

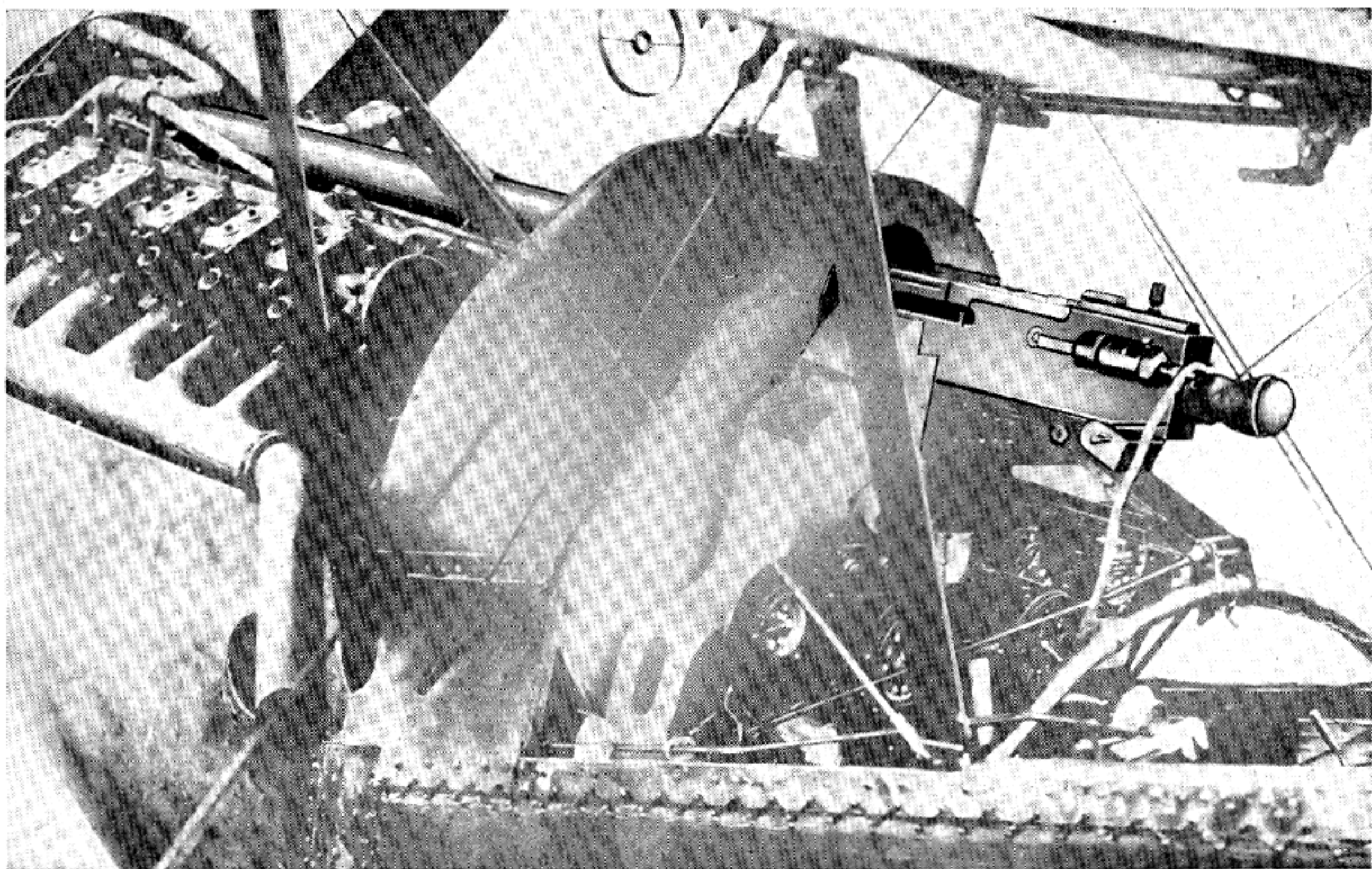
BROWNING AIRCRAFT MACHINE GUNS

First Attempts at Air Firing

The caliber .30 Browning aircraft machine gun, which was designated the Model 1918, did not see combat service during World War I. The reason was that the poor choice of metals used in its construction and the demand for a high rate of fire caused the front lower part of the receiver to spread after comparatively few bursts and become unserviceable. The fault was ordered remedied by the addition of a stirrup at the affected part to give greater strength. As the Armistice followed shortly after delivery of the first guns, this failure and its subsequent correction seemed of small importance at the time.

Following the war the Army, which was charged with development of this weapon, set about to make the necessary modifications. Since there was no longer the critical time factor of the war years, the matter was closely studied. In order to produce a machine gun that would be adequate for years to come, many changes were found to be necessary. Some of the modifications were trivial, while others were so costly that it was sometimes felt the designing of a completely new weapon would have been more economical.

For like all aircraft machine guns it too evolved from a ground gun with one part changed, another lightened, and so on until the numerous alterations fitted the circumstances at



Browning Aircraft Machine Gun Mounted on a Bristol Fighter in England for First Test of the Browning in the Air.

hand. Then if the devisement did work, an increased rate of fire was demanded. This last feature almost invariably brought disaster to the successor of a once reliable, slow-firing, water-cooled, easily serviced gun.

This most certainly was true as far as the first Browning aircraft machine gun was concerned, as it had the same basic principles of the heavier infantry model lightened on a drawing board until it met a theoretical requirement.

Since a major overhaul was imminent, it was wisely concluded that all possible corrections should be made at the same time. As a result an Aircraft Armament Board was formed in 1920 and given power to make any changes thought necessary to meet future requirements. The report made by this board on the Browning guns tells in no uncertain manner all the modifications needed, along with what was considered desirable in the larger caliber aircraft machine guns that soon should be making their appearance.

The general report of the Aircraft Armament Board which convened to study the aviation ordnance question gives a most graphic description of the existing state of affairs. It first met on 29 March 1920, and after numerous sessions made its final report 5 years later. Its section on the Browning aircraft guns is here extensively quoted.

(It is hard to believe that 2 years after World War I the United States air force had no machine gun suitable for combat save the modified Colt '95 model gun, known as the Marlin Aircraft Machine Gun, Model 1917-18. Attention is invited to the number of new parts that had to be added and old ones reworked on the short-recoil-operated weapon Model 1918 before it was considered serviceable.)

The Aircraft Armament Board Report

"Browning Caliber .30, for Aircraft Use

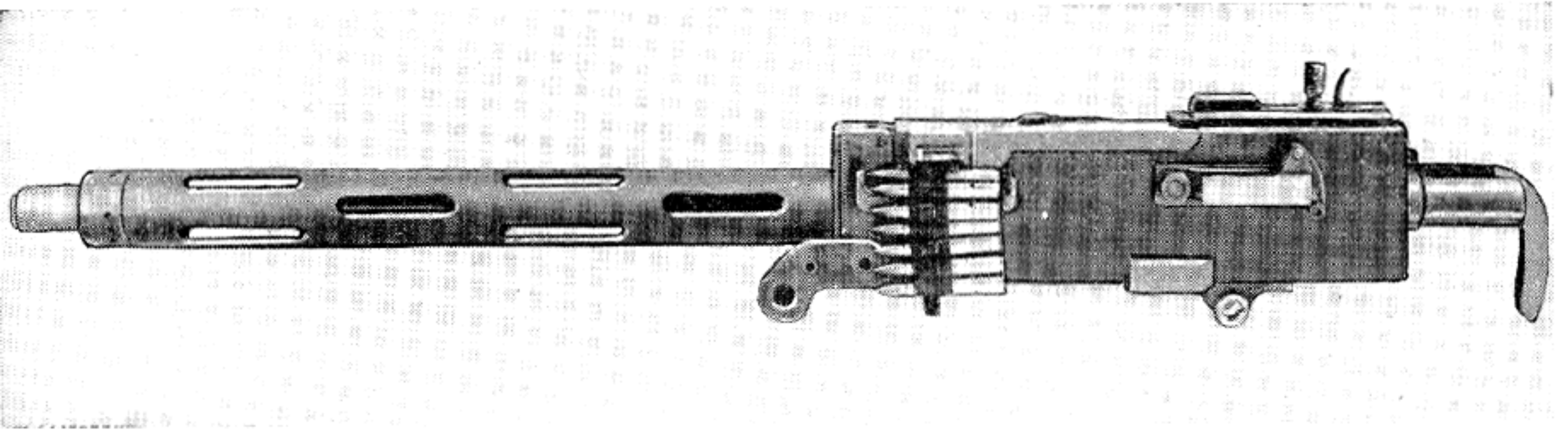
"(1) This Browning machine gun belongs to that class of automatic weapons known as short recoil operated, air cooled and belt fed. It is chambered for the standard caliber .30 U. S. ammunition. The force of recoil is utilized to perform the mechanical operations of feeding, load-

ing, extracting, cocking and ejecting the empty cartridge cases through the bottom of the receiver while the buffer and driving spring returns the counter recoiling mechanism to battery position. The weight of this gun is 23.5#, being intermediate between the Marlin and the heavy Browning water-cooled machine guns. . . .

"(2) As the Browning aircraft caliber .30 machine gun now stands, the 2,576 plus 491 guns, as delivered by Westinghouse Company and the Marlin-Rockwell Corporation respectively, are faulty in their construction and have not been issued to the Service for general use. The Ordnance Department has undertaken the alteration of these guns and a remedy of all existing defects as well as adding certain parts necessary for convenience in mounting and ease of operation. This work is now in progress at Springfield Armory and has been reviewed by the Board which has witnessed the firing of some of these guns and has examined the drawings of the machine guns being tested. The Board recommends that all existing guns be modified to conform to the developed models and that enough squadrons be armed to give the gun as thorough an air test as is possible during times of peace. The remainder of the guns to be stored subject to Air Service requisition.

"(3) This gun is capable of firing standard .30 caliber ammunition at approximately 2,700 feet muzzle velocity and is effective against the ordinary targets incident to airplane combat. This gun, as modified, is capable of being mounted in such a way that its mechanism is readily available to the operator for the purpose of reducing jams and clearing stoppages. The gun itself does not develop during fire any particular stresses on the airplane to such an extent as to render its mounting difficult. One of the most commendable features of the gun is its high rate of fire, about 1,000 rds. per minute. It is thought this is the highest rate of fire that the gun can stand, on account of the character and weight of its construction, and it is not thought necessary to initiate any further development tending to give a higher rate of fire.

"(4) The gun is capable of being used with the Nelson Synchronizer and as modified renders its connection with this attachment a simple mat-



Browning Aircraft Machine Gun, Model 1918, M1, Cal. .30.

ter. Its firing mechanism is of such character as to make it the equal of any synchronizable gun so far as its synchronizing properties proper are concerned. Its effective range is sufficient for present and future needs. Its cooling device is designed for use in aircraft and is satisfactory. The gun will withstand for a reasonable length of time storage on the plane itself and does not require the great care that other machine guns do on account of its large clearances and small number of working parts.

"(5) The gun can be disassembled and assembled in a comparatively short time and does not require an expert to keep it in proper working condition. The gun can be cleaned and repaired without removing it from its mounting and so not disturbing the sights. The gun is not sensitive to the action of dust and grit on account of the closed construction of its receiver.

"(6) It is regarded as possible to develop a right and left hand feed for the Browning aircraft machine gun for use with the existing gun. The Board recommends that this development be initiated and that when said development has

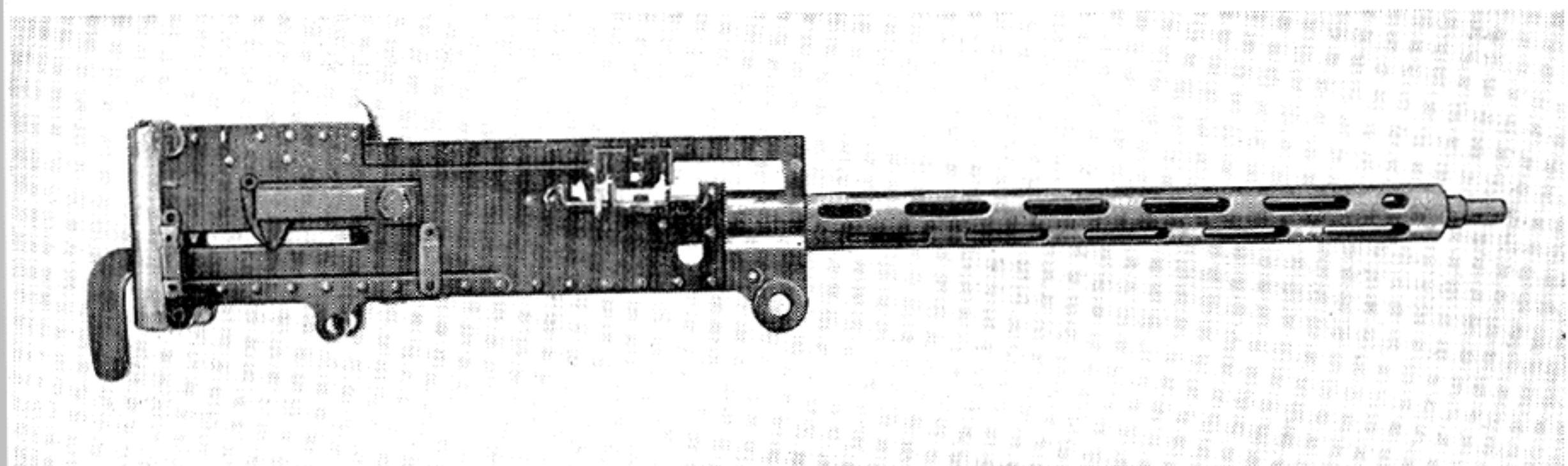
been concluded it be given a thorough test, both on the ground and in the air.

"(7) The feeding device of the Browning aircraft gun is considered to be superior to all others.

"(8) The gun is capable of being fired from any position and will fire through an arc of 360 degrees except from a horizontal upside-down position, when the cartridges falling back in the receiver will probably cause jam.

"(9) The interchangeability of parts is sufficiently standard.

"(10) Although some of the major parts of the gun are interchangeable with corresponding parts of the Browning machine gun used in the ground service, the majority of parts are not interchangeable. Nearly all the differences in the two guns, however, have been dictated by a desire to obtain higher efficiency of the gun in the air and it is thought that no attempt should be made to accomplish an interchangeability between the ground and air Brownings. The Ordnance Department had initiated a project involving the manufacture of a new model Brown-



U. S. Aircraft Machine Gun, Model 1921, Cal. .30, Fixed.

ing aircraft machine gun, which shall avoid all the faults in design made apparent in the first lot of Browning machine guns manufactured on drawings prepared during the war. The Board is of the opinion that this project is correct and recommends that it be carried to its completion, that a sufficient number of model guns be constructed to give a thorough service test and that all data relative to tools, gauges, fixtures and manufacturing drawings, methods involved, etc., should be completed and filed in the Office of the Chief of Ordnance and held available for future manufacture.

"The following changes have been found necessary in the Browning aircraft machine gun as at present manufactured and these changes are being incorporated in the re-development project now being followed out by Springfield Armory.

"(a) Adapters. These properly locate the mounting pins in respect to the feedway. The rear adapter includes also the stirrup for the support of the bottom plate and the forward one includes a bearing for the rocker shaft unit of the Nelson synchronizing gear.

"(b) Operating slide and handle. To permit greater accessibility, so far as loading arrangements are concerned, to the pilot.

"(c) New firing mechanism.

"(d) Modification of latch to include a positive lock. It is very necessary, as in the event of the gun flying open under the vibration of necessity encountered in airplanes, a failure to fire would result and consequent stoppage.

"(e) Addition to link guide to the front cartridge stop.

"(f) Removal of front.

"(g) Provision of means to hold the cover extractor spring in place.

"(h) Alteration of the angle of the breech

lock cam and corresponding surface of the breech lock.

"From the original gun the following parts have been eliminated: (a) Mount adapters and rivets; (b) Elevating brackets and screws; (c) Cartridge stop, front and sear slide.

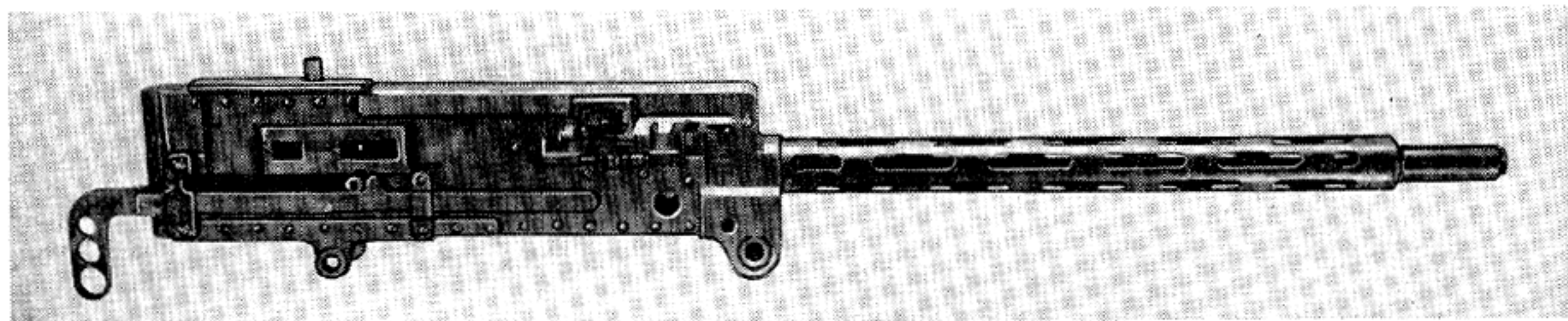
"The following parts are modified: (a) Barrel extension; (b) Bolt; (c) Cocking lever; (d) Cover; (e) Ejector; (f) Extractor cam; (g) Extractor cam plunger; (h) Latch; (i) Side plates; (j) Top plate; (k) Latch spring.

"The following new parts are added: (a) Bolt stud; (b) Cartridge stop, front, including link guide; (c) Included in (f); (d) Latch lock; (e) Operating slide and guides; (f) Firing mechanism; (g) Stirrup and rivets; (h) Trunnion adapters and rivets.

"Browning 11-mm Machine Gun for Aircraft Use

"A project has been initiated by the Ordnance Department . . . to develop a Browning 11-mm aircraft machine gun. The efficiency of this weapon depends entirely upon the efficiency of the ammunition. It would be a single purpose gun, probably used for the destruction of kite balloons. A short description of the 11-mm tracer incendiary ammunition, which would be the principal ammunition used with this gun, is as follows:

"The tracing incendiary composition consists of Barium Nitrate, Barium peroxide, powdered Magnesium and Carnuba Wax. The composition is contained in a round case bullet of brass hollowed out to receive it and is of such bulk that the bullet not only traces but has excellent incendiary properties. The muzzle velocity of the bullet is low, being about 2,000 feet per second, and the maximum trace is approximately 1,850 yards, varying from 1,300 to this figure. The



U. S. Aircraft Machine Gun, Model 1922, Cal. .30, Fixed. This Weapon Was Designed to Feed from the Left or Right Side.

maximum powder pressures developed are low, not exceeding 20,000 # per square inch. The case is of brass and has a flanged edge for extraction. The facilities exist in the United States for the manufacture of this cartridge and there are on hand 1,182,580 rds. of 11-mm ammunition which will become useless in the event that the 11-mm machine guns (Vickers) are recalled from service. Considerable experiments have been continued on the 11-mm ammunition. By virtue of the bulk of the projectile, it has been possible to develop a highly efficient explosive bullet.

"Browning Caliber .50 Aircraft Machine Gun

"A project for the development of the Browning caliber .50 aircraft machine gun has been initiated by the Ordnance Department and a contract has been placed with Colt Patent Fire Arms Company, of Hartford, Connecticut. The specifications of this gun as at present defined, give the following characteristics:

"Weight—50 #.

"Rate of Fire—500–600.

"Muzzle Velocity—2,700 ft/sec.

"Weight of Ammunition—1,830 grs. (about) (800 gr. bullet).

"Pounds per hundred rds.—26 (without links).

"Penetration—A. P. 1½" armor plate at 25 yds.

"This gun probably comes in a class of machine guns not peculiar to Air Service alone, and which are intermediate between the .30 caliber machine gun and small cannon. The tactical reasons for its development are as follows:

"(1) By virtue of the bulk of the projectile fired from this gun and the muzzle velocity with which it can be fired, it is anticipated that a

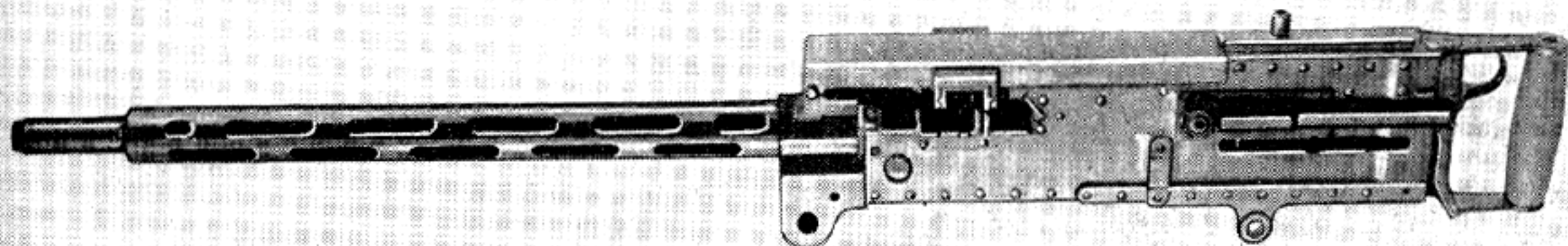
much more efficient armor piercing, tracer and incendiary bullet can be effected. An explosive bullet can also be developed much more easily than in the case of a smaller bullet, like the 150 gr. .30 caliber now in use.

"(2) It is to be anticipated that a machine gun to be efficient against aircraft of the future must be efficient against light armor plate. Armored planes were coming into being at the close of the war, both on the part of the Allies and Germans. Against armor capable of being carried by aircraft our .30 caliber ammunition would be of doubtful utility and of necessity we must go to higher calibers and higher muzzle velocities to obtain an effective ammunition for such combat.

"This statement might be thought to be incompatible with some of the recommendations of the Board. It should, however, be borne in mind that aerial combat in the future may consist of several kinds of aircraft specially built to attain certain altitudes: that is,

"(a) High flying scout planes which may attain an altitude from 15,000 feet up and of necessity must carry light weapons and light ammunition to keep down the military load and to obtain a maximum effectiveness from the motor at altitudes at which they may be expected to fly.

"(b) Other low flying pursuit, aerial surveillance and artillery observation and day bombardment planes, medium pursuit planes, not intended to fly at such heights may be able to carry heavier weapons and a heavier weight of ammunition. These planes are the ones which may be expected to encounter armored airplanes, and consequently should be equipped with guns having the characteristics of the proposed .50 caliber Browning aircraft machine gun. It will be seen then that this weapon is not



U. S. Aircraft Machine Gun, Model 1922, Cal. .30, Flexible. This Weapon Fired Over 20,000 Rounds in Test and Was Still Serviceable.

meant to replace the present existing .30 caliber weapons except in the case of planes working under 15,000 feet and so, as far as the general Air Service is concerned, should be classed as a special and additional weapon for which there will be a great deal of necessity. Work upon this gun has been undertaken by the Ordnance Department in connection with the development of a .50 caliber gun for ground and antiaircraft purposes. A priority has been established and approved by the Ordnance Committee as follows:

"(1) Aircraft .50 Caliber Browning Machine Gun.

"(2) Ground type .50 Caliber Browning Machine Gun.

"(3) .50 Caliber Tank Machine Gun.

"This priority is correct and it is thought that the aircraft gun should be given all possible preference.

"This development is not in such state now as to afford good grounds for any prophecy as to its ultimate efficiency. The Board has, however, examined all drawings available of the gun and of its ammunition and submits recommendations. . . ."

Browning Aircraft Machine Gun, Caliber .30

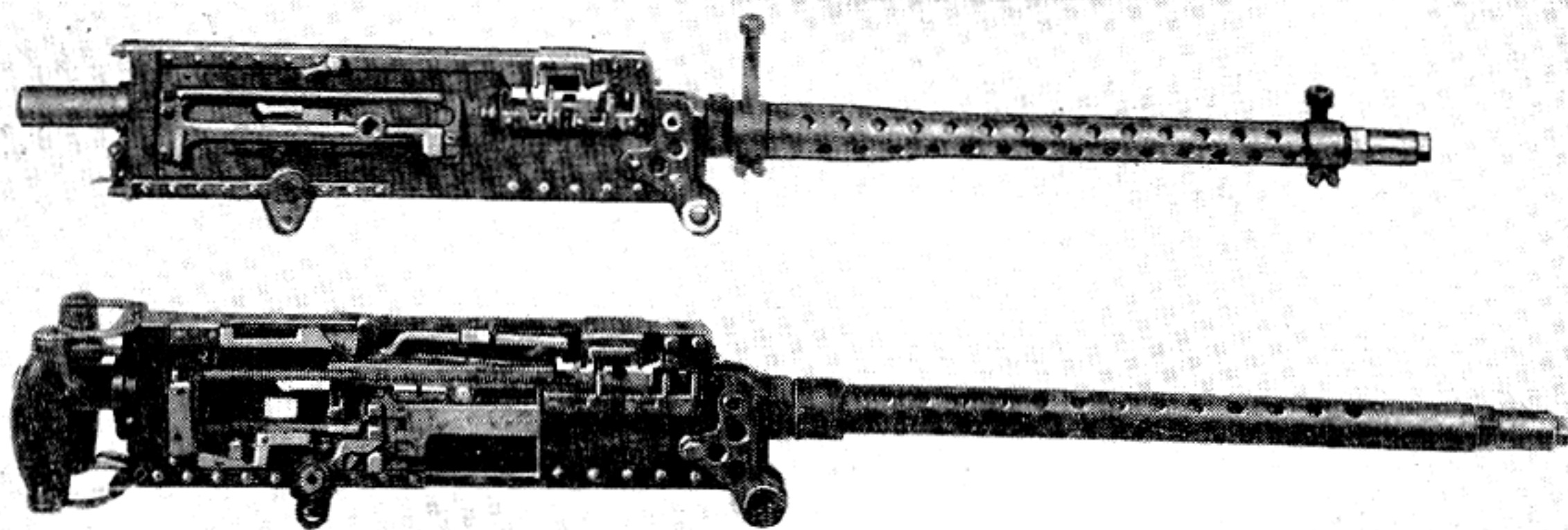
Before the Armament Board's report had even been put in rough form, work was well under way to correct one of the main faults with the original models. This bad feature was that the weapon fed only from the left, no provision

being made to bring the cartridge belt from the opposite side. This made installation in planes quite a problem, especially where it was desired to place the weapons side by side.

Using one of the first guns completely modified according to specifications recommended by the Board, the project was begun at Springfield Armory. In a comparatively short time a prototype was finished to the point where its originators considered it ready for test. While the trial that soon followed showed numerous weaknesses: it did fire 10,000 rounds and, in order to avoid confusion, it was given the nomenclature, U. S. Aircraft Model 1921, Caliber .30.

Continued work was authorized not only to perfect the operating mechanism but also to incorporate a method of releasing the sear from the sides in order to synchronize by means of a solenoid. A second model embodying the desired features was ready in due time and 10,000 rounds were fired with only two breakages that require replacement. Half the ammunition was fed right hand and then the direction of feeding was reversed without incident.

This modified weapon was then sent first to Aberdeen Proving Ground, and following a successful trial, to McCook Field. After 20,000 rounds were expended, it was shipped again to Springfield where it was examined and found to be in good working condition. The experimental department recommended that with a few minor changes the model could be considered practically complete as far as specifications for this type of weapon were concerned. The only



Top: Browning Aircraft Machine Gun, M2, Cal. .30, Fixed. Bottom: Browning Aircraft Machine Gun, M2, Cal. .30, Flexible (Sectionalized).

suggestion for further improvement was the addition of a rounds counter to inform the pilot of the amount of ammunition left in his feed boxes.

The weight of the gun was now 20 pounds and the rate of fire was officially set at 1,000 rounds a minute. In order to facilitate installation, numerous features were standardized so that it could be used fixed or flexible by changing the mounts. A method of placing twin guns on a Scarff ring was also worked out and specifications were written to take care of all future production.

During the period from 1927 to 1930 when Wright Field, Springfield Armory, and others continued to work on a light caliber .30 high-speed aircraft machine gun, no concise requirements had been prepared for inclusion in an official specification to cover military characteristics. These facts, as shown by the record, indicate considerable controversy as to what was wanted. When a real demand was shown in 1929 for such a gun to perform under the approved military demands, the Colt's Co. brought out the fully developed right- and left-hand feed gun that was later standardized as the Browning Machine Gun, Caliber .30, M2.

In developing this improved gun, every effort was made to retain the best features while simplifying manufacture. The type of steel that proved best was specified. Rivets were standardized, all being made with oval countersunk heads, wherever possible. Almost all basic dimensions were kept at an even fractional part of an inch and parts were designed for complete interchangeability in quantity production.

Everyone who worked on the project resulting in this M2 caliber .30 weapon deserves great credit for his contribution. By the late 20's it was a successfully tested weapon, capable of firing at the rate of 1,000 shots a minute. It could be fed from either right or left and seared off from the side by an electrically operated solenoid.

It is indeed fortunate that this work was done at the time, as practically all machine gun development stopped shortly afterwards, that is, as far as the United States was concerned. It was partly due to lack of funds but more from the

peaceful lethargy that invariably settles on this country after each war. In 1938 the caliber .30 Browning gun, better known as the B. A. M. G., was still being made in very limited quantities with the same specifications as the original Model M2. As a larger caliber machine gun was still looked upon by the Air Force as a special objectives weapon, the caliber .30 was its first-line machine gun for both fixed and flexible mounting as late as 7 December 1941.

Browning Caliber .50 Aircraft Machine Gun

The Germans put a heavily armored plane into service during the closing days of World War I. This act made obsolete for all time the rifle-caliber machine gun for aerial use. Some countries were slower to accept the fact than others but nevertheless it cannot be disputed. The United States was among the first to come to this realization. The dramatic incident that caused it was the shooting down by such an aircraft of the young pilot, Quentin Roosevelt.

Gen. John J. Pershing, commander in chief of the American Expeditionary Forces, was among the first to see that the lightweight rifle caliber bullets would be ineffective against armored planes. With his characteristic promptness, he cabled the Army Ordnance Department to begin immediate development of a machine gun having a bore of at least a half inch with a minimum muzzle velocity of 2,700 feet per second.

At the time there was already under way an effort to use an 11-mm French cartridge in a Browning action, but when Pershing was informed that the velocity was not up to his requirements, he ordered renewed effort on the development of a larger cartridge and a higher bullet speed. The Browning caliber .50 machine gun that resulted was first made as a water-cooled weapon that later was lightened enough to be acceptable for aircraft use. The latter became known as the Browning aircraft machine gun, caliber .50, 1921. The water-cooled version also had the same model designation. In other words, for test purposes both a water-cooled and an aircraft caliber .50 gun were available and, while



First Trials of Browning Cal. .50 Machine Gun in Colt's Pasture. Fred Moore Firing the Weapon and John M. Browning Standing.

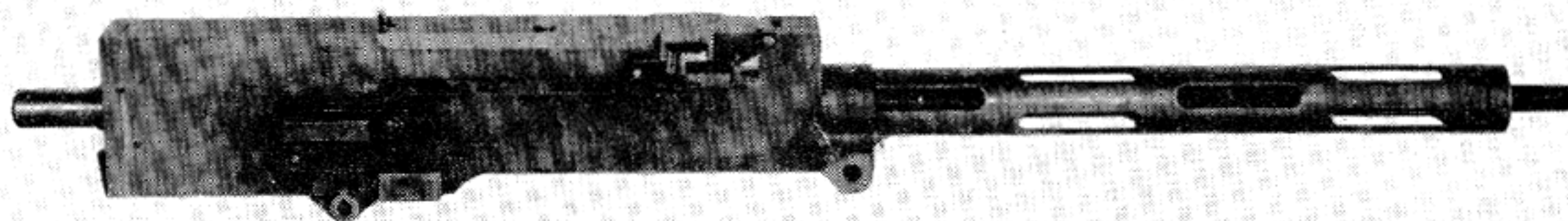
operating parts were interchangeable to a limited degree, this did not hold true for most of the costly and vital components.

This condition existed until Dr. S. G. Green (colonel during World War II), who is now chief of the Engineering Section, Small Arms Branch, Industrial Division of the Office of the Chief of Ordnance, Department of the Army, conceived and put into effect the design of what is known now as the Browning Machine Gun, Caliber .50, Basic M2. This devisement allowed the manufacture of one receiver that could be used on seven different types of guns: Army and Navy anti-aircraft water cooled, ground and turret-type heavy barrel, and fixed, flexible, and turret aircraft guns.

Dr. Green was awarded the Exceptional Civilian Award for his work prior to the war and the Legion of Merit for his outstanding commissioned service in World War II. There is no way to estimate the value of his contribution to

the Allied cause, as it allowed wholesale production of a single type of receiver that could be adapted in a matter of minutes to any specific use required.

The caliber .50 machine gun initially developed by John M. Browning at Winchester and further refined by Browning and Fred T. Moore at the Colt's plant resulted in its standardization in two forms, the Browning aircraft machine gun, caliber .50, M1921, and the Browning machine gun, caliber .50, M1921, water-cooled. The guns were manufactured and used experimentally as aircraft and anti-aircraft weapons between 1921 and 1937. They both had relatively lightweight barrels and the feed mechanisms were so arranged that the belts were fed from the left-hand side only. This meant that, when installed in pairs for either aircraft or anti-aircraft use, the mounting was unduly complicated. The caliber .50 ammunition available during this same period had a velocity of ap-



Aircraft Machine Gun, Model 1918, Cal. .50, Manufactured by Winchester Arms Company.

approximately 2,700 feet per second, identical with that of the caliber .30 ammunition.

The barrel of the water-cooled gun extended some 2 inches forward of the water jacket, which resulted in the muzzle becoming overheated when long bursts were attempted. The light barrels used on the aircraft caliber .50 machine guns also caused overheating after relatively short bursts. The weapon's limitations revealed in the early service trials of the water-cooled version raised a serious doubt with the Army and Navy during the period from 1927 to 1933 as to its potential worth either as an aviation gun or for antiaircraft use.

In the years from 1927 to 1930 the armed services made many studies on the employment of Browning weapons for all conceivable uses. Many comparative trials were conducted in aircraft with the Browning aircraft machine gun, caliber .30, M1921, and similar antiaircraft tests were made with the Browning machine gun, caliber .50, M1921, water-cooled. Limited experiments were also made with a heavy barrel type of the caliber .50 M1921 for arming combat vehicles.

No requirements were forthcoming prior to 1933 for an improved type of caliber .50 machine gun. The results of the past years were appraised and the problems given intensive study by Dr. Green between 1927 and 1932. The innovations disclosed were applied to a basic receiver and operating mechanism, which was so designed that seven principal types of caliber .50 Brownings could be readily assembled by the substitution of such parts as barrel jackets, barrels, and other items on aircraft, antiaircraft, combat vehicle, or ground-type machine guns. The elements replaced or added to the assembled weap-

ons to adapt them to the specified use could be interchanged without the use of machine tools. No compromise, such as combinations, was made, and each complete assembly resulted in a superior gun for the required purpose.

The basic receiver had all the improved features, such as the right- and left-hand feed, and a new means was provided for obtaining a mechanical advantage in retracting the bolt. The strength of the driving spring and the weight of the barrel was increased to permit use of a more powerful cartridge, which allowed a longer barrel for maximum velocity and greater durability. The receiver and the fundamental operating mechanism were patterned after the caliber .50 heavy-barrel gun, developed earlier by Colt. It was indicated in 1932 that these advanced features developed by this firm, as represented by the pilot gun, and those developed by Dr. Green could be combined into a composite weapon that should and did give superior performance when used for the intended needs.

The Ordnance Department lacked funds in the period from 1927 to 1933 (as evidenced by the fact that not a single machine gun was manufactured in 1928) to undertake the development and production of a new type of caliber .50 gun for two basic reasons:

(a) The depression severely curtailed available funds.

(b) No requirement had been established for the development or manufacture of such a series of guns.

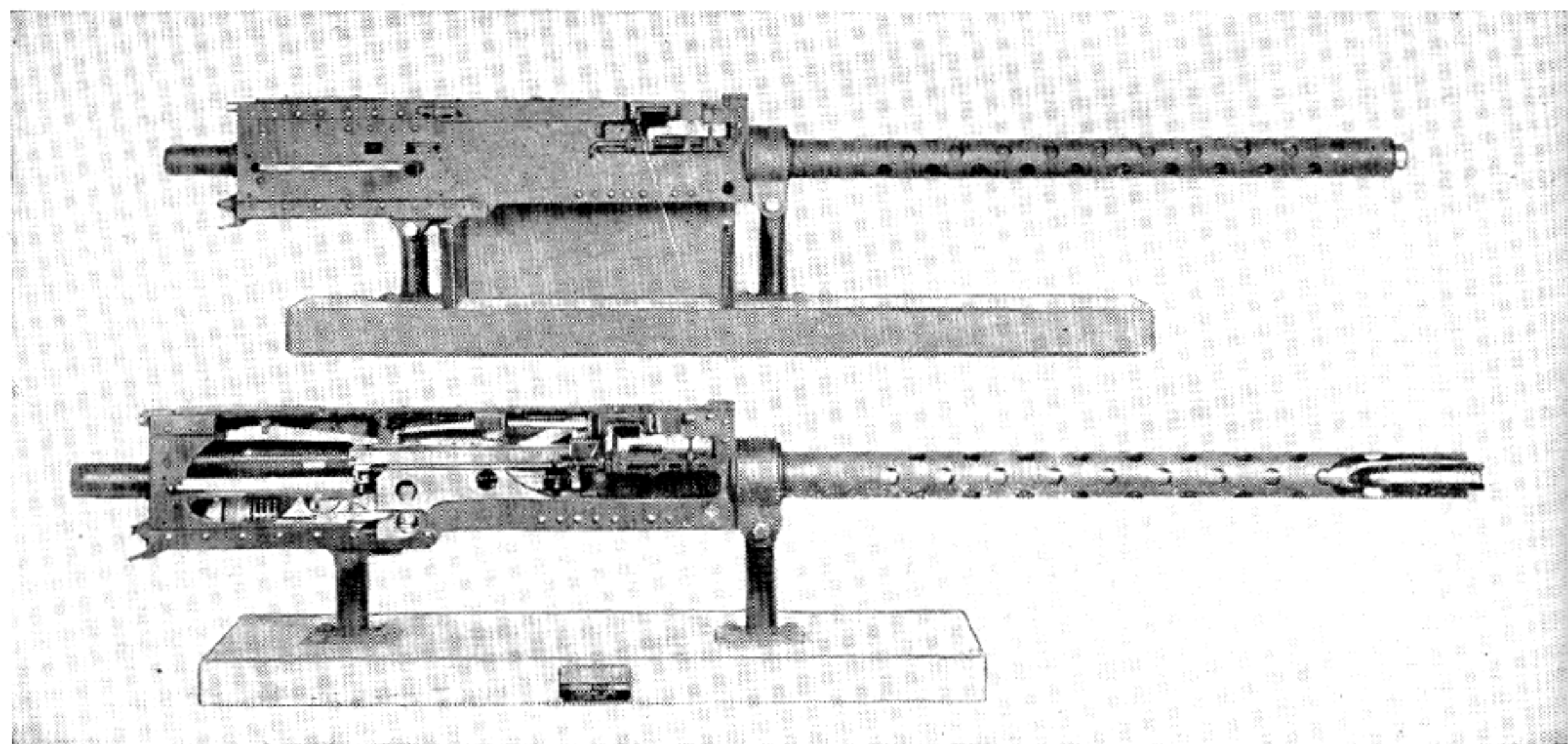
Consequently the limited funds available to the Army could not be spent for such a project. The Colt's Co., using components it developed on the heavy-barrel, air-cooled gun and the new

features developed by the Government, manufactured for the Ordnance Department in early 1933 two modified Browning machine guns, caliber .50 (later known as M1921A1); two Browning aircraft machine guns, caliber .50 (designated the M1921E2); and two improved Browning machine guns, caliber .50, heavy barrel. These were the first weapons to represent the combined innovations of the two models. They were tested at Aberdeen Proving Ground, Frankford Arsenal, Fort Monroe, and Wright Field, and were also demonstrated at the Naval Proving Ground, Dahlgren. Test results were most favorable and interest in the improved caliber .50 Browning was greatly intensified. When invited to furnish a complete set of ordnance drawings, the Colt's Co. suggested that their preparation at Springfield Armory from the firm's drawings, would be more economical.

During 1932 Gen. Samuel Hoff, Chief of Ordnance, Army, after observing concentrated activity on Dr. Green's part day after day, jokingly asked for an explanation. He replied that an attempt was being made to solve a problem having great bearing on the future of the caliber .50 machine gun, even though no requirement had been presented to the Ordnance Department. In order to do so, it might be necessary to apply the famous quotation by Thomas Car-

lyle framed on Dr. Green's desk—"He who would accomplish much must concentrate to such an extent that to the idle observer it borders on insanity." The general was also shown another saying, credited to Edison, which read: "I always do my best work when other people tend to their own business by going to sleep."

The Army, in 1933, without funds to carry forward the development of a complete series of new caliber .50 machine guns, interested the Navy in the results of the previous tests of both the aircraft and antiaircraft, water-cooled models. With the approval of General Hoff and Maj. Julian S. Hatcher (now major general, retired), Chief of Small Arms Division, Manufacturing Service, Ordnance Department, contact was made by Dr. Green with Commanders John J. Mahoney, Edgar R. McClung and Forrest P. Sherman (now admiral, Chief of Naval Operations), all of the Bureau of Ordnance, Navy Department, to determine whether they would be interested in the improved weapons. They responded enthusiastically and arranged for an early demonstration at the Naval Proving Ground, Dahlgren, Va. Commander Malcolm F. Schoeffel (now admiral) and Commander George F. Hussey, Jr. (later chief of the Bureau of Ordnance, Navy, now admiral, retired) were most interested in testing the new guns and aided



Top: Aircraft Machine Gun, Cal. .50, M2, Fixed. Bottom: Aircraft Machine Gun, Cal. .50, M2, Fixed (Sectionalized).

materially in their early standardization for both the Army and Navy.

Further conferences were held with Commanders Sherman and Mahoney, who took the matter up with Admiral E. B. Larimer, Chief of the Bureau of Ordnance, Navy. The latter not only approved assistance in further research on aircraft and antiaircraft caliber .50 M2 machine guns but authorized an immediate expenditure in 1932-33 of approximately \$150,000 to be used in the development and supply to the Navy of as many weapons as possible with the funds available. The Navy placed orders early in 1933 with the Ordnance Department of the Army for the manufacture by Colt of the basic M2 type improved caliber .50 machine guns. Navy funds were used for compiling data needed for drawings, manufacturing requirements, such as descriptions of procedures, technical notes, etc., later to be used in training manuals and maintenance work. These data were obtained by War Department personnel at the Colt's plant, where the many problems relating to production and manufacturing improvements were solved jointly by company and government representatives.

The support given by the Navy in the program was of material benefit in compiling instructional material, such as standard nomenclature lists, training manuals, specifications, and Government drawings during the development period at the Colt's Co. and at Springfield Armory. The funds made available by the Navy made it possible to set up a firm policy for preparing, first, basic drawings, and then establishing tolerances to govern both manufacture and final inspection. Colt's contribution with respect to the latter was outstanding, as evidenced by the very successful use of the Government drawings during World War II. More than eight major manufacturers produced interchangeable machine guns and components that gave outstanding performance, even though they were made in great quantity.

The development, pre-manufacturing study and production engineering during the initial manufacture of the caliber .50 M2 Browning machine gun were made possible by the unexcelled teamwork among Navy and Army Ordnance personnel, Springfield Armory, and the Colt's Co. The interest and support given by

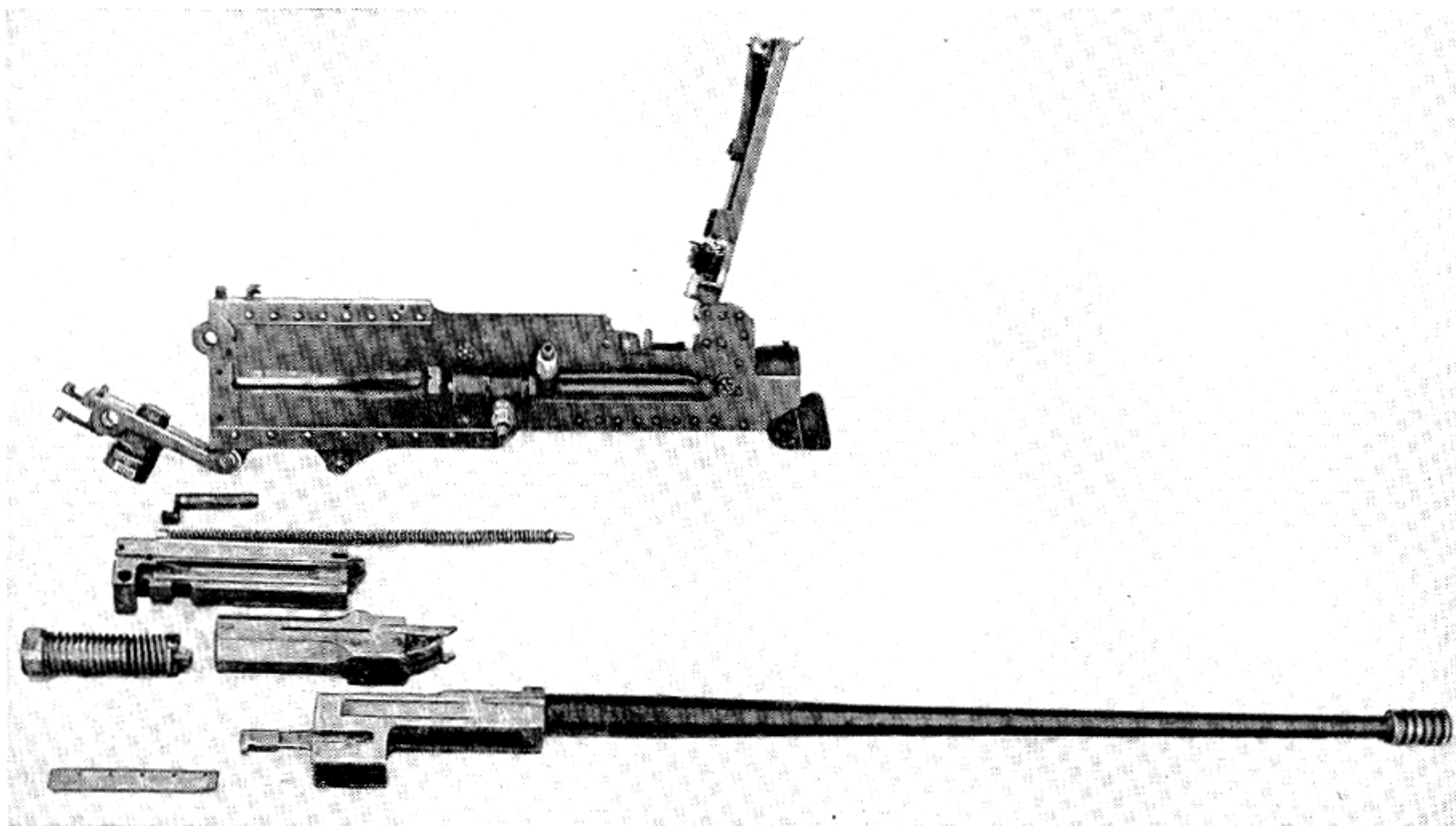
Admiral Larimer, Commanders Sherman, Schoeffel, Mahoney, and McClung, and by Navy financing made it possible to prepare a comprehensive and positive program to cover all phases of the problem. The work of Fred T. Moore, general works manager of the Colt's Co., and many of its production and design engineers, and by Maj. Guy H. Drewry (now general, retired), Mr. Hopkins, Mr. Ambrose, and other engineering personnel at Springfield Armory, was outstanding in the preparation and coordination of engineering data obtained for the most part from Colt's Co. and from Dr. Green, who worked at Springfield and at Colt's in directing the over-all program.

The restudies made during production engineering reviews included a consideration for the first time of building into an automatic weapon a measured reserve to insure reliable functioning under adverse conditions. A belt lift of 17 pounds was established as a minimum, it being appreciated that longer belts would be needed to obtain the full potential of this new type of gun. This was the first time that any automatic weapon had included in its specifications and drawings a definite measurable performance. This requirement was later increased to some 35 pounds by the Colt's Co. and the High Standard Manufacturing Co., working with Captain Adams of the British Service, when the increased throw of the belt feed slide was provided along with a wider cover.

The back plate was also replaced by one of much larger diameter, using Belleville washers of the type developed by the Colt's Co., the Fabrique Nationale, Mr. Hopkins of Springfield Armory, and Dr. Green.

Highly favorable reports were received from the battle areas of North Africa, Sicily, and on the continent of Europe on the caliber .50 guns, which showed that they were most reliable and their performance outstanding. A typical report is one received from the commanding general of the Army Air Forces (in November 1943) which states in part:

"1. The Commanding General of the Army Air Forces, with the full realization of the many outstanding achievements of the Ordnance Department in developing and producing large



Japanese Copy of the Browning Aircraft Machine Gun, Cal. .50, Type 1941, Fixed.

quantities of outstanding equipment for the United States Forces, wishes to specifically commend the Ordnance Department of the Army Service Forces for the magnificent achievement in furnishing the Army Air Forces with the most outstanding aircraft gun of World War II, namely the Caliber .50 Aircraft Machine Gun.

"2. This weapon, together with its ammunition, is the backbone of offensive and defensive guns for American aircraft and was brought to such a state of perfection by the Ordnance Department during the years of peace prior to the present conflict that it has enabled the Army Air Forces, the U. S. Navy, and Marine Corps to show a definite superiority in aircraft gun power throughout this global war."

Similar reports were received from the Army Air Forces Matériel Command during the last phase of the Tunisian campaign, where 72 enemy airplanes were destroyed with less than 200 rounds per gun expended on 35 fighter planes without a single machine-gun stoppage. M2 guns mounted on trucks also gave a good account of themselves and often supplied the sole means of protection of small supply convoys. A typical action shows that the drivers brought down two

of five attacking enemy planes and scattered the remaining three.

The Navy and Marine Corps also had many reports of the Browning's excellent performance at Bougainville, Guadalcanal, and all other major operations. One such observation was the report of Capt. Malcolm F. Schoeffel (now admiral) to the Bureau of Ordnance, Navy, which showed that during a cruise of the *Saratoga* some 200,000 rounds of caliber .50 ammunition were fired with only two serious jams, and two dozen stoppages of all types. Captain Schoeffel declared that, although one of the purposes of his inspection trip in the Pacific was to locate troubles, he had difficulty finding them because of the high performance of the weapon.

A typical comment from the Armed Services Joint Report was:

"It is gratifying to note the acclaim with which the Caliber .50 Machine Gun is being received, for it is felt that this reflects, in a great measure, the efforts that have been expended in producing and accepting only quality weapons."

In World War II the M2 was produced by the following industrial firms: Colt's Patent Fire Arms Co., High Standard Co., Savage Arms

Corp., Buffalo Arms Corp., Frigidaire, AC Spark Plug, Brown-Lipe-Chappin, Saginaw Divisions of General Motors Corp., and Kelsey Hayes Wheel Co.

The translation of the new designs into a producible and dependable series of weapons by mass production methods showed that the groundwork and coordinated effort by the Army, Navy, and Industry team were well done and in a comprehensive form. Even though the production engineering data, drawings, and other information were in excellent shape, industry made a real contribution by applying new techniques with improved machinery, such as high speed broaching and multiple tools for performing rapidly many operations previously done separately.

Cycle of Operation

The following cycle of operation is for the Browning machine gun, caliber .50, basic M2, but with minor deviations to compensate for a difference in caliber, it will also cover the entire family of Browning short-recoil-operated machine guns.

When the trigger is pressed, the trigger bar pivots on its pin, causing the front end to press down on the tip of the sear. Its notch is disengaged from the shoulder of the cocked firing-pin extension, allowing it to fly forward and fire the chambered round. At this instant the barrel, barrel extension, and bolt, known as the recoiling portion, are in battery position.

The bolt is held securely in place by the breech lock, which extends up through the barrel extension into a notch in the underside of the bolt. After the powder charge explodes and the bullet starts to travel through the bore, the force of the explosion drives the operating parts rearward. During the first three-quarters of an inch of travel the breech lock is pushed off the breech lock cam step and out of the notch in the bolt by action of the breech lock depressors. This frees the bolt. As the recoiling portion continues to move back, the barrel extension rolls the accelerator rearward. The tip of the accelerator claws strikes the lower projection on the bolt and speed this part to the rear. The barrel and barrel extension have a total rearward travel of

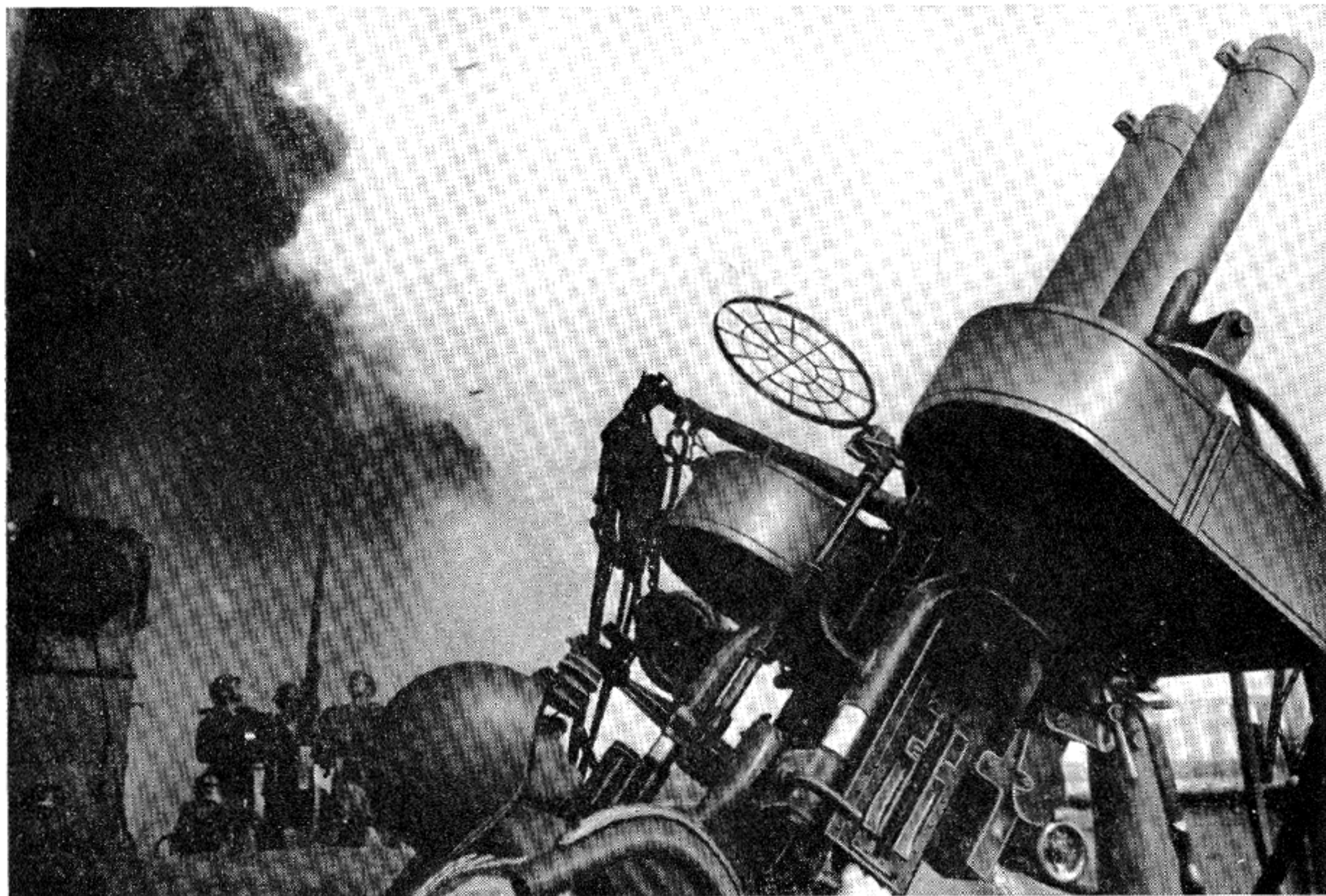


Loading Cal. .50 Ammunition on an F6F Aboard the USS Saratoga.

1 $\frac{1}{8}$ inches at which time they are completely stopped by the oil-buffer body assembly.

During this movement the oil-buffer spring is compressed by the barrel-extension shank. The spring is locked in this retracted position by the claws of the accelerator which are moved against the shoulders of the barrel-extension shank. The action of the oil in the buffer tube aids the spring to cushion the shock of recoil of the barrel and barrel extension. During the rearward travel the piston head is forced back from the forward end of the oil-buffer tube. The oil at the rear of the tube under pressure of the piston head and valve escapes to the front. Its only path is through restricted notches between the edge of the piston-rod head and the oil-buffer tube.

The bolt travels rearward for a total of 7 $\frac{1}{8}$ inches. During this movement the nested driving springs are compressed. The rearward stroke of the bolt is finally stopped as it strikes the buffer plate and compresses the fiber discs to the



Browning Machine Gun, Cal. .50, Water Cooled, in Action as Antiaircraft Defense.

extent of one-eighth of an inch. Thus, part of the recoil energy of the bolt is stored in the driving springs and the remainder in the back plate buffer assembly.

After completion of the recoil stroke the bolt is forced forward by the energy stored in the driving spring and the compressed buffer discs. When the bolt has moved forward about 5 inches the top of the accelerator is struck by a projection on the bottom of the bolt. As the accelerator rolls forward from this blow, its claws are moved away from the shoulders of the barrel-extension shank to release the oil-buffer spring. The energy of the spring shoves the barrel extension and barrel ahead.

No restriction to motion is desired on the forward or counterrecoil stroke of the barrel and its extension; therefore, on the stroke additional openings for oil flow are provided in the piston rod head of the oil buffer assembly. The piston valve is forced away from the piston rod head .050 inch as the parts move forward, uncovering

other openings. The resulting larger flow permits oil to escape freely through the ports in the piston valve as well as at the edge of the piston next to the tube wall.

As the barrel extension moves forward, the breech lock contacts the breech lock cam and is forced upward. The bolt, which has been continuing its forward motion after striking the accelerator, has now reached a position where the notch on its under side is directly above the breech lock, thus permitting the latter to engage its locking recess. The bolt is thereby locked to the breech end of the barrel extension three-quarters of an inch before the counterrecoiling parts reach their final forward position.

The act of cocking the gun is begun as the bolt starts to recoil immediately after firing. Thus the tip of the cocking lever, which is in the V slot in the top plate bracket, is forced forward. The lever is pivoted so that the lower end forces the firing-pin extension rearward. The firing-pin spring is thus compressed against the sear-stop

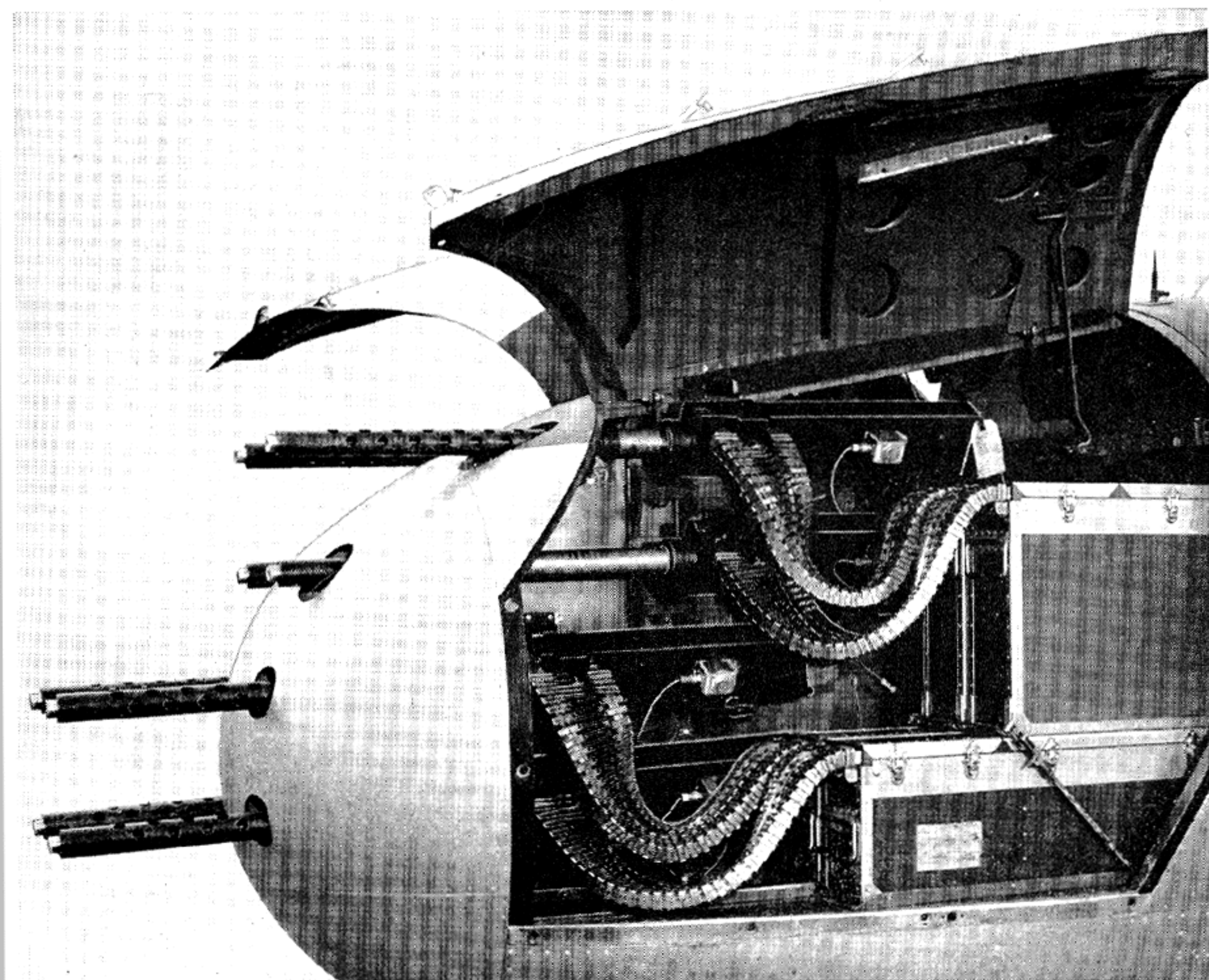
pin. The shoulder at the back end of the extension is hooked over the notch at the bottom of the sear under pressure of the sear spring. During the final forward motion of the bolt the tip of the cocking lever enters the V slot of the top plate bracket. This action swings the bottom of the lever out of the path of the firing pin extension, allowing space for the pin to snap forward to fire the cartridge.

When the counterrecoiling portion is one-sixteenth of an inch from battery, the gun is ready to fire. If no trigger action is given at this instant, the operating parts assume final forward position and the gun ceases operation.

The belt-feed mechanism is actuated by the bolt. The ammunition belt is pulled into the

gun by the pawl which is attached to the belt-feed slide. When the bolt is in battery, the belt-feed pawl has positioned a cartridge directly above the chamber. The belt-holding pawl is in a raised position behind the incoming round to prevent the ammunition belt from falling out of the gun.

As the bolt recoils, the belt-feed slide is moved out over the belt, and the belt-feed pawl pivots so as to ride over the next cartridge. At the end of the recoil stroke the throw of the belt-feed slide is sufficient to permit its pawl to snap down behind the incoming link in order to pull the belt into the gun. As the bolt moves forward on counterrecoil, the belt is pulled into the gun by the leverage exerted on the belt-feed pawl. The



"Eight-Gun Nose" Installation for B-25 Aircraft. Each Browning Cal. .50 Is Provided with 400 Rounds of Ammunition for Ground Strafing.

belt-holding pawl is forced downward as a cartridge is pulled over it. When the forward stroke of the bolt is completed, the belt-holding pawl snaps up behind the next round and performs the function of retaining the belt in the gun.

As recoil starts, a cartridge is drawn from the ammunition belt by the extractor claw. At the same time the empty case is withdrawn from the chamber with its cannelure held in the T slot on the front face of the bolt. The empty case, having been expanded by the force of explosion, tends to stick to the walls of the chamber and the case may be torn if withdrawal is too rapid. To prevent this and to insure slow initial extraction, the top front edge of the breech lock and the front side of the notch in the bolt are beveled. Thus, as the breech lock is totally disengaged, the bolt first creeps away from the barrel and barrel extension in a gradual manner.

The cover-extractor cam now begins to force the extractor down, causing the round to enter the T slot in the bolt. As the extractor is moved, the lug on its side rides against the top of the switch, causing it to pivot downward at the rear. Near the end of the bolt's movement the extractor lug overrides the end of the switch, which then snaps back to its normal position.

On counterrecoil the extractor is forced farther down until halted by the extractor stop pin as the lug then rides forward under the switch. The incoming round in the T slot ejects the empty case. The extractor stop pin in the bolt serves as a means of positioning the incoming round, so that the cartridge, assisted by the ejector, enters the center of the chamber. When the cartridge is nearly seated, the extractor rides up its cam, compresses the cover extractor spring and its claw snaps over the cannelure of the cartridge in the feedway.

For automatic firing the trigger is pressed and held down. The sear is depressed as its tip is carried against the beveled surface of the trigger bar by the forward movement of the bolt near the end of the counterrecoil stroke. The notch in the bottom of the sear releases the firing pin, thus automatically firing the next cartridge at the completion of the forward stroke. The gun will operate automatically as long as trigger action is maintained and until the ammunition supply is exhausted.

The B. A. R. Since World War I

Following World War I, the exclusive rights to manufacture the B. A. R. (Browning Automatic Rifle) reverted to the Colt's Co. The Belgian Fabrique Nationale d'Armes de Guerre at Herstal, Belgium, was licensed in 1920 to manufacture and distribute the weapon in Europe, under the name Herstal light machine gun, along with many other Browning-designed guns.

In 1922 the United States Army brought out the Cavalry model 1922 machine rifle. This version of the B. A. R. had a heavy ribbed barrel, a bipod and an adjustable stock rest. A different rear sight from that of the model 1918 was utilized. The gun was never issued in great numbers.

Colt put the gun out in two commercial models. One was a military-type gun, equipped with a pistol grip and a light bipod fastened to the gas cylinder at its junction with the barrel. A number of foreign governments purchased this arm in considerable quantities. Another model of the B. A. R., called the Colt Monitor, was offered in 1933 as a police and bank-guard weapon. It was modified by a shortened barrel, the attachment of a Cutts compensator and addition of a vertical pistol grip. A number of these weapons appear to have fallen into the hands of criminals, judging from seizures made by the F. B. I.

Numerous foreign governments have employed the B. A. R. The Fabrique Nationale produced in 1921 a Swedish Army 6.5-mm model, having a vertical pistol grip and a slightly curved magazine. It is reported that a limited number in caliber 7.5-mm were manufactured by the Belgian plant for France or Switzerland or for the oriental trade.

After the 1914-18 war and up to 1936, the British tested the weapon and in 1922 provisionally designated it as the light machine gun to be produced in the event of another war. Later the Bren gun was standardized for the caliber .303 cartridge to fit this need. England's home guard was fitted with B. A. R.'s from the United States during the invasion peril of 1940 and 1941.

The Polish Army was supplied with the FN model 1928 B. A. R., firing the 7.92-mm Ger-

man Army type cartridge. And B. A. R.'s bearing the patent date 1932 were captured from the Japs in the 1942 Philippine campaign. These weapons had a 21-inch barrel of 7.7-mm caliber. The principal difference from American types was the hinged piston rod and forearm, permitting rapid removal of the gas cylinder.

The latest version of the B. A. R., which was supplied to United States armed forces in World War II, is the B. A. R. Model M1918A2. Weighing 19 pounds, it is heavier than the earlier models and is fitted with a flash hider and a medium-weight bipod at the muzzle. A conventional butt-stock without pistol grip is used. A decelerating device which can be thrown on and

off allows a high and low cyclic rate of fire. There is no semiautomatic fire from this model, but the low rate of fire is such that single shots can be discharged easily by pulling and quickly releasing the trigger. There is no readily changeable barrel, so delivered fire is limited to what one barrel can stand in any brief period.

Models of Browning Recoil-Operated Machine Guns

The following tabulation lists the various models and bores of Browning recoil-operated machine guns that have been produced for use by the nations of the world:

Name	Country	Designation	Bore
Browning ground	U. S. A.	Model 1917	.30/06
Browning ground	U. S. A.	Model 1917A1	.30/06
Browning training	U. S. A.	M1	.22
Browning tank	U. S. A.	M2	.30/06
Browning training	U. S. A.	M3	.22
Browning training	U. S. A.	M4	.22
Browning tank	U. S. A.	M1919	.30/06
Browning tank	U. S. A.	M1919A1	.30/06
Browning cavalry	U. S. A.	M1919A2	.30/06
Browning gen. purp.	U. S. A.	M1919A3	.30/06
Browning gen. purp.	U. S. A.	M1919A4 early	.30/06
Browning gen. purp.	U. S. A.	M1919A4 later	.30/06
Browning tank	U. S. A.	M1919A5	.30/06
Browning ground	U. S. A.	M1919A6	.30/06
Springfield ground	U. S. A.	Experimental	.30/06
Rock Island ground	U. S. A.	T13	.30/06
Colt ground	U. S. A.	Experimental	.30/06
Browning ground	U. S. A.	M1919 w/c	.30/06
Browning aircraft	U. S. A.	M1918	.30/06
Browning aircraft	U. S. A.	M1918	11 mm
Browning aircraft	U. S. A.	M1918M1	.30/06
Browning aircraft	U. S. A.	M1919	.30/06
Browning aircraft	U. S. A.	M1921	.30/06
Browning aircraft	U. S. A.	M1922	.30/06
Browning aircraft	U. S. A.	M2	.30/06
Browning infantry	Mexico	M1919	7 mm
Browning infantry	Argentina	M1928	7.9 mm
Browning infantry	Poland	M1930	7.9 mm
Browning	Bolivia	Commercial type	7.65 mm

Name	Country	Designation	Bore
Browning infantry	China	Commercial type	7.9 mm
Browning ground	Norway	M1929	7.9 mm
Browning ground	Norway	M1929T	7.9 mm special
Browning ground	Sweden	M1936	6.5 mm
Browning ground	Sweden	M1936	7.9 mm
Browning ground	Guatemala	M1924	7 mm
Browning ground	Guatemala	M1942 .....	.30/06
Browning tank	Japan	Type 4	7.7 mm
Browning tank	Japan	Type 97	7.7 mm
Browning aircraft	Norway	M1929	7.9 mm
Browning aircraft	Greece	M1937	7.9 mm
Browning aircraft	France	Commercial type	7.5 mm
Browning aircraft	England	Mark II	7.7 mm
Browning aircraft	England	Mark II*	7.7 mm
Colt ground	Commercial	MG 38	Various
Colt ground	Commercial	MG 38B	Various
Colt aircraft	Commercial	MG 40	Various
Colt ground	Commercial	MG 52 .....	.50
Colt ground	Commercial	MG 52A .....	.50
Colt ground	Commercial	MG 52-2 .....	.50
Colt aircraft	Commercial	MG 53 .....	.50
Colt aircraft	Commercial	MG 53A .....	.50
Colt aircraft	Commercial	MG 53-2 .....	.50
Browning	Commercial	FN .....	.50
Browning	Commercial	FN	13.2 mm
Browning AA	U. S. A.	M1921 .....	.50
Browning AA	U. S. A.	M1921A1 .....	.50
Browning AA	U. S. A.	M2 .....	.50
Browning AA	U. S. A.	M2 Navy special .....	.50
Browning aircraft	U. S. A.	M1921 .....	.50
Browning aircraft	U. S. A.	M2 .....	.50
Browning aircraft	U. S. A.	M2 Navy special .....	.50
Browning ground	U. S. A.	M2 HB .....	.50
Browning	U. S. A.	M2 HB Navy special .....	.50
Browning aircraft	U. S. A.	M2 TT .....	.50
Browning aircraft	U. S. A.	M3 .....	.50
Browning ground	Guatemala	M1924 .....	.50
Browning ground	Guatemala	M1942 .....	.50
Browning aircraft	Japan	Model 1 .....	.50

HOTCHKISS AIRCRAFT MACHINE GUN

Aerial Uses of the Hotchkiss

The French were in many ways leaders in military aviation. One of their most creditable achievements was not being misled by the blind faith in dirigibles that was sweeping other countries. While the civilian population was terrified by them, military men always contended that the huge size of the airships would bring about their own destruction. In the matter of arming aircraft, while not the first to fire a machine gun from a plane, the French most certainly capitalized early on this accomplishment.

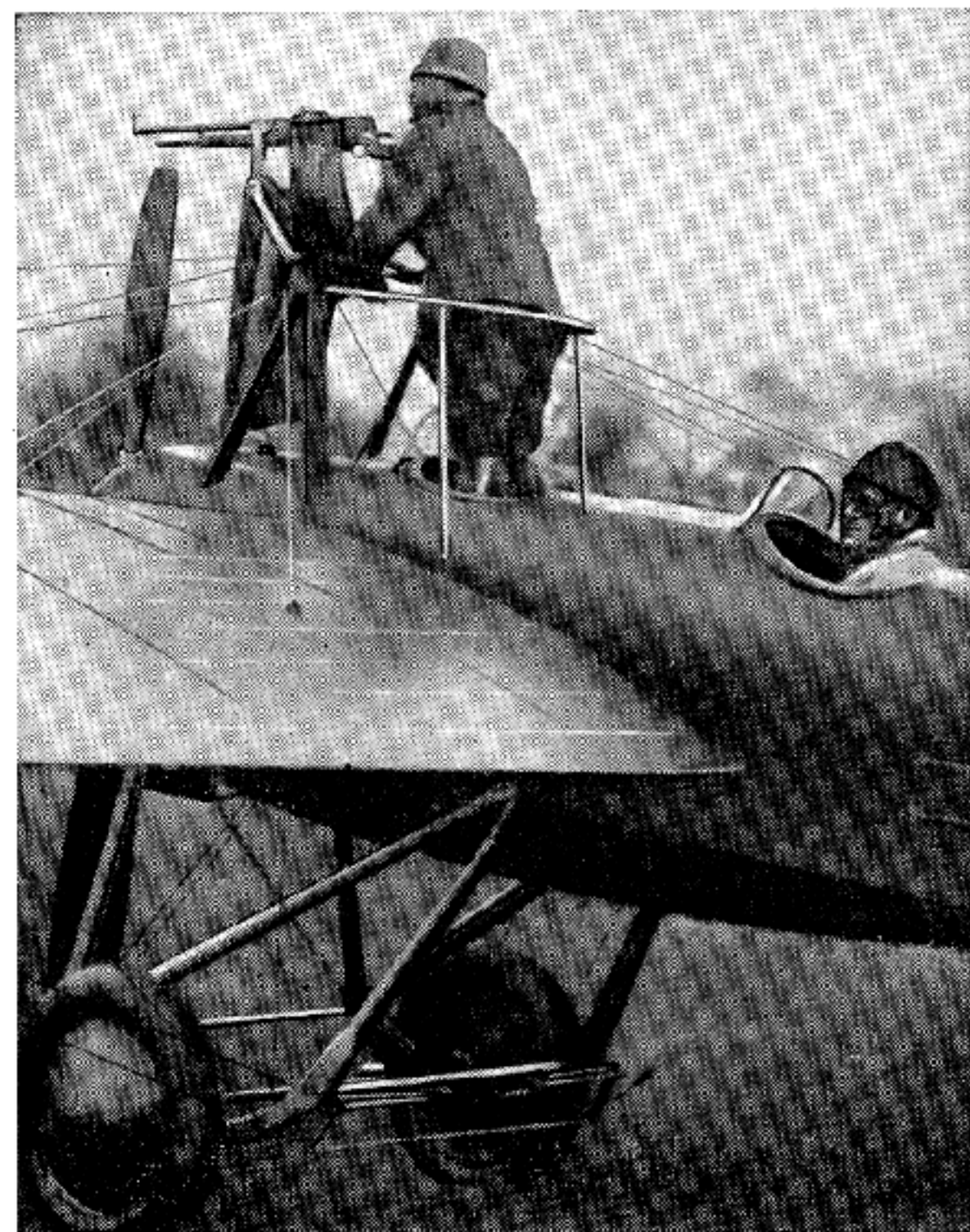
Two years before World War I a French Deperdussin monoplane had a machine gun permanently mounted on a post arrangement from which the observer located in front of the pilot could rise and fire over the propeller arc. As the gunner stood inside the rail, he was also partially protected by 4 millimeters of steel armor. This contrivance was originated by a M. Loiseau. Later the first public demonstration took place in February 1914 before high army officials at Villacoublay near Paris. The pilot for the occasion was Lieutenant Prevost, with M. Loiseau, the designer, acting as observer gunner.

The arrangement consisted of a machine gun attached in a yoke to a support braced to the mast and fuselage, with a high enough support to enable the gunner to fire forward over the propeller even with considerable depression. The operator was encased in a shield of light armor and had a light railing around the sides and rear. Even with these safety precautions he was still in danger, not only from falling out of the airplane, but from exposure to enemy fire.

The pilot's view was likewise obscured, even with small sections cut out of the trailing edges of the wings adjacent to the fuselage to allow him more visibility downward. Regardless of its clumsy appearance, it was at least an attempt to mount a machine gun permanently on a war

plane. It was thought to be the only possible way to maneuver a weapon so as to fire forward of the propeller.

Even this method was not altogether original. There had been earlier experiments with a Nieuport plane where the observer merely stood up in his seat, braced his elbows on the upper wing and fired a repeating shot gun or military rifle forward in the same manner. However, in the Deperdussin plane the weapon was a mounted machine gun and the date, 11 February 1914, marked the first instance of a military plane with a permanently installed forward-firing machine gun. The weapon selected as the most suitable for aviation use was the light, or



Firing the Benét-Mercié Machine Gun from a Deperdussin Airplane, 1914.

"portative," Hotchkiss, better known in the United States as the Benét-Mercié.

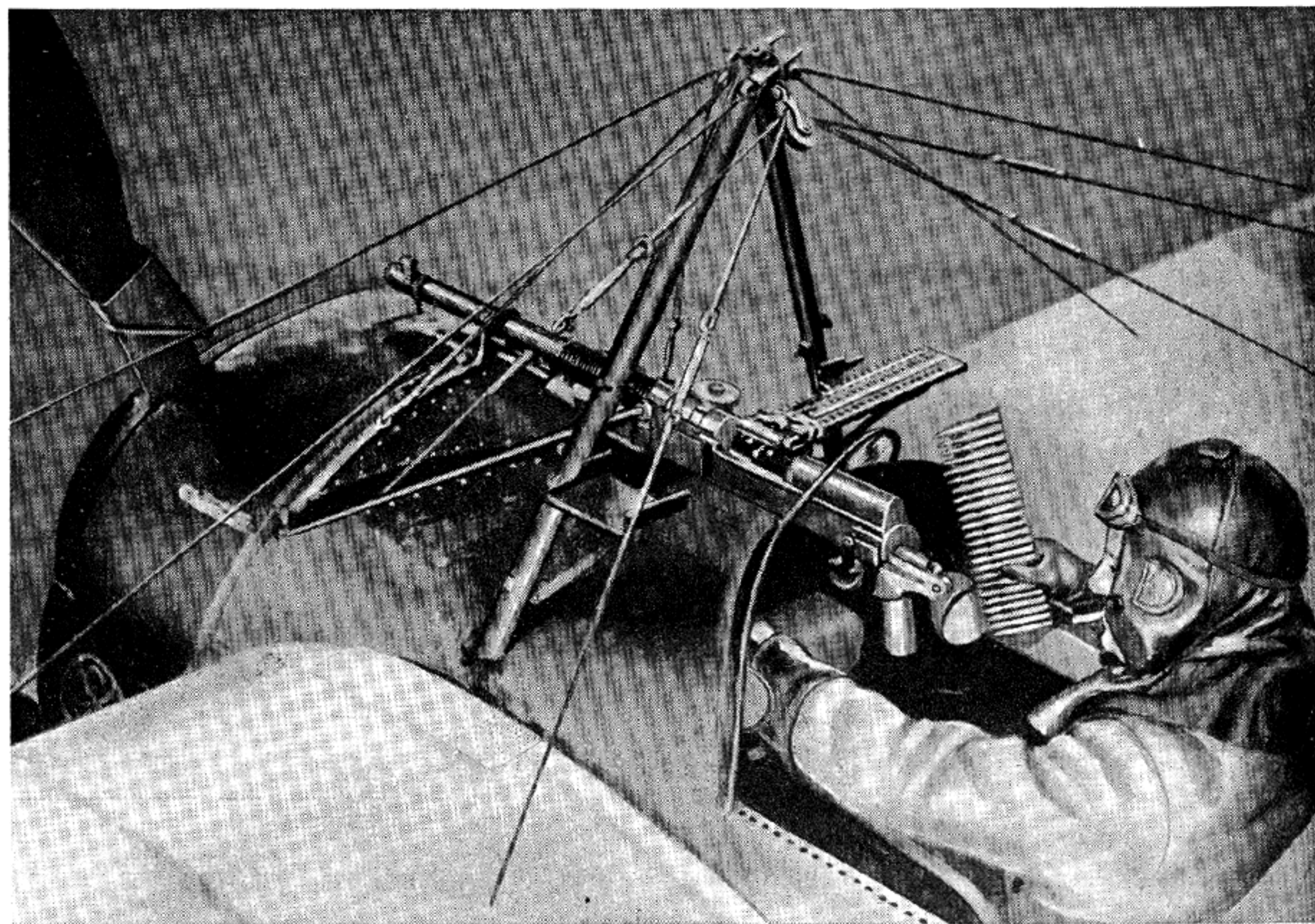
Nothing was done to the weapon itself to make it more adaptable for aircraft use, but in other instances it was modified to feed by a belt in lieu of the strip feed. The time-honored system of having the belt and cartridges rolled on a drum and all attached to the weapon's receiver was used so as not to interfere with its flexibility.

An interesting sidelight in connection with this test is the relationship of the Deperdussin plane to the famous Spad machine, the finest Allied fighting aircraft in World War I. Armand Deperdussin was a French silk dealer who was reputedly very wealthy. He took to making fast airplanes as a hobby in 1911 and spent so much money on them that he went bankrupt. When his affairs were investigated, he was sent to jail for fraudulent transactions in silk.

Deperdussin was languishing in prison when

one of his machines won the Gordon Bennett Cup in 1913 for flying at the record-breaking speed of 124.8 miles per hour. The pilot and others of the racing team sent a sentimental telegram of congratulations to their "bon patron" behind the bars.

Soon after the outbreak of the war M. Bleriot another famous French pioneer of the air, took over the Deperdussin business to preserve the organization and staff of the firm. It then became known as the Société Pour les Appareils Deperdussin, from which the initials S. P. A. D. are derived. The plane was developed and perfected so that it became the one machine that assured the Allies air superiority in the war. It was fitted with an eight-cylinder Vee-type water-cooled Hispano-Suiza motor. This solid, fast and highly maneuverable plane carried twin synchronized machine guns and later was outfitted with one of the first air cannon.



Benét-Mercié Machine Gun Firing Forward. The Propeller is Protected by a Deflection Plate Originated by R. Garros.

The science of military aviation was much farther along in France than it was with her English ally when war was declared by Germany in 1914. This was true not only with respect to the facilities at hand but likewise to pilots.

Of the earliest French fighter pilots one of the outstanding figures was Roland Garros, an airman of superb skill and daring. As early as 1912 he set an altitude record of 15,000 feet. During the war he had many exciting aerial fights ranging from the throwing of missiles to the use of the machine gun. It did not take him long after carrying the Hotchkiss Portative with him as a free gun to see the great possibilities of being able to fire straight ahead through the propeller arc. All pilots no doubt had noted the same thing before, but Garros was the type to do something about it immediately.

Early in 1915 he had his ordnance men mount directly in front of him a clip-fed Hotchkiss Portative machine gun. He had found out from confidential British reports on firing a machine gun forward through the air screw arc that with a normal rate of fire only 2 percent of the bullets struck the blade.

To the practical-minded Garros the solution of the 2-percent factor seemed simple. He fashioned two tempered pieces of triangular metal that could be clamped on the propeller so that when the blade was turned until the metal pieces faced the bore of the gun, it formed a pyramid. The sharp-pointed top of the triangular pieces then was bore-sighted with the center of the barrel. When a burst was fired, 98 percent went safely by the space between the blades and the other 2 percent ricocheted harmlessly off the hardened angles of the metal attachment, leaving the propeller unharmed.

Unfortunately for the Allies, Garros was forced down behind the German lines with motor trouble, although not before he had shot down many German planes with his device. His crude bullet deflector was shown to Antony Fokker, Germany's leading aircraft designer, who at once visualized an improvement and set about devising a reliable mechanical fire interrupter for his planes. The operation of the Garros deflector was one of the most sought-after secrets of the war, as the Germans could not fathom how he fired steadily through the air

screw without injuring it. Garros later escaped to fight again, but by then his idea had been bettered and German planes began to appear with the fire interrupter that was to give them air supremacy for at least the next 6 months. Garros, nevertheless, was the first man to mount a machine gun in such a manner that maneuvering of the plane made it a gun-laying device instead of merely a flying platform.

The French, at the very outbreak of war, were ready with a secret weapon that made the world realize the effective use of the airplane against large movements of ground troops. Odd as it may seem, machine guns were not employed in the first ground strafing. The French high command had for several years prior to the war secretly practiced dropping bundles of steel arrows that separated on the downward flight. A bundle of a thousand arrows gave good coverage over a half acre of land. The missiles were very tiny and light, being 6 inches in length and brought to a needle point at one end. Tests made with them showed that, when dropped from 1,500 feet, one of them would go through the body of a horse. The Germans soon learned



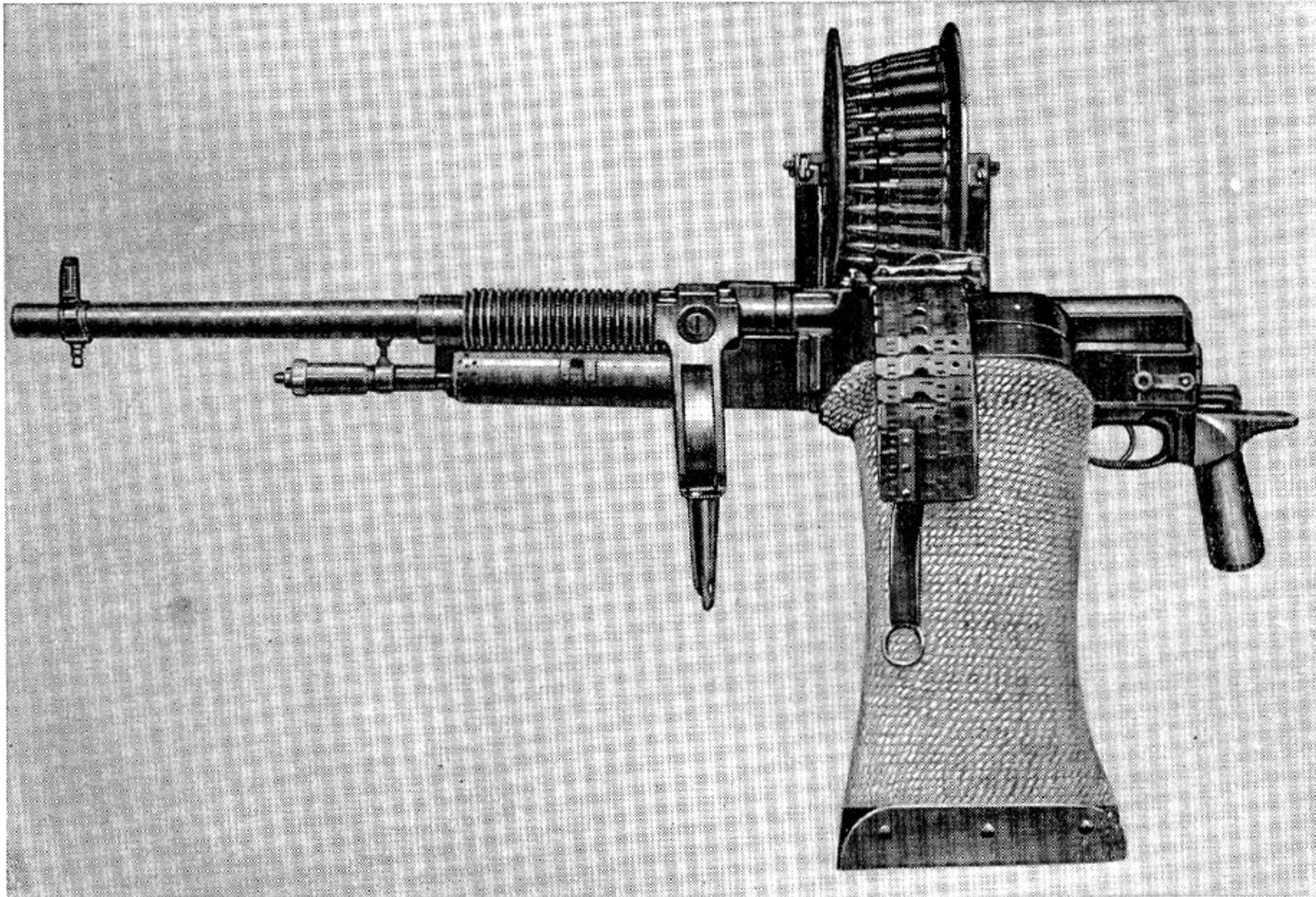
An Early Front-Gun Spad with False Nose to Accommodate Gunner.

that dispersion on the approach of a plane was the best defense against the arrows and they soon were replaced by machine guns for ground strafing.

In order to regain air supremacy from the Fokkers with the fire interrupter, the French attempted to solve the problem of firing through the air screw of a tractor-type plane by equipping a Spad with a false nose in front of the propeller. It housed a gunner and a swivel-mounted Portative Hotchkiss. A wire guard kept the gunner's head out of the propeller in the event he thoughtlessly leaned back. This scheme only showed the desperation of the French at the time.

In 1916 the French developed another unusual fighting plane which was called the "Mechanical Owl." Its intended purposes were for night fighting, or more specifically, to seek out observation balloons, and for any other missions that required night flying. This plane was

a pusher-type Maurice Farman, mounting a 11-mm belt-fed Hotchkiss in the forward part of the cockpit. It was felt that the large bullet held enough incendiary mixture to set fire to any observation balloon or hydrogen-filled dirigible. As further armament the large plane also carried six rockets, three on each wing, that could be fired electrically by the pilot. The rockets were considered extremely accurate up to 400 yards. The craft represented a formidable weapon against hydrogen-filled airships, both the fast-moving dirigible and the anchored observation balloon. Primarily designed for night fighting, the planes were equipped with a battery of headlights fastened above the landing gear and below the pilot. These searchlights served the dual purpose of lighting up the runway when the pilot returned at night to his home air base, and of illuminating the target once he could approach close enough to detect the huge balloon in the dark.



Benét-Mercié Machine Gun Adapted as an Aircraft Flexible Mount.

The rockets used on this plane were the invention of a French naval officer named Le Prieur and, while their use was restricted to observation balloons and Zeppelins, they had great potentialities in other fields. One of their most notable successes was the day before the great Somme offensive in 1916 when French pilots practically cleared the sky of the big hydrogen-filled bags, leaving the German artillery without observers.

The Le Prieur rocket was powered by ballistite. While the body was short and contained only a small amount of propellant, it was accurate for a reasonable distance after which it would wobble badly. This made it impossible to hit anything much beyond a 400-yard range. However, it was considered adequate for its intended use on the huge sides of a hydrogen-filled target.

Hotchkiss machine guns did not see much service in World War I as aircraft weapons. When the war came, France was desperately in need of heavy infantry-type machine guns and for this purpose the Hotchkiss was considered among the best. As fast as produced, they were sent to the front. The weapon, because of its design, could not readily be adapted to aircraft use, since feeding was done by inserting long metal trays of cartridges from right to left. This made plane installation practically out of the question.

Another reason for the sparing use of Hotchkiss guns was the fact that the British had two superb aircraft machine guns for free and synchronized installation. France, recognizing this, depended upon her ally to furnish armament for her planes. This is no reflection on the Hotchkiss. It was not originally designed for aircraft and some of its best features as an air-cooled infantry weapon made it impossible to convert to aerial use without practically complete redesign.

After the Armistice there was no immediate development work on machine guns at the Hotchkiss plant, but in 1922, at the suggestion of military authorities of other governments, the company did start experimental work on a large caliber automatic weapon designed primarily for aircraft use. Its operating mechanism was similar to the older models and a few fea-

tures were added to compensate for the increased shock due to the high rate of fire demanded for such a weapon.

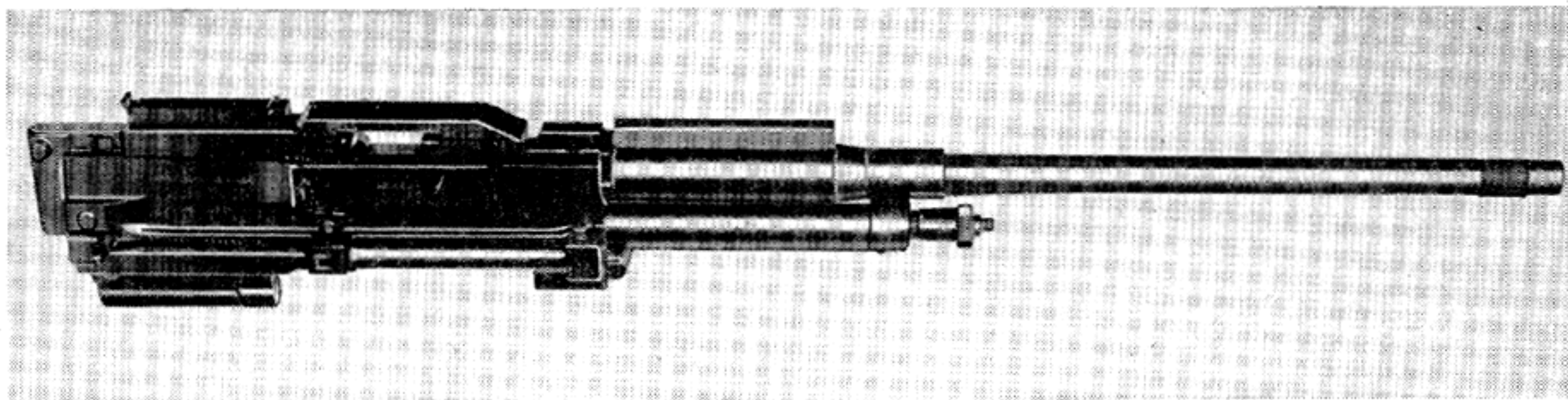
On the 13.2-mm aircraft Hotchkiss, cartridges were fed by means of a disintegrating metal belt that came in lengths of 100 to 150 cartridges. Although the quick-disconnect barrel was chambered for a cartridge with a tremendous powder charge, the design was so thorough that the great load was not excessive.

While produced at the suggestion of foreigners, as soon as this model made its appearance and showed promise in early firing tests at the Hotchkiss company's range, the French Government put its development in secret status. This act did much to retard progress on the arm and no doubt kept it from being used throughout the world by other powers.

The French air force visualized the 13.2-mm Hotchkiss as an ideal engine gun and mounted it experimentally to fire through the propeller hub of a Hispano-Suiza engine. When so installed in aircraft a compressed air cocking system was employed for both charging and solenoid operation. The rate of fire was 600 rounds a minute and the fast recoiling parts were buffed by a heavy spring-loaded plunger attached to the back plate. The bolt and piston assembly remained in the retracted position at the completion of a burst.

When thus mounted, the ammunition container was located above the receiver with a flexible cartridge guide extending over to the feedway. This ideal arrangement provided practically a gravity flow of ammunition into the gun once firing was started.

After the French had officially tested the gun at Calais until they were satisfied that they had an adequate machine gun for any aviation work that required a heavy high-velocity armor-piercing bullet, they then adapted it to be used on their own armored vehicles. A mounting arrangement was provided that gave the gunner a high degree of maneuverability. This particular Hotchkiss machine gun is little known because in the years between the two great wars the French, confident that it was their chief aviation machine gun for the future, suppressed all information concerning it. Before they could get



Hotchkiss Aircraft Machine Gun, 13.2 mm.

it into use on any large scale in World War II, however, the country was overrun by the Germans. The conquerors, already equipped with aircraft armament they felt superior, made no attempt to utilize the 13.2-mm Hotchkiss machine gun.

The basic principle being the same, the cycle of operation was naturally identical with that of other well-known Hotchkiss guns.

On 28 April 1927 representatives of the Okura manufacturing concern in Japan began negotiations with Hotchkiss for the purchase of manufacturing drawings for a large caliber anti-aircraft machine gun. This gun was suitable for both shipboard and ground installations, having been developed from the aircraft 13.2-mm model. The French authorities permitted Hotchkiss to offer this same mechanism and caliber, withholding only information on the compo-

nents that made it adaptable for aviation use. They specifically insisted that no means of belt feeding be revealed. The result was that the Japanese acquired the rights to make a 30-shot clip-fed weapon using the same operating parts as the original gun, but designed solely for anti-aircraft use. It was a heavy-barrel weapon with radial fins for cooling that had a maximum rate of fire set at 450 rounds a minute. The Japs gave this devise the official designation, 13.2-mm A. A. Machine Gun Model 93 (1933), and it was used extensively by them all through World War II.

In the Russo-Japanese War of 1904-05, which was the first major conflict in which both sides employed machine guns, the Japanese were armed with the Hotchkiss, which they found reliable and efficient. Since they were the victors and the Hotchkiss machine gun contributed to



Hotchkiss Ground Machine Gun, 13.2 mm.

the war's hasty conclusion, Japanese military men retained a highly favorable opinion of the weapon.

It was natural that Japan, in planning future offensives, placed the Hotchkiss high on the list to be adapted to its specific needs. Thus many Japanese machine guns were produced with strange appearances, designations, model numbers and physical outlines that actually housed Hotchkiss mechanisms.

These adaptations and straight copies ranged from lightweight infantry machine rifles to larger caliber antitank versions. Even standard ground Hotchkiss models, in a variety of calibers and provided with almost every conceivable feed system, were converted to aircraft use. Supply officers had seven distinct small arms cartridges to provide for troops that used such machine guns. In Japanese logistics it seemed to mean nothing if two machine guns were designated 6.5-mm; it was possible that the only identical thing about the caliber referred to was the bore dimension. In most cases each weapon had to have its own particular cartridge.

A fairly safe procedure of classifying a strange-looking Jap gas-operated machine gun was to look upon it as some form of Hotchkiss until proved otherwise. A few of the first-line Jap weapons that were undeniably Hotchkiss are given in the following table:

Model	Type	Year	Caliber
Light machine gun	11	1922	6.5 mm
Light machine gun	96	1936	6.5 mm
Heavy machine gun	3	1914	6.5 mm
Heavy machine gun	92	1932	7.7 mm
Antiaircraft machine gun	93	1933	13.2 mm
Tank machine gun	91	1931	6.5 mm
Aircraft machine gun . .	89	1929	7.7 mm
Aircraft machine gun . .	97	1937	7.7 mm
Aircraft machine gun . .	100	1940	7.92 mm
Aircraft machine gun . .	3	1943	6.5 mm

Tabulation of Hotchkiss Machine Guns

The following tabulation is intended as a ready reference of the various Hotchkiss models used by the nations of the world:

Name	Country	Designation	Bore
Hotchkiss	Experimental	Model 1895	8 mm Lebel
Hotchkiss	Chile	Model 1896	7 mm Mauser
Hotchkiss	France	Model 1897	8 mm Lebel
Hotchkiss	France	Model 1900	8 mm Lebel
Hotchkiss	France	Model 1914	8 mm Lebel
Hotchkiss	Mexico	Model 1896	7 mm Mauser
Hotchkiss	Venezuela	Model 1896	7 mm Mauser
Hotchkiss	Guatemala	Model 1896	7 mm Mauser
Hotchkiss	Spain	Model 1907	7 mm Mauser
Hotchkiss	Spain	Model 1914	7 mm Mauser
Hotchkiss	Brazil	Model 1896	7 mm Mauser
Hotchkiss	Ethiopia	Model 1914	8 mm Lebel
Hotchkiss	Belgium	Model 1906-1912	7.65 mm
Hotchkiss	Norway	Model 1898	6.5 mm Krag
Hotchkiss	Norway	Model 1898T	7.9 mm Jung TL
Hotchkiss	Sweden	Model 1900	6.5 mm Mauser
Hotchkiss	Commercial	Model 1899	As desired

Name	Country	Designation	Bore
Hotchkiss	Commercial	Model 1903	As desired
Hotchkiss (Navy)	Portugal	Model 1914	7 mm Mauser
Hotchkiss	Japan	Model 1905	6.5 mm Arisaka
Hotchkiss	Japan	Model 1914	6.5 mm Arisaka
Hotchkiss	Chile	Model 1920	7 mm Mauser
Hotchkiss	Japan	Model 1932	7.7 mm
Hotchkiss	Japan	Model 1941	7.7 mm
Hotchkiss	France	Balloon gun (World War I) ..	11 mm
Puteaux	France	Model 1905	8 mm Lebel
St. Etienne	France	Model 1907	8 mm Lebel
St. Etienne	France	Model 1907 T	8 mm Lebel
St. Etienne	Italy	Model 1907 F	8 mm Lebel
St. Etienne	Turkey	Model 1907 (converted)	7.9 mm Mauser
St. Etienne	Greece	Model 1907	8 mm Lebel
St. Etienne	Yugoslavia	Model 07/15	8 mm Lebel
Benét-Mercié guns:			
Hotchkiss LMG	France	Model 09/13	8 mm
Hotchkiss Army	USA	Model 1909 .....	.30/06
Hotchkiss Army	USA	Model 1910 .....	.30/06
Hotchkiss Navy	USA	Mark I .....	.30/06
Hotchkiss Navy	USA	Mark I Mod 1 .....	.30/06
Hotchkiss LMG	England	Mark I .....	.303
Hotchkiss LMG	England	Mark I* .....	.303
Hotchkiss LMG	Spain	Model 1922	7 mm
Hotchkiss LMG	Norway	Model 1911	6.5 mm

NAMBU AUTOMATIC WEAPONS

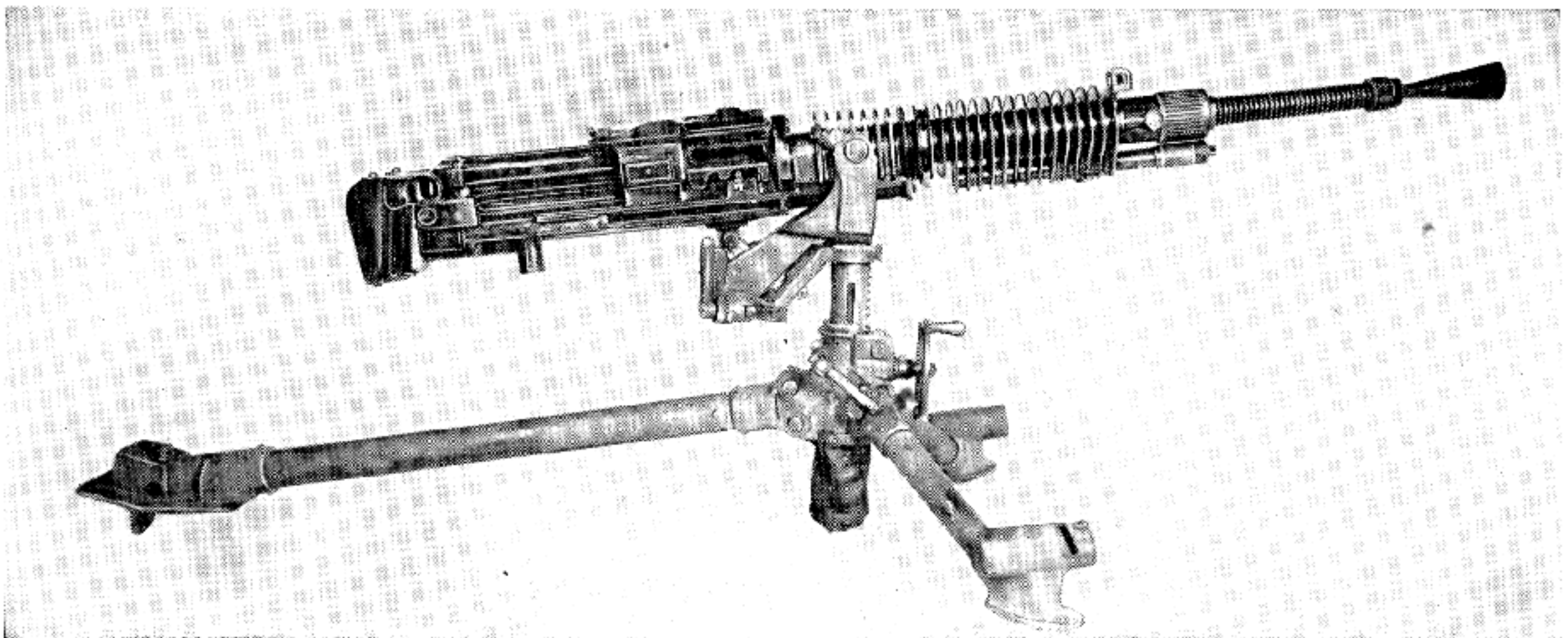
Between World Wars I and II, Japan constantly surveyed the development and experimental work of all nations in an attempt to provide for her own armament the best in automatic weapons these countries had to offer. The Japanese have long been noted for their lack of originality and their meticulous effort in copying, and later refining, those things in which they had special interest. Weapons were by no means an exception to this rule, since it was one of the first major powers to use machine guns in combat in the Russo-Japanese War of 1904-05. The automatic weapon used to such good advantage was the French Hotchkiss and the country naturally leaned towards this very reliable system of gas operation as a model for its future machine guns.

However, research was constantly directed towards the improvement of all makes of standard automatic weapons to meet specific needs of the armed forces. Manufacturing difficulties and metallurgy problems were often overcome by accepting a lower muzzle velocity, even the solution to muzzle flash being approached from this

angle. Such sacrifice of bullet speed and the corresponding chamber pressures made it possible to get satisfactory operation from lower grade materials.

Since the trend was for the simplification of already existing weapons and the substitution of inferior metals, the development of aircraft machine guns and automatic cannon showed little or no originality, all being close copies of similar armament of other countries. One of their most popular aircraft cannon was a Browning aircraft machine gun scaled up to 20 millimeters. Other arms were patterned after the German Rheinmetall and Italian designs.

One of the most discussed of Japanese automatic weapons was the so-called Nambu machine gun, devised by Lt. Gen. Kijiro Nambu. This officer first began the study of automatic weapons in 1898. In 1904, he designed a pistol, which, however, was not accepted by the Japanese Army. After modification, it finally became in 1925 an official side arm, being given the designation, Type 14 pistol. In the meantime he had turned his attention to machine guns. In his pistol he



Machine Gun, Model 3 (1914), 6.5 mm, Japanese.

did show some originality but his machine guns were straight Hotchkiss systems, with a few physical and external modifications to suit special conditions.

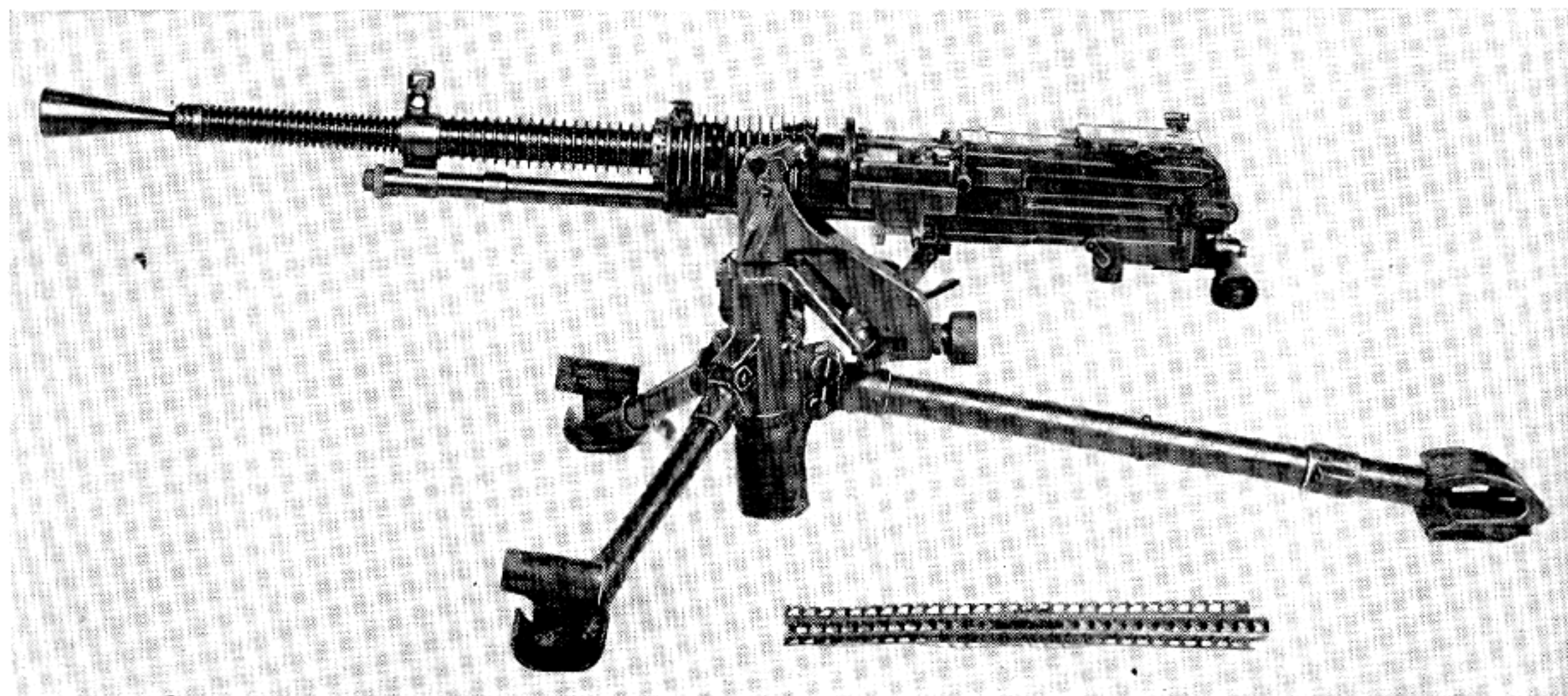
The first Nambu machine gun appeared in 1914 and was known as the Type 3 heavy machine gun. In 1922 it was improved and became the Type 11. General Nambu founded a rifle company bearing his name at Sankomaje-Nakano, Tokyo, in 1927. At this place he developed what was to become later the Type 92 medium machine gun which superseded the Type 3 in the Japanese Army. He again modified this medium gun as the need for its improvement had become obvious, producing the version known as Type 96.

In 1937 the Nambu Rifle Works merged with the Chuo Kogyo Kaisha Co. of Tokyo, and 2 years later he introduced the Type 99 light machine gun. Until his retirement in 1943 Nambu acted as an ordnance consultant to this firm. From 1939 to 1945 the Chuo Kogyo Kaisha plant manufactured 4,794 Type 96 and 1,179 Type 99 machine guns.

All Nambu machine guns were gas operated and air cooled with many radial fins giving more surface for cooling. The earlier models had rectangular gravity oil reservoirs so that as rounds were fed into the feed opening they engaged a spring-loaded lubricator. This action caused oil to flow through perforations onto the cartridge

cases. Such lubrication was needed because manufacturing the components to such close tolerances as to permit a workable head space had not been possible at the time. The oil permitted the cartridges to slip back against the bolt until lock clearance was taken up, thereby eliminating the danger of a ruptured cartridge case.

The ejection system in these guns is the only deviation from the Hotchkiss, it being an exact duplication of the Lewis method of pivoting a piece over the bolt body. During forward movement of piston and bolt the bolt head raises the nose of the ejector upward out of the body, which forces the tail of the extractor to descend through the opening in the bolt. On rearward movement the aft end of the ejector lifts, causing the nose to descend through the opening in the bolt and strike the cartridge at its base. The case is then knocked through the opening in the side of the receiver. The rate of fire can be adjusted by means of five different sized orifices. The gas regulator has a positioning catch with a spring-loaded plunger that engages slots in front of the gas cylinder. Initial extraction takes place during the first phase of unlocking after the locking piece has risen and the bolt commences its first movement rearward. Full extraction occurs when the piece is unlocked and the gas piston and bolt assembly are driven back together. The extractor is the conventional flat-spring type with a recess cut in the back end of the barrel to ac-



Machine Gun, Model 01 (1941), 7.7 mm, Japanese.

commodate it when the bolt is all the way in battery.

The Model 99 Nambu 7.7-mm light machine gun is undoubtedly the most familiar Japanese automatic weapon. The main refinement was in the machining which permitted better head spacing and consequently did away with the necessity of oiling the ammunition.

A new spring-loaded clip magazine was used that gave the gun the appearance of the well known Bren. Four different types of the Model 99 were tested before the weapon was fully standardized and adopted in May 1939.

To fire the Nambu Model 99 machine gun, the operator, generally prone, first snaps into its recess on top of the receiver a loaded clip. He cocks the gun by pulling back on the charging handle until the recess of the piston engages the bent of the scar, which holds the bolt back under driving spring compression. When the trigger is pulled, its nose depresses the scar, disengaging it from its recess in the piston. The bolt and piston now fly forward under energy of the compressed driving spring. During this movement the face of the bolt picks up the first round in

the magazine mouth and starts it toward the chamber.

The bolt arrives home first and completely chambers the cartridge. With the extractor lip camming itself over the rim of the case, the piston, still moving forward, raises the back end of the bolt into its locking abutment by means of a linkage arrangement, and the projection on the end of the piston strikes the firing pin to explode the propellant.

As the bullet is driven out of the barrel, a portion of the gas is vented through the gas regulator into a cylinder to strike the piston head a sharp blow, driving it rearward. When the piston has traveled $\frac{3}{8}$ inch, the bolt is free to unlock, forcing the aft end of the bolt out of engagement with the locking step.

The first recoiling movement begins initial extraction of the empty cartridge case and withdraws the firing pin. Continued movement brings ejection and full compression of the driving spring. A small spring-loaded buffer at the rear of the receiver absorbs all surplus energy and starts the operating parts back into counterrecoil. The cycle is repeated as long as the trigger remains depressed.

REVELLI AIRCRAFT MACHINE GUN

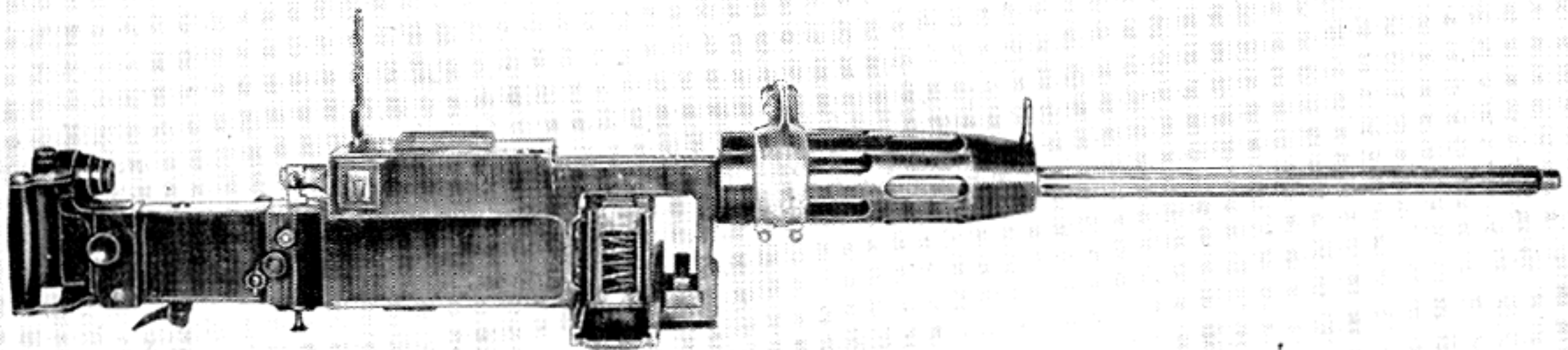
The Italian Air Force during World War I was so desperate for an adequate rifle-caliber machine gun of native origin that it ordered the lightening of the water-cooled 1914 model Revelli. This was accomplished by the removal of the water jacket and use of an air-cooled barrel with longitudinal ribs. It not only gave more cooling surface but also strengthened the barrel, cutting down dispersion. The rate of fire was increased by use of ammunition more thoroughly lubricated by means of a built-in oil pump. While the modifications definitely improved the ground gun, it was still far from an ideal aircraft weapon. After limited use the Italians went back to the reliable synchronized Vickers for fixed installations and the Lewis gun for flexible mounting.

As soon as hostilities were ended, Italian military authorities immediately turned their energies towards the development of a light machine gun for both infantry and aircraft use. This trend was hastened by the British decision to stop exporting Vickers ammunition. They negotiated for the purchase of a thousand Darnie guns from France but these proved unsatisfactory. The Italians wanted, if possible, for infantry use to combine the advantages of a light machine gun with the ruggedness of the heavy; and for the air force, to employ it both for flexible and fixed mounts.

They wished to raise the caliber to eight millimeters or even more, but were plagued by the presence on hand of huge stores of the outmoded 6.5-mm ammunition produced during the war. This obstacle forced them to do the next best thing, namely to improve what was already in use and if anything was designed in the future to be certain to chamber it for the readily available 6.5-mm cartridge.

Italy has always used the unique ordnance development method of giving contracts to different companies for machine guns based on identical specifications and then holding competitive trials to see which company has turned out the best gun. This odd system of government-sponsored competition makes identification very confusing, for one often finds practically identical guns, marked in some instances with the same model numbers, that are named for the various plants that produced them.

The Fiat Co., the first manufacturer of Revelli's guns, offered to the Italian Government for trial in 1926 a lightweight machine gun that it contended would fill all demands placed upon it. It was designed, according to its producers, to take into account reliability of action, minimum weight, simplicity of construction and ease of handling, all being factors that must be taken into consideration in order to have a practical unit. The principal parts were given as receiver,



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

barrel extension, bolt, breech lock, barrel, jacket, and ammunition box.

The receiver is square in shape. In its front there is an integral threading into which is screwed the cylindrical sleeve where the recoiling barrel slides. The operating or spade grip handle is fixed to the extreme rear of the receiver. The oil reservoir is located at the upper part of the receiver and is provided with a small hinged door for filling. On the right side of the piece an ejection slot is cut, while the left part has a portion milled out to admit the ammunition box.

The inside of the receiver has a longitudinal square cut in which the bolt and barrel extension slide during recoil. A rectangular transversal hole located in the middle accommodates the key that limits the sliding movement of the barrel and its extension. Another such slot near the handle serves for the key holding the spade grips into position.

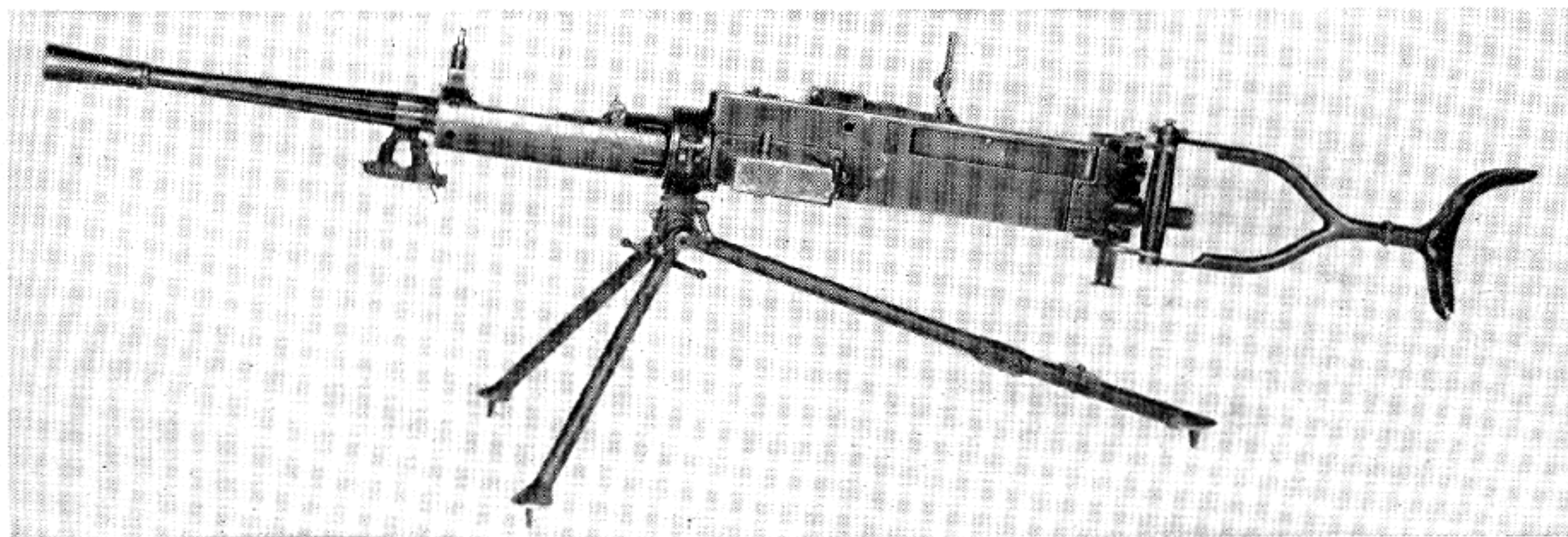
The barrel extension is a square section with interrupted threads in the front part for quickly attaching the barrel. Its upper part has a rectangular opening through which the bolt lock is inserted. An opening on the left side admits the loaded round and on the right side there is a similar opening for ejecting the case. Internally the piece has a longitudinally square opening that serves as a slide way for the bolt.

The bolt is made square to fit into the barrel extension with a wider portion left on the aft end to engage the retracting hook at the bottom and the rear sear at the top. Internally it has a cylindrical hole of two different diameters into which the firing pin moves to perform its func-

tion. In the bolt face is a recess to accommodate the base of the cartridge. On the left side is a rib that engages the incoming round from the ammunition box and forces it into the chamber, while the extractor is fastened on the right of this piece. There is also a device housed in the bolt body called the safety lever. It prevents release of the firing pin before the breech lock is in battery position, since it cannot be removed from the path of the firing pin until its recess is reached which is coincidental with the locking action.

The bolt lock has a hole through which it is secured to the receiver by means of a pin, and around which it partially rotates during its function. The front flat part of this lock rests in the recess in the upper part of the bolt and the rear part on the barrel extension. On the upper part is a heavy spring-loaded curved rod to which is pinned the breech lock. The firing pin is cylindrical having two different diameters and is fitted with a rib which acts as a guide in the slot cut in the left side of the bolt. This rib has a cammed angle that causes it to be jacked back slightly by the first movement of recoil and at the end of the bolt's farthest travel rearward it is retracted fully. The weapon is fired automatically when the safety lever pivots down in the recess at the end of counterrecoil, releasing the cocked firing pin.

The barrel has externally cut longitudinal cooling ribs. It is attached to the barrel extension by insertion in the chambered section and is held fast by means of a four-tooth interrupted thread. A lever prevents the barrel from rotating and



Revelli (Fiat) Machine Gun, Model 1926, 6.5 mm.

consequently disconnecting itself from the barrel extension. This arrangement permits a quick barrel change and a short asbestos-lined handle is provided to facilitate this necessary action.

The weapon is hand charged by means of a handle that protrudes through the back plate with connecting slides that engage the rear end of the bolt at its rearmost projection. This permits hand cocking, as well as complete retraction of all recoiling parts.

The ammunition feed on the 1926 Revelli is a metal holder attached to the left side of the receiver. This device, which is normally removed during transportation, holds 20 rounds of ammunition and is held in place after insertion by a latch near its mouth. The ammunition is placed in the feed after first being inserted in a special metallic loading device. After this loading container is discarded, the last round to enter goes over a cartridge-holding pawl that retains it in position in the feed mouth. The rib on the bolt then picks it up for chambering.

The producers of the weapon recommended that the barrel should be changed after every 200-round burst and before firing suggested that the mechanism be worked back and forth manually a few times in order to lubricate thoroughly the ammunition before commencing to fire.

In order to fire the weapon, the following steps had to be undertaken to prepare it properly for reliable operation:

Check oil reservoir to ascertain if sufficient lubricant is in tank; pull rearward on the charging lug until rear sear engages bolt; push charging handle all the way home manually until it is locked by its detent; insert magazine in left side and lock in position; open trap door on right side to permit empty cases to be ejected; then introduce through this opened trap on the right side 20 cartridges from their metallic holder, pushing cartridges across the feedway until the last one crosses the holding pawl.

When the magazine was thus loaded, the container was discarded and the weapon was ready to fire.

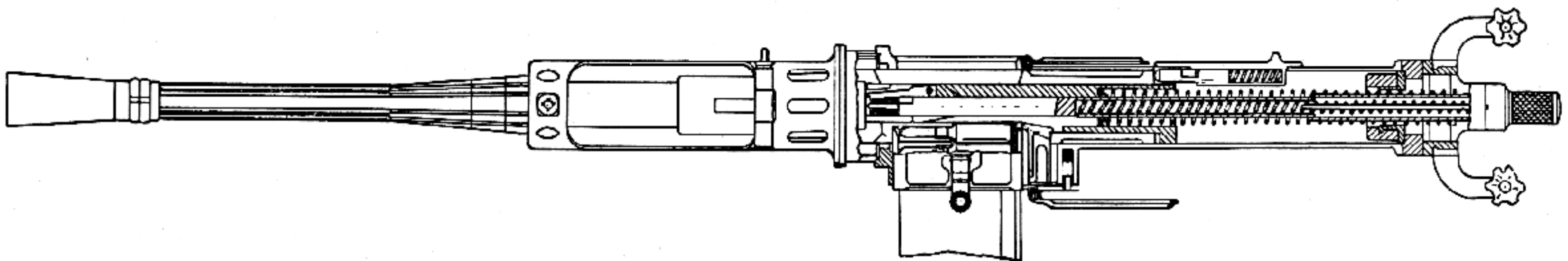
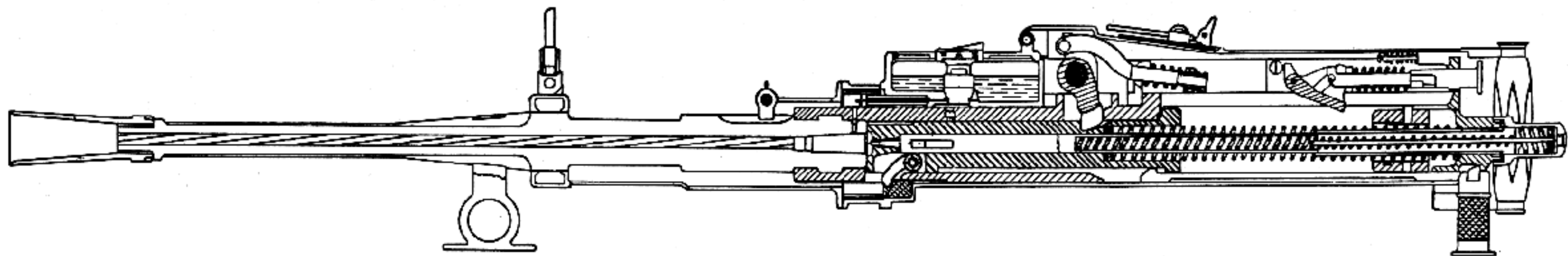
The Fiat Co. appeared to have produced an entirely new machine gun but closer examination of the operating parts showed it to be just another version of the earlier 1914 Revelli with refinement being merely external. The basic op-

erational features were the same as the original model. While the Italian Government did not adopt the "new" gun, it did encourage development by buying 2,000 for general use. This was enough financial incentive for the Fiat Co. to continue with its experimental work.

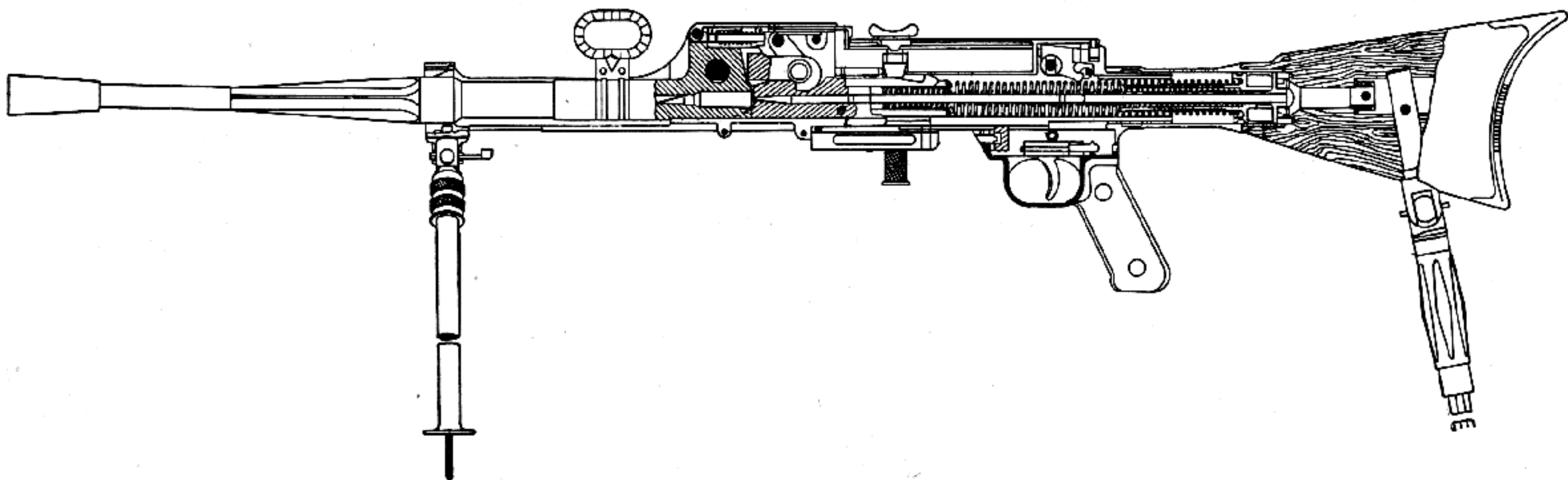
The manufacture of the 2,000 weapons that the Government agreed to buy was turned over to a newly formed corporation at Turin. Basically Fiat was an automobile manufacturing plant but since it found machine gun production a profitable sideline, a separate plant was built exclusively for the fabrication of automatic weapons. The new establishment was known as the Società Anonima Fabbrica Armi Torino, which accounts for the 2,000 weapons, officially designated the Fiat, Model 1926, having a Safat nameplate.

It having been plainly pointed out to Fiat that all branches of the service were disappointed in the lack of new operational features in its 1926 model, the firm again proceeded with intentions of redesigning and manufacturing a suitable arm. As an incentive the Government withheld adoption of an official model, and development could be undertaken with the knowledge that appearance of a superior product could result in complete outfitting of all branches of the service with a suitable automatic firing mechanism.

The result of this second effort was the Fiat Model 1928. It had many features not to be found in previous designs. The caliber naturally remained at 6.5 millimeters and the rate of fire was the same, as was the feed system. This time the changes were internal and not external, as had been the case with the 1926 machine gun, the main modifications being in the locking components. The company, after many years of production, had finally dropped Revelli's retarded blow-back system and incorporated in this mechanism a positive locking arrangement invented by Giuseppe Mascarucci, an engineer in the employ of Safat. By this method the barrel and bolt were positively locked for the first fraction of an inch of recoil and at a predetermined distance the linkage pinned to the breech lock was raised, pulling the lock out of engagement with its recess in the bolt. This changed the action from retarded blow-back to straight recoil operation. The remainder of the recoiling parts, however,



Drawing of Fiat Model 1926, 6.5 mm.



Drawing of Fiat Model 1928, 6.5 mm.

were very similar in appearance to standard Revelli components.

The purchasing of the Mascarucci patents caused Revelli to terminate his business connections with Fiat after nearly 20 years' association. Although the company lost the services of one of Italy's most prolific automatic weapon inventors, there is no question that the Mascarucci lock was a worthwhile improvement and the army immediately ordered it into test status for the purpose of adoption. By early 1929 over 200 had been delivered to various proving grounds.

In the 1928 Fiat, the action was securely locked until the gas pressure had dropped to a safe operating limit, making lubricated ammunition unnecessary. The weapon, when correctly head-spaced, no longer had ruptured cases from the retarded blow-back type of operation whereby the lock seeks to become disengaged even while gas pressure is at its peak with bullet in the barrel. The minute opening between the bolt face and the breech end of the barrel resulted in separated cases when a point beyond the elastic limit of the brass was reached.

The weight of the gun without tripod or shoulder piece was 21 pounds. One of the most exorbitant claims ever made for a machine gun barrel was the producer's statement that with bursts of a length prescribed by proving ground regulations, the barrel could be depended upon to give accuracy for 20,000 rounds. The implication was made that some advanced heat-treat process was responsible for the phenomenal feat.

Disassembly without the aid of tools could be accomplished in a matter of seconds. Simplicity and the use of few moving parts were most certainly taken into consideration, as the bolt, firing pin, and two springs were all operating parts that could be withdrawn with the removal of the back plate buffer.

To fire the weapon, the operator is generally prone. After the box magazine is snapped into position on the left side, the bolt handle is grasped with the right hand and drawn to the rear. The rear searing device then catches in the notch in the aft end of the bolt, holding it in the cocked position. The firing pin is also retracted by this movement.

The special metal loading device holding 20 cartridges, inserted from the right hand side of

the feedway and shoved in until the last cartridge is so loaded, passes over the cartridge-holding pawl. The metal charger is then withdrawn and put aside. The magazine now being loaded and the firing mechanism cocked, the weapon is ready to fire. If the pistol-grip trigger is used, it is pulled to the rear and with the aid of a bar raises the sear, allowing the action to be thrust forward by the energy of the compressed driving spring.

As the bolt goes home, the projection on its left side shoves the positioned cartridge in front of it into the chamber. The barrel and barrel extension are held to the rear, a half inch out of battery, by a small spring. When the locking notch in the bolt is directly under the locking lever, the whole assembly is then driven all the way into battery by the greater force of the driving spring. As the entire assembly moves forward, the link arrangement cams the lock into positive engagement with the recess in the bolt. This last forward travel of the bolt also brings into alinement the firing-pin recess controlled by the trigger bar. The open sear allows the firing pin to snap forward automatically and strike the primer of the cartridge.

While the peak pressure is in the chamber, the bolt latch securely holds the bolt, barrel extension, and barrel together until a half-inch travel is reached. The link now begins to raise the bolt latch slowly and then suddenly releases the recoiling parts with a small spring housed in the top of the receiver holding the barrel and extension in a retracted position. This gradual unlocking makes possible the slow pulling and loosening of the cartridge case by the extractor before total unlocking. The bolt is now free to travel rearward, assisted by considerable residual pressure in the bore acting on the face of the bolt. The extractor holds the base of the cartridge in position to strike the ejector and be thrown through the ejection slot in right side. At the first movement of recoil a cam surface action on the firing pin lug retracts it slightly beyond the bolt face. By the time two-thirds of the recoil stroke is accomplished, this piece is retracted. At the completion of recoil, the driving spring, being fully compressed, starts the bolt assembly forward to repeat the cycle of operation. However, if trigger pressure has been re-

leased, the sear in the upper rear of the receiver snaps down and engages its mating notch in the bolt body holding the firing mechanism in a cocked position.

The Fiat Co. also made an attempt at this time to produce a 12.7-mm machine gun along similar lines, but did not get beyond a few working models that were tested by the Italian Navy for shipboard use against torpedo plane attack. It too was clip fed, a detail in itself that rules out its usefulness.

The next Fiat design was in the form of a larger caliber aircraft weapon. It was chambered for 7.7-mm rifle caliber ammunition with the use of a disintegrating metallic link belt in place of the box magazines that had by now become something of a permanent fixture with all Italian machine guns. While the operating principle was identical with the '28 model infantry gun, the rate of fire was later increased to 800 rounds a minute by the addition of a muzzle-booster recoil-actuated accelerator and a star-wheel recoil-actuated feed system. Otherwise all components were basically the same as those of the light machine gun.

The stepping up of the cyclic rate at first was not looked upon with favor by pilots and observers, who expressed themselves as preferring lower rates, with well regulated and reliable mechanism, to the faster firing. They argued that inaccuracy and waste of needed ammunition were the only results when a weapon was fired faster than it could be aimed properly. This viewpoint had much to do with the reluctance of the Air Ministry to specify anything beyond a normal operating speed for the armament of aircraft. However, when the 800-shot-a-minute gun did prove reliable to a certain degree, it did not take long for the flyers to reverse their former opinion.

Little was done in machine gun development in Italy until the mid-thirties when Fiat brought out another model at a time when the nation was faced with war.

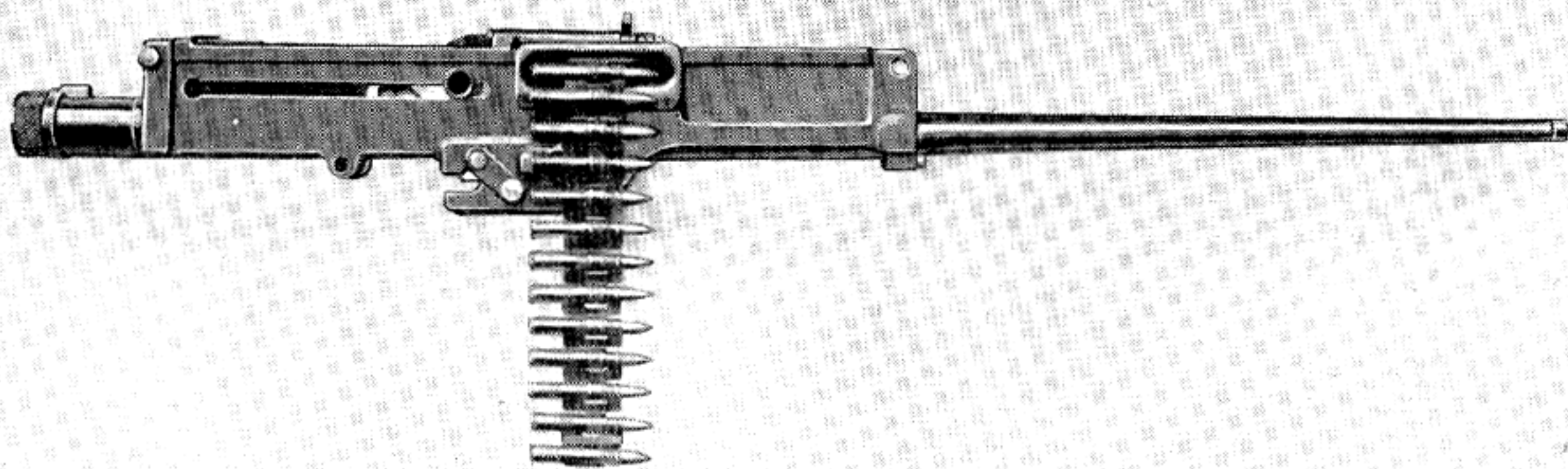
No single action portrays so vividly the misguided helplessness of the Italians after a quarter century of effort to produce an adequate machine gun of native design than did the appearance of the Fiat Model 1935. This gun was but



Fiat Machine Gun, 12.7 mm, Antiaircraft.

a rehash of the 1914 model Revelli, which was considered basically wrong from the start as an automatic weapon, since its locking system was operated by retarded blow-back. This meant that, from the instant of firing, the bolt, in trying to unlock, created a variable head space. Such a condition would result in ruptured cartridge cases unless lubrication were applied to allow them to slip in the chamber and follow the partially opened bolt rearward. Needless to say, the Fiat Model 1935 retained this feature. In fact many of them were actually modified weapons of the 1914 series, although some were of new manufacture.

The gun's chief modification consisted in the

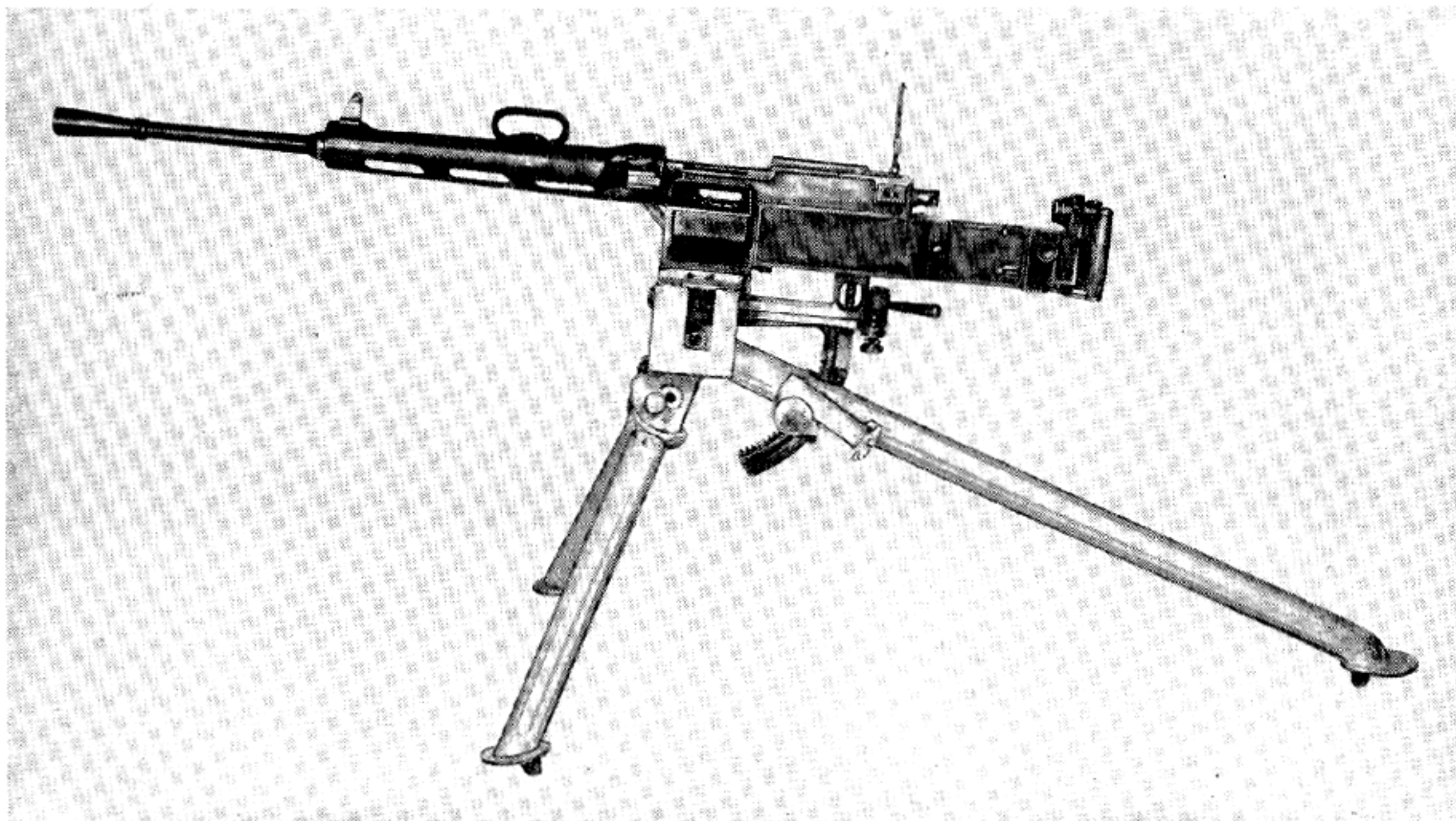


Fiat Aircraft Machine Gun, Model 1928 A, 7.7 mm

addition of a heavier barrel chambered for an 8-mm cartridge. Its chamber was fluted to aid in extraction of the case, since the splines in the chamber allowed gas to leak between the cartridge case and chamber walls. According to Revelli's patents, which he had assigned to Fiat before leaving the organization, the fluting would insulate the case from the chamber as adequately as oil. Such a theory must have been arrived at without test for rapidity of fire. There

was no oil pump on the model, such as had been incorporated in the receiver of the earlier model. The change proved to be a mistake, as the fluted chamber functioned only at slower rates of fire when time was allowed for the high chamber pressure to drop before unlocking.

In order to keep the new weapon functional, there was added a device called the de-accelerator, that worked just as the name implied. It slowed the cyclic rate from a normal 500 to 120



Fiat (Revelli) Machine Gun, Model 1935, 8 mm.

rounds a minute. On the few guns that did not incorporate this feature the ammunition was lubricated by brushing on the oil externally before being loaded into belt or can. The feed box with its compartments could also be removed and an attachment substituted that allowed a non-disintegrating metal belt holding 300 rounds to be used if desired. Some guns were modified to feed from the left and eject to the right, and others made to do just the reverse.

A combined safety catch and charging lever on the rear cross-piece allowed both single-shot and automatic fire. A slotted or skeletonized barrel jacket with the front sight mounted on top was also added.

Another feature that will ever remain a mystery was incorporated. It was modified to fire

from a closed bolt, an act that also showed adoption without ample proof firing. The latter would undoubtedly have revealed that any burst of great length through the air-cooled barrel, before letting the bolt go home on a live round, would result in a cook-off. The position of the combination bolt end and cocking piece was so located that if the gunner attempted to withdraw the live round from the hot chamber to prevent such a dangerous situation and the weapon did fire, as would be very likely under such conditions, the hand of the operator would be between the back of the bolt and the rear buffer.

The Fiat Model 1935 was perhaps the greatest known example of misapplied talent and inadequately tested theories in ordnance history.

BERGMANN, DREYSE AND MG-13 MACHINE GUNS

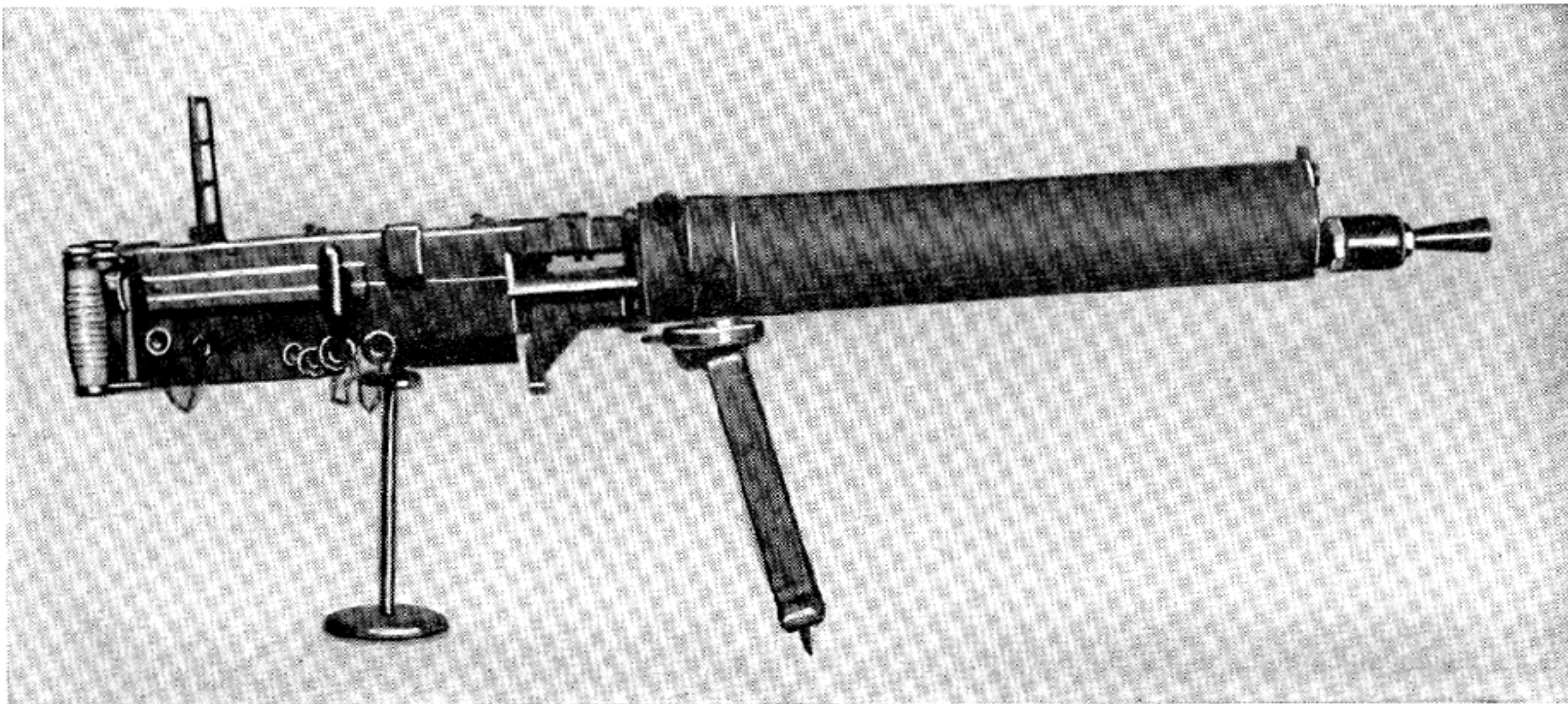
German Light Machine Gun Models in World War I

The German high command early in World War I realized the need for a light companion arm for the heavy, water-cooled machine gun that lacked mobility for modern offensive infantry tactics. True, they had the ideal weapon in Heinemann's Parabellum but this weapon was in such demand by the air force that the thousands needed by the army were not available. The German ordnance department was also greatly concerned with producing the desired weapon as cheaply as possible with simplicity of design for easy mass production.

In early 1915 a conference was held and the best known German automatic arms designers were assigned the task of developing the proposed weapons. The Rheinische Metallwaren und Maschinenfabrik of Dusseldorf and the Bergmann Industrie Werke Abt. Waffenbau of Suhl were the companies selected for the undertaking. Rheinmetall was to produce the light

highly portable machine gun for infantry use, while the latter plant would develop an aircraft version especially adaptable for flexible mounting. If this should prove reliable, it would free thousands of Parabellums urgently needed for fixed installations.

Rheinmetall, which owned Louis Schmeisser's patents upon which the action of the Dreyse machine gun was constructed, attempted to solve the problem simply by modifying the already existing Dreyse Model 1912. The parts were lightened together with a little redesign and a change in metal. The result, which used Schmeisser's pivoting lock, was given the factory designation, Dreyse Machine Gun, Model 1915. The change in manufacturing procedure and, in particular, the poor selection of metal resulted in a bad showing by the weapon during subsequent tests. It was practically dropped as a project until 1918 when more pains in manufacture and a better choice of steel resulted in a reliable gun that became known as the Model 1918. However the war was too close to its end to draw



Dreyse Machine Gun, Model 1915, 7.92 mm.

any conclusions beyond proving ground reports, which showed it to be an unusually good weapon.

The Bergmann Co. was more successful with its assignment. It likewise used the simplest approach by lightening the receiver and components of its well-known Bergmann action. Good engineering paid big dividends, as the improved design was successful from the start. But the failure of Rheinmetall to furnish an adequate gun forced the use of this weapon for infantry, because the critical need for this type of weapon gave it priority even over air force requirements.

When both companies were ordered to produce their respective models, it was understood that either could use any patented features belonging to the other. For this reason the guns have been frequently confused because of similarities in a few respects.

Bergmann Model 1915, N.A., Machine Gun

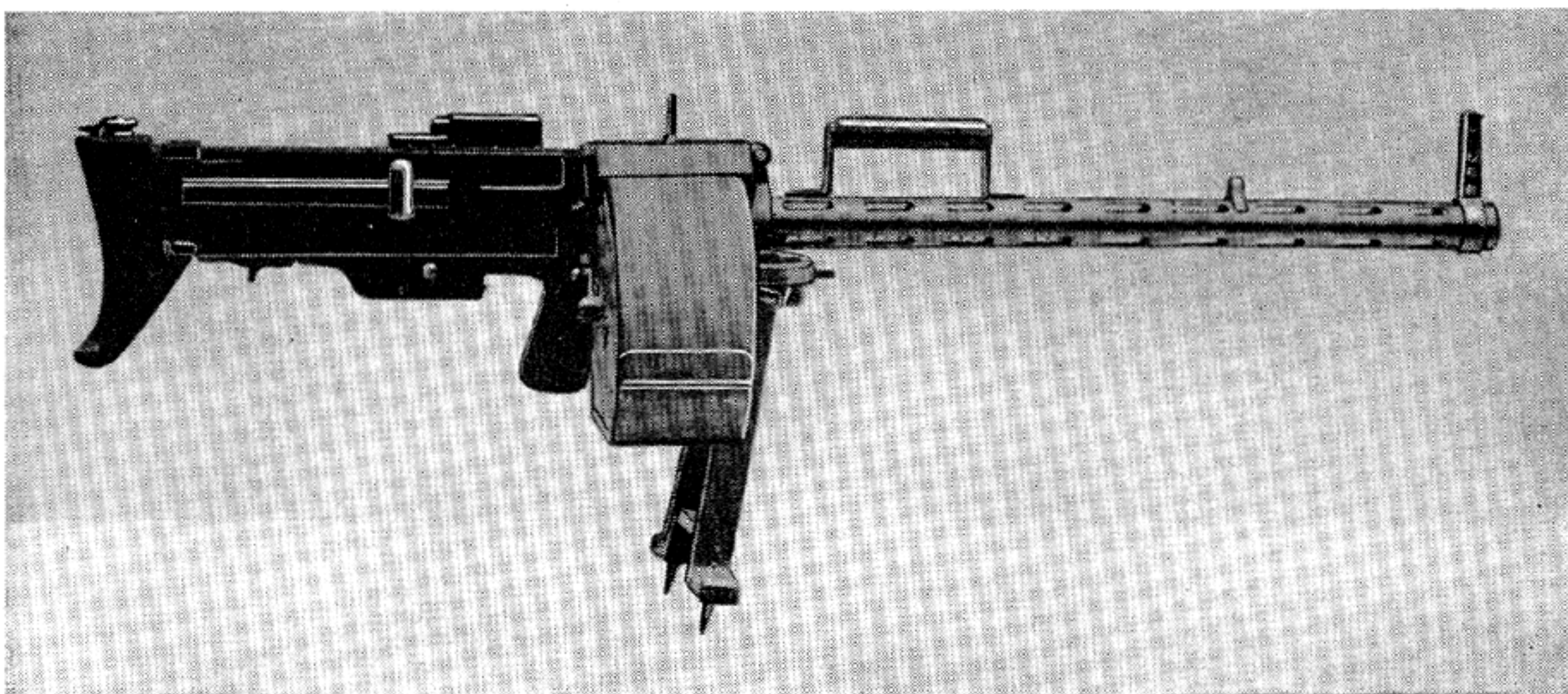
A prototype of the successful Bergmann World War I gun could appropriately be called the Model 1915. This weapon had a few features that were found by test to be unnecessary. It had larger holes in the barrel jacket, which was itself of greater dimensions. The so-called 1915 gun was rear seared and at the end of a burst a spring-loaded device caught and held the bolt in the cocked position. A pull on the

trigger would release the firing mechanism to go into battery and fire the round.

The weapon that soon followed was given the designation, Bergmann Model 1915, N. A. (Neu Art, or new type). This weapon was equipped with a short shoulder stock and slotted barrel jacket for air cooling purposes. On the right side attached to the receiver was incorporated a curved sheet metal ammunition box holding 200 rounds of caliber 7.9-mm ammunition belted in either a web or a non-disintegrating flexible metal belt.

The weapon fired from the closed-bolt position, making a cook-off in an air-cooled barrel possible due to overheating of the chamber. Just why the rear searing of the prototype gun was not used cannot be readily understood, as it would have eliminated a very objectionable feature.

The main advantages found in the weapon were its simple but solid breech construction and the straight-line movements of all working components. The entire mechanism consisted of 81 pieces, and by raising the top cover all moving parts could be readily inspected or worked upon, if necessary. Although of rugged construction its weight still placed it in the light machine gun class. In the Model 1915 N. A., the use of a light barrel gave an increase in recoil speed over the one formerly used when it was water cooled. This hastened unlocking, thereby



Bergmann Machine Gun, Model 1915, N. A., 7.92 mm.

adding materially to speeding up the cycle of operation.

The action was operated by a system known as short recoil employing the typical Bergmann lock where a rising block, vertically positioned under the bolt, locked and unlocked by a cam. To increase the rate of fire further, an improved accelerator similar to that of the Dreyse was used. It consisted of a curved lever vertically pivoted to the receiver with its free end resting against the rear of the bolt. When the gun recoiled to the point of unlocking, the semi-circular portion of the accelerator was struck by the barrel extension's rearward traveling shoulder at the exact moment the depressed locking piece was disengaged from its recess in the bolt. This sudden blow and the mechanical advantage of the accelerator hastened the bolt rearward and gave a cyclic rate of 800 rounds a minute.

A redesigned and stronger rear buffer, housed in the short shoulder stock, was placed on this model to compensate for the increased speed. By checking the previous designs of Bergmann machine guns it appears that the German engineers took a few good features of other mechanisms and after further refinement added them to their own action.

The ammunition belt runs in a slot and its movement is governed by a ratchet slide block. The movement of the block is actuated by the recoil of the barrel. During the rearward travel the feed slide is carried to the right to be positioned behind the cartridge. During counter-recoil movement of the barrel, the slide block returns to place, causing the round to be moved over one space.

In order to facilitate movement and to avoid binding with the barrel caused by pulling the loaded belt over one space each time it feeds a round, the slide block is continuously forced to the left by a strong spring which is compressed by the barrel during its recoil movement. In the earliest of the Bergmann automatic firing mechanisms the locking of the breech is accomplished by means of a block capable of taking up motion in a vertical plane, this movement being regulated by guides in the receiver body. The block upon rising locks the bolt to the barrel extension.

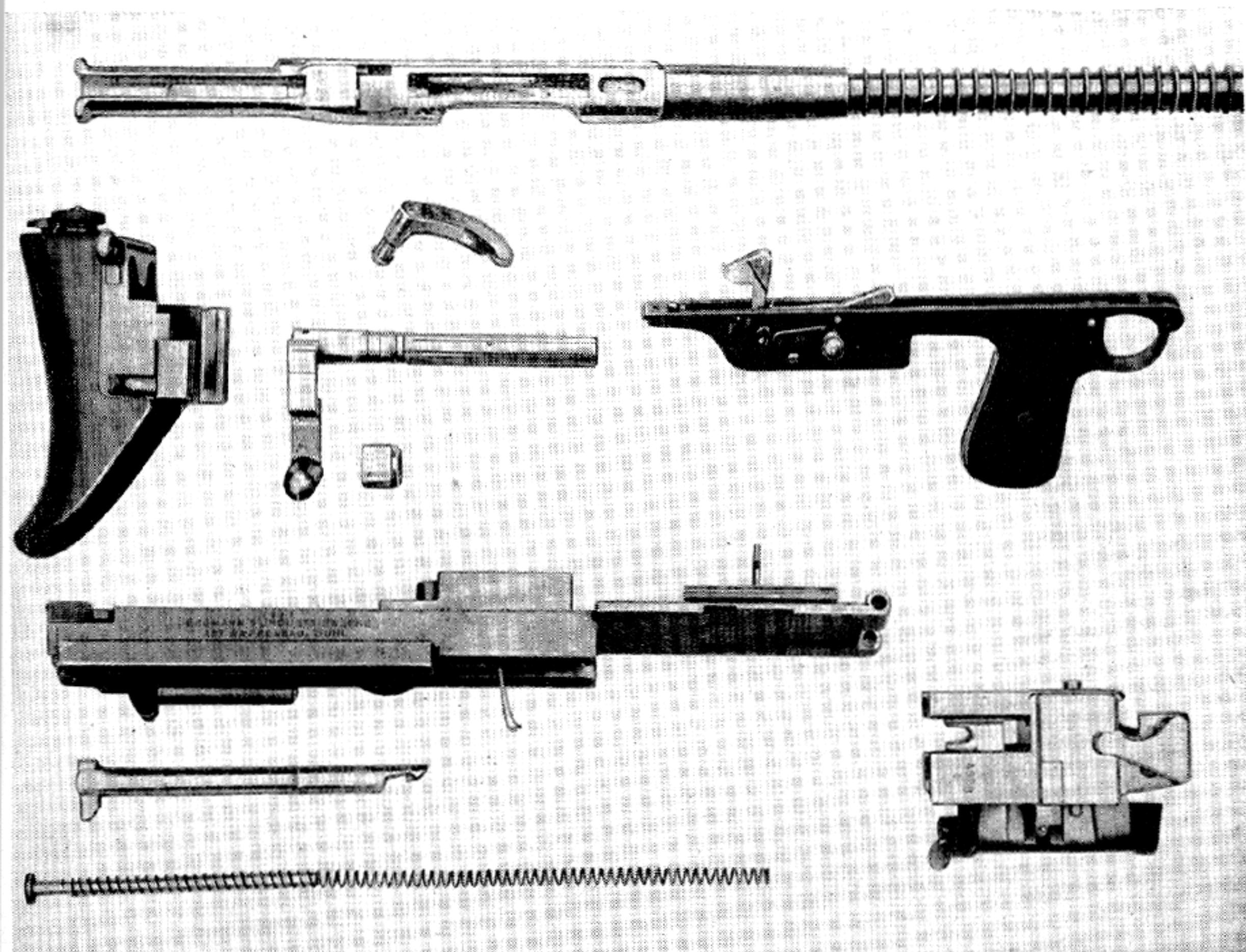
The very earliest model Bergmann used a special push-out metal belt that permitted the

cartridge to be shoved out of the link into the chamber. The Model 1915 N. A. employs either a metal or web belt that requires the pulling of the round out of its pocket to be carried rearwards slightly beyond its overall length before it could be positioned for firing. For this purpose a spring-loaded extractor claw in the feed slide removes the round and draws it to the rear. Another finger-shaped device, acting under influence of its spring, forces the cartridge down in front of the counter-recoiling bolt.

The Bergmann Model 1915 N. A. was of excellent design and had many features that made it highly adaptable for both aircraft and infantry use, but it was not so well known as other German machine guns. American ordnance officers in 1919, after the occupation of Germany, conducted a thorough test with the gun and reported it to be "well made, reliable and very light for a weapon of such rugged construction, but it did not show any outstanding features that were not already known nor was it considered as better than many other light machine guns of similar appearance." That the Germans counted heavily on the weapon is attested by the fact that after the Armistice the Inter-Allied Control Commission found over a thousand guns of this model in the Bergmann plant at Suhl.

To fire it, 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 striker. Upon flying up, the latter hits 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 cammed down by the angular surface in the bottom of the receiver. This forces down the front part located under 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 striker is caught by the bolt lock and held in its rearmost position by the safety sear. The base of the cartridge strikes against the right guide which serves as the ejector and kicks the



Components of the Bergmann Machine Gun, Model 1915, N. A.

empty cartridge out the left side of the gun at a downward angle. The claws on the main spring housing draw the new cartridge from the belt, and the housing, continuing to travel to the rear, contacts 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 claw on the main spring housing depresses 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 now releases the barrel and extension from a retracted position to go into battery. The locking block

which is then raised by the cam on the bottom of the receiver locks the barrel, barrel extension, and bolt together.

The stud on the main spring housing carries the feed lever in all the way 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 striker that drives the firing pin forward to fire the next cartridge.

MG—13

After the Armistice the German ordnance department, when it found it was possible to ig-

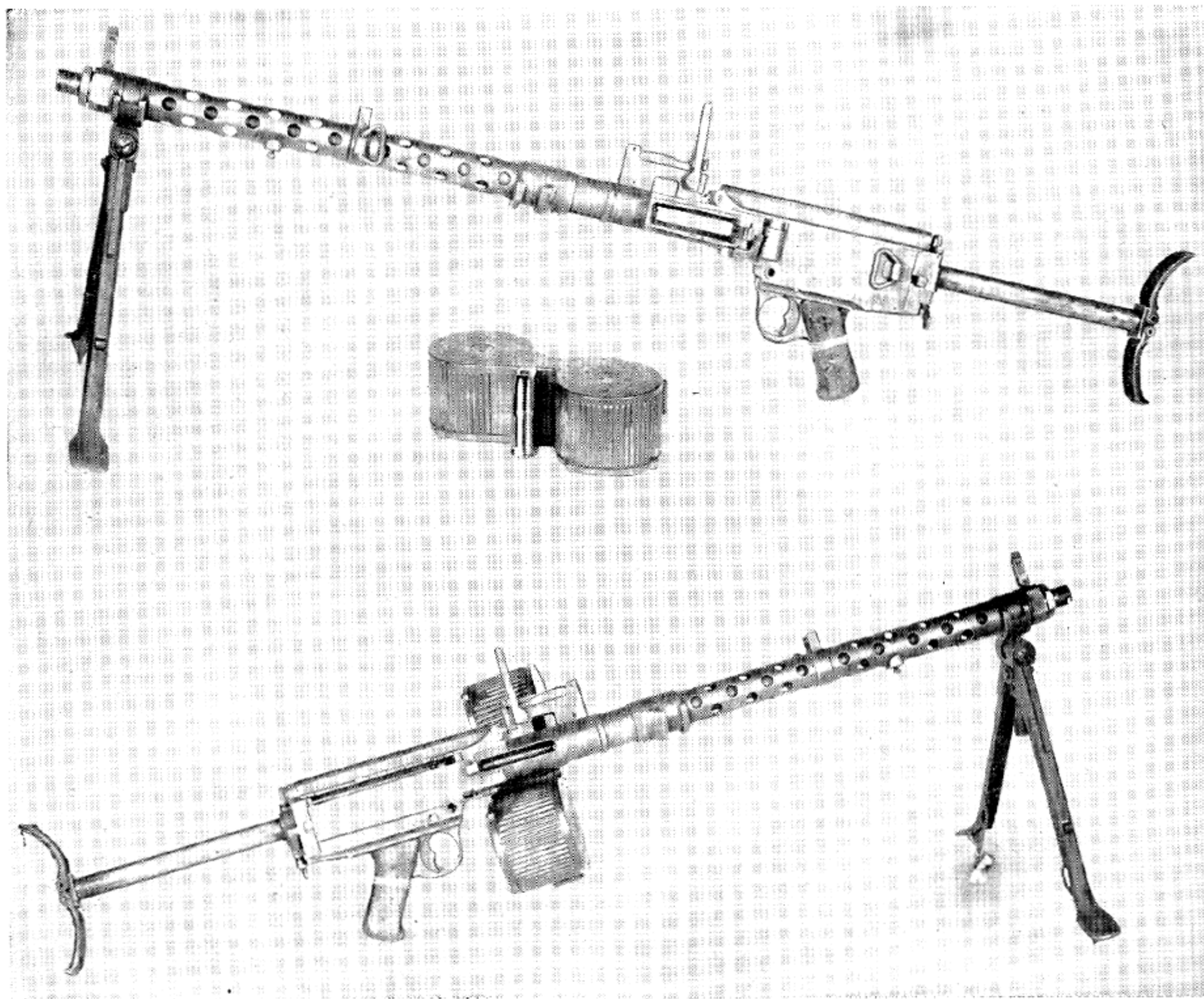
nore the restrictions placed upon it by the Versailles treaty, attempted to develop an extremely light, short-recoil, air-cooled machine gun that could be transported and operated by the individual infantryman. Tactical changes had shown them that the lengthy bursts that only a water-cooled gun could perform were no longer necessary.

The Dreyse Model 1918 water-cooled machine gun, being one of the lightest and most advanced weapons of its type to date, was considered the most desirable to alter for this purpose, especially since a large number was on hand. There is a record that the Allied occupation commission found 3,000 finished weapons in water-cooled form in one factory as early as 1919. They showed

great refinement over the earlier 1915 model. These much improved weapons had been given the designation Dreyse Model 1918 in the closing days of the war.

The guns did not see action against the enemy. They represented the best effort the Germans had made toward light machine guns and little was done to change them from their original form until Hitler came into power. Then all Dreyse machine guns in existence were immediately ordered to be reworked for the purpose of lightening and streamlining as much as possible. The firm of Simson & Co. of Suhl, Thuringia, was given the main contract to modify and refine the weapon.

It is very difficult to recognize the weapon



Machine Gun, Model 13, 7.92 mm.

visually as a modified Dreyse Model 1918. It is further confusing that under the Hitler regime all automatic weapons were given a number and no other form of identification. This particular weapon became known officially in Germany as the MG-13 and as late as 1935 it was the main machine gun for German infantry units and engineers and for anti-personnel use on tanks, armored cars, and motorcycles.

The principal changes on the MG-13 from the parent gun were the replacement of the water jacket with a ventilated air-cooled one, the addition of a lightweight shoulder stock and pistol-grip trigger housing, the elimination of the belt feed and the substitution of a spring-loaded slightly curved 25-shot magazine that could be filled directly out of the five-shot cartridge clips. When the last shot in the magazine had been fired, the firing mechanism was held back in the rear position by the slide catch. The cover group opened up as in the old Dreyse but the rear end or back plate was hinged down. These two opera-

tions made all working parts instantly available for inspection or maintenance by first swinging the accelerator out of the way. It also permitted dropping the hot barrel out the rear end in the event a quick change was needed. A selector switch located on the left side of the receiver over the trigger guard gave the gunner a choice of either single shot or automatic fire by mere pressure of the finger.

A combination muzzle booster and flash hider was used on this version. The booster, added to the recoil forces, gave a maximum rate of fire of 750 rounds a minute. A saddle-shaped drum magazine was later designed that held 75 cartridges and was mounted underneath the receiver. This design was resorted to in an effort to be able to carry enough ammunition in a magazine for a substantial burst and still not have the heavy loaded magazine too far off the center line of action. This would result in poor dispersion during automatic fire.

The gun's main importance lay in its use as a



German Troops Training with the MG-13.

training weapon for Hitler's new army while German manufacturers and inventors were working desperately to produce a more perfect instrument. The Dreyse MG-13's were eventually withdrawn from service and held in reserve until

just before World War II. The bulk of them were then sold to Spain and Portugal. Spain retained the German designation but Portugal called them the Dreyse 1938 after the year of acquisition.

VILLAR-PEROSA AIRCRAFT MACHINE GUN

On 8 April 1914 Bethel Abiel Revelli, then a major in the Italian Army and residing in Turin, applied for patents on a machine gun designed primarily for aircraft use. This very interesting weapon was the forerunner of a number of aviation weapons invented by this officer. Revelli's claim to fame is originality of design, as is evidenced by his other machine guns the novel features of which have since been copied and adapted for present day weapons.

Revelli's attempt became internationally known as the Villar Perosa, because he assigned patent rights to a company of that name in Pinerola, Italy, which manufactured the unusual-looking gun. It was double barreled and could be fired simultaneously or separately at will. It may be classified as a retarded-blow-back, magazine-fed, air-cooled, dual-mounted aircraft machine gun. The short barrel version weighed only 14 pounds 4 ounces with the loaded 50-round magazine attached. The barrels were chambered for the 9-mm Parabellum pistol cartridge which was at the time being used in the Italian Army's service pistol.

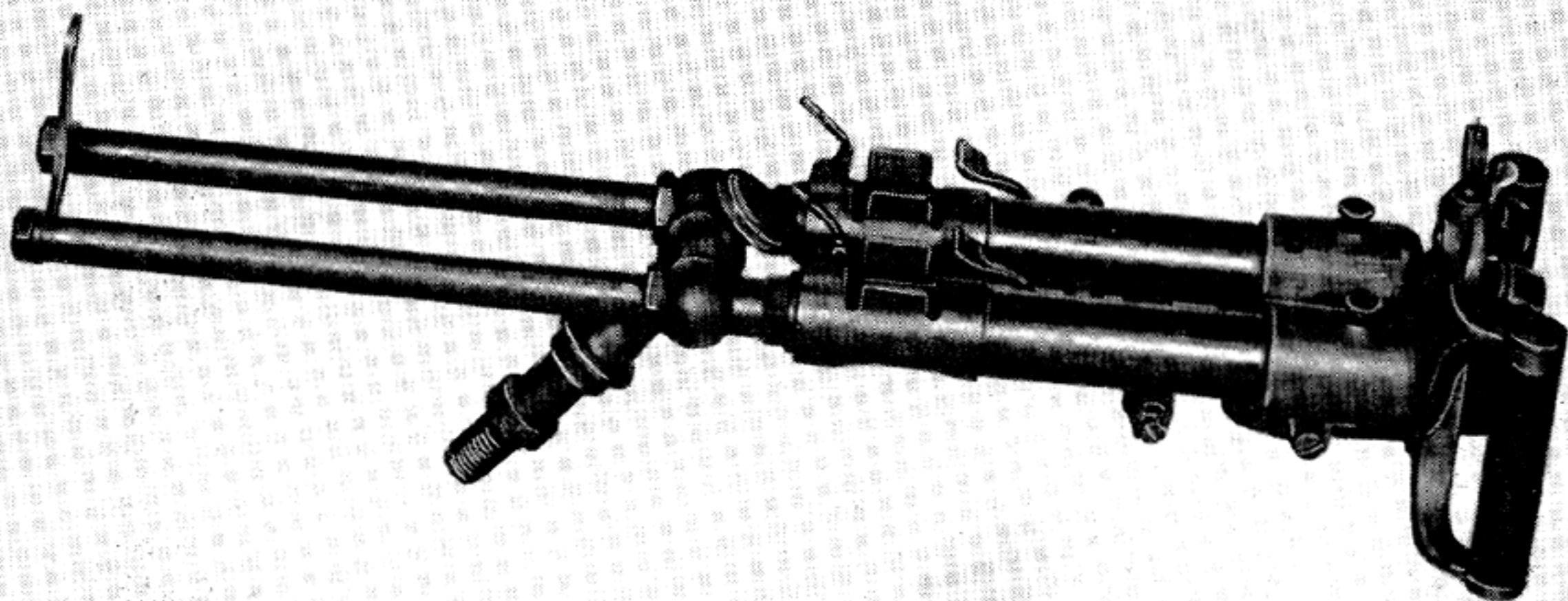
The reciprocating parts, bolt and striker, were

very light, weighing only ten ounces and had a travel of only $1\frac{3}{4}$ inches. This factor tended to give the weapon a phenomenally high rate of fire, it being officially rated at 3,000 rounds a minute, or 1,500 per barrel. Many guns were converted to ground use where they proved more successful than for aircraft. The small pistol-type cartridge did not have sufficient aerial striking power. Utilization of these weapons by infantry is said to have started the design of submachine guns for such a purpose.

A large number of Villar Perosas fell into the hands of the Germans and Austrians following the Italian disaster at Caporetto in October 1917. The Germans immediately set to work producing their version of a machine pistol that they felt was adequate to the needs of their infantry troops. It is odd indeed that the first weapon to be designed solely for aircraft failed in that department but showed a need for such a gun for ground troops.

Major Revelli, in presenting his weapon before an ordnance board for an official test, described its action in the following manner:

"The Villar Perosa consists of two distinct but



Villar-Perosa Aircraft Machine Gun, 9 mm.

identical breech and firing mechanisms and is provided with barrels connected by a cross bar. It has two fixed handles one of which serves for training and the other for elevating purposes. Each of the breech and firing mechanisms comprises a hollow cylindrical casing provided with a lower lug and screwed to the corresponding rifle barrel.

"In the breech casing a block provided with a projection carrying a handle slides longitudinally with a small rotary movement. The front and rear faces of the shoe or projection are each formed with a right-handed helical surface. It slides in a slot formed in the breech casing and is rectilinear for the major portion of its length, but helicoidal at its forward end wherein the projection is guided by two helical faces. The breechblock is hollow and within it slides a cylindrical percussion pin or striker provided with a projection to guide it in the rectangular portion of the slot. The front face of the tooth is formed with a left-handed helical surface bearing on the helical face of the breechblock in order to insure the passage of the striker beyond the head of the block when the latter is rotated in its closed and locked position. The percussion pin or striker is hollow and contains in its interior a coiled spring that controls it. This spring is mounted on the guide rod of the closure plug screwed to the breech casing.

"Around the forward end of the breech casing a sleeve is rotatably mounted provided with projections serving to fix the magazines during firing. A spring-controlled stop maintains the said sleeves in both positions. The breech is provided with a stationary or fixed ejector adapted to engage a corresponding slot formed in the breechblock. The latter has a levered extractor pivoted and actuated by a spring.

"The mechanism of each gun is naturally identical. Being in duplicate, they are connected at the forward end by means of a bent cross member with the front sight at the forward end of the cross bar. The butt end carries the rear sight, which has a graduated opening for the different distances to be used in firing. This latter cross member is fastened at its forward end to two cylindrical cavities into which the two breechblocks are inserted, and held in place by means of pins. Below this piece two triggers are

mounted, each having an L-shaped projection on the upper arm. This member also has a safety lever with spring stops governed by the controlling handle. Two lateral locking arms, according to the position of the handle, engage underneath the safety buttons and prevent firing or leaving the said buttons exposed to accidental contact."

Each magazine is provided with a socket having projections with which the sleeve engages as soon as it is rotated for fixing the magazine. The latter is somewhat curved in order to account for the slight conicity of the cartridges so that the latter, although superimposed in variable number, constantly present themselves in front of the barrel opening forming a certain angle with respect to the barrel. The magazine may contain 25 or 50 cartridges in double rows, whichever number is found necessary. It consists of a rectangular casing with rounded-off edges and terminated at the bottom with two lips that curve in such a manner as to retain the cartridges.

In order to fire the Villar Perosa, the breechblock is drawn backward by the retracting handle until it automatically engages its sear. Subsequently the safety lever is brought into the locked position. The cartridge magazine is then placed on the breech casing and secured thereto by means of the sleeve. The gun is trained, the safety is then rotated into a releasing position and the button depressed for firing. The breechblock and the striker advance simultaneously under the action of the driving spring and the former pushes a cartridge from the feeder into the chamber. At the end of its rectilinear travel the breechblock is forced to turn to the right under the action of the helical part of the slot formed in the breech casing. At the same time the striker continues to advance with respect to the block.

The sliding of the helical surface of the tooth on the corresponding face of the notch formed in the breechblock results in firing the shot. The gases of the explosive charge start the projectile through the bore while they tend to push back the breechblock. The latter offers resistance for a moment in view of the inertia of its mass and the resistance offered by the helical notch formed in the casing. Subsequently, it recoils completely withdrawing the empty cartridge with the ex-

tractor until the cartridge strikes the ejector and is thereby expelled.

If the firing button is kept in a depressed position, the weapon fires continually until the cartridge magazine is exhausted. One of the most outstanding features of the Villar Perosa is the simultaneous closing of the breechblock with the advancement of the striker. The rear shoul-

der of the helical notch acts as a stop during the movement of parts into battery and as a friction brake to reduce the speed of unlocking during the first stage of recoil. The combined system has only a single degree of freedom, so that any displacement of either one of these two elements (the breechblock and the firing pin) definitely constrains the movement of the other.

S. I. A. AIRCRAFT MACHINE GUN

One of the early Italian designs of an automatic firearm was originated by Giovanni Agnelli, of Turin. Although he applied for a patent on 17 February 1914, the weapon lay dormant for several years. Agnelli's rights were assigned to the motor firm, Società Italiana Ansaldo of Turin, and hence acquired the designation, S. I. A. Near the close of the conflict the government of Italy placed an initial order with the Fiat Co. of Turin for 10,000 aircraft machine guns utilizing Agnelli's S. I. A. design. Each gun, complete with necessary spare parts and 15 magazines, was to cost \$320 at the factory.

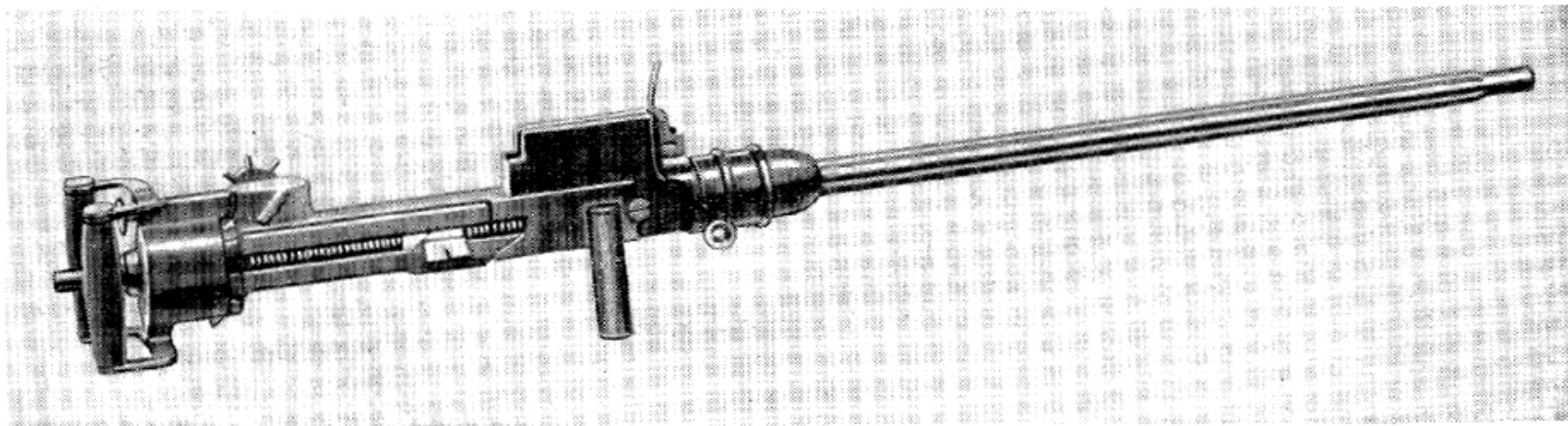
The weapon was chambered for the 6.5-mm model 1891 infantry rifle cartridge. This specification in ammunition was considered very important in Italy since its other machine guns were chambered for several different calibers making the burden of supply heavier. Great Britain had heretofore furnished ammunition for Italy's automatic weapons and it was felt that should England not be able in the future to export this crucial item the situation would be desperate. It was therefore decided to standardize, beginning with this machine gun, all future design in order that the Italian infantry rifle cartridge could be used.

In early tests the S. I. A. aircraft model gave what the authorities termed "satisfactory re-

sults," both as a free gun and fixed installation. When used as a free gun, it was invariably mounted in pairs. It did not, however, give good enough performance to take the place of the English Vickers then being used in the fixed forward firing positions. Still, the S. I. A. was modified to take the Vickers synchronizer in the event a change-over should prove necessary.

Neither the S. I. A. aircraft gun nor its ground model saw service in World War I. Although 2,000 were manufactured for the air force and 3,000 for the ground forces in the summer of 1918, the actual date of issue was immediately after the Armistice. It is believed that the Italians were holding them until perfected so they could be thrown into the big spring offensive planned for 1919. Immediately following the end of hostilities the army, confident of its superior design, issued the S. I. A. as its standard light machine gun and it was so considered throughout the twenties. It had a maximum rate of fire of 700 rounds per minute.

The vertical-type magazine held 50 cartridges for ground guns and 100 for aircraft use. Its body was rectangular in shape and made of stamped sheet steel, the cartridges fitting into place in an oblique angle five cartridges in width. This unusually wide magazine located in the center of the receiver made the weapon unwieldy, es-



S. I. A. Aircraft Machine Gun, 6.5 mm.

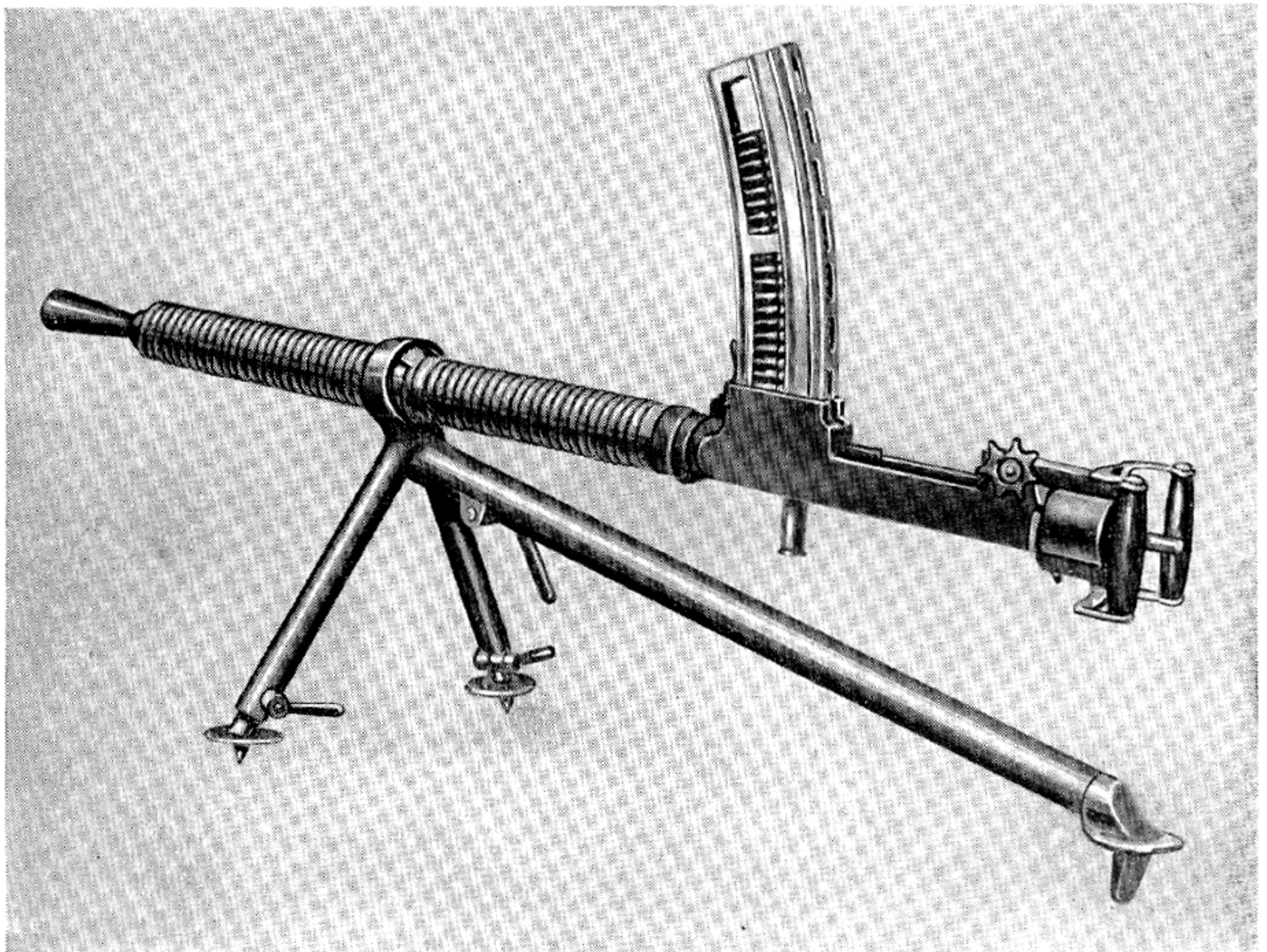
pecially with the 100-shot version, while sighting had to be mounted in a well offset position to compensate for the magazine.

Both the aircraft and ground guns had spade grips and all other features were identical, except for the cooling system. The aircraft model had long splines cut the full length of the barrel. This advanced feature not only gave greater radiation surface but also strengthened the barrel greatly, cutting down dispersion. The ground gun employed a heavy barrel together with unusually large circular aluminum fins, that extended all the way to the flash hider. For some unknown reason these fins remained the same size the entire length of the barrel, giving the weapon an extremely heavy appearance. On another style of barrel assembly the radial fins increased in size as they went forward, creating the

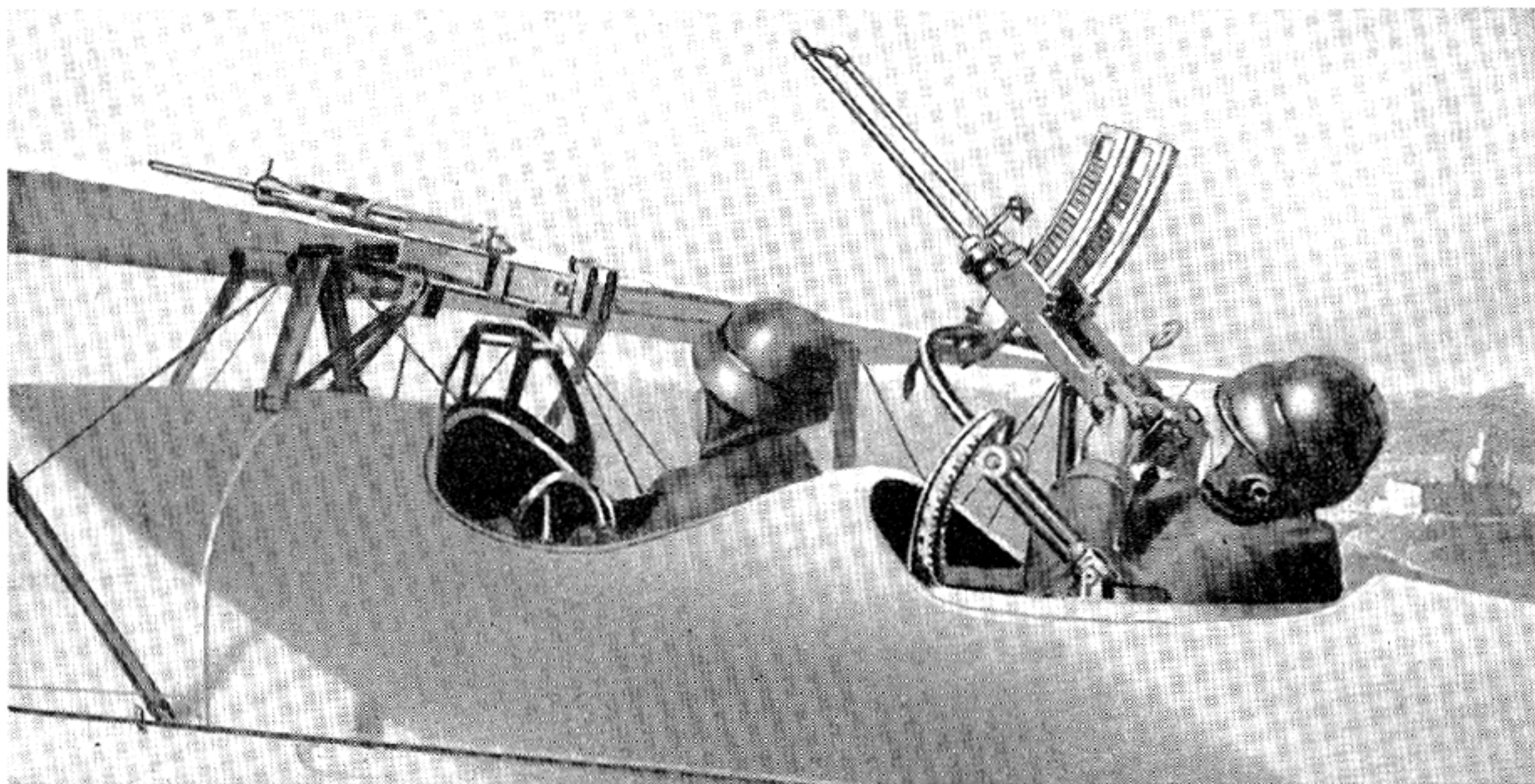
most awkward silhouette to be found on any machine gun.

A collar-shaped device located on front of the trunnion joined the barrel and trunnion by a quarter turn rotation. The funnel-shaped breech end of the barrel served as a cartridge guide. The sight arrangement, which was offset to the left of the magazine, consisted of a rotating three-part affair graduated at 300, 700, and 1,000 meters. The charging handle was located on the right side and after full retraction it was shoved forward by the gunner until it locked in its spring-loaded detent.

The safety, located on the upper right rear on the receiver, was marked *S* (for *Safe*) and *F* (for *Fire*). The S. I. A. had no provision for single shots and when the gunner pushed selector button *F*, full automatic fire was accomplished. The



S. I. A. Machine Gun, 6.5 mm.



S. I. A. Aircraft Machine Gun, 6.5 mm, Dual Flexible Mount.

ejector, which was fastened in a T slot in the receiver body, passed through a slot in the bolt body. A recess was cut in the rear of the bolt to furnish a relief at the point where it turned to lock.

The sides of the ejection slot in the bottom of the receiver were machined to permit the addition of a container to catch the empty cartridges. This arrangement was used when the gun was mounted as a free gun to prevent flying brass from injuring tail surfaces of the aircraft or hitting other friendly planes in formation.

The bolt was round on its rear portion with its front half cut away to form a flat surface a little above the center line of the firing pin. On the right side appeared the locking lug, a beveled projection that traveled in a slideway until it was cammed down in the receiver body's locking recess by the advancement of the firing pin lug housed centrally in the bolt body.

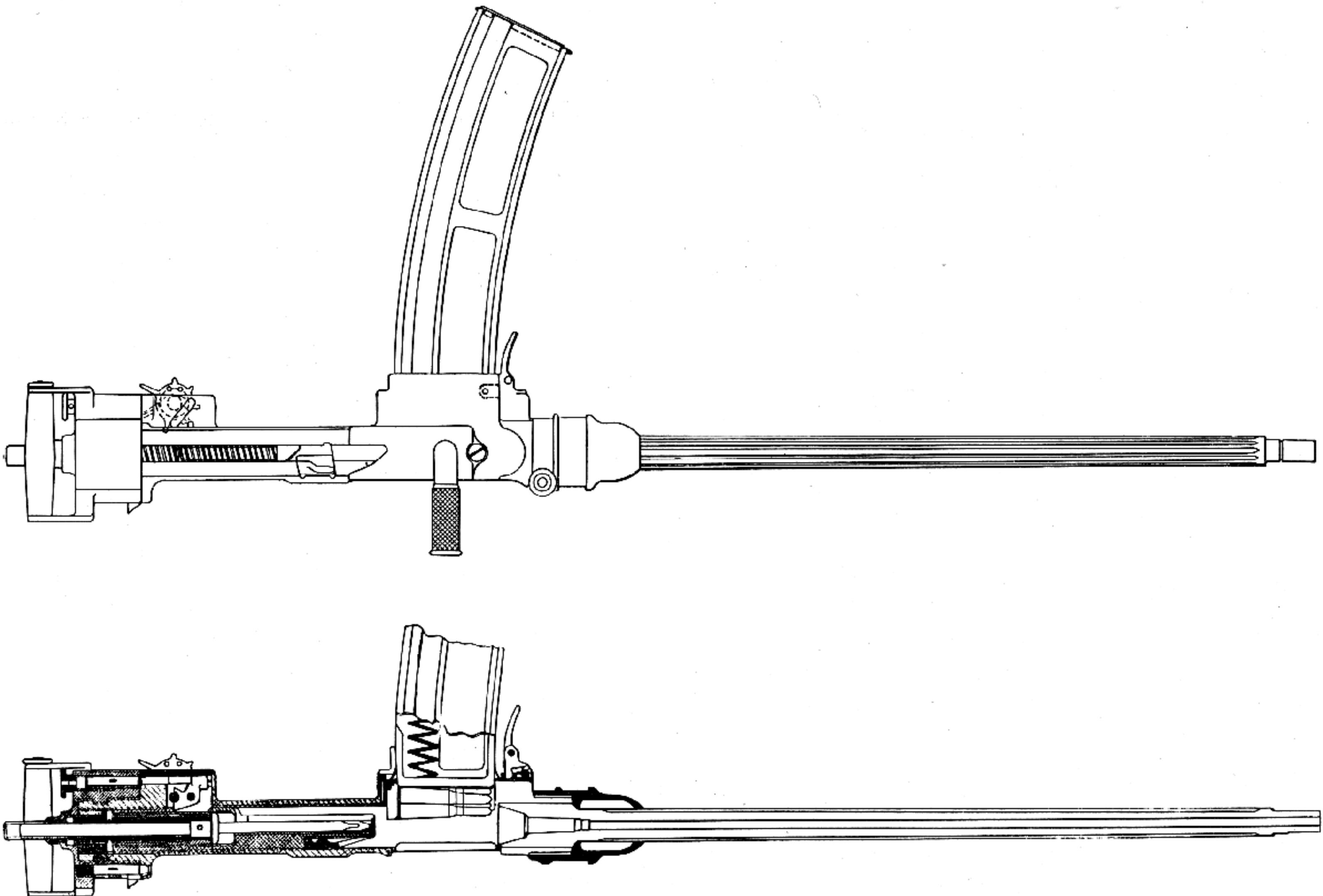
To fire the S. I. A., the operator installs a loaded clip in its recess on the receiver until the release lever on the front of the bracket clicks, shoving it securely in position. Then as the charging handle on the right is grasped, it is freed of its detent-holding pawl and pulled rearward. The front bottom piece of the retracting

assembly has a cam angle cut at this point that engages the locking lug and frees it from the receiver to which it has been locked. This movement also jacks the firing-pin assembly back to the cocked position by partial rotation of the engaging cams. With the weapon unlocked and firing pin retracted, the recoiling assembly is pulled rearward until the searing device in the upper part of the receiver drops into its recess. All parts are held to the rear under tension of the driving spring that has been compressed by the retracting movement.

The charging handle is then shoved all the way forward until it is locked in place by a short spring-loaded detent. Such locking is very necessary before firing in order to prevent faint strikes.

If the selector has been set on *F* and the trigger button pushed forward, the entire firing mechanism is impelled forward by the large driving spring. As the upper bolt face passes the rear of the magazine, it strips the positioned round and starts to chamber it. Continued forward travel carries the nose of the bullet into the funnel-shaped recess in the barrel's breech that guides the ammunition into the chamber.

When the lug on the bolt has reached a place above the locking recess in the receiver, the round has been fully chambered. The 45° angle



Section Drawing of S. I. A. Aircraft Machine Gun.

on the firing pin, riding in engagement with the corresponding angle in the bolt body, rotates the bolt a fraction of a turn downward, freeing the firing pin to continue advancement under influence of the operating spring. This drives the firing pin into the primer to discharge the weapon.

Until the bullet is out of the bore, the gun is secured by the locking lug of the bolt. Its disengagement with the face of the locking recess in the receiver is thus slowed. This slight hesitation is known as retarded blow-back, as the locking angles hold only long enough to permit the bullet to clear the muzzle. The weapon then unlocks

and the blow-back, or high residual pressure in the bore, further actuates the mechanism.

The bolt starts rearward, carrying with it the lubricated cartridge case, held by the extractor at its base until it collides with the ejector that is riding in a groove in the bolt body. When struck, the base of the round is pivoted down out of the ejection slot in the bottom of the receiver. The strong driving spring, the only spring working during operation of the weapon, is being compressed all the time until it stops the bolt before it reaches the rear of the receiver. If the trigger button remains pushed in, the cycle of operation will repeat itself.

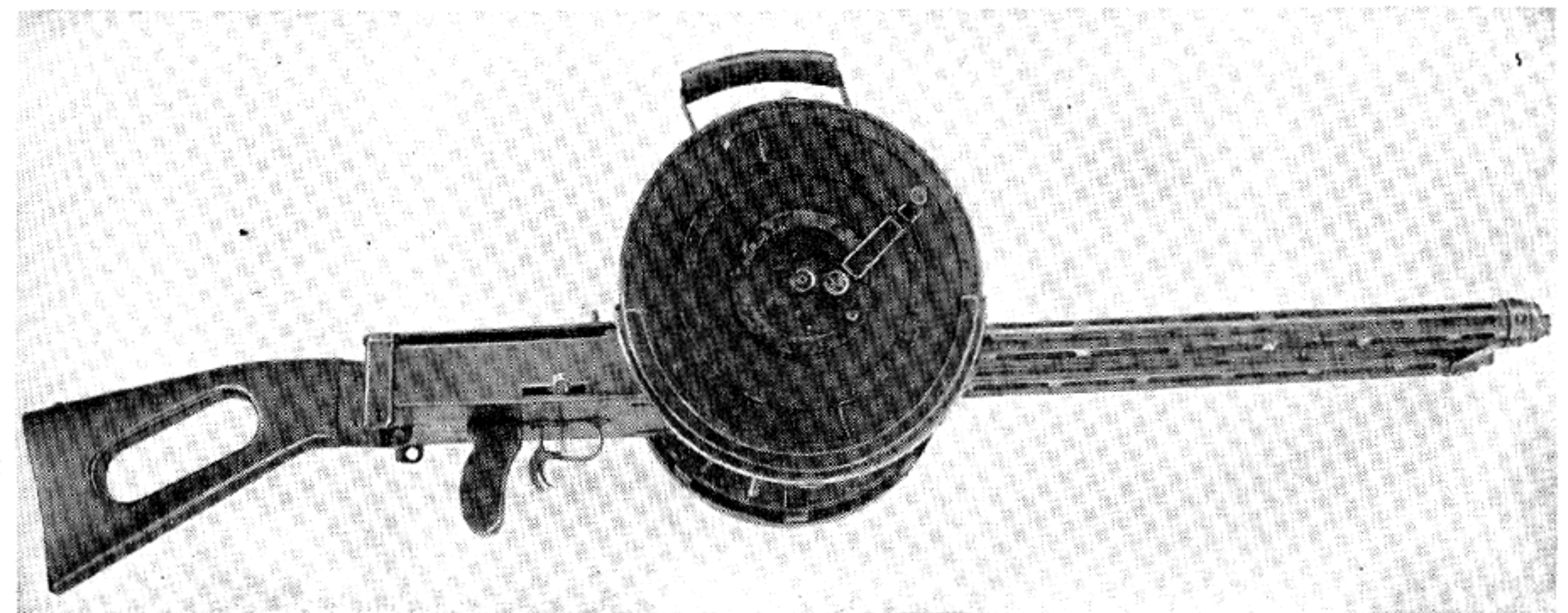
GAST AIRCRAFT MACHINE GUN

After the successful conclusion of World War I as far as the Allies were concerned, it was found the Germans had been desperately trying to put into action a secret weapon, namely a machine gun capable of firing at a rate of 1,600 shots a minute. In order to turn out this high-speed gun, it was given the highest priority of manufacture, even over aircraft. The weapon first produced in January 1916 by Carl Gast of Barmen, Germany, was very similar in principle to an automatic machine gun patented by Bethel Burton in Great Britain 22 March 1886 (No. 4,008). It was a double-barrel machine gun of the recoiling type. The object was to provide an improved means of operating the firing mechanism and in doing so, to produce a cyclic rate higher than is found in standard automatic weapons.

In order to accomplish this, the two barrels were combined in such a manner that each recoiling breech and firing mechanism furnished the energy to lock and fire the other. The whole system was based on the fundamental idea that with the explosion of each shot, the recoiling force from one barrel could load, fire, extract, and eject the rounds in the other barrel. In this

way a series of uninterrupted shots could be obtained. In trials the Gast fired at rates of 1,600 rounds per minute, as issued, and with a spring-loaded recoil adapter to buff the action and hasten its return, cyclic operation was stepped up to a rate of 1,800 shots per minute. There was also a means of firing single shots if desired, and the construction was such that should one barrel be put out of commission, the other barrel could fire single shots.

The ammunition was not fed in belts of disintegrating links, as was customary, but in magazine drums that were fastened by slipping them into position on the sides until the holding latch snapped into place. These flat circular drum feeds were placed on the sides in order to make ejection possible from the dual mounting. Each drum, which contained a strong spring that was compressed tighter as each cartridge was placed in position, had a maximum capacity of 180 rounds of the standard German 7.9-mm rifle caliber machine gun cartridges. The changing of the feed devices was accomplished by an experienced gunner in a matter of seconds. The light weight (60 pounds without ammunition) and the



Gast Aircraft Machine Gun, 7.92 mm.

phenomenally high rate of fire made the German air force feel that the Gast was the perfectly designed aircraft gun and according to all available records it was expected to sweep the skies clear of opposition if enough could be installed in time.

For aircraft installations a high-power telescope with cross hairs for sighting was mounted on the receiver midway between the magazines. Another attractive feature was that all working parts were instantly accessible by the application of thumb pressure on the back plate latch. One minute was all the time required to field strip the piece.

Following a successful demonstration of the Gast, promoted by Vorwerk and Co. of Barmen on 22 August 1917, ordnance representatives were so impressed that the company was immediately given an order for 3,000 guns with necessary spare parts and ten drums for each gun. They were likewise given the highest production priority. A price of 6,800 marks per unit was set, including the drums.

Vorwerk agreed to the terms and promised to furnish 100 complete units by 1 June 1918 and to increase delivery by 100 a month until September; after that it was estimated 500 a month could be delivered. Records show the contracting company delivered far more than promised. Such results can be accounted for by every effort being made to supply vitally needed materials to the firm for production, sometimes at the expense of other badly needed equipment. This fact shows that the authorities looked upon the Gast as the one thing that could change the desperate situation of the Germans when they lost air supremacy to the Allies.

The following letter from the commander of

the German Trial Section for Arms dated 20 September 1918 to Vorwerk indicates the desperate pressure being put on the company:

"Referring to my repeated telephone conversations of these last days with your firm, I request you once more to deliver Gast machine guns with the greatest possible speed.

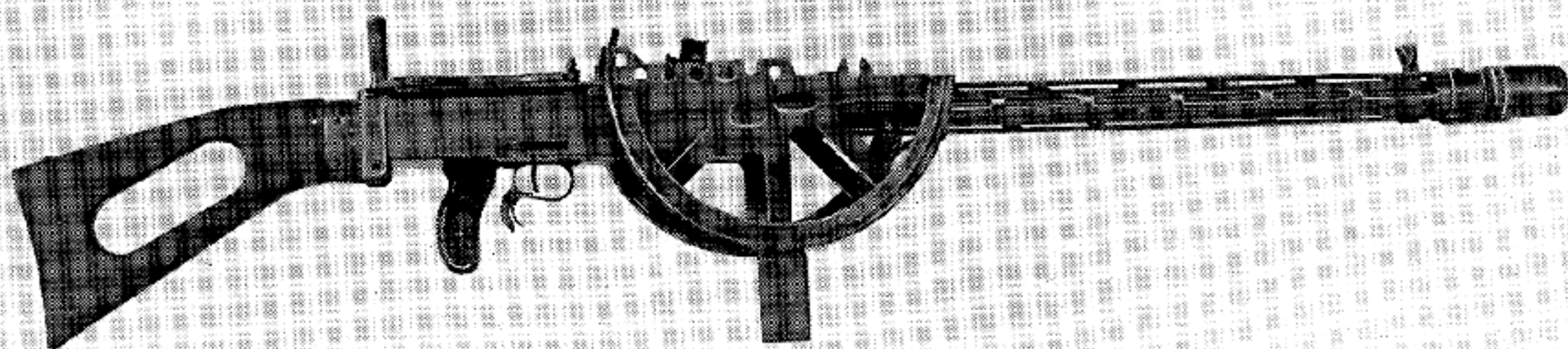
"The strained situation on the battle fields urgently requires the use of superior and most modern arms. The Gast gun is being used with great success on battle-planes, for scouting as well as for anti-aircraft. I therefore urge the firm to deliver these guns in large quantities and with the greatest possible speed.

"Changes in construction are not necessary on account of the present favorable results and the reliable working of the guns. A further order of about 6,000 guns will be passed shortly by the office involved.

"With a view to the favorable reports which reached the commanding general about the Gast gun and his request for more machine guns, I feel obliged to point out to you the necessity of the prompt delivery of large quantities.

"(Signed) LOCHTE,
"Commander of the Trial Section for Arms."

While records show they had limited use in actual warfare, the secret was kept so well by the Germans that not until 3 years after the Armistice did agents of the Inter-Allied Control Commission uncover a secret hiding place near Königsberg, where 25 Gast machine guns, ammunition, and manufacturing drawings were found. They were turned over to the Aeronau-



Gast Aircraft Machine Gun, 7.92 mm, With Feed Drums Removed.

tical Control Commission in Paris for study and test.

Army Intelligence a short time later gained possession of a letter from the German office of aeronautics, an agency that according to the Versailles Treaty was not supposed to be in existence. This agency, operating secretly, as can be readily seen from the contents of the translated captured documents, was not only functioning but was also trying to arm Germany with the last word in aircraft machine guns for the day she would again take the field against the world. This letter to Vorwerk & Co. from the underground German bureau is given verbatim, as it shows better than any other medium of expression not only its high regard for the Gast gun but also its careful preparing for another war:

"CHARLOTTENBURG, Nov. 18, 1921.

"The firm Vorwerk & Co.,
Barmen.

"The Gast gun made by you having become of no use any more at the front, I feel obliged to state that at the present moment we still consider the gun of the latest type. The accuracy of the work and the firing were never, not even approximately, attained by the other hitherto existing machine gun systems.

"We may say that the Gast gun may be qualified as the ideal of the aeroplane armament. We also declare that you can further continue delivering the remainder of the complete order for 3,000 guns.

"If, with a view to the *present circumstances* some doubt might have arisen as to this delivery, I certify herewith that we shall fulfil the obligations of the contract. I enclose herewith certificates from the command of the trial section at Döberitz as also from the officer in charge of the Air Service who gave his instructions for the use of the weapon in flying planes at the front.

"Thanking you for having provided the Aviation troops with such a remarkable gun, I shall also be very much obliged to you if you will also thank the constructor, the engineers and workmen who handled this arm.

"(Signed) BUFE."

After the uncovering of the Gast guns and

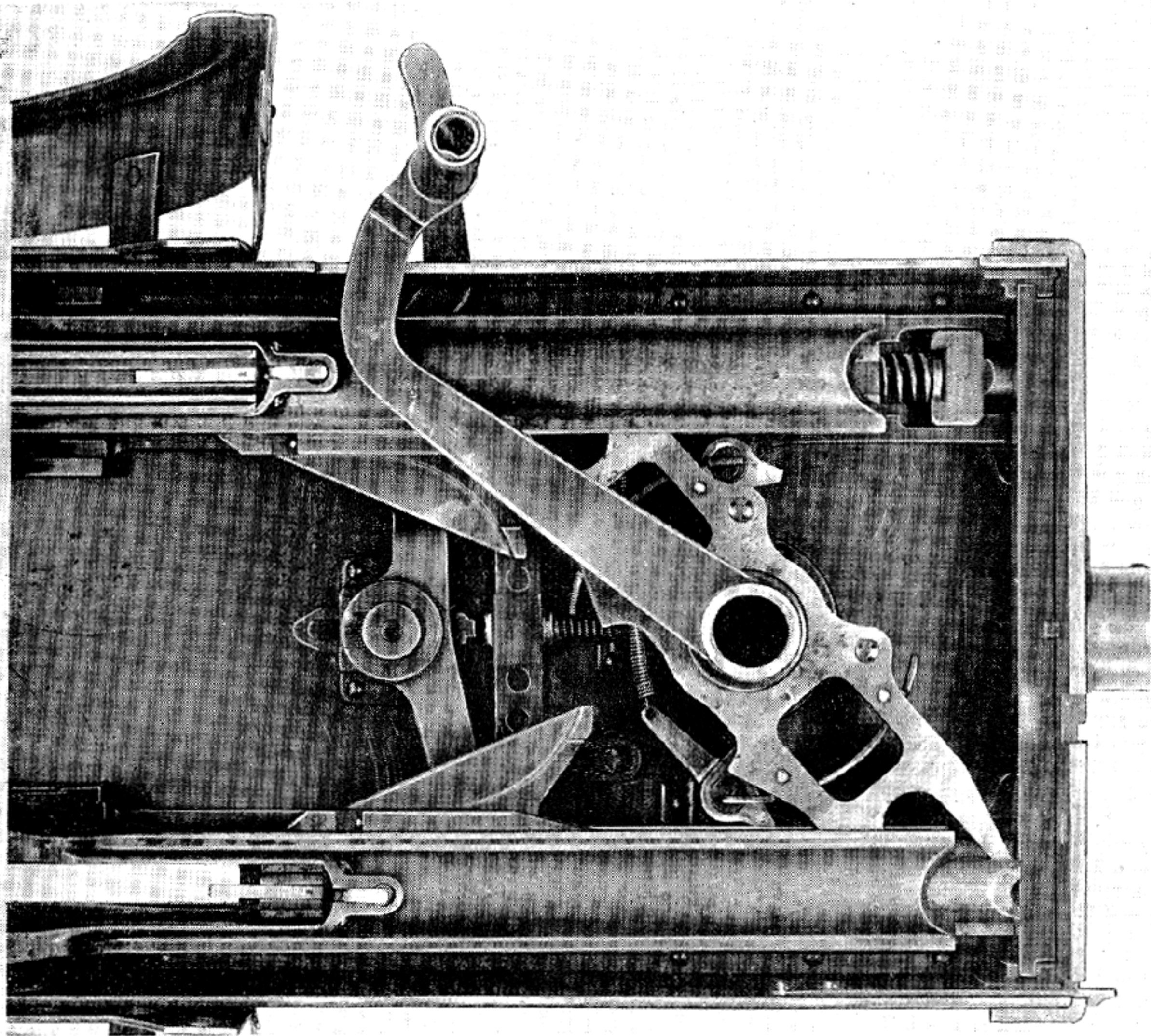
manufacturing drawings the American Ordnance Department requested that the Allied Commission make available for test and evaluation at least one of the guns and 4,000 rounds of ammunition. After exchange of much correspondence, on 14 March 1922 one Gast gun, serial number 156, and 3,838 rounds of 7.9-mm rifle caliber ammunition were received by the property officer of the Munitions Building in Washington, D. C. However someone negligently forgot to send the drum magazines and there was another long delay before the weapon could be officially tested at Springfield Armory, Springfield, Mass.

In the meantime the War Department was notified that United States patent rights had been assigned by the inventor to a mechanical engineer, Mr. H. C. Isenberg, of the George W. Goethals Co., New York City, and that, if the Army was interested in the gun for purposes of adoption, Isenberg would represent Carl Gast. After limited firing on the Springfield range the following conclusions were reached by the examining board which met on 17 August 1923:

"The Ordnance Department having tested the 7.9-mm machine gun is now familiar with its construction, operation and functioning. . . . The gun is practical mechanically and operates reliably. It is sturdy and a good type of recoil operated machine gun. However, it offers no advantage over standard types now in use in the United States Army, and if adopted would require entire new facilities for its production. As it is not believed to be superior to the Browning gun, and as there are ample manufacturing facilities for the Browning gun, the recommendation is made that no action be taken looking into the acquirement of any rights in manufacturing the Gast gun or acquirement of additional ones for further test."

The report was signed by J. P. Wilhelm, Assistant to the Adjutant General, U. S. Army.

The American representative, Mr. Isenberg, feeling that the weapon had not been subjected to enough test to warrant rejection on the grounds stated above sought through the Secretary of War to have the board submit to him a written statement as to the reason for rejection on evidence gathered from actual test. He insinuated that it was not proper to come to a



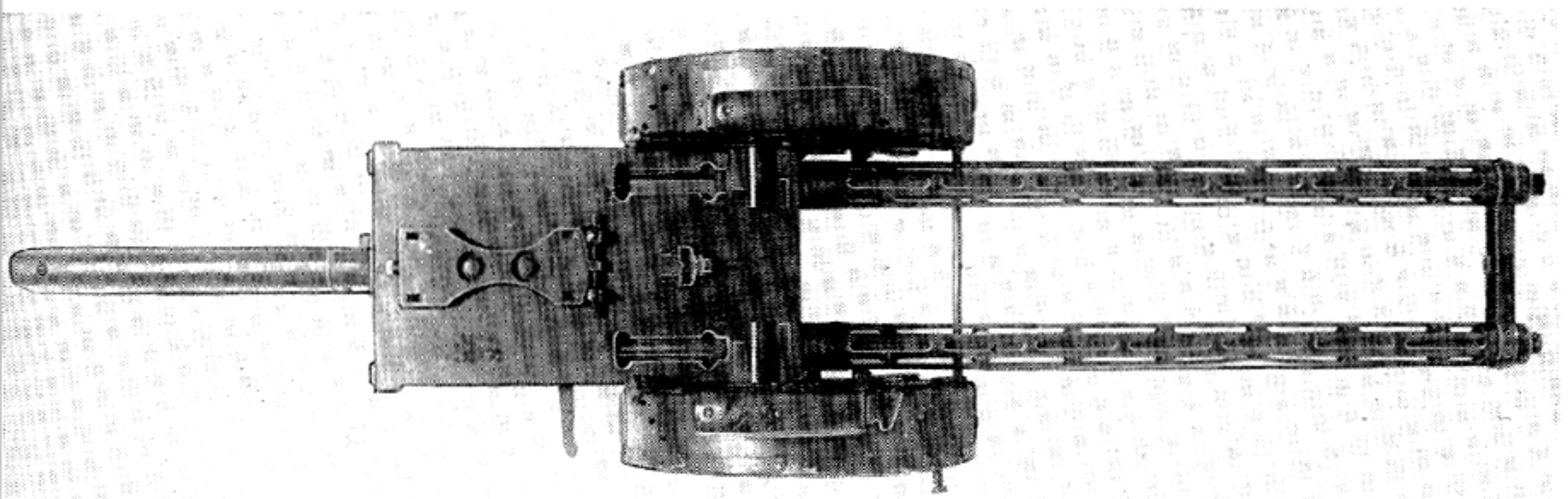
Breech Mechanism of Gast Aircraft Machine Gun.

conclusion that a weapon had no value to the Army when it did everything claimed on submission for testing. The Secretary of War refused this request and nothing more was done about the Gast in the United States.

To fire the Gast machine gun, the operator first places into position two loaded drums and pulls the loading lever with the right hand smartly to the rear until the firing mechanism, then in its most retracted position, goes fully into battery. On the way forward the bolt face forces the incoming round into the chamber and the firing pin is compressed by means of a

stationary collar contacting the U-shaped projection to which it is attached.

During the last portion of forward travel the release pin of the charging lever strikes against the slide stop and swings it out in such a manner as to disengage the charging lever, so that it will remain stationary during firing. This slight motion of the stop slide causes the locking discs to strike their camming angles, thereby rotating them until the rear face of the discs is arrested and the bolt and barrel are securely locked to the extension. While the firing mechanism is in battery and ready for firing, the bolt



Gast Aircraft Machine Gun, 7.92 mm. Top View with Feed Drums in Place.

assembly of the opposite barrel is at the extreme distance rearward it can travel.

A single trigger operates both mechanisms through a trigger bar contacting each sear, which, upon being pulled to the rear, allows the spring-loaded firing pin to fly forward and fire the chambered round. The barrel, bolt, and breech slide (barrel extension) recoil together for a short distance, at which point unlocking begins. Complete unlocking of the breech lock from the breech slide is caused by the face of the locking discs striking the fixed cam. The timing is such that the tip of a lug will strike the breech-lock lever at the moment of unlocking. The impact of the lug on the lever at a place near the pivot gives a greatly accelerated motion to the piece which is in turn transmitted to the already recoiling bolt. The latter begins

to move rearward more rapidly than the breech slide, while at the same instant the other bolt, formerly in a retracted position, is correspondingly shot forward.

The sudden forward motion of the counter-recoiling bolt is of sufficient force to strip a round from the feeder and cock the firing-pin spring, while simultaneously the recoiling bolt with its extractor carrying the empty cartridge case makes contact with the ejector. The latter strikes the base of the empty case pivoting and knocking it free of the gun through the ejection slot in the bottom of the receiver. As the recoiling bolt continues rearward, the other bolt approaches battery until the round is chambered and the mechanism is securely locked. At this point, if the trigger continues to be depressed, the cycle of operation begins all over again.

DARNE AIRCRAFT MACHINE GUN

About halfway through World War I the French brought out an aircraft weapon that had been manufactured with great secrecy. The weapon was the invention of Regis Darne and his son, Pierre. Their factory was in the town of St. Etienne, located in the coal mining area lying between the Loire and Rhône valleys. At the time this company had the Government contract for manufacturing all the Lewis guns made in France, its capacity then being 5 a day. The first Darne gun was introduced in 1916 and a few were issued in 1917. It attracted the attention of the French military high command to the point that in August 1918 the factory was ordered to produce all possible Darne-type machine guns for the planned spring offensive.

With the coming of the Armistice shortly afterwards, the Darnes were requested by their government to continue development of automatic weapons with the understanding that the technical services of both French artillery and air force would furnish data on new requirements. This company bent every effort towards standardizing and simplifying the various components in order to accelerate production in the event of an emergency. This, they thought, would not only facilitate instruction in ordnance classes whereby the weapon would be comparatively easy for gunners to master, but also make easy its manufacture, thereby creating the large reserve stock of spare parts so necessary for actual combat.

For over 15 years following World War I, this company manufactured high-grade shotguns and hardware to remain solvent, but it likewise experimented on a large scale with its machine gun. At the end of this time, it not only standardized the weapon but also produced enough to issue to many French units in Africa and to several Balkan States for their air forces which subjected them to severe field tests. That they passed the rigorous conditions laid down

in the official specifications is best judged by the fact these countries reordered several times.

At Cayaux in August 1932 at an altitude of 25,000 feet with a temperature of -18° C, a pair of Darne guns were mounted on a Scarff ring and the weapons fired by remote control. The test was to subject them to low temperature and exposure. Records show they functioned satisfactorily.

The weapon was gas operated, as were all French machine guns, with no provision made to regulate the amount of gas bled from the bore to the face of the piston. The company placed a port of predetermined size leading to the gas chamber and made it so that the individual gunner could not get it out of adjustment. That the largest possible orifice was used is attested by the fact that the aviation model Darne had an abnormally high rate of fire.

The weapon can be fed by both metallic strip or fabric belt, the system being so constructed that by rearrangement of parts it can be fed either right or left handed. The aviation model had both a pistol grip with a trigger device actuated by a rearward movement of the finger and a synchronizing device that mechanically released the sear and controlled the firing of the weapon through the propeller. When the gun is fired and pressure is exerted on the piston by the gases, this piece is driven forcibly to the rear. At the same time the gas piston starts to compress the driving spring. If the trigger bar continues to be held down, the piston cannot be caught by the sear at the end of its backward movement and the driving spring reacts in turn to throw the whole group forward, repeating the firing cycle.

These alternating movements of the gas piston shuttle the firing mechanism in the longitudinal slideways of the receiver. The breechblock covers the upper solid part of the gas piston of which it is an integral part. The rear spur of



Darne Aircraft Machine Gun, 7.5 mm. Dual Flexible Mount.

this piece is set in a recess corresponding to the aft end of the upper portion of the piston. When the latter moves forward under the impulse of the driving spring, the sliding movement of the recoiling mechanism in that direction is stopped at the end of its slideway. The piston with attached firing pin continues on its course.

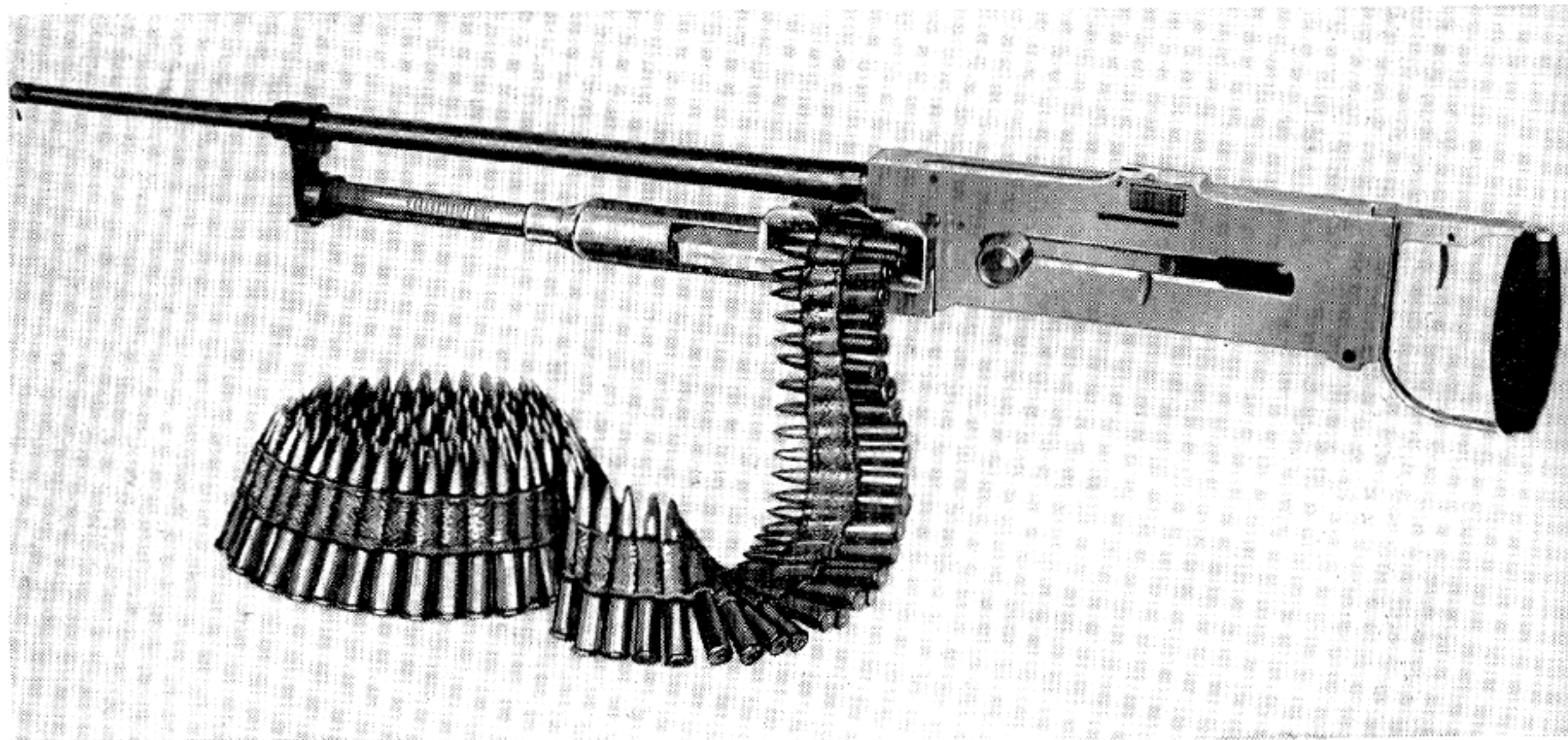
The projection comes in contact with the corresponding cam on the breechblock which is opposite it. The breechblock is thus jacked up at the rear and held in this position placing the piston in alinement necessary for its forward movement. This rising of the breechblock brings it into its seat in the oblique recess made above its upper portion.

The rear face of the breech is then buttressed against the supporting part at the aft end of the recess securely locking the mechanism. This piece is specially heat treated as it has to stand the shock which will be produced by the exploding powder gases. The locking mechanism thus raises the bolt in the rear making way for the gas piston to continue its forward movement. The latter is provided in the front portion of its solid part with a firing pin which comes forward to strike through the opening in the bolt face against the primer of the cartridge. The round cannot be fired until the gas piston has raised all parts into battery and the arm consequently is safely locked.

As pressure builds up in the bore and the piston is thrust backwards by the impact of the gases, one of the two cams borne on its upper solid part comes in contact with the lock. The effect is to bring the rear of the breech into the axis of the upper slideways of the receiver.

As the unsupported breech no longer opposes the sliding movement, the piston pulls the breechblock rearward, at which point the extractor withdraws the empty cartridge case from the chamber. In this recoiling movement the breechblock strikes near the end of its course, the rear stud of the ejector forcing it to pivot. This oscillation brings the front stud into the path of the cartridge case, throwing the empty case through the ejection slot in the receiver. The piston and its components then reach the end of their course, at the same time compressing the main driving spring.

During this part of the cycle the cartridge carrier has previously seized between its claws a cartridge at the base of the case, and pulling it to the rear extracts it from the belt. At this moment the rear face of the claws is buttressed around the rim of the incoming round. During the first fractional inch of pulling the cartridge, the bullet pusher, actuated by its strong spring, presses against the front end of the bullet and follows it as it moves backwards. Thus the effect of inertia is neutralized with a view of avoiding



Darne Aircraft Machine Gun, Model 1918, Cal. .303.

the malfunction commonly known as a short round.

After having exerted its action, the bullet pusher is cammed forward again by the transverse movement of the next cartridge sliding into the feed slot. As soon as the point of the bullet has passed into the clear, the bar actuated by the cartridge carrier spring raises the incoming round at its middle part. The cartridge at this point assumes an angle of approximately 45° with the point of the bullet resting a little above the axis of the bore. During this final movement the front boss of the feed cam strikes the free end of the small rod carrying it towards the rear and the round is chambered. The action in battery is ready to repeat the cycle if the trigger remains depressed.

The Darne has often been erroneously referred to as another type of Hotchkiss machine gun because of its physical appearance and the fact that both are gas operated. Many things in the basic design of the Darne machine gun, however, are to be found only in this weapon. The feed system is indeed unique both as to position and method of operation. The two claws attached to the gas piston withdraw the incoming round from the feedway after it has been pushed from its link by an odd device that cams the cartridge positively back by pushing with great force on the nose of the bullet. They also prop the round up on a 45-degree angle, with two fingers attached to the gas piston, without relinquishing its hold. This unusual method of feeding has many good features, such as performing all its necessary functions on the powerful recoil stroke of the piston where there is surplus

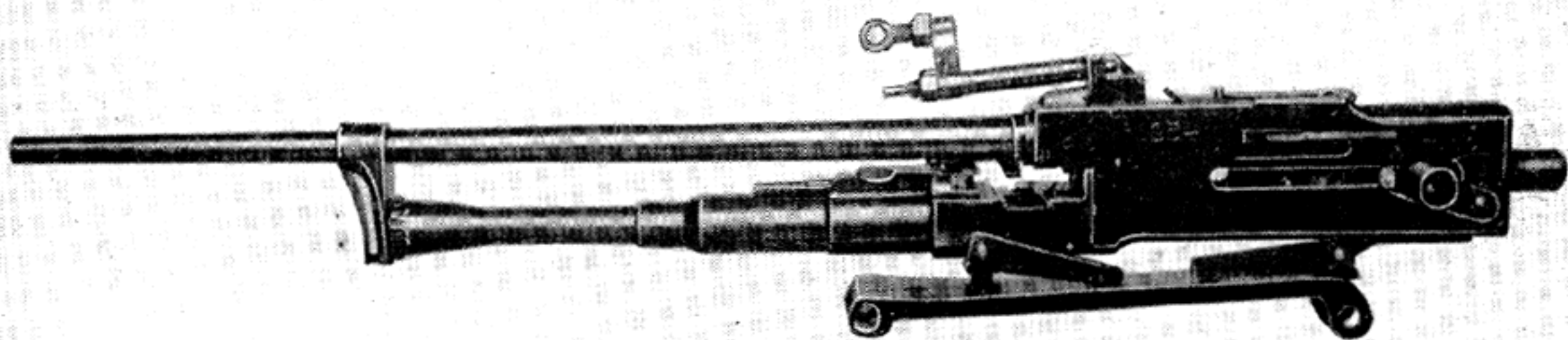
energy. The design also makes possible a short bolt stroke. These two features contribute much to the weapon's high rate of fire, that has been vouched for by competent American observers to be as high as 1,700 rounds a minute when the 7.5-mm rifle cartridge was used.

The French mania for economy may have been the biggest factor in the lack of success of this gun, as the Darne Co. did everything possible to cheapen its construction, offering as an argument the short life of an airplane which made it foolish to build a gun that involved too much expensive machining. These guns were furnished to the French Government in 1931 for 700 francs, then equivalent to \$28. Such a price was more in keeping with the cost in America of a good single-shot rifle than it was for an aircraft machine gun. At this attractive price the company, in the period from 1918 to 1931, sold 11,000 machine guns in all. Serbia got 2,500, Italy 1,000, Spain 1,200, Brazil 150, and the remainder were delivered to France at a rate of 10 a day.

The aircraft version was also adopted by Lithuania following a competitive test held in December 1934. In May 1935 a British commission arrived at the Darne plant to witness a test of the guns for the purpose of buying license rights to manufacture them in Great Britain. The weapon passed the French test but failed at a later trial in England.

The Darne Co. took great pride in the fact that the weapon did not have a single piece of forged steel in its construction, making possible production of an inexpensive yet reliable gun.

A tourelle magazine was also designed for avi-



Darne Aircraft Machine Gun, 7.5 mm. This Is a Fixed Gun for Synchronizing.

ation use, having the unusual capacity of 500 rounds available for continuous fire. The double-barrel Gast machine gun, which was then held in such high esteem by both German and Allied ordnance officers, had a maximum cyclic rate of fire of 1,800 rounds a minute. By mounting two Darne guns side by side to resemble the much heavier Gast, the arrangement gave a minimum of 2,400 shots per minute. The company was proud of this system of mounting and catalogs appeared in many languages showing its alleged superiority.

Several hundred guns were sold to Spain which were used in the Moroccan campaign. On these weapons was installed the load indicator, a device that showed the gunner not only if the gun was loaded but the amount of ammunition left in the feed box.

Following what it considered the success of the aircraft model, the Darne Co. then developed a light machine gun, a heavy one for infantry use, and an antitank automatic gun chambered for the 11-mm military cartridge.

All Darne machine guns were rough in appearance, being produced in this manner intentionally since refinement in appearance would only add to the cost. Cheapness and ease of manufacture were the main points considered in their design.

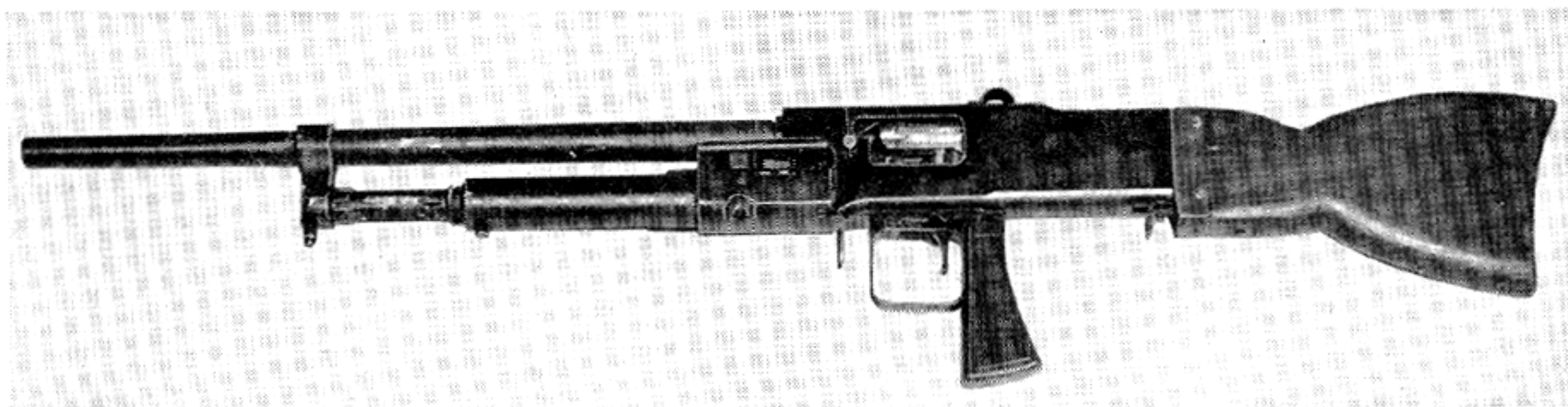
The barrel was made with exterior projections and the gas port had a conical exit into which the gas tube fits. The piston had only three bearing surfaces, one at the front where the force of the gas was taken in and two at the rear where it fitted loosely in the guides of the receiver. The

feed mechanism was one of the most positive known, being actuated by the recoil stroke of the gas piston. The two fingers holding the cartridge in position for chambering were indeed unique.

Initial extraction was employed to loosen the empty cartridge case before the extractor snatched it from the chamber. Ejection also was satisfactory. The heavy bolt was securely locked during firing by a shoulder on the gas piston, camming the rear of the bolt up into the locking recess milled into the receiver body. Had many of the ingenious methods employed in this cheaply constructed weapon been given refinement and placed in a well-designed receiver, it no doubt would have been among the best of the gas-operated type.

The Darne Co., in 1935, also tried designing a 25-mm aircraft motor cannon with rounds being fed to it from a belt with metal clips. This weapon was placed in secret status by the French Government and, when France was overrun by the Germans in World War II, it, with all data on its performance, fell into enemy hands. This weapon was reputed to have fired at a rate of 750 shots a minute. Experiments were also made with a triple 7-mm rifle caliber machine gun, but it, like the 25-mm automatic cannon, never got beyond the prototype stage.

Darne machine guns have been mentioned both favorably and otherwise, but on two things everyone is agreed. The most outstanding features about the factory were the outmoded machinery the company used and the poorly illuminated, cramped quarters in which 400 men had to work.



Darne Machine Gun, Model 1929, 7.5 mm.

BEARDMORE-FARQUHAR AIRCRAFT MACHINE GUN

The Beardmore-Farquhar machine gun was one of the lightest machine guns ever constructed, weighing only 16¼ pounds with a 77-shot drum magazine attached and loaded with the .303 British service cartridge. This weapon was the invention of Col. Moubray Gore Farquhar, of Birmingham, England, and was manufactured by Messrs. William Beardmore & Co., also located in Birmingham.

Many special features were claimed by the promoters, such as its cheapness to manufacture, the practically jam-proof mechanism, perfect breech locking and a safety feature making it impossible to fire the weapon without the breech being securely locked. It was recommended that no oil be used on the highly polished close-fitting mechanism, thus making it an ideal weapon for an observer in a plane where great altitude gummed up the working parts of similar firing mechanisms that demanded lubrication. The makers of the gun also claimed the heat of the barrel did not affect the other parts, as they would continue to function properly even if the barrel was red hot during the entire time of operation.

The weapon was similar in appearance to other drum-fed observer guns that had been used so successfully by the British Royal Air Force during World War I. The manufacturers, however, considered it to be a real improvement over similarly constructed ones because of its unusual method of operation.

The most unique feature of the gun is the extensive use of springs for its operating energy. It is placed in the unusual classification of being actuated by both gas piston and spring. The power of the exploding powder charge does not act directly on the bolt's unlocking mechanism but compresses and stores up spring energy until the bore pressure drops to a safe operating limit. The bolt is then unlocked by the smooth action of the strong spring, which gives positive unlock-

ing without the jarring effect of a straight gas-piston-driven mechanism. The piston is contained in a cylinder which is fastened to the barrel and connected to the bore by a drilled orifice. The main driving spring is housed in the front end of a part known as the spring tube, with a kind of sear device also located in this part. The front of the housing is held in position by a tube cap and fore end piece.

The design of this peculiar weapon also has what is called the bolt-closing spring. It is placed around a central rod, and when installed, is located at the rear of the spring tube underneath the barrel.

When the cartridge is fired and the bullet passes the orifice in the barrel, gas is bled into the gas-cylinder chamber forcing the piston rearward and compressing the main spring until it is held in this position by the catch or sear. The spring is thus compressed between the catch and head of the tube. It remains compressed until the resistance to turning the bolt head, caused by the pressure of the gas in the chamber working on the locking lugs against the body, is so reduced that it can be overcome by the strength of the compressed spring.

The main spring held securely by the sear, with its firm abutment against the holding washer, extends rearwards carrying with it the bolt carrier to which the bolt is attached. The force of the main spring, upon opening the bolt, extracts and ejects the empty cartridge case and compresses the bolt-closing spring. The main spring, now being fully extended and no longer pressing against the sear and catch, disengages, allowing the now-compressed bolt-closing spring to start counterrecoil movement of the parts. They in turn strip a fresh round from the feeder and return the main-spring-sear washer and piston to battery position and in the final movement forward lock the bolt securely to the barrel.

The breech action is of the straight-pull type



Beardmore-Farquhar Aircraft Machine Gun, Cal. .303.

whereby the bolt carrier slides in slots outside the body. The carrier is provided with an internal cam slot which engages the bolt arm. The bolt is composed of a non-rotating cocking piece and a rotating bolt head. The locking lugs are at the front of the bolt head and engage with corresponding resisting shoulders located in the receiver directly behind the chamber. When the lugs have entered the body, the arms engage its face. The bolt arm, continuing its forward movement, is turned by the cam slot until the lugs engage the resisting shoulders and the bolt is securely locked in battery. The extractor, in its final movement forward, cams itself over the rim of the chambered round.

The ejector consists of a pin supported by a spring and housed in the bolt, with the point of the ejector pin protruding through the face of the bolt. When home over the face of the cartridge, the ejector pin is depressed flush with the bolt face. But if the empty case has been extracted far enough that the front end is not supported by the chamber, the ejector pin jumps smartly forward throwing and pivoting the

empty case through the ejection slot in the left side.

The bolt always remains locked in the Beardmore-Farquhar until the force required to unlock it is less than the strength of the compressed main spring. This makes it impossible for any extra amount of gas pressure to hasten unlocking, or for that matter, affect the operation in any way.

The feed mechanism is also very interesting in that it is a rotary affair holding two layers in the drum. The cartridges are put under spring tension and likewise indexed and stopped by a spring-loaded catch. The entire drum can be unloaded manually in an instant by depressing the two feed stops simultaneously.

It was claimed that the operating mechanism was not as likely to heat up from barrel heat as other guns of similar design. Since the connecting parts of the metal were of reduced section or skeletonized to a great degree, the heat was thus confined only to the barrel.

To simplify further the construction of the weapon, there were no radial fins or like ar-

rangements on the barrel for cooling purposes. On an official test the weapon fired 640 shots in rapid succession without jamming from overheating. The manufacturer contended a weapon of such design would never be called on in air combat to equal or exceed this. Therefore, he could not see the logic of adding to the weight by placing more metal into the barrel.

The inventor demonstrated on every possible occasion the good features of his weapon and personally fired it. The colonel must have been a good marksman as well as an ingenious inventor, as he once placed 75 hits on a target with a one-drum burst, at the required military range distance.

On 14 November 1919 the Royal Air Force gave the Beardmore-Farquhar machine gun an official aerial test. The weapon was presented by Colonel Farquhar and immediately fitted in a Bristol fighter machine on a Scarff-ring mounting. Firing trials were then carried out at high altitudes. The pilot was Flight Lieutenant Rea and the gunner, Flight Lieutenant Pynches. Twenty rounds were fired automatically at 4,000 feet and the gun functioned perfectly. At 18,300 feet, 320 rounds were fired at various angles of elevation, depression and training.

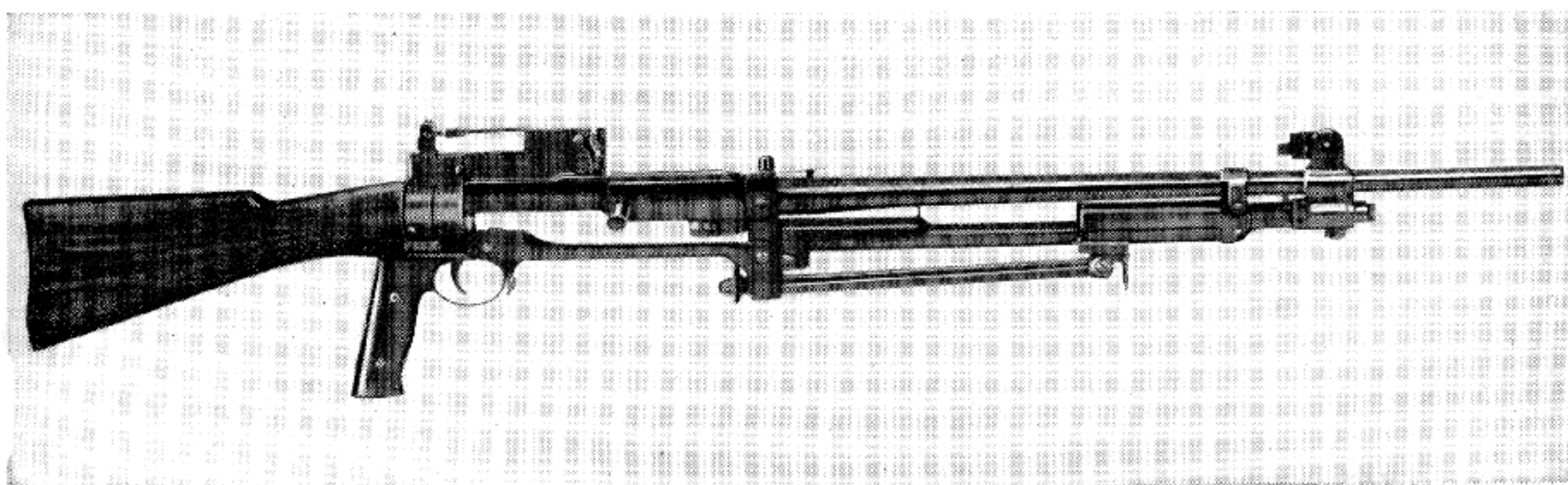
Up to a maximum firing position it was reported the gun was very easy to handle at any desired position and no difficulty was experienced in shipping and unshipping the rotary magazine. The rate of fire at the maximum altitude attained, 18,300 feet, was figured at 430 rounds per minute, which was considered the limit for ground firing. The angles of elevation,

depression, and training in a firing position were the same as obtained by other guns that had been previously tested on the same mounting.

The cartridge cases were ejected about 6 feet out of the gun and carried by the slipstream past the fuselage of the aircraft. Only in one instance did the ejecting of an empty cartridge case fail. This occurred in the last round of the first magazine when firing at the maximum elevation in altitude. The cartridge case was eventually extracted by alternately withdrawing and releasing the bolt about 20 times. The case was unfortunately ejected overboard but it was thought by the gunner that the jam was due to faulty ammunition, probably to an over-sized rim.

No other stoppages or jams occurred during the remainder of the test. During the flight, loaded magazines had been placed flat on the floor of the aircraft and the vibration released the spring-loaded cut-off in the feed which opened it and emptied the ammunition on the floor. Ordinarily during flight these magazines or drums would have been stowed on a stud. It was agreed that excessive vibration fouled the cut-off projection during the stowing of the magazine, thus causing the loss of the ammunition.

The authorities in charge of the test recommended that a stop on the magazine be placed immediately behind the cut-off to eliminate the above possibility, as it was sometimes customary for pilots to carry the drums on the floors of their planes. It was also suggested that the flat steel rod connected to the reciprocating breech mechanism should have a guard over it, since it was possible for the gunner's fingers to be in the



Beardmore-Farquhar Aircraft Machine Gun, Cal. .303.

way of the recoiling breech. The guard would also prevent oil thrown out by the engine from getting into the working parts of the weapon. Another recommendation was that an additional handling advantage could be obtained by adopting a round section handle projecting to port about two inches and bent downwards to form a hand grip instead of the present method of handling.

The testing board's conclusions were that the gun compared very favorably with other weapons of similar design, with the additional advantage of having less kick. The rate of fire was not quite as high as similar designed guns. The weapon was lighter and less liable to jams. A much more extensive trial would however be necessary before a definite conclusion could be

arrived at on the foregoing points as well as the behavior of the gun after ordinary long service usage. It was further noted that the 77-round drum could be detached and a 5-round magazine, using the infantry cartridges in their present clips, could be placed on in a matter of seconds, converting it quickly from an aircraft gun to a lightweight automatic rifle for infantry use. The rapid-change barrel system employed by this weapon was also commended.

After tests conducted at a later date the British Government decided that the weapon was not so much superior to others of similar nature already in existence as to justify its over-all adoption as the Royal Air Force observer gun, and with this decision all work and development stopped.

BRIXIA MACHINE GUN

The Brixia machine gun Model 1920 was devised by engineers of the Brescia Metallurgical Works, formerly the Tempini-Brescia Company, producers of 40,000 Fiat machine guns under Italian Government contract. From their background and a comparative study of all known machine gun mechanisms, they developed what was considered an improvement that "fulfilled in all respects the requirements suggested by experience of five years of war." In the weapon's design special attention was paid to: (1) Lightness, yet reliability of construction; (2) simplicity and solidity of component parts; (3) maximum ease in stripping and assembling; and (4) safety and ease of operation.

One of the Brixia's most unusual features was the complete housing of the recoiling parts to

prevent introduction of sand, dust or other foreign matter that would hinder operation. In the event of premature explosion of a cartridge the operator was fully shielded by the encased receiver. The method of feeding was also claimed by the producers to be much simpler than that of other machine guns. The gun was fed automatically by metallic loaders formed into rectangular boxes and attached to the receiver.

There was also incorporated in the weapon a means of regulating rate of fire while the gun was in action. Cooling was accomplished both by air and water. When water cooled, the conventional jacket was used, but in the aircraft model the barrel was cooled with radiation of the flanges that were an integral part of the barrel. For the water-cooled version the barrel was



Brixia Machine Gun, 6.5 mm.

lock passes when in battery, rests upon the rear of the projection. Directly above it is a hole to house the safety spring. The latter holds the locking lever up in line with the slot cut for its path when the breech lock is removed from its path by being in the locked position.

In addition, a slot is cut high up on the left side of the receiver for the ejection of empty cartridges and an opening on its lower right side provides for the introduction of ammunition by means of a magazine. The ejector is a portion of the receiver made to butt into the base of the empty cartridge. It recoils rearward while being held by the extractor, which is peculiarly located on top of the bolt.

The trigger arrangement consists of a button, the movement of which is limited by the rate-of-fire regulator, a goose-neck-shaped bolt inserted and held transversely in the receiver. While in various positions and in conjunction with the trigger mechanism, it lengthens or shortens the travel of the recoiling parts. This unusual firing device is provided with a thumb piece that pro-

trudes from the left side of the receiver and, by means of finger pressure, controls the speed of operation. The regulator itself is an eccentric bolt. The cylindrical part is moved along an axial plane while the periphery of the other half has two grooves which are at variable distances from the axis of rotation, and in which rest the tops of the middle fingers that serve to accelerate the recoiling action rearward. Pushing down the regulator on the left side of the gun with trigger button depressed at various levels controls the distance of movement fore and aft.

To operate the Brixia, a loaded magazine is inserted in the corresponding slot until the loosening of the restraining catch shows it to be completely seated. With his right hand, the gunner draws the charging handle attached to the loading bar back smartly for the maximum distance and releases it. The recoiling parts are then sent forward with great speed by the compressed driving spring. On the way to battery they strip from the magazine attached on the right lower side a live round and by the employment of two



Brixia Machine Gun, 6.5 mm.

lower flanges guide the cartridge into the chamber. When this is accomplished, the loading bar carried by the recoiling parts returns to its original position, locking itself on its catch. The breech lock, being pushed forward from the breech, is inserted between the loading bar and recoil mechanism to insure complete locking before the act of firing.

The firing pin, held back by the front part of the cocking lever, is now in the cocked position. By pushing forward on the trigger button, the round is fired. The pressure of the exploded powder charge causes the recoil of barrel, bolt, and bolt extension all locked securely together for a distance of about 5 millimeters. At this point the weapon begins to unlock as the breech lock turns over backward and by doing so acts as an accelerator.

After the short recoil the barrel extension is stopped by a buffer. The bolt, now unlocked from the barrel, continues to the rear, carrying the empty cartridge case gripped at the top of its

rim by the extractor. At a distance slightly greater than the over-all length of the incoming cartridge, the base of the brass case hits the ejector projection that is an integral part of the receiver and kicks the expended case out the upper left side of the receiver. The recoil movement is stopped by a buffer housed in the back plate and under the influence of the driving spring and the buffer starts the operating parts into counter recoil. The magazine-fed cartridge slips into position in the carrier and is lifted up in line for the incoming bolt to strike and thrust it into the chamber.

The bolt is now locked to the barrel and extension and the firing pin remains in a cocked position provided the firing button is not depressed. In order to execute continuous fire, the firing lever must remain pressed down as far as possible. The lever is then placed at the bottom of the inclined face and will allow the weapon to fire automatically. When so held, a maximum rate of 600 shots per minute is attained.

MENDOZA LIGHT MACHINE GUN

Señor Rafael Mendoza, a foreman at the National Arms Co., Mexico City, D. F., in 1920 started the design and development of a light machine gun. Twelve years later he felt his working model was at a point of perfection that would justify testing by the Mexican war department for official adoption.

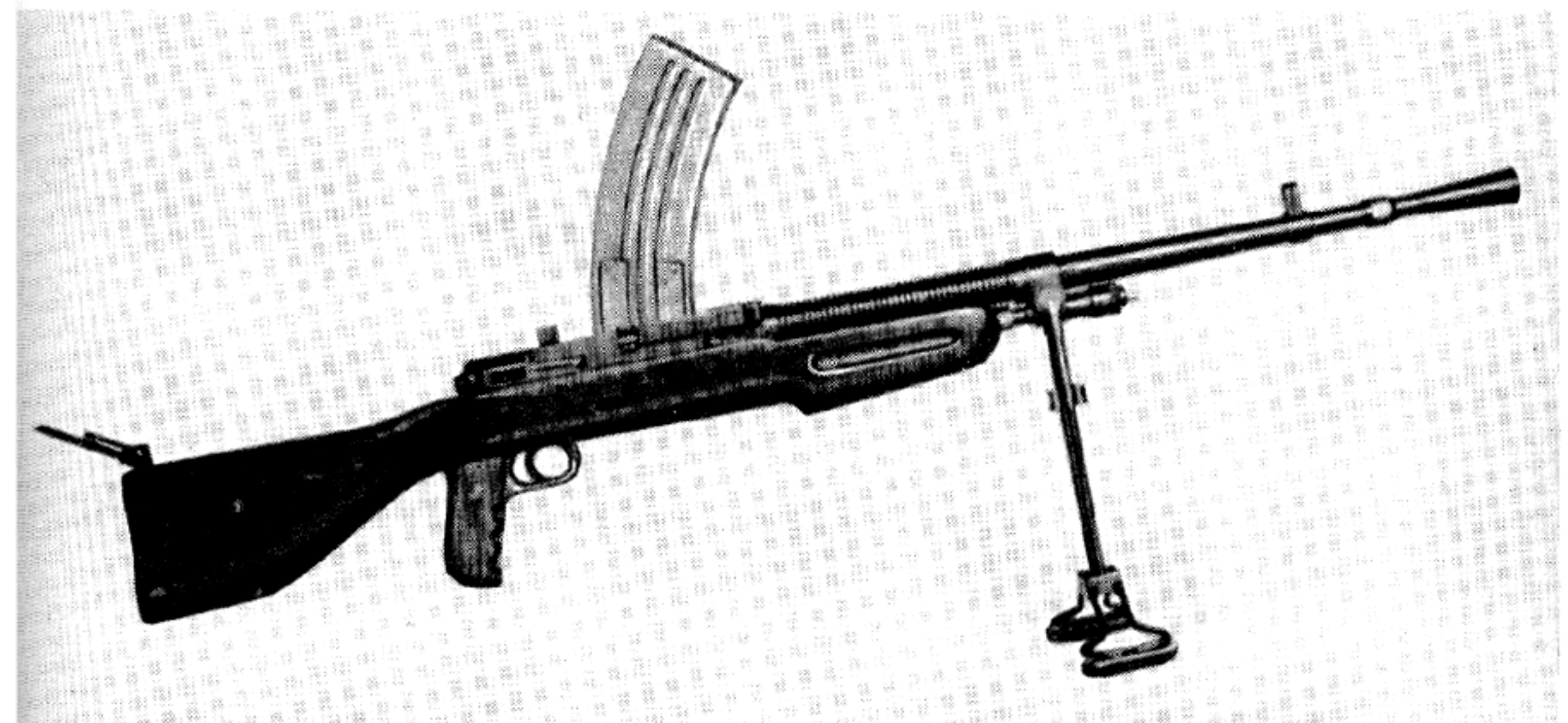
The gas-operated weapon had a non-recoiling air-cooled barrel and a 30-shot spring-loaded double-column magazine. Its maximum rate of fire was 500 shots a minute and its weight was 18½ pounds. It could be fired both semi- and full automatic, the bolt remaining open after the trigger was released. The magazine was located on the top right side of the receiver which did not necessitate the offsetting of the sight system.

The standard Mendoza gun came with bipod but it could be instantly adapted to antiaircraft mounting. The barrel, which had cooling fins, was chambered for the Mexican infantry Mauser 7-mm rifle cartridge and could be changed in a

matter of seconds when necessary. A flash hider was always incorporated in the design. Barrel removal in the field was accomplished in the following manner: First the gun was cocked, after which the barrel latch on the forward end of the receiver was pressed in; the large lug holding the barrel to the receiver was freed; and the barrel could then be pulled forward.

The weapon was constructed with only 22 working parts. This fact alone showed great skill in design and planning, as such simplicity eliminated many malfunctions.

In October 1932, at the Rancho del Charro, D. F., the Mendoza, along with several other light machine guns, was officially tested under strict security by a board of officers representing the Mexican Government. They were greatly impressed by the performance of this Mexican-designed and produced light machine gun. After consulting with Mendoza, the government in June 1933 invited M. H. Thompson, a well-known New York engineer who had previously



Mendoza Machine Gun, 7 mm, Right Side.

done ordnance work for Mexico, to visit the National Arms plant for refinement of the weapon. This was done and in August 1933 the president of the republic ordered the limited manufacture of the improved gun for further test and experimental purposes.

This work was carried out in great secrecy, even to its adoption as the Mexican Army's standard light machine gun in December 1933. On 6 June 1934, after all tests and experiments were successfully concluded, the National Arms Factory was ordered to proceed with full production on these efficient lightweight weapons. The government took over Mendoza's invention, paying him well both in money and honors and applied for a patent in the United States in his name. The first twenty guns were issued to the 48th Infantry Battalion, then stationed at Chapultepec.

The Mexican Commission of Military Studies requested that as soon as delivery was made of the Mendoza machine guns they be distributed to the tactical units, as follows: 18 guns to each cavalry regiment and 24 to each infantry battalion. They were to replace the automatic weapons with which the troops were armed at the time, namely—Hotchkiss, Colt, and Vickers, all of which were eventually withdrawn and put in reserve as the new Mendozas were received.

After the army had already been armed se-

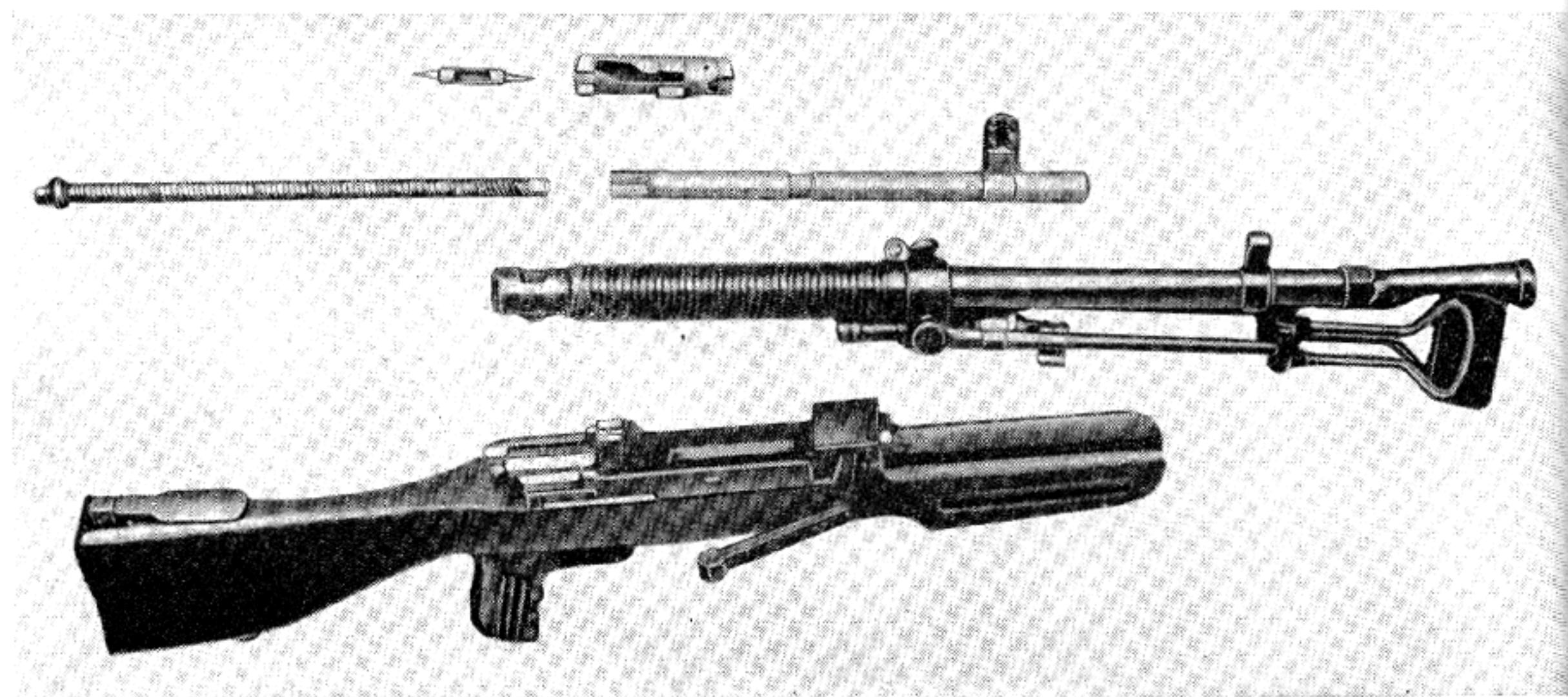
cretely with this weapon, the Mexican war department published the following bulletin:

"Order No. 42, 6 December 1934.

"By order of the Substitute Constitutional President of the Republic dated 31 October 1934 the Mendoza machine gun rifle ('fusil ametrallador') and the Mendoza light machine gun are hereby declared regulation in the Mexican National Army and Navy. The War Department has already taken the necessary steps that the corresponding armed units may be equipped with this material with as little delay as possible."

The weapon has many advanced features, although the main principles of operation are as old as automatic firing mechanisms. Basically and from an operational standpoint it is a Lewis action but this system is noticeably improved by incorporating a double cam slot. The device did much to equalize the torque and consequently reduce the locking friction, so common when the bolt face is held securely behind the cartridge base.

Although the gas cylinder greatly resembles the Hotchkiss, the conventional method by which it encloses the piston is not employed. Instead, a cuplike arrangement in the gas assembly houses a short and separate piston which after a brief stroke rearwards allows the powder gases to dissipate into the air. This is exactly the



Components of the Mendoza Machine Gun.

reverse of the ordinary gas-operated firing mechanisms.

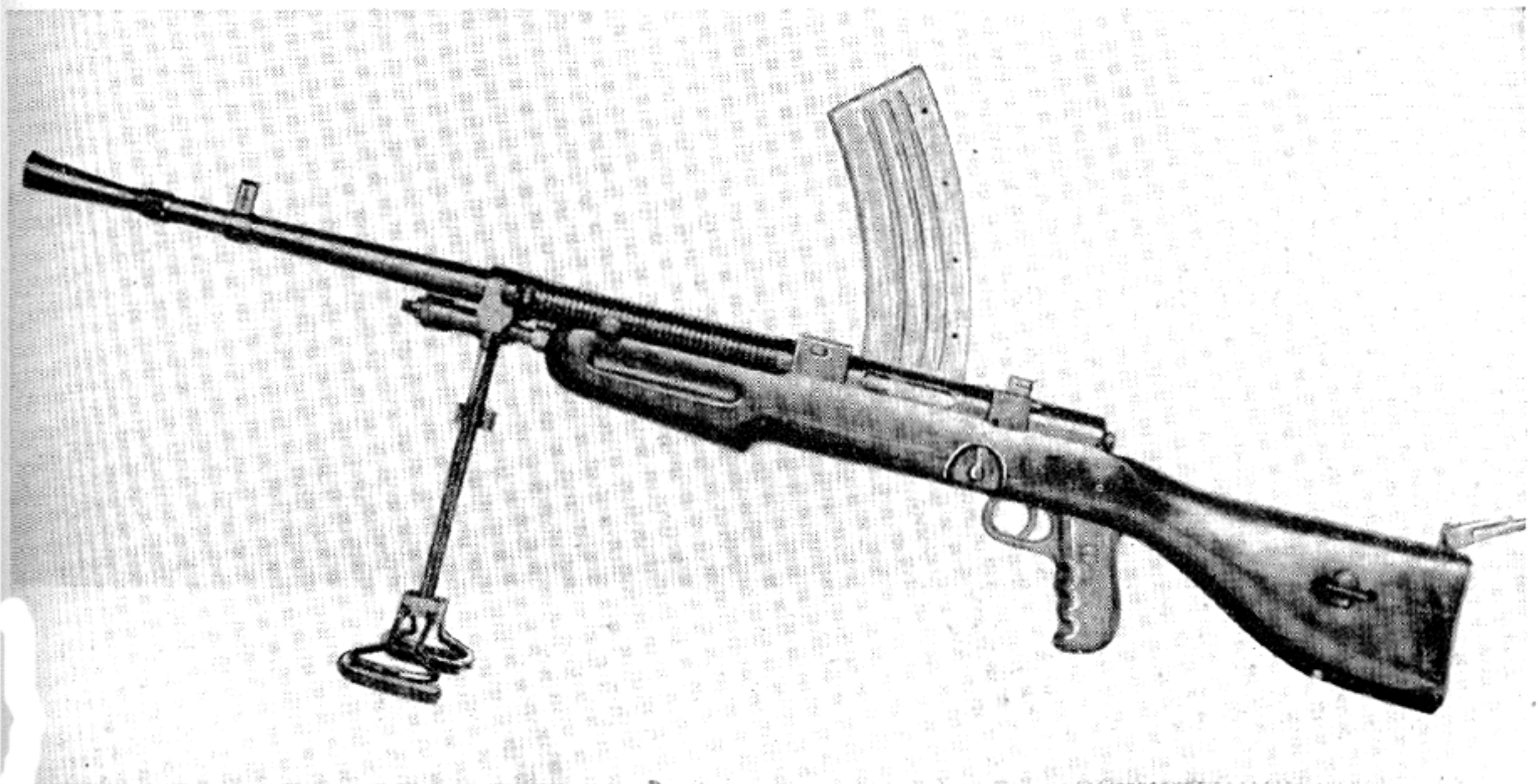
The selector switch is located on the left side of the receiver above and slightly in front of the trigger guard. A most unusual cocking method is employed. On the left side near the end of the firearm projects a small piece to be pulled by the left hand directly to the rear until the sear engages and holds the gas piston and bolt in a retracted position.

The firing pin is unique in construction. Driven forward into the primer of the cartridge by its attachment to the bolt extension, it is made with two identical protrusions so that when a tip is broken off it may be remedied simply by reversing the ends.

Another interesting feature is the ejector, a long finger pinioned in the right side of the receiver and an integral part of an assembly which includes a bolt-hold-back device. The rear end of the bolt is used as a cam on the right side so that as it moves to the rear it noses the ejector and hold-back device out of the way. But as the aft end of these members is struck, the cammed surface forces the ejector's nose back into a slot in the forward part of the bolt, while the nose of the hold-back moves into a notch on the bolt's right side.

No provision is made for head spacing as neither barrel nor receiver has the necessary threads. The barrel is simply inserted into the receiver, its rear end being slotted to take the locking key. The latter also passes through the receiver and is held by the same retaining pin. On the last shot a three-cornered stop attached to the magazine follower protrudes past the lips of the magazine into the receiver, blocking the movement of the hold-back pawl. Thus the empty magazine holds the bolt to the rear with the expenditure of the last cartridge. When a fresh magazine is inserted, it releases the rear sear, at the same time letting the bolt come forward just enough for it to engage the notch in the actuator. This makes instant action possible with the weapon after a loaded magazine has been placed in position.

To fire the Mendoza Model C-1934, the operator, generally prone, inserts a loaded magazine into its locking recess on top of the receiver. If automatic fire is desired, the selector switch is moved forward from its safety position. The charging handle is pulled with the left hand all the way to the rear until the hold-back sear engages its notch in the bottom of the bolt extension, the short gas piston remaining in its housing under the gas port.



Mendoza Machine Gun, 7 mm, Left Side.

Being cocked and with a cartridge in place for stripping, the weapon is now ready to fire. A pull of the trigger to the rear disengages the sear and the operating parts are driven forward by the tension of the compressed driving spring. As the bolt face passes the rear of the double column-type magazine, it pushes the first cartridge from the lower right edge of the magazine as the extractor cams itself over the cannellure of the cartridge. When the cylindrical bolt has chambered the round and stopped, the eight locking lugs of the bolt are in line with the fixed lugs. The bolt extension, still three-fourths inch from battery, continues forward, rotating the bolt and locking it to the receiver.

The rotation removes the obstruction from the path of the firing pin. This piece, attached by a lug on the bolt extension projecting vertically through the firing pin and bolt, can now be driven forward to fire the round. As gas pushing the bullet through the bore reaches a port 11 inches from the breech end of the barrel, a portion is released into the short gas piston. The bolt extension moves rearward about three-fourths inch before its lug strikes the cam in

the bolt slot. The firing pin, which is a cylinder with a point on each end, starts backwards with the actuator.

The continued movement of the extension rotates the bolt, unlocking it and carrying it to the rear. The extractor in the left side of the bolt body withdraws the empty cartridge case from the chamber. As the bolt and bolt extension keep on, the ejector contained in the right side of the receiver strikes the cartridge case at its base, knocking it through the left side of the slot in the receiver. The full energy of the moving parts is absorbed by compression of a driving spring. At the completion of the recoil stroke the whole assembly is started into counterrecoil movement to feed, lock, and fire each round.

Mexican military authorities were justly proud of the Mendoza, as it was very efficient and served the purpose for which it was designed. The Mexicans have always been admirers of fine weapons and their history includes inventions that have contributed much to the art and development of automatic arms. On this list Rafael Mendoza's contribution ranks high.

CHATELLERAULT MACHINE GUN

The French, ending World War I with the realization that they had been armed throughout the conflict with the worst automatic weapon ever designed, the Chauchat, were the first of the Allies to adopt a post-war machine gun. This new arrival was the Chatellerault, named after one of the French Government arsenals, Manufacture d'Armes de Chatellerault. It was in design very similar to both the Berthier and the American (Browning) B. A. R., having many features of each.

It first made its appearance in prototype stage in 1921 but was not officially adopted by the French Army until 1926; and then only after many modifications had been made on the original, giving it even more Browning characteristics. About the only basic difference was the employment of a box magazine holding 30 rounds inserted from the top that made unnecessary the forked piston used on the B. A. R.

The Chatellerault had two triggers housed by a

guard, the forward one for single shot, the rear for automatic fire. A gas device, that could be regulated, worked in conjunction with an adjustable back-plate buffer to permit variable rates of fire at the control of the gunner. The top magazine arrangement made necessary an awkward off-setting of the sight.

The French had found from earlier attempts at machine gun design that their 8-mm Lebel rifle cartridge with its stubby and steep conical rimmed case was most certainly not the best-shaped cartridge for automatic use. Therefore included in the plans for this gun were drawings for a completely new round of ammunition. The result was a 7.5-mm rimless cartridge case with practically no taper on it, very similar in appearance to the Swiss Army cartridge from which it was closely copied even to the boat-tail 149-grain cupro-nickel bullet.

The Chatellerault weighed slightly under 20 pounds and was not only heavier but much more



Chatellerault Machine Gun, Model 1923, 7.5 mm. This is a Prototype Gun, Serial Number 11.

expensive to make than the Chauchat, since the latter gun was more of a plumbing assembly than a precision-made automatic weapon.

The French, as usual, had very little money for development and production of machine guns. As it has always been a policy of theirs to encourage adoption of their own weapons by friendly powers and prospective Allies, their military attachés who were located in such countries were instructed to spread favorable reports on the performance of the Chatellerault machine gun, even before it was officially tested, and to indicate it would be available for purposes of adoption if the authorities could be interested.

In 1925 the Yugoslav Government was carrying on a competitive trial in which several European-made machine guns were tested. The Hotchkiss Co.'s entry made the most satisfactory showing and was on the verge of being contracted for when the French attaché offered the Chatellerault gun at the ridiculously low price of 2,000 francs, although it had not been entered in the competition. He intimated that it had successfully met all the demands of the French proving grounds.

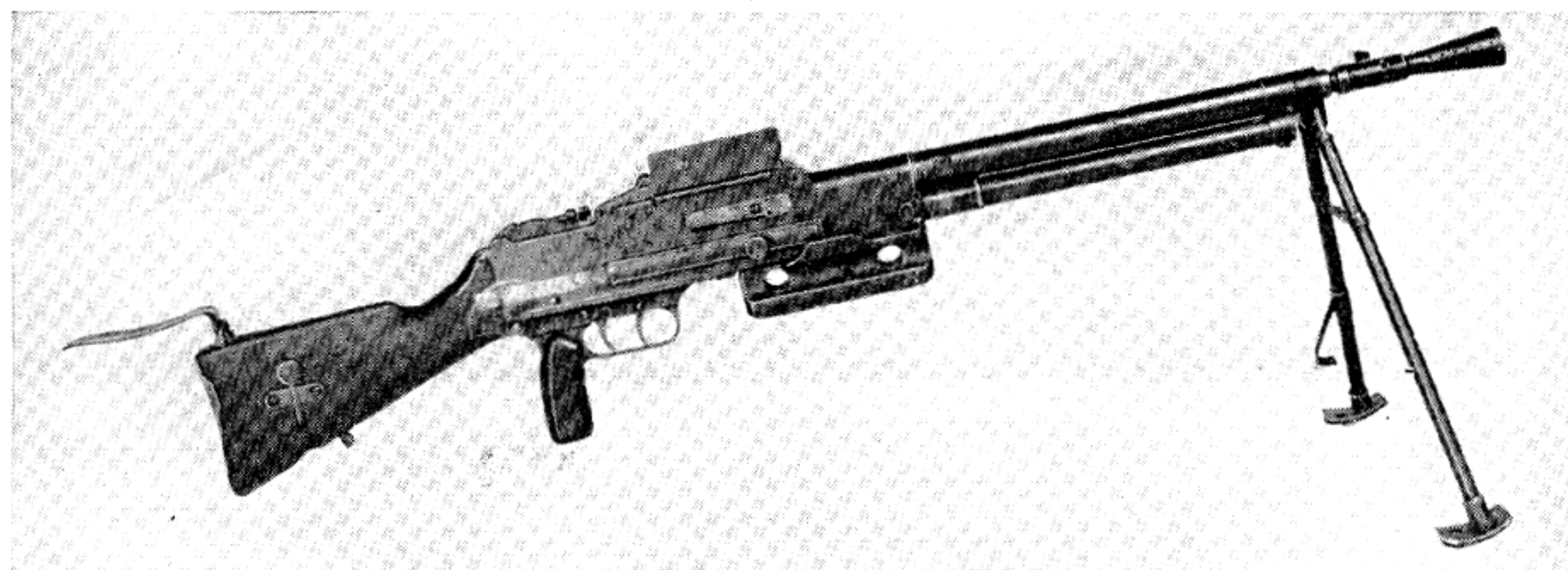
A Yugoslav commission was then sent to France to investigate the claims of the Chatellerault. It was found the price quoted could not be met but, although higher than first stated, it was still considerably less than the market price of similar machine guns. The catch this time was that only a few pilot models were in existence as their manufacture on a large scale had

not yet begun. The Yugoslavs, desiring an early date of delivery, called for another competitive test. This time they did not find either the Chatellerault or the Hotchkiss acceptable, the contract going for a machine gun made by another country.

A similar situation arose with the Rumanians who also sent their commission to France. However, they demanded and arranged a test before consideration of purchase. During one of the demonstrations, with one of the group firing the weapon while other members stood by, an explosion occurred in the receiver of the gun. The operator was seriously injured, as well as several others of the commission.

The Rumanians were told that through sabotage a cartridge with only enough powder barely to drive the bullet into the bore, caused two bullets to be present in the barrel for the next round, causing the regrettable incident. No explanation as to how the sub-loaded cartridge had gotten into the feed was forthcoming. The Rumanians, not quite satisfied with the explanation, in the presence of the French military attaché, produced the same condition with a Hotchkiss machine gun. The result was a swollen barrel but no violent explosion occurred.

After the weapon's adoption by the French Army, a number of explosions of identical nature took place, and quite a few soldiers were injured. As the blame could not be placed on defective ammunition, but rather on the weapon itself, it is easy to understand that the French



Chatellerault Machine Gun, Model 1924 29, 7.5 mm.

soldiers were considerably exercised over its dangerous characteristic. The troops in the field asked that they be issued the heavier and outmoded Hotchkiss in place of the Chatellerault.

The country's high command was brought to the realization that development work, if any, must be paid for by France and not by some smaller country, and that modification should be made without delay as the weapon had made such an unfavorable impression even among French troops. Necessary redesign was finally done, but, as is usually the case, once a weapon gets the reputation for unreliability, its bad name outlives by years the correction that remedies the malfunction.

It was also a severe blow to the sensitive pride of French military engineers that they did not seem able to copy either the B. A. R. or Berthier, both having proved reliable weapons, especially since, just before the weapon was tested, newspapers heralded the new gun built in great secrecy and now ready to be shown to the public for the first time. A sample follows of such advance publicity, as written by a reporter for the *Paris Echo* on 6 February 1924:

"A machine gun, the Chatellerault, said to be the invention of a French artillery officer . . . is equal or superior to its competitors with respect to its manner of operation, and is far ahead of them in regard to facility with which it can be handled and its principles taught to recruits—factors which are more and more important to recognize owing to the short time of military service and the considerable amount to war material, the handling of which all has to be taught to recruits . . . French arsenals are now working overtime to supply a large part of the French infantry with the new Chatellerault automatic rifle. A soldier can fire 30 shots from one burst from the shoulder with the new rifle and the French authorities consider it the most effective weapon of any army of the world. Eventually every French soldier will carry the new rifle."

It later came to light that nothing was basically wrong with the design of the weapon. The main fault lay in the pressure brought to bear by the two government arsenals, Chatellerault and St. Etienne, on high officials to have all developments done at these two army-controlled factories. It was pointed out by personnel of these

government plants that they had successfully produced weapons for the army since their date of establishment. But money always being a big factor, these places were constantly restricted by their lack of appropriations, making it questionable whether superior metals and proper heat treatment were always used.

The phases of operation with this machine gun are divided into rearward and forward movement. The stages that take place on the rearward movement are compression of the driving spring, action of the gas, movement of the bolt and the slide to the rear, unlocking, withdrawal of the firing pin, extraction of the empty cartridge case, ejection of the empty case, and cocking. The operations that occur on the forward movement are decompression of the recoil spring, feeding, locking, and firing.

To fire the 1924 model Chatellerault, the operator first attaches a loaded magazine in position and pulls smartly rearward on the charging handle until the gas piston and bolt are held in a cocked position by engagement with the rear sear. If automatic fire is desired, the selector is placed on *F* (*Fire*) and the rear trigger pulled, releasing the sear which allows the compressed driving spring to thrust the bolt and gas piston forward. The feed rib on top of the bolt enters between the lips of the magazine and shoves the bottom round forward. The nose of the bullet strikes the bullet guide in the top front portion of the receiver, guiding the incoming round down towards the chamber. As the slide and bolt continue forward, the base of the cartridge is forced by the magazine spring down onto the face of the bolt behind the extractor, thus aligning the round with the chamber.

The nose of the bullet has now entered the chamber which acts as a guide from there on until the cartridge is fully seated. When the slide is three-eighths inch from being fully forward, the bolt strikes the bridge of the receiver stopping its advancing movement. The slide, however, continues on and the lower bolt link pin moves forward with the slide, causing the bolt links to rotate around the upper bolt link pin. The bolt is pushed up and locks the shoulder in the rear to the top of the receiver. Before the bolt links complete their rotation, the firing pin, which is moving forward with the slide, advances



Components of the Chatellerault Machine Gun.

through the bolt face striking the primer of the cartridge.

The powder charge having been ignited, the bullet starts forward under pressure of the expanding gases. When the bullet reaches a point four inches from the muzzle, the gases pass through a port in the bottom of the barrel into a cylinder housing the gas piston. The action of the gas is that of a severe blow on the head of the piston, moving it back approximately three-eighths inch, after which the gas escapes through slots in the gas-cylinder tube. During this movement the piston and slide move to the rear.

This action tends to pull the bolt down at the rear out of engagement with the locking shoulder in the top of the receiver. The bolt and slide are now free to move to the rear. During the first quarter inch unlocking movement there is no movement of the bolt, but the slide and the gas piston withdraw the firing pin from the face of the bolt. During the last eighth inch movement the bolt moves back, slowly pulling the empty cartridge case free in the chamber before unlocking. This initial extraction takes place while the

bolt links are rotating and the bolt is dropping down from in front of the locking shoulder.

With the continued rearward movement the empty case is pulled out of the chamber and held against the face of the bolt by the extractor. When the mechanism has traveled approximately five inches, the rear left portion of the base of the cartridge strikes the ejector which is an integral part of the buffer housing. This forces the empty case to pivot around the extractor and fly out through the ejection slot cut at the right of the receiver. At the termination of the movement the rear of the slide strikes the sear buffer compressing its release spring.

When the sear buffer release moves back, it allows the buffer plunger spring to force the sear up and catch the slide, holding it to the rear. This occurs only in semiautomatic fire.

In full automatic fire the slide strikes the sear buffer release which flies back compressing its spring. In this case the rear of the sear has locked the buffer down so that it will not catch the slides. Therefore the slide goes back and forth over the sear and its buffer, never making



Chatellerault Aircraft Machine Gun, Model 1934-39, 7.5 mm, Fixed.

contact until the pressure on the trigger is released.

The safety is shaped so that, when turned to *S* (*Safe*), the two ribs on its shaft prevent either or both of the triggers from being pulled. When set on *F* (*Fire*), the two ribs are freed allowing either trigger bar to release the sear.

The dual-trigger system is very unique. When the rear trigger is squeezed, it rotates on its pin camming the front end of the sear up and forcing it to rotate, thus bringing the rear of the sear down. This action compresses the sear spring and disengages the sear from the slide, allowing it to go forward under the tension of the compressed recoil spring. This action constitutes full automatic fire.

When the front trigger is squeezed, it rotates on its pin. A disconnecter is attached directly to the trigger. Its rotation causes the front end to be depressed, which forces the disconnecter up against the under surface of the front of the sear.

When pressure on the trigger is released, this action forces the disconnecter down against the forward face of the sear. It is thus snapped out of engagement with the trigger, permitting single shots to be fired.

In order to utilize the Chatellerault for other than infantry use, the mechanism was modified for feeding with belted ammunition in lieu of the spring-loaded magazine. Further redesign resulting in faster operation made it adaptable for aircraft use. These changes made their appearance in what was designated the Chatellerault Tank, Armored Car, Fortress, Model 1931. Essentially the gun was the same as the 1924-29 models with the exception of better heat treat-

ment of parts and the substitution of a huge magazine-driven feed for the clip.

The tank- and armored-car gun had a post and feed drum somewhat like the Lewis projecting horizontally from the right side plate only. For fortress use only, as in the Maginot line, the same feed could be fastened on either the left or the right side with ejection through the bottom of the receiver. The weight of the gun as 36 pounds and the empty drum weighed ten pounds. These figures show the unusual weight of the drum in relation to the gun. Its capacity of 150 rounds naturally made it much more out of proportion when loaded and secured to the side of the gun.

For fortress use, the Chatellerault had as an accessory an unusual cooling device that operated from the recoil and counter recoil of the bolt to inject from the chamber end a small jet of water into the barrel between extraction and loading. The French kept this feature secret, claiming that from a fixed position like the Maginot line where water was available they could fire bursts of unheard-of lengths without overheating the barrel.

After the 1931 model had definitely corrected the bad features of the 1924-29 gun, the French air force, in seeking a lightweight high speed gun, ordered the Chatellerault Arsenal to improve the design further. In a relatively short while the Chatellerault Aircraft Machine Gun, Model 1934, A, TO and 39, was produced. Again it was basically the same as previous models. The "A" was for "Aile" or wing mounting; "TO" for tourelle installation, both drum fed; and the "M 34/39" was a belt-fed version for wing mounting.

The rate of fire on the aircraft guns was officially given as 1,500-1,600 rounds per minute but American representatives in France credited it with not more than 1,300 rounds a minute. The 1934 version had a much longer feed post than the Fortress model, since the magazine held 500 cartridges. The circular feed was gear driven by the gas action of the gun, with a ring gear encircling the upper portion of the magazine which had the abnormal depth of 16 inches in order to accommodate the 500 cartridges. The ring gear was attached to a rack that engaged teeth on the body of the gas piston. To be installed in a plane, the weapon had to be placed with the left side plate down. The magazine support post attached to the right side plate made mounting on its sides difficult in fixed positions.

The French kept all work and development on

the Chatellerault aircraft gun in highly classified status, but it was learned that a 1934 model had also been successfully synchronized and that a new driving spring was employed that gave results far in excess of anything previously used. The idea was by no means original since, according to M. Brisorgueil, Assistant Director and Production Manager of Chatellerault Arsenal, "the new type of spring has a life at least double that of the usual type."

He considered that "the new spring provides a radical improvement in automatic weapon functioning. The design is attributed to the Russians. It was discovered by examination of Russian aircraft machine guns used in Spain. . . . In place of forming the spring by coiling a single wire, the spring is formed by coiling three lengths of smaller diameter piano wire which have been twisted together."

MADSEN AIRCRAFT MACHINE GUN

The Aircraft Version of the Madsen

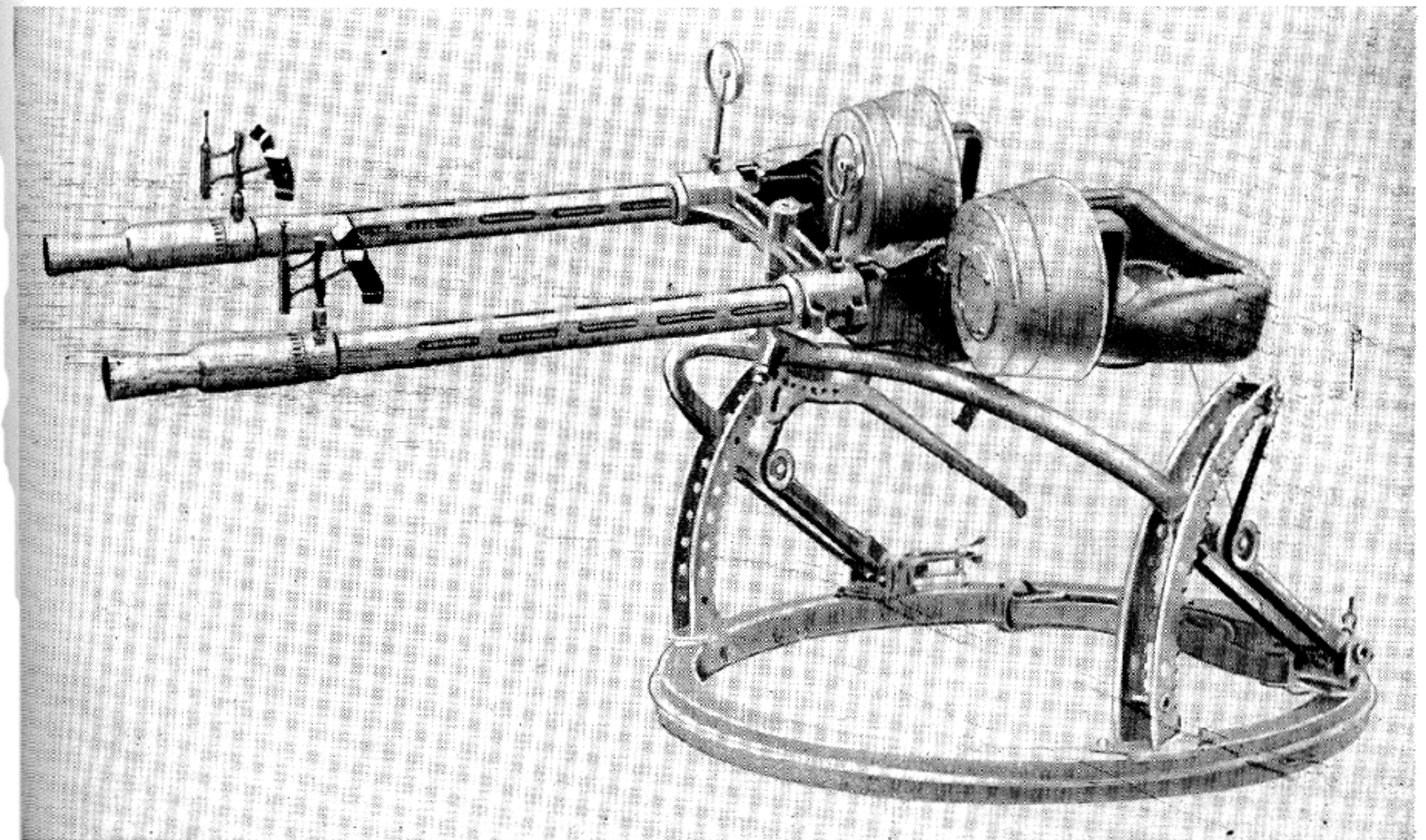
The Danish Recoil Rifle Syndicate of Copenhagen in 1923 assigned its chief engineer, a Mr. Hambroc, the job of redesigning the existing Madsen rifle-caliber infantry-type machine gun to aircraft use. Because of its flat profile, the weapon was comparatively easy to adapt to plane installation. The only significant change made was the addition of a muzzle booster with considerable restriction in its throat and a heavy spring buffer to dampen out the shock of the accelerated recoil the booster gave to the operating parts.

The rifle-caliber aircraft version weighed 18½ pounds and had a cyclic speed of 1,000 rounds a minute. One of the main selling points with

this machine gun was that it could be synchronized for fixed installations and still be light and maneuverable enough for successful flexible mounting.

The Junkers aircraft plant in Denmark, which assembled its planes from components made in Germany, bought thousands of the weapons for use in its products. This firm was German-owned but in order to operate and be free of Allied control, it had assembly plants in Denmark and Sweden. It sold fighter craft equipped with Madsen machine guns of varying calibers to any country interested.

Chambering the barrels to handle any rifle-caliber ammunition desired was comparatively easy for the Danish gun company, as it had already produced over a hundred different models



Madsen Aircraft Machine Gun, 7.92 mm, Flexible Twin Mount.

for infantry use ranging in caliber from 6.5 mm to 11.35 mm and using both rimmed and cannelure-type cartridges.

The caliber 11.35-mm machine gun had an oil buffing arrangement to slow the heavier but equally fast barrel and its extension. It too had a rate of fire officially stated as being 1,000 shots per minute. The first successful working model of this type of weapon was proofed at the company's range near Copenhagen in 1926.

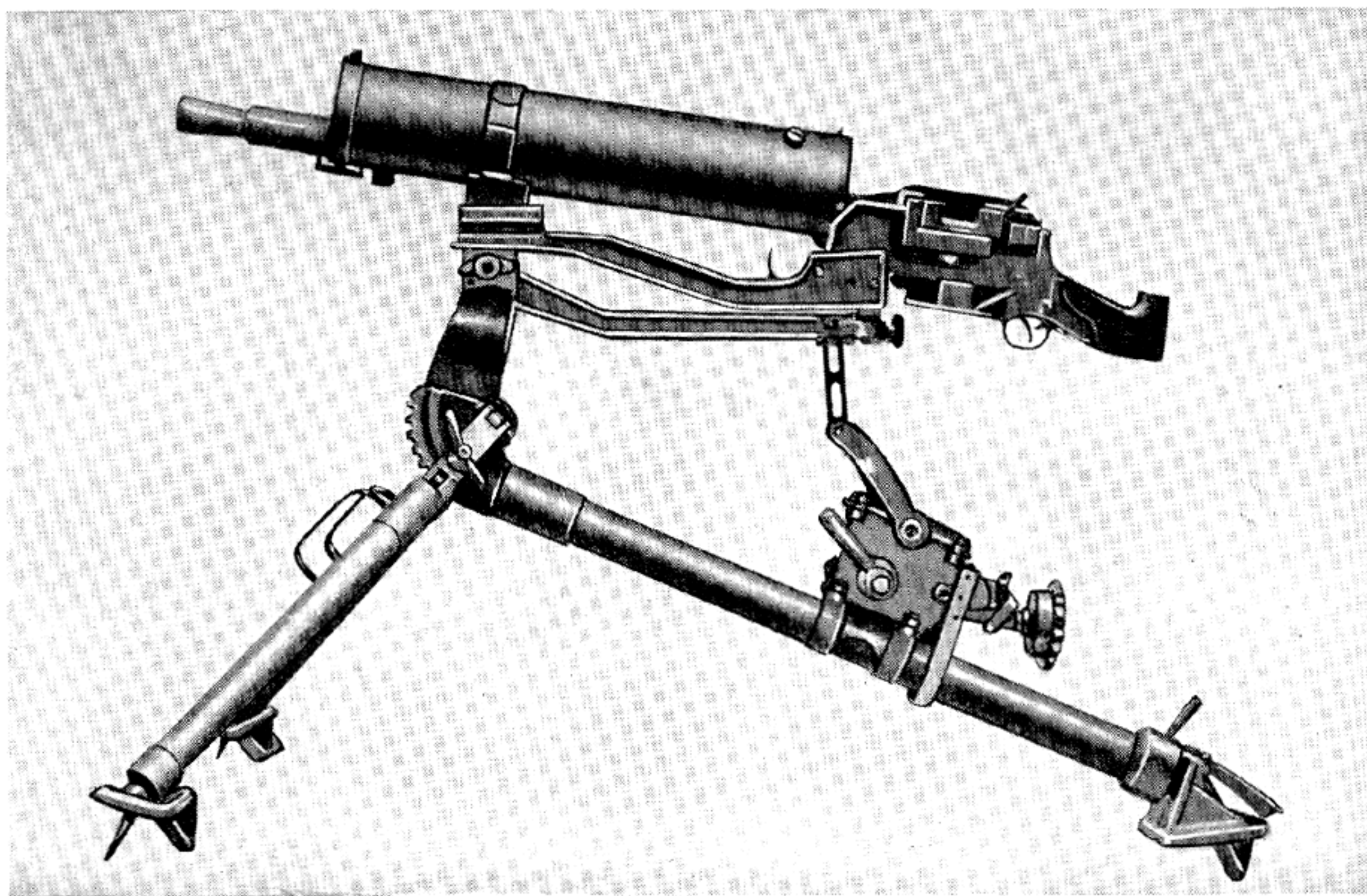
The mounting of the Madsen as a flexible gun was very unusual in appearance as the shoulder stock in some form was retained. Installation was done in pairs on the conventional Scarff ring with a bar arrangement connecting the two rifle butts shaped in such a manner that the gunner could use its center as a brace for his chest.

Both triggers of the guns were operated from a single trip mechanism. The feeds were peculiarly shaped drums with carrying handles in the rear. Each gun had its separate aircraft-type

ring sight so that the weapons could be operated independent of each other. Everything considered, it was a very clumsy arrangement and was never popular outside of small countries that had to have low-cost aircraft armament.

The Danish Recoil Rifle Syndicate prided itself that its fine machinery, as well as its system of shop management, were of American origin. The owners claimed that it was the only arms producing plant on the continent capable of mass production equal to that of a similar factory in America.

The cycle of operation for each model is identical. 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



Madsen Machine Gun, Model 1926, 7 mm, Water Cooled.

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 taking place between the barrel extension and the piece supporting the incoming round until the cartridge is forced through the feed slot in the receiver.

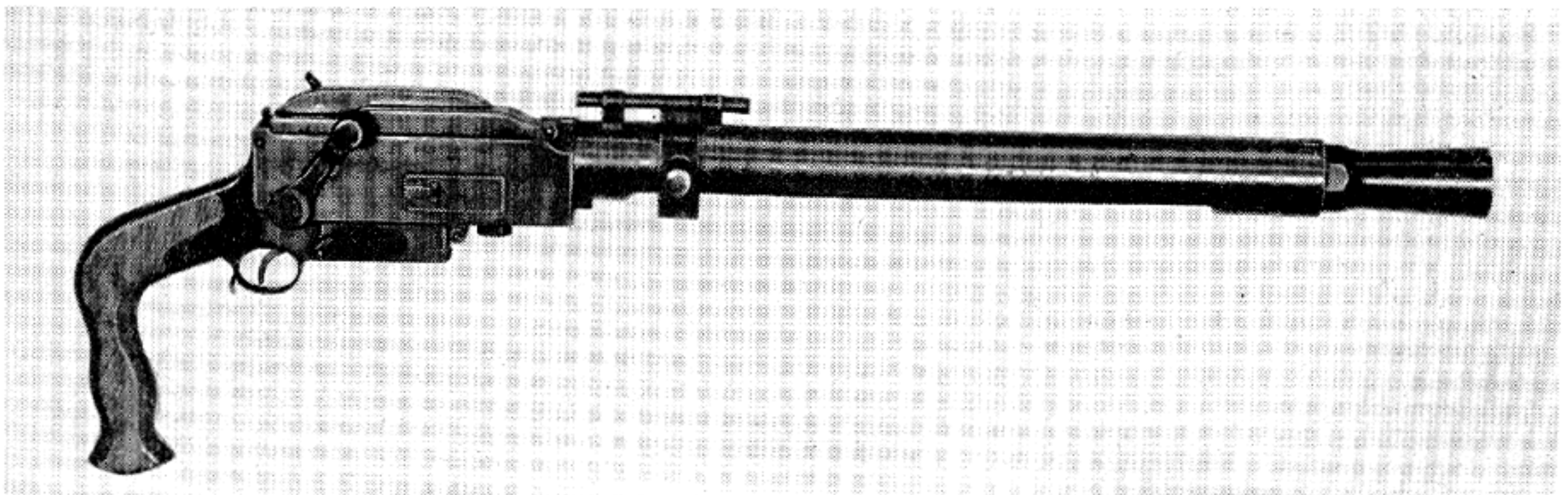
At this time a spring-loaded claw snaps over the rim of the cartridge. The pivoting of the feed arm actuates the claw rearward and withdraws the cartridge from the belt, positioning it in the feed trough in the top of the bolt. The pivoting lever has by now taken its place behind the round. Upon release 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 breechblock 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. During 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.



Madsen Tank Machine Gun, 7.5 mm.

Models and Users of the Madsen

Perhaps no machine gun has been made in so many different models and bought by so many countries as the Madsen. The following tabulation covers five decades of the weapon's distribution throughout the world:

Country	Model	Bore
Argentina	1910	7.65 mm
Argentina	1925	7.65 mm
Argentina	1926	7.65 mm
Argentina	1928	7.65 mm
Argentina	1931	7.65 mm
Argentina	1935	7.65 mm
Bolivia	1925	7.65 mm
Brazil	1908	7.00 mm
Brazil	1913	7.00 mm
Brazil	1916	7.00 mm
Brazil	1925	7.00 mm
Brazil	1928	7.00 mm
Brazil	1932	7.00 mm
Brazil	1934	7.00 mm
Brazil	1935	7.00 mm
Brazil	1936	7.00 mm
Brazil	1946	7.62 mm
Bulgaria	1915	8.00 mm
Bulgaria	1927	8.00 mm
Chile	1923	7.00 mm
Chile	1925	7.00 mm
Chile	1926 w/c	7.00 mm
Chile	1928 w/c	7.00 mm
Chile	1940	7.00 mm
Chile	1946	7.62 mm
China	1916	7.92 mm
China	1930	7.92 mm
China	1937	7.92 mm
Czechoslovakia	1922	7.92 mm
Czechoslovakia	1923	7.92 mm
Denmark	1904	8.00 mm
Denmark	1916	8.00 mm
Denmark	1919	8.00 mm
Denmark	1924	8.00 mm
Denmark	1939	8.00 mm
Denmark	1946	7.62 mm

Country	Model	Bore
England	1915	7.69 mm
England	1919	7.69 mm
England	1929	7.69 mm
England	1931	7.69 mm
England	1939	7.69 mm
Esthonia	1925	7.69 mm
Esthonia	1937	7.69 mm
Ethiopia	1907	7.92 mm
Ethiopia	1910	7.92 mm
Ethiopia	1934	7.92 mm
Ethiopia	1935	7.92 mm
Finland	1919	7.62 mm
Finland	1920	7.62 mm
Finland	1921	7.62 mm
Finland	1923	7.62 mm
France	1915	8.00 mm
France	1919	8.00 mm
France	1922	8.00 mm
France	1924	8.00 mm
Holland	1919	6.5 mm
Holland	1923	6.5 mm
Holland	1926	6.5 mm
Holland	1927	6.5 mm
Holland	1934	6.5 mm
Holland	1938	6.5 mm
Holland	1939	6.5 mm
Honduras	1937	7.00 mm
Honduras	1939	7.00 mm
Hungary	1925	7.92 mm
Hungary	1943	7.92 mm
Italy	1908	6.5 mm
Italy	1910	6.5 mm
Italy	1925	6.5 mm
Italy	1930	6.5 mm
Italy	1931	6.5 mm
Lithuania	1923	7.92 mm
Mexico	1911	7.00 mm
Mexico	1934	7.00 mm
Norway	1914	6.5 mm
Norway	1918	6.5 mm
Pakistan	1947	7.69 mm

Country	Model	Bore
Paraguay	1926	7.65 mm
Peru	1929	7.65 mm
Portugal	1930	7.69 mm
Portugal	1936	7.69 mm
Portugal	1942	7.69 mm
Portugal	1936	7.92 mm
Portugal	1940	7.92 mm
Portugal	1947	7.92 mm
Russia	1904	7.62 mm
Russia	1915	7.62 mm
Salvador, El	1934	7.00 mm
Spain	1907	7.00 mm
Spain	1922	7.00 mm

Country	Model	Bore
Sweden	1906	6.5 mm
Sweden	1914	6.5 mm
Sweden	1921	6.5 mm
Turkey	1925	7.92 mm
Turkey	1926	7.92 mm
Turkey	1935	7.92 mm
Turkey	1937	7.92 mm
Thailand	1925	8.00 mm
Thailand	1930	8.00 mm
Thailand	1934	8.00 mm
Thailand	1939	8.00 mm
Thailand	1947	8.00 mm
Thailand	1949	8.00 mm
Uruguay	1937	7.00 mm

B. S. A. AIRCRAFT MACHINE GUN

During the latter days of World War I the British realized that with the advent of armor on planes a machine gun capable of canceling this advantage had to be developed. They first tried to raise the caliber of the very reliable .303 Vickers, which was done with questionable results. The next attempt was in January 1924 when the Birmingham Small Arms Co., which had produced the successful Lewis gun in great quantities in the war years of 1914-18, presented its design of a larger caliber machine gun somewhat along the lines of the justly famous Lewis. In fact, the resemblance was so striking that the weapon has often incorrectly been classified as a caliber .50 Lewis.

However, with physical appearance all similarity ends, for the B. S. A., as it is officially known, is a recoil-operated weapon that could be cooled by both air or water depending on the jacket used. It employed, in lieu of the metal link belt, the drum-type feed that held 37 caliber .50 cartridges. The weapon was simple in construction, and could be fired either single or full automatic. The components were very strong, and disassembly and assembly could be performed manually without the aid of tools. The need for a larger caliber free gun for observers was thought necessary as a companion arm to the forward firing ones in the wing installations.

The B. S. A. made its first appearance in 1928 and was tested by both the Royal Air Force and the British Navy. The aircraft version was cooled by radial fins on the barrel and by large holes bored in the jacket allowing circulation of air. The water-cooled gun had a conventional barrel jacket that allowed water to be pumped through the system by means of flexible hoses leading to a simple supply pump.

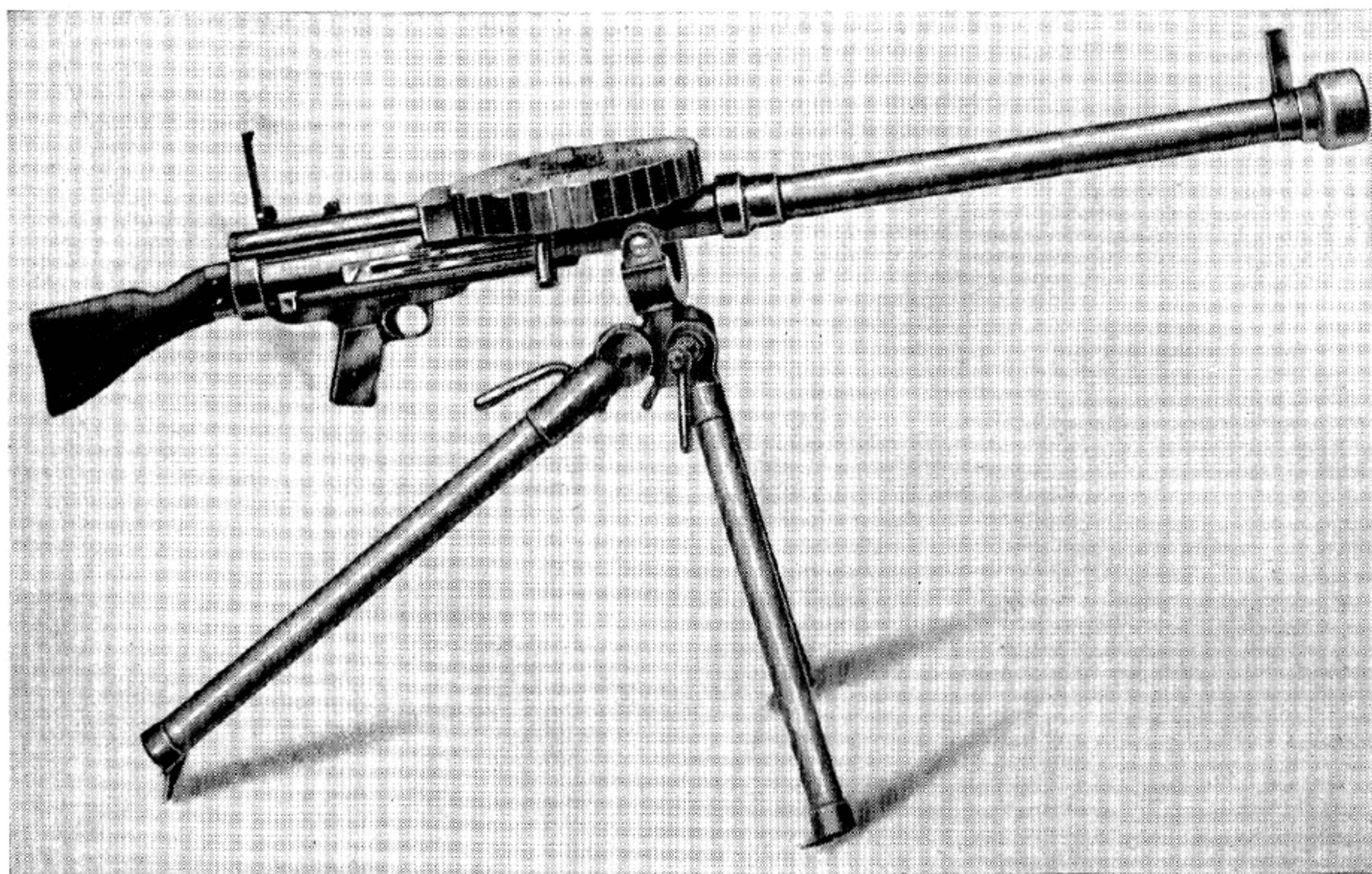
While the feed system was visually the same as used by the Lewis, it had a feature not to be found on any other such type of feed. The drum with but a 37-round capacity could by no means

be considered adequate. Through spaces cut on top, however, the gunner could replenish his supply without interfering with his readiness for instant action, as removal of the drum from its post for recharging was not necessary. Cartridge cases were ejected from underneath the action. This was a distinct advantage for aircraft use, especially from an observer's standpoint, since the empty brass would be thrown on the floor of the cockpit and not out into the windstream to hit other friendly ships in a formation. Both spade grips and slide chargers could be placed on the receiver for aircraft use if desired by the operator.

To fire the caliber .50 B. S. A., the loaded magazine is placed on its post with the first cartridge positioned at the cam mouth of the magazine center. The charging handle is pulled to the rear until the bolt engages the sear holding the entire recoiling mechanism in a cocked position. The selection lever is then placed on single shot or automatic, as desired. When the trigger is pulled, the operating mechanism goes forward under the stored energy of the compressed driving spring, strips the round from the feeder and chambers it. The spring-loaded firing pin is tripped by the rotation of the bolt sleeve, locking it to the barrel. The firing pin is thereby allowed to fly forward and fire the chambered round.

The recoil action that follows the building up of the powder gases from the exploded charge finds the barrel, barrel extension, bolt, bolt sleeve, and two pieces called extension rods, all locked together for a $2\frac{7}{8}$ -inch recoil. At the end of this travel the unlocking lug has revolved by means of an engaging cam. This causes the lug to revolve the bolt sleeve enough to unlock the bolt from the extension and barrel.

The rearward movement of the barrel is stopped by the front extension collar coming in contact with its buffer. The barrel is then brought back by its stout return spring to its



B. S. A. Aircraft Machine Gun, Cal. .50.

forward or normal position. The bolt, its sleeve, and striker all continue rearwards. The slow unlocking action permits initial extraction and when the bolt is nearing the end of its backward stroke, the front face of the end of the slot in the upper side strikes the protruding end of an ejector piece. The latter is slidably located in an inclined slot in the upper resistance lug in the bolt head and ejects the spent cartridge case in a downward direction through openings in the under side of the receiver.

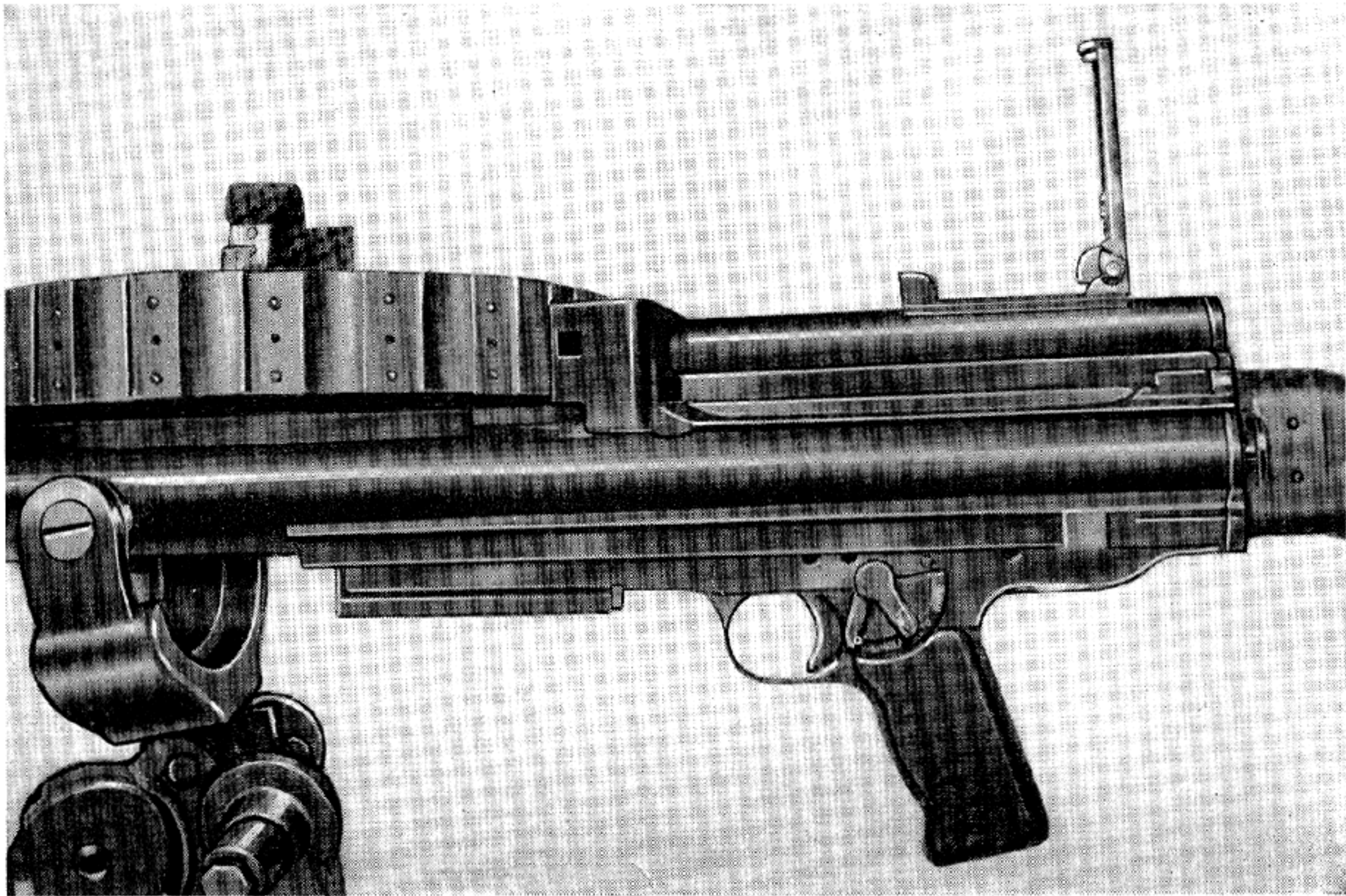
In order that the breech bolt sleeve, breech bolt, and striker may be held in a cocked position until the barrel and barrel extension have reached battery position, the weapon has a safety lever device incorporated in the trigger guard frame. One lever is pivoted to the fulcrum pin of the sear, while its rear end is so constructed as to be moved by a spring into engagement with the bent on the bolt sleeve while its forward end is mounted on the fulcrum pin of the trigger. A second lever in this complicated arrangement engages a cam in the underside of

the barrel extension and when the latter is returned to battery, this depresses the trigger bar and permits firing only when all operating parts are securely locked.

The inner construction of this gun is very unusual. In the sides of the barrel extension are found open-sided slots, in which move what are called resistance lugs located on the head of the bolt sleeve. Near the front end of the barrel extension piece are shoulders that engage the resistance lugs. This operation is effected during the limited independent longitudinal movement of the bolt sleeve in relation to the bolt body.

The bolt body is provided at its rear end, on its upper and lower sides, with flat bearing surfaces that engage its slideway in the barrel extension. The front end of the bolt sleeve has lugs that engage the open-ended slots formed in the sides of the barrel extension.

The hollow bolt body houses the striker which is connected to the sleeve by means of a cross bar arranged to pass through a helical slot in the body. The slot is designed to permit a limited in-



Receiver, Grip and Feed of B. S. A. Aircraft Machine Gun, Cal. .50.

dependent longitudinal movement of the bolt sleeve and striker, during which a part rotative movement is imparted to the bolt to effect locking and unlocking by the resistance shoulders in the barrel extension piece engaging the resistance lugs.

Two such B. S. A. weapons were manufactured. One was turned over to the Royal Air Force and the other to the British Naval Air Force, for testing purposes. The ammunition was the same as used successfully in the Vickers caliber .50 gun and was manufactured by the Kynoch Co. of Birmingham, which cooperated with B. S. A. to produce an adequate round of ammunition. The velocity of the 813-grain projectile was officially set at 2,600 feet per second.

The trial was held at Hythe, England, and proved very disappointing. After the low rate of fire, namely, 400 rounds per minute, the most criticized feature was the capacity of the drum. It was suggested that this be increased to a mini-

mum of 97 rounds. The long travel of $27\frac{7}{8}$ inches before unlocking made it practically impossible to speed up the gun without complete redesign.

The $27\frac{7}{8}$ -inch recoil travel before unlocking is an inexplicable feature on the B. S. A. This movement is the longest known for such a recoil-operated mechanism. Technically, it comes under the classification of short-recoil operation, since the travel does not exceed the over-all length of the cartridge. It remains a mystery why the British slowed down the cycle of operation with such a long unlocking stroke, as it had been proved in earlier machine guns using the same cartridge that unlocking the recoiling parts after $\frac{3}{4}$ inch rearward travel was safe.

Its faults, coupled with the fact that power-driven turrets were beginning to take the place of the observer and his free gun in aircraft, left the B. S. A. with no future in British aircraft weapon design.

The gun is an outstanding example of what

generally happens when a machine gun that has been used to good advantage in the past for a specific purpose is copied to any extent when a weapon serving another function is needed. The Lewis gun, which was so similar in appear-

ance to the B. S. A., was quite satisfactory as a light free caliber .303 gun for open cockpit observers. When weight was added for the large caliber, it became too unwieldy and the rate of fire was prohibitive.

BREDA MACHINE GUNS

The locomotive works known as the Società Italiana Ernesto Breda of Brescia, Italy, during the emergency created by World War I, commenced production of machine guns for the Italian Government. Plans and specifications were furnished the Breda firm by order of the military authorities. The first automatic weapon so made was the water-cooled Revelli, Model 1914, the manufacturing drawings being farmed out to it by the Fiat Co., holder of the patents. Breda built a separate plant adjacent to its locomotive works which, during the war and immediately thereafter, engaged in manufacturing and delivering thousands of the above-mentioned Revelli guns.

Following the Armistice, as with other arms companies in Italy, work came to a near halt with only enough government orders for modifications on existing models to keep a skeleton force active. However, all service branches were in need of an Italian-designed lightweight machine gun for infantry and a heavy one that could be used both as a heavy ground machine gun and with a modified mechanism for aircraft installation. Such a weapon could be mounted both as a synchronized fixed gun for forward firing and as a free one for observers.

The first Breda attempts at securing the lucrative government contracts, then being offered as an inducement by General Buffi, the assistant director general of all machine gun experimental work, was the production of the Breda 1924 model. The weapon introduced at this time was chambered for the 6.5-mm caliber cartridge and weighed slightly under 20 pounds. The rate of fire was officially credited as being 500 rounds a minute. The feed system had an oddly designed magazine that pivoted for charging. The barrel could be changed instantly as it connected to the barrel extension by means of heavy interrupted threads. The rear of the receiver was round while the center part over the feedway was flat, giving the weapon an unusual silhouette.

A skeletonized barrel jacket gave the necessary support for recoil of the moving parts and also served as a base for the front sight. Large flanges on the upper part of the barrel body acted as guides, while a flash hider was attached to the muzzle end. A graduated rear sight was placed on the receiver. It could be either elevated or depressed without need for the gunner to rise from the prone position generally taken when this weapon was fired. A large oil reservoir was built into the top of the receiver, directly over the



Breda Machine Gun, Model 1924, 6.5 mm. The Operator is Loading the Weapon.

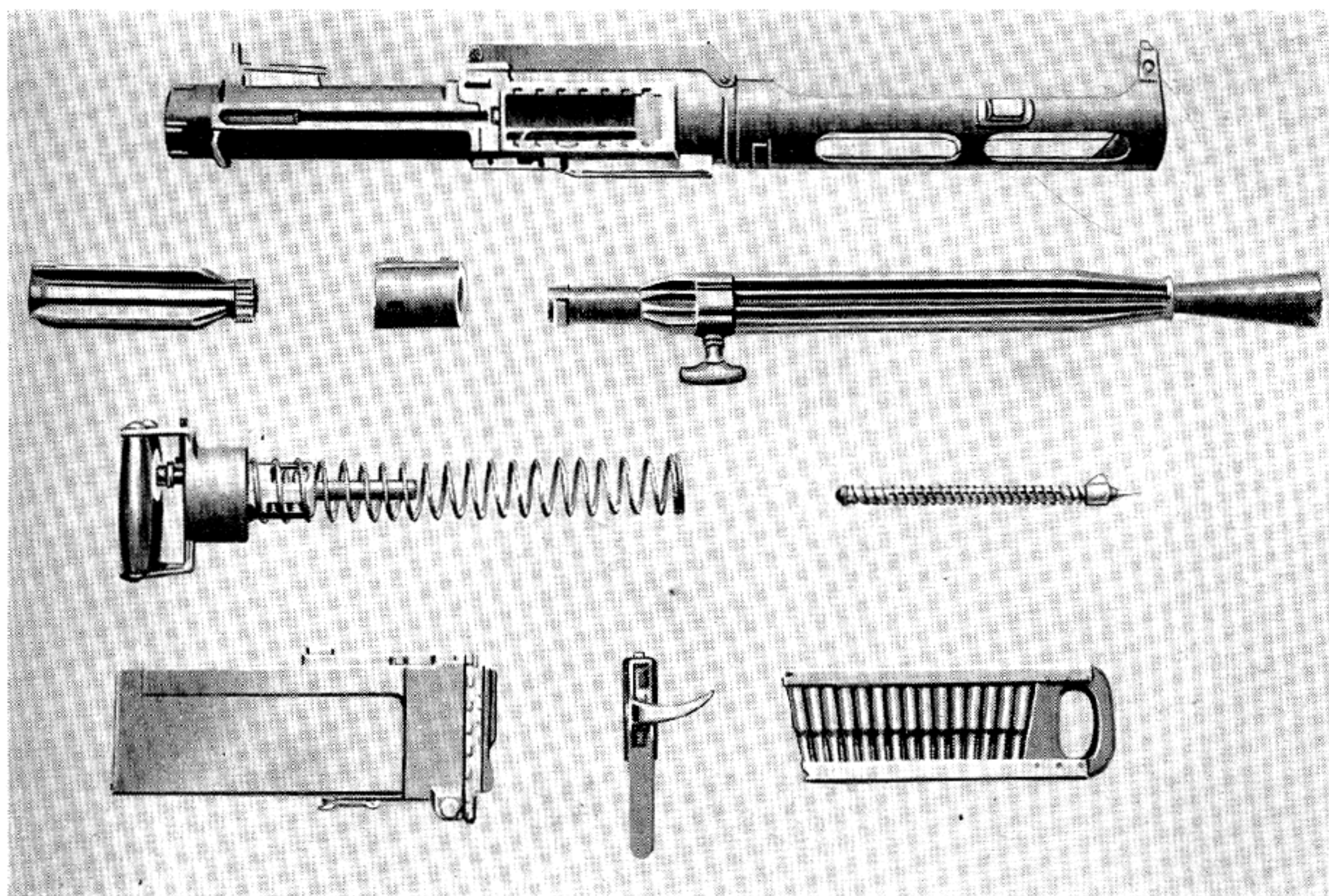
feedway. This lubricator was operated by the recoil and counterrecoil movement of the barrel and barrel extension, squirting oil with each complete cycle on the rounds then being positioned on the floor of the feedway.

To operate the Breda 1924 light machine gun, the gunner is generally in a prone position with the stock at his shoulder. The magazine is first released by its latch holder and the end pivoted towards the muzzle. This exposes the rear of the magazine so that the cardboard container holding 20 rounds of ammunition is positioned in the mouth and by a forward movement of the finger the cartridges are shoved into the magazine until the last round has been secured behind the holding pawl. At this time the cartridge container is discarded and the loaded magazine is swung into position with the last cartridge in place to be picked up by the bolt.

The charging handle is grasped by the right hand and pulled all the way to the rear, compressing the driving spring and cocking the

piece. At the rearmost position the charging handle is released and it and the operating parts are all driven forward by the energy of the driving spring. On the forward travel of the bolt a feed rib on the side contacts the base of the first round in the magazine, forcing it towards the chamber. For approximately one-half the length of the magazine the cartridge slides forward held by the lips. When the round is slightly over half-way out of the magazine, under pressure of the spring-loaded follower it is kicked out of the feed system into alignment with the chamber. During this movement the nose of the bullet is guided by the bullet ramp on the bolt lock. Continued travel forward chambers the round, and the extractor snaps over into the cannellure of the cartridge case.

When the bolt is $1\frac{1}{2}$ inches from home, it begins to enter the locking ring, and at a point $\frac{3}{8}$ inch from its battery position, the bolt strikes the breech end of the barrel. The force of the strong driving spring causes the bolt, barrel, and



Components of the Breda Machine Gun, Model 1924.

lock to move forward. This motion causes the rear lug on the locking ring to engage the fixed cams in the receiver forcing the lock to rotate partially around the end of the barrel and the locking lugs on the front of the bolt, thus locking these two pieces positively into position. The Breda is now ready to fire.

Pressure on the trigger forces the sear release forward compressing its spring. The sear is cammed down out of engagement with the notch in the rear end of the firing pin which flies ahead to strike the primer detonating the powder. As the pressure from the explosion starts to build up, the locked barrel and bolt move together $\frac{3}{8}$ inch to the rear. During this recoil the front lug on top of the locking ring engages the fixed unlocking cam in the receiver, causing the lock to rotate. The bolt is suddenly unlocked without benefit of initial extraction.

The extractor snatches the empty cartridge case from the chamber and holds it on the bolt face. The ejector riding on the right side of the bolt pivots out under tension of its spring. The extractor holds the case firmly against the ejector until it is snapped out when the ejection slot in the left side of the receiver is reached. As the bolt continues on to strike the buffer it also carries with it the firing pin. The rear end of the pin passes through the buffer into the sear housing. At this point the firing pin spring is fully com-

pressed and the sear drops in its recess, holding it back under full tension.

On counterrecoil the bolt and all other operating parts are driven forward by the energy of the driving spring and the rebound of the recoiling parts off the buffer. As the bolt passes the magazine, it picks up a round and chambers it. When securely locked, if the trigger is still pulled back, the rear end of the bolt cams the firing pin safety sear out of the path of the pin, allowing it to go forward and fire the gun again.

On counterrecoil the bolt and all other operating function. The oiler piston is cammed up into the oil cylinder by the bolt. As the piston is raised, it creates a pressure, squirting the lubricant out of a small spout on the right side of the cover. The latter is fixed directly in line with the mouth of the magazine so that incoming rounds are oiled as they are positioned in the feedway. On the recoil movement of the bolt, the piston rides in a groove on top of the bolt until it is approximately one inch from its rearmost position, at which time it has reached the end of its beveled cam. All pressure is released, and air taken in for the return stroke.

When the safety is placed on S, a guard shaped like the letter U is dropped over the trigger to prevent rotation. When changed to F, this part is removed and the trigger is free to move. As this weapon fired from a front-seared bolt and held



Breda Machine Gun, 6.5 mm, Showing Ease of Barrel Change.

a cartridge in the hot chamber after a long burst, a rear sear device was placed on this gun that allowed the gunner to pull the charging handle to the rear and hold the operating mechanism until cool enough to resume firing. To release this arrangement, the bolt handle had only to be retracted beyond its catch point.

The Breda Co. soon after the introduction of the 1924 model made several external refinements and brought it out in competition to the Fiat owned Safat plant which was at the time producing a machine gun that also carried the same designation and was known as Model 1926. The two guns were tested together and the Breda proved the best, although neither was adopted at the time. The Breda firm, however, was given an order for 2,000 not only to pay for time and effort spent in producing this gun but also to encourage continued development. Feeling that this sizable order warranted further improvements the designers 2 years later made a few minor changes in the appearance of the gun and gave it the official nomenclature of Breda Model 1928. The operating mechanism was, however, practically identical with the earlier models.

The firm also began production of a 12.7-mm aircraft machine gun in 1928 but did not get beyond a working model. Following unsuccessful trials on its own test range, the company abandoned the project.

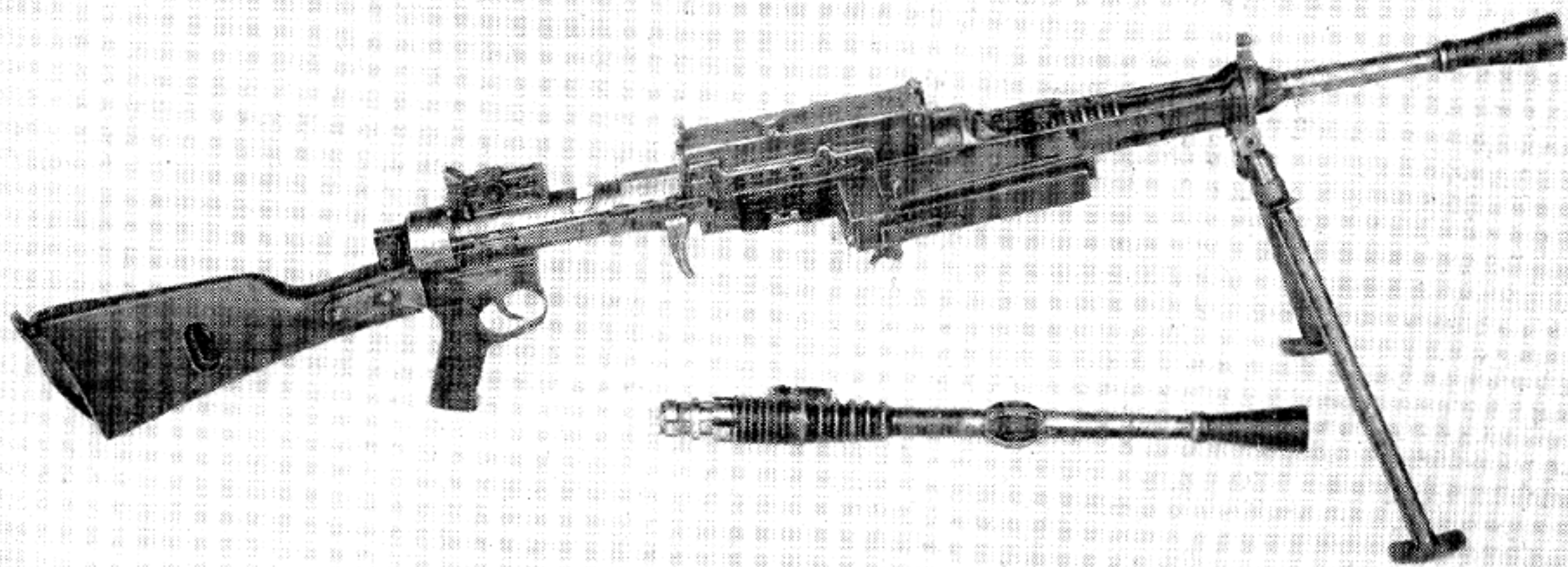
Late in 1930 the Breda Co. took over from

the Fiat Co. all machinery, patents, etc., for the manufacture of small arms such as machine guns and automatic rifles. Plans were made for the construction of a plant, called Breda-Fiat located at Piacenza, Italy, near the Fiat tractor factory.

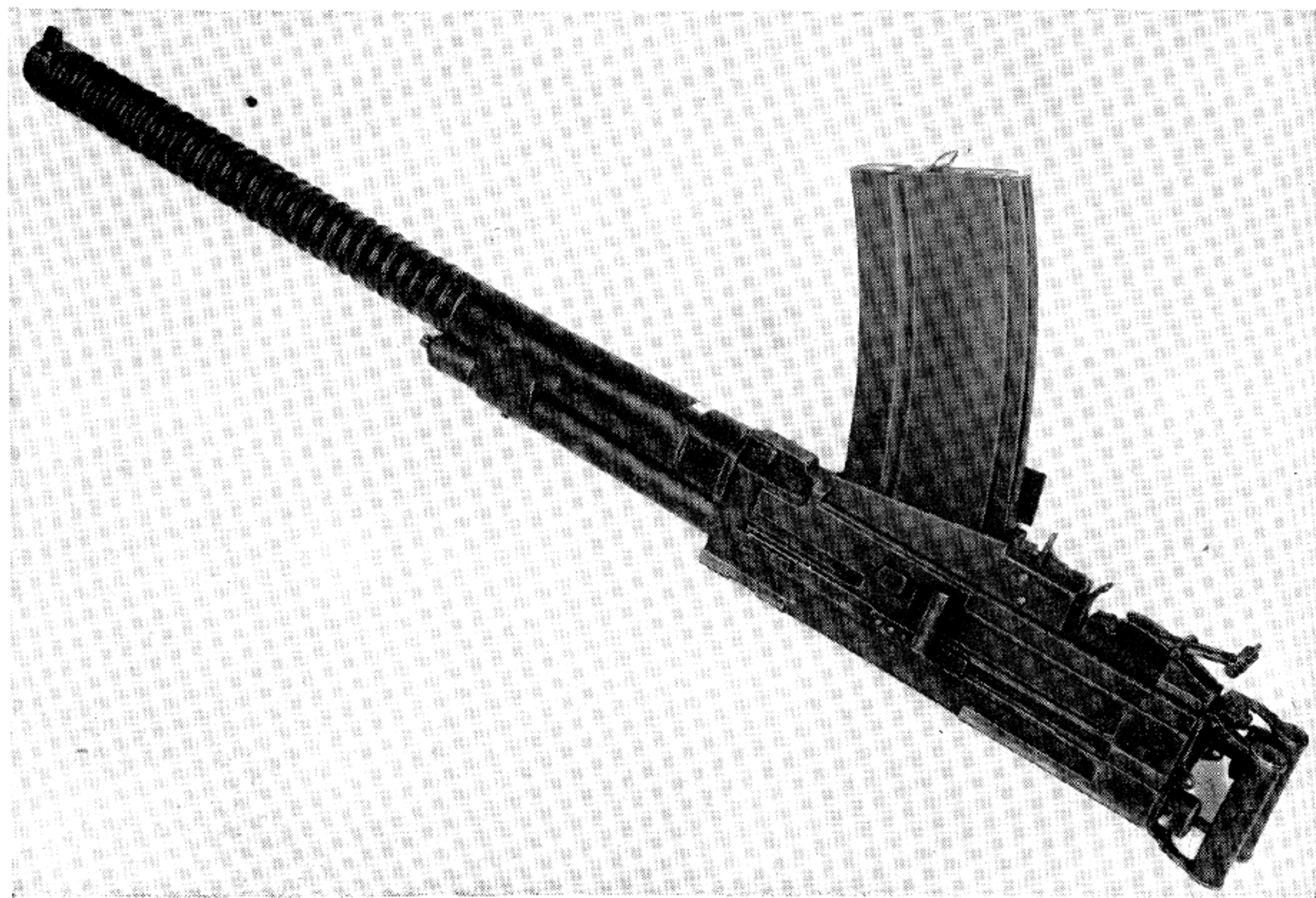
The next venture was the 1930 model light machine gun made in 6.5, 7, and 7.92 millimeter bores. While given different model designations the mechanisms and methods of operation were identical with the 1921 model except for minor refinements and an assortment of calibers. This weapon was sold to other countries, Portugal and some of the Baltic states buying the 7.92 model. Development continued until the appearance of the 13.2-mm 1931 model gas-operated machine gun designed for antiaircraft and tank use.

The 1931 model Breda was a radical departure from previous designs. Early firing tests proved it to be basically sound. During the following years efforts were begun to scale the large caliber gun down to use the 8-mm cartridge.

This attempt culminated in the Breda model 1937. The gas-operated weapons of this type had many peculiar features. One of the most outstanding was the placing of the empty cartridge case back in the feed tray after firing and ejection of the whole tray. The breech lock was cammed straight up into its recess by action of the inclined surfaces on the piston extension, so that the projection on its upper surface engaged in an opening in the top of the body. The car-



Breda Machine Gun, Model 1930, 6.5 mm.



Breda Machine Gun, Model 1931, 13.2 mm.

tridges were fed from plate chargers holding 20 rounds, each round being housed in a separate compartment.

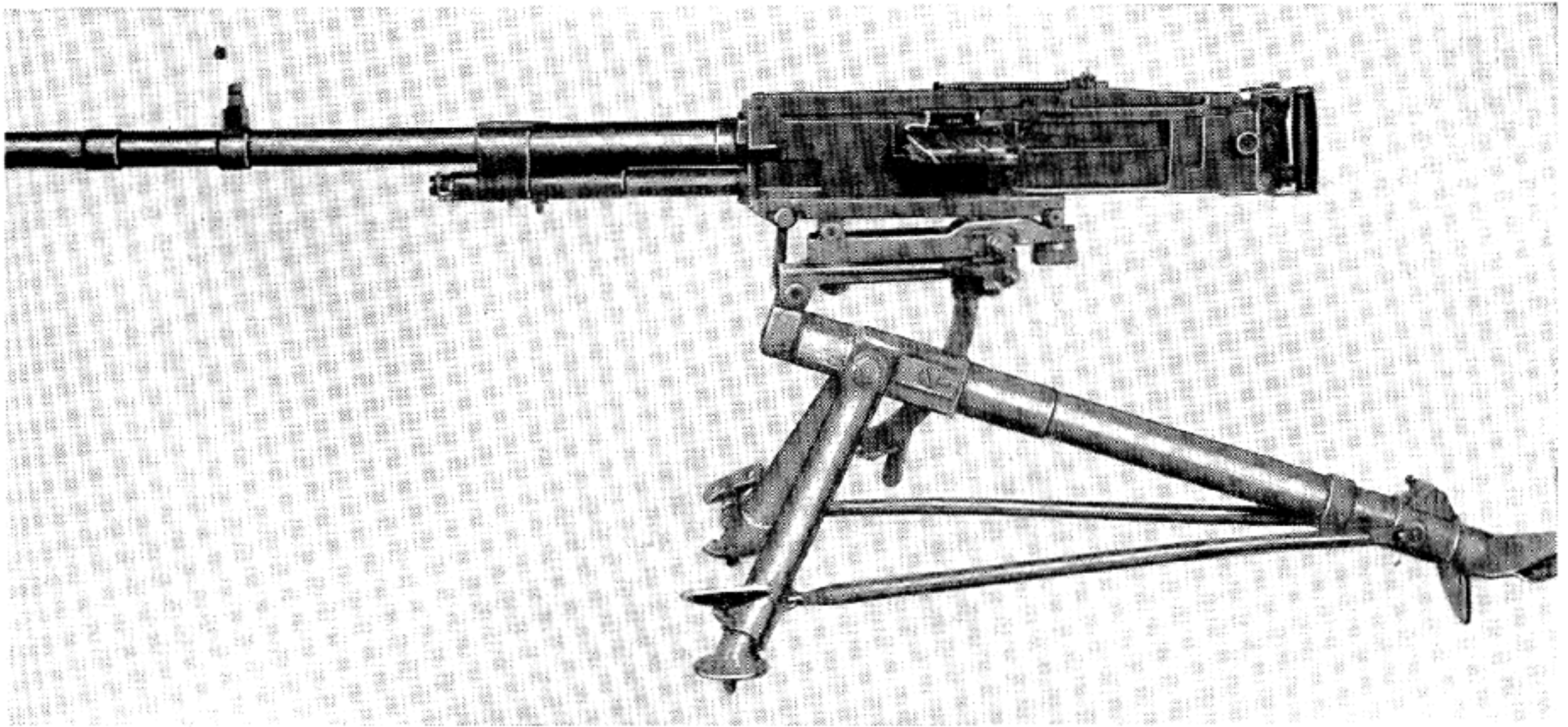
No provision was made for single-shot operation. When the safety was removed, the weapon would fire full automatic only. A special clamp permitted quick barrel change, and the piston was made with an interchangeable head. Cyclic rate could be controlled by ten different settings of the gas regulator.

Like all Italian machine guns oil was used freely on the ammunition since head space was not adjustable on the weapon. The fixed relation between the front face of the breech-lock receiver and the gas port in the barrel made impossible rotation of the barrel in order to advance or retract the chamber for correct head space. The oiling of the ammunition was resorted to in this case in order to compensate for the above condition.

The firing mechanism was held in the cocked

position by a rear searing device. When the pressure had been removed from the trigger button, the device dropped in position at the full-recoil stroke of the gas piston holding the entire assembly aft. The barrel was of unusually heavy construction ($9\frac{7}{8}$ pounds) permitting the discharge of quite a long burst before overheating caused bullets to "tumble," with resultant loss of accuracy and effectiveness.

To fire the Breda Model '37, the operator inserts a loaded tray holding 20 cartridges in the feed slots in the left side of the receiver and the charging handle on the right side is pulled back as far as it will go. A searing device engages the gas piston locking the whole firing mechanism in the cocked position. When the operating parts are moved rearward by pulling back on the retracting handle, the feed tray is indexed over one space positioning a round. If the trigger is taken off *safe* position and the button pushed in, the sear is disengaged from the gas piston and the as-



Breda Machine Gun, Model 1937, 8 mm.



Breda Machine Gun, Model 1938, 8 mm.

sembly goes forward, pushing the cartridge out of its container in the feed tray into the chamber. When this is accomplished, the bolt stops and the gas piston continues forward, forcing the breech lock up into the locking recess in the top of the receiver. On the last movement forward of the gas piston after the mechanism is locked, a projection on top of the gas piston strikes the firing pin which in turn hits the primer to detonate the propellant charge.

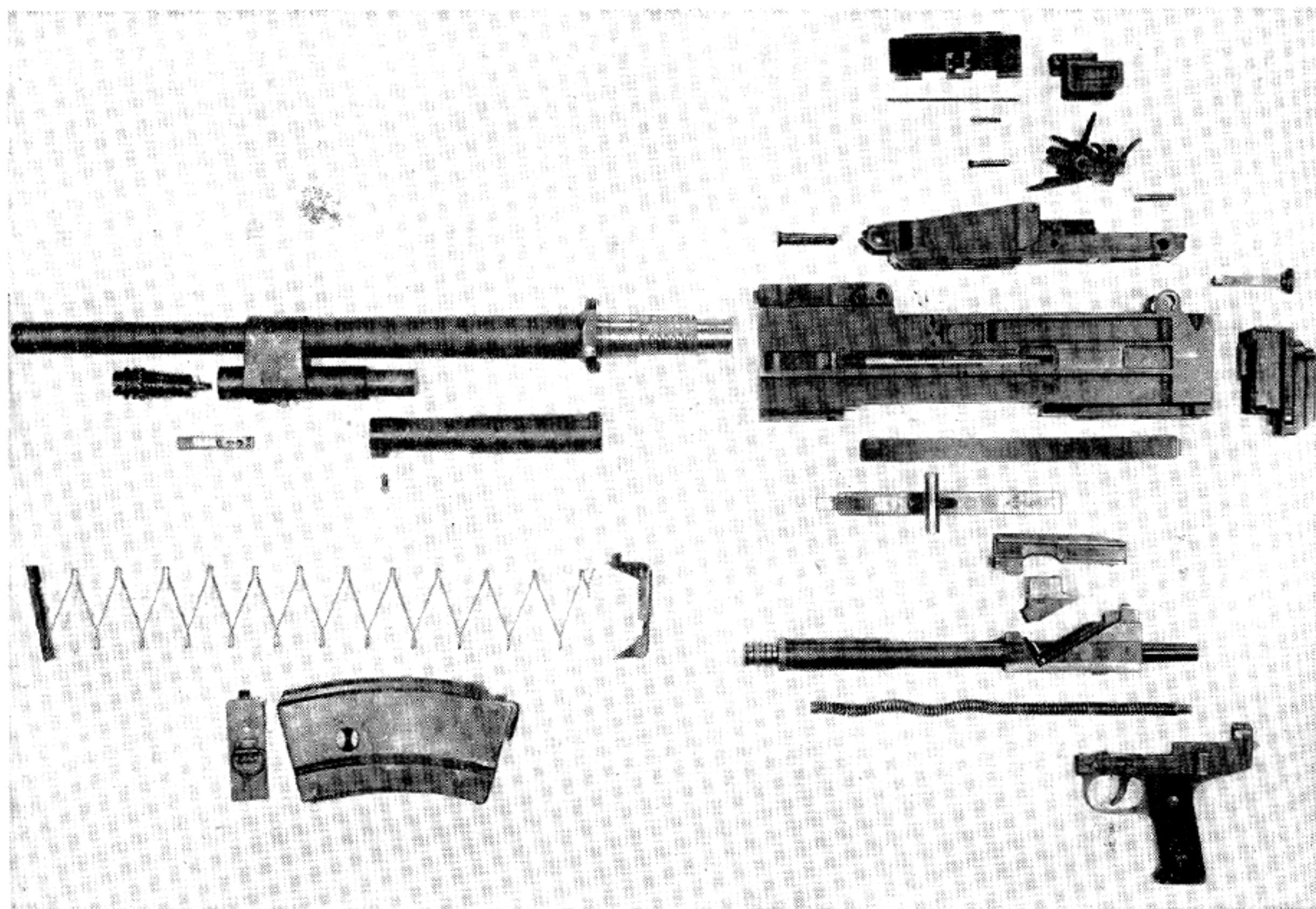
The expanding gases forcing the bullet out of the bore enter a gas port on the underside of the barrel at a point two-thirds of the distance from the breech end. The gas upon entering the gas cylinder exerts a sudden pressure on the face of the piston housed by the cylinder. The impact force drives the piston to the rear. The piston movement pulls the firing pin back and the breech lock down, freeing the bolt. Its first stage of unlocking jacks the bolt back a few thou-

sandths of an inch, loosening the empty case before fully unlocking.

The bolt and piston then start rearward with the extractor holding the cartridge case to the face of the bolt. At a point directly under the feed tray, a dog on the receiver stops the rearward motion of the case; at the same time a cam forces the empty case up into the space it formerly occupied in the feed tray. Continued recoil of the bolt and gas piston causes the next round to be indexed by a movement to the right of the ammunition clip. When all 20 rounds have been fired, the clip containing the empty cartridges is thrown clear of the gun on the right side after the last shot is fired.

The bolt and piston after striking the spring-loaded buffer start into counterrecoil and, if the trigger button remains depressed, the mechanism will continue forward to fire the next round.

This model of the Breda, chambered for the



Components of the Breda Machine Gun, Model 1938, 8 mm.

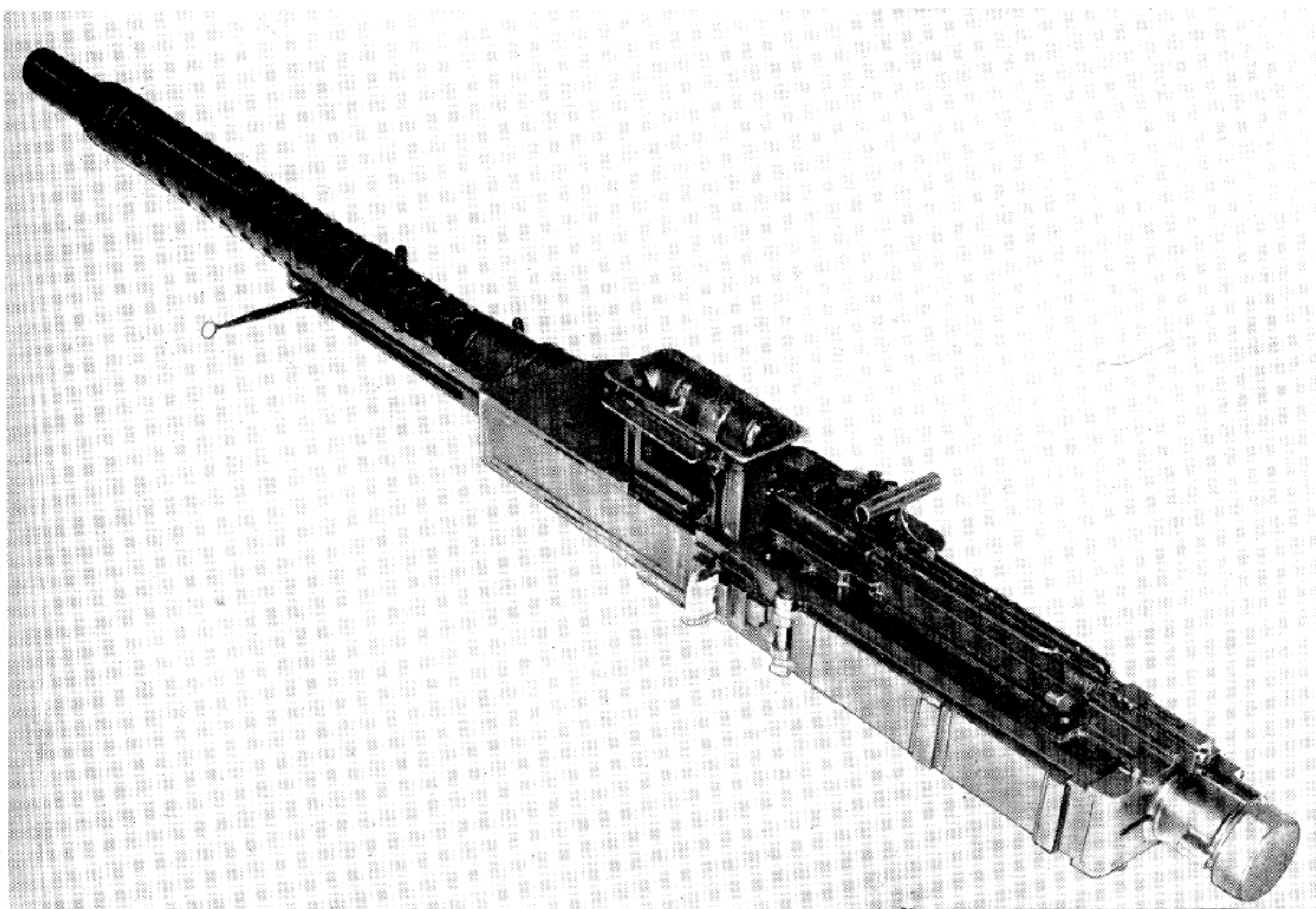
rifle caliber cartridge, showed only the weak points of an otherwise well-designed automatic firing mechanism and these features were corrected at once. It was felt the system of feeding was unsatisfactory; and the following year the 1938 model, having an overhead clip feed, was introduced. It ejected the cartridges out of the bottom of the receiver. The weapon also had a pistol grip. The operating parts and all other principles remained identical with the two preceding models.

A short while before the first of the gas-operated ground machine guns made its appearance, production of all automatic weapons was put under the direct control of the government and Breda was given the assignment of developing an adequate aircraft machine gun. By the middle thirties Safat, the arms division still under control of Fiat, had made a few successful working models that employed the breech lock patented by Mascarucci. The mechanism was later im-

proved by Breda engineers, who inverted the lock, putting it on the bottom, and added a muzzle booster and a recoil-actuated accelerator. These completed modifications were looked upon so favorably by the Ministry of Air that it ordered the immediate production of the gun. To expedite what was considered a superior aircraft weapon, after considering Safat's prior arms commitments, the government directed the Breda Co. to start making the weapon from drawings furnished by the originating company.

These guns were then designated Breda-Safat, Model 1935, to include both designer and manufacturer. They were made in three bores: 7.7, using the same cartridge as the Vickers and Lewis guns, 7.92, and 13.02, for use against armored aircraft and vehicles. The last cartridge was to have had an explosive bullet but it was found to be a violation of international law.

The 7.7-mm aircraft machine gun weighed only 27 pounds with a rate of fire of 800 rounds



Breda Aircraft Machine Gun, 12.7 mm.

a minute. Feeding was done by means of a metal disintegrating belt and was interchangeable from one side to the other. An extractor claw withdrew the loaded round and knocked out the empty case through the ejection slot in the bottom of the receiver. Charging was accomplished by means of a T-shaped handle fastened on the right side of the receiver. There was no provision for single shots. When the trigger was actuated, automatic fire resulted as long as it was held back. If mounted on a flexible gun, a pistol-grip handle with trigger guard was used. An arrow-shaped safety device was placed on top of the receiver, just behind the feed opening. British ammunition, caliber .303, would function satisfactorily in this gun. The chamber was fluted to facilitate extraction by allowing the high-pressure gas at the instant of firing to cushion or float the empty case.

When mounted as a fixed gun in a wing, a hydraulic charger was added. The weapon was carried in a cocked bolt position, allowing cool air to circulate through the bore after a burst. The muzzle booster allowed the expanding gas after the bullet had cleared the muzzle to be brought to bear on the face of the barrel. Thrust was thus added to the recoiling parts and in so doing unlocking was hastened. All of these factors together resulted in a higher cyclic rate.

While there was very little similarity in appearance, this Breda-Safat gun was the direct outgrowth of the first Fiat mechanism using the Mascarucci locking principle. The cycle of operation remained basically the same but later was refined and modified by adding accessories until it resulted in the standard aircraft machine gun of the Italian air force, regardless of manufacturing designation.

FURRER MACHINE GUN

Col. Adolf Furrer, when serving as director of the Swiss Government's small arms factory at Berne, Switzerland, applied for a patent in 1924 on a machine gun that was to affect the automatic weapons used by Swiss soldiers for years to come. And while it was produced in great quantities in calibers ranging in size from rifle to cannon, the basic operating features remained identical.

His first gun was known as the model 1925 Furrer and was a lightweight (18 pounds) air-cooled ground gun with a shoulder stock. It was clip fed by a 30-shot magazine, and chambered for the 7.5-mm infantry rifle cartridge used in the Swiss army for over 40 years. The barrel had longitudinal ribs to give strength and cut down dispersion, besides allowing more radiation surface for cooling purposes. It was constructed of steel that had been given a special heat treat to insure greater life. These barrels were manufactured by Rudolf Hammerli of Lenzburg, Switzerland, who also made a number of the weapons under contract.

Colonel Sonderegger, then Chief of Staff of the Swiss Army, was impressed by the performance of the simple mechanism of Colonel Furrer's design and ordered its manufacture on a limited scale until fully corrected by firing and endurance tests. By 1928, however, 5,150 weapons of the 1925 model had been made and delivered to the army. The French, being skeptical of Swiss claims that the barrel could fire 25,000 rounds and retain a semblance of accuracy, bought one gun, several barrels and enough ammunition to test it. They reported that the barrels could fire as much as 18,000 rounds "without appreciable loss in accuracy of fire."

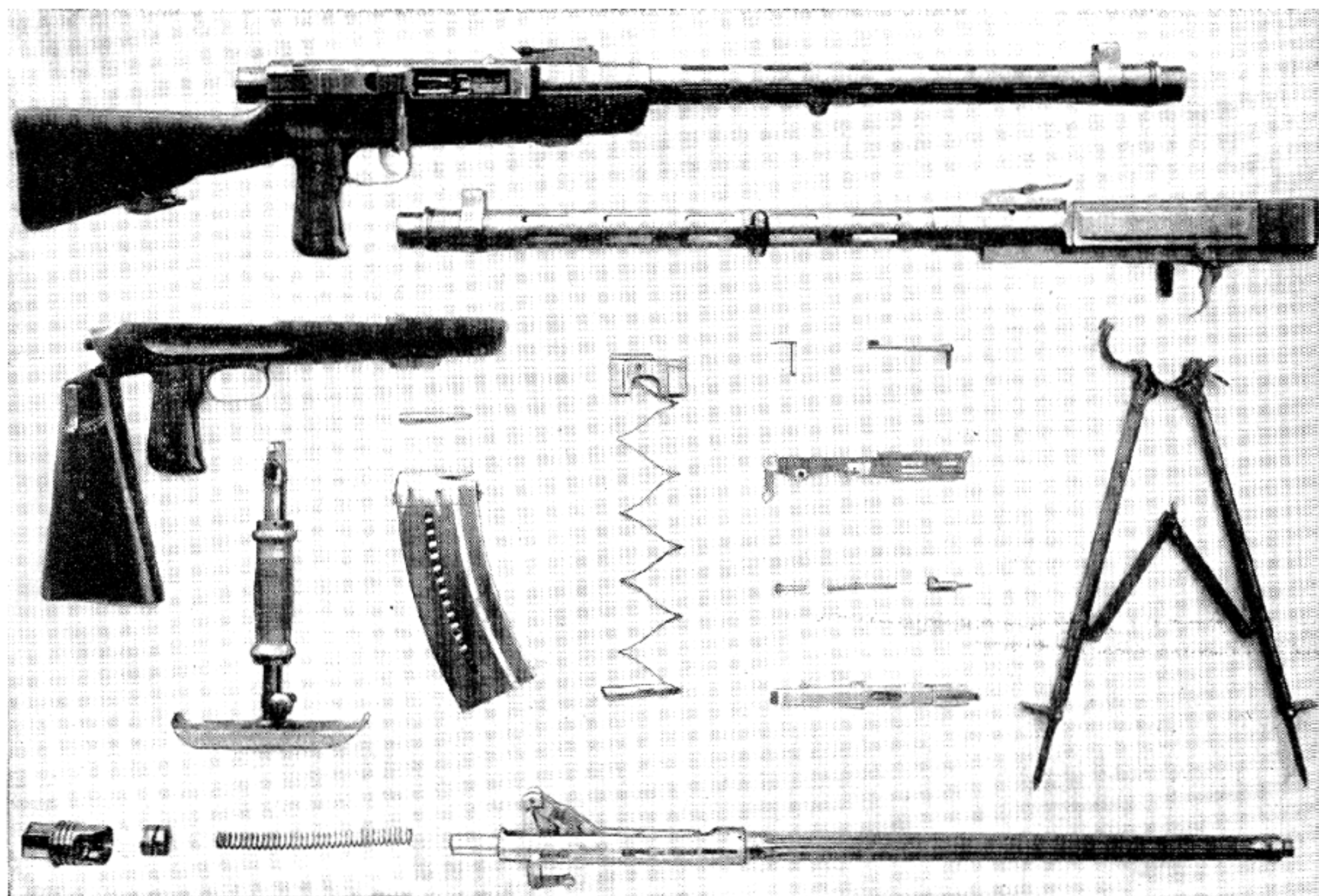
The normal rate of automatic fire for the ground gun was 450 rounds a minute maximum. Every gun was furnished with 34 spare magazines holding 30 rounds each. It was necessary to stop and allow the barrel to cool after 400 shots had been fired full automatic. A device working

in conjunction with the safety permitted the operator to fire single shot or full automatic as desired. It was recommended that the gunner fire the weapon in bursts of six or eight shots until the magazine was empty.

The 1925 model was closely followed by a 13-mm version, having a rate of fire of 300 rounds a minute with a muzzle velocity of 2,624 feet a second. This gun weighed 66 pounds and was adaptable to both antitank and aircraft. One of the most novel features in the construction of the Furrer weapon was that the barrel was changed by pulling it, with the entire firing mechanism remaining attached, from the rear of the receiver. A new firing mechanism and barrel assembly were then inserted. This complete change of both operational parts and barrel was quite unique in machine gun design.

Furrer made skillful use of timing his weapon, which was so constructed that the barrel and its extension were held in a retracted position after unlocking. When counter recoil was approaching the end of its stroke, with the barrel and bolt securely locked, the gun fired a few thousandths of a second before the fast moving parts collided with the stationary receiver. This allowed recoil to start before metal-to-metal contact was achieved, giving the weapon a unique buffing action that produced not only smooth performance but added greatly to the longevity of its components.

The locking and unlocking of this mechanism was accomplished through the breaking of a toggle joint by a hinged lever in the rear that was fastened by a pin to the receiver. When the toggle was broken, the locking lugs began to be released and roll about a curved surface until they were completely disengaged. All models had a very strong buffer and driving spring. A flash hider, blast suppressor, and muzzle booster were always incorporated in the construction.



Furrer Machine Gun and Components, Model 1925, 7.5 mm.

For aircraft use the metal non-disintegrating belt was employed. The fixed guns were made to be interchangeable with flexible ones. However, mounting as free guns was always done in pairs with ammunition boxes holding 120 rounds each feeding from above so that ejection would be down into the fuselage or into an empty cartridge-case container.

The Furrer guns were highly characteristic of the Swiss genius for precision-made instruments and equipment. The weapons were made up of a multiplicity of intricate parts that performed unusually well but did not lend themselves to mass production.

The aircraft models had the following interesting details in common: (1) Feeds that were interchangeable from left to right, or vice-versa; (2) mounting of guns for either flexible or fixed use; (3) a rounds counter on the back plate showing the gunner, when firing flexibly, how many rounds were left in the ammunition box; (4) a feed pawl disengagement which halted feeding

in order to leave the bolt in battery on an empty chamber when overheated; (5) a belt that did not disintegrate when a round was withdrawn, being loaded with 120 rounds for flexible guns and 500 for fixed installations; (6) a short muzzle booster and bearing support; (7) longer barrels than those employed on the same mechanisms for ground use; and (8) a single grip on the flexible gun in lieu of the conventional two-grip or spade, type.

The rate of fire of aircraft models using rifle caliber ammunition was increased to 1,200 rounds a minute by the employment of a special apparatus. This device trapped the still-expanding gas after the bullet left the bore and brought it to bear on the muzzle of the barrel, causing the latter to be thrust suddenly to the rear. The added recoil hastened unlocking which, together with a strong spring-loaded buffer, gave an appreciable increase in cyclic rate. In fixed installations the gun could be mounted in practically any desired position as ammunition was fed in

on one side and ejected from the opposite one.

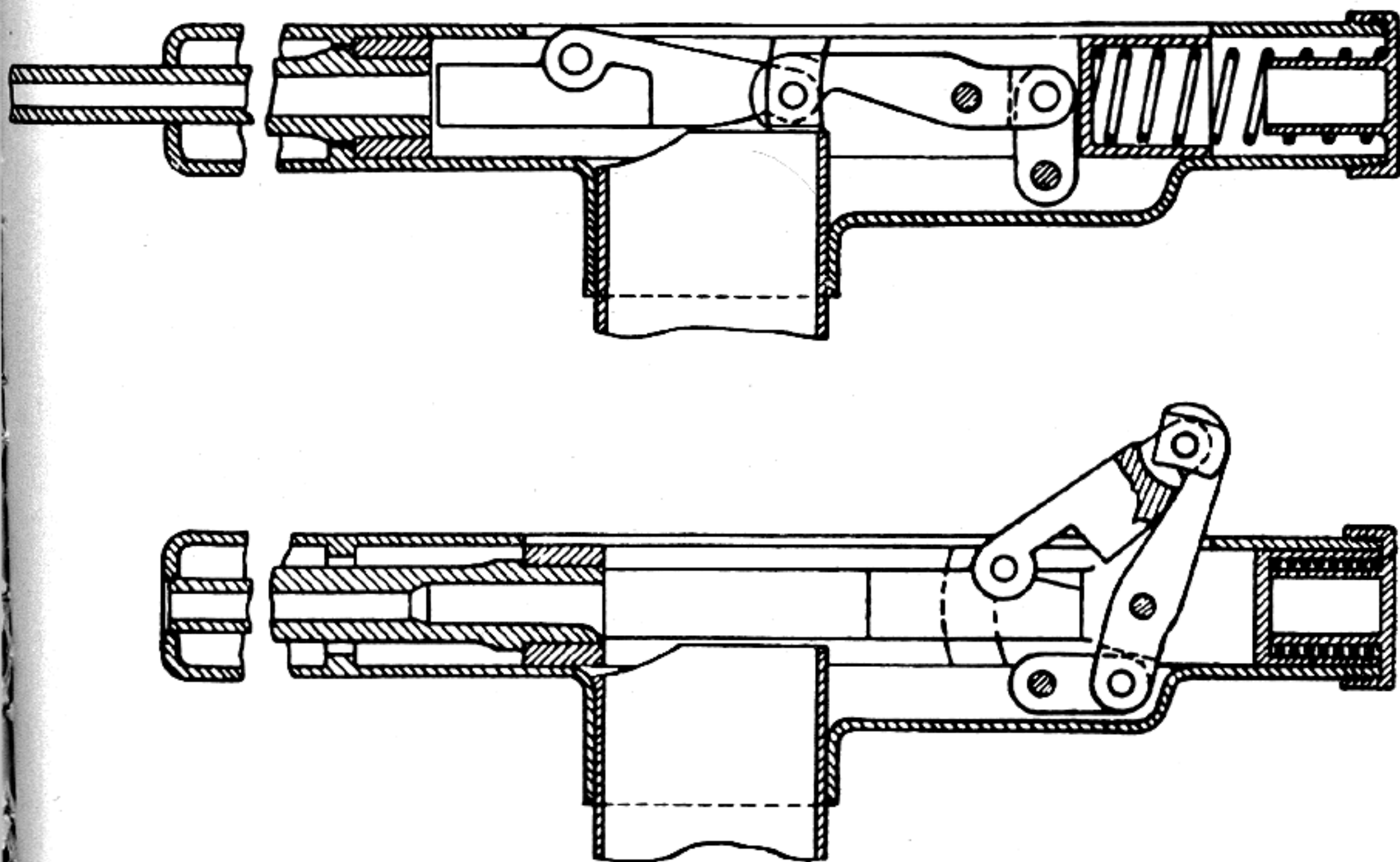
An example of the ingenuity of the Swiss armament designers is found in the national small arms factory at Berne, where the Furrer guns were produced. The nation realized that a war would make steel in large quantities practically unavailable and an emergency system whereby worn-out infantry rifle barrels could be used as liners for machine gun barrels was developed at the Berne plant in the period prior to World War II.

The following method was used: A worn-out rifle barrel is heated in electric furnaces and drawn out to proper shape. It is then inserted in a deteriorated machine gun barrel which has previously been drilled out to proper diameter. The inserted barrel is then expanded by the auto-frettage method of forcing a series of reamers or wedges through the interior until it has been expanded to the desired dimensions. This cold-working produces a very hard metal and lengthens the life of the lined barrel. The insert is then drilled, reamed and rifled to correct specifications.

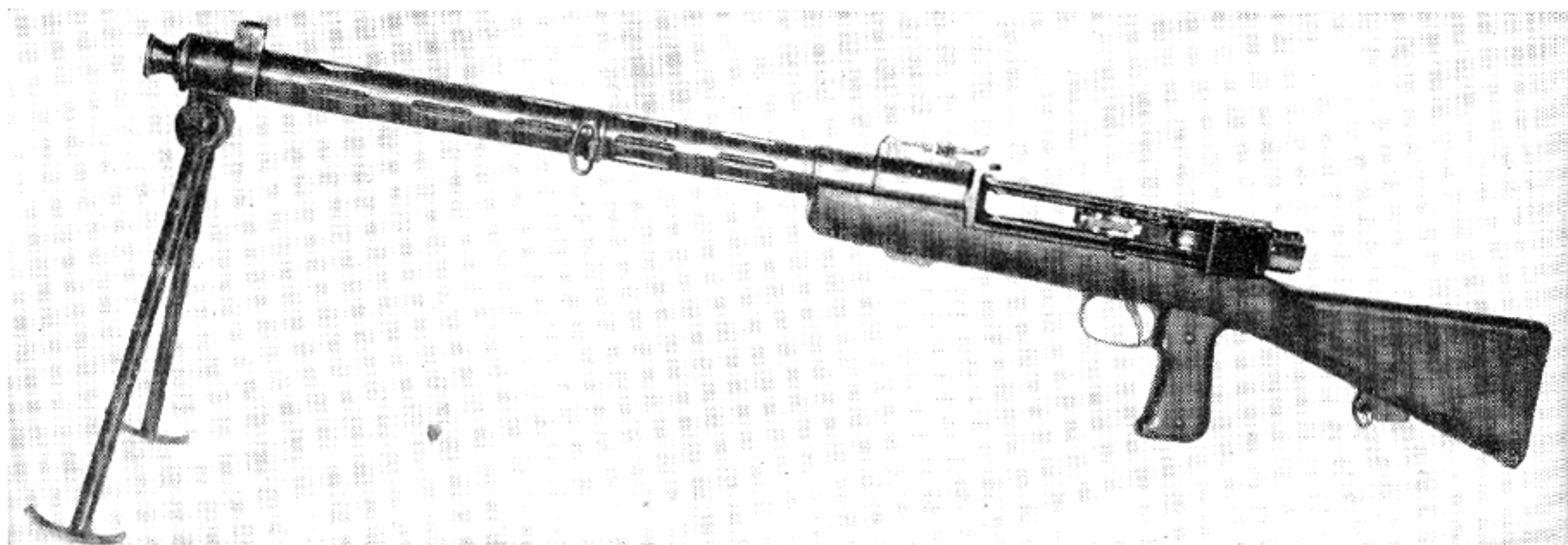
Otto Walker, an inventor of firearms and their accessories, residing in Zürich, is sometimes erroneously credited with originating what is known as the Furrer system. However, research does not show any basis for the claim. Colonel Furrer was the creator of the action named for him, despite its close resemblance to the Borchartt, or, as it is more commonly known, the Luger, action.

The cycle of operation on all Furrer-type automatic weapons is as follows: After the belt, or magazine, is put into place, bringing the cartridge in position to be picked up by the bolt face, the action is retracted all the way to the rear. When released, the compressed driving spring gives the firing mechanism a thrust forward. As the bolt face comes abreast of the rear of the feeding system, a loaded round is shoved forward into the chamber. On the last fraction of an inch of forward travel the toggle joint is forced into line and locks, cocking the piece. The weapon is now loaded, ready to fire.

The sear is rotatable in the breech-bolt frame, and upon being actuated, pivots, releasing the



Drawing of Furrer Machine Gun Action.



Furrer Machine Gun, Model 1925, 7.5 mm. Left Side.

firing pin to fly forward under tension of its spring and strike the primer of the cartridge. This in turn fires the charge. For the first fraction of an inch of recoil the barrel is rigidly connected with the barrel extension and bolt. During this time it slides backwards under action of recoil in the guides cut in the stationary receiver. The breech-bolt frame contains the bolt which is also moving rearward. It is connected by a link with the front end of a pivoted member also in the form of a link.

The latter is rotatably mounted in the breech-bolt frame on a pivot. The rear end is connected by means of a pivot pin with one of the supporting links, the other end of which attaches to the barrel extension. The bolt only becomes unlocked from the barrel after the barrel and breech bolt have reached a point where a projection in the stationary receiver breaks the straight-line action of the pivoting links. This allows the bolt to open slowly at first to produce initial extraction and then to complete the function, carrying the fully loosened cartridge case held to its face by the extractor.

The first breaking action of the links withdraws the firing pin slightly within the bolt face. The continued recoil movement not only holds

the firing pin in this position but carries the cartridge to a point where its base collides with an ejector that is built into the receiver. At this point the empty cartridge case is pivoted and ejected through a slot opposite the one through which it was fed. The barrel with its extension being unlocked from the bolt remains in a retracted position. The bolt having completed its full recoil stroke starts counterrecoil movement and the bolt face, when in position, picks up the incoming round out of the feedway ready for chambering.

At this time the projection on the firing pin catches the sear mounted in the barrel extension. In the final act of locking, the bolt compresses the firing-pin spring. When the bolt and barrel are locked, the continued thrust of the driving spring then shoves the retracted barrel assembly into battery. If the trigger remains depressed the sear releases again, firing the chambered cartridge.

The Furrer is so constructed that the firing pin can be released before the locked bolt and barrel strike the receiver, and in this manner the fast-moving counterrecoiling parts are buffered with the start of recoil before making metal-to-metal contact.

ZB MACHINE GUNS

ZB Model 1926

The arms producing company, Ceskoslovenska Zbrojovka Akciová Společnost v Brně of Brunn, Czechoslovakia, was first formed in 1922. It began as a stock company, with 75 percent of the shares owned by the government, 20 percent by the Skoda Works and 5 percent by the employees. In its early days it manufactured not only automatic weapons but also military rifles and two-cylinder automobiles.

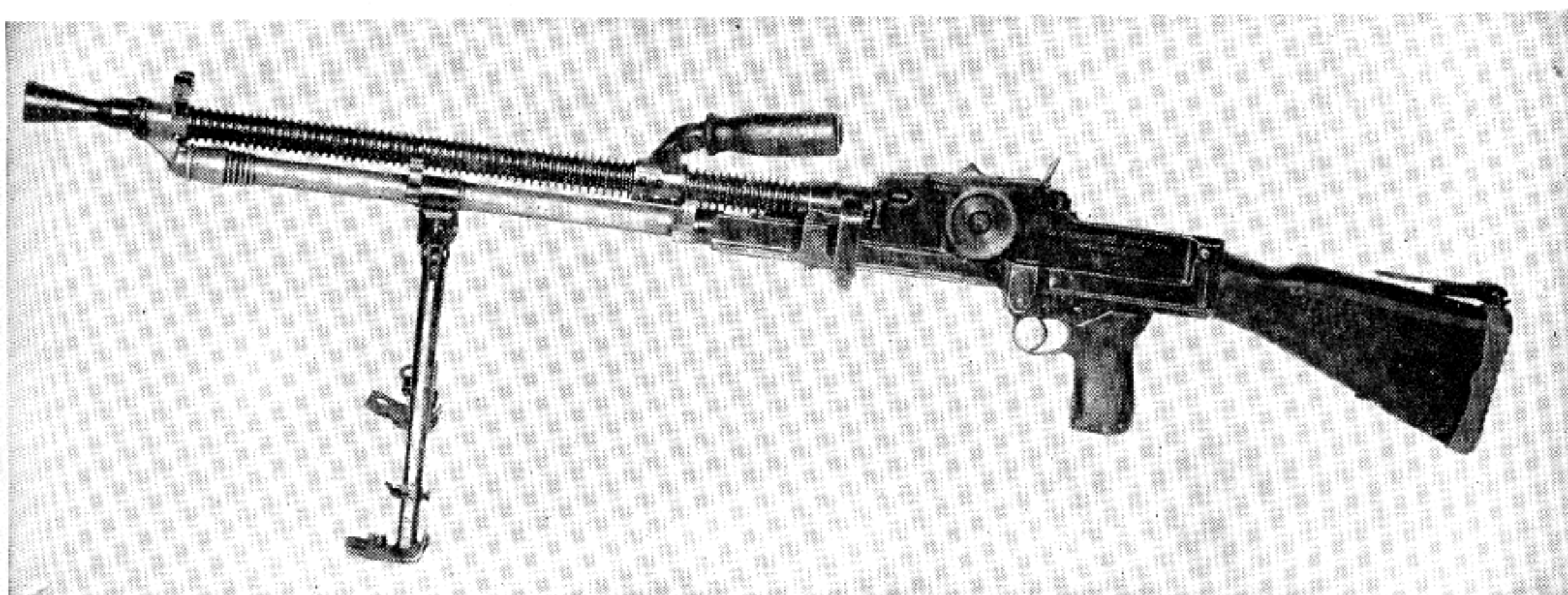
The first machine gun from the new company was the light Hotchkiss model of 1922, built through the cooperation of French authorities. Relations between the war offices of France and the Czech Republic were extremely close and the manufacture and sale of automatic arms by the new state were encouraged by the French.

In 1924 the firm introduced a prototype weapon of its own design, identifying it by the year of its first appearance. This weapon was less an invention than a devisement, being an application of many sound automatic weapon principles that had been proved by use in other guns such as the Berthier, B. A. R., Hotchkiss,

and Chatellerault. Development continued until it was thought to be perfected to a point where it could meet all demands placed upon it. It became known as the Brno ZB Model 1926, the initials obviously coming from an attempt to reach an intelligent solution to a name foreigners found impossible to pronounce, with Brno being an earlier spelling of Brunn.

Of the many skilled gun designers who contributed to the various models of ZB machine guns, perhaps the most outstanding were the Holek brothers, Vaclav and Emanuel. Both were natives of Czechoslovakia. Other well known designers in the employ of the firm were Anton Marek, an Austrian by birth, and Antonin Podrabsky, a Pole.

Vaclav Holek stood head and shoulders above the rest of these capable men. Starting as an ordinary workman in the Zbrojovka works he showed great interest in machine gun design and produced several working models of his own while still a foreman gunsmith. A demand for a light machine gun by the Czech Army soon after the nation gained her independence gave him the opportunity for which he had been waiting,



ZB Machine Gun, Model 1925, 7.92 mm.

and he designed the first of the series of ZB light machine guns. Completion of this model took him only three years from conception to finished product.

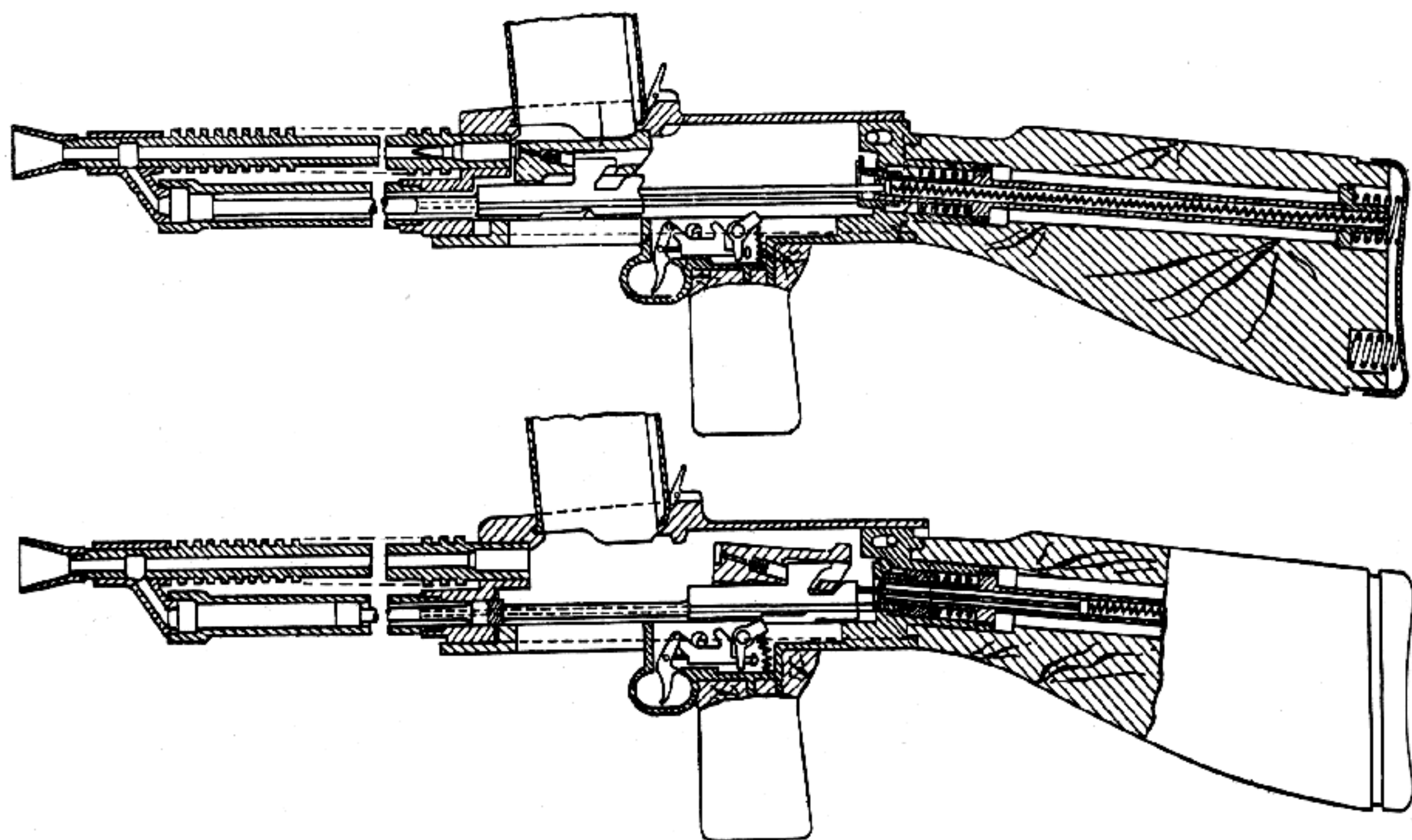
At the time he was only being paid the equivalent of \$20 a week, but he patented various features in the devisement of the weapon that later not only made him a very wealthy man but saw him quickly promoted to chief of the plant's experimental laboratory. The Czech Army officials put the company's first offering through the most strenuous tests they could conceive. During the trials the rugged mechanism stood up even after being buried in mud or fired until the barrel was red hot and then dropped purposely in a vat of cold water.

The Brno Model 1926 comprised 143 component parts in two categories, fixed and recoiling. To the former belonged the barrel, receiver, trigger mechanism, stock, and magazine. The recoiling parts were the bolt, bolt carrier, gas piston, and driving spring.

The barrel on the model adopted by the Czech Government was chambered for the 7.92-mm infantry rifle cartridge. Its outer surface was

covered with cooling fins. On the breech end there were interrupted threads divided into three sections which permitted solid locking to the receiver by means of a locking nut. On the under side of the barrel was located the port through which the expanding powder gases were directed into the gas cylinder housing the piston. A lug in the receiver was fitted into a slot below the chamber. When locked, it prevented the rotation of the barrel but it forced longitudinal movement forward when loosened. The middle of the barrel had a removable collar to which the carrying handle was attached. If turned to the left, the handle could be grasped by the gunner when firing to stabilize the piece.

The inside of the receiver was milled out square to contain the operating parts. On the forward end was an extension to which the gas cylinder was screwed. The upper part formed the barrel bearing in which the locking nut was bedded in such a manner that it could rotate but could not be displaced. The nut had a tap divided into three sections corresponding to the thread on the barrel and possessed an arm by which, in its vertical position, the barrel coup-



Section Drawing of the ZB Machine Gun.

ling was closed and retained on the receiver by a spring-loaded pawl. When the arm was turned at an angle of 60 degrees, the pawl, acting first on the lever, caused a separation of the barrel and nut, at the same time making the former move forward. It then was easily removable by a pull on the carrying handle.

The extension of the receiver was joined in front to the gas cylinder that extended under, and parallel to, the barrel. This part housed the gas piston, while the top of the receiver had a rectangular opening into which the loaded magazine was inserted by a single operation of the hand. On the rear edge of the opening were a spring-loaded pawl and the fixed ejector. The bottom had an opening through which the empty cartridges were ejected. The opening had a sliding cover which was moved aside at the first firing.

On the right side was the cocking handle. The slideway in the receiver contained a strong spring clip that held the handle in forward position when it was returned after firing the first shot. At the rear and partly below, the stock was joined by two hinged bolts. It contained the driving spring and trigger guard, through which, after the upper hinge was loosened, all the operating parts could be pulled out from the rear of the receiver. This greatly facilitated examination, maintenance, or repair in the field.

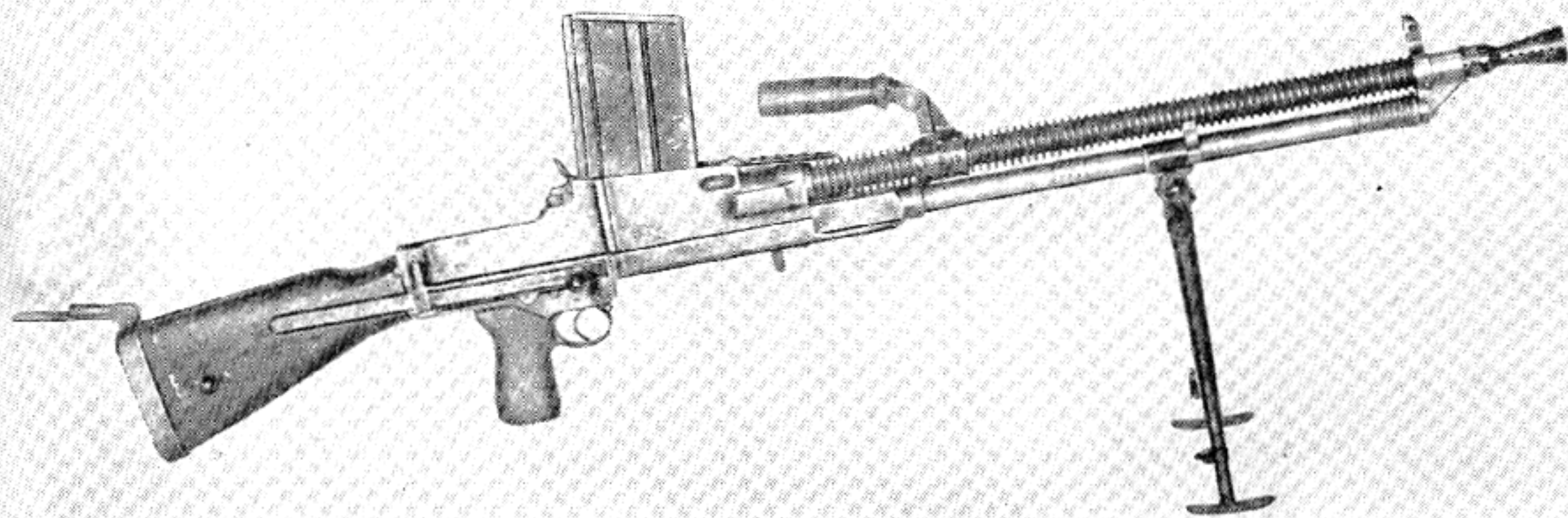
The magazine was a simple sheet-metal box into which two rows of 20 cartridges each were staggered. They always were held against the re-

ceiver wall because of pressure from above by the compressed magazine spring.

In the gas cylinder the piston moved on its extension in the bolt carrier housed in its slideway in the receiver. A lug on the bolt carrier, opposite the firing pin in the bolt body, formed the hammer. On the under side of the bolt carrier was a recess into which the sear of the trigger mechanism was engaged. The bolt carrier was the driving part of the bolt and transmitted to this part forced movements back and forth. Locking was caused by two beveled lugs on the bolt carrier engaging two other lugs on the bolt. The lifting into the locking recess was accomplished by the carrier camming these parts up with its locking lugs, the bolt rising on a bearing against the fixed receiver during the instant of discharge and remaining until the bullet was out of the bore.

A device that permitted the firing of single shots if desired was called the interrupter. When the safety was turned for single-shot firing, the interrupter was pressed down during firing by the recoiling bolt carrier. Thereby the sear was liberated from its locked position and engaged the notches in the bolt carrier after the firing of each individual shot, necessitating the pulling of the trigger each time to fire a shot. If the safety were put on automatic firing and the trigger kept to the rear, the sear remained in a down position and would not catch the shuttling bolt and bolt carrier.

The striking of the firing pin by the bolt carrier was accomplished by a system known as



ZB Machine Gun, Model 1926, 7.92 mm.

inertia firing. When the last cartridge had been fired out of the magazine, the bolt and its carrier were held in a cocked position by the feeder plate protruding from the magazine mouth. At the insertion of a loaded magazine, the bolt and carrier moved forward a few thousandths of an inch to be blocked again by the sear. This allowed the bolt to be held ready to fire at the moment the magazine was placed in position.

This light Brno ZB Model 1926 possessed the technical qualifications necessary to satisfy all tactical conditions under which it would be used. The factory was well equipped with the most up-to-date machine tools. Operations were organized on modern principles of mass production so that all machine gun parts made in the factory were interchangeable. The steel used was provided by the world-famous Skoda plant.

The normal effective range of the gun was said to be 1,000 to 1,200 yards. Location of the magazine on top meant that the sights had to be offset to the left. The maximum cyclic rate was 450 to 500 rounds a minute. Each gun came equipped with two barrels and to change them was but a matter of a few seconds. The red-hot barrel could be plunged into cold water without any ill effects. If fire was maintained at a rapid rate, it was recommended that the barrel be changed after every third magazine had been emptied.

The Bren Gun

In 1932 the British Army, in its quest for a light machine gun to replace the Lewis, became very much interested in its military attachés' reports on the simply constructed reliable machine gun known on the Continent as the ZB Model 1926. A series of trials were immediately begun in which by way of competition some fine and efficient weapons were entered. Among them were the well-known Madsen and Vickers-Berthier. The latter seemed certain to be adopted, but after an exhaustive test the British decided on the ZB weapon. Certain changes were demanded in order to meet British ammunition characteristics. The specifications were drawn and submitted to the parent company. The result bore the temporary designation of Model ZBG.

Two principal changes from the earlier models were made. The removable barrel was chambered for the caliber .303 infantry rifle. It was shortened and the gas port was brought nearer the breech end to compensate for the shorter barrel. The stock was also modified and a recuperator spring added in the recoil mechanism to permit a slight barrel movement rearward. These modifications gave a higher rate of fire and a considerably smoother action. The stock did not hinge, due to a redesign of the recoil mechanism.

In February 1934 the *London Telegraph* carried an article by Capt. B. H. Liddell Hart, from which the following is quoted:

"A start is to be made this year in equipping the British army at home with a new light machine gun. The cavalry are to be the recipients of the much needed replacement of the obsolescent wartime weapons still in use. The new weapon is known as the ZB, a new light machine gun of Czech origin, which has come to the front as a 'dark horse' in recent tests. . . ."

Having obtained a license to manufacture it, the Enfield government arms plant was ordered to begin manufacture of the weapon and in January 1935 the completed drawings from the ZB firm were received. In September 1937 the first gun was assembled and given the name Bren, the first two letters being taken from Brunn, location of the original producer in Czechoslovakia, and the last two from Enfield, the British arsenal. By December 1937, 30 Bren guns had been completed, with 12 already under test. By January 1938 an even 200 guns had been assembled. By July of the same year production had been stepped up to 300 a week and remained at that figure until September 1939, when it was found that the guns were coming off the assembly line at a rate of 400 a week.

The Royal Small Arms factory continued to be the sole producer of the weapon, with B. S. A. and Austin having contracts for the production of spare magazines. The feed systems made by the latter two companies gave considerable trouble because the Czechs designed the magazines to hold rimless cartridges, while the British continued to use outmoded rimmed ammunition for their automatic weapons. The mistake was remedied but not before thousands of magazines



Bren Machine Gun, Mk I, Cal. .303.

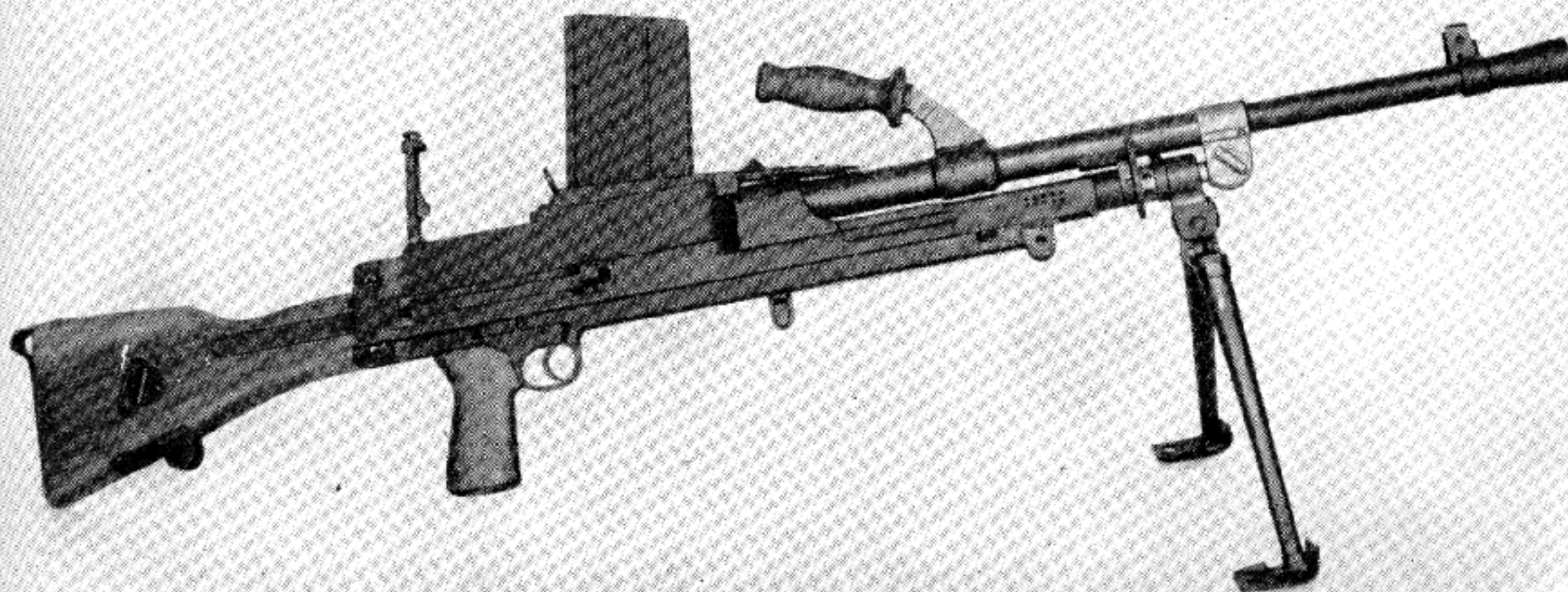
had been manufactured. It was found that they would function correctly if loaded with only 29, instead of the customary 30, cartridges. The magazines were marked plainly to this effect. Issued after the outbreak of World War II, the weapon was manufactured in tremendous quantities not only in England but in Canada as well.

Japanese Models of the ZB

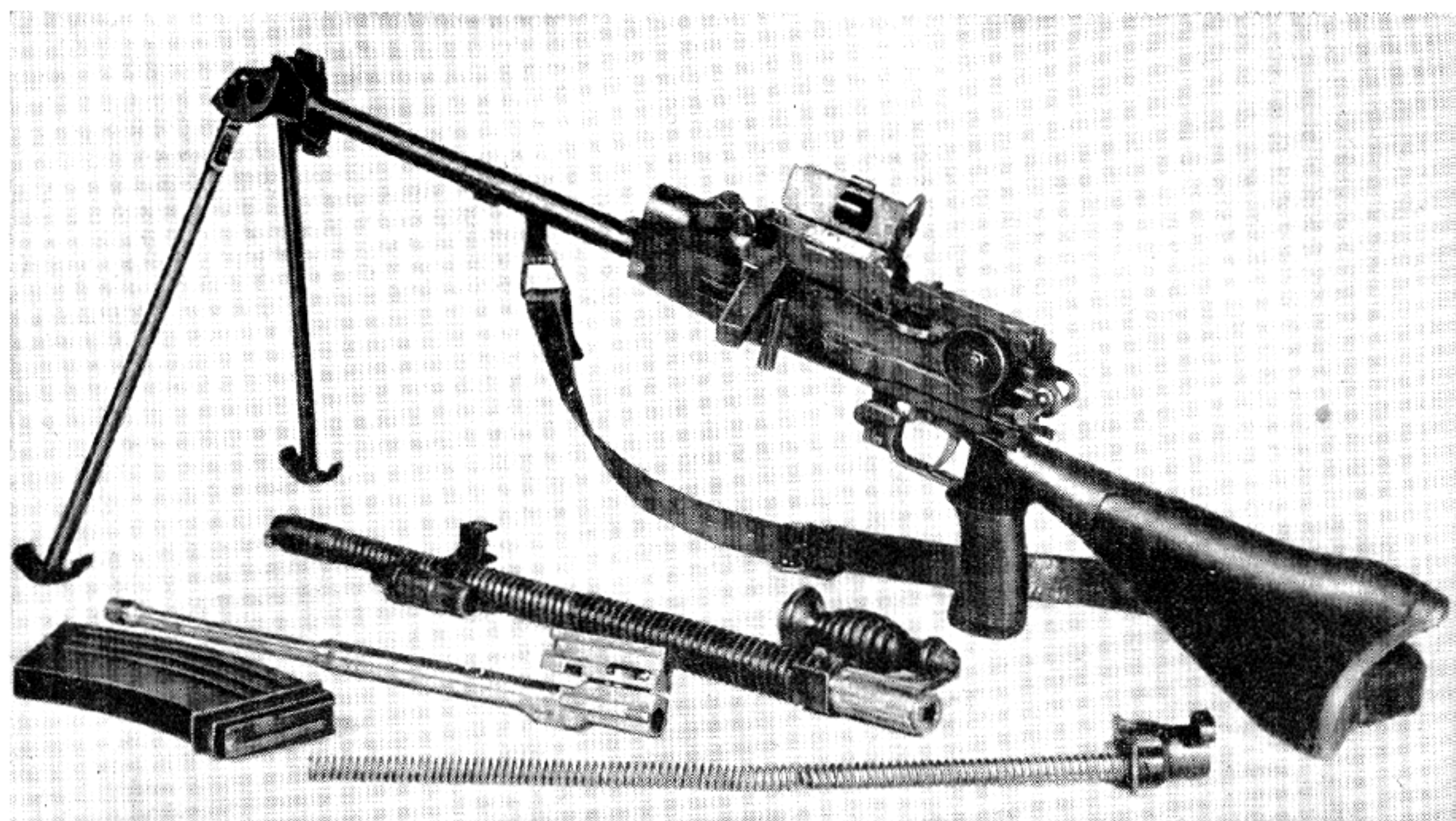
In the year 1936 a ZB-type gun made its appearance in the Japanese Army and was designated Model '96, 6.5-mm. Research shows that

the weapon actually was produced in a Chinese arsenal which, when captured by the Japs, continued operation and placed many such arms into the hands of the Japanese infantry. The gun was later adopted and produced in Japan, becoming a part of the country's haphazard automatic armament. It appeared as Model '97 (1937) for use in tanks, and as Model '99 (1939), with a lighter construction for infantry and paratrooper use. Both were chambered for the 7.7-mm cartridge.

Some of the tank models were designed to mount a long telescopic sight on top of the re-



Bren Machine Gun, 7.92 mm. A Czech Weapon Adopted by the British and Manufactured for the Chinese in Canada.



ZB Machine Gun, Model 96, 6.5 mm. A Japanese Copy of the Czech Weapon.

ceiver. A manual captured with one of the guns shows that the weapons were identical with ZB machine guns used practically all over the world. A translated portion of the manual is given below:

"The Japanese Model 97, 7.7 tank machine gun is a gas-operated air-cooled Brno-type machine gun designed to be mounted in tanks. It is equipped with conventional sights and also has a telescopic tank-type sight mounted on the left side of the receiver. The use of conventional sights and a bipod carried separately in the tank allows the gun to be used on the ground as well as in the tank. The weapon has a removable box magazine holding 30 rounds and uses only the Model 99 rimless 7.7 ammunition."

Unlike the original ZB machine guns there was no carrying handle on this particular model and the cooling fins ended 5½ inches from the muzzle end of the barrel. The operating parts were as identical as it was possible for the Chinese and Japs to copy.

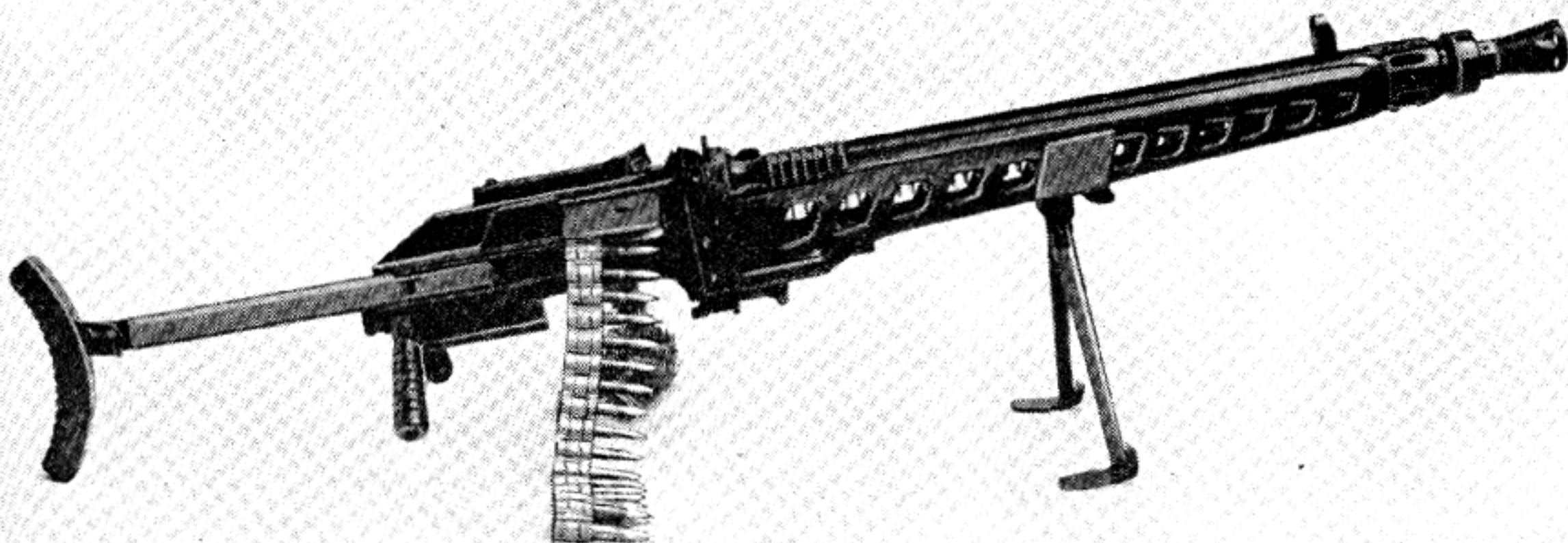
ZB-50 Machine Gun

The ZB Co., after a number of years' experience with its light gas-operated machine gun that

enjoyed a world-wide reputation for reliability and clean cut design, turned its attention in 1932 to the promotion of a machine gun that operated by recoil forces. In the creation of this new weapon the company advertised that it "made efficient use of all the knowledge and methods which modern technical science puts at the disposal of the successful designer. Painsstaking study and research were undertaken to determine kinetic and dynamic conditions in the mechanism of the machine gun. Cinematopographic research was made use of, and radiation of heat from the barrel was the subject of thorough investigation based on the latest data of the science of thermology."

This weapon was given the official designation of ZB-50 and the main change was that the breech mechanism was operated by utilizing the recoil, and the bolt was cushioned by a strong spring so that this heretofore undesirable feature did not influence the accuracy of the weapon when in the act of firing.

The bolt assembly was very similar in appearance to the earlier gas-operated models, but in lieu of a gas piston actuating the recoiling parts an accelerator was added that transferred energy



ZB Machine Gun, Model 50-1932, 7.92 mm. The Only Weapon Designed by ZB Based on the Short Recoil Principle.

during the movement of recoil and at the instant of unlocking exerted its full force on the bolt, speeding it rearward. These features were invented and patented by Anton Marek, one of the noted gun designers in the employ of the ZB plant. The accelerator was in appearance very similar to the well-known Browning type.

This model unlike its magazine-fed predecessors employed metal push-out type links to form a non-disintegrating belt for the purpose of placing cartridges in the feedway. After the discharge of the last round the belt fell out the left side and the bolt and its components were held by a stop in the cocked position. When a loaded belt was inserted, the stops were raised and the bolt moved forward a few thousandths of an inch to be caught by the rear sear. This necessitated a pull of the trigger to release.

The only thing needed for complete disassembly in the field was a loaded cartridge, with the bullet point being used to depress certain spring-loaded detents.

The trigger housing was so designed that it slid on the bottom of the breech casing when released from its spring-loaded detents to cock the mechanism manually. The housing had two small grips on each side that acted as the charging piece. The advantage of this arrangement was that the two grips could be used to cock the piece when it became necessary to load the weapon by hand.

A muzzle booster that trapped the powder gas

after the bullet left the barrel was used to increase rate of fire by bringing this pressure to bear on the face of the barrel. This device working in conjunction with the mechanical accelerator gave a cyclic rate of 600 shots a minute. The muzzle booster was also designed so as to act as a flash hider and front barrel bearing.

The safety catch was of unusual design on this weapon, being so constructed that, when it was on, it held not only the sear locked but also threw the point of the incoming round down at an angle so that if by any chance whatsoever the sear did become disengaged and the bolt go forward the cartridge was in such a position that it would not chamber.

Perfect coordination between the counterrecoiling barrel and the moving belt was assured by a specially constructed piece that permitted the return movement of the bolt only after the barrel had gotten into battery.

To fire the ZB-50, the gunner, generally prone, raises a cover in front of the feedway and inserts a loaded cartridge belt from the right side until the first cartridge is under the spring-loaded holding pawl. Then the firing grips are released from their detent and shoved forward until the sear engages the bolt. It is then pulled all the way to the rear. At this point the rear sear engages its recess in back of the bolt, holding the firing mechanism in the retracted position. Rearward motion also compresses the driving spring

and moves the belt over one space in the feedway, thus positioning the first round. When the trigger button is pushed, the sear disengages the bolt which flies forward under the influence of the driving spring energy.

The bolt face, arriving at the rear of the feed, begins the first phase of chambering the round by pushing it out of the link into the guideway that positions the nose of the bullet into the entrance of the chamber. The bolt is made in two pieces. The portion containing the bolt and its rear locking face arrives in battery first with the rear end directly under a locking recess milled into the barrel extension. The second part, which is connected to an extension spring and is held to the rear of the first part by means of the locking lug, is now free to move forward. The angle on the locking lug cams the back end of the bolt up into the locked position. The last forward motion of the bolt assembly's second portion brings the face of the locking lug to bear suddenly on the firing pin housed in the bolt and the weapon is fired.

In the first half inch of recoil, the bolt assembly and barrel are locked to the barrel extension. At the same time they build up tension in the extension-type mainspring. This spring is connected to the accelerator which, upon being activated by the spring, pivots and shoves to the rear the part of the bolt carrying the lug. This unlocks the weapon and also accelerates the already recoiling parts to the rear. The empty case is withdrawn from the chamber and ejected through the bottom of the receiver. When the bolt assembly reaches its rearmost position, coun-

ter recoil will begin, repeating the cycle of operation as long as the trigger button is depressed.

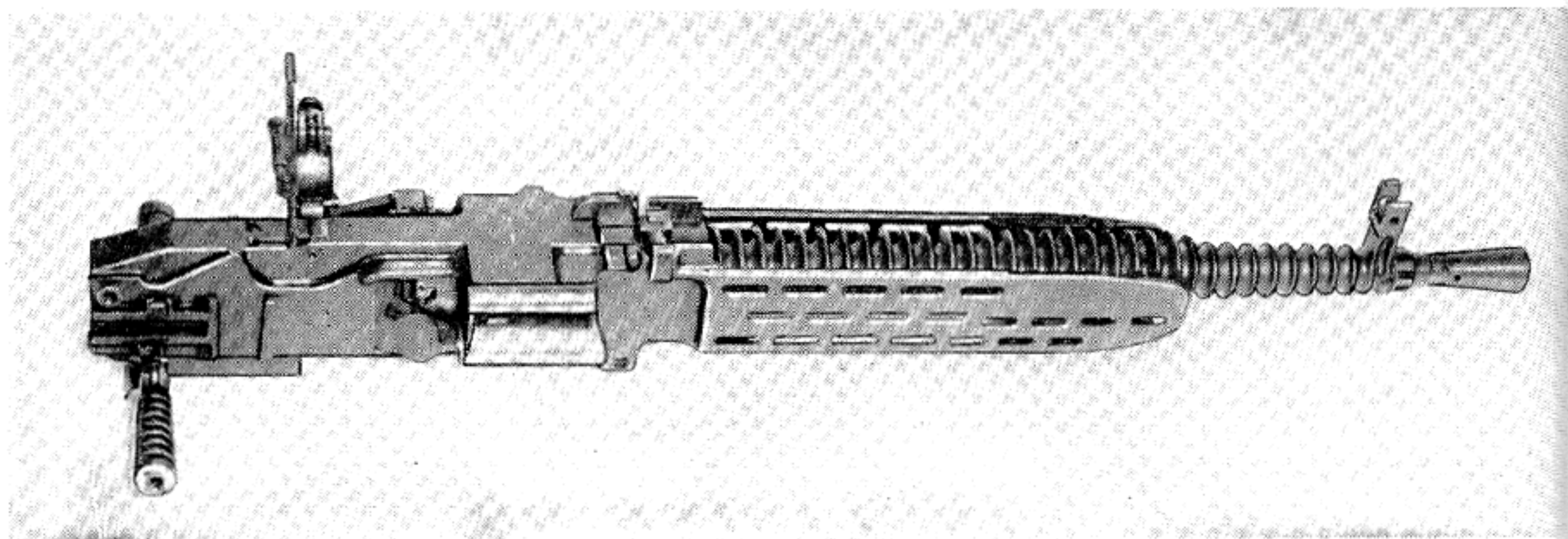
Besa—ZB-53 Machine Guns

The British modifications on the 1926-30 models that became known as the Bren led the ZB firm to bring out an identical gun in every respect except for the caliber. This was changed from the British .303 to the Czech rifle cartridge, 7.92 millimeter. The greatly improved design was called the ZB Model 1934 and the highly efficient weapon was bought or copied by countries all over the world.

In 1937 V. Holec, the official in charge of the firm's experimental weapon design, introduced and patented a gas-operated firing mechanism that was given the official designation ZB-53 Model 1937. While it had many physical changes, the operating parts remained basically the same as all the other gas-piston-actuated ZB's.

The British were much impressed with this weapon and adopted it at once for equipping their armored vehicles. They proceeded to acquire manufacturing rights, and in a short time it was being produced in England in the Enfield Royal Arms Manufacturing Arsenal and the Birmingham Small Arms plant. This gun produced in England was known as the Besa. ("B" for Brno, "E" for Enfield, and "SA" representing the last two initials of the Birmingham firm.)

British cartridges not being suitable for the action, the barrels were chambered for the 7.92-mm Czech cartridge instead of their own caliber .303.



ZB Machine Gun Model 53-1937, 7.92 mm.

Later the same mechanism was scaled up by the ZB Co. to take a 15-mm high-velocity cartridge for anti-tank use. This large bore machine gun was likewise adopted and manufactured by the British. The smaller caliber guns were designated Besa 7.92-mm Mk I and II; the larger weapon was known as the Besa 15-mm Mk I.

The physical appearance of the guns themselves was rather conventional, but a few features most certainly were not. The charging handle for cocking the weapon was the pistol-grip-shaped trigger guard that was shoved forward until a sear engaged the piston extension. The guard was pulled back, carrying the operating parts to the rear sear, after which it was returned to its normal position. Needless to say, the fingers must not be placed inside the guard as pulling back into place would fire the weapon after return of the guard to its former position.

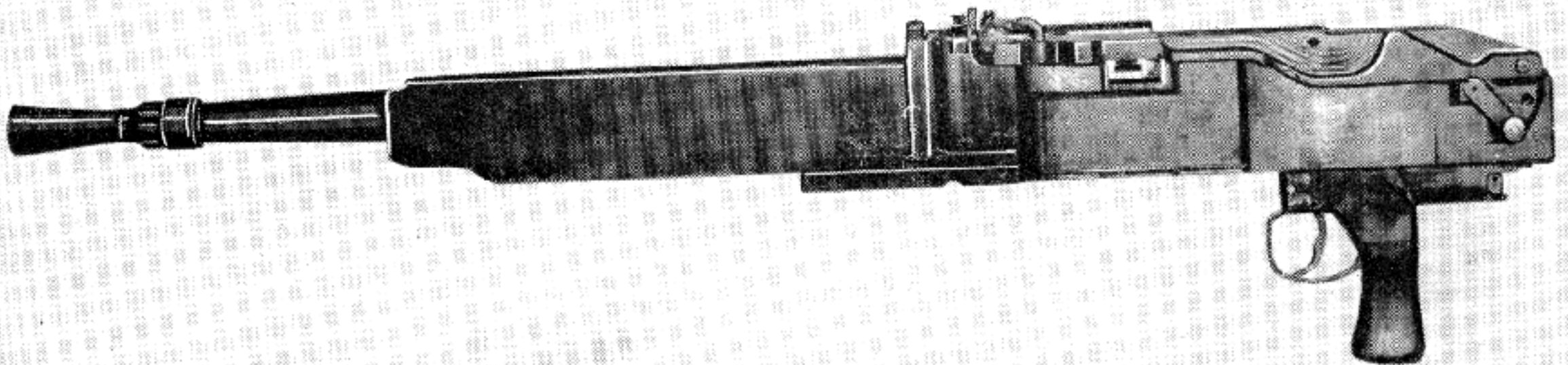
Before the barrel could be removed, the gun must always be cocked. Two different sized orifices were drilled into a circular piece that could be rotated. This was inserted between the port in the barrel and the gas piston cylinder. By turning this part, the gunner could obtain an adequate amount of gas for successful operation.

The Besa-ZB-53 guns were equipped with considerably heavier barrels than most air-cooled machine guns. Bursts of greater duration were thus made possible. They also differed from the earlier ZB-model guns from which they originated in that they had no shoulder stocks and that the rear of the receiver housed a heavy spring-loaded buffer system that could be set to deliver a slow or fast rate of fire. This device could be moved up out of the way. Then the bolt

could not only travel farther on the recoil stroke but had the energy of the compressed driving spring alone to return it. This noticeably slowed the action and, when used with the small orifice, produced a rate of fire of 450 to 500 rounds a minute. If a higher rate was desired the operator snapped the L-shaped heavy buffer in the down position. The stroke was then shortened and the fast recoiling bolt was deflected back to battery at a higher speed. The use of this buffer, often erroneously called the accelerator, gave a rate of fire of 800 to 850 shots a minute.

The principal difference between the rifle-caliber weapon and the 15-mm Besa were the features in the latter that were patented by V. Holek, namely the method for holding the barrel to the rear by a spring-loaded detent. The bolt had to chamber the cartridge slightly out of battery and the firing take place before the fast moving components made metal-to-metal contact on counter-recoil. This allowed the recoil forces to begin just before the stopping of the bolt, barrel, and extension by the receiver. This not only gave longer life to the operating parts but resulted in smoother functioning.

The method used in retracting the barrel was unique in that the cover had to be raised. This actuated a linkage that jacked the barrel back until the detent located on the bottom side slid into its recess. Cocking was done also by the unusual method of releasing the pistol-grip-shaped trigger guard. It was shoved forward until it latched on to the rear end of the gas piston and was then pulled to the rear until the sear engaged it to hold in until released by the trigger. A continued movement rearward naturally



Besa Machine Gun, Mk II, 7.92 mm.

brings the trigger guard back to its normal position.

The so-called accelerator was not incorporated in the design of the larger caliber weapon. The device was in reality a strong spring buffer that could be dropped into position to shorten the recoil stroke and speed up by bolt deflection the rate of fire. The barrel was machined in such a manner as to have three points of contact with the inside of the barrel jacket. This gave sufficient support but did not create undue friction on recoil.

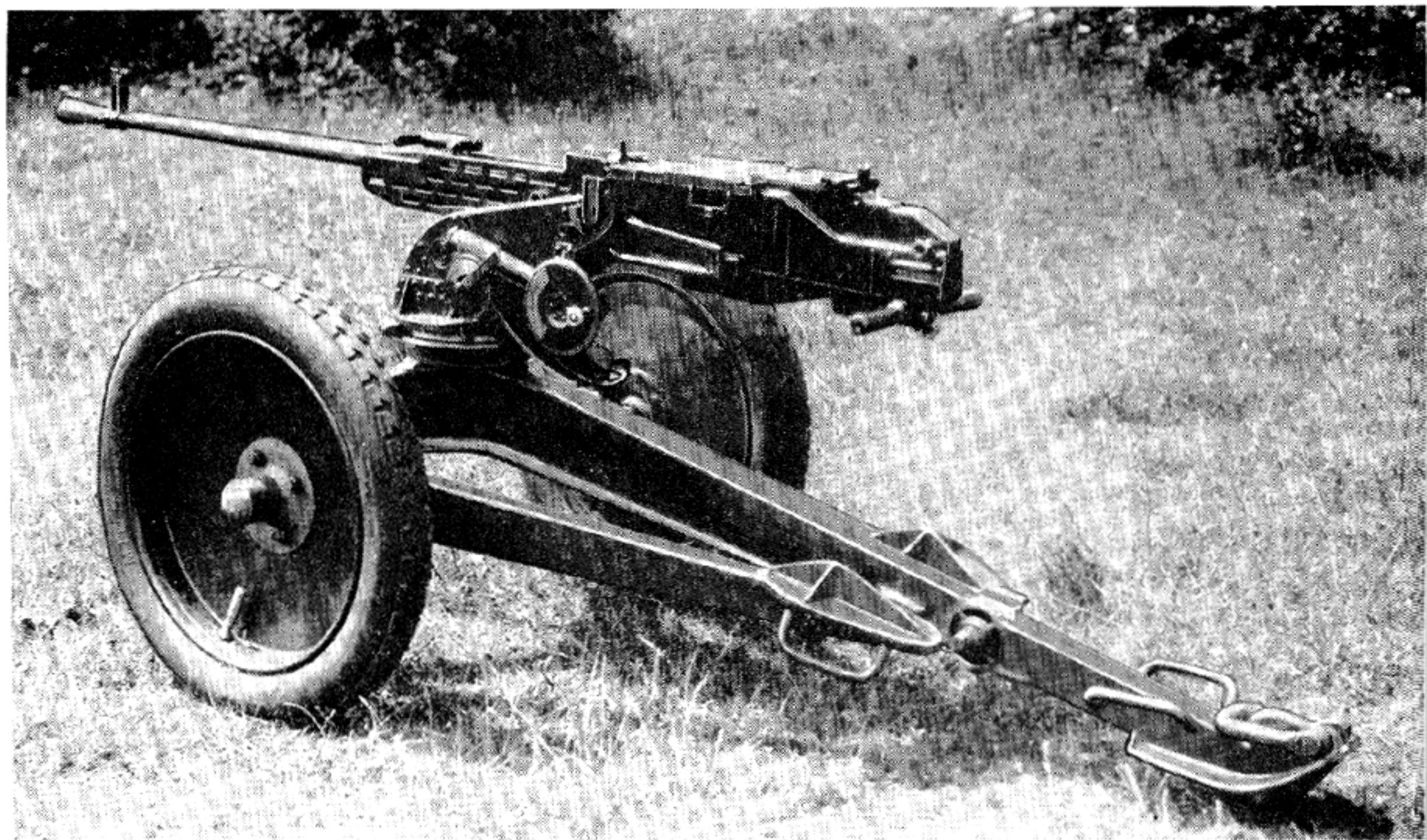
By turning the selector switch to its extreme left position, single shot firing could be accomplished. The feed system used the metal push-out type of link and was fed from right to left. The belt was drawn over one space by a lug on the gas piston which engaged the feed pawl and by a long movement gradually but forcefully pulled the belt over during each movement of recoil.

While the barrel could be readily removed, it was still a two-man job, for one had to hold it while the other raised the carrying handle of the barrel retainer a half inch and pushed the partly freed barrel forward until it could be turned up.

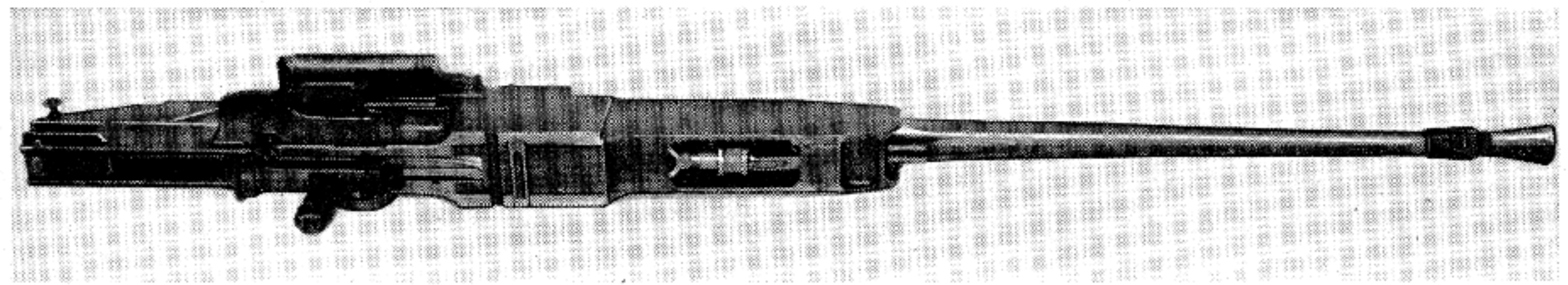
At a distance of 13 inches from the breech end, a special slot was machined for this purpose. The second man then raised the aft end until it cleared the barrel extension. They jointly eased it forward to lift out. The projection guides on the barrel were freed from their slideways in the receiver by the last of the forward motion.

A flash hider was always used on this heavy duty gun as the terrific powder charge in the 15-mm cartridge had enough muzzle flash to impair seriously the aim of the operator unless suppressed by some device.

The cartridges were fed to the gun through a feed mechanism actuated by the piston extension. The latter piece was provided on its lower face with a cam way in which the under arm of the feed lever operated. The upper arm actuated the feed pawl and moved the belt over one space, positioning the cartridge to be chambered. The feed system was not dependent on the action of the breechblock but obtained its operational power from the piston extension. This method insured positive feed as the power stroke was used in place of energy derived from a compressed driving spring.



ZB Machine Gun, Model 60-1938, 15 mm.



Besa Machine Gun, Mk I, 15 mm, as Viewed from Below.

This weapon was so close in principles of operation as to be nearly identical with the early gas-operated ZB guns but the few new features added from time to time were in themselves radical enough to warrant the presentation of a cycle of operations for comparative purposes.

To fire the 15-mm Besa Mk I or the ZB-60 Model 1938, as the Czech company version was marked, the operator shoves the tab of the metal cartridge belt through the feedway from the right side, which is then pulled to the left until the first cartridge snaps behind the belt-holding pawl.

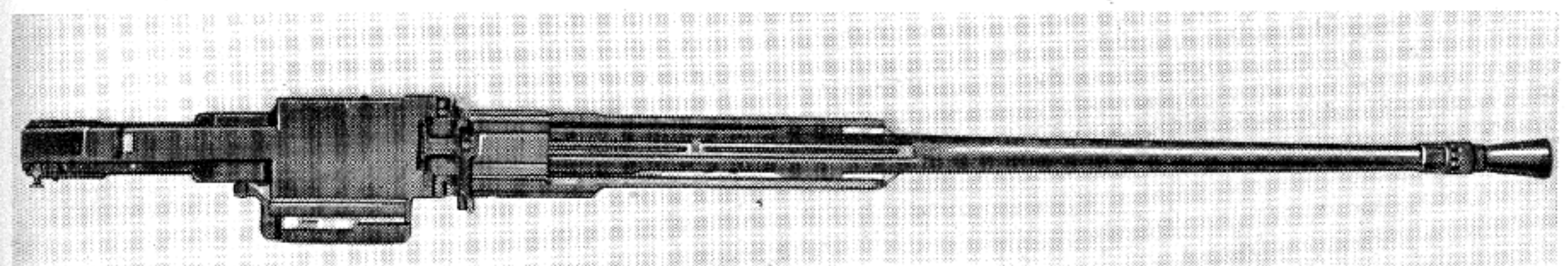
The detent holding the feed cover group is held down allowing the cover to be raised to the up position and then brought back to position. This movement jacks the barrel back where it is held in the retracted position by a strong spring-loaded catch. The pistol-grip trigger guard is released, allowing it to be slid forward in its slideway until a plunger in its housing is forced into a recess in the piston extension. The trigger-guard housing is then pulled smartly to the rear bringing with it the bolt and the extension.

At the completion of the rearward movement the rear sear engages the notch in the piston extension, holding the entire assembly in the cocked bolt position. The pistol grip that has served as the charging handle is now in place and, if the selector switch is on single shot or full automatic, the weapon is loaded and ready to fire.

The rearward movement of the piston extension also cammed the feed pawl over, thus posi-

tioning a round to be stripped from the link. The release of the sear by pulling the trigger starts the firing mechanism toward battery and a projection on top of the forward part of the bolt passes through the center of the link, shoving the cartridge ahead of it into the chamber. The bolt arrives first into battery with the rear end directly under its locking recess in the bolt extension. The gas-piston extension, being held to the rear by a beveled locking lug, can now continue forward since the lug cams the rear end of the bolt up into the recess and out of its path. The last fraction of an inch of travel of the piston extension releases the barrel holding catch and the entire assembly—bolt, barrel, piston, and extension—start final movement to battery. The faster moving locking lug on the piston extension, however, strikes the firing pin, discharging the weapon and starting recoil movement slightly before all the moving parts strike the stationary receiver.

The main recoiling parts are locked together until the terrifically high gas pressure has dropped to a safe operating limit. At a point in the barrel one-third of the way up from the breech, gas is let through a port into the chamber, where it strikes the face of the piston driving it rearward. The bolt is unlocked as the back of the lug on the piston extension pulls it down out of its recess. At the same time the retracted barrel is held back by its latch. A strong extractor withdraws the empty cartridge from the chamber and holds it until it strikes the ejector positioned in



Besa Machine Gun, Mk I, 15 mm, Top View.

the belt guide. It is then knocked downward through the slot in the piston extension and receiver.

Continued rearward movement completely compresses the driving spring and final travel of the recoiling parts is dampened by the heavy spring buffer. The barrel recoil spring positioned in the cover group reduces the upward jump of the barrel's muzzle and in doing so increases accuracy.

This weapon was intended for aircraft use as well as anti-tank work. For the former purpose an explosive 15-mm bullet was developed. Its high muzzle velocity of 3,200 feet a second was used as an argument in favor of its use in place of the larger bore automatic weapons then being placed in fighting planes. For ground work 40 rounds was the normal length of an ammunition belt, but the company was quick to point out that in aircraft installations the length would be governed only by the capacity of the plane.

The very modern and highly efficient ZB automatic arms plant was taken over by the Germans early in World War II and operated throughout the war under the name of Waffenwerke Brunn A. G. The conquerers not only used the excellent ZB weapons already in existence but kept production going in full force. Characteristically, they called for many modifications on the weapons, some in the nature of improvement and others merely for adaptation to special purposes.

The most outstanding illustration of the firm's craftsmanship, showing its genius for weapon design to the utmost, was an experimental model of a new type of machine gun that was in prototype stage at the time of the German invasion. Fortunately for the Allies, the model, pictures, and drawings found their way to the United States just before the plant fell into enemy hands. Security reasons do not permit any further mention of this weapon.

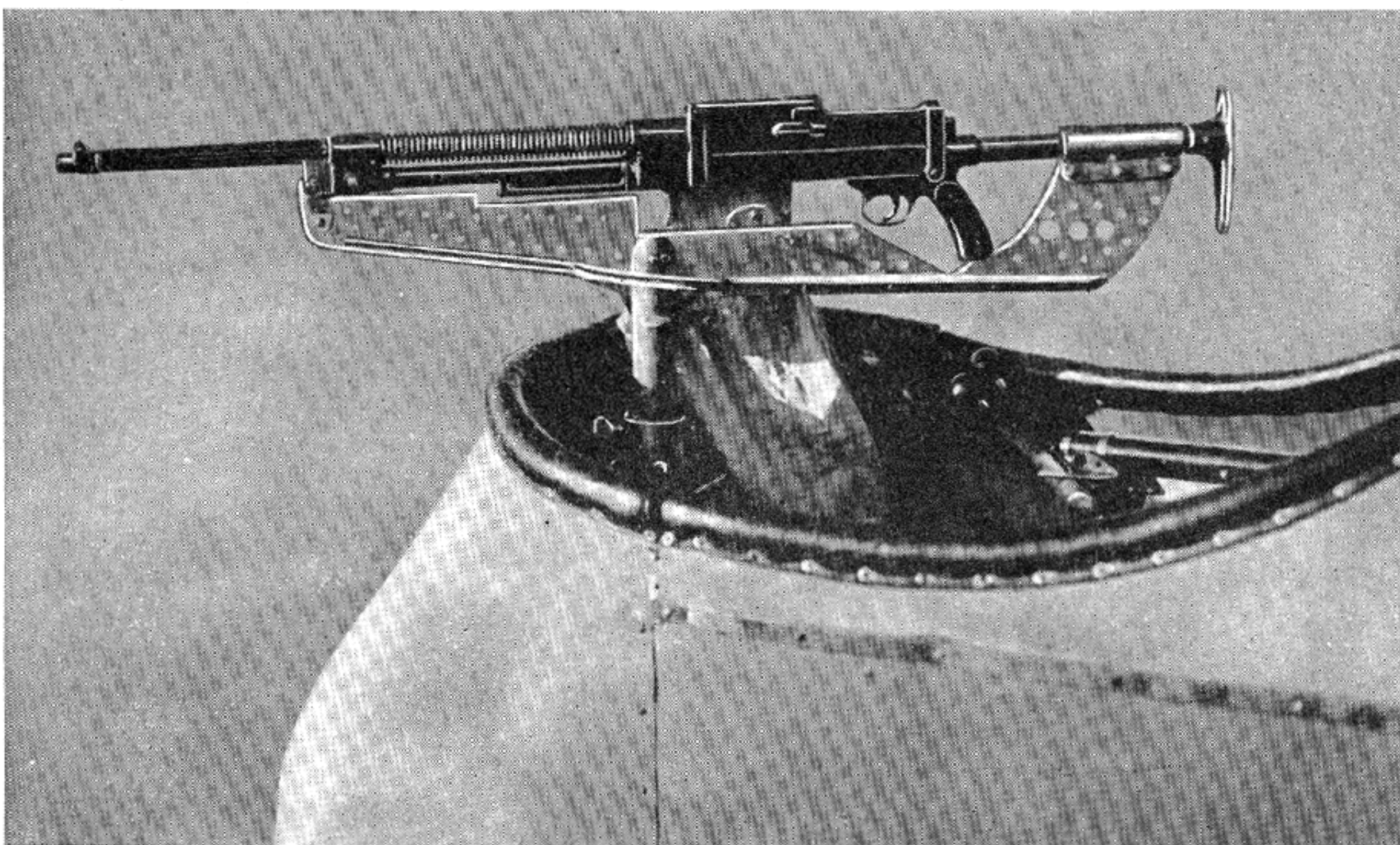
VICKERS-BERTHIER MACHINE GUN

In 1925, the Vickers Co. in England, having acquired the manufacturing rights to all Berthier machine guns, started production on a limited scale. This was done more to keep the personnel of its large Crayford plant employed than to fill the needs of the British services for a machine gun, since at this time the gun-making industry, as far as military types of automatic weapons were concerned, was at a low ebb.

The first such guns produced were in the form of light machine rifles. They were put on the market commercially, engaging in competitive tests in many of the Balkan States and in the Dutch East Indies. The Latvian military authorities adopted the light machine rifle chambered for their infantry rifle cartridge. In the Dutch East Indies test, the Vickers-made Berthier bested

the field but no contract was received because the Dutch Government thought it more economical to manufacture a modified royalty-free Lewis gun in its own government arsenal. Spain bought a number of the weapons for use in Morocco and many South American republics purchased them in limited quantities. They were also adopted officially by the Indian Army. Actually the sum total of sales was only enough to keep this part of the Vickers Co. operating at a bare profit.

It was more from financial necessity than military need that Vickers in these days started to develop an aircraft gun based on the Berthier principles. An effort was made to interest the Royal Air Force in its adoption as an ideal observer's gun. The result is officially known as the



A Berthier Machine Gun, Cal. .30, Mounted as a Flexible Gun in a Curtiss Plane by the U. S. Navy, 1917.

Vickers G. O. ("gas-operated") machine gun, which made its first appearance in 1928.

Its main selling points were the extreme simplicity of its characteristic features and its very light recoil. The principal components could be assembled and disassembled without the aid of tools, and so constructed that they could not be put together incorrectly. The operating parts were housed in such a manner as to protect them from inclement weather. The silhouette was very clean, having no objectionable knobs or handles that would shuttle back and forth while firing.

The recoil was so light that a gunner could get in long bursts without being thrown off his aim. When overheated, the easily detachable barrel could be changed by an experienced operator in five seconds without touching it manually or disassembling other parts of the mechanism. The Vickers Co. recommended that a barrel be changed after a 240-round burst of rapid fire, but held it was possible to continue on if necessary. If it was determined that longer bursts were needed in aerial combat, a heavier barrel could be used and the ability to keep up sustained fire for great lengths of time could be greatly augmented.

All components were interchangeable, and manual manipulation of a device located near the trigger would instantly give the gunner a choice of single-shot or automatic fire.

The Vickers designers, knowing the main difficulties encountered in the maintenance of a machine gun in the air, tried to overcome these objectionable features by making it possible to change the extractor and ejector externally, if broken or damaged during fire, without stripping the gun. If disassembly for any reason was necessary, it could be done in less than 30 seconds. In order to take advantage of all cooling, the breech remained open upon cessation of fire leaving the hot chamber empty. This not only made a cook-off impossible but permitted cold air to circulate through the bore.

A drum-shaped feed of peculiar design, holding 97 rimmed caliber .303 cartridges and weighing 11¾ pounds when loaded, was used. This system, although resembling the Lewis feed in many respects, did not rotate when the weapon was firing, as it was latched securely in place fore

and aft. Each round was positioned by means of a pre-tensioned spiral spring.

A very clever rounds counter was also incorporated in the G. O. gun's design. To wind the spring, a flat piece is located on top with a recess cut for inserting the finger. When the drum is fully loaded, this flat winding lever revolves and the gunner can see at a glance how many rounds remain in the drum. The top of the drum is marked in such a manner that, whenever the combination winding lever and rounds indicator stops, the amount of ammunition left in the feed is revealed.

The addition of accessories necessary for aircraft use was the only difference between the ground machine rifle and the observer's gun. In the latter, however, the rate of fire was stepped up to 950 rounds a minute by a larger gas orifice leading to the gas cylinder chamber and a more efficient heavy-duty buffer to compensate for the faster recoiling parts. When used as an aircraft gun, it was mounted both singly and in pairs on a Scarff ring.

If its date of production is taken into consideration, the Vickers-Berthier was quite advanced, as it proved to be a reliable, easily maneuverable, high-speed machine gun that served the needs of the gunner-observer firing from an open rear cockpit. It is an example, however, of what happens to any piece of aviation ordnance when change in design of aircraft makes it obsolete. This very reliable high-performance rifle-caliber machine gun is practically unheard of today, because, coincidental with preparations for World War II, British aircraft with power-driven turrets to take the place of the rear observer and his free gun were beginning to make their appearance. This act doomed all specially made free guns regardless of their state of perfection, as the turrets were all armed with belt-fed fixed-type weapons with higher speed, mounted in groups of two or more. Although the weapon was outmoded, England was so desperate for machine guns of any type that it was held in reserve for training purposes and the arming of armored vehicles. Manuals were printed on its use and maintenance all through World War II.

To fire the Vickers-Berthier aircraft machine gun, a loaded magazine is slipped into a recess



Vickers-Berthier Aircraft Machine Gun, Mk I, Cal. .303.

on top of the barrel until it engages its holding catches fore and aft. The charging knob, on the left side, 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.

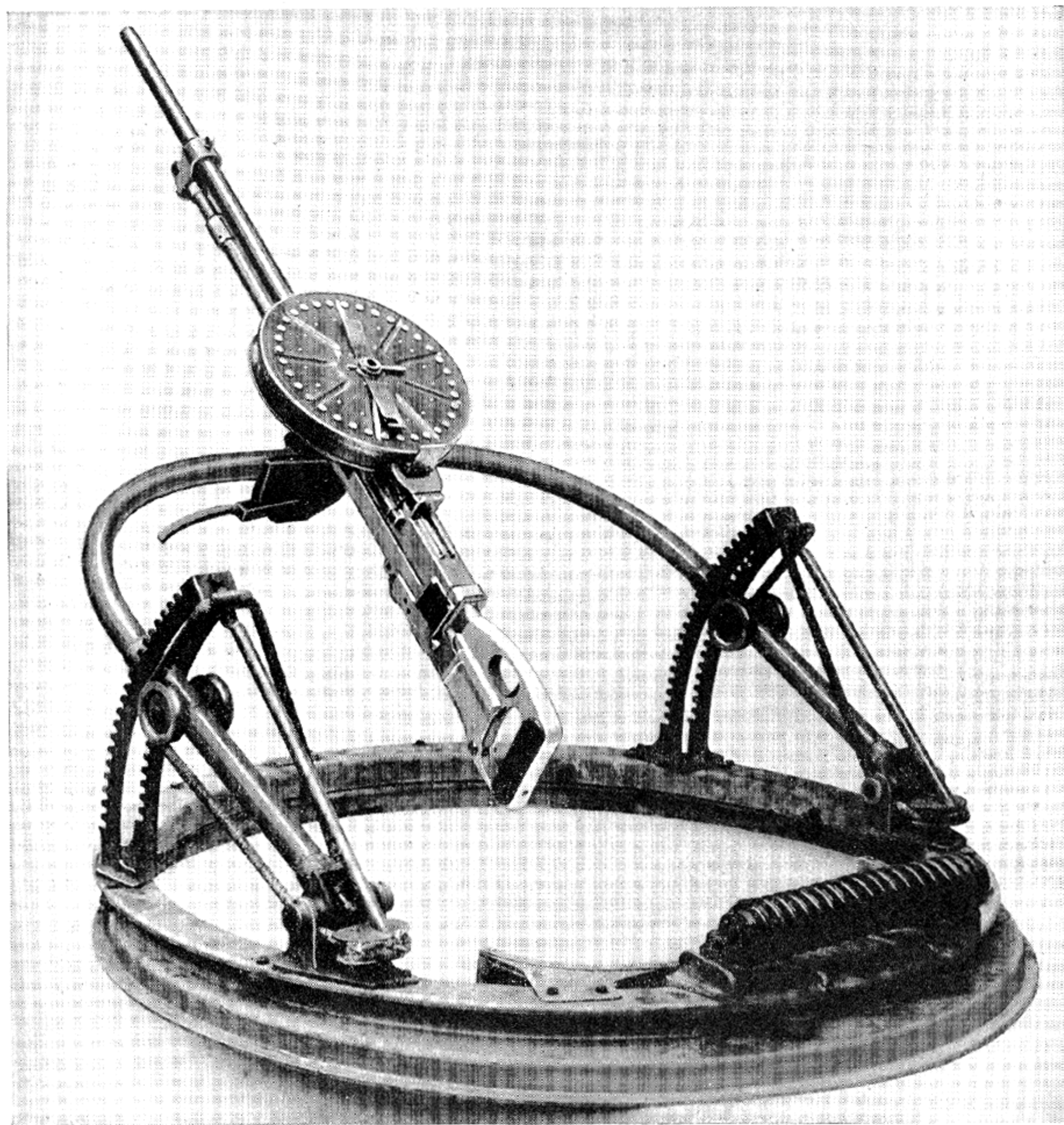
Driven forward by the energy of the compressed driving spring, the upper face of the bolt strips a cartridge from the mouth of the magazine and starts to chamber it. During this act the extractor rides over the cartridge rim and snaps into the cannellure.

Coincidental with 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 con-

nected with 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 this part of the bolt up and against the locking step in the receiver body.

This swinging, or propping up, of the rear end of the piece 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



Vickers-Berthier Aircraft Machine Gun, Mk 1, Cal. .303, Mounted on a Scarff Ring.

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 swinging portion of the bolt against the locking step. 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 down through the opening to the right into a deflector for catching the empty cartridge. 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.

LAHTI (SUOMI) (L/S) MACHINE GUN

The Valtion Kivääritehdas (State Rifle Factory) at Jyväskylä, Finland, produced in 1926 a light machine gun that operated on the short recoil system. It was the invention of Finland's most outstanding automatic weapon designer, Aimo Johannes Lahti, who for a number of years was chief of this government arsenal. Lahti originated weapons for his country's use in all sizes from rifle caliber to cannon and, unlike most inventors, did not exploit a single basic system of operation but employed various methods ranging from short recoil to gas.

The Lahti (Suomi), or L/S, light machine rifle was one of his most refined models and was later used extensively by his countrymen in the Russian campaign. It was greatly respected by the Soviets and copied extensively by them. Ironically, while the Finns produced it primarily for sale either to England or to Germany, they were forced to use it first in defense of their homeland. The weapon, as modified in 1932, was given the factory designation, L/S Machine Rifle Model 26-32. It was air cooled and could be fired both full automatic and single shot.

The physical appearance of the weapon was practically the same as a standard army rifle and it was pointed out by the promoters that one in-

fantryman armed with the L/S 26-32 could lay down as much fire power as an ordinary company firing the bolt-action rifle.

This weapon was produced originally for possible sale to the two major powers, England and Germany, which the Finns felt were potential enemies of each other. The weapon was chambered for each country's cartridge and it was especially designed so that, by merely switching the barrel and bolt, either cartridge could be used.

As evidence that the producers of the L/S 26-32 used this method of impartially seeking the business of both sides in any future war, a portion of a promotional booklet dated 1933 is quoted:

"The greatest advantage of this machine gun is that it at last solves the problem of a universal machine rifle of different calibers. It is designed so that after fitting in different operational parts the firing of cartridges of different calibers is possible. At present machine guns with firing mechanisms for British and German army cartridges are being made. During the manufacture, trials have also been made with 7.9-mm and 6.5-mm military cartridges and it was proved then



Lahti Machine Gun, Model 26/32, 7.92 mm.

the functioning and the accuracy of the weapon were equally good as with the above-mentioned cartridges. It is accordingly fully possible to chamber the weapon for every known cartridge powerful enough to operate its mechanism.

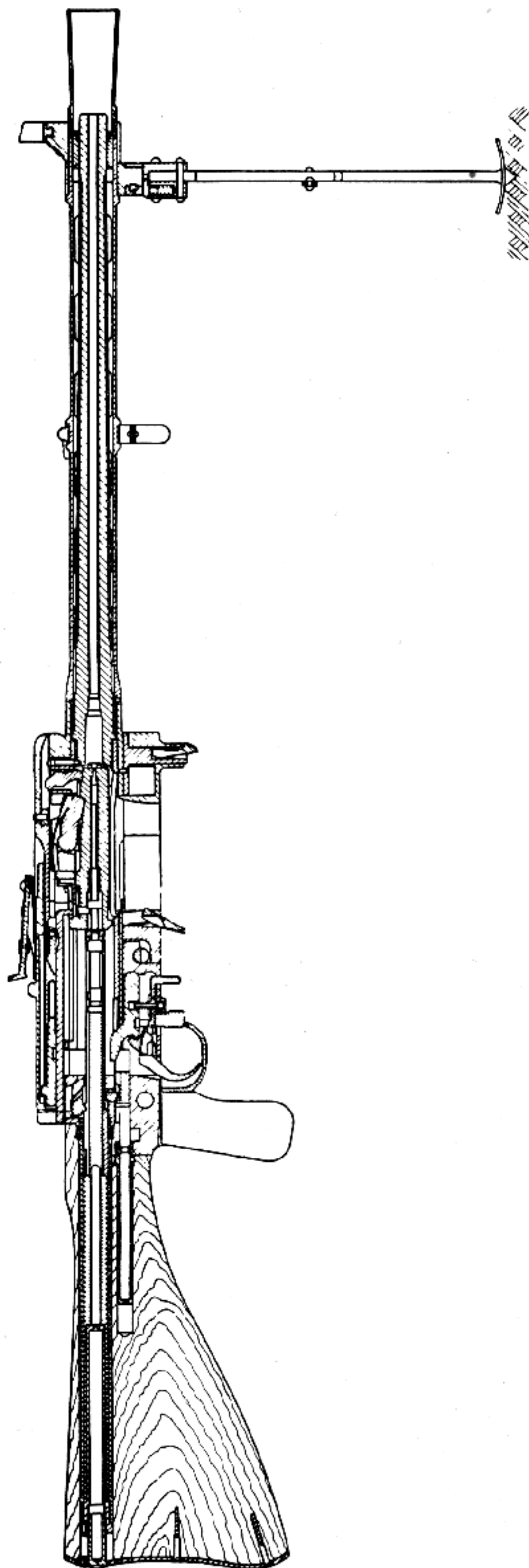
"It must be pointed out as a noteworthy fact, that for countries that use cartridges of different calibers, this machine gun has one great advantage in that it is built exactly in the same way for all kinds of cartridges, with the exception of the easily exchanged recoiling parts which must be changed, of course, on account of differences in chamber and bore measurements. To the recoiling parts belong the barrel, barrel extension and bolt.

"It must be remembered that the receiver is absolutely the same for all recoiling units, so therefore the operational parts are changed as one piece, because the barrel is rigidly screwed together with the barrel extension. . . . All bolts are exactly the same in appearance and dimension provided the cartridge rims do not differ too much. In that case the bolt must also be exchanged. For instance, when firing 7.92-mm, 7.7-mm, and 6.5-mm caliber cartridges it is not necessary to change the bolt because the difference in diameter of the cartridge rims is so insignificant with these cartridges that it does not cause any disturbance in functioning.

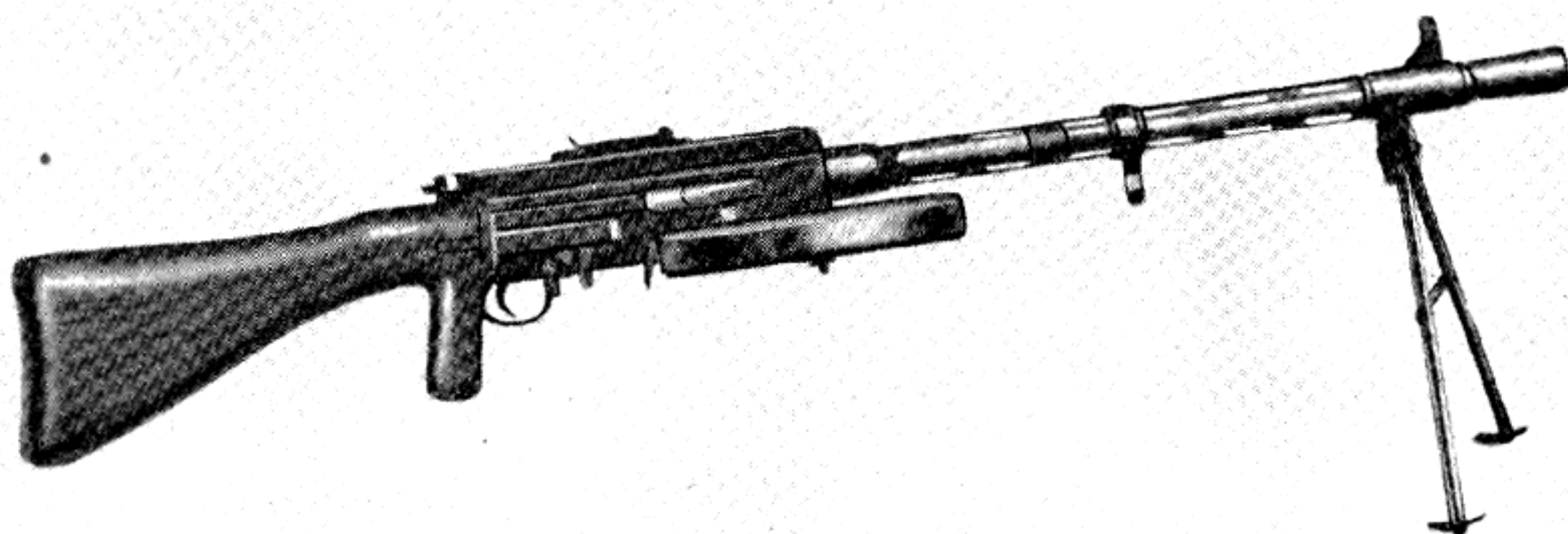
"There is another advantage which must be observed also and that is that in a state of war, in case of capture of any of the above kinds of cartridges, this machine gun can use the ammunition by putting in other operating parts in their own receivers. . . .

"These changes can be made during the actual fighting and they would only take some eight seconds to perform, provided the necessary operating parts are brought along by the machine gun section. *Every state, however, knows its possible future opponent in war, and what kind of ammunition they will use and can always keep a certain number of exchange systems in stock.*"

The feed system is either a spring-loaded clip that holds 25 British caliber .303 or German 7.92-mm cartridges, or a flat drum magazine with a capacity of 75 rounds of the same ammunition. The weapon is chambered for either the British or German Army rifle cartridge, with a maxi-



Section Drawing of the Lahti Machine Gun, Model 26/32.



Lahti Machine Gun With Drum Magazine.

mum rate of fire given as 500 shots a minute. The safety device operates so that, when the slide in front of the trigger is pressed back as far as it will go, a projection comes up under the sear. This makes it impossible to pull it down for release until the device is again moved forward.

For semiautomatic fire, the selector switch is moved off the safe position. As the trigger is pulled, the connector moves downward and draws the sear with it, releasing the bolt. Further pull on the trigger causes a nose on the front end of the connector to turn the latter around on the axle, whereby it is disengaged from the sear. This piece, under spring influence, engages its recess in the bolt before going forward to fire another shot.

The operator must release the trigger so that the connector may again engage the toe of the sear. Another pull on the trigger releases the sear to repeat the two distinct movements necessary for single shot firing.

To change either the conventional box-type magazine or the drum-shaped one, the magazine catch is pressed and the empty magazine removed by pulling down. A fresh one is then inserted, after observing that the holding catches are correctly engaged.

A loaded round cannot be left in the chamber of a hot barrel after a burst of long duration, as the bolt is automatically held to the rear after releasing the trigger. This not only prevents a

cook-off but allows cool air to circulate through the open bore.

The barrel may be removed in a few seconds merely by turning the lever 180 degrees. This releases the catch holding the butt stock to the receiver. Then after lifting the receiver cover, the barrel extension with barrel and bolt can be pulled out to the rear. A cool barrel complete with extension and bolt is then inserted in place of the hot one. To prevent disassembly of the barrel and its hot members, the whole operating unit is changed.

To fire the L/S 26-32 light machine gun, the operator, if using the flat 75-shot drum, first removes the magazine support and pushes the drum up until its holding latch snaps. From the prone position, the charging handle is grasped by the right hand and pulled all the way to the rear. At this point the rising spring-loaded sear engages the notch in the bottom of the bolt, holding it to the rear. The weapon being cocked and ready to fire, the selector switch is moved from *Safe* to *Automatic fire* and the trigger pulled.

As the sear disengages the bolt, it is thrust forward by the energy of the compressed driving spring. The feed rib on top of the bolt shoves the first round out of the lips of the magazine and starts to chamber it. At a distance of one-half inch out of battery, the bolt seats behind the cartridge and the extractor claw snaps over its rim. At the same time the bolt-locking piece is cammed

down into its locking notch on the bolt and this act releases the holding device that has been keeping the barrel and extension to the rear.

The locked barrel, its extension and its bolt start final movement forward and at a point one-sixteenth inch from full battery position a pivoting pin in the tip of the bolt body that has been in the path of the retracted firing pin contacts a ramp in the receiver and is levered up out of the way. The firing pin is now released to fly forward, striking the primer. The timing is such that recoil forces of the exploding powder charge are set up before the fast traveling locked mass strikes the solid receiver, thus utilizing these forces to buff the action.

The recoiling parts are locked securely together for a distance of a half inch; the stud on the bolt lock then engages a cam in the receiver that lifts it out of its locking recess. The movement is done in such a manner as to allow the

bolt to creep a few thousandths of an inch rearward before total unlocking. This permits the extractor to break the gas seal and fully loosen the cartridge during this phase. At the instant of firing, energy is transferred from the fast recoiling barrel to the bolt by means of an accelerator, which, upon pivoting, speeds the bolt to the rear with the extractor holding the empty cartridge case. When its rim strikes the solid ejector, it is knocked out of the slot in the right side of the gun.

The first recoil movement starts to jack the firing pin to the rear and continues to do so until its sear in the top of the bolt drops in front of the circular projection over the body of the pin. The barrel and its extension at the moment of bolt release is held in a retracted position by its holding latch. When the bolt has reached its final recoil stroke, compression of the driving spring starts it into counterrecoil to repeat the cycle.

RHEINMETALL-BORSIG MACHINE GUNS

Introduction

It is appropriate that the background of Rheinmetall-Borsig A. G., the giant of the German munitions industry in World War II, be outlined in order to help explain some of the reasons for the firm's mushroom growth.

On 12 February 1888 the directors of the already established firm of Horder Bergwerk of Westfalen, Germany, accepted a large contract to produce a new style jacketed bullet for the German Army. At the time it was decided it would be more satisfactory to have production of the bullets carried on by a separate company at another location. Consequently, a factory was completed at Derendorf, a suburb of Düsseldorf, on 13 April 1889. It was named Rheinische Metallwaren und Maschinenfabrik A. G., and on 7 May 1889 actual operations began.

The new company's technical adviser and vice chairman of the board of directors was Heinrich Ehrhardt, formerly a manufacturer of business machines in Düsseldorf and later famous as an ordnance engineer and inventor of gun mechanisms. The company prospered from government contracts for artillery and ammunition. A large volume of business for the same materials was also carried on with foreign governments, and at the outbreak of World War I Rheinmetall was second only to the great firm of Friedrich Krupp A. G. in the field of munitions.

During the conflict the company was engaged to the limit of its capacity in all kinds of ordnance production. It then began for the first time development and manufacture of machine guns, making, as did many other plants, the Maxim Model '08.

After the Armistice Rheinmetall's ordnance and munitions division had to be dismantled in accordance with Articles 168 and 169 of the Versailles Treaty. It was suspected and later confirmed that 23,000 tons of the firm's lathes, dies,

drawings, and patents were shipped at this time to neutral Holland and stored in warehouses in both Delft and Rotterdam.

In accordance with other clauses in the treaty, the Inter-Allied Control Commission authorized the two firms, Krupp and Rheinmetall, to construct a limited number of weapons for the then small German Army and Navy. It was specified that the work was to be divided in such a way that Krupp would build all guns with a caliber over 17 centimeters and Rheinmetall all with this bore diameter and below. Krupp was thus confined to production of naval guns, since land cannon as great as 17 centimeters were forbidden to Germany. Consequently, all army weapon development fell to Rheinmetall and between the years 1925 and 1927 the company was permitted to install, subject to Inter-Allied supervision, the many special facilities necessary to carry on such activities.

From this point on Rheinmetall began to formulate plans that would put it in a position to regain its lost world trade. An attempt was made to establish a subsidiary company in Holland under the name of Hollandische Industrie und Handels Maatschappij (HIH), but this venture turned out to be anything but satisfactory. With the severance of its Dutch connection in 1929, Rheinmetall acquired ownership of a concern then known as Waffenfabrik Solothurn A. G. in Solothurn, Switzerland.

This Swiss plant originated as a watch-making concern. Following the war the company had trouble keeping solvent because of the slump in that industry. It was sold at a sacrifice to a Swiss citizen named von Steiger, who previously had been a director in the Deutsche Waffen- und Munitionsfabrik A. G. of Germany. Von Steiger left the employ of D. W. M. when the enforcement of the disarmament clauses in the Versailles treaty by the Inter-Allied Control Commission ended its activity by completely dis-

mantling this mighty automatic weapon manufacturing company.

The new owner converted his establishment to the making of cartridges for small arms and failed financially a short while later. The factory was then taken over by Fritz Mandl of Hirtenberg, Austria. The Solothurn plant, upon passing into Mandl's control, was immediately converted to the manufacture of various types of small arms. It was with Mandl that Rheinmetall dealt in purchasing the Solothurn plant in order to control a weapons factory in a neutral country free from Allied restrictions.

In accordance with the terms of purchase, Fritz Mandl was retained in 1929 as director of the new subsidiary of Rheinmetall. Since the parent company was 51 per cent owned by a German Government holding corporation, and as 90 percent of the ownership of Solothurn was in the hands of Rheinmetall, it can be readily seen that the German military authorities could control its policy. Through the Rheinmetall offices in Berlin, an agreement was also worked out with a large armament factory in Austria and similar contracts were also made with other manufacturers, particularly in Austria and Hungary, for production of component parts of automatic weapons.

It is incredible that in a matter of months after being taken over by the Rheinmetall firm, Solo-

thurn, with its limited facilities, could have manufactured all the weapons known to have been sold bearing its name. Actually it has been found that Solothurn procured the necessary components from inside Germany and Austria and used the plant primarily as a place of assembly.

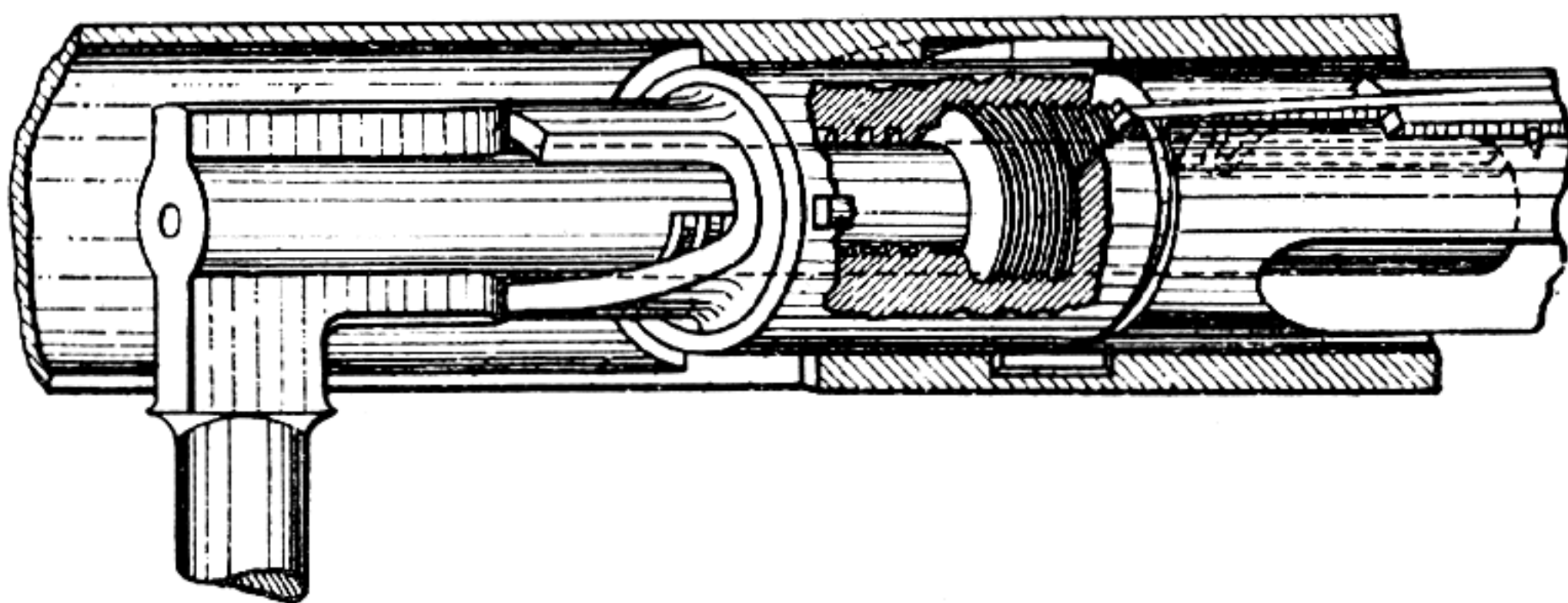
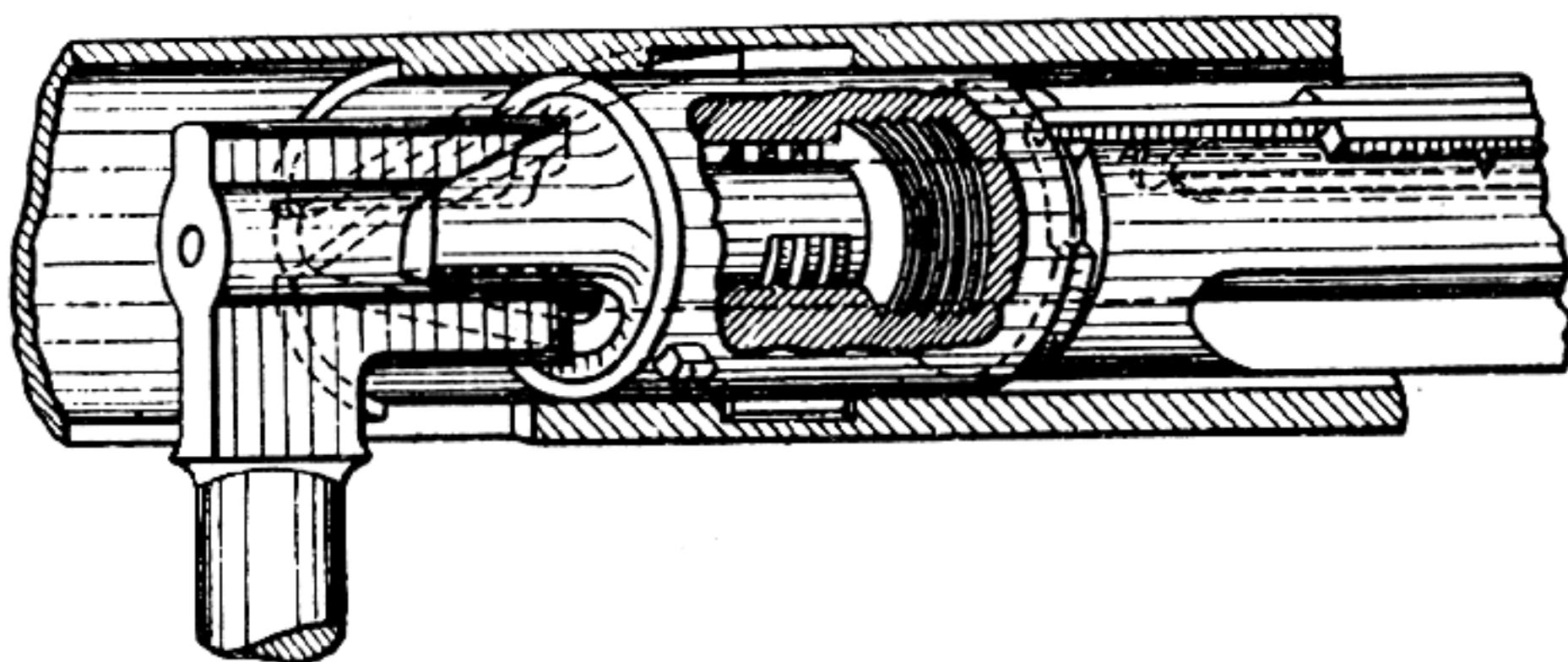
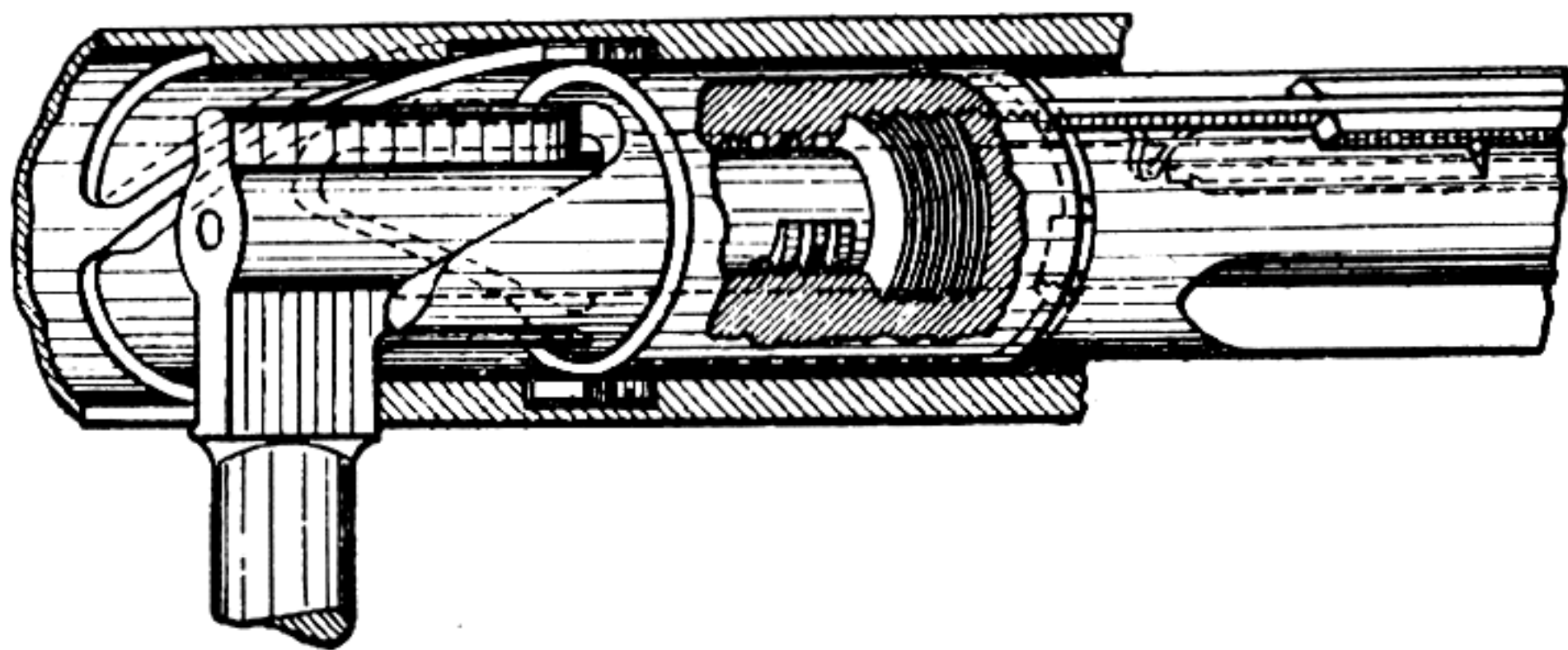
In this manner it served the holding company well. It allowed Rheinmetall to sell not only to nations friendly to Germany, but also to politically hostile ones which needed armament but dared not arouse public opinion at home by buying munitions directly from a German firm. Both Solothurn and the customer nation found it agreeable to hide at the moment behind the shield of Switzerland. Apparently only the Germans knew exactly what was going on, as it will be noted they always possessed a weapon superior to the one being offered for sale. In other words, they could see no harm to the Fatherland in allowing the rest of the world to pay for experimental and development work while they prepared for another war.

Solothurn Model 29

Within 2 months after its sale to Rheinmetall was approved on 4 April 1929 by the stockholders of the old company, Solothurn offered a new machine gun, Model 1929, to the military powers of the world. This would have set an all-time



Solothurn Machine Gun, Model 1929, 7.92 mm.



Drawings Showing Slange's Action. Top: Bolt in Battery, Locked, Ready to Fire. Center: Gun Fired, Barrel Recoil Rotating Locking Ring. Bottom: Locking Ring Fully Rotated and Bolt Unlocked.

high for conception, design, and production had the Solothurn craftsmen actually done this. The truth of the matter was that the weapon was originated and developed at Rheinmetall by Louis Stange, who is rated among the best of Germany's many fine automatic arms designers.

Stange first started work in the Theodor Bergmann arms factory at Suhl as an apprentice of Louis Schmeisser, one of the most prolific creators of sound automatic weapon systems in all Europe. They included self-loading pistols and submachine guns in addition to refinements on already existing mechanisms. Schmeisser, like Stange, became affiliated with Rheinmetall and assigned many of his patents to this company.

Most of Germany's other talented mechanics who had shown their ability to produce successful automatic gun mechanisms were also on Rheinmetall's technical staff. The most outstanding of these designers were Karl Heinemann, of Berlin, developer of the Parabellum action in World War I, Fritz Herlach, Karl Voller, Alfred Krum, all of Düsseldorf, and Herman Henning and Wolfgang Rossmanith, of Berlin.

These names are given to show the significance of the following statement made by Solothurn in literature announcing its debut in the gun-producing business:

"The Waffenfabrik Solothurn A. G., of Switzerland, is authorized to copy and reproduce all patterns of construction of the Rheinische Metallwaren und Maschinenfabrik A. G. (Rheinmetall-Ehrhardt), of Düsseldorf, Germany."

With the financial backing and the design genius that was thus made available to the small plant located outside of Allied jurisdiction, there is little wonder that many fine weapons began to make their appearance bearing the name "Solothurn."

The Solothurn Model 1929 was an air-cooled, short-recoil-operated machine gun of very light construction, weighing only 17 pounds. The barrel was chambered for the German 7.92-mm infantry rifle cartridge. It was of extremely simple construction with few component parts. These pieces, as the promoter pointed out, were machined almost exclusively in lathes. Thus the manufacture of spare parts would offer no difficulty to any government that purchased them. South American countries were particularly in-

terested in them because of being able to make needed replacement parts in their own machine shops.

The bolt was cylindrical in shape with a central locking ring rigidly holding the bolt and barrel together by means of six interrupted threads. The striker was enabled, by the removal of the obstruction at the time of locking, to continue on into the primer of the cartridge. This method was known as timed inertia firing. When the magazine was emptied by the discharge of the 25 cartridges, a catch then rose and held the bolt in the cocked position. It also warned the operator that it was necessary to place a fresh magazine in position. The safety was a device that locked bolt and trigger together, allowing the insertion of a loaded magazine with the bolt locked on safe.

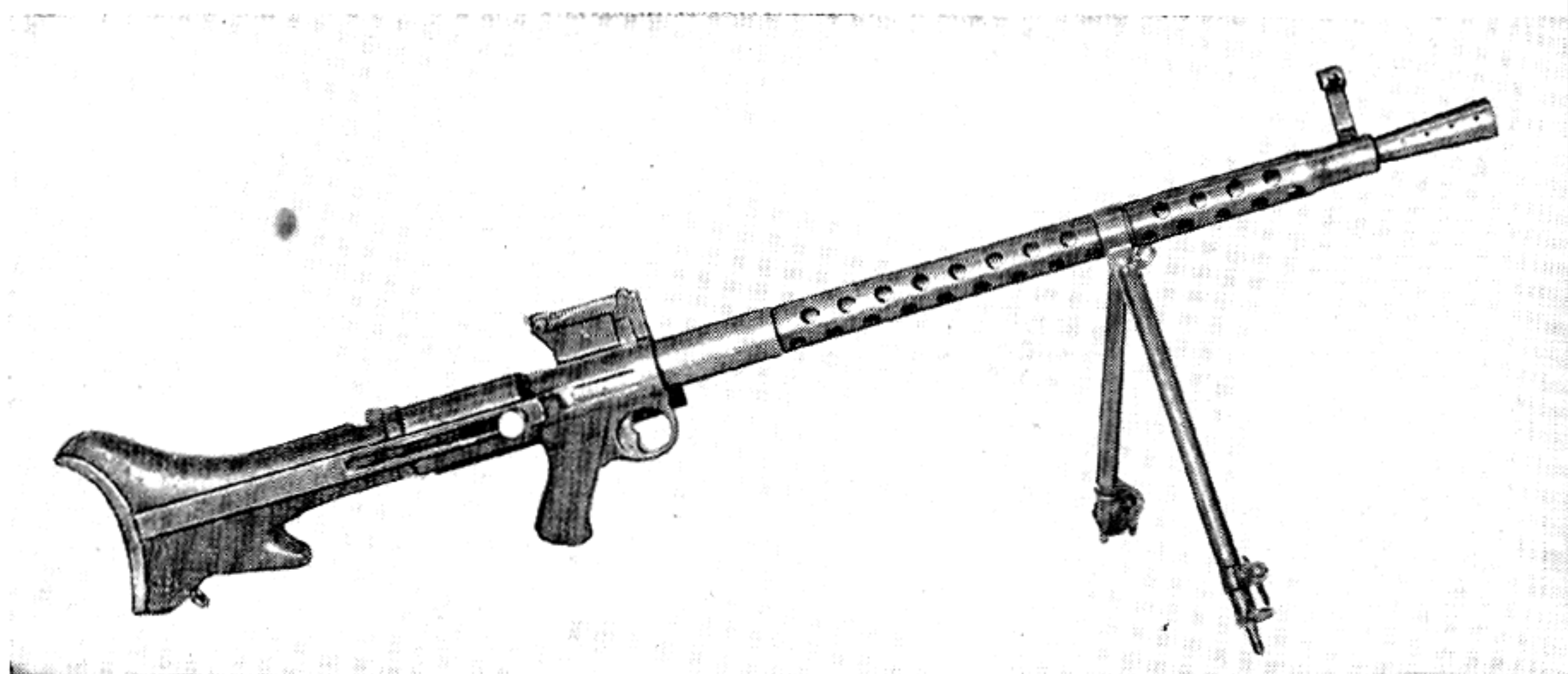
Single shots, or automatic firing, of the Solothurn Model 1929 could be accomplished without interrupting the gunner's aim. The operational energy was derived from the recoiling masses. Under heavy strains brought about by abnormal testing conditions, the mechanism proved to be very reliable.

MG-30

These weapons had hardly been made available when Solothurn—as Rheinmetall's outlet—put on the market a more refined version, designated by the factory the S-2-200, and by the German Army the MG-30. Its method of operation was basically the same as that of the earlier model.

A considerable number were sold to European governments. Austria, for instance, adopted the gun in 8-mm bore, calling it Model 30; while Hungary put it into her service with the designation, Model 31. In the next 5 years these nations alone purchased over 5,000 S-2-200 light machine guns. That the two neighboring countries accepted this type is quite understandable since the Steyr arms factory, in Austria, is credited with furnishing everything about these weapons except for assembly, which was done at Solothurn.

As with the earlier model, when the last shot was fired, the bolt stayed in a retracted position. The loaded magazine could be inserted regard-



Solothurn Machine Gun, Model 1930, 7.92 mm.

less of the position of the bolt. Two circular depressions were cut one above the other on the front face of the trigger. Pressure on the top one gave single shot operation, while a pull on the lower portion delivered automatic fire. This permitted the operator to change from one to the other without interference with his aim.

The barrel of the MG-30 also was air-cooled, but a different provision from that of the earlier versions was made for changing it. The switch from a hot barrel to a cool one was done in a quick and unique manner. The shoulder piece was moved from the receiver by pressing on a locking spring. The stock was then turned 60° to the left and pulled backward, the driving spring and its guide remaining in the rear housing. The barrel, with the attached bolt and carrier assembly, then were shaken out of the receiver to the rear. The assembly was disconnected from the hot barrel and placed on a cool one. The replacement was then inserted in the jacket and the procedure reversed.

The German Army ran a 100,000-round test on the model and reported very good results. However, it was not adopted for general service, although many were used for drill purposes.

When the MG 30 is fired, the barrel, bolt, bolt extension, mainspring guide, and locking ring move backward under action of recoil as a rigid assembly with respect to the receiver. At a predetermined distance, the rollers on the lock-

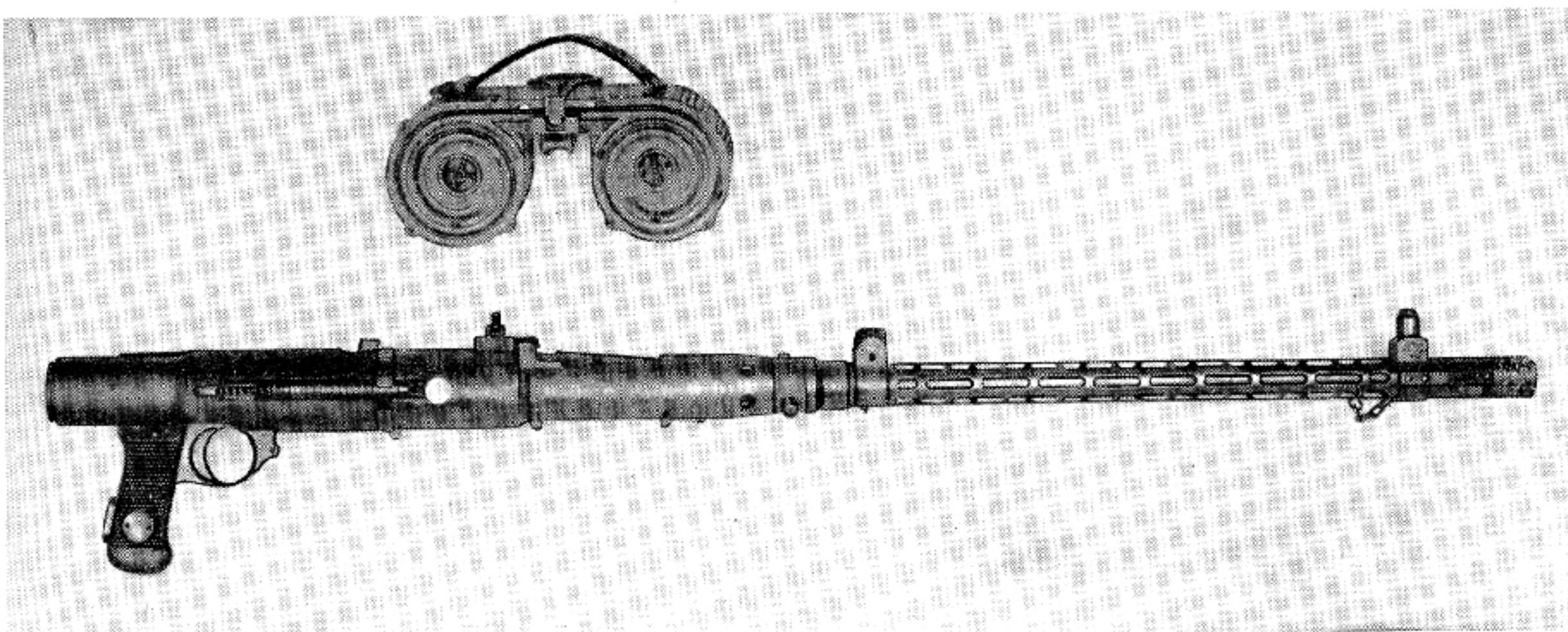
ing ring engage the spiral groove in the walls of the receiver.

Further rearward movement turns the locking ring and unlocks the bolt. At this point the recoiling of the barrel, bolt extension, and locking ring is checked by a buffer and they are held in this retracted position. The bolt and mainspring guide now move rearward under the accelerated force imparted by the spiral grooves, as the extractor withdraws the empty cartridge. Further recoil ejects the case and compresses the main driving spring. When these parts have reached the extreme distance they can travel, counter recoil commences.

As the bolt moves forward, it picks up a round from the magazine and chambers it. The bolt, being seated in its carrier, pushes the carrier, barrel, and locking ring forward. The latter, turning under the influence of its lugs, engages the spiral grooves and locks the assembly. When the bolt first starts into counterrecoil movement, a sear engages its notch in the firing pin, holding it while the rest of the assembly continues on to compress the firing-pin spring. The final movement of going into battery automatically releases the firing pin.

MG-15

In 1932 Rheinmetall presented the German Air Force two weapons that were the outgrowth



Rheinmetall Aircraft Machine Gun, Model 15, 7.92 mm.

of the MG-30. Both were rifle-caliber aircraft machine guns and were given the designations, T6-200 and T6-220. They were promptly adopted by the German aviation section the following year and officially named the MG-15 Fixed and MG-15 Flexible.

Only minor modifications were made from the MG-30 to adapt them to aircraft use. If examined closely for comparative purposes, there was no difference in the basic action of these weapons and of Stange's earlier models. The rate of fire on the aircraft version, however, was increased from 750 to 1,000 or more shots a minute by the employment of a muzzle booster with a restricted orifice. Ammunition was carried to the fixed gun by means of a metal disintegrating belt. An odd but efficient recoil-actuated ratchet-type feed system indexed each round and could feed from right or left, as desired, by the mere repositioning of parts.

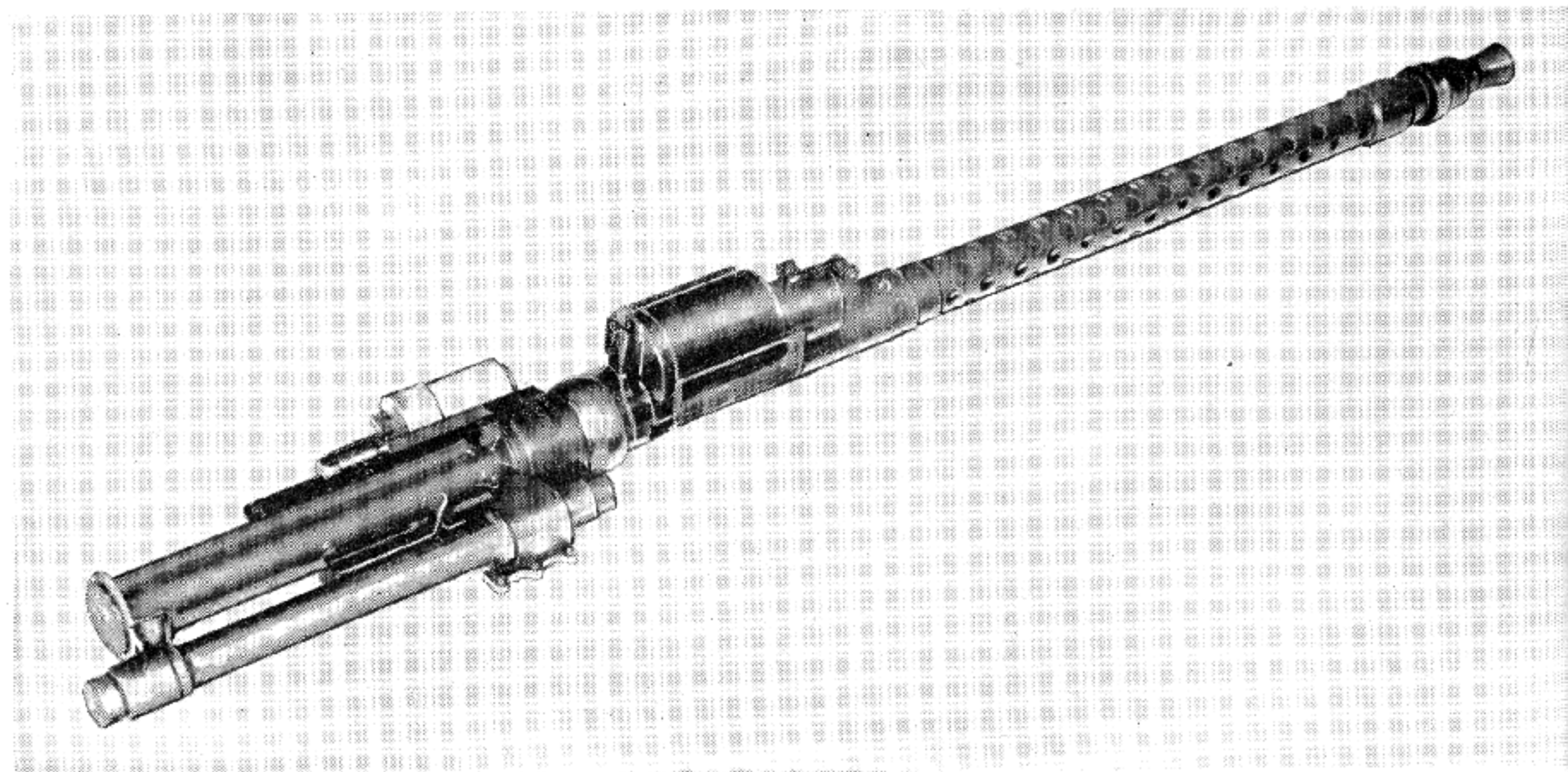
On the MG-15 Flexible gun, ammunition was fed from a twin-drum magazine, holding 75 rounds. The cartridges were lodged in two containers fitted to the right-hand and left-hand sides of the gun. In this system of cartridge feed by twin drums, the two halves of the drum were alternately emptied, so that the center of gravity was not affected by the gradual emptying of the container. The magazine could be changed with one hand in a very short time.

The MG-15 Fixed gun would fire on an average of 200 rounds a minute faster than the one

with flexible mount. This was due to the rigidity in mounting the stationary gun that could utilize more of the recoil force of the exploded powder charge. The fixed gun was also easily adapted to fire between the propeller blades by use of a synchronizer. One particularly bad feature about the wing installation, however, was that, in the event of a condition known as a runaway gun, no provision was made for stopping it and uncontrolled fire would continue until all ammunition was expended.

MG-17

The German Air Force decided that, while the lightweight high-speed MG-15 had many good features, it could still be made more suitable for aircraft use if it were not rear seared after each burst, since this presented a serious synchronizing problem. The cocked bolt was considered essential in designing ground-type weapons in order to leave the overheated chamber empty after each burst and prevent cook-off of the loaded cartridge. It was not considered a critical factor, however, in aircraft installations. The fixed weapons could be cooled with high velocity air by ventilation and, if a cook-off were to happen, there was little danger of the bullet striking friendly materiel or personnel. In addition, guns were being mounted in the wings outside the propeller arc and were divorced from any attention or maintenance from the pilot



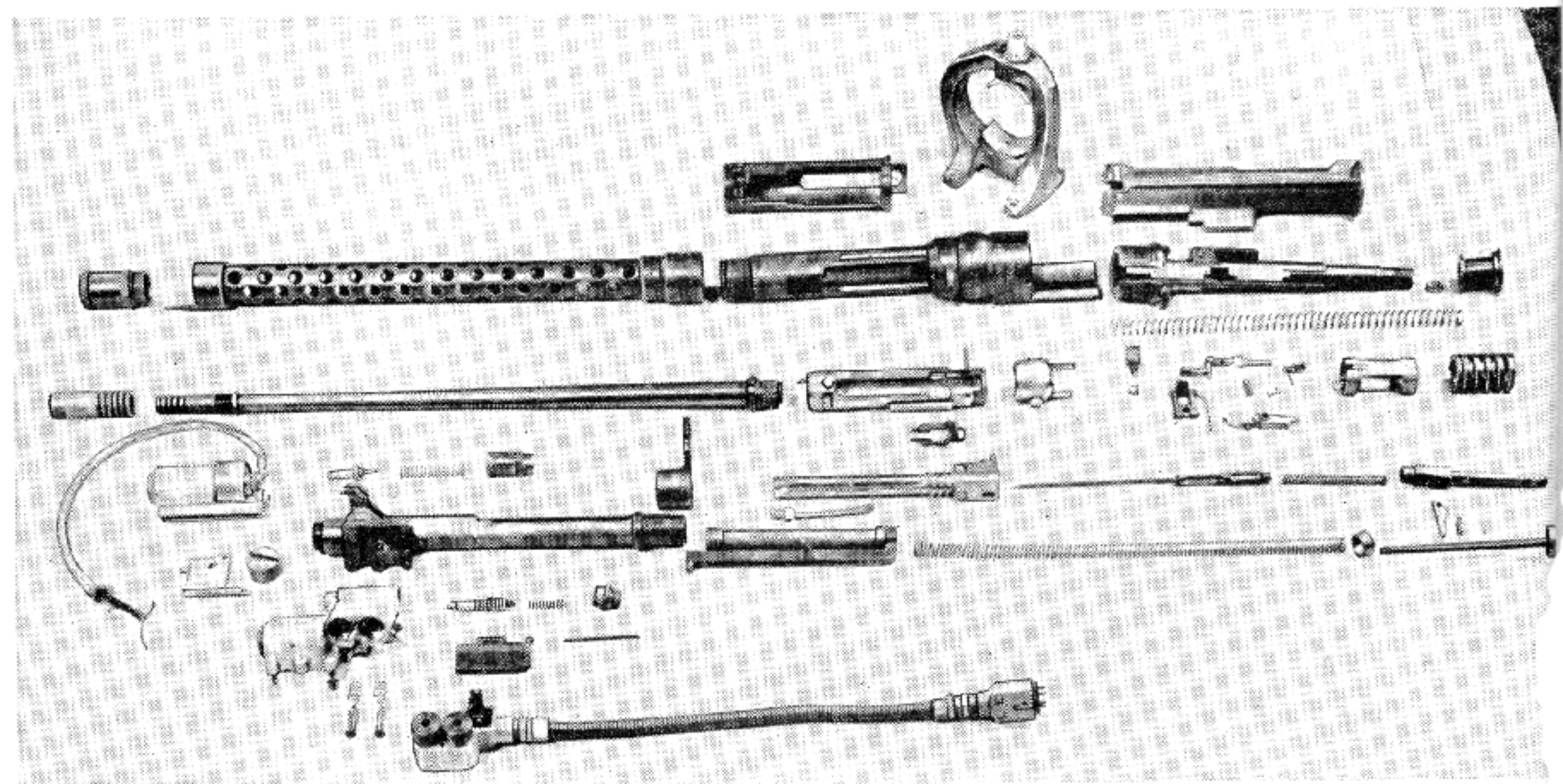
Rheinmetall Aircraft Machine Gun, Model 17, 7.92 mm.

gunner. This necessitated the use of devices that performed the functions of charging and firing the weapons by remote control.

With these problems in mind Rheinmetall designers made several improvements on the original MG-15 by modifying it so that it could be loaded and cocked by means of a charging device. It was actuated by compressed air and

then fired by an electrically controlled trigger contrivance called a solenoid.

In order that this closed-bolt firing version operating by remote control would not be confused with the models not having the above modifications, this machine gun was officially known throughout the German armed services as the MG-17. Other than the refinements mentioned



Components of the Rheinmetall MG-17.

there was no difference between it and similar Rheinmetall guns that preceded it.

The abnormally high speeds demanded of aircraft machine guns made head-spacing a critical dimension. Provision was made on this gun whereby an ordnance man in the field could arrive at this measurement quickly and efficiently by use of a case-hardened gage. The instrument was made in the form of a cartridge to be inserted in the chamber. The bolt latch was raised and the bolt lock rotated until pressure was felt. It was also necessary, when head-spacing the MG-17, to make a compensating adjustment on the solenoid. Consequently, they were manufactured with four choices of measurements designed to take care of any permissible head space movement.

The charging device was operated by compressed air, the planes first being equipped with small compressors that operated off the main engine and later with cylinders that were charged on the ground. Carbon dioxide bottles were also used but it was found that, although this method was most efficient under certain conditions, it had a tendency to freeze up the mechanism of the charger, because of the extremely low temperature of the expanding gas.

MG-131

Shortly after the introduction of the MG-15 by the German Air Force, negotiations were started for the amalgamation of Rheinmetall with then bankrupt Borsig works, which had an enormous well-equipped plant at Tegal, a northern suburb of Berlin. In the past the firm had made locomotives and other heavy steel fabrication. On 1 January 1936 the deal was completed and Rheinmetall-Borsig A. G. first came into existence.

Hitler then held full power over Germany and Herman Goering had been given the responsibility of building up German aviation might. One of Goering's first official acts was to make a former World War I squadron mate chairman of the new corporation's board of directors. This officer was Rettmeister Bolle, a much decorated fighter pilot, and he sought to show the fatherland that he was worthy of the "Pour Le Merite" by introducing improved aerial weapon design.

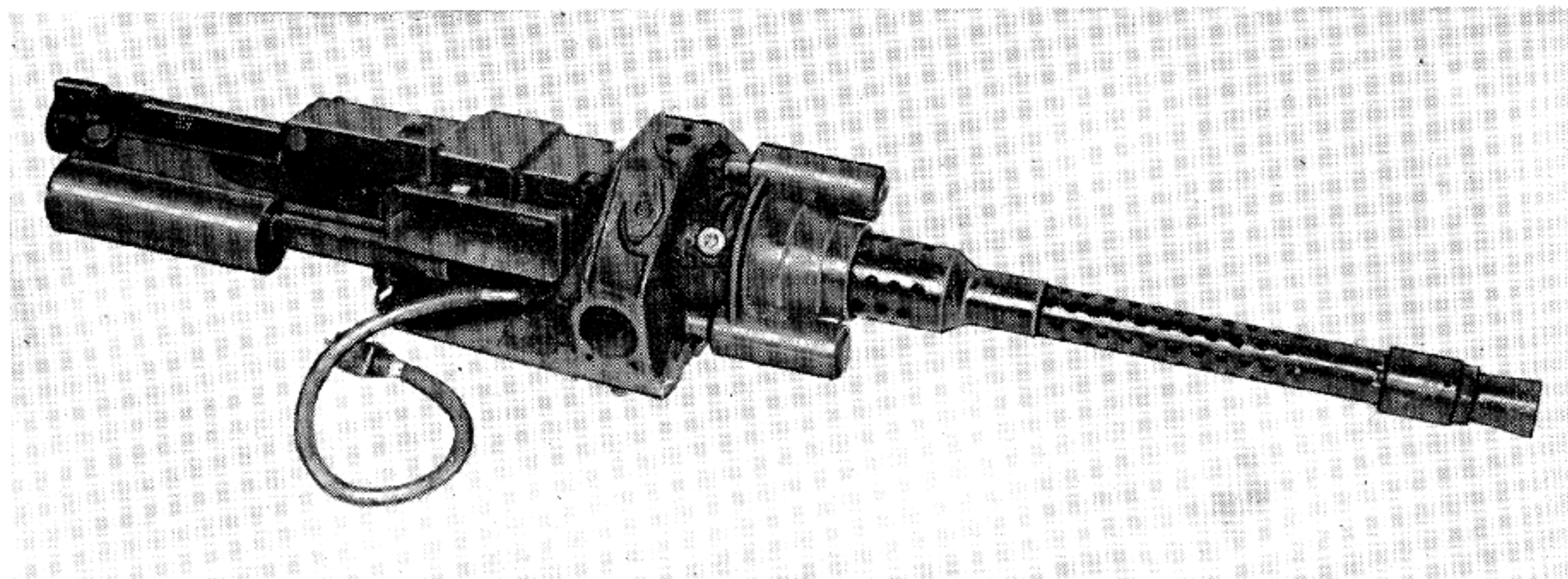
The German Air Force well realized its need for a high-speed light machine gun chambered for a caliber larger than the standard rifle cartridge. As soon as the restrictions placed upon them by the Allies were lifted, a directive from Goering to the Rheinmetall-Borsig firm ordered it to develop and produce a suitable weapon in this category. The resulting machine gun was given the official marking, MG-131.

This belt-fed, air-cooled weapon weighed only 40 pounds, and had a rate of fire officially accepted as 960 rounds a minute. The most important thing, as far as the Germans were concerned, was that it was chambered for a specially constructed 13-mm cartridge propelling a bullet with the high velocity of 2,560 feet. In addition to being light and reliable for its larger caliber, another advantage was the use, in place of a standard percussion striker, of a spring-loaded firing pin that detonated the primer by means of electricity. The greatest benefit of this method of detonation was for synchronization and fire interruption.

Although Louis Stange first started work on such a gun in 1933, it was not until Germany was on the threshold of war in 1938 that the weapon made its debut, and then in the greatest secrecy. Germany wanted her potential enemies to believe she still had nothing larger than the 7.92-mm aircraft machine gun.

Its initial appearance was in very limited numbers for paired installation in turrets, being the first heavy caliber machine gun to be used in a German land plane. A pair was mounted in a power-driven turret on the DO-217E2. This plane also carried another MG-131 in the rear central position, which, however, was operated manually.

The feed system was interchangeable from left to right, and vice versa, by repositioning of parts. Empty cases were ejected through a slot in the bottom of the receiver, a very necessary feature for aircraft use. Cocking, when done by hand, was accomplished by use of a ratchet handle that required $8\frac{1}{2}$ strokes for full retraction of the parts. When not in operation, the handle, which was the invention of Georg Engel and Alfred Winter, two Rheinmetall engineers, folded down out of the way and was shoved for-



Rheinmetall Aircraft Machine Gun, Model 131, 13 mm, Fixed.

ward. It could be changed if need be from one side to another.

When the bolt was locked to the barrel, as in battery, it required more energy than most individuals possessed to pull the action back against both the driving and barrel springs until the rotary locking ring released the bolt. This made necessary a hand-charging arrangement, so constructed as to give the gunner great mechanical advantage when performing this act.

A metal disintegrating push-out-type link belt was always employed in getting ammunition to the feedway. No provision was made for single shots with this weapon. When the selector switch was turned on, the result was full automatic fire only. The buffing system was new in relation to earlier models. It used multiple springs in order to dampen the shock and friction by acting as a brake shoe upon a sleeve which is locked to the receiver.

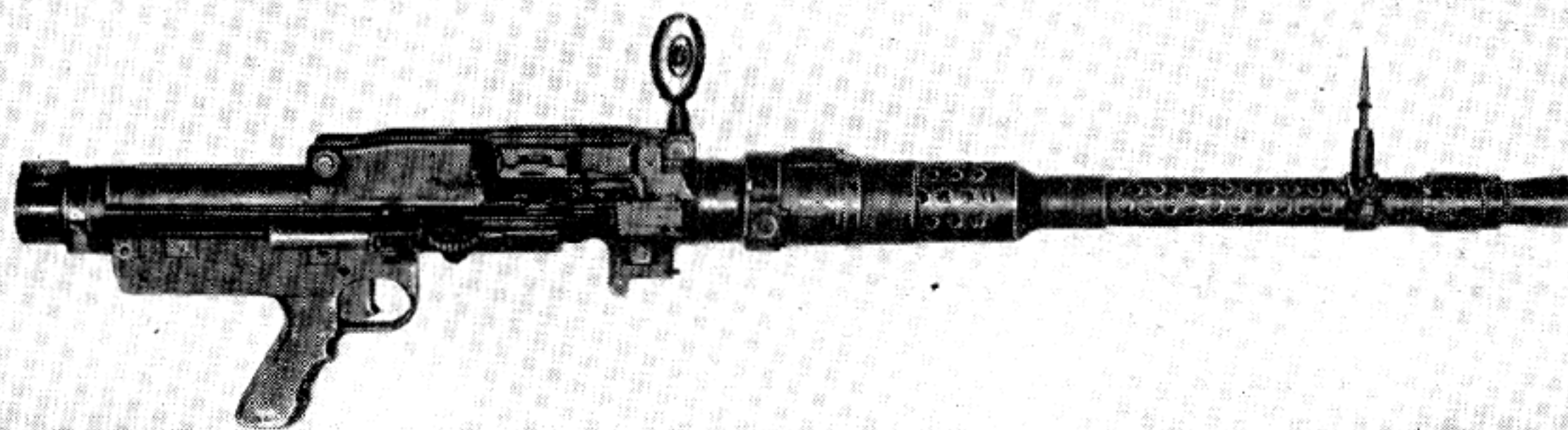
The mechanical safety device took the form of a lever which rotated the sear lock in the path of the sear and also cut off the electrical detonating current. Ahead of the stationary receiver there was housed the barrel return mechanism, which in addition to the heavy ring spring comprised a rotating locking sleeve and a coupling device between the barrel and breech. The rear end of the receiver contained the bolt and driving spring.

The ammunition feed system indexed each round half by recoil and then completed the operation by counter-recoil. Two sets of rollers

in the cover group engaged ramps machined along the top of the bolt. When feeding from left to right, the bolt being in recoil, the outboard rollers would climb the inclined surface on the bolt and cause the outer feed pawl to index a round into position for stripping. The center pawl meanwhile was extended its full throw to snap behind the next round.

When the bolt started back to battery after having picked up the positioned round from the feedway, it would cam up the inboard set of rollers. This movement retracted the center pawl, moving the incoming round over one half space and at the same time sliding over the outside pawl behind the cartridge. When the cycle was repeated, the recoiling movement of the bolt completely indexed the incoming cartridge which was then chambered by counter recoil. This simple method relieved the bolt of high side loads and resulting friction usually found in track-type feed levering systems.

The MG-131 had Stange's patented locking ring with several added features that, while not original, were somewhat radical in design. For instance, barrel recoil was speeded up by a gas booster, which in turn transmitted energy to the bolt by a pivoting accelerator acting on the under side of the bolt at the instant of unlocking. The barrel, after three-fourths inch of recoil, was held in the retracted position by a sear device that was tripped only after the bolt contacted the barrel, allowing the parts to lock on the way into battery. This permitted the timing



Rheinmetall Aircraft Machine Gun, Model 131, 13 mm, Flexible.

of the firing mechanism whereby the powder charge could be exploded and recoil forces set in a few hundredths of an inch before the fast and heavy moving parts collided with the rear end of the stationary receiver. In high-speed weapons especially, the act of buffering the action on counterrecoil not only insured longer parts life but gave smoother performance.

Another of Stange's typical features on this weapon was that the forward top surface of the bolt was movable up and down and spring loaded so as to remain in the up position. He had noticed that, in order for the incoming round not to interfere with the bolt body when being moved into position, a long bolt stroke was necessary. Sufficient distance was thus given for it to be moved into place after the bolt had recoiled beyond the base of the round in the feeder. The new device permitted a shorter stroke and raised the cyclic rate.

As the bolt, with its pivoted, spring-tension top recoiled, the cartridge was indexed in the stripping position and as the movement continued, the top came in contact with the under side of the cartridge case to depress the pivoting surface of the bolt. It slid easily under the round and as soon as the bolt face cleared the rim of the cartridge, the spring snapped the front part of the bolt face up to push the base of the cartridge out of the link.

Ammunition for the MG-131 consisted of either high-capacity explosive bullets or armor-piercing ones containing incendiary or tracer elements in the base. The explosive bullet had a supersensitive impact fuze that was completely bore-safe. The armor-piercing bullet was unusual in that it employed a rotating band and

the tungsten-hardened projectile was not enveloped in a gilding metal jacket.

The German Air Force held the MG-131 in high regard. At the outbreak of the war, when its fighters found themselves with only 7.92-mm guns attacking British bombers armed with Browning caliber .30, the situation called for immediate installation of the high-speed 13-mm weapon in all attack planes. Eventually it too became obsolete from the trend to automatic weapons of even higher cyclic rates, capable of firing a shell with considerably more bursting charge.

The MG-131 was produced for the German Luftwaffe by these firms: Rheinmetall-Borsig, of Berlin; Deutsche Waffen- und Munitionsfabrik A.G., Posen; I. C. Wagner, Muhlhausen; and Heinrich Krieghoff Waffenfabrik, Suhl.

To fire the weapon, the gunner first positions a loaded belt in the feedway and, if it is to be manually operated, jacks the ratchet-type cocking handle back $8\frac{1}{2}$ strokes until the rear sear engages its recess in the bottom of the bolt. By actuating the solenoid, the sear is disengaged and the operating parts sent forward by the driving spring. The pivoting member on top of the bolt strikes the indexed round, driving it into the chamber. The bolt assembly, moving forward, contacts the barrel and a camming angle on the left side of the bolt engages the barrel release catch, forcing it down. Upon being freed, the whole assembly starts toward battery under tension from the heavy barrel return spring, and the bolt and barrel are locked together as the locking ring is rotated one-quarter turn clockwise.

On the right side of the receiver near the breech end of the barrel is an electric switch. It energizes the circuit when the whole counter-recoiling mass is one-sixteenth inch out of battery. The weapon then fires and recoil forces start in before the bolt and barrel strike the receiver. With the building up of the peak powder pressure and for a half inch of free travel during recoil, the bolt and barrel continue rearward as one unit. The lugs in the receiver then rotate the locking ring a quarter turn counterclockwise and unlock the recoiling parts. The barrel hold-back device is thereby forced out, retaining the barrel in its retracted position.

Coincidental with the unlocking, a pivoting accelerator located in front of the bolt transmits the energy of the recoiling barrel to the bolt face and speeds this part to the rear.

After initial extraction, the extractor withdraws and holds the loosened round until, upon contact with the ejector, it is kicked through the bottom of the receiver. The bolt continues towards its rear buffer. The recoil feeds a cartridge over one-half space, and in counterrecoil it is completely indexed. The driving spring, now being fully compressed, throws the bolt into counterrecoil, and as long as the solenoid is energized, the cycle of operation is repeated.

SCOTTI MACHINE GUNS

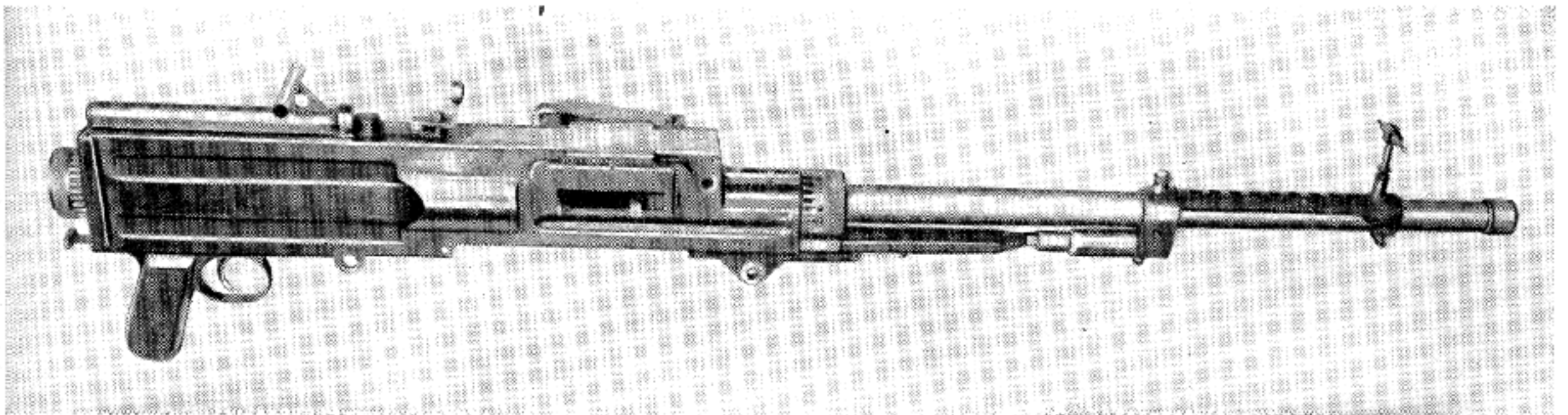
In 1928 there appeared the first of a series of machine guns by an Italian designer named Alfredo Scotti, who maintained offices in Brescia, Italy. In practicing his profession, Scotti always depended upon companies with manufacturing facilities to make and promote the sale of his weapons on a contract and royalty basis. His place in design history rests upon the exploitation of a single principle or system. In itself, it was not original, being based solely on the act of unlocking by rearward movement of a gas piston at a time when a high enough residual pressure remained in the chamber to complete the cycle of operation. While automatic firing mechanisms bearing the name of Scotti range from pocket pistols to cannon, they all have the rotating bolt head actuated by a gas piston.

A number of firms have been associated with weapons designed by Scotti. The Grandi Co., located at Solbiate, Italy, near Milan, manufactured many models for test including sub- and light machine guns and a 20-mm cannon. The Ansaldo firm in Italy produced a light machine gun and a 37-mm automatic cannon that was entered without success in an Italian Navy test in 1931. The main producer of Scotti's models was the Isotta-Fraschini Co., Italy's largest automobile and aircraft engine manufacturer. It fabricated one or more models of 30-mm cannon and several aircraft machine guns ranging in

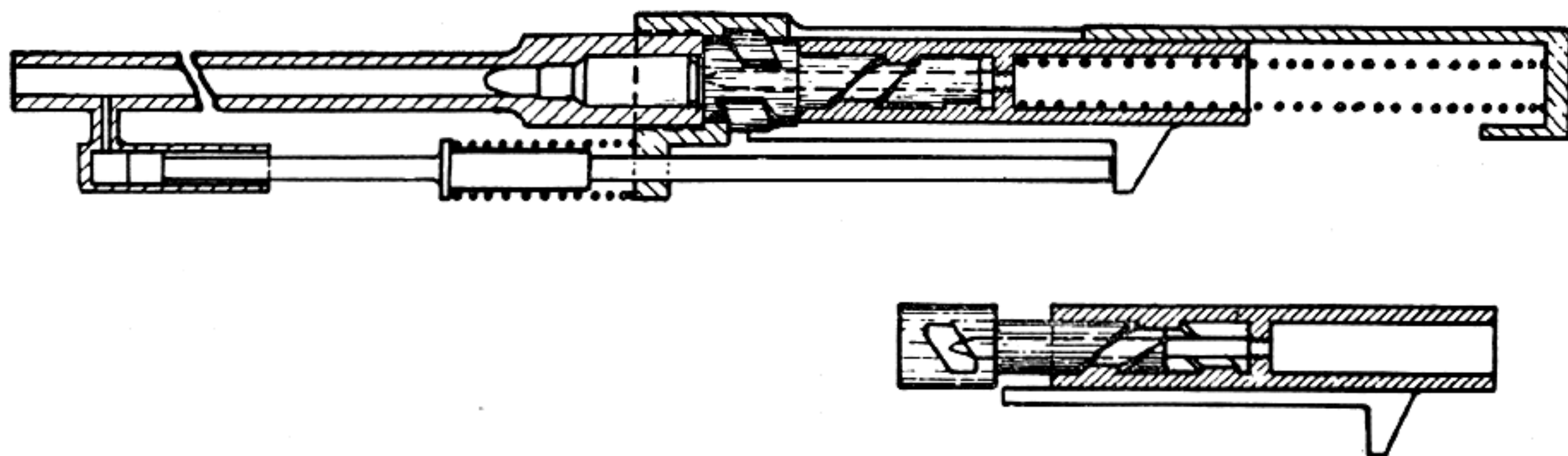
bore from 6.5 to 12.7 millimeters. Guns made by this company in 7.7 and 12.7 millimeters were used to a limited degree by the Italian Air Force throughout World War II.

Scotti's activities were by no means confined to his native land. To handle the manufacture and sale of his weapons in all countries outside of Italy, he established Scotti-Zürich, a firm in Zürich, Switzerland. Some of the main components for these guns were made by the Swiss firm, Oerlikon, while lesser ones were obtained by contract from the Swiss Industrial Society at Neuhausen. In November 1932, Oerlikon purchased outright Scotti-Zürich, including all foreign rights to Scotti-type guns. Italian rights were reserved by Isotta-Fraschini.

The only variations in Scotti guns were in size and external appearance. The most radical of his designs on record was his triple-barrel machine gun, made in bores of 6.5 to 8 millimeters. It employed a handle to rotate a fresh barrel into position, thereby allowing the gunner to keep up continuous fire by having a cool barrel available at all times. While this may have seemed very original to Scotti and he was given a patent on it, both he and the patent researchers must never have seen the specifications of the hand-operated Lowell gun, recorded in the United States in 1875.



Scotti Aircraft Machine Gun, 7.7 mm.



Drawing of Scotti's Action. Top: Bolt in Battery and Locked. Slide in Forward Position to Prevent Bolt Head from Rotating. Bottom: Slide Retracted by Gas Piston, Allowing Bolt Head to Rotate and Unlock.

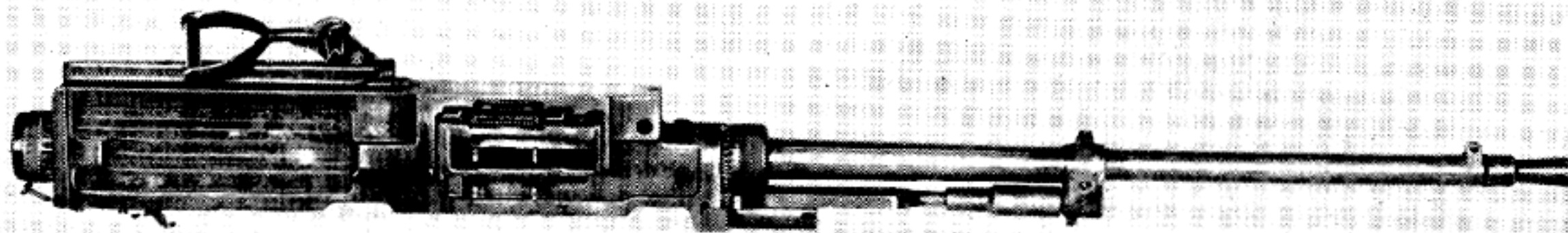
On one model Scotti used a feed system that had been patented previously by another Italian, Giuseppe Perino, in 1901. This method of feeding was accomplished by a metal strip housing each cartridge individually. The bolt pushed the loaded cartridge out of its housing and after being fired, replaced it in its original position on recoil stroke. The metal clip was indexed over one space after each shot and was ejected completely out of the right side when the last round was fired.

To fire any weapon of the Scotti system, the operator installs a loaded belt, strip, or drum, as the case may be, and pulls the firing mechanism to the rear by the charging handle. This first movement unlocks the bolt and retracts the firing pin. The assembly is held in the cocked position under tension of the compressed driving spring. By actuating the trigger, the sear is released and the bolt starts home, stripping a round out of the feedway, and pushing it ahead as the two-piece bolt starts into the last phase of chambering the round. Lugs on the forward part

engage cams in the barrel extension, giving the bolt head a fraction of a revolution turn and locking the barrel and bolt head together.

The firing pin is housed inside the bolt and is attached to slides that, upon removal of the obstructing lugs, are forced forward by both inertia and driving-spring pressure. The firing pin is directed into the primer which detonates the propellant charge. When the projectile passes a port in the barrel, sufficient gas is bled into a cylinder that houses the gas piston. This closely metered gas gives the piston a slow backward thrust movement at just the right instant to permit contiguous slides to move rearward, allowing the bolt head to rotate while a high residual pressure remains in the bore.

The locking lugs being inclined at an angle of 60° make unlocking require little energy, as the gas pressure acting on the face of the bolt would rotate the lugs and unlock were they not covered by the slides. The latter having retracted the attached firing pin, the whole mechanism starts to the rear, with the operational force now



Scotti Aircraft Machine Gun, 12.7 mm.

coming from the remaining gas, or blow-back. The empty lubricated cartridge case, being held to the bolt face by the extractor, slips back with the recoiling bolt and is pivoted out of the receiver upon making contact with the ejector.

The bolt continues to recoil until stopped by contact with its spring-loaded buffer and compressed driving spring. If the trigger continues to be depressed, it then starts on its counter-recoil stroke to repeat the cycle of operation. Release of the trigger pressure causes the sear to rise and engage the recess in the rear of the bolt, holding the entire bolt assembly to the rear.

While this action was undoubtedly retarded blow-back, it should not be confused with other methods, particularly of Italian origin, where the whole bolt assembly creeps rearward at the instant of firing and opens up progressively afterwards. The Scotti principle positively locked the bolt and barrel together and the gas bled into the cylinder was for the purpose of unlocking only. This system most certainly was not new, as Mannlicher used it successfully and patented it in 1899, even to the rotating bolt head for unlocking. However, Scotti gave it greater use, as he employed it in everything from hand gun to cannon.

BANG AIRCRAFT MACHINE GUN

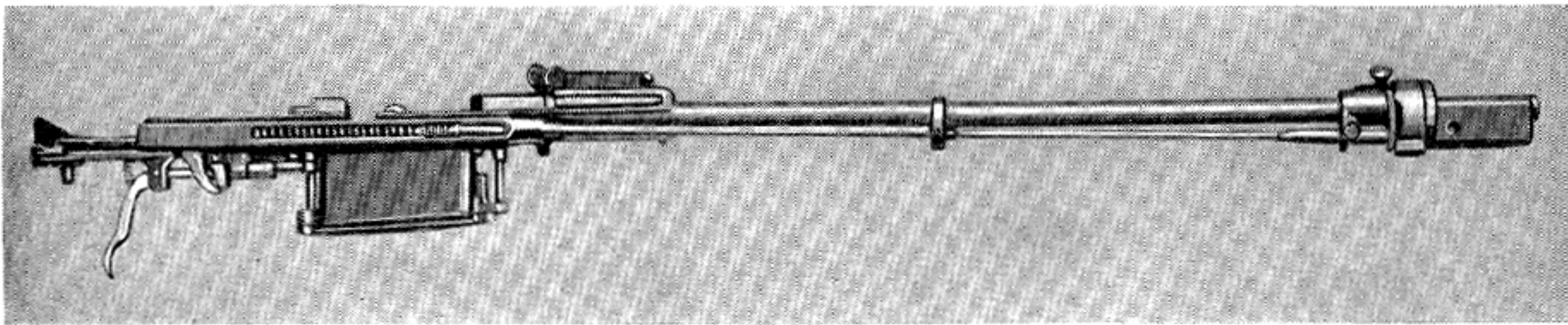
The Danish Rifle Syndicate of Copenhagen, Denmark, in 1929 formed a company to produce a caliber .276 flexible aircraft machine gun to be known as the Bang. The weapon was the invention of Soren Hansen Bang, an employee of the Syndicate. It used a method of capping the muzzle with a cone-shaped device.

This system was by no means new, having been patented by Sir Hiram Maxim and used successfully by John M. Browning on his first experimental model in 1889. Its main drawback was that it demanded many clumsy accessories to accomplish very little. Even the preliminary operation was only begun well after the bullet left the bore, which made the method notoriously slow. After one working model was constructed and factory tested, the project was dropped. There is no record of another of the Bang aircraft machine guns being made.

The method of firing the weapon is as follows:

After a loaded magazine is put in place and the action charged, a pull on the trigger fires the piece. The bolt remains securely locked behind the base of the cartridge until the bullet leaves the bore. The muzzle has a cone-shaped device that can slide parallel with the barrel and is attached by means of rods to the locking system. The expanding gases are trapped in the cone after the bullet is clear. This sudden explosion in the cone jerks it forward and, in doing so, unlocks the breech.

Helical cuts on the inner surface of the receiver act as opposing angles on the bolt and rotate the bolt out of the locked position. It is then accelerated in recoil by the trapped gas pressure acting on the base of the cartridge driving the bolt assembly to the rear at high speed. The compression of an unusually stout driving spring absorbs all surplus energy and puts the operating parts in counterrecoil.



Bang Aircraft Machine Gun, Cal. .276.

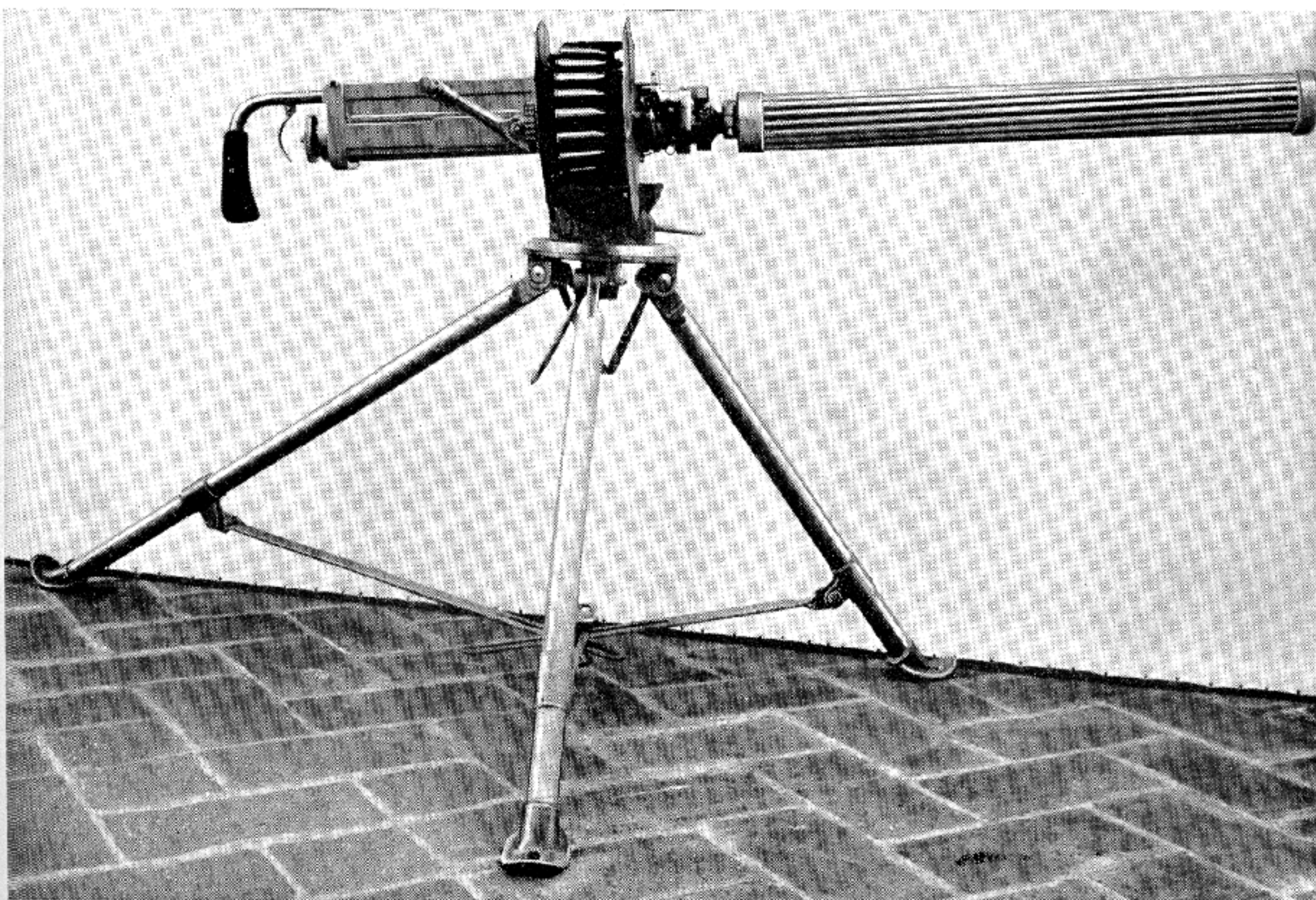
SISTAR MACHINE GUN

On 3 December 1932 there was filed in the Italian patent office an application covering the design of a recoil-operated machine gun, which, according to its inventor, Niccolo Mancini, of Florence, Italy, was a decided improvement on existing automatic firing mechanisms.

Not having the financial means to exploit his invention, he placed it with the Sistar Co. in Florence. Sistar actually was not a producing organization but a promotion and design firm which specialized in developing and financing likely looking patents. By this business connection, Mancini gained all the prestige needed to

call on interested parties. He was made president of Sistar's machine gun section, a title that no doubt was more impressive than the salary.

Demonstration machine guns were produced, both in light and heavy models. While the operating mechanisms were identical, the two types varied in the following characteristics. The light gun chambered the 6.5-mm infantry rifle cartridge; the heavy the 7.92-mm Mauser type. The light gun with its 22 pounds was half the weight of the latter, and the rate of fire was 700 rounds a minute on the small weapon and 500 on the other. The magazine on the lightweight



Sistar Heavy Machine Gun, 7.92 mm.



Sistar Light Machine Gun, 6.5 mm. The Operator Is Loading the Magazine.

version held 20 rounds, while the other utilized a semi-rigid metal belt holding 250 rounds wound on a drum.

The light machine gun, while having only a 20-shot magazine, did have a feature that the company made great effort to demonstrate on every occasion. The gunner, without rising, could pivot the swinging magazine forward from the prone position and insert in a matter of seconds a fresh supply of loaded rounds directly from the cardboard container into the feed system. By this ease and speed in loading he could keep up practically uninterrupted fire.

The weapon was recoil operated, the barrel having an open jacket that gave it support and a bearing for "floating" the recoiling parts. The barrel return spring was housed inside this skeletonized jacket. A large charging and carrying handle was located on the left side considerably forward of the usual placement of retracting assemblies. The trigger was placed underneath and slightly to the right. However, the customary guard, to protect it from accidentally striking some object and discharging the piece unintentionally, was omitted.

The recoiling parts were housed completely in a boxlike receiver on the top of which was a graduated sight. Air cooling was provided by circular fins machined along the barrel to give greater surface for heat radiation.

A built-in oil pump on the left side of the receiver sprayed a small jet of oil on the incoming rounds as each was positioned for chambering. This device was actuated by the recoil counter-recoil movement of the barrel extension.

The heavy machine gun had identical operating parts, but most certainly did not resemble the lighter gun in any other way. Its cooling was by air, but the barrel housing resembled the conventional water-cooled jacket. Long aluminum tubes grouped around the barrel were supposed to dissipate heat more efficiently. The 7.92-mm ammunition was fed to the weapon in a belt using push-out-type links, also originated and patented by the inventor of the gun. A clumsy looking handle with unprotected trigger was used on this heavy Sistar machine gun.

Both versions appeared only in prototype form. While many of the principles have later been proved sound, especially the locking method, apparently nothing was ever done to develop either one. There is no record of any extensive test conducted either by the factory or the government. Consequently, it had a very short-lived competitive existence.

To fire the lightweight 6.5-mm gun, the operator first assumes the prone position and with his right hand releases the catch allowing the swinging magazine to pivot forward. This leaves



Sistar Light Machine Gun, 6.5 mm. The Operator Is Charging the Weapon.

The rear part open for inserting the front end of the 20-round cardboard cartridge container. After positioning it in the magazine mouth, finger pressure forward shoves the cartridges from the box into the spring-loaded magazine. When filled, the empty container is then thrown aside and the loaded magazine is swung back and latched securely in the ready position.

The operator then grasps the barrel retractor with his left hand and the bolt charging handle with his right, and simultaneously pulls both fully rearward. This unlocks the piece and compresses the driving spring. Upon being released at the rear the bolt assembly goes forward to battery while stripping a round from the magazine, chambering it and locking the piece for firing.

With the safety off, pressure is put on the trigger and the striker flies forward under spring compression to ignite the primer. As the powder gases are reaching peak pressure with the bullet still in the bore, the barrel, bolt, and barrel extension are securely locked and continue to be

for a travel slightly over a half inch. The breech lock, pinned to the recoiling barrel extension, then rides up a ramp machined in the top of the stationary receiver. The end of the breech lock is pivoted up, unlocking the bolt and allowing it to continue rearward free of the other recoiling parts. The barrel driven by its strong spring returns to battery. This gradual freeing of the bolt allows the extractor to pull the empty case free, insuring initial extraction of the fired case before complete unlocking gives it a snatching movement.

The bolt, continuing rearward, carries the empty case held in position by the extractor until the base of the cartridge case strikes the ejector. The latter pivots and kicks it out of the ejection slot on the left side.

The bolt, at its rearmost position, compresses its spring buffer and then is driven forward. The rebound off the buffer, in conjunction with the driving spring, located in a housing offset to the left of the operating parts, starts counterrecoil. As the bolt face passes the mouth of the maga-

zine, it pushes the indexed round ahead of it into the guide way of the chamber. The firing pin assembly at this point has been traveling with the bolt as a unit, but at a distance of $1\frac{3}{4}$ inches out of battery a spring-loaded sear located on the back of the breech lock lever engages the front face of the striker housing, holding it back while the bolt continues to go on into battery.

At this point, if the trigger button is still depressed, the breech lock in reaching its recess pivots down in front, securely locking the barrel, barrel extension, and bolt together at the same time. The sear on the back of the breech lock lever is raised, freeing the firing pin it has been holding in the cocked position. The pin flies forward and again fires the piece. If trigger tension is not applied, the breech lock will still release the firing pin but instead of flying all the way forward it will merely snap forward a few thousandths of an inch and come to rest on the

trigger sear. Further actuation of the trigger is needed to release it.

The United States Government in 1935, upon hearing from officials of the Sistar Co. of the various advantages this machine gun had over others, requested its attachés to report on the performance of the gun and what it had to offer. Upon investigation it was found that the Sistar firm as a manufacturer was non-existent and that the few models that were then being used for limited demonstration were produced by hand in various job shops. All available models at the time were in Rome where they were being given consideration by the Italian Government for purposes of adoption.

Italian authorities, however, did not see fit to produce this weapon for either air or ground use, and it never got beyond the prototype stage in development. The army, with its partiality to the retarded blow-back system, held in disfavor the Sistar's straight-recoil operation.

KNORR-BREMSE MACHINE GUN

Swedish military authorities, upon becoming interested in a strangely designed machine gun, invented by Hans Lauf of Charlottenburg, Germany, had their government small arms factory manufacture the weapon for testing purposes in 1933. Lauf, in presenting it, described it as a gas-pressure-operated machine gun and made many claims for the unusual contrivance. The inventor was well known in the gun world and at the time was a director of the Knorr-Bremse Manufacturing Co. of Lichtenberg, Germany. However, since the Swedes showed initial interest, he permitted them to manufacture the first models with the understanding that, if adopted, he would receive royalties.

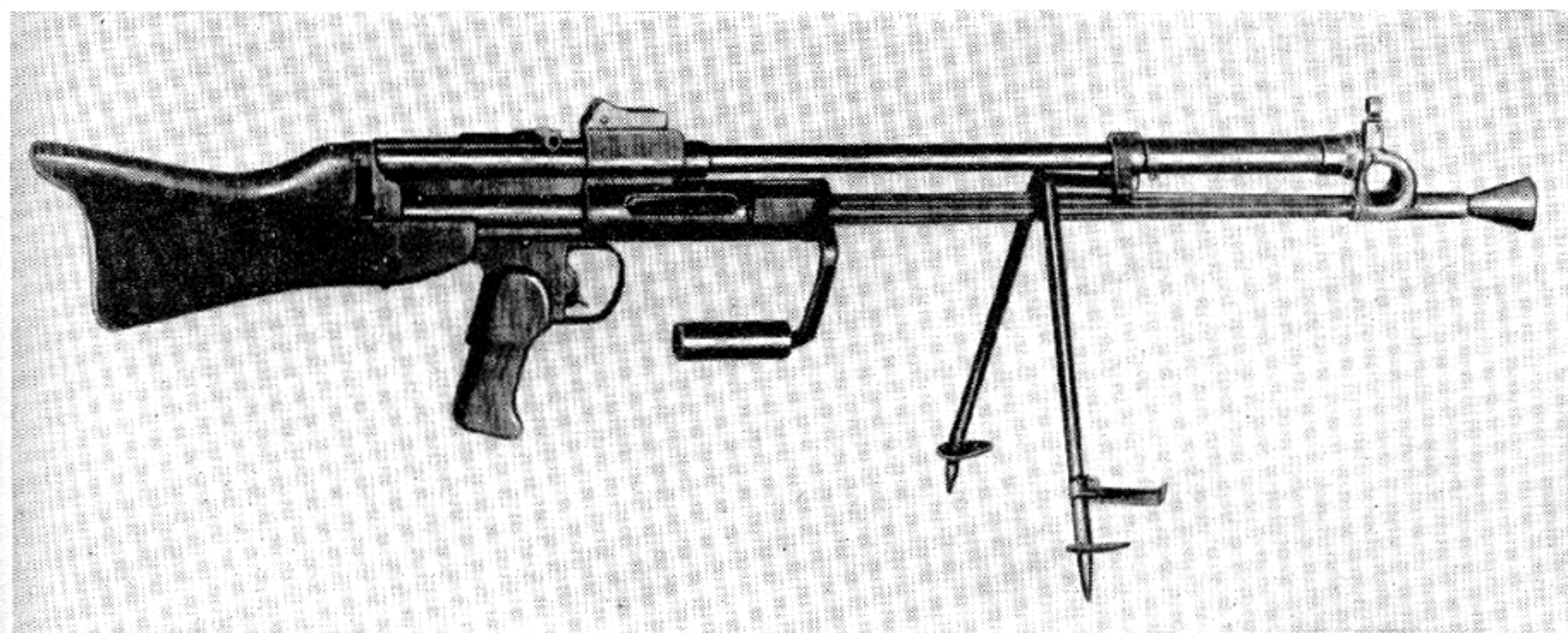
These Swedish-made weapons were given the designation L. H. 33, the markings probably being specified by Lauf to include the initials of his name and the year produced. After extensive trials the authorities did not see fit to adopt the weapon and Lauf turned to the Knorr-Bremse company to produce and promote it commercially.

The firm made a limited number and Lauf bent every effort to interest representatives of

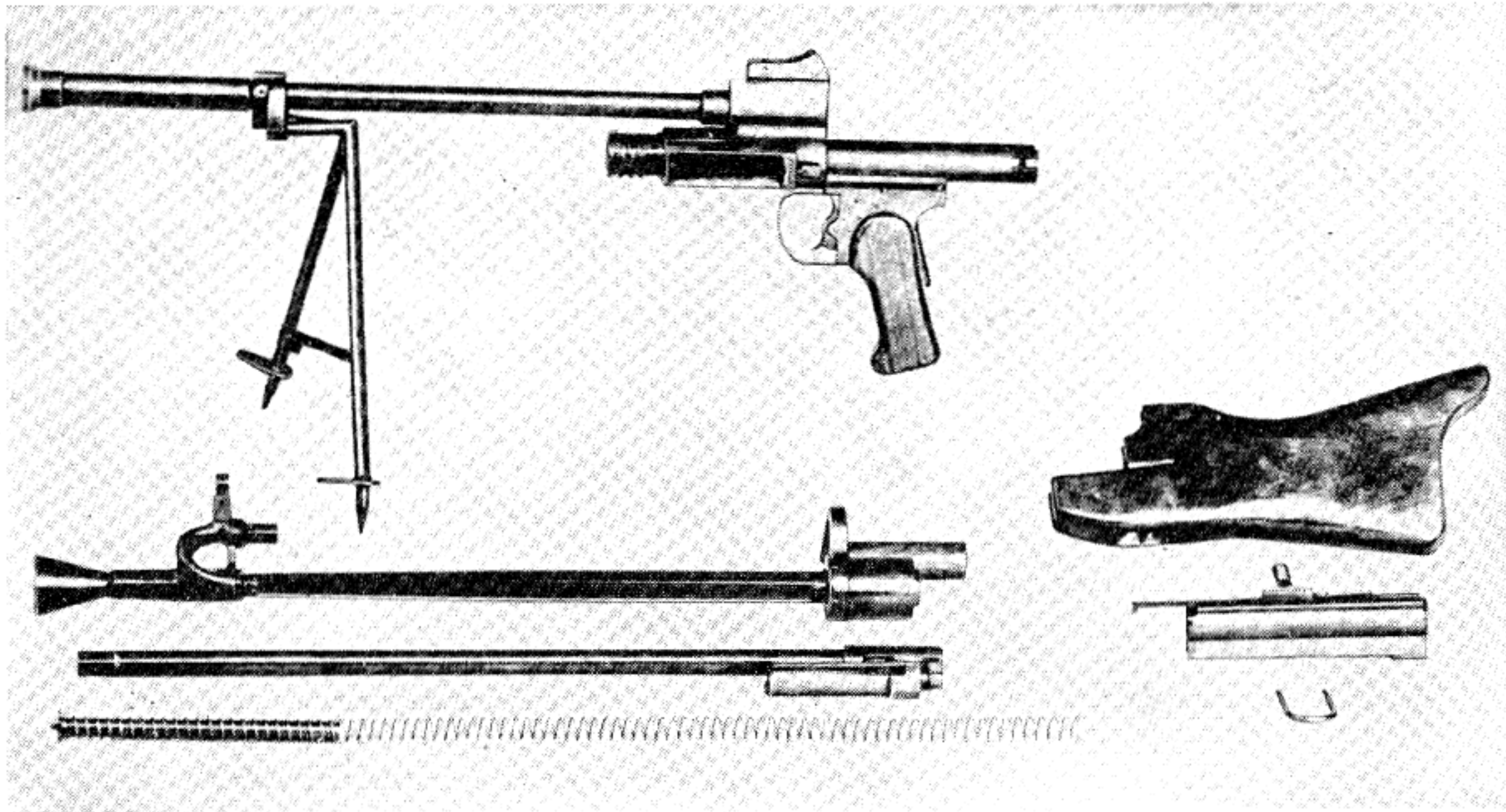
many countries, giving personal demonstrations in each instance at the Knorr-Bremse firing range at Tegel to show off the good features claimed for the gun. The weapons made by the German company were officially labeled Knorr-Bremse 35/36. Those who witnessed Lauf's firing demonstrations failed to observe any features so outstanding as to warrant more investigation. The design was by no means revolutionary nor did it contribute a performance superior to that of the many tried and proved weapons of the time.

The barrel on this gun was very short and, due to this fact, even when an oversize flash hider was employed, it still had enough brilliant flame at the muzzle to impair aiming. The balance of the weapon was exceedingly poor and the absence of a wooden forearm made it impossible to discharge the piece in any other way than in the prone position with the use of a bipod because of the heat. The excessive length of the heavy stock also resulted in an undesirable distance to the rear sight.

Firing from a cocked-bolt position, with the mechanism being held back by an unusually strong spring that was supposed to help dampen



Knorr-Bremse Machine Gun, Model 1933, 7.92 mm.



Components of the Knorr-Bremse Machine Gun, Model 1933.

recoil, made the gun lurch forward each time the action slammed home on single shots, with a natural destruction of accuracy. And while the barrel could be changed rapidly, the machined clearances on its components, that had to be removed first to make this change possible, resulted in considerable gas leakage.

The 25-shot magazine, when filled and inserted into the left side of the gun, made the weapon "left-heavy," and threw the gunner's aim off during first stages of automatic fire.

On the favorable side, a very novel feature was that by merely pulling the trigger at its top portion it could be changed from single shot to automatic fire. This piece was pivoted in the center and its depression at the bottom resulted in a full automatic burst. The cost of manufacturing the components was reasonable due to their simple construction. The barrel had longitudinal ribs that not only gave more rigidity but also furnished more cooling surface for heat dissipation. In the entire assembly there were only 62 components, no tools being required to disassemble or put it back together again. A single spring performed all recoil operation.

The main point of improvement emphasized by the inventor and one that, according to wit-

nesses of the demonstrations, was practically useless was the unique method of getting the gas pressure from the barrel without tapping it, as was customarily done by all weapons that operated by the forces of the still expanding gas.

This device functioned as follows: When the projectile passed through the flared-out portion at the muzzle, the gases entered a trombone-shaped nozzle and exerted considerable pressure on the gas piston which was thrust evenly to the rear, unlocking the bolt from the barrel and shoving it to its full recoil position.

Lauf's only new feature was to entrap at the muzzle end the gas that was shoving the bullet through the bore. It was then used to operate his mechanism in the manner employed by numerous other actions powered by the forces of expanding gas. He was forced to use an unusually short barrel in order to have high enough residual pressure to operate the mechanism after waiting for the projectile to clear the muzzle.

The safety located at the rear of the pistol grip handle was the squeeze type commonly found on automatic pistols.

While the German Army was not even mildly interested in this peculiar gun, it did get desperate enough for automatic weapons during



Knorr-Bremse Machine Gun, Model 35/36, 7.92 mm.

World War II to manufacture a limited number for its ally, Finland, which reportedly had also bought the few that were made up by the Swedish Government. All known models were chambered for the 7.92-mm German infantry rifle cartridge.

The Knorr-Bremse company also had under construction an automatic 20-mm cannon built on the Hans Lauf principle but like the others it did not get much beyond the prototype, or limited use, stage.

To fire the L. II. 33, or the Knorr-Bremse 35/36, the gunner from a prone position inserts a loaded 25-round clip in the left side of the feedway. The retracting handle is then pulled back until the gas piston extension is engaged by the rear sear. The pistol grip is grasped by the right hand to depress the safety and, if automatic fire is desired, the center pivoting trigger is pulled back at the bottom. The bolt connected to the piston extension flies forward under tension from the driving spring, thus stripping the first cartridge from the mouth of the magazine and chambering it.

At the moment of going into battery, the rear

of the bolt arrives directly over a recess in the stationary receiver. This permits the piston extension in continuing forward to actuate a linkage arrangement that forces the back of the bolt down into its locking recess. In doing so, it aligns the firing pin in the bolt with the L-shaped end of the piston extension that on the final forward movement smashes into the protruding firing pin which in turn detonates and fires the cartridge.

The bolt is securely locked to the receiver until the bullet is clear of the bore. The greatly reduced gas pressure is now diverted by means of a large trombone-shaped pipe that, by use of its reduced force, evenly thrusts the gas piston rearward. Its first movement breaks the link and the end of the bolt is then lifted up out of engagement with its locking recess. It starts to recoil as the extractor first pulls the empty cartridge from the chamber and then holds it until the ejector pivots the used case out through the slot cut in the right side of the receiver. At the end of its recoil movement under energy of the compressed driving spring, the action starts in counterrecoil movement to repeat the operation.

MAUSER MACHINE GUNS

Background

Very few arms companies have been as influential in world affairs as the Waffenfabrik Mauser A. G. from the date of its inception in 1871 until the end of World War II. At its very beginning Mauser products were used by the German Government to disseminate German beliefs. The authorities of that country recognized that by arming soldiers and police of smaller countries, it could also influence greatly their military way of thinking.

The company was organized by and named for Paul Mauser, who devoted his life to the invention and development of all kinds of weapons in the interest of his fatherland. The youngest of 13 children, he was born on 27 June 1838 at Oberndorf, Germany. His father, Andreas Mauser, was himself a master gunsmith in the Government arms factory at Oberndorf. At 12 years of age, Paul was already an apprentice gunsmith. After completing his schooling, he and several of his brothers were well established as craftsmen in weapon construction.

Europe, as usual, was on the verge of a war and young Mauser was called up for military duty in 1859. At this time he so impressed his officers that he was immediately placed on inactive status and given a responsible position in the Royal Fire Arms Factory at Oberndorf, where he might turn his creative talents to good ends. It was here that he developed his famous bolt-action rifle that was to become the design pattern for practically every military power in the world. And here he organized the company that bears his name.

It is not generally known that the first patent to be applied for by Mauser on his rifle was sought from the United States Patent Office. The rifle was followed by numerous other inventions that included many types of semiautomatic actions. They were later to be copied and modified

into full automatic mechanisms by arms designers in every corner of the world. These superb small arms, both bolt-action and semiautomatic, made the name Mauser synonymous with ordnance of exceptional quality. His conception and development of this type of armament brought him fame and fortune, and his government a chance to rise in military strength. Mauser died in 1914 as his country stood ready to challenge the power of the rest of the world.

After the war, the Allies occupied the country with a commission established in order to limit the ability of the German arms companies to produce for military use the many automatic weapons that had proved so deadly. The Mauser Co. continued in existence and it was hurt least of all by the occupation forces, since its factories turned out mainly rifles and semiautomatic pistols.

The large machine gun producing plant of Deutsche Waffen- und Munitions-Fabriken (D. W. M.), with which the Mauser Co. often contracted, was completely dismantled and the latter firm was allowed to acquire its patent assignments. Among them were the Luger pistol and the many improvements by Karl Heine-mann on the Maxim machine gun, then known by the D. W. M. code name of Parabellum. The company was not permitted to manufacture the Parabellum because of the Versailles Treaty and therefore, in order to remain solvent, an output of sporting guns and general small arms was manufactured commercially until 1934 when Germany, under the Hitler regime, openly began to rearm.

The Nazi high command, realizing the potentialities of the great Mauser organization, started at once to recruit talent and make a loan necessary for maximum production. In this manner the Waffenfabrik Mauser A. G. was officially launched in an all-out race for arms supremacy.

MG-34

Its first effort was in the field of rifle caliber machine guns. A pressing need at that time was for a single machine gun using the 7.92-mm rifle cartridge, which would incorporate in it all the special features of modern weapons. It should be capable of use as both a light and heavy machine gun and, if need be, for antiaircraft work against low flying attack planes. The basic design for the weapon was sent to Mauser from Berlin and was the further development of a mechanism patented by Louis Stange, an engineer of Rheinmetall-Borsig. The specifications further stated the weapon must feed from both left and right and be fed by either drum or belt.

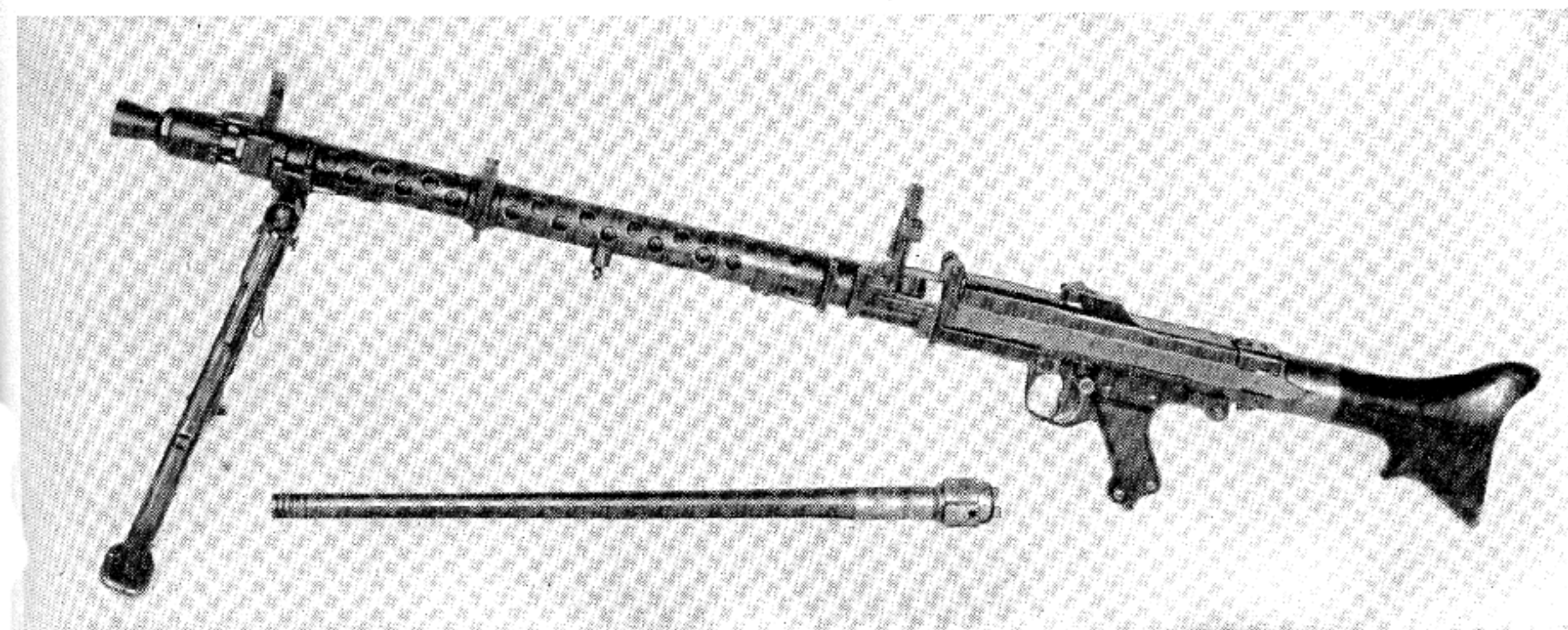
The weapon conceived by the officials in Berlin was the last word in machine gun design and eliminated the locking ring. In lieu of this system they recommended a rotating bolt head, the origin of which has been credited to Paul Mauser, Ferdinand Mannlicher, and even Alfredo Scotti. True, Mauser, at a much earlier date, successfully used a bolt that locked in a somewhat similar manner but for energy after unlocking by recoil forces he resorted to the high residual pressure in the chamber to give him the needed power to complete the cycle of operation. Mannlicher and Scotti used a gas piston both to actuate and unlock the operating mechanism. Stange's method, applied to the new weapon, differed inasmuch as it unlocked by re-

coil and used barrel energy and an accelerator to speed the bolt action to the rear.

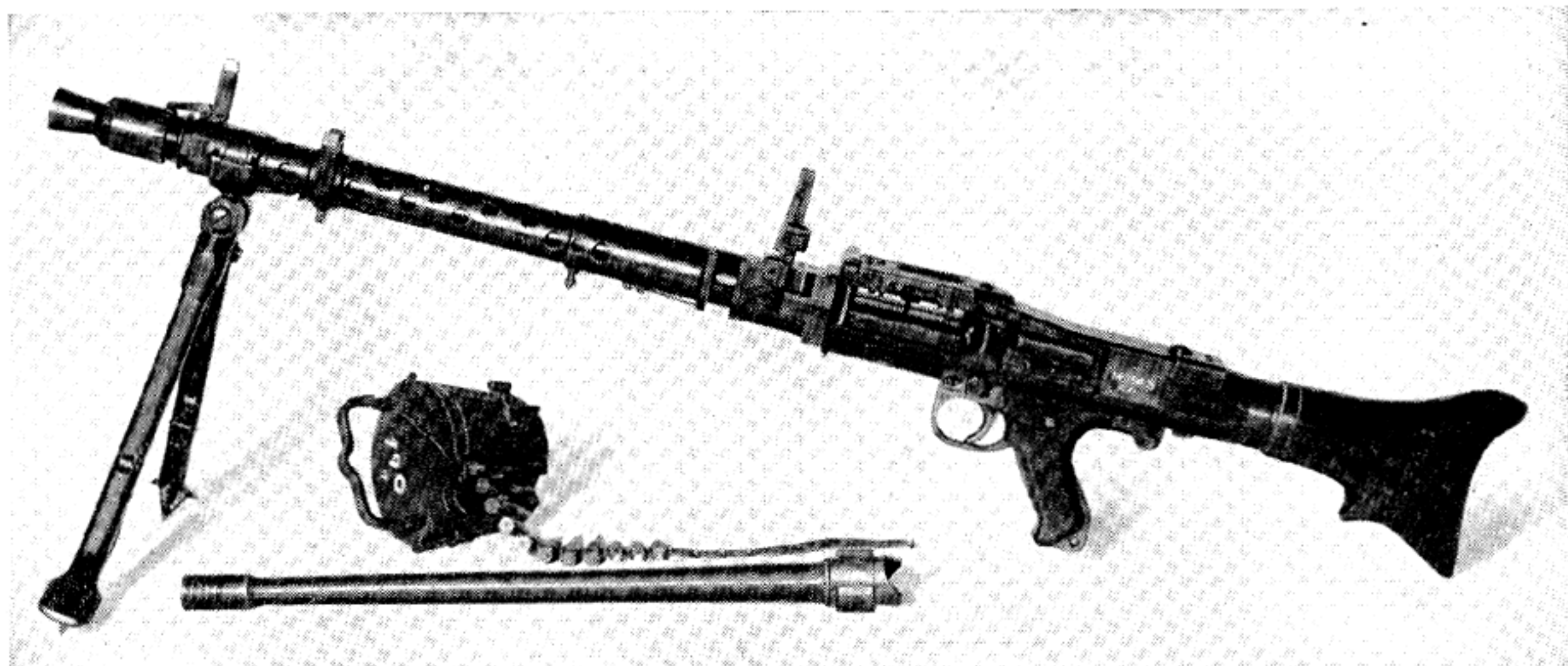
The bolt body was first accelerated when the unlocking cams were engaged. On release of the bolt head, the rear portion of the two-piece bolt traveling at a high speed pulled the front piece with it. A closely calculated distance for unlocking, which utilized the safe but very high chamber pressure then being exerted on the face of the bolt, further added to the rate of fire. The pressure and recoil forces were both abetted by the muzzle booster that fitted over the end of the barrel. The booster not only held the high gas pressure after the bullet had cleared, but made it do double work by bringing it to bear on the barrel face for additional rearward thrust of the recoiling parts.

The result of Mauser's development of this method of operation was called officially the MG-34. It represented not so much a departure from conventional design as it did the sensible application of many well-established principles in the design of this most efficient machine gun. For instance, the muzzle booster was so constructed that it served as a flash hider and front barrel bearing as well as a gas trap.

Few machine guns on first appearance showed as much refinement as did the MG-34. The German high command evidently was greatly impressed as it was adopted in short order. Although development was not begun until 1934, it was put into production in 1936. Its most de-



Mauser Machine Gun, Model 1934, 7.92 mm.



Mauser Machine Gun, Model 1934 S, 7.92 mm.

sirable feature was that, even with a high rate of fire, the straight-line action did not jar or impede the gunner's aim. The weapon was nearly as accurate as an infantry rifle when fired single shot.

The MG-34 soon became the standard machine gun of the German Army. It was mounted for light machine gun work with a bipod and for heavy duty with a tripod that could raise it to a high enough position to make it readily adaptable for antiaircraft use. A dual mount was also made at a later date whereby two weapons could be operated by a single soldier and, although designed for antiaircraft use, it could and often was employed by armored vehicles.

The MG-34 can be described as being an air-cooled, rear-loaded, short-recoil-operated, belt- or drum-fed, dual-purpose light machine gun, chambered for the 7.92-mm rifle cartridge.

It normally employed a nondisintegrating push-out type metal link belt, which came packed in 50-round lengths. It was common practice in the field for the gunner's helper to clip as many as five such belts together. At the beginning of each one there protruded a small rectangular tongue, while the last link contained a matching hole. To join as many belts as needed, the tongue of one was merely passed through the hole in the last link of another until a small projection in the tongue snapped into place, joining the whole assembly together. The belted round then made

it impossible for the links to separate until the cartridge was removed. In certain field operations necessitating rapid movement, a 50-shot drum was often employed. The magazine fitted against the left side of the receiver and was loaded with a single 50-round belt.

To insure against firing out of battery, a mechanical device, located on the right side of the breech lock, serves as an obstruction to the cocked firing pin. It can be removed only by a short sloping face beneath the front end of the bolt carrier camming it down after the barrel and bolt are locked together. To avoid rebound of the bolt assembly, a spring-loaded catch is fastened at the rear end of the barrel extension in the path of the outer roller on the bolt head. The piece is depressed during locking operations and rises again when the roller passes over it, thus serving as a sort of flexible chock. After the first three-sixteenths inch backward travel of the barrel and bolt, the roller is forced over the catch and only then is the bolt free to unlock.

Another safety that prevents accidental discharge is located in the receiver immediately above the trigger. A relief is cut in it that permits movement of the sear when the lever is in *Fire* position. The sear release is shaped like a pivoting lever and, on *Safe*, it pins the front end of the trigger bar, thereby preventing it from actuating the sear.

The firing pin, housed in the bolt body, is cocked during the recoil movement. It is nested inside its spring under constant slight tension. Full compression on its rearward travel is reached by means of two cam shoulders at the rear end of the bolt head bearing against corresponding shoulders at the front end of the bolt carrier. During the partial rotation movement brought about by unlocking, the carrier is cammed back and the firing-pin spring compressed. At this point the sear engages the notch in the firing pin holding it back and is released by the revolution of the bolt head after the bolt is locked to the barrel. This removes a safety obstruction and at the same time lifts the end of the firing-pin catch, allowing it to be driven forward.

Upon pulling back on the top portion of the trigger, for single fire, the rear end of the lever mounted on the trigger depresses the sear that allows the bolt to go forward. The projection on the bottom of the bolt pushes down a short upper arm of the sear-lever trip; this frees the sear-lever bar to go forward and the sear to rise; thereupon, with the return of the bolt on its recoil stroke, the sear is forced into its recess in the bolt holding it in the cocked position.

When the bottom part of the trigger is pulled, for automatic fire, the sear is depressed and the bolt driven towards battery. Housed in the main body of the trigger is a small auxiliary trigger. Upon being retracted, its projecting lug at the rear is raised above the trigger guide pin, thus permitting further rearward travel of the larger trigger than when firing single shots. Consequently, it is not possible to align the sear with its recess in the bolt and automatic fire results.

The mechanical means by which the push-out type link belt is fed into the gun is housed in the cover group and has a pivoting arm the ribs of which form a groove into which rides a stud located on top of the bolt. A holding pawl under spring tension is mounted in the feed slide and positions itself behind each cartridge with every throw of the slide. Heavy spring-loaded guides press each successive round down into alignment for chambering, with the full indexing movement of the cartridge belt.

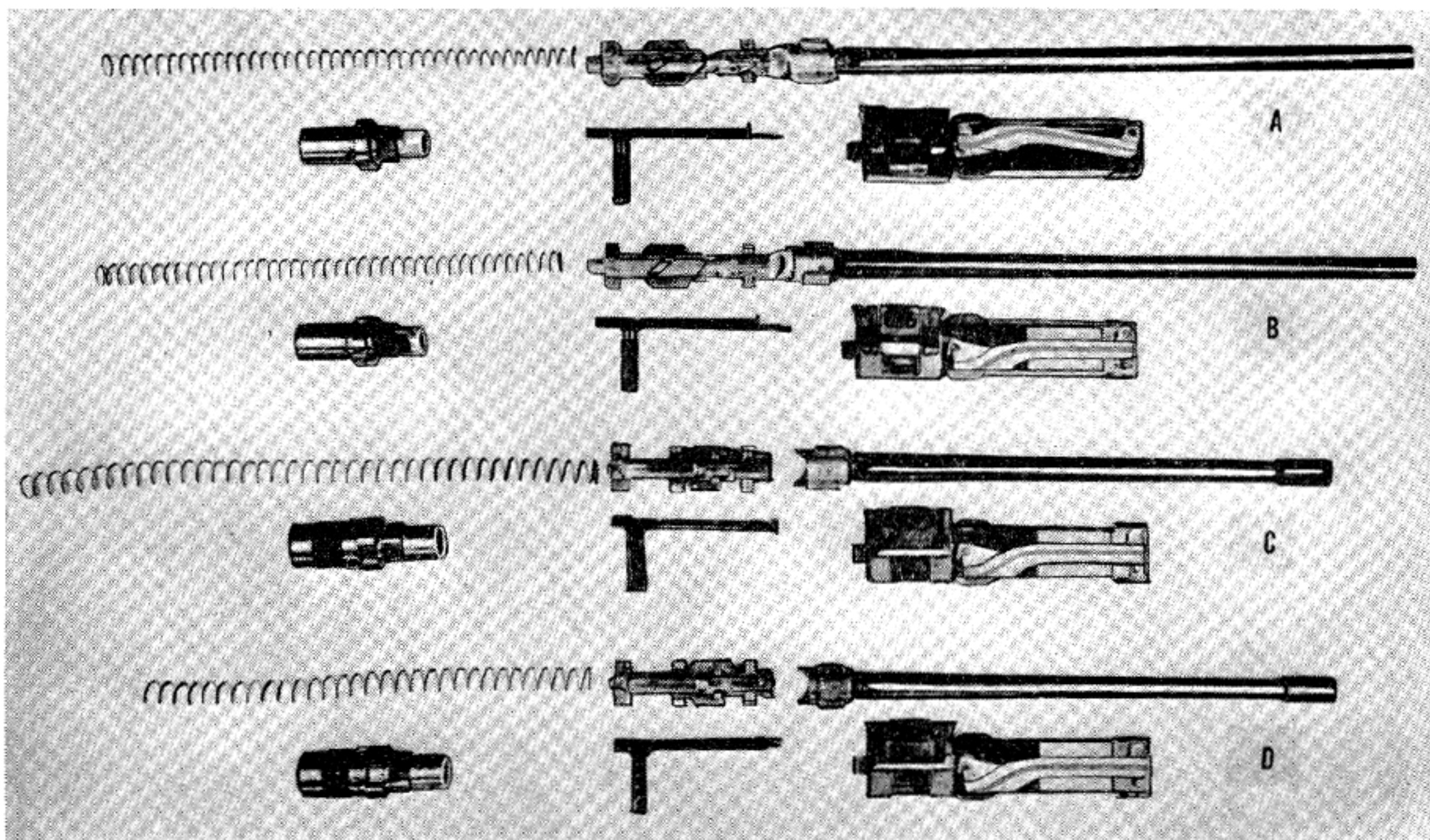
When mounting the drum magazine, the feed block must first be removed. The cover group

is provided with an opening that is closed from the weather by hinged flaps when the drum is not in use. Beneath the ejection slot a dust cover (for the protection of operating parts) automatically opens when the trigger is pressed.

The ejector has no spring in its construction, being in the form of a pin housed in the head of the bolt. It has a cut-away portion for its retainer that allows it a longitudinal travel of only three-sixteenths inch. During recoil, when the empty case has been withdrawn the necessary distance, the pin contacts a case-hardened stop on the right side of the receiver body. The empty cartridge is struck by the pin at the top of its base, pivoting and at the same time knocking it down through the ejection slot in the bottom of the receiver.

The weapon was later altered for use in armored vehicles and differed from the parent gun by having a heavier barrel jacket to adapt it to a ball-type mount. It was known as the MG-34 (modified) and was followed by the MG-34-S and MG-34-41, identical in appearance except for the barrel jackets but marked as distinct models. They differed from the original MG-34 in the following points: (1) Full automatic fire only; (2) shorter barrel; (3) a trigger group of simpler construction; (4) a larger buffer; (5) larger muzzles on the barrels to add more surface for booster gas to bear upon; (6) elimination of the firing-pin nut; and (7) minor changes in the feed system.

To fire practically any of the MG-34 machine guns, the operator, if using a drum feed, presses a catch on the drum to slide back the cover. The end of the cartridge belt is pulled out and inserted in the left side of the feedway. The drum is attached to the forward part of the receiver guides, front end first, and the rear pivoted around to the lugs in the feed block. The end of the belt is then pulled to the right until the first round is engaged by the three pawls on the underside of the feed cover. The gun is charged by pulling the cocking handle smartly to the rear as far as it will go, then shoving it forward until the holding detent snaps into its locking recess. The catch on the safety lever is depressed to firing position until the letter *F* (*Fire*) is uncovered.



Comparison of Component Parts of the Mauser Machine Guns of the MG-34 Series. (A) MG-34. (B) MG-34 (Modified). (C) MG-34 S (D) MG-34/41.

For automatic firing, the bottom part of the trigger is pulled to the rear. This releases the sear and the bolt, which has been held in the cocked position, flies forward from the energy of the compressed driving spring. A feed piece on top of the bolt, being spring loaded, rises and strikes the base of the indexed cartridge, pushing it out of its linked position for chambering. Continuing on, the feed arm, actuated by the projection on the top rear end of the bolt carrier, causes the carrier to move the cartridge belt over a half space.

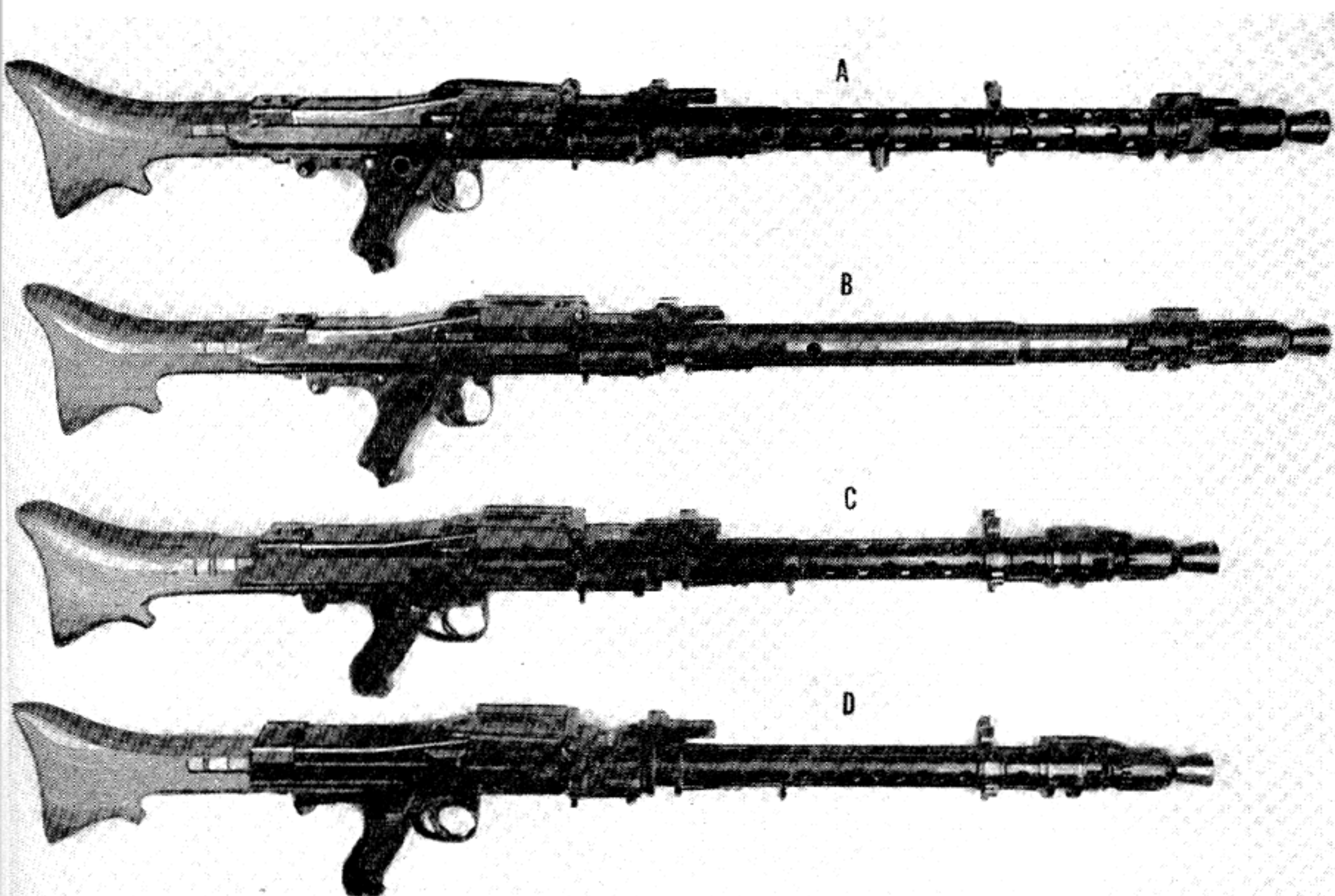
At the same time, the two inner rollers on the bolt head engage the cams on the barrel sleeve, causing a partial rotation of the bolt head clockwise so that the bolt buttress threads engage those on the cam sleeve and lock the bolt to the barrel. This movement also forces the extractor lip over the rim of the chambered round. The bolt carrier can now continue forward just enough to allow the firing pin to be driven into the primer.

The counterrecoil stroke is stopped completely as the shoulder on the bolt carrier's right

front strikes the cocking-handle stop. The bolt-locking catch has now lifted behind the outer roller on the bolt head, and the exploding powder charge starts recoil movement with barrel and bolt locked together for three-sixteenths inch of rearward travel. The bullet has now cleared the bore but a high residual pressure still remains in the chamber.

The rate-of-fire booster traps the muzzle blast which reacts with great force on the face of the barrel adding considerable thrust to the recoil. After three-sixteenths inch free travel, the outer rollers on the bolt head contact the two cam faces in front of the barrel extension and the bolt head makes a quarter turn counter-clockwise, thus unlocking the bolt from the barrel. Recoil movement of the barrel is then stopped as its cam sleeve butts against the shoulders in the front end of the receiver. The feed arm stud moves the feed pawl until it slips over the first round in the belt.

As the bolt continues to the rear, the empty cartridge case is held by the extractor claw. The latter had loosened the round by its initial rear-



Comparison of Mauser Machine Guns of the MG-34 Series. (A) MG-34. (B) MG-34 (Modified). (C) MG-34 S. (D) MG-34/41

ward movement when the bolt head rotated to unlock, and now holds the base of the cartridge to the front of the bolt. The rear end of the ejector pin next strikes its stop, pushing it through the bolt face, pivoting and knocking the spent case through the ejection slot in the bottom of the receiver. The complete recoil stroke of the operating assembly is finally stopped by the buffer which absorbs the surplus energy and deflects it forward into counter-recoil movement to repeat the cycle.

The use of a rotating bolt head in place of the locking ring featured in earlier German machine guns has caused writers to credit the series of weapons that soon followed to other inventors. But, if Stange's patent granted in 1928 is checked closely, it will be disclosed that the roller locking arrangement will accelerate the rear portion of the two-piece bolt by recoiling barrel movement at the instant of unlocking. While earlier machine guns had locked and freed the bolt by turning the head of this part, they most cer-

tainly did not utilize speed of barrel recoil to accelerate its movement rearward.

It has been a moot question as to why the locking ring, successfully used by early ground guns, was suddenly dropped in favor of this system. The answer seems to be that the locking ring made barrel change, although fast, possible only with components that later had to be removed from the hot barrel and placed on the cool one. The rotary bolt allowed all operating parts to be retained in the receiver while the overheated barrel was quickly removed by itself. This feature alone justified the substitution.

The German field manual recommended that a barrel change should occur after 250 rounds had been fired continuously or with only short pauses between bursts. The following procedure was specified: The operator cocks the bolt to the rear after setting the selector lever on *Safe*. He depresses the receiver catch just below and back of the back-sight pivot and turns the receiver body 180° to the left. The muzzle is then raised

until the barrel drops out of the rear end of the jacket, after which it is lowered and a cool barrel dropped in. The receiver is turned to the right until the catches snap into the holding detents. The operator switches to *Fire* and grasps the cocking handle with his right hand. The trigger is pulled with the other hand and the bolt goes home slowly. The weapon is now ready to be cocked and firing resumed.

The following arms firms manufactured the MG-34: Mauser Werke and Maget, both of Berlin; Gustloff Co., of Suhl, Saxony; Steyr-Daimler-Puch A. G. of Vienna; and Waffenwerke Brunn A. G. of Czechoslovakia.

MG-81

In 1936 when the MG-34 was put into production for the ground troops, the German Air Force became interested in the weapon as an aircraft machine gun for flexible and fixed mounting. The rifle caliber gun then in use in German aircraft was the MG-15 manufactured by Rheinmetall. The MG-15 was slow and expensive to produce so the Mauser firm was directed to develop an aircraft weapon, using the 7.92-mm rifle cartridge, and incorporating the bolt action of the MG-34. The new design was accepted in 1938 and put into production by Mauser in 1939.

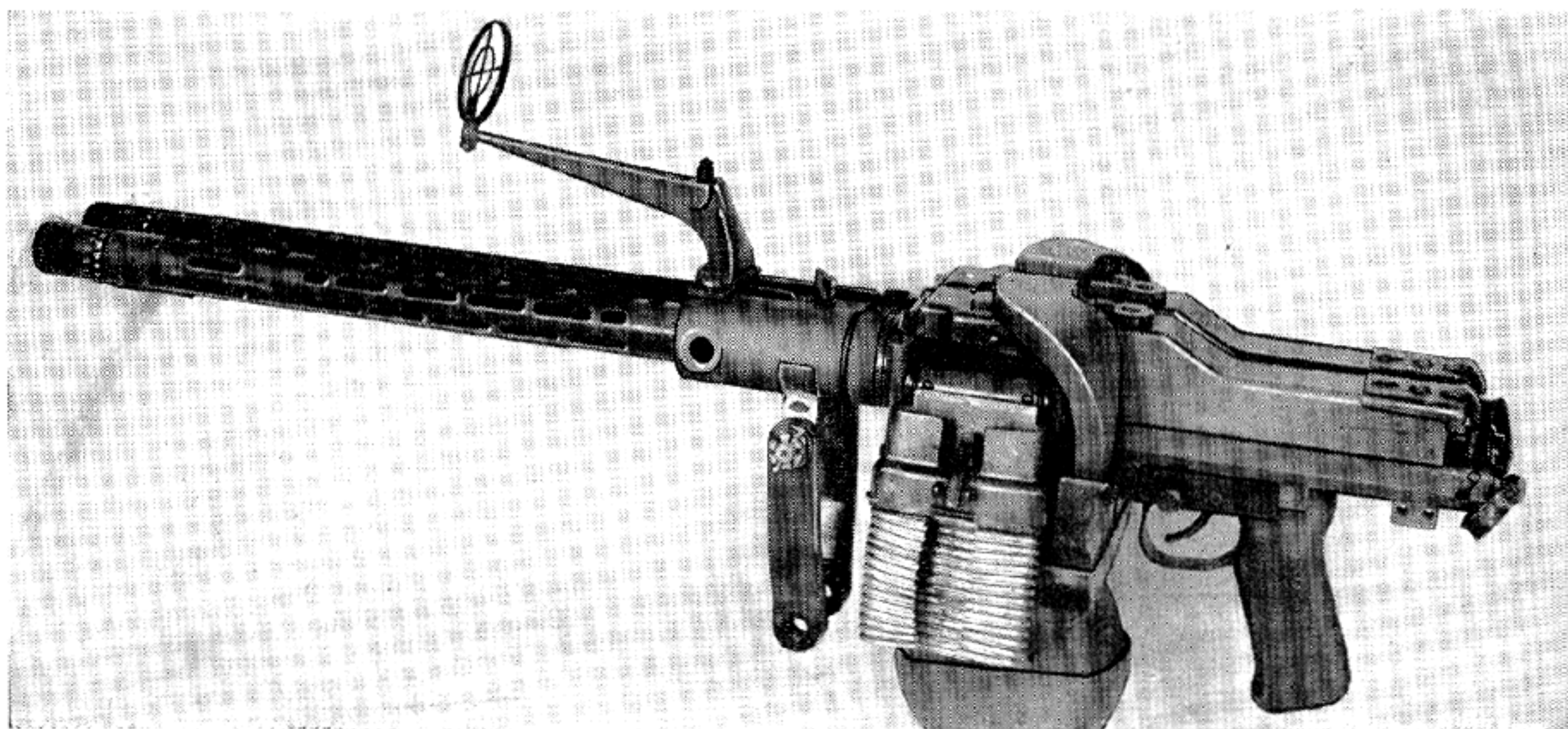
For flexible mounting where an operator was

available to hand charge and fire the piece a pistol grip handle was used. A strong spring buffer, fastened to the rear and inside the receiver, was also added.

This weapon was designated the MG-81. A small cocking handle was located at the rear of the receiver. It had a very high rate of fire, officially listed as 1,000 to 1,200 rounds a minute. A muzzle booster with a small orifice and an abnormally strong buffer spring was responsible for the increase over the MG-34, which was closely copied in operating action. No provision was made for firing single shots.

A very odd thing about the design of the gun was that its muzzle booster had no flash-hiding device attached to the end, as did all the other German machine guns of this type, whether for aircraft or ground use. Since it was produced for flexible mounting where it would be manually trained and fired, it was mystifying that this extremely high-speed short-barrel gun did not employ the conventional cone-shaped flash hider.

Feeding was done by means of a flexible disintegrating metal link belt rather than the saddle drum magazine used on its predecessor. The ammunition box could be attached to the side of the receiver, if desired, and permitted bursts of longer duration than did the drum arrangement. Power-driven turrets were being introduced at



Mauser Aircraft Machine Gun, Model 81, 7.92 mm, Dual Mount.

about the time this weapon made its appearance and resulted in making the observer and his free gun practically a thing of the past. In view also of its small caliber the weapon was destined to occupy a very minor position in World War II.

The MG-81, however, was the first aircraft machine gun to be installed by the Germans in twin mountings. It was so mounted in the Bola 81Z, and a few were later placed singly in the JU-88-A4, FW-189, and ME-110.

The weapon was manufactured for the German Luftwaffe by the following firms: Mauser Werke A. G., Oberndorf, which fabricated 46,000; Norddeutsche Maschinenfabrik G. m. b. H., Wittenberg; I. C. Wagner, Muhlhausen; Heinrich Krieghoff Waffenfabrik, Suhl; and L. O. Dietrich, Altenburg. Waffenfabrik Brunn A. G. also produced the MG-34, in addition to the ZB weapons, following the German occupation of Czechoslovakia.

JOHNSON LIGHT MACHINE GUN

Melvin M. Johnson, Jr., is one of America's gifted gun designers. Born in Boston in 1909, he is a graduate of Harvard University and Harvard Law School. In 1933 he was commissioned in the Marine Corps Reserve and became captain in 1938. As early as 1937 Johnson produced experimentally a prototype light machine gun chambered for the caliber .30/06 United States infantry rifle cartridge. Empty, it weighed only 12½ pounds and was capable of delivering a maximum rate of fire of 500 shots a minute. The weapon had many good features, but the American Government viewed it with the customary caution it displayed toward progressive ideas on automatic arms.

After his rough version of the machine gun, Johnson modified and redesigned it in the years that followed. About 1 July 1940 he completed his first model of the Johnson light machine gun. It had a horizontal feed, and fired from an open bolt on automatic and from a closed one on semi-automatic.

In 1941 the light machine gun was tested by the Marine Corps at Quantico, Va., including a parachute jump from 400 feet. Packed in a pouch, the gun was assembled and fired within 90 seconds from the time of the jump.

The Marine Corps Equipment Board recommended its adoption for issue to parachute troopers and raiders. It was used in limited quantities with considerable success by Marine units in the Pacific and by the Army's First Special Service Force in the Italian campaign and landings in southern France. The annals of the latter group state that "pound for pound it was the most valuable armament the Force possessed." About 5000 Johnson light machine guns in all were produced by the manufacturer, Johnson Automatics, Inc., Boston, Mass., at a plant in Providence, R. I.

In August 1942, after seven months of war, the United States Army Ordnance Department

bought five Johnsons for test and experimental firing. It was reported, after examining the weapons, that "while called light machine guns by the manufacturer, they are not considered such by the War Department since they do not use belts but are fed from 20-round magazines." This official decision seems odd since the Browning Automatic Rifle was fed in the identical manner with the same number of rounds.

The five weapons, after a visual inspection, were shipped to Aberdeen Proving Ground for check firing. There it was discovered that the safety lever was defective and the group was promptly sent back to the manufacturer for correction. Upon being returned to the Proving Ground in September 1942, a total of 50 rounds was fired from each of the five. Then all were shipped to the Infantry Board to fulfill a request from that organization to see them.

No further government testing was done until December 1943 when the Johnson firm offered an improved model to the Ordnance Department. Incorporated in its construction were many things found more desirable as a result of over two years of combat use. The new version, known as the Model 1944, had only 11 parts and could be field stripped in less than 20 seconds and reassembled in 30 seconds. The method of operation was unchanged, short recoil with unlocking timed to coincide with a high but safe operating gas pressure.

The 1944 model differed from earlier designs in that it had a folding monopod mount and a slight improvement in barrel change. A field cleaning kit was placed in the butt stock of the gun. In some experiments at the factory a muzzle booster was used to accelerate the recoil forces for a higher rate of fire. This did hasten the cycle of operation but resulted in considerable breakage. For an infantry weapon its rapidity of fire had always been considered as high as needed and the muzzle attachment was dropped.



Melvin M. Johnson, Jr., Firing the Weapon He Designed.

In automatic firing, rotation of the bolt tripped the sear releasing the spring-loaded firing pin. For semiautomatic discharge, the trigger had to be pulled with each shot. The Aberdeen report of this model stated: "Test results were generally very satisfactory under normal conditions, but unsatisfactory under adverse conditions of mud, cold and dust."

Again the weapon was returned to the factory and in March 1944 its performance showed considerable improvement under adverse conditions. It fired successfully during the standard rain test for 200 rounds, but became more difficult to operate as the trial progressed, finally becoming inoperative after the 383rd round.

It failed to fire full or semiautomatic after the dust test with either a clean or dusted magazine. When the weapon had been liberally oiled, a dusted magazine was fired without difficulty.

Also 100 cartridges were fired without interruption after 17 hours in a cold room at a temperature of 40 degrees below zero Fahrenheit.

The Marine Corps Equipment Board had been testing similar guns at Quantico, Virginia, and this board recommended that the Johnson light machine gun be adopted in place of the Browning Automatic Rifle. The suggestion was not followed for the reasons stated below:

"(1) The swift tempo of Marine Corps operations with subsequent limitations on training time available. (2) The fact that the Marine Corps considers itself to be a customer of the Ordnance Department in small arms matters, and consequently, is reluctant to adopt an automatic shoulder weapon which is not an Army standard."

The same letter from the Commandant of Marines provided support and recognition of the inventor's contribution:

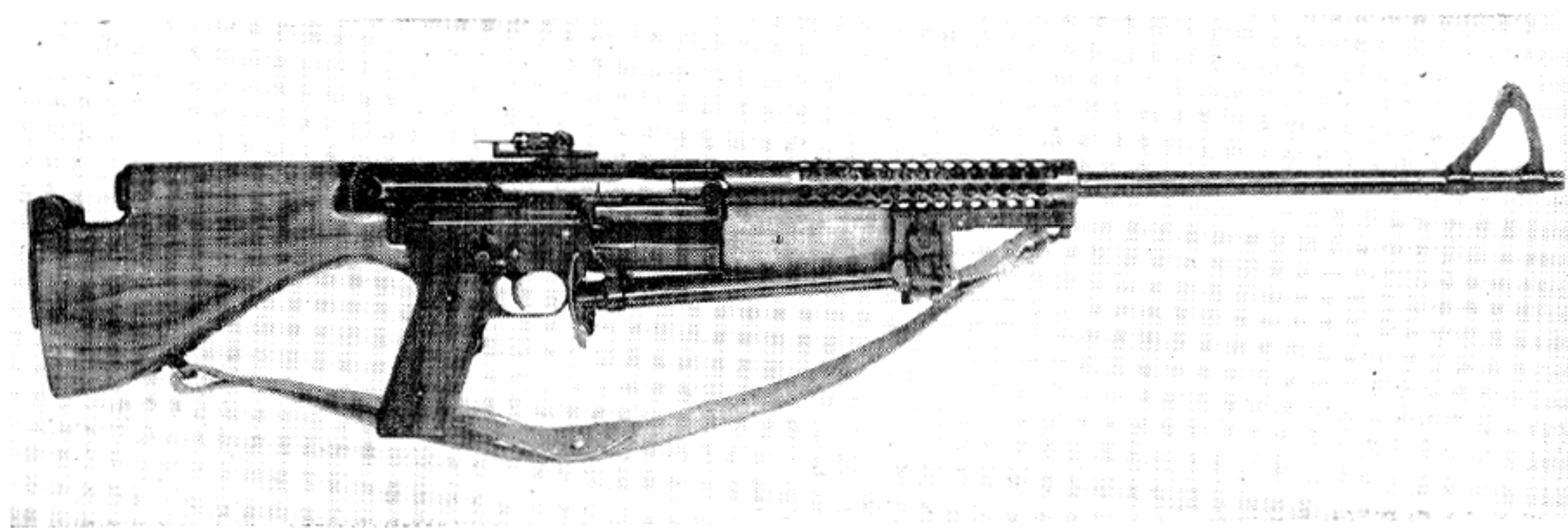
"The Marine Corps desires to lend impetus to the continual development of the Johnson light machine gun, and stands ready to perform such functions in that connection as may be considered desirable."

The Ordnance Department at a later date (May 1945) reviewed all the information available and decided to purchase 10 guns and accessories which were delivered and distributed as follows: Infantry Board, 3; Marine Corps, 2; Aberdeen Proving Ground, 2; Headquarters, Army Ground Force, 1; and Small Arms Development Division, 2. All spare parts were sent to the Aberdeen Proving Ground.

A final report on the Johnson weapon was made in October 1945, three months after the end of the war. No definite conclusion was cited, but it was intimated that it would be desirable to convert it to a belt-fed machine gun and that research and development were continuing.

Undoubtedly the Johnson light machine gun was an excellent weapon with many attractive and novel features, many of which were quickly copied by the enemy.

The selector switch is located on the right side back of the top part of the trigger. For semiautomatic fire the change lever is rotated into the forward position. If the cocking handle is pulled back to the rear and released, it will chamber the round and lock the bolt ready for single shots



Johnson Light Machine Gun, Model 1941, Cal. .30/06.

at each trigger movement. When the automatic-fire position is used, the bolt will remain retracted at the end of each burst, allowing air to circulate through the open bore.

If, after firing a short burst, it is found desirable to recharge the magazine, it may be done by inserting the five-round clips through the loading aperture on the right side of the receiver, regardless of whether the bolt is open or closed. In semiautomatic fire a full magazine can be kept available for an emergency that would call for an extended burst. Loading in this manner is not normally intended for automatic fire, as replacing the magazine with a fresh one is but a matter of seconds.

One of the most desirable features on this light machine gun is the gunner's ability to fire semiautomatic with a closed bolt merely by changing the selector switch with finger pressure. Thus shooting was as accurate as with any similarly constructed rifle. Lurching forward off the rear sear, an act that disturbs aim in all guns employing the rear sear for inertia firing, is thus eliminated in this method of single-shot firing.

It would seem impossible to make a quicker system of barrel change. On the 1944 model with the bolt at the rear, the point of a bullet is inserted in the latch and shoved forward. This releases the holding catch and forces the barrel forward due to the action of the barrel return spring. The barrel, if hot, may then be shaken all the way out, or withdrawn if it can be handled. To assemble, the cool barrel is shoved down as far as it will go. Upon being seated, the

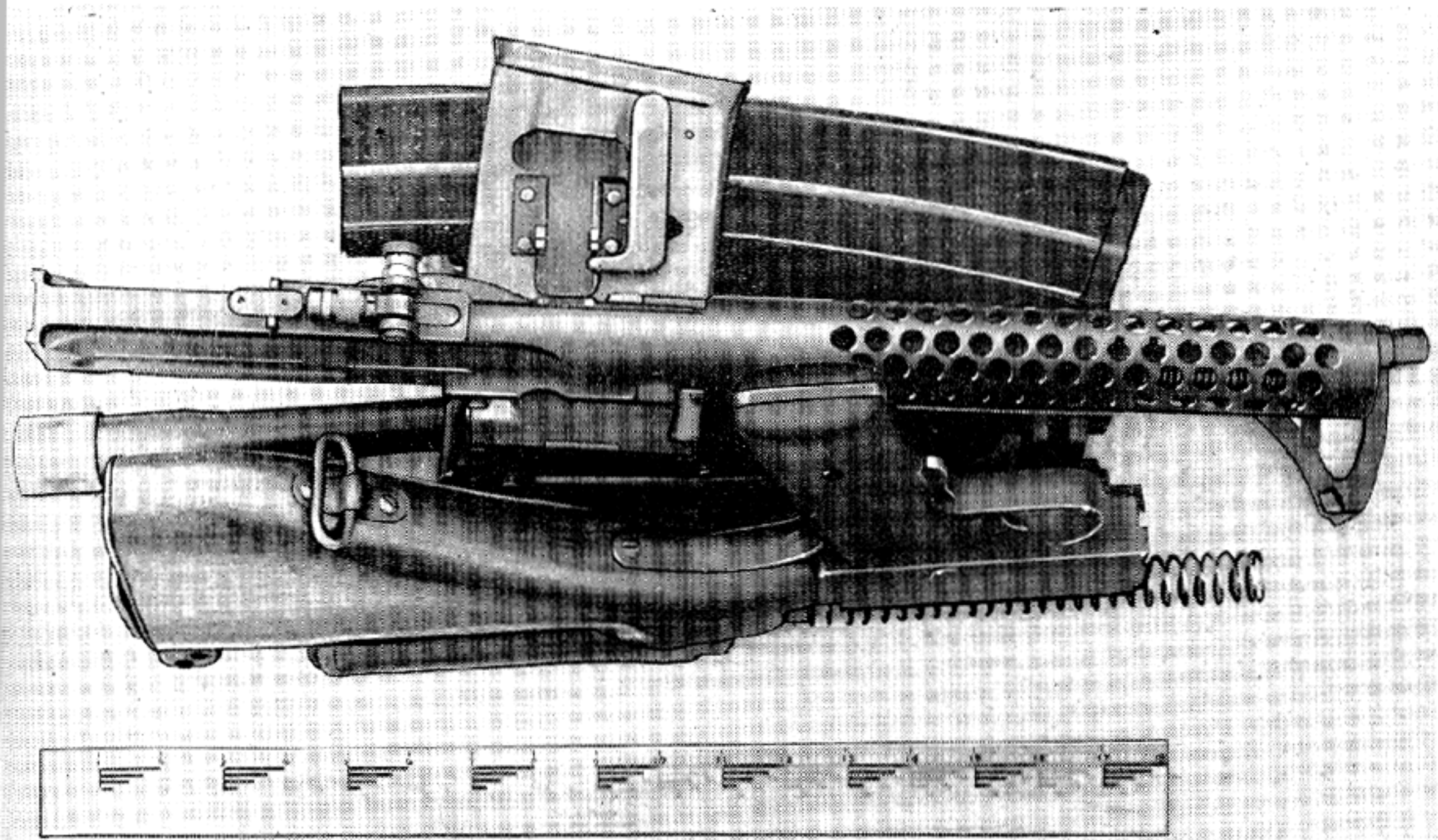
locking latch will be cammed into place holding it secure. During demonstrations a complete barrel change has been done in six seconds.

To fire the Johnson light machine gun, a loaded clip is inserted in the left portion of the receiver until the holding catches click into engagement. If automatic fire is desired, the selector switch is set and the cocking handle pulled all the way back or until the rear sear engages its notch in the bolt. When the trigger is pulled the connecting sear is released from the bolt, allowing it to be thrust forward by compression of the driving spring in the butt stock.

After pushing the cartridge out of the magazine, the bolt chambers it as the extractor cams its claw over the rim. Just below final forward movement is halted, the locking cam on the rear of the bolt rotates the latter piece. It is fully secured as the action goes through a 20-degree arc, engaging all eight of the locking lugs. This last movement also releases the firing pin which flies forward, detonating the primer.

When the cartridge is fired, the barrel, its extension and bolt locked together recoil for a full one-eighth inch at which point the angled face of the operating cam contacts its corresponding face in the receiver body. This causes the bolt to rotate until the piece is free to recoil. This act is timed to coincide with a high residual pressure in the bore which adds to the speed of the bolt. The barrel, traveling only seven-sixteenths of an inch rearward, is brought back to battery by its return spring.

The locking angle on the lugs permits sufficient creep during the act of unlocking. The



Johnson Light Machine Gun, Model 1941, Disassembled. For Paratroop Work.

empty cartridge is jacked back and freed in the chamber so that the extractor has only to hold it in position for ejecting. This is done when the ejector strikes the base of the round and kicks it out the right side of the receiver. The bolt continues to go to the rear until stopped by the compression of the driving spring.

All operational parts are then put in counter-recoil. As the bolt passes the rear of the magazine mouth, its face pushes the next cartridge

out of the lips of the feed system and starts to chamber it. As long as the trigger is held to the rear, the cycle will continue.

In addition to his light machine gun, Melvin Johnson developed and produced a highly regarded semi-automatic rifle, some 50,000 of which were made and delivered during the war to various Allied forces. He also originated, at the request of the Navy Department, a 20-mm aircraft cannon.

MG-42 MACHINE GUN

In 1942 the Germans, after nearly 3 years of war, introduced into their services a machine gun known as the MG-42. It represented during World War II one of the finest machine guns manufactured for effort and money expended. The Germans, using the already highly successful MG-34 as a guide for such factors as length, weight, ballistics, and rate of fire, attempted to solve for the duration of the war their army's light machine gun problems. Only the soundest and most proved features known to them were put into its construction.

It was a weapon of devisement, contributed to by many, rather than the single invention of

any individual. For instance, the barrel change was an improvement over the Italian Breda, and the locking was an adaptation of the patented locking arrangement of Edward Stecke, a citizen of Warsaw, Poland. It is believed by many that, with the overrunning of Poland in 1939, one of the things seized by the Germans was a mock-up of a machine gun having Stecke's locking action. Realizing that it had many advantages, they added it to the list of fine features to be incorporated in a single ideal machine gun.

After the mechanism was finally decided upon, Dr. Grunow, a German industrialist, whose specialty was mass production by metal stampings,



Machine Gun, Model 42, 7.92 mm.

was ordered to devote his talents toward manufacture of the weapon without employing complicated methods or equipment. Dr. Grunow's accomplishment of this task by extensive use of pressing, riveting, and spot welding was a thing that will be studied and closely copied in machine gun construction for years to come. While its finished appearance was by no means as striking as that of other German machine guns, its battle life and performance was even greater than the normally high German standards for such arms.

The need for frequent barrel change because of the unusually fast rate of fire was met by the introduction of a most novel and efficient method for accomplishing it. A barrel throw-out lever was hinged on the right side of the receiver. It could be swung out bringing with it the hot barrel, which was supported by a metal loop attached to the inside of the actuating lever. The barrel could then be pivoted out of the rear of the barrel jacket and dropped without handling.

Feeding was done by a continuous metal belt through the feed block. Two feed pawls were linked to the front end of the arm by an intermediate link in such a way that when one was chambered, the other was being positioned behind the next round in the belt. Loading was thus performed in two stages instead of one continuous movement. This made lurching of the belt less violent and did not impede the gunner's aim.

The Germans, being perfectly satisfied with its ballistics, adapted the MG-42 to take the 7.92-mm infantry rifle cartridge. Although it did not weigh much more than an ordinary military rifle, no provision was made whereby it could be fired single shot, the only two settings on its selector switch being for *Safe* and for *Automatic fire*.

The system of operation was short recoil. Free travel of locked bolt and barrel was allowed for a short distance. The bolt was then unlocked and the high chamber pressure being held by the muzzle booster exerted itself on the barrel face and through the bore to the now empty cartridge, thus giving an abnormal rate of fire for such a light firing mechanism. Its cyclic rate, when using special ammunition, was asserted to be 1,350 rounds a minute and the normal num-

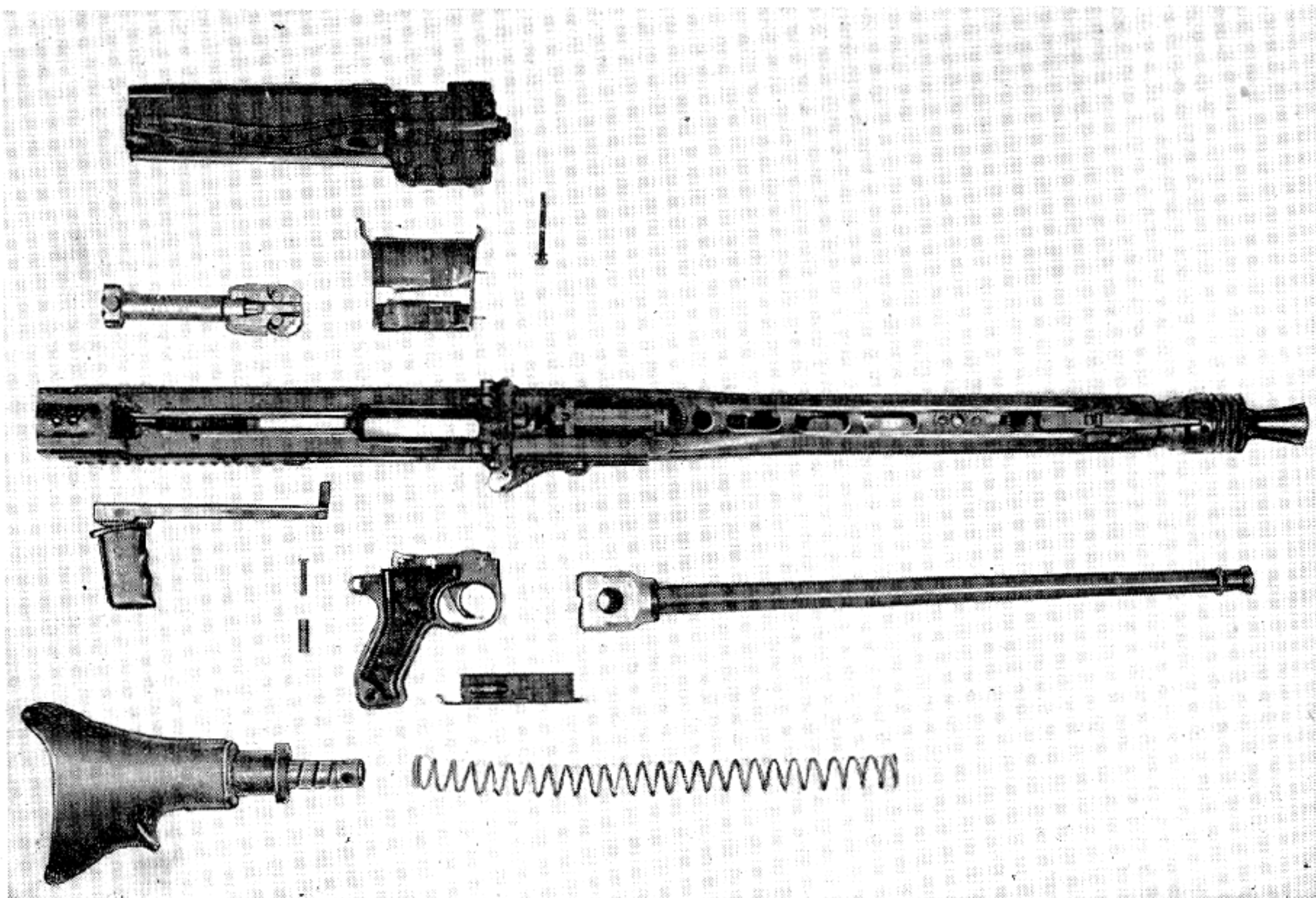
ber of rounds per minute with standard ammunition was 1,200 shots. While this may seem unnecessarily high for an infantry weapon, its importance for fire power effect was obvious.

In lieu of the rotating bolt head, successfully used on earlier machine guns of this type, locking of the bolt to the barrel was achieved by means of a wedge situated in the bolt head. This wedge was formed by two locking pieces, each being a small two-dimensional roller arranged symmetrically in slots in the sides of the bolt head with their axles vertical. The rims of the circular locking pieces were forced outwards so that the axles which projected above and below the slots engaged corresponding grooves in the barrel extension. On recoil the locking parts were forced in by stationary ramps and the light bolt was free to move to the rear under the action imparted by the gases from high chamber pressure exerted on the bolt face by the spent cartridge case.

The MG-42 was used with a bipod as a light machine gun, and on a tripod as a substitute for the heavier type. The barrel-jacket cover and feed parts and receiver were constructed of stamped lightweight sheet steel welded lengthwise. The bolt's slideways were welded inside the receiver. The shoulder piece was made of plastic. On the right side of the barrel jacket a long slot purposely was left open so that the barrel could more easily be removed. Manipulation of the lever in the receiver on this side would force the rear of the hot barrel out and allow it to slide untouched to the ground.

As an example of the thoroughness of design whereby each component or accessory performed as many functions as possible, the muzzle booster is perhaps outstanding. This simple device, fastened to the forward end of the barrel jacket, not only trapped the still expanding gases after the bullet left the bore, but it also served as a front barrel bearing and flash suppressor. It was so slotted that the escaping gas, after it had been reworked, hit against angled buffers to serve as a muzzle brake for stabilizing the weapon during a short burst at an abnormally high cyclic rate.

The Germans, in developing and producing the MG-42, abandoned all former rules and regulations on both production and finishing of material. This led to the erroneous belief that



Components of the Machine Gun, Model 42.

a desperate shortage of certain materials existed in Germany and that automatic weapons of inferior quality were being made, since externally they did not meet the erstwhile meticulous German standards. The truth of the matter was they simply had mastered the art of producing fine automatic weapons with no more expense and time than would be needed to make a dozen cap pistols.

About the only real weakness was its variety of tactical uses, in line with a typical German characteristic. Once a fine weapon has been in production, invariably an attempt was made to adapt it to every conceivable use from anti-aircraft in batteries to individual-burst fire by the infantryman. Its employment by the latter incidentally was its most effective. And while many have pointed out that its terrifically high rate of fire for infantry use would make the muzzle climb if a long burst were tried, it must be remembered that the weapon was ordinarily only fired for a fraction of a second during each burst.

Since it was being discharged at a rate of 22 shots a second, the striking bullets could be held to a small enough area to cover it thoroughly. It acted more in the capacity of a long-range shot gun than as a machine gun. The German Army considered the MG-42 one of the most excellent weapons known not only for inflicting heavy casualties on infantry in movement but doubly so for its effectiveness in keeping the enemy pinned down when dug in.

Ammunition was fed to the weapon by flexible metal belts, each holding 50 rounds, that could easily be spliced to any length desired. A drum magazine, also holding one 50-round belt, could be attached to the left side and a few have been known to be modified to take a saddle drum feed that held 75 belted cartridges.

In loading the MG-42, the feed cover can be either open or closed, so long as the first round is positioned at the cartridge stop. The spring-loaded cover for keeping dirt out of the ejection slot flies open the instant the trigger is pulled

back. When firing has been interrupted for any length of time, this piece is snapped shut by hand. It is one of the easiest known machine guns to unload. The selector is simply switched to *Safe* and, after unlatching, the feed cover is raised as far as it will go. The remainder of the belted ammunition can then be lifted out.

The bolt is removed first by letting it go home, then by twisting the butt stock to detach the latter. The driving spring and bolt then slide readily out the rear. The barrel has a relatively short but heavy barrel extension which is screwed to its aft end.

To fire the MG-42, the operator, generally from the prone position, puts the tab end of the cartridge belt through from the left side of the feedway and pulls to the right until the first cartridge comes to rest against its stop. With the weapon set at *Safe*, the charging handle on the right side of the gun is pulled all the way to the rear. The searing device will then engage its locking notch in the bottom of the bolt. The selector switch is turned to *Fire* and the trigger pulled.

As the bolt is thrust forward by the compressed driving spring, the bolt face knocks the cartridge out of its link ahead of the counterrecoiling parts into the chamber. As the movement continues, a locking stud on each side and at the front of the bolt starts to engage a corresponding cam in the barrel extension. By forcing the lugs into their locking recesses, the bolt face is brought securely behind the base of the already chambered cartridge. Final movement cams the extractor lip over the rim and into the cannellure of the round. At the same time, the firing pin, which is now an integral part of the rear portion of the bolt, is driven forward by inertia and detonates the primer to explode the powder charge.

While the powder gases are reaching peak pressures and the bullet is still in the bore, the bolt is held securely to the barrel, both pieces traveling rearwards as a unit until a distance of one half inch is reached. Then travel of the barrel and its extension is stopped. At the same time the pins in the locking head are cammed out by contact with the unlocking ramps, withdrawing them from their seats. The bolt is thus freed to continue to the rear, accelerated by the impact

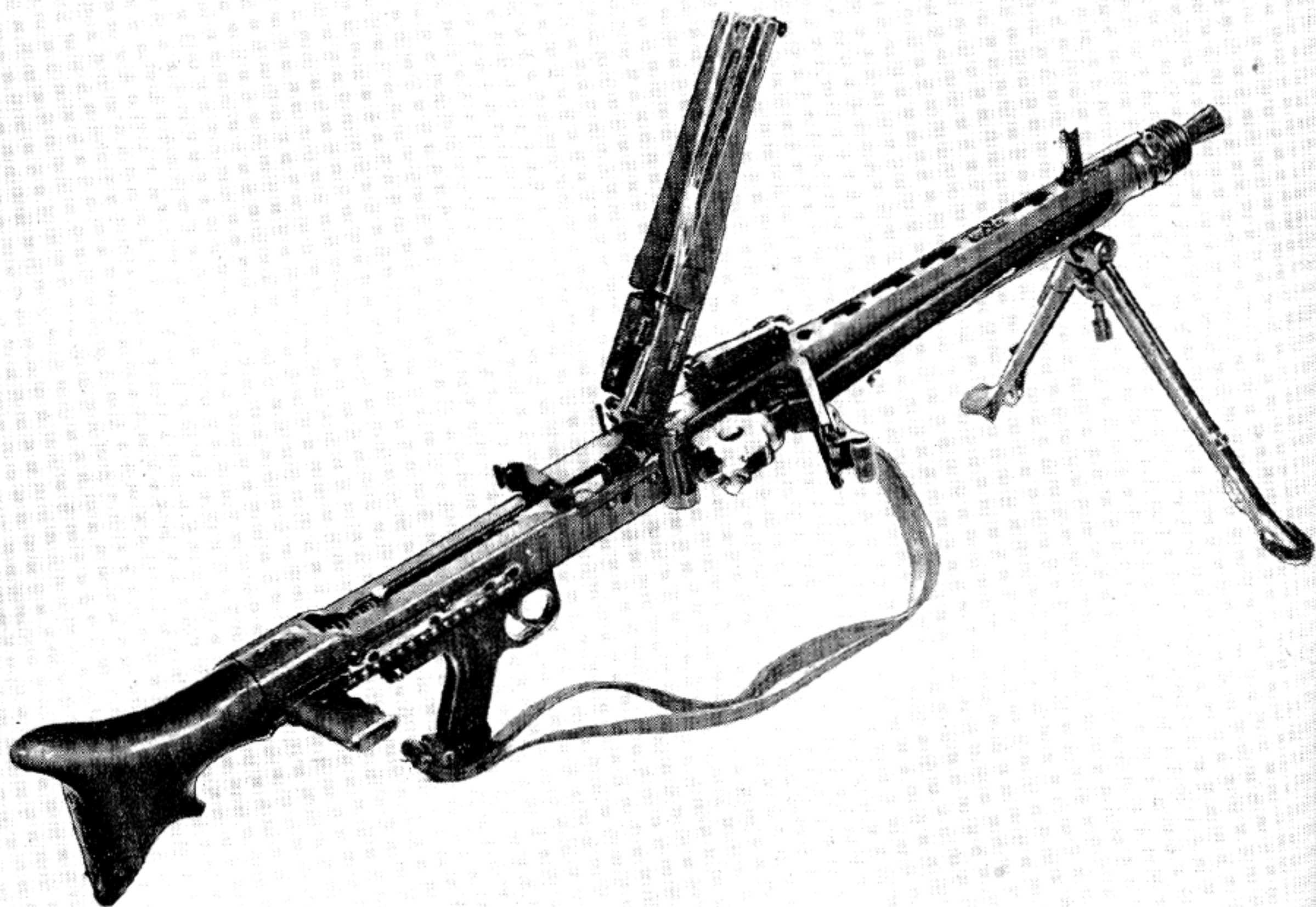
of the high residual pressure in the bore on the face of the bolt, while the barrel-return spring pushes the barrel and extension back to battery.

The cartridge case loosened by the first act of unlocking is carried to the rear by the extractor and is held until the ejector knocks it through the opening in the bottom of the receiver. The first movement of the bolt in recoil levers the next round in the belt into position and places the feed pawl behind the next cartridge as the bolt continues to go rearwards until it strikes the strong helical spring located in the shoulder stock. Deflection, working in conjunction with the stored energy of the driving spring, starts the operating parts back into counterrecoil to repeat the cycle of operation.

When placed in use as a heavy machine gun, it was found necessary to provide a specially constructed muzzle brake for the MG-42. The device counteracted the tendency of the muzzle to jump when a burst of long duration was fired. This followed the unsuccessful trials of a standard booster. The first use of the specially designed muzzle brake was late in 1943 and it was continued effectively until the war's end. The brake, which was attached to the flash eliminator and gas-pressure trap, had two baffle plates and was made to give more braking effect and lower cyclic rate than did the standard one.

The following arms plants manufactured the MG-42 for the German Army: The Johannes Grossfuss Metall- und Locierwarenfabrik, Dobeln, Saxony (Dr. Grunow was on its staff); Mauser Werke, Berlin; Maget, Berlin; Gustloff Co., Suhl Gun Works, Suhl, Germany; and Steyr-Daimler Puch A. G., Vienna, Austria.

After the United States entered the war against Germany, the Ordnance Department sought to copy a captured German MG-42. The Saginaw Steering Gear Division of General Motors was given the assignment. Drawings were completed in June 1943 and the first guns produced were test fired on 1 October 1943. Serious malfunctions were found to result and the components were then reworked. When it was thought to be ready, it was again put on trial in February 1944. The results were so discouraging that the discharge of a hundred rounds had to be done in bursts of two and three shots. Again the parts were modified and "beefed up" until it



Machine Gun, Model 42, 7.92 mm. View Shows Cover Open and Barrel Release Latch Open with Barrel Partly Removed.

was thought to be capable of the basic 10,000-round endurance test required by the Army before being considered even for limited use. After 1,483 rounds had been expended, the test was stopped, there having been over 50 serious stoppages.

An intensive study was ordered on the failure of American engineers to copy successfully this German machine gun which had been stamped out of the most ordinary of materials. The investigation revealed that inadequate compensation for the difference between the cartridge length of our caliber .30 M2 and the German 7.92-mm cartridge case had been made and that the receiver on the American version was too

long. The rear lugs on the bolt body also had not been placed far enough back to allow the bolt face to recoil behind the ejection slot in the bottom of the receiver. As a result the receiver yoke interfered with the cartridge guide plate by as much as a quarter of an inch.

It was concluded that extensive redesign would be necessary to correct these serious defects in both receiver and bolt mechanisms and further expenditures or developments were ordered stopped. Two models of this American-made failure, known officially as Machine Gun Cal. .30T24, were shipped to the Springfield Armory and placed in its museum for reference and historical purposes.

FG-42 MACHINE GUN

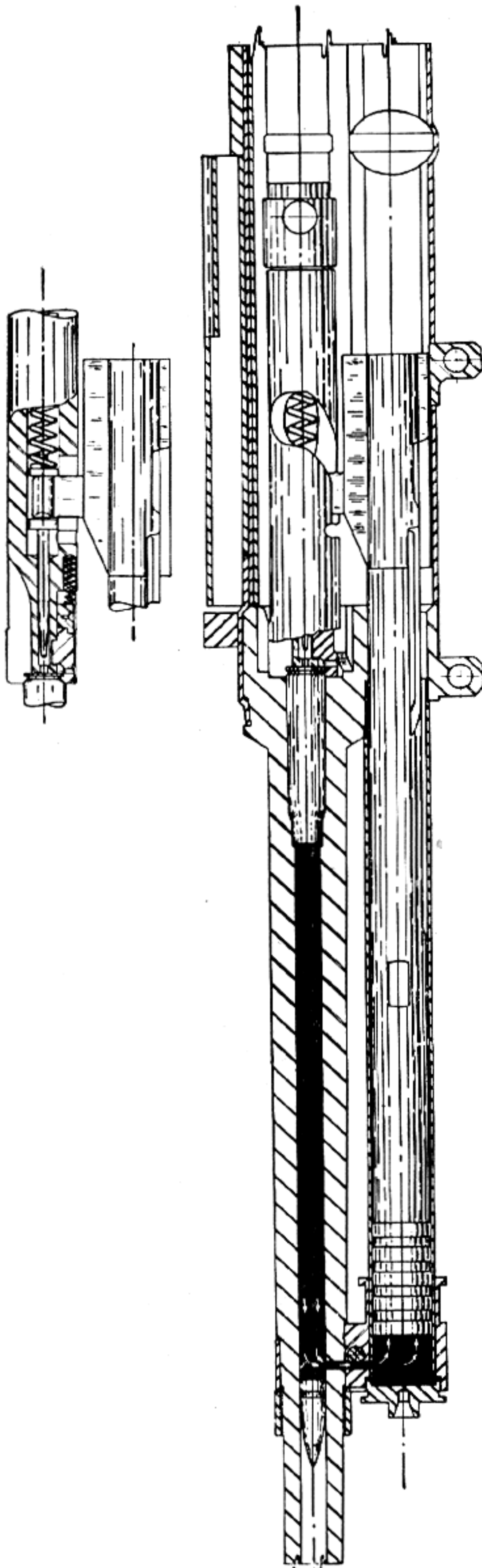
German military and industrial leaders, believing they had taken care of infantry armament needs, next turned their attention to a machine gun on which consideration had to be given to balance and lightness of weight. This weapon, manufactured by Heinrich Krieghoff Waffenfabrik, Suhl, Saxony, was intended for air-borne soldiers, a mode of warfare so far untried. With the invasion of Crete by air the Germans introduced the new paratroop machine

gun, called the FG-42. It was promptly confused with the MG-42 by observers reporting the incident. The designation given the air-borne weapon represented the initials for Fallschirm Jaeger Gewehr (paratroop machine gun).

The gas-operated, air-cooled, bipod-supported weapon had a large ventilated fore-arm grip and an unusually light and short shoulder stock. It weighed only 14 pounds with bipod and a loaded clip magazine that held 20 rounds. The



Machine Gun, Model FG-42, 7.92 mm.



Section Drawing of the Machine Gun FG-42, Showing the Action Immediately After Firing. Gas from the Barrel Is Acting on the Piston Which Will Rotate and Unlock the Bolt.

receiver body, which contained the slideway for operating parts, was stamped out of sheet metal. The fixed barrel was permanently fastened both fore and aft by having the receiver swaged circumferentially in a recess around each end and then further secured by the locking pin. A projection on the left side opened to permit insertion of a fresh loaded magazine when all cartridges were expended from the previous one. When not in use, it was closed by two metal spring-loaded flaps which flew open when their latch was shoved forward.

A combination flash suppressor and muzzle brake was screwed on the muzzle end of the barrel, being held in place by a spring latch attached to the front sight. This device absorbed a high percentage of the recoil forces. A gas cylinder beneath the barrel was held in place by a locking nut. An orifice selector permitted the gunner to regulate the amount of gas going into the cylinder from the port in the barrel, center punch marks showing him in advance whether the movement would position a large or small orifice.

The gas cylinder had four equidistant ports located far enough away from the forward end to permit the piston rod to unlock before uncovering the ports. It then discharged the expanding powder gases at the end of its rear stroke and took in air on the return movement. The gas piston consisted of a tube closed on the forward end. Its rear portion had a recess machined in its upper side in which a rear-searing device engaged. Two D-shaped holes were machined at its middle to contain a cocking handle. The driving spring, held in place by a guide, was inserted into and housed by the gas piston. A rather strong spring-recoil buffer at the rear of the receiver, just aft of the gas piston, was designed to stop the latter on completion of its recoil stroke. The rear-inserted bolt assembly operated in a slideway in the receiver, while a cartridge guide stamped in the receiver, held the cartridge in alinement for chambering.

The two halves of the sheet-metal trigger mechanism were welded together. This unit housed the sear, selector switch, and safety latch. A sear protruding through the receiver acted against the underside of the gas piston and permitted the gunner freedom to fire either single

shot or full automatic. The short wooden stock was held in place by a spring-loaded catch and could be readily removed by depressing the locking latch located at the right rear.

The Germans, being on the receiving end of the very efficient Lewis gun during World War I, developed a great respect for this fine and reliable mechanism. It is natural that, when possible, many experiments were conducted in order to incorporate any single feature or the whole basic action for their own advantage. The FG-42 was the result. However it was so highly refined and modified to meet special needs that it was hardly recognizable. The most unusual feature was the cleverly designed triggering mechanism that enabled the operator by a turn of the selector switch to fire full automatic or single shot. At the same time it gave the gunner the privilege of firing with either a closed bolt for accuracy when used single shot, or of leaving the bolt in the open position for cooling purposes at the completion of a burst of full automatic fire.

This weapon represented the highest degree of refinement the Lewis type of automatic firing mechanism had ever attained and was well designed for its intended purpose.

To fire the FG-42 full automatic, a loaded 20-shot magazine is inserted after the spring-loaded flaps over the feedway are opened by releasing the catch. The safety lever, locked in the up position, is pushed down and the selector switch swung forward to *Full automatic*. The cocking handle, grasped on the right side, is pulled smartly to the rear until the gas piston and bolt are held there as the rear sear engages its locking notch beneath the piston. The weapon is now cocked and a cartridge is positioned for firing.

When the trigger is pulled, the driving spring thrusts the bolt and piston forward. The face of the bolt engages the base of the first cartridge in the mouth of the magazine. As the round is forced forward, it leaves the magazine and is directed by the cartridge guide for alinement with the oncoming bolt and chamber. As the

bolt reaches the end of its forward motion, the extractor lip snaps over the cartridge rim and the bolt face seats against the breech end of the barrel. The locking recesses are in position with the lugs on the bolt. However, the piston can still continue to travel and, in its attempt to do so, the beveled projection riding in the curved slot in the bolt body causes the bolt to rotate the lugs in their recesses and lock the piece. This act removes the obstruction that has been holding the action rearward. The added free travel permits the gas piston to drive the firing pin through the bolt face into the primer which in turn fires the powder charge.

The bolt remains securely locked supporting the cartridge while the bullet is in the bore. However, when it has passed the gas orifice, a portion of the expanding gases is let into the gas cylinder through one of the four regulating orifices. Pressure is exerted on the gas piston which starts to move rearward, carrying with it the firing pin held by the yokelike section on the rear part of the piston. The bullet is now clear of the muzzle and the yoke, after having had a free travel inside the bolt for over an inch, starts to act against the cam causing the bolt to rotate and become disengaged from the barrel extension.

When unlocking is complete, the bolt is free to be speeded back by the high residual pressure in the chamber. As it continues rearward, the empty cartridge case is withdrawn by the extractor and its rim brought into contact with the ejector operating through a slot in the bolt body. The empty case pivots about its extractor and is knocked through the ejection slot in the right side of the receiver, where it is deflected forward by a curved piece that is fastened rigidly to the outside of the receiver for this purpose. Additional movement rearward during the recoil stroke compresses the driving spring. The remainder of the energy of the operational parts is absorbed by their striking the heavy spring buffer. The latter, assisted by the driving spring, deflects the action forward to repeat the cycle of operation.

PART V

AUTOMATIC AIRCRAFT CANNON

After reviewing the material on the more recent large-bore automatic-firing mechanisms, it seems quite obvious that future armament of aircraft for years to come is to be found in this type of weapon. While quite ironically the bulk of our source material is in this particular field, due to security reasons the amount that can be openly discussed has become less and less. Only features that have been well known over a period of years are mentioned. All other models having peculiarities of construction that might reveal possible improvements in future design have been purposely deleted from this publication.

DAVIS NONRECOILING GUN

When representatives of the great powers affixed their signatures to the treaty in St. Petersburg, Russia, in 1868, their main purpose was to eliminate the possibility of using explosive and purposely deformed bullets on personnel in warfare. In order to insure that no such projectiles be employed against the individual soldier, they collectively agreed to set 450 grams as the legal minimum weight for a projectile and its explosive content.

This simple specification made it impossible for any nation to put a bursting charge in any bullet of small dimensions. In fact, at this time no firearm existed which could utilize successfully a projectile based on these figures. It remained for the weapons manufacturer, B. B. Hotchkiss, then producing manually operated machine guns in Paris, France, to design the minimum size in artillery shells to be effective and still come within the legal requirements. This Hotchkiss projectile had stability of flight, penetration, and great destructive power from blast. When gaged up, it was found to be 37-mm in diameter.

The humanitarian intentions of the delegates who attended the convention resulted in a great restriction on aircraft armament all through World War I. For any plane that carried guns other than those in the rifle-caliber class had either to use a solid nonexploding projectile or mount at least a 37-mm cannon. As the cannon's slow rate of fire did not warrant employment of the nonexplosive shot, armament designers turned their attention to adapting shrapnel-firing cannon to the flimsy aircraft of the time. As a result, World War I saw aircraft weapons with bores equal in size to those used in another war some 25 years later.

The first recorded method of firing an artillery piece in the air was the invention of Commander Cleland Davis, an Annapolis graduate with a brilliant career, including a citation for

bravery in commanding machine gunners in the Manila campaign of 1899. His simple but unorthodox idea was so far advanced beyond the times that it reappeared as a "new discovery" in the latter days of World War II. In attempting to overcome the terrific recoil forces of artillery mounted in aircraft, he applied on 22 August 1911, for a basic patent on recoilless artillery and electric primer ignition. His wording in the patent claims bears repeating in order to show just how prophetic his conception was:

"It having been demonstrated that it is practicable to navigate the air under normal atmospheric conditions, and while as yet the practice is too hazardous for ordinary commercial



Cleland Davis When He Was a Lieutenant, USN.



A Davis Gun Mounted on a Naval Seaplane. The Gunner Has Pivoted the Breech to the Open Position for Loading.

purposes, still aircraft have already become a part of the military equipment of most of the civilized nations. . . . They have, however, so far developed little, if any, offensive value, it being practically impossible to strike a comparatively small target, such as the deck of a battleship, the vulnerable part of a fort, or even a large building, by merely dropping explosive from a high altitude. . . . Furthermore, the mere dropping of a high explosive on the deck of a ship, or a fort, would occasion very small damage, for the force of the explosive would ordinarily, aboard ship, be confined to the region above the protective deck and little damage would be done. . . .

"In order to secure the desired velocity to penetrate even thin armor, or a protected position anywhere, the explosive would have to be contained in a projectile, and this projectile would have to be propelled with sufficient velocity to penetrate said armor. . . .

"In order for a gun to be effective for such purposes, it must comply with the following conditions: (1) It should be of caliber sufficiently large to discharge a projectile carrying a considerable quantity of explosive. (2) It should be capable of giving a muzzle velocity to the projectile that would enable aimed shots to be fired at distances of 2,000 yards, or more. (3) It should be so designed that the shock of recoil will bring little or no strain upon the structure of the aeroplane."

"In order to meet the above condition, I have devised the apparatus . . . to which reference will now be had. . . ."

The invention was provided with an electric primer operated by a suitable source of electricity, such as a battery. The gun itself consisted of a barrel open at both ends to the atmosphere, a projectile and a propellant charge for the missile, and a recoil weight in the rear of said propelling charge. The weight was adapted to be expelled from the gun into the air when the charge was fired, thus neutralizing the backward thrust incident to the expulsion of the projectile. The shell was to be held in the gun by some friable connection and the resistance of shearing the set screw slightly exceeded the resistance required to start the shell in the bore. Thus the shell would move forward before the gun started to the rear.

By this arrangement of having the projectile and gun bring forces in opposite directions, a comparatively small amount of shock would be brought on the framework of the airplane. The resistance to the rearward travel of the gun in its sleeve obviously would be approximately equal to the resistance of the projectile in its passage through the bore of the gun. Then these two forces would neutralize each other, thereby relieving the gun support of any heavy strain.

Commander Davis did not stop with the conception of this novel weapon, as he demonstrated a working model at the United States Naval Academy at Annapolis, Md., several years before he actually put what he considered a perfected recoilless cannon into production.

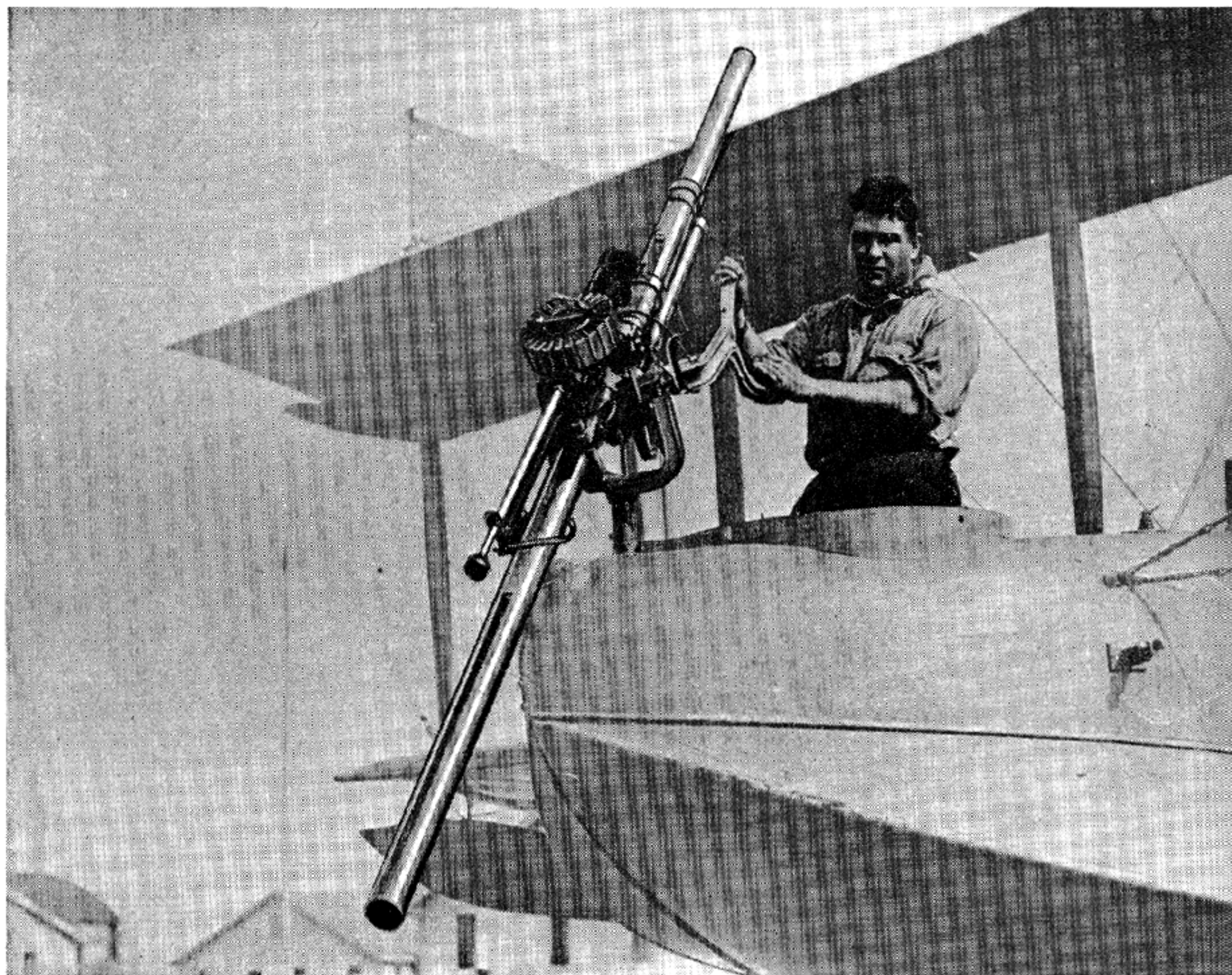
The *Scientific American* on 21 April 1917, after its reporter had witnessed a factory demonstration of the weapon, published a glowing account of what it would make possible in aircraft use. In conclusion, the possibility it would offer as artillery for ground troops was described:

"Nonrecoiling guns of large size may also be mounted upon dirigibles, armored cars, or actually be carried by hand, greatly increasing offensive power without increasing the size of the vehicle or impairing the mobility of the infantryman in any way."

Like numerous other inventions of radical design, the possibilities of this new kind of aviation cannon were not realized except to offer a token demonstration of its capabilities during the last days of the war. On 2 August 1917, the largest gun yet fired from an airplane in America was tried out at the Curtiss Aircraft Co.'s testing range at Buffalo, N. Y. The weapon was a 75-mm Davis nonrecoiling gun, manufactured by the General Ordnance Co. of Derby, Conn. It was mounted at the front of the cockpit of a Curtiss J-N twin tractor operated by a factory test pilot, named Carlstrom, the company's representative, Mr. F. B. Towle, acting as gunner.

This pioneer performance of firing successfully such a large cannon from an airplane caused considerable comment in the newspapers and predictions of its effect on all artillery were freely made.

The velocity given for the big projectile was 1,175 feet per second and its accuracy was as good



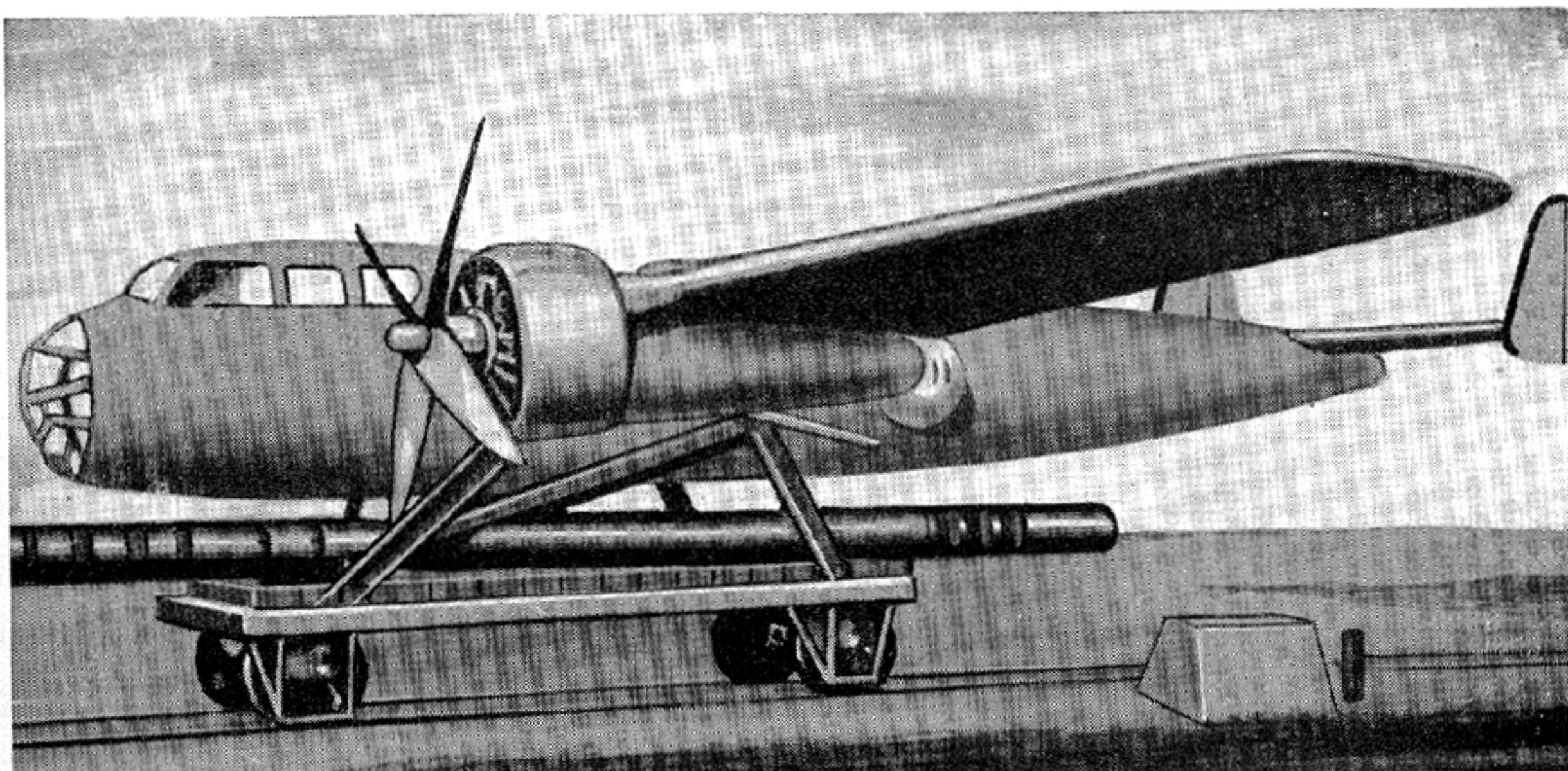
Davis Gun Mounted for Anti-Submarine Patrol.

as that expected from a rifled barrel. A unique means of sighting the gun was employed. A Lewis gun was fastened on top and in the middle of the long tube and, as the pilot approached within range of the target, the gunner pressed one of a dual-trigger arrangement. This fired the Lewis gun and the gunner could observe where his bullets were hitting. When he had corrected his aim, by watching the bullets strike, until he felt he was on the target, the lower trigger was pulled back and by means of electric ignition the large cartridge in the Davis cannon was fired. This type of sighting was especially effective against submarines.

The Navy, which alone of the military services showed interest in the cannon, mounted it on seaplanes in three different calibers, 47-mm,

65-mm, and 75-mm, firing from six- to nine-pound projectiles. The Davis gun was distinctly an American Naval accomplishment, in that none of similar construction were developed, or even experimented with, by any other nation during the war. Both France and England were furnished the recoilless cannon by the Navy and it was put to limited use during the conflict. The Army made no attempt to utilize it as a land gun.

Actually the Davis gun practically dropped out of existence with the signing of the Armistice only to be rediscovered at a later date. During the course of World War II both the United States and Germany were working on secret projects relating to recoilless artillery. An American Army adaptation of the Davis gun was put



The Davis Principle Applied in World War II. The Germans Attempted Firing a 1500-Pound Shell from this Dornier 217.

in operation, called the recoilless rifle. It was used effectively as highly portable artillery.

Rheinmetall-Borsig developed two types of the Davis gun. The first (the Device 104) had a bore of 14 inches. It fired forward a naval gun projectile of armor-piercing type, weighing 1,500 pounds, and ejecting backwards, as the counter-recoiling projectile, a cartridge case of the same weight. Its muzzle velocity was over 1,000 feet a second. The whole round was loaded on the ground. The tube was 37 feet long and the complete unit (tube, projectile, and cartridge case) weighed 7,500 pounds. Its function was to improve the striking power of aircraft against capital ships. The cannon was mounted on a Dornier 217 attack plane.

The main difficulty the Germans experienced resulted from the muzzle blast. To lead the blast away from the fuselage, a deflector was fitted to each end, but even this did not prove sufficient and armor had to be installed on the bottom of the plane.

The other type of nonrecoiling aircraft cannon used by the Germans was mounted vertically in batteries and was known officially as the SG-113A (*Sonder Gerat* or *special purpose equipment*). The counterprojectile in this arm was

also the cartridge case. It was designed primarily to attack tanks from the air. The FW-190 was used to mount these 45-mm cannon. An armor-piercing projectile was fired straight down against the relatively thin roof armor on the tanks. The aiming and firing of the salvo was controlled by the disturbance of the earth's electric or magnetic field caused by the presence of the tank. Fortunately for the Allies this ultra-modern armament was never produced in quantity. By the time the Nazis were satisfied with the performance of this installation, volume production could not be reached because of the concentrated bombing of German industrial plants.

Also under construction at the same time was another vertical-firing cannon, known as the SG-116. It fired a 3-cm shell straight up and was fitted into the fuselage of a fighter plane. It was sighted and fired by radar when a bomber formation was directly overhead.

The Davis recoilless cannon was not used to more advantage in World War II because the United States between wars did not see fit to exploit the principles originally outlined in the Davis patent, and Germany, although desperately trying to make use of it after being convinced of its possibilities, could not do so following the bombing out of her industry.

VICKERS AIRCRAFT CANNON (C. O. W. AIRCRAFT CANNON)

The first mounting and firing of a conventional type of cannon from an airplane was in July 1913. The Vickers Ordnance Co., which was conducting a series of tests on the effect of recoil on plane construction, suspended an airplane built by Short Brothers, Ltd., from the interior of a hangar. It was a large pusher biplane and mounted in the front of the cockpit was a two-pounder cannon, a naval quick-firing gun that had been modified for the occasion. Vickers engineers found that the airplane to a certain extent acted as its own recoil cylinder.

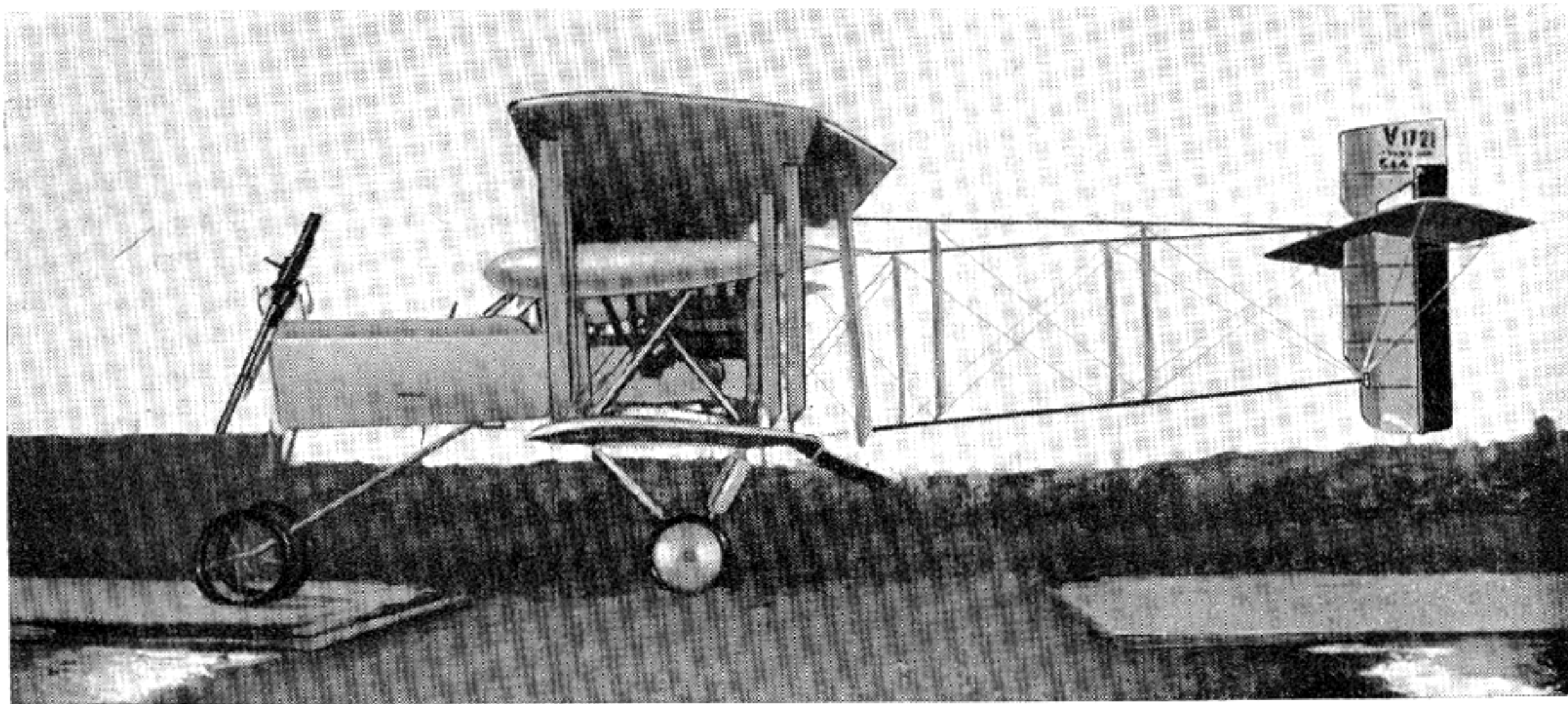
As a result of these studies, a test hop was undertaken by a young naval officer, Robert Clark Hall, who successfully fired the altered cannon. He reported that, while there was no damage to the aircraft, "there was a blinding flash and the plane actually seemed to stand still during the explosion of each round."

As the weapon itself was only a worked-over deck cannon, it does not warrant description or

cycle of operation. It had to be loaded manually and its place in aviation ordnance history is simply that of being the first air-borne cannon to be fired without disaster.

The United States became interested in the demonstration and sent a representative abroad to witness the next scheduled firing. This trial was not, however, a success and all work on the gun was stopped in favor of a full-automatic 37-mm cannon then in experimental development by the Coventry Ordnance Works, Coventry, England. The firm's initials were used by British flying officers in naming it the C. O. W., or "Cow," gun.

The cannon proved to be much more usable than the previous one. Upon completion, it was tested at the government range at Shoeburyness. The purpose of the experiments was to determine whether or not the automatic mechanism would function at all angles of elevation and depression.



C. O. W. 37-mm Automatic Aircraft Cannon Mounted in a Voisin Battle Plane, 1915.

Three cannon were used. They were first elevated to an angle of 85° and fired. Two out of the three emptied the five-shot clip without malfunction. One, however, would not go back to battery, the return spring not being strong enough to position the operating parts. The two guns that fired properly were then depressed until the barrel was vertical. The performance took place on a pier and the weapons functioned well, although the shooting was so close to the water that it drenched both guns and ammunition during the test.

The C. O. W. cannon were used to a very limited degree by the British Navy in the latter days of World War I. They were never popular because of their habit of delivering the terrific impact of recoil into the body of the light plane carrying it. In one instance the gun was mounted in a Voisin plane and, after four shots, the wings came off the fuselage. As a result, the plane plunged into an airdrome, killing all occupants. Such accidents and the common-sense fact that a plane carrying such a weapon in that period

was overloaded contributed to its early abandonment.

The gun operated by what is known as the long-recoil system. The barrel and breech lock were held securely locked together until the distance of the recoil movement was greater than the over-all length of the incoming round. The lock was then freed and remained held to the rear while the counterrecoiling barrel went into battery, literally pulling the chamber off the empty cartridge case. This type of action, which was simply a scaled-up version of the Chauchat long-recoil-operated machine rifle, was quite commonly used on large-bore automatic weapons. While slow, it was reliable and solved such problems as the necessity of opening the breech under high gas pressure if short recoil were used. The gun had an air-cooled barrel, was magazine fed, and fired both semi- and full automatic.

To fire the C. O. W. automatic cannon, the five-round clip is first put into position with the bolt forward. The gunner, with the aid of a crank, jacks the operating mechanism to the



C. O. W. 37-mm Automatic Aircraft Cannon Mk III.

rear until the holding device stops the rammer and carrier frame. Upon release, the barrel returns to battery and at the instant of doing so releases the carrier. The latter strips the first round from the feeder. Upon chambering it, the rotating bolt is locked behind the round.

The weapon now being loaded and ready for firing, the trigger is depressed. The force of the exploding powder starts the barrel, the breech lock, and carrier to the rear, all rigidly locked together. After the assembly has traveled a distance greater than the over-all length of the incoming round, the breechblock is cammed a partial revolution and the carrier to which the extractor is attached is engaged by its holding sear. The barrel can then start back to its former position, while the carrier and extractor remain stationary with the extractor claws over the rim of the fired cartridge case. The barrel, in going forward, separates the chamber from the empty case.

Just before the barrel completes counterrecoil movement, a dog is cammed in that releases the carrier to start forward. On the first movement the ejector pivots the empty case through the ejection slot in the bottom of the receiver. Continued travel causes a rib on the carrier to push the loaded cartridge in the feed mouth into the chamber. The rim of the live case, upon being seated, strikes a device that rotates the bolt, rigidly locking it to the barrel extension. The carrier then completes full movement forward and the extractor claws are forced over the rim of the loaded round. If the trigger is held to the rear, the striker will again fly forward to discharge the weapon.

At the same time, the British developed a few larger experimental models with 47-mm and 75-mm bores. The latter were made for the French at their request.

Since the conventional rifle-caliber machine guns played the dominant role in early air warfare, these pioneer cannon, as far as the British were concerned, did not see too much action and in the years following the Armistice they met with little or no official encouragement for future development.

During the twenties and early thirties the Vickers Armstrong Co. copied the design of the C. O. W. 37-mm gun and proceeded to refine it,

keeping the bore at 37 millimeters and adapting it for installation in large seaplanes. The Blackburn "Perth" flying boat first mounted the gun.

It employed the identical system of long recoil for operation. In contrast with the original C. O. W., this air-cooled clip-fed gun had separated recoil and counterrecoil casings below the barrel and the mainspring had been housed. A crank was used to retract the mechanism for loading.

Upon orders from the Royal Air Force, the Vickers Co. produced a 40-mm cannon, using the same cartridge as the antiaircraft batteries with a muzzle velocity of 2,500 feet a second. Although British military authorities gave Percy R. Higson of Vickers much credit for the design of the Vickers-Armstrong 40-mm cannon, in reality it was fundamentally the firing mechanism of the Coventry Ordnance Works gun of a much earlier date.

Test firing was first done in August 1939 and the results were considered satisfactory. A Wellington bomber was soon equipped with one such gun in the nose. It was contemplated placing another in a power-driven turret then under consideration, but this project was dropped in favor of rifle-caliber machine guns. It was possible to have six cartridges ready to fire, if desired, one in the chamber and five in the cylindrical magazine. In this type of feed a center coil spring pushed each round into place for feeding.

After the design was considered acceptable, the Birmingham Small Arms Co. was also engaged by the government to make the weapons and carry on additional development. July 1940 was set as the delivery date for the first guns off the assembly line.

In arming twin-engine planes with large-bore automatic cannon having an extremely high muzzle velocity, Great Britain was following the example of the Russians. These high priority cannon were to be used offensively against shipping, submarines, power plants, and large storage tanks; and defensively on invasion barges and shipping in general. All development work was actively supported by the Coastal Command and the Fleet Air Arm, which had found from experience that smaller bore cannon, even in multiple installations, lacked sufficient striking power against these targets.



Vickers-Armstrong 37-mm Automatic Aircraft Cannon, Mounted in a Blackburn "Perth" Flying Boat.

The next progressive step was the use of a predictor sight which triggered the operating mechanism when on the target and the whole clip of five rounds was fired automatically.

Against shipping it was decided to concentrate fire on a vessel's boilers. All patrol pilots using aircraft so armed were provided with drawings, diagrams, and photographs of various types of ships showing boiler locations.

Again following the Russian pattern for ground support, the Ministry of Aircraft Production authorized the immediate design of a single-engine monoplane for low-altitude use against tanks, small ships, and similar land and sea targets. The aircraft was to be fitted with twin 40-mm Vickers automatic belt-fed cannon, mounted in the nose of the fuselage. A single Rolls Royce Model 45 low-altitude engine with pusher-type propeller powered the plane which had a top speed of 250 miles an hour.

The engine and the pilot's compartment were heavily armored against small arms ground fire, with no defensive armament for use against enemy aircraft. This special objectives plane had only a three- or four-hour patrol range. Operational use of the craft was dependent upon the protection being afforded at all times by an adequate "umbrella" of fighters. The Air Staff felt

that such an aircraft would form an important element as an Army support weapon.

There is also a record that the Ministry of Aircraft ordered 12 Hurricane fighters equipped with two 40-mm cannon, one mounted underneath each wing for firing outside the propeller arc. These planes, upon being modified, were shipped to the Middle East to be used against tanks.

Colonel Moore-Brabazon, the Minister of Air Production, was responsible for the air-borne cannon program and the passing years have proved it to be broad, intelligently conceived, and done in a manner that produced the greatest results in critical times. The Air Ministry, however, conceded it was following closely Russian strategists in this field, as these early advocates of big-bore ordnance, both ground and air-borne, were setting the pattern on the eastern front in supporting their infantry with cannon-bearing planes.

The British, in the latter days of World War II, turned to an even larger cannon. This time Vickers scaled up the same battle-tested mechanism and produced a 57-mm automatic gun that was placed in the nose of the Mosquito plywood bomber. This six-pounder, as the British always referred to it, had terrific powers of destruction and saw considerable active service before the end of the war.