THE GENERAL BOARD
United States Forces, European Theater
Antiaircraft Artillery Section

# V-2 ROCKET ATTACKS AND DEFENSE

Mission: Prepare Report Covering the Characteristics and Effectiveness of the German A-4 Long-Range Rocket (V-2) and submit Recommendations for Countermeasures.

The General Board was established by General Orders 128, Headquarters European Theater of Operations, US Army, dated 17 June 1945, as amended by General Orders 182, dated 7 August 1945 and General Orders 312, dated 20 November 1945, Headquarters United States Forces, European Theater, to prepare a factual analysis of the strategy, tactics, and administration employed by the United States forces in the European Theater.

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THE GENERAL BOARD
UNITED STATES FORCES, EUROPEAN THEATER

# V-2 ROCKET ATTACKS AND DEFENSE

## PART ONE

## INTRODUCTION

1. Background

a. World War II has witnessed the development and employment of offensive weapons of the rocket type which have become a matter for serious concern, if not well-founded apprehension, by all individuals who bear any portion of the burden of their country's defense. The long range, accurate control, and devastating effect actually attained by present rocket-type weapons seem fantastic. However, sober reflection gives still greater apprehension for the future. The perfection of techniques already near completion, including the addition of atomic power, makes it difficult to over-estimate the potential of the rocket or guided missile as a military weapon, or to exaggerate the appalling consequences of failure to cope with this menace.

b. In 1929 Germany embarked upon a program to develop long-range rockets for military use. A series of 10 rockets, known as the "A" series, resulted; the best known was the "A-4", which was generally called "Vengeance Weapon Number Two", or simply the "V-2". The V-2 was the only one of the series that was operationally successful.[1] It is of interest to note that the "Vengeance Weapon Number One", also variously known as the "V-1"[2], the "Pilotless Aircraft", or "PAC" was not a rocket and was not in the "A" series project. The V-2 was a supersonic-velocity, cigar-shaped rocket, about 47 feet long. It reached a velocity of about 3,400 miles per hour, a range of about 200 miles and a maximum ordinate of over 50 miles. The main propulsion fuel consisted of five tons of liquid oxygen and four tons of alcohol. These liquids were forced simultaneously into the jet motor by a 460 horsepower turbine-operated pump, which used 375 pounds of hydrogen peroxide and 25 pounds of sodium permanganate to generate steam for its power. The total weight of the rocket, including a one-ton warhead, was about 14 tons.

2. The Purpose of This Study is to invite attention to the tremendous importance and difficult nature of the problems involved in offensive and defensive use of long-range rockets and guided missiles, and to make specific recommendations for dealing with those probelms.

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1 P 23 Bibliography Ref 15.

2 P 23 Bibliography Ref 23.

THE GENERAL BOARD
UNITED STATES FORCES, EUROPEAN THEATER

V-2 ROCKET ATTACKS AND DEFENSE

PART TWO

NARRATIVE REPORT

CHAPTER 1

HISTORY OF DEVELOPMENT OF THE V-2

3. The Long-Range Rocket Program of the Germans included a huge research project designed to develop several types of rockets under the title of the "A" Series[1]. There were 10 types in the series, from A-1 through A-10. In the entire series, the A-4[2], better known as the V-2, was the only one to be used operationally. This study, therefore, is concerned mainly with the V-2.

4. Purpose. The purpose of the rocket project was to develop and produce long range weapons. Tremendous strides in rocket development were made in the program and it is not hard to visualize what could have been in store for the Allies had the Germans been given time to complete the development.

5. History of Development of the "A" Series. The Germans started various development work on long-range rockets in 1929, but due to lack of government subsidy, the program gradually died out. However, in 1932 the German army placed General H. C. Dornberger in charge of a group of scientists to continue development in the rocket field. Professor Von Braun was given control of the development of the "A" Series of long-range rockets, and it was he who added much impetus to the program. The development continued and finally, in 1938, rockets of the A-3 and A-5 type were first fired. They were experimental models which preceded the development of the A-4. The A-4 was first fired successfully in October 1942.

6. Most of the Experimental Work was carried out at a tremendous laboratory at Peenemunde, Germany, (P9532)[3]. Production was started near the end of 1942, with a planned output of 900 rockets per month. This experimental station was bombed by the Royal Air Force (British) in August of 1943, and so heavily damaged that development and production were seriously retarded. It is estimated that production was delayed at least six months. However, the A-4 was produced at various places throughout Germany by factory dispersion. An underground plant was built

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1. The A-Series did not include various rocket-type projectiles used by German artillery.
2. In this report the German Long-Range Rocket A-4 will be referred to by the commonly known term, V-2.
3. All map coordinates listed in this study refer to the G.S.G.S. Series (British) Nord de Guerre Zone.

at Nordhausen, Germany, (RD 1227), which reached a production rate of 250 rockets per month. The total production for all plants reached 700 per month by February 1945. By the end of the war, the A-10, a guided missile designed to bombard New York, was ready for construction.

7. Details of Series A-1 to A-10.

a. A-1. This rocket was probably started in 1931.[1] Von Braun dates it as 1933, saying that it was never launched, due to many difficulties. It was directly stabilized by one large gyro in the nose. This equipment weighed approximately 88 pounds. Nitrogen expulsion was to be used. It was intended to be launched vertically from an adjustable platform, usually referred to as a launching table.

b. The A-2 was very similar to the A-1 except that the gyro was placed in the center.[1] In 1934 the A-2 was successfully launched vertically from a launching table, and attained a height of two miles.

c. The A-3 was designed primarily for propulsion research. It was launched vertically from a table, and was steered automatically by rudders in the exhaust stream. It did not reach supersonic speeds. It did reach an altitude of about 1,300 yards. It was a cigar-shaped missile, reported to have been about four feet-six inches long and about 12 inches in diameter.

d. The A-4, commonly known as the V-2, is the subject of this report.[2] It was developed and tested at Peenemunde, Germany, (RP9532) and had its first successful flight in October 1942. Experience gained with the A-3 and the A-5 contributed to the development of the V-2. The cost of production of the V-2 was estimated to be approximately $60,000 each. This figure is probably inaccurate since a great deal of slave labor was used in its manufacture.

e. The A-4b[3] is an A-4 with small wings to increase the range from about 180 miles to about 270 miles by gliding.[4] It was designed to cover this distance in about 19 minutes. It was intended to use the A-4b (which could be easily made from an A-4) until the A-9 was developed and put into production.[5]

f. The A-5 was primarily used for research in control mechanisms.[6] This was the first model to use graphite blades for the jet-stream rudders. It attained a maximum horizontal range of about 11 miles when launched at an angle, and a maximum ordinate of about seven miles when launched vertically. The missile was recovered by parachute for re-use. It did not reach supersonic speeds. The A-5 was reported to be about 20 feet long with an 18-inch diameter and to be powered by a hydrogen peroxide-potassium permanganate motor.

g. The A-6 was designed to obtain supersonic speed but was never constructed.[7] The motor used Salbei (nitric acid) and Visol (a hydrocarbon mixture) but had too low a specific impulse for the purpose.

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1. P 23 Bibliography Ref 20.
2. P 23 Bibliography Ref 15 and 21.
3. P 22 Bibliography Ref 11. P 23 Bibliography Ref 21.
4. P 22 Bibliography Ref 13.
5. P 22 Bibliography Ref 11.
6. P 23 Bibliography Ref 21.
7. P 23 Bibliography Ref 22.

h. The A-7 resembles an A-5 with small wings.[1] It was launched horizontally from an airplane to obtain experimental data on gliding.

i. The A-8 was planned but never built.[2] Use of a liquid alcohol motor was contemplated.

j. A-9.[3] The A-9 was similar in appearance and results to the A-4b[4], but was of different internal construction. It was proposed to develop and manufacture the A-9 in place of the A-4. However, the conversion would have been difficult, and the A-4b, which could be produced much more quickly, was being developed as a temporary substitute. The plan was to shoot the missile vertically into the air and then incline it toward the target. Its design included wings to enable it to glide until over the target, where it would go into a vertical dive. It was expected to travel about 375 miles (its maximum range) in 17 minutes. A proposal was made to launch it from a catapult to increase its range. It was also proposed to install a pressurized cabin, and to use a human pilot. The pilot would drop the warhead on the target, and then return to his base. A retractable landing gear would be used in the landing. Landing speeds as low as 100 miles per hour were anticipated.

k. The A-10 was never built, but plans for its production were completed.[3] It was to be used as a take-off motor for the A-9, supplying a 200-ton thrust for this purpose. When the A-9 attained a velocity of approximately 1,500 miles per hour, its own motor would begin to function, and the A-10 would be jettisoned. It was expected that the A-9 would then attain a velocity of about 3,360 miles per hour and a range of about 3,500 miles.[5] It was also proposed to use a human pilot in this combination.

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1. P 23 Bibliography Ref 22.
2. P 23 Bibliography Ref 22.
3. P 23 Bibliography Ref 23.
4. P 22 Bibliography Ref 13.
5. P 23 Bibliography Ref 14.

# CHAPTER 2

# DESCRIPTION AND OPERATION

## SECTION 1

## GENERAL DESCRIPTION

8. Physical Characteristics. The V-2 rocket[1] is a cigar-shaped, streamlined, guided missile, 46 feet-10 inches long, with a maximum diameter of five feet-five inches. It consists of a sharp, conical warhead, a cylindrical center section, and a tapered afterbody carrying four external fins. The take-off weight is 14 tons, of which one ton is explosive and nine tons are fuel. This fuel is all consumed in the first 60 seconds of flight.

9. Power Supply. The fuel pump of the V-2 is an auxiliary steam turbine pump, operated by 375 pounds of hydrogen peroxide and 25 pounds of sodium permanganate. It develops 460 horsepower in one second, and forces the entire main fuel supply, consisting of nine tons of alcohol and liquid oxygen, into the main combustion chamber in one minute. The ignition of the alcohol-oxygen mixture produces a 28-ton thrust from the large venturi at the moment of take-off, which gives the V-2 an initial acceleration of 32.2 feet per second per second.

10. Control of the V-2 is by means of fins, both in the tail surface and in the jet stream. These fins are positioned by hydraulic servo mechanisms operated by an extremely elaborate intelligence or control system. The central control system consists of the following: Two gyros to provide stability about the three axes of the missile; a radio to provide azimuth control; an integrating accelerometer to turn off the power when a specific velocity for range control is reached; and a time switch control which causes the missile to tip on a 47 degree slant toward the target after it has been launched vertically.

## SECTION 2

## DETAILED DESCRIPTION

11. The V-2 is Composed of the Following Main Components:[2]

a. The warhead.
b. The control compartment.
c. The center section (contains main fuel tanks).
d. The auxiliary power unit (turbine for forced fuel supply).
e. Main power unit (combustion chamber and venturi).
f. Tail unit and thrust ring.

12. The Warhead is a very pointed cone six feet-five inches long and contains 1,620 pounds of high explosive (cast amatol). When loaded it weighs 2, 190 pounds. It contains three fuzes: Two inertia fuzes and

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1 P 23 Bibliography Ref 15.
2 P 23 Bibliography Ref 16.

and electrical nose fuze. The warhead is suitable for carrying atomic bombs; there is little doubt that it was intended for that purpose.

13. The Control Compartment is six feet-four inches long and contains all of the various control equipment. The compartment normally contains:

| Unit | Function |
|---|---|
| (a) "Vertikant" Gyroscope | Controls the rocket in roll and yaw. |
| (b) "Horizont" Gyroscope | Controls the rocket in pitch. |
| (c) Control Amplifier | Transmits control signals to control surfaces at tail end of rocket. |
| (d) Integrating Accelerometer | Shuts off fuel supply at predetermined velocity. |
| (e) Radio Transmitter-Receiver | Shuts off fuel supply. (alternate for the Integrating Accelerometer) |
| (f) Radio Control Receiver | Controls the rocket in line. |
| (g) Time Switch | Over-riding control to shut off fuel supply. |
| (h) "Stirg" Unit | Warhead arming unit. |
| (i) Three Storage Batteries | Power Supply. |
| (j) Main Electrical Distribution Panel | Power Distribution. |
| (k) Three Motor Alternators | Control of power supply. |
| (l) Three Compressed Air or Nitrogen Bottles | To pressurize alcohol tank after rocket reaches rarefied atmosphere. |

14. The Center Section contains the main alcohol and liquid-oxygen fuel tanks. It is 20 feet long and is completely insulated with spun glass to prevent the extreme heat generated by skin friction during flight from exploding the fuel. The forward tank has a capacity of 1,000 gallons of alcohol. The rear tank, of equal capacity, contains the liquid oxygen. The fuel line, from the alcohol tank, passes through the oxygen tank, and is insulated to prevent the alcohol from freezing.

15. The Auxiliary Power Unit is within the tail section between the main combustion chamber and the oxygen tank.

a. It consists of:

(1) Hydrogen peroxide tank.
(2) Sodium permanganate tank.
(3) Combustion chamber.
(4) Turbo-pump and main fuel pumps.
(5) Heat exchanger.

b. The hydrogen peroxide and potassium permanganate enter the small combustion chamber and generate high pressure steam which, in turn, operates the fuel pump turbine. The fuel is pumped out so rapidly that means must be taken to avoid the formation of a vacuum with the resultant collapse of the fuel tanks. In the case of the alcohol tank, this purpose is served by an air-vent and air bottles. In the case of the oxygen tank, the heat exchanger used exhaust steam to warm a limited amount of oxygen, which then returns to the oxygen fuel tank in greatly expanded form, and establishes the necessary internal pressure.

c. The rear of the thrust frame, which is in the center section, carries four universal joints to which the forward end of the main combustion chamber and venturi assembly is fastened by steel rods. It is this frame that actually receives the forward thrust of the venturi tube.

16. The Main Power Unit is the place of production of the terrific

jet stream which propels the rocket. The unit consists of the combustion chamber and the venturi tube which is welded to, and in prolongation of, the chamber. Alcohol and liquid oxygen, pumped separately but concurrently into the chamber through 18 cups located at its head, are ignited in the chamber.[1] The venturi tube is of a double-wall construction and is cooled by the flow of alcohol between the inner and outer walls on its way to the combustion chamber. In addition, there is a series of small vents around the inside of the venturi tube which, in permitting a small amount of alcohol to enter the venturi tube directly, influence the propulsion process.

17. The Tail Unit and Thrust Ring Assembly consists of a welded and riveted steel shell, supporting four large stabilizing fins mounted radially and at right angles to each other. At the outer end of each fin is located a stabilizing tab. These tabs are the principal means of directional control for the rocket while it is below the stratosphere. The overall length of the tail unit is 14 feet-six inches. This includes the 10-inch overhang of the four fins. Fastened to the end of the tail unit and the venturi tube is a thrust ring. Four carbon tabs, or internal control vanes, are mounted on the thrust ring and located in the path of the jet stream. These vanes assist the external tabs in directional control while the rocket is below the stratosphere, and perform this entire function unassisted while the rocket is in the stratosphere.

18. The Dimensions and Weight are as follows:

a. Overall length, 46 feet-10 inches.
b. Largest diameter of body, five feet-five inches.
c. Maximum width across fins, 11 feet-10 inches.
d. The entire unit, when empty, weighs 8,800 pounds. With its warhead and fuel load its weight is approximately 14 tons.

## SECTION 3

## DESCRIPTION OF FLIGHT

19. The Flight of the Rocket combines the action of a controlled missile and a free projectile.[2] In four seconds it reaches an altitude of approximately 2,000 feet, when the time switch actuates the directional control system which, in turn, directs the rocket along a curved path until it reaches an angle of 47 degrees with the horizontal. It then continues in straight flight along this course until it has reached the pre-computed velocity required for it to hit the target. Approximately 60 seconds after launching, it has reached this velocity, and the integrating accelerometer switches off the power unit. The velocity, at this time, is about 3,400 miles per hour. After the power unit has been cut off, the V-2 follows the trajectory of a free body in space, reaching a maximum ordinate of more than 50 miles before returning to the surface of the earth. When the rocket returns to the atmosphere, it is slowed down to about 1,800 miles per hour. Air friction causes the rocket surface to reach a temperature of about 300 degrees centigrade, just before it strikes the earth. Developments were delayed because this extreme heat caused some premature air bursts. This malfunction was largely overcome by insulation. The range at which the V-2 can operate most effectively is a little less than 200 miles. As was mentioned before, the rocket was used beyond its most effective operational range against London.

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1 See paragraph 22k, below.
2 P 23 Bibliography Ref 15 and 24.

## CHAPTER 3

## ORGANIZATION AND OPERATIONS REQUIRED FOR LAUNCHING THE V-2

### SECTION 1

### TACTICAL ORGANIZATION

20. Organization.

a. The initial German field organization for the tactical operation of the V-2 was a division under the command of General Kammler. This division later became part of the Reprisal Corps (formed during February and March 1945). General Kammler was designated to command the corps, which operated both the V-2's and the Pilotless Aircraft (V-1). The rocket organization was called the Reprisal Division.

b. The Reprisal Division consisted of three firing regiments and special technical units. The regiments consisted of a regimental headquarters, three firing batteries and one security battery. Each of the three firing batteries consisted of three platoons. The first platoon was the launching or firing platoon. The second was the technical platoon, and was responsible for testing and repairing damaged rockets. The third, called the fuel and rocket platoon, was responsible for transportation of the rockets from the railhead to the technical platoon and the transportation and loading of fuels. Each launching platoon was capable of launching six V-2's per day.

### SECTION 2

### EVENTS PRECEDING LAUNCHING

21. Establishing the Firing Sites.

a. The division commander determined the localities in which regiments were to conduct operations. The regimental commander then assigned an area to each of his three firing batteries. Each battery commander then selected three firing sites (normally about one thousand yards apart) within his area. Engineers, from the special technical units of the division, when necessary, built or improved the road net, and accomplished the surveys and calculations for orientation and firing. The firing platoon prepared the three firing sites of the battery.

b. The requirements for a V-2 firing-site were simple. It was necessary to have a firm foundation of wood, concrete, or metal sheeting, for the firing table,[1] and a suitable place to position and dig in the various accessory vehicles,[2] such as the control vehicle, generator-test vehicle and air-pressure vehicle. Radios were also set up when "radio-motor cut- off" control was used instead of the integrating accelerometer. When all vehicles were in and the electrical cable and communication lay-out was completed, the site was ready for operation.

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1 P 23 Bibliography Ref 19.
2 P 23 Bibliography Ref 18.

22. Preparations for Firing.

a. The technical troop erected a special lifting crane at the railhead, for use by the fuel and rocket platoon, to transfer rockets from freight cars to the Vidalwagon (rocket transport vehicle). The rocket was then taken to the technical battery's shops for an overall functional test in the horizontal position. This was the second of three tests performed on each rocket. The first was at the plant, in the vertical position, and the third was at the firing site, in the verticle position. The second test was required because the rockets were not weather-proofed and, if exposed to the elements for a few weeks after manufacture, they usually needed electrical adjustments and sometimes mechanical replacements.

b. The technical unit made all tests, adjustments, and necessary repairs, then mounted and fuzed the warhead. The rocket was then ready for transfer from the technical battery to the launching battery. The launching battery placed the rocket on the Meillerwagon (a vehicle for moving the rocket to the firing site and erecting it for firing).

c. Two or three hours before the time scheduled for firing, the rocket was received from the technical platoon ready to fire, except for the operations described below.

d. The Meillerwagon was driven up to the launching site, where the rocket was erected in its cradle and the firing table was raised under it until it took the weight of the rocket. The Meillerwagon was then pulled about a yard away, where its scaffolding was used in testing and fueling the rocket.

e. The rocket was then leveled so that its longitudinal axis was vertical.

f. The hatches were opened and the external electrical control cables inserted in snap-away receptacles, enabling quick release of the cables at take-off.

g. The carbon control vanes were then attached. These were left off until the rocket was erected, since they were quite easily broken.

h. Next, the main vertical tests were conducted. These consisted of running the gyros and checking the vane control systems, pressures in air bottles, functioning of radio control equipment, and electrical switches and wiring.

i. When all tests were successfully completed, the rocket was reported ready for fueling. The four types of fuel needed were loaded separately in this order: Alcohol, liquid oxygen, hydrogen peroxide, and sodium permanganate.

j. Upon completion of fueling, the rocket was checked for azimuth. One pair of vanes had to be exactly in line with the target, or direction of fire. The final testing of the steering mechanism was performed at the same time.

k. The site was then cleared and the order for launching given. Three engineers in the control vehicle were required to carry out the sequence of operations to launch the rocket. The fuel was allowed to flow into the combustion chamber, where it was ignited. As soon as the flow was even and the engineers were satisfied that everything was functioning properly, the circuit was closed. This initiated the mixing of the

sodium permanganate and the hydrogen peroxide, which in turn developed steam so rapidly that the fuel pressuring turbine was brought to 460 horsepower in one second. As soon as the fuel started entering the combustion chamber at full pressure, the tremendous thrust was developed. This thrust lifted the rocket off the ground[1] and started it on a rapid acceleration which finally reached eight times the acceleration due to gravity.

1. The tactical mobility of a V-2 launching unit was comparable to that of a medium artillery battery. The time from when the rocket was brought to the launching site until all signs of activity had been removed after firing was believed to be two to three hours.

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1 P 23 Bibliography Ref 17.

# CHAPTER 4

## EXTENT AND EFFECT OF V-2 ATTACKS

### SECTION 1

### EXTENT OF EFFORT

23. Beginning and Duration. The V-2 attacks started on England and the Continent at about the same time. On 8 September 1944 a V-2 landed on Paris, and a few hours later, London had its first bomb. This heralded a long sustained rocket campaign on Continental targets and London. The attack lasted until the firing units in Holland and Germany had been over-run during the last days of the war in Europe.

24. Attack on London. On 8 September 1944 the first V-2 Rocket in the assault on London exploded at Chiswick, England (a suburb of London). This was the beginning of a long and bitter campaign which lasted until March 1945. A great deal of property damage in London was caused by this continuous attack, but the Allied war effort was never seriously affected. At no time did the attack assume such importance that a major diversion of air force bombing missions to combat it became necessary. The assault on London ended on 28 March 1945 when the Allies overran the launching sites. During the entire assault 1,116 rockets fell on England. A large percentage of these fell within the built-up area of London. Inasmuch as London was actually beyond the intended operational range of the V-2, many of the rockets fell short.

25. Attack on Continental Targets. During the V-2 campaign a number of targets on the Continent were attacked with varying intensity. The first and least important was Paris. This was followed by attacks on Antwerp, Brussels, and Liege in Belgium, and Maastricht (VK 5552) in Holland. There was only one recorded tactical use of the V-2, which was on 17 March 1945, when 11 rockets were directed against the Ludendorf Bridge at Remagen, Germany (WF 6422). Some officers are of the opinion that this attack was partly responsible for the final collapse of that important bridge across the Rhine. The strategical use of the weapon will be covered in the following paragraphs. The attacks on Antwerp and Liege were the most extensive and will be discussed in detail.

26. Attacks on Antwerp and Liege.

a. After the single rocket fell on Paris on 8 September 1944, no more were fired against targets on the Continent until 13 September 1944, when a rocket fell near Brussels. The next day four more rockets fell in the Brussels area. That day (14 September 1944) can be regarded as the real beginning of the long range rocket campaign.

b. During this early period, no good intelligence or reporting system had been developed; consequently, the figures on the number of rocket incidents are not reliable. The best available figures show that during the period 14 September 1944 to 12 October 1944 an average of four and one-half V-2's per day were directed at Liege (an undetermined few possibly intended for Maastricht), and a very few directed at Lille (VH 7946), Brussels and Ghent (VJ 1980). Liege bore the brunt of this attack.

c. The attack shifted from Liege to Antwerp on 13 October 1944, and from then until the war's end (except for the previously mentioned one-day attack on the Remagen bridge) was concentrated on that city. From that date until 13 December 1944, an average of nine plus V-2's per day landed in the vicinity of Antwerp. Near the end of October 1944 and the beginning of November the number of rocket incidents[1] was over 100 per week and the biggest day recorded was 2 November 1944, with 24 incidents.

d. A more reliable Allied intelligence system was started on 14 December 1944, and marked the beginning of operation of the Continental Crossbow[2] Forward Unit of Supreme Headquarters, Allied Expeditionary Force. From the date of its becoming operational until the end of the campaign, the Crossbow unit recorded not only rocket incidents but also launchings. Figures subsequent to this date can be considered quite reliable. During the first three weeks of this period, the launchings continued at a rate of more than 100 per week. This was the most intense period of the entire campaign. From 1 January 1945, the attack fell off steadily until the close of operations on 28 March 1945. There was an exception during the third week in February, when the launchings for the week reached 91, but this was a short-lived spurt and the downward trend continued.

27. Summary of the Effort.

a. From 8 September 1944 to 1800 hours 14 December 1944, 888 V-2 ground incidents were recorded on the Continent. From 1800 hours 14 December 1944 to 0845 hours 28 March 1945 (when rocket attacks ceased) 914 rockets were successfully launched. The total number of recorded V-2 incidents was 1,802. This figure cannot be considered better than a good estimate because, during the early period, there was not an adequate collecting and collating system of V-2 intelligence, and during the entire period there was no way of accounting for those rockets that never climbed high enough to be observed visually or by radar.

b. By scientific study of ground incidents, prisoner of war interrogations, and other means a final estimate was made that 1,950 V-2's were fired during the rocket campaign, of which approximately 1,780 were aimed at Antwerp, and the remaining 170 at other Continental targets, including Liege, Paris, Lille and possibly Maastricht, Brussels and Ghent. It appears from a study of the fall of shot between Liege and Maastricht, along the Meuse River, that the Germans experimented with the feasibility of attacking river crossings with V-2's, as they did against the Remagen bridge.

## SECTION 2

## EFFICIENCY AND EFFECTIVENESS

28. Efficiency.

a. The rockets may be classified in three general groupings as regards their efficiency:

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1 Incident - the official term adopted to indicate the fall and explosion of a missile.

2 "CROSSBOW" was the code word adopted to indicate defense against long-range missiles.

(1) Failures - Rockets which did not rise high enough to be picked up by the radar surveillance sets.

(2) Wild rounds - Those rockets which were detected but did not fall within an 18 mile circle around the center of the target[1].

(3) Successes - Those rockets which did fall within an 18 mile circle around the center of the target.

b. The number of failures has been determined by questioning prisoners of war, and from diaries kept by local inhabitants near certain launching sites. Although the information is rather meager, it is used as a means in computing percentages on various sub-divisions of failures, wild rounds and successes. The sub-division of failures is as follows:

(1) Cancelled launchings - These were usually due to mechanical failures within the rocket mechanism. If the delay was greater than 100 minutes after oxygen fueling the launching had to be cancelled because the liquid oxygen froze other elements and the rocket had to be thawed out.

(2) Standing Duds - These rounds were ignited but failed to leave the ground due to some mechanical breakdown within the rocket.

(3) Rising Duds - These rounds left the ground but never rose high enough for radar detection and usually fell to earth in the vicinity of the launching site.

c. Tabulation of Efficiency. After careful evaluation of all data, the following percentages for V-2 efficiency were computed:

| | | |
|---|---|---|
| Failures | | 24.5% |
| Cancelled launchings | 12.0% | |
| Standing duds | 5.0% | |
| Rising duds | 7.5% | |
| Wild rounds | | 10.5% |
| Successes | | 65.0% |
| Within six mile circle | 39.0% | |
| Outside six mile circle, but within 18 mile circle | 26.0% | |
| | | 100. % |

From the above tabulation, it may readily be seen that 65 percent of all attempts to launch rockets resulted in hits within the 18-mile circle around the center of the target which included 39 percent within a six-mile circle. Since cancelled launchings involved the expenditure of effort at least equal to that required for successful launchings, they are included in the above tabulations to show the efficiency of the launching operations. A recomputation excluding cancelled launchings would show the percentage of launched rockets falling within the 18-mile circle to be 74 percent, including 44 percent within the six-mile circle.

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1 A circle, 18 miles in diameter, was arbitrarily selected as roughly covering the area of Greater London.

29. <u>Effectiveness.</u>

a. The Germans hoped, by their Continental V-2 campaign, to destroy or cripple the Allied supply line through Antwerp and Liege. Antwerp bore the brunt of the attack, due to its greater importance as a major port. Liege received about 10 percent of the attacks. It was of considerable importance as a communications center and railhead, and was located on a main supply route. The effect on the flow of supplies through both of these targets was practically negligible. Therefore, the V-2 attack failed in its primary objective.

b. Although the V-2's did not achieve success in their primary mission against Continental targets, they were eminently successful in diverting manpower and equipment from important military functions to render civil defense services. The entire passive air defense systems of Antwerp and Liege had to be overhauled. This was necessary in order to keep dock workers, railroad men, and other essential civilians, from leaving the areas.

c. Casualties and materiel damage resulting from V-2 attacks were severe. In Antwerp, Liege, and vicinity, some 5,400 persons were killed, 22,000 wounded, and 90,000 houses were destroyed. These losses were not determining military factors, but they did adversely affect morale, and made it difficult to maintain an adequate supply of civilian labor.

## CHAPTER 5

## COUNTER MEASURES PAST AND PROPOSED

### SECTION 1

### DEFENSIVE MEASURES USED IN WORLD WAR II

30. General. a. Several considerations relative to the setting up of any defensive measures against V-2 were apparent when the subject was first studied by Supreme Headquarters. The first requirement was to organize a unit to collect and evaluate all available information on the rockets. Next, someone had to be made responsible for analyzing the operational use of the weapon by the enemy. Finally, someone had to be charged with the planning of defenses against the rocket attacks.

b. The Supreme Commander, after careful analysis of the problem, charged the Assistant Chief of Staff, G-2, with collecting all available intelligence information on the V-2 rocket project. He charged the Air Defense Division with the responsibility of gathering and evaluating all information on fall of shot and other matters pertinent to rockets. In other words, the G-2 was charged with intelligence prior to launching and the Air Defense Division was charged with collecting information on the rockets after they had been launched. In addition, the Air Defense Division was charged with preparations for defense against V-2's and with a study of the feasibility of the use of a similar weapon by the Allies. The G-2 delegated the evaluation of the intelligence data to the Assistant Chief of Staff, A-2, who attached the necessary officers to the Air Defense Division to assist in evaluating intelligence, and to act as Air Force advisers to the Chief of the Air Defense Division.

c. After much thought, two methods of intelligence collecting were devised and put into practice, together with the counter measures to be instituted, which consisted principally of air attacks against V-2 facilities. These counter measures will be covered in detail in this chapter.

31. Intelligence. a. Intelligence is considered as a defense method in this study because it had such an important bearing on the active defensive methods used in the operation. Supreme Headquarters set up several different units, all under the Air Defense Division, for collecting information on the launching, flight and fall of V-2's. The means of gathering this information were a sound ranging unit, a radar detection unit, and a fall of shot organization. In addition to the above units, field force units, also, rendered periodic reports covering fall of shot and launchings.

b. Information on the fall of shots was reported by the army groups, armies, Headquarters Communications Zone and the fall of shot organization set up around the targets. The latter unit was called a Counter Battery and Field Observation Unit. It reported through the Continental Crossbow Forward Unit[1] and Advance Headquarters of the Air Defense Division, Supreme Headquarters.

c. Intelligence as to the location of rocket firing areas was

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1 The headquarters comprising the staffs needed to supervise the operation of the Royal Air Force (British) and U.S. and British army rocket detection resources.

obtained from radar surveillance units and from visual observation of condensation trails of ascending rockets.[1] This information was reported to a special section within the Air Defense Division at Supreme Headquarters, called the Collating Section.

d. Collation of Information. The Collating Section of the Air Defense Division at Supreme Headquarters, after reviewing all available information, welded it together into a coherent story and distributed its daily reports and weekly summaries to all concerned. There was a considerable time lag in confirmed accurate reports. Inasmuch as the Collating Section had to serve two purposes, that of dissemination of tactical information and the collection of information for scientific research, it rendered three types of reports: First, a Flash Report on all unconfirmed information for possible emergency tactical use; secondly, a more accurate daily totals report without much detail; and thirdly, a complete detailed report for use in research and future planning. The detailed report had an average time lag of approximately 32 hours.

e. Information regarding rocket launching and field storage sites, routes, and means of conveyance was obtained by the Intelligence Section from ground agents, prisoners of war, photographs and the Collating Section. Based on this information, recommendations for active defense were prepared for the Chief, Air Defense Division. (For the latter's action see paragraph 34 below.)

32. Passive Defense Measures. In all of the target areas civilian defense organizations had to be carefully reorganized by the military commanders in order that as much assistance as possible could be given to the local population. This was very important because large numbers of civilians were needed in handling ship cargoes and transportation in the various target areas. A mass evacuation of Antwerp or Liege would have had serious effects on the logistical support of the field armies. Therefore, it was necessary to divert much effort to making the passive air defense organization in the affected cities as efficient as possible.

33. Active Defense Measures.

a. General. The Chief, Air Defense Division, Supreme Headquarters, was charged with coordination of all counter-measures, whether active or passive, relating to V-2's. Therefore, he received recommendations from the Intelligence Section on active defense. Specifically, the Intelligence Section (known in full as the Crossbow Intelligence, Interpretation, and Operationl Recommendations Section) was responsible, under the direction of the Assistant Chief of Staff, A-2 Division, to the Chief, Air Defense Division for:

(1) Recommending areas for armed reconnaissance and targets for attack, after evaluating information from the Collating Section, agents' reports, and photographic reconnaissance.

(2) Requesting photographic reconnaissance through A-2 channels.

(3) Requesting target material through A-2 channels.

(4) Furnishing appreciations on long-range rocket matters as required.

Using the information at his disposal, the Chief, Air Defense Division,

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1 P 23 Bibliography Ref 25.

Supreme Headquarters, made suggestions to the staff section concerned (mostly Air Staff) that certain defensive actions be implemented.

b. Air Defensive Measures. The air action, against targets and areas associated directly or indirectly with the firing of rockets against Continental targets, was taken by Second Tactical Air Force (British) pursuant to instructions issued by Air Staff Headquarters on 16 November 1944. These instructions stated that the defense of the Port of Antwerp was vital, and ordered that appropriate air action should have a flexible priority varying from "just below special projects" to "above routine missions." The anticipated figure of 48 rockets launched every 24 hours was never reached and it was never necessary to assign air counter-measures against rocket attacks a higher priority than that stated above.

c. There were four types of air attack on rocket activities:

(1) Prearranged attacks on specific targets.

(2) Armed reconnaissance sorties over areas in which static targets were suspected or fleeting targets might present themselves.

(3) Rail interdiction missions to check transportation of supplies to firing areas or field storage sites.

(4) Night intruder missions into V-2 supply areas.

The pre-selected targets were almost invariably vital points in the supply system. Launching or storage sites could not be located from aerial reconnaissance, so were not subject to prearranged attacks. The armed reconnaissance missions were normally routine missions and picked up whatever rocket information they could. The rail interdiction missions were the most effective of all types of missions against the V-2. The railway routes to the launching areas were kept under almost constant air interdiction, and an analysis of the interdiction attacks against these routes showed definite results. The night intruder missions were valuable because it was known that practically all activities concerning V-2's were carried out under cover of darkness. Several rocket railheads were bombed by these night intruders.

d. Although the exact degree of effectiveness of air counter measures taken cannot accurately be determined, information available points to the conclusion that, generally speaking, the air effort against rocket installations and their transportation and supply facilities was effective -- the rocket effort invariably went down as the air effort went up, and vice versa.

## SECTION 2

## COUNTER MEASURES

34. Measures Taken to Combat V-2's, after they had been launched, were ineffectual. Some minimizing of damage and casualties was accomplished by passive defense means, but no method was devised to combat the V-2 in flight. Air bombardment against laboratories, factories, installations and supply facilities of V-2 did achieve considerable success, and was a major factor in giving the Allies time to complete their ground offensive, and actually occupy German territory. It is pointed out and emphasized that the only proven means of definitely stopping V-2

attacks is to overrun and physically occupy all territory from which these missiles could be launched. Prior to such occupation the only means of combatting the V-2 was to attack, through the air, the factories, supply facilities, lines of communication, transportation facilities and, where possible, the launching sites. Our margin of time was not great, and it is certain that more extensive attacks were dangerously near. Report number 237-45 of the United States Navel Technical Mission on guided missiles, reads as follows:[1] "There is little of humorous nature in the statement so often heard that the Germans intended to bombard New York from launching sites in Europe, as two missiles, the A-9 and A-10[2] were under development for use against the U.S. in the early months of 1946. This contemplated use was scientifically possible and undoubtedly would have been realized had time permitted." It is clear that the United States must establish at once, within the structure of the national defense, a major organization for the development and production of long-range rockets and guided missiles suitable for offensive and defensive action. Units must be established, equipped, and trained in the use of these weapons so that they may be brought into action immediately upon a threat to our national security. The organization indicated above should include elements of forces which have primary interest in long-range missiles and which have progressed farthest in the development of the necessary equipment, technique of employment and organizational structures required for offensive use of this weapon and for defense against it. The underlying principles governing the employment and application of strategic destructive power remain the same regardless of the carrier which transports the destructive agent to the target. Planning for the offensive use of long-range missiles must take advantage of experience already gained in the application of strategic air power.

35. Proposed Passive Defense Measures must be considered which will include all practicable steps to avoid or minimize the effects of guided-missile attacks upon the United States. These measures will include: Permanent, federally-sponsored relief, rescue and rehabilitation organizations; dispersal of strategic industries and important defense facilities; and the use of underground and overhead protection.

36. Proposed Active Counter Measures, subdivided into two types: offensive and defensive, are discussed below.

a. Offensive Counter Measures are those steps taken to control or cripple an enemy's ability to produce, assemble, and launch rocket projectiles. Two courses of action present themselves: First, to attack the enemy from a distance by long-range bombardment; and secondly, by invading and physically occupying his territory. The first course dictates the development by us of supersonic-velocity missiles, incorporating the most advantageous military characteristics of long range, accurate control, and deep penetration. The second course of action, that of invasion, is beyond the scope of this study.

b. Defensive Counter Measures are those steps taken to combat enemy rockets after they have been launched against us. These measures come within the scope of antiaircraft artillery, and indicate drastic changes in equipment and in our present conception of defensive methods. Development in the following fields is envisioned:

(1) Greatly improved radar, infra-red, or other beam control.

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1 P 22 Bibliography Ref 1.
2 The A-9 and A-10 were designed to be used together as one unit.

(2) Homing devices (target seeking).

(3) Television.

(4) Proximity fuzes (for counter rockets).

(5) Atomic explosive.

(6) Remotely-controlled detonation.

c. To date, there is no proven method of successfully combatting supersonic-velocity projectiles in flight. The British devised a plan for an antiaircraft artillery defense of London in World War II. The plan was based upon two premises: First, that a warning could be received upon which a prediction could be made of the one-mile square within which a V-2 would fall; and secondly, that a gun defense could place an umbrella of shell fragments of sufficient magnitude and intensity above the threatened area that the V-2 would be destroyed. The plan was never put to a test. It is believed to be impracticable on account of the prohibitive number of antiaircraft units required. There is no experience upon which to base a conclusion as to the probable effect of shell fragments on V-2's.

CHAPTER 6

37. Conclusions and Recommendations.

a. Conclusions: In view of the facts developed in the foregoing study, it is concluded that :

(1) The V-2 rocket is so new to warfare, its characteristics so novel and of such magnitude as to distance and speed that its offensive possibilities have, to date, far outstripped defensive measures.

(2) The German use of V-2 was not a decisive factor in World War II, as it did not deliver a crippling blow to the Allied war effort. It did, however, inflict enormous casualties and suffering on Allied civil population, and was a serious morale problem and military threat.

(3) Rockets and guided missiles are on the threshold of attaining additional development of such sensational characteristics of range, control and destructive power that they certainly will become a decisive military factor.

(4) Passive defense measures involve a comprehensive dispersion of vital industry, and the development of underground faculties.

(5) Active defense measures necessitate the ability to control or cripple an enemy's ability to produce, assemble and launch rocket projectiles.

(6) To date there is no proven method of successfully combatting V-2's in flight.

b. Recommendations: In view of the summary of known facts about V-2 weapons set forth in the preceding conclusions, it is obvious that to insure a continuation of our national existence we must take prompt and vigorous counter measures against the possibility of attacks upon ourselves by any potential enemy. It is therefore recommended that:

(1) A major organization be established within the national defense structure, to be charged with responsibility for:

(a) Development and production of guided missiles suitable for defense against long-range guided missile and rocket attack.

(b) Development and production of supersonic-velocity guided missiles and rockets suitable for offensive action at long range.

(c) Organization and training of a corps of units, established and equipped, for offensive and defensive operations with guided missiles and rockets of both super and subsonic speeds.

(2) There be established permanent federally-controlled passive defense organizations to be charged with responsibility for measures to minimize the effects of rocket and guided missile attacks upon the United States. These measures to include:

(a) Organization and training of relief, rescue and rehabilitation organizations.

(b) A study of the necessity for, and ways and means of, dispersal of strategic industries and important defense facilities.

(c) A study of the necessity for, and ways and means of, duplication of communication and transportation facilities.

(d) Development of overhead and underground protection.

THE GENERAL BOARD
UNITED STATES FORCES, EUROPEAN THEATER

V-2 ROCKET ATTACK AND DEFENSE

# PART THREE

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2. Booklet, An Account of the Continental Crossbow Operation 1944-1945. Compiled by the Air Defense Division, Supreme Headquarters, Allied Expeditionary Forces. This booklet is a report of the entire Continental V-2 offensive.

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6. SHAEF Air Defense Review Number 4, dated 23 November 1944, Section IV, Long Range Missiles.

7. SHAEF Air Defense Review Number 5, dated 22 December 1944, Section IV, "V" Weapons, and Section VII, Passive Air Defense.

8. SHAEF Air Defense Review Number 6, dated 7 February 1945, Section IV, "V" Weapons.

9. SHAEF Air Defense Review Number 7, dated 18 March 1945, Section IV, "V" Weapons.

10. SHAEF Air Defense Review Number 8, dated 30 April 1945, Section IV, "V" Weapons.

11. Appendix I, A-4b Long-Range Rocket.

12. Appendix II, A-4b Long-Range Rocket.

13. Appendix III, Flight Path of A-4b and A-9 Long-Range Rockets.

14. Appendix IV, Flight Path of A9/A10 Long-Range Rocket - 3,500 miles.

15. Appendix V, V-2 (A-4 Long-Range Rocket) in Flight.

16. Appendix VI, Cut-Away Diagram of V-2.

17. Appendix VII, V-2 (A-4 Long-Range Rocket) Being Launched.

18. Appendix VIII, List of Principal Ground Installations and Vehicles Required for Firing. Published by SHAEF.

19. Appendix IX, Typical Launching Site, showing simplicity of permanent facilities.

20. Appendix X, Characteristics of A-1, A-2, and A-3.

21. Appendix XI, Characteristics of A-4, A-4b, and A-5.

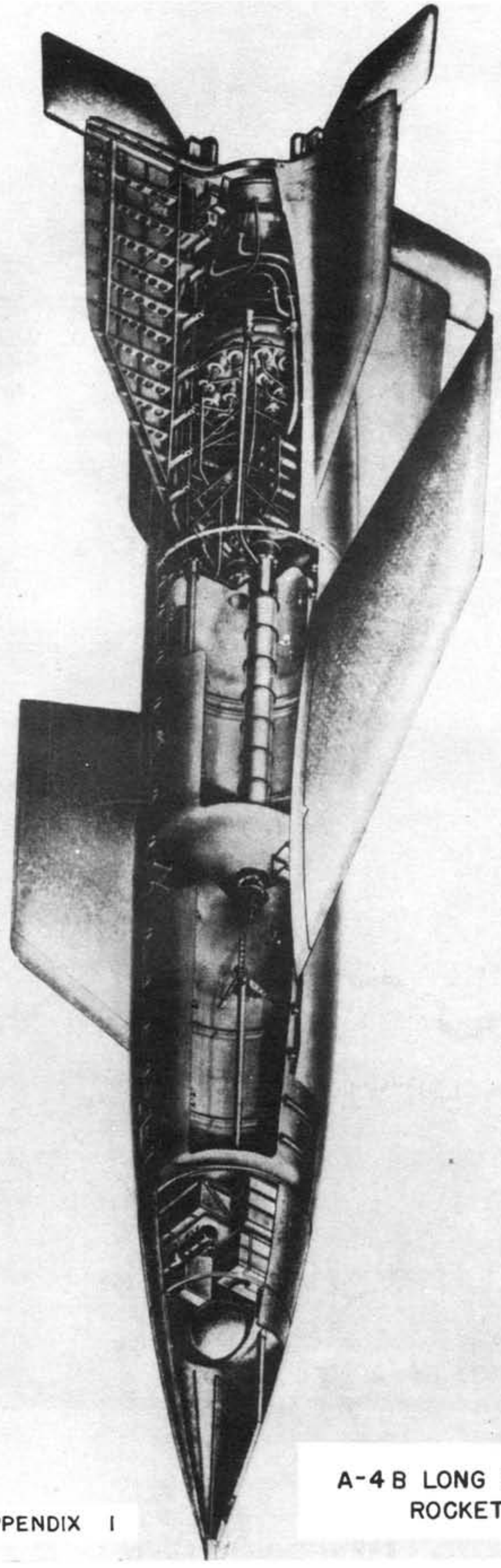
22. Appendix XII, Characteristics of A-6, A-7, and A-8.

23. Appendix XIII, Characteristics of A-9, A-10, and 8-103 (V-1).

24. Appendix XIV, Flight Path of V-2 (A-4 Rocket).

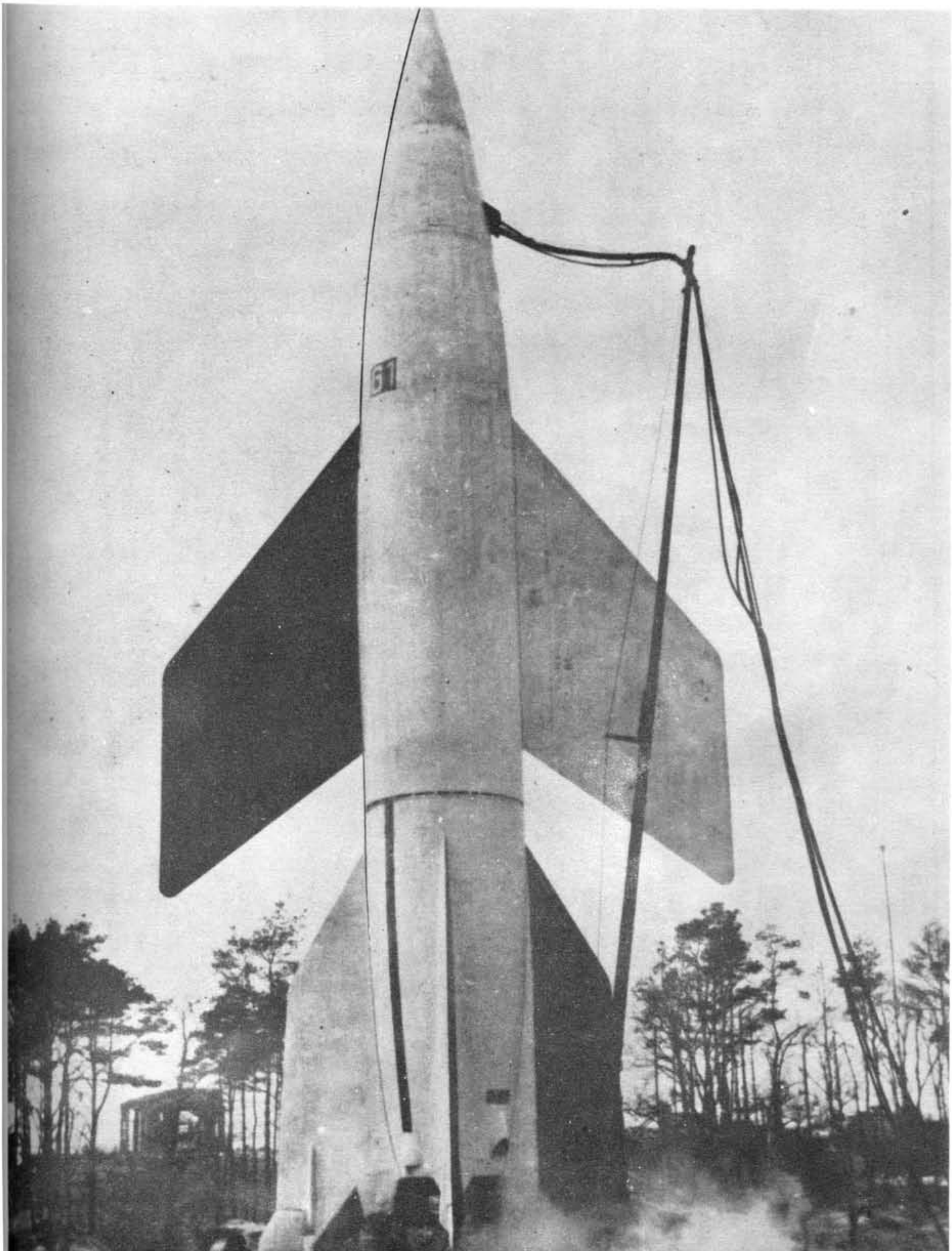
25. Appendix XV, Photograph of Condensation Trails of two V-2's over Antwerp.

26. Appendix XVI, XVII; XVIII, XIX, XX, Miscellaneous Photographs of V-2 Rockets and Rocket equipment.



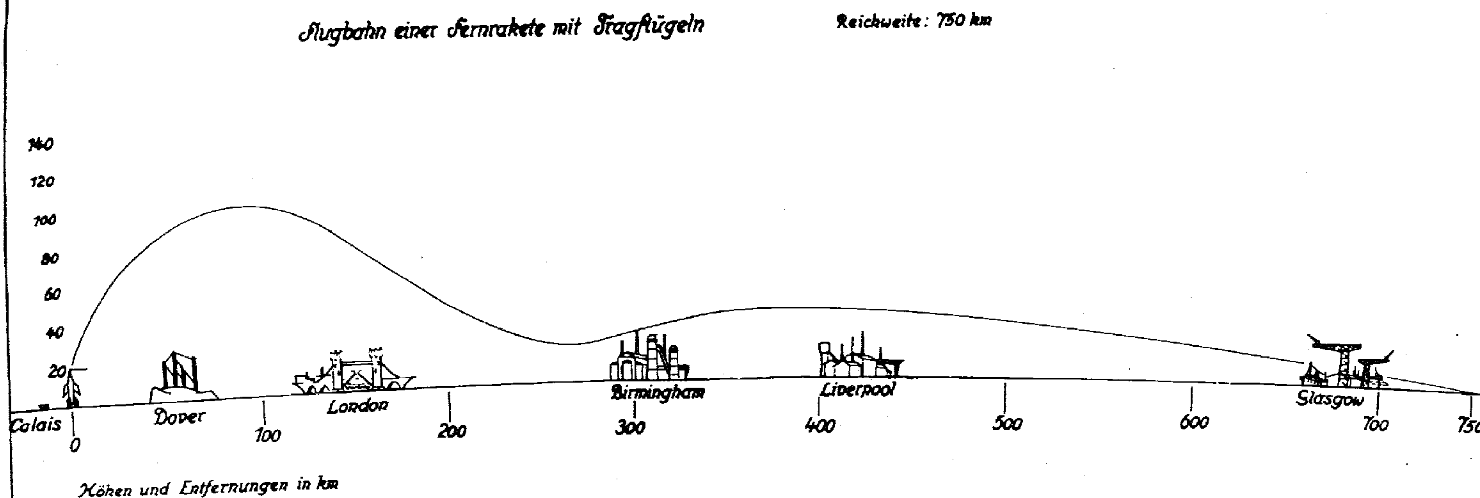

A-4 B LONG RANGE
ROCKET

APPENDIX I




APPENDIX 11 A-4B LONG RANGE ROCKET

APPENDIX III

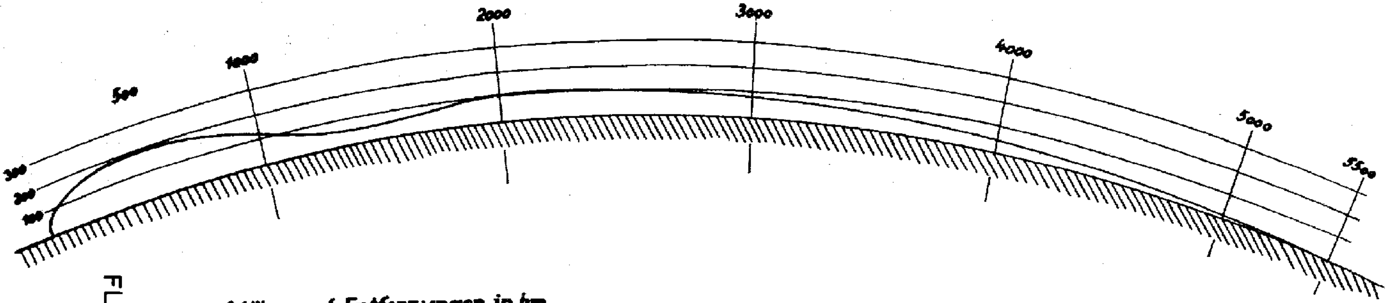



FLIGHT PATH
OF A-4B AND A-9
LONG RANGE ROCKET

APPENDIX IV

FLIGHT PATH OF A-9/A-10
LONG RANGE ROCKET
3500 MILES

*Flugbahn einer zweistufigen Fernrakete mit Tragflügeln   Reichweite: 5400 km*

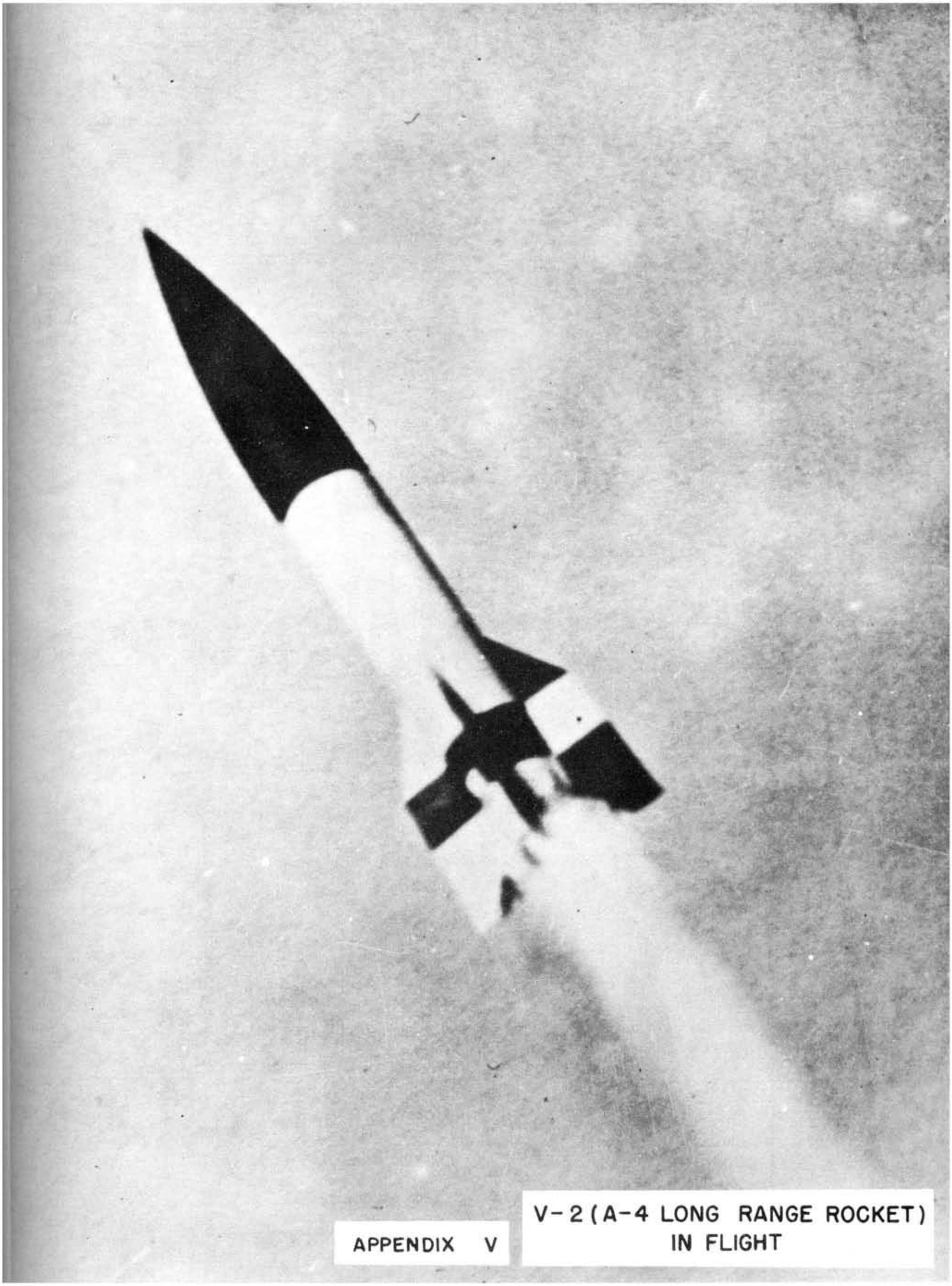



*Höhe und Entfernungen in km*

B113/47 BSM

3201-c

A18D-GIA4V12/c
Flugbahn



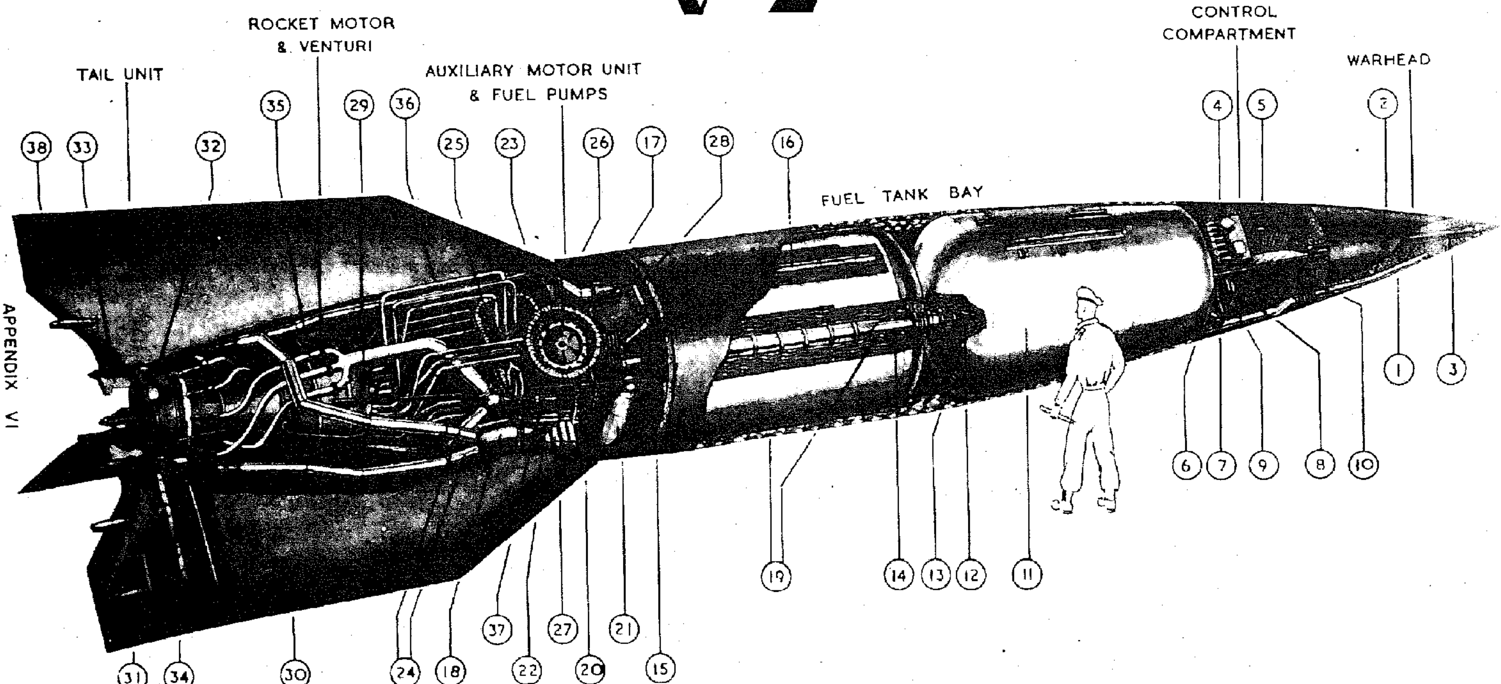
APPENDIX V

V-2 (A-4 LONG RANGE ROCKET)
IN FLIGHT

# GERMAN LONG-RANGE A-4 ROCKET

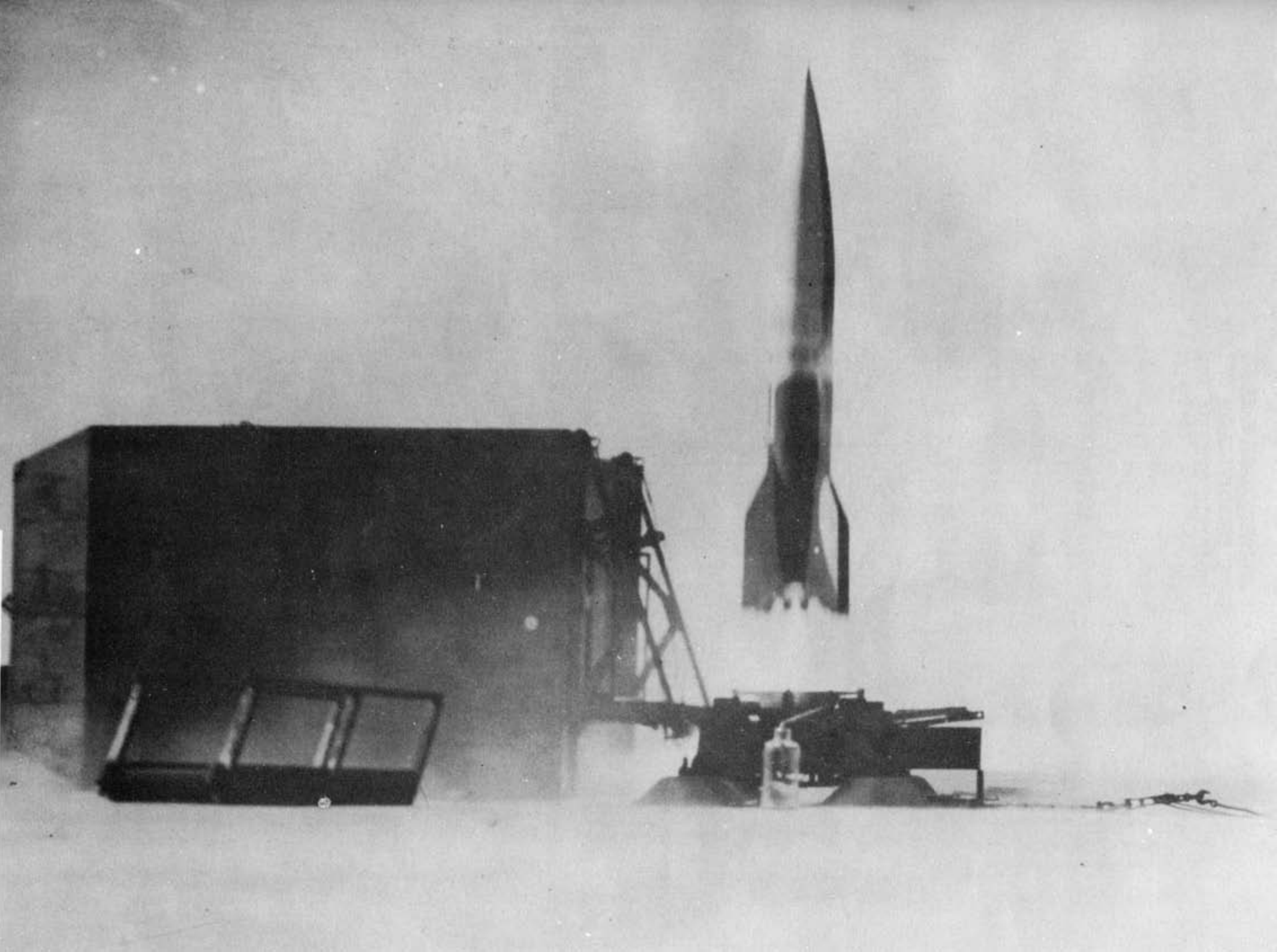
# V-2

APPENDIX VI




1. ALCOHOL TANK PRESSURISING PIPE
2. SLINGING POINT
3. CENTRAL EXPLODER TUBE
4. MAIN DISTRIBUTION BOX & GROUND CONTROL PLUGS
5. ALTERNATOR & REGULATOR
6. TIME SWITCH
7. ALCOHOL FUELLING INLET
8. AIR PRESSURE GAUGE & HAND CONTROL COCK
9. AUTOMATIC PILOT
10. CONTROL AMPLIFIER
11. ALCOHOL TANK
12. OUTLET VALVE
13. DRAINAGE VALVE
14. ALCOHOL DELIVERY PIPE
15. OXYGEN FUELLING INLET
16. STACK PIPE
17. DOUBLE SEAT VALVE
18. HEAT EXCHANGER UNIT
19. GLASS WOOL
20. TURBINE
21. HYDROGEN PEROXIDE TANK
22. SODIUM PERMANGANATE TANK
23. OXYGEN & ALCOHOL PUMPS
24. TURBINE EXHAUSTS
25. OXYGEN MAIN VALVE
26. BRACED STEEL FRAME
27. COMPRESSED AIR BOTTLES
28. DISTRIBUTION BOX
29. BURNER ASSEMBLY
30. STABILISING FIN
31. OUTER RUDDER
32. THRUST RING
33. CARBON VANE
34. SERVO MOTOR
35. ALCOHOL FEED PIPES
36. OXYGEN FEED PIPES
37. AUXILIARY COMBUSTION CHAMBER
38. AERIAL SUPPORTS

APPENDIX VII



V-2 (A-4 LONG RANGE ROCKET)
BEING LAUNCHED

RESTRICTED

SUPREME HEADQUARTERS
ALLIED EXPEDITIONARY FORCE
AIR DEFENSE DIVISION

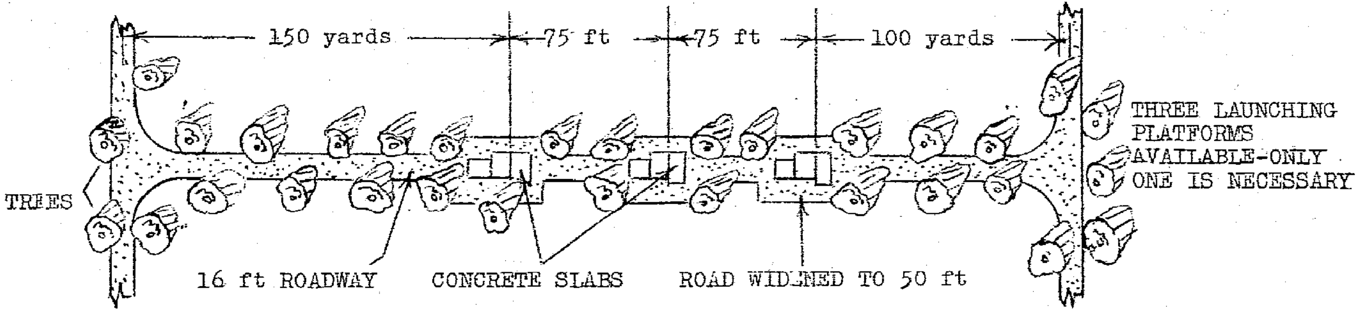
# LIST OF PRINCIPAL GROUND INSTALLATIONS AND VEHICLES REQUIRED IN FIRING GERMAN LONG RANGE ROCKET (A-4)

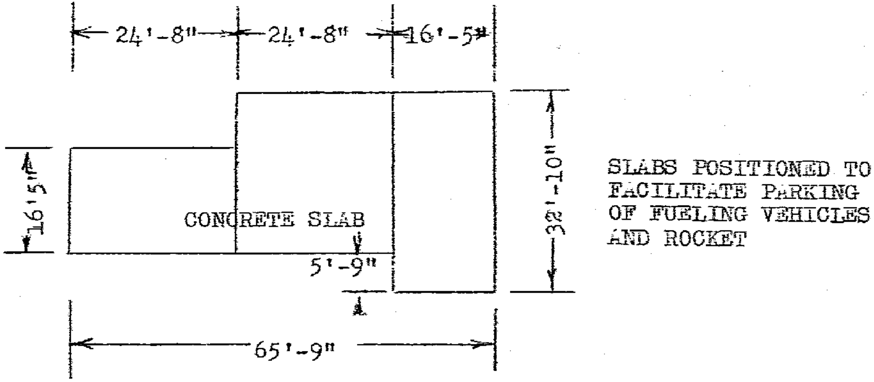
APPENDIX VIII

# LONG RANGE ROCKET GROUND EQUIPMENT

| ITEM | | REMARKS | NO REQ. |
|---|---|---|---|
| 1. | Vehicles and Trailers | | |
| a. | Fire Control Car | Control launching and in some cases, flight of the rocket | 1 |
| b. | Firing Platform | Platform from which rocket is launched | 3 |
| c. | Transport and Erection Trailer | Erection of rocket at firing site | 3 |
| d. | Trailer for liquid oxygen | Fueling on site | 3-5 |
| e. | Trailer for liquid alcohol | Fueling on site | 3-5 |
| f. | Hydrogen Peroxide tanker | Fueling on site | 2 |
| g. | Heating Trailer for T-Stoff | | 1 |
| h. | Generators | Power supply for control car, etc | 3 ? |
| i. | Leitstrahl and Bronschluss vehicles and trailers | Ground control in azimuth and range | 9 |
| j. | Cranes | Moving rockets from rail cars | 2 |
| 2. | Equipment and Accessories | | |
| a. | Calcium permanganate containers | Fueling on site | 30 |
| b. | Oxygen pump | Transfer of fuel from trailer to rocket | 1-2 |
| c. | Alcohol pump | Transfer of fuel from trailer to rocket | 1-2 |
| d. | Hydrogen peroxide Pump | Transfer of fuel from trailer to rocket | 1-2 |
| e. | Oxygen hoses | Transfer of fuel from trailer to rocket | 12 |
| f. | Alcohol hoses | Transfer of fuel from trailer to rocket | 8 |

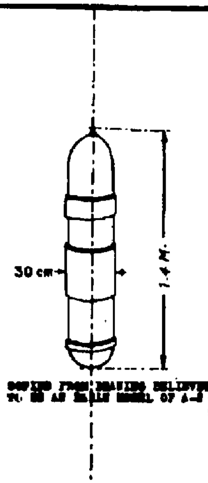
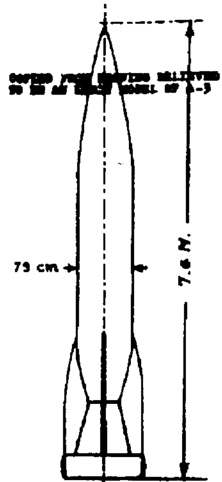
| ITEM | | REMARKS | NO REQ |
|---|---|---|---|
| g. | Hydrogen Peroxide hoses | Transfer of fuel from trailer to rocket | 4 |
| h. | Couplings for fueling | Transfer of fuel from trailer to rocket | 2 |
| i. | Valve for fueling | Transfer of fuel from trailer to rocket | |
| j. | Valve containers | | 1-3 |
| k. | Quintiple coupling and cable | From Meilerwagen to rocket | 3-5 |
| l. | Cables | All electrical connections for ground equipment | |
| m. | Air compressors | Fueling | 1-2 |
| n. | Equipment to produce hot air | | 1 |
| o. | Special plugs with cables | Drop when rocket leaves platform | 2 each |
| p. | Box containing relay mechanism and transformer sites | | 1-2 |
| q. | Igniters | Ignite Fuel at launch | 30 |
| r. | Test Equipment | | |
| s. | Ladder | For testing rocket when in launch position | 1 |
| t. | Platforms with frames for adjusting rocket components | Fitted to rocket when in launch position | 4 |




TYPICAL LAUNCHING SITE - V-2 (A-4 ROCKET PROJECTILE)

# GERMAN A-SERIES ROCKETS

| [illegible] OF MISSILES | [illegible] OF A-1 WAS NOT AVAILABLE |  |  |
|---|---|---|---|

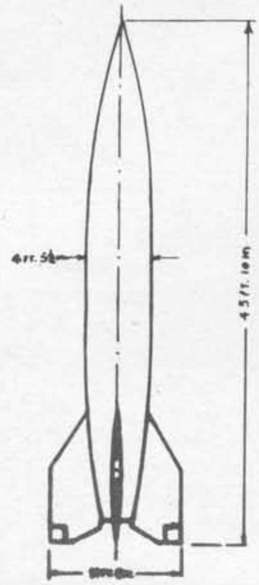


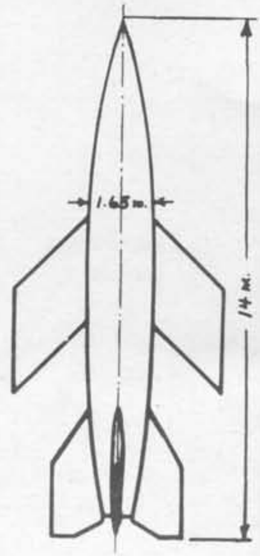


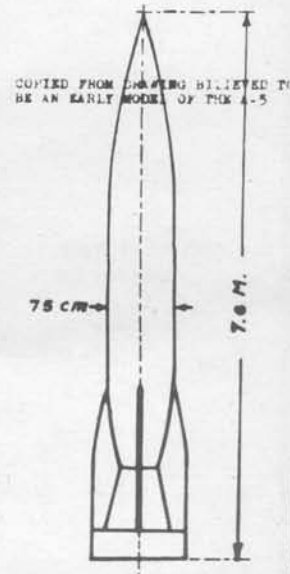
| MISSILE | A-1 | A-2 | A-3 |
|---|---|---|---|
| CODE NAME | | | |
| USED AS | DESIGN STUDY | DESIGN STUDY | DESIGN STUDY OF MOTORS |
| 1. SPEED RANGE | NOT KNOWN | NOT KNOWN | SUB SONIC |
| 2. DEVELOPED BY | DR. VON BRAUN | DR. VON BRAUN | PEENEMUNDE |
| 3. MANUFACTURED BY | NOT KNOWN | NOT KNOWN | ELECTROMECHANISCHE |
| 4. STATUS (a) EXP. UNITS BUILT | NUMBER NOT KNOWN | NUMBER NOT KNOWN | NUMBER NOT KNOWN |
| (b) EXP. UNITS TESTED | NUMBER NOT KNOWN | NUMBER NOT KNOWN | PEENEMUNDE, NUMBER NOT KNOWN |
| (c) EXP. UNITS TESTED AT | NOT KNOWN | NOT KNOWN | PEENEMUNDE |
| (d) PRODUCTION CONTRACT | NONE | NONE | NOT KNOWN |
| 1. DATE | " | " | " " |
| 2. CONTRACT QUANTITY | " | " | " " |
| 3. TOTAL BUILT | " | " | " " |
| 4. MAX. MONTHLY PRODUCTION | " | " | " " |
| 5. METHOD OF LAUNCHING | FIRED FROM A TABLE | FROM FIXED BASE | FROM FIXED BASE |
| 6. AUXILIARY LAUNCHING PROPULSION UNIT | NONE USED | NONE USED | NONE USED |
| (a) TYPE | " " | " " | " " |
| (b) MAKE | " " | " " | " " |
| (c) MANUFACTURED BY | " " | " " | " " |
| (d) TOTAL IMPULSE | " " | " " | " " |
| (e) DURATION OF THRUST | " " | " " | " " |
| (f) THRUST | " " | " " | " " |
| (g) WEIGHT OF UNIT | " " | " " | " " |
| 7. LAUNCHING ATTITUDE | VERTICAL | VERTICAL | VERTICAL |
| 8. LAUNCHING MECHANISM | FIXED BASE | FIXED BASE | MOBILE OR FIXED LAUNCHER |
| (a) LENGTH OF GUIDE | NONE USED | NONE USED | NONE USED |
| (b) AIMING RANGE | ZERO | ZERO | PRE-SET |
| 9. VELOCITY MAXIMUM | NOT KNOWN | NOT KNOWN | SUB SONIC |
| (a) LAUNCHING | ZERO | ZERO | ZERO |
| (b) END OF PROPULSION BURNING | NOT KNOWN | NOT KNOWN | NOT KNOWN |
| 10. PROPULSION UNIT (a) MAKE | " " | " " | ARMY WEAPONS DEPARTMENT |
| (b) MANUFACTURED BY | " " | " " | " " " |
| (c) TYPE UNIT | LIQUID ROCKET | NOT KNOWN | LIQUID ROCKET |
| (d) BURNING TIME | 16 SECONDS | 16 SECONDS | 45 SECONDS |
| (e) WEIGHT | 110 KG. | NOT KNOWN | 300 KG. |
| (f) TOTAL IMPULSE | 4800 KG.SEC. | NOT KNOWN | 7500 KG.SEC. |
| (g) FUEL TYPE | ALCOHOL & LIQUID OXYGEN | " " | ALCOHOL & OXYGEN |
| (h) FUEL CAPACITY | 40 KG. | 40 KG. | 450 KG. |
| (i) THRUST | 300 KG. | 300 KG. | 1500 KG. |
| 11. MISSILE DIMENSIONS | | | |
| (a) WEIGHT 1. TOTAL | 150 KG. | 150 KG. | 750 KG. |
| 2. EMPTY | NOT KNOWN | NOT KNOWN | NOT KNOWN |
| 3. WAR HEAD | " " | " " | " " |
| 4. EXPLOSIVE | " " | " " | " " |
| (b) DIMENSIONS 1. LENGTH | 1.4 METRES | 1.4 METRES | 7.6 METRES |
| 2. SPAN | NOT KNOWN | NOT KNOWN | NOT KNOWN |
| 3. DIAMETER | 30 CM. | 30 CM. | 75 CM. |
| 12. CONTROL (a) TYPE IN USE | ONE GYRO | ONE GYRO | AUTOMATIC |
| (b) CODE NAME | NOT KNOWN | NOT KNOWN | NOT KNOWN |
| (c) MANUFACTURED BY | " " | " " | " " |
| (d) PROPOSED TYPES | " " | " " | " " |
| (e) CODE NAMES | " " | " " | " " |
| (f) STATUS | " " | " " | " " |
| 13. HOMING (a) TYPE (IF USED) | NONE | NONE | NONE USED |
| (b) MAKE (CODE NAME) | " | " | NONE |
| (c) MANUFACTURED BY | " | " | NONE USED |
| (d) TYPES PROPOSED | " | " | NOT KNOWN |
| 1. CODE NAMES | " | " | " " |
| 2. MANUFACTURER | " | " | " " |
| 14. FUSES (a) TYPES | NONE USED | NONE USED | NONE |
| (b) CODE NAMES | NONE | NONE | " |
| 15. OPERATING RANGE (a) RANGE | NOT KNOWN | NOT KNOWN | NOT KNOWN |
| (b) ALTITUDE | " " | 2 KM. | 1800 METRES |

# GERMAN A-SERIES ROCKETS

SKETCH OF MISSILE




| | | | |
|---|---|---|---|
| MISSILE | A-4 | A-4B | A-5 |
| CODE NAME | | | |
| USED AS | GROUND TO GROUND MISSILE | GROUND-TO-GROUND MISSILE | TEST A-4 CONTROLS |
| 1. SPEED RANGE | SUPER SONIC | SUPER SONIC | SUB SONIC |
| 2. DEVELOPED BY | PEENEMUNDE | PEENEMUNDE | PEENEMUNDE |
| 3. MANUFACTURED BY | ELECTROMECHANISCHE | ELECTROMECHANISCHE | ELECTROMECHANISCHE |
| 4. STATUS (a) EXP. UNITS BUILT | NUMBER NOT KNOWN | NUMBER NOT KNOWN | NOT KNOWN |
| (b) EXP. UNITS TESTED | PEENEMUNDE & NE GERMANY, NO. UNKNOWN | " " " | 30 (MINIMUM) |
| (c) EXP. UNITS TESTED AT | PEENEMUNDE & NE GERMANY | PEENEMUNDE | PEENEMUNDE |
| (d) PRODUCTION CONTRACT | YES | NOT KNOWN | NOT KNOWN |
| 1. DATE | NOT KNOWN | " " | " " |
| 2. CONTRACT QUANTITY | 900 PER MONTH | " " | " " |
| 3. TOTAL BUILT | NOT KNOWN | " " | " " |
| 4. MAX. MONTHLY PRODUCTION | " " | " " | " " |
| 5. METHOD OF LAUNCHING | FROM MOBILE OR FIXED BASE | MOBILE LAUNCHING BASE | FROM FIXED BASE |
| 6. AUXILIARY LAUNCHING PROPULSION UNIT | NONE USED | NONE | NONE |
| (a) TYPE | " " | " | " |
| (b) MAKE | " " | " | " |
| (c) MANUFACTURED BY | " " | " | " |
| (d) TOTAL IMPULSE | " " | " | " |
| (e) DURATION OF THRUST | " " | " | " |
| (f) THRUST | " " | " | " |
| (g) WEIGHT OF UNIT | " " | " | " |
| 7. LAUNCHING ATTITUDE | VERTICAL | VERTICAL | VERTICAL |
| 8. LAUNCHING MECHANISM | MOBILE OR FIXED LAUNCHER | MOBILE OR FIXED LAUNCHER | MOBILE OR FIXED BASE |
| (a) LENGTH OF GUIDE | NONE USED | NONE USED | NONE |
| (b) AIMING RANGE | PRE-SET | 360° | ZERO |
| 9. VELOCITY, MAXIMUM | SUPER SONIC | SUPER SONIC | SUB SONIC |
| (a) LAUNCHING | ZERO | ZERO | ZERO |
| (b) END OF PROPULSION BURNING | 1500 METRES /SECOND | NOT KNOWN | 300 METRES PER SECOND |
| 10. PROPULSION UNIT (a) MAKE | PEENEMUNDE | PEENEMUNDE | PEENEMUNDE |
| (b) MANUFACTURED BY | " | " | ELECTROMECHANISCHE |
| (c) TYPE UNIT | LIQUID ROCKET | LIQUID ROCKET | LIQUID ROCKET |
| (d) BURNING TIME | 65 SECONDS | 65 SEC | 45 SECONDS |
| (e) WEIGHT | 422 KG. | 4000 KG | 300 KG. |
| (f) TOTAL IMPULSE | NOT KNOWN | NOT KNOWN | 67500 KG.SEC. |
| (g) FUEL TYPE | ALCOHOL & OXYGEN | ALCOHOL & LIQUID OXYGEN | ALCOHOL & LIQUID OXYGEN |
| (h) FUEL CAPACITY | 8700 KG. | 8757 KG | 450 KG. |
| (i) THRUST | 2500 KG. (PEAK) | 25,000 KG (PEAK) | 1500 KG. |
| 11. MISSILE DIMENSIONS | | | |
| (a) WEIGHT 1. TOTAL | 12800 KG. | NOT KNOWN | 750 KG. |
| 2. EMPTY | 4000 KG. | " " | NOT KNOWN |
| 3. WAR HEAD | 1000 KG. | " " | " " |
| 4. EXPLOSIVE | 750 KG. | | " " |
| (b) DIMENSIONS 1. LENGTH | 14036 MM. | 14 METERS | 7.6 METRES |
| 2. SPAN | 3564 MM. | NOT KNOWN | NOT KNOWN |
| 3. DIAMETER | 1651 MM. | 1.65 METERS | 75 CM. |
| 12. CONTROL (a) TYPE IN USE | RADIO, GYRO & TIME | RADIO, GYRO & TIME | DESIGN STUDY FOR CONTROLS |
| (b) CODE NAME | LEITSTRAHL | LEITSTREHL | NOT KNOWN |
| (c) MANUFACTURED BY | LORENZ | LORENZ | " " |
| (d) PROPOSED TYPES | STABILIZED PLATFORM | NOT KNOWN | " " |
| (e) CODE NAMES | NOT KNOWN | " " | " " |
| (f) STATUS | " " | " " | " " |
| 13. HOMING (a) TYPE (IN USE) | NONE USED | NONE | " " |
| (b) MAKE (CODE NAME) | NONE | " | " " |
| (c) MANUFACTURED BY | NONE USED | " | " " |
| (d) TYPES PROPOSED | NOT KNOWN | NOT KNOWN | " " |
| 1. CODE NAMES | " " | " " | " " |
| 2. MANUFACTURER | " " | " " | " " |
| 14. FUSES (a) TYPE | IMPACT (ELECTRICAL) | " " | NONE USED |
| (b) CODE NAMES | NOT KNOWN | " " | NONE |
| 15. OPERATING RANGE (a) RANGE | 300 KM. | 450 KM | 18 KM. |
| (b) ALTITUDE | 80 KM. | 180 KM | 12 KM. |

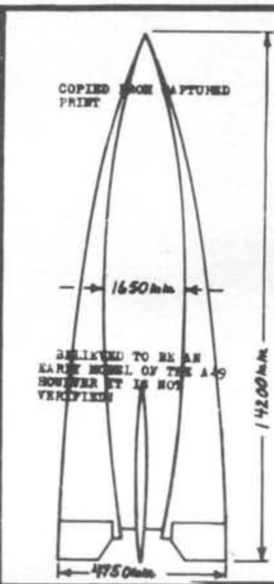
# GERMAN A-SERIES ROCKETS

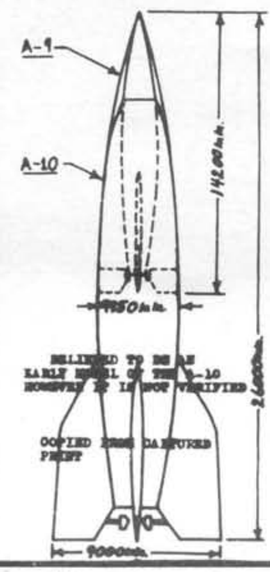
| | | | |
|---|---|---|---|
| SKETCH OF MISSILE | SKETCH OF A-6 WAS NOT AVAILABLE | SKETCH OF A-7 WAS NOT AVAILABLE | SKETCH OF A-8 WAS NOT AVAILABLE |
| MISSILE | A-6 | A-7 | A-8 |
| CODE NAME | | | |
| USED AS | DESIGN STUDY OF SUPER SONIC SPEED | DESIGN STUDY FOR GLIDING | SUBSTITUTE FOR A-9 |
| 1.SPEED RANGE | SUPER SONIC | SUB SONIC | SUPER SONIC |
| 2.DEVELOPED BY | PEENEMUNDE | PEENEMUNDE | PEENEMUNDE |
| 3.MANUFACTURED BY | ELECTROMECHANISCHE | ELECTROMECHANISCHE | ELECTROMECHANISCHE |
| 4.STATUS (a) EXP. UNITS BUILT | NEVER BUILT | ONE BUILT | NONE BUILT |
| (b) EXP. UNITS TESTED | NONE | NOT KNOWN | NONE |
| (c) EXP. UNITS TESTED AT | NEVER BUILT | " " | NONE BUILT |
| (d) PRODUCTION CONTRACT | NONE | NONE ISSUED | NONE ISSUED |
| 1.DATE | " | " " | " " |
| 2.CONTRACT QUANTITY | " | " " | " " |
| 3.TOTAL BUILT | " | " " | " " |
| 4.MAX. MONTHLY PRODUCTION | " | " " | " " |
| 5.METHOD OF LAUNCHING | FROM FIXED BASE | FROM AN AIRCRAFT | FIXED FROM FIXED BASE |
| 6.AUXILIARY LAUNCHING PROPULSION UNIT | NONE | NONE USED | NONE USED |
| (a) TYPE | " | " " | " " |
| (b) MAKE | " | " " | " " |
| (c) MANUFACTURED BY | " | " " | " " |
| (d) TOTAL IMPULSE | " | " " | " " |
| (e) DURATION OF THRUST | " | " " | " " |
| (f) THRUST | " | " " | " " |
| (g) WEIGHT OF UNIT | " | " " | " " |
| 7.LAUNCHING ATTITUDE | VERTICAL | HORIZONTAL FROM AIRCRAFT | VERTICAL |
| 8.LAUNCHING MECHANISM | MOBILE OR FIXED BASE | AIRCRAFT | FIXED LAUNCHING BASE |
| (a) LENGTH OF GUIDE | NONE | NOT KNOWN | NONE |
| (b) AIMING RANGE | ZERO | " " | NOT KNOWN |
| 9.VELOCITY, MAXIMUM | SUPER SONIC | SUB SONIC | SUPER SONIC |
| (a) LAUNCHING | ZERO | NOT KNOWN | NOT KNOWN |
| (b) END OF PROPULSION BURNING | NOT KNOWN | " " | " " |
| 10.PROPULSION UNIT (a) MAKE | PEENEMUNDE | PEENEMUNDE | PEENEMUNDE |
| (b) MANUFACTURED BY | ELECTROMECHANISCHE | ELECTROMECHANISCHE | ELECTROMECHANISCHE |
| (c) TYPE UNIT | LIQUID ROCKET | LIQUID ROCKET | LIQUID ROCKET |
| (d) BURNING TIME | 45 SECONDS | 45 SECONDS | NOT KNOWN |
| (e) WEIGHT | 300 KG. | 300 KG. | " " |
| (f) TOTAL IMPULSE | 67500 KG.SEC. | 67500 KG.SEC. | " " |
| (g) FUEL TYPE | ALCOHOL & LIQUID OXYGEN | ALCOHOL & LIQUID OXYGEN | ALCOHOL & LIQUID OXYGEN |
| (h) FUEL CAPACITY | 450 KG. | 500 KG. | NOT KNOWN |
| (i) THRUST | 1500 KG. | 1500 KG. | " " |
| 11.MISSILE DIMENSIONS | | | |
| (a) WEIGHT 1. TOTAL | NOT KNOWN | 800 KG. | NOT KNOWN |
| 2. EMPTY | " " | NOT KNOWN | " " |
| 3. WAR HEAD | " " | " " | " " |
| 4. EXPLOSIVE | " " | " " | " " |
| (b) DIMENSIONS 1. LENGTH | NOT KNOWN | 7.6 METRES | NOT KNOWN |
| 2. SPAN | " " | NOT KNOWN (HAD SMALL WINGS) | " " |
| 3. DIAMETER | " " | 75 CM. | " " |
| 12.CONTROL (a) TYPE IN USE | NOT KNOWN | NOT KNOWN | NOT KNOWN |
| (b) CODE NAME | " " | " " | " " |
| (c) MANUFACTURED BY | " " | " " | " " |
| (d) PROPOSED TYPES | " " | " " | " " |
| (e) CODE NAMES | " " | " " | " " |
| (f) STATUS | " " | " " | " " |
| 13.HOMING (a) TYPE (IN USE) | " " | NOT KNOWN | NOT KNOWN |
| (b) MAKE (CODE NAME) | " " | " " | " " |
| (c) MANUFACTURED BY | " " | " " | " " |
| (d) TYPES PROPOSED | " " | " " | " " |
| 1. CODE NAMES | " " | " " | " " |
| 2. MANUFACTURER | " " | " " | " " |
| 14.FUSES (a) TYPES | " " | NOT KNOWN | NOT KNOWN |
| (b) CODE NAMES | " " | " " | " " |
| 15.OPERATING RANGE (a) RANGE | " " | NOT KNOWN | NOT KNOWN |
| (b) ALTITUDE | " " | " " | " " |

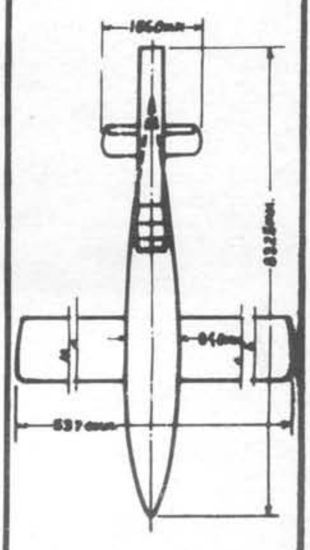
# GERMAN A-SERIES ROCKETS

# PILOTLESS AIRCRAFT V-1

SKETCH OF MISSILE



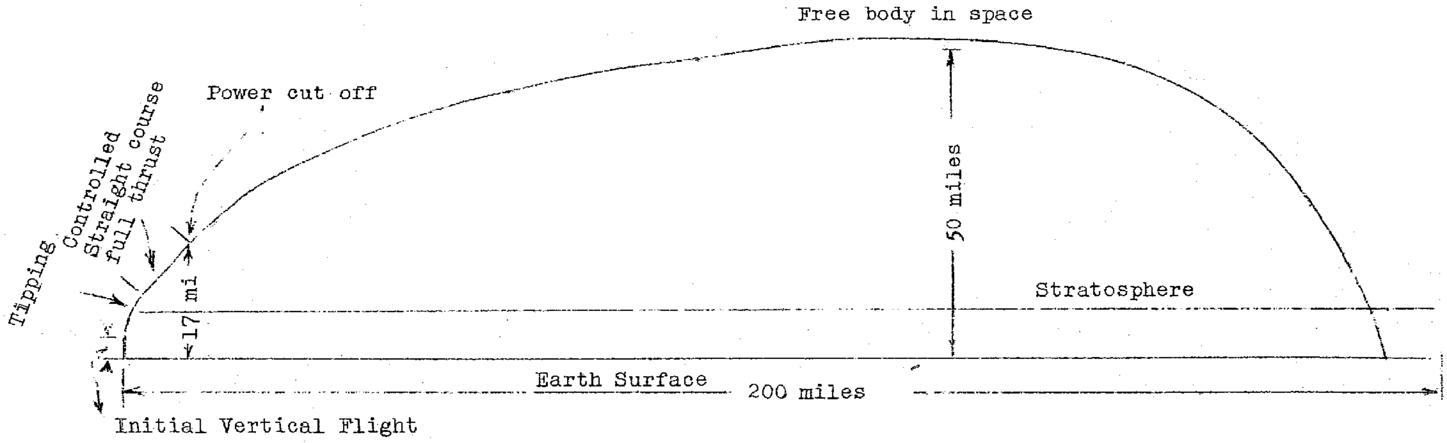



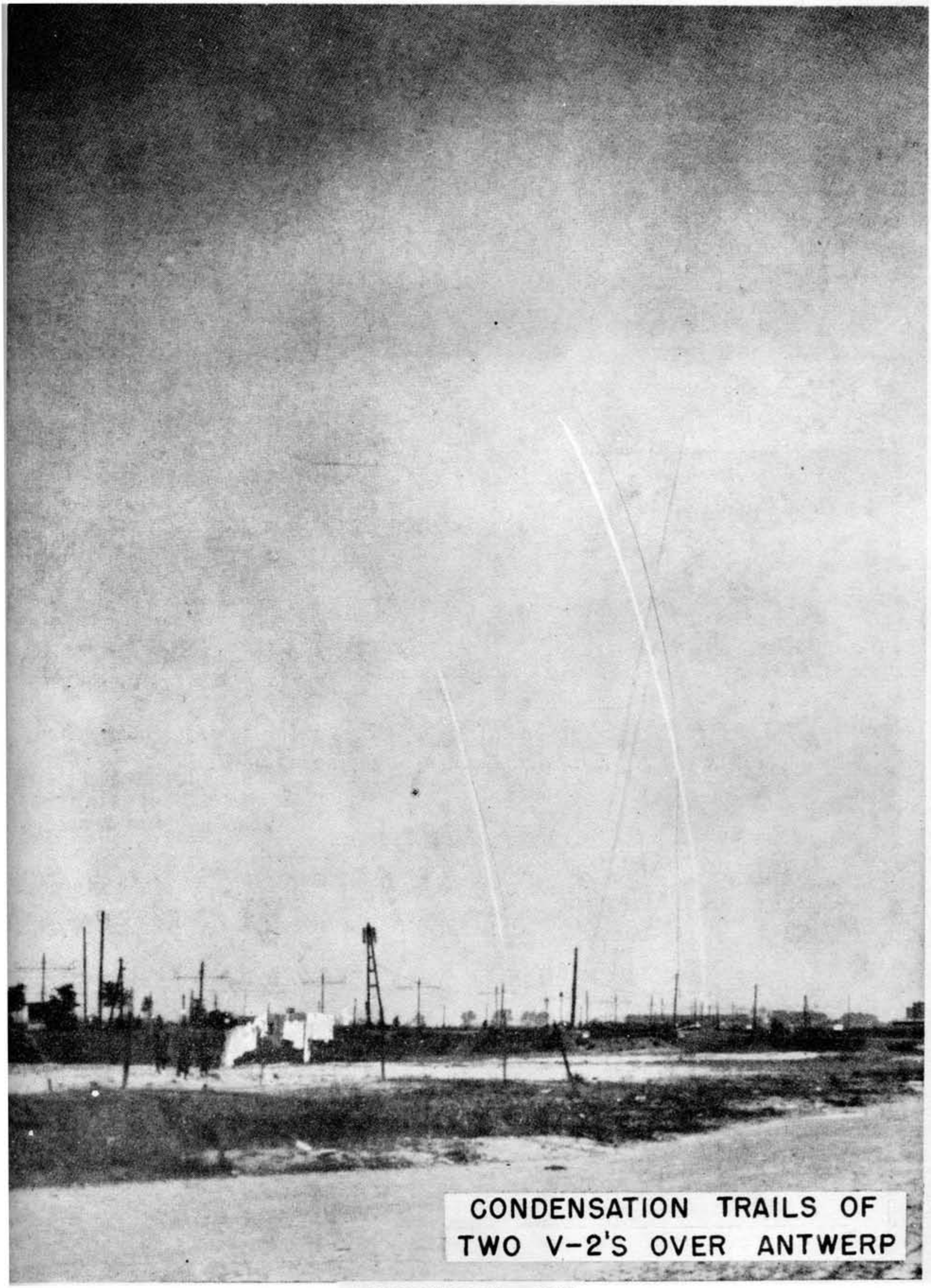

| MISSILE | A-9 | A-10 | | 8-103 |
|---|---|---|---|---|
| CODE NAME | | | | FZG-76 |
| USED AS | GROUND TO GROUND MISSILE | GROUND-TO-GROUND MISSILE | | GROUND TO GROUND MISSILE |
| 1.SPEED RANGE | SUPER SONIC | SUPER SONIC | | SUB SONIC |
| 2.DEVELOPED BY | PEENEMUNDE | PEENEMUNDE | | LUFTWAFFE |
| 3.MANUFACTURED BY | ELECTROMECHANISCHE | ELECTROMECHANISCHE | | LUFTWAFFE IN VARIOUS PLANTS |
| 4.STATUS (a) EXP. UNITS BUILT | NEVER BUILT | NONE | | NOT KNOWN |
| (b) EXP. UNITS TESTED | NONE | " | | " " |
| (c) EXP. UNITS TESTED AT | NONE | " | | " " |
| (d) PRODUCTION CONTRACT | NONE ISSUED | " | | YES |
| 1.DATE | " " | " | | NOT KNOWN |
| 2.CONTRACT QUANTITY | " " | " | | " " |
| 3.TOTAL BUILT | NONE | " | | (EST.20,000 FIRED) |
| 4.MAX. MONTHLY PRODUCTION | " | " | | NOT KNOWN (EST.4000) |
| 5.METHOD OF LAUNCHING | FROM A-10 | FIXED LAUNCHING BASE | | FIXED RAMP |
| 6.AUXILIARY LAUNCHING PROPULSION UNIT | NONE | LIQUID ROCKET | | NONE |
| (a) TYPE | " | " " | | " |
| (b) MAKE | " | PEENEMUNDE | | " |
| (c) MANUFACTURED BY | " | " | | " |
| (d) TOTAL IMPULSE | " | " | | " |
| (e) DURATION OF THRUST | " | NOT KNOWN | | " |
| (f) THRUST | " | " " | | " |
| (g) WEIGHT OF UNIT | " | " " | | " |
| 7.LAUNCHING ATTITUDE | VERTICAL | VERTICAL | | ANGLE (8 TO 15 DEGREES) |
| 8.LAUNCHING MECHANISM | SPECIAL LAUNCHER | FIXED LAUNCHER | | LAUNCHING CRADLE OR AIRCRAFT |
| (a) LENGTH OF GUIDE | NONE | NONE USED | | APP.144 FEET |
| (b) AIMING RANGE | NOT KNOWN | 360° | | STRAIGHT AHEAD |
| 9.VELOCITY, MAXIMUM | NOT KNOWN | SUPER SONIC | | MACH NO 0.72 |
| (a) LAUNCHING | NOT KNOWN | ZERO | | 70.9 METRES/SECONDS |
| (b) END OF PROPULSION BURNING | " " | 2000-3000 METERS/SEC | | 800 KM/HR. |
| 10.PROPULSION UNIT (a) MAKE | PEENEMUNDE | PEENEMUNDE | | ARGUS |
| (b) MANUFACTURED BY | ELECTROMECHANISCHE | " | | ARGUS |
| (c) TYPE UNIT | LIQUID JET | LIQUID ROCKET | | RESO JET |
| (d) BURNING TIME | 68 SECONDS | 50 SEC | | 22 MINUTES |
| (e) WEIGHT | 1000 KG. | 25,000 KG | | 753 KG. |
| (f) TOTAL IMPULSE | NOT KNOWN | 10,000,000 KG SEC | | 331,000 KG.SEC. |
| (g) FUEL TYPE | LIQUID OXYGEN AND ALCOHOL | ALCOHOL & LIQUID OXYGEN | | GASOLINE |
| (h) FUEL CAPACITY | 8000 KG. | 62,000 KG | | 380 KG. |
| (i) THRUST | 25000 KG (PEEK) | 200,000 KG | | 252 KG.AT 2 KM.ALTITUDE |
| 11.MISSILE DIMENSIONS | | 1ST STAGE | 2ND STAGE | |
| (a) WEIGHT 1. TOTAL | 13000 KG. | 85,320 KG | 16,[illegible] KG | 2760 KG. |
| 2. EMPTY | NOT KNOWN | 17,000 KG | 3,000 KG | NOT KNOWN |
| 3. WAR HEAD | " " | NOT KNOWN | NOT KNOWN | 830 KG. |
| 4. EXPLOSIVE | " " | NONE | 1,000 KG | 830 KG. |
| (b) DIMENSIONS 1. LENGTH | 14200 MM. | 26 METERS | 14.2 METERS | 25 FEET 4.5 INCHES |
| 2. SPAN | 4750 MM. | 9 METERS | 4.1 METERS | 15 FEET |
| 3. DIAMETER | 1650 MM. | 4.75 METERS | 1.65 METERS | NOT KNOWN |
| 12.CONTROL (a) TYPE IN USE | NOT KNOWN | NOT KNOWN | NOT KNOWN | ALTIMETER, COMPASS & GYRO |
| (b) CODE NAME | " " | NOT KNOWN | | NOT KNOWN |
| (c) MANUFACTURED BY | " " | " " | | ASKANIA |
| (d) PROPOSED TYPES | " " | " " | | DECIMETER |
| (e) CODE NAMES | " " | " " | | KOGGE |
| (f) STATUS | " " | " " | | DEVELOPMENT |
| 13.HOMING (a) TYPE (IN USE) | " " | " " | | NONE USED |
| (b) MAKE (CODE NAME) | " " | " " | | " " |
| (c) MANUFACTURED BY | " " | " " | | " " |
| (d) TYPES PROPOSED | " " | NOT KNOWN | | NOT KNOWN |
| 1. CODE NAMES | " " | " " | | " " |
| 2. MANUFACTURER | " " | " " | | " " |
| 14.FUSES (a) TYPES | NOT KNOWN | " " | | ELECTRICAL & MECHANICAL & TIME |
| (b) CODE NAMES | " " | " " | | ELAZ(106) & 80A & Z(17)8M |
| 15.OPERATING RANGE (a) RANGE | 800 KM. | 3000-4000 KM | | 235 KM. |
| (b) ALTITUDE | NOT KNOWN | 60 KM | | NOT KNOWN |

## APPENDIX XIII

APPENDIX XIV

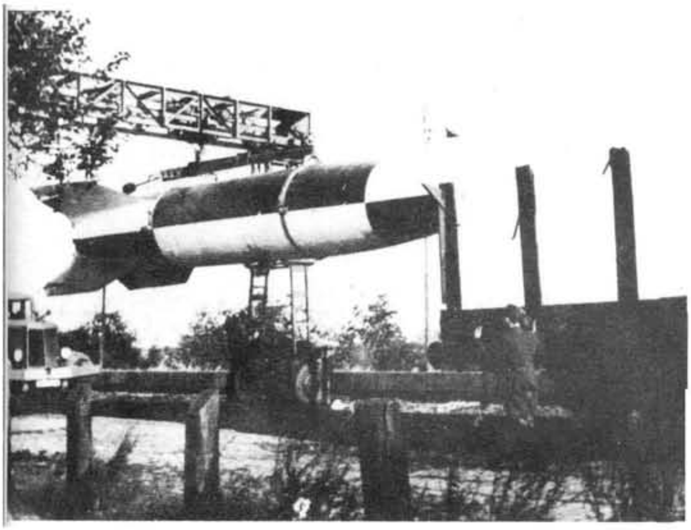
FLIGHT PATH OF V-2 (A-4 GERMAN ROCKET)





CONDENSATION TRAILS OF TWO V-2'S OVER ANTWERP

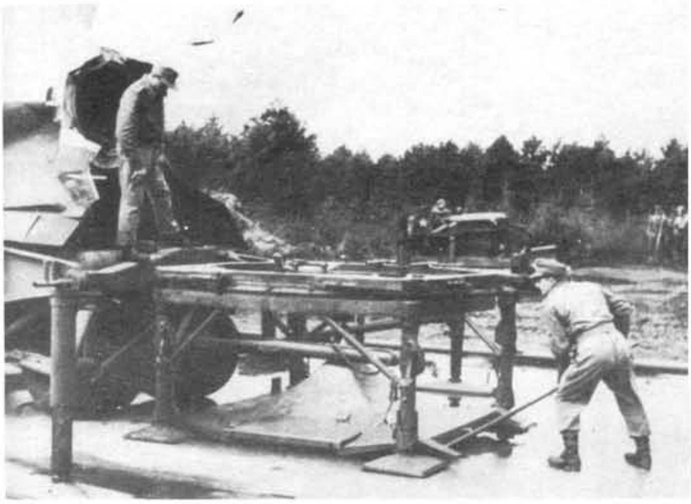
APPENDIX XV



Rocket being shifted from railroad car to VIDALWAGEN by mobile gantry-crane(STRABOKRAN)

Fuel convoy; vehicles towing alcohol, hydrogen peroxide and oxygen trailers.

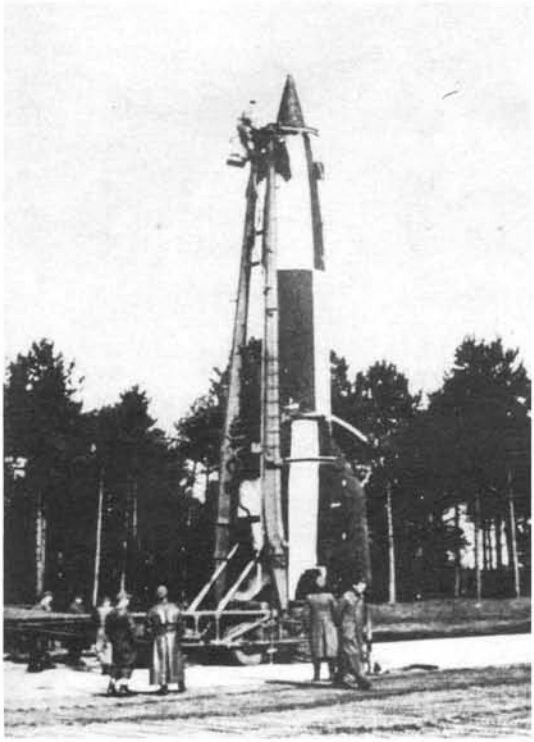
Oxygen trailer being filled at Railhead from railway tanker.



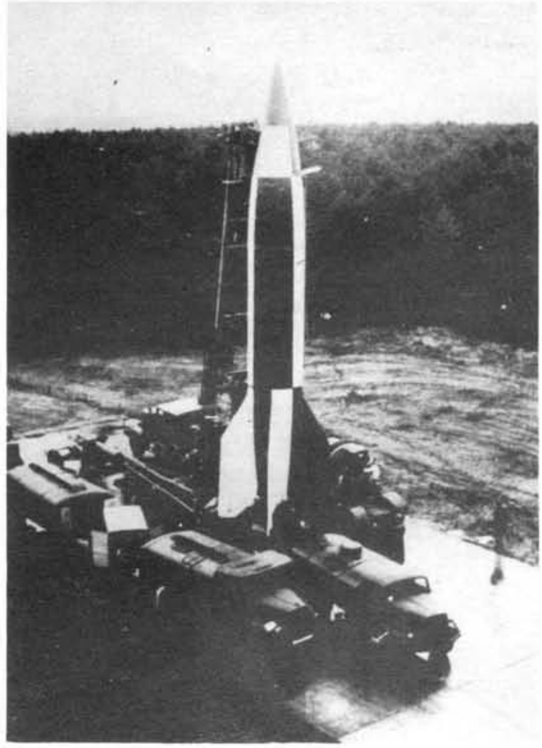
Deflector plate being placed in position under firing table.

Rocket loaded on MEILLERWAGEN being brought up to firing table.

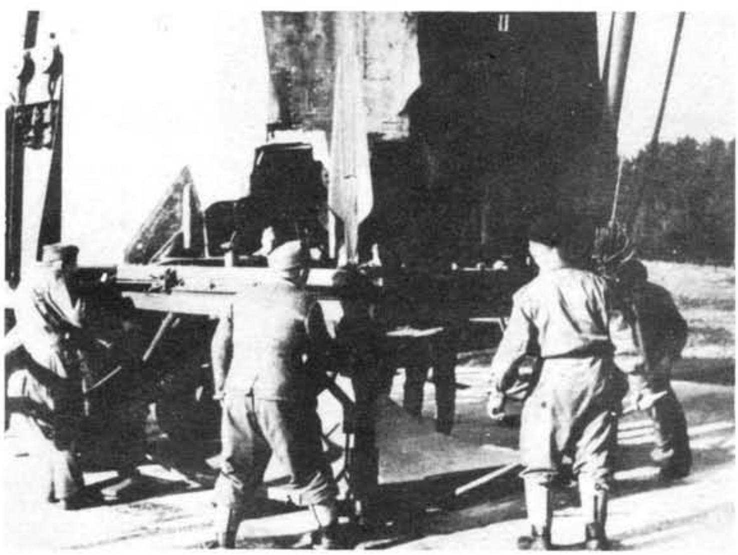
MEILLERWAGEN elevating rocket into vertical position on firing table.



"Girdles" securing rocket to MEILIER-WAGEN being removed.



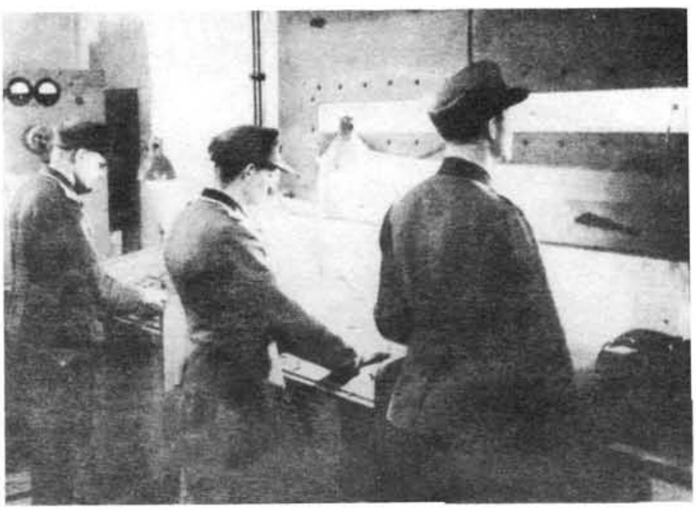
Fuel vehicles in position at rocket.



Rocket being positioned on firing table

FEUERLEITPANZER(mobile armored fire control tank) towing ABSCHUSSTISCH (firing table)

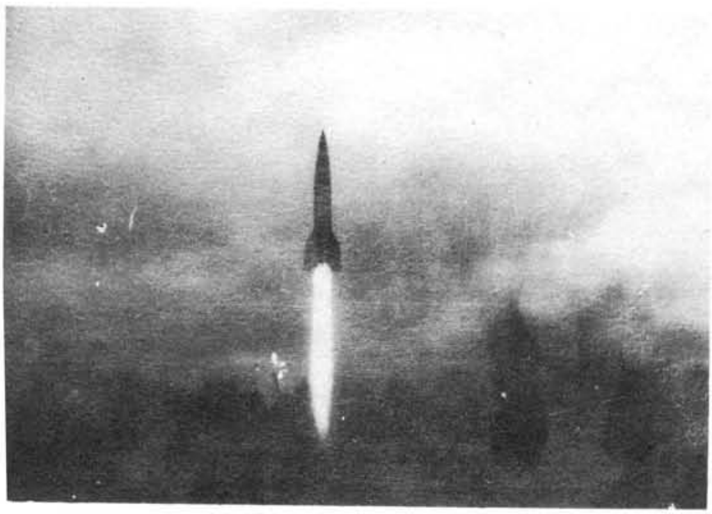
FEUERLEITPANZER in position



Interior of Fire Control Chamber; showing control panels; these are normally in the FEUERLEITPANZER

"Lining up" rocket to ensure in the true vertical position.

Start of ignition of fuels



Rocket lifts into the air

APPENDIX XX