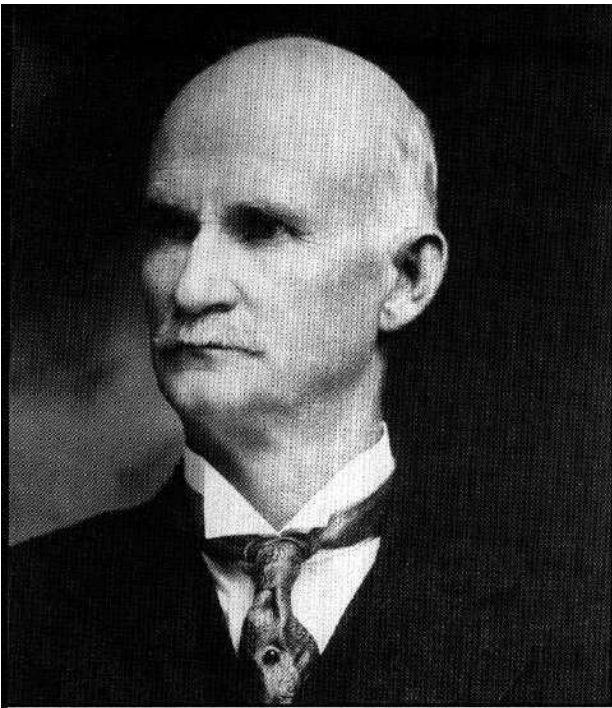


# THE MACHINE GUN

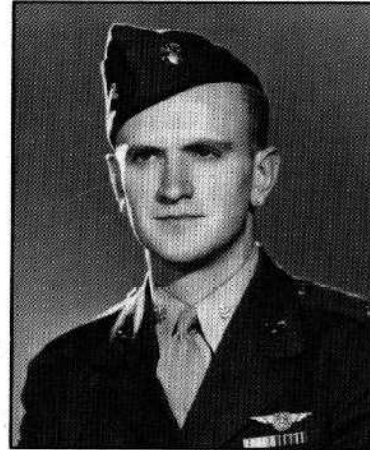
VOLUME V

PARTS XII, XIII, XIV, XV, XVI, AND XVII





**John M. Browning**



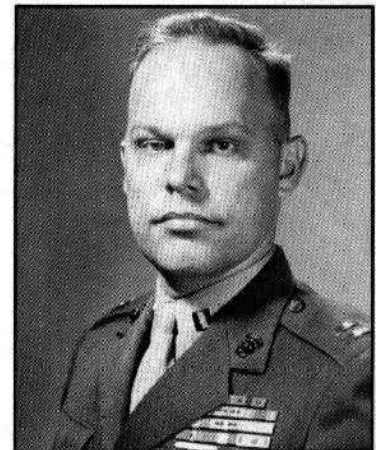
**Commander W. Dan Snively**  
United States Navy



**Maj. George McGarry**  
USMC (Ret.)



**Col. Ross Jordan**  
USMC (Ret.)



**Maj. Jack Elliott**  
USMC (Ret.)



**Marvin Haines**



**William Blaine**  
Naval Sea System Command



Ed Hoffschmidt



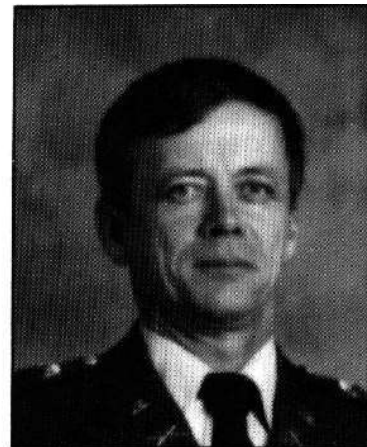
Col. Samuel Green



Col. Donald Fenton  
USMC (Ret.)



Adm. R. A. Matter



Maj. David Baskett



Theodor Rakula



Rev. Louis Erhman

# THE MACHINE GUN

VOLUME V

PARTS XII, XIII, XIV, XV, XVI, AND XVII



# **THE MACHINE GUN**

Development of Full Automatic Machine Gun Systems,  
High Rate of Fire Power Driven Cannon, and  
Automatic Grenade Launchers  
by the United States and her Allies,  
following World War II,  
Korean Police Action, and the Vietnam Conflict.

by

**George M. Chinn**

COLONEL, USMC (Retired)

**Volume V of Five Volumes**

**1987**

DOWNGRADED FROM  
CONFIDENTIAL  
TO  
UNCLASSIFIED  
BY AUTHORITY OF  
FPSO-CNC-B3 of 3249  
JULY 1970

Personnel involved in automatic weapon development seldom agree on anything, but there is one facet in this field of endeavor that all are in complete accord. Namely, that the successful aircraft weapon represents the highest state of the art.

There is no known aircraft cannon or machine gun, either automatic or externally powered, that cannot be modified for ground or ship board use. However, there are many outstanding automatic firing mechanisms that are suitable for ground deployment that cannot be successfully altered, modified, or reengineered for aircraft armament.

Consequently, the purpose of this volume is to focus primarily on aircraft weaponry. Perhaps future studies will cover the evolution and progress of ground versions, but in an effort to preserve the flavor and clarity of Volume V all other types must, regrettably, be omitted.

# PREFACE

A series of publications entitled "The Machine Gun," sponsored by the Bureau of Ordnance, Department of the United States Navy, was prepared with the belief that the next best thing to actual knowledge, is knowing where to find it. The research summarized within the covers of these volumes was compiled in such a manner as to place in the hands of those rightfully interested in the art of automatic weapon design, the world's recorded progress in this field of endeavor.

Volume V begins with 1952 and continues to 1987. The primary purpose being to update the concepts, experiments, success, or failure of the state of the art in machine gun development. Volumes I, II, III, and IV of "The Machine Gun" series brought conventional weapons systems up to 1952, at which time further development was officially terminated.

This work consists of artists' conceptions, line drawings, photographs, progress reports, company brochures, along with proving ground tests, plus combat recommended changes, to correct malfunctions that inevitably occur.

All source material used to prepare and finalize the manuscript was excerpted from documents previously downgraded to unclassified (by authority of EPSO-CNC-B3 of 3249 July 1970), and all patents revealed are in public domain. Volume V is neither government funded nor sponsored. In this way, we were able to document chronologically the success or failure of each contract entered into by industry and the military in attempting to advance the state of the art in the evolution of the machine gun and aircraft cannon.

For purposes of clarity and uniformity, the topics within the chapters have been arranged in as nearly the same format as possible. Because the goal of this book is to present, without editorializing, the case history of each gun in the form the cognizant activities chose. Deviations from their arrangement of material have been made only where the original reports were organized so differently that rearrangement for consistency of presentation seemed desirable.

So that this technical information can be presented in an orderly manner, it is further broken down into the basic principles that have governed the development of automatic weapons since the beginning of their conception.

Held to the strictest interpretation of the definition<sup>1</sup> and to the means by which the function is accomplished, there is only one primary force that actuates any automatic weapon: namely, the energy generated by the explosion of the powder charge contained in the chamber of the barrel. There have been, to date, only two known means that can be derived from this source of power that have resulted in successful operation: (1) the rearward thrust of the recoiling mass; and (2) pressure generated in the bore by the expanding gas of the progressive burning charge. The former is known as recoil actuation, while the latter is labeled gas operation. All known means used in making an automatic weapon complete a full cycle fall into this broad classification, whether the mechanics employed be reciprocating or rotary.

The recoil-operated type of weapon can be further broken down into two distinct classifications: short and long recoil. Gas operation, however, seems to have no limit in its application. For instance, the residual pressure remaining in the bore a few milliseconds after the projectile has cleared has been, for lack of a better term, called blowback, while in reality it is but another form of gas operation.

However, the most common method of employing the energy created by the gas of the exploding propellant is to tap the barrel and let the expanding gas be brought to bear on an actuating device such as a piston, lever, etc. The system is universally referred to as "gas operation," erroneously implying that this is the only way gas pressure is utilized as a source of power.

If one were satisfied only with generalities, it would be quite in order to state that there are only five known practical applications for accomplishing sustained fire as outlined in the definition of an automatic gun: (1) short recoil; (2) long recoil; (3) gas pressure in the bore bled off externally through an orifice (gas operation); (4) residual pressure remaining in the bore a few milliseconds after the projectile has cleared (blowback); and (5) blast energy generated by the expanding gases after being released from the confines of the barrel at the muzzle end (muzzle blast actuation)<sup>2</sup>. These are considered the basic principles and from these simple variants of power, more than 3,000 patents have been issued since 16 June 1884 on operational features of machine guns.

So thoroughly have the gun designers of the past covered the subject that since World War I the individual was indeed skilled in his profession if he could even make an improvement on a feature that had already been in existence a long time, much less originate something that could rise to the dignity where it could truthfully be called an invention.

There is a tendency to use general terms too loosely in describing certain types of actions. For instance, the word "blowback" is invariably employed when describing any weapon that uses this form of actuation either wholly or in part. This unusual power supply has been exploited to such a degree that it takes at least four distinctly different classifications to cover the application of this method of utilizing residual pressure for completing a cycle of operation: (1) pure blowback (Bergmann); (2) retarded blowback (Schwarzlose); (3) delayed blowback (Scotti); and (4) advanced primer ignition (Becker). Each system is strictly adaptable to certain types of actions and is utterly impractical other than for a specific purpose. For example, the calibre .22 Colt Woodsman pistol uses pure blowback and is a well-balanced, highly efficient hand arm, and for this type of weapon such a method practically defies improvement. However, if this system were applied to a conventional 20mm cannon, the bolt alone would need to weigh in the neighborhood of 380 pounds, with an approximate rate of fire of 200 rounds a minute, both of which would be totally unacceptable. If advanced primer ignition were used, the weight of the 20mm weapon could be held to 90 pounds and the rate of fire would be about 600 rounds a minute, while if delayed blowback were employed, the overall weight of the gun would be slightly more (about 100 pounds), but the weight of the bolt or recoiling parts could be held to a bare minimum (6 pounds), and the rate of fire could be brought up to as much as 1,000 rounds a minute. On the other hand, the maximum elasticity of the conventional type cartridge case, coupled with the inevitable high chamber pressures of today, makes the timing factor too critical to permit any consideration of retarded blowback in the design of a large calibre automatic weapon. Such comparisons are limitless when based on the fundamental principles governing the design of automatic weapons.

If this work can help in any small way to revive in this country the almost forgotten art of automatic weapon design, a field so thoroughly dominated by Americans in the past, the effort and toil that have been spent in preparing the book will have been repaid.

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<sup>1</sup>Automatic Machine Gun—A weapon capable of sustained fire with its operating energy being derived wholly from the force generated by the explosion of the propellant charge.

<sup>2</sup>Although relatively unimportant, two other systems should be mentioned to complete the picture. "Blowforward" is a method in which the barrel is held to the rear by heavy spring pressure against a solid non-recoiling breech that supports the cartridge, gas pressure driving the projectile forward through the bore to move the barrel off the empty cartridge case. "The Gast system" is a double-barrel arrangement whereby the firing of one barrel furnishes the power to load, lock, and feed the other barrel, with unlocking being tied in with the first part of recoil movement.

# ACKNOWLEDGMENTS

The help and encouragement received from many sources in the preparation of this work can never be fully acknowledged. The following individuals are listed in at least partial recognition of such contributions.

Special recognition must go to Adm. Malcolm F. Schoeffel for initiating the program that resulted in THE MACHINE GUN series, Volumes I, II, III, IV, and V. It was only through his foresight that the project came into being.

To Ms. Joyce Ward Watts, Editor and Research Evaluator; Ms. Donna Bodner Duncan, Typesetter and Lay-out Artist; and Ms. Rebecca Sadler McKinney, Research Analyst; who after volunteering to assume full responsibility for arranging an overwhelming collection of material from a meaningless mass of unorganized facts inherited from earlier attempts to produce Volume V, THE MACHINE GUN, goes the full credit for making this publication possible.

Expertise, combined with their determined head on facing of the challenge with such high professional skill, left all others involved in the project with a deep respect of their talents, and a few of us with a bit of envy.

That three dedicated local women could compile such a highly technical manuscript into readable continuity that here-to-fore defied the efforts of highly trained engineers, was beyond comprehension. Too much praise cannot be given for this accomplishment, for which the country in general, and those who must design and foster automatic weapons, should be forever grateful.

The untiring personal interest, guidance and professional advice of three service friends, Maj. Jack Elliott, USMC; M. Sgt. George McGarry, USMC; and Marvin Haines, USN; is deeply appreciated, and they are responsible for whatever measure of success Volume V of this series achieves. There is no way to evaluate the efforts of these three living legends of Navy and Marine Corp Aviation Weaponry.

The meticulous reading of the manuscript by Byron Crawford and his valuable suggestions, based on an extensive knowledge of automatic weapons, added greatly to the completeness of this work.

Commendation must be given to Tom Griswold, Spindle Top Research Project, for his patient and industrious acquisition of much of the original research material that forms the nucleus for this publication.

The mass of data, consisting of a compilation of technical manuals, operational pamphlets, design specifications, and test reports, was loaned from the files of Ms. Joan Elizabeth Brookes-Smith, former head of the Kentucky Microfilm Department.

The cutaway drawings and diagrams of complicated mechanisms, as well as other technical art work, were prepared by Tim White, Ramp Staff Artist, in a manner that reflects the highest of skill.

Norman Lawson, a Kentucky Legislative Research Commission Consultant, displayed an encyclopedic knowledge in the field of marking and official designations, which was invaluable to the overall project.

For excellent cooperation and service, special thanks are extended to the staff of the many libraries, museums and other activities that were consulted. Among them, the Naval Photographic Center, the Library of Congress, Army Library, Army War College Library, Sea Systems Command Library, Aberdeen Proving Grounds Library and Museum, and the U.S. Marine Corp Museum and Library, Quantico, Va.

## ACKNOWLEDGMENTS

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Dr. Theodore Jacobs; Ray Thorkildsen; Val A. Browning; Col. Donald "Barrell" Fenton, USMC (Ret.); "Pony" Maples, Ramo; William H. Woodin, Woodin Laboratories; Photo credits: Michael Woodin; Leo Abernathy; Frank Marquadt; Maj. David Baskett, Research Development Coordinator, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Grounds; Walter Wood, Naval Ordnance Station Louisville; Jim Sames, Val Forgette, President, Navy Arms Company; Eugene Stoner; Sgt. Maj. Donald R. McNally, USMC, MCAS Cherry Point; Pete Dickey; Dr. Edward Ezell; Ms. Dee Swenson, McDonnell Douglas Helicopter Corp.

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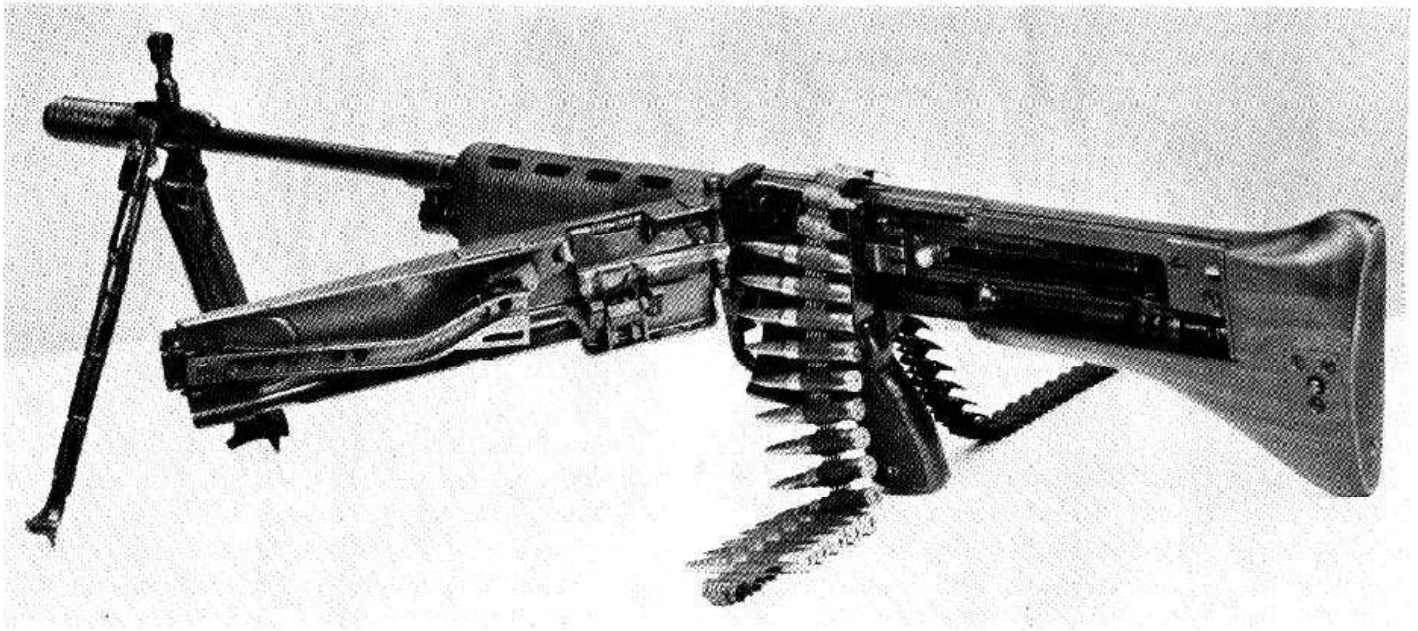
Last but not least I would like to acknowledge Gene Click, Charles Hardin, and Royce Isham, my local consultants, who were always on hand to volunteer their services.

A handwritten signature in black ink that reads "George M. Chinn". The signature is written in a cursive, flowing style with a large, prominent "G" and "C".

Colonel, USMC (Retired)

## Chapter 25

# 7.62mm M60 MACHINE GUN MAREMONT CORPORATION



7.62mm M60 Machine Gun

### History

The M60 machine gun, originally designated T-161E3, is the result of a series of designs started near the end of World War II at Springfield Armory. The first of these was called the T44 and was essentially a combination of the belt feed mechanism of the German MG42 with the operating mechanism, rotating bolt, of the FG42 automatic rifle. In turn, certain features of the FG42 were taken from the US designed Lewis Gun used in World War I. A less extensively modified version of the T44 was the T52, from which evolved the T161 series after the wooden stocks were replaced with plastic. The first version of this series was in calibre .30. The T161E2 adapted the design to the improved calibre .30 cartridge (T65E3) and the T161E3 used the NATO 7.62mm cartridge. This final version was put into production as the

M60.

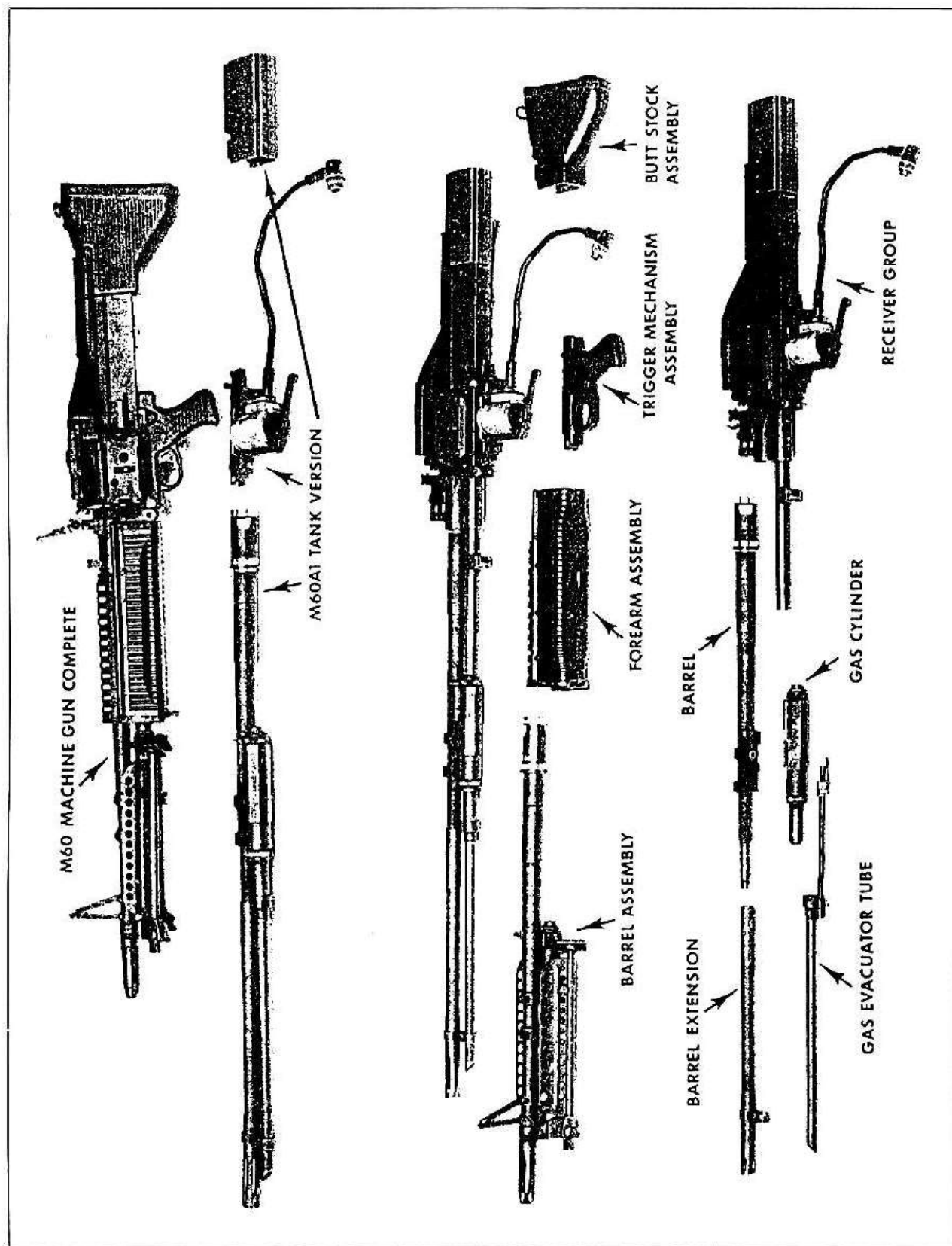
The M60 has been modified since original manufacture. The receiver has been strengthened by the addition of several pins and the feed tray now has a hanger assembly pinned to it.

A modified version of the M60 machine gun, the M60E1, has been developed. The principal reason for the development is to simplify barrel change and decrease the number of parts.

Continuing since 1967, Maremont Corporations has been modifying the M60 model machine gun for tank use. The M60E2 offers the armed forces an alternate 7.62mm tank machine gun to the M37 or M219 types.

### Description and Purpose

The 7.62mm M60 machine gun is a lightweight,



Assembly Groups

### Characteristics

|                               |                    |
|-------------------------------|--------------------|
| Calibre .....                 | 7.62mm (Nato)      |
| Rate of Fire (Maximum) .....  | 550 rpm (approx.)  |
|                               | Sustained: 100 rpm |
| Muzzle Velocity .....         | 2800 fps approx.   |
| Weight .....                  | 23.2 lbs.          |
| Length .....                  | 43.50 in.          |
| Chamber Pressure .....        | 52,000 psi.        |
| Maximum Range .....           | 4100 Yards         |
| Maximum Effective Range ..... | 1200 yards         |
| Flat Trajectory               |                    |
| Gas Operated                  |                    |

gas operated, air cooled, link-belt fed general purpose machine gun designed to replace all existing calibre .30 ground mounted machine guns. It is designed to fire the NATO standard 7.62mm cartridge using the same cartridge-link combination used with the M73 machine gun, and is capable of being fired from either the hip, shoulder, or on the ground using its integral bipod for the direct fire role and the M122 tripod mount for the prearranged fire role.

The M60 is called a general purpose gun because it replaces the calibre .30 Browning light machine gun. The M60 is the first United States machine gun to have a true quick-change barrel. It was specifically designed to be lightweight, and its components design was simplified for manufacture. Stampings or fabrications were used wherever possible. The quick-change barrel, lightweight, and adaptability for use as either a heavy or light machine gun, as well as relative ease of manufacture, make the M60 a superior gun.

### Cycle of Operation

With the gun loaded, in the cocked position, the following is the cycle of operation:

Pulling the trigger raises the front of the sear, dropping the rear of the sear out of its engagement notch in the operating rod.

The operating rod, released by the sear, is propelled forward by the energy stored in the drive spring by the cocking operation. The bolt, engaged by the operating rod cam yoke is carried forward with the rod, as is the gas piston, should it be positioned to the rear.

The bolt top locking lug strikes the rear edge of cartridge in the feed plate groove, where the car-

tridge is positioned by the belt link and the feed cover guides and springs. The bolt strips the cartridge from its link, carrying the cartridge forward out of the feed plate. The empty link is retained in the feed plate by the cartridge guide and the next round.

As the bolt enters the barrel socket, the round has been deflected downward and into the chamber by the front cartridge guide, the receiver feed ramps, and the barrel socket feed ramp. The barrel socket lead cams impart clockwise rotation to the bolt sufficient to enter the locking lugs into the socket locking cam. At this point the round is seated in the chamber, its base contacting the extractor and ejector. The forward motion of the operating rod and bolt compresses the ejector spring, and moves the extractor out to snap over the rim of the cartridge.

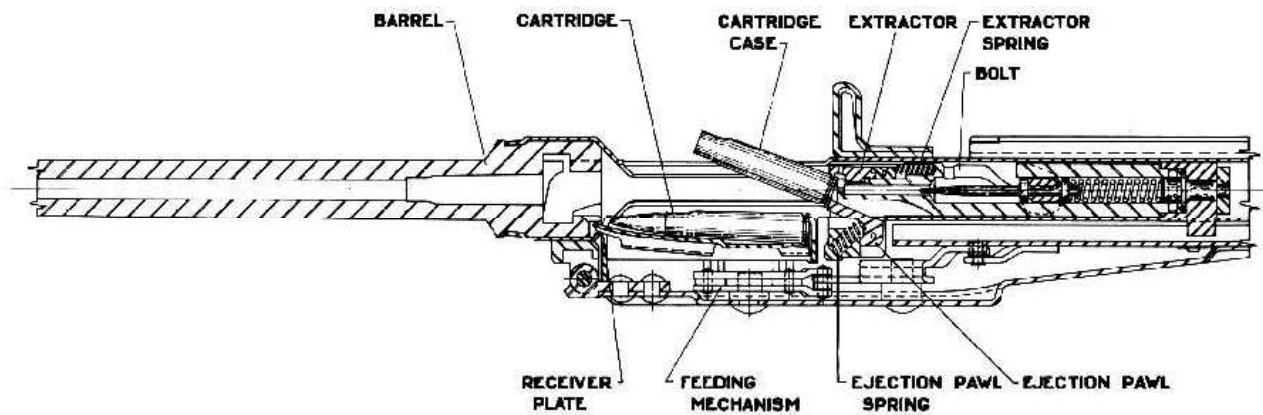
The firing pin, held back by the bolt cam and its engagement with the operating rod, has also compressed its drive spring during cocking. As the bolt rotates, its rotating cam releases the firing pin. The firing pin spring now contributes its energy to the operating rod through the bolt rotating cam and aids the drive spring to complete the bolt locking rotation. The operating rod continues forward, carrying the firing pin with it until the pin strikes the cartridge primer and ignites it. The firing pin is stopped by its seat in the bolt at the pin front bearing spool, stopping the operating rod. The operating rod has also positioned the piston in its forward position.

After ignition of the powder charge by the primer, the bullet is forced down the bore by the gases released. At a point about 8 inches from the muzzle, the bullet passes the barrel gas port, allowing part of the gases under pressure to enter the gas cylinder and hollow piston through their respective ports, which are aligned with the barrel port.

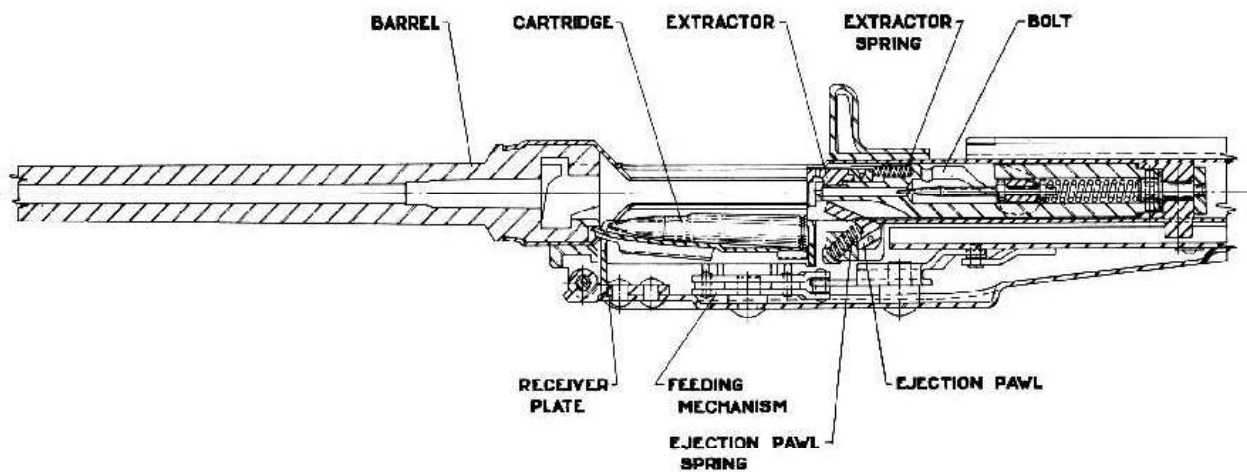
Gas under pressure, bled from the bore by the gas port, fills the hollow piston until enough pressure is built up to overcome the mass of the piston and operating rod and the load of the operating rod spring. The piston begins its travel rearward, propelled by gas pressure against the forward end of the cylinder. After a very short travel rearward, the piston ports and collector ring are out of line with the barrel gas port, sealing off a measured charge of gas under pressure in the cylinder and hollow piston. By this time, the bullet is well out of the bore, and gas pressure in the bore rapidly falls to help provide easy extraction of the spent round.

The piston, propelled rearward by the trapped expanding hot gases, forces the operating rod rear-

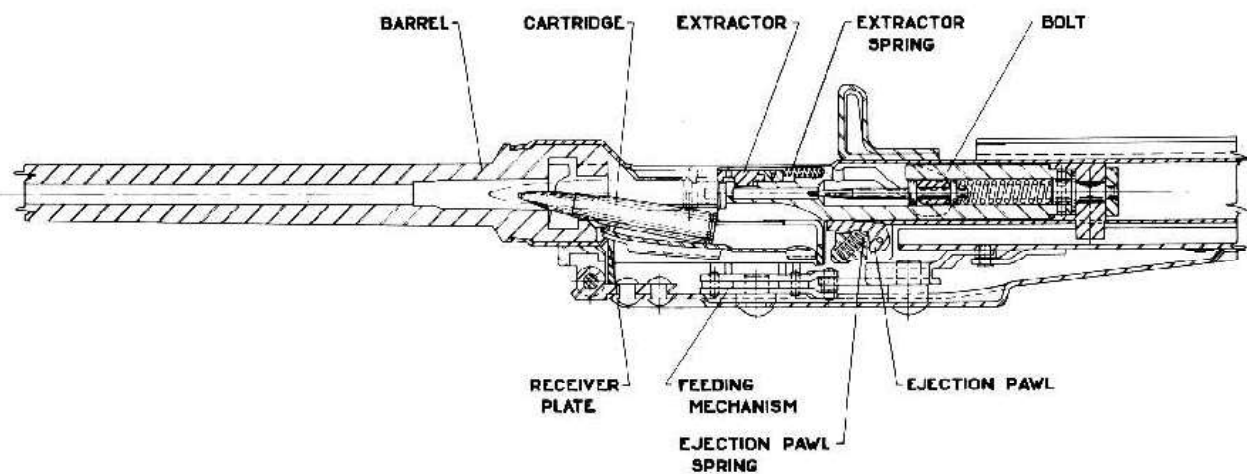
## THE MACHINE GUN



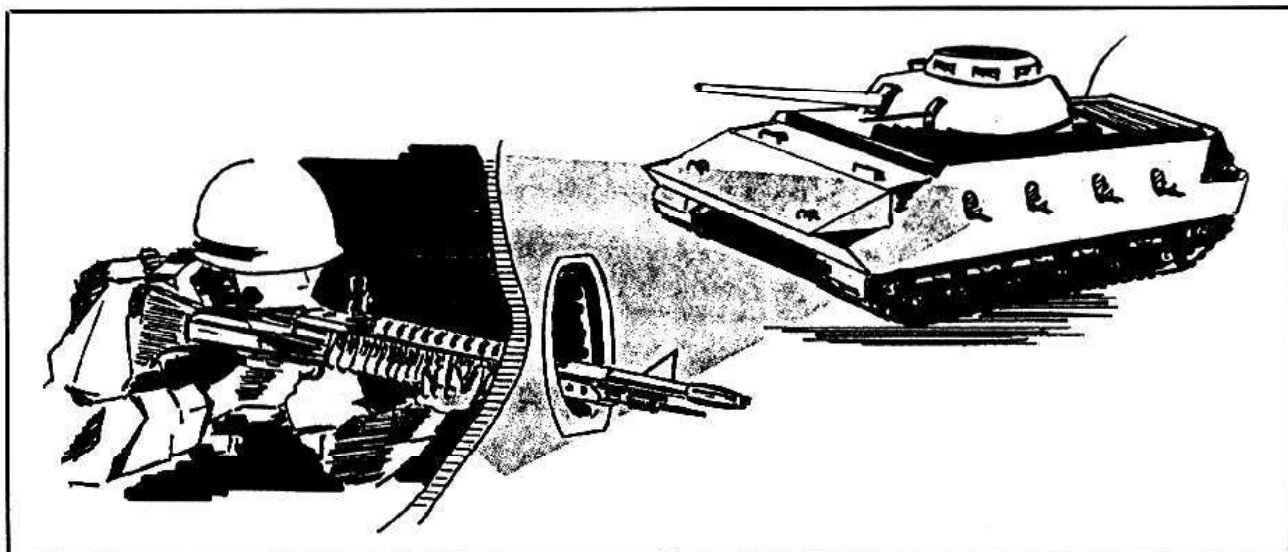
Cartridge Being Ejected



Bolt in Ramming Position



During Ramming



For Personnel Carrier Employment a Short Gas Evacuator Tube is used.

ward to contact the firing pin rear spool. This compresses the firing pin spring withdrawing the firing pin from the cartridge primer as well as compressing the operating rod spring. Rearward motion of the operating rod continues in the "dwell" slot of the bolt rotating cam, until the rod yoke rollers contact the spiral, or counterrotating part of the bolt cam.

The bolt now begins its counterclockwise rotation and unlocking, urged by the energy of the operating rod. At full unlock, the firing pin spring is fully

cocked, the roller of the rod cam yoke contacting the rear of the bolt rotating cam.

Bolt and rod together continue to the rear, propelled by the energy of the expanding gas, withdrawing the spent cartridge from the barrel chamber. As the spent cartridge leaves the chamber it is moved sideward in the direction of the ejection port, the ejector spins the case sideward to pivot about the extractor lip and disengage, allowing the case to be ejected with force out of the port, and against the



The M60 Machine Gun as a Personnel Weapon and a Waist Gun, "D" Version for a Helicopter.

## THE MACHINE GUN

ejection deflector which propels it downward.

In this interval, the piston has reached the limit of its travel. Spent gases are exhausted through ports provided in the gas cylinder, uncovered by the piston in its rearward travel.

Air behind the piston is exhausted through a set of ports near the rear of the gas cylinder, allowing escape of dirt and powder residuc.

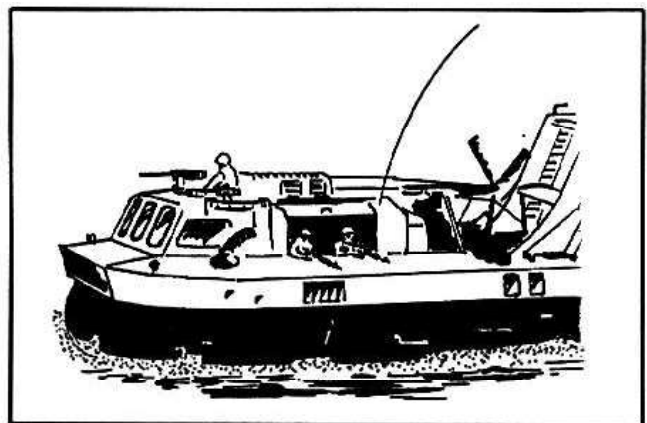
The bolt and operating rod continue rearward, propelled by stored energy and inertia, compressing the operating rod drive spring. As the drive spring is fully compressed, the operating rod contacts the buffer through the drive spring guide rod collar. Energy remaining in the rod and bolt is now transferred to the buffer. As the buffer plunger is forced rearward against its pads and preloaded springs, the rubber pads are compressed, acting as a high-rate spring. The rubber is forced to flow radially, to expand frictional surfaces tight against the buffer tube wall. Further rearward motion compresses the buffer return spring and the sliding friction of the pads on the tube wall absorbs the remaining energy of the rod and bolt. The moving parts now come to rest, and the counterrecoil cycle begins.

The energy stored in the drive spring now forces the operating rod and bolt forward. The frictionally damped buffer springs return the buffer plunger to its initial position. The firing pin spring also contributes some force until it is halted by the front of the rod yoke, which stops the firing pin in the "cocked" position in the bolt rotating cam. As the rod continues forward with the bolt, if the trigger has been released, the sear is held up against the bottom of the rod by the sear spring. As the sear engages the sear notch in the rod, forward motion stops, and the weapon is held in cocked position, ready for fire. If the trigger has not been released, the weapon continues to fire until interrupted by the sear, or until the ammunition is exhausted. If the last round is fired and the trigger held down, the gun will close on any empty chamber, and must be recoiled manually.

*Feed Cycle.* For simplification of description, this portion of the operation is considered separately.

As the bolt travels forward for firing, the feed cam mounted in the feed cover is engaged by the feed cam actuator roller attached to the rear of the bolt. Forward motion of the bolt and actuator causes the feed cam to swing to the right, forcing the front of the feed cam lever to the left. This carries the cartridge feed pawl plate assembly to the left where the pawls drop over and engage the next or second round for transport, and remain there until the round in the plate is stripped and fired.

As the bolt recoils, the actuator forces the feed cam to the left, and the feed pawl assembly transports the round to the right into the feed plate groove. The round is forced down into the groove by the cartridge guides and their springs. The empty link left on the plate is pushed out the port in the feed plate by the new round as it is fed. The feed plate contains a spring-loaded retaining pawl that retains the belt, holding the second round when the first round is in the plate groove. Two anti-friction rollers help guide the belt in place, and support the hanging belt. The weapon is provided with sufficient reserve power to lift a 100-round belt vertically under all normal operating conditions.



Internal Mounting of Modified M60 on Riverene Craft.

