INTERROGATION STATEMENT OF WERNHER VON BRAUN, 1945

"Survey of the Development of Liquid Rockets in Germany and Their Future Prospects"

Professor von Braun

"We consider the A_4 stratospheric rocket developed by us (known to the public as V-2) as an intermediate solution conditioned by this war, a solution which still has certain inherent shortcomings, and which compares with the future possibilities of the art about in the same way as a bomber plane of the last war compares with a modern bomber or large passenger plane.

"We are convinced that a complete mastery of the art of rockets will change conditions in the world in much the same way as did the mastery of aeronautics and that this change will apply to both the civilian and the military aspects of their use. We know, on the other hand, from our past experience that a complete mastery of the art is possible only if large sums of money are expended on its development and that setbacks and sacrifices will occur, such as was the case in the development of aircraft.

"A few private groups of inventors started serious work on liquid rocket development in Germany in the years 1929-1930. One of these groups, called 'Rocket Flying Field Berlin,' located at Berlin-Reineckendorf, had Professor Dr. von Braun as a student among its members. Simple fundamental tests with rocket combustion chambers were carried out there, and small uncontrolled liquid rockets were fired which reached heights up to 1000 meters and landed by means of a parachute. At the end of 1932 the work of these groups was slowed down by lack of cash, but the Army Weapons Department was interested in carrying on the work and took over the services first of Professor von Braun and later of most of the other engineers.

"This special division of the Army Weapons Department was put under the direction of Dr. Ing. H. C. Dornberger, and the first rockets developed by them were designed solely for experimental purposes and were of no military value. In 1934, liquid rockets of the A_2 type were successfully tried out. They had a thrust of 300 kg, were directly stabilized by means of a large gyro, and reached a height of approximately 2000 meters. In 1938 the first trials were carried out with liquid rockets of the A_3 and A_5 types, which were fitted with an automatic control system and rudders in the gas stream. These rockets reached a height of 12 km when fired vertically, and had a range of 18 km when fired at an angle. They could land in both cases by means of parachutes and be used again.

"In view of the successful results achieved with liquid rockets, it was decided in 1936 to begin with the construction of a large experimental establishment for rocket development at Peenemünde on the Baltic. It was already recognized at that time that the development of rockets showed great promise in the field of aeronautics as well as in that of artillery, and it was therefore decided to build two separate establishments at Peenemünde, one for the Army and one for the Air Force, which are two distinct branches of the 'Wehrmacht' in Germany. At Peenemünde-Ost, comprehensive test beds and workshop facilities were set up for the construction and testing of rocket drives and controls, whilst at Peenemünde-West an airfield was built for testing rocket aircraft, and pilotless rocket-propelled aircraft, as well as auxiliary drives for standard aircraft, such as rocket-assisted take-off devices. The cost of construction of the complete installation at Peenemünde totalled approximately 300,000,000 Marks after completion. The close proximity of the rocket development work to the aeronautical development side is one of the principal reasons for the success of the work undertaken at Peenemünde.

"The following considerations were decisive in the choice of Peenemünde, and these considerations will always be important when choosing a site for rocket development work.

a) Secluded location, far away from large towns, (safety during launching, nuisance caused by noise of large test beds).

b) Favorable weather conditions (during firing and flight trials of rockets and of rocket aircraft blue skies are always desirable).

c) Reasonably satisfactory communications. The development work necessitates constant close contact between development engineers and certain branches of industry.

"The successful experimental rocket A_5, previously mentioned, had a thrust of 1500 k lasting 45 seconds. Based on the results obtained with the rocket, the order was give to develop a long-distance rocket with a range of 250 km, as high an accuracy as possi and a warhead weight of 1000 kg. This rocket, known as A_4, was first launched succe fully in October, 1942. The A_4 has a thrust of 25 tons for combustion period of 68 seconds max. It is fired vertically from a firing table, without guides of any sort, as was the case with all the previous rockets. The steering of the rocket to an inclined position is effected by means of a 'programme' apparatus. The lateral directio is determined by the exact setting of a turntable on the firing table. The exact range is determined by shutting off the propulsion unit upon reaching a previously calculated speed.

"The development of the A_4 required a great number of preliminary scientific investigations, the most important of which are briefly outlined below:

a) Wind tunnel tests at all ranges of air speeds between 0 and 1500 m/sec. During these tests, such factors as the stability of the rocket, the distribution of the air pressure, the working of the rudders, and several others were investigated apart from the drag measurements, both with and without exhaust gas stream. Both the supersonic wind tunnel and the measuring methods had to be developed over a period of years of hard work.

b) Test-bed investigations on the combustion chamber of the rocket, and on the complete propulsion unit. This too necessitated the development of appropriate test beds and measuring methods.

c) Investigations connected with the steering of the rocket at all ranges of airspeeds covered by the rocket. For this purpose a special technique of models, reproducing the attitude of the rocket in flight, was developed.

d) Development of measuring methods for plotting the complete flight path of the rocket.

e) Investigation connected with the influence of the exhaust gas stream on the wireless communication between rocket and ground, etc.

"In view of the increasing strength in number of flight aircraft in England and the resulting increased losses of bombers operating against England, orders were given at the end of 1942 to produce the A_4 rocket in quantities. The accuracy of aim was still unsatisfactory and limited the use of the rocket to large-area targets, foremost of which was London. Nevertheless, some 60,000-65,000 drawing modifications were required before the first experimental A_4 rocket became a real series production job. This indicates the number of absolutely new problems which arose during the trials of the A_4 which was subjected to hitherto unknown physical conditions.

"Meanwhile the development side was attempting to improve the accuracy of aim of the rocket. To this end, radio guide beam devices were developed to improve the lateral direction; and improved propulsion unit cut-off devices, to reduce the dispersion in range. These improvements, however, were incorporated operationally on a small scale only, and were in use chiefly in the attack on the harbor of Antwerp.

"The original objective of further development was to produce long-distance rockets of greater range. It should be noted here that the maximum ranges up to 450 km were achieved, thanks to certain improvements which, however, never came into operational use.

"Certain A_4 rockets were used to carry out vertical trajectory trials, and a maximum ceiling of 170 km was reached during these trials.

"It was planned in the spring of 1945 to fire, from an island situated near Peenemünde, a few A_4 rockets vertically, equipped with special instruments for research into the top layer of the atmosphere. The measuring instruments were set in a watertight container capable of floating, which was to have been descended by parachute. This project, all preparations for which were completed, could not be carried out on account of military events. It could be done in a short time, however, with some of the A_4 rockets still at hand.

"The problem of increasing the range of the A_4 after completion of the A_4 development program could only be carried on at a greatly reduced rate, as the development of a guided antiaircraft rocket was given first priority and absorbed much of the personnel, in consequence of the increasing air superiority of the Allies. A rocket for this purpose was developed at Peenemünde, bearing the code name 'Wasserfall.' This rocket was also propelled by liquid fuel and could be guided by radio from the ground on to flying targets. Various successful tests were carried out, but series (batch) production of the weapon was not achieved.

"A further development of the A_4 long-distance rocket is the A_9 on which work was done as far as the priority work on 'Wasserfall' would allow. The propulsion unit was the same as for A_4. The A_9 rocket has wings, which enables it to glide through the stratosphere. This enables the flight path to be increased to such an extent that the range of the A_9 is nearly double that of the A_4, that is, approximately 600 km, notwithstanding the fact that the fuel consumption of the A_9 is no greater than that of the A_4. Development could not be completed on account of the end of the war. Special control devices would have given the A_9 at least the same accuracy as the A_4. It was proposed that the weapon should go into a vertical dive at the end of the glide, similar to that of the V-1.

"As a further development, it was intended to design the A_9 winged rocket to carry a crew. For that purpose the rocket was to be equipped with a retractable undercarriage, a pressurized cabin for the pilot, manually operated steering gear for use when landing, and special aerodynamic aids to landing. The landing speed of this piloted A_9 rocket would have been as low as 160 km/hr, as it would have contained very little fuel on landing, and would consequently have been light. This piloted A_9 rocket would cover a distance of 600 km in approximately 17 minutes.

"The range of the A_9, both in the piloted and the pilotless versions, could be increased considerably if the propulsion unit were switched on only after the rocket had reached a certain initial velocity. There were two possible ways of achieving this end.

1) Use of a long catapult with only a slight gradient, which would have given the rocket an initial velocity of approximately 350 m/sec. There was experience on hand of this type of catapult at Peenemünde, as such a catapult developed by an industrial firm for launching the V-1, was tried out at Peenemünde. Experience showed that catapults could be built for launching at supersonic speed. These high speeds are essential for rockets such as A_9, because the rocket is completely filled with fuel at the start and would not fly if it left the catapult at lower speeds.

2) Development of a large assisted take-off rocket of 200-T thrust, on which the A_9 rocket would be mounted, and which would give the latter an initial velocity of 1200 m/sec. After the assisted take-off rocket has exhausted its fuel, the A_9 would become separated from it, and its own propulsion unit would be switched on. The maximum speed of the A_9 at the end of its power dive under these conditions would be approximately 2800 m/sec, which would mean that this combination could give the A_9 a range of approximately 5000 km, both in the piloted and the pilotless versions. The large assisted take-off rocket, called A_{10}, was to be equipped with air brakes, and a special parachute, which would have enabled it to be used again after alighting on water.

It was proposed to launch the A_9/A_{10} combination vertically, thus obviating the necessity of erecting large ground launching devices.

"In the more distant future, the development of liquid rockets offers in our opinion the following possibilities, some of which are of tremendous significance:

1) Development of long-range commercial planes and long-range bombers for ultra high speeds. The flight duration of a fast rocket aircraft going from Europe to America would be approximately 40 minutes. It even would be possible to build very long-range bombers, which would turn around at supersonic speeds in a very wide curve after having released their bombs, and return in a glide to land at their point of departure. The high speed of such aircraft would make defense against them ineffective with present day means.

2) Construction of multistage piloted rockets, which would reach a maximum speed of over 7500 m/sec outside the earth's atmosphere. At such speeds the rocket would not return to earth, as gravity and centrifugal force would balance each other. In such a case the rocket would fly along a gravitational trajectory, without any power, around the earth in the same way as the moon. According to the distance of the trajectory from the earth, the rocket could complete one circuit around the earth in any time between 1-1/2 hr and several days. The whole of the earth's surface could be continuously observed from such a rocket. The crew could be equipped with very powerful telescopes, and be able to observe even small objects, such as ships, icebergs, troup movements, constructional work, etc. They could also carry out physical and astronomical research on problems which could only be tackled at that altitude, due to the absence of the atmosphere. The importance of such an 'observational platform' in the scientific, economic, and military spheres is obvious. When the crew of the rocket wants to return to earth, all they need do is to reduce the speed of the rocket slightly, which can be done by rocket propulsion. The rocket then enters the upper layers of the atmosphere tangentially, and its speed is gradually reduced by friction. Finally it can land like an ordinary airplane by means of wings and auxiliary gear. It would also be possible to relieve the crew and provision the 'observation platform' by means of another rocket, which would climb up to the platform and pull up beside it.

3) Instead of having a rocket set up an 'observation platform' outside the earth, it would be possible later on to build a station especially for the purpose, and send the components up into the interstellar spaces by means of rockets, to be erected there. The erection should be easy, as the components would have no weight in the state of free gravitation. The work would be done by men who would float in space, wearing divers' suits, and who could move at will in space by means of small rocket-propulsion units, the nozzles of which they would point in the required direction.

4) According to a proposal by the German scientist, Professor Oberth, an observation station of this type could be equipped with an enormous mirror, consisting of a huge net of steel wire onto which thin metal foils could be suspended. A mirror of this nature could have a diameter of many kilometers, and its component facets could be controlled by the station which would enable the heat and light of the sun to be concentrated on selected points of the earth's surface. This would enable large towns, for instance, to get sunlight during the evening hours. The weather, too, can be influenced by systematic concentration of the sun's rays onto certain regions. Rain could be induced to fall on regions hit by draught, by concentrating the sun's rays onto distant lakes and seas, and increasing their evaporation. The clouds thus formed could be driven to the required spot by influencing the centers of low and high pressure through radiation from other facets of the mirror. If the mirror is made large enough, and it could be of extremely light construction, it would even appear possible to generate deadly degrees of heat at certain spots of the earth's surface.

5) When the art of rockets is developed further, it will be possible to go to other planets, first of all to the moon. The scientific importance of such trips is obvious. In this connection, we see possibilities in the combination of the work done all over the world in connection with the harnessing of atomic energy together with the development of rockets, the consequence of which cannot yet be fully predicted.

"To conclude, we think, after what has been said above, that a well-planned development of the art of rockets will have revolutionary consequences in the scientific and military spheres, as well as in that of civilization generally, much in the same way as the development of aviation has brought revolutionary changes in the last 50 years.

"A prophecy regarding the development of aviation, made in 1895 and covering the next 50 years, and corresponding to the actual facts, would have appeared at least as fantastic then as does the present forecast of the possibilities of rocket development.

"In the same way as the development of aviation was not the work of a single man but became possible thanks to the combined experience of many thousands of specialists who concentrated exclusively on this one branch of science for years, so the development of the art of rockets will require a systematic effort by all specialists who have gained experience on this subject."