THE VICKERS-MAXIM MACHINE GUN

MARTIN PEGLER

WEAPON

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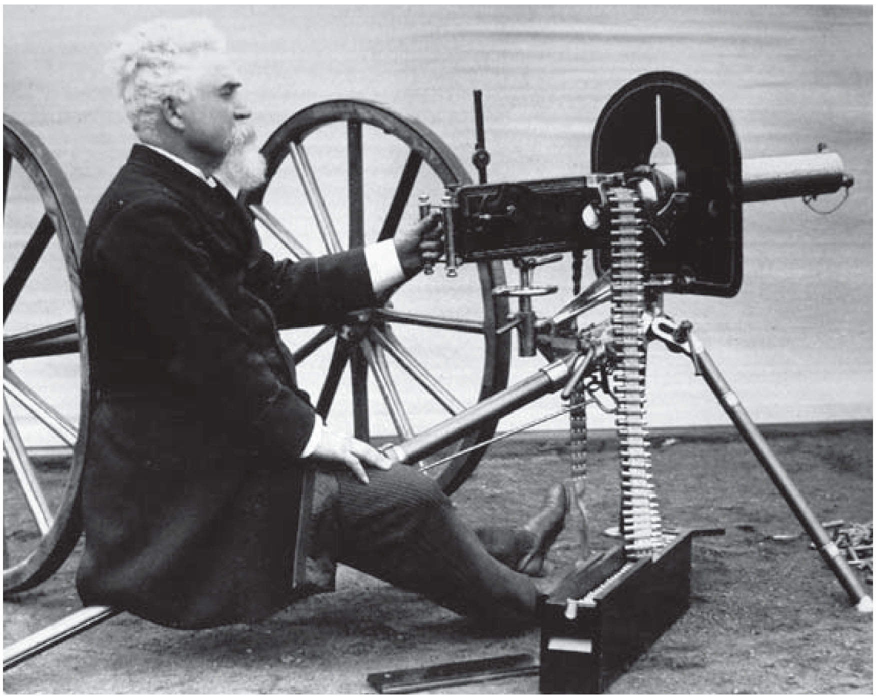

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INTRODUCTION

There are certain firearms that have achieved iconic status in modern society through various means: either as a result of press exposure as evinced by the Thompson submachine gun and its much-publicized criminal use in the 1920s, or through extensive use in cinema, where apparently the .45 Colt Single-Action and the Winchester rifle were the only guns ever carried by cowboys; most people today can recognize the Luger pistol as a result of film and TV exposure. Sometimes photographs of military subjects in newspapers and magazines make weapons familiar to the public – almost everyone nowadays recognizes an AK-47, for example. However, there is a secondary category of weapons made up of those that have never really achieved the public recognition that they perhaps deserve. These are the firearms that have done exactly what they were designed to do, without fuss or public acclaim, and in the process have probably been responsible for causing more casualties in warfare than all of the other groups combined.

At the top of this list must surely be the family of machine guns designed by an unknown American possessed of an unusual mechanical genius. Hiram Maxim was to perfect the fully automated machine gun just in time for its use in the greatest conflict yet seen in human history, World War I. This timing proved sadly coincidental, for the appearance of Maxim's gun was the culmination of years of hard work and experimentation to find a method by which a repeating firearm could be made to shoot continuously for as long as ammunition was available. It had long been the dream of firearms designers and manufacturers to create such a device, but they had inevitably been thwarted by technological limitations that always seemed to prevent the next step forwards. Maxim's good fortune was to live at a time when solutions to these mechanical conundrums were at last being found.

The hurdles to be overcome were many, for the earliest attempts in the 18th century to create a repeating gun were hampered by the need for

A Vickers engaging a German aircraft. Even for experienced gunners, this was mostly a waste of ammunition as deflection was almost impossible to estimate accurately using ordinary sights. Note that this gun has the Sangster emergency tripod fitted, to enable the gun to be used if the Mk IV tripod was unavailable. (IWM Q 5172)

powder and ball to be loaded into separate chambers and for each shot to be fired by a less-than-reliable flintlock ignition system. Until the invention in the 1820s of percussion ignition there was no more efficient method of igniting multiple chambers; but percussion finally enabled guns to be kept loaded and primed until they were ready to be fired. It revolutionized long arms and by the mid-19th century had resulted in the production of the modern revolver, by makers such as Adams, Colt and Remington.

In reality, the manufacture of such guns would probably not have been possible were it not for parallel improvements in other vital areas, notably the manufacturing process invented by Sir Henry Bessemer (1813–98) to improve the steels used for cannon production. By blowing oxygen through pig iron he created a high-carbon steel that was stronger and cheaper than anything hitherto produced. If outwardly this invention bears little relationship to the development of the modern machine gun, it must be remembered that all inventions are merely a series of incremental steps, often borrowing from unrelated technologies, each one moving the product up a level in a progress towards eventual perfection. Manufacturers of small arms seized on the process and as a result firearms became stronger, more efficient and cheaper to mass-produce.

Improvements in design and technology continued at an increased pace through the 19th century, each new idea fuelling another. By the early 1860s the simple percussion cap had been adapted to fit inside the base of a hollow brass-foil tube, which was then filled with powder and fitted with a lead bullet. This was the first use of primitive forms of centrefire ammunition and its introduction made possible the development of some of the earliest forms of machine guns. Aside from the mechanical

Zillebeke, in the Ypres Salient, early in 1915. A Mk I Vickers is being cleaned in what appears to be a quiet support trench behind the front lines. At this period, tactical use of the guns was mostly limited to providing immediate cover for the front-line trenches. (IWM Q 51194)

limitations of these early guns (most relied on manual operation, normally by means of a hand crank to operate the mechanism), all of them were hampered by the shortcomings of the available ammunition, to which at the time there seemed to be no ready solution.

The first problem was the impracticability of the brass-foil wrapping of the cartridges, which deformed easily, sprouted verdigris that cemented the brass inside the hot breech and – worst of all – had an unfortunate habit of allowing the extractor to pull off the riveted-on steel base of the cartridge, leaving the remains firmly jammed in the breech of the gun. The secondary problem was that of the propellant, black powder, which suffered from so many shortcomings that it is difficult to know where to begin. Among the more severe were the heavily corrosive residue left behind after firing that would render an uncleaned weapon rusted and useless after a couple of days, the pall of grey-white smoke (300 times the powder's own volume) that hung in the air after shooting, and the powder's ability to soak up moisture like blotting paper. To keep any form of firearm working required meticulous cleaning, and when used in an automatic weapon black powder quickly gummed up breeches, fouled barrels and caused mechanisms to seize.

The solution to the problem of the brass was to come as a by-product of a totally different technology, for its manufacture as a decorative and practical material had been known before the third millennium BC; indeed, in the 4th century BC Plato wrote of it as being as valuable as gold. It had been possible to manufacture sheet brass for centuries but the technology to form it into complex shapes, other than by hand-beating or casting, did not exist until the late 1800s when experiments into copper/zinc alloys produced a new formula that, allied to the introduction of new high-pressure casting machines, made it feasible to extrude or die-form a thick brass disc into the long tube shape required for cartridge brass.

At the same time a hitherto unknown French chemist, Paul Vielle (1854–1934), had been working on solving the perennial problems of black powder. When in 1884 he perfected a nitro-cellulose-based propellant that was impervious to moisture, produced almost no smoke and created three times the power for the same weight as gunpowder, it seemed like an answer to a prayer. Finally, automatic weapons could be designed that did not require the firer to regularly cease shooting to clean the mechanism; but the problem still remained of how to most efficiently design an automated firearm that took as much of the human element (aside from squeezing a trigger) out of the process as possible.

That it was to fall to Hiram Maxim to do this was as much of a surprise to him as anybody, for he had no background in firearms design. Indeed much of his early work was centred on electricity; but the history of technological improvement is littered with accidental geniuses such as Maxim. What he did was to create a machine that in its day was regarded as being almost as fearsome as nuclear weapons are today, a device which would prove so efficient at killing that Maxim forlornly hoped that it would 'serve to prevent wars' (Maxim 1915: 6). In fact, it was to prove the ultimate killing machine on the World War I battlefields of France and Flanders, causing an estimated 80 per cent of the casualties during the Somme battles of 1916 and ultimately resulting in a branch of weapons technology that would see service in every conceivable role – on land, sea and air – up to the present day. How this came about is the subject of this book.

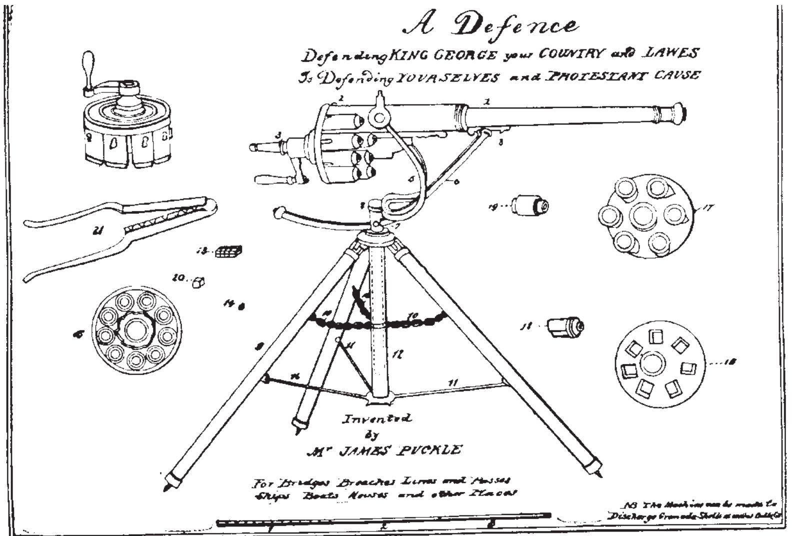
DEVELOPMENT

The search for the perfect mechanism

ORIGINS

In the 18th century, where linear warfare was still the method by which all wars were fought, the perceived need for an automatic gun was not perhaps as obscure as it may first appear. Speed of loading and firing was paramount on the battlefield and accuracy was relatively unimportant at the sub-100yd ranges at which battles generally occurred. The side that could hold its nerve, load and shoot the fastest generally won the day, by the simple virtue of putting more lead into the enemy than he was able to withstand. Any device that increased the ability of the common soldier to fire above three or four rounds per minute was certainly desirable and many firearms designers and manufacturers had tried and failed to create weapons capable of such a feat.

The first that history identifies was a Scot, William Drummond, who on 17 May 1626 was granted a patent for a machine that mounted 50 musket barrels fastened together like the spokes of a wheel '... in such a manner as to allow one man to take the place of a hundred musketeers in battle'. Sadly, it is not recorded whether this was ever manufactured – or, if it was, how efficient it proved to be – but shortly afterwards an inventor named Dudley Palmer presented to the Royal Society a paper outlining the theoretical possibility of using recoil and the force generated by the burning gas in a barrel to automatically load, fire and reload a weapon using a seven-barrelled gun designed by one Caspar Calthoss. Alas, this proposal was probably two centuries ahead of its time, for in the 17th century the technology was barely extant to bore a barrel straight, let alone make one so tightly fitting for its bullet that it would be possible to trap the propellant gas, most of which was visible as the wasted flame and



No. 1 The Barrel of the Gun
2 The Sett of Chambers Charg'd put on ready for Firing
3 The Screw upon which every Sett of Chambers play off and on
4 a Sett of Chambers ready charged to be Slip'd on when the first Sett are pull'd off to be recharg'd
5 The Crane to rise fall and Turn the Gun round
6 The Curb to Level and fix the Guns
7 The Screw to rise and fall it
8 The Screw to take out the Crane when the Gun with the Trepeid is to be folded up
9 The Trepied whereon it plays
10 The Chain to prevent the Trepieds extending too far out
11 The hooks to fix the Trepied and Unhook when the same is folded up In order to be carried with the Gun upon a Man's Shoulder
12 The Tube wherein the Pivot of the Crane turns
13 a Charge of Twenty Square Bullets
14 a single Bullet
15 The front of the Chambers of a Gun for a Boat
16 The plate of the Chambers of the Gun for a Ship shooting Square Bullets against Turks
17 For Round Bullets against Christians
18 a Single Square Chamber
19 a Single round Chamber
20 a single Bullet for a Boat
21 The Mould for Casting Single Bullets

Whereas our Soveraign Lord King George by his Letters patterts bearing date the Fifteenth day of May in the Fourth year of his Majesties Reign was Graciously pleas'd to Give & Grant unto me James Puckle of London Gent my Exors Admors & Assignes the sole priviledge & Authority to Make Exercise Work & use a Portable Gun or Machine (by me lately Invented called a Defence in that part of his Majesties Kingdom of Great Brittain call'd England his Dominion of Wales Town of Berwick upon Tweed and his Majesties Kingdom of Ireland in such manner & with such Materials as should be ascertain'd to be the sd New Invention by writing under my Hand & Seal and Inrolled in the High court of Chancery within Three Calendar Months from the date of the sd pattent as in & by his Majties Letters Pattents Relacon being thereunto had Doth & may amongst other things more fully & at large appear NOW I the said James Puckle Do hereby Declare that the Materials whereof the sd Machine is Made are Steel Iron & Brass and that the Trepied whereon it Stands is Wood & Iron And that in the above print (to which I hereby Refer) the said Gun or Machine by me Invented is Delineated & Described July the 25th 1718./

49:180

Ja: Puckle

A broadsheet for the patent of the Puckle gun, showing the square and round chambers. Aside from the obvious mechanical shortcomings of a flintlock machine gun, the basic outline is not dissimilar to that of a modern machine gun. (Royal Armouries)

smoke that were emitted during firing. While not technically feasible at the time, Palmer's ideas were important and the concept was certainly to re-surface in the future.

Work continued unabated towards realizing the dream of automatic fire and it is arguable that the laurels must go to James Puckle (1667–1724), London gentleman, inventor, lay-preacher and alchemist, for the production of the first workable machine gun. Today, Puckle would probably be considered a candidate for professional mental care because of his many bizarre beliefs, prominent among which was that separate firearms should be used against Christians and Muslim Turks, the latter of whom he reviled for no discernible reason. The result of this and his considerable mechanical ability, was the Puckle gun, patented on 25 July 1718, which was in effect a giant revolver mounted on a tripod, with a crank handle that rotated the seven-shot cylinder. It was flintlock-ignited but had the charming distinction of being supplied with two patterns of cylinders, one chambering round ball for use against Christians and the other firing square bullets for use against Turks.

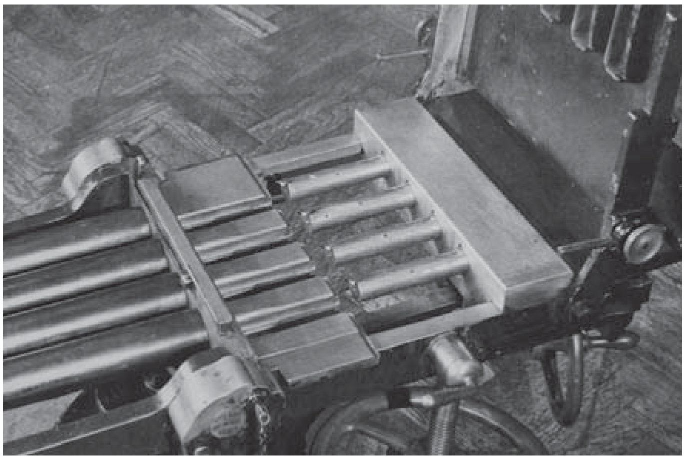
As can be imagined, there were a number of drawbacks to such a contrivance; the flintlock mechanism was self-cocking but notoriously unreliable, fouling of the pan and ignition hole was frequent, and the accuracy of firing square shot (each bullet was actually cast in four pieces, producing a shotgun-like effect) through a round barrel is hard to envisage. Although much derided, both at the time and subsequently (a satirist of the day commented that the only known casualties of Puckle's gun were those who owned shares in his company), Puckle's device was perhaps the first realistic attempt at making a working repeating firearm, albeit limited by the available technology of the time.

INTO THE 19th CENTURY: MONTIGNY TO GARDNER

Through the subsequent centuries, a few attempts were made to improve on the existing designs of machine-operated guns but there were few successes, although great strides were made in areas such as manufacturing technology, with improved steel quality, mechanization of production and the ability to mass-produce rifled barrels of uniformly high quality. In 1859 a Belgian, Joseph Montigny, produced a workable machine gun that had 37 barrels inside a round steel casing; this weapon used a pre-loaded breech-block chambering 11mm brass-foil needle-fire cartridges. Unfortunately all the barrels fired simultaneously, limiting its efficiency, although later models fired in staggered sequence. It could shoot at a theoretical 250rpm (rounds per minute) but, mounted on a huge wheeled carriage, it weighed some 2,000lb and was unwieldy in the extreme. Still, while not entirely practical, it certainly indicated the way forward for future development and a few examples were to be used with some effect in the Franco-Prussian War of 1870–71.

However, it was to take another conflict, this time between the Union and the Confederacy, to generate new interest in automatic weapons. The American Civil War (1861–65) saw the biggest advances in firearms design in any single period before or since. It began as a war where many soldiers still carried smoothbore flintlocks or percussion muzzle-loaders and ended with the use of metallic cartridges, breech-loaders, repeating rifles and machine guns. It proved, if nothing else, what could be achieved with weapons development given sufficiently strong demand and fewer financial limitations. During the years of the conflict, two machine guns appeared that would lay the foundations for their descendants right up to the present.

The first, by a year or so, was the Agar. Although barely known now, it was a simple single-barrelled weapon that incorporated many features of modern weapons and remains in history as the first machine gun ever sold commercially. Designed by Wilson Agar, it was a hand-cranked design of .58in calibre; it used a hopper to hold its cartridges and it bore a striking resemblance to the common coffee-grinder, so was inevitably known as the 'Agar Coffee-Mill'. The combustible paper cartridges were held in pre-capped metal tubes; these were ejected once fired and then reloaded and placed back in the hopper. In its original form it could fire at more than 250rpm and when exhibited to President Lincoln, so excited him that he ordered ten at the then-colossal total cost of US$13,000 (£216,000 or US$352,000 at today's value). The rate of fire proved problematical, though, for the barrel overheated quickly and it was difficult to keep up a steady supply of ammunition. Despite Agar's supplying quick-change spare barrels and limiting the cyclic rate to 110rpm, the barrel still overheated, so a forced-air cooling system was devised, using air from a fan turned by the crank handle that was pushed through a cooling tube over the barrel. These improvements were never entirely satisfactory, however, and although 60 were purchased, few Agars were ever used in anger by the Union Army.

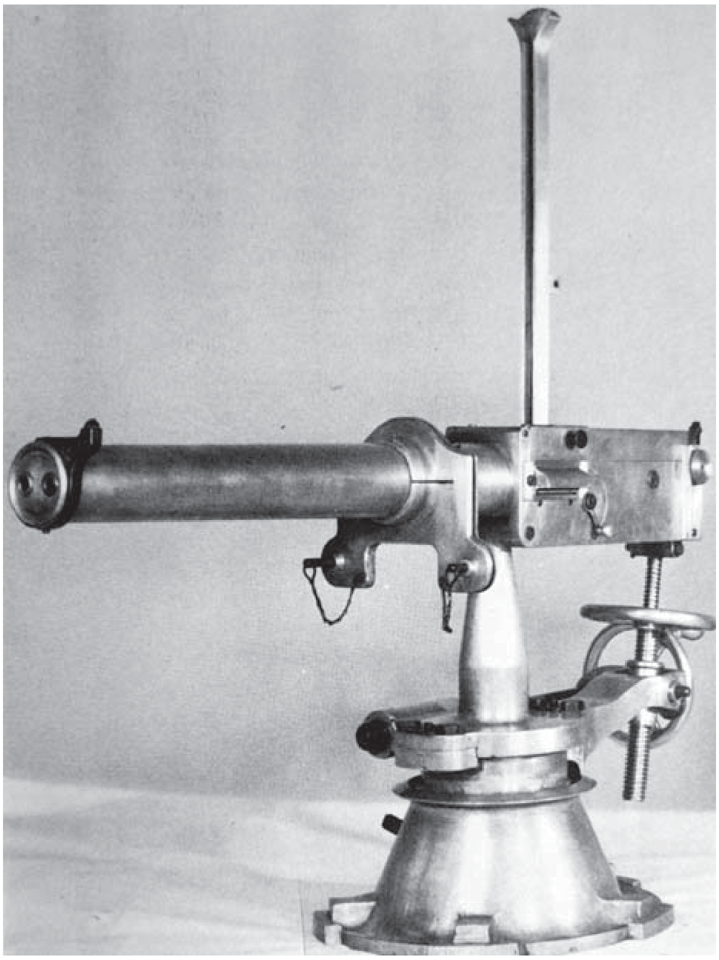


The complex breech mechanism of a Nordenfelt showing the breech blocks and firing pins. The gun quickly became very fouled and required continual cleaning to function properly. (Royal Armouries)

Of perhaps greater significance was a gun that appeared in 1862, designed by a North Carolinian, Dr Richard Gatling (1818–1903). A physician as well as a talented inventor, he had an oddly humanitarian interest in firearms, for he wrote that having watched every day the wounded, sick and dying being brought from the battlefield, it occurred to Gatling that 'if I could invent a machine – a gun – that would by its rapidity of fire enable one man to do as much battle duty as a hundred ... it would to a great extent supersede the necessity of large armies and consequently exposure to battle and disease would be greatly diminished' (quoted in Wahl & Toppel 1966: 18). This naive belief carries an echo of Hiram Maxim's later hope that such weapons would shorten war and thus ultimately save lives.

The design that Gatling developed was exactly the opposite of that being produced by revolver designers of the period, for while they were abandoning the concept of clusters of rotating barrels in favour of a short cylinder and single barrel, Gatling's design adhered to the former principle. His genius was in realizing that the generation of a high rate of fire presented specific problems to be solved. Chief among these were the need to cool the barrels and the need to ensure that there was sufficient ammunition available.

The first issue at least could be solved fairly simply, by mounting the series of revolving barrels axially around a central spindle that was hand-rotated by a handle, giving each barrel a chance to cool before being fired again. A camming system pulled the bolt backwards, allowing loose .58in-calibre combustible cartridges to drop in turn from a circular drum magazine into the pre-capped steel chamber, where each was fired. The

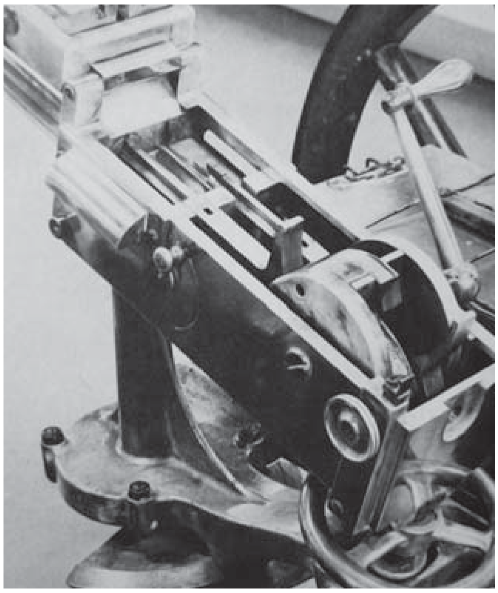


A two-barrelled Gardner. The vertical magazine relied on gravity feed and cartridges often jammed in it, but it was mechanically reliable. This pintle-mounted example was for Royal Navy use. (Royal Armouries)

Gatling generally performed very reliably, and could discharge at around 200rpm without suffering from the overheating problems faced by the Agar. It was as different from normal firearms, Gatling explained, as a mechanical reaper was from a hand sickle. One of the design's major shortcomings, the need for separately priming each chamber prior to firing, was soon overcome by the introduction of reliable rimfire ammunition, and the first use of the Gatling in earnest was during the siege of Petersburg in Virginia in June 1864. With the new ammunition a rate of fire in excess of 300rpm was feasible. Gatling also introduced two calibres – a ten-barrelled .45in gun for infantry use and a larger, six-barrelled version in 1in calibre for naval use – and was perhaps the first designer to recognize that these two branches of the armed forces had different requirements. By 1873, the introduction of centrefire ammunition enabled Gatling to raise his rate of fire to 600rpm, and in tests at Fort Monroe, Virginia, his gun was able to hit a target at 500m (546.8yd) 557 times out of 600, an impressive feat by any standard.

Of course, Gatling was not alone in attempting to develop the perfect machine gun, and a great stride forwards was made with the introduction of a gun based on a design by a Swede, Helge Palmcrantz (1842–80). His gun was of a now-familiar type, being multi-barrelled with up to 12 parallel barrels, and was lever-actuated. It was patented in 1873, but manufacture was undertaken by fellow Swede Thorsten Nordenfelt (1842–1920), who moved the company to Britain; it was under his name that the gun was manufactured and marketed. Although quite crude it was certainly effective; under test conditions at Portsmouth Dockyard it fired off 3,000 rounds in 3 minutes and 3 seconds. It was adopted in the early 1880s in 1in calibre by the Royal Navy as an anti-torpedo-boat weapon, but the design was already dated and production had ceased by 1890.

However, in connection with the story of the Maxim gun, the name Nordenfelt was to continue in a different guise, as will become evident. At about the same time the Navy had also adopted another design, by American William Gardner (1843–87), and this bore more than a passing resemblance to the Agar, being a brass-cased two-barrelled gun in .45in calibre that used a vertical, gravity-fed magazine mounted above the breech. As was the norm, it was crank-operated, but was reliable; it certainly impressed the British Board of Ordnance when in tests at Woolwich in 1880 it fired 16,750 rounds before a stoppage occurred. The problem of cooling was partially solved by the introduction of a five-barrelled design, and it was used during the battle of Abu Klea (16–18 January 1885) in the Sudan. Despite the timely introduction of centrefire cartridges, these guns suffered from the same mechanical shortcomings, for all relied on hand mechanical operation, by lever or rotating crank handle, and their rate of fire was limited by their gravity-fed ammunition supply and the requirement at some point for allowing the barrel or barrels to cool. What was required was a method by which the mechanism could be operated automatically, the barrel kept cool and ammunition supplied by a more efficient method than hand-loaded magazines or breech blocks. The solution to all of these problems was to be found by a quiet American inventor with a passion for electricity, named Hiram Maxim.



The rotating breech mechanism of the Gardner showing the crank handle and breeches. (Royal Armouries)

HIRAM'S LIGHT BULB

Born in rural Maine in 1840, the son of a miller and woodturner, from his earliest years Hiram Maxim showed a rare ability to analyse and understand complex mechanical concepts, having a quick and very enquiring mind. The first practical outlet for this was his construction, around the age of 12, of an automatic mousetrap that used a clockwork mechanism to re-set itself each time it was tripped by an entering mouse. Although it worked perfectly it was far too expensive for production and Maxim learned an important economic lesson – that technical success had to be evenly matched with economic reality. Although interested in the concept of firearms, he was not an avid shooter or hunter but shortly after the end of the Civil War was offered the chance to shoot an issue Springfield rifle, which he did, and was surprised at the strength of the recoil. This set him thinking, to use his own words:

> … that the energy in the kick of a military rifle would be amply sufficient to perform all the functions of loading and firing, so that if the cartridges were strung together in a belt, a machine-gun might be made in which it would only be necessary to pull the trigger, when the recoil would feed the cartridge into position, close the breech, release the sear, extract the empty case, expel it from the arm and bring the next loaded cartridge into position. (Maxim 1915: 12)

A transitional gun, combining Maxim's locking crank, fusee spring and belt-feed mechanism. Note the pistol grip and trigger. (Royal Armouries)

Maxim was sufficiently intrigued by the idea to discuss the possibilities with his father, who had, in 1854, produced his own design for a lever-actuated automatic gun. However, his father judiciously pointed out that with the available technology the resultant weapon would be far too complicated and expensive and 'would not be employed as a military weapon, though it might be a mechanical curiosity' (Maxim 1915: 15).

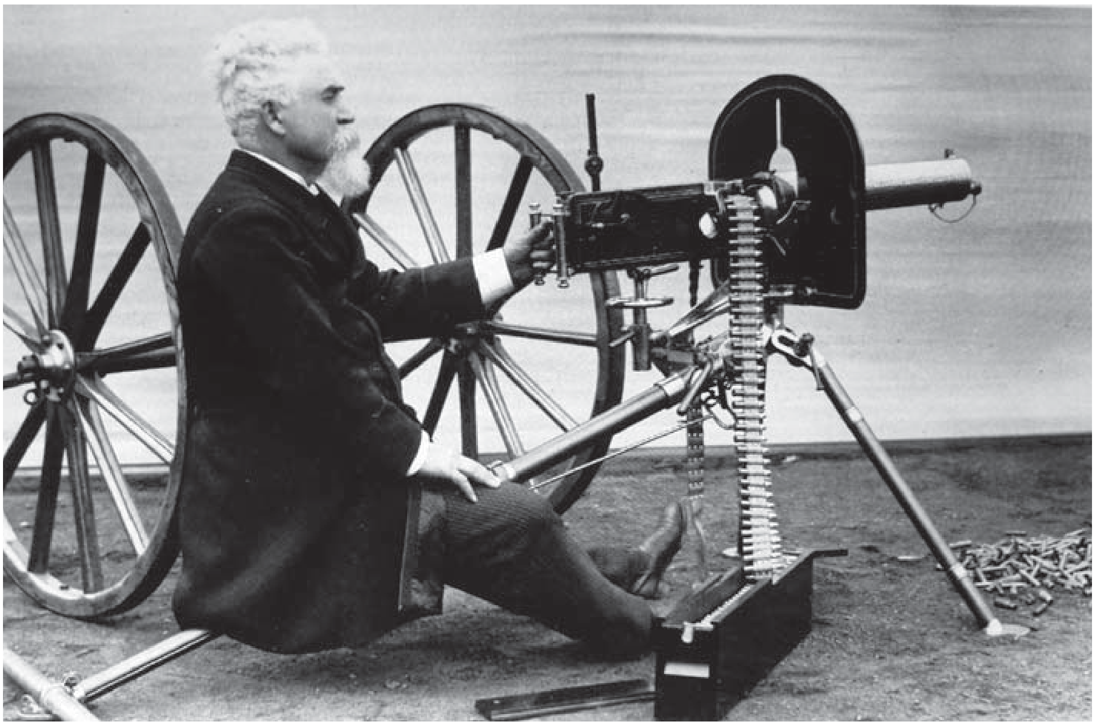
Maxim did not pursue it, for his fertile mind was already busy elsewhere, as he was heavily involved in the new science of electricity. He had filed his first patent in 1866, at the age of 26, which was for an improved electric hair tong; over the next 18 years he patented another 84 inventions, most of which employed electrical mechanisms of some type. By far the most significant, and directly related to the later production of the machine gun, were his 1880s patents for electric lamps. By this time he had, in fact, beaten his rival Thomas Edison (1847–1931) to the goal of producing the first practical incandescent light bulb, and for good measure the next year he patented the first efficient current regulator, once again relegating Edison to second place.

This was not good news for Edison's financial backers, who took the unusual step of offering Maxim employment as a roving technical advisor in Europe, but on the firm understanding that he cease all work on his own electrical inventions for a period of ten years. The carrot for this move was the incredible salary of US$20,000 per year that they offered, for in comparative income terms this equates to US$488,000 (£300,000) today. Thus in 1882 Maxim found himself of independent means, with a remit to travel the world, although he had little idea of where to go, or what to do. On 22 July 1896, in an article in *The Times* of London, he said that the idea of looking once again at weapons development came from a chance conversation with an acquaintance in Vienna. 'Oh, hang your chemistry and electricity,' his acquaintance said. 'If you want to make a pile of money invent something that will enable these Europeans to cut each other's throats with greater facility.' Casting his mind back to his father's comments about automatic weapons being too costly, Maxim decided to resurrect his original idea, as shortage of money for experimentation was no longer a hindrance.

Maxim decided to settle in London, which he liked, although this decision was influenced in part because it was the centre of the manufacturing world in the late 19th century. Once there he began examining existing weapons designs and his first patent (British patent 3178, dated 26 June 1883) was not for a machine gun, but for a recoil-operated Winchester rifle. This was not as unrelated a move as might first appear, for Maxim was well aware that any work on machine guns would attract unwelcome interest and potentially damaging competition, so in perfecting a recoil-assisted mechanism he was subtly laying the groundwork for later developments. He was materially assisted by the fact that solid-drawn brass-cased ammunition was now readily available and the troublesome paper or foil cartridges were a thing of the past.

Having ascertained how he could use recoil to operate the breech block in the Winchester design, Maxim then turned his attention to producing a magazine-fed mechanism that used blowback, the power generated by firing the cartridge, to move the breech block rearwards after firing, returning it forwards by use of a hydraulic spring to collect another cartridge and chamber it. His problem was not so much creating a working mechanism, as finding a means by which he could reliably feed ammunition into the breech. Initially he had sewn together a double-weave fabric belt that was pulled into the feed mechanism by two metal star-wheels, and he used grooved-cased, rimless cartridges of his own design. In testing it fired six cartridges in half a second and he wrote 'I was delighted, and saw certain success ahead' (Maxim 1915: 18). He prophetically called this mechanism the 'Forerunner' and patented it, but it was to prove only the start of a lifetime of problem-solving and development work. He had to build into the breech a method of delaying its opening until the chamber pressure had dropped to a safe level, and he could not find an effective method of harnessing the waste gases generated when the cartridge fired. He came up with an unusual solution to the first problem, by using indirect gas operation via a port in the barrel that created a vacuum in a chamber, actuating a piston and rod and driving back the breech mechanism. He patented this invention on 3 January 1884; it was something of a watershed in machine-gun development, for it paved the way for a new family of gas-operated mechanisms.

It was only a halfway solution, though, and Maxim worked tirelessly at solving a myriad other problems. By 1884 he had set up a small workshop at 57D Hatton Garden in London; throughout the year he examined each internal part minutely and made endless changes wherever they were required, but his foremost problem was the poor-quality commercial ammunition he was using. (He was by this time using .45in-calibre Gatling-Gardner cartridges.) He contacted the Board of Ordnance for supplies of military-issue .450in ammunition, which was manufactured



Hiram Maxim seated at his 1887 'World Standard' gun. A belt of .45in Maxim cartridges is *in situ*, and a pile of spent cases can be seen on the floor. (Royal Armouries)

to far more rigorous standards. Although initially he asked to purchase 1,000 cartridges, he soon required several thousand more. When asked why such large numbers were needed Maxim was forced to explain the reason to the Board, but from then on he was supplied with all the ammunition he needed.

The gun used a bell-crank breech working with a coil spring, and it revolved in alternate directions to ensure a constant rate of fire. Moreover, it had a 'positive lock' breech, a recoil-buffer system and an unusual regulator-trigger that by means of an external lever could adjust the rate of fire from 2rpm to 666rpm. Naturally the faster the gun fired, the more urgent became the need for cooling, but Maxim soon determined that the only effective means of keeping the barrel at a safe working temperature was by using water, calculating that every .45in-calibre cartridge raised the temperature of 1lb of water by 1½ degrees Fahrenheit. This required 'as much heat to evaporate 1lb of water as it does 5lb of iron, [so] it will be obvious that weight for weight water is much more effective than iron in absorbing heat' (Maxim 1915: 22). The new prototype, therefore, had a water-jacket surrounding the barrel; he had several prototype guns made at Hatton Garden.

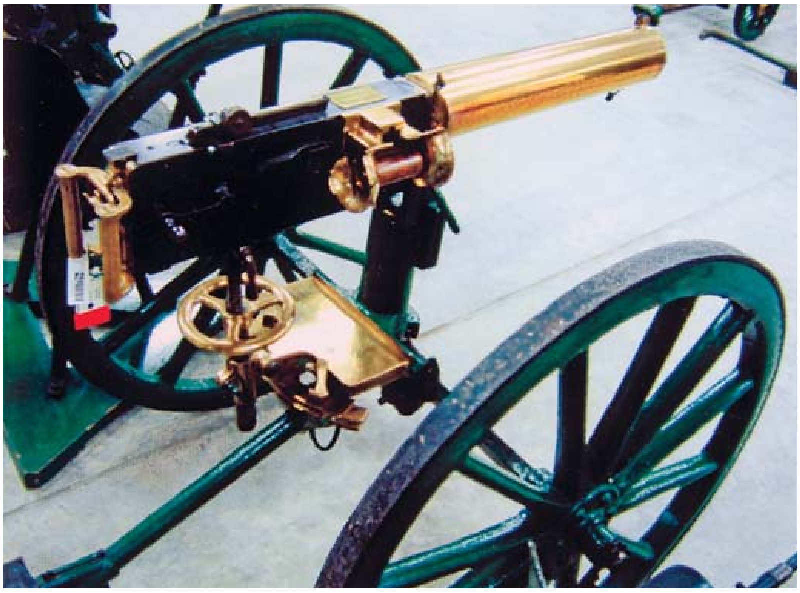
The new weapon was beautifully made, of blued steel and brass, was 5ft 2in long and 3ft 6in tall on its tripod and weighed a hefty 140lb without water or ammunition. When exhibited at the Institution of Mechanical Engineers in April 1885 it caused a sensation, and later that summer Maxim was awarded a gold medal at the International Inventions Exhibition. In practice, though, the vacuum operation was not reliable and the ammunition belts proved to be too heavy, straining the feed mechanism; the recoil spring was unreliable and the cartridges themselves frequently failed to ignite. Maxim also needed to find a method by which the speed of firing could be automatically restricted, and it seemed that no sooner had he found one solution than another problem cropped up.

THE 'PERFECT GUNS'

Despite these setbacks, the basic design was sound, and generally the guns performed well. Sufficient interest was created for him to form 'The Maxim Gun Company' on 5 November 1884 with the backing of a number of wealthy investors who purchased £50,000-worth of shares at £20 each. Among them was one Albert Vickers, who bought 417 shares. He and his brother Tom ran the old family steel firm of Vickers, Son & Company Ltd, and it was Albert who was elected as the chairman of the new company, with Maxim as managing director. But Maxim was still unhappy with his design, for he knew the gun was uneconomic to manufacture and required considerably more work to make it lighter, simpler and more reliable.

Maxim continued to work on the core of the design and his Patent No. 1307 of 29 January 1885 begins to show the genius of the man in being able to refine his existing design without compromising the original concept. He created an entirely new internal mechanism, abandoning the complex feed-wheels, and he also changed the fragile feed design so that a belt of loaded cartridges was now drawn into the breech by a far stronger sliding-pawl mechanism. The old lock, hydraulic pistons and vacuum devices were abandoned and replaced with a simpler crankshaft-operated breech block and short recoiling barrel, and a more energy-efficient, wound-steel 'fusee spring' replaced the old coil spring.

The internal mechanism was now very different from that of his original design. The breech-block design was unique, being fitted with a vertically sliding breech-face that on cocking was able to extract a cartridge, chamber it and prepare to extract a second by means of one cocking movement. The block itself ran along a pair of cammed tracks in each side-plate and this provided the lift required for the breech-face, enabling it to extract, feed and eject. When the trigger was pulled the cyclic action was able to continue without further human intervention. With each shot the barrel and breech block were pushed backwards simply by the force of the exiting bullet; this movement was arrested by the fusee spring, which was attached to a short chain and cam on the left side of the receiver, to help absorb the rearwards motion of the breech block. The spring would reach the limit of its travel then contract, pulling the block sharply forwards to enable it to once more chamber its freshly extracted cartridge. When firing, the breech block was locked in place by a toggle mechanism much the same in function as a human arm or knee joint. It folded easily under rearward pressure of the barrel, but once straightened by the pull of the fusee spring it locked rigidly until the next round was fired. It was at the same time mechanically complex but extremely simple, using a single, fluid motion to perform several actions.



One of the first 'Perfect Guns' on its wheeled carriage. Its beautiful construction is evident, from the polished brass jacket, ammunition box tray and spade handles to the mahogany roller on the side of the feed block. It represented Victorian engineering at its finest. (Royal Armouries)

FIRST ORDERS

At this point, Maxim was given some very sage advice by Lieutenant-General Sir Andrew Clark, Inspector of HM Government's Fortifications. Clark told Maxim to ensure that his guns were so simple that they could be stripped, checked and cleaned with no tools whatsoever, apart from a pair of hands. Only then, he said, would they prove of any interest to the military. By March 1887 Maxim had produced three prototype .45in-calibre weapons for testing, using his own solid-drawn ammunition, based on the .450in Martini-Henry Service round. The first two were water-cooled at 60lb each, while a third was a 'lightweight', air-cooled model at a mere 40lb; this particular model was crucial, for the British Government had stipulated that any machine guns submitted for testing should weigh 'no more than 100 lbs [and] should be able to fire 400 shots in one minute, 600 shots in two minutes and 1,000 shots in four minutes' (Goldsmith 1989: 39). They must also pass strenuous dust, mud and rust testing and

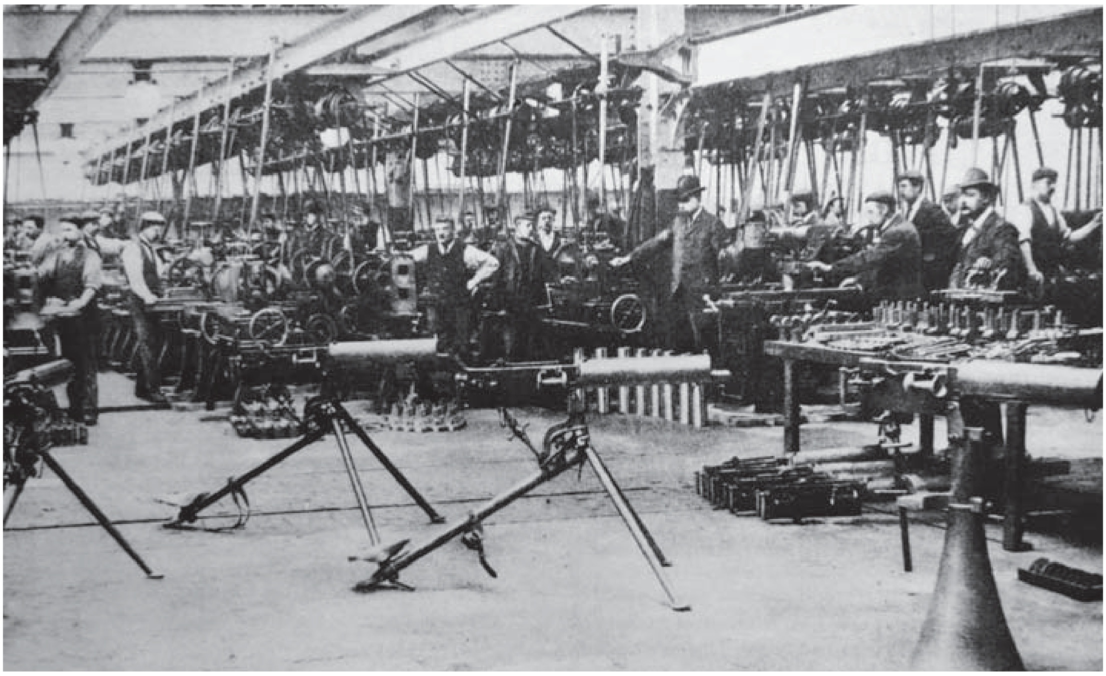
A Maxim-Nordenfelt of about 1889 on a rare 'Carriage, Parapet'. This enabled the gun to be wound upwards on the ratcheted track to fire over the top of breastworks. In reality, it was impractical and too expensive to manufacture. A simpler version was introduced in limited numbers in 1915. (Royal Armouries) be capable of being field-stripped using no special tools. As Maxim wrote later, 'I introduced the belt ... I pulled the trigger and cartridges commenced to go off at the rate of about 670 a minute. Both regular and lightweight guns were accepted and paid for by the Government, and this was the commencement of my success as a gun maker' (Maxim 1915: 27).

The British Government placed an order for six guns in March 1887 and later that year Maxim and Albert Vickers attended a machine-gun field test at Thun in Switzerland, where Maxim's lightweight gun was to be pitted against those developed by Gatling and Gardner, and an improved Nordenfelt. It should have been a foregone conclusion, as the Swiss Army had already decided on the Gardner, but despite the Maxim being chambered for the somewhat underpowered 11mm (.43in) black-powder round, it held its own. The crucial test was the requirement to fire at 1,200m (1,312yd) at a representative artillery battery, which was further than the weapon's sights were graduated, so Maxim quickly calculated the bullet trajectory and using some careful guesswork fired a full belt of 333 rounds.

The result astonished the observing officers, one of whom approached and said, 'No gun has ever been made in the world that could kill so many men and horses in so short a time' (quoted in Maxim 1915: 31). Presciently, following a further demonstration in Vienna, Field Marshal the Archduke William Franz-Karl of Teschen (1827–94) was unusually silent. He finally turned to Maxim and with a shake of his head murmured 'It is the most dreadful instrument that I have ever seen or imagined' before departing (quoted in Goldsmith 1989: 42). He was perhaps one of the first people to understand the terrible potential of the new gun. Nevertheless, financially the demonstrations were an unqualified success, for the result was an order for 26 guns from Italy, priced at £250 each (inclusive of 10,000 rounds of ammunition per gun). The Austrians ordered 131, these being discounted to £215 each (roughly £18,700 or US$30,200 at today's values).

Clearly, an order this large was impossible for the tiny Maxim Gun Company to meet without greatly enlarged premises, so the Hatton Garden workshops were reluctantly vacated and despite considerable misgivings Maxim entered into an agreement with the Nordenfelt company to help manufacture the guns required; this was formalized on 18 July 1888, when the old Maxim Gun Company was wound up. The agreement between Maxim and Thorsten Nordenfelt was uncomfortable for both parties; Nordenfelt was reduced to making a gun that was superior to his own design and Basil Zaharoff, his sales manager, did all he could to sabotage the amalgamation. Maxim did not entirely approve of the manufacturing methods used by Nordenfelt, which he felt did not produce the quality he required. Nevertheless, additional new premises were found for Maxim at a small factory site in Crayford in Kent and this, allied to the 10-acre facility at Erith occupied by Nordenfelt, gave the new Maxim-Nordenfelt Company unparalleled manufacturing ability.

The contracts for the new weapons kept coming, for the first British order on behalf of the Crown Agents in Natal was placed on 29 March 1889, and this was followed by several more War Office contracts as well



Maxim's Crayford works in about 1892. (Vickers Archive)

as orders from the governments of Germany, France, Australia and Spain. In fact the demonstration to the Kaiser nearly altered the course of world history, when at Spandau Arsenal in the spring of 1888, the auto-traverse mechanism on the Maxim gun being fired by the Kaiser was accidentally activated so that the whole gun began to revolve of its own accord. The Kaiser would have mowed down the entire German General Staff and every spectator had Maxim not leapt forwards and disconnected the mechanism. Shortly afterwards, the mechanism was quietly dropped from the list of options.

The subsequent order from Germany proved crucial to Maxim's success, for in 1888 it resulted in a 20-year sales agreement with the vast Krupp organization, and in 1892 in a seven-year agreement between himself and a machine manufacturer and toolmaker named Ludwig Loewe of Berlin that enabled the Maxim gun to be manufactured under licence. Unknown to anyone, this was to have far-reaching consequences in the very near future. The year 1891 was also something of a landmark, for the first Enfield-manufactured Maxim was produced, the first of 2,568 to be made at the arsenal.

INNOVATIONS IN AMMUNITION

Despite the success of the 'Perfect Guns', Maxim would not rest, for he was convinced he could improve still further on them. He now referred to these production guns as the 'World Standard Maxim Gun' but many of his current problems resulted from events beyond his control. The early guns had been designed around the .45in-calibre Gatling-Gardner round, a powerful black-powder cartridge with heavy bullet that generated tremendous recoil, highly suitable for operating the mechanism on the weapons. Maxim's own variant of the Martini-Henry round, the .45in Maxim, was also perfectly suitable, as converting the 11mm (.43in) barrels simply called for a machining modification to the breech.

The problem lay with the new smokeless powder invented by Paul Vielle, for the new smaller, lighter bullets achieved far higher velocities than the old conical lead ones, the 8mm Lebel adopted by France reaching 725m/sec (2,380ft/sec) as compared to the 435m/sec (1,430ft/sec) of the 11mm Mauser, but they generated far less recoil. Within an almost indecent space of time, almost every army in Europe had followed the French and changed over to small-calibre, high-velocity ammunition. Indeed, the Swiss Government order specified an 8×50mm Service cartridge for use with its Maxims. (In 1911 the Swiss changed to the 7.5×54mm cartridge.) While the new ammunition had greatly improved range and accuracy, and expunged all of the problems associated with fouling, it posed Maxim with a conundrum, for the recoil forces were simply insufficient to generate the power required to automatically re-cock the mechanism on his guns. However, he was astute enough to appreciate that the future of firearms design lay with the new cartridges, so he was forced to recalculate the operating parameters for the guns to deal with the reduced recoil energy of the smokeless cartridges; by the start of 1890 he had managed to do this successfully.

Vickers-Maxim ammunition. From left to right: a .450in Martini rolled-brass cartridge, a .45in Gardner-Gatling, a .45in Maxim and a Mk VII .303in. (George Yannaghas)

THE VICKERS YEARS

Maxim did not have the field of machine-gun design entirely to himself, for in the final decade of the 19th century other efficient designs were being perfected. In 1894 Austria-Hungary had adopted the Maschinengewehr Modell 1893, which used a peculiar delayed-blowback mechanism and had a cyclic adjuster that enabled the rate of fire to be adjusted, not unlike the first Maxim. France had introduced the air-cooled, gas-operated 8mm Mitrailleuse Hotchkiss Modèle 1897 – the designer of which, Laurence Benet, was coincidentally also American – and in 1895 there appeared a new threat from the Browning brothers in the United States, in the shape of the gas-operated 6mm Colt machine gun.

Nevertheless, Maxim's guns continued to sell well, but the rift between Maxim and Nordenfelt was growing. Among other models Maxim had designed was the popular and large-calibre 'pom-pom' gun, so called because of the noise it generated when fired. Chambered for a 1lb (or 37mm) armour-piercing or high-explosive shell, it was more correctly an automatic cannon rather than a machine gun, although the mechanical principles were the same. Made jointly with Nordenfelt, some 35–40 guns were produced in 1895–96 and it appeared to a casual observer that the joint company was proving highly successful, but the truth was very different; orders for Nordenfelt's own guns had slowed to almost nothing and the company had expanded far too quickly, overstaffing the Erith works. By 1897 their finances were in dire straits.

At this point, the interest expressed by Maxim's partners, the Vickers brothers, became more apparent. In 1888, in the wake of receiving a large order from the British Admiralty for large naval guns, Vickers had realized that they were, to quote the official history, 'occupying a half-way house' (Richardson 1905: 10) in industrial terms. They were, as their history states 'predominantly a steel manufacturing firm, with one foot in armaments' (Richardson 1905: 12). With the rapid expansion of British naval power to match that of Germany, the Vickers brothers understood that while naval armaments, specifically engines, armour plate and guns of huge calibres, were well within their scope to manufacture they could also see the sales potential of the new breed of smaller automatic guns. As a result in 1896 they paid £1,353,000 (today, equivalent to £117,000,000 or US$190,557,000) for the Maxim-Nordenfelt Guns and Ammunition Company. From 1 October 1897 the new company was called Vickers, Sons and Maxim Ltd. To realize their dream of producing something larger, they also purchased the Barrow Shipbuilding Company. They would soon be in the unique position of producing both Dreadnoughts and machine guns.

In 1899 Maxim had ceased to be the company's managing director, the position being taken by Sigmund Loewe, the brother of Ludwig. The start of the 20th century was a momentous time for Hiram Maxim, for in 1900

A Model 1906 'New Light' gun, the first of the Vickers family, later adopted as the class 'C' gun. Its standard tripod proved too fragile and awkward in use and later models adopted the ubiquitous Mk IV tripod. (Royal Armouries)

A Vickers and captured German MG 08 providing support fire at Mouquet Farm on the Somme, late summer 1916. Crews of both weapons and the photographer are taking great care to stay below the skyline, indicating the enemy are not too far distant. Use of captured German machine guns was routine, as their mechanical systems were almost identical to the British weapons. (IWM Q 1419)

he became a naturalized British subject and the following year was knighted for his services to the Empire. In 1902, Vickers signed an agreement that prohibited Maxim from undertaking any further work on his designs in return for a handsome fee of £1,200 per year (£102,000 or US$166,500 today) and although Hiram initially oversaw the continued development of these rifle-calibre guns, he was increasingly being distracted by other newer technology, in particular powered flight. Until 1911, all Maxim guns manufactured were marked 'Vickers, Sons and Maxim Ltd' but this ceased by 1912. All later development work on the design was undertaken by Vickers engineers, under the aegis of Sir Arthur Trevor Dawson, an ex-naval gunnery specialist who was to become the most senior and influential figure in the company.

The guns produced after 1889 were chambered for modern high-velocity rifle calibres and were now capable of an average rate of fire of 450rpm. They were instantly recognizable with their handsome but heavy brass water-jackets, but their early use in colonial wars had raised some questions about reliability. One of the greatest shortcomings was in the lock design, for it was almost impossible to replace a firing pin or spring without workshop facilities; neither could headspace[1] be accurately adjusted for the cartridge. As a result, each gun had to be supplied with three locks, which were only usable with that specific weapon. The feed block also caused problems, for it was heavy, awkward to remove or replace and had a vulnerable wooden roller; overall, the guns were regarded as still being too heavy.

In their first major revision of the design, Vickers brought out the Model 1901 'New Pattern', which addressed all of the existing problems. Most significantly, the brass water-jacket was changed for a lighter rolled-steel one and the lock was much simplified, being field-strippable in seconds with no special tools. A method of headspacing was devised using thin steel washers that could be added to the connecting rod of the crank. It was simple, accurate to set up and efficient. The feed block was lightened and produced entirely in brass and steel, and a host of smaller but equally important changes were made to simplify the design and the mounting system. Although this pattern was in production for five years, all guns ordered in 1902 by the War Office were inexplicably specified to be the brass-jacketed 1893 model.

1 This is the permitted tolerance between the face of the breech block and the base of the loaded cartridge – too little and the cartridge slams backwards on firing, causing stress and heavy wear; too much and the base is compressed, leading to difficult extraction and jamming.

IN GERMAN SERVICE

The pre-1914 years were to prove to be turbulent ones for the development of the new Vickers Company, for the seven-year manufacturing agreement with Ludwig Loewe in Germany expired and there was a scramble for licensing of the commercial manufacturing rights relating to the guns. In 1896 Loewe had formed a new company, Deutsche Waffen- und Munitionsfabriken (DWM). He had been making a copy of the Model 1894 Maxim, which was adopted by the German Navy, and he copied the Model 1901, which was purchased by the German Army, who equipped 16 machine-gun detachments, so that every army corps incorporated a Maxim detachment. German observers of the Russo-Japanese War (1904–05) saw at first hand the devastating effects of the fire from these guns on attacking infantry, but also began to appreciate the shortcomings of the existing designs.

Some of the German modifications were, to say the least, a curious mix of the practical and puzzling. The Germans immediately set about improving the design of the Model 1901 by reducing its overall weight, eliminating the awkward and heavy tripod in favour of an equally clumsy and heavy Schlitten 08 mount (sledge mount). Inexplicably, they ignored the improved 1901 lock, opting to retain the old non-adjustable 1889 design, which meant that only trained armourers could headspace the locks and resulted in all World War I-production sledge mounts being manufactured with stowage boxes to accommodate two spare locks. Cold-weather performance was sometimes poor, due to internal resistance from parts stiff with frozen oil, so a muzzle booster was added; this increased the recoil force on the barrel, improving the performance and marginally raising the rate of fire from a relatively slow 350rpm to a more respectable 450rpm. Unlike the British, the Germans also added a side mount on to which a telescopic sight, the Zielfernrohr 1912 (Zf 12), was fitted; oddly, no optics were ever provided for the Vickers guns. The mechanical function of the new guns was unaltered from the early model and it was adopted as the Maschinengewehr 1908 (MG 08). The total weight of the water-filled gun and mount was a hefty 137lb and this was to place some tactical limitations on its use during the forthcoming war.

A comparative photograph showing the size difference between the receivers on an MG 08 (top) and a Mk I Vickers, and the different placing of the cocking handles. The feed blocks are also of different patterns and the top covers are partially opened for comparison. (Author)