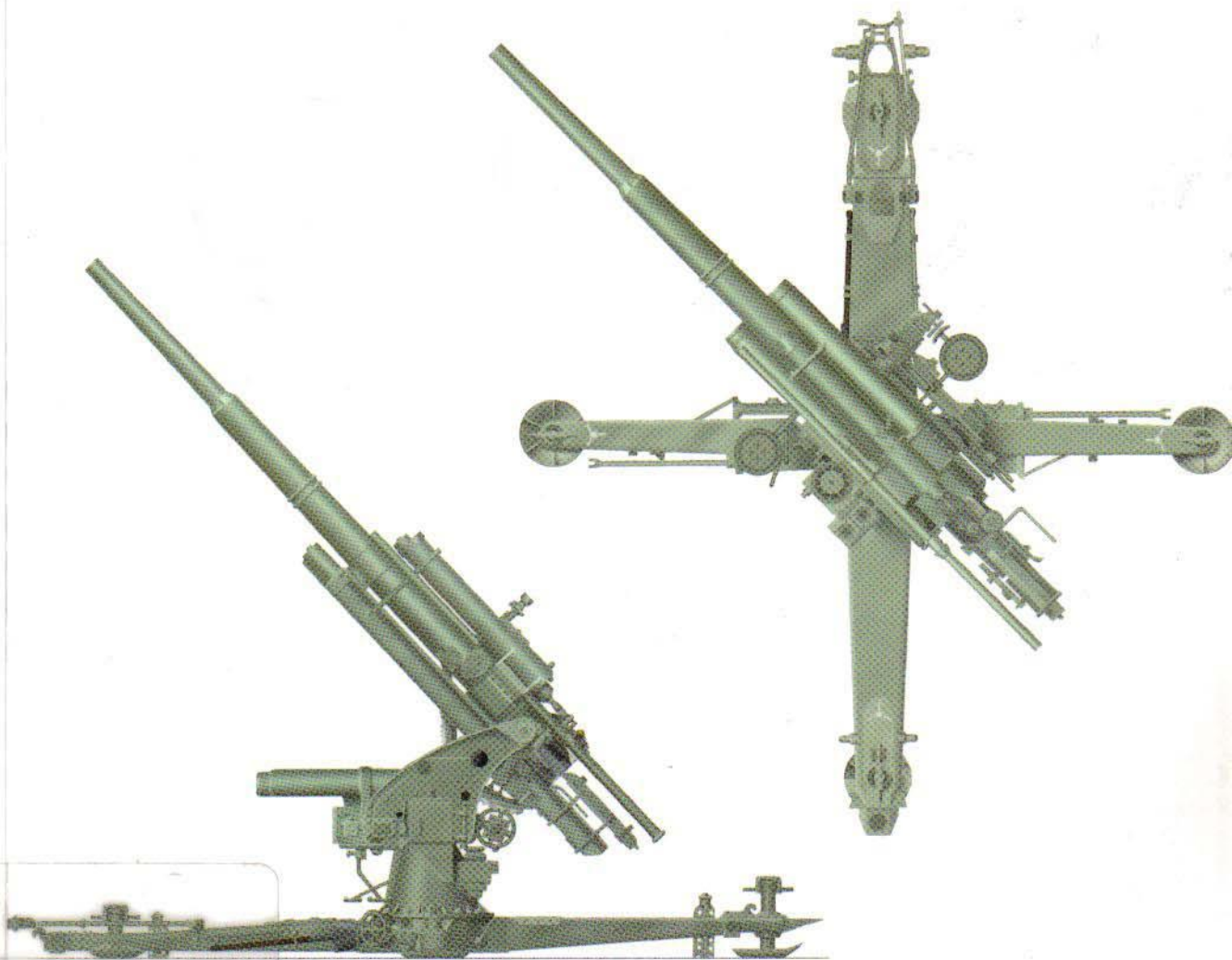
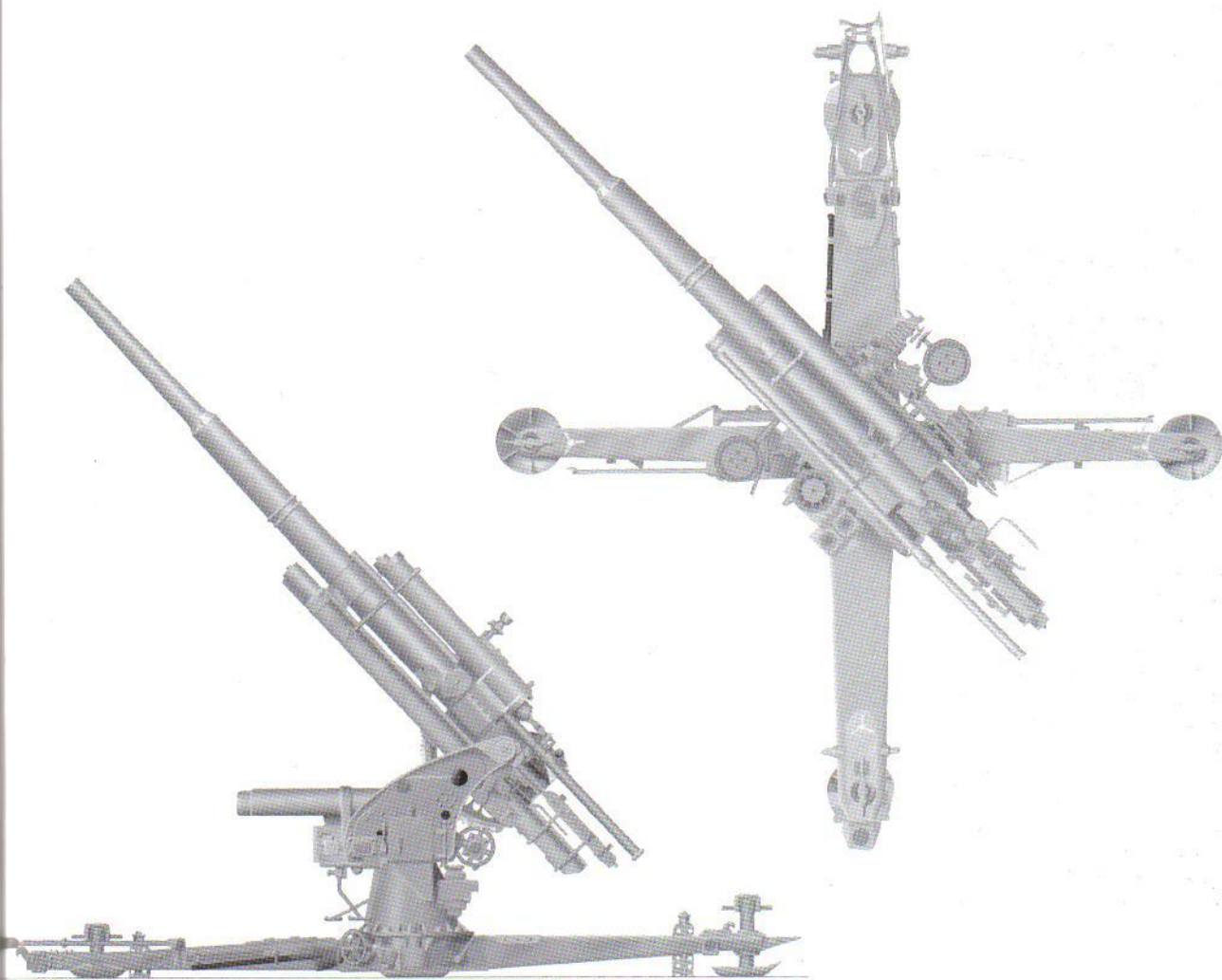


88 mm FlaK 18/36/37/41 & PaK 43 1936–45



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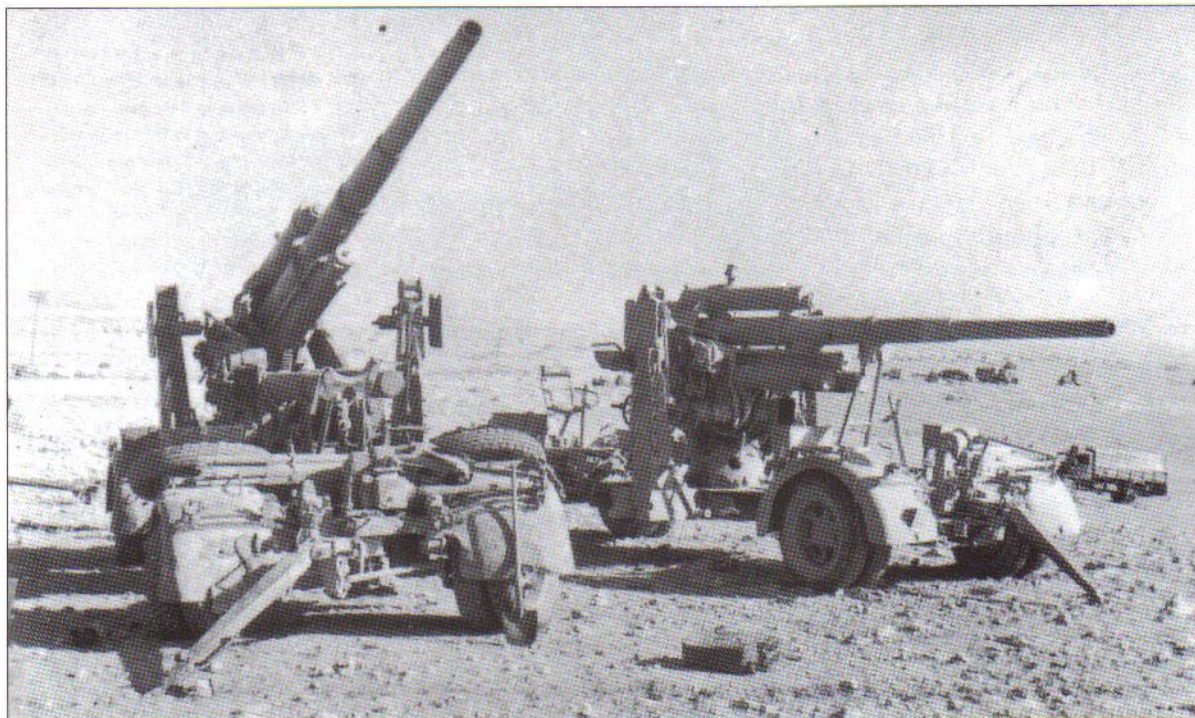
88 MM FLAK 18/36/37/41 AND PAK 43 1936-1945

INTRODUCTION

Unarguably the most famous piece of German artillery to have seen service during the whole of the Second World War, the 88 mm gun was originally designed for use as an anti-aircraft weapon. By a strange quirk of fate, the design became instead the most formidable anti-tank gun of the war. But despite its change of use on the battlefield, large numbers continued to serve in the anti-aircraft role.

The 'Eighty-eight' (or just '88' as the Allies referred to it) entered service in 1933. It had been developed in great secrecy by a team of technicians from the German armaments giant Krupp who had been on secondment to Bofors, the Swedish armaments firm, between 1920 and 1930. In the early inter-war years, when Germany lurched from one political crisis to the next, no-one could have foreseen what a versatile weapon the Wehrmacht had at its disposal. Different versions were used at various times by all three branches of the German armed forces, and although the Allies had comparable weapons of their own (the British 3.7 in. anti-aircraft gun, the French 90 mm gun and the American 90 mm anti-aircraft gun), none ever gained the same reputation as the 88.

Two 88s abandoned by Germans near Mersa Matruh in 1942. They lack the gun shields fitted to twin-tyred carriages.



The first 88

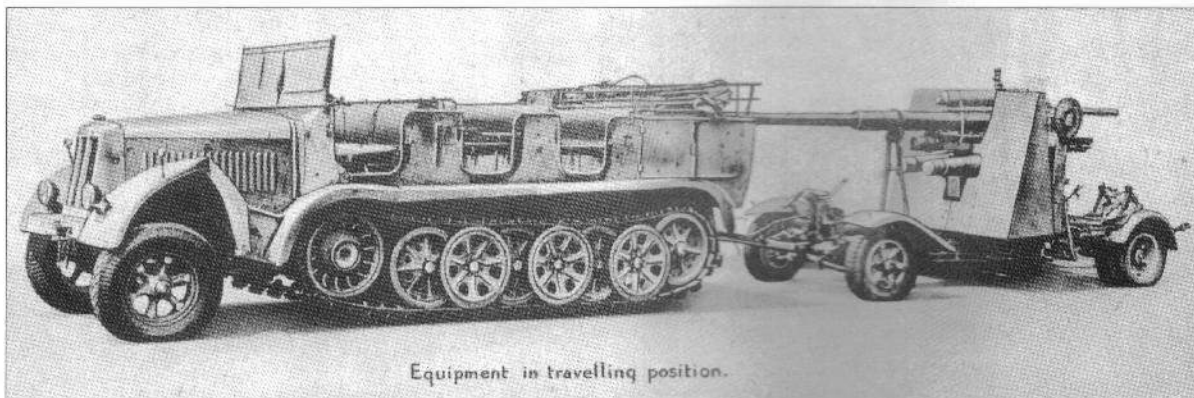
The forerunner of the 88 was an 8.8 cm FlaK or anti-aircraft gun, developed in 1917 by Krupp and Erhardt (Erhardt later became Rheinmetall). It was fitted with a semi-automatic action, a horizontal sliding breech block and was capable of firing 9.5 kg shells. A good crew could fire up to ten rounds per minute. The gun weighed 7,300 kg in action, and was fitted to a pedestal mount on a cruciform-shaped carriage fitted with two sets of single-tyred wheels for mobility. Although more usually towed, it is understood that there were plans to mount some guns on the rear of army lorries to provide better mobility. The barrel could be elevated to more than 70 degrees, and with a muzzle velocity of 785 m/sec, the vertical ceiling of the shell was 3,850 m, so the gun was more than adequate to engage the slow-moving aircraft of the day. Mounted on a pedestal, the gun could be traversed through 360 degrees to follow a target; in the ground role, the 88 mm gun was capable of firing a shell out to a horizontal range of nearly 10,800 metres.

The 88 mm gun was used to defend industrial centres around the Ruhr and Rhine, which were vulnerable to Allied bombing raids. In an effort to oppose attacks by aircraft such as the Handley-Page bombers of the nascent Royal Air Force, factories and power stations were protected by batteries containing between six and eight guns. After the war ended in 1918, the Allies imposed severe limitations on Germany's armaments industry, prohibiting the ownership or development of anti-aircraft artillery, tanks, aircraft or weapons of mass-destruction such as poisonous gas. And so the advanced design for the 8.8 cm anti-aircraft gun was apparently consigned to the scrap heap.

DEVELOPMENT

In the aftermath of the First World War many German armaments firms went out of business as a result of the restrictions imposed by the Treaty of Versailles in 1919. However, some companies, such as Krupp, chose to relocate their highly experienced staff of designers and researchers to foreign armaments companies across Europe. Some production teams of German gunmakers managed to evade arms controls by forming alliances with foreign companies and at the same time gaining valuable

A FlaK 18 gun in travelling mode being towed by an SdKfz 11 half-track. The gun was always towed with the barrel facing forward towards the prime-mover vehicle. The crew rode in the vehicle and could quickly deploy to bring the gun into action. (Ian Hogg)

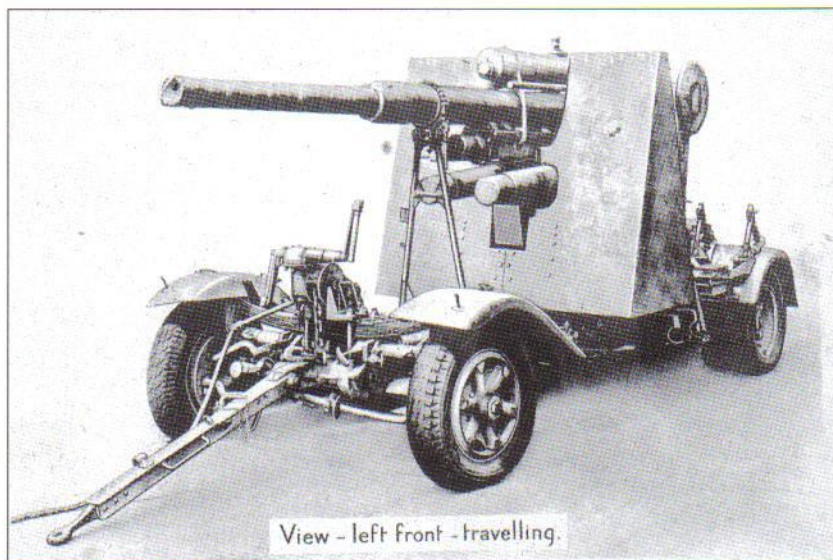


Equipment in travelling position.

experience. One such co-operative move involved a team headed by Krupp artillery designers who went to work with Bofors in Sweden during the 1920s. Krupp held some six million shares (out of the total 19 million shares) in this leading Swedish armaments manufacturing company. In 1931 the Krupp team of temporarily expatriate technicians decided to make a pre-emptive move and returned to their factory at Essen. Here they unveiled their plans for a completely new anti-aircraft gun with a calibre of 88 mm (sometimes referred to as 8.8 cm), which they had been working on in Sweden. Such weapons development contravened the Treaty of Versailles and Germany was breaking the Military Code.

Krupp organised a secret series of intense tests and field trials, during the course of which some slight modifications were recommended. Outwardly, there was nothing unusual about the new gun. However, on closer inspection it was revealed to have a number of innovative features. In fact, the design was so advanced that the weapon could be mass-produced on 'flow-lines', for example at car factories or tractor plants, without the need for specialised equipment.

When Adolf Hitler came to power in 1933 he immediately dismissed the Treaty of Versailles which prevented Germany's armaments development. The German army had, by various subterfuges, still managed to maintain the skills and techniques surrounding the development of anti-aircraft gunnery, so by 1934 when Hitler openly declared that Germany was entering a re-armament programme, the new 88 mm anti-aircraft gun was already in full production.



A FlaK 18 on a travelling carriage. Note the single pneumatic tyres fitted to the carriage and the towing bar. The large gun shield afforded the crew some degree of protection from small arms fire and shell splinters. (Ian Hogg)

The 88 mm FlaK 18

Krupp had secretly built a prototype of the new gun and demonstrated it to the German army in 1932. Krupp's investment in time and attention to detail ensured that the 88 was approved almost immediately by the army. After successful field trials the gun went into full production and entered service in 1933 as the 8.8 cm FlaK 18 (*Flugabwehrkanone 18*).

The gun itself was of fairly conventional design, but the barrel was built in two sections, contained within a 'jacket'. If one part became

worn out through firing, it could be replaced without having to replace the whole barrel. The barrel was an L/56 type of 53 calibres in length, giving an overall length of 4,664 metres. However, the real ingenuity lay in the horizontal sliding breech mechanism which was operated semi-automatically by spring power, which was in turn tensioned as the gun recoiled on being fired.

The gun carriage was fitted with two pairs of bogies for travelling, comprising single-wheeled pneumatic tyres which could be removed before the gun was deployed for use, in which order it weighed 6,681 kg. In many respects, the platform was similar to the type used on the original 8.8 cm FlaK of the First World War: it was a four-legged unit of cruciform shape (known in German as *kreuzlafette*) in plan view, which carried a central pedestal to which was mounted the barrel. This permitted the weapon to traverse a full 360 degrees and the barrel could be elevated between -3 degrees, for engaging ground targets, and +85 degrees for the anti-aircraft role. Two sets of two-wheeled limbers could be hooked on to the ends to allow the gun to be towed by prime moving vehicles, such as the FAMO or Hanomag SdKfz 11 half-track carriers. These vehicles also transported the gun crews, with other attendant vehicles bringing up resupply ammunition.

A well-trained crew could fire up to 15 rounds of high-explosive ammunition in one minute; one high-explosive projectile weighed 10.4 kg. Later on, a shell containing a 9.2 kg armour-piercing round with a muzzle velocity of 820 m/second would also be produced. The high volume of fire was made possible partly by the use of 'fixed round' shells: the projectile head and cartridge case were in one piece, rather like a giant rifle bullet. Indeed, this was to be a feature throughout the life of the 88 mm, even when other models of the gun, with enlarged chambers, were developed.

The weight of the FlaK 18 in action was 4,985 kg and it proved accurate in both the horizontal and vertical planes. The standard high

BELOW AND RIGHT
Men of 172 Battery, 58 Light Anti-Aircraft regiment, Royal Artillery using 88 mm guns against their former owners, December 1944. Note the spent shell cases being ejected and the man at right holding a firing lanyard. Each of the wicker-type ammunition cases contain three shells.

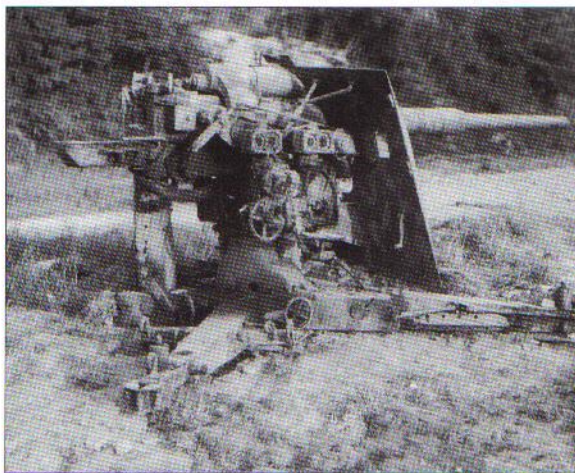


explosive shell could reach a height of 9,900 m, but its effective ceiling – the height at which it was most powerful – was 8,000 metres. The FlaK 18 had a maximum ground range of over 14,800 m, which was used to provide covering artillery fire to screen advancing infantry. The FlaK 18 also became an effective anti-tank weapon, capable of engaging targets at ranges of up to 3,000 metres. In effect, whatever target the crew of the 88 mm could see to aim at, they had a good chance of actually hitting. In 1939 the Waffenamt realised the deadly potential of the FlaK 18 in the anti-tank role and ordered ten units of the gun. They were mounted on the chassis of the 12-tonne Daimler-Benz DB10 Zugkraftwagen and given the designation SdKfz8. These were to be used as heavy anti-tank guns and to destroy fortified positions. In 1940 a further 15 units were ordered, mounted on the 18-tonne FAMO Zugkraftwagen and designated SdKfz9, with the additional role of providing anti-aircraft cover. These 25 units were the only series of their type produced, and although plans were laid in 1942 to produce another 112 units for the Luftwaffe and army using the later FlaK 37 gun, the order was abandoned in mid-1943.



The Spanish Civil War 1936–39

When the Spanish Civil War erupted between the Communist Republican forces and the Nationalists in 1936, Italy and Germany sent volunteer forces and military aid to support the Nationalists led by Generalissimo Francisco Franco. The German contingent known as the 'Kondor Legion' was mainly Luftwaffe personnel, and was equipped with the new 88 mm FlaK 18 anti-aircraft guns. Some historians regard the Spanish Civil War as a testing ground for weaponry later used during the Second World War. Contemporary observers noted that German anti-tank weapons, in particular, performed especially well. One German officer, General Ludwig Ritter von Eimannsberger, saw the future potential of the 88 in an anti-tank role as early as 1937. A series



An abandoned FlaK 36 in an area possibly south of Caen in France. It was sited in a location close to a railway line. Note one of the outrigger legs is in the upright position.

German army on the move in North Africa, January 1942. The 88 is being towed in the standard method, with crew riding on the prime mover stacked with extra fuel, ammunition and personal equipment. Note the 'kill' rings painted on the barrel which indicates the number of targets destroyed by the gun crew.



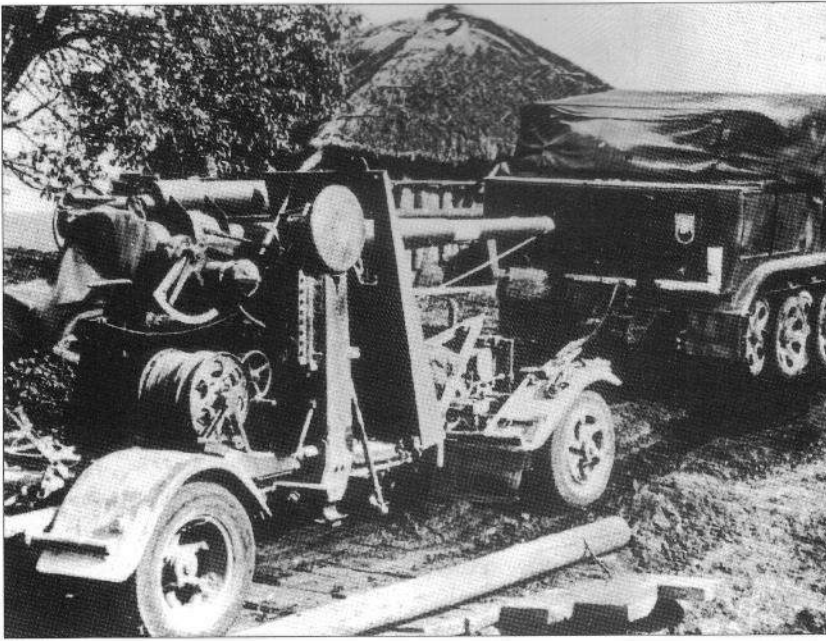
of articles in such propaganda news-sheets as *Der Adler* and *Die Wehrmacht* discussed the new *Blitzkrieg* tactics, especially the role of the artillery branch. The book *Deutsche Kampfen in Spanien* explained how anti-aircraft guns could be used in an anti-tank role: 'From the beginning of 1937 "FlaK" artillery was used more and more in ground warfare, for which its precise aim, its rapid fire and its range made it especially suited... This led finally to the use of "FlaK" in the last great offensive of the Spanish War, in Catalonia, in the following proportions: of the total ammunition fired by these guns, 7 percent was against air targets and 93 percent against ground targets.'

Despite these statistics, some German staff officers, such as General Heinz Guderian, held an opposite view, claiming that because of the harsh terrain, and the obsolete tanks used by inexperienced Republican crews, Spain was a less than perfect testing-ground for weapons. However, refinements were made after the experiences in Spain. Proper direct-fire optical sights, and special anti-tank armour-piercing ammunition were developed. The actual projectile of this Panzergranate 40, or AP 40, weighed 10.4 kg and comprised a mild steel body and tip with a core of tungsten carbide steel. The actual projectile had an alloy cap to improve its ballistic qualities when fired.

THE NEXT GENERATION OF FLAK GUNS 1936-37

From experience gained during the fighting in Spain the German army looked closely at tactics and weapon designs. It noted a few weak points in the FlaK 18's design and recommended modifications.

This led to the introduction of two improved models of the 88, the FlaK 36 and the FlaK 37. On the outbreak of the Second World War in September 1939 there were three versions of the 88 mm gun in service, all of which were termed as FlaK, being short for either *Flugzeugabwehrkanone* or *Flugabwehrkanone*, anti-aircraft gun. An official German army training manual entitled *Procedures for the Attack of Fortified Defensive Positions*



Towed by a half-track prime mover, an 88 moves forward on the Eastern Front. The gun's deadly fire was directed against mass armoured attacks by the Soviet army.

was issued in the summer of 1939, just before the German invasion of Poland. It stated: 'assault detachments, closely followed by anti-tank and 88 mm guns, will be thrust through any gap in the defensive front...' But while this was stated tactical doctrine, the reality could not be further from the truth when put into practice. The rapidity of the German advance into Poland was so swift, and the Polish Air Force so completely overwhelmed by the Luftwaffe, that those 88 mm guns in the front line were hardly ever deployed as laid down in the text books. The 37 mm anti-tank PaK 36 guns in service with the German army at the time were more than equal to the task of destroying the lightly armoured Polish tanks such as the TK-3 and 7TP. At the time of the Polish invasion, the German army had over 9,000 pieces of anti-aircraft artillery, of which 2,600 were of 88 mm and 105 mm calibre.



A single 88 deployed in the middle of a road in an unidentified town on the Russian Front. Although not tactically concealed, the gun could quickly provide fire support against aerial targets or vehicles moving directly against position.



A crew of an 88 mm FlaK 36 in action in Russia. The gun is being fired from its cruciform base with the wheels removed. One set is visible to right of picture. Note the wicker cases in the foreground which contained shells for the gun. (Ian Hogg)

The FlaK 36

Combat experience in Spain suggested that some modifications were required to the FlaK 18 both to simplify manufacture of the gun and to improve operation in combat conditions. The platform carriage was modified to improve gun stability, and the design was simplified to ease production. For example, the front and rear wheel limber sections were made identical with pneumatic tyred double-wheels that could be hooked up to either end of the cruciform platform. Each section was fitted with a barrel support, which meant that the latest version of the 88 gun, the FlaK 36, could be towed with the barrel facing in either direction. It did not have to be specially stowed in a travelling position, which greatly speeded up the time of going into and coming out of action. The gun barrel was now made in three sections held together by an enveloping 'outer sleeve'. When wear occurred to a particular section of the barrel, only that worn-out section needed to be replaced instead of the whole barrel, which amounted to a considerable saving in steel and manpower resources.

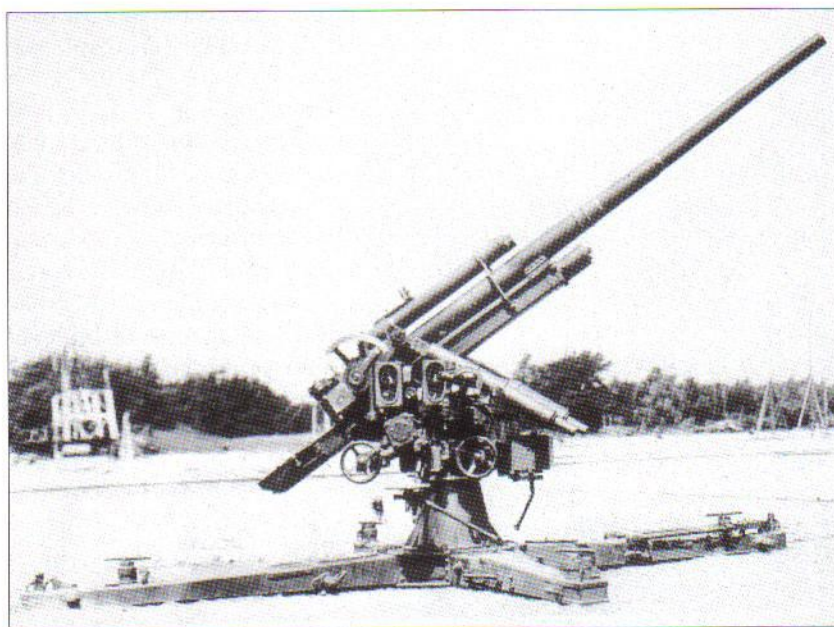
A FlaK 41 captured by the British 8th Army in March 1943 during the advance from El Hamma to Gebes. It has been abandoned along with its prime mover vehicle. Note the folding sides to the gun shield, characteristic of the FlaK 41.



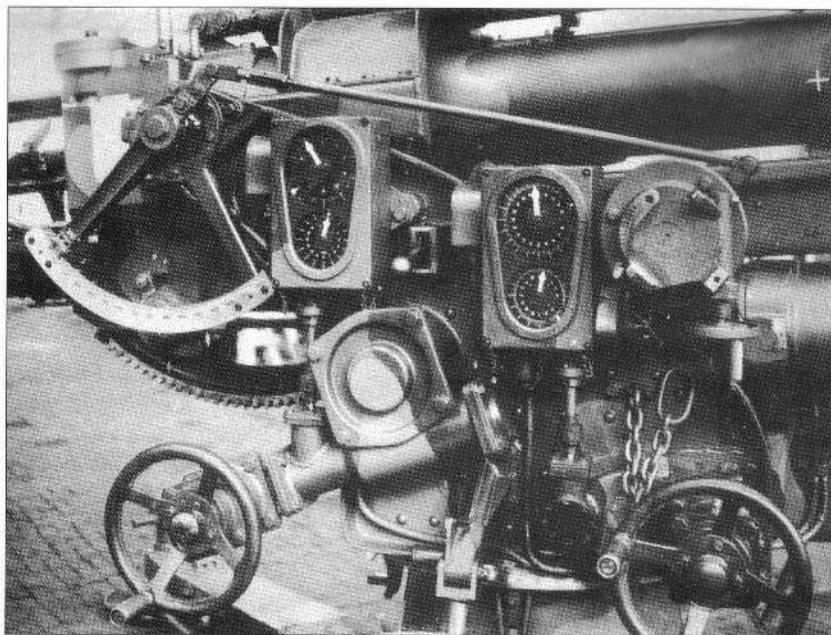
The barrel length of the FlaK 36 was identical to the FlaK 18, at 4.664 m and was fitted with the same type of semi-automatic, horizontal sliding breech. Traverse remained at 360 degrees along with the same -3 degrees to +85 degrees of elevation. The effective ranges of the FlaK 36 in both horizontal and vertical planes were exactly the same as for the FlaK 18. The FlaK 36 was also fitted with a gun shield as on the FlaK 18. During the war another version of the FlaK 36 gun was developed and pressed into service as a stop-gap weapon. This was known as the 88 mm FlaK 36/43 and was essentially the barrel of the later model FlaK 41, which entered service in 1942, mounted on to the carriage of the FlaK 36 by means of adaptors. This particular version of the 88 was manufactured when barrel production for the new FlaK 41 outstripped that for the carriages of the FlaK 41 gun. In order to overcome this problem, the barrels of the FlaK 41 were fitted to carriages of the FlaK 36, also known as the *Sonder Anhanger 202*.

The FlaK 37

Improvements continued to the sights of anti-aircraft guns and the fire-control system. The gunlayer's dials were changed to a simpler 'follow-the-pointer' system. In the anti-aircraft role, two members of the gun crew controlled the elevation and azimuth used to track a moving target. The system of gun-laying known as 'follow the pointer' was developed to make their task simpler and to improve accuracy. Two sets of dials fitted with two sets of differently coloured pointers were mounted on the gun. The dials received information sent via electrical signals transmitted from the battery central fire direction post. When fire-control information was sent to the gun, one of the coloured pointers within the dial moved to a determined setting. The two crew members then simply had to position the gun to the correct angle of elevation and azimuth setting until the second set of pointers matched those set by fire direction post.



A FlaK 37 shown fitted with a data transmission system. This model was a dedicated anti-aircraft gun and unlike the other versions of the 88, could not engage ground targets. (Ian Hogg)



Detail of the 'follow the pointer' dials on the FlaK 37 which were important to determine the exact moment of firing to engage aircraft. This information was fed to the gun from a central command post. (Ian Hogg)

The information was passed to the gun by means of a *Funkmessgerate* or 'Predictor', a mechanical analogue computer, which was used to calculate the position of an aircraft and the firing data for the anti-aircraft gun. The operator of the *Funkmessgerate* used a tracking telescope to acquire the target and from this, the aircraft's azimuth and elevation was calculated by means of an in-built clock. This target information was fed to the gun position along with the speed and course of the aircraft. The *Funkmessgerate* also contained information

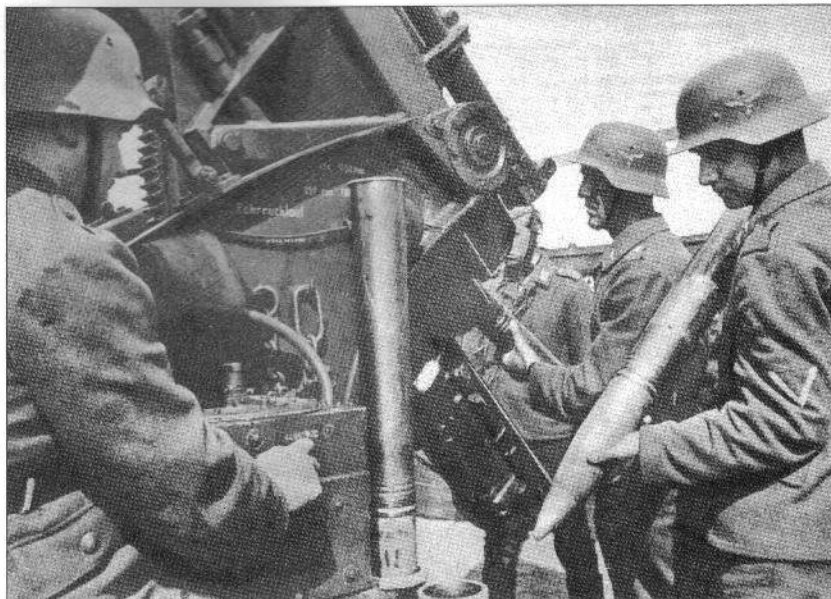
about the site of the gun and ballistic data on the type of shell and fuse. Once the position of the aircraft had been calculated, the *Funkmessgerate* would compare weapon data and calculate the optimum time to fire, so that the shell intercepted the target at the right time and height. The crew inserted the nose of the shell into the gun's fuse setter which automatically set the time fuse of the high-explosive round to detonate at the correct height once fired.

With these changes, the series of 88 mm anti-aircraft guns was designated the FlaK 37. The barrel reverted to a two-piece design, but apart from this and the improved fire-control system, the gun was the same as the FlaK 36, with the same overall combat capabilities in range and rate of fire. However, the advanced data transmission system used on the FlaK 37 meant that it was not used in a secondary anti-tank role like its earlier counterparts.

Later in the war, a stop-gap design based on the FlaK 37 was developed, the FlaK 37/41, which was intended to provide a high-performance gun while the FlaK 41 was in development. As with the FlaK 36/41, it was simply a normal FlaK 37 fitted with a new barrel which had the same dimensions as the FlaK 37 barrel externally, but had an enlarged chamber to enable it to fire a shell with a more powerful cartridge. For this reason it was fitted with a double-baffle muzzle brake to assist in recoil control. A total of 12 FlaK 37/41 guns were built for testing, but by the time they were completed the problems with the FlaK 41 had been overcome, production was under way, and there was no longer any need for the stop-gap design. The Model 37 appeared shortly afterwards, which incorporated several technical improvements, but essentially the gun's performance was unchanged.

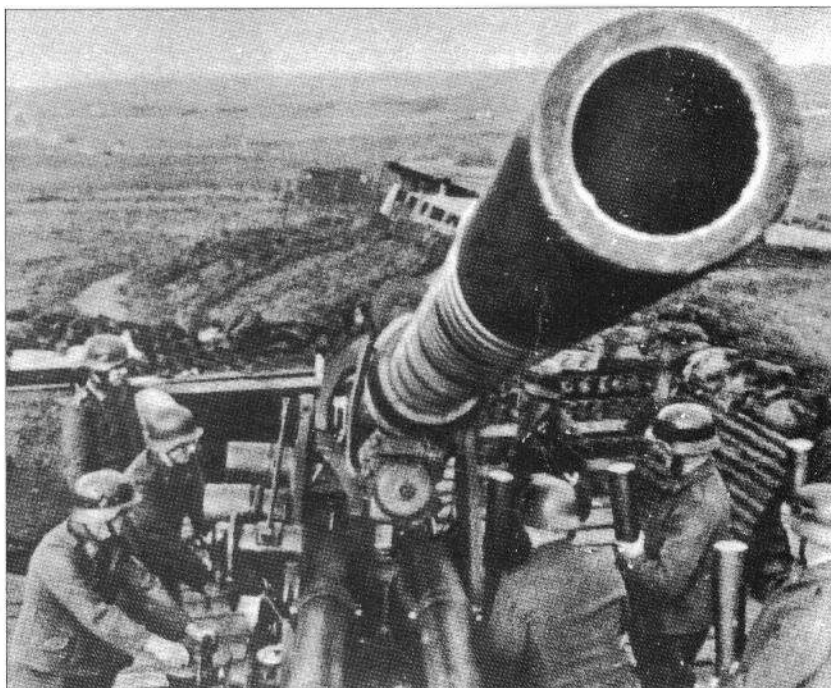
On the battlefield the standard method of deploying emplaced 88 anti-aircraft batteries was typically four guns, each served by a crew of ten, laid out in a 'square' formation. In the centre of their position was the secondary command post with range-finding equipment, in direct

A Luftwaffe crew of a FlaK 37 placing nose cones into the fuse setter. (Ian Hogg)



communication with each of the guns within the battery. This command post was also in direct communication with the battery commander equipped with the off-carriage *Funkmessgerate* fire-control system. This post was, in turn, linked to each of the guns by means of a distributor box. As the Allied air threat increased against cities and industrial centres, so the Germans built special FlaK towers which mounted anti-aircraft guns of all calibres, including versions of the 88. As early as 1941, Munich, for example, was ringed by 33 batteries of anti-aircraft guns, including 66 88 mm guns. Together, the three versions of anti-aircraft

A FlaK 37 gun with barrel well elevated to engage aircraft. Note crewmen on left are operating the 'follow the pointer' dials, while the crew on the right handle shells into the fuse setter. The white rings on the barrel indicate credited 'kills'.



guns, FlaK 18/36 and 37, constituted the backbone of the German air defence systems both within the Reich and also on the frontline. In fact, by August 1944 there were nearly 11,000 units of 88 mm FlaK guns in service. When the 88 mm guns were deployed for use with the German army they equipped the heavy batteries of the divisional *abteilungen* and also certain *Heersflak abteilungen* (army anti-aircraft battalion). A Panzer division numbered more than 13,700 men with support units including batteries of anti-tank and anti-aircraft artillery. In the divisional organisation the anti-aircraft battalion had a strength of 762 men to serve eight 88 mm and 18 units of 20 mm guns.

In January 1945 the Supreme Headquarters Allied European Forces (SHAEF) compiled *Air Defense Review No.6*, a document which examined the effects of German anti-aircraft fire against bombers of the US 8th Air Force. It concluded that 'During the three months ending August 1944, German AA fire accounted for no less than 66 percent of the 700 bombers lost and 98 percent of the 13,000 bombers damaged. In 1943, 33 percent of the bombers lost and 66 percent of the damaged were attributed to Flak'. It can be seen from this report that the Germans took the air defence of their cities very seriously, and exacted a rising toll in Allied aircraft which was even greater than that inflicted by fighter cover. But it is not possible to state exactly what proportion of the losses inflicted on the US Air Force can be directly attributed to the 88 mm guns.

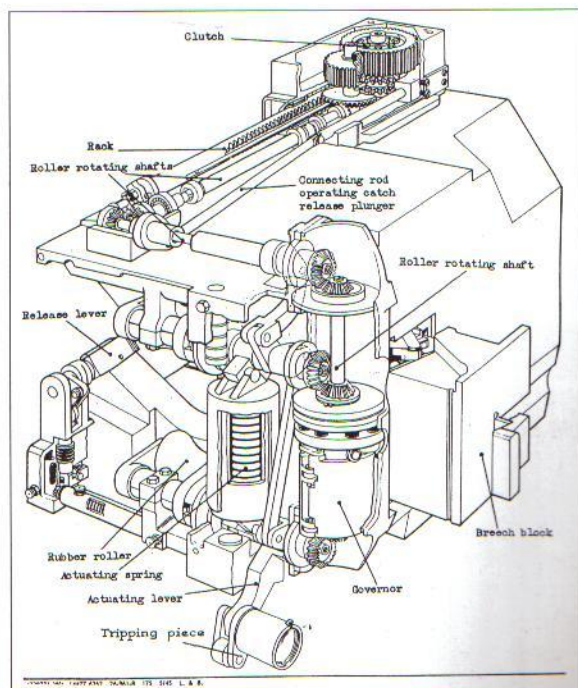
Anti-aircraft batteries were concentrated mainly in the most heavily threatened areas such as Berlin and the industrial heart of Germany, the Ruhr. In 1943 the formation of '*Grossbatterien*' were authorised, and such units could contain 18 88 mm guns or fewer numbers of larger calibre weapons. Each *Grossbatterien* was controlled by a single radar feeding information into the *Funkmessgerate* or predictor. '*Vorfeldbatterien*' or 'line of approach batteries' provided another method of organising anti-aircraft guns: over 600 guns of all calibres encircled a threatened area.

The 88's reputation as an efficient anti-tank gun began in the early stages of the war and special ammunition was developed for this role. This success led to anti-tank ammunition being developed for various other types of artillery, including anti-aircraft guns up to the calibre of 128 mm. The reasoning behind this was that tanks might appear anywhere on the battlefield, perhaps by-passing anti-tank guns, and therefore, other artillery, including anti-aircraft guns, would have to be pressed into service to deal with the threat.

The 88 mm FlaK 41

With its sound design, the 88 mm gun was to remain the backbone of German air defence throughout the war, and was used by all branches of the German armed forces. Even at the beginning of the war the Luftwaffe realised the need for an improved gun with a higher ceiling and increased muzzle velocity. Rheinmetall-Borsig began to develop one, with prototypes being ready in early

Detail of the ramming mechanism for the FlaK 41. This was essential when loading the heavier shells into the breech, particularly when the barrel was at a high angle of elevation. (Ian Hogg)



1941, but first deliveries of their 88 mm gun, termed the FlaK 41, were not made until March 1943.

The upgraded version of the 88 mm was a very good weapon with greater ballistic performance and a much improved mechanical design. Improvements made on this model included changing the recoil and recuperator gear, which could be adjusted to compensate for elevation in the anti-aircraft role. The cradle was altered from a vertical to a horizontal design which lowered the weapon's height. The pedestal mounting was replaced by a turntable on the platform, which complemented its lower silhouette and improved stability. The barrel was a complicated L/74, constructed of three bore sections held by a 'sleeve', which resulted in difficulties with the extraction of fired shell cases. The problem was identified as being the joint between two barrel sections which met at the mouth of the shell case. On firing, the rim of the steel case expanded into this joint and got stuck. Changing to brass shell cases resolved the problem, but the barrel was eventually redesigned to a two-piece unit. The FlaK 41 had a travelling weight of 11,240 kg and weight in action was increased to 7,800 kg. It was a much heavier weapon than any of the three earlier 88 mm counterparts, but was still much lighter than any mark of the British 3.7 in. anti-aircraft gun. The barrel of the FlaK 41 was 72 calibres in length, or 6.336 m, and the muzzle velocity of the standard 9.2 kg high explosive projectile was 1,000 metres per second. It still used the semi-automatic, horizontal sliding breech which now used a ramming mechanism to assist in loading the larger shell. Elevation was increased to 90 degrees, but it still retained the ability to depress the barrel to -3 degrees to engage ground targets. The gun incorporated a separate firing circuit for use when firing against ground targets such as tanks. In theory a well-trained crew could fire 20 rounds per minute, but for all practical purposes (and essentially to conserve ammunition) this was never an accepted battle procedure. The maximum vertical range was 15,000 m, but the effective ceiling with the more powerful cartridge was in the region of 10,000 m,

The VFW 1 with the FlaK 41 barrel set at high angle. Note the side panels lowered to permit the crew to operate the gun; the large fixed gun shield is standard for the FlaK 41.

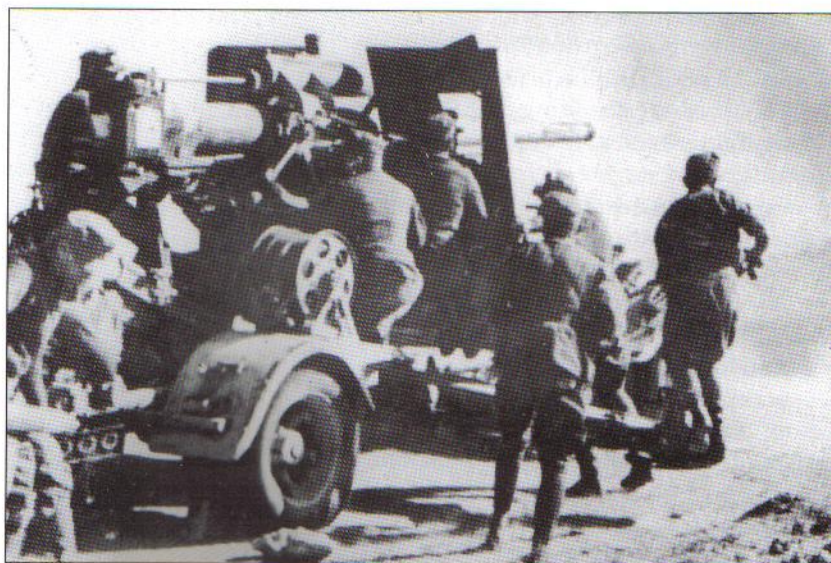


which made it some 25 percent better than the standard FlaK 36. In the horizontal ground role the FlaK 41 could fire 10.4 kg high-explosive projectiles to ranges of over 19,700 metres.

THE SELF-PROPELLED ANTI-AIRCRAFT GUNS

In order to provide protection against attack from aircraft while the army was on the move, the Germans developed a series of self-propelled anti-aircraft guns. Remarkably, however, it was not until 1942 that the 88 mm gun was considered for mounting into any of these designs, although earlier trials had been implemented using the FlaK 18. Again, it was left to Krupp to produce the prototypes for the project, known as *FlaK auf Sonderfahrgestell*, or *Flakpanzer für schwere FlaK* – ‘self-propelled anti-aircraft gun on tracked chassis’. The concept originated in 1941 when the Waffenamt ordered another heavy Panzerjaeger, the 88 mm K (Pz Sf) auf Sonderfahrgestell, in which it planned to mount a specially adapted version of the FlaK 36 L/56 88 mm gun in an open turret. The chassis was based on the PzKmpf IV and was known as the Pz Sf IVc; later versions were intended to carry FlaK 41 L/71 guns. Another proposed version, known by the codename ‘Gerat 42’, would have been armed with a new version of the 88 mm gun, the FlaK 42 L/71 which Rheinmetall was developing. However, Rheinmetall encountered a number of production problems with this weapon, so that by November 1942 only a wooden mock-up was available for study and the programme was finally scrapped in February 1943.

In August 1942 there were three prototypes of the original PzSf design ready for trials, but by now, as the war on the Eastern Front expanded, tank production was given precedence. The future of the project was in doubt as the gun’s worth was questioned. It was argued that mobile or self-propelled anti-aircraft guns would provide protection to a column on the march and also when laagered in camp. The



A FlaK 36 in operation against ground targets, possibly tanks in North Africa. It is firing from the wheeled carriage with all crew in appropriate positions. Note crewman in left hand corner with shell.

standard allocation of anti-aircraft vehicles was eight units to protect one regiment of 52 tanks; the output of tanks would barely have been affected by such limited production. The prototypes underwent field trials at the FlaK testing ranges at Ostseebad-Kuhlingsborn in October 1943, which showed the weapon to have great promise. The project was hampered by the size and weight of the completed vehicle, the PzSf, which had a combat weight of 26 tons, and was heavier than a standard self-propelled artillery piece, such as the Hummel which carried a 150 mm calibre weapon. The dimensions were also on the large side; at 7 m in length it was longer than many tanks and self-propelled guns in service and the width of 3 m would have caused problems when moving the vehicle by rail. Amazingly, however, its overall height was 2.8 m which came in under the 3 m regulation height restriction placed on armoured vehicles by the German army.

The 88 mm gun was mounted in a turret fitted with collapsible side panels which, when lowered, allowed the gun to traverse through 360 degrees, and the barrel to depress to -3 degrees to engage ground targets. The barrel could elevate to $+85$ degrees, but the drawback was all operations concerning tracking and engaging a target had to be

A self-propelled anti-aircraft Auf. Sfl IVc (VFW 1) fitted with the barrel of a FlaK 37 gun. It is shown here undergoing troop trials. It was not a success, but the development programme continued until January 1945.





The VFW 1 fitted with the barrel of a FlaK 41, seen here at the Krupp works in Essen. Note the side panels which are lowered to permit all-round traverse of the gun. It never entered service.

performed by hand. Despite this, the vehicle could have provided an armoured column with comprehensive defence against air and ground attack. A crew of eight served the weapon and with the Maybach HL90 engine, the vehicle could manage 35 km on roads with a combat range of 250 km on roads. The project lingered on until 13 January 1945, when Albert Speer, the Armaments Minister, finally cancelled it. Lighter calibre self-propelled anti-aircraft guns were developed and this project was perhaps the only time when the 88 mm gun was not successfully incorporated into a design during the war years.

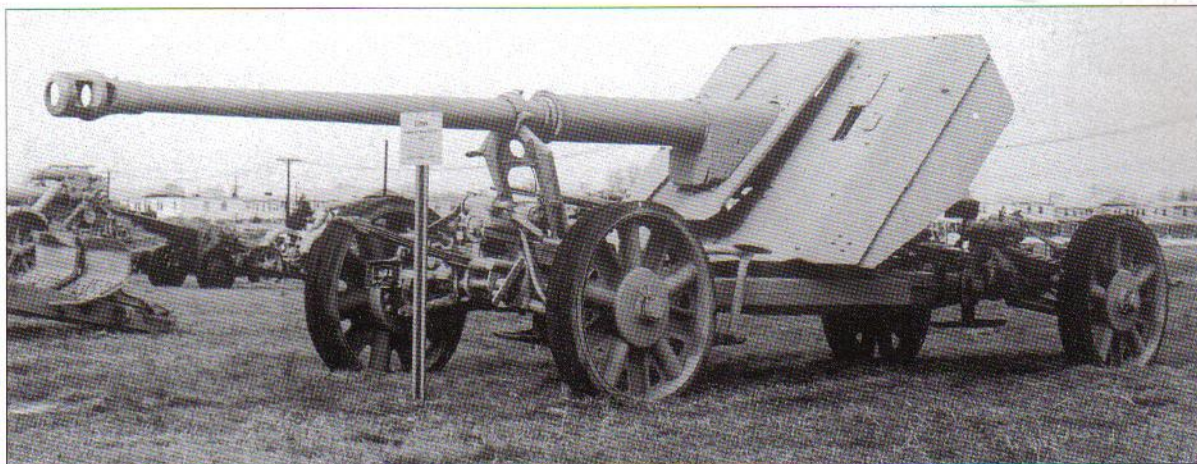
PERFORMANCE OF FLAK AMMUNITION USED AGAINST ARMOUR

Weapon	Ammunition	Weight (kg)	Muzzle velocity (m/sec)	Penetration of homogenous armour plate at 30 degrees from vertical (mm)				
				100 m	500 m	1,000 m	1,500 m	2,000 m
FlaK 18 & 37/L56	Pzgr	9.5	810	97	93	87	80	72
FlaK 18 & 37/L56	Pzgr 39	10.2	800	127	117	106	97	88

THE PAK GUNS

On 10 May 1940, following several months of 'Phony War', the Germans launched the much-vaunted Blitzkrieg into Western Europe. Driving through Holland and Belgium into France they seemed unstoppable. Localised resistance crumbled and the Allies retreated against fierce armoured attacks. On 21 May just outside Arras, units of the French and British armies were consolidated. Elements of 50th Division, supported by tanks of the 1st Army Tank Brigade, launched a counter-attack upon the German 7th Panzer Division commanded by General Erwin Rommel, who believed he was under attack by five divisions. The 37mm light PaK 36 guns had little or no effect on the British Matilda Mk II and French SOMUA 35 tanks, so Rommel ordered FlaK 18 88 mm anti-aircraft guns to engage the Allied tanks. The fighting was fierce and the Allies could not hope to match the ferocity and daring of the Germans; it was the Allies' first taste of the 88, but they were not in a position to immediately appreciate the fact. Meanwhile, further south, the German army was attacking parts of the Maginot Line, such as Marckolsheim, where casemates fell to direct fire from 88s pressed into service against ground targets.

A PaK 43 on a wheeled carriage fitted with solid rubber tyres. Note the well-sloped gun shield, low silhouette and double-baffle muzzle-brake. (Ian Hogg)



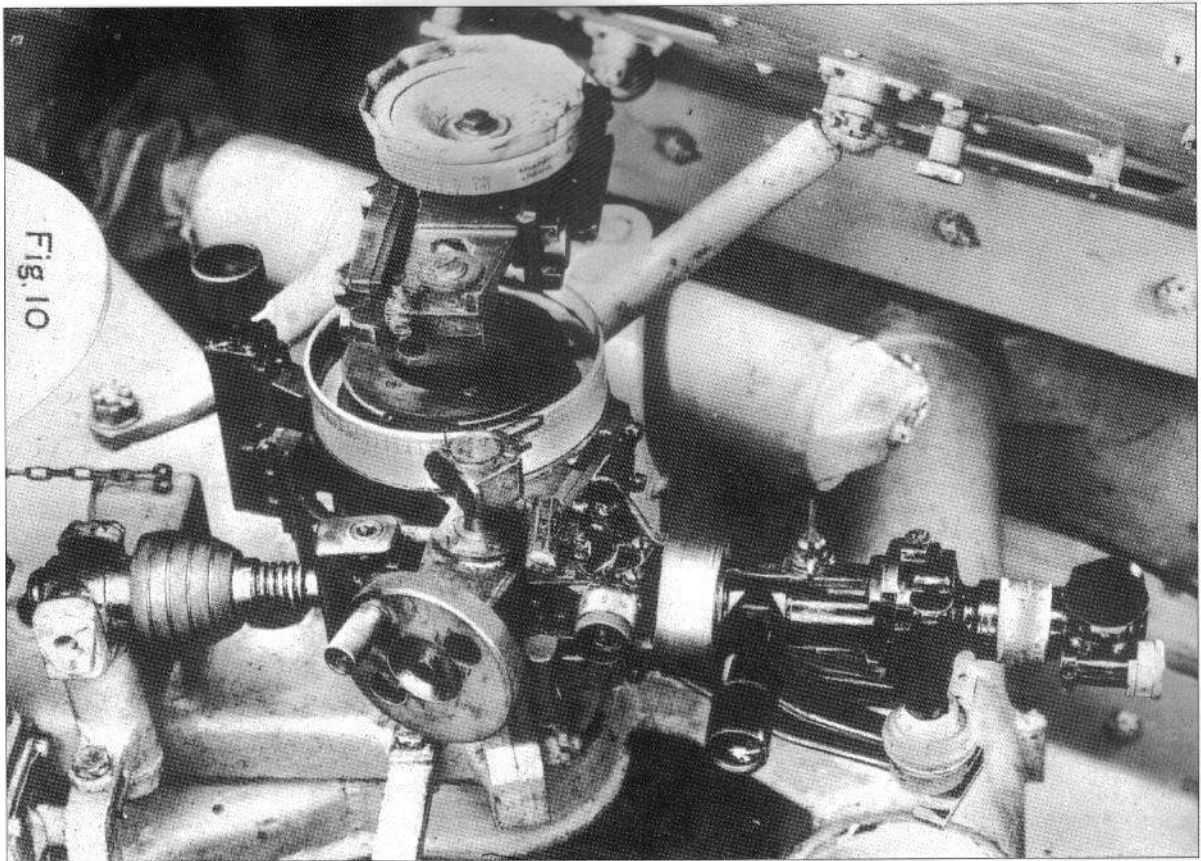
Although the 88 gun had been used as an anti-tank gun earlier in its history, it was really during German involvement in the North African campaign (1941–43) that it was to earn its fearsome reputation as a tank-killer. German involvement in this theatre of operations did not begin until the arrival of General Erwin Rommel with the advance forces of the newly created Afrika Korps in February 1941. Consolidating his troops, Rommel went on to the offensive and regained much territory lost by the Italians during 1940. Under pressure from Winston Churchill, General Wavell was forced to launch Operation Brevity in May 1941, directed towards Rommel's positions in Capuzzo and the Halfaya Pass, which soon became known to the British troops as 'Hellfire Pass'. It emphasised just how strong the Germans could be in defence. The following month Operation Battleaxe was launched on 15 June, and German anti-tank gunners once again provided a rude shock for many Allied tank crews. During this action the British are known to have

lost almost 90 tanks to a battery of well-dug-in 88s. To conceal the gun in a defensive location required the crew to dig a weapon pit measuring 6 m x 3 m, leaving only the barrel exposed above the rim of the position. With such a low profile, the guns were not easily spotted and their fire against the tanks was unexpected.

At this phase of the campaign there was no obvious requirement to use the 88 in the anti-tank role, because the terrain of the desert favoured mobile warfare, allowing attacks by large-scale tank formations, supported by standard field artillery and specialised anti-tank guns known as *Panzerabwehrkanone*, or PaK guns. Each German division had 24 anti-tank guns attached, with calibres between 37 mm and 50 mm, but the vast area of fighting meant these weapons were often very thinly deployed. Some sources claim that an unidentified German officer ordered 24 88 mm guns of a Luftwaffe FlaK regiment to be deployed in the anti-tank role, but other sources say it was Rommel himself. Whoever ordered the weapon's change of use on this occasion is purely academic, because the 88 already had a proven reputation as an anti-tank weapon dating from June 1940 in France. The Luftwaffe had air superiority in North Africa in 1941 and could afford to re-allocate these guns to bolster the weaker anti-tank units across the divisional front. The 88 mm became known as the German's 'trump card', capable of penetrating 99 mm of armour at ranges of more than 2,000 m. However, engagement of targets at such extreme ranges was often severely restricted by the

A gun crew of an 88 deploy in the Western Desert, May 1942. The gun is lowered on to its cruciform base and the crew are in the process of unloading ammunition. The man in the centre is carrying a wicker ammunition case.





The optical sight unit fitted to a PaK 43/41. Using this instrument an experienced crew could destroy tanks at ranges in excess of 2,000 m. (Ian Hogg)

limited visibility caused by sand and dust storms, which added to the heat haze and hampered target acquisition.

In this largely uninhabited theatre of the war, it was not uncommon for individual armoured brigades of the British army to take the initiative and fight independently, a fact which also applied to German *Kampfgruppen* (battlegroups). On 19 November 1941, for example, one tank regiment of the British 4th Armoured Brigade attacked positions at Gabr Saleh, which was held by the German Kampfgruppe Stephan, supported by 12 field guns and four 88 mm anti-tank guns. The result, for the British, was catastrophic. With a range of 2,000 m, the 88 mm could be used to engage targets in support of a German armoured attack in the desert without being committed to the actual battle. Indeed, it was not unknown for 88s to be at least 1,000 m behind the Panzers and still manage to hold off British armour. The British army had three times as many 3.7 in. anti-aircraft guns as the Germans had 88s, but for some inexplicable reason they were never fully utilised as an anti-tank weapon. The 3.7 in. gun had a calibre slightly larger than the 88 mm, and in theory was a better anti-tank gun than the German weapon. However, only 12 examples of the modified 3.7 in. guns reached the British army, and even then, according to one source they failed to make any impression because of defective gunsights.

In 1942 General Bernard Montgomery arrived in North Africa to take over as commander of the British 8th Army. He intended to build up its strength and laid plans which would lead to the final expulsion

These two photographs show the 1st Batterie Hamburg-Osdorf which saw service throughout Italy and North Africa in 1942.



The FlaK 36 88 mm gun on a prime mover half-track in complete travelling mode.

and defeat of Axis forces from North Africa. This culminated in the battle of El Alamein, 23 October to 4 November 1942, and afterwards he relentlessly pursued Rommel towards Tunisia. In his *Memoirs*, Montgomery records on 24 October, in the early part of El Alamein, that, 'There was not that eagerness on the part of senior commanders to push on and there was a fear of tank casualties; every enemy gun was reported as an 88 mm.' According to German records for 1942, the Afrikakorps only had 86 88s directly employed in the anti-tank role, but these were obviously bolstered by Luftwaffe guns. The reputation of the 88 as a 'tank-killer' had clearly dented Allied morale.

Crew of 1st Batterie Hamburg-Osdorf in action with gun set to engage tanks. Note the impressive tally of 'kill' rings painted on the barrel.

While Rommel was fighting in North Africa, the German army was preparing to mount its next major offensive, Operation Barbarossa, the attack on Russia launched on 22 June 1941. The Germans had concentrated 3 million men, over 3,500 armoured vehicles and more than 7,000 pieces of artillery, which naturally included the 88. Indeed, legend has it that the firing of an 88 gun signalled the beginning of the assault into



Russia. However, it was not until the appearance of the Soviet T-34 tank that the 88 was pressed into service properly as an anti-tank gun to supplement the lighter 50 mm calibre guns. Up to ten anti-tank guns were grouped together in a concentrated defensive position called a 'PaK front', to meet armoured thrusts by the enemy. The concerted fire of the anti-tank guns would then break up the assault. Initially, the tactic worked well, but massive Russian tank attacks over-



Abandoned 88 mm FlaK 37 gun being examined by British troops as they advance towards the L'Escaut Canal near the Dutch border. It appears that the crew used the trees as natural camouflage to screen the gun from Allied aerial reconnaissance.

ammunition which could be fired from existing guns and would penetrate the armour on the new Russian tanks. Tungsten-core rounds survived the shock of high-velocity impact, penetrating the armour plating of a tank, whereas ordinary steel shot frequently shattered. As tungsten was unavailable, Krupp was asked to design a new version of the 88 specifically for anti-tank role operations

PaK 43

Krupp responded by modifying the FlaK 37, which became known as the 88 mm PaK 43 on entering service in 1943. It had a very low silhouette and was fitted with a well-sloped shield to protect the crew. The gun was still mounted on the *kreuzlafette*, cruciform carriage, and fitted with pneumatic tyred wheels for transportation, but the design now incorporated two sets of single tyres. Later, the pneumatic tyres were altered to a solid design as rubber supplies declined. The PaK 43 could be brought into action by simply lowering jacks which bore the weight of the carriage, while the two sets of transport wheels were removed and the 'outrigger' stabilising arms were lowered into place. The carriage design was a departure from the standard practice of fitting split trails to anti-tank guns. As a true anti-tank gun, the elevation of the PaK 43 was restricted to operating between -8 degrees and $+40$ degrees.

One advanced feature of the design was that it was not always necessary for the crew to remove the carriage wheels before firing. Krupp had allowed sufficient strength in the suspension to enable the PaK 43 to be fired from its wheels to engage targets of opportunity when they appeared. However, when firing in this fashion it was limited to only 30 degrees of traverse either side of the centreline. When fully deployed on the ground it regained a full 360 degree traverse on the turntable.

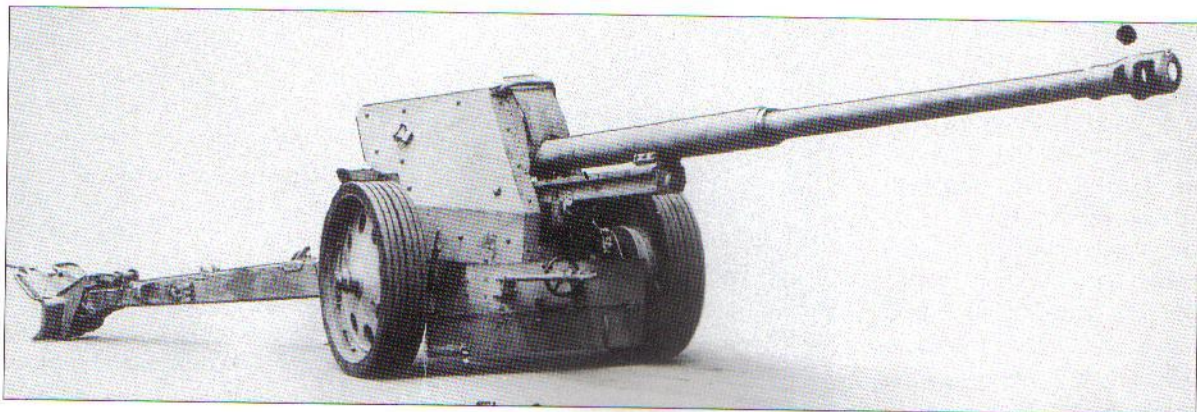
whelmed such efforts simply by numerical superiority.

Unfortunately for the frontline soldier, there was a lack of specialised ammunition caused by a severe shortage of tungsten, the tough steel used in armour-piercing anti-tank ammunition. With supplies of this metal much reduced, it was decided to reserve existing stocks for tools to make more weapons. However, in order to defeat the T-34 and heavier Soviet tanks, the army desperately needed an anti-tank gun with higher muzzle velocity than the standard 50 mm PaK 38. Deprived of such a weapon, the Wehrmacht demanded unrestricted supplies of tungsten-core

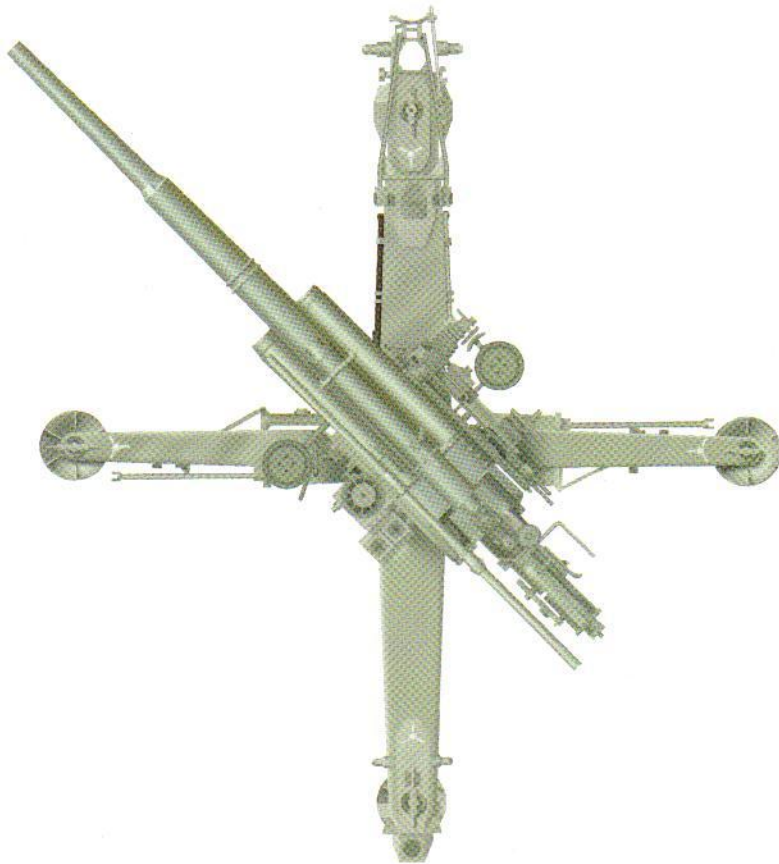
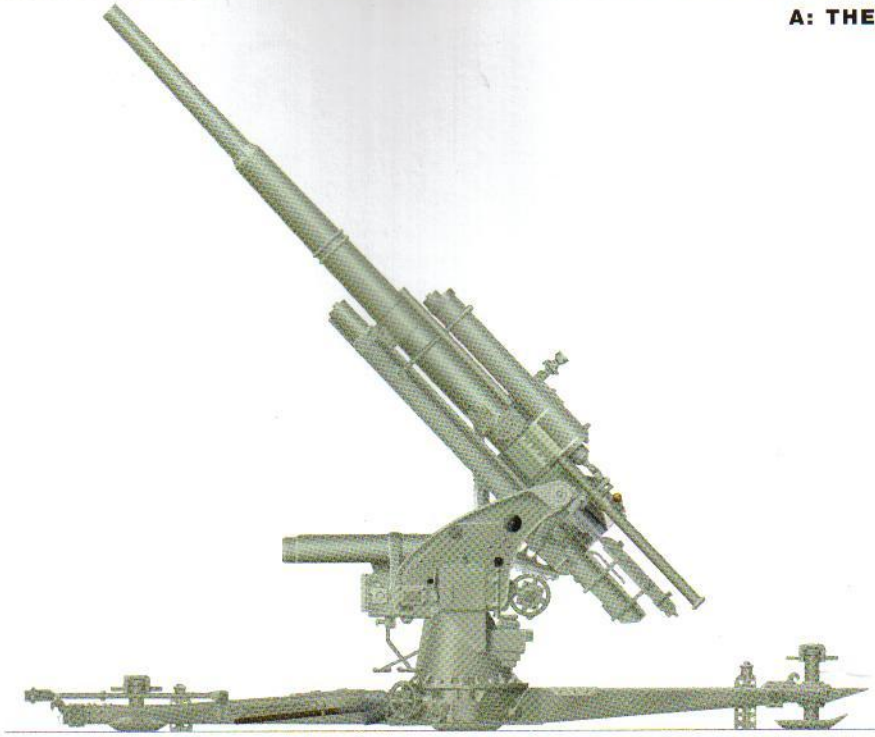
The layout of this new version of the 88 gun resulted in a much lower profile, only 2.02 m in height, and when the wheels were removed from the platform, the PaK 43 could be set so close to the ground that the height to the top of the gun shield was 1.5 metres, which made concealment much easier. The main drawbacks to the PaK 43 were that with a travelling weight of 5,000 kg, a travelling length of 9.15 m and the need to remove the travelling wheels, the gun was a trifle slow to bring into action. But even so, it was still more than 4,300 kg lighter than the British 3.7 inch Mk 1 anti-aircraft gun. The time factor for deployment was a minor problem, since most anti-tank guns were operated from well prepared defensive positions. With its bogie wheels removed, the combat weight of the Pak 43 was reduced to 3,700 kg and when sited in prepared anti-tank defences to form 'PaK Fronts' the outrigger arms could be further secured by hammering in metal stakes to prevent movement during recoil.

The firing mechanism was electric, an unusual feature for a field weapon, and safety switches were built in to ensure that the gun would not fire if it happened to be at a particular angle or elevation where the breech might strike one of the platform legs on recoil. The breech mechanism was a semi-automatic vertical slide action, which ejected the lacquered steel cartridge case after firing. The barrel was 6.2 m in length and could fire up to ten rounds per minute with three types of ammunition available, all of which were the 'fixed' type. It was also fitted with a double-baffle muzzle brake to help reduce the force of recoil on firing. The high-explosive projectile weighed 9.2 kg with a muzzle velocity of 968 m/sec, and could be fired out to ranges of 21,000 m to provide artillery support to infantry. In the anti-tank role the PaK 43 fired the standard armour piercing tungsten cored shell, the AP 40, which weighed 10.4 kg, and was termed APCR (armour piercing core rigid). The AP 40 had a muzzle velocity of 1,200 m/sec and could penetrate some 167 mm of armour at 1,000 m range at 30 degrees impact. Even at 2,000 m it could still penetrate more than 139 mm of armour at a 30 degree impact. Special anti-tank shells using the chemical energy of high explosive, known as HEAT (high explosive anti-tank) to penetrate armour were in the design stage when the war ended in 1945 and never saw service. By any standards, the PaK 43 was a truly outstanding design, proving itself to be a highly successful weapon wherever it appeared.

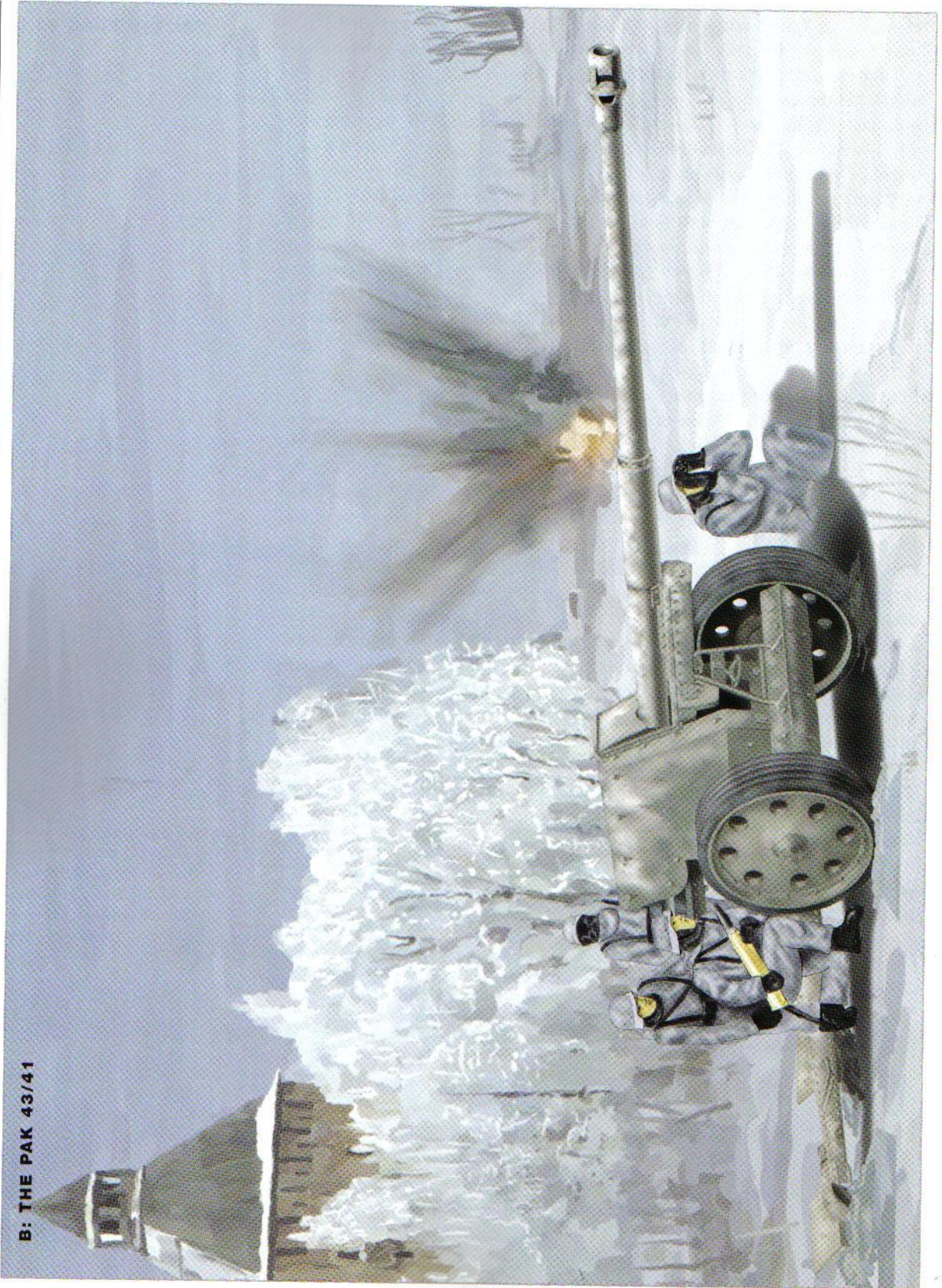
A PaK 43/41 towed anti-tank gun with the distinctive double-baffle muzzle brake. Note the well-sloped gun shield and junction where the barrel connection is made. (Ian Hogg)

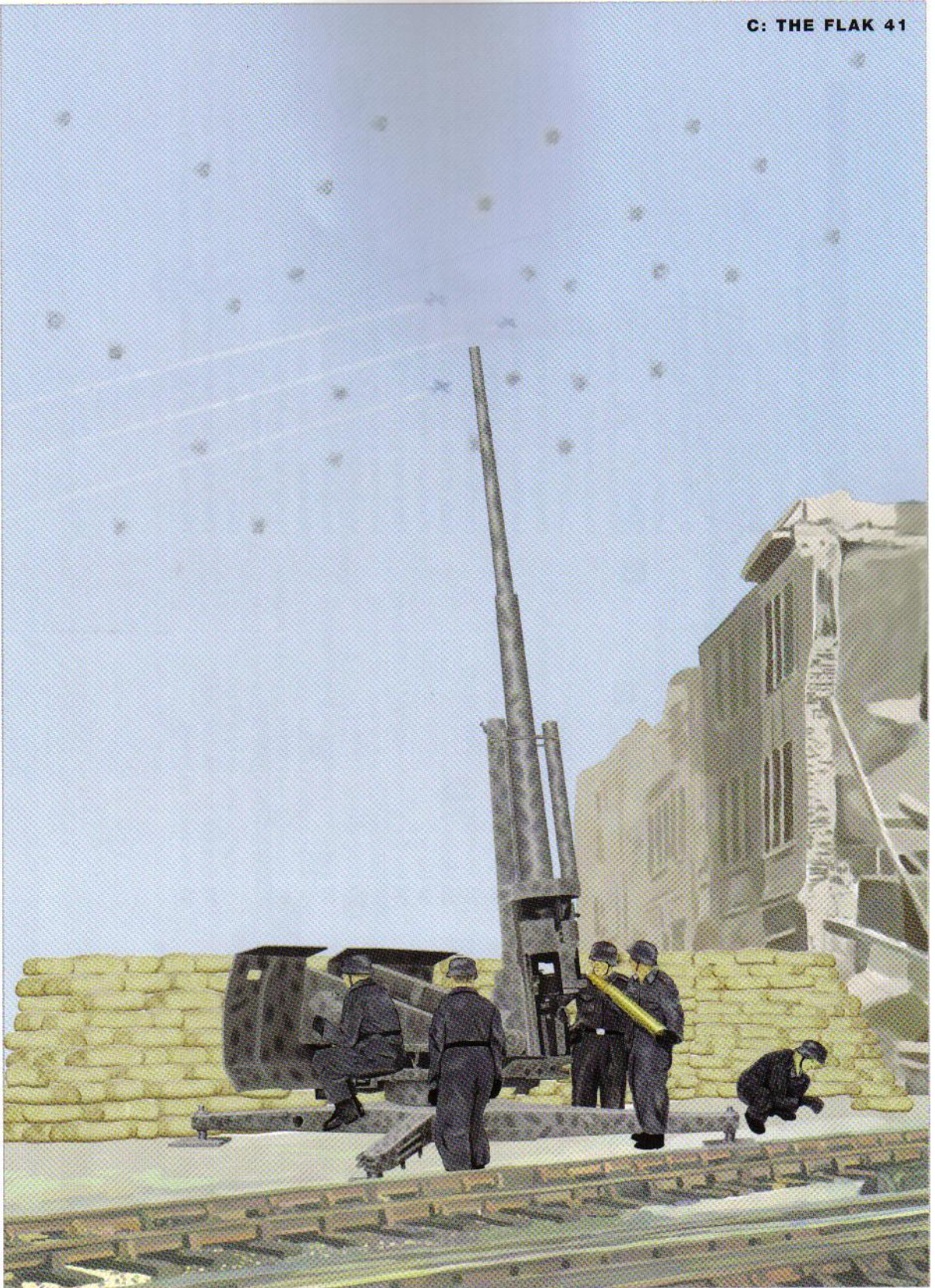


A: THE FLAK 37



B: THE PAK 43/41





E: THE PAK 43





THE FLAK 18

KEY

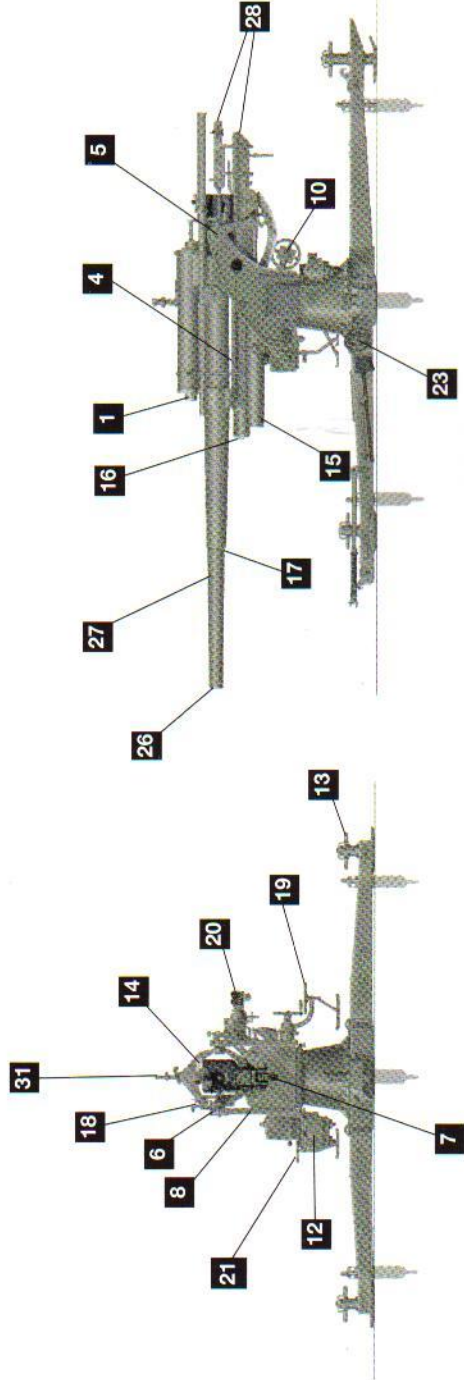
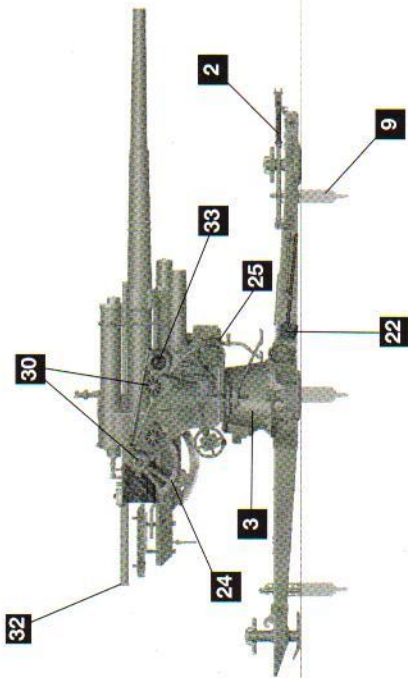
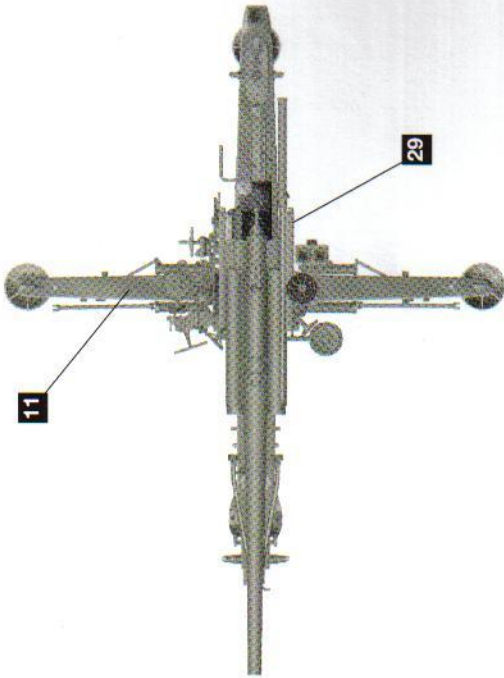
- 1 Hydro-pneumatic recuperator
- 2 Barrel rest for securing barrel when in transit
- 3 Traversing pedestal to permit 360 degree traversing to follow targets
- 4 Gun cradle to support barrel
- 5 Trunnion bearings
- 6 Cap square to secure the barrel trunnions in place
- 7 Balancing gear support bracket for use when barrel is elevated
- 8 Saddle of riveted and welded design to support the barrel and permit mounting on pedestal
- 9 Metal securing spike or stake; hammered into ground to secure the cruciform legs of platform when used from dug-in defensive positions
- 10 Elevating mechanism handle for use in anti-aircraft role
- 11 Firing platform; cruciform in plan view with outrigger arms in lowered position
- 12 Fuze-setting equipment for use with shells in anti-aircraft role
- 13 Stabilising jacks for balance; one was fitted to the end of each arm to compensate for uneven ground
- 14 Breech mechanism
- 15 Equilibrators to balance the muzzle of the barrel

- 16 Recoil tube
- 17 Barrel joint, screw threaded; straight stepped distinct from later models such as FlaK 36 and FlaK 37
- 18 Telescopic sight for direct fire in anti-tank role
- 19 Seat for anti-aircraft gunner to monitor predictor settings
- 20 Anti-aircraft sight unit
- 21 Gunner's seat
- 22 Spade used for digging in
- 23 Horizontal levelling mechanism for fine balancing when sited in position
- 24 Angle indicator for elevation of barrel
- 25 Traversing mechanism handle
- 26 Muzzle of barrel
- 27 Barrel
- 28 Ramming mechanism and folding guard protector for use in anti-aircraft role
- 29 Firing lever
- 30 Follow the pointer dials giving information when engaging aircraft
- 31 Telescopic sight ZF20E to provide elevation and azimuth against all types of moving targets; naval, aerial and ground
- 32 Eyepiece for telescopic sight
- 33 Fire control equipment

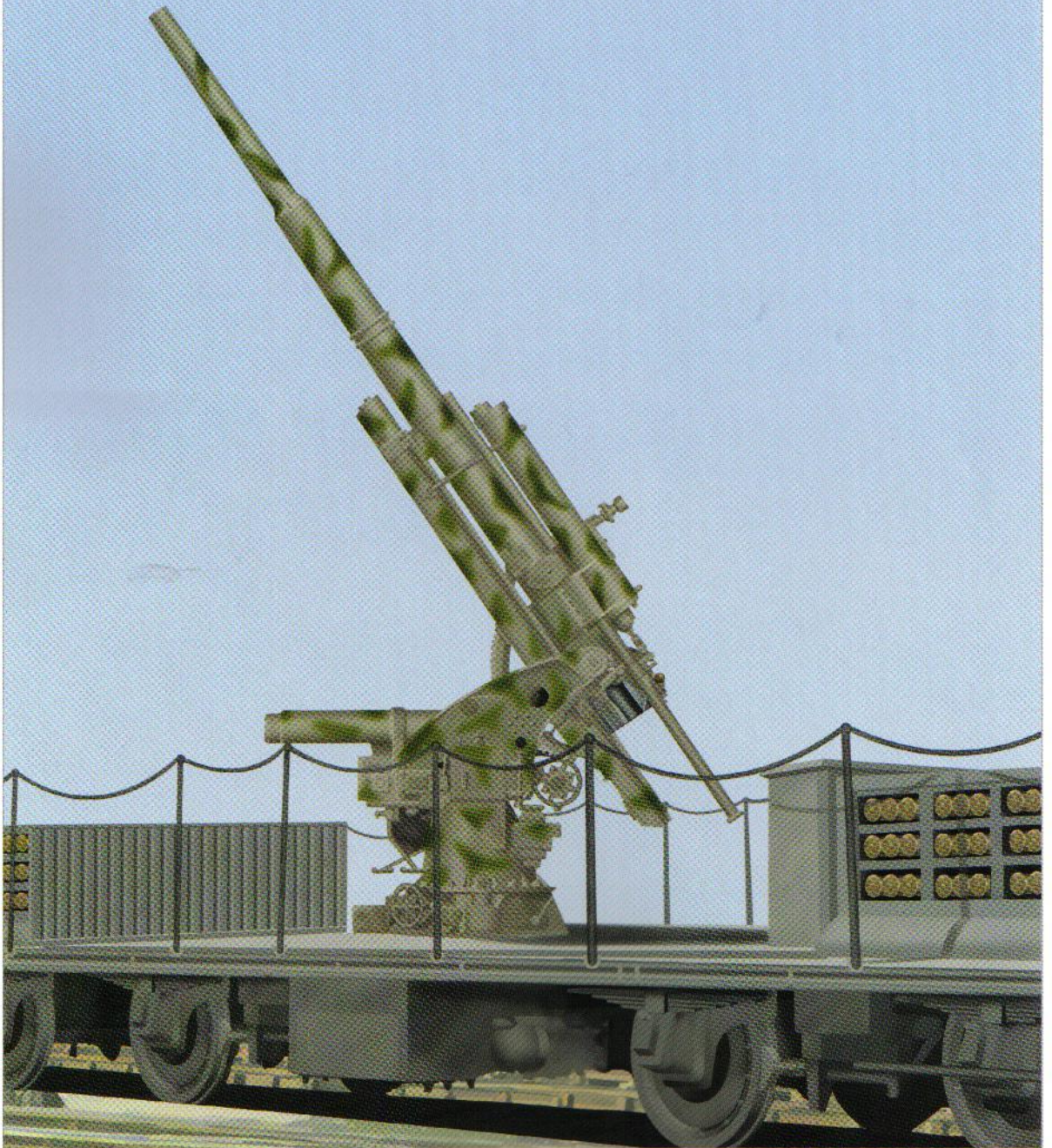
SPECIFICATION

Overall dimensions in travelling role:

- Length:** 7.7 m
Height: 2.4 m
Width (front): 2.19 m
Width (rear): 2.3 m
- Overall dimension in firing role:**
- Length:** 5.8 m
Height: 2.1 m
Width of outrigger arms: 5.14 m
Weight in action: 4,986 kg
Calibre: 88 mm
- Overall length of barrel:** 4.7 m
- Length and type of rifling:** 4 m with 32 grooves right hand twist
- Total weight of barrel:** 1,336.7 kg
- Muzzle velocity:** 820 m/sec
- Rate of fire:** 15 rounds per minute
- Maximum range horizontal:** 14,813 m
- Maximum ceiling:** 9,900 m
- Maximum effective ceiling at 70 degrees:** 7,620 m
- Maximum elevation:** +85 degrees
- Maximum depression:** -3 degrees
- Traverse:** 360 degrees
- Length of wheelbase:** 4.19 m
- Ground clearance:** 34.7 cm
- Crew:** 11 to 12 men including driver of prime mover towing vehicle
- Time into action from travelling with 6 man crew:** 2.5 minutes
- Time out of action to travelling with 6 man crew:** 3.5 minutes



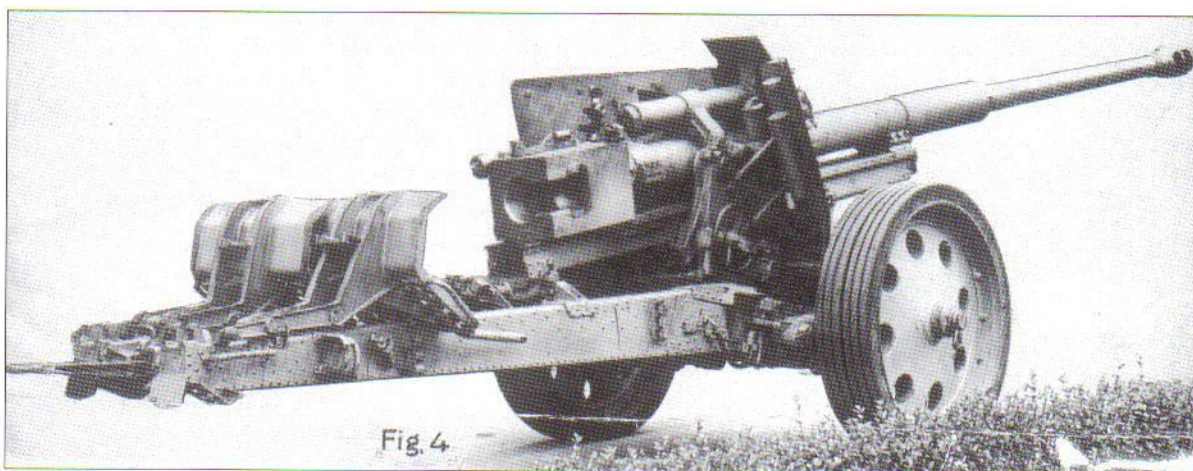
G: RAILWAY MOUNTED ANTI-AIRCRAFT GUN



PaK 43/41

In order to engage the heavier tanks on the Russian Front, the performance of the 88 had to be improved still further, however. The enlarged chamber, which allowed the more powerful cartridge to fire 88 mm projectiles at higher muzzle velocities was retained, but mobility and time into action had to be improved. What was to be the last version of the 88 designed by Krupp entered service in 1943 as the PaK 43/41. Originally Krupp had planned to keep the cruciform carriage despite its complexity, but manufacturing problems led to delays and production output was compromised. Krupp devised a two-wheeled carriage using stock components from other weapons. The design also returned to the traditional split trail carriage, the arms of which terminated in recoil spades which dug into the ground on firing to give improved stability. The PaK 43/41 gun was mounted on a two-wheeled solid tyred field carriage constructed from elements of the 10.5 cm gun-howitzer le FH 18/40 matched with wheels from the S18, 15 cm series of guns. The breech block had reverted to the horizontal sliding mechanism with a modified semi-automatic gear. In true anti-tank gun design, elevation was from -5 to $+38$ degrees, but traverse was now restricted to 28 degrees left and right of the centreline of firing because it was no longer mounted on a turntable feature. The buffer and recuperator mechanism were contained in a cylinder housing above the barrel, and the balancing cylinders were mounted vertically either side of the carriage.

A 3/4 rear view of a PaK 43/41 breech mechanism. Note the box-girder-type trail legs and the large spades which would normally be deployed when sited in soft ground. (Ian Hogg)



The resulting design was a large, cumbersome weapon, which the troops quickly nicknamed 'Scheunentor', the 'barn door', because of its huge gun shield. With an overall travelling length of 9.15 m it was never popular with the gunners who found its 4,380 kg combat weight clumsy to manoeuvre, particularly in the deep snow and mud on the Russian Front. The PaK 43/41 was 2.53 m in width and 1.98 m in height. But, despite this, there was nothing wrong with the operational performance of the new design; the only real drawback was its weight which hampered mobility.

As usual there was a price to pay for the new technology. The PaK 43/41, although still of 88 mm calibre, was a much-altered weapon and

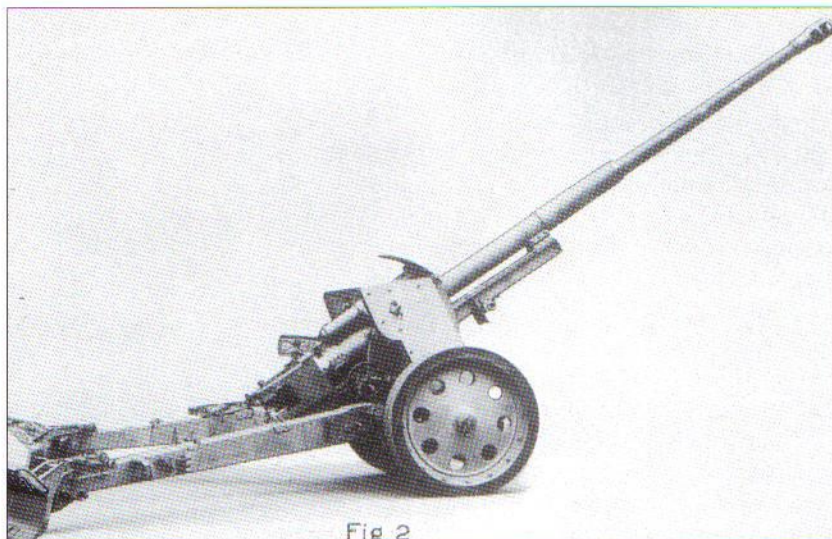


Fig. 2

Side-on view of the right side of a PaK 43/41. The wheels are fitted with solid rubber tyres rather than pneumatic. Note the length of the barrel which terminates in the double-baffle muzzle brake which controlled recoil. (Ian Hogg)

bore little resemblance to the original 88. The barrel length was 71 calibres and it was fitted with a double-baffle muzzle brake to reduce recoil forces on firing. The larger shell weighed 23 kg, and produced dense clouds of smoke on firing, which in cold, calm weather conditions could linger around the site of the gun's position. This not only betrayed the position of the weapon, but it also obscured the gunner's sight when traversing the weapon to engage the next target. It was recommended, therefore, that rates of fire be kept to under 15 rounds per minute in order to prevent build-up of vibration in the barrel. However, no gun crew could ever expect to fire 15 rounds per minute, especially given the fact that the new shells weighed almost twice as much as the original 88 mm shell, and ten rounds per minute was the given specification. Even at ranges of more than 3,000 m the new shell still had more penetrative power than the original 88 mm shell at 1,000 m. At close ranges the new shells were truly devastating, and one documented account illustrates how well the 88 mm gun functioned on the Russian Front: 'penetrative performance of the Panzergranat 39 [the standard armour-piercing shell for the 88 mm as also used by the guns of Tiger tanks] is satisfactory at all ranges, so that all enemy tanks appearing in this sector - T-34, KV1, JS2 - could be engaged with destroying effect. On being hit, the tanks showed darting flame three metres high and were burned out. Turrets were mostly knocked off or torn away. A T-34 was hit from the rear at a range of 400 metres and the engine block was flung out a distance of five metres and the turret cupola for 15 metres'. Although the PaK 43/41 was most widely used on the Russian Front, some units were also deployed against the Western Allies as they fought towards Germany.

By 1944 the Allies had even encountered the 88 in Italy, and a grudging respect for the powerful gun began to emerge. In 1946, a German officer captured at Salerno explained the actions of his battery of 88 mm anti-tank guns to an American officer: 'Well, it's like this. I was on a hill as a battery commander with six 88 mm anti-tank guns, and the Americans kept sending tanks down this road. We kept knocking them out. Every time they sent a tank we knocked it out. Finally, we ran out of

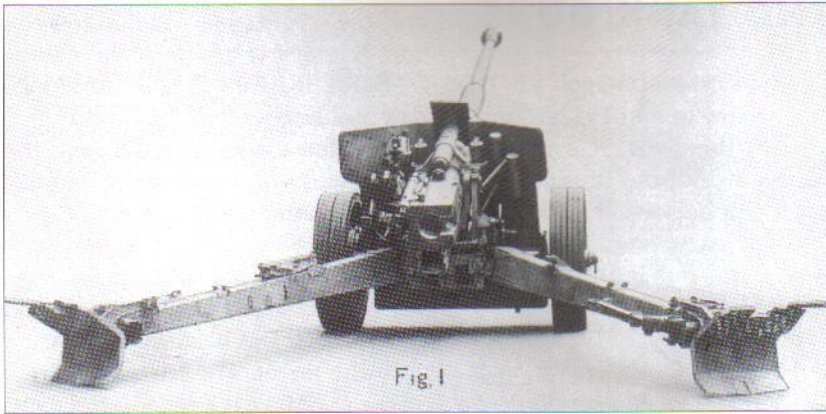


Fig. 1

Rear view of Pak 43/41 looking forward along the length of the gun from the breech end. The box-girder trails are deployed with spades lowered. Note the very narrow width of the gun which helped in concealment on the battlefield. (Ian Hogg)

ammunition and the Americans didn't run out of tanks.' To put it another way, the action, although relatively low scale, was one of attrition, to see which side would give up first. But that is no way to conduct a combat action.

The next trying time for the Western Allied armour came during D-Day on 6 June 1944. Here, the crews of the 88s in all versions, including the FlaK 18 and PaK 43, as well as tank guns and self-propelled models, were waiting for the Allied armour. As the fighting extended inland to the area of French countryside known as the *Bocage*, the 88 continued to exact a toll on Allied tanks and other equipment. In one engagement, for example, at St Aignan-de-Cramesnil, the Polish 2nd Armoured Regiment was badly mauled and lost nine tanks to one 88, out of a total of 26 tanks destroyed. By August, after much hard fighting the Allies were approaching Paris, where defences were believed to include at least 20 batteries of 88 guns. In the event, Paris was declared an 'open city', but even as the Allies entered, sporadic fighting broke out and some German anti-tank gunners used an 88 to open fire on a French armoured column equipped with Sherman tanks. The French returned the fire with amazing accuracy and destroyed the gun's position.

Detail of the breech mechanism of a PaK 43/41 showing the horizontal action of operation. Being semi-automatic, it ejected the shell case when opened which allowed the loader to insert another round with little delay. (Ian Hogg)

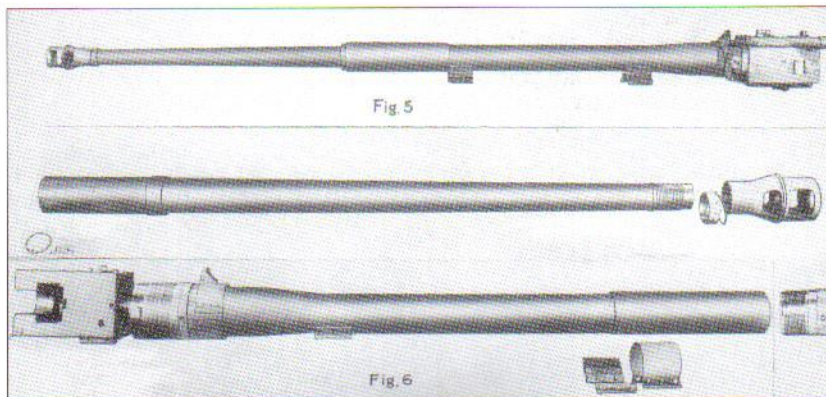
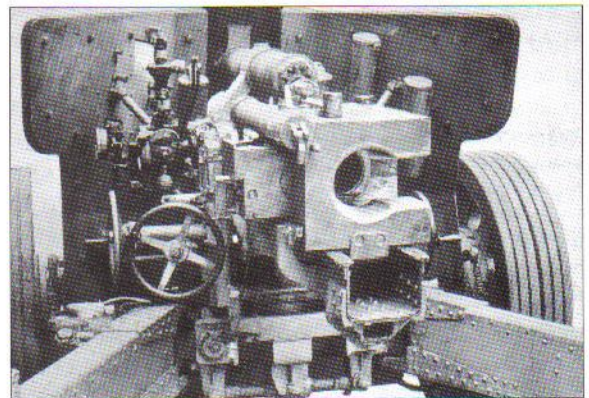


Fig. 5

Fig. 6

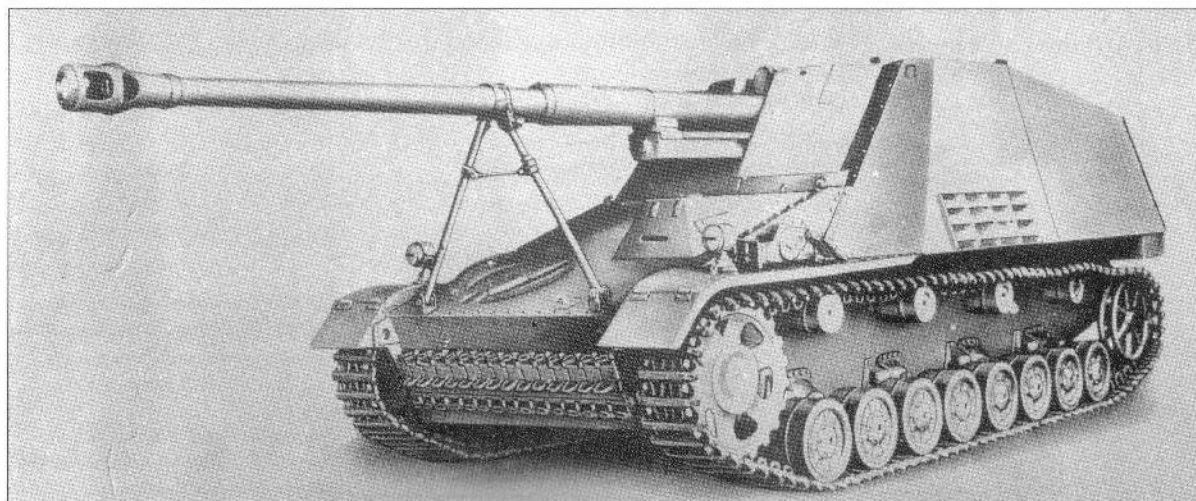
Detail showing the construction of the Pak 43/41 88 mm barrel. It shows how sections are built up to allow any worn-out or damaged sections to be replaced. Note the method of attachment for the double-baffle muzzle brake. (Ian Hogg)

THE TANK GUNS

The PanzerKampfwagen VI 'Tiger I', SdKfz 181 Ausf E, was introduced into service in mid-1942. It was a slower and heavier tank than previously used by the German army and had been developed in response to the appearance of the Russian KV-1 and T-34 tanks on the Eastern Front. It had been decided that this 55 tonne tank, with armour up to 110 mm thick in parts, would be equipped with an 88 mm gun as the main armament, rather than a 75 mm weapon. The weapon selected was a version of the 88 mm FlaK 36 with a barrel length of 56 calibres and termed KwK 36 L/56 (*Kampfwagenkanone 36*). It was balanced by a heavy spring contained in a tube to the left of the turret. The barrel was fitted with a double baffle muzzle brake in order to reduce the recoil, along with a recoil mechanism which used a system of hydraulic buffers with hydropneumatic recuperators, which allowed the gun to be fitted into the turret of the Tiger I. The breech mechanism for the KwK 36 was similar in design to the 75 mm calibre L43 and L48 tank guns, and uniquely, the Tiger I Ausf E was the only vehicle to be fitted with this version of the 88 mm gun. The gun was still electrically fired, as were all German tank guns, and used the same type of ammunition as the FlaK 18, 36 and 38 guns, although it was referred to as Panzergranate (Pzgr) to identify stocks as tank ammunition. The ammunition, as with all tank guns, was still of the fixed round type. Two types of ammunition were used by the KwK 36 L56 gun, the Pzgr 39 and Pzgr 40, which could penetrate up to 100 mm and 138 mm of armour plate at ranges of 1,000 m respectively. The Tiger I normally carried a total of 92 rounds ready to use within the vehicle, but some 84 tanks were fitted with additional radio equipment which reduced the number of rounds carried to only 66 shells.

The first combat unit to receive the Tiger I was the 1st Platoon of the 502nd schwere Panzerabteilung, which went into action at Leningrad in August 1942. The Tiger I saw service with heavy tank units of at least three SS divisions, including the Grossdeutschland Division, and inflicted heavy losses on all fronts where it was deployed. Perhaps one of the finest moments – and a demonstration of the power of the weapon – came at the hands of Obersturmführer Michael Wittmann, commanding the

The Hornisse SdKfz 164 self-propelled heavy anti-tank gun fitted with the PaK 43/1 L/71. Some 494 vehicles of this design were built between 1943 and 1945, and used in Italy and Russia. (Ian Hogg)



An 88 destroyed by the RAF flying in support of the British 8th Army. Note the twin-tyred pneumatic wheels and barrel support. It has been smashed along with its half-track prime moving vehicle.



2/sSS-PzAbt 101, during the Normandy Campaign of June 1944. On the morning of 13 June Wittmann concealed himself in a small copse beside the road leading out of Villers-Bocage where he could observe a column of vehicles from the 7th Armoured Division moving from the town. The column included a tank battalion from the 4th County of London Yeomanry (Sharpshooters) and elements of 1st Rifle Brigade in half-track carriers. Wittmann waited until the column was less than 80 m away from his position, and opened fire on the leading tank, a Cromwell, destroying it with a single shot. The road forward was now blocked to the column, and, taking advantage of the situation, Wittmann moved along the length of the column firing as he went. For daring and audacity the action was a masterstroke, but Allied superiority in numbers of vehicles meant that such engagements could not be maintained by the Germans who were experiencing logistical resupply problems.

The Tiger I was in service from 1942 until the end of the war in 1945 but despite its psychological value its size and weight meant that it could be out-manoeuvred by the more agile Allied tanks which used the simple expedient of attacking from the rear. However, once again, the presence of the mere 88 mm gun had terrific propaganda value, because its prowess was wildly exaggerated by Allied troops. Indeed it would appear that this combination of gun and armour instilled far more dread than the actual numbers of vehicles committed to the battlefield would have us believe.

The PzKpfw VI 'Tiger II' Ausf B. SdKfz 182 first entered service with training units between February and May 1944, with the first units arriving in Normandy in June 1944. These tanks were armed with the more powerful version of the 88 mm gun, which had a barrel length of 71 calibres and was based on the highly successful PaK 43 design, the KwK 43/L71. The cartridge cases were modified, but the projectiles themselves (Panzergranate) were the same as those fired by the FlaK 41. The Tiger II carried 78 rounds, and the Pzgr 40/43 shell could penetrate up to 193 mm of armour at ranges of 1,000 m. The semi-



Captured 88s being examined by British troops just south of Rome in January 1944. They had fired on a convoy as it moved out of the Anzio beachhead. Counter-fire forced the crew to abandon the gun virtually intact.

automatic breech mechanism was a simplified version of that fitted to the Tiger I, being based on the same weapon, the 75 mm L48 and 88 mm L56. As with all tank guns, they were fitted with vertical sliding breech-blocks and were operated by spring actions of the type fitted to the PaK and FlaK versions of the 88 mm gun. The gun mounted in the Tiger II was fitted with a double-baffle muzzle brake for recoil control and represented the largest type of main armament to be fitted to a conventionally designed operational tank in service with the German army. Unfortunately, the high velocity ammunition wore down the barrel, so later models were fitted with guns constructed in two parts. This was similar to the barrel construction of the standard 88 mm and permitted the easy replacement of worn parts rather than the whole barrel. Only 485

units of the Tiger II were completed, but they saw service between their introduction in 1944 and the end of the war in 1945. The L71 version of the 88 mm gun was also fitted to three other armoured vehicles: the 'Hornisse' SdKfz 164, the 'Elefant' SdKfz 184, and the Jagdpanther SdKfz 173, all of which were specialised anti-tank vehicles and had specific terms for their guns.

THE SELF-PROPELLED UNITS

Known variously as either the 'Nashorn' (rhinoceros) or 'Hornisse' (hornet), the SdKfz 164 was the first specialised tracked self-propelled anti-tank gun to enter service with the German army. Fitted with the PaK 43/1 L/71 version of the 88 mm gun, the Auf PzJg III/IV had been designed in 1942 specifically to provide a mobile platform for the anti-tank gun. Over 100 units were planned for May 1943. The *Nashorn* was developed in response to the problems experienced by troops trying to move the towed version of the PaK 43 through the deep mud on the Eastern Front.

The chassis came from a PzKpfw IV hull and suspension. It was fitted with a Maybach HL 120 TRM V-12 water-cooled inline petrol engine which developed 300 hp at 3,000 rpm to give speeds of 40 km/h on roads and 24 km/h cross-country, with a combat range of up to 200 km. The carrier chassis had to be modified to provide a large fighting compartment which was laid out behind the centreline of the hull, and meant lowering the deck of that compartment, with the 88 mm gun mount fixed to the floor. When mounted, the muzzle of the barrel came to a height of 2.24 m, some 600 mm higher than when the gun was on its towed cruciform ground mount. It could be elevated between -5 degrees and +20 degrees, with traverse being restricted to 30 degrees. The vehicle had a crew of four and all controls of the gun were carried out by hand. There were those who maintained that it was too vulnerable to serve as a direct-fire gun, due to the lack of armour protection, but despite this the *Nashorn* served in its role of carrying the



A completely destroyed 88, possibly a FlaK 36, somewhere in Holland 1944.

88 mm gun well enough. It could scale vertical obstacles up to 600 mm in height, cross trenches up to 2.3 m wide and negotiate gradients of 30 degrees. In fact, this kind of capability allowed the vehicle to be sited in ideal tank ambush positions. With an overall height of 2.95 m, the *Nashorn* just complied with the 3 m height regulation, and indeed, it was this very factor which gave the greatest cause for concern. The arrival of the first units of the *Nashorn* on the Eastern Front, which went to the 655th schwere Panzerjägerabteilung, did much to bolster the numbers of towed versions of the 88 mm PaKs. The *Nashorn* served from 1943 until 1945, during which time some 494 units of an initial order for 500 vehicles was completed.

The second specialised tank destroyer mounting a version of the 88 mm to enter service was known officially as the 'Sturmgeschütz m/8.8 cm PaK 43/2, Sdkfz 184' or less formally as either the '*Elefant*' or the '*Ferdinand*' after Dr Ferdinand Porsche, the automotive engineer and tank designer. It was developed on the orders of Hitler himself, who was pressing for a self-propelled gun with a turret large enough to mount the 88 mm KwK L71 gun. The design for a heavy tank destroyer mounting an 88 mm gun used a version of the Tiger tank designed by Porsche which had not entered service because of technical problems with the petrol-electric drive. The result, in September 1942, was a 64-tonne vehicle with a fixed superstructure, a frontal armour thickness of 200 mm, and mounting the PaK 43/2 L71 version of the 88 mm gun facing forward.

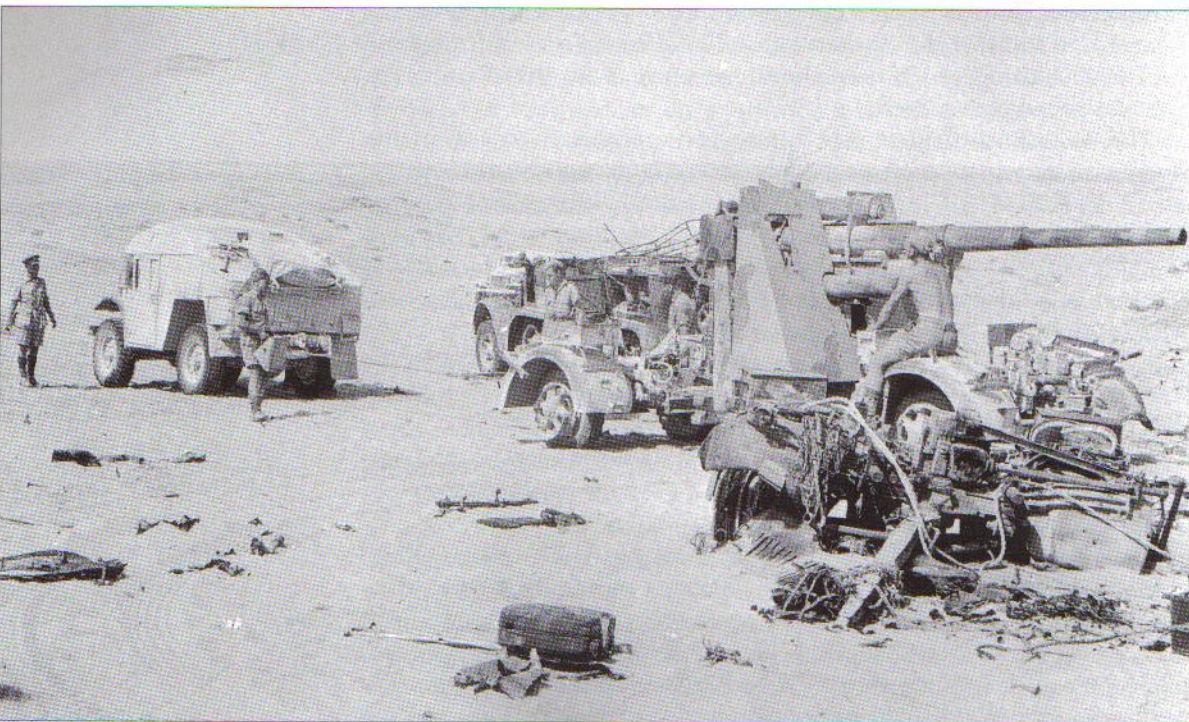
When Porsche lost the contract for the Tiger I, his company had more than 90 chassis in various stages of completion. Rather than scrapping them, and losing valuable production time, the design team working on the new self-propelled tank destroyer decided to use them for Hitler's project. They were delivered in time for the Kursk Offensive in the summer of 1943, where they entered the battle deployed by the



ABOVE AND BELOW

Two photographs showing a British army recovery unit seizing abandoned 88s during the battle of El Alamein. Although left behind by the retreating enemy, they were still serviceable and had to be removed from the battlefield to deny them to the Germans in the event of a counter-attack.

traverse 28 degrees and elevate between -8 degrees and $+14$ degrees. Access to the fighting compartment was through a circular hatch to the rear plate, where the six-man crew shared the space with 50 rounds of 88 mm ammunition. The Ferdinand was able to destroy most Allied tanks at ranges far greater than they could effectively return fire. The great thickness of armour meant that it was virtually invulnerable to any attack by Allied anti-tank guns from the front. It was a formidable weapon, but like all non-turreted weapons, its main weakness was vulnerability to attack from the flanks and rear.



654 and 653 Panzerjager-abteilungen. The vehicles gave good account of themselves and were later used in small numbers on the Italian front.

In appearance the Ferdinand had a large box-like superstructure which extended over the rear half of the hull, with as much slope to the armour as the design would allow. Even though it was set so far back, the barrel of the 88 mm gun still overhung the front by some 1.2 metres. The gun was laid using hand controls and could

With a combat weight of over 65 tonnes, the vehicles were in constant danger of bogging down and careful reconnaissance was vital to avoid this. The Ferdinand was capable of scaling vertical obstacles up to 780 mm in height, crossing trenches of 3.2 m in width and fording water obstacles up to 1.22 m in depth. The great size and slow 20 km/h road speed, coupled with a combat range of only 150 km, made advance reconnaissance doubly important. Great things had been expected of this highly specialised tank destroyer and they performed well at Kursk before the advantage of their great size was turned against them. Initially, they led the attack and broke through the Soviet defences, but as the Russians counter-attacked, elements of the units issued with the Ferdinand found themselves surrounded in the rear areas and almost wiped out. In the later stages of the war on the Eastern Front, the remaining Ferdinands were used as mobile pillboxes, a role in which they were far more successful. Although only 90 units of this vehicle were made, they saw combat service between 1943 and 1944.

The last specialised tank destroyer armed with the 88 mm gun to enter service was the 45.5 tonne Jagdpanther, SdKfz 173. This vehicle carried the PaK 43/3 L/71 88 mm weapon. There is some debate over whether the Jagdpanther carried 57 or 60 rounds ready to fire, but the number probably varied from one vehicle crew to another and was dependent on stocks available at the time of resupply. The gun had traverse limited to 13 degrees either side of centreline, and could be elevated between -8 degrees and +15 degrees. Introduced into service in June 1944, the Jagdpanther was issued to the 559th and 654th Panzerjägerabteilungen, specialised anti-tank units. The paper strength of a typical Jagdpanther battalion was 30 vehicles, but in reality this was only rarely realised due to delivery difficulties. Perhaps the only time a unit was above combat strength was when the 654th took delivery of some 42 units. The vehicle was in service between 1944 and the last days of the war when some of the last surviving vehicles were deployed to several Panzer Divisions, including the Führer Grenadier Division. The Jagdpanther had also given the Allies a nasty surprise during the Ardennes Campaign in December 1944, at a time when most considered the war in the west was all but over. Although understood to be very popular with its crews, the production run, which lasted from January 1944 until March 1945, only managed to turn out 382 vehicles.

TANK GUNS

Weapon	Ammunition	Weight (kg)	Muzzle velocity (m/sec)	Penetration of armour plate at 30 degrees from vertical (mm):				
				100 m	500 m	1,000 m	1,500 m	2,000 m
KwK36/L56	Pzgr 39*	10.2	773	120	110	100	91	84
KwK36/L56	Pzgr 40	7.3	930	171	156	138	123	110
KwK43/L71	Pzgr 39-1	10.2	1,000	203	185	165	148	132
KwK43/L71	Pzgr 40/43	7.3	1,130	237	217	193	171	153

* Pzgr = Panzergranate: Solid shot armour-piercing shell.

MISCELLANEOUS 88s

The Schiffskanone C/35 and Unterseebootlafette C/35 were naval versions of the weapon, used for arming surface ships and U-boats respectively. Although technically unrelated to the more powerful and better-known PaK and FlaK versions of the 88 mm gun, and although its performance was not as good, the lightweight C/35 was still valuable in hitting targets such as slow-moving landing craft.

Although the C/35 was of the same calibre as the anti-aircraft and anti-tank guns, it was a totally different weapon and its inclusion here only really serves to illustrate how the 88 mm calibre gun appeared in various shapes and sizes. In fact, the C/35 actually represented the last in a long line of 88 mm calibre ship and submarine guns which had been used to arm German warships in the First World War. The gun was fitted to a pedestal mounting and had a gun shield to protect the gun crew, complete with chest pads as fitted to the model for use on U-boats. The gun was only intended to be used as a stop-gap weapon, deployed to fill any weak spots in coastal defences, and some were sited at various prepared coastal artillery positions along the Normandy coast. In one engagement on the morning of D-Day, a detachment of Canadian troops landing on Juno Beach found themselves under fire from one such mounting on the harbour exit at Courseulles. The gun continued to fire until it was finally destroyed by Sherman tanks.

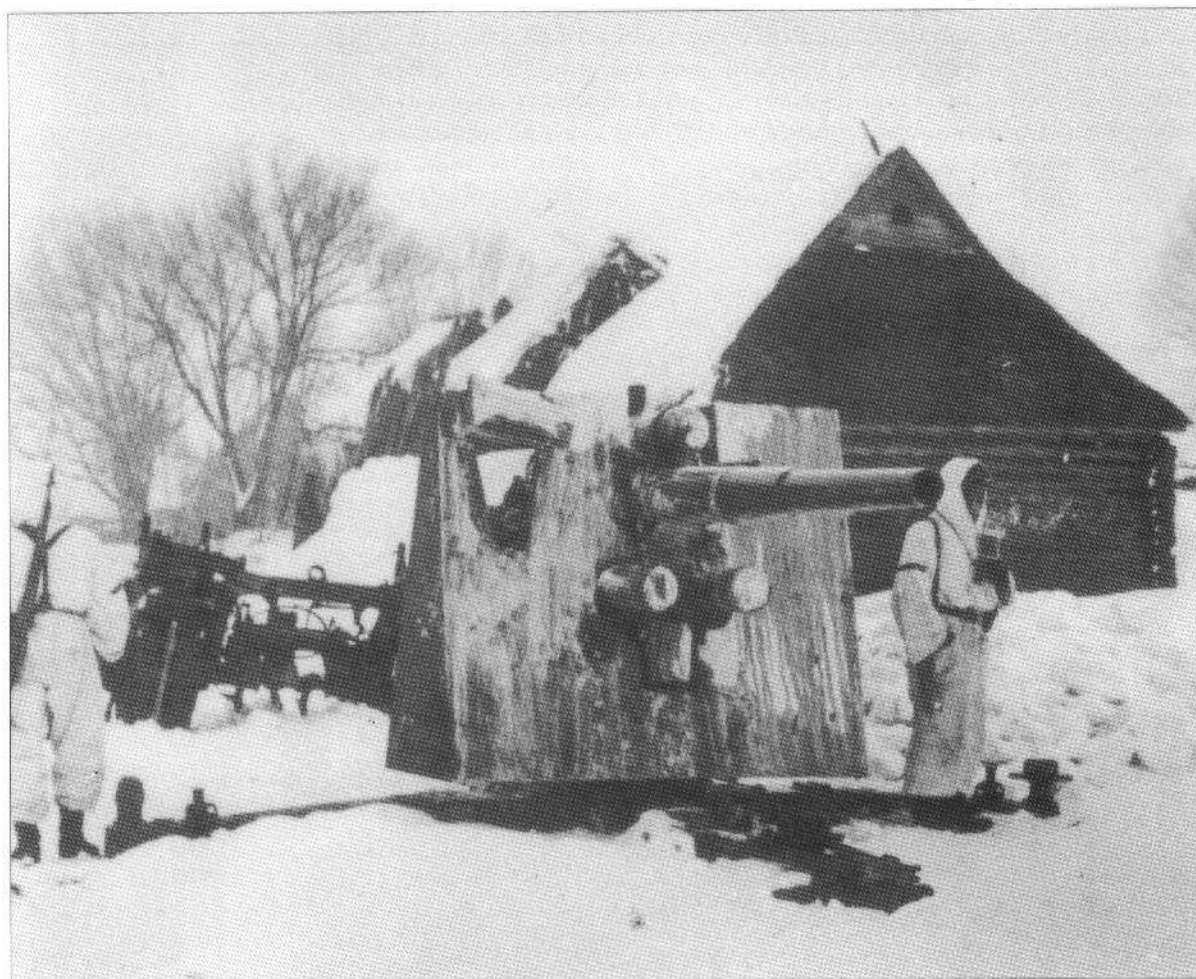
One of the truly amazing things about the German armaments industry is the fact that it continued production of war matériel until the last weeks of the war. This may be viewed as a form of collective denial that the 'thousand year' Reich was losing the war, but for the armaments manufacturers, at least, it was business as usual and wherever possible the lathes kept turning until the very last. Rheinmetall, for example, was involved in a plan to mount an 88 mm FlaK 41 on to the chassis of a Panther tank to provide another self-propelled anti-aircraft gun. Despite all their experience in arms manufacture, the company ran into production and design difficulties with the turret, leading, in turn, to a delay in producing the prototype vehicle which did not appear until February 1945 when Germany's armed forces were engaged in fighting a full retreat on all fronts. Rheinmetall produced a wooden mock-up of the design which was very advanced and without doubt outside the capabilities of Germany's armaments industries at the time. Known simply as the 8.8 cm FlaK 41 auf Panther, the gun was to be mounted in a polygonal turret which would have been almost as long as the Panther chassis, more than 6 m in length. The overall height of the vehicle was just under the 3 m restriction placed on armoured fighting vehicles developments. The whole of the centre section of the superstructure was removed down to the track-guards, and the huge turret, with its 360 degree traverse capability, was mounted on the pivot centre. It was a last gasp from a dying giant and completely unworkable at any stage in the war because of the enormous amount of refitting involved in converting the Panther chassis.

Another late-war weapon programme was the *Leichte Einheitswaffenträger* or 'light standardised weapons carriage', one version of which would have been equipped with an 88 mm PaK43 L/71 with 34 rounds of ammunition. Krupp had overall control of the project with, Rheinmetall, Ardelet and

Steyr all developing different chassis for producing the carrier to transport dismountable artillery. Versions using 105 mm guns had provided the concept, based on the Panzer III/IV chassis, as early as 1943, but the Ordnance Proving Branch 4 had considered the programme too costly. Production was to have commenced in the spring of 1945, with a production rate of 350 units per month by September 1945. The weapon had a full 360 degree traverse with the 88 mm version being fitted with the Rblf36 sight unit. It was capable of elevating the barrel to +20 degrees and depressing to -8 degrees to fulfil an anti-tank role. The 88 mm version used components from the 38(t), which had been used on other designs such as the Hetzer and ammunition carriers. It underwent trials at Hillersleben as late as 27 April 1945. This trial probably involved the Ardel prototype, but with the war only days from ending there was no sense in pursuing the project further.

The Jagdpanther Starr tank destroyer was another work in progress when the war ended. The development programme for this particular project worked on fitting a prototype rigid-mounted 88 mm PaK43/1 L/71 in the Jagdpanther. Krupp was investigating the possibility of mounting the gun along the centreline of the fighting compartment, but set farther back in the vehicle. Earlier successes on prototypes with

An 88 mm FlaK deployed in snow near Barsov in Russia. Capable of destroying Russian tanks at long range, the 88 gave the German army an edge over massed tank attacks.



rigid-mounted guns in the Jagdpanther 38(t) had proved the concept workable, but in the end the programme was just another set of blueprint plans for the Allies to examine after their victory.

Finally, there is the case of the *Dusenkanon*, a single-shot recoilless gun mounted in attack aircraft and designed for use against ground targets. Several development programmes had been in progress since 1939, but the most promising of these was the Rheinmetall 'DKM-43' or 'DUKA-88 mm', which, as the term implied, used the standard projectile head of the 88 mm high explosive FlaK shell, but fitted to a special cartridge case. The weapon was fitted with the usual sliding breech block, but the chamber had two venturi tubes through which the efflux of gases could pass when fired, greatly reducing recoil on firing. The weapon was loaded prior to take-off and on firing it functioned like standard recoilless weapons in use with ground forces. The *Dusenkanone* packed all the power of the normal 88 mm, the only drawback being the fact that it had only one shot. Development was in hand to manufacture a multiple-shot version, but the war ended before it could be produced.

The 88 in all its guises had served the German armed forces long and faithfully. It had been used on all fronts, in all weathers and terrain, and had a record of achievement second to none. Wherever German troops had been deployed in occupied territories, the 88 had followed. Even in

A FlaK 37 being used in an anti-tank role. The gun is ground emplaced on its cruciform platform with wheels in the background of picture. Note the man at left handling ammunition from the wicker boxes for shells.



the Channel Islands, the only part of British territory to be occupied between 1940 and 1945, the Germans deployed 96 units of the 88 to serve as anti-aircraft guns, with a secondary role as coastal artillery. Jersey and Guernsey each had 36 guns, whilst Alderney, a smaller island, had 24 guns.

It was only towards the end of the war, when armour on tanks became increasingly thick, that Allied tank crews could begin to relax their attitude towards the dreaded 88. But even then it could still render a tank immobile by knocking a track off, even if it did not penetrate the armour. As the Second World War progressed the design of Allied tanks improved. Not only did the thickness of the armour increase, but the increased range of the main armament meant that tank crews stood a better-than-even chance of survival when fired on by an 88 and could even fire back with increased odds of destroying the gun site.

Although by 1945 the 88 had lost much of its mystique, legends die hard, and today the 88 is still regarded as the benchmark of anti-tank guns during the Second World War. In the post-war years a handful of countries used the 88 for a short period, among them Spain, Portugal and Yugoslavia, who used them for coastal defence until they were phased out. Argentina also used versions of the 88 after the war, having purchased numbers of the weapon in 1938. These, too, were not phased out of service until the 1950s.

From the Polish campaign of 1939, the Blitzkriegs in 1940 and 1941, through the Normandy and Ardennes campaigns of 1944 and in the midst of the rubble in Berlin, German gunners had crewed the 88 with devastating effect and left a lasting impression on those who encountered it on or above the battlefield. So what made the 88 so special? In a word, nothing. On its own the 88 was a conventional piece of artillery, but through a series of upgrades, imaginative use and a range of ammunition, it became a legend. Not unfairly, the PaK 43 version of the 88 has been called 'without question the single most famous artillery piece used in World War Two'.

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COLOUR PLATE COMMENTARY

A: THE FLAK 37

The FlaK 37 version of the 88 mm gun was used by the Luftwaffe for the anti-aircraft role throughout the whole period of the war between 1939 and 1945. It was operated by an eleven-man crew, with mobility being provided by the SdkfZ 7 half-track prime-mover. Although tasked primarily with engaging enemy aircraft, for which it was equipped with either the Zunderstellmaschine 19 or 37 fuze setter, the FlaK 37 was supplied with armour-piercing shells and could engage tanks and fire high-explosive shells at ground targets. Depending on conditions it could be used with or without the gunshield in place.

Here the FlaK 37 has had its gun shield removed and is free-standing on its cruciform mounted for firing from a static position. The recuperator is clearly visible above the barrel, with the recoil cylinder under the barrel. The equilibrators can be seen protruding from in between the cradle into which the barrel is fitted by means of the trunnions. Elevation was between -3 degrees and +85 degrees with full 360 degree traverse either emplaced as here or with the road wheels fitted to the platform. The seat for the controller operating the elevation and traversing controls is visible on the right hand side with the aimer's and firer's seat on the left hand side. Fitted to the end of each leg of the cruciform platform is a stabilising jack which ensured a firm grip when lowered.

The barrel of the FlaK 37 was 'stepped' where the barrel joints were secured, and had an overall length of 4.9 m with 32 rifling grooves in a right hand twist. The overall height was 2.42 m and the width was 2.3m. It had an all-up travelling weight in the order of 6,861kg with an overall length of 7.62 m.

The gun detachment comprised of eleven men, who were detailed off as following:

- 1) Gun Commander.
- 2) Tractor driver.
- 3) Layer for elevation.
- 4) Layer for line traversing.
- 5) Loader.
- 6) Ammunition handler.
- 7) Ammunition handler.
- 8) Fuze setter operator.
- 9) Fuze setter; round handler.
- 10) Ammunition handler.
- 11) Ammunition handler.

With a rate of fire at 15 rounds per minute the eleven-man crew were kept busy when in action. The number of ammunition handlers were necessary if the gun was to be kept firing during the height of the battle and good training meant they knew unerringly what to do in any situation. Should any member of the crew be injured or killed another crewman would stand in for that role, which, in the case of ammunition handlers, that meant redoubling their efforts to keep up with supplying shells.

For greater stability the cruciform platform could be further secured in place by means of steel pegs being hammered into the ground through special slots at the end of each leg. Although this ensured stability when firing, it did mean more

time spent coming out of action. In fact, this means of securing the platform probably led to the high number of weapons being abandoned during tactical withdrawals.

B: THE PAK 43/41

When the PaK 43/41 version of the 88 mm gun arrived on the Eastern Front in 1943 it was as a direct result of appeals by the army for a more powerful anti-tank gun, which would have enough 'punch' to destroy the heavy Russian tanks. Although it was used mainly in Russia, the PaK 43/41 did see limited service against the Western Allies.

The gun carriage itself was formed from a composite design using components from weapons on to which was fitted the long-barrelled 88 mm gun, with its distinctive double-baffle muzzle brake. Although of standard 88 mm calibre the chamber was enlarged to accommodate the bigger cartridge case which produced muzzle velocities of 3,282 fps with the standard armour-piercing shell, 3,710 fps with the armour-piercing composite rigid shell and 2,640 fps with the high-explosive shell. In fact, the powerful APCR 'AP 40/43' shell could penetrate 241 mm of vertical armour at 1,000 m and 159 mm of vertical armour at 2,250 m ranges.

The PaK 43/41 was the only two-wheeled towed version of the 88 to be developed and enter service. Despite its powerful performance the PaK 43/41 was not a popular weapon with the crews who nick-named the gun 'Barndoor' on account of its large size. With a weight in the order of 4,380 kg and an overall length of 9.14 m it was a struggle for the crew to manoeuvre the gun in the snow and mud on the Russian Front.

As the rubber shortage in Germany became more critical pneumatic tyres were replaced by fitting a series of solid rubber bands to pressed steel wheels. This is what is seen here as the crew prepares to load an armour-piercing shell, identified by its black-coloured projectile head, in readiness to engage tanks on the Russian Front. The trail spades fitted to the ends of each arm of the split trail have been lowered into position to assist in controlling the recoil of the gun, by digging into the ground as the gun fires.

C: THE FLAK 41

Responsibility for providing anti-aircraft defence to the German homeland fell squarely on the Luftwaffe, which had to provide thousands of extra personnel in addition to those troops serving in frontline units. In the first years of the war the first versions of the 88 mm FlaK guns were sufficient to deal with the Allied bombers, but as heavier bombers were introduced the Luftwaffe pressed for the introduction of the long-awaited FlaK 41. As the newer Allied aircraft flew at higher altitudes the FlaK 41 was the only gun for the moment which could be used to engage them with any success.

The FlaK 41 had been on the drawing boards since 1941, but it was not until 1943 that the first units entered service, by which time the Allies were flying 'Thousand Bomber' raids into the industrial heart of Germany. For home defence six FlaK 41s were formed into a Flakbatterie, which was sub-divided into three platoons or Flakzug, each with two guns. In frontline units the number of guns in a battery was reduced to four, but had the additional protection of two batteries of 20 mm AA guns.

Each FlaK 41 was served by a crew of 12 men, including an assistant gun layer, and under ideal conditions could

achieve a firing rate of twenty rounds per minute. The gun had an enlarged chamber to accept the more powerful cartridge which could be used to engage targets in excess of 49,000 feet, which was more than adequate to counter aircraft of the day. With a muzzle velocity of 3,280 fps the FlaK 41 could be used to engage all aircraft types, including the escort fighters accompanying the daylight bomber formations of the USAAF, which is what is seen here.

To assist in loading the heavier shells when the barrel was elevated to extreme angles a special mechanical loading device was fitted to the FlaK 41. Rubber rollers gripped the shell and fed it into the breech, which greatly speeded up loading times. Seen here is part of the twelve-man Luftwaffe crew serving a FlaK 41 mounted in a static position on its cruciform firing platform, with their position protected by sandbags. The loader is preparing to insert a yellow-coloured HE into the breech, having first had the fuse set according to information passed to the gun position via the Funkmessgerate, which tracks the target and predicts its position for firing.

The FlaK 41 was also issued with anti-tank shells, and these, plus the fact that the barrel could be depressed to -3 degrees, meant that it could be used to engage ground targets at ranges comparable to the PaK 43 guns. The gun could also fire HE shells to engage ground targets and to provide fire support as conventional field artillery.

D: THE FLAK 18

Ammunition illustrated is High Explosive (HE). This is seen with the distinctive yellow-coloured projectile head fitted to the brass shell case. As the war progressed and economies dwindled, the driving bands on the projectile were changed to a sintered iron design. The nose-fuzed Kopfzundung, Kz, which was standard issue ordnance for HE shells, is seen here. Known as the Sprenggranate (SprGr), the HE shell weighed 9.4 kg and was fired from the FlaK 18, FlaK 36 and FlaK 37 guns. This same shell was also fired from the KwK 36 gun as fitted to the Tiger I tank.

E: THE PAK 43

The PaK 43 was the first purpose-built anti-tank version of the 88 mm series of weapons. Introduced in 1943 it was used on all fronts, including Italy where it is seen here, being used to engage tanks while still mounted on its wheeled carriage. As with the heavier PaK 43/41 the PaK 43 was originally designed with pneumatic tyres, but as the war progressed these were replaced with rings of solid rubber fitted to pressed steel wheels. It was fitted with a well sloped gun shield which gave it a distinctive appearance, along with the double-baffle muzzle brake, which assisted in helping to control the recoil forces on firing. In Italy the PaK 43, along with other versions of the 88 mm gun, look a heavy toll on Allied tanks.

The PaK 43 version weighed 5,000 kg and could be towed by a variety of half-track prime-movers, such as the SdkfZ 8 which was designed for such a role. The powerful charge in the cartridge case produced muzzle velocities of 1,000 m/sec when firing the AP 39-1 shell, which limited the barrel life to only 500 rounds, after which time accuracy and range would fall off as the rifling eroded even further. On its cruciform platform the PaK 43 had a full 360 degrees traverse, but when firing from its wheeled base, as is the

case here, the barrel traverse was limited to 30 degrees either side of centre line. Its low silhouette made it easy to conceal, making good use of any cover available. A well experienced crew could engage targets out to 2,000 m and even more in some cases where visibility was ideal.

F: THE FLAK 36

All three versions of the FlaK 88 mm gun were taken into the North African theatre of operations by the Afrikakorps, commanded by Erwin Rommel, in 1941. Seen here is the FlaK 36 version with part of the crew formed by men of the Afrikakorps, the army responsible for anti-aircraft defence in the field. A typical army battalion would have two or three batteries each with four 88 mm guns with 20 mm guns for additional protection.

The half-track is the SdkfZ 7 prime-mover which would carry the eleven-man crew for the gun, with their personal equipment. It was standard operational procedure to tow the gun with the barrel facing forwards toward the towing vehicle. In Africa the FlaK 36, and other anti-tank guns exacted a high toll among the lightly armoured Allied tanks, especially at Halfaya Pass, which the Allies referred to as 'Hellfire Pass' due to the number of tanks lost there. On 12 June 1941, for example, during the battle of Gazala, the British army lost 250 tanks, out of a total force of some 330 tanks, to tank guns and anti-tank guns.

The towing vehicle could also carry enough ammunition to permit the gun to come into action with further supplies being brought up by other vehicles. It was not uncommon for the crews to paint white 'kill rings' around the barrels of their weapons in order to keep an unofficial tally of their success rate in the anti-tank role. Some crews also painted aircraft symbols on the gun shields and some examples were captured with shipping symbols also displayed. This would probably indicate where the gun had been pressed into service as part of coastal defences.

The FlaK 36 could also fire standard high explosive shells out to almost 15,000 m range to provide fire support to cover infantry attacks. However, the 88 mm was at its most deadliest when formed into defensive 'PAK' Fronts, specifically organised to engage tanks, where it made a really telling mark on the Allies.

G: RAILWAY MOUNTED ANTI-AIRCRAFT GUN

The versatility of the 88 was such that it could be mounted on various platforms to increase the weapon's all-round mobility. This was never more so than the concept which saw it being mounted on railway trucks to quickly move anti-aircraft FlaK-train batteries, known as Eisenbahnflak, en masse from one location to another. As the Allies increased their bombing raids against German industrial centres, such anti-aircraft trains could be allocated to wherever they were most needed to counter the bomber forces. Many such railway mountings were improvised from standard railway rolling stock, but the Geschutzwagen III (Eisb) Schwere FlaK was a standardised conversion. This is the version seen here and could mount any model of the 88 in the anti-aircraft role. It was fitted with drop sides to allow a larger working platform for the crew and carried its own supply of ammunition in storage lockers. Overall length was 15.8 m with a fully loaded weight of 45.8 tonnes including one 88 gun and stock of ammunition.

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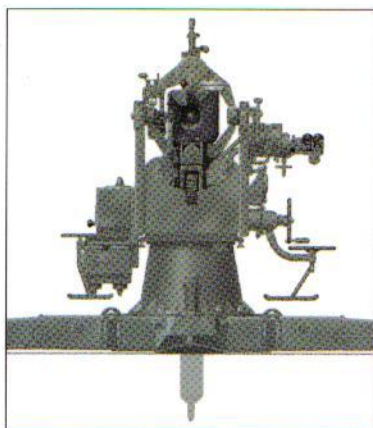
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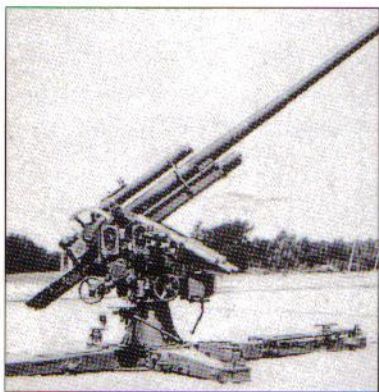
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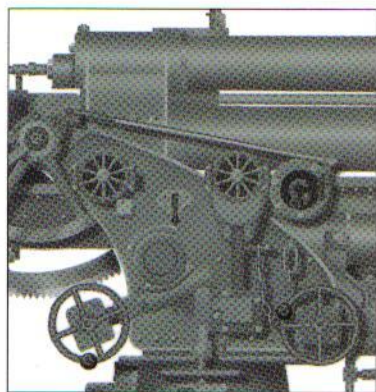
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88 mm FlaK 18/36/37/41 & PaK 43 1936-45

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