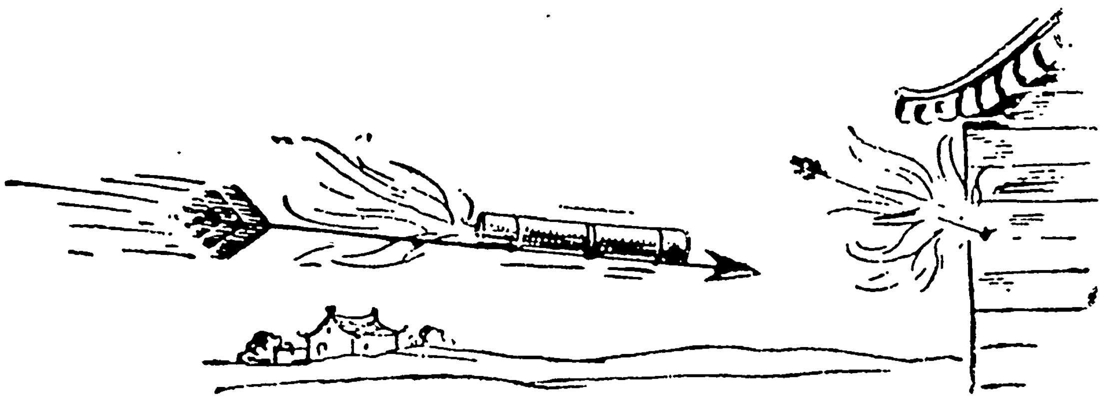


Fig.1 - Chinese Fire Arrow

The British General Congreve, whose soldiers experienced the impact of this weapon, understood this future well. As soon as he returned to England, Congreve began to experiment with rockets. The Indian rockets weighed five to six kilograms. The rockets with which the British shelled besieged Copenhagen in the year 1807, weighed already twenty kilograms and had a range of three kilometers.

All of the European States became interested in rocket weapons and started to form projectile-launching units in their respective armies. There was a boom in the number of pyrotechnical laboratories and rocket workshops in which various aspects of the explosives were studied and in which different types of rockets were made; some were made in the form of shells, some were made with grapeshot, some had flares, etc.

The first European rockets designed for warfare were crude prototypes. Like their earlier counterparts in China and in India, the European rockets had a simple structure. The only difference was in the replacement of the bamboo stalk with a metal cartridge case.

Those who actually did the firing of artillery projectiles observed that in practice the speed and range of the projectile depends largely on the volume of gases which are created by the combustion of the charge, whose amount in turn depends on the size of the external frame of the projectile.

In the early rockets, the combustive substance burned only on the outside of the frame. If a channel is drilled through the powder-charge chamber, the charge will not only burn on the outside but from within the channel as well.

A groove was made in the powder-charge chamber, creating just such a channel, and the rockets began to fly faster and farther.

An incendiary or explosive fuze was then placed into the rocket head. To prevent rotation in flight of the entire projectile, a long wooden tail was attached along the side of the cartridge case. Despite all this, however, the rocket remained unsteady in flight, while the attachment of a tail to the cartridge case was at best less than comfortable for firing.

When attached to flare and signal rockets of lesser size, such a tail was used as a ground-launching device. To put it another way, the rocket tail was simply stuck into the ground and the charge was then ignited.

However, the gas-operated and incendiary rockets increased gradually both in weight and dimension. The rockets began to weigh several tens of kilograms and sometimes a great deal more. The rocket caliber, or the diameter of its cartridge case, increased from 5 to 12 cm.

It was difficult to send such rockets flying upward after the tail was inserted into the ground. A launching platform or ramp was badly needed. In principle, the simplest device of this kind would be a wooden bipod. It would not, however, be very easy to do accurate firing from such a bipod. Instead, a tube was made and

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

mounted on a tripod. For the purpose of range-finding, the tube mounted in this manner could be elevated or lowered, or it could be traversed according to need.

But, no matter how simply the rockets were mounted, their construction was by no means easy. In one after another of the workshops where rockets were being made, unexpected explosions occurred.

To illustrate the point, let us take a look at enormously magnified powder flakes found in the cartridge case of the rocket. These gunpowder flakes will appear to us like a set of nuts placed in a glass. Between any two of the juxtaposed nuts there is an air pocket which fills the interspace. If the powder is ignited, the flame will spread rapidly via these air pockets and the charge will burn up instantly, creating a sudden explosion.

If the rocket is to fly over long distances without exploding, the powder charge must burn gradually. Therefore, if longer flights are to take place, the powder flakes must be compacted. This will cause the flakes to group closer together; consequently, the air pockets will diminish, while the flame will be prevented from spreading rapidly over the entire charge which, given this added condition, will burn gradually without setting off an explosion. While the gunpowder is being compacted, the air within the charge itself becomes more dense due to the absence of an avenue of escape and, in becoming denser, will heat up.

All the rocket loading was being done by hand. Quite frequently, the air would heat up to such a degree that the powder would catch fire and cause the gases to burst the cartridge case. Moreover, accelerated solidification of gunpowder provoked friction of its individual particles and a single careless tap sufficed in setting off an explosion.

Sometimes, already fired rockets would misfire and disintegrate completely in an area where they were not supposed to explode. As a result of such misfirings, the opponents of rocket development took a dim view of the fact that the rocket was unpredictable to the extent that it could inflict damage to lives and materiel not

STAT

only on the enemy but on their own army as well. There was a kernel of truth in this. Of course, not every rocket would burst at the wrong time and place. On the other hand, it is undeniable that misfirings did occur. The soldiers themselves cared little for such new weapons and looked upon them with fear and apprehension.

Some of the other rocket drawbacks were its short range and its poor accuracy.

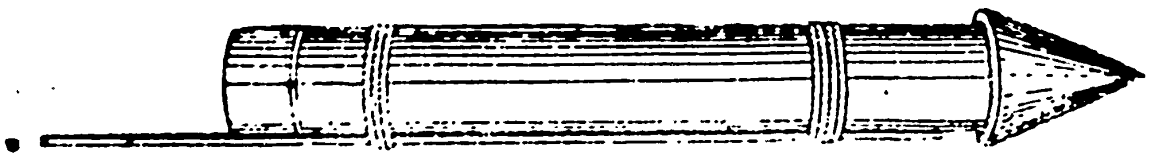


Fig.2 - Outer View of Rocket

At the same time, the rockets were not without certain advantages. Rocket weapons are quite maneuverable, they weigh less and are simpler than artillery pieces. It is also easy to arm with light rocket weapons such mobile units as cavalry and small naval craft. Rocket weapons could also be of enormous usefulness in mountain warfare.

When necessary, simple rocket-launching devices could be transported in large quantities from one place to another. The rocket was also less expensive than artillery shells in general and could be produced more rapidly than an ordinary artillery shell.

The rocket made quite an impression on the enemy unfamiliar with its effect. It flew with a loud whistling noise and a tongue of flame would project from its tail. Frequently, the rocket would ricochet from the ground as if it were seeking to take with it human lives even before the actual explosion would take place.

The French soldiers who first saw the rocket in Spain during the year 1814, became so panicky that they jumped with full field packs into the water, many of them perishing.

Rockets also made a strong impression on the cavalry. As it turned out, cavalry became one of the rocket's easiest targets. One or two rockets, fired in its direction, would send the whole cavalry unit running for cover.

These valuable warfare qualities of the rocket caught the attention of artillery experts, although the rocket was not as yet a weapon in the real sense.

The Frence Marshal Marmont said that "the rocket will bring success and glory to that genius who first grasps and then develops all of the advantages that can be expected of it".

A Russian proved to be precisely such a genius.

At the entrance of the main building of the Artillery Academy there is a marble plaque on which the names of those cadets who became known throughout Russia for their noteworthy work in the field of artillery science are inscribed with golden letters. The first place among them is occupied by the name of lieutenant general Konstantin Ivanov Konstantinov.

Konstantinov was graduated from the Artillery Academy during the year 1836 and devoted his entire energy to the development of rocket weapons. He can be rightfully called the creator of the Russian rocket weapons.

Konstantinov learned the history of the rocket and went abroad in order to familiarize himself with the production and the use to which the rocket was being put in foreign armies.

At that time, the foreign armies were leading in terms of sheer numbers of rocket units. Even naval craft of varying size were armed with rockets. Institutes for rocket research and pyrotechnical laboratories were appearing everywhere.

Nevertheless, the rocket still had many defects. Konstantinov, being not only an excellent engineer and inventor but also a Russian artillery expert, understood and correctly evaluated the enormous importance of the rocket within the framework of the Russian artillery. He did not exaggerate the role of the rocket. Instead, he understood clearly that artillery pieces and rockets were neither enemies nor friends but, rather, friendly rivals. There was still much work to be done on rock-

STAT

et improvement. It had to become accurate and able to span long distances and, at the same time, a way had to be found for eliminating its poor accuracy and its enormous consumption of combustible materials if a relatively large and safe production of the rocket was ever to be attained. It was with such thoughts that Konstantinov returned to Russia.

The glorious history of the Russian rocket started some two hundred years ago, long before Konstantinov began to work on it.

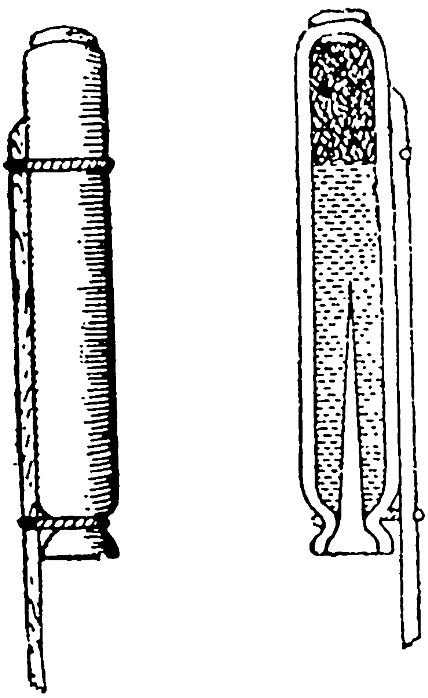


Fig.3 - Signal-Type Rocket from the Times of Peter I

Even Peter the Great was interested in it and, according to contemporary eyewitnesses, he made rockets by himself in a workshop. The signal-type rocket made by Peter the Great was used for the next two hundred years without significant changes. The road toward a rocket that could be used in warfare, however, was still a long one.

The Russian military rockets were to appear only at the time of the Russo-Turkish War of 1828-1829, when general Shilder armed a few tens of naval craft with them.

This is then the first page of the glorious history of the Russian military rocket.

We now pass over the next eighteen years.

In 1846, upon request of the Governor for the Caucasus region, Prince Vorontsov, the first set of rockets was sent there. Ten years later, Vorontsov wrote to the War Ministry: "When I saw the rocket in action..., it became at once clear to me that the rocket could develop into one of the most useful artillery weapons, especially in mountain warfare... . Of course, quite an inconvenience is created where the supply depot for such rockets is located far away and where only a few artillery

STAT

rockets are available at a time when we should have them everywhere in the required quantities, especially since it is either difficult, dangerous, or almost impossible to make any other type of rockets".

The early rocket workshops remained primarily small craft workshops in which it was extremely dangerous to work. Dispite this fact, the demand for rockets increased constantly. Rockets were then in demand by the tens of hundreds and even by the thousands.

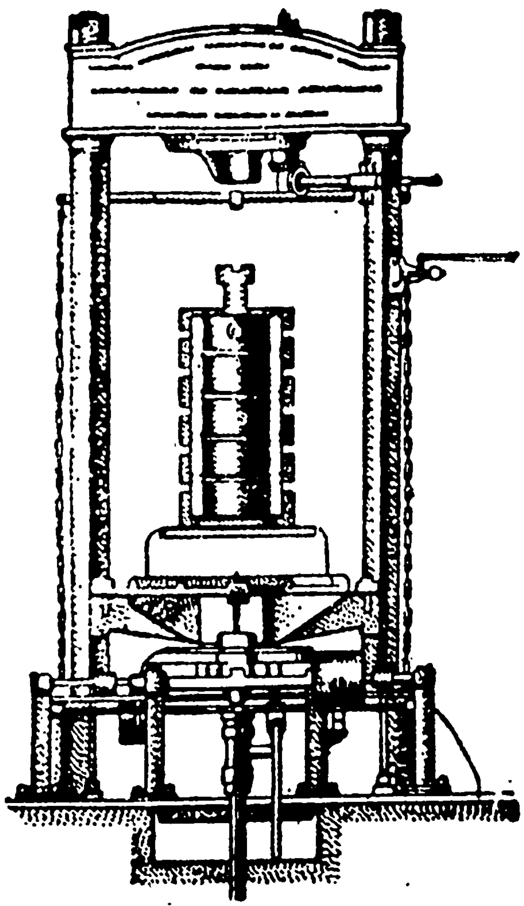


Fig.4 - Hydraulic Press for Rocket Loading

When he became officer in charge of the rocket workshop in St. Petersburg, Konstantinov began by making sure that the work done on the construction of the rockets would be safe.

How the pyrotechnician sweated in their efforts to avoid frequent explosions which took place during loading of the rocket. They were attempting in essence to develop a kind of gunpowder which would ignite only at very high temperatures. As a result, all the testing efforts were directed toward soaking the gunpowder in alcohol. Such a "wet" rocket required several weeks to dry before it could be actively used, however. Finally, the pyrotechnicians attempted to make a hole in the rod used for packing the gunpowder to let the air escape and thus prevent it from increasing in density and heating. However, all these attempts were unsuccessful.

The unique achievement consisted in substituting the dangerous method of loading the rocket by hand with a safer one, namely that of loading by machine. Konstantinov invented a special automatic press for loading of rockets, a press which was easy to regulate. Alongside the loading press, he placed a machine for cutting the cartridge case sheets and another machine for piercing holes into the powder compound. He also added other implements which improved and simplified the rocket production. Soon thereafter, Konstantinov announced with satisfaction that the St. Petersburg rocket workshop which, by that time, had become a regular machine factory, could fill all rocket orders of every military district unit of the Russian Army. In this way, Konstantinov solved the first problem in development of rocket weapons, namely that of establishing safe working conditions simultaneously with mass production of rockets.

Konstantinov also succeeded in increasing the range and accuracy of the rocket without a corresponding increase in man-hours. The results of this kind of work were not slow in becoming apparent: The Russian military rocket began to fly four times faster than its earlier model.

Konstantinov did not stop at this point either. He invented a simple and easy-to-use rocket-launching device as well as the means for transport. He selected a launcher which was lighter than the infantry weapons and which could be carries by the cavalry with ease. Work on the rockets was rendered less dangerous by a pretective tube which Konstantinov conceived.

Thus, Konstantinov solved the second problem in the development of rocket weapons: how to manufacture a long-range rocket which, at the same time, was easy to manipulate in action. Personnel throughout the Army became interested in the use of rockets, and it was not too long before rocket batteries and even a rocket corps were formed. It was, therefore, necessary to train a large number of instructors who could explain the use of the rocket. Konstantinov trained such instructor-specialists at the St. Petersburg workshop. He even designed a special rocket that was to be used for training and instruction of artillery personnel in rocket use.

Many officers of the Russian Army began to learn the methods of rocket produc-

STAT

tion and how it can be used in action. Within the framework of the artillery Detachment of the Guards Corps, a separate rocket division was formed. Konstantinov proposed the formation first of a training rocket brigade and then of a corps in which artillerymen from all the military units would learn the rocket use along with all types of rocket artillery, namely field, infantry, cavalry, blockade and fortress-defense types.

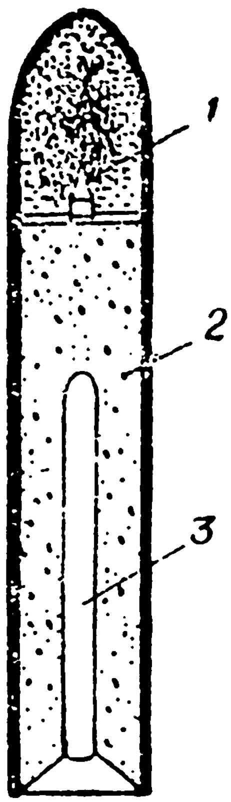


Fig.5 - Military Rocket

1 - Warhead firing pin

2 - Rocket combustible compound

3 - Empty space

Konstantinov was tireless in his efforts to familiarize Russian artillerymen with the new weapon, and soon the rocket ceased to be a novelty. Even regimental commanders asked for permission to form rocket batteries. It was also decided to arm the warships of the Azov Sea Fleet with rockets. Artillery units conducted constant target practice and experiments with the rockets.

No matter where it would be decided to use the Russian military rockets, one would always meet former students of Konstantinov.

The age-yellowed pages of publications dealing with the earlier war days of the rocket reveal the success of the Russian rocket weapons.

"The accurate rocket firing forced the enemy to abandon elevated positions and thus our charging cavalry met with little opposition", reported the officer in charge of a rocket battery in Turkestan.

"With frequent and successful firing we broke the enemy attack", reported the commanding officer of a rocket battery in Siberia.

In this way, Konstantinov solved the third problem in the development of rocket weapons, namely the availability of personnel skilled in the use of these weapons.

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

The rocket underwent a major experiment about the middle of the last century. On the basis of this experiment, Konstantinov established when and how the rocket can best be used. He created what was being called the tactics of the new type of weapons.

His book on military rockets, his lectures, articles, and resourcefulness became known throughout the entire world.

"The organization of the rocket production should proceed in accordance with the methods implemented be Konstantinov", recommended the foreign manufacturers engaged in importing from Russia machinery for their own workshops.

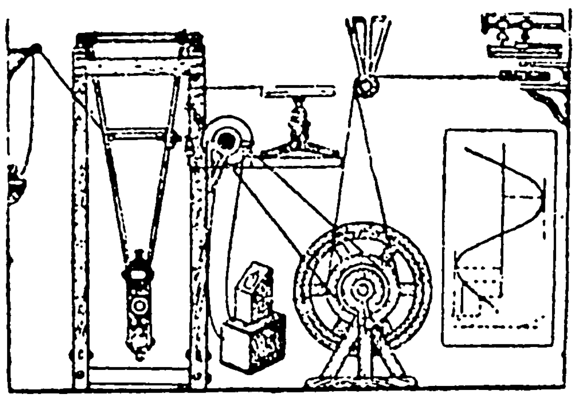


Fig.6 – Ballistic Pendulum after Konstantinov

Lieutenant general Konstantinov, who brought great glory to Russian-made weapons, gained world-wide recognition. For his achievements in the field of rocket development, Konstantinov was decorated with many Russian and foreign medals.

As a technician and a scientist, Konstantinov sought to complete still another task.

Whenever he worked on the construction and production of rockets, whenever he lectured, or whenever he wrote books, Konstantinov engaged in empirical observation. The well-known Russian scholar, Pavlov, called him a "tireless fact gatherer with a bug for learning". Thus, Konstantinov gathered facts, made experiments and kept observing the effectiveness of rockets.

Konstantinov constructed an ingenious device, the ballistic pendulum, which made it possible to observe the performance of the rocket.

"The rocket pendulum gave us many indications relative to the rocket effectiveness", stated Konstantinov.

STAT

Through observation, it was discovered that it is possible to develop a mathematical theory for rocket construction. Konstantinov came to this conclusion while studying extensive materials, basing it on the sum total of his own experiments.

Shortly before his death, Konstantinov wrote: "This is still a science to be developed".

Konstantinov was unable to develop this new science. He died in 1871.

This branch of science was worked out by another notable Russian scientist, Tsiolkovskiy.

The success of artillery, noted at the end of the last century, led artillery-rocket experts to double their efforts in order to prevent the rockets from falling behind the more advanced artillery pieces.

Camouflaged near-by targets can best be hit from above. In order to do so, the shell must be fired upward in a rather sharp curve. This is done by the howitzer.

Uncamouflaged distant targets can best be hit by firing the shells at not too high an angle but over a long distance. This is done by regular artillery pieces.

Thus, two types of rockets were being made. The first type would develop a very high and sudden speed and would fly upward at an acute angle, dropping head first on the target. This type was the diving rocket.

The other type would gather speed in progression and would fly over long distances, destroying remote targets. This type was the delayed-action rocket.

Artillery was becoming increasingly accurate. Various types of artillery pieces were being improved. Several of these, in discharging the shell, would make the latter rotate about its own axis with a tremendous velocity.

A body rotating at such speed is bound to be also very steady. The steadier the shell is in flight, the less it will deviate from the target and the more accurate will be the aim.

Rockets that rotate in flight were also manufactured. These rockets not longer had a tail attached. Gradient or propelling channels for the escape of gases were located at the rear of the rocket. The gases would propel the rocket forward, while rotating it like a wheel at the same time.

Nevertheless, the rocket started to fall behind in the race with artillery pieces. In principle, the rocket range was not inferior to that of an artillery piece. However, the artillery pieces were considered more successful. Gradually, the rocket was used less and less as reliance on the accuracy and long range of convention[illegible] projectiles increased.

However, work on rockets did not cease completely, since the rocket remained of accasional usefulness to artillery.

Rocket flares were used, for example, in the Russo-Japanese War. This is what A.Stepan[illegible], the author of the historical novel "Port Arthur", has to say about rockets:

"The soldiers carrying rockets... pulled out the launchers, placed a rocket in each and lit the fuzes... . The flame would travel over the fuze, and the rockets, releasing a sheaf of sparks, would leap into the sky. When exploding in the air, the rockets would fragment into literally thousands of burning stars, illuminating all emplacements in the area."

The flare-type rockets were being launched in still another way.

"Two soldiers crawled out of the trenches, carrying small rockets in their hands. [illegible] lights were attached to these rockets. On being shot upward, the rockets would flare and illuminate the entire area. The rockets then descended close to the ground 'crawling like snakes', as the soldiers were fond of calling them, and after traversing forty to fifty steps finally collapsed on the ground. In the meantime, the soldiers would spot the 'snake' illuminated targets and fire salvos from their fortified positions."

The rocket is also effective as an underwater weapon. For this reason, te[illegible] STAT were conducted to enable the rocket to travel underwater, like torpedoes. It turned out that a modified rocket of this type moved much faster than the regular torpedo which is set in motion by compressed air acting as a force which rotates the propeller. It was also proposed that a jet-propelled air torpedo be made. In doing so, an old idea was being used in a new way.

In the earlier days, to make the rocket spin, its rear section was provided with slanted channels.

Later on, it became apparent that to spin huge rockets or torpedoes weighing over half a ton, by using channels, was at best inadequate. For this reason, a chamber in which all the gases converged was installed ahead of the channel. In order to make the rocket fly further, tests were made on installing, at the gas exhaust, a full-fledged turbine which was to act as a gyroscope.

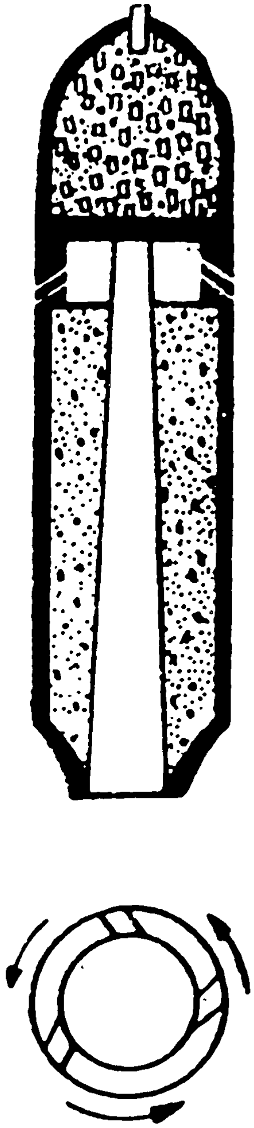


Fig.7 - The Rotator of the Military Rocket

Shortly before the first World War, the Russian scientist Pomortsev conducted experiments with rockets. His rocket differed from the ordinary type. Inside the covering, there was a compartment filled with air condensed to a pressure of 100-125 atm. Combustibles like gasoline or ether were then poured in. Over the surface of the rear part of the rocket body, Pomortsev attached a steel ring. With these added implements, the rockets were able to span 8-9 km.

Also in the earlier days, light naval craft were being armed with rockets. When the first airships appeared, attempts were made to arm them with rockets. In addition, testing was being conducted during World War I on arming airplanes with rockets.

Tens of rockets, mounted in tubes, were attached to the struts of biplane wings.

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

These first aerial rockets were not widely used, however. The rockets did not fly much farther, and the targets were frequently missed in flight.

Plans were being made to arm also fighter aircraft with incendiary rockets, to be used against naval craft.

Again, rockets were used for setting fire to captive barrage balloons.

The accuracy of rockets of naval and air-to-sea torpedo type was still far from being satisfactory. The results of World War I were such that, while very little was heard on the subject of rockets in action, the artillery and aircraft development advanced far ahead of the rocket.

At the end of that War, aircraft flew at speeds of almost 300 km/hr. The aircraft were armed with bombs and machine guns and tests were being conducted on arming regular aircraft with artillery.

Artillery had already attained firing ranges of 40 to 50 km. At the end of the war, artillery pieces capable of covering an area of over 120 km were in existence.

This success of the artillery was quite costly, however. Costly, since each round fired from these gigantic, long-range artillery pieces would cost up to several tens of thousands of gold rubles. The gun bores wore out rapidly, and the accuracy of the artillery piece decreased after firing the first few dozen shells. Averaging the time during which such an artillery piece is of maximum use, gives the startling figure of 2.5 sec! This is true enough: It takes 0.05 sec to fire one round from a long-range artillery piece. If we multiply this time by the amount of rounds, say 50, we will find that the average useful life of such a piece amounts to 2.5 sec.

Every 50 to 70 rounds, the barrel of the artillery piece would have to be replaced. As no gun carriage could alone sustain the 150-ton load of the huge piece, it was decided to mount it on the platform of a railroad car. Subsequently, it was also mounted on a 200-ton concrete base. Of course, it was not easy to move such a piece. In addition, it was not difficult to spot such a piece and to destroy it after having spotted it. For the new enemy of artillery, the airplane, this was a

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

relatively easy task. In the meantime, it was still necessary to be able to fire over as large a distance as possible.

The guns mounted on aircraft were not solidly emplaced. On the other hand, the piece did hamper the plane itself because of its recoil*. During World War I, a French aircraft was armed with a large-caliber gun for some time. This aircraft disintegrated in the air after its first shot, so strong was the recoil. Yet, shooting from aircraft could only be effective if a large-caliber gun was used.

The medium-caliber artillery pieces with which the infantry had to be outfitted before going into battle, created a dual difficulty. On the one hand, it was necessary to provide heavy artillery fire for the support of the advancing infantrymen, while, on the other hand, the artillery pieces had to be concealed, light, and mobile.

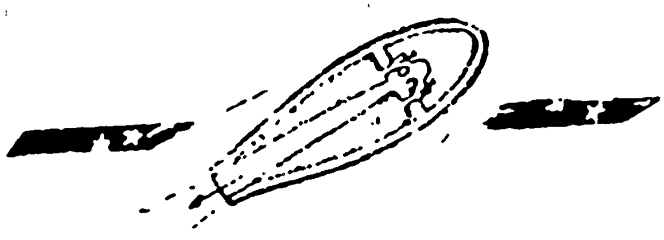
Any further improvement in artillery posed immense difficulties. A substantial contribution to the solution of these difficulties was provided by the rival of the gun - the rocket - whose theory was developed by the Russian scientist Konstantin Eduardovich Tsiolkovskiy.

---

* "Recoil" - a violent backward movement of the body of an artillery piece, occurring during the actual firing. In hand weapons, this is known as "kick".

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3



Chapter II

THE ROCKET SCIENCE

Attempts to explore the flight of rockets - as is the case today with aircraft and projectiles - with the aid of a clearer and more precise mathematical terminology, were made even before Tsiolkovskiy's time.

However, Tsiolkovskiy was first to arrive at the theory which was to become the basis for the new technology of jet propulsion.

Tsiolkovskiy was not just a scientist. He was an inventor who possessed a style of his own. The path which Tsiolkovskiy followed in his research was imaginative.

Men have dreamed of interplanetary travel for centuries. A large number of science fiction books dealing with travel between planets began to appear. Is there anyone who has not read the absorbing science fiction of Jules Verne and H.G.Wells dealing with the flights to the Moon.

What were the means by which science fiction writers proposed to do this, in their books ?

Some of the means proposed were artillery, volcanic force and rockets that would ascend at tremendous speed, all of which would be able to overcome the force of gravity; electricity harnessed from the Sun; centrifugal apparatuses; and scores of others. All of these means had one thing in common only: they were not conceived in vain.

As a youth, Tsiolkovskiy dreamed of interplanetary travel and tried to invent various means and ways in which it could be attained.

The first book he wrote was on the subject of the force of gravity that kept man on the ground. He conceived an amazing laboratory consisting of a falling trolley and a huge rotor with which the force of attraction could be altered at will.

He drew sketches of life on asteroids or small planetoids which, once reached by man, would give him adequate bases for eventual flight into space because of their insignificant specific gravity.

In his fantasy, Tsiolkovskiy "visited" the Moon and drew sketches of the enigmatic lunar world.

"In essence, the intertwining of thought and fantasy is unavoidable. Scientific observation thrives on this fact", wrote Tsiolkovskiy of inventiveness.

Thus, imagination produced scientific observation.

The rocket is capable of speeds that cannot be equaled by any other vehicle.

The rocket is capable of developing such speeds gradually.

The rocket can travel effectively in space as well.

This is what Tsiolkovskiy's scientific calculations were showing.

The fantasy transformed itself into science. What others were only imagining, Tsiolkovskiy proved.

He went further than that. He also formulated a mathematical theory for the construction of the rocket, a theory at which Konstantinov could not arrive.

Formulas worked out by Tsiolkovskiy demonstrated that the speed of the rocket depends upon the gas exhaust velocity which, in turn, depends on the heating potential of combustible materials. Thus, the larger the amount of combustible substances, the higher will be the speed of the rocket.

This is why black gunpowder, used in rockets for centuries, was a poor combustible substance.

If the combustible and explosive materials are arranged according to their relative quality as technical heating media, the gunpowder would be in the last place

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

ranking far below benzene, gasoline, or naphtha. Gunpowder, as a rapidly burning substance, is irreplaceable where artillery is concerned. In general, however, the rocket does not require a rapid burning process. "The ultimate speed of a rocket in space will not depend on its own explosion or on how and when this will occur", concluded Tsiolkovskiy."In terms of speed, it matters little whether this will be an evenly spread activity or whether it will be prolonged for a second or for a millenium."

Gunpowder is not usable in rockets designed for long-distance flights since the energy supplied by it is minimal. For this very reason, its use in aircraft would require such a large quantity that one kilometer traversed by an aircraft propelled by gunpowder combustion would cost several thousand gold rubles.

It was only a matter of time before he would be proven correct. Today, long-range rockets and jet-propelled aircraft use only liquid propellants.

Formula established by Tsiolkovskiy also demonstrated that the rocket can be used to the best advantage only if flying at enormous speeds. This opinion was also held by Konstantinov, who presupposed that the use of rockets in balloons, land-operating vehicles, and naval craft would not be advantageous. What Konstantinov presupposed, Tsiolkovskiy proved.

The formulas which Tsiolkovskiy worked out showed that a greater speed and altitude could be reached with a composite rocket which was to be made of several simpler rockets. Today, the planning of stage rockets, capable of crossing great distances - across the Atlantic Ocean - is steadily going on.

For a thousand years, the rocket was made for one purpose only - to destroy. The use of another type, namely a rocketed vehicle that would help man to conquer distances, never went beyond the planning stage. The science formulated by Tsiolkovskiy gave life to this second type.

Tsiolkovskiy composed the first set of blueprints for a huge passenger rocket propelled by liquid fuel. Subsequently, he devised plans for a jet-propelled rocket

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

engine fueled by liquid propellants. All contemporary liquid-fuel jet engines, both here at home and abroad, work on the basis of these plans.

If we take no matter what contemporary class of large rockets (long-range rocket projectiles, high-altitude meteorological rockets, liquid-fuel jet fighters or aerial torpedoes), we will find many things that Tsiolkovskiy foresaw long before the era of modern jet propelled aircraft.

Fig.8 – K.Ye.Tsiolkovskiy

Tsiolkovskiy's rocket was an entirely new type. As such, it created new problems which technology had to face.

No problem existed in reaching the propellant feeder line within a rocket, operated on gunpowder. This was done in the combustion chamber for the combustible materials.

This time the combustible substances were being kept separately and the feed had to be reachable. Tsiolkovskiy pointed out various ways in which this could be done. Tsiolkovskiy's ideas are now being used in modern rocket technology.

In rockets operating on gunpowder there is no problem of cooling its parts. Such a rocket does not have a long flight range and never heats up excessively.

The jet-propelled rocket engine, fed by liquid fuels, was designed to fly over longer distances and thus required cooling. Tsiolkovskiy proposed several methods for cooling. This too, is applied in modern rocket technology.

Rockets which run on gunpowder create no problem of guidance in flight. As the rocket began to fly over longer distances, it became necessary to be able to guide it.

STAT

Tsiolkovskiy pointed out various ways in which the rocket could be guided in flight. These ways are also being used in rocket technology.

The gunpowder-operated rocket created no landing problems either. Military rockets required no landing facilities for obvious reasons. Where there was need for making the rocket land, as in the case of signal type rockets, a parachute was used. For huge rockets and for future interplanetary rockets this would no longer be the case. It was therefore necessary to invent a way in which the landing of such rockets could be effected. Tsiolkovskiy again pointed out several ways in which this could be done. Once more, these were applied to rocket technology.

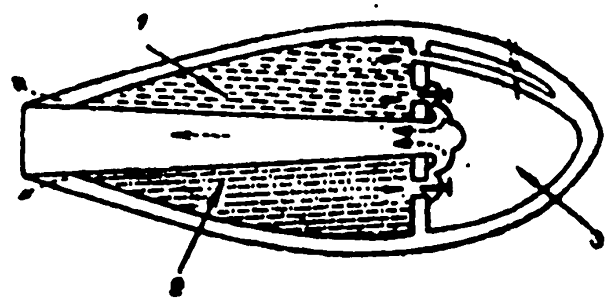


Fig.9 - Tsiolkovskiy's Rocket
1 - Liquid oxygen; 2 - Liquid fuel; 3 - Passenger cabin

Along the scientific path outlined by Tsiolkovskiy, the rocket advanced from rocket cars to rocket aircraft and stratoplanes (aircraft able to ascend to great altitudes).

Tsiolkovskiy was not only working with an eye on the contemporary technology of jet propulsion. He was working toward the technology of jet propulsion of tomorrow.

Approximately three months before his death, Tsiolkovskiy was visited by a correspondent of a Moscow newspaper to whom he explained the work he was doing, in some detail:

" - Much is being said today on the subject of flight to the stratosphere. Our daring pilots have already reached altitudes up to 22 km. What a courageous upward trend! My newest research deals with the basic principles of a design for machines capable of going outside the atmosphere, into the stratosphere, with the aid of jet propulsion... . These devices can be of two kinds: those which ascend perpendicularly without wings but which are capable of returning by means of automatic devices, and others like airplanes which are being flown at an angle and which have a cockpit. The cockpit can be pressurized or else the pilot himself would have to wear a protective suit known as skafander.* Such jet-propelled machines would not have to depend at all on atmospheric density and could fly not only into the stratosphere but beyond any boundaries as well. - "

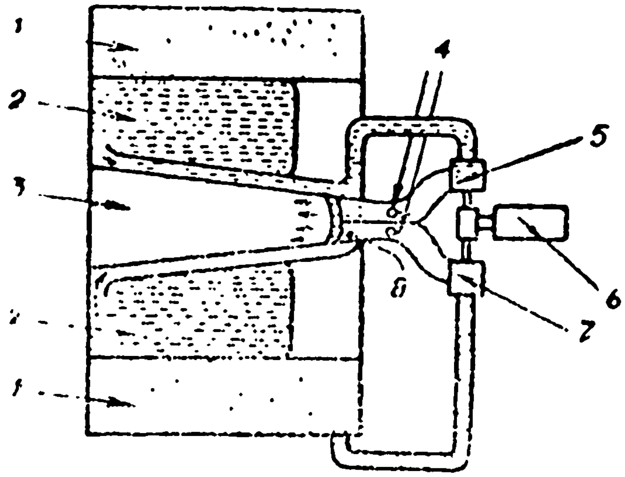


Fig.10 - Schematic Diagram for Jet-Propelled Engine, Fueled by Liquids

1 - Storage for liquid oxygen; 2 - Storage for combustible substance; 3 - Exhaust duct; 4 - Valves; 5 - Combustible substance feed pump; 6 - Motor for driving the pump; 7 - Oxygen feed pump; 8 - Grating

Tsiolkovskiy became quiet for a moment and then added thoughtfully:

" - My renewed efforts are a product of work over a period of many years and still not everything has been accomplished by far. I have to work much longer and harder before we can conquer the upper limits of the stratosphere and eventually reach beyond any boundaries. This can be done only by us, here in the Soviet Union. - "

"Beyond the Earth" was the title of Tsiolkovskiy's book dealing with future interplanetary rocket travel. In it, he imagined how people would gradually conquer the unlimited space of the Universe.

Imagination led to scientific calculations and technological ideas.

We can only marvel today at how elaborately and resourcefully Tsiolkovskiy worked on the development of interplanetary rockets.

He proposed ten types of interplanetary rockets - from a small rocket designed for testing purposes to the huge composite rocket capable of carrying a dozen

---

* A protective suit for diving or flying in the stratosphere.

passengers.

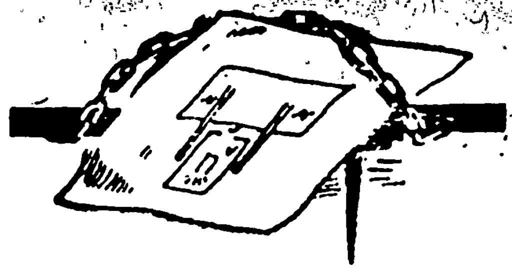
He also proposed devices which could be used for training of future interplanetary travelers.

He developed a launching device (catapult-action) for interplanetary rockets. He studied the probable living conditions during actual flights of an interplanetary rocket, foreseeing everything and including its re-entry into the atmosphere and contact with the Earth.

He invented a method whereby the rocket could safely return to Earth.

Only when keeping in mind how man-made rockets left the laboratory stage to fly faster than even the fastest of aircraft, can we appreciate the significance and the intellectual audacity of this Russian scientific genius. A genius who anticipated the day when the rocket would become the conqueror of the most untameable natural force - gravity.

STAT



CHAPTER III

THE ROCKET ENGINE

"The technology of reactive motion is the most difficult one in the world", wrote Tsiolkovskiy.

The entire history of the rocket engine confirms the premise expounded in these words.

Experiments directed toward the use of a sky-rocket go back to the times of antiquity, almost coinciding with the appearance of the rocket itself.

An ancient Chinese legend relates how an unsuccessful attempt to ascend to high altitudes with rockets was made. In due time, military rockets were perfected to the point where they could carry heavy shells over fairly long distances. It is therefore quite natural that inventors directed their thoughts repeatedly toward the rocket as a means for flying.

Among those who concentrated their attention on the rocket as a means for flying was a Russian inventor, Kibalchich, who proposed that rockets operating on gunpowder should be used. Kibalchich's project was singularly interesting because he grasped quite correctly one of the most important of the attributes of rockets: the possibility of it being guided.

Unfortunately, the outcome of Kibalchich's great ideas remained uncertain until the time of the great October Revolution.

Kibalchich was the first to approach the rocket as if it were merely another machine, based on and subjected to the same immutable laws of physics.

What are the laws which guide the rocket in flight? This is wh t the third fundamental law of mechanics states: "Every action involves an equal and op osite reaction".

Let us first examine the forces generated at the instant an artillery shell is set in motion, while still inside the gun barrel.

The force of the gases created by the gunpowder and acting on the shell is enormous. This means that the artillery piece ought to move together with the shell, only in a direction opposite to that of the shell. This is true enough: When firing takes place, a bullet or a shell will fly in one direction while the rifle or the artillery piece will move in another. The mass of the bullet or shell is many times less than the mass of the rifle or the artillery piece. Consequently, the effect of this force acting on the rifle or the artillery piece is insignificant. However, no matter how minimal the effect of this force, it will be felt exactly as is the case in firing rifles and artillery pieces.

Fig.11 - N.I.Kibalchich

We have known this force as "kick" or recoil. Its motion is the result of repulsion and can only accur where motion itself is present. The reactive force which propels the rocket is essentially the force of recoil. The only difference is that, in the rocket, this force alone will carry the shell in flight, while the motion of the shell will be created by the artillery piece.

This is how we came across the reactive force which was long hidden under a

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

wrong designation.

It is possible that this force was solely dependent on gunpowder.

If we ask what moves a car, you will automatically reply that it is being moved by the engine. You are wrong, since the engine does not set a car into motion. It only rotates its wheels.

The process is essentially as follows: The fuel burns in the combustion chamber of the cylinder block and moves the pistons which, in turn, set the crankshaft into motion. The latter then rotates the wheels which exert traction on the ground, finally causing the car to move forward. This is how long it takes the motion to be

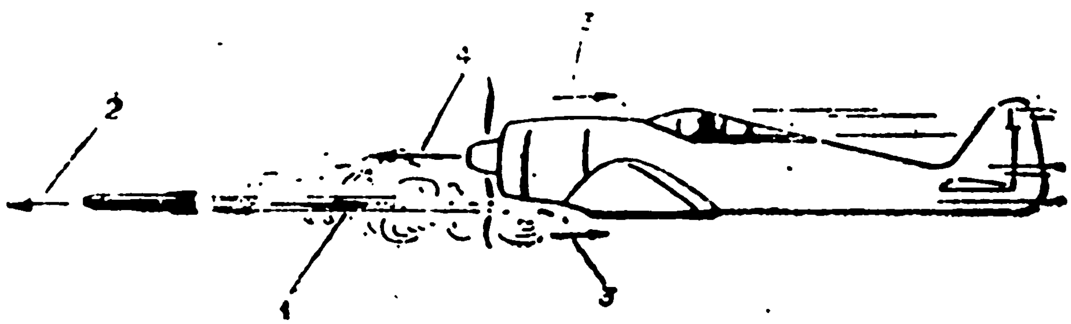


Fig.12 - Forces which Propel the Aircraft and the Rocket

1 - Gas stream; 2 - Force of reaction; 3 - Air scooped by the propeller; 4 - Propeller hub

transmitted before the car can move from its stationary position. It follows from this that the engine does not move the car but that it moves the wheels.

What is then the force which moves the car itself? It is produced by traction or adhesive friction of the ground and the wheels. The force of traction, the recoil, and the force of reaction are one and the same.

In traction we thus find still another designation under which the reactive force was hidden.

The earth is a compact body. Therefore, we can rebound from it. Can we rebound from the air? What moves an airplane, for example? Perhaps this time you will not be too quick in answering that it is the engine that sets the airplane into motion.

As in the automobile, the aircraft engine produces movement essentially in the same manner: the shaft rotates, setting the propeller in motion. The propeller scoops the air and, at the same time, hurls it backward.

Within a single second, the propeller of a modern aircraft will hurl backward about 150 cm^3 of air at great speed. In performing this repulsion of air, the propeller moves the entire aircraft.

This is also a force of reaction.

As established later, the force of reaction is involved whenever a motion takes place. For every action there is a reaction. This is one of the fundamental laws of mechanics.

This explains the presence of the reactive force. The force of reaction is thus the counteracting force of this law.

Sometimes it is difficult to perceive this force immediately, as was the case with automobiles and aircraft. The difficulty lies in the more apparent and misleading function of the intermediary parts, namely the wheel between the car and the ground or the propeller between the aircraft and the air. The motion is not derived through a direct reaction of these parts.

In rockets, the reactive force is immediately evident. The et engine creates a set of gas streams which move the rocket forward. The motion in this instance is derived by direct reaction.

The aircraft propeller hurls backward a large mass of air, but the speed of this process is relatively minor. Conversely, the rocket engine hurls backward a minor amount of gases but it does this at an enormous speed which is not the case with the intermediary part of the aircraft, namely the propeller.

The possibility of doing away with these intermediary parts attracted a great deal of interest among inventors. The first jet engine was constructed approximate-

STAT

ly 120 years before our era. It consisted of a kind of spherical structure with two bent tubes attached. This ball-like structure was made to spin by the force of the recoil of the steam issuing from the two tubes.

Inventor Segner constructed a reactive wheel driven by water. "Segner's Wheel" was used a great deal for teaching students attending physics laboratories throughout various schools.

The idea for exploring the reactive motion originated at a time when other types of motion were already being tried.

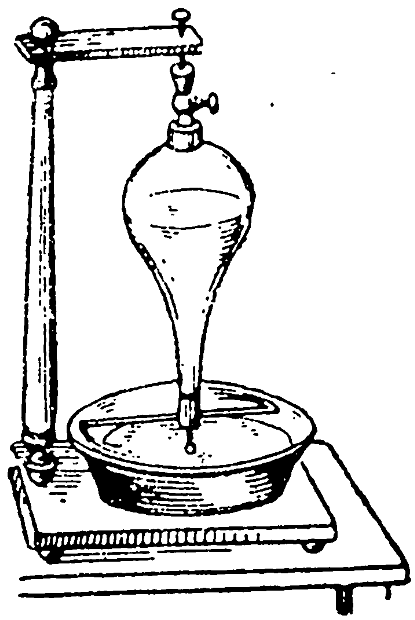


Fig.13 – Segner's Wheel

Along with vessels propelled by paddle wheels and screw propellers, there appeared ships which moved by reaction.

The water was sucked in through the forward part of the ship. The water then passed through the pump which hurled the water mass backward and out via the stern ducts, setting the entire vessel into a forward motion.

The first vessel propelled by reaction reached a speed of seven kilometers per hour.

During the next few years, the controversy between the advocates of the screw propeller and the advocates of the jet engine increased considerably. A huge ship, with a powerful steam engine which set the water pumps in motion, was constructed. At the same time, two ordinary screw-propelled vessels with dimensions similar to those of the ship propelled by reaction were being tested for speed. At that particular time, the jet-propelled ships already reached a speed of about eighteen kilometers per hour. In spite of its successful performance, the jet-propelled ship was outrun by its rival, the screw-propelled vessel, with comparative ease.

The inventors of jet-propelled vessels continued their disagreement. Their ef-

STAT

forts were now concentrated on finding a way to reduce the energy loss occuring while the water mass passed through the vessel itself. They perfected the water pump and constructed a jet-propelled ship that could reverse its motion: The ducts through which the water flows outward could now be inverted, changing the direction in which the ship had been moving previously. As soon as this was done, the inventors challenged the screw-propelled vessels to a speed match... and, once again, were defeated. The ship propelled by the force of reaction appeared to be less practical than conventional vessels since considerable energy was being lost through its internal work.

The inventors then proposed that reactive motion be applied to aircraft, also. In this, they were prompted by considering the possibility of utilizing this type of motive power as one which is simpler and less costly than any other.

In the case of ships, this power was to be supplied by water while in aircraft it was to be supplied by air. The air was scooped up by the aircraft propeller and then hurled backward into the atmosphere, all of which resulted in the creation of reactive motion. Projects of this kind began to outdistance all others. A strong resemblance was detectable in all these projects. The only difference was in the method by which the air was to be compressed.

Some inventors proposed that the entire craft should spin with its engine: its centrifugal force, by a rapid rotation of the central shaft, would force the air particles outward, collecting these at the bottom and thus creating the reactive motion.

Others proposed that a separate fan-like impeller be used for compressing the air.

Still others proposed that the aircraft carry within its structure small balloons which were to be charged with the compressed air prior to take-off.

Russian inventors carried out a series of tests for application of reactive motion to aircraft. In this undertaking, they were aided by circumstances which were

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

fortunate, namely by the fact that the Russian rocket technology was at a very high level and, in the realm of rocket construction, Russia occupied one of the first places among the nations of the middle of the Nineteenth Century.

"Toward a way of guiding balloons", was the title of a book written by the Russian inventor, the Engineers' Staff-Captain Treteski, who was working on blueprints for a jet-propelled balloon, back in 1849. The reactive power which was to move the balloon could be derived either from steam, gases, or compressed air discharged from openings in the stern of the balloon. Treteskiy named his balloons steam-balloons, gas-balloons, and air-balloons accordingly.

"The airship ought to fly as the rocket does" reasoned inventor N.Sokovnin who was working on a dirigible jet-propelled airship, as early as 1866. His airship was to move by the force of reaction, resulting from the streams of compressed air discharged through the bent tubes. In the opinion of the inventor, it was possible to guide the airship without its stern since these tubes could rotate back and forth.

The Russian inventor Fedorov advanced, in one of his books, the idea for a reactive apparatus which would be propelled by the recoil force of the compressed air or gases, as the case may be. His book was entitled "New method of aviation which would prevent the atmosphere from being a medium of resistance".

Fedorov was referring to a jet engine as the means for flying beyond the atmosphere and into interplanetary space.

Although projects of this kind failed to materialize, they showed that the Russian inventors were extremely interested in the idea of flying by means of reactive motion. They persistently continued to work on this idea.

Many inventors were working on the idea of flying by means of reactive motion, while they were engaged in experiments for the use of steam or gases generated by combustion of fuel, as was the case with the rocket.

All of them added something new, and patents or grants to inventors conferring upon them exclusive author rights, began to appear one after another.

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

Patents were especially widespread in the field of technical literature, which listed millions of inventions and as many authors... but which had few readers. The few who did read this literature were mostly experts from the patent office and the inventors themselves.

There was virtually no branch of technology that were not represented in the patent literature. There were also branches of technology presented only by a few patents and again others presented by hundreds and thousands of patents. The rocket branch was among the latter.

The emergence of the theory of reactive motion, as stated by Tsiolkovskiy, greatly facilitated the task of inventors by giving them the right direction, namely a direction founded upon science.

[redacted]

CHAPTER IV

BETWEEN THE TWO WARS

Aircraft preceded the liquid-fuel rocket by a quarter of a century.

However, the airplane appeared only after the rocket science was already formulated and the rocket technology already developed and firmly entrenched as such.

Both the rocket and the airplane served one major purpose - to help man get off the ground.

With the flying craft, man aspired to conquer the air space.

With the rocket, man planned to climb further and get beyond the range of the aircraft.

Aircraft and rocket did not have the same fate.

The first World War led to the development of a new kind of weapon, military aviation. The airplane itself predated this weapon by fifteen years.

The new rocket appeared only during the second World War, since it took all of four decades to develop it.

The new rocket was developed through the joint efforts of a whole army of scientists and technicians. Their work resembled an active order of battle formation. Over and above the entire army, there were reconnaissance men - the scientists. They discovered new avenues of approach, pointed the way, and crystallized problems that had to be solved. Next came the advance patrols - the inventors, who sought to find immediate solutions to these problems. They were finally followed into the bat-

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

tle by the main bulk of forces: the engineers, technicians, overseers, and designers who, in turn, experimented, tried out, checked, constructed, and applied.

In this instance, as in any battle, the immediate deployment of forces may have varied as one action led to another, but the main objective remained the same: to construct a rocket that can fly fast, high, and over long distances.

Twenty-five years were to pass since the turn of the century, which is when Tsiolkovskiy formulated the rocket science, before such a rocket would be ready for its actual take-off.

Many difficulties had to be resolved first.

Above all, a suitable type of fuel for the rocket had to be found. This fuel would have to have a high heating value. Its relative efficiency would have to be very high if bulky fuel chambers were to be avoided.

This fuel would have to boil at high temperatures without evaporating prematurely, if it was to supply a steady heat requirement from the fuel chamber.

Two heating agents, fuel and oxygen, would have to mix well within the chamber. These agents would have to be readily inflammable and capable of rapid combustion.

Finally, such fuel would have to be readily available at low cost.

There are many forms of liquid fuel. When the actual selection of the fuel most suited for the rocket propulsion took place, no single form of fuel was found to be adequate - not even emulsions of highest quality. In order to get such a fuel form then, a suitable oxidizer had to be discovered.

As the search for the final fuel product that would best suit the rocket went on, a series of emulsions involving fuel substances and oxidizers were tried out. Hundreds and even thousands of experiments and observations to this effect were made. Nor were these the only difficulties.

As the fuel burns, the pressure within the internal combustion engine mounts rapidly.

This also occurs in the cylinder blocks of ordinary engines, with the following important difference: The pressure increases and decreases at regular intervals allowing the fuel to enter at the moment when the pressure is lowest.

In the rocket, the chamber is working under constant high pressure which prevents an easy inflow of fuel. To resolve the problem of feeding the fuel into the chamber, it was decided that a kind of compressed gas ought to be used. This gas was to be forced into balloon-like containers located directly above the combustion chamber. As the gas expands, its counterpressure would drive the fuel into the chamber.

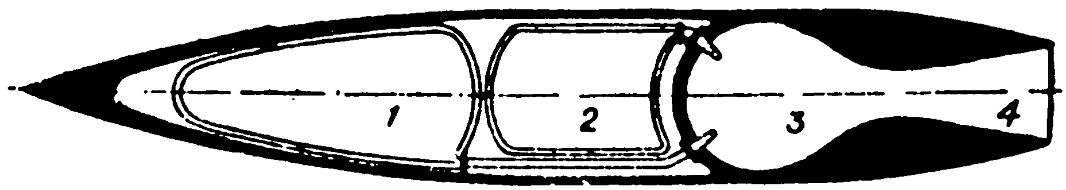


Fig.14 - Sketch of a Liquid-Fuel Rocket

1 - Tank for liquid oxygen; 2 - Fuel chamber; 3 - Combustible chamber; 4 - Gas exhaust duct

Feeding the chamber in this way turned out to be exceedingly awkward. Besides the constant high pressure within the chamber, its walls were thick and too heavy. This very problem had already taxed the imagination of Tsiolkovskiy.He proposed that a fuel pump be constructed instead. In this way, the walls of the combusion chamber could be made considerably thinner and the whole bulk thus lightened.

The jet engine requires a huge amount of fuel many more times than the ordinary aircraft engine. Only a pump could do the job of feeding the engine with hundreds of kilograms of fuel without great difficulty.

A great deal of effort was still required before the fuel could be fed into the combustion chamber with ease. Much work ensued. The oxidizer and the fuel had to be well matched. The fuel had to burn up rapidly without creating a deposit of combustion products.

As a result, it was proposed that a two-part chamber be constructed. Within the first part, the mixing of fuel components would take place along with the fuel ignition. The actual combustion of the ignited fuel would be completed in the second part. Constant mixing of the fuel components would be ensured by their constantly being agitated during the flight.

The ignition of the fuel itself provided still another difficulty.

The first rockets frequently exploded on take-off.

No one knows exactly how many ways of igniting the fuel were tried at one time or another - from the simplest way of placing guncotton at the end of a rod, to ignition by electrical or chemical reaction. This problem was finally solved also.

At present, the fuel is fed into the combustible chamber where it is burned. Here another difficulty, that of heat occurs. The chamber temperature reaches as much as 3500°. At such temperatures, many substances not only melt but boil as well. This difficulty is by no means restricted to the chamber alone. The end opening of the duct from which the discharged gases issue is subjected to intense heat and tends to wear rapidly as a result of the enormous exhaust velocity which may be as high as two thousand meters per second.

Tsiolkovskiy pointed out that the combustion chamber and the nozzle of the gas exhaust duct would have to be made of the strongest heat-resistant steel alloys. Since this alone might not be adequate, he maintained that both the chamber and the nozzle should be cooled.

Tsiolkovskiy came up with a simple way for doing this: The fuel itself would act as the cooling agent. It would first absorb the heat from the metal parts of the engine and then diffuse it, after intensification, throughout the fuel chamber. Such a transfer of heat would also facilitate the ignition of the fuel itself. Thus, one more problem was solved.

At the beginning, the combustion within the rocket engine lasted only a brief interval of time. Later, liquid-fuel rockets capable of continuous internal combus-

STAT

tion appeared. The fact that their engines could now be used as aircraft [illegible] presents the result of persistent efforts in the field of rocket development between the two Wars.

The gases issue from the nozzle of the exhaust duct, propelling the rocket forward at ever increasing speeds.

But, the rocket still had to be guided in its flight trajectory.

To this end, Tsiolkovskiy proposed that a rudder impeller, made of strong heat-resistant materials, be placed in the path of the gas stream, as was the case in the juxtaposition of the aircraft control surfaces and the air flow. When tilted to one side, the rudder vane would change the direction of motion of the exhaust which would in turn change the course of the rocket. The rudder vane could be tilted automatically.

This is how the large rockets were to be steered in flight.

Large rockets appeared relatively late.

The first liquid-fuel rockets were rather small in size and were never used for actual flights. They were mounted on the launching platform while observations relative to their gas-stream performance were made. Serious mishaps occurred even with these small rockets, since occasionally the fuel chamber exploded or the combustible chamber burned completely in its own flames.

When the construction of larger rockets took place, additional protective measures had to be taken. The rocket engine would be set in motion by remote control from a great distance, while its effect would be observed with binoculars and field glasses, as if the rocket were a wartime enemy.

All the observing was done behind a heavy concrete wall. Explosions and ensuing fragmentation were not infrequent and closely resembled actual combat conditions.

Nevertheless, the day when the victory was won finally came. The liquid-fuel rocket, developed by the Soviet inventor and Fellow of the Artillery Science Academy, M.K.Tikhonravov, underwent a series of highly successful flight tests. As the news-

STAT

tion appeared. The fact that their engines could now be used as aircraft engines represents the result of persistent efforts in the field of rocket development between the two Wars.

The gases issue from the nozzle of the exhaust duct, propelling the rocket forward at ever increasing speeds.

But, the rocket still had to be guided in its flight trajectory.

To this end, Tsiolkovskiy proposed that a rudder impeller, made of strong heat-resistant materials, be placed in the path of the gas stream, as was the case in the juxtaposition of the aircraft control surfaces and the air flow. When tilted to one side, the rudder vane would change the direction of motion of the exhaust which would in turn change the course of the rocket. The rudder vane could be tilted automatically.

This is how the large rockets were to be steered in flight.

Large rockets appeared relatively late.

The first liquid-fuel rockets were rather small in size and were never used for actual flights. They were mounted on the launching platform while observations relative to their gas-stream performance were made. Serious mishaps occurred even with these small rockets, since occasionally the fuel chamber exploded or the combustible chamber burned completely in its own flames.

When the construction of larger rockets took place, additional protective measures had to be taken. The rocket engine would be set in motion by remote control from a great distance, while its effect would be observed with binoculars and field glasses, as if the rocket were a wartime enemy.

All the observing was done behind a heavy concrete wall. Explosions and ensuing fragmentation were not infrequent and closely resembled actual combat conditions.

Nevertheless, the day when the victory was won finally came. The liquid-fuel rocket, developed by the Soviet inventor and Fellow of the Artillery Science Academy, M.K.Tikhonravov, underwent a series of highly successful flight tests. As the newspapers reported at the time: "The flight of the rocket presents an extremely beautiful spectacle. The cigar-shaped silvery body of the rocket is placed upon the launching platform several meters high. The actual take-off is triggered by means of an electric switch located half a kilometer from the launching site. As soon as the switch is thr , a strong oise is heard and almost simultaneously a narrow flame tongue appears at the rear of the rocket and mushrooms into a light-yellow flower bud. The rocket then slides upward along the straight rails built into the launching platform and, finally, is hurled into the air. Upon reaching its uppermost point of

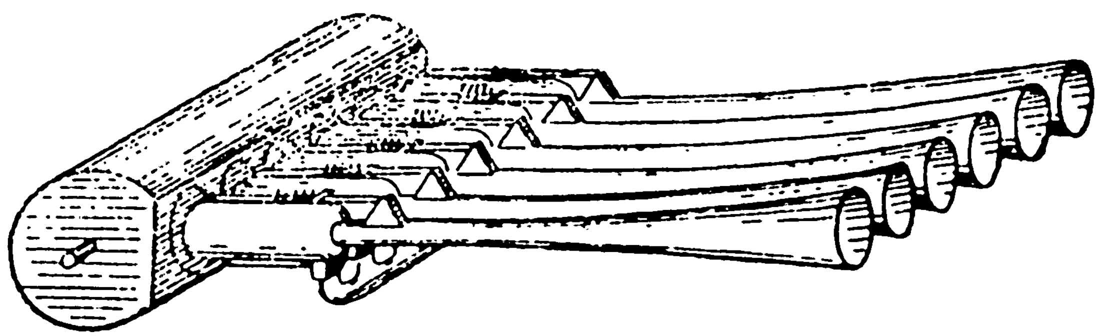


Fig.15 - Project for the Air-Jet Engine

elevation, a white parachute opens, and the rocket descends slowly to the ground."

This is what happened fifteen years ago. Today, similar rockets will ascend to altitudes up to 180 km, and even this is far below the possible altitude a rocket can attain in the future.

Despite these successful achievements, the rocket fueled by liquids had one major drawback: It cons d too much fuel. If such a rocket is mounted on a flying aircraft, it will become apparent that excess weight is being carri in the form of oxygen which can be obtained directly from the air. The fact that oxygen can be tapped directly from the air was utilized later in constructing rocket engines known as air-jet engines. The air-jet engine requires only fuel to run, and therefore the choice of the latter must be made more carefully than in the case of the liquid-fuel jet engine.

STAT

During the year 1908, an inventor proposed that an initial air-jet engine be constructed. In doing this, he fastened to its cylinder block a set of exhaust nozzles through which gases, formed within the cylinder block, were discharged into the atmosphere, giving the rocket its reactive thrust.

But, before the air-jet engine became a part of regular aircraft, an additional thirty years had to pass by.


Fig.16 - N.Ye.Zhukovskiy

As early as the 1880's, the great Russian scientist and inventor, N.Ye. Zhukovskiy, wrote a book on the reactive action of the liquid jet exhaust.

The nature of the reactive motion greatly interested Zhukovskiy. His entire scientific effort was centered on this subject.

His unusual inventive versatility led him to construct models of the autogiro, helicopter rotors, and air-jet engines, As Academician Leybenzon put it: "N.Ye.Zhukovskiy realized that the main difficulty lies in constructing a relatively light-weight engine. 'The heart of the aircraft is its engine', asserted Zhukovskiy. That is why he invented the air-jet engine. The forward part of this engine is so placed as to be in direct contact with every blade of the impeller. As the impeller rotates, the air is taken in through part of the engine where it is mixed with [illegible] which has been fed through the impeller hub. The combustible mixture is ignited by electrical means, and the generated gases are discharged through a nozzle located at the tail end of the entire reactive device. The impact of the reactive power, derived in this manner, centers along the main engine shaft which, in turn, causes the impeller to rotate."

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

The closest relative of the propeller is the jet gas turbine. The impeller of a turbine is rotated by the impinging action of the reactive power of the gases, or, to put it another way, the gases which issue from the end openings or exit nozzles revolve the bucket wheel of the turbine.

The Russian inventors worked out the original plans for reactive turbines.

In one of these turbines for example, the fuel mixture is compressed and burns within the piston cylinder block, while the spiral-shaped side ducts at the bottom

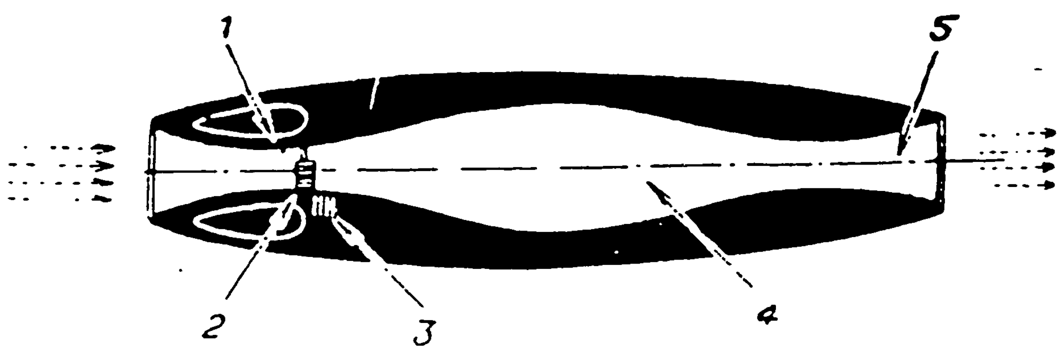


Fig.17 - Free-Burning Jet Engine

1 - Fuel; 2 - Fuel feed; 3 - Ignition device; 4 - Combustion chamber; 5 - Exit nozzle

of the cylinder block discharge the gases, thus rotating the impeller in a manner similar to the action of the waterflow on a Segner Wheel.

Another turbine with separate fuel chamber resembles a multiblade propeller: A continuous series of internal combustions occurs within the chamber and the turbine impeller rotates rapidly.

A combined steam-gas turbine has three chambers. In one, fuel is burned while in the other water is evaporated. The action within the first two chambers heats the walls of the third, from which gases are discharged at the exit causing the turbine rotor to turn.

Fellow of the Academy of Science, B.S.Stechkin, formulated a theory of the air jet engine while engaged in the further expansion of the work done earlier by Z[illegible]skiy. This theory made a tremendous contribution to the development of this type of engine. Zhukovskiy examined the effect of the liquid jet exhaust in relation to jet airships. Stechkin studied the reactive effect of the air stream on the fuel in relation to the jet aircraft engines.

Both in the air-jet and in the ordinary piston engine, a mixture of fuel and air is burned. This is why the two types resemble each other.

In the piston engine, the mixture of fuel and air is compressed in its entirety. This compressed mixture burns immediately inside the cylinder block. As the gases expand, they move the pistons which, in turn, move the propeller shaft.

In the air-jet engine, the mixture of fuel and air is not entirely compressed – only the air part of the mixture. The compressed air then enters the combustion chamber where the fuel is added.

This is the case with Diesels. In the cylinder block of Diesel engines only the air is compressed while the fuel is injected into the cylinder block.

Despite these similarities, the air-jet engine differs from ordinary engines. Its gases are discharged at the exit of the combustion chamber and thus create the forward thrust.

Although this solved the general operating principle of the air-jet engine, the inventors still had to cope with serious difficulties.

The air had to be compressed first and the inventors disagreed widely on how this was to be done. One group of inventors took the easiest way out. Since the flying aircraft moves through the air at a very high speed, the air ram against it creates a pressure force that can be harnessed for air compression. No simpler free-burning air-jet engine, as some people call it, can be conceived. This looks like an athodyd with an inside duct of equal length, open at both ends. During the flight, the air enters the forward end of this duct and there becomes fully compressed, due to the ram impact of the speed. The air thus compressed then mixes with

STAT

the fuel and the resulting gases flow out through the rear-end opening which is nothing more than an extension of the pipe-channel.

Attempts were made to arrange the engine in still another way, namely to separate the combustion chamber from the exhaust portion of the duct by means of a valve partition. While the fuel is burning, the combustion pressure increases and closes the valve. As the gases flow out, the pressure decreases and the valve opens. At the same time, fuel has to be injected.

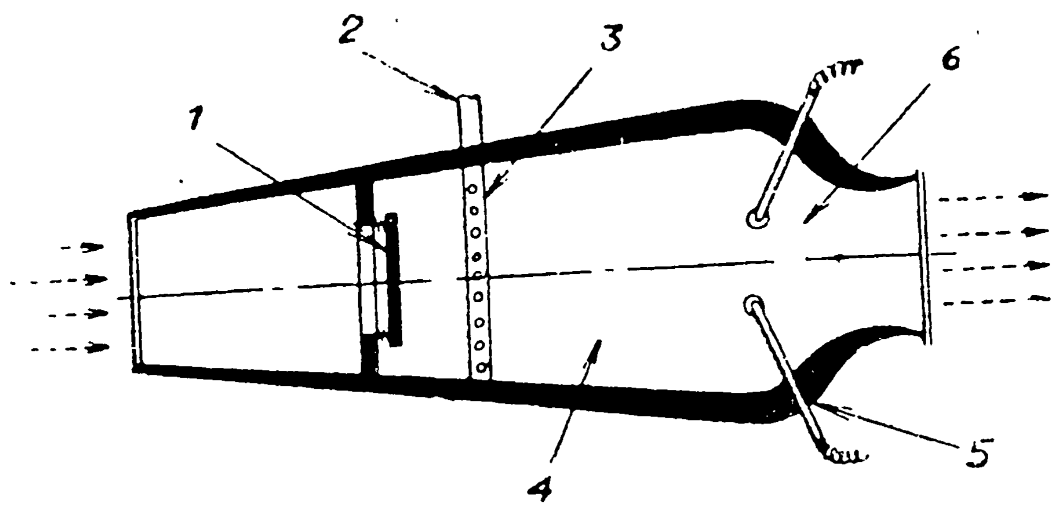


Fig.18 - Air-Jet Pulse Engine

1 - Valve; 2 - Fuel feed tube; 3 - Atomizer; 4 - Combustion chamber; 5 - Igniter; 6 - Exit nozzle

This is the so-called pulse-jet engine and is very similar to the one Tsiolkovskiy discussed. This engine is slightly more complicated than our ram-jet engine. At the same time, it is a lot simpler than some of the other engine types.

Both of the engines proposed by the inventors had one drawback: They were not suitable for low-speed flying.

If combustion is to be complete, there must be enough air pressure and, in order to have enough air pressure, the speed must be very high. Our simplest air-jet engines will thus start to work only at high speeds, and their maximum efficiency

STAT

will be maintained only as long as the speed remains high.

Proposals were made for still another type of a very simple air-jet engine. Air can be compressed once it has been made to rotate, which means that its compression cam be obtained by means of the centrifugal force which increases away from the propeller shaft. The point of the highest speed impact is located at the tips of the

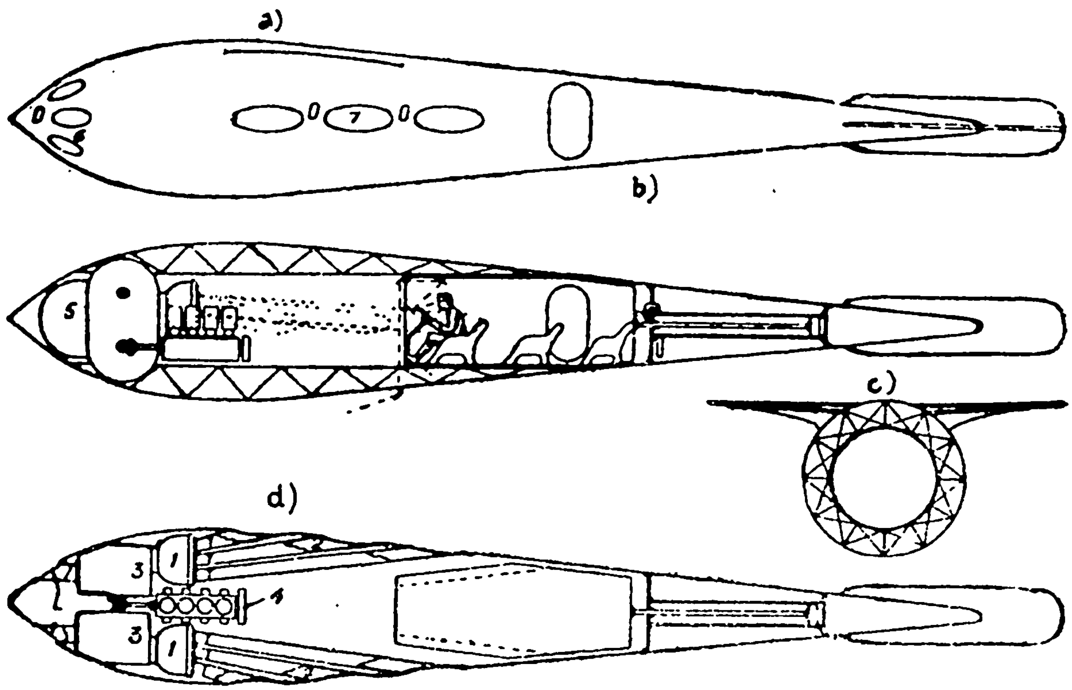


Fig.19 - Aircraft in Flight with a Jet Engine, of the Gorokhov Type

1 - Combustion chamber; 2 - Exit nozzle; 3 - Compressors; 4 - Motor; 5 - Fuel tank; 6 - Air intake nozzle; 7 - Gas exhaust nozzle a) Exterior view; b) Longitudinal section; c) Cross section; d) Base plan

propeller blades. If these radial blades are curved inward, the air will be scooped up by them and will be compressed as the propeller rotates. Only fuel need then be added and the air-jet engine will work. Here too, the air compression proved to be insufficient.

Another group of inventors followed a different approach which was more complicated but, at the same time, more fully worked out.

Making the air rotate was their main concern; however, the means for making the

STAT

air spin would have to be much faster in performance than the hollow blades of ordinary propellers, if air is to be efficiently compressed. This job can be done by a separate piece of machinery - the compressor.

A compressor must be made to work before it can compress air.

The compressor can be made to operate by means of an ordinary aircraft engine.

As early as 1912, the Russian inventor Gorokhov proposed an airplane with an engine to this effect.

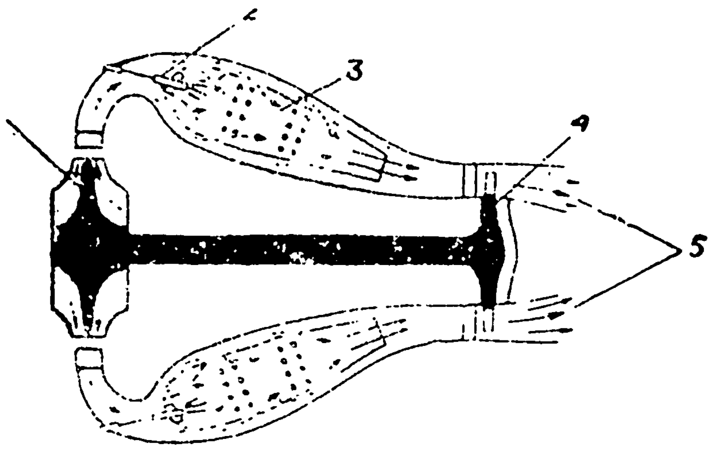


Fig.20 - Turbojet Engine

1 - Compressor; 2 - Atomizer; 3 - Combustion chamber; 4 - Gas turbine; 5 - Exit nozzle

Although propelled by an ordinary engine, this airplane was by no means ordinary in design. It had no propeller. Instead of the propeller, its engine revolved the compressor.

But, since the conventional engine was retained, some of its drawbacks remained also.

Therefore, the inventors sought to replace the conventional engine with a new power plant - the gas turbine which would make the compressor work.

The original inventor of the gas turbine gave it only modest functions: to revolve a furnace poker, to toll a bell, to swing a seesaw, or to perform other domestic chores.

It so happened that the gas turbine transcended this modest framework and began to be used for the most diversified technical applications.

Thus, the gas turbine was applied to the airplane.

When the turbine rotor is placed in the path of gas streams within the air-jet engine, it will revolve as a result of the power of the gases acting on it. The gases can then be released into the atmosphere. The compressor is linked to one of the

STAT

turbine shafts which will rotate it, causing it to compress the air.

The radial blades of the turbine heat up immensely besides revolving at very high speeds. It became necessary to construct an especially hard and heat-resistant type of steel for both the engine and the turbine blades, a steel that would be 100% stronger than ordinary steel. It is this kind of steel that made the construction of the gas turbine possible during the second World War. With the turbine came the military jet aircraft.

During the interwar years, our old acquaintance - the gunpowder rocket - was not forgotten. The only difference now was that the inventors did not attempt to waste time on useless work. They knew that wherever the rocket is required to span great distances and hence maintain a constant internal combustion, gunpowder will no longer do. Short-range artillery, this is where the rocket belongs.

Men specializing in various fields were now working on the rocket.

Chemists were discovering new and better types of gunpowder.

Metallurgists made new rocket materials such as the stronger and lighter steel alloys.

Artillery experts equipped the rocket with a fuze and, together with aerodynamics engineers, observed and studied the rocket motion and its flight stability.

Many ways to make the rocket in flight stable were being proposed. Among these, some were quite original, as for example the proposal to equip the rocket with collapsible wings. On firing the rocket, a set of springs would eject the wings causing them to open and spread out. Proposals for the construction of propellerlike wings were also made. These wings would be rotated by the force of the oncoming air. One of the inventors even proposed that the rocket ought to be made to spin by means of an electric motor before being fired into the air.

Finally, the rocket was equipped with a stabilizer similar to the one used in airplanes, while the larger rockets acquired still another airplane feature - its wings.

STAT

Gradually, the new rocket was built. Compared to this new rocket, some of the earlier models look like Stevenson's "rocket" when compared to a locomotive of today.

The history of weapons is a continuous duel between the forces of attack and defense: the shell and the armor, the bomb and the reinforced concrete.

In order to be able to destroy the new reinforced concrete or armor-clad materiel, the bomb has to possess a tremendous speed. This is why the bomb has to be dropped from high altitudes. The high altitudes reduce the accuracy of the bomb, however. The rocket can drive the bomb rapidly downward on the target. Subsequently, there appeared airplane rocket bombs that could destroy a tank on the ground as if it were an egg shell.

The rocket was not only a weapon used by the airplane. It was also used against it. Many projects for antiaircraft rockets were being proposed.

It was proposed, for example, that the rocket be used for carrying metal wires into the air. The wires would then "catch" the propellers of the passing aircraft, causing the latter to crash. Someone also thought of using an artillery shell charged with rockets which were to act as shrapnel balls.

Attempts were made also to equip the rocket with automatic guns which would spray bullets in the vicinity of the rocket.

It was not for long that rockets were used exclusively by artillery. Soon, they were used as an aid to aircraft. Mounted under the airplane wings, the rockets facilitated the landing of the airplane by reducing its landing speed.

When heavier airplanes were used, the rockets would act as take-off boosters. Occasionally, rocket catapults were used too.

The rocket was given still additional functions. It was used as an antihail measure. On firing two or three rockets into the hail-carrying cloud, rain would fall instead of hail, since the rocket explosions dispersed the air masses which tended to create the hail.

Rockets were also used for the purpose of liaison across rivers, gorges, and shore-to-ship liaison in the rough sea zones. Rescue rockets which carried rope to sinking ships were widely used back in the Nineteenth Century. Konstantinov worked out his own type of rescue rocket, which proved to be superior to its British counterpart. Along the Baltic shores and under the personal supervision of Konstantinov,

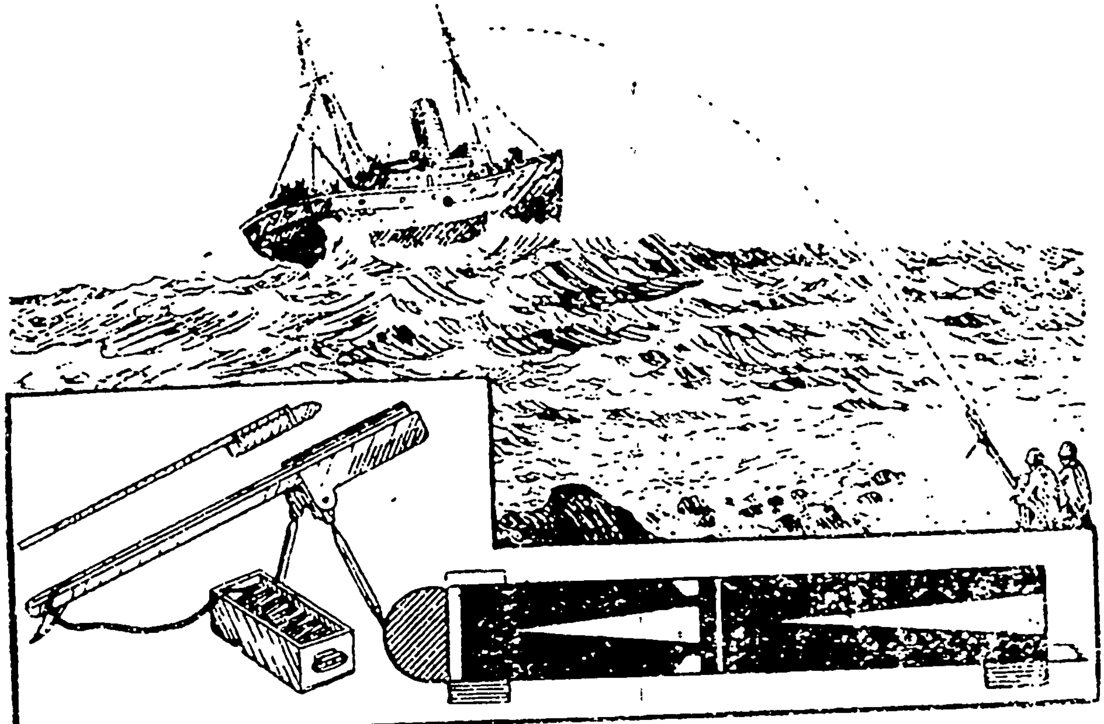


Fig.21 - Rescue Rocket of the Konstantinov Type

four stations equipped with rescue rockets were constructed. Still another task was assigned to the rocket: It was to become a "carrier".

The rocket "carrier" could be used for mail deliveries to inaccessible places, as for example in mountains. The rocket would drop a mail container by parachute, after passing over its point of delivery.

In the mountains, the rocket could help alpinists to climb steep slopes: the main bulk of the rocket's body would be wrapped in heavy rope, while the anchor-shaped rocket head would dig deeply into the ground with the anchor prongs and would remain fastened to it. With such a rocket, climbers could throw the rope over a distance of several hundred meters.

Scientists made an interesting experiment. They placed the rocket in an evacuated tube. The dynamometer - a device which measures the rocket power - showed consistently that the rocket power is greater in empty space than it is in the atmosphere.

Tsiolkovskiy was right: The rocket can fly in empty space. The air is merely an obstacle to the rocket. This is why its power is less in the atmosphere than in empty space.

Tsiolkovskiy's theory was amply confirmed by experiments.

Stationary experiments were now applied to bodies in motion.

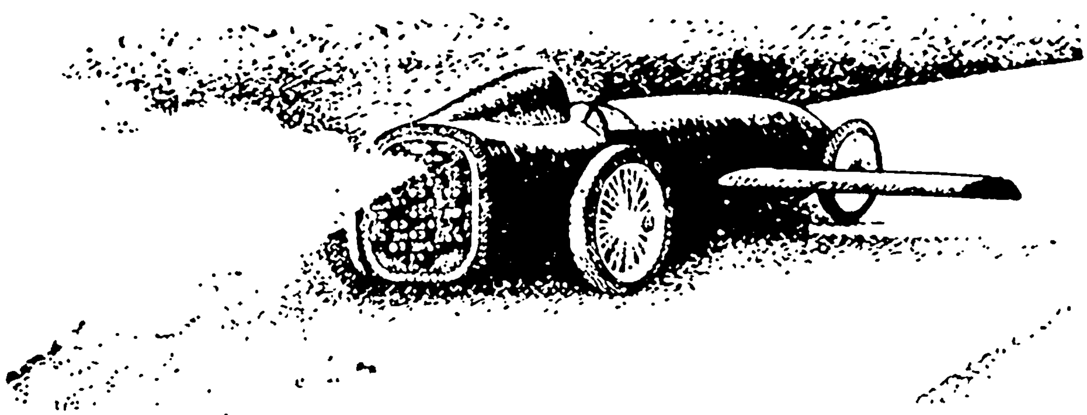


Fig.22 - The Rocket Automobile

Gunpowder-charged jet engines, being both the simplest and the most tested, were used first.

The construction of rocket automobiles, rocket trolleys, rocket sleds, rocket motorcycles, and even rocket bicycles ensued.

A blast from a battery of tens of rockets, a smoke cloud, a flame tongue, and the rocket automobile zooms over the ground. It ran so fast that it became necessary to equip it with wings to prevent it from going off the ground. Its wings were oval-shaped and, instead of lifting the vehicle off the ground, they helped keep it there.

For a few seconds, the automobile would run at extreme speed and then slow down and finally come to a stop.

STAT

The world speed records were being constantly broken.

However, such races were always too costly. Often, the trolleys or automobiles would explode. It was almost impossible to ride on these vehicles. Moreover, the automobile could only zoom, as if fired from a cannon, over a few hundred meters.

It was impossible to drive such an automobile since it was more of a jet projectile than a car. Although the rocket automobile hardly resembled the power plant of Jules Verne's "Colombie" its passenger would not have been any more comfortable than the heroes of Jules Verne.

The enormous acceleration of the vehicle forces the would-be driver to the back of the seat, making it next to impossible for him to man the controls and, in a few seconds, the automobile comes to a stop anyway.

The gunpowder-charged jet engine proved to be one of the least suitable means for transporting man over the ground.

No matter how the power plants are subdivided, from the most modern to the original steam engine, the above will hold true.

Tsiolkovskiy was right: The rocket is suitable only for very high speeds so that it would be extremely difficult to use it on the ground.

It can function efficiently only when airborne. It was, therefore, only natural that experiments for applying the rocket to airplanes were being conducted.

At the beginning, attempts were made to install the gunpowder-charged jet engine into aircraft. But, neither the run of the rocket automobile nor the flight of such an airplane lasted very long. It was, therefore, decided to equip the airplane with a liquid-fuel jet engine. Subsequently, however, the air-jet engine was more widely used.

Plans for jet-propelled ships and dirigible airships propelled by the reaction of water or air began to reappear.

According to one inventor, the aerodynamic hull of the ship should have a huge circular opening, looking like the mouth of a whale, in its forward part. Water is

STAT

sucked in through this opening by means of powerful pumps inside the vessel. The water jets which are then released through pipes located at the port and stern would thrust the ship forward.

The air would be scooped in through openings located all around the airship, argued another inventor.

Huge propeller blades were to hurl the air through an opening at the stern portion of the dirigible. Such an airship could stay, according to the inventor, several days in the air - as long as the fuel, without which the propeller could not be made to rotate, would last.

The jet-propelled ship and the dirigible had one thing in common: The reactive force was created by a propeller located inside and not outside the hull, as was the case ordinarily.

However, this is precisely their disadvantage. Both air and water have to be forced into the hull first, pass through it, and then be discharged backward. Internal channels are necessary for this operation and, regardless how simple the channels might be in structure or form, energy is inevitably lost through friction.

Technology directed its efforts toward the logical task of lessening the frictional loss of energy. After all, let us not forget that friction is energy by remembering the flat-bottom raft driven at a slow pace by the mere frictional interaction of its body and the water.

In order to reduce the energy loss, the intake and exhaust channels of the ship or dirigible airship would have to be as short as possible.

For this purpose, the most suitable channel is one whose length is equal to zero.

In turn, this means that the propeller should be outside rather than inside the vessel, as was the case with earlier ships and dirigibles.

The concept of a jet-propelled ship attracted a great deal of attention among the inventors. The external location of the ship propellers has its drawbacks. An external propeller can be prevented from proper functioning when striking an obstacle. It was, therefore, necessary to protect it. If the propeller were installed inside the ship, these difficulties would be removed. The openings through which the water is being sucked can be equipped with devices that would protect the propeller-engine system from hard and bulky objects carried by the water. Water-jet engines can fit without difficulty within the hull of the ship. The jet-propelled ship has another advantage. The principal part of its water-jet engine is the powerful water pump

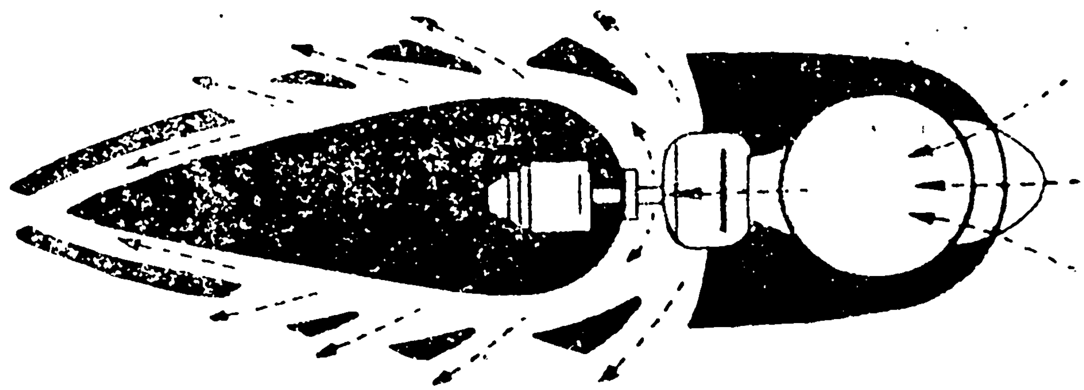


Fig.23 - Project for a Jet-Propelled Ship

which can pump water from the vessel in case of leaks or can be used as a fire extinguisher.

While working on water-jet engines, inventors attempted to reduce as much as possible the loss of energy due to friction. Such friction cannot be totally avoided, but where the advantages of the jet-propelled ship are greater than its drawbacks - as in shallow waters - it can be used successfully.

Several tugs equipped with water-jet engines that could be called "water dredger" were constructed in Moscow, during the year 1946. These water scoops were then placed inside one of the ship planks. The engine rotated the shaft, and the blades of the scoop or impeller hurled the water backward through the rudder unit. In this way, the reactive force propelled the vessel forward.

Such a vessel would be of more use where the paddle-wheelers or propellers of

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

ordinary steamships would wear out, namely in shallow-water rivers.

It is different in the case of air. The reactive force of the air-jet is sufficient to propel the airship only when the jet is discharged at very high speeds. The air has to be literally forced into the engine, and to do this with a pump would be impossible. There is only one way. While the fuel is burning, its heat is transmitted to the air. The resultant gas stream discharged from the combustion chamber will then create the indispensible reactive power. The same process takes place in modern aircraft powered by air-jet power plants.

Soviet scientists and engineers continued successfully the work of Tsiolkovskiy - "that noted scientist and inventor who formulated the theory of reactive motion, which is at the very core of modern jet technology and who carried research on this item beyond any limits" (from the speech made by N.A.Voznesenskiy at the Five-Year Plan Session of the Supreme Soviet for the USSR).

When a group of those who studied reactive motion under the auspices of the "Osviakhim"* turned to him for advice, Tsiolkovskiy wrote: "You manifest such activity that I believe I can do nothing more to add to it. I am amazed and elated by your energy. In essence, the conquering of space beyond the atmosphere will be preceded by the conquest of the rarified atmospheric strata - the stratosphere. Your activities are exceedingly useful... .

...I can only say: only my great proletarian country, only my Fatherland can strengthen and educate people who will bravely lead modern mankind toward happiness and contentment."

The efforts of F.A.Tsander, M.K.Tikhonravov, V.P.Vetchinkin, V.P.Glushko, S.P.Korolev, B.S.Petropavlovskiy, V.I.Dudakov, V.A.Artemiev, N.I.Tikhomirov and other engineers and scientists played an important role in the development of the Soviet rocket technology.

A new and very important period of the rocket history was at its beginning.

---

* "Society for the Promotion of Aviation and Chemical Defense of the USSR".

STAT

The rocket was being prepared for warfare.

Once again, during the war, we saw the rocket - the oldest and the newest weapon.

Through the efforts of the Soviet scientist and designer a terrible rocket weapon was built, a weapon which was successfully used against the German looters and the Japanese imperialists. It is this weapon that demonstrated to the entire world the extraordinary level and might of the Soviet jet technology.

CHAPTER V

THE ROCKET DURING THE WAR

A new weapon appeared at the beginning of the war for the defense of our great country. At that time, there were only a few men even in the artillery units who were familiar with this weapon. It did not look like an ordinary weapon in that it almost reminded one of a mobile crane. Can there be actually a weapon which has no barrel, no breech, and no gun carriage? The new weapon answered the question with a salvo! Long and fiery tongues were hurled toward the enemy in ever increasing numbers. Steel and fire descended upon the enemy with an unexpected and all-destructive force.

"It was a nightmare. Not only the groups of our soldiers in the midst of it all were gripped by panic, but even those on the outer flanks tried to save themselves by running away. It seemed as if a hundred pieces were firing simultaneously."

This is what the prisoners of war had to say about the new weapon.

Surprise, concentrated firepower, and maneuverability - these were the powerful features of the new weapon. Debris from the concrete slabs and barbed-wire entanglements flew everywhere, bunkers and shelters were destroyed, trenches were filled. The enemy suffered great losses. The few soldiers who lived through the ordeal remained unconscious for long periods of time. Nothing could save the armies of the enemy, be it shelters, bunkers reinforced by a dozen protective layers, barbed-wire entanglements or densely mined fields.

This is what happened at Stalingrad and Bryansk, Orel and Kursk, Odessa and Belgorod. This was also the picture in Germany in the battle for Berlin.

At one time, the infantry mine-throwing battalions which were concentrated in the direction of the main assault on the enemy received orders to shift their firing positions overnight. The following morning found them combat-ready in a new place, some 50 km from the previous position. The enemy was firmly convinced that the attack would come from the former direction. Suddenly, shells and fire dropped on the enemy from a direction quite different from that from which the attack was expected. This was the beginning of the end. The command of the enemy was disorganized, his artillery knocked out of action. Fighting was carried deep into the rear of enemy defense lines through which our new units now penetrated like an irresistible stream. The retreat began.

This was the picture everywhere where the infantry mine-thrower "Katyushas" appeared. This fighting way ended gloriously in Berlin.

The rocket reappeared on the battlefield after a pause that lasted half a century. But this half a century did not pass in vain. The new rocket embodied in itself all the achievements of the rocket technology.

Together with improvements, the new rocket inherited many features from its predecessor - the Russian Nineteenth Century military rocket.

In general, the earlier design remained the same. The component parts of this reactive projectile underwent a complete change, however.

The gunpowder-charge explosion creates a high pressure in the barrel of the artillery piece, a pressure which hurls the shell out of the barrel. This pressure is so great that, within a fraction of a second, the shell reaches supersonic speed. It is therefore necessary for both the barrel and the shell to be thick and strong. Something entirely different occurs within the combustion chamber of a reactive projectile. One of its ends is open. The gunpowder in it does not explode but burns up gradually. That is why, for example, the pressure in it is ten times less than

STAT

the pressure within the barrel of an artillery piece. This allows the chamber to be smaller and not as strong as the shell. Thus, for example, the thickness of the 85mm reactive-projectile walls is only 2 mm.

The barrel of the reactive artillery piece does not require the pressure created by the gunpowder gases, and thus the barrel concept was abandoned in favor of a simple launching device - a light-weight tube on aiming rails. Several tens of such

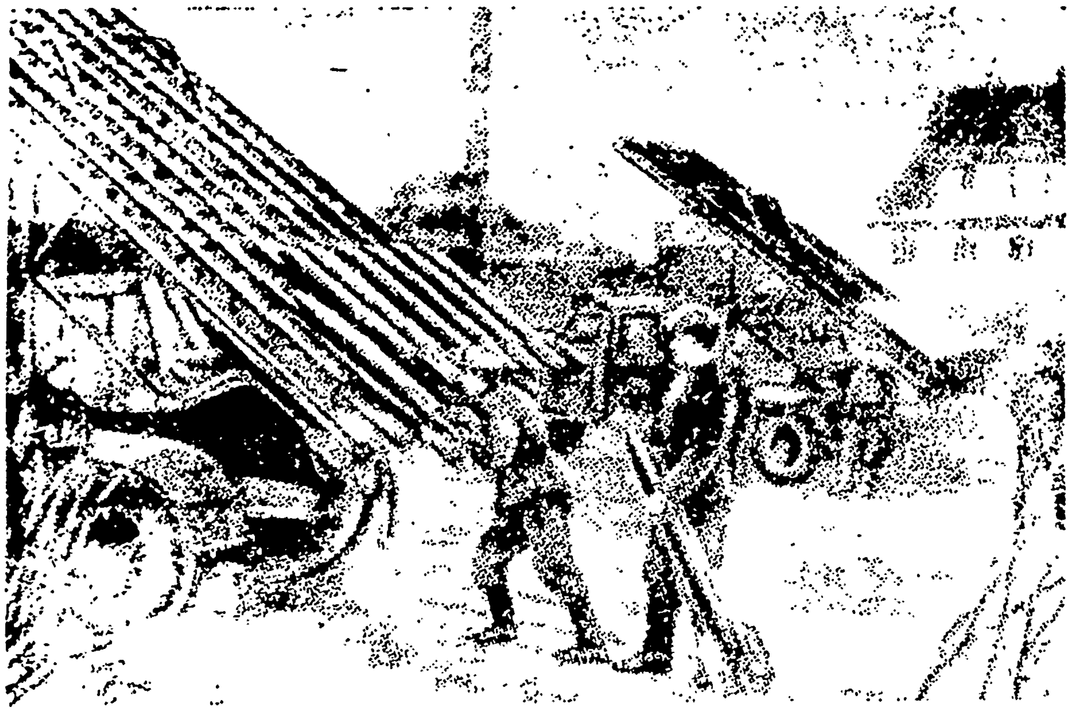


Fig.24 - Infantry Mine-Throwers in Position

"artillery pieces" can be welded together into one structure which, of course, cannot be done with regular artillery pieces.

Therein lies the difference between the rocket and the artillery piece. The rocket is a self-propelled projectile, moved by reactive force, while the ordinary shell gets only its initial thrust from the artillery piece.

Not every type of gunpowder is suitable for military rockets. The main thing to keep in mind is that the reactive projectile is supposed to move along without exploding. This means that there must be a prolonged and not instantaneous burning of the gunpowder. The gunpowder charge of the rocket must burn at a steady rate otherwise the flight of the rocket will be erratic and the proje[illegible] will [illegible] its target.

Besides, the manufacturing of gunpowder is a very complex affair. The gunpowder components are arranged in a strictly defined correlation, at a definite moisture percentage. The actual mixing is performed... by a machine. There is mothing surprising in this. Only by mechanical means will a highly homogenous and accurate mixture be obtained. In this instance, precision determines the success of the undertaking. The firing accuracy is the ultimate product of the manufacturing precision. Should the gunpowder charges, in two different reactive projectiles, vary even slightly, the two projectiles will not soar evenly.

The mixture is prepared as follows: The ingredients are passed through a set of rollers which convert them into a long and thin sheet. This sheet is cut by a special machine into long and thin strips. The strips are then fed through a casting machine after which they reach a huge press which gives the material its required shape. This represents the most important part of the process. The press is located in a room with meter-thick reinforced concrete walls and exerts a pressure equal to 500 kilograms per square centimeter. The press is remote-controlled.

Finally the material is cut into narrow portions of the desired length.

The gunpowder is not ready for use as yet. The powder flake may have a hole or crack, invisible to the naked eye. Even the most minute crack will be disadvantageous since it will cause the gunpowder pellet to burn too rapidly.

This is why every cut piece is checked by means of X-ray or ultrasound devices.

After the material has been checked, in order to give it its final form, it is being cut into pieces of definite weight and further checked as to shape and dimension. Thus, an attempt is being made at this stage to make gunpowder charges that differ as little as possible.

Finally, the gunpowder is packed into waterproof coverings to prevent it from absorbing excess air moisture.

The requirements must be exacting not only as to the gunpowder itself since, no matter how expertly the gunpowder charge is made it will be of little use if loaded into a poorly made rocket chamber.

It seems that nothing could be simpler than to take a metal cylinder, pierce a hole at its bottom - and the chamber is ready. But such an oversimplified chamber will perform poorly.

There is no machinery in which some energy will not be lost. The relative loss of energy is determined according to the coefficient of the starting impact. This determines, at the same time, to what extent unnecessary loss of energy occurs within a machine.

The greater the coefficient of the starting impact, the lower will be the loss of energy. It can be said that the perfecting of any machine requires a preceding attempt to reduce this loss.

The same attempts at a reduction of energy loss must be made for any machine having a gas or steam jet issuing at high velocity, as is the case in wind tunnels, jet engines, and turbines. The solution consists in the installation of an exhaust nozzle or special extension, through which the steam or gases are ejected. This exit nozzle is indispensable for an increase in the exhaust velocity, leading toward a more economic harnessing of energy.

This is the reason why the reactor does not end in an ordinary opening but in a special extension - the exit nozzle.

The gases generated by the burning charge enter the nozzle directly at a tremendous velocity. This causes the gases to heat and produce erosion as well as corrosion of the exit nozzle.

For maximum performance, the inside walls of the exit nozzles in long-range rockets and rocket engines were smoothened, beveled, and even polished. Moreover, the engine was to be cooled while in operation.

The chamber containing the charge is equipped with a fuze. The target effect-

STAT

iveness of the entire projectile depends on satisfactory operation of this fuze which is an important part of the projectile. Long-range rockets are not equipped with only one fuze but with several fuzes, which form a system of automatic ignition.

Sometimes it is necessary for the rocket to hit targets moving at high speeds. A high-speed fighter aircraft moves at about 250 m/sec.

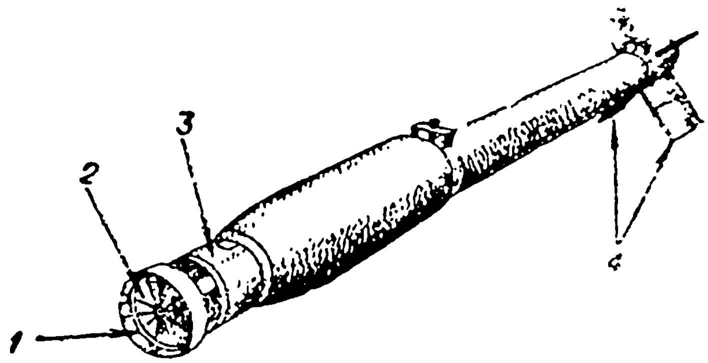


Fig.25 - Projectile with a Radio Fuze

1 - Antenna; 2 - Mill; 3 - Radio fuze; 4 - Rudder

The antiaircraft rockets carry a radio-controlled fuze which is actually a miniature transceiver set. When the radio waves strike the approaching moving target they are collected by the fuze receiver. When the projectile is about 15-20m from the aerial target the warning signals, amplified by a special device, set off the fuze mechanism.

It is not easy to hit the same target twice, even if the target is stationary. No matter how precisely manufactured, two rocket projectiles will never strike the same place. This is due to the fact that each projectile will have a slightly different powder charge than another. Moreover, the wind strength has its effect upon the projectile. The flight of a projectile is also influenced by the composition of the air, whether dense or rarified, warm or cold. The flight of the projectile is influenced in addition by the decreasing weight of its body, due to the loss of the burning powder charge.

Although by no means new to designers, the task of making the rocket stable in flight proved extremely difficult. One of the factors which contributed largely toward a possible solution was the spinning effect of ordinary rifle bullets and artillery shells. The interior of the rifle bore was wound with a steel band and the bullet, on leaving the bore, went into a high rate spin - up to 3000 revolutions per second.

This spinning action also assists the rocket projectile. The barrel of jet artillery pieces was made with spiral grooves to replace the spiral band in the barrels of ordinary guns. A 90-year old invention was also applied. The projectile was capable of spinning by itself for the duration of the flight. This was the reason for designing combustion chambers with lateral exhausts, causing the projectile to spin like the original Segner wheel.

The spinning action could not occur without a causative agent - energy. In order to produce the spinning action, a portion of the energy created by the powder charge must be diverted from propulsion, which means that there will be less energy for the forward thrust of the projectile. This shortens the range of the rocket.

The designers improved the old invention. The same air which obstructed the flight of the projectile now helped it to fly more accurately toward the target. On being forced into the spiral grooves of the barrel, the air would engage the surface of the shell and spin it.

This method, however, was not suitable for all rocket projectiles. Such projectiles weighing a ton or more were created. One can imagine the amount of energy necessary to make such a projectile spin at high speeds! Neither the force of the gases created by the burning gunpowder, nor the power of the air jets would suffice in this instance. Projectiles of this kind, as well as any other kind of projectiles where the spinning is difficult, require an additional thrust surface. Let us use the ancient name of "fire arrow" for such a rocket.

After release, the rocket projectiles are discharged at tremendous speeds, as if they were some fantastic fiery birds. The trails are engulfed in their own flames, and where the birds ordinarily dive for prey there is now a thunder of explosions as the mass of steel and fire pours over the enemy.

The rocket mine-throwers operate as follows: What a peculiar weapon a mine-thrower is! A light-weight tube is mounted on a tripod. The tube is open at one

STAT

end and closed at the other. The bottom of the tube is provided with a firing pin. A sighting device is used for determining the proper angle of the tube. The mine is then dropped into the tube. As it falls into the tube, under its own weight, it strikes the firing pin. The charge bursts into flame at the tail end of the mine. With a boom, the mine flies upward and out of the tube. While one mine is on its way to the enemy, the second has already left the tube. This is followed by a third and fourth mine. Within a minute, the mine-thrower can fire ten to twenty rounds - a veritable shower of mines.

The rocket mine-thrower is more complex than an ordinary mortar. On the other hand, it is capable of creating not merely a shower but a regular torrent of mines. The tubes, or barrels, of the rocket mine-throwers can be joined together. One salvo - and a dozen of mines are airborne.

There are mine-throwers with twelve, sixteen, twenty, and even sixty barrels in existence. Such installations could fire over distances up to 7 km, while some of the multibarrel installations mounted on landing craft could fire as many as 1000 rounds per minute.

The rocket projectiles are not as accurate as artillery pieces, but they more than compensate for this inadequacy.

The rocket mine-thrower is not merely a weapon with a terrifying fire power. When mounted on a truck, it has an added feature - mobility, which enables it to follow cavalry and mechanized army units in raids deep behind the enemy lines. During the great war for the defense of our country, rocket mine-thrower detachments made 500-800 km raids without lagging behind the cavalry.

Tanks can also be armed with mine-throwers. All this is possible because of the structural simplicity of rocket mine-throwers.

Tank crews of a certain unit learned that pilots were able to use rocket projectiles quite successfully and decided to make an experiment. They mounted 2 straight rails on the turret of a tank - and the reactive installation was all ready for

STAT

use. Once all the projectiles are used up and no additional supplies are available, the entire reactive installation can easily be dismantled and taken off the tank.

Rockets were now being used in tank warfare not only as defensive but also as offensive weapons.

The competition between rocket and tank began earlier - when the rocket was earmarked for destroying armored targets by aircraft.

It soon became apparent that tanks can be destroyed with a rocket that need not be of the air-to-ground type. Rocket mine-throwers were used for this purpose, becoming the first antitank rocket mine-throwers.

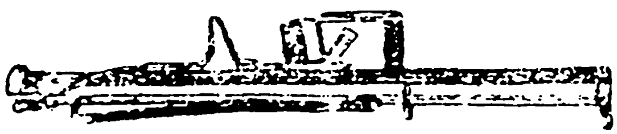


Fig.26 - Rocket Antitank Rifle

The antitank rocket mine-thrower has to be lightweight for combat use. It fires lightweight mines of not more than one kilogram. Such a mine can penetrate armor of fifteen centimeters thickness.

This mine compares favorably with the penetrating power of a 105-mm artillery piece; however, while an artillery piece of this caliber weighs two tons, the mine-thrower weighs only 16 kg.

The rocket antitank rifle weighs even less - approximately 5 kg - and is neither heavier nor more difficult to operate than an ordinary rifle.

On releasing the trigger of the rocket antitank rifle, current flows in a miniature electric generator, producing a spark which ignites the charge. There is a flame-tongued back blast while the mine is thrust forward toward the tank... .

The problem of equipping the military aircraft with heavy caliber weapons proved to be both difficult and complex. Caliber means weight and excess weight means more fuel storage space, lower speeds, and shorter flight ranges.

There was an additional obstacle - the recoil.

We have already mentioned what happened to aircraft armed with a heavy artil-

STAT

lery piece. On firing the first round, the airplane disintegrated. This was caused by the kickback which had not been taken into account while the airplane was being designed.

The problem of recoil led to many proposals on how to deal with it. Attempts were made, for example, to construct an artillery piece that would fire two shells at once - one explosive, the other a dummy. The explosive shell would be hurled toward the target while the dummy would absorb the recoil impact and would be discharged by it in the direction opposite to that of the target.

In automatic weapons, the recoil functions as a starting force: it reloads and discharges rounds. Nonetheless, automatic weapons remained rather heavy in terms of weight.

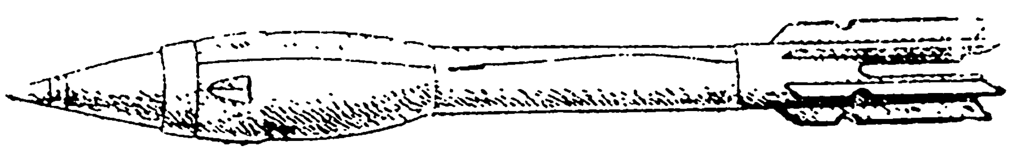


Fig.27 - Rocket Mine for Antitank Rifle

There was a time when military aircraft was unarmed. Now, battery guns and bombs are standard equipment.

In addition, some military airplanes were equipped with lightweight guide rails or tubes, mounted underneath the wings. These were the rocket guns.

Picture an aircraft approaching its target.

Here is what some of the targets are likely to be: column formations of tanks and armored cars, a railroad junction with its narrow and serpentine-like rails that looks like a dark streak from high altitude, or a convoy of tankers protected by naval craft. The aircraft nose is now facing the ground - it dives. The target is in the center of the bombsight. The push button is depressed, producing an electric spark. A blast follows with a light kick and the projectile, which had just off the launching rails, rushes toward the target at increasing speed.

Rocket guns are not heavy or complicated. Their barrels, consisting of guiding or launching rails or tubes, are only a few milimeters thick. The electric ignition system controls are located in the cockpit. Once the button is pushed, the system can be regulated to fire either one projectile at a time or all at once.

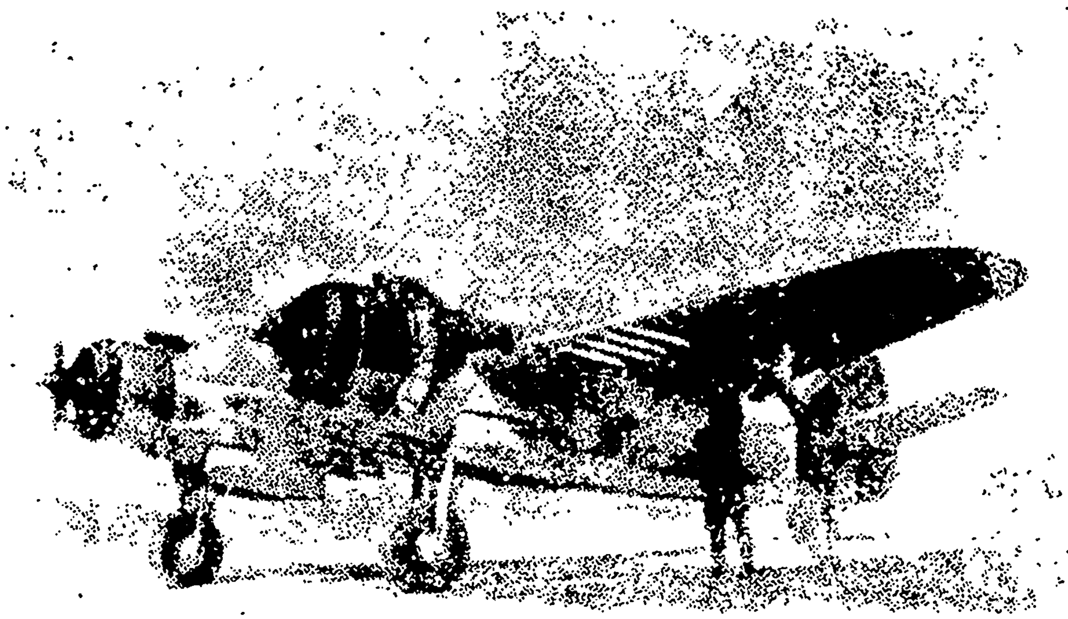


Fig.28 - Rocket Projectiles Mounted on Aircraft

However, even the lightweight metal tubes of the target guns seemed too heavy to the designers.

This led to the development of rocket guns with barrels made of plastics capable of resisting the firing impact.

The plastics weighed three times less than steel.

The rocket projectiles performed their missions successfully: They destroyed the designated ground targets. The rocket projectiles were also quite accurate at short range.

During the war, aircraft equipped with rocket guns would frequently fire on ships at sea. When one of the German ships, fired on by rocket-carrying aircraft, went aground in shallow waters - it was discovered that six out of ten projectiles

STAT

had hit it. At the end of the war, underwater bombs with jet engines were developed. Such a bomb would be dropped from a bomber flying at low altitude.

As soon as the bomb hit the water, a percussion fuze ignited the solid fuel of the propelling rocket and the bomb, guided by a gyroscope, quickly approached the ship underwater.

In order to sink a huge ship, many projectiles are necessary. The entire load of the airborne rocket guns consists of 6-8 projectiles. Many airplanes are therefore necessary for a successful attack on a ship.

The antiaircraft defense a ship can muster is far from being ineffective. A fiery rain engulfs the attacking aircraft. The ship is showing its teeth – it is quite enduring and not easy to cope with.

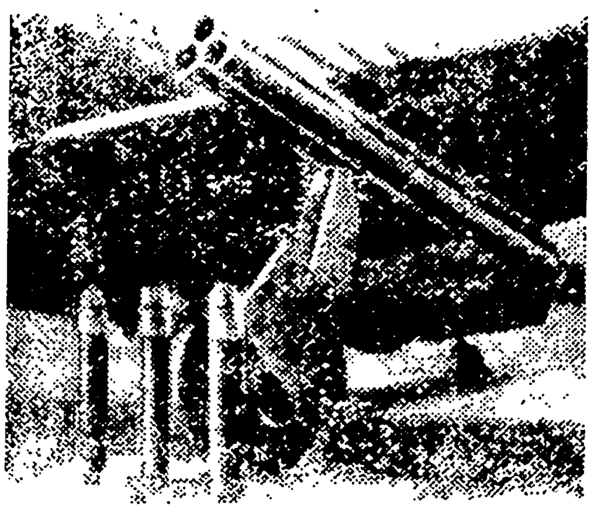


Fig.29 – Rocket Guns Made of Plastics

Can a ship be destroyed? Yes, by not getting near it and by releasing the projectiles from a safe distance, as is done by torpedo-carrying aircraft.

Torpedo – this is the means by which the task can be accomplished. It cannot be an ordinary torpedo that approaches a ship underwater, however, but must be an aerial torpedo. Such a torpedo resembles more a small airplane than an artillery shell. It has wings and slotted flaps and carries approximately a ton of explosive.

A small fighter aircraft cannot lift such a torpedo. It is carried aloft by a heavy, multiengine bomber which releases it from an altitude of several kilometers.

The torpedo begins its own flight. However, this is not all there is to it. It cannot be left to itself. An aerial torpedo is an aircraft – and aircraft have

STAT

to be guided.

People have been dreaming for long of pilotless aircraft that can be remote-controlled by radio. Science fiction novels described attacks made by whole squadrons of such aircraft, capable of flying over several thousand kilometers and delivering their deadly load deep into enemy territory.

Radio-controlled aircraft capable of taking off, flying and landing, were constructed. Such an aircraft was usually guided by radio from another aircraft.

These accomplishments were now used for guiding the rocket aerial torpedoes.

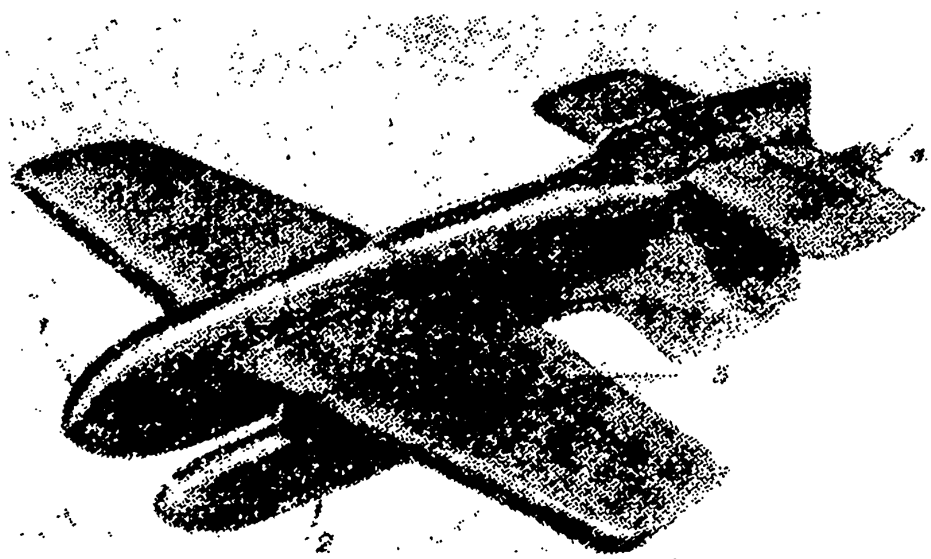


Fig.30 - Rocket Aerial Torpedo

1 - Bomb; 2 - Fuel; 3 - Gas exhaust; 4 - Tail light

As soon as the torpedo is released from a high altitude, the pilot transmits radio signals to the torpedo-guiding mechanism which then guides it toward the target.

Some torpedoes are equipped with a television device which enables the pilot of the radio craft to see the target as seen by the torpedo itself.

Rocket projectiles were now not only used for arming the airplanes but also for air combat.

Rocket aerial torpedoes were used against entire bomber squadrons. They were

STAT

being fired from radio-controlled craft. Antiaircraft artillery also began to us rocket projectiles.

Projectiles were developed for pursuit of other radio-controlled projectiles and airplanes.

Still another type projectile was used for carrying mined barrage nets into the air. There were projectiles that could place "barbed-wire entanglements" in the air by carrying thin steel wires high into the air and then dropping them slowly by parachute. Such a wire would disintegrate the wings and propellers of all aircraft caught in it.

There were rocket projectiles which would release, at a certain altitude, dozens of fragmentary projectiles that would hit a large area.

Ships too, were armed with rocket antiaircraft installations. The ship has only limited available space and, in order to repel an aerial attack, it needs a dense firing capability. Multibarrel rocket guns are especially suitable for this purpose.

They are not only suitable for hugh ships.

Small landing craft were also armed with multibarrel rocket guns.

During the month of March 1918, the front lines were located some 100 kilometers from Paris, and only occasional night raids by German aircraft reminded Parisians that the front lines were not too far away. Suddenly, the city was hit by one, two, three projectiles, while the skies remained empty of any aircraft. The antiaircraft batteries were silent, but the mysterious projectiles kept coming one after another.

Parisians were puzzled. The enemy could not possibly have crossed the distance of 100 kilometers in one night!

The answer to the mystery could be found approximately 120 kilometers from Paris. There was a German extreme-range battery of artillery pieces which were being fired on Paris.

These artillery pieces looked strange and reminiscent of some prehistoric monsters. Each piece weighed 150 tons and each base platform 200 tons! The shell of

STAT

each round of ammunition for such a piece weighed 100 kg alone, while its charge weighed twice as much. The piece was capable of firing rounds to an altitude of 40 km, almost reaching outer space.

But the cost of such a weapon was enormous and the huge piece did not last for long. Its life span proved to be 250 times shorter than that of an ordinary artillery piece and each of its ammunition rounds would cost tens of thousands of rubles.

New ways for extreme-range firing were now being explored.

Projects for electrically operated artillery pieces were developed.

An artillery piece of this type was to represent a gigantic solenoid which could fire rounds by means of electromagnetic power. But when attempts were made to establish the minimum energy required for the use of an electrically operated artillery piece, it was found that a single round would require as much as 500,000 horsepower. This requirement is equal to the entire output of a large electric power plant.

Moreover, the cost of electrically operated weapons was too great and their feasibility nominal.

The main secret of extreme-range firing lies in firing projectiles to as high an altitude as possible, in order to enable them to fly in rarefied air.

There is only one type of power plant capable of developing tremendous speeds in rarefied air, namely the jet engine.

This is how the idea for the creation of the reactive extreme-range artillery came into existence.

Rocket aerial torpedoes were already capable of spanning distances 10-15 km longer than those traversed by ordinary rocket projectiles.

Soon afterwards, aerial torpedoes capable of spanning even greater distances appeared. These torpedoes resembled more an airplane then ordinary torpedoes for attacking ships underwater. They looked like jet aircraft in miniature. Their engines were less arranged like those of rocket projectiles than like those of military air-jet engines. In spite of this, they were nothing more than projectiles be-

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

cause their only passenger was a payload consisting of one ton of explosive material.

These torpedoes were appropriately called: Aircraft Missiles.

A long tube is attached above its fuselage. The forward part of the tube contains a grate which can be closed by valves. During the flight, the oncoming air penetrates the tube, mixes with the fuel, and causes the mixture to burn. As the chamber pressure increases, the valves are forced against the grate, preventing outflow of the air. After the gases have been discharged through the exit nozzle, the

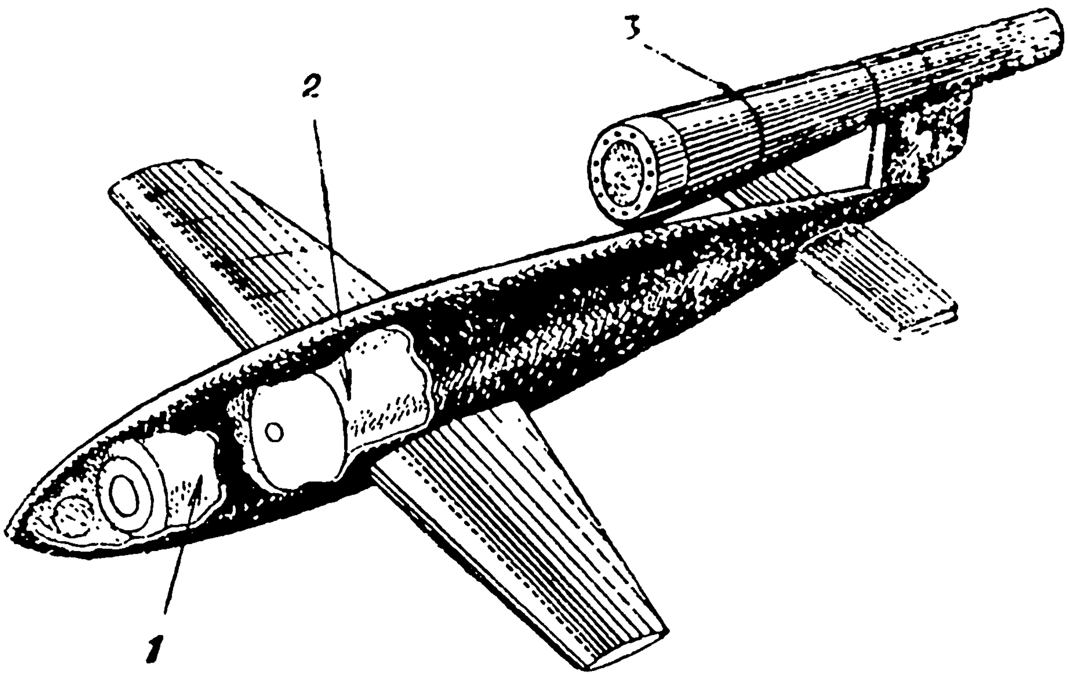


Fig.31 - Aircraft Missile

1 - Charge compartment; 2 - Fuel storage; 3 - Jet engine

pressure drops, the valves open, and the air reenters the fuel chamber. The entire process is repetitive and rapid. By the time the observer counts to "one" - within the space of one second - the valves have opened and shut 45 times, the fuel has been mixed and the pulsating gas stream has been discharged through the nozzle in a manner that resembles the continuous flow of a strong electric current.

The automatic pilot guides the aircraft missile on its course. The air revolves the tilt mill located in its nose, and as soon as the tilt mill has made a pre-

STAT

determined number of revolutions, the automatic device tilts the projectile from horizontal to a diving position. This is the way the aircraft missile is made.

The month of June 1944 was marked by a lull in the front lines. The Channel devided the British from the Germans. Only rarely did short skirmishes between shore batteries take place.

Not only were the stubborn and fierce air battles interrupted. The Germans were unable to win a decisive victory. They did not even have enough planes to bomb English cities regularly.

Up to that time, the Germans had lost over 60,000 aircraft on the Soviet front. They could not muster enough pilots. Each air attack would cost the Germans dozens of bombers. Then the Germans started using ersatz bombers – the aircraft missiles.

The Germans announced the advent of the "secret weapon" with great fanfare. London was hit daily by over a hundred of these aircraft missiles. The Germans thought that this city would be destroyed soon.

But... , this goal was no nearer than before the "secret weapon" appeared. Here too, the perennial race between defense and attack took place. If a new weapon can be made, there is no reason why its defensive counterpart cannot also be made.

The speed of aircraft missiles is comparatively low, slightly lower than the speed of a modern fighter. On overtaking the aircraft missile, the fighter destroys it with its guns. Antiaircraft artillery also is effective against aircraft missiles. Moreover, the aircraft missile has its own Achilles heel. It is not easy to hit a target accurately, even with long-range artillery pieces. It is next to impossible to hit a target accurately with an aircraft missile.

The probability of hitting a target with an accurately guided aircraft missile is one in fifteen million. Try to pull out a black ball out of fifteen million white ones without looking!

The perfectly suitable target for the aircraft missile is a city area of a size exceeding one square kilometer. This is not accurate firing any more, but the

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

game of head or tails: maybe you get it and maybe you will not.

If we compare the aircraft missile with a bomber, we will find that for replacing the bomber which does reach its target, several thousand aircraft missiles are needed, provided they all reach the target area. Near the end of the constant shelling of the city of London, the action taken against the aircraft missiles proved to be so successful that only one out of forty were able to reach the target area. The rest were destroyed on their way by fighter aircraft and antiaircraft artillery. This means: In order to replace one bomber in action, not merely a thousand but tens of thousands of aircraft missiles are needed.

At one time, somewhere in England, people heard a deafening explosion that was much stronger than the one created by aircraft missiles. Everyone heard it: factory workers, army men in barracks, pedestrians. What was it? - they asked one another -. An aircraft missile? A factory explosion?

It was neither.

It was the new "secret weapon", the extreme-range rocket. This rocket is more complicated than either the gunpowder rocket or the torpedo with an air-jet engine. It weighs over ten tons.

Its engine uses liquid fuel, with the fuel and oxidizer stored separately. Alcohol is used as fuel and oxygen as the oxidizer.

The fuel and oxygen must be fed into the combustion chamber. As in other pump-fed engines, pumps are necessary here. The jet engine has a long operating time but requires cooling. Finally, the rocket has to be guided.

The rocket is placed on a concrete platform. The engine is fed through pumps which also force the mixture into the combustion chamber. The mixture is ignited by an electric primer. There is a strong explosion and the rocket leaves the ground. The engine begins to work faster and faster. The rocket disappears into the sky with a thundering noise, leaving behind it a trail of dense smoke.

Within one minute after take-off, the rocket has reached the altitude of 30 km.

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

It continues to ascend automatically. An automatic mechanism tilts the rocket from its vertical to a more angular flight position. At this point, the rocket differs little from an ordinary artillery shell in everything except speed and altitude: while ascending, its speed may reach 5700 km/hr.

No artillery shell could climb higher than the rocket: The latter is capable of reaching an approximate altitude of 100 km. Even the speed of sound cannot overtake it - the rocket travels several times faster than sound. At such speeds, the air friction makes the fuselage red-hot.

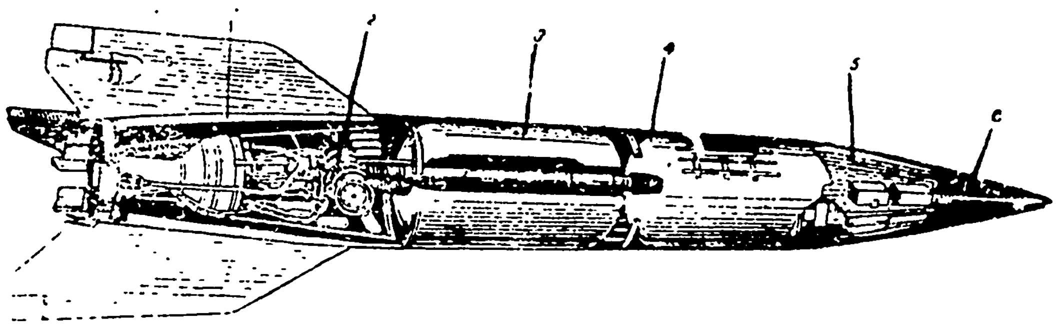


Fig.32 - Long-Range Rocket

1 - Combustion chamber; 2 - Turbine and fuel pumps; 3 - Liquid oxygen tank; 4 - Alcohol tank; 5 - Guiding mechanism; 6 - Warhead

Now, the rocket hits the ground with a boom. This is followed by a deafening roar, which is the noise of the rocket in flight delayed until after the rocket had reached the ground. This is logical since the rocket travels faster than sound. The fragments of the exploding rocket are hurled in all directions. Unbelievable as it may sound, some of the rocket fragments have a thick layer of ice. The rocket is red-hot and, all of a sudden, there is ice! Actually, the ice represents the remnants of the liquid oxygen.

This is the rocket in action.

Although at first glance the rocket appears to be a most terrible weapon, it has its weak points. The rocket does not spin in flight and its target accuracy is

STAT

negligible. Its destructive power cannot be increased by using a larger quantity of rockets since the rocket is an unusually expensive and complicated mechanism.

The distance such a rocket can span is great but it is not enormous. Its thrust lasts only five minutes, during which time the rocket can cover approximately 300 km. If its capability to span longer distances is to become greater, it will be necessary to reduce its explosive charge and increase the amount of fuel. This would, in fact, make the rocket worthless as a weapon.

Rockets also have their enemy - the bombers capable of destroying successfully the rocket-launching sites.

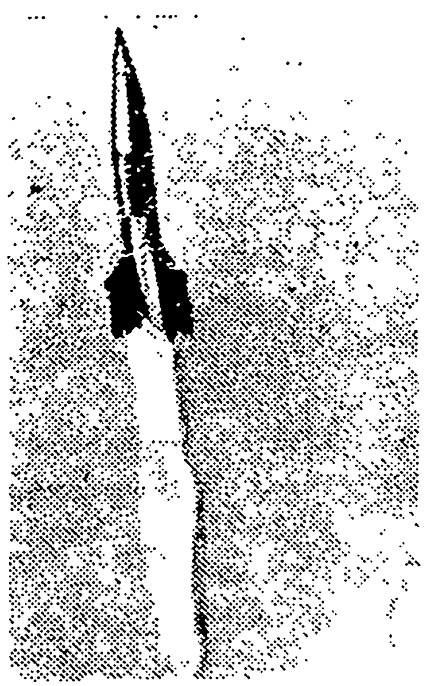


Fig.33 - The Rocket in Flight

Let us make the balance sheet:

The artillery piece has its drawbacks, including its weight. This is a fact that has to be reckoned with, and even if a solution for the excessive weight is found, such a piece cannot fire shells farther than 100-150 km.

The rocket does not need a heavy barrel. It has no recoil. It covers greater distances than the artillery shell.

On the other hand, the artillery piece does have advantages. Its main advantage is its high degree of comparative accuracy, which is something the rocket lacks.

For hitting long-range targets, powerful bomber aircraft, capable of finding designated targets thousands of kilometers from their base were developed.

But these bombers too had their weakness. Besides the craft itself, space is needed for spare parts, bombs, armament, large amounts of fuel, and airfields with complex operational and supply installations, airplanes for training purposes, pilots, mechanics, and technicians are required.

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

CHAPTER VI

THE NEW AIRCRAFT ENGINE

Let us now see how an ordinary piston engine works.

The combustible substance burns in the cylinder block. The gases created within a small area are so powerful as to cause the pressure to rise instantly inside the cylinder block. The gases force the piston downward. The distance traveled by the piston is not great, a mere few tens of centimeters. Consequently, the piston traverses this short distance at the speed of several tens of meters per second. The piston then travels upward, pushing before gases which now have a free exit: The release valve permits the gases to escape from the cylinder block. The gas pressure remains high during the time the flowing gases are discharged. What is the result? The admixture of fuel and air is burned, the gases spread and issue from the combustion chamber at very high speeds. The gas stream creates the reactive power which is then used as an additional thrust force.

Today, almost all flying craft are equipped with jet exhaust systems which support the action of the propeller by increasing the speed of the aircraft by 15-25 km/hr.

The jet-exhaust system resembles the jet engine. The engine cylinder serves as the combustion chamber, while the exhaust tube through which the burning gases are discharged into the atmosphere replaces the exit nozzle. An engine can have as many "jet unit" as it has cylinders, since each cylinder has its own exhaust tube. The action of the exhaust tube closely resembles the action of a pulsating air-jet en-

STAT

gine, since the mixture within the cylinder of the engine does not burn constantly.

Moreover, a duplex tube can be made for each pair of adjoining cylinders. At times, the exhaust gases from several cylinders are discharged through only one port, at which time the gases converge into a special device - the collector. At the point of convergence and as a result of the extreme velocity of outflow in the multicylinder engine, the pulsating streams are leveled, causing a steady outflow of gases. The process is similar to that of a continuous electric current.

The aircraft may be equipped with still another type of air-jet engine.

A liquid-filled radiator is placed inside a special duct or channel, within the airplane. Cool air flows through this tunnel. The radiator transfers its heat to the air which thus is heated. As a result, the air velocity increases and a reactive thrust is created - although it is true that the thrust force in this instance is rather negligible since the air cannot be warmed sufficiently. Such a ducted radiator resembles the free-burning air-jet engine, except that the radiator now takes the place of the combustion chamber.

At that time, both gunpowder and liquid-fuel rockets were used on conventional aircraft. These were in use long before the first jet aircraft were built.

The question of take-off assist for aircraft interested aircraft designers for a long period of time. For a successful take-off, the aircraft must be able to gain sufficient speed while moving on ground. A fighter aircraft requires a distance of 500 m to accomplish this, a medium bomber needs roughly one kilometer, and heavy bombers - Flying Fortress - require a runway several kilometers long. Not only does a heavy bomber require a runway of such length, but actually a regular highway: a concrete super highway several tens of meters wide!

It is imperative for the airplane to shorten its take-off distance, especially when taking off from a combat-zone airfield or from the deck of an aircraft carrier. The dimensions of the airfield required for the take-off of heavy bombers could become significantly smaller should a way be found to reduce the distance needed for

STAT

gaining the take-off speed. In order to attain this goal, designers followed three

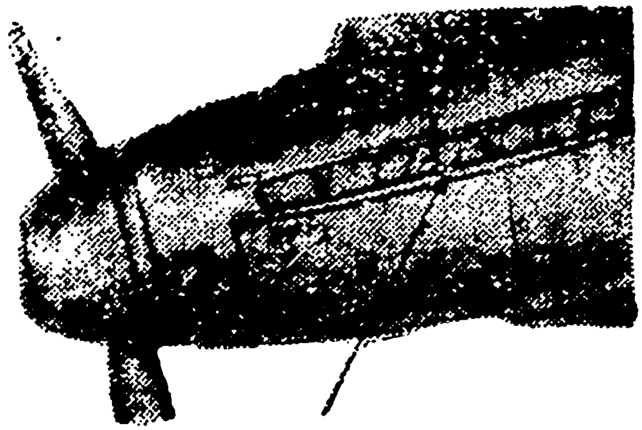


Fig.34 - Jet-Exhaust Tubes or Combusted Aircraft Gases

different approaches. The first was to boost, for a brief period coinciding with the time of starting, the power of the engine by injecting special fuel mixtures into the engines cylinder. The second was to increase the power of the propeller, which meant that the propeller had to be enlarged considerably. The third approach was to launch the aircraft from a catapult.

Neither of the three approaches proved to be entirely successful. The first

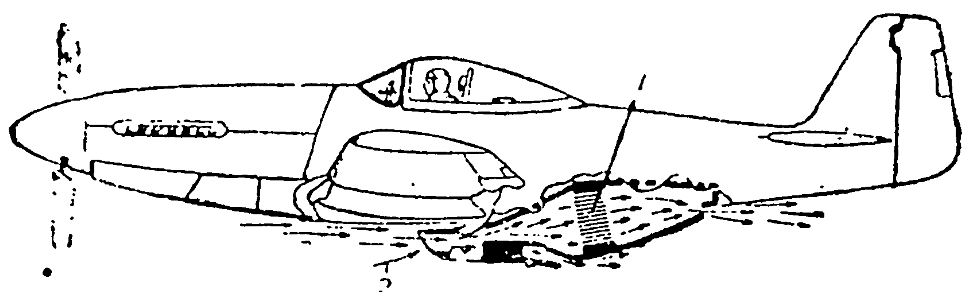


Fig.35 - Ducted Radiator

1-Radiator; 2-Airport within the ducted radiator

was harmful to the aircraft itself, while the second led to an overweight propeller

STAT

which interfered with the rotation. The third approach proved unworkable under combat conditions. It is at times imperative to launch as many aircraft during actual combat as possible so that a single catapult would be of little use.

The rockets came to the aid of the airplane. However, these were not of the conventional military rocket type.

The take-off rockets carried no explosives and did not fly. Attached to the airplane, these rockets assisted the aircraft by providing the initial forward thrust

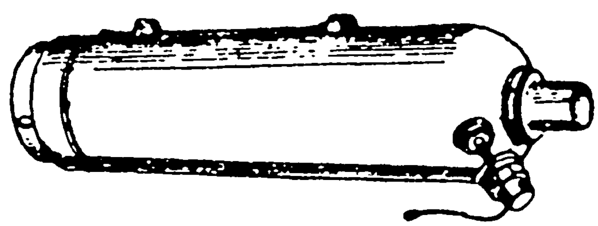


Fig.36 - A Take-Off Rocket

until the aircraft left the fround. A battery of such take-off rockets could create a thrust of 2000 kg and thus shorten the take-off distance by half. These rockets weigh relatively little. Moreover, take-off rockets can be used as take-off assists for gliders .

A four-engine transport aircraft reaches the required take-off speed four times faster with the aid of rockets.

Take-off rockets operate only a few seconds. However, this is all the time required for accomplishing the take-off.

Once the aircraft is airborne, the rockets become unnecessary and can be dropped by parachute to the ground where they are overhauled and readied for further use.

Following this line of approach, the ideas of another inventor proved feasible. During the year 1911, which marked the twilight of modern aviation, the Russian inventor Cherkavskiy proposed that the energy obtained from the combustion of the

STAT

gunpowder charge be harnessed for the purpose of facilitating the aircraft take-off.

There are also liquid-fuel take-off rockets. These are more complex than gunpowder rockets in that they have additional fuel tanks. Such boosters are placed either under the wing or underneath the fuselage. Rocket boosters are able to assist the airplane not only in take-off but also during flight if sudden and short-time speed bursts are required.

As soon as the pilot throws the ignition switch, a force of 0.5 ton is made available to the engine.

The airplane gains speed rapidly and suddenly becomes airborne.

A lever is pulled and, under the white dome of the parachute, the rocket booster is dropped to the ground. A force of 0.5 ton is no negligible force! If several

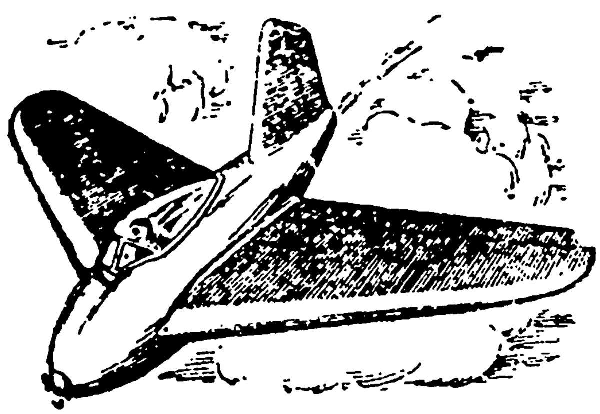


Fig.37 - Fighter Interceptor with a Liquid-Fuel Power Plant

such liquid-fuel rockets are attached, there will be no need for an engine.

An aircraft with a liquid-fuel jet engine is rather interesting, since it possesses a property of considerable importance where aircraft are concerned - a high take-off speed.

Imagine a city deep in the rear lines. It is surrounded by rings of antiaircraft batteries. Spotlights, radar, ack-ack batteries and conventional artillery - everything is in a state of readiness. Fighter aircraft patrol the skies. Fighter-

STAT

interceptors, ready to pursue the enemy during the night, are on constant alert at the airfields. In this situation, mere seconds may become decisive.

The fighter interceptor with a liquid-fuel jet engine can overtake a propeller fighter aircraft with ease. Within 3.5 min an altitude of 10 km can be reached whereas it takes three times as long for a conventional fighter aircraft to reach the same altitude. The higher the altitude, the more difficult will it be for a conventional fighter aircraft to operate. Conversely, the higher the altitude, the easier it becomes for jet aircraft to do so. Within a single minute it climbs 6000-12,000 m.

At an altitude of 10 km, the jet aircraft can climb vertically at a speed of 100 m/sec, or four times faster than conventional fighter aircraft.

It can attain a speed of 1000 km/hr!

However, such aircraft has a serious drawback. The liquid-fuel engine consumes huge quantities of fuel - 5 kg per second and, in order to supply it with such a

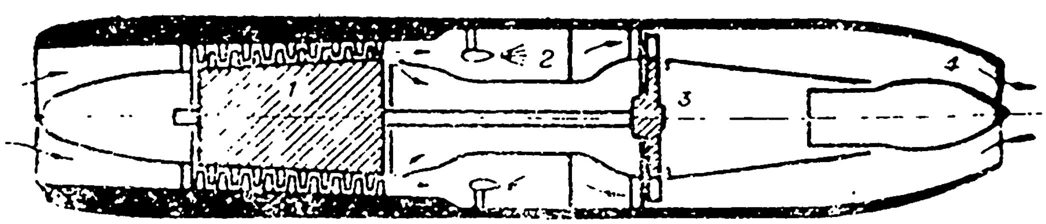


Fig.38 - Schematic Diagram of a Gas Turbine Jet Power Plant

1-Compressor; 2-Combustion Chamber; 3-Gas Turbine;

4-Exit nozzle

quantity of fuel, a special feed pump is required. The fuel supply is sufficient for only 9-10 min of flight.

It is true that such an aircraft could save fuel by putting its engine to work on an intermittent basis. Such an aircraft could stay in the air for prolonged periods of time. However, it would then no longer be an aircraft but a glider run by a

STAT

jet engine. Such an engineless aircraft leaves a trail of white smoke on taking off. The white trail of smoke disappears as soon as the engine is cut out. The trail appears and disappears again, as if the aircraft were a trace of a dotted line in the air. Although the engine can be operated in this intermittent manner, the flight is prolonged by less than an hour - which is not very much.

The new type of jet engine, now widely in use, has no such a shortcoming. To be sure, many different forms of this engine appeared but they were basically all similar.

These engines were called turbo-compressor power plants, since one of their basic components is the air compressor which condenses the air. They also became known as gas-turbine engines since their second basic component part is the gas turbine which rotates the compressor.

Finally, they were called air-jet engines. Jet, since one of the most important parts of the engine is the exit nozzle, and air-jet, since the engine requires oxygen from the surrounding air for combustion.

The combustion chamber and the exit nozzle together constitute the conventional liquid-fuel power plant. This is the simplest type of internal combustion engine, containing no moving parts.

The compressor and the gas turbine constitute the gas-turbine assembly, whose moving parts revolve. This assembly contains parts which revolve several times faster than the propeller of the most powerful conventional airplane. Some of these parts are able to rotate at 16,000 rpm.

We already know how the liquid-fuel jet engine works. What remains is to become acquainted with another part of the turbo-compressor jet engine.

Let us examine this part of the turbo-compressor assembly, consisting of the gas turbine and the compressor.

The gas turbine is one of the most important combustion engines. None of its parts move rectilinearly; all rotate. This is the reason for the unusual compactness

STAT

of the turbine.

Modern internal combustion engines are constructed in an extremely complex manner. High-power aircraft engines are especially complex. There are 42 cylinders in such powerful aircraft engines. How many non-propelling operations must go on within

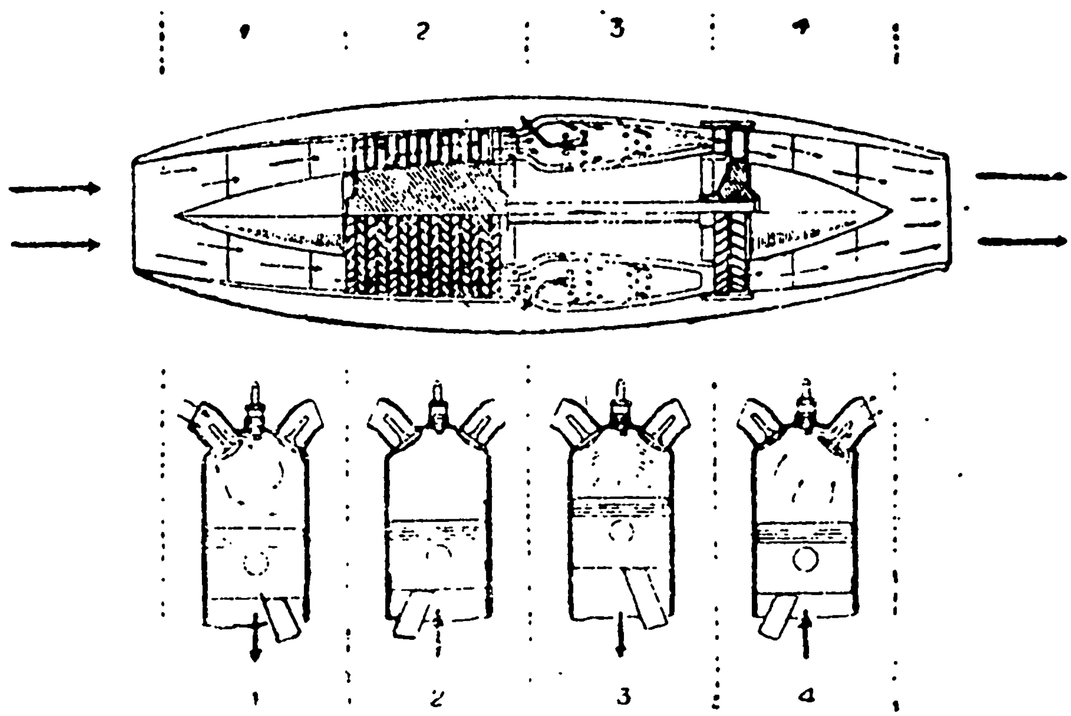


Fig.39 - Strokes in Gas-Turbine and Piston Engines 1-Suction; 2-Compression 3-Combustion; 4-Exhaust. These processes occur at a steady pace in the gas-turbine engine. In the piston engine, they are alternating.

the engine! Of the four strokes suction, compression, expansion, and exhaust stroke, only one - the expansion stroke creates a propulsive type of motion, in that the gases move the pistons.

There is only one continuous action within the turbine - gas expansion and rotation of the disk. All the way through, this single action supplies the propulsive motion.

The turbine is capable of producing enormous power since it creates and maintains a constant high-speed rotation.

Moreover, the compact turbine weighs relatively little. In fact, the aircraft gas turbine is one of the least heavy engines.

The compressor is essentially a turbine, but of the "inverted" type. In this type, the pressure does not decrease as, for example, in the steam turbine. Rather, it increases. As in the turbine, the main part of the compressor is its impeller with uniformly distributed blades. As it revolves, the air is forced from the axle

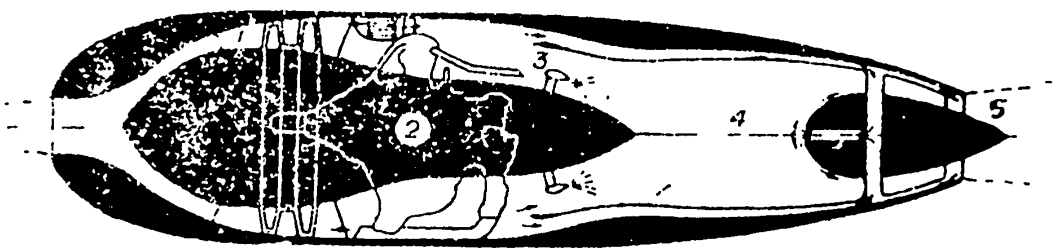


Fig.40 - Schematic Daigram of a Motor-Compressor Jet Power Plant
1-Compressor; 2-Piston Motor; 3-Atomizers; 4-Combustion Chamber; 5-Exhaust Nozzle for Combustion Gases

toward the outer edges where it is compressed, thus raising the pressure. This is the operating principle of a centrifugal compressor in which the air moves along the radius - from the center of the rotor toward its edges. For this reason, such a compressor is called centrifugal.

The axial-flow compressor contains a drum with several rows of bent blades. These blades entrain and propel the air which then is compressed and drops to the next row of blades (compression stages) where it is further compressed, and so on. The number of such stages can be very large. There are compressors with twelve and even seventeen stages.

This is the operating principle of an axial compressor, in which the air cascades from stage to stage.

Between each pair of the revolving blade rows, there is a set of curved stationary blades attached to the engine block. These blades perform the function of equibrating the waves of air current which, in turn, follows a linear path of motion along the axis.

For this reason, this type of compressor is called an axial-flow compressor.

The compressor must be capable of enormous output. A conventional engine of a

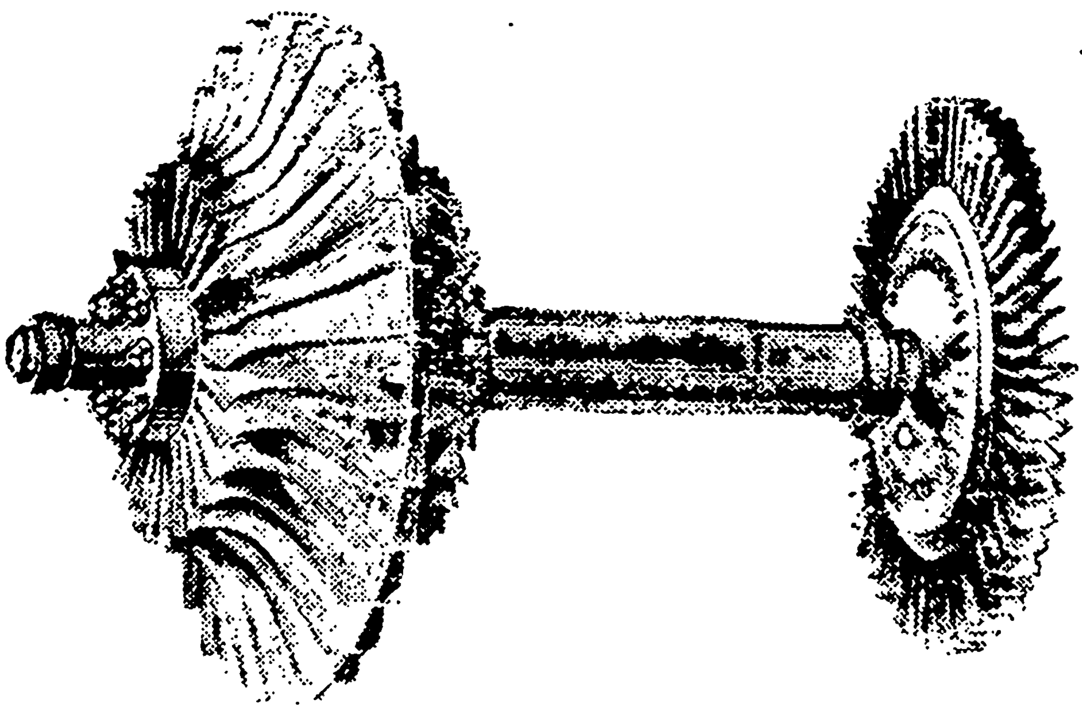


Fig.41 - Gas Turbine with Compressor

modern fighter aircraft consumes one kilogram of air per second, while the air-jet engine consumes twenty times as much!

The compressor compresses the air up to 3 - 3.5 atm. Such gage pressure is necessary if the engine is to be fed tens of cubic meters of air per second for combustion and thus for ensuring sufficient thrust.

This is the function of a compressor in jet engines.

STAT

Might it be possible to simplify the turbo-compressor jet engine if the compressor is no longer driven by the turbine but by another engine - say, the conventional aircraft engine?

This concept resulted in the so-called motor-compressor engine.

However, all of these types are too voluminous and too heavy. Therefore, the gas turbine was used as the engine most suitable for our purpose. Thus, the gas turbine power plant became the principal aircraft engine in use.

It is true that the conventional engine had one advantage: it was older, and as such it had been fully developed and tested. The gas turbine was quite new and, as such, it had barely been developed. On the other hand, the gas turbine is much simpler and it has an overall advantage.

Like the compressor, the turbine has a rotor with rows of blades. There can also be several rotors: As in the case of compressors, they contain several rows of stationary blades.

The streams of combustion gases strikes the turbine rotor blades with a tremendous impact. As the gases spread, the pressure decreases. Part of the resultant energy revolves the rotor while the other part provides the thrust.

The turbine rotor operates under extremely difficult conditions. While it is constantly revolving at enormous speeds, the centrifugal force destroys the rotor.

The compressor functions under the same hazard, but performs successfully without being destroyed.

It is not obligatory for the compressor rotor to revolve at 12,000 - 15,000 rpm. It is, however, tied to the turbine shaft: One end of the shaft carries the turbine rotor and the other end the compressor rotor. Although the distance between the two is only two meters, the conditions prevailing at the two opposite ends of the turbine shaft are vastly different.

At the forward part of the shaft there is only pure air; as the shaft rotates, the air is moderately heated. At the end part, the gas stream creates a temperature

STAT

of 800°C.

The turbine rotor does not only revolve but heats up to red heat.

This raises the question why such high-temperature gases are directed toward the rotor.

If the compressed-air jet from the compressor were less compact, the temperature would drop, causing the turbine to operate under less difficult conditions. However,

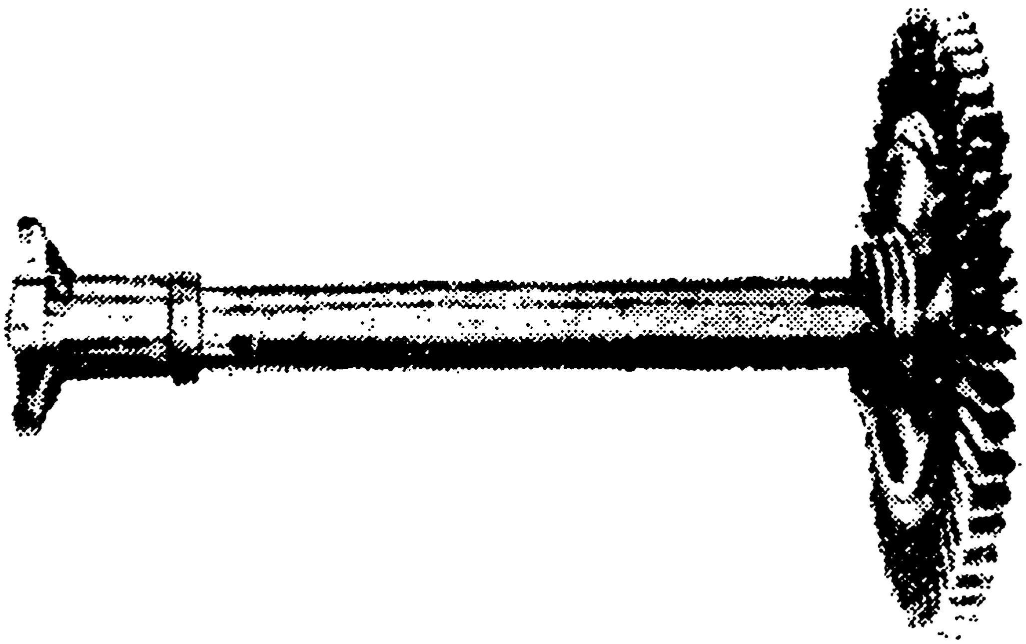


Fig.42 - Gas Turbine

it was found that such is not the case. If the temperature of the gases entering the turbine is lowered, the turbine will perform poorly due to a huge loss of energy.

This proved the main stumbling block in the development of gas turbines and constitutes the reason for the fact that the first working gas turbines appeared only about 40 years ago, despite the fact that the first gas-turbine patent was granted over 200 years ago.

Actually, no type of conventional material used for constructing machine parts can endure the difficult conditions under which the turbine rotor is required to operate: The enormous and destructive force of extreme temperatures.

There are many types of steel with which glass can be cut.

One of these is the heat-resistant steel which can withstand high temperatures up to 650°C. However, even such high-quality steel will not last if subjected not only to heat but also to excessive pressure.

This is precisely what happens to the gas-turbine rotor. Even in a relatively slow moving turbine, the rotor blades are under pressure exceeding 1700 kg/cm.

The complex composition of alloys and the harnessing of rare elements contributed toward the solution of the problem. It was necessary to test literally hundreds of steel alloys before the problem was solved, however. There were alloys which proved to be a dozen times better under red-hot temperatures than ordinary steel.

Moreover, the steel used for gas turbines must have a high tensile strength. Another thing can happen in the case of steel. Under excessive stress, the blades may gradually begin to "creep" and elongate, which would make them mesh with the internal ring of the turbine.

Each rotor blade must be designed with extreme care. The most minute surface roughness could ruin everything; each blade must differ as little as possible from the rest in shape, dimensions, and weight.

The blade has a complex shape and is therefore difficult to construct.

It was necessary to mold the rotor blades on presses. When struck by a heavy hammer, the blade material is forged into its required shape. The blade is then placed in a special machine where it is ground, beveled, and polished until it becomes smoother and brighter than a mirror.

After a careful check designed to reveal even the most minute scratches and roughnesses, the blade is ready for use.

Blades were also made by casting molds used in experiments in the jewelery industry. The complex shape of these blades required a most careful and accurate method of operation. To make small parts, like jeweled ornaments and objects of art, high-precision molds have to be used. For this purpose, wax is poured under high pressure into a metal die. The wax fills out all grooves and fissures. A special, quick-setting substance is then poured over the wax. During the process of heating, the wax melts and flows out of the die. Then molten metal is charged into the mold under a certain amount of pressure. After cooling, the mold is broken, which automatically cleans the resultant casting. As a result, the casting obtained in its final form is so precise that further work becomes unnecessary. For example, an article of 10 cm length can be cast to within an accuracy of 0.25 mm. This is the method used for the manufacture of gas-turbine blades.

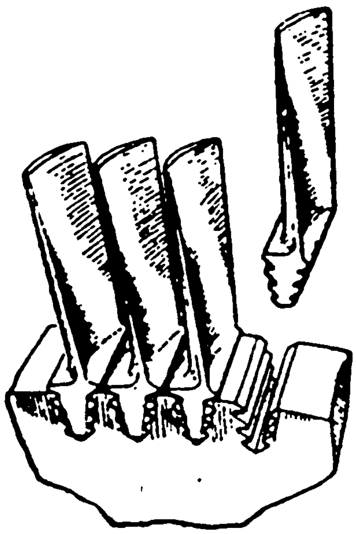


Fig.43 - Gas-Turbine Blades

The turbine rotor is made with equal care. Here a new task consists in joining the blades and rotor. This is not a simple operation, since each blade must retain its rigidity while being connected to the rotor under extremely difficult working conditions.

In certain gas turbines, the blades can be welded to the rotor, although this does not preclude other joining methods. The shank of the blade, inserted into the rotor has a herringbone shape, with corresponding herringbone grooves cut in the rotor. The blades are then pushed into these grooves which engage the blades and hold them securely.

Numerous experiments on the development of aircraft assemblies and the improvement of metals went on simultaneously with the manufacturing of gas-turbine jet power plants.

The gas-turbine jet engine proved far superior to piston engines.

STAT

The gas-turbine engine weighs three times less than its piston counterpart and has significantly fewer component parts. Due to the complete lack of parts subject to heat of friction, these power plants could be kept in top shape, with minimum maintenance. Consequently, the manufacture of jet engines require fewer materials, machinery, and workers. Furthermore, they are easily and rapidly made.

Let us now discuss the engine in flight and describe its control.

A small drive motor rotates the turbine shaft. The turbine begins to rotate, causing the compressor to rotate and forcing the compressed air into the combustion chamber.

Next, the engine has to be started. Fuel for initial start is fed to the chamber, the temperature increases, and the turbine revolutions gather momentum. Eight

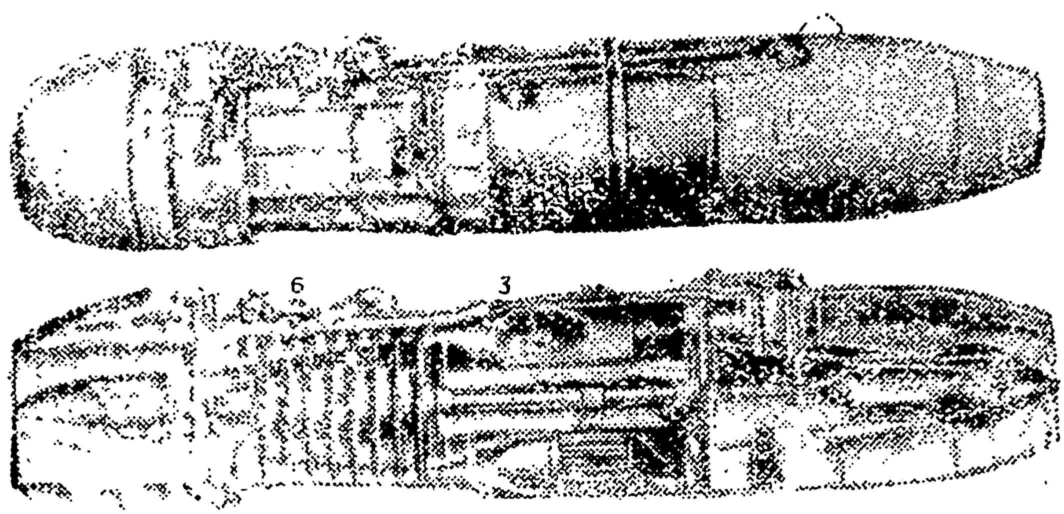


Fig. 14 - Gas-Turbine Jet Power Plant 1-Starter Motor; 2-Compressor; 3-Combustion Chamber; 4-Atomizers; 5-Gas Turbine; 6-Governor for controlling the rpm; 7-Exhaust nozzle cone.

hundred, one thousand, two thousand revolutions.

The small drive motor is disconnected and the power plant begins to operate on the main fuel supply. The rate of revolutions increases, and the aircraft gains speed.

STAT

on different assemblies and levers for flying the aircraft.

In a jet fighter, the pilot has only one lever - the gas throttle. Instead of eight control panels there are only three.

How is this possible ? - will be the obvious question. Is it not true that an aircraft is flying at a constant and uniform flight: The altitude and the flying speed vary, which means that the engine cannot have a uniform performance at all times. This cannot be done with only one lever! There must be in addition levers which control the turbine revolutions, the fuel consumption, and the forward thrust.

This is correct. This is even more true of the jet engine than of the piston engine. We already know the difficulties involved in the operation of the turbine. If we inject more fuel than required, the temperature will surge suddenly and the blades will melt. The engine will outlive its usefulness ahead of time. The optimum service life of the jet engine is not very great - only about 200 hrs. The conventional engine has a longer life. For this reason, the jet engine has to be operated with maximum care.

How can this be done ?

It is done with the aid of automatic engine controls.

Let us see how these work.

The flying speed increases together with the air pressure. The compressor scoops up air which is already slightly compressed. The rpm does not increase, which means that the compressor begins to perform unnecessary work since it supplies more air than needed. The temperature of the gases upstream of the turbine decreases and the gases become diluted with excess air.

This cannot be permitted to happen since this will prevent the turbine from operating. Therefore, the engine must be boosted rapidly.

Looking at outlet end of the engine, you will see a small cone which can be displaced along the shaft length. While the speed is negligible, this cone remains stationary without interfering with the gas exhaust. As soon as the speed increases.. the cone comes to life, sliding toward the exhaust nozzle and partially closing it. This forces the gases to flow out through a small annular opening. The gas jet decreases within the engine which returns to normal operation.

The altitude is increasing. The surrounding air becomes less dense. The amount of air sucked into the engine decreases and the temperature rises. This is also impermissible since it might cause the turbine to slide out of the assembly. More air is needed immediately! The cone retracts, like a snail in its shell, and the gas stream increases. The engine is working normally again.

Fig.45 - Exhaust-Tube Cone

Who or what controls this "clever" cone ?

The automation. It follows carefully the operation of the engine and, when necessary, assists the engine by moving the cone. This automatic device is very simple.

Its brain consists of a small aneroid box resembling the aneroid barometer. Actually, this is a barometer except that it does not record the air pressure but the air pressure differential. The air is taken in through the front opening and is discharged through the rear port.

During the pressure change within the compressor, i.e., during a variation in flying speed which leads to a higher or lower outside pressure, the aneroid box is compressed and contracts a spring which ultimately triggers a miniature electric motor through a system of transmission ducts. The miniature motor then moves the cone-holding rack and pinion.

STAT

How does the pilot manage the gas throttle? The gas throttle controls the fuel flow, which means that it determines how the engine will work and how long the flight will last. With the aid of the gas throttle, the pilot engages another automatic device - the governor which control the number of revolutions.

The engine is supplied fuel by a pump which is rotated by the turbine shaft. The faster the rotation of the pump cogwheels, the more fuel is fed by the pump.

The governor which maintains the number of revolutions dictated by the pilot, ensures a steady inflow of fuel. It works in the following manner: Two ball-like weights are placed inside the shaft socket. A distributing device (slide valve) is also located within the shaft. It resembles a small bar with two valves. The upper valve is controlled by the pressure of a spring located above it. The balls act as spring weights. This is the entire structure of the automatic device.

When the engine shaft revolves, the ball weights spin with it. The centrifugal force pushes the ball weights aside and, by exerting pressure on the upper valve, opens the gate. This is the entire operation. The spring is so regulated as to react only to a definite pressure, thus maintaining a balanced ball-weight pressure. The slide valve or gate shuts off the intake opening for oil flowing inside the governor. The equilibrium is maintained as long as the number of shaft revolutions remains unchanged.

Now, the number of revolutions increases. The centrifugal force becomes greater and the spring contracts and displaces the gate, under the increased pressure of the ball weights. The oil which also is under high pressure enters the gate which shifts and prevents the fuel from entering the engine. In that case, the pump is inoperative.

As soon as the number of revolutions decreases, the gate shuts off the oil again. With the equilibrium reestablished, the rotational speed returns to its original value.

When the number of revolutions is reduced, the oil enters the sluice under high

STAT

pressure, shifting the sluice gate and thus reopening the fuel feed.

When the pilot wants to change the number of revolutions, he shifts the rack-and-pinion drive by means of the gas throttle and thus regulates the spring recoil. The governor does the rest by closely following the number of revolutions and keeping them constant.

These simple mechanisms perform complex operations while they assist the pilot.

The flight is nearing its end and the pilot prepares the aircraft for landing. Even for conventional aircraft, landing is no easy feat. Normally, the aircraft first follows a path of vertical descent to a low altitude where it levels off and continues to fly horizontally, reducing its speed at the same time. Considerable flying experience is required of the pilot for a proper landing. As the speed of the aircraft is reduced to the point where the wing lift force becomes negligible, ascent becomes rather difficult. The aircraft is now gliding through the air without the aid of its power plant. It must touch the ground smoothly with its two main wheels and its tail skid making a "three-point landing" as the manual states. Finally, the aircraft is firmly on the ground as it rolls along the runway.

To land a jet aircraft is not the same as to land a conventional airplane. After cutting its engine, a jet aircraft needs considerable time before it begins to lose speed. As soon as the speed reduces to the point where the landing gear can be lowered, the pilot must judge his landing distance with great accuracy. If a first landing attempt should fail, the pilot of the conventional airplane can always make a "second approach". It is very difficult to do the same with a jet aircraft since it is a rather complex operation to start the engine again. A jet engine is far slower to start than its conventional counterpart. For this reason, during both landing and attack, the jet aircraft must be successful the first time.

Aircraft with gas-turbine power plants use a tricycle landing gear – with a nose wheel – which ensures safe landing in case the speed of the craft is too high at the instant of landing. Aircraft with liquid-fuel power plants use skis instead of the [illegible]

The manufacture of a jet engine is both difficult and complex, [illegible] constant fight against obstacles each of which has to be overcome if the entire engine is to work smoothly and properly. A jet engine has to be tested, readjusted, and retested before it becomes ready for the final ground and flight tests after accumulating a certain test mileage.

One of the most difficult problems involved the feeding and combustion of fuel. Engineers working on the construction of gas turbines encountered a sudden and unpleasant surprise: While testing one of the jet power plants, the latter functioned poorly. Its turbine supplied only half of the needed number of revolutions. It was found that the feeders failed to feed the fuel properly! The feed spring overheated and did not contract. The fuel combustion was inefficient and, when the supply of fuel was increased, the fuel did not burn in the air chamber, ahead of the turbine, where it was supposed to burn. It burned, instead, behind the turbine.

When the combustion chamber was improved, the number of turbine revolutions increased. However, this was still far below the required number.

The unpleasant surprises relative to combustion continued in subsequent testing of jet engines. The turbine-rotor blades broke under extremely high gas temperatures and heavy rotational loads. Various types of combustion chambers were tested separately until the desired results were attained. No sooner was a new combustion chamber installed into the power plant assembly that a new unexpected phenomenon occurred. It was necessary to redesign the various combustion chambers several times before proper feeding of the fuel became possible.

Another difficulty involved poor compressor performance. The compressor refused to provide the necessary pressure. Attempts were made to build entirely new types of compressors...but their performance only dropped further. While searching for the reason, it was discovered that gases from the combustion chamber leaked into the compressor. A small hole was drilled through the compressor wall - and a flame

STAT

emerged. Suddenly, during the testing of one of such compressors, its blades began to engage the compressor wall. Within thirty seconds all the blades were broken and the effort of eighteen months was cancelled. Finally, a third experimental engine with a prefabricated compressor added another thousand revolutions to the rotating turbine. However, a new snag developed next. It was found that the blades melted and dropped off the rotor during the rotation of the turbine. It became necessary to find another method of keying the blades to the rotor.

After overcoming all these obstacles, the entire power plant was retested...and again the engineers suffered defeat.

It was only after additional repairs and testing that the power plant began to function properly.

The gas-turbine jet power plant has many advantages. We have already examined some of these. The system is lighter, simpler, and easier to produce than the piston engine.

Its dimensions are considerably smaller than those of the piston engine. For example, the turbojet engines of Navy fighter aircraft have a diameter of only 0.5 m. This permits their installation into the wings.

There are other advantages. The jet engine requires no special fuel. It can use equally well not only gasoline but even cheaper fuels like gases, kerosene, and Diesel fuels.

The jet engine has no propeller. At too high a speed, propellers do not work efficiently. Besides, the jet engine fits comfortably into a propeller-driven air-craft, thus improving its flight performance. The hulls of flying boats were made more streamlined by replacing the propeller with a jet engine.

However, the jet power plant has certain disadvantages. We have mentioned some previously.

In spite of all the improvements, the jet engine has a relatively short life. Designers were much concerned with this drawback. In every conceivable way, they

STAT

tried to improve the engine by increasing its thrust and by determining the optimum use for the heat created.

A jet engine takes five to six times longer than a piston engine to reach full speed. If too much fuel is fed in an attempt to gain full speed prematurely, the

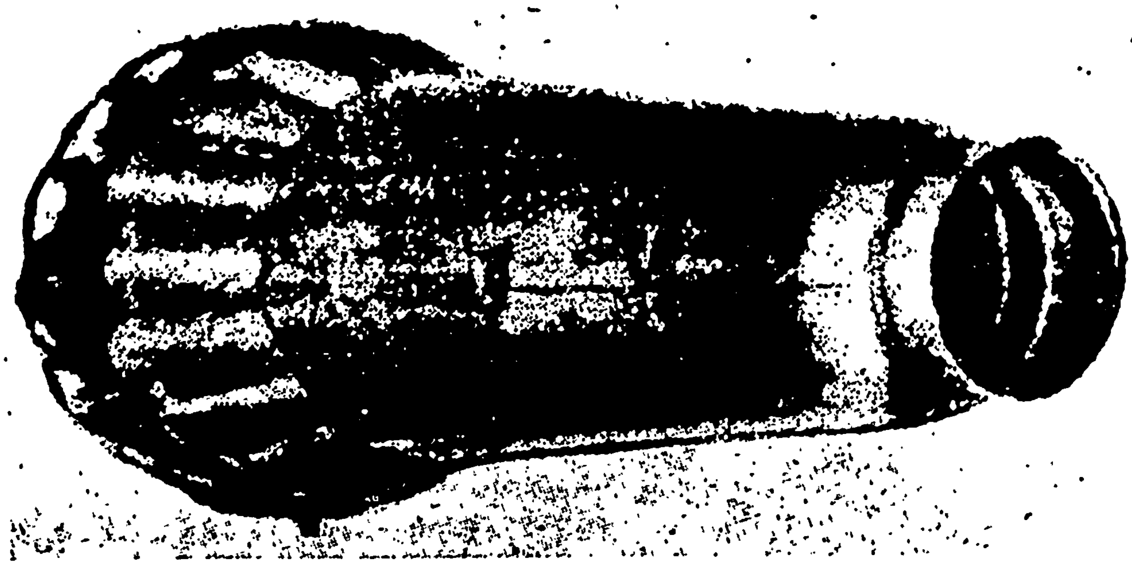


Fig.46 - Gas Turbine Jet Engines with 16 Combustion Chambers

engine will overheat. When this happens, the governor is forced to control maximum rpm, the fuel flow will increase, there will be a shortage of air, causing a temperature rise.

This is a dangerous engine condition. Each degree above normal heating temperature means the loss of one percent of the material life.

To obtain better protection of the engine, a special automatic device was invented. It would permit an increase in fuel flow only on increase in air flow. Thus, the turbine-rotor blades were protected from overheating.

Several other excellent methods were discovered for constructing a jet engine which would become the best, the safest, and the most economical.

It would be next to impossible to name all of them. Nevertheless, we will discuss one of these: The turboprop engine.

In the piston engine, the starting coefficient is greatest at the beginning and then decreases. In the gas-turbine jet engine, the coefficient is constantly high.

The faster the aircraft, the more economical will its engine become.

The thrust of piston engines first increases with the speed and then decreases again. In the gas-turbine jet engine, the opposite is the case: The thrust first decreases and then keeps rising.

In the piston engine, the thrust increases with altitude and then decreases, while in the gas-turbine engine it decreases constantly but at a much slower pace.

The piston engine, on gaining altitude, first consumes and then consumes more, while the opposite is the case with the gas-turbine power plant under the same conditions.

How can this be so ?

The piston engine functions well at low speeds and low altitudes: It develops a large thrust on take-off, precisely when it is most needed. It consumes relatively

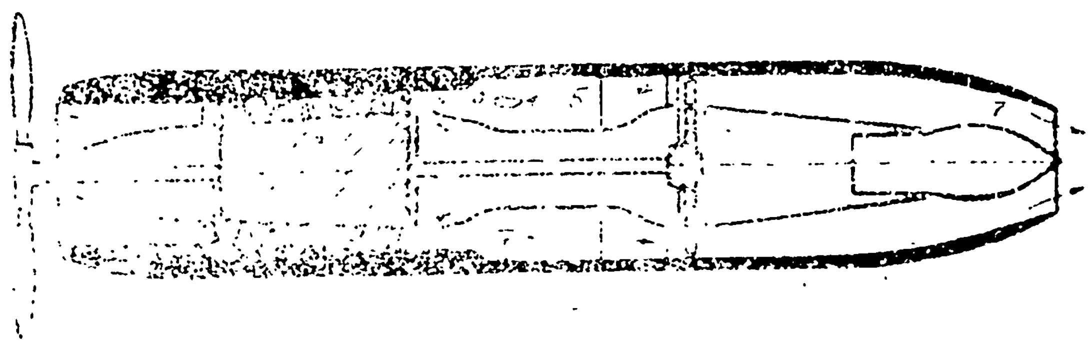


Fig.47 - Schematic Diagram of a Gas-Turbine and Propeller Engine 1-Propeller; 2-Reducer; 3-Compressor; 4-Atomizers; 5-Combustion chambers 6-Gas turbine; 7-Gas exhaust nozzle

little fuel and responds well to the piloting by the pilot.

On the other hand, the piston engine becomes capricious at high speeds and high

STAT

95

The jet engine works the other way around. At low speeds [illegible] thrust decreases and its fuel consumption increases by almost ten to twelve times over the consumption of piston engines. The jet engine increases in efficiency as the speed becomes progressively higher. Its thrust increases and its fuel consumption drops.

At low speeds, the propeller of a conventional airplane works efficiently. In a sense, the propeller prevents the engine from running at optimum performance.

However, all these difficulties show only when the flying speed reaches about 900 km/hr.

Can a conventional propeller be used in jet aircraft? Is it true that the jet aircraft travels at high speeds all the time? Yes, except on take-off and landing. Here, the propeller can be extremely useful.

This is what led to the creation of the gas-turbine and propeller engine.

This system closely resembles the jet power plants discussed above. The only added feature is the propeller.

The gas turbine is capable of 8000 rpm, which means that the velocity impact on the tips of the propeller blades would exceed the velocity of sound. The impact would become even greater after the aircraft has taken off. No propeller could withstand the colossal pressure which results from the centrifugal force of rotation. Even the comparatively low revolutions of an ordinary propeller create an impact equal to tens of tons on the blade tips.

For this reason, a reducing gear (toothed transmission) is installed between the turbine shaft and the propeller. This device is used for reducing the number of revolutions.

In such gas-turbine assemblies, the thrust and the propeller rotation can be regulated.

During take-off and at low speeds, the propeller is rotating at full speed,

STAT

while at high speed the thrust would be maximized.

This is of special importance, since it is now possible to reduce the take-off distance and to increase the take-off speed.

At tremendous speeds, the propeller can be put into a position parallel to the air flow as is done with a wind vane. Such an engine then becomes gas-turbine

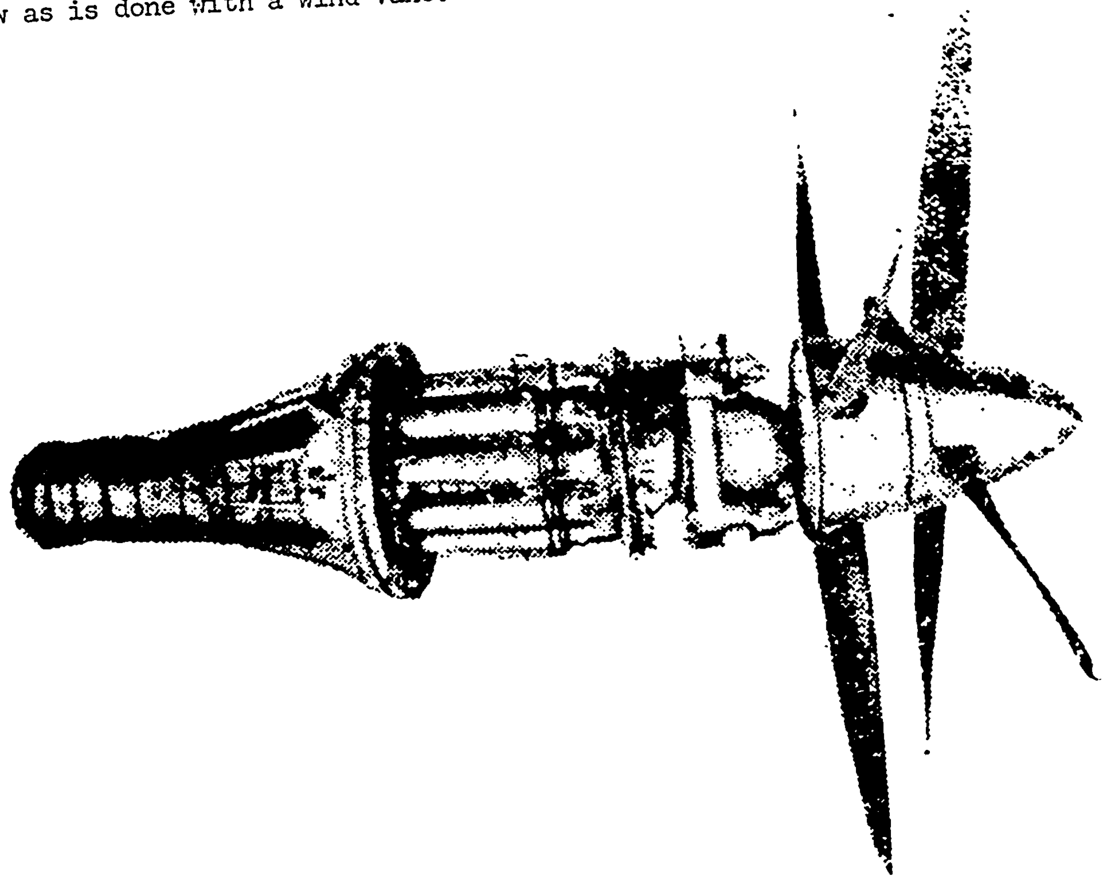


Fig.48 - Gas-Turbine and Propeller Power Plant

driven.

The jet engine creates additional demands. It consumes much fuel and thus larger tanks are needed. Fuel tanks which are jettisoned when empty, were being mounted on jet aircraft.

A jet engine can be installed at various points of the aircraft.

It can be placed in the fuselage. Several jet aircraft are of this design. The fuselage resembles the mouth of a shark, because of the large front opening through which the air is sucked in.

STAT

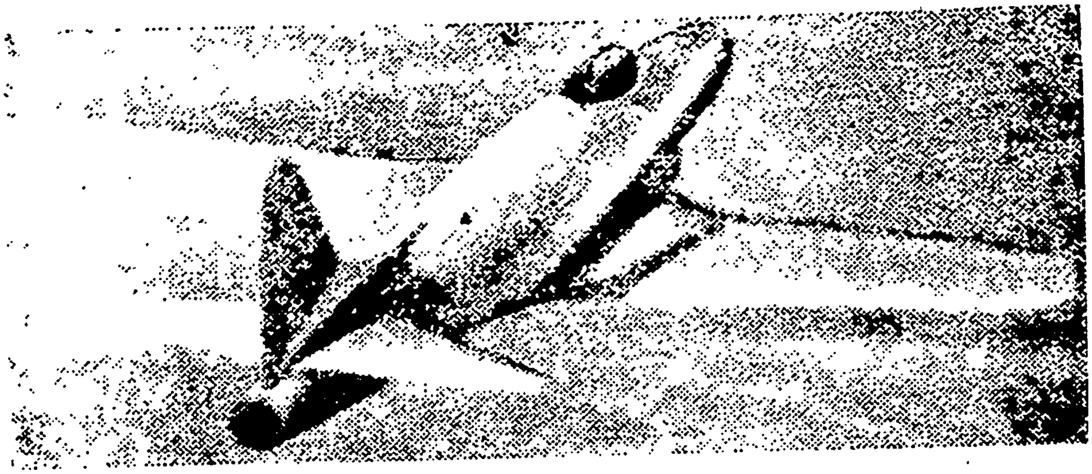


Fig.49 - Airplane with Jet Power Plant in the Fuselage

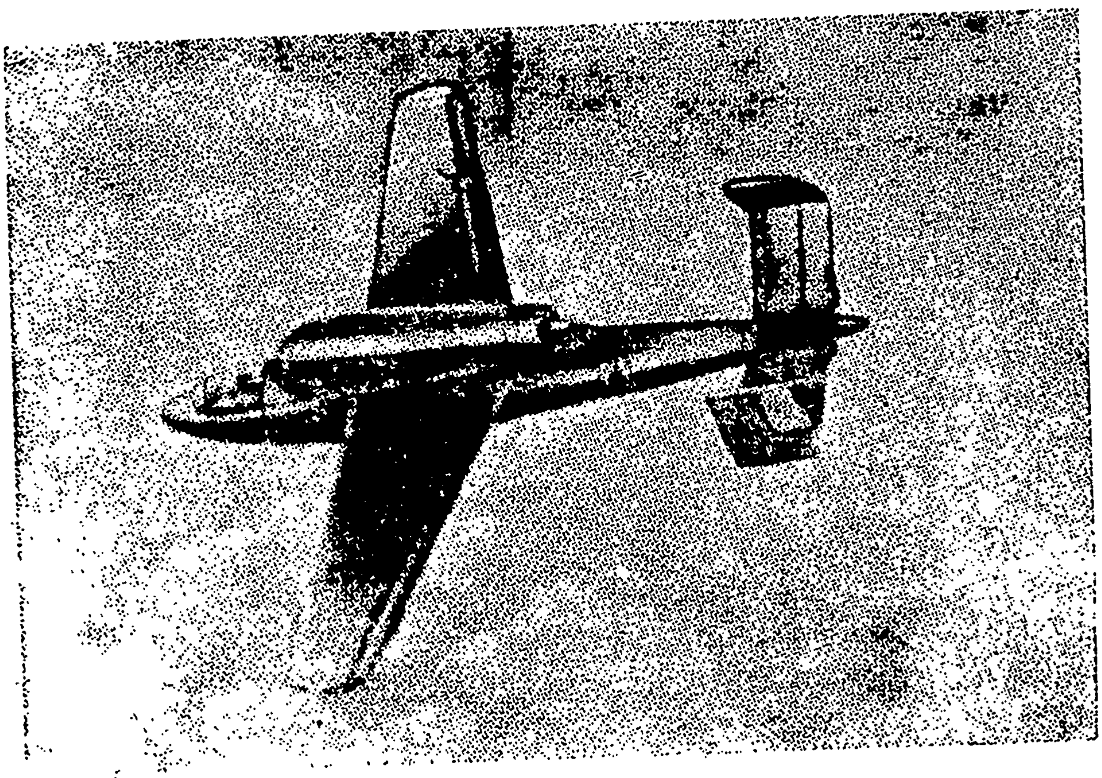


Fig.50 - Airplane with Jet Power Plant above the Fuselage

It is not sufficient to merely suck the air into the aircraft; the air must be fed into the engine.

The installation of air ducts would, however, decrease the fuel-storage space.

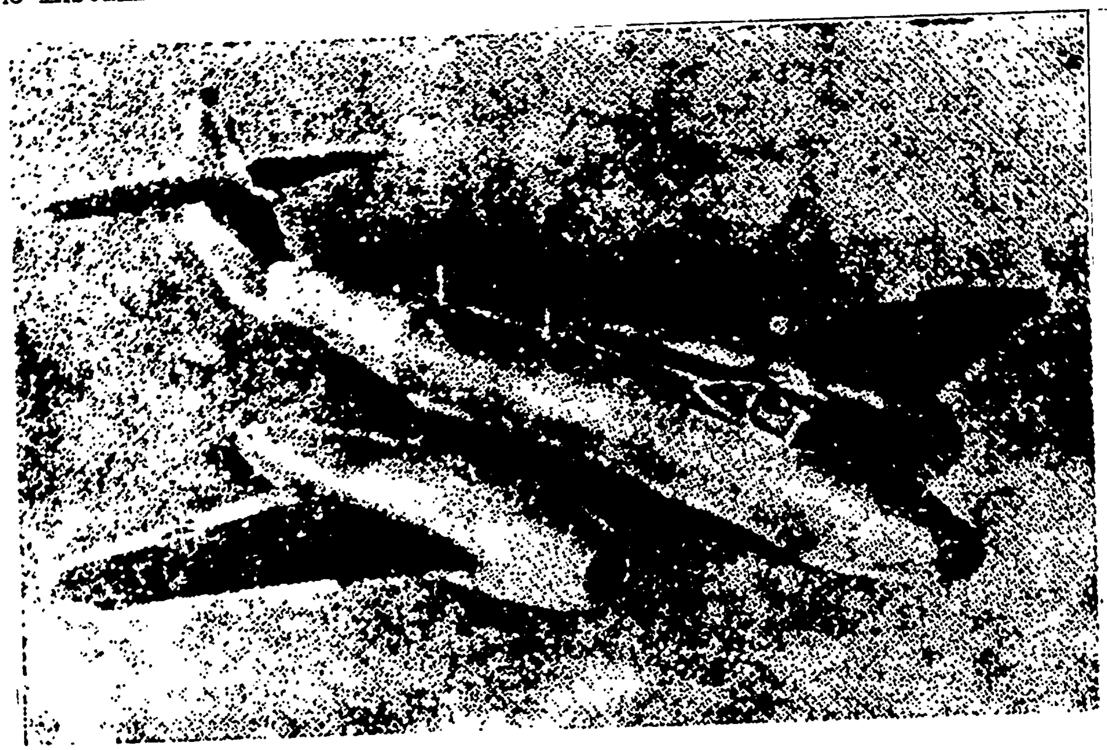


Fig.51 - Airplane with Jet Power Plants in the Wings

The fuselage could become too bulky and thus create added drag.

The jet engines can be placed into a nacelle-like compartment which can, in turn, be installed wherever it is most suitable: Under the wing, under the fuselage, or above the fuselage. In this way, the fuselage would remain streamlined and would produce minimum drag. Moreover, the fuselage could then house additional fuel supply.

The new aircraft engines led to the construction of new aircraft - the jet aircraft.

We will discuss these in the next Chapter.

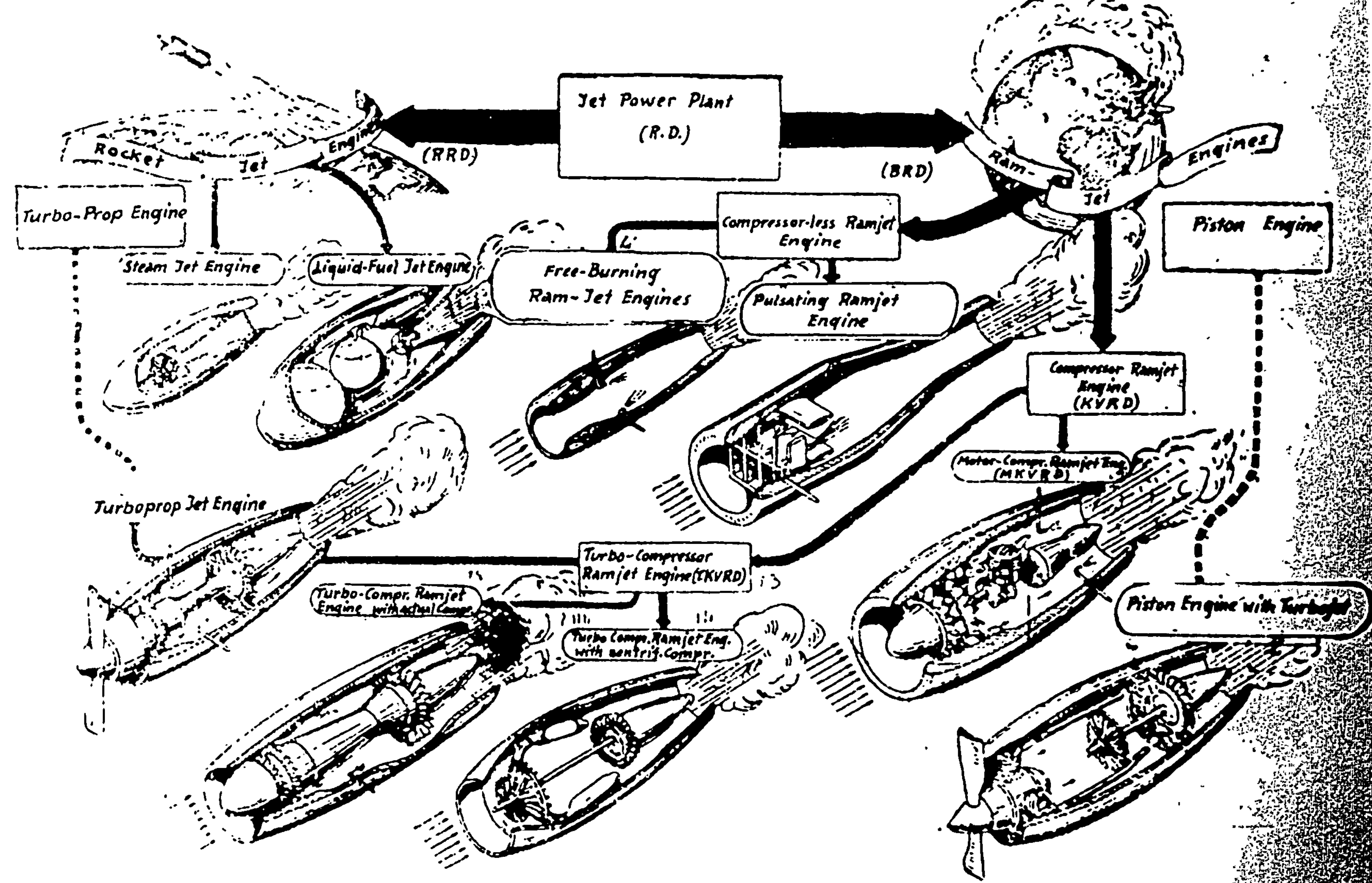


Fig.52 - Types of Reactive Power Plants

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

CHAPTER VII

THE JET AIRCRAFT

On August 18, 1946, thousands of Muscovites jammed the huge Tushino airfield for the first time since the war. The country was celebrating Stalin's Aviation Day.

Bombers, transport aircraft, fighters, long-range "Flying Fortress" bombers flying in parade formations over the Tushino airfield.

Suddenly, amid the noise made by conventional aircraft engines, there was a new sound.

Unusual propellerless aircraft flew over at dazzling speeds. In an instant of time they soared into the skies, leaving smoke streaks as the only means by which spectators could tell that they really saw them in flight.

New jet aircraft were flying over the airfield... .

"The aircraft propels itself at unusual speed", said colonel Gallay, the test pilot who spoke of his flight in a jet aircraft. "When I took off, I did not even hear the sound which usually accompanies speed acceleration. When I glanced beyond my aircraft control panel I could hardly believe what I saw. At high altitudes, it ordinarily seems to the pilot as if the landmarks are merely 'crawling'. Now, villages, hill tops and fields all loomed before me as if they were on a screen of some kind. Soon, I saw my airfield. And, no sooner had I been able to see it, when the airfield was already behind me... ."

The flight of a jet aircraft resembles the flight of an engineless glider.

STAT

The flight of a jet aircraft resembles the flight of an engineless glider. There are no engine sounds and instead of a deafening roar there is only a relatively mild whistling sound.

The jet engine is simpler than its piston counterpart. A jet aircraft has fewer assembly parts. In addition, there is little difficulty in flying it.

"It is an excellent aircraft!" - concluded the pilot.

A year went by. Moscow was again celebrating Aviation Day. Once more, the Soviet pilots were able to demonstrate their brilliant mastery while flying over the Tushino airfield.

No sooner had the noise of engines subsided when a very sharp whistling sound, reminiscent of the one made by an artillery projectile in flight, was heard over the viewing stands. A jet aircraft designed by the Hero of Socialist Labor, A.S.Yakovlev flew over the airfield at a speed close to the speed of sound. It then soared upward, engaging in the most complicated flying acrobatics. To this day, no pilot in the world had been capable of a flight performance superior to that of the Soviet airmen. The audacious Soviet airmen are able to handle with proficiency all new and extremely complex means of technology.

Three more jet aircraft flew over the airfield. Rapidly and in close formation, they approached the airfield and... in a second disappeared into the skies. A moment later, a group of jet aircraft reappeared over the mid section of the airfield and began to sky-write a series of signs with stunning rapidity.

The jet craft also took part in a simulated air battle staged over the airfield. There, behind the powerful bomber craft, behind the "Flying Box Car" transport aircraft, behind the "Yaks" and "Lavs" of World War II battle fame, the jet aircraft reappeared at the beginning of the main parade of the military aircraft. They marked a new and notable success of Soviet aviational technology.

One of the test pilots, the Air Force major-general P.M.Stefanovskiy, led a group of "Lav" fighters equipped with jet take-off assists. With a shattering noise,

STAT

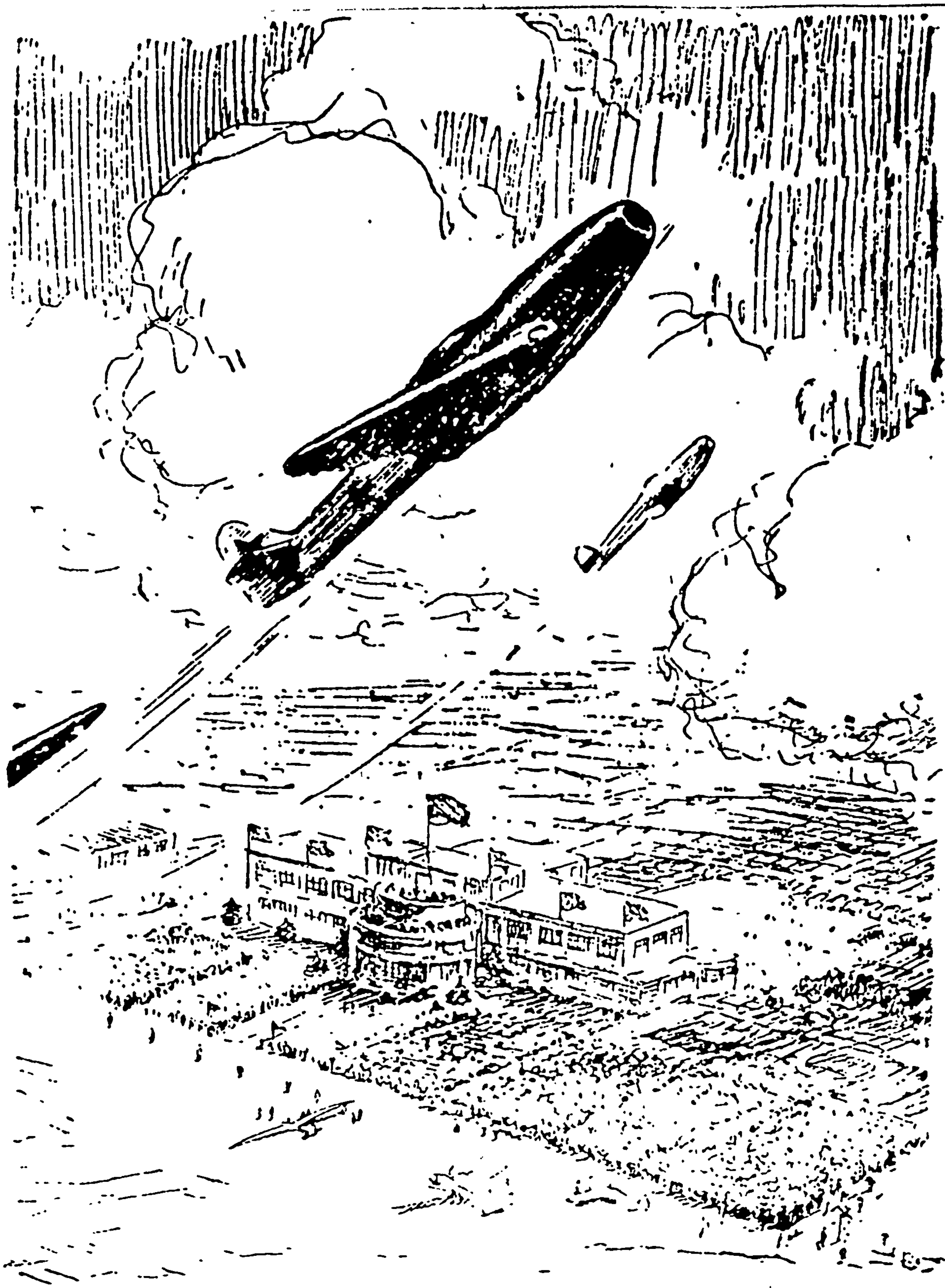


Fig. 53 - Jet Aircraft in the Aviation Day Parade

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

the latter flew over the airfield disappearing almost instantly [illegible]

The sound of these ships barely had died down when jet aircraft, built by the Stalin Prize Laureates, Mikoyan, Lavochkin, Sukhi, Gurevich, Yakovlev, Tupolev, Ilyushin, flew over one after another.

"As a test pilot, I often fly jet aircrafts", said the test pilot, engineer-major A.G.Terentiev. "Their speed is tremendous and is close to the speed of sound.

"During the air show, we flew jets in close formations. The flight chart could not give us much of a bearing. We passed over the water reservoir, Istra, and the Tushino airfield. Without the slightest exaggeration, I would say it took no more than a minute for all this to happen.

"...Sometimes, I would participate in training 'air battles' involving both propeller-driven and jet-propelled aircraft. All the advantages of the jet aircraft would emerge clearly in 'battles' of this type. In just such a 'battle', Comrade Manucharov, the test pilot who flew the jet, defeated me rapidly. I did not even get a chance to register a single 'hit' with my machine-gun camera, which shows the great superiority of the new aircraft. Our airmen have attained a high degree of expertness in the piloting of jet aircraft. There are no acrobatic sky maneuvers involving modern jet aircraft that Soviet pilots cannot execute."

It was our country that gave the world for the first time its scientific theory of flying and subsequently the theory of jet propulsion which constitutes the basis for modern jet technology. The Soviet Union is a country in which aviation is wide-spread as a discipline. New aircraft, built by Soviet designers and manufactured by Soviet industry, demonstrate the increasing power of our Air Force and the mastery of the Stalin Flying Eagles.

It was Russian science that paved the way for the perfection of aircraft.

"The era of propeller-driven aircraft, will be followed by the era of jet aircraft." There were no jets when Tsiolkovskiy wrote this prophetic sentence.

We have already discussed the work done on the aircraft jet engines. We are not going to deal with the design and construction of aircraft equipped with jet engines. The main achievement here belongs to the field of aviation science - aerodynamics.

Today, aerodynamics or the science which deals with the motion of bodies in the air, is no longer a single field of science as it used to be during the twilight of aviation but is a composite field consisting of an entire series of individual fields.

Fig.54 - S.A.Chapligin

Not too long ago, the problem of high speeds was added to the general field of aerodynamics.

The leading role in high-speed aerodynamics was played by Russian scientists.

In the year 1902, one of the honorary lecturers at the Moscow University, Sergei Alekseyevich Chapligin, brilliantly defended his doctor thesis entitled "On Gas Jets". Worked out in minute detail, his thesis contained an elaborate theory on overcoming the drag of bodies flying through the air at speeds approximating the speed of sound. No aircraft were in existence when Chapligin wrote his thesis. Chapligin's work, which made Russian aerodynamics famous, became the basis for the then new science of gas dynamics. Gas dynamics is indispensable for high-speed aircraft and rockets of today. It is moreover indispensable in the study of the motion of gases when the latter travel at enormous velocities through such vessels as tubes and orifices. Gas dynamics is furthermore of paramount importance for theories which deal with turbines and jet engines. The notable work of S.A.Chapligin became

STAT

[illegible]

once held in Rome in 19[illegible] which dealt with high speeds in aviation, Chaplygin's [illegible] was recognized as the foremost in the field.

Thus, the work of the Academician **Chaplygin**, Hero of Socialist Labor, formed the foundation on which all computations pertinent to high-speed aircraft were based. The method developed by **Chaplygin** proved exceedingly beneficial to the further developments in gas dynamics.

It helped the Soviet scientists, whose work in the fields of aerodynamics and gas dynamics occupies first place in the world, to advance furthermost the science on which the modern technology is founded. Broad research in gas dynamics and the application of **Chaplygin's** methods to various problems of aviation, jet technology, and the construction of gas turbines were included in the Five-Year Plan of the Academy of Sciences of the USSR.

The great Russian scientists, Nikolay Egorovich Zhukovskiy being the most prominent among them, wrote several papers on gas dynamics. He was principally interested in the problems of gas motion at high velocities.

Soviet scientists, including Academicians S.A.Khristiyanovich and M.V.Keldish and the member-correspondent of the Academy of Sciences A.I. Nekrasov, pursued the theoretical problems of modern aerodynamics. The experimental side of the research in aerodynamics as related to high speeds was pursued by a group of TS.A.G.I.* workers, under the leadership of S.A.Khristiyanovich, a group on whom the Stalin Prize had been bestowed more than once.

As flying speeds increased constantly, the structure and shape of aircraft became more and more important. Although considerable attention was paid from the beginning to the shape of aircraft today the question of aircraft shape is of prime importance in aviation.

It became evident that aircraft flying at high speeds react differently from

*TSAGI = The Central Aerohydrodynamic Institute. (Author's remark) aircraft flying at low speeds.

"While testing an aircraft, I went into a dive and began to check the flying speed", stated a test pilot. "At about 1000 km/hr, I saw a wave of dense air glimmering in the sun's rays. It resembled the edge of a cellophane wrap and covered the entire wing as it extended from the fuselage. With an increase in speed, the wave would fall back while with a decrease in speed it would move forward, towards the leading edge of the wing. When the aircraft was no longer in a diving attitude, the wave disappeared completely."

Thus, what students of aerodynamics had anticipated and studied a long time ago was being confirmed in practice.

As a French scientist put it, figuratively speaking, "the shock wave first appeared at the tip of the theoreticians' pens."

But, even without actually seeing the wave of dense air, or "shock wave" as it is being called, the pilot gets a warning from the aircraft itself as if the latter were saying: "Attention! The sound barrier is being approached!" The pilot can sense its arrival in the way the aircraft reacts.

The ship begins to "shiver". It vibrates in its entirety. The stability of the aircraft becomes capricious and a great deal of effort is required to master it. The stick, which is easy to manipulate at slow speeds, becomes hard to manage as if excessive pressure had been put on it. Quite unexpectedly, it may start moving freely from one direction to another with such a force that the pilot finds himself unable to control it.

Finally, the aircraft goes into an uncontrollable dive as if some invisible obstacle were ahead to prevent it from following the path of level rectilinear flight.

What causes this? Why is it that air, which actually helps an aircraft to fly at low speeds, now acts as an obstacle to flying?

In order to obtain an answer to these questions many years of hard work, stubborn research, calculations, and testing were necessary.

STAT

At the time when the notable Russian scientist S.A.Chapligin [illegible] this problem, science was interested either in slow, subsonic speeds at which bodies moved on land and water or else in tremendous supersonic speeds at which artillery shells moved through the air.

Chapligin established in theory that, at high speeds which remain subsonic or else are at the transsonic borderline, the air resistance of a given body in motion fluctuates widely.

This finding was confirmed in practice. As the wing of an aircraft moves through the air at a relatively low speed, the air flows smoothly over it. As the wing pushes with greater force against the air, the wave "informs" the air, as it were, of its arrival. As it receives this "message", the air in turn begins to guide the wing. The air gives way to the oncoming wave and the wing, as it follows the laid-out track, meets with relatively slight resistance.

The "signal" created by the wing of an aircraft has a rather peculiar feature: It is sent out by the wing itself moving at a speed equal to the speed at which sound is propagated. This is understandable: Sound is basically provoked by an increase in pressure created at the source of the sound, as the latter rotates about it in a wavelike fashion much as waves form in water when a stone is thrown into it.

The science of physics ascertains the fact that sound does not travel at uniform velocity under different conditions. It travels faster in water and slower in air. The speed of sound in air, in the immediate vicinity of sea level, amounts to 1224 km/hr. As the altitude increases the speed of sound decreases.

When the wing gathers momentum as it moves through the air, either approaching or else equaling the speed of sound, the smooth airflow about it disappears. The air cannot receive the "message" from the wing in flight and consequently does not give way. As a result, the wing has to plough its own way through the "block" of air in its path. The air, which at low speeds is not in an aggregate form like liquids, now becomes solid and therefore bendable. The shock wave, or the dense air-

[illegible]

actually prevents the flight of the latter by moving simultaneously [illegible] it. During this time, the wing is moving with increasing difficulty and the drag increases.

This is how the wing reaction in flight changes at sonic speeds.

Many scientists were already aware of this phenomenon while studying the flight of artillery shells. The shape of artillery shells was the particular concern of a separate branch of artillery science, called exterior ballistics. Artillery projectiles fired by several types of artillery pieces could travel faster than sound. A dense airwave would persist throughout the flight of these artillery projectiles, whose head moved through the very center of the wave path. Since the center of the wave path happens to be the hardest to penetrate, the projectile must expend additional energy in order to overcome the resistance of the dense air, i.e., the head wave. To reduce the influence of the head wave, projectiles with extremely narrow heads were being made. A tapered-ogive projectile moves through the air much easier since the wave is pushed slightly toward the rear so that the projectile head is not forced to penetrate an equal mass of dense air.

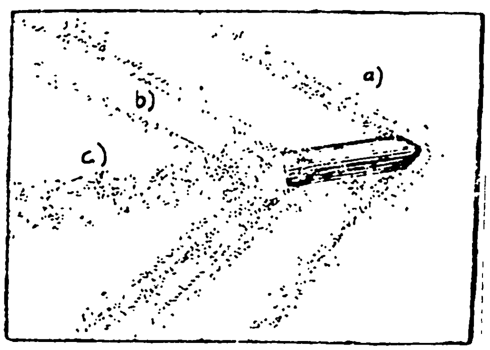


Fig.55 - Airflow over an Artillery Shell
a) Vortex; b) Tail wave; c) Head wave

Both the fuselage and the wings of an aircraft are given a smooth, aerodynamic shape. Any jutting surface, as for example wing wires, prolongs the path of air particles forcing them to travel faster so as to prevent these from lagging behind other particles which travel over a shorter path. Each protruding wire can thus form its own shock wave. It is because of this that attention must be paid not only to the shape but also to the quality of design of exterior aircraft parts.

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

[illegible] speed increases, there is [illegible] of the conditions under [illegible] surfaces of the aircraft work, which both stabilize and guide the aircraft.

This is the reason for the strange behavior of an aircraft flying at enormous speeds.

The density of the air does not only affect the performance of the wings which are the lifting airfoils of the aircraft. It also affects the functioning of the propeller. Scientists knew this long before aircraft were capable of approaching sonic speeds. In cross section, the propeller resembles a small wing. As in the case of a regular wing, a part of the total propeller-blade surface is level while the rest is protruding. The air flows about the propeller blade much in the same way as it does about the wing. The only difference is that the propeller which is essentially a small wing moves far faster than the airplane itself so that, besides moving simultaneously with the whole craft, it rotates at a much higher speed. For example, when an aircraft is flying say at 900 km/hr, the tips of the propeller blades - which are farther away from the axis and thus rotate faster - will acquire a speed 1.5 times greater than the speed of sound.

The shock waves which appear at high speeds (900 - 1000 km/hr) create additional drag so that, as soon as the propeller blades attain this velocity, the entire propeller begins to function poorly, losing much energy. Intensive work is now being done on designing propellers suitable for high speeds. Our country already has [redacted] propellers.

And now, we have aircraft flying at a high speed... .

It is difficult to calculate and trace all phenomena taking place while the aircraft is flying at high speed, although this does not mean that attempts are not being made in this direction. It is much easier, however, to reverse the process: to let the air flow while the aircraft remains stationary. It is much easier to study an aircraft that is standing still.

This is done by means of wind tunnels in which artificial air currents are being created. Meanwhile however, aircraft continually increased in size. There were aircraft with a wing span that exceeded forty meters. Let anyone try to build a tunnel for such giant aircraft and, on top of that, try to create air currents capable of attaining the necessary speeds! The cost of such projects is immense.

As a result, either a small-size model aircraft is placed into the tunnel or else some of its parts. In either case, they are attached to scales. Only, these scales are far from resembling the ordinary kind which we are accustomed to seeing. The aerodynamic scales do not measure weights but the force which acts upon the model via the tunnel air currents.

Wind tunnels were known for a long period of time: one of the first such tunnels was constructed by Tsiolkovskiy in 1887. With the progress in aircraft design, wind tunnels became indispensable. A combination of wind tunnels and actual flight tests provided many answers to problems facing the designer, problems that could not be solved merely by way of estimates and computations on paper.

A modern wind tunnel is a huge structure. There are even some wind tunnels in which not only models but also full-scale aircraft are tested. Full-scale wind tunnels permit studying the structure, control, and maneuverability of aircraft.

Actual flying conditions can be created in such tunnels by model aircraft which are guided by various complex systems of remote control.

Such models are instrumental in the improvement of aircraft flying.

It became necessary however to build more up-to-date tunnels capable of geSTAT-ing immense internal speeds.

Originally, such tunnels looked more like toys.

The first prototype of wind tunnels, designed for high internal velocities, had a diameter of only a few centimeters. It was not powered by any motors or fans. Instead, it was connected to a vessel from which the air had previously been ex-

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

hausted... The connecting tap would then be opened and the atmospheric air would enter the vacuum vessel through the tunnel at a tremendous speed. After a few seconds, the air current would come to a complete standstill.

The tunnel had thus terminated its work... .

Yet, in a tunnel this size it is possible to observe only the physical action of the airflow on the model, and no valid measurements can be made.

Eventually, huge tunnels capable of functioning along the lines of these smaller prototypes were built. The new tunnels made possible observation, measuring, and photographing - but only for a short period of time.

Therefore, in order to lengthen the time of active air-current flow, these large tunnels were being equipped with powerful accessories. Motors which rotated the multiblade wind machines were able to develop to 25,000 hp.

But this was not enough.

Even if the motor power was to be increased severalfold, the current of air would act spirally on the model located within the tunnel and a shock wave, visible even to the naked eye, invariably would appear. Besides, the air overheats and the noise created by the wind is so shattering as to render the tunnel-sounding no more useful than an open circuit while the telephone is connected to transmit speech. New ways and new means had therefore to be found.

Instead of wind machines, compressors were now being used for generating air currents within the tunnels. In addition, cooling devices were being provided to prevent the air from overheating.

In order to photograph phenomena taking place at immense speeds, high-speed motion-picture cameras were being used. Cameras were developed that took 200,000 exposures per second. Later on, these frames were projected on a screen in slower motion so that instantaneous events, photographed at tremendously rapid pace, could now be observed over a much longer period of time.

As the speed of air varies according to density and pressure, variable -

density tunnels were also being constructed, resulting in the attainment of sonic speeds.

Since the velocity at which sound travels through different gases tends to vary, gases other than air were also being used, leading to speeds six to eight times higher than the speed of sound without, at the same time, increasing the horsepower of the wind-tunnel motors.

When traveling through helium, the speed of sound reaches 3500 km/hr. When traveling through freon, the speed of sound is only 480 km/hr. Therefore, one part of the wind tunnel is filled with helium, the other with freon. The model aircraft obtains its initial thrust from a catapult or a gun and, as soon as it reaches the speed of sound within the helium zone it enters the freon zone. As a result, the speed at which the experimental aircraft travels through the freon exceeds several times the speed at which sound would ordinarily travel through it.

Tests with experimental aircraft were being made not only in wind tunnels but also under actual flying conditions. For the latter purpose, the model is mounted to the nose of an airplane or a rocket converted into a veritable individual laboratory for aerodynamics. The reaction on the model in actual flight would then be either photographed by ultrarapid cameras or transmitted by radio.

Scientists had gathered an enormous amount of data relative not only to the interaction of the air and the aircraft wings or, for that matter, other individual aircraft parts, but also the entire aircraft flying at high speeds.

It became apparent that what we already discussed in relation to the behavior of aircraft flying at high speeds could be confirmed in practice.

As aircraft began to fly at sonic speeds, pilots were able to actually see what had hitherto been known only to scientists. In the final analysis, practice had confirmed the theory that air actually "bends" at high speeds.

To make the aircraft fly faster, researchers, engaged in the development of aerodynamics, worked out new types of aircraft wings.

Of course, much remained unclear and unsolved. However, science moved onward relentlessly, attacking the sound barrier. All obstacles would be overcome! Aircraft will fly faster than sound!

It is not enough to give the aircraft a proper form. In order to travel at near sonic speeds, the aircraft must be basically sound. This means that besides considering many other factors, we must know how to build aircraft and what materials to use in their construction.

As flying speeds approached the speed of sound, new methods for wing design were required. A very thin wing having a sharp leading edge is indispensable in high-speed flying.

It was proposed to make such wings by forging, while a machine for smoothening the wing surface was to be employed to give the wing the required shape. This also meant that wing wires were to be eliminated and that new ways for making wing joints had to be found - as for example by welding.

The windows in the pilot cabins of most aircraft were usually made of a transparent plastic known as Plexiglass which proved unsuitable at enormous speeds since Plexiglass bends easily under the immense heat of friction. Instead, a metal cabin canopy was installed, with small Plexiglass windows. The cockpit was also cooled artificially after having been hermetically sealed prior to take-off.

In order to overcome the sound barrier, an aircraft must be equipped with powerful engines. The power needed in this case can be generated by jet aircraft.

High speeds did not only affect the shape - the aerodynamics - of aircraft. They affected the air battle tactics as well, since the aircraft maneuverability changed radically.

The speedometer jumped now from 600 to 700 and to 900 km/hr... .

Attention! An enemy bomber is sighted! At this point the pilot of the jet aircraft begins to maneuver. A jet aircraft flies much faster than ordinary airplanes but, at the same time, it maneuvers much more slowly. At such high speeds,

STAT

232

the pilot cannot execute sudden air maneuvers since he would be crushed by his own weight. The entire impact of the centrifugal force, which appears while the aircraft is making sharp turns, creates an overload which tends to increase the weight of a body severalfold.

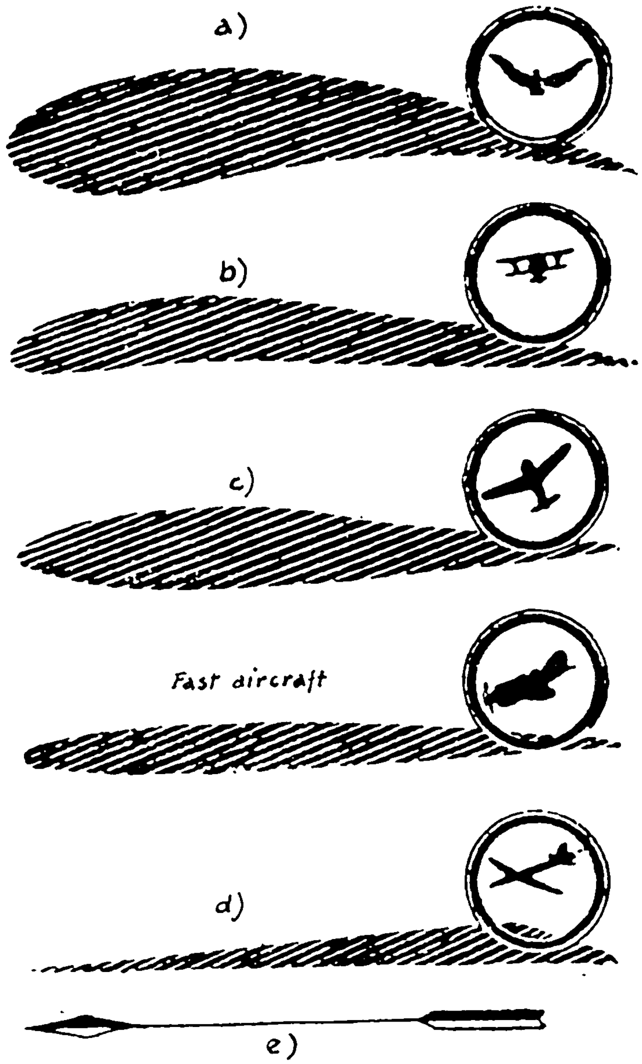


Fig.56 - Change in Wing Profiles, as Flying Speeds Increase

a) Sky-roamers (Birds, gliders); b) Low-speed biplanes; c) High-speed monoplanes; d) Recent supersonic profile; e) Direction of flight

This means that sudden turns must be avoided, which requires the pilot to increase his maneuvering time.

By the time a jet aircraft has been able to place itself in a position from which it can attack, the bomber will already have disappeared and the entire process must be repeated.

Again, the pilot increases the aircraft speed; 900 - 960 km/hr .... Stop! The speedometer pointer is on the red dot. The plane is at the threshold of sound and all the difficulties relative to the loss of stability and control now begin. Soon, the pilot is forced to reduce the speed! This in turn can be done by means of special air brakes.

Once again, the enemy bomber is in the gunsight of the fighter. To avoid by-passing a target moving at a relatively low speed, the pilot lessens the reactive engine thrust.

The jet fighter is now attacking the bomber from the front. The two aircraft are facing each other. And now, the target is right in the middle of the gunsight hair. Fire!

The jet pilot had barely fired a salvo from the wing-mounted cannon the enemy bomber is already left far behind. It is easy to see that the time in which a jet pilot can make a pass is extremely short.

It is no less difficult for one jet aircraft to engage in battle with other jet aircraft, including jet bombers. The air battles between jet aircraft are carried out at a terrific pace. In dog fights, the fighters approach one another so rapidly that their pilots have an extremely short period of time available during which they must both make decisions and execute them. "With jet aircraft, one must apply split-level thinking", stated one of the fighter pilots. In high-speed maneuvering, it is imperative to anticipate an incipient overload, a short-time increase in weight caused by the action of the centrifugal force. To minimize this overload, various steps were taken. For example, the pilot was placed in a prone position in the cockpit. In such a position, the pilot is able to withstand the overload with comparative ease.

Similarly, air battles between jet fighters and jet bombers are carried out at an extremely fast pace. To score a victory, a jet fighter must be capable of firing a tremendous amount of bullets in an instant and, in order to be able to do so, it must be well armed. A jet fighter craft is usually equipped with four to six guns or else with a whole battery of rocket projectiles. In this way, the jet aircraft can alter the battle tactics.

It is also suitable for jet aircraft to attack the enemy from the rear. As the speed is decreased by means of airbrakes, the target is approached, fire opened, and the jet engines are given the gun which in turn enables the pilot to gain altitude passing a target moving at a relatively low speed, the pilot lessens the reactive engine thrust.

The jet fighter is now attacking the bomber from the front. The two aircraft are facing each other. And now, the target is right in the middle of the gunsight hair. Fire!

The jet pilot had barely fired a salvo from the wing-mounted cannon the enemy bomber is already left far behind. It is easy to see that the time in which a jet pilot can make a pass is extremely short.

It is no less difficult for one jet aircraft to engage in battle with other jet aircraft, including jet bombers. The air battles between jet aircraft are carried out at a terrific pace. In dog fights, the fighters approach one another so rapidly that their pilots have an extremely short period of time available during which they must both make decisions and execute them. "With jet aircraft, one must apply split-level thinking", stated one of the fighter pilots. In high-speed maneuvering, it is imperative to anticipate an incipient overload, a short-time increase in weight caused by the action of the centrifugal force. To minimize this overload, various steps were taken. For example, the pilot was placed in a prone position in the cockpit. In such a position, the pilot is able to withstand the overload with comparative ease.

Similarly, air battles between jet fighters and jet bombers are carried out at an extremely fast pace. To score a victory, a jet fighter must be capable of firing a tremendous amount of bullets in an instant and, in order to be able to do so, it must be well armed. A jet fighter craft is usually equipped with four to six guns or else with a whole battery of rocket projectiles. In this way, the jet aircraft can alter the battle tactics.

It is also suitable for jet aircraft to attack the enemy from the rear. As the speed is decreased by means of airbrakes, the target is approached, fire opened, and the jet engines are given the gun which in turn enables the pilot to gain altitude and get out of the battle zone instantly.

With the increase in altitude, the flight distance of the turbojet aircraft increases. At an altitude of 10,000 m, it is twice as high as near the ground. It is because of this feature that jet aircraft are very suitable for high-altitude flying.

Bombing raids can also be conducted by jet aircraft. A jet propelled bomber

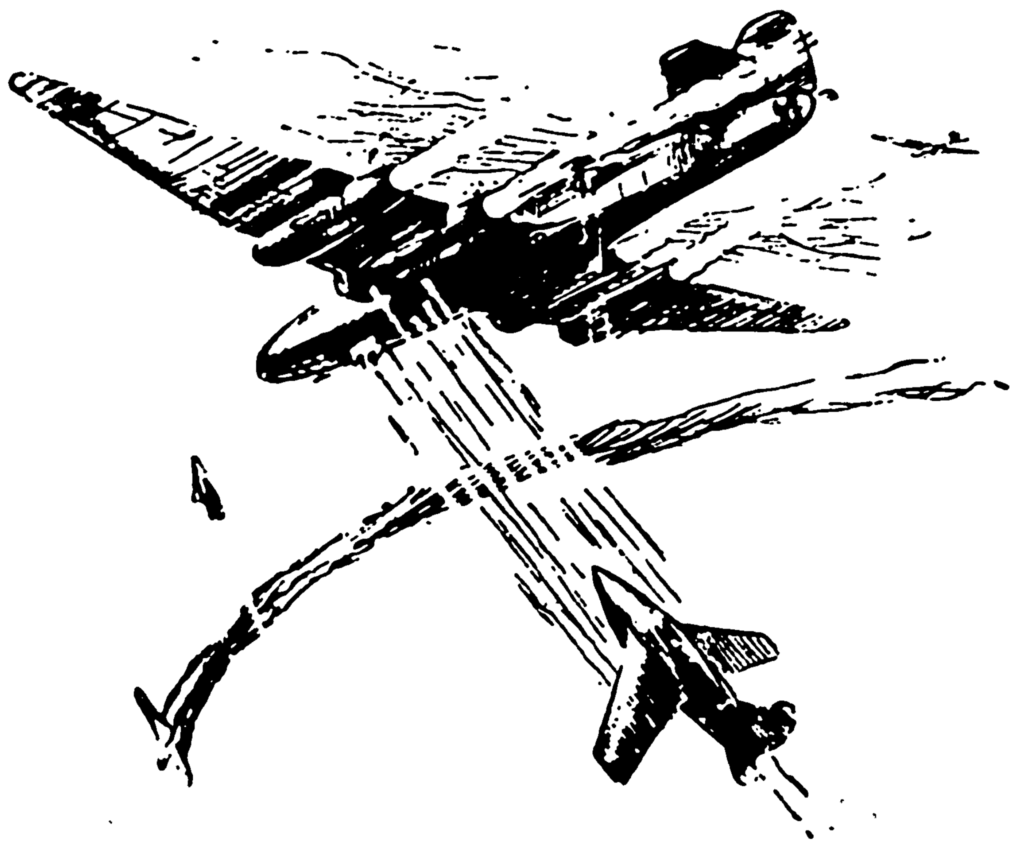


Fig.57 - Fight between Jet Aircraft

flies roughly twice as fast as the ordinary bomber aircraft. The faster a bomber flies, the less time it has to spend over enemy territory, thus minimizing the potential danger of being hit by enemy antiaircraft artillery units. However, dropping of bombs on the target is very difficult. A jet-propelled bomber flies over the target area so fast that the bombardier has little time in which to aim the bomb.

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

To overcome this, special bomb sights became necessary. These sighting devices could anticipate the target from far away so that bombs could be released accurately before the aircraft would find itself directly over the target area.

Compound units, consisting of both piston and jet engines are quite suitable to fighter planes which escort bomber squadrons into enemy territory. During cruising flights which do not exceed 700 km/hr, only the piston part of the compound engine is operating. Once the air battle begins or in cases of hot pursuit of enemy aircraft, all the pilot has to do is cut in the jet engine and thus increase the speed of his aircraft.

The battle tactics of liquid-fuel jet aircraft are not routine. A jet fighter powered by liquid-fuel jet engines gains altitude very fast which makes it indispensable where the enemy has to be overtaken in the air. At high altitudes, a jet fighter propelled by a liquid-fuel jet engine is master of the situation. It is therefore to its advantage to fight at such altitudes. It pursues the enemy, overtakes it, attacks it while scoring hits with accuracy, and destroys it. Because of these features, the liquid-fuel jet aircraft must be able to muster at will a rapid, accurate, and powerful firing power.

Plans were made for the construction of liquid-fuel jet fighter interceptors which could be launched into the air instantly by means of booster rockets, enabling it to overtake the enemy aircraft and destroy it with rocket projectiles. Upon completing the mission, both the pilot and the entire aircraft would parachute to safety separately, the pilot bailing out first.

Jet fighters on bomber escort duty are capable of rapidly repelling an enemy attack, while fighter interceptors can overtake the enemy either during air patrol or by taking off directly from the ground.

Let us ask ourselves a question at this point: Will jet aircraft replace conventional types?

This very question was asked long ago, even before there were any jet-propelled

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

aircraft.

Many people maintained that there was no doubt that such would be the case.

Essentially, however, aviation went into a dead-end street. The compressor* is not useful because it diminishes the total engine energy. The higher the altitude,

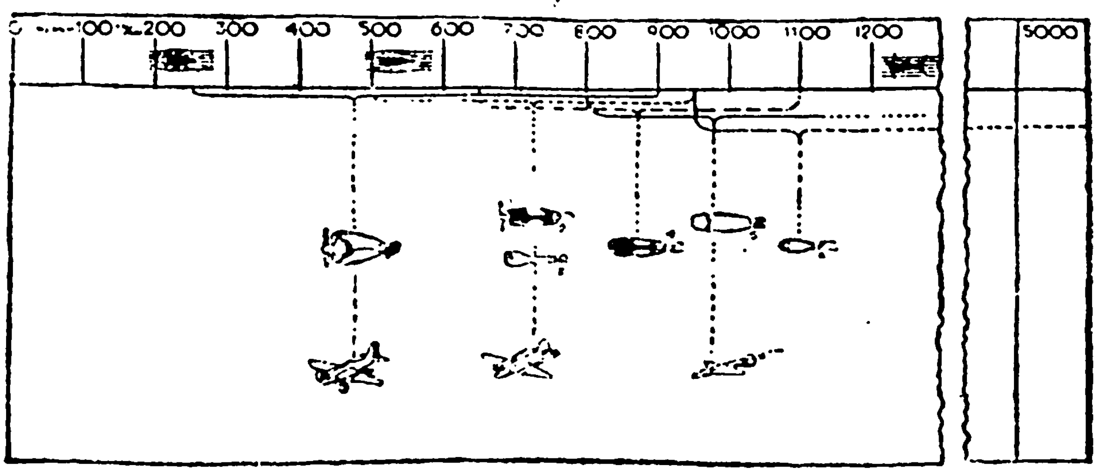


Fig.58 - Speed Ranges in which Various Types of Jet Engines are being Used: 1 - Gunpowder (solid) fuel engine with exhaust duct for combustion gases; 2 - Gas turboprop engine; 3 - Ram-jet engine; 4 - Gas turbojet engine; 5 - Ram-jet free-burning engine; 6 - Liquid fuel jet engine. (The numerals indicate speed in terms of kilometers per hour)

the more power is taken away by the compressor from the engine. Only the jet engine permits the aircraft to reach high altitudes, and altitude means speed.

Is this being attained?

Yes and no. Yes, - because a piston engine is not suitable for high-altitude flying but only for low altitudes. No, - because the jet engine is suitable for high altitudes only.

The piston and the jet engine between themselves have divided the flying speeds

*The Condenser-Compressor, which drives air into the piston engine during flight, derives its power from the main engine shaft. (Author's remark)

STAT

into two domains. The piston engine is the master in one, while the jet engine is the master in the other.

The turboprop engine can either enter the realm of the piston engine or it can enter the realm of the turbojet engine.

Aircraft equipped with power-plant systems which contain both types of engines can fly at either high or low speeds.

In the future it will be possible to have liquid-fuel engines which will propel aircraft even faster than sound and faster than artillery projectiles. These will help man conquer time and space.

It is only now, in retrospect, that we can see what evolved from the rocket: from fireworks to extreme-range artillery; from Heron's Ball to reactive turbines; from the early projects of athodyds to the modern jet engine capable of reaching sonic speeds. From all this, one can appreciate the gigantic effort made by the audacious human mind in the process of creating a new branch of technology. It is only now that one can understand and evaluate the great role played by Russian science and technology in helping to bring about that which exists today: a new engine and a terrible combat weapon.

CHAPTER VIII

A GLIMPSE INTO THE FUTURE

While dividing the flying speed capabilities between the piston and the turbojet engines we stated that the turbojet engines are capable of exceeding a speed of 900 km/hr.

Therefore, these engines will be used widely in aircraft designed for rapid flying. Gas turbines with propellers will, on the other hand, be widely used in heavy aircraft as well as in aircraft designed for low-speed flying. In addition, heavy transport aircraft will fly at 10 - 12 km altitude and will be capable of non-stop travel over considerable distances.

It is not impossible to foresee that, within the not too distant a future, jet aircraft will fly non-stop around the world for the first time.

The dream of a great flier of our time, Valeri Chkalov, to "fly around the globe" will become a reality.

The Air Force major-general, P.M.Stefanovskiy, writes in his article entitled "Around the World in Three Hours"* that "it is quite possible to expect in the near future that there will be rocket aircraft capable of flying around the world in three to four hours without landing, at an average speed of 10,000 km/hr".

This is feasible since more powerful jet engines will be used in lighter air-

*See: Around the World in Three Hours by P.M.Stefanovskiy translated into Bulgarian in the publication Science and Technology, Nos.6, 7 and 8, 1947. (Author's remark) craft. Such projects are being worked on today.

Jet engines will have still another use in aviation.

One of the closest disciples of N.Ye.Zhukovskiy, and a meritorious worker in the fields of science and technology, Academician B.N.Yurev - one of the first designers of the helicopter - proposed an original jet propeller project.

A simple jet propeller functions in the following manner: Air enters the hollow propeller bulk by way of the shaft socket. As a result of the centrifugal force created by the shaft rotation, air is forced into the propeller tips where it condenses and from where it penetrates into a set of small combustion chambers fed with fuel through miniature tubes. The combustion products are exhausted via the end orifices, creating the reactive power which in turn rotates the propeller.

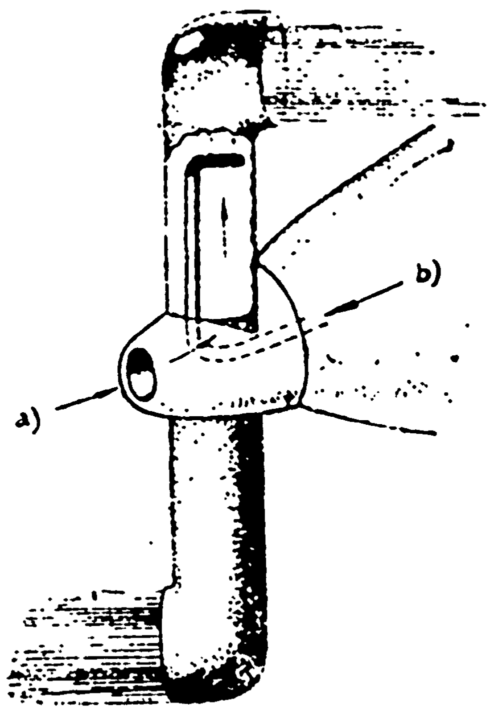


Fig.59 - Jet Propeller

a) Air; b) Combustion

In more complex cases, air is first condensed by compressors and then supplied to the propellers.

One of the features of the jet propeller is that, even at slow flying speeds, its tips attain a great velocity. This feature is instrumental for improving the conditions of fuel consumption. It is quite true that a jet propeller has a higher fuel consumption than its piston-powered counterpart. But the simplicity of its construction, its ability to operate on low-cost fuels, and the simplicity of its repair and maintainance are factors which could make the jet propeller aircraft far more economical than the ordinary engine-powered aircraft.

There is only one step in converting a jet propeller for helicopter use.

The gas turbine assembly of a jet helicopter is located within its belly and, as it functions, the out-flowing gases impel the helicopter by the exhaust action via the jet-propeller tips. Small combustion chambers could be contained within the propeller tips, while air could be fed to them by means of a compressor operated by a separate motor of any given type. Moreover, an ordinary jet engine can be used in larger helicopters to replace the tail rotor.

Mixed systems can be used not only in helicopters but in multiengine aircraft as well. Ordinary propeller engines will provide the power necessary for take-off and climb. Once these engines begin to stall at high altitudes, the jet engines can take over. The ordinary engines are cut out and the propellers are feathered in such a way as not to hamper the flight. From that point on, the aircraft is powered by the jet engine alone.

Finally, plans are being made for jet-powered airships. While at low altitudes, conventional engines within the airship will rotate the propellers while the exhaust gases will supply the additional reactive thrust. At high altitudes, these propellers cease to function and the airship is propelled by jet power alone. Such a proposed airship will have an adjustable-diameter metal hull. The idea of an all-metal airship, first promulgated by K.Ye.Tsiolkovskiy, is feasible.

The Soviet inventor Grokhovskiy proposed the building of a stratospheric glider equipped with jet engines. In addition to its hermetically sealed crew cabin, the glider was to have six liquid-fuel jet chambers. A gas-filled balloon takes the strato-glider to an altitude of 25 - 30 km where the latter is detached from it. As it begins to gain speed through a downward plunge, its jet chambers are fired and the glider begins to climb by itself until it reaches an altitude of 50 km from where it begins to glide back toward the earth.

What is the extent of the area within which turbojet engines function properly? Which heavier-than-air craft dominates the speed range which exceeds several times

STAT

the speed of sound?

As had been related, both turbojet and piston engines function properly only within a fairly well-defined range of flying speeds.

At supersonic flying speeds there is no need for compressors since, as a result of the tremendous pressure, the air becomes exceedingly dense anyway. But this is not all: A compressor will function poorly at high flying speeds for the simple reason that it does not properly compress the air. If at the take-off, the compressor provided 3.5 atm pressure, at speeds three times greater than the speed of sound it can provide only half as much.

This means that at supersonic speeds we now have, instead of a turbocompressor ram-jet engine, a free-burning ram-jet power plant.

When we compared earlier in the text the piston with the turbojet engine, we maintained that the turbojet engine is the simpler of the two.

A free-burning engine is still simpler. It weighs less than the turbojet engine which, in turn, is lighter than the piston engine.

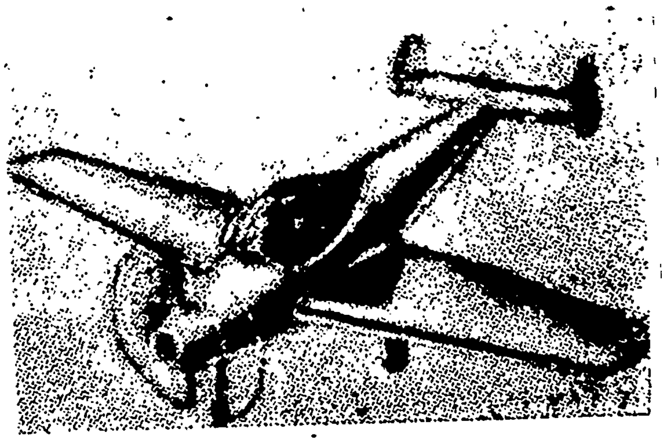


Fig.60 - Aircraft with a Jet Propeller

Its power increases faster than its speed and the faster it flies, the more useful will it become by providing greater thrust and consuming less fuel.

Yet, the most notable feature of a free-burning engine is its extreme simplicity of design. It would be difficult to find an engine that boasts of a design less complicated than the free-burning ram-jet engine.

A piston engine consists of parts which rotate and parts which follow a rectilinear of motion. On the other hand, all of the parts within a turbojet engine ro-

STAT

276

tate. Once the fuel-feeding auxiliary mechanisms cease to function, no part of a free-burning engine either rotates or follows a straight line of motion.

What then is the domain of speed within which a free-burning jet engine is liable to operate?

As a result of air resistance, there are speed limits within which even a free-burning ram-jet engine is confined. This in turn implies that such an engine should operate at high altitudes where there is no air and where, therefore, air resistance cannot obstruct the flight performance.

This is precisely what the ram-jet engines cannot do.

At high altitudes, where the air density is minimal, the ram-jet engine begins to stall much in the same way piston engines did earlier.

This is why the free-burning engine was replaced by the liquid-fuel jet engine – the rocket. The rocket was the first basic form of the jet power plant. More likely than not, it will also be its ultimate form.

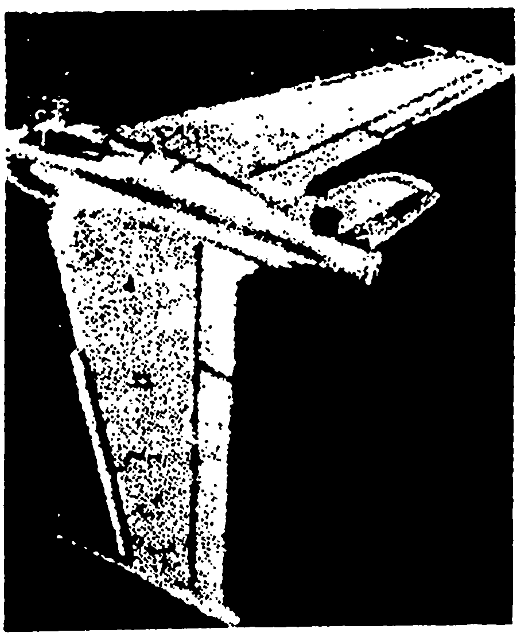


Fig.61 – Aircraft with Sweptback Wings

Liquid-fuel jet engines will be able to gain altitude rapidly and once they have reached high altitudes, they will fly at speeds ranging up to several thousand kilometers per hour.

The supersonic flying speeds will determine the future external form of aircraft as well as their manufacturing methods.

Even today, there are a number of jet aircraft of unusual design. Their wings are swept backwards resembling the tip of an arrow. It was proved later that sweptback wings have a notable characteristic. The difficulties caused by increasing

STAT

density of the air at high flying speeds are considerably ameliorated by the sweptback-wing design or, to put it another way, ordinary wings are much earlier subjected to these difficulties.

There will be aircraft in the future consisting only of wings, acting both as fuselage and wings, which will reduce the drag area while carrying, at the same time, both the crew and the jet engine within the wing structure. Such "flying wings" will most likely retain the current delta-wing form.

As aircraft start flying at very high altitudes, the wing area will invariably decrease further. In fact, future aircraft will resemble an artillery projectile more than anything else.

Major-general P.M.Stefanovskiy describes unusual aircraft which are capable of non-stop flights around the world within two to three hours in the following way: "It has a semioval shape, characteristic of an artillery projectile but with a cut-off bottom part. This is very necessary in order to give it an additional lift surface by making its bottom part flat. The fuselage nose is sharply pointed. The fuselage houses the crew, the fuel, and the power plant, rendering the wing thickness insignificant. The tail section of the fuselage contains the exhaust nozzle. The main wing feature is its thin profile and sharp edges, both leading and trailing. At tremendous flying speeds, the importance of the wings is generally lessened, as indicated by the fact that at 10,000 km/hr, the aircraft maintains two third of its equilibrium by fuselage support and only one third by wing-lift support."

He continues, "a straight rail ramp, laid across a reinforced concrete base, is indispensable for the rocket aircraft take-off. Such a ramp should be equipped with a starter sledge which is completely secured against either vertical or sidewise derailment and which has an automatic retaining device for the starting assembly to prevent it from taking off with the aircraft as the latter detaches itself from the starter sledge. The sledges should be equipped with rocket assemblies capable of developing a tremendous thrust within no more than 15 sec... .

STAT

355

"The flight trajectory should resemble the trajectory of an extreme-range artillery projectile, whose path of descent is extended lengthwise as a result of gliding.

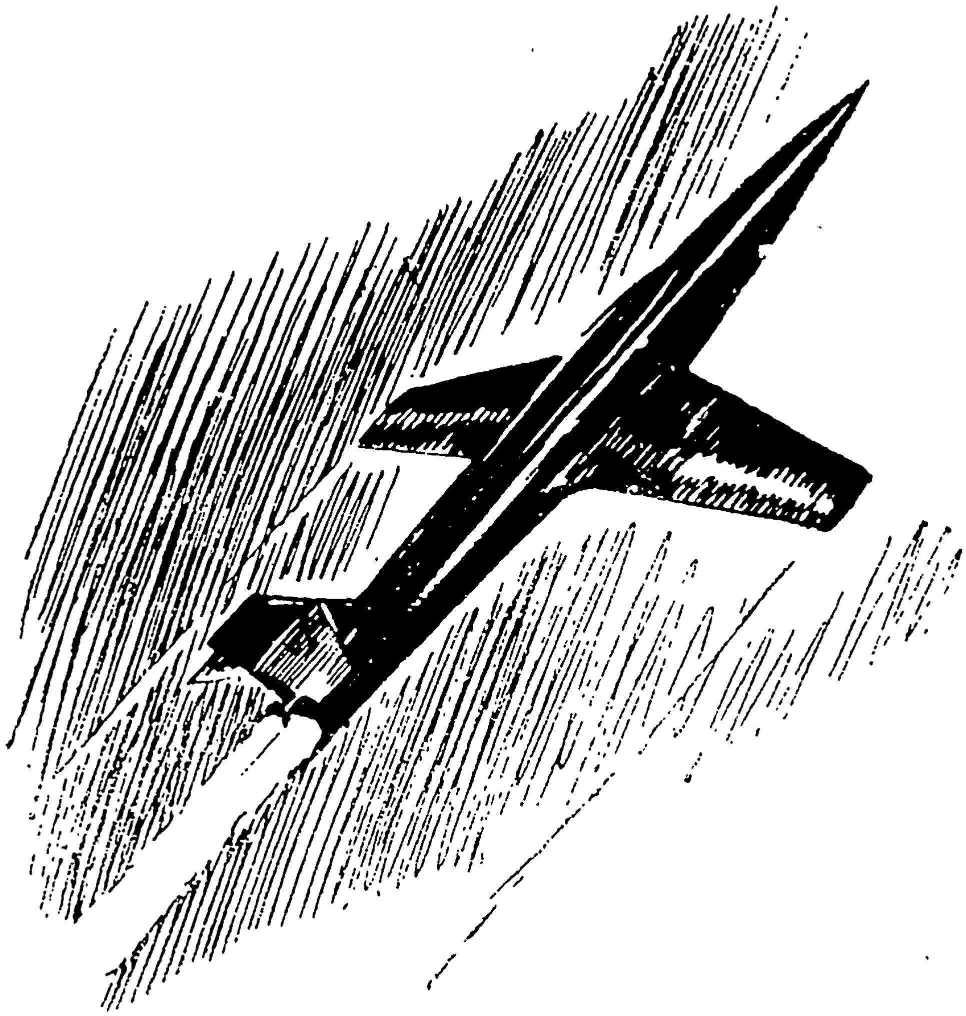


Fig.62 - Aircraft of the Future

In this way, its flight speed along a trajectory of several thousand kilometers decreases from a very high initial speed to a normal landing speed.

"... The time is not far away when mankind will realize a bold concept by being able to induce the rocket aircraft to reach altitudes of 50 - 200 km, while flying over great distances at speeds ranging from 15 - 30 000 km/hr.

The peculiar feature of such aircraft is that they are forced to carry enormous

STAT

quantities of fuel which is consumed during the actual f[illegible] Thus, the weight of such aircraft at landing is considerably less than at take-off, a feature which in turn facilitates the landing procedure.

Today, we are not easily awed by unusual designs of the futuristic aircraft. But when rocket aircraft appeared for the first time during the war and when the British fliers who saw them reported that they had seen propellerless aircraft, their commanding officers sent them for medical treatments. As time went by, unusually designed and propellerless aircraft began to appear more and more often in the air.

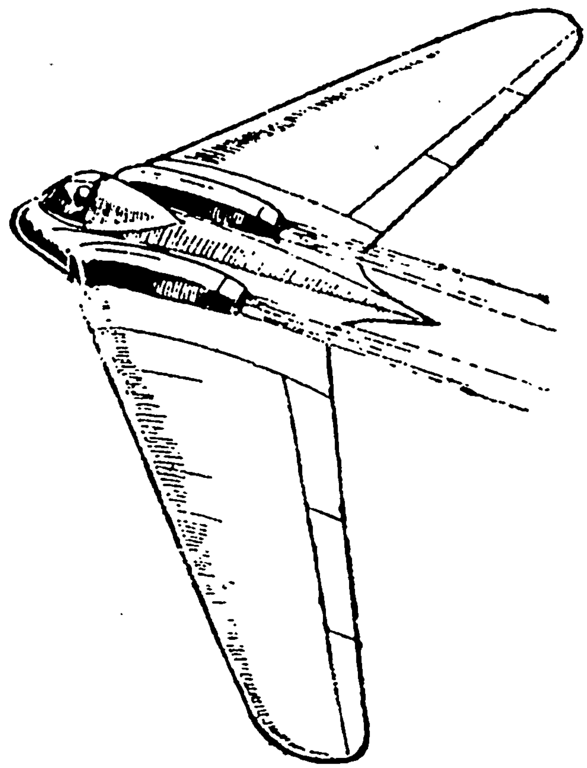


Fig.63 - A Futuristic Sweptback Delta-Wing Jet Aircraft

There is little doubt that in the future we will become familiar with unusual aircraft which, in outer form, look much like swift-flying long-winged swallows. The design of the main aircraft bulk as well as of secondary aircraft parts will change substantially in the future. Even today, there are propellers driven by turboprop engines which are of unusual design in that their blades resemble a sword.

We have already stated that, in essence, the propeller is nothing else but a miniature wing. The propeller blades which resemble a sword have also a delta wing span. The reason they are made this way is to improve the propeller performance during high-speed flying.

High velocities, which are apt to occur during air acrobatics with very fast aircraft, have a harmful effect on the pilot. This is why plans are being made for the manufacture of aircraft in which the pilot would be placed in a comfortable prone position which would, in turn, greatly help him to withstand high velocities.

It is, of course, difficult to foresee at present all of the changes within aviation as a result of high-speed flying. But the main thing is clear: High-speed flying and jet engines are inseparable, since only the jet engine is capable of making the aircraft surpass sonic speeds and conquer enormous altitudes.

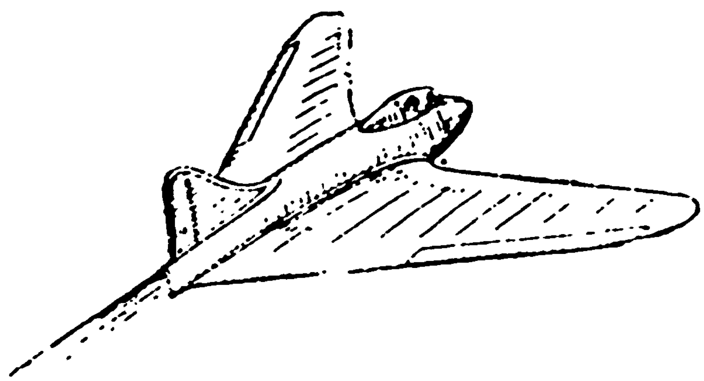


Fig.64 - A Futuristic Forward-Swept Delta-Wing Jet Aircraft

Man had started to attack high altitudes a long time ago. Stratoships were able to reach altitudes up to 22 km; balloons, up to 36 km altitude.

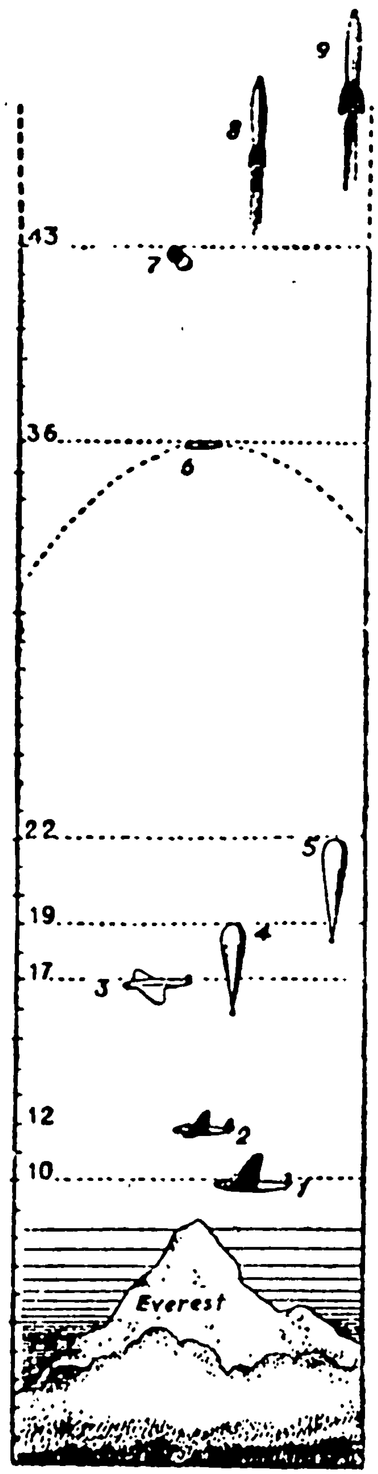
For a long time, this thirty-six kilometer altitude remained a ceiling impossible to exceed. It became necessary to employ indirect means. Thus sound, light, and radio became the scouts of the atmosphere.

The air speed depends a great deal upon the air temperature. As it passes from the hot to the cold air wave, sound alters its speed. By measuring the speed of sound waves one could determine the stratospheric temperature. Various visual phenomena like twilight, dusk, polar light, bright cloud formations and the like furnished data on the stratosphere. A study of the propagation of radio waves, cut off by the upper-limit layers of the atmosphere, provided valuable information. However, the stratosphere was still awaiting the scouts that could not err, namely accurate and precise instruments.

The rocket does not only serve to carry metereological instruments aloft, al-

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3



though stratospheric rockets with self-recording devices are yet to discover the innermost secrets of the stratosphere and thus, enable man either to confirm or deny what today is either only theory or only supposition. The rocket can be used for other purposes.

A small movie camera was installed in the tail of the rocket. This camera was run by a small motor. Its film magazine was placed in a thick armored steel chamber. While the rocket keeps climbing, the camera continues photographing the earth's surface. At an altitude of 120 km, this camera is capable of photographing a huge section of terrain since the visibility at that altitude encompasses an area of a radius of 1200 km. Having used-up its rolls of film, the camera which is housed in a steel container, is dropped automatically to the ground. On developing the negatives, a most unusual set of pictures is obtained, since the earth is seen from an altitude never reached by man.

Such aerial photography will enable man to film the entire surface of the earth in order to revise the existing geographical maps with a greater degree of accuracy.

Fig.65 - Conquering of Altitudes
1 - Low-level bomber; 2 - Fighter and long-range bomber; 3 - Record-setting aircraft; 4 - Strato glider (attached to a balloon) "USSR-1"; 5 - Strato glider (attached to a balloon) "Osoaviakhim"; 6 - Artillery projectile; 7 - Exploratory balloon; 8 - Long-range rocket 9 - Meteorological rocket

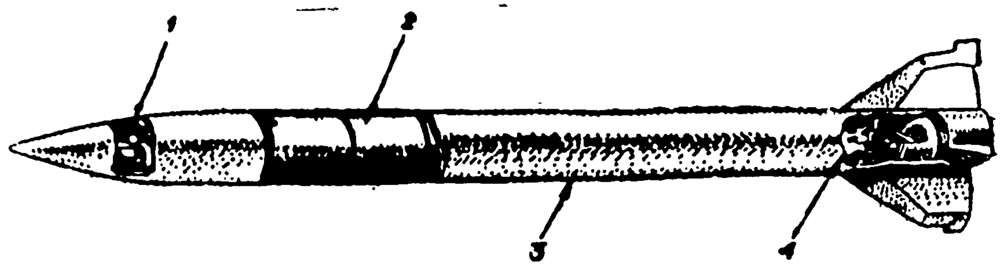


Fig.66 - Meteorological Rocket

1 - Atmosphere-exploring instruments; 2 - Fuel tanks; 3 - Oxygen tanks; 4 - Jet power plant

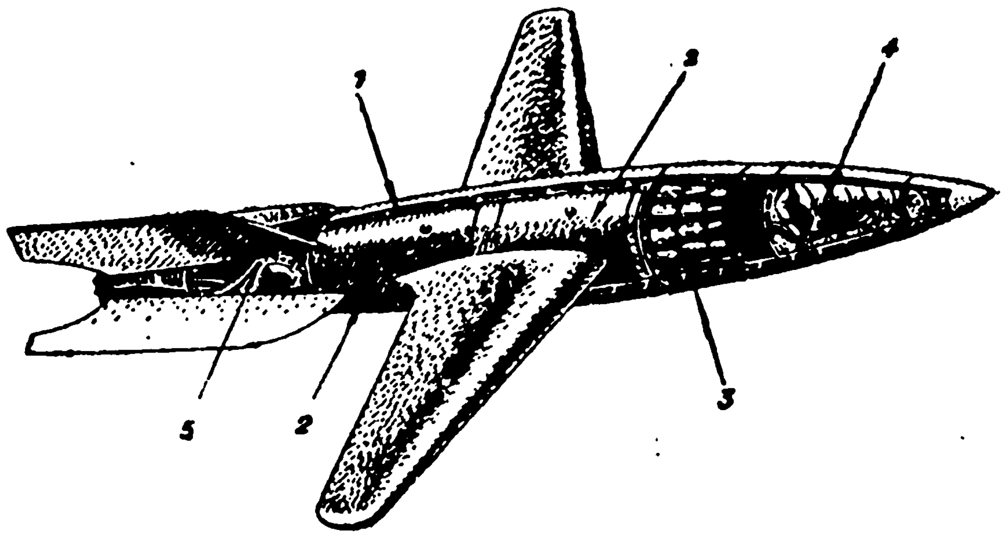


Fig.67 - Winged Rocket

1 - Double armor; 2 - Fuel tanks; 3 - Mail van; 4 - Crew cabin; 5 - Jet power plant

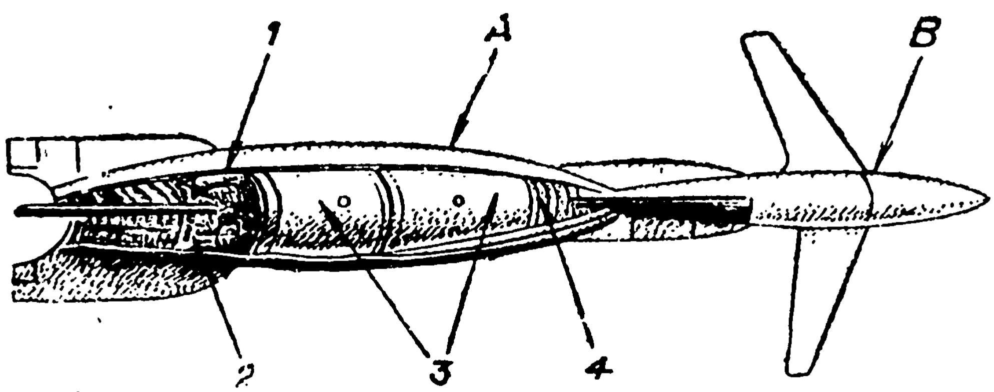


Fig.68 - Composite Rocket (A - Auxiliary Rocket Speed Boosters; B - Main Rocket)

1 - Double armor; 2 - Jet power plant; 3 - Fuel tanks; 4 - Parachutes for landing the auxiliary rocket speed boosters

The rocket has now reached the uppermost point of its trajectory. Slowly, it begins to lose speed and then, suddenly, plunges toward the earth. It behaves essentially like an artillery projectile in that it reaches the ground ahead of the sound made by its motion.

If an extreme-range rocket is fired at an angle rather than vertically, it will travel over a distance of two to three hundred kilometers. Let us now equip it with additional wings. As a result of the increased gliding, such a rocket can now travel even further.

Ten years ago, a rather unusual stamp became a collectors' item. This stamp was pasted on letters mailed by an equally unusual carrier means, namely a winged rocket used for postal service. This rocket carried about six thousand letters over a distance of 1.5 km.

Since that time, both the altitude and the distance performance of the rocket increased several times. Perhaps some day, there will be rockets capable of carrying mail from Moscow to Vladivostok in 1.5 hr and from Moscow to Leningrad within a few minutes.

With the use of composite rockets, the flying distances will further increase.

A composite rocket can fly beyond the limits of the atmosphere.

Rockets will keep climbing higher and higher, travel faster and faster, until they attain an average speed of 8 km/sec.

The daydreams of Tsiolkovskiy which he had set down on paper back in 1918, in his science-fiction novel "Beyond the Earth", will become reality.

"Thought must precede the attainment of these goals, just as accurate observations are preceded by fantasy", wrote Tsiolkovskiy.

He drew the blueprints for conquering interplanetary space, establishing that this is possible by the unrefutable and precise language of mathematics.

After completing test flights at high altitudes, the rocket will soon thereafter carry human passengers on flights around the world. The first interplanetary

STAT

flight as well as a large passenger rocket will ensue. With an increase in flight distances, the passengers will have means by which their metabolism will be kept at the state of that on earth. A certain degree of artificial gravity will be obtained by spinning of the rocket.

The rocket will then move further onward. It will reach the Moon's orbit. A small moon rocket will carry the pioneering passengers to the Moon. If it encounters an asteroid, the rocket will be able to decelerate, enabling the passengers dressed in pressurized suits to visit the surface of the asteroid. Subsequently, the rocket will approach other planets.

And now, the time has come to return to Earth. After having circled the Sun's orbit, the rocket is driven toward the Earth as it loses speed on its way down.

Besides approaching other planets, the rockets will be able to land on them in due time.

"To be able to stop in flight, to avoid asteroids, to lift with one's own hand a piece of stone from the Moon, to observe the planet Mars from a mere distance of 10 km, to be able to land on its satellites or even on Mars itself - what can be more fantastic? From the moment that man is able to use instruments in rockets, a whole new era in astronomy will follow and we will have witnessed a novel period of sky observation and sky study", stated Tsiolkovskiy.

With the direct participation of K.Ye.Tsiolkovskiy himself, a movie dedicated to the future flight to the Moon was made. It was entitled Cosmic Flight.

"When I decided to make a movie dealing with the flight to the Moon, I wrote a letter to Tsiolkovskiy", said the movie director V.N.Zhuravlev: "He replied immediately and I went to see him at once in Kaluga... . He explained to me in great detail how the flight to the Moon is going to be made, how human beings will be able to go there and return to Earth... ."

The movie "Cosmic Flight", seen by children all over the world with a great deal of interest, illustrated what future interplanetary travel will be like.

STAT

... Aimed high towards the sky, we see the rocket "USSR-1". It is beginning to move faster and faster and, suddenly, it is high above the ground. The cosmic flight has begun. The doors of a special hydraulic compartment now open and passengers in special suits enter so as to be able to better withstand the increasing weight. These compartments were also proposed by Tsiolkovskiy.

The covers of the searchlight units are being lifted and parts of the universe never seen before now appear in front of the passengers' eyes.

Once again, the passengers are returned to the hydraulic chambers. The engines keep on working and, as their power is reduced, the rocket lands on the Moon. All passengers wear pressurized suits, lead shoes, intercom radio sets, and backpack oxygen containers. The space travelers now place a signal reflector on the surface of the Moon in order to facilitate the guidance of other rocket ships which may follow later. Observations are completed and the rocket travels again through space, descending to Earth by parachute.

Konstantin Eduardovich Tsiolkovskiy worked out and proposed many interesting ideas relative to the question of interplanetary travel.

He advanced the idea of a cosmic rocket train, composed of several rockets which function in sequence starting with the head rocket. Gradually, one after another, they consume their fuel supply and return to Earth. Only the last rocket, which by now had acquired an enormous speed, continues the long journey. A rocket train, with five component rockets, can attain sufficient take-off speed while a rocket train consisting of 10 rockets can develop enough speed to reach the asteroids.

Tsiolkovskiy also advanced the idea for a cosmic rocket formation consisting of several tandem rockets which function simultaneously. As half of their fuel supply is consumed, the rocket formation breaks into two parts. The one part transfers the remaining half of its fuel to the other part and descends to the ground immediately after the transfer. The other part of the rocket, which now again has a full fuel supply, continues on its way. This process is then repeated again and again, until

STAT

the last rocket of the formation acquires sufficient speed to finish the long journey.

These ideas of Tsiolkovskiy were directed particularly toward reaching cosmic speeds which would be sufficient for leaving the earth's surface and for entering interplanetary space.

A number of interesting ideas in the same direction were advanced by a disciple of Tsiolkovskiy, the Russian engineer F.A.Tsander, who likewise devoted his efforts to the study of space travel.

He proposed building a winged rocket which, during the time of its actual travel, breaks off, disintegrates, and consumes its own metal parts as fuel. At the end of the journey by the winged aircraft rocket, only the bare fuselage with small wings and rudders, which are necessary for atmospheric "landings", will remain. Such a rocket is capable of developing velocities which are quite sufficient for the purpose of interplanetary travel.

His was an original rocket since it was especially earmarked for the development of tremendous cosmic speeds. The huge main rocket is supplemented, along its sides, with a set of smaller rockets, mounted to its spiral rings. As these auxiliary rockets consume their own fuel, they are pulled into the main rocket where they are melted down and used as additional fuel supply.

Interplanetary travel requires the generating of enormous energy and, in considering this factor, we must not forget the massive source of energy - the Sun. This too, was already pointed out by Tsiolkovskiy.

Tsander proposed subsequently that solar energy be harnessed for the purpose of interplanetary travel by means of reflective mirror screens.

Another Soviet engineer, M.K.Tikhonravov, advanced the proposal that solar energy can be harnessed during the actual flight by means of a phototube.

The interplanetary rocket is equipped with a set of large phototubes which convert solar energy into electric current. Under the action of electric energy, mo-

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

lecular hydrogen can be split atomic hydrogen: ordinary diatomic hydrogen can be converted into monatomic hydrogen. Monatomic hydrogen is not very stable, however, and is therefore reconverted into diatomic hydrogen. This process produces thermal energy. The resulting heat is sufficient to give the hydrogen particles a speed of 20 km/sec.

This property of hydrogen is also useful in rockets. Liquid hydrogen is charged into the rocket beforehand and then the "electric station" (the set of phototubes) begins to function at an altitude of 65 km above the Earth.

The interplanetary rocket reaches this particular altitude by means of an attached starter rocket. Once at that altitude, the interplanetary rocket begins to harness solar energy. The phototube "fan" will subject the phototubes to the rays of the Sun. The heat, obtained during the conversion and recombination of the hydrogen, heats the gas which is exhausted at a velocity of 11.5 km/sec. The return flight to the planet Earth is made by gliding.

According to the calculations by M.K.Tikhonravov, a liquid-hydrogen powered interplanetary rocket for two passengers weighs 38 tons, including all equipment, crew, and phototubes. The starter rocket weighs 75 tons alone. In order to reach the Moon, a rocket should weigh 1250 tons, provided a substantial part of its own structure is consumed as fuel by the rocket itself.

Still another interesting idea was advanced by Tsiolkovskiy.

This was the idea of establishing space stations which are to serve as launching sites for future interplanetary ships. This is what the internationally famous Soviet author, Aleksandar Belyayev has to say about the space station in his science-fiction novel, called The Star Ace, which was inspired by the ideas of Tsiolkovskiy.

"The space station is located several thousand kilometers above the Earth which it circles once within 100 hours. It maintains its contact with Earth by means of a light-signal telegraph system. It also keeps in touch with rockets engaged in interplanetary travel by means of radio.

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

While working on the concept of space stations, the Soviet engineer Yu. Kondratyuk came up with the proposal to supply such a space station with everything it may need from the Earth by means of artillery projectiles fired (from the Earth by means of a special artillery piece) through a long glass tunnel. An optical telegraph would inform the space station that the shell had been fired. While on its way through the tunnel, the artillery shell would flash automatic light-signals which are observed from the space station by means of a special telescope. The space station then would send a rocket to intercept the shell at the point where it loses momentum, attach it to itself, and bring it to the space station platform.

The space stations can vary in form. A space station may look like a thick tetragon with a searchlight at each of its four corners. As Kondratyuk maintained on the basis of his mathematical computations, a space station should be given a permanent tetragonal shape. Another space station may look like a cylinder or a cone-type glass house, having a negligible artificial gravity. Supplied with plenty of light, carbon dioxide, and suitable temperature, such stations may give excellent results. There is also a spherical type of space station which rotates slowly, in order to create a certain degree of artificial gravity.

Various thermoelectric and thermal power plants will be capable of harnessing the unlimited energy of the Sun.

"Almost the entire solar energy is of little use to mankind since the Earth gets two billion times less energy than the Sun actually releases", wrote Tsiolkovskiy. It was also he who proposed how the solar energy that goes to waste could be harnessed.

A negligible gravity makes it possible to install even the most complex assemblies on such space stations. Various types of laboratories can conduct scientific research while interplanetary space is being studied.

Rockets using the space stations as jumping-off point for the flight to the Moon or other planets will enrich mankind with the scientific data gathered on their

STAT

Declassified in Part - Sanitized Copy Approved for Release 2013/03/13 : CIA-RDP81-01043R001800190005-3

flights.

A gigantic concave reflector, made of supersmooth sheet metal, which may be called an "artificial sun" will send additional solar rays to Earth from space. Polar regions will be converted into a network of fertile oases.

Tsiolkovskiy foresaw the way in which the skies will be conquered, first by flights to the stratosphere and then beyond it. The future space stations will enable man to harness solar energy for a variety of purposes, including domination of the entire solar system itself.

In addition, it will be possible in the future to visit small planets - asteroids - and turn them into colonies for interplanetary travel.

This is the way in which mankind will start conquering the Universe.

Besides Tsiolkovskiy, many other scientists devoted themselves to the task of examining different ways in which space travel can be attained, beginning with the trajectories of the future space ships and ending with the conditions of human survival during interplanetary travel.

Tsiolkovskiy, for example, proposed for the future interplanetary travel that the would-be passengers should be trained ahead of time both in a spinning laboratory with a built-in artificial gravity greater than that of the Earth and in a kind of a free-falling laboratory in which artificial gravity is entirely absent.

Many difficulties will have to be surmounted before interplanetary travel becomes reality.

"It must be admitted that reaching of cosmic speeds and flying beyond the stratosphere is connected with great difficulties. But there is no reason to doubt that they can be eventually overcome. The daily advance of science confirms this amply. The only question is when", stated Tsiolkovskiy.

The interplanetary rocket must have at its disposal an enormous amount of fuel in order to reach the essential cosmic speed, as for example a rocket which is moonbound should weigh 1250 tons, including fuel. The largest aircraft in existence in

STAT

the world today do not exceed a weight of 200 tons!

"It turned out that the energy generated by the fuel used for take-offs is by far inadequate in that it liberates only enough energy for removing the air-bound vehicle from the immediate gravity of the Earth... The splitting of the atom gives us a great source of energy. This energy is 400,000 greater than even the most powerful of the chemically created force", adds Tsiolkovskiy.

The harnessing of atomic energy will greatly reduce the weight of the interplanetary space ship, relieving it thus of the excess burden of carrying tremendous supplies of fuel.

The discovery of new sources of energy and the harnessing of atomic energy will assist greatly in reaching the goal of interplanetary travel.

Within the framework of the Five-Year Plan, proposed by the Academy of Sciences of the USSR, considerable attention will be devoted to questions dealing with reactive technology. Soviet scientists will devote themselves to the study of reactive power plants, to the simplification and elaboration of gas dynamics - the flow impact upon bodies flying at high speeds and the stability of rocket and jet aircraft moving at very high speeds.

We are going to have interplanetary rocket ships. The prophetic statements of Tsiolkovskiy will become a reality:

"In the beginning, flights will be restricted to the stratosphere. Then, they will extend beyond the atmosphere and later on even further, into the Moon's orbit. Finally, man will be able to travel within the solar system itself. Sooner or later, the victory will be won!

"We must work harder and harder in order to be able to conquer the stratosphere completely first and then reach beyond it. That can be done only here, in the Soviet Union!"

The following is what Konstantin Eduardovich Tsiolkovskiy had to say during the celebration of May Day in the year 1933:

STAT

316

"Here in the Soviet Union there are many kinds of young pilots whom I would like to call youthful model-aircraft fans, children who pass time by flying gliders, and young pilots of real aircraft. I place great hope in them. It is they who will make it possible for my discoveries to materialize... ."

Soviet children have indeed been greatly interested in the notable ideas of Tsiolkovskiy. Young technicians made jet aircraft models and familiarized themselves with rocket technology. They are the ones whom Tsiolkovskiy designated to be the future pilots and copilots of cosmic ships.

"The achievements of Tsiolkovskiy will be echoed in the future. Our future generations are going to conquer interplanetary space. They are the ones who will really appreciate and hold Tsiolkovskiy in high esteem, because it was he who first laid down the scientifically based hypothesis of interplanetary travel."

These words of the Central organ of the Bolshevik Party, the newspaper Pravda, are the best evaluation of the role played by Tsiolkovskiy, "a notable man of science" as he was called by Comrade Stalin, as well as the role played by Russian science in the future conquering of outer space.

STAT

196

CONCLUSION

Many fantastic novels were devoted to the subject of rockets.

In one of the science-fiction novels published before the war, the rocket armies of the future were described. Infantry was professed to be armed with light rocket artillery while motorized units were supposedly armed with widely differing types of rockets. These included antiaircraft rockets, radio-guided rockets, long-range rockets, and many other types.

Within a few years, that writer's fantasy became quite real. Infantry of today has a new weapon, the rocketed mine throwers. Tanks, aircraft, and naval vessels are being armed with rockets. Rockets are being used in tank-to-tank combat, aircraft launch rockets against other aircraft, and naval units engage in rocket duels.

Today, rockets are capable of going further and faster than any of the projectiles fired by the biggest existing types of artillery pieces.

"Europe to the United States in six minutes" was the title given to a science-fiction story which appeared some 20 years ago and which dealt with the subject of transoceanic rocket flight. At that time, the statement that this was feasible was considered pure fantasy. Rockets, at that time, could barely climb to altitudes exceeding a few hundred meters and without a single passenger. After a mere fifteen years, the rocket was able to climb altitudes of several tens of kilometers.

The actual performance of modern rockets would stun even the imagination of the writer we have referred to. The highest speed that can be attained by an ordinary propeller aircraft driven by a piston engine is 760 km/hr. Moreover, such an air-

STAT

269

craft is especially constructed for the purpose of record setting. A jet aircraft, fully loaded and fully armed can fly slightly above 900 km/hr. Without armaments and without any load at all, the jet can develop a speed of 991 km/hr - close to the speed of sound.

Jet aircraft are, however, merely capable of fluctuating about the threshold of the speed of sound.

The most fantastic novels were written on the subject of rocket interplanetary travel. And now, mankind is getting close to the realization of this goal.

All this has been made possible by the development of rocket technology, whose home is Russia. The history of the development of rocket technology contains the names of many famous Russian scientists and inventors, such as Konstantinov, Kibalchich, Tsiolkovskiy, and many others.

"All my efforts in the fields of aviation, rocket navigation, and interplanetary research belong to the Bolshevik Party and the Soviet authorities - the true guides of progress and culture of mankind" wrote Tsiolkovskiy in his deathbed letter to Comrade Stalin, "and I am convinced that they will successfully complete all of them."

These beliefs held by the great Russian scientist are shared by the entire Soviet people..

STAT

5.00

Table of Contents