Chapter 3

BROWNING AUTOMATIC MACHINE GUNS

John M. Browning's Early Years

The next outstanding step in automatic weapon design was made by a young western gunsmith, John Moses Browning. It would be impossible to produce a greater contrast in men than that existing between the two great masters of automatic weapons, Maxim and Browning. Hiram Maxim, a brilliant opportunist, needed only the incentive of promised wealth to turn from electricity at the age of 44; and, on his first attempt at producing an automatic machine gun, he succeeded where countless hundreds before him had failed. John M. Browning, on the other hand, was destined by inheritance to be a gunmaker.

His father, Jonathan Browning, an outstanding riflesmith, produced weapons that were as advanced as was possible considering the ammunition of the day, which consisted of loose powder, ball and percussion cap. Born in Sumner County, Tenn., in October 1805, he went to Nashville for his apprenticeship in gunsmithing. When he was about 21 years old, he moved to Davidson County, Tenn., where he set up his own gunsmithing business. He subsequently moved in 1834 to Adams County, Ill., where he invested largely in land and carried on agricultural pursuits in connection with his gun and blacksmith trade. From 1842 to 1846 he conducted his business in Nauvoo, Ill., followed by a move to Kanesville now known as Council Bluffs, Iowa.

Here he engaged in manufacturing guns, wagons, and other equipment. He also continued his farming and discharged the duties of magistrate, an office he had held in his other places of residence. The merits of his various repeating guns are described in the following advertisement in the Kanesville *Frontier Guardian* of 19 September 1849:

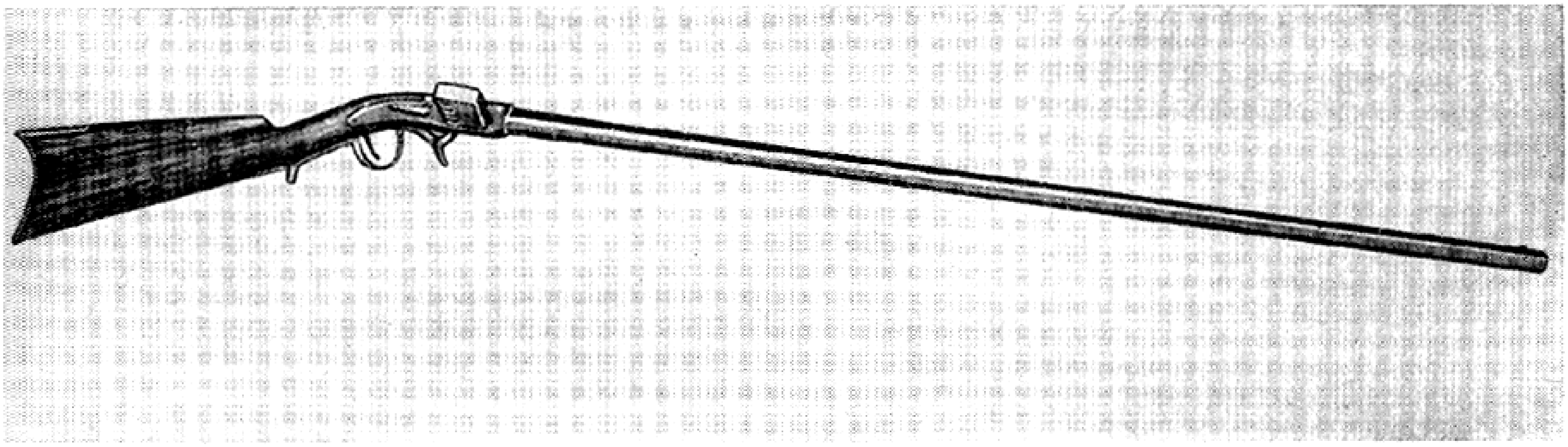
"Gunsmithing

"The subscriber is prepared to manufacture, to order, improved Fire-arms, viz: revolving rifles and pistols; also slide guns, from 5 to 25 shooters. All on an improved plan, and he thinks not equalled this far east. (Farther west they might be.) The emigrating and sporting community are invited to call and examine Browning's improved fire-arms before purchasing elsewhere. Shop eight miles south of Kanesville on Musquito Creek, half a mile south of Trading Point.

"JONATHAN BROWNING."

During his stay in Kanesville, Jonathan Browning produced two different styles of repeating rifles. One was a slide-action weapon that had a rather ingenious arrangement whereby the five-shot magazine alined each chamber concentric with the bore. The magazine was a rectangular piece of bar iron, chambered to accommodate powder and ball. The magazine, or bar, slid through an opening in the breech from left to right, being manipulated by finger pressure on a small lever on the side. At the same time it jacked the action forward, forming a gastight seal between chamber and barrel. This weapon was hailed as a great achievement by the gun trade, as it allowed the user not only to have several quick shots ready in the gun, but also to carry a number of loaded magazines.

Success encouraged Jonathan to make another repeater of different design. This time the breech mechanism housed a cylinder having six chambers operating somewhat on the order of the single-action revolver. Neither of these weapons, which added to the fame of Jonathan Browning throughout the frontier, was ever patented. It is indeed probable that he did not even consider the idea.



Original Repeating Rifle Developed by Jonathan Browning.

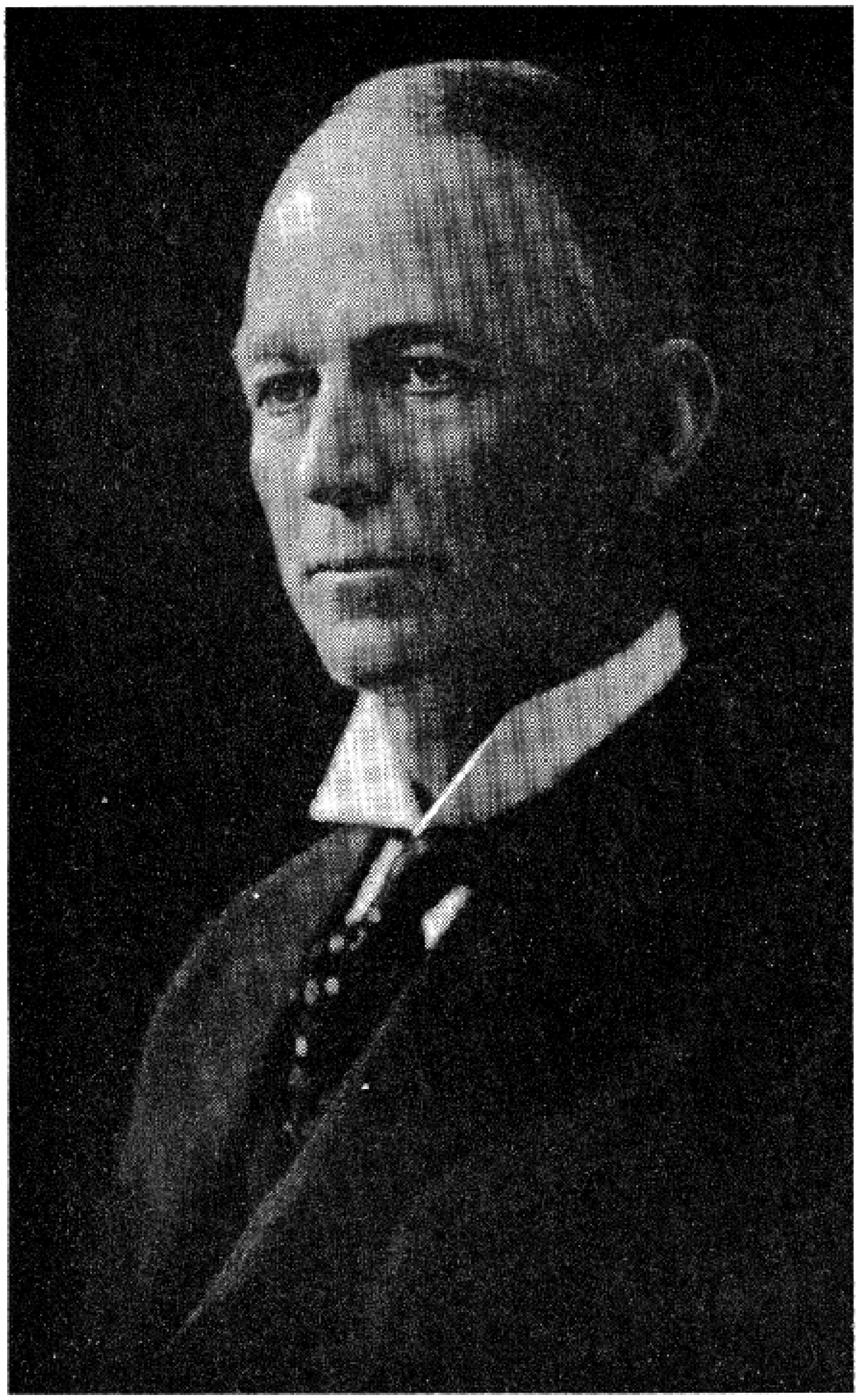
After accumulating a small amount of money, he deemed it appropriate to move further west, and was selected to captain a wagon train, being regarded by his neighbors to be as resourceful and reliable as the weapons he made. Despite the ever-present danger that existed in such an undertaking, he led his wagon train safely through the territory of Utah to the Mormon settlement of Ogden, and opened a gun shop there in 1852.

Money was scarce, and, though there was no end to the demand for superior weapons, profits had to be kept at a minimum in order to sell. Jonathan's gun shop was small. And, as was the custom of that day, his home was but a modest addition to his workshop.

It was in these surroundings that John Moses Browning was born in 1855. He soon showed his heritage from Jonathan Browning. Before he was 20 years old, he was supplying the family table with wild chicken killed by a gun of his own construction. He also made an improved rifle for his brother, Matthew, which his proud father admitted was the best gun he had ever seen and far surpassed anything he had made in all his years as a riflesmith.

John Moses was given an interest in the business and worked daily at the foot-power lathe that the elder Browning had brought with him by oxcart from Council Bluffs. He served as an apprentice for 10 years before he applied for his first patent. It was on a single-shot rifle, operated by a trigger guard lever that opened the breech, ejected the empty cartridge case, and cocked the piece; when locked for firing, the hammer was out of the line of sight. The patented mechanism was promptly bought by the Winchester Arms Co. of Hartford, Conn., and made in numerous calibers. Thus began an association between Browning and Winchester that lasted for many years. His reputation established, he only worked harder to improve and originate other types of weapons that he felt

John Moses Browning when 18 Years Old.



Matthew Sandefur Browning.

would meet the demands of the critical public.

The successful partnership between John Moses and Matthew Sandefur Browning resulted from the death of their father and the added responsibility of providing for the family—as well as from their inherited love for fine guns and pride in their ability to produce them. These basic demands and the unlimited resourcefulness which characterized the lives of the two young men were the deciding factors that lifted the J. M. & M. S. Browning Co. of Ogden, Utah, from obscurity to world fame.

Each believed a man does best that for which he has the most natural aptitude, and wisely decided at the very first to separate their business duties. In complete agreement, they decided that John M. should devote his entire time to the origination of new weapons and the improvement of previous designs, since he had already shown his ability along this line. On the other hand, Matthew, having exhibited unusual talent in marketing products and in handling patents, contracts and investments, would devote his attention to business and financial problems. It was the latter's shrewd foresight that made them stop catering to individual demands for custom-made weapons. Instead they would decide on a promising design and proceed to have made in the little shop as many as 600 identical guns before a single one was put on the market.

Matthew found that, by this standardization and an assembly-line method of production, not only could he manufacture more economically, but also he was in a position to bargain with larger gun companies by virtue of his potentialities as a serious competitor.

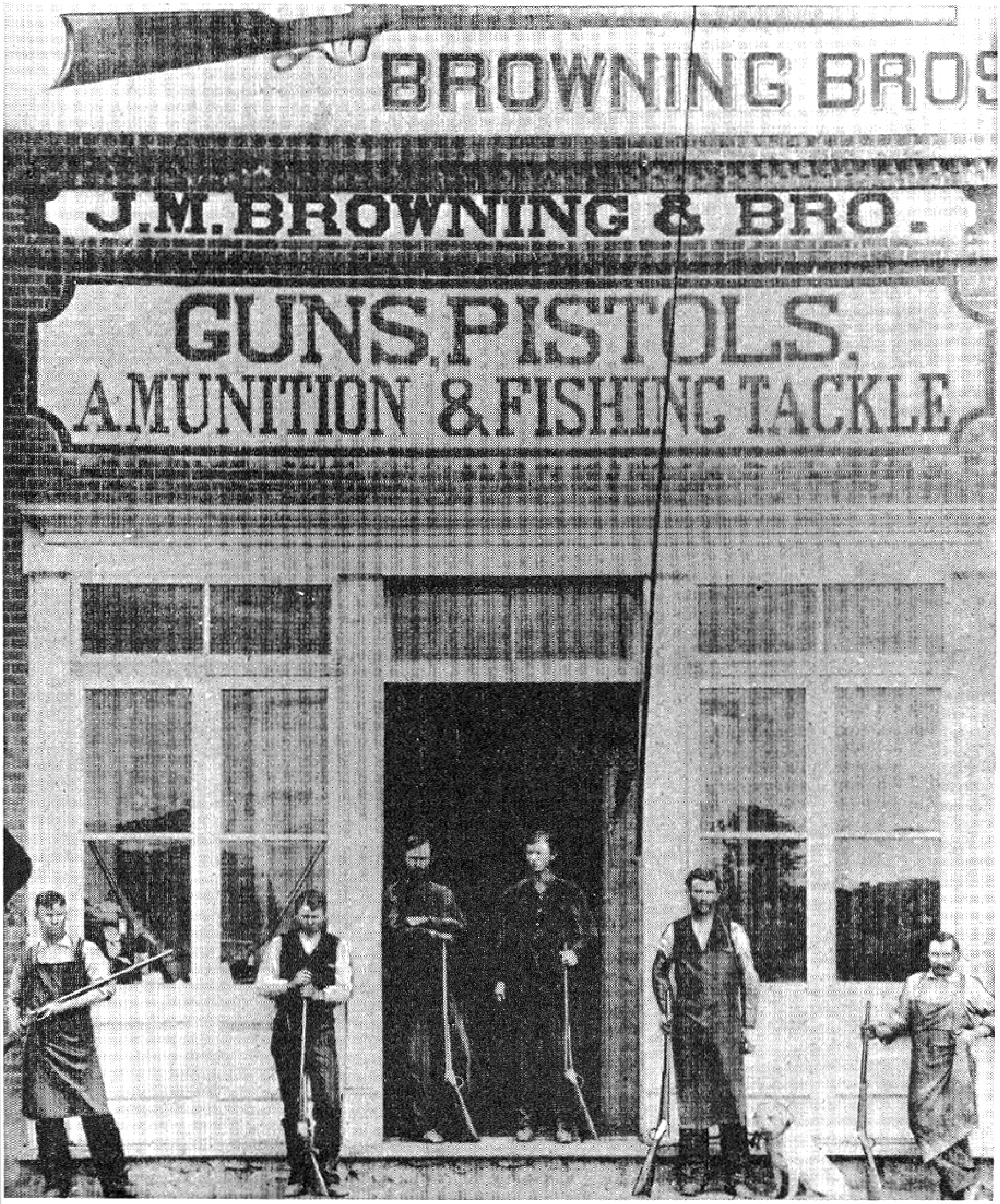
One of the earliest successes of the J. M. & M. S. Browning Co. was the sale, at a good profit, of the complete output of 600 rifles of a popular design to the Winchester Arms Co. The wholesale part of the business became so lucrative that they were able to employ a well-known gunsmith as well as their half brothers, Samuel, George, and Ed Browning, at the tedious task of handmaking and assembling the rifles.

Manufacturing activities expanded and the brothers were forced to buy a two-story building for their business. The lower floor was outfitted as a sporting goods store, in which they displayed for sale not only their own, but also all the popular brands of firearms. The upper floor was converted into a workshop and a pattern room, where John M. made mock-ups of guns that time would prove to be the world's best.

At the age of 26, the designer conceived the idea of a lever-action repeating rifle. The patent was granted in 1884, assigned to Winchester on a royalty basis, and in a comparatively few years the weapon literally monopolized the market. It became known as the '86 model Winchester.

A business competitor of Winchester, shortly after the deal, said to Mr. Browning, "I don't know what you received for the repeater you sold Winchester, but I would have given half my factory for it."

The design was so basically sound that thousands of the weapons are in existence today, and



The First Shop and Arms Factory. John and Matt Browning are Shown in the Doorway. Left to Right Are Sam, George, John, Matt, and Ed Browning, and Another Gunsmith.

John M. Browning at the Height of his Career.

it is said that practically every improvement in repeaters since that time has been influenced by this mechanism. The cartridges were carried in a tubular magazine under the barrel. Fore and aft movement of the lever controlled the entire operation of opening the breech, cocking the gun, ejecting the empty cartridge, picking up and inserting the incoming round into the chamber, closing the breech, and securely locking it. All this was done in less than a second's time. The trigger finger could remain in position for firing while this was being accomplished.

The mechanism of this gun was an improvement over that of any other rifle of this period. It was especially effective since the joint between breech and barrel was perfectly sealed. When closed, the sliding part of the locks fitted into place so accurately that the breech had the appearance of one solid piece. The ease and simplicity of locking and the economy of manufacture, coupled with the ruggedness and reliability of the weapon as a whole, made all other rifles obsolete. A carbine version accompanied Admiral Perry to the North Pole, and Theodore Roosevelt chose a custom-built caliber .405 model for his African hunting expedition.

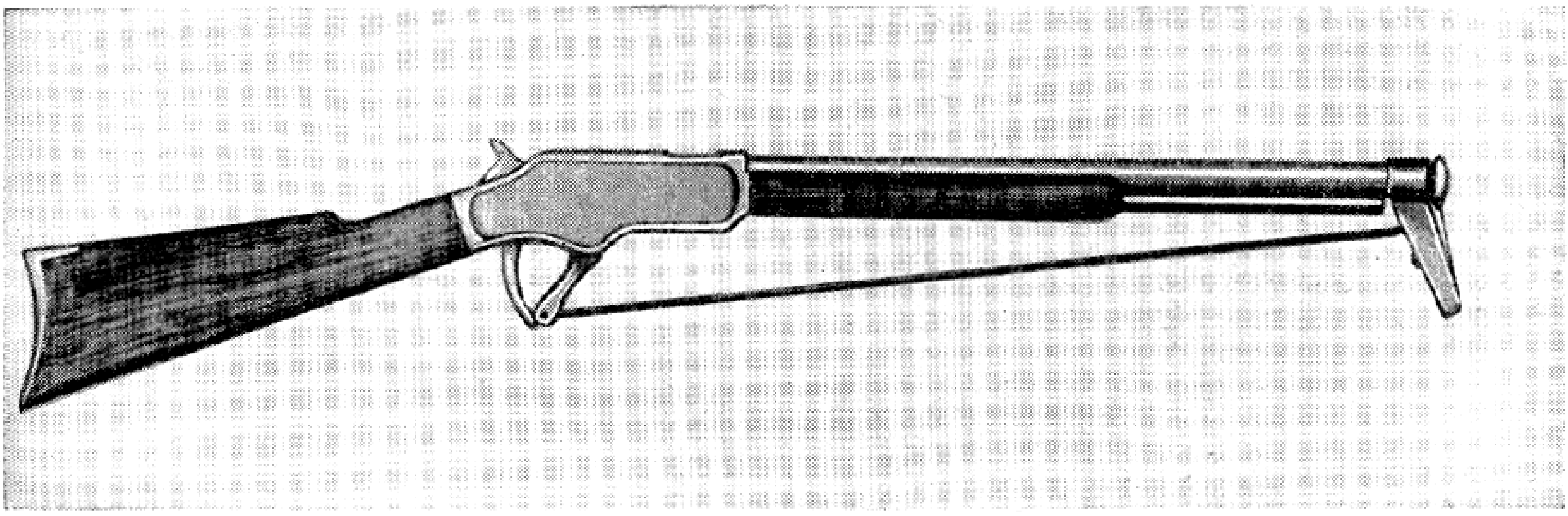
The Winchester Co. became so convinced of Browning's skill and gun talent that it asked him if he could design for it a caliber .22 (short) repeating rifle. Browning sent drawings of a proposed model. To his utter surprise, he soon received a letter telling him to discontinue his efforts, as the weapon he had submitted could not possibly work. Browning made a working model of the gun, according to the submitted plans. Upon completion, he took it personally to the factory to show to the officials who had said it would not fire and stated, "You said it would not work, but it seems to shoot pretty well for me."

Not only did he design for Winchester, but also for Remington, Stevens, Colt, and other arms companies. His rifles, shotguns, and pistols have been used so long under other factory names that it is often forgotten that they were the inventions of this gun genius.

The Colt Model '95 Machine Gun

In 1889 John M. Browning made a discovery which, in due time, affected all the military world. Like most great events its place of origin was unimpressive. He was function firing one of his latest rifles in the salt marshes near Ogden, Utah, when he noticed something countless other men had seen before, but had not thought worth remembering. Every time Browning fired, the bulrushes parted from the blast for quite a distance from the muzzle. To others this phenomenon meant nothing. But to Browning's mechanical mind it revealed a wasted, perfectly timed power source which could be utilized to operate the weapon's mechanism and produce sustained fire. Just as Maxim had observed the possibilities of the kick of a gun for harnessing the recoil, Browning likewise realized the potentialities of the muzzle blast—which at the time did no more than make a loud report. The keen observations of a man firing a high-powered rifle in tall rushes resulted in the experiments producing the first successful gas-operated automatic machine gun.

In order to ascertain the amount of power gen-



Browning's First Experimental Model of a Gas-Operated Automatic Firearm.

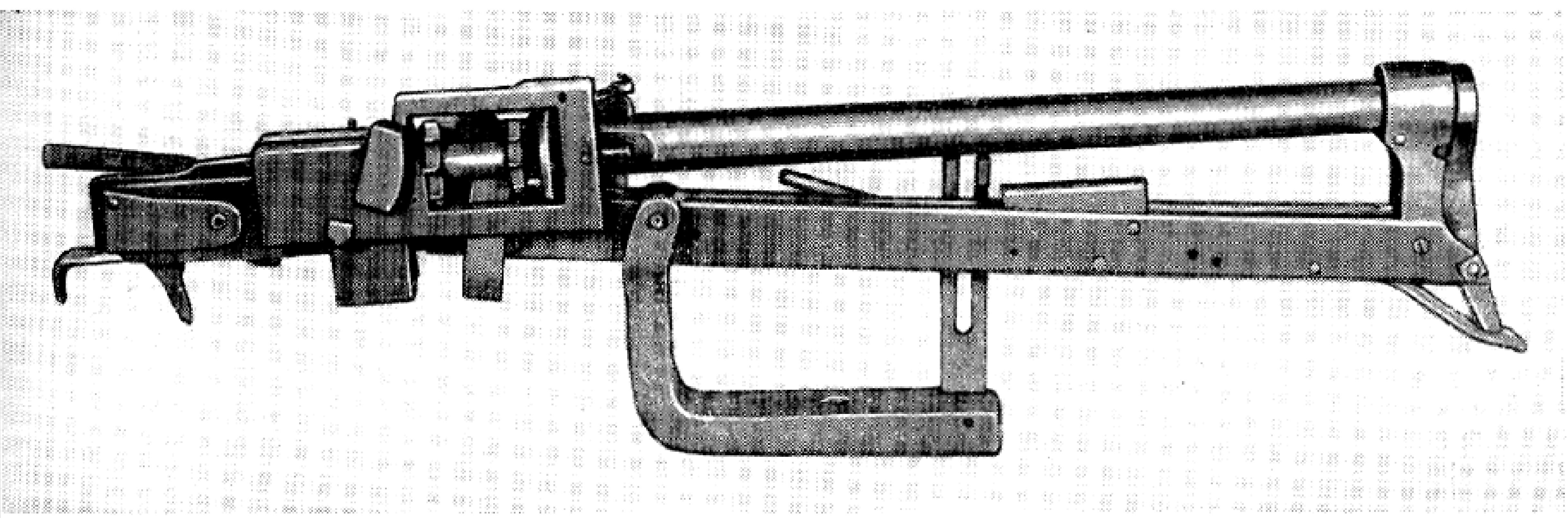
erated by the muzzle blast, Browning made a device in his shop to fasten to the identical rifle he had fired in the marsh. One inch in front of the muzzle he put a 4-inch square piece of iron weighing approximately 5 pounds. The iron block had a hole drilled in the center, which he adjusted until it was in alinement with the bore. By means of a long lanyard, he pulled the trigger. As anticipated, after the bullet had passed through the hole, the subsequent blast blew the iron block the full distance of the room.

He next made a concave cap of steel with a hole in the center to fasten over the muzzle of the rifle, and connected it by a hinged arrangement to the spring-loaded operating lever. When the bullet passed through the opening, the blast blew the cap down, pulling the loading lever forward. The spring returned the lever rearward to the locked position, and another pull of the trigger repeated the cycle.

This experiment was followed almost immediately by still another rifle modification. This time the rifle was magazine fed and rigged to fire full automatic. The barrel was tapped near the muzzle, and a gas piston was actuated while the bullet was just clearing the bore. At the completion of the cycle of extraction, ejection, loading, locking, and cocking, a built-in device seared off the piece. The action was continuous as long as the trigger remained depressed.

Such was the modest introduction of the world's first successful automatic gas-operated weapon. This unusual gun has been credited with firing 16 shots a second, using caliber .44-40 black powder cartridges.

Much more experimentation and hard work produced the basic design for the first automatic gas-operated machine gun to be developed by Browning. It was offered for production to the Colt's Patent Fire Arms Co. in a letter in Matthew S. Browning's own handwriting dated 22 November 1890.



Browning's First Gas-Operated Machine Gun.

2461 Washington Ave., Ogden — 155 Main Street, Salt Lake City. JOHN M. BROWNING, MATT S. BROWNING

Ogden Utah 22nd Nov. '90

Colts Pat. F. A. Mfg. Co.
Hartford Conn

Dear Sirs:

We have just completed our new Automatic Machine gun & thought we would write to you to see if you are interested in that kind of a gun. We have been at work on this gun for some time & have got it in good shape. We made a small one first which shot a 44 W.C.F. Ctge at the rate of about 16 times per second & weighed about 8#. The one we have just completed shoots the 45 Gov't ctge about 6 times per second & with the mount weighs about 40#. It is entirely automatic & can be made as cheaply as a common sporting rifle. If you are interested in this kind of guns we would be pleased to show you what it is & how it works as we are intending to take it down your way before long. Kindly let us hear from you in relation to it at once.

Yours very truly
Browning Bros

Original Letter from Browning Brothers to Colt's Patent Fire Arms Company, 1890.

"Dear Sirs:

"We have just completed our new automatic machine gun & thought we would write to you to see if you are interested in that kind of a gun. We have been at work on this gun for some time & have got it in good shape. We made a small one first which shot a 44 W. C. F. chge at the rate of about 16 times per second & weight about 8 #. The one we have just completed shoots the 45 Gov't chge about 6 times per second & with the mount weighs about 40 #. It is entirely automatic & can be made as cheaply as a common sporting rifle. If you are interested in this kind of gun we would be pleased to show you what it is & how it works as we are intending to take it down your way before long. Kindly let us hear from you in relation to it at once.

"Yours Very Truly,

"Browning Bros."

The gun was tested by the United States Navy as early as 1893. By 1895 it had been perfected to a point where it would successfully handle both the caliber .30-40 Krag (Army) and the 6-mm Lee (Navy) smokeless powder, rifle cartridges. Known officially as the Colt '95 model machine gun, it was promptly nicknamed by the service the "potato digger," on account of the unusual movement of the gas-actuating arm that swung in a half arc beneath the muzzle.

The following report was made by the Inspector of Ordnance to the Secretary of the Navy in 1896. It shows that the trend of the Navy was to get away from the manually operated machine gun and secure as soon as possible a reliable weapon capable of firing sustained bursts full automatic, at a minimum of 400 rounds actually fired during 1 minute of operation.

"The year has been an eventful one in machine-gun matters, and though at this date a final decision has not been reached as to which one of several competing guns is the most desirable for adoption as the standard naval gun, much has been done toward that end, and it seems probable that a few weeks at most will see the question settled.

"In the last annual report from this office three machine guns were named as being in course of development in this district for submittal to the naval board on machine guns; shortly afterwards, and before the August session of the board, the Pratt & Whitney Company suspended work on their gun, a two-barreled, crank-operated gun, on the Gardner system, having become convinced after long experiments that no crank gun could be made to handle successfully and safely the modern smokeless powder ammunition, owing to the danger from hang-fires. Repeated instances occurred of cartridges exploding after being entirely drawn from the gun, in rapid fire, and in one case a cartridge was discharged when partially out of the chamber, damaging the mechanism.

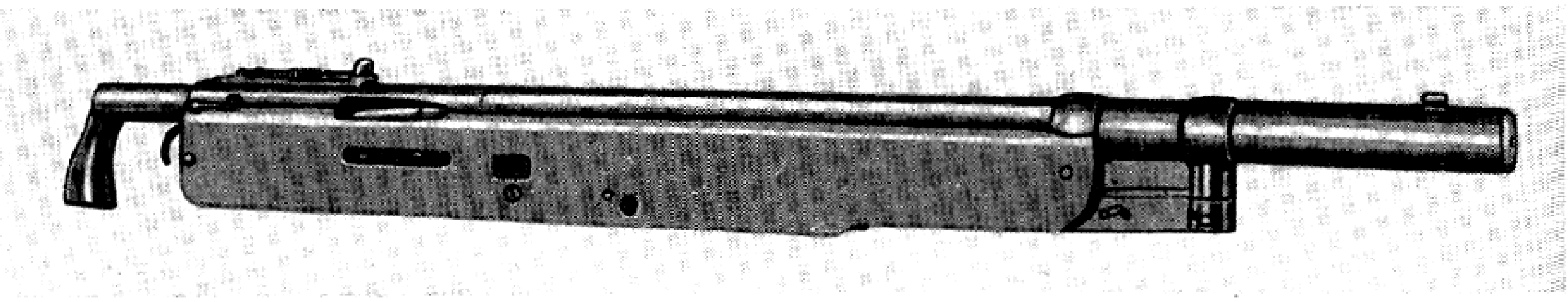
"The Gatling Gun Company, still having faith in the crank principle, and having met with gratifying success in handling .30-caliber ammunition, completed a gun of 6-millimeter caliber and submitted it in competitive trial to the Navy board.

"The Colt automatic gun was also completed and was tested by the board. Other guns submitted were the Accles Improved Gatling, the Maxim automatic, [and an automatic weapon produced by a French arms company].

"The board held several sessions, at which all these guns were tested, and in January, 1896, all tests having been completed, a report was submitted. Shortly after, 50 guns of the Colt automatic type were ordered from the Colt's Patent Fire Arms Manufacturing Company, and the Maxim and French companies informed that a second opportunity would be given them to exhibit their guns to the board before the remainder of the guns required were ordered.

"The Colt Company accepted the order for 50 guns, guaranteeing perfect operation with rimless cases (all competitive tests were with flanged cartridges) and a minimum uninterrupted speed of 400 shots per minute for one minute. Work was at once begun, and a model gun made, which has been tested and found to work in an eminently satisfactory manner, justifying the Bureau's conclusion that a successful automatic gun could be produced.

"Three guns have been completed, assembled, and provisionally tested. Lack of suitable ammunition has made it impossible up to this time to give any of these guns the exhaustive tests contemplated by the Bureau, or even to prove them for acceptance. It is hoped at an early date to



Colt Machine Gun, Model 1895.

receive a large shipment of Troisdorf powder, when sufficient ammunition can be furnished to complete the tests of the three finished guns. Thereafter the remainder of the order will be rapidly pushed to completion, a large percentage of the parts being already in hand.

"The Colt gun is exceedingly simple in construction, and has not more than one hundred separate parts, a surprisingly small number, considering the type. It has been designed with great care and with due attention to the often conflicting requirements of lightness and strength, so that with a maximum weight of 40 pounds no part, with the single exception of the extractor, has been broken in the course of a number of very severe tests.

"The rifling adopted is the same as that decided upon for the barrels of the new small arms. It is of pure Medford form, consisting of six grooves of a uniform depth of 0.004 inch, and having a twist of one turn in 7.5 inches. The life of this rifling has not yet been determined, but it is evidently considerably longer than that of the experimental rifling previously used, in which the groove was of slightly different form and of more rapid twist.

"A flat-leaf front sight has been adopted, which is grooved on each side, leaving a bead at the top, upon which the eye is quickly fixed without effort. The rear sight is a plain folding-bar sight with spring slide. It is marked for all ranges from 300 to 2,000 yards. In the course of the experiments for marking the sight several hundred shots were fired, with most gratifying results as to accuracy. The idea held in some quarters that the motion of the pendulum would seriously affect the accuracy of the gun has not been borne out by experience. The vertical jump-angle of the gun and service mount is only about 4′ of arc, and is practically constant in all ranges and at all rates of fire. On one occasion, in an ammunition test, 140 shots were fired rapidly at a 300-yard target; 2 sighting shots not considered, all the rest fell in a circle of 12-inch radius, the greatest lateral dispersion being about 7 inches. The gun was unclamped and in hand during this firing.

"The slight recoil of the automatic gun and the absence of strain on the mount are evidenced by the facts that it can be fired from the shoulder without inconvenience, that when placed in the saddle without a retaining pin and fired for several seconds the displacement is so small that the pin can usually be readily entered without moving the gun, and that when secured in the saddle, the tripod placed on a smooth platform, and the gun fired, there is only a slight rearward movement of the tripod after considerable firing.

"A tripod mount has been designed for use on shore, the pivot of the saddle being of such a diameter as to fit the adapters hitherto used for mounting Gatling guns in 1-pounder cage stands. The shore mount will weigh about 52 pounds. Two men will be able to transport gun and mount without inconvenience.

"With each gun and mount there will be furnished ten belts, each holding 250 cartridges, and a small box of accessories and spare parts. The accessory box and the jointed wiping rod will be secured to the tripod, and will thus always be at hand when required.

"In case the Bureau should, in the future, order additional guns of this type, a few minor improvements might be made. As at present constructed, the interior of the receiver is difficult of access, some other automatic guns being superior to it in this respect. It would not be a difficult matter to so alter the design that free access could be had into the mechanism without detracting anything from the strength of the frame. There are a number of screws used in the gun, which, though not particularly objectionable, as their removal is not often necessary, might be replaced by pins with locking devices. All pins could be brought to one or two standard sizes without affecting weight or strength materially.

"In addition to the 6-millimeter gun, the Colt Company has also perfected guns of the same type of other calibers for handling the following cartridges:

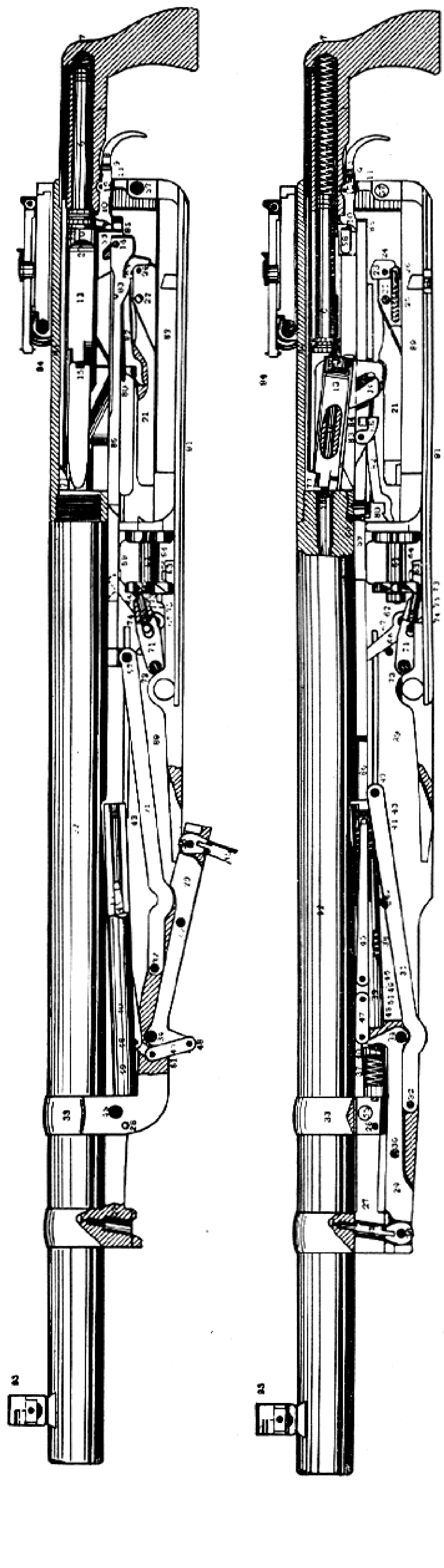
		Caliber
United States Army	inch	.30
Remington	millimeters	6
Mauser	millimeters	7.65
Mexican	millimeters	6.5
Austrian	millimeters	7 "

The Navy's order of 50 Colt weapons, which were delivered in 1897, represented the first purchase of an automatic machine gun by the United States Government. It is a matter of history that their use in the hands of the Marines saved the foreign legations in Pekin during the Boxer uprising.

In 1898 an additional 150 Colts were procured. The machine gun field, as far as the Navy was concerned, had been cleared of crank-operated guns. Browning had proved that the gas-operated automatic weapon was not only a possibility, but an accomplished fact. The Army, however, thought otherwise and kept the Gatling as standard equipment for another decade.

The model '95 consists of a heavy barrel attached to the breech casing which carries the mechanism for charging, firing and ejecting the shell. The loaded belts are contained in boxes to be attached to the gun casing so that the ammunition supply will not be affected by vertical or horizontal motion of the weapon. The mechanism is operated by the pressure of the powder gases in the barrel after the projectile has received its maximum velocity, and is done without injuring either the range or penetration. In the barrel to the rear of the muzzle a small radial vent opens downward from the bore. This is closed by a piston which fits in the gas cylinder surrounding the outer edge of the vent. The piston is pivoted to a gas lever in such a way that the latter adjusts itself to the gas cylinder. The lever swings in a vertical plane.

The small weight and bulk of the gun ren-



Section Drawing of Colt Model 1895.

dered it ideal for landing parties, since it could be carried by the individual soldier, or on a mount attached to the side of a landing craft.

On 20 April 1897 the auto-loading pistol was patented. It was the forerunner of the Army Colt caliber .45. In order to promote further his commercial models, Browning became connected with the Fabrique Nationale d'Armes de Guerre of Liége, Belgium. The first gun produced was a hammerless auto-loading pistol which made its appearance in 1900. Six years later a quarter million had been sold. Twelve years from the time the first weapon was produced, the millionth pistol was made. After this fact was engraved on the receiver, the weapon was presented to John M. Browning during the ceremony of conferring the title "Chevalier de l'Ordre de Leopold" by King Albert of Belgium. Unlike Maxim who renounced his citizenship to receive an equivalent British honor, Browning accepted it as one of the necessary nuisances accompanying success. But from that day on, the title, medal, and all lay unused in his desk drawer.

Of all the design problems that confronted Browning, producing an auto-loading shot gun was the most challenging; and its successful accomplishment in 1900 was his greatest pride. It was first manufactured in Belgium by the Fabrique Nationale, and later by American arms plants, as were his auto-loading rifles, including the high-powered and the numerous caliber .22 models. All these later Browning-designed rifles, manufactured originally in Belgium, were also made by the Remington Arms Co. of Ilion, N. Y.

About the only real purpose served by the Colt machine gun Model '95 was to introduce a full automatic weapon into equipment of American armed forces. Its use at Santiago de Cuba was limited to Navy landing parties going into action beside the Army's Gatlings under Lt. J. H. ("Gatling Gun") Parker. The first model was modified in 1902 and again in 1904.

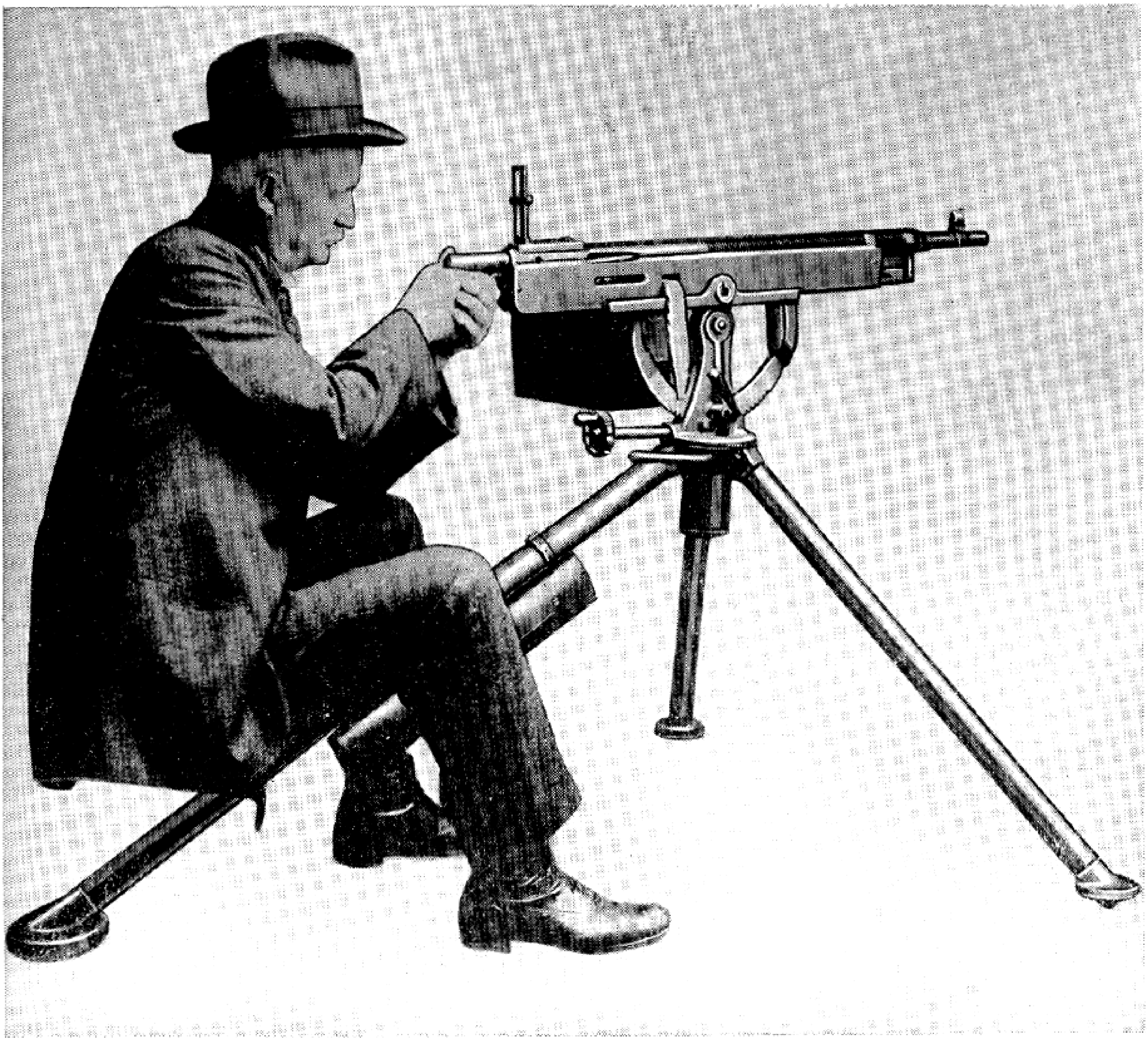
The modified Colt was purchased in considerable numbers by all the South American countries and by most of the great European powers. One of the distinguishing features of the early models was that no adjustments were to be made by the gunner, the weapon having been adjusted at the factory to shoot at a rate slightly greater than 400 shots per minute.

Cooling was dependent upon the heavy barrel construction. The system was inadequate in not permitting a sustained burst of undue length, nor could the weapon be fired with the gunner lying prone on the ground. The fore and aft sweep of the gas-actuated loading lever made this impossible.

To operate the weapon, the gunner pushes the brass tip of the loaded belt through the opening in the feedway and, at the same time, swings the loading lever downward and to the rear until it strikes the bottom plate of the gun. Upon release of the spring-loaded lever at the extreme end of the movement, it will return to its ready position, at the same time chambering the round, cocking the piece, and locking the breech. The safety latch is then pushed to the fire position and the gunner pulls the trigger actuating the sear. After the powder charge has exploded and the bullet has passed the orifice, the gases expand through the radial vent upon the piston in the end of the gas lever. When forced downward and to the rear, the latter opens the breech, extracts the empty case, ejects it, and feeds the incoming round into position in the carrier. The lever, returned by a spring, chambers the live round, closes and locks the breech, and in the final act of locking, releases the sear of the firing mechanism. The cycle continues as long as the trigger is held rearward.

The working parts were all readily accessible. One of the selling features of the gun was that the hammer allegedly pumped cool air into the chamber. Regardless of this exorbitant claim, it was considered necessary that the gunner unload the weapon immediately after firing, as the rapid heating of the barrel made it hazardous to leave a live round in the chamber following a burst of moderate length. This necessitated unloading the chamber at the end of practically every burst if the weapon was not to be put immediately in action again.

As a result of the Navy's successful use of the '95 model Colt in the Spanish-American War, the Army also became interested in the weapon. But it could not use the Navy's guns due to the difference in caliber between Army and Navy rifle ammunition. In December 1898 a joint



John M. Browning with the "Browning Peacemaker."

Army-Navy board met and recommended standardization not only of rifle cartridges, but of all small arms in the service. The report was as follows:

"The board is of the opinion that there are no conditions in the nature of the service peculiar to the Army, Navy and Marine Corps which require a different caliber for their small arms and machine guns.

"Since the board finds no sufficient reason for a different caliber of small arms and machine guns for the Army, Navy and Marine Corps the board is of the opinion that the same caliber should be adopted for these services, and since interchangeability of ammunition is the special advantage to be gained by the use of a single caliber, a standard and uniform cartridge to the extent of securing interchangeability should be adopted.

"As the board is of the opinion that there should be but one caliber of small arms and machine guns for the Army, Navy and Marine Corps, and as great numbers of satisfactory caliber .30 rifles are now in service in the Army and are being manufactured at a considerable daily rate, after large preliminary expenditures for plant, and as, under the prospective enlarged sphere of the Army's action and possible increase in numbers, it will require an immediate additional supply of such arms, the board is further of the opinion that the retention of the caliber now in use is at present imperative for the Army, and therefore, under their previous conclusions, it should also be adopted for the Navy and Marine Corps.

"The board, however, while recognizing the desirability of a uniform caliber for both services, does not deem it of vital importance, and is of the opinion that the change of the Navy caliber might well be postponed until it has been definitely settled whether or not it is advantageous to modify the Army cartridge by the use of a cannelured instead of a rim case.

"In considering a standard cartridge the board recognizes that the cannelured case is a simple one for small arms and machine guns, and its use in the Naval weapons of these classes has been satisfactory. It is further of the opinion that, if found practicable at moderate cost to adapt the present Army rifle to the use of such a case, a cartridge conforming in other external forms and dimensions to the present Army cartridge should be adopted as the standard and uniform small-arms cartridge for the Army, Navy and Marine Corps."

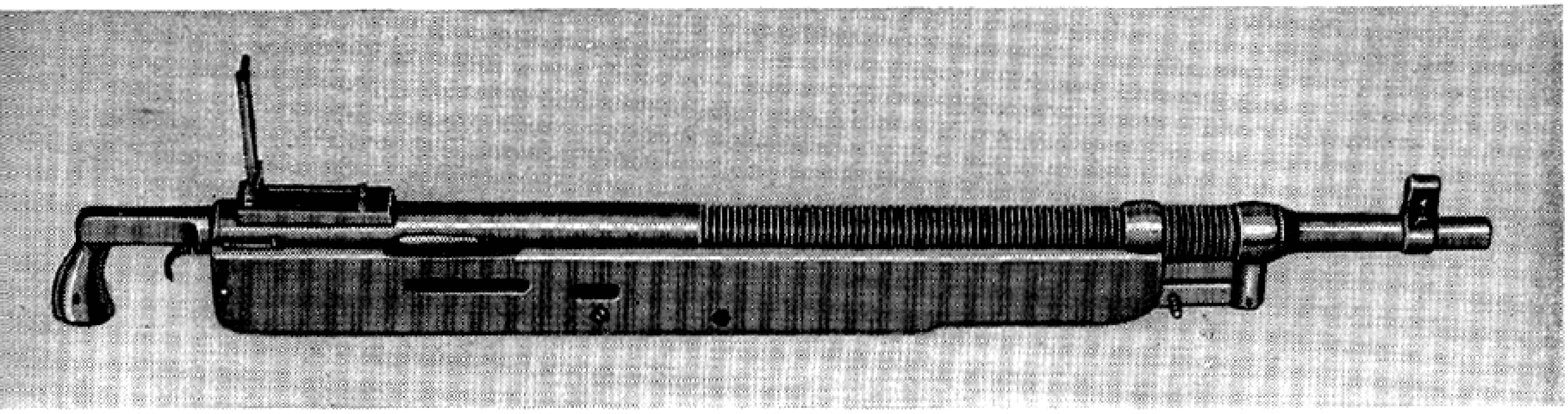
After the agreement to standardize all small arms and ammunition, the Navy ordered all its 6-mm guns rechambered for the caliber .30-40 Krag ammunition – making them practically identical with the gun in which the Army was interested. However, each service retained its own system of identification. The Navy continued to designate with Mark and Roman numeral; the Army with model and year. The Navy's 6-mm gun was known officially as the Colt machine gun, Mark I, and the modified weapon rechambered for the caliber .30-40 was called the Mark I Modification 1.

At a later date, when the Krag caliber .30-40 was dropped from the service in favor of the Springfield caliber .30, the Navy again rechambered the weapon to use the new service round. But, for reasons unknown, unless it was considered too obsolete to warrant the additional trouble, the Mark and Modification numbers were not changed. This is believed to be the only time a major power twice rechambered the barrels of an automatic machine gun while it was still in the status of being in active service.

While the Army gave it the designation known throughout the world, there is no record of its ever having officially adopted the '95 model Colt machine gun. Instead, the Gatling gun, after the successful demonstration at San Juan Hill, had a tremendous following in the Army. And while the Colt '95 was tested at regular intervals, and made a creditable showing in every instance, the Army's official stamp of approval was never given. The following report of a machine gun board at Springfield Armory to the Chief of Ordnance, United States Army, on 14 June 1895, is typical of the weapon's reception:

"The Colt automatic gun is an ingenious, compact, and relatively light arm. Its continuous automatic firing depends upon the action of the ammunition used. It is easily pointed by hand, and its fire is completely under the operator's control. Its rapidity of fire during the tests was about 100 rounds in 17 seconds.

"A perusal of the tests made shows that stoppages in the firings were experienced from various causes, necessitating in each case a recocking of the piece by hand, and in consequence it appears that the uninterrupted automatic firing of a belt of 100 or more cartridges is not apt to be obtained. The mechanism, composed of a large number of working parts and spiral springs, was prevented from working by such a small particle as the piece of brass punched out for the gas channel in a cartridge shell head, and as experience shows that pieces of the primer or cartridge shell, if detached from any cause, are apt to fall into the working parts, this is considered a serious defect. During the firings there was a constant vibration of the muzzle, and in general the elevation was increased, due, undoubtedly, to the action of the gases in escaping through the vent in the underside of the barrel and the repeated striking of the gas lever on the same point of the barrel when returned to its position by the gas-lever springs.



Colt Machine Gun Model 1895, as Modified in 1914.

"It is thought probably that the heat developed in a prolonged, continuous firing would so expand the gas cylinder and the piston on the gas lever as to interfere with uninterrupted automatic action, and that the continuous action of the gases on the head of the piston and also the striking of the gas lever on its return may so upset the piston as to have the same effect. The liability of the mechanism to derangement would require a gun crew equipped for and practiced in making repairs.

"The advantages of this arm are: Relative lightness, compactness, automatic action, ease of manipulation, complete control of the firing, small gun crew required, and absolute safety from hang fires.

"The disadvantages are: Numerous small working parts, dependency upon spiral springs, delicacy of mechanism, liability to be clogged by foreign particles, decrease in initial velocity due to loss of gases escaping through vent, vibration of muzzle and consequent inaccuracy, necessity of loading belts by hand before gun can be used, and frequent interruptions in automatic firing from various causes. The board is of the opinion that in its present form, as shown by the tests made, this arm is not suitable for ordinary service and has no place in the land armament.

"There being no further business before the board, it adjourned sine die.

"D. M. Taylor,
Captain, Ordnance Department.
"Jas. Rockwell, Jr.,
Captain, Ordnance Department.
"Jno. T. Haines,
First Lieutenant, Fifth Cavalry.
"Tracy C. Dickson,
Lieutenant, Ordnance Department.

"The foregoing proceedings and opinions are approved.

"A. Mordecai,
Colonel, Ordnance Department,
U. S. A., Commanding."

At the outbreak of World War I our unpreparedness made the Government disregard the fact that the Colt '95 was outmoded. Due to our deplorable lack of machine guns on entering the conflict, large contracts were given for the weapon. While it was admittedly obsolete in every respect, it still represented about the only machine gun with any chance of speedy delivery. Since Colt was tooled up for it and other companies were making a rechambered version for Russia, these firms would be able to turn out large quantities of the weapon in short order. The only change made in the weapon was that it was to have an interchangeable barrel and to identify this version it was known as the Mark III (Navy) or the Model 1917 (Army).

The Colt Co. supplied 1,500 of these weapons before the end of the war. But by this time recoil-operated machine guns (also a Browning design) were being delivered. They were so superior to the gas-operated "potato digger" that the latter was relegated to training uses only.

The Browning Model 1901 Machine Gun

American-made recoil-operated guns had their inception at the turn of the century. Like most machine gun designers, Browning determined that the cleanest, most efficient and practical principle for a high-rate-of-fire automatic weapon was the short recoil system. As early as 1900 he

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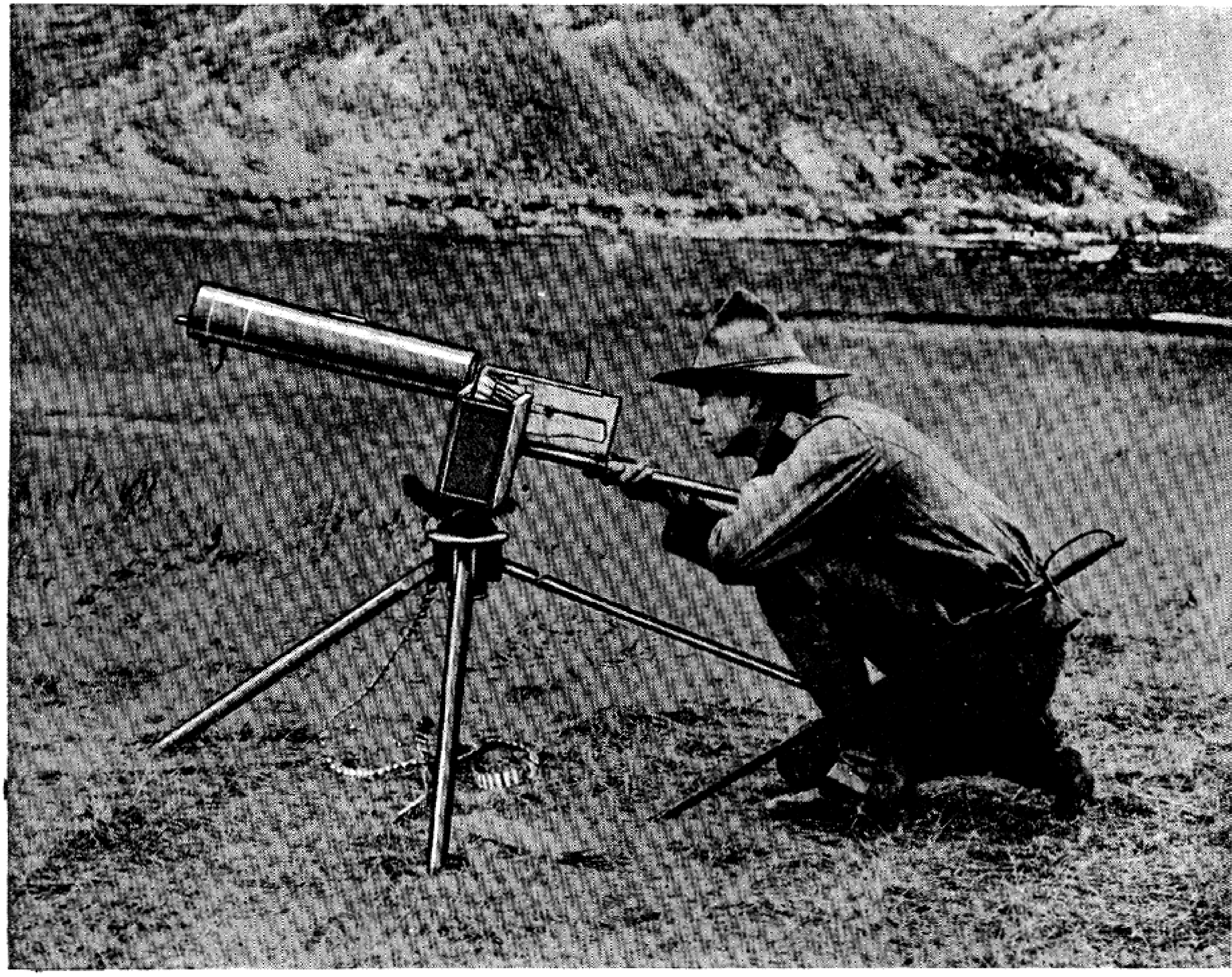


Marriner A. Browning, Son of Matthew S. Browning, Firing the Recoil-Operated Machine Gun, Model 1901.

filed application, and in 1901 was granted the patent for a short-recoil-operated water-cooled gun, incorporating all the basic features of the present line of Browning automatic arms.

Due to the lack of financial support from the United States Government for the development of an automatic weapon, he let this design lie dormant until 1910, as there was a ready civilian market for his hunting rifles, shot guns, auto-loading pistols, and high-powered weapons to keep him busy during this interval. But having reached the zenith in gun design for commercial purposes, he turned again to machine guns.

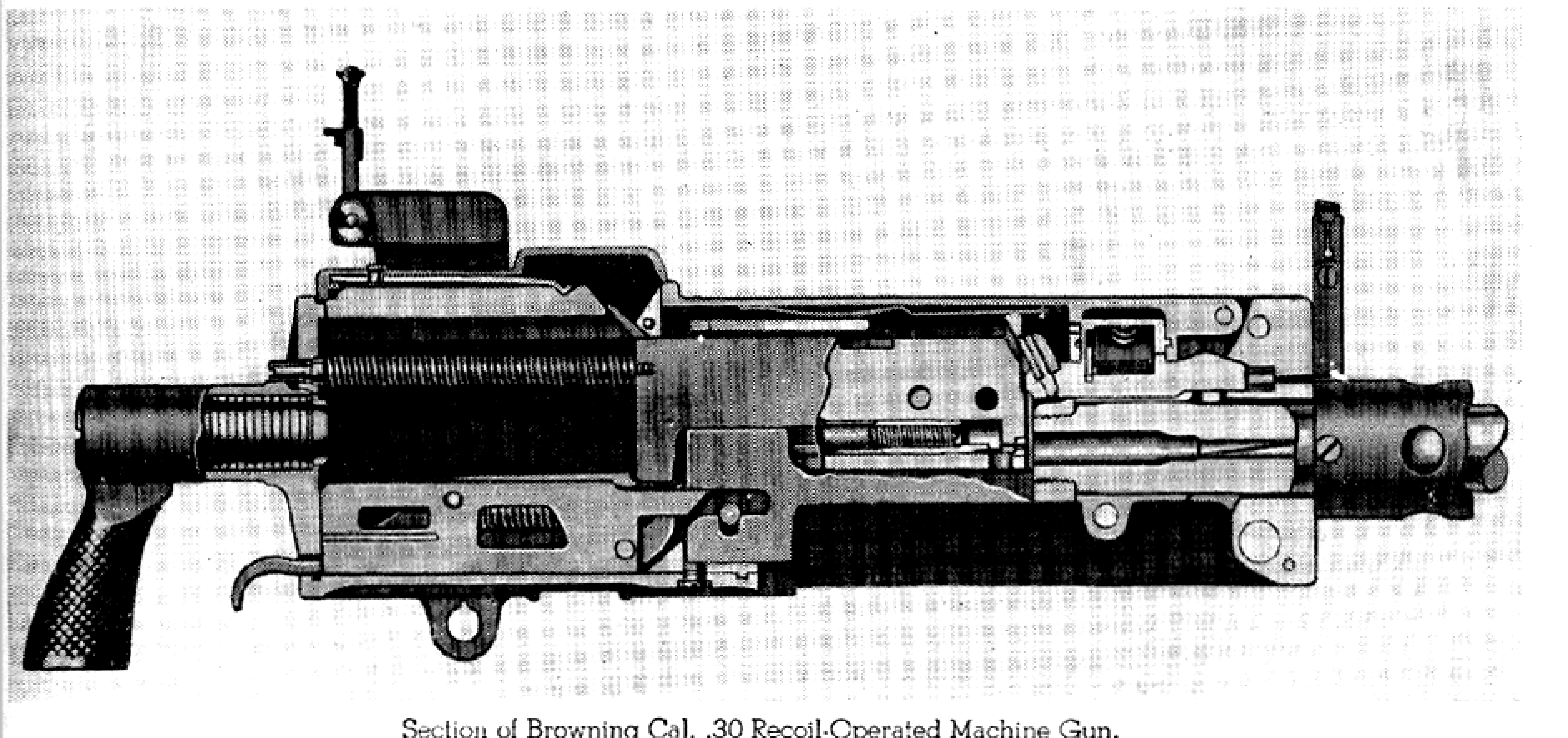
In case there is doubt that our present family of Browning machine guns is of such early origin, quotation is made from Browning's own description of the weapon's cycle of operation, written in 1900 (current nomenclature added in brackets):

"The operation is as follows: The belt, which contains cartridges, is fed into the opening . . . in the casing until the flange of the first cartridge in the belt enters under the hook of carrier [extractor claw] . . . and the second cartridge is just past the cartridge-feed stop [belt holding pawl] . . . Now grasp handle and draw the bolt back. As the bolt and barrel extension are in this position locked together by the locking-block [breech lock] . . . , the barrel will move back with the bolt, compressing both barrel [buffer] and bolt [driving] springs and cocking the hammer [striker], which is caught by both sears. The cartridge is drawn back by the hook of the carrier [extractor claw]. (It thus appears that the hammer [striker] cannot fall against the firing-pin except when the barrel is in its forward position, in which position the barrel and bolt are firmly locked together.) When the pin . . . of the locking-block [breech lock] reaches the downward incline . . . of the cam-groove [breech lock cam] in the casing [receiver], the locking-block [breech lock] will be forced downward, freeing the barrel from the bolt. The barrel is then thrown forward by the action of its spring [buffer spring]. . . . The pressure of plunger [cover extractor cam] . . . throws down the forward end of the carrier [extractor claw], causing the front of the cartridge to fall into the receiver [**T** slot] . . . so as to move forward below the cartridge-belt in line with chamber. The forward movement of the barrel is stopped by the barrel-latch [accelerator claws] . . . engaging the projection . . . of the barrel extension [shank].

"The projection . . . on the barrel extension or receiver at the same time locks the bolt-latch [accelerator] . . . so that the bolt cannot be engaged thereby. . . . The feed-lever . . . , feed-slide . . . , and feed-pawl will have been moved to the proper position . . . by the backward movement of the cam. . . . If the grasp on the bolt be now released, the bolt [driving] spring will throw the bolt forward, carrying the cartridge into its chamber in the barrel. When the bolt is near the limit of its independent forward movement, the cam . . . on its under surface engages the arm [claw] . . . on the barrel latch [accelerator], thus forcing down said latch [accelerator] and releasing the barrel to continue its forward movement under the influence of the barrel [buffer]-spring.

"The barrel and bolt then move forward together, and as pin . . . of locking-block [breech lock] . . . rides up the incline in the casing . . . the locking-block [breech lock] is forced into engagement with the groove [locking recess] . . . in the bolt, so that the barrel and bolt are locked together. When about at the limit of its forward movement, the forward end of extension . . . of the barrel-piece strikes sear . . . and disengages this sear from the hammer [striker], leaving the sear . . . in engagement and the gun in position for firing by bearing on the trigger . . .

"When the gun is fired and as long as the trigger is held down and cartridges supplied, the automatic action of firing will be continued in manner as has been explained, . . . the sear . . . then alternately holding and releasing the hammer [striker]. The action of the bolt moves the cartridge-feed [belt feed lever], as has been explained, and as long as there are cartridges in place in the belt the firing will continue unless trigger . . . is lifted, when the firing will cease.



Section of Browning Cal. .30 Recoil-Operated Machine Gun.

The cartridges are fed forward by the bolt almost their whole length while the barrel is held back by the barrel-latch [accelerator]. This allows them to feed into the receiver just forward of the retracted position of the carrier [extractor claws] with little lost motion.

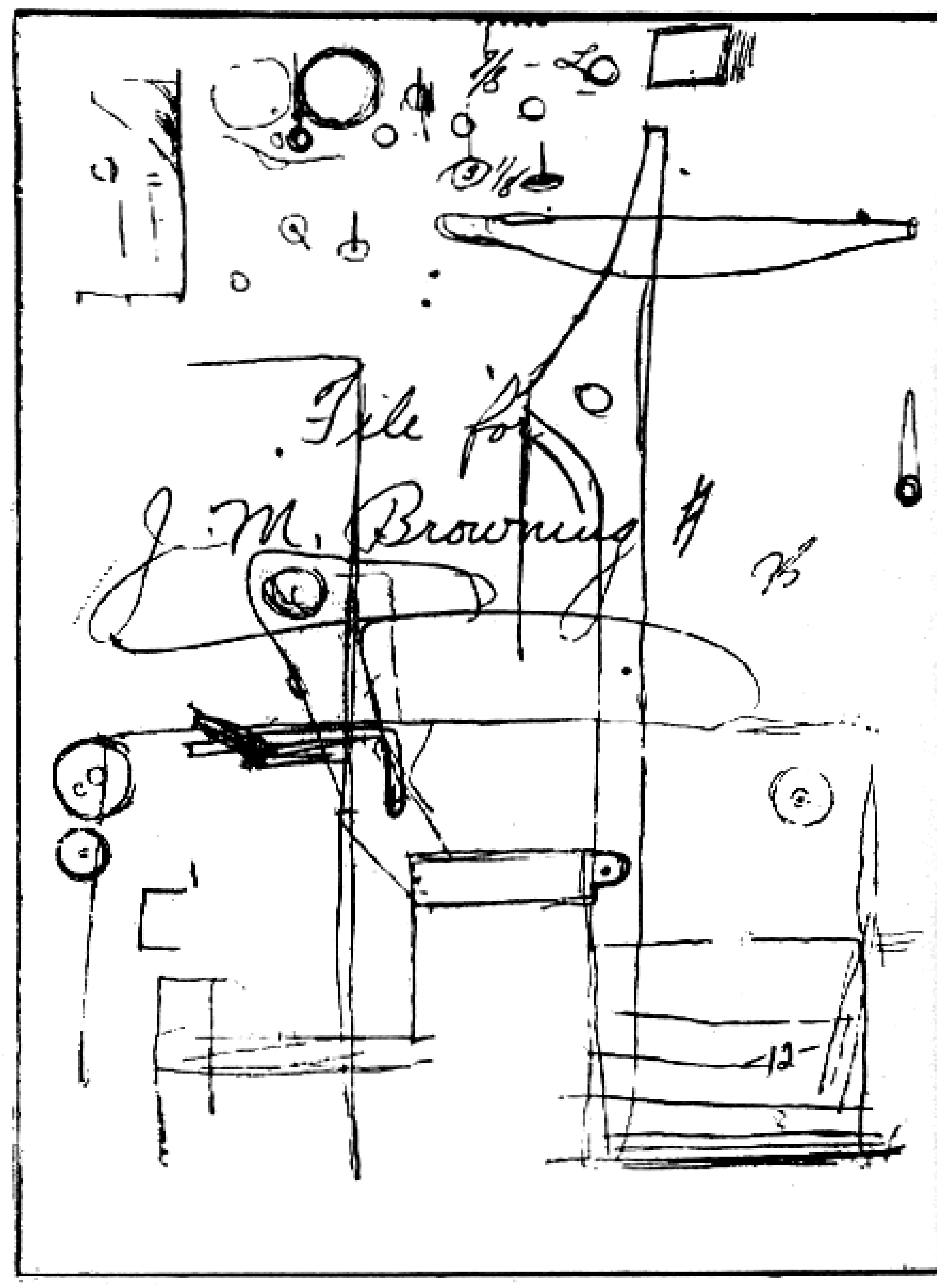
"As the barrel moves forward while the bolt is held back by the latch [accelerator claws] . . . a stud [combination extractor feed cam and ejector] . . . on the left-hand side of the barrel extension, which extends into the path of the cartridge (the bolt being grooved to allow it), comes into contact with the rim of the fired shell as it is held back by the ejector and ejects the shell. . . . When the gun is fired, the barrel recoils to a position further back than when the bolt is drawn back by hand, and by its action on the cushion-rocker [accelerator body] accelerates the backward movement of the bolt, while its own motion is gradually checked by the rocker [accelerator body], as explained.

"The bolt . . . has a bayonet-catch groove . . . cut around the bore, in which the bolt-[driving-] spring . . . is inserted, and the rod, . . . which guides the spring, has a pin . . . projecting at one side, which pin can enter said groove, so that when the spring is compressed and the rod forced into the bore of the bolt with its pin in the groove a partial turn of the rod will lock the spring in place, when the rear cover [back plate] . . . can be lifted if in place . . . or can be applied to the casing if said cover has been removed and can then slide down over the rod. Then by drawing the bolt back, the rear end of rod will project through the rear cover, and by turning the rod the spring is released and bolt thrown forward. The rear cover [back plate] is retained in place by the rod . . . projecting through a hole in said cover . . . "

The weapon ejected the empty cartridge case from an opening in the right side of the receiver, and not through the bottom. This feature, however, had no bearing on the basic principles of operation used throughout the development of the later guns. The absence of a rear buffer should also be noted; but since high rates of fire were not demanded, it was of small consequence. The barrel buffer and driving springs were adequate in stopping the recoiling parts and returning them to battery at a speed considered reasonable.

Browning's description of the preceding cycle of operation was written when there were only 45 states in the Union and 3 years before the Wright brothers made the first flight in an airplane. This serves as a yardstick by which to measure just how far this remarkable man was ahead of his time with his basic machine gun principles.

The water-cooled prototype of 1910, built on the 1900 specifications, was proofed at Ogden, Utah, and worked reliably. Browning thought that it needed only refinement and increased rate of fire. The first change was to do away with side ejection of the empty cartridge. Though dependable, it presented the problem of hot empty brass flying at a right angle, thus limiting the area in which another gun could be operated.



A Drawing from J. M. Browning's Drafting Board. Browning Often Worked from Freehand Sketches Made on Wrapping Paper.

It was solved by cutting an opening in the bottom of the receiver just forward of the breechlock cam. The incoming brass, forced down by the extractor, knocked the empty case straight down to the ground. The last round fired was struck by the ejector tip and thus cleared the gun.

In order to return the bolt to battery faster and smoother, a buffer filled with horn fiber discs served the two-fold purpose of absorbing the surplus energy and bouncing the bolt back at a greater speed. Browning also did away with the hammer method of firing, replacing it with a two-piece firing pin that had a sear notch on the rear, and had sufficient weight to serve as both striker and firing pin.

A trigger bar was added which allowed the operator to actuate the sear from two positions. The nose of the bar, upon being depressed, pushed the sear down out of engagement with the sear notch on the aft end of the firing pin.

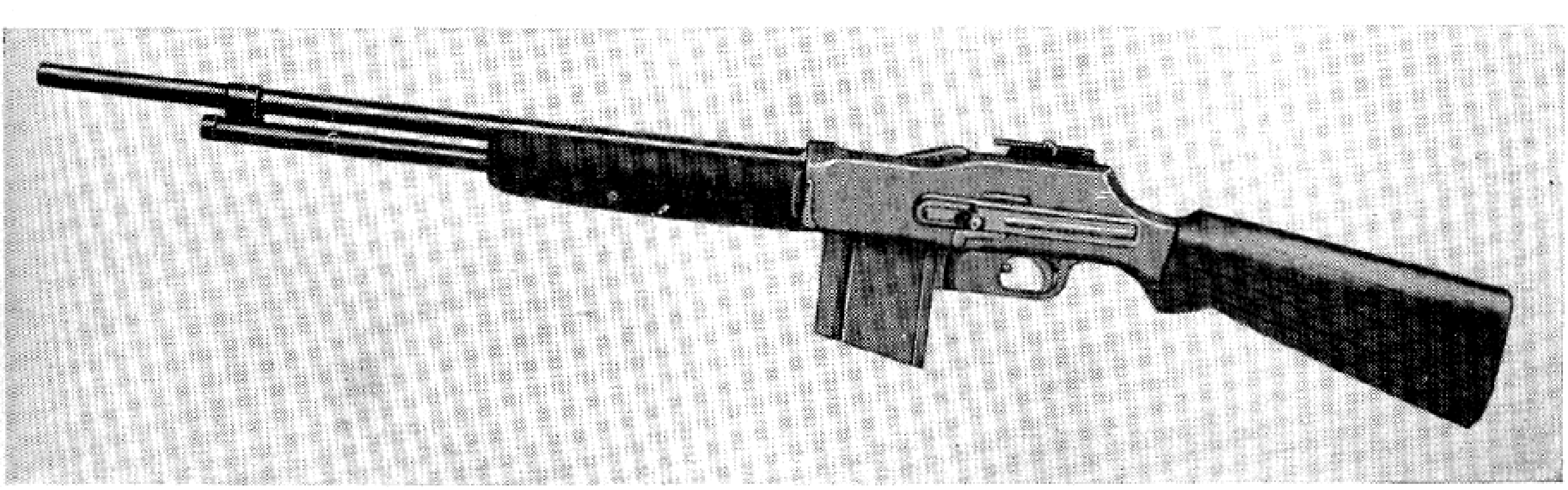
Other minor improvements included the use of breech lock depressors to assist in disengaging the breech lock from the locking recess in the bottom of the bolt. However, all these changes were merely refinements. Not a single basic feature was used that John M. Browning did not already have in his 1900 design. The reliability of the mechanism and its freedom from adjustments enabled the individual soldier to obtain a large volume of fire without much preliminary training and its simplicity of construction from a manufacturing standpoint was quite acceptable. Browning, on his own initiative, developed and improved the weapon until he corrected practically all the minor defects.

Browning Guns in World War I: B. A. R. and Browning Machine Gun Model 1917

The United States showed no interest in machine guns until after we were officially at war with Germany, at which time Browning, along with other inventors, was asked to submit weapons with a view of adoption. It is true that there had been earlier trials of various machine gun mechanisms of both American and foreign manufacture. But nothing resulted from them except a passive interest by our Government. Thus, although we had practically two years to prepare after the start of World War I before we entered and it was almost a foregone conclusion that we were to be a participant, there had been no effective machine gun program in spite of the early demonstration by Germany as to the deadly employment of the weapon.

Machine gun development in this country floundered on one thing only: Those in authority could not make up their minds on what was wanted. Had they come to some happy conclusion as to what weapon would be adequate, there would have been no machine gun problem to face on 6 April 1917. On that afternoon the headlines proclaimed that a state of war existed between the United States and the Imperial German Government. But the public was not told of a confidential report issued the same day to the military high command that to fight this strictly machine-gun war there were on hand only 670 Benét-Merciés, 282 Maxims, Model 1904, and 158 Colts, Model '95.

In other words, we had a total of 1,100 of what

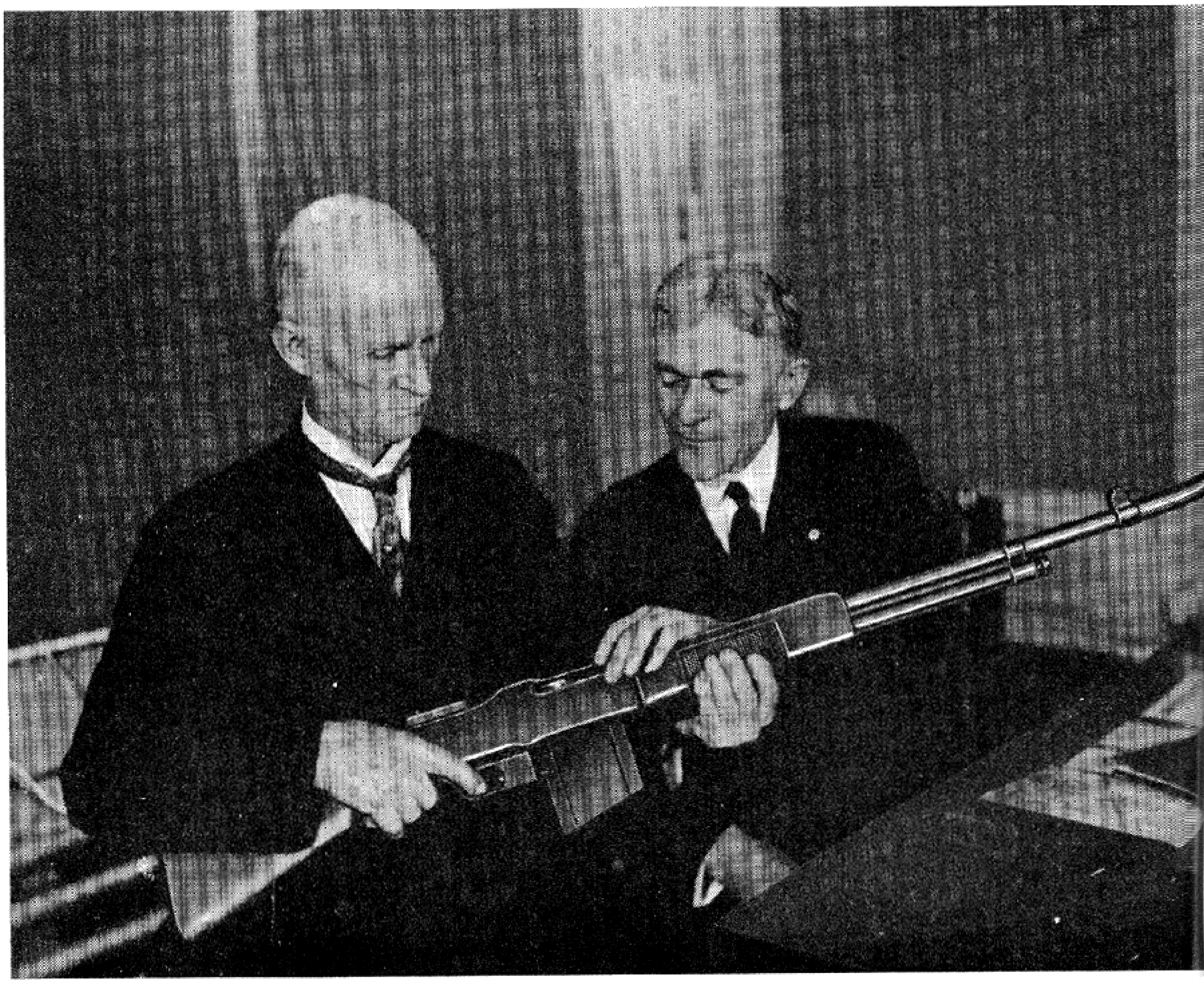


The Prototype Model of the B. A. R.

could be called machine guns (if one was generous enough to include the gas-operated, lever-action Colts, and the outmoded Benét-Merciés), while our requirements were at the time conservatively estimated at no less than 100,000 machine guns. Germany, upon entering the war over 3 years before, had done so with 12,500 highly improved Maxim-type guns with an additional 50,000 under construction. And she only needed to have each of her ordnance plants manufacture a moderate number each year to possess a staggering total at this period of the war.

In order for the United States to participate in the war with a semblance of machine gun armament, it was finally agreed, after still more debate, that until we did put into production something of our own design, our forces sent overseas would be armed with whatever the French had to offer. The arms sold us, as can be easily understood, were their second best. The fact remains, regardless of how unpleasant it may be, that the country which originated and showed the world how to produce this deadly instrument actually entered the war with a most obsolete assortment of machine guns. They would have been more in keeping with the armament of revolutionists in a banana republic than as weapons of soldiers representing one of the richest and most progressive nations on earth.

The first French machine guns used to arm American troops were chambered for the Lebel 8 mm rim-type cartridge, necessitating the issuing of two different types of cartridge by our



John M. Browning Examining One of His Automatic Machine Rifles in 1918 with Mr. Burton, One of Winchester's Experts.

supply department, one for machine gunners, another for riflemen. And as they invariably operated together as a unit, the logistics involved certainly should have given much aid and comfort to the enemy.

During the prewar period of indecision, John M. Browning personally brought to Washington, D. C., for purposes of demonstration, two weapons, the heavy (water-cooled) machine gun and the machine rifle (to be known later as the B. A. R.). These were both chambered to take the standard Springfield rifle cartridge known throughout the service as the .30/06.

The B. A. R. (Browning Automatic Rifle) had been designed as an answer to the demand for "walking fire"—thought to be so necessary to the individual soldier in trench warfare. The rifle can either be fired single shot or be converted instantly to full automatic with a maximum rate of 480 shots per minute. It is gas actuated, air cooled and employs a 20-shot magazine that can be emptied in 2½ seconds. The unloaded magazine can be detached and a fresh one put in its place in about the same length of time. Three orifices are on the gun to insure smooth functioning. The weapon's seventy pieces can be completely disassembled and assembled in 55 seconds.

The rifle is designed to be carried by the advancing infantryman with the sling over his shoulder, allowing the butt to be held firmly against the hip. When necessary to fire a burst, the safety switch is moved to "Automatic," and as long as the trigger is held the weapon will continue firing.

The operating mechanism is rear seared. The trigger releases the bolt to go forward. The latter strips the round from the magazine and starts to chamber it. When two inches from battery, a circular cam surface on the bottom of the bolt lock begins to ride over the rear shoulders of the bolt support, camming up the rear end of the bolt lock.

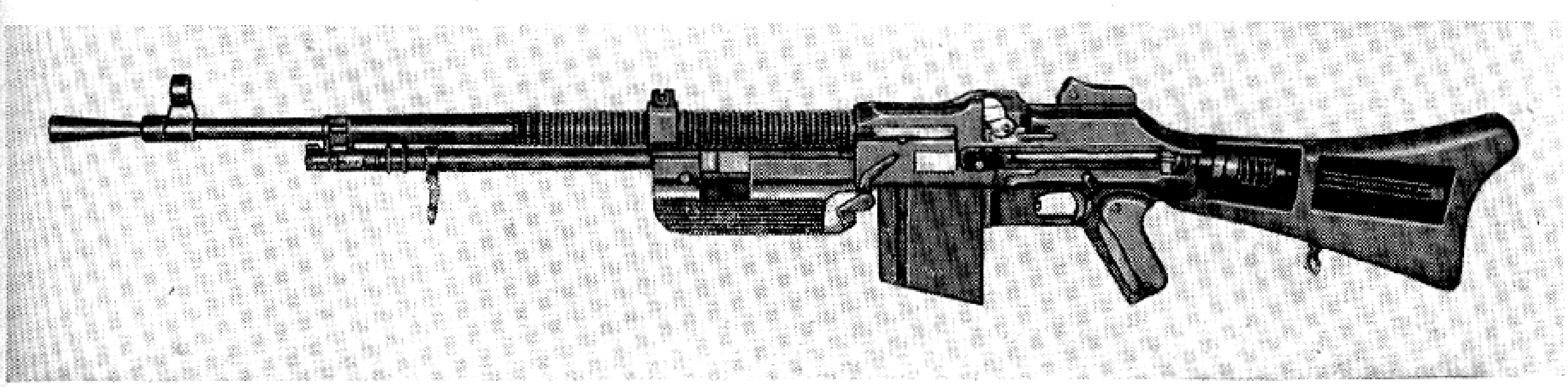
As the link pin rises above the line joining the bolt and hammer pins, the bolt lock is alined with its locking recess in the receiver and pivots about the bolt-lock pin. The hammer pin on its link revolves, forcing upward the bolt lock. The rounded surface of the lock slips over the locking shoulder in the "hump" of the receiver and provides additional thrust, forcing the bolt all the way into battery.

This final act removes the obstruction from the firing pin, exposing it to the center rib of the hammer. On the final movement forward of the slide, the hammer drives the firing pin into the primer exploding the powder charge in the cartridge. All counter recoil is ended when the slide strikes the shoulder at the rear end of the gas cylinder tube.

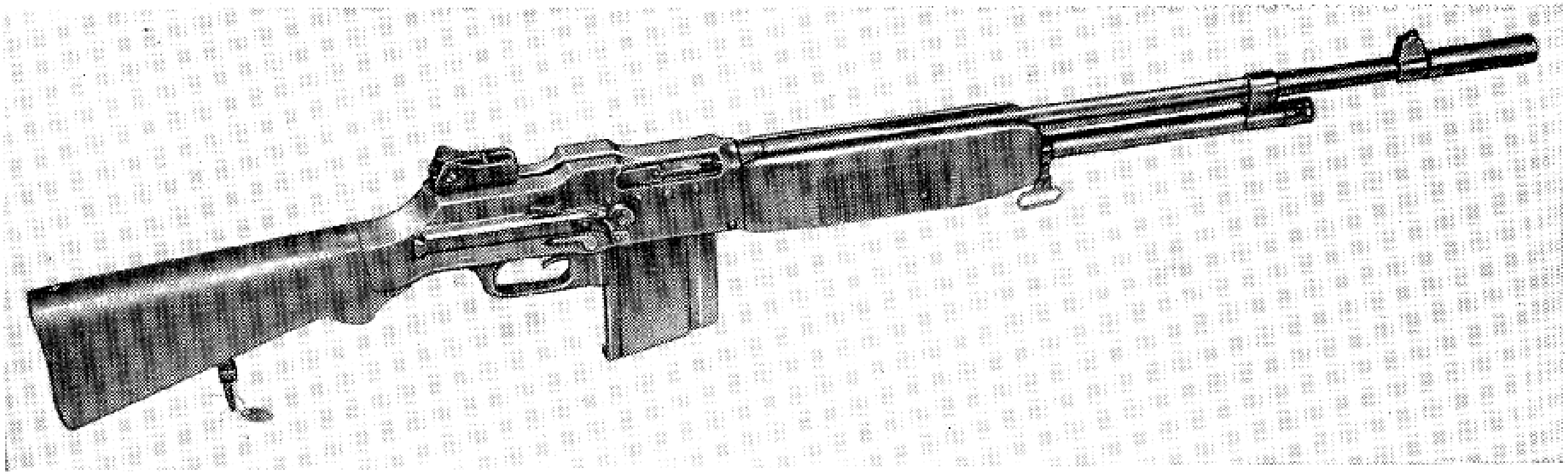
Prior to the bullet's clearance of the bore, the gases pass through a port 6 inches from the muzzle, expanding in the cylinder and impinging on the piston head. This sudden blow forces the piston to the rear.

The initial backward movement of the slide cocks the hammer before moving either the attached bolt lock or bolt. The circular cam on the lower part of the bolt lock, operating in conjunction with the rear shoulders of the bolt support, produces a leverage that loosens the empty case in the chamber. This initial extraction occurs before the weapon is fully unlocked.

After the piston has carried the slide rearward, the gas is exhausted through six ports located at the rear of the gas-cylinder-tube brackets. Two rings on the piston prevent the gas from returning through the cylinder tube.



A Sectionalized B. A. R., Cal. 7.92 mm, of Polish Manufacture.



B. A. R., Cal. .30, as Standardized for U.S. Service, Serial Number 5.

When the recoil has reached one-fifth of an inch, the breech pressure is low enough to allow the bolt to be safely unlocked. At this point the link is compelled to revolve forward about the hammer pin, drawing the bolt lock down clear of the "hump" in the receiver. A cam slot in the bottom side of the bolt lock comes in contact with the firing-pin lug, drawing the tip of the firing pin away from the primer.

After the piece unlocks, the empty case is carried rearward on the face of the bolt, held there by the extractor. When the base of the cartridge strikes the ejector, the extractor serves as a pivot point to throw the brass through the slot in the right side of the receiver. As the cartridge case passes through the opening, the brass strikes the outside frame and is deflected to the right and forward.

At the end of the extreme rearward travel of the bolt, the recoil spring is fully compressed, storing energy for the return movement. The sear nose is now in position to catch in the notch at the underside of the slide and hold the mechanism back under spring compression ready for the next pull of the trigger. If the trigger is still held to the rear, the weapon continues the cycle of operation.

The first public firing demonstration of the B. A. R. and the water-cooled machine gun took place on 27 February 1917 at a location outside the city limits of Washington, D. C., known as Congress Heights. It was witnessed by 300 people including men of high rank in our own military service, many Senators and Congressmen, members of the armed services from Great Britain, France, Belgium, and Italy, and representatives of the press. The latter wrote much about the exhibition. They gave a glowing account of the reliability and tremendous firepower of both weapons and painted verbal pictures in the local papers of how a hundred men advancing with these weapons firing full automatic would literally sweep an enemy out of the way. The only feature they seemed to forget was that though war, at this point, was practically inevitable, the superb weapons demonstrated were the only ones in existence and were a long way from mass production.

The successful exhibition at Congress Heights, however, did create an interest that encouraged Browning to continue personally to improve and function fire his water-cooled gun at the Colt plant until he was satisfied that it was ready for endurance trials. The Government had adopted the B. A. R. from its initial showing at Congress Heights, but felt that a machine gun of the water-cooled type should be tested more thoroughly because of the more rigorous treatment given this type of weapon. In May 1917 he brought his heavy water-cooled gun to the Government Proving Ground at Springfield Armory for an official test. It showed a reliability that was amazing for a newly introduced weapon. A total of 20,000 rounds was fired without a malfunction or broken part at a cyclic rate in excess of 600 rounds a minute.

After the splendid performance of the weapon, Browning decided to test it further and fired an additional 20,000 rounds. All 40,000 cartridges were expended without the failure of a component part. This was such an unusual performance for a new weapon that it aroused great in-

Browning Machine Gun, Model 1917, Cal. .30, as Introduced to the Service in World War I.

terest and some skepticism among its most ardent backers.

In order to show that the gun was not especially prepared for the test, a second weapon was used that not only duplicated the original trial, but bettered it by operating continuously for 48 minutes and 12 seconds. This was accomplished by having available sufficient belted ammunition for this phenomenal burst.

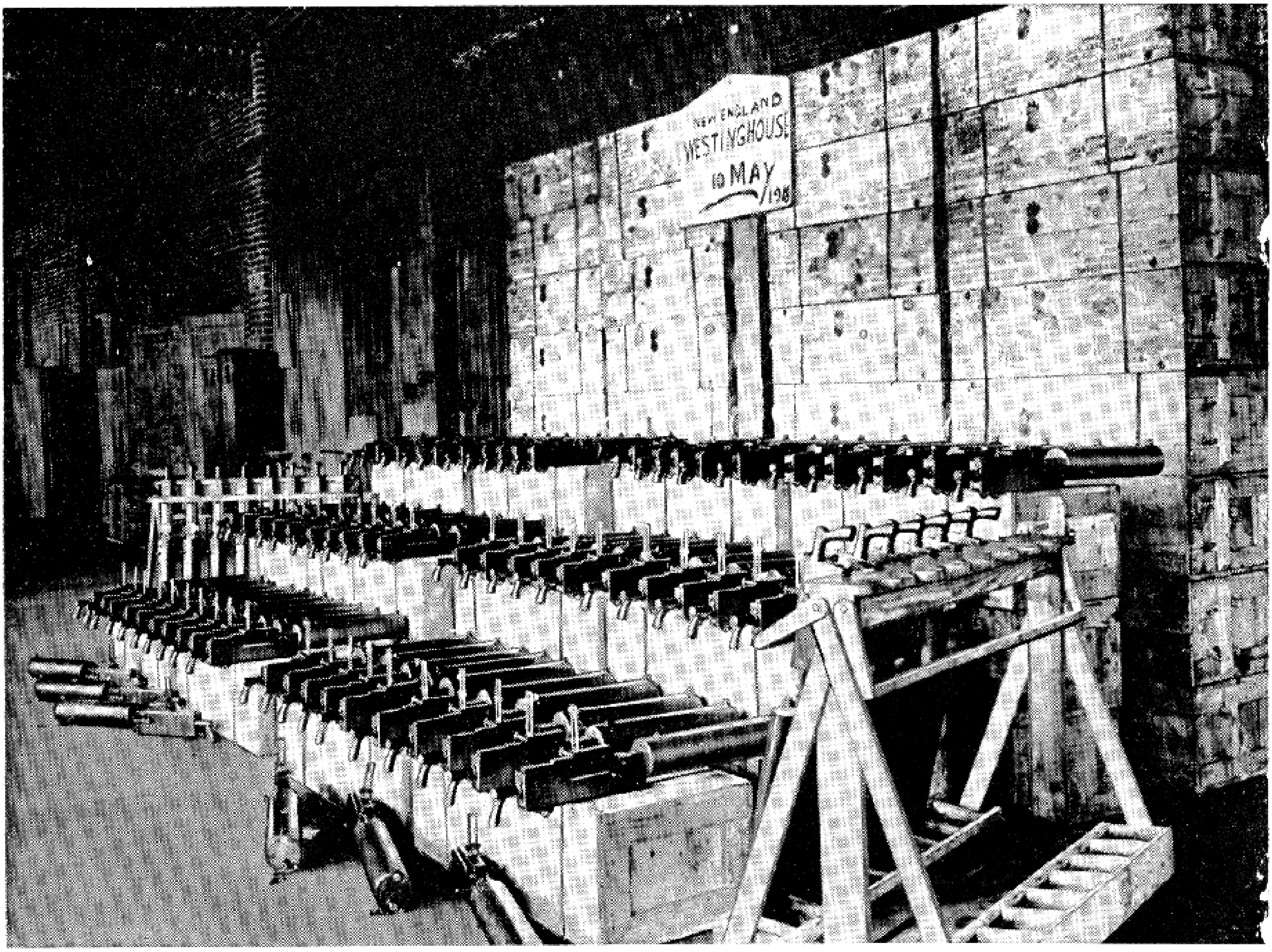
Following this excellent demonstration, the board of five Army officers and two civilians appointed by the Secretary of War to study the problem of machine gun supply recommended for immediate adoption the water-cooled Browning, pronouncing it and the previously accepted B. A. R. the "most effective guns of their type known to the members."

The outstanding features were reliability and simplicity of design. The officers who demonstrated the weapons showed that it was possible for the operator, while blindfolded, to take them down and reassemble them in a matter of minutes. This was so impressive that all machine gun schools adopted the blindfold test as a "must" in their courses of instruction.

The easily constructed mechanism was a great selling point for the Government, as it appeared possible to get the weapons into mass production quickly. Nothing was more important at this critical stage.

After the hasty adoption of the Browning automatic machine gun and the machine rifle, it was quite apparent that no single manufacturing plant was capable of taking care of the vast war need for these weapons. The Colt's Patent Fire Arms Co., which had an exclusive concession to manufacture the weapons under the Browning patents, agreed to sell its rights to the Government. By July 1917 it delivered prepared gages and drawings that other companies could work from in producing the guns.

During July and August 1917, more than 2



Westinghouse Production of Model 1917 Cal. .30 Browning Machine Guns.

months after our entry into the war, a survey was made of facilities and plants thought capable of turning out the water-cooled version in quantity. The Colt Co. established a plant at Meriden, Conn., for the manufacture of 10,000 guns. In September 1917, Remington Arms Union Metallic Cartridge Co. of Ilion, N. Y., was given a contract to produce 15,000. On 1 January 1918, the New England Westinghouse Co. was approached concerning its availability to construct 20,000 and a contract was agreed upon on 10 January 1918.

The Westinghouse production schedule proved to be very outstanding. In 29 days a hand-made pilot model had been constructed, and in 63 days the first gun came off the assembly line. Some 3,500 rounds were fired through this gun without a single malfunction or stoppage. And at the time the Armistice was signed 9 months later, this plant was producing 500 guns a day.

From the quantity standpoint Westinghouse was the most prolific in the manufacture of this machine gun. It was the middle of May before Remington began to deliver the completed weapon, having been delayed due to a previous Russian contract. Colt, strange as it may seem, was the last to come into production, as it was late in June 1918 before its Meriden plant started to deliver the guns. The company's time had been largely occupied by the preparation of mechanical drawings and the manufacturing of precision gages for the other plants, and by its earlier contract with the British for the making of the Maxim-Vickers machine gun.

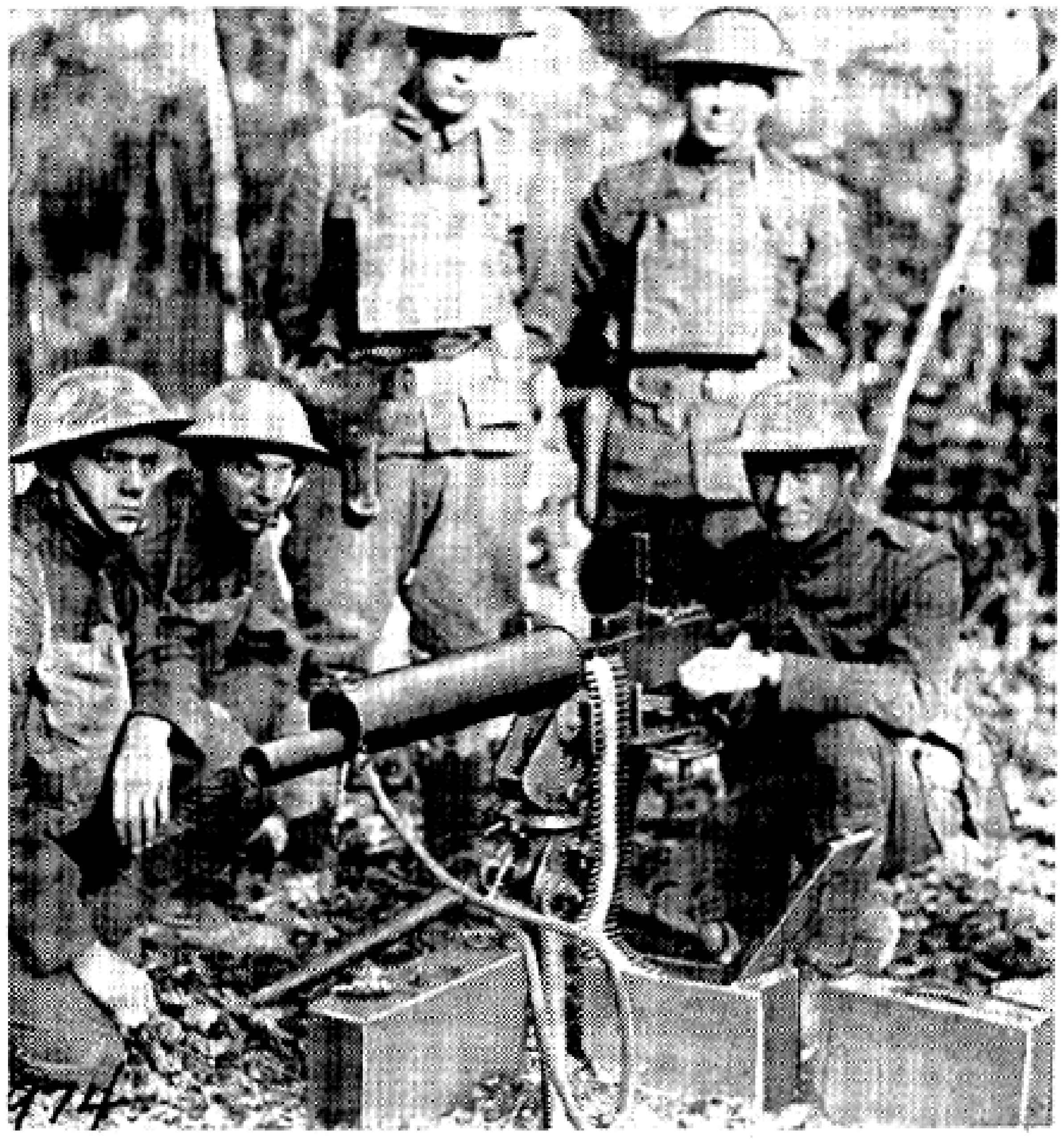
The final production schedule illustrates how some forethought on what was needed would have found us properly prepared for war. For, once put into operation, the wheels of industry started a constant flow of these weapons from the plants. By the end of June 1918, Westinghouse had a cumulative production of 2,500 and Remington a production of 1,600 weapons. As of 1 August both plants had made a few under 10,000; 2 months later, they had turned out 26,000. And when the Armistice was signed, the three companies had sent from their proof ranges nearly 43,000 machine guns of this type, divided as follows: Westinghouse, 30,150; Remington, 12,000; and Colt, 600.

While these figures are most impressive, it can be readily seen that this stupendous effort was practically worthless as far as the war effort was concerned. The dates of delivery were far too late to get the weapons into the hands of our troops in France, who were still armed with the French and English war surplus. Great emphasis has been placed on the impressive number of Browning machine guns made during World War I, but those who have boasted most of this accomplishment have negligently failed to mention the fact that these guns arrived too late to offer more than a token demonstration against an already defeated enemy. Our allies, though impressed by the clean lines and simplicity of construction of the Browning automatic machine guns, never considered them as having been battle tested.

The first of these weapons sent overseas were routed to machine gun schools to acquaint the soldier with the much publicized American product that would rid him of the French arms. They met with the enthusiastic approval of all who viewed them. Requests came from the Allied high command to speed up delivery so as to have their presence felt at the front. The war ended, however, before we had equipped even a small portion of our own Army.

First combat use of the Browning automatic machine guns was on 26 September 1918 by a small detachment of the 79th Division. The following report was sent General Pershing by the commanding officer of this detail:

"During the 5 days that my four guns were in action they fired approximately 13,000 rounds of ammunition. They had very rough handling due to the fact that the infantry made constant halts, causing the guns to be placed in the mud.



Lt. Val A. Browning, Son of John M. Browning, in France Instructing Troops in the Use of the Browning Machine Gun, Cal. .30.

The condition of the ground on these five days was very muddy, and considerable grit, etc., got into the working parts of the guns. Guns became rusty on the outside due to the rain and wet weather, but in every instance when the guns were called upon to fire, they fired perfectly. During all this time I had only one stoppage, and this was due to a broken ejector."

Only after Browning's guns had been officially adopted by the United States Government and production had reached its peak, did a conference take place between representatives of the War Department and agents of the J. M. & M. S. Browning Co. in regard to royalties.

The Government representative was asked what he thought would be a fair remuneration for the use of all Browning patents on machine guns and the caliber .45 auto-loading pistol. When he suggested a certain sum, the Browning Co.'s agent stated that his firm's instructions to him were to allow the Government to set its own price and to accept this cheerfully without hesitation or further bargaining. The records reveal the settlement amounted to less than one-tenth the amount our government usually allowed its inventors.

The Secretary of War, upon hearing of the generous terms the Brownings had agreed upon as a settlement, sent John M. Browning the following letter in expressing the whole country's gratitude, not only for his invaluable contribution in the field of weapon design, but also for his patriotism in accepting such a modest return on the products of his genius.

"WAR DEPARTMENT
"WASHINGTON

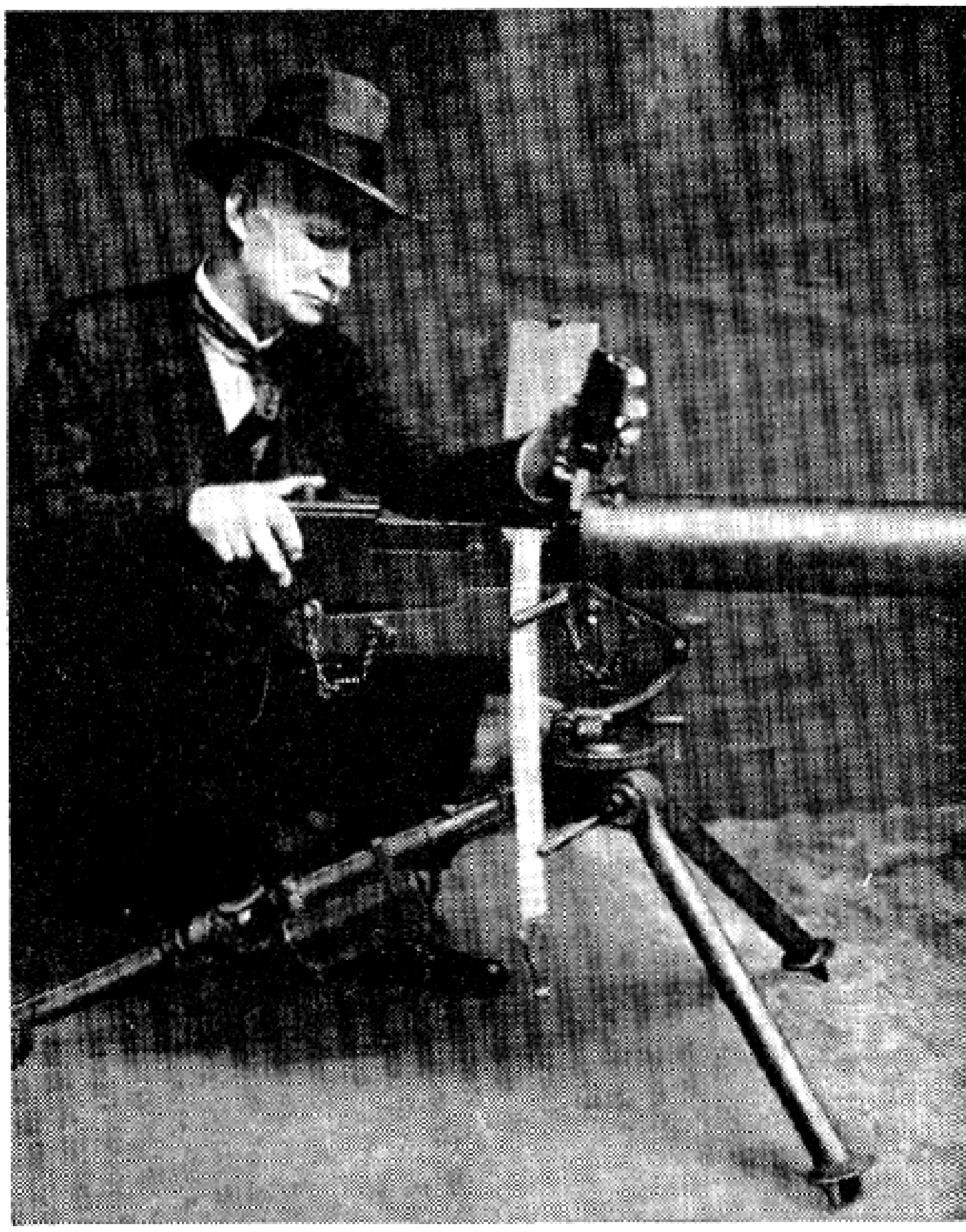
"NOVEMBER 13, 1917.

"MY DEAR MR. BROWNING:

"I have learned from Major Little of the patriotic and generous attitude taken by you in the negotiations for the use of your patents of light and heavy machine guns in this emergency, and beg leave to express my appreciation of it.

"You have performed, as you must realize, a very distinct service to the country in these inventions, and contributed to the strength and effectiveness of our armies. You have added to that service by the attitude you have taken in the financial arrangements necessary to make your inventions available to the Government.

"Cordially yours,
(Signed) "NEWTON D. BAKER,
Secretary of War."

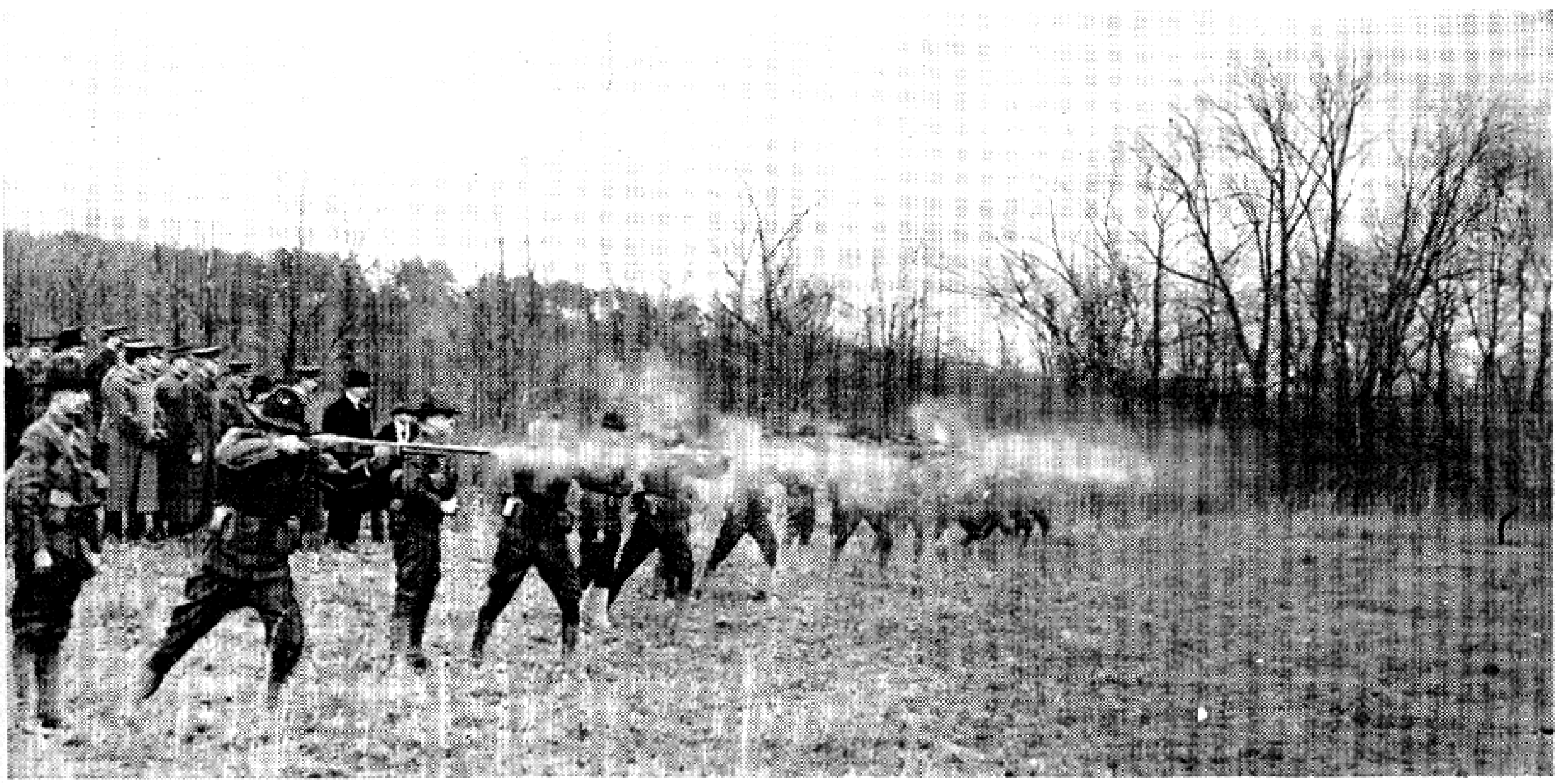


John M. Browning with His Cal. .30 Machine Gun.

While the production effort in turning out these arms was most commendable, the major weakness of the system of mass production manifested itself. All identical components are constructed with a manufacturing tolerance of within a few thousandths of an inch. Once tooled up, if an error is made, thousands of weapons would be turned out with the "built-in" malfunction. Correcting an inherent defect in design sometimes resulted in an expenditure of time and money greater than the original cost of manufacture.

This was most certainly the case with the 1917 model gun; and while its use was very limited in World War I, it is indeed most fortunate that the gun did not see too much service. The receiver of this mass-produced weapon was found to have a weakness in the bottom plate, caused, not from faulty design, but from choosing an inadequate metal. The mistake could have been prevented had time permitted more strenuous endurance firing of sample weapons taken from random lots. Such a part failure necessitated the construction of a piece known as a reinforcing stirrup that fitted over the affected spot on the outside of the receiver. Over 25,000 guns were modified by this addition in one year, and this and other hand work required as much time and expense as did the construction of the gun.

The production of the B. A. R. followed a similar pattern. Browning carried on most of his early development on the machine rifle at the Colt's Patent Fire Arms Co. Later, Winchester gave valuable assistance in connection with the preparation and correction of the drawings, adding many refinements to the gun. Winchester was the first to start manufacture on this model. Since the work did not begin until February 1918, it was so rushed that the component parts of the first 1,800 to be put out were found to be not strictly interchangeable. Production had to be temporarily halted until the required manu-



A Demonstration of the B. A. R. in 1918.

facturing procedures were altered to bring the weapon up to specifications. At the end of the war the Winchester Co. was producing 300 B. A. R.'s a day. A total of 63,000 items was canceled at the time of the Armistice.

The Marlin-Rockwell Corp. intended originally to use the Hopkins and Allen Co. plant for the construction of this weapon, but found that a contract for making rifles for the Belgian Government fully occupied its facilities. The corporation then acquired the Mayo Radiator Co.'s factory for use in its contract to produce the B. A. R. The first gun from this source was made on 11 June 1918, and by 11 November 1918 the company was turning out 200 automatic rifles a day. The postwar cancellation was 93,000 weapons.

The Colt Co., because of the heavy demands of previous orders, produced only 9,000 B. A. R.'s. The combined daily production by all companies was 706 and a total of approximately 52,000 rifles was delivered by all sources.

In July 1918 the B. A. R.'s arrived in France in the hands of the United States 79th Division, which was the first organization to be equipped with them and took them into action on 13 September 1918. The 80th Division was the first American Division already in France to be issued the weapons. It is an interesting fact that First Lt. Val Browning, son of the inventor, personally demonstrated the weapon against the enemy.

The B. A. R. was more enthusiastically received in Europe than the heavy water-cooled gun, and requests for purchase by all the Allied Governments were made immediately after it arrived overseas. The French Government alone asked for 15,000 to take the place of the inferior machine rifle, then being used by both French and American troops. The latter weapon was found so unreliable that many were actually thrown away by troops during action.

However, the war ended so soon after this that the bulk of the American forces were still equipped with machine guns supplied by the British and French.

Browning Caliber .50 Machine Gun

The Browning caliber .30 machine guns had scarcely been introduced overseas when a larger weapon was demanded by the commanding officer of the American Expeditionary Forces, Gen. John J. Pershing, who had observed the rapid advances of the British and French in raising their machine gun caliber from .303 and 8 mm to caliber .50 and above. This change was considered vital in order to be able to penetrate the armor that was beginning to make its appearance on combat vehicles, tanks, and in some cases, the individual soldier. The smaller bullet was no longer considered completely effective against such targets.

At the United States Army machine gun school at Gonducourt, France, the officer-in-charge, Col. John Henry Parker, had noted the deadliness of the 11-mm incendiary, armor piercing bullets used in lately developed French weapons to penetrate armor and ignite hydrogen-filled observation balloons. He learned from a liaison officer that a French proving ground had two prototype machine guns, entirely new in principle, that successfully fired a bullet and powder charge even larger than the 11-mm one.

Colonel Parker, always a man of action, detailed Capt. Henry B. Allen to look into the situation and secure as much information as possible. The weapons were located at Bourges Arsenal and arrangements were made for Captain Allen to take one of the guns to the United States for study.

The American Army's ordnance engineers had tried earlier to meet the increased caliber demand by rechambering a caliber .30 heavy (water-cooled) barrel to take the French 11-mm cartridge. The attempted quick-fix met with only fair success, because of the great difference in the ballistic characteristics of the two cartridges that were to operate the same mechanism. Nevertheless the Army Ordnance Department gave an experimental order to Colt for eight guns to be rechambered in this manner for the 11-mm shell.

General John J. Pershing, Whose Specifications Resulted in the Cal. .50 Machine Gun.

By this time the French gun secured by Captain Allen had arrived and, after being thoroughly checked, it was decided that its velocity was too low to meet General Pershing's demands. He had specified that the bullet should weigh not less than 670 grains with a muzzle velocity of at least 2,700 feet per second. The French ammunition could not approach this and all work on machine guns to fire 11-mm cartridges was consequently dropped.

As early as July 1917, John M. Browning, using the facilities of the Colt plant, undertook the problem of increasing the caliber of his machine gun, while keeping its simplicity of construction and all basic operating features.

The Winchester Repeating Arms Co., in cooperation with Browning, attempted to develop a suitable cartridge. Winchester, forced by the ever-present time element, scaled up the present caliber .30/06 case, but put a rim on it in hopes it could be used in both the machine gun and the clip-fed, belt-action, anti-tank rifle it was manufacturing at the time.

When the specification for this ammunition was delivered to General Pershing, he cabled the Ordnance Department on 18 July 1918 rejecting the Winchester cartridge, and ordered that the case be immediately redesigned to be rimless.

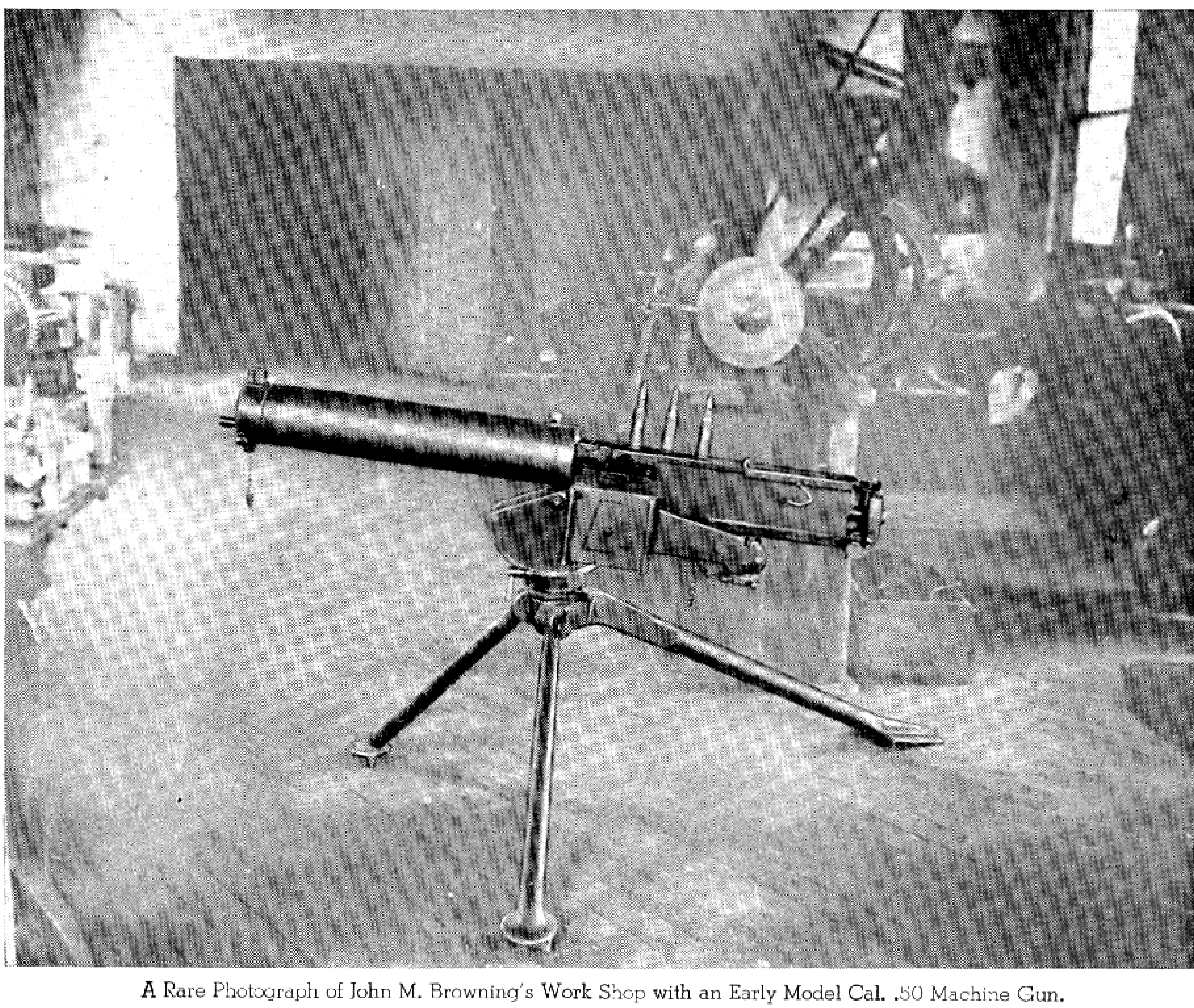
Winchester followed instructions and sent a dummy round for Browning to use in his mock-up, then under way at the Colt plant. This was a prototype that retained all the mechanical features of the caliber .30 gun, but possessed larger physical proportions to stand the increased powder pressures.

To expedite the project, Browning took his original gun to the Winchester Co. for experimental single-shot firing in order to determine quickly a balanced load that would give the greatest velocity and the minimum strain on the component parts. The work progressed so well that although the weapon was originally started at Colt's, he decided to stay on at Winchester to develop it.

On 12 September 1918 Browning received from the Colt Co. all the parts it had completed to date, allowing him to assemble finally the first caliber .50 machine gun. Winchester agreed to start the construction of six more guns. This was deemed to be a sufficient number to permit the endurance tests that are necessary to detect and eliminate the various errors of design in any new weapon.

On 15 October 1918 the first caliber .50 machine gun was ready for the proving ground. Upon its initial attempt the weapon fired 877 rounds in bursts of 100 to 150 rounds each. The rate of fire was under 500 rounds per minute. The five and a quarter inch cartridge had a 707-grain bullet that developed a velocity of less than 2,300 feet a second. This velocity was also under the minimum set by General Pershing.

Impressed by the test, the Engineering Division of the Office of Chief of Ordnance recommended that Winchester be given an order for 10,000 guns. The original model was water cooled and had only a 30.5-inch barrel, the longest that Winchester was then equipped to rifle. The Ordnance Department was assured that a better balanced powder charge and a longer barrel would bring the velocity up to the required specifications and that this would be accom-



A Rare Photograph of John M. Browning's Work Shop with an Early Model Cal. .50 Machine Gun.

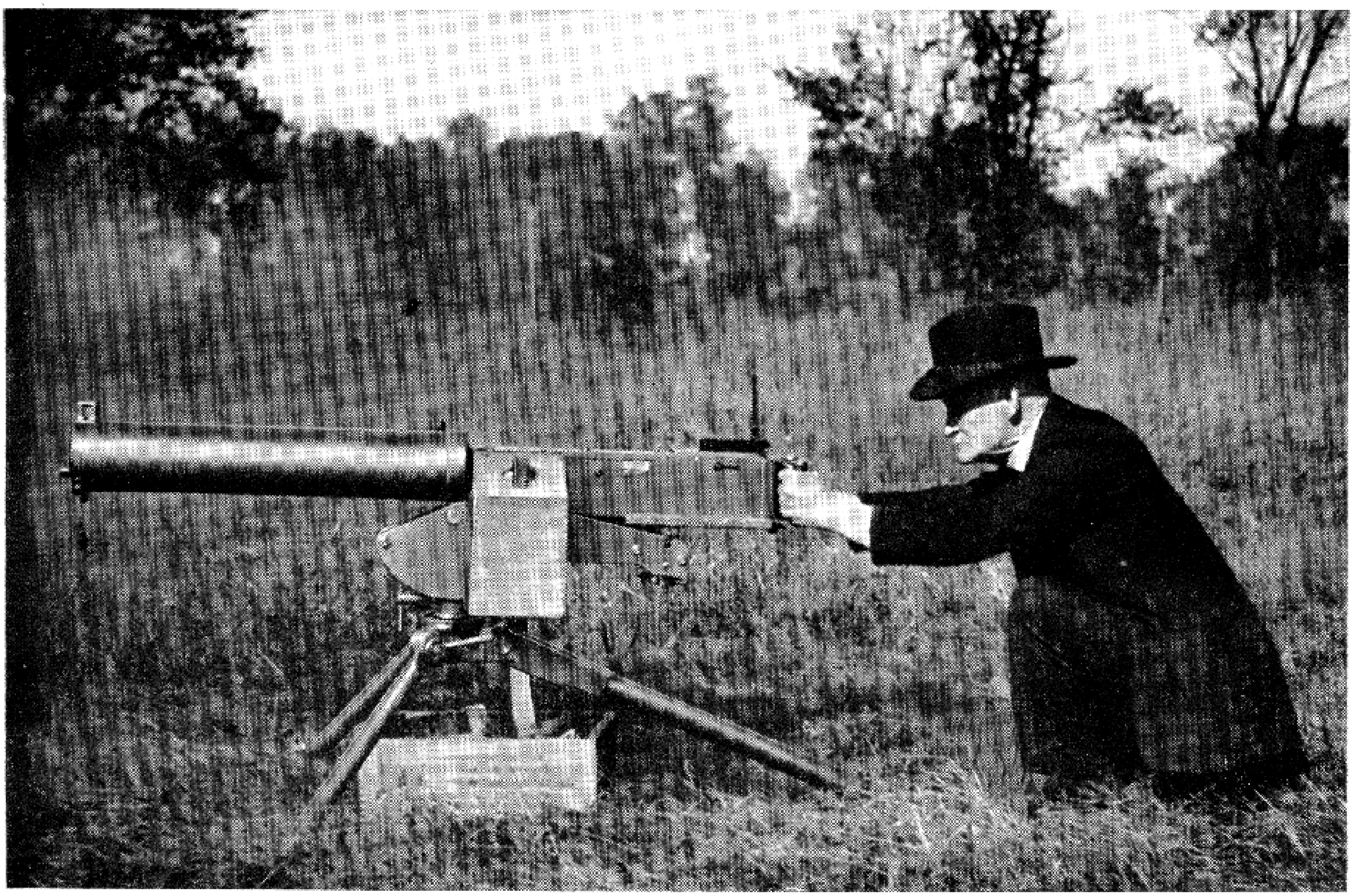
plished long before the delivery of the weapons on order.

The gun, in later tests conducted by the infantry, was found to be extremely difficult to keep on a target when fired full automatic, as the energy developed was so much greater than that of the smaller bore weapon. It was practically impossible to hold the gun down for horizontal fire. The weight of the gun and tripod was about 160 pounds, a fact that made quick mobility extremely difficult. For these reasons, strictly as an infantry arm the weapon did not meet with approval. And for tank use it was not overly successful, since the rate of fire was too slow for anti-personnel use and the bullet was too small to penetrate the thicker armor on the late model tanks. Before the weapon had gotten too far along in development, a few German anti-tank rifles were captured, together with some 12.7-mm ammunition. It was found that the Germans were getting a muzzle velocity in excess of 2,700 feet a second with an 800-grain bullet that would penetrate one inch of armor at 250 yards.

Not to be outmoded before completion, Winchester immediately increased the penetration requirements of the caliber .50 under development to conform to the identical ballistic properties of the German anti-tank rifle cartridge.

One important deviation that Browning made from the caliber .30 mechanism was in the addition of an oil buffer. It was employed for a dual purpose: first, to absorb the excess energy of the recoiling parts resulting from use of an increased powder charge; and second, to provide a method of regulating the firing speed. The oil buffer tube could be turned to any required position for opening or closing the valve. When the oil flow was restricted, the buffer absorbed more recoil and reduced the rate of fire.

On 1 December 1918 the Ordnance Department decided that all future development of the caliber .50 ammunition would be done at Frankford Arsenal instead of at the Winchester plant.



John M. Browning Firing His Cal. .30 Machine Gun in Colt's Pasture.

Products of John M. Browning's Genius.

This did not take effect immediately, as Winchester continued to furnish caliber .50 ball ammunition to the Government all through 1918 and 1919, until production at Frankford reached a point where it was felt that it could take over. The Arsenal did very little to alter Winchester's established load and weight dimensions for the powder charge and projectile that in turn had been copied from the German 12.7-mm anti-tank rifle cartridge. The latter developed a maximum chamber pressure of 52,000 pounds and a muzzle velocity of 2,750 feet per second.

Browning incorporated a few minor features in this weapon that are not to be found in his small caliber automatic machine guns. For instance, a latch located at the upper rear of the receiver securely held the bolt in the rear position. In lieu of the pistol grip of the smaller gun, the caliber .50 was provided with a double spade grip attached to the back plate. The back plate also housed the bolt latch release and the thumb piece that actuated the trigger bar. When the weapon was fired from the latch-back position, thumb pressure released the latch mechanism, allowing the bolt to drive forward under compression from the driving springs. If continued pressure of the thumb on the sear release was applied, the weapon would fire automatic as long as this condition remained.

The head space adjustment, the most important feature in the Browning caliber .30 machine gun, was retained. This critical feature could be regulated in the field by the most inexperienced ordnance man by the simple use of gages. The original water-cooled gun without the mount weighed 82 pounds when the 16-pint jacket was filled. The barrel rode in close-fitting bearings at the muzzle and breech, packed with fabric washers to allow it to recoil freely without leaking.

The total time consumed by John M. Browning on the caliber .50 machine gun from conception to successful firing was slightly over a year. When asked by the press to what he attributed his achievement, he replied, "One drop of genius in a barrel of sweat wrought the miracle."

Browning can surely be called a self-made man. He had no formal education except a few months now and then when he could be spared by his father. He picked up a fair working knowledge of French in the course of his work at the Fabrique Nationale in Belgium in his later years. His thorough knowledge of mechanical drawing, mathematics, and manufacturing procedure was gained simply by observation in the course of developing his designs through model room to production line.

He died suddenly at Liége, Belgium, on 26 November 1926 while supervising the manufacture of arms of his own design. In a long eulogy delivered by the Honorable Dwight F. Davis, Secretary of War at the time, the following words were used:

"It is a fact to be recorded that no design of Mr. Browning's has ever proved a failure, nor has any model been discontinued. The War Department, through its agency, the Ordnance Department of the Army, will be greatly handicapped in its future development work on automatic firearms as a result of the loss of Mr. Browning's services. It is not thought that any other individual has contributed so much to the national security of this country as Mr. Browning in the development of our machine guns and our automatic weapons to a state of military efficiency surpassing that of all nations."

Chapter 4

HOTCHKISS AUTOMATIC MACHINE GUNS

Background

After the successful efforts of Hiram Stevens Maxim to produce a weapon that delivered sustained fire from the generated energy of its recoil forces, inventors of all countries tried to design firing mechanisms that were capable of duplicating this act without infringing on Maxim's patents. One of the most effective European attempts to accomplish this was made by a young Viennese nobleman and officer in the Austrian Army, Capt. Baron Adolph von Odkolek, who constructed a prototype gas-operated automatic machine gun. Seeking a market for his invention, he brought it in 1893 to the Hotchkiss gun manufacturing plant at St. Denis, France, just outside the city limits of Paris, in hopes he could interest this already world-famous establishment in producing his weapon.

The company at this time was in a very disorganized state. It had flourished when the manually operated revolving cannons it produced were purchased by almost every major power in the world. In 1884 the business of the firm having outgrown the capacity of the St. Denis factory, connection was made with William Armstrong & Co. for manufacture of Hotchkiss material at the Elswick works in England. The following year the founder and president, Mr. B. B. Hotchkiss, died and by 1887 the parent branch was reorganized under the name of Société Anonyme des Anciens Etablissements, Hotchkiss et Cie. with offices at 21 Rue Royale, Paris, and the English plant under the firm name of Hotchkiss Ordnance Company, Limited, with offices at 25 Victoria Street, London. The management of both firms was under the control of the French office.

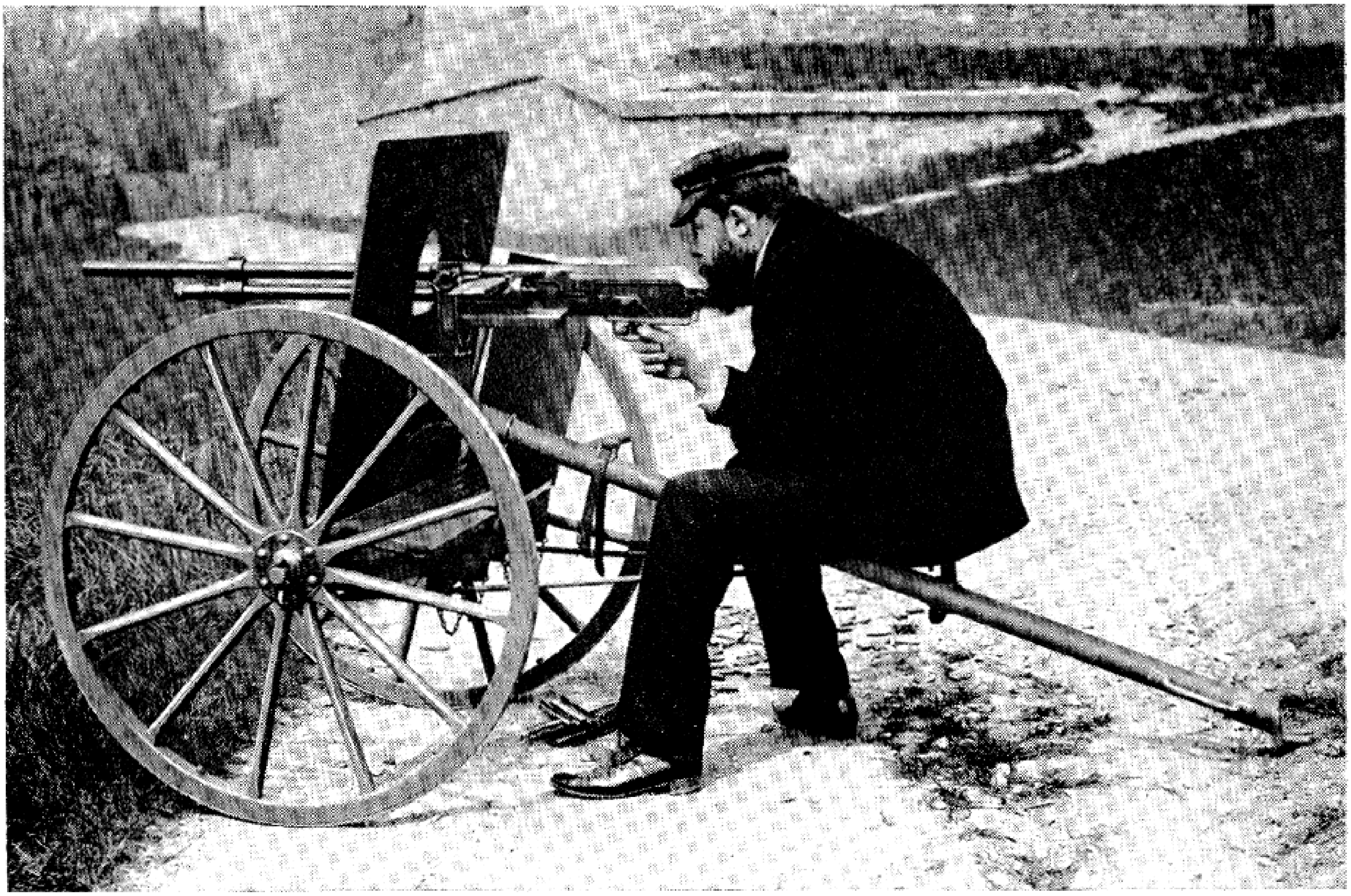
In the same year, the stockholders decided to appoint as head engineer and promotion manager an American, Laurence V. Benét, who had been connected with the company prior to the death of Mr. Hotchkiss. Few men of his age had a more qualifying background for this kind of work. His father, Gen. S. V. Benét, the United States Army's Chief of Ordnance following the Civil War, was famous for his progressive development of cartridge case and primer design that contributed greatly to the early successes of the Gatling and other manually operated machine guns.

General Benét was very ambitious for his son's future and realized better than any one else the difficulties of earning a living in the United States in the machine gun field. He advised his son to go to France and seek out his friend, B. B. Hotchkiss, for employment in a field where the products of his labor would not only be appreciated but also result in financial gain.

Hotchkiss was delighted to have the services of this brilliant young man, already a recognized authority on certain types of artillery, particularly at a time when Maxim's introduction of the full automatic gun had made obsolete the manually operated weapons then being manufactured. He hoped that Benét would be able to carry the Hotchkiss Co. through this transition period from manual operation to full automatic. But before anything had been settled upon as the optimum automatic weapon, Hotchkiss died and reorganization followed, with Benét as the man in charge of the company's future policy.

Laurence Benét showed from the start a talent not only for gun design but also for choosing good associates. A very interesting sidelight in this connection was his affiliation with Henri A. Mercié, who was selected as his chief assistant.

When the Hotchkiss plant was being built, everything went along smoothly until a power source was installed. The machinery on hand was found to require far more energy than anticipated by the plans. The French Government, anxious to assist the plant in every way possible, offered the loan of a railway locomotive as an



Laurence V. Benét Firing the First Model Hotchkiss Machine Gun.

auxiliary power supply until a more permanent one could be arranged. In due time the locomotive arrived and was placed adjacent to the buildings housing the steam-driven machinery. To operate this stationary engine, the railroad supplied an elderly engineer named Mercié and his son, Henri, who was serving as an apprentice.

Young Mercié showed such natural aptitude in solving the many problems that faced this makeshift arrangement that Benét never forgot it. At the first opportunity, he offered him a place high in the management of the company, an act that not only showed Benét's sound judgment but later added much to the success of a company that was trying to regain a world market.

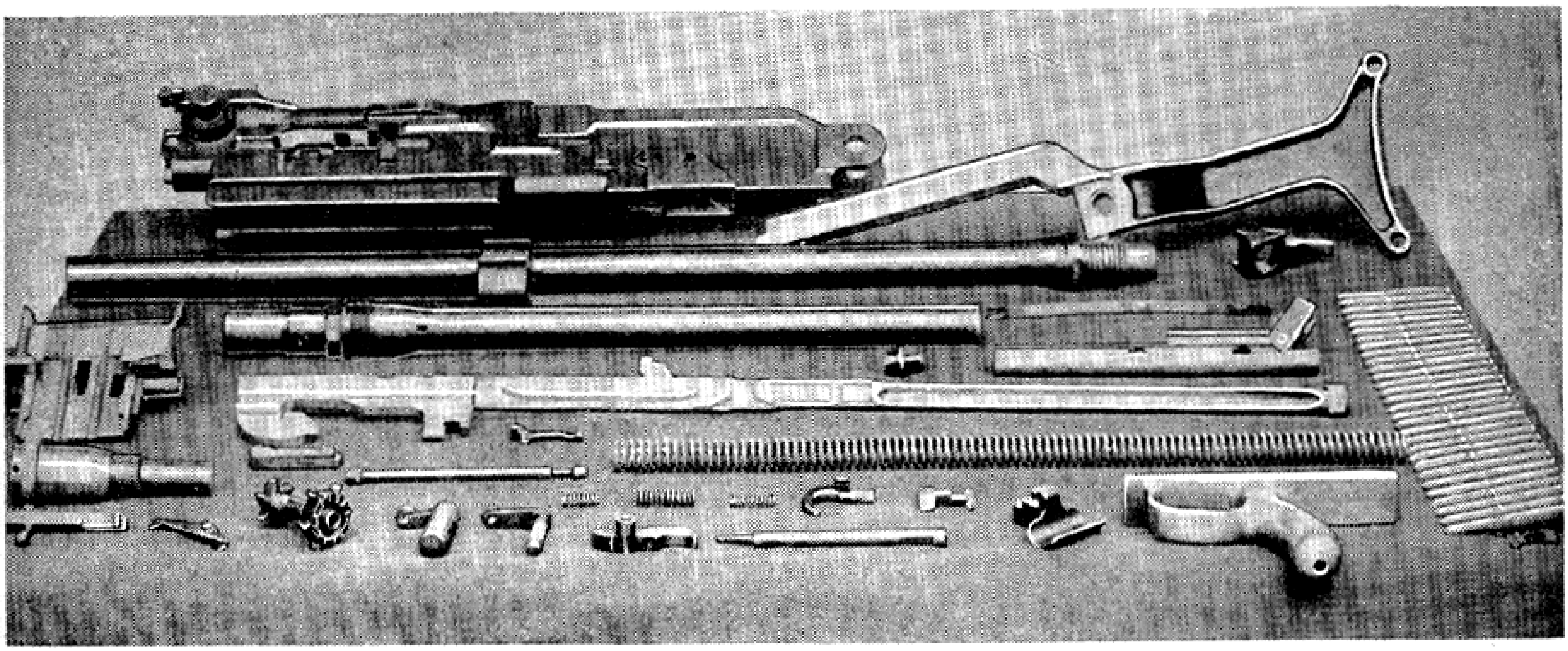
Hotchkiss Machine Gun

Captain Odkolek appeared at this time with his prototype machine gun under conditions that an inventor too often fails to encounter. He had unconsciously picked a moment when there was a demand for just the type of weapon he had brought along to show the business executives of Hotchkiss.

Benét and Mercié saw certain basic principles in the model which could be employed in building a reliable and efficient machine gun. As for Odkolek's weapon itself, they thought little of it and firing tests at the plant later proved their judgment to be right. But the one thing covered by his patent claims which they desired was the operation of a simple mechanism by a housed piston fastened beneath the barrel.

The Hotchkiss Co. refused to make Odkolek's weapon on a royalty basis, but offered to buy the patent outright in order to use certain desirable features. The inventor agreed to this, accepting a lump sum for assigning all manufacturing rights to the company.

Benét and his assistants immediately began refinement and development of the principles sold them until they had produced a weapon



Components of Hotchkiss First Model Gun.

which in their opinion would give competition to any in the world without infringement of patents. The redesigned gun, chambered for the 8-mm Lebel cartridge, was strictly gas-operated and employed a simple reciprocating piston, instead of a swinging lever, as did Browning's gas-operated Colt machine gun. As a tribute to the founder of the company, the finished product was named "the Hotchkiss."

The first of these guns was tested at the St. Denis factory by Laurence Benét in 1895. While the mechanical features held up even better than anticipated, there was a tendency for the heavy barrel to overheat and after a relatively small number of rounds the rifling was destroyed.

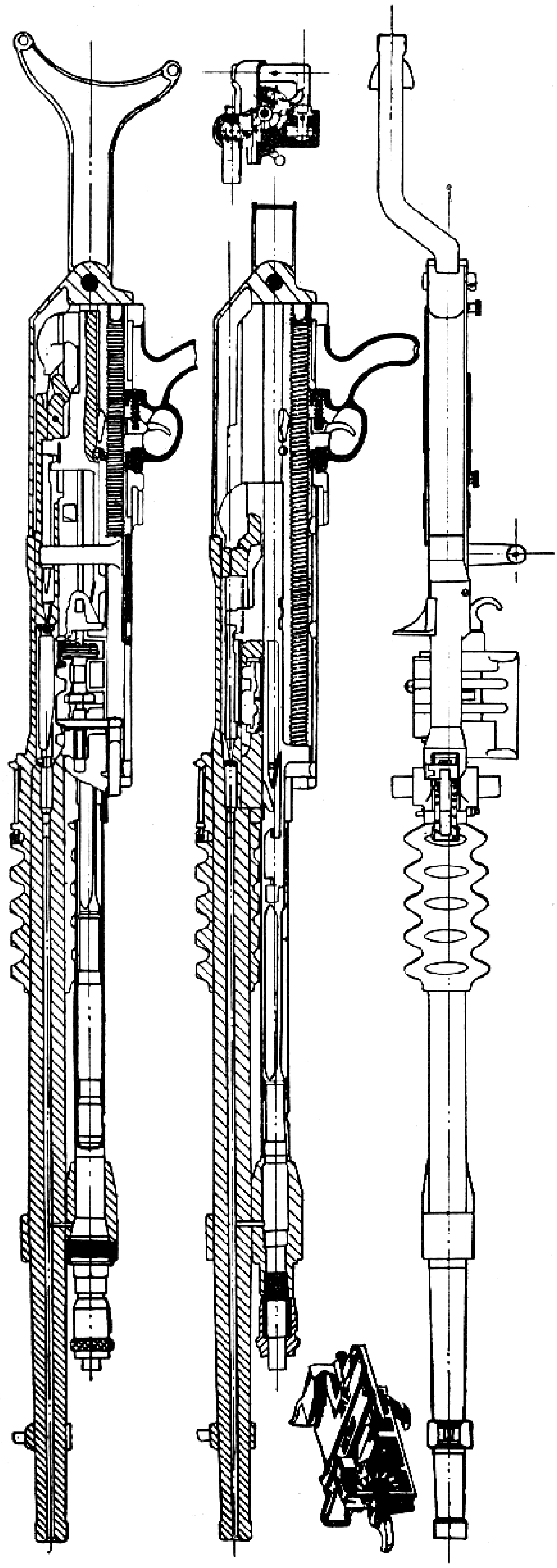
Benét's alert mind quickly found a solution for this problem. He realized that a mass of metal toward the breech end of the barrel was necessary to absorb the great amount of heat generated at this point. But instead of adding to the solid metal, which would make the weight of the gun prohibitive, he formed heavy circular doughnut-shaped fins at the critical heating places. The fins added little weight and gave more than ten times the original radiating surface for air cooling. This feature, which proved so successful, has been identified with the Hotchkiss gun so long that the slightest change in its design is noted immediately by those familiar with it.

The following description is derived from a contemporary Hotchkiss pamphlet on the first model. It outlines the simple operation and improved features that distinguished the weapon from the conventional belt-fed, water-cooled, recoil-actuated machine gun of that day.

The first round is loaded by hand, after which the operations of feeding, firing, extracting, and ejecting are carried on automatically but under complete control of the operator. Slow automatic fire may be delivered at any rate up to about 100 rounds per minute, and rapid fire at the rate of 500 to 600 rounds per minute.

The weapon's single barrel is securely fastened to the breech, allowing none of the moving parts to be subjected to the heat developed by the powder gas. Consequently a water jacket or any other cooling device is superfluous, and the gun may be fired indefinitely without danger of jams from expanded parts. The design is extremely simple, comprising 38 parts in all, exclusive of the sights, but including barrel, shoulder-piece, etc. In the whole mechanism there are but four springs, viz: main, sear, extractor, and pawl springs, and no screws. With the exception of the barrel and the cylinder, the gun may be completely dismounted and assembled without tools, a wrench being necessary for these two parts only.

Beneath and parallel to the barrel is fixed a small cylinder, which is in communication with the bore through a port drilled through the barrel a few calibers from the muzzle. To the rear of the cylinder is an exhaust port opening to vent



Section Drawing of Hotchkiss Machine Gun, Model 1897.

off this gas. On the discharge of the gun, as soon as the bullet has passed the port connecting bore and cylinder, the powder gas enters the latter throwing a long piston to the rear. When the piston has recoiled a given distance, the exhaust port is uncovered, permitting the gas to escape, and the piston is held in its backward position by an ordinary sear. On releasing the latter, the piston is thrown forward to its original position by the mainspring. It is obvious that if the sear is held out of engagement by the trigger and the supply of cartridges is kept up, the piston will have a constant and automatic reciprocating motion. The piston engages with the breechblock, which is somewhat similar to the original Lee rifle straight-pull bolt. Its motion opens and closes the breech, unlocks and locks the bolt, and fires; performing, in other words, the function of the soldier's hand when operating a straight-pull rifle.

Instead of feeding ammunition in fabric belts, the Hotchkiss uses metal strips. The cartridges are packed in these clips, each containing 30 rounds, and having a length of about 15 inches. Each loaded strip is in an ordinary pasteboard box, from which, when opened, it may be fed directly to the gun. The feed mechanism consists of a spur wheel, which engages in cams cut in the piston, and in openings formed in the clip. It is so arranged that the feed strip may be engaged, with breech either open or closed. The strips being so constructed as to lock one with another, a series may be fired without the necessity of cocking the gun each time by hand.

To the breech is fitted a shoulderpiece, or stock, which the operator brings to his right shoulder, and the sear is controlled by a trigger mounted in a pistol grip. Aiming and firing are therefore carried out, as in all Hotchkiss guns, with the same facility as when firing a rifle from a rest. A safety lock is fitted to the piston, by which the mechanism may be secured with the breech closed or open, as may be desired.

It is an interesting bit of ordnance history that the United States Navy tested the original Hotchkiss machine gun before any model number had ever been assigned. This test took place on 3 January 1896, at which time the weapon failed due to improper heat treatment of components and poor choice of metals in construction. At the suggestion of the Navy, the Hotchkiss Co. employed Mr. Edward G. Parkhurst, of Hartford, Conn., to correct the manufacturing errors that caused the gun to fail.

Parkhurst, who had done such outstanding work on the Gardner manually operated machine gun, suggested certain changes in design and submitted them to the company, which not only used the ideas but thanked him through the Navy Department for his contribution.

The improved gun then came out as the Hotchkiss '97 model and has been basic ever since. As no water jacket was employed, the weapon's weight was held at about 20 pounds.

To prepare the '97 model gun for firing, the operator turns the lever of the cocking handle upward and to the left as far as it will go. The nibs on the collar in the guard are then opposite the closed grooves in the cocking handle, while the lugs on the head of the latter are engaged in front of the collar in the piston rod. After pulling the cocking handle smartly rearward to its full extent, the operator then pushes it forward, still keeping the lever slightly to the left of vertical. When it is fully home, the lever is set at an indicator according to the nature of fire desired. The weapon is now ready to fire.

A pull on the trigger releases the sear latch on the under side of the piston. The energy of the recoil spring then forces the piston forward. The lug of the firing pin resting between the firing-pin projection and the breechblock tang of the piston is held back in this safe position. The nose of the piston bearing against the breechblock lock carries this part forward. The front face of this piece forces the forward end of the ejector out of the path of the operating mechanism. The lower part of the breechblock face strikes the base of the cartridge, stripping it from the feed clip and driving it forward into the chamber.

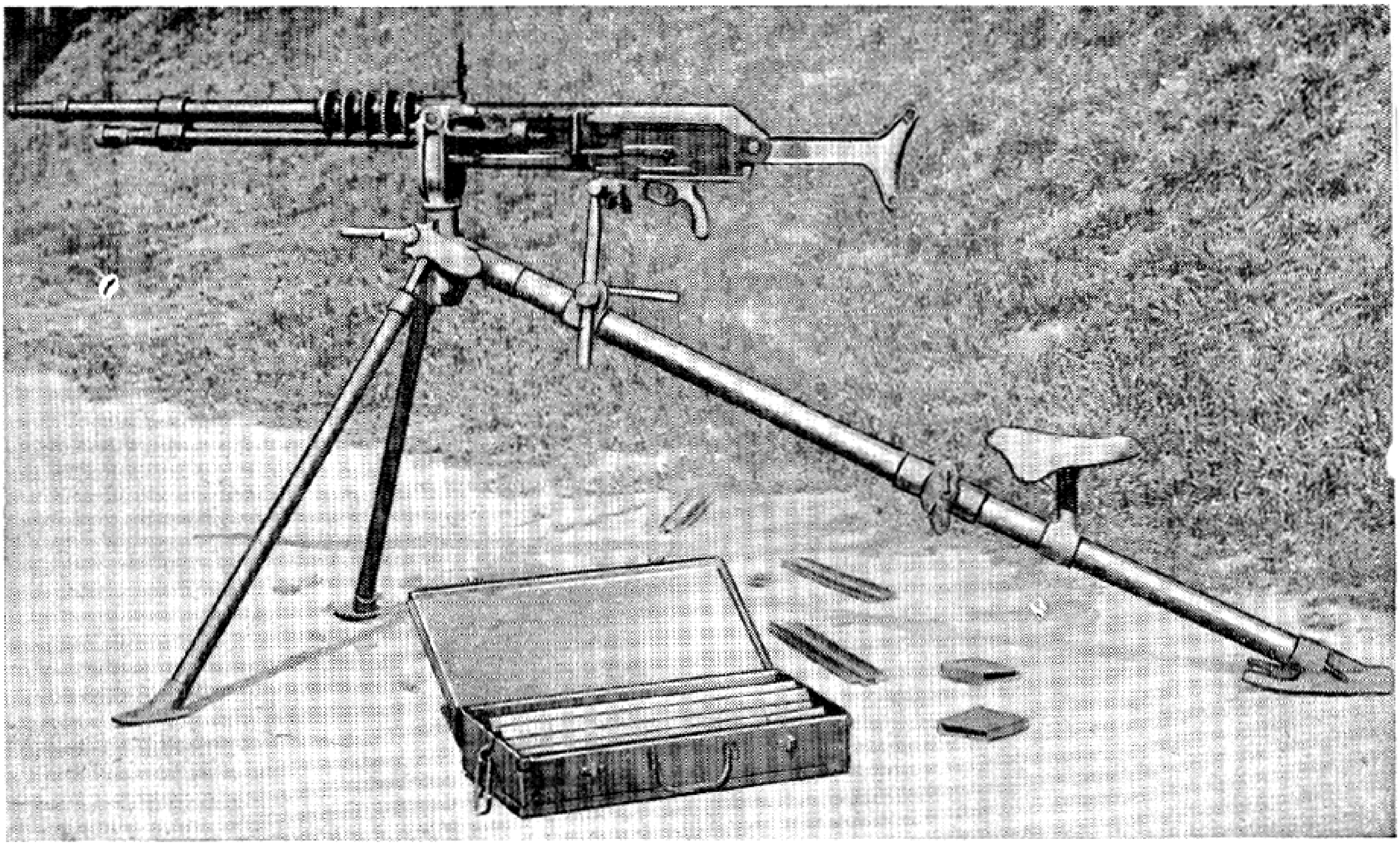
The feed wheel is advanced through the first half of the feeding movement by the action of the large feed cam of the piston against an operating lug on the wheel's ratchet. The cartridge-holding pawl is then engaged by the ratchet, thus preventing rebound. As the breech lock chambers the round, the extractor cams itself over the rim of the cartridge. The breechblock lock is in position above the recoil block in the receiver and is now free to lock. This movement is against the cam surface of the breechblock lock, causing its rear end to tilt up in front of the recoil blocks.

The piston continues forward, carrying the firing pin which detonates the primer in the cartridge. After the explosion of the powder charge in the cartridge and before the bullet has cleared the muzzle, it passes a gas port in the barrel. The gases expand through this orifice into the gas chamber and impinge against the head of the piston forcing it to the rear. This action compresses the recoil spring and stores up energy for counter recoil.

The piston withdraws the firing pin from the primer, as the lower cam of the breechblock lock on the upper cam surface of the piston raises the lock clear of the recoil blocks. The breechblock tang on the piston strikes the rear shoulder of the breechblock and carries it back. The extractor withdraws the empty shell from the chamber, while the rear end of the ejector rides out of its groove in the breechblock. The front end is thus pivoted into the path of the cartridge, striking it at its base and throwing the empty case clear of the slot in the receiver and to the right.

The small feed cam on the piston now completes the rotation of the feed wheel and places the next cartridge in position above the stripping finger, while the feed-wheel pawl engages the feed-wheel ratchet and prevents rebound. This backward motion is limited by the rear end of the piston striking its buffer. If the trigger is still held back manually or by the automatic trigger catch, the mechanism starts immediately on its forward motion. If, however, the trigger has been released, it springs up and engages the sear notch of the piston, holding the gun in a cocked-bolt position. When the feed strip has been fed entirely through, it allows the upper lug of the arrester catch to engage the lug on the piston. This locks the piston back so as to allow loading of the next strip.

Laurence Benét retained his American citizenship throughout his connection with the Hotchkiss Co. and at the outbreak of the Spanish-American War he returned to this country, serving in the United States Navy with the rank of ensign. At the end of hostilities he went back to his duties in France with the Hotchkiss Co. The French Government in the meantime had purchased a limited number of the Hotchkiss,



Hotchkiss Machine Gun Model 1897.

model '97, for its armed services. Its military leaders looked with great favor on the weapon's air-cooled feature, as desert warfare was at its height in the African colonies, where cooling by water would have been a serious problem.

A modified version, known as the Hotchkiss 1900 model, appeared at the turn of the century. The so-called improvements consisted more in refinement of the mount than in the weapon itself. The only changes in the gun were the substitution of circular steel cooling fins in lieu of the brass ones and a barrel designed to withstand the terrific heat resulting from long bursts.

This model with its added features was tested at Springfield Armory by an Army board on 3 May 1900. The purpose was to determine whether the new barrel would pass the rigorous endurance test that was based on performance of water-cooled guns. The barrel was made with only 0.020 percent carbon, but with 5 percent nickel added, and was considered by its creators as being far superior to former barrels made with a high carbon content.

The physical properties of the new barrel were as follows: Tensile strength, 98,730 pounds per square inch; elastic limit, 48,800 pounds per square inch; percent elongation, 15.3; percent reduction of area at fracture, 41. The ammunition used throughout the trial was of Frankford Arsenal manufacture with a velocity of 2,200 feet per second. The propellant charge was 36 grains of Peyton smokeless powder.

Firing commenced at 10:47 a. m. and the weapon successfully expended 1,376 rounds in 4 minutes and 10 seconds before a serious stoppage was caused by the jarring of a cartridge out of the feed strip which jammed the mechanism. This necessitated removal of the bolt to clear the malfunction.

The officers observed that after 2 minutes and 20 seconds of continuous firing the barrel showed a dull red and at the end of the 4 minutes and 10 second burst it was bright red from the radial cooling fins to the muzzle end.

At 10:56 firing was resumed and a burst of 848 rounds was completed before another stoppage took place, again caused by a cartridge falling prematurely from the feed strip into the mechanism.

The barrel already having been heated to a

Hotchkiss Machine Gun, Model 1903. The First Hotchkiss Gun to Use a Belt Feed.

very high degree from the previous firing, it was noted that in 1 minute and 8 seconds it showed a dark red, and before the end of the 848 rounds of sustained fire it was again a bright red.

Upon examination of the working components, there was evidence of much fouling in the receiver, while all the oil had been burned away from the forward part of the piece. These parts were working sluggishly when charged back and forth by hand. A total of 2,224 cartridges had been fired in 6 minutes and 8 seconds of actual firing time.

As the mechanism showed such fouling, it was decided by the board to allow the barrel to cool so it could be checked for both fouling and erosion. When examined, it was found that erosion began just in front of the chamber, with the rifling showing noticeable wearing away to a point aft of the gas port. The forward portion of the rifling showed very little wear.

When the weapon was reassembled, the cocking piece worked hard and further examination showed it to be sprung out of shape and "considerable filing and hammering had to be done before it could be made to work freely again."

After lunch, firing was resumed at 2:29 p. m., at which time 773 rounds were discharged. A lug on the gas piston then broke, stopping the weapon. The time consumed was 2 minutes and 5 seconds. A new piston was substituted for the broken one and firing was resumed. The first round jammed the mechanism in the act of feeding. The officers held that the round had been jarred out of the strip when the piston change was made. When this malfunction was cleared, the test continued. After 750 rounds were fired on this attempt, the extractor failed to pull the empty cartridge case from the chamber. When the case was removed and firing commenced, it was found that the extractor had failed at this point and a new one was substituted.

The remainder of the ammunition that had been put into the feed strips, 816 rounds in all, was then fired without incident, making a total expenditure of 4,500 rounds.

The weapon was then disassembled and all components were examined thoroughly for excessive wear or signs of breakage. None were found to be unserviceable, and, with the exception of the piston lug and the extractor, all parts finished the test in serviceable condition. The barrel was ordered sawed in half. Slight erosion was found, although the rifling was practically worn away from breech to muzzle end. The sawed portion of the barrel was photographed as a record of the event.

The Army report concludes as follows:

"The system of feeding the cartridges into the gun by the use of metal feed strips has not shown itself to be as satisfactory as a canvas belt feed, but the advantages of having an additional source of supply in case of emergency would, in the opinion of the board, warrant the use of this gun in addition to the Maxim and Colt, both of which have already been reported upon as being suitable for adoption."

The members of the board were: John E. Greer, Major, Ordnance Department, U. S. A., president; Jno. T. Thompson, Captain, Ordnance Department, U. S. A.; and Odus C. Horney, Captain, Ordnance Department, U. S. A., Recorder.

In approving the report, Lt. Col. Frank H. Phipps, commanding officer at Springfield Armory, added:

"These tests seem to indicate conclusively that a high percent of carbon in a gun-barrel steel shortens the efficient life of the barrel.

"The rapidity of fire in this test was greatly in excess of what it would be in service; the great heat generated caused the wearing away of the rifling before the completion of 4,500 rounds.

"The desirability of a water jacket for automatic guns has been demonstrated by the tests of the board."

The Russo-Japanese War (1904–05) was the first conflict between major powers in which machine guns were employed by each participant. The Russians were equipped with Maxims, while the Japanese had the Hotchkiss. The deadliness of machine-gun fire was demonstrated time and again by the two armies using these different types of automatic weapons.

Puteaux and St. Etienne Machine Guns

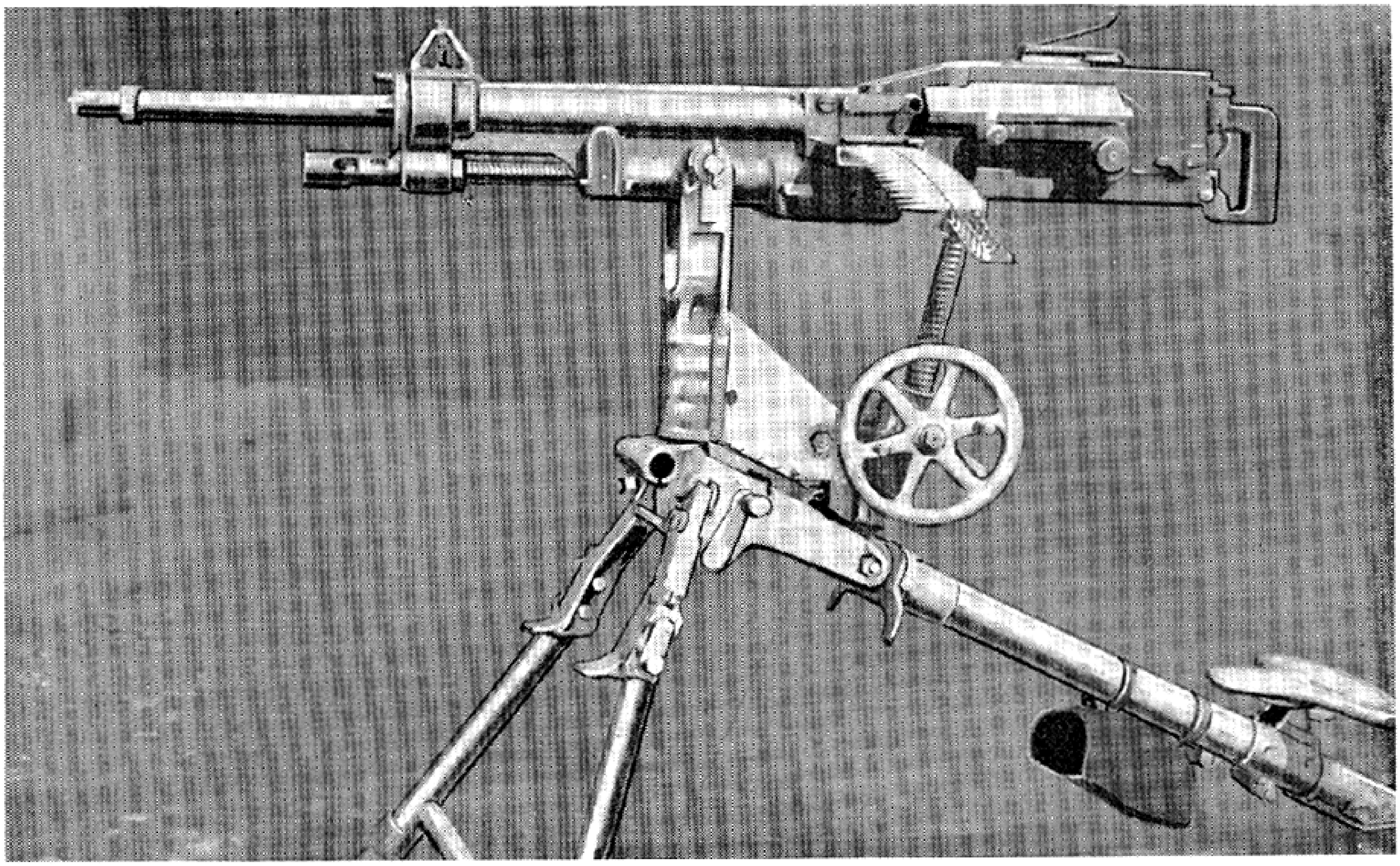
Since 1900 French Army officers had worked continuously on refinements that in their opinion would result in the ultimate in machine guns. The National Arsenal at Puteaux produced in 1905 a version that used a modified version of the Hotchkiss system. The normal rate of fire was 500 rounds per minute but the gun had a device that permitted regulation of the cycle of operation from eight shots a minute minimum to 650 maximum. The weapon had a series of brass circular fins that extended from the breech to the muzzle of the barrel. It was issued to French colonial troops in 1906 but was never as popular as the standard Hotchkiss, over which it was supposedly an improvement. It was soon relegated to reserve units and fortifications. The latter use was so widespread that it is sometimes erroneously known as the "Fortification model."

In another attempt to improve existing machine guns, the officers at the St. Etienne Arsenal in France made what is known as the 1907 model St. Etienne. This weapon was a compromise between the Puteaux 1905 and the Hotchkiss 1900. However, the gun used one of the most unusual methods of operation yet to be developed. While it was gas actuated by means of a piston, the French reversed the conventional principle.

Instead of the piston thrust rearward furnishing the source of energy to operate the piece, the gas propels the piston forward to unlock the bolt. The piston is attached by a spring-loaded rod to a gear rack. This in turn engages a spur gear which is fastened to an actuating lever. When the lever is in the forward horizontal position and engages a cam slot in the bolt, the gun is locked. Upon firing, the gas drives the piston forward, compressing the spring and causing the spur gear to rotate clockwise. The actuating lever turns with the gear for a half revolution, retracting the bolt and stopping at the rear horizontal position. The driving spring then forces the piston rearward, which reverses the action and returns the bolt to battery.

The weapon is readily distinguishable by the heavy brass casting of the barrel receiver. The actuating spring, located under the barrel and behind the gas piston, is always visible, as the heat from its close proximity to the barrel would destroy its life if housed.

It is of interest that Baron von Odkolek, whose original patents were the basis of the Hotchkiss weapon, attempted to produce another machine



St. Etienne Machine Gun, Model 1907.

gun during this period. In order to stay clear of his already assigned patents, he resorted to features that were unusual from an engineering standpoint.

For instance, the weapon was both water cooled and gas operated. In order to cover the barrel and gas piston cylinder with a water jacket that would not allow the liquid to leak into the critical gas-cylinder chamber, he constructed the barrel and gas-cylinder chamber out of one piece, by turning the muzzle and breech ends eccentric. This method allowed a sufficient mass of metal, which was offset from the breech end and was an integral part of the barrel, to house the gas-cylinder chamber.

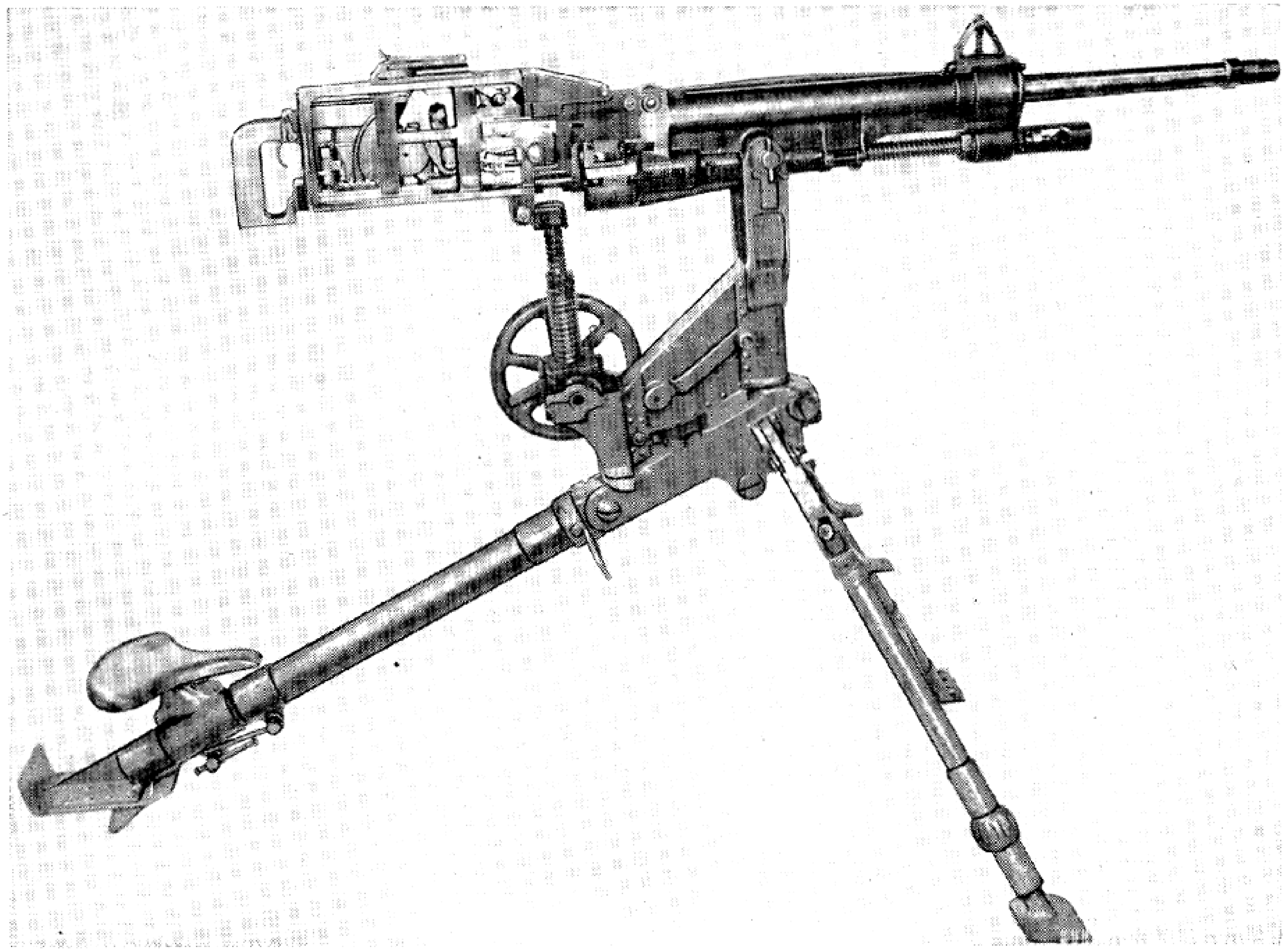
The gas cylinder was located on top, instead of on the underside, of the barrel. This 180° turn no doubt was intended to help make the model look more original. However, a close examination shows that the operating mechanism was very similar to the prototype weapon submitted to the Hotchkiss Co. in 1893.

The feed was the only radically different feature, for in lieu of brass strips of 30 cartridges each, he used a drum and reel arrangement, on which 250 cartridges were attached to a belt made of light and flexible brass. The Odkolek weapon was never recognized and did not progress beyond its prototype stage.

Benét-Mercié Machine Rifle

The French Army ordnance engineers at the government arsenals, in their attempts to produce an all-purpose machine gun modeled on the Hotchkiss, had succeeded only in developing two weapons of questionable merit. In 1909 another modification appeared, a highly portable machine gun developed by the Hotchkiss Co. It differed in a mechanical way from the 1900 and 1907 guns only in the means of closing the breech, and the upside-down introduction of the feed clip from the right side, so that the cartridges were underneath the clip. This was just the reverse of earlier models. The gun was even simpler in construction than its predecessors, having only 25 parts.

This weapon was the joint effort of Laurence



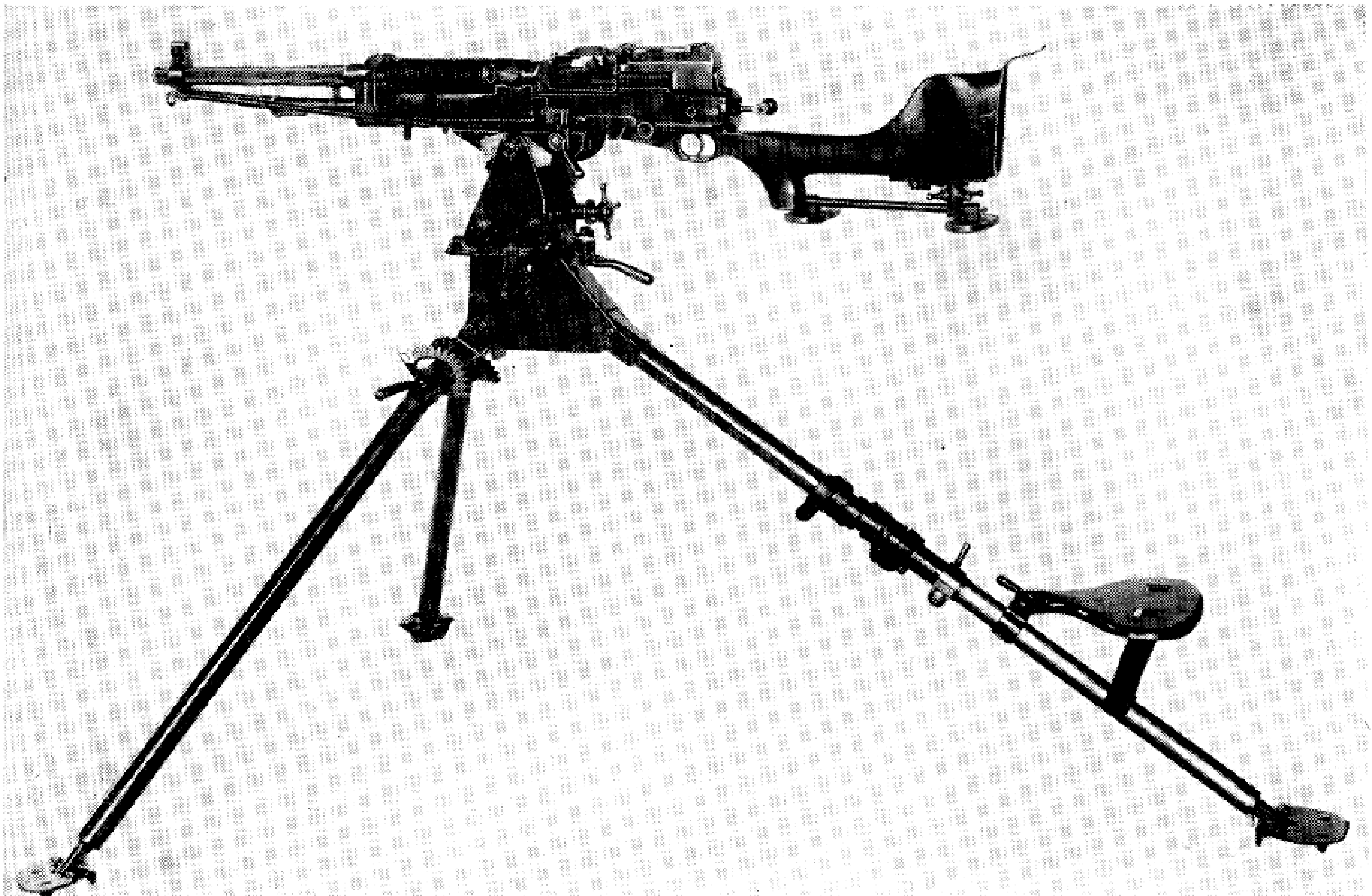
St. Etienne Machine Gun, Model 1907, 8-mm, Sectionalized.

Benét and his assistant, Henri Mercié. While it was known on the Continent as the Hotchkiss Portative, it was called both in England and America the Benét-Mercié machine rifle Model 1909, since the weapon was fitted with a shoulder stock. It was adopted by both the French and American armies in 1910. The French chambered theirs for the 8-mm Lebel cartridge, while our army used a caliber .30/06.

The breech is locked by a device called the "fermature nut" which is cylindrical in shape. On top of this piece a long longitudinal cut provides clearance for the cartridge in loading. Near the left rear end is a semicircular depression to allow the passage of the front side of the feed strip. The rear shoulder of the fermature nut is beveled and has a lug to engage the corresponding recess in the gas piston. The function of the latter piece is to lock the breechblock slightly before firing and to unlock when gas pressure has dropped to a safe operating limit.

This locking system is located in the forward part of the receiver, directly in the rear of the breech, and is held in place by a shoulder on the barrel. On the top side of the piston actuator is a large slot that moves the camming projection on the rear surface of the fermature nut. If the locking nut holding the assembly is permitted to work loose, it allows the barrel to creep slightly forward resulting in excessive head space. In an emergency this can be corrected by turning the nut as far past the locked position as possible. The locking screw is then screwed up tightly, holding it for a short duration.

To fire the Benét-Mercié Model 1909 machine rifle, great care must be taken to enter the 30-shot feed strip properly into the feedway in the upper right side of the receiver. Then the gas



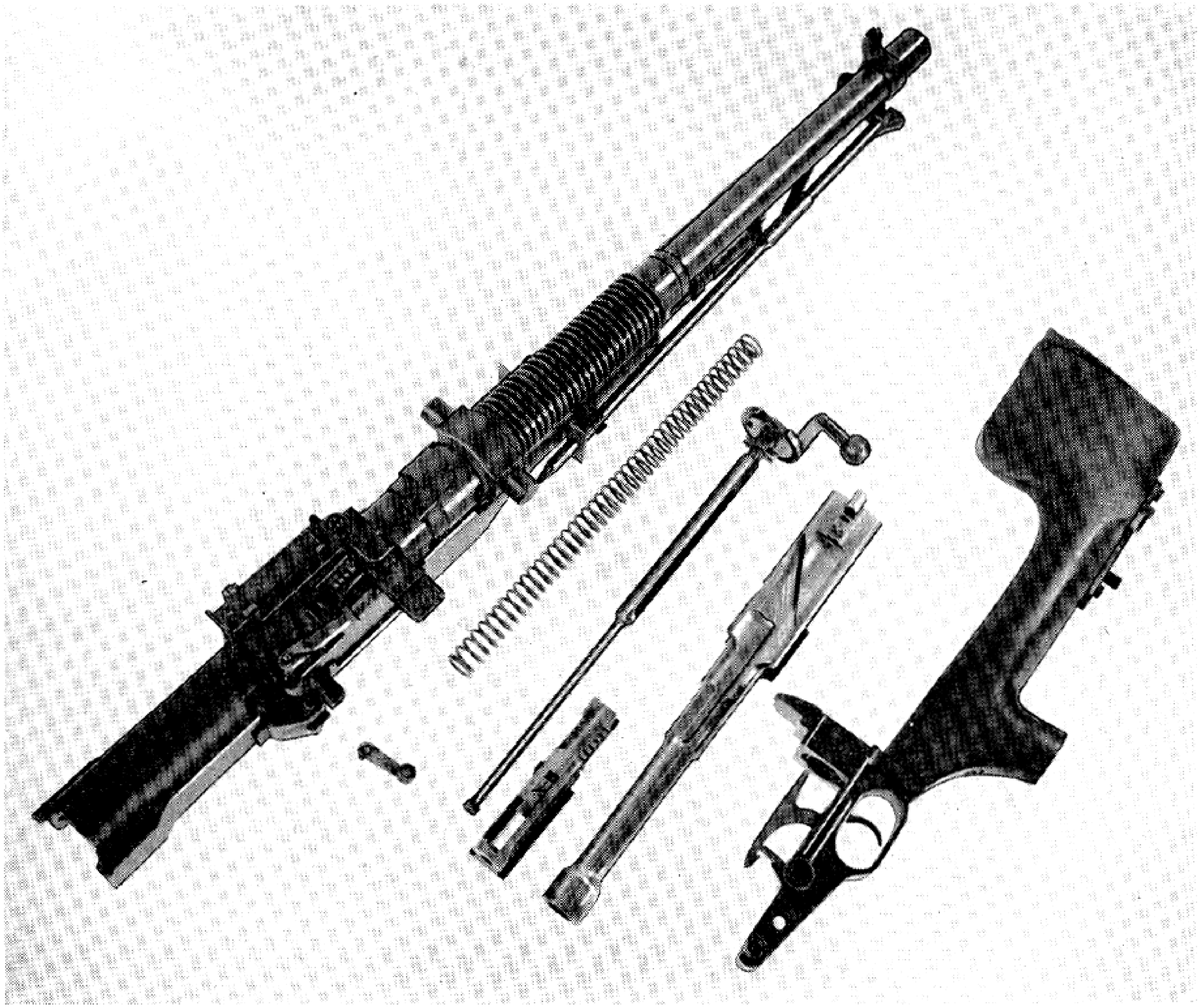
Benét-Mercié Machine Rifle, Model 1909. This Weapon Manufactured by Colt's Patent Fire Arms Company is Serial Number "O".

piston and bolt assembly is pulled to the rear by means of the cocking handle until it engages the sear holding it in a cocked position. The handle is then pushed forward. When all the way home it may be turned to the right and lined up with either the letter "A" (for *Automatic*) or "R" (for *Repeater* or *Semi-automatic fire*) as desired.

A round has now been positioned and the weapon cocked ready for firing. When the trigger is pulled back, the sear releases the action that starts forward under compression of the driving spring. The face of the bolt strikes the first round in the feed strip forcing it into the chamber while the claw of the extractor snaps into the cannelure of the cartridge. As soon as the bolt engages the fermature nut, the firing pin and its large lug contact the ramp in the receiver, causing the firing pin to rotate partially and disengage the lug from the transverse cut in the bolt. Immediately after the bolt is locked rigidly behind the chambered cartridge, the pin is free to go forward and is driven into the primer discharging the weapon.

When the bullet has passed the gas port in the barrel, a part of the powder gases is bled into the gas cylinder and forces the actuating piston to the rear. The cam surface cut in its upper portion engages the lug in the fermature nut the rotation of which unlocks the bolt. The firing pin then turns on its axis and is withdrawn, coming to rest with its lug in the transverse cut in the bolt, thus holding it retracted.

Engaging the rim of the empty case, the claw of the extractor draws it from the chamber and holds it during recoil until the ejector strikes the cartridge base and knocks it out the ejection slot on the left side of the receiver. When the gas piston has recoiled over half-way, the cam surface cut on its right side fits into the upper lug of the feed piece causing the latter to rotate from right to left on its axis.

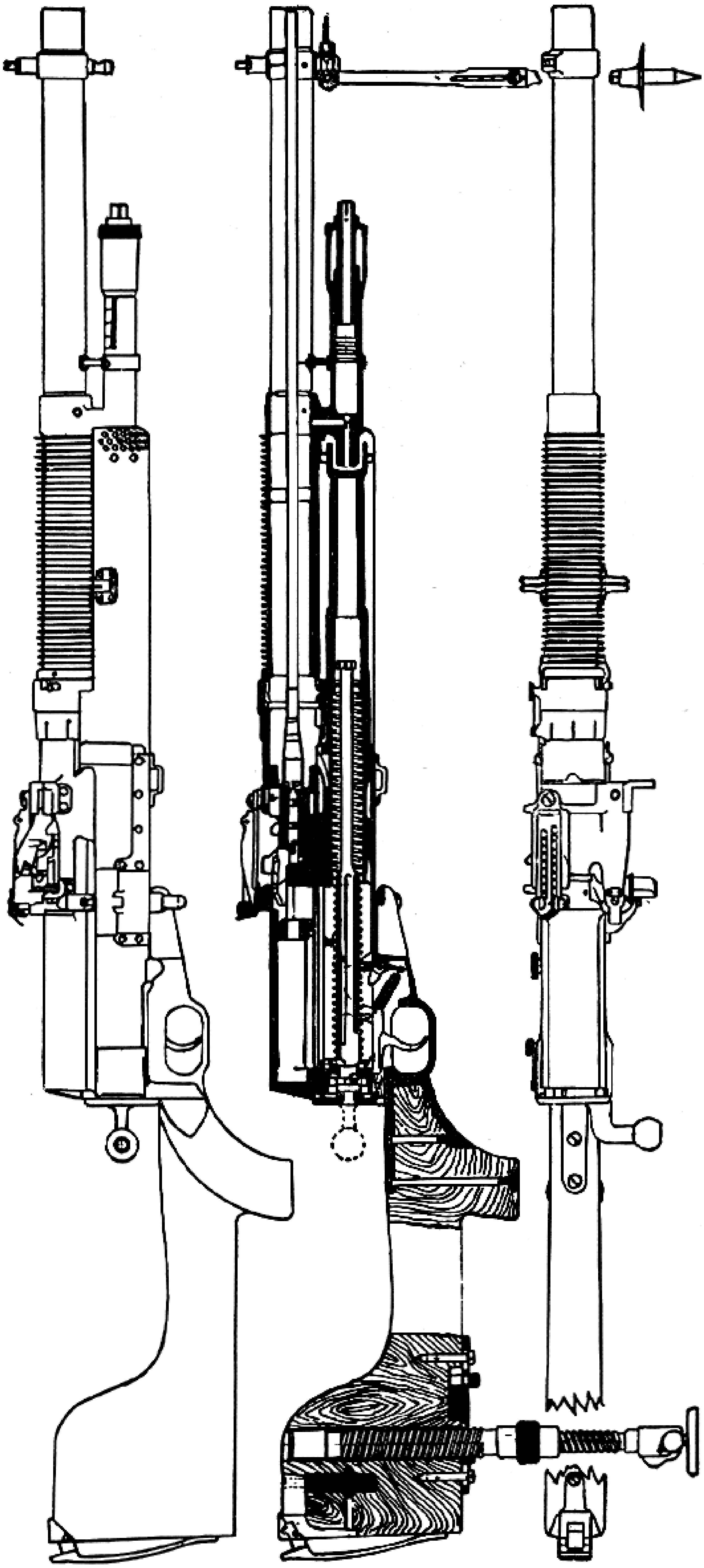


Components of the Benét-Mercié Model 1909.

The feed arm engages the lug in the central opening of the feed strip, indexing the next round for loading into the chamber. Full recoil stroke is accomplished when the driving spring is completely compressed and the operating parts then start counter recoil movement. The cycle of operation is repeated as long as the trigger is held back.

The Benét-Mercié remained our standard automatic machine gun until 1917. It saw limited service at the landings at Vera Cruz in 1913 and fell into general disrepute during the border trouble in 1916 with the Mexican bandit, Pancho Villa. The Benét-Mercié failed to operate during Villa's night raid on Columbus, New Mexico. The alibi given by the machine gun squads was that the weapons could not be operated after dark because of their intricate system of loading. Newspapers throughout the United States had a field day with this statement and wrote many sarcastic stories, calling the Benét-Mercié the Army's famous "daylight gun" and suggested that the rules of warfare be rewritten so that no fighting take place except in daylight in order that our machine guns could participate.

Discontent in the press with our inadequate equipment was further increased when a short time later efficient American-made Colt guns (model '95) chambered for our caliber .30/06 ammunition, as well as medium and heavy



Section Drawing of the Benét-Mercié Model 1909.

Hotchkiss '97 machine guns, were captured from the Mexican guerrillas by our troops. The American Army's commander, Gen. John J. Pershing, sent them to the West Point Museum.

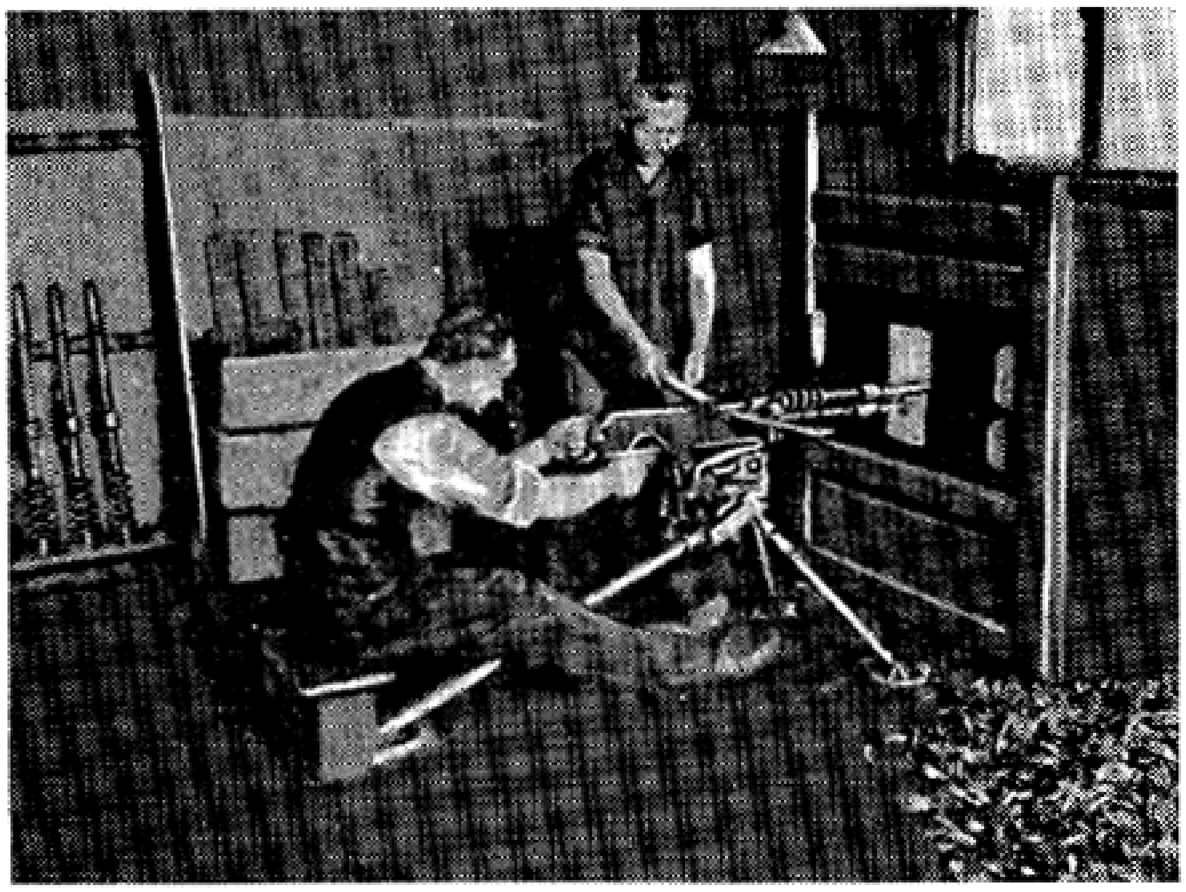
The United States, like all other countries, soon realized that no type of machine rifle could supplant the machine gun. While the Benét-Mercié was quite popular with the troops in peacetime because of its light weight, it could in no way meet the demands of warfare which required the heavier belt-fed weapons.

Hotchkiss Machine Gun Model 1914

The summer of 1914 found France at a serious disadvantage because of its small stock of automatic arms. Army leaders, however, did feel that they were very fortunate to have available a thoroughly tested weapon simple to construct and reliable enough to give a good account of itself under any condition. In preparation for the coming war, the Hotchkiss machine gun was given a final bit of refinement and went into production as the Model 1914.

It soon became evident that machine guns would be required in unthought of quantities. The government factories at St. Etienne and Chatellerault lacked the manufacturing capacity for the numbers required, and the French War Department called upon the Hotchkiss Co. to prepare for quantity fabrication of the Model 1914.

Most of the first guns so produced were issued to territorial regiments of the line, then held in reserve, so there was little opportunity to judge their merits in actual fighting during the operations of 1915.

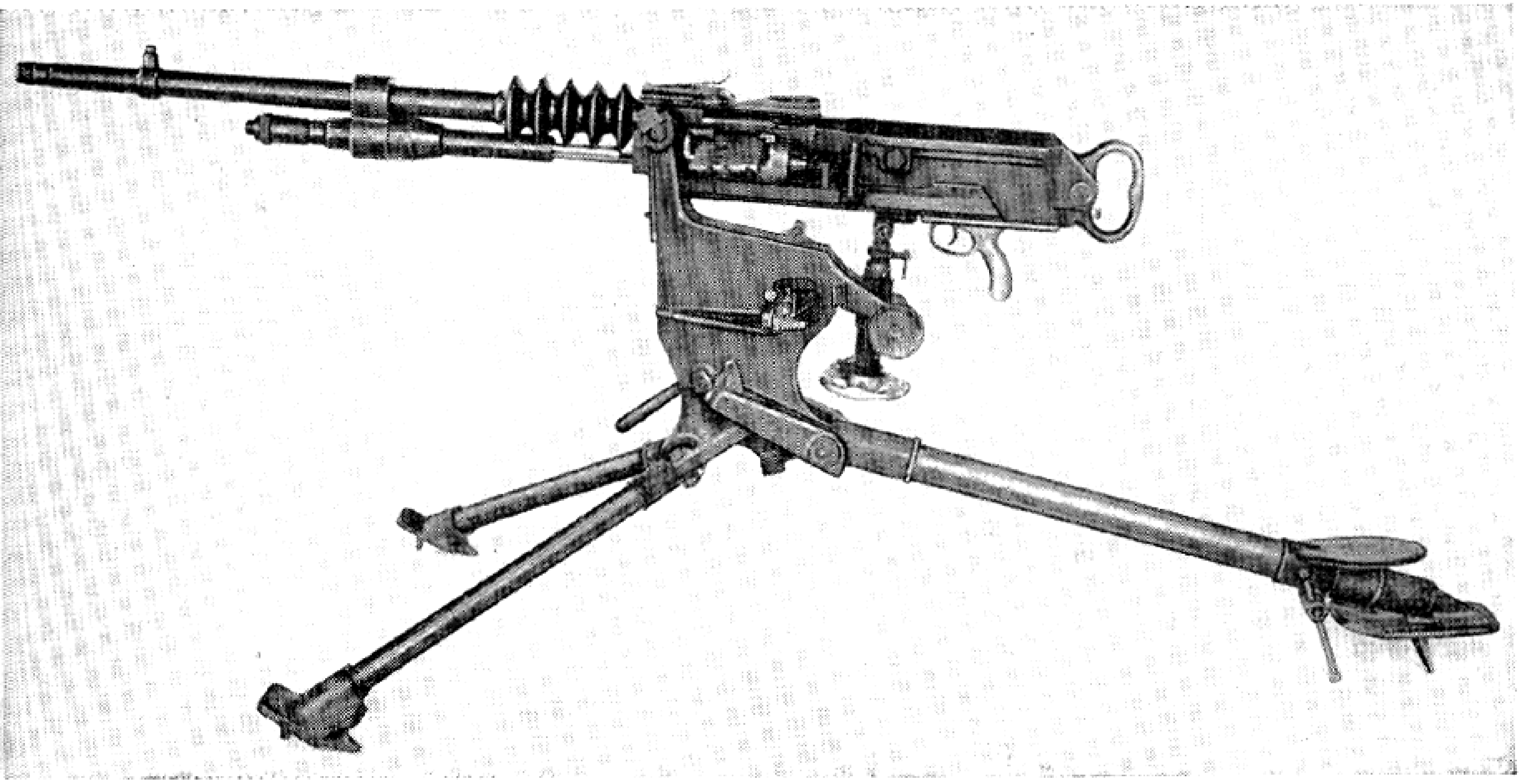

Function Firing the Hotchkiss Model 1914 in France.

In the following year when mass production had been realized, the Hotchkiss machine gun was issued as first-line equipment, a large number of brigade companies having been formed and armed with this weapon. The reliable qualities of the Hotchkiss gun were then promptly recognized by the entire army.

The best instance, among many, demonstrating the efficiency of the weapon was in the spring of 1916, during the heroic defense of Verdun, when a section armed with two Hotchkiss machine guns held its position near Hill 304 for 10 consecutive days and nights. Entrenched 150 yards behind the crest which the Germans were endeavoring to seize, this unit repulsed unaided all assaults, mowing down the succeeding waves of attack as they reached the summit. During these 10 days, the section, cut off from all supplies and communication expended over 150,000 rounds of ammunition. The original and normal supply of a section was 5,000 rounds. Fortunately, a dump of infantry cartridges was near at hand and, such was the enthusiasm aroused by the fire of the machine guns that all hands, including the officers, set about reloading the feed strips, thus enabling the section to carry on to the end. When it is realized that each gun fired upwards of 75,000 rounds and still was serviceable, one must have admiration for weapons that proved so reliable under such conditions.

The winter of 1916–17 confirmed the favorable opinion of the French Army for the Hotchkiss gun, as it could always be relied upon in spite of snow, mud, or the bad condition of the ammunition available. In March 1917, the French contingent operating in Belgium had to have its St. Etienne weapons, model 1917, replaced with Hotchkiss guns, because "this gun is the only one which works in spite of the sand, which on the Nieuport dunes constantly blows into the mechanism." By this time there arose a spontaneous demand from all French armies for the Hotchkiss.

On 15 July 1918 the weapon reached the zenith of its achievements. Military authorities



Hotchkiss Machine Gun, Model 1914, 8 mm.

agree that the heroic defense made that day by the Fourth (Gouraud's) Army against the last desperate German drive, marked the end of the offensive power of the enemy, and permitted Foch, 3 days later, to launch the general offensive that continued without respite for nearly 4 months and only ended with final victory for the Allies.

The brilliant tactical use of artillery and machine guns by General Gouraud resulted for the first time since the beginning of the war in stopping short a powerful general attack at the exact point of prepared defense. So completely was the attack shattered by the devastating machine-gun fire that the enemy withdrew in disorder, leaving more than half of his force as casualties on the field, and so broken and demoralized that no further attack was ever attempted.

On 18 July 1918 the Allied offensive began by the attack of the Franco-American Army under Mangin from Château-Thierry toward Fere-en-Tardenois. Midway between these positions the advance of the French division was stopped by extremely violent fire from a large number of machine guns. The situation was critical, for these machine guns, concealed and scattered in fields of wheat, escaped the effects of artillery and an exposed clearing 1,500 yards in depth prevented an advance within range of direct fire. All the machine guns of the entire French division were promptly united into a single battery and proceeded methodically to sweep the area occupied by the Germans. The effect was immediate and complete, and the enemy abandoned its positions with considerable loss.

It was with the 8-mm 1914 model that American soldiers were originally armed when our entry into World I found us practically without machine guns of our own. Twelve American divisions were equipped with this weapon.

The Army, in order to solve the logistics involved in carrying two kinds of ammunition, one for riflemen and another for machine gunners, had rapidly replaced the original 8-mm Hotchkiss machine guns with ones chambered for our .30/06 service rifle cartridge. After a brief period of battle use, there arose a pressing need for extra barrels. This shortage became very critical and it was with the greatest difficulty that the supply organization found the 20,000 spare barrels required. Manufacturing plants in America had not been tooled up long enough to meet the demand for the vast amount of extra barrels chambered for American ammunition. The urgency of the situation greatly alarmed the commanding officers of the sectors held by our troops.

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Hotchkiss Balloon Gun, Cal. .472.

Hotchkiss 12-mm Machine Gun

The French Army is noted for the work of its artillery men in producing some of the world's most outstanding heavy ordnance. Needless to say, their influence in military planning has been great and when the machine gun became such a lethal reality, they asked for the development of a long-range machine gun capable of inflicting heavy damage on observation balloons and on mobile artillery gun crews attempting to bring their pieces into action.

This demand resulted in much experimental work on such a weapon. Although research had been undertaken from time to time beginning with the turn of the century, it was late in the war before the Hotchkiss company really approached perfection along this line with the introduction of the 12-mm machine gun. To distinguish it from the rifle-caliber weapon, it was referred to as the "balloon gun," since its employment on observation balloons at great range was most effective. The large caliber bullet contained an adequate charge of incendiary compound that ignited the hydrogen-filled bags upon contact.

The mechanism of the gun consisted of only 18 parts and was very similar in design to that of the rifle-caliber gun. The initial velocity, however, was 2,020 feet per second with a mean maximum pressure of 37,000 pounds per square inch at the breech. The range of the gun was 3,000 yards; the armor-piercing bullet at its extreme range had a velocity of 500 feet per second. French officers felt that this weapon would be able to put any mobile artillery gun crew out of action at a range which would be impossible with the rifle-caliber gun. The importance of this additional reach could hardly be overestimated in engagements in which the opposing forces of both armies were armed with machine guns.

The maximum rate of fire of the Hotchkiss balloon gun is 400 to 500 rounds. At a hundred yards the armor-piercing bullet would perforate one inch of homogeneous steel plate. The weapon can be fed by the conventional metal tray that holds 20 rounds of ammunition or by a long belt consisting of a series of cartridge holders on a flexible metal strip, which are hinged together to make possible a continuous feed.

Each holder has four clips which embrace the cartridge at the neck and near the base. To the first cartridge holder is hinged a thin steel tongue by means of which the belt is started into the feed. The cartridges are packed in a continuous belt of 250 rounds, having a length of 20 feet. Being wholly metallic, the belt is not affected by oil, water or temperature, and may be used repeatedly without deforming. The loaded belts are carried already folded in light wooden chests from which they can be fed directly to the gun.

It was this weapon that Col. John Henry Parker heard about when it was in its prototype stage and, knowing that the United States was at the time trying to raise the caliber of its machine gun, he made arrangements with the French Government to borrow one of the two weapons under test and send it to this country.

After a thorough study was made of its ballistic features, it was decided not to adopt the weapon as it did not meet the minimum specifications in regard to bullet weight and muzzle velocity laid down by General Pershing in a cablegram to the Army's Chief of Ordnance. While the gun was undoubtedly superior to the rifle-caliber-type gun for certain tactical uses, it was dropped as far as the United States was concerned. Time has proved the wisdom of Pershing's decision not to consider any large-caliber machine gun that did not have a muzzle velocity of at least 2,750 feet per second.

The military authorities of all countries had great respect for this model and it was adopted by many governments. When the velocity was later increased, it was considered an ideal weapon for special objectives.

Chapter 5

NORDENFELT AUTOMATIC MACHINE GUN

A weapon that made its appearance on the continent in prototype stage only was known as the Nordenfelt Model 1897. It was actually the invention of Capt. W. Bergman of the Swedish Army, who sold his patent outright to the Nordenfelt Co., then located in Paris, France.

This company, like all other arms manufacturing plants that were selling manually operated weapons, suddenly found its products made obsolete by the success of automatic machine guns.

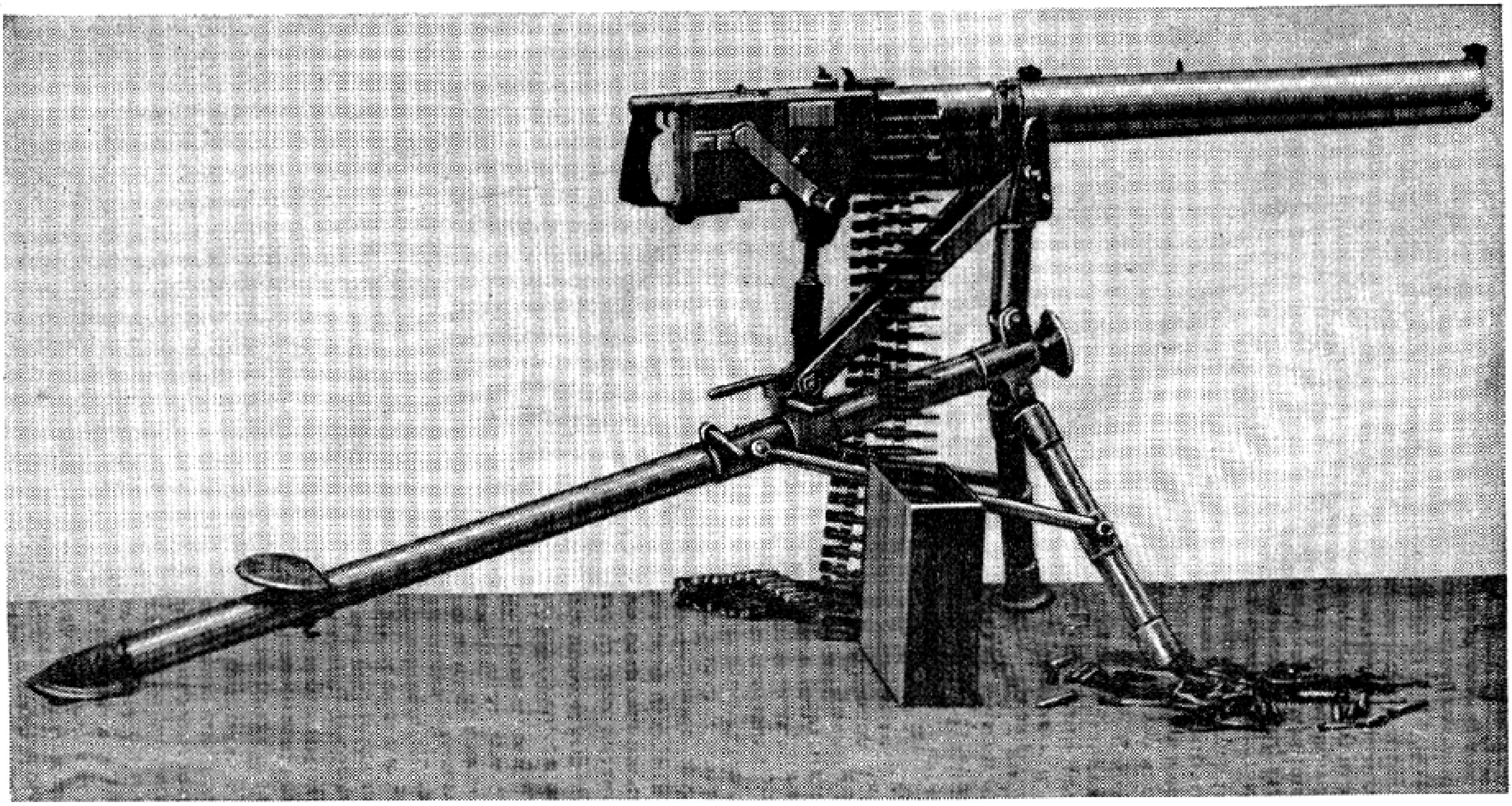
A booklet was published by this firm in order to arouse the interest of military authorities in the Nordenfelt Model 1897. It described the basic operating principles and went into great detail about the advantages to be found exclusively in this model.

The outstanding feature of the gun was that it was designed for both automatic and manual operation. Its rate of fire was 600 rounds per minute when fired full automatic. On conversion to manual operation, it had a rate of fire of 130 shots per minute.

The operating mechanism is completely contained in a receiver, with bearings that support the barrel fore and aft. The gun is water cooled, having a jacket with valves to vent off steam. The rear of the receiver has two quick openings that permit the operator to get at the mechanism for purposes of inspection or clearing a malfunction.

A barrel extension is attached to the barrel and recoils with the latter between the parallel inner walls of the receiver. The bolt is thrown rearward at high speed by an accelerator. The barrel, extension and all operating components move longitudinally and are locked together for only a fraction of an inch, making this one of the shortest recoil actions known.

To load the piece for automatic fire, the operator places the first cartridge in the belt under



Nordenfelt Machine Gun, Model 1897.

the star wheel in the feed. After placing the fire regulator on *Safe*, the handle is pulled smartly to the rear four times and released. The compressed driving spring, in returning the mechanism to battery the required number of times, performs the cycle of feeding first by taking the cartridge out of the link in the feed belt and then by chambering it.

The piece is fired by a trigger located at the upper forward part of the pistol-type handle. While the powder charge is building up its peak pressure, the bolt is securely locked to the barrel and barrel extension and recoil begins. In less than an inch of rearward travel, the accelerator lever starts to pivot about the pin.

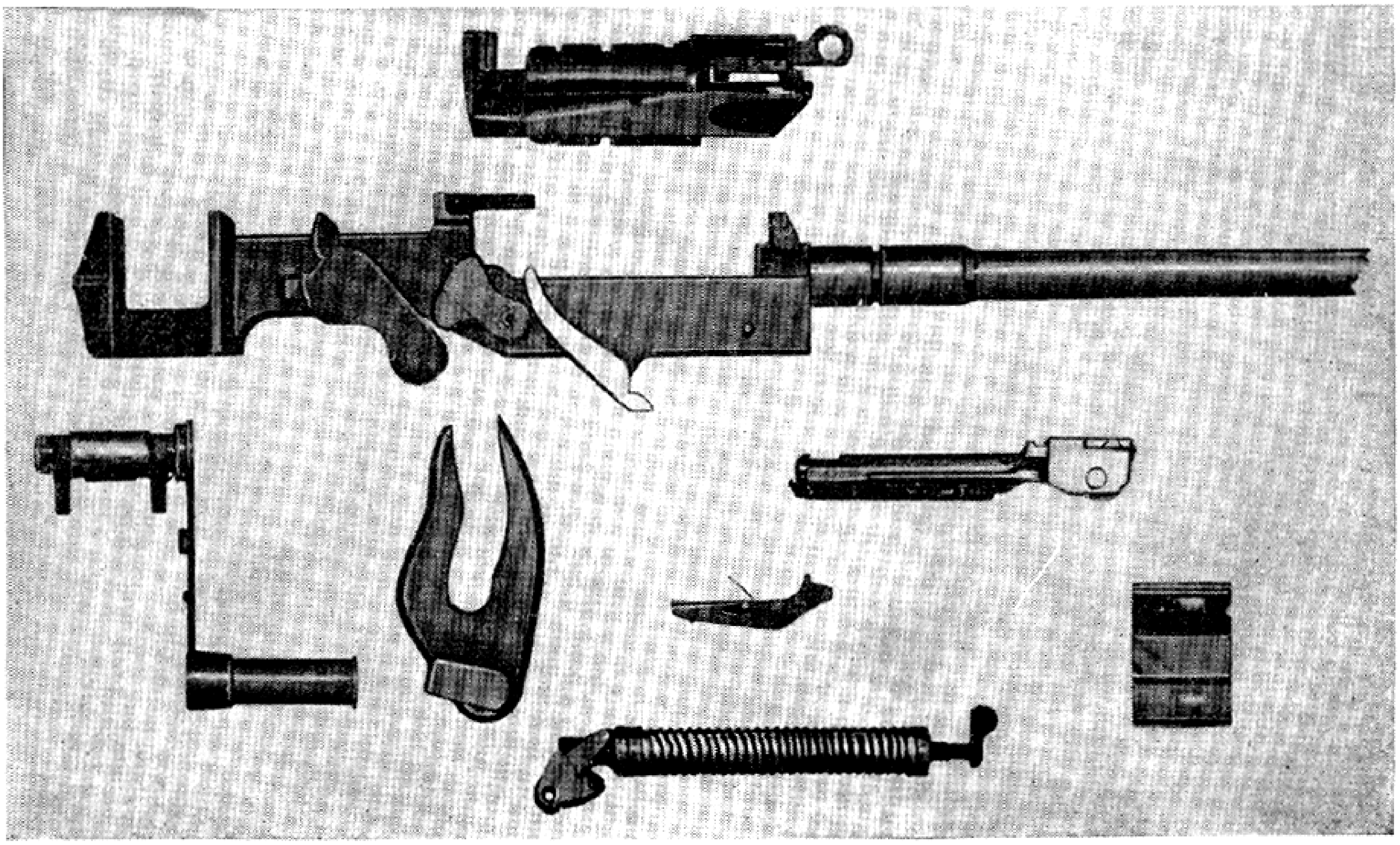
This rotation moves the roller in the accelerator cam groove of the locking angle and starts the accelerator cam turning rearward. The roller, which is attached to the bolt and rides in the accelerator cam groove, whips the bolt back at high speed, driving this part during recoil at a ratio of four to one.

In order to relieve the shock on the mechanism and prevent rupture of cartridge cases, the weapon is so designed that not until well after the chamber pressure has passed its peak does the breech lock begin to open. Then the recoil movement is utilized to loosen gradually the empty cartridge case in the chamber before sudden extraction takes place. The case is ejected in the most peculiar fashion ever used by a machine gun. It is wiped from the face of the bolt and pushed through an opening on the upper right side of the receiver and on the same side from which it is fed.

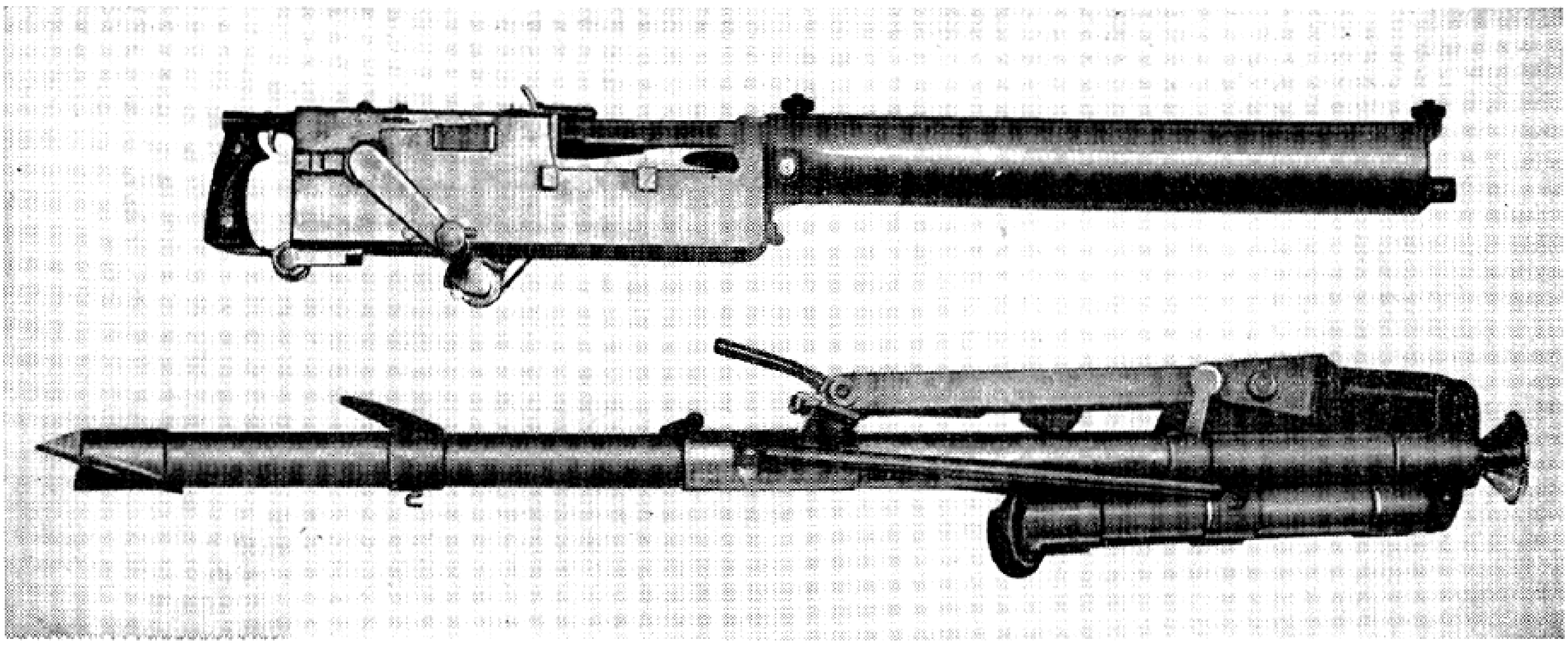
After unlocking, the bolt assembly, consisting of the bolt, striker, striker spring, extractor, and two sears, recoils as a unit, and during this movement the striker is compressed against its spring and the weapon cocked. This is brought about as the accelerator cam engages the rear of the striker. When fully retracted, the sears drop into their notches.

The gun is front seared and the accelerator lever times the release point for the striker during full automatic fire. It will continue to operate as long as the trigger mechanism is actuated.

To convert the weapon for operation by hand, the selector on top of the cover is moved from



Components of the Nordenfelt Machine Gun.



Nordenfelt Machine Gun, Model 1897, with Mount Folded for Carrying.

Automatic to *Manual* and the large crank on the right side is rotated in a counterclockwise direction. An eccentric on the crank cycles the barrel and barrel extension which in turn throws the bolt rearward.

By continued rotation the lugs on the operating crank shove the bolt into battery and chamber the incoming round at the same time. The lug then comes into position behind the bolt. This securely locks the mechanism so that the whole assembly will not recoil as in automatic fire. When this position is reached, the handle cams in the manual sear that protrudes through the right rear side of the receiver and the cartridge is fired. The operation will be repeated as long as the crank is rotated.

The ammunition is loaded 200 rounds to a belt and is fed from right to left. The feed mechanism consists of a star wheel with six divisions or spaces. When feeding during automatic fire, the recoil of the barrel extension actuates a projection on the feeder to the rear. This piece is engaged in a helical cam and the movement of the lug causes the cam to rotate one-sixth space counterclockwise, and winds a torque spring fastened to the star wheel shaft.

When the lug has made full movement, an escapement allows the stored energy in the spring to index the feeder. A ratchet arrangement then releases the barrel extension and permits the assembly to return to battery.

The belt enters the right side near the top of the receiver. If the weapon is to be fired manually and the force of the barrel-return spring is not utilized to help load the weapon, as is done when it is set for automatic fire, the crank handle must be rotated four complete revolutions to index the belt over the feeder and put the first round in the chamber.

One of the many peculiarities of the weapon is that if set on automatic fire and the trigger is actuated before the crank handle has been secured in its rest position, the latter will on the first shot rotate to its proper place and remain motionless throughout the remainder of the burst.

A barrel-return spring of the Maxim type, located underneath the front part of the receiver, can be adjusted to give any desired pressure by the adjustment of a winged nut.

The most notable feature of the feed system is that in 1897 the gun employed a push-out type of metallic link that is practically identical with ones used today.

Thorsten Nordenfelt was of the school that did not believe the automatic weapon was here to stay. Having long built and promoted the sale of manually operated multibarreled guns that enjoyed a fair amount of popularity throughout the world, he had little confidence in self-loading weapons. This was his first and last attempt to enter a field strange to him and towards which he was bitter and hostile.

Chapter 6

DE KNIGHT WATER-COOLED MACHINE GUN

On 20 July 1898 Victor P. De Knight, a resident of Washington, D. C., applied for a patent on a gas-operated water-cooled automatic machine gun. Originally chambered for the caliber .30 Krag United States infantry rifle cartridge, it had a rate of fire of 600 rounds a minute. While it represented one of the few water-cooled gas-operated guns ever to get beyond the design stage, it still was unsuccessful and is described here only to show the great lengths an inventor will go to in order to avoid infringement of anyone else's patents.

De Knight interested the Pratt & Whitney Co. in producing a prototype, which was given the designation, Model 1902. At the time this company was seeking a mechanism to market in place of its hand-operated Gardner, then being outmoded by the appearance of self-loading rapid-firing guns.

The weapon, although very clumsy in many respects, did have a few advanced features. The hinged top of the receiver not only made all working parts readily accessible but also housed the driving spring. Inertia firing, a pivoting bolt that was securely locked by the advance of the gas piston, and a simple screw in the side of the receiver that served as an ejector were also innovations. But the complicated gas system cov-

De Knight Automatic Machine Gun, Cal. .30, Manufactured by Pratt and Whitney.

ered by a water jacket with a regulating device that supposedly could be adjusted from the outside doomed the weapon from the start.

Feeding was accomplished by a lug on the gas piston which cammed the feed slide over one space on the recoil stroke. With the return of the piston a heavy spring pulled the feed pawl over behind the next round. The cartridge rim was engaged by a spring-loaded hook device that, when pulled a sufficient distance to the rear, removed the round from the belt and pivoted, forcing the bullet end down in alinement with the bore.

To fire the De Knight, the tab on a belt of ammunition is slipped through the left side of the feedway and the bolt-handled charger is pulled until the first cartridge is seated behind the stops and the next round in front of the holding pawl. When the bolt is pulled all the way to the rear, the operating mechanism is held by a sear located at the top of the pistol grip. The cartridge has been removed from the belt and tilted for chambering. Actuation of the trigger releases the bolt and gas piston to be pulled forward by the spring in the top of the receiver. The bolt face hits the bottom rim of the cartridge and drives it ahead into the breech end of the barrel.

As the bolt reaches battery, the extractor snaps over the cartridge rim and a lug on the gas piston in completing counter-recoil movement cams down the forward part of the pivoting breech lock. The rear end is thrust up into its locking recess in the receiver. The front part of the lug exposes the firing pin, which is struck by a portion of the gas piston to discharge the chambered cartridge.

When the bullet clears a gas port located nearly three-fourths of the way up the barrel, gas is let through the orifice and, after being vented through a long tubular affair, is finally released in a large cylinder and brought to bear on the piston. By this time the bullet has cleared the bore. As the piston is shoved back, the lug strikes the rear of the pivoting piece unlocking the action. The gas piston and bolt start recoil movement with the extractor claw holding the rim of the cartridge until it collides with the ejector screw, kicking it out the right side of the receiver. Meanwhile, the incoming round has been removed from the belt and pivoted down. The recoil movement is stopped by driving spring tension and, if the trigger remains depressed, automatic fire will result.

Outside of a few unofficial demonstrations nothing was done in the way of development since the De Knight first appeared in 1902. Even in the few trials it did have, it could by no means be classified as reliable, having at all times an abnormal number of stoppages. In 1916, with the United States at the point of war, interest in the weapon was revived and a thorough test was ordered by the Army on 31 May 1917. The only change from the earlier model was the use of a spring-loaded firing pin in place of inertia firing. That this was a mistake is evident by the results of the trial.

Part of the test report is given in order that the reader may judge for himself the reliability of the De Knight water-cooled machine gun.

"During the first 1,150 shots, three breechblocks broke and there were also many misfires and other malfunctions.

"The gun was then temporarily withdrawn by the representatives of the company in order to procure new parts.

"Upon resuming the test there were many malfunctions during the first 6,000 shots, and the representatives again desired to withdraw it for alterations and repairs. This the board did not allow on account of the short time remaining at its disposal and the gun then was permanently withdrawn.

"Total number of malfunctions: Misfires—143; Jams—5; Broken parts—7; Ruptured cases—1; Failure to eject—1; Failure to extract—0; Failure to feed—16; Other malfunctions—9. Total—182. Total number of rounds fired 7,150."

Chapter 7

MADSEN AUTOMATIC MACHINE GUNS

There came into existence in 1902 an automatic machine gun the parentage of which has been one of the most controversial subjects in the history of such weapons. It has been officially known under the names, Madsen, Rexer, D. R. R. S., and Schouboe, and was originally manufactured by the Dansk Rekylriffel Syndikat of Copenhagen, Denmark.

It derived the title by which it is best known, Madsen, from the name of the Danish Minister of War of that period, as a tribute to his enthusiasm for the weapon at the time of its adoption by the country's armed services. The use of the name, Rexer, is due to a long-standing policy of the British Empire in not considering for adoption any small arm that was not fabricated on English soil. Thus, in order to interest the authorities, many of these guns were made at a

Madsen Machine Gun, Model 1903, Being Demonstrated by Lt. Schouboe.

British arms factory known as Rexer. The D. R. R. S. title uses the initials of the Danish firm. The designation of Schouboe comes from the widespread belief that Theodor Schouboe, the director and engineer of the rifle company, was the actual inventor of the weapon.

Research on this bewildering topic adds even more complications. While it is true that Schouboe on 14 February 1902 did patent the basic operating principles of the mechanism, it is also a fact that on 15 June 1899 Julius Alexander Rasmussen, the director of the Royal Military Arms factory, in Copenhagen, applied for and was subsequently issued a patent on the identical features claimed by Schouboe three years later. To confuse the issue further, Rasmussen assigned his patent rights to the Dansk Rekylriffel Syndikat, the first to produce the weapon.

The original patent grant to Rasmussen covers fully all principles involved in utilizing an automatic rifle in which the energy of its recoil forces makes the arm automatically feed, fire, extract, and eject. It employs the basic system, first manually used in the lever-operated Peabody and Martini rifles, whereby a pinned breechblock rises during the forward lever stroke to uncover the base of the fired cartridge case, thus allowing its extraction and ejection. Then by its first rearward action, the bolt or breechblock falls below the barrel opening to permit chambering of the incoming round. The final movement forces the bolt to rise again to give support behind the loaded cartridge.

These actions, on the automatic weapons, are governed by a circular stud on the recoiling barrel extension working in grooves on a switch plate fastened to the receiver. The bolt is locked in the up position for the first half inch of recoil and so held until the bullet has traveled through the bore and the powder pressure has dropped to a point where it is considered safe to start the cycle of operation.

While this unique system has worked with great reliability, many still insist that the action is unsound in an automatic weapon, for the reason that each round, upon being rapidly loaded, is slightly distorted into an arc while being chambered. This view is supported by the fact that a very high percentage of stoppages results from stuck cases, especially when rimmed ammunition is used. This is thought to be caused by a deformation of the round in the act of loading.

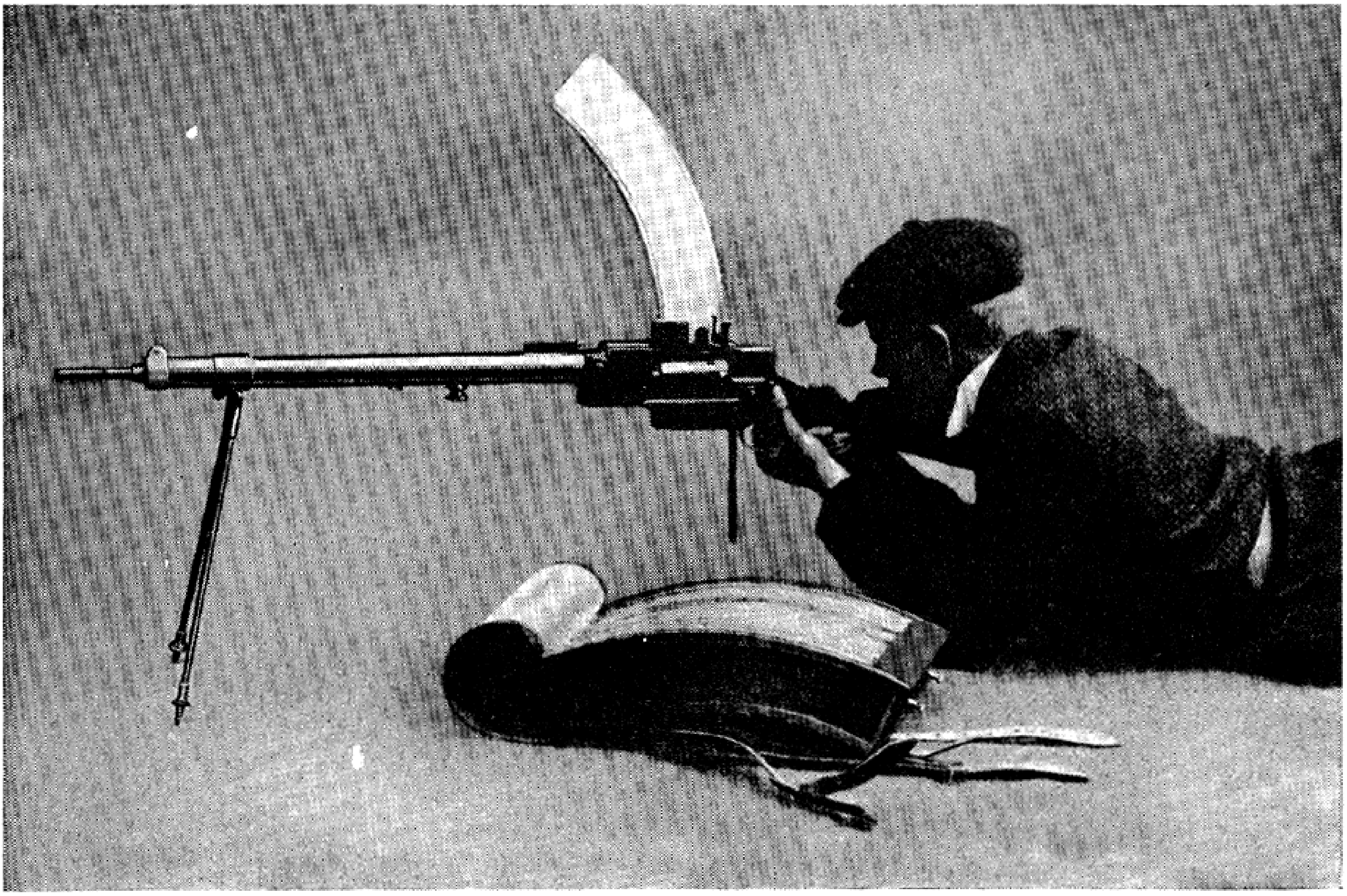
The pilot model was chambered for the 8-mm Danish Krag-Jorgensen round with a muzzle velocity of 2,228 feet per second. This was nearly identical with the service rifle cartridge employed by the United States Army just after the Spanish-American War. Practically all models that followed were designed for rimless ammunition, which was always considered more reliable, since a more tolerant head space can be allowed.

The first-mentioned use of the Madsen in warfare was by Russian forces in the Manchurian war of 1904–05. Some of their cavalry units were armed with it, but the foreign observers barely made note of the fact beyond a statement that a few had been seen.

Officials tests were begun by the United States Army on the machine rifle version on 9 September 1903, at Springfield Armory, Springfield, Mass., and later concluded at Fort Riley, Kans. The firing was done by Lt. Theodor Schouboe, of the Danish Army, who personally represented the Dansk Rekylriffel Syndikat. In this test the feed was considered unsatisfactory and, when the ammunition was not lubricated, a ruptured cartridge case generally resulted.

A total of 7,163 rounds were fired, during which enough malfunctions occurred to justify the official conclusion that the Madsen weapon had not reached a stage of reliability to warrant adoption. The most objectionable feature occurred when the driving spring repeatedly failed to propel the mechanism home and Lieutenant Schouboe then had to rise to a kneeling position in order to exert enough force on the charging handle to shove the action full into battery. In combat such a movement would make the operator an outstanding target. The weapon's accuracy was considered satisfactory and complimentary reference was made to its unusually light weight.

An air-cooled, belt-fed heavy Madsen machine gun, designed for calibers from 6.5 mm to 11.35 mm, made its appearance shortly after this. Many of the earlier malfunctions were corrected, so that it was considered reliable for special objectives. If certain peculiarities are overlooked, the



Madsen Machine Gun, Model 1903. Photographed During United States Trials.

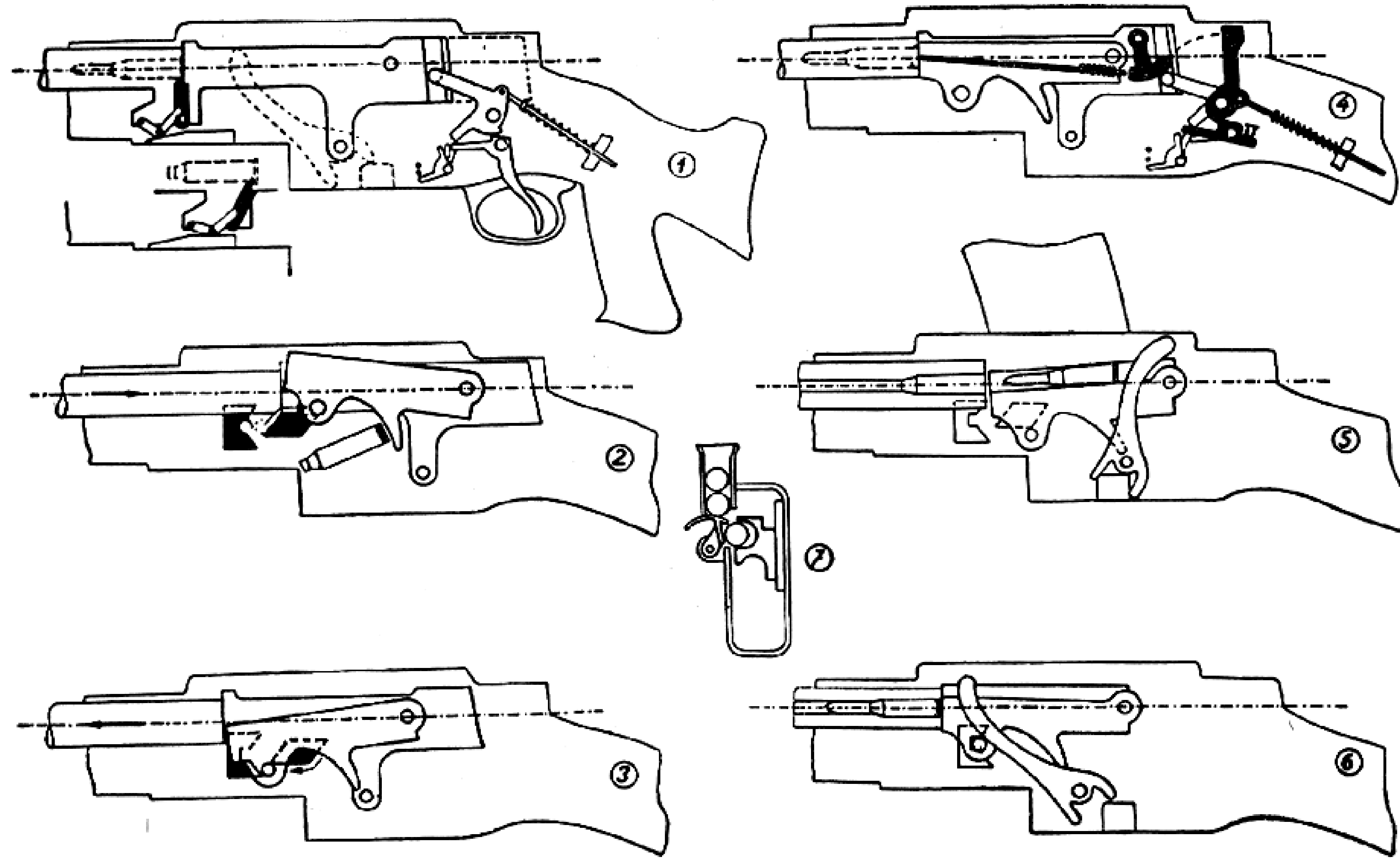
Madsen can be classed as one of the few automatic weapons that have successfully stood the test of time.

When the belt-fed automatic machine gun version is prepared for firing, the ammunition belt is started into the left side. The disintegrating links used in the feed belt are of peculiar design. The front of the link fits over the shoulder of the round which has to be pulled through it by the feeding action. The rear portion of the link is of the type known as the "push-out" or "half-link," in that it does not go all the way around the base of the cartridge. A sharp claw of spring steel holds the case firmly until it is finally withdrawn.

Once the weapon is cocked and the first cartridge is placed under the belt-holding pawl, the large charging handle on the right side is pulled back. This action moves the barrel extension a considerable distance to the rear after the bolt rises. The pawl holding the cartridge in position is carried to the right by the camming action which takes place between the barrel extension and the piece supporting the incoming round until the cartridge is forced through the feed slot in the receiver.

At this time a spring-loaded claw cams itself over the rim of the cartridge. The pivoting of the feed arm actuates the claw rearward and withdraws the cartridge from the belt, positioning it in the feed trough in the top of the bolt. The pivoting lever has by now taken its place behind the round. Upon release of the cocking handle the energy of the compressed driving spring sends the lever forward. The front end of the bolt is pivoted down below the bore in the barrel. Further movement forward of this lever causes it to strike the base of the cartridge, ramming it into the chamber. The final pivot movement raises the breech block full behind the bolt and the weapon is ready to fire.

The rearward pull of a trigger releases the large striker which flies upwards in an arc against a firing pin, detonating the primer. Dur-



Action of the Madsen. (1) Loaded, Locked, and Ready to Fire. (2) After Firing, Bolt Pivots Up to Eject Cartridge. (3) Bolt Pivots Down for Loading. (4) Loaded, Locked, and Ready to Fire. (5) and (6) The Action of the Loading Arm. (7) Magazine Cut off Device.

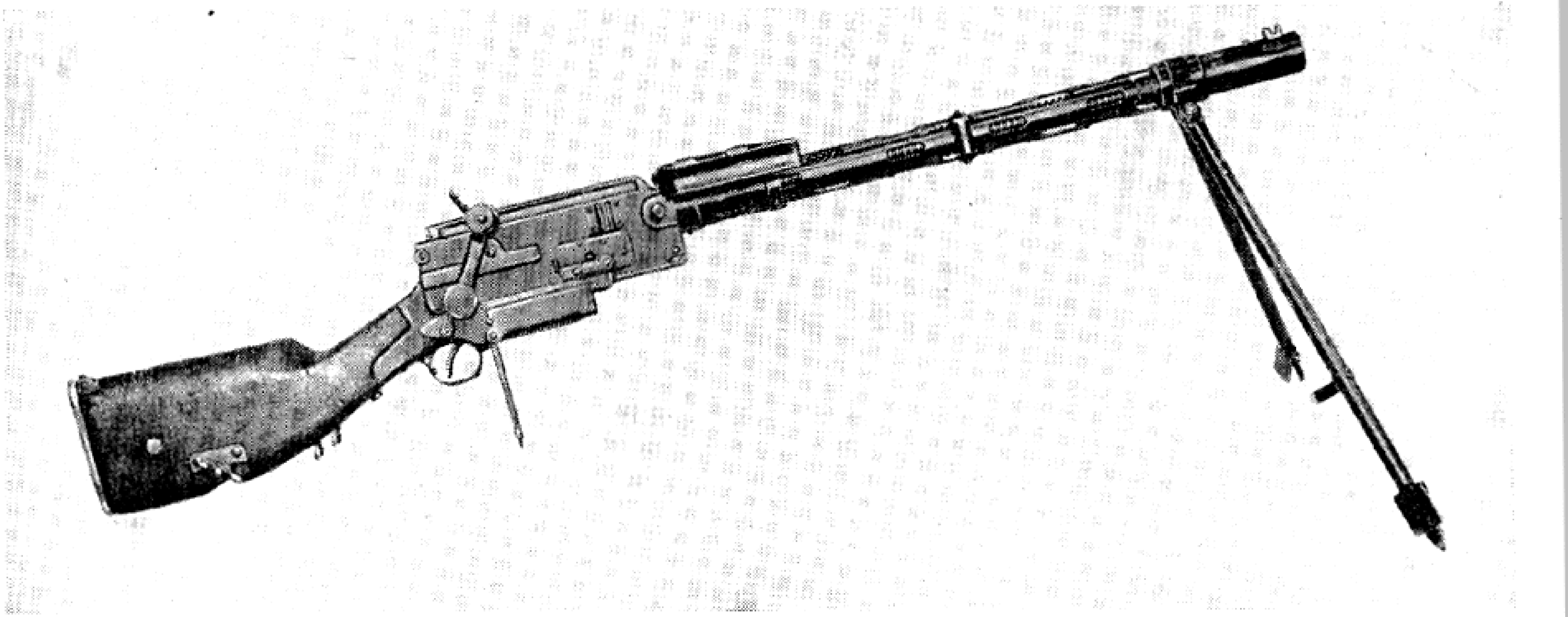
ing recoil, the barrel, barrel extension, and bolt are securely locked for one-half inch, until the trigger bar is struck by the rear of the recoiling bolt mechanism. This frees it, allowing the striker to be forced back to the cocked position and the spring-loaded firing pin is withdrawn into the bolt body. The guide stud then passes out of the horizontal groove and travels up the top cam of the switch plate to pivot the bolt face upwards. The base of the empty cartridge case is thus uncovered, permitting the recoiling extractor to apply a sudden mechanical advantage as it strikes the lug in the bottom of the receiver. The extractor claw, in one rolling motion, not only withdraws but ejects the empty case from the chamber. The case is guided out of the receiver by the curved contour of the bolt until it falls clear to the ground.

During the last of the recoil movement the barrel extension has cammed another round into the receiver feed slot, and the pivoting feed and operating arm positions it in the trough formed by the machined recess in the top of the bolt. Counterrecoil, originating in the stored energy of the driving spring, when it starts the entire operating assembly back to battery, first depresses the bolt and then drives the cartridge into the chamber.

The bolt and barrel extension are then accelerated forward by this spring acting through the medium of the cammed pivoting of the radial operating arm. When the counterrecoil movement is almost completed and the base of the cartridge is fully covered by the rising of the pivoting bolt, a cam on the arm automatically releases a sear if the trigger is still held rearward. The striker again flies up to continue the cycle.

This was the most unusual employment of the short-recoil principle known to date. Although the bolt unlocked in scarcely a half-inch rear travel, the barrel extension continued to recoil to a point slightly exceeding the combined over-all length of the cartridge case and projectile.

On some models a device was fastened to the barrel jacket at the muzzle end to trap the blast after the bullet cleared the bore. This was done



Madsen Machine Gun, Model 1914, 8 mm.

by a controlled orifice that permitted the bullet to clear along with some of the still-expanding gases. The remainder acted on the face of the barrel somewhat on the order of a piston, accelerating the recoil forces and resulting in an increased rate of fire plus an added amount of belt pull.

The Madsen was greatly respected by European governments and met in open competition all the machine guns that were commonly known at the time. Although it was more reliable than spectacular and had a notoriously slow rate of fire when the muzzle booster was not used, it nearly always managed to pass successfully the various trials. An experimental Madsen gun with a muzzle booster, fast return spring and very light working parts was once found capable of reaching a very high speed but had frequent stoppages due to ruptured cartridge cases. However, this was eventually overcome by lubrication of the ammunition.

Many consider the Madsen the first truly light machine gun to make its appearance in the automatic field. It was accurate, reliable with good ammunition, and had little recoil to disturb the gunner's aim. It was however prone to serious stoppages that were exceedingly hard to clear unless ammunition was used that was above the average issued for service use. And while it was fairly simple and very robust in design, it was found to be unusually expensive to manufacture due to certain features that required extensive machining.

While the Madsen was standard equipment of the Danish and Norwegian Armies and was used by some small states on the Continent, it was not looked upon favorably by the larger powers. Both England and Germany tested the weapon experimentally during World War I. England used a few to a very limited degree while Germany rejected it outright.

The action on this machine gun has been exploited perhaps as much as any other system in existence. This has resulted in over a hundred different models that were used by most of the military forces of the smaller nations, with the Balkan and South American countries buying the bulk of these weapons. It has been chambered at one time or another for just about every size rifle cartridge that has ever been developed.

BERGMANN AND DREYSE MACHINE GUNS

Bergmann Machine Gun

Perhaps there has been more confusion surrounding Bergmann and Dreyse machine guns than for any other automatic weapons on record. Although these two are separate and distinct mechanisms, they are here presented in the same chapter in an attempt to show clearly the differences between them.

The original gun was designed by Theodor Bergmann of Gaggenau, Germany, and patented by him in 1900. The weapon was known as Model 1902 and was manufactured by Bergmann Industrie Werke Abt. Waffenbau of Suhl. It was followed shortly by Model 1903, which differed from the first gun only in mounting and positioning of the feed box.

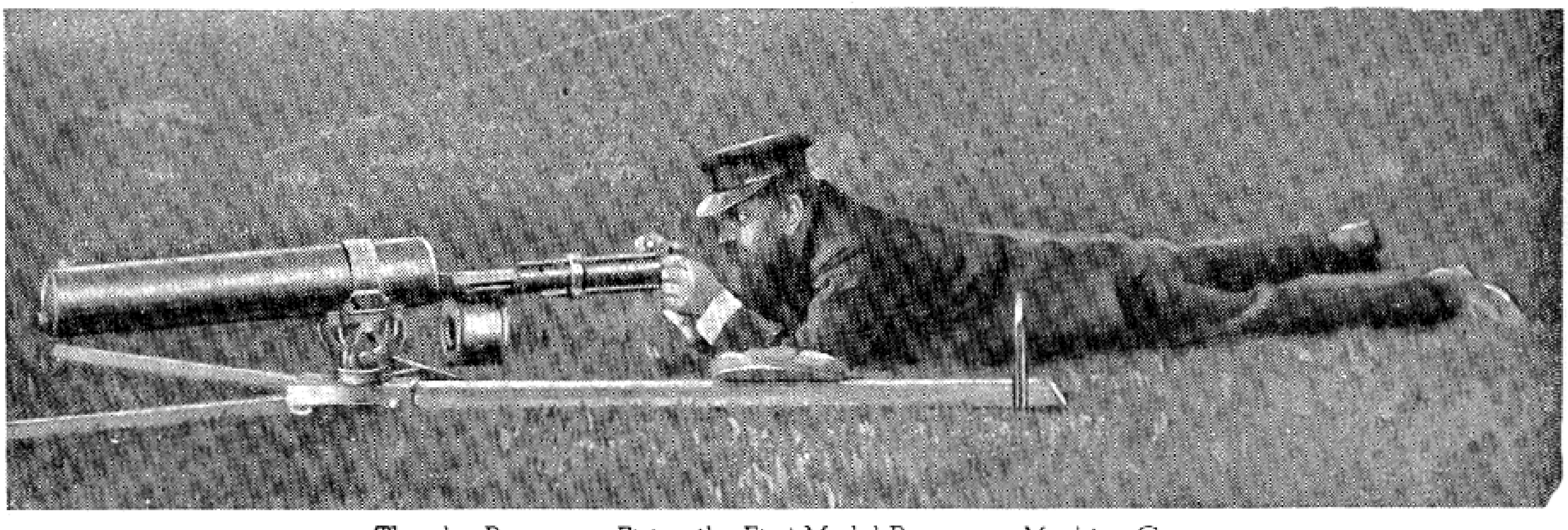
The Bergmann is operated on the principle of short recoil, whereby all recoiling parts are securely locked until the bullet has cleared the bore. At the instant of unlocking the bolt is free to move to the rear, with all components working in a straight-line movement. Its simple construction makes it possible for the soldier in the field to disassemble and put the mechanism together again without the aid of tools. A vertical rising type lock is employed.

There are three principal parts to the gun: The receiver, which houses the barrel, barrel extension, and water jacket; the back plate, which contains the trigger mechanism and has fastened to it the spade grips; and the cover group, which encases the feed system and serves to lock the receiver to the cover.

To fire the weapon, the gunner places the first round in the cartridge belt under the belt-holding pawl until the round comes to rest against the cartridge stop. The bolt is then manually pulled back by a cocking handle. When it starts rearward, the claw of the feed slide begins to extract the loaded cartridge from the feed belt. This rearward action also pushes the striker down until it engages the sear that holds it in a cocked position. By the time the bolt has reached its full stroke, the feeder arm pivots over and places another round in the belt in place of the one just removed.

When the bolt is released, it is driven forward by the driving spring. In doing so, it picks up the cartridge held by the feed claw and chambers it. At the same time the extractor lip is cammed over the rim of the cartridge case.

The weapon is now charged and ready to fire. The disc-shaped upper part of the trigger is

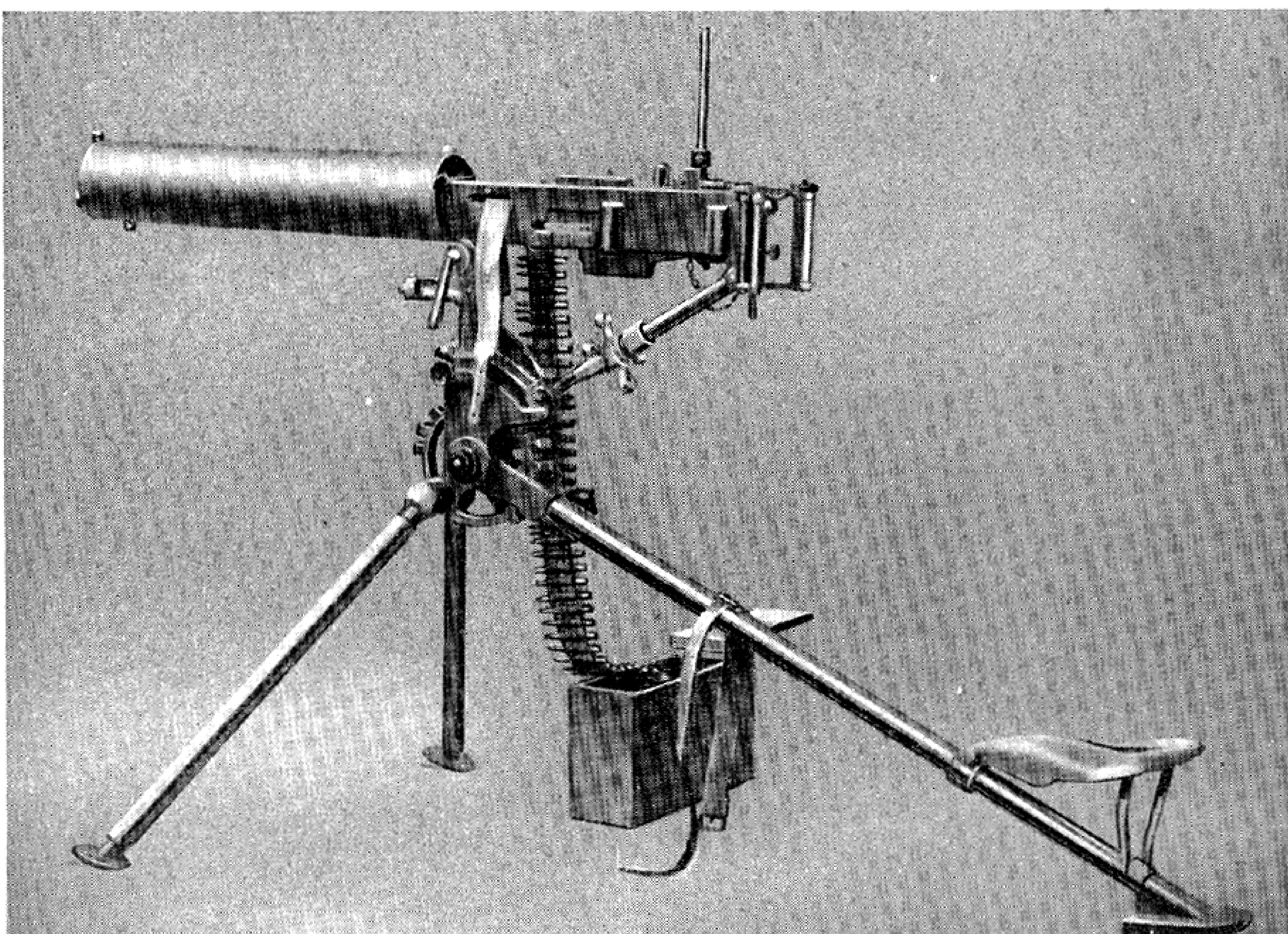


Theodor Bergmann Firing the First Model Bergmann Machine Gun.

pressed forward after the safety catch has been disengaged to force back the trigger bar. This in turn pulls the sear away from the cocked hammer, which flies up detonating the primer in the cartridge. Upon discharge of the cartridge, all recoiling parts move together securely locked for one-half inch. At this point the bolt is unlocked. The breech lock is cammed down out of its locking recess and allows the bolt to recoil free of the heavier parts. The extractor withdraws the empty case and holds it in position for the ejector, a curved spring-loaded arm fastened in the top of the receiver. It strikes the empty case a blow on its base, knocking it through an opening in the left side at an angle of 45 degrees downward. This cycle of operation is continued as long as the gunner depresses the trigger piece located between the spade grips.

The Bergmann machine gun was looked upon favorably by the German Army because of its many refinements. It was compact in form, built on small dimensions and protected from dust, mud, and moisture by its tight-fitting receiver. The so-called "straight-line" action has always been regarded by the Germans as the most durable and the one that would require the least servicing in the field.

The barrel had a quick disconnect that could be changed in 20 seconds, being held securely to the receiver by a bayonet lock that could be disengaged merely by pressure on this part. The most notable feature about the gun was that this act could be accomplished without losing the water out of the jacket. This was done by tilting the barrel down at a 45° angle. When the barrel extension and barrel were pulled out from the rear, a leather stopper was placed in the front barrel bearing to prevent a leak. The insertion of



Bergmann Machine Gun, Model 1910.

a fresh barrel simply knocked the plug out of the bearing as it was inserted in the proper position.

The cover could be lifted to expose the breech lock and recoiling parts. The operator thus had full view of all parts that might need maintenance. As the feeder was housed by the cover, any fault could be easily corrected without delay.

A double safety arrangement gave absolute security against accidental discharge from any conceivable source. This was considered of great importance by the Germans as their maneuvers required machine gun units to drag loaded weapons through thick underbrush.

The rate of fire was fairly low, with a maximum of only 400 to 450 shots per minute. This feature was also felt to be adequate by the Germans, as it was thought that with the Bergmann gun's medium weight any higher cyclic rate would only increase dispersion.

One of the best features was the withdrawing and positioning of ammunition from a belt by an extractor claw arranged on the feed slide. The part was so located that the claw would engage the rim of the incoming cartridge case even when haphazardly belted. This permitted reliable firing of ammunition the linkage of which would prohibit use in other machine guns. The belt itself was constructed of aluminum non-disintegrating links.

Such refinements show the meticulous skill of Theodor Bergmann, who not only designed this fine weapon but had numerous other patents on all types of automatic arms ranging from heavy machine guns to blow-back-operated submachine guns and pistols. His products have always demonstrated the highest degree of skill in the art of gun creation.

The weapon was again modified and issued as the Bergmann machine gun Model 1910. The changes in the basic mechanism were slight, the mount receiving the major alterations.

Dreyse Machine Gun

In 1912 a new water-cooled machine gun, caliber 7.9-mm, was introduced to the German service. The weapon was called the Dreyse, in honor of Johann Nikolaus von Dreyse, the inventor of the German needle gun and founder of the arms factory so named. This mechanism was patented by Louis Schmeisser of Erfurt, Germany, in 1907 and all rights were assigned to Rheinische Metallwaren und Maschinenfabrik A.G. of Düsseldorf. Although at first glance the gun appeared to be but an improved Bergmann, basically it is different and there is no similarity in the mechanism. The main difference between the two is that the Bergmann lock rises vertically while the Schmeisser (or Dreyse) lock pivots.

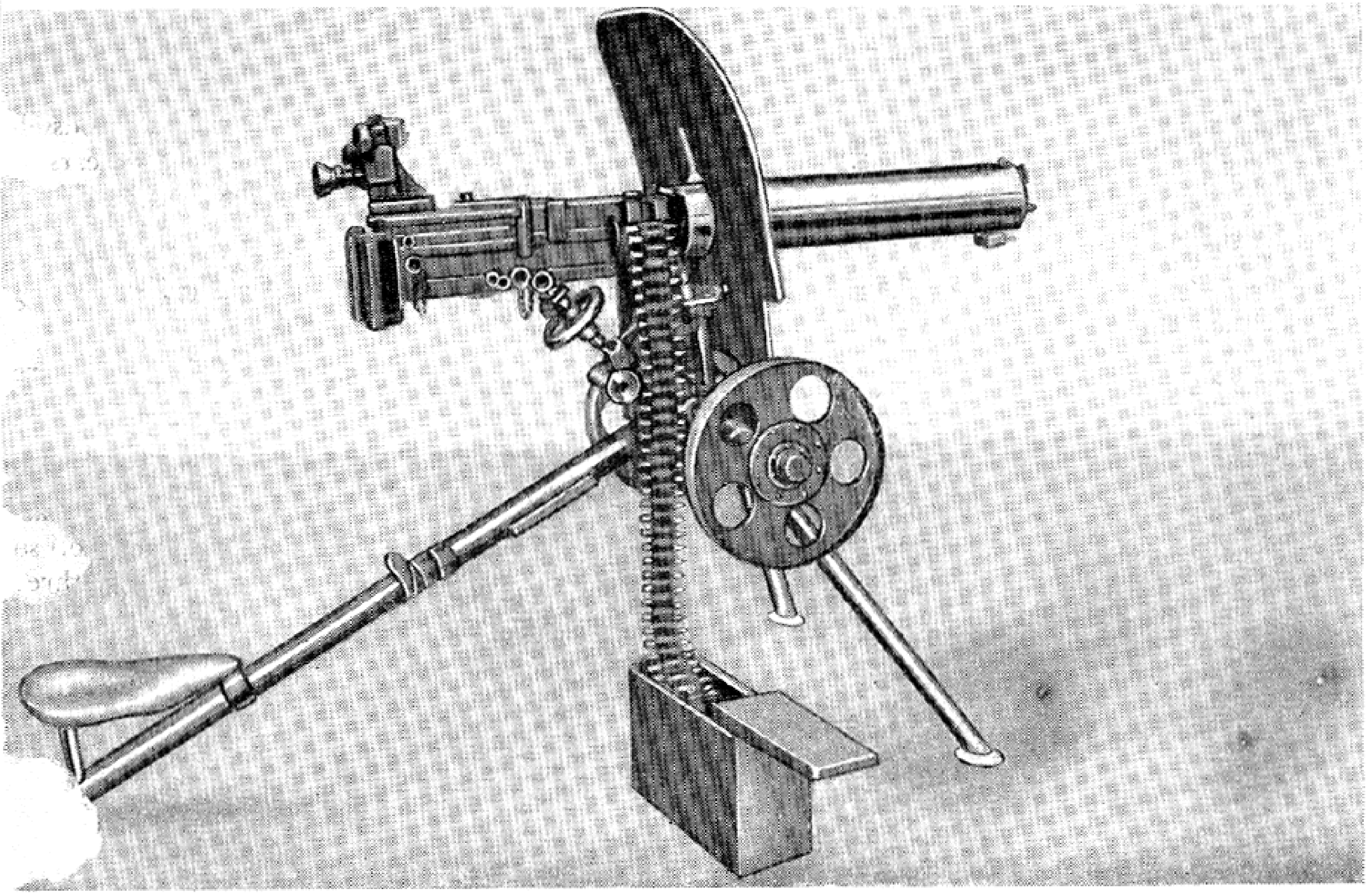
The principal features found in the gun were the mechanical accelerator and a three-claw arrangement on the mainspring housing that withdrew the cartridges from the feed belt. The claws were positioned in a manner that made it practically impossible to have belted ammunition so much out of alinement that one of the claws would not pick it up and position it for chambering.

The breech lock was known as the oscillating or pivoting type. It was pinned at the bottom of the barrel extension, swinging down for unlocking as the rear portion rode up a ramp on the recoil stroke. The addition of the accelerator gave a rate of fire of 600 shots a minute.

The weapon, when it made its first appearance, was looked upon as just another machine gun by German military leaders. Later the Dreyse Models 1915 and 1918 were introduced as the possibilities of its design were better appreciated. The Model 1915 did not perform successfully. However the Model 1918 proved to be quite reliable.

The German Army, which had been committed to the Maxim, found that this heavy weapon and its sled-shaped mount did not lend itself to the mobility that had by this time been found vitally necessary. A lightweight machine gun was needed that could be carried by a single soldier and was capable of delivering sustained fire so that relatively few men so armed could hold a position until reinforcement by the heavier Maxims was possible.

The Dreyse had been designed for just such a use. It could fire bursts of great duration since it was water cooled. It was the lightest gun of its type then known, weighing only 37 pounds with water jacket empty. The Germans had several light machine guns but the others were air cooled and the authorities thought much more highly



Dreyse Machine Gun, Model 1912.

of the efficiency of the water-cooled weapon. Since only a few pounds separated the two different styles, they looked very favorably on the extremely lightweight Dreyse. The large tripod mount originally designed for it was removed, and a bipod was substituted. This permitted the advancing infantryman to fire from the prone position. It was thought that this weapon, so mounted, best fulfilled the high command's conception of the primary function of all automatic weapons, namely, to deliver economically the greatest volume of fire power without sacrifice of mobility and accuracy.

Provision was made on the receiver for mounting a telescope sight; otherwise the conventional graduated iron sights that could be folded down when not in use were employed. The double safety arrangement was retained from the original design. There were only three main groups in its construction: The receiver, the back plate, and the cover. The receiver housed the barrel, barrel extension, operating parts, and water jacket; the back plate contained the buffer spring and trigger mechanism; while the cover held the feed slide and components.

To unload the weapon, the belt-holding pawl was lifted, allowing the belt to be pulled back so that the feed pawl would not engage the last round. Then the chambered round was removed by pulling back all the way on the retracting handle and then releasing it.

To fire the Dreyse water-cooled machine gun, Model 1918, a loaded cartridge belt is placed in position and the tip is pulled to the left until the first round snaps behind the belt-holding pawl. The retracting handle is withdrawn all the way and released, only one pull being necessary to withdraw the cartridge from the belt and chamber it. The trigger is now pushed in to pivot the sear back, releasing the hammer which, upon flying up, strikes the firing pin and detonates the powder charge. After the barrel extension, barrel, and bolt recoil a distance of less than a half inch, the breech lock is lifted at its rear end by the cammed surface at the bottom of the receiver. This forces down the front part

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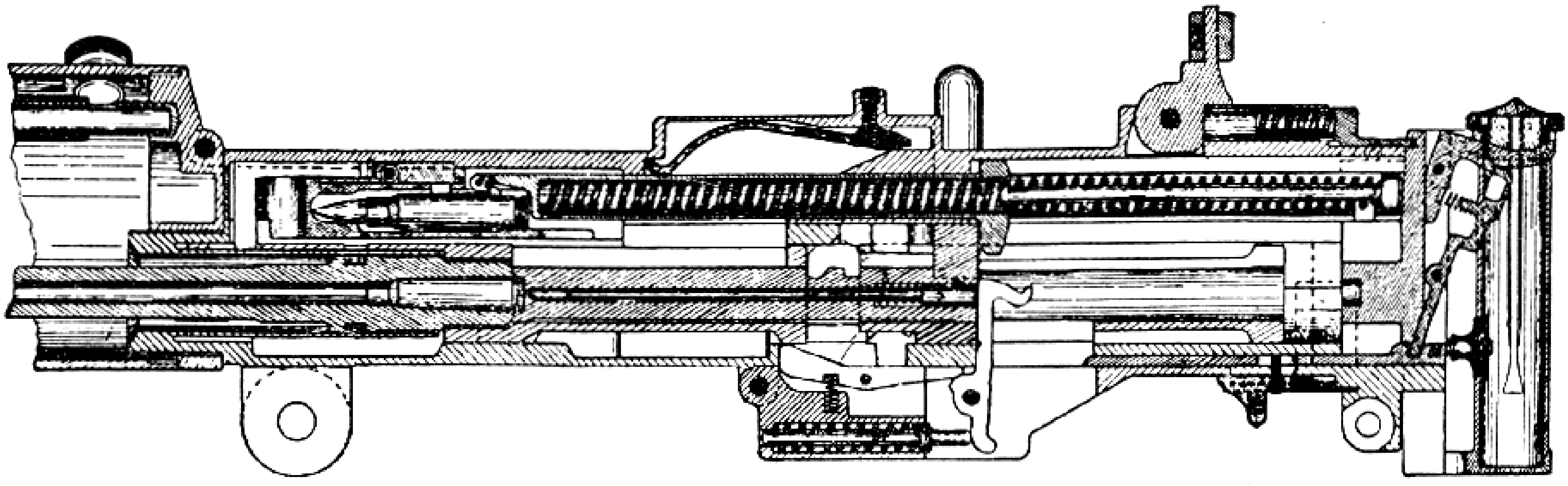
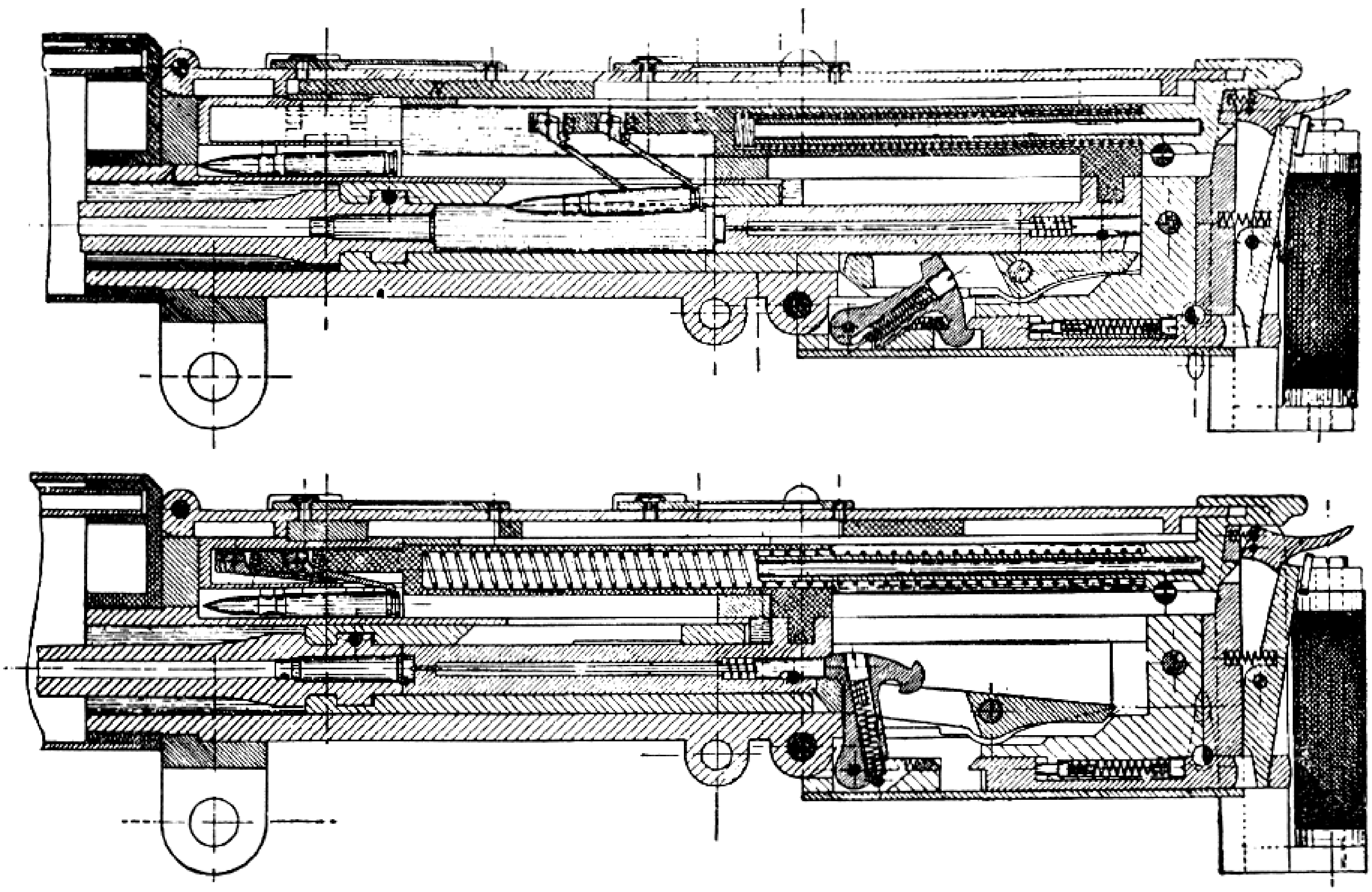


Section Drawing of Bergmann Machine Gun.



Section Drawing of Dreyse Machine Gun.

located behind the bolt, allowing it to recoil free of the heavier parts.

Actuated by the stud on the barrel extension, the accelerator then drives the bolt to the rear. The hammer is caught by the bolt lock and held to its rear position by the safety sear. The base of the cartridge strikes against the right guide which serves as the ejector and kicks the empty cartridge out the left side of the gun at a downward angle. The rear claws on the mainspring housing draw the new cartridge from the belt, and the housing, continuing to travel to the rear, catches the feed lever by means of a stud. The longitudinal movement is thus translated into transverse motion, actuating the feed slide over one space and positioning the incoming round.

The belt-holding pawl at the same time slips behind the next cartridge in the belt and holds it for the next phase. The two remaining claws on the mainspring housing depress the withdrawn cartridge into the feedway. The recoil stroke having reached an end, the stored energy in the driving spring then starts the firing mechanism forward. After chambering the round, the accelerator releases the barrel and extension from a retracted position to go into battery. This pivots the swinging lock, which is raised by the cam on the bottom of the receiver, and locks the barrel, barrel extension, and bolt together.

The stud on the main spring housing carries the feed lever all the way in to place the incoming round against a cartridge stop in position for the extractor claw to slip over the cannelure of the cartridge. A projection on the barrel extension will trip the safety sear if the trigger is still depressed. And the last forward movement of the locked bolt and barrel releases the cocked hammer that drives the firing pin forward to discharge the next cartridge.

Chapter 9

PERINO MACHINE GUN

Italian inventors, like those of every other nation in Europe, felt as a matter of national pride that their military forces should be armed with an automatic machine gun that was not only designed but fabricated in their own country.

In 1901 Giuseppe Perino, officer in charge of the Italian artillery factory in Rome, designed a machine gun that must still be admired today for its many advanced features.

The Italian Government, coming to the conclusion that it had a superior arm, immediately placed it in confidential status. Only a few at a time were built and experimented with, until it was felt the weapon was improved enough to compete with well-known machine guns.

In 1908 the government conducted a secret trial to compare the Perino with the Maxim. The test revealed that the Perino had a higher rate of fire than the latter, and that when water boiled in the jacket from prolonged bursts, the liquid could be changed during continued operation in the Italian gun but not in the other.

The mechanism was also found to be of simpler construction and was far easier to handle in the field, although it weighed 50 pounds without mount.

The most objectionable feature noted by the examining board was the delay caused by the need for manual removal of empty cartridge cases from the strips before they could be reloaded. This was an odd complaint since it was a by-product of one of the best and most unique methods of feeding to be found at this early date.

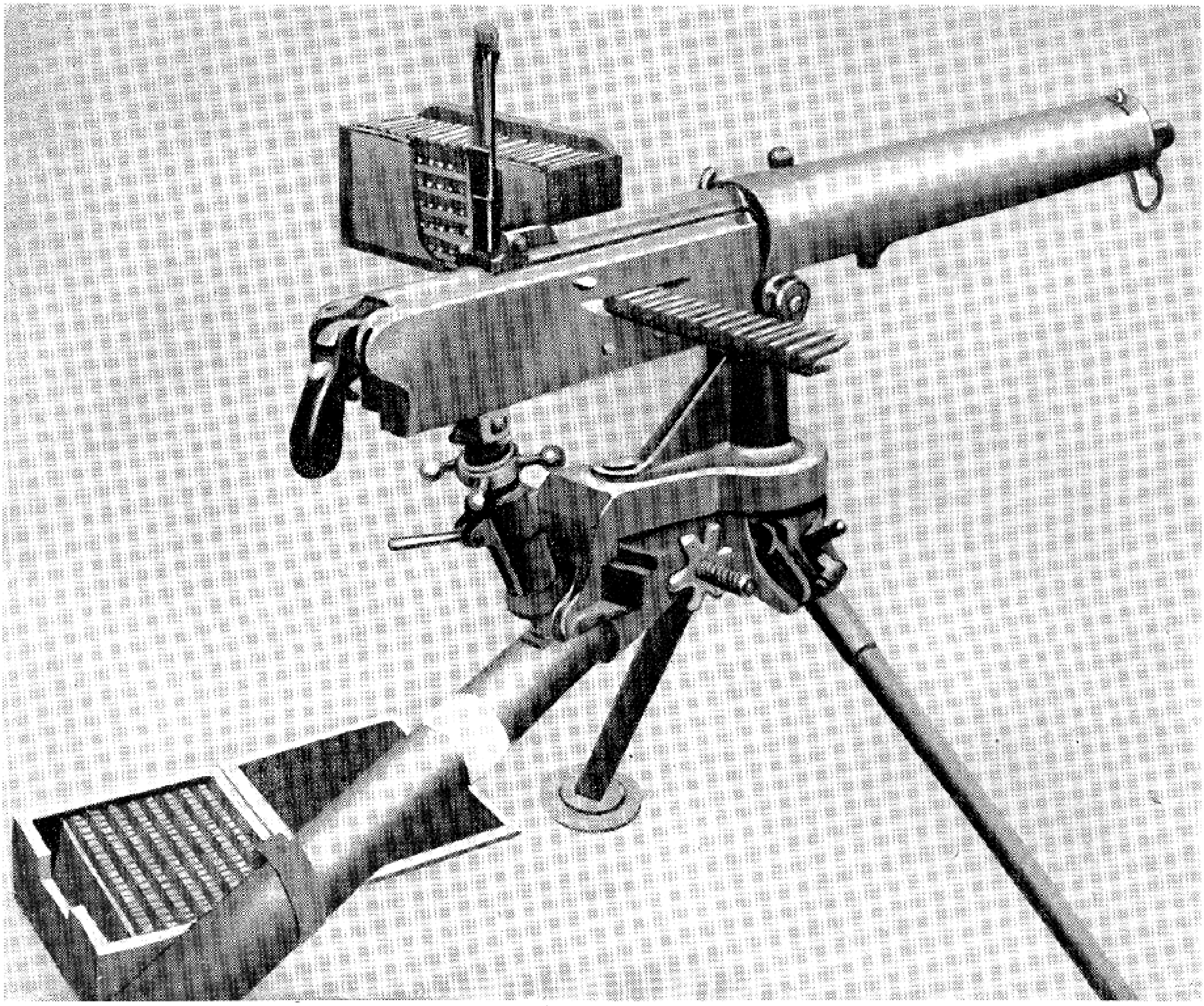
Metal trays holding 25 rounds of 6.5-mm cartridges were fed into the gun from left to right. The ammunition box held five such trays or clips. The weapon fed the trays one at a time from the bottom of the ammunition container. In this manner it was easy for the gunner's assistant to keep the box full by laying loaded ones on top of the stack. It also allowed a sustained fire as long as the gun functioned. A loaded tray followed immediately behind the ejection of an expended one from the right side of the weapon with the empty brass reclipped in the tray. In this manner of feeding, no metal link or fabric belt was required and no case ejection chute was necessary, since the empty case was placed back in the tray after being extracted from the chamber.

To fire the Perino, a clip or tray of ammunition is inserted in the feed opening on the left side. This is done only when the bolt is in battery, and secured by the pivot lock that is fastened to the barrel extension and engages the locking grooves on both top and bottom of the bolt.

The charging handle is then pulled smartly to the rear. When it reaches its full rearward stroke, a sear engages the bolt recess and holds it in the cocked-bolt position. This movement also indexes a round in position to be chambered. Upon pulling the trigger, the sear releases the bolt, which is then driven forward by the stored energy of the barrel-return spring. The bolt does not strip the round, as in most other machine guns of this type, but pushes it out of the clip into the chamber. It actually passes over the top of the clip where the cartridge was formerly held.

When the round is chambered, it is fired by inertia after the bolt is securely locked. After firing, the barrel, barrel extension, and bolt are locked together until the barrel pressure has reached a safe operating limit. At this point the unlocking lug of the lock engages a cam in a fixed receiver and pivots the lock to free the bolt from the barrel.

At the instant the bolt is freed, the cocking device, consisting of a two-forked lever pinned to the barrel extension, strikes a fixed stop in the bottom of the receiver. Further recoil of the



Perino Machine Gun, 6.5 mm.

barrel extension causes the cocking lever to rotate. The top end of the lever engages the bolt, and its rotation first retracts the firing pin and then accelerates the bolt to the rear.

When this movement starts, a lever attached to the barrel extension engages a gear rack in the bottom of the receiver. This is done to utilize all the energy of the extremely long recoil stroke, and to give positive timing between the bolt and barrel cycle. This linkage arrangement acts as an accelerator both for carrying the bolt to the buffer and for returning it to battery, with the bolt and barrel both in their most rearward position. The lever takes the place of a driving spring. For as the barrel return spring forces the barrel back to battery, this linkage whips the bolt forward, insuring that it will overtake the barrel in time to go into battery together. It also positions the bolt so that the cam-operated lock can engage it, thus preventing any possibility of firing before the piece is securely locked.

The long recoil stroke allows a gradual loosening of the empty cartridge case in the chamber. When the fired brass is withdrawn by the extractor, it travels its length rearward and in place of being ejected from the gun, it is released by the extractor and snapped down in the feed tray. The bolt continues its travel. After it has passed clear of the cartridge tray and is at the extreme end of its recoil stroke, the lug on the barrel extension cams the feed tray over one space, indexing the next round into position. If the trigger is held, the automatic action will continue.

Italy planned to manufacture the Perino weapon in its federal arms plants, believing that this, coupled with its simple design, would allow the economical production of one of the world's finest machine guns.

After the secret trials the only important change was an alternate method of supplying cartridges besides the strip feed. This modification consisted of a drum arrangement on the left side of the weapon upon which was rolled the belted ammunition fixed on a flexible brass strip. The feature of rebelting empty cartridge cases was retained. The loaded ammunition still was fed in from the left side while the belted empty brass emerged from the right. The belts had a quick detachable snap at two-foot intervals, so that the gunner could instantly separate the strip if he cared to move the weapon's position when the empty brass and belt began to pile up.

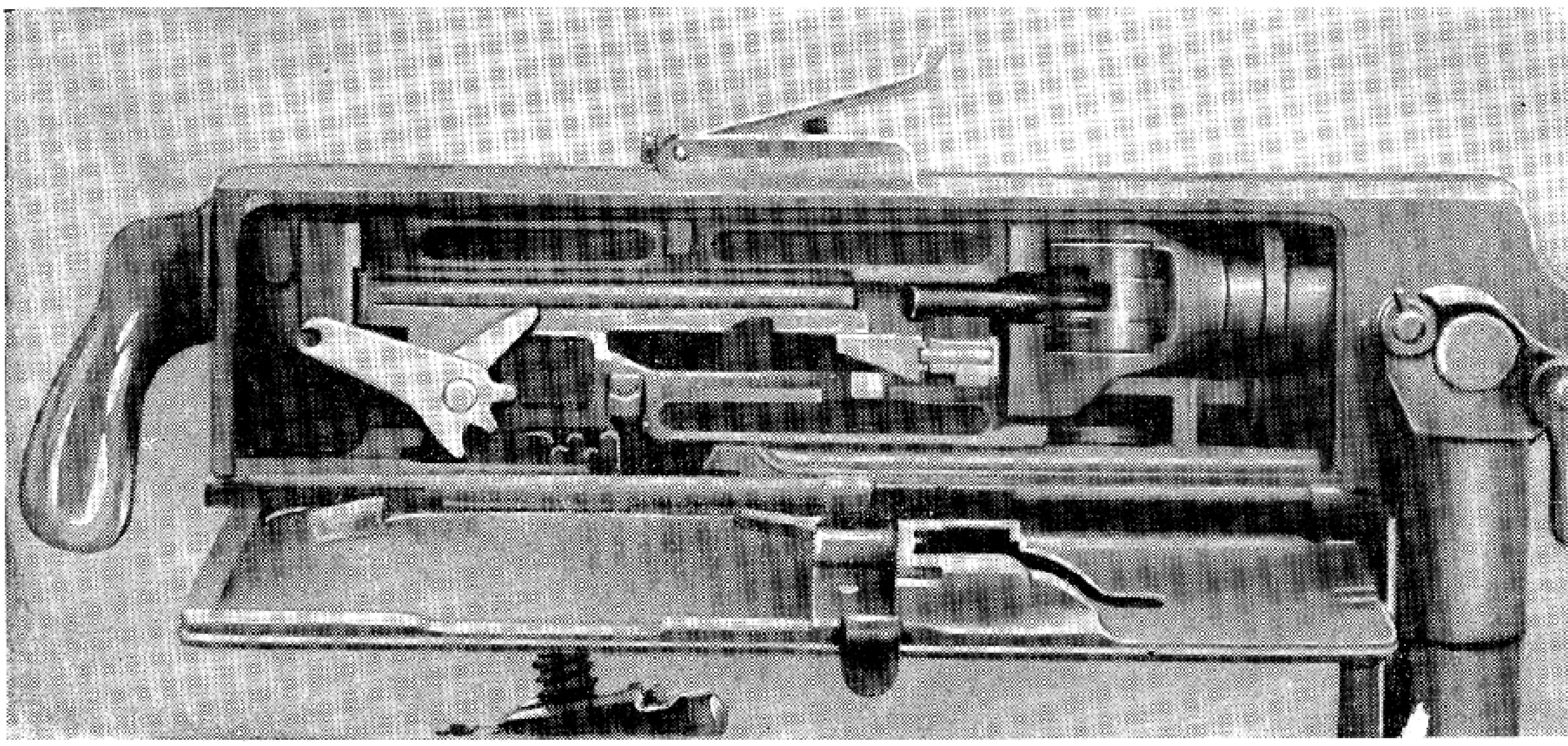
This model was designed for cooling both by air and water. When the latter method was used, the barrel acted as a small reciprocating pump operating from recoil, insuring a constant circulation of water in the jacket during firing. A longitudinally ribbed barrel was employed, aiding in the control of dispersion when long bursts were fired. The ribs gave added strength with little weight and allowed considerably more surface for radiation.

A built-in device at the muzzle, after permitting the bullet to clear the bore safely, trapped the blast. This heretofore wasted energy was employed to accelerate the recoil further. No driving spring was used in this weapon, as the barrel-return spring and accelerator lever returned the bolt to battery. A muzzle booster with this unusual bolt action reached its highest efficiency at 600 shots per minute.

The cartridge was indexed by the surplus barrel-recoil energy. The ammunition tray or belt, if the latter was used, could be released from the mechanism of the weapon merely by pushing a button disconnect. This permitted the clearing of a feed failure without access to the working parts.

To clear a malfunction, the whole right side hinged down and exposed all the operating parts. A soldier, while lying prone on the ground without exposure to enemy fire, could completely disassemble and replace any parts that failed in action. The Italian authorities felt that this feature was of extreme importance.

To keep the weapon in secret status, the government actually purchased and equipped its army with Maxims, while at the same time continuing to perfect the Perino gun. Shortly after



Perino Machine Gun with Right Side Hinged Down to Expose the Mechanism.

the next trial there appeared what is known as the 1908 model, which was only a highly refined version of the original design. A 1910 model followed later.

Still no effort was made by the authorities of the Italian army to put the weapon in open trial. Had the Perino gun been given competition and failures corrected by firing as they appeared, it would no doubt have been ranked with the best the world had to offer. The ultra-security measures of the Italians did more to retard the development of the weapon than anything else. The gun, having been in existence for so long without any proof of its efficiency, was for this reason considered outmoded before it had been adequately proved. The Perino heads the list of fine machine gun principles that have been stifled by over-security.

Chapter 10

CARR MACHINE GUN

The Navy's Bureau of Ordnance on 14 April 1901 was requested by the Driggs-Seabury Gun and Ammunition Co., 43 Cedar Street, New York City, to arrange a test of a new machine gun at the Naval Proving Ground, Indian Head, Md. The inventor of the gun, produced by this company, was Howard Carr of San Francisco.

The Navy assured Driggs-Seabury that it would give the weapon a trial and consider it for adoption if it proved capable of meeting certain requirements. The date for the test was set for 16 July 1901, at which time the weapon would be given an official rating on rapidity of fire, efficiency, accuracy, durability, and simplicity of design.

Since the request did not originate with the Navy, it was specified that all ammunition used would be provided by the Government but paid for by the promoters of the weapon. This was agreed upon and Mr. Carr, the inventor, arrived at the appointed time with his gun, having elected to fire the weapon himself.

The following account is taken from official records of two trials. Lt. Francis Broughton, USN, Inspector of Ordnance, was officer in charge.

The gun, which was chambered for the caliber .30 Krag-Jorgensen rifle cartridge, was recoil operated and drum fed, having a single barrel. A fire regulator allowed both single-shot and automatic firing. The gun was mounted on a tripod, fitted with a seat for the operator. Changes in both train and elevation were obtained by gear and screw attachments, which could be thrown quickly out of action and the gun aimed by the pistol grip or shoulder stock.

The magazine was circular in shape, and slipped into position on top of the breech end of the receiver. The drum was divided into 62 radial compartments, each holding 4 cartridges, making it hold 248 in all. An even larger drum, holding 310 rounds, 5 to a compartment, was also brought with the gun.

Carr, in describing the weapon's action to the Navy Board, gave the following cycle of operation:

"Upon discharge, the barrel recoils about one inch, extending a heavy return spring fitted underneath the receiver. The barrel and bolt, at the moment of firing, are held securely locked by a jointed lever. The end of this lever engages a sear located in the pistol-grip. After unlocking, the barrel is returned to battery by the barrel return, while the lock continues to travel rearward.

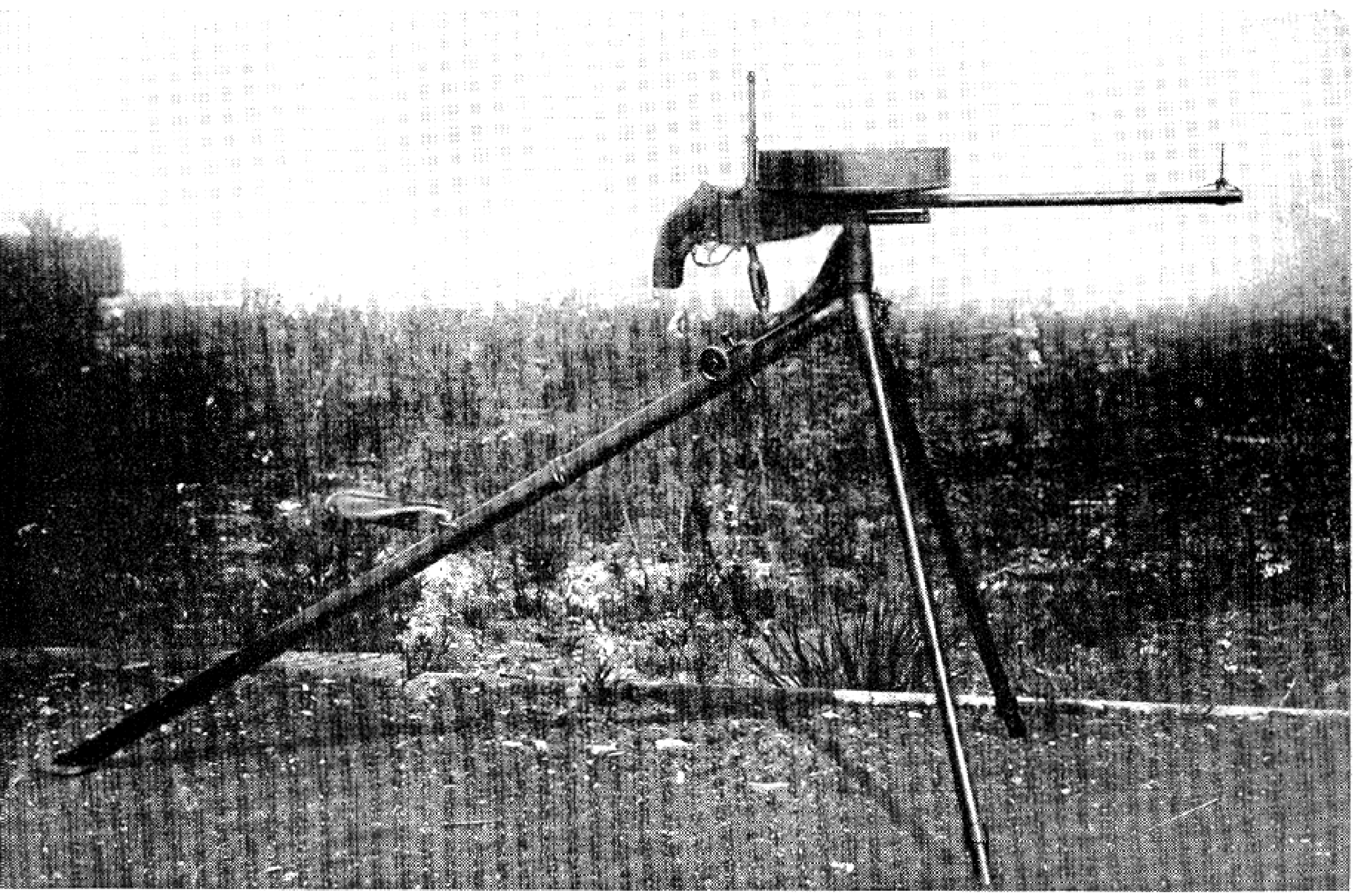
"When about half of the recoil movement is accomplished, the empty cartridge case is extracted from the chamber and ejected downwards through a slot in the bottom of the receiver. A lug on the side of the receiver revolves the magazine and at the same time places a cartridge in position, forcing it down in line with the chamber. The driving spring then completely closes the breech, throwing the toggle lever into a straight line with the breech block, and, in case of automatic firing, releasing the firing pin.

"Automatic or single firing can be obtained by placing the fire regulator in the position desired. Fitted on the right side of the breech is a lever for charging the mechanism by hand. It is used to clear feed failures or any other malfunction that might arise, obviating any considerable delay in firing."

Mr. Carr, in order to demonstrate the general action of the gun to the assembled officers, fired 20 shots singly and 20 full automatic. It worked perfectly during this part of the test. To show how rapidly it was possible to assemble the weapon in the field, the gun, feeder, and tripod were brought in separately. In 40 seconds they were assembled and the first shot fired.

To prove the general efficiency of the mechanism, the Carr gun was tested under the following conditions:

(a) Twenty-five rounds were fired, with a dummy cartridge every fifth round. It was



Carr Machine Gun.

found that the "dud" was in every case quickly removed by means of the hand charger.

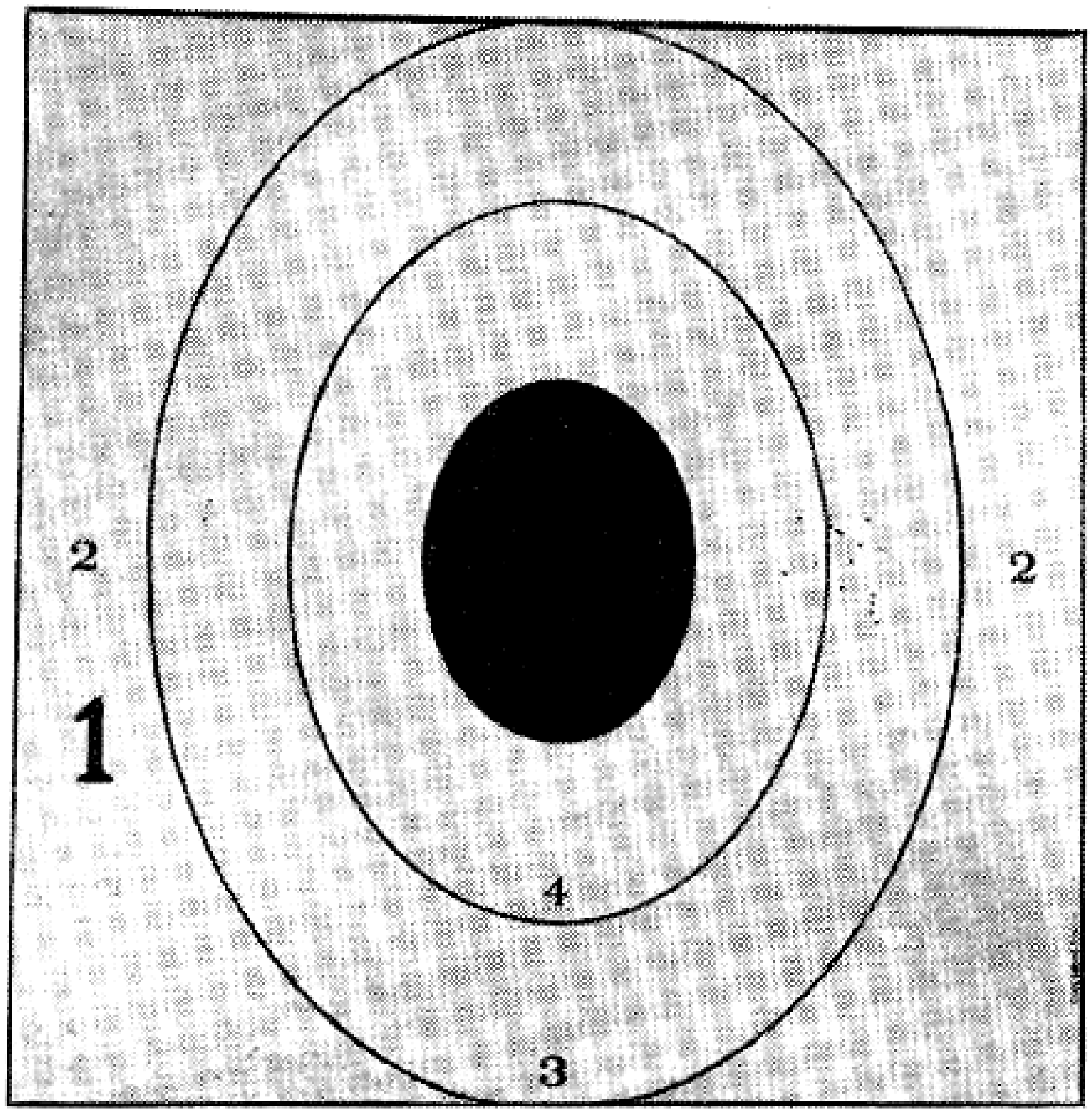
(b) Twenty-five rounds were fired with one vacant space at the end of the first five rounds, two at the end of the second five rounds, three at the end of the third five rounds, and four at the end of the fourth five rounds. The gun ceased functioning upon coming to the vacant spaces. To resume firing, it was necessary by means of the hand charger to revolve the magazine until the next cartridge was dropped. Ten rounds were then placed in the feeder, one of them being a cartridge that had been purposely deformed so that it would not enter the chamber. When fed into the gun, it jammed the mechanism, but was extracted manually without difficulty.

(c) Fifty rounds were successfully fired with the gun elevated 15°, and another 50 with the gun depressed the same amount.

(d) On two different occasions a handful of dust was thrown into the mechanism, the time taken to clean the lock and fire the first shot being 35 and 40 seconds, respectively. Carr did not deem it necessary to dismount any portion of the mechanism for cleaning, but charged the gun by the hand-operating lever until all parts worked freely.

Three targets were made at a range of 120 yards, using the Army B target. Seventeen rounds were fired single shot, using the elevating and training gear. Fifty rounds were fired full automatic, using the elevating and training gear. Twenty rounds were fired singly, with the elevating and training gear thrown out of action, the gun being held by means of the pistol grip.

Carr experienced considerable difficulty in holding on the target, so that only a few shots hit the bull's-eye. He attempted to account for this by stating that the sight had not yet been adjusted for drift. As the shoulder bar had not been sent with the gun, it was not deemed safe to endeavor to make a target with the gun firing



Target Made by Carr Gun in 1901 Trials.

automatic, while the elevating and training gear was disconnected. A velocity check showed 1,966 feet per second 88 feet from the muzzle. The velocity obtained with this cartridge in the Army rifle is given as 1,954 feet per second 53 feet from the rifle.

The bolt was withdrawn by the inventor and entirely taken apart in 50 seconds without the use of any tools. It was reassembled in 3 minutes. There were very few screws, those in use being principally for the purpose of holding small springs. During the test a great many empty cartridge cases were pulled apart upon extraction, breaking at a point about one-half inch from the base. This part was extracted and ejected, the rest of the case remaining in the gun. It was not found difficult to remove it with an ordinary cleaning rod.

In order to ascertain whether the ammunition was defective, 100 rounds were fired in the Colt automatic gun. None of the cartridge cases pulled apart nor showed any signs of breaking. It was, therefore, considered that the defect lay with the gun, and was due either to a swelling of the rear portion of the chamber or to a failure of the breech-block in holding the cartridge home sufficiently secure. The ammunition used came from Frankford Arsenal. It was loaded with W. A. powder and primed with H–48 primer.

It had been intended to test the gun for durability by firing 1,000 rounds as rapidly as possible, observing afterwards the condition of the barrel, the rifling, and the mechanism, and obtaining velocities and targets. As the firing was interrupted frequently by reason of the splitting of the cartridge cases, it was considered impossible to carry out this test.

Another barrel fitted with a small water jacket was sent with the gun. This also would have been used in the durability test, had it not been postponed until the inventor thought his weapon could meet the required demands.

On 25 July 1901 the second and final phase of the trial began, Carr having declared his weapon ready for the endurance and rate of fire test.

It was found that 4 minutes and 45 seconds were required for one man to load a drum with 248 rounds. To test the extractor, six cartridges were coated with varnish, so as to stick in the chamber. They were extracted satisfactorily. In 35 seconds 192 cartridges were fired full automatic; in 40 seconds, 240 cartridges were fired in a single burst. This was at a rate of 360 rounds per minute.

The endurance test of 1,000 rounds of sustained fire was attempted, but interruptions were so frequent that it was not completed. The failures were due principally to: (1) A lack of operating power, the magazine gear not leaving enough force to close the breech; and (2) failure to extract, the extractor slipping from under the rim of the cartridge.

The splitting of the cartridge cases in the first trial was found to be due to the fact that the cartridge was not shoved completely home. This was remedied by screwing the barrel one thirty-second of an inch further into the breech casing, thus forming a more perfect head space. Why the weapon started to rupture cases during the latter part of the second trial was not determined by the board.

The test was then stopped by the officer in charge as the weapon had not shown a degree of reliability that warranted further consideration. Overheating was of such a nature as to cause the weapon's operating mechanism to seize and slow it until there was not enough energy to rotate the feeder and lock the bolt.

It was interesting that this machine gun employed the drum-type feed that was used so much at a later date. While Hiram Maxim was the originator of this method of feeding, Howard Carr was the first to attempt to put it to practical use. The unusually large number of rounds in the feeder made the weapon breech heavy and when this large mass rotated, it was found that unless the weapon was securely fastened to the front mount it was exceedingly hard to hold on the target. It also added greatly to the clumsy appearance of the gun.

These were the only official tests run on the Carr weapon. By this time the inventor no doubt realized it had fallen so far short of Navy requirements that to meet them would require complete redesign. On the whole, the weapon was quite inferior to many guns that had already been proved reliable.

Chapter 11

SCHWARZLOSE MACHINE GUN

Andreas Wilhelm Schwarzlose of Charlottenburg, Germany, was an inventor who was already well known on the continent by 1900, having produced many designs for self-loading pistols. His first one used a locked breech with short-recoil action. It was later developed into what was known as the blow-forward system, in which the breech remains motionless while the entire mechanism, including the barrel, goes forward when the shot is fired.

Schwarzlose is best remembered for his machine gun, patented in 1902 but first manufactured in 1905 by the Steyr arms works in Austria. He was perhaps the first machine gun designer to accomplish true simplicity of mechanism. He determined to eliminate the hard-to-manufacture lock and moving barrel of the Maxim and also to avoid any of the gas-operating features of the Hotchkiss. A straight blow-back mechanism, as used in several successful self-loading hand arms, was out of the question; all smokeless-powder high-pressure rifle-caliber cartridges ruptured unless the initial extraction was slow enough to permit pressure to drop to a degree where they would not stick to the chamber.

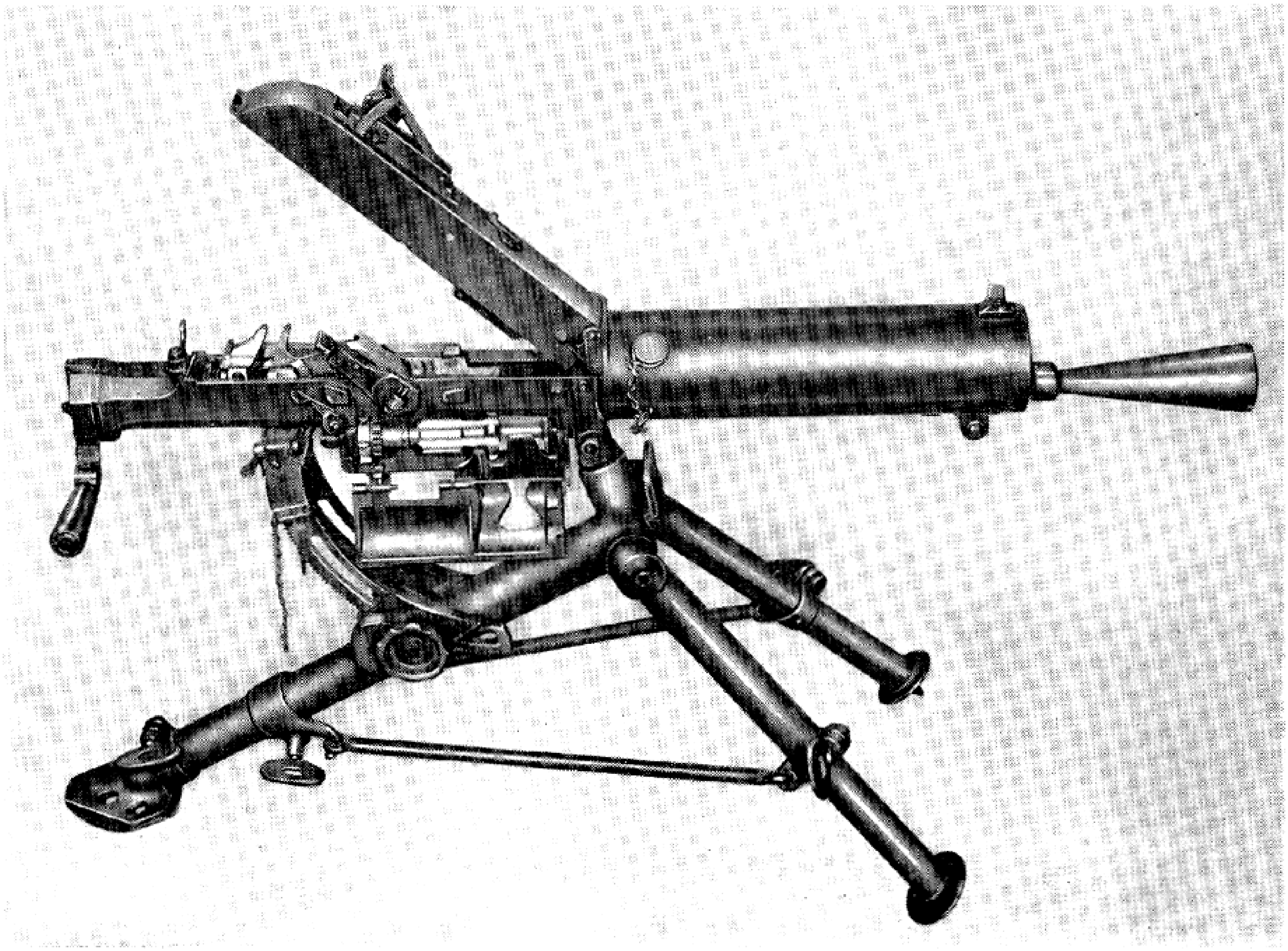
Schwarzlose solved the problem in an unusual manner. A powerful mainspring and heavy bolt were used that provided inertia enough to resist the first rearward thrust of the exploding powder charge. But this alone was not sufficient. A comparatively short barrel was also employed, coupled with an arrangement of levers that caused the bolt to act at a mechanical disadvantage when trying to compress the mainspring suddenly.

To fire the weapon, a tag at the beginning of the cartridge belt, on the under side of which are held the rounds, is inserted in the belt guide at the lower right side of the feed. The belt is then pulled to the left and over the sprocket wheel of the feeder until the first cartridge engages a tooth. The charging handle is pulled smartly to the rear three times and released. The driving spring, in taking the parts to battery on the third return, alines the round with the chamber.

The gun has a double trigger actuated by the thumbs. In order to fire, one thumb has to keep an automatic safety catch to the left before the other can depress the trigger releasing the sear. When the powder charge is detonated, the barrel, not being locked to the bolt, does not recoil as in other automatic weapons. The pressure exerted on the base of the cartridge is transmitted to the face of the bolt. In order to keep the action in a closed position as long as the bullet is in the barrel, the bolt is so constructed that when in battery it forms a linkage. An elbow joint is attached to the bolt with another arm pivoted to a fixed axis in the receiver.

During the initial movement rearward the elbow has to move through an arc. Since there is a very small angle between the linkage and crank when the breech is closed, much of the shock of initial recoil is absorbed by the receiver. This movement is utilized first to withdraw the firing pin from the primer and cock the weapon by engaging the crank handle in the receiver with a camming toe on the cocking piece.

After the retarding action the bolt starts to recoil. It carries the empty cartridge which the extractor is holding by the rim in position to be struck and thrown out of the left side of the receiver by the ejector. The movement of the bolt is completed, against the resistance of the unusually strong return spring, by the acquired momentum of the heavy moving parts of the mechanism. The bolt then starts counterrecoil from the stored energy of the driving spring. When the incoming round from the feed is rolled into position and chambered, the striker is seared off automatically. This operation will continue as long as the two thumb triggers are actuated.



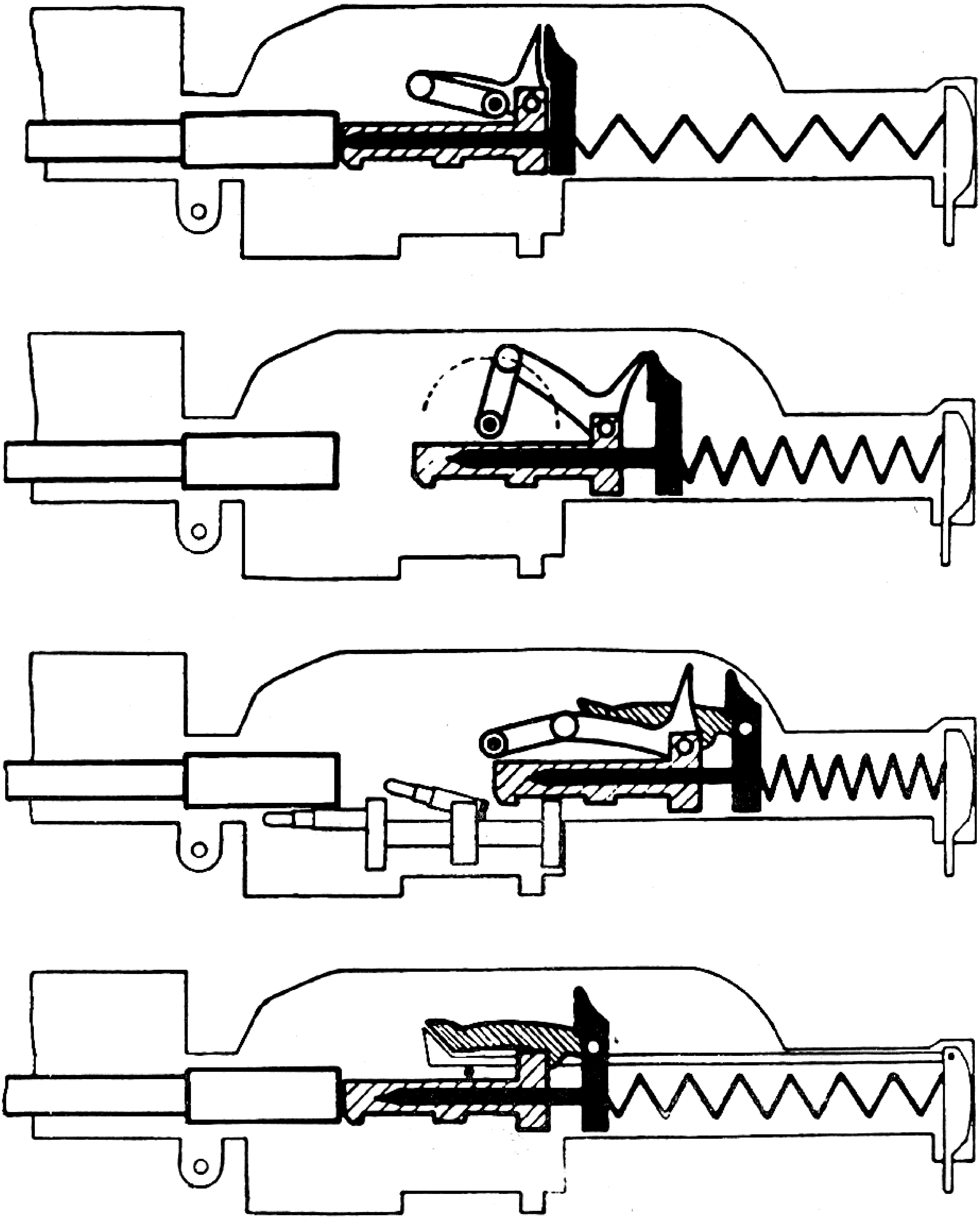
Schwarzlose Machine Gun, Model 1907/1912.

The breech mechanism of the Schwarzlose weapon is never positively locked. The necessary delay in opening the breech is largely dependent upon the inertia furnished by the elbow-type linkage, the resistance of a strong spring, and the absorption of the first shock of the early stage of peak pressure by the receiver. However, the major factor is the use of a 20¾-inch barrel. This is the maximum length that can be used to insure the bullet's clearing the bore before recoil of the bolt begins. If any longer barrel were to be used, with the rifle caliber cartridge it was designed for, the mechanism, to be safe, would assume such large proportions that it could not remain in the portable machine gun class.

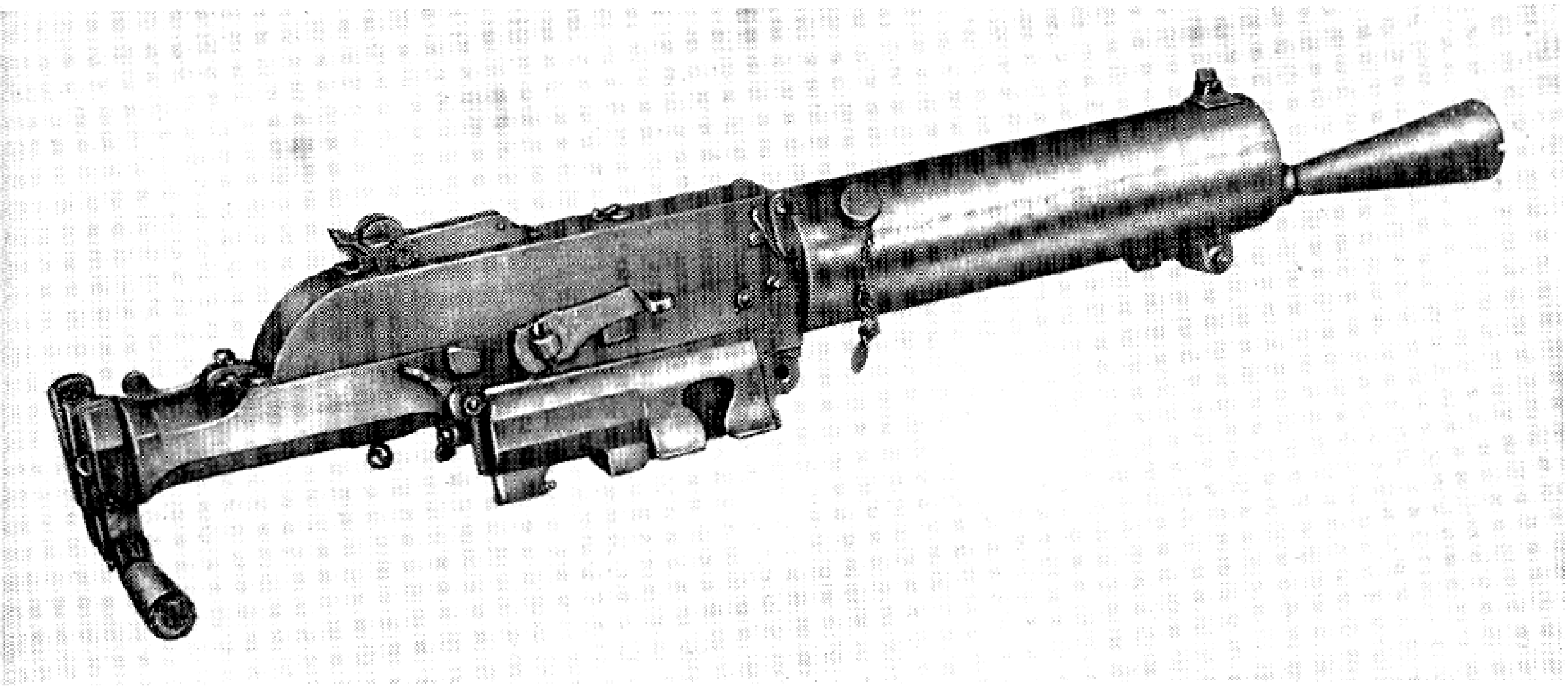
The Schwarzlose is constructed so that it can be disassembled in a few seconds. In its design the theme of simplicity is followed so closely that operating parts are kept at a minimum. One outstanding example of efficiency is the employment of a single large rear-positioned spring that serves as a buffer, bolt return, and firing pin spring, performing each cycle in turn.

The feed is unique, being a star-wheel type located on the lower right side. It consists of only two working parts, the feed roller and the detent slide. The roller engages the cartridges in its sprockets as the belt is pulled into the mechanism by action of the bolt on the roller. As the ammunition passes through the wheel, the rounds are slowly cammed rearward for a short distance before the extractor claw on the bolt makes a final withdrawal. This initial movement adds greatly to the ease of feeding, as contrasted with other weapons of a similar nature which attempt to pull the round from the belt by a sudden jerk rearward.

The roller is synchronized with the bolt so



Action of the Schwarzlose Gun.



Schwarzlose Machine Gun, 8 mm.

that, when the latter is at its rearmost position, the top sprocket wheel rolls the cartridge upon an inclined shelf directly in line with the chamber. It is so confined in this recess that the rim always makes contact with the bolt face that pushes it forward into the chamber.

This system is appropriately designated retarded blow-back. Due to the fact that the cartridge is extracted under relatively high gas pressure, it was found necessary to lubricate the ammunition. Schwarzlose settled this problem by installing, as an integral part of the weapon, a pump to lubricate the cases. This device pumped a squirt of oil in the chamber between each extraction and loading. The combination of the lubricated ammunition, heavy spring, large bolt assembly, and short barrel allowed the use of an unlocked action which proved quite satisfactory.

The Schwarzlose was fairly popular with European governments and was used by a number of foreign powers at one time or another. The gun was water cooled, belt fed, and tripod mounted, with all typical blow-back peculiarities, including the low rate of fire of 400 rounds a minute. It was originally chambered for the Austrian service rifle 8-mm rim cartridge, and came in three models, the 1905, 1907, and 1912.

The 1912 model was redesigned to fire dry ammunition, no oil pump being required for its functioning. This was done by adding more weight to the bolt, a heavier driving spring and slightly more angle in the linkage action. Having no breech lock, this new toggle design put the blow-back forces to a still greater mechanical disadvantage, allowing the crank to be moved far enough off center to permit the pressure to push the bolt back more slowly. When the 1912 gun is in battery, the crank is not quite on dead center, so that the first action of the gas pressure is to raise the crank out of line. This longer delay in starting the mass in recoil is just enough to dispense with the lubrication of the ammunition.

Chapter 12

McCLEAN MACHINE GUN

Before going into the description and background of the McClean automatic weapons, first patented in 1902 and government-tested both in 1903–05 and in 1916–18, it is necessary to bring attention to the fact that the inventor is often confused with Dr. James H. McLean, patent medicine salesman and so-called machine gun inventor of the manual-operated period. The designer of the weapons under discussion resembles the St. Louis doctor only in the close spelling of the last name.

Samuel Neal McClean at an early age began to patent improvements on magazine repeating arms. He then progressed to designing a full-automatic firing mechanism and formed the McClean Ordnance & Arms Co. of Cleveland, Ohio, to produce it in both rifle and shell gun caliber.

The first gun made by this new company had a bore of 37 millimeters and was commonly called a one-pounder. This truck-mounted cannon was completely automatic in action and according to the company would revolutionize artillery through its rapidity of fire and mobility.

McClean, feeling that the weapon should be introduced by an official capable of insuring its being brought to the attention of the proper people, employed Gen. Joseph Wheeler, United States Army, Retired, to present the weapon to the Army board for purposes of trial and adoption. The request for an official test was granted and Brig. Gen. William Crozier, Chief of Army Ordnance, ordered that it be scheduled on 10 November 1904. The inventor was allowed to conduct two earlier firings in order to bring to light and correct any malfunctions that might jeopardize the performance during official considerations.

The Sandy Hook Proving Ground was selected for the test. While 670 rounds were fired in the preliminary stages between 8 March and 2 April 1904, many stoppages resulted. It was decided to ship the weapon back to the place of manufacture after McClean concluded that certain modifications would be necessary.

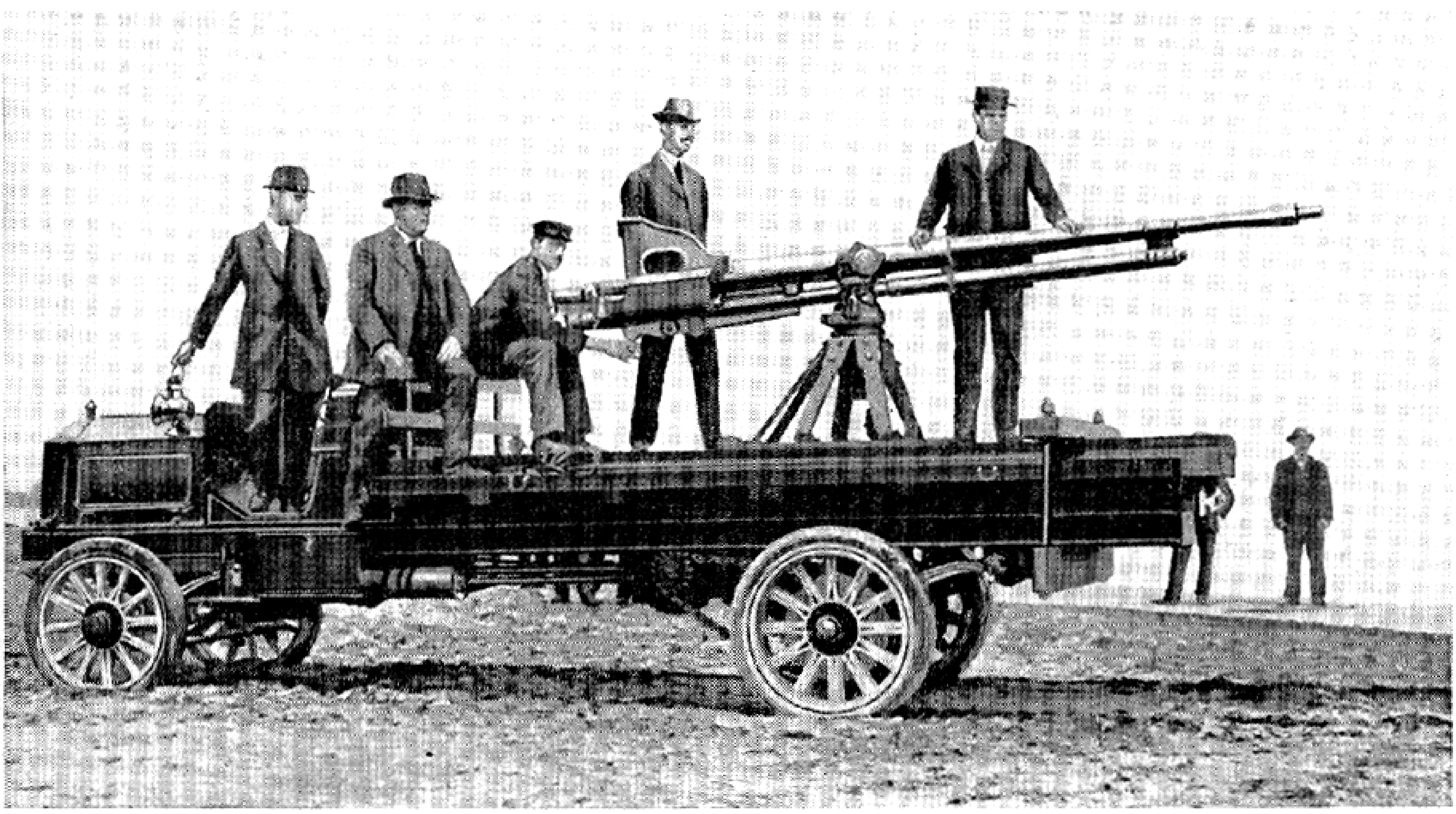
After the needed changes it was returned and 518 rounds were expended between 17 June and 26 August 1904. While the reworking of the components showed a marked improvement in performance, the gun was again sent to the factory to incorporate in it other refinements in order to be in first-class condition for the official test in November.

In these two warm-up runs, McClean did the firing and other members of the company were present to assist. The Chief of Army Ordnance was also an interested spectator during these attempts. For the final trial an Army board convened at the time set by General Crozier and the weapon was presented and described by the inventor. As each component was disassembled, its function was outlined. The speed with which it could be put into action and its mobility were especially stressed.

The McClean cannon is clip fed and gas-piston actuated, with a non-recoiling barrel. The principal parts are the barrel, the receiver to which it is fastened, the gas cylinder located directly beneath the barrel, and the bolt assembly that operates from and in conjunction with the gas piston. The ammunition is fed into the mechanism by means of two sizes of clips, holding five and ten cartridges respectively.

In order to reduce the shock of recoil, which, if not taken into consideration, would make mobile mounting of such a large bore gun impossible, a device located at the front end of the barrel has been added. This serves as a muzzle brake through the action of the expanding gases striking angular slots in the attachment after the projectile clears. The application of blast at this instant counteracts the recoil forces to a marked degree.

The operating mechanism consists of a reciprocating and rotating breech lock as an integral



Samuel M. McClean Demonstrating His 37-mm Automatic Cannon.

part of the bolt, a gas-actuated piston, a sear, and a trigger so constructed that single-shot firing can be converted to full automatic without the gunner taking his finger from the trigger. The port in the barrel through which the gas bleeds for action on the piston has a regulator that controls the size of the orifice. The rate of fire is governed by the setting of this device.

The gas-driven piston is so constructed that by a series of consecutive steps it controls the entire cycle of automatic fire. It has a cam engagement with the breech lock which regulates positively the unlocking, reciprocating, and locking action of the bolt by the breech lock. It also has another cam that engages the cartridge feed to insure the alternate positioning of the incoming cartridges. Finally, an inertia-type firing pin and sear notch for engagement with the sear controls firing action for either automatic or single shot.

The heavy steel receiver screws to the breech end of the barrel. It has a cylinder housing in which the bolt travels and a companion opening in which the piston rod moves. On the under side there is a pistol grip encasing the trigger and a dial that can be set to regulate the rate of fire. The upper right hand side has a short slotted post arrangement in which are slipped the loaded clips. A latch permits the instant freeing of the clips after insertion.

An easily removable gas-actuating assembly is connected at one end to the gun barrel, a short distance from the muzzle, and at the other to the frame. The piston rod is a hollow tube. A piston at the forward end is screw-threaded into the bar to permit a coiled return spring to be added to, or removed from, the piece. The rear part of the piston is provided with an upwardly projecting arm to the forward end of which the firing pin is attached. It has a cam that mates with one on the breechblock to give positive control over the locking action of the gun. Another cam on its right side engages the feed in such a manner as to position and then chamber the incoming cartridge.

The breechblock is a cylindrical bolt having an interrupted screw thread. This forms a series of lugs that are cammed down into the locking recesses cut in the receiver near the chamber. A heavy conical-shaped firing pin is also fastened to the piston. The lugs have to be in position for engagement before the piston can advance all the way into battery and drive the firing pin

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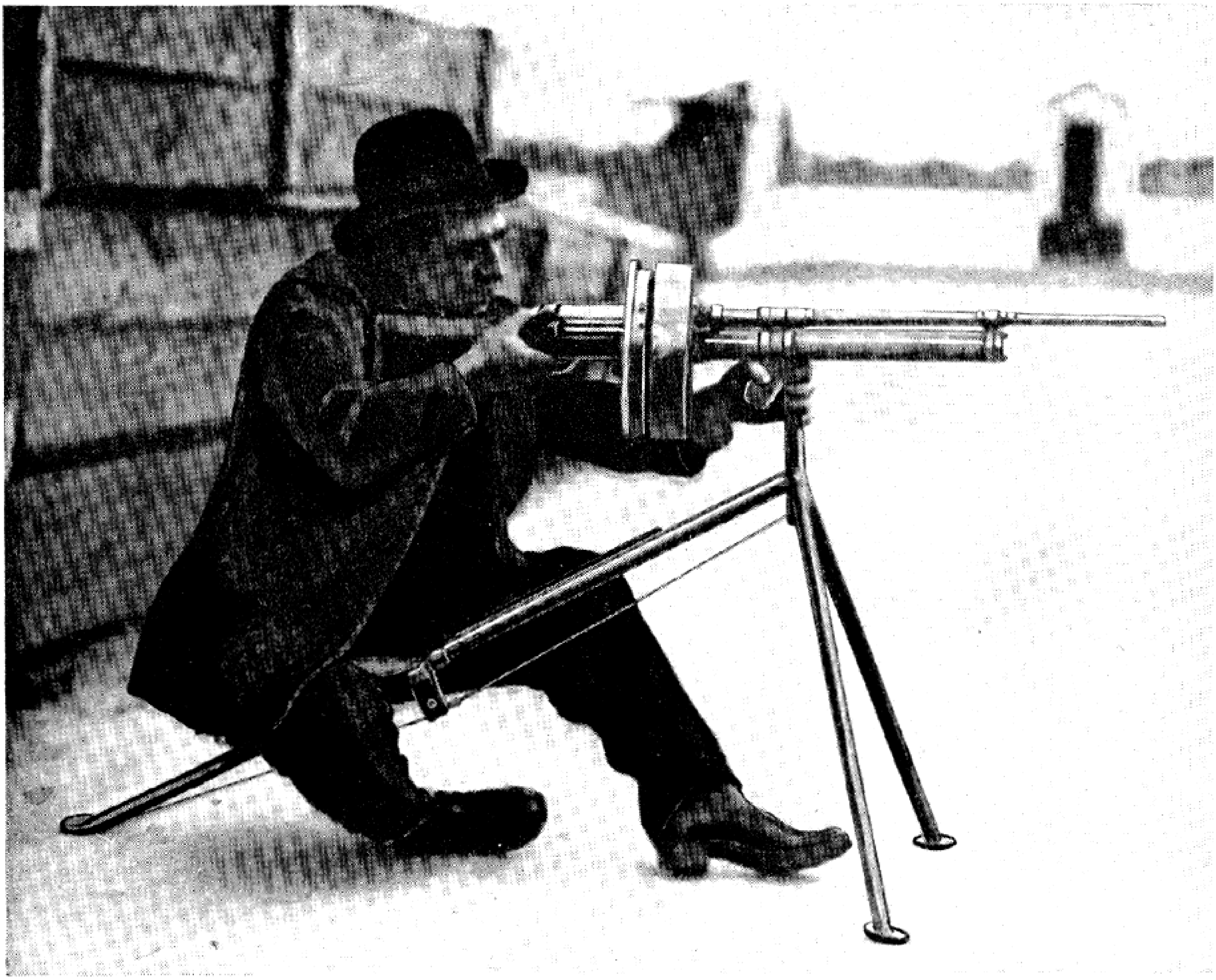


McClean Machine Gun, Cal. .30, Being Fired by the Inventor.

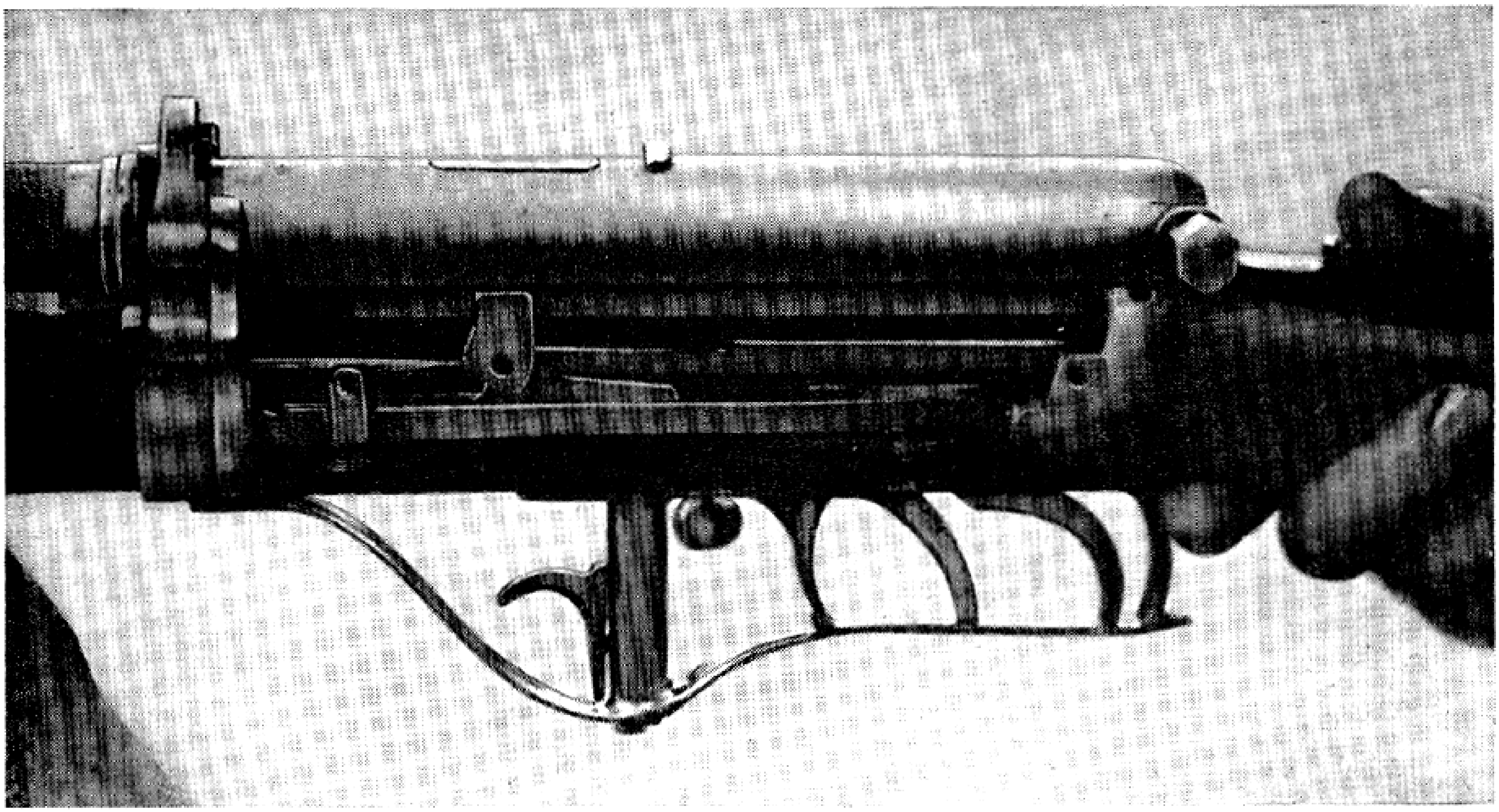
into the primer. The bolt also houses the extractor hooks which are short stiff hooks so formed as to lock into the extractor seats and fasten over the rim of the cartridge in a modified form of **T** slot. It is not released until the empty case has been fully withdrawn.

A swinging lever, which is a part of the bolt, is designed so that when the empty cartridge is over the ejection opening in the receiver, the rear of the ejector rides up on an angle and pivots the front down. The spent round is thus knocked clear of the operating parts.

The whole extractor and ejection system is carried on the bolt in three pieces, two extractors and the ejector, which could be removed from the gun and replaced in a matter of seconds. The firing indicator lever, with a dial showing the type of firing desired, is located on the right side of the pistol grip. The entire mechanism can be completely disassembled and put back together without the aid of wrenches or tools other than a specially designed shoulder bar.

The cartridge slips are formed of sheet metal and have a flanged guide that form a **T** slot to engage the rims of the shell cases. They were designed for five or ten rounds as desired. The ammunition is the standard service fixed one-pounder or 37-millimeter with a muzzle velocity of 2,100 feet per second and capable of generating a maximum chamber pressure of 25,000 pounds.

Five proof charges were fired with the Mc-



McClean Machine Gun.

Clean automatic cannon that reached a peak pressure of 39,700 pounds and a close visual inspection showed no breakage or deformation of parts. But when the official tests for automatic fire got under way, numerous stoppages were encountered, most of them being feed jams. When these were cleared, an attempt was made to fire 100 rounds in two 50-round bursts; during this try there were eight malfunctions. The stoppages were the result of the piston slowing up and finally halting. The officers present thought this was due to the expansion of the moving parts from heat.

A total of 200 rounds were tried next in one burst; this was done in 6 minutes and 51 seconds. It also was not accomplished without piston seizure taking place. Temperature of the bore at the muzzle was taken before starting and recorded at 230° F.; at the end of the burst it was 428°.

It was observed that all stoppages took place when the end of the feed pawl was in the cam groove at the rear position of the piston's stroke. The board was asked that McClean be allowed to change the angle of the cam slightly with a view to improving conditions. This was permitted; however, the time delay was charged to the gun. When firing resumed, the same type of stoppage persisted. After 1,182 rounds had been fired, the trial was terminated. McClean expressed a desire to send the piston back to the factory and increase its diameter in order to give it more operating power.

The weapon had a very improved buffer for this early date. It operated by compressed air, the recoiling parts striking the piston backed up by a high air pressure.

The following conclusions are taken from the official reports of the Army board:

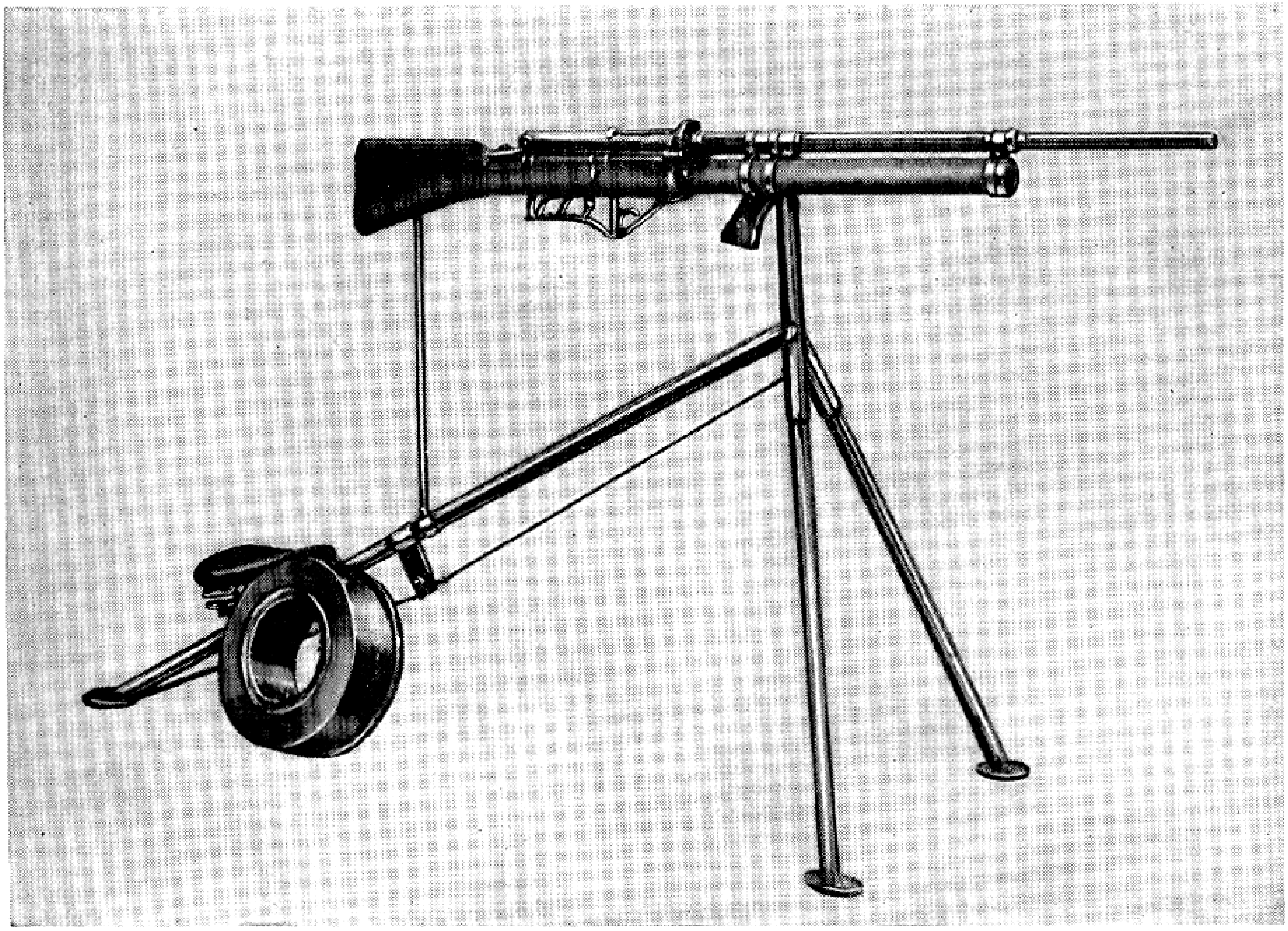
"The results of the trials of the gun and mount are not satisfactory. . . . The muzzle attachment takes up a considerable percentage of the recoil in a useful manner: the reciprocating piston rod and its control of the breechblock is simple and effective and its action has not, so far as observed in these trials, been materially interfered with by fouling of the piston from the powder gases. The mechanism of the gun otherwise comprises a large number of springs and small parts which govern important functions in operation and the trials have been characterized by a great number of breakages and interruptions, including especially the feed mechanism, the extractors, the ejector, and the cushion piston. The sights are not satisfactory, nor the training gear. The rate of aimed fire is very low. It has not been practicable to secure a good rate of continuous fire at will, and the accuracy of fire at fixed targets, and especially at moving targets, shows a very low standard generally.

"The failure . . . [of the piston rod] . . . to work properly especially in the 200 rounds continuous automatic action test and also in the dust and rust tests renders the trials unsatisfactory. It is thought a gun of this character should be capable of delivering a considerably greater number than 200 rounds continuous fire without trouble, and the number of rounds for this test in one-pounder automatic guns in future may properly be increased to 300."

The members of the board were: Charles S. Smith, Colonel, Ordnance Department, president; R. Birnie, Major, Ordnance Department; George L. Anderson, Major, Artillery Corps; and B. W. Dunn, Major, Ordnance Department.

To fire the McClean one-pounder, the gunner drops five loaded rounds into the hopper feed and pulls the operating mechanism rearward by means of a drawbar. When released, the parts are driven forward as the compression of the driving spring strips the round from the feeder and chambers it. Continued movement forward locks and cocks the piece.

When the trigger is pulled, the exploding powder charge starts the projectile through the bore. After it has passed a port in the barrel, the expanding gases enter the gas cylinder and impel the actuating piston rearward. Mounted on the piston is the unlocking lug to which is attached the firing pin. The first movement rearward withdraws the pin, which works in a slideway in the piston, and further travel of the piston rotates the bolt body with its lugs, thus unlocking the action.



McClean Machine Gun with Feed Drum.

The projectile has now safely cleared the muzzle. The empty shell case withdrawn by the extractors is held by these pieces until the opening in the bottom of the receiver is reached. A pivoting ejector then snaps over the bolt face, striking the empty case and knocking it through the ejection slot.

The operating parts continue to recoil until the rear buffer is struck. The latter absorbs all surplus energy and, aided by the fully compressed driving spring, starts counterrecoil movement. A raised part of the bolt body makes contact with the first round in the hopper and starts to chamber it. At a distance of one and a half inches from battery, the firing pin is held in a retracted position while the gas piston, in going home, fully rotates the bolt body, engaging its lugs in their locking recesses. The obstruction in front of the firing pin is removed by this means, and if the trigger continues to be held back, the striker flies forward to drive the firing pin into the primer.

The stockholders of the McClean Arms & Ordnance Co. were so disappointed at the performance of the automatic cannon that they would not underwrite another venture on the weapon and for the most part dropped all financial backing of the company. Reorganization followed, but instead of developing the larger gun, this time all energy was placed on producing a caliber .30 automatic lightweight machine gun, chambered for a service rifle cartridge. For promotional work the services of Lt. Col. O. M. Lissak, United States Army Ordnance, were secured. The weapon when produced was even called the McClean-Lissak machine gun, although there is nothing to show that Lissak contributed anything beyond his business ability. The weapon was still McClean's early invention with many features of the automatic cannon being scaled down to rifle caliber and used in this model.

It was quite apparent that the designers tried to create a weapon that excelled any known weapon in every feature. The McClean-Lissak weighed only 19 pounds and the operating parts were fewer in number than those of the Benét-Mercié. The company claimed the barrel could be removed in one-half the time required by any other machine gun.

The McClean cannon, which never passed a successful proving ground test either for the Army or the Navy, dropped out of existence for a while. During World War I, Russia, desperately in need of any kind of armament, did buy quite a number from its new producer, the Poole Engineering Co. of Baltimore, Maryland. As late as 1916 the United States gave Poole Co. officials another chance to demonstrate the "improved" model, but it also failed as miserably as its predecessors.

This gun, with its unenviable record, still has a leading place in weapon history. The features patented by Mr. S. N. McClean were assigned by him to the Auto Ordnance Co., of Buffalo, New York, and were later used in the devisement of one of the outstanding early aircraft machine guns. A close study reveals the similarity of construction in the two arms.

After McClean had sold his patents to the Buffalo firm and their utilization in an adapted form had turned out to be highly successful, he tried once again to produce a machine gun by a method known as reversing the principle.

The flat drum feed was moved from the top to the side, making the weapon very cumbersome and heavily unbalanced at the part to which the feed was attached. The mechanism itself was practically identical with the one-pounder. In May 1919 McClean finally interested the Navy to the extent that he was allowed to demonstrate this model to the Bureau of Ordnance at the Naval Air Station, Anacostia, D. C. While he did fire the weapon to a more or less satisfactory degree, it did not warrant, in the opinion of the Chief of the Bureau of Ordnance, any further testing and on 31 May 1919 McClean was so notified.

This decision ended his long period of machine gun development. And while it takes considerable research to identify his name with productive machine gun design, nevertheless automatic arms development owes much to his patient inventive efforts.

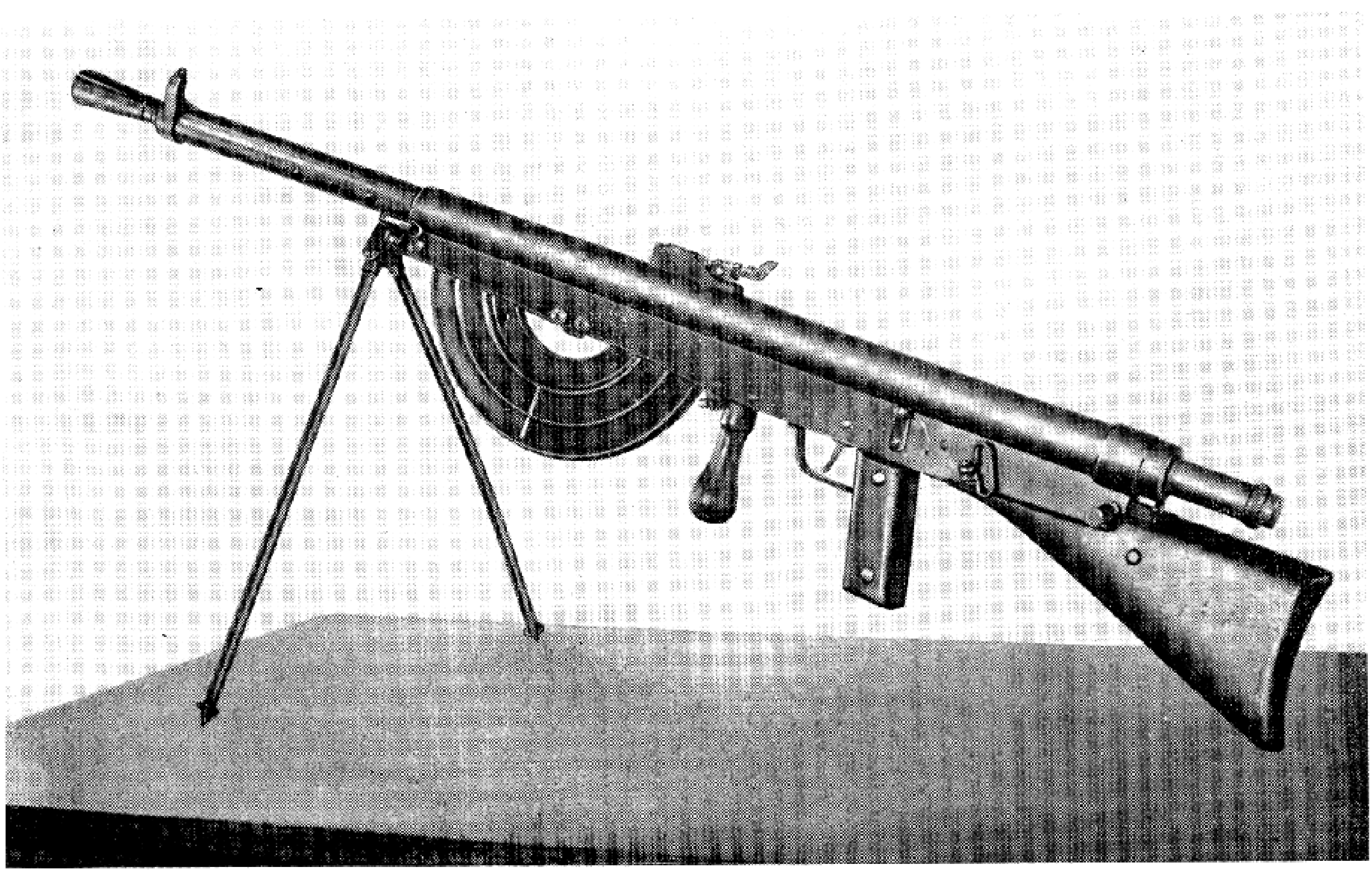
Chapter 13

CHAUCHAT MACHINE GUN

In 1903 the French Government, having what it felt was an adequate heavy machine gun, started looking about for a machine rifle as a companion arm. Of the numerous types taken under study, the French Army board became interested in an extremely lightweight automatic arm that could be fired either single shot or full automatic and be carried by the soldier with as little difficulty as the standard infantry rifle. It became known as the Chauchat.

This weapon, while originally made at the French Government arsenals, was most certainly not native in design. It was undoubtedly inspired by the experimental weapon invented by the Hungarian arms designer, Rudolf Frommer, who had already become well known for his weapons built on the long-recoil system and had demonstrated a similar design at an earlier date. The fact that this machine rifle employed the long-recoil system for its operation is in itself of great interest, as it represents the only automatic machine gun ever produced by France that did not use gas as the actuating force. Although it has been experimented with by inventors of every country in the world, the French for some reason have always looked upon the operation of machine guns by gas as a specialty of their own. That they should deviate at this time indicates an outside influence in the matter of design.

The Chauchat employs a front-locking bolt



Chauchat Machine Rifle, Model 1915, 8 mm.

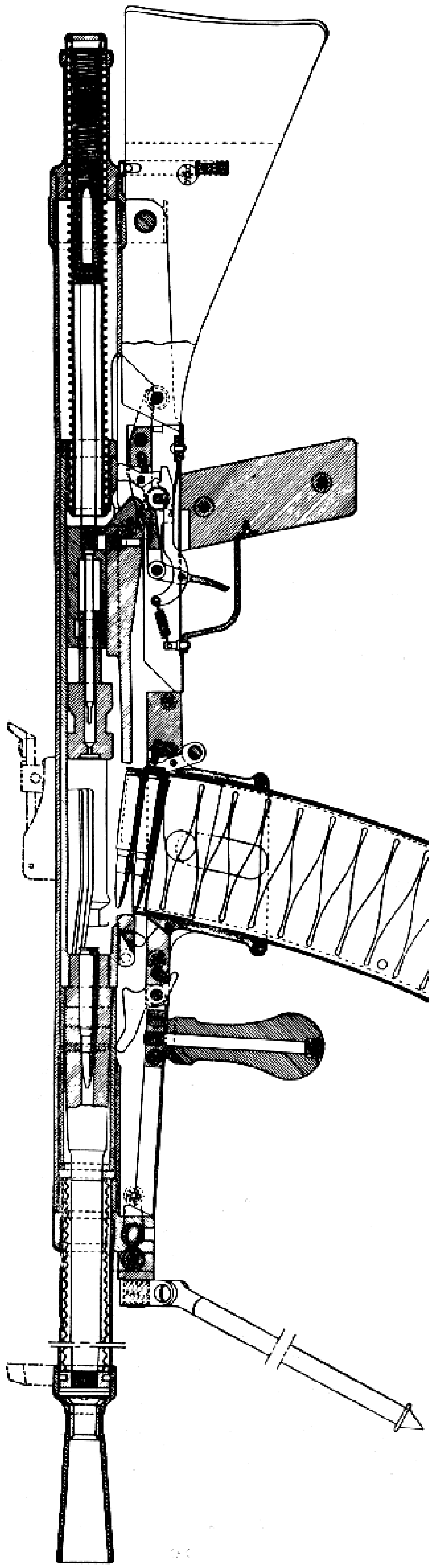
that releases on the straight-pull principle found both in Mannlicher and Frommer self-loading pistols. This rotary bolt has four locking lugs, is of heavy construction, and is actuated by a recoiling non-rotating sleeve. In this piece are incorporated the striker, a hook to engage the sear, the feed bar which projects forward under the bolt, and the cocking piece which in turn carries a rod to operate the feed block.

The tail of the bolt has two cams which engage in helical slots cut in the sleeve. They are locked together in the retracted position by a spring-loaded stud which is released only when the bolt is in the act of turning in battery position. The helical slots in the sleeve are cut on a shallow pitch, so that the sleeve carrying the striker must advance one full half inch after the bolt is closed and locked before the striker can make contact with the primer of the chambered cartridge. Another unusual safety feature is that a spring-loaded plunger projecting from the face of the bolt must be compressed by the rim of the seated cartridge in order to remove the plunger from alinement with the striker point. In effect, the bolt must be home, securely locked, and the plunger cammed back by a round in the chamber before the primer can be touched.

The feed is semicircular in construction and holds twenty 8-mm Lebel cartridges. Its unusually clumsy design is very adaptable to the steeply conical round. A swinging feed block operating in conjunction with the cocking piece during the cycle of operation first positions and then guides the incoming rounds from the circular magazine into the chamber.

To fire the Chauchat, a loaded magazine is inserted between the side plate and bottom of the barrel. The rear end is then pushed up until the magazine catch snaps, holding it in position. To fire single shot, the fire regulator is changed from "S," or *safe* ("sur" in French), to "C," or *control* ("controle" in French). If automatic fire is required, the regulator is moved to "M," *machine gun* or *automatic fire* ("mitrailleuse" in French).

Assuming that automatic firing is desired and the regulator is properly set, the operating knob is pulled to the rear until the sear engages the notch in the feed piece holding the action in the cocked-bolt position. Pulling the trigger rear-



Section Drawing of Chauchat Model 1918, Cal. .30.

ward releases the operating mechanism, allowing it to fly forward under energy of the compressed driving spring. The rolling action of the cocking assembly pushes a cartridge from the magazine mouth, where it is picked up by the bolt and chambering of the round begins. This action is assisted by the cartridge guide which cams the point of the bullet up into the entrance of the chamber. A cam then moves the guide out of the way of the magazine mouth.

As the bolt travels forward, the locking lugs are vertical. To insure their remaining temporarily in this position, the bolt stop is used. This consists of a conical plug that fits partly in the bolt body and partly in the bolt head, thus preventing a torque motion between the two parts except when released. When the cartridge is firmly seated, the bolt stop rides inside the breech housing forcing the bolt head to turn. This locks the assembly securely when the movement forward has reached its limit. The driving spring continues to drive forward the portion of the bolt body that carries the striker, since the final rotary motion of the locking lugs frees the striker to detonate the primer.

The bolt, barrel, and barrel extension recoil rearward, still locked together, for a distance greater than the combined overall length of the cartridge case and bullet. At a point slightly less than its full recoil stroke, the bolt lugs unlock the bolt from the barrel extension and barrel. The bolt is then held to the rear by a searin[illegible] device and the barrel extension and barr[illegible] counter recoil. As the rim of the fired [illegible] is held secure by the extractor in the bo[illegible] face, the barrel and barrel extension, in starting forward to battery, pull away from the spent brass. When the barrel has traveled a distance that will permit it, a spring-loaded ejector bearing on the empty case kicks it from the ejection slot in the right side of the receiver.

If the trigger remains depressed, the barrel assembly cams the sear off just before it reaches battery, releasing the bolt that had been held to the rear and the cycle is repeated.

No more crudely designed nor uglier automatic weapon has ever been put in the hands of soldiers of a first-rate power than this weapon. The Chauchat was cheap to construct and easy to adapt to mass production methods, as its careless manufacturing tolerances were of such a nature that anything could be accepted. When the danger of war became imminent, it was made by the thousands. To cite instances of its simple construction, the barrel jacket, barrel extension and receiver were constructed of convent[illegible] tubing. Even the locking lugs were stampin[illegible] shrunk on, and the remainder of the frame co[illegible]sisted of assembled stampings that were screwed together. Anything resembling refinement was

American Troops Training with the Chauchat Machine Rifle.

conspicuously absent. The handle did not even ... the appearance of a pistol grip, being only ... angled piece of wood screwed onto a ... trigger guard and frame. And while the total production ran into many thousands, there was no interchangeability of parts, as the French methods did not call for such close gaging of components. Thus, the weapon could be considered hand finished as far as interchangeability is concerned.

The weight of the Chauchat weapon (19 pounds, including folding bipod) definitely placed it in the lightweight machine rifle class. The extreme distance of travel of the operating parts, brought about by the long recoil action, made it difficult to hold on a target and consequently it was very inaccurate. It is to be considered incomparably the worst machine gun of its class used by any belligerent in World War I.

At the time the United States entered the conflict, the country did not possess anything comparable even to the Chauchat, and when the A. E. F. landed overseas, the Government contracted with the French for enough of these weapons to arm each division as it arrived. While the American troops read glowing accounts of production feats at home with the superior Browning automatic machine guns, they were compelled to fight the war to the end armed with Chauchats. It is a matter of record that their issue to American troops was nearly twice what was anticipated as they were almost invariably thrown away in action.

The use of a weapon designed for the French cartridge made it necessary for our supply department to carry two kinds of rifle ammunition as all combat units had guns with both calibers. This situation was undesirable from a logistics viewpoint. It was found that with little difficulty and few changes the 8-mm Chauchat could be rechambered to take our caliber .30 service cartridge. On 17 August 1917, 5 months after we were in the war, an order was placed with the French commission to alter 25,000 weapons in such a manner. The revised gun was to be known as the caliber .30 Model 1918, with the reworking to be carried out by the original

The Chauchat in Action with American Troops.

producers of the basic mechanism. As a result it was practically the same arm as before, except for the chamber. The magazine was cut from 20- to 16-cartridge capacity and there was a slight increase in rate of fire. The modified gun did not even approach expectations, being more unreliable than the original. The most prevalent malfunctions were parts breakage, feed jams, and cartridges sticking in the chamber as soon as the barrel became slightly hot.

Despite many requests from the field for certain changes, it was impossible to incorporate them because of the way the contract with the French was drawn. All modification and inspection was placed in their hands and the guns, as soon as passed by the French inspectors, were shipped to this country to arm divisions about to go overseas.

From 31 December 1917 to 3 April 1918, 37,864 Chauchats were purchased in 8-mm or altered to caliber .30, and nine American combat divisions were armed with them in the United States before sailing for Europe.

The gun got its name from Colonel Chauchat, chairman of the French commission that adopted it. It was customary in European countries, for some reason that can only be surmised, to name a weapon for a high government official, particularly if the said person showed an especial interest in the adoption of the piece under consideration. By the same token, this machine rifle is sometimes called the C. S. R. G., paying tribute to all members of the board that selected the automatic rifle for the French Army. The board was composed of Messrs. Chauchat, Suterre, Ribeyrolle, and Gladiator.

The last named member of the board at a later date went to Greece and manufactured the identical weapon with his own name on the piece in lieu of that of Chauchat. From the character of the gun's reputation, one can only marvel that anyone cared to have his name so implicated.

Chapter 14

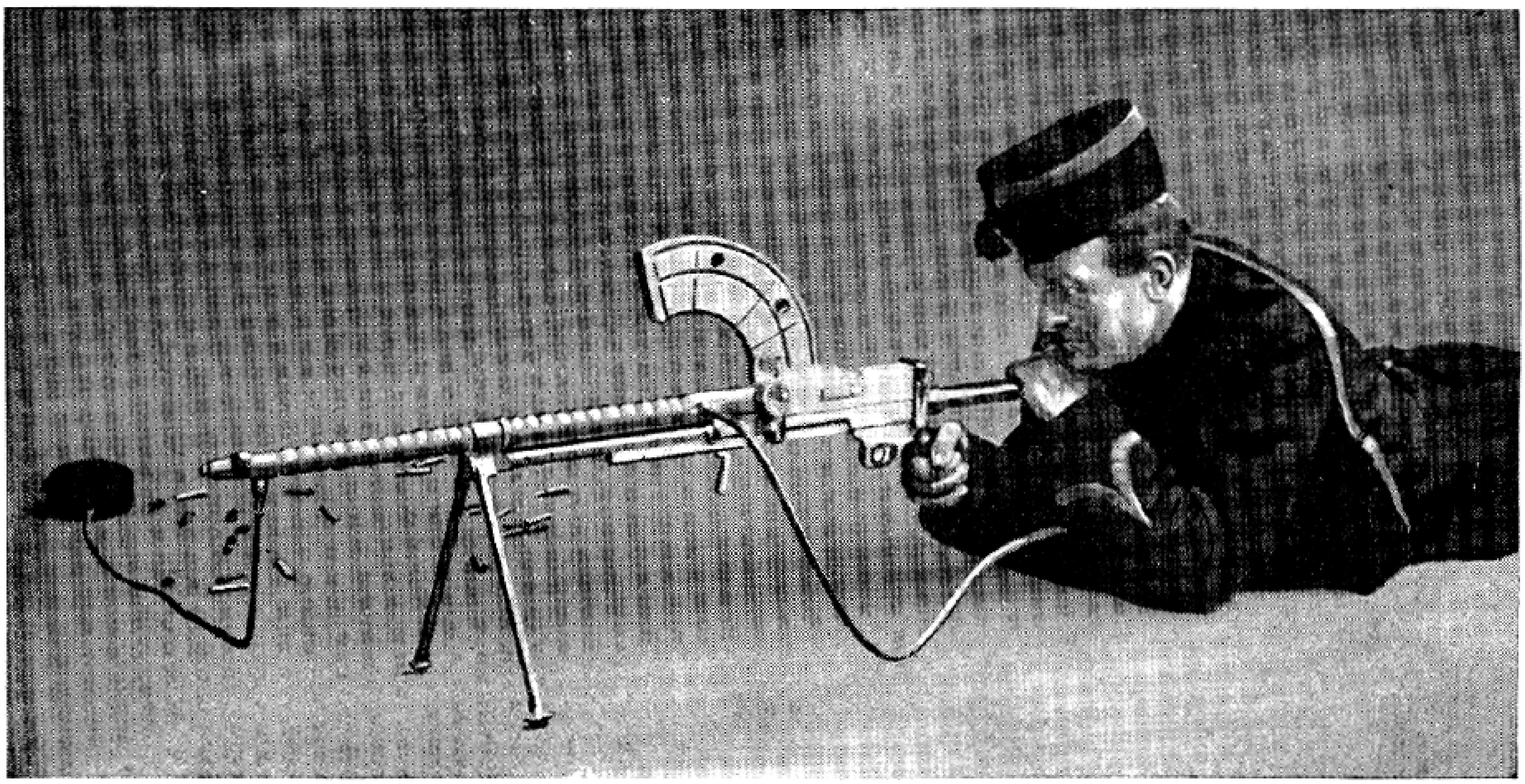
BERTHIER MACHINE GUN

The French Army, from the earliest days of automatic arms, has considered gas operation as the most logical method of deriving the necessary forces to actuate the firing mechanism. As was customary at the time, practically every young officer showing any aptitude in advanced weapon design was given a chance to carry out his ideas. Most notable of these was Lt. André Virgile Paul Marie Berthier, who, feeling that the Hotchkiss heavy machine gun was adequate in its field, tried to make for the infantryman a lightweight machine gun that could be carried with the ease of a carbine and at the same time had the fire power of the heavier weapon.

As early as 1905 Berthier applied for a patent in Belgium while serving in Constantinople, Turkey. His first gun was simply a straight pull rifle of the Mannlicher type. A gas cylinder with piston was installed on the right side of the receiver. It drove the bolt handle rearward by means of gas pressure being exerted on the face of the piston. The bolt and handle were returned by driving-spring compression. The weapon used a conventional magazine feed located underneath it. This model was known on the continent as the Berthier-Pacha. The latter name, also spelled "Pasha," was added as an honorary title granted by the Turkish Government in recognition of Berthier's contribution to ordnance.

Three years later he perfected another design that would fit the specifications demanded for an infantryman and still be rugged enough to stand the rigorous trials of the French proving grounds. The weapon, when it first appeared, was known as the Berthier Model 1908.

The rate of fire on this early Berthier was approximately 450 rounds per minute. It was first manufactured by the Anciens Etablissements Pieper at Herstal, Belgium, and a pamphlet pub-



Berthier Machine Gun, Model 1911.

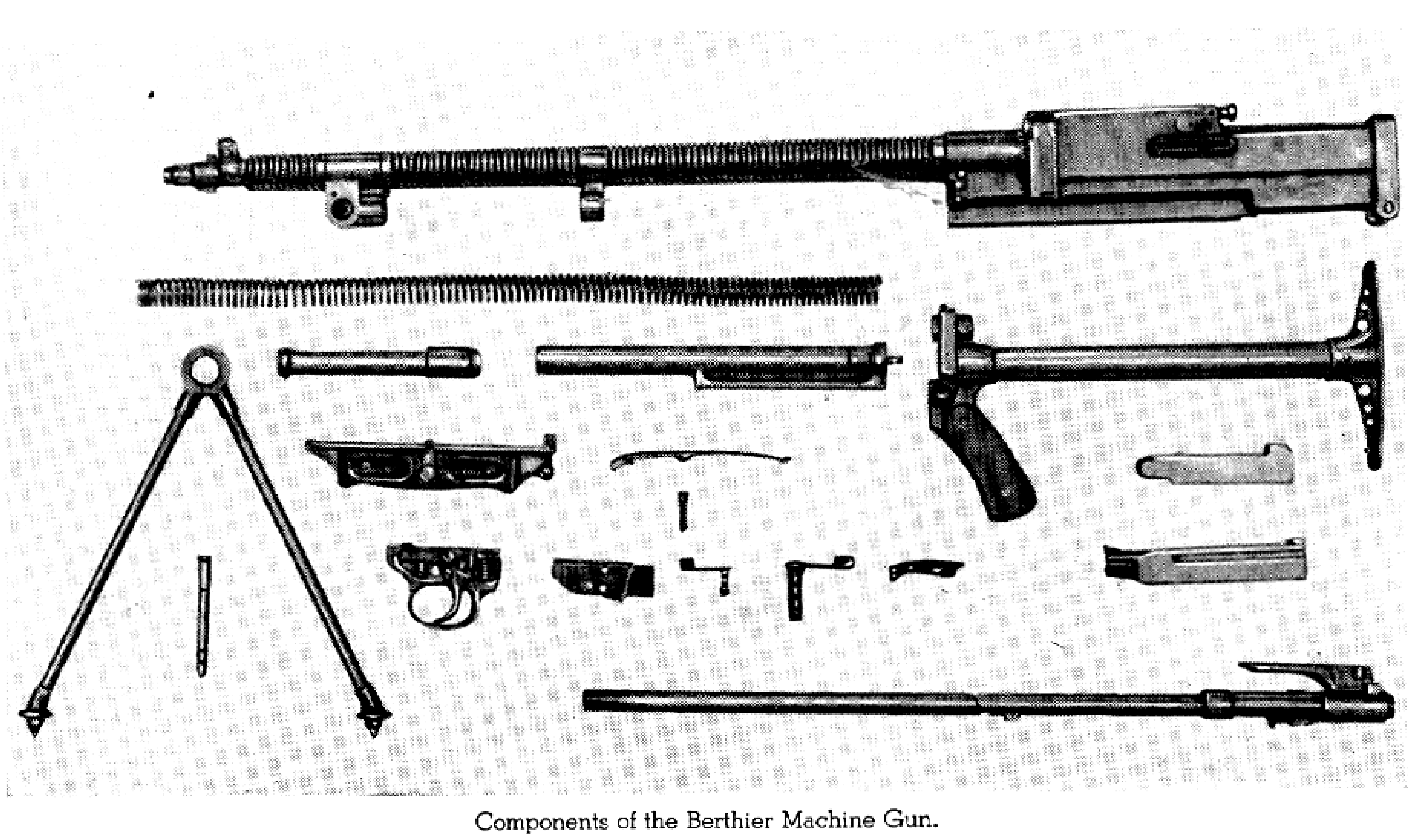
lished by the company not only gave its many features as an infantry arm but also pointed out its adaptability to cavalry tactics. Like all air-cooled machine rifles that were forced to use lightweight barrels, heating was the paramount problem. As a solution Berthier devised a system that permitted him to cool the barrel with water and still retain its low weight. The barrel was covered by a fairly close-fitting jacket made in two compartments. Using two small connecting rubber bags containing water, the gunner's assistant forced the liquid through the jacket from one container to another. This system was found to be adequate for up to 600 rounds of sustained fire. As a further remedy, the barrel and receiver were joined by an interrupted thread that allowed the barrel to be changed in a matter of seconds.

It is gas operated and locked by the "prop-up" method. That is, a part of the bolt when in battery is cammed in a vertical plane by the gas piston arm that actuates it as it continues on in a horizontal path. The barrel and receiver are designed so that the gun can use both air and water cooling. It is fed from a 30-cartridge clip located on top of the receiver. The cocking lever is placed on the side of the breech cover, allowing the operator to pull it to the cocked-bolt position, where it is held until released by the trigger. The firing pin, being attached to the gas-piston-actuating arm, detonates the primer from the continued forward travel of the gas-piston arm after it has cammed or "propped" the bolt up into locking position.

The main component parts may be divided for purposes of description into four main assemblies: Barrel group, consisting of the barrel, firing regulator, and gas block; receiver components, being the gas cylinder, buffer, trigger mechanism, and shoulder stock; recoiling parts, consisting of the bolt, piston, and driving spring; and the feed, which is in the form of a semicircular spring-loaded magazine.

All of the barrel assembly is easily detached as a unit. A trap, called the gas block, located about one-third of the way back from the muzzle, houses the cylinder and when removed can be inspected or readily cleaned. The group also has a regulator that has four settings to allow additional gas pressure to be vented to the face of the operating piston.

The receiver is milled from solid stock, the



Components of the Berthier Machine Gun.

front being threaded to take the barrel, below which is constructed the gas cylinder. A recess is cut in the rear into which can be fitted a detachable stock, while a rectangular piece is formed on top of the receiver which locks the magazine in place. An ejection slot in the right side of the receiver is closed by a spring-loaded catch except at the time of firing. Immediately behind the magazine housing is the locking shoulder, consisting of a transverse piece of case-hardened steel, set into the roof of the receiver and beveled on its leading lower edge to engage the rear of the tilted bolt. There are also four additional removable hardened cams (these comprise the feed piece) and the bullet guides that govern the cartridge's position on approaching the chamber. A recess to house the buffer is milled at the rear above the mainspring tunnel. This absorbs surplus energy and accelerates the return to battery of the recoiling bolt and gas piston assembly.

The recoiling group is summarized as follows. The head of the piston is slightly cupped with three annular grooves cut into the body to prevent formation of carbon. Its rear is constructed with a projection to form what is known as the cross head. This carries two cams which engage with inclined grooves inside the bolt. A third cam in the rear, known as the actuating cam, fits into a recess in the rear of the bolt body. A flat is cut on the bottom of the cross head with a notch to contact the sear. In front of the cross head is a shoulder to engage the piston stop cut into the receiver. It holds the entire assembly in the rear position when the trigger is released.

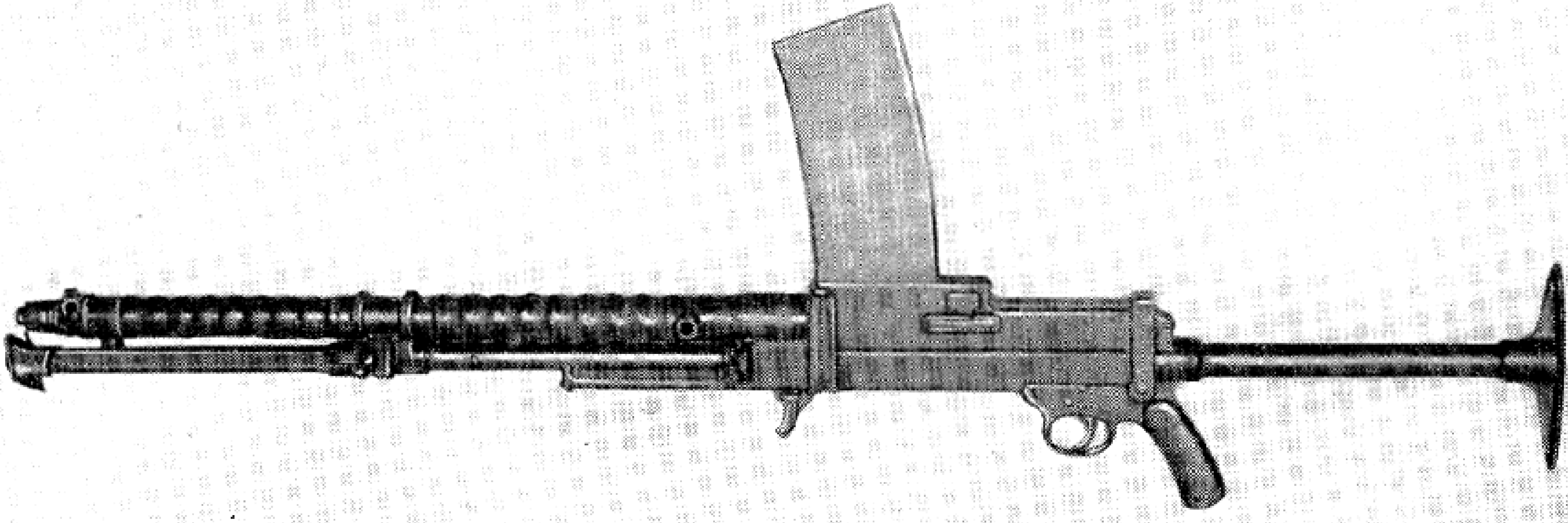
The bolt is a long rectangular block that not only slides horizontally between its recesses in the receiver wall but at the end of its travel is allowed a certain degree of tilting in a vertical plane. It is milled out on the rear underside to permit insertion and necessary lateral movement of the cross head. A groove is also cut on the bottom forward part to furnish a slideway for the lock lifting cam. The extractor is located on the right side and the feed guide on the top portion.

The left side of the bolt is cut away sufficiently to accommodate the ejector. The rear upper part of the piece that engages the locking shoulder is cut with a corresponding angle and casehardened to coincide with its mating part in the locking shoulder.

The cocking piece on the right side of the gun does not form part of the recoiling group. In order to cock the piece, the handle is drawn to the rear and its catch engages the notch in the guide key on the right side of the cross head. This pulls both bolt and piston back together until the latter engages the sear. The cocking lug is then pushed forward until it snaps into a one-way arrangement that prevents its recoiling with the operating mechanism.

The Berthier weapon represented the lightest water-cooled rifle-caliber machine gun that had yet been developed. Why it did not more than fulfill the requirements of the infantryman is not known, as it most certainly was an advance over the alleged machine rifles that were making their appearance at the time. One cannot help but note the comparison between the operating mechanism of the weapon upon which Berthier based his patent claim in 1909 and the later Browning automatic rifle that has proved so reliable in United States military service. The gas-operated rotating bolt in Berthier's first design of 1905 was a system that time has also proved to be among the best. It is hard to conceive that the French Army, having in its possession the nuclei of two fine automatic rifles, could have veered so far away as to consider the Chauchat. Only one conclusion can be drawn, namely, that mass production, so necessary to win wars, could not be geared to produce this well-balanced but hard-to-manufacture weapon, whereas the Chauchat, although admittedly inferior, could be turned out in practically any plumbing shop.

To fire the Berthier gun, a loaded magazine is slipped into a recess on top of the barrel until it engages its holding catch. The charging knob is pulled to the rear and then shoved forward. The selector located at the right rear is turned to automatic fire. This cams down one of the two sears that lock the piston. The other is released when the trigger is pulled and permits the bolt to leave the cocked position. Driven forward by the energy of the compressed driving spring, the upper face of the bolt strips a cartridge from the mouth of the magazine and starts to chamber it. During this act the extractor rides over the cartridge rim and snaps in the cannelure. Coinci-



Berthier Machine Gun, Water Cooled.

dental to reaching its extreme forward travel, the rear of the bolt goes slightly beyond a locking step that is machined in the top of the receiver body. The bolt has an opening machined in its rear portion in which is riding the camming lug of the cross arm. This is all connected or a part of the gas piston. When the bolt reaches its locking recess, the speed and inertia of the piston cause the camming lug of the cross arm to engage a corresponding angle inside the bolt body, pivoting the rear of the bolt up and against the locking step in the receiver body.

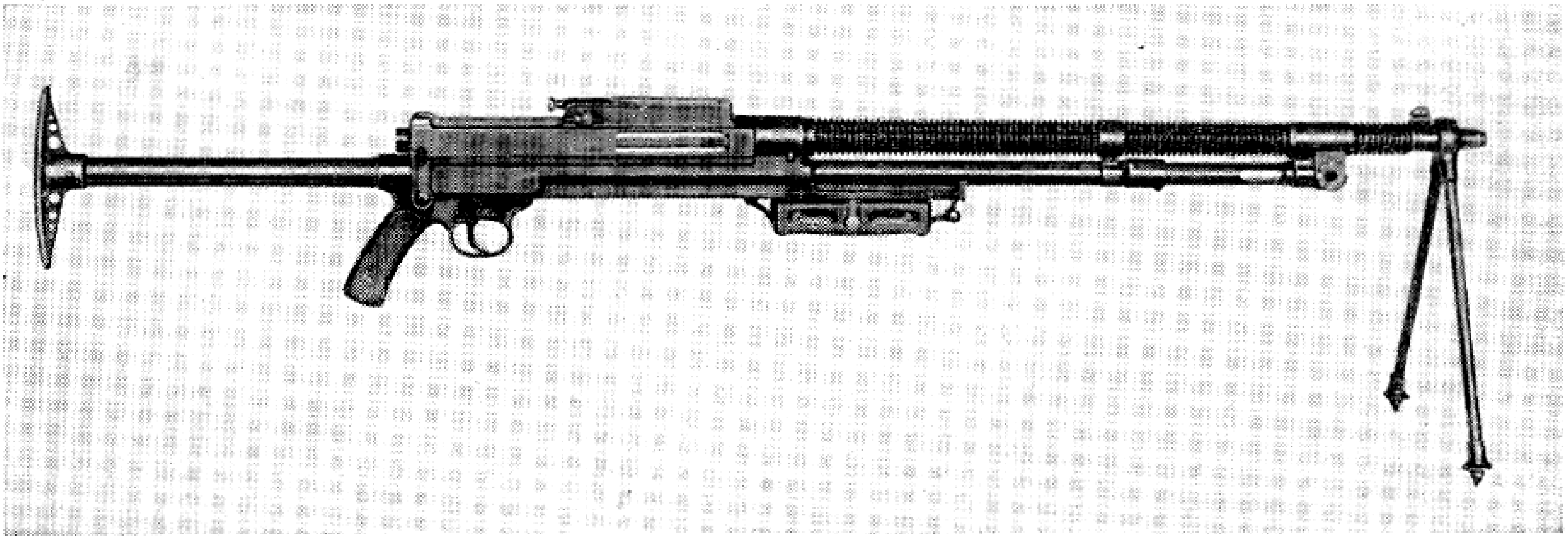
This swinging, or propping up, of the rear end of the bolt removes the obstruction that has been holding back the cross arm on which the firing pin is attached. Being forced by the sudden pivoting of the rear portion of the bolt body, the cross arm and firing pin can continue to advance with great speed for one half inch. The firing pin then enters its tunnel and its tip smashes into the primer of the chambered round.

After the powder charge explodes and the bullet has passed a port about two-thirds of the way up the barrel, gas is admitted through a controlled orifice that acts on the face of the gas piston. The latter's first movement rearward withdraws the firing pin tip from the primer, and after the cross arm is driven back approximately one-half inch it disengages the two cams that are holding the rear of the bolt against the locking step. The rear of the bolt assumes the horizontal in its slideway and starts to the rear.

A spring-loaded extractor withdraws the empty case and holds it close to the bolt face until the ejection slot is reached in the receiver. At this time the ejector fastened in the receiver collides with the base of the cartridge, pivoting and throwing it through the opening and to the right. The spring-loaded magazine pushes another round in position and the recoiling parts continue on against the loading forces of the driving spring. Full recoil takes place when the moving parts make contact with a spring-loaded buffer that not only absorbs the surplus energy but accelerates the operating mechanism during counter recoil. If the trigger remains to the rear, the return movement results in repetition of the cycle.

During the years between the weapon's conception and World War I, there was only enough interest shown by the various governments to which it was demonstrated to keep it from being totally forgotten. Many countries made inquiries and experimented at odd times with this machine rifle. However, France, the home of the inventor, seemed to go to great lengths to ignore it.

In 1916 Berthier, who had risen to the rank of general in the French Army, came to the United States to develop the weapon further, more by refinement of components for the purpose of being mass-produced than anything else, as the operating principles remained the same. On its first official trial by the United States



Air-Cooled Berthier Machine Gun Tested by the United States Army, 1917.

Army in May 1917 the gun did not meet requirements. On 29 June of the same year, the Marine Corps after a very comprehensive test, reported it suitable for its use. The Ordnance Board tested the weapon again shortly after the Marine Corps made its report and this later Army board concurred with the Marines, who had again conducted trials that resulted in another favorable report.

The Army then ordered, on 2 October 1917, the manufacture for issue of 5,000 of these guns chambered for our caliber .30/06 infantry cartridge, provided the order did not conflict with other machine rifle production that was being planned. It was found that the Hopkins & Allen Co. of Norwich, Connecticut, was under contract by foreign interests that controlled the Berthier manufacturing rights. It was estimated that the firm could start producing within 8 months, as it was 80 percent tooled up. Contracts were given for the Army's 5,000 guns. An additional 2,000 were ordered by the Navy for the Marine Corps, and given the designation Mark IV. This division of Hopkins & Allen had been incorporated, after receiving the contract, under the name of the United States Machine Gun Co. But financial and other complications arose and the parent firm was forced to drop all plans for manufacturing the weapons. As no other source was available that could give any promise of delivery within a reasonable time, all contracts were canceled. Consequently the guns were never manufactured in the United States, except for a few handmade pilot models.

This weapon is one of the best examples of a good idea developed at a time of peace when its perfection was cut short by lack of interest and money for development. When it was urgently needed in war, it had still not been proved to a point that justified the expensive and time-delaying job of tooling up to make the components with the precision demanded of such a weapon.

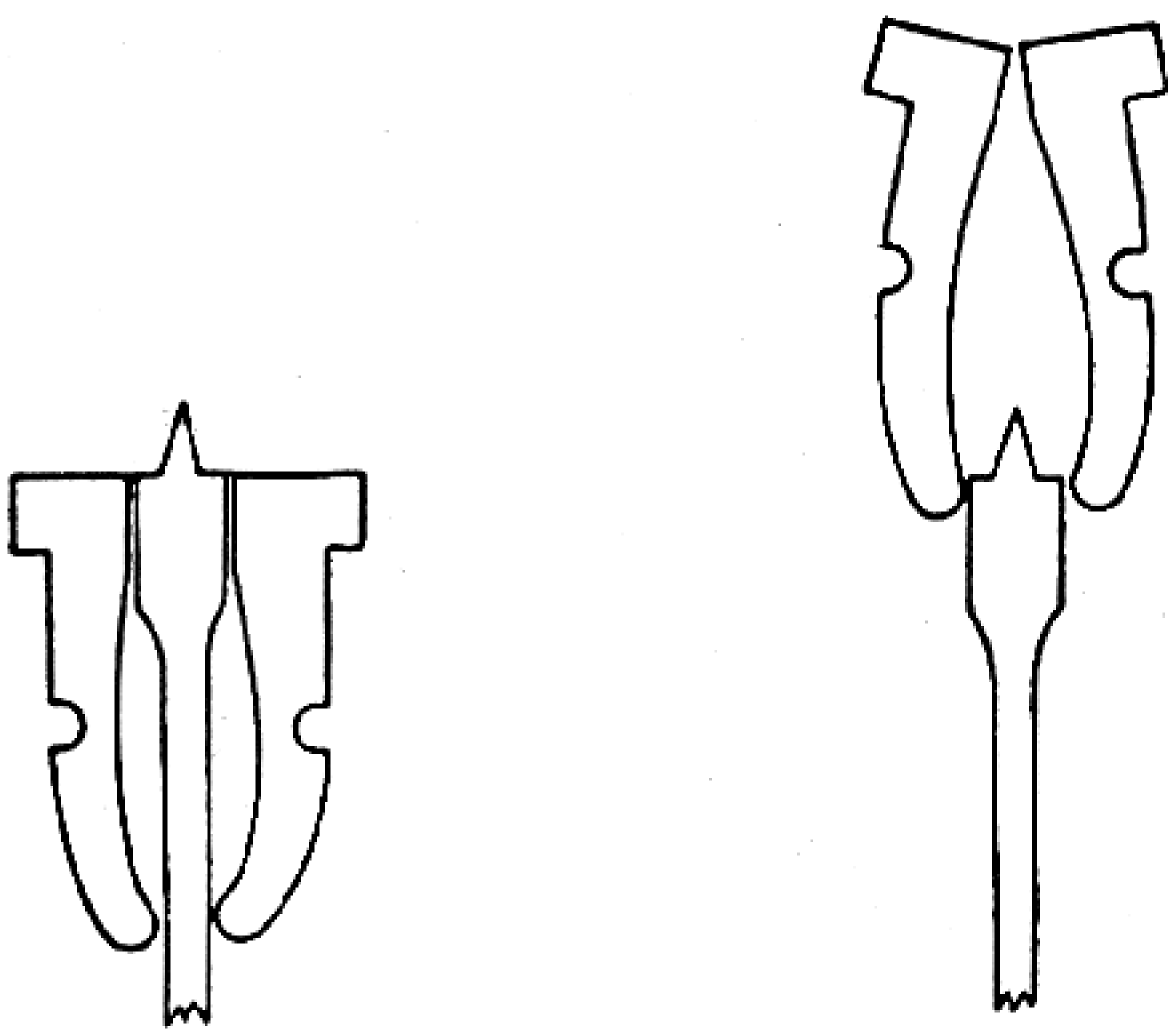
Had any country, at the introduction of the Berthier 1908 model, seen fit to function fire and correct the inevitable errors of design that appear during this experimental stage, it undoubtedly would have had in its possession at the beginning of World War I one of the world's most reliable and efficient machine rifles. There is very little question that the mystery of mass production to Europeans, and especially the French, was the contributing factor that made them treat the gun as being simply non-existent. That the basic principles were sound is shown by the fact that at a much later date several battle-tested light machine guns and rifles have used identically the same operating features first presented by Berthier in his two designs of machine rifles.

Chapter 15

KJELLMAN MACHINE GUN

Sweden made the next contribution to automatic weapon development with a very interesting automatic machine gun. Officially known as the Kjellman, it was the result of what could be called "two-stage" progression. Originally designed for the 6.5-mm Swedish Army rifle cartridge, it was water cooled, belt fed, recoil operated, and had a rate of fire of 500 to 600 rounds per minute. The weight of the weapon, minus water in the jacket, was only 28 pounds, which puts it in the lightweight class. The rear-seared firing mechanism left it at the end of a burst in a cocked-bolt position. The operating energy derived from what is known as the short recoil system.

By "two-stage" development, it is meant that the basic operating principles were originally conceived and patented by Lt. D. H. Friberg of the Swedish Army as far back as 1870, in an attempt to design for his country an efficient manually operated machine gun. His endeavors resulted in the development and patenting of many features, especially the locking system. His death, however, cut short any attempt at actually producing a shooting model of his designs. In 1907, 37 years later, a civilian gun mechanic, Rudolf Henrik Kjellman of Stockholm, Sweden, in trying to enter the automatic machine gun field, became interested in Friberg's basic principles. In line with the Swedish lieutenant's conception, he made a pilot model of an automatic firing mechanism that employed short recoil to actuate the components.

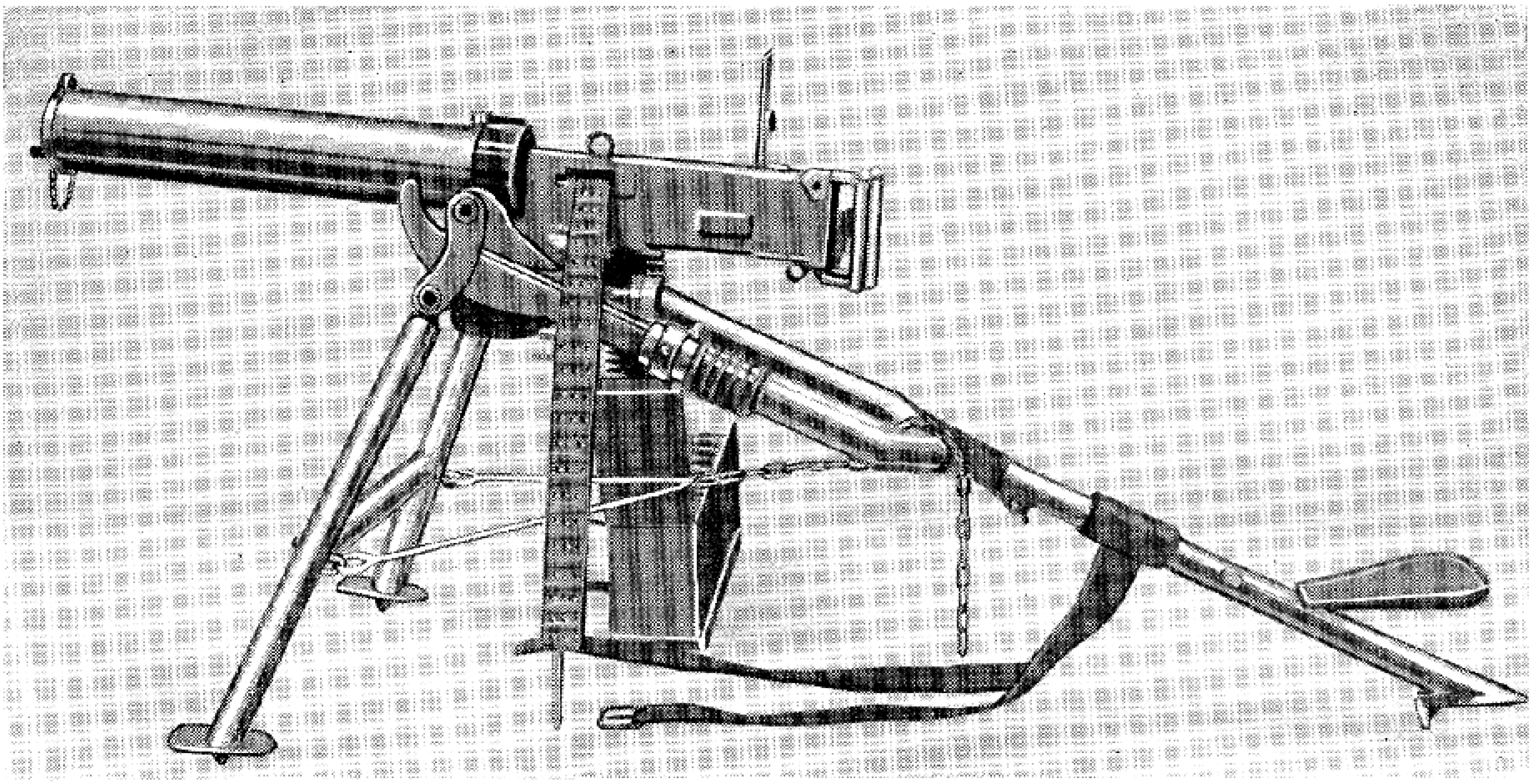


Locking System Designed by Friberg and Used by Kjellman.

On the Kjellman-Friberg automatic machine gun, the barrel and bolt recoil securely locked together for a distance of 18 millimeters. At this point the bolt is unlocked from the barrel and continues to the rear, accelerated by a pivoted lever. Two projections at the point of unlocking hold the barrel and barrel extension to the rear against the barrel return spring and the bolt continues to compress the driving spring. The fired cartridge case is extracted by a **T** slot on the face of the bolt and the empty brass travels with the bolt to the extreme rear position. It is ejected on counterrecoil by the introduction of the incoming round in the **T** slot, plus contact with a gradual angle that engages the empty core during this part of its forward movement.

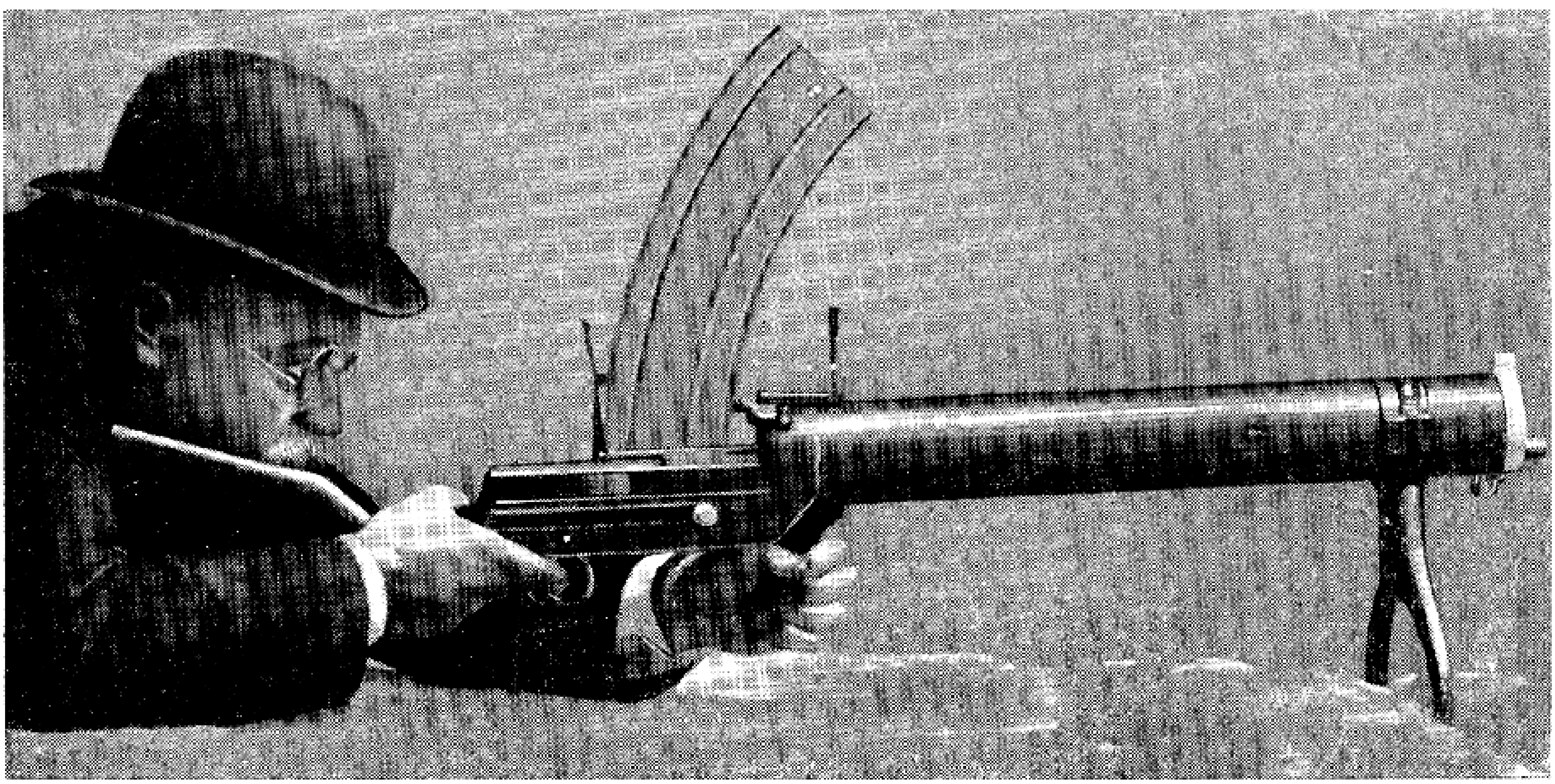
The round being chambered is first positioned by a movement of a sliding bolt face very similar to that of the Maxim. When the counterrecoiling bolt has reached a distance of 18 millimeters from battery, it strikes the pivoting breech locks. This simultaneously releases the barrel and barrel extension and locks them to the bolt, and all continue as a unit towards battery. If the trigger is held back, the firing pin is automatically released just before the entire recoiling mass makes contact with the receiver. The safety feature is also controlled by the breech locks which serve as an adequate obstruction in the path of the firing pin until the firing mechanism is securely locked.

A fire regulator is located on the left side of



Kjellman Heavy Machine Gun.

the weapon. It permits the operator to choose automatic or single shot. Due to the gradual camming effect on the empty cartridges, the cases, while positively ejected, are done so without being thrown forcibly from the gun. This unusual method caused Kjellman to incorporate, as an accessory to his gun, a metal receptacle that fitted in a slot beneath the receiver. This box has a trap in the top and each round, as ejected, is cammed through this opening. The bottom of the container slides between two right angles. It is spring loaded and at the end of a long burst or after cumulative firing, the gunner can pull back on a metal tab and dump the empty cases.



Kjellman Light Machine Gun Being Fired by the Inventor.

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When the last round has been fired from a belt, the operating mechanism is automatically seared to the rear. This feature facilitates loading as the bolt has to be in a retracted position when the first round is positioned. The conventional fabric belt is employed. It holds a total of 250 rounds, already packed in a light wooden container.

This weapon was given official consideration by the Swedish Army. Extensive trials were held and, for its stage of development, it held up remarkably well. Sweden, however, like the United States, not only had long been at peace, but saw no immediate prospect of war. Nothing but tests by the Army and a passive Government interest, as shown by the purchase of less than half a dozen of these weapons, ever resulted from the combined efforts of the two inventors.

Kjellman, thinking he could possibly arouse more interest if he refined the weapon to a point where it could be used by the infantryman as a machine rifle, did reduce the profile and streamlined the gun by adding a lightweight stock and tripod. For some unknown reason he retained the water-cooling feature with its bulky jacket. Had he chosen to make an air-cooled gun along these lines, he no doubt would have given the Madsen machine rifle severe competition.

Captain Lindengren, of the Swedish Army, who was considered one of the leading authorities on small arms, made many complimentary statements in writing about both weapons after witnessing the official trials. He wrote an article pointing out that, while the gun employed a very short recoil to work the mechanism, it was more securely locked than any other known automatic arm. To prove his statement he showed by spark photography that the bullet was 98 feet from the muzzle of the weapon before unlocking of the breech began.

REVELLI MACHINE GUN

A young Italian inventor in the year 1908 applied for his first patent on machine guns. It was to be followed by many others during the years in which his name was practically synonymous with Italian automatic weapon design. This prolific designer, later to become a high ranking military officer, was Bethel Abiel Revelli, a resident of Rome.

The automatic firing mechanism he had developed was a water-cooled machine gun with a box magazine, chambered for the 6.5-mm service rifle cartridge and weighing 38 pounds without mount. The maximum rate of fire was officially set at 500 rounds per minute. It was one of the few medium-weight machine guns to employ a magazine instead of the customary belt. Its unique method of feeding employed a metal box with 10 compartments of 5 rounds each, making a total of 50 shots per magazine. The ammunition container, when inserted in the feedway, was so constructed that, after the first five shots, the magazine itself was indexed over one compartment. When these additional five rounds had been fed through, the process was repeated until the entire contents were expended without interruption of fire. An oil pump for automatic

Revelli (Fiat) Machine Gun, Model 1914, Cal. 6.5 mm.

lubrication of each round was an integral part of the receiver.

There being no immediate prospect of war, nothing was done about the manufacture of the weapon except for the few handmade working models produced locally by the inventor. Revelli early became associated with the Fiat automobile plant located at Turin, Italy, and it was this company that first became interested enough to make a few demonstration models. There is an official record of the submission of a Revelli machine gun to an United States Army board in 1911, and in 1913 a test report by the Italian Government stated the weapon was suitable for service use. The gun employed at the time a 100-round magazine in lieu of the 50-round device. While it functioned satisfactorily, it was thought to exert too much weight at the left side of the mechanism when first positioned in the feedway, and restoration of the smaller box was recommended.

Italy's entry into World War I gave Revelli and his theories of machine gun construction a great opportunity, of which he took full advantage. This water-cooled model was turned out in great numbers by the Fiat Co. along with many other designs by this creator of Italian machine guns. The main Italian automatic infantry weapons stemmed from the earlier trial and development projects initiated by Fiat. The tests had been personally conducted by Revelli, who by this time held a captain's commission in recognition of his being instrumental in furnishing Italy with a machine gun of native origin.

To fire the weapon, the selector switch is moved from "Sicura" (*safe*) to "Rapido" (*fast, or full automatic*) and the trigger button pushed forward, bringing the sear out of contact with the bolt. This permits the striker to be thrust forward under compression of its driving spring, sending the firing pin into the primer to explode the powder charge in the cartridge. As the bullet travels down the barrel, the rearward action of the gas pressure against the cartridge base pushes with corresponding force against the breechblock.

The barrel sleeve and breechblock move back locked together for a distance of a half inch. The barrel extension is stopped at this point by a cross bar fixed to the receiver. Unlocking now begins by means of a wedge which starts to rotate about a fixed axis at right angles with the bore. As the breechblock goes back, the wedge is forced to swing to the rear.

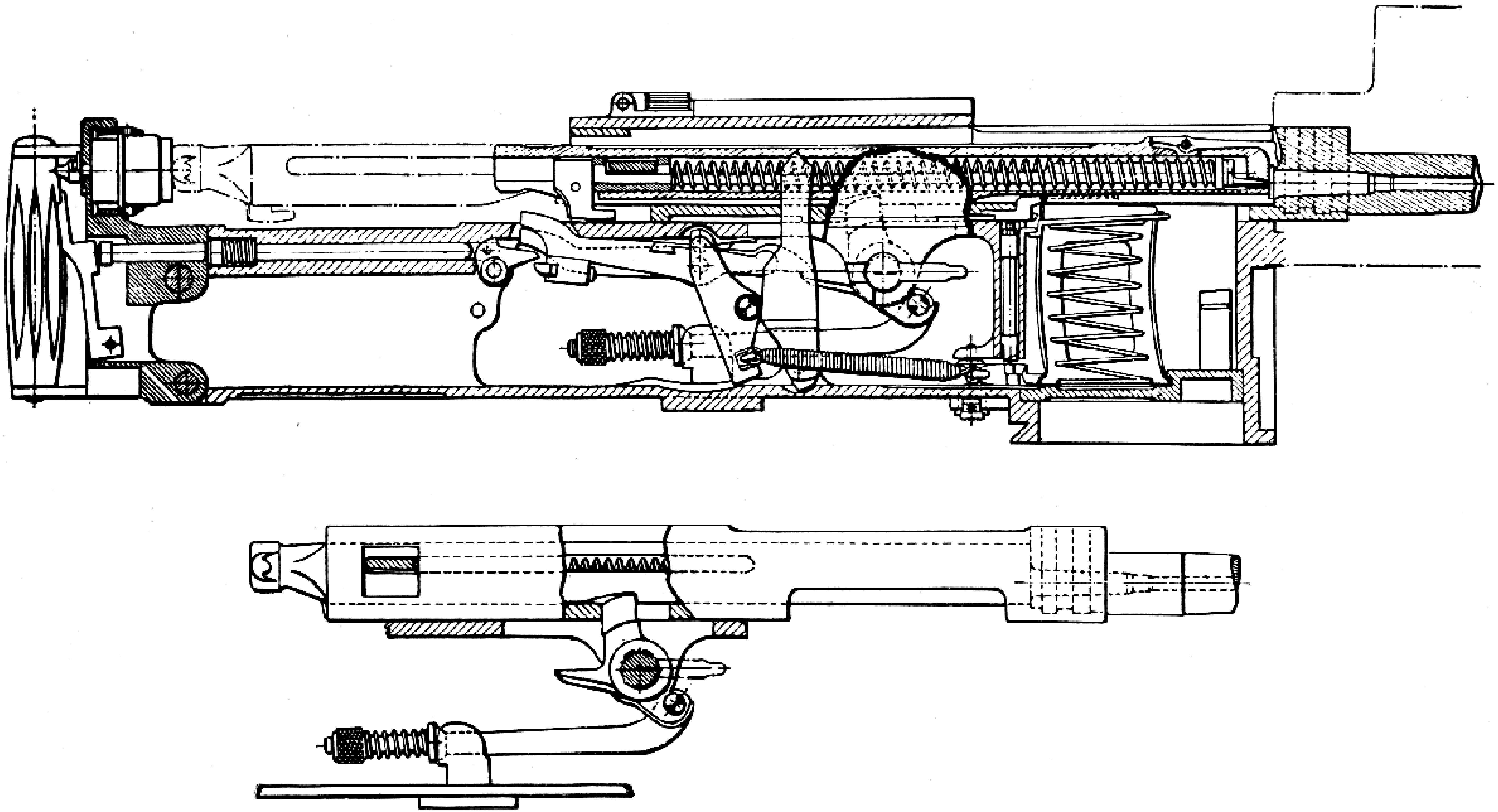
The wedge passes through a slot in the under side of the sleeve at an angle that cams the sleeve and barrel to the rear. This slight delay permits the bullet to clear the bore and the gas pressure to drop to a safe operating limit. At this point the wedge is moved entirely out of engagement with the breechblock. The latter travels backward under the momentum imparted to it by the blow-back gases. A nose on the under side of the breechblock holds the wedge down for the remainder of the rearward action. During the retracting movement the extractor guides the empty cartridge case out of the chamber, holding it to the face of the bolt until its base collides with the ejector which hurls it through the top opening in the gun. As each magazine compartment is emptied, the projecting tip at the rear of the compartment raises a pawl which permits the feed ratchet arm to index the next compartment of the magazine.

A strong coil spring, which is extended during the rearward motion, provides energy for return. It is attached to a connecting rod, one end of which hooks to a claw on the bottom of the rotating wedge and the other end to an adjustable spring fastened to the frame of the gun.

As the breechblock continues traveling to the rear, its spring is compressed against the head of the receiver. When the force of the recoiling action has been dissipated, the spring attached to one end of the frame in the lower part of the receiver exerts tension on the clamp at the bottom of the wedge. The sleeve and barrel are drawn forward as the firing-pin spring acts to force the breechblock forward at the same time that the sear holds the striker back out of engagement.

In counterrecoil the breechblock strips the cartridge from the magazine, then positions, and finally chambers it. The operating parts are now in battery, ready for the release of the firing pin, which will start the cycle all over again.

An unusual feature of the Revelli is that the cocking handle is incorporated in the rear portion of the bolt, and protrudes unhoused from the rear of the gun. It is shaped like a cross per-



Section Drawing of Revelli Mechanism.

mitting the fingers to be locked around both semicircular projections so that it may be drawn back against the tension of the firing-pin spring. This allows the gunner to cock the piece independent of the recoil action.

There is also a lever device, located directly above the thumb trigger piece, which permits both single shot and automatic firing at the will of the gunner. When single shots are desired, the selector switch is moved to "Lento" (*slow*) on the left side of the safety switch, permitting one shot to be fired each time the trigger is pressed. Pushed to "Rapido" (*fast*, or *full automatic*) at the extreme right, it fires automatically as long as the trigger is depressed. The vertical center position of the lever is marked "Sircura" (*safe*).

To load the magazine, the Revelli uses a trick magazine feeding system known as the "mouse-trap action." In theory, the device provides far more flexibility than is possible from a belt-fed mechanism. The magazines are small and compact. They can be inserted rapidly and are expelled automatically from the gun when empty. In actual warfare, however, it was found that the magazines damage very easily. This alone offsets the apparent advantage of the system.

A tip on the magazine follower on each section protrudes from the back. This part may be pressed down by the thumb of the left hand while the base of the cartridge is forced down in front of the follower and slides in under the locking lips of each section. Five cartridges may thus be fed into each of the magazine wells, thereby replenishing the ammunition without removing the box from the gun.

To install the magazine, it is inserted in guides

American Troops Receiving Instructions on the Revelli Model 1914.

in the feedway from the left-hand side of the gun. As each cartridge is chambered, the individual spring in the compartment forces the next cartridge up the line to be picked up by the forward motion of the breechblock. When the fifth and last cartridge in the compartment has been fired, the tip protruding from the back of the magazine engages a part of the mechanism. The latter shifts the box over to the right far enough to bring the next magazine compartment into line with the counter-recoiling bolt. When completely empty, the magazine is expelled from the gun on the right side.

A hinged plate covers the ejection slot on top of the gun. When ready to fire, the operator lifts it up to allow the empty cartridge cases to be thrown out through the opening.

The method of operation employed in the Revelli is known as "recoil and blow-back," or, in other words, retarded blow-back. The rearward thrust of gases in the firing chamber acting against the case pushes it back against the breechblock, causing a slight delay in unlocking. In the true sense of the word, the weapon is at no time securely locked, as in recoil-operated mechanisms, but utilizes hesitation to drop the gas pressure to a safe operating limit. The breech is then opened by the rotating wedge which connects the breechblock and barrel during the first stage of recoil movement to the rear.

Chapter 17

LAIRD-MENTEYNE MACHINE GUN

On 15 September 1913 a test of an English-made machine gun was ordered at Springfield Armory, Springfield, Mass. In the trial that followed it failed so miserably that it is mentioned here only to straighten out the classification of the weapon. It has been referred to as the Coventry machine gun, the C. O. W. rifle-caliber machine gun, and the Laird-Menteyne automatic gun. The first two designations were acquired because the Coventry Ordnance Works of Coventry, England, manufactured and promoted it in the testing at Springfield. A representative of the company was present to fire the piece.

The mechanism really was the invention of two French mechanical engineers, Paul M. Menteyne and Pierre A. Degaille, who as early as 20 October 1909 filed for a patent on the newly designed gun. Lacking capital, they spent 4 years before they finally interested a responsible gun manufacturing company in making a working model. The Coventry Ordnance Works produced two guns and offered them for trial by the United States Army. Charles W. Laird, a British engineer, was associated with the firm's development of the gun.

The weapon is best described as an air-cooled, magazine-fed, recoil-operated machine rifle using our standard service cartridge. The bolt is revolved to lock and unlock by engaging cams in the receiver, and the gun was loaded from beneath. It was so arranged that when the last cartridge was fed into position for chambering, the empty magazine automatically detached itself and fell to the ground. A fully loaded one was then inserted. It could be fired single shot or full automatic by the movement of a post device that was located directly in front of the trigger. A safety feature was incorporated in its construction whereby the cams that rotated the bolt for locking also revolved into alinement the firing pin with its tunnel in the bolt body. It was an impossibility to fire the weapon before the action was securely locked. The large main spring served also as firing-pin spring, since the inertia of the mass going into battery drove the end of the firing pin into the primer after cams turned the lugs on the bolt into the mating recesses in the receiver.

Considering the date of application for patent, this weapon had many advanced features that were used successfully in later guns, despite the failure of the Laird-Menteyne when subjected to the vigorous Springfield Armory test. The inventors stated in their claims that the mechanism was more adaptable to a larger shell gun than to the commercial rifle caliber as demonstrated.

PART IV

AIRCRAFT AND AIR-BORNE WEAPONS

Chapter 1

EARLY AIRCRAFT DEVELOPMENTS

Aerial History Before Kitty Hawk

The development of the automatic machine gun was so far ahead of the rest of the mechanical world that shortly after the turn of the twentieth century, as if by a predetermined agreement, progress in this field of endeavor temporarily ceased. It seemed to be waiting for a companion achievement, the airplane, to join in a combination that would result in man's most devastating instrument of war.

Of all the classes of society, perhaps the highly practical gun designer heaped the most ridicule on the "crackpots" who continually tinkered with horseless carriages and contraptions with wings. During this era some of the world's most skilled mechanics worked on the perfection of weapons, since this work represented a certain means for inventors to be reimbursed financially for their efforts. Having accomplished themselves what heretofore was considered impossible, they very humanly did not credit others with being able to do the same. The ability of man to fly in the air was thought to be hardly more than childish fantasy, but patience and ingenuity were at last making a fact of the unbelievable.

As early as the vision of the wonders of flight itself came premonitions of the inevitable horror that would surely follow the phenomenon. Even the early legends of India contain prophecies that in time there would be built "an aerial chariot with sides of iron and clad with wings which hurled down upon the city missiles that destroyed everything on which they fell."

During and following the ancient and medieval ages, men wrote boldly of flying but did little or no experimenting. Most of their theories during these sterile centuries were naturally based on the flight of birds. Roger Bacon, of gunpowder fame, described in his writings an "instrument to flie withall so that one sitting in the midst of the instrument doe turn an engine by which the wings, being artificially composed, may beat the ayre after the manner of a flying bird." Leonardo da Vinci, another prophet of the future, conceived the parachute, "a domed roof of starched linen, 18 feet wide and 18 feet long," by means of which a man could "throw himself from any great height without fear or danger." Theoretical discussion of flying continued to increase throughout the sixteenth, seventeenth, and eighteenth centuries until at last something practical in the way of flight was attempted.

On 19 September 1783, the Montgolfier brothers of Paris, France, built the first successful hot air balloon. Their gas-filled envelope was sent aloft with a sheep, a rooster, and a duck as passengers before the assembled court of Louis XVI. Three days after all had returned in good shape, a brave individual named Jean François Pilâtre de Rozier became the first human aerial passenger. He had hardly landed safely when M. de Vilette, a representative of the *Journal de Paris,* went aloft with de Rozier. While the newspapers made much of a Frenchman being the first human being to make an ascent, greatest emphasis was placed in pointing out the advantages the balloon would give to an army on land and to a navy at sea. In short order, books were being hawked on the streets of cities in every land close to France predicting that the French would descend upon them some still night, with troops being transported by noiseless balloons. This psychological scare seemed to excite almost everyone about the possibility of the balloon in warfare except the French, who took it simply as a great national achievement and very little else.

A more important discovery took place across the channel in England in 1810 when Sir George Cayley built the world's first glider. It worked to the extent of successfully carrying a man in the air. The glider was a brilliant achievement in that it not only lifted a man in free flight and landed without killing the operator, but also laid down the first sound aerodynamic principles upon which heavier-than-air machines are based. For in order to be successful, Cayley had to master many complex problems that worked in direct opposition to each other, such as cross-wind stresses, drag, and the constant pull of gravity. Sir George patiently sought by experience just how things actually worked instead of going by mental calculations that were based for the most part on hypothesis. Like many others before him he died thinking himself a failure, whereas in reality he left a great contribution in his chosen field. He undoubtedly was the pioneer in the study and development of elementary aerodynamics.

Although Cayley proved that a man-carrying heavier-than-air machine could be kept aloft by air currents, practically all effort in this direction was dropped in favor of the balloon, the popularity of which was growing by leaps and bounds. The French Revolution gave it its greatest impetus and its first use as a military device. Scarcely a war followed in which the gas-filled bags did not play a conspicuous part.

In this country a Professor Lowe organized the United States Army's aeronautical corps, which saw much active service during the Civil War. The professor himself logged more than 3,000 ascents in captive balloons, often staying aloft all day to observe movements of the Confederate troops. One of his companions on numerous ascents was a young German military attaché, Col. Ferdinand von Zeppelin, who at the time was serving as an observer for his government. He seemed to be more interested in the possibilities of the balloon in warfare than in the tactics employed by the opposing forces.

Its desperate position in the Franco-Prussian War caused France to authorize the formation by Felix Nadar of the "Ballon Poste" in order to float mail and passengers out of the besieged city of Paris. Later, the entire French Government used this method of escape when it seemed certain the city would be captured.

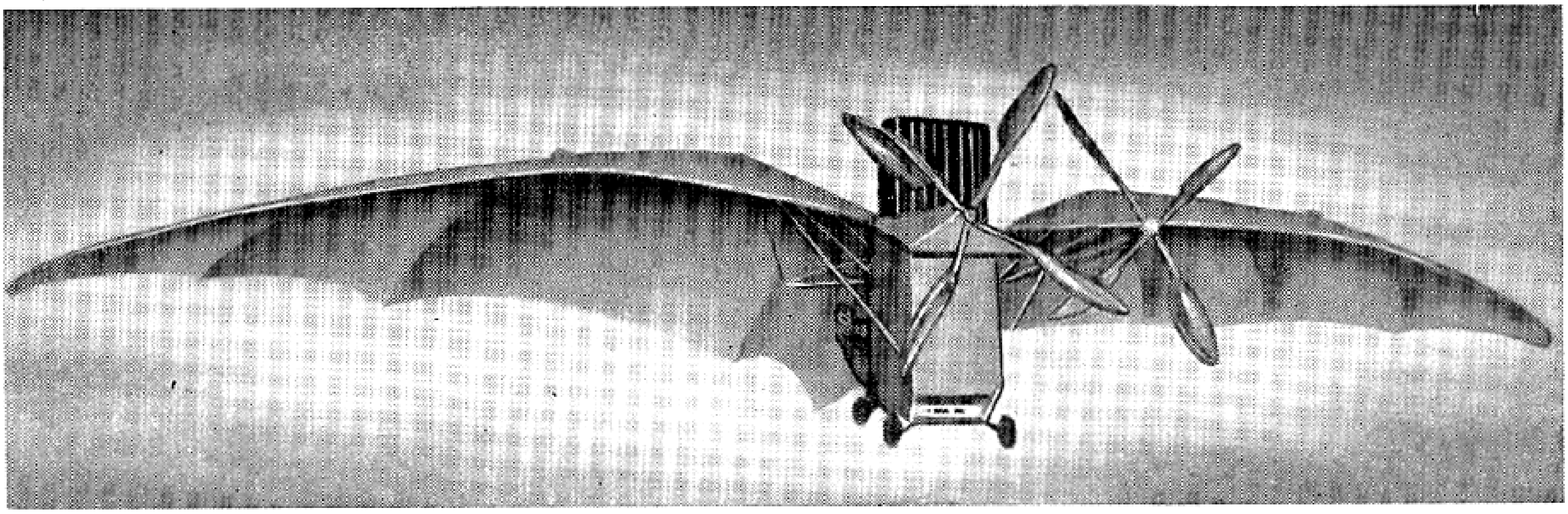
It was during the blockade of Paris that American citizens were first subjected to antiaircraft fire. W. W. Reynolds, an agent for the Remington Arms Co., and C. W. Way, a New York merchant, were caught in the siege. They persuaded the authorities to build them a balloon, and on 7 October 1870, they ascended, accompanied by two French aeronauts. The basket was heavily loaded, mostly with French gold in payment for armament sold to the Emperor Napoleon, and failed to rise properly. As it drifted low toward the German lines, it was shelled by Prussian artillery, sniped at by infantry and followed by troops of galloping horsemen. After several perilous escapes they were finally blown out of range of their pursuers and landed safely beyond the Prussian lines in a field near Amiens.

With the development of a power source known as the gasoline engine, the construction of balloons made with a longitudinal lattice framework of ribs with a light aluminum skin followed. The name "dirigible" was given to this type of airship. The designers believed the day had at last arrived when a balloon could be guided by an outside power source to and from any destination and not be dependent on changeable currents of air for its motive power.

An airship of this type was devised by the French in 1897 but it was far from successful. Two years later Germany developed the first practical aircraft along these lines. Santos-Dumont, a Brazilian living in France, working on different principles from the German inventor, also succeeded in constructing a successful lighter-than-air ship.

The French Army, however, had other ideas concerning aircraft and paid little attention to the successes of the dirigibles. As early as 1891 it had commissioned Clement Ader, considered the foremost aeronautical enthusiast in France, to build for the army its first military heavier-than-air plane. Ader, an electrical engineer by profession, was closely associated with the development of the telephone in France. In observing the activities of balloons at that time, he thought the nation could best protect herself by the construction of flying machines. After selecting the bat as the best model to imitate, he started to build a craft similar in appearance to this creature, which he called the "Avion." It was provided with a 40 horsepower motor driving 2 propellers.

The whole project was kept in great secrecy.



Ader's Avion, the First Government-Sponsored Flying Machine.

The French Government, considering the Ader flying machine already an accomplishment, appropriated $100,000 for the founding of an arsenal to construct and subsequently arm a fleet of the planes. The plan proved disastrous to both Ader and his military backers, for on 14 October 1897, after 6 years of hard work, the aircraft was completely wrecked in its initial attempt at flight and the authorities refused to advance any more money for further experiments. No doubt the government was anxious to avoid criticism over its already vast expenditure which had nothing to show for it beyond a totally wrecked aircraft.

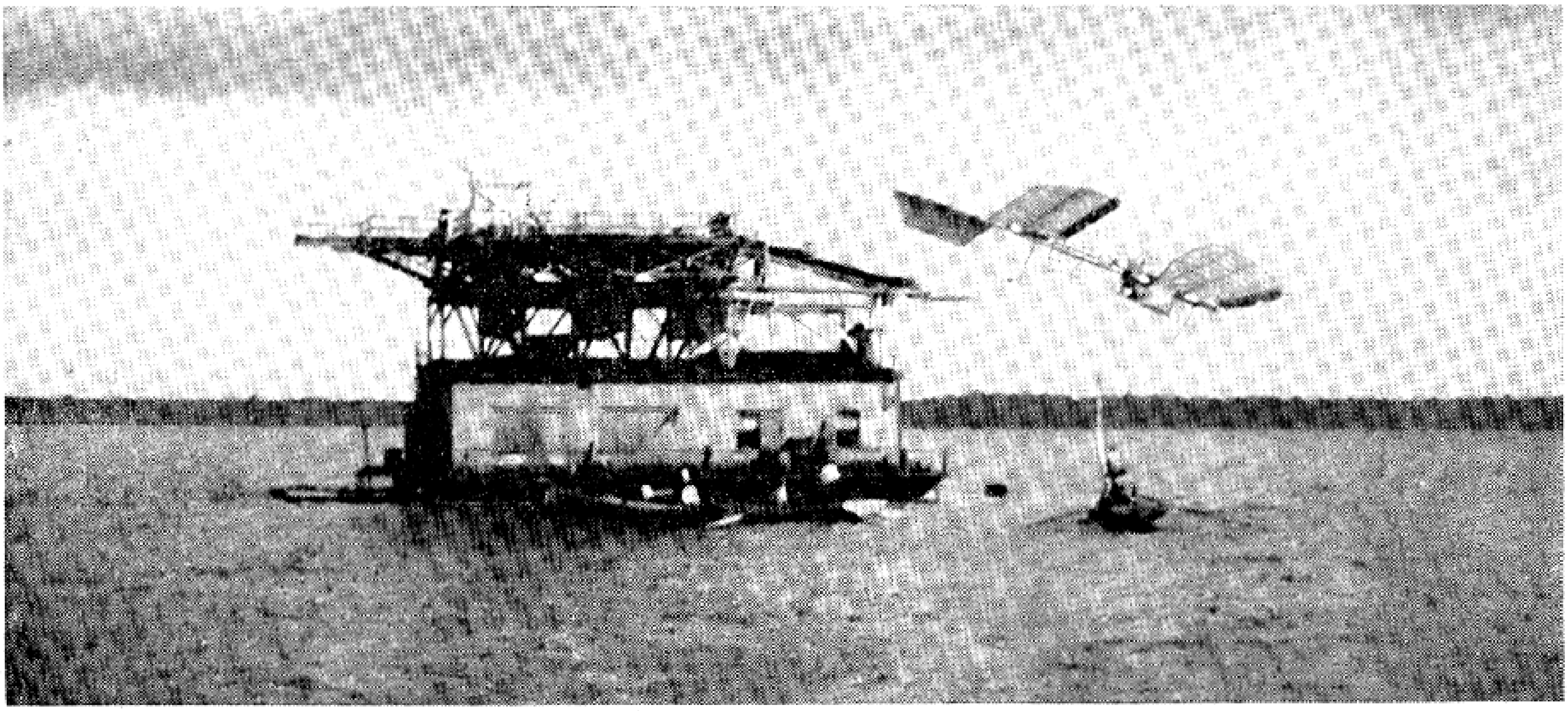
Sir Hiram Maxim, who originated the world's first successful automatic machine gun, was approached by the British Government which agreed to finance the building of a flying machine if Maxim would design it. The inventor, never a modest man about his ability in any field, agreed to construct a large aircraft of the multiplane type with a wing spread of 120 feet. He provided it with 2 steam engines, each capable of generating 175 horsepower. The completed assembly weighed 7,000 pounds, but like Ader's plane it too was wrecked in its first attempt to fly and the project was abandoned. The British Government, evidently expecting perfect performance as in the case of Maxim's first model of his machine gun, was disappointed and withdrew its support.

Ader's and Maxim's efforts can best be summed up as serious efforts to fly but with no proved results. However, Maxim did contribute one thing to aviation. He argued successfully that an airplane, because it was intended to fly, did not necessarily have to flap its wings like a bird. As he stated, "If airplanes should be constructed like birds to be more efficient, then by the same token locomotives should be built like horses."

Samuel P. Langley was a great pioneer in American aviation who was continually harassed by bad fortune. This former architect, in association with Charles E. Manly, built several contraptions called "Aerodromes" and while they never managed to fly, present-day authorities have adjudged them magnificent failures. That is, they were of sound construction and as advanced as it was possible to be at the time, especially in respect to motive power.

Langley was fortunate in having the services of Manly, a typical American inventive genius. He had designed gasoline engines, weighing only 125 pounds and capable of developing 52 horsepower, which were far in advance of anything known at the time. One of these engines officially generated 1 horsepower to 2.4 pounds in weight. It was successfully run in spite of the assurances of many eminent engineers and experts that it was impossible for a power plant to be designed under eight pounds per horsepower. The five-cylindered liquid-cooled motor ran, in an official test, 10 hours without stopping. This happened during an era when it took practically that much time to get the conventional automobile engine started.

In 1903 the Board of Ordnance and Fortification of the United States Army directed Langley to construct a large model of his Aerodrome and appropriated $50,000 to defray the cost of the experiment. This craft with its 52-horsepower



The Launching of Langley's Aerodrome, 7 October 1903.

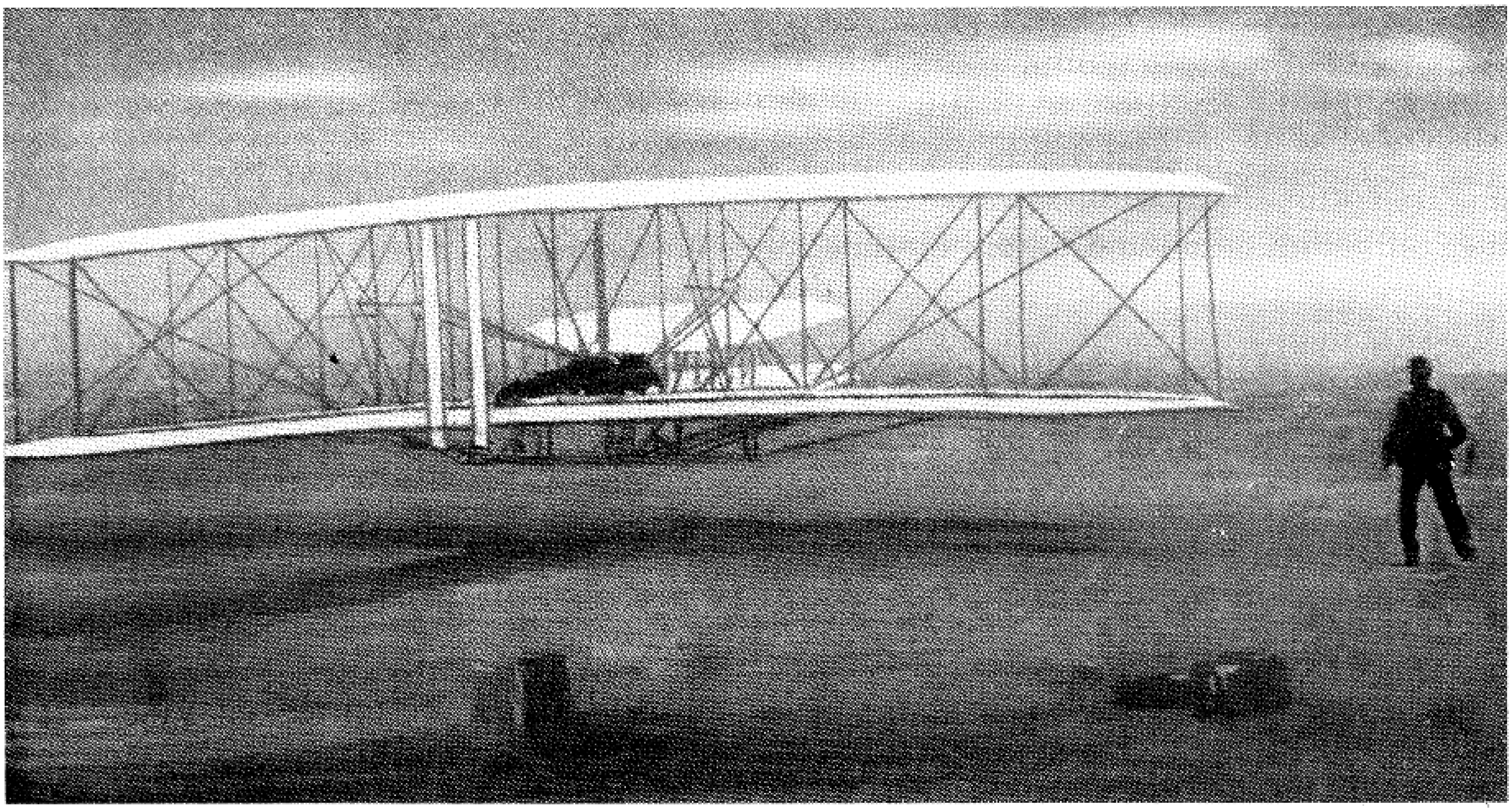
engine weighed only 830 pounds. Its dimensions were 48 feet in width and 52 feet in length. Two attempts were made to launch the craft from Langley's houseboat on the Potomac River, near Washington, D. C., on 7 October and again on 8 December 1903. During both efforts, according to witnesses, the Aerodrome became entangled in the launching gear and fell headlong in the Potomac. Following the last attempt, the press ridiculed the whole project so much that Congress refused to vote any more money for the venture. Regardless of its apparent good design, the fact remains that it did not fly and each effort to do so resulted in the complete wreckage of the craft in an inglorious manner. As one of the spectators put it, the Aerodrome "slid into the water like a handful of mortar."

The Wright Brothers and Other Early Pilots

It became the lot of two modest young men, Orville and Wilbur Wright, whose background consisted mainly in the building of bicycles, to fulfill the age-old dream that had bested mankind from the earliest days to the twentieth century. For on 17 December 1903, their "contemptible orange crate," held together with glue and wire and powered by a wheezing 4-cylinder gasoline engine, became air-borne after being launched into a 27-mile wind at Kitty Hawk, N. C. Orville Wright was at the controls through the element of chance, the brothers having tossed a coin as to which one would have the signal honor. Wilbur had won, but the first attempted launching 3 days earlier had been unsuccessful because of a broken guy wire at the time of take-off, and it was now Orville's turn. This act, like almost all others of world-shaking importance, took place in the humblest of surroundings, as the sand dunes on this bleak shore were hardly an appropriate backdrop for what was destined to become both the wonder and the scourge of civilization.

In a halting erratic flight of 120 feet, aviation, as we know it today, came to life. The 12-second phenomenon was witnessed by five heretofore skeptical local residents and by a confident Wilbur Wright. The watchers were John Ward, a boy of 16, John T. Daniels, W. S. Dough, and A. D. Etheridge, all of the nearby Kill Devil life-saving station; and W. C. Brinkley, a lumber buyer. Three of the five had come only to give help in case of disaster, but all had attended the most astounding event of the twentieth century.

Three other flights were made that day. The final one, with Wilbur piloting, started at 12 noon. The distance covered was 852 feet and the time of flight 59 seconds. Immediately following a successful landing, a sudden gust of wind blew



The First Flight by Man. The Wright Brothers at Kitty Hawk, 17 December 1903.

the airplane over and damaged it so severely it was never flown again.

The Wright brothers' accomplishment was no accident. Their great advance was not in the building of a superior power plant, as Manly, by every known standard of comparison, had surpassed them in the Langley plane. Rather, the real basis of this success was their brilliant achievement in obtaining balance in flight and control of direction by means of wires which acted as rudders and warped the wings of the biplane in any manner desired.

The inventors had prepared carefully for the eventuality of flight, having taken advantage of what little trustworthy science was known on the subject. They then set about to solve for themselves heretofore unmastered difficulties by dogged persistence and great natural aptitude. For example, in constructing their propellers, they profited from what they considered a mistake in Langley's propeller design, and built a homemade wind tunnel to prove the professor's scientific approach on this feature was wrong.

Likewise they gained much from the earlier glider studies of Sir George Cayley and the great German experimenter, Lilienthal. They actually built and flew identical gliders in order to see for themselves how these men had arrived at their basic principles of aerodynamics. That they were ever watchful for any possibility of betterment in design can best be judged by Orville Wright's statement that he got the idea of wing warping (a means of lateral control in lieu of ailerons or wing flaps) from twisting the top on a cardboard box when wrapping a package in his bicycle store.

The brothers from the first realized that, if they ever got an airplane into the air, they must learn to control it. "We thought," said Wilbur, "that if some method could be found by which it would be possible to practice by the hour instead of by the second there would be hope of advancing the solution of a very difficult problem."

The Wrights decided that the best way to do this was to find some place where the wind commonly blew at about 20 miles an hour, which they estimated was the best velocity in which to practice. They found such a place at Kitty Hawk in the late summer of 1900.

Using various models of gliders, they observed the effects of speed, lift, and pull in varying positions so that they slowly began to learn exactly what to expect when they first attempted to fly.

They experimented with new shapes of wings and found that, by twisting its surface in conjunction with a pivoting rudder, the glider could be balanced in flight.

When not making glider flights, the Wrights utilized all kinds of wing surface materials in the wind tunnel they had made for themselves. Thousands of tests were conducted in this device, 16 inches square and 6 feet long. During the greater part of 1902 they not only sought to find the most efficient manner in which to construct a propeller, but actually designed and built an engine to drive it.

The first aircraft to be successfully air-borne was a mixture of bicycle manufacturing knowledge with considerable aeronautical experience, plus a large measure of genius. Its total weight, including the pilot, was 750 pounds. The motor was officially rated at 12 horsepower, and carried air-borne 63 pounds of weight per horsepower. It had a maximum motor revolution of 1,020 per minute, while each of the 2 propellers had a revolution of 340 times per minute when in flight.

The event was heralded in the press with banner headlines and the public accepted it with both skepticism and awe. People were hardly able to visualize man flying through the skies when the roads and streets were cluttered by "cranks" trying to nurse the "one-lungers" of their horseless carriages back to life. At the same time many individuals realized the military potentialities of aircraft if refinement did follow and a reliable motor could be made that allowed such a device to be used for these purposes. That is, practically everyone realized this but military men themselves, who seemed very content to tinized nitroglycerin with cellulose to form a progressive burning propellant.

This situation was true in all countries, doubtless as a result of the earlier failures of craft designed by Ader, Maxim, and Langley. Nevertheless, the successful flight of the Wright airplane was destined to affect warfare, and especially machine-gun design, just as much as did Vieille's discovery of smokeless powder by rolling gelatinized nitroglycerin to form a progressive burning propellant.

In 1904 the Wright brothers continued their experiments on Huffman Prairie, near Dayton, Ohio, with a new machine. Over a hundred flights were carried out. In 1905 distances up to 24 miles were covered. In the next 2 years the brothers devoted a great deal of their energies to the construction of new machines and to business negotiations. Still very little attention was attracted to their remarkable flights.

In the fall of 1907 the Aerial Experiment Association was organized by Dr. Alexander Graham Bell, inventor of the telephone. Commencing in 1908, simultaneously with the Wright brothers' activities, the association carried on its experiments, with headquarters at Hammondsport, N. Y. The organization was composed of Dr. Bell, Glenn H. Curtiss, Thomas E. Selfridge, F. W. Baldwin, and J. A. D. McCurdy, the latter two being Canadians.

The association built a number of machines, the design of each being credited to an individual member. The first plane constructed was the "Red Wing," which covered a distance of 319 feet on 12 March 1908. Selfridge was given credit for its general plan although the test flights were conducted by Baldwin.

On 8 August 1908, Wilbur Wright captured the imagination of Europe when he flew his machine over a race course near Le Mans, France. Actually there had been earlier short flights in Europe. Alberto Santos-Dumont, for instance, had flown his biplane for a distance of 150 feet in October 1906 and made other brief hops the same fall. And in 1907 Henry Farman had piloted a Voisin machine at Issy, France, in a circular flight of 1 kilometer.

At Le Mans, Wright was air-borne for only a minute and forty-seven seconds, but 3 days later he was aloft for 4 minutes, during which time he executed all kinds of maneuvers. On 21 September 1908, he remained in the air for more than an hour and a half, flying a distance officially estimated at 42 miles, and afterwards made many other prolonged flights.

The successes of the Wright brothers started a frantic renewal of effort on the part of European inventors and flying machines were constructed in every major country of Europe. The next 5 years were spent in attempts to create new air records. In the middle of 1909 flights of unusual proportions became an everyday occurrence.

Men like Bleriot, Santos-Dumont, Farman, Latham, and Voisin were among the most prominent to contribute to the rapid growth of aviation. They flew great distances and at unbelievable heights in their rickety contraptions. On 15 July 1909, Bleriot crossed the English Channel from Calais to Dover, a distance of 31 miles, in 37 minutes. He landed in a meadow only a few feet away from the spot where Blanchard and an American doctor, Jeffers, had ascended in their balloon for the first aerial channel crossing 120 years before. On 16 November 1909, Farman covered 134 miles in 4 hours, 17 minutes, and 53 seconds.

An American, Glenn Curtiss, carried away the Gordon Bennett prize when an air show was staged at Rheims, France. He did it in a plane of his own construction that averaged the unheard-of speed of 47 miles per hour over the whole course. Curtiss came back to America and won $10,000 offered by the *New York World* for the first flight from Albany to New York down the Hudson River. By this time he had invented and patented a system whereby a movable hinged aileron controlled a machine in flight, a feature considered by many to be one of the greatest contributions to aviation.

Beginnings of Military Aviation

In this country Congress, having already sponsored a signal failure, was reluctant to give aid to aviation, but in 1908 the Army did show an interest. In October of that year the first test flight for the United States Army took place at Fort Myer, Va. It reserved the right to pay the designer $25,000 provided the machine met certain specifications, which were incidentally above and beyond anything thought remotely possible. One was that the aircraft's speed must hold a continuous 40 miles per hour and fly a distance of 100 miles. The Wrights were the only applicants to submit a complete machine and fulfill the requirements. In the official test the Wright plane flew slightly faster than the specified speed and covered the maximum distance of its fuel load, a total of 125 miles. The entire trial was conducted without any serious mishap. Specifications for the machine, prepared in the administration of Theodore Roosevelt, father of the modern Navy, gave the United States Army the first airplane ever used for military purposes.

This test, purposely carried out over Washington, D. C., where all could see for themselves, created much more of a sensation than did the Kitty Hawk flight 5 years earlier. In fact the press could hardly find sufficient adjectives to describe this new tool of war. Enthusiasm was dampened greatly a few days later by an untimely and tragic accident when Orville Wright, with Lt. Thomas E. Selfridge as co-pilot, on taking off from Fort Myer entangled his propeller with a guy wire, causing the plane to fall to earth. Selfridge became the first airplane fatality, while Wright was severely injured. The public was brought face to face with the sobering fact that, although flying was at length accomplished, the price for future advancement would have to be paid for in blood by its pioneers.

The year 1909 also marked the beginning of aeronautics in Russia. It was started principally as a sport. A private school, located in Moscow, was operated by a civilian named Maslenicoff. It was soon taken over by the government and known from then on as the Aviation School of the Moscow Imperial Aeronautic Association. Later another school was organized at Odessa, and at each army maneuver held after this, officer graduates were invited to show their piloting skill. Any proved ability was recognized by promotion. The training became so popular with the army that a third government flying school was established at Sebastapol. The honor graduates of the earlier classes of the Imperial School, Captain Ulianin and Lieutenants Rudneff, Piotrovsky and Matsievitch, were placed in charge, after first having been ordered to France to observe the latest techniques in the art of handling planes.

The Russian Army Aviation Force was a part of the Engineering Corps, known as the General Military Technical Department, with headquarters at Petrograd. The Russians have always been air minded and their progress was steady throughout this early development period.

The specifications set by the United States Army in 1908 for testing aircraft formed the standard by which the rest of the military world judged the value of planes until 1910. The French then organized what was called the

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French Military Competition, which was originated to further the refinement and betterment of design of airplanes in that country.

The conditions to be met by the competing aircraft and the prizes to be awarded the winners were based on the following requirements:

The airplane and engine must have been constructed in France and be capable of a flight of 180 miles without stop, carrying at the same time 660 pounds above the fuel load; the speed must average a minimum of 37.3 miles per hour; and if this much of the test is completed successfully, then altitude flights must be made during which the machine must rise with a full load to a height of 1,460 feet within 15 minutes of taking off.

The machine turning in the best performance would be bought by the Ministry of War for the sum of 100,000 francs, and the manufacturer given an order for 10 additional machines of identical design at 40,000 francs each. An extra bonus of 500 francs would be allowed for each mile an hour reached above the 37.3 minimum.

The makers of the machines turning in the second and third best performance would receive orders for six and four machines respectively, at the same price. If only one machine came up to specifications, the designers would receive an order for all 20 aircraft.

Encouraged by the monetary inducements offered, 16 French producers designed and constructed special types of airplanes, 34 in number, for trial in the 1911 Military Competition. The final test was over the 496-mile course between Rheims and Amiens. Eight planes passed the test, the winner being a pilot named Weyman, flying a Nieuport monoplane with a Gnôme motor. He had an average speed of 73 miles per hour.

This unique plan to give an incentive to aircraft development proved the most beneficial thing that could be done for aviation and, as it turned out, was the salvation of France. The French proceeded from this point to outstrip the world in aircraft design, especially with respect to military types, which were tried as an aid to scouting during army maneuvers. Trials under field conditions showed the officers the minimum amount of service that a plane could contribute while still being of value to the ground forces, and the requirements that would have to be met by an airplane in order to be suitable for general military work.

France's great strides forward in aeronautics were watched closely by her old enemy, Germany. When it became apparent that the French were leaving everyone else far behind in this field, the Kaiser, on 27 January 1912, offered a prize of 50,000 marks as an incentive to improve aviation for German military use. The contest was to be arranged and awards made by members of the Imperial Automobile Club, Imperial Aero Club, members of the German Automobile Constructors' Association, and delegates of the Navy and War Departments.

This gesture from the Kaiser was the signal for the German nation to concentrate on aviation. The Aerial League of Germany started a public subscription which brought in 7,234,506 marks the first year. The plan of the league was to train the largest number of pilots in the shortest time in order to form an adequate reserve, thus encouraging civilian interest in the scheme. Its success was out of the ordinary; by the end of 1912, 230 military pilots were registered and by the next year 600 were graduated. The number of builders grew from 20 in 1912 to 50 the following year. These successes of the Aerial League were instrumental in causing the Reichstag to pass a bill authorizing 35,000,000 marks for military aeronautics for the next 5 years.

This was all that was needed to bring German aviation to a point of efficiency where record after record began to fall. The year 1913 saw the endurance mark raised by Reinhold Boehm to 24 hours and 12 minutes, and an altitude figure set by Heinrich Oelrich at 26,246 feet. In this one year over a hundred other records were established. For instance, an aviator named Landsmann covered 1,335 miles in a single flight which was at the time the longest distance ever traveled by man in one day. The secret of the plane lay in the design of its Mercedes motor, which was a direct result of the interest created by the Kaiser's award to encourage inventors.

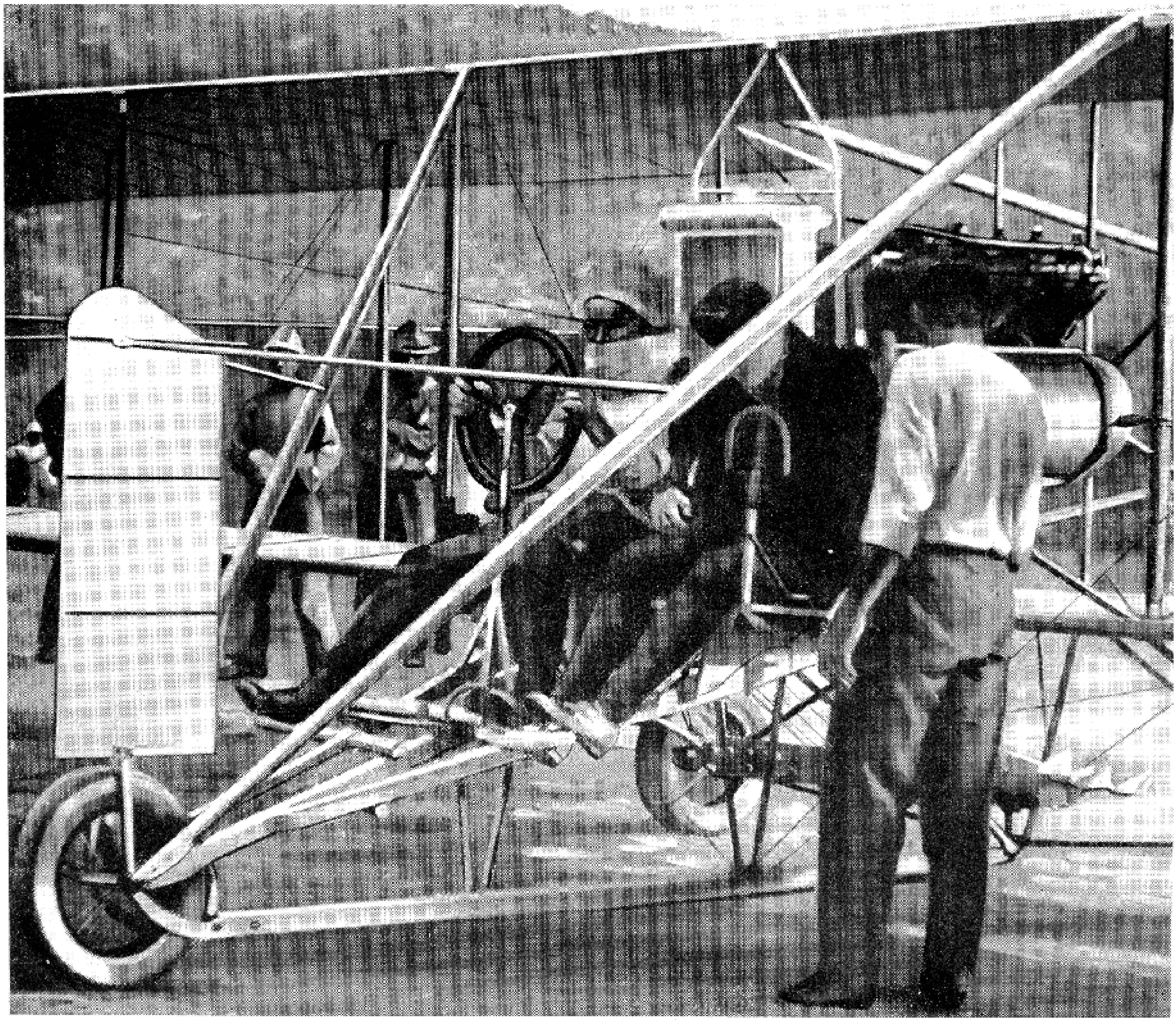
After the accident that cost the life of Lieutenant Selfridge, there was a stalemate in American military aviation. The next official flight took place at Fort Myer again, although not until

July 1909. The machine, which was another Wright, successfully passed the tests and was bought by the Government. Lts. Frank P. Lahm and Benjamin D. Foulois were assigned to receive flying lessons from the Wrights. An aviation field was established at College Park, Md., and a young captain, Charles DeForest Chandler, then disbursing officer of the Signal Corps, was made officer in charge of the Aeronautics Division of the Signal Corps.

Wilbur Wright served as the instructor and taught Captain Chandler and Lts. F. P. Lahm, Benjamin D. Foulois, Frederick E. Humphreys, T. DeWitt Milling, H. H. Arnold, and George C. Sweet, the latter being assigned to the school for instruction by the Navy Department.

The next venture by the Army in aviation was the acceptance of its first dirigible in October 1909. It was commanded by Capt. Thomas G. Baldwin. It too was initially tested at Fort Myer, with Lieutenant Lahm in charge. After successfully meeting all requirements, it was flown to Omaha and turned over to Lts. R. S. Bamberger and John G. Winter, both of the Cavalry.

These developments were followed by the failure of Congress to allow adequate appropriations for aviation. Again things came to a standstill as far as the Army was concerned through 1910–11,



One of the Airplanes Used by the Constitucionalistas in Mexico to Bomb Federal Gun Boats.

while officers of the newly formed Army Aeronautics Division attended voluntarily nonmilitary aviation meets and followed the literature on the work done by civilian enthusiasts.

European countries were in the midst of preparing for the day when airplanes would be used in conflict, but to Mexico goes the distinction of being the first country to employ aircraft in warfare. During the Constitucionalista campaigns against the Diaz regime in late 1910, a conglomerate assortment of aircraft was purchased from civilian builders in the United States and American aviators employed to fly the planes. In spite of the questionable quality of the flying matériel that was assembled and the still more dubious military value of the aerial maneuvers, this small flying force did do patrol and reconnaissance work, particularly in locating guerrilla troops in their mountain retreats. With the victory of the Constitucionalista regime, the American professionals were released and the Flying Corps of the Republic of Mexico formed.

During the Mexican border incident of 1911 the United States Army found itself without a single plane to send to the troops in the field. This greatly agitated the few aeronautically minded officers who were in the service, as they could see that any good work done at this time by a flying machine would be invaluable in future planning and a wonderful incentive for asking Congress to appropriate desperately needed funds.

With air development left in the hands of civilians and with military authorities still taking a dim view of the role aircraft could play in warfare, by an odd quirk of fate the United States was still the first government to use an airplane under conditions that approximated war between major powers. The border incident with Mexico was a logical opportunity for this to occur and the ever-alert civilian promoters did not let it go unheeded. A Wright flying machine, the personal property of Mr. Robert J. Collier, president of the Aero Club of America, was loaned to the United States Government for use on the border. With this machine Lt. B. D. Foulois and a civilian, Mr. P. O. Parmalee, made a number of flights along the border carrying messages between officers in command.

Pioneer Attempts at Aerial Armament

Civilian enthusiasts in the United States were aware of the fact that without Government backing they could never progress beyond the novelty stage of flying. They continuously planned events calculated to impress or at least interest the military high command. This was often done with the aid of aeronautically minded Army personnel who willingly donated their services whenever possible to further the cause.

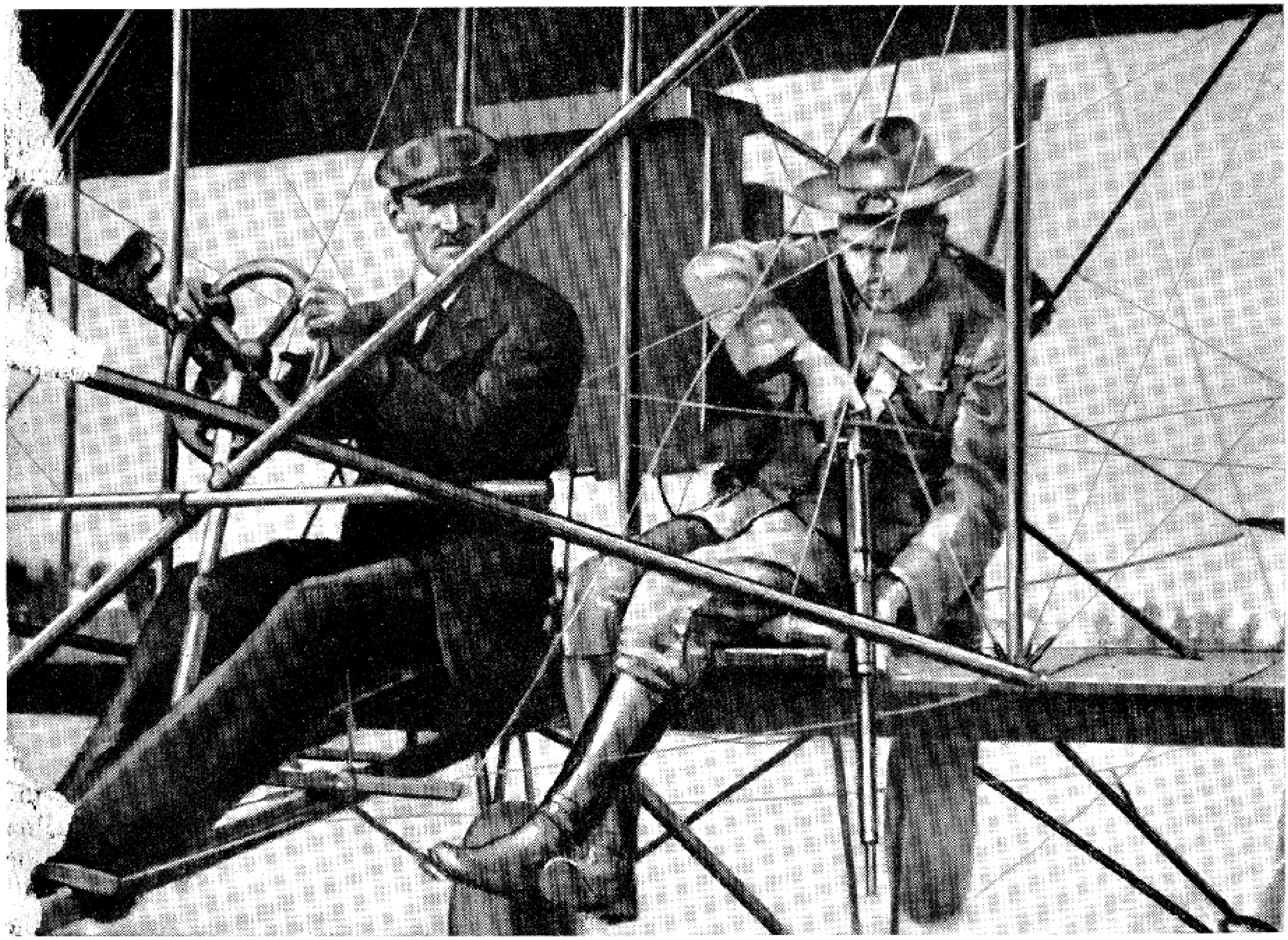
One of the most colorful of these demonstrations, which was to have a far reaching effect, was carried out before a crowd at Sheepshead Bay race track on Long Island, N. Y. in August 1910. A pusher plane piloted by Glenn Curtiss, an aviation pioneer second only to the Wrights, also carried 27-year-old Second Lt. Jacob E. Fickel, who had won a reputation as an expert marksman in his 3 years of military service since enlisting as a private.

All afternoon the tense crowd had been watching the antics of the flimsily constructed flying machines. The spectators had been promised an act that had never before been attempted, and they waited patiently as the young soldier climbed aboard carrying with him a regulation caliber .30 Springfield infantry rifle.

Lieutenant Fickel's intention was to fire the first shot from an airplane in flight at a target on the ground. Because of his proved marksmanship he was chosen to perform in the opening act of a drama the final outcome of which no one can even imagine.

With Curtiss at the controls and Fickel clutching the rifle with one hand and a wing strut with the other, the plane took off. After gaining an altitude of 300 feet it circled the target that had been erected in the center field of the race track. Four times the young officer, when he was not clinging for dear life, took aim and fired. Two of his four shots were bull's-eyes. The startled crowd roared its admiration of his skill and at the same time must have sensed the beginning of things certain to follow.

At the time just to keep a machine air-borne was a feat in itself, but to possess also the power to bring an adversary to earth stimulated the imagination, and the press made the most of it. Soldiers were pictured being transported by



The First Shot Fired from an Airplane. Glenn Curtiss, Pilot, and 2nd Lt. Jacob E. Fickel Holding the Rifle.

planes or silent gliders and noiseless invisible wars were predicted by the use of smokeless powder and rifle-muffling devices. The impact on the public was terrific, but military minds remained skeptical. They mustered mathematical calculations to prove that nothing but a rifle could be fired from a plane, one shot at a time, and under certain conditions only since successive and rapid explosions would upset the plane. And under no conditions could any great weight be dropped in flight since its sudden release would be certain to make the plane fall out of control.

The development of speedy aircraft was also discounted by the "experts" as being wholly unnecessary as far as their use for war was concerned. Those who expressed the possibility of equipping airplanes with two motors were laughed at loudly. A principle of aerodynamics was claimed that, if two engines were mounted, one would exert a mere fraction of its power due to its proximity to the other. It was happily concluded that no single engine could possibly lift the additional one, and that, in case such an impossibility was accomplished, failure of one motor would force the plane into a power-driven spin. But these theories and calculations soon went the way of most expert advice from people who have been educated beyond their own capacity for intelligence.

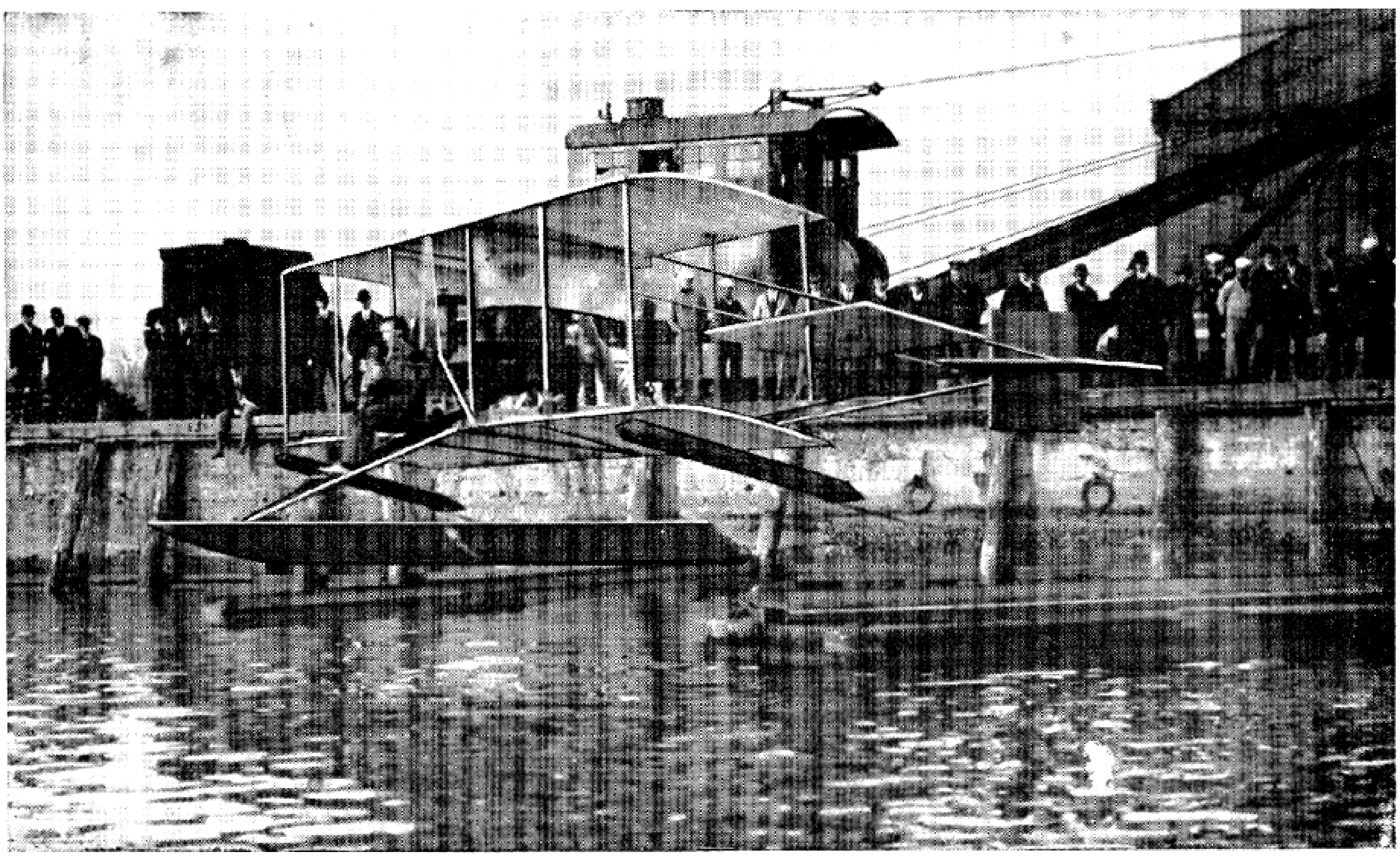
On 14 November 1910, a Curtiss plane piloted by Lt. Eugene Ely took off from the United States cruiser *Birmingham* and on 18 January 1911, another Curtiss plane, also piloted by Lieutenant Ely, landed on the quarter deck of the armored cruiser *Pennsylvania,* anchored in San Francisco Bay. A crude arresting gear, with hooks fastened on the under carriage of the plane and an ingenious arrangement of ropes attached to sand bags stretched across the wooden deck, brought the machine to a stop within 30 feet after landing. A half hour later the pilot raced his machine down the boarded landing strip and became air-borne before reaching the edge of the deck.

This was the first step to adapt aircraft to naval use. A week later, on 26 January 1911, Glenn Curtiss, after one unsuccessful attempt to make a hydroplane out of his machine, the "June Bug," put floats under another plane and took off after a short run. A Frenchman, Henri Fabre, on 28 March 1910, had previously arisen from the water and flown about 1,000 feet but was completely wrecked in trying to land. Curtiss made the first successful take off and landing.

On 17 February 1911, Curtiss made another advance in naval aviation, for on that date he flew his pontoon-equipped aircraft alongside the *Pennsylvania* in the harbor at San Diego, Calif., and was hoisted aboard with the ship's crane. After a short stay aboard the vessel, the machine was lifted over the side and Curtiss flew it back to its hangar on North Island. The system of hoisting a seaplane on board and putting it over the side with a crane is still followed by British battleships and cruisers.

While development in land planes was unquestionably greater in several other nations, the American Navy was making her bid for world supremacy in naval aviation. An aeronautical school was established on the academy grounds at Annapolis, Md. The study of getting an aircraft into flight from a battleship's deck was the first major problem taken up at the school.

It was the opinion of United States naval architects that a more practical method of launching an aircraft than putting it over the side was needed if the airplane itself was to play a dominant role in future wars. The daily papers, approximately 18 months after Curtiss made his novel experiment, announced the successful test of a launcher for catapulting planes from the deck of a ship. The device was constructed at the Navy Yard, Washington, D. C., and a successful trial was held there on 12 November 1912. Naval authorities announced through the



The Successful Trial of the Chamblis Catapult at the Washington Navy Yard, 12 November 1912.

press that the device would make possible the use of older and outmoded ships as floating hangars and launching platforms. Planes from these vessels could be used profitably in conjunction with the main fighting units of the fleet for scouting and spotting work.

Navy mathematicians also brought out the startling information that if an aircraft so used could maintain a speed of 47.4 miles per hour it was absolutely safe from enemy antiaircraft fire. Such phenomenal speed would at the same time render the craft useless for anything other than close observation work. No rifleman in the aircraft, they said, could possibly hit anything from an object moving at such a rate, and, as they further pointed out, any sudden release of a heavy object would be certain to upset the plane. Dropping a bomb was thus out of the question, and as there was no possibility of damaging a battleship, the airplane in warfare seemed to qualify only as a harmless nuisance.

The Italians were the first to destroy the myth that heavy bombs could not be dropped. During the Italian-Turkish War of 1911, they not only used heavier-than-air ships initially in actual warfare between major powers, but also were the first to drop bombs on an enemy. Previously, Lt. Myron S. Crissy, United States Army, in January 1911, had dropped a small bomb in San Francisco Bay, and gained the distinction of dropping the first such projectile from the air. His pilot was a civilian, P. O. Parmalee.

Italy had already made secret tests to determine the effect on airplanes of releasing heavy objects while in flight. Capt. Alessandro Guidoni of the Royal Italian Navy, considered in his country a leading authority on aerodynamics, was in charge. The plane used was an English-built Farman capable of lifting torpedoes weighing 700 pounds. Captain Guidoni became so efficient in this type of launching that he is recorded as making 9 direct hits out of 10 tries on a target a mile and a half distant. He exploded the accepted theory that a plane is upset by the sudden release of a heavy object in describing his plane's reaction during the successful torpedo droppings.

"When the motion forward is uniform, there is a dynamic equilibrium betwen the different forces. As soon as the launching has taken place, two resultants will act upon the plane, one vertical due to the difference between the lift and the weight and one horizontal due to the difference between the thrust and head resistance.

"Owing to these two forces the plane acquires two corresponding accelerations until the dynamic equilibrium is regained, the vertical acceleration giving a rising motion to the machine. Thus there always exists an equilibrium between the applied force when the forces of inertia and the resistance meet in the ascending motion."

The Italians first put this information into application by dropping sizable bombs on the Turks. The damage was slight because of the fact that no sight other than the aviator's guess was employed in putting the bombs on the target. The event contributed nothing other than a glimpse of the kind of warfare that was to follow.

The year 1912 in the United States found our Army interested in establishing aviation in the Phillippines. Lt. Frank P. Lahm, with a single Wright plane, was sent to the islands for the purpose of establishing a flying school. This was again followed by a lack of congressional appropriations and even such meager plans were prevented from being put into effect. What a few years before promised to be the nucleus of an air force had by now practically ceased to exist.

Finally on 24 August 1912, Congress did appropriate $100,000 for the purchase, maintenance, and operation of Army aircraft. Twelve planes were contracted for in that year, and Maj. Samuel Reber was put in charge of the so-called Aeronautics Division. The appointment came close to being an empty honor. When an inventory was taken nearly a year later in June 1913, it showed the exact distribution of machines and pilots to be: Texas City, Tex., 11 pilots, 6 training machines and 4 suitable for military use; North Island, San Diego, Calif., 5 pilots, 1 training plane, and 1 military plane; Phillippine Islands, 1 pilot, 1 training plane and no plane suitable for military use. The general equipment of this handful of aviators consisted of the barest necessities, as the allowance made by Congress was too slight to afford more than the most necessary spare parts, with a few tents to house both matériel and men.

The next fiscal year's appropriation was scarcely better, being only $125,000. This made it impossible to acquire the motor trucks, repair shops, extra motors, and other equipment considered absolutely vital.

With so little money the Signal Corps was unable to extend the aviation branch beyond a mere hand-to-mouth existence. Progress in this branch of the service naturally ceased, although it was able to muster two machines and five pilots for the war maneuvers held in Connecticut beginning 24 August 1912. This represented the first official use of aircraft on United States Army maneuvers. The pilots were Capt. F. B. Hennessy, and Lts. B. D. Foulois, Harold Geiger, T. DeWitt Milling, and Harry Graham.

Lieutenants Milling and Geiger barely averted a serious accident when their plane was slow to get airborne after take-off with the wind, and missed a head-on collision with a stone wall by inches. An alert Signal Corps cameraman recorded the incident for posterity. An investigation later proved the near accident was due to the manner in which Army engineers had built the field. The only way pilots could take off was to the north, since the south end came to an abrupt end flush with a forest of tall trees. Unfortunately the prevailing winds were such as to be always behind the craft. The Army learned from this experience that air fields had to be constructed with the winds taken into consideration.

The British Admiralty, which must have known about the successful dropping of aerial torpedoes by Italy, did not accept completely the American Navy's theory that the battleship could not be harmed by the airplane. In order to come to a definite conclusion, the British built at Hendon, England, a mock battleship and then bombed it with exact duplicates of the Italian high explosive and incendiary bombs. The latter did the most damage to the dummy vessel. The report on the incident shows more than anything else the size and over-all damage potentialities of the bombs.

"The harm done by bombs dropped from airplanes on battleships is still little more than a theory. There are some who think the battleship still adequately protected from aerial bombs, but we must not take for granted that aerial bombs will never be made heavier than 10 or 15 pounds, and an airplane will never be able to drop a weight heavy enough to harm a battleship without losing its control. Actual experiments have shown that such a weight up to 175 pounds can be dropped without the plane being thrown out of control, and, needless to say, a bomb or a similar load of explosives from 26 to 100 pounds can do harm to the most heavily armored battleship."

A Curtiss Airplane, the First to Accompany the Army in Maneuvers, Clearing a Stone Wall.

This report showed for one thing that the British, aware of both the Italian weight dropping and the contradictory theory of the Americans, were still as confused at the end of the experiment as they were at its beginning.

College Park, Md., had become the United States Army's chief aeronautical experiment station. When the possibility of bombing became an accepted fact, it was approached from the typical American viewpoint. What good was the dropping of high explosives unless they could be placed where they would do the desired damage? First Lt. R. E. Scott, U. S. Coast Artillery, was ingenious enough to find a workable solution to the problem. For he originated a device that could be aimed at the target. It made a simple computation whereby speed, drift, and time of fall were calculated and the world's first practical bombsight came into being. What is now known as the timing-sight principle was used.

As early as October 1911, Scott made experimental bomb droppings from an airplane at College Park, piloted by Lt. T. DeWitt Milling. Scott simplified the problem of air bombing by combining a gunner's quadrant, a telescope, and a stop watch. With this device he could determine ground speed quickly and with the known altitude, transpose from a set of tables the proper angle at which to aim the telescope. The bomb was released when the target appeared in the sight and reasonable accuracy was assured.

The telescope was mounted on gimbals and could be pivoted along the graduated arc from vertical to a horizontal position. To operate the bombsight, Scott, when approaching the target at a known altitude, read from a barometer, would first find his ground speed. He did this by setting the telescope at 45° and sighting an object. The telescope was then swung to the vertical position and the stop watch clocked the time interval necessary for the object to reappear. With this information he would read from a chart the proper angular setting of the telescope to hit the target. When the target then passed in view, the bomb was released.

From the experience of hundreds of drops, Scott made himself a set of prepared tables that took in practically every speed and height that were commonly used and accepted in bombing tests. The most difficult was the obtaining of accurate data from which he could compute the angular table for determining the exact instant of drop.

Following these experiments, Army aviators who witnessed them agreed that the device was a complete success, and that only target practice was needed. It was also decided that the pilot's skill would play no small part in the successful hitting of targets and that a reasonable degree of accuracy could be obtained from altitudes exceeding 3,000 feet. Below this height it was not thought that an airplane would be sufficiently immune from hostile fire to warrant its use.

When this practical sighting system had been developed, the Army found that further trials were not possible on its small appropriations and all experiments were ordered discontinued. Scott, being very disappointed at this turn of events, carried his sight abroad where it aroused great interest. He entered the Michelin competition held in France, which offered as much as $30,000 in prizes for the best bomb drop on a target 20 meters in diameter at various altitudes from 200 to 1,000 meters. Scott won first prize at the 200-meters altitude by placing his bomb within 1½ meters of the target center. He hit in the target at every height up to 1,000 meters.

Scott was faced with the decision many other American inventors before him were forced to consider. He realized that inducements abroad were such as to preclude wasting his time on further developments of a device that was not wanted at home. Patriotism alone could not contribute sufficient material inducement for staying in the service of his own government and he reluctantly resigned his commission to exploit his invention overseas.

The Navy at its aviation station at Annapolis also made a great contribution to flying at this time. On 26 July 1912, the first wireless message ever sent from an aircraft was transmitted from a hydroplane to the United States torpedo boat *Stringham*. The message, radiocast by Ensign Charles Hamilton Maddox from a height of 300 feet and a distance of 1 mile, consisted of, "We are off the water, going ahead full speed on course for Naval Academy."

The entire apparatus was designed by Maddox and had many new improvements over previous unsuccessful experiments. Besides making it much lighter, a few other features were added that included a new type of aerial and a shielding device that overcame the noise of the engine. The achievement was truly remarkable as the lifting capacity of hydroplanes was so limited it was thought to be impossible to design a light enough sending set capable of transmission.

This weight factor was so critical that the Army was searching for a substitute for radio, then being used universally on land. The efforts to develop another means of aircraft communication resulted in consideration and testing of a device that today can hardly be taken seriously.

This gadget was known as the Means Smoke Telegraph System. The signal apparatus, fastened on the leading edge on the upper wing of the plane, was first tried out at Signal Corps Aviation Field in College Park. A trigger arrangement was located beside the pilot who could control the length of time for opening a valve that allowed dense smoke to be expelled. The aviator could then fly along puffing out dots and dashes, a long puff for the dash and a ball of smoke for the dot. Much publicity was given the contrivance by the promoter and even the conservative *Literary Digest* predicted that bulky wireless instruments, and perhaps even the conventional telegraph, were doomed by this clever machine.

It may be true that the Army's test of the Means smoke telegraph today has a humorous angle, but most certainly the next experiment successfully carried out by the Army at its College Park flying field has proved anything but funny. From the day of its conception it has presented to every nation on earth one of the most serious problems to confront it. For the combination of machine-gun fire with mobility of aircraft then made its first appearance.

Chapter 2

LEWIS AIRCRAFT MACHINE GUN

The First Aerial Machine Gun

A week after the world was saddened by news of Wilbur Wright's death from typhoid fever on Memorial Day, 1912, an event concerning aviation took place on 7 June 1912, that would in time directly affect mankind far more than did the pioneer flight at Kitty Hawk. For on this day, Capt. Charles DeForest Chandler successfully fired a full automatic weapon from an aircraft in flight for the first time in aviation history.

The experiment was carried out unofficially. Lt. Col. Isaac N. Lewis, Coast Artillery, United States Army, had devised a weapon for the Automatic Arms Co. of Buffalo, N. Y. Feeling it was a most progressive step in machine-gun construction, he visualized its use in the most promising development of the day, the flying machine. With this in mind and knowing that success of his experiment would guarantee endless favorable publicity, he arrived at College Park with no introduction other than his rank. The suggestion that the weapon be air fired as an incentive both to aviation and machine-gun development was placed before Captain Chandler, the commanding officer at College Park. The latter not only granted the request but offered to fire it personally.

This early model of the Lewis air-cooled automatic machine gun weighed 25 pounds, 6 ounces, and was chambered for the caliber .30/06 United States Army infantry rifle cartridge. The ammunition was contained in a circular drum that slipped over a post on top of the receiver. The rate of fire of the weapon was given as well above 750 rounds per minute. For this trial, however, it was slowed down by putting unusual tension on the return spring. Lewis thought the best rate for the occasion to be 500 shots a minute, allowing the gunner to empty the drum in 6 seconds. The gun had no sighting arrangement other than looking along the top of the unusually large aluminum barrel jacket.

Chandler, after being shown by Lewis how to operate the weapon and being made familiar with the kick and amount of jump when operating it full automatic, took his place in the Type

Lt. Col. Isaac N. Lewis, U. S. A.

B Wright pusher plane with the muzzle of the gun resting on the cross bar upon which pilot and observer placed their feet. It had been agreed that the firing was to take place a short distance in front of the hangar. In the interest of safety a decision was made to fly at a low altitude.

A target, consisting of a piece of cheesecloth 6 by 7 feet in size, was laid on the ground. Lewis calculated that the plane would travel over the length of the target in one-tenth of a second. Lt. T. DeWitt Milling, who was piloting the plane, made three approaches at an altitude of 250 feet. Each time a short burst was fired. Examination showed five hits on the target and several bullet holes directly in front of the cheesecloth. Chandler could not see where the bullets were hitting on the ground and when circling over some adjacent fish ponds, he fired the remainder of the drum into the water to observe the spacing of the bullets by the splashes.

This unscheduled burst caused the colonel much concern. Thinking that Chandler may have fired the weapon accidentally, he asked the observers to take cover in the hangars as a precautionary measure. He concluded that if the trigger had been pulled once accidentally, it might be done again. Later Lewis was much relieved by the captain's explanation for firing into the pond.

Realizing they had contributed to aviation history, they jubilantly planned another trial the following day. This time a target 2 yards wide and 18 yards in length was used, and again the 2 officers, Chandler and Milling, took off. From experience gained the day before, they decided to raise the altitude to 550 feet. Even at the increased height, 14 shots out of 44 fired hit the target, and the remainder of the bullets left holes in the ground close by. As the limited space allowed the gunner practically no traverse, accuracy depended much on steering the machine steadily over the target.

For once the newspapers were caught by surprise and although the firing was done almost within sight of the Nation's capitol, the news did not reach the public until the following day. Had it not been for an enthusiastic amateur photographer named MacCartee, who journeyed to College Park and asked Captain Chandler to pose with the gun in the plane, no picture of the event would be in existence today. At the time, Lieutenant Milling was away on duty and Lieutenant Kirkland had to "stand in" as the pilot when the picture was being made.

Newspapers and magazines everywhere carried the picture and much was written about the future of aircraft in warfare. The experiment proved that sustained fire would not upset a plane's balance, as the experts had accepted as a certainty. In accordance with a customary journalistic privilege, reporters assigned to the War Department used the incident to interview a spokesman of the General Staff. They came away with a very clear understanding from the high command that aircraft were suitable for scouting only. Any dream of aerial conflict was simply the product of a too fertile imagination, a failing often found in younger men with insufficient service to recognize certain things as utterly absurd. Besides the experiment had been run without official sanction, which, as far as the military authorities were concerned, left it in the category of having never happened.

There is no desire at this point to take advantage of the hindsight that the passage of time affords. The limited flying and erratic performance of aircraft in the United States had impressed officials only with their possibilities for scouting and message carrying. On the other hand, officers, mentally capable of mastering the problems of staying aloft with their intricate machines, were also the type who had not only vision but the means of extending it to reality. Even so, it was extremely doubtful if a single officer at College Park at the time could foresee the mighty surge of aircraft armament development that was to occur in the next 5 years, particularly in Europe where war was only months away.

If the high military authorities had any idea of dampening Lewis's enthusiasm for the potential uses of his machine gun in aircraft, they certainly overlooked his reputation. The colonel was a man who did not discourage easily. When dedicating himself to a purpose, he was no respecter of person, rank, or position in life, and he had already acquired the title, "the stormy petrel of the service." Having been a successful inventor throughout his military career, he had the utmost contempt for those who could not see the

Captain Chandler, the First Man to Fire a Machine Gun from the Air, with Lt. Kirkland, His Pilot, at College Park, Maryland.

obvious possibilities of anything that had required so much of his time and labor to conceive and construct.

Early Development of the Lewis Gun

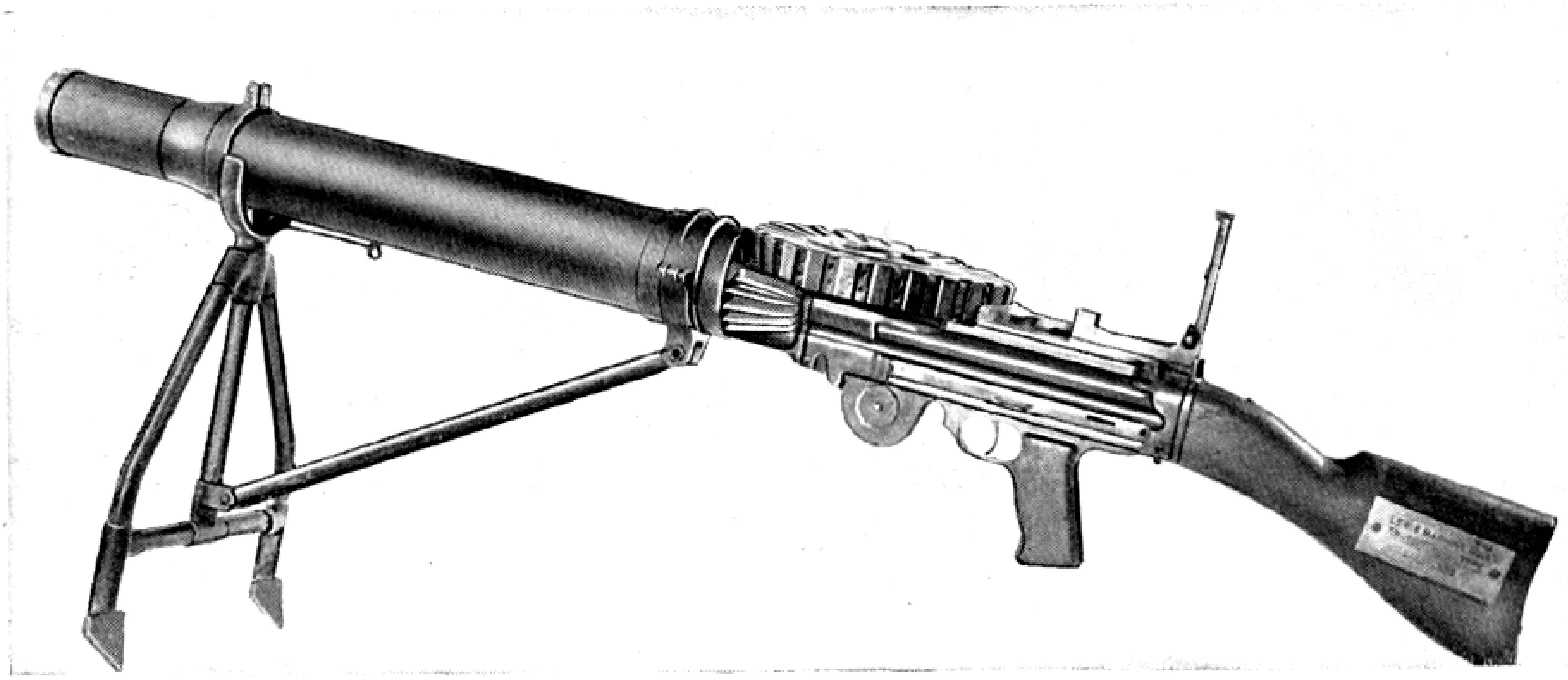
Isaac Newton Lewis was born at New Salem, Pa., on 12 October 1858, and was taken west by his parents while he was still a child. He was appointed to the United States Military Academy from Kansas in 1880 when 21 years of age. He graduated eleventh in a class of 37 in 1884, and was commissioned a second lieutenant in the Coast Artillery. From 1894 to 1898 he was a member of the board on regulation of Coast Artillery fire in New York Harbor. In 1898 he became recorder of the Board of Ordnance and Fortification of Washington, D. C., and the following year made a study of weapons in Europe. This led to the reorganization and rearmament of our field artillery. He later invented a number of rangefinders and mechanical and electric instruments used for controlling artillery fire. From 1904 to 1911 he was instructor and director of the Coast Artillery School at Fortress Monroe, Va., and rose to the rank of lieutenant colonel.

In the early part of 1910 Lewis was approached by officials of the Automatic Arms Co., Buffalo, N. Y., in relation to assigning him substantial stock in the company if he would produce a machine gun based either on patents they already owned or on anything he cared to originate. He agreed to the proposal and joined the firm. This business union resulted in his devising an air-cooled machine gun. In 1911 when the prototype reached a stage he felt was advanced enough to be exhibited, he brought a handmade model to Washington, D. C., and showed it to Maj. Gen. Leonard Wood, then Army Chief of Staff.

A short time later Lewis made four more guns patterned after the prototype he had shown the Army Chief of Staff. These weapons were also presented in person to the Secretary of War and other high ranking Army officers. He fired them many times before these dignitaries on the Fort Myer rifle range and, while in no ways was it an official test, many were distinctly impressed. The guns were chambered for the standard United States infantry rifle cartridge caliber .30/06.

After the College Park demonstration of aerial firing, the weapons were formally presented to the Board of Ordnance and Fortifications for consideration. When no definite decision was reached by the Board, Lewis became annoyed by what he called "a strictly negative attitude," and like practically all successful machine-gun inventors before him, he turned to Europe for a ready market and appreciation of his effort. He asked for leave of absence and in January 1913 sailed to Liége, Belgium, taking with him the four guns manufactured originally for testing by the United States Army.

These weapons were exhibited in various countries in Europe and resulted in the forma-



Lewis Machine Gun, Cal. .303, British.

tion in Liége of a company known as the "Armes Automatiques Lewis." While manufacture was originally centered at Liége, the whole program was later removed to the British Small Arms Co., of Birmingham, England, which at the time was the world's largest producer of small arms. Its officials, after having seen the demonstration of the Lewis gun and the enthusiasm of the generally conservative British officers, immediately offered to erect necessary buildings and take over large-scale fabrication of the weapons. The proposal was agreeable to the president and stockholders of the Automatic Arms Co., who did everything possible to help the English company to attain mass production of the lightweight automatic weapon.

Just as Maxim was the first to introduce the full automatic gun, so Lewis was the father of the lightweight automatic machine gun. Its weight and self-contained feed system holding 47 or 96 cartridges without use of links or belting made it possible for one man to represent the threat formerly offered by a three- or four-man machine-gun crew.

Without detracting from the skill Colonel Lewis showed in assembling one of the lightest and most reliable firing mechanisms ever devised, it must be remembered that the basic operating principles were already the property of the Automatic Arms Co. before Lewis became a member of the firm in late 1910. At the time of the firm's organization Samuel Neal McClean assigned to it all patent rights to his machine gun, better known as the McClean-Lissak automatic rifle. The producers of the weapon made several unsuccessful attempts to interest the Government in it but McClean, like many other inventors, could not leave well enough alone. Having the basic principles for a reliable automatic machine gun, he added various other gadgets until the assembly was so overburdened it lost practically all value as a compact and efficient military weapon.

Lewis deserves full credit for concentrating on the problem at hand and refining the original idea down to the barest necessities that would permit reliable operation, especially for lengthy bursts. The McClean gun was originally made to use both water and air cooling and to be tripod mounted. The gun could also be detached for shoulder firing. This intended all-purpose weapon, as is usually the case, was too bulky for any specified purpose.

Lewis's own originality and inventive ability were displayed when he overcame obstacles in the difficult task of improvement. His solutions to the various problems were patented and assigned to the Automatic Arms Co. Among the most notable innovations were the cooling jacket, the clock-type spring and the rate-of-fire regulator. The finished weapon is rightfully called the Lewis gun, as the colonel redesigned, assembled, refined, and, in some features, created an automatic machine gun that soon became the most discussed instrument of war of its day.

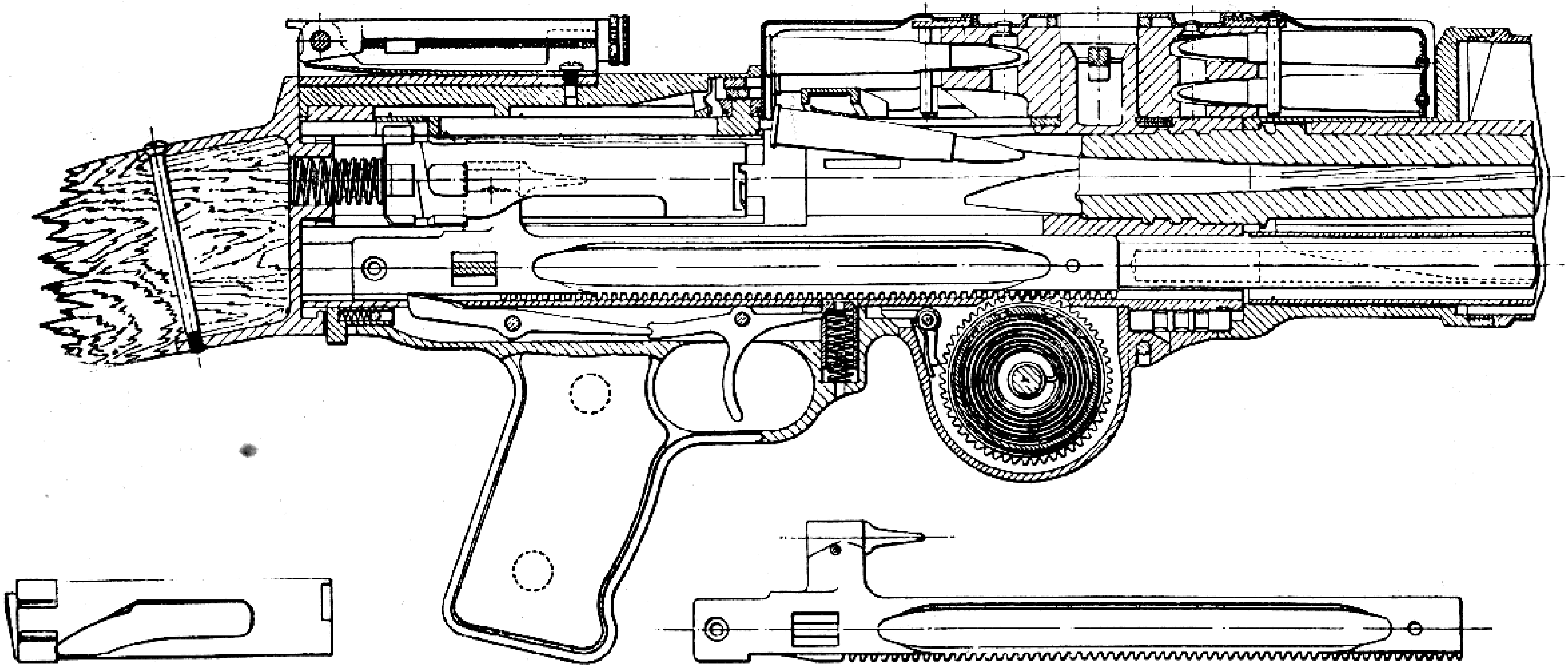
After 25 years of active duty in the Coast Artillery, Lewis retired in order to be able to devote his entire time to further improvement and promotion of his gun. When he left, he held the rank of colonel.

The Lewis Gun in World War I

A Serbian student named Princip, armed with an American-designed auto-loading pistol, on 28 June 1914, assassinated Archduke Francis Ferdinand of Austria to start what might well be called the First Great Machine Gun War. The automatic weapon had heretofore been employed only in minor conflicts, which had served to show its potentialities. In the 1914–18 war it was estimated that 92 percent of all casualties were inflicted with this highly lethal type of weapon.

After the declaration of war, the entire capacity of the Birmingham Small Arms Co. was turned over to the production of Lewis guns. It was estimated by the manufacturers that six Lewis guns could be made to one Maxim-Vickers. Lewis must be credited with knowing the value of being able to produce a weapon quickly in an emergency. To this end he worked diligently, simplifying all components that required skill above normal to fabricate.

The demand of the British and Belgians for Lewis guns was so great that their factories could not begin to keep pace with the use, and the Savage Arms Corp., of Utica, N. Y., was contracted with to make the weapons in the United States. The Savage Co. was organized in 1894 to manufacture a hammerless repeating high-power



Section Drawing of Lewis Machine Gun.

rifle invented by Arthur Savage, a rifle designer far in advance of his time. By 1915 it was manufacturing, in addition to high-power rifles and ammunition, several .22 caliber rifles and an automatic pistol. In that year the corporation was merged with the Driggs-Seabury Ordnance Co., which held a number of basic patents on automatic arms.

In 2 years, this plant reached an output of 400 Lewis guns per week. After production was well under way and thousands had been delivered, the Lewis was adopted by the British as its first-line light machine gun. By that time all modifications were established and the weapon was made without any basic changes throughout the war.

The action of the weapon is quite simple. The locking of the breech depends upon the semi-circular movement of locking lugs at the rear of a rotating bolt, a principle first used by the Mannlicher straight-pull rifle and later by the Schmidt-Rubin. The striker is located on a post fixed at the rear of the gas piston and reciprocates in a helical slot cut in the bolt body.

When the piston is engaged by a sear, the bolt is held retracted in what is known as the cocked bolt position. Upon its release by pulling rearward on the trigger, the piston and bolt are driven forward by the stored energy of the clock-type return spring. The face of the bolt shoves the already indexed cartridge ahead of it into the chamber.

At this point the striker post is held securely in a recess at the rear of the bolt slot, with its left side bearing against an inner portion of the curved part of the slot. The locking lugs on the bolt engage with the guide grooves on the action body and prevent the bolt from being rotated until such time as the lugs are opposite their locking recesses. The continued forward motion of the striker post along the curved portion of its slot rotates the bolt body and lugs in their recesses, while the striker continues on along a straight path in the slot until its point smashes into the primer of the chambered cartridge.

The barrel, bolt, and piston are all securely locked until the bullet has passed an orifice in the barrel at which point gas is bled into a cylinder and force brought to bear on the head of the gas piston. By the time the action begins a rearward movement, the bullet has safely cleared the bore and the gas piston is then suddenly thrust back with great force.

This movement of the piston withdraws the striker and next the rotation of the bolt unlocks the action. The extractor holding to the base of the cartridge then withdraws it from the chamber and a pivoting ejector knocks the empty case to the ground. The continued action rearward of the gas piston actuates the circular drum type feeder, by means of a lug, causing it to rotate a fraction of a revolution and index the incoming round in position to be picked up by the bolt for chambering.

Some of the distinctive features of the weapon are the positive safeguard against firing until the bolt is securely locked, and the design of the return spring mechanism. The latter consists of a clock-type spring mounted inside a pinion which engages a rack on the under side of the gas piston. The entire spring mechanism is mounted in a casing on the pistol grip unit. The advantages of this simple and ingenious arrangement are many. The easily accessible spring is located out of the way of the reciprocating parts. It is practically impossible to get dirt and other foreign matter into its housing. The whole unit can be removed in a matter of seconds along with the trigger assembly, also located on the pistol grip. Any desired amount of tension can be attained without stopping the gun, as the clocklike spring can be wound externally until the desired result is reached. This permits to a limited degree the control of rate of fire. The trigger assembly also has a very simple design with very low inertia. An unusual feature is that no provision is made for firing single shots, the weapon being designed for full automatic only.

Another radical departure from conventional machine-gun design is the unique feed system. Although Maxim in 1889 successfully used such a cartridge container and the American Government likewise had tested the Carr gun with a similar flat rotating drum feed, it remained for Lewis to lighten it by practical design. By using a reasonable cartridge content of 47 for ground use and 96 for air, both weight and profile are held to a minimum. The Carr drum held as many

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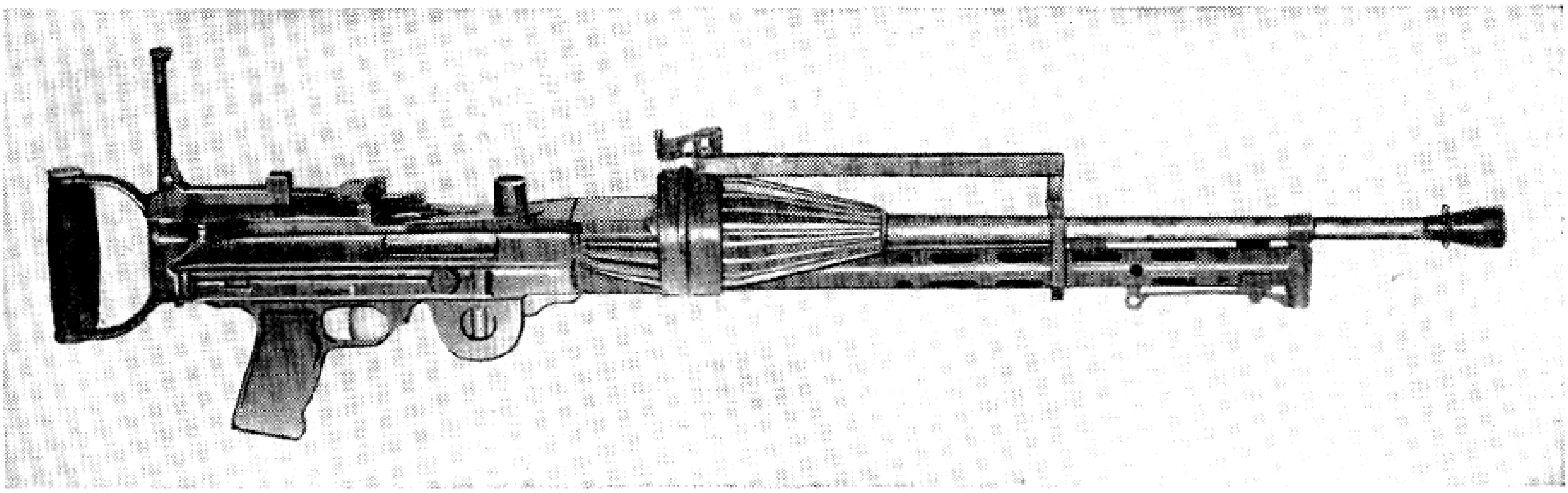

Lewis Aircraft Machine Gun, Model 1914, Cal. .303, British.

as 305 rounds, which made the gun too clumsy and breech heavy to be handled without tripod.

The standard Lewis drum holds 47 rounds in two circular rows and is fastened horizontally by a clip to a top post located to the rear in line with the chamber. During operation the drum is rotated counterclockwise by a ratchet pawl working off the reciprocating piston body. It can be exchanged in a few seconds, in fact so fast that only a slight pause in a long burst is apparent, since belt or links are not required and firing is generally interrupted anyway after 50 shots. This is one of the weapon's many desirable features for military service.

The British made a slight change in the gun by using a closer-fitting metal tube of aluminum in place of the conventional radiator in order to lighten the weapon for aircraft use. This model was employed in the first aerial firing of a machine gun in England. (A similar exhibition, made by Belgian pilots with the Lewis gun at the Brasschaet Military Aeronautics Grounds in Belgium in December 1912, was the first official demonstration of its kind in Europe.) The British plane, a Graham White biplane, was piloted by Marcus D. Manton, a civilian, and the demonstration took place above the Bisley airfield on 27 November 1913. A machine gunner, from an improvised platform located between the pilot and the landing gear, fired repeated bursts with the Lewis machine gun at targets on the ground and despite his precarious position scored a substantial number of hits.

Although the above test was made a full 10 months before the start of World War I, the only British aircraft equipped with machine guns at the outbreak of hostilities were two seaplanes of the Royal Navy Air Service, and even then they were not permanently mounted. All planes sent to France by the Royal Flying Corps were unarmed when the first British pilots crossed the channel on 13 August 1914. Aircraft at the time were constructed far too lightly to carry very heavy armament. The planes were regarded as of value only for scouting and observation work, without being suitable for inflicting damage on the enemy. Aerial warfare was as yet unknown, although sometimes a pilot took with him a rifle, revolver or a few hand grenades, with which to answer the derisive and obscene gestures usually tendered at such an encounter.

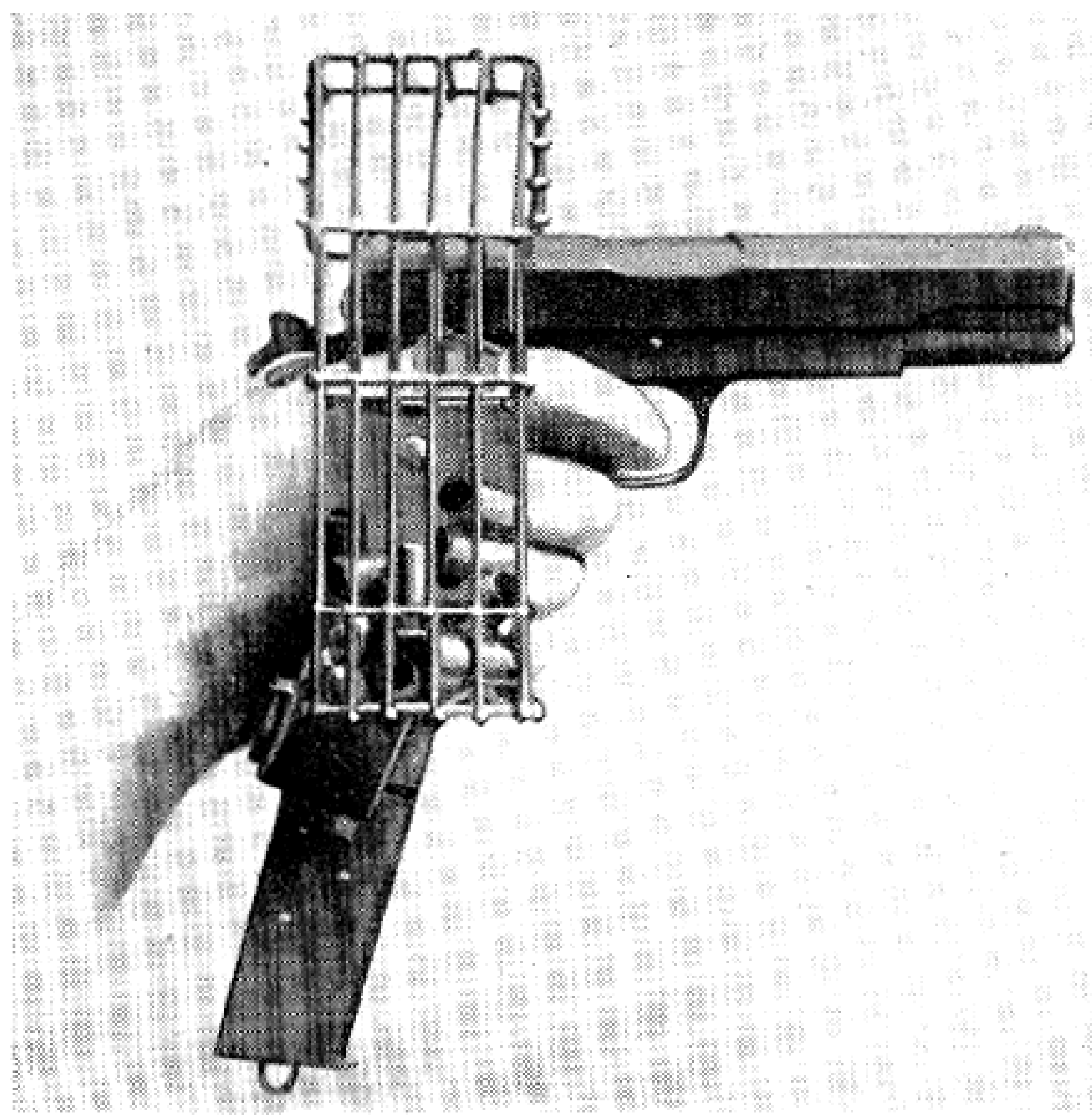
German observers, besides carrying standard military bolt-action rifles, sometimes found it convenient to be provided with a self-loading arm. The most popular one was the highly advanced gas-operated Mondragon, the invention of a Mexican officer, Manuel Mondragon, patented on 8 August 1904, and adopted by his country's army in 1911. It was manufactured in Switzerland by the Schweizerische Industriel Gesellschaft at Neuhausen on the German border. At the beginning of World War I, all production was diverted to Germany. Large numbers of specially designed magazines holding 30 cartridges each were made up and issued to the observers. They remained in use only until the mounting of flexible full automatic guns.

On 22 August 1914, two young British pilots, Lts. L. A. Strange and Penn Gaskell, helped to make aviation history. These two officers, acting on their own initiative, placed a Lewis gun aboard their aircraft and took off looking for the enemy. In a very short time, at an altitude of 5,000 feet, a German Albatross was seen approaching. Using every known means of coaxing their aircraft along, the aviators could not get closer than an estimated 1,000 yards. Seeing that they were being outdistanced, Gaskell took aim with his Lewis gun and fired an entire drum at the German plane. The pilot and observer of the German aircraft flew on unharmed and perhaps never knew they were the party of the second part in another of aviation's historical events. For this was the first record of a machine gun being fired at an enemy in the air.

After returning to their home field the officers recorded their initial attempt in a full report of the incident. They stated that, although they did not inflict any visible damage to the enemy, there was every reason to believe that machine guns could easily replace the rifles, bricks, pistols, etc., then carried by practically all pilots on both sides.

Strange and Gaskell were in for a rude awakening if they thought progress would come from their dramatic effort. The report resulted in an order by the High Command prohibiting the use of machine guns in aircraft. Such a practice would only cause the pilot to seek out other enemy planes to try out this newfangled idea, thereby diverting his attention from watching troop movements and spotting artillery fire. The latter, it was pointed out, was the primary duty of the pilot and observer and the excuse for the aircraft's existence in warfare. For a brief time this directive stopped such unorthodox practices as far as the British were concerned. Such an attitude is surprising since the British originally became interested in the Lewis gun as a superior aircraft weapon, and England was one of the first European countries to fire a machine gun from the air. It is perhaps logical to assume that the British did not desire to be the first to introduce a type of warfare that could easily have unpredictable consequences.

In any case the order did not stay in effect too long. Before it was rescinded, British aviators had brought down a few German aircraft by plane-to-plane rifle and pistol fire and, in one instance, by a shotgun loaded with buckshot. Only a few days later a machine gun was used by Lts. C. W. Wilson and C. E. C. Rabagliati to



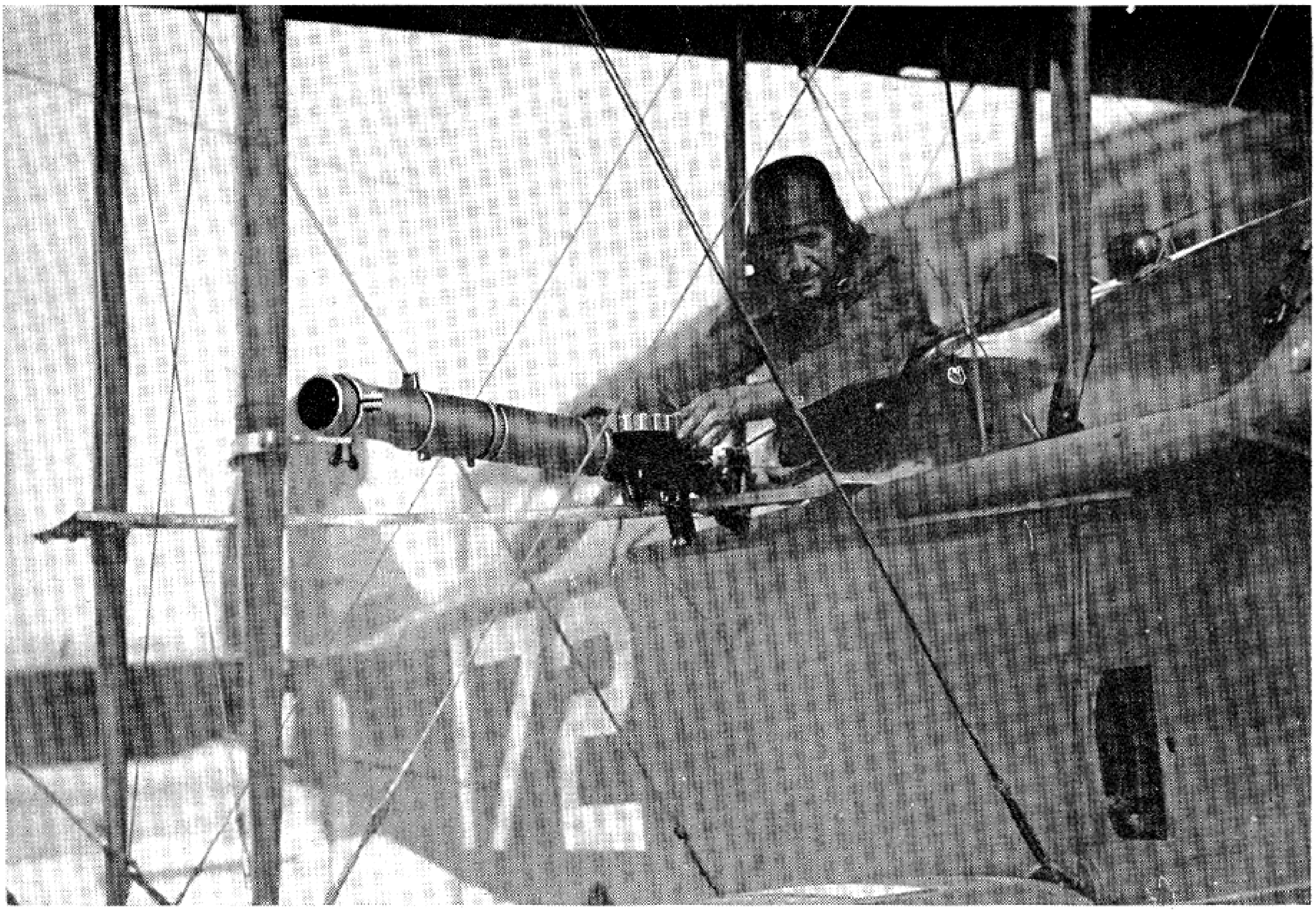
A Cartridge Catcher, Designed to Keep Spent Cartridges from Striking the Airman or his Ship when Firing at the Enemy.

shoot down a German plane at Le Quesnoy behind the British lines. By the end of September 1914 a few British aircraft began to arrive at French flying fields each armed with a single Lewis free gun.

The weapons were mounted to fire only backwards, downwards, and upwards; forward firing was prohibited by the whirling propeller of the tractor-type plane. Because of this factor the pusher plane was given high priority in development for fighting purposes, although the tractor in every other respect was much to be preferred. Soon afterwards Lewis guns were mounted on brackets outside of the propeller arc of tractor planes. The weapon was fired by a mechanical triggering device operated by either the pilot or the observer.

From the start the Lewis gun was considered a superior weapon for use in the air. Dirt and foreign material were precluded from getting in the operating parts, and its extreme lightness made it an ideal free gun. Issuance to the air force of a 96-shot drum in place of the 47-shot one furnished a much needed ammunition reserve and gave British pilots the assurance of the best possible aircraft weapon.

Shortly after the larger drum made its appearance during the Somme offensive of 1916, the



Forward-Firing Lewis Machine Gun Mounted on a Pivoting Bracket so the Magazines Can Be Changed.

stock was removed and spade grips were substituted. This made a better balanced gun and the change was met with enthusiasm by the English flyers. The drum-fed gun, when used on a free mount, could be maneuvered suddenly at any chosen angle without fear that the belt of cartridges would swing loose, as in the case of a belt-fed device.

Lewis, encouraged by the success of his weapon, informed the United States Navy, through Commander J. P. Jackson, on 23 May 1916, that he intended to design an automatic machine gun somewhat similar to the one in current use. The finished product, however, would weigh only half as much and have the general appearance and silhouette of the United States infantry rifle. It would be clip fed and fire full automatic. He pointed out that such an automatic rifle would be invaluable not only for aircraft armament, but also for quick assaults as executed by Marine landing parties, since it gave a small body of men the fire power of many their number. Lewis further stated that, when completed by the use of a device to reduce the kick or recoil, it could be fired full automatic from the shoulder of a comparatively strong man. It seemed also to be his plan to permit the new gun to be fired single shot, as he described it as being as accurate when fired singly as our conventional army rifle. It is not known whether Lewis ever undertook such a weapon. Certainly all evidence seems to indicate he did not.

The great powers fighting Germany used the Lewis gun with such satisfactory results that their leaders, both civilian and military, seemed pressed for words to praise adequately its reliability under battle conditions. Even the Germans complimented its deadly performance by nicknaming it the "Belgian Rattlesnake," because of Belgian tactics in waiting concealed with the Lewis and firing without warning other than the sudden hail of bullets.

The Controversy over the Lewis Gun in America

It is a matter of record that Great Britain, Belgium, and France bestowed many honors on Lewis, together with financial backing in producing his weapon. At the same time a dispute arose between Lewis and this country's Ordnance Department on the merits of the gun. Regardless of who was at fault, no one but the future enemy benefited from it and an appalling state of unpreparedness for machine-gun warfare resulted. While the colonel complained bitterly that his weapon was being considered with a "strictly negative attitude," written reports of the office of the Army's Chief of Ordnance indicate that it was just as upset over inability to get the Automatic Arms Co. to submit one or more weapons for testing. It wished to give the guns fair field and endurance trials in accordance with Army regulations.

A memorandum from the Chief of Ordnance at the time is given verbatim in order to show that a conflict of opinion existed. It should be remembered that well before the report was written, 40,000 Lewis guns had already been battle-tested both on the ground and in the air and acclaimed by their users the "greatest single contribution to the Allied cause." The report of General Crozier, Army Chief of Ordnance, dated 17 June 1916, is as follows:

"1. The Lewis Machine Gun was first offered to the Board of Ordnance and Fortification by a letter dated 2 May 1912, from the Automatic Arms Company, inviting attention to an air-cooled, gas-operated, automatic machine gun, and asking for a field test. Mr. R. M. Calfee, attorney, and Mr. Huberty, machinist of the company, appeared before the Board and exhibited the model of the gun. Arrangements were made for the Board to witness a firing test of the gun at Fort Myer, on May 3. . . .

"2. *The Board, on June 6, 1912,* resumed consideration of the letter dated May 2, 1912, from the Automatic Arms Company, presenting an automatic machine gun and asking for a field test. Members of the Board witnessed a firing exhibition of the gun at Fort Myer, on May 6.

"3. The Board recommended that the Automatic Arms Company be informed that 'the kind of test proposed by them has limitations which the Board does not care to accept, for the reason that the field test proposed usually follows tests made to determine the mechanical suitability of a weapon; but if they will submit a gun for such tests as seem suitable to determine its fitness for the service, it will be subjected to the tests usual for guns of this class under the Ordnance Department, including a field test. Their representatives will be permitted to be present during the tests, and the company will be furnished with a copy of the report.'

"4. *The Board of Ordnance and Fortification,* at a meeting on July 2, 1912, considered a letter dated July 1, 1912, from the Automatic Arms Company, requesting reconsideration of the action in regard to a field test of their gun. The Board recommended that 'the Automatic Arms Company be informed that after careful consideration of their letter the Board is of the opinion that the usual procedure should be followed, namely, the gun must be submitted to a technical test by the Ordnance Department. During this test, the representatives of the company will be permitted to be present and, preliminary to the test, to give such an exhibition of the performance of the gun as they may see fit, in the presence of the representatives of the Ordnance Department charged with the technical examination of the gun. After this demonstration is completed the gun will then be submitted to such tests as the Ordnance Department may deem necessary. Ammunition for such exhibition and tests will be furnished by the Government.

" 'The parties representing the gun may have the privilege of declining to subject it to any portions of the test which may be proposed to which they may not wish to have it subjected at the time, but in respecting their wishes in this regard the report of the test will, of course, state the facts.

" 'In the course of the complete test, the gun will have the kind of field test which they desire, and copies of all reports in regard to the test will be furnished the company.

" ' It is also recommended that the company be informed that the Board has no objection to the gun being fired at Monterey, before the

British Troops with Lewis Guns Resting Between Attacks.

School of Musketry, or at College Park, by the Signal Corps, but such tests will have no weight whatever until the technical tests have demonstrated the structural efficiency of the gun.'

"5. *The Board of Ordnance and Fortification,* at a meeting on March 6, 1913, considered a 'letter dated March 5, 1913, from the Automatic Arms Company, presenting for consideration with a view to its adoption as a type for use in service, their .30-caliber, air-cooled gun, and requesting that the gun be given a thorough competitive test by a board of officers from the several arms of the service engaged in the manufacture and tactical use of machine guns. . . .

" 'It is recommended that the Board of Officers be appointed as requested by the Automatic Arms Company, the Board to carry out a competitive test of all models of machine guns submitted. . . . The Board should also make such tests as will determine the value of the guns for use for war purposes from airships, and the suitability of guns and mounts for use for attacking airships from the ground. . . .'

"6. In the above record, no mention is made of the fact that the gun submitted by the Automatic Arms Company is the 'Lewis Machine Gun.' However, in view of the fact that Mr. Calfee represented the Lewis gun at the test, there can be no question but that the gun referred to in the correspondence with the Automatic Arms Company is the Lewis Machine Gun.

"7. The Board convened for the competitive test of automatic machine guns submitted to it, met at the Springfield Armory on September 15, 1913. The Lewis gun submitted to this Board and tested by it, was one of two model guns manufactured in England (serial numbers 39,153 and 39,930). It is presumed that the guns were manufactured by the Birmingham Small Arms Company, of Birmingham, England, in view of the fact that on July 18, 1913, Mr. Calfee, as Secretary of the Automatic Arms Company, acknowledged receipt of rifle tools and gages shipped to Colonel I. N. Lewis in care of the Birmingham Small Arms Company.

"8. In the 1913 test, seven different makes of automatic machine guns were considered and tried out. The Board consisted of two officers of the Infantry, one of the Cavalry, one of the Field Artillery, and an Ordnance officer. The arsenal test narrowed the competition down to the present service machine gun—the automatic machine rifle, caliber .30, model of 1909, and the Vickers Rifle Caliber Gun, Light Model. It was not desired to adopt a gun on simply an arsenal test, and three additional Vickers guns and four automatic rifles, caliber .30, model of 1909, were submitted to the Board for an extensive field test, which was held at Texas City and Leon Springs, Texas. As a result of this test, the Board recommended the adoption of the Vickers Rifle Caliber Gun, Light Model, and the Vickers Tripod, Model J.

"9. The new gun differs in one essential from the present gun in that it is water-cooled instead of air-cooled. It is slightly heavier when filled with water than the present gun, the weights being about 29 pounds and 36 pounds, respectively. The cost of the new gun is about twice that of the present gun, unless a tripod be added to the latter, in which case it would be about one and one-half times as great.

"10. This test, in so far as the Lewis gun is concerned, indicated that the mechanism had not been developed to a satisfactory stage, having, in the endurance test, 206 jams and malfunctions, 35 broken parts, 15 parts not broken but requiring replacement, as against respectively 23, 0 and 0 for the Vickers gun, and 59, 7 and 0 for the [Benét-Mercié] automatic machine rifle, caliber .30, model of 1909.

"11. The Board concluded, after a careful consideration of the data collected, together with the knowledge of the suitability of the various designs of machine guns gained by observation during the tests, that 'the Lewis Automatic Machine Rifle, as at present designed, is not considered superior to the service automatic machine rifle, on account of failure to maintain continuous fire, the large number of parts that were broken, and the large number of jams, many of the latter being reduced only after much difficulty and considerable time.'

"12. The Lewis gun was therefore not given the field test, in view of the fact that the Board recommended a competitive test of this nature for the Vickers gun and the Automatic Machine Rifle only.

"13. On the conclusion of the field tests at Texas City and Leon Springs, the Board expressed the opinion that 'when the present service machine rifle (automatic rifle, model of

A Device for the Lewis Gun Allowing It to be Fired from the Shoulder with Ease.

1909) was originally tested some seven years ago, it was then without doubt the best type of machine gun in existence, but during the past seven years the Vickers Company have developed a gun which not only overcomes all the serious defects inherent to the service type of Maxim gun (model of 1904), but compares very favorably in weight with the automatic machine rifle, caliber .30, model of 1909.

" 'The service machine rifles furnished the Board for test were well made and finished, and only a small number of parts were either broken or replaced during the test, indicating that the large number of jams and stoppages of fire which occurred, particularly during the field firing, were not due to either defective material or workmanship.'

"14. Effort has been made from time to time, within the past year and a half, to obtain a Lewis Machine Gun for further test. These efforts have not been successful until recently, when satisfactory arrangements were made with the Savage Arms Company, of Utica, New York, the American manufacturers of the Lewis Machine Gun, to submit a gun to tests similar to those held in the competitive trial of machine guns, in 1913. The Board testing this gun was composed of one officer of Cavalry, one officer of Infantry, and one officer of the Ordnance Department. . . .

"15. In order to further test this weapon, arrangements have been made for the purchase of three Lewis Machine Guns, chambered for British ammunition, which it is intended to mount on aeroplanes on the Texas border and in Mexico. These weapons have been procured with a view to determining whether this particular type of gun has peculiar and special adaptability for aeroplane work."

Very few things in American military history have produced as much controversy and as many contradictory opinions from people in high office as did the failure to procure the Lewis gun for the services. A few quotations are given to show the position held by defenders of the Lewis gun against the Army's claim that it was unserviceable when tested by it.

Sidney Brooks, a British publicist and correspondent, wrote in the *Philadelphia Public Ledger* on 14 February 1917:

". . . But there has recently been an even more striking instance of the discrepancy between British experience on the one hand and the views of American officialdom on the other. I refer to the controversy over the Lewis machine gun. Here again I speak simply as a layman and not at all as an expert. But I do know, and every Englishman knows, that the following statements are facts:

"*First.* That the present war is so largely a war of machine guns—I remember Mr. Lloyd George stating that more than ninety percent of the casualties were due to them alone—that whereas at its beginning we had only two to each thousand men, we now have thirty-two.

Flexible Lewis Machine Gun Mounted on a Scarff Ring.

"*Second.* That of all the machine guns in use in the Allied armies the Lewis gun is by far the most popular and the most effective.

"*Third.* That some 4,000 officers and about 400,000 men use it exclusively, and that in the British, French, Italian and Russian armies there are at this moment nearly 40,000 in actual and daily operation.

"*Fourth.* That virtually all our aeroplanes are armed with Lewis guns, and that of the seven Zeppelins we have accounted for six were brought down by the Lewis gun.

"*Fifth.* That both on Salisbury Plain and at the machine-gun school in France most of the instruction is done with the Lewis gun.

"*Sixth.* That it owes its pre-eminence partly to its mobility, partly to its light weight, partly to its capability of being used in any position and partly to the simplicity of its working; and that after fully two years of daily experience in the battlefield it stands higher than ever in the judgment of the British armies.

"Yet this is the gun the American Government virtually turned down. I have heard all sorts of explanation of its action, mainly of a personal or political character. But I have never yet heard it asserted that the Lewis machine gun was rejected by the authorities at Washington on its merits or that they have any better gun or any that is as good up their sleeve.

"Incidents such as these have a somewhat more than depressing effect on an Englishman, who has seen at first hand the terrible effects of a state of unpreparedness and who has no dearer wish than that the United States may be wise in time."

Maj. Gen. Leonard Wood, commander of the Department of the East, declared, "In my private opinion, the Lewis Machine Gun is the best light-type gun yet developed for troops in the field." He added that he favored "having . . . a reserve supply of 25,000 machine guns as in the end one in ten men will carry a 26-lb. machine gun as he now carries a rifle."

Will Irwin, war correspondent for the *Saturday Evening Post,* declared:

"Modern warfare had developed a real necessity for machine guns both light and heavy, but as far as I saw, the Lewis Gun far outnumbered all other machine guns of the light type among the Allied armies.

"In the last engagement I saw in the recent Somme offensive, whole detachments were going into the trenches with every man carrying a Lewis gun as one would carry an ordinary rifle."

Charles Edward Russell, an American sociologist, wrote in the *Cleveland Press,* in October 1916:

"Nothing the whole war had brought out has been of so much real use to the British Army as the Lewis machine gun. It has done wonders. It has almost counteracted the British aversion to tactics. . . .

"The merits of the Lewis gun are long past any discussion in British army circles after so many months of testing. It has also added a much-needed redeeming quality to the fame of American products in general.

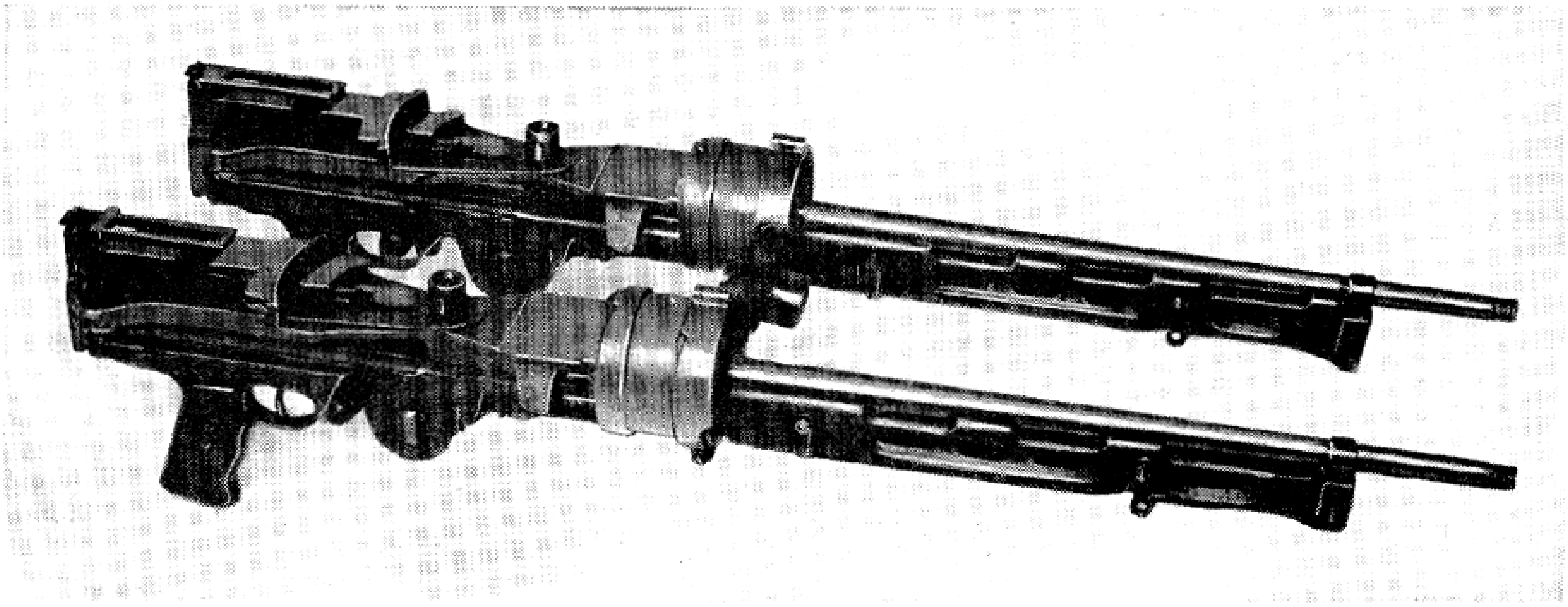
"One odd little fact is that they nearly all believe the American army to be equipped with the Lewis guns. 'But then you have your Lewises.' British army officers would say to me when the United States was trying to get an army to the Mexican border. 'Rum country, rum country,' they would say when I told them we hadn't."

And from the *Army and Navy Register* of 30 December 1916 is quoted:

"It appears to be conceded that between sixty millions and seventy millions have been spent for these guns by the Entente Powers, and they are used in all the French and English armies for the first line trenches. Heavier, more durable and water-jacketed machine guns being preferred for the second line. Are all the war authorities of France, England and Russia at fault? If not, why is not the Lewis gun good for the United States?"

There must have been a logical reason for the failure of the Lewis gun to meet the Army's requirements. The most probable explanation was brought to light years later. If valid, it serves as an outstanding example of how certain minute dimensions, which are only slightly out of adjustment, can ruin the performance of a weapon.

When Lewis presented his gun to the Board of Ordnance and Fortification in 1913, it must



Lewis Aircraft Machine Gun, Model 1914, Cal. .303, Twin-Mounted, French.

be remembered that it represented a handmade product in its earliest prototype stage. Constant experimentation was daily being carried on in an attempt to perfect the mechanism. Construction of the gas-operated gun required the attachment of the barrel and receiver so that the orifices in the barrel are at an exact place underneath it. The weapon could then be mass produced and the components quickly assembled. This precluded the conventional means of adjusting head space by screwing in or out on the barrel, as head space was permanently fixed with respect to the barrel and receiver. The only remaining adaptable factors were the angle of the locking cam on the bolt and the straight portion cut in this piece that allowed the piston to recoil a certain amount before unlocking action commenced.

This very critical dimension in first firing attempts has always been determined by trial and error. About the only help engineering can give is to furnish calculations for a safe starting point. The first Lewis guns submitted to the Board were still in highly experimental stage and the gas piston had been designed for the highest rate of fire possible. After the bullet passed the orifice and gas pressure was brought to bear on the piston, the latter had a free movement of 0.875 inches. The spiral cam of the bolt was then engaged by the lug on the gas piston, causing it to rotate and unlock.

The distance of the free movement was such as to give the first weapons an unusually high rate of fire, since unlocking took place while a residual pressure too high for practical use remained in the barrel. The free travel of only 0.875 inches hastened unlocking and caused the bolt to withdraw its support from the base of the cartridge. This slight easing back of the bolt had the same effect as too much head space, and many resulting malfunctions thus occurred. Too, the completed unlocking was done under such pressures that when the empty cartridge cases did not stick or rupture, the bolt was carried rearward with such force from the added blowback as to overstrain the other recoiling components. This resulted in a parts breakage that was all out of proportion.

Impatient at the delay of the Army Board, Lewis sailed for Europe taking his four guns with him. During his demonstrations abroad, British and Belgian ordnance officers pointed out that his rate of fire was far above what was considered ideal for battle use. In order to reduce the rate, the straight portion of the cam slot was redesigned until it had a free travel or "dwell" of 1.0625 inches. The additional free movement permitted the chamber pressure to drop before the bolt started to relax behind the base of the cartridge. It also established an average rate of fire of around 600 shots per minute when used in conjunction with a fixed gas orifice of .130, a dimension that produced a satisfactory rate of fire and the smoothest performance.

As England was at war and the most trivial thing concerning machine-gun construction was considered top secret, it is easy to understand why information on this redesigned part was not made available. In fact it is possible that the change may have been made by engineers of the Birmingham Small Arms Co. when the manufacturing drawings were converted from our measurements to the metric system and that Colonel Lewis did not even know of it. When the Savage Arms Co. contracted to make the weapons here in the United States, this change from the original drawings was noted for the first four guns.

It was felt at first that the weapon would not handle the United States infantry rifle cartridge because of its higher velocity, chamber pressure, etc. However, the theory was exploded when the Savage Arms Co. produced its version of the gun. It was basically the same as the unsuccessful earlier models with the exception of the added dwell before the bolt unlocked. The Lewis guns made by the Savage Co. stood the test.

Later Development and Production of the Lewis Gun

General use of the Lewis gun in the air led to the construction of many accessories that made it even more efficient. It was determined by actual battle use that the wind blew the cartridge case deflector and canvas bag back and that sharp maneuvers of the plane closed up the bag, causing stoppages in the ejection chute. As a result, a satisfactory sheet metal deflector and receptacle was designed, which was later replaced by an even better device made of die cast aluminum.

For aircraft mounting it was found convenient to cut into the gear case above the pin to allow sufficient clearance from the receiver locking pin. Removal of the casing without unscrewing the receiver from its locking piece was thus facilitated. To permit the fitting of an adequate sight, the gas chamber was modified so that the front sight base could be mounted on top with a dovetail fit and retaining screw.

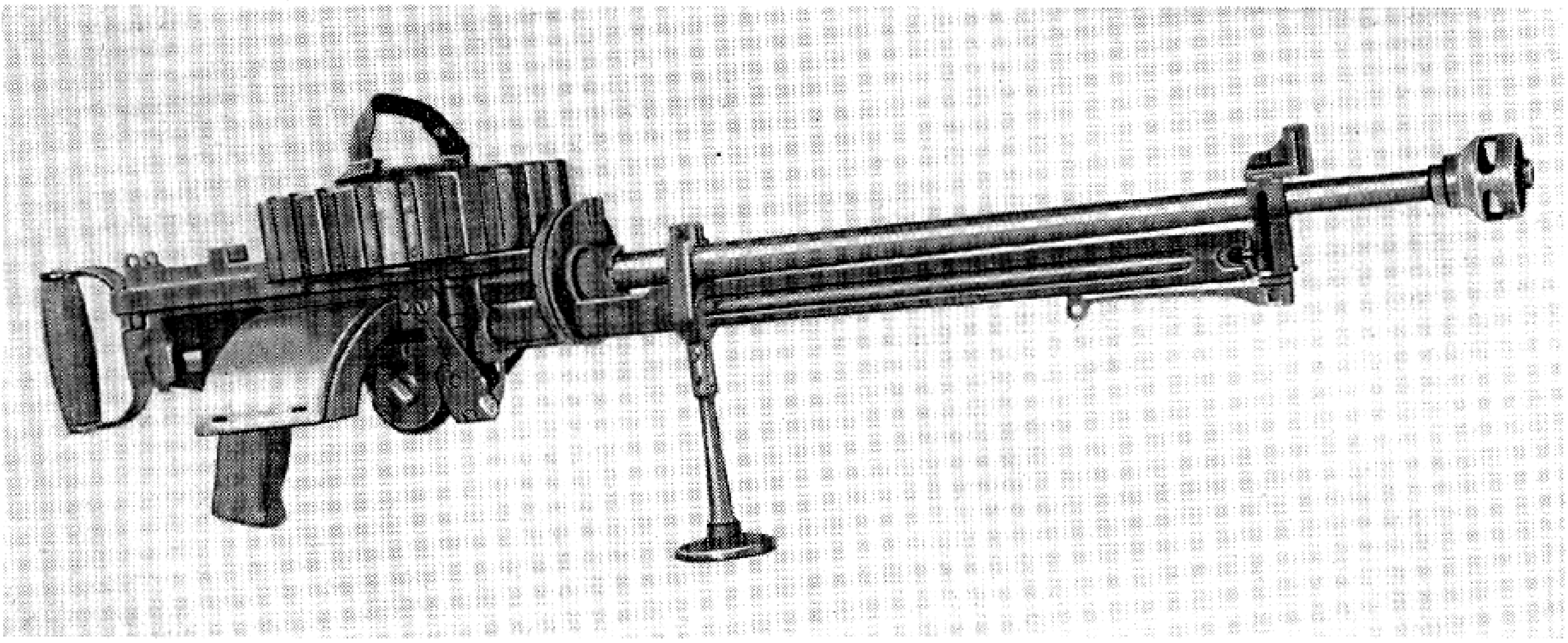
The most urgent demand from Lewis gunner pilots was for a simple indicator to show the number of rounds, if any, left in the drum at the end of a burst or engagement. Many devices were tried, the most successful one being designed and made by the Veeder Manufacturing Co., Hartford, Conn. The counter was mounted on top of the magazine plate and operated by a small gear, the teeth of which engaged in the notches of a latch lock located in the spacer ring. The indicator was set at zero when the drum was filled; after firing commenced, the revolution of the magazine's rim operated the indicator through its gearing. When only 19 rounds were left in the drum, a luminous figure "one" appeared and stayed until only 9 rounds remained. The number then disappeared and a red marker came into view to indicate to the gunner that the drum should be changed at the first opportunity.

This reliable counter was very ruggedly constructed and was considered the most useful accessory on the Lewis gun. Its acceptance by airmen was of such an enthusiastic nature that one of the indicators was sent in each carton containing six spare drums. The early style drums that were not designed to work with the indicator were soon properly altered.

On 28 May 1918, the Office of the Chief of Ordnance, United States Army, received the following cable from General Pershing: "Request information as to what experimental work has been done towards speeding up Lewis gun in the United States. French are at present doing considerable experimenting along this line; methods pursued being first to increase duration of gas pressure acting on piston by fitting muzzle attachment, which is approximately equivalent to increasing length of barrel by increasing spring tension, adding more length to barrel, and by adding buffer spring in rear end of racks to soften blow against butt tang. Suggest this matter be taken up with Savage Arms Company and reports forwarded to this office."

The Office of the Chief of Ordnance made an inquiry to ascertain the new French rate of fire and how much was desired by the American Expeditionary Force, and received the following reply:

"The rate of fire of Lewis guns should be as high as possible consistent with reliable performance of the gun. The French at present have produced a reliable speed of about 850



Lewis Aircraft Machine Gun, Model 1918, Cal. .30, with 97-Round Magazine and Muzzle Booster.

shots per minute. A speed of over a thousand per minute has been attained but performance of gun has not been satisfactory."

No attempts had been made in this country to speed up the gun, as it had just been adjusted to work satisfactorily at its normal speed. But upon General Pershing's suggestion an order was placed with the Savage Arms Co. for experimental work of this nature. It was recommended that a rate of fire of 900 rounds a minute would be acceptable. The company made up a special spade grip, with two buffers having heavy springs to act against the end of the feed operating stud and rack. A hardened buffer plug was added at the end of this part. And to increase the force of recoil of the gas piston greatly the orifice was opened up from .130 to .190. The latter change was found upon test to be far too great for smooth performance. It resulted only in having the extractor tear through the rim of the empty case which was still under terrific gas pressure. The company officials were unable to fire a single full drum of ammunition without some serious malfunction or parts breakage.

Without expending further effort, the Savage Arms Co. asked permission to give up the experiments as an impossibility. The Ordnance Department was not so easily discouraged. It ordered Savage to reduce the gas orifice from .190 to .150 and put the Hazelton attachment on the muzzle. The device trapped the gas momentarily after the bullet had cleared the muzzle. A high residual pressure was held in the bore to add greater operating power and recoil to the piston stroke. This modified assembly increased rate of fire greatly but it resulted in wearing off the stop, rebound and feed pawls, after the firing of a few magazines. Innumerable failures to feed resulted.

The fault was finally overcome by continued firing and experimental heat treatment of the affected parts until the breakage stopped. Thereafter one Lewis gun was fired as much as 8,000 rounds, when the rate of fire was 800 to 850, without what was considered excessive wear. As many as 1,000 shots a minute were obtained by restricting the orifice in the muzzle attachment, but a high percentage of broken parts again resulted when the orifice was thus choked. It was decided that a maximum of 800 to 850 rounds per minute could be fired without affecting the reliability of the gun's action. The most serious difficulty encountered at the latter rate of fire was the tendency of the powder gas to blow back into the operating parts and clog or foul up the recoiling mechanism. It was remedied by drilling three holes, 0.0625 inch in diameter, through the cylinder and casing a little ahead of the rearmost position of the piston head on recoil.

All modifications were officially approved and 5,000 muzzle boosters were ordered from the Savage Arms Co. to be attached overseas to Lewis guns already in action. Before this was done, it was found more desirable to complete the speeded-up gun at the factory, since it had been apparent that the ramps on the receiver needed a milled-out cut. This could be done in a satisfactory manner only in a well-equipped manufacturing plant. After the modification was done, only a limited number of the improved guns were actually delivered.

The Savage Arms Co., having been a large and efficient armament factory for half a century before the war, was considered well equipped to furnish all the standard-type Lewis guns needed for United States military service and no contracts were made with other plants. The original order for the ground gun was placed during the latter months of 1917. By May 1918 more than 16,000 had been produced and delivered. Over 10,000 of these were of the aircraft type; the other 6,000 were delivered to the Navy for Marine Corps use. By August 1918, 25,000 of the aircraft type alone had been made and by Armistice Day, 34,000 of this model had been delivered.

The Savage Arms Co. must be credited from the very start with keeping production ahead of requirements and overseas supply was held up only because of shipping difficulties. There were comparatively few insoluble manufacturing problems in the production of the weapon. This can be rightfully attributed to the foresight of Colonel Lewis in emphasizing simplicity of manufacture.

Because the bolt was held in a cocked position, the Lewis gun could not be synchronized to fire through the propeller arc as could front-seared machine guns. This limited its method of mounting, although many novel ways of firing outside the propeller arc were tried, a number of which were successful.

The main use of the Lewis was as a free gun. At first it was necessary to modify the ground weapon to mount in a plane, but an aircraft model was soon issued that could be easily adapted to any kind of mounting desired. It was first installed on biplanes over the observer's seat by means of a tourelle. Often two guns were placed together in a yoke and the torque action of the yoke combined with a knuckle arrangement permitted a perpendicular action of the mounting. Aiming in all directions was thus made possible. Both guns could be fired simultaneously by means of a Bowden connection. A recoil reinforcer was sometimes added to the mounts to make the operating action more positive and to increase its rate of fire to a limited extent.

When certain altitudes were reached, freezing up of guns was a common complaint. In this situation various methods were employed to heat the operating parts. An electric heater, obtaining its power from the motor's generator, was usually attached under the feed cover.

The front sight was originally made of bronze but combat conditions proved the metal too soft to be satisfactory, as the set screw could not hold the sight in place. The easily burred material allowed the base to loosen. Steel sights had to be made to replace the original ones.

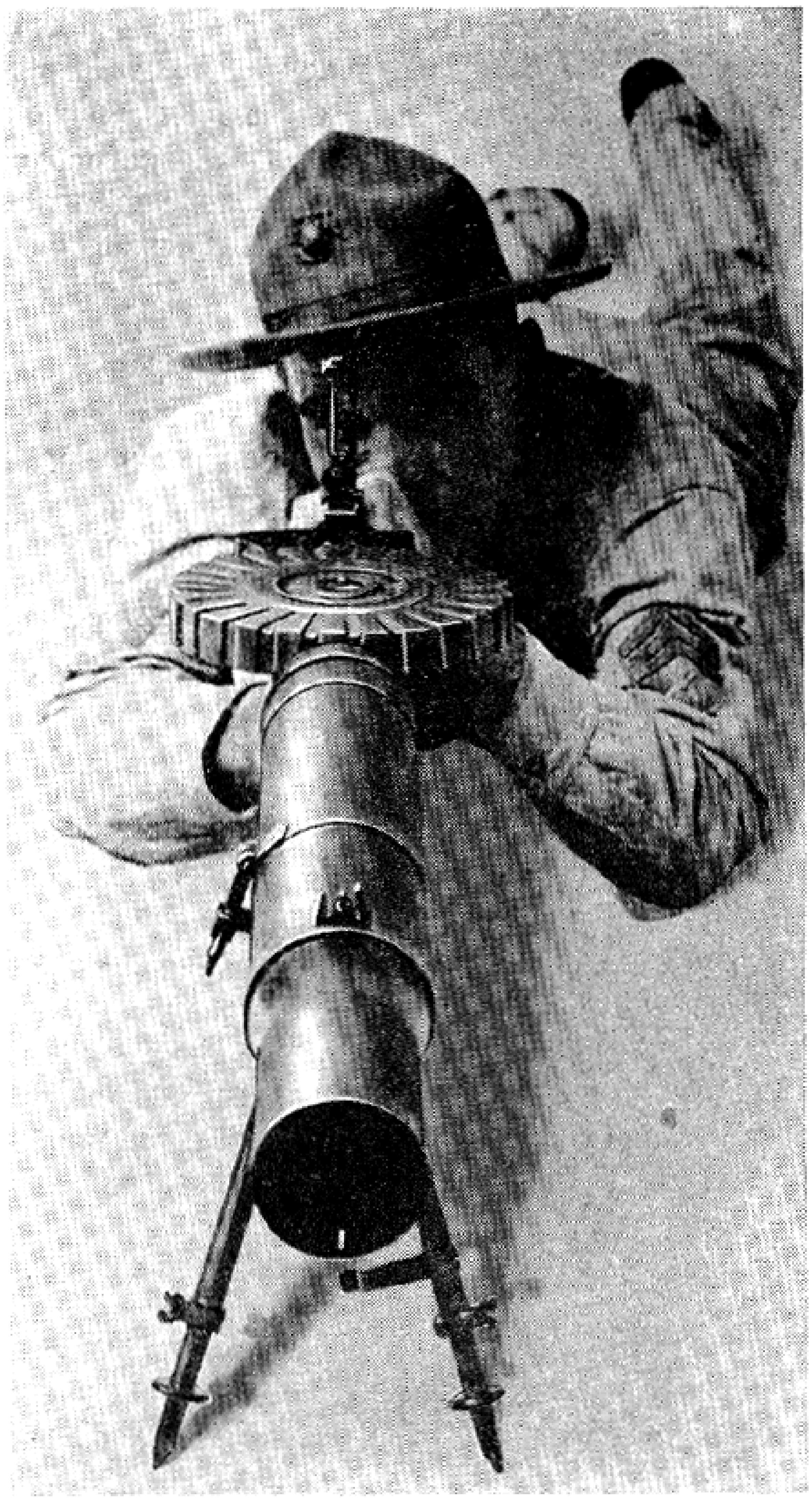
A simple set of magazine rim and spacer pin gages for use in the field by ordnance men was developed. Their intended purpose was to give a quick means of checking accurately the critical dimensions of these two parts. On the standard gun firing at 600 rounds a minute, it was thought a recoil check or muzzle brake, used over the muzzle, would result in smoother performance by eliminating the kick. However, when a test was made with such a brake designed by the French, so much carbon and fouling was found in the mechanism that the idea was dropped.

Use of the Lewis Gun by the Navy

One of the most peculiar things about the Lewis controversy is that the Navy did not concur in the belief that the weapon was unreliable. The Navy, in its effort to supply the Marine Corps with an adequate light machine gun, had the Marines test the weapon. Complete satisfaction with its performance was expressed.

In September 1917, an officer from the Aviation Ordnance Section, Lieutenant Commander Stone, who had been sent abroad to collect data and specimens of foreign aircraft ordnance, returned to the Bureau with voluminous information and a quantity of English and French aircraft armament, among which was a British Lewis gun.

The Navy ordered the Savage Arms Co. to modify the standard Lewis gun to conform to the sample submitted so that it would be identical with those used by Great Britain and France for both aviation and ground use. These instructions were complied with and large quantities were delivered to the Navy by 1 January 1918. From that date the Navy never suffered for lack of machine guns. Since there was an ample supply for training the Marines at home and outfitting them before going overseas, they were the only American troops to arrive in France armed with Lewis guns. Other units were given whatever the French and English high command could conveniently spare, the Chauchat being offered in most cases.



U. S. Marine Training with a Lewis Gun, 1917.

The Navy was long an interested party in machine-gun development. It had adopted the Colt '95 model while other branches of the service still clung doggedly to the hand-cranked Gatling. It was realized early that the Lewis gun would best suit Naval needs in World War I for both land and air use. Having previously been satisfied with its performance, the Navy ordered enough weapons, in advance of the war, to give it an adequate supply for training purposes. Once this need was met, an ever-increasing flow from the factory kept ahead of the demand.

Such foresight was due to a large extent to the efforts of the newly formed Naval Aviation Ordnance Section, created after 6 April 1917, as a subsidiary of the Gun Mount and Small Arm Section. On 1 October 1917, the unit became officially known as the Aviation Ordnance Section. The section had under its cognizance responsibility for obtaining machine guns, sights, mounts, ammunition, bombs, and pyrotechnics, along with any other large caliber guns as long as they were intended for use in aircraft. After war was declared, Lieutenant Commander Stone, an officer from this section, was sent to the front, as mentioned above, to gather samples of the best weapons with which to fight an aerial war.

While the new section's complement was very small and its quarters cramped, it certainly proved competent in every respect. The reason for its existence was best stated in its letter of organization:

"To plan and develop by years of experience, the needs of Naval aviation and base its requirements under conditions of war, and never upon those of peace. The principal function of this organization is to harness authority and responsibility so that they can never be separated . . . . so that a designer cannot design a gun, then throw credit or blame onto the producer, or later escape the final issue and responsibility therefor. One man is to be responsible for each bit of material or development from its start to completion . . . . its issue, its service performance, and later its overhaul or repair. Given this responsibility, he is to be clothed with the requisite authority over all its details."

One of the unit's first acts was to place contracts for the Lewis gun. It had expressed dissatisfaction with the heavy water- and air-cooled automatic weapons that had been previously tested. The Savage Arms Co., already tooled up for the caliber .303 Lewis gun for the British, had been approached as early as 5 February 1917 (before the section was set up) on the production of sufficient caliber .30/06 guns for Marine Corps testing. Through the hard labor of an already overworked factory at the urgent insistence of the Navy, this was done and by 5 April 1917, one day before declaration of war, successful acceptance tests were run by both Navy and Marines. On 25 April 1917, the first contract with the Savage Arms Co. was given for 3,500 guns. A second followed on 22 June 1917, for 350 more; a third on 6 April 1918, for 2,500; and a final one on 13 June 1918, involving 3,000 additional guns.

A total of 9,350 guns with spare barrels and accessories was delivered in time for actual service before Armistice Day. All reports concerning use of the Lewis gun under combat conditions stated it was indeed most reliable, and could be fired and serviced by a single gunner. Although jams and stoppages were infrequent, little difficulty was experienced in clearing them when they did occur.

One of the most inexplicable acts of World War I, and one that curtailed American combat use of the Lewis guns, happened when the Marine divisions arrived in France, fully equipped with the weapon. They were soon attached to Army units and under the command of the latter, they were ordered to turn their Lewis models in. Greatly inferior Chauchats were issued as replacements.

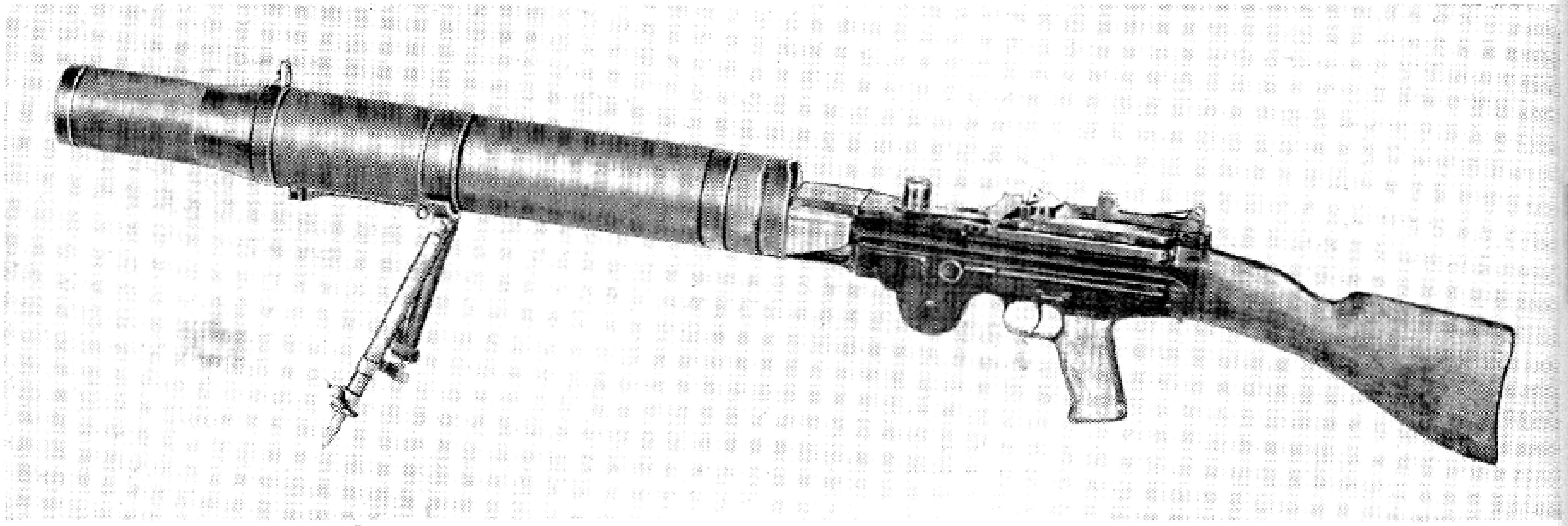
The Routing of the Zeppelin Menace

If the Lewis gun had not fired another shot during World War I, its part in breaking up the Zeppelin raids over England would have more than compensated the Allies for the cost and effort expended on its production. The German aircraft was named for its inventor, Count Ferdinand von Zeppelin. He was born on 8 July 1838 in Constance, Baden, Germany, and after over 30 years of service in the German Army retired in 1890 with the rank of general. He announced his intention of devoting the remainder of his life to the study of aeronautics and the building of lighter-than-air machines. His decision was influenced partially by his term as military attaché in the United States during the Civil War, at which time he made his first balloon ascension with Professor Lowe to reconnoiter the Confederate forces.

Unable to find financial backing at first, Count von Zeppelin sold his family estate and all other valuables in order to raise the $150,000 needed to conduct his first experiment. Within 2 years the inventor had his first airship, using a 16-horsepower Daimler motor for power, ready for flight. After a short trial in the air, it was destroyed by an accident, as were also Zeppelins II, III, and IV. The indomitable count was financially ruined after so many failures and very low in morale, when the German Government agreed to finance the next airship, to be known as the *Deutschland*. Through tireless effort on the part of the inventor and his assistants, a craft was produced capable of carrying passengers with comparative safety. In 1910 it made such a flight for a distance of 300 miles. This feat stirred the imagination of the German people and over $1,500,000 poured in for the purpose of more experimentation.

The *Deutschland* was also wrecked by a sudden and violent wind as it attempted to land, but the government now had implicit faith in the Zeppelins. Further experiments showed that greater engine power was needed, and one of the dirigibles powered with 75-horsepower engines successfully rode out a storm for 3 days with gales at times of 80 miles per hour. Between 1900 and 1914 the Zeppelin Corp. constructed over 115 airships of the rigid type.

Up to this point Germany had practically a monopoly on dirigibles as other European countries had dropped them in favor of heavier-than-air models. The German military command realized that it had at its disposal what might constitute a powerful weapon, as the Zeppelins could stay aloft hours longer than conventional airplanes. They could also reach a greater altitude than any plane. Their speed, especially with a favorable wind, was far in excess of that of standard military aircraft. Best of all, the designers reasoned that the huge area and unlimited carrying power of the dirigibles furnished a platform upon which to mount weapons. This would


Lewis Machine Gun, Model 1917, Cal. .30.

allow them to fight off anything that dared approach the flying arsenal.

As one very enthusiastic supporter explained, "For an airplane to engage a Zeppelin with the limited armament the plane could carry would be like a canoe attacking a battleship." Since the Zeppelin could reach prohibitive altitudes and needed no weight limitation on the number of machine guns and even cannon that could be mounted, the arguments of its supporters seemed to be too one-sided even to be logically disputed.

Although Germany had built up a mighty Zeppelin fleet, she most certainly had not done so at the expense of her heavier-than-air machines. Her military leaders knew, however, that every other major power in Europe had an air force of conventional-type planes equal and, in some instances superior to, her own. They earnestly believed that the Zeppelin was Germany's ace weapon and that, when "the day" arrived, the mighty ships would cruise unmolested to and from strategic targets deep in enemy territory.

This belief was not a German monopoly, as the French and British begrudgingly accepted it in every respect. Such a generally conceded point of superiority gave the Germans a psychological weapon in itself. From the outbreak of hostilities, they released propaganda building up horror in the Allied countries that Zeppelin raids and the destruction of unprotected cities were certain to follow.

As a result of constant predictions of impending doom by journalists and military experts, the general public was left in a state of near hysteria at the mere thought of the inevitable Zeppelin raids to come.

It was fortunate that the Germans also believed in the invincibility of their "Air Armada." Feeling so secure, they disregarded observations supplied by their secret operatives that British pilots had been firing in their Lewis guns newly designed ammunition recently patented by George Thomas Buckham of London.

The first Zeppelin assault on England took place at Great Yarmouth on 19 January 1915. It resulted in minor damage and was considered merely a token raid, a dress rehearsal for the main event. An English newspaper made the statement: "What made the people indignant was not so much the ruthlessness of the Germans, but the failure of their own naval and military to offer any protection . . . or even to harass them when they came."

It took years in time and millions in money to build up the Zeppelin myth, but it was shattered quickly when British airmen found the fatal weakness of the huge airships. The following report on bringing down a Zeppelin, the L–53, by Lieutenant Culley, of the Royal Air Force, illustrates a typical encounter:

"The naval units informed me at 8:30 a. m. there was a Zeppelin approaching from NE at an estimated 15,000 feet altitude. I got my 'Camel' into the air at 8:41 a. m., and with the sun at my back, I climbed upwards. When first sighted, the airship was broadside but evidently having sighted me it had turned end on and had climbed to 19,000 feet. As we approached, the Camel sat tail down unable to climb another inch of altitude. At this close point the airship started to pass slowly overhead. I pressed the trigger of my two Lewis guns mounted above the wing and after firing a long burst observed the bullets strike and flash as they hit the metal in the under belly structure of the huge ship.

"A propeller on an engine on the port side was seen to stop and as nothing else seemed to happen I dived my plane, followed a moment later by an explosion as the whole airship exploded in flames. One of the crew succeeded in jumping with a parachute and was saved."

Lieutenant Culley could have mentioned the fact that he was using the new Buckham incendiary bullets in his guns.

Destruction of the Zeppelins with the deadly combination of the Lewis gun and incendiary bullets gave English and French morale its greatest boost of the war. The weapon with its highly inflammable ammunition literally shot the dirigibles out of the air. Of the 12 Zeppelins destroyed in attacks over London, the Lewis is officially credited with shooting down 10 of them.

The Buckham incendiary bullet consisted of a flat-nosed cupro-nickel jacket, containing in its nose an 8-grain charge of yellow phosphorus. The charge was held in place by a serrated plug of lead backed up by a larger base plug of the same material. A small hole through the jacket, located near the junction of the two plugs, was filled with a low fusible alloy. The latter melted as the bullet passed through the bore and permitted the phosphorus to ignite.

The yellow phosphorus, when brought into contact with the highly flammable hydrogen gas-filled envelopes of the great airships, resulted in immediate fire and explosions. The metal framework inside the dirigibles increased the hazard as the flat-nosed bullets, upon striking a support member, had a tendency to rupture and scatter the flaming mixture over a wide area.

Thus in a comparatively few months the death knell was sounded for the great German menace, the Zeppelin. The people of Great Britain and France, being relieved of the horror of mass annihilation by the successful employment of the Lewis gun, looked upon it with more admiration than is usually accorded a common weapon of war. They felt their governments could not give too much official praise and credit to it.

Colonel I. N. Lewis, U. S. A. (Retired).

Conclusion

It would be possible to write an entire book on why the United States seemed to ignore the Lewis weapon when machine guns were so desperately needed. Regardless of who was right or wrong, or for what particular motive, other than intense patriotism, the fact remains that Colonel Lewis sent to the Secretary of War certified checks for over a million dollars, representing his portion of the royalties on Lewis guns bought by the United States, during and following hostilities. Lewis's notation was "I will not accept one cent of royalty for a single Lewis gun purchased by the government of my country."

Even the acceptance of the colonel's first check covering his royalties on guns sold to the War Department involved him in a characteristic dispute with General Crozier, the Army's Chief of Ordnance. The check, which was for $10,889.17, was sent for deposit to the credit of the United States Government on 16 February 1917. Mr.

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W. G. McAdoo, the Secretary of the Treasury, asked the War Department for an opinion on the propriety of accepting the donation, especially since the Savage Arms Co., which paid the royalties to Lewis, was still competing for Government orders. General Crozier prepared a memorandum saying that acceptance of the check would not embarrass the Department in dealing with the Savage Co. Then he continued with some adverse comments on Lewis's claims that he had never sought pecuniary recompense from the United States Government for his inventions, and that he had never had any assistance or encouragement from the Ordnance Department.

Colonel Lewis was advised by the Secretary of War, Mr. Baker, of the general's comments and his reply follows:

"No. 1 Russell Terrace, Montclair, N. J.,
May 12, 1917.

"The Honorable the Secretary of War,
Washington, D. C.

"My Dear Mr. Secretary: Your letter of April 29th, with its inclosed memorandum from the Chief of Ordnance, has been received and very carefully considered.

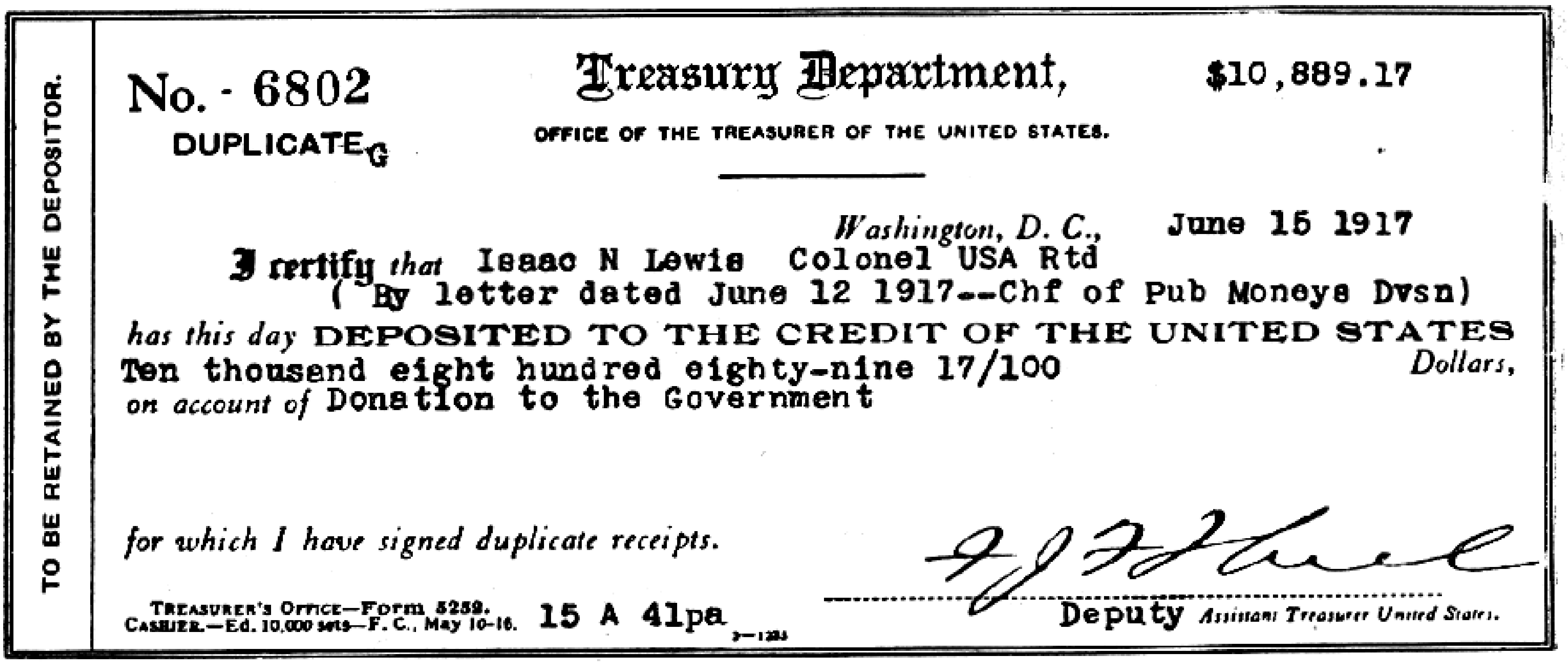
"I *do* care to have the money represented by the check sent you in my letter of February 16th, 1917, deposited in the Treasury of the United States simply on the ground stated in my original letter, without any understanding that you are now examining or undertaking to determine any controverted question as to the breach of relations between me and the War Department or any branch or division of it, and I now have the honor to request again that you so accept and deposit it.

"My letter of February 16th, 1917, was sent you solely for the reasons stated therein and for no other.

"I can see no possible embarrassment to the War Department nor to the Ordnance Department in the acceptance of my check. It is possible, however, that your acceptance and deposit of the check may embarrass the present Chief of Ordnance personally.

"The memorandum from the Chief of Ordnance to which you invited my attention is so widely at variance with what I know from personal knowledge to be the facts in the case that I can not fairly consider any of the questions raised by Gen. Crozier therein without controversy, and I understand it to be your wish and direction that there be no further controve

"In the present very grave national emergency I am directly instrumental in supplying, delivering, and putting on the actual firing lines against the fighting enemies of my country more machine guns each week than the present Chief of Ordnance has supplied for the use of our



TO BE RETAINED BY THE DEPOSITOR.

No. - 6802 **Treasury Department,** $10,889.17

DUPLICATE

OFFICE OF THE TREASURER OF THE UNITED STATES.

Washington, D. C., June 15 1917

I certify *that* Isaac N Lewis Colonel USA Rtd
(By letter dated June 12 1917--Chf of Pub Moneys Dvsn)
has this day DEPOSITED TO THE CREDIT OF THE UNITED STATES
Ten thousand eight hundred eighty-nine 17/100 *Dollars,*
on account of Donation to the Government

for which I have signed duplicate receipts.

Deputy *Assistant Treasurer United States.*

Treasurer's Office—Form 5259.
Cashier.—Ed. 10,000 sets—F. C., May 10-16. 15 A 41pa

Royalties Returned by Colonel Lewis.

.wn Army of defense during the whole of the 14 'ears that he has been in office. I have done, and m doing, this without one penny of assistance .d without one word of encouragement or ac- :nowledgment from anyone connected with the Ordnance Department and in spite of the long- continued and active opposition of that department.

"I am therefore content to now rest the mat- er with you simply as a personal appeal for justice.

"Very respectfully, your obedient servant,

"I. N. LEWIS,

Colonel, United States Army (retired)"

General Crozier found no objection to accept- ıg the colonel's check and it was deposited in ne United States Treasury in the name of Isaac N. Lewis, on account of "Donation to the Gov- ernment." No such difficulties accompanied later refunds made by Colonel Lewis.

As might be expected, the Lewis gun did not) out of existence following World War I. It ' much use in the hands of the United States .ines in the Nicaragua campaign, and it was ie favorite infantry arm for many smaller coun- ries long after the major powers sought to re- lace it with a more efficient weapon. The Nor- wegians made it under license in a 6.5-mm cali- ber and it is the only light machine gun defi- itely known to be used by their army. Japan produced it under the designation Models 1929 and 1932.

In fact, the Lewis gun, although it had undergone practically no change for three decades, was still on hand by the thousands in this country at the beginning of World War II, a fact that was most fortunate for the Allied cause. When the Germans practically disarmed the British army in the debacle at Dunkirk, 80,000 Lewis guns were purchased by England from the United States and other friendly powers. And when the Japs struck at our fleet on 7 December 1941, the first pictures rushed back from Hawaii showed the old reliable Lewis being used as a makeshift antiaircraft gun.

After the arms situation in Britain got back to normal, the thousands of Lewis guns were given to the home guard and to small units in the fleet. It is recorded that on more than one occasion the outmoded guns brought down planes that made the fatal mistake of coming within range of the gunners, who in many cases were veterans of the first World War and no strangers to the Lewis gun.

Models of the Lewis Gun

The various models of the Lewis gun and the countries using them were too numerous to list in the text. As a handy reference, they are tabulated herewith:

:ountry	Designation	Bore
(1) Ground		
). S. Test	Model 1911, (one, handmade)	.30/06
. S. Test	Model 1912, (4 manufactured)	.30/06
Belgium	Model 1913, Liége (A few were made in Belgium during this year, before contract was transferred to Birmingham Small Arms.)	.303
Belgium	Model 1914, B. S. A. (This was called "the Belgian Rattlesnake" by the Germans.)	.303
Belgium	Mark VII, B. S. A.	.303
Belgium	Mark VIII, B. S. A.	.303
Great Britain	Mark I (Model 1915, B. S. A.)[1]	.303
Great Britain	Model 1915 (Savage)[1]	.303
Great Britain	M1916 (Savage)[1]	.303

[1] Between the world wars all these were modified to Mark I except those sold as surplus.

Country	Designation	Bore
Great Britain	Model 1916 (Mk VII, B. S. A.)[1]	.303
Portugal	Model 1917	.303
U. S. Army	Model 1916	.303
U. S. Army	Model 1917	.30/06
U. S. Navy	Mark VI (also Mk VI Mod 1)	.30/06
Honduras	Ex–U. S. M1917	.30/06
Nicaragua	Ex–U. S. M1917	.30/06
Commercial	Model 1919	.303
Holland	Model 1920	6.5 mm
France	Model 1922	8 mm
Russia	Same as British Mk I	7.62 mm
Japan	Model 1932	7.7 mm
(2) Aircraft		
Great Britain	Mk VII Model 1916	.303
Great Britain	Mk II	.303
Great Britain	Mk III	.303
France	Model 1916 (Darne)	.303
U. S. A. F.	Model 1917	.30/06
U. S. A. F.	Model 1918	.30/06
U. S. A. F.	Model 1919	.30/06
U. S. Navy	Mark X	.30/06
Italy	Same as British Mk II	.30 & .303
Russia	Same as British Mk II	7.62 mm
Japan	Model 1929	7.7 mm
Japan	Model 1932	7.7 mm

[1] Between the world wars all these were modified to Mark I except those sold as surplus.

Chapter 3

VICKERS AIRCRAFT MACHINE GUN

In the early months of 1916 the British Royal Air Force first attempted to adapt the Vickers-Maxim rifle caliber machine gun to aircraft use. Heretofore planes had in most instances served as flying platforms upon which weapons were mounted to be aimed and maneuvered by the operator. The propeller served as an effective barrier against mounting guns permanently to shoot straight forward. If the latter could be accomplished, it would change the craft into a gun-laying device, as had been done previously by Roland Garros, the great French air fighter. The plane's flight attitude would then govern at all times the bullet trajectory of the forward-firing weapons. The R. A. F. was very conscious of this unused firing area and tried in many ways to put it to use.

By actual test in late 1914 it was found that only 2 percent of the shots fired by a machine gun through the arc of an air screw would hit the blade and that it then required quite a number of caliber .303 bullets to weaken the propeller to the point of being unserviceable. This, the authorities thought, justified the mounting of one Vickers machine gun to fire straight ahead for use in an emergency only. As a result, every pilot upon engagement with the enemy naturally considered it an emergency situation and used the weapon upon all occasions. The arrangement turned out to be a faulty makeshift, for in more instances than deemed necessary a gunner pilot had started home after a victorious fight only to have his propeller disintegrate from bullet holes of his own making. Crash landings resulted, with numerous fatalities or capture by the enemy of valuable ace fighters.

Since the Vickers was belt fed and therefore of little use as a free gun, its part in the early stages of aerial warfare of 1914 was indeed limited. Its streamlining though had been undertaken from the start, many things having been done to cut down its weight and make it more efficient for air use. An example was the replacement of the water jacket with a skeletonized tube and cap to allow cooling by air circulation. This device not only supported the barrel adequately but reduced the weapon's weight to 30 pounds. The handle block was replaced by a flat plate and the front and rear of the covers were milled out to permit various triggering installations. One of the most radical changes was the redesign of the left-hand cartridge box and feed to allow the mounting of two guns adjacent to each other. As another refinement a retracting handle was added which allowed adjustment of the return spring's tension from the rear end of the gun.

But the device that made the Vickers machine gun a superb aircraft weapon was the invention of a reliable synchronizing gear. This brilliant achievement came from the efforts of George Constantinesco, a Rumanian engineer living in London, who had specialized in devices for transmitting power by impulse.

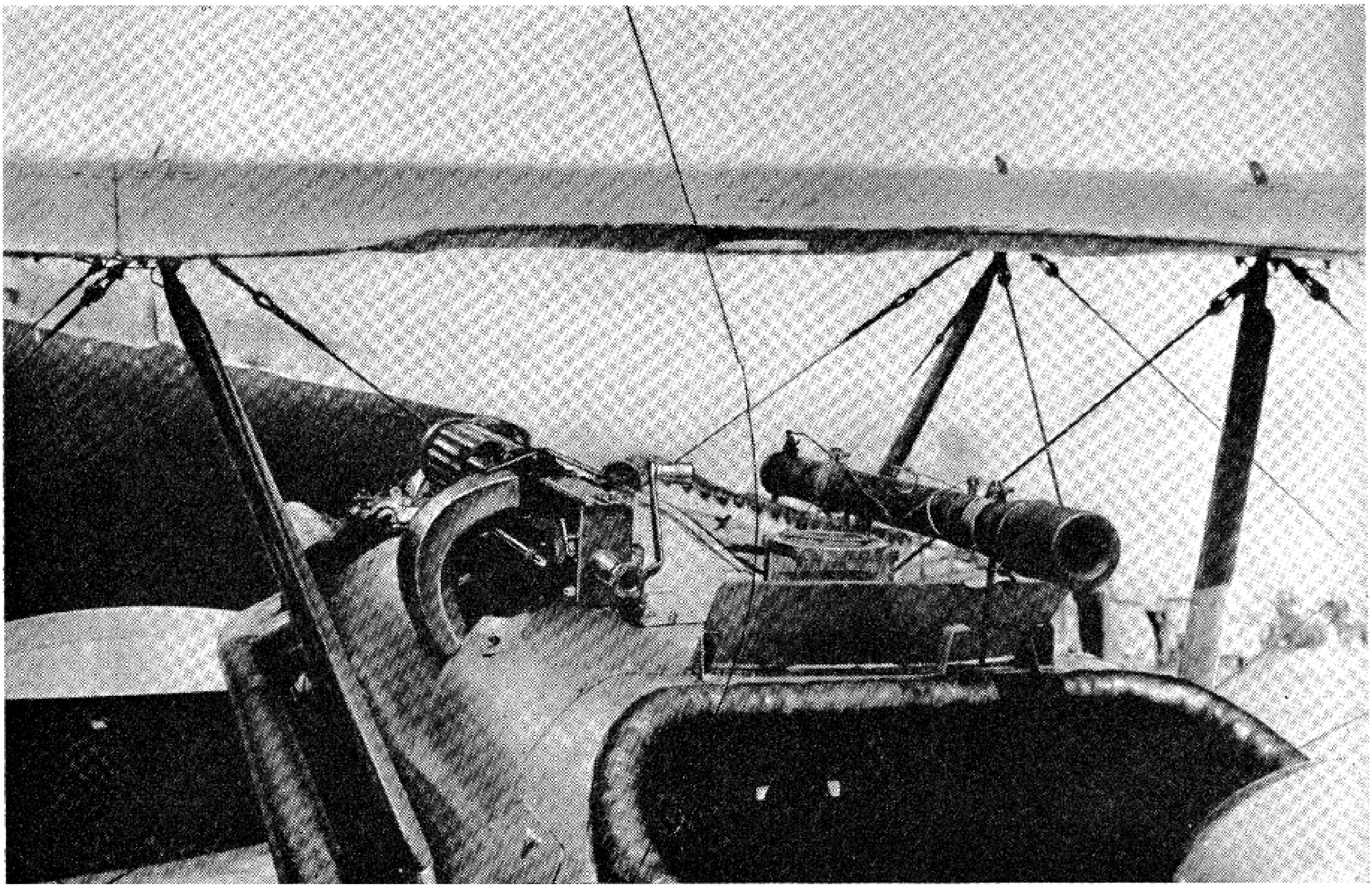
Actually the Rumanian was only one of many attempting to solve this problem. There came into being at about the same time the Scarff-Dibovsky synchronizing gear, developed by Warrant Officer Frederick William Scarff, R. A. A. S., who had made aviation history by inventing the Scarff gunners' ring, and Lt. Victor V. Dibovsky, of the Imperial Russian Navy. It was a mechanical gear consisting of cogs and teeth operating off the propeller shaft. Another such contrivance was invented by Maj. A. V. Bettington, commanding officer of the Aeroplane Repair Section No. 1, Aircraft Depot. This was known as the "Arsiad" synchronizer, the name arising from the initials of the major's command. It also was an arrangement of gears, cams, and levers attached from the propeller shaft to the machine-gun trigger. Still another was the Vickers trigger

Vickers Aircraft Machine Gun, Model 1915, Equipped for Synchronizing. Mount is for Purposes of Photographing Only.

actuator, designed by George H. Challenger, an engineer of the Vickers establishment. The number of approaches from various angles shows the great importance placed upon a solution to this vital problem.

All three of these synchronizing gears depended on mechanical means for firing the gun at the requisite instant. The main operating principle was that a cam driven by the engine and working through a series of push rods and levers tripped the trigger at intervals and was so regulated that the revolving propeller was clear of the line of fire. The mechanism was set in action with a trigger controlled by the pilot. Although effective, these devices were crude and mechanically unreliable, since adjustment of the rods had to be extremely accurate and continued firing might jar the original setting.

The Constantinesco synchronizer, however, did not employ such features in its design. It was based on one of the inventor's earlier patents concerning the operation of a hydraulic rock drill. The impulses transmitted through a column of nonfreezing oil under pressure in a pipeline furnished the energy to depress the trigger at intervals regulated by the position of the blades. A cam on the propeller shaft engaged a lug on an oil pump at the instant the trailing edge of the propeller was clear of the bore of the gun and continued to hold the trigger actua-



Vickers Machine Gun, Synchronized with Propeller in a Pursuit Plane, World War I.

tor down until the leading edge approached. The lug then ran off the cam and the spring-loaded trigger depressor let up on the sear interrupting the fire. The device was operated by a simple oil pump that furnished pressure until the leading edge of the propeller started to line up with the gun muzzle. At this point it released tension only to take it up after the blade passed.

Overnight all mechanically operated synchronizer gears were obsolete. Manufacture was started at once by the Vickers Co. and the first model made by this firm was successfully demonstrated on a BE2C in August 1916. It showed perfect reliability and was adaptable to any type of airplane engine. From then on until the end of the war, the units were fitted to all aircraft as fast as both could be produced. Over 6,000 were installed on British planes alone between March and December 1917, and 20,000 more were added between January and October 1918.

The first planes to go into combat with the hydraulic synchronizer were a squadron of DH–4's which arrived on the continent on 6 March 1917. Two days later two groups of Bristol fighters were fitted with the same arrangement. From then on aircraft with this aid to fire power were delivered at regular intervals. Now the planes could fire straight ahead, in addition to maneuvering one or two machine guns on a free mount.

At first the Constantinesco gear was designed to fire only one machine gun, but it was soon adapted to operate two mounted parallel to each other. The Sopwith "Camel" was the first plane so equipped. It had a fire power of 1,600 shots a minute or, as the British figure it, 40 pounds of projectiles in the same period.

The synchronizing device was so successful that it became a must in British aircraft armament. It was placed in all subsequent models as fast as they appeared. As a result of its introduction on the DH–4s and Bristol fighters, the Allies recaptured supremacy of the air from the Germans, and while there were times when it was gravely in jeopardy, it was never relinquished for the remainder of the war.

The Vickers gun was ideal for synchronizing because it employed a spring-loaded firing pin. This was released only when the weapon was in battery and the bolt securely locked.

The next officially adopted modification was a speeding-up device invented by Lt. Comdr. George Hazelton of the British Navy. It consisted of a specially designed sleeve and conical spring between the followers and barrel discs. The only other change in the gun was the hardening of the front left recoil plate and the substitution of a much heavier roller washer pin. The latter change was necessitated because experimental firing showed that the ordinary pin vibrated loose.

While the Hazelton attachment accelerated firing up to 1,000 rounds a minute, and one Vickers, so modified, went 14,000 rounds on a test before the first critical break of a component part, this rate was thought to be too high for reliable performance. The booster was then altered to slow the weapon to 850 shots per minute, which was the optimum speed decided upon officially.

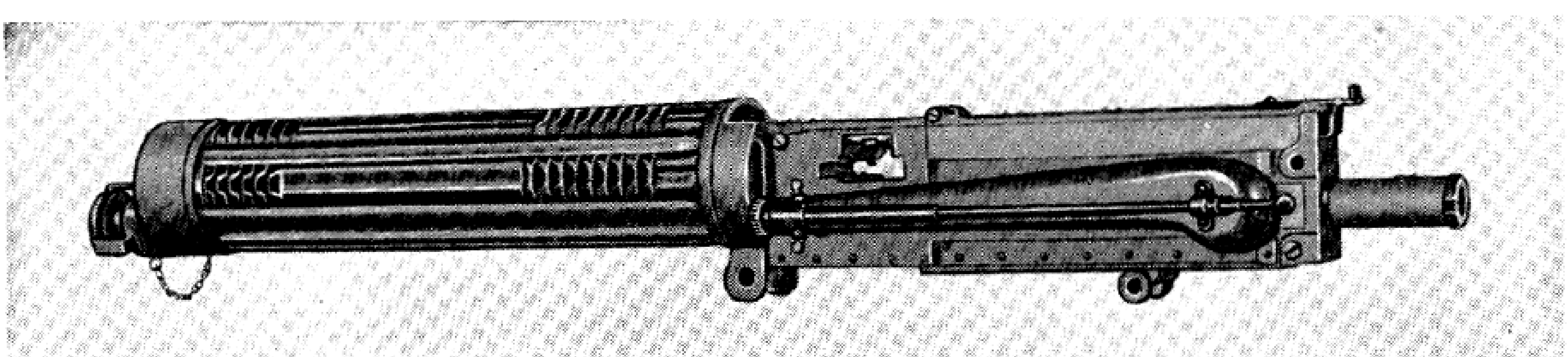
The first British planes equipped with the fully modified speeded-up Vickers guns were ordered not to fly beyond their own lines as the changes were classified as "Top Secret" and the Royal Air Force wished to battle-test the improvements thoroughly behind its own lines before beginning mass production. It did not want the Germans to salvage one of its test planes through being shot down behind enemy lines. No doubt memories were still vivid of the forcing down of Roland Garros in German territory and the capture of his bullet deflector which resulted in the reliable Fokker synchronization system.

Another increased rate-of-fire attachment under consideration at the time of the Hazelton device was the invention of Lieutenant Dibovsky of the Russian Navy, who had earlier been unsuccessful in getting his synchronizer adopted. While his booster did get the Vickers well over 1,000 rounds per minute, the action of the gun was so violent that it required many other compensating adjustments to keep breakage from being prohibitive. The parts of the Dibovsky attachment were also very complicated to manufacture. Since the speeds of both the Dibovsky and the Hazelton were practically identical, it was logical that the British adopted the latter.

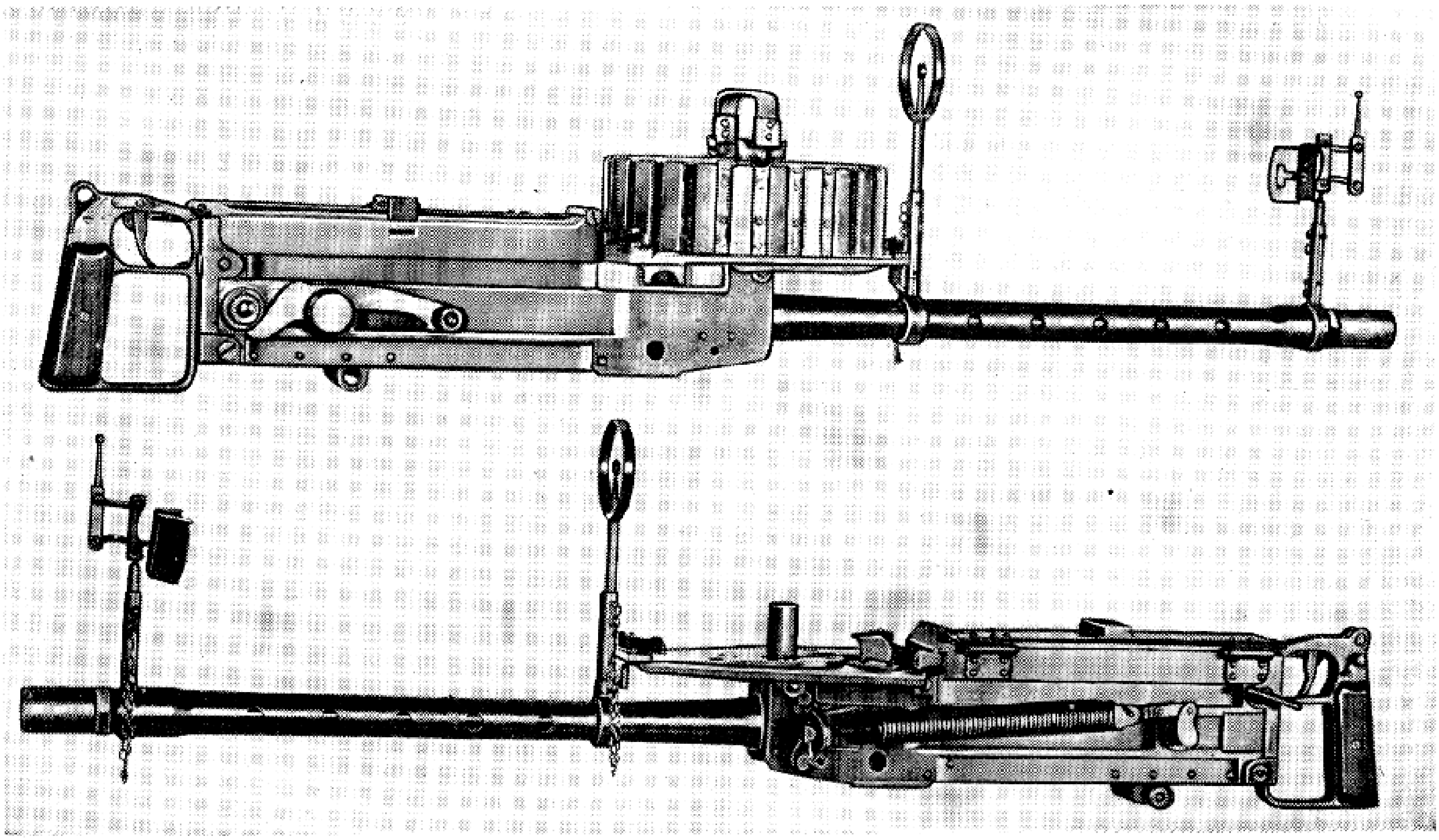
Both devices utilized the blast following the bullet's clearance of the muzzle to add to the recoil forces and furnish surplus energy to accelerate the recoiling mechanism. The trapped gas expanded in the chamber and, acting on the face of the barrel, shoved it rapidly to the rear.

A great deal of difficulty was experienced in using cloth or fabric ammunition belts in air firing the Vickers, because during a "dog fight" the empty end of the belt would blow back in the pilot's face or become entangled with some part of the plane. The problem was remedied by the adoption of the metal link disintegrating belt. As each cartridge was extracted and fed into the gun, the link would separate from the rest of the belt and either drop in a canvas bag or fall harmlessly over the side. This unique but practical method of feeding the Vickers was invented in 1917 by William de Courcey Prideaux of Weymouth, England, a French civilian who at the time was residing in Great Britain. One of the best features of the disintegrating links was that all Vickers could be modified to use them simply by changing two small parts in the feed system.

As each new problem in aerial warfare pre-



Vickers Aircraft Machine Gun, Model 1918, 11 mm Manufactured by Colt's Patent Fire Arms Co.



Vickers Aircraft Machine Gun, Class "F", Cal. .303.

sented itself, it was solved by some eager inventor. Difficulty in sighting was overcome by the appearance of tracer ammunition in which the base of the bullet contained a mixture that ignited when going through the bore and provided a luminous trajectory from the muzzle to the target. The mixture first used consisted of barium oxide, a very high oxidizing agent, combined with powdered magnesium, a substance that burns rapidly with a visible flame. This, like the other refinements, only added to the deadliness of the weapon. The tracer not only allowed the gunner pilot to correct the course of his plane until his bullets made contact, but in many cases, it ignited gas or inflammable surfaces upon hitting the plane and the victim plunged to earth in flames.

Within a few months armament on all fighting planes had increased tremendously without basic changes merely by refinement of an existing machine gun. The effectiveness of air combat increased proportionately. This short period removed for all time the early semicomical aspect of military aviation; in fact it was an unusual month after January 1917 that did not bring either some radical refinement or an accessory that contributed to the deadliness of air warfare. The machine gun was already far ahead of aviation and only needed application of various theories to make it as efficient in the air as it was on the ground.

During 1917 the Allied air command saw need for an aerial machine gun larger in caliber than the conventional rifle bore for use against observation balloons. The French were the first to modify the Vickers to take their 11-mm Desvignes cartridge in order to provide more of the tracer and incendiary elements.

The Russians were using a larger caliber Vickers than the other Allies and this fact made it the easiest of the various Vickers to modify for the large French cartridge. An order was placed with Colt's Patent Fire Arms Co., Hartford, Conn., to alter a thousand Russian guns to shoot the 11-mm cartridge. When this was done, early firing tests showed that the rifling pitch was too pronounced and threw the tracer element out of the bullet soon after leaving the muzzle. The difficulty was caused by the rifling which cut the bullet jacket too deep and made the rear of the bullet fan out. When the pitch was changed from one turn in ten to a complete revolution in 22 inches, the performance of the bullet was satisfactory.

The design of the weapons, except for the caliber, was identical with that of the smaller bore guns, and they were accepted with such enthusiasm that large orders were placed both in England and America. An additional order was placed with Colt for 1,700 guns after the company had filled the initial order. The weapon fired at a rate of 600 rounds a minute with an effective incendiary tracer range of 1,850 yards.

American ammunition factories were also ordered to make the new French incendiary bullet. This cartridge and the conventional gun made an excellent combination for attacking observation balloons and firing the gas tanks of fighter planes.

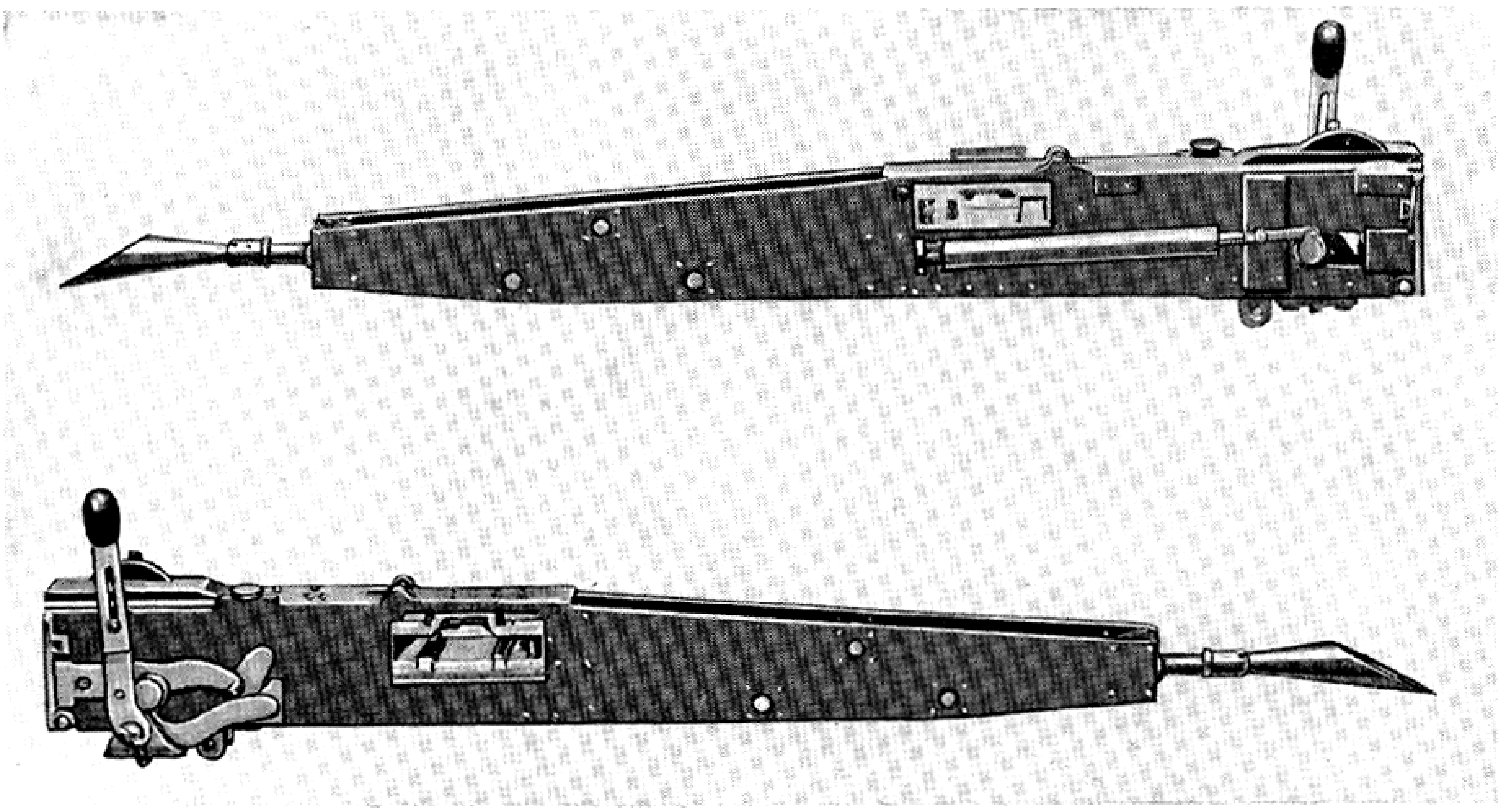
The Russian Vickers was chosen to be altered largely because at this time a revolution was raging in Russia and the Colt Co. could not deliver weapons ordered by the Czarist Government. The Allies, knowing they would have to rechamber the barrels anyway in order to use them, felt they were the most logical ones to alter for the larger cartridge.

The inferior French ammunition, inadequate as it was in some respects, showed aviation authorities that a large bore machine gun or automatic cannon was a necessity in air warfare of the future.

The Vickers-Maxim mechanism was so reliably constructed that an attempt was even made to convert it to an observer's gun, in spite of the fact the Royal Air Force believed it already had the world's best gun of this type. The conversion consisted in putting a 97-shot drum feed on the weapon although belted cartridges could be used if need be. The drum was actuated by recoil of the barrel and barrel extension which engaged a lug with a cam on the circular feed and rotated it enough to index a round in line with the rising T slot on the bolt face.

This large drum protruding above the already high receiver did not make a very compact weapon. Most certainly it could not compare with other machine guns which were more in keeping with conditions of limited space and maneuverability. The location of the drum across the line of sight also made necessary an unusually high and unsatisfactory sighting arrangement. The weapon remained in a protoype form for a few years following World War I.

When motors capable of high altitudes were



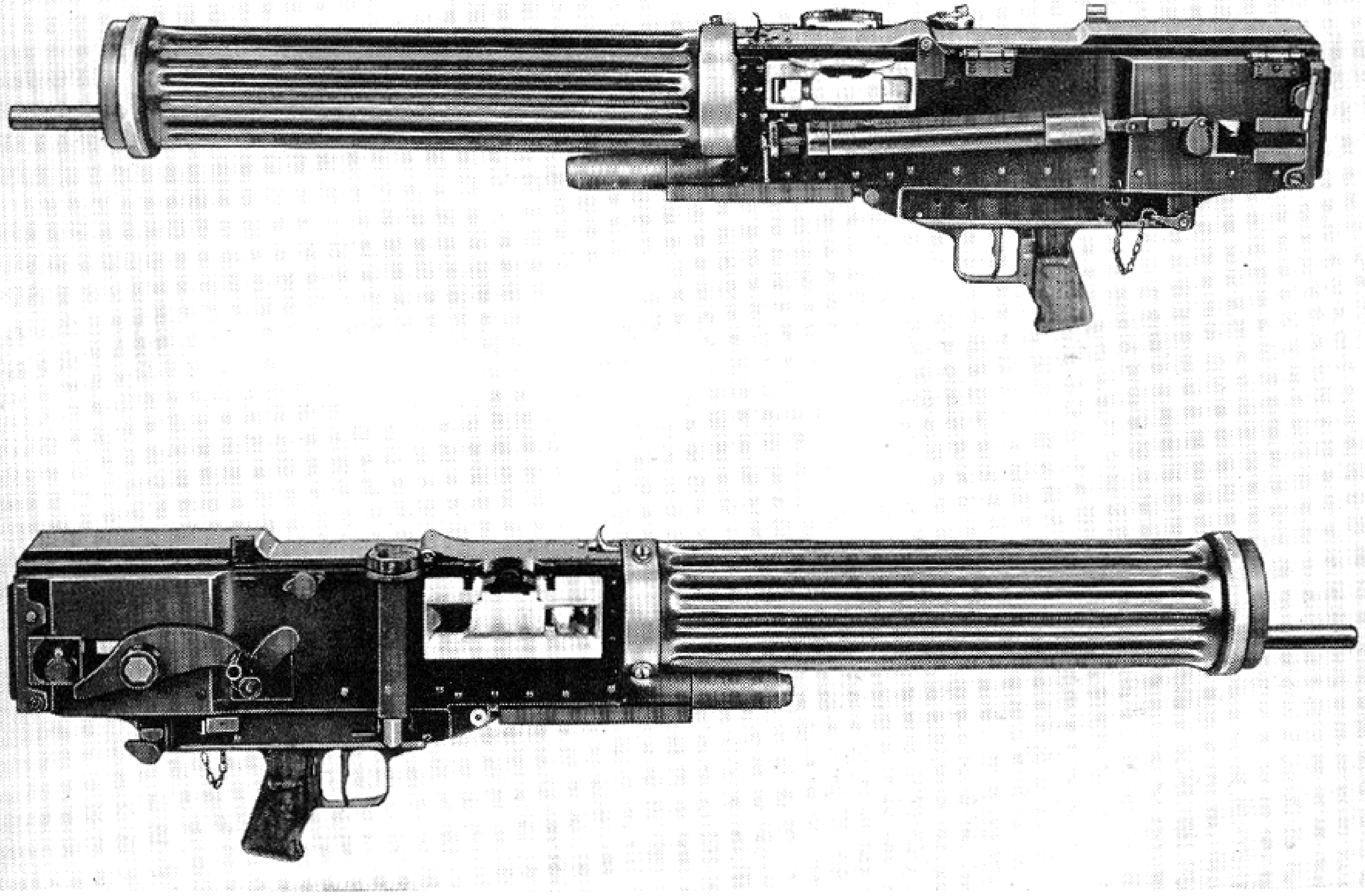
Vickers Machine Gun, Mark C, Cal. .50.

finally designed, naturally air fights took place at the new heights and pilots began to have new kinds of malfunctions that were traced to the extreme cold at these altitudes. Reports of stoppages became so prevalent that electric heaters were improvised by ordnance mechanics in collaboration with field electricians. Finally when a heater was made that proved adequate, manufacturing drawings were sent to the Vickers Co. and it was mass produced.

The greatest percentage of stoppages at high-altitude firing came from the gumming up of oil on the mechanism and the resulting sluggish movement caused excessive jams. To correct the situation, the parts were heated by copper pads on each side of the weapon, held in place by the same bolts that secured the cam. As all the moving parts were at one time or another brought into contact with the cam, it was felt that, if the latter was kept hot, it would in turn keep them warm enough to function smoothly under any cold encountered. The weapons were also aided by the type of mountings used. In most cases they were placed in recesses in the cowling with only the top half of the jacket and the bore of the barrel uncovered.

To operate the Vickers high-speed aircraft machine gun, the pilot gunner first places the brass tag end of the cartridge belt, if a fabric belt is used, through the feed block from the right side. With the left hand he pulls it through as far as it will go. At the same time the crank handle is rocked back on its roller to its full limit, and while in its rearward position the belt is again pulled one more space, indexing the incoming round.

The crank handle is now released and flies forward under its spring tension. The sliding face on the bolt moves up when all parts are in battery, allowing its T slot to slip over the cartridge rim. Again the handle is pulled rearward and at the same time the ammunition belt is pulled over the space of one round. When the



Vickers Machine Gun, Mark V, Cal. .50.

belt moves left as far as it will go, the handle is released.

This second cycle places the first cartridge in the chamber and the **T** slot is over the incoming round in the feed belt. The weapon is now charged for firing. The pilot, when ready, depresses the trigger fastened on his stick and by either a mechanical or oil pump arrangement the synchronizing device sears off the first shot, with the powder gases driving the bullet down the bore. The barrel and bolt remain locked together until the bullet clears.

The Hazelton device is located on the end and as soon as the bullet leaves the muzzle, it enters an orifice that is slightly larger than the bore. The gas that has been driving the bullet expands in the trap back of the orifice, and acts on the face of the barrel. It accelerates the rearward action, not only hastening unlocking but greatly speeding up the recoiling parts.

As the weapon's toggle joint is being broken to unlock, it exerts initial extraction on the empty case and loosens it in the chamber. By the time it unlocks, the cartridge case is free as the **T**-slot extractor carries it rearward. The **T** slot withdraws the incoming round from the belt and the bolt face is forced down by action of the side cams. When the recoiling parts reach the extreme rearward position, they encounter the modified buffer which returns the mechanism at high speed. As the bolt moves to battery, the live round is put into position for chambering and at the same time knocks the empty case free of the **T** slot through the opening beneath the receiver. In the last fraction of travel into battery the **T** slot is cammed up over the rim of the incoming round. The sear is released when the toggle locking joint advances beyond the center line. As long as the sear remains depressed, the cycle is repeated.

Following World War I, a vast number of Vickers aircraft machine guns were left in stock, but their manufacture had been such that the interchangeability of parts could not be assured. They had been fabricated by many different companies under war conditions. With the let-down in ordnance development that followed the conflict the difficult task of overhauling these guns was undertaken, including the modification of certain parts to improve reliability and insure the ease of changing parts.

The guns, when completely gone over, were designated Mark V. It took from five to eight of the earlier models to make one of the improved versions. England finally wound up with a sizable quantity of the weapons and felt secure as far as aircraft armament was concerned until the decision was made to arm its future fighters with eight guns apiece. Then the director of equipment realize that the guns in storage would not last any time in the event of war.

The Vickers-Maxim guns on hand at the beginning of World War II included the outmoded class E of World War I vintage, and the class F observer's gun that fed from both drum and belt. Both weapons were in rifle caliber. In caliber .50 were the Mark C, a peculiarly designed weapon intended for use against armored vehicles and for antiaircraft work and the Mark D for antiaircraft use. The latter fired a high velocity projectile having a rate of 3,000 feet per second.

While these weapons were admittedly out of date, they were not replaced by better aircraft guns until after they had carried the Royal Air Force victoriously through the battle of Britain in a decisive struggle for air supremacy from the Allies' point of view.

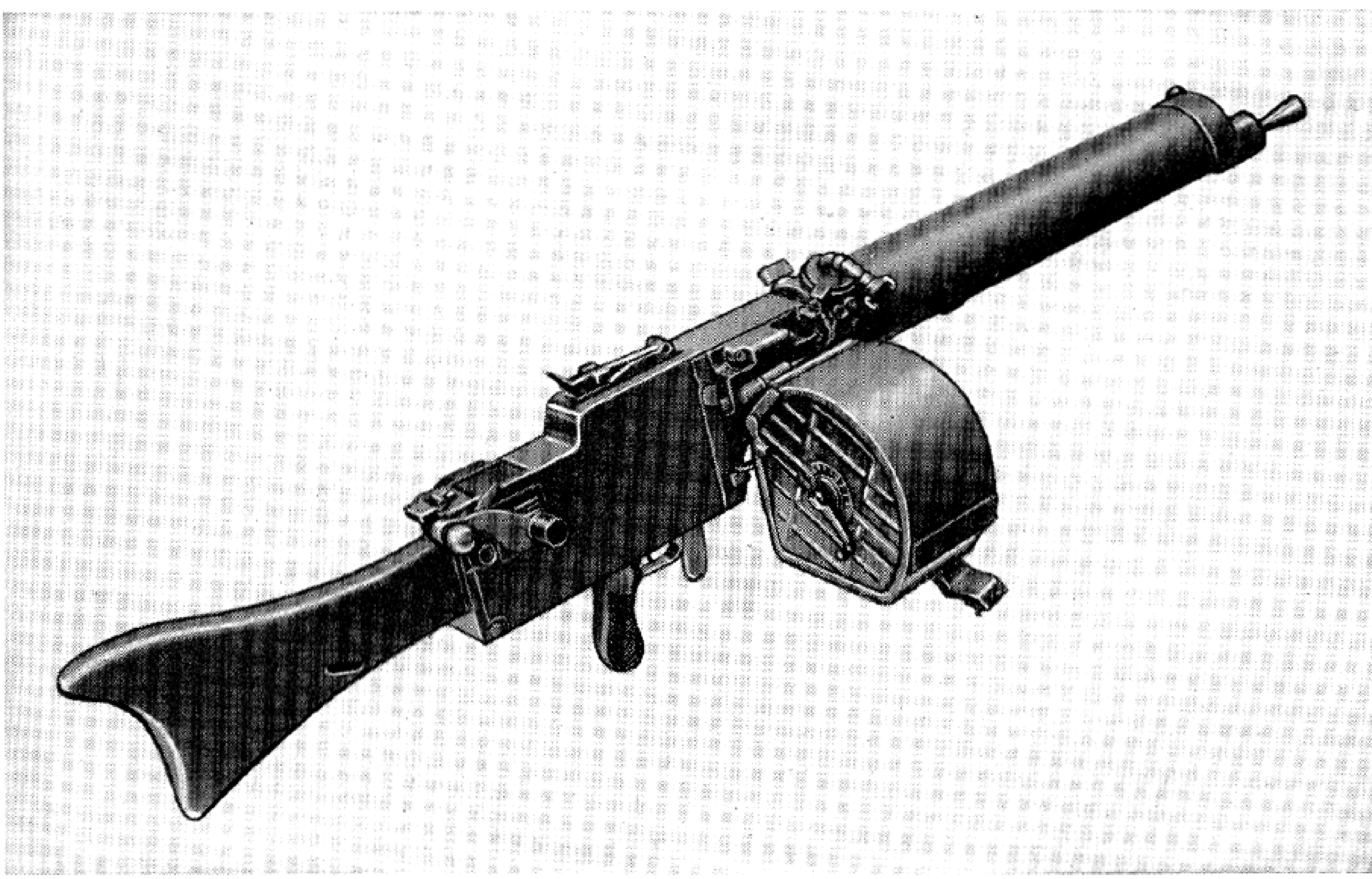
Chapter 4

GERMAN MAXIM-TYPE AIRCRAFT WEAPONS

Early Adaptations

The German Government had prepared well for the inevitable conflict known as World War I. It decided early that machine guns would play a dominant role and concluded from secret tests that the Maxim machine gun, as it was still known in Germany, was the most reliable firing mechanism yet designed. The Model '08 Maxim was adopted as its first line machine gun. A later refinement to the standard '08 model resulted in a lighter version known as the '08/15. The water-cooled weapon was still fairly heavy and its 50-round belt with container could be attached on the side. A shoulder stock was also added together with a lightweight bipod of 2½ pounds. The total weight without water but with bipod was 31 pounds. The '08/15 differed from the '08 gun principally by its method of cooling. On this version the water jacket was simply filled and the jacket plug screwed in. There was no way to circulate the water as provided for in the heavier gun.

The weapon was produced in unusually great quantities as its modification from the original '08 model was comparatively easy. Allied intelligence agents estimated that at the outbreak of the war Germany had at least 12,500 Maxim-type guns stored in huge warehouses and 50,000 more on order. That the nation's existence was



Maxim Machine Gun, Model '08/15, 7.92 mm, German.

entrusted to this one type of machine-gun mechanism shows the extent of German confidence in the principles developed by an American, Hiram Stevens Maxim.

The '08 and '08/15 models were both used extensively in arming Zeppelins against hostile aircraft. The Germans felt that the tops of the dirigibles made unusually stable platforms from which to fire bursts of any length desired, thanks to the water cooling of the barrels. The lack of a critical weight factor with the Zeppelins allowed German airship commanders to install water-cooled Maxims both on the top gun platforms and along the sides of the gondolas.

As early as a year before the war, the German press publicized the remarkable successes scored by machine gunners firing from the decks of Zeppelins. Part of a story appearing in September 1913 is here quoted to show the confident attitude of the crews that manned the airships:

"As could be foreseen from the absolute stable nature of that gun platform and from the entire lack of vibration and swaying, these tests were almost as successful as they would have been had the machine been discharged from the top of a mountain. The writer speaks from experience having made tests in aiming from the window of the cabin of the Zeppelin in flight. . . . We can depend upon seeing cannon appear on the large dirigibles in strict accordance with this stage of development by the enemy just as we saw machine guns appear which are now ample protection against airplanes."

But with all their planning, the Germans did not foresee the incendiary bullet and its effects. The British shot the Zeppelin and its superior armament out of the sky by puncturing its huge hydrogen-filled envelopes with flaming bullets. In a few short months the reign of the much-dreaded airship ended.

Parabellum Machine Gun

The German Government a good many years prior to the war placed large orders for machine guns with its main arms-producing factory, the Deutsche Waffen- und Munitionsfabriken, located in Berlin. This company had unquestionably the greatest staff of gun experts to be found in any country. Its original head engineer had been an American, Hugo Borchard, the inventor of a pistol afterwards erroneously named for his assistant and successor, Georg Luger. Early in 1911 a gun designer, Karl Heinemann, joined the firm. He had already made a name for himself in the field of automatic weapons. Heinemann was given the all-important job of refining the Maxim gun. His resulting achievement was one of the most outstanding efforts to come from World War I. The German Army, committed to the Maxim gun which was already under production, specified the mechanism must be of this type. It requested a lightweight high-speed gun that would fire the same 7.9-mm Mauser cartridge as did its heavy machine guns and infantry rifle. To make a definite improvement on such a time- and battle-tested weapon required the utmost skill and Karl Heinemann proved equal to the occasion.

The product of his effort was labeled the "Parabellum," which was the code name of the D. W. M. plant when referred to in correspondence. This superb weapon, like so many of its contemporaries in other countries, did not attract the attention it deserved until the necessity of war gave it a place among the finest automatic firing mechanisms.

Heinemann made the toggle joint break up instead of down, as in the original Maxim. The return spring was placed centrally against the crank and stored energy during the recoil stroke. The act of feeding was performed by a pawl working off the lock instead of by vertical movement of the lock itself. A differential action was also incorporated to speed up feeding of the next to the indexed round. This was done by forcing the barrel forward by cams before the recoiling lock had reached its extreme travel rearward. A faster rate of fire was made possible by such utilization of the feed pawl. The feed belt was made of cloth or fabric wound on a spool fastened to the gun's receiver, thus allowing it to swing with the gun. In contrast with the earlier model the fusee spring was not adjustable.

This refinement by Karl Heinemann was the lightest Maxim-action gun ever designed. It weighed only 22 pounds without accessories, with a 700-round-a-minute rate of fire. Needless to say, it was the very thing the German Air Force

Parabellum Aircraft Machine Gun, Model 1913, 7.92 mm. This Early Type Used the Water-Cooled Jacket Slotted for Air Cooling.

was looking for when its Zeppelin threat was exploded by British machine-gun fire. The Parabellum was the German first-line aircraft machine gun throughout the war. A few have also been found equipped with water jackets for ground use or perhaps more logically for Zeppelin mounting.

The following cycle of operation of Karl Heinemann's Parabellum, or refined Maxim gun, is given:

When the cartridge is fired, the whole inside portion travels backward with the breechblock still firmly locked to the barrel until the outside crank comes in contact with the resistance roller. The crank then begins to turn downward, carrying with it the connecting rod, the other end of which draws the breechblock away from the barrel.

The weapon has a sliding **T** slot that also recedes, with the live cartridge drawn from the belt and the empty case from the barrel. It is guided and supported by the projections extending sidewise from its upper end, which ride over the straight part of the side cam, riveted to the side plates, until the cartridge just drawn out of the belt is clear of the feed way. Then the projections follow the downward-curved edge of these cams, guided from the top by an inversely curved cam, formed on the guide piece for the breechblock and riveted to the under side of the cover.

During this period the connecting rod in its downward movement presses against the tail of the tumbler, which, in its turn, draws back the firing pin and compresses the mainspring. The sear engages into a notch in the tumbler and the safety sear re-engages with a shoulder on the firing pin. When nearly at the end stroke of the breechblock, the **T** slot's projections leave the points of the side cams and the **T** slot drops into its bottom stop by its own gravity assisted by the guide directly above it.

This alines the cartridge with the chamber of the barrel, which pushes the empty case clear of the bolt face and through the slot in the bottom of the receiver. The crank, having now completed its rearward turn, begins its return stroke, and the advancing breechblock forces the live cartridge into the chamber.

In this operation the Parabellum's **T** slot is steadied, as its projections are kept in contact with the lower surface of the side cams. As the crank returns toward its horizontal position, projecting cams, or side levers of the connecting rod, come in contact with the ends of the lifting levers, pivoted to the breechblock and thereto by the pin. The other ends of these lifting levers are engaged between two lugs on the carrier. When they are pivoted by leverage of the cams on the connecting rod, the carrier rises with a steadily increasing velocity and the lower part of the upper stop slides over the head of the live cartridge in the chamber. At the same time the upper part of the **T** slot slips over a fresh cartridge in the feed way and retains it in position between the grooves of the **T** slot and the upper and lower parts of the stop.

When the **T** slot arrives at the top, the end of a leaf spring, riveted to the right-hand recoil plate, drops into a notch cut on its side and keeps it in that position until, in its rearward travel, the projections slide onto the side cams and support it.

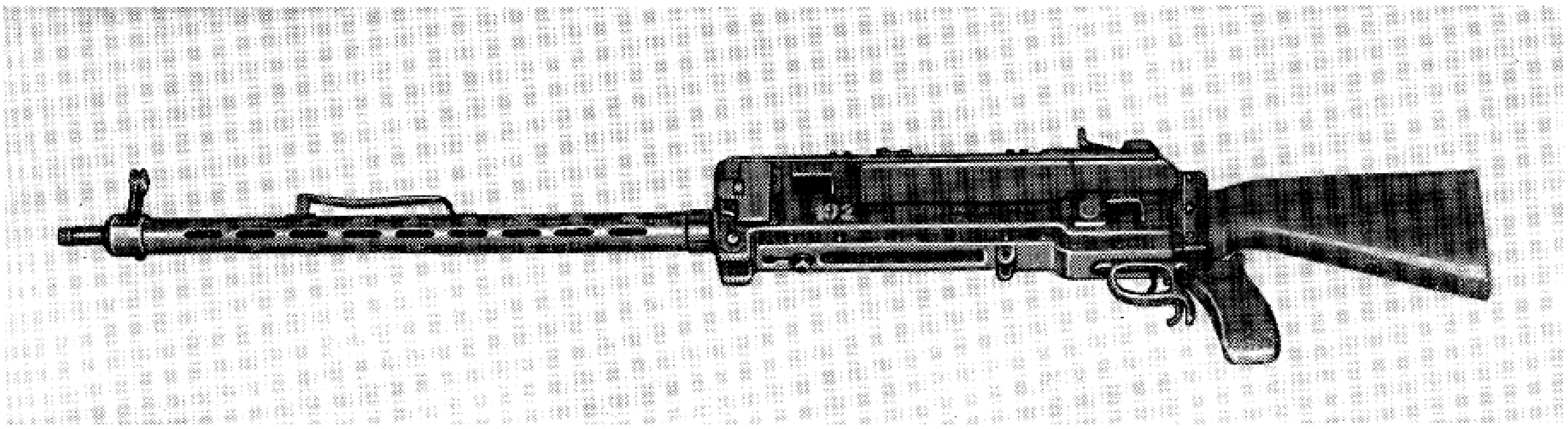
The crank and connecting rod, having resumed their firing position, brace the breechblock hard against the breech. At the last moment the connecting rod lifts the safety sear. The effort of the mainspring is thrown upon the hand sear. If now the trigger bar at the bottom of the gun casing is held to the rear by continued pressure on the trigger connected thereto, the tail of the sear will strike against the lug at the free end of this bar and set free the firing pin, the point of which will pass through its tunnel in the bolt face and explode the primer. The cycle described will continue as long as the trigger is kept depressed.

The Fokker Synchronizer

Since the action of the Parabellum was front seared, it was ideal for synchronizing when employed as an observer's gun. It was used in such a manner after Antony H. G. Fokker, the famed aircraft designer, developed a mechanical method of firing safely through the propeller blades.

He conceived his idea when shown the crude arrangement of a French plane that had been shot down when attempting to fire through the air screw. Bringing his inventive genius to play after examining the enemy device, Fokker produced an interrupter gear. While he was acclaimed for his feat, his invention was actually based on a patent issued in 1913 to Franz Schneider, a Swiss aeronautical engineer, who had offered his invention to the German Army as early as 1912. After examination, it had been rejected as unnecessary, since there was no possibility that the airplane would ever become a fighting machine. At the time the Zeppelin so dominated the German mind as the perfect aerial weapon that the value of Schneider's patent could not be foreseen. It was only in an hour of desperation that Germany was provided with Fokker's version of the Schneider synchronizer.

Antony Fokker was born in Batavia, Java, in 1890 and at an early age showed a genius for invention. This brilliant Netherlander was already an experienced aviator and airplane designer when World War I broke out. He had previously offered his designing talents to his own country, then to France and to Britain, only to be ignored by each. Germany accepted his services at once and the resulting relationship came within a hairbreadth of costing the Allies the war. Eng-



Parabellum Aircraft Machine Gun, Model 1913, 7.92 mm, with Refined Barrel Jacket.

land, which had paid no attention to the "young fanatic," later secretly offered him £2,000,000 for his services.

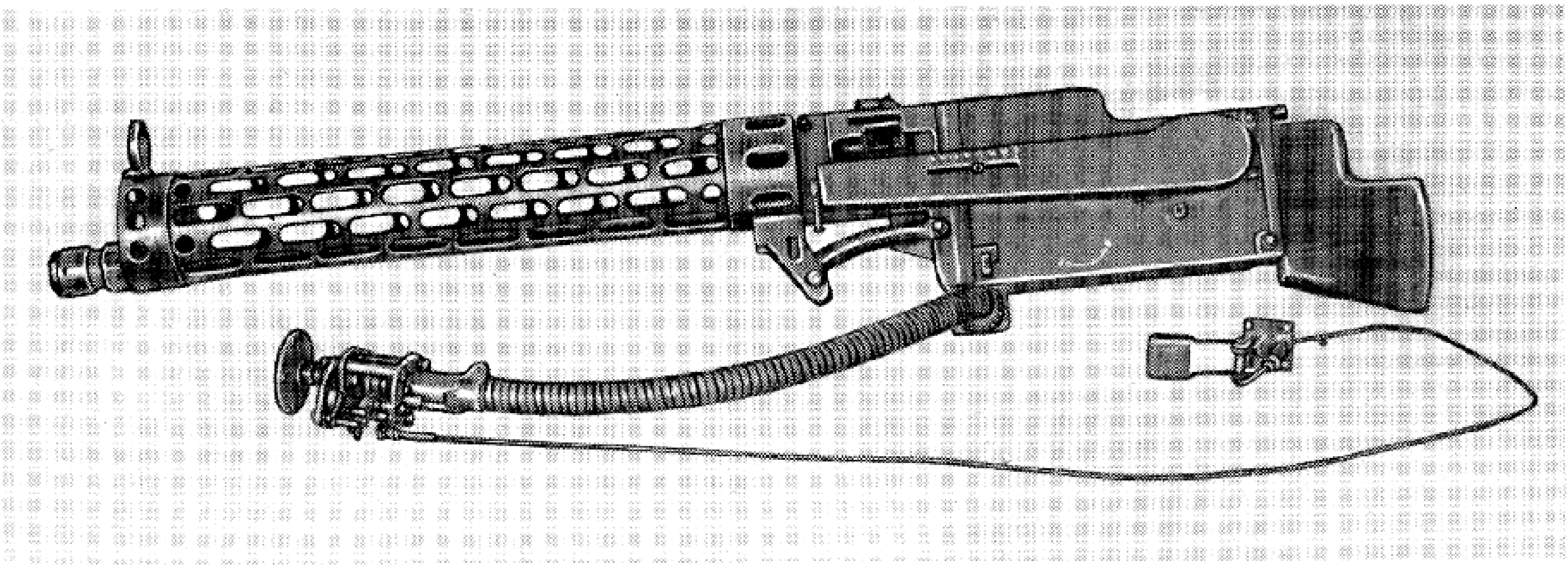
It is hard to believe that this man who gave Germany domination of the air for 6 months was barely 24 years old at the time. The act that accomplished it was but incidental to his really notable work in the design and construction of the Fokker fighter planes. Within 48 hours after examining the makeshift French device, he produced a reliable interrupter gear based on Schneider's patents. It added a hundredfold to the deadliness of the superb fighting craft of his own design. The fact that he had never handled a machine gun before in his life made his feat even more astounding. The German staff was highly incredulous that he could turn out anything worthwhile in such a short time, and Fokker gained its confidence only by repeated demonstrations with a motor on the ground.

The first German pilot to use the synchronizer against the enemy was Lt. Oswald Boelke, later to become Germany's pioneer ace in great part because of this device. The next flyer to install one on his plane was Lt. Max Immelmann, also destined to become a great air fighter. After hesitation in the beginning, the General Staff became wildly enthusiastic about the new weapon. They had a right to be as the synchronizer gave them a superiority that took many months for the Allies to overcome.

While there was great similarity between the German and the later British mechanical firing devices, except the Constantinesco type, the secret of the Fokker-Schneider system was that the interrupter gear kept the trigger depressed while the propeller arc was clear. It let up on the sear at the approach of the leading edge of the blade which acted as an interrupter only in a burst. The British device worked just the opposite in that it tried to release the sear by a series of lugs striking cams. This allowed bullets to hit the blade if anything worked loose or if anything happened to change the timing of the weapon, since each individual impulse fired a shot. The German synchronizer fired a continuous burst except when the approach of the propeller and its corresponding lug on the shaft interrupted fire until the trailing edge of the blade had cleared.

The German fighting plane's propeller in normal flight rotated 1,200 times per minute, and as this made the blades pass a given place 2,400 times, it can readily be understood that the timing device must be foolproof in design. With a 6-inch space passing a given point 2,400 times a minute, the fundamental fact underlying the successful operation of any synchronizer is the relatively greater velocity with which the bullet is traveling to that of the turning blade.

The first Fokker planes, the E1, E2, and E3, equipped with the Dutch inventor's interrupter gear, appeared on the Western Front in December 1915. They gave the Allies a decided setback and caused many casualties until something as efficient was produced as a countermeasure. The Fokker fire interrupter was one of the German Air Force's top secrets, although in April 1914 Franz Schneider not only had allowed the New York publication, the *Scientific American*, to print an article describing the device, but had furnished drawings showing its construction. The Allies, however, did not realize its value until much later.



Maxim Machine Gun, Model 08/15, 7.92 mm, Modified for Synchronizing. This Weapon Manufactured at the Spandau Arsenal is Often Called the Spandau Machine Gun.

In connection with the first test of the synchronizer, the following graphic story is told in Fokker's own words:

"While I was flying around about 6,000 feet high, a Farman two-seater biplane, similar to the ones which had bombed me, appeared out of a cloud two or three thousand feet below. That was my opportunity to show what the gun would do, and I dived rapidly toward it. The plane, an observation type with propeller in the rear, was flying leisurely along. It may even have been that the Frenchman didn't see me. It takes long practice and constant vigilance to guard against surprise air attack, for the enemy can assail one from any point in the sphere.

"Even though they had seen me, they would have no reason to fear bullets through my propeller. While approaching, I thought of what a deadly accurate stream of lead I could send into the plane. It would be just like shooting a rabbit on the sit, because the pilot just couldn't shoot back through his pusher propeller at me.

"As the distance between us narrowed, the plane grew larger in my sights. My imagination could vision my shots puncturing the gasoline tanks in front of the engine. The tank would catch fire. Even if my bullets failed to kill the pilot and the observer, the ship would fall down in flames. I had my finger on the trigger. . . . I had no personal animosity toward the French; I was flying merely to prove that a certain mechanism I had invented would work. By this time I was near enough to open fire and the French pilots were watching me curiously, wondering, no doubt, why I was flying up behind them. In a moment it would be all over for them.

"Suddenly I decided that the whole job could go to hell. It was too much like 'cold meat' to suit me. I had no stomach for the whole business, nor any wish to kill Frenchmen for Germans. Let them do their own killing!"

Introduction of Armored Planes

In 1917 the Gotha Waggonfabrik Co. designed and built for the German Air Force a battle plane that had great influence on future machine-gun design. This aircraft was known as the Gotha biplane, a huge affair with a wing span of 78 feet and an over-all length of 41 feet. The motors were encased in nacelles resting in the lower wing. It was a three-seater, with space for two observer gunners and a pilot. The armament consisted of three machine guns, two Parabellums and a water-cooled Maxim. The latter was mounted in an ingenious tunnel under the aft part of the fuselage so that the rear gunner could fire with an unobstructed view below and to the rear of the machine.

Having great lifting power and with weight not being a critical factor, the Gotha had armor placed over vital parts in the engine and around crew members. The unusual fire power, armor and absence of unprotected blind spots made it a formidable foe to encounter. The Allies lost many pilots who tried to attack the ship from beneath only to be cut down by the concealed gunner, using a water-cooled gun that permitted bursts of any necessary length.

Quentin Roosevelt, an American pilot and son of ex-President Theodore Roosevelt, was killed while attacking one of these Gotha planes from below. Witnesses of the fight saw many of Roosevelt's tracers hit the Gotha only to bounce harmlessly off the armor. The young pilot's death and the impotency of his guns made our ordnance officers realize something had to be done at once to overcome this tremendous advantage.

The caliber .30 was definitely outmoded from then on. The first thing done was to use the principle of Thorsten Nordenfelt and produce an armor-piercing bullet. The next was to demand the design of a larger caliber higher velocity cartridge and a machine gun to fire it. The Gotha battle plane was the first incentive for larger bore guns. It was only a few days after Quentin Roosevelt's death that Gen. J. J. Pershing cabled our Ordnance Department giving minimum specifications that he considered necessary for an adequate machine gun. In this correspondence he stated that the velocity should not be under 2,750 feet per second and the caliber be a minimum of one-half inch. While the passing years have proved the general's wisdom, it was the German Gotha biplane which showed to all concerned that the day was over when an infantry type machine gun could bring to earth a military fighting ship.

The T. u. F. Machine Gun

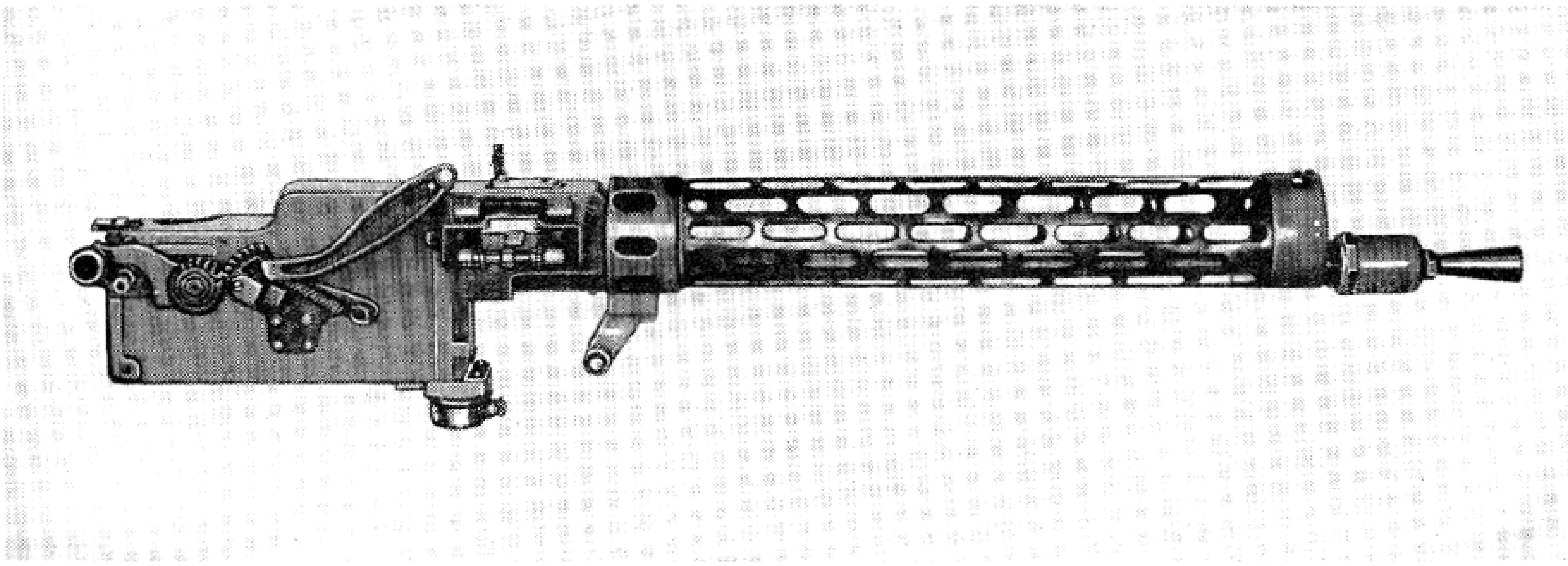
The Germans, being the first to armor their own planes, knew that by doing so their existing rifle-caliber machine guns likewise would be made obsolete for aircraft use. They proceeded with typical thoroughness to prepare for the day when their airmen would have to contend with armor on enemy planes. This vital need for a machine gun firing a bullet large enough and with enough velocity to penetrate heavy armor was brought to their attention in a more forceful way by the British use in 1917 of heavy armored motor-propelled land vehicles called tanks.

To combat this new weapon, the Germans quickly scaled up their 7.9-mm infantry rifle cartridge to 12.7 millimeters, having a 770-grain boat-tailed bullet with a muzzle velocity of 2,650 feet per second. When a tungsten steel core was used, to their agreeable surprise it penetrated the sides of captured British and French tanks easily at 100 yards. The armor was in some places as much as one and a fifth inches in thickness. The newly designed cartridges were then being fired in a clumsy bolt-action single-shot rifle, employed through desperation as an antitank weapon. It was realized that, if an automatic firing mechanism could be produced capable of handling the new ammunition, the British advantage from the use of armored tanks would be quickly overcome.

As the Maxim Model '08 caliber 7.9-mm machine gun was Germany's main standby in its highly efficient automatic weapon units, and as the German ordnance designers had seen the identical mechanism used in a shell gun of 37-mm bore, called the "pom-pom," the most logical solution for the problem seemed to be the designing of a Maxim action between these two extremes that would successfully handle the high-velocity 12.7-mm antitank rifle cartridge. In early 1918 this was done in great secrecy and with a manufacturing priority second only to that of the high cyclic rate Gast aircraft machine gun. The latter weapon was counted on to give the nation air superiority.

The German high command felt that the large caliber machine gun would simply annihilate the armored units of the enemy both on the ground and in the air. Consequently they named their new and deadly devisement the "T. u. F." (*Tank und Flieger,* meaning *Tank and aircraft*) machine gun. The intended use was clear from its name. But regardless of the excellence of the idea, the fabrication of components did not reach a stage where it ever saw action against the enemy. There were 4,000 T. u. F. machine guns on the point of delivery when the Armistice was signed.

With the coming of the army of occupation, the German Army's ordnance section, which supposedly did not exist, according to the Versailles treaty, but was nevertheless highly active, or-



Maxim Machine Gun, Model '08/15, 7.92 mm, Modified for Aircraft Installation.

dered that the weapons be hidden and that all correspondence concerning them be done in code.

Two of the code designations given the weapon were "Machine gun 08" and "SS machine gun." The Germans believed that the Allied intelligence had knowledge of the development of a super antitank and aircraft machine gun, but felt the weapons could be concealed since none had ever been on a battlefront. The designation "Machine gun 08" was used to create confusion with the ordinary 7.92-mm infantry-type machine gun. During the war numerous model '08 Maxims were altered to take a Schwere cartridge having a slightly different shaped bullet, and these guns were marked with a large letter "S" on top of the receiver to show modification. The Maxims so labeled were known in an unofficial way as the "S" machine guns. The Germans hoped that the addition of a second "S" in their code for the T. u. F. would obscure its existence.

Photographing of the gun and its movement to storage without first being covered were not permitted. However, an Allied commission sent into Germany not only learned of the existence of the weapons but also seized all correspondence between the underground German ordnance group and the companies that manufactured and assembled the components. They found beside the 4,000 originally promised for fall delivery that an additional 2,000 had been ordered as late as October 1918. Thus the German Army expected to have on hand 6,000 such weapons to meet the well-advertised Allied spring offensive that the Armistice canceled.

The T. u. F. was made up of 250 components, manufactured by 60 different companies. These parts were delivered to the Maschinenfabrik Augsburg-Nuremburg, which was especially charged with assembling and mounting the weapon. All steel used in this high priority work was delivered exclusively by the Siegen-Solingen-Gusstahl A. V., located in Solingen.

The Germans succeeded, after finding that the Allies had possession of all facts concerning the gun, in destroying practically all assembled ones and it was with the greatest difficulty that ordnance men of the United States Army in August 1921 finally located a T. u. F. with 82 cartridges. This gun, along with the small amount of ammunition, was eventually shipped to Springfield Armory for test. There being only the few cartridges available at the time, no conclusion as to its merit could be reached. Besides, there was under development by Colt's Patent Firearms Co., of New Haven, a caliber .50 machine gun that was considered by all to be a genuine improvement on the German version. The cartridge used by the American gun, however, was later copied from the one fired by the T. u. F., it having better ballistic characteristics than the one being developed in this country.

The unusually high regard the German authorities had for the weapon is shown by the following: Even after practically all of the supply had been destroyed, as a result of the Inter-Allied Control Commission's discovery, the outlawed German ordnance authorities notified by telephone the 60 plants previously engaged in making the components not to stop fabrication of these parts. A written order was later found that guaranteed payment to the companies for the finished parts even if they were seized by the Allied occupation forces, and that directed them to "continue to manufacture them at all costs." The Allies in due time stopped all production on the gun in Germany but it took several years to accomplish it.

In 1923 it was reported to the United States Army Ordnance Department that German patents had been granted on the design of the T. u. F., which had been sold to Czechoslovakia by Mr. A. Ten Bosch, a civil engineer of the Hague, Holland, to whom they had been assigned. Ten Bosch had retained the rights for production of the weapon in the United States, but the Army was not interested.

Models of Maxim Guns

At the conclusion of the discussion of Maxim-type weapons in this publication, a tabulation is given, for ready reference, of the various Maxim systems and models used by the nations of the world:

System	Country	Designation	Bore
Vickers	Holland	Model 1918	7.92 mm
Maxim	Germany	Model 1899	7.92 mm
Maxim	Germany	Model 1901	7.92 mm
Maxim	Germany	Model 1908	7.92 mm
Maxim	Germany	Mod. '08/15	7.92 mm
Maxim	Germany	Mod. '08/18	7.92 mm
Parabellum	Germany	Model 1914	7.92 mm
Parabellum	Germany	Model '14/17	7.92 mm
Maxim T. u. F.	Germany	Model 1918	13 mm
Maxim DWM	Germany	(circa 1902)	37 mm
Maxim	United States	Model 1904	cal. .30
Vickers	United States	Model 1915	cal. .30
Vickers AVN.	United States	Model 1918	cal. .30
Vickers AVN.	United States	Model 1918	11 mm
Vickers AVN.	Japan Navy	Type 97	7.7 mm
Vickers AVN.	Japan Army	Type 89	7.7 mm
Vickers	Japan	Type 98	7.7 mm
Vickers A. A.	Japan	Model 17, Type 1	40 mm
Maxim (captured)	Greece	German type	7.95 mm
Vickers TNK.	Greece	British type	7.9 mm
Maxim	Austria-Hungary	Model 1889	8 mm
Maxim	Austria-Hungary	Mod. '89/04	8 mm
Maxim (F. N.)	Belgium	Model 1911	7.65 mm
Maxim[1]	Belgium	Model 1908	7.65 mm
Maxim[1]	Belgium	Mod. '08/15	7.65 mm
Vickers AVN.	France	British type	7.7 mm
Vickers AVN.	France	British type	11 mm
Vickers	France	Model 1909	7.7 mm

[1] Converted German.

System	Country	Designation	Bore
Vickers	France	Model 1909	8 mm
Maxim (ex-German)	Poland	Mod. '08	7.92 mm
	Poland	Mod. '08/15	7.92 mm
Maxim	Chile	Model 1902	7.92 mm
Maxim	China	Model 1935	7.92 mm
Maxim	Italy	Model 1906	6.5 mm
Vickers-Maxim	Italy	Model 1911	6.5 mm
Maxim	Peru	Model 1901	cal. .301
Maxim	Peru	Model 1911	cal. .301
Maxim	Great Britain	(circa 1891)	cal. .45 (Martini-Henry)
Maxim	Great Britain	(circa 1893)	cal. .303
Maxim	Great Britain	(circa 1899)	cal. .303
Maxim conv. Mk I	Great Britain	(circa 1902)	cal. .303
Maxim conv. Mk II	Great Britain	(circa 1898)	37 mm
Vickers	Great Britain	Mark I (circa 1912)	cal. .303[2]
Vickers	Great Britain	Mark I	cal. .303[3]
Vickers TNK.	Great Britain	Mark VII	cal. .303
Vickers TNK.	Great Britain	Mark IVa	cal. .303
Vickers TNK.	Great Britain	Mark IVb	cal. .303
Vickers TNK.	Great Britain	Mark VI	cal. .303
Vickers TNK.	Great Britain	Mark VI*	cal. .303
Vickers AVN.	Great Britain	Mark II	cal. .303
Vickers AVN.	Great Britain	Mark IIa	cal. .303
Vickers AVN.	Great Britain	Mark III	cal. .303
Vickers AVN.	Great Britain	Mark V (rebuilt from Mk IIa and III.)	cal. .303
Vickers AVN.	Great Britain	Mark VI (new mfg.)	cal. .303
Vickers AVN.	Great Britain	Mark VI* (converted circulator)	cal. .303
Vickers AVN.	Great Britain	Mark VII (new mfg.)	cal. .303
Vicker TNK.	Great Britain	Mark I	cal. .50
Vickers TNK.	Great Britain	Mark II	cal. .50
Vickers TNK.	Great Britain	Mark IVa (converted Mk I)	cal. .50
Vickers TNK.	Great Britain	Mark IVb (converted Mk I)	cal. .50
Vickers TNK.	Great Britain	Mark V	cal. .50
Vickers Naval	Great Britain	Mark II	cal. .50
Vickers	Portugal	Model 1917	7.7 mm

[2] Ground.

[3] Air, converted from ground.

System	Country	Designation	Bore
Vickers	Portugal	Model 1930	7.7 mm
Vickers	Portugal	Model 1937	7.92 mm
Maxim	Switzerland	Model 1894	7.45 mm
Maxim	Switzerland	Model 1900	7.45 mm
Maxim	Switzerland	Model 1911	7.45 mm
Vickers AVN.	Czechoslovakia	British type	7.92 mm
Maxim (former German).	Turkey	Model 1908	7.92 mm
	Turkey	Mod. '08/15	7.92 mm
Vickers	Turkey	British type	7.92 mm
Maxim (former German).	Lithuania	Model 1908	7.92 mm
Maxim	Esthonia	German type	7.7 mm
Maxim	Finland	Model 1932	7.62 mm
Maxim	Russia	Model 1905	7.62 mm
Maxim	Russia	Model 1910	7.62 mm
Maxim Tokarov	Russia	(circa 1924)	7.62 mm
Maxim Kolesnikov	Russia	(circa 1924)	7.62 mm
Vickers	Bulgaria	British type	7.7 mm
Maxim	Serbia	Model 1909	7 mm
Maxim	Bulgaria	Model 1909	8 mm
Maxim	Yugoslavia	Model M8M[4]	7.92 mm

[4] Converted spoils of war. Serbian and Bulgarian Model 1909 Maxim, 7 and 8 mm, respectively, both changed to 7.92 mm.

Chapter 5

MARLIN AIRCRAFT MACHINE GUNS

The mounting of Browning-designed machine guns in aircraft dates back to the Colt-Browning model, nicknamed the "Potato Digger" by the infantry because the operating lever after each shot swung down in pendulum fashion underneath the barrel. Due to a scarcity of machine guns, a few of these were placed in French and British pusher-type planes during the early stages of World War I. When this country entered the conflict, there was desperate need for any kind of machine gun. The type that could be mounted readily in aircraft without demanding too much of the already limited space or requiring any protruding accessories was especially in demand. While the swinging lever of the '95 model gun had the advantage of giving smoother action and exceptional reliability in ground operation, it was found to be very much in the way for aerial firing.

The Marlin-Rockwell Corp., New Haven, Conn., which had been given the contract to produce many thousands of the Colt-Browning '95 model for infantry use, undertook to remedy the situation and make the weapon acceptable for aircraft use. Marlin was no new name in the gun manufacturing business. In 1870, the founder, J. M. Marlin, began making single-shot pistols and revolvers under the Ballard patents in a small New Haven shop. Later he brought out the J. M. Marlin-Ballard single-shot rifle that became one of the world's outstanding target arms because of its simple strong action and deep Ballard rifling. In 1880 Marlin himself designed a repeating lever action rifle that has been a specialty of the plant ever since.

Carl G. Swebilius.

Ten years later the Marlin Firearms Co. introduced a silent side-ejection big game rifle that was a notable contribution to safety and convenience. This lever-action magazine repeating arm created a sensation. Sturdy yet light, it was amazingly simple and practical in design and a reliable, accurate repeater.

In 1915 the firm was taken over by the Marlin-Rockwell Corp., which was established in New Haven for the production of machine guns on a vast scale. Carl G. Swebilius was placed in charge of experimental work. The Swedish-born Swebilius came to America in 1896 at the age of 16, taking a position with the Marlin Co. Beginning as a gun-barrel driller, he soon became one of the outstanding American firearm designers.

In World War I, Swebilius modified the Colt-Browning gun by doing away with the lever and substituting a straight-line gas-actuated piston. Such a change presented problems of its own. Instead of giving a slow and gradually accelerated backward thrust through a connecting rod arrangement, as in the case of the lever-operated weapon, the piston was driven back hard at the very beginning of its stroke. This caused a loss of initial extraction and resulted more often than not in tearing off the cartridge head instead of extracting the empty case. The fault was soon remedied by further modifying the action through the addition of greater weight to the piston. The first rearward movement of the bolt was thereby somewhat retarded.

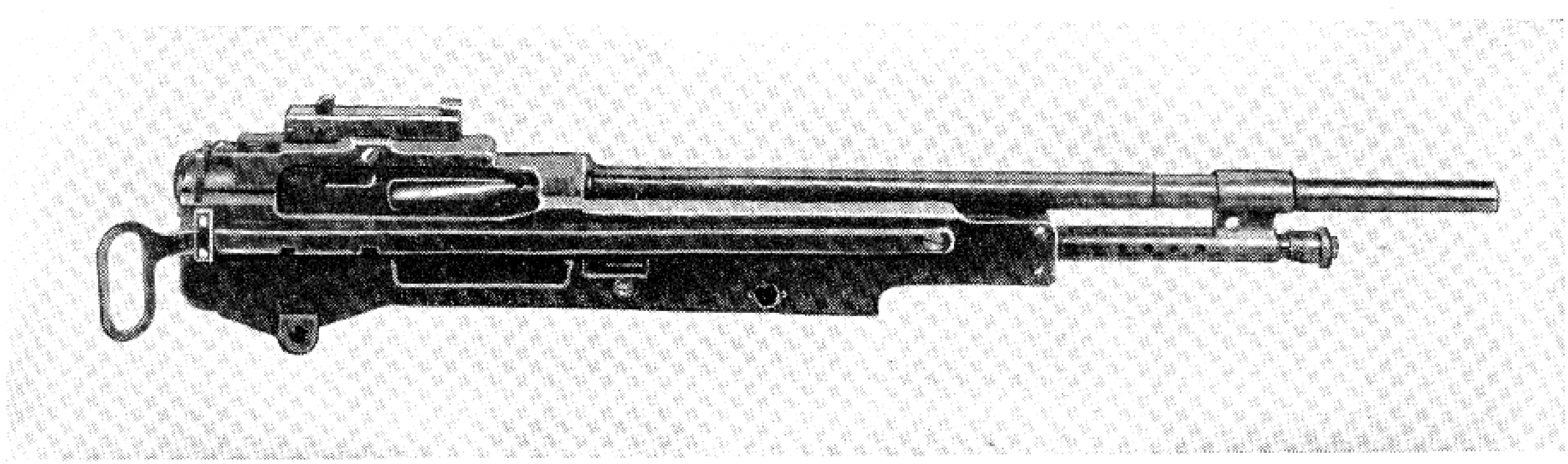
Swebilius deserves great credit for accomplishing this most difficult task, especially since it was performed in a few weeks' time. In this short period he made the Marlin gun a reliable automatic arm that was used throughout the war and for 3 years afterwards as the principal synchronized automatic machine gun of the American air force. Later it was also adapted to tank use. The weapon met with considerable enthusiasm on the western front as the following cablegram from A. E. F. headquarters in February 1918 shows: "Marlin aircraft guns have been fired successfully on four trips from 13,000 to 15,000 feet altitudes at a temperature of –20 degrees Fahrenheit. On one trip guns completely covered with ice. Both metallic links and fabric belts proved satisfactory."

Development of the Marlin aircraft gun was primarily one of modification and refinement from the gas swinging lever Colt '95 model. Marlin was so successful in the undertaking that new features were constantly being added. On 1 January 1918, the Signal Corps requested the design of a different firing mechanism that would permit single or automatic shots when used with four-bladed propellers and with the new and improved Nelson mechanical synchronizing gear. An arrangement whereby the hydraulic and mechanical trigger motors could be attached to the front of the lock container was also desired. The lock container was to be redesigned and the hammer materially lightened to increase the rate of fire.

An informal test was held on 27 December 1917, at which time another type of hydraulic synchronizing gear, also manufactured by the Marlin-Rockwell Corp. and similar to the Constantinesco gear, was tried out at rates varying from 200 to 600 rounds per minute with a total angle of dispersion of 63°. It was the closest and most accurate synchronization accomplished in this country with any type of machine gun so far. The Marlin aircraft machine gun has the distinction of being the first gas-operated weapon to be synchronized successfully.

The arm employed either a fabric or a disintegrating metal link belt that could be made up with as many as 500 rounds. Actually metallic links were generally used in aircraft throughout the war because of the inconvenience of disposing of the fabric belt's loose end after firing.

On 8 January 1918, a conference was held by the Army Ordnance Department at New Haven to decide on changes to be incorporated in the firing mechanism. Both the Signal Corps and the Marlin-Rockwell Corp. submitted new designs. Tests in the last days of that month proved the Marlin-Rockwell device satisfactory and the Signal Corps design a total failure because of easy breakage of parts. This was accountable for both by inferior material and by generally poor construction. A new hydraulic trigger motor was adopted at the same time and a contract for 15,000 motors and modified firing mechanisms was placed with Marlin-Rockwell. By this time the alteration and redesign of so many parts meant that they were not interchangeable with similar components of the old guns. To distinguish it in nomenclature from its original parts,



Marlin Aircraft Machine Gun, Model 1917, Cal. .30.

the improved product was called the Marlin Aircraft Machine Gun, Model 1918.

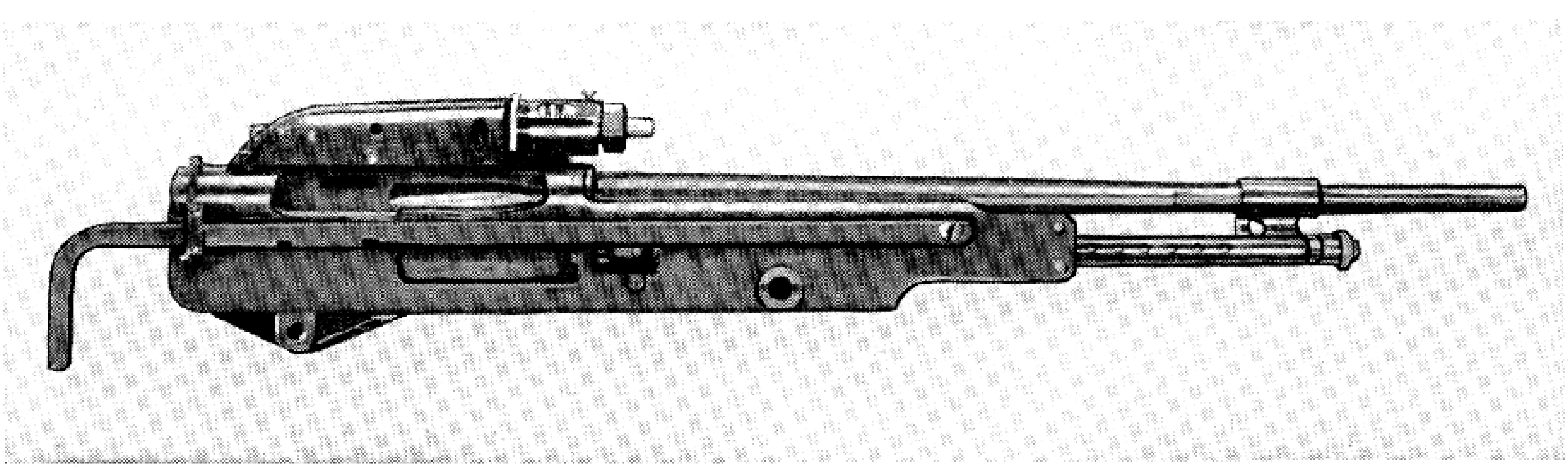
The modified weapon's principal point of difference from the 1917 model lay basically in its ability to be adapted to fire single shot or full automatic. This permitted much closer synchronization than full automatic alone. At the conventional propeller speeds of the day, however, the rate of fire was almost as great as with the automatic principle.

One of its main points of difference from the components of the 1917 model was a reduced gas pressure in order to cut down the parts breakages and stoppages caused by recoil. It was accomplished by enlarging the size of the gas piston and by drilling out less of the gas adjuster screw. The latter increased the volume of expansion of the gas chamber in the cylinder and cushioned its action. By milling three slots about one sixteenth of an inch in diameter through the side of the gas adjuster barrel, a vent was provided for the gas in the cylinder. It could be opened or closed at will by means of the adjuster. The double purpose was thus achieved of satisfactorily cushioning the recoil and also affording a wide range of adjustment of gas pressure acting on the piston. The increased recoil power necessitated a change in the bolt's cam slot pin to eliminate excessive breakage. More stock was added to the rear end of this piece to strengthen the cross section at a point where fracture was most frequent.

The fin was also given a glass-hard treatment followed by spot annealing. Material of the bolt pin was changed to chrome nickel steel to increase its durability as breakage often resulted from the severe wear on it after the first few hundred rounds. The newly designed and more powerful hammer action also proved too strenuous for the firing pin assembly and the pin had to be redesigned with a long gradual taper throughout its entire length. This made it not only stronger but at the same time more flexible.

In order to eliminate accidental firing by contact of the firing pin with the extractor, a three sixteenth inch piece of stock was added at the top of the latter's lug employed to support the front of the bolt. It was also found necessary to bevel off the end of the receiver on the left hand side directly behind the ammunition belt. Interference at this point with the base of the cartridge had a tendency to twist the belt and cause stoppage. A hole was drilled through the right side of the lock container in which a key, known as the functioning operating cam, was inserted. Rotation of this key raised the trigger, thus enabling the gun to fire full automatic for testing and firing without the synchronizing gear.

An interesting device added to the new Marlin was known as the jam preventer. It consisted of a small steel stamping which was applied without further alteration to the ratchet lever in place of the ratchet lever pin washer. Its function was to prevent the lever's pawl from engaging the feed wheel when the cartridge was in the act of feeding and thus blocking the stop against further rotation of the wheel. The device would have been more appropriately named an anti-double-feeding device. According to reports from the field a reduction of stoppages resulted from use of the jam preventer. Unloading of the gun could also be accomplished by this arrangement without removing the belt as was heretofore found to be necessary.



Marlin Aircraft Machine Gun, Model 1918, Cal. .30.

One more improved feature was the placement of the trigger motor at the forward end of the lock container and connecting it with the trigger by means of a timing gear. With this attachment the bolt could be removed without dismounting the trigger motor and carrier as was necessary with the 1917 model.

The gun's wide range of gas adjustments made it very dependable and it would fire positively under the most extreme conditions. Although originally adopted as a temporary substitute, the gun was improved by continued effort to such a highly satisfactory degree as to be pronounced the equal of the Vickers and other aircraft machine guns in excellence, synchronization and general reliability. Its success overseas was phenomenal. It was enthusiastically received by both the A. E. F. and the French as soon as pilots had mastered its few idiosyncrasies. The following reports bear witness to its competence.

"Pershing. 810–2. 3–29–18. Further test Marlin guns with both flexible and synchronized mounting made at 20,000 feet altitude, temperature below zero. Both guns functioned perfectly throughout the test."

"Pershing. 859–6. 4–12–18. Nine flights made to date with Marlin machine guns at altitudes ranging from 10,000 to 20,000 feet. Temperatures ranging from zero to well below zero Fahrenheit. Total rounds fired 1700. Guns used on both standard fixed and improvised flexible mounts. Both metallic and fabric belts used. No difficulties encountered and no stoppages. Recommend shipment of this gun continued rapidly as possible."

Various aerial squadrons added their praise with such words as the following: "In fact, all pilots have expressed a decided preference for the Marlin, as they shoot faster than the Vickers and are easily cleared of feed troubles." "The four Marlins we are using have kept up their perfect record." And "Thus far no Marlin guns have jammed in the air and they are in high favor among all pilots."

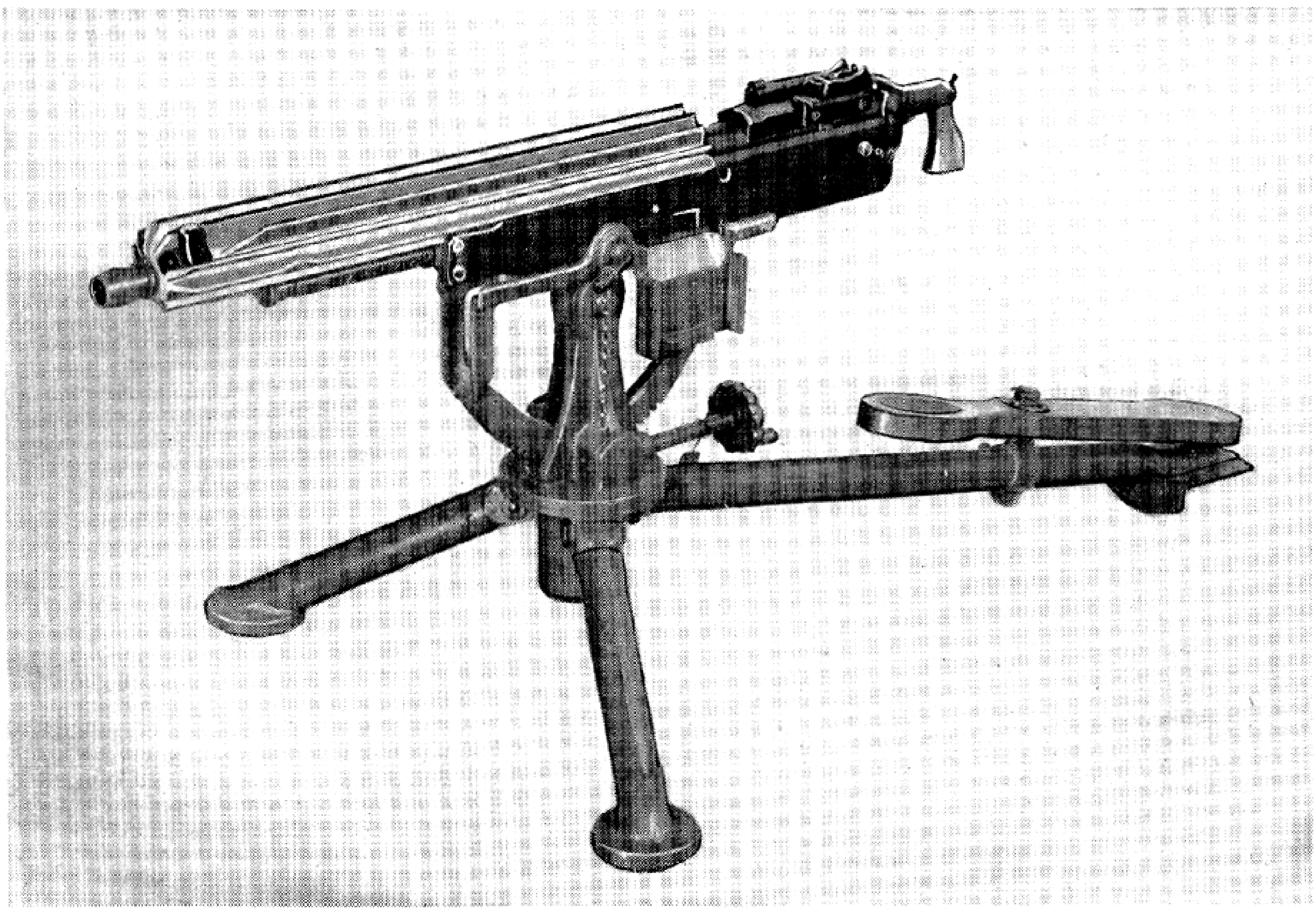
A report from the Chief Ordnance Officer of the A. E. F., dated 23 November 1918, stated that 22 squadrons at the front were either partially or fully equipped with Marlins having both hydraulic synchronizing gear and mechanical synchronizing gear. They gave thorough satisfaction, being used on various planes such as the U. S. D–4, Spad 8, Spad 7, Salmson, and Breguet observation planes. Some difficulty was encountered in adapting the Marlin to planes bought from the French and British Governments since the fittings of these planes already had feeding arrangements intended for caliber .303 Vickers. But this trouble was soon overcome and in August 1918 the first squadron of French planes equipped with Marlin guns arrived at the front.

The last gun of this type made, which was the thirty-eight thousandth, was taken from the assembly line and subjected to an endurance test of 10,000 rounds without a single stoppage or malfunction. At the end of the test it was found that only the replacement of a cracked shell extractor was necessary. There had been no appreciable increase in headspace and the condition of the gun after this firing was apparently as good as at the beginning. It passed inspection and was shipped as a new gun.

The first large shipment of 2,000 was sent to France on 11 October 1918, one month exactly before the end of the war, but it was not received in time for use at the front. The development of the Marlin as a flexible gun was also undertaken with promising success. The war was over, however, before much could be done with this type of gun.

All model 1918 Marlin aircraft guns were supplied with a trigger motor attached to the lock container, adapted for connections with both the Nelson and the C. C. synchronizing gear. The trigger motor, consisting of a piston and spring, was contained in a bronze cylinder which was screwed into the forward end of the lock container. The cylinder was provided with a coupling nut and tube into which the main pipe leading from the synchronizer could be soldered. A small vent screw located on top of this cylinder allowed the release of air from the system by bleeding. The C. C. synchronizing trigger motor was very similar to that used with the model 1917 aircraft gun.

These weapons also had electric heaters in order to prevent oil gumming up at the low temperatures accompanying extreme altitudes. The heaters were developed for both models of the Marlin aircraft machine gun. Each unit consisted of a resistance grid surrounded by insulat-



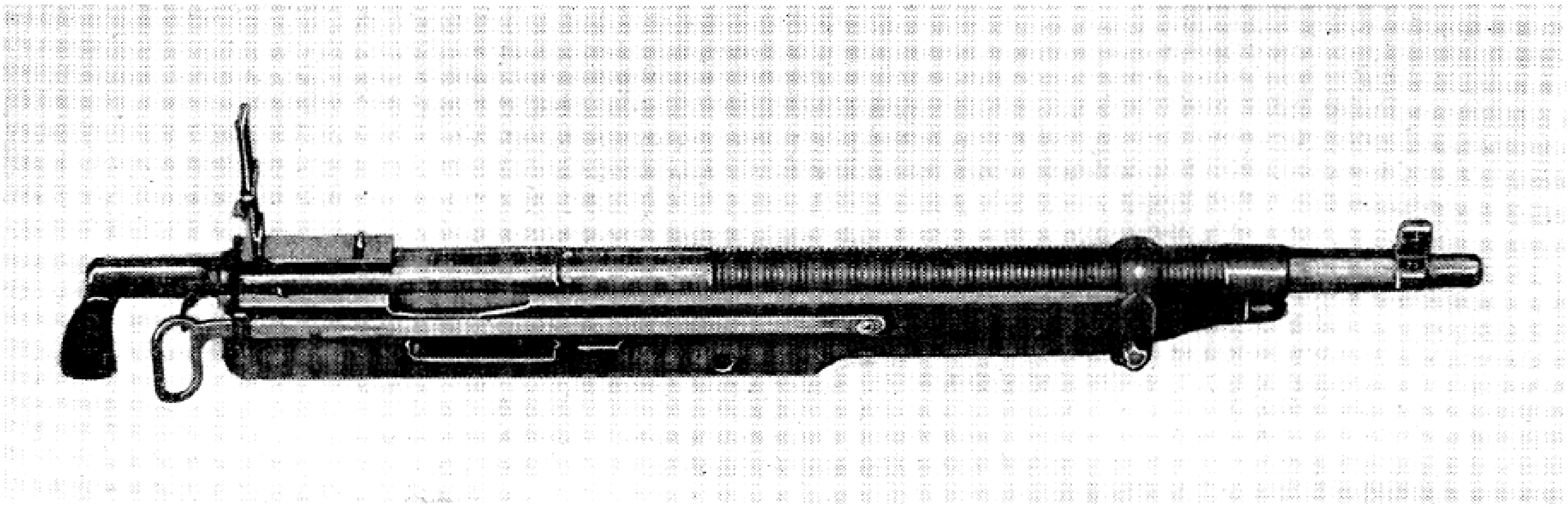
Marlin Tank Machine Gun, Model 1918, Cal. .30.

ing material and was riveted to the inside of the gun's bottom plate. It was connected with a bayonet plug on the under side of the bottom plate providing connection with the leads. The heater consumed 60 watts at 12 volts and was fed from the generator supplying the plane's lighting and heating system.

The Marlin gun, as issued, was belt fed, gas operated, and air cooled. It had a weight of 22½ pounds and without any speeding-up accessories normally fired 630 shots a minute.

To place the weapon in operation, a brass tip of the loading belt usually containing 250 rounds is inserted through the belt opening in the left-side plate and the first cartridge is forced up into position on the feed wheel. By pulling the charging handle lever twice to the rear, the cartridges are forced first into the feedway and then into the chamber. The gun is now ready for firing. When the trigger motor releases the sear, the nose of the trigger is disengaged and the hammer forced forward by the spring tension, striking the firing pin and firing the piece.

When the bullet passes the gas port near the muzzle on the barrel, a small portion of the live powder gas goes through the port and through a corresponding aperture in the gas chamber. There it strikes the piston forcing it to the rear and compressing the action spring. The spring then furnishes power for the forward movement. The lug on the slide strikes the feed lever forcing it to the rear. A pin located on the lever operates in the cam slot of the ratchet lever to force it upward, while the ratchet lever pawl becomes engaged in the feed wheel. As the slide which is fastened to the piston rod moves to the rear, it carries with it the bolt and extractor. The extractor claw withdraws a cartridge from the belt and places it on the carrier for chambering. The bolt pin working in the cam slot underneath the bolt forces its aft end upward and unlocks the piece. As the recoiling parts go to the rear, the



Marlin Ground Machine Gun, Cal. .30.

empty shell is pulled from the chamber by the extractor.

The base of the cartridge case during this movement strikes the shoulder of the ejector, and it is thrown out of the ejection slot on the right side of the receiver. The bolt on its continued backward motion strikes the hammer and forces it upward, compressing the strong hammer spring. The hammer then rides on the bolt for the balance of the recoil movement which ends as the slide strikes the springs on the buffer block. At this point counterrecoil movement begins, actuated by the force of the compressed action spring. The slide starts to move forward carrying the bolt with it. The cam on the bottom of the slide working against the carrier dog forces the carrier upward and alines the cartridge in front of the bolt. Continued movement forward then positions the round in the chamber.

As the bolt locks securely, the extractor cams itself over the rim of the cartridge case. At the same time the lug on the slide strikes the feed lever forcing it forward. During this final movement the feed lever pin working in the cam slot in the ratchet lever forces it downward. As a result the ratchet lever pawl turns the feed wheel. This action places the incoming cartridge in position to be engaged by the extractor.

The extractor claw then takes its position over the rim of the cartridge in the belt. Just before the bolt drops into the locked position, the hammer engages in the sear and trigger notch, provided the sear is not depressed. If the trigger is held down, the cam cut on the slide works on its corresponding lug on the firing mechanism forcing it out of engagement. This frees the sear from its notch and allows the hammer to strike the firing pin which discharges the cartridge. The cycle of operation continues until the trigger is released or the ammunition is exhausted.

If the trigger is released before all the cartridges have been fired, the bolt closes over a shell in the chamber but the hammer does not go forward. If the trigger is held down until the ammunition is exhausted, the bolt closes over an empty chamber.

The total number of the 1918 model Marlins manufactured was 15,000, as compared with 23,000 of the 1917 model. Conclusion as to whether the Marlin 1918 model machine gun was the U. S. Army's first line aviation weapon in World War I can be drawn from the report of a board of officers convened in 1920 by the War Department. The board was to meet as often as necessary for the purpose of considering the development of aircraft machine guns and aircraft cannon. The meetings took place regularly over a period of years until 1925 when it made its final report from which the following is quoted:

"The Board recommends that the Marlin machine gun, model of 1918, be continued in service, but that no further steps to improve the development of the gun itself be undertaken, in view of the present state of its development and a desire on the part of the Board to have all funds available for development work expended on the Browning aircraft machine gun.

"It is further believed that this gun is a satisfactory air service weapon, although its limitations are acknowledged. It is not so efficient as to ease of assembly. Its clearances are smaller. It is more sensitive to dirt and rust than other guns examined by the Board. And it must be removed from its mountings for the purpose of cleaning and repairing in the airdromes. It is made to function with the Nelson mechanical gear and aside from the Browning aircraft machine gun no other machine guns have been made with that end in view. And these are the only two weapons now in the possession of the United States which as issued will so function. The question therefore solves itself, as the Marlin aircraft machine gun, model of 1918, is the only gun at present which can be issued to function with the Nelson gear. In the event that a more satisfactory type of gun passes successful tests and is accepted by the Air Service as a satisfactory machine gun for their use, upon completion of the redesign and tests now in progress it is recommended that these Marlin models of 1918 be withdrawn from service and held in reserve for emergency use only."