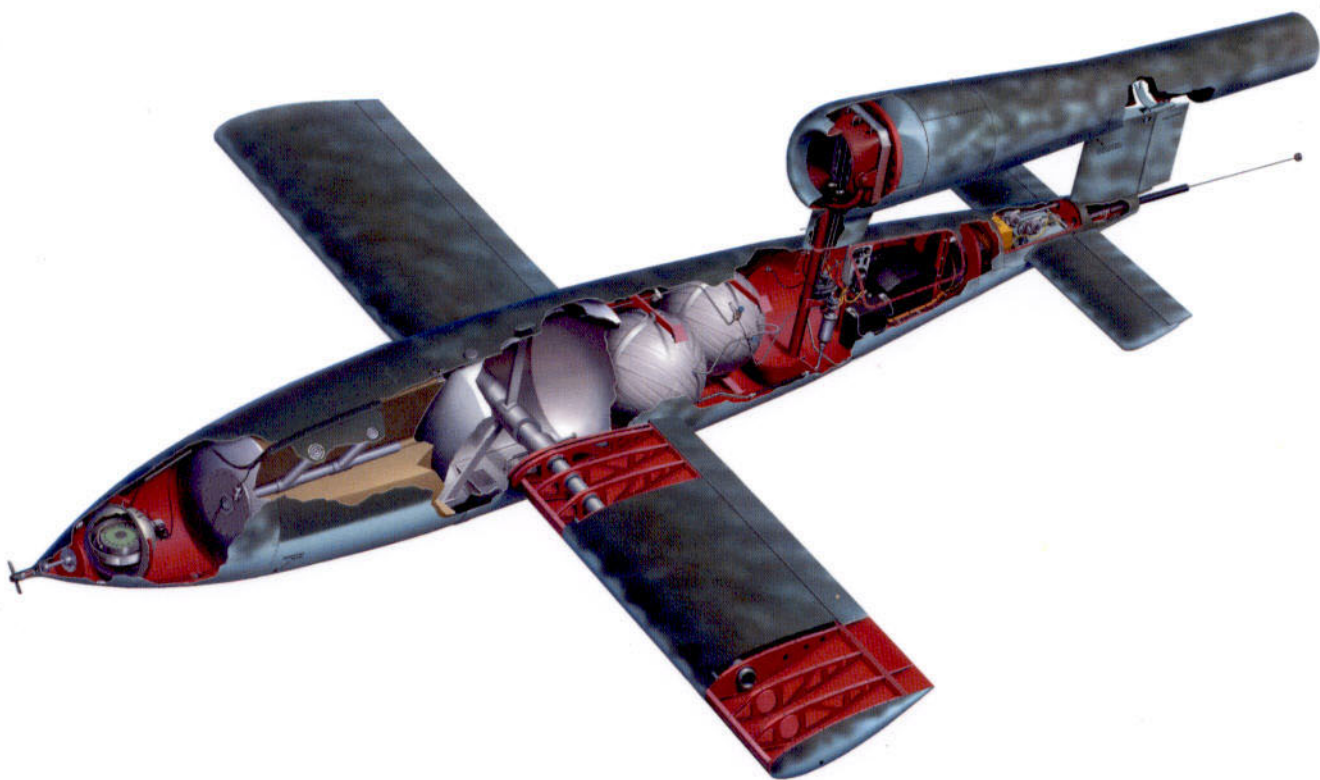


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# V-1 Flying Bomb 1942–52

Hitler's infamous "doodlebug"



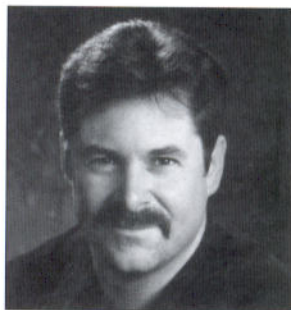
Steven J Zaloga • Illustrated by Jim Laurier

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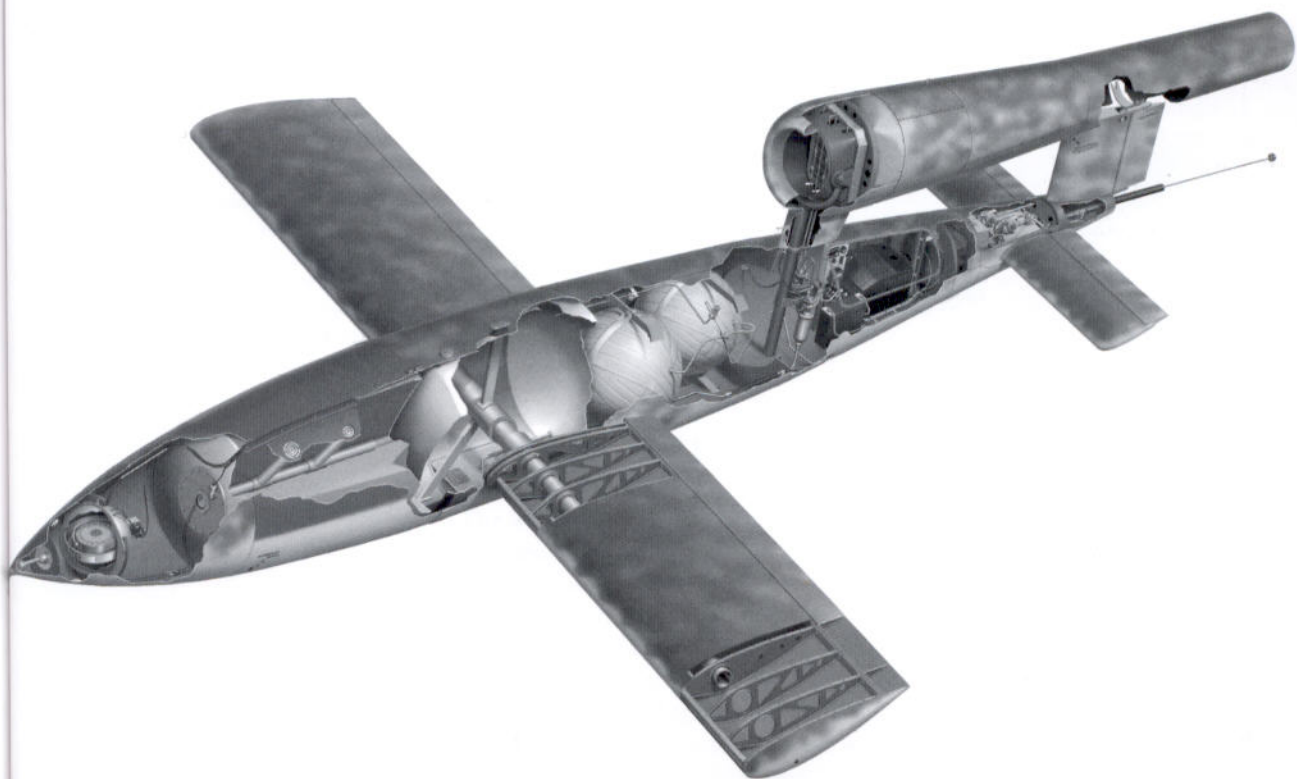


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# V-1 Flying Bomb

## 1942–52

Hitler's infamous "doodlebug"



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## Artist's note

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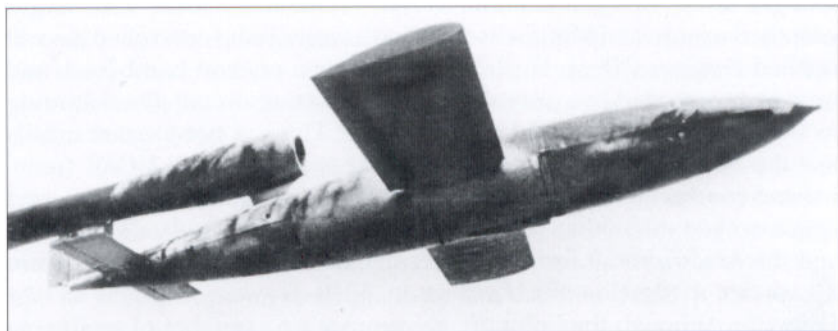
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# V-1 FLYING BOMB 1942-52: HITLER'S INFAMOUS "DOODLEBUG"

## INTRODUCTION

The V-1 flying bomb was the most widely used guided missile of World War II and the world's first successful cruise missile. In comparison to its wartime stable-mate, the V-2 ballistic missile, the V-1 was significantly simpler, easier to manufacture, and more practical to operate in combat conditions. It was employed for terror attacks against London, Antwerp and other European cities, causing tens of thousands of civilian casualties. But its technical shortcomings and vigorous Allied countermeasures prevented it from fulfilling its mission. Copies of the V-1 were manufactured by the United States, the Soviet Union, and France, but it was rapidly overtaken by more advanced missile designs in the 1950s.

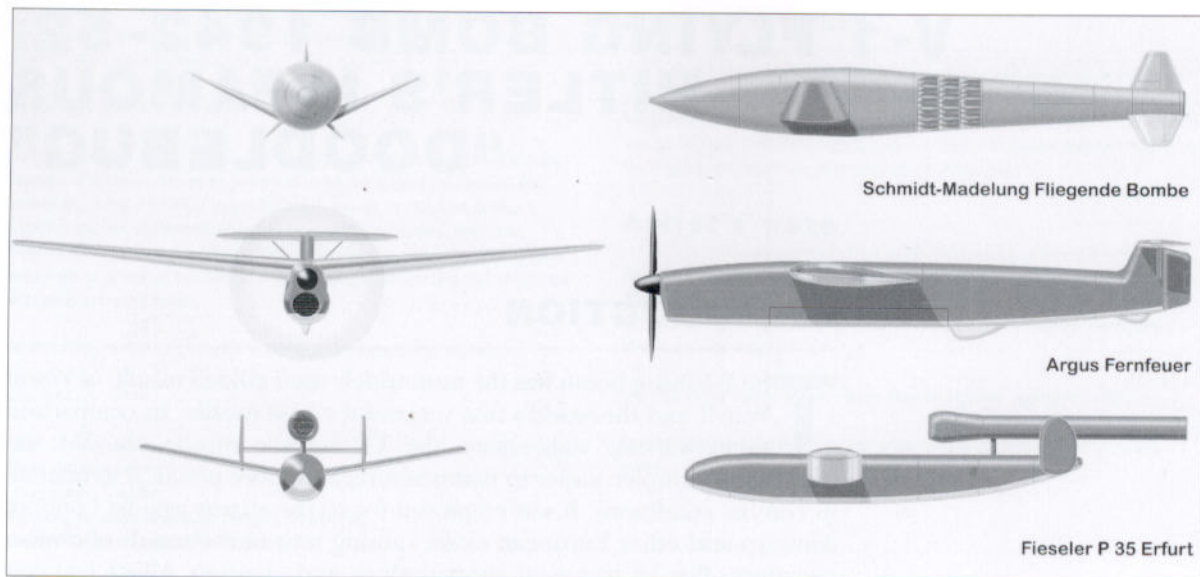


A wartime German propaganda photo purporting to show a V-1 launch. V-1 was only one of a number of names given to the Fieseler Fi-103 cruise missile during the course of its brief combat career. (USAOM-APG)

## FLYING BOMB ANCESTORS

The idea of converting a small airplane into a pilotless flying bomb is nearly as old as military aviation. In 1915, the Sperry Gyroscope Co. in the United States experimented with "aerial torpedoes" using gyroscopes to guide a small aircraft. Britain followed suit, with weapons such as the Larynx flying bomb launched from HMS *Stronghold* during trials in 1927. None of these missiles proved practical, but little-known propeller-driven flying bombs remained in development by the US Navy well into World War II.

The most significant German innovation in flying bombs was to use a jet engine. Paul Schmidt was a pioneer of early pulse-jet engines and he was quick to realize that such a simple and inexpensive powerplant would be ideal for a missile. In 1935 he offered a design to the Luftwaffe which he had conceived with Prof. G. Madelung. His flying bomb was ahead of its time, including among its features a novel mid-fuselage air intake. The Luftwaffe, however, rejected the project as "technically dubious and uninteresting from the tactical viewpoint."



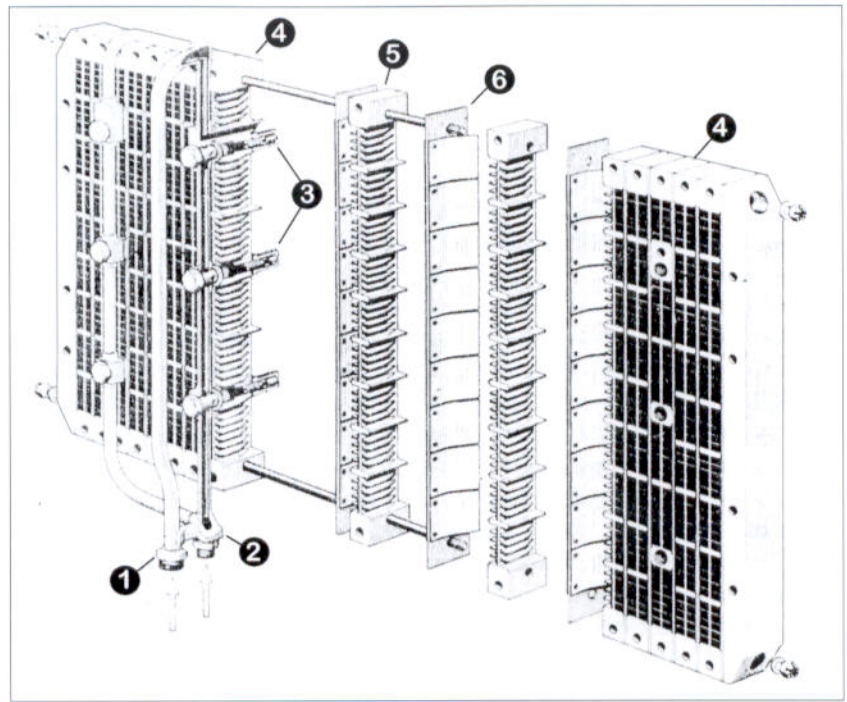
Entirely separately from these ventures, Dr Fritz Gossiau of the Argus Motor Works in Berlin developed the FZG-43 (*Flakzielgerät-43*, Anti-aircraft Target Device 43) which was a remote control model airplane for use as a target drone by Luftwaffe anti-aircraft crews. In October 1939 Argus proposed a more ambitious scheme using a larger radio-controlled aircraft dubbed *Fernfeuer* ("Deep Fire"). It could carry a one-ton bomb-load, and would be controlled by a piloted version of the same aircraft. On delivering its bomb, the *Fernfeuer* would return to base. This was not a cruise missile like the Schmidt design, but rather an ancestor of today's UCAV (uninhabited combat air vehicle). The Luftwaffe was intrigued by the idea, and Argus worked with other firms including the Lorenz guidance company and the Arado aircraft firm to perfect the idea. However, attempts to win a contract to develop the *Fernfeuer* in 1940–41 were rebuffed by the Luftwaffe. Although the Luftwaffe was sponsoring a number of projects to develop precision attack missiles, such as the Henschel Hs-293 anti-ship missile, there was no enthusiasm for area bombardment missiles.

In 1941 the efforts of Gossiau and Schmidt began to converge. Argus was primarily an aircraft engine firm, and since 1939 had been working on pulse-jet engine designs independently of Schmidt. Pulse-jets are an earlier, and significantly different, type of engine from the later and more successful turbo-jet. The first primitive pulse-jet engines had been studied as early as 1908 but did not reach maturity until the 1940s. In a pulse-jet engine, fuel is injected into a combustion chamber where it is mixed with air and then ignited, with the resulting jet exhaust directed back through an exhaust tube. Early studies showed that, under ideal conditions, the combustion cycle could be self-sustaining since secondary shock waves returning to the combustion chamber could be used to ignite subsequent pulses. Nevertheless, there was the need for a practical technique to prevent the jet pulse from also exiting through the air intake at the front of the engine.

In 1940 the Luftwaffe encouraged Schmidt and Argus to cooperate in the hopes of developing a practical design. Schmidt's innovation was a simple but effective shutter system that allowed air to enter the combustion

V-1 ancestors. (Author)

The heart of the Argus-Schmidt pulse-jet was this complicated matrix of vanes and fuel injectors located at the front of the engine. A mixture of compressed air (1) and fuel (2) was injected into the combustion chamber through nozzles (3) mounted in assemblies (4). The spring steel shutters (6) were mounted to carrier plates (5) and allowed in air to start the detonation process, but prevented the exhaust from exiting the front of the engine. (MHI)



chamber, but which automatically closed when the fuel detonated, forcing the energy back out the exhaust tube. This method was superior to the approaches being studied by Argus, and was incorporated into their next design in late 1940.

In the meantime Argus had developed an innovative method of injecting atomized fuel into the combustion chamber which permitted a stable combustion sequence. The resulting Argus-Schmidt engine design was remarkably simple and cheap compared to the rival turbojets, and had an excellent power-to-weight ratio. On the other hand, it had several significant drawbacks: it was not fuel efficient and a resonating engine with combustion detonations occurring several dozen times per second caused physical damage to the airframe.

Argus began testing its new pulse-jet engine on automobiles in January 1941, and it first flew on a Gotha 145 biplane on April 30th, 1941. It was promising enough that the Luftwaffe supported further research on more substantial aircraft. Gossiau was intrigued by the idea of using it to power a flying bomb, but Argus lacked an experienced airframe designer. A Fieseler engineer, Robert Lusser, visited Argus on February 27th, 1942, and Gossiau proposed a cooperative effort between Argus and Fieseler on a flying bomb. Gossiau sketched a simple aircraft with a pulse-jet under each wing. Lusser instead sketched an alternative idea with a single pulse-jet mounted above the tail. This brief meeting was the genesis of the V-1 flying bomb.

## THE KIRSCHKERN PROGRAM

Lusser completed a preliminary design at the end of April 1942. Radar or radio command systems were possible guidance options, but these were

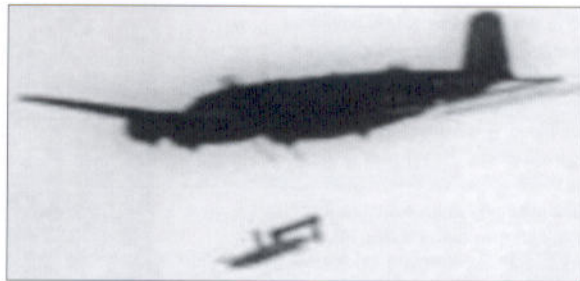
quickly rejected since the Allies could develop electronic counter-measures. Instead, the Germans turned to inertial guidance based on gyroscopes, as pioneered by Sperry in 1915. The proposed P35 Erfurt would have a range of 300km (186 miles) with a half-ton warhead and a speed of 700km/hr (435mph). When submitted to the Luftwaffe on June 5th, 1942, the Erfurt found a much more receptive audience than in years past. The attitude of the senior Luftwaffe leadership towards area bombardment weapons had changed due to the declining strategic situation. Britain had begun systematic heavy bomber attacks against Germany in March 1942, and Hitler demanded retaliatory strikes against England. The Luftwaffe lacked a heavy bomber force due to delays in its Heinkel He-177 program. Furthermore, the German Army was muscling in on the strategic bombardment mission with its A-4 ballistic missile program, better known by its later propaganda name, V-2. The Army attempted to win Hitler's support for the A-4 ballistic missile program by pointing out that it would succeed where the Luftwaffe had failed in the 1940 Battle of Britain. This insult was the last straw and, for the prestige of the service, the senior Luftwaffe leadership decided they needed a missile program of their own. The project was approved on June 19th, 1942, and incorporated into the *Vulkan* ("Volcano") program, which managed Luftwaffe missile efforts. Internally at Fieseler, the P35 was renamed in the standard fashion as the Fieseler Fi-103. The Luftwaffe assigned it the code name *Kirschkern* ("Cherry Stone"). It was later given another cover-name, FZG-76 (*Flakzielgerät 76*), linking it to the innocuous Argus FZG-43 target drone.

Argus remained in charge of the pulse-jet engine, now designated as the Argus AS 109-014. The guidance system was entrusted to the Askania company in Berlin which was already involved in the development of inertial guidance systems for other Luftwaffe missiles. Rheinmetall-Borsig developed a rail launcher using a rocket sled to launch the *Kirschkern*.

The first Fi-103 was completed on August 30th, 1942. It differed from the original Erfurt design in numerous respects including the use of a single rudder instead of a twin tail. A refined version of the Argus pulse-jet was completed in September 1942 and began flight trials. Failure of the high-speed flight trials nearly led to the program's termination, but these problems were gradually overcome after it was realized that many of the anomalous test results were due to the peculiar effects produced by pulse-jets during wind-tunnel tests.

While the problems with the engine were being sorted out, the first flight tests of the *Kirschkern* were attempted by the Luftwaffe Test Establishment at Karlshagen at Peenemünde-West, near the A-4/V-2 ballistic missile test site. The first unpowered flight was conducted from an Fw-200 Kondor bomber on October 28th, 1942. The missile proved to be well designed and very stable in flight. The first powered test was conducted on December 10th, 1942, with Fi-103V7, the V7 indicating the seventh test (*Versuch*) airframe.

A launch site for the Rheinmetall-Borsig catapult was established at Peenemünde pointing out eastward along the Baltic coast. The first catapult test was conducted on October 20th, 1942, using a concrete ballistic dummy, followed by the test of a fuselage and Argus powerplant,



**The first powered launch was conducted from an Fw-200 Kondor bomber over the Baltic on December 10th, 1942, using Fi-103V7. Note that some early airframes had an unusual vertical rudder in front of the pulse-jet engine. (DAVA)**





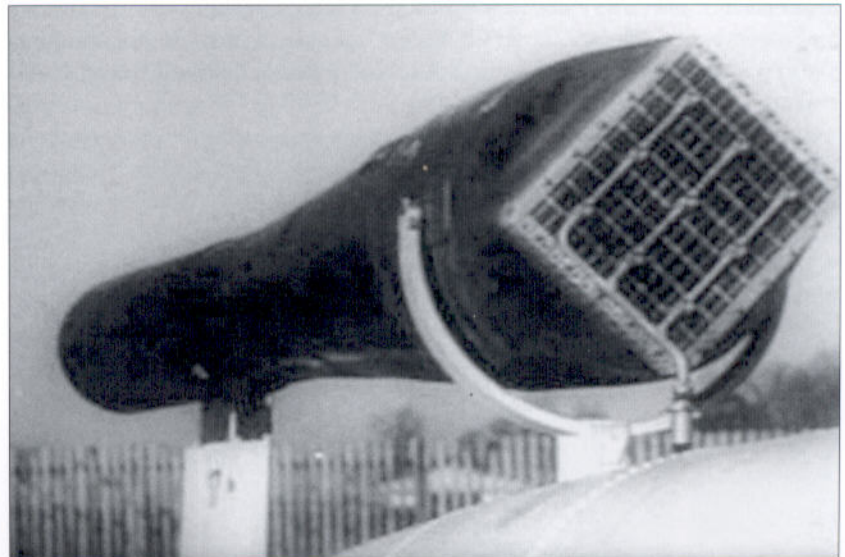
**This test film from the launch of Fi-103V6 on January 13th, 1943, shows the use of the initial Rheinmetall-Borsig rocket sled. The early missiles had a deeper rudder which extended below the fuselage as seen here. (DAVA)**

minus the wings. The first powered launch followed on December 24th, 1942, with Fi-103V12. The flying bomb flew for about a minute and reached speeds of 500km/hr (310mph) before crashing into the Baltic. Although far short of its design specifications, this was an important milestone which led to approval for full-scale development.

Due to the urgency of the program, the testing of the airframe, pulse-jet, guidance, and launch catapult were conducted in parallel. This created

some significant problems, since in the event of crashes or other failures, it was often impossible to determine which of the sub-systems had been responsible for the problem. Shortcomings of the Rheinmetall-Borsig launcher led to an alternative catapult being designed in early 1943, the Hellmuth Walter Werke (HWW) Schlitzrohrschleuder (split-tube catapult). The Walter design used a gas generator powered by a combination of *T-stoff* (hydrogen peroxide) and *Z-stoff* (sodium permanganate) rocket fuel. It worked much like a modern aircraft carrier steam catapult: high pressure gas was pumped into a tube inside the launch rail box that propelled a piston, connected underneath the Fi-103.

The test program was plagued by crashes, many induced by the pulse-jet engine. The fuel detonated inside the engine 47 times per second, creating an enormous amount of noise and vibration that could literally shake the fuselage and wings to pieces. The most common problem was the disintegration of the shutters in the front of the pulse-jet, upsetting the air flow into the engine if enough failed. Through the end of July 1943, 84 Fi-103 flying bombs had been launched, 16 from the air and 68 from ground catapults. Of the catapult launches, only 28 had been successful. About a third of the missiles failed to launch, or after leaving the catapult, rolled and crashed into the Baltic seconds later. None of the missiles had yet been fitted with the full guidance system, which was still in development, nor had any been launched at full combat weight as the Walter catapult was still not ready. On a more positive note, at least one



**The early test missiles had an exposed pulse-jet frame and external engine yoke support as seen here on Fi-103V17. A cowl was later added to channel the airflow. (DAVA)**

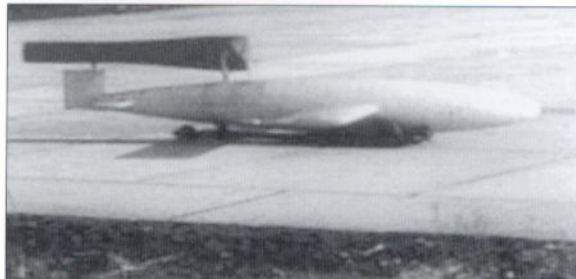
Fi-103 had attained speeds of 625km/hr (390mph), and had reached distances of 225km (140 miles).

Trials with the new Askania autopilot guidance system began in the summer of 1943. A magnetic compass served as the azimuth control, keeping the missile heading along a predetermined magnetic bearing to the target. A pair of gyroscopes monitored yaw and pitch, while a barometric device monitored the altitude. A small propeller on the nose of the missile was linked to an air-log which measured the distance that the missile had traveled. The autopilot was preset prior to launch regarding the missile's cruising altitude and target range, while the azimuth was determined by the orientation of the launcher. Once the air log had determined that the range had been reached, two detonators fired which caused the rudder and elevators to lock, pushing the missile into a steep dive towards its target. Fieseler boasted that 90 percent of the production missiles would strike within a circle 10km (6 miles) around the target, and that half would land within a circle 6km (3.7 miles) in diameter around the target.

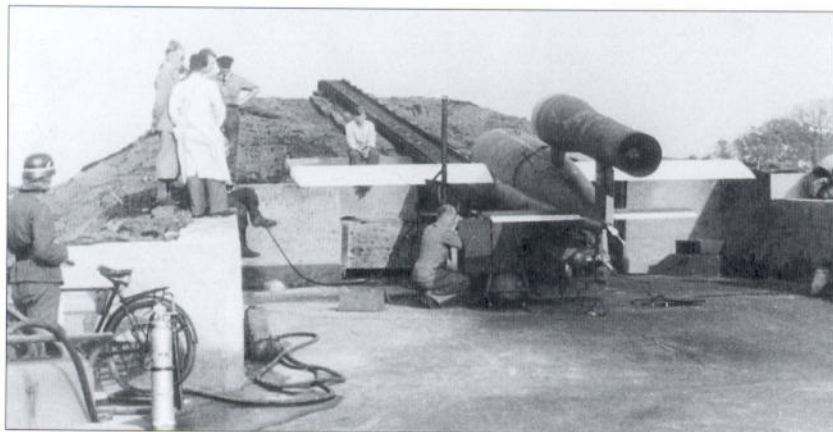
On Hitler's orders, a special commission was convened on May 26th, 1943, to determine whether the Luftwaffe's FZG-76 cruise missile or the Army's A-4 ballistic missile was the preferable bombardment weapon. The commission concluded that both the FZG-76 and A-4 should be manufactured since they were complementary to one another. The FZG-76 was judged to be more vulnerable to interception, but was far less expensive to manufacture and much simpler to operate; the A-4 ballistic missile was invulnerable to interception, but was very expensive to manufacture and complicated to operate. By the late summer of 1943, the *Kirschkern* had progressed far enough to begin plans for serial production. The original plans called for serial production to begin in August 1943 so that 5,000 missiles would be ready when combat use began on December 15th, 1943.

### Flying bomb designations

Among the more confusing aspects of the Fieseler flying bomb were its numerous names and codenames. As mentioned earlier, its early names included the Fieseler designation Fi-103, and the Luftwaffe cover-names FZG-76 and *Kirschkern*. On April 30th, 1944, Hitler ordered that FZG-76

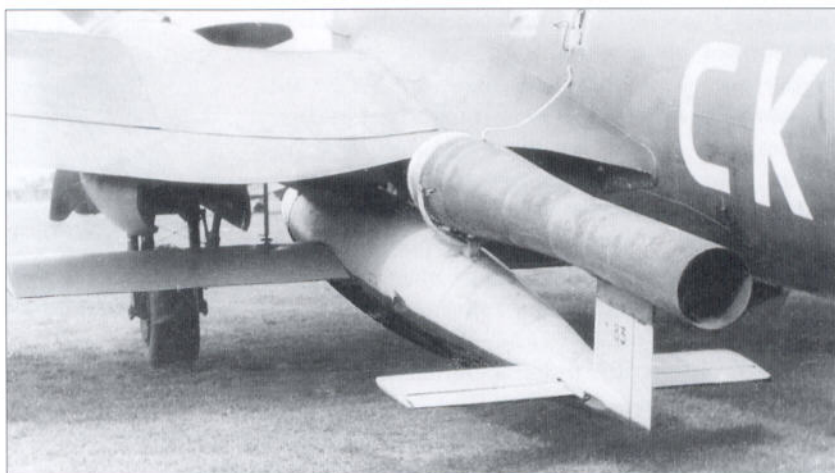


The early V-zellen prototype missiles, such as Fi-103V17 seen here, had a somewhat sleeker shape than the production missiles, and many small detail differences. The probe on the nose contained a flare used in tracking the missile after launch. This particular missile was launched on March 11th, 1943. (DAVA)



The unsuccessful Rheinmetall-Borsig launcher was replaced by a Walter design and the first prototype is seen here during trials in the autumn of 1943. (NARA)

Some of the Fi-103s were tested from aircraft, in this case an He-111 of *Erprobungskommando Banneick* at Karlshagen. This particular missile, Fi-103V83, was launched on August 22nd, 1943, and inadvertently crashed on Bornholm island. Danish resistance provided pictures of the wreckage to British intelligence, the first detailed glimpse of the new weapon. By this stage, the *V-zellen* missiles had the improved air intake at the front of the engine but still employed the external yoke mounting. (NARA)



*Kirsch kern* be dropped in favor of *Maikäfer* ("June Bug"). This was one of the more short-lived names as the German propaganda ministry started using the term V-1 (*Vergeltungswaffe-1* – "Retaliation weapon 1") during radio broadcasts on June 23rd, 1944, and Hitler made this its official name on July 4th, 1944. V-1 lasted until November 2nd, 1944, when Hitler renamed it *Krähe* ("Crow").

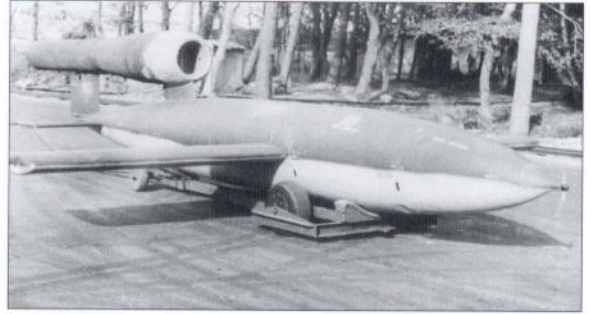
### **The FZG-76 enters service**

In April 1943 Colonel Max Wachtel was appointed to command the first missile unit, *Lehr-und-Erprobungskommando Wachtel* ("Wachtel Training and Test Command"). This unit was deployed at the Zempin test range near Peenemünde and another catapult site was built on the Baltic for training. This was the seed for the later combat unit, *Flak-Regiment 155 (W)*, the W indicating *Werfer*, or "launcher", and not Wachtel as is so often reported.

There was no consensus on how best to deploy the new missiles. The Luftwaffe Flak commander, Lt. Gen. Walther von Axthelm, wanted the missiles deployed in a large number of small field bases that could be easily camouflaged. The head of the Luftwaffe production program, Field Marshal Erhard Milch, favored a small number of large bomb-proof bunkers, a position that was supported by Hitler based on the success of the heavily fortified Brest U-boat shelters in resisting Allied bomber attacks. On June 18th, 1943, Luftwaffe chief Hermann Göring held a meeting with Milch and Axthelm to settle the issue. Göring suggested a compromise: four large missile bunkers would be built, along with 96 field sites. In addition, the launch of FZG-76 missiles from bomber aircraft would also be employed. Production would start in August at a rate of 100 per month, gradually ramping up to 5,000 monthly by May 1944. Göring wanted 50,000 per month, but no sober official treated this seriously. Hitler approved the plan on June 28th, 1943, setting in motion the *Kirsch kern* construction program.

Manufacture of the Fi-103 started months late. Initial production was scheduled to begin at the Volkswagen plant at Fallersleben and at Fieseler in Kassel-Bettenhausen in August 1943. Minister for War Production Albert Speer continued to favor the Army's A-4 missile program, and a Luftwaffe decision to emphasize fighter construction adversely impacted the FZG-76 program since it was considered a bomber-substitute. In some respects, the

delay was not entirely unwelcome as the FZG-76 was still not mature. Through August 1943, only 60 percent of the test launches were successful. The early FZG-76 missiles were categorized in three batches, the *V-zellen* (*Vorserienzellen*: prototype airframes); *M-zellen* (*Modellserienzellen*: pre-production); and *G-zellen* (*Grossserienzellen*: serial production). Although 200 *V-zellen* had been planned, only 120 were actually completed and most had been launched by the end of the summer of 1943. By September 1943, only 38 *M-zellen* missiles had been delivered, and the first training launch by Wachtel's regiment did not take place until October 26th, 1943. The guidance system was still not mature. In December 1943 British intelligence decrypted the tracking reports from radar stations along the Baltic which revealed that guidance problems were still so severe that, if the FZG-76 had been launched against London as planned in December 1943, fewer than one in six would have landed in the city, even discounting premature crashes and British counter-measures.



This is Fi-103M23, one of the *M-zellen* pre-production missiles tested in the fall of 1943. (NARA)

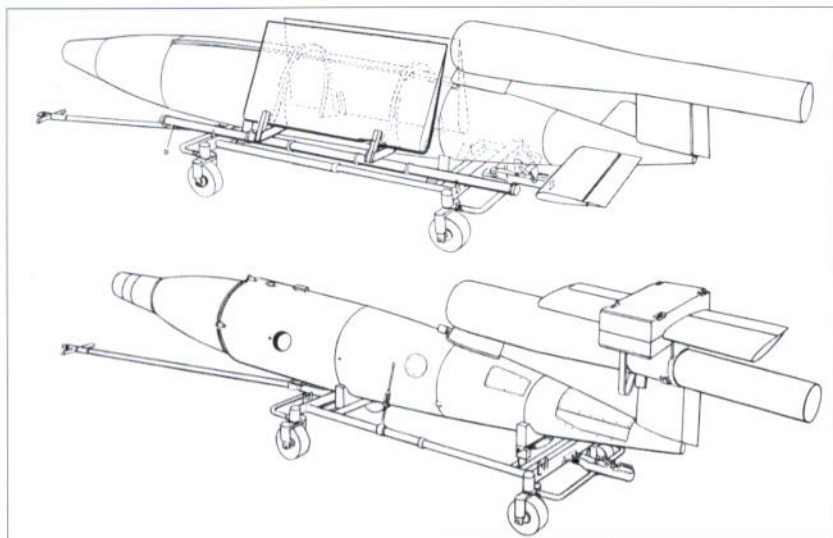
On October 22nd, the RAF raided the Fieseler plant, shutting down its Fi-103 line. Production was further delayed by the endless stream of changes and modifications to the design. The *M-zellen* missiles were prone to flip over on their backs after launch due to shortcomings in the new guidance system, and the serial production *G-zellen* were even worse, often losing their wings after launch. The *G-zellen* problem was traced back to a production change between the pre-series and mass-produced missiles where spot-welding had replaced more time-consuming riveting. The new lightweight stamped-steel wing rib proved too weak and the first batch of 1,400 airframes had to be scrapped. At the end of November production was halted until the problems could be remedied. Significant production did not resume until March 1944 after the production faults had been ironed out. An Allied bombing attack on the Fallerleben plant missed the FZG-76 production line and in July FZG-76 production was started at the notorious underground Mittelwerke plant near Nordhausen since it was less vulnerable to bombing.

### FI-103 SERIES PRODUCTION

	Jan	Feb	Mar	Apr	May	Jun	Total
1944		76	400	1,700	2,500	2,000	6,676
1945	2,000	2,482	2,027				6,509
	Jul	Aug	Sep	Oct	Nov	Dec	Total
1944	3,000	2,771	3,419	3,387	1,895	2,600	17,072
1945							
	<b>grand total</b>						<b>30,257</b>

Unlike conventional aircraft, the FZG-76 was not completely assembled at the plants. Instead, the major components such as the fuselage, engine, wings, warhead and other sub-assemblies were delivered to a Luftwaffe munitions depot. Four of these were assigned to the FZG-76 program, of which the most important were Pulverhof in Mecklenberg and Karlwitz near Dannenberg. There, the components were merged; the fuselage, engine, and warhead were assembled, and the rest of the components

The FZG-76 was delivered from the manufacturing plant on its TW-76 trolley to the Luftwaffe munitions depots in the configuration shown in the lower illustration with no warhead and the tail fastened above the rudder. The depot then mated the warhead to the fuselage, added the wings and wing-spar to the trolley, and delivered the semi-complete missile to the forward supply units as shown in the upper illustration. (NARA)



along with the completed fuselage mounted on a TW-76 trolley. This made it easier to deliver the missile to the field depots in France. At that point, the sensitive equipment such as the autopilot and compass were fitted, and from these depots the missiles were delivered to the launch sites. It was only at the launch site that the FZG-76 was completely assembled.

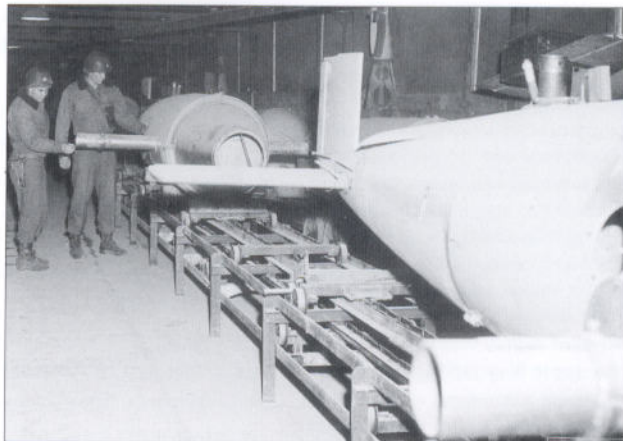
When the Fi-103 finally reached quantity production in March 1944, the time to manufacture the missile had been reduced to 350 hours of which the complicated autopilot accounted for 120 hours. The unit cost was RM5,060, only four percent of the cost of a V-2 ballistic missile, and only about two percent of the cost of a twin-engine bomber.

To test whether the improvements worked, on April 14th–17th, 1944, the Luftwaffe conducted field tests of 30 Fi-103 missiles from the Heidelager test range near Blizna in Poland. Nine missiles crashed shortly after launching but the remaining missiles all struck within 30km (18 miles) of their target, and ten landed within 10km of the target. One recurring problem was the fuel-pressure regulator which was supposed to alter the fuel supply automatically depending on altitude. No short-term solution to the problems could be found so in May 1944 the regulator was simplified which meant that the cruise altitude was only 4,500ft instead of the expected 9,000ft. This made the FZG-76 more vulnerable to light anti-aircraft guns such as the ubiquitous 40mm Bofors used by many British and American anti-aircraft units.

### **Combat deployment in France**

If development and production were six months behind schedule, deployment plans at the missile bases in France were also delayed, starting only in August 1943. The initial phase was Site System 1 which contained 96 Type A sites along the Channel coast from Dieppe to Calais. Each site included a launch ramp shielded on either side by a concrete wall, a non-magnetic alignment building for final adjustment to the magnetic compass prior to launch, a launch bunker, three long missile storage buildings, and several smaller buildings for storing fuel and other supplies. The precise location of each of the buildings was dependent on the site, and some effort was made to use local terrain such as hedges and tree lines

to camouflage the more conspicuous structures. The missile sites were usually located next to existing roads, which were upgraded with smooth concrete surfaces to facilitate the use of the many handling trolleys servicing the launch site. Often, the site was located near farms or other buildings which could be taken over to house the launch crews, and which also helped to camouflage the site. Site System 2 was a set of reserve sites, with the intention to complete one reserve site for each battery by December 1943. Site System 3 was a more ambitious scheme to deploy the missile bases in a wider band from Cherbourg to Flanders in Belgium which would be manned by four new battalions (*V-VIII Abteilungen*). Eight of these sites were begun in Normandy but since the new battalions were never raised, they were allotted to IV/FR155W.



**FZG-76 production was extended to the underground Mittelwerke plant near Nordhausen after the original aviation plants were bombed. Here, some US Army officers examine some unfinished missiles after the plant was captured in April 1945. (NARA)**

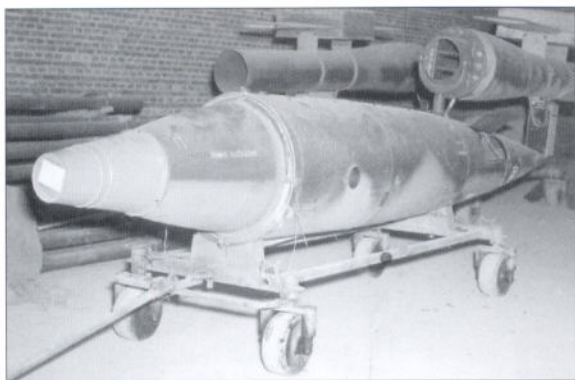
Wachtel's FR155W included four launch battalions (*Abteilungen*) each with three launch batteries and a maintenance and supply battery. Each launcher battery had three launch platoons, each with two launchers, meaning 18 launch ramps per battalion and 72 launch ramps for the regiment. Each launch ramp was manned by about 50 personnel, and the regiment as a whole totaled about 6,500 personnel. Due to the technological complexity of the new weapon, FR155W was supported by several dozen civilian engineers from the factories called the *Industrie-Hilfstrupp Gehlhaar* (ITG).

### FLAK REGIMENT 155 (WERFER)

Unit	Code-name (to Aug 44)	Commanders
FR155W	<i>Flakgruppe Creil</i>	Col. Max. Wachtel
<i>I. Abteilung</i>	<i>Zylinder</i> ("Top-hat")	Maj. Hans Aue
<i>II. Abteilung</i>	<i>Werwolf</i> ("Werewolf")	Capt. Rudolf Sack
<i>III. Abteilung</i>	<i>Zweiback</i> ("Biscuit")	Lt. Col. Erich Dittrich
<i>IV. Abteilung</i>	<i>Zechine</i> ("Sequin")	Capt. Georg Schindler (Maj. Steinhof)
Signals <i>Abteilung</i>	<i>Vandale</i> ("Vandal")	Capt. Henry Neubert

As the battalions from FR155W completed their training at Zempin, they were transferred to France in late October 1943 to assist in preparing the missile bases. To coordinate the bombardment of London by the Luftwaffe Fi-103 and the Army A-4 ballistic missile, on December 1st, 1943, the Wehrmacht created a hybrid organization, the *65. Armee Korps zur besonderen Verwendung* (65th Army Corps for Special Employment), staffed by Army and Air Force officers. Command of the 65th Corps was given to Generalleutnant Erich Heinemann, previous commander of the Army artillery school, and the chief of staff was Luftwaffe Colonel Eugen Walter. After inspecting the missile sites, the corps staff was dismayed by the poor planning and unrealistic expectations of the high command which seemed to be completely unaware of the problems. The high command insisted that the missile attack on London begin in January 1944, ignoring the fact that the bases were not complete, training had not been concluded, and there were no stores of missiles.

**RIGHT This map illustrates a typical "ski site," No. 13 built near a farm along the Chemin du Moulin à Vent outside Le Rocher near Hardinvast in Normandy. The launcher (1) and launch bunker (2) are aligned with the non-magnetic guidance building (3). To the east are three of the distinctive "ski" buildings (4) used to store V-1 missiles. The support buildings are to the west and include the fuel bunkers (5, 7); blockhouse (6); assembly building (8); pump building (9); and preparation garage (10). (Author)**



This shows an Fi-103 on its TW-76 trolley in shipping configuration at the Luftwaffe's Karlwitz munitions depot near Dannenberg in 1945. The warhead is not fitted yet, and the standard blue protective cover is fitted to the nose which served to protect the delicate auto-log propeller as well as contain the fuzes for the warhead which were not fitted until at the launch site. (NARA)

### The Crossbow campaign

In late August 1943 a FZG-76 crashed on the island of Bornholm and Danish resistance workers spirited out photos of the wreckage to Britain. British technical intelligence was on the lookout for missile sites due to intercepted signals and other evidence. By October 1943 British intelligence had also learned from the French resistance of a flurry of unusual construction in Normandy and the Pas de Calais. One of the first sites to be completed was located in a wooded area near Abbeville called Bois Carré and, after receipt of a detailed French report on the site, it was photographed by RAF reconnaissance aircraft

in late October. The most distinctive features of the sites were three long storage buildings which an RAF photo interpreter thought resembled skis turned on their side, so the missile bases were called "ski sites" or "Bois Carré" sites. Ominously, the ramp structure at the site was aimed at London. Photos taken over Peenemünde in November revealed a small winged aircraft and another reconnaissance run over Zempin on November 28th actually showed one of the missiles on a launch ramp like those in France, along with several of the characteristic buildings. Intelligence analysts estimated that each site could store 20 missiles, suggesting that the missile bases could launch up to 2,000 missiles per day against England.

By this time, Allied work to identify German missiles and missile sites had come under the heading of "Crossbow," named after the investigative committee set up by Churchill in the summer of 1943 to coordinate all of the reports emerging from occupied Europe about secret missile programs. RAF photo interpreters quickly identified new sites because of their use of standardized buildings. A German Air Force officer assigned to the missile units later described efforts to camouflage the sites as a farce. By December 1943, more than half the sites were complete, and by late January, Allied intelligence had identified all 96 launch sites of Site System I.

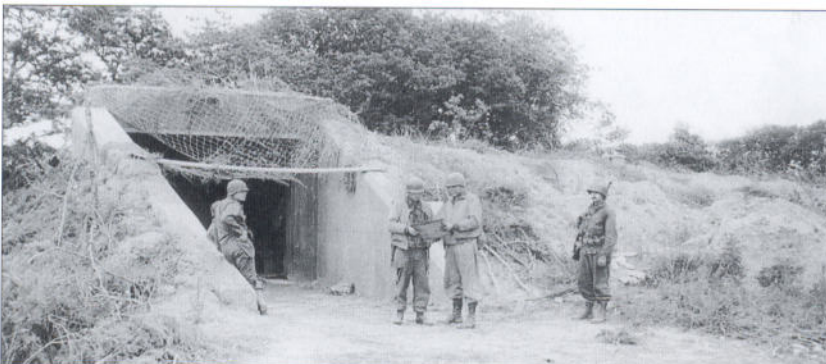




Besides the dispersed ramp sites, four *Wasserwerk* ("Waterworks") heavy sites were begun in September 1943, Siracourt and Lottinghen in the Pas de Calais and Nardouet and Brecourt on the Cotentin peninsula. The massive missile bunkers were 212m (232 yards) long and 36m (39 yards) wide and could house up to 150 missiles. A single ramp exited the middle of the structure, aimed at London. The first of these to enter construction, *Wasserwerk St. Pol* near Siracourt, was identified almost immediately by Allied reconnaissance aircraft. Due to their complexity, the heavy sites were not expected to be ready until August 1944. The sites would require another regiment to operate them and the planned ten sites would have a rate of fire of 480 missiles daily and 1,680 weekly.

The first Allied air attacks on the Crossbow sites began on December 5th, 1943, when B-26 aircraft of the US Ninth Air Force attacked three sites near Ligescourt. Due to weather conditions the results were poor, and the RAF became convinced that heavy bombers would be needed. The first Bomber Command attack took place on the night of December 16th/17th, 1943, on sites near Abbeville. The results were poor due to the difficulties of conducting precision bombing against such small and bomb-resistant targets at night. On December 15th, the Joint Chiefs of Staff (JCS) decided to begin employing US heavy bombers in daylight, and when clear weather arrived on Christmas Eve, 672 B-17 and B-24 bombers delivered 1,472 tons of bombs on 24 sites. By the end of the year, 52 sites had been attacked and nine were believed to have been seriously damaged. Actually, seven sites had been put out of action of which three had been completely obliterated.

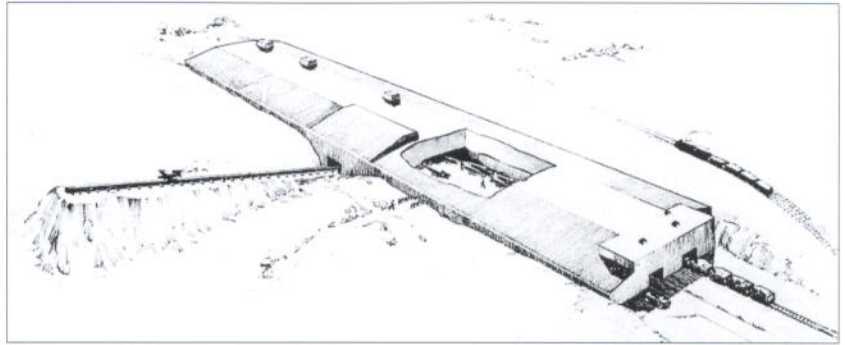
**The original launch sites had large walls to protect the launch ramp. This is one of the eight sites constructed on the Cotentin peninsula in Normandy which were never used due to the Allied Crossbow air attacks. (NARA)**



**This is how the "ski" buildings appeared from the ground. These long storage bunkers could contain 20 missiles on their shipping trolleys. This particular site is one of those on the Cotentin peninsula in Normandy captured by the US Army in June 1944. (NARA)**



This is an illustration from the wartime Sanders' report showing how the *Wasserwerk St. Pol* missile bunker near Siracourt might have looked had it been completed. The launch ramp was oriented towards London but was never finished. (NARA)



The December attacks were only the beginning of a long air campaign against the Crossbow sites which added to the problems FR155W had in preparing for combat. The relentless Allied air attacks systematically pulverized Site System 1. According to the regimental diary, by the end of March 1944, nine sites had been destroyed, 35 seriously damaged and 29 had suffered medium damage. By the end of April, 18 sites had been destroyed and 48 suffered heavy damage, and by mid-May, 24 had been destroyed and 58 had suffered serious damage. The large bunker sites received special attention. Siracourt was bombed 27 times with a total of 5,070 tons of bombs including an 11-ton Aphrodite guided-aircraft bomb and several Tallboy 6-ton bombs, making it the most heavily attacked of all Crossbow sites.

The Crossbow campaign absorbed about 14 percent of all Allied heavy bomber missions from August 1943 to August 1944, and about 15 percent of the medium bomber missions. The diversion of reconnaissance aircraft was greater, absorbing about 40 percent of the missions from May 1943 to May 1944. The figures below summarize the scale of Crossbow missions, though it should be kept in mind that these included attacks on V-2 sites as well as V-1 sites, and also raids on Peenemünde, production plants, storage areas, and fuel depots.

#### **CROSSBOW BOMBING CAMPAIGN AUGUST 1943–MARCH 1945**

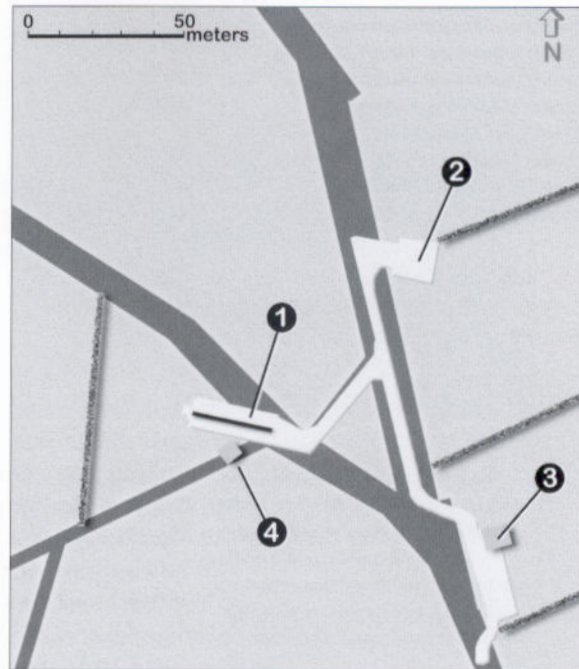
<b>Unit</b>	<b>Sorties</b>	<b>Tons of bombs</b>
US Eighth Air Force	17,211	30,350
RAF Bomber Command	19,584	72,141
US Tactical Air Forces	27,491	18,654
RAF Fighter Command	4,627	988
<b>Total</b>	<b>68,913</b>	<b>122,133</b>

Although the Crossbow campaign was costly in terms of aircrew losses and the diversion of bomber missions, the initial attacks proved very effective in delaying the start of the missile campaign against London. In early December 1943, before the attacks, Wachtel reported that he expected to be ready to start the campaign later in the month, and even the more skeptical General Heinemann thought it might be possible in January. In fact, the bombing so disrupted the creation of launch sites, and so badly interfered with training and deployment, that the missile campaign started six months late. General Eisenhower later wrote that,

if the missile campaign had started on time at the end of 1943, it might have disrupted the D-Day plans. This is a misunderstanding of the role of the missiles, as neither Hitler nor any of the other senior leaders had the sense to use the missiles against the invasion fleet, so obsessed were they with their revenge mission against London. The Crossbow campaign also lessened the volume of the summer missile attacks since it reduced the production rate of the missiles through attacks on the factories, and forced the Germans to adopt less efficient launch bases, with a lower rate of fire than the original configuration.

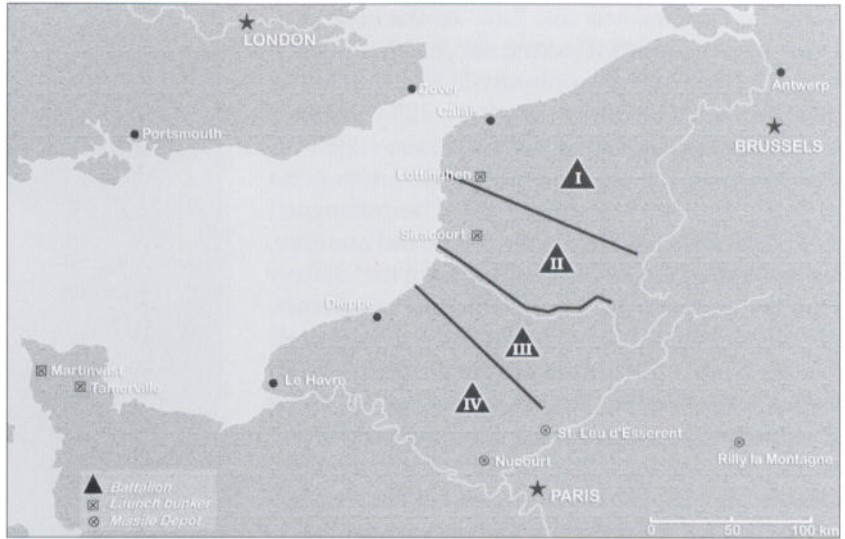
In late December 1943, General Heinemann held a conference for all leaders of the FZG-76 program, in order to determine how to get the program back on track. The conference concluded that neither missile production nor manufacture of the Walter launcher were going to be ready until late February 1944. Heinemann therefore concluded that the existing Site System 1 and the four heavy bases were such obvious targets for attack that they could not be used in the forthcoming missile campaign. Instead, the French work crews would complete them, and even effect modest repairs after Allied air raids, in order to distract attention from a new series of bases. The new Operational Site System would be constructed by German engineer battalions with no participation by French construction firms, and security around the sites would be draconian. The new sites would have as little construction as possible to prevent their detection by Allied intelligence. The only concrete fixtures at the sites would be a basic concrete platform for the launch ramp, a concrete floor for the non-magnetic alignment building, a small garage for preparing the missile, and a modest amount of concrete road improvements. None of the distinctive "ski" buildings or other facilities would be used, and no distinctive missile equipment would be allowed near the sites until six days before the start of the missile campaign. Storage of missiles and their equipment would be moved to local caves and tunnels and not specialized bunkers. The simplified sites were also much easier to construct, taking only eight days compared to eight weeks for the "ski-sites." These new bases, called "modified sites" or "Belhamelin" sites by Allied intelligence, proved much more difficult to locate, and the first was not identified until April 26th, 1944. After the meeting, the Germans referred to the Type A ski sites as *Stellungen alter Bauart* ("Old pattern sites") and the new types as *Einsatz Stellungen* ("Special sites").

Heinemann realized that photographic reconnaissance coverage over London was unlikely when the missile attacks began, so novel methods were concocted to determine whether the missiles had hit their target. Fieseler equipped about seven percent of the FZG-76 missiles with radio transmitters which would permit tracking where they landed. This was supplemented by a special SS observation battalion using sound location and seismographic instruments. Heinemann planned to start the campaign on March 1st, 1944, but by the spring of 1944 the Crossbow



This map illustrates a typical "modified" V-1 launch site, No. 240 at the entrance to La Maison de Bricqueboscq in Normandy. A stretch of Route D204 was reinforced with concrete where it met the château's entrance road. A pad for the launcher (1) has been created, along with an aligned pad for the non-magnetic guidance platform (2). A launch control bunker has been built near the launch pad (4) and a small "garage" bunker (3) for preparing the V-1 was built near the road access point. (Author)

**Deployment of Flak Regiment 155 (W) in northern France in June 1944 for Operation Eisbär.**  
(Author)



campaign had effectively delayed construction of the launch sites and Allied air attacks against the railroad network in France to support the D-Day invasion further undermined the missile program.

Besides the ground-launched missile program, the Luftwaffe began an air-launched missile program in early 1944. Aircraft had already been used in the test program, but had been ignored as possible combat launchers since, unlike fixed land bases, there was no existing navigation system accurate enough to determine the precise launch point. Tests of various navigation systems began in November 1943, and a conference was held at the Rechlin test base on March 18th, 1944, to examine some of the options including the *Egon*, *Y-Gerät* and *Zyklop*, and *Knickebein* navigation systems. The only practical way to perform this mission was to pre-set the guidance on the Fi-103 for launch from a single predetermined location along a predetermined bearing. Needless to say, this offered a much lower level of accuracy than the ground launchers. On April 6th, 1944, tests began of various bombers, and the Heinkel He-111 was selected. A program began to convert old subtypes into the He-111H-22 configuration with a launch station under the right wing. General Milch was not very keen on this program but acquiesced, feeling that the bomber launches would help confuse the British. In early May 1944, III/Kampfgeschwader 3 was assigned the missile mission and sent to Karlshagen for training.

The last launcher option examined before the start of the campaign was a local initiative by FR155W to develop a mobile, vehicle-mounted launch system, but this did not progress very far.

**A supply battery of Flak Regiment 155 (W) prepares missiles for launch. The missile on the left is mounted on the Zubringerwagen loading trolley which was mated to the launch ramp, and the missile slid into place. (NARA)**



**Operation Eisbär**

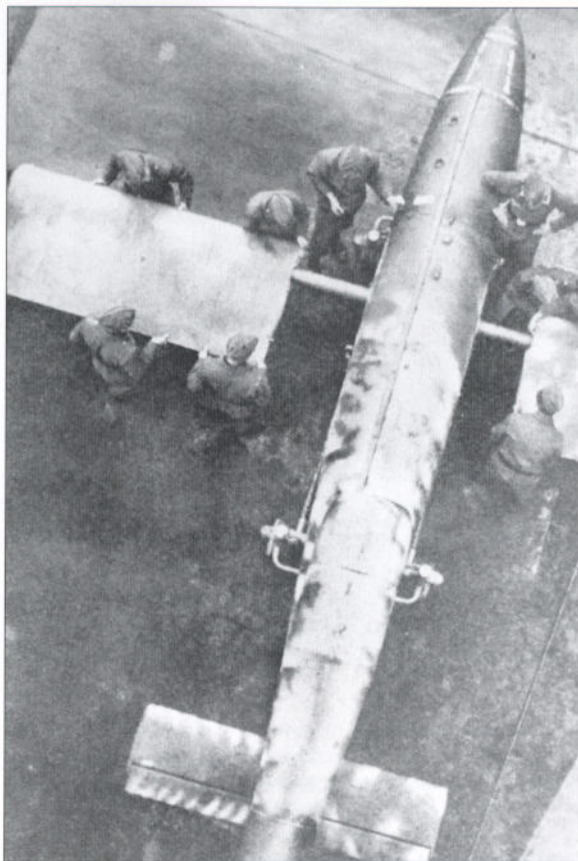
On May 16th, 1944, Hitler issued an order to start the missile attack on London by mid-June. Hitler wanted a massive attack with a 1,000 ground-launched missiles combined with aircraft-launched missiles, long-range coastal artillery, and bomber attacks. The codeword *Rumpelkammer* ("Junk-room") would alert the participating units to prepare the attack and

would be followed ten days later by the codeword *Eisbär* ("Polar Bear") initiating the attacks. By early June, FR155W had an inventory of 873 missiles. In response to the D-Day invasion, Field Marshal von Rundstedt's headquarters issued the codeword *Rumpelkammer* late on June 6th (D-Day) with plans to begin the attack on June 12th. The regimental staff warned that they would not be ready in time, especially after P-47 Thunderbolts hit a fuel convoy on June 8th destroying 270,000 liters of missile fuel. That same day, Allied fighter-bombers also severely damaged one of the trains bringing missiles to the launch sites. Due to the D-Day landings, the nine ski sites and 31 modified sites in Normandy were abandoned without firing any missiles in combat. Likewise, the 23 new launcher sites for two new battalions located west of the Seine were never used.

The codeword *Eisbär* was issued on June 12th, and General Heinemann departed for the FR155W command post at Saleux, southwest of Amiens. A rail-yard near the command post was heavily bombed that night which knocked out all the land-lines to the launch sites and forced a delay of the first launches to 2300hrs. The launch batteries reported that 63 of the 72 launch sites were ready to fire but, of the first salvo, only nine missiles actually left the launchers, and not one of these reached England. The second salvo, scheduled for 0330hrs, was only slightly more successful. Ten missiles were launched of which four immediately crashed in the vicinity of the launchers. Two more crashed into the Channel, and four reached England, one actually landing in London in Bethnal Green at 0418hrs. The Heinkel missile launchers were not yet ready and did not participate in the initial assault as planned. One of Churchill's advisors, Lord Cherwell, remarked that, "The mountain hath groaned and given forth a mouse!"

Heinemann ordered a cessation of launches and camouflaging of all launch sites until an inquiry could be made. It became quite clear that the launch troops, although very enthusiastic, had taken too many shortcuts to get the launch sites ready for the attack. The next attack, on the night of June 15th/16th, was far more successful. A total of 55 launchers fired 244 missiles, of which 45 crashed after launch, 144 reached the English coast, and 73 fell on London. Seven were shot down by fighters and 25 by anti-aircraft guns. On their own initiative, the 65th Corps also launched 53 missiles against the ports in the Portsmouth-Southampton area, hoping to disrupt Allied naval forces and shipping. When higher headquarters was informed of the port attacks, 65th Corps was reprimanded for violating Hitler's orders to concentrate on London.

Churchill held a meeting of the War Cabinet on the morning of June 16th and activated the "Diver" air defense plan. The British Anti-aircraft Command had developed the Diver plan in December 1943, but when the flying bombs failed to appear, the gun-belt shriveled due to the demand for anti-aircraft guns for Normandy. Instead, fighter aircraft were given a more



Once near the launch ramp, the tubular wing spar and wings were finally mounted to the fuselage. From the details of the warhead, this is a standard Fi-103A-1 of the type used in the campaign against London. (NARA)



**A member of the launcher section makes final adjustments to the missile autopilot assembly prior to launch. (NARA)**

V-1's one-ton warhead with unpleasant consequences for the fighter. Some of those destroyed by fighters were not actually shot down. In late June, pilots accidentally discovered that if they could fly alongside the V-1 they could tip it over by banking their aircraft. When upset in this fashion, the V-1 gyroscopes could not cope with the sudden change and the missile plummeted to the ground. The top V-1 ace of the war was Squadron Leader Joseph Berry flying a Tempest with No. 501 Squadron with 60 victories.<sup>1</sup> Of the aircraft types, the Tempest was the high scorer with 663 claims, followed by Mosquito night fighters with 486. The two top-scoring squadrons were both Tempest units, No. 3 Squadron (257 kills) and No. 486 Squadron (221).

By mid-July 1944, FR155W had fired about 4,000 missiles. Only about 3,000 actually reached the air defense corridor to London and 1,192 were knocked down, 924 by fighters, 261 by guns, and 55 by balloons. Hitler was exhilarated by press accounts of the terror the missile was causing in London and ordered the Luftwaffe to expand the effort. On July 12th, surveys began for additional launch sites, and on July 17th, the new FR255W was formed in order to create a V-1 missile brigade.

The V-1 attacks caused panic in London and there was an unofficial exodus from the city that summer. In addition, under a government plan, over 360,000 women, children and infirm were evacuated. What was especially frightening about the Doodlebugs was their eerie sound during the final approach. The pulse-jet engine was extremely noisy and could be heard from a great distance, but after the auto-log locked the tail

prominent role. A balloon barrage was added on June 22nd, increasing from 480 balloons to 1,400 balloons. By moving guns from elsewhere in Britain, by June 28th there were 376 heavy guns and 576 light guns in the Diver belt protecting London against the "Doodlebugs," plus a further 560 light guns of the RAF Regiment and two US Army radar-directed AA battalions. The Allies used many nicknames for the Fi-103. Besides official terms like Crossbow and Diver, popular names included Doodlebug, Buzz Bomb, and Hellhound, but V-1 became the most widely used.

After a brief survey, the RAF concluded that its Tempest fighter was by far the best choice for daylight interception both due to its excellent speed and the potent effect of its 20mm cannon. The pilots were aided by the fact that the V-1s often slowed down from their peak speed after about 15–20 minutes of flight due to the gradual disintegration of the shutters at the front of the pulse-jet. German radar plots in late June indicated that the V-1s were flying about 80km/hr (50mph) below their anticipated speed. Pilots soon realized that care had to be taken in firing on these small missiles from too close a range since a 20mm cannon round could detonate the

<sup>1</sup> See: Chris Thomas, *Typhoon and Tempest Aces of World War 2*, Osprey Aircraft of the Aces 27.

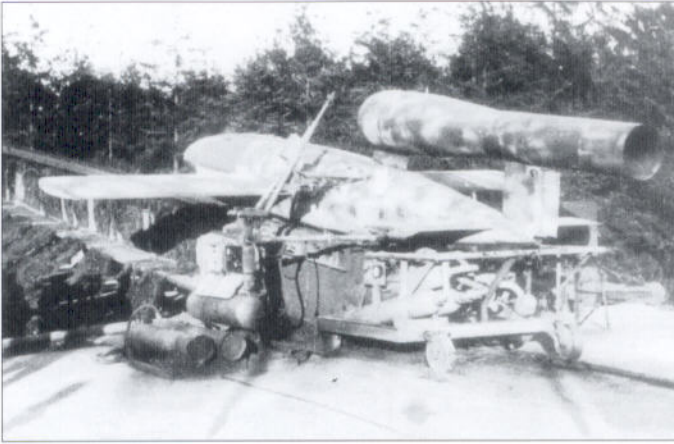


The ramp catapult was powered by a gas generator mounted on the Dampferzeuger trolley which was wheeled into place behind the ramp. These were nicknamed the *Kinderwagen* and were built by the Mansfeld GmbH in Leipzig beginning in September 1943. Each firing site had two of these. (T. Desautels)

controls into a dive, the engine usually shut off. The sputtering roar of the pulse-jet abruptly ended, followed by a sinister silence as the Doodlebug descended. This was not caused by the exhaustion of fuel as was widely believed, nor was the engine shut off intentionally. The Germans expected that the Fi-103 would go into a powered dive, not realizing that the engine vanes were so weakened by the hammering of the pulse-jet during the flight that the dive usually caused a massive shutter failure which ended engine combustion.

Churchill demanded that more action be taken to silence the missile batteries. Air attacks against the modified sites were intensified in early June 1944 but proved difficult as they were easy to camouflage and quick to move. More lucrative targets were the large missile storage centers, or *Feldmulag* (field munition depots), located in old quarries north of Paris. The Luftwaffe had planned to create 17 of these which could have sheltered about a thousand missiles each, but only three were operational: Leopold No. 1106 near St. Leu d'Esserent, Nordpol No. 1111 near Nucourt, and Richard No. 1116 near Rilly la Montagne. The two first sites were hit by the US Eighth Air Force in late June, but the thick caves at Leopold required another attack by the RAF's No. 5 Group with massive Tallboy bombs, which collapsed the tunnels during bombing on July 4th/5th. There was a decline in V-1 attacks for a few weeks until new supplies could be brought forward.

Even though one third of the missiles were being shot down by the London defense in early July, this was still not good enough. A significant problem for the air defense was achieving the proper mixture of guns and aircraft since, when fighters were present, the guns had to remain silent. To improve the air defense system, the anti-aircraft and fighter commands agreed to reorganize and introduce improved equipment. The anti-aircraft guns would be shifted to the coast where the new American SCR-584 gun-laying radars would have an unobstructed view of the missiles as they approached. The move took place on July 16th-17th, 1944, and required re-laying almost 2,000 miles of telephone cable and moving thousands of tons of weapons, ammunition, and equipment. The US Army also added a further improvement with the first combat use of its top-secret "variable-



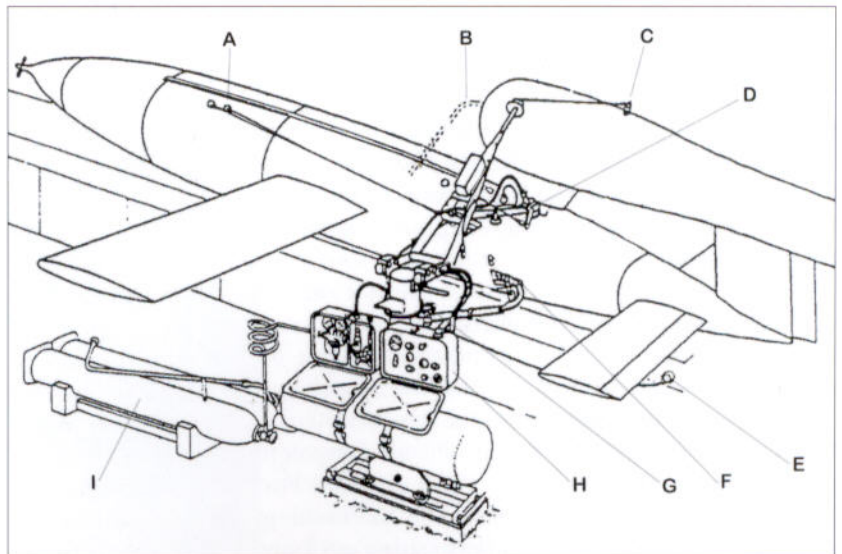
An Fi-103A-1 is loaded on the ramp with the Dampferzeuger catapult trolley in place and ready for launch. The Anlassgerät starter device immediately behind the wing provided the missile with pressurized air and electrical power prior to launch. (NARA)

time" (VT) fuze which proved to be more than five times as effective as conventional fuzes. The VT fuze was a miniaturized radar proximity fuze that detonated the projectile when it approached close to the target (standard anti-aircraft fuzes had to be set before firing according to the predicted height of the target and were therefore less accurate). The US Army had been reluctant to use the new design, fearing that, if any fell into enemy hands, a German copy could wreak havoc among the Allied heavy bombers over the Reich. The improvement was dramatic. During the third week of July, the guns accounted

for half of all flying bombs reaching the London area and continued to improve, reaching 83 percent by the end of August. The redesigned defenses proved much more effective, downing about 40 percent of the Doodlebugs before the move, and nearly 60 percent after the move.

The peak V-1 assault occurred on August 3rd when 316 missiles were launched, of which about 220 reached London. But the number launched subsequently began to fall due to the growing problems of supplying the sites, and the gradual loss of the launching areas. After having started with 72 launch sites on June 12th, the regiment suffered gradual attrition due to Allied air attacks, averaging 34 operational launchers per day during the course of the summer campaign. By mid-August, Allied forces were across the Seine river and threatening the launch area. General Heinemann ordered all surplus equipment moved towards Antwerp and bases in the Netherlands. On August 9th, *IV Abteilung* was ordered to pull out, and the neighboring *III Abteilung* the following day. The corps headquarters was moved from France to Waterloo in Belgium on August 18th-19th. By the end of August, only *I Abteilung* continued to launch missiles, firing its last from France at 0400hrs on September 1st.

This illustration from the FZG-76 technical manual shows the manner in which the Anlassgerät starter device was attached to the missile. This included the electrical line to the fuzes (A); compressed air line to the engine intake (B); electrical line to the engine spark plug (C); electrical connections to the autopilot (D); connection to the launch ramp (E); air pressure connection (F); attachment controls (G); control panels (H); and air pressure cylinders (I).





During this first phase of the missile campaign, a total of 8,617 V-1 missiles was launched by FR155W, of which 1,052 crashed immediately after take-off and 5,913 made it to Britain; 3,852 were knocked down by air defenses (1,651 by guns). So only about 2,300 missiles actually impacted in the target area, about a quarter of those launched.

### The air-launched missile campaign

Although there had been plans to begin launching FZG-76 missiles from the He-111 bombers of III/KG3 at the start of the Operation *Eisbär* in June, delays in equipping and training the squadron delayed its start. On July 9th, the squadron began attacks on London from Dutch airbases. By July 21st, a total of 51 FZG-76 missiles had been launched. On the evening of September 2nd, 23 were launched against Paris with little effect. By September 5th, 1944, when the first wave of attacks ended, III/KG.3 had launched 300 missiles against London, 90 against Southampton and 20 against Gloucester at a cost of two He-111 bombers.

The air-launched missiles were particularly inaccurate; none hit Gloucester and British authorities thought the shots against Southampton had been aimed at Portsmouth. About half the air-launched missiles fell within a circle 50 miles around the target, which was about three times worse than the ground-launched versions. The rapid Allied advance into Belgium and intense Allied air activity over the Netherlands forced the squadron to withdraw into Germany. Reorganization and expansion followed, with III/KG3 becoming I/KG53 and two more squadrons were allotted to the mission in October. When ready, the three wings deployed again to Dutch airbases.

At first, the British air defenses did not realize that aerial missile launches were being conducted but radar began tracking the missiles coming in from the North Sea, and starting on September 16th the gun belt was extended towards Great Yarmouth to deal with the threat. The air campaign proved costly and difficult for the Luftwaffe. For example, on a typical night assault on the evening of September 16th, of 15 bombers setting off, only

A Walter Schlitzrohrschleuder WR 2.3 catapult abandoned in northern France in late August 1944. The front end of the ramp has collapsed, but this photo gives an impression of its great length. The ramp was constructed of six to eight modular sections with a length of 36–48m (118–158ft). (NARA)

A view of a Walter WR 2.3 launch ramp abandoned near Amiens in August 1944. The missile was placed on a Spazierstock frame, one of which is evident in the foreground. A piston was placed in the circular tube inside the ramp which clipped to the missile. (NARA)

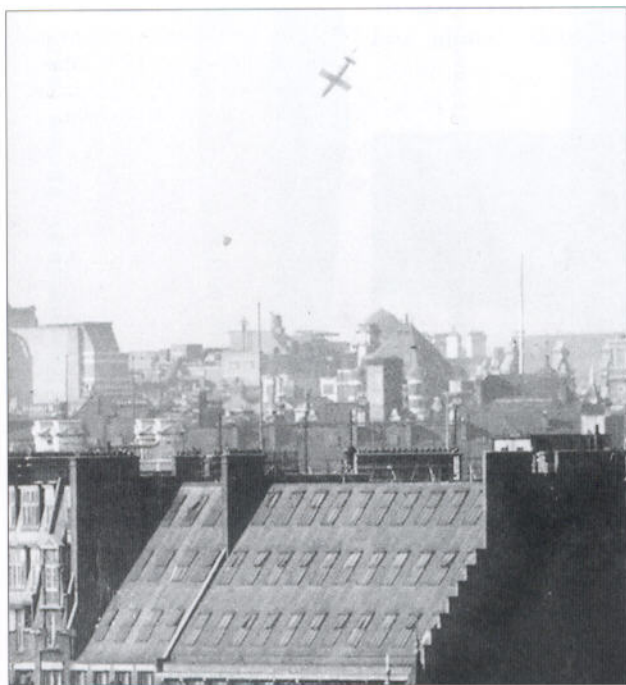






A V-1 on its way to London photographed during the summer 1944 attacks. (NARA)

A V-1 falls towards Piccadilly on June 22nd, 1944, during the opening phase of the missile attacks on London. (NARA)



nine released their missiles successfully; three of these were shot down by ships, two more by anti-aircraft and only two reached the London area. Launch failures averaged a quarter to a half of all missiles dropped.

When the land-launched V-1 campaign ended on September 1st, 1944, the air-launched missiles became more conspicuous and the RAF began a more vigorous effort to stamp out the threat. On September 24th, No. 25 Squadron began deploying Mosquito night fighters over the North Sea to look for the intruders. The Heinkels were caught unawares and on the night of September 25th, four

bombers with their missiles were shot down, and two more were lost on September 29th. The weight and drag of the missile reduced the cruise speed of the He-111H-22 to 270km/hr (170mph) and, even though the bombers were fitted with Liechtenstein radar-warning receivers, if a Mosquito spotted one, the Heinkel stood very little chance of survival. Three more bombers were caught by Mosquitoes in October.

The campaign continued through the fall, with the force slowly growing. On October 20th, KG53 had an operational strength of 77 bombers and a further 24 under repair. In November 1944, improved navigational aids were introduced including the *Schwan* ("Swan") FM transmitter and three *Zyklop* ("Cyclops") beacons on the Dutch coast. By early November, a total of 1,287 Fi-103 missiles had been launched during the air attacks. In December, fuel shortages reduced the sortie rate to only 20 per day and operations had to be halted for two weeks after a dozen bombers were lost in two operations when missiles detonated prematurely. On Christmas Eve, KG53 staged Operation *Martha*, its first and

only large scale attack against Manchester by 50 bombers. Only 30 Fi-103 missiles reached the English coast; half of these got to within 15 miles of the center of the city but only one actually landed within the city. By this time, KG53 had reached its peak operational strength of 117 bombers plus 85 more under repair. The last aerial launch was conducted on the night of January 14th, 1945, and nine days later the flights came to a halt due to the lack of fuel. By the end of the campaign, 1,776 missiles had been launched of which Allied radars identified 1,012. Of these, 404 were shot down including 320 by anti-aircraft, 11 by the Royal Navy, and 73 by the RAF. Only 388 impacted in England of which only 66 reached London. A total of 77 He-111 bombers was lost during the attacks, at least 16 to Mosquitoes, and the rest to weather and accidents. In other words, less than four percent of the missiles reached their target and more than one bomber was lost for every missile reaching London, a woefully ineffective record.



The V-1 was designed with very sensitive fuzes to detonate on contact. This shows the devastating results of an impact at St. John's Hill, Battersea on June 17th, 1944, during the first week of the attacks. (MHI)

## IMPROVED FI-103 MISSILES

Although FR155W had made repeated requests for changes and improvements to the Fi-103, the manufacturing plants were very reluctant to make any substantial alterations that might lower production. As a result, all of the missiles used in the summer 1944 campaign against London were the basic Fi-103A-1 version. Once production was well underway by the summer of 1944, a series of improvements and changes began. In June, a portion of the Fi-103s arrived with a hardened-steel cable-cutting blade along the front of the wing and the first 50 of these were launched on June 28th–29th. Provision was added for dispensing propaganda leaflets: a cardboard container about 1.5m (5ft) long could be carried in the tail and then released using a pyrotechnic device. FR155W also conducted its own experiments, dropping incendiary bombs and small anti-personnel bomblets from the missile.



A fairly intact specimen of a V-1 found near a Ninth Air Force airfield in northern France. Judging from the warhead, it is an Fi-103A-1, the standard type used in the campaign against London. It has had its two fuzes removed. (NARA)

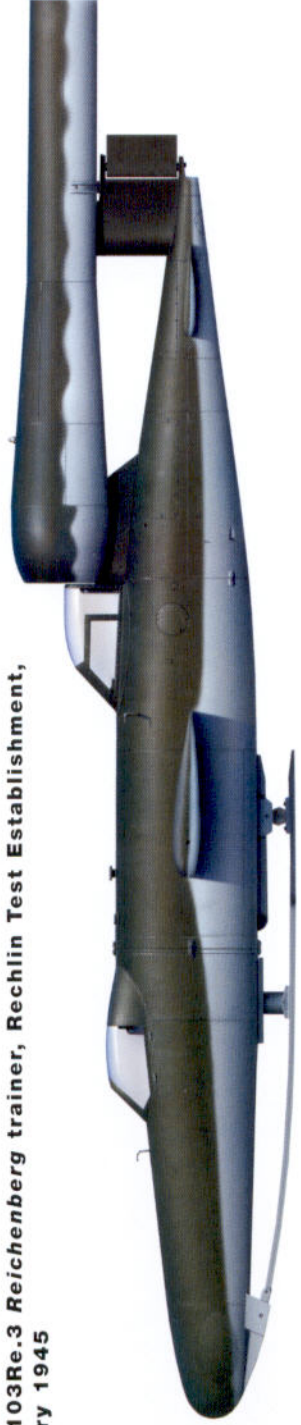
**A1: Fi-103 V-zellen, Peenemünde, spring 1943**



**A2: Fi-103 M-zellen, Lehr-und-Erprobungskommando Wachtel, Peenemünde, fall 1943**



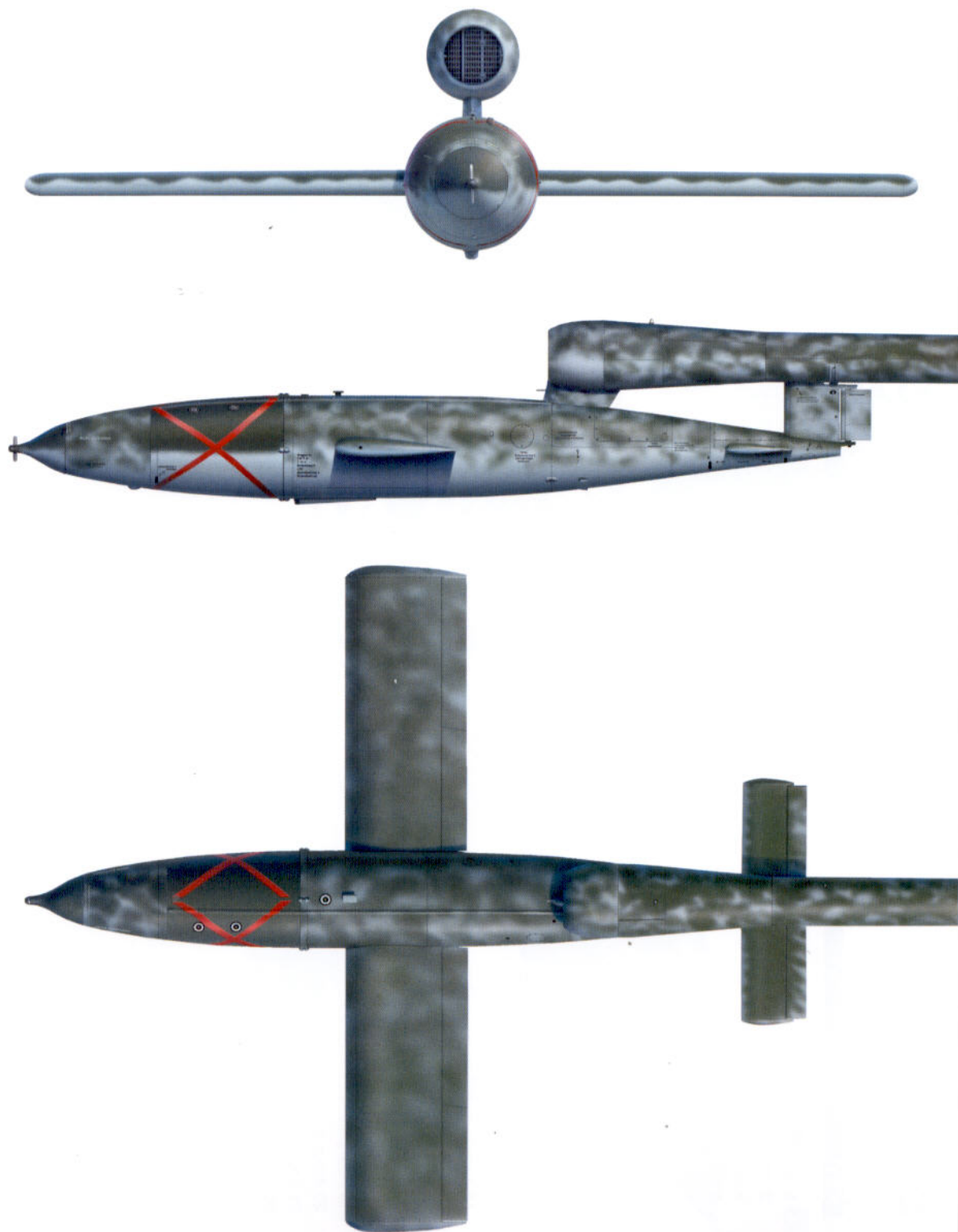
**A3: Fi-103Re.3 Reichenberg trainer, Rechlin Test Establishment, February 1945**



**B: Diver Down! London, August 1944**



C: Fi-103A-1, *Flak Regiment 155 (W)*, summer 1944



# D: FI-103A-1, FLAK-REGIMENT 155 (W), 1944

## KEY

- 1 Air pilot propeller
- 2 Magnetic guidance compass
- 3 Belly impact fuze
- 4 Main warhead exploder tube
- 5 Warhead explosive filling
- 6 Reinforcement support for launch rail
- 7 Main wing spar
- 8 Stamped metal wing reinforcing rib
- 9 Forward compressed air bottle
- 10 Rear compressed air bottle
- 11 Fuel flow control
- 12 Electrical battery
- 13 Flight control
- 14 Askania gyro flight control box
- 15 FuG-23 radio transmitter
- 16 Control surface servos
- 17 Trailing FuG-23 radio antenna
- 18 Rudder
- 19 Rear pulse-jet engine yoke
- 20 Argon As-109-014 pulse-jet engine
- 21 Engine ignition spark plug
- 22 Venturi assembly
- 23 Engine shutter assembly
- 24 Forward engine support yoke
- 25 Pilot tube
- 26 Fuel tank
- 27 Center lifting lug
- 28 Fuel filler cap
- 29 Rear Z80A fuze pocket
- 30 Forward Z80A fuze pocket

## SPECIFICATION

**Fuselage length:** 21ft 10in. (6.65m)

**Overall length:** 25ft 4in. (7.73m)

**Fuselage diameter:** 2ft 8in. (0.825m)

**Wingspan:** 17ft 6in. (5.33m)

**Launch weight:** 4,858lbs (2,200kg)

**Fuel:** 160 US gal (610 liters; 134 Imp gal) E-1 aviation gasoline

**Warhead:** 1,870lbs (850kg) Amatol high explosive, redundant impact fuzes

**Guidance:** Askania pre-set autopilot with gyro inertial platform and magnetic compass

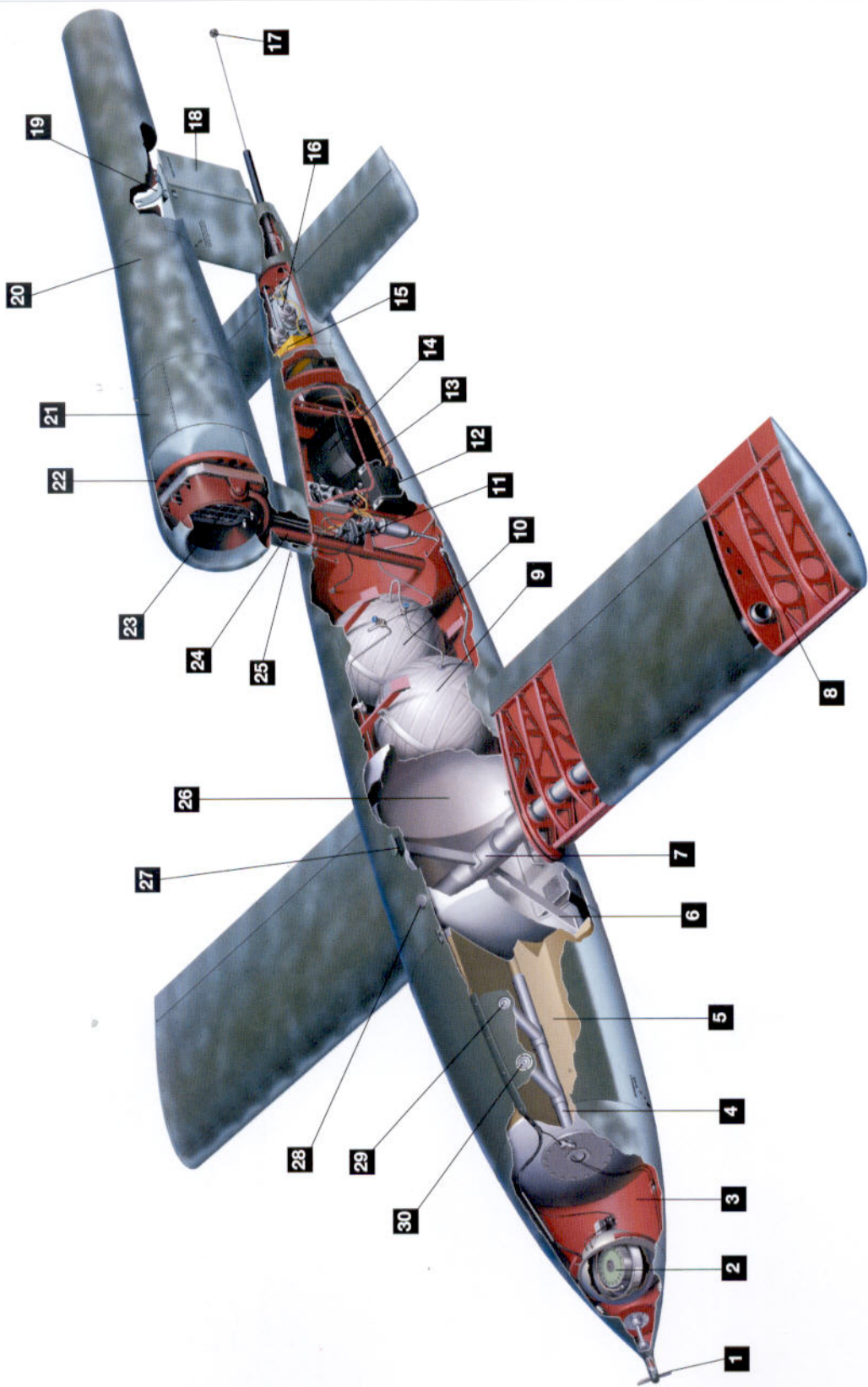
**Engine:** Argon 109-014 pulse-jet, max. thrust 310kg at 1,000m at 700km/hr

**Max. cruise speed:** 415mph at 4,500ft (670km/hr at 1,375m)

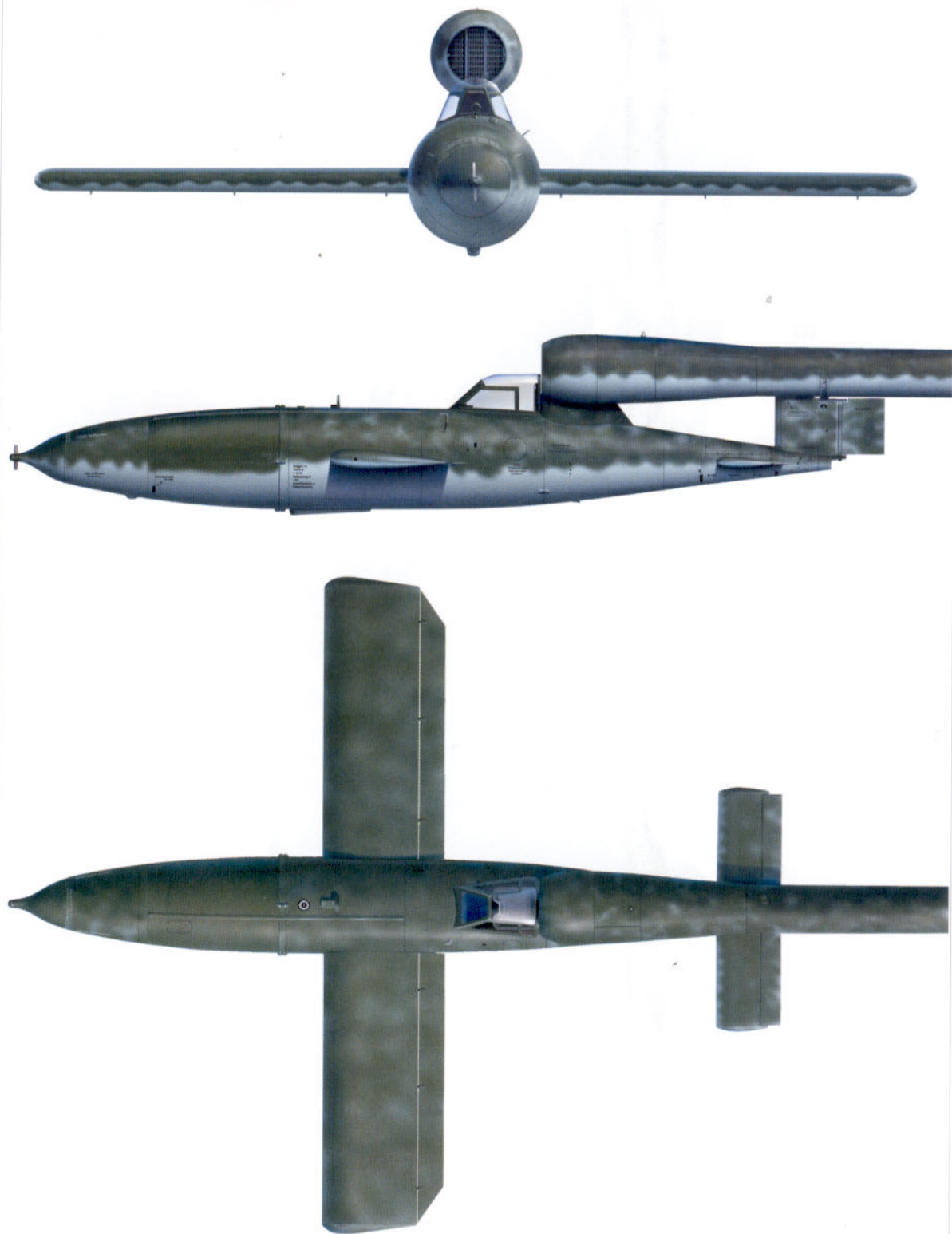
**Maximum range:** 125–130 miles (200–210km)

**Rate of fire:** 72 per launcher per day maximum; about 3 per day actual rate in 1944

**Accuracy (ground-launched):** Circular error probability of 8 miles (13km)



**E: Fi-103Re.4 Reichenberg, Karlwitz Munitions Depot,  
Dannenberg, Germany, 1945**

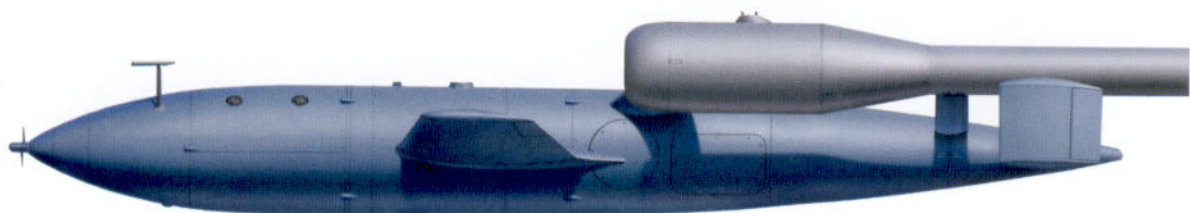
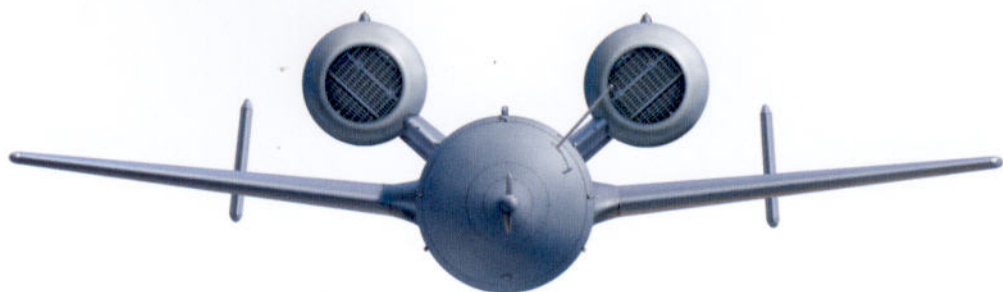






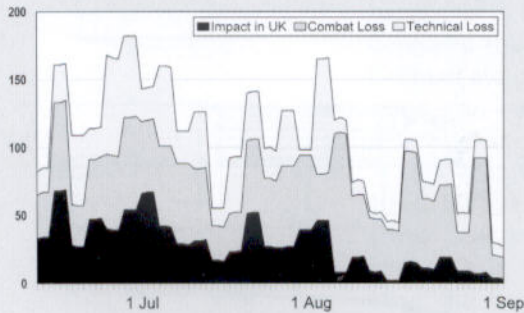
F: Hellhounds over the North Sea, October 1944

**G: 16Kh *Priboy*, Soviet Air Force, 1951**



## V-1 Launches Against London

June 12 to September 1, 1944



This chart shows the pace of missile launches by *Flak Regiment 155 (W)* against London in the initial phase of the campaign from June 12th to September 1st, 1944. The lower band shows the number of missiles which landed in England, the middle band shows the missiles brought down by air defense, and the upper band shows the missiles which crashed after launch or otherwise disappeared due to technical problems. Due to discrepancies in accounting between German and British records, the data are based on three-day averages which tends to level the extremes. (Author)

substantially, and during the final actions of March 1945, more than half the missiles had this feature.

Due to steel shortages, a number of efforts were made to conserve material including the design of a wooden wing. The wooden wings had a slightly greater span than those of the original metal-wing A-1, and they reduced the wing weight by about 38kg (85lbs). The first of the wooden-wing versions was the Fi-103B-1 which also substituted plywood for steel in some of the nose construction and had some other changes such as the location of the fuze pockets. The first wooden-wing Fi-103 missiles were launched in late February 1945. There was some change to the wooden wing late in the production run. A wooden-wing Fi-103 currently preserved at the Ordnance Museum at the US Army's Aberdeen Proving Ground shows that the internal framing of the wing was wood, but that a thin sheet-metal cover was added over the wood. The Fi-103B-2 was similar to the B-1 but substituted Trialen explosive and improved fuzing. The Fi-103C-1 used a lighter SC 800 aircraft fragmentation bomb inside the fuselage instead of the normal warhead to extend the range. The Fi-103D-1 was designed to carry chemical warfare agents; so far as is known there was no series production.

In the fall of 1944, intensive work was undertaken to extend the range of the Fi-103 so that it could be launched against London from sites in Holland. The initial version was the Fi-103E-1 which was fitted with a wooden wing, an enlarged fuel tank with a capacity of 810 liters (214 US gallons; 178 Imperial gal) instead of the usual 690 liters (182/152 gal), and a smaller plywood-encased warhead. The definitive long-range version was the Fi-103F-1 with 1,025 liters (271/225 gal) of fuel and the warhead reduced to 530kg (1,168lbs). A final type with the fuel tank increased to 1,180 liters (312/260 gal) was found at the Mittelwerke by Allied troops, but does not appear to have entered serial production.

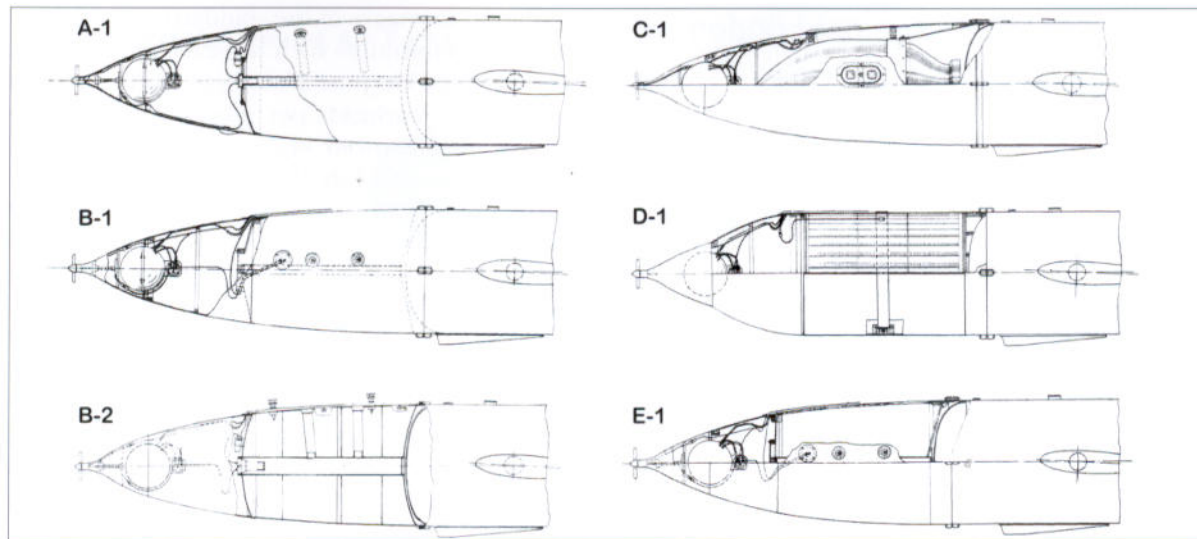
One of the lingering problems with the Fi-103 design was the inefficiency of its pulse-jet engine. Design studies for a jet-powered Fi-103 using the Porsche 109-005 turbojet engine were begun, but these did not progress very far before the war ended.

### Operation *Donnerschlag*

FR155W managed to extract about three-quarters of its troops from France, but all of the heavy launch equipment except that from

Due to shortages of the standard Amatol 39A+ explosive, substitutes such as 52A+ were used in some missiles. On June 25th, 1944, Hitler ordered that 250 V-1 warheads per month be filled with Trialen, an enhanced blast explosive, and these were first used on July 18th, 1944. Other types of explosive such as Myrol were planned but not employed. By 1945 shortage of explosives led to the substitution of low-grade commercial Donarit explosive in many warheads.

During the 1944 summer campaign against London, about seven percent of the missiles were fitted with FuG-23 transmitters to help triangulate the location of the impacts. In later campaigns, the percentage fitted with this device increased

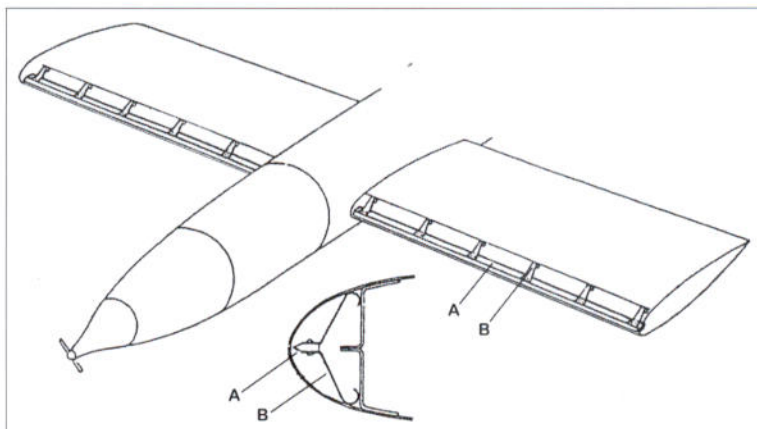


III Abteilung was lost. The regiment was reorganized around two launch battalions and the other two were converted to flak units. New launch sites were scouted along the Rhine in Sauerland and northern Westerwald, but there was some anxiety about launching near heavily urbanized regions of Germany due to the large numbers of missile crashes. Since some launch sites had already been scouted in the Eifel forests along the Belgian frontier, these were the first sites to become active. The Eifel region was in range of the port of Antwerp, and the border area had only scattered German villages that were less likely to be hit by wayward missiles. By mid-October, one battery from III/FR155W was ready to begin launching missiles from the Eifel near Mayen, but examination of the 329 missiles in inventory found 226 to be defective, and repairs delayed the launches.

The first launches of Operation *Donnerschlag* ("Thunderclap") began from Germany at 0723hrs on October 21st, 1944. Of the 410 missiles launched in late October, 55 were aimed at Brussels and the remainder at Antwerp. The improved autopilot permitted a new "oblique firing" (*Winkelschuss*) tactic. The launcher no longer had to be directly aimed at the target since the missile could make one course correction after launch to align itself to the target. The main advantage of this feature was that it made it difficult for the Allies to track the missile launch path back to the launch site. The disadvantage was that it caused a higher rate of crashes. By the end of the month, eight launch sites were operational in the Eifel, none of which was discovered by Allied aircraft due to the forest cover in the region. In spite of the best efforts of FR155W to avoid hitting German towns, V-1 and V-2 missiles often crashed after launch, and so the V-weapons were grimly dubbed the *Eifelschreck* ("Horror of the Eifel").

These original German plans show the warhead configurations of the main types of Fi-103. Externally, the Fi-103 variants can be distinguished by the location of the fuze pockets; otherwise, most of the warhead shapes were similar.

Starting in late June 1944, some of the V-1 missiles launched against London were fitted with a Kuto cable cutter to deal with the threat of barrage balloons. This illustration from the manual shows how the cutter was contained within the leading edge of the wing with the blade (A) attached by metal clips (B).



When Antwerp was captured by British forces in September, Field Marshal Montgomery recognized that the port would be a likely target for the Doodlebugs and asked Eisenhower to provide US anti-aircraft battalions to help defend the city. IX Air Defense Command originally deployed three gun battalions in mid-October, but as the pace of the German attacks increased, this grew to two AA brigades, four AA groups, seven gun battalions, two automatic weapons battalions, and a British searchlight regiment by early November.

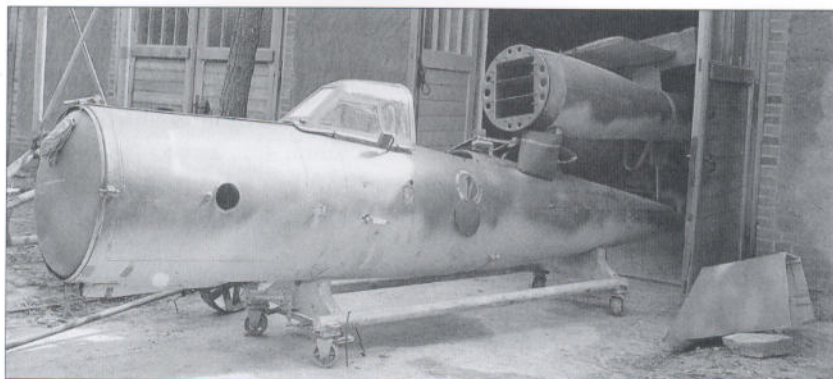
The 65th Corps was renamed the 30th Army Corps on October 24th, 1944, for deception purposes. The original plan had been to use the corps headquarters to control both the V-1 and V-2 units, but when control over the V-2 missiles was usurped by the SS in the summer of 1944, the rationale for the corps disappeared. The corps was disbanded on November 16th, 1944, and the Luftwaffe combined FR155W and the partially organized FR255W into 5th Flak Division (W) with Colonel Walter of the corps staff as its commander.

On November 20th, 1944, III/FR155W began Operation *Ludwig*, launching missile attacks on Liège. This was prompted by continued requests from Army Group B since Liège was the center of US Army supply efforts for the fighting around Aachen. Anti-aircraft defense of Liège was begun on November 23rd, 1944, and proved far more difficult than at Antwerp due to the significant number of anti-aircraft rounds that fell into US Army troop concentrations nearby. To avoid this problem, the anti-aircraft units were moved as close to the front-line as possible.

As the tempo of launches increased, FR155W began reconstituting a third battalion but the location of launch sites remained contentious. By December, 20 sites had been completed along the Rhine and eight launchers erected, but the continued high rates of crashes led to reluctance to launch from sites near German cities. Instead, the regiment decided to establish new sites in the Netherlands since, according to the regimental diary, "in Holland there is no need to worry about the civilian population in respect to premature crashes." Two battalions deployed to new sites around Deventer in the Netherlands, beginning their campaign against Antwerp on December 16th, while III/FR155W continued its attacks from the Eifel against Liège.



A collapsed Walter WR 2.3 launcher ramp discovered by US troops after the January 1945 Ardennes fighting pushed III/FR155W out of the Eifel region of northwestern Germany. These well-camouflaged launch sites in dense forests were shielded by winter overcast and ground fog, making them almost impossible for Allied aircraft to find. (MHI)

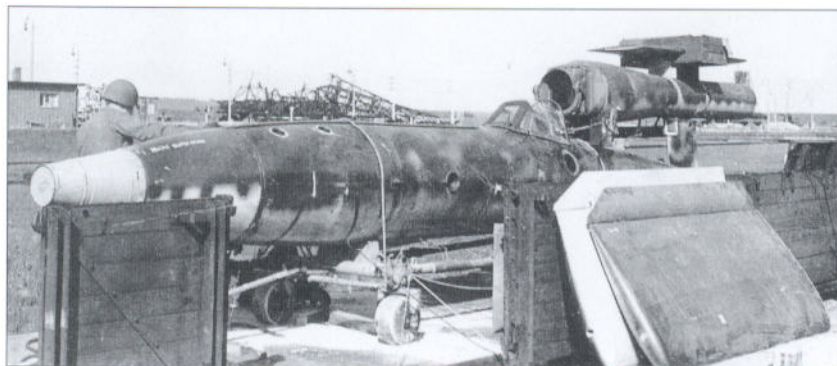


One of the curiosities discovered by the US 29th Infantry Division at the Luftwaffe's Karlwitz munitions depot near Dannenberg in April 1945 were these incomplete Fi-103Re.4 piloted missiles. The fairing that sat behind the cockpit canopy can be seen in the lower right. (NARA)

The start of V-1 attacks from Holland in December forced a reorganization of the Antwerp defenses to cover the northeastern approaches, but when the Germans launched their Ardennes offensive on December 16th, the US Army removed seven AA battalions from the defenses. Two British heavy AA regiments were added in their place. The anti-aircraft units assigned to Liège were in the thick of the Ardennes fighting, and were reassigned as improvised anti-tank units. Air defense of Liège was never reestablished.

The Dutch missile sites proved more vulnerable to Allied aircraft, in part due to the help of the Dutch resistance in identifying the sites. For example, on January 24th, 1945, a flight of P-47 Thunderbolts caught a crew loading a missile which was destroyed on its launch rail. The next day an attack destroyed a missile storage area, blowing up 30 missiles and a considerable amount of fuel. The vulnerability of the sites led to a revival of the tactics used in France to move the sites periodically to avoid detection. The test of this tactic, called Operation *Mülleimer* ("Trashcan"), shifted batteries of II/FR155W to the Rotterdam area, and fired about 300 missiles in eight days starting on January 27th, 1945.

The failure of the German counter-offensive in the Ardennes in December 1944 threatened the Eifel launch bases and, on January 27th, III/FR155W was told to prepare for Operation *Oktobertfest*, a concentration of all three missile battalions in the Netherlands. Since not enough sites were ready there, one battery began launches from the abandoned launch sites around Cologne for a week starting on February 11th, 1945. The US Army restored the Antwerp defenses in late January, with the northeast corridor facing Holland receiving the most guns. The most important



One of the few Fi-103Re.4 piloted missiles found with its intended warhead was this one, found near Rheinmetall's Hillersleben artillery proving ground on its TW-76 trolley. Its wings are stacked near the side of the rail car and show the ailerons that were added to this version of the missile. (USAOM-APG).

change was the decision to permit the use of proximity fuzes, which increased the kill rate. Nevertheless, air defense was difficult due to the close range of the launch sites, restrictions on the placement of guns due to Allied airfields and populated areas, and the low altitude of the missile approach. In total, FR155W launched 8,696 Fi-103s against Antwerp, 3,141 against Liège and 151 against Brussels. Of the 8,696 launched against Antwerp, only 4,248 actually reached the Antwerp region, and of the 2,759 that entered the air defense zone around Antwerp, 1,766 were shot down and only 211 fell into the port area. The last Fi-103 struck Antwerp on March 27th, 1945, at 2245 hours. Casualties due to the Fi-103 totaled 3,736 civilians and 947 military killed, plus 8,166 civilians and 1,909 military wounded. Of the total 14,758 casualties in Belgium, Antwerp bore the brunt of the share, 10,145 (8,333 civilian, 1,812 military), and Liège most of the remainder.

#### FI-103 ATTACKS ON BELGIAN CITIES

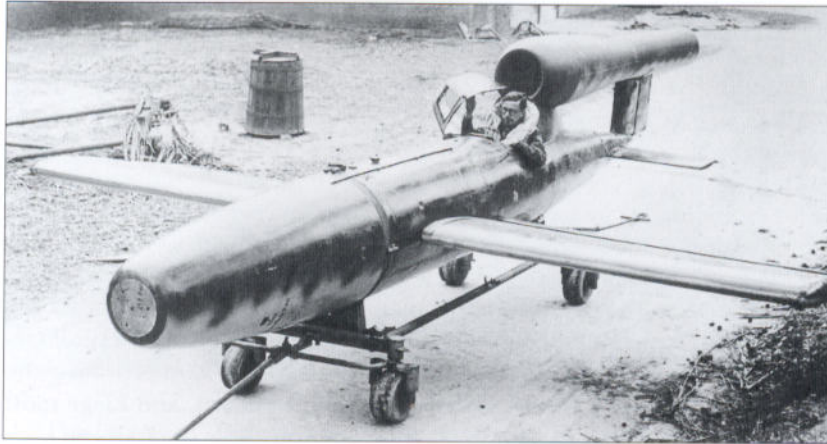
	Oct 44	Nov 44	Dec 44	Jan 45	Feb 45	Mar 45	Total
Launched	410	2,119	2,568	2,537	2,787	1,567	11,988
Crashed	48	292	363	429	374	225	1,731

FR155W was subjected to more reorganization in early 1945 due to the declining fortunes of the German war effort. Fuel was strictly rationed, and the supply of missiles was cut from 160 to 100 per day. At the end of January 1945, the 5th Flak Division was ordered to convert part of its force into an infantry regiment for dispatch to the Eastern Front, which cut the manpower in the launch units to a bare minimum. In mid-February, SS-Gen.Lt. Hans Kammler, SS special commissioner for missile operations, took over control of the division, and Walter was replaced by Wachtel as divisional commander after he refused to switch to the Waffen-SS.

The new extended range Fi-103E-1 missile became available in February 1945 and could reach London from launch sites in the Netherlands. A total of 21 launch sites was prepared for Operation *Pappdeckel* ("Pasteboard"). The attacks began on March 3rd, 1945, and 275 missiles were launched against London through March 29th, 1945. Of these, only about 160 flew any significant distance, 92 were downed by air defenses and only 13 reached London, the last on March 28th, 1945. With their launch sites about to be overrun in the Netherlands, the missile campaign came to an end. In total, the Doodlebug attacks had killed about 5,500 people and wounded 16,000 in England as well as causing substantial damage.

In retrospect, the V-1 was a far more effective weapon than the V-2 in terms of the much smaller cost of developing, manufacturing, and employing the missile.<sup>2</sup> Paradoxically, the greater vulnerability of the V-1 to interception prompted the Allies to expend a great deal of effort to defend against it, both in the initial Crossbow bombing campaign, as well as the air defense efforts over London, Antwerp, and Liège. Nevertheless, the Allies could afford to divert resources to counter the V-1 while it is questionable that the German efforts on the V-weapons were commensurate to the results. The warheads of the V-weapons consumed the equivalent of half the total explosive consumption of the entire Wehrmacht in the critical

<sup>2</sup> See: Steven Zaloga, *The V-2 Ballistic Missile 1942-52*, Osprey New Vanguard 82.



Although this is one of the best-known photos of a *Reichenberg* piloted missile, the configuration is a bit suspect. This particular example was assembled from parts found at the Karlwitz munitions depot near Dannenberg in May 1945 by a US Navy Technical Mission Europe team. It is by no means clear that this particular type of plywood warhead casing was actually intended for this version. The officer demonstrates how difficult it would have been for the volunteer pilot to have escaped from the missile while wearing the prescribed life vest. (NARA)

months of July, August, and September 1944, and equal to the total explosives production of the fall of 1944. At a time when the fate of the Third Reich was in the balance, the V-weapons were wasting more than half of the available explosives to kill a thousand British and Belgian civilians a month. By the fall of 1944, the prodigal expenditures of the V-weapons program led to a shortage of explosives that was so acute that rock salt was being used as an extender in explosives for artillery ammunition, and severe limits had to be placed on the anti-aircraft defense of the Reich due to the ammunition shortage. While the V-1 attacks caused considerable misery for Londoners in the summer of 1944, the end of the war was in sight and the attacks had no profound impact on British morale. The attacks on Antwerp were even more severe, but only a couple of hundred V-1s actually landed within the port area, the ostensible objective of the campaign, and caused little significant damage. While the V-weapons may have satisfied Hitler's thirst for revenge, from a military perspective, they were utter folly.

### **The *Reichenberg* piloted missile**

The most notorious version of the Fi-103 was the Fi-103R *Reichenberg*, a piloted version intended for attacks on high-value targets. Hitler's favorite adventurer, Otto Skorzeny, and the famous test pilot, Hanna Reitsch, have both laid claim to the idea. The pilot would steer the missile at the target and, if lucky, would parachute out at the last second. Many Luftwaffe commanders were disturbed by the suicidal nature of the scheme, recognizing that other guided missiles such as the Hs-293 or the Mistel could perform the same role. But in the paranoid atmosphere of the time, it was unwise to challenge the pet projects of Hitler's associates.

Modification of the Fi-103 was fairly simple, and the Henschel plant at Berlin-Schönefeld designed a rudimentary cockpit plus a pair of ailerons to provide better flight control. Flight tests of a prototype began at the Rechlin test center in September 1944. The pilot of the first flight suffered severe spinal injuries due to the high speed of the landing and the use of a rudimentary landing skid without shock absorbers. During the second flight, the canopy blew off and the pilot was seriously injured during the landing. After improvements were made, additional flights were conducted, including several by Willy Fiedler of Fieseler and Hanna Reitsch.





Since most of the *Reichenbergs* discovered at Dannenberg lacked a warhead, many of the examples sent back to the United States for display ended up with bogus noses. This particular example was part of a display in Washington, DC, immediately after the war and has both a fake nose and a phony swastika marking on the tail. (MHI)

The Fi-103Re.1 proved difficult to fly, and so in September a two-seat, unpowered trainer was built as the Fi-103Re.2 and in November the Fi-103Re.3 powered two-seat trainer was assembled. During the second test flight of the Fi-103Re.3 on November 5th, 1944, the left wing fell off due to vibrations from the engine, though test pilot Heinz Kensché managed to extract himself from the cramped cockpit. This inadvertently demonstrated the enormous difficulty of parachuting from the *Reichenberg*, even for a skilled test pilot.

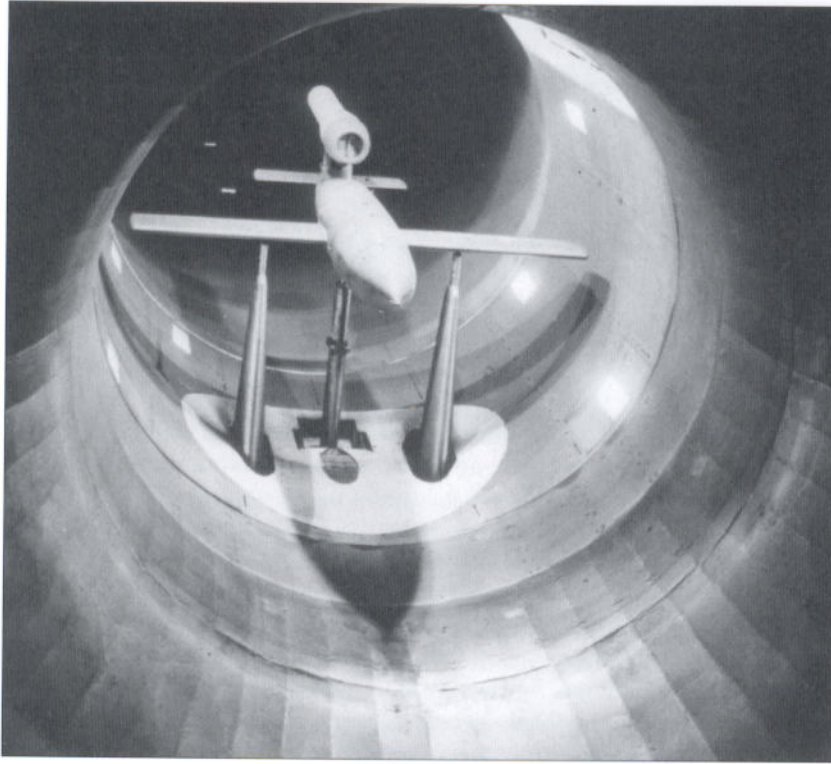
*Reichenberg* operations were assigned to the "Leonidas Staffel" of the special-operations unit, KG200. The Inspector of Bombers, Generalmajor Walter Storp, wanted to create an entire suicide division, dubbed *Jägerdivision Hermann Göring*. Of the 70 volunteer pilots, about half had received some measure of training by late February 1945, when further training was suspended due to a lack of fuel. Testing of the *Reichenberg* continued at Rechlin, and on March 5th, 1945, test pilot Kensché's luck ran out when a modified Fi-103Re.3 with shortened wings had both wings peel off during a test flight. This was the last straw for the commander of KG200, Oberstleutnant Baumbach, who got into a bitter argument with General Storp over the stupidity of the whole venture. Baumbach asked the head of the German war industry, Albert Speer, for help. On March 15th, Speer and Baumbach visited Hitler and Speer helped convince him that suicide attacks were not part of the tradition of German warriors. Hitler agreed, and later that day, Baumbach ordered the commander of IV/KG200 to disband the unit. Over 200 *Reichenberg* missiles were converted by Luftwaffe munitions depots at Dannenberg and Pulverhof, but none were ever deployed except for those at the Rechlin test establishment.

Curiously enough, Japanese liaison officers visited the facility on several occasions. German technological assistance formed the basis for the Japanese analog of the *Reichenberg*, the Kawanishi *Baika* ("Plum Blossom") kamikaze aircraft which was not finished before the end of the war.

## FOREIGN COPIES OF THE V-1

### The JB-2 Thunderbug

The US Army Air Force in 1944 was very impressed with the V-1 if for no other reason than the enormous amount of resources used to combat it. Nearly a ton of V-1 parts were rushed to Wright-Patterson Field on July 12th, 1944, and the staff was ordered to build 13 copies called the JB-2 (Jet Bomb 2). Amazingly, these were completed in three weeks, and a recommendation was made to begin quantity production. The War Department was not very keen on the idea, pointing out that its lack of accuracy limited its use to terror bombing. But production was finally authorized with an understanding that its guidance would be improved. In late July 1944, the USAAF ordered 1,000 JB-2 missiles with Republic and Willys building the airframe, and Ford the engine. Northrop designed a new ramp with rocket sled since details of the German launcher were not available. The USAAF planned to order 1,000 per month, increasing to



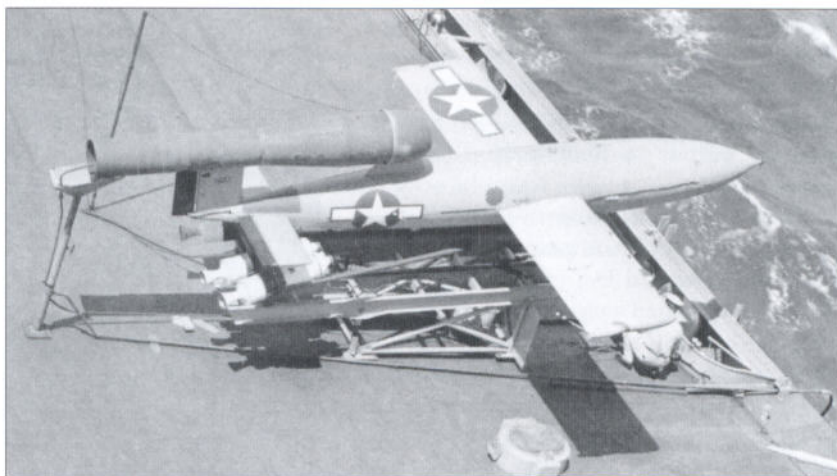
The US Army Air Force was quick to exploit captured V-1 technology and manufactured a copy, the JB-2, in late 1944. This shows a test example in a wind tunnel. (NARA)

5,000 per month by September 1944. General Spaatz (commanding US strategic bomber forces in Europe) was not keen on deploying the JB-2 in Europe, feeling that it would adversely impact the supply of more conventional ordnance and that it was not accurate enough to be worth the trouble. After the initial burst of enthusiasm, a more sober appreciation of the limitations and high cost of the program sank in, and in late January 1945 the War Department stopped any further production contracts for the JB-2. When production ended in September 1945, 1,391 JB-2s had been built.

The first JB-2 Thunderbug was launched at Eglin Air Force Base in October 1944. The USAAF had many of the same problems as the Germans and, by early December 1944, only two of ten test launches had been successful. By June 1945 the record had improved to 128 out of 164 test launches. The USAAF tested several launch methods including a 400ft inclined ramp, a level ramp with rocket sled, and 50ft trailer ramps. Air launches were also attempted, flying two JB-2 Thunderbugs under the wings of a B-17G bomber. The USAAF also tested improved guidance, using radar tracking to provide data for radio commands to update the inertial autopilot. After expending the remaining missiles during tests in 1949, the air force abandoned the JB-2 due to its poor accuracy and the limitations of its pulse-jet engine. None were used in combat.

Not to be cut off from this new technology, in 1945 the US Navy asked the USAAF to set aside 351 missiles which it called the LTV-N-2 Loon (Launch Test Vehicle-Naval). Under Project Derby, these were initially launched from shore-based ramps and surface ships. The Navy had many problems with these, managing only five successful launches out of its first 84 from January 1946 to December 1947. The Navy shifted the emphasis

The US Navy was not keen on long launch ramps, and eventually developed a zero-length launcher using rocket-assisted take-off, as seen here with Loon No. 244 aboard the test ship *USS Norton Sound* in August 1949. (NARA)



of the program in 1946 to study the use of cruise missiles from submarines, and conducted the first launch of a cruise missile from a surfaced submarine on February 12th, 1947. The Navy wanted a less cumbersome launcher, and developed a zero-launch ramp using an improved rocket booster that was first tested from the *USS Norton Sound* on January 26th, 1949. During the last series of trials from January 1948 to March 1949, 37 of 70 launches were successful. However, the Navy was never very happy with the Loon, and began working on a jet-powered cruise missile, the Regulus, in November 1947. Some thought was given to firing a few Loons at North Korea during the 1950–53 war, but there was no compelling reason to do so. Curiously enough, a Hollywood movie, *The Flying Missiles* (starring Glenn Ford), was made based on the missile submarines.

### Soviet V-1 copies

News of the German missile attacks on London prompted Stalin on June 13th, 1944, to order the start of a program to develop a Soviet counterpart. Vladimir Chelomey had been working on pulse-jet engines, so was assigned the task in October 1944 and given control of the OKB-51 design bureau after the famous fighter designer N.N. Polikarpov died. The Red Army collected a partial V-1 at the Blizna test range in Poland. The initial V-1 copy was called the 10Kh and later *Izdeliye 10* (“Article 10”). The Russian Cyrillic letter “Kh” resembles the Roman “X” so these early missiles were nicknamed the “Iksy” or “Xs” for this reason. Serial production was scheduled to begin in March 1945 starting at 100 per month and building up to 450 monthly by later in the year.

Since no launch ramps were ready, the first launch was conducted from a Pe-8 bomber on March 20th, 1945, in central Asia near Tashkent.

By late August, 63 missiles had been launched, of which about a third reached the target area. A batch of 180 improved 10Kh (*Izdeliye 30*) missiles with wooden wings was built, and 73 more air launches were conducted in December 1948. A ground-launched version called the 10KhN was also tested in 1948 using rocket-assisted

The US Navy Loon program was intended to examine the suitability of future cruise missiles for submarine launch. Here, Loon No. 995 is launched from SSG-337 *USS Carbonera* off the California coast on December 2nd, 1950.



take-off and a ramp. In all the program dragged on for more than five years as improvements were made to the guidance, propulsion and launch system but the last series of tests in 1951 was disappointing.

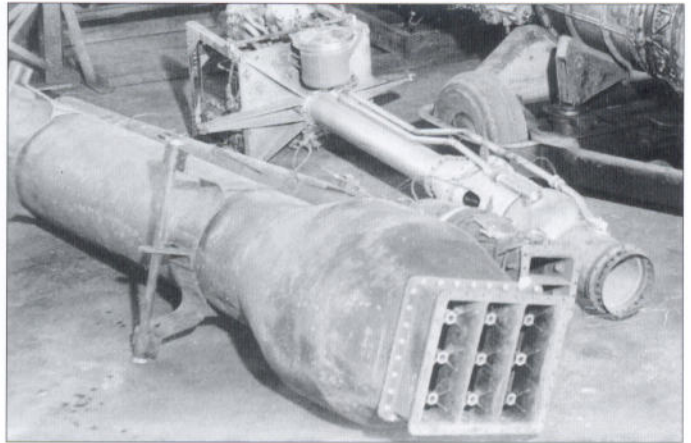
In parallel to the improved 10Kh with its D-3 pulse-jet, ten improved 14Kh with the more powerful D-5 engine were built in 1947. These had a tapered wooden wing with ailerons, but otherwise resembled the 10Kh. Test launches were conducted from Pe-8 bombers in July 1947.

By this time it was becoming clear that both the 10Kh and 14Kh were a technological dead-end due to the inaccuracy of their guidance system. A new radar beam-riding system was in development at the time, codenamed *Kometa*, and this was fitted to the new 16Kh *Priboy* ("Surf") missile, which also introduced paired D-14-4 pulse-jet engines. Test launches of the 16Kh were initially conducted from a Tu-2 bomber and 17 launches were made in January-June 1948. Improvements were made to the *Priboy*, and work on a TV-guided version also started. Following 1951 tests from the Tu-4 bomber, the state commission recommended putting the missile into production, but the Soviet Air Force was unhappy with its poor accuracy, unreliability, and cold weather performance. In parallel to the 16Kh, the Mikoyan fighter bureau was developing a jet-powered cruise missile, the KS-1, that offered a more satisfactory performance. KS-1 production began in late 1952, and the first series production missiles were turned over to a Tu-4K bomber regiment of the Black Sea Fleet in May 1953. This missile was later called the AS-1 *Kennel* by NATO. As a result, the 10KhN land-launched missile and 16Kh air-launched missile programs were terminated on February 19th, 1953, in favor of the Mikoyan missile, though there were some efforts to revive them as test drones in the mid-1950s. In spite of the failure of the program, Chelomey later went on to head NPO Mashinostroyeniye which became one of the most successful Soviet missile design bureaus, developing numerous cruise missiles, ballistic missiles, space boosters, and satellites.

Besides the Chelomey missile program, in October 1945 the Soviet-controlled Junkers plant at Dessau in Soviet-occupied Germany was assigned to develop a piloted attack fighter version of the V-1, called the EF-126. A total of five pilots were completed in 1946, and glide tests began in May 1946. The definitive production version would be armed with a pair of 20mm cannon and a new Jumo 226 jet engine. The second test flight on May 21st, 1946 resulted in a crash which killed the German test pilot. The remaining prototypes along with pilot versions of the Jumo 226 engine were sent to the Soviet Union, but the program was soon abandoned.

### Other V-1 copies

Of the major powers, Britain never manufactured a copy of the V-1, though the Red Rapiet cruise missile program of 1950 was certainly inspired by it. Therefore the only other air force to copy the V-1 in any significant numbers was the French. Arsenal de l'Aéronautique in



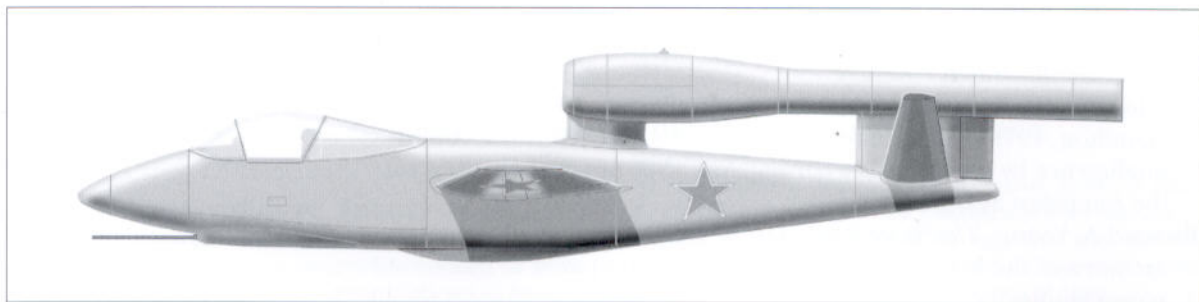
The Germans provided the Japanese with considerable information on the V-1 and its Argus pulse-jet engine. The only tangible outcome of this cooperation was the construction of prototypes of the Maru Ka-10 pulse-jet engine for the still-born Kawanishi *Baika* kamikaze. One is seen here in the foreground along with a Toko Ro.2 rocket motor copied from the Walter HWK 509A of the Me-163 *Komet* fighter. (NARA)

Châtillon began work on a V-1 copy in 1947. It was not intended as a cruise missile, but rather as a jet-powered target drone for use with new air-to-air missiles that the firm was designing. Designated as CT 10, the first trials of the drone were completed in April 1949. It was actually smaller than the V-1, and used twin rudders like the original German Erfurt proposal. CT 10 could be launched from a ground ramp using solid rocket-assisted take-off, or from aircraft such as the Leo 451 medium bomber. About 400 were manufactured and some were sold to Britain and the United States.

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There is an extensive assortment of books and articles on the V-weapons, and not surprisingly, the accent in the English-language books is on the campaigns against London, as well as the Crossbow campaign to stop the missile attacks. Besides the books listed below, there is a wealth of secret reports prepared in the 1940s which have been declassified over the past decade. The US War Department prepared a massive study called "Handbook on Guided Missiles: Germany and Japan" with a very useful section on the V-1. A useful study of German pulse-jet development was prepared for the US Navy's Project Squid by one of the German engineers, Günther Diedrich, as "The Aero-resonator Power Plant of the V-1 Flying Bomb" (1948). One of the best overviews of V-1 operations was a study by Lt. Col. M. Helfers, "The Employment of V-Weapons by the Germans During World War II." Other useful studies are those by Mary Welborn "V-1 and V-2 Attacks against the United Kingdom during World War II" (Operations Research Office ORO-T-45, 1950), Frank Heilenday "V-1 Cruise Missile Attacks against England: Lessons Learned and Lingering Myths from World War II" (Rand Corp. 1995), and "Tactical Employment of Antiaircraft Units Including Defense against Pilotless Aircraft (V-1)" (US General Board, 1947). A US view of German missile production and the impact of Allied bombing can be found in the volume in the US Strategic Bombing Survey "V-Weapons (Crossbow) Campaign." A German perspective on the missile campaign can be found in the study prepared for the US Army's Foreign Military Study program in 1947 by Gen. Eugen Walter of 65th Corps and later commander of the 5th Flak Division: "V-Weapon Tactics (LXV Corps)" and a developmental perspective can be found in "The German V-1" (Naval Air Missile Test Center Memo Report 29, 1949). The Imperial War Museum in London has a translation of the war diary of Flak Regiment 155 (W) which is extremely detailed. The German April 1944 field manual for the FZG-76 is also informative. There

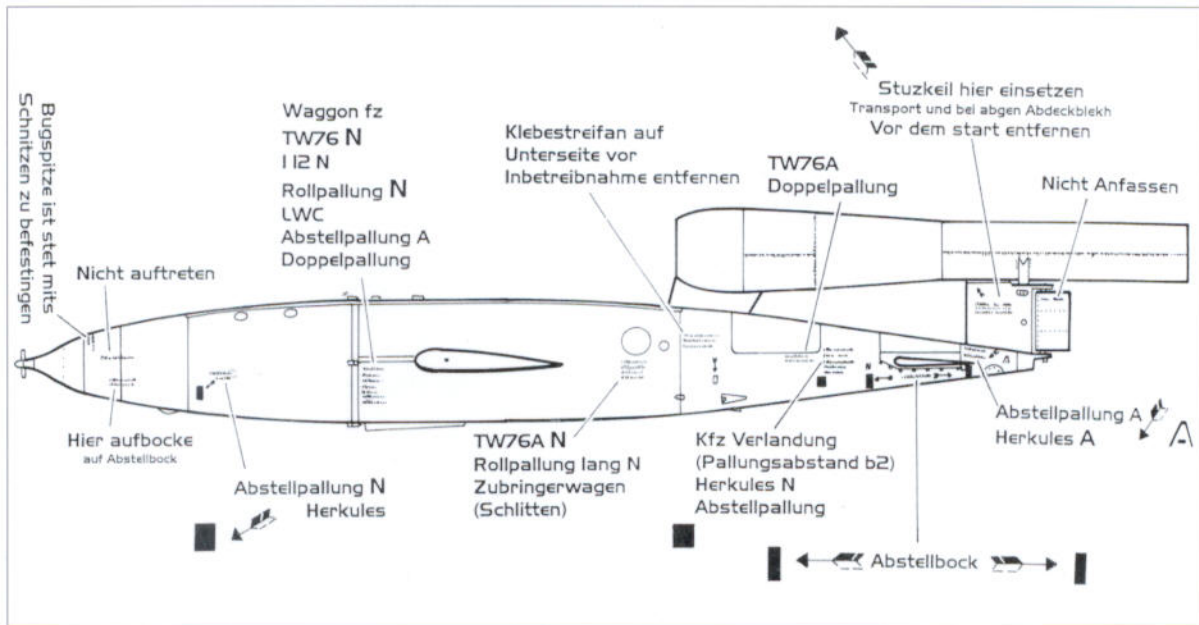
The Soviet EF-126 attack aircraft. (Author)



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# COLOR PLATE COMMENTARY



## A1: FI-103 V-ZELLEN, PEENEMÜNDE, SPRING 1943

Test missiles were often painted in bright colors to assist in visual tracking. Originally, they were painted in overall yellow, but this switched to bisected yellow and black which made it easier to see if a missile flipped on to its back. The Argus engine was left in its original unpainted steel finish. The serial number was painted on the tail, in this case, 91 for V91.

## A2: FI-103 M-ZELLEN, LEHR-UND-ERPROBUNGSKOMMANDO WACHTEL, PEENEMÜNDE, FALL 1943

The pre-series *M-zellen* missiles were finished in a relatively neat scheme of RLM 71 (The *Reichsluftministerium* – German Air Ministry – had an official series of numbered designations for paint colors, prefixed “RLM”) dark green over RLM 65 light blue. The serial number was applied to the tail in white.

## A3: FI-103RE.3 REICHENBERG TRAINER, RECHLIN TEST ESTABLISHMENT, FEBRUARY 1945

The few photos that exist of these trainers show them to be in a fairly neat finish. On August 15th, 1944, the RLM ordered the withdrawal of RLM 65, substituting three new greens after existing paint was exhausted at the factories. Bombers retained the RLM 65 light blue, which also affected Fi-103. The results were not that noticeable on the V-1 as most surviving examples seem to show the use of RLM 71 dark green or the similar RLM 83.

## B: DIVER DOWN! LONDON, AUGUST 1944

This scene depicts one of the duels between the Doodlebugs and RAF Tempests. In some circumstances, such as when they had run out of ammunition, fighter pilots would position

This illustration shows the typical stenciling on the V-1. Usually, the stencils were in white on the green upper surfaces and black on the light blue undersurfaces. (Author)

one of their wingtips under the Doodlebug wing, and then bank sharply, the slipstream causing the V-1 to tumble out of control as is seen here.

## C: FI-103A-1, FLAK REGIMENT 155 (W), SUMMER 1944

Many of the FZG-76 missiles used in the summer of 1944 had a very motley finish as little care was taken in applying paint on a cheap, expendable weapon. In addition, the missile was assembled from components coming from different plants, so the camouflage schemes on the all the parts did not match. The base color was the usual RLM 65 light blue over which RLM 71 dark green was sprayed in irregular patterns. The wing and tail surfaces as well as the spine of the engine tended to have a more solid finish of dark green. Missiles with Trialen enhanced blast warheads sometimes had a large red X painted on either side of the warhead casing as seen here.

## D: FI-103A-1, FLAK-REGIMENT 155 (W), 1944

## E: FI-103RE.4 REICHENBERG, KARLWITZ MUNITIONS DEPOT, DANNENBERG, GERMANY, 1945

As in the case of the *Reichenberg* trainer shown in Plate A, the *Reichenberg* trainers theoretically were painted in late-war RLM colors of RLM 65 light blue and RLM 83 dark green. This shows the standard configuration of the missile had it been deployed in the spring of 1945.

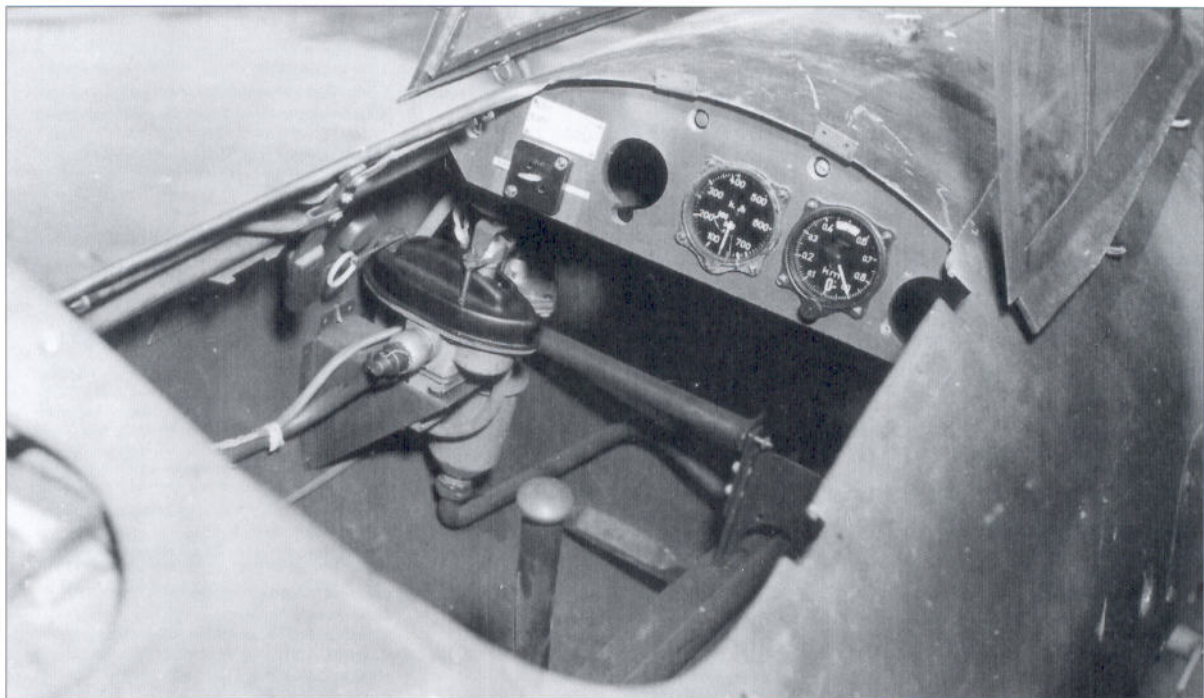


**ABOVE** This V-1 was one of many that prematurely crashed after launch in the French countryside, and is being examined by a member of the French resistance. The fuselage has split open behind the center fuel tank, exposing one of its two pressurized air bottles. (NARA)

**BELOW** This V-1 was found by US troops near Plomion, France, on September 2nd, 1944, in the sector where I/FR155W was formerly based. The Germans codenamed these crashed missiles as *Kieselsteine* ("Gravelstones") and special teams were sent to deal with the unexploded warhead which is missing on this example. (NARA)







**F: HELLHOUNDS OVER THE NORTH SEA, OCTOBER 1944**

This scene depicts a night launch of an Fi-103A-1 over the North Sea by an He-111H-22 of KG3. The missiles were usually released from an altitude of at least 1,500 ft as they tended to drop a few hundred feet after launch until the engine accelerated the missile to cruise speed. The Heinkel is quickly banking away, since the launches were visible for long distances and would attract the unwanted attention of Mosquito night fighters.

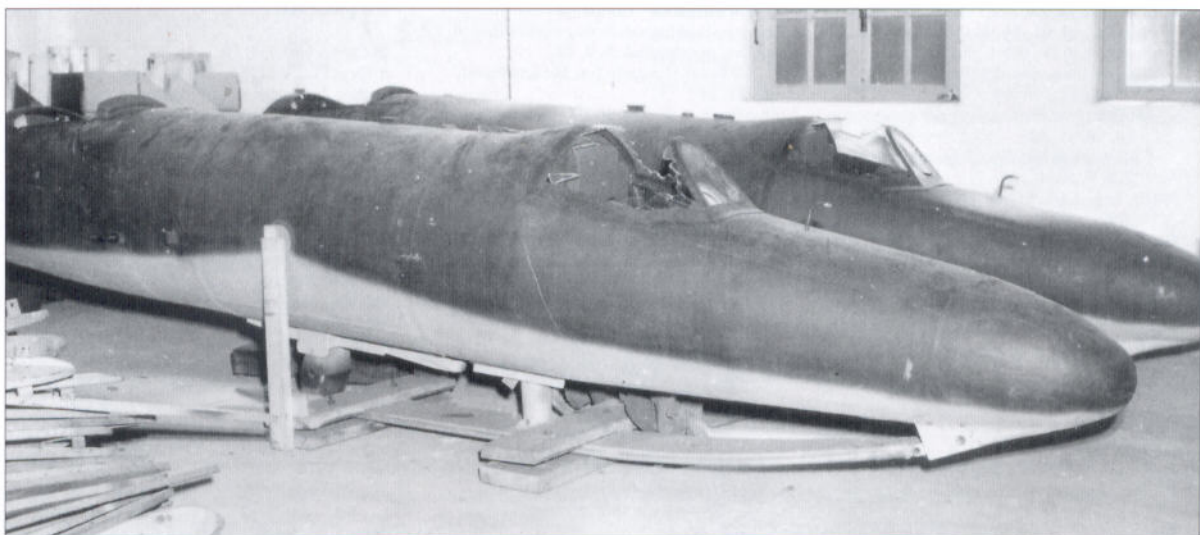
**G: 16KH PRIBOY, SOVIET AIR FORCE, 1951**

Although the Soviet Air Force was shifting to the use of bare

aluminum finishes on its jet aircraft in 1950, air-to-surface missiles such as the *Priboy* sometimes remained in the standard late 1940s camouflage finish of overall AMT-11 gray-blue. However, since this was a test missile, the engine remains in a bare steel finish.

ABOVE A view into the cockpit of one of the Fi-103Re.4 *Reichenbergs* discovered at Dannenberg shows the very elementary controls and instruments. (NARA)

BELOW Another discovery at Dannenberg was a small number of incomplete Fi-103Re.3 two-seat trainers. (NARA)



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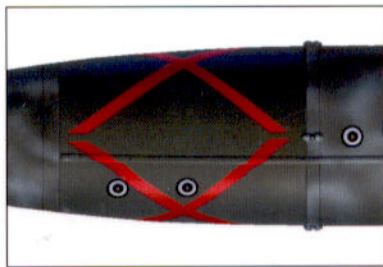
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- Zempin test range **9, 12, 13**

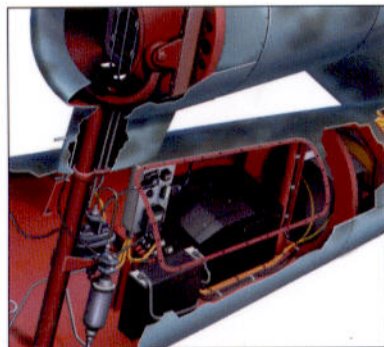
The design, development, operation, and history of the machinery of warfare through the ages



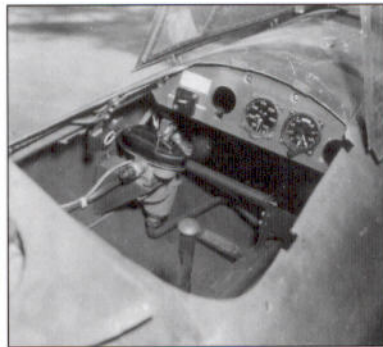
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Unrivaled detail



Cutaway artwork



Photographs

## V-1 Flying Bomb 1942–52

Hitler's infamous  
"doodlebug"

The first deployment of the V-1 was in June 1944 when, following two years of tests, Hitler gave the order to attack England. Known to the Allies as the "Buzz Bomb" or "Doodlebug," the V-1 was the world's first cruise missile. This book examines all aspects of the V-1 in detail, including the initial concept, the V-1's first use in 1944, various Allied counter-measures, and the later use of the V-1 during the Battle of the Bulge. The major foreign derivatives, including the US copy "JB-2 Loon" and numerous post-war Soviet variants, are also covered.

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