Chapter One: An Introduction to the Age of Modern War

> *"All Frenchmen are permanently requisitioned for service in the armies. The young men shall fight, the married men shall forge weapons and transport supplies... the public buildings shall be turned into barracks, the public squares into munitions factories."*
>
> **- Decree of the National Convention, 1793**

The first step down the road to mass warfare had been taken. The policy outlined in the decree of 1793 promised to give revolutionary France a decided advantage over its reactionary neighbours. France certainly had the largest population in Western Europe, together with a substantial agricultural base. The *levée en masse* would be capable of creating an army of almost one million men to defend the republic and spread the ideals of the revolution beyond the borders of France. None of Europe's monarchies could hope to field an army of comparable numbers.

While troops had become far more abundant, however, weapons had not. Neither France, nor any other European state for that matter, had the capability to arm and equip such a large army. Although the centralized government of revolutionary France managed to get far more from the economy, it was still not sufficient to field the army that conscription theoretically made possible. Even had French industry been able to produce enough weapons and *matériel*,[1] the existing transportation network was simply not capable of moving such vast amounts of equipment and supplies.

[1] *Matériel*: the weapons, equipment and supplies required by military organizations.

Armies such as those envisioned by the National Convention would not be seen on the battlefield until industrial and technological developments made them feasible. As technology advanced, it was also inevitable that weapons far superior to smoothbore muskets and cannon would appear.

The Advancement of Technology

Developments in Military Technology

The basic weapons of war had not changed substantially in Europe since the middle of the seventeenth century. Both artillery pieces and small arms were muzzle-loaded and smooth bored. Some innovation had taken place, for example, the replacement of the matchlock with the more reliable flintlock for muskets, and the development of a coarser gunpowder that improved artillery performance. The socket bayonet had become standard issue for all infantrymen, thereby eliminating the need for pike men to protect musketeers during reloading. The increasingly decisive role of

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firepower on the battlefield had also dramatically reduced the role of cavalry.

The Napoleonic wars were fought with the same weapons of the previous century. What *had changed* was how these weapons were employed. Artillery had traditionally been assigned to infantry and cavalry units, with two to four guns per regiment. Napoleon employed massed artillery, with independent batteries of up to eighty cannon delivering concentrated fire as a prelude to assault by infantry. Armies were reorganized along divisional lines, capable of operating independently or in concert with other divisions. The tactical use of infantry columns replaced the use of lines, especially in revolutionary France. Columns were more manoeuverable, and required less rigorous training and discipline than linear formations. Given the number and nature of conscripts, the French found columns were ideal for employing relatively inexperienced troops in battle.

The Development of the Modern Rifle

Small arms underwent revolutionary changes in the nineteenth century.[2] The first innovation was that of the percussion cap, developed by Alexander Forsythe in 1820. Using mercury fulminate, he created a charge that was unaffected by moisture and detonated on impact. The cap replaced the flintlock mechanism and virtually eliminated misfires, and muskets were easily converted to the percussion cap firing mechanism. By 1839, the British army was fully equipped with muskets incorporating the percussion cap.

Perhaps the most significant technological development of small arms in the nineteenth century was the replacement of the musket with the rifle. The rifle was a contemporary of the musket, but it was very difficult and time consuming to load. Although it was far more accurate and had a significantly greater range, its slow rate of fire precluded its use on the battlefield.[3] The musket, though inaccurate and having a limited range, was the weapon used by all European armies. Its rate of fire was approximately four times that of the rifle, and firing en masse in volleys compensated for its inaccuracy.

After the Napoleonic wars, efforts were directed toward developing a rifle that could match the rate of fire of the smoothbore musket while maintaining the rifle's greater range and accuracy. The problem was addressed in two different ways. In Britain, and later France, efforts were focused upon designing a muzzle-loading rifle. The basic shape of the musket ball was altered (cylindroconoidal bullet), so that the base of the projectile deformed when the gun was discharged. Expanding gases flared the rear portion of the bullet out, creating a tight bore seal that allowed the bullet to pick up the rifling. By 1849, the muzzle-loading rifle was perfected. The Minié rifle had a comparable rate of fire to the musket (two rounds per minute), and an effective range of more than 1 000 metres.

In Prussia, Johann von Dreyse tackled the problem quite literally from the other end of

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[2] Classification of small calibre weapons including muskets, rifles, handguns and automatic weapons.

[3] Rifling is the thread running the length of the barrel's interior. The projectile emerged from the barrel spinning on a horizontal axis, giving it a much truer trajectory. Therefore the ball had to be slowly eased down the barrel, allowing it to pick up the rifling, and the loading process was much slower than that of the musket. The tight seal created also resulted in a much higher velocity and effective range.

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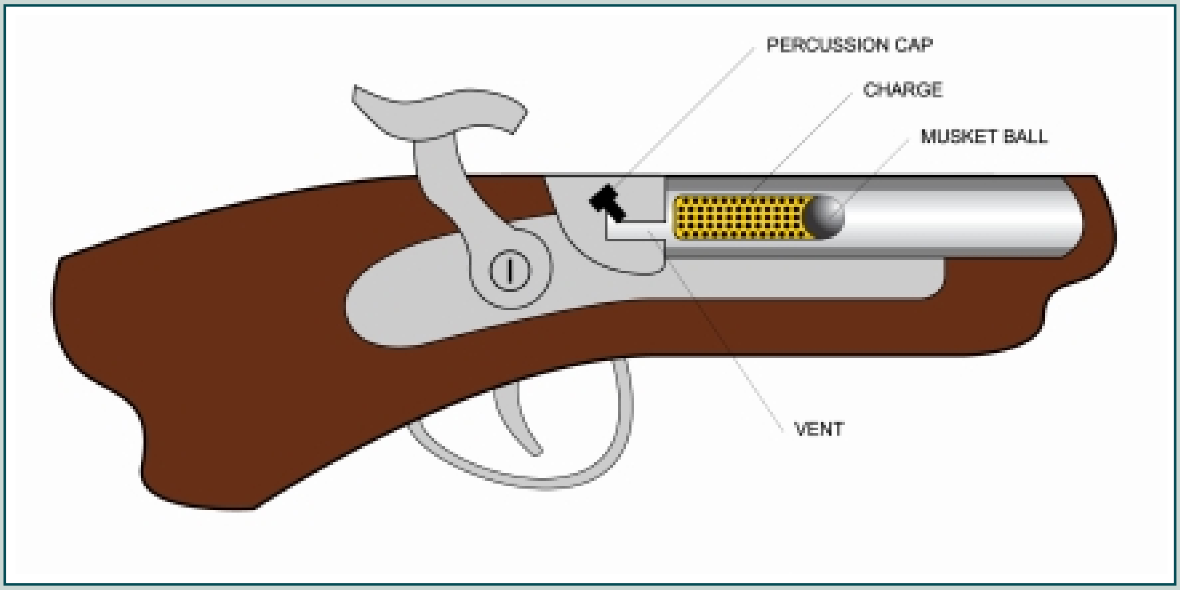

Illustration 1.1: Percussion Cap Musket
The hammer strikes the percussion cap, mercury fulminate in a shallow brass cylinder. The cap explodes, hot gases are forced through the vent, detonating the gunpowder charge.

the barrel. Taking advantage of the percussion cap technology, von Dreyse designed a breech-loading weapon with a firing pin to detonate a percussion cap contained in the base of a brass cartridge. The Dreyse needle-gun did not maintain a complete seal at the breech, which reduced the effective range of aimed fire to 400 metres, but it had an impressive rate of fire, seven rounds per minute. Unlike the muzzle-loading rifle, which still had to be loaded standing upright, von Dreyse's gun could be loaded and fired from any position.

By the end of the century, the infantry rifle had been perfected. Soldiers were uniformly equipped with bolt-action breech-loading rifles, and could be expected to deliver fire at a rate of ten rounds or more per minute.

Advances in Artillery

The improvements in small arms had a profound effect upon the development of artillery. During the era up to and including the Napoleonic wars, the cannon was basically a larger version of the infantry musket. The smoothbore muzzle-loading pieces fired a solid projectile up to a range of 900 metres. Cannon of the period enjoyed range superiority over the musket of approximately six to one. Artillery needed an unobstructed field of fire to be tactically effective, and cannon was routinely fired "over the sights" with a flat trajectory. For that reason batteries had to deployed adjacent to other units, or on higher ground behind the troops.

The only significant development was in ammunition. Colonel Shrapnell, a British

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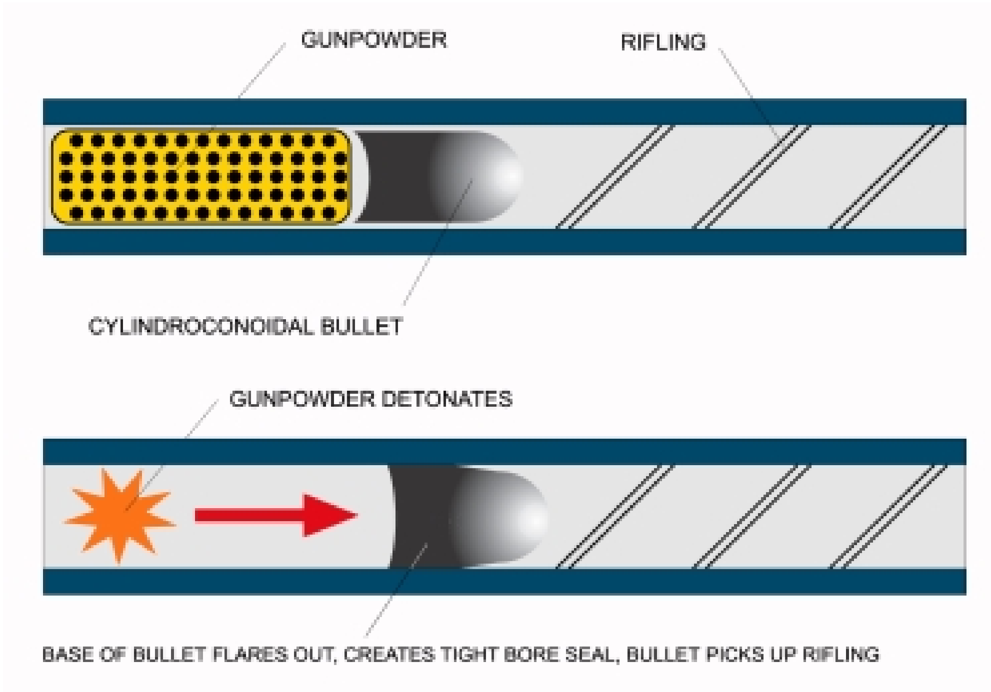

Illustration 1.2
Basic operation of the Minié bullet for muzzle-loading rifles.

artillery officer, had perfected a fused hollow shell[4] containing gunpowder and musket balls, officially designated as spherical case shot. As the shell was fired, the fuse was lit, and ideally the shell would explode over the heads of enemy troops, showering them with a lethal rain of musket balls and metal fragments. A shell was usually fired from a howitzer, a short barreled smoothbore artillery piece designed to lob projectiles in a high arc. Shrapnell's shell, however, could be fired from a standard artillery gun as well. During the Napoleonic Wars, only the British army used the "shrapnell" shell.

[4] An explosive projectile fired from an artillery piece.

The improvements in small arms meant that by the middle of the nineteenth century, rifles equaled and in some cases surpassed the range of artillery. The casualty rate among artillery crews was notably higher during the American Civil War, and there was a significant reduction in casualties inflicted by artillery.[5] Clearly, artillery had to incorporate rifle technology or become obsolete.

Within a relatively brief period of time, cannon evolved into breech-loading rifled guns, regain-

[5] Of 144 000 recorded casualties, 108 000 were inflicted by rifle bullets and 13 000 by artillery projectiles. During the Napoleonic Wars, artillery had been responsible for approximately 50% of battlefield casualties.

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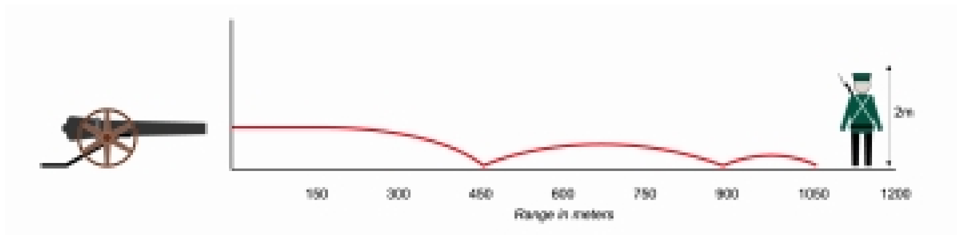

Illustration 1.3
Firing a 9 pound smoothbore cannon at 0º elevation: “over the sights”.

ing their tactical advantage over small arms. The advantage was increased with the invention of high explosives, which were quickly incorporated into artillery projectiles. By 1870, the Prussian army was equipped with breech-loading artillery using high explosive shells. They were designed to explode on impact, scattering hundreds of deadly metal fragments over a wide area.

However, artillery could not yet achieve the same rate of fire as infantry rifles. The recoil of artillery pieces was substantial; the gun was thrown back upon firing, and had to be manhandled back into firing position and retrained on its target. In 1896, the French perfected a hydraulic mechanism on the gun carriage that effectively absorbed recoil. There was no need to resight the gun and artillery could now maintain a rate of fire comparable to that of the rifle. The system was soon adopted by the armed forces of all major powers.

The Machine Gun

As the techniques for producing high quality steel and machining precision parts continued to improve, the technology needed to produce a gun with a mechanical firing system became available. An American, Dr. Richard J. Gatling designed the first practical machine gun. It was a manual device, with the gunner hand-cranking the mechanism that loaded each of the ten barrels and rotated them into firing position. In field tests the Gatling gun had an impressive rate of fire of three hundred rounds per minute, but the rate had a tendency to decrease as the gunner tired.

Gatling had used a multi-barrel design to prevent the overheating that would result from such a high rate of fire. This made the Gatling gun heavy and unwieldy, and it was necessary to mount it on a field gun carriage. In addition, the physical exertion required of the gunner made delivering consistent and accurate fire difficult.

In France and Sweden, similar efforts were being directed toward designing a manually operated rapid-fire weapon. In 1869, Montigny, a Belgian gunsmith and machinist, produced the multi-barreled *mitrailleuse* for the French Army. It too, was mounted on a gun carriage, making it cumbersome to manoeuvre and difficult to aim. Four years later, the Swedish engineer, Palmcrantz, patented the *Nordenfelt* gun. It was also a multi-barreled weapon that was manually operated, and

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shared the same awkward characteristics as the Gatling gun and *mitrailleuse*. In August of 1870, the French army graphically demonstrated the awesome power of their new weapon by gunning down five hundred horses in one and a half minutes.

Although these rapid-fire guns promised to dramatically increase the firepower of any force that possessed them, they were soon eclipsed by far more sophisticated and manageable weapons. The increasingly rapid rate of technological progress and innovation would soon render these weapons obsolete before they could be produced and employed in any significant numbers.

Two American inventors, Benjamin Hotchkiss and Hiram Maxim,[6] working independently, devised essentially the same mechanism. Both sought to harness the energy of the expanding gases that created recoil when a gun was fired (Newton's Third Law). The same energy could be employed to power the mechanism that would empty the breech of the expended cartridge, load a new cartridge into the breech, and drive the firing pin that detonated the cartridge. This would replace the physical force of the gunner, as with the Gatling gun, *mitrailleuse*, and *Nordenfelt,* with the chemical energy that created recoil. The result would be a small calibre weapon that continued to fire as long as the gunner depressed the trigger.

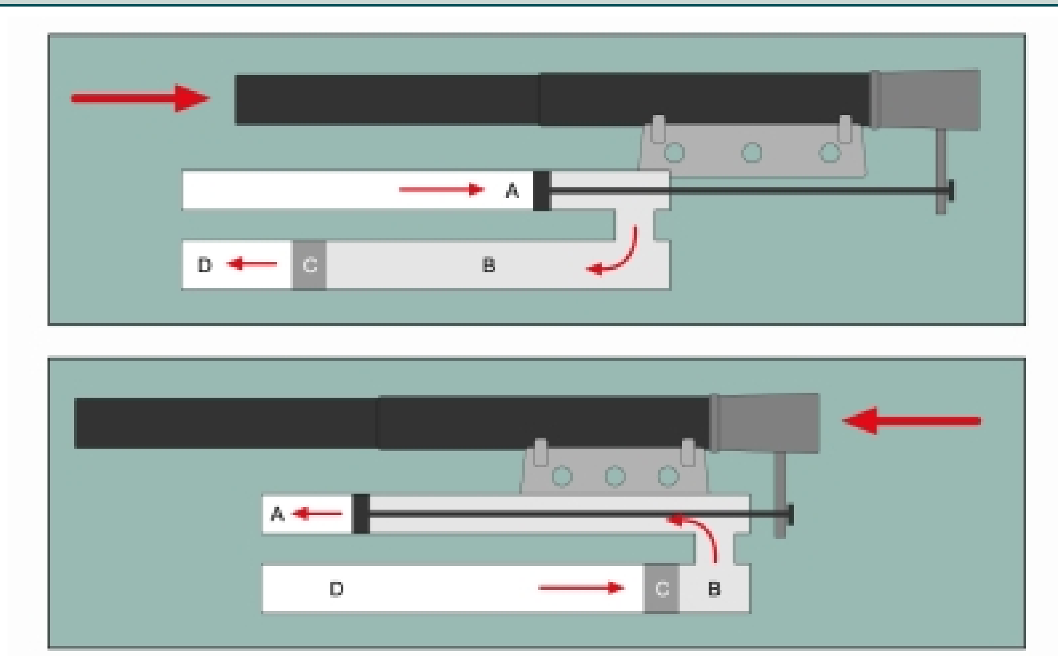

Illustration 1.4: Basic Recoil System
As the gun fires, the recoil drives the piston (A) back, forcing the hydraulic fluid (B) into the lower cylinder. The fluid pushes the lower piston (C) forward, compressing the air (D) in the lower cylinder. After the recoil has been absorbed, the compressed air (D) forces the hydraulic fluid (B) back up into the upper cylinder, driving the piston (A) forward and returning the gun to its original firing position.

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The resulting machine gun, with a rate of fire of six hundred rounds per minute, was truly an automatic weapon.

The two inventors handled the problem of overheating differently, however. Hotchkiss used a barrel with cooling rings to dissipate heat, while Maxim chose to encase the barrel in a water-filled cylinder. By abandoning multi-barrel construction, both Hotchkiss's and Maxim's guns were far lighter than their hand-cranked predecessors. This made them considerably more portable and manageable, eliminating the need for an unwieldy gun carriage. Machine guns could be easily carried and deployed by infantry.

Many of these new weapons were first employed in the mad scramble for colonies in Asia and Africa. The percussion cap proved its worth in the First Opium War. In 1841, two companies of British marines succeeded in rescuing a small group of Indian Sepoys[7] during a torrential rainstorm. One thousand Chinese troops, equipped with flintlock muskets, found their guns rendered useless in the deluge, while the Marines, armed with percussion cap muskets, annihilated them with impunity.

The Minié rifle was employed against the Bantu with devastating effect. Exploding artillery shells made their debut in Surinam. In Tanganyika in the early 1890's, a German officer and his assistant, with ample ammunition and a clear field of fire for their two machine guns, gunned down over a thousand native insurgents in a matter of minutes.

[6] Maxim would subsequently become a British subject, knighted for his service to the empire.

[7] Indian troops trained and commanded by British officers.

Perhaps the most stunning illustration of the incredible power of the new weapons was at the Battle of Omdurman in 1898 in the Sudan. Armed with rifles and supported by six Maxim guns, the British infantry slaughtered thousands of fanatical dervishes attacking in wave after wave. Many of the attackers were literally torn apart by the hail of bullets. One witness reported, "It was not a battle, but an execution."

Other Developments

As the century drew to a close, innovation and invention led to improvements to old weapons and variations on existing ones. Two are noteworthy. The grenade had traditionally been a hollow iron ball filled with gunpowder and detonated by a fuse that was lit before throwing. It had been almost as dangerous to the user as to the recipient. By 1900, it had evolved into a smaller sophisticated device, with a pin that held the trigger in place.

The pin was pulled and the trigger released as the grenade was thrown. A timed fuse detonated the grenade in three to five seconds. The steel jacket was designed to shatter into scores of deadly fragments, making the grenade a formidable weapon at close ranges. The trench mortar was a much smaller version of the artillery piece that bore the same name. It was a portable mortar, ideal for lobbing small explosive projectiles over obstacles in a high trajectory. The mortar round was similar in design and effect to the fragmentation grenade, but effective at much greater ranges. Both were added to an already extensive array of weapons available to infantry.

At the turn of the century, artillery and small arms had undergone qualitative changes. Both the range and rate of fire had been substantially

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increased. As the nineteenth century had progressed, another trend had become evident. The duration of battles gradually increased. Even the largest clashes of the Napoleonic era, Austerlitz, Friedland, Borodino and Leipzig (to name only a few), had been essentially one-day affairs. The Waterloo campaign, which lasted four days, was comprised of three separate battles: Ligny, Quatre Bras and Waterloo. By the end of the century, battles had become periods of sustained combat that lasted for days and eventually weeks. This tendency cannot be explained solely in terms of new weaponry. In fact, the increased lethality of weapons should have actually had the opposite effect. With the ability to inflict casualties at a significantly higher rate, a confrontation should have been resolved in relatively short order. Clearly, other developments outside the military arena must have occurred.

Developments in Civilian Technology

By the end of the eighteenth century, the major powers of Europe and the fledgling American republic were about to embark upon a period of mass industrialization and unprecedented technological progress. British textile factories had led the way in industrialization, followed closely by several innovations that increased the production of inexpensive high quality iron. The steam engine had been invented and utilized by Britain's established industries, and would soon have a great impact on transportation. Other European states soon followed Britain's lead.

Mass Production

It is somewhat surprising that the same technology was not applied to the manufacture of weapons. The long protracted wars that were waged against France in the early years of the nineteenth century must certainly have created a great demand for armament of all types. However, gunsmithing had remained a cottage industry. Governments handed out contracts to entrepreneurs, who in turn sub-contracted out to a number of individual gunsmiths in order to meet the government quotas.

Gunsmiths were highly skilled craftsmen. They were responsible for all the tasks associated with producing a gun, casting and boring of the barrel, machining the individual components of the flintlock firing mechanism; and carving, shaping and finishing the wooden stock (the origin of the expression "lock, stock and barrel"). There were sufficient gunsmiths scattered throughout the cities of the Western Europe to enable states to equip their armies, provided the armies did not increase in size.

It was in America that the mass production of small arms evolved. There existed a critical shortage of gunsmiths due in great part to Britain's policy of not allowing skilled tradesmen to emigrate to North America (prior to and after the American Revolution). Indeed, the British government took steps to prevent tradesmen from emigrating to any other state in an effort to preserve the economic ascendancy that British industrialization had created.

The young American republic was finding it difficult to produce sufficient weapons to arm itself, and the wars in Europe meant that there was no surplus of European-made muskets available for purchase. In 1798, Eli Whitney offered to produce ten thousand muskets in a

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relatively short period of time. Whitney was confident that the new methods he had devised would enable him to produce quality weapons quickly. Although gunsmiths were in short supply, other tradesmen, blacksmiths, machinists, locksmiths and carpenters, were not as scarce. Whitney reduced the process of gunsmithing into a series of smaller individual tasks; blacksmiths forged the barrels, machinists[8] and locksmiths crafted the firing mechanism, and carpenters made the stocks. At the end of the process, unskilled labourers assembled the components.

Eli Whitney had developed the two key elements of mass production, division of labour and interchangeability of parts. There was another significant advantage to Whitney's system. Different components of a musket wore down at different rates, with the firing mechanism usually the first to go. Prior to mass production, it was necessary to return the musket to the original gunsmith for repairs, or as was the more common practice, replace the entire gun. Now it was possible to stockpile those components that wore out most frequently, and it was a simple matter to replace them.

The manufacturing of weapons in Europe lagged far behind. It took Prussia twenty-six years to re-equip its three hundred thousand-man army with the Dreyse breech-loader. In Britain, the conversion of muskets from the flintlock to the percussion cap mechanism took almost ten years. By mid-century, little had changed in the arms industry. But the advent of the rifle, the development of Minié bullets and the complex breech-loaders required precisely made parts, parts which traditional gunsmiths found very difficult and time-consuming to duplicate.

In America between 1820 and 1850, mass production techniques had continued to improve. A capital-intensive system had evolved, producing automatic and semi-automatic milling machines designed specifically to manufacture weapon components. At the Great Exhibition in London in 1851, Samuel Colt disassembled a number of Colt revolvers, mixed up the parts and reassembled the gun from parts randomly chosen. The reassembled revolver operated perfectly.

By 1859, the British had imported and installed American milling machines for mass production of small arms, and by 1870 all major powers had made similar purchases of American manufacturing equipment. European factories could now produce weapons and ammunition in huge numbers. Within a relatively brief period of time, mass production techniques had also been applied to artillery and naval armaments.

Concurrently, a new process of steel production was becoming widespread. Sir Charles Bessemer had invented an economical method of turning pig iron directly into high quality steel. His steel works in Sheffield specialized in producing steel for guns and rails. With this process high quality steel was far easier and less expensive to produce. It was able to withstand the pressure and stress created by the new weapons. Bessemer had done for the steel industry what Darby, Cort and

[8] Machining had made great advances in America. Sam Slater, a British machinist, had emigrated from Britain disguised as an agricultural labourer. With Orziel Wilkinson, he pioneered the fabrication of machine parts. Wilkinson's son David continued Slater's work, inventing the sliding rest lathe and perfecting the process for producing precise machine parts.

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Wilkinson had done for the iron industry in the previous century.

Transportation and Communication

Railways and Telegraphy

The steam engine had a profound impact on the transportation industry. George Stephenson harnessed the energy of the steam engine to power the first steam locomotive, and before long railways were being constructed in all industrialized states. Railways could transport large amounts of goods and people over vast distances with speed and efficiency. Given the sheer immensity of the United States compared to western European nations, American railway construction had led the way; the railway was essential to its economy, transporting raw materials to the industrialized eastern cities and manufactured goods to the hinterland. It was obvious to the military establishment that railways could also be used to transport troops and *matériel*. It was possible to deploy much larger forces and keep them supplied. With railways maintaining a steady stream of men and armaments, battles increased in duration in spite of the growing rate of casualties that the new weapons inflicted. Railways played a major role in the American Civil War, and an even more prominent one in the Franco-Prussian War.

Another development that was closely tied to the expansion of railways was the telegraph. The effective management of complex railway systems, with an intricate network of tracks and several trains operating simultaneously, required a reliable and rapid means of communication. The challenging task of railway management could not have been accomplished without the telegraph, and wires were strung out along every major railway line.

The telegraph also had major implications for military commanders. The simultaneous transmission of information created the possibility for senior officers to issue orders, receive reports, and gather intelligence over great distances. During the Napoleonic wars, a general's command had not extended far past his field of vision. The only technical aid was a small telescope. His means of communication with individual units was mounted staff officers, who galloped off with written, and in many instances, verbal orders. The commander based his decisions upon what his eyes and ears told him.[9] This method of command continued and was still the predominant practice during the Crimean War.

By the turn of the century, other more sophisticated means of communication had been developed. The "wireless" radio and telephone made possible communication over distance on land and at sea. It was to be during the American Civil War that the impact of railways and telegraphs together on the conduct of war would be first convincingly demonstrated.

Steamships

The steam engine would also revolutionize the ship building industry. The development of steam-powered ships progressed rapidly after Robert Fulton's steamboat had first traveled up

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[9] At the Battle of Salamanca, Wellington had decided that a bold move against the French right flank could proceed because the French had not moved against his left flank. From that part of the battlefield he heard only the occasional "popping" of skirmishing muskets, not "the crashing volleys" of line regiments, which would have indicated a major assault by the enemy.

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Window on War: Fuentes de Oñoro - 1811

The powerful voice of our Marshall rang out. "*L'Empereur récompensera celui qui s'avancera!*" Slowly, with determined purpose, our column marched forward toward the British lines.

Our foe had chosen his position well. The rolling terrain had afforded the enemy a measure of protection from our artillery bombardment, and he was as yet invisible to us as we advanced. As we crested the last rise, we could see for the first time the object of our attack.

The British troops stood quietly, and from their steadiness appeared to be a long red wall. As we got nearer, our soldiers began to shout "*Vive L'Empereur! En avant, à la bayonette!*" The column swept forward, now on the double. Some fired shots as we advanced. Although we were now only two hundred yards distant, the British line remained silent and still, with ordered arms, appearing to ignore the storm about to break.

In our minds we all thought that the enemy was a long time in firing, and that this fire held for so long, would be very unpleasant when it did come. Our spirit began to cool, and we hesitated, desperate now to close with the enemy. When we had advanced to within forty paces, the British shouldered arms and leveled their muskets. An indescribable feeling rooted many of our soldiers to the spot; the British opened fire.

Their steady concentrated volleys swept our column. Decimated, we staggered and turned, seeking to recover our balance. Three deafening cheers broke the silence of our opponents. At the third they swept forward through the acrid smoke, and their bayonets pushed our disorganized flight.

-based upon the account of Marshall Bugeaud

the Hudson river in 1807. Just thirty years later, the paddle wheeler *Sirius* became the first steamship to cross the Atlantic, and, in 1843, the screw propeller has been perfected. This allowed the steam engine that powered it to be located deep in the hull, giving propeller-driven steamships a much lower centre of gravity and making them more stable and seaworthy than the earlier paddle-wheelers. This innovation would also make the steamship a more suitable vessel for military use. Paddle wheelers had both the engine and paddles exposed amidships, while the machinery of propeller-driven vessels was located safely below the waterline.

The steamships had several advantages over sail-driven vessels. They were no longer subject to the variable conditions of wind and weather. With sailing vessels, voyages to and from ports were unpredictable at best. Sailing with prevailing winds to a destination was considerably shorter than the return trip, which would involve tacking, a lengthy process. A voyage from a North American port to Europe involved much less time than one from Europe to North America because of the prevailing westerly winds. Steam-powered ships were liberated from the limitations that nature imposed on sailing ships. However, the freedom that steam technology gave ships did not come without a price. Steamships depended upon coal for fuel and fresh water for the boilers. This meant that stations had to be

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established along major shipping lanes where ships could replenish their supply of coal and water. In addition, the more demanding technical needs of steam technology would require additional facilities for the maintenance and repair of steam engines at coaling stations. Sailing ships, while more subject to the whims of nature and occasionally becalmed, never ran out of fuel.

The Internal Combustion Engine

In 1876, Nicklaus A. Otto built the first practical internal combustion engine. Unlike the steam engine, combustion took place within the engine, and it generated more consistent power. Otto had used gasoline as fuel, a by-product of kerosene distillation[10] that was generally burned off because of its extreme volatility. Otto chose gasoline as his fuel for that reason. All that was required for ignition was a tiny electrical spark.

The first internal combustion engines did have some problems, the most notable being a supply of a reliable gasoline-air mixture that would ensure consistent combustion. Gottlieb Daimler, who invented the carburetor in 1885, solved the problem. The carburetor made it possible for Carl Benz to build the first practical automobile a year later.

In 1892, innovation produced a more powerful but heavier engine. Rudolf Diesel's engine relied on air compression and the resultant rise in temperature to ignite a heavy fuel oil sprayed into the cylinder. The diesel engine had several advantages over the gasoline powered engine. The fuel oil was far less volatile than gasoline, and there was no risk of explosive combustion. The engine also produced a high compression ratio and considerably more power. The size and weight of the engine, however, made it less than ideal for powering small vehicles.

The internal combustion engine would power the revolutionary new weapons that appeared early in the twentieth century: submarines, aircraft and tanks. At the same time, vehicles and craft that used internal combustion engines would also be dependent upon a complex network of facilities to supply and maintain them.

Advancements in Naval Technology

The Evolution of the Dreadnought

At the beginning of the nineteenth century, war at sea was dominated by ships-of-the-line, large wooden vessels outfitted with intricate sails and rigging and brandishing three decks of cannon. It would be irrational to assume that the rapid advances in civilian and military technology would not have a momentous effect upon the conduct of naval warfare. However, not all innovations in weaponry would prove immediately practical for combat on the high seas.

While the perfection of the basic explosive artillery shell by Colonel Shrapnell promised to be devastating to a ship's rigging and deck crews, the realities of naval gunnery precluded its adoption. Shells were delivered on a high trajectory, which required not only precise calculations but also a stable firing platform. The constant motion of a ship's deck while sailing, which became even more pronounced

[10] A Canadian geologist, Abraham Gesner, had developed the distillation of kerosene from crude oil in 1854.

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once the ship opened fire as it absorbed the recoil of several cannon firing in unison, made the use of shells virtually impossible.

In 1824, Henri Paixhans developed a horizontal trajectory shell gun. It could deliver explosive shells on a flat trajectory, which made it immediately applicable for use at sea. The period of relative peace after the Congress of Vienna presented no opportunities for Paixhans' gun to prove itself. It was not until the Crimean War that it would be able to demonstrate its capabilities, and in that time the technology of shells had advanced considerably.

On 30 November 1853, a squadron of ten Turkish ships sailed into the Bay of Sinope with the intention of bombarding the Russian's coastal defences. Russian ships equipped with Paixhans guns confronted them. Within a matter of minutes nine of the Turkish ships had been reduced to flaming, splintered hulks and four thousand Turkish sailors had perished. The significance of the event was not lost on the navies of Europe. The great wooden ships-of-the-line were an endangered species.

The obvious solution was armour plate. Explosive shells could wreak havoc with wooden vessels, but would be ineffective against armour plate. The added protection would only have to extend to the waterline, considering the flat trajectory of the shell-firing gun. The first "ironclads" were essentially transitional, main-

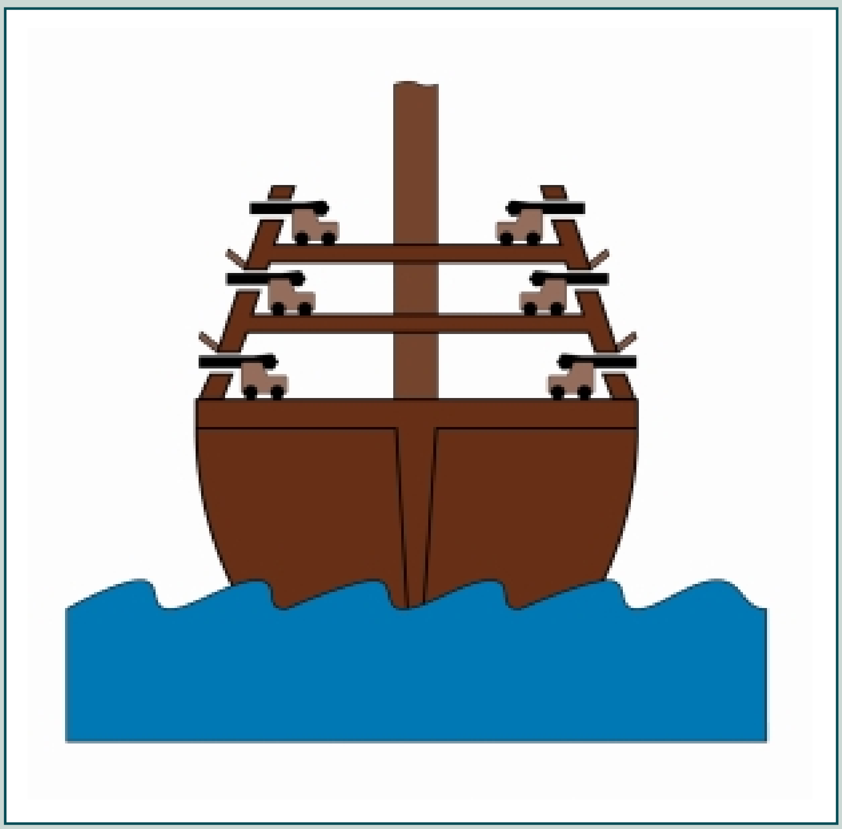

Illustration 1.5:
Cannon deployment on a First Rate ship-of-the-line.

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taining the rigging of the earlier warships and the placement of guns broadside.

The invention of the propeller had made steam engines a practical alternative for powering warships for three reasons. The engine and propulsion system were located in the relative safety of the hull below the waterline. Deck space was not taken up with the considerable bulk of a steam engine, and the paddle wheels were eliminated (previously located amidships and reducing the number of broadside guns).

The first clash of "ironclads" occurred in the American Civil War. The Confederate ship *Virginia* (converted from a captured Union steam frigate, *Merrimac*) had attacked a squadron of conventional warships, sinking two and scattering the rest. It was challenged by the *Monitor*, which carried cannon in a centrally mounted turret.

The two ships pounded each other relentlessly, but the armour plate could not be penetrated by the solid round shot of their smoothbore guns. While neither side could claim victory, the *Monitor* had at least prevented the *Virginia* from doing any more damage.

The invulnerability of armour plate to conventional solid round shot created a problem that was eventually solved through trial and error. The first attempt was to fire round shot from rifled guns, in the hopes that the increased velocity of the shot would effect penetration. It was discovered that while the velocity of the shot was substantially increased, the spinning of the cannonball caused it merely to glance off the armour plate at wildly unpredictable angles, and the target was left unscathed.

The eventual solution was twofold. The shape of the projectile was altered, and closely resembled the cylindroconoidal bullets used by small arms. In order for the shot to penetrate armour plate, it had to be made from very hard steel. Sir William Palliser had managed to produce an extremely hard steel projectile through a process of rapid cooling. In tests conducted in the summer of 1872, his armour-piercing shell fired from a rifled gun completely penetrated an iron target 18.5 inches thick (47 cm) backed by one foot (30.5 cm) of solid teak, far heavier than the armour carried by any of the contemporary ironclads.

The result was a technological race between armour and firepower. The answer to armour piercing shells was thicker armour. Since the velocity and composition of the armour-piercing shell had been maximized, penetration could only be improved by increasing the weight of the projectile, requiring larger guns. And so it went. Thicker armour was countered with bigger guns. Bigger guns demanded even thicker armour.

The comparatively rapid shift to "big guns" also called for radical change in the design of warships. Guns had become too large to be mounted broadside, yet mounting them fore and aft meant a greatly reduced radius of fire. The answer was the rotating turret. It could traverse the guns up to 270 degrees, the only obstacle being the superstructure. Although the number of guns carried by a ship had been dramatically reduced, the range and hitting power had not. The steam-powered ironclad battleship could hurl 885 kg. shells up to a range of 20 km.

The British *Dreadnought* (meaning "to fear nothing") was the ultimate naval weapon of its day. Larger than any previous battleship, the *Dreadnought* sported immensely thick armour and huge guns. It represented the most intensive application of technology, from the huge

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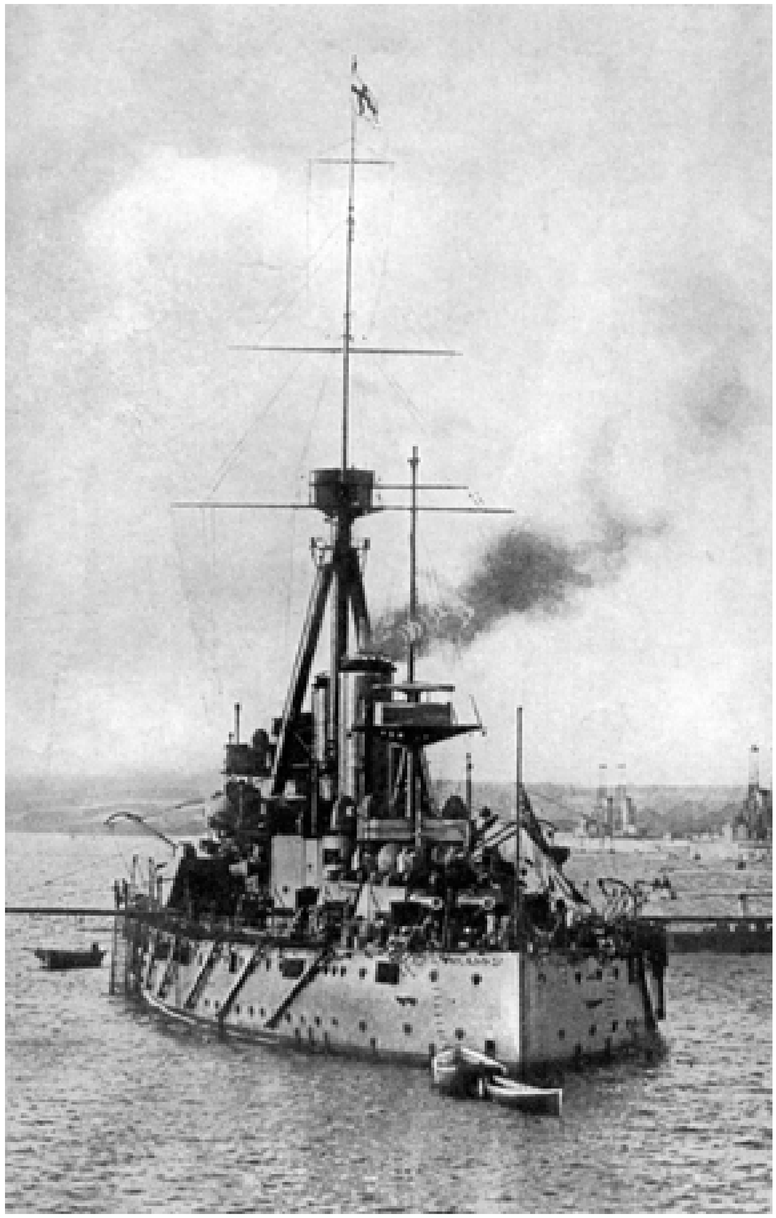

Times, *The Times History of the War*, vol. 1 (London: The Times, n.d.).
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Dreadnought
Heavily armoured and mounting ten 12 inch guns, the *Dreadnought* was capable of steaming at 21 knots.

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steam turbines and massive propellers to the intricate mechanisms of electrically powered turrets. All this in addition to the impressive sophistication of its weaponry and the metallurgic marvel of its armour. However intimidating the Dreadnoughts (as all ships that utilized its design were called) may have been, other developments had already occurred that would seriously challenge their supremacy on the high seas.

The Torpedo

The concept of the torpedo was first proposed in 1864. While several technical uncertainties had to be dealt with, by 1868, the torpedo had been refined to the point where it was a reliable weapon. The torpedo was powered by a compressed air turbine, and carried an explosive charge that detonated on impact. It required very little in the way of supporting ordnance. Lightweight launching tubes were all that was required, and these could be mounted on a small craft.

Torpedo boats made their first combat appearance in the Russo-Turkish war of 1877, and performed well enough to attract the notice of the major naval powers. It was quickly realized that these small agile vessels could easily avoid the fire of big guns, and had the capability of seriously damaging or even sinking a battleship. The threat was further enhanced by the fact that the torpedo hit larger ships in the area where they were most vulnerable, below the water line. The assumption had always been that battleships would be engaging other battleships, and consequently heavily armoured protection ended just below the water line.

To counter this threat, the destroyer was created. This ship was certainly much larger than a torpedo boat, but had sufficient speed to deal with it. Destroyers carried smaller calibre guns with a rate of fire that would be able to neutralize the advantages that speed and manoeuverability gave the smaller craft.

Submarines

A more stealthy method of delivering torpedoes was about to appear on the naval scene. The submarine was not a new idea. Evidence suggests that Leonardo Da Vinci had designed the first submarine, but did not make his idea public for fear it would be used for nefarious purposes. Some dubious attempts had been made to construct and employ it, but the technology required for an effective submersible warship had not existed.

By the 1870's, the technology did exist. An American, George Brayton, had invented a primitive gasoline-powered engine two years before Nicklaus Otto. Otto's engine was eventually proven to be the superior one, but not before John Holland had used Brayton's engine to build a workable submarine. Between 1878 and 1888, Holland built four submarines with an internal combustion engine-plus-electric battery propulsion system. The gas-powered engines provided power as the submarine cruised on the surface while it charged the batteries that supplied the propulsive power when the submarine was submerged. Holland switched to the superior Otto engine, but there were still considerable problems with gasoline-powered submarines. There were several serious explosions on submarines due to the volatility of gasoline, and also problems with gas fumes being inhaled by crewmembers to dangerous levels.

The invention of the Diesel engine provided the solution. The heavy oil fuel had none of the shortcomings associated with gasoline

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engines. It was far less volatile and diesel engines generated considerably more power. By 1908, the British admiralty had introduced the first diesel-powered submarine. From that time onwards, all British submarines were diesel powered, and the other major powers followed Britain's lead.

The torpedo was the natural armament for the submarine. Submarines carried launching tubes fore and aft. Although their envisioned use was limited to coastal patrol and defence, they were an inexpensive counter to the dreadnought.

The arsenal of the major powers' navies had expanded substantially with a variety of other weapons, such as the mine, while others had been relegated to a secondary role by the appearance of the dreadnought. Cruisers of all types, which represented the transition from unarmoured battleships to dreadnoughts, were prime examples. It was thought that light cruisers, armoured cruisers and battle cruisers could still be tactically effective working in concert with dreadnoughts. These ships represented a considerable investment of time and capital, and navies were reluctant to part with them.

The Impact of Technology

The military institutions of the major powers did not accurately foresee the effect of technological progress on the conduct of war. Carl von Clauswitz, perhaps the most influential military theorist of the nineteenth century, had died in 1831, before the major advances in military technology and mass production had occurred. Clauswitz's ideas were based upon intensive studies of Napoleonic warfare and his own experiences during the Napoleonic Wars. In his work *On War*, Clauswitz worked from the premise that the destruction of an opponent's army effectively eliminated his ability to wage war. War must be waged aggressively, and casualties accepted as an unpleasant but necessary consequence.

> “*He who uses force unsparingly, without reference to the bloodshed involved, must obtain a superiority if his adversary uses less vigour in its application... To introduce into a philosophy of war a principle of moderation would be an absurdity... War is an act of violence pushed to its utmost bounds; as one side dictates the law to the other, there arises a sort of reciprocal action, which logically must lead to an extreme.*”[11]

The intensity of the attacker must be met inevitably with the same intensity by the defender. Victory will go to the one who can apply the maximum concentration of military force most energetically.

As the nineteenth century progressed, the ability of a nation to wage war would depend more and more upon its industrial capacity. Military losses could be more easily sustained. Armies could be raised, equipped and transported within a relatively short period of time. One decisive operation was no longer sufficient to ensure victory.

In the area of naval strategy, Alfred Thayer Mahan's *The Influence of Sea Power upon History: 1660-1783* was certainly the most widely read work by naval officers in the late nine-

[11] von Clauswitz, Carl *On War*, translation. Col. J.J. Graham, Pelican Books Canada Ltd. Markham Ont. 1968, 1971, 1974 pp.102-103.

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Window on War: Manassas - 1862

We were told that the Yankees were massing for an assault on our position, and that the future of the Confederacy was in our hands. Our commanders had ordered us to take up a position along a steep railway embankment, and we were all grateful for the protection that it gave us from Union fire if and when it did come.

Some of the new Virginian conscripts, no more than boys in some instances, were wide-eyed with apprehension and excitement. One of them stood up to get a better view of the Union troops, a mile distant. The clear morning air carried the noise of the rattling and scraping of steel upon steel from the enemy lines, the unmistakable sound of bayonets being fixed. Some of us could see the glint of the morning sun on the cold steel.

“Lord save us!” the young Virginian cried out. For most of us, a bullet meant a quick and merciful end; far preferable to the slow, agonizing death that a bayonet brought.

“Don’t you worry none,” said the voice of our grizzled staff sergeant, “them Yankees won’t never get close enough to use ‘em.” The young soldier looked at him with serious doubt on his face, not at all reassured by the sergeant’s comment.

Across the broad expanse of the meadow, we heard the Union bugles sound. As our attention turned in that direction, we could see the regimental colours advancing, and a mass of blue began to slowly move toward us. When they had closed to half a mile, the order was given to open fire.

The Union troops were cruelly exposed as they tried to charge through the hail of bullets we delivered. Many of them simply fell and lay still, others flailed wildly at the air before collapsing. We just kept ramming powder and ball down the rifle barrel, cocking the hammer and firing. Some of the more seasoned men worked in pairs, one soldier firing his rifle, then the other, while his partner reloaded each gun as it was handed back to him.

The Yankees continued to charge our position, but most were cut down. None of their infantry ever got to the embankment, save for one mounted officer. He waved his sword in impotent fury, and cursed and raged at us for a few moments before he was riddled with bullets.

Although the numbers had been greatly in favour of the Union, our regiments had beaten them back with very little trouble. When the smoke cleared and the action had subsided, the meadow was carpeted with blue-clad dead. We had sustained hardly any casualties thanks to our protected position, but we had used almost all our ammunition.

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teenth century. Mahan based his theories upon a study of the Royal Navy during the wars of the seventeenth and eighteenth centuries. History had consistently shown that combat between massed battle fleets was the only way naval supremacy could be achieved, and naval supremacy was necessary to apply the blockade as an effective strategy. For Mahan, the ironclad battleship was the new ship-of-the-line. Naval supremacy could only be achieved with a large fleet of battleships. While technology had significantly improved the combat capabilities of ships, basic naval strategy had not changed. This ignored the technical realities, but Mahan's ideas were reassuring to the naval establishment, who viewed the advance of technology with unease. Mahan's theories allayed their fears, and were instrumental in precipitating the naval arms race between major powers that eventually produced the dreadnought.

There were indications that technological progress would have a profound effect upon the nature of war, but these were for the most part ignored. Most military establishments had assumed that the new weaponry would greatly increase the offensive capabilities of their armies. It seems almost incomprehensible that it didn't occur to them that the same weapons would increase an army's defensive capabilities as well. There were ample warning signs but they went unnoticed.

The American Civil War

While many new weapons were introduced during the Civil War, their numbers were too small to have an appreciable effect. The war was waged with muzzle-loading rifles and smoothbore cannon. Although the rifle represented the only improvement in weaponry that was universally used in the war, the results were alarming. More American soldiers died in the Civil War than in both World Wars, Korea and Vietnam combined.

The Union and Confederate armies entered the war with tactical methods that had not changed since the time of Napoleon. Large masses of troops were employed in attacks, and men deployed in lines delivered fire. In the era of muskets, attacking troops might expect to receive two rounds of fire before reaching the enemy position. Rifles however, had a much greater range and were far more accurate. Attackers came under fire while still a kilometre from the enemy, and would be subjected to at least ten rounds of aimed fire during an advance. The result was carnage. At the battle of the Second Manassas in 1862, eighteen thousand Confederate soldiers deployed along a protective railway embankment bloodily repulsed fifty thousand Union troops.

Another trend was becoming evident. Whenever soldiers arrived at a new position, they began to dig in, minimizing their vulnerability to fire. By 1865, field works had grown extensively, complete with dugouts, connecting trenches and barbed wire entanglements. It was also clear that rifle-armed troops with protective cover could repel the attacks of much larger numbers of men. The defence had gained a significant tactical advantage over the offence.

Railways played a crucial role in the war. The extensive network allowed for the rapid movement of troops and equipment and a steady supply of men and material. The Union had a decided edge over the Confederacy in that respect. The North was more populous than the South and it was also more heavily industrialized. Its railways extended that advantage.

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The telegraph had made it possible to command and control the increasingly large armies that could be conscripted. It was instrumental for gathering intelligence at a central command centre, issuing orders and coordinating the movement of armies over large areas.

Observers in Europe tended to dismiss what had happened in the American Civil War. They concluded that the events in the United States were a result of conditions peculiar to the American theatre of operations. There was also little awareness of how important a role economic factors were beginning to play. Unfortunately, the next major conflict in Europe would do little to alter this perception.

The Franco-Prussian War

The last war of German unification did much to maintain the illusion that accepted offensive doctrines were sound. On paper, the French Army was formidable. It outnumbered the Prussian army and was well equipped by contemporary standards. Yet the Prussians won a resounding victory in just five months, in stark contrast to the protracted struggle in America. German unity had indeed been forged with "Blood and Iron."

The spectacular triumph of Prussia could not be explained solely in terms of weapon superiority. The Dreyse breech-loader was inferior in range and accuracy to the French *Chassepot* rifle, and the Prussians had no weapon comparable to the *mitrailleuse*. However, Prussian artillery was more technically advanced. Their Krupp breech-loading artillery certainly outperformed the smoothbore muzzle-loaders of the French, but this disparity alone could not explain the magnitude of the Prussian success. The victory was due to the superior use of technology, specifically the utilization of railways and telegraphy.

The Prussian Army had deployed 500 000 troops on the French frontier in a mere eighteen days. This impressive feat required excellent planning. While regular army units had already begun to move to the forward areas, thousands of reservists were called up. They were formed into regiments and issued arms and equipment. The units were then transported by rail to assembly points to join their divisions. Divisions were combined to form corps. The process was carried out with relentless precision. The utilization of the railways by the Prussians was so well executed that the war was virtually decided before the first shot was fired. The Prussian army was able to win decisive victories at Sedan and Metz before the French Army had been fully mobilized.

The French actually possessed a more extensive railway network and had had a decided numerical advantage in locomotives and railway cars, yet they had no detailed plans for incorporating the use of the civilian railroad system for military mobilization.

There were other factors. The *mitrailleuse* was deployed in massed batteries like cannon, and made excellent targets for the Prussian artillery. French rifles had greater range and accuracy than the Prussian ones, but the Prussian commanders had merely held their infantry out of range and let the high explosive artillery shells blow the French infantry to pieces.

In other nations, the war had been observed with keen interest. Two things had become abundantly clear. Artillery had regained its ascendancy on the battlefield, and the fast and efficient mobilization of armies had been

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decisive. The Franco-Prussian war had not lasted long enough for the devastating power of modern weapons to become fully evident. The superiority of the offensive doctrines had been confirmed. Military professionals continued to stress the words morale, resolution, *élan* and *ésprit de corps* as if courage and determination could overcome bullets.

Almost immediately, every major power formulated plans for mobilization against potential enemies. Logically, mobilization would be most effective if it began before hostilities commenced. It was no surprise that the high commands of the major powers all arrived at this same conclusion. Once the possibility of war had been averted, the state could de-mobilize. But to de-mobilize prematurely may have disastrous consequences, and with the mutual distrust that would exist between potential enemies, the process would become a deadly variation of the pre-adolescent process "I'll let go if you let go." Obviously, mobilization would be regarded as an unofficial declaration of war, and the events in the summer of 1914 would illustrate this all too well.

In 1897, a Warsaw banker first published *The War of the Future in Its Technical, Economic and Political Relations* in Russian.[12] In this impressive work, I.S. Bloch predicted the nature of the next war with startling accuracy.

> "*At first there will be increased slaughter – increased slaughter on so terrible a scale as to render it impossible to get troops to push battle to a decisive issue. They will try thinking that they are fighting under the old conditions, and they will learn such a lesson that they will abandon the attempt forever... everyone will be entrenched in the next war.*"

Bloch, a committed pacifist, was not taken seriously by military professionals. They were not receptive to ideas that contradicted their own theories about how wars should be fought. Bloch had neither preconceived notions about warfare nor a vested interest in maintaining the prevalent offensive doctrines. It was most likely his detachment from the military world that allowed him to correctly assess the profound impact that technological progress would have on war.

> "*War has become more and more a matter of mechanical arrangement. Modern battles will be decided, so far as they can be decided at all, by men lying in improvised ditches they have scooped out to protect themselves from a distant and invisible enemy... War... will become a kind of stalemate, in which neither army will be able to get at the other.*"

While Bloch's accurate predictions were to be ignored, there was one more confrontation, which would indicate the probable nature of the next war.

The Russo-Japanese War

In 1905, Russian and Japanese imperial ambitions collided as they both sought to extend their influence in North-East Asia. Imperial Russia wanted an ice-free port on the Pacific, and the newly industrialized Japanese state needed resources. The Germans had advised the Japanese in the creation of their modern army, and it should not be surprising that Japanese mobilization, requiring the efficient

12 Also published in translation under the titles *The Future of War* and *Is War Impossible?*

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Window on War: Prussian General Staff

The creation of the General Staff was one of the many reforms that were instituted after the French routed Prussian armies at Jena and Auerstädt in 1806. In 1810, the *Kriegsakademie* was founded in Berlin. Officers were provided with an extensive education in tactics, strategy, military technology and other disciplines. The best pupils were selected for training on the General Staff.

The Prussians recognized that waging war was becoming a complex process. Commanders could not be expected to deal effectively with the variety of tasks that were now associated with the conduct of military operations; troop transportation and deployment, establishing supply lines, gathering intelligence, coordinating the movement of army corps over an extended theatre of operations; in addition to the primary responsibility of battlefield command.

The officers of the General Staff were highly trained experts in their area. They were responsible for planning all the logistical elements of a military operation. Essentially, they ensured that commanders had all the necessary resources to wage a successful campaign.

The effectiveness of the Prussian General Staff was most evident in the 1870 Franco-Prussian War. The rapid mobilization of the Prussian army and reserves was due to the superb operational planning of the General Staff, and was a major factor in the defeat of France. Although other nations had staff officers to aid commanders, their training did not begin to approach that of the Prussian staff officers.

In the American Civil War, General Ulysses S. Grant, among others, still managed all the logistical requirements himself. His staff officers were little more than clerks. This was true in most other armies of the period. By the turn of the century however, most modern armies had adopted a system based upon the Prussian model.

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coordination of naval and army units, was rapid and effective.

The Japanese had turned to the British for their recognized expertise in naval affairs to establish a navy. Many Japanese ships had been built in British shipyards and their officers and crews trained by British instructors. The Anglo-Japanese alliance had been formed, and the Americans were sympathetic to the Japanese cause.

The war had begun with a surprise attack on Port Arthur by the Japanese navy, a tactic highly applauded by the British and Americans. (In 1941, the Americans were to have very different sentiments about Japanese surprise attacks.) The Japanese objective was to neutralize the Russian ships in the harbour, and render them ineffective.

The war had two distinct areas of operations. In the north, the military action was comparatively fluid, with the Japanese forces advancing on Harbin in a series of well-executed manoeuvres. Around Port Arthur it was a very different situation. The Russians had constructed a deep network of fortifications consisting of strong points connected by extensive trenches and screened with barbed wire entanglements. The Russian forces had a variety of weapons including Maxim machine guns and hand grenades, which would prove to be highly effective against the massed attacks of Japanese infantry.

The Japanese deployed German-made Krupp artillery in addition to eighteen of their own Osaka siege guns, capable of firing five hundred pound shells up to five and a half miles (nine kilometres). The effect of artillery bombardment was reduced by the Russian fieldworks and Japanese attacks on the Russian trenches met with dismal failure, incurring very heavy losses. General Maresuke Nogi launched three massive frontal assaults on the Russian positions, incurring ten thousand casualties on the last day alone.

A stalemate ensued, but Russian defeats further north meant that Port Arthur could expect no relief by land and must eventually fall. The Russian situation was made even more precarious because it depended upon a single railway line, the Trans-Siberian Railway, for reinforcements and supplies from European Russia. The railway extended for five thousand kilometres, and at Lake Baikal, there was no railway at all. In summer, shipments had to be unloaded, placed upon boats, transported across the lake, and loaded up again on waiting railway cars. In winter, horse-drawn sleds transported shipments.

In an effort to turn the tide, the Czar had dispatched the Baltic fleet to Port Arthur. The Russian battleships sailed halfway around the world, and arrived just in time to be blown out of the water by the Japanese Imperial Navy in the Tsushima straits.

The military professionals in the West again dismissed the carnage around Port Arthur. The fact that a small Asian nation had defeated a major European power elicited no concerns. The Japanese were seen as a courageous little nation with a gift for copying western technology and methods, but lacking creativity. The Russians had long been regarded as a nation with a great quantity of poor quality troops. Thus the war was regarded as a unique occurrence, a fight between a gifted amateur and a large but slow-witted opponent.

The naval operations however, were seen as a vindication of Mahan's theories and the su-

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premacy of the battleship. The fact that mines destroyed over 50% of the ships sunk in the conflict was conveniently ignored.

European perception was highly selective; taking notice only of those events that confirmed their own views. In 1914, the European nations were to pay a heavy price for disregarding the warning signs. Bloch's predictions would come true with a vengeance. ▪

Chapter Summary

By the turn of the century, all the elements necessary to wage mass warfare were in place. Conscription was a feature common to all nations with the exception of Britain. Advances in weapons technology had greatly increased the ability of armies to inflict casualties. Industrialization meant that armies numbering in the millions could be armed, equipped and supplied with huge stockpiles of arms and ammunition.

The development of extensive railways enabled nations to move armies and equipment in vast quantities, and maintain them with a steady flow of additional men, supplies and ammunition.[13] The steamship extended the economic capabilities of a nation, as resources needed to maintain industrial production could be transported from overseas. The telegraph, telephone and "wireless" radio gave military organizations the means to control and coordinate millions of troops deployed over great distances.

[13] Logistics: the art of moving, deploying, supplying and maintaining units in the course of military operations.

The potential existed for war to be conducted on a scale far greater than had been previously possible or even imagined. For the most part, few appreciated or understood how the very nature of war would be changed by the technological and industrial advances of the nineteenth century.

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Recalling Facts

Match each name with the correct description.

A. Alfred Thayer Mahan
B. Eli Whitney
C. Johann von Dreyse
D. John Holland
E. Alexander Forsythe
F. Sir Charles Bessemer
G. Henri Paixhans
H. Carl von Clauswitz
I. Richard Gatling
J. J.S. Bloch

1. invented the first practical submarine
2. wrote the treatise *On War*
3. developed the first practical shell gun for naval use
4. invented the breech-loading rifle
5. invented the percussion cap
6. pioneered the techniques for mass production
7. authored The Influence of Sea Power upon History: 1660-1783
8. accurately predicted the nature of mass warfare
9. revolutionized the process for manufacturing high quality steel
10. produced the first machine gun

Chapter Review

1. a. What were the basic weapons used up to and including the Napoleonic Wars?
b. What was Shrapnell's contribution to the improvement of artillery?

2. a. Why did the mass production of small arms appear first in the United States?
b. Describe the main features of Eli Whitney's production methods.
c. What were the advantages to Whitney's system?

3. a. What were the basic elements of Mahan's naval strategy?
b. How did his ideas contribute to the naval arms race?

4. a. How did the Franco-Prussian War reinforce the prevailing attitudes of the Western military establishments?
b. What were the main factors that led to a Prussian victory?

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Critical Thinking

"Battles now more than ever, are battles of men... Attack is always, even on the defensive, an evidence of resolution and gives moral ascendancy. Rifled cannon and accurate rifles do not change...tactics at all."

- Colonel Ardant du Picq

"Put a man in a hole, and put a good battery (of artillery) behind him, and he will beat off three times his numbers, even if he is not a very good soldier."

- Colonel Theodore Lyman

"Weapons, if the right ones can be found, constitute ninety percent of victory."

- J.F.C. Fuller

"Morale is to matériel as three is to one."

- Napoleon Bonaparte

Evaluating Opinions

Discuss the validity of the above statements in relation to the developments of military and civilian technology in the nineteenth century.

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