

Trench warfare

Trench warfare is a type of land warfare using occupied fighting lines consisting largely of military trenches, in which troops are well-protected from the enemy's small arms fire and are substantially sheltered from artillery. The most famous use of trench warfare is the Western Front in World War I. It has become a byword for stalemate, attrition, sieges, and futility in conflict.^[1]

Trench warfare occurred when a revolution in firepower was not matched by similar advances in mobility, resulting in a grueling form of warfare in which the defender held the advantage.^[2] On the Western Front in 1914–1918, both sides constructed elaborate trench and dugout systems opposing each other along a front, protected from assault by barbed wire, mines, and other obstacles. The area between opposing trench lines (known as "no man's land") was fully exposed to artillery fire from both sides. Attacks, even if successful, often sustained severe casualties.

With the development of armoured warfare, emphasis on trench warfare has declined but still occurs wherever battle-lines become static.



German soldiers of the 11th Reserve Hussar Regiment fighting from a trench, on the Western Front, 1916

Contents

Overview

- Field works
- Symbol for the futility of war

World War I: Entrenchment

- Implementation
- Trench defensive systems
- Trench construction
- Trench geography in World War I

World War I: Life in the trenches

World War I: Death in the trenches

Weapons of World War I trench warfare

- Infantry weapons
- Wire
- Machine guns
- Artillery
- Mortars
- Helmets
- Mines
- Gas
- Aircraft

New weapons

Mining

Trench battles

Strategy

World War I tactics

World War I communications

World War I – breaking the stalemate

Infiltration tactics

Tanks

World War II

European Theatre

Pacific War

Post-1945 to modern trench warfare

See also

Notes

References

External links

Overview

Field works

Field works are as old as armies. Roman legions, when in the presence of an enemy, entrenched camps nightly when on the move.^[3] In the early-modern era troops used field works to block possible lines of advance.^[4] For example:

- Members of the Grand Alliance built the Lines of Stollhofen at the start of the War of the Spanish Succession of 1702-1714. The works ran for about 15 km (10 mi) from Stollhofen on the Rhine to the impenetrable woods on the hills east of Bühl. They played a pivotal role in manoeuvring that took place before the Battle of Blenheim (1704). The French captured these lines in 1707 and demolished them.^[5]
- The French built the 19-kilometre-long (12 mi) Lines of Weissenburg during the War of the Spanish Succession under the orders of the Duke of Villars in 1706. These were to remain in existence for just over 100 years and were last manned during Napoleon's Hundred Days (1815). By 1870 the Lines no longer existed, but the two central forts in the towns of Wissembourg and Altenstadt still possessed fortifications that proved useful defensive positions during the Battle of Wissembourg.^[6]
- The French built the Lines of Ne Plus Ultra (Latin for "no further") during the winter of 1710–1711, which have been compared to the trenches of World War I.^[4] They ran from Arras to Cambrai and Valenciennes where they linked up with existing defensive lines fronted by the river Sambre. In the 1711 campaign season the Duke of Marlborough breached them through "a magnificent piece of manoeuvring".^[7]
- During the Peninsular War, the British and Portuguese constructed the Lines of Torres Vedras in 1809 and 1810; these proved effective in stopping the French advance on Lisbon in 1810.^[3]



Lines of Torres Vedras

Though Napoleon Bonaparte started his military career in artillery, campaigning in the Napoleonic Wars generally emphasized movement rather than static entrenchment. But innovations in trench warfare became more prominent in the course of the 19th century.

In the New Zealand Wars (1845-1872) the indigenous Maori developed elaborate trench and bunker systems, employing them successfully as early as the 1840s to withstand British cannon, muskets, and an experimental poison-gas mortar.^{[8][9]} British casualty rates of up to 45 percent, such as at Gate Pa in 1844 and the Battle of Ohaeawai in 1845, proved that contemporary firepower was insufficient to dislodge defenders from a trench system.^[10]

The Crimean War (1853-1856) saw "massive trench works and trench warfare",^[11] even though "the modernity of the trench war was not immediately apparent to the contemporaries".^[12]

North American armies employed field works in the American Civil War (1861-1865) — most notably in the sieges of Vicksburg (1863) and Petersburg (1864-1865), the latter of which saw the first use by the Union Army of the rapid-fire Gatling gun,^[13] the important precursor to modern-day machine guns. Trenches also featured in the Paraguayan War (which started in 1864), the Second Anglo-Boer War (1899-1902), and the Russo-Japanese War (1904-1905).

Fundamentally, as the range and rate of fire of rifled small-arms increased, a defender shielded from enemy fire (in a trench, at a house window, behind a large rock, or behind other cover) was often able to kill several approaching foes before they closed with his position. Attacks across open ground became even more dangerous after the introduction of rapid-firing artillery, exemplified by the "French 75", and high explosive fragmentation rounds. The increases in firepower had outstripped the ability of infantry (or even cavalry) to cover the ground between firing lines, and the ability of armour to withstand fire. It would take a revolution in mobility to change that.^[14]



Trenches at the Siege of Vicksburg
1863

Trench warfare has become archetypically associated with the First World War of 1914–1918, when the Race to the Sea rapidly expanded trench use on the Western Front starting in September 1914.^[15] By the end of October 1914 the whole front in Belgium and France had solidified into lines of trenches, which lasted until the last weeks of the war. Mass infantry assaults were futile in the face of artillery fire as well as rapid rifle and machine-gun fire. Both sides concentrated on breaking up enemy attacks and on protecting their own troops by digging deep into the ground.^[16] Trench warfare also took place on other fronts, including in Italy and at Gallipoli.

Symbol for the futility of war

Trench warfare has become a powerful symbol of the futility of war.^[17] Its image is of young men going "over the top" (over the parapet of the trench, to attack the enemy trench line) into a maelstrom of fire leading to near-certain death, typified by the first day of the Battle of the Somme (on which the British Army suffered nearly 60,000 casualties) or the grinding slaughter in the mud of Passchendaele. To the French, the equivalent is the attrition of the Battle of Verdun in which the French Army suffered 380,000 casualties.^[18]

Trench warfare is associated with mass slaughter in appalling conditions. Many critics have argued that brave men went to their deaths because of incompetent and narrow-minded commanders who failed to adapt to the new conditions of trench warfare: class-ridden and backward-looking generals put their faith in the attack, believing superior morale and dash would overcome the weapons and moral inferiority of the defender.^[19] British public opinion often repeated the theme that their soldiers were "lions led by donkeys".^[20]



The Boer trench at the Battle of Magersfontein contributed to the surprise defeat of the Highland Brigade on 11 December 1899 during the Second Boer War.

World War I generals are often portrayed as callously persisting in repeated hopeless attacks against trenches. There were failures such as Passchendaele, and Sir Douglas Haig has often been criticised for allowing his battles to continue long after they had lost any purpose other than attrition.^[21] Haig's defenders counter that the attrition was necessary in order to cause attrition in the German army.^[22]

The problems of trench warfare were recognised, and attempts were made to address them. These included improvements in artillery, infantry tactics, and the development of tanks. By 1918, taking advantage of failing German morale, Allied attacks were generally more successful and suffered fewer casualties; in the Hundred Days Offensive, there was even a return to mobile warfare.

World War I: Entrenchment

Implementation



German forward detachments guarding the entrance to a trench line in front of Arras in 1915

Although technology had dramatically changed the nature of warfare by 1914, the armies of the major combatants had not fully absorbed the implications. The French and German armies adopted different tactical doctrines: the French relied on the attack with speed and surprise, and the Germans relied on firepower, investing heavily in howitzers and machine guns. The British lacked

an official tactical doctrine, with an officer corps that rejected theory in favour of pragmatism.^[23]

While the armies expected to use entrenchments and cover, they did not allow for the effect of defences in depth. They required a deliberate approach to seizing positions from which fire support could be given for the next phase of the attack, rather than a rapid move to break the enemy's line.^[24] It was assumed that artillery could still destroy entrenched troops, or at least suppress them sufficiently for friendly infantry and cavalry to manoeuvre.^[25]

In the face of modern warfare, digging in was standard practice by the start of WWI. To attack frontally was to court crippling losses, so an outflanking operation was the preferred method of attack against an entrenched enemy. After the Battle of the Aisne in September 1914, an extended series of attempted flanking moves, and matching extensions to the fortified defensive lines, developed into the "race to the sea", by the end of which German and Allied armies had produced a matched pair of trench lines from the Swiss border in the south to the North Sea coast of Belgium.



Trenches of the 11th Cheshire Regiment at Ovillers-la-Boisselle, on the Somme, July 1916. One sentry keeps watch while the others sleep. Photo by Ernest Brooks.



1st Lancashire Fusiliers, in communication trench near Beaumont Hamel, Somme, 1916. Photo by Ernest Brooks.

Trench warfare prevailed on the Western Front from late 1914 until the Germans launched their Spring Offensive on 21 March 1918. After the buildup of forces in 1915, the Western Front became a stalemated struggle between equals, to be decided by attrition. Frontal assaults, and their associated casualties, became inevitable because the continuous trench lines had no open flanks. Casualties of the defenders matched those of the attackers, as vast reserves were expended in costly counter-attacks or exposed to the attacker's massed artillery. There were periods in which rigid trench warfare broke down, such as during the Battle of the Somme, but the lines never moved very far. The war would be won by the side that was able to commit the last reserves to the Western Front.^[26]



French Trench in northeastern France



Hot Shower-Bath establishment installed by an ingenious French engineer, November, 1914

Early World War I trenches were simple. They lacked traverses, and according to pre-war doctrine were to be packed with men fighting shoulder to shoulder. This doctrine led to heavy casualties from artillery fire. This vulnerability, and the length of the front to be defended, soon led to front line trenches being held by fewer men. The defenders augmented the trenches themselves with barbed wire strung in front to impede movement; wiring parties went out every night to repair and improve these forward defences.^[27]

The small, improvised trenches of the first few months grew deeper and more complex, gradually becoming vast areas of interlocking defensive works. They resisted both artillery bombardment and mass infantry assault. Shell-proof dugouts became a high priority.^[28] The space between the opposing trenches was referred to as "no man's land" and varied in width depending on the battlefield. On the Western Front it was typically between 90 and 275 metres (100 and 300 yd), though only 25 metres (30 yd) on Vimy Ridge.

After the German withdrawal to the Hindenburg line in March 1917, no man's land stretched to over a kilometre in places. At the "Quinn's Post" in the cramped confines of the Anzac battlefield at Gallipoli, the opposing trenches were only 15 metres (16 yd) apart and the soldiers in the trenches constantly threw hand grenades at each other. On the Eastern Front and in the Middle East, the areas to be covered were so vast, and the distances from the factories supplying shells, bullets, concrete and barbed wire so great, trench warfare in the West European style often did not occur.

In the Alps, trench warfare even stretched onto vertical slopes and deep into the mountains, to heights of 3,900 m (12,800 ft) above sea level. The Ortler had an artillery position on its summit near the front line. The trench-line management and trench profiles had to be adapted to the rough terrain, hard rock, and harsh weather conditions. Many trench systems were constructed within glaciers such as the Adamello-Presanella group or the famous city below the ice on the Marmolada in the Dolomites.

Trench defensive systems

Very early in the war, British defensive doctrine suggested a main trench system of three parallel lines, interconnected by communications trenches. The point at which a communications trench intersected the front trench was of critical importance, and it was usually heavily fortified. The front trench was lightly garrisoned and typically only occupied in force during "stand to" at dawn and dusk. Between 65 and 90 m (70 and 100 yd) behind the front trench was located the support (or "travel") trench, to which the garrison would retreat when the front trench was bombarded.

Between 90 and 270 metres (100 and 300 yd) further to the rear was located the third reserve trench, where the reserve troops could amass for a counter-attack if the front trenches were captured. This defensive layout was soon rendered obsolete as the power of artillery grew; however, in certain sectors of the front, the support trench was maintained as a decoy to attract the enemy bombardment away from the front and reserve lines. Fires were lit in the support line to make it appear inhabited and any damage done immediately repaired.

Temporary trenches were also built. When a major attack was planned, assembly trenches would be dug near the front trench. These were used to provide a sheltered place for the waves of attacking troops who would follow the first waves leaving from the front trench. "Saps" were temporary, unmanned, often dead-end utility trenches dug out into no-man's land. They fulfilled a variety of purposes, such as connecting the front trench to a listening post close to the enemy wire or providing an advance "jumping-off" line for a surprise attack. When one side's front line bulged towards the opposition, a salient was formed. The concave trench line facing the salient was called a "re-entrant." Large salients were perilous for their occupants because they could be assailed from three sides.

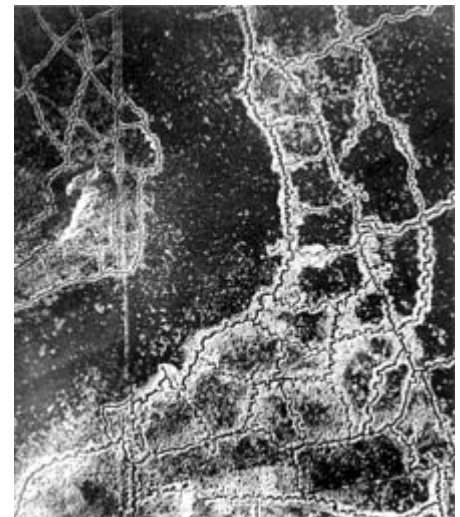
Behind the front system of trenches there were usually at least two more partially prepared trench systems, kilometres to the rear, ready to be occupied in the event of a retreat. The Germans often prepared multiple redundant trench systems; in 1916 their Somme front featured two complete trench systems, one kilometre apart, with a third partially completed system a further kilometre behind. This duplication made a decisive breakthrough virtually impossible. In the event that a section of the first trench system was captured, a "switch" trench would be dug to connect the second trench system to the still-held section of the first.

The Germans, who had based their knowledge on studies of the Russo-Japanese War,^[29] made something of a science out of designing and constructing defensive works. They used reinforced concrete to construct deep, shell-proof, ventilated dugouts, as well as strategic strongpoints. They were more willing than their opponents to make a strategic withdrawal to a superior prepared defensive position. They were also the first to apply the concept of "defence in depth", where the front-line zone was hundreds of metres deep and contained a series of redoubts rather than a continuous trench. Each redoubt could provide supporting fire to its neighbours, and while the attackers had freedom of movement between the redoubts, they would be subjected to withering enfilade fire.

The British eventually adopted a similar approach, but it was incompletely implemented when the Germans launched the 1918 Spring Offensive and proved disastrously ineffective. France, by contrast, relied on artillery and reserves, not entrenchment. The characteristic barbed wire placed before trenches, in belts 15 m (49 ft) deep or more, differed, too; the German wire was heavier gauge, and British wire cutters, designed for the thinner native product, were unable to cut it.^[30]

Trench construction

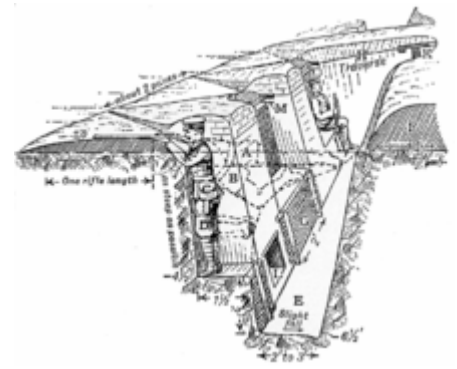
A well-developed trench had to be at least 2.5 m (8 ft) deep to allow men to walk upright and still be protected. Trenches were never straight but were dug in a zigzagging or stepped pattern, with all straight sections generally kept less than a dozen meters (yards). Later, this evolved to have the combat trenches broken into distinct fire bays connected by traverses. While this isolated the view of friendly soldiers along their own trench, this ensured the entire trench could not be enfiladed if the enemy gained access at any one point; or if a bomb, grenade, or shell landed in the trench, the blast could not travel far.



Aerial view of opposing trench lines between Loos and Hulluch, July 1917. German trenches at the right and bottom, British at the top-left.

The banked earth on the lip of the trench facing the enemy was called the parapet and had a fire step. The embanked rear lip of the trench was called the parados. The parados protected the soldier's back from shells falling behind the trench. The sides of the trench were often revetted with sandbags, wire mesh, wooden frames and sometimes roofs. The floor of the trench was usually covered by wooden duckboards. In later designs the floor might be raised on a wooden frame to provide a drainage channel underneath.

Dugouts of varying degrees of comfort would be built in the rear of the support trench. British dugouts were usually 2.5 to 5 m (8 to 16 ft) deep, whereas German dugouts were typically much deeper, usually a minimum of 4 m (12 ft) deep and sometimes dug three stories down, with concrete staircases to reach the upper levels.



Trench construction diagram from a 1914 British infantry manual



Australian light horseman using a periscope rifle, Gallipoli 1915

To allow a soldier to see out of the trench without exposing his head, a loophole could be built into the parapet. A loophole might simply be a gap in the sandbags, or it might be fitted with a steel plate. German snipers used armour-piercing bullets that allowed them to penetrate loopholes. Another means to see over the parapet was the trench periscope – in its simplest form, just a stick with two angled pieces of mirror at the top and bottom. A number of armies made use of the periscope rifle, which enabled soldiers to snipe at the enemy

without exposing themselves over the parapet, although at the cost of reduced shooting accuracy. The device is most associated with Australian and New Zealand troops at Gallipoli, where the Turks held the high ground.

There were three standard ways to dig a trench: entrenching, sapping, and tunnelling. Entrenching, where a man would stand on the surface and dig downwards, was most efficient, as it allowed a large digging party to dig the full length of the trench simultaneously. However, entrenching left the diggers exposed above ground and hence could only be carried out when free of observation, such as in a rear area or at night. Sapping involved extending the trench by digging away at the end face. The diggers were not exposed, but only one or two men could work on the trench at a time.

Tunnelling was like sapping except that a "roof" of soil was left in place while the trench line was established and then removed when the trench was ready to be occupied. The guidelines for British trench construction stated that it would take 450 men 6 hours at night to complete 250 m (270 yd) of front-line trench system. Thereafter, the trench would require constant maintenance to prevent deterioration caused by weather or shelling.

The battlefield of Flanders presented numerous problems for the practice of trench warfare, especially for the Allied forces, mainly British and Canadians, who were often compelled to occupy the low ground. Heavy shelling quickly destroyed the network of ditches and water channels which had previously drained this low-lying area of Belgium. In most places, the water table was only a metre or so below the surface, meaning that any trench dug in the ground would quickly flood.



Soldiers training in trench warfare, with well-defined fire bays connected by offset traverse trenches, with zigzag communication trenches leading to the rear area

Consequently, many "trenches" in Flanders were actually above ground and constructed from massive breastworks of sandbags filled with clay. Initially, both the parapet and parados of the trench were built in this way, but a later technique was to dispense with the parados for much of the trench line, thus exposing the rear of the trench to fire from the reserve line in case the front was breached.



Breastwork "trench", Armentières, 1916

Trench geography in World War I

The confined, static, and subterranean nature of trench warfare resulted in it developing its own peculiar form of geography. In the forward zone, the conventional transport infrastructure of roads and rail were replaced by the network of trenches and trench railways. The critical advantage that could be gained by holding the high ground meant that minor hills and ridges gained enormous significance. Many slight hills and valleys were so subtle as to have been nameless until the front line encroached upon them. Some hills were named for their height in metres, such as Hill 60. A farmhouse, windmill, quarry, or copse of trees would become the focus of a determined struggle simply because it was the largest identifiable feature. However, it would not take the artillery long to obliterate it, so that thereafter it became just a name on a map.

Battlefield features could be given a descriptive name ("Polygon Wood" near Ypres or "Lone Pine"), a whimsical name ("Sausage Valley" and "Mash Valley" on the Somme), a unit name ("Inniskilling Inch" at Helles named for the Royal Inniskilling Fusiliers) or the name of a soldier ("Monash Valley" at Anzac named after General John Monash). Prefixing a feature with "Dead Man's" was also popular for obvious reasons, such as "Dead Man's Road" leading in to Pozières, or "Dead Man's Ridge" at Anzac.

There were numerous trench networks named "The Chessboard" or "The Gridiron" because of the pattern they described. For the Australians at Mouquet Farm, the advances were so short and the terrain so featureless that they were reduced to naming their objectives as "points" on the map, such as "Point 81" and "Point 55."

Enemy trenches, which would become objectives in an attack, needed to be named as well. Many were named for some observed event such as "German Officers' Trench" at Anzac or "Ration Trench" on the Somme. The British gave an alcoholic flavour to the German trenches in front of Ginchy: "Beer Trench", "Bitter Trench", "Hop Trench", "Ale Alley", and "Pilsen Trench." Other objectives were named according to their role in the trench system, such as the "Switch Trench" and "Intermediate Trench" on the Somme.

Some sections of the British trench system read like a Monopoly board, with names such as "Park Lane" and "Bond Street". British regular divisions habitually named their trenches after units, which resulted in names such as "Munster Alley" (Royal Munster Fusiliers), "Black Watch Alley" (Black Watch Regiment) and "Border Barricade" (Border Regiment). The Anzacs tended to name features after soldiers ("Plugge's Plateau", "Walker's Ridge", "Quinn's Post", "Johnston's Jolly", "Russell's Top", "Brind's Road" and so forth).

World War I: Life in the trenches

An individual unit's time in the front-line trench was usually brief; from as little as one day to as much as two weeks at a time before being relieved. The 31st Australian Battalion once spent 53 days in the line at Villers-Bretonneux, but such a duration was a rare exception. The 10th Battalion, CEF, averaged front line tours of six days in 1915 and 1916.^[31] The units who manned the front line trenches the longest were the Portuguese Expeditionary Corps from Portugal stationed in Northern France; unlike the other allies the Portuguese couldn't rotate units from the front lines due to lack of

reinforcements sent from Portugal, nor could they replace the depleted units that lost manpower due to the war of attrition. With this rate of casualties and no reinforcements forthcoming most of the men were denied leave and had to serve long periods in the trenches with some units spending up to six consecutive months in the front line with little to no leave during that time.^[32]

On an individual level, a typical British soldier's year could be divided as follows:

- 15% front line
- 10% support line
- 30% reserve line
- 20% rest
- 25% other (hospital, travelling, leave, training courses, etc.)

Even when in the front line, the typical battalion would only be called upon to engage in fighting a handful of times a year—making an attack, defending against an attack or participating in a raid. The frequency of combat would increase for the units of the "elite" fighting divisions—on the Allied side; the British regular divisions, the Canadian Corps, the French XX Corps and the Anzacs.

Some sectors of the front saw little activity throughout the war, making life in the trenches comparatively easy. When the I Anzac Corps first arrived in France in April 1916 after the evacuation of Gallipoli, they were sent to a relatively peaceful sector south of Armentières to "acclimatise". Other sectors were in a perpetual state of violent activity. On the Western Front, Ypres was invariably hellish, especially for the British in the exposed, overlooked salient. However, quiet sectors still amassed daily casualties through sniper fire, artillery, disease, and poison gas. In the first six months of 1916, before the launch of the Somme Offensive, the British did not engage in any significant battles on their sector of the Western Front and yet suffered 107,776 casualties. Only 1 in 2 men would return alive and unwounded from the trenches.

A sector of the front would be allocated to an army corps, usually comprising three divisions. Two divisions would occupy adjacent sections of the front and the third would be in rest to the rear. This breakdown of duty would continue down through the army structure, so that within each front-line division, typically comprising three infantry brigades (regiments for the Germans), two brigades would occupy the front and the third would be in reserve. Within each front-line brigade, typically comprising four battalions, two battalions would occupy the front with two in reserve. And so on for companies and platoons. The lower down the structure this division of duty proceeded, the more frequently the units would rotate from front-line duty to support or reserve.



Distribution of *pinard* (ration wine) in a French trench in winter, considered important for morale



"Studying French in the Trenches", *The Literary Digest*, October 20, 1917.



A barber in a French trench

During the day, snipers and artillery observers in balloons made movement perilous, so the trenches were mostly quiet. Consequently, trenches were busiest at night, when cover of darkness allowed the movement of troops and supplies, the maintenance and expansion of the barbed wire and trench system, and reconnaissance of the enemy's defences. Sentries in listening posts out in no man's land would try to detect enemy patrols and working parties or indications that an attack was being prepared.

Pioneered by the Princess Patricia's Canadian Light Infantry in February 1915,^[33] trench raids were carried out in order to capture prisoners and "booty"—letters and other documents to provide intelligence about the unit occupying the opposing trenches. As the war progressed, raiding became part of the general British policy, the intention being to maintain the fighting spirit of the troops and to deny no man's land to the Germans. As well, they were intended to compel the enemy to reinforce, which exposed his troops to artillery fire.^[33]

Such dominance was achieved at a high cost when the enemy replied with his own artillery,^[33] and a post-war British analysis concluded the benefits were probably not worth the cost. Early in the war, surprise raids would be mounted, particularly by the Canadians, but increased vigilance made achieving surprise difficult as the war progressed. By 1916, raids were carefully planned exercises in combined arms and involved close co-operation of infantry and artillery.

A raid would begin with an intense artillery bombardment designed to drive off or kill the front-trench garrison and cut the barbed wire. Then the bombardment would shift to form a "box barrage", or cordon, around a section of the front line to prevent a counter-attack intercepting the raid. However, the bombardment also had the effect of notifying the enemy of the location of the planned attack, thus allowing reinforcements to be called in from wider sectors.

World War I: Death in the trenches

The intensity of World War I trench warfare meant about 10% of all fighting soldiers were killed. This compared to 5% killed during the Second Boer War and 4.5% killed during World War II. For British and Dominion troops serving on the Western Front, the proportion of troops killed was 12.5%, while the total proportion of troops who became casualties (killed or wounded) was 56%.

Medical services were fairly primitive and antibiotics had not yet been discovered. Relatively minor injuries could prove fatal through onset of infection and gangrene. The Germans recorded that 15% of leg wounds and 25% of arm wounds resulted in death, mainly through infection. The Americans recorded 44% of casualties who developed gangrene died. Fifty percent of those wounded in the head died and 99% of those wounded in the abdomen died. Seventy five percent of wounds came from shell fire. A wound resulting from a shell fragment was usually more traumatic than a gunshot wound.

A shell fragment would often introduce debris, making it more likely that the wound would become infected. These factors meant a soldier was three times more likely to die from a shell wound to the chest than from a gunshot wound. The blast from shell explosions could also kill by concussion. In addition to the physical effects of shell fire, there was the psychological damage. Men who had to endure prolonged bombardment would often suffer debilitating shell shock, a condition not well understood at the time.

Although World War I was the first war in which disease caused fewer deaths than combat, sanitary conditions in the trenches were quite poor, and common infections included dysentery, typhus, and cholera. Many soldiers suffered from parasites and related infections. Poor hygiene also led to fungal conditions, such as trench mouth and trench foot. Another



A German machine gun position just after its capture by New Zealand soldiers, with a dead German among the debris, Grevillers, 24 August 1918, Hundred Days Offensive

common killer was exposure, since the temperature within a trench in the winter could easily fall below freezing. Burial of the dead was usually a luxury that neither side could easily afford. The bodies would lie in no man's land until the front line moved, by which time the bodies were often unidentifiable. On some battlefields, such as at the Nek in Gallipoli, the bodies were not buried until after the war. On the Western Front, bodies continue to be found as fields are ploughed and building foundations dug.

At various times during the war—particularly early on—official truces were organised so that the wounded could be recovered from no man's land and the dead could be buried. Generally, senior commands disapproved of any slackening of the offensive for humanitarian reasons and so ordered their troops not to permit enemy stretcher-bearers to operate in no man's land. However, this order was almost invariably ignored by the soldiers in the trenches, who knew that it was to the mutual benefit of the fighting men of both sides to allow the wounded to be retrieved. So, as soon as hostilities ceased, parties of stretcher bearers, marked with Red Cross flags, would go out to recover the wounded, sometimes swapping enemy wounded for their own.

There were occasions when this unofficial cease fire was exploited to conduct a reconnaissance or to reinforce or relieve a garrison. One famous truce was the Christmas truce between British and German soldiers in the winter of 1914 on the front near Armentières. German soldiers began singing Christmas carols and soon soldiers left their trenches. The soldiers exchanged gifts and stories, and played several games of football. The commanders of the warring nations disapproved of this cease fire, and the British court-martialed several of their soldiers.



Stretcher bearers, Passchendaele, August 1917



Dead German soldiers lie in the rubble of a trench destroyed by mine explosion, Messines Ridge, 1917

Weapons of World War I trench warfare

Infantry weapons

At the start of the First World War, the standard infantry soldier's primary weapons were the rifle and bayonet; other weapons got less attention. Especially for the British, what hand grenades were issued tended to be few in numbers and less effective. This emphasis began to shift as soon as trench warfare began; militaries rushed improved grenades into mass production, including rifle grenades.

The hand grenade came to be one of the primary infantry weapons of trench warfare. Both sides were quick to raise specialist grenadier groups. The grenade enabled a soldier to engage the enemy without exposing himself to fire, and it did not require precise accuracy to kill or maim. Another benefit was that if a soldier could get close enough to the trenches, enemies hiding in trenches could be attacked. The Germans and Turks were well equipped with grenades from the start of the war, but the British, who had ceased using grenadiers in the 1870s and did not anticipate a siege war, entered the conflict with virtually none, so soldiers had to improvise bombs with whatever was available (see Jam Tin Grenade). By late 1915, the British Mills bomb had entered wide circulation, and by the end of the war 75 million had been used.

Since the troops were often not adequately equipped for trench warfare, improvised weapons were common in the first encounters, such as short wooden clubs and metal maces, as well as trench knives and brass knuckles. According to the semi-biographical war novel *All Quiet on the Western Front*, many soldiers preferred to use a sharpened spade as an improvised melee weapon instead of the bayonet, as the bayonet tended to get "stuck" in stabbed opponents, rendering it useless in heated battle. The shorter length also made them easier to use in the confined quarters of the trenches. These tools could then be used to dig in after they had taken a trench. As the war progressed, better equipment was issued, and improvised arms were discarded.

A specialised group of fighters called *trench sweepers* (*Nettoyeurs de Tranchées* or *Zigouilleurs*) evolved to fight within the trenches. They cleared surviving enemy personnel from recently overrun trenches and made clandestine raids into enemy trenches to gather intelligence. Volunteers for this dangerous work were often exempted from participation in frontal assaults over open ground and from routine work like filling sandbags, draining trenches, and repairing barbed wire in no-man's land. When allowed to choose their own weapons, many selected grenades, knives and pistols. FN M1900 pistols were highly regarded for this work, but never available in adequate quantities. Colt Model 1903 Pocket Hammerless, Savage Model 1907, Star Bonifacio Echeverria and Ruby pistols were widely used.^[34]

Various mechanical devices were invented for throwing hand grenades into enemy trenches. The Germans used the *Wurfmaschine*, a spring-powered device for throwing a hand grenade about 200 m (220 yd).^[35] The French responded with the *Sauterelle* and the British with the Leach Trench Catapult and West Spring Gun which had varying degrees of success and accuracy. By 1916, catapult weapons were largely replaced by rifle grenades and mortars.^[36]

The Germans employed *Flammenwerfer* (flamethrowers) during the war for the first time against the French on 25 June 1915, then against the British 30 July in Hooze. The technology was in its infancy, and use was not very common until the end of 1917 when portability and reliability were improved. It was used in more than 300 documented battles. By 1918, it became a weapon of choice for *Stoßtruppen* (Stormtroopers) with a team of six *Pioniere* (combat engineers) per squad.

Used by American soldiers in the Western front, the pump action shotgun was a formidable weapon in short range combat, enough so that Germany lodged a formal protest against their use on 14 September 1918, stating "every prisoner found to have in his possession such guns or ammunition belonging thereto forfeits his life", though this threat was apparently never carried out. The U.S. military began to issue models specially modified for combat, called "trench guns", with shorter barrels, higher capacity magazines, no choke, and often heat shields around the barrel, as well as lugs for the M1917 bayonet. Anzac and some British soldiers were also known to use sawn-off shotguns in trench raids, because of their portability, effectiveness at close range, and ease of use in the confines of a trench. This practice was not officially sanctioned, and the shotguns used were invariably modified sporting guns.



British Mills bomb N°23 Mk II, with rod for launch by rifle



Various trench weapons used by British and Canadian soldiers in WWI on display at the Canadian War Museum



French soldiers with a Sauterelle bomb-throwing crossbow, c. 1915

Wire

The use of lines of barbed wire, razor wire, and other wire obstacles is effective in stalling infantry traveling across the battlefield. Although the barbs or razors might cause minor injuries, the purpose was to entangle the limbs of enemy soldiers, forcing them to stop and methodically pull or work the wire off, likely taking several seconds, or even longer. This is deadly when the wire is emplaced at points of maximum exposure to concentrated enemy firepower, in plain sight of enemy fire bays and machine guns. The combination of wire and firepower was the cause of most failed attacks in trench warfare and their very high casualties. Liddell Hart identified barbed wire and the machine gun as the elements that had to be broken to regain a mobile battlefield.



French soldiers struggle to pass multiple lines of barbed wire

A basic wire line could be created by draping several strands of barbed wire between wooden posts driven into the ground. Loose lines of wire can be more effective in entangling than tight ones, and it was common to use the coils of barbed wire as delivered only partially stretched out, called concertina wire. Placing and repairing wire in no man's land relied on stealth, usually done at night by special wiring parties, who could also be tasked with secretly sabotaging enemy wires. The screw picket, invented by the Germans and later adopted by the Allies during the war, was quieter than driving stakes. Wire often stretched the entire length of a battlefield's trench line, in multiple lines, sometimes covering a depth 30 metres (100 ft) or more.

Methods to defeat it are rudimentary. Prolonged artillery bombardment could damage them, but not reliably. The first soldier meeting the wire could jump onto the top of it, hopefully depressing it enough for those that followed to get over him; this still took at least one soldier out of action for each line of wire. In World War I, British and Commonwealth forces relied on wire cutters, which proved unable to cope with the heavier gauge German wire.^[30] The Bangalore torpedo was adopted by many armies, and continued in use past the end of World War II.^[37]

Machine guns

The Germans embraced the machine gun from the outset—in 1904, sixteen units were equipped with the 'Maschinengewehr'—and the machine gun crews were the elite infantry units; these units were attached to Jaeger (light infantry) battalions. By 1914, British infantry units were armed with two Vickers machine guns per battalion; the Germans had six per battalion, and the Russians eight.^[38] It would not be until 1917 that every infantry unit of the American forces carried at least one machine gun.^[39] After 1915, the Maschinengewehr 08 was the standard issue German machine gun; its number "08/15" entered the German language as idiomatic for "dead plain". At Gallipoli and in Palestine the Turks provided the infantry, but it was usually Germans who manned the machine guns.



Vickers machine gun

The British High Command were less enthusiastic about machine guns, supposedly considering the weapon too "unsporting" and encouraging defensive fighting; and they lagged behind the Germans in adopting it. Field Marshal Sir Douglas Haig is quoted as saying in 1915, "The machine gun is a much overrated weapon; two per battalion is more than sufficient".^[40] The defensive firepower of the machine gun was exemplified during the first day of the Battle of the Somme when 60,000 British soldiers were rendered casualties, "the great majority lost under withering machine gun fire".^[41] In 1915 the Machine Gun Corps was formed to train and provide sufficient heavy machine gun teams.

It was the Canadians that made the best practice, pioneering area denial and indirect fire (soon adopted by all Allied armies) under the guidance of former French Army Reserve officer Major General Raymond Brutinel. Minutes before the attack on Vimy Ridge the Canadians thickened the artillery barrage by aiming machine guns indirectly to deliver plunging fire on the Germans. They also significantly increased the number of machine guns per battalion. To match demand, production of the Vickers machine gun was contracted to firms in the United States. By 1917, every company in the British forces were also equipped with four Lewis light machine guns, which significantly enhanced their firepower.

The heavy machine gun was a specialist weapon, and in a static trench system was employed in a scientific manner, with carefully calculated fields of fire, so that at a moment's notice an accurate burst could be fired at the enemy's parapet or a break in the wire. Equally it could be used as light artillery in bombarding distant trenches. Heavy machine guns required teams of up to eight men to move them, maintain them, and keep them supplied with ammunition. This made them impractical for offensive manoeuvres, contributing to the stalemate on the Western Front.

One machine gun nest was theoretically able to mow down hundreds of enemies charging in the open through no man's land. However, while WWI machine guns were able to shoot hundreds of rounds per minute in theory, they were still prone to overheating and jamming, which often necessitated firing in short bursts.^[42] However, their potential was increased significantly when emplaced behind multiple lines of barbed wire to slow any advancing enemy.

During WWI machine guns were adapted for use on tanks and aircraft for the first time.

Artillery

Artillery dominated the battlefields of trench warfare. An infantry attack was rarely successful if it advanced beyond the range of its supporting artillery. In addition to bombarding the enemy infantry in the trenches, the artillery could be used to precede infantry advances with a creeping barrage, or engage in counter-battery duels to try to destroy the enemy's guns. Artillery mainly fired fragmentation, high-explosive, shrapnel or, later in the war, gas shells. The British experimented with firing thermite incendiary shells, to set trees and ruins alight. However, all armies experienced shell shortages during the first year or two of World War I, due to underestimating their usage in intensive combat. This knowledge had been gained by the combatant nations in the Russo-Japanese War, when daily artillery fire consumed ten times more than daily factory output, but had not been applied.^[43]



Loading a 15 in (380 mm) howitzer

Artillery pieces were of two types: infantry support guns and howitzers. Guns fired high-velocity shells over a flat trajectory and were often used to deliver fragmentation and to cut barbed wire. Howitzers lofted the shell over a high trajectory so it plunged into the ground. The largest calibers were usually howitzers. The German 420 mm (17 in) howitzer weighed 20 tons and could fire a one-ton shell over 10 km (6.2 mi). A critical feature of period artillery pieces was the hydraulic recoil mechanism, which meant the gun did not need to be re-aimed after each shot, permitting a tremendous increase in rate of fire.

Initially each gun would need to register its aim on a known target, in view of an observer, in order to fire with precision during a battle. The process of gun registration would often alert the enemy an attack was being planned. Towards the end of 1917, artillery techniques were developed enabling fire to be delivered accurately without registration on the battlefield—the gun registration was done behind the lines then the pre-registered guns were brought up to the front for a surprise attack.

Mortars

Mortars, which lobbed a shell in a high arc over a relatively short distance, were widely used in trench fighting for harassing the forward trenches, for cutting wire in preparation for a raid or attack, and for destroying dugouts, saps and other entrenchments. In 1914, the British fired a total of 545 mortar shells; in 1916, they fired over 6,500,000. Similarly, howitzers, which fire on a more direct arc than mortars, raised in number from over 1,000 shells in 1914, to over 4,500,000 in 1916. The smaller numerical difference in mortar rounds, as opposed to howitzer rounds, is presumed by many to be related to the expanded costs of manufacturing the larger and more resource intensive howitzer rounds.

The main British mortar was the Stokes, a precursor of the modern mortar. It was a light mortar, simple in operation, and capable of a rapid rate of fire by virtue of the propellant cartridge being attached to the base shell. To fire the Stokes mortar, the round was simply dropped into the tube, where the percussion cartridge was detonated when it struck the firing pin at the bottom of the barrel, thus being launched. The Germans used a range of mortars. The smallest were grenade-throwers ('Granatenwerfer') which fired the stick grenades which were commonly used. Their medium trench-mortars were called mine-throwers ('Minenwerfer'). The heavy mortar was called the 'Ladungswerfer', which threw "aerial torpedoes", containing a 200 lb (91 kg) charge to a range of 1,000 yd (910 m). The flight of the missile was so slow and leisurely that men on the receiving end could make some attempt to seek shelter.

Mortars had certain advantages over artillery such as being much more portable and the ability to fire without leaving the relative safety of trenches. Moreover, Mortar were able to fire directly into the trenches, which was hard to do with artillery.^[44]

Helmets

During the first year of the First World War, none of the combatant nations equipped their troops with steel helmets. Soldiers went into battle wearing simple cloth or leather caps that offered virtually no protection from the damage caused by modern weapons. German troops were wearing the traditional leather Pickelhaube (spiked helmet), with a covering of cloth to protect the leather from the splattering of mud.

Once the war entered the static phase of trench warfare, the number of lethal head wounds that troops were receiving from fragmentation increased dramatically. The French were the first to see a need for greater protection and began to introduce steel helmets in the summer of 1915. The Adrian helmet replaced the traditional French kepi and was later adopted by the Belgian, Italian and many other armies.

At about the same time the British were developing their own helmets. The French design was rejected as not strong enough and too difficult to mass-produce. The design that was eventually approved by the British was the Brodie helmet. This had a wide brim to protect the wearer from falling objects, but offered less protection to the wearer's neck. When the Americans entered the war, this was the helmet they chose, though some units used the French Adrian helmet.

The traditional German 'pickelhaube' was replaced by the Stahlhelm or "steel helmet" in 1916. Some elite Italian units used a helmet derived from ancient Roman designs. None of these standard helmets could protect the face or eyes, however. Special face-covers were designed to be used by machine gunners, and the Belgians tried out goggles made of



French soldiers operating a compressed-air trench mortar of 86-millimetre calibre

louvres to protect the eyes. Additionally, tank crews were issued with or fashioned makeshift face masks to protect against the hot metal fragments that ricocheted around the compartment when the exterior of the tank was hit with machinegun fire.

Mines

Landmines were widely used in WWI trench and tunnel warfare to destroy or disrupt enemy's trench lines.^{[45][46]}

Gas

World War I saw large-scale use of poison gasses. At the start of the war, the gas agents used were relatively weak and delivery unreliable, but by mid-war advances in this chemical warfare reached horrifying levels.

The first methods of employing gas was by releasing it from a cylinder when the wind was favourable. This was prone to miscarry if the direction of the wind was misjudged. Also, the cylinders needed to be positioned in the front trenches where they were likely to be ruptured by enemy bombardment. Later, gas was delivered directly to enemy trenches by artillery or mortar shell, reducing friendly casualties significantly. Lingering agents could still affect friendly troops that advanced to enemy trenches following its use.

Early on, soldiers made improvised gas masks by urinating on a handkerchief and putting it over their nose and mouth so the urea would disable the poison. Armies rushed to issue regulation gas masks as regular equipment for front line troops. Anti-gas equipment and procedures improved significantly during the war, to the point that gas attacks had become less devastating at the war's end.

Several different gas agents were used. Tear gas was first employed in August 1914 by the French, but this could only temporarily disable the enemy. In April 1915, chlorine gas was first used by Germany at the Second Battle of Ypres. Exposure to a large dose could kill, and those not killed could suffer permanent lung damage. But the gas was easy to detect by scent and sight. Phosgene, first used in December 1915, was the most lethal killing gas of World War I; it was 18 times more powerful than chlorine and much more difficult to detect.

However, the most effective gas was mustard gas, introduced by Germany in July 1917. Mustard gas was not as fatal as phosgene, but it was hard to detect and lingered on the surface of the battlefield, so could inflict casualties over a long period. Even if not inhaled, it could slowly burn the skin, but quickly burned via the eyes or any wounds, causing blindness and intense suffering. Casualties from mustard gas were unlikely to be fit to fight again, yet only 2% of mustard gas casualties died. The added burden of long-term care of casualties from mustard gas actually increased its overall effectiveness compared to more immediately lethal gas agents.

Aircraft

The fundamental purpose of the aircraft in trench warfare was reconnaissance and artillery observation. Aerial reconnaissance was so significant in exposing movements, it has been said the trench stalemate was a product of it.^[47] The role of the fighter was to protect friendly reconnaissance aircraft and destroy those of the enemy, or at least deny them the



Australian infantry wearing gas masks, Ypres, September 1917

freedom of friendly airspace. This involved achieving air superiority over the battlefield by destroying the enemy's fighters as well.

Spotter aircraft would monitor the fall of shells during registration of the artillery. Reconnaissance aircraft would map trench lines, first with hand-drawn diagrams, later with photography, monitor enemy troop movements, and locate enemy artillery batteries so that they could be destroyed with counter-battery fire.

New weapons

In 1917 and 1918, new types of weapons were fielded. They changed the face of warfare tactics and were later employed during World War II.

The French introduced the CSRG 1915 Chauchat during Spring 1916 around the concept of "walking fire", employed in 1918 when 250,000 weapons were fielded. More than 80,000 of the best shooters received the semi-automatic RSC 1917 rifle, allowing them to rapid fire at waves of attacking soldiers. Firing ports were installed in the newly arrived Renault FT tanks.

The French Army fielded a ground version of the Hotchkiss Canon de 37 mm used by the French Navy. It was primarily used to destroy German machine gun nests and concrete reinforced pillboxes with high explosive rounds, but an armour-piercing round was designed to defeat the German tanks, making it the first anti tank gun.

A new type of machine gun was introduced in 1916. Initially an aircraft weapon, the Bergmann LMG 15 was modified for ground use, with the later dedicated ground version being the LMG 15 n. A. It was used as an infantry weapon on all European and Middle Eastern fronts until the end of World War I. It later inspired the MG 30 and the MG 34 as well as the concept of the general-purpose machine gun.



German soldier with MP 18, 1918.

What became known as the submachine gun had its genesis in World War I, developed around the concepts of infiltration and fire and movement, specifically to clear trenches of enemy soldiers when engagements were unlikely to occur beyond a range of a few feet. The MP 18 was the first practical submachine gun used in combat. It was fielded in 1918 by the German Army as the primary weapon of the stormtroopers, assault groups that specialised in trench combat.

Mining

The dry chalk of the Somme was especially suited to mining, but with the aid of pumps, it was also possible to mine in the sodden clay of Flanders. Specialist tunneling companies, usually made up of men who had been miners in civilian life, would dig tunnels under no man's land and beneath the enemy's trenches.^{[48][49]} These mines would then be packed with explosives and detonated, producing a large crater. The crater served two purposes: it could destroy or breach the enemy's trench and, by virtue of the raised lip that they produced, could provide a ready-made "trench" closer to the enemy's line. When a mine was detonated, both sides would race to occupy and fortify the crater.

If the miners detected an enemy tunnel in progress, they would often counter-mine and try to drive a tunnel under the enemy's tunnel in which they would detonate explosives to create a camouflet to destroy the enemy's tunnel. Night raids were also conducted with the sole purpose of destroying the enemy's mine workings. On occasion, mines would cross and fighting would occur underground. The mining skills could also be used to move troops unseen. On one occasion a whole British division was moved through interconnected workings and sewers without German observation. The British

detonated 19 mines of varying sizes on July 1, 1916, the first day of the Battle of the Somme. The largest mines—the Y Sap Mine and the Lochnagar Mine—each containing 24 tons of explosives, were blown near La Boisselle, throwing earth 4,000 feet into the air.

At 3.10 AM on June 7, 1917, a series of mines was detonated by the British to launch the Battle of Messines. The average mine contained 21 tons of explosive and the largest, 125 feet beneath Saint-Eloi, was twice the average at 42 tons. As remarked by General Plumer to his staff the evening before the attack:

"Gentlemen, we may not make history tomorrow, but we shall certainly change the geography."^[50]

The craters from these and many other mines on the Western Front are still visible today. Two undetonated mines remained in the ground near Messines, with their location mislaid after the war. One blew during a thunderstorm in 1955; the other remains in the ground.^[50] Significant mining operations were also carried out on the Italian Front.

Trench battles

While trenches have often been dug as defensive measures, in the pre-*firearm* era, they were mainly a type of hindrance for an attacker of a fortified location, such as the ditch (or moat) around a castle. An early example of this can be seen in the Battle of the Trench.

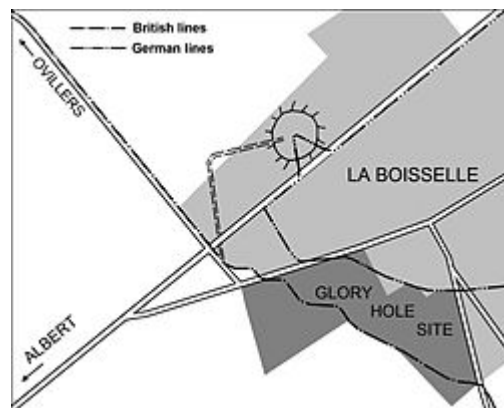
Only with the advent of accurate firearms did the use of trenches as positions for the defender of a fortification become common. Elaborate trench and bunker systems were employed by the Māori to withstand British artillery barrages and bayonet charges during the New Zealand Wars in the 1840s. Trench systems were also employed in the Russo-Japanese War^[29] and American Civil War. The military usage evolved very quickly in the First World War, until whole systems of extensive main trenches, backup trenches (in case the first lines were overrun) and communication trenches had been developed, often stretching dozens of kilometres along a front without interruption, and some kilometres further back from the opponent's lines.

Strategy

The fundamental strategy of trench warfare in World War I was to defend one's own position strongly while trying to achieve a breakthrough into the enemy's rear. The effect was to end up in attrition; the process of progressively grinding down the opposition's resources until, ultimately, they are no longer able to wage war. This did not prevent the ambitious commander from pursuing the strategy of annihilation—the ideal of an offensive battle which produces victory in one decisive engagement.



Explosion of a mine seen from a French position. 1916



Plan of the Y Sap mine



German trenches in Vimy

The Commander in Chief of the British forces during most of World War I, General Douglas Haig, was constantly seeking a "breakthrough" which could then be exploited with cavalry divisions. His major trench offensives—the Somme in 1916 and Flanders in 1917—were conceived as breakthrough battles but both degenerated into costly attrition. The Germans actively pursued a strategy of attrition in the Battle of Verdun, the sole purpose of which was to "bleed the French Army white". At the same time the Allies needed to mount offensives in order to draw attention away from other hard-pressed areas of the line.

World War I tactics

The popular image of a trench assault is of a wave of soldiers, bayonets fixed, going "over the top" and marching in a line across no man's land into a hail of enemy fire. This was the standard method early in the war; it was rarely successful. More common was an attack at night from an advanced post in no man's land, having cut the barbed wire beforehand. In 1915, the Germans innovated with infiltration tactics where small groups of highly trained and well-equipped troops would attack vulnerable points and bypass strong points, driving deep into the rear areas. The distance they could advance was still limited by their ability to supply and communicate.

The role of artillery in an infantry attack was twofold. The first aim of a bombardment was to prepare the ground for an infantry assault, killing or demoralising the enemy garrison and destroying his defences. The duration of these initial bombardments varied, from seconds to days. Artillery bombardments prior to infantry assaults were often ineffective at destroying enemy defences, only serving to provide advance notice of an attack. The British bombardment that began the Battle of the Somme lasted eight days but did little damage to either the German barbed wire or their deep dug-outs, where defenders were able to wait out the bombardment in relative safety.

Once the guns stopped, the defenders had time to emerge and were usually ready for the attacking infantry. The second aim was to protect the attacking infantry by providing an impenetrable "barrage" or curtain of shells to prevent an enemy counter-attack. The first attempt at sophistication was the "lifting barrage" where the first objective of an attack was intensely bombarded for a period before the entire barrage "lifted" to fall on a second objective farther back. However, this usually expected too much of the infantry, and the usual outcome was that the barrage would outpace the attackers, leaving them without protection.

This resulted in the use of the "creeping barrage" which would lift more frequently but in smaller steps, sweeping the ground ahead and moving so slowly that the attackers could usually follow closely behind it. This became the standard method of attack from late 1916 onward. The main benefit of the barrage was suppression of the enemy rather than to cause casualties or material damage.

Capturing the objective was half the battle, but the battle was only won if the objective was held. The attacking force would have to advance with not only the weapons required to capture a trench but also the tools—sandbags, picks and shovels, barbed wire—to fortify and defend from counter-attack. A successful advance would take the attackers beyond the range of their own field artillery, making them vulnerable, and it took time to move guns up over broken ground. The Germans placed great emphasis on immediately counter-attacking to regain lost ground. This strategy cost them dearly in 1917



French troopers using periscope, 1915

when the British started to limit their advances so as to be able to meet the anticipated counter-attack from a position of strength. Part of the British artillery was positioned close behind the original start line and took no part in the initial bombardment, so as to be ready to support later phases of the operation while other guns were moved up.

World War I communications

Because the battlefield of trench warfare was very deep and hazardous, communications were a major difficulty. Wireless communications were still in their infancy in World War I, so the available methods were telephone, telegraph, semaphore, signal lamps, signal flares, homing pigeons, and message runners. Though telephone was the most effective method, with telegraph a close second, their cables were vulnerable to artillery fire and were often broken early in the battle. To help compensate for this, the cables could be laid in a ladder-like pattern so that multiple redundant lines were available.



British and French soldiers lay a telegraph cable in Gallipoli, 1915

Frequently, message delays caused them to be out-of-date by the time they were received. Communication with higher division, corps and army HQs incurred even longer delays, which were doubled if a reply was needed. Some messages were misdirected or lost completely. If a message sent out did not get a reply or confirmation back, the sender could not tell if the original message did not get through, or if it did but the reply did not get back, resulting in confusion worse than if no communication had been attempted.

It was not uncommon for a commanding officer had to wait hours for messages over the course of a battle, making any changes of plans almost impossible. The outcome of many battles was left in the hands of the company and platoon commanders in the middle of the action, who often had less experience, had very limited additional resources or information, and very limited authority to deviate from the original orders given before the start of the battle. Unable to react to any changing battle situation, many opportunities were lost, and many hopeless attacks persisted.

Only starting in 1916, on the battlefield of Verdun, came the use of portable small radio stations that could transmit short Morse codes. Radio frequency overlap occurred with neighboring divisions until precise regulation and radio discipline developed. Also, enemy interception was common until effective codebook practices were enforced. These problems were not completely resolved until the war's end.

World War I – breaking the stalemate

Throughout World War I, the major combatants slowly developed different ways of breaking the stalemate of trench warfare; the Germans focused more on new tactics while the British and French focused on tanks.

Infiltration tactics

As far back as the 18th century, Prussian military doctrine stressed maneuver and force concentration to achieve a decisive battle (*Vernichtungsschlacht*). The German military searched for ways to apply this in the face of trench warfare. Experiments with new tactics by Willy Rohr, a Prussian captain serving in the Vosges mountains in 1915, got the attention of the Minister of War. These tactics carried Prussian military doctrine down to smallest units — specially trained troops maneuvered and massed to assault positions they chose on their own.^[51] During the next 2 years the German army tried to establish special stormtrooper detachments in all its units by sending selected men to Rohr and have those men then train their comrades in their original units.

Similar tactics were developed independently in other countries, such as French Army captain André Laffargue^[52] in 1915, and Russian general Aleksei Brusilov in 1916, but these failed to be adopted as any military doctrine.

The German stormtrooper methods involved men rushing forward in small groups using whatever cover was available and laying down covering fire for other groups in the same unit as they moved forward. The new tactics, intended to achieve surprise by disrupting entrenched enemy positions, aimed to bypass strongpoints and to attack the weakest parts of an enemy's line. Additionally, they acknowledged the futility of managing a grand detailed plan of operations from afar, opting instead for junior officers on the spot to exercise initiative.^[53]



German *Stoßtruppen* (stormtroopers) rising from trenches to attack

The Germans employed and improved infiltration tactics in a series of smaller to larger battles, each increasingly successful, leading up to the Battle of Caporetto against the Italians in 1917, and finally the massive German Spring Offensive in 1918 against the British and French. German infiltration tactics are sometimes called "Hutier tactics" by others, after Oskar von Hutier, the general leading the German 18th Army, which had the farthest advance in that offensive. After a stunningly rapid advance, the offensive failed to achieve a breakthrough; German forces stalled after outrunning their supply, artillery, and reinforcements, which could not catch up over the shell-torn ground left ruined by Allied attacks in the Battle of the Somme in 1916. The exhausted German forces were soon pushed back in the Allied Hundred Days Offensive, and the Germans were unable to organise another major offensive before the war's end. In post-war years, other nations did not fully appreciate these German tactical innovations amidst the overall German defeat.

Tanks

Tanks were first introduced by the British as a means to attack enemy trenches, by combining heavy firepower (machine guns or light artillery guns), protection from small-arms fire (armour), and battlefield mobility (tracks). These tanks were designed with rhomboid-shaped tracks to easily crush barbed wire lines and cross trenches. They were first deployed in 1916 at the Battle of the Somme in limited numbers, proving unreliable and ineffective at first, as mechanical and logistical issues overshadowed implementing a coherent tank doctrine, with the additional challenge of traversing ground torn apart by years of shell fire. At the First Battle of Cambrai in 1917, improved tanks in larger numbers demonstrated the potential of tank warfare, though German improvised anti-tank tactics, including using direct fire from field artillery, also proved effective.



This British Mark IV tank displays a "tadpole tail" extension for crossing especially wide trenches.

By 1918, tank capabilities and tactics improved, their numbers increased and, combined with French tanks, finally helped break the stalemate. During the last 100 days of the war, Allied forces harried the Germans back using infantry supported by tanks and by close air support. By the war's end, tanks become a significant element of warfare; the proposed British Plan 1919 would have employed tanks a primary factor in military strategy. However, the impact of tanks in World War I was less than it could have been, due to their late introduction and the inherent issues that plague implementing revolutionary technology.

Between the two world wars many nations developed their own unique tanks and divergent theories of tank tactics, including the UK, France, the Soviet Union, Czechoslovakia, Japan, the US, and Italy. Though German tank development was restricted by the terms of the treaty ending World War I, Germany successfully combined their own tanks (plus Czech

tanks from occupied Czechoslovakia) with infiltration tactics to produce blitzkrieg during World War II.^[54]

World War II

European Theatre

In the decade leading up to World War II, the French built the Maginot Line, based on their experience with trench warfare in World War I. The Maginot Line was an extensive state-of-the-art defensive system far superior to any previous trench system: a chain of massive constructions of concrete, iron, and steel fortresses, bunkers, retractable turrets, outposts, obstacles, and sunken artillery emplacements, linked by tunnel networks. It covered the length of the Franco-German border, and 20–25 kilometres (12–16 mi) wide. It was supported by numerous underground barracks, shelters, ammo dumps and depots, with its own telephone network and narrow gauge railways with armoured locomotives, backed up with heavy rail artillery. French military experts placed high value on the Line, saying it would curb German aggression, as any invasion force would be halted long enough for French forces to mobilize and counterattack through Belgium. It was only partially successful; in the Battle of France, the main German "Blitzkrieg" attack struck through the weakly held Ardennes forest, the gap between the end of the Maginot Line and the advancing Anglo-French mobile forces heading into Belgium. Small secondary German attacks concentrated at a few points in the Line had moderate success. The bulk of the Maginot Line was untouched, and survives today.



A retractable turret of Ouvrage Hochwald, one of the largest fortifications of the Maginot Line, 1940

The return of mobile warfare in World War II reduced the emphasis of trench warfare, as defenders commonly lack the time to build up such battlefield defenses before they are forced to redeploy, due to the more rapidly-changing strategic situation. But trench systems can still be effective locally, wherever mobility was limited, the front lines are static, or around known critical objectives that cannot be bypassed. More quickly improvised defensive fighting positions, using "scrapes" or "foxholes", possibly supplemented by sand bags, local materials, debris, or rubble, remain in common use. These will typically be improved and expanded by the defenders, eventually becoming full trench systems, if given enough time and resources.

At the Battle of Sevastopol, Red Army forces successfully held trench systems on the narrow peninsula for several months against intense German bombardment. The Western Allies in 1944 broke through the incomplete Atlantic Wall with relative ease through a combination of amphibious landings, naval gunfire, air attack, and airborne landings. Combined arms tactics where infantry, artillery, armour and aircraft cooperate closely greatly reduced the importance of trench warfare. It was, however, still a valuable method for reinforcing natural boundaries and creating a line of defence. For example, at the Battle of Stalingrad, soldiers on both sides dug trenches within the ruins. In addition, before the start of the Battle of Kursk, the Soviets constructed a system of defence more elaborate than any they built during World War I. These defences succeeded in stopping the German armoured pincers from meeting and enveloping the salient.^[55]



Soviet soldiers running through the ruins of Stalingrad, 1942.

The Italian Campaign fought from 1943 until the end of the war in Europe largely consisted of the Allies storming strongly fortified German lines which stretched from one coast, over the mountains to the other coast. When the Allies broke through one line, the Germans would retreat up the peninsula to yet another freshly prepared fortified line.

At the start of the Battle of Berlin, the last major assault on Germany, the Russians attacked over the river Oder against German troops dug in on the Seelow Heights, about 50 km (31 mi) east of Berlin. Entrenchment allowed the Germans, who were massively outnumbered, to survive a bombardment from the largest concentration of artillery in history; as the Red Army attempted to cross the marshy riverside terrain, they lost tens of thousands of casualties to the entrenched Germans before breaking through.



Soldiers of the Brazilian Expeditionary Force in a trench in Montese during the Italian Campaign of World War II, 1944.

Pacific War

The Japanese used a labyrinth of underground fixed positions to slow down the Allied advances on many Pacific Islands. The Japanese built fixed fortifications on Iwo Jima, Okinawa, and Guadalcanal using a system of tunnels to interconnect their fortified positions. The Japanese had on Battle of Iwo Jima several levels of honeycombed fortifications. The Japanese caused the American advance to slow down and caused massive casualties with these underground fixed positions. The Americans eventually used flamethrowers and systematic hand-to-hand fighting to ouster.

Post-1945 to modern trench warfare

Trench warfare has been infrequent in recent wars. When two large armoured armies meet, the result has generally been mobile warfare of the type which developed in World War II. However, trench warfare reemerged in the latter stages of the Chinese Civil War (Huaihai Campaign), the Korean War (from July 1951 to its end), and at Dien Bien Phu and other later locations and engagements during the Vietnam War. During the Cold War, NATO forces routinely trained to fight through extensive works called "Soviet-style trench systems", named after the Warsaw Pact's complex systems of field fortifications, an extension of Soviet field entrenching practices for which they were famous in their Great Patriotic War (the Eastern Front of World War II).

Another example of trench warfare after World Wars I and II was the Iran–Iraq War, in which both armies lacked training in combined arms operations. Tactics used included trench warfare, machine gun posts, bayonet charges, use of barbed wire across trenches and on no-man's land, Iranian human wave attacks, and Iraq's extensive use of chemical weapons such as mustard gas against Iranian troops.

Although mainly a siege, it was not unusual to find an extensive trench system inside and outside the city of Sarajevo during the siege of 1992–1996. It was used mainly for transportation to the frontline or to avoid snipers inside the city. Any pre-existing structures were used as trenches; the best known example is the bobsleigh course at Trebević, which was used by both Serb and Bosniak forces during the siege. Another example of trench stalemate was the Eritrean-Ethiopian War of 1998–2000.^[56] The front line in Korea and the front lines between Pakistan and India in Kashmir are two examples of demarcation lines which could become hot at any time. They consist of kilometres of trenches linking fortified strongpoints and in Korea surrounded by millions of land mines.



Afghan and U.S. soldiers provide security while standing behind a blast wall made from HESCO bastions at Zhari district, Kandahar Province, Afghanistan, 2012.

A recent example of trench warfare occurred in the War in Donbass, in which Pro-Russian rebels fought the Ukrainian government. More than 6,000 people were killed in a year of combat. To consolidate and defend their territory and/or gains, government and rebel forces have dug trenches and have initiated warfare reminiscent of World War I, such as open trench warfare with troops staying in and fighting from trenches for months at a time. Despite the Minsk peace agreements low-intensity firefights and combat patrols continue to this day.^[57]

See also

- Blitzkrieg
- Breastwork (fortification)
- Christmas truce
- Defensive fighting position
- Harry Patch
- Medieval warfare
- Mining (military)
- Mobile warfare
- No man's land
- Sangar (fortification)
- Shell shock
- Siege
- Tunnel warfare


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