

THE MACHINE GUN

VOLUME III, PARTS VIII AND IX



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THE MACHINE GUN

VOLUME III, PARTS VIII AND IX

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George M. Blinn

THE MACHINE GUN

Development During World War II and Korean Conflict
by the United States and their Allies,
of Full Automatic Machine Gun Systems and
High Rate of Fire Power Driven Cannon

by

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PREFACE

The series of books entitled "The Machine Gun" has been 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 has been compiled by the Bureau of Ordnance, Department of the Navy, in order 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.

The primary purpose of Parts VIII and IX of Volume III is to make available to those in authority pertinent data on the experimental work carried on to improve the design of automatic aircraft cannon by the United States and other major powers during and since World War II. Through data given in Volume III, personnel reporting for duty in research and development activities can acquaint themselves with certain phases of developmental work that already have been accomplished.

The information in most instances was compiled by the originators of the mechanisms and is presented in substantially the same form as when first prepared. The claims, recommendations, and conclusions represent the opinions of responsible personnel at the time the reports were submitted. No editorial comment has been included; accordingly, opinions formed by the reader will be based solely on authenticated source material.

For purposes of clarity and uniformity, the topics within chapters have been arranged in as nearly the same order as possible. Because the goal of this book is to present 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.

Parts VIII and IX of Volume III, unlike Part I through VII of Volumes I and II, deal strictly with technical aspects of the mechanisms; therefore, charts are included to give specific engineering data in condensed form. It is hoped that these graphic presentations will aid in the quick location of facts when this volume is used as reference material during a conference or other similar situation.

To show the evolution of some of our most advanced automatic firing mechanisms, it was necessary to illustrate several weapons that are so outmoded that they are not listed in the chapter entitled "Automatic Gun Designations." Accordingly, it was thought appropriate to introduce them pictorially in order to establish proof of the existence of the parent design.

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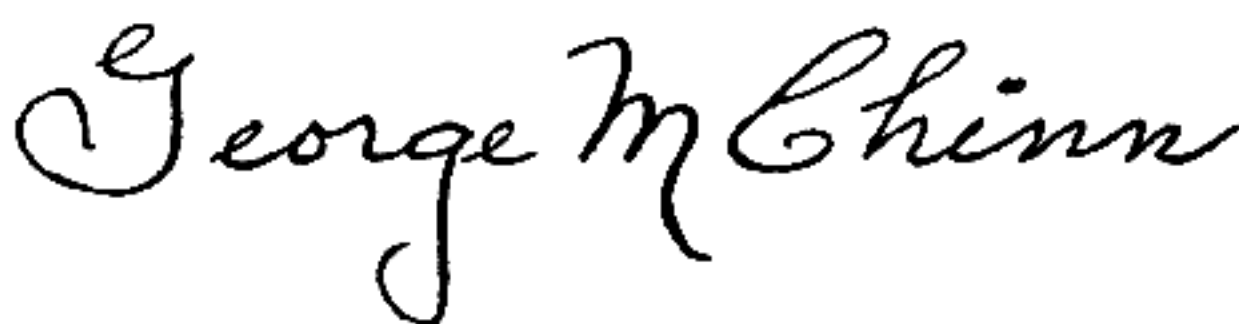
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Lieutenant Colonel, USMCR.

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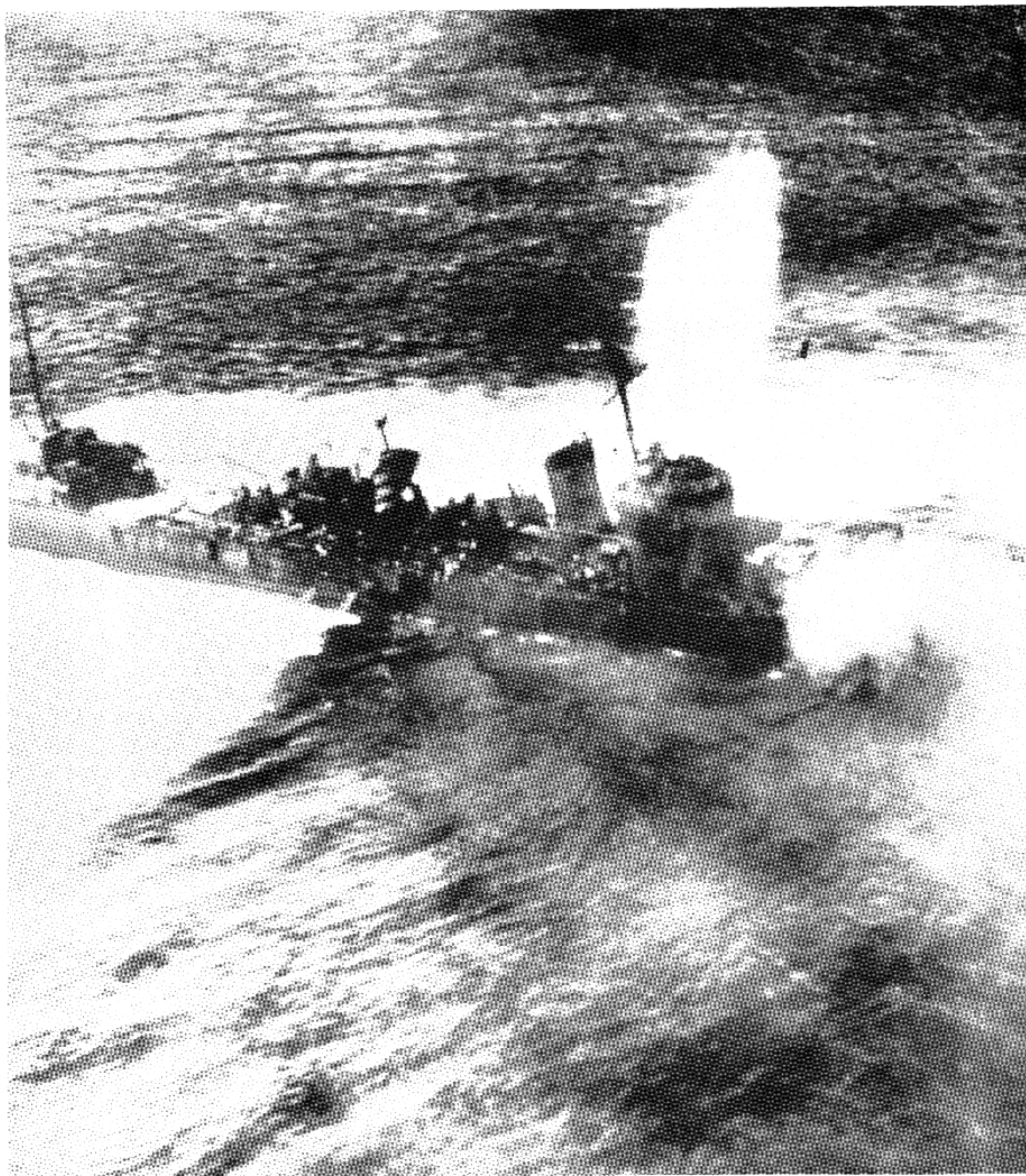
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Frontispiece. In World War II, Japanese warship receiving a fatal shot from a 75-mm aircraft cannon.

CONFIDENTIAL

PART VIII

AUTOMATIC WEAPON DEVELOPMENT DURING AND AFTER WORLD WAR II BY THE UNITED STATES

CONFIDENTIAL

Chapter 1

AUTOMATIC GUN DESIGNATIONS OF THE
ARMED SERVICES

SECTION 1. INTRODUCTION

Automatic weapons for the Armed Forces of the United States are procured, with minor exceptions, by two agencies, the Ordnance Corps of the Army, and the Bureau of Ordnance of the Navy. When a project is set up to develop a new item or modify a standard piece, a distinctive designation is assigned to identify it.

The Army method prior to 1925 was to assign a designation of model and year to each design. Since that time, model has been abbreviated with a capital M and consecutive numbers are assigned. Items in the development stage are given numbers with a capital T prefixed. To indicate changes in the development stages, the capital letter E may be suffixed to the T number followed by an Arabic numeral. Experimental changes to standard, or M-numbered items are also indicated by suffixed E numbers. Standard, or M-numbered items with approved changes, or standardized alterations, are identified by suffixed A numbers.

When a Navy ordnance item is approved for testing, it is assigned a Mark number. It retains this Mark number whether finally approved for service use or rejected. Modifications to the original Mark design are treated likewise. At the present time a proposal is under consideration to use EX numbers for Navy aircraft ordnance items while they are still in the development stage.

To identify an automatic gun completely, the caliber must be mentioned, then the correct letter and number designations. In some cases it is necessary to name the gun or mechanism, for example:

"Gun, Machine, Caliber .50 M2," and "20-mm Machine Gun Mechanism Mk 2 Mod 0." Complete identifications of this type are needed since T numbers, M numbers, and Mark and Mod numbers begin with No. 1 for each of various types of ordnance and other military equipment. In addition to reuse of numbers, there is some difference of usage of letter designations. For example: the Chemical Warfare Service has used E and R designations for experimental items instead of the T and E numbers of the Ordnance Department.

One of the most confusing things associated with the official designations of weapons is the prefix "AN", extensively used during World War II. This, when found attached to a model number, sometimes has caused the erroneous impression that there is a physical difference between a weapon so marked and one that bears only the model number, for example, "Gun, Machine, Caliber .50, AN-M2," and "Gun, Machine, Caliber .50 M2." The "AN" means that the weapon was adopted by both the Army and the Navy, and no difference exists between a gun so marked and the basic design.

On the front end papers of this book is a list of United States large-caliber automatic guns. In this chapter, the distinguishing characteristics of these guns are summarized. The reader should note that not all these designs were fabricated in metal. Some were made as wooden "mockups" and others were discarded while still on the drawing board. Weapons firing rifle, pistol, or carbine ammunition have been omitted purposely.

METHOD OF ASSIGNING T NUMBERS TO AUTOMATIC AIRCRAFT GUNS

OLD

From 1926 to 1950 there were four separate lists from which T numbers were assigned to automatic aircraft guns.

Low# High# Bore

T1	T65	Cal.30	GUN, MACHINE
T1	T60	Cal.50	
T17	T66	Cal.60	
T54	T56	20mm	
T1	T129	20mm	GUN, AUTOMATIC
T120	T121	30mm	
T1	T4	Cal.90	GUN, Cal.90
T1	T49	37mm	GUN, 37 mm

After March 1950 numbers were drawn from a single index which is generalized as

"WEAPONS"

This weapons index includes all howitzers, guns and mortars regardless of bore, function, or use.

GUN, AUTOMATIC,	Cal.60	T130
GUN, AUTOMATIC,	27mm	T150
GUN, MACHINE, TANK	Cal.30	T152
GUN, AUTOMATIC,	15 mm	T154
GUN, AUTOMATIC,	20 mm	T160
GUN, MACHINE,	Cal. 50	T164
GUN, AUTOMATIC,	37 mm	T172
GUN, AUTOMATIC,	30 mm	T182

In the future all bore sizes of new guns will be stated in mm.

All numbers between the low and the high were not necessarily assigned to machine or automatic guns. Some were proof, sub-caliber, or other types.

UNDER THIS SYSTEM ANY T NUMBER HIGHER THAN 130 WILL BE ASSIGNED ONLY ONCE TO A 'WEAPON' but there are other classifications such as 'RIFLE' and 'LAUNCHER' which will have a similar number

Figure 1-1. Method of assigning "T" numbers to ordnance items.

SECTION 2. CHARACTERISTICS OF UNITED STATES LARGE-CALIBER AUTOMATIC GUNS

Caliber .50 Machine Guns

Gun, Machine, Caliber, .50, Model 1918. In April 1918 the AEF, in a cable to the War Department, expressed an urgent requirement for a high-powered, large-caliber machine gun and ammunition primarily for aircraft, with second priority for ground use. Available knowledge on the perform-

ance of a German 13.2-mm rimmed antitank cartridge, as well as information on the British development of a caliber .50 cartridge, led to a decision to develop a caliber .50 machine gun and ammunition. Guns were designed under the supervision of John Browning at the Colt's Patent Fire Arms Manufacturing Co. (ground type) and at the

Winchester Repeating Arms Co. (aircraft type). (See *The Machine Gun*, vol. 1, p. 335.)

Gun, Machine, Caliber .50, Model 1921. This series of Browning guns were the first standard machine guns of caliber .50 to be adopted by the United States Government. There were variations for ground, air, and naval use. All this material is now obsolete.

Gun, Machine, Caliber .50 T1. An early design in the program to modify the Browning caliber .50 gun to permit right and left-hand feed. Both air- and water-cooled guns were made.

Gun, Machine, Caliber .50 T2. An intermediate stage in the development of the caliber .50 M2 series.

Gun, Machine, Caliber .50 T21. The Browning T21 was a collaborative effort by Colt and Springfield. This weapon underwent tests at Aberdeen Proving Ground from 1940 to 1942 with unfavorable results. The importance of that project was the establishment of a standard of performance for an acceptable high-speed gun. One breakage and five malfunctions were to be permitted in 5,000 rounds of firing at 1,200 rounds per minute.

Gun, Machine, Caliber .50 T22. Early in 1942 the High Standard Manufacturing Co. designed a high cyclic rate caliber .50 Browning machine gun and made two models. These guns, designated T22, were submitted to the Aberdeen Proving Ground for test 10 August 1942. One gun was fired on that date, 554 rounds at a cyclic rate of 1,066 rounds per minute, during which five stubbed rounds and two failures to feed occurred. Both guns were returned to High Standard for modification. A total of 10 guns were made.

Gun, Machine, Caliber .50 T22E1. This was a version of the T22 tested February 1943 which failed after firing 111 rounds. Failure was due to a broken sear.

Gun, Machine, Caliber .50 T22E2. Tested in March 1943 this gun fired 3,700 rounds at cyclic rate of 1,219 rounds per minute. There were 43 malfunctions and 7 breakages.

Gun, Machine, Caliber .50 T22E3. The records do not indicate the history of the T22E3.

Gun, Machine, Caliber .50 T22E4. Tested in August 1943 this gun fired 5,000 rounds at a cyclic rate of 1,108 rounds. There were 36 malfunctions and 2 breakages.

Gun, Machine, Caliber .50 T22E5. Modification of T22E4. Two guns were produced but when fired at Aberdeen their rate of fire was less than 1,000 rounds per minute.

Gun, Machine, Caliber .50 T22E6. Tested late in 1943 the T22E6 first gave poor results. In the development of this gun an effort was made to hold to a minimum the changes from the standard Browning M2 gun. Because of defects inherent in the mechanism it was decided that further development could not be expected to produce a completely acceptable weapon. Accordingly, further development of the T22E6 gun, as such, was not undertaken by the Ordnance Department although certain features of the weapon were incorporated in the T36 (M2A1) and T25E3 (M3) guns.

Gun, Machine, Caliber .50 T25. In the development of the T25 by Frigidaire no restriction was placed on the number of changes from the M2 gun, and the contractor was permitted to proceed by making all changes necessary to provide reliable functioning at a rate of fire of 1,200 rounds per minute. For example, the backplate buffer, barrel buffer, and receiver were redesigned. It was not until 10 March 1944 that the first T25 gun was submitted to Aberdeen Proving Ground for test. The gun gave a fair performance for 2,000 rounds, but from that point on excessive breakages and mal-

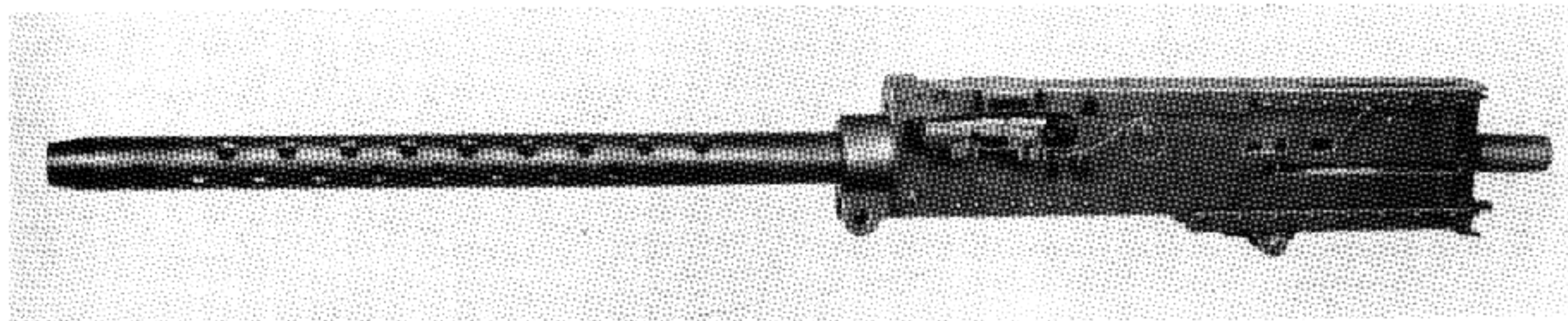


Figure 1-2. Gun, Machine, Caliber .50 T22E6.

functions occurred, and at 3,100 rounds the test was discontinued because of the breakage of the backplate buffer.

Gun, Machine, Caliber .50 T25E1. Work was immediately started on a second gun, the T25E1, which was tested at Aberdeen 10 May 1944. This gun was completely unsatisfactory. Nine breakages and three malfunctions occurred in 770 rounds and the test was stopped. Satisfactory functioning had not been obtained with the T25 series guns but certain features of those guns were considered very desirable.

guns, and to expedite procurement of this weapon, the Army Air Forces requested its standardization in April 1945. Ordnance Committee action was immediately taken to standardize the T25E3 gun as Gun, Machine, Caliber .50 M3, Aircraft, Basic.

Gun, Machine, Caliber .50 T26. Modification of the Browning M2 gun produced and tested at Aberdeen. Included a short-round device submitted by the Army Air Force and the cover assembly of the T22E5. The extractor assembly was also taken from the T22 series as was the backplate assembly. A muzzle booster with a 0.65-inch hole

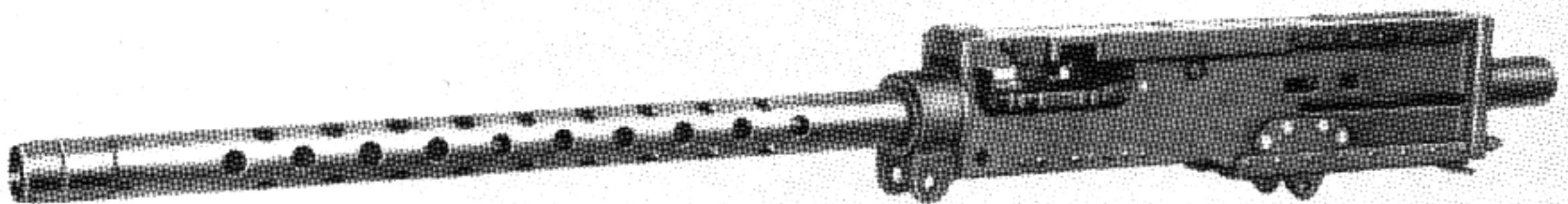


Figure 1-3. Gun, Machine, Caliber .50 T25E1.

Gun, Machine, Caliber .50 T25E2. To permit further study of the causes of this unsatisfactory functioning, the T25E2 gun was made up by substituting the bolt, top cover and recoil booster of the T22E6 gun for corresponding components of the T25E1 gun. This gun was fired at Aberdeen Proving Ground in June 1944. Functioning continued unsatisfactorily, and the test was stopped at 1,800 rounds. A careful examination indicated that the nested helical springs in the backplate buffer were breaking and causing extreme impact forces on the gun component.

Gun, Machine, Caliber .50 T25E3. The first T25E3 gun was tested at Aberdeen 19 July 1944. The functioning of this gun was greatly improved over that of the T25E1, and the cyclic rate averaged 1,250 rounds per minute. Eight malfunctions occurred, but for the first time in the development, it was possible to determine the specific cause of each malfunction. A projecting corner on the bolt was responsible for "shorting" rounds in the feedway and causing failures to feed; the remainder of the malfunctions were caused by fatigue of the sear spring. After the satisfactory tests of the T25E3

was used and a pneumatic buffer and a modified sideplate switch.

Gun, Machine, Caliber .50 T27. This was a Browning developed by High Standard to provide a kit of parts which could be used to convert the standard M2 gun to a high-speed weapon. The test was stopped before completion in January 1944.

Gun, Machine, Caliber .50 T27E1. Unsatisfactory performance, since one of the two guns made blew up. Test discontinued about February 1945.

Gun, Machine, Caliber .50 T27E2. The records do not indicate that the history of the T27E2 extends beyond the blueprint stage.

Gun, Machine, Caliber .50 T27E3. Tested in March 1944; numerous malfunctions.

Gun, Machine, Caliber .50 T27E4. Fired at a rate of 1,330 rounds per minute when tested in April 1944 but suffered numerous breakages and malfunctions.

Gun, Machine, Caliber .50 T27E5. Tested in June 1944; excessive malfunctions terminated the test after the one gun blew up.

Gun, Machine, Caliber .50 T27E6. Tested early in 1945, it successfully fired 5,000 rounds at a rate

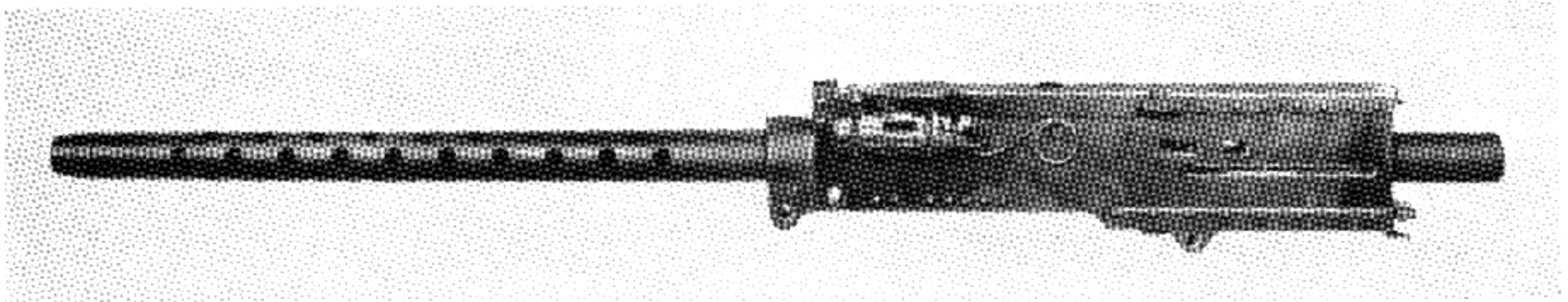


Figure 1-4. Gun, Machine, Caliber .50 T27E6.

of over 1,000 rounds per minute with only one breakage of major parts but 1 of the 4 guns tested had 11 malfunctions.

Gun, Machine, Caliber .50 T27E7. In March 1945 the last version was tested and successfully completed the 5,000 round test without going beyond the numbers of acceptable malfunctions but suffered excessive breakage of minor parts. In the overdevelopment of the T27 series, unsatisfactory performance and danger to personnel and equipment caused by the unusual number of breakages and explosions were responsible for the decision in March 1945 that no further consideration would be given this weapon.

Gun, Machine, Caliber .50 T28. Developed by Springfield Armory to produce a high cyclic rate gun. Specifications called for 1,200 rounds per minute without breakages.

Gun, Machine, Caliber .50 T34. Air Force requirement for the fabrication of a gun which would have a cyclic rate of 1,500 rounds per minute. Project assigned to Springfield. This was to be an entirely new mechanism, operating on a principle suitable for very high-speed operation. Preliminary drawings of this gun were received in August 1945,

and after careful study, the Springfield Armory was requested to supply additional drawings.

Gun, Machine, Caliber .50 T35. To fulfill the Air Force requirement for a gun with a cyclic rate of 1,500 rounds per minute, a project was set up to modify the M2 Browning.

Gun, Machine, Caliber .50 T36. During the development of a high speed caliber .50 machine gun, certain very valuable improvements were made which were applicable to the standard M2 caliber .50 aircraft gun. In September 1944, it was decided to incorporate immediately into the M2 gun these features which had been proven in tests of various experimental high speed guns. This improved gun, designated T36, was designed to accomplish limited objectives, compared to the M2 gun, namely: (1) reduction in recurrent malfunctions; (2) increase in cyclic rate of approximately 100 rounds per minute; and (3) increase in belt lift capacity to 30 pounds minimum consistent with the accomplishment of these objectives.

Gun, Machine, Caliber .50 T38. A further development of the M3 by Frigidaire in 1945. This design was also in response to the Air Force requirement for a 1,500 round per minute gun. Limited

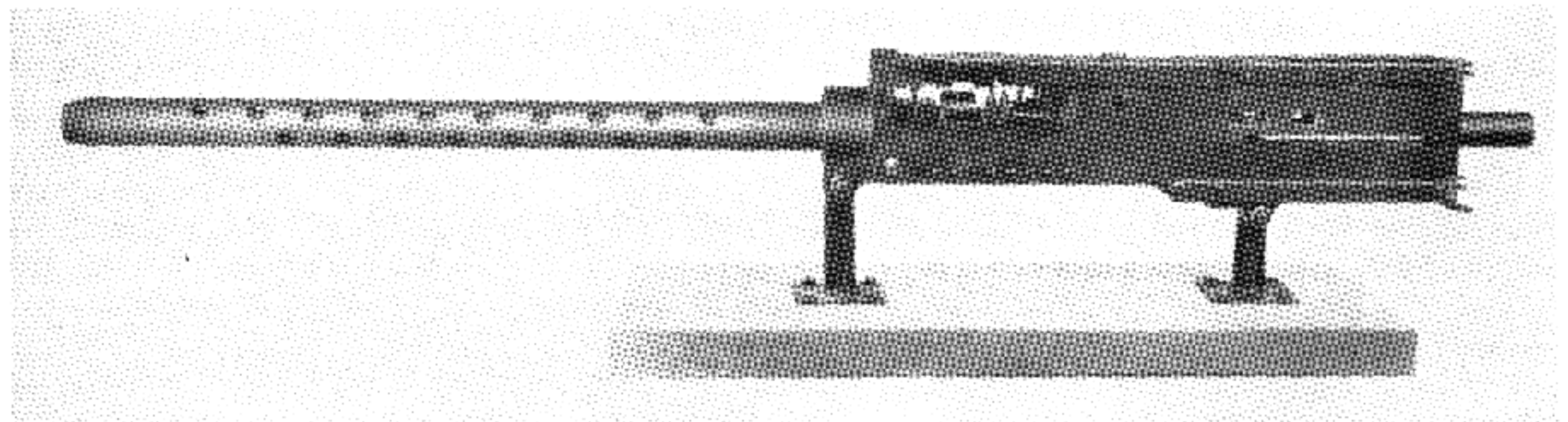


Figure 1-5. Gun, Machine, Caliber .50 T36.

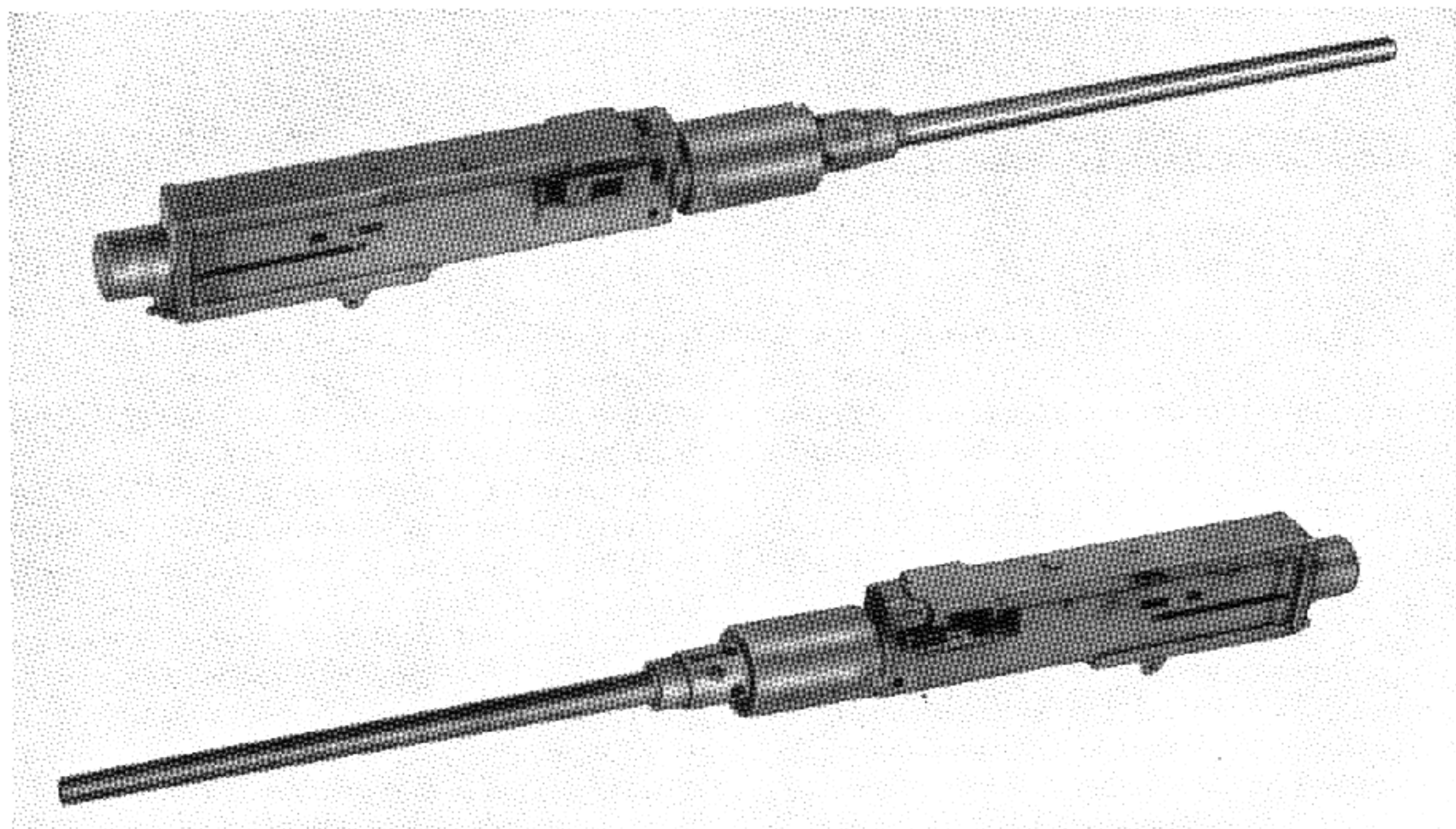


Figure 1-6. Gun, Machine, Caliber .50 T42.

firing was conducted at rates up to 1,450 rounds per minute by Frigidaire.

Gun, Machine, Caliber .50 T42. Intended for use as an antiaircraft weapon with a rate of fire of 700 rounds per minute. Similar to the Browning M3 but uses heavy barrel and short barrel support.

Gun, Machine, Caliber .50 T60. This was a project set up in 1948 to develop an aircraft gun with a rate of fire 2,000 rounds per minute.

Gun, Machine, Caliber .50 T164. The armored force established a requirement for a caliber .50 machine gun for use on tank turrets with the provision that it must incorporate a short receiver. Springfield Armory built a revolver type based on the 20-mm T74 and this is designated the caliber .50 T164.

Gun, Machine, Caliber .50 T175. Similar to the T176, except barrel energy is transmitted by hydraulic means. Also intended for tanks.

Gun, Machine, Caliber .50 T176. The T176 was designed in response to the requirement for a short receiver tank gun. It is a nonconventional type in which the barrel energy is used to operate the mechanism indirectly through Belleville springs. It

was designed for alternate use at a high and low rate of fire.

Gun, Machine, Caliber .50 M1. The experimental Browning T2 caliber .50 machine gun was standardized for cavalry and infantry without modification as the M1. This model never went into production.

Gun, Machine, Caliber .50 M2. Further development of the Browning system produced the M2 series which was standardized in 1933. The three principal versions were water-cooled, aircraft, and heavy barrel. The three guns utilized the same basic receivers. The water-cooled gun was for anti-aircraft use; the heavy-barrel gun was intended for use by and against armored vehicles, and the aircraft gun with its 36-inch air-cooled barrel was for use in aircraft. Later, several other varieties were standardized, all of which used the same basic receiver. An important characteristic of the M2 series is the ability to convert from one type to another.

Gun, Machine, Caliber .50 M2A1. In 1944, the limited procurement of 31,336 of the T36 guns was authorized. This procurement was discontinued

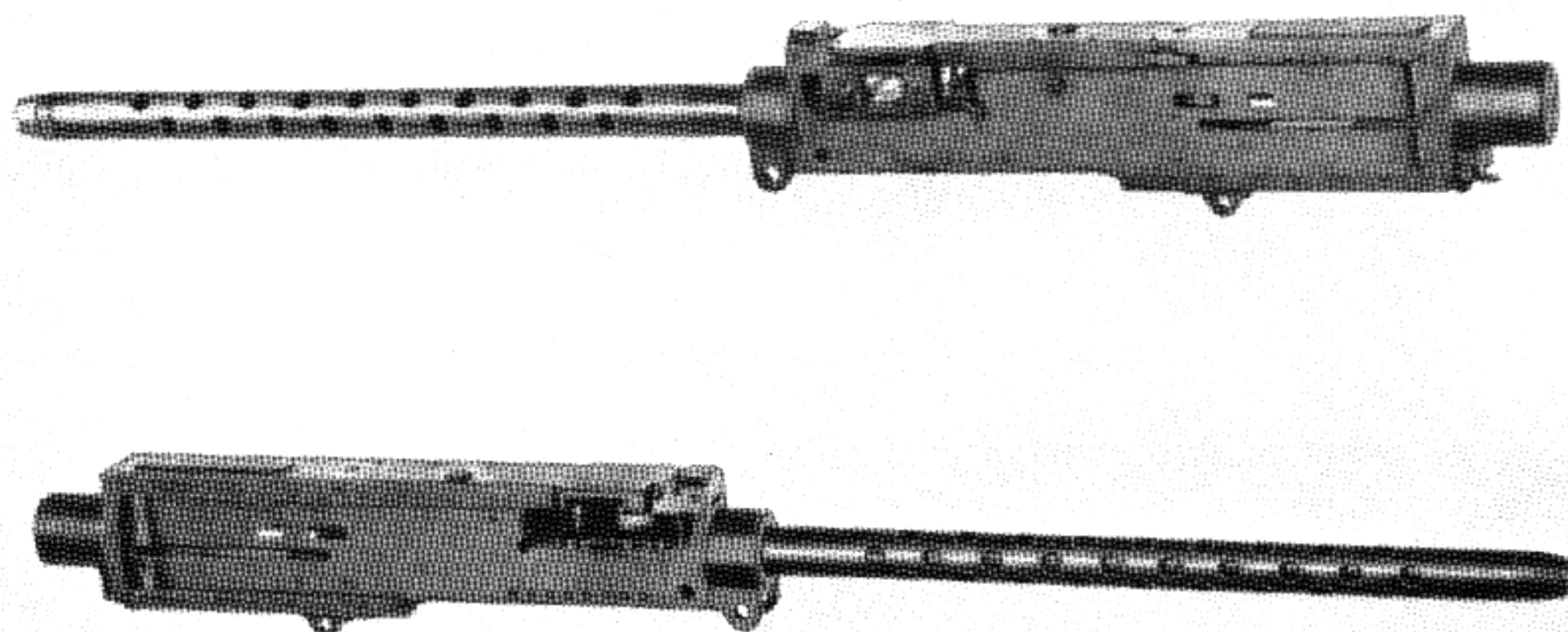


Figure 1-7. Gun, Machine, Caliber .50 M3.

after approximately 8,000 guns had been produced because of the unexpected progress made in the development of the T25E3 high-speed gun, which led to its standardization as the M3 earlier than had been thought possible. Following the standardization of the M3 gun, the T36 gun was reclassified as limited standard, and redesignated Gun, Machine, Browning, Caliber .50, M2A1, Aircraft, Basic.

Gun, Machine, Caliber .50 M2E1. The records do not indicate the history of the M2E1.

Gun, Machine, Caliber .50 M3. In 1945 the caliber .50 Browning T25E3 was standardized as the M3. There are slight variations in guns of early and later manufacture. The M3 gun is based upon the caliber .50 aircraft machine gun M2 and has essentially the same exterior dimensions, except for the increased diameter of the backplate buffer, and the length added by the recoil booster. It fires at a cyclic rate of approximately 1,200 rounds per minute with standard ammunition and links. Nearly all parts of the M3 gun differ in detail from

those of the M2, having been improved in design and metallurgy.

Caliber .60 Machine Guns

Bendix 15-mm Machine Gun. The first attempt to meet the characteristics for the caliber .60 aircraft machine gun was to modify a 20-mm Hispano-Suiza automatic cannon. The receiver was identical and parts of the gun were interchangeable with the 20-mm, M1. The chief difference was in the barrel, which was chambered for the 20-mm case, bored and rifled for the 15-mm bullet and fixed in relation to the mount. The whole gun was rigidly mounted and the muzzle brake and recoil mechanism used on the 20-mm gun were eliminated.

Gun, Machine, Caliber .60 T17. In September 1942, a project was initiated to convert the 15-mm German aircraft gun, MG 151, a recoil-operated, air-cooled, and belt-fed gun, to use the caliber .60 cartridge. In October 1942, Colt's Patent Fire Arms Manufacturing Co. undertook this conversion.



Figure 1-8. 15-mm Bendix Machine Gun. Top view.

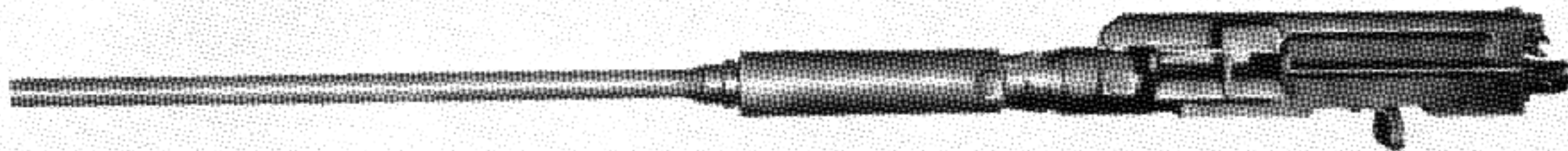


Figure 1-9. Gun, Machine, Caliber .60 T17E1.

The gun was designated Caliber .60 Machine Gun T17. It was found necessary to rechamber the barrel, lengthen the receiver, feedway, bolt, cam tube, and cover, and to make a few other minor design changes. New links were provided by the Autoyre Co.

Gun, Machine, Caliber .60 T17E1. The Frigidaire division of the General Motors Corp., Dayton, Ohio, undertook in January 1943 to provide 10 pilot models of the aircraft machine gun, caliber .60 T17E1. The model was to be essentially the same as the T17, except that the rate of fire was to be increased to 800 rounds per minute and the high trunnion reactions were to be lowered by incorporating in the design a recoil adapter developed by the Edgewater Steel Co. at the request of the ordnance officer at Wright Field. Links for the gun were developed by the Autoyre Co. of Oakville, Conn. Complete drawings of the T17 gun were prepared by Frigidaire and an engineering study was made to redesign the weapon for cheaper mass production.

Gun, Machine, Caliber .60 T17E2. The Frigidaire division was then asked to prepare two additional models which would use strengthened components and a barrel with a thicker walled chamber as the chamber had expanded during tests of earlier models. SAE 1060 steel was used in the T17E1 wherever possible. In the T17E2 this policy was abandoned and SAE 4640 steel was substituted. Fabrication of these models involved the use of sheet metal stampings and hydrogen brazing. This gun was designated the T17E2. In May 1943 the General Electric Co., Bridgeport, Conn., accepted a contract to develop an electric charger for the T17E2 gun. It appeared at this time that the most profitable development of this item would be a charger integral with the gun. Two T17E2 machine guns were delivered to Aberdeen Proving Ground for test on 25 August 1943. Each was equipped with

manual charging and firing equipment and recoil adapters. Electrical charging and firing solenoid were provided as alternate components. One gun was fired 557 rounds. Ejection difficulties developed, but after modification of the ejector the gun functioned fairly satisfactorily with a rate of fire of 600 rounds per minute. The second gun with the General Electric charging mechanism was fired 143 rounds. A combination gun was built from parts of guns No. 1 and 2 and fired 327 rounds at 658 rounds per minute and a maximum muzzle velocity of 3,696 feet per second. Numerous malfunctions were encountered which indicated that considerable further development work was needed.

Gun, Machine, Caliber .60 T17E3. Beginning in September 1943, attention was concentrated upon the manufacture of seven T17E3 guns with both percussion and electric ignition. On 15 December 1943 this order was increased to 10 guns. The electrical ignition mechanism was modeled upon that of the German 20-mm gun. A program was also initiated for the development of a bolt with the sear forward. It was expected that this, together with electrical ignition, would permit synchronization of the gun when either electrical or percussion primed ammunition was used. On 16 November 1943 Frigidaire was requested to develop four auxiliary gun chargers to be used as a standby device in case of failure of the electric charger. Because of a requirement placed with the Ordnance Department by the Navy Bureau of Ordnance for delivery of 2,500 caliber .60 aircraft machine guns with auxiliaries and spare parts in 1944, limited procurement of the T17E3 was initiated 2 December 1943 and approved 16 December 1943. Rock Island Arsenal was commissioned to make these guns. This gun weighed 135 pounds, including recoil mounting adapter, electrical charger and solenoid, and feed mechanism. The rate of fire was 600 rounds per

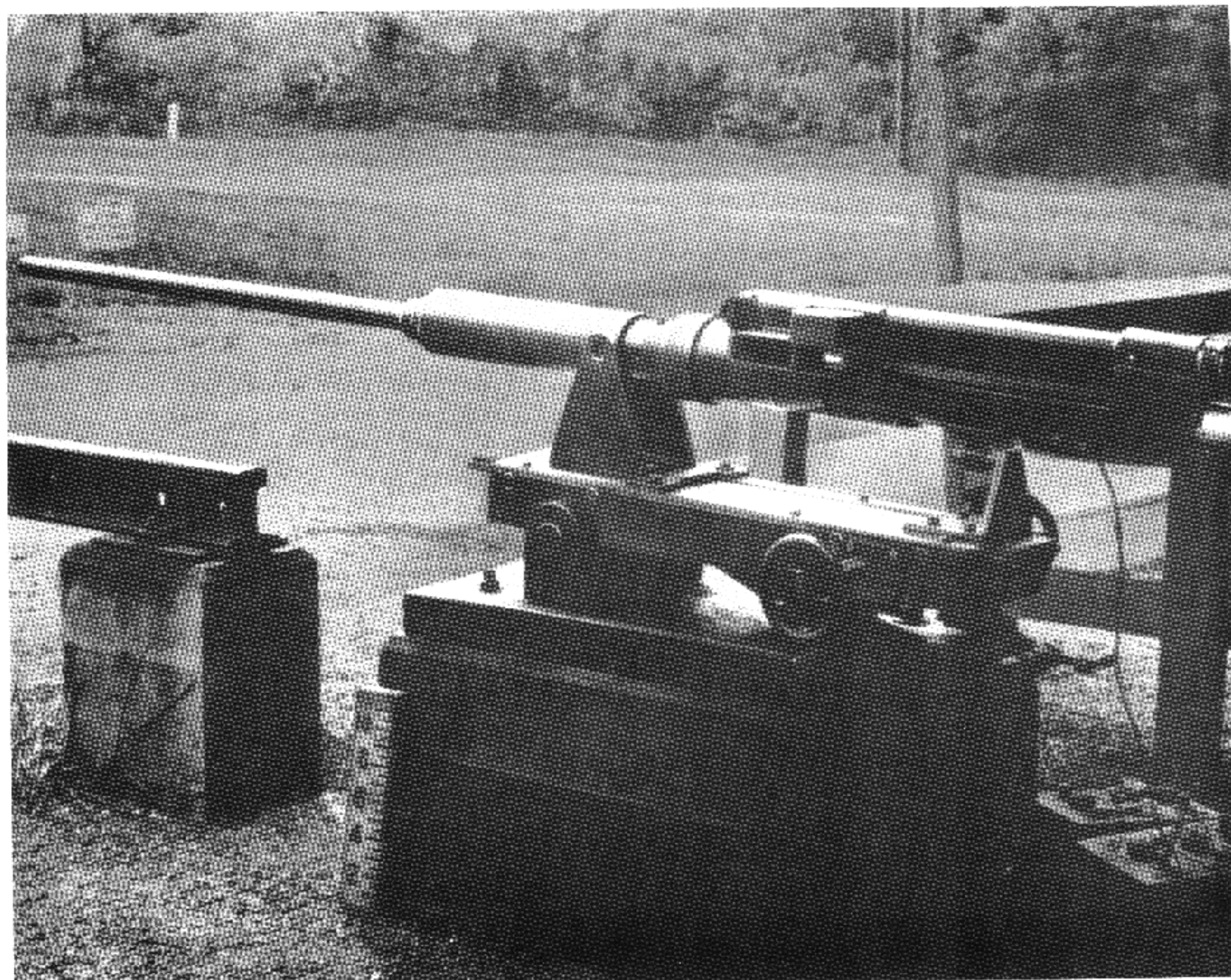


Figure 1-10. Gun, Machine, Caliber .60 T17E2.

minute, and the muzzle velocity was 3,500 feet per second. The gun was 92 inches long and had a maximum trunnion reaction of 3,500 pounds. At the request of the Army Air Forces the original procurement was increased to 5,025 guns by Ordnance Committee action on 23 December 1943.

Gun, Machine, Caliber .60 T17E4. Similar to the T17E3 with modification of the mechanism to use ammunition belted in a new link. Developed by Sanford Engineering Co.

Gun, Machine, Caliber .60 T17E5. Similar to the T17E3 with modification of locking lugs on bolt-head and breech ring and change in design of locking and unlocking cams. Developed by the Frigidaire division of General Motors.

Hispano-Suiza Caliber .60 T18 Machine Gun. A second modification of the 20-mm Hispano-Suiza cannon was made by rechambering the barrel for caliber .60 case and boring and rifling for the caliber .60 bullet. Corresponding changes were made in the bolt and extractor. This gun was fired a small number of rounds (not more than 50) automatically. Official designation of the gun was Caliber .60, T18. Since radical redesign of the Hispano-Suiza cannon appeared necessary if this gun was to meet aircraft requirements, work on this model was discontinued.

Gun, Machine, Caliber .60 T18E1. After approval by Headquarters ASF, it was recommended that further investigation of caliber .60 mechanisms

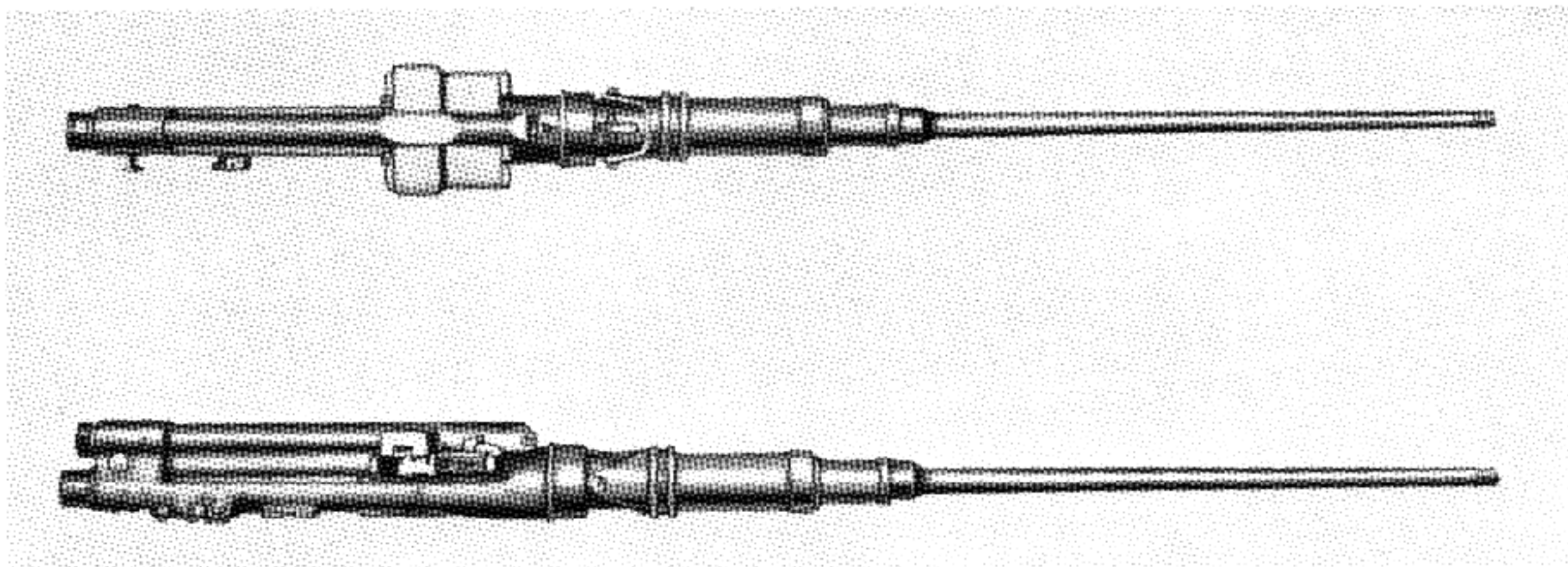


Figure 1-11. Gun, Machine, Caliber .60 T17E5.

be conducted with a modification of the 20-mm Hispano-Suiza automatic cannon, M2. This modified 20-mm weapon was designated T18E1 because there had previously been made a gun called T18 which was a 20-mm automatic cannon, M1, modified to fire the caliber .60 cartridge. The earlier

gun was fed from a five-round magazine and served only to show that the action was sufficiently strong to fire the cartridge.

Gun, Machine, Caliber .60 T19. This designation was assigned to an experimental design to be developed by the High Standard Manufacturing

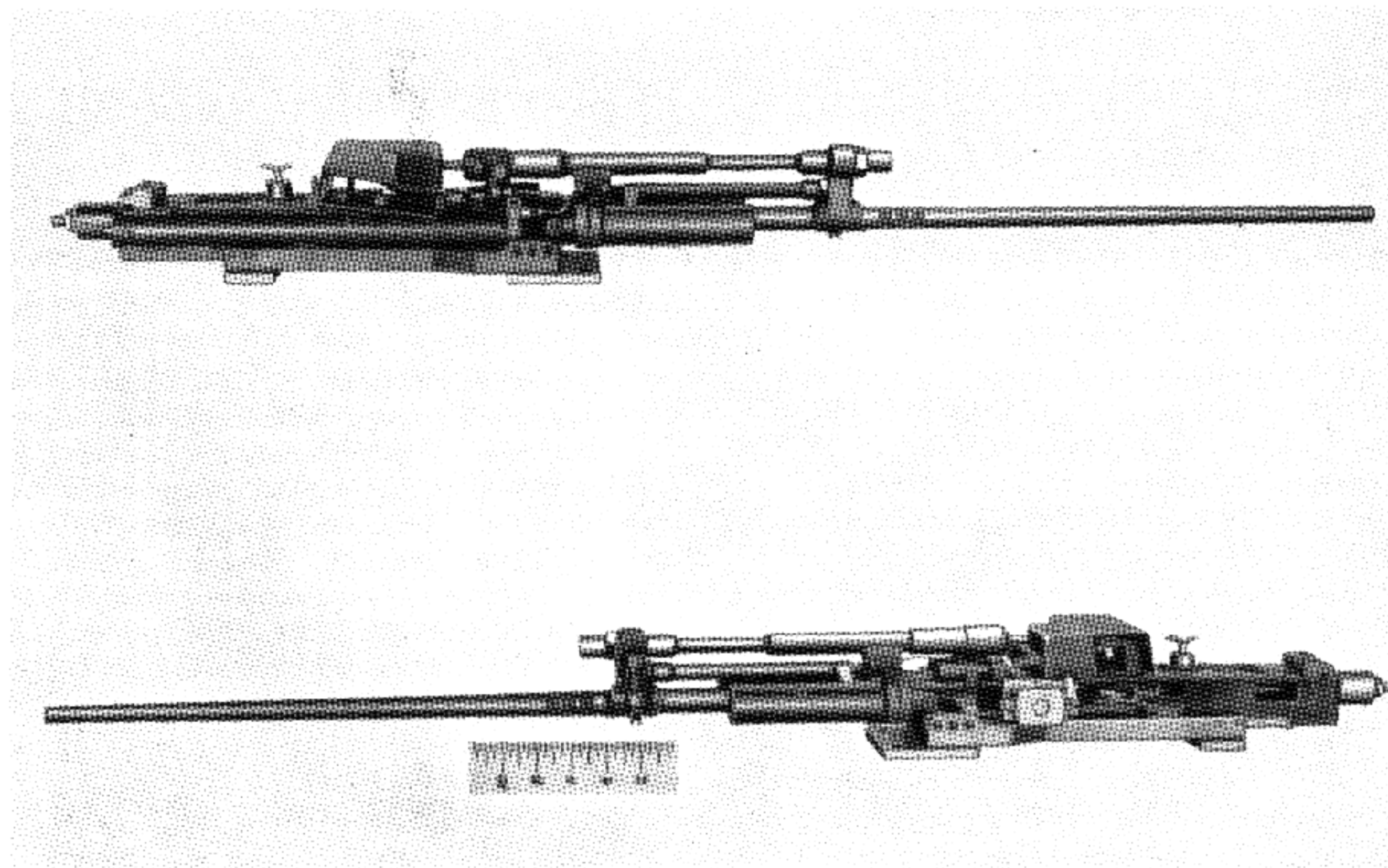


Figure 1-12. Gun, Machine, Caliber .60 T18E1.

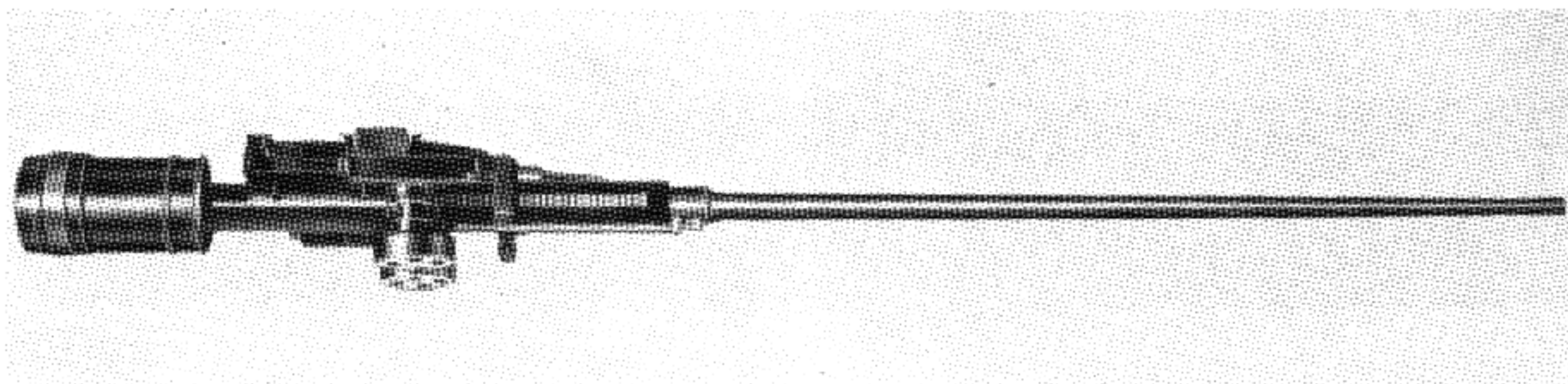


Figure 1-13. Gun, Machine, Caliber .60 T31.

Co. The design apparently went no further than the drawing board stage.

Gun, Machine, Caliber .60 T31. On 1 July 1944 Gazda Engineering Co. contracted to develop a gun along the lines of the 20-mm Oerlikon machine gun, but with the added features of "flywheel inertia locking," continuous belt feed, and a rate of fire in excess of 1,000 rounds per minute and capable of fire interruption (fired from a closed bolt). This gun was designated the T31. By 1 November 1944, manufacture of the gun parts had begun. On 16 January 1945, receipt of the last assembly drawing of the gun parts was acknowledged; but a complete set of detail drawings on all parts was never received. The gun, as shown by these drawings, was a composite which used a modified 20-mm Oerlikon bolt buffer, a modified 20-mm Oerlikon receiver, the T17E3 feed box and feed system, and a quick release barrel similar to the MG 151 (German). The gun was charged by a 20-mm (T2) Bendix hydraulic charger. In June 1945, the T31 was fired forty rounds by Gazda Engineering at its plant and broke a rack which connects the drive springs to the bolt. About 25 September 1945, this gun was fired again in the presence of a representative of the Office, Chief of

Ordnance, and after a few rounds a number of other parts broke.

Gun, Machine, Caliber .60 T39. The Caliber .60 T39 Machine Gun differs from the T17E3 only in that it has an electric bolt and bolthead, interchangeable with the percussion bolt, and a contact switch with the necessary wiring to an external power source to fire electrically primed ammunition. It is expected that this model will meet all of the Army Air Forces requirements for synchronization and fire interruption. The first electrical bolt, the E1, was a copy of the German MG 151. This bolt gave excellent ignition time and was remarkably free from "contact bounce," but the contactor which passed through the bolt and bolthead cam broke with great frequency. This design was complicated and required major modification of the bolt, bolthead and bolthead cam, and receiver.

Gun, Machine, Caliber .60 T41. This caliber .60 gun is a version of the caliber .60 T17E3, with two new and three modified components to provide a gas assist to the short recoil method of operation. Purpose was to provide a weapon which would function reliably, using T41 ammunition at a cyclic rate approximately equal to T17 ammunition (ball) in the basic T17E3 gun.

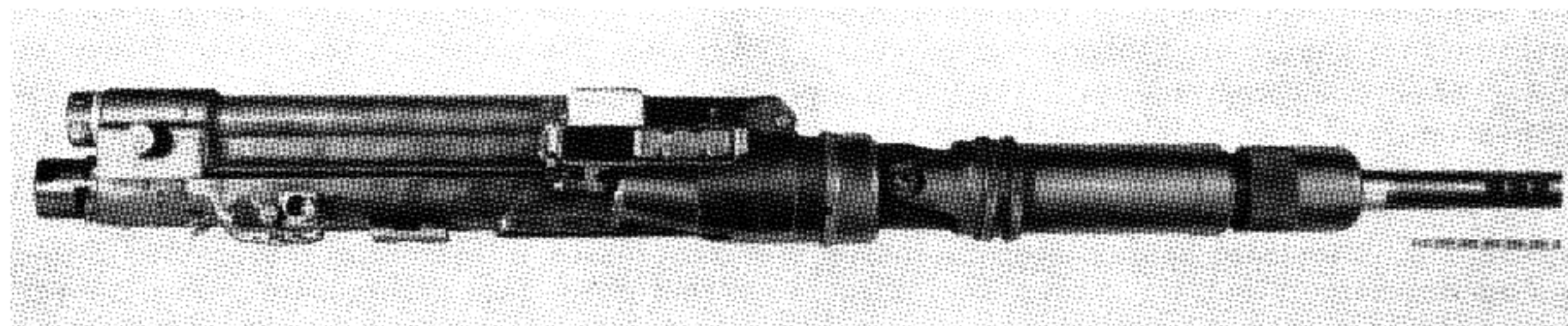


Figure 1-14. Gun, Machine, Caliber .60 T41.

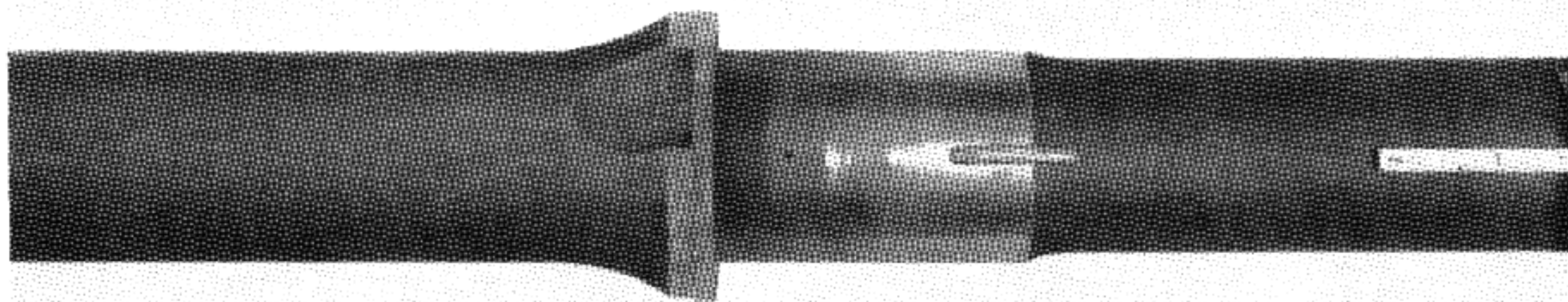


Figure 1-15. Gun, Machine, Caliber .60 T41. Closeup view of modified barrel showing gas assist port.

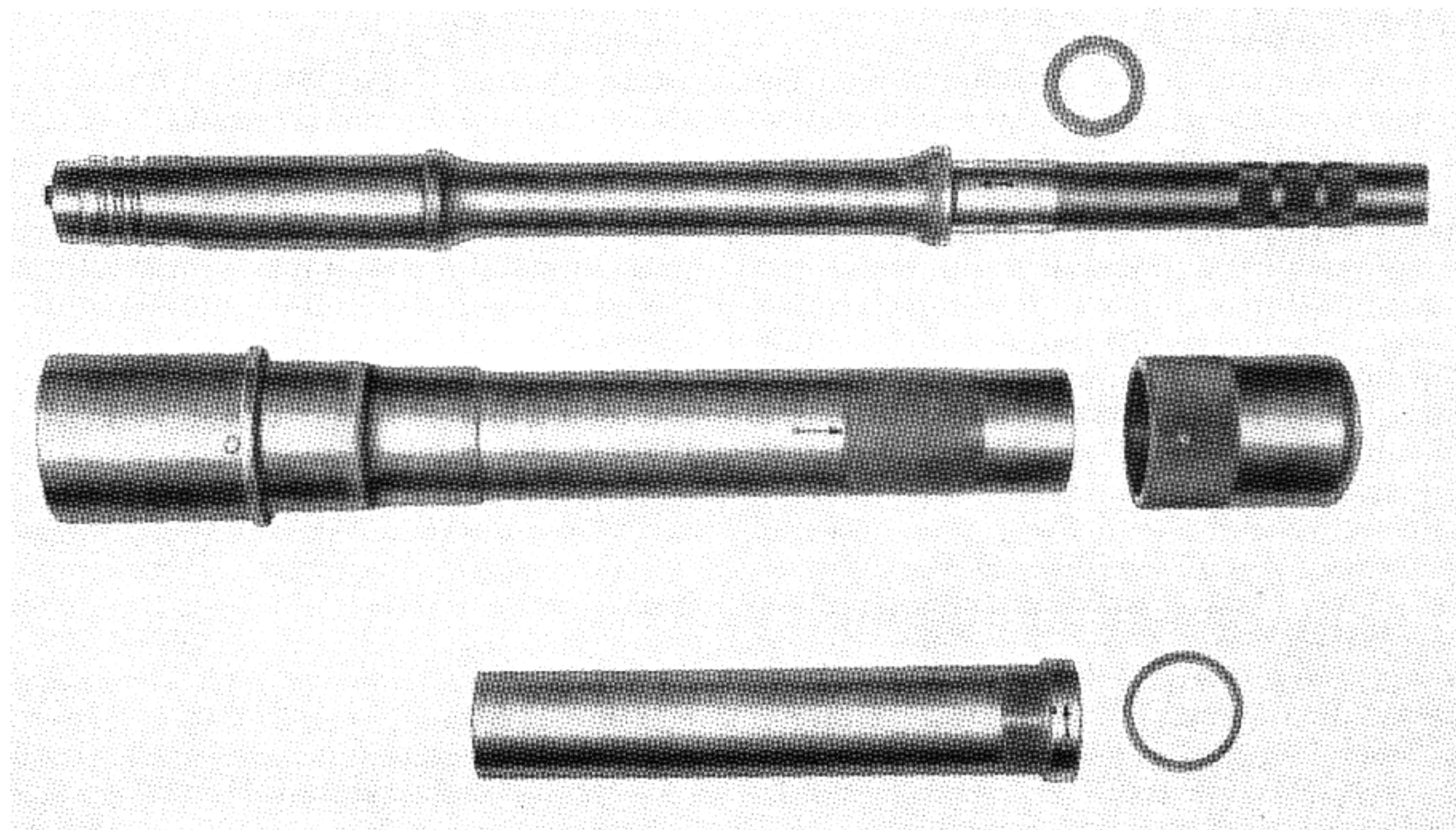


Figure 1-16. New or modified parts used in the conversion of the Caliber .60 T17E3 gun to the Caliber .60 T41.

Gun, Machine, Caliber .60 T45. Motor-driven machine gun with several barrels based on the Gatling system developed by the General Electric Co. under the supervision of the Ordnance Corps. Rate of fire 6,000 rounds per minute. Weight of gun approximately 427 pounds with 60-inch barrels.

Gun, Machine, Caliber .60 T46. Modification of the T17 series to permit synchronization by using a front sear. Developed by the Frigidaire division of General Motors.

Gun, Machine, Caliber .60 T47. Developed to demonstrate the problems and practicability of radi-

cally relocating gun components from their traditional position. Developed by the Frigidaire division of General Motors to use the existing caliber .60 cartridge. Designed to fire at a rate of 1,000 rounds per minute and to weigh 130 pounds including recoil adapter and feed. Length to be 70 inches with a maximum of 10 inches behind breech face of barrel.

Gun, Machine, Caliber .60 T49. Short 52-inch aircraft gun. Uses the standard .60 caliber cartridge, requiring changes in design and configuration of certain parts of the 20-mm version. Limited

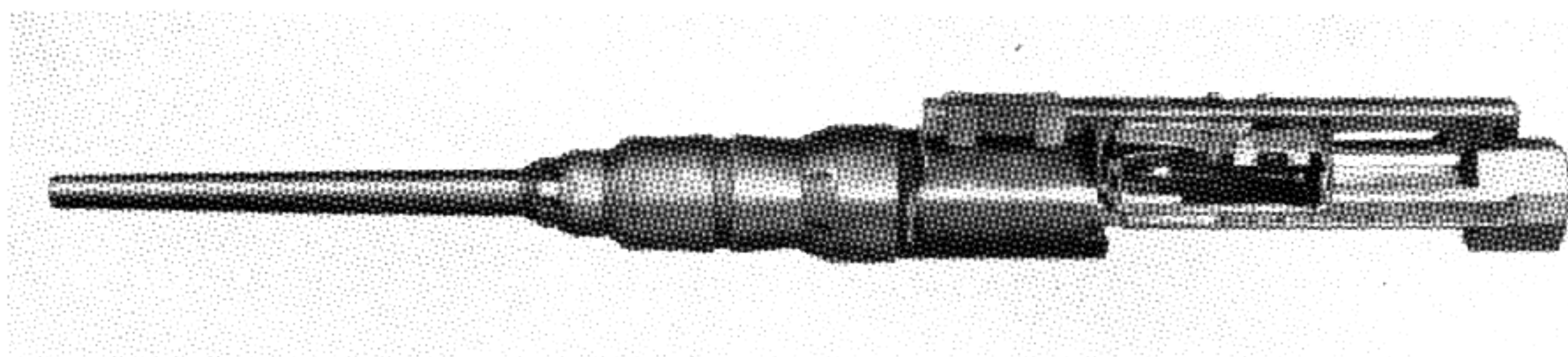


Figure 1-17. Gun, Machine, Caliber .60 T51.

development was conducted by Armour Research Foundation.

Gun, Machine, Caliber .60 T50. Short aircraft cannon based on the T17E5, with firing solenoid removed from rear of gun and placed on side or bottom, removal of electric charger, shortening of buffer. Developed by Naval Gun Factory.

Gun, Machine, Caliber .60 T50E1. Modification of the T50 with leaf type buffer springs replacing Belleville type.

Gun, Machine, Caliber .60 T51. Short aircraft gun based on the T17 series with firing solenoid and electric charger removed from rear of gun to side or bottom; buffer mechanism, receiver, and bolt shortened to maximum possible extent; and barrel cutoff to give 52 inches maximum overall length. Developed by Frigidaire division, General Motors.

Gun, Machine, Caliber .60 T58. Short aircraft gun with barrel and bolt action similar to the T17 series but having an externally driven feeder for electric primed ammunition. Proposed rate of fire 1,000-rounds-per-minute minimum.

Gun, Machine, Caliber .60 T59. Modification of the caliber .60 T39 gun to install in it the firing mechanism of the T17E5 gun for electric primed ammunition.

Gun, Machine, Caliber .60 T59E1. Version of the T59 gun having electrical charger with remote control box; spring loaded nonretractable firing pin; cam actuated extractor for ejection purposes.

Gun, Machine, Caliber .60 T62. An experimental weapon primarily for aircraft turrets with six barrels and same mechanism as Gun, Machine, caliber .60 T45, but with barrels shortened to give gun an overall length of 52 inches. Developed by General Electric Co.

Gun, Machine, Caliber .60 T63. Modification of the T17 series to increase the cyclic rate and to reduce the length and weight. An experimental percussion-fired weapon with 900 rounds per minute, cyclic rate of fire, recoil operated with integral feed mechanism, 78-inch length and 110-pound weight.

Gun, Machine, Caliber .60 T64. Modification of the T59 series to increase the cyclic rate and to reduce the weight. An experimental electric-fired weapon with 1,000-round-per-minute cyclic rate, recoil operated with external powered feed mechanism, 78-inch length and 140-pound weight.

Gun, Machine, Caliber .60 T130. Gas-operated revolver gun based on the 20-mm T74 and the German MG 213 which includes improvements over

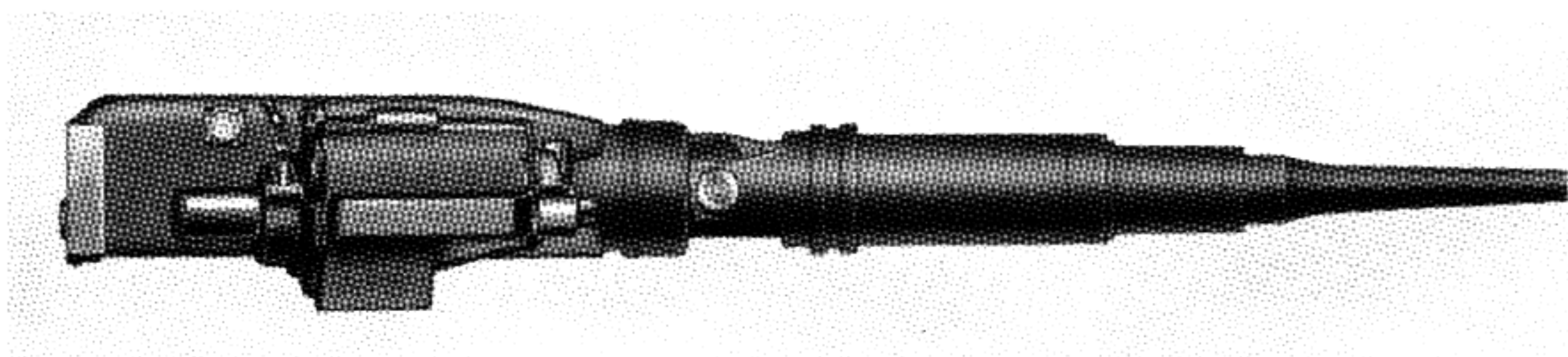


Figure 1-18. Gun, Machine, Caliber .60 T58.

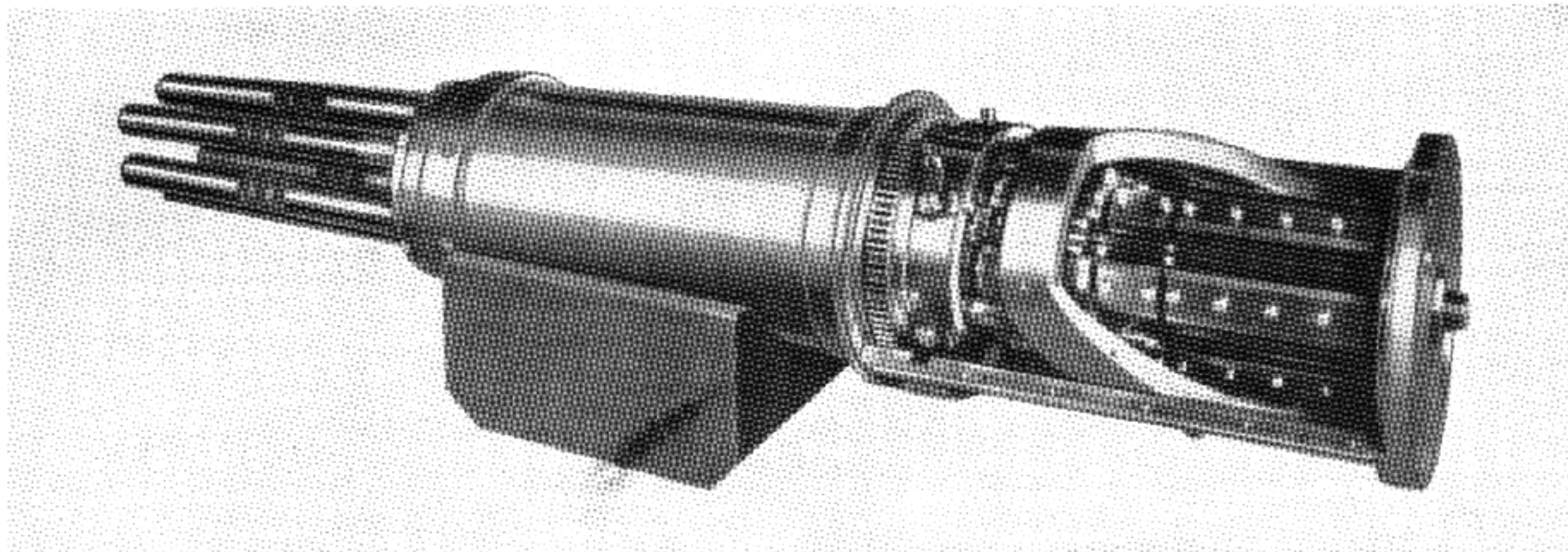


Figure 1-19. Gun, Machine, Caliber .60 T62.

the German gun consisting mostly of a rearrangement of components to secure small profile, lighter weight, improved accessibility of parts for servicing, and a general shortening of components to keep gun length to a minimum, the latter being an important advantage of this type of mechanism. The gun is of the gas-operated type with a rate of fire of 1,600 rounds per minute. Development by Armour Research Foundation.

Gun, Machine, Caliber .60 T130E1. A version of the caliber .60 automatic gun T130 to utilize a closed link and associated feeder.

Gun, Automatic, 15-mm T154. (This gun does not fire the caliber .60 rounds as normally loaded.) In response to an Air Force requirement for a shorter gun action it was proposed to construct a twin-barrel alternate firing gun using separate loading ammunition. The cartridge case to be removed from the conventional location. Ammunition development by Frankford Arsenal and Remington Arms Co., gun by Frigidaire.

Gun, Machine, Caliber .60 T173. An improved version of the T17 series for use as an anti-aircraft gun in the ground forces. Fires a percussion primed caliber .60 ammunition.

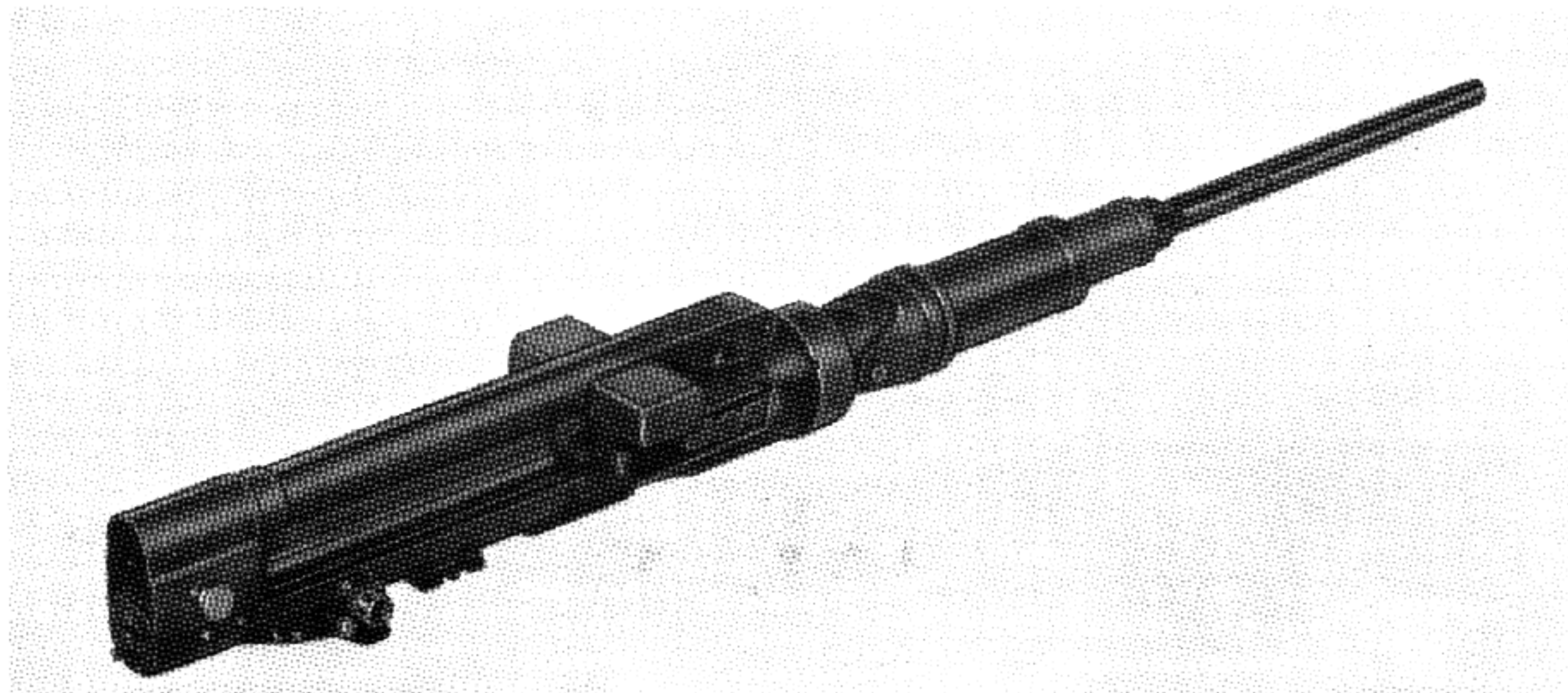


Figure 1-20. Gun, Machine, Caliber .60 T63.

20-mm Automatic Guns with T and M Numbers

Gun, Automatic, 20-mm T1. The Hispano-Suiza type 404 was tested in the United States beginning in 1938 and was officially designated the 20-mm T1.

Gun, Automatic, 20-mm T9. Standard Hispano M2 gun with modified chamber.

Gun, Automatic, 20-mm T10. Standard Hispano M2 gun with a different modification to the chamber.

Gun, Automatic, 20-mm T12. Standard Hispano M2 guns with another chamber design.

Gun, Automatic, 20-mm T14. Standard Hispano M2 gun except chamber and origin of rifling 1-mm short.

Gun, Automatic, 20-mm T15. Standard Hispano M2 gun with chamber modified to the design used on the British Mark II gun.

Gun, Automatic, 20-mm T16. Developed by the United Shoe Machinery Corp. Has the same ballistics as the M1 and M2. Project was canceled in August 1944.

Gun, Automatic, 20-mm T18. The T18 gun was the Hispano M2 which used, instead of the gas cylinder, a mechanical unlocking means, actuated by the recoil of the gun. The mechanical unlock was supplied with two cams, the slopes of which were 40° and 30°, respectively. Preliminary tests showed that such a device might be practical, but, after thorough tests at Aberdeen Proving Ground on a flexible mount, in July 1944 it was decided to cancel this development since the unlocking mechanism lowered the cyclic rate of the weapon.

Gun, Automatic, 20-mm T19. Developed by the Draper Corp. Lighter and more compact than any

previous 20-mm gun, the T19 employed the use of gas to operate the integral feed mechanism. The receiver body was a modified M2 inverted with a double key arrangement. A key plate strengthened the side of the receiver which had been weakened by the removal of the charging cylinder. The buffer had both inner and outer preloaded concentric springs, which provided a yielding instead of a solid stop in case of occasional excess force of the blow-back. The tube had an additional gas port for the gas-operated feed so located that it came in the next rifling groove ahead of the regular port.

Gun, Automatic, 20-mm T20. Developed by Colt. The 20-mm automatic gun T20 development was undertaken to apply a gas-operated feed to a Hispano 20-mm gun to overcome the difficulties encountered in recoil-operated feed mechanisms. One pilot model of the T20 was produced and proved successful in test at the manufacturer's range. The feed mechanism developed was gas operated and fed the belt by a reciprocating pawl similar to that on the caliber .50 machine gun.

Gun, Automatic, 20-mm T21. The records do not indicate the history of the 20-mm T21.

Gun, Automatic, 20-mm T22. The Ordnance Corps contracted with the Colt Co. to develop a gun based on the German MG151 but using a different locking system. The standard 20-mm round was used, loaded for a higher velocity.

Gun, Automatic, 20-mm T23. Developed by Colt. Hispano gun unlocked by recoil instead of gas pressure. In adapting the mechanical unlock unit the following modifications were made to the M2 gun: The gas port was plugged and the gas cylinder bracket removed; the gas tube attachment lug was modified at the rear by cutting a slot in it;

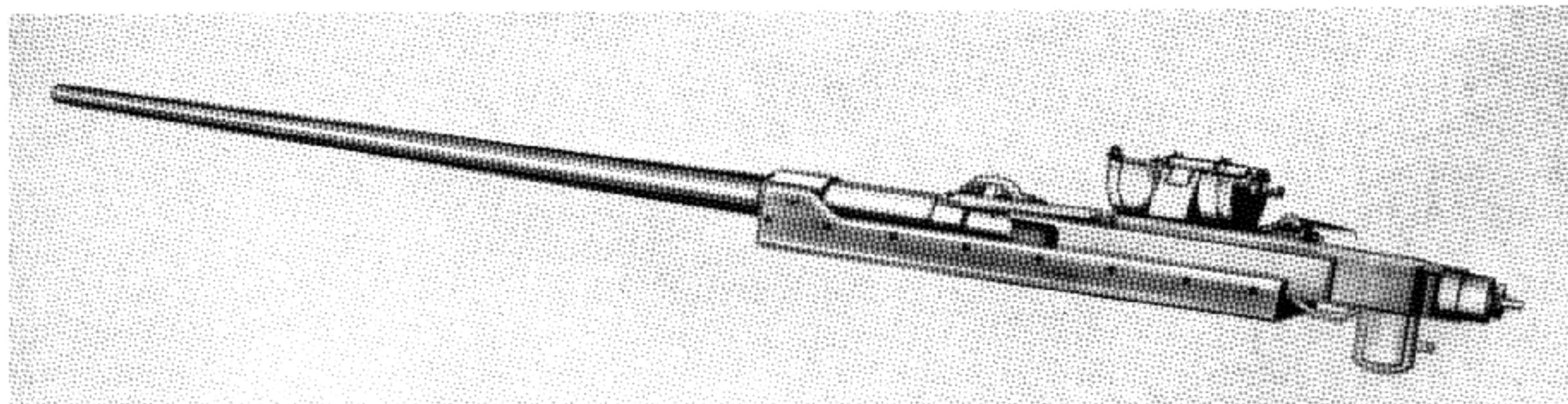


Figure 1-21. Gun, Automatic, 20-mm T18.

the push rod holes were increased in depth by $1\frac{1}{16}$ inches, and two new push rods $4\frac{5}{8}$ inches long were supplied. The action of the mechanical unlock mechanism was simple. On firing a round, the gun recoiled, turning the actuating levers so that the ball end of both levers made contact with and moved the two push rods. The push rods in turn acted upon the breech lock slides. From this point on, action on unlocking the bolt was the same as in the standard gas-operated gun.

Gun, Automatic, 20-mm T24. Redesign of the T22 to use a larger cartridge case. Built by Colt.

of the advanced state of the T31 gun and its pending service test by the Army Air Force.

Gun, Automatic, 20-mm T26. Developed by Oldsmobile. To determine to what extent the standard 20-mm automatic guns M1 and M2 could be lightened without adversely affecting the life of parts or without increased hazards in connection with the firing, it was decided, during August 1943, to modify a number of 20-mm automatic guns M1 and M2. They were to have the following characteristics: A reduction in weight of approximately 25 pounds; a decrease in barrel length of 15 inches:

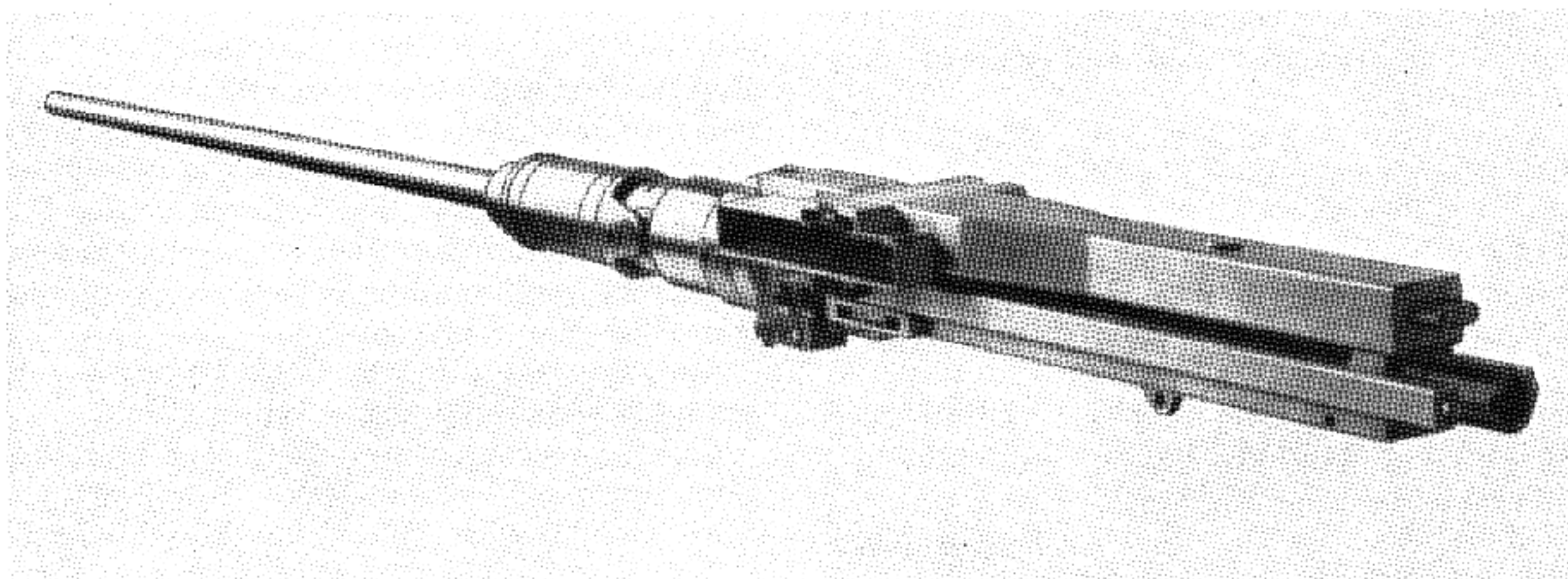


Figure 1-22. Gun, Automatic, 20-mm T24.

Gun, Automatic, 20-mm T24E1. Modification of the T24 having 0.006 chrome plate in bore.

Gun, Automatic, 20-mm T24E2. Modification of the T24 having a 0.010 chrome plate in bore.

Gun, Automatic, 20-mm T25. Developed by the United Shoe Machinery Corp. A conventional M2 bolt was modified with a searing arrangement that would prevent the firing pin from striking the primer when the bolt slides had reached the battery position. When firing, the sear was actuated by means of a solenoid, releasing the firing pin which was carried into the primer by action of a separate firing-pin spring. As the round was fired and the bolt unlocked by the conventional means of the Hispano-Suiza type guns, the firing pin was cocked by the slides and held on sear position until the bolt was again returned to battery and the sear released as described above. However, in December 1944, T25 development was considered complete because

they must be capable of using a nonadjustable ring-spring adapter; have a muzzle velocity reduction of not more than 80 feet per second; have a cyclic rate of about 750 rounds per minute; and be capable of firing with the bolt closed and locked. The modified gun was designated 20-mm Automatic Gun T26, which, complete with T14 feed mechanism, weighed about 110 pounds, approximately the weight of the German MG 151/20 provided with the same accessories. Although the T26 gun was not capable of synchronization, it provided fire interruption in battery position by a solenoid operated plunger.

Gun, Automatic, 20-mm T27. M2 gun redesigned by Oldsmobile for firing with bolt closed and locked. The mechanism of 20-mm automatic gun T27, similar to that of the T25 gun, was completed and tested with the T26 gun, and consideration was given to its application to the M2 gun. The T27 gun was incapable of synchronized fire. A later re-

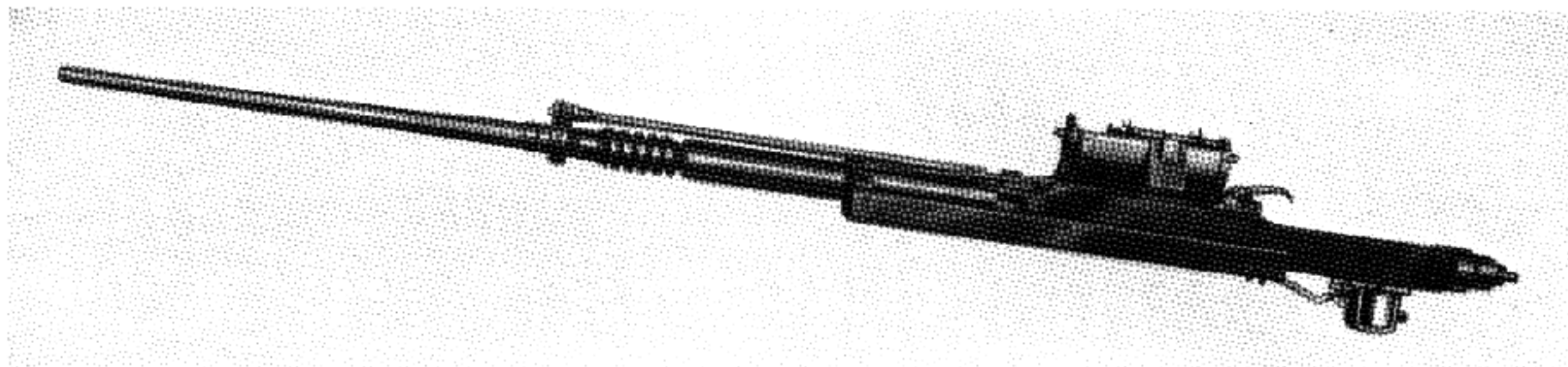


Figure 1-23. Gun, Automatic, 20-mm T26.

quirement by the Army Air Force for a new design of a 20-mm gun that could provide synchronous fire through the propeller arc of an airplane, using both electric and percussion primed ammunition, as well as the selection by the using services of the T31 gun for these purposes, caused cancellation of the development of the T27 gun in August 1944.

Gun, Automatic, 20-mm T28. M2 gun redesigned by Watervliet for firing from battery position.

Gun, Automatic, 20-mm T29. Same as T28 but for electric firing. Watervliet Arsenal developed both the 20-mm automatic gun T28, capable of mechanical synchronization, and the 20-mm automatic gun T29, capable of electrical synchronization. Both guns fired with the bolt forward in a closed and locked position. A pilot model incorporating the features of the T28 and T29 guns was completed. Firing was accomplished by changing the bolt. To simplify nomenclature these developments were combined, together with the desirable features of the T26 gun, to become the 20-mm automatic gun T31.

Gun, Automatic, 20-mm T30. Six inch shorter tube. The records do not indicate the history of the T30.

Gun, Automatic, 20-mm T31. This is an automatic blowback and gas-operated aircraft weapon. The basic difference between the 20-mm AN-M2 and the 20-mm T31 is that the T31 is a light-weight high-speed gun having the recoil system and cradle built into the gun, whereas the AN-M2 gun uses the Edgewater adapter, and the mount is a part of the airplane to which the gun is attached. The basic concept of this cradle and recoil system came from Oldsmobile and design and development of the weapon was done at Oldsmobile. The T31 gun complete with feeder, cradle, recoil system, and

solenoid weighs 116 pounds while the AN-M2 basic gun without mounts or solenoid weighs 115 pounds. The T31 gun has an overall length of 77.75 inches and the AN-M2 is 92.8 inches overall. The rate of fire of the T31 gun is approximately 720 rounds per minute, while that of the AN-M2 gun is about 100 rounds per minute less. This gun was produced in quantity at Oldsmobile. The T31 combined features of the T26, T28 and T29. This project was supervised by Watervliet. T31 indicates the rear-seared gun. This was standardized as the M3.

Gun, Automatic, 20-mm T31E1. This number was assigned to the forward seared mechanical percussion bolt design.

Gun, Automatic, 20-mm T31E2. This number was assigned to the forward seared electric ignition design which was standardized as the M24 series.

Gun, Automatic, 20-mm T32. The feed mechanism of this gun was to be operated by the same gas piston used to unlock and accelerate the bolt. The operation of this gas piston is as follows:

1. High-pressure gases flow through the gas orifice when the projectile uncovers the orifice on its forward travel through the bore of the gun.

2. The high-pressure gases pass through the valve, completely filling the chambers.

3. As the projectile moves down the bore, the pressure in the tube recedes and since there is a larger piston area on the forward end of the piston than on the rear end, the high-pressure gases in chambers move the piston to the rear closing the valve.

4. With the valve closed, the pressure in chamber continues to move the piston to the rear until the end of the piston uncovers the orifice so that the gas in the chamber can exhaust through the bore.

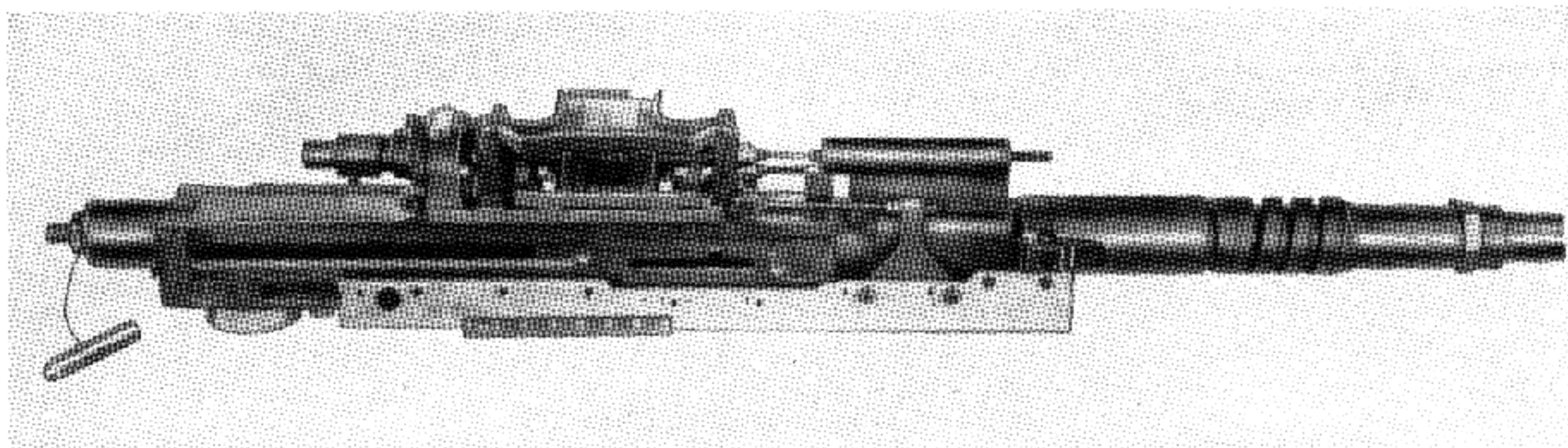


Figure 1-24. Gun, Automatic, 20-mm T32.

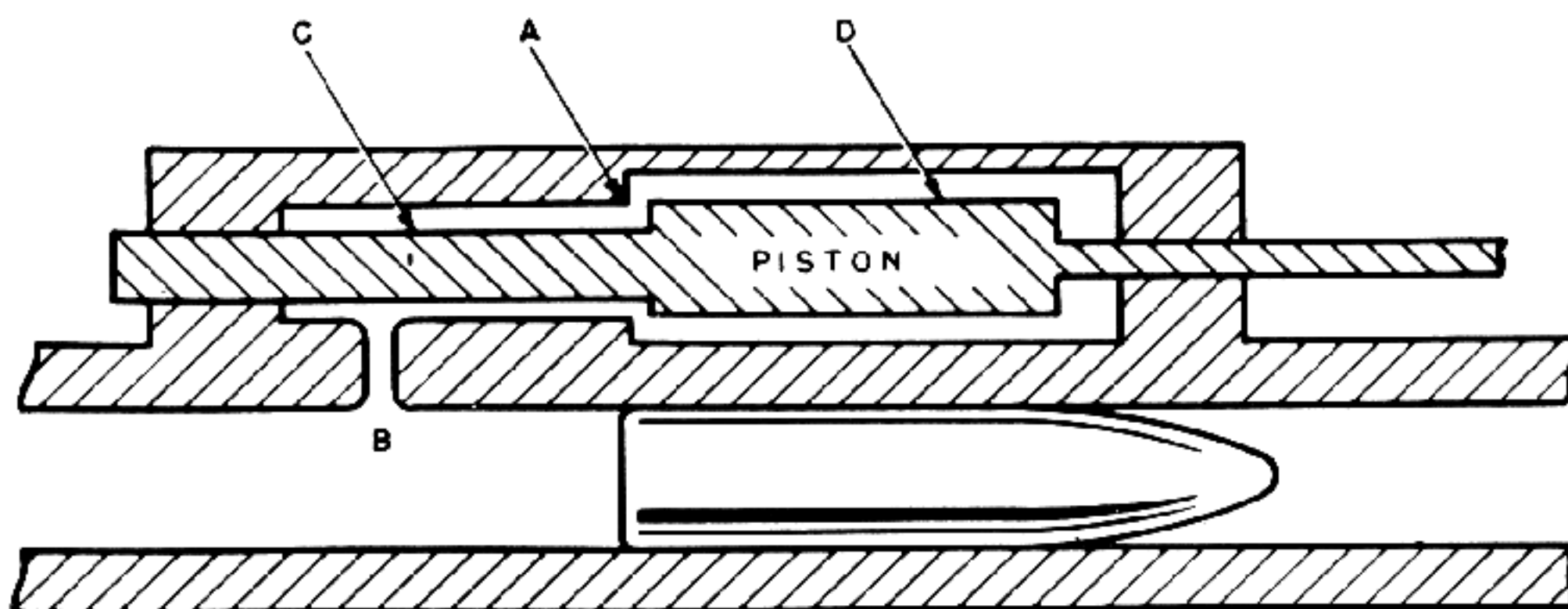


Figure 1-25. Gun, Automatic, 20-mm T32. Gas system.

5. The bolt returns the piston to the right upon its return to the in-battery position and the cycle is repeated when the next round is fired.

The bolt is locked in battery by a sliding block that moves upward as the bolt assembly enters the in-battery position. The gas piston cams the sliding block down and accelerates the bolt rearward. The stroke of the piston also operates a helical spline on the feed mechanism, keeping the sprocket wound. There are no drive springs in the gun and the gun is charged by firing a caliber .30 blank cartridge. There are two rails in the receiver of the gun that have two cam paths, one for guiding the round into the chamber and one for ejecting the extracted cartridge case. The gun is designed for electrically fired ammunition. The bolt assembly telescopes the bolt buffer thus allowing a shorter receiver design. There has been no change in the tube design to allow for the increased heating due to the higher cyclic rate, however, placing the gas operating pis-

ton near the cartridge chamber of the tube adds more metal at the "hot spot" giving a better hold-over for the heat.

Gun, Automatic, 20-mm T33. This assignment called for the design and development of a 20-mm gun, capable of handling new special high-velocity (3,500 feet per second) ammunition. The following features were stipulated: Integral crossfeed capable of lifting a 100 pound load of ammunition, right or left feed by interchangeable components, 750 rounds per minute minimum firing rate, 5,000 pounds maximum trunnion load. Design work was started late in 1944 and not quite completed by June of 1945 at which time the contract was terminated at Oldsmobile and turned over to Armour Research Foundation, Chicago, for completion. A wood mockup was made. The bolt has a lock on each side, similar to the bolt in the German 30-mm automatic gun, MK 103.

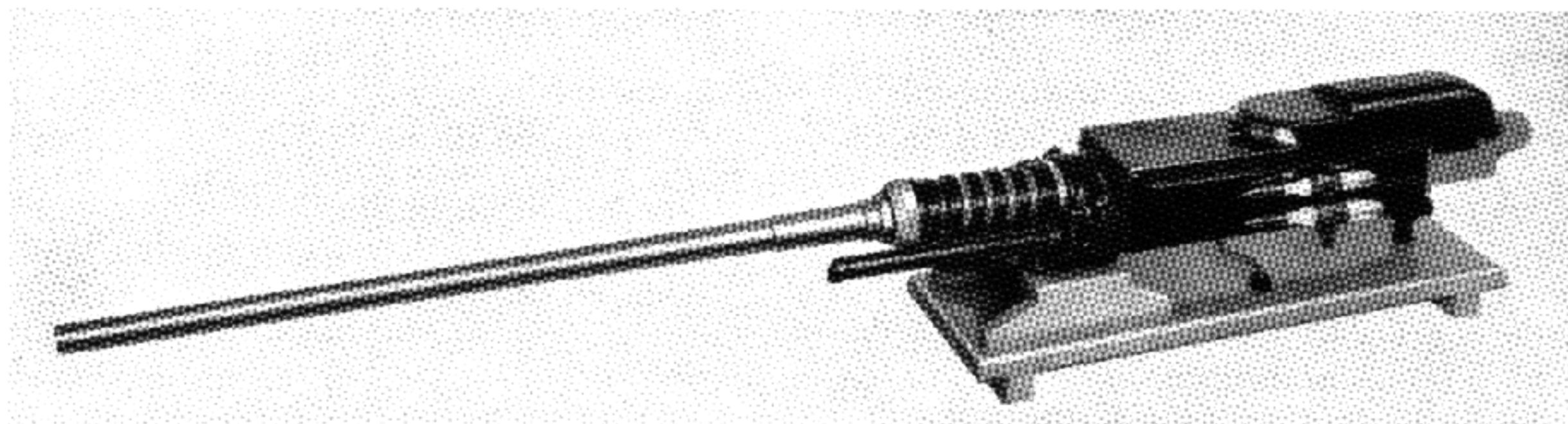


Figure 1-26. Gun, Automatic, 20-mm T33.

Gun, Automatic, 20-mm T33E1. Modification of the T33 which included 0.006 chrome plating in bore.

Gun, Automatic, 20-mm T33E2. Modification of the T33 which included 0.010 chrome plating in bore.

Gun, Automatic, 20-mm T33E3. Two versions of this T33E3 were made. The first, model A, used pivot locks in the barrel extension and was chambered for the large T7 case. One gun was built and tested. Model B, designed by Armour and built by the Naval Gun Factory, incorporated a new bolt

and rotary locks, a rammer actuated by bolt recoil, a gas-operated feeder utilizing feed pawls instead of sprocket, and design features which greatly simplified manufacture, assembly, and servicing. For some components there were alternate designs for the model B gun. Although the T33 series was originally based on a study of a Rheinmetall gun, changes made by the several design facilities involved have produced a weapon which does not readily classify in any of the well-known systems.

Gun, Automatic, 20-mm T34. Developed by Oldsmobile and based on 20-mm M3 gun with modi-

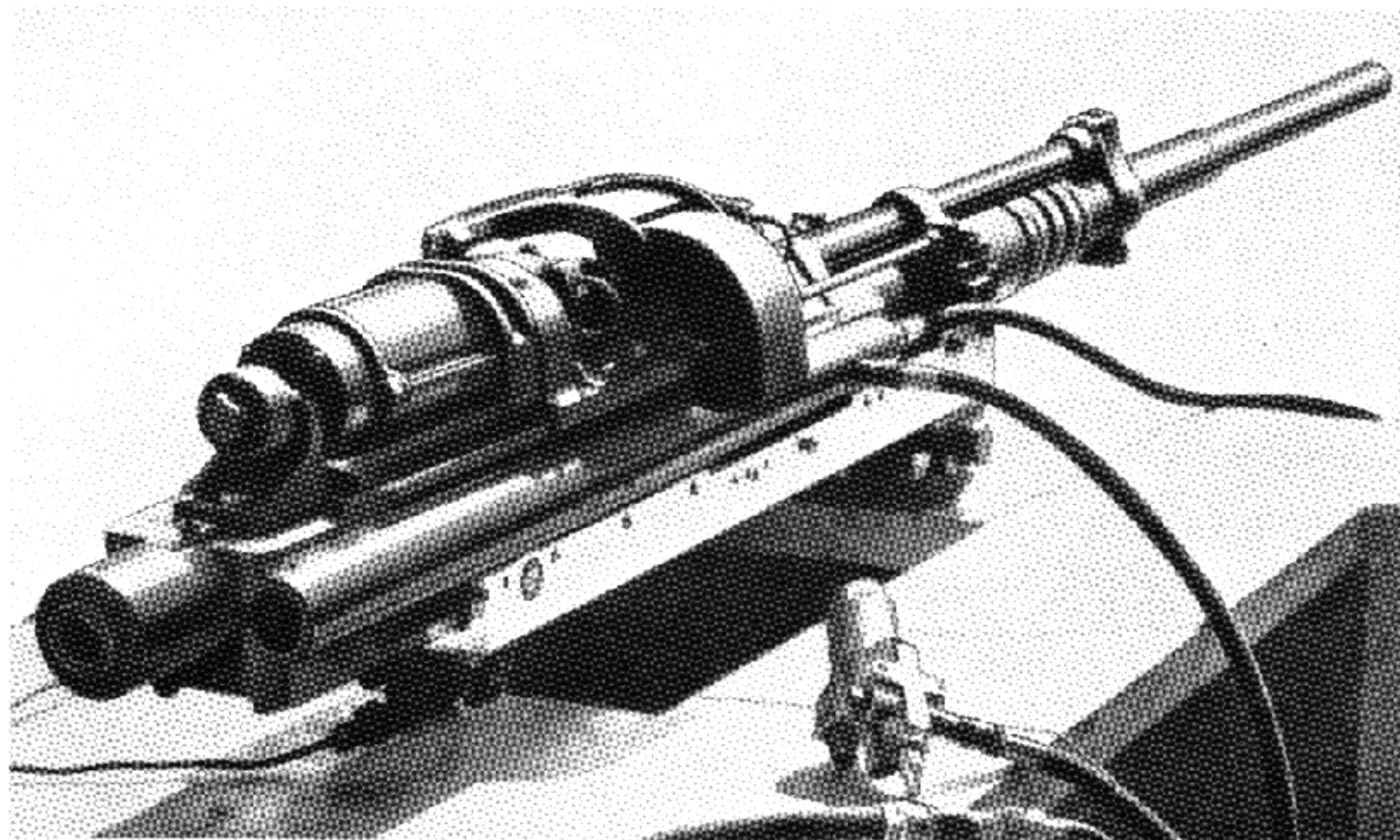


Figure 1-27. Gun, Automatic, 20-mm T34.

fications to increase the cyclic rate of fire to 1,000 rounds per minute. The four modifications are: The installation of a new type breechblock buffer stronger recoil spring, lighter recoiling parts, and installation of a higher pressure gas operating system. As originally designed, it was chambered for the large T5 case, but in April 1945 it was converted to standard ammunition to fulfill a Navy need for a high cyclic rate shipboard defense against suicide planes. By V-J Day, when the project was suspended temporarily, 12 T34 guns, with a claimed parts life of 1,500 rounds, had been delivered. Tests revealed numerous deficiencies, chiefly short-lived parts such as driving spring, firing pins, gas piston rings, receiver, slides, and slide key.

Gun, Automatic, 20-mm T34E1. This is the electric-fired version of the T34 gun, development of which was commenced in March 1948. The purpose of the project was to meet a Navy requirement for a high cyclic rate, electric-fired gun. Early changes eliminated two of the most serious T34 defi-

ciencies; the receiver weakness was eliminated by utilizing a modified M2 receiver of which large stocks were available, and the driving spring was removed by utilizing a double-acting pneumatic charger fitted into the new receiver.

Gun, Automatic, 20-mm T34E2. The T34E1 gun when modified to fire 1,600 grain projectiles.

Gun, Automatic, 20-mm T35. High cyclic aircraft gun using supersonic ammunition, with matched projectiles and two types of mechanical bolts and one type of electrical bolt. Designed by Oldsmobile division of General Motors.

Gun, Machine, 20-mm T54. This gun is the Navy Mark 10 Mod 0. It is designed as a double-barrel, low-silhouette weapon, containing its own feed mechanism driven by means of the bolt extension. It contains a pneumatic charging mechanism. Two rounds are extracted from the belt on the recoil stroke and two rounds are fed during counterrecoil. A unique feature is the method employed to feed two barrels from one belt of ammunition. The as-

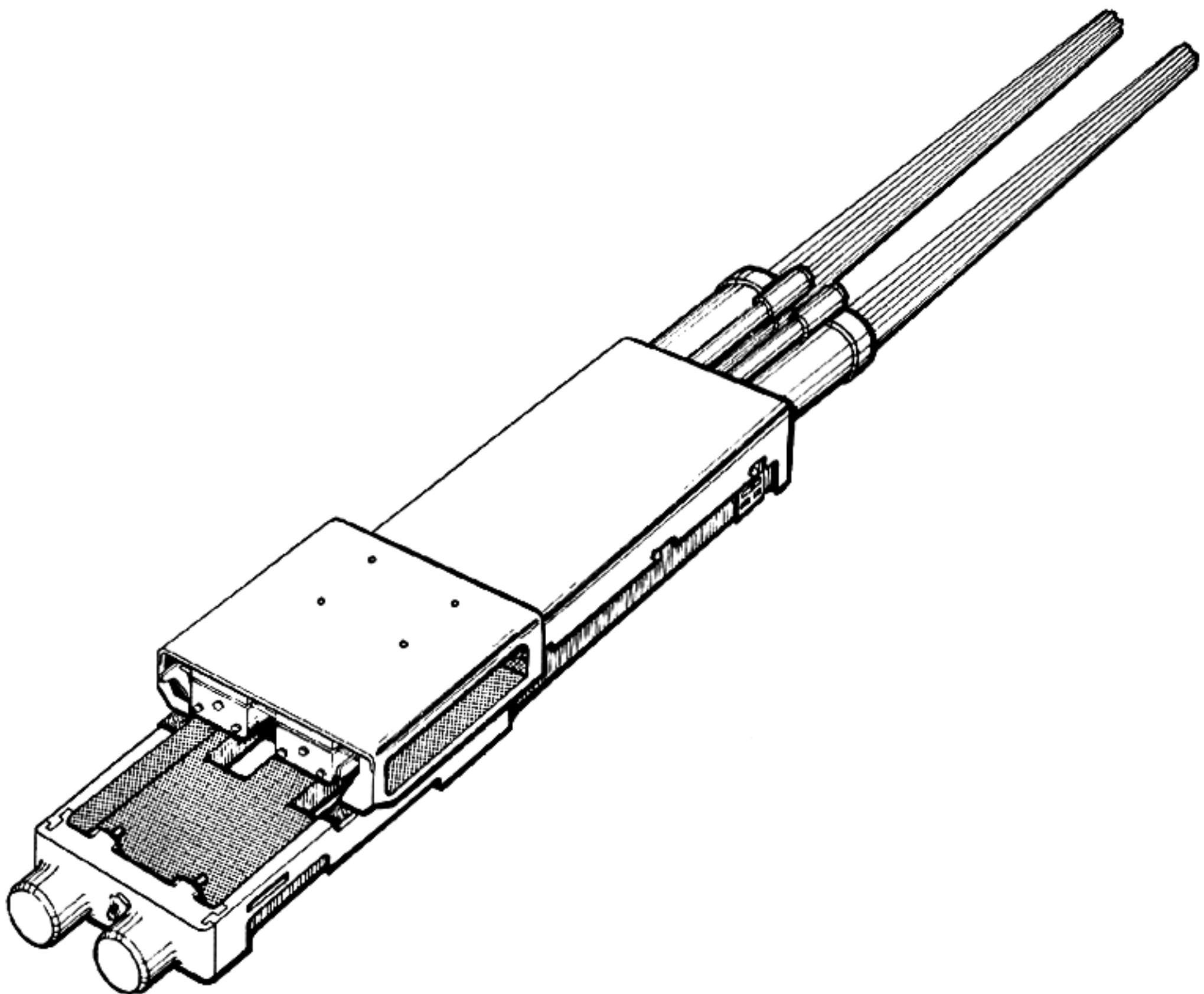


Figure 1-28. Gun, Machine, 20-mm T54.

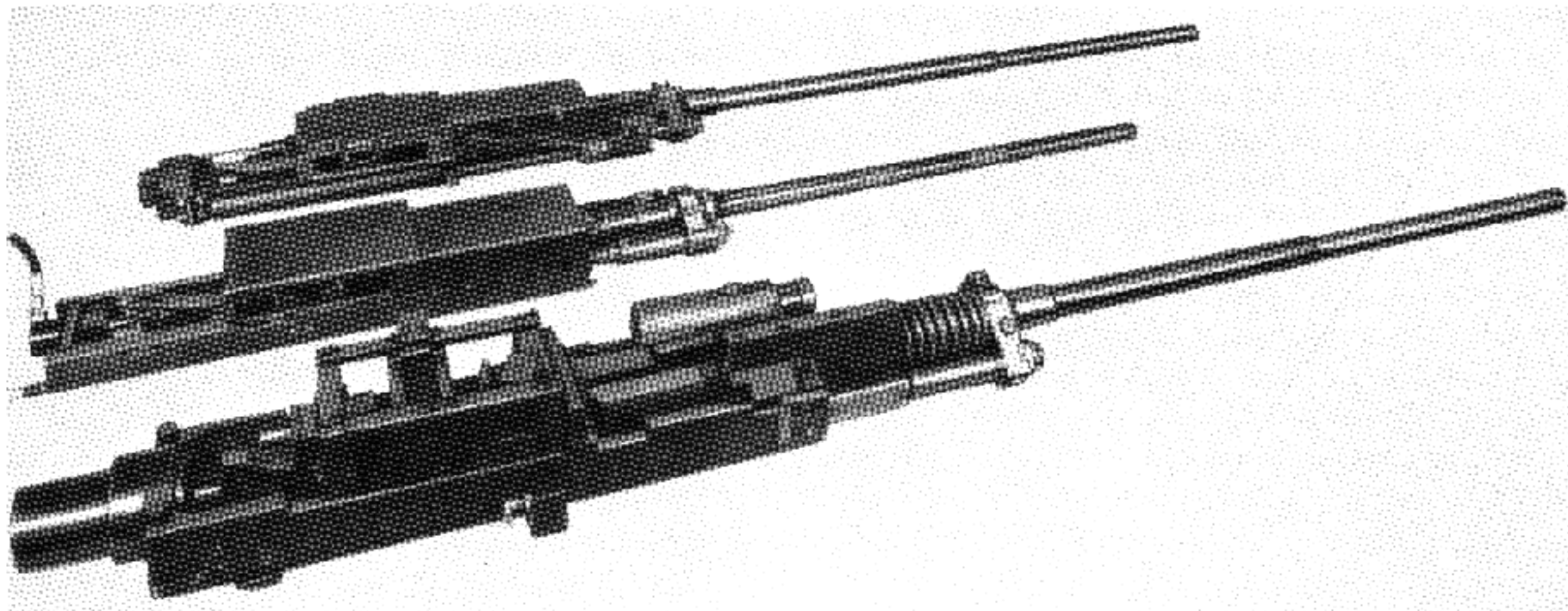


Figure 1-29. Stages in the development of the T55 gun. Front to rear: EX 1 Type 1; Mk 9 Mod 0; EX 1 Type 2.

signment of Ordnance Corps T numbers to Naval developments is done merely to facilitate identification to Army activities.

Gun, Machine, 20-mm T55. This designates a series of guns which were developed by the Navy and the Shirgun Corp. These guns also have Navy nomenclature. The latest version to which T55 was applied is known in the Navy as the Mk 9 Mod 0. The gun is a single-barrel, low-silhouette weapon, with a high belt-pulling capacity. It has an easily detached, integral-feed mechanism driven by the bolt extension. Pneumatic pressure is required for charger, bolt buffer, and sear operation. The charger and sear are controlled by solenoid operated valves mounted externally. The gun fires 20-mm M90 series ammunition, belted in M7 or M8 links.

These guns were later modified and known as T128 guns.

Gun, Machine, 20-mm T56. Actually designated Gun, Machine, 20-mm T56. Modification of Gun, Machine, Caliber .60, T17E5 to use a 20-mm cartridge. The gun can be prepared for either left- or right-hand feed. Firing is by means of a solenoid. A shock-absorbing adapter serves as a front mounting. The gun is charged by an electric charger mounted in the cover and fired from an open bolt. The gun is changed from a caliber .60 to a 20-mm by simply inserting the proper barrel.

Gun, Automatic, 20-mm T57. This gun is basically the 20-mm T31 aircraft gun with a lightened bolt assembly, a long-stroke Belleville spring buffer, and high-pressure gas-operating pistons. The rea-

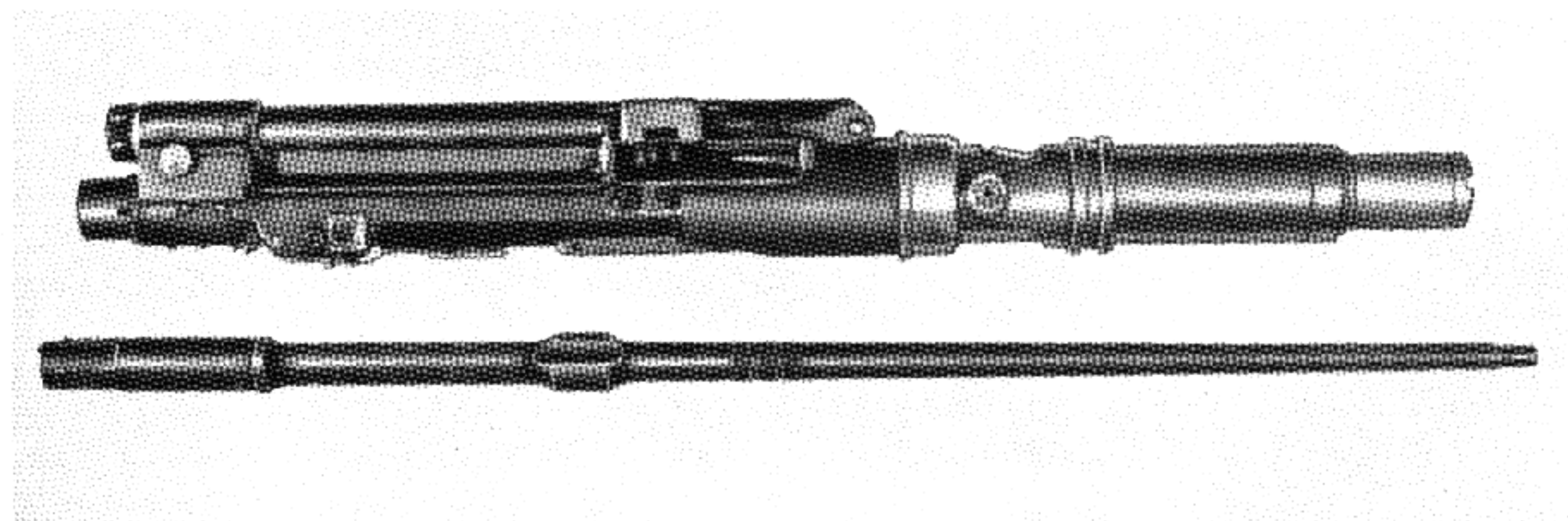


Figure 1-30. Gun, Machine, 20-mm T56.

son for operating the gun off the high gas pressures was to take advantage of the fact that a differential in pressure of 5,000 p. s. i. at gas pressures around 45,000 p. s. i. has less effect on the operation of the gun than a differential in pressure of 5,000 p. s. i. at gas pressures around 30,000 p. s. i. A large part of the erratic firing of the 20-mm T57 gun was due to the differences in pressure curves caused by bleeding the high-pressure gases off near the rotating band of the projectile. The design of gas-operating pistons caused early unlocking of the bolt with a resultant increase in the amount of flashback. Firing of the T57 gun at Salisbury Beach on 2 July 1945 disclosed the fact that the whole feed mechanism was engulfed with flame when the gun fired. No difficulty seemed to be experienced with early extraction of the cartridge case, but a number of cartridge cases showed marks of the ejectors cutting completely through the base of the cartridge rims due to the high velocity of the bolt.

Gun, Automatic, 20-mm T67. Navy development. Modification of M3 gun to incorporate a small oil pump to lubricate the chamber, thus eliminating necessity for lubricated ammunition. Bolt parts changed to provide for earlier firing on firing pin stroke to overcome effects of slide bounce.

Gun, Automatic, 20-mm T74. Gas-operated revolver-type weapon based on the German MG-213 firing a special cartridge case.

Gun, Automatic, 20-mm T109. This gun was developed by Armour Research Foundation.

Gun, Automatic, 20-mm T110. This is a variation of gun, automatic, 20-mm T74 with the barrel at the bottom of the receiver.

Gun, Automatic, 20-mm T115. Experimental weapon based on Mauser action. No record of having been produced.

Gun, Automatic, 20-mm T116. Experimental weapon based on Mauser action. No record of having been produced.

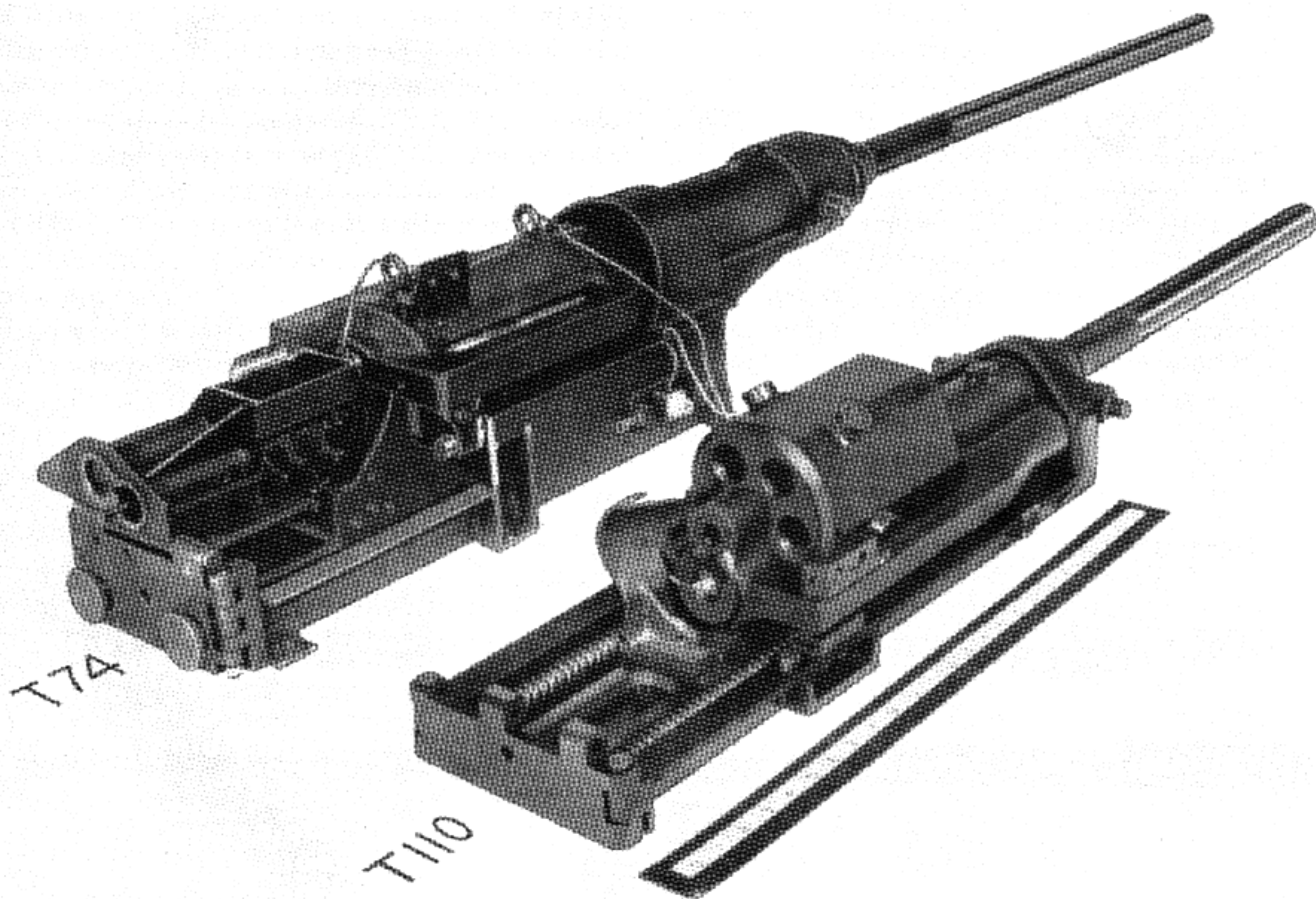


Figure 1-31. Gun, Automatic, 20-mm T74 and Gun, Automatic, 20-mm T110.

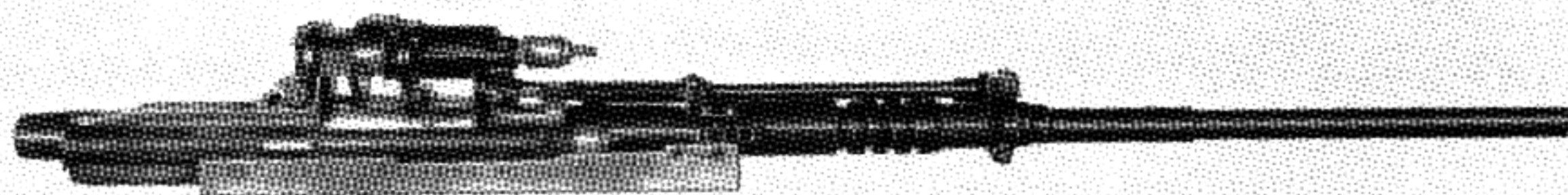


Figure 1-32. Gun, Automatic, 20-mm T118.

Gun, Automatic, 20-mm T117. This is the Navy Mk 11 gun. The gun is a double-barrel, two-belt feed, recoil driven weapon with revolver type breech. The electrically primed ammunition is carried to the gun by wire linked, electrically fired projectors which serve to load the ammunition in the revolving chamber and also to carry the fired cases and duds away from the gun. The gun is designed to clear duds automatically and to continue firing without releasing the firing switch. One of the unique features of the gun is the method employed for loading the firing chambers by means of the primed ammunition projectors.

Gun, Automatic, 20-mm T118. This nomenclature was established in the latter part of 1948 to identify a T34E1 gun rechambered and modified to fire a 1,600-grain projectile using the caliber .60 cartridge case. Approximately 20,000 rounds had been fired in tests of the T118 gun and feeder up to 30 June 1950. Subsequently the Navy adopted the T130 round for use in the T118 gun. This round consists of a 1,700-grain caliber .60 case but approximately 0.266 longer in the body than Army ammunition. This gun was adopted into the Navy as the Mk 12. However, the Navy guns are chambered for ammunition approximately one-quarter inch longer than the Army ammunition.

Guns, Automatic, 20-mm T122 and 20-mm T123. The designations 20-mm T122 and 20-mm T123 have appeared in some documents. These numbers were given in error for 20-mm T128 and 20-mm T129, respectively. No 20-mm guns were ever designated T122 or T123.

Gun, Automatic, 20-mm T126. An experimental percussion-fired weapon with 900-rounds-per-minute cyclic rate, recoil operated with integral feed mechanism, 78-inch length and 110-pound weight. Differs from the weapon designated as

Gun, Machine, 20-mm, T56 in increased cyclic rate and reduced length and weight.

Gun, Automatic, 20-mm T127. An experimental electric-fired weapon with 1,000-rounds-per-minute cyclic rate, recoil operated with external-powered feed mechanism, 78-inch length and 140-pound weight. Fired electric-primed ammunition employing a caliber .60 cartridge case and 20-mm projectile. Differs from gun, automatic, 20-mm T116 in increased cyclic rate and reduced length.

Gun, Automatic, 20-mm T128. This is Navy 20-mm gun mechanism Mk 9 Mod 1.

Gun, Automatic, 20-mm T129. This is Navy 20-mm gun mechanism Mk 13 Mod 0.

Gun, Automatic, 20-mm T160. This is a version of the caliber .60 T130 gun firing the 60/20-mm Army cartridge.

Gun, Automatic, 20-mm T171. This is a conversion of the caliber .60 T145 gun to fire the 60/20-mm Army cartridge. These guns operate on the Gatling principle.

Gun, Automatic, 20-mm M1. This was the standardized version of the T1 (Hispano-Suiza 404). It was never in active service. Designed as a motor-mounted gun, it was fed by a drum magazine. The receiver was 7 pounds lighter in weight than that of the M2.

Gun, Automatic, 20-mm M2 Series. This is the standard gun as used in World War II. The M2E1 used a special tube having a twist of 1 in 10 calibers, right hand; M2E2, 1 in 40 calibers, right hand; M2E3, 1 in 60 calibers, right hand; M2E4, 1 in 100 calibers, right hand. The designation, Gun, Automatic, 20-mm M2, had earlier been applied to a Solothurn antitank gun but that action had been rescinded.

Gun, Automatic, 20-mm M3. Standardization of the T31.

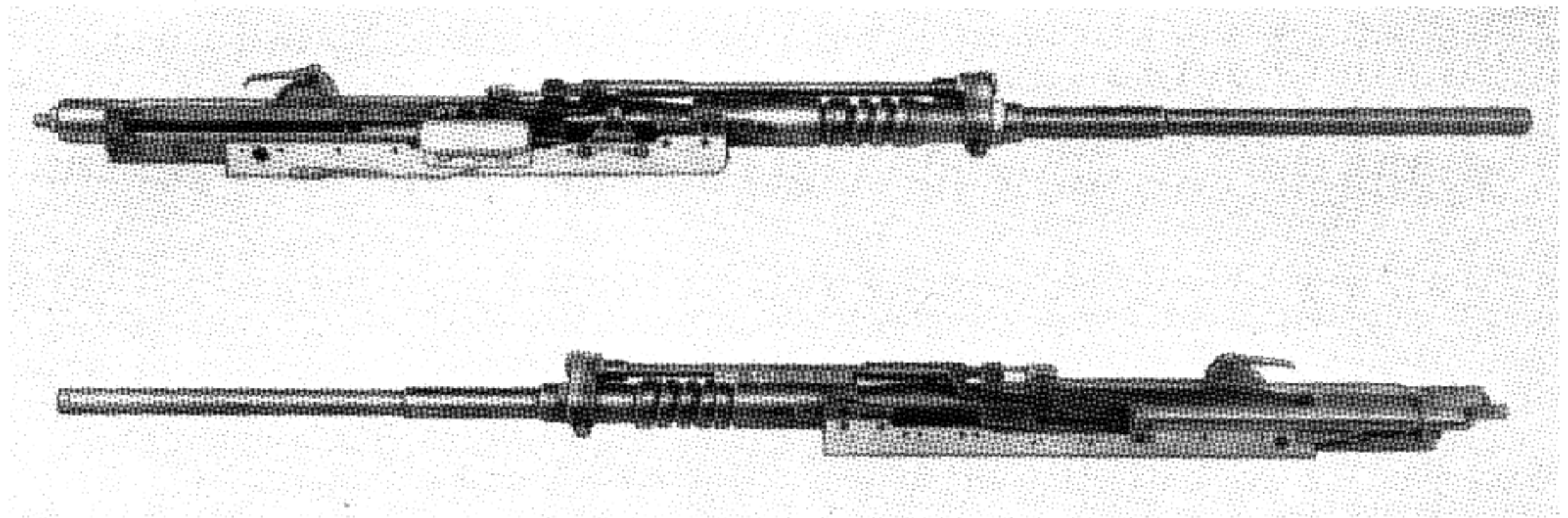


Figure 1-33. Gun, Automatic, 20-mm M23.

Gun, Automatic, 20-mm M23. For synchronized firing or fire interruption from the battery position, using percussion-primed ammunition.

Gun, Automatic, 20-mm M24 Series. The M24 is a standardization of the T31E2. The M24E1 differs in size of gas vent hole to maintain 750 rounds per minute cyclic rate for use of the 1,600 grains projectile, practice, 20-mm T61E1. In the M24E2 the bolt is modified to permit the incoming round to assist in controlling extraction and ejection of complete round in chamber. The M24A1 incorporates a barrel plunger and modified gas system. This was followed by an improved version known officially as the M24A2.

20-mm Automatic Guns with Mark and Mod Numbers

20-mm Machine Gun Mechanism Mk 1. No Mk 1 assigned to United States equipment. British Oerlikon.

20-mm Machine Gun Mechanism Mk 2 Mod 0. Manufactured from drawings prepared for production of the British Mark II Oerlikon.

20-mm Machine Gun Mechanism Mk 2 Mod 1. Refinement of the Mk 2 Mod 0.

20-mm Machine Gun Mechanism Mk 3. No Mk 3 assigned to United States equipment. British.

20-mm Machine Gun Mechanism Mk 4 Mod 0. Oerlikon manufactured from drawings prepared by NOP Centerline. Same as Mk 2, except tolerances. Limited interchangeability with Mk 2.

20-mm Machine Gun Mechanism Mk 4 Mod 1. Oerlikon, differs from Mk 4 Mod 0 in having new

breech casing rear cap and shortened trigger needed for use on mounts Mk 20, Mk 21, and Mk 24.

20-mm Machine Gun Mechanism Mk 4 Mod 2. The Mk 4 Mod 0 changed as follows:

1. Breechbar cam is attached to right breech bar.
2. Special trigger for use with Solenoid Mk 29.
3. Solenoid Mk 29 replaces trigger cover plate.
4. Uses back cover without handgrips; this permits the use of R. H. recoil operated belt feed.

20-mm Machine Gun Mechanism Mk 4 Mod 3. The Mk 4 Mod 0 changed as follows:

1. Breechbar cam is attached to left breech bar.
2. Special trigger for use with Solenoid Mk 29.
3. Solenoid Mk 29 replaces trigger cover plate.
4. Uses back cover without handgrips; this permits the use of L. H. recoil operated belt feed.

20-mm Machine Gun Mechanism Mk 4 Mod 4. Differs from Mk 4 Mod 0 in that trigger, breechbar securing bolt retaining pins, handgrip, and magazine catch lever are redesigned or modified to suit mount Mk 15.

20-mm Machine Gun Mechanism Mk 4 Mod 5. Eliminates machining for double-loading stop on Mk 4 Mod 0.

20-mm Machine Gun Mechanism Mk 4 Mod 6. Eliminates machining for double-loading stop on Mk 4 Mod 1.

20-mm Machine Gun Mechanism Mk 5. No Mk 5 assigned to United States equipment. British Oerlikon.

20-mm Machine Gun Mechanism Mk 6 Mod 0. Experimental Oerlikon design by Pontiac. Similar to Mk 4.

20-mm Machine Gun Mechanism Mk 7. No Mk 7 assigned to United States equipment. Reserved for British gun.

20-mm Gun Mk 8 Mod 0. The 20-mm T31 (M3) adapted to Mark 25 mount by Emerson Electric Co., St. Louis, Mo. This was an attempt to use the Hispano as an antiaircraft defense against suicide planes.

20-mm Gun Mk 8 Mod 1. The 20-mm T31 (M3) adapted to Mark 22 mount for shipboard antiaircraft use.

20-mm Gun Mechanism Mk 9 Mod 0. Developed from EX 1, designed by Shirgun Co. 20-mm self-fed, feed operates off bolt travel. There were improvements in the pneumatic system and the firing pin was scared. With the 52½-inch barrel a muzzle velocity of 2,680 feet per second was obtained at a rate of fire of 1,000 rounds per minute. Built at the Naval Gun Factory. There were two guns of this type made.

20-mm Machine Gun Mechanism Mk 9 Mod 1. Modified from Mod 0, these guns use Hispano electric primed ammunition at a rate of 1,100 rounds per minute. The feed is operated by a camway on the bolt extension. The pneumatic sear was removed. Two guns of this type were produced by modifying the Mod 0 units.

20-mm Gun Mechanism Mk 10 Mod 0. This was a proposed twin-barrel gun to feed from a single belt. Early design work by Shirgun Co. was based on the Hispano round. The Naval Gun Factory later made studies for the use of 60/20 electric primed ammunition. Only a wooden model has been made.

20-mm Gun Mechanism Mk 11 Mod 0. 20-mm double barrel, revolving breech, self-fed gun. Uses aluminum 60/20 mm cartridge cases. Uses two belts and relinks the cases.

20-mm Gun Mechanism Mk 12 Mod 0. An improved version of the T118 with chamber lengthened to take the 60/20 mm Navy round.

20-mm Gun Mechanism Mk 12 Mod 1. Short barrel version for use in the turret.

20-mm Gun Mechanism Mk 12 Mod 2. Includes modification to improve parts life and permits standardization for mass production.

20-mm Gun Mechanism Mk 13 Mod 0. This gun resembles the Mark 9, Mod 1, but is chambered for the short 60/20 round of the Army Ordnance Corps. The 60-inch barrel gives a muzzle velocity of 3,300 feet per second. There is no driving spring and ignition is electric. Built at the Naval Gun Factory, only two of this Mark have been made.

20-mm Gun Mechanism Mk 14 Mod 0. 20-mm version of 30-mm Mark 1. Mechanism is same except chamber and barrel. High-velocity ammunition.

20-mm Gun Mechanism Mk 15 Mod 0. Modification of 20-mm T110 to use Navy 60/20 round.

20-mm Gun Mechanism Mk 15 Mod 1. Refinement of the Mk 15 Mod 0.

20-mm Gun Mechanism Mk 16 Mod 0. 20-mm M3 gun modified by NGF to use Mk 8 feed.

20-mm Gun Mechanism Mk 17 Mod 0. 20-mm M24 gun modified by NGF to use Mk 8 feed.

20-mm Machine Guns with EX Designations

20-mm Gun Mechanism EX 1, Type 1. This project was placed on contract with the Shirgun Corp. by the Bureau of Ordnance. The weapon was developed into the Mk 9 Mod 0.

20-mm Gun Mechanism EX 2. This project was initiated in July 1942 to develop an integral feed 20-mm aircraft gun which could utilize 20-mm Oerlikon ammunition. The proposed gun was to replace the current 20-mm aircraft gun which had been experiencing excessive malfunctioning of the feed mechanism and presented installation difficulties in various planes. The Navy contacted the NDRC and outlined its desires for a new 20-mm gun. The NDRC in turn contacted Johnson Automatics, Inc. to develop the proposed weapon. The Johnson gun was gas operated, belt-fed, and first used Oerlikon ammunition, later being modified to use Hispano rounds.

20-mm Machine Gun Mechanism EX 3. This was the project which developed into the Mk 10 Mod 0.

20-mm Machine Gun Mechanism EX 4. This project developed into the Mk 11 Mod 0.

20-mm Machine Gun Mechanism EX 5. Based on the Mark 13 Mod 0 with major improvements. Feed operates off barrel extension and twin locks are used instead of single locks.

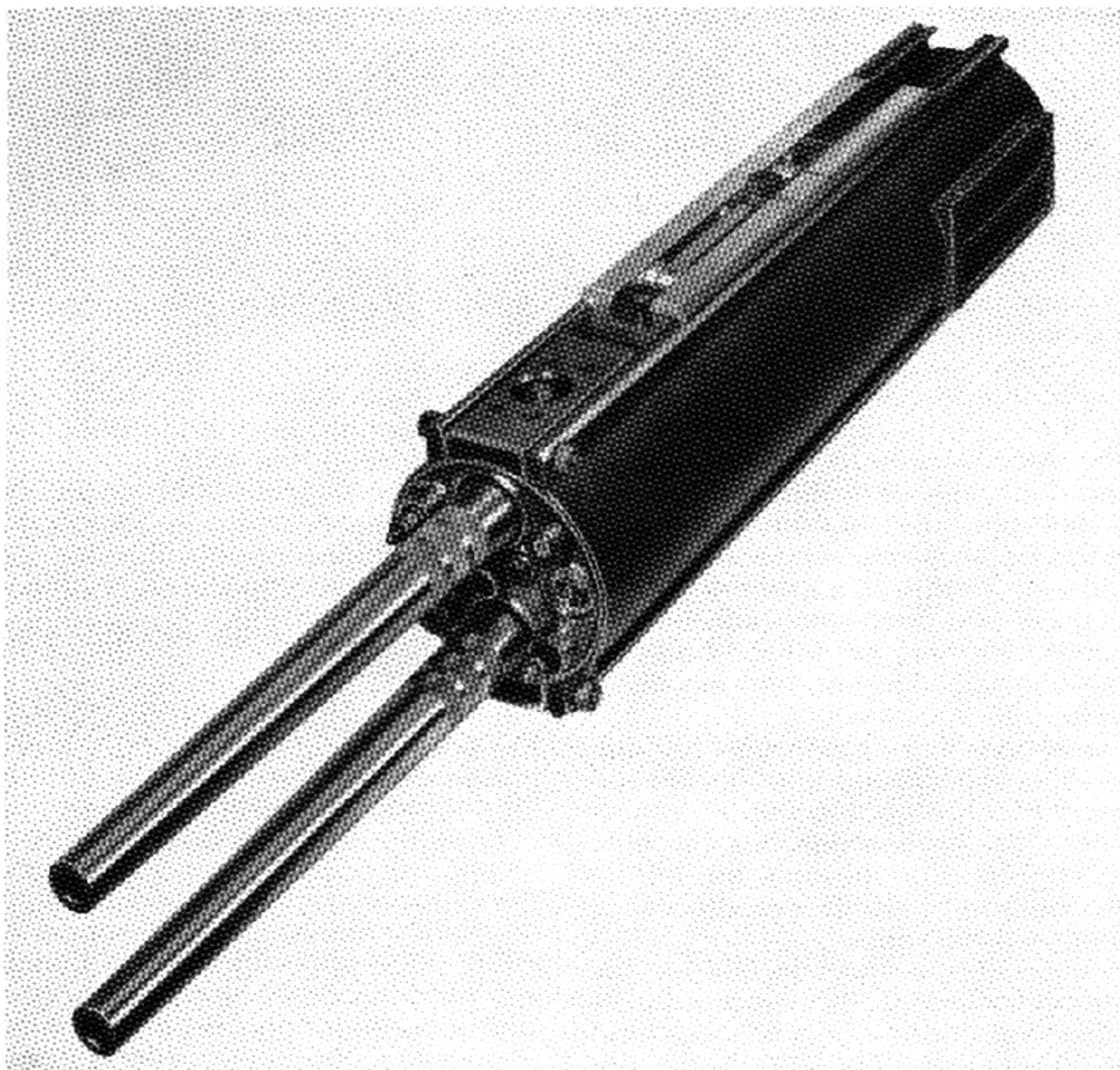


Figure 1-34. 20-mm Machine Gun Mk 11 Mod 0. Three-quarter front view.

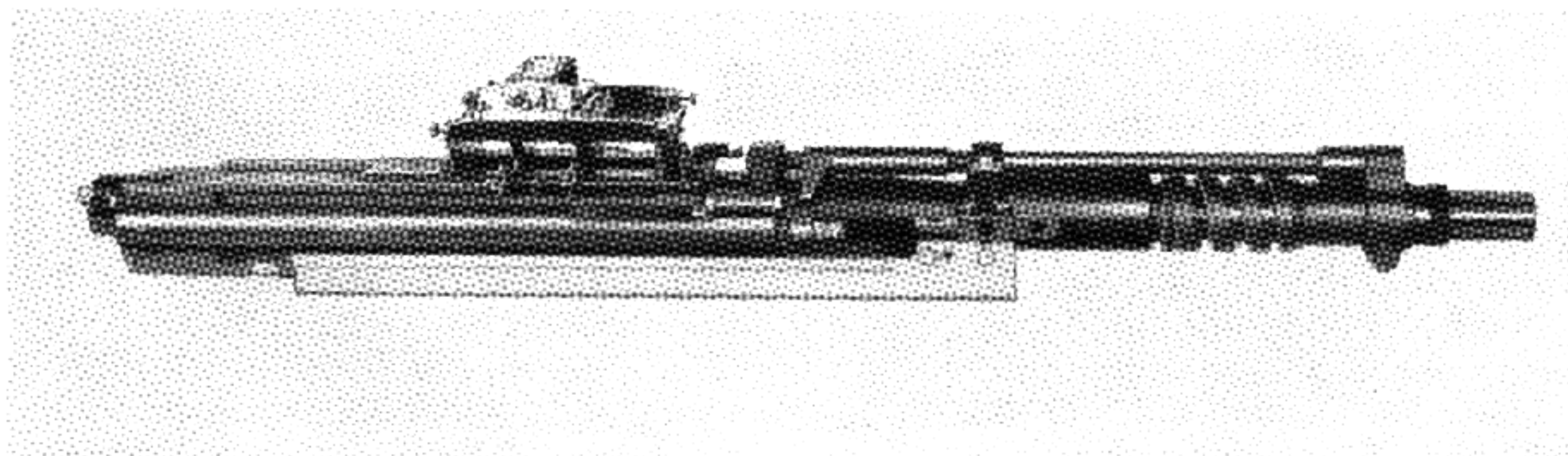


Figure 1-35. 20-mm Gun Mechanism Mk 12 Mod 1.

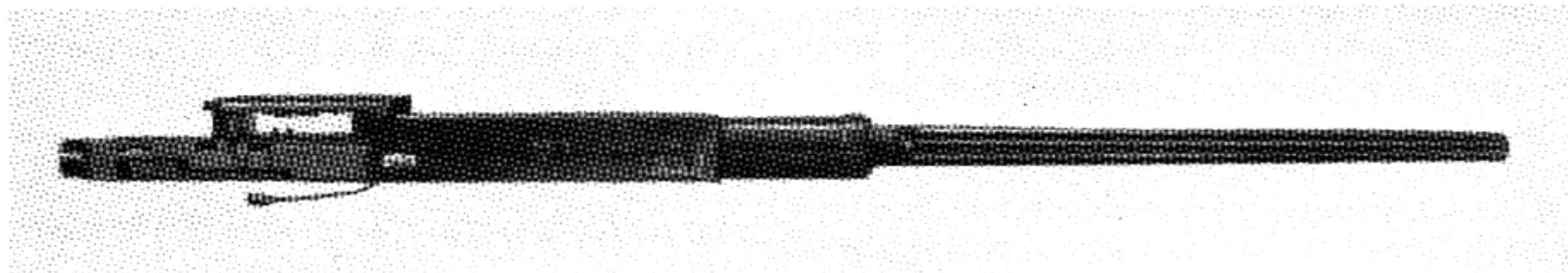


Figure 1-36. 20-mm Gun Mechanism Mk 13 Mod 0. This weapon is also known as the T129.

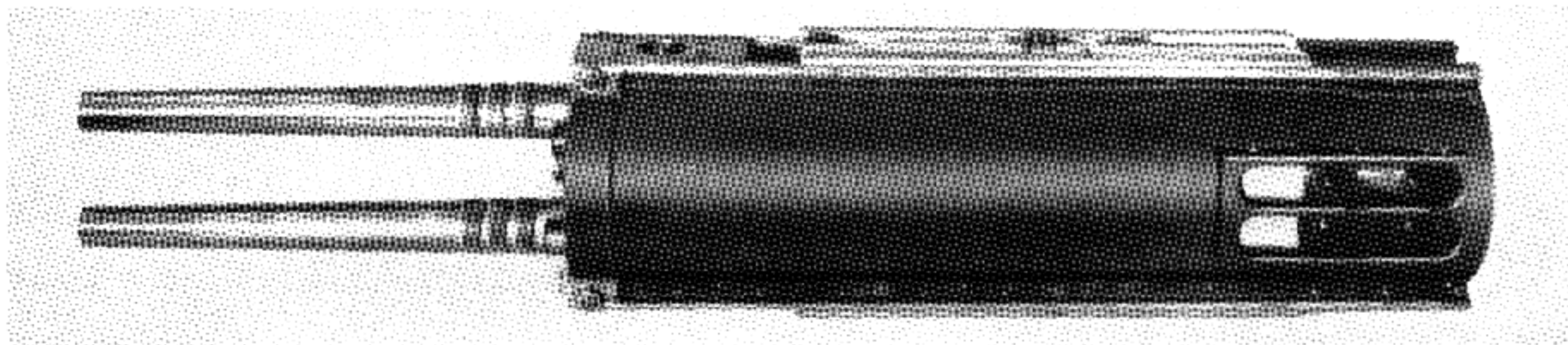


Figure 1-37. High-velocity 20-mm Machine Gun Mk 14 Mod 0. Side view.

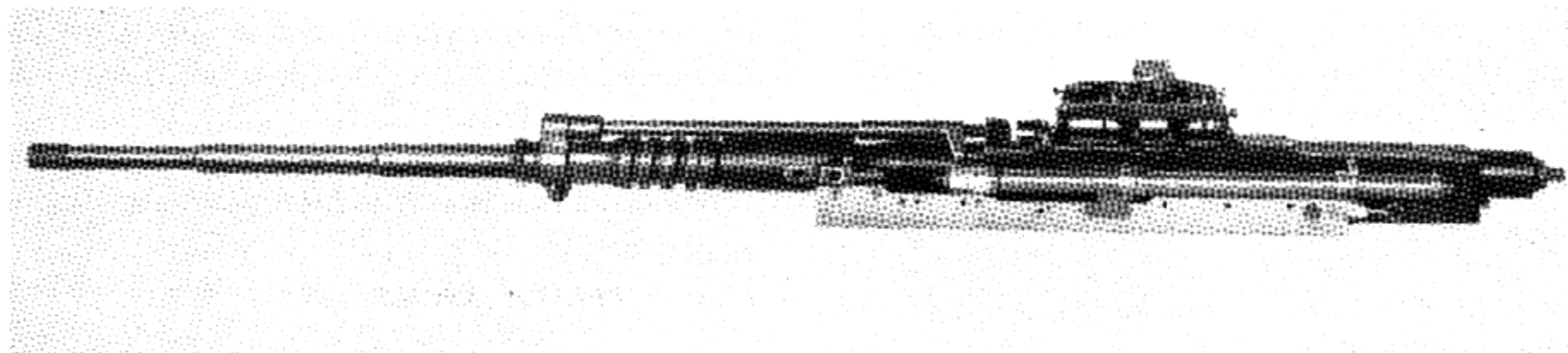


Figure 1-38. 20-mm Gun Mechanism Mk 16 Mod 0.

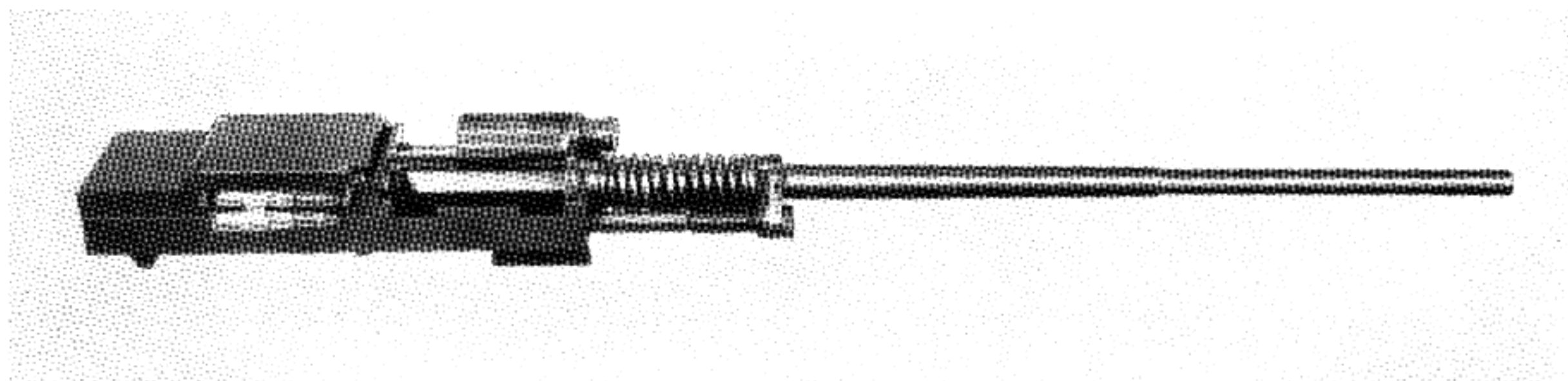


Figure 1-39. 20-mm Aircraft Cannon EX 1 Type 1. Prototype.

Redesign under direction of Dr. Walter F. Grasse, Dr. Richard H. Braun, and Mr. Theodor Rakula.

20-mm Machine Gun Mechanism EX 6. Utilizing short recoil, blowback, and gas for its operating power for both breechblock and feeder. Double roller locks used for securely holding breechblock and barrel extension together during moment of firing. Cammed unlocking. This version is to furnish engineering design data for use in construction of a 30-mm gun. Responsibility for design given to Lt. Col G. M. Chinn, USMCR.

Caliber .90 Machine Guns with T Numbers

Gun, Machine, Caliber .90 T1. This gun was built at Rock Island Gun Arsenal and used a necked-down 1.1-inch cartridge case. The muzzle velocity was 2,850 feet per second and the rate of fire was 150 rounds per minute.

Gun, Machine, Caliber .90 T2 Series. The T2 series were built by Watervliet and based on the Oerlikon design. Refinements of the caliber .90 T2 were made in Gun, Machine, Caliber .90 T2E1 and Gun, Machine, Caliber .90 T2E2.

Gun, Machine, Caliber .90 T3. Similar to the T2 but included a blowback retarding device.

Gun, Machine, Caliber .90 T4. Built by the Colt Co. and based on the design of the Browning long-recoil cannon. Although the T4 was developed to provide an automatic aircraft weapon of great striking power, the need for an antitank gun more powerful than the caliber .50 machine gun but lighter and more mobile than the 37-mm gun M3, caused serious consideration of the T4 for this purpose.

27-mm Automatic Guns with T Numbers

Gun, Automatic, 27-mm T150. Modification of the caliber .60 T45 to permit use of a 27-mm projec-

tile from the same basic cartridge case. The mechanism is based on the Gatling principle.

Gun, Automatic, 27-mm T151. Gas operated revolver similar to the caliber .60 T130. These guns are American improved designs based on the German MG213.

30-mm Automatic Guns with T Numbers

Gun, Automatic, 30-mm T120. This is a conversion of the 20-mm T109 to 30-mm and is the equivalent of the Navy 30-mm Mk 5 Mod 0.

Gun, Automatic, 30-mm T121. Similar to the 20-mm T110 but fires the 30-mm round. Gas-operated revolver gun.

Gun, Automatic, 30-mm T182. Similar to the 30-mm T121 but fires a higher-velocity round.

30-mm Machine Guns with Mark and Mod Numbers

30-mm Machine Gun Mechanism Mk 1 Mod 0. Modification of 20-mm Mk 11 to fire low-velocity 30-mm ammunition.

30-mm Machine Gun Mechanism Mk 2 Mod 0. Modification of 20-mm T110 to fire low-velocity 30-mm ammunition.

30-mm Machine Gun Mechanism Mk 3 Mod 0. Modification of 20-mm Mk 13 to fire low-velocity 30-mm ammunition.

30-mm Gun Mechanism Mk 4 Mod 0. Modification of 20-mm Mk 12 to fire low-velocity 30-mm ammunition.

30-mm Gun Mechanism Mk 4 Mod 1. Shortened Mk 4 Mod 0 for turrets to fire low-velocity 30-mm ammunition.

30-mm Gun Mechanism Mk 5 Mod 0. Modification of the 20-mm T33 series to fire low-velocity 30-mm ammunition.

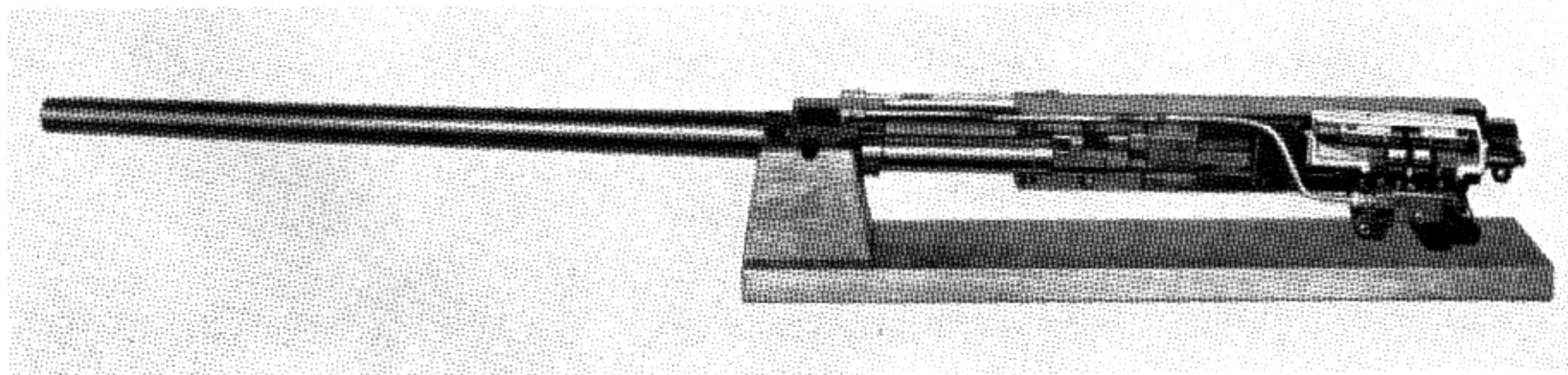


Figure 1-40. 30-mm Gun Mechanism Mk 5 Mod 0.

1.1-inch Machine Guns with Mark and Mod Numbers

1.1-inch Machine Gun Mechanism Mk 1 Mod 0. The recoil operated antiaircraft machine gun designed by the Bureau of Ordnance for shipboard use. Used in World War II and declared obsolete upon demobilization.

1.1-inch Machine Gun Mechanism Mk 1 Mod 1. Variation of the Mk 1 Mod 0.

1.1-inch Machine Gun Mechanism Mk 1 Mod 2. Another variation of the Mk 1 Mod 0.

1.1-inch Machine Gun Mechanism Mk 2 Mod 0. Gas-operated, experimental machine gun.

37-mm Automatic Guns

Gun, Automatic 37-mm T1. Built about 1924 and based on a design by Col. Thomas Jervey, United States Army Ordnance.

Gun, Automatic 37-mm T2. The T2 Browning was tested at Aberdeen in June 1925. It was designed for muzzle velocity of 3,057 feet per second.

Gun, Automatic 37-mm T2E1. This modification increases weight of barrel to overcome weakness of T2 barrel. This gun has a water jacket.

Gun, Automatic 37-mm T3. This was a Browning design with a muzzle velocity of 1,350 feet per second.

Gun, Automatic 37-mm T5. Designed by the Ordnance Department and built at Rock Island Arsenal.

Gun, Automatic 37-mm T5E1. In September 1938 the subcommittee on aircraft cannon recommended that the 37-mm automatic gun T5 of Ordnance design be turned over to the Air Corps for further test after the completion of tests under way at Aberdeen Proving Ground. After modifications making the gun lighter, the designation was changed

to 37-mm automatic gun T5E1. Preliminary tests at Aberdeen Proving Ground were made in January 1939. The results demonstrated that the weight of the gun was excessive, the cyclic rate of fire comparatively low, and the feed mechanism unsatisfactory. The Ordnance Committee in June 1939 directed that the project be canceled and the pilot weapon sent to Watervliet Arsenal for use in connection with the study and design of automatic weapons.

Gun, Automatic 37-mm T9. The T2 gun was modified as a result of the experience gained from the various tests, until eventually a gun designated T9 was ready for test. In September 1939 this gun was mounted first in the nacelle of an A-20A attack plane, and later in P-38 and P-39 fighter planes. Further modifications of the experimental T9 gun, utilizing the knowledge gained from the extensive tests it had undergone, led to an acceptable weapon which was standardized as the M4. This gun was to be employed by fighter planes in attacks from the rear at long range against single large bombers and for ground strafing.

Gun, Automatic 37-mm T19. Actually no 37-mm automatic gun T19 was ever made. The designation was used to set up the characteristics of the ideal gun. Early in 1942 intensive efforts were made to establish the necessity for a high-velocity 37-mm automatic cannon for aircraft use. The primary mission of this piece was to be the attack of mechanized ground forces, a task for which the ballistic characteristics of the ammunition used by the 37-mm automatic gun M4 was inadequate. Experience gained with a 37-mm antiaircraft gun M1A2 mounted in an airplane determined the desired military characteristics. The weight, including gun, tube, and feeding device, was not to exceed 400

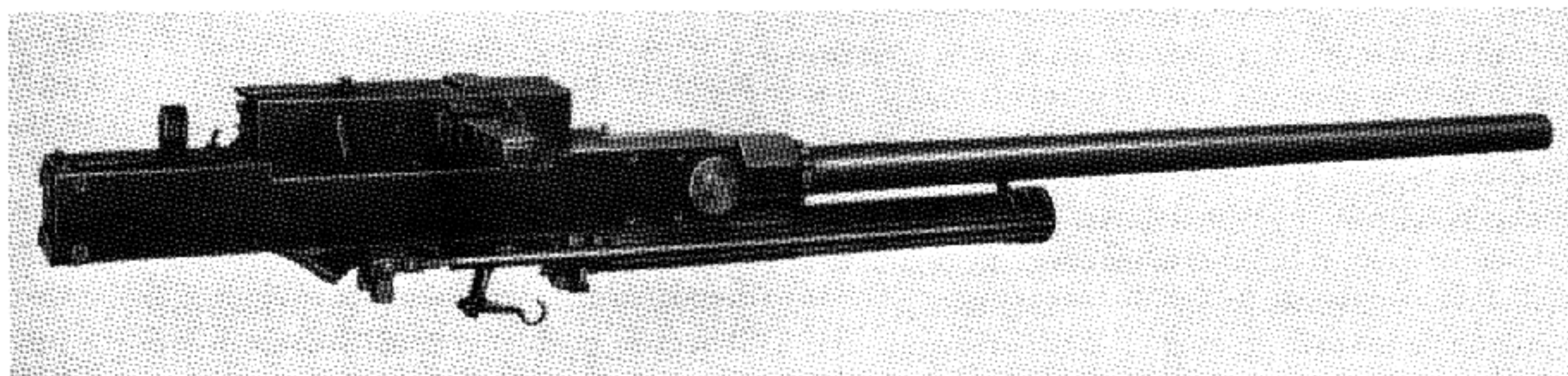


Figure 1-41. 37-mm Browning Gun T9 showing ejection chute for the five-round feeder. Right side view.

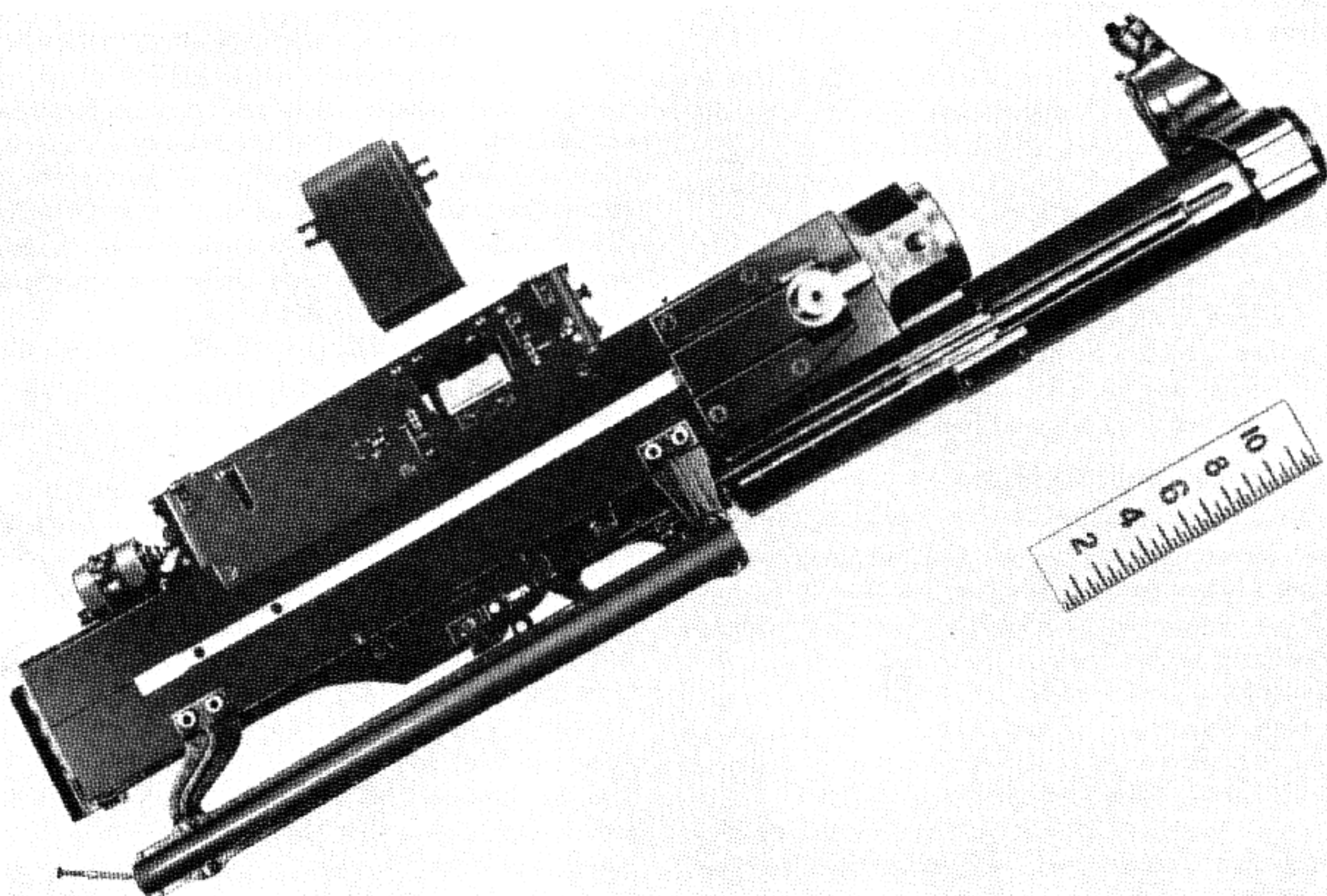


Figure 1-42. 37-mm Browning Gun T20 with barrel removed. Right side view.

pounds. Both charging and firing gun were to be by remote control and the feed was to be by a disintegrating link belt, or, as a second choice, the belt or magazine. Firing was to be at the highest cyclic rate possible.

Gun, Automatic 37-mm T20. In the spring of 1942 Oldsmobile under Ordnance Department contract instituted a study of the redesign of the 37-mm antiaircraft automatic gun M1A2 to adapt it to fulfill the characteristics of a high velocity 37-mm automatic gun for aircraft installation. Designation of the new gun was 37-mm automatic gun T20. Substantially, this gun was the M1A2 gun, modified to incorporate a disintegrating belt feed, with a change in the external barrel dimensions and external recoil mechanism dimensions to permit installation of this gun in the P-39 airplane.

Gun, Automatic 37-mm T20E1. Because the installation in the P-39 airplane of the new high-velocity 37-mm automatic gun T20 had not yet

been set up by the Army Air Corps, it was considered desirable, in December 1942, to eliminate the special barrel and recoil system needed for this installation. This change involved using the barrel and recoil system of the M1A2 antiaircraft gun. The gun, as modified, was designated 37-mm automatic gun T20E1, and embodies fewer changes from the M1A2 than the T20, thus facilitating production.

Gun, Automatic 37-mm T20E2. The development and standardization of the T20E1 gun as 37-mm automatic gun M9, for left-side feed resulted in the development of the 37-mm automatic gun T20E2, a right-hand feed weapon. The principal difference between the left-hand feed and the right-hand feed was in the construction of the feedbox. The gun could be changed from a left-hand to a right-hand feed, and vice versa, by replacing the feedbox and the carrier bearing brace.

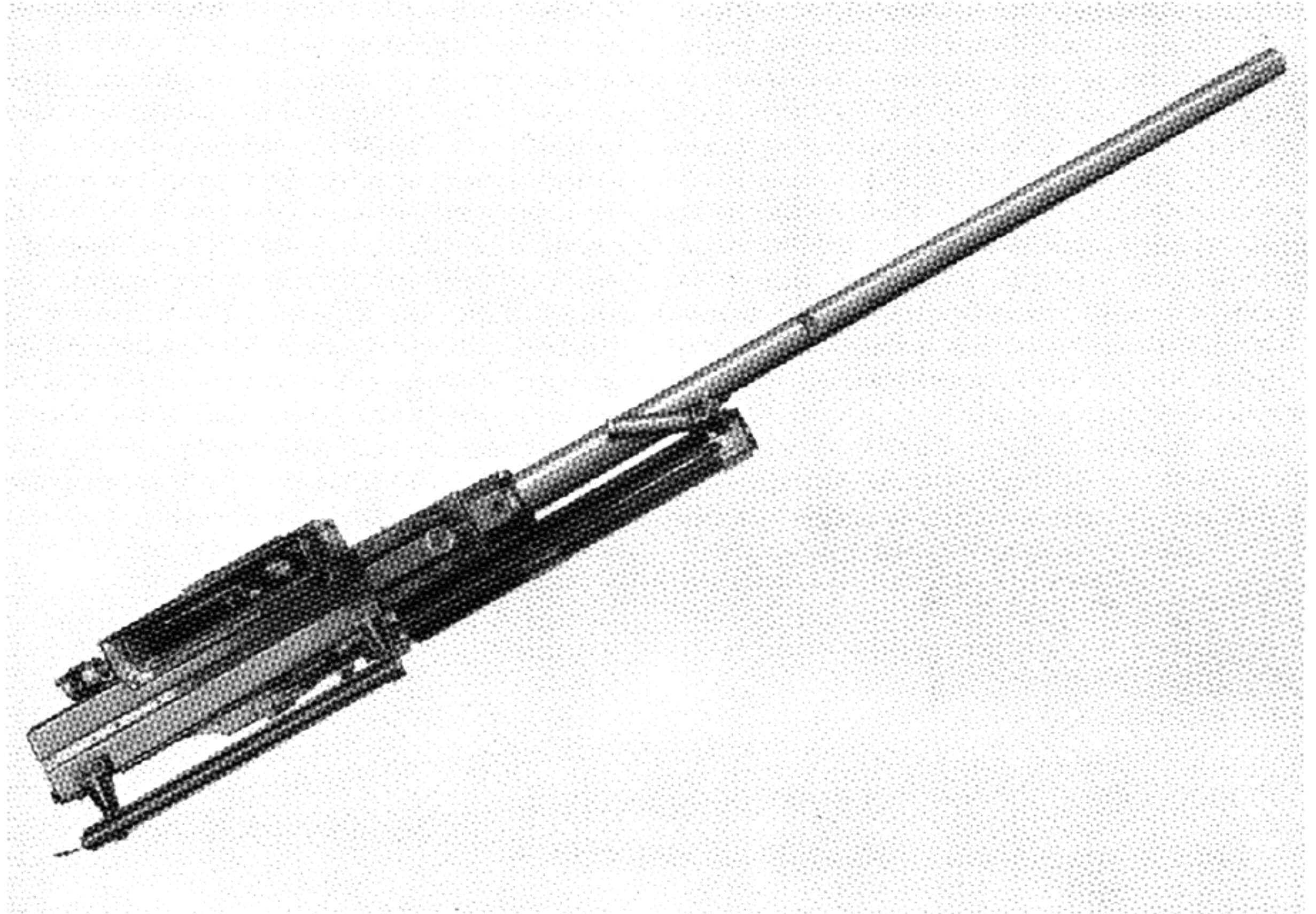


Figure 1-43. 37-mm Browning Gun T20E2. Right side view.

Gun, Automatic 37-mm T37. Designed by the United Shoe Machinery Corp. It includes a recoil operated integral feed, an integral charger and electric ignition. The first pilot model of this weapon was completed in November 1945. The first test resulted in several broken parts. This gun will be used to gain information for a complete redesign of a 37-mm weapon. This gun operates on the German Mauser principle. The receiver of the gun has two rails with two cam paths, one for ejecting the extracted cartridge case, and the other for guiding the round into the chamber. The gun is designed for electrically fired ammunition. The breech end of the tube has gear teeth machined on the top surface that operate the feed mechanism. A sprag type clutch is used to transmit the energy from the recoiling tube to the feed mechanism. The rotating bolthead is tied to the bolt body through a helical spline. There is no provision for

buffing the picking up of the bolthead by the bolt body during the recoil stroke. The bolthead changes from a rotational velocity to a translational velocity in a very small interval of time on the recoil stroke and from previous experience with the cal. .60 Mauser action gun, which has a buffer between the boltbody and bolthead, it is believed excessive forces due to high accelerations will result in short life and breakage of parts. There are four sets of interrupted locking lugs on the bolthead and upon examination of the detail drawing for the bolthead, it is noticed that the internal spline removed a large portion of the metal locking lugs. Failures of the metal supporting the locking lugs of the caliber .60 boltheads, proved the necessity for supporting the locking lugs with sufficient metal. A very ingenious mechanical buffer has been developed for buffering the bolt as it comes into battery on the counterrecoil stroke. Energy is absorbed by vi-

brating a mass of steel between two saw-tooth surfaces. It is claimed that this mechanical buffer will change the velocity of the bolt from about 25 feet per second to about 6 feet per second. The gun will be started in motion by use of a cartridge charger. The bolt buffer consists of a series of helical compression springs distributed around the periphery of a cup enclosing the boltbody thus minimizing the length of the receiver. The parts of this gun were completed except for the final machining of the bolthead and boltbody and it was stated that the gun would be assembled at the earliest practicable date.

Gun, Automatic, 37-mm T37E1. The records do not indicate the history of the T37E1. The T37E1 gun changes the T37 from a gas-operated

light reciprocating bolt and recoiling barrel, should make a very high cyclic rate gun. A unique design of ammunition loading, accomplished during counterrecoil of the barrel, had not been completed because of the difficulty in designing a satisfactory means of diverting power from the recoil barrel to the ammunition carrier, which must travel at slightly greater than twice the barrel speed. Design was still at the rough layout stage when canceled.

Gun, Automatic, 37-mm T46. Developed by Production Methods, Inc. The preliminary designs utilized several features common to guns of the Solothurn type and in their existing form showed considerable promise. No guns were ever made.

Gun, Automatic, 37-mm T49. High cyclic rate automatic aircraft gun firing new high-velocity am-

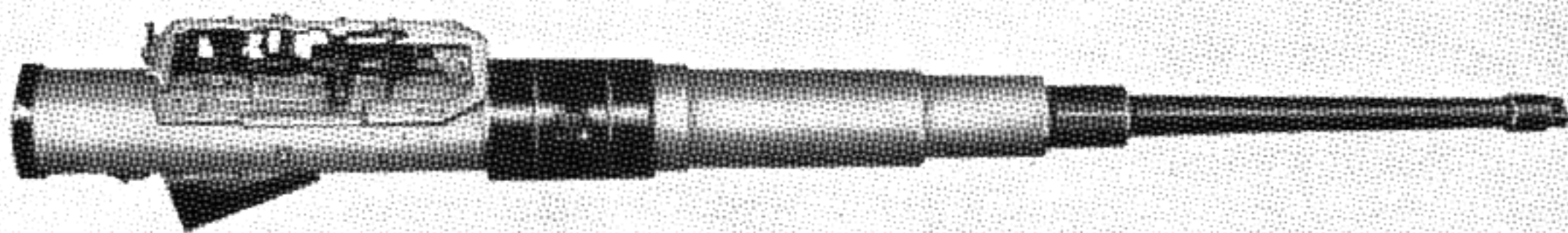


Figure 1-44. Gun, Automatic, 37-mm T37E1.

to a recoil-operated gun. Rollers operating in a stationary cam path induce rotary motion to a cylinder which in turn transmits lateral motion to the bolt operating slides through helical splines machined in the inside of the cylinder and the outside of the two slides. A hydraulic bolt operating system which operates from the hydraulic pressure obtained from the recoil cylinder was designed but not built.

Gun, Automatic, 37-mm T44. Developed by the Colt Co. to satisfy the same requirement as the T37. The records indicate that no gun was ever constructed to this design.

Gun, Automatic, 37-mm T45. This was an unconventional design by the Bartelt Engineering Co. It used a hinge-type sliding shutter to replace the conventional breechblock. This, combined with a

munition, with the matched projectiles. Developed by Bartelt Engineering Co., Rockford, Ill. This was a modification of the Hispano-Suiza 20-mm gun M2 with a forward firing bolt. An integral recoil feed mechanism was under construction according to this design.

Gun, Automatic, 37-mm T172. Believed intended for radar jamming by firing shells loaded with tinfoil strips.

Gun, Automatic, 37-mm M1. A 3,000-feet-per-second antiaircraft gun designed by Browning. It was tested at Aberdeen Proving Ground on 23 June 1925 and was considered a success, although it gave some trouble: the muzzle end of the barrel, beyond the water jacket, was too thin and overheated badly; there were numerous stoppages resulting from failure to eject the empty cartridge cases. After fur-

ther experimenting by Colt (Mr. Browning had died in 1926) a second pilot was built and then standardized as the Browning 37-mm automatic antiaircraft gun, M1, in May, 1927.

Gun, Automatic, 37-mm M1E1. In 1937 the M1 guns were modified and improved and redesignated M1E1.

Gun, Automatic, 37-mm M1A1. In October 1938 the gun was standardized as the M1A1 but without water jacket. In addition to improvements in the functioning of the mechanism, there was another change in the gun: the velocity was dropped from the hoped-for-but-not obtained 3,000 feet per second to the more realistic 2,800 feet per second. This reduction also cut down erosion.

Gun, Automatic, 37-mm M1A2. The accuracy of the M1 had always been unsatisfactory and investigation showed that the projectile was unstable in flight. In 1939 an increase was made in the twist of the rifling from 1 turn in 35 to 1 in 30 calibers. The modified gun was designated the M1A2. A year later, a final change was made in the characteristics of the gun—the muzzle velocity was reduced again, to 2,600 feet per second.

Gun, Automatic, 37-mm M1A2E1. The 37-mm gun M1A2 was tested at high altitudes to determine whether it would be satisfactory as an aircraft gun. As results of the tests were favorable, in May 1942

the Army Air Corps initiated a project to mount it in the nose of the A-20A airplane, requesting that an endless articulated belt magazine be furnished with the gun. Designed for this installation, the 37-mm endless belt magazine T9 was similar to the M6 magazine on the 37-mm gun M4 on the P-39 plane, except that the thrust of the loaded belt on the short turns was taken on wheels instead of on the magazine trackway. To accommodate the magazine T9, the M1A2 gun was modified with a loading handle and a lock frame embodying a carrier lifter cam, and designated 37-mm Automatic Gun M1A2E1. It was subsequently discovered, from extensive firing tests in a "bathtub" installation projecting below the bomb bay, that the blast from the two guns was so severe that the lower part of the fuselage was damaged, particularly in the area around the hatch for the front landing wheel. Since this condition could only be overcome by extensive reinforcement of the structure, it was decided to use the T20E1 gun and not the M1A2E1. As the T20E1 gun used a disintegrating link belt type feed, the requirement for the T9 magazine no longer existed. Therefore, although the 37-mm endless belt magazine T9 functioned satisfactorily, its development was cancelled in October 1943.

Gun, Automatic, 37-mm M4. The modifications made on the T9 model to produce the M4 effected

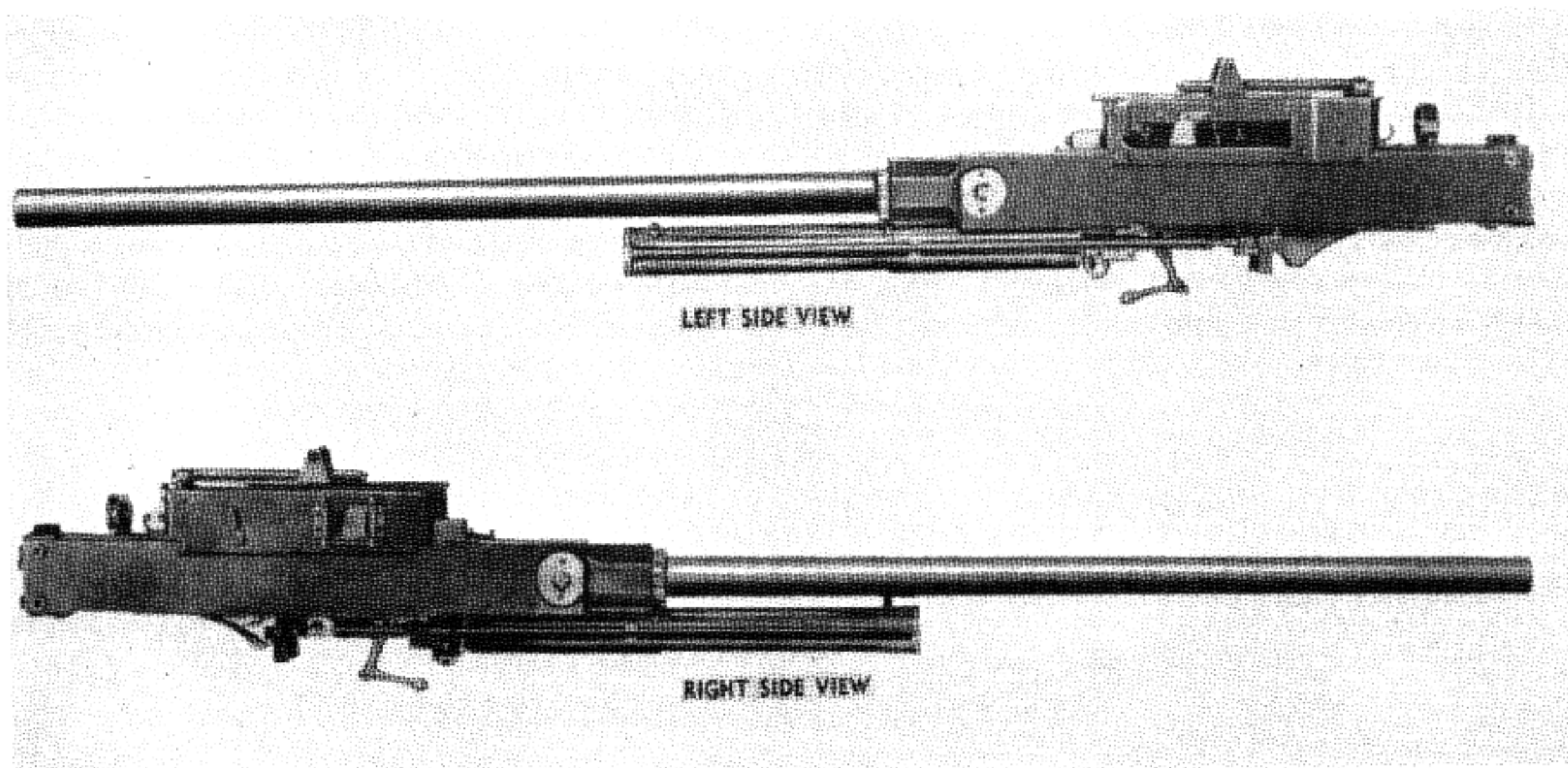


Figure 1-45. Gun, Automatic, 37-mm M4.

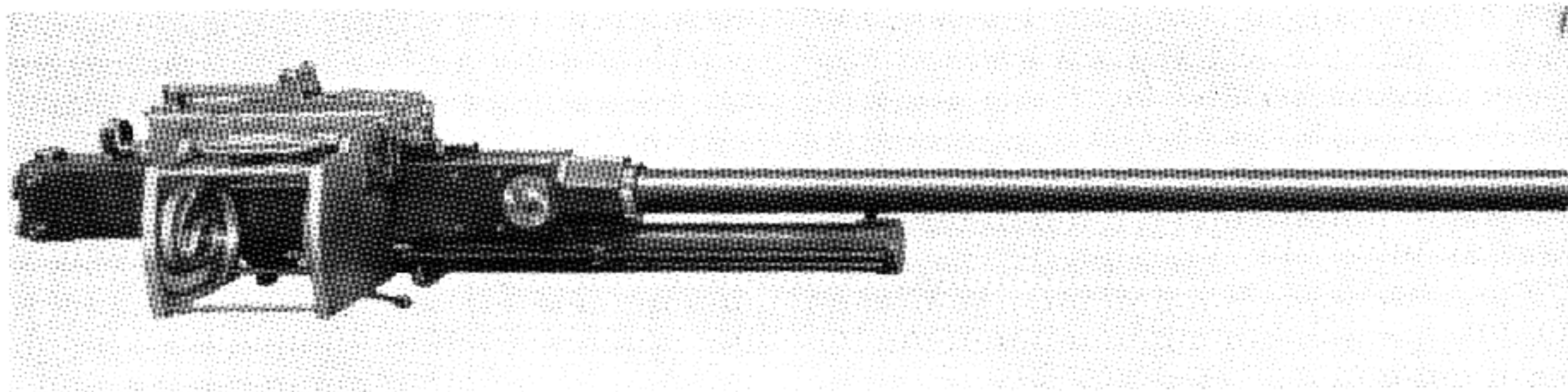


Figure 1-46. 37-mm Browning Gun M4E1. Right side view.

a number of important improvements. The backplate of the M4 was reinforced and the buffer on the backplate assembly was changed; the recuperator bushing ports of the recuperator cylinder were enlarged to increase the rate of fire; a stronger carrier catch spring enabled the carrier catch to return faster to its normal position; the trigger extension mechanism on the T9 lock frame was placed on the tube extension of the M4; and helical springs on the buffer of the M4 replaced the Belleville springs of the T9.

Gun, Automatic, 37-mm M4E1. In 1941 the Army Air Corps, in order to increase the armament of certain planes, established requirements for planes with wing-mounted 37-mm automatic guns fed from the fuselage. This requirement made it necessary to develop a gun with right-hand feed to pair with the left-hand feed of the 37-mm automatic gun M4. To supply this need the M4 gun was modified to feed from the right and was designated 37-mm automatic gun M4E1.

Gun, Automatic, 37-mm M4E2. The M4E2 gun had a modified feedbox and tube extension; the left-side plate was slotted to receive the feed assembly lever when the gun was fed from the right

side. The M4E2 gun was changed from a right- to a left-hand feed by shifting the following parts of the feedbox mechanisms. The feed slide lever was taken from the right bracket, turned upside down, and placed in the left bracket; the feed crank was rotated 180° so that the opposite feed crank stud engaged the slot in the feed slide lever; the feed slide was taken from the right side of the feedbox frame, turned around, and inserted in the left side of the feedbox frame; and the stops in the pawl assembly were turned upside down and interchanged. The complete assembly was shifted to the left.

Gun, Automatic, 37-mm M4E3. This was simply the M4 modified for use with a disintegrating link belt feed mechanism to feed from the left side. The method of feeding was the same as that of the standard feedbox, except in the shape of the parts, and in the operation of the stop and holding pawls. Attached to the forward end of the recuperator was a cylindrical expansion chamber, closed at the top, into which the oil could flow as it expanded. The development of the M4E3 was given a low priority to permit earlier development of the high velocity 37-mm automatic gun with a disintegrating link

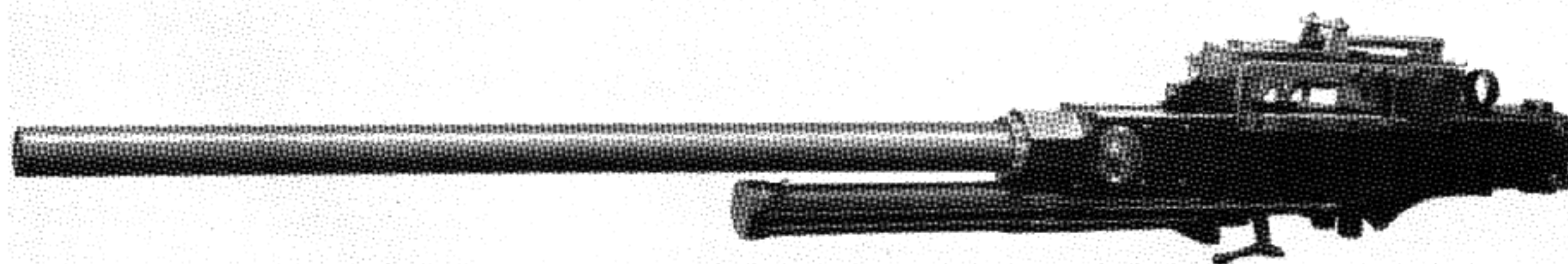


Figure 1-47. 37-mm Browning Gun M4E2 showing the M4 converted to feed from either side.

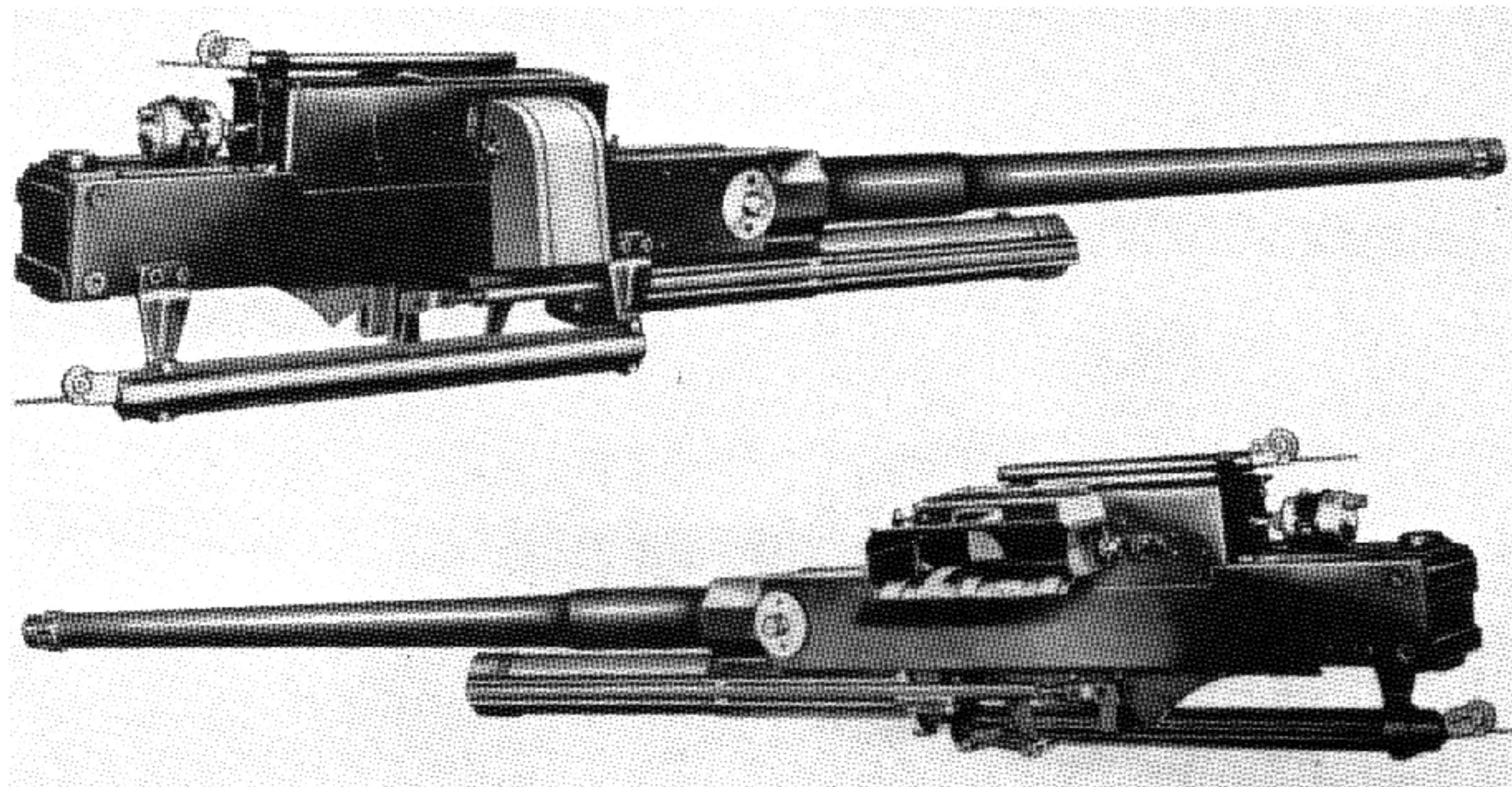


Figure 1-48. 37-mm Automatic Gun M4E3.

belt feed mechanism. As soon as this latter development was completed and the gun standardized as 37-mm automatic gun M9, the development of 37-mm automatic gun M4E3 was assigned higher priority because of the increasing difficulty in providing endless belt feed mechanisms for the M4 gun.

Gun, Automatic, 37-mm M4E4. Similar to the M4E3 except that it incorporated a right-hand feed.

Gun, Automatic, 37-mm M9. After tests of the T20E1 gun at Aberdeen Proving Ground and at Eglin Field, Fla., recommendations resulted in minor modifications to improve the functioning of the gun for use in aircraft. It was approved in January 1943 for standardization as a 37-mm gun M9. The 37-mm automatic gun M9 was basically the same as the 37-mm antiaircraft gun M1A2 in general appearance and functioning. The chief differences in the appearance of the two guns were in the shape of the recuperator expansion tube socket and the position of the recuperator expansion tube. The M9 gun socket was built with a filler screw and bracket on each side, while the gun socket of the M1A2 gun had a single filler screw and bracket on the right side only. In the M9 gun the expansion tube was placed to the rear of the socket and extended upward at an angle. In the M1A2 gun the

expansion tube was in front of the socket and parallel with the gun tube. Unlike that of the M1A2 gun, the M9 gun tube had splines machined at its muzzle end. The flats machined at approximately the middle of the M1A2 gun tube for application of the tube wrench were not incorporated in the M9 gun tube. The cartridge tray for the M1A2 gun feedbox was not used with the M9 gun, as the M9 gun used an inlet feed chute and a link ejection chute attached to the feedbox by eyebolts and wing nuts. The lower end of the operating lever on the M9 gun had a round hole to admit a charging pin, while the M1A2 gun's operating lever had a triangular hole to permit use of a priming rod. A sighting slot was incorporated in the trunnion block of the M9 gun, near the tube lock depressor, but the M1A2 gun had no such slot.

Gun, Automatic, 37-mm M9E1. In November 1943 the Army Air Corps requested the Ordnance Department to modify a 37-mm M9 gun so that it could be installed in the P-63 fighter plane. The following January a project was authorized for this purpose with the designation 37-mm automatic gun M9E1. The requirements outlined by the Army Air Corps called for reduction of the tube diameter and modifications of related parts to allow

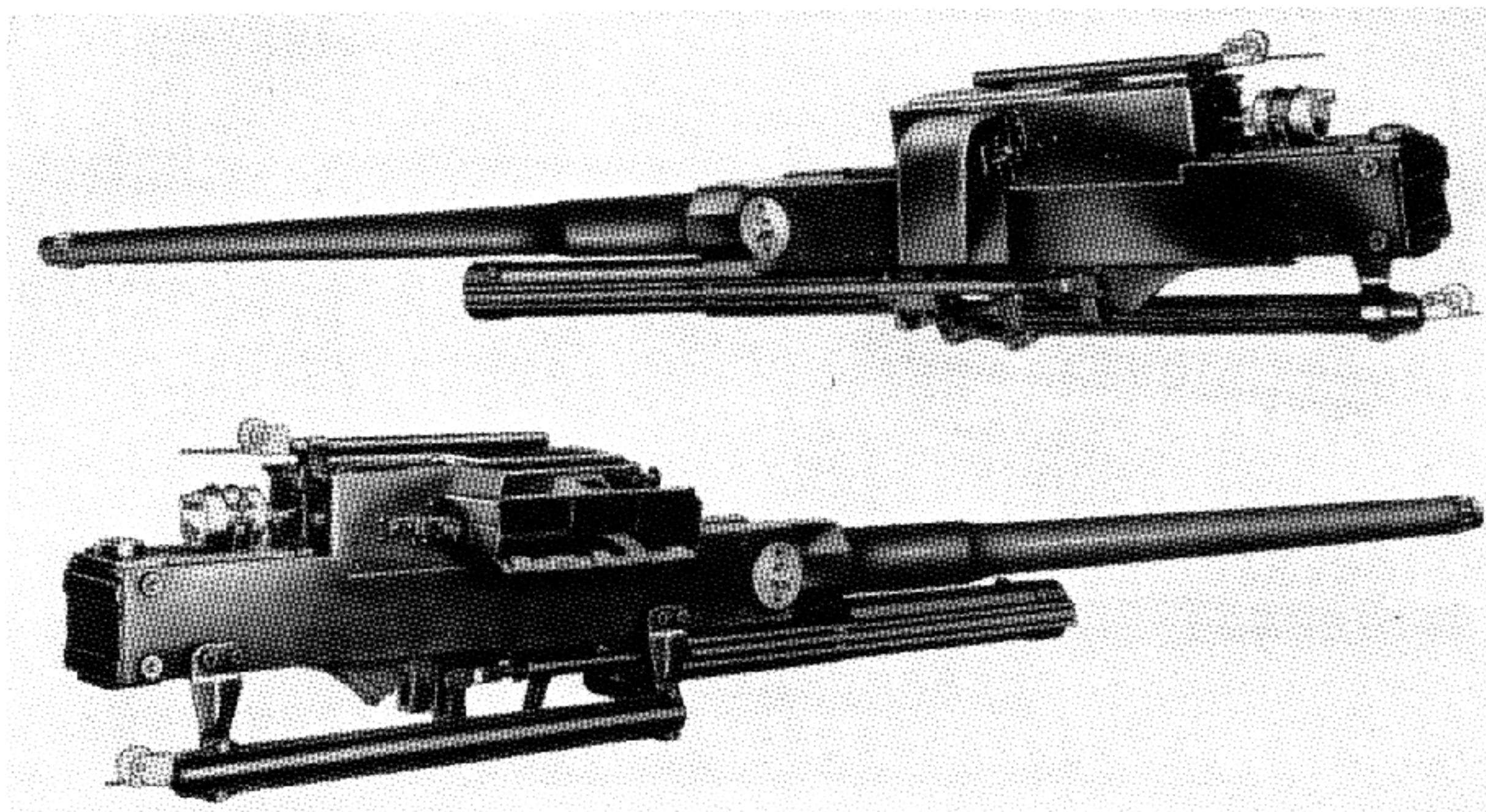


Figure 1-49. 37-mm Automatic Gun M4E4 with right-hand feed box assembly.

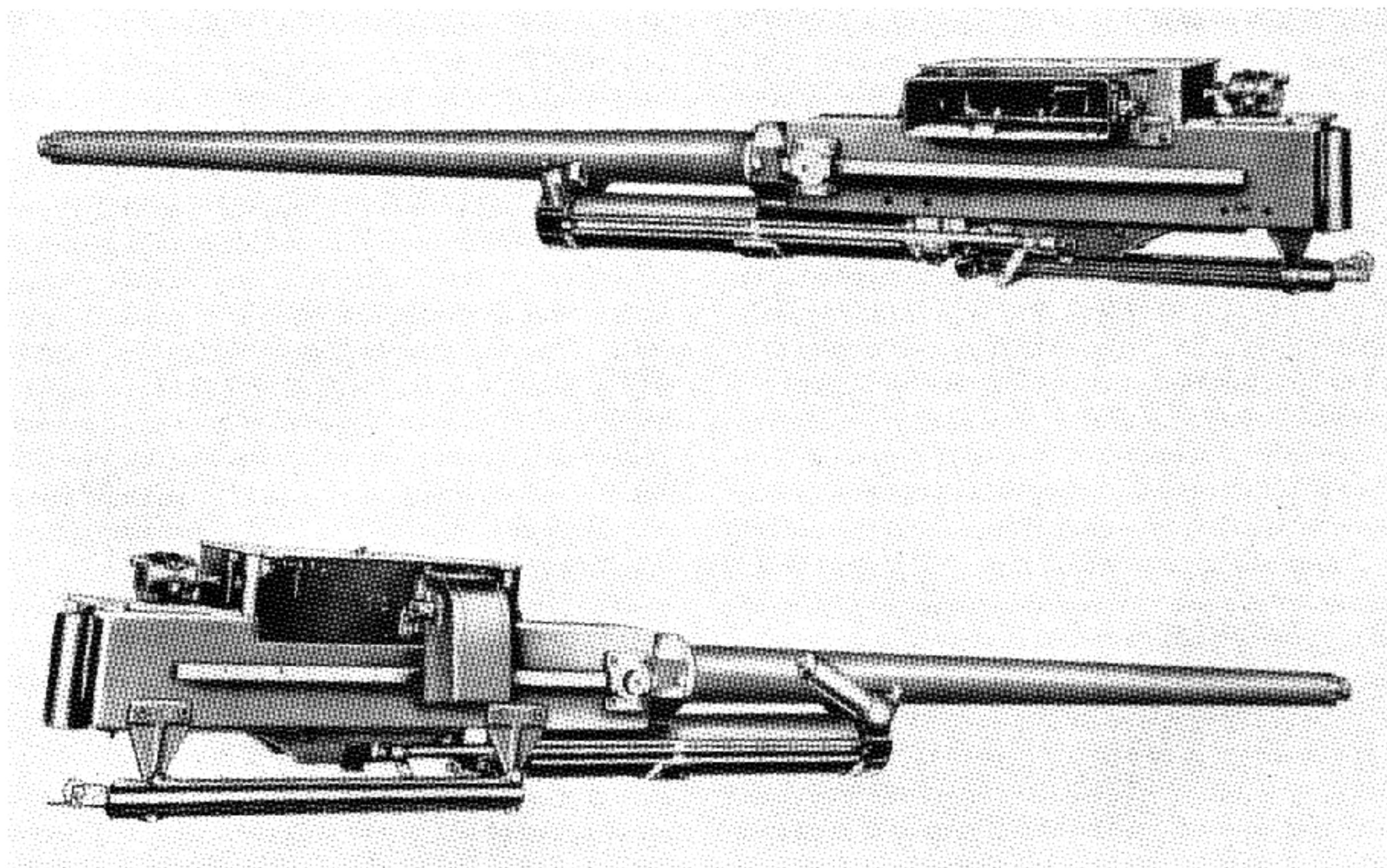


Figure 1-50. Gun, Automatic, 37-mm M9, with parts positioned for left-hand feeding.

removal of the gun through the propeller hub. Weight added at the tapered section in front of the bearing allowed a reduced section near the muzzle for freedom of movement in bore sighting.

Gun, Automatic, 37-mm M9A1. Firing tests of M9E1 models conducted at Aberdeen indicated that the operation of the gun was completely satisfactory. An HE shell was detonated in one M9E1 tube to determine the characteristics of the tube and material. Results of this test were also completely satisfactory and indicated that the tube was sufficiently strong to withstand any firing that would be encountered in service. In September 1944 the M9E1 gun was standardized as 37-mm automatic gun AN-M9A1.

Gun, Automatic, 37-mm M9A1E1. This was a project to utilize M9 tubes to supplement production of M9A1 guns.

Gun, Automatic, 37-mm M10. The Army Air Corps, which was kept fully informed of the progress of Ordnance development of the 37-mm automatic guns M4E3 and M4E4, at this juncture directed that the M4E4 be placed in the P-63 fighter plane. This action was taken because the M4E4 fired 25 to 30 shots faster and had double the ammunition capacity of the 37-mm automatic gun M4. However, the M4E3 and M4E4 were not yet ready for standardization, since minor modifications to the feedbox were necessary and the gun had not been service tested.

It was expected that the first 400 guns would differ from the standard gun in minor details: therefore they would require modification at a later

date. It was also expected that by December 1943, when the first 400 guns would be completed, all modifications would have been approved and standard drawings would be available according to which the remaining guns of the initial procurement could be produced. Consequently, in August 1943, the procurement of the M4E3 gun was increased to 2,500. By March 1944, all ground tests and aerial tests of the modified gun had been satisfactorily performed, and 37-mm automatic gun M4E3 and 37-mm automatic gun M4E4 were standardized as 37-mm automatic gun M10, with separate stock numbers issued for right and left side feed.

37-mm Automatic Guns with Mark and Mod Numbers

37-mm Automatic Gun Mk 1 Mod 0. This is the Army 37-mm M9 left-hand feed for wet use as the submarine antiaircraft gun.

37-mm Automatic Gun Mk 2 Mod 0. This is the Army 37-mm M9 right-hand feed for wet use as the submarine antiaircraft gun.

37-mm Automatic Gun Mk 3 Mod 0. This is the Army's 37-mm antiaircraft gun M1A2 for wet use.

40-mm Automatic Guns with T and M Numbers

Gun, Automatic, 40-mm T1. The Ordnance Committee had, on 6 February 1941, expressed its approval of the Bofors light antiaircraft gun. Manufacturing rights were to be sought, drawings were to be prepared, components and major assemblies

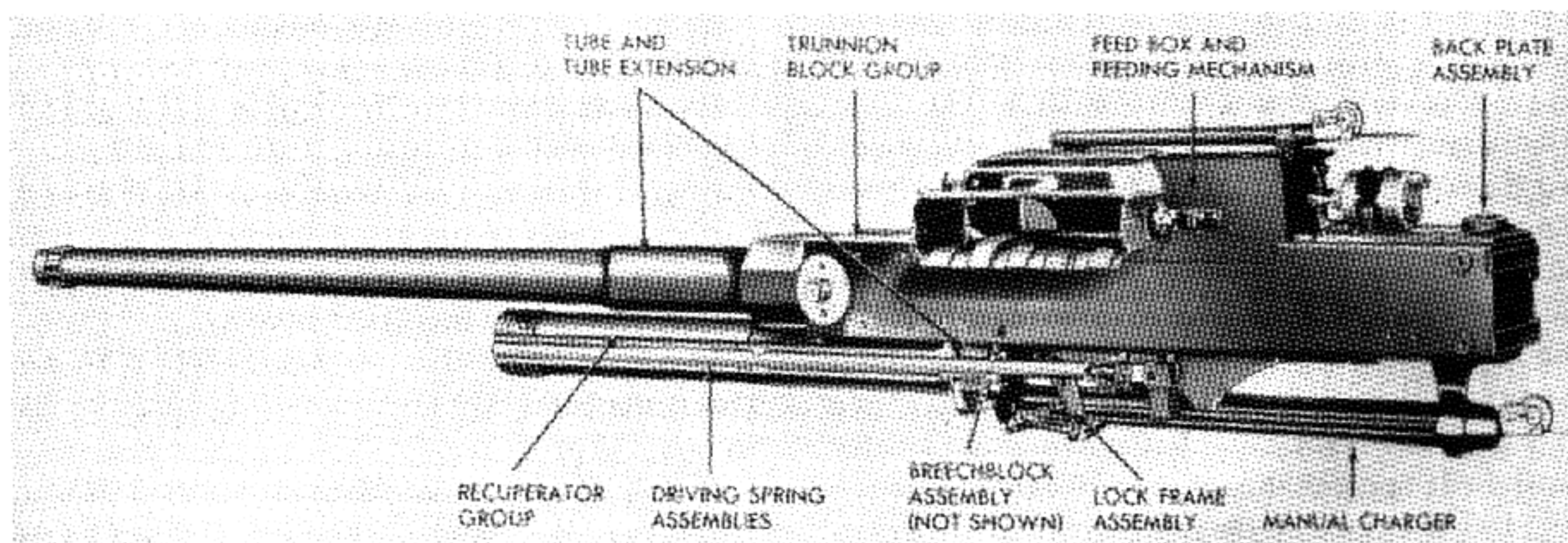


Figure 1-51. 37-mm Gun M10, left-hand feed.

were to be interchangeable as between British and United States Army Ordnance-made units, 2 complete pilot units were to be manufactured, 2 guns and carriages with 2 spare barrels and all equipment were to be procured from the British.

Gun, Automatic, 40-mm T2. Right-hand loader for twin 40-mm gun mount. This material is standardized with T3 without modification as Gun, Dual Automatic, 40-mm, M2.

Gun, Automatic, 40-mm T3. Left-hand loader for twin 40-mm gun mount. This material standardized with T2 without modification as Gun, Dual Automatic, 40-mm, M2.

Gun, Automatic, 40-mm T4. Standard M1 gun modified for use with two caliber .50 machine guns and computing sights on combination gun mount. Requires drilling of special holes and machining of bases on sideplate.

Gun, Automatic, 40-mm M1. Standardization of the T1.

Gun, Automatic, 40-mm M1A1. Modification of M1 for application of certain computing sights.

Gun, Automatic, 40-mm M1E1. Left-hand twist, increasing 1 turn in 45 calibers at breech to 1 turn in 30 calibers at muzzle.

Gun, Automatic, 40-mm M1E2. Never beyond blueprint stage.

Gun, Dual Automatic, 40-mm M2. To adapt the 40-mm gun M1 to twin mounting, a new gun mount, T12, was developed. This consisted of a left-hand gun T3 and a right-hand gun T2. T3 is essentially a standard 40-mm gun M1 slightly modified so the extractor lever could be installed on the bottom side of the gun. The extractor spindle was modified so as to permit installation from the left side. The right gun, T2, is similar to the Navy 40-mm gun, right hand. It differs from the standard 40-mm gun, M1 in the following respects: It has right-hand feed features; its hand-operating lever is on the right side; the firing mechanism is on the right side of the inner breech casing; right-hand frame of the top carriage is modified; the extractor lever is on the bottom of the gun; the breech closing spring and the outer crankshaft closing spring are located on the side opposite that of the M1 gun; the breech ring lock is located on the right side; and the elevating scale is on the right side.

40-mm Machine Guns with Mark and Mod Numbers

40-mm Machine Gun Mechanism Mk 1 Mod 0. The design of these mechanisms and barrels is essentially that of the Swedish Bofors 40-mm antiaircraft gun. The design provides for a rapid fire, recoil operated, automatic mechanism, with a maximum cyclic rate of approximately 160 rounds per minute. The Mk 1 Mod 0 is a left-hand mechanism manufactured by York and is water cooled.

40-mm Gun Mechanism Mk 1 Mod 1. Left-hand mechanism manufactured by Chrysler.

40-mm Gun Mechanism Mk 1 Mod 2. This is a Mk 1 Mod 0 with feed improvements.

40-mm Machine Gun Mechanism Mk 1 Mod 3. This is a Mk 1 Mod 0 with feed improvements.

40-mm Machine Gun Mechanism Mk 1 Mod 4. This is the Mk 1 Mod 0 with additional modifications.

40-mm Machine Gun Mechanism Mk 1 Mod 5. This is the Mk 1 Mod 1 with further changes.

40-mm Machine Gun Mechanism Mk 1 Mod 6. Modifications of the Mk 1 Mod 0.

40-mm Machine Gun Mechanism Mk 1 Mod 7. Modifications of the Mk 1 Mod 1.

40-mm Machine Gun Mechanism Mk 2 Mod 0. Right-hand mechanism built by York.

40-mm Machine Gun Mechanism Mk 2 Mod 1. Right-hand mechanism built by Chrysler.

40-mm Machine Gun Mechanism Mk 2 Mod 2. Mk 2 Mod 0 with improved feed.

40-mm Machine Gun Mechanism Mk 2 Mod 3. Mk 2 Mod 1 with improved feed.

40-mm Machine Gun Mechanism Mk 2 Mod 4. Additional modifications of the Mk 2 Mod 0.

40-mm Machine Gun Mechanism Mk 2 Mod 5. Additional modifications to the Mk 2 Mod 1.

40-mm Machine Gun Mechanism Mk 2 Mod 6. Further changes to the Mk 2 Mod 0.

40-mm Machine Gun Mechanism Mk 2 Mod 7. Further changes to the Mk 2 Mod 1.

40-mm Machine Gun Mechanism Mk 3 Mod 0. This is the Mk 1 Mod 0 with feed modified by the Shirgun Corp.

40-mm Machine Gun Mechanism Mk 3 Mod 1. This is the Mk 1 Mod 1 with feed modified by the Shirgun Corp.

40-mm Machine Gun Mechanism Mk 4 Mod 0. This is the Mk 2 Mod 0 with feed modified by the Shirgun Corp.

40-mm Machine Gun Mechanism Mk 4 Mod 1. This is the Mk 2 Mod 1 with feed modified by Shirgun Corp.

40-mm Machine Gun Mechanism Mk 5 Mod 0. The 40-mm single-gun mechanism M1 installed on mounts M3 for Navy use was procured for the War Department from Chrysler Corp. Slight modifications, such as difference in paint and buffer fluid were made to the mechanism M1 to adapt it to Navy use. The arrangement required that the Navy procure mechanism M1 for the War Department, deliver them to Army activities for single-mount assembly. During the period of production of 40-mm single mounts M3 and guns M1, numerous Ordalts were prepared by the Naval Gun Factory to better adapt the equipment to Navy use. The major portion of these Ordalts was incorporated into production of the equipment. Close liaison was maintained between the design sections of the Gun Factory and the War Department and Army drawings were modified as necessary to cover changes in design requested by the Navy. Even though the drawings and specifications for the manufacture of this equipment were exclusively under control of the Army, the Navy was able to modify the equipment in production as desired. The Army Transportation Corps had a few requirements for the mount M3 for transport vessels. However, it ac-

cepted the assembly with all Navy modifications and spare parts sets. Modifications to the mechanism finally required that it be given a new designation. This was done in March 1945 and the designation was changed from M1 to Mk 5 Mod 0. By letter of 29 November 1944 the War Department was requested to change the designation of the mount stand to Mk 3 Mod 1. In reply dated 30 April 1945 the War Department advised that it could not comply in that the stand was classified as Army standard material and model numbers are not assigned to Army gun mount subassemblies. Therefore, the mount is still designated as 40-mm mount M3.

40-mm Machine Gun Mechanism Mk 5 Mod 1. This is a modification in the sight adapter.

40-mm Machine Gun Mechanism Mk 5 Mod 2. Modification for wet use in a submarine.

40-mm Machine Gun Mechanism Mk 5 Mod 3. Additional slight changes.

40-mm Machine Gun Mechanism Mk 5 Mod 4. Another slight variation.

40-mm Machine Gun Mechanism Mk 6. Mk 6 was never assigned.

40-mm Machine Gun Mechanism Mk 7 Mod 0. Mk 1 Mod 0 modified to air cooled by Shirgun.

40-mm Machine Gun Mechanism Mk 8 Mod 0. Mk 2 Mod 1 modified to air cooled by Shirgun.

57-mm Automatic Guns

Gun, Automatic, 57-mm T78. Design copied directly from the German MK 112.

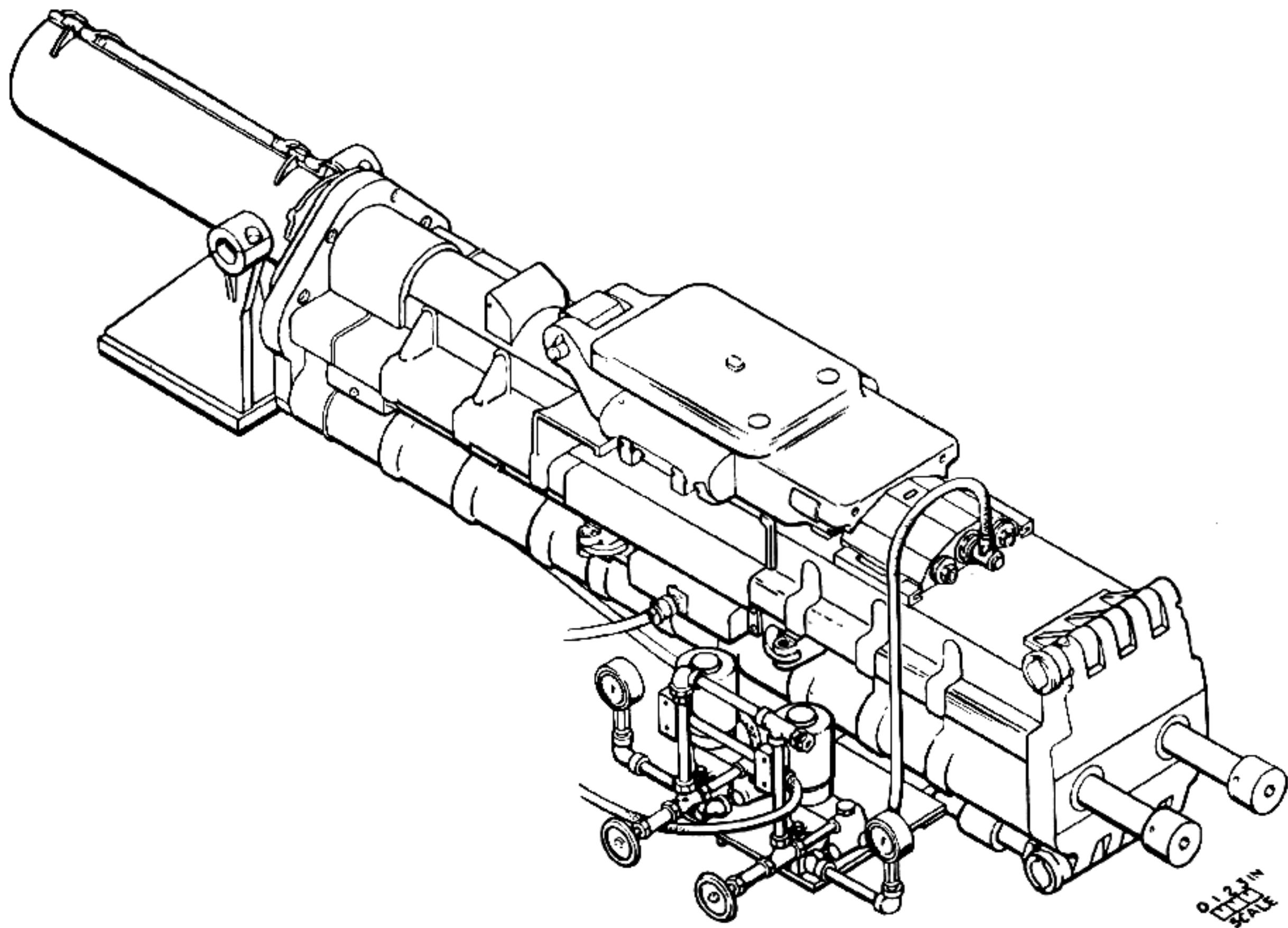


Figure 1-52. Gun, Automatic, 57-mm T78. This weapon is a conversion of the German MK-112.

Chapter 2

ORDNANCE CORPS GAS-OPERATED REVOLVER CANNON

SECTION 1. HISTORY AND BACKGROUND

The Ordnance Corps has originated a group of gas-operated revolver cannons using a mechanism based on a captured German revolver cannon known officially as the Mauser MG-213. The accompanying table includes an identification of the weapons that used this type of mechanism.

An MG-213 No. V6/10 was brought to the United States in a badly burned condition in 1945 and was restored to operating condition by the

United States Naval Gun Factory. American-made ammunition was used for a series of tests. Evidence indicates that the British obtained a specimen of the MG-213 earlier than 1945 and shipped it secretly to England.

The revolver principle had been employed in cannon such as the De Brame as long ago as the American Civil War, but the Germans were the first to build a type in which the drum is reloaded

MG-213 Revolver Type Guns

Designation	Developed by	Description
MG-213.....	Mauser.....	Automatic, revolver type, high-speed, aircraft machine cannon made in both 20-mm (high velocity) and 30-mm. 20-mm gun No. V6/10, a captured gun, was rebuilt by U. S. Naval Gun Factory.
T74 model A.....	ARF (Armour Research Foundation).	20-mm. Second rebuilding of the captured gun intended to secure information needed for a United States version. Some changes were incorporated. Rebuilding accomplished in 1947.
T74 model B.....	ARF.....	20-mm. Ordnance Corps design based on the captured gun. The barrel position was changed from the top to the bottom of the cylinder.
T74 model C.....	ARF.....	20-mm. Design emphasis was placed on reduction of weight and reduction of overall dimensions to meet limitations specified by the Ordnance Corps. This design was later redesignated T110.
T110.....	ARF.....	This weapon is the T74 model C redesignated in 1948.
T121.....	ARF.....	Designation assigned to 30-mm caliber of this type of gun. In preliminary study phase in 1949.
T130.....	ARF.....	Same mechanism as T110 except chambered for caliber .60 ammunition.
T151.....	ARF.....	Same mechanism as T130 except chambered for 27-mm ammunition.
T160.....	ARF.....	Same mechanism as T130 except chambered for 60/20 small round.
T164.....	ARF.....	Caliber .50 version of the T130 built at Springfield Arsenal.

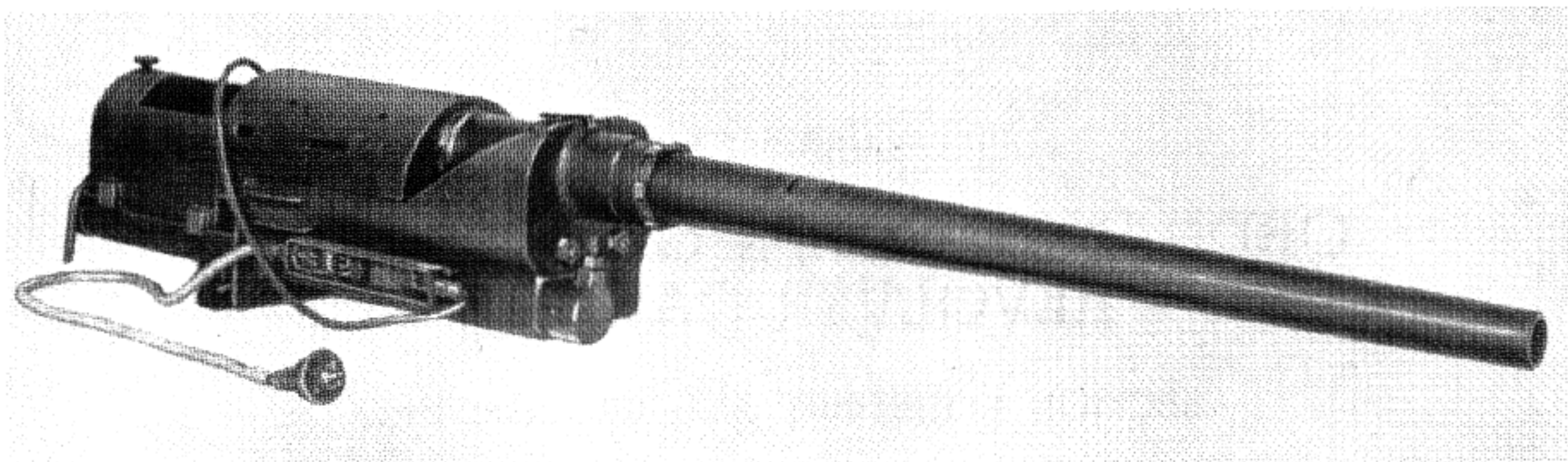


Figure 2-1. German MG-213. Right front view.

during firing. It is curious that the German gun had its barrel near the top, away from the center of gravity, since the barrel of the 1862 American De Brame gun was on the bottom.

Background of the MG-213 in its Various Stages of Development

Late in 1942 the Luftwaffe desperately faced a need for a 20-mm aircraft gun of superior performance. Specifications were issued calling for a gun having a rate of fire of 1,000 rounds per minute with a minimum muzzle velocity of 1,000 meters per second. Since it was obviously impossible to meet such a requirement with the existing types of ammunition, the firm of Hasag was selected to develop the needed round.

It was known that the firm of Heinrich Krieghoff Waffenfabrik in Suhl, Germany, had a very promising gun design under development, but this weapon was not based on the revolver principle. This firm, which before World War II had worked mostly on sporting arms, did not have facilities to push the project to a quick conclusion. The Luftwaffe, therefore, ordered the development, transferred to Waffenfabrik Mauser A. G. The mechanism was improved by the Mauser plant to a point where it gave the required performance, but parts breakages were excessive.

Because of the difficulties with the original weapon, a simultaneous attempt was made to develop another reciprocating action type of gun proposed by a Mr. Linder, one of the Mauser engineers. It was first called the MG-215 but later received other designations; within the company, it was sometimes referred to as the MG-213M. There

were also references to it in German reports calling it the 7-43. When the need for clarifying the designations of the several guns in the series became apparent, this design became standardized as the MG-213B. This designation was retained until work on the model was stopped in favor of the revolver principle. The original designation, MG-215, was eventually assigned to another mechanism which has no relation to the present 213 series.

The gas-operated revolver-type weapon we know today as the MG-213 was the idea of another Mauser engineer, named Politzer, who appears to have been considerably influenced by the feed system of the Russian Shkas gun. The Mauser Co. was so impressed with his idea that it took up the matter with the German High Command and obtained permission to make a prototype. It was originally called MG-216. Subsequently, it became the MG-213C; still later, when converted to 30-mm bore, it was known as the MK-213C.

When it became obvious in early 1945 that it was but a matter of time before Germany collapsed, United States ordnance specialists were sent into the field to find anything of value in experimental weapons that the Germans had under test or in contemplation. After the surrender of Germany, several of the high ranking technicians at the Mauser plant revealed that an intensive program was under way on the MG-213 series of guns.

It was claimed by these technicians that with their latest development 150 rounds could be fired in 1 continuous burst without overheating or undue wear, and that 250 rounds could be expended at a single flight when simulated combat conditions were fol-

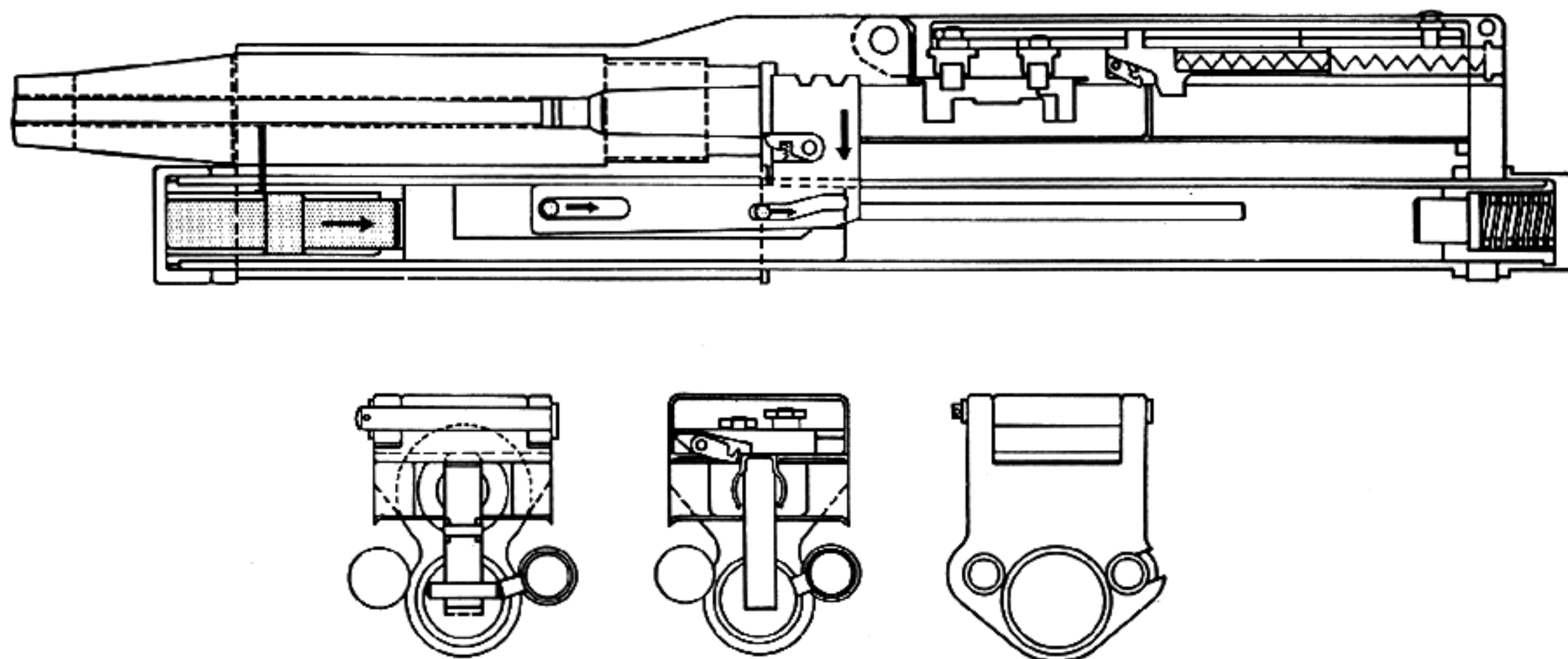


Figure 2-2. German Mauser MG-213B, designed by Linder. Sectional view. The design was also called MG-213M, MG-215, and 7-43. Arrows indicate direction of travel of parts during unlocking.

lowed. Greatly improved barrel life was the result of a special process used in polishing the bore and chamber.

The first successful pilot model of the 20-mm MG-213 was constructed by the Mauser Works as early as 1943. By the time Germany was overrun by the Allies, 5 prototypes of the final design had been fabricated, and 10 more, numbered V6/1 to V6/10, were in various stages of completion. One of the development models, No. V6/10 which had been damaged by fire, was captured at the end of

the war along with some 20-mm ammunition and shipped to the United States.

First ARF Development Program

This captured gun formed the basis for the development program initiated under contract W-11-022 ORD-11053 with Armour Research Foundation (ARF).

The program was conducted in four major phases which overlapped with respect to time, as shown in the accompanying table.

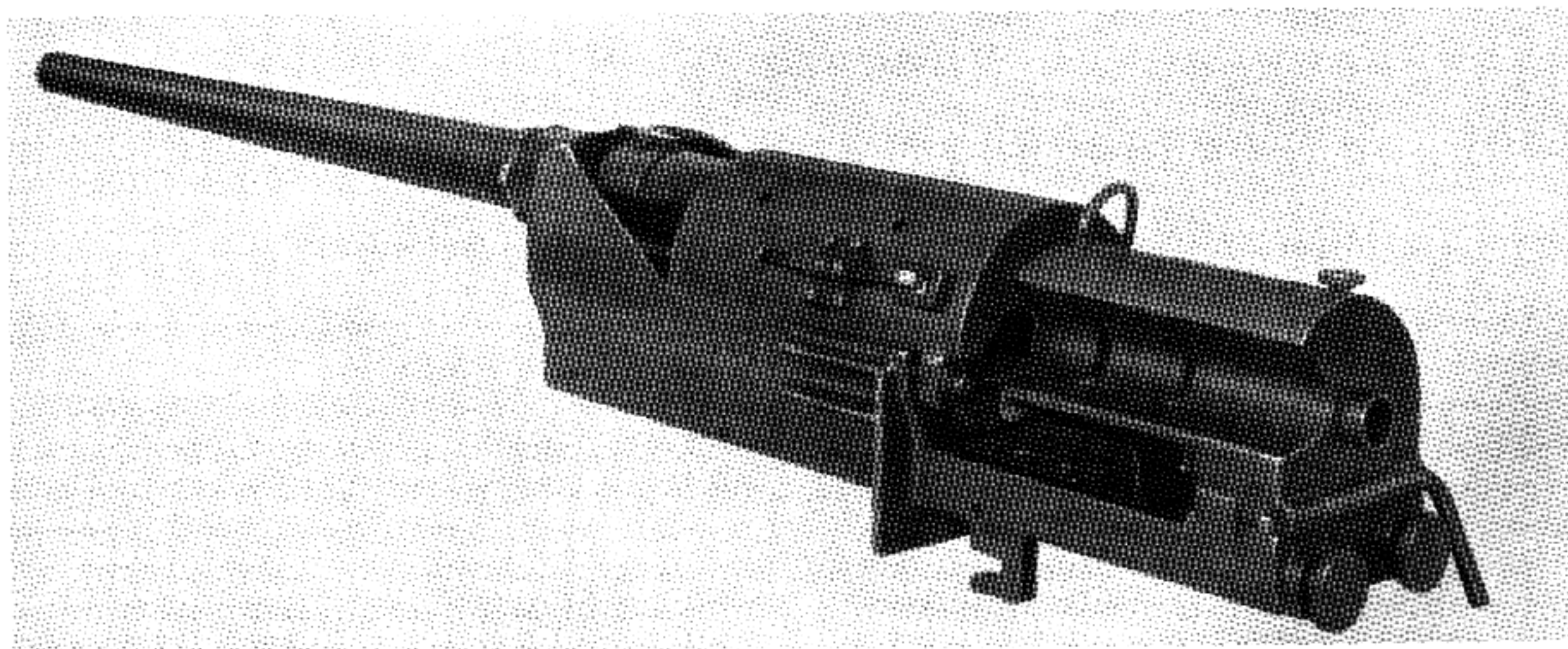


Figure 2-3. German MG-213. Left rear view.

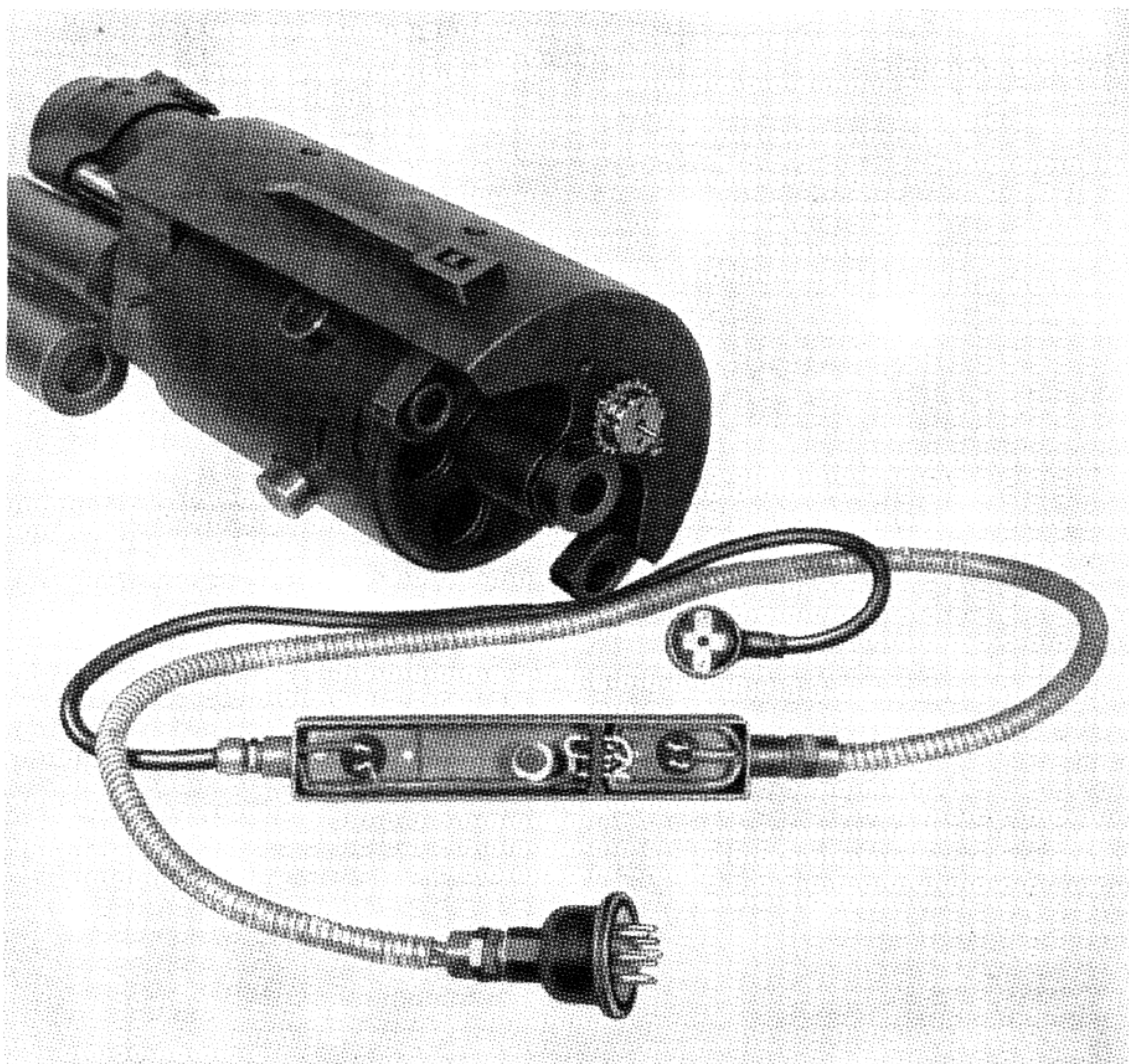


Figure 2-4. Drum, drum housing, and electric trigger connection of the German MG-213.

Under phase 1, the captured German 20-mm automatic gun MG-213 was studied and analyzed to determine the advantages of its design features and principles of operation. The weapon was reconditioned, assembled in its 20-mm form, and fired to obtain preliminary performance data.

Under phase 2, the captured German weapon was reworked and modified to permit more extensive study and analysis of operating principles and design features, and to permit more extensive firing for per-

formance data. This reworked weapon was designated 20-mm T74 Model A.

Under phase 3, a new model was designed and built, duplicating to a large extent the features of the 20-mm automatic gun T74 Model A, and incorporating design improvements based upon the knowledge gained from the studies, analyses, and tests made of this weapon. This second model was designated 20-mm Automatic Gun T74 Model B.

Under phase 4, another new model was designed

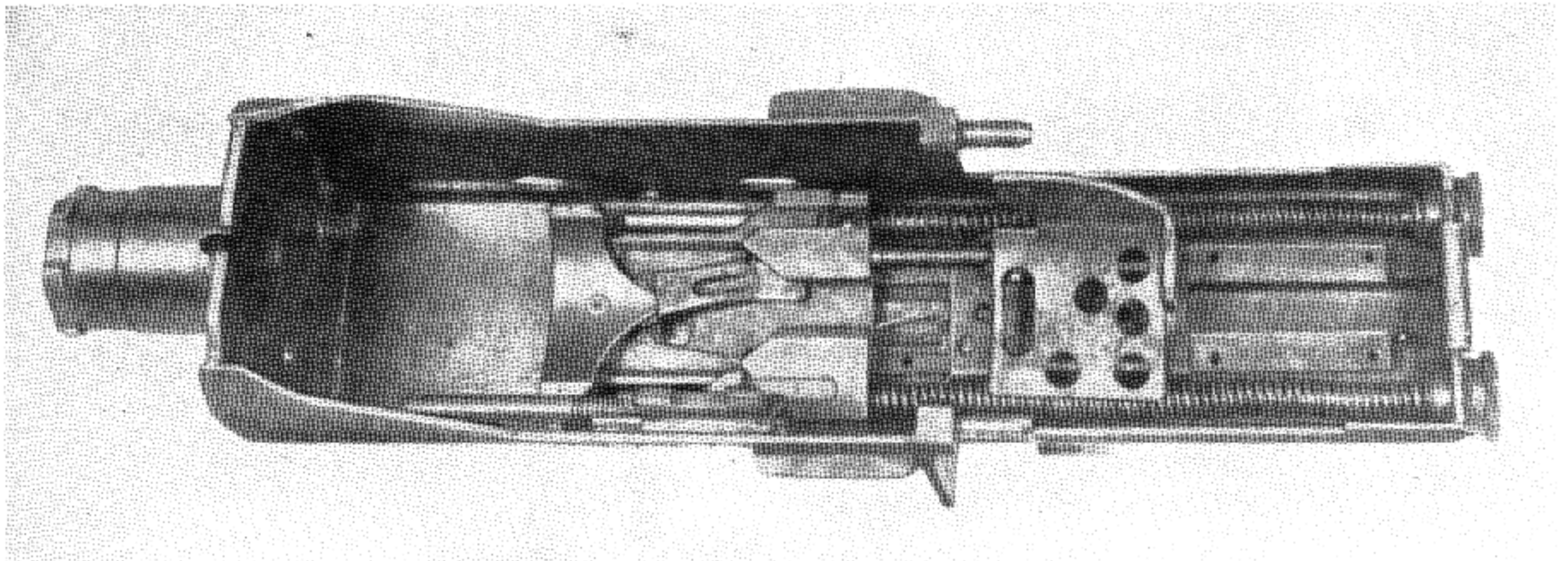


Figure 2-5. Slide, drum revolving mechanism, rammer, and driving spring of the German MG-213.

and built which incorporated major design changes to effect reduction in weight and overall dimensions; to make assembly, disassembly, and servicing easier; and to improve cyclic rate and performance. This model was designated 20-mm Automatic Gun T110.

The difficulties encountered in each model, the design changes made to overcome difficulties in pre-

ceding models, the results of kinematic and stress analyses, and photographs and assembly drawings of each model were studied.

In December 1949, the Ordnance Corps decided to terminate the contract and to continue the development of the 20-mm automatic gun T110 under a new contract with the Armour Research Foundation.

Research and Development Time Schedule for Armour Research Foundation Project

Phase	I	II	III	IV
Gun	MG-213	T74 A	T74 B	T110
Study, analysis, and design.	April 1946 to October 1946.	November 1946 to June 1947.	November 1946 to September 1947.	December 1947 to March 1949.
Manufacture and rework.		January 1947 to September 1947.	November 1947 to May 15, 1948.	October 1948 to July 1949.
Test and modification...	September 1946 to October 1946.	June 14, 1947 to May 1948.	May 15, 1948 to August 1949.	May 15, 1949 to December 1949.

Description of the MG-213

The German gas-operated gun MG-213, upon which the development of all models of the revolver-type of automatic cannon developed by the United States was based, is a gas-operated, belt-fed, electrically fired, pneumatically charged weapon which fires at a rate of approximately 1,200 rounds per minute. By changing certain parts, it may be con-

verted from a 20-mm to a 30-mm weapon; by reversing certain components, it may be changed from left-hand to right-hand feed.

The distinguishing feature of this weapon is its revolving drum containing five cartridge chambers parallel to its axis of rotation and mounted upon a shaft within a housing so that each chamber is brought into alinement with the bore of the barrel

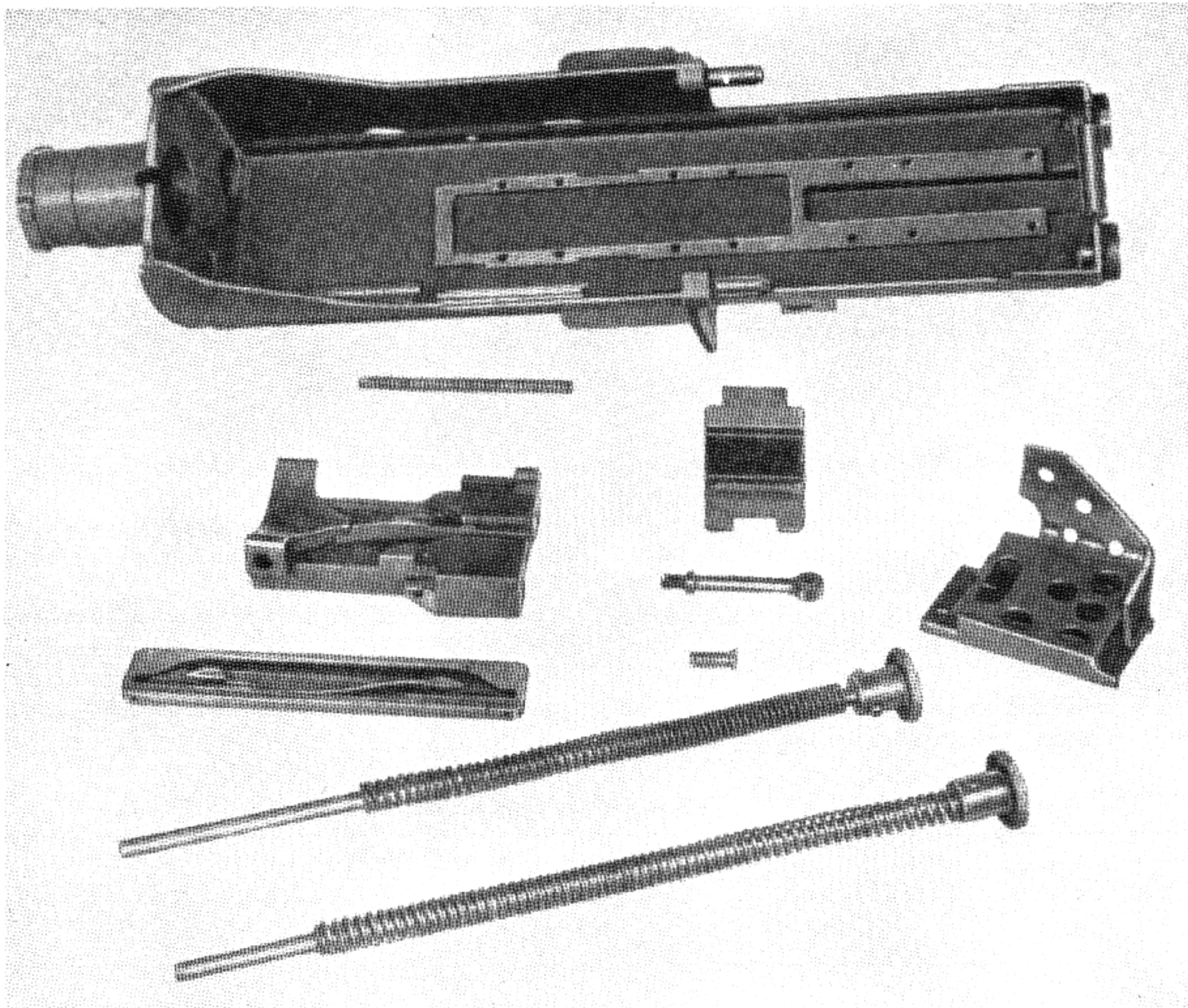


Figure 2-6. Slide, drum revolving mechanism, and rammer of the German MG-213. Disassembled view.

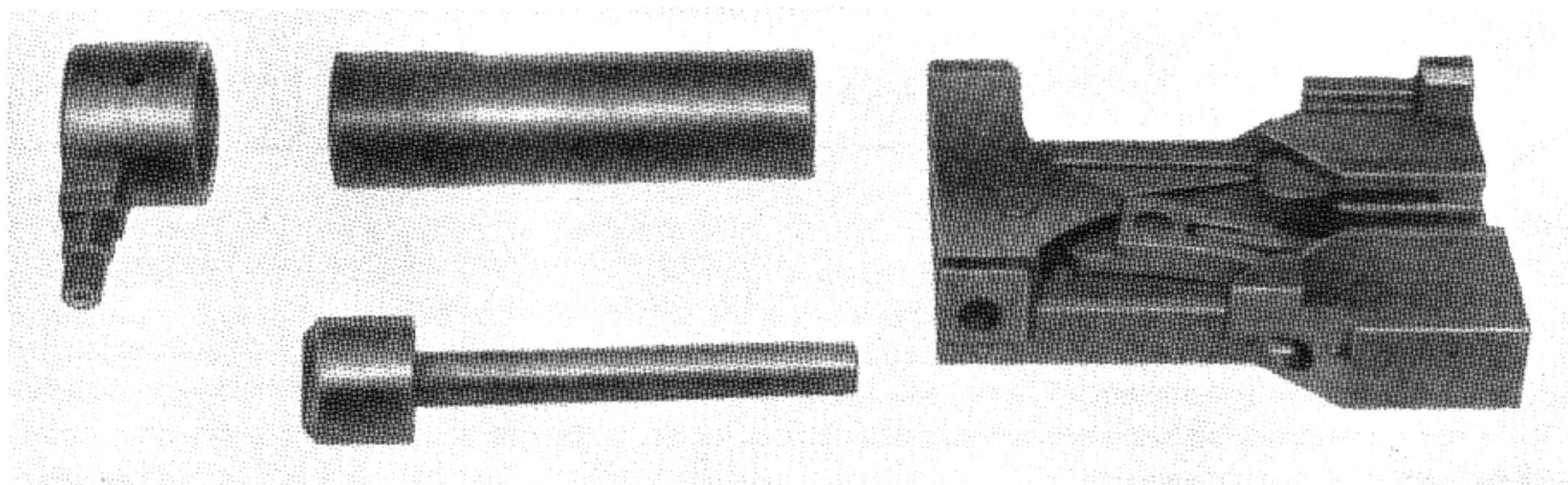


Figure 2-7. Drum revolving mechanism and charging piston of the German MG-213.

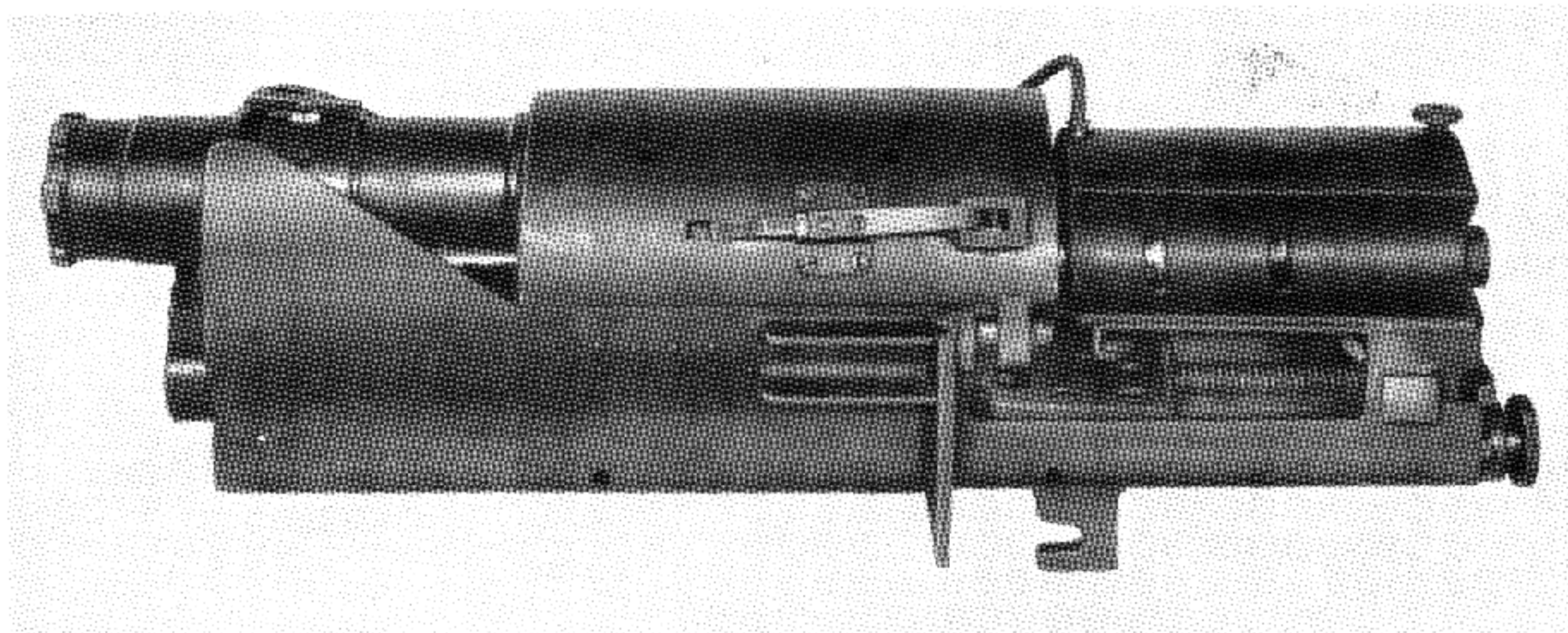


Figure 2-8. Receiver assembly of the German MG-213.

when it reaches the 12 o'clock position during drum rotation. The barrel is housed in a tube support attached to the front end of the drum support and is retained by interrupted screw threads and a key lock. When assembled, the receiver, the barrel, and the front end of the tube support extend through and are supported by a sleeve at the front end of the receiver. The rear end of the drum support is supported by two pins extending from each side of the receiver through holes in the drum support. The barrel, drum, drum support, and other parts attached to the drum support constitute the recoiling parts of the weapon and are guided in recoil by the tube support within the sleeve at the front end of the receiver and by two pins extending from the receiver through each side of the drum support.

Recoil and counterrecoil forces are limited by ring springs housed in the recoil cylinders at the front end of the drum support and are transmitted to the receiver by piston rods which are attached to the front end of the receiver.

The drum is held in alinement with the barrel during firing and indexed to bring the next chamber in alinement with the barrel by means of the five rollers on the periphery of the drum, which engage a cam track on an actuating slide in the bottom of the receiver. The actuating slide is moved rearward by a piston which receives its energy from powder gases bled from the barrel into a cylinder which is attached to the front end of the drum support. The slide is returned to its forward, or in-battery, position by two springs in the rear of the

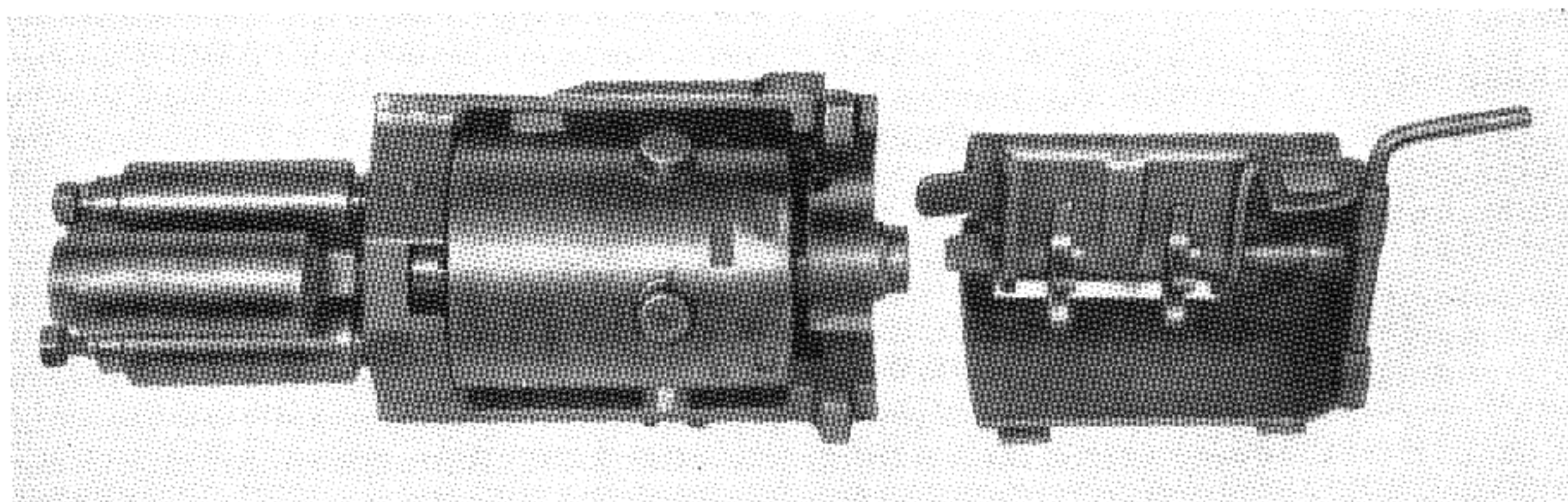


Figure 2-9. Parts of the German MG-213. Drum, drum housing, feed guide, and feed wheels.

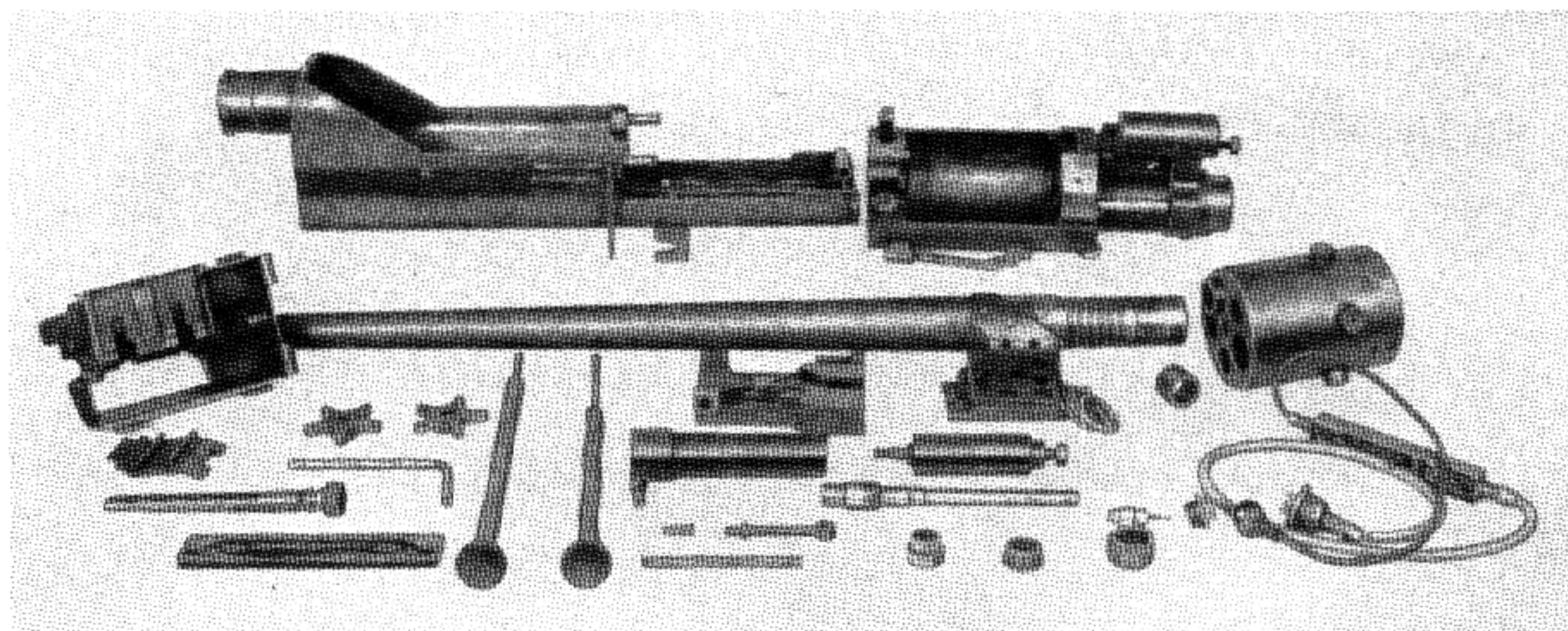


Figure 2-10. German MG-213. Disassembled view.

slide. The slide has a switch tongue which pivots about a pin through its forward end to change the cam path. The switch tongue is moved from one side to the other during slide travel by a pin extending through the slide and engaging a stationary cam in the bottom of the receiver.

Parts. The parts listed here constitute the components of the MG-213 automatic gun: drum support; drum; drum guide roller; drum actuating slide; switch tongue; rammer; slide drive springs; charger; gas cylinder; recoil spring housing; recoil spring housing sleeve; feeder; cartridge retaining detent; scaling sleeve; extractor; receiver; extractor actuator; switch tongue actuating cam; extractor linkages; ratchet notch (right-hand feed); ratchet notch (left-hand feed); firing pin; ejection gas orifice; drum counterrotation plunger hole; guide pins.

Operation of the MG-213

Preparation for Firing. Remove the drive springs and pull the slide back to its rear position. Fit the feeder shaft tool into the back end of the feeder shaft and, while holding up the drum shaft latch, pull the shaft rearward until the shaft is disengaged from the drum at the dog-face clutch.

Feed the ammunition belt with the first link empty into the feeder, engaging the link with the sprockets in the guide track. Rotate the feeder shaft with the feeder shaft tool until the empty link is in the first rammed position. Push the feeder shaft forward

engaging the dog-faced clutch. Be sure the drum is engaged.

Push the slide into battery position and replace the drive springs. Charge the gun three times using the percussion charger to bring the first round into firing position.

Cycle of Operation. When the gun is ready to fire, the slide is in its forward position, the switch tongue is on the left side, and a drum roller is engaged by the straight portion of the cam path at the rear end of the slide, which maintains alignment of the chamber with the bore.

When the round is fired, the slide is driven rearward by the gas piston, and the drum roller, in following the cam path to the right, causes the drum to rotate in a counterclockwise direction. As the active roller emerges from the right side of the cam, the next roller enters the cam track on the left side, and at the same time the switch tongue is cammed to the right to permit the roller to move into the straight portion of the cam as the slide returns to its forward position under pressure of the drive springs. This brings the next chamber in alignment with the barrel. When the roller passes the rear end of the switch tongue, the switch tongue is cammed to its left position again.

Ramming is accomplished in two stages by means of a rammer, which is attached to the rear of the actuating slide. A five-pronged feeder sprocket in the feeder, located to the rear and in alignment with the drum, is driven by the drum through a shaft ex-

tension and maintains the rounds in alinement with the chambers in the drum, as the linked ammunition is pulled into the feeder from the right side of the gun.

As the slide moves forward, the rearward ramming face of the rammer engages the base of the cartridge, pushes it part of the way through the link into the third chamber counterclockwise from the round which has just fired. At the same time, the forward ramming face of the rammer contacts the base of the cartridge which was partially rammed on the previous cycle and completes chambering it in the fourth chamber counterclockwise from the one which has just fired. Also, at the same time, the round in the fifth chamber, counterclockwise from the round which has just fired, moves into alinement with the barrel and the round which has just fired moves into engagement with the extractor.

The rear end of the drum support serves as an anvil for the round during firing and houses the firing pin assembly. When an empty case is in engagement with the extractor and a completely chambered round is in engagement with the detent retainer, the round is kept from moving rearward until the drum moves it in front of the anvil.

The extractor is actuated through the mechanical linkage which is engaged by the spring-loaded ex-

tractor actuator. The extractor actuator is struck by the slide on its forward stroke immediately after the drum ceases rotating, and the empty case is engaged by the extractor.

Ejection is accomplished by propellant gases from the next round, which are bled from the barrel and directed into the mouth of the empty case through the front end of the chamber by the gas orifice. (The orifice on the opposite side is used when the weapon is assembled for right-hand feed.) Firing occurs when the slide reaches its in-battery position and closes the electrical firing circuit.

Obturation between the forward end of the chamber and the end of the barrel is accomplished by means of sealing sleeves which are held against the face of the barrel by the pressure of the propellant gases acting on the rear end of the sleeve.

There are two sets of five notches located around the periphery of the drum. One set is used for right-hand feed, the other set for left-hand feed. The notches are engaged by a spring-loaded plunger in a hole, which prevents counterrotation of the drum during the firing cycle.

The weapon is charged by a pneumatic piston and cylinder which is actuated by gas from an external source. The piston charges the weapon by forcing the actuator slide to the rear.

SECTION 2. ARF PHASE 1: 20-MM MG-213 (MAUSER)

Examination, Analysis, and Study

Metallurgical Study. Spectroscopic and wet chemical analyses were made to determine the type of steel used in the various parts of the weapon. Steel used in different parts of the 20-mm version corresponded approximately to United States specifications as follows:

Cartridge drum: SAE 1045.

Cartridge drum roller: SAE 1020, carburized.

Barrel: SAE 1350.

Belleville spring: Silicon manganese 0.90 percent carbon.

Switch tongue cam: SAE 1020.

Driving spring: SAE 1090.

Switch tongue: SAE 1045.

Other parts: Plain carbon steel.

Hardness Examination. Since the weapon had been damaged by fire, various parts were tested for hardness to determine the degree of softening of

hardened parts. The following values were obtained:

Belleville springs: 30 Rc to 34 Rc.

Gas cylinder piston: 32 Rc.

All other parts (including barrel and cartridge drum for 20-mm gun)

Soft: 85 Rb to 105 Rb.

Links for 20-mm ammunition: 47 Rc.

Thermodynamic Investigation. Because of the reported high cyclic rate of this weapon, 1,200 rounds per minute, it was believed that the temperature rise in the barrel and cartridge drum might be a very serious one. A theoretical study of the temperature distribution in the drum and barrel, therefore, was made to determine the number of rounds that could be fired before reaching the propellant "cook-off" temperature in the cartridge drum. The calculations were based on two main assumptions.

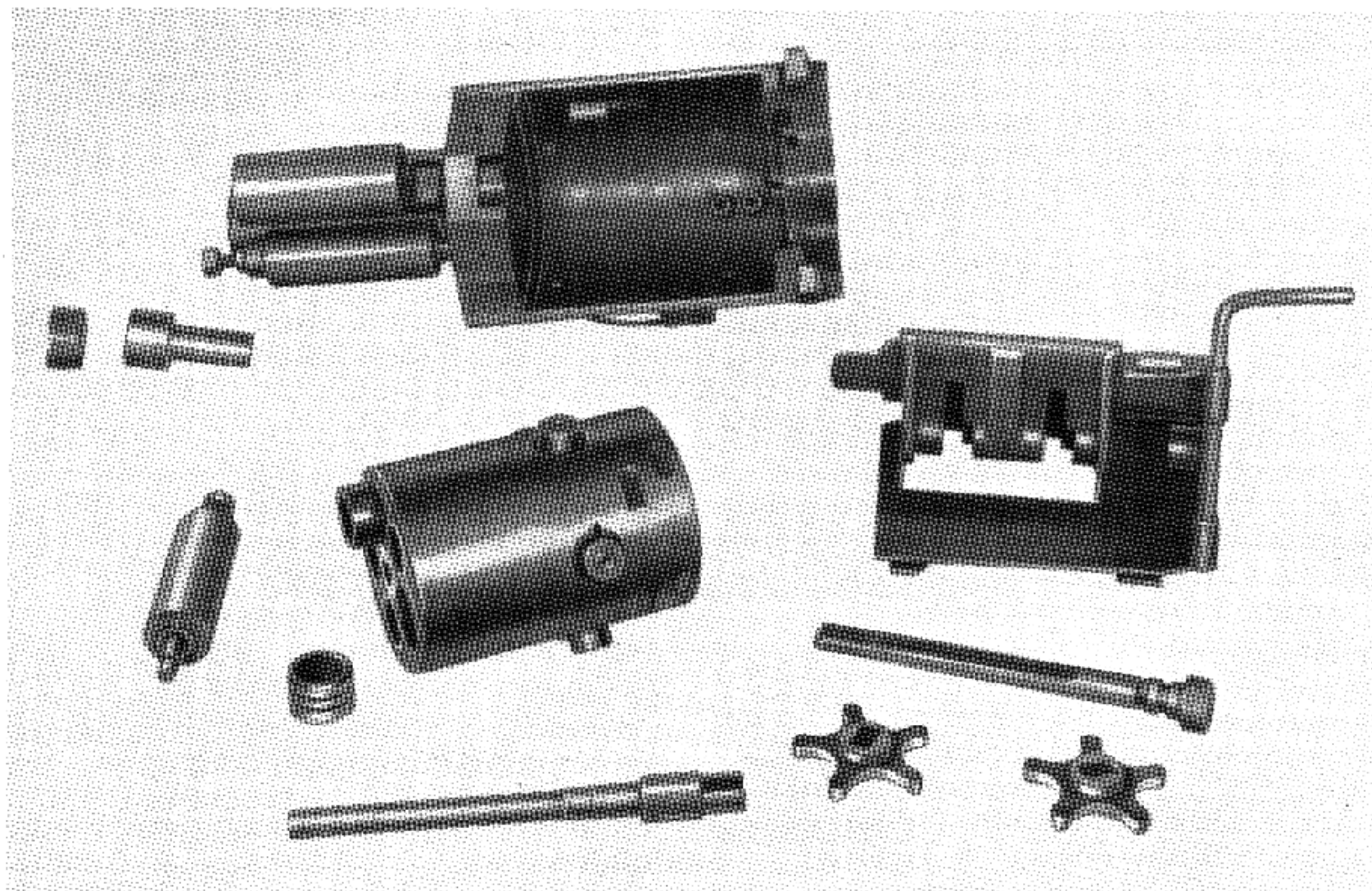


Figure 2-11. Drum and feed mechanism of the German MG-213. Disassembled view.

1. That 25 percent of the heat generated is given off to the gun (according to Cranz's Interior Ballistics), and that the total heat given to the gun is uniformly distributed along the length of the barrel and the chamber.

2. That the physical properties of the gun material remain constant.

The analysis was made by two methods, the "approximate method" and the "cylindrical heat source method". On the basis of the assumptions made, it was concluded that after 200 rounds the temperature rise of the drum would not reach the "cook-off" temperature of the cartridge, and that the average temperature rise of the barrel would be less than 500° C., at which temperature the barrel would still have sufficiently high tensile strength.

Reconditioning of Weapon. Before the weapon could be fired, it was necessary to:

1. Replace all springs which were damaged by fire.
2. Replace or repair worn or damaged parts.

3. Straighten the barrel.

4. Restore the hardness to parts softened by heat of the fire.

5. Manufacture cartridge drum gas cylinder seals.

6. Manufacture 50 cartridge links.

7. Modify the feed mechanism for use with the new links.

8. Build an electrical ignition circuit.

Initial Firing Tests and Modification. During the period 24 September through 26 October 1946, five firing tests were conducted. Numerous minor changes in firing circuit and gun components had to be made before a short burst could be fired without major malfunctions. The rate of fire was determined to be approximately 1,000 rounds per minute. Results of these preliminary tests showed that:

1. The ratchet arrangement for preventing rotation of the drum in the wrong direction could be removed without affecting the functioning of the weapon.

2. The cam plate for operating the cam switch tongue could be replaced with a leaf spring and a short cam.
3. The slide drive springs were overstressed.
4. Interference between the ejected cases and the

feeder sprockets would require close timing and rapid ejection of cases.

5. The links would require redesigning to attain sufficient strength to prevent spreading in order to avoid jamming from interference with the rammer.

SECTION 3. ARF PHASE 2: GUN, AUTOMATIC, 20-MM T74 MODEL A

Modification and Rebuilding of Mauser MG-213

It was decided to rebuild the German weapon, to replace badly worn or damaged parts, and to incorporate design changes found desirable as a result of the preliminary firing tests, in order that more extensive firing tests and engineering studies could be conducted. After the following design changes and part replacements were made, the weapon was designated 20-mm Automatic Gun T74 Model A.

1. A new barrel, duplicating as closely as possible the German barrel, was made. It followed the exact rifling twist as measured in the German barrel.

2. The receiver was modified to provide greater rigidity.

3. A new tube socket, which is integral with the drum support, was made longer than the original, and the bearing for the tube socket was modified to receive it. This was done to eliminate looseness and to provide support for approximately one-fourth of the barrel length.

4. The rear drum support guide pins and bearings were badly worn and were replaced.

5. The drum shaft was badly worn and was replaced with a new one.

6. The drum support was bent beyond machining limits. The piece was straightened and reinforced.

7. The ratchet arrangement on the drum was eliminated.

8. The guideways with the actuating slide were replaced to provide closer fit and more accurate alignment of the drum chambers with the barrel.

9. Six-inch-longer driving springs were made to eliminate permanent set which occurred on the shorter springs, and the spring sockets were extended to provide for the extra length of spring.

10. A new firing-pin assembly was made to replace worn parts.

11. New rollers and pins were made for the drum to replace badly worn parts.

12. A new gas cylinder and a new piston were made. This was necessary because of the muzzle modifications. A gas exhaust port was incorporated in the cylinder, and the piston rings on the piston were replaced with grooves. Gas leaving the exhaust port was expected to produce a scavenging action and result in less fouling of the piston. Omission of piston rings was expected to result in less possibility of the piston jamming from powder gas fouling.

13. A new feeder and link were designed to transmit the belt pull through the center of gravity of the round. The feeder was designed also to deflect the ejected cases sideways, thus permitting a decrease in the effective overall length of the gun.

Tests and Modifications

The weapon was subjected to limited proof firing tests, then shipped to Springfield Armory on 26 June 1947 for testing to obtain performance data. A variable port opening in the gas cylinder was installed, and single-shot tests were performed with openings varying from 0.082 to 0.187 inch diameter to determine the relation between gas port opening and cyclic rate. Time displacement records were obtained and cyclic rates were determined from the time of individual cycles. These tests showed no significant change in cyclic rate as a result of changing the size of the gas port opening.

The time displacement record also showed that the slide was recoiling from 4.6 to 5.2 inches instead of the normal 5.6 inches. The short slide travel, the irregular time-displacement curve, and the badly battered counterrecoil surface of the cam, caused by roller impact, indicated that the drum rollers were leaving the cam surface during the recoil travel of the slide, instead of smoothly following the cam contour. This condition was probably the reason for the small effect of the gas orifice size upon cyclic rate.

The cam then was modified to reduce the steepness of the cam curves. This resulted in smoother action, normal slide travel, and increased cyclic rates.

Tests were then conducted with the feeder and new experimental links, manufacture of which had just been completed. The initial test resulted in only 3 inches of slide travel and jamming of the mechanism caused by interference between the rammer and the third link. Inspection of the links revealed that they did not conform to the drawings. The links were modified to eliminate interference,

and damaged slide and feeder were then repaired.

High-speed motion pictures of ejection during bursts of two rounds, hand loaded, showed that ejected cases were striking the feeder sprocket. The gas port of the ejection chamber, therefore, was increased from one-thirty-second to one-sixteenth inch diameter to obtain faster ejection.

Subsequent tests and high-speed motion pictures showed that the ejected cases were clearing the sprocket but were missing the deflector lug by approximately one-half inch. However, to prevent

Comparative Data: Several 20-mm Automatic Guns

Characteristic	MG-213	T74, Model A	T74, Model B	T110
Weight.....pounds..	180	200	225	130
Overall length.....inches..	75.1		74 $\frac{5}{32}$	52
Overall width.....do.....	8.75		9 $\frac{3}{32}$	8 $\frac{1}{8}$
Overall height.....do.....	9.65		9 $\frac{1}{32}$	7 $\frac{3}{4}$
Approximate rate of fire.....rounds/minute..	1,200	1,200	1,200	1,200
Approximate muzzle velocity.....feet/second..	3,280	3,280	3,120	2,950
Charger.....	(1)	(2)	(2)	(2)
Extraction and ejection.....	(3)	(3)	(4)	(4)
Length of barrel.....inches..	54 $\frac{7}{8}$	54 $\frac{7}{8}$	54 $\frac{3}{4}$	33
Distance from muzzle to face of chamber.....do.....	62 $\frac{3}{8}$	62 $\frac{3}{8}$	62 $\frac{3}{8}$	40 $\frac{19}{32}$
Bore:				
Number of grooves.....	8	8	8	9
Width of lands.....inches..	0.097	0.097	0.097	0.068
Depth of grooves.....do.....	0.011	0.011	0.011	0.015
Diameter across grooves.....do.....	0.809	0.809	0.809	0.817
Diameter across lands.....do.....	0.787	0.787	0.787	0.787
Twist.....	(5)	(5)	(5)	(5)
Length of recoil.....inches..	$\frac{1}{4}$ - $\frac{1}{2}$	$\frac{1}{4}$ - $\frac{1}{2}$	$\frac{1}{4}$ - $\frac{1}{2}$	$\frac{3}{8}$
System of operation.....	Gas (revolver principle)			
System of locking.....	Stationary breech			
System of feeding.....	Metal disintegrating belt			
Method of headspace.....	Factory established; cannot be adjusted			
Location of feed opening.....	Lower left side			
Location of ejection opening.....	Upper right side			
Method of cooling.....	(6)	(6)	(6)	(6)
Barrel weight (approximate).....pounds..	42	42	42	27 $\frac{1}{2}$
Rate control.....	Can be controlled by rheostat			
Barrel removal.....	Not considered quick disconnect			
Pitch.....	1 turn in 40 inches increasing to 1 turn in 30 inches			

¹ Electropneumatic.

² Manual.

³ Mechanical and gas.

⁴ Mechanical.

⁵ Progressive.

⁶ Air.

further possible damage to the gun, a hole was cut in the rear plate to permit the ejected cases to travel straight to the rear, as in the original weapon, instead of being deflected to the side.

Cyclic rates in excess of 1,200 rounds per minute were obtained. However, these rates were based upon time of cycle for individual rounds and were obtained without any ammunition belt load and without satisfactory ejection of empty cases. On the basis of the results of these tests, it was decided

- that the following design changes should be incorporated in the model B weapon.
1. A mathematically calculated cam path in the drum actuating slide.
 2. An extractor mechanically operated from the counterrecoil travel of the slide.
 3. A firing pin with ball contact to prevent jamming or short circuiting.
 4. A sliding contact, electric ignition switch for greater dependability.
 5. A guide in the feeder for the extracted cases.

SECTION 4. ARF PHASE 3: GUN, AUTOMATIC, 20-MM T74 MODEL B

Design and Description

The model B weapon was the first model completely designed and manufactured by Springfield Armory with designs furnished by Armour Research Foundation. This model utilized the basic principles of the previous models and followed the same general arrangement of components. However, it incorporated numerous design changes based upon the experience gained from the previous models and upon analysis made by using the performance data from the model A weapon.

- Following is a list of the major design features in which the model B weapon differs from the original German weapon.
1. Means of replacing the 20-mm tube with a 30-mm tube were eliminated. The gas port in the barrel was located at the position of the port for the 30-mm tube in the original weapon.
 2. The drum support was designed to minimize bending due to non-uniform distribution of mass.
 3. The receiver was designed for greater rigidity. The rear end was made removable to permit easier

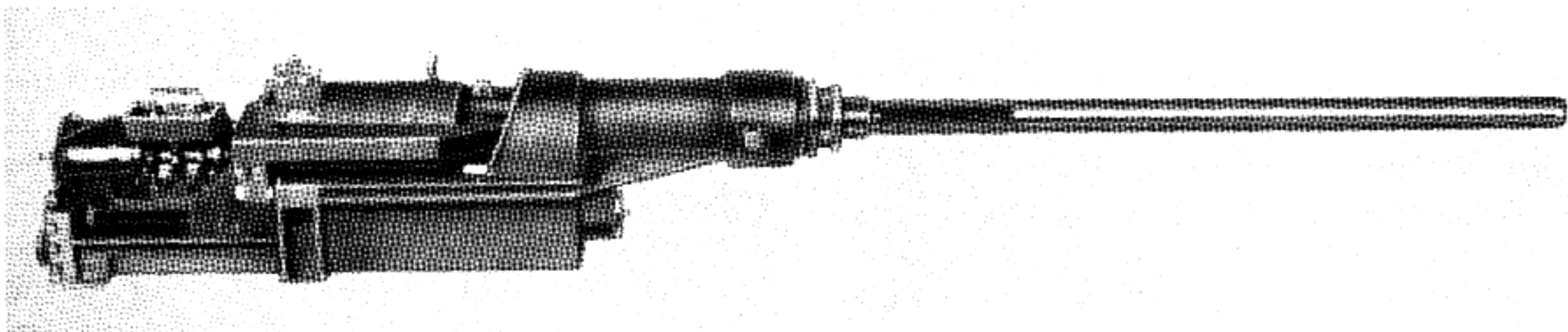


Figure 2-12. United States Ordnance Corps 20-mm Automatic Gun, T74, Model B.

Comparative Data: MG-213 and 3 Designs of the 20-mm T110

Characteristic	MG-213	20-mm T110		
		Design No. 1	Design No. 2	Design No. 3
Weight.....pounds..	180	150	160	170
Length.....inches..	75	54	54	54
Height.....do....	9 ⁵ / ₈	7 ³ / ₄	7 ¹ / ₈	8
Width.....do....	8 ³ / ₄	8 ¹ / ₂	10 ¹ / ₈	8 ³ / ₄

removal of the slide and rammer. The tube support was extended forward to support the tube for approximately one third of its length. Conventional trunnions were incorporated in the tube support section in the plane of the bore centerline.

4. To provide more accurate alinement, greater strength, and easier assembly, the drive coupling between the drum and feeder shafts was changed from tongue-and-groove to spline construction.

5. The rings on the slide actuating piston were replaced with grooves. An exhaust port was incorporated in the gas cylinder, and the gas orifice was made replaceable to permit testing with orifices of various diameters. The gas cylinder, instead of being made integral with the drum support, was made removable and was mounted in the receiver where it was more accessible for possible use with a percussion charger.

6. The bearing area of the slide guideways was increased to reduce wear.

7. The slide drive springs were relocated to positions along the outer edges of the slide to permit the springs to bear against lugs at the front end of the slide instead of against the rear. This permitted the length of the springs to be increased by an amount approximately equal to the length of the slide without increasing the overall length of the weapon.

8. The connection between the slide and rammer was made adjustable for determining the optimum head space.

9. A ball-type firing contact was used in place of the conventional pin type in order to avoid shorting out the primer by scraping metal across the base of the case.

10. The gas-ejection system was eliminated, and a new mechanical extractor was designed to operate on the forward motion of the slide. The original system utilizing gas ejection with a mechanical extractor was not reliable.

11. The sliding contact firing switch was made adjustable for determining the optimum firing position.

12. The recoil and counterrecoil system, consisting of two sets of Belleville springs mounted below the bore centerline, was changed to a system consisting of ring springs mounted concentrically with the barrel in order to obtain a more balanced system.

13. The pneumatic charger incorporated in the original weapon was eliminated. However, space was provided for a charger to be incorporated later.

14. The drum roller cam path in the operating slide was redesigned in accordance with a mathematical analysis of the forces and motions involved. The design provided a closed cam path which eliminated the necessity for the ratchet arrangement for preventing rotation of the drum in the wrong direction.

15. Ammunition links and feeder were redesigned to give more reliable performance.

Analytical Studies

Recoil Calculations. Recoil calculations were made to determine the trunnion reaction, recoil travel and recoil time for various values of recoil spring rate. These calculations were based on the following data:

Weight of projectile: 0.3 pound.

Weight of powder: 900 grains equal 0.1283 pound.

Weight of recoiling parts: 105 pounds (estimated).

Muzzle velocity: 3,090 feet/second.

Gas pressure at the muzzle: 16,000 p. s. i.

Length of barrel: 41 1/4 inches.

Area of bore: 0.502 square inch.

At the time these calculations were made, it was intended to limit the length of the weapon to 52 inches and to design ammunition with the same ballistic characteristics as the German ammunition. The calculations, therefore, were based on the use of a short barrel (41 1/4 inches) and the ballistics of the German ammunition. Later it was decided that manufacture of a short barrel would delay the program too much, and the weapon was designed for use with a long barrel (54 7/8 inches) already available from the previous model. The weight of the projectile used was in error and should have been 1,800 grains, or 0.257 pound.

Determination of Cam Profile and Forces Acting on the Cam. As a result of calculations, it was concluded that an elliptical cam path should be used in designing the cam for indexing the cartridge drum. A method was used for calculating the forces acting on the cam in moving a variable drum mass in which the effect of friction and of the slide drive spring was neglected. An intensive program was

initiated to alleviate difficulties that had been encountered in the past from this miscalculation.

Stress Analysis of Cartridge Drum. In designing the model B weapon, difficulties were encountered when an attempt was made to analyze the stresses in the cartridge drum. Since this component was a heavy-walled shape of nonuniform thickness, it was not susceptible to good mathematical analysis. The problem, therefore, was approached experimentally, and the brittle-material method was selected as the one offering the most practical approach, although some development of technique was necessary before quantitative results were obtainable.

A replica of the drum was made from Aridized No. 1 pottery plaster and tested under internal air pressure, simulating statistically the effect of firing a cartridge in one of the chambers. The specimen broke when the initial pressure was 125 p. s. i. The ultimate strength of the material measured in simply loading beams of the same plaster was 426 p. s. i. If all the material properties were as assumed (the stress-strain relationship is linear to failure, and failure is a function of maximum tensile stress only), this would mean that when the internal pressure in the drum chamber is 10,000 p. s. i., the maximum stress is $426 (1,000)/125$, or 3,408 p. s. i.

Gas Resistance to Slide Motion During Return of Slide to Battery Position. One of the factors which conceivably retards the slide during its return to battery position is the gas resistance encountered as the slide pushes the gas piston ahead of it. During this motion, the gas-air mixture retained in the cylinder is compressed in the space forward of the piston and flows back into the barrel through the orifice. The built-up pressure, which retards the piston motion, depends upon (1) the residual pressure remaining in the cylinder from the previous rearward movement of the slide, and (2) the escape of gas through the orifice while the piston returns to battery. Calculations were made to evaluate these effects.

1. The residual pressure remaining in the gas cylinder at the time the slide, during its return to battery position, contacts the piston rod, is expected to be very close to atmospheric, so that no slowing down of the slide may be expected because of it.

2. The pressure rise in the gas cylinder during return of slide and piston to battery position is negligible. The pressure is not expected to increase to more than 3 p. s. i. above atmospheric pressure, and the corresponding force on the piston is not sufficient to cause appreciable deceleration.

Investigation of Gas-Piston Bounce. One of the causes for deceleration of the actuator slide during its return to battery is the impact and subsequent bouncing between the slide and the gas piston rod. This bounce had been observed on high-speed movie films on which slide motion and piston motion were recorded simultaneously. A mathematical and experimental investigation of this condition was made at ARF to correct this. The following conclusions were reached:

1. During its return to battery position, the actuator slide is decelerated as a result of impact with the gas piston.

2. Depending on whether the process takes place inelastically or elastically, the reduction in slide velocity may be slight (8 percent of the velocity before impact) or so great that, as a result of repeated impacts, the slide never reaches battery position.

Test results confirmed the existence of at least one bounce. However, further experimentation would be required before final conclusions concerning the details of these impact phenomena could be drawn. Since there was no evidence that gas piston bounce had appreciable effect on cyclic rate, continuation of the investigation was not considered to be warranted.

Tests and Modifications

During the firing test of the weapon, a number of parts failed or deformed, and numerous difficulties (concerning the functions of extraction, feeding, ramming, and ignition) occurred. These problems were solved, or partially solved, as follows:

Firing Pin. The firing pin broke on the initial firing test where the smaller diameter anvil portion joins the larger diameter base portion. By chamfering the bore in the drum support and adding radius at the point of stress concentration in the firing pin anvil, this difficulty was eliminated.

Gas Piston. One failure occurred where the rod joins the piston. This was attributed to severe load imposed when the slide jammed because the

switch tongue pin dropped out of place. No modification was made and no subsequent failure occurred.

Actuating Slide Switch Tongue. The switch tongue cam surfaces were being deformed continually by impact of the drum rollers, and on one occasion the switch tongue broke. Also, the switch tongue cam-follower pin frequently failed. To reduce breakage of the switch tongue cam-follower pin, the solid steel cam in the receiver for switching the tongue at the end of the slide recoil was spring-loaded in the direction of slide travel. Breakages still occurred, so the spring-loaded cam was replaced with a leaf-spring cam. This greatly reduced the impact forces between the drum rollers and the switch tongue, but did not eliminate breakage of the switch tongue pin.

It was then concluded that breakage of the switch tongue pin was caused also by impact of the pin against the forward solid steel cam which returns the tongue on forward travel of the slide. The forward cam then was replaced with a leaf-spring cam, but the spring leaves could not withstand the impact loads, and they failed. A cam made of Micarta also failed. A steel cam was used for the remainder of the tests.

The switch tongue frequently dropped out of position because of failure of its snap ring retainer. This failure caused the mechanism to jam and the pin to break. This was a design weakness which was overcome in a later model.

Recoil Springs. During one firing test, the recoiling parts failed to return to battery because several elements of the recoil ring springs seized in the compressed position and did not disengage. Lubrication of the mating surfaces of the springs with Dixon XP190 graphite grease and packing with Dixon XP271 graphite grease, as recommended by the ring spring manufacturer, eliminated this difficulty.

Drum Roller Studs. Two failures of drum roller studs occurred due to stress concentration at the two diameters. New studs with a larger radius in the corner were made and installed, and no further difficulty with this part was experienced.

Actuating Slide, Extractor Lug. This lug sheared off once. It was decided, however, that

the extractor set back against the return spring on recoil and permitted the extractor lever to rotate into such a position as to permit the lug on the slide to jam against it on its rearward travel. This trouble was eliminated by increasing the preload on the extractor return spring.

Ejection Difficulties. An empty case, upon extraction, is thrown rearward into the feeder ejection chute where the base of the case strikes an inclined surface which deflects it to the side. If the case does not clear the chute before the next round is fired, the feeder sprockets rotate with the drum and engage the extracted case. The case is mashed or cut through, and the mechanism becomes jammed. This calls for a very fast acting ejector and a feeder ejection throat which offers a minimum of interference.

The energy for ejection is obtained from the kinetic energy of the slide on its counterrecoil stroke and from the force of the slide drive springs. Since the reduction in slide velocity due to extraction reduces the cyclic rate, it is desirable to keep the energy requirements for extraction to a minimum. The energy required with the original extractor was so high that the slide frequently failed to return to battery position to fire the next round. This occurred with a 20 pound per inch extractor return spring. With a weaker spring, however, the extractor frequently failed to return in time to engage the next case and extract it. Furthermore, the spring took a permanent set of as much as one-half inch after several rounds. In conjunction with this problem, the extractor buffer springs, consisting of Belleville washers, also took a permanent set after a few rounds. High-speed motion pictures showed that the extractor was being displaced rearward about one-half inch on recoil because of its inertia.

The return spring was replaced with a stranded wire spring, 20 pounds per inch, to dampen the oscillations, and its initial load was increased to 30 pounds by adding a spacer. The extractor lever was changed to reduce the positive travel of the extractor from 1 3/4 inches to 1 1/4 inches, and the moving parts of the extractor were reduced in weight about 20 percent. The Belleville buffer spring was replaced with a Fabreka buffer one inch long. Modifications improved the performance of the ex-

tractor, but jamming of the cases in the ejection chute still occurred at cyclic rates of over 1,000 rounds per minute.

Other attempts to improve ejection were made by enlarging the feeder ejection throat and by installing a deflector at the rear end of the throat to deflect the cases to the side. Various deflector angles were tested. A deflector mounted against Fabreeka also was tested. Although these modifications of the extractor and of the feeder extraction throat improved extraction performance, the problem was never completely solved on the model B weapon.

Ramming Difficulties. High-speed motion pictures of the Model B weapon showed that the rounds were being stripped free of the links during initial ramming. Since the round was not completely chambered until after the second ramming stroke, the round was out of control between the two ramming cycles. Attempts were made to improve this condition by increasing the "push through" resistance of the link from 50 pounds to 70 pounds by embossing detents into the forward holding fingers of the links, and by reducing the effective stroke of the first ramming cycle.

High-speed motion pictures taken during subsequent tests showed that the rounds were still being stripped completely from the links on the first ramming stroke. An attempt was then made to control the stripped round by installing a spring-loaded retainer on the drum support. High-speed motion pictures showed that this retainer functioned as expected, preventing the round from falling out of the chamber until fully chambered by the second ramming stroke.

Occasionally a round was not sufficiently chambered by the second ramming stroke to clear the face of the anvil, possibly because of an oversize case and insufficient kinetic energy of the rammer; this condition resulted in jamming of the mechanism when the drum rotated. To prevent firing under these circumstances, an electric contact was connected into the firing circuit and arranged to operate in conjunction with the cartridge detent located in the rear end of the drum support. This change made it necessary for the switch to be closed by pressure of the detent in its undepressed position behind the completely chambered round before firing could occur.

Ignition Difficulties. Occasionally primer insulation was blown from the base of the cartridge onto the firing pin and prevented electrical contact with the primer of the next cartridge. This occurred only when firing German ammunition. It never occurred when United States ammunition was fired.

Cyclic Rate. The time of the firing cycle is the sum of: primer ignition time; time for rearward motion of operating slide; and time for forward motion of operating slide.

Time-displacement records of the slide show that the forward velocity of the slide is decreased greatly after the slide contacts the extractor. Attempts were made, therefore, to reduce the kinetic energy taken from the slide by improving the mechanical operation of the extractor. As previously described, the extraction and ejection problems were not overcome to the extent that sustained bursts could be fired.

Attempts were also made to reduce the energy required for extracting the case by lubricating the ammunition. When the ammunition was lubricated with a 5-percent solution of Ceresin wax in carbon tetrachloride, there was an apparent increase in the cyclic rate of approximately 100 rounds a minute.

Various gas orifices were tested to determine the effect of orifice diameter upon cyclic rate. Time-displacement records of slide movement indicated that the size of gas orifice does have some effect upon cyclic rate. However, there were so many other variables affecting cyclic rate which were so difficult to control that the quantitative data were not considered reliable. Tests were conducted to determine the effect upon primer ignition delay of increasing the ignition voltage from 45 volts to 170 volts. No effect was apparent.

Tests of Components for Model C Weapon

Since much of the model C weapon design had been completed while the model B weapon was undergoing tests, some of its design features were tested in the model B weapon.

The gas operating cylinder was reduced from 1½ inches in diameter to 1¼ inches in diameter in order to approximate the piston area in the model C gun. Comparison of the time-displacement rec-

ords of the slide showed no significant difference in performance and indicated that a $1\frac{1}{16}$ inch diameter was sufficient.

Performance Data

The following data were obtained during the firing tests conducted:

Length of recoil: $\frac{1}{4}$ to $\frac{1}{2}$ inch.

Cyclic rate: Over 1,200 rounds/minute.

Maximum pressure in gas cylinder:

With $\frac{1}{2}$ -inch orifice: 1,380 p. s. i. (average of two tests).

With $\frac{1}{8}$ -inch orifice: 2,440 p. s. i. (average of five tests).

With $\frac{3}{16}$ -inch orifice: 5,200 p. s. i. (average of eight tests).

Slide velocity during recoil: Approximately 40 feet/second.

SECTION 5. ARF PHASE 4: GUN, AUTOMATIC, 20-MM T110

Design and Description

While the 20-mm Automatic Gun T74 Model B was being manufactured, design of another model was initiated. This model was initially designated T74 Model C and later redesignated T110.

In designing this weapon, emphasis was placed upon reduction of weight and reduction of overall dimensions to meet the following limitations specified by the Ordnance Corps:

Overall length: 52 inches.

Overall width: 8 inches.

Overall height: 8 inches.

In order to meet the maximum silhouette requirements, major changes in the arrangement of components were made, and whenever possible these changes were also made to facilitate assembly, disassembly, and servicing. Layouts of three different arrangements of components were prepared. Weight and overall dimensions for these three designs were estimated. These data have been tabulated for comparison with the original MG-213.

Comparison of Weight and Overall Dimensions of the MG-213 and 3 Designs of the 20-mm T110

Characteristic	MG-213	Design No. 1	Design No. 2	Design No. 3
Weight in pounds.....	180	150	160	170
Length in inches.....	75	54	54	54
Height in inches.....	$9\frac{5}{8}$	$7\frac{3}{4}$	$7\frac{1}{8}$	8
Width in inches.....	$8\frac{3}{4}$	$8\frac{1}{2}$	$10\frac{1}{8}$	$8\frac{3}{4}$

All three designs incorporated the same principles of operation. However, design No. 1 was selected on the basis of weight, silhouette dimensions, number of parts, ease of assembly, and accessibility for cleaning.

A list of the major T110 design features which are different from those of the T74 model B follows.

1. The barrel was relocated with respect to the drum for firing from the chamber at the bottom position instead of from the top of the chamber, as in the German method. This arrangement reduced the overall height and brought the line of action of the recoil force closer to the center of mass. This made it necessary, however, to relocate the drum rollers

from positions between the chambers to positions opposite the chambers; this, in turn, made it necessary to make the roller studs an integral part of the drum.

2. The front bearing of the drum support was redesigned. The rifling torque and the torque produced by the force of the drum roller on the slide actuating cam was transmitted directly to the trunnion yoke instead of to the receiver. This change was accomplished by making the front end of the tube support and the mating portion of the trunnion yoke hexagonal.

3. The recoil springs were located in two nests in the drum support in a horizontal plane through the

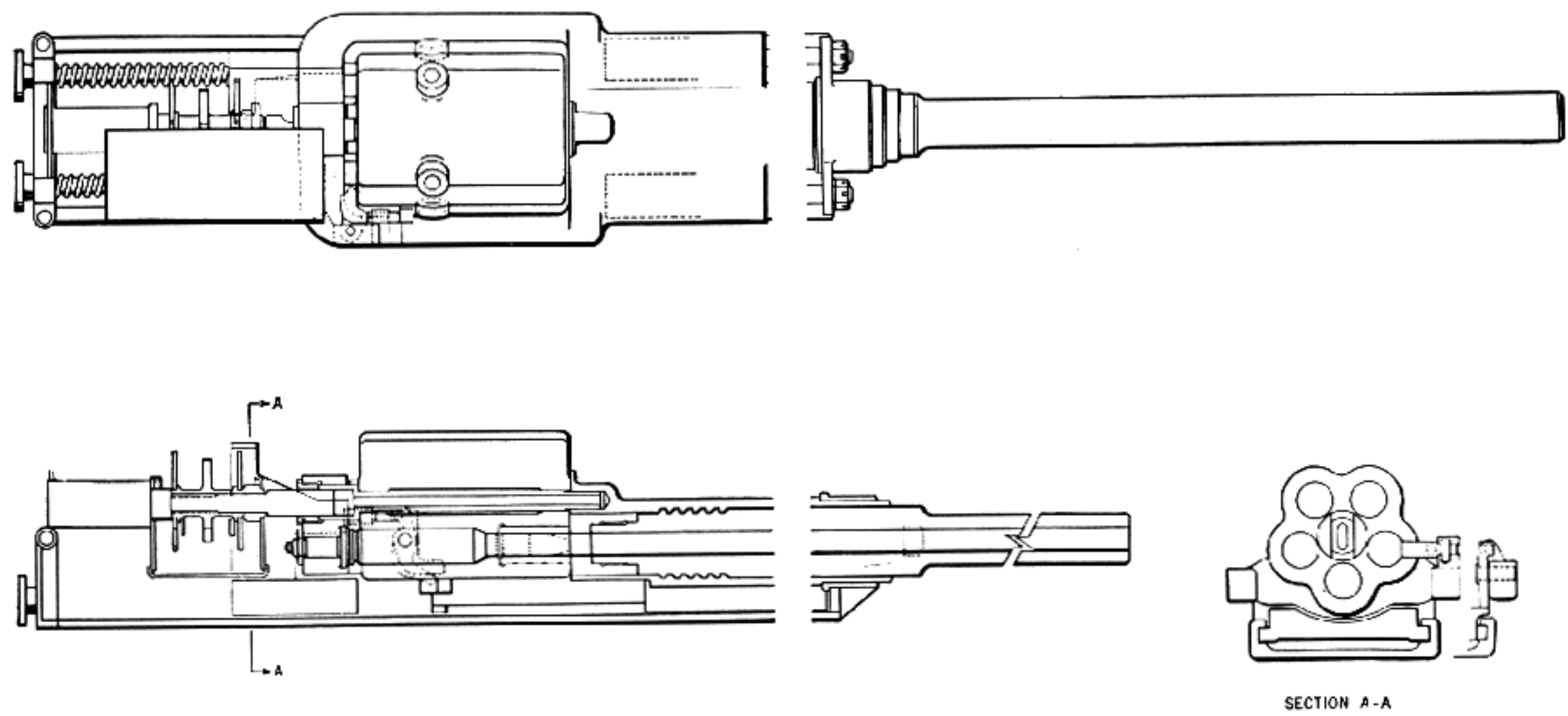


Figure 2-13. United States Ordnance Corps 20-mm Automatic Gun, T74, Model C. Assembled view.

bore centerline. This permitted connecting the recoil rods to the trunnion yoke so that the recoil force was transmitted directly to the trunnion yoke rather than to the receiver.

4. The gas cylinders were made integral with the drum support. Since the drum support is a part of the recoiling mass, the reaction of the slide against the action of the piston absorbs recoil energy and reduces the forces acting on the recoil springs.

5. The gun barrel was shortened to comply with the 52-inch overall length requirement.

6. Items 1, 2, 3, and 4 greatly reduced the strength requirements of the receiver and permitted considerable weight reduction. Additional weight reduction was realized also by the use of an aluminum alloy casting.

7. The feeder was redesigned; feeding and ejection of cases and links from the same side was changed to permit multiple installations in a minimum of space.

8. The extractor was redesigned to incorporate the features of the extractor on the British gun, aircraft, 30-mm Aden.

9. The rammer and actuator slide were made in one piece to provide greater rigidity. These adjustable parts in the model B weapon frequently became loose and caused binding in the slide guides.

Analytical Studies

Determination of Cam Profile and Forces Acting on the Cam. Forces acting between the drum roller and the cam on the slide were investigated for the following cam profiles and gas piston strokes:

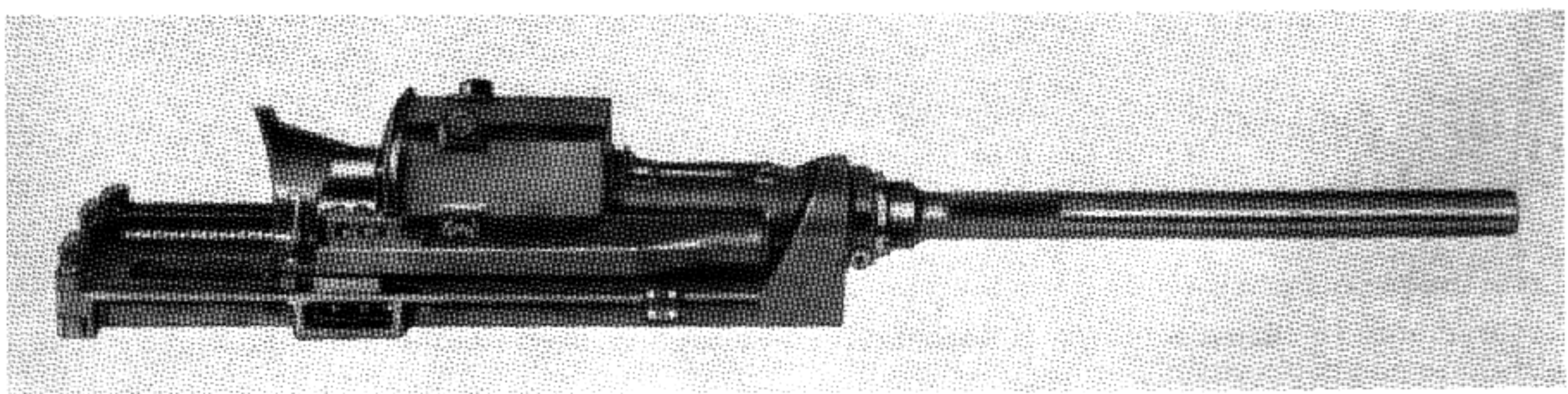


Figure 2-14. United States Ordnance Corps 20-mm Automatic Gun, T110.

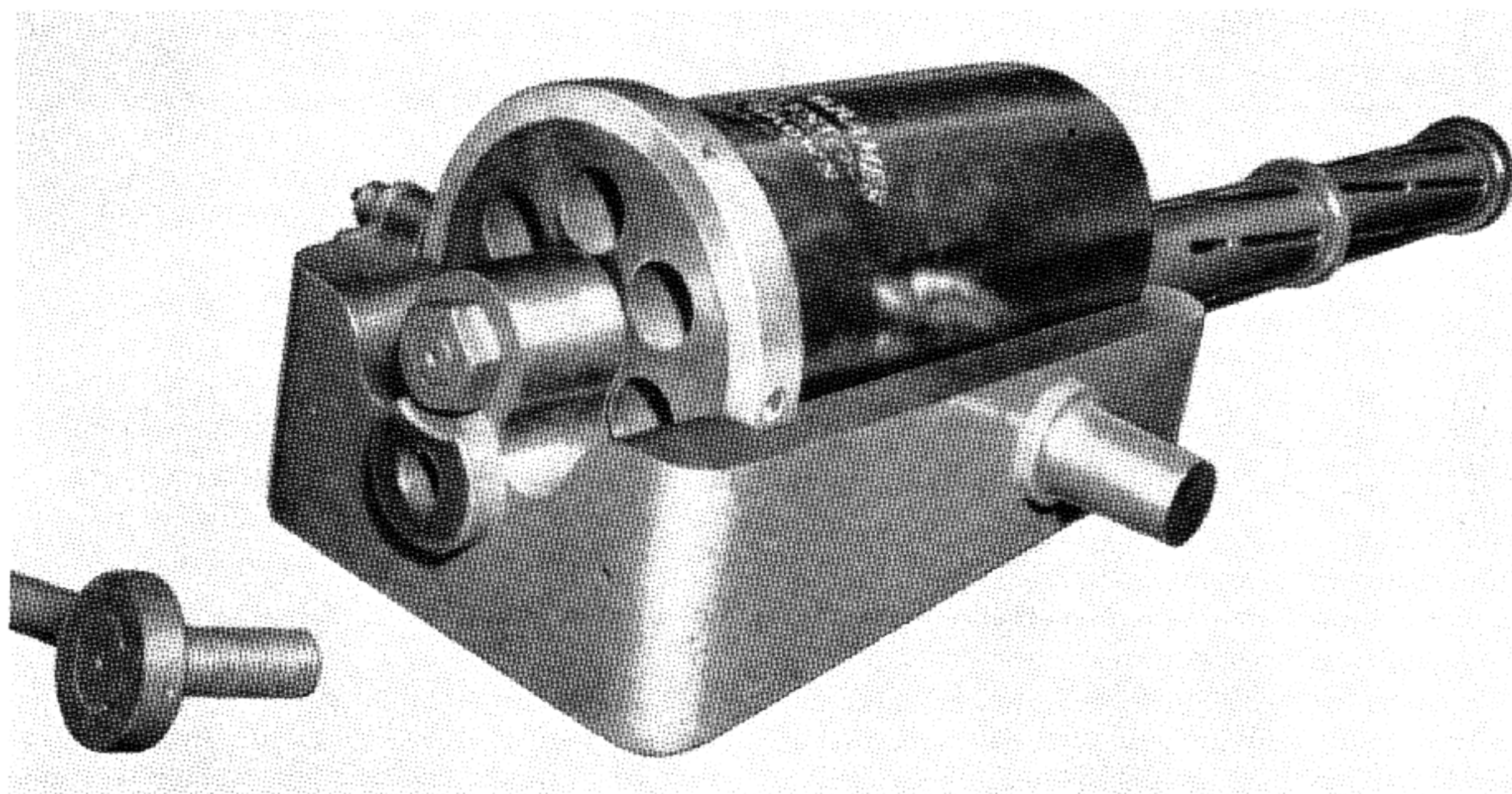


Figure 2-15. The American DeBrame Cannon of the Civil War Era. This weapon is hand operated and resembles modern, gas-operated revolver cannon.

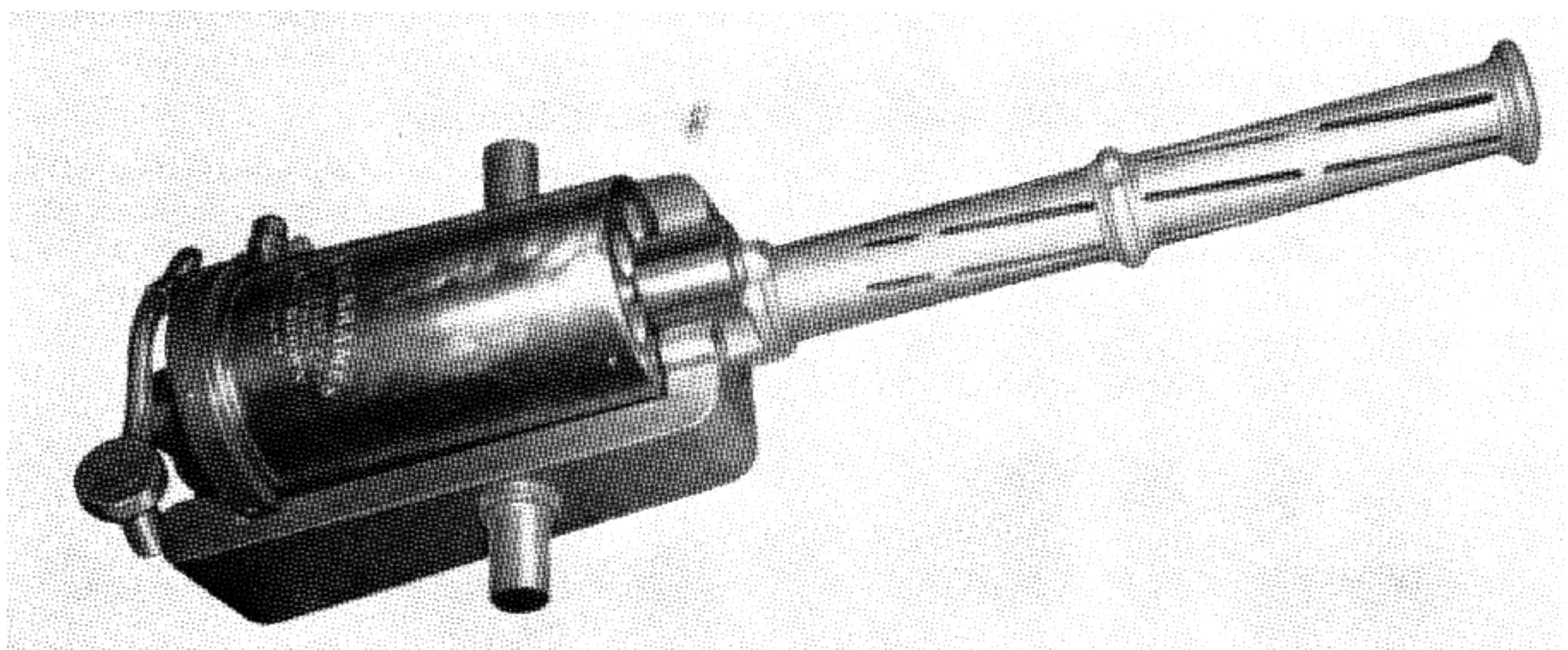


Figure 2-16. The DeBrame Gun. View from above, showing the patent date.

CASE A: ELLIPTICAL ARC. This profile was used in the T110. Three different periods of operation were considered for the gas piston:

Case A1. Pressure system operative for a short interval following the firing stage.

Case A2. Pressure system operative until the drum roller approaches the curved portion of the cam.

Case A3. Pressure system operative during the entire rearward travel of the slide.

CASE B: PARABOLIC ARC. The pressure system is considered effective during the entire rearward travel of the slide.

CASE C: CIRCULAR ARC PLUS STRAIGHT-LINE TANGENT. The pressure system is considered effective during the entire rearward travel of the slide.

CASE D: TWO TANGENTIAL PARABOLIC ARCS. This cam profile is approximately the same as that used in the German MG-213. The pressure system is considered inoperative until the drum roller approaches the curved portion of the cam.

Equations of motion of cam slide and drum were derived from the various conditions listed, neglecting friction. Solutions were presented showing the components of forces of the cam face perpendicular to the direction of slide motion. The components of the forces in the direction of slide motion were small for all cases considered.

The maximum forces acting between the drum roller and the cam face during the rearward travel of the slide are of the order of 16,000 to 17,000 pounds for the cases considered. The high value is due to cam profiles with severe discontinuity in the radius of curvature. For the elliptic cam selected for the T110 weapon, the maximum force is of the order of 7,000 pounds.

Further analytical study also indicated that for a given cyclic rate the effect of varying the interval during which the pressure-driving system is operative has little effect on the forces acting on the cam faces. Increasing the duration of the pressure stroke, however, permits the use of a smaller diameter piston.

Analysis of Forces on the Receiver. A study of the forces acting on the receiver indicated that the section of the receiver between the trunnion and the points of mounting (directly under the T-slots for guiding the rear end of the drum support) would be subjected to a torque of 7,500 inch-pounds or

less. In this study it was considered that the critical forces transmitted to the receiver were those resulting from drum rotation. The maximum force between the drum roller and the cam was computed to be approximately 700 pounds, and this value was used in computing the torque acting on the receiver.

Analysis of Forces on the Drum Support. A study of the forces acting on the drum support indicated that the drum support would be subjected to an axial tension of approximately 80,000 pounds. In this study, it was considered that the critical force acting on the drum support was the force produced by a maximum powder pressure of 65,000 p. s. i.

Tests and Modifications

During the firing tests the following difficulties, failures, and deformation of parts were encountered.

Firing Pin. The anvil of the firing pin failed where the body joins the larger diameter anvil. Increasing the thickness of the anvil eliminated this difficulty.

Slide Guideways. The slide guideways in the aluminum receiver deformed under the force of the drum roller on the cam, causing the slide to bind in the ways. A steel plate was set into the receiver between the guideways to increase their lateral stiffness.

Gas Pistons. Impact of the gas piston against the end of the cylinder upset the end of the cylinder around the piston rod, causing it to seize. Replacing the chamfer around the piston rod hole with a counter bore eliminated this difficulty. The piston rods also bent and failed where they join the pistons. To reduce this weakness, the length of the piston rods was decreased by increasing the length of the cylinder.

Rammer. High-speed motion pictures showed that the rammer vibrated excessively during ramming. Reinforcing rims were added to reduce this vibration.

Receiver. High-speed motion pictures showed that the rear end of the receiver deflected downward about the rear point of support an excessive amount at the end of the counterrecoil stroke of the drum support. Since there is no force acting directly on the rear end of the receiver which could cause such a deflection, it was attributed to the force of impact of the recoiling parts upon the trunnion yoke, which, acting below the center of mass, produces a couple

in the weapon which causes the receiver to bend upward between the trunnions and rear points of support. This deflection indicates the necessity of designing the receiver for greater rigidity. For all subsequent firings, the rear end was clamped firmly to the firing mount to prevent deflection.

Switch Tongue. The cam surfaces of the switch tongue upset near the pivot end from impact of the drum roller. To eliminate this condition, the slide and switch tongue were modified by shortening the length of the cam surface on the switch tongue and adding to the slide the portion of the cam surface removed from the tongue. This allowed more time for switching the tongue before the roller contacted it; the additional switching time permitted switching by the switch tongue cam and not by impact of the drum roller. Also, it was necessary to increase the hardness of the switch tongue from 40 Rc to 50 Rc to prevent deformation of the cam surface by the pressure of the drum roller.

The stop pad on the under side of the switch tongue and the surface of the slide contacted by the stop pad deformed also. This condition was eliminated by increasing the thickness of the pad from three thirty-seconds of an inch to seven thirty-seconds of an inch.

In an attempt to eliminate the various difficulties experienced with the switch tongue and switch cam in the three 20-mm models tested, a different type of slide and drum actuating cam was conceived. A wood model of this cam, called the "butterfly" cam, was made. The beveled edge on each side of the slide forms a cam surface for the drum rollers. These two surfaces, sliding between two rollers, maintain alinement of the drum with the bore during the time the rollers are in contact with the straight portions of cam.

On each side of the slide, at the curved portions of the cam track, is a movable piece, referred to as a cam wing, which pivots about a shaft running parallel to the direction of slide travel. The two wings are connected with a cross link which causes them to move together. The left wing is spring loaded in such a way as to cause it to be normally depressed while the other wing is held in alinement with the beveled cam surface of the slide proper.

As the slide moves rearward, the left cam roller clears the depressed wing and enters the curved cam path while the other roller follows the active cam

surface of the opposite wing to cause the drum to rotate in a counterclockwise direction. As the drum continues to rotate and the slide reverses direction, the roller in the cam path depresses the active wing and follows the curved cam surface on the slide. At the same time the left wing moves up into alinement with the cam surface of the slide proper just as the next roller of the drum moves into engagement with it.

As the slide returns forward to battery position, the straight portions of the cam surface moving between the two drum rollers maintain alinement of the drum chamber with the bore.

This slide arrangement appeared to have the following advantages over the switch tongue type of slide.

1. It was expected that impact of moving parts of the cam would be reduced greatly.
2. The drum rollers were mounted between chamber openings instead of directly over them. This permitted the roller studs to be attached to the drum rather than to be made an integral part of the drum and simplified drum construction.

Development of a cam of the butterfly type for the 20-mm automatic gun T110 was not undertaken during this period of the contract.

Extractor. The main difficulty encountered during the firing test was the same as that encountered in the previous model; that is, insufficient extraction velocity of the empty cases to clear the feeder sprocket. Various modifications of the extractor were made in an attempt to increase this velocity. The leading edge of the extractor pawl was sloped so that the drum rotated into extraction position, the pawl cammed the case out of the chamber and broke it loose before extracting. Also, the extractor was more rigidly attached to the drum support to eliminate vibration and to provide greater resistance to the forces of extraction. A new extractor lever and various pickup lugs designed to give a greater extraction velocity, by increasing the mechanical ratio, were made and tested.

These changes did have some beneficial effect but did not improve the extraction velocity sufficiently to insure that the cases would always clear the feeder sprockets. The changes resulted also in a decrease in cyclic rate, because more energy was taken from the slide by extraction, thus decreasing the average velocity of the slide after extraction

began. Other methods of extraction and ejection, therefore, were investigated.

Schematic drawings were made that showed an extractor which utilizes an air spring restoring energy taken from the propellant gases. Release of the air spring sear by forward motion of the slide permitted the piston to move rearward under the action of the air spring and actuate the extractor. Such a system allowed the storing of as much energy as is needed for extraction. Since it required merely that the slide trip the sear, it had no effect on cyclic rate.

ARF engineers designed an extractor which utilized hydraulic fluid to transmit kinetic energy from the slide to the extractor. This system, like the mechanical system installed on the weapon, affected the cyclic rate of the weapon.

A type that showed the most promise, however, was a mechanical extractor very similar to the British type. It had a mechanical ratio of 3 to 1, whereas the British type had a mechanical ratio of $2\frac{1}{2}$ to 1. Also it was designed to have less friction than the British type.

The use of a nondisintegrating ammunition belt with links designed to receive the ejected cases was considered also as a means of overcoming the ejection problem. Such an arrangement would require only sufficient case velocity to seat the empty case in the link before the feeder rotates to eject the link with the empty case. With a lower extraction velocity required, the British type extractor probably would be satisfactory.

The use of nondisintegrating belt links had other advantages. The ejected belt and cases could be confined within the gun compartment. Also, a force could be applied, through sprockets, to the ejected belt to prevent jamming of the gun when an acceleration force opposing ejection was applied during maneuvering of the aircraft. The ejected belt could be fed to a position where it would best maintain the weight distribution within the aircraft.

A pilot model link and test feeder were made, and tests of this type of feeder and link arrangement proved very promising. Development of a link and feeder for the weapon was then initiated.

By this time, a new contract for continuation of work after 31 December 1949 had been written.

This included further development of extractors and nondisintegrating links.

Cyclic Rate. In an effort to improve cyclic rate, firing tests were conducted with larger orifices and stronger slide drive springs mounted on extension rods through the rear of the receiver. These tests indicated that the heavier drive springs produced a shorter cyclic time due largely to a better carry-through of the slide during extraction. However, tests to determine the optimum orifice diameter and slide drive spring rate were not completed during the period of this contract.

Performance Data

Cyclic Rate. Because of ejection difficulties, very few bursts of more than five rounds were fired during the period of the contract. (The longest burst fired was 12 rounds.) Therefore, cyclic rate data obtained were based upon the time of cycle for individual rounds or, at best, for several rounds.

The accompanying table lists cyclic rates obtained under various conditions but without any ammunition belt load. These data indicate the desirability of a large gas orifice, heavy slide drive springs, and lightweight slide for high cyclic rates.

Cyclic Rates of 20-mm Automatic Gun T110 Under Various Conditions

Orifice diameter (inches)	Drive spring rate (pounds/ inches)	Weight of slide (pounds)	Approximate cyclic rate (rpm)
0.093.....	5	*9.6	1,040
.093.....	5	**11.2	886
.093.....	13.2	***13.7	1,230
.110.....	13.2	13.7	1,350

*Original weight of slide.

**Weight increased to determine effect of slide weight on cyclic rate.

***Weight increase due to modification of slide for use with heavier springs.

Recoil, Time-Displacement, and Trunnion Reactions. From a typical time-displacement record for two rounds, the cyclic rate was computed to be 1,206 rounds per minute. On the first round, the slide velocity during recoil was of the order of 48 feet per

second, and during counterrecoil it was of the order of 16 feet per second. After the slide struck the extractor lever, the slide velocity was reduced to approximately 12 feet per second.

One test was conducted to determine the trunnion reactions. A special firing mount was constructed to obtain this measurement by means of strain gages mounted on linkages which transmitted the trunnion

reactions. This single test indicated a total reaction of the order of 8,000 pounds.

Extraction. Velocity of extracted cases determined from high-speed motion pictures was of the order of 40 to 45 feet per second. This velocity was not sufficient for the case to clear the feeder sprockets except at case-extraction velocities of approximately 85 feet per second.

SECTION 6. GUN, AUTOMATIC, CALIBER .60 T130 MODEL D

In the late 1940's, there was a demand for a higher-velocity projectile which apparently could be fulfilled only by employing the existing caliber .60 round of ammunition. The official designation T130 was assigned on 1 December 1950 to a specific type of weapon employing the conventional caliber .60 round of ammunition. Shortly thereafter the Armour Research Foundation was given a contract to develop the gun.

General Description and Principles of Operation

The caliber .60 automatic gun T130 is a gas-operated, belt-fed, electrically fired, percussion-charged weapon. By changing certain parts, it may be changed from left-hand to right-hand feed. The following description applies to the weapon when assembled for right-hand feed.

The distinguishing feature of this weapon is a re-

volving drum, containing five cartridge chambers parallel to its axis of rotation and mounted upon a shaft within the drum support, so that each chamber is brought into alignment with the bore of the barrel and momentarily stopped when it reaches the 6 o'clock position during drum rotation.

The barrel is housed in a tube support attached to the front end of the receiver and is retained by interrupted screw threads and a latch in the front end of the drum support. When assembled to the receiver, the hexagonal front end of the drum support engages a hexagonal socket in the rear end of the tube support.

The rear end of the drum support is supported at each side by an L-slotted block attached to the receiver. The barrel, drum, drum support, and other parts attached to the drum support constitute the recoiling parts of the weapon and are guided in recoil by the tube support at the front end of the

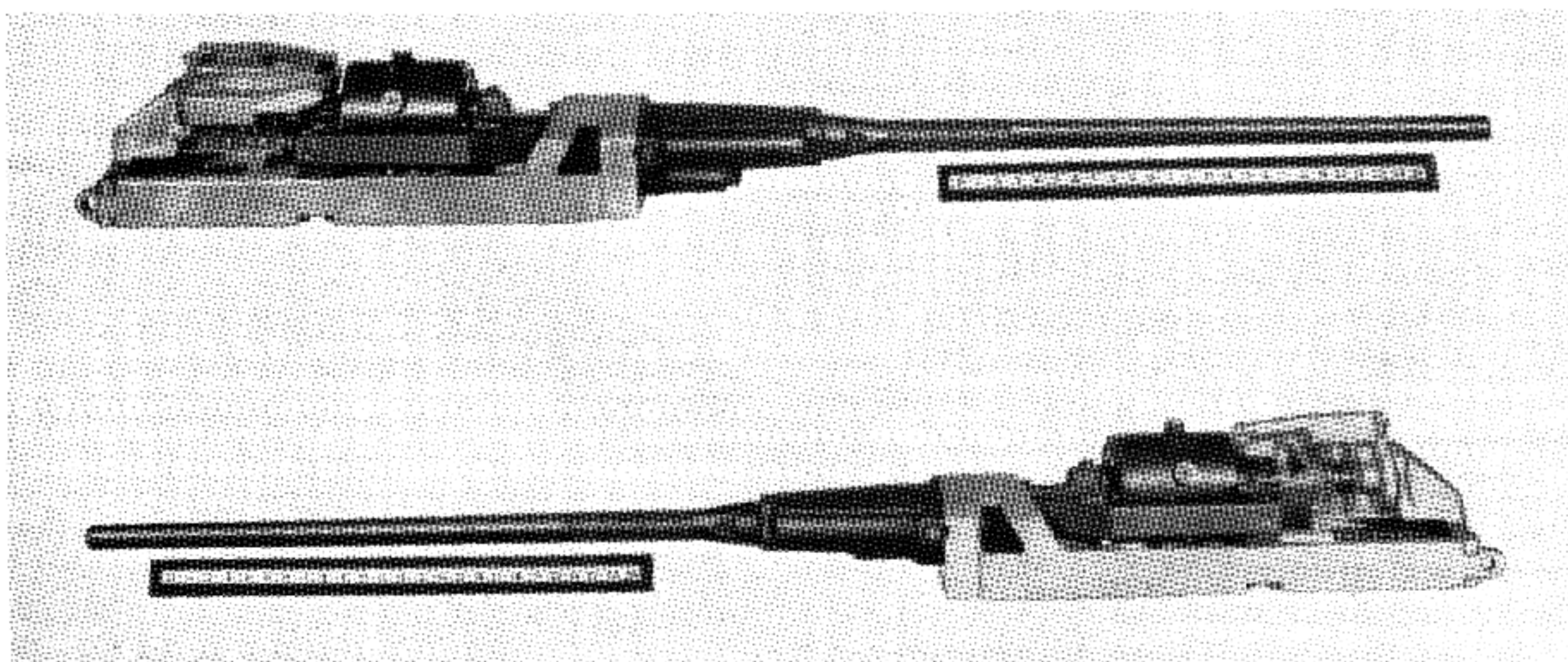


Figure 2-17. United States Ordnance Corps Caliber .60 Automatic Gun, T130, Model D.

receiver and by the L slots at each side of the rear end. Recoil and counterrecoil forces are limited by two sets of ring springs housed in the tube support, one on each side of the tube, and are transmitted to the springs by rods which are attached to lugs on the front end of the drum support.

A chamber in the drum is held in alinement with the barrel during firing and is indexed to bring the adjacent chamber in alinement with the barrel by means of five rollers on the periphery of the drum

which engage a cam track on an actuating slide in the bottom of the receiver. The actuating slide is moved rearward by a piston which receives its energy from powder gases bled from the barrel into the cylinder in the front end of the drum support. The slide is returned to its forward, or in-battery, position by interaction between the rotating drum and the cam in the actuating slide, assisted by two stranded wire drive springs. The slide has a switch tongue which pivots about a pin through its forward

General Data: Caliber .60 T130 Model D

Gun length, overall: 72 inches. Gun weight: 187 pounds. Rate of fire: 1,200-1,300 rounds/minute. Muzzle velocity: 3,400 feet/second. System of operation: Gas rotation of cylinder. System of locking: Revolver principle. System of feeding: Disintegrating metallic link. Method of headspace: Factory established (cannot be adjusted). Location of feed opening: Left hand rear. Location of ejection opening: Right hand. Method of charging: Cartridge. Method of cooling: Air. Weights of major subassemblies: Receiver and tube support assembly (including switch cam, charger bracket, recoil springs, ways): 41.9 pounds. Drive springs, guide rods, end gate: 2.6 pounds. Feeder and drum shaft assembly: 9.9 pounds. Drum assembly: 22.2 pounds. Drum support assembly (cast): 29.1 pounds. Actuator slide assembly: 11.8 pounds. Total weight of major subassemblies without charger T10, charger cylinder, and gasline: 148.8 pounds. Charger cylinder and piston assembly: 4.1 pounds. Charger T10: 7.5 pounds. Gasline: 1.6 pounds. Total weight of major subassemblies including charger T10, charger cylinder, and gasline: 162.0 pounds. Weights of recoiling parts: Drum assembly. (See above.) Drum shaft: 1.3 pounds. Feeder shaft: 0.6 pound. Drum support assembly. (See above.) Barrel: 31.3 pounds. Recoil springs (1/2 weight): 0.8 pound. Recoil rods and nuts: 1.6 pounds. Switch cam: 1.5 pounds. Total weight of recoiling parts: 88.4 pounds.	Barrel length: 53.56 inches. Barrel weight: 31.3 pounds. Rate control: None. Barrel removal: Not quick change type. Bore: Number of grooves: 8. Groove depth: 0.016±.002 inch. Groove width: 0.150±.010 inch. Pitch: 1 turn in 18 inches. Direction of twist: Right hand. Form of twist: Constant. Weight of parts moving with actuator slide: Actuator slide assembly: 11.7 pounds. Drive springs (1/2 weight): 0.4 pound. Total weight of parts moving with actuator slide: 12.1 pounds. Overall width: 8 inches. Overall height: 7 7/8 inches. Distance from muzzle to rear end of chamber: 59.90 inches. Diameter across grooves: 0.604 inch. Diameter across land: 0.588 inch. Gas piston diameter: 1.125 inches. Gas piston stroke: 1.625 inches. Length of recoil springs for 1,250 pounds preload: 7.24 inches. Free length of slide drive spring: 15 5/8 inches. Miscellaneous design data: Type of charger: Percussion. Type of firing: Electrical. Preload in recoil spring: 1,250 pounds. Total drive spring load, slide forward: 80 pounds. Total drive spring load, slide rearward: 187 pounds. Performance data: Length of recoil: 1/2 inch, approximate. Slide stroke: 5 1/2 inches. Recoil force: Less than 5,000 pounds. Counterrecoil force: Less than 5,000 pounds. Velocity of extracted cases: 80 feet/second, approximately.
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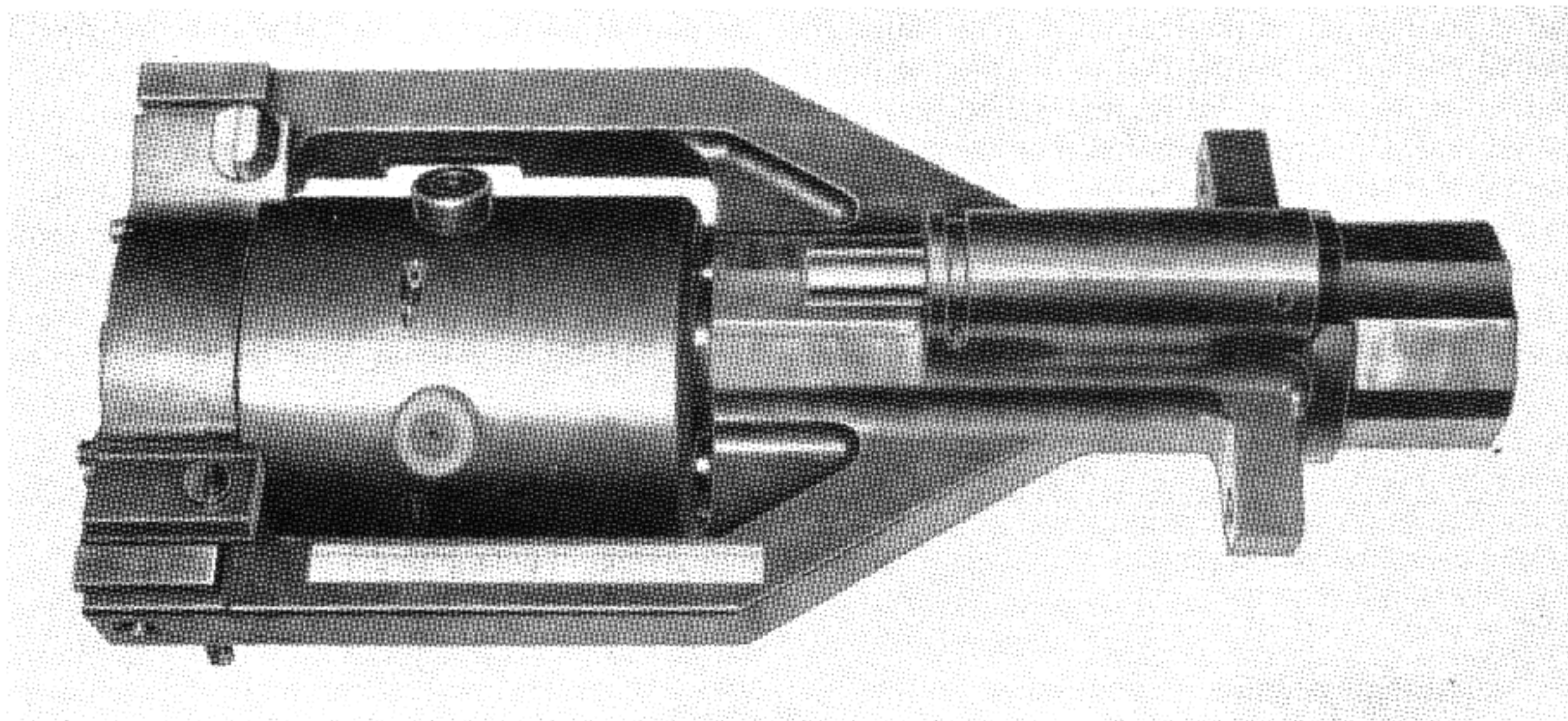


Figure 2-18. Automatic Gun, Caliber .60, T130. Drum and drum support assembly.

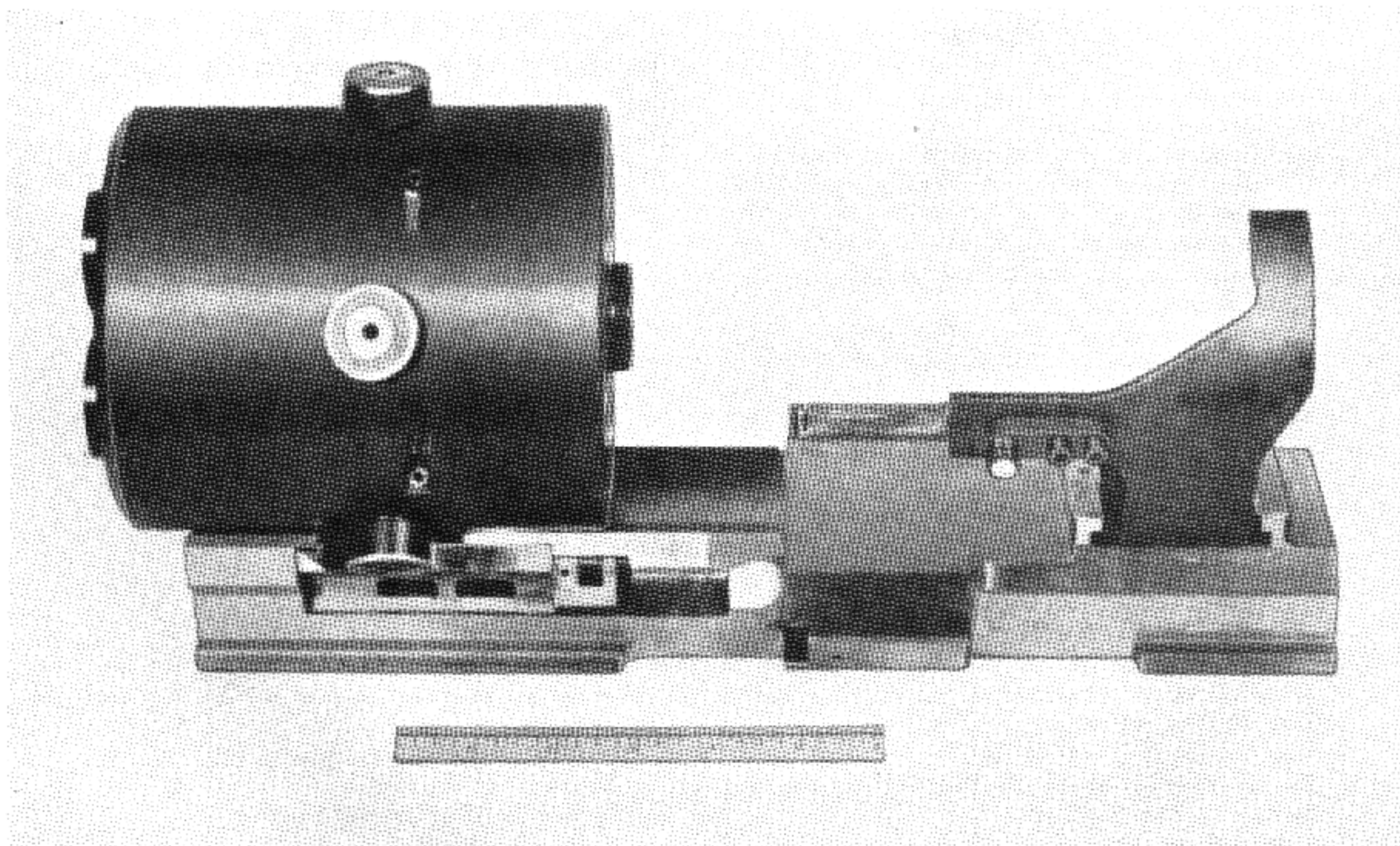


Figure 2-19. Automatic Gun, Caliber .60, T130. View showing engagement between drum rollers and actuating slide. (Slide in forward travel after exciting roller has depressed the right butterfly cam wing and caused the left wing to rise into engagement with the oncoming roller.)

end to change cam path. The switch tongue is moved from one side to the other during slide travel by a pin extending through the slide and engaging a switch cam in the bottom of the receiver. The switch cam is attached to the drum support by ears on the front end of the cam which engage a groove around the gas cylinder. The switch cam recoils with the drum support in slideways attached to the bottom of the receiver.

When the gun is ready to fire, the slide is in its forward position, the switch tongue is on the left side, and a drum roller is engaged by the straight portion of the cam path at the rear end of the slide, which maintains alinement of the chamber with the bore.

When the round is fired, the slide is driven rearward by the gas piston. The drum roller, in following the cam path to the right, causes the drum to rotate in a counterclockwise direction (when looking from the rear toward the muzzle). As the active roller emerges from the right side of the cam, the next roller enters the cam track on the left side. At

the same time, the switch tongue is cammed to the right to permit the roller to move into the straight portion of the cam as the slide returns to its forward position by kinetic energy transferred by the drum and by pressure of the drive springs. This brings the next chamber in alinement with the barrel. When the roller passes the rear end of the switch tongue, the switch tongue is cammed to its left position again.

Ramming is accomplished in two stages by means of a rammer, which is attached to the actuating slide. A five-station feeder sprocket in the feeder, located to the rear of and in alinement with the drum, is driven by the drum through a shaft extension and maintains the rounds in the ammunition belt in alinement with the chambers in the drum, as the linked ammunition is pulled into the feeder from the right side of the gun. Upon firing, the gas piston drives the slide rearward.

On the forward, or return, stroke of the slide, the upper ramming face of the rammer engages the base of a cartridge and pushes it through the link and partially into the chamber in line with the cartridge.

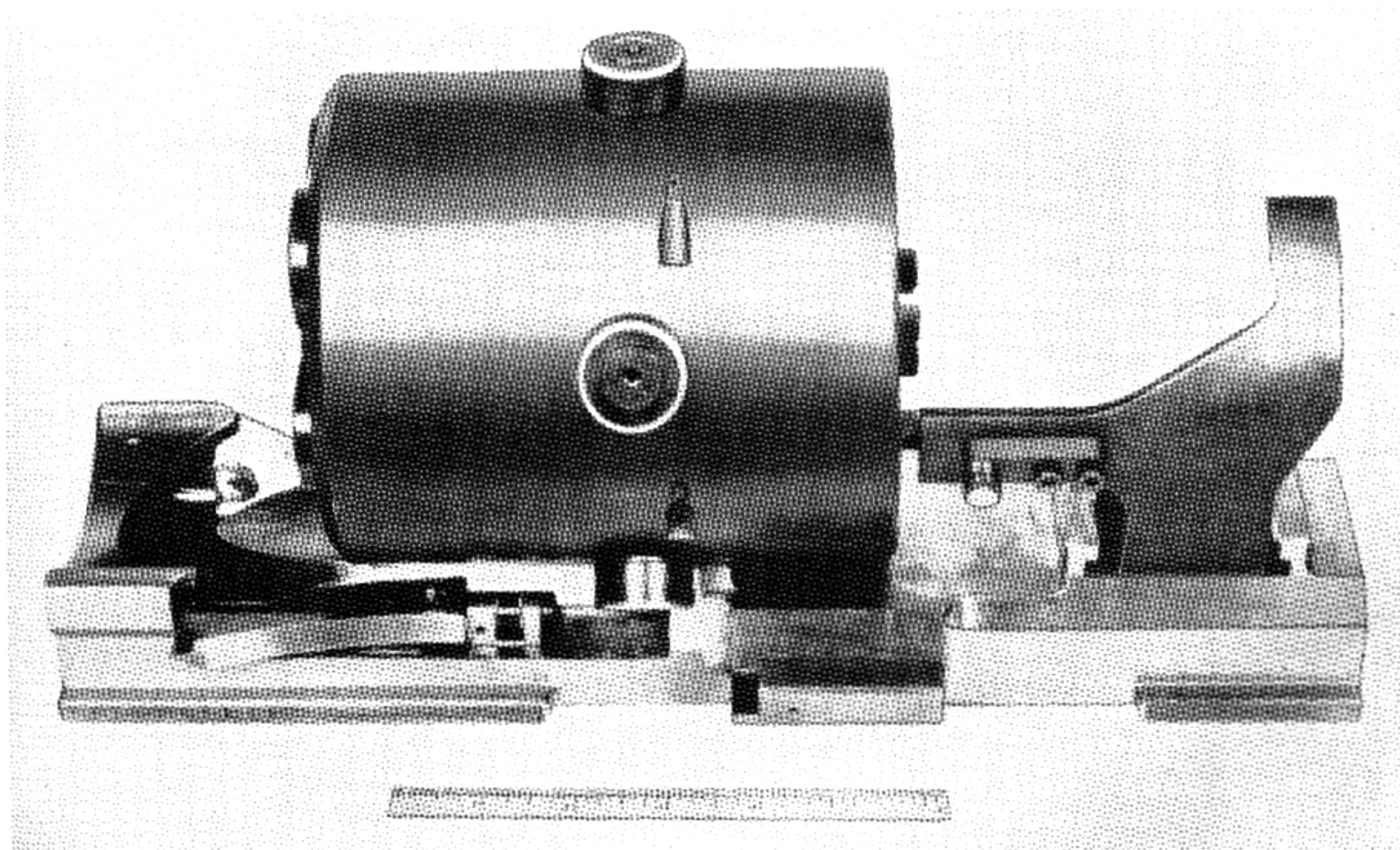


Figure 2-20. Automatic Gun, Caliber .60, T130. View showing engagement between drum rollers and actuating slide (Slide forward.)

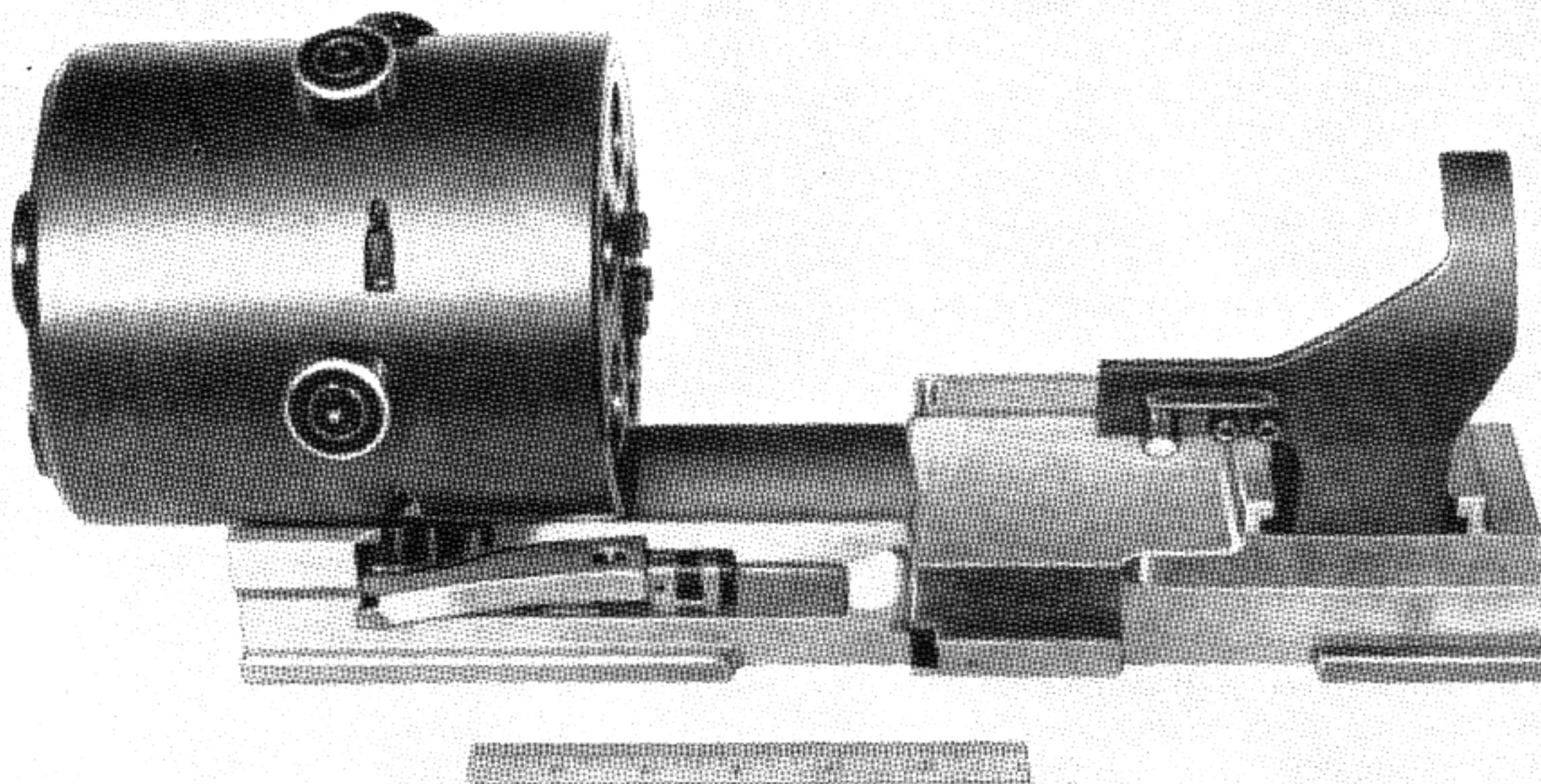


Figure 2-21. Automatic Gun, Caliber .60, T130. View showing engagement between drum rollers and actuating slide. (Slide rear.)

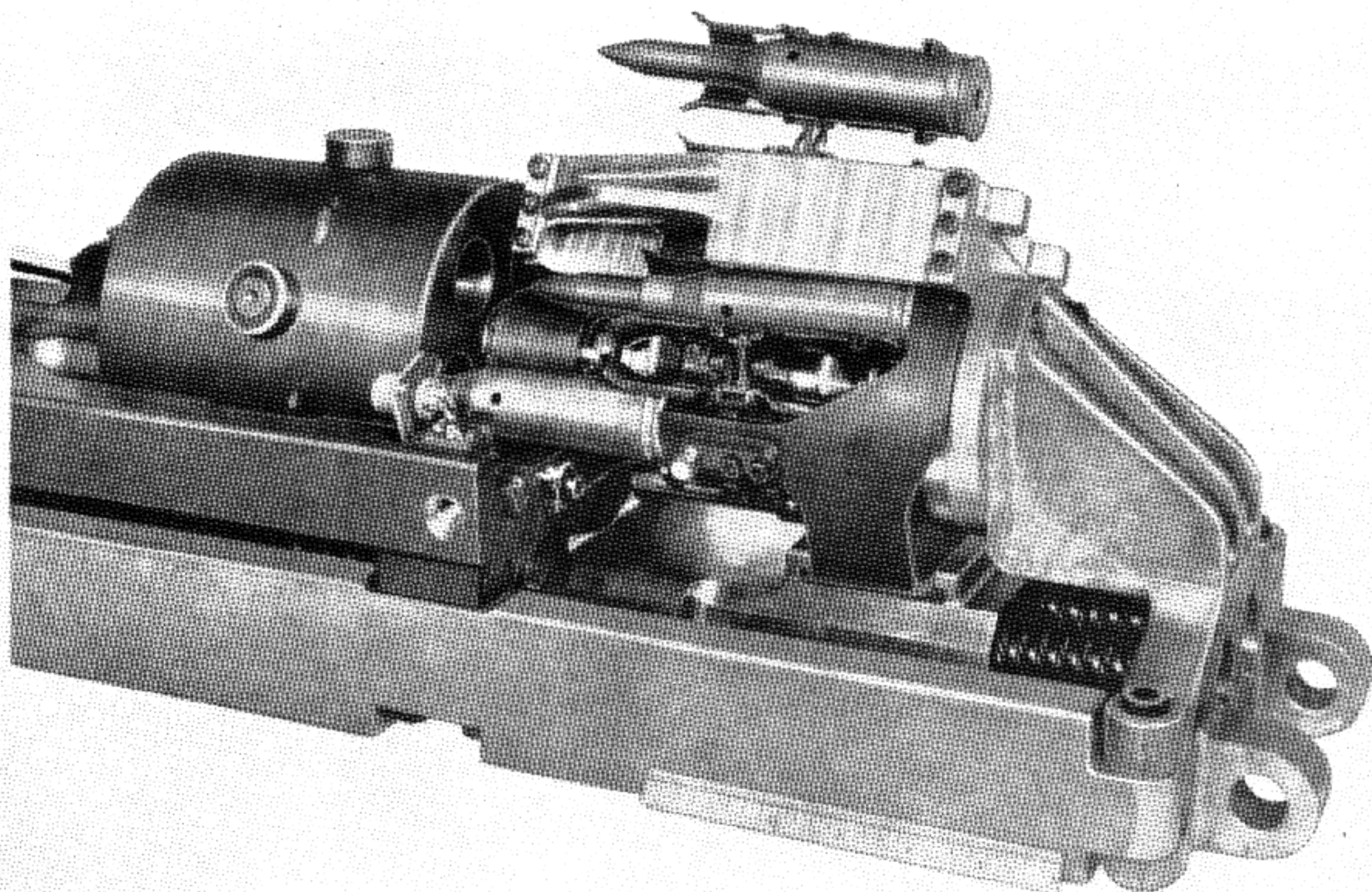


Figure 2-22. Automatic Gun, Caliber .60, T130. View showing start of ramming stroke.

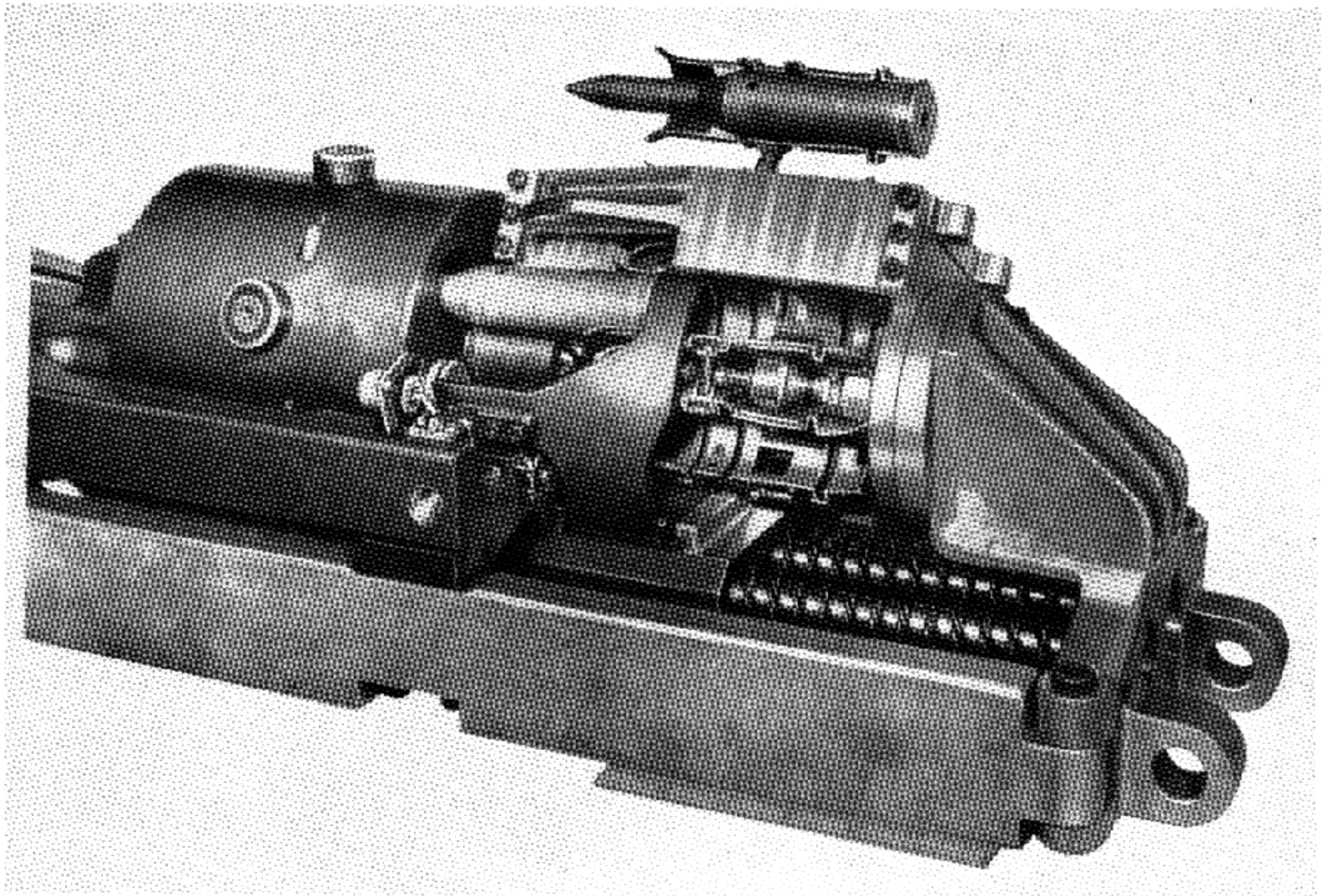


Figure 2-23. Automatic Gun, Caliber .60, T130. View showing completion of ramming stroke.

At the same time, the lower ramming face of the rammer contacts the base of the cartridge which was partially rammed on the previous cycle and completes chambering it. A spring-loaded detent in the rear end of the drum support retains the rammed cartridge in the chamber.

Simultaneously with the ramming action just described, the round which was completely chambered on the previous cycle moves into alignment with the barrel and into contact with the firing pin, and the expended case of the round which was fired at the start of the cycle moves into engagement with the extractor, located on the right side of the drum support.

The extractor is actuated by a striker located in a lug on the right side of the slide, which strikes a lug on the lower end of the extractor shaft and causes it to rotate. This occurs on the forward stroke of the slide when it is about 2 inches out of the battery immediately after the drum has ceased rotating and

the empty case has been engaged by the extractor.

Firing occurs just as the slide reaches its battery position. Firing is initiated electrically by the engagement of a male contact on the slide with a female contact on the rear end of the drum support. Closing of these contacts permits an electric current from an external power source to flow through the firing pin into the electric primer.

Two types of feeders are provided for this weapon: the disintegrating type and the relinking type. The disintegrating type ejects the empty links through the lower opening on the right side of the feeder and deflects the extracted cases to the right as they are ejected rearward. Without cases or rounds in them, the links are free to separate. The relinking type feeder positions the empty links in line with the extraction station, where they receive the extracted case. Cases and links are then ejected in a continuous belt through the lower opening on the right side of the feeder.

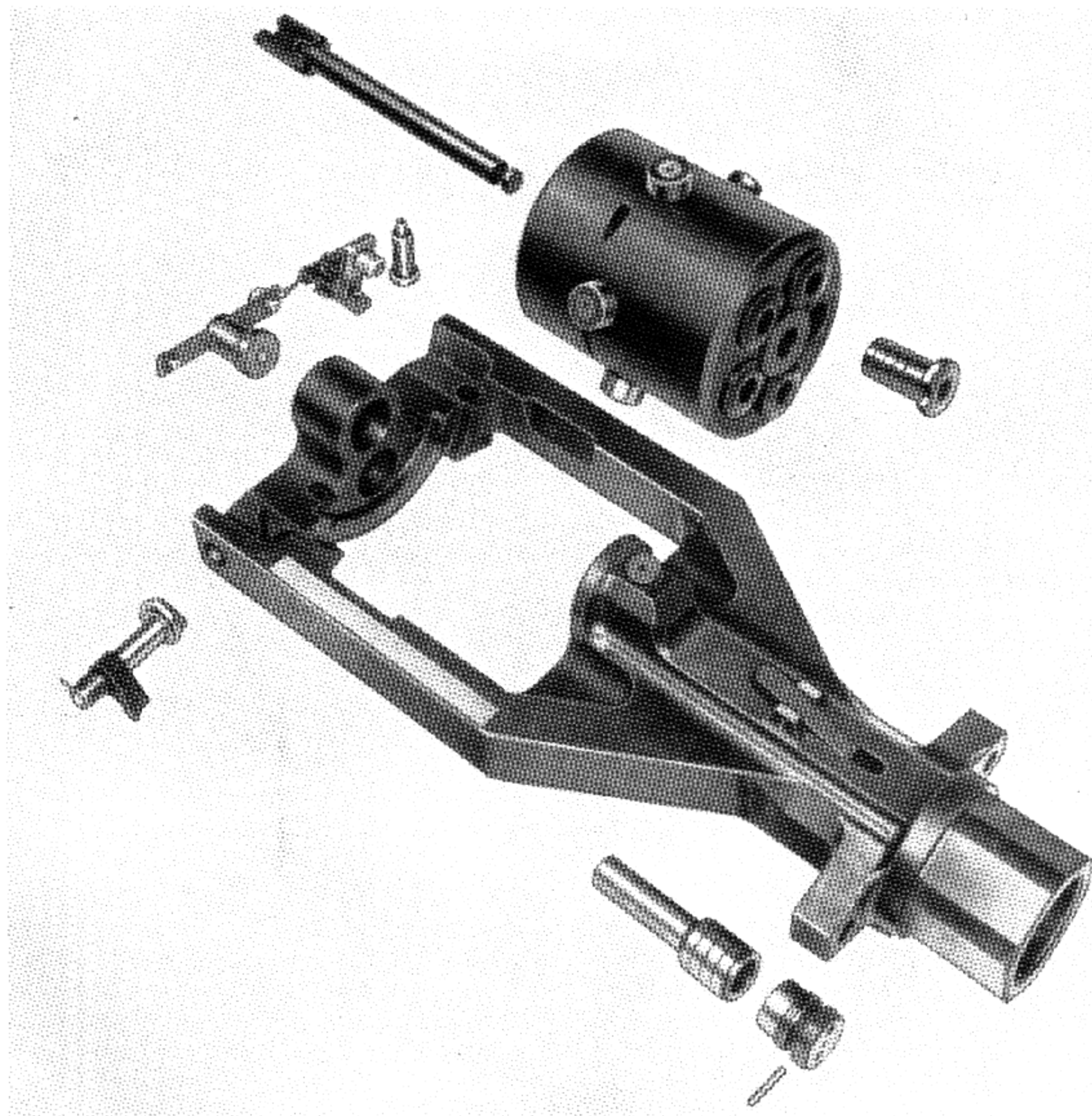


Figure 2-24. Automatic Gun, Caliber .60, T130. Drum and drum support, disassembled.

Obturation between the forward end of the chamber and the end of the barrel is accomplished by means of sealing sleeves, which are held against the face of the barrel by the pressure of the propellant gases acting on the rear of the sleeve. The weapon is charged by a gas piston in a cylinder housed in the receiver and tube support. It is actuated by gas pressure from the firing of a caliber .30 grenade cartridge M3 in the percussion charger T10. The pis-

ton charges the weapon by forcing the actuating slide to the rear. The percussion charger T10 and the charger cylinder were developed under a contract separate from the caliber .60 gun T130 model D.

Description of Design and Construction Features

The weapon is designed for transmission of the recoil forces through trunnions cast integrally with the steel tube support, which also houses the recoil

springs. The rifling torque and the torque produced by the force of the drum roller on the actuating slide cam are transmitted through the trunnions by means of the hexagonal bearing at the front end of the drum support and the mating hexagonal socket in the rear end of the tube support. However, because of flexure of the sidearms of the drum support, some of the torque produced by the force of the drum roller on the actuating slide cam is transmitted to the receiver through the L-slot connections at the rear end of the drum support. This torque can be transmitted directly to the gun-mounting structure by changing the location of the rear mounting points to directly under the drum support L slots. This latter position was made possible by providing a hole in each slide of the receiver under the drum support L slots, allowing engagement of the points with a supporting trunnion on the gun-mounting structure. Similar holes have been provided near the rear end of the receiver; however, it is recom-

mended that the gun be supported at the drum support L slots, as this location subjects the weapon to minimum stress, and results in minimum dispersion when firing from a rigidly supported structure.

Because of the arrangement just described, it was possible to design the receiver for minimum loads and cast it from an aluminum alloy. At points where the receiver engages moving parts, steel mating members (drum support L-slot supports, actuating slideways, switch cam slideways), have been bolted to it. The receiver and tube support are held together with six socket-head cap screws and are aligned by the engagement of horizontal and vertical keys on the rear end of the tube support with mating key ways in the front face of the receiver.

The recoil ring springs are assembled to the recoil rods within sleeves, in the form of a cartridge unit, and have been tightened to a preload of 1,250 pounds. A cotter pin through the preload nut prevents loosening during firing. When assembled in

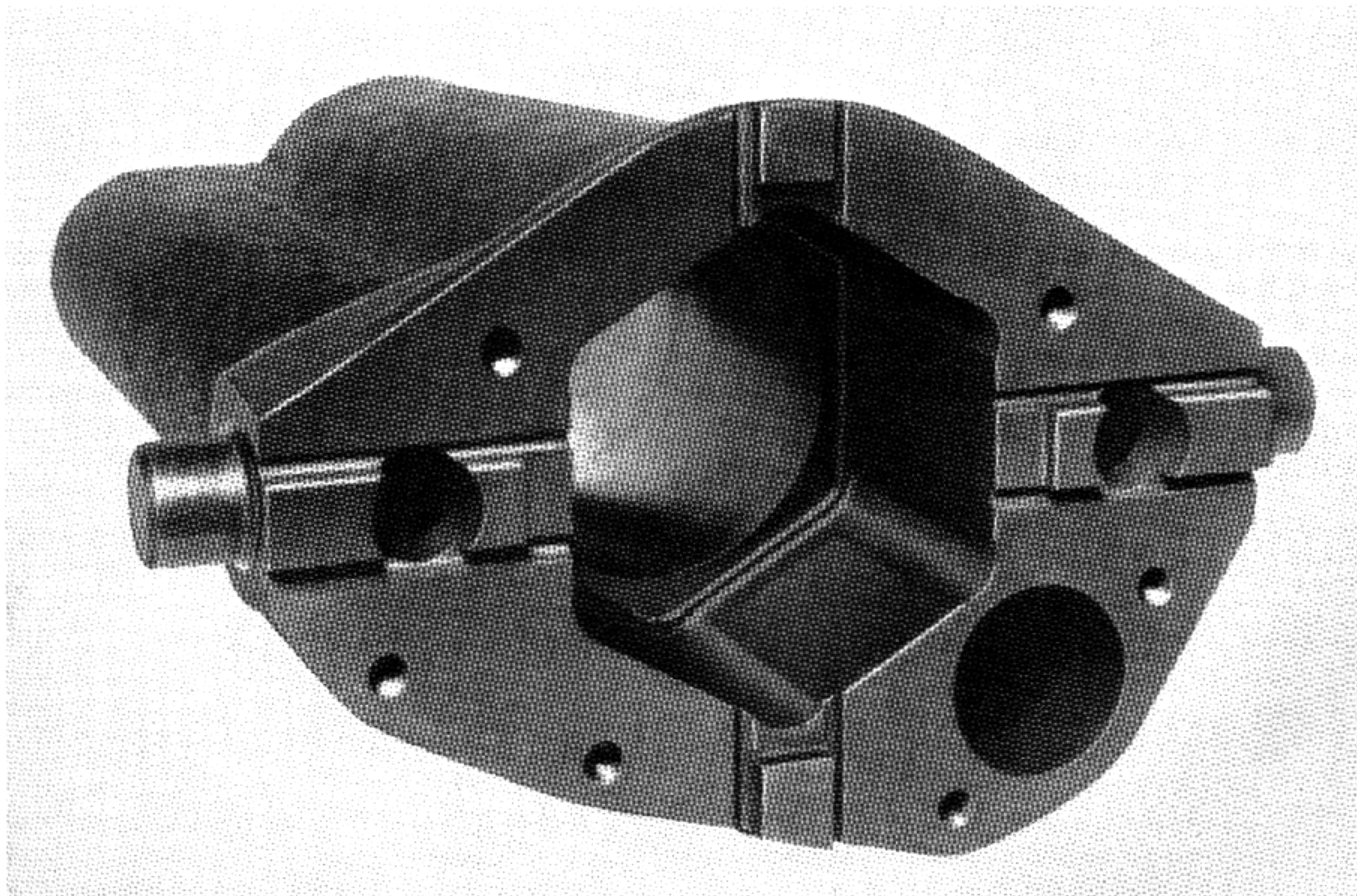


Figure 2-25. Automatic Gun, Caliber .60, T130. Trunnion.

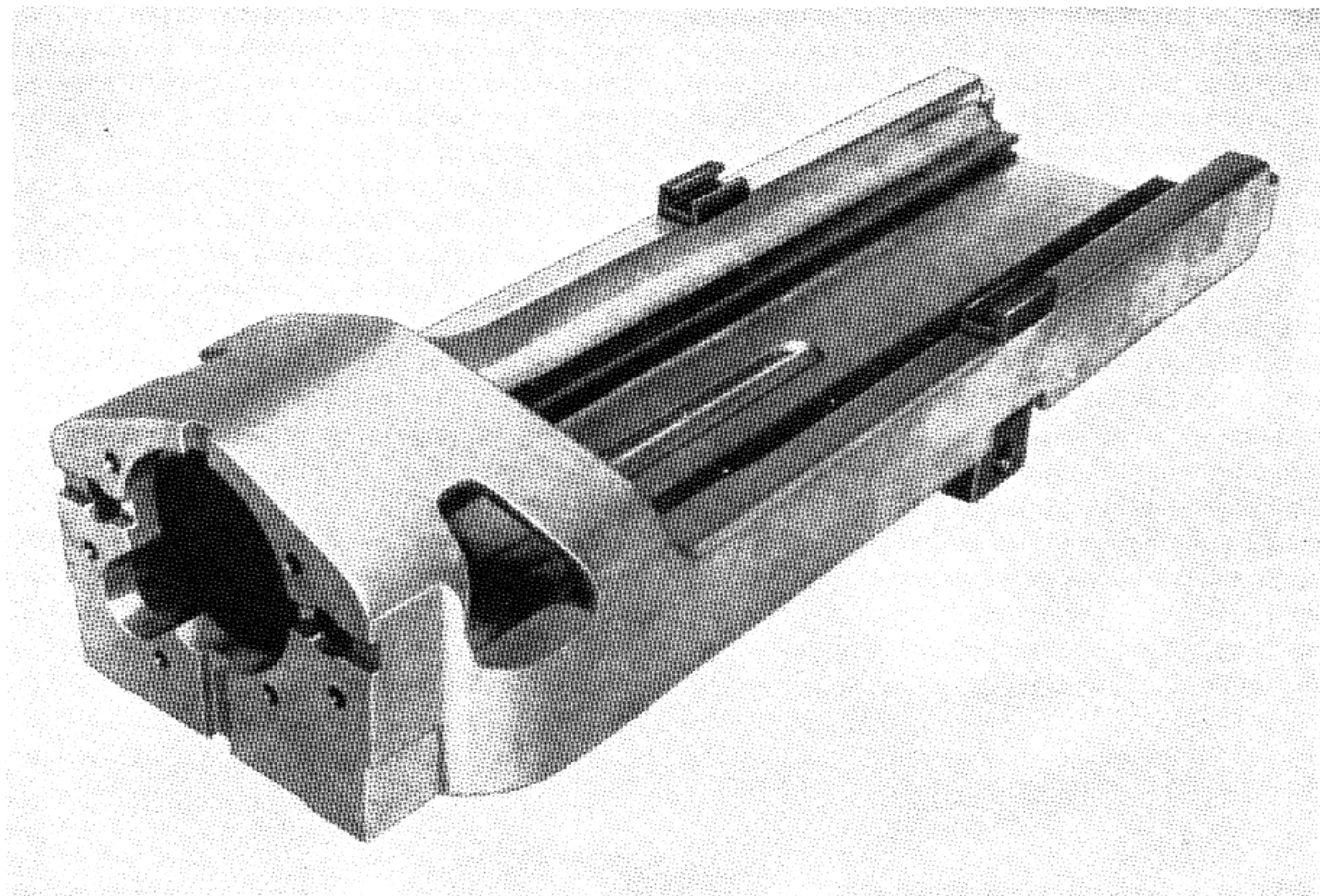


Figure 2-26. Automatic Gun, Caliber .60, T130. Receiver assembly.

the tube support, the recoil rods extend through holes into the receiver and attach to ears on the front end of the drum support. Plugs, screwed into the front end of the tube support against the front collar of the recoil spring assembly, position the springs against the rear ends of the cylinders, in such a way that there can be no free movement of the recoiling

parts in either direction without compression of the springs. Accordingly, the springs are double acting, and limit the counterrecoil forces as well as the recoil forces.

The tube is supported at two points, by a close fitting bore within the drum support and by a similar bore at the end of the tube support.

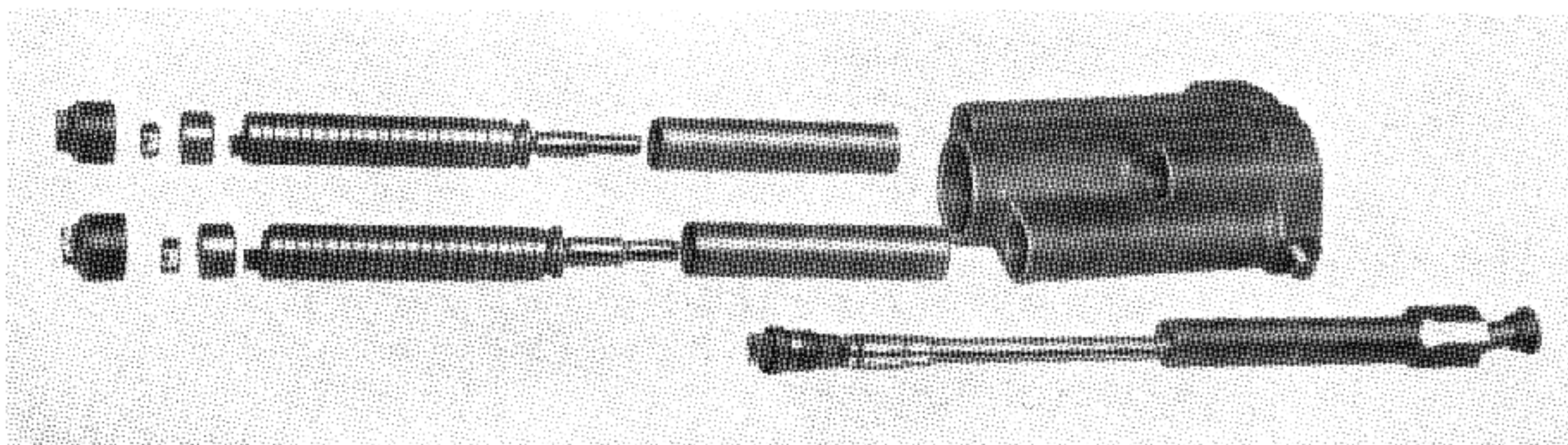


Figure 2-27. Automatic Gun, Caliber .60, T130. Trunnion group, disassembled.

Considerable force is exerted on the rear of the tube by the sealing sleeve on the rear end of the tube (approximately 38,000 pounds). To resist this force as well as the forward frictional force of the projectile, two sets of four interrupted threads have been provided on the tube, which engage mating threads in the front end of the tube support.

The gas cylinder which contains the piston for actuating the slide forms an integral part of the drum support. This arrangement permits bleeding gas from the tube through a straight passage leading directly from the tube into the gas cylinder. Since the gas cylinder is a part of the recoiling mass, the force exerted by the gas piston on the slide opposes the recoil force and reduces the load on the recoil springs by an amount dependent upon the size of the gas orifices.

Leakage of gas from the tube gas port between the tube and the mating bore of the drum support has been minimized by machining six labyrinth grooves in the tube, three on each side of the gas port.

Leakage of gas past the gas piston is prevented by three labyrinth grooves around the piston.

The rear end of the drum support houses the firing-pin assembly which serves as the anvil for supporting the case during firing. The firing pin assembly has been made small in diameter in order to provide for maximum strength in the rear end of the drum support. This strength is necessary because of (1) the concentrated load imposed on the drum support by the gas pressure acting on the cartridge case and (2) the distributed load imposed by the gas pressure acting on the bottom of the sealing sleeve recess in the drum.

The drum is machined from a forged steel billet. It contains five equally spaced chambers, with a gas sealing sleeve at the front of each chamber. Sealing against gas leakage between the sleeve and the sleeve recess in the drum is accomplished by four grooves around the sleeve, and by longitudinal grooves around the rear end of the sleeve at 90° spaced intervals. Gas pressure acting on the rear end of the sleeve forces the sleeve out against the face of the tube and prevents serious leakage of gas between the end of the sleeve and the face of the tube during firing. Around the periphery of the drum and radial with the chambers are five rollers mounted on studs and retained by blind snap rings. The studs are

integral with the drum, thus providing adequate strength in the outside chamber walls.

The drum is mounted upon a shaft supported in the drum support and is keyed to it by dogs machined on the rear end of the shaft. The shaft rotates with the drum and causes the feeder shaft to rotate with it by means of a universal joint connecting the two. This universal joint provides for any misalignment caused by deflections during firing. A spring-loaded latch pin in the front end of the drum support engages a groove in the end of the drum shaft to prevent axial motion.

The actuating slide fits in guideways in the bottom of the receiver and moves backward and forward beneath the drum and drum support under the action of the gas piston and the drive springs. Its stroke is 5½ inches. Machined into the slide are two cam paths which engage the drum rollers and cause the drum to rotate as the slide moves through its cycle. These two cam paths consist of curved portions 3½ inches long which curve in toward the longitudinal axis of the slide and merge into a central straight portion 2 inches long. A part of the inside edge of each cam path is formed by a movable member, called the switch tongue, which pivots about its forward end. The position of this switch tongue determines which cam path is made continuous throughout its length.

Underneath the slide is a cam which engages a stud on the switch tongue or a spring-loaded pin within the stud. This cam is designed so as to cause the switch tongue to move from one side to the other at the proper time in the cycle, thus changing the continuity of the cam path in the slide from one side to the other and causing the drum to move in one direction on both the rearward and forward stroke of the slide. The straight portion of the slide cam keeps the drum stationary for the first 2 inches of the rearward travel. Thus the chamber is aligned with the barrel while the projectile is in the bore during the first 2 inches of slide travel, and the empty case is at the extraction station during the last 2 inches of slide travel.

Variable relative motion between the drum and switch cam from round to round cannot be tolerated, as the switch tongue must be switched precisely at the proper position of the drum roller in the cam path. Therefore, since the drum is a recoiling part, and since the recoil cycle does not follow a consistent

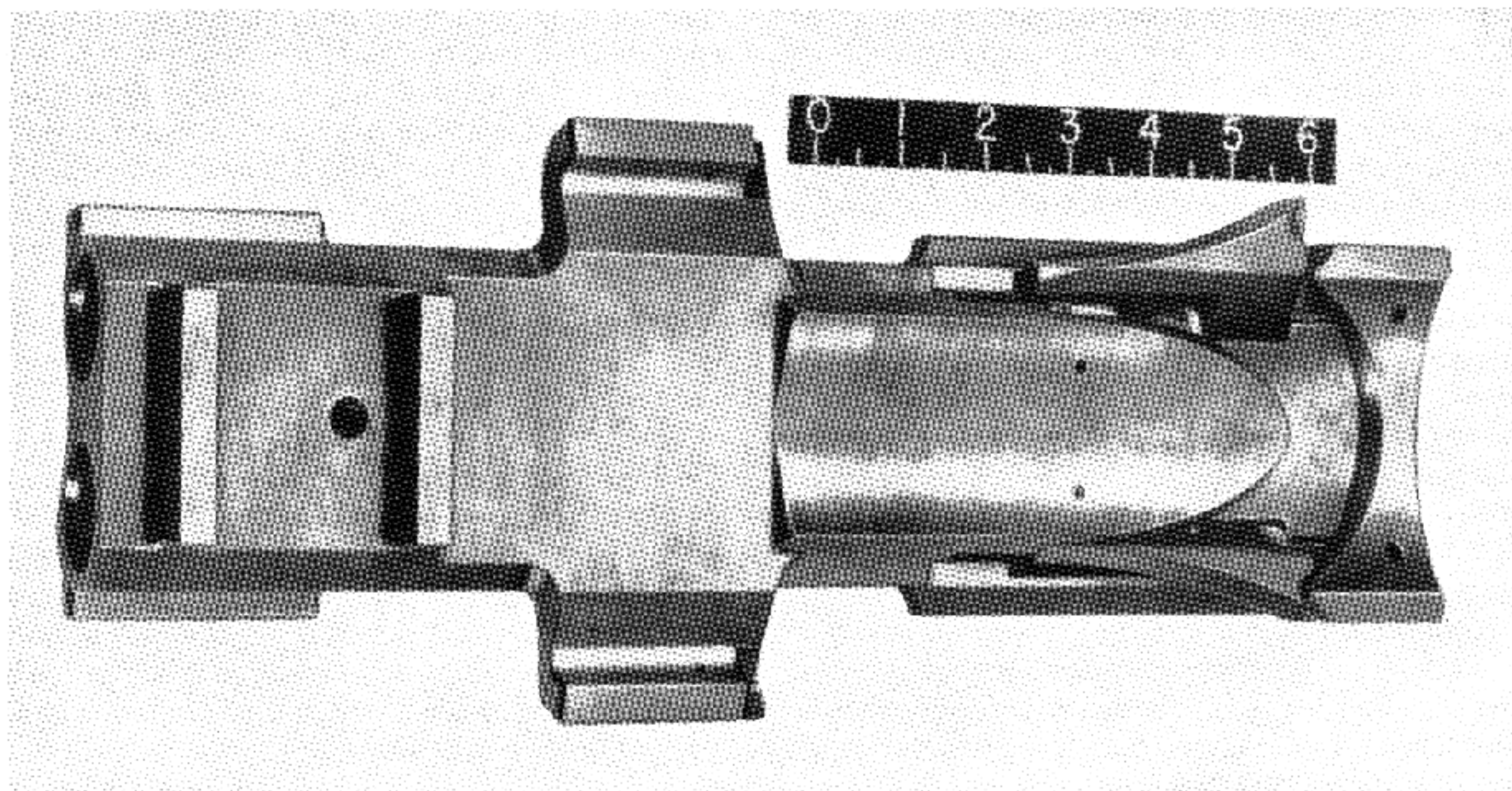


Figure 2-28. Automatic Gun, Caliber .60, T130. Actuating slide assembly.

pattern, it was necessary to make the switch cam a recoiling part. This was done by machining a groove around the outside of the gas cylinder on the drum support to engage ears machined in the front end of the switch cam. The guide plate, attached to the bottom of the receiver, guides the cam during its recoil travel.

In addition to actuating the drum, the slide actuates the extractor and carries the rammer which rams the rounds from the links and chambers them.

The extractor, located in the rear end of the drum support, is kinetically one piece. It consists of a shaft with a striker face on its lower end and an extractor pawl on its upper end.

As the slide returns to battery, a replaceable striker housed in a lug on the right side of the slide strikes a face on the lower end of the shaft, causing the shaft to rotate and allowing the slide to continue to battery. The extractor pawl is held in a retracted position after extracting the case, until the slide moves rearward again. When the lug on the side of the slide clears the end of the extractor shaft, a torsion spring on the upper end of the extractor shaft returns the extractor to extraction position with the pawl against the face of the drum.

The torsion spring returns the extractor with sufficient force to cause the pawl to bounce rearward from the face of the drum and to miss frequently the rim groove of the oncoming case to be extracted. Therefore, an antibounce device was incorporated in the extractor to reduce the amount of bounce and prevent failure to extract.

This device consists of a spring-loaded detent housed in the drum support which engages a shallow hole in the hub of the extractor pawl when the pawl is against the face of the drum. The ratio of movement of the end of the extractor pawl to the movement of the point struck by the slide is approximately 1.67 to 1. Case extraction velocities are of the order of 80 feet per second.

The rammer consists of a single piece mounted in guide slots at the rear end of the slide and held in place with a cap screw. For right-hand feed, the rammer curves outward to the left to clear the feeder sprocket and the edges of the open-sided links presented to the rammer by the feeder. The two slide-drive springs are of stranded wire construction. They engage holes in the rear end of the slide and are held in position at the rear by guide rods which engage bayonet locks in the receiver end

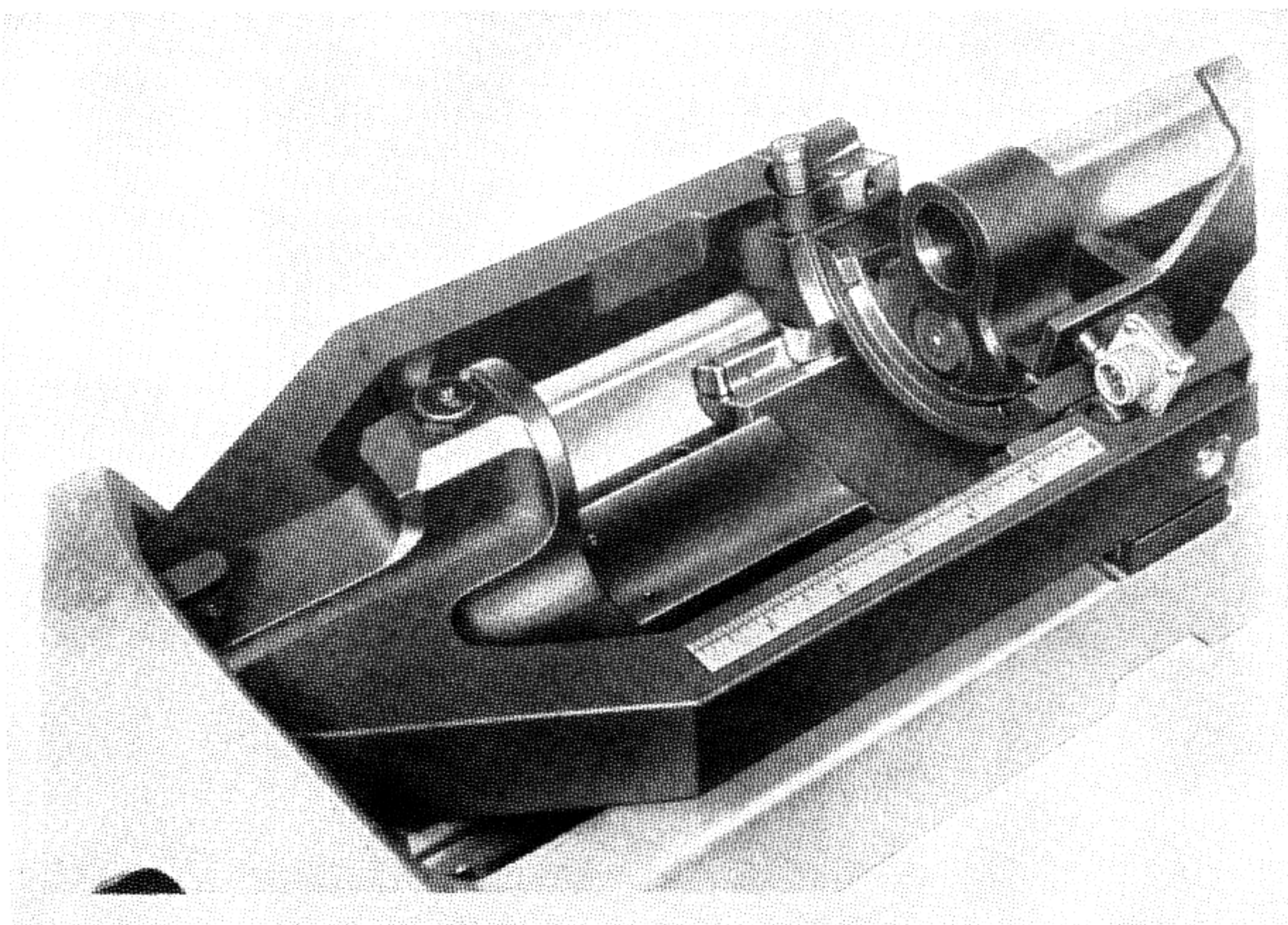


Figure 2-29. Automatic Gun, Caliber .60, T130. View showing extractor and extractor striker on slide. (Drum removed.)

plate. The springs exert a total force of 80 pounds when the slide is forward, and 187 pounds when the slide is rearward.

The disintegrating belt feeder consists of a cast magnesium-aluminum alloy frame which houses the sprocket, sprocket shaft, link guides, and case deflection chute. The elements of the sprocket, which are splined to the shaft, consist of the following:

1. One drive sprocket, which engages the ammunition belt links at the link connectors.
2. Two sprockets, one on each side of the drive sprocket, which force the link connectors out to their proper distance from the center of rotation.
3. One guide sprocket ahead of the front connector spacing sprocket, which bears against the side of the link, and keeps the link aligned with the chamber.

4. Front guide sprocket, which controls the round after it is rammed from the link into the chamber.

5. Rear ramming stop sprocket, which engages the link on the front side of the rib at the rear, and prevents the link from moving forward under the force of ramming. This sprocket also assists in keeping the link aligned with the chamber.

Also mounted on the shaft are two guide tracks, which engage the two ears on the ammunition belt link and hold the first and last links of the ammunition belt on the sprocket against centrifugal force acting on the link and round during sprocket rotation. The intermediate links in a belt are held in the sprocket by their adjacent links.

The ammunition belt enters the feeder horizontally from the right through an opening at the top and engages the sprocket tangentially as the ears enter the guide tracks. After ramming, the empty

links continue around the sprocket and leave the feeder through an opening on the right side; then they are free to disintegrate.

Mounted in the right side of the feeder and opposite the extraction station is a curved deflection chute which deflects the ejected cases out of the feeder to the right, clear of the sprocket.

The feeder assembly is held to the top of the receiver by two headed studs on each side of the receiver which engage slots in the sides of the feeder frame. Two spring-loaded pins, one on each side of the receiver, engage holes in the feeder frame and prevent forward or rearward movement of the feeder.

The relinking feeder is similar to the disintegrating belt feeder with respect to the drive sprocket and method of mounting on the receiver. It also has a cast magnesium-aluminum alloy frame; however,

the belt entrance is at an angle of 25 degrees with the horizontal. The empty links are carried on around the sprocket further than in the disintegrating belt feeder to a position in line with the extraction station, where the extracted case reenters the link and is stopped by the end of the feeder frame.

The relinked case and link then leave the feeder through an opening on the right side under the belt entrance opening. With the ejected cases in the links, the belt cannot disintegrate.

The gun firing circuit components consist of the firing pin assembly mounted in the rear end of the drum support, a female contact consisting of two steel leaves and insulating strips mounted on the rear end of the drum support, a male contact and insulating strip mounted on top of the slide at the rammer mounting screw, and an external power receptacle mounted on a bracket on the rear end of

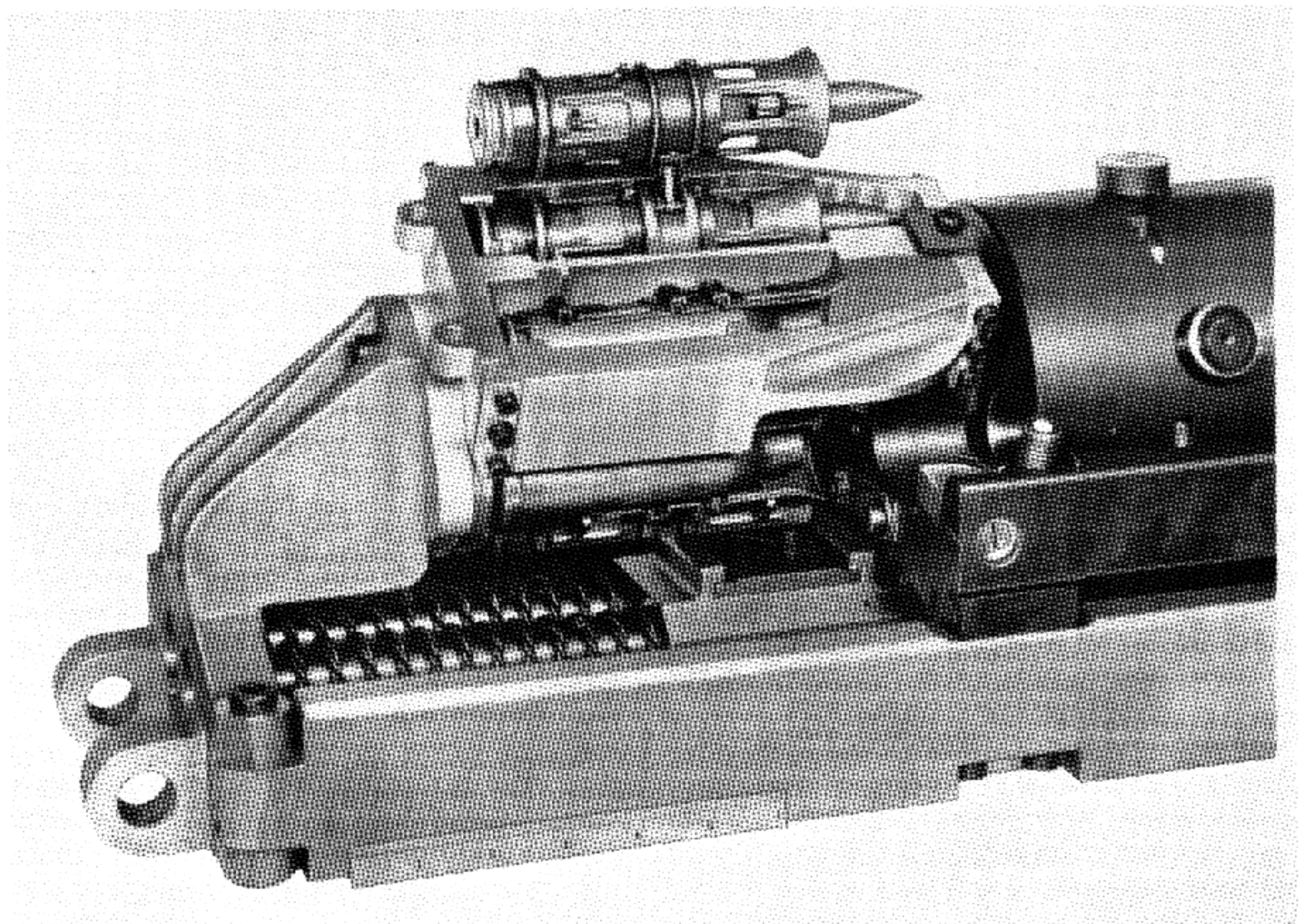


Figure 2-30. Automatic Gun, Caliber .60, T130, showing the fired case returned to the link for ejection.

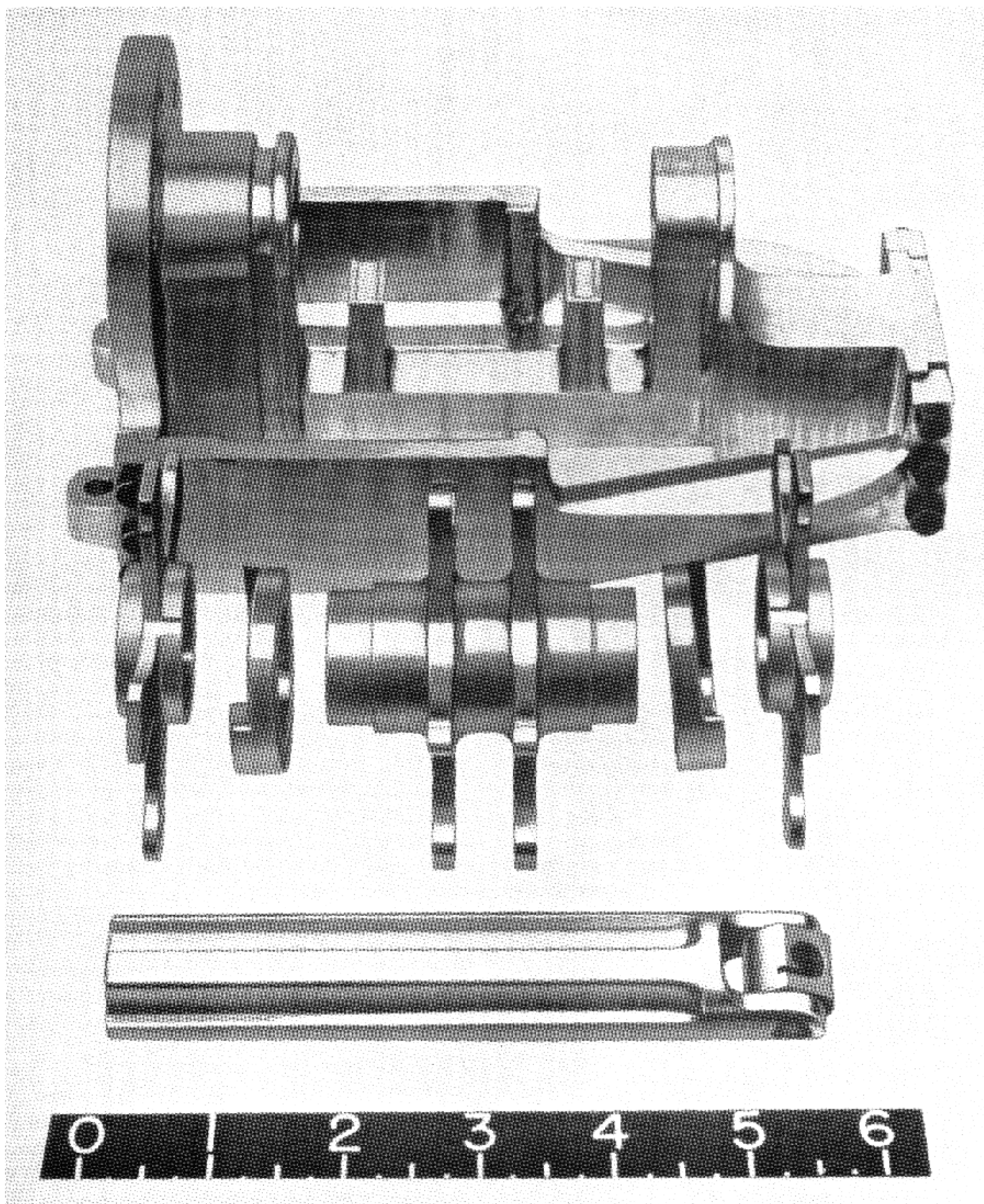


Figure 2-31. Automatic Gun, Caliber .60, T130. Feeder, disassembled.

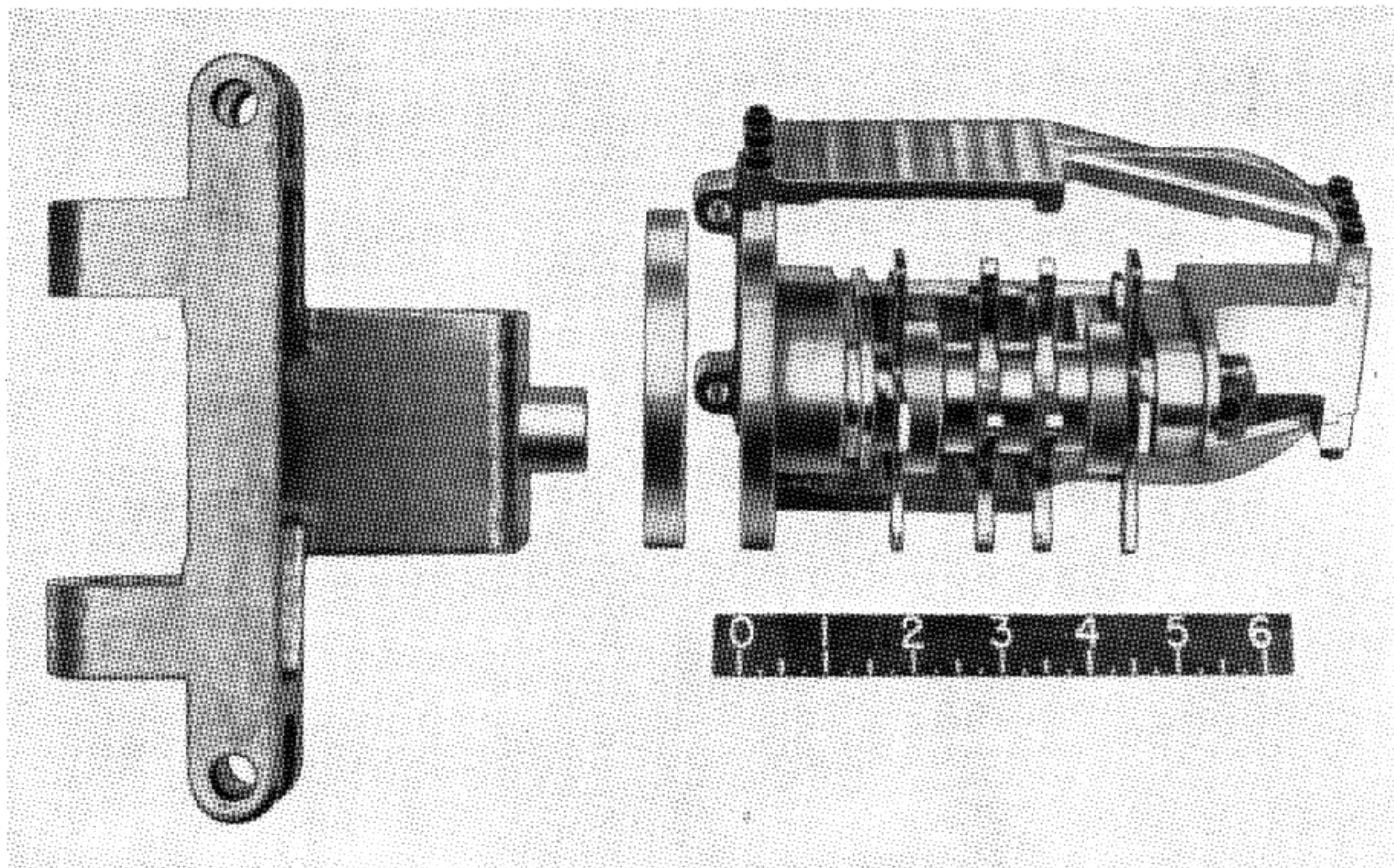


Figure 2-32. Automatic Gun, Caliber .60, T130. Feeder and tail gate assembly.

the drum support on the side opposite the extractor. The two leaves of the female contact and the insulated firing pin are connected in series to one side of the power receptacle when the female contact is engaged by the male contact. The other side of the power receptacle is connected to ground.

When the slide is in battery, the male contact is pressed between the two leaves of the female contact, which completes the circuit to the primer when it is in contact with the firing pin. Thus, when external power is applied to the receptacle, the gun fires automatically on successive rounds when the slide reaches battery position and brings the male contact on the rammer in engagement with the stationary female contact.

The charging system, developed by Norman McDonald Co. consists of percussion charger T10, the charger cylinder assembly, and the U-shaped gasline connecting the charger to the cylinder.

The charger is mounted in a bracket which fits over the end of the tube support and over the end of the right recoil spring retainer.

A large-headed screw which screws into the end of the recoil spring retainer holds the bracket in position. The charger cylinder assembly is housed in the tube support and extends through the end of the receiver on the right side in such a way that the end of the piston is against the end of the actuating slide. It is held in position by an adapter screwed into its front end.

Gas pressure produced by the firing of a caliber .30 grenade cartridge M3 in the charger actuates the charger piston, which forces the slide rearward. The forward stroke of the slide returns the charger piston.

Mounting

Mount the gun on a rigid structure which supports it at the trunnions and at one of the two sets of receiver mounting holes. For minimum dispersion, use the receiver mounting holes located under the rear end of the drum support. The rear mounting must restrain the receiver in a vertical plane and provide freedom of movement in a longitudinal

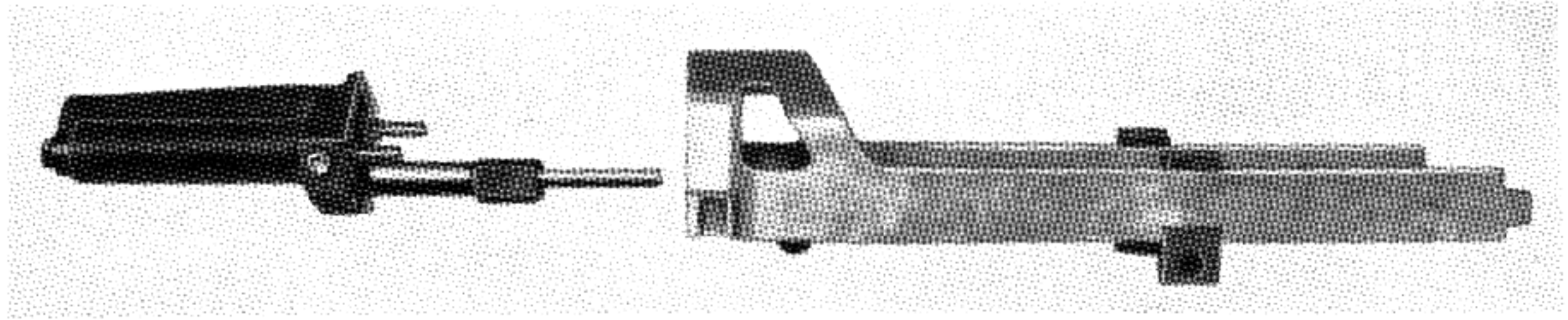


Figure 2-33. Automatic Gun, Caliber .60, T130. Trunnion and receiver.

plane so that the front trunnions take all the longitudinal load. The mounting structure must be sufficiently rigid so that it does not deflect in torsion at either the front or rear mounting points.

Preparation for Firing

Remove the drive springs and pull the slide back to its rear position. Fit the feeder shaft tool into the back end of the feeder shaft and while holding up the drum shaft latch, pull the shaft rearward until the shaft is disengaged from the drum at the dog clutch face. Feed the ammunition belt with the first link empty into the feeder; engaging the link with the sprockets and guide track. Rotate the feeder shaft with the feeder shaft tool until the empty link is in the first ram position. Push the feeder shaft forward engaging the dog clutch face. Be sure the drum shaft latch is engaged. Push the slide forward into battery position and replace the drive springs. Charge the gun three times, using the percussion charger to bring the first round into firing position. The loading procedure is the same for either the relinking or disintegrating belt feeder.

Connect the external firing circuit to the gun-firing circuit at the power receptacle.

Disassembly by Groups

Removal of Feeder. To remove the feeder, depress the lock pin releases and pull the feeder back until the base of the feeder holds down the lock pin. Screw on the feeder shaft tool at the rear of the feeder. Pull up on the drum shaft latch and remove the feeder assembly by pulling back on the feeder shaft tool until the drum shaft is clear of the drum support.

Removal of Drum. With the drum shaft removed, the drum may be removed by lifting it up from the drum support with the slide fully forward.

Removal of Tube. Pull up on the tube latch.

Give the tube a quarter turn and pull it forward until it clears the tube support.

CAUTION. Do not remove the tube from the gun before the drum is removed. The scaling sleeve may slip out of the drum into the space occupied by the tube. This prevents the removal of the drum until the sleeve is pushed back into position.

Removal of Drum Support.

1. Remove the drive springs by inserting a screwdriver into the slotted head of the spring guide assembly. Push in on the assembly until it clears the recessed section of the receiver end plate. Turn the spring guide a quarter turn and remove the springs through the end plate.

2. Pull the slide back to its most rearward position. Use a $\frac{3}{4}$ -inch open-end wrench and remove the nuts and washers which attach the recoil rods to the drum support. Pull the drum support back until it clears the front bearing and rear guides, and lift it up from the receiver.

Removal of Actuator Slide Assembly and Switch Cam.

1. Unfasten the safety wires and remove the end-plate pins and the end plate.

2. With the drive springs and end plate removed, the slide and switch cam are removed by sliding them rearward until they clear their respective guides.

Removal of Charger and Charger Bracket.

1. Remove the gasline between the charger and the charger cylinder.

2. Unfasten the safety wire and remove the $\frac{3}{8}$ -inch hexagonal head screw holding the charger bracket to the right recoil spring retainer.

3. Slide the charger and charger bracket forward until it clears the tube support.

4. Remove the right slide guide from the receiver from the right front side of the tube support. Push the charger cylinder rearward, and remove it.

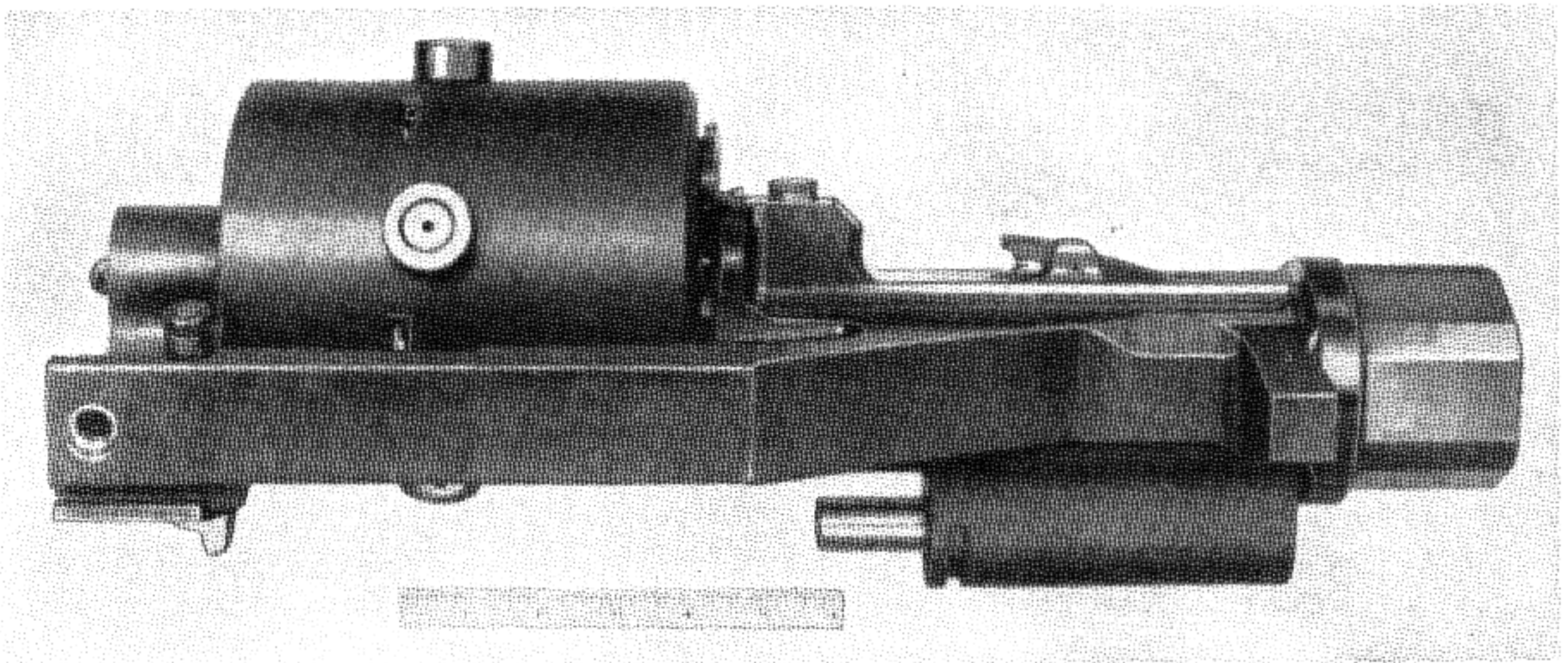


Figure 2-34. Automatic Gun, Caliber .60, T130. Drum and drum support assembly.

Removal of Recoil Springs. Remove the recoil spring retainer using a $\frac{3}{4}$ -inch open-end wrench and a special spanner wrench. Push the recoil rods forward to remove the recoil spring assemblies from the tube support.

Detailed Disassembly

Feeder.

1. **DISINTEGRATING BELT FEEDER.** Remove the feeder shaft through the front of the feeder. This releases the sprockets and guide tracks for removal. Remove the front end and the rear feeder shaft bush-

ings. The internal guides and chute may be disassembled by removing the appropriate socket-head cap screws.

2. **RELINKING FEEDER.** Remove the feeder shaft through the front of the feeder. This releases the sprockets and guide tracks for removal. Remove the front and rear feeder shaft bushings. The center and stationary guides may be disassembled by removing the necessary socket-head screws.

Drum.

1. The sealing sleeves are removed by slipping them out of the drum chambers.

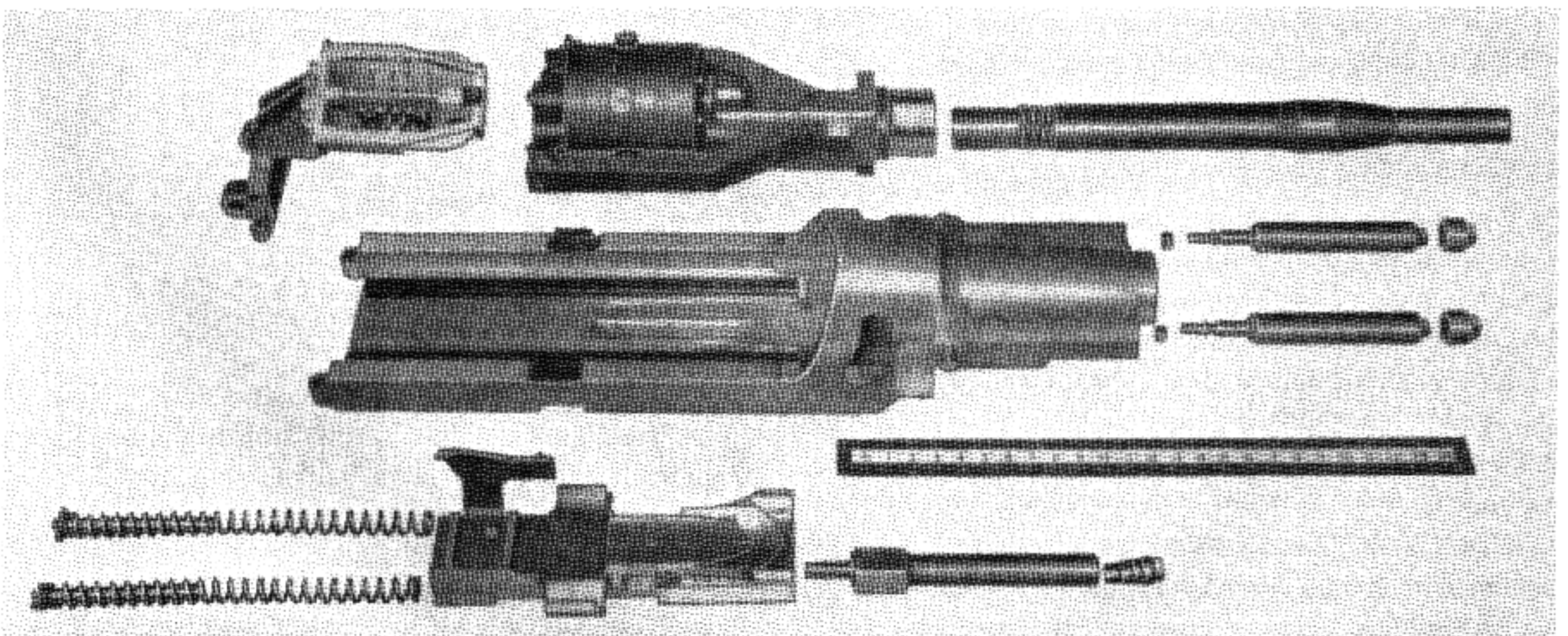


Figure 2-35. Automatic Gun, Caliber .60, T130. Major components.

2. The drum rollers are held to the drum trunnions by internal snap rings and in general should not be removed unless they are damaged and need replacement. The rollers must then be removed by hand grinding, taking special care not to damage the trunnions.

CAUTION. Do not attempt to pry the rollers off the trunnions. The trunnions will be damaged.

Disassembly of Tube. The gas orifice is the only removable part of the tube and can be withdrawn with a screwdriver.

Disassembly of Drum Support.

REMOVAL OF GAS PISTON. Drive out the cylinder cap retaining pin and unscrew the gas cylinder cap, using a special tool. Push the gas piston forward and out of the gas cylinder.

DISASSEMBLY OF EXTRACTOR. Drive out the roll pin holding the extractor cap to the extractor shaft. Remove the extractor cap, extractor spring, and extractor pawl from the extractor shaft, being careful when removing the pawl that the detent ball and spring do not fly out of the drum support. Remove the detent ball, spring, and sleeve from the inner side of the drum support and the extractor shaft from the bottom of the drum support.

Drive out the roll pin holding the extractor stop to the drum support and remove the extractor stop.

REMOVAL AND DISASSEMBLY OF FIRING PIN ASSEMBLY. Screw the threaded tool into the firing-pin anvil retainer pin and pull out the retainer pin. Remove the $\frac{1}{4}$ -inch slotted nut from the rear of the firing-pin shaft. Push the shaft forward to remove the firing-pin anvil, being careful not to drop the firing-pin plunger assembly. Remove the firing-pin plunger spring, firing-pin shaft, and insulator. Remove the two $\frac{1}{2}$ -inch socket-head cap screws holding the female contacts. Drive the contact receptacle roll pin and contact receptacle pin out and remove the female contact and the contact receptacle.

REMOVAL OF DRUM SHAFT LATCH AND TUBE LATCH. Drive out the drum shaft latch roll pin and remove the drum shaft latch head, allowing the drum shaft latch and spring to drop down through the hole in the bottom of the drum support. Follow the same procedure for removing the tube latch.

REMOVAL OF ROUND RETAINER. Drive the round retainer roll pin from the rear of the drum

support through the contact screw hole. Lift the round retainer and spring from the pocket.

REMOVAL OF PIPE PLUG. The pipe plug may be removed by unscrewing the top of the drum support.

Actuator Slide.

REMOVAL AND DISASSEMBLY OF SWITCH TONGUE. Drive the two $\frac{1}{8}$ -inch roll pins out and remove the two serrated head shoulder screws holding down the cam insert. Remove the cam insert and lift out the switch tongue.

Depress the locking pin through the locking plate hole. Slide the locking plate out, being careful that the locking pin and locking pin spring do not fly out. Remove the locking pin, locking pin spring, and switch tongue pin from the switch tongue.

REMOVAL OF EXTRACTOR STRIKER. To remove the extractor striker, drive out the roll pin and pull out the striker.

REMOVAL OF MALE CONTACT AND RAMMER. To remove the male contact and rammer, remove the $\frac{3}{8}$ -inch hex-head screw and lift the firing contact and insulator out. The rammer may then be removed by sliding it out of its ways.

Recoil Spring Assembly.

CAUTION. Under normal use, there should be no reason for the disassembly of the recoil spring assembly; however, if necessary, be sure that the ring elements are kept in their original order so that their calibration will be the same.

To disassemble the recoil springs, slide the recoil spring sleeve off. Remove the cotter pin and nut from the end of the recoil rod. The recoil spring spacer, recoil spring elements, and recoil spring seat can now be slipped off the recoil rod.

Disassembly of Receiver and Tube Support.

1. To separate the receiver and tube support, remove the six $\frac{5}{16}$ -inch socket-head cap screws and lockwashers from inside the receiver. Pull the receiver trunnion apart, being careful not to damage the tube support key slots.

2. To remove the rear drum support guides, remove the four $\frac{3}{8}$ -inch socket-head cap screws from the bottom of the receiver and lift the guides out.

3. To remove the switch camways, remove the six $\frac{10}{32}$ -inch socket-head cap screws from the bottom of the receiver. Then lift the switch camways out.

4. To remove the actuator slideways, remove the twelve $\frac{1}{4}$ -inch socket-head cap screws from the

bottom of the receiver. Then lift the slideways out.

5. To remove the feeder frame pins, drive out the $\frac{3}{16}$ -inch roll pins and lift the pins out.

Assembly

Assembly of Receiver and Tube Support.

1. Replace the feeder frame pins into their proper holes in the receiver. Drive out the $\frac{3}{16}$ -inch roll pins.

2. Replace the actuator slideways in the receiver base, alining the holes in the slideways with the holes in the receiver. Fasten the slideways to the receiver with the twelve $\frac{1}{4}$ -inch socket-head screws.

3. Replace the switch camways in the receiver base, alining the holes in the camways with the holes in the receiver. Fasten the ways to the receiver with the six $10/32$ -inch socket-head cap screws.

4. Replace the rear drum support L-slot guides in their respective places in the receiver and fasten them to the receiver with two $\frac{3}{8}$ -inch socket-head cap screws.

5. Alinc the keys at the rear face of the tube support with the key slots in the front face of the receiver. Push the tube support and receiver together, being careful not to damage the key slots. Replace the six $\frac{5}{16}$ -inch socket-head cap screws and lock-washers, thus fastening the tube support and receiver together.

Recoil Springs. Replace the recoil spring seat against the shoulder at the rear end of the recoil rod. With the recoil spring elements assembled in the proper sequence and original order, slip the front end of the recoil rod through the elements, being careful not to drop them. Replace the recoil spring spacer, recoil spring nut, and recoil spring sleeve. To set in a preload of 1,250 pounds, tighten the nut until the distance between the rear face of the recoil spring seat and the front face of the recoil spring spacer is 7.24 inches. With this distance set, lock the nut in place using a cotter pin. Replace the recoil spring assemblies in their housing in the tube support.

CAUTION. Be sure to lock the nut in place with the cotter pin. Operation of the gun without the cotter pin will result in loosening of the nut and changing the preload in the ring springs. This will cause erratic recoil and possible damage to the gun.

Charger.

1. Replace the charger cylinder in the tube support.

2. Slide the charger and charger bracket over the front end of the tube support.

3. Replace the gas line between the charger and the charger cylinder. Make sure the fittings are tight so that there will be no gas leakage.

Actuator Slide and Cam Switch.

1. Replace the switch tongue pin and the locking pin spring into position in the switch tongue. Place the locking pin on top of the locking pin spring, then depress the locking pin far enough to slide the locking plate over the locking pin until the locking pin locates itself in the locking plate. Replace the switch tongue and cam insert into their position on the slide. Replace the two serrated-head shoulder screws holding down the cam insert. Drive in the two $\frac{1}{8}$ -inch roll pins that prevent the shoulder screws from turning.

2. Replace the extractor striker into position on the right side of the slide and lock in place by driving in the roll pin. Be sure in replacing the striker that the most forward part of the sloped face of the striker is on the outside of the slide.

3. Slide the rammer into position at the rear of the slide. Replace the male contact insulator and the male contact into position on the rammer and fasten to the slide by the $\frac{3}{8}$ -inch hexagonal-head screw, being sure that the male contact remains insulated from the slide.

4. Place the slide on top of the switch cam, making sure the switch tongue pin is engaged in the cam surface. Slide the actuator slide and switch cam simultaneously into their respective ways in the receiver.

Drum Support.

1. Replace the pipe plug on top of the drum support. Be sure this is tight so that no gas from the tube orifice will leak around the tube and out of this locating hole.

2. Replace the round retainer spring and the round retainer into the pocket at the left rear section of the drum support. Drive the round retainer roll pin forward through the contact screw hole.

3. Place the tube latch spring over the shank of the tube latch and slip them into the tube latch hole from the rear of the tube support. Use a long rod to hold the latch up in position so that the tube

latch head can be placed on the tube latch shaft. Drive in the roll pin holding the tube latch head to the tube latch.

Follow the same procedure in replacing the drum shaft latch.

4. Firing pin assembly. Place the firing-pin spring in the recessed hole of the firing-pin shaft and insulator assembly. Replace the shaft in the drum support. Place the firing-pin plunger assembly into the hole of the firing pin anvil and slide this into the large hole at the rear of the drum support. Replace the firing-pin anvil retainer pin for holding the anvil in position in the drum support. Place the female contact and insulators into position on the rear face of the drum support and replace the two $\frac{1}{4}$ -inch socket-head cap screws and the $\frac{1}{4}$ -inch slotted nut. Replace the contact receptacle and the contact receptacle pin, and lock in position on the drum support by driving in the contact receptacle roll pin.

5. Extractor assembly. Replace the extractor shaft in the drum support. Replace the detent spring into the blind hole in the detent sleeve, and replace the sleeve into the detent hole in the drum support. Place the detent ball against the detent spring and depress the ball until it is flush with the side of the drum support so that the extractor pawl may be replaced on the extractor shaft. Replace the extractor shaft spring and extractor shaft cap. Drive in the roll pin holding the assembly together. Replace the extractor stop on the drum support and drive in the roll pin.

6. Gas piston. Slide the gas piston into the gas cylinder of the drum support. Replace the gas cylinder cap using the special tool. Drive in the gas cylinder cap retaining pin.

7. The drum support may now be slipped into position with the receiver and tube support by first engaging the front hexagonal section of the drum support with the tube support socket, the recoil bolts with the drum support lugs, the L slot supports with the L slots, and the notch at the front bottom of the drum support with the ears of the switch cam. Next, replace the nuts fastening the drum support to the recoil rods, tightening them sufficiently to bring the rear shoulder of the recoil rod up against the drum support lug. Now pull back on the drum support so that the rear end of the recoil spring assembly is seated against the rear end of the bore in the drum support which houses the spring assembly.

Replace the recoil spring retainers, making sure that they are only hand tight. Replace the $\frac{3}{4}$ -inch hexagonal-head screw into the end of the right recoil spring retainer to hold the charger bracket to the drum support. Place the cotter pins on the rear nuts of the recoil rods and safety wire the left recoil spring retainer and the hexagonal-head screw in the end of the right recoil spring retainer.

WARNING. Proper functioning of the gun requires proper assembly of the recoil spring system to the drum support and tube support. Careless and improper assembly will result in erratic recoil and subsequent damage to the gun; therefore, be sure:

1. The drum support lug is against the shoulder of the recoil rod.
2. The rear end of the recoil spring assembly is seated against the shoulder in the tube support.
3. The recoil spring retainers are replaced hand tight.
4. All nuts of the recoil system are cotter pinned and the retainers safety wired.

Tube. Replace the tube orifice. Slide the tube into the tube support. Lift up the tube latch and continue sliding the tube rearward until it stops. Release the tube latch and rotate the tube until the latch drops into engagement with the hole in the tube.

CAUTION. Be sure that the tube latch is engaged with the hole in the tube.

Drum. Replace the sealing sleeves in the drum with the unnotched faces forward. Place the drum in the drum support with the actuator slide fully forward. Be sure that the drum roller is properly engaged with the slide cam.

Feeder.

1. Replace the feeder end plate and the end plate pins. Safety wire the end plate pins.
2. Insert the guide rods in the slide drive springs, and slip the assemblies through the holes in the end plate in the holes in the rear of the slide. Engage a screwdriver with the slotted head of the drive spring guide rod and compress the spring until it clears the notched section of the end plate. Rotate the assembly 90° so that it is aligned with the recessed section of the end plate. Let up on the screwdriver enough to seat the drive spring guide against the end plate. Repeat the procedure for the second spring.

3. Assembly of feeder.

Disintegrating belt feeder. Replace the front and rear feeder shaft bushings. Replace the internal guides and chute. Safety wire all socket-head cap screws. Insert the feeder shaft through the front bushing and replace the tracks and sprockets in the following order: front guide track, front guide sprocket, link connector support sprocket, drive sprocket, link connector support sprocket, spacer, rear guide track, ramming sprocket.

Relinking feeder. Replace the four stationary guides. Insert the center guide so that the front and rear bushings may be replaced. The bushings must be replaced before the socket-head screws are replaced. Safety wire all screws. Insert the feeder shaft through the front bushing and replace the guide and sprockets in the following order: guide track with track facing center of feeder, spacer, link connector support sprocket, drive sprocket, link connector support sprocket, spacer, guide track with track facing center of feeder, ramming sprocket with hub toward the center of the feeder.

4. To replace the feeder on the gun, first slip the drum shaft through the rear drum shaft support, the drum, and the front drum shaft support. It may be necessary to hold up the drum slightly in order to align the drum and drum-shaft bearings. Lift up on the drum-shaft latch. Now push forward and down on the feeder frame until the feeder is locked into position by the feeder locking pins. Release the drum shaft latch, rotating it until it engages the groove in the drum shaft.

CAUTION. Be sure the latch is engaged in the groove.

Conversion from Right-Hand to Left-Hand Feed

The following parts are either changed or reversed in assembly for conversion from right-hand feed to left-hand feed.

Switch Cam. A different switch cam is used for left-hand feed to provide clockwise rotation of the drum.

Rammer. The right-hand feed rammer must be replaced with one made for the left-hand feed. For left-hand feed, the rammer is located on the right side of the slide.

Extractor Striker. The extractor striker is replaced with one made for left-hand feed. Its position for left-hand feed is on the left-hand side of the slide, with the most forward part of the striker face on the outside of the slide.

Extractor Assembly. The right-hand feed extractor must be replaced with one made for the left-hand feed. Also for left-hand feed, the extractor is assembled on the left side of the drum support. The extractor stop is for either right- or left-hand feed. For left-hand feed, the stop is located on the left side of the drum support.

Receptacle Bracket Assembly. The receptacle bracket assembly can be used for either right- or left-hand feed, however, for left-hand feed the bracket assembly is located on the right side of the drum support.

Round Retainer. The round retainer must be assembled on the right side of the drum support for left-hand feed.

Feeder. For left-hand feed, a left-hand feeder frame and deflector must be used. The feeder sprockets and guides are the same.

Chapter 3

ORDNANCE CORPS POWER-DRIVEN
MULTIBARREL REVOLVER CANNON

SECTION 1. HISTORY AND BACKGROUND

Before the end of World War II, the Ordnance Corps realized that greatly increased rates of fire of aircraft guns would be required to be effective against the increasing speed of jet aircraft. In order to obtain any marked improvement in automatic weapons, it was essential that the fundamental characteristics of existing types be improved, such as (a) increase in firing rates, (b) reduction and smoothing of machine gun actions and (c) increased muzzle velocities in spite of the resultant barrel erosion problems.

The conventional types of single barrel reciprocating action weapons whose rate of fire is determined by gun energy, were approaching their design limit of rate of fire. These weapons require the reciprocating mass to be stopped at the time of locking and the direction of motion to be reversed when rebounding from the buffer during each cycle. As the velocity of the reciprocating mass reaches increasingly higher limits for the increased rates of fire, the impacts become an important problem, since they have to be absorbed by the weapon and imparted to the aircraft frame. Increasing rates of fire had caused increasing difficulties in barrel erosion and control of moving parts. It was believed that this situation would be remedied by the use of several barrels rather than one, thus securing better cooling periods for each barrel. Further, the use of a continuous power source, rather than the impulsive action of the powder gases, was expected to provide smoother action and longer life of components.

The best known progenitor of this type of weapon is the Gatling gun. While this weapon, whose operating principles were originally patented 4 November 1862, was operated by hand at a moderate

rate of fire, it was decided to investigate the possibility of using a power drive. In early 1946, an electric motor drive for a model 1903, 10 barrel, 45-70 Gatling gun was provided and operated for a short period at the rate of 5,000 shots per minute. A theoretical study of the mechanism showed that even higher rates of fire were attainable. Such a gun, to be profitable, must show a profit in terms of weight per barrel, rate of fire per barrel, and in other ways, to overcome the handicap introduced by making all the barrels subservient to a common operating mechanism.

On 18 January 1946, the General Electric Co. submitted, at the invitation of the Ordnance Corps, proposed methods for conducting a development study to work out an improved aircraft gun of increased firepower, improved ballistics, better control

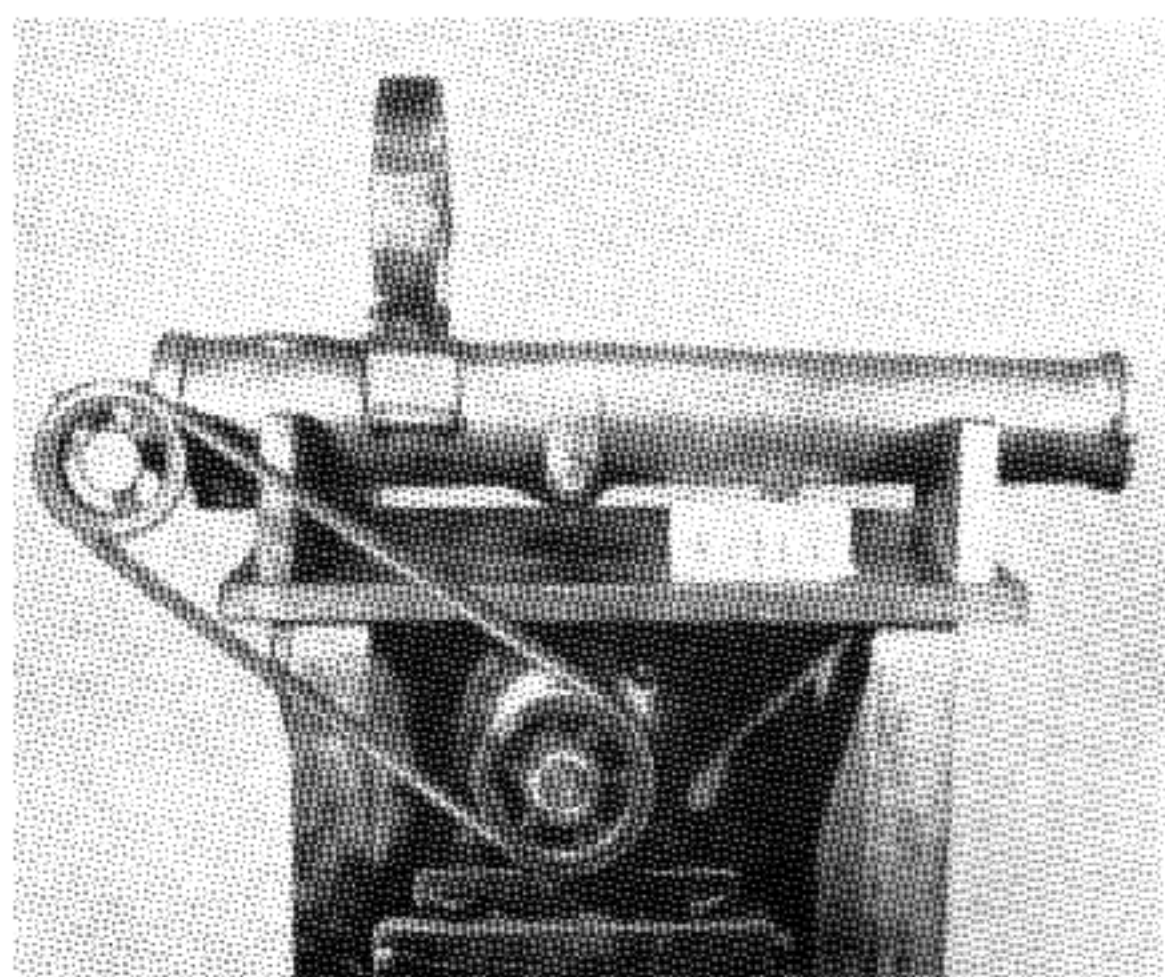


Figure 3-1. An old Gatling Gun with motor drive. This gun was used experimentally in the development of the T45.

of reciprocating components, and reduced length to improve its aircraft adaptability. The General Electric Co. was requested by the Ordnance Corps to quote on the study and development of a multi-barreled gun of the Gatling type.

In June 1946 a contract was negotiated with the General Electric Co., Schenectady, N. Y., for a preliminary design study for a gun to meet the following gun design characteristics:

Mechanism: A multibarrel gun, similar to the Gatling gun, driven by an external power source. The number of barrels in the initial design is not prescribed. A jam in one barrel should not affect the others.

Caliber: .60/50 (T41 cartridge; later changed to caliber .60 round.)

Barrel length: 60 inches.

Maximum gun length: 80 inches.

Maximum weight: 100 lb/barrel.

Minimum rate of fire: 1,000 r. p. m./barrel.

Firing mechanism: Electrical primers.

Feed: To be determined by analysis.

Firing control: Electrical. To permit firing without loss of time and stopping without loss of ammunition. Maximum rate of fire is desired throughout burst. Clutch or cutout may be provided to decrease up-to-speed time.

Cook-off controls: Provision must be made so that no cartridge remains in a chamber at the end of a burst. Barrels should remain open after firing to permit cooling by natural air draft. Provisions for fluid cooling if required.

Reloader: Gun to be initially loaded by armorer; necessary for reloader mechanism to be deter-

mined by possibility of normal feeding cycle being interrupted by malfunctioning.

Mounting provision: Spring-loaded mounting to provide for smoothing of recoil load transmitted to the airplane structure. Installation proposed for aircraft.

Access: Vital parts of the gun must be accessible for servicing.

Basic Design

The design arrangement selected for the first test gun was a five-barrel model of medium size and performance suitable for construction as a development sample.

The principal parts may be designated as: Support; feed unit; housing; bolt; rotor; barrel; drive unit; lock.

The design follows the Gatling principle, which lends itself satisfactorily to the application of modern ammunition and electrical control. Where there is duplication of parts, like the bolts and barrels, other items like the recoil spring supports and general structure are common. This arrangement results in a considerable saving in weight and space. Barrels are grouped in a circle and fastened at the breech end to a single central member. There is an additional support approximately 2 feet forward of the breech. The central member, which is referred to as the rotor, carries individual bolts in guide slots which reciprocate in a conventional function under the action of a spiral cam on the outside of the housing member.

A reduction in diameter at the muzzle is achieved by bringing the barrels together at the end at an

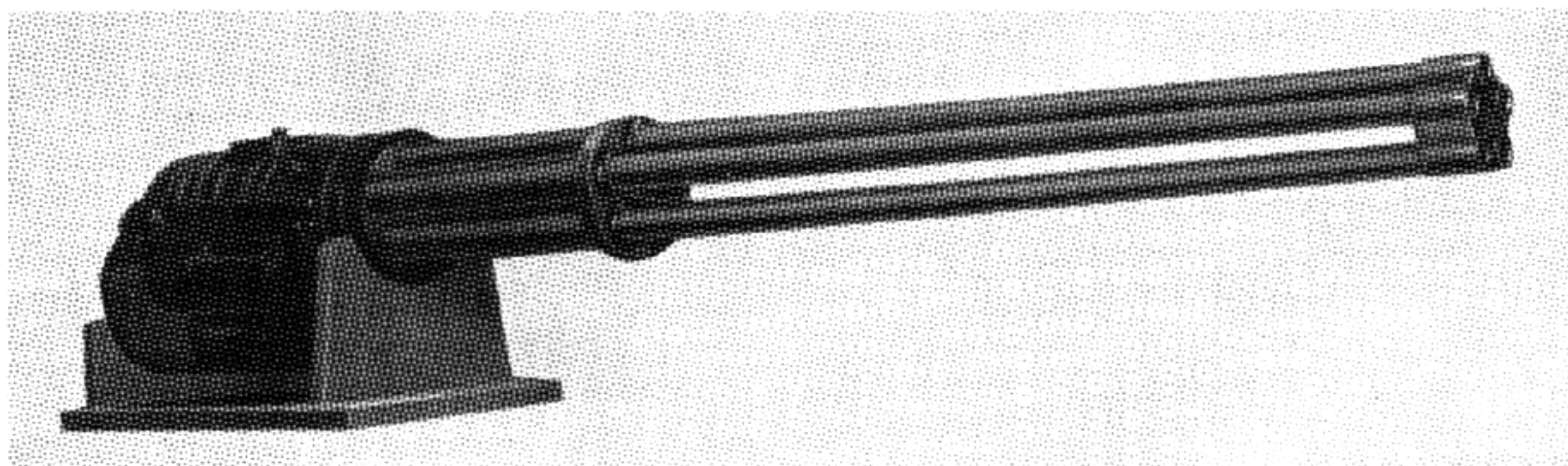


Figure 3-2. Wooden model of the early stages of Ordnance Corps Electric-Operated Machine Gun.

angle of approximately three-quarters of a degree, instead of maintaining parallel axes. The relative value of this arrangement is easy to see.

Ammunition is fed by belt from the side with links discharged before entering the gun, as in the 20-mm M2 feed mechanism. The cartridge is driven by a sprocket into the space ahead of the bolt from which point it is forced into the barrel, fired, and the case ejected in the course of the bolt's reciprocating travel. Suitable guides maintain the cartridge in position during its motion.

Early Design Problems

The necessity of quick starting of the gun without undue stresses on the ammunition belt and the matter of clearing the gun for prevention of cook-offs have necessitated the use of certain control auxiliary which would not have been otherwise required.

It was early determined that, in a gun of the proportions that existed in this type of mechanism, it would be possible to store sufficient energy in a small flywheel to permit starting of the gun rotor in a satisfactorily short space of time, 0.1 to 0.2 second. Hence with the use of a flywheel and a quick-acting clutch and brake unit, it became possible to positively start and stop the gun every time it was so desired.

Clearing the barrels of live ammunition is more difficult. If cooling were adequate, this problem might not have arisen. At this time, however, the cooling problem was not considered sufficiently developed to say what the possibilities were.

A second rather simple expedient was to back up the gun after firing by employment of a heavy spring. This required that the bolt secure a firm hold on the cartridge at an early stage, a mechanical problem which was not solved at this time. It also implied that due provision was needed for some backward motion of the ammunition belt. In either of these methods, the feed sprocket was attached directly to the drive and moved with the gun rotor. General Electric engineers elected, however, at this time at least, to adopt a more complicated but more comprehensive method of clearing the gun. The scheme decided upon was to provide for independent stopping of the feed and gun rotor. There were variations of this cycle, but basically the feed was stopped before the gun, an arrangement which permits the gun to empty itself before stopping. A

special type of brake and clutch combination assuming precise angular engagement and disengagement had to be developed to fulfill this need.

The operating cycle based on the overall arrangement may be described briefly as follows:

As a preliminary to firing, a master switch or action switch is closed; accordingly, the electric motor with its attached flywheel is started. This part of the system is designed to operate on a continuous basis. The firing switch is now closed as desired, operating through electrical switching. The main clutch is actuated, bringing the gun rotating element up to speed. At the same time the circuit to the electric primer is energized. During this part of the cycle, the ammunition feed sprocket is locked to the gun rotor in the correct angular relationship, so that ammunition feeding commences with the starting of the gun rotor. The main clutch is so designed that the time required for obtaining full speed is between 0.1 and 0.2 second, fast enough to meet normal firing requirements but slow enough to prevent high acceleration forces on the ammunition belt. At the conclusion of the burst, the feed sprocket is stopped abruptly by the feed clutch action within approximately 30 degrees of angular rotation. This action stops the first round of ammunition with an acceleration equivalent of 40 g's; however, because of the elastic action of links and chute, the shock on succeeding rounds is reduced rapidly. Simultaneously with the feed clutch action, the main clutch is changed from driving to braking position. Since the braking action is designed to occur in the predetermined time limits of 0.1 to 0.2 second, the gun rotor continues to turn for a sufficient angular distance to clear the gun of all live rounds. Whether or not the residual rounds are fired out or discharged live is determined by the time delay or interlocking relationship of the primer circuit. It is expected that the primer will be operated from a relay having suitable time delay on dropout. Actual firing of the cartridge takes place after the bolt has pressed the cartridge into the breech and is securely locked. Firing is accomplished by the closing of the final contact to the primer button by means of a fixed contact in the fixed gun cover. An extension on the bolt strikes this contact as it passes in the course of its circular motion.

The action of the bolt in handling the cartridge, the method by which it is held securely during the

interval of high chamber pressure, the feed action and the recoil are vital functions which deserve some extended explanation and discussion. These functions must be synchronized and timed in such a way as to insure reliable working of the other component parts.

The Locking Function. The means by which the bolt is held forward against the cartridge butt during the firing period is important to the safety of operation. A force of approximately 50,000 pounds is developed momentarily during the combustion period, diminishing gradually to from 2,000 to 3,000 pounds at the time of extraction. The total time of the locking cycle is approximately 6 milliseconds corresponding to a linear travel of about 2 inches at a mean pitch diameter of $5\frac{3}{4}$ seconds. Since there are five bolts, the roller lock is performing a locking operation during 50 percent of the total firing time. The forces are so great and the duty so severe that there was some question at this time of the ability of a roller of moderate size to stand up. There was a further consideration that several horsepower in friction can easily be consumed at this point. This problem presented one of the biggest obstacles to be overcome by the General Electric engineers in the construction of this unusual weapon.

While the roller lock possessed certain virtues, particularly that of simplicity, there were disadvantages of high roller stress, friction, and deflection, all of which made it difficult to predict successful operation. Roller stresses were calculated to be in excess of 400,000 pounds per square inch, and it was difficult to predict the friction developed under such conditions even where materials were able to withstand the direct loads. The maximum deflection was estimated to be as much as one-sixteenth inch. It was decided to use not the roller lock but an interrupted thread attaching the bolthead directly to the barrel extension. In this arrangement, the bolthead is rotated 13° at the forward end of the stroke into locking position. This motion is accomplished by means of a linkage in the barrel extension, which is operated by a drum cam on the frame.

Bolt Action. The bolt carries the cartridge from the feed groove into the barrel; fires the primer and blocks the breech during the combustion period; pulls out the fired case by means of springtype extractors; and holds it in position to be discharged through the case disposal chute. The reciprocating

motion by which the bolt performs these operations is obtained through contact between a driving roller and a spiral double-acting cam surface. There is a substantial dwell period at each end of the stroke, the one at the rear position being necessitated by the interval of disposing of the empty case and placing a new round in the feed slot. The dwell period at the forward end is determined by the time required (about 6 milliseconds) for the gas pressure to rise and fall during the bullet discharge. The pressure of these dwell periods is the same as steepening the cam slope of the intervening space. The cam is a critical element. It must be designed for minimum acceleration forces in three directions and must have a safe stall angle. It was believed that the cam angle of 60° was as high as could be safely used and that 45° would be much better. A smaller cam angle could be obtained by reducing the bolt stroke or by increasing the mean diameter. The diameter is determined by the number of barrels. It was decided to go to a six-barrel design, thereby reducing the cam slope from 60 to 55 with a resultant decrease in horsepower of the motor, increase in rate of fire from 5,000 r. p. m. to 6,000 r. p. m., and increase in total weight of 30 pounds, which is the weight of the additional barrel. The rate of fire per pound of weight was increased by about 10 percent.

Firing of First Completed Model

The first firing model was completed and fired in April 1949. Considerable bench testing had been done prior to this date. One of the advantages of this gun is that it can be cycled rapidly by the motor, or slowly by hand before actual firing is done, thereby saving money and time in the development program. Rates of 2,500 r. p. m. were obtained for short bursts. There were occasional misfires due to external electrical circuits or primer misfires. Starting and stopping action was rapid and smooth.

Conference on Electric Primers and Gun Ignition Circuits. Personnel from General Electric, Frankford Arsenal, Springfield Armory, Ballistic Research Laboratory, and Aberdeen Proving Ground, and other interested parties were invited to a conference held in Washington on 17 March 1949, to exchange information relative to electric primers and gun ignition circuits.

Information disclosed at this meeting indicated that:

1. The primer would function satisfactorily at 50,000 feet altitude and as low as -80° F.
2. The resistance of the wireless type primer (T59E2) could not be controlled within the limits requested by General Electric.
3. It is necessary to use a condenser discharge firing circuit.
4. Functioning of the wireless type primer is independent of resistance.
5. The application of higher voltage (180 to 250 volts) insures uniform functioning and minimum ignition time.

Based on this information, General Electric withdrew its objections until such time as further tests indicated trouble was occurring.

Experiments Conducted With Electric Primers. Preliminary measurements at General Electric of current and voltage requirements to fire this ammunition indicated minimum resistance of 50 ohms and a voltage sensitivity somewhat higher than the previously submitted Remington sample lots that required 50 and 100 volts for firing. In order to use this ammunition, currents of at least 0.2 ampere were employed. General Electric stated that they believed that the use of this ammunition could be expected to lead to early failure of presently designed firing components by arcing and serious erosion of contacts, especially at high altitude, and they thought this might jeopardize the development of the T45 gun.

Primer leakage was encountered with ammunition containing T59E2 primers, as shown by dark ring deposits on bolt face coinciding with the primer diameter. This evidence indicated that the primer had ruptured and the powder gases had discolored the bolt face. It was also concluded that the link stripping arrangement, together with the feed and guide systems, needed further refinement to establish reliability. Careful examination was made of all parts with only slight corrections being found necessary before further firing tests were satisfactorily conducted.

Other Results of Firings. Mounting and recoil did not appear to be serious problems. Due to the high-firing frequency, it would be possible to realize the low forces obtainable with single-barreled guns,

but in relation to weight and fire power, the figures should be as good or better.

By June 1950, 20 round belts had been fired at average rates of 4,000 rounds per minute, with a maximum in excess of 5,000 rounds per minute with dispersion of $3\frac{1}{2}$ mils for 100 percent of shots. All firing was conducted from a fixed mount, using a standard capacitor circuit. By September 1950, maximum rate of fire of 6,000 rounds per minute had been obtained. Work progressed slowly due to fund restriction.

The first model used a handmade link of the 20-mm type. A two-piece link previously developed for the caliber .60 round with further development, appears to be more practicable. The second gun fabricated to use this link was completed and fired in July 1950.

Designations and Characteristics of Various Models

In September 1950 four more "A" prototype guns were proposed to be used by the Ordnance Corps and Air Force for engineering tests and installations. Two additional models, designated B1 and B2, to include refinements due to testing of the "A" models, were to be made. Twenty-five additional models, designated "C", to be made with temporary production tools were scheduled.

An ammunition booster mounted on an ammunition container of 200 rounds capacity was designed and fabricated. The booster was driven directly from a gear takcoff on the gun through a flexible shaft. This booster functioned satisfactorily and a burst of 157 rounds was fired without trouble. With the exception of a single round, all shots fell within a 3-mil diameter.

As of May 1952, 7 "A" model guns had been delivered, were under test, and had been fired a total of 75,000 rounds, one gun having fired 7,300 rounds without a stoppage. Three additional "A" models were scheduled for completion by June 1952. These are all prototype guns with experimental features, consequently, their weights are excessive. A detailed description of the "A" models is given in section 2. The rate of fire on these models is being held between 4,000 and 4,500 r. p. m. although this model has been fired at 6,000 r. p. m. These guns have the flywheel feature described earlier. Twenty-seven "C" models were scheduled to be built as

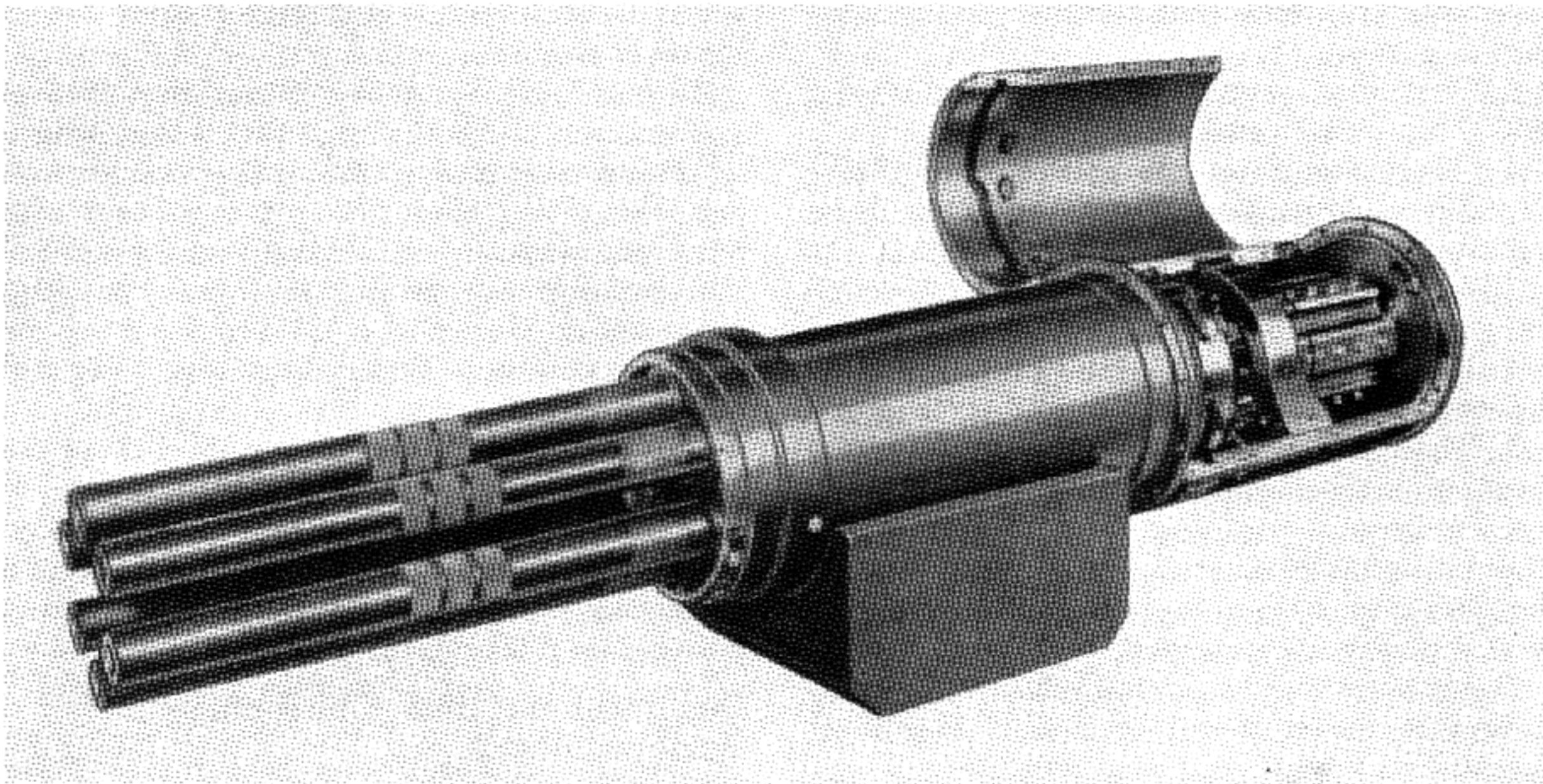


Figure 3-3. Ordnance Corps Electric-Operated Machine Gun, Caliber .60, T62. Receiver cover open.

20-mm T171 guns, delivery starting in August 1952. These guns are lighter in weight, weighing about 365 pounds of which 180 pounds are barrels. Six conversion kits to convert to T45, caliber .60 guns, and five kits to convert to T150, 27-mm will be provided. The 27-mm guns will weigh about 330 pounds because of shorter barrels. These conversion kits will consist of barrels, barrel clamp and front sprocket and stripper in the feeder. Calibers of the guns may be changed quickly by removing barrel clamps, replacing barrels which are of the quickly removable type, and changing to a feeder containing the appropriate parts. A further model, designated "D", is contemplated, which will be

materially reduced in weight, weighing about 300 pounds and will fire at an average rate of 6,000 r. p. m. There was a T62 model, intended to meet a requirement of 52 inches overall and a barrel length of 38 inches. The requirement for this model has been withdrawn.

The varying characteristics for the different calibers in the "C" models may be summarized as shown in the accompanying chart. All "C" models are intended for aircraft use.

The general design of the "C" models will follow that of the "A" models, with improvements in design. Therefore, the general data given for the "A" models are applicable to the "C" models.

	T45	T150	T171
Weight:			
without barrels.....pounds..	185	155	185
with barrels.....pounds..	365	335	365
Muzzle velocities.....ft./sec..	3, 550	3, 300	2, 000
Primer.....	(1)	(1)	(1)
Length of round.....inches..	6 ⁵ / ₈	6 ⁵ / ₈	6 ⁵ / ₈

¹ Electric.

SECTION 2. "A" MODEL T45 CALIBER .60 MACHINE GUN

Design Data and Specifications

Type: Electrically operated, rotating, multiple barrel.

Weight:

Without barrels: 256 pounds.

With barrels: 427 pounds.

Length: 74 inches.

Approximate profile dimensions: 14 by 14 inches.

Number of barrels: 6.

Rotation: Clockwise when viewed from muzzle end.

Power sources:

Motor: 24 volts, d. c. power, 300–350 amperes.

Firing circuit: 250–350 volts, d. c. power, 100 ma.

Firing rate: 4,000 rounds/minute at 668 revolutions/minute and 24 volts at motor.

Suggested maximum safe firing time (continuous burst): 7 seconds.

Dispersion: 3 to 4 mils (80 percent circle).

Time interval to obtain full firing rate: 0.2 to 0.4 second.

Recoil reaction: 4,000 to 8,000 pounds on 250,000 pounds/inch firing platform. 18,000 to 20,000 pounds on rigid mount.

Location of cartridge and link ejection: Bottom.

Location of feeder: Right side at 45°.

Recommended maximum ammunition belt pull at feeder: 50 pounds.

Recommended maximum length of belt without booster: 5 feet horizontal or 4 feet vertical.

Feed is by belt, with disintegrating link of strip-off type.

Belt speed corresponding to above rate of fire: 500 feet/minute, with maximum acceleration of 1.5 g.

General Description

The T45 gun is an electrically operated, multi-barreled, caliber .60 machine gun, designed for handling belted electric-primed ammunition at speeds

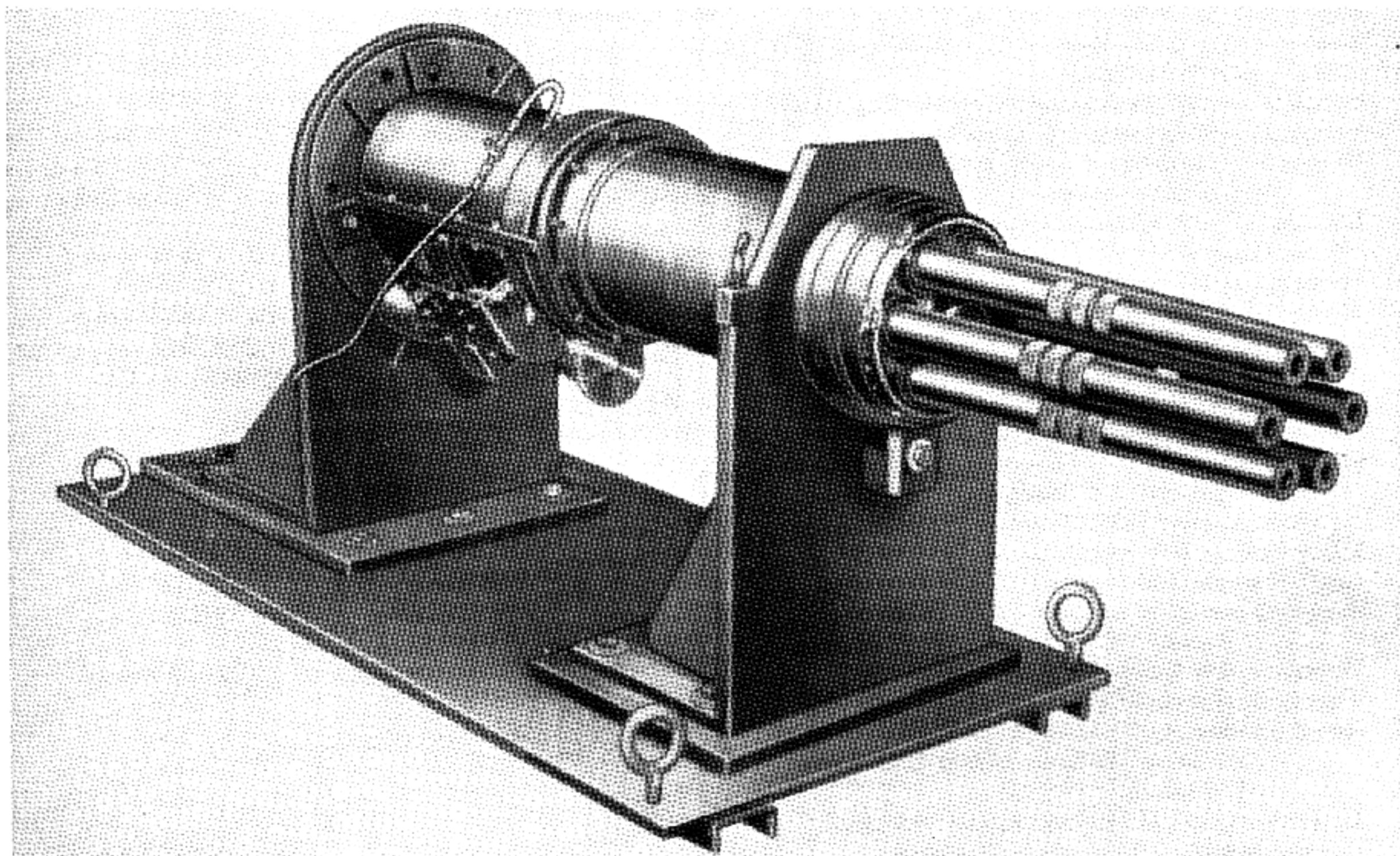


Figure 3-4. Ordnance Corps Electric-Operated Machine Gun, Caliber .60, T62. Mounted on test stand.

up to 4,000 rounds per minute. The gun is driven by a 24-volt d. c. drive motor. The associated solenoids require a 24-volt d. c. power supply and a firing circuit, a minimum of 250 volts d. c. power. No separate charger is required.

The T45 gun consists of a rotating firing mechanism with six 60-inch barrels. The weapon will operate satisfactorily with caliber .60 electric-primed ball ammunition belted by means of T44E4 links.

Firing Mechanism. The firing mechanism consists essentially of a stationary member which encloses a rotating member. The stationary member is made up of an end cover, upper and lower housings, forward casing, drive unit, feeder, and main cam. The rotating member consists of a rotor assembly

(rotor and connection block), rotor extension, six slide assemblies, and the forward bearing block. The rotating member is supported in the stationary member on two sets of bearings. Five thrust bearings, in the rear of the rotor, transmit recoil forces to the housing by means of a shaft through the back cover. Six bearing and roller assemblies in the forward bearing block support the front end of the rotating member in the forward casing.

Recoil adapters, one on each side of the casing, provide the two primary mounting supports.

The drive and feeder assemblies are mounted to the outside of the lower housing, one on each side of the gun. The main cam is fastened to the inside of both the upper and lower housings. In addition,

General Data Caliber .60 T45 Machine Gun

Gun length: 74 inches.

Gun weight:

With barrels: 477 pounds.

Without barrels: 306 pounds.

Rate of fire: 4,500-5,000 rounds/minute.

Muzzle velocity: 3,000 feet/second.

System of operation: Power-driven multibarrel (Gatling principle).

System of locking: Each barrel has own locking device.

System of feeding: Disintegrating metallic link.

Method of headspace: Factory established (can be adjusted if necessary).

Location of feed opening: Upper right-hand side at 45 degrees.

Location ejection opening: Bottom of receiver.

Method of charging: Electric.

Method of cooling: Air.

Approximate profile dimensions: 14 inches x 14 inches.

Number of barrels: 6.

Rotation: Clockwise when viewed from muzzle end.

Power sources:

Motor: 24 volts, d. c. power, 300-350 amps.

Firing circuit: 250-350 volts, d. c. power, 100 ma.

Firing rate: 4,000 rounds/minute at 568 revolutions/minute and 24 volts at motor.

Suggested maximum safe firing time (continuous burst): 7 seconds.

Dispersion: 3 to 4 mils (80 percent circle).

Time interval to obtain full firing rate: 0.2 to 0.4 second.

Recoil reaction: 4,000-8,000 pounds on 250,000 pounds/inch firing platform; 18,000-20,000 pounds on rigid mount.

Location of cartridge and link ejection: Bottom.

Location of feeder: Right side at 45 degrees.

Barrel length: 38 inches.

Barrel weight: 28½ pounds each (38-inch barrel).

Rate control: Rheostat.

Barrel removal: Not quick disconnect.

Bore:

Number of grooves: 8.

Groove depth: 0.016 inch.

Groove width: 0.150 inch.

Pitch: One turn to 18 inches.

Direction of twist: Right-hand.

Form of twist: Constant.

Recommended maximum ammunition belt pull at feeder: 50 pounds.

Recommended maximum length of belt without booster: 5 feet horizontal or 4 feet vertical.

Feed is by belt, with disintegrating link of strip-off type.

Belt speed corresponding to above rate of fire: 500 feet/minute with maximum acceleration of 1.5 g.

Ammunition:

Ball T77 caliber .60 cartridge.

Weight per pound: 0.52 pound.

Weight per link: 0.12 pound.

Primer: Electric.

Diameter of case: 1⅝ inches.

Length of round: 6⅝ inches (normal).

Links (GFE): Modified T44E2 or T44E3.

Number of rounds per foot of belt: 1.

Barrels (GFE): Supplied from Springfield Arsenal.

the upper housing carries a locking cam and the firing contact, while the lower housing supports a set of 12 guides.

The rotating group is turned by the drive assembly through a gear machined on the connection block. The feeder, located on the opposite side of the gun, is driven from this gear. The rotor of this group carries the six slide assemblies which move back and forth in slots. The connection block supports six locking levers which are actuated by the locking cam.

The six barrels of the T45 machine gun are arranged circumferentially in the rotating member and are supported by the connection block and the forward bearing block. The barrels are held in the connection block by three sets of teeth located on the outside of the barrels. Spring locks on the forward bearing block, one for each barrel, lock the barrels in place. The barrel clamp is fastened to the muzzle end of the six barrels to give rigidity to the 60-inch barrels when the T45 machine gun is operated at high speed.

Slide Assembly Bolt. The slide assemblies are made up of a body, a cam follower, firing pin assembly, bearing shoes, and a bolthead. The bolt has teeth for locking the bolt in the connection block. It also carries a single-tooth gear, the extractor springs, and part of the interlock switch. The remainder of the interlock switch is a spring mounted on the side of the bolt body. The firing pin assembly is spring loaded inside the bolt body to insure proper contact with the primer on the round. The cam follower is fastened to the bolt body by an eccentric shaft to permit adjusting headspace.

NOTE. Headspace of the firing mechanism refers to the distance between the back of the teeth in the connection block and the back of the teeth on the bolthead at the instance that the bolthead starts to lock.

Feeder and Gear Box Assembly. The feeder assembly is made up of a fabricated housing containing gearing, a shaft carrying two sprocket wheels, link guides, stripper fingers, and the link discharge. The feeder sprockets are driven through a gear train by a gear on the connection block. The feeder is so designed that the sprocket wheels and link guides position a belted round of ammunition so that the link passes under the stripper finger while the round passes over it. The feeder also contains stationary fingers to cam the spent cases out of the bottom of the lower housing.

Drive Assembly. The drive assembly comprises a 24-volt d. c. drive motor, a flywheel for energy storage, a double-action solenoid, a clutch, a brake, and the necessary reduction gearing.

The flywheel is mounted near one end of the drive unit housing. It is supported on two radial bearings and is driven directly by the output shaft of the motor by engaging flats on the drive shaft with the socket on the flywheel. This permits relative axial motion of the flywheel, which is absorbed by thrust washers at each end of the flywheel. Two sets of pressure plates are mounted near the front end of the drive unit. One set is driven by the flywheel through planetary gearing. The other set is held stationary. A disc on the output shaft is located between the sets of pressure plates. The disc is moved axially by an actuator connected to

Comparative Data: Caliber .60 T45 Machine Gun

Characteristic	Gun Length (inches)	5 Barrel	6 Barrel
Total weight, 60-inch barrel (weight per barrel, 30 pounds).	74	368 pounds.....	402 pounds.
Total weight, 38-inch barrel (weight per barrel, 22 pounds).	52	328 pounds.....	354 pounds.
Weight per barrel.....	74	73½ pounds.....	67 pounds.
Do.....	52	65¼ pounds.....	59 pounds.
Height.....		14½ inches.....	14¾ inches.
Width.....		11¾ inches.....	12¼ inches.
Rate of fire rounds-minute.....		5,000.....	6,000.

the plunger of the solenoid assembly. The solenoid assembly is made up of two coils. When both solenoids are de-energized, the actuator holds the disc in a neutral position between the pressure plates. Neither the clutch nor the brake are engaged, and the output gearing is free to turn. When energized, the rear solenoid moves the top of the pivoted actuator to the rear. This causes the disc on the drive shaft to engage the stationary pressure plates, locking the output gearing. De-energizing the rear solenoid and energizing the front solenoid causes the top of the actuator to move forward; the output shaft disc is pushed against the rotating pressure plates and the motor is clutched to the output gearing.

NOTE. The two solenoids should not be energized at the same time.

Main Cam. The main cam is essentially oval in shape with a groove for the bolt cam follower on the inside. The cam is made with a small removable segment at the back to permit removing the bolts from the rotor.

Cycle of Operation

The T45 machine gun is operated in two steps: (1) closing the master switch and (2) closing the firing trigger. Closing the master switch energizes relays which set the brake and start the drive motor.

NOTE. These relays are not an integral part of the T45 machine gun, although they may be supplied in a test control box.

The motor brings the flywheel up to speed. After the motor and flywheel combination are brought to speed, the gun is ready for firing. On closing the trigger, the solenoids operate to release the brake and to clutch the drive to the rotor. At the same time, the firing circuit is closed to the firing contact at the top of the gun. The "stored energy" in the flywheel accelerates the rotor. The six bolts on the rotor are moved forward and backward by interaction between the bolt rollers and the main cam.

As the rotor is turned, the feeder sprockets draw the belted ammunition into the gun. The sprockets pull the ammunition so that the link passes under the stripper finger while the round rides over the top. Guides in the feeder hold the link parallel to the bottom of the feeder. Continued rotation of the feeder sprockets cause the round to ride up on the stripper finger lifting it out of the link. The link is

then ejected out of the link discharge opening at the bottom of the feeder. As the round is carried around in the feeder, it is cammed out of the sprocket wheels into the rotor bolt groove ahead of a bolt by guides on the inside of the casing. For each revolution of the rotor, the feeder supplies 6 rounds, 1 to each of the 6 rotor slots.

Further rotation of the rotor causes the bolt to be moved forward by the main cam. As the bolt advances along the lugs in the rotor, it pushes the round ahead of it. Additional guides inside the housing direct the round into the chamber. When the rotor and main cam combination have pushed the round into the chamber, the extractor fingers on the bolt head engage the cannelure of the round. At the same time, the firing pin in the bolt comes into contact with the primer on the round; however, the round will not fire until the bolt interlock contact is closed and moved against the firing contact.

After the bolt head is pushed all the way into the connection block, additional rotation of the rotor causes a finger on the bolt head to engage a locking lever on the connection block. This lever is actuated by a follower in the locking cam in the top of the housing. Motion of the locking lever rotates the bolt head with respect to the bolt body. This rotation causes the teeth on the bolt head to enter mating recesses in the connection block, locking the bolt to the rotor. At the same time, the rotation of the bolt head closes the firing-pin interlock contact on the bolt.

Continued rotation of the rotor brings the interlock switch into contact with the firing contact, closing the firing circuit and firing the cartridge. The recoil forces are transmitted through the teeth on the bolt to the rotor, then through the back cover, and finally to the casing. The recoil adapters on the casing absorb much of the force of recoil and of counterrecoil.

During firing, rotation continues with the bolt locked through the dwell period; then the locking cam actuates the locking lever to unlock the bolt head. The main cam then forces the bolt to the rear. As the bolt moves rearward, the empty case is withdrawn from the chamber by the extractor fingers. Additional guides in the housing keep the case in the rotor slots as the bolt withdraws. When the empty case reaches the ejection position, stationary fingers on the feeder cam the case out of the

extractor fingers and eject it through the case discharge opening. The bolt is then carried around the rotor to come behind the next round fed into that rotor slot by the feeder.

The firing mechanism continues to strip, fire, and eject until the firing trigger is released. When the firing trigger is released, the solenoids on the drive unit actuate to declutch the motor from the rotor. At the same time, the brake is applied to rapidly stop the rotor.

NOTE. It is recommended that the firing circuit be kept energized until rotation of the unit stops. A time delay relay is used in the test line to accomplish this.

Control Box. The control box contains the relays, switches, capacitors, and connectors used in operating the firing mechanism during the test. For wiring, use only approved procedure.

Links. The link being used with the "A" model guns is a two-piece disintegrating type designated T44E4.

Advantages of the T45 Gun

Advantages of the external power driven gun over the normal type of gun mechanism are:

1. No gun charger is required and gun stoppage does not result from misfires, round being extracted automatically.

2. As gun mechanism does not start and stop at each cycle and uncontrolled reciprocating parts are eliminated, the resulting impact loads occurring in normal type guns are eliminated. The majority of gun failures are caused by impact.

3. The use of springs is reduced to a minimum. Failure of gun springs subjected to repeated impacts at high frequencies is one of the main troubles with standard type guns.

4. As the belt of ammunition is not subject to the repeated starting and stopping occurring in standard type guns, the belt is not as subject to separations.

Operation Precautions

1. Be sure that the access opening on the main cam is fully seated and the screws tight before operating the gun. A slight misalignment will damage the cam rollers.

2. Be sure to use only links of approved dimensions.

3. Dummy rounds having open primer holes will strain or break the firing pins on the slide assemblies.

4. Load a single belt of ammunition into the feeder of the gun from the right side with the single loop first.

5. When loading, be sure that the first round is fully engaged by the feeder sprocket before applying appreciable torque.

6. The firing rate of 4,000 rounds per minute is obtained at 22 to 24 volts at the motor terminals. Higher potentials will produce greater speeds which are above the present safe operating limits.

7. Do not allow brake coil of solenoid to remain energized for more than 5 minutes at a time, to prevent overheating.

8. Do not run the motor for extended periods, as the heat rating is critical.

9. If starting or stopping is sluggish, a slight adjustment of the drive unit solenoid may be necessary.

Cleaning, Lubrication, and Inspection: General

Proper functioning and the accuracy of firing depend largely upon care, cleaning and oiling. The weapon should be checked daily for cleanliness and lubrication. The following instructions should be carefully observed. Relubricate after cleaning to prevent subsequent rusting.

Cleaning

All parts should be checked to insure that they are clean and lubricated. If not, clean according to the directions in the following paragraph.

Thorough cleaning after firing is extremely important and should be performed as soon as possible. The bore and other portions exposed to primer fouling should be thoroughly cleaned of primer salts, using rifle bore cleanser. The corrosive primer salts are water soluble but are not soluble in petroleum distillates.

Barrels. Except in emergencies, barrels should be removed for cleaning to avoid accumulation of deposits in connector block. Barrels are cleaned by running wet patches impregnated with bore cleaner through the bore. After the bore is thoroughly coated with bore cleaner, the barrels should be allowed to sit a minimum of one-half hour or overnight if possible. After allowing the barrels to sit, clean the bore cleaner out of the bore with a dry clean patch. Loosen the foreign particles in the bore by running a wire brush through it several times. Using warm soapy water and a clean patch,

thoroughly clean the bore. Follow this procedure with dry patches run through the bore until they come out clean and dry. Barrels are then ready for use. However, they should be coated inside and outside with a thin coat of Navy specification U51 oil if they are to be left standing more than 2 hours. Before firing, all oil should be removed from the barrel bore.

NOTE. If barrels are to be stored, the preceding operation should be repeated on three separate days.

Slide Assemblies (Bolts). Slides are wiped clean after removing them from the gun. The heads should be immersed in bore cleaner to permit freer action of the solvent.

Rotor and Connection Block. If there appears to be an excessive accumulation of dirt in the rotor and/or connection block, remove the upper and lower housings and clean with brushes.

Lubrication

Lubrication is required according to a chart furnished with the weapon. Use lubrication sparingly.

Inspection and Checks

A thorough systematic inspection at regular intervals is essential. These inspections should include (1) preventive maintenance and (2) determining whether replacement of parts is necessary because of ordinary wear and defective parts.

Prefiring

1. Be sure ammunition and links are in acceptable condition: clean, free of burrs, and within drawing dimensions.

2. Be sure that access plate is securely bolted in place. Failure to seat properly will damage cam roller and may cause failure of gun.

3. Check all sliding parts and bearing guides for burrs or abrasive foreign matter.

4. Be sure that the firing contact pin completely engages each of the six slide contact pins and that the interlock contacts engage with approximately one-eighth inch interference. The engagement must be positive but not excessive. Since wear may take place on the contact pin, it may be necessary to replace it. The recommended contact dimension is 0.010 to 0.020 inch interference.

5. Check to see that ejection openings for spent cases and links are not obstructed. Also make sure

that they cannot bounce back into the ejection openings.

6. Check condition of feeder and ejection arms for looseness of parts, breakage, or wear. The feeder must be in excellent shape at all times.

7. Make sure that the feeder chutes are installed correctly and that there is no interference.

8. Before loading the gun, check the operation of the motor and clutch unit to insure proper functioning.

9. Run a belt of at least six dummy rounds through by hand. If any binding or sluggish movement is noted, determine the cause and make the necessary checks and repairs.

10. Check all bolts for looseness or breakage of safety wires.

11. Be sure that recoil adapter bolts are snug and suitably locked.

12. Check extractor springs for tension or mechanical defects. All extractor springs should have one or more pounds of preload and should have an initial resistance to lifting by the finger.

13. Check extractor clamp screws. If loose, either replace or restake.

14. Check bearing shoes for deep scratches or wear.

15. Make sure the firing pin is free and centered with suitable electrical clearance. Make occasional ground resistance checks at some elevated potentials such as 500 volts.

16. Be sure that the ammunition chute (not furnished) is securely fastened and accurately aligned.

Performance

1. Check the condition of the bearings occasionally by turning the gun by hand.

2. Take headspace reading frequently. Values should read 0.0025–0.005 inch.

3. Inspect the slide assemblies after every 200–300 rounds according to prefiring instructions, just given.

4. Check firing contact pin frequently according to prefiring instructions.

Removal, Disassembly, and Installation

The multibarrel gun should be disassembled only to the extent described in applicable manuals. In cases where a component is faulty, it should be removed, repaired, and replaced in the gun in accord-

ance with the appropriate instructions. Some units cannot be removed without prior removal of other subassemblies.

NOTE. It is recommended that the six slide assemblies be removed prior to the removal of any subassembly.

With the exceptions noted, the reassembly of each subassembly is the reverse of the disassembly and therefore is not included.

Barrels—REMOVAL.

1. To remove the barrel clamp, remove the six nuts which hold it in place and slide it off the ends of the barrels.

2. Pry up the barrel lock springs on the bearing block. Turn the barrel one-sixth of a revolution counterclockwise (when looking into the muzzle) and pull the barrel out.

REPLACING THE BARRELS AND BARREL CLAMP. Reverse the procedure just given. Care should be taken to see that the barrel clamp nuts are pulled up evenly.

Slide Assembly (Bolt). Any of the parts of the slide assembly may be replaced when necessary.

NOTE. All slides are numbered and should be inserted in the correct rotor slot.

REMOVAL.

1. Using an Allen-head wrench, reach into the access opening on the end cover, and remove the two screws from the cam insert located in the main cam. Turn the rotor until a rotor guide appears directly above the insert. Pull the insert out.

2. Turn the rotor one-twelfth of a revolution either way and pull out a slide assembly through the opening. Continue by turning the rotor one-sixth of a revolution and removing each slide assembly in turn.

DISASSEMBLY.

1. Remove head from body by turning head clockwise until it unlocks, and pull it off.

2. Remove contact pin, insulation, roller, and washer from head.

3. Remove the two extractor springs from the head by removing the three screws and clamp.

4. Pull off four bearing shoes.

5. Using an adjusting locknut wrench, unscrew the locknut on the bottom of the roller assembly. Be sure to note the position of the mark on the shaft in relation to the body of the slide assembly. In reassembly, the shaft must be aligned correctly with

the slide body in order to give proper headspace. Push out the shaft and roller assembly. Remove the washer and roller from the shaft if necessary.

NOTE. In reassembly, be sure that one of the teeth of the locknut lies over the center of the hole in the slide body. If this cannot be done, use another nut.

6. Remove the contact assembly by removing the 2 screws, retainer, insulation, 2 contact springs, 2 insulation washers, and insulation.

7. Tap out the split dowel pin, using a pin punch and a hammer.

8. Push out the firing pin assembly.

INSTALLATION. When installing a slide assembly in gun, reverse the procedure for removal. Be sure to check headspace according to procedure in test section.

Feeder and Gearbox Assembly. The feeder housing is riveted together. Do not remove the rivets. Replace with a new assembly if the housing is not usable. Each guide and stripper assembly is individually fitted to each feeder. Therefore, if something is wrong with the guide and stripper assembly, replace the entire feeder. During reassembly of feeder and gearbox assembly, be sure to conduct tests noted later in this section.

REMOVAL.

1. Remove 3 screws and 3 washers holding ammunition chute to feeder. Remove chute.

2. Remove 10 screws, 10 lockwashers, and 2 dowel pins holding feeder to housing, and 3 screws, 3 lockwashers, and dowel pin holding gearbox to housing. Lift the assembly off the housing.

DISASSEMBLY.

1. Remove gearbox from feeder by removing 3 screws, 3 lockwashers, 2 dowel pins, which hold gearbox to feeder. Slide gearbox away from side of feeder housing.

2. Disassembly of gearbox: Remove retaining ring and spacer. Slide shaft out. Shaft fits fairly tight, and it may need to be tapped out. Be careful of Woodruff key. Press out needle bearings if bearings are bad.

3. Disassembly of feeder: Tap taper pins out of sprockets. Slide shaft out. (Do not lose the two spacers.) Remove gear. Do not lose Woodruff key. Drive taper pin out of gear. Press out needle bearings if necessary.

INSTALLATION.

1. Reassemble gearbox to feeder: Slide end of gearbox into feeder housing, making sure the gears on the feeder and the gearbox mesh correctly. Fasten gearbox to feeder with 3 screws, 3 lockwashers, and 2 pins.

2. Fasten feeder and gearbox assembly to gun. Be sure to check for backlash and clearance.

NOTE. Before reassembly, refer to later section for timing of feeder.

Drive Unit. The drive unit should not be completely disassembled. Only the pinion, the drive gear, the solenoid, and the motor should be removed from the drive unit and disassembled as far as stated here.

REMOVAL.

1. Remove 4 screws, 4 lockwashers, and 2 dowel pins holding bracket to gun assembly, and 3 screws and washers holding flange to gun assembly. Remove drive unit from gun. Be careful of wires.

DISASSEMBLY.

1. Pinion: Remove three screws holding gear cover to drive unit and remove cover. Remove nut and lockwasher. Slide stud assembly out of bracket. Remove two thrust washers and pinion from stud. Press needle bearings out of pinion if necessary.

2. Drive gear: Remove retaining ring. Pull off gear. Be careful of Woodruff key.

3. Solenoid: During reassembly, be sure to adjust position of solenoid. Remove solenoid by removing 4 screws and 4 lockwashers holding solenoid to drive unit. Remove end covers after removing the 4 screws and 4 lockwashers located on both covers. Take top and bottom covers off after removing the 2 screws and 2 lockwashers located on both covers. Pull out solenoid coils.

4. Motor: Remove 4 bolts and 4 lockwashers holding plate and motor assembly to clutch mechanism. Lift off plate and motor assembly. Remove 4 bolts and 4 lockwashers holding motor to plate. Lift off motor.

INSTALLATION. After reassembly, install drive unit on gun. Be sure to check backlash.

Contact Assembly.

REMOVAL FROM GUN. Remove 4 screws and 4 lockwashers holding contact assembly to gun. Remove contact assembly.

REASSEMBLY. Be sure to adjust contact pin.

Housing. Either half of the housing may be removed at any time during disassembly. The main cam must be supported when both halves of the housing are removed.

UPPER HOUSING.

1. Removal: Remove the 18 screws, 18 washers, and 4 pins holding upper housing to lower housing and end cover. Remove 4 screws, 4 lockwashers, and dowel pin holding housing to main cam. Remove six lockwashers holding housing to casing and extension assembly. Lift off housing.

2. Replacing locking cam: Remove upper housing. Remove 3 screws and 3 washers holding cam to housing. Carefully tap locking cam out of housing.

LOWER HOUSING.

1. Removal: Remove drive unit and feeder and gearbox assemblies. Remove the 18 screws, 18 washers, and 2 dowel pins holding lower housing to upper housing and end cover. Remove 6 screws and 6 lockwashers holding housing to main cam. Remove 6 screws and 6 lockwashers holding housing to casing and extension assembly. Lift off housing.

2. Replacing guides: There are 12 graduated guides, 6 on each side of the lower housing. The guides may be removed from the housing after removing the housing from the gun assembly. If any of the guides are worn, a complete set should be replaced. Be sure they are replaced in the correct order. After replacing guides, run a dummy round through the firing mechanism and check to see that the round does not bind between the rotor and the guides. If the round binds, the position of the guide should be shifted slightly. (1) Remove guides individually or as a set by removing screws and lockwashers holding guides to housing.

End Cover. Do not remove the end cover before removing at least half of the housing. Be sure the rotor is supported when removing end cover, as gun assembly will be top-heavy.

REMOVAL.

1. Remove one half of housing.
2. Remove 6 screws and 6 lockwashers holding other half to housing end cover.
3. Remove end cover after removing locknut, nut, and washer from rear of gun assembly.

Main Cam. Extreme care should be taken when removing main cam from gun assembly. Be sure

to remove the six slide assemblies before removing the main cam from the firing mechanism.

REMOVAL.

1. Remove upper housing.
2. Remove end cover. Support the rear gun assembly as it will be top-heavy.
3. Remove 6 screws and 6 washers holding cam to lower housing.
4. Carefully slide cam off of rotor.

INSTALLATION.

1. Carefully slide cam over rotor, being careful to support the cam when it is positioned.
2. Replace screws holding cam to housing.
3. Replace end cover.
4. Replace upper housing.

Rotor Assembly.

REMOVAL. Be sure to remove the six slide assemblies before removing the rotor assembly from the firing mechanism.

1. Remove gun barrels, forward bearing block, casing, and extension according to instructions that follow.

2. Roll gun over until it rests on the upper housing.

3. Remove lower housing. (The feeder and gearbox assembly and the drive unit may be replaced if desired.)

4. Remove end cover, using extreme care not to let the rotor drop on the upper housing.

5. Slide the rotor assembly (rotor and connection block) and rotor extension out of the main cam and upper housing.

6. Remove the six screws and washers holding the rotor extension to the connection block and remove the extension. (The rotor and connection block have been fitted together in manufacture and require a special key. If it is necessary to replace a rotor or a connection block, they should be replaced as a unit.)

REPLACING ROTOR AND CONNECTION BLOCK COMPONENT.

1. Guide plates: Certain rotors have removable plates: If the guide plates on these rotors become damaged in operation, they may be removed and replaced. To remove guide plates, take out the screws and lift the plate off. When replacing a guide plate, use extreme care to be sure it is properly lined with the other plates in the set. Improper alignment will

leave protruding corners which will be struck by the slide assembly.

2. Bearings: The after bearings may be removed and replaced without removing the rotor from the gun. To do this, remove the end cover. Remove the bearing retainer and bearings per instructions below, and replace them. Replace the after bearings as a complete set of five. To replace the bearings, remove the six screws and lockwashers which hold the bearing retainer in place and lift the retainer off. Using the bearing shaft for a grip, pull the bearings out. To install the bearings, line the set up so that the lines on the outer race form a V, then insert them in the bearing bore with the sharp end of the V entering first.

3. Locking lever assembly: Remove the 2 screws and 2 washers and lift the locking lever bracket off the connection block. The dowel pins will remain in the bracket. Lift the locking lever off the connection block. Press the pivot pin out of the lever. Replace the damaged part or parts and reassemble by reversing the above instructions.

Forward Bearing Block—REMOVAL.

1. Remove barrels.
2. Remove locknut, nut, and washer, which hold the bearing block to the rotor extension.
3. Using a bearing puller, pull bearing block off of rotor extension.

REPLACING BEARINGS ON BEARING BLOCK.

1. Remove pin on back side of roller assembly.
 2. Pull out roller shaft. Roller will drop off as shaft slides out.
 3. Press needle bearings out of rollers if necessary.
- NOTE.** If needle bearings are removed from the rollers, new bearings should be installed.

Casing and Extension—REMOVAL.

1. Remove barrels and bearing block.
2. Remove 12 screws and lockwashers which hold the casing and extension to the upper and lower housing.
3. Slide casing and extension off.

Recoil Adapters. To remove the recoil adapter from the gun, take out the eight screws and lockwashers which hold it in place. Remove the four dowel pins and lift the adapter off.

Headspace Adjustment

Checking Headspace.

1. Bring slide assembly up to fire position.

2. Connect headspacing gage. There are 5 pieces (2 with a bushing attached) and 4 bushings (counting 2 attached bushings).

3. Slide rod into top barrel.

4. Attach end fitting. Bring it against the end of the barrel. Tighten the thumb screws. Center as well as possible.

5. Slide the dial indicator into the hole in the end fitting and fasten in place by tightening the nut. The dial indicator should be positioned so that it is approximately in the center of travel.

6. Remove the rotor in a counterclockwise direction (facing the forward end of the barrels) until the high spot on the cam is located. Stop the rotor with the cam follower on the high spot and zero the dial indicator.

7. Move the rotor in a clockwise direction until a follower clears the high spot. Read the headspace from the dial indicator.

NOTE. Headspace should be 0.0025–0.005 inch. If it is not, adjust headspace as directed below.

8. After reading headspace on the locking side, zero the dial indicator before revolving the rotor further.

9. Revolve the rotor in a clockwise direction until the high spot on the unlocking side of the cam is located. With the cam follower on the unlocking high spot, read the unlocking headspace directly from the dial indicator.

NOTE. Locking and unlocking headspace should be within ± 0.001 of each other.

10. Continue to check headspace on all slide assemblies.

Adjusting Headspace.

1. Remove the slide assembly from the gun.

2. Remove the slide roller assembly, taking care to note the position of the shaft with respect to the body.

3. Turn the shaft so that it rotates a distance of one spline tooth with respect to the body. Fasten a roller assembly in place.

NOTE. If the headspace is too high, rotate the shaft so that the small hole in the shaft moves toward the slide head. If the headspace cannot be adjusted to within limits by turning the shaft, a new shaft should be installed. Two types of shaft are made: one with the high spot located between two teeth,

the other with the high spot located on one tooth. Either type shaft may be used.

Feeder Timing

Feeder-timing marks and holes have been put in the completed feeder and gearbox assembly to facilitate timing. However, timing should be carefully checked each time the feeder and gearbox assembly is removed from the gun.

Timing the Feeder and Gearbox Assembly.

1. Rotate the rotor so that the number one barrel is on top and the lines marked "T" are lined up.

2. Rotate the feeder sprockets so that the line (on the sprocket tooth) marked "T" lines up with the upper support. Clamp or hold the sprockets in this position.

3. Rotate the gears in the gearbox so that a $\frac{1}{8}$ -inch dowel pin will slide into the holes in the gearbox and the gear.

NOTE. If new gears or sprockets are installed, holes or lines should be added to them in the same position as the holes or lines are on the replaced parts.

4. Assemble gearbox and feeder.

5. With the rotor, feeder, and gearbox locked in the above positions, slide the feeder and gearbox assembly into place on the lower housing and insert the dowel pins. Install several screws to hold the feeder in place while checking timing. After timing is checked, install rest of screws and lockwashers.

Checking Timing.

1. Remove the cam insert.

2. Remove the number one slide (all slides may be left out if desired).

3. Turn the number one barrel to the "Fire" position, and insert a dummy round in the feeder.

4. Slowly revolve the rotor in the clockwise direction (viewing from the front), at the same time watching the round through the opening in the end cover.

5. If the feeder is properly timed, the round should just clear the leading edge of the rotor slot (0.001–0.005-inch clearance).

6. If the feeder is not properly positioned, re-adjust the feeder and gearbox assembly so that the

gear in the gearbox mates with the next tooth in the connection block or so that the gearbox pinion mates with the next tooth in the internal feeder gear.

Contact Assembly Adjustment

Checking Travel.

1. Remove the electrical fitting.
2. Remove the insulation washer, spring, and stop from the contact.
3. Insert a $\frac{1}{4}$ -inch dowel pin into the contact and place a dial indicator on the housing such that it will read the travel of the dowel pin.
4. Rotate the rotor in the running direction noting the reading on the dial indicator as each slide passes under the contact. This travel should read 0.010–0.020 inch. If not, remove a shim from under the contact or replace the contact button.

Solenoid Adjustment

The solenoid should be positioned so that the movement fore and aft is approximately the same, measured from the free or midposition. This should produce a starting and stopping time of from 0.2–0.4 second.

1. Loosen the four screws holding the solenoid to the drive unit.
2. Slide the solenoid forward to decrease starting time or aft to decrease stopping time.

The gun should at all times be supported by a suitable cradle. The firing stand may be used as a support for the shop servicing. The main frame of the firing mechanism is sufficiently strong, but the total weight should not be supported by the external auxiliaries, such as the firing contact, the feeder bracket, or the drive motor. Barrels are normally removed for handling.

Chapter 4

ORDNANCE CORPS SHORT-RECOIL-OPERATED AUTOMATIC MACHINE GUN

SECTION 1. HISTORY AND BACKGROUND

During the first year of American entry into World War II, the Army Ordnance Corps, in anticipating the needs for a machine gun for aircraft use having a bore of larger diameter and higher muzzle velocity than the universally used Browning caliber .50 machine gun, started development of a caliber .60 aircraft machine gun.

The first attempt to meet the characteristics for the caliber .60 aircraft machine gun was to modify a 20-mm M1 Hispano-Suiza automatic cannon. The receiver was identical, and parts of the gun were interchangeable with the 20-mm M1. The chief difference was in the barrel, which was chambered for the 20-mm case, bored and rifled for the 15-mm bullet and fixed in relation to the mount. The whole gun was rigidly mounted and the muzzle brake and recoil mechanism used on the 20-mm gun were eliminated.

The Eclipse machine division of the Bendix Aviation Corp. undertook the modification and fabrication of the modified gun. A type of feeder known as the "Burgess," which was operated by the recoil

of the weapon, was tried at first but was not successful. The pilot model was equipped for a 47-round magazine, to be mounted rigidly on the gun. This magazine was similar in appearance to the 60-round drum which was standard on the 20-mm M1 gun. The pilot weapon was fired more than 800 rounds, but further testing was discontinued after it was found that the velocity obtainable from the cartridge used was approximately 150 to 200 feet per second less than could be obtained with the caliber .60 cartridge case.

A second modification of the 20-mm Hispano-Suiza cannon was made by rechambering and boring and rifling the barrel for the caliber .60 case and bullet. Corresponding changes were made in the bolt and extractor. This gun was fired a small number of rounds (not more than 50) automatically. Official designation of the gun was caliber .60 T18. Since radical redesign of the Hispano-Suiza cannon appeared necessary if this gun was to meet aircraft requirements, work on this model was discontinued.

General Data: Caliber .60 T18 Machine Gun

Gun length: 100.625 inches.
Gun weight: 115 pounds.
Rate of fire: 650-700 rounds/minute.
Muzzle velocity: 3,000 feet/second.
System of operation: Gas unlocking, blowback actuating.
System of locking: Swinging lock.
System of feeding: Drum and spring-wound feeder.
Method of headspace: Governed by component manufacturing tolerance.
Location of feed opening: Top of receiver.
Location ejection opening: Bottom of receiver.
Method of charging: Air, hydraulic, or manual.
Method of cooling: Air.

Barrel length: 67.52 inches.
Barrel weight: 47.8 pounds.
Rate control: None.
Barrel removal: Not designed for field removal.
Bore: Number of grooves: 8.
Groove depth: 0.016 inch.
Groove width: 0.150 inch.
Pitch: One turn in 18 inches.
Direction of twist: Right hand.
Form of twist: Constant.

NOTE: Modification of 20-mm Hispano-Suiza cannon by using barrel chambered for cal. .60 (see Fig. 1-12, p. 12).

After approval by Headquarters, ASF, it was recommended that further investigation of caliber .60 mechanisms be conducted with a new design (T31) and a modification of the 20-mm Hispano-Suiza automatic cannon M2. This modified 20-mm weapon was designated T18E1 because there had previously been made a gun called T18, which was a 20-mm automatic cannon M1 modified to fire the caliber .60 cartridge. The earlier gun was fed from a five-round magazine and served only to show that the action was sufficiently strong to fire the cartridge.

In August 1944, it was decided to reopen this phase of the development in order to determine whether a caliber .60 gun could be produced from the 20-mm M2 weapon by replacing or modifying a small number of parts. It was hoped that a satisfactory weapon could be produced rapidly by utilizing several thousand 20-mm guns which were on hand and for which there existed no immediate military requirement.

A contract was placed with the Autoyre Company. The specifications called for a gun with a quickly detachable barrel, a feeding mechanism, a front (synchronizable) sear, and a recoil adapter. A new link was also developed to facilitate the design of the feed mechanism.

It was decided to retain the existing gas-operated means of unlocking the bolt. An extension was fastened to the forward end of the receiver to provide for the quickly removable barrel. The feed mechanism was operated by an additional gas piston and cylinder mounted above the unlocking cylinder. This upper piston was arranged so that gas pressure would compress the feed springs which would then expand and feed the belt as rapidly as the timing of the gun permitted. The cartridge was forced from the bottom of the feed link and was not

pushed through it. The caliber .60 cartridge was larger in diameter than the 20-mm cartridge and, accordingly, the height of the bolt was increased so that the extracted case would not be pushed off by the following round. The link used with the new ejector proved to be one of the major causes of trouble.

Modifications were made to the firing pin and locking slides so that the gun could be fired with the bolt in the forward position. This was done by placing the plunger of the firing solenoid in the path of one locking slide.

Functioning of the gun was believed good, considering the short time which had elapsed since the development had started. However, difficulty was encountered with ejection, with stubbing of the cartridge, and with failures to fire. It was found that the latter were caused by the bolt rebounding from the breech face, a malfunction which was corrected by the use of brass impact surfaces. The feeding difficulties were traced to slowness of feed and faulty design of the feedway opening. The ejector troubles required complete redesign of the ejector assembly.

Because of the heavy workload at Aberdeen Proving Ground, Md., the development program was transferred to Springfield Armory and final tests were conducted there. It was found that the sear release time was slow due to the large mass of the firing parts. This characteristic, together with the extensive modifications which had to be made to the 20-mm gun, made it impossible to achieve the original aim.

Had all the malfunctions been corrected, the product would still have been a conversion, but the amount of work required to change or replace existing parts would have justified an entirely new start. Accordingly, the project was dropped.

SECTION 2. CALIBER .60 T17 MACHINE GUN

Summary of Development

In September 1942, the Ordnance Corps initiated a project to convert the German Mauser MG 151/20 to a caliber .60 machine gun. The MG 151/20 was a 20-mm short-recoil-operated, air-cooled, belt-fed weapon. A German gun had been shot down in the Battle of Britain and turned over

by the British authorities to the United States for study and development.

In October 1942, the Colt Patent Fire Arms Co. of Hartford, Conn., undertook this conversion. The Ordnance Corps designation was caliber .60 machine gun T17. It was found necessary to rechamber the barrel, lengthen the receiver, feedway, bolt, cam tube, and cover, and also to make a few other

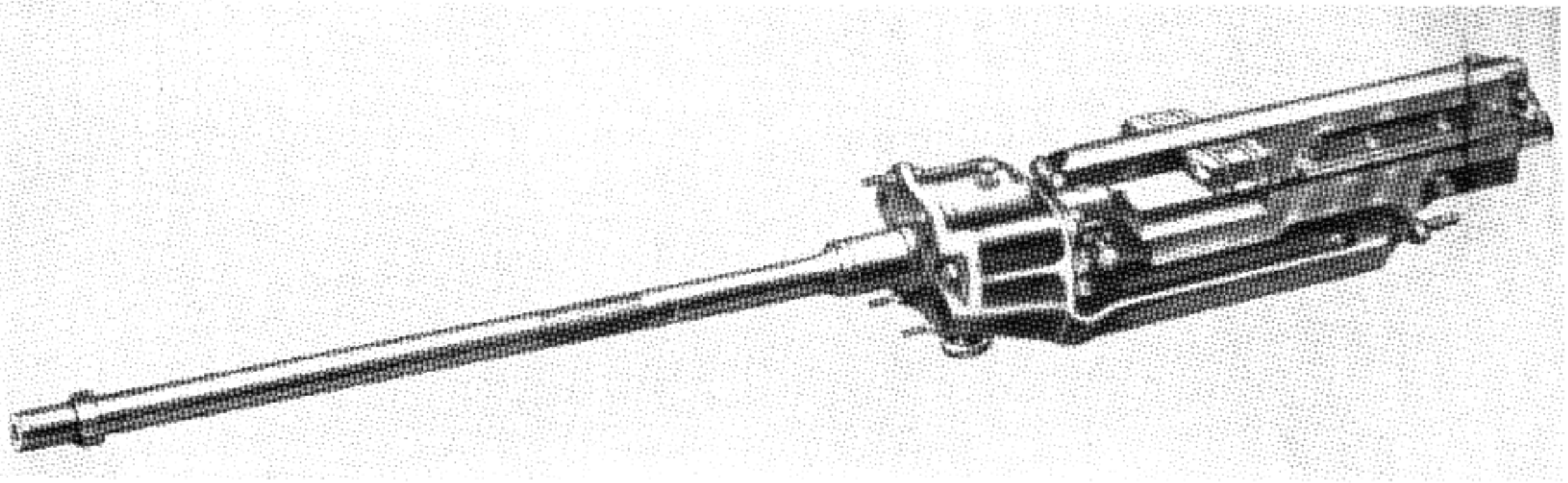


Figure 4-1. German Mauser 20-mm Automatic Gun MG-151/20.

minor design changes. New links were provided by the Autoyre Co.

The first test firing of the gun was at the Colt plant on 23 November 1942. It was found that the recoil was very heavy and that extraction was too early as evidenced by expanded cases. It was assumed by the designer that the rate of fire was much above the desired rate, and a recoil brake was added to the muzzle. However, this did not reduce the rate of fire as much as expected. The gun was then sent to the Aberdeen Proving Ground, Md., where it was fired approximately 350 rounds. The rate of fire was then determined to be approximately 700 rounds per minute. Bursts of four rounds were fired satisfactorily. A barrel 51 inches long, the same length as the German gun barrel, was used. A muzzle velocity of 3,000 feet per second was obtained.

Unlocking and extraction occurred early, as evidenced by expanded shoulders of the cases. It was discovered that minor modifications should be made to strengthen certain portions of the bolt and to provide for later unlocking in extraction. Further development at Colt's was discontinued as the Colt plant was not suitably adapted for continuing this development as speedily as was desired.

Basic Barrel Development

Development work on the gun barrel has been carried on by Springfield Armory and Frankford Arsenal. The initial requirement for the T17 gun

called for a quickly detachable and replaceable barrel. This feature, suggested by Frigidaire, had earlier been taken from the German MG 151/20 design. Springfield Armory made the first barrels and integrated the barrel design. After the initial barrels were fired, Springfield Armory worked on improvements in metal strength characteristics and heat treatment problems. Frankford Arsenal developed the original data on bore diameter and depth of rifling, and it determined that 590 grains of powder (IMR 4996) would yield an instrumental velocity at 78 feet of $3,500 \pm 30$ feet per second with a 1,200-grain projectile.

In March 1944, a groove diameter of 0.604 ± 0.002 and a land diameter of 0.588 ± 0.002 with one caliber of free travel were adopted. Data presented by Frankford Arsenal showed that one caliber of free travel reduced the peak chamber pressure approximately 2,000 pounds per square inch and the initial muzzle velocity by approximately 100 feet per second. The standardized depth of rifling of 0.007 to 0.009 inch was an increase of 0.004 inch in depth over the first barrels used.

At approximately the same time, it was desired to increase the capacity of the cartridge case and to make it more nearly cylindrical to facilitate manufacture and stowage. Accordingly, modified chambers and cartridge cases were designed and tested. The old cartridge (T1) was characterized by a 0.050 body taper, the new (T22) by a 0.035 body taper.

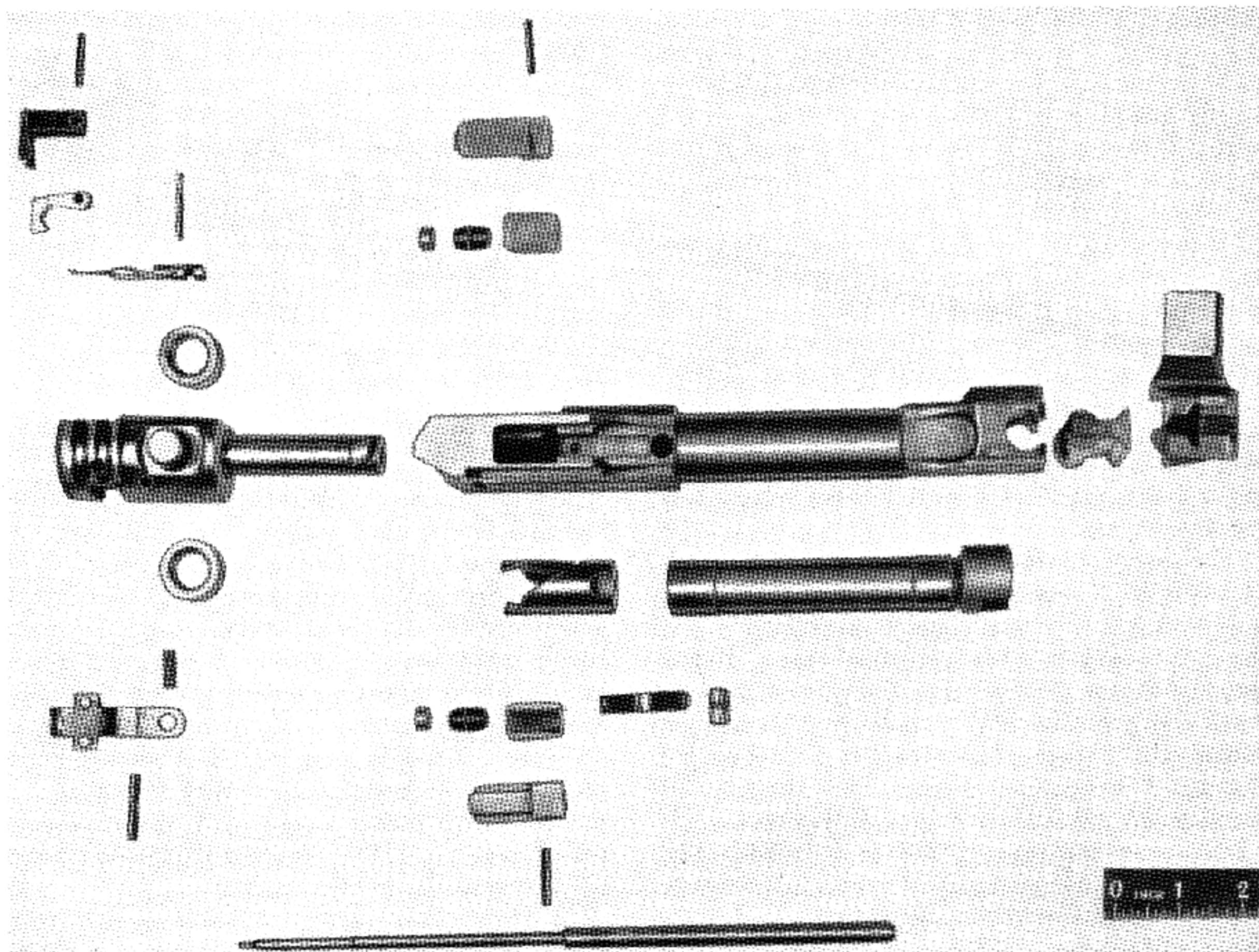


Figure 4-2. Gun, Machine, Caliber .60, T17. Bolt components.

SECTION 3. CALIBER .60 T17E1 MACHINE GUN

Summary of Development

In January 1943, the Frigidaire division of the General Motors Corp., Dayton, Ohio, undertook to provide 10 pilot models of the aircraft machine gun, caliber .60, T17E1. The model was to be essentially the same as the T17 except that the rate of fire was to be increased to 800 rounds per minute and the high trunnion reactions were to be lowered by incorporating in the design a recoil adapter developed by the Edgewater Steel Co. at the request of the Ordnance Officer at Wright Field. Links for the gun were developed by the Autoyre Co. of Oakville, Conn. Complete drawings of the T17 gun

were prepared by Frigidaire and an engineering study was made to redesign the weapon for cheaper mass production.

The pilot model T17E1 was delivered to Aberdeen Proving Ground for test on 2 May 1943. Tests indicated that the bolt either was made of improper material or had been overhardened, as the locking lugs and a section of the bolt face were broken after only a few rounds had been fired. New components were made and after firing 70 rounds on 24, 25, and 26 May 1943, an explosion occurred which ruptured the cartridge case and destroyed all of the operating parts of the gun.

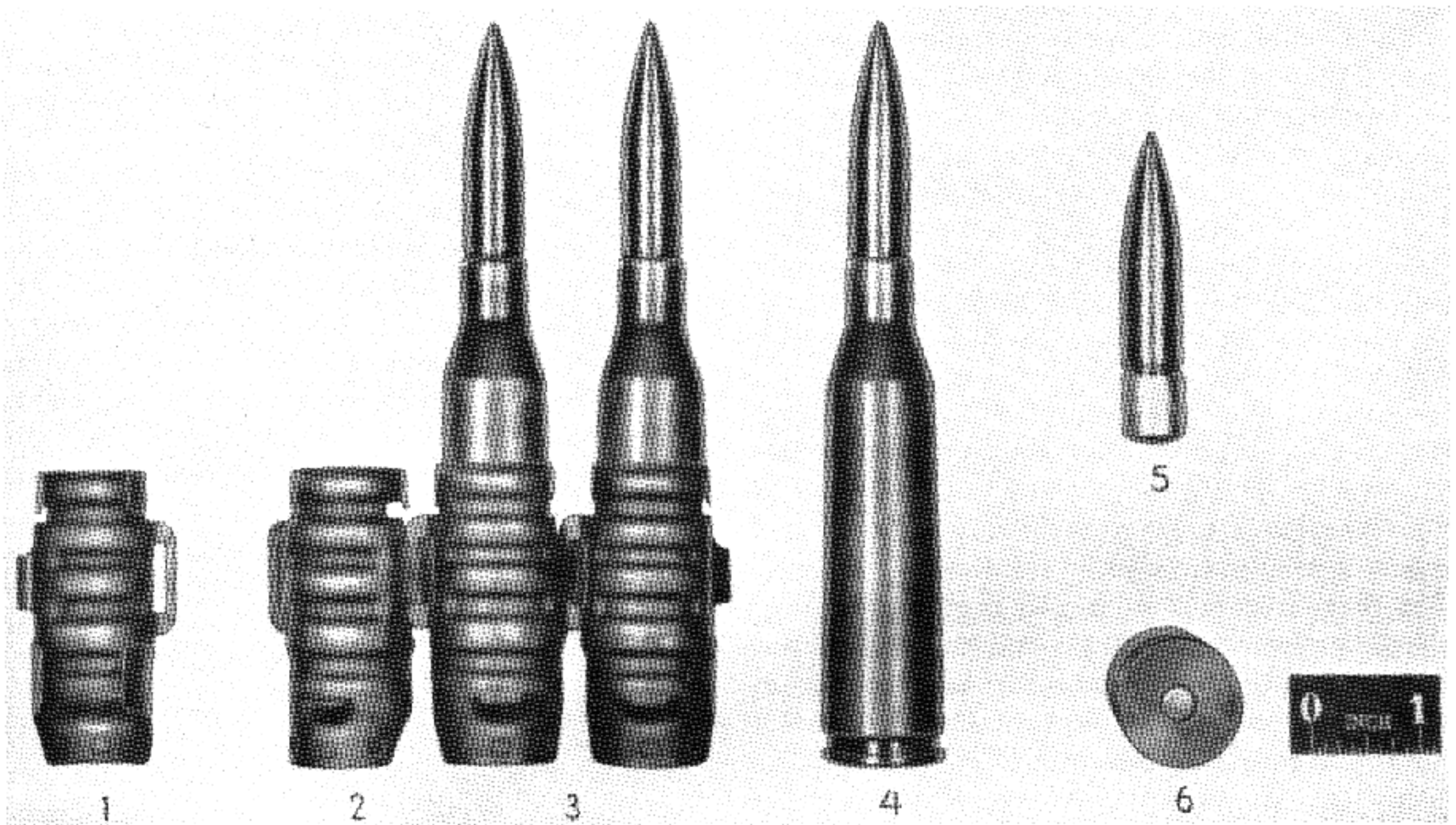


Figure 4-3. Ammunition and links for Caliber .60 Machine Gun T17.

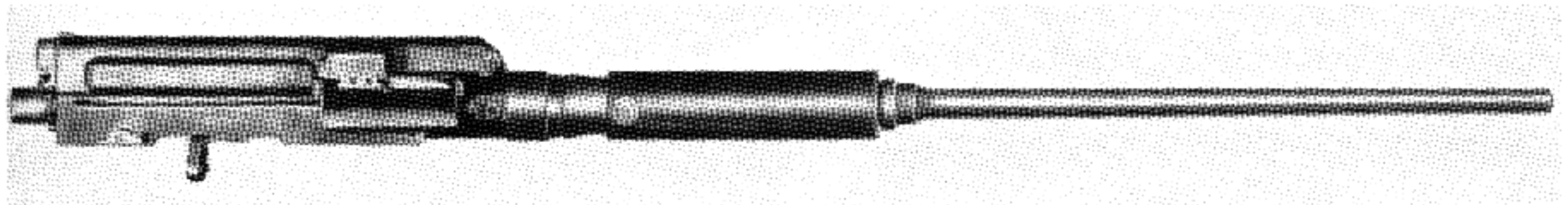


Figure 4-4. Gun, Machine, Caliber .60, T17E1. This design was derived from the German MG-151.

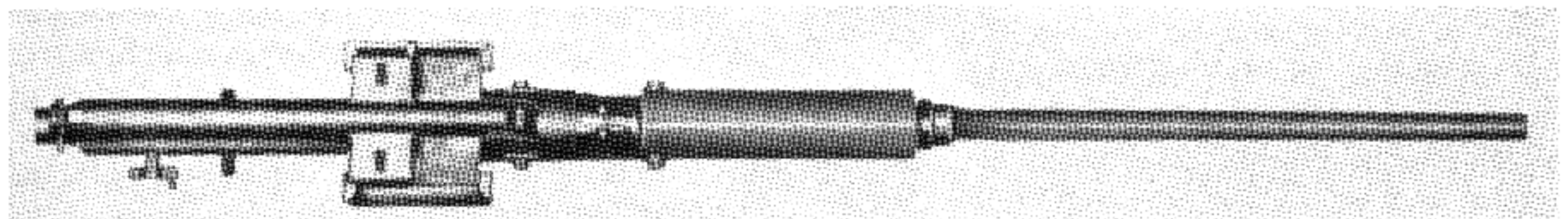


Figure 4-5. Gun, Machine, Caliber .60, T17E1. Top view.

SECTION 4. CALIBER .60 T17E2 MACHINE GUN

Summary of Development

The Frigidaire division was then asked to prepare two additional models which would use strengthened components and a barrel with a thicker wall chamber, as the chamber had expanded during tests of earlier models. SAE 1060 steel was used in the T17E1 wherever possible. In the T17E2 this policy was abandoned and SAE 4640 steel was substituted. Fabrication of these models involved the use of sheet metal stampings and hydrogen brazing. This gun was designated the T17E2.

In May 1943, the General Electric Co., Bridgeport, Conn., accepted a contract to develop an electric charger for the T17E2 gun. It appeared at this time that the most profitable development of this item would be a charger integral with the gun. The electric reloader drive unit is composed of an electric motor which drives a lead screw, a ball nut assembly which travels on the lead screw and moves an adapter group, and mechanical and electrical controls to govern the operation of the motor. The adapter group picks up the drive bushing as it moves to the rear down the lead screw and retracts the bolt to the rear. The lead screw passes through the center of the drive spring and drive bushing. The drive bushing engages the bolt. As the bolt passes over the sear, it depresses a device that determines the rotating direction of the charger motor, called the telltale, which actuates a switch and reverses the rotation of the motor. The adapter group travels forward into the cam tube lock and is forced against

the rear of the cam tube lock. Since the ball nut cannot turn, this pressure forces the lead screw to the rear; and in this way, the switch arm is actuated, the current to the motor is broken, and the circuit to the solenoid is closed.

The mechanical linkage between the solenoid and the sear is so arranged that it retracts the telltale when the sear is retracted, but the telltale may be retracted by the bolt without retracting the sear. The solenoid was mounted as an integral part of the gun. By this method an integrated unit assembly was provided which, it was believed, would be superior to the previous practice of developing the gun separately and then attaching the charger as an appendage.

Two T17E2 machine guns were delivered to Aberdeen Proving Ground for tests on 25 August 1943. Each was equipped with manual charging and firing equipment and recoil adapters. Electrical charging and firing solenoids were provided as alternate components. One gun was fired 557 rounds. Ejection difficulties developed, but after modification of the ejector, the gun functioned fairly satisfactorily with a rate of fire of 600 rounds per minute. The second gun with the General Electric charging mechanism was fired 143 rounds. A combination gun was built from parts of guns numbered 1 and 2 and fired 327 rounds at 658 rounds per minute with a maximum muzzle velocity of 3,696 feet per second. Numerous malfunctions were encountered which indicated that considerable further development work was needed.

SECTION 5. CALIBER .60 T17E3 MACHINE GUN

Summary of Development

Beginning in September 1943, attention was concentrated upon the manufacture of seven T17E3 guns with both mechanical and electrical ignition. The electrical ignition mechanism was modeled upon that of the German MG 151/20. A program was also initiated for the development of a bolt with the sear forward. It was expected that this arrangement together with the electric ignition would permit synchronization of the gun with either electric or percussion primed ammunition.

On 15 December 1943, because of increased interest by the U. S. Navy, this order was increased to 10 guns.

On 16 November 1943, Frigidaire had been requested to develop four auxiliary gun charges to be used as a standby device in case of the failure of the electric charger.

Because of a requirement placed with the Ordnance Corps by the Navy Bureau of Ordnance for the delivery in 1944 of 2,500 caliber .60 aircraft machine guns with auxiliaries and spare parts, limited procurement of the T17E3 was initiated 2 De-

ember 1943 and approved on 16 December 1943. This procurement was begun immediately even though preliminary service tests of the T17E3 had not been held.

When the decision was made to rush the preparation for manufacture of the caliber .60 machine gun at Rock Island Arsenal, it was recognized that the expenditure of large sums of money would be required to put changes in design of the components into production. However, it was felt that a major portion of the tooling for the gun would ultimately be usable, and that the plan followed would save priceless time in getting fully developed guns into the hands of the Air Force and the Navy. The Rock Island Arsenal was commissioned to make these guns.

Up to this time, the only unit to fail consistently was the bolthead. Redesign of this unit was immediately undertaken. The breech ring, firing pin, bolthead buffer springs, and a few minor components had broken, but it was believed that improved metallurgy of these components would satisfactorily increase their life.

This gun weighed 135 pounds including recoil mounting adapter, electrical charger and solenoid, and feed mechanism. The rate of fire was 600 rounds per minute, the muzzle velocity was 3,500 feet per second. The gun was 92 inches long and had a maximum trunnion reaction of 3,500 pounds.

At the request of the Army Air Force, the original procurement was increased 5,025 guns by Ordnance Committee action on 23 December 1943. Twenty-five guns of this procurement were allotted to the Ordnance Corps for experimental purposes.

Two T17E3 machine guns manufactured by Frigidaire were delivered to Aberdeen Proving Ground on 29 December 1943 for test. The breech ring on gun number two broke after a few hundred rounds, severely damaging the gun. Gun number one successfully fired several thousand rounds. The gun fired erratically with frequent and long hesitations. These hesitations were later found to be caused by stubbing of the bullet point against the breech face of the barrel. A 25-round burst was considered good.

During January 1944, a research project was established with the Battelle Memorial Institute, Columbus, Ohio, for the purpose of making recommendations on heat treatment and other metallurgi-

cal operations of the caliber .60 machine gun. Battelle recommended a longer draw temperature and larger fillets in the breech ring. These proved successful.

During February and March 1944, Frigidaire engineers decreased the weight of the bolt to 5 pounds, increased the diameter of the bolthead roller trunnions to 0.656 inch, removed the link stripper from the feedway since it was found unnecessary and added a cartridge holddown lever and a feed pawl control lever to the feed box. The feed pawl control lever prevents a round from being fed into the feedway by the feed pawls while another round is already over the feed slot in front of the holding pawls. This is accomplished by a linkage attached to the feed pawl control lever, which lifts the feed pawls and prevents them from engaging the feed belt when a round is already over the feed slot and forward of the holding pawls. The cartridge hold-down lever positions the round in the feed slot and holds the round down as the bolthead drives it forward.

In April and May in 1944, this gun was tested. It fired 100 rounds at a uniform cyclic rate without a stoppage and the cyclic rate was estimated to be approximately 600 rounds per minute. Malfunctions were reduced to 1 percent and breakages to 0.3 percent.

On 13 March regular weekly conferences were initiated by the Small Arms Development Division, Research and Development Service, United States Army, to integrate all information on the progress of the project. This conference series was attended by representatives from Field Service, Industrial Service, Office of the Air Ordnance Officer, Navy Bureau of Ordnance, Frankford Arsenal, and occasionally by representatives from Aberdeen Proving Ground, Rock Island Arsenal, and Frigidaire. In these meetings, all changes in the gun design were discussed and transmitted to the Industrial Service, which in turn sent the information to Rock Island Arsenal. The minutes of these meetings, which were held weekly until 15 January 1945, biweekly until 27 August 1945, and monthly thereafter, were filed in the Small Arms Development Division, Research and Development Service, and in other Ordnance establishments.

By June 1944, Rock Island Arsenal through the Industrial Service had been furnished complete

drawings for the caliber .60 T17E3 machine gun and all accessories developed up to that time except the bore-cooling device. Tooling at Rock Island Arsenal was approximately 80 percent completed. Every effort was made to cooperate and assist Rock Island Arsenal in this tooling and to modify components and assemblies and simplify design to assist manufacture. The weekly meetings were almost entirely devoted to this work.

Rock Island Arsenal had completely assembled three caliber .60 T17E3 machine guns from parts made at the Arsenal and by its subcontractors. These guns were test fired approximately 100 rounds each. Ammunition did not feed properly. The cam tube was redesigned by Rock Island Arsenal as a two-piece construction without prior firing tests. This was not satisfactory, as the forward locking end became separated from the remainder of the tube. This was corrected by Rock Island Arsenal as soon as observed.

Further firing tests disclosed that these guns fired erratically with a cyclic rate of approximately 600 rounds per minute. Frequent bolt head and breech ring breakages were encountered. Rock Island Arsenal breech rings failed at an approximate average of 1,000 rounds each, while Frigidaire breech rings were failing at approximately 5,000 rounds average life. Later, one Frigidaire breech ring was fired more than 20,000 rounds. Difficult extraction was encountered with frequent breakages of extractors. As a result of this performance, manufacturing operations were reduced.

An invitation from Army Ordnance brought Navy, Rock Island, Industrial Service, and Army Ordnance representatives to Aberdeen Proving Ground on 15 August 1944 to witness a firing demonstration of the Frigidaire manufactured gun. It was fired 1,000 rounds with one malfunction and no breakages. A few days later, a firing test was conducted at the Frigidaire plant. Frigidaire personnel fired another Frigidaire manufactured gun 2,138 rounds without a malfunction. An intensive development study was initiated to correct the differences between the Frigidaire division and Rock Island manufactured guns.

At the end of World War II, the development picture as a whole was considered very promising. Manufacturing difficulties had been overcome to an extent, and the drawings had been entirely stabil-

ized. With a continued delivery of uniform production parts, performance of the gun became truly predictable, the malfunctions were localized, and their number and occurrence were reduced.

In March 1946, the average malfunction rate was one per thousand rounds. This was based upon the firing of not more than 5,000 rounds in any single gun and required replacement of parts according to the schedule below.

Component	Replacement required after round			
	1,000	2,000	3,000	4,000
Firing pin.....	X	X	X	X
Drive spring.....	X	X	X	X
Bolt head.....		X		X
Bolt head cam.....		X		X
Bolt head rollers.....		X		X
Bolt head buffer spring.....		X		X
Bolt head buffer blocks.....		X		X
Extractor cushions.....		X		X
Extractor.....		X		X
Roll pins A7160389.....		X		X
Roll pins A7160220.....		X		X

More than 309 T17E3 guns had been manufactured and more than 950,000 rounds of ammunition of various types had been fired in them. Tests were continued to ascertain the life of the various components and to reduce the malfunctions. The principal components requiring early (1,000 round) replacement are the firing pin and the drive spring. Several types of these were then under development and test. Because the major components of the gun appeared to be serviceable for much more than 5,000 rounds, work was started to establish a 10,000 round life for the gun by replacing a few parts at 5,000 rounds and by continuing the replacement table beyond that point. Ground tests in several aircraft and Eglin Field Air Force Proving Ground tests were completed. The Ordnance Corps certified to the Air Force that it believed the gun to be operational. Consideration was being given to use of the gun as an antiaircraft weapon in armored vehicles.

General Description of the Model

A general description of the T17E3 machine gun is as follows. It consists of a receiver supporting a cover, breech ring and barrel. Within the receiver slide a bolt and bolthead. In the cover is a cam tube with a helical slot cut in it. Riding within the cam tube, guided by a helical slot, is the drive bushing which encloses one end of a drive spring. On the outside of the cam tube near its forward end is cut a spur gear which engages the rack that operates the feeding mechanism. When the cover is closed, a stud on the drive bushing engages a raised portion of the bolt and in operation the bolt, bolt-head, and drive bushing travel together. The firing pin is fastened in the front of the bolt and projects into the bolthead. The charger retracts the drive bushing which in turn pulls the bolt back to the sear which is located at the rear of the receiver. When the sear is released, the bolt goes forward, and the bolthead is rotated and locked by the cams on the breech ring and bolt. As the bolt head rotates, the bolt moves forward in relation to the bolthead. This causes the firing pin to protrude, ready to fire the primer.

A buffer spring and a buffer plate are mounted in the buffer block at the rear of the receiver. This assembly arrests the rearward movement of the bolt assembly and with the assistance of the drive spring returns the bolt assembly to battery during automatic fire.

Component Development

Development of a New Type Electric Reloader. The electric reloader developed by the General Electric Co. for the T17E3 gun is an apparatus designed to replace the manual reloading mechanism in the T17E2 gun with equipment that will clear stoppages automatically and reload the gun when required. The standard 27.5-volt d. c. system for airplanes is used as the power source for the operation of this charger and its controls.

This reloader includes all parts and assemblies necessary for its operation. The cable and cross pin in the cover (used in manual reloaders) are replaced by the reloader drive unit which consists of a motor, lead screw, and adapter group, plus other miscellaneous connecting and mounting parts.

The adapter group houses a ball-bearing thrust nut which rides on the lead screw. As the lead

screw is rotated by the motor, the adapter group is driven to the rear along the screw, picking up the drive bushing and retracting the bolt until it engages the sear. This operation also compresses the drive spring. The adapter group is then returned to the front of the lead screw ahead of the bolt by reversing the direction of rotation of the motor by means of a telltale and switch located in the receiver.

The electric operation of the sear is accomplished by the firing solenoid, which is bolted to the back of the buffer block. The armature in the solenoid is attached to a lever arm, which actuates the link bar. The bar, in turn, is fastened to the sear mechanism. When the solenoid is energized, the link bar is moved to the rear. This action depresses the sear and frees the bolt, which is forced forward by the drive spring and fires the gun.

The motor of the drive unit is series wound with a reversing field and is rated at 0.4 horsepower at 10,000 r. p. m. at 25 amperes and 24 volts d. c.

First Bolt for Electrically Primed Ammunition. During April 1944, two T17E3 machine guns were completed at Frigidaire and fitted with bolt assemblies to fire electrically primed ammunition. These bolt assemblies were adapted from the bolt used in the German MG 151/20 to fire electrically primed ammunition. The electrical connector between the outside power source and the bolthead passes through the right side of the receiver opposite the case ejection chute. During the firing of a few rounds of electrically primed ammunition at Frigidaire, a bolthead was severely damaged by primer failure. This experimental work was continued on the caliber .60 machine gun T39.

Preformed Strand Wire Spring Development. In the initial test firing of the T17E3, the drive spring set severely at approximately 50 rounds. This drive spring was of the conventional type. It was believed that the very short life of this component was due to surges set up in the spring by the high cyclic rate. Helical coil springs made from three-strand preformed wire were then tried. These springs had been used successfully by foreign gun manufacturers as drive springs on machine guns. The usage was confined to applications requiring relatively long, soft springs capable of large amounts of deflection with a minimum change in loading, as is generally required in machine gun drive springs and frequently in firing pin springs.

The first springs of the multiple-strand preformed wire type were observed in Russian machine guns used during the Spanish Civil War. This type spring had also been used for driving and ejector springs in the British Hispano-Suiza automatic 20-mm cannon Mark II. Springs of this type were adopted and were in actual use in the early part of 1940 by the French and British. The preformed wire spring is not claimed to be interchangeable with conventional springs.

A project to develop multistrand preformed wire springs was initiated by the William D. Gibson Co., Chicago, Ill., in November 1942. Trouble was experienced in obtaining wire from the wire manufacturers and in coiling the wire. A quantity of springs of various wire sizes were made and various tests conducted. The following information was obtained:

1. The overall diameter of the stranded wire after coiling remained very close to what it was before coiling.
2. The outside diameter of the coil increased greatly when the spring was compressed.
3. Under static loading there was very little energy absorption due to friction.
4. It was indicated that these springs gave longer life under dynamic loading.
5. It was not possible to coil these springs on production coiling machines.

In June 1944, the Gibson Co. stated that they could not continue the research on this project as their facilities were occupied with work on aircraft valve springs and other vital war production.

The Eaton Manufacturing Co., Detroit, Mich., was given a contract to develop a number of springs suitable for small arms, particularly drive springs for the caliber .60 machine gun, and to design and construct a fatigue testing device capable of testing these springs under conditions similar to those encountered in machine guns.

The company started on the assumption that the motion imparted to one end of the spring is propagated along the longitudinal axis with infinite velocity. Actually, the spring has a finite velocity of propagation; but so long as the velocity of propagation is quite high in comparison with the velocity of displacement, no great errors result from the design assumption based on the concept of infinite propagation velocity. If the velocity of displacement

exceeds the velocity of propagation, a condition inherent in conventional machine gun drive springs and firing pin springs together with almost all types of counterrecoil springs, the resulting motion produces higher stresses in the end coils than in the more centrally located intermediate coils.

The beneficial damping effect of the friction provided by the use of preformed wire strands and helical springs is influenced by the number of elements in the strand and by the pitch angle of the elements. For a small number of elements, the strains set up in the stranding are greater than those for larger numbers of elements. It is important in preformed wire springs to coil the helix in such a manner that the twisting moments tend to produce frictional binding on the strand elements. It is vitally necessary to coil these springs to a helix opposite in direction to that in which the strand elements are twisted.

A comprehensive fatigue schedule permitted the conclusion that the optimum preformed wire-strand spring would be made from music wire material using three elements in the strand, the elements being twisted at a helix angle of approximately 73° and the elements of the strand in the coils of the spring being formed as helices, in opposite directions to one another. On the average, such springs were indicated as having a life expectancy of three and one-half times that of the equivalent conventionally designed single-wire spring.

A fatigue testing machine was developed which would vibrate the spring at its resonant frequency and would induce in it the wave motion which is characteristic of the duty imposed on the spring. This machine is similar to a conventional crank-rig testing machine in that it consists of an electric motor, a variable speed control unit, a belt drive, flywheels, adjustable throw crank, and a vertical crosshead which is connected to a means for actuating the spring under test.

The most important difference concerns the rotational speed of the crank. In a conventional machine, the crank rotates at such a low speed that one can assume an infinite velocity of propagation of the distribution along the coils of the spring grinder test, and one can therefore base stress computations on ordinary "static" formulas. In the machine constructed, the rotational speed of the crank is relatively high and is adjusted for each test so that the spring is substantially in resonance, in

which case, the velocity of propagation is approximately equal to the velocity of displacement. In consequence of this condition, the motion imparted to the coils is a wave motion of extreme amplitude, substantially like the wave motion imparted to the coils of the spring in the actual gun or other mechanism which the spring was designed to actuate.

Another difference found in the use of this machine, compared with a conventional machine, concerns the lives of the springs tested in the ordinary low speed tests. Where failures are generally found to occur in hundreds of thousands and millions of strokes in the resonant machine, failures occur in thousands and tens of thousands of strokes. This is an important consideration, because the springs in service under highly vibratory conditions generally fail in the latter order of number of strokes.

The location of failures in the coils of the springs is another characteristic difference found when testing in the respective machines. Failures occur in any coil when a conventional machine is used, but in the resonant machine failures occur invariably in the region of the end coils. This latter location is typical of actual failures in service under highly vibratory conditions. Fatigue failures were obtained in this machine which duplicated in appearance and location those which occurred in service. Hence, results obtained from the fatigue test could be counted upon as indicative of the service life expectancy.

After several trials the Eaton Co. furnished a three-strand preformed wire drive spring which satisfactorily met the requirements as to life except the end coil would spread and creep out over the conical surface on the motor mount seat, thus interfering with the drive bushing. To prevent this, five coils were wound solid on this end and the end of the last coil brazed to its adjacent coil.

Bolt Assembly. In June 1944, 10 boltheads made at Rock Island Arsenal by production methods were received at Frigidaire for test in the original Frigidaire guns. Five were broken with a maximum life of 287 rounds. Examination revealed that production boltheads were made of WD 4340 steel instead of the recommended WD 4640 steel, from which the Frigidaire boltheads were made.

It was observed that the finish on these boltheads was not as good as the finish on those that Frigidaire manufactured. The undercut at the base of the

locking lugs had not been finished round to a fine finish. Metallurgical examination revealed in the bolthead surfaces a decarburized layer approximately 0.010 inch deep, caused by improperly controlled furnace atmosphere.

With these refinements completed along the lines observed for Frigidaire boltheads, the life of the bolthead increased to approximately 2,000 rounds. However, when the cyclic rate of the gun was increased to 750 rounds per minute, the frequency of breakage again increased and the average life decreased to less than 1,000 rounds. With a decrease in bolt weight and an increase of the locking cam angle on the breech ring to 101°, the trunnions broke less frequently and locking lug failures remained as the predominant form of breakage.

Various heat treatments were tried on WD 4340 metal. The most successful was the "Martempering" operation submitted by the Battelle Memorial Institute. Because the entire lot of WD 4340 steel had been purchased for the manufacturer of the boltheads, only a few heads were made of WD 4640 steel for limited tests. Many types of patented tool steels were tried without success.

In June 1945, Rock Island Arsenal submitted for test three boltheads made of WD 4820 steel. These boltheads were fitted with replaceable trunnions and had a carburized and ground finish. These boltheads failed in the locking lugs at approximately 3,500 rounds. Early investigations had established that no increase in life in the bolthead is obtained by using removable trunnions if breakages are occurring elsewhere on the bolthead, so this bolthead with integral trunnions was established as standard.

About 15 February 1945, Frigidaire was requested to design a bolthead and breech-ring combination which would consistently fire 5,000 rounds without breakage. No restrictions on redesigning the gun were applied. In April 1945, Frigidaire submitted their first model made from WD 4640 steel, together with drawings of the required gun modifications, to Aberdeen Proving Ground for test. The bolthead fired approximately 1,000 rounds when the trunnion broke. This bolthead was then returned to Frigidaire and equipped with a removable trunnion made of WD 3312 steel and returned for further test. The bolthead fired an additional 5,000 rounds without breakage.

Three more additional bolthead breech-ring combinations were delivered for test. The breech rings were all fired more than 9,000 rounds without breakage, and the boltheads fired more than 6,000 rounds each with replacement at approximately 1,000 rounds of the original trunnions with trunnions made from WD 3312 steel. This design called for a longer bolthead with a different style locking lug and required that the barrel and barrel recoil ring springs be moved forward seven thirty-seconds inch to compensate for the increased length of the bolthead. The design required retooling and could not be incorporated in the first production lot of guns.

BOLTHEAD ROLLER GUIDE. In the early T17E3 model, the bolthead rollers were held onto the bolthead trunnions by a **C** ring, which fits into a groove in the center of the trunnions and the center of the rollers. The **C** ring was compressed into the groove in the trunnion, the roller slipped over the **C** ring and released. The **C** ring expanded into the groove in the roller and prevented the roller from coming off.

By leaving the **C** ring off, it was observed that the rollers moved out and rolled along the full surface on the unlocking cam, thus greatly reducing the pressure on the cam surface and increasing the life of the unlocking cam. To assure that the bolthead rollers would remain on their trunnions while they were returning to battery and locking the bolthead, Frigidaire added a recoil spring sleeve between the unlocking cam and the breech ring. This guide limits the distance that the rollers can leave the trunnions at that time. By the addition of the bolthead roller guide, the bolthead rollers were confined to the trunnions of the bolthead at all times, thus making possible the removal of the **C** clips as suggested by Rock Island Arsenal and greatly increasing the life of the unlocking cam.

BOLTHEAD BUFFER SPRINGS. At the beginning of recoil, the bolthead is in a retracted position in relation to the bolt body with substantially zero velocity. As recoil proceeds, the bolthead is unlocked as it passes through the unlocking cam. Its velocity and acceleration to the rear are the same as that of the recoiling barrel while the bolt travels rearward as a free body at an increasingly greater velocity.

Soon after the bolthead is unlocked from the

breech ring, the bolt body picks up the bolthead, the system now having been forced into an extended position during the unlocking. The bolt then imparts additional energy to the bolthead, and this energy is transmitted through the bolthead buffer spring assembly. On the early T17E3 guns and earlier models, this assembly consisted of a **U**-shaped piece of spring steel with a steel plug inserted in the **U** to limit the travel of the spring. As the cyclic rate was increased from 450 to 700 rounds per minute, the amount of energy per round transmitted through this assembly increased as the velocity of the bolt group increased. Breakages became more frequent until they were excessive. The **U**-shaped spring assembly was removed and a small steel block containing a very stiff helical steel spring was substituted.

When the cyclic rate was increased to 800 rounds a minute, this spring became highly stressed with the increased load, and the tips of the ends frequently broke when the spring was ground flat. This tip would fall into the bolthead cam and jam the bolthead. The manufacturer of these spring ends was then changed from a "grind flat" to a special end, which gave the wire a square cut ground only one quarter flat on top. This proved highly satisfactory.

EXTRACTOR AND EXTRACTOR SPRINGS. The first T17E3 and subsequent models gave difficult extraction and frequent failures to extract. The extractor spring set quickly. As the cyclic rate was increased, the failures to extract and broken extractors became as frequent as 20 per 100 rounds. Experience showed that the extractor spring was not heavy enough to move the extractor lip up behind the rim of the case in the time required. A double spring assembly with one spring placed outside the other was substituted. This arrangement did not prevent the extractor from slipping over the rim of the case and only increased the number of broken extractor lips.

In June 1944, a widened extractor with a heavy lip was tried at Frigidaire. These extractors would extract several thousand rounds but gave rim shears and continued to slip from the rim of the case. Some rounds were so difficult to extract that noticeable hesitations occurred during automatic fire.

Space limitations prevented the use of a higher rate spring, so a solid rubber plug was used. This

proved to be quite satisfactory and entirely eliminated failures to extract caused by the extractor not engaging the rim of the case. To reduce the operations required of the extractor and improve its service life, a slot the width of the base of the cartridge was cut from the top of the bolthead; accordingly, when the bolthead drove the cartridge into the chamber, the base of the round would follow across the bolthead face and force the rim into the entrance groove without the extractor snapping over the rim of the case when the bolthead closed. To strengthen the lip of the extractor, the extractor was increased 0.020 inch in length and the breech face of the barrel shortened 0.020 inch for clearance. This permitted the design of an extractor with a heavy lip. This proved to be the first entirely satisfactory extractor lip. This slotted bolthead, together with the rubber extractor spring, was found to be a real improvement.

There was also tried an extractor design with the extractor hole the same size in both the extractor and the bolthead. A solid steel pin was used. The pin sheared or the extractor broke in a few rounds in all models tested. The clearance between the extractor and the extractor pin allowed movement forward of the extractor when load is applied so the load is taken on the extractor wings.

Aberdeen Proving Ground submitted a bolthead with a projection on the lower edge into which was milled a slot that served as an extractor.

Frigidaire tested a bolthead with an extractor welded into the bolthead. These designs were not thoroughly tested because the extractor slot in these designs would not engage the rim of the case if the round chambered with the rim in advance of the extractor slot, a condition which would not exist except under unusual circumstances. Preliminary tests conducted on these designs gave good results.

Excessive rim shears and erratic firing caused by difficult extraction were not eliminated until fluted barrels were adopted.

BOLT. In May 1944, an effort was made to increase the cyclic rate of the T17E3 gun from an average of approximately 615 rounds to 800 rounds per minute. The bolt body weighed $3\frac{3}{4}$ pounds. A series of bolt bodies, weighing from $3\frac{1}{4}$ pounds to $2\frac{1}{4}$ pounds were made at May's Auto Parts, Inc., and tested. The cyclic rate increased approximately 75 rounds per minute for a $2\frac{1}{2}$ pound bolt

and substantially eliminated bolthead breakages in the rear around the cam lugs. It also greatly increased the life of the bolthead buffer spring assembly. The bolt was standardized after discussion at the caliber .60 meeting of 1 May 1944 at $2\frac{3}{4}$ pounds with a center cross section which was square on three sides and round on the bottom. The $2\frac{1}{4}$ -pound bolt produced at May's Auto Parts, Inc., had a hollow center circular cross section with additional holes drilled at right angles through the bolt to remove weight. Preliminary tests on this design showed it to be entirely satisfactory.

FIRING PIN. The firing pin designed for the T17 series of guns originated with the German MG 151/20. The tip of the firing pin was 0.078 inch in diameter with a 0.038-inch radius point. The primer used in the caliber .60 round is the same as that used in the caliber .50 round. Because of pierced primers and firing pin tip breakages, the point was changed to 0.90 inch in diameter with a 0.045-inch radius point. Firing pin breakages were still excessive. The firing pin frequently broke forward of the shoulder which passes through the bolthead cam. This breakage was found whenever a gun accidentally fired out of battery.

The major redesign was done on the firing pin. The clearance was greatly increased between the firing-pin hole in the bolt, and the firing pin. The bolthead cam in the firing pin, had a large fillet placed on the shoulder which is forward of the bolthead cam. The firing-pin hole in the rear of the bolthead was chamfered to accommodate this fillet. The firing pin point was increased to 0.110 inch in diameter with a 0.045-inch spherical radius blended with a 90° conical cut. Firing-pin breakages were so numerous, there were times that, if a few hundred rounds were expended per firing pin, it was considered excellent firing.

After extensive firing tests with different firing-pin point diameters and designs, it was conclusively shown that a 0.090 inch diameter tip with a 0.045-inch radius spherical point gave the best results and fewer pierced, plugged, and blown primers. However, this design did not entirely eliminate the condition. Firing pins with chrome-plated tips of the preferred dimensions were then tried with success.

Mounting Supports. The rear support used on the T17E2 and the earlier models was designed from the German MG 150/20. This support was quite

difficult to manufacture and was difficult to fit on a mount or cradle. Originally beneath the gun, it was raised on the T17E3 to provide a more nearly axial mounting.

Soon after mockups were furnished the Navy Department, a proposal was submitted by it to change this feature to a rear mount which would be more convenient to use and a front mounting scheme which would give less dispersion than the trunnions with which it was originally provided. The Navy built a number of cradles which used both type rear mounts and a new annular ring type front mount and furnished them to Aberdeen Proving Ground for test.

Based on the results of this test, the Navy type rear mount (flat slide type) and the annular rings about the rear of the ring spring adapter were adopted as AN standard. The Air Force insisted that the forward mounting trunnions be retained, so both types of front mounting were included in the approved design.

Feed System. On models previous to the T17E3 the feedway was held in place by the cover and latterly by two small tabs on each side which slipped over the outside of the receiver. On the early T17E3 guns, the cover rose during firing. This allowed the feedway to rise and the bolt missed the rim of the cartridge which was to be fed into the chamber. When this condition was established, Frigidaire was requested to design a feedway which would remain down against the receiver at all times regardless of the position of the cover.

The first model submitted had pins attached to the receiver over which slipped hooks that were welded to the rear of the bottom of the feedway. These hooks had a slight interference with the auxiliary charger bracket and were not very wide. Two holes were placed in the front of the feedway into which slipped two dowel pins that were mounted in the receiver just above the unlocking cam.

Rock Island Arsenal took this design and produced a feedway with wider lugs and with the interference eliminated. This feedway arrangement was adopted as standard and all guns manufactured by that date were modified accordingly.

As the rate of fire increased and the belt pull was improved, the cartridge stop became tattered and loose in a few thousand rounds and permitted the cartridge to carry over the feed slot. Rock

Island Arsenal began extensive tests on an improved method of securing the cartridge stop. Bolting the stop to the feedway was tried but was found unsatisfactory because of sheared bolts.

After extensive trials during which high speed motion pictures were taken, it was discovered that the feed pawl spring did not depress the feed pawls fast enough for the feed pawls to catch the round, thus causing failures to feed. Also it was believed that the feed pawl control lever and its linkage, plus the cartridge holddown lever, required enough energy to reduce the belt pull as much as 50 rounds.

The Autoyre Co. was engaged to design a feed system which would be more easily manufactured and have an increased belt pull. The Autoyre Co. designed the belt feed slide which replaces the cartridge holddown lever and the feed pawl control levers and its linkage. This slide was fired approximately 35,000 rounds with good results.

Ejector Development. The ejector on all the T17 models prior to June 1944 was located in the bolthead. The ejector formed a portion of the top of the bolthead face and was pivoted about a pin which passed through the bolthead. The top of the ejector was struck during recoil by a projection of the feed tray which forced the ejector downward, displacing the case from the bolt face.

If the projection on the feed tray was too high or moved upward when the gun recoiled, it would either fail to strike the ejector or strike it across the very top, thus giving poor ejection. If the projection was too low, it interfered with the movement of the bolthead and reduced the cyclic rate. Manufacturing tolerances and wear in a few hundred rounds often caused ejection to pass from the latter to the former condition.

Boltheads having an integral ejector were often cracked back of the front locking lugs where the ejector slot passed. The recoil plate used had to be thin to prevent cracking between the recoil plate hole and the vertical ejector slot. To improve the strength of the bolthead and reduce manufacturing costs, a project was initiated to improve the ejector.

Rock Island Arsenal submitted a model which consisted of a large leaf spring attached to the rear of the feed way and bent in a loop so that the end rode in the horizontal ejector slot in the bolthead. This model was not successful because of excessive breakage in the spring.

Frigidaire submitted two models. The first one, submitted in August 1944, was a bar hinged in a pin attached to the rear of the feedway and confined by a slot in the cover, which limited its movement upward and rearward. The bar was further guided by a pin attached to the feedway and which passed through a long slot in the end of the bar opposite the hinge. On the bottom of the bar, a second bar, the ejector bar, was welded perpendicular to the first. This second bar rode in the horizontal ejector slot in the bolthead. A small spring mounted between the guide pin and the first bar held the ejector down against the bolt and bolthead. This model was difficult to adjust to proper height, and the upper bar soon bent the cover slot until it was impossible to make an adjustment. To make this adjustment last the life of the gun, a bar was welded across the cover slot which served as an ejector stop. This arrangement was entirely successful except that it required hand fitting to each ejector and made the cover and feedway of each gun not interchangeable. The ejection was entirely satisfactory. Because of the improved ejection, all T17E3 guns manufactured at that time were fitted with this ejector.

Frigidaire continued development, and in May 1945 a full floating self-adjusting ejector was submitted for test. This ejector fired 15,000 rounds without adjustment or failure. This ejector was guided by two pins which were attached to the feed tray and passed through two slots in the ejector bar. Two small helical springs held this bar away from the face of the feedway and against the slot in the cover. The vertical movement of the bar was regulated by an angular stopping surface cut at the bottom of the cover which engaged two angular shelves on the face of the ejector bar. These surfaces were at a 45° angle with the vertical, and parallel with the ejector surface on the bar which rode in the ejector slot of the bolthead and ejected the case during recoil. All T17E3 guns manufactured after 1 November 1945 were fitted with the latter design.

The Sear. The sear used in the T17 and T17E1 were copies of the sear used by the German MG 151/20. The development of a satisfactory sear to be operated by a solenoid was undertaken by the General Electric Co. The solenoid should be as small as possible; therefore, the sear must have as low a release load as possible.

The General Electric Co. based its design on the roller-type sear which would give minimum frictional loads on the searing surface. Three designs were tested extensively and several others failed in preliminary tests. The "roll and counterweight" type designed to maintain balance and prevent accidents on rough landings of aircraft carriers, was used on the T17E2 and the T17E3 models. This sear would not always stop the gun and even if it did it was often several rounds after release. High-speed motion pictures showed that the sear assembly had too much mass to recover and remain in a position to stop the bolt after the bolt bounced off the buffer. Also, the force required to stop the bolt was too great to be accomplished without some type of shock absorbing mechanism. When the mass of the sear was decreased so that it would operate properly, breakage was caused in the sear frames and roller trunnions.

The final design adopted was the "block type" sear, which has a light sear frame and a shock absorber to take the load when the bolt is seared. This construction has been entirely satisfactory and is unique in machine gun sear design. In this design the sear roller, when released, is moved upward by a spring under the sear frame and engages a projection on the bottom of the bolt, which drives the sear roll and frame upward and forward. A pin which passes through the sear frame and sear block is carried forward against the spring which is housed in the sear block and which absorbs the initial shock. This pin also guides the sear roll and the sear roll stop on the rear of the sear block.

Several other designs were tested. One was a roller which replaced the projection on the bottom of the bolt. Another had a spring-operated projection attached to the bottom of the bolt, which dropped down after passing over the sear roll and engaged the sear roll on its return from the buffer. These designs were discarded because the adopted design gave better performance.

Electrical Controls. To operate the reloader automatically, it was necessary to build into the gun and synchronize with the sear, a telltale device to ascertain the position of the bolt in relation to the sear, and to operate the switch that controlled the reloader. This device operated in parallel with the sear and was actuated by the sear bar. The adjustment of this arrangement due to tolerance buildup

and wear became the major problem. An adjustable telltale was designed, but even then some guns could not be adjusted properly.

In the new sear assembly, a double bar replaced the single bar. This design permitted independent adjustment of that portion of the mechanism connecting the solenoid to the sear. It was not necessary simultaneously to adjust the part which connected the telltale with the motor control switch. Both parts were operated in parallel by the sear solenoid. This arrangement proved quite satisfactory. In the T17E2 design a double switch and cam were operated by the telltale, but the second switch, which was in series with the solenoid control side of the first switch, was found to be unnecessary because of the rapid charger operation in production chargers.

Breech Ring. The original breech rings developed by Frigidaire and fired in Frigidaire guns gave satisfactory performance and life. The original breech rings manufactured by Rock Island Arsenal did not meet these standards. Many of the first lot of Rock Island breech rings failed at less than 1,000 rounds. Careful inspection and examination revealed that the heat treatment of the breech rings was not as recommended by Frigidaire and that the finish on the interior working surface was not adequate.

Examination of a Frigidaire breech ring disclosed that the generation of the locking cam began at $100^{\circ}50'$, while the Frigidaire and Ordnance drawings specified $96^{\circ}30'$. The Rock Island Arsenal breech rings were made to $96^{\circ}30'$. This error occurred when the Frigidaire drawings were first made. After many layouts and conferences, a quantity of breech rings was fabricated, having an improved heat treatment, finer ground internal and external surfaces, and a locking cam angle of $102^{\circ}30'$. Samples with locking angles of $103^{\circ}30'$ and $105^{\circ}30'$ were also tested. These were unsatisfactory as they had an average life of only 1,500 rounds.

A third lot was made with heat treatment recommended by Frigidaire. This lot also had additional metal added under the locking cam and at the rear of the recoil spring shoulder. These breech rings proved satisfactory, firing 5,000 rounds without failure.

The Bureau of Ordnance, Navy Department, submitted a design, and later samples, for firing tests of a breech ring with new locking and stop cam surfaces, and which operated with a special unlocking cam and bolthead cam design. Two of these combinations were tested and found to give a marked improvement in gun performance, longer life of operating parts, and a higher cyclic rate. Because of the expense and difficulties in retooling for this design, it was not used in the T17E3 machine gun.

Bolt Buffer Assembly. All models prior to the T17E3 and the first T17E3 guns had a nest of three high-rate helical springs made of wire with a rectangular cross section. These springs were found to be satisfactory when used in a low cyclic rate gun, but at cyclic rates in excess of 700 rounds per minute, these springs set quickly and broke after a few hundred rounds.

In January 1945, Frigidaire made and submitted for test several sets of Belleville bolt buffer springs. Rock Island Arsenal had earlier suggested the use of Bellevilles to avoid a difficult manufacturing problem. These springs decreased the cyclic rate of the gun approximately 15 rounds per minute, but provided springs which would last the life of the gun. These were adopted as standard, and manufacture was begun by Rock Island Arsenal.

Bore Cooling Devices. Research on a bore cooling device for the caliber .60 machine gun was actively pursued at Purdue and Frigidaire. The average barrel life for this gun was less than 400 rounds when fired in 25 round bursts with a 2-minute cooling interval between bursts.

In February 1944, the fundamental studies were completed at Purdue University and in March 1944, research and development projects were accepted by the Bendix Aviation Corp. and the Diesel Engineering and Manufacturing Corp. It was found that a bore cooling device for this weapon was highly desirable to increase the barrel life.

Concurrently other methods of increasing barrel life were being investigated and before a satisfactory bore cooling device was obtained, the life of the barrel had been considerably increased by the use of chromium plating and stellite liners. Because of the success of the liner and plating program,

the bore cooling project soon became of minor importance.

Barrel Development. Because of difficult extraction, an extensive barrel chamber investigation was launched. Barrel chambers were honed, horizontally lapped, or fine ground, for test firing. None of these consistently gave "easy" extraction. Experiments in headspace and "crush-up" were conducted but failed to give conclusive data. The Oldsmobile division of General Motors Corp. was engaged to flute the chambers of the trial lot of barrels by an extrusion process which used a mandrel. The initial requirements were for 16 flutes .010 inch deep running from forward of the bullet seat to two-thirds the length of the body of the case. The initial barrels were delivered about 15 November 1944 and proved a great success. For the first time, the gun fired at long bursts at a uniform cyclic rate. The cyclic rate increased 75 rounds a minute and no other trouble was experienced with difficult extraction. Barrel chambers having 12, 16, 20, and 24 extruded flutes 0.006 inch and 0.012 inch deep were test fired, but unfortunately the flutes did not carry forward of the bullet seat. Chambers having 16 extruded flutes 0.012 inch deep but running various lengths down the chamber from forward of the bullet seat were tried.

Three-fourths of the length of the case was found to be optimum. These were the first fluted chamber machine gun barrels adopted for use in the United States.

Forward Sear Bolt. The military characteristics for the caliber .60 gun called for automatic synchronized fire. Two concurrent developments were initiated: A bolt to fire electrically primed ammunition, and a bolt with a mechanical forward sear to be operated by a trigger motor.

In June 1944, the first models of the forward sear bolt were fired at Frigidaire. Because this bolt had to replace the standard bolt, the design was greatly handicapped by limitations imposed by these space requirements. Nine models were prepared by Frigidaire, four entirely different designs were tested. Three of these designs were mechanically perfect, but only one design had sufficient life of parts to warrant extensive test. This design had a cocking

lever similar to the caliber .50 machine gun which operates in a slot in the receiver and which is interrupted by using a standard trigger motor.

The mechanism was quite complicated and required a complete new bolthead and bolt design. Adequate tests were conducted to determine the frequency of the breakage of parts.

Heater Development. Since most aircraft machine guns are equipped with gun heaters when they are used in combat, a program for the development of a heater was initiated about 1 October 1943 with the Pioneer Products division of the General Electric Co. Most aircraft gun heaters manufactured at this time were of the "sandwich" type. They were bolted onto the receiver where the heat was required. Since the heat would be required the full length of the track on which the bolt travels, it was believed that the sandwich-type heater would be inadequate. One-quarter-inch tubing was brazed beneath the bolt tracks in the receiver with ends protruding from the rear. General Electric initiated a project to develop a "Calrod" unit to fit into these heater tubes.

Several units were installed in receivers and tested at Aberdeen Proving Ground. Two units had the Calrod heater element inside the heater tube of the gun. These units failed at the rear end where the electrical conductor joined the Calrod unit. The vibration of firing flexed the joint until it broke after a few hundred rounds. Four receivers were submitted with Calrod units in the annular space between the two brazed sections of the receiver outside the heater tubes. Each unit was one continuous Calrod tube, grounded at one end and fastened to an amphenol connector on the other. These units broke after less than 50 hours and 3,000 rounds, either at the ground or at the amphenol connector. When statically tested, without firing, one heater unit was operated for 1,400 hours and was still operating successfully when the test was discontinued. No satisfactory connection was made between the Calrod unit and the amphenol connector on the gun.

No sandwich-type heating elements were tried, but one unit was being prepared for tests when V-J Day was proclaimed and the project was discontinued with the General Electric Co.

SECTION 6. CALIBER .60 T17E5 MACHINE GUN

Description

The gun standardized as the caliber .60 T17E5 aircraft machine gun is a recoil-operated, air-cooled, belt-fed weapon. The belt is of the metallic link disintegrating type. The gun can be prepared for either left- or right-hand feeding. Firing is by means of a solenoid, but a manual release for the sear is also provided. The weapon is provided with a shock absorbing adaptor which also serves as a front mounting. The gun is charged by an electric

charger mounted in the cover and fired from an open bolt.

The gun is composed of several groups of parts: barrel, cover group, bolt group, feedway and ejector group, receiver and barrel support group, and adaptor group.

Barrel. The function of the barrel is to direct the discharged projectile. The rifling in the bore (8 grooves, 1 turn in 18 inches) causes the projectile to rotate.

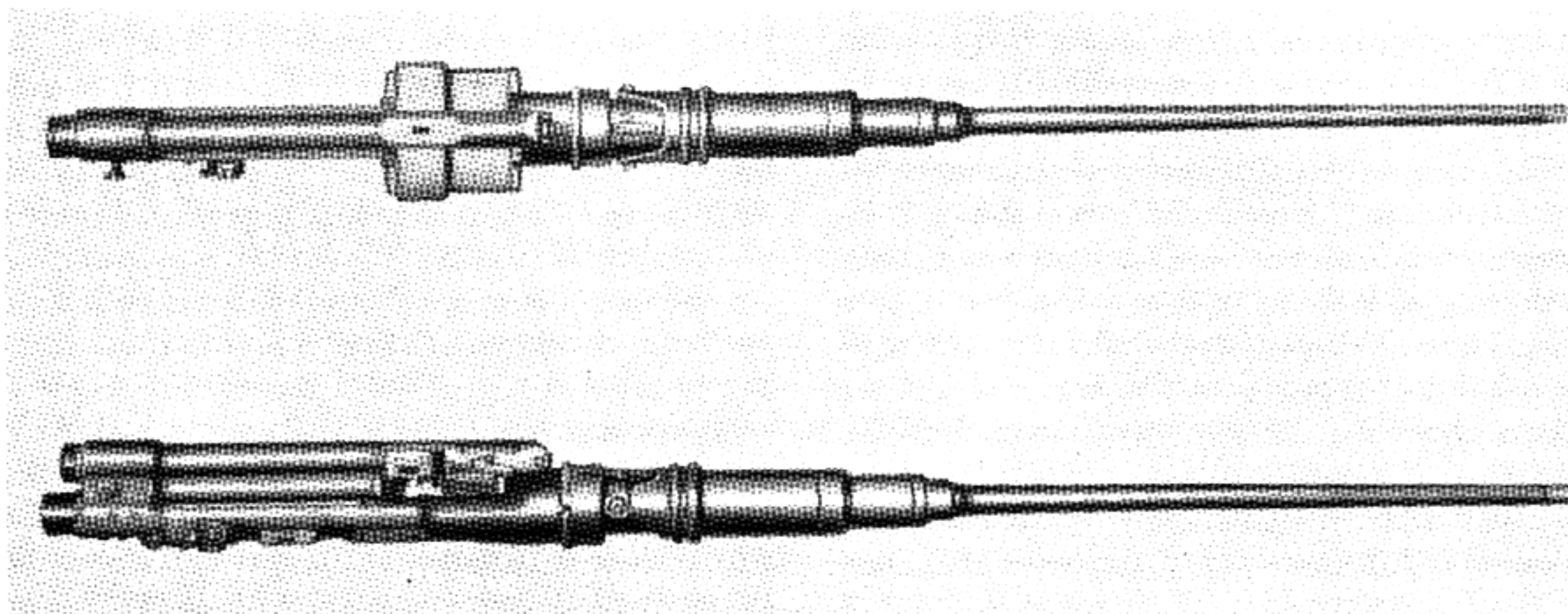


Figure 4-6. Gun, Machine, Caliber .60, T17E5.

General Data: Caliber .60 T17E5 Machine Gun

Gun length: 91.7 inches.
 Gun weight, complete with charger: 127 pounds.
 Rate of fire: 700-750 rounds/minute.
 Muzzle velocity: 3,400-3,500 feet/second.
 System of operation: Short recoil.
 System of locking: Rotating bolt head.
 System of feeding: Disintegrating metallic link belt.
 Method of headspace: Factory established.
 Location of feed opening: Right or left hand.
 Location of ejection opening: Bottom.
 Method of charging: Electric.
 Method of cooling: Air.
 Overall width at feed assembly: 8 inches.
 Overall height of gun: 6.5 inches.

Barrel length: 60 inches.
 Barrel weight: 30.25 pounds.
 Rate control: None.
 Barrel removal: Quick disconnect.
 Bore:
 Number of grooves: 8.
 Groove depth: 0.016+0.002 inch.
 Groove width: 0.150+0.010 inch.
 Pitch: 1 turn to 18 inches.
 Direction of twist: Right hand.
 Form of twist: Constant.
 Cartridge: '177.
 Weight of round plus 1 link: 0.607 pound.
 Muzzle velocity: 3,510 feet/second.
 Weight of projectile: 1,150 grains.
 Range, maximum: 5,520 yards.

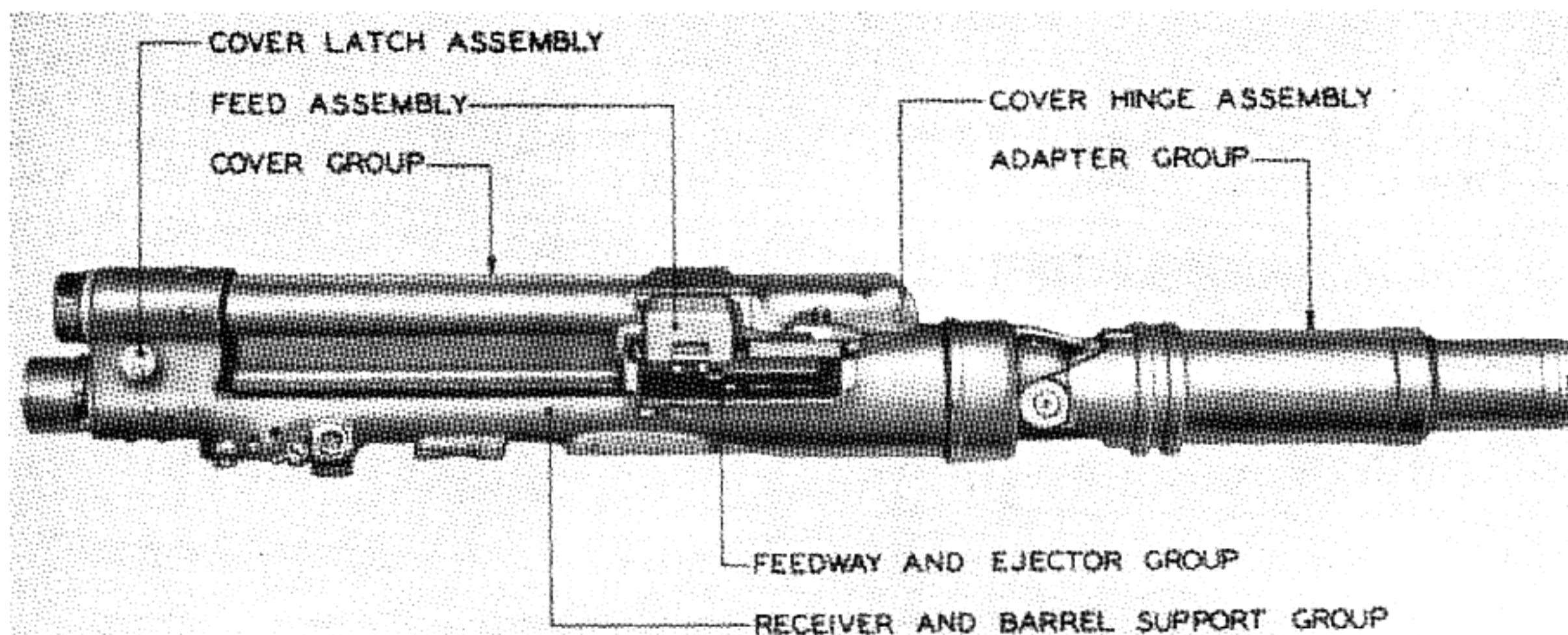


Figure 4-7. Gun, Machine, Caliber .60, T17E5. General assembly of groups.

A hardened barrel liner has been provided to lengthen the life of the barrel. Three knurled bands down the middle provide a convenient gripping surface when assembling the barrel. An enlarged fluted section to the rear of these knurled bands slides within the barrel, bearing the recoil and counterrecoil of the barrel.

The barrel flares outward to a shoulder, to the rear of the fluted section. This shoulder contacts the barrel buffer thrust collar near the end of recoil to stop the rearward travel of the barrel.

Buttress locking lugs around the outside of the barrel, at the breech end, engage mating lugs in the breech ring to lock the barrel in the breech ring assembly. Two small projections, which extend from the breech end of the barrel, are partial safety devices which will interfere with the bolthead if the barrel is not turned to at least two-thirds of its fully locked position. If the bolthead interferes with these projections, but cannot move the barrel forward, as when the barrel is turned less than two-thirds of its locked position, the bolthead will not lock and the firing pin will not strike the primer to fire the cartridge. However, if the barrel is not fully inserted in the breech ring, or if the bolthead interferes with these projections but moves the barrel forward, as when the barrel is fully inserted but not turned at all, then the firing pin can protrude to strike the primer and fire the round if the extractor is holding the cartridge against the face of the bolt.

At the top of the barrel, near the breech end, is a longitudinal locking groove which engages the barrel lock. If the gun is fired with the barrel rotated beyond two-thirds of its locked position, but not locked, it will rotate progressively to the left until the barrel lock engages the locking groove.

Cover Group. The cover group includes an electric charger as well as those parts and assemblies whose function is to feed ammunition into the gun.

The front end of the cover is attached to the receiver by means of a cover hinge assembly, which engages the hook projection on top of the receiver.

This cover hinge is designed to permit the removal of the cover when the gun is mounted in a limited space. The design also permits removal by raising the rear end of the cover and pushing it forward. When the cover is closed, it is secured by the cover latch which engages the cover latch block on the receiver. The cover latch spring maintains pressure on the cover latch handle to keep the latch closed. The rolled machine edges of the cover form an upper guide for the bolt.

The belt feed tube is mounted in the top part of the cover and is held in place at its forward end by the belt feed tube lock.

The electric charger, which is assembled inside of the belt feed tube, has a motor assembly with a set of electrical contacts which engage a matching set of contacts in the receiver when the cover is closed. The motor rotates in either direction de-

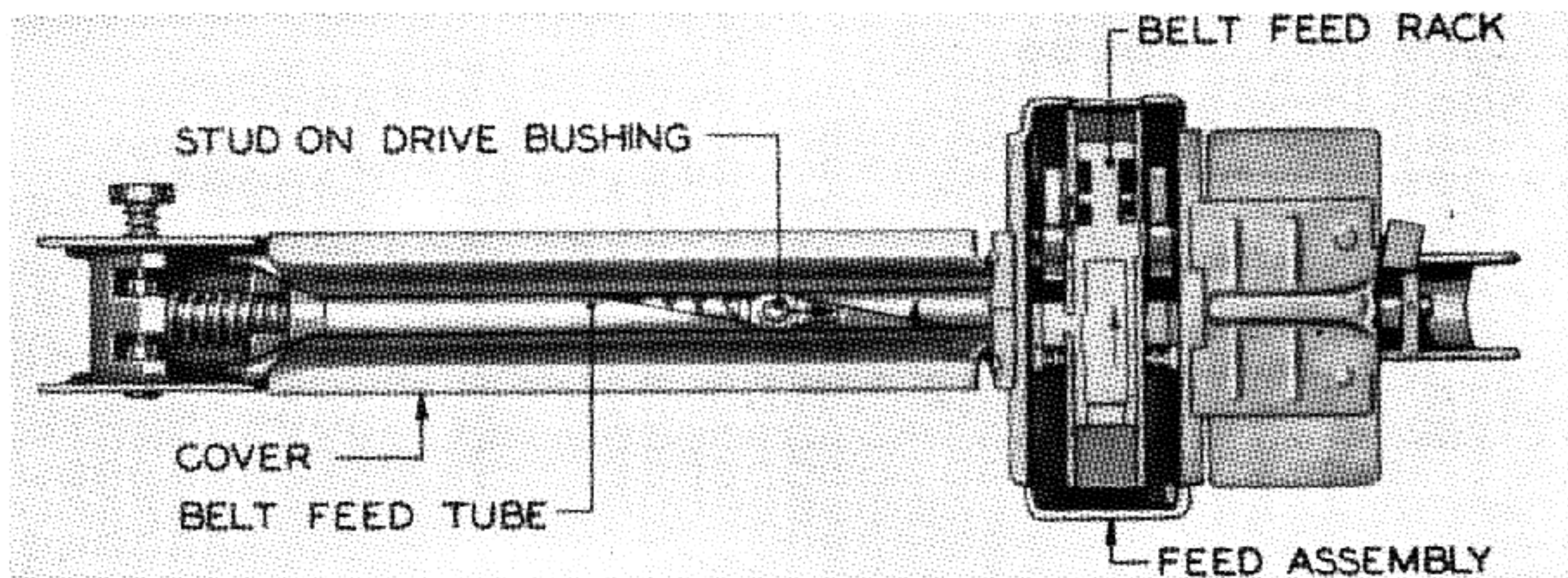


Figure 4-8. View showing how belt feed rack is moved outward during counterrecoil.

pending on the duty required. The motor contains a locking plunger which engages a mating hole in the cover for retaining the charger. The motor mount also provides the housing for the lead screw which is rotated by the motor through the friction drive assembly.

The feed assembly is mounted on the under side of the cover and is secured to the cover by two feed body locks. The stripper rack assembly includes the belt feed rack, universal stripper and belt pawl, as well as minor parts. The belt feed tube moves the stripper and rack assembly back and forth in a sidewise direction to feed the ammunition. The purpose of the stripper is to position the cartridge for feeding and to hold the link during stripping.

Ammunition may be fed into the gun from either side, depending on which belt feed tube is used and the installation of the feed assembly. (Both right- and left-hand belt feed tubes are supplied to provide movement in the proper direction for feeding ammunition from either side of the gun.)

The drive bushing assembly slides inside the belt feed tube. A stud projects downward from the drive bushing and engages a socket in the top of the bolt. A roller on this stud rides in a track formed by the sides of the cover to keep the drive bushing assembly from turning in the cover. Hardened cam surfaces at the base of the stud contact a spiral slot in the belt feed tube. During the forward movement of the bolt assembly and the drive bushing as-

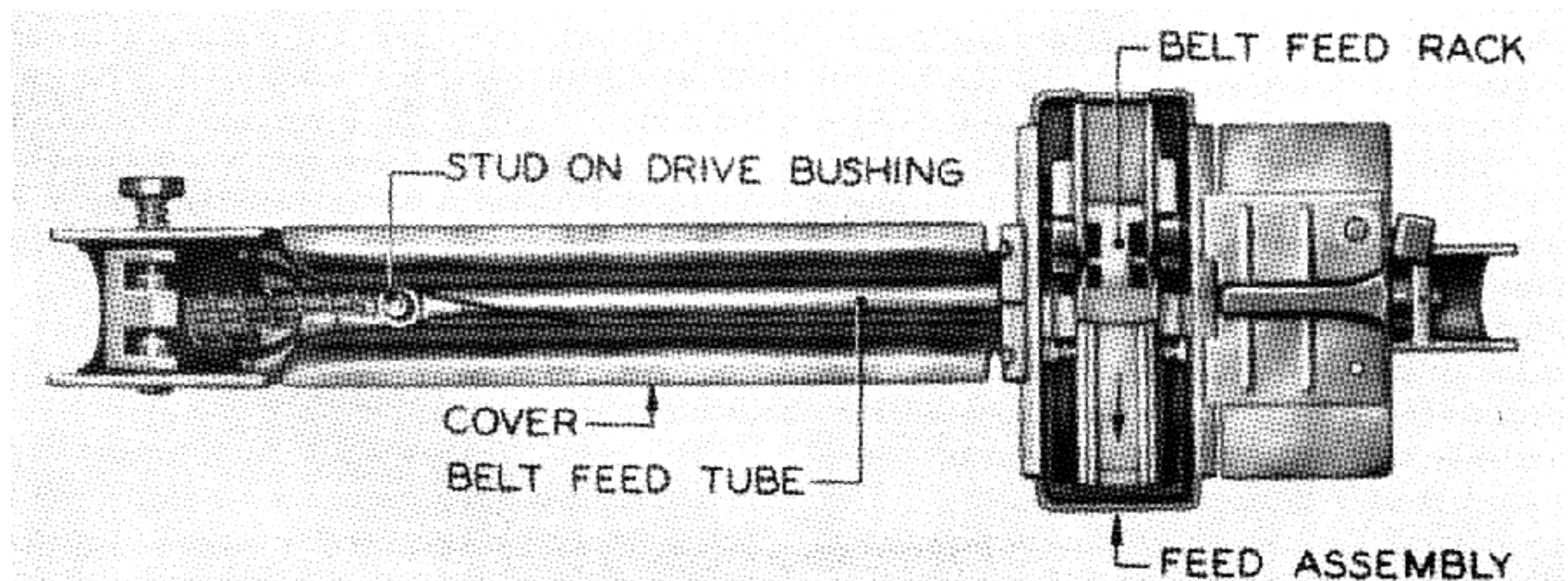


Figure 4-9. View showing how belt feed rack is moved inward during recoil.

sembly, these cam surfaces cause the tube to rotate about half a turn, thus moving the belt feed rack out towards that side of the gun into which ammunition is being fed. This movement of the rack with the tube is a result of the tube being geared to the rack. As the bolt assembly and the drive bushing assembly move rearward, the cam surfaces on the drive bushing cause the belt feed to rotate in the opposite direction.

This movement forces the belt feed rack inward and pulls a cartridge toward the center of the cartridge belt feedway.

When the gun is ready to fire, the bolt assembly is held rearward and a cartridge is centered in the cartridge belt feedway by the universal stripper.

As the bolt assembly moves forward, the cartridge is forced out of the link by the top front edge of the bolthead and the belt holding pawls continue to retain the cartridge belt in position by holding the empty link. At the same time, the belt feed rack is moved outward and the belt feed pawl hinges upward to ride over the link of the next cartridge.

At the completion of the forward movement of the bolt assembly, the belt feed rack has been carried still farther outward, and the belt feed pawl snaps down behind the next cartridge.

As the bolt assembly recoils, the belt feed rack and the belt feed pawl draw the belt into the gun.

The belt holding pawls hinge outward to clear the entering cartridge.

As the bolt assembly reaches the rearmost position, the belt holding pawls snap downward against the link to hold the cartridge and the universal stripper holds the cartridge down in the slot of the cartridge belt feedway so that it projects below the feedway where it can be engaged by the top front edge of the bolthead.

The cartridge guide assembly is slid onto the cover and retained by the contact of the cartridge guide spring with the cover. Attached to the cartridge guide assembly is a spring loaded cover safety catch, which is positioned under the edge of the cover. Whenever it is in a raised position, to prevent the cover from accidentally closing on the hands of the operator, this cover safety catch must be swung out of the way before the cover can be closed.

Bolt Group. The bolt group includes the bolt, bolthead, bolthead roller, bolthead cam, bolthead buffer bodies, volute springs, extractor, extractor spring, firing pin, recoil plate, and minor parts.

The recoil plate is pressed into the front end of the bolthead. The extractor spring exerts pressure against the rear end of the extractor, which is pivoted to the bolthead by a double roll pin. This pressure, at the rear of the extractor, forces the front end firmly into the extractor groove of the cartridge and

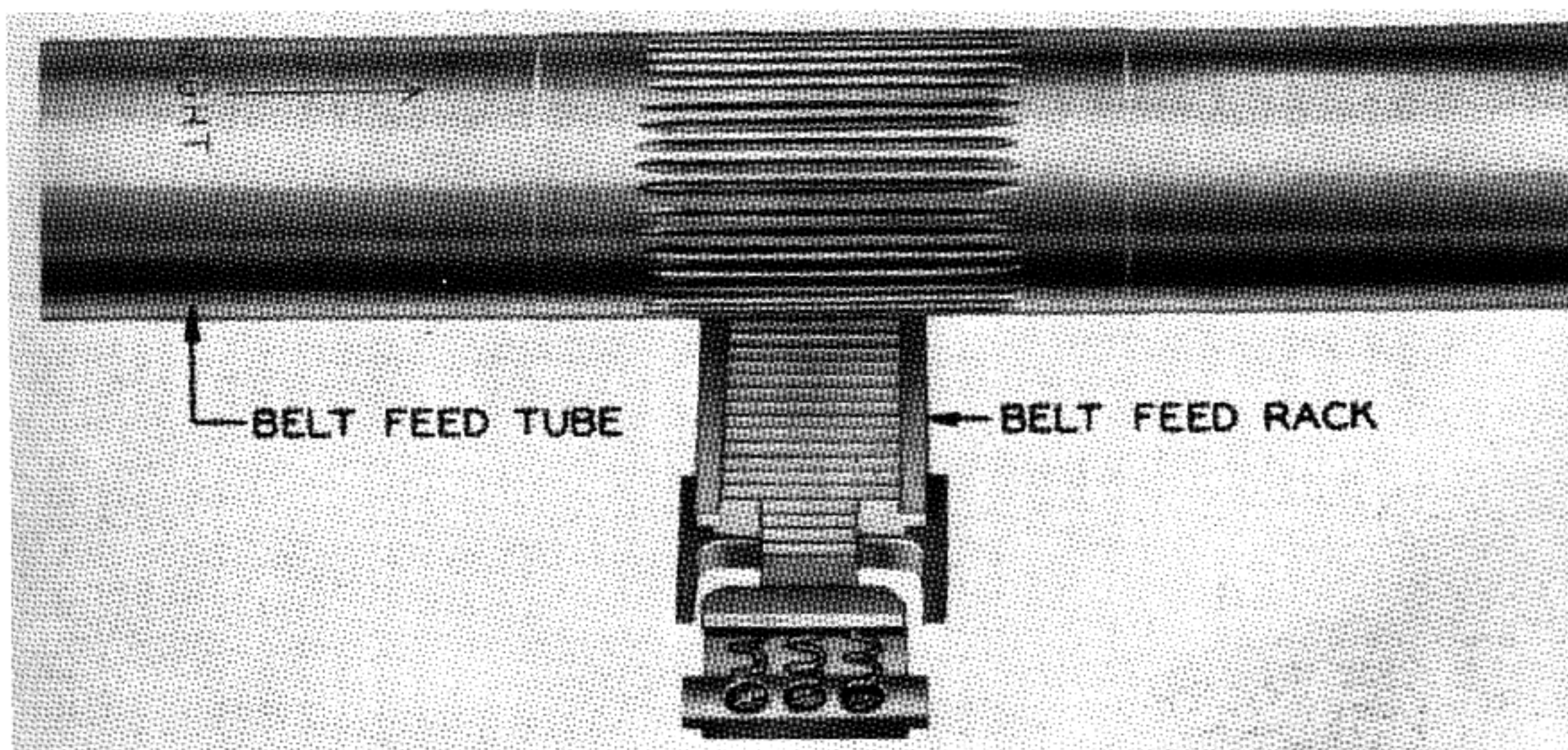


Figure 4-10. View showing engagement of belt feed tube and rack.

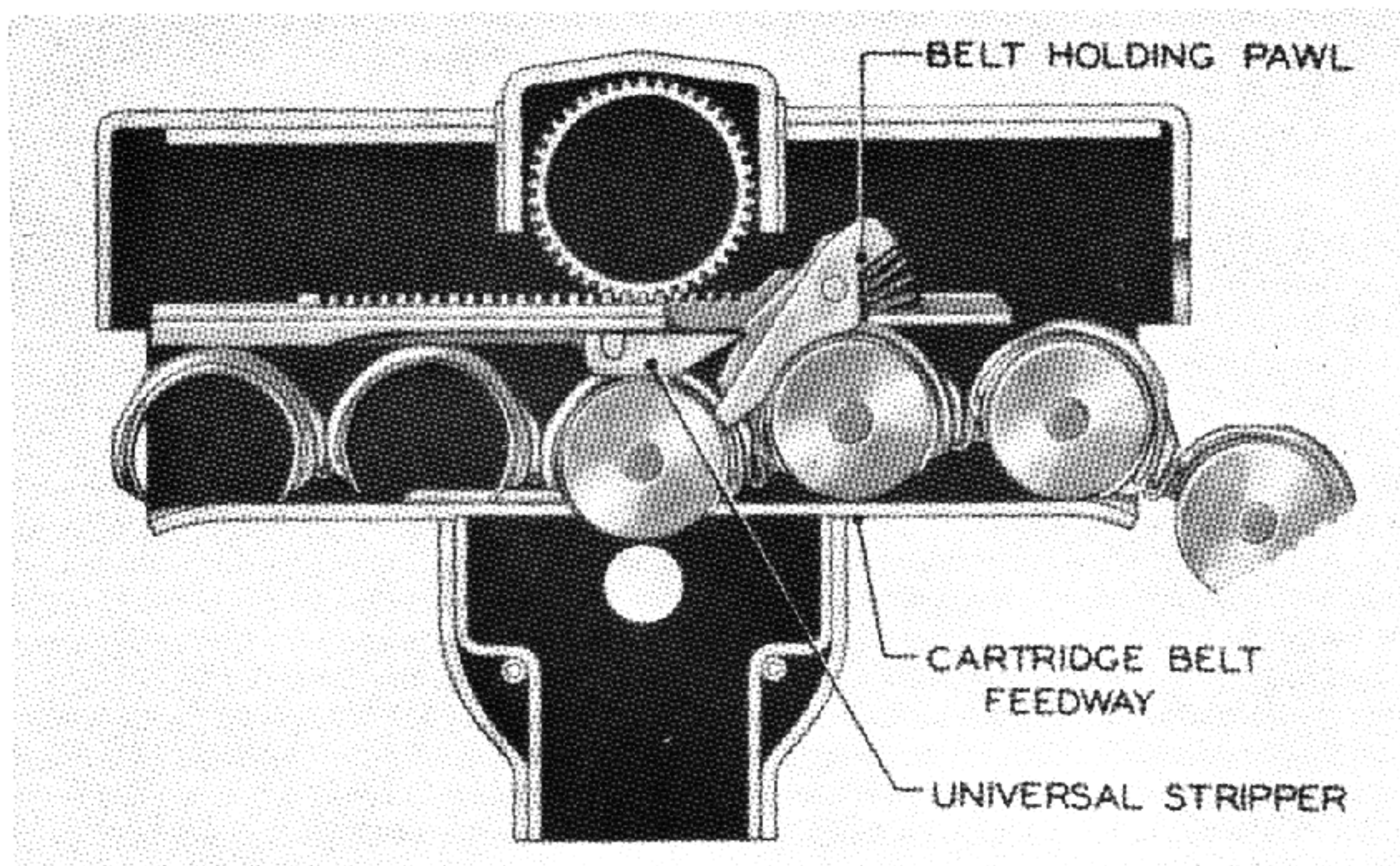


Figure 4-11. View showing how cartridge is held alined in feedway.

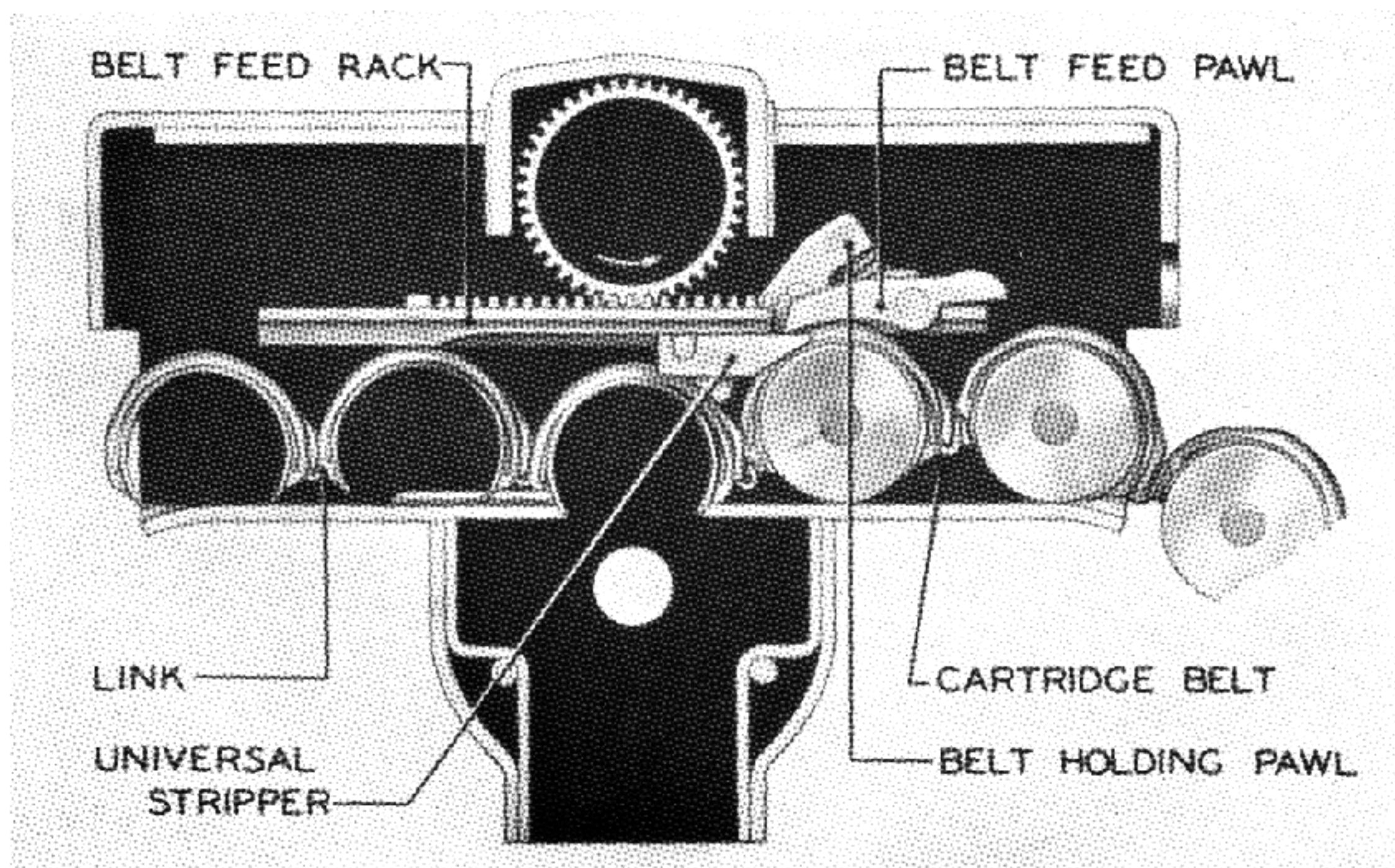


Figure 4-12. View showing how backward movement of belt is prevented when rack shuttles.

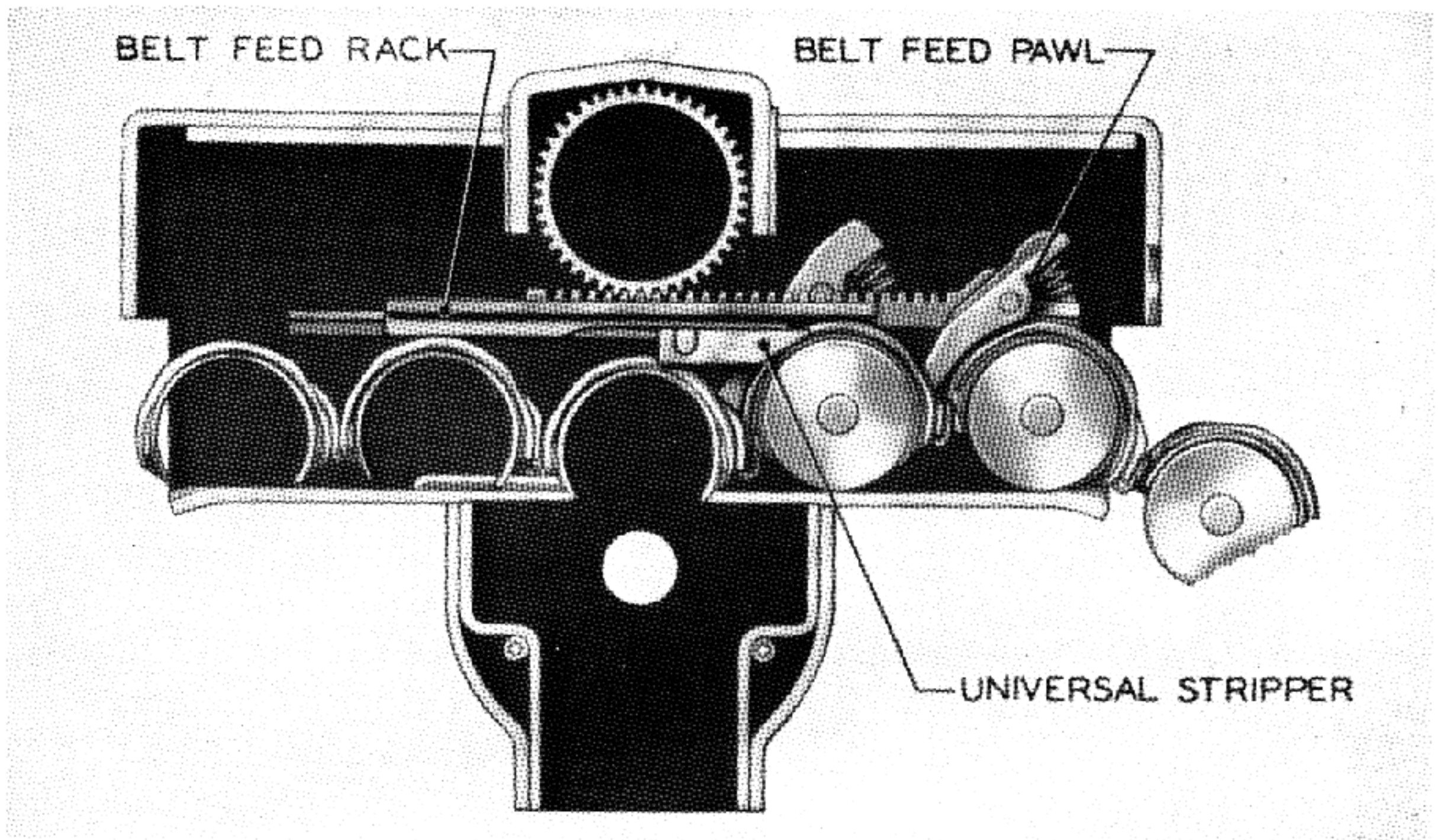


Figure 4-13. View showing how belt feed pawl grasps next cartridge.

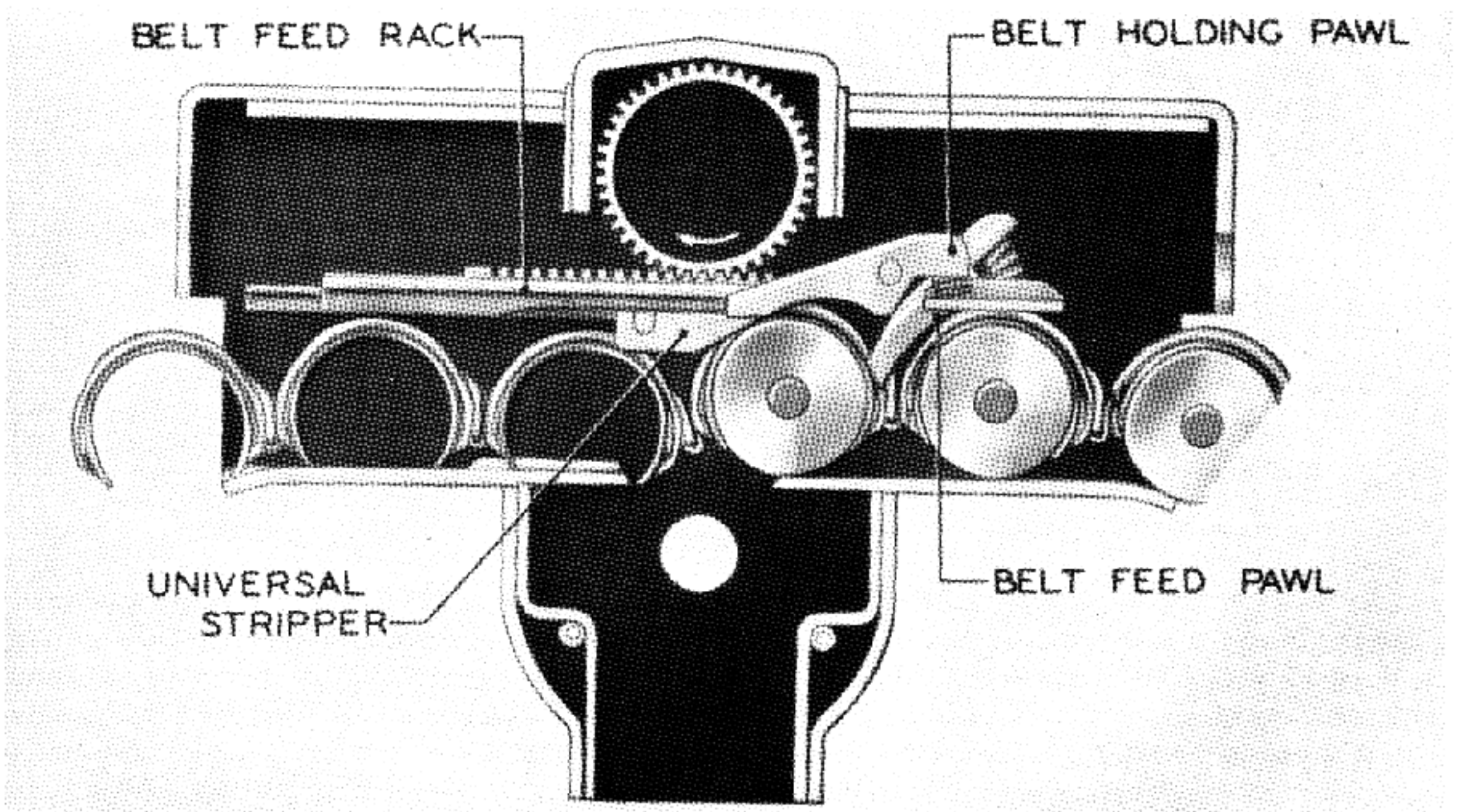


Figure 4-14. View showing how belt feed pawl positions next round in feedway.

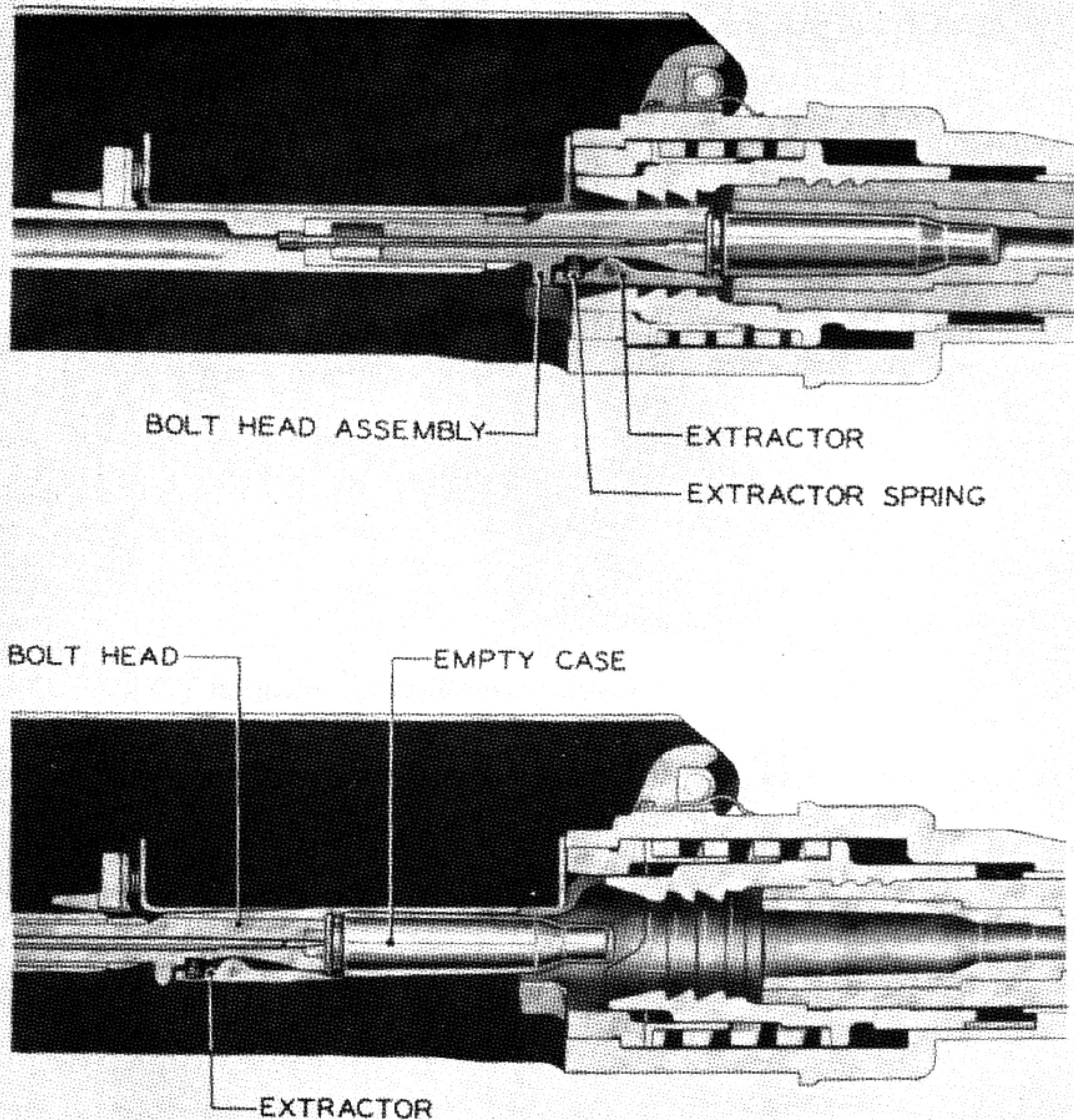


Figure 4-15. The extracting phase in the operating cycle of the Caliber .60 T17E5 Machine Gun.

pulls the empty case loose from the chamber. The extractor is provided with projections to take the extraction and ejection load instead of the load being transmitted to the pin.

As the recoil continues, the extractor holds the empty case in the recess of the bolt head and bolt head rollers operate against cams to cause the locking and unlocking of the bolt head during the firing cycle.

These rollers ride on the track in the receiver during the forward and rearward travel of the bolt assembly.

Cam lugs on the sides of the shank of the bolt head operate in spiral grooves in the bolt head cam assembly, which is recessed in the bolt. The cam is positioned, during assembly, by the bolt head cam pin. While the gun is being cocked, prior to firing, the travel of the spiral cam grooves past the lugs

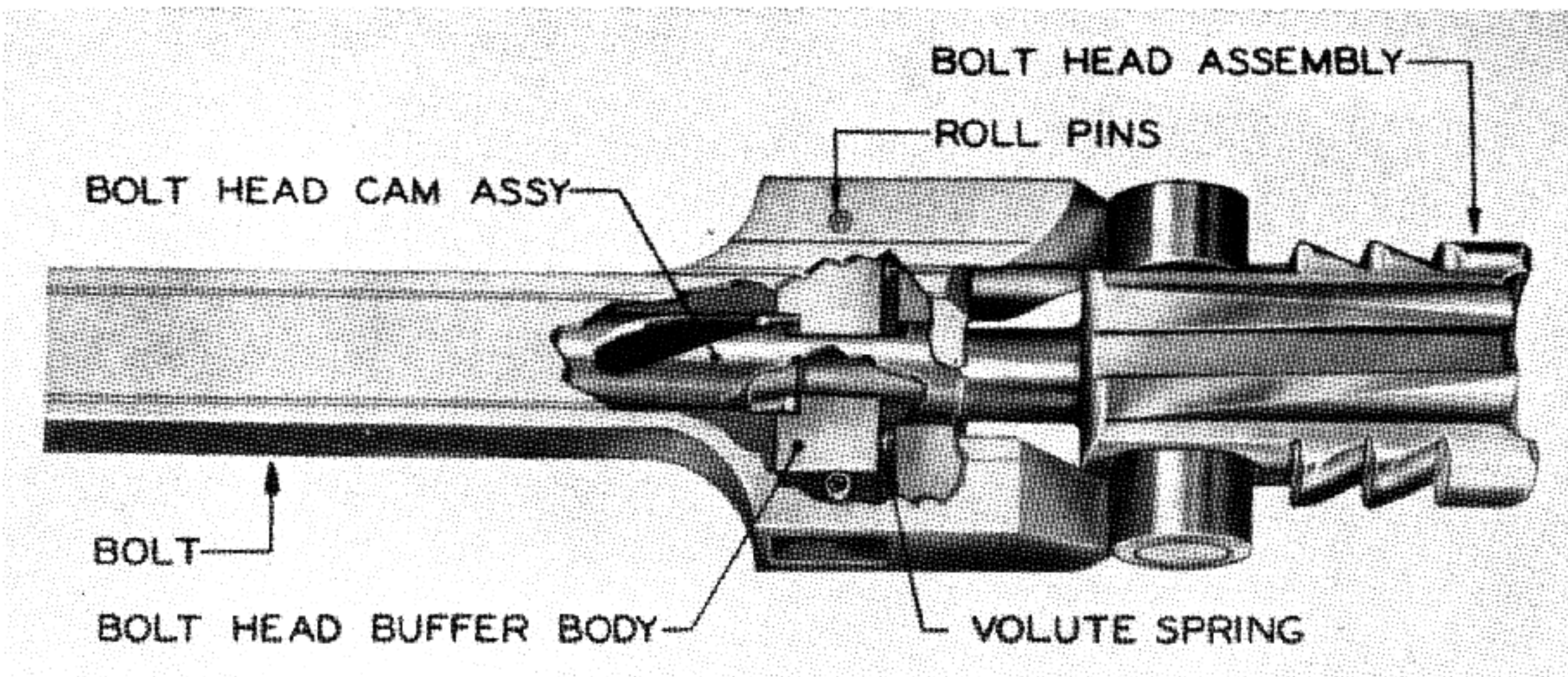


Figure 4-16. Cutaway view of bolt of Caliber .60 T17E5 Machine Gun, showing buffer between bolt body and bolthead.

causes the bolthead to turn and unlock from the breech-ring assembly. This makes it possible to cock the gun without compressing the recoil spring or contacting the unlocking cam. The bolthead cam assembly also holds the firing pin rearward in its recess in the bolt.

The bolthead buffer bodies and volute springs are assembled into each side of the bolt. The rounded inner surfaces of the buffer bodies bear against the shank of the bolthead. Double roll pins hold the buffer bodies in position. The buffer bodies project into the squared section of the slot in the bolthead

cam to keep it from turning and prevent it from moving forward. The buffer springs cushion the shock as the accelerated bolt pulls the bolthead rearward after being unlocked from the breech ring assembly. The forward surface of the cam lug on each side of the shank of the bolthead is driven against the rear surface of the bolthead buffer body.

The under surface of the wider section, at both front and rear of the bolt, slides on the track of the receiver. A lug, which projects outward from each side at the rear of the bolt, rides in a slot between the receiver and the cover. A horizontal hole

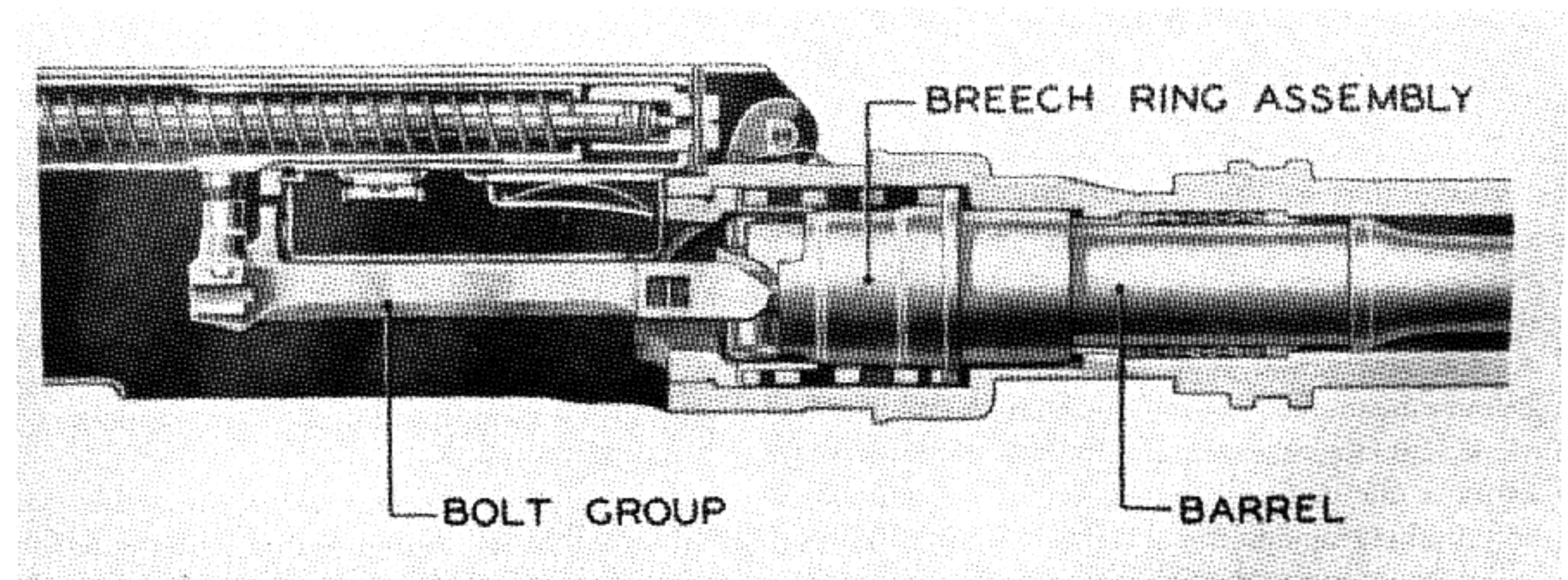


Figure 4-17. Recoiling mass of Caliber .60 T17E5 Machine Gun.

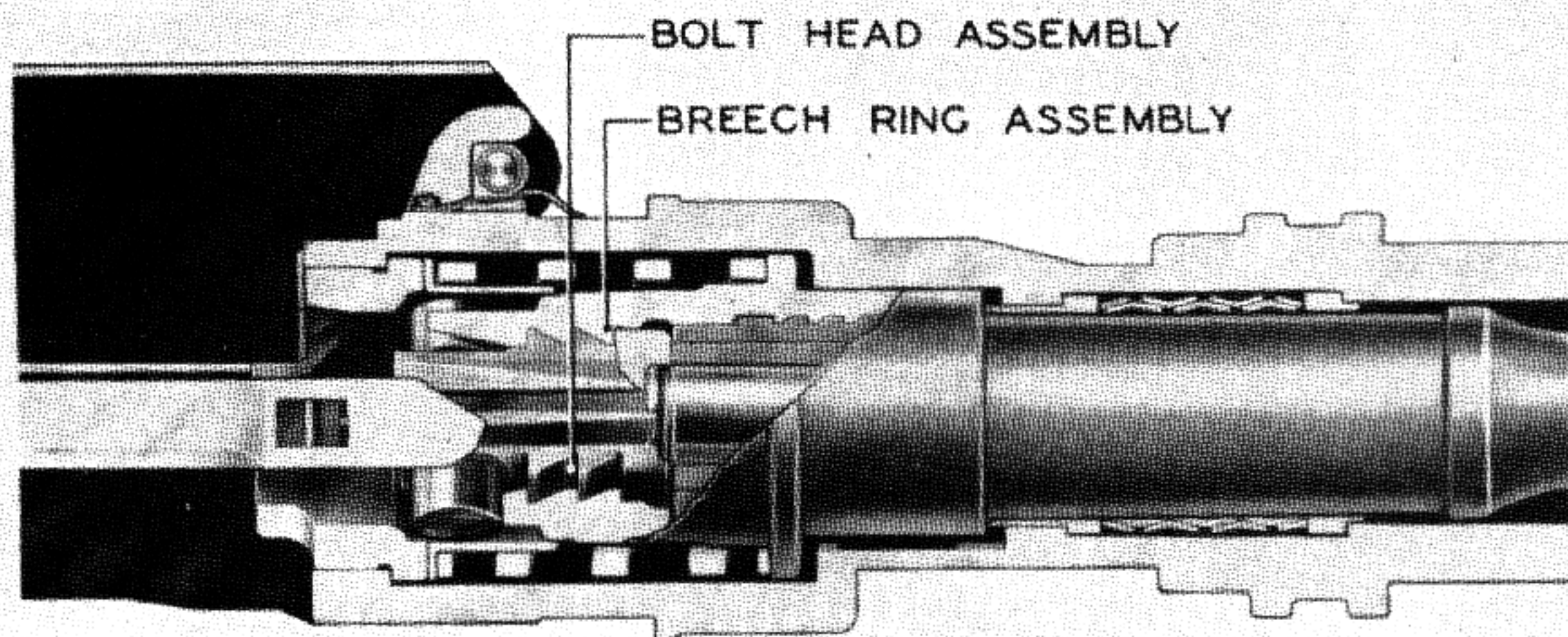


Figure 4-18. Bolt head locking lugs of Caliber .60 T17E5 Machine Gun.

through the projection at the rear of the bolt is to provide clearance for the ejector when the bolt assembly is in its forward position.

The complete cycle of the recoiling portion of the gun, which takes place as each cartridge is fired, consists of the recoil stroke, when certain parts of the gun move rearward, and the counterrecoil stroke, when these same parts move forward. At the instant of firing, the recoiling portion is in the forward position of the gun. At this time, the bolt head is locked in the breech ring assembly against the base of the cartridge. Buttress locking lugs on the inner surface of the breech ring assembly are engaged with mating lugs on the outer surface of the bolt head.

As the cartridge is fired and the projectile travels out of the barrel, the force of recoil drives the recoiling portion rearward. After recoiling about $\frac{7}{16}$ inch, the bolt head rollers engage the cam surfaces of the unlocking cam. Continued rearward travel of the recoiling portion causes the bolt head to rotate and unlock from the breech ring assembly.

As the bolt head is thus rotated, the rearward movement of the bolt, which has been nested with the bolt head, is accelerated and the bolt moves rearward from the bolt head by action of the bolt head rollers pushing against the bolt nose cams. This acceleration occurs as the bolt head is being unlocked from the breech ring assembly. The firing pin,

which is retained in the bolt, is withdrawn from the surface of the bolt head during this action.

The recoil spring is being compressed throughout the rearward travel of the barrel and breech ring assembly. Following the unlocking of the bolt head from the breech ring assembly, the barrel and breech ring assembly continue to travel rearward, until stopped by the snubbing action of the barrel buffer spring inside the barrel support assembly. The total recoil distance of the barrel and breech ring assembly is approximately $1\frac{1}{4}$ inches.

During the rearward travel of the bolt assembly, the drive spring assembly is compressed by the bolt acting through the drive bushing assembly. The rearward stroke of the bolt assembly is finally stopped as it strikes the buffer plate which is cushioned against the Belleville buffer springs.

While the bolt assembly is still recoiling and recocking the gun, the barrel and breech ring assembly are forced forward in counterrecoil by the energy stored in the recoil spring. When the barrel has moved forward into firing position, the barrel buffer spring inside of the barrel support again comes into action to stop the barrel and breech ring assembly.

If the sear roller has been held down, either manually or electrically, the bolt assembly rebounds from the buffer plate and is driven forward on another firing cycle by the energy stored in the drive spring

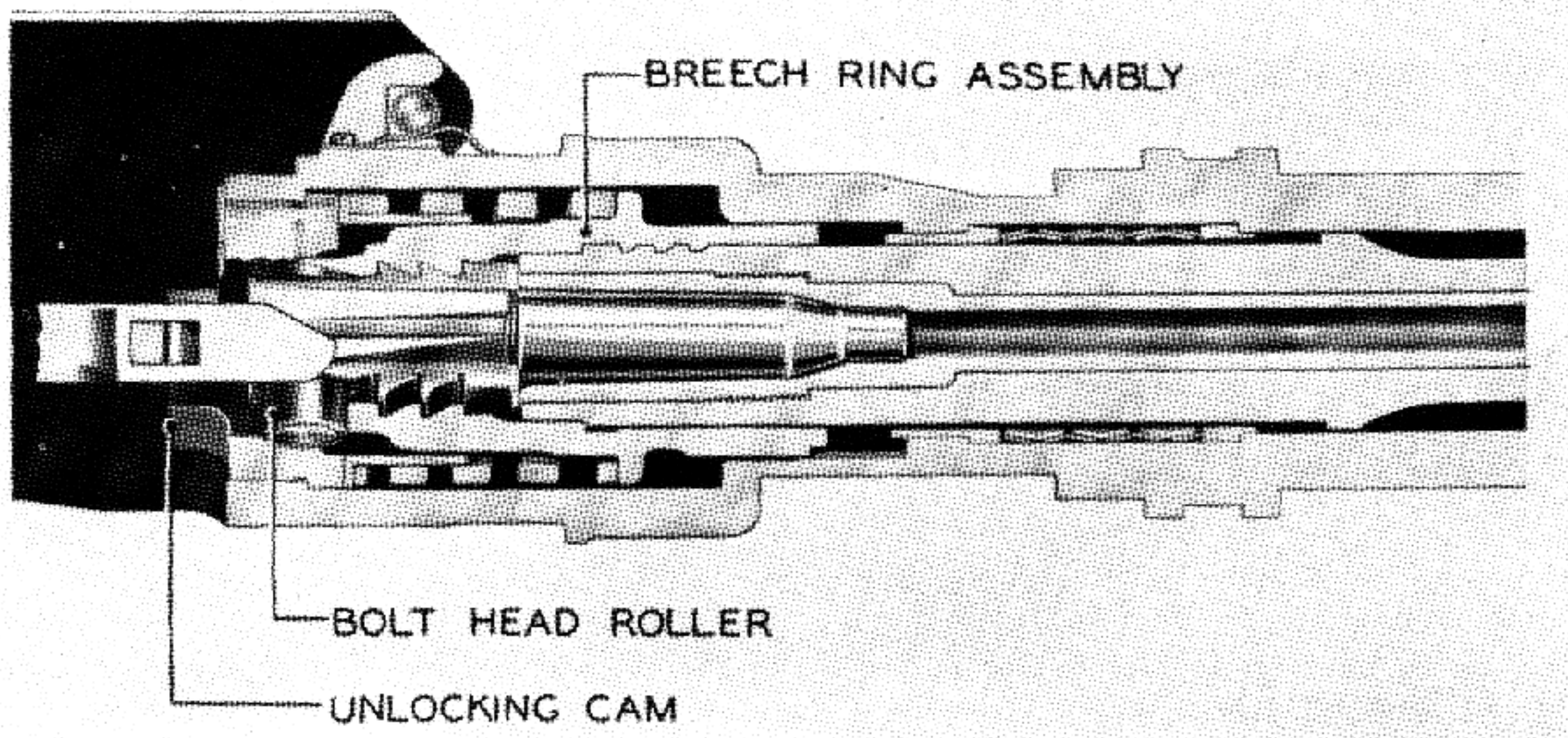


Figure 4-19. Unlocking action of Caliber .60 T17E5 Machine Gun.

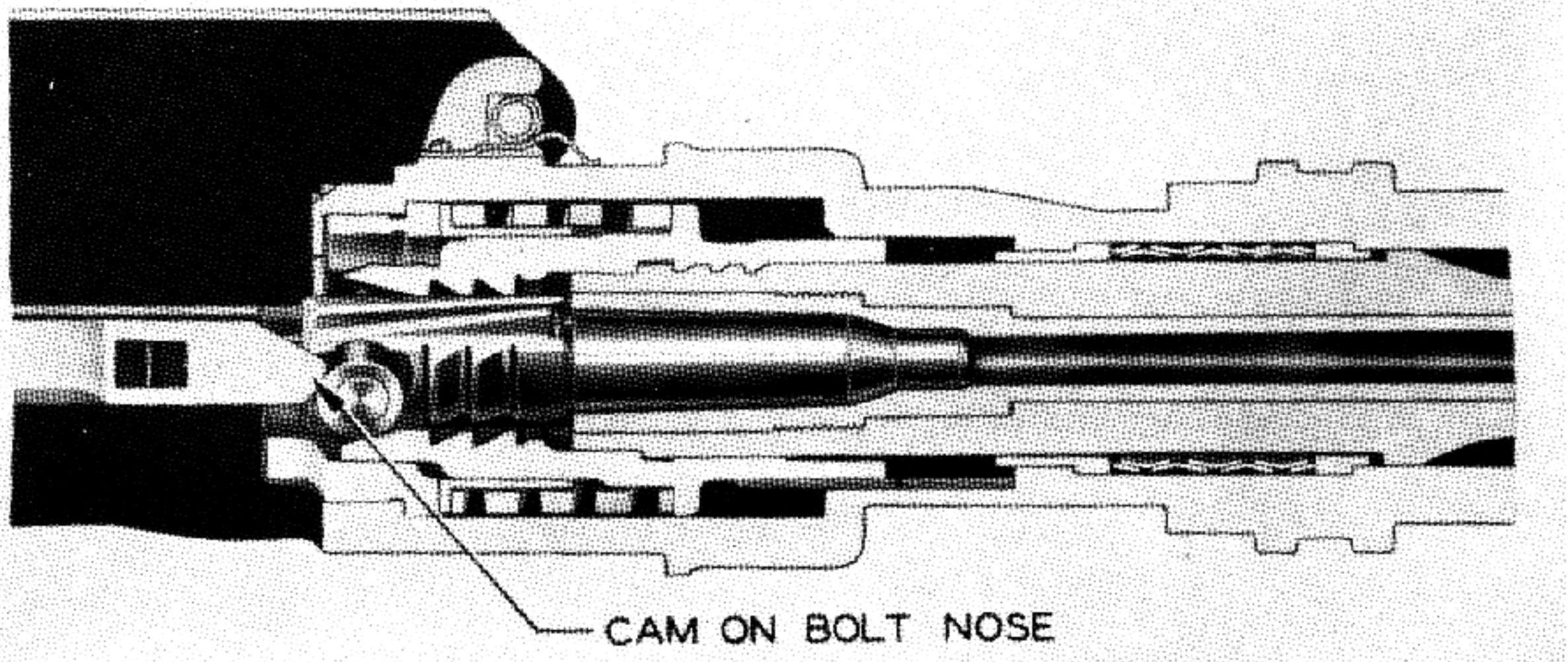


Figure 4-20. Method of accelerating bolt.

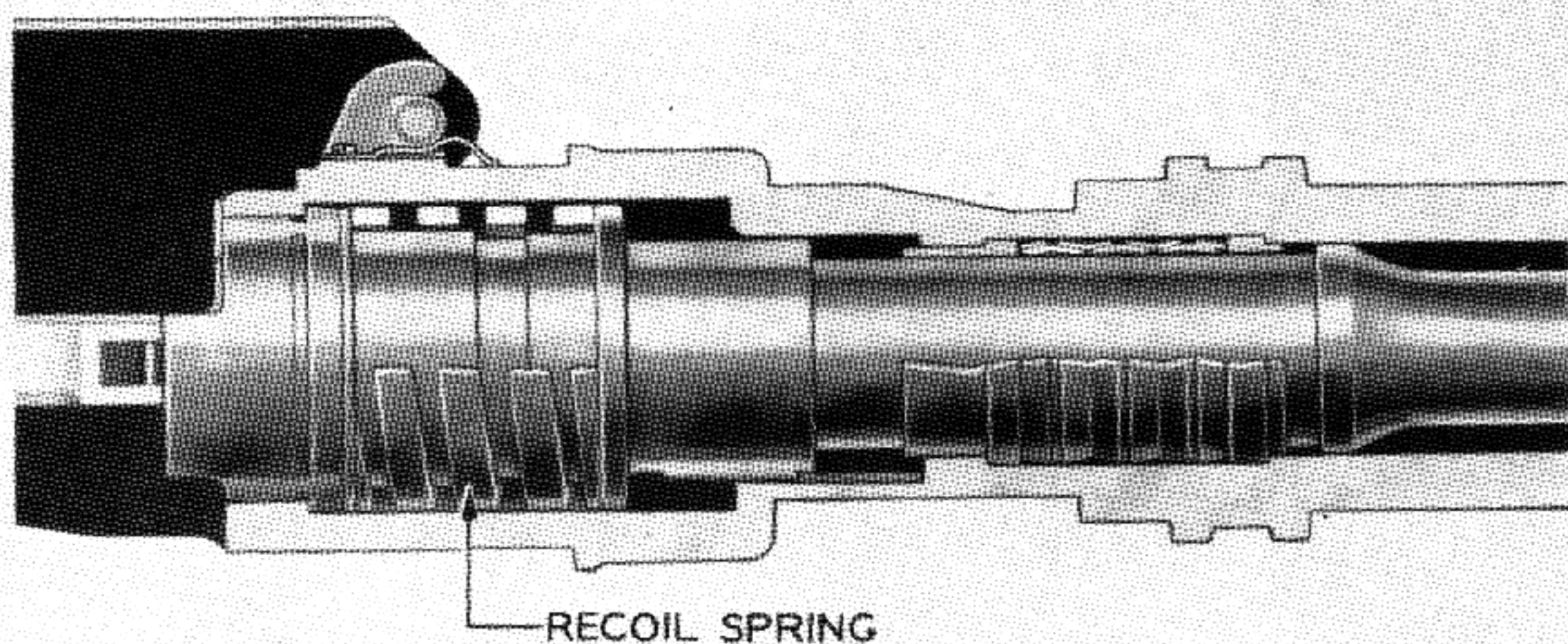


Figure 4-21. View showing recoil spring compressed.

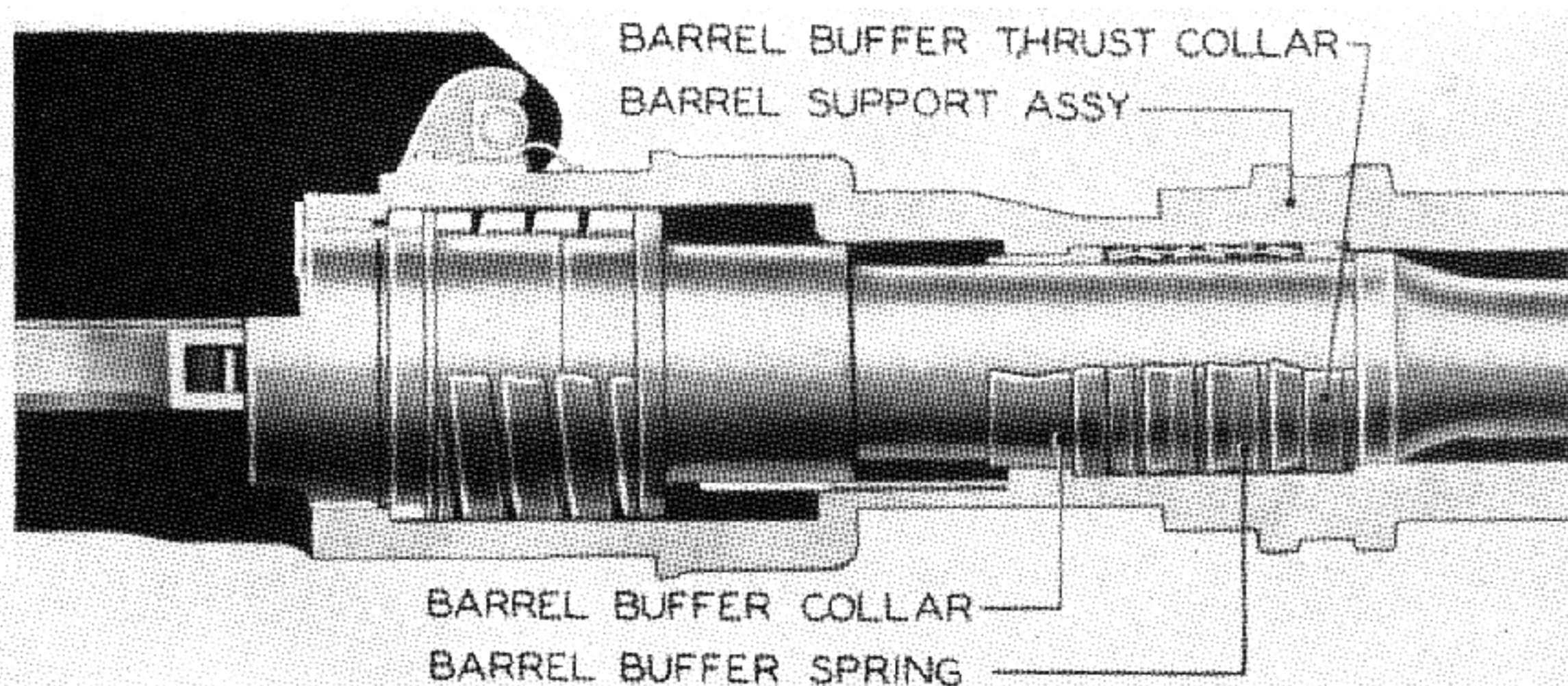


Figure 4-22. View showing how barrel buffer stops barrel recoil.

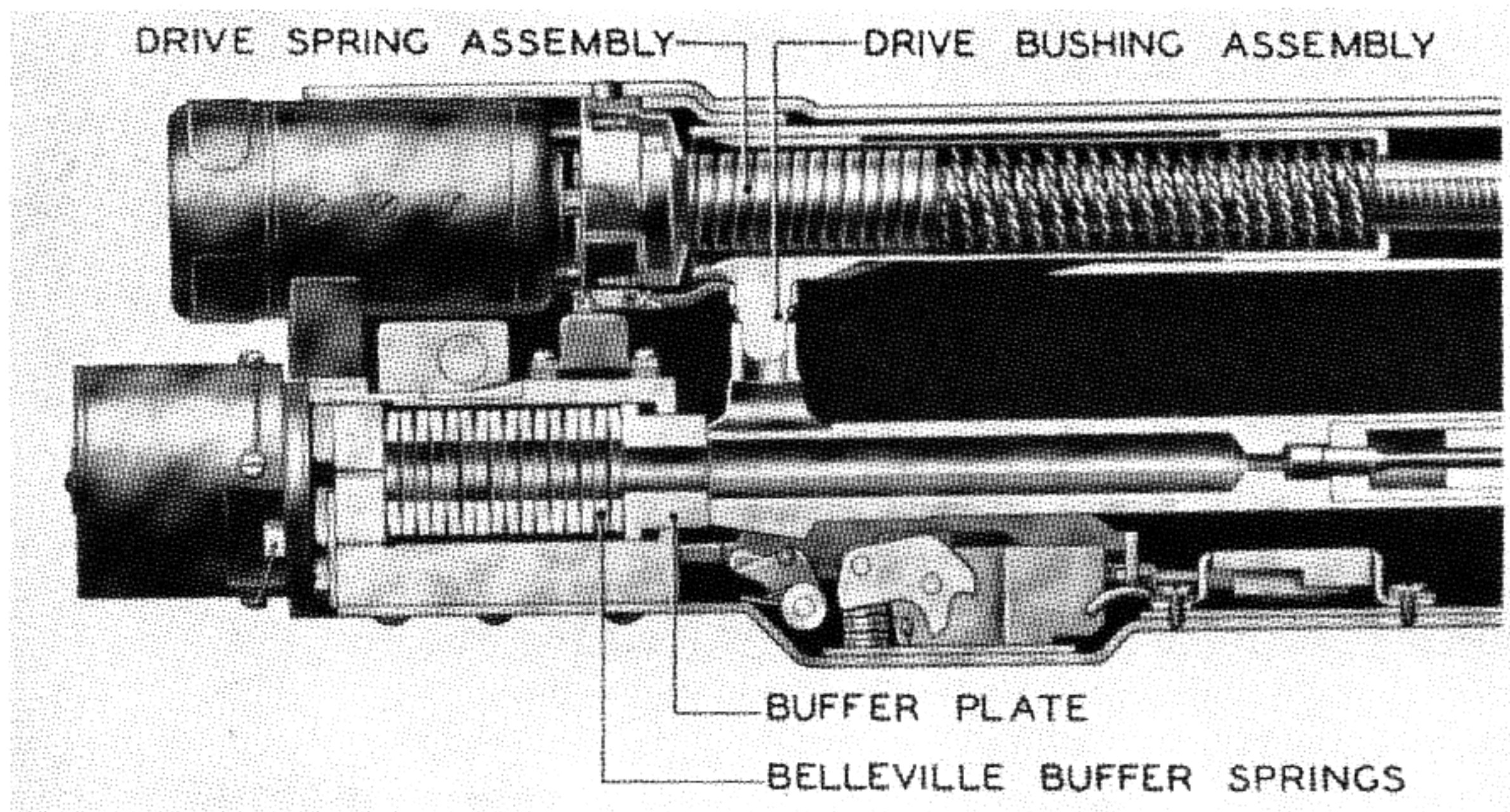


Figure 4-23. View showing how bolt buffer stops bolt recoil.

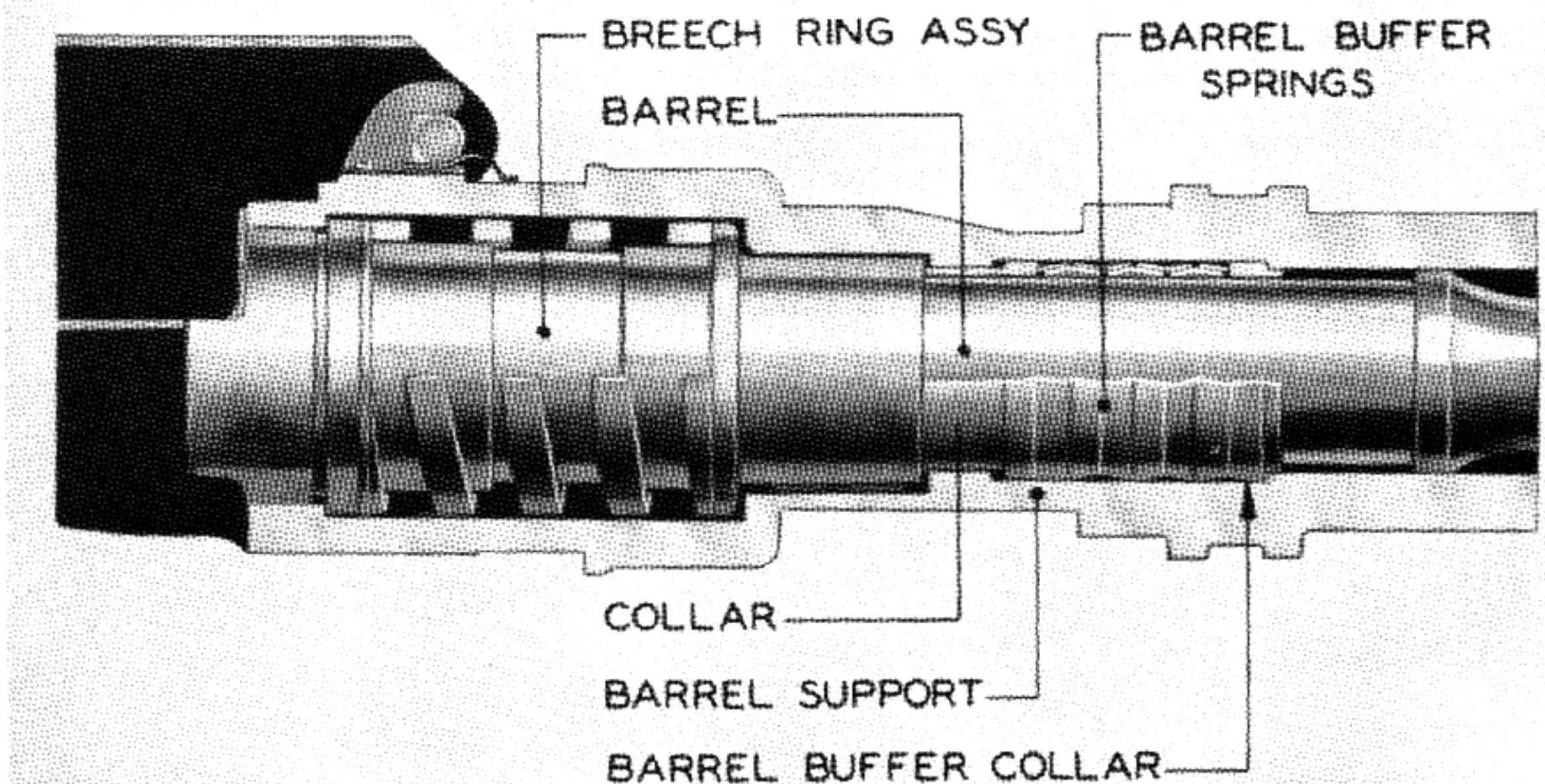


Figure 4-24. View showing how barrel buffer stops barrel counterrecoil.

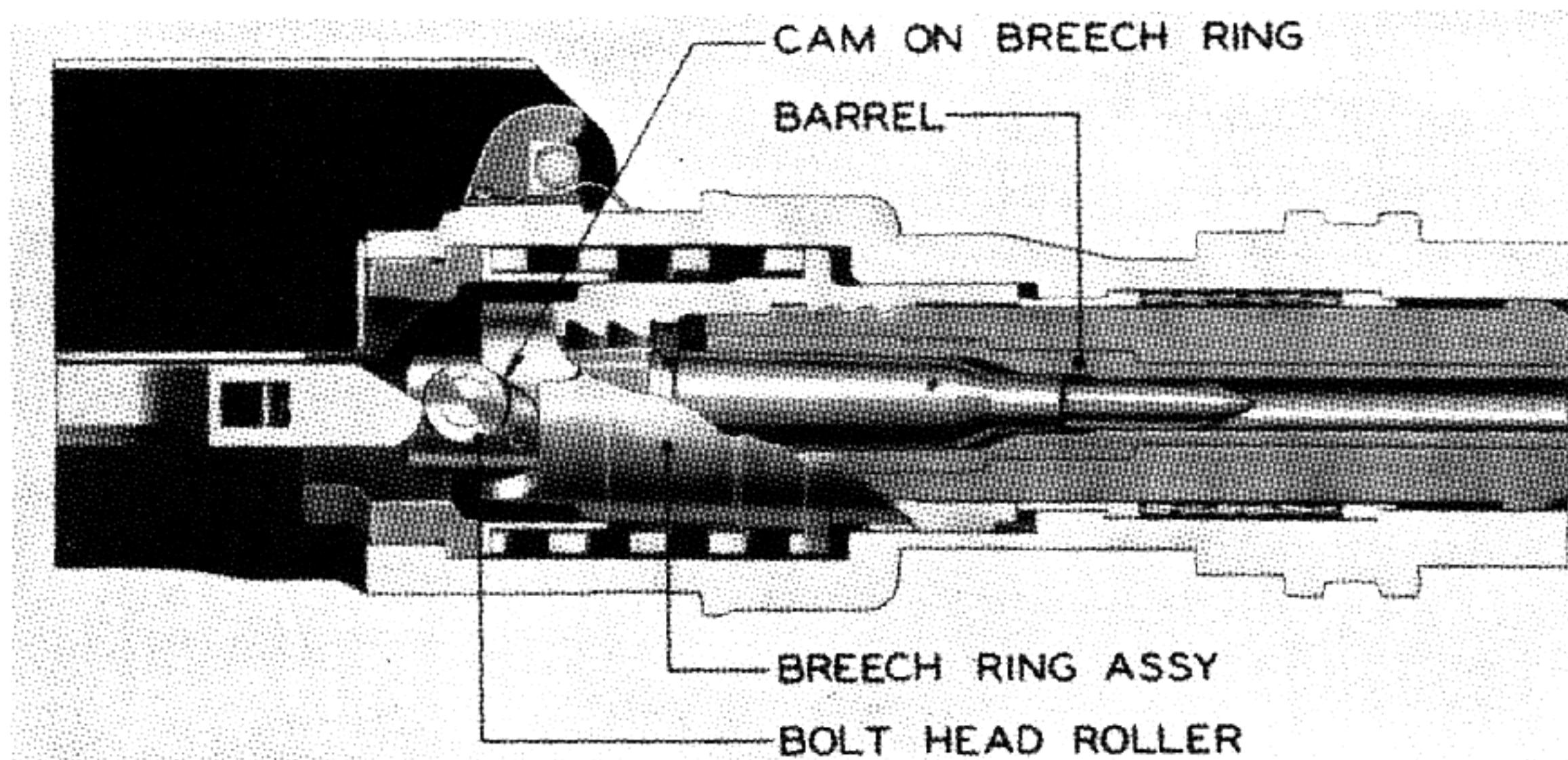


Figure 4-25. Beginning of locking action.

assembly and buffer spring, thus producing automatic firing.

When the next cartridge is within about $\frac{5}{16}$ inch of being chambered, the bolthead rollers contact the breech ring cams. This gives the bolthead a chance to begin rotating in preparation for locking to the breech ring assembly.

While being rotated by the breech ring cams, the bolthead continues its forward travel and chambers

the cartridge. After the cartridge is fully chambered and the forward motion of the bolthead has stopped, the rotation of the bolthead continues through the action of the bolt nose cams against the bolthead rollers. This locks the bolthead to the breech ring assembly.

During this locking action, the bolt continues to move forward and nest around the bolthead. The final forward movement of the bolt pushes the firing

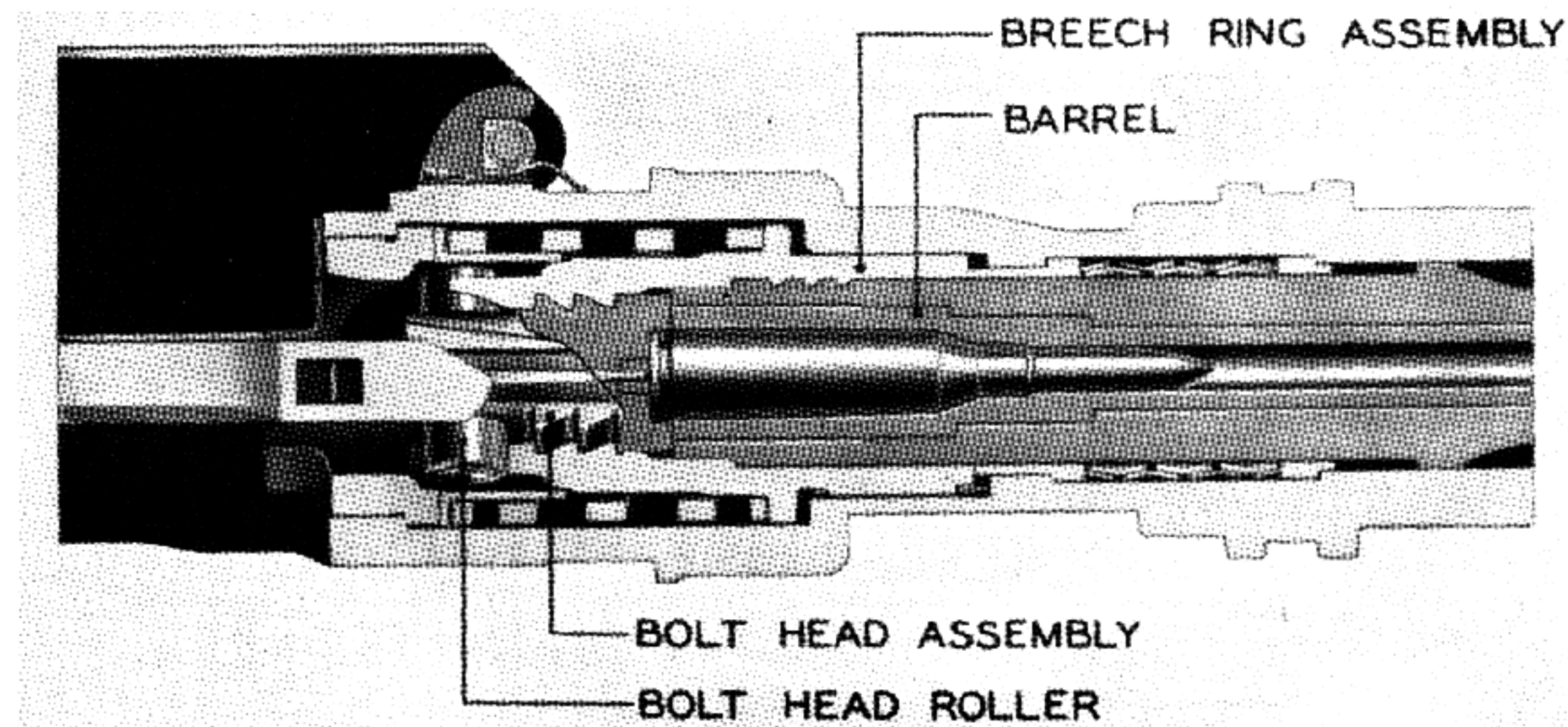


Figure 4-26. Completion of locking action.

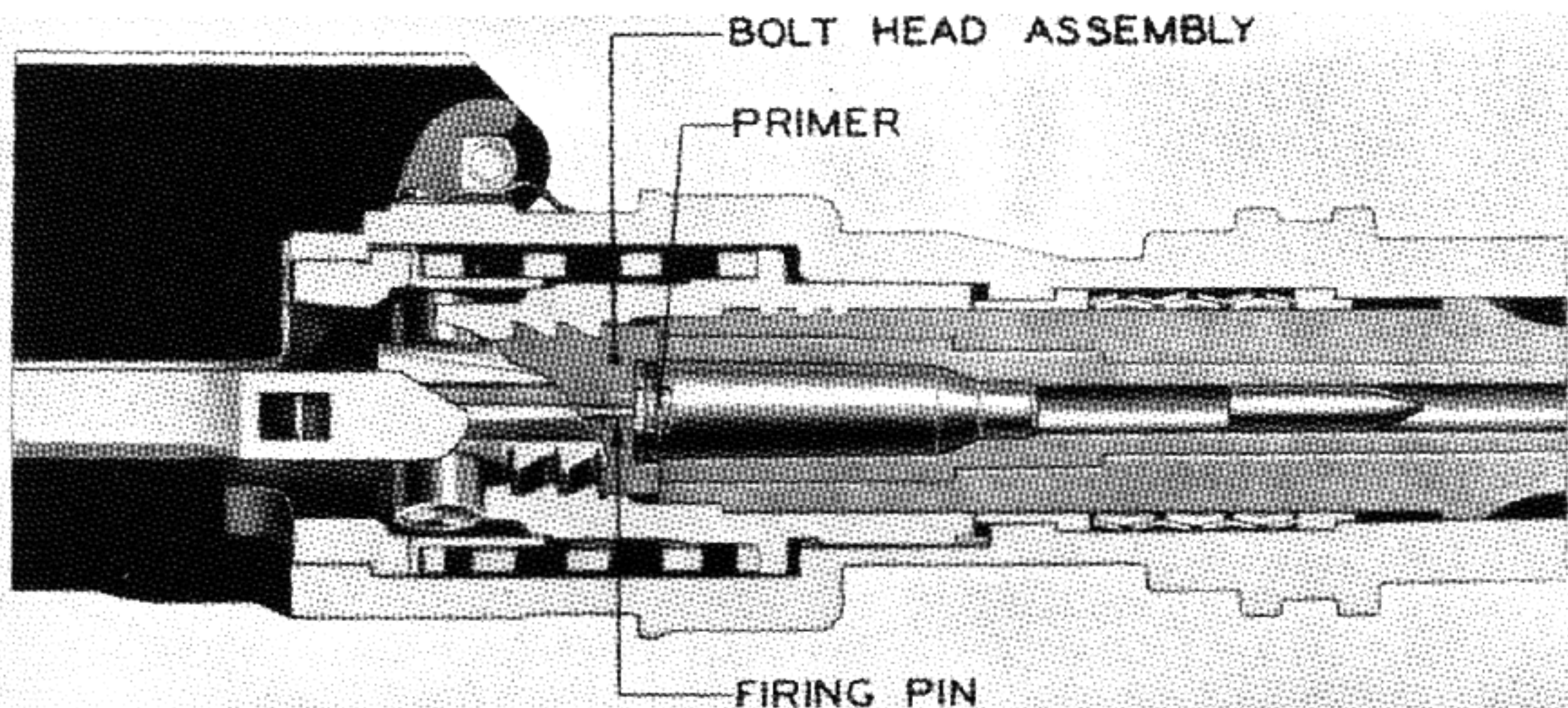


Figure 4-27. Ignition phase.

pin beyond the face of the bolt head to strike the primer and fire the cartridge.

Feeding and Ejector Group. The feedway and ejector group is mounted in the top forward portion of the receiver and is held firmly in position when the cover is closed. The group consists of the feedway and ejector assembly and the cartridge stop assembly. When the empty case is extracted from the

chamber and carried rearward by the bolt assembly, it strikes the ejector, which is mounted on the rear of the feedway. This causes the case to hinge downward over the extractor, ejecting it through the opening in the bottom of the receiver. The cartridge stop assembly prevents the cartridge from overriding the slot in the feedway and guides the empty links as they are forced from the feedway.

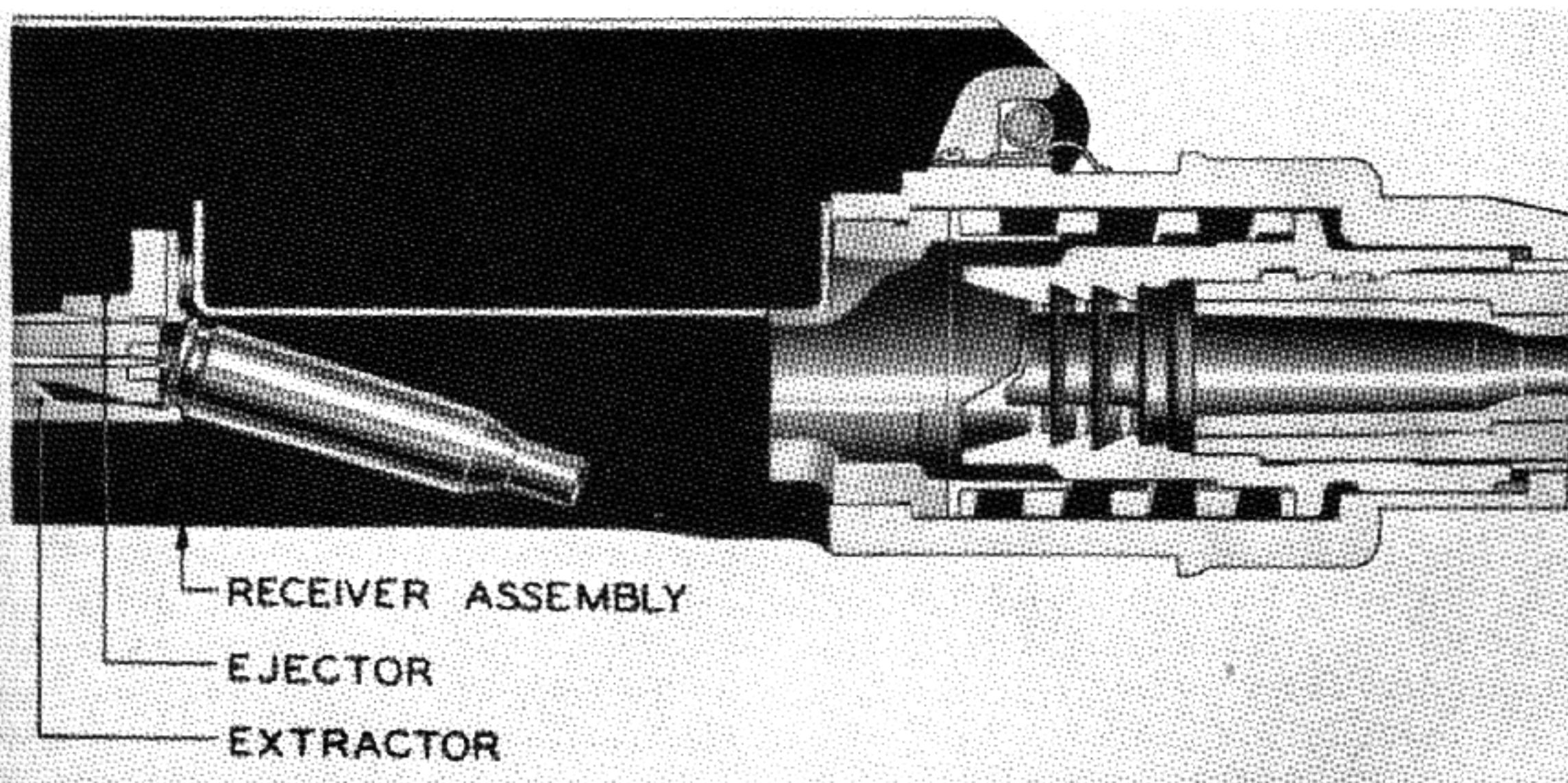


Figure 4-28. Ejection of empty case from gun.

Receiver and Barrel Support Group. The receiver assembly provides a housing for the buffer group, solenoid assembly, lower contact group, switches, telltale group, sear assembly and sear manual release group, and minor parts.

The buffer housing is located at the rear of the receiver and houses the buffer group. This group is composed of the buffer plate, Belleville buffer springs, buffer housing screw, and buffer housing screw retainer. These parts cushion the recoil with the bolt assembly when the rear of the bolt strikes the buffer plate. The energy is transmitted to the Belleville buffer springs which are positioned by the buffer housing screw. This screw is held in adjustment by the buffer housing screw retainer. The energy stored in the buffer springs starts the bolt assembly forward on the counterrecoil stroke.

The solenoid assembly, which is used to electrically operate the sear, is fastened to the rear of the buffer housing with two solenoid mounting screws. The solenoid assembly is composed of the solenoid coil assembly, armature, solenoid arm, solenoid shield plate, solenoid mounting plate, and minor parts. The solenoid arm is attached to the armature by the solenoid hinge pin. The arm is held stationary at the upper end by the pivot pin, causing the lower end of the arm to move through a distance greater than the travel of the armature. The electrical contact is made by the solenoid contact plug engaging the solenoid contact receptacle located in the rear end of the buffer housing.

The lower contact group is mounted above the rear end of the buffer housing. When the cover is closed, the three contacts mate with corresponding contacts on the electric charger and provide for two electrical circuits, namely, the power stroke circuit and the return stroke circuit.

The shroud switch assembly is located above in the front end of the buffer housing and includes the switch, switch shroud, switch shroud insulator, and shroud shims. The insulator lines the inside of the shroud and the switch is fastened in the shroud with two screws. There is an opening in the top of the shroud to allow the lower switch arm and switch arm shoe, located in the motor mount of the charger, to operate the switch. The switch assembly is fastened to the receiver with four screws and is properly spaced with the shroud shims. The switch opens and closes the return stroke circuit of the

charger, and opens and closes the firing circuit. When the return stroke circuit is open, the firing circuit is closed; and vice versa.

The telltale group, located forward of the buffer housing, determines the rotating direction of the charger motor. This group is composed of the telltale spacer, telltale, telltale spring, telltale spring capstan, capstan pin, and telltale pivot pin. The spacer, telltale spring, and capstan, respectively, fit over the pivot pin which is positioned by holes in the side walls of the receiver. One end of the spring engages the hole in the telltale, and the other end is connected to the capstan. The capstan is turned until the correct forward pressure is put on the telltale, and the capstan is then fastened by inserting the capstan pin into one of the holes in the capstan and allowing the capstan to turn back until the pin is stopped by the bottom of the receiver.

The sear assembly is mounted in the bottom of the receiver, forward of the telltale group. The sear assembly includes the sear block assembly, sear frame assembly, sear frame pin, sear roller, sear roller pin, sear yoke, sear locating spring, sear spring, and minor parts. The sear block is fastened to the receiver by the sear block screw and two sear block valve screws. The sear frame is mounted to the sear block by the sear frame pin. The sear roller is held in the sear frame by the sear roller pin. The sear frame and the sear roller are normally held upward by the sear spring. The sear roller and related parts hold the bolt assembly in the rearward position by engaging the shoulder on the bottom of the bolt. The sear yoke and the sear locating spring serve to cushion the initial shock as the sear roller engages the shoulder on the bottom of the bolt at the start of counterrecoil stroke of the bolt assembly.

The sear manual release group is located on the right side of the receiver. This group is composed of the sear manual release lever, sear manual release shaft, sear manual release retainer, and the sear manual release spring. The lever is used to manually depress the sear roller. Normally, the lever is held out of engagement by the spring.

The switch housing assembly, located forward of the sear assembly, is composed of the housing switch, switch housing, cam rod, cam, switch cam adjusting nut, and minor parts. The switch is fastened in the switch housing with two screws. The cam rod, on which is mounted the cam that operates the switch,

passes through one side of the housing. The switch assembly is fastened to the receiver by the two switch housing screws. The telltale bar is positioned on the cam rod by the switch cam adjusting nut. The sear bar extends through a hole in the buffer housing and is connected, at the rear end, to the solenoid arm. The switch is controlled by the position of the telltale. The power stroke circuit is closed through the switch when the telltale is in the upward position. The return stroke circuit is closed through the switch when the telltale is in the downward position.

A connector is fastened to the right side of the receiver with four screws. The purpose of this connector is to provide means of making electric connections to the gun.

To the inside of the receiver are the tracks on which the bolt assembly rides. The heater tubes, which are underneath the tracks, are used to house electric resistance heaters with which to heat the tracks to avoid congealing of oil at low temperature, which would cause sluggish operation of the bolt assembly.

The bolt holding keys are attached to the receiver in front of the buffer housing. The bolt slides underneath the keys as it nears the end of the recoil stroke. These keys serve to prevent the bolt assembly from being forced upward over the sear by the pressure of the drive spring assembly when the cover is raised with the bolt assembly in its rearward position.

The rear support slide, which is welded to the under side of the receiver, provides a rear support for the gun.

The hook-shaped projection on which the cover hinges is located on the front end of the receiver. The cover hinge spring serves to hold the cover rearward when the cover is in a raised position.

The unlocking cam is located in the forward part of the receiver and serves to unlock the bolthead during firing.

The barrel support assembly provides a housing for the breech ring assembly, recoil spring, barrel buffer spring assembly, barrel buffer retaining sleeve assembly, barrel lock, and various parts.

The breech ring assembly is located at the junction of the receiver and barrel groups and serves to couple the bolthead to the barrel. Near the forward end of the breech ring are internal buttress locking lugs which retain the barrel, and near the

rearward end are similar lugs which retain the bolt-head during firing. Cam surfaces at the rearward end of the breech ring bear against the bolthead rollers to start the rotating motion which locks the bolthead to the breech ring for firing. Following the initial rotation, the breech ring cam serves to stop the forward motion of the bolthead as the bolt nose cam bears against the bolthead rollers to turn the bolthead approximately one-sixth turn and complete the locking action. Tangent to the surfaces which stop the forward motion of the bolthead are surfaces which bear against the bolthead rollers to stop the rotation of the bolthead after locking has been completed.

The recoil spring surrounds the rear section of the breech ring assembly and is compressed between the unlocking cam in the receiver and the shoulder on the breech ring. The recoil spring cushions the recoil of the barrel and returns the barrel to its forward position. The bolthead roller guide, which is assembled to the rear of the recoil spring, prevents the bolthead rollers from flying off as the bolthead moves into the locked position.

The barrel buffer spring assembly, which is composed of a series of buffer springs, exerts a snubbing action to keep the movement of the barrel uniform on both the recoil and counterrecoil stroke. Near the end of the recoil stroke, the shoulder on the barrel strikes the barrel buffer thrust collar and compresses the buffer spring against the barrel buffer collar assembly which, in turn, contacts the shoulder on the barrel support and stops the rearward movement of the barrel. Near the end of the counter-recoil stroke, the front of the breech ring strikes the barrel buffer collar assembly, compressing the buffer spring against the barrel buffer thrust collar which, in turn strikes the barrel buffer retainer sleeve assembly and stops the forward movement of the barrel.

The barrel buffer retainer sleeve assembly performs two functions, namely: it holds the barrel buffer thrust collar, buffer spring, and barrel buffer collar assembly in position against the shoulder on the barrel support; and it contains the barrel bearing, to support the bearing surface of the barrel.

The barrel lock is located near the rear end of the barrel support. The front end of this lock is forced downward by the barrel lock spring to engage a slot in the top of the barrel to keep the barrel from turn-

ing out of engagement with the breech ring assembly. The rear end of the lock engages a notch in the barrel support coupling to prevent the coupling from turning out of engagement with the receiver.

A key which projects upward from the barrel support, forward of the barrel lock, rides in the key way in the adapter assembly to keep these parts properly in line as the barrel support assembly moves back and forth inside the adapter assembly.

The barrel support coupling provides a means of fastening the barrel support assembly to the receiver assembly and provides the means of supplying the initial compression to the recoil spring.

Adapter Group. The adapter body assembly provides a housing for the adapter spring assembly, which is composed of a series of adapter rings and two adapter thrust rings, one on each end. The function of the adapter spring assembly is to exert a snubbing action to stop the movement of the gun on both the recoil and counterrecoil strokes.

The trunnions at the rear of the adapter assembly are provided for mounting the gun in the cradle. A groove in the yoke also serves for mounting in the cradle as well as for installation in aircraft.

Operation

Loading.

1. The cover should be closed before any firing is attempted. This also includes loading. Make certain that before the cover is closed, the bolt assembly is in its foremost position. This will insure that the stud on the drive bushing engages the socket in the top of the bolt. As a check on the correct position of the bolt assembly before closing the cover, the rear end of the bolt should be approximately five-sixteenths inch rearward of the end of the ejection

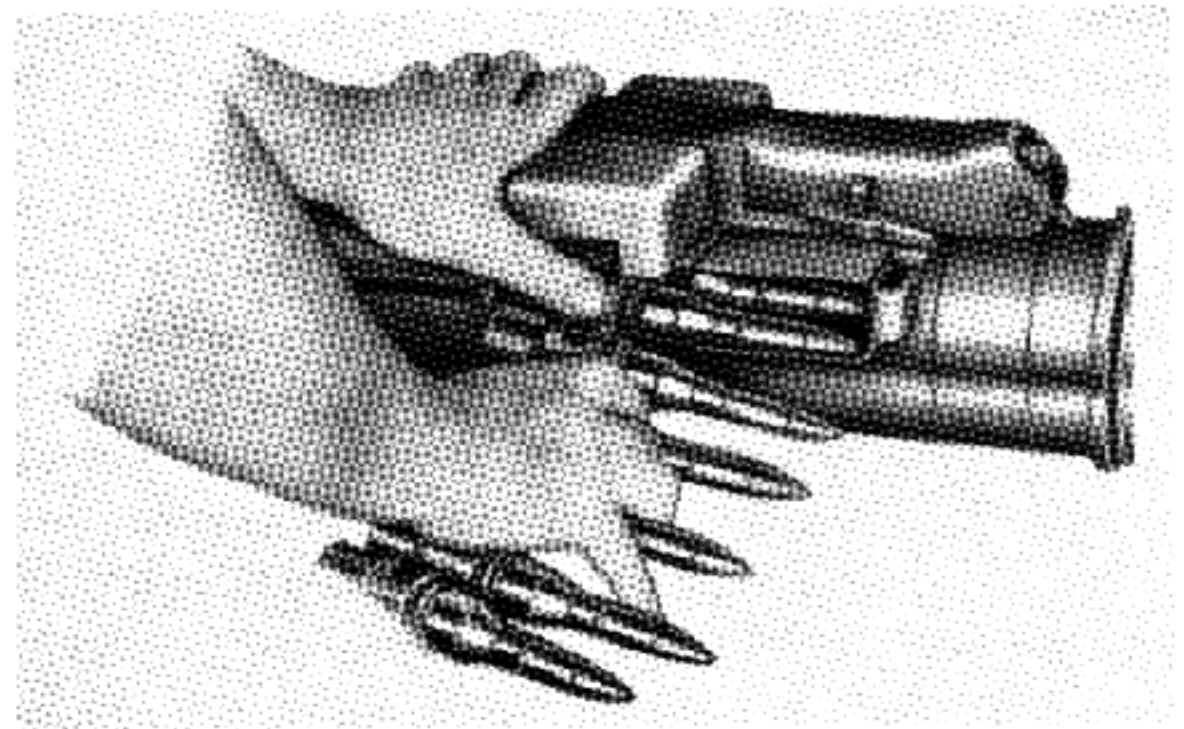


Figure 4-29. Method of inserting ammunition belt.

tor. Never load the gun when the bolt is being held by the sear roller in the cocked position.

2. Insert the ammunition belt with the open side of the links down against the feedway. Push in on the belt until the second cartridge is well inside the edge of the feedway. Pull outward on the belt to make certain that the belt is properly engaged by the belt holding pawl.

Firing.

1. When the ammunition belt is started into the gun, the cocking of the gun places the mechanism in a ready to fire position with the bolt assembly held rearward and the cartridge positioned for chambering in the feedway.

2. To fire the gun, the sear roller must be depressed either manually or electrically. To depress the sear roller manually, push in on the sear manual release lever until it engages the sear frame assembly. Then turn the lever downward about one-sixth turn.

To depress the sear roller electrically, close the firing switch. This energizes the solenoid, pulling the sear bar rearward and depressing the sear roller.

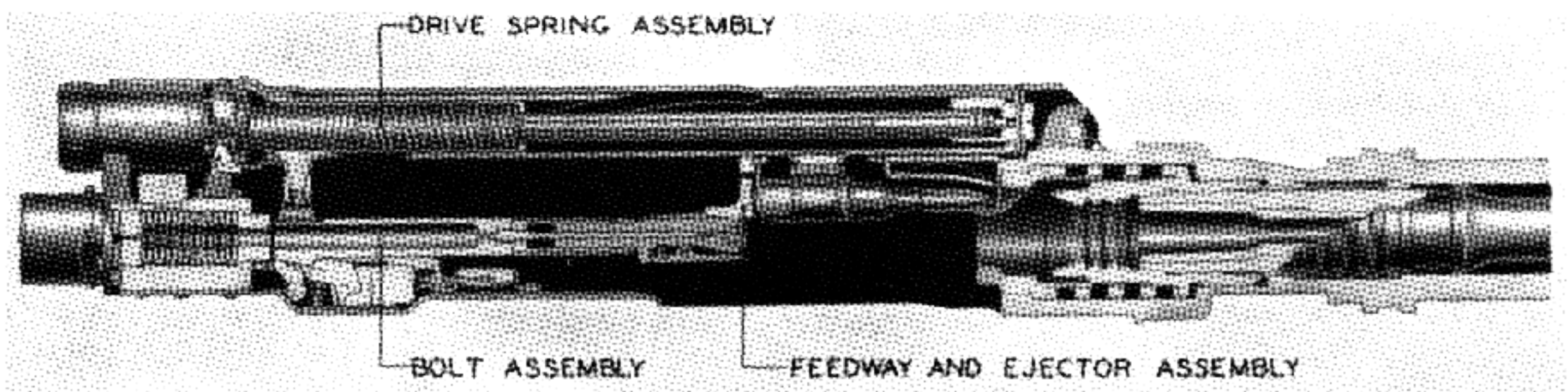


Figure 4-30. Caliber .60 T17E5 Machine Gun ready to fire. Longitudinal section.

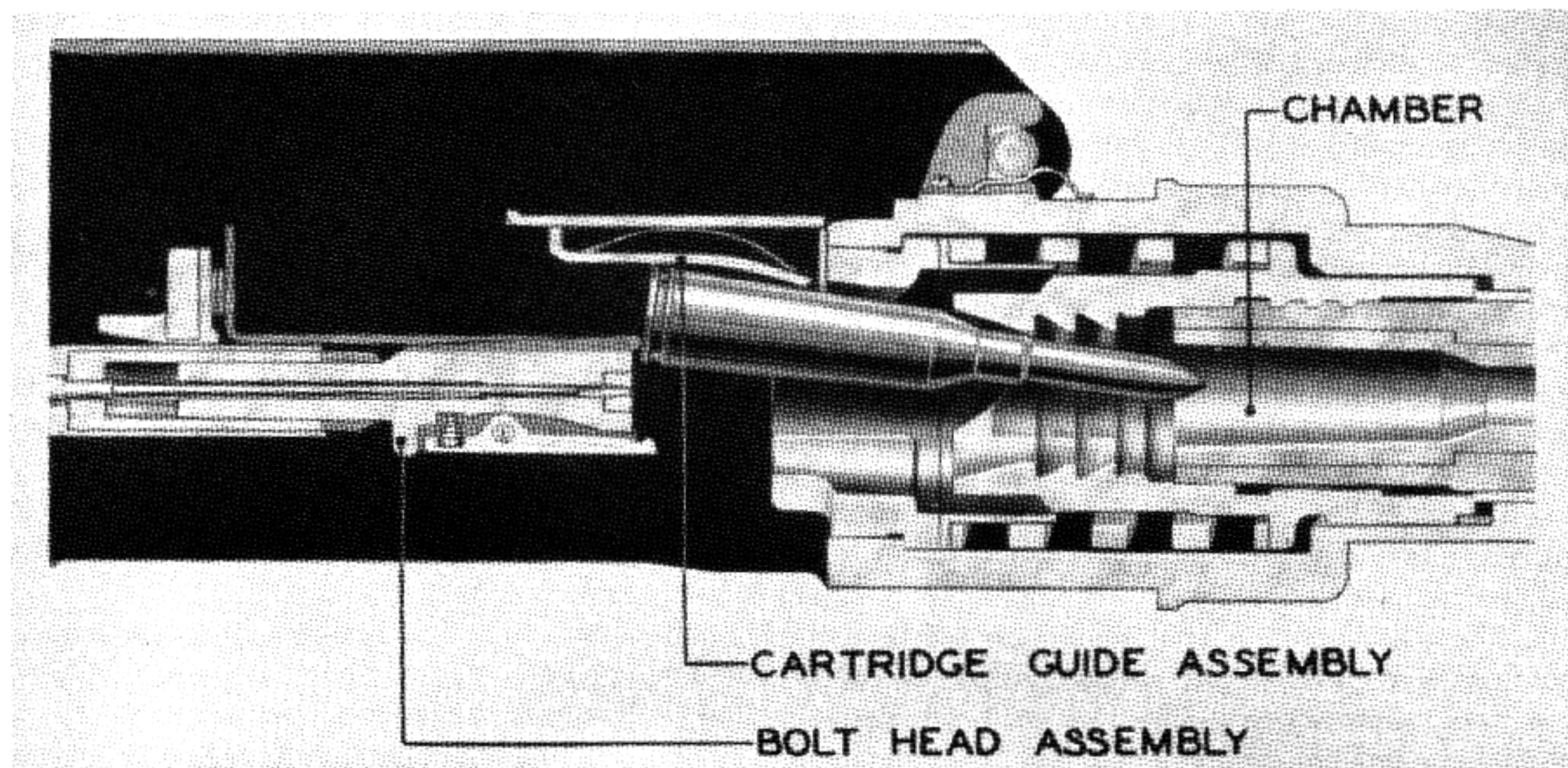


Figure 4-31. Guiding the cartridge toward the chamber.

With the sear roller depressed, the bolt assembly moves forward. The top front edge of the bolt head hits the base of the cartridge and moves it forward, stripping it from the link. The cartridge is guided downward toward the chamber through the front end of the slot in the feedway assembly by means of the cartridge guide assembly.

3. When the forward motion is completed and the cartridge is held securely in the chamber by the bolt head assembly, the bolt pushes the tip of the firing pin beyond the face of the bolt head to strike the primer and fire the cartridge.

4. The gun will then fire automatically, until the sear roller is permitted to spring upward, either manually or electrically, so that it engages the shoulder on the bottom of the bolt. The telltale, however, is still held downward by the bolt which is directly above it.

5. Combat firing is unrestricted, but bursts of longer duration than 150 rounds (12-second bursts) may lead to a stoppage due to overheating. Non-combat firing should be restricted with the duration of bursts and cooling governed by the "life expectancy" of the barrel.

CAUTION. In case of misfire with a hot barrel, the gun should be cleared within 10 seconds after the stoppage. If the gun cannot be cleared within 10

seconds, the round should be allowed to remain in the chamber a minimum of 10 minutes, making sure the gun is aimed in the opposite direction from personnel and equipment. If the gun is cleared between the 10 seconds and 10 minute period, the extracted cartridge may explode outside the weapon causing serious injury to personnel or equipment.

Unloading.

1. To unload the gun, the cover must be raised. Before raising the cover, carefully note the position of the bolt assembly. If the bolt assembly is in the extreme forward position, the cover can safely be raised. However, if the bolt assembly is held rearward by the sear roller or jammed ahead of the sear assembly, extreme caution must be exercised when raising the cover.

CAUTION. The bolt assembly must positively be held rearward using a screwdriver or some such tool while the cover is being raised. On guns which are provided with a slot in the cover, a screwdriver or some similar tool should be used to jam down into the rear of the feed rack.

2. After the cover is raised, remove the ammunition belt. Depress the sear roller with the sear manual release lever and move the bolt assembly slightly forward to clear the bolt holding key. Remove the bolt assembly and also the feedway and ejector

assembly from the gun. Then make a careful inspection to determine whether or not there is a cartridge in the chamber and if there is, the barrel should be removed. Then the cartridge can be easily removed from the chamber.

CAUTION. Never permit the bolt assembly to move forward to the locked position with the cover open if a live cartridge is, or can be, chambered.

3. Replace the parts that have been removed from the gun. Push the bolt assembly into its extreme forward position. Close and latch the cover. During periods of storage or nonuse, the gun parts should be left in this position as all operating springs will be under their normal initial compression.

Changing Feed.

1. The gun may be assembled so that ammunition may be fed into it from either the right- or left-hand side. In order to change the gun from right-hand feed to left-hand feed or vice versa, the proper belt feed tube must be installed, the position of the feed assembly must be reversed and the cartridge stop assembly must be repositioned in the feedway and ejector assembly. The correct position of the various parts for both the right- and left-hand feed are furnished in an instruction manual that is sent with each gun.

2. The following description explains in general terms the change from right-hand feed to left-hand feed. By reversing the process, the gun may be changed from left-hand feed to right hand.

COVER GROUP:

1. Remove the cover.
2. Remove the cartridge guide assembly.
3. Remove the electric charger.
4. Remove the stripper and rack assembly.
5. Remove the feed assembly.
6. Remove the right-hand belt feed tube and replace it with the left-hand belt feed tube.
7. Reinstall the feed assembly in a reversed position.

NOTE. The opening for the stripper and rack assembly should always be on the side from which the ammunition is to be fed.

8. Assemble the stripper and rack assembly to the feed assembly.

NOTE. Be sure that the feed body locks are all the way out in their locked position, otherwise they will interfere and prevent the

stripper and rack assembly from being moved into position.

9. Install the cartridge guide assembly.

NOTE. The cover safety catch may be located on either side of the cartridge guide assembly.

10. Install the electric charger.

FEEDING AND EJECTOR GROUP:

1. Remove the feedway and ejector assembly.
 2. Detach the cartridge stop assembly.
 3. Install the cartridge stop assembly on the right-hand side of the feedway and ejector assembly.
 4. Remove the cartridge belt feedway pad.
- NOTE.** Used with right-hand feed only.
5. Place the feedway and ejector assembly in position on the receiver.
 6. Push the bolt assembly into the extreme forward position.
 7. Assemble the cover to the receiver.
 8. Test the feed mechanism by operating the charging mechanism to be sure that the parts work freely without binding, and that they have been correctly reassembled.

Disassembly by Groups

The major groups of the gun are the barrel, cover group, bolt group, feedway and ejector group, adapter group, and receiver and barrel support group. It is assumed that the gun is set up for right-hand feeding.

CAUTION. Before starting to disassemble the gun, make certain that it is not loaded. Follow the instructions sent with each gun giving procedure and detail for assembly and disassembly.

Barrel. Depress the rear end of the barrel lock and turn the barrel about one-fourth turn counterclockwise. Then pull the barrel forward out of barrel support.

Cover Group. Press inward on the cover latch handle and raise the cover just enough to disengage the cover latch and then allow the rear end of the cover to rest upon the rear end of the receiver. Using a screwdriver, turn the cover hinge plug as far as it will go. Then raise the rear end of the cover at least 2 inches to permit the disengagement of the drive bushing from the bolt, which should be in the forward position, and slide the cover rearward from the receiver.

Bolt Group. Pull rearward on the bolt to unlock the bolthead from the breech ring assembly. Then

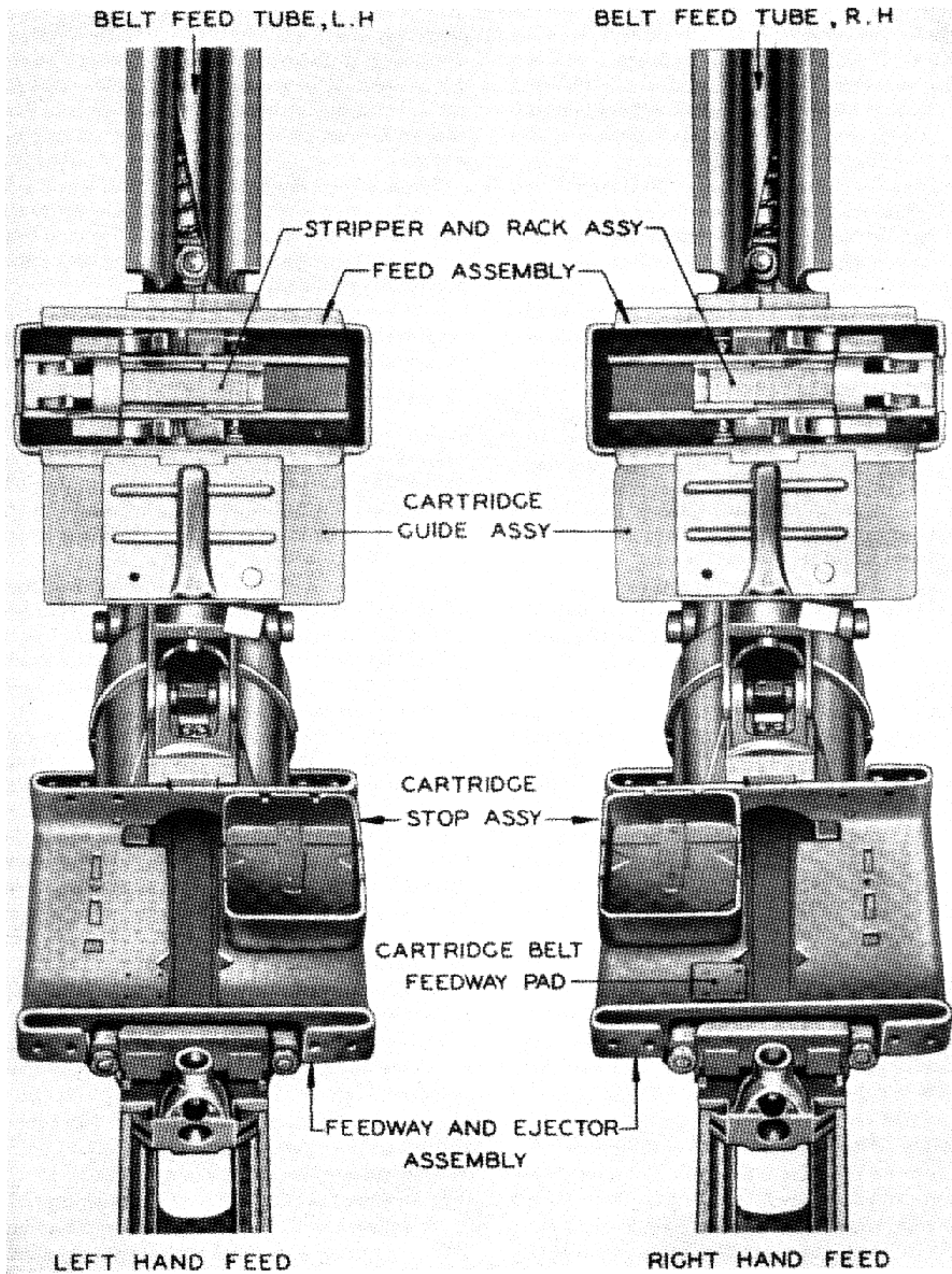


Figure 4-32. Comparison of feed assemblies for left-hand and right-hand feeds.

grasp the bolt firmly and lift it from its ways in the receiver. If the bolt is pulled too far back before it is lifted up, the rear end will engage the bolt holding keys, making it impossible to lift it out until the sear roller is depressed and the bolt slid forward enough to clear the keys.

Feedway and Ejector Group. Pull the feedway and ejector assembly rearward about three-eighths inch and then lift it from the receiver. This rearward movement is to clear the feedway retaining studs and locating pins.

Adapter Group. To remove the adapter assembly from the barrel support, drive out the roll pin and then unscrew the adapter retainer nut at the front end of the adapter, using the combination wrench. With the adapter retainer nut removed, the adapter can be slipped forward off the barrel support.

Assembly by Groups

Adapter Group. Slip the adapter assembly on over the front end of the barrel support, with the trunnions toward the rear of the gun. Line up the keyway in the adapter with the locating key on the barrel support, and slide the adapter back until the full length of the locating key in the barrel support is covered by the adapter. Then start the adapter retainer nut on the threads at the front end of the barrel support and draw it up tight with the combination wrench. The adapter retainer nut should be just flush with the adapter ring retainer nut. Line up the pinholes and drive the roll pin in place.

Feedway and Ejector Group. Place the feedway and ejector group in position with the ejector to the rear. Raise the ejector as high as it will go. Slide the feedway and ejector assembly forward until the feedway retainers engage the feedway retaining studs.

Bolt Group. Start the bolt assembly into the top opening in the receiver, directly to the rear of the feedway and with the bolt head toward the front of the gun. With the bolt resting on the tracks in the receiver, push it forward until the bolt head locks into the breech-ring assembly. At this time, the rear end of the bolt should be approximately five-sixteenths inch rearward of the end of the ejector.

Cover Group. Place the cover group on the receiver and barrel support group so that the hinge plug holes come into approximate alignment with the cover hinge assembly. Release the cover safety

catch and allow the rear end of the cover to rest upon the rear end of the receiver. Using a screwdriver, turn the cover hinge plug until it is as far out as it will go. Press in on the cover latch handle, and push down on the cover until the cover latch is engaged.

Barrel. Start the breech end of the barrel into the barrel support with the indicating arrow at the top. Push the barrel in as far as it will go and then turn it in the direction indicated by the arrow stamped on the barrel.

CAUTION. The front end of the barrel lock must snap down into the locked position to insure that the barrel is locked in place.

Detailed Disassembly and Assembly

General.

1. In the following description of the detailed disassembly and assembly of the gun groups, it is assumed that the ordnanceman is familiar with the operations involved in removal and installation of groups as a whole.

2. In disassembling the gun, it will be found helpful to place the parts neatly in order as they are removed.

3. Place disassembled parts on a clean, flat surface and guard against loss of pins, springs, and other small parts.

4. Parts for each gun should be kept intact and separated from those of other guns. Although parts are interchangeable, they will work best in their original combination.

5. When two roll pins are used, one inside the other, they should be driven out together and then separated one from the other before reassembly. In assembling the roll pins, each pin should be driven separately, care being taken that the openings in the pins are opposite.

6. Before assembling, clean all parts thoroughly and oil lightly.

7. When assembling the gun, always line up the parts carefully and insert the roll pins properly before attempting to drive the pins into place. Seat springs correctly, replace and spread cotter pins, and install locking wire where prescribed.

Disassembly of the Cover Group.

1. Remove the cartridge guide assembly by sliding it forward until it disengages from the cover. The cover safety catch and the cover safety catch

spring may then be removed, if necessary, by driving the roll pin out and then removing the pin retaining collar and the cover safety catch pin.

2. To remove the electric charger from the cover, first depress the motor mount locking plunger, which engages a hole in the top of the cover, and keep it depressed while starting to turn the charger in a counterclockwise direction. Grasp the motor and turn it about one-eighth turn, at which time the charger will be pushed back one-quarter inch by the compressed drive spring. Turn the cover in an upside down position. The removal of the charger may then be started from the cover. In order to provide clearance for the drive bushing as the charger is pulled rearward, the charger must be turned clockwise about one-eighth turn, so that the stud on the drive bushing will line up with the notch in the cover. The charger assembly can then be drawn out of the cover.

3. Depress the belt feed pawl and pull the stripper and rack assembly out of the feed body.

4. The removal of the stripper and rack assembly permits movement of the feed body locks. Pry the lock nearest the front end of the cover rearward so as to release the feed assembly. The feed assembly can then be removed by raising the front edge of the assembly.

5. To disassemble the feed assembly, the following operations are necessary.

(a) To remove the feed body locks, remove the cotter pins from the locks and withdraw the locks from the feed body.

(b) To disassemble the belt-holding pawls, remove the cotter pins from the belt-holding pawl studs and unscrew the studs. Then remove the belt-holding pawls, belt-holding pawl springs, and holding pawl spacers.

6. To disassemble the stripper and rack assembly, the following operations are necessary.

(a) Remove the three belt feed-pawl springs by compressing them with a small screwdriver.

(b) Remove the belt feed pawl pin.

(c) Hold the stripper and rack assembly in one hand and insert a slender drift or piece of drill rod (.100 diameter) into the spring channel until its end pushes the spring follower out of the notch in the lockpin. Tap the lockpin in about $\frac{3}{16}$ inch, using a drift. Insert the drill rod or drift in the second spring channel and drive out the lockpin.

(d) Slide the universal stripper back and remove the springs and followers.

CAUTION. As the stripper is moved back, the spring and follower will fly out and a hand should be placed so as to catch them to prevent loss.

(e) The universal stripper can now be slid back until it is clear of the rack.

7. To remove the belt feed tube, place the cover in a vertical position with the front end up, and rotate the tube until the arrow on the tube is centered in the opening in the cover. (Precaution should be taken that the end of the tube is not battered when dropped from the cover.) The belt feed tube will then fall, or can be moved, out of engagement with the tube lock and can be removed from the cover.

8. To disassemble the belt feed tube lock from the cover, remove the roll pin and turn the lock one-quarter turn in either direction. Then push the lock rearward from the cover.

9. To disassemble the cover latch, drive the roll pin out of the cover latch handle. Then the handle, cover latch pin, and cover latch spring can be removed from the cover.

Assembly of the Cover Group.

1. Place the cover in a vise and clamp firmly. Assemble the cover latch and cover latch spring into the cover and line up the cover latch pin with the hole in the cover. Also line up the hole in the cover latch handle with the hole in the cover latch. Insert and drive the roll pin home.

2. Push the belt feed tube lock into the hole in the cover and turn it $\frac{1}{4}$ turn so that the cutout in the lock is up. Insert and drive the roll pin home.

3. Place the cover in a vertical position with the rear end up. Insert the belt feed tube into the cover, with the slotted end up, and carefully let it drop into place. Rotate the tube until the arrow on the side of the tube is centered in the opening in the cover. The tube will then drop enough to engage the belt feed tube lock. After engaging the lock, the tube should be turned slightly in either direction to complete the locking action.

4. To assemble the feed assembly, the following operations are necessary.

(a) To assemble the feed body locks, insert the locks in the holes in the feed body, and insert and spread the cotter pins.

(b) To assemble the belt holding pawls, partially insert the holding pawl stud, assemble the holding pawl spacer on the threaded end of the stud, and insert the belt holding pawl spring in the recess in the pawl. Hold the two pieces together and start the upper end of the spring on the stud on the under side of the holding pawl spring support. Lift up the pawl in such a manner as to compress the spring and push it into the feed body until the spring is in a vertical position. In order to compress the spring and to raise the pawl into position, grasp the end of the pawl with pliers and raise straight up. At the same time apply pressure to the stud with a screwdriver and then shift the pawl until the stud enters a hole in the feed body. Now continue to shift the pawl slightly until the threaded end of the stud lines up with, and enters, the threaded hole in the support in the feed body. Screw the stud in securely and insert the cotter pin in such a position as to prevent the stud from turning.

(c) Assemble the remaining belt holding pawls using the same procedure.

5. To assemble the stripper and rack assembly, the following operations are necessary.

(a) Insert the universal stripper in position on the belt feed rack assembly.

(b) Aline the head of the lockpin with the notch in the stripper, and tap the lockpin into its hole to a depth of approximately $\frac{3}{8}$ inch.

(c) Slide the stripper back approximately 1 inch, insert the first spring and follower, and slide the stripper forward.

(d) Compress the spring with a drift or piece of drill rod until the follower clears the lockpin. Drive the lockpin in until its end passes the first spring channel.

(e) Repeat steps (c) and (d), inserting the second spring and follower and driving the lockpin in until its head is flush with the surface of the stripper.

(f) Assemble the belt feed pawl to the belt feeder rack assembly.

(g) Push the belt feed pawl pin into place.

(h) Assemble the three belt feed pawl springs by compressing them with a small screwdriver.

6. Place the feed assembly in position over the cover with the opening for the stripper and rack assembly on that side of the cover into which the ammunition is to be fed. Tip the front of the feed assembly upward and engage the rear edge in the

notch in the cover, being sure that the feed body lock toward the hinge end of the cover is drawn back into the feed body. The feed assembly can then be lowered into place and locked to the cover by pushing both feed body locks outward.

7. Turn the belt feed tube until the lengthwise mark on the tube is in alinement with the assembling line on the cover. Then insert the stripper and rack assembly into the feed body, with the pawl end outward. Depress the belt feed pawl and push the stripper and feed assembly inward. If the belt feed tube is positioned correctly and if the upper belt feed tube (left-hand or right-hand) is being used, the gear teeth on the tube and the teeth on the rack will engage, and the rack can be pushed into position. It may be necessary to turn the belt feed tube slightly either right or left as required to engage the teeth. If the rack teeth engage the teeth on the belt feed tube, but the belt feed tube cannot be pushed completely into the feed body, it will usually be found that one of the feed body locks is not fully in the outward or locked position and is interfering with the rack.

8. The cover safety catch may be installed on either side of the cartridge guide assembly, but it is normally installed on the right-hand side. Insert the cover safety catch pin into its proper hole in the cartridge guide assembly. Place the cover safety catch over the pin with the long end of the catch forward. Place the cover safety catch spring on top of the catch, one end of the spring engaging the hole in the rear end of the catch. Place the pin retaining collar over the pin on top of the spring. Line up the holes in the collar and the pin, and insert and drive the roll pin flush with the collar.

9. The cartridge guide assembly should be slid rearward on the flat portion of the cover toward the feed assembly. The cover safety catch spring must be compressed forward as the cartridge guide assembly is being assembled.

10. To install the electric charger, turn the belt feed tube so that the slot at the rear end of the tube is toward the opening in the cover. Insert the charger into the cover so that the stud on the drive bushing will slide through the notch in the cover. Engage the stud in the slot in the belt feed tube, and push the charger assembly forward. The charger must then be turned slightly, counterclockwise, so that the slots in the charger housing line up with the

studs projecting inward from the cover. Push the charger completely forward, and turn it clockwise until the motor mount locking plunger snaps into position.

Disassembly of the Bolt Group.

1. The bolt head rollers can be readily removed, as there is nothing to retain them in place.

2. Place the bolt on a wooden block, and with a hammer and a drive punch of the proper size drive out the roll pins. Start the removal of the buffer bodies by tapping with a block of wood. Pull the bolthead out of the bolt. Then grasp the projecting firing pin and pull it forward, removing the bolt-head cam assembly with the firing pin. If the firing pin and bolthead cam assembly cannot be removed in this manner, insert a rod, $\frac{3}{16}$ inch in diameter and about 9 inches long, into the rear recess of the bolt and through the $\frac{3}{16}$ -inch diameter hole to the rear of the firing pin. Drive the firing pin and bolthead cam assembly forward from the bolt.

3. With the bolthead assembly, bolthead cam assembly, and firing pin removed, the bolthead buffer bodies and bolthead buffer springs can be removed by prying or pushing them out of the recesses on each side of the bolt.

4. Insert a piece of steel, $\frac{1}{4}$ -inch square by 3 inches long, into the ejector slot in the bolthead. Then clamp the bolthead assembly firmly in a vise with protective facings. With a drive punch of the

proper size, drive out the roll pins holding the extractor and remove the extractor and extractor spring.

Assembly of the Bolt Group.

1. Insert a piece of steel, $\frac{1}{4}$ -inch square by 3 inches long, into the ejector slot in the bolthead. Then place the extractor and the extractor spring in position with the larger end of the spring bearing against the extractor. Clamp the bolthead assembly firmly in a vise with protective facings. Drive the roll pins in until the ends of the pins are slightly below the surface of the bolthead.

2. Insert the firing pin into the bolt, and make sure that it seats fully back in its recess. Place the bolthead cam assembly, with the slotted end toward the front, over the firing pin and push it back into the bolt. Care should be taken that the pin in the bolthead cam assembly is in alignment with the hole in the bolt. When fully seated, the front of the cam will be approximately one-eighth inch inside the opening in the bolt.

3. Position the bolthead assembly over the firing pin so that the top surface of the bolthead lines up with the top of the bolt, and insert the bolthead shank in the bolt recess so that the lugs in the shank slide in the slots of the bolthead cam. Permit the bolthead to turn and push it rearward. Then insert the bolthead buffer springs into the recesses in the bolthead buffer bodies. The bolthead buffer spring

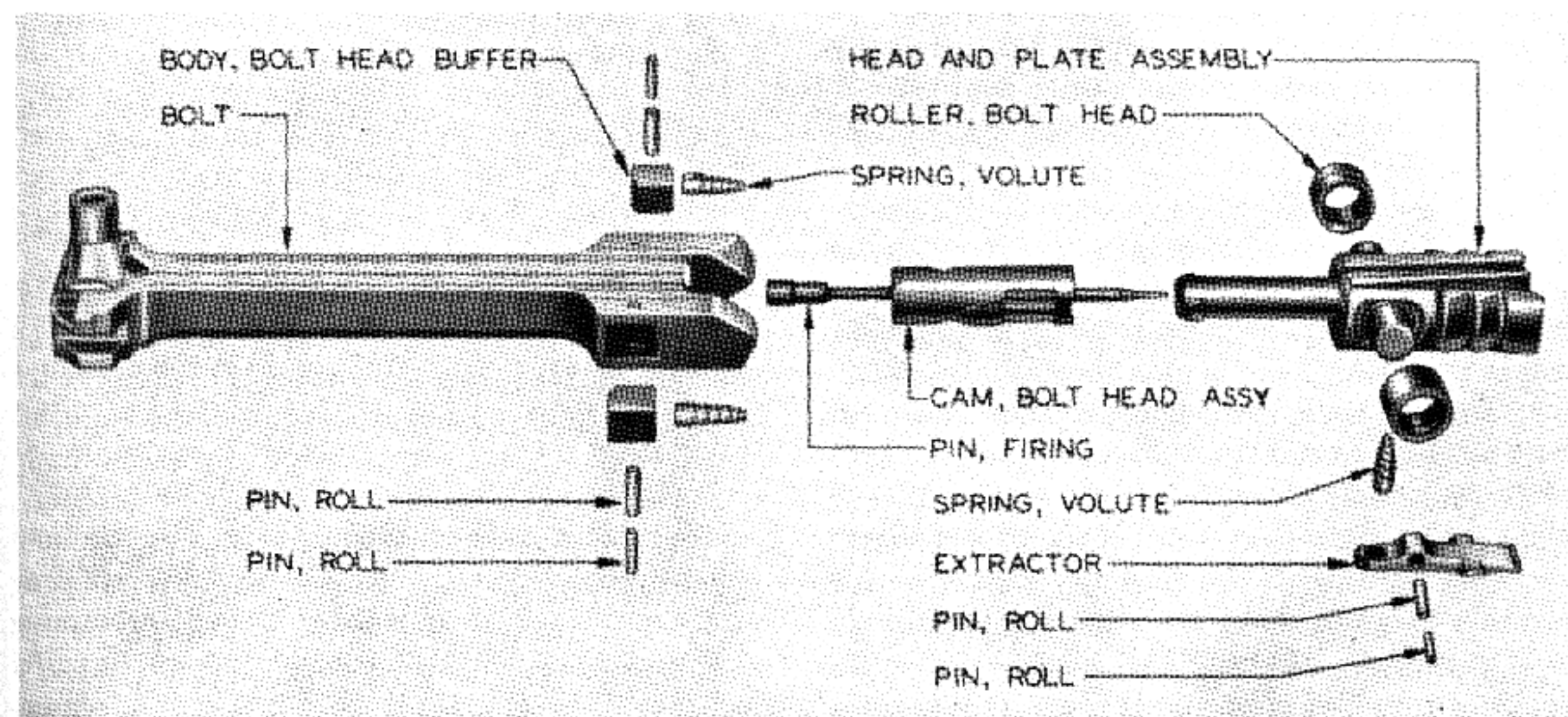


Figure 4-33. View of bolt group, disassembled.

may be compressed with pliers and the bolthead buffer bodies and spring inserted in their recesses on each side of the bolt in such a way that the curved surfaces of the bodies bear against the rounded shank of the bolthead and the small ends of the springs are toward the front of the bolthead. Then holding the bodies firmly inward against the shank, insert the roll pins and drive them flush with the top surface of the bolt.

4. In assembling the bolthead rollers, precaution should be taken that the chamfered edge of the hole is against the bolthead.

Disassembly of the Feedway and Ejector Groups.

1. To remove the cartridge stop assembly, hold the feedway and ejector assembly, and, with the point of a drive punch, push the cartridge stop retaining spring stud out of its hole in the feedway. The cartridge stop assembly can then be slid rearward until its lugs are disengaged from the holes in the feedway.

2. To remove the cartridge belt feed pad, remove the screws holding the pad to the feedway.

3. To remove the ejector, place the feedway and ejector assembly on a wooden block. With a drive punch of the proper size, drive the roll pins out of the ejector retaining collars and the ejector pins. The ejector and ejector springs can then be readily removed.

Assembly of the Feedway and Ejector Groups.

1. To assemble the ejector, place the ejector springs in the recesses in the ejector and slide the ejector onto the ejector pins. Place the feedway on a wooden block, and, with the ejector retaining collars assembled in place, drive the roll pins in flush with the collars.

2. Before attaching the cartridge stop assembly to the feedway and ejector assembly, it should be noted that the cartridge stop assembly is always attached to the side of the feedway which is opposite to that from which the ammunition is to be fed.

3. To attach the cartridge stop assembly to the feedway and ejector assembly, engage the hook which projects downward from the rear of the cartridge stop in the square hole on the proper side of the feedway. Then, holding the cartridge stop assembly forward, make sure that the lugs on the front of the assembly enter the square holes on the vertical front section of the feedway. When the cartridge stop assembly is all the way forward, the

cartridge stop retaining spring will force the stud down into the locking hole in the feedway, thus locking the assemblies together.

4. To assemble the cartridge belt feedway pad, position it in the feedway so that the beveled edge is adjacent to the feedway slot. Assemble the screws with a screwdriver.

NOTE. The cartridge belt feedway pad is used with right-hand feed only.

Disassembly of the Adapter Group.

1. Drive out the roll pin in the front end of the adapter.

2. Replace the adapter on the barrel support in its assembled position so that the adapter is retained from turning, and, using the combination wrench, remove the adapter ring retainer nut.

3. After removing the adapter from the barrel support, remove the adapter spring assembly, being careful to retain the spring components in their assembled position.

Assembly of the Adapter Group.

1. If the adapter has been disassembled for the purpose of cleaning or lubricating, care should be taken that the components of the adapter spring assembly are reassembled in their original position.

2. After the spring assembly has been installed, start the adapter ring retainer nut into the adapter, and turn it by hand as far as possible.

3. Replace the adapter on the barrel support in its assembled position so that the adapter is restrained from turning.

4. Using a combination wrench, tighten the adapter ring retainer nut until it projects approximately $\frac{1}{16}$ inch beyond the front face of the adapter. Line up the pin holes and drive the roll pin in place.

Disassembly of the Receiver and Barrel Support Group.

1. Place the adapter spring compressor in position, and tighten the hexagon head on the front end until the recoil spring is compressed. Remove the barrel lock and the barrel lock spring by removing the roll pin. Using the adjustable spanner wrench, unscrew the barrel support coupling. If necessary, tap the wrench with the rawhide-face hammer until the coupling loosens. Disassemble the coupling from the receiver. Remove the adapter spring compressor and remove the coupling from the barrel support. Remove the barrel support from the receiver.

2. Remove the bolthead roller guide, recoil spring, and breech ring assembly from the barrel support. Also remove the unlocking cam from the front end of the receiver.

3. Place a block of wood against the flat surface of the cover hinge assembly and drive it from the hook-shaped projections on top of the receiver. Remove the locking wire from the two cover hinge spring screws and remove the screws. Then the cover hinge spring can be removed.

4. Clamp a steel bar, $\frac{5}{16}$ inch by $\frac{1}{2}$ inch by 5 inches long, in a vise. Place the front end of the barrel support so that the bar engages the slots in the barrel buffer retainer sleeve. Insert a steel rod, $\frac{1}{2}$ inch in diameter by approximately 18 inches long, through the holes in the barrel support and turn in a counterclockwise direction until the sleeve is disassembled.

5. Remove the barrel buffer spring assembly and the barrel buffer collar, being careful to retain the spring components in their assembled position.

6. To remove the solenoid assembly, remove the locking wire from the solenoid mounting screws. Then remove the solenoid mounting screws, using the nut-and-bearing-spanner wrench from the electric charger tool set. Pull the solenoid straight back for about one-quarter inch to disengage the solenoid contact plug from the solenoid contact receptacle which is located in a 2-o'clock position in the rear end of the receiver. Then, being careful not to strain the sear bar, tilt the solenoid to the left far enough to disconnect the solenoid arm from the pin in the end of the sear bar.

7. Remove the buffer housing screw retainer screw and the buffer housing screw retainer. Place the receiver in a vise and unscrew the buffer housing screw, using one end of the combination wrench, until it can be removed from the buffer housing. Care should be taken not to damage the end of the sear bar with the handles of the wrench in removing the buffer housing screw. In order to retain the Belleville buffer springs in their assembled position, insert a rod or large screwdriver through the springs and the recoil plate, and remove them from the rear end of the buffer housing.

8. To remove the sear assembly, remove the locking wire, the sear block screw, and two sear block dowel screws from the bottom of the receiver, being

careful that the sear bar or the telltale bar is not sprung during the removal of the sear assembly.

9. Insert the drift pin from the electric charger tool set in the top hole of the telltale spring capstan and pull forward. Then remove the capstan pin from the capstan. Insert the drift pin and a similar pin alternately into the holes in the capstan, allowing the capstan to turn slowly counterclockwise, thus relieving the tension of the telltale spring. Remove the cotter pin from the end of the telltale pivot pin and remove the telltale pivot pin from the left side of the receiver. Then the telltale spring capstan, telltale spring, telltale, and telltale spacer can be removed from the receiver.

10. To remove the telltale bar, disengage the sear bar spring hook from the slot in the telltale bar. Then pull the telltale bar from the shank of the switch cam adjusting nut.

11. Remove the switch cam adjusting nut from the cam rod. Then the sear bar spring hook can be removed from the cam rod. Withdraw the sear bar from the hole in the buffer housing and remove it from the receiver. The sear bar must be turned approximately 90° in removing it from the hole in the buffer housing. Care should be taken not to strain the sear bar during removal.

12. If it is necessary to replace the housing switch in the switch housing, remove the two switch housing screws and the switch housing screw locks. Tilt the switch housing about 90° , taking care that the wires are not chafed in doing so. Remove the two screws and the switchette screw anchor. Keep the terminals sufficiently free to permit the removal of the wires. Then replace the housing switch with a new unit. Resolder the wires to the terminals, taking care that each wire is connected to its proper terminal. Replace the switchette screw anchor and the two screws, and resolder the ends of the screws on the top of the switch housing.

13. If it is necessary to replace the electrical plug connector on the right side of the receiver, remove the locking wire and four screws. Pull outward on the connector to take up the slack in the wires. Push the wire insulators back on the wires. Heat the connector terminals sufficiently to permit the removal of the wires. Replace the connector with a new unit and resolder the wires to the terminals, taking care that each wire is connected to its proper terminal. The polarity plug of the connector must

be to the rear. Replace the wire insulators in position and bend the wires downward, so as to prevent grounding on the heater tube because of pinched wires. Place the connector in the hole in the receiver, twisting it back and forth to set the wires into position. Replace the four screws and locking wire. Replace the two switch housing screws and switch housing screw locks. Also replace the ground wire under the head of the rear screw.

14. If it is necessary to replace the shroud switch, remove the locking wires and the four screws holding the switch shroud to the receiver. Then remove the two screws holding the switch to the shroud. Remove the shroud and insulator from the switch, keeping the insulator intact in the shroud. Also remove the shroud shims from the receiver. Heat the terminals on the switch sufficiently to remove the wires, preferably one at a time, and connect them to the new unit, care being taken that each wire is connected to its proper terminal. Replace the shroud and insulator on the switch and replace the screws holding the switch to the shroud. Resolder the ends of the screws to the shroud. Replace the shroud and switch groups, shroud shims, and the four screws and locking wire.

15. If it is necessary to replace the solenoid contact receptacle, remove the wire retainer by pulling it out of the buffer housing. Lift the receptacle straight up from the slot in the buffer housing. Heat the terminal on the receptacle sufficiently to remove the wire. Replace the receptacle with a new unit and resolder the wire to its terminal. Be sure that the solenoid wire insulator is positioned properly. Replace the receptacle in the slot in the buffer housing. Replace the wiring retainer by inserting it in the slot and pushing it rearward. Stake the retainer in place.

16. To remove the sear manual release, drive out the roll pin and remove the sear manual release lever and the sear manual release spring. Position the sear manual release retainer, then remove the retainer and the sear manual release shaft.

Disassembly of the Sear Assembly. The sear assembly may be completely disassembled by performing the following operations.

1. Place the sear assembly in a vise and remove the sear frame pin. Then the sear frame and roller assembly can be removed.

2. Place the sear block assembly in a vise and remove the double roll pin. Then remove the assembly from the vise and remove the sear locating spring support, sear locating spring, and sear yoke from the sear block.

3. Place the sear frame assembly on top of the vise and remove the sear roller pin. Then the sear roller can be removed from the sear frame assembly.

Assembly of the Sear Assembly. The sear parts can be assembled into a complete sear assembly by performing the following operations:

1. Place the sear frame assembly, sear roller, and vise and remove the sear roller pin. Then the sear sear roller pin in a vise, and press the sear roller pin being assembled.

2. Assemble the sear yoke, sear locating spring, and sear locating spring support into the sear block. The sear yoke must be so positioned that the slots in the head line up with the holes in the sear block. Place these parts in a vise and drive the roll pin into place.

3. Place the sear block in a vise and place the sear frame and roller assembly in position. Drive the sear frame pin into place. The sear frame and roller assembly should move freely after being assembled.

Assembly of the Receiver and Barrel Support Group.

1. Examine the sear bar before assembly to see that it is straight. In assembling the sear bar, insert the rear end of the bar into the hole in the buffer housing, allowing the front end to lie flat with the notched surface up. Push it through the hole until the rear end protrudes beyond the rear of the buffer housing. Place the sear bar spring hook on the cam rod, and screw the switch cam adjusting nut on to the cam rod until it is flush with the end of the rod.

2. To assemble the telltale bar, place the sear bar spring hook in the slot in the telltale bar. Place the front end of the bar on the shank of the switch cam adjusting nut. Then position the telltale bar on the sear bar. Take hold of the front end of the telltale bar and the rear end of the sear bar and move them back and forth to see that the sear bar moves freely in the buffer housing and also that the cam rod moves freely.

3. Insert the telltale pivot pin in the hole in the left side of the receiver. Place the telltale spacer on the pivot pin, pushing the pin in far enough to

hold the spacer in position. Assemble the telltale, telltale spring, and telltale spring capstan, in the order named and as a unit, with one end of the spring in the hole in the telltale and the other end in the hole of the capstan. Insert the telltale stud into the slots in the telltale bar and the sear bar, and rotate the unit until it is in alinement with the pivot pin. Push the pivot pin through the hole in the right side of the receiver. Insert and spread the cotter pin. Insert the drift pin from the electric charger tool set and a similar pin alternately into the holes in the capstan, turning the capstan forward until the ninth hole comes to the top. Insert the capstan pin into this hole and allow it to rest against the receiver. Push down on the telltale and observe the action of the telltale bar. The telltale bar and the cam rod must be free to operate on the tension of the sear bar spring. Also see that the sear bar operates freely on this spring.

4. Place the sear spring in place on the sear spring guide pin in the bottom of the receiver. Then place the sear assembly in position and see that the pin in the sear frame enters the slot in the sear bar without straining the sear bar or the telltale bar. Replace the sear block screw and the two sear block dowel screws. Replace the locking wire through the heads of these screws.

5. To assemble the sear manual release, insert the sear manual release shaft into the hole in the right side of the receiver, with the projection on the end of the shaft toward the front. Insert the sear manual release retainer into the slot in the shaft, and position it. Then line up the retainer with the shaft so that the prongs on the retainer are on the inside of the receiver. Assemble the sear manual release spring and the sear manual release lever into position. Insert and drive the roll pin in.

6. The Belleville buffer springs and the Belleville buffer plate should be positioned by a large screwdriver and assembled into the rear end of the buffer housing. Push the parts forward until the smaller end of the buffer plate protrudes from the front end of the housing. Screw the buffer housing screw into the housing until the buffer plate can no longer be turned with the fingers. Then, using one end of the combination wrench, tighten the buffer housing screw from three-quarter to one complete turn, until one of the locking slots is vertical. Care should be

taken not to damage the end of the sear bar with the handles of the wrench in assembling the buffer housing screw.

CAUTION. Do not tighten the buffer housing screw excessively so as to fully compress the buffer springs.

The rear surface of the buffer housing screw will be approximately flush with the rear end of the buffer housing when tightened properly. Place the buffer housing screw retainer in the locking slot in the buffer housing screw and fasten it in place with the buffer housing screw retainer screw. When the retainer screw is tightened, lock it in place by bending up the locking tip on the lower end of the retainer against one of the flat sides of the screwhead.

7. Hold the sear bar rearward and connect the pin in the rear end of the bar with the solenoid arm. Swing the solenoid assembly up into position. Insert the solenoid contact plug into the solenoid contact receptacle, and push the solenoid into place. Replace the solenoid mounting screws, using the nut-and-bearing-spanner wrench from the electric charger tool set. Replace the locking wire.

8. Check the height of the sear roller and check the position of the switch cam adjusting nut.

9. Place the cover hinge spring in position between the hook-shaped projections on top of the receiver. Replace the cover hinge spring screws and the locking wire. Position the cover hinge assembly and, placing a block of wood against the flat surface of the hinge assembly, drive it into place.

10. Assemble the unlocking cam into the front end of the receiver with the narrow key at the top.

11. Place the barrel support in a vertical position with the small end up. Drop the barrel buffer collar into the end of the barrel support with the large end up. See that the holes in the collar are in alinement with the holes in the barrel support. Place a screwdriver through the holes in the barrel support and the collar. Place the barrel buffer retainer sleeve in a vertical position with the threaded end down. Position the barrel buffer spring assembly on top of the sleeve with the barrel buffer thrust collar contacting the end of the sleeve. Place the small end of the barrel support over the spring assembly and the sleeve and slide it down until the thread on the end of the sleeve is engaged. Screw the sleeve into the barrel support as far as possible by hand. Retain the screwdriver in the holes in the barrel support

and the collar until the spring assembly exerts pressure on the collar and then remove it.

12. Clamp a steel bar, $\frac{5}{16}$ by $\frac{1}{2}$ by 5 inches long, in a vise. Place the front end of the barrel support so that the bar engages the slots in the barrel buffer retainer sleeve. Insert a steel rod, $\frac{1}{2}$ inch in diameter by approximately 18 inches long, through the holes in the barrel support and turn in a clockwise direction until the sleeve is tightened. Line up the pinhole in the sleeve with the hole in the barrel support and drive the roll pin in.

13. Assemble the breech ring assembly in the large end of the barrel support, lining up the key on the breech ring with the keyway in the barrel support. Assemble the recoil spring against the breech ring assembly, and place the bolt head roller guide into the head of the recoil spring.

14. Assemble the large end of the barrel support into the front end of the receiver, lining up the stud in the barrel support with the slot on the bottom of the receiver. Place the barrel support coupling on the barrel support.

15. Place the adapter spring compressor in position, and tighten the hexagon head on the front end until the recoil spring is compressed. Assemble the barrel support coupling to the receiver and turn it as far as possible by hand. Using the adjustable spanner wrench, tighten the coupling. Place the barrel lock and barrel lock spring in position, and drive the roll pin in. Check the barrel lock to see that it works freely and that it engages a notch in the barrel support coupling. Remove the adapter spring compressor.

NOTE. Make certain that the barrel support coupling is fully tightened before attempting to fire the gun.

Adjustments

It may be necessary to make various adjustments to compensate for the normal wear of certain gun parts. The following instructions for making these adjustments should be carefully followed.

Height of the Sear Roller.

1. The height of the sear roller in its depressed position should be approximately flush with the top of the sear block. With the cover opened, this should be checked in two ways.

(a) Depress the sear roller with the manual release lever, and pull the bolt assembly to the rear.

With the bolt held firmly down on the receiver tracks, it should not contact the sear roller. If the bolt does contact the sear roller, examine the assembly to determine the cause. Probable cause may be a sear spring with too great a solid height, or, the sear spring stop on the sear frame may be too long. If so, replace the sear spring or file the end of the sear spring stop until the condition is corrected.

(b) Depress the sear roller by closing the firing switch and manually depressing the shroud switch. Pull the bolt assembly to the rear and with the bolt held firmly down on the receiver tracks, it should not contact the sear roller. If the bolt does contact the sear roller, remove the solenoid and add shims, one by one, between the solenoid mounting plate and the buffer housing until the bolt does not contact the roller.

2. The height of the sear roller in its released position should be approximately 0.250 inch above the sear block, and should be such that it will just contact the bottom of the bolt just forward of the sear projection.

Switch Cam Adjusting Nut.

1. The proper relation of the bolt to the opening and closing of the power stroke and return stroke circuits is obtained by the adjustment of the switch cam adjusting nut.

2. Depress the sear roller with the manual sear release lever (both the sear and telltale are controlled by the firing switch and solenoid, preventing use of the firing switch for this purpose). Pull the bolt rearward, holding it firmly down on the receiver tracks until the housing switch is heard to release with an audible click. Make a reference mark on the receiver edge using one of the rear guide lugs of the bolt as a point of origin. Free the manual sear release and pull the bolt to the rear until the sear roller rises and engages the bolt. Press the bolt forward as far as the sear roller permits. Again mark the receiver edge using the same point of origin. If the distance between the two marks on the receiver edge is between three-sixteenths and one-quarter inch, the telltale setting is correct. If incorrect, adjust the switch cam adjusting nut until the correct setting is obtained.

3. The analyzer may be employed to determine the make or break point of the power circuit instead of depending on ear to hear the housing switch click. Connect the analyzer. Hold the analyzer test prod

on the power circuit contact of the lower contact assembly. Flashing of the blue (continuity) analyzer indicator will disclose the make or break point of the housing switch.

Shroud Switch.

1. Sufficient play may develop between the cover and the receiver to prevent the switch arms from properly depressing the shroud switch button. Shims should be added under the switch shroud until this condition is corrected. Spare shims are kept on the top of the switch shroud flanges.

2. Shroud switch adjustment should be made after the following check of cover clearance.

(a) Close the power switch to permit charger operation through one cycle; close and open the firing switch to release the bolt (manually operate the sear if necessary). The power switch must be left open during the succeeding operation to prevent reoperation of the charger.

(b) With the feeler gages, check the clearance between the cover and the receiver at a point immediately below the cover latch. This clearance should be the maximum at which the cover will just latch.

(c) Raise the cover and add 0.040 inch to the previous gage reading.

(d) Insert the combined gage, and close the cover. Although the cover will not latch, the solenoid circuit should be closed. Check by closing the firing switch to energize the solenoid and actuate the sear. (If the circuit analyzer is connected correctly, the green indicator should flash.)

(e) If the circuit does not close, adjust the shroud switch by adding sufficient shims under each flange of the switch shroud. This adjustment (cover 0.040 inch from closed) is sufficient to compensate for wear and no further adjustment should be needed during the normal life of the gun.

SECTION 7. CALIBER .60 T39 MACHINE GUN

The caliber .60 machine gun T39 differs only from the T17E3 in that it has a special bolt and bolthead interchangeable with the percussion bolt, and a contact switch with the necessary wiring to an external power source to fire electrically primed ammunition. It was expected that this model would meet all the Air Force requirements for synchronization and fire interruption.

The first electrical bolt was a copy of the German MG 151/20. This bolt gave excellent ignition time and was remarkably free from "contact bounce," but the contactor which passed through the bolt and bolthead cam broke with great frequency. This design was complicated and required major modification of the bolt, bolthead and bolthead cam, and receiver.

Frigidaire was requested to redesign this bolthead, reduce the number of contactors required, and reduce the number of modifications required to convert T17 guns to T39 guns. The new assembly required no modification to the bolthead cam, but a new recoil plate in the bolthead, an enlarged firing pin hole in the bolt, and a contactor attached to the rear of the bolt were necessary. A switch attached by a bolt was added to the side of the re-

ceiver. The firing pin in this model was a WD 1090 wire 0.040 inch in diameter, which ran from the bolt contact in the rear of the bolt to the face of the bolthead when the assembly was retracted. The time of firing was controlled by the location of the switch on the receiver engaging a contact in the rear of the bolt. The firing pin used in this design failed after a few hundred rounds, and the contacts arced and chattered.

Frankford Arsenal Laboratory developed the E3 design independently. It was an improved E1 which required less modification of the T17 parts. This model failed because of excessive part breakage.

Arrow Engineering Co., Chicago, was engaged to redesign the E1. This redesign was called the E4, and it had an improved firing pin and contact mechanism in the bolt and a knife blade switch between the bolt and the receiver. The timing of the bolt was the same as in the E2.

Quality Hardware Corp. was then engaged to develop the E5.

The timing of this firing pin was accomplished by the movement of the bolt body in relation to the bolthead and is independent of the bolt switch.

This design also incorporates a chatterproof contact in the bolt. Test data on the E4 and E5 bolt assemblies was submitted and eventually accepted.

Various other experimental designs of electrical units were tested and efforts were made to modify T17E3 guns along with T39 weapons using electrical units fabricated by the Alpha Engineering & Machine Works. These guns were furnished by an order of 50 such guns at Rock Island Arsenal. Results of tests as a whole were unsatisfactory and further development of electrical firing units for this gun were limited due to the changeover to the T17E5 mechanism. Of the tests that were con-

ducted at the Aberdeen Proving Grounds to obtain data for possible use in future gun development, the designs tested did not prove to be satisfactory; however, some features in their switch and contact designs did appear desirable. The Naval Gun Factory at Washington, D. C., also built two types of bolt-heads of the T39 type.

The demand for a short aircraft gun led to a radical redesign of the T17 type guns to produce a version known as the T51. The buffer, receiver, bolt, and barrel were shortened to the minimum possible length to give an overall length of 52 inches. This development took place in 1947.

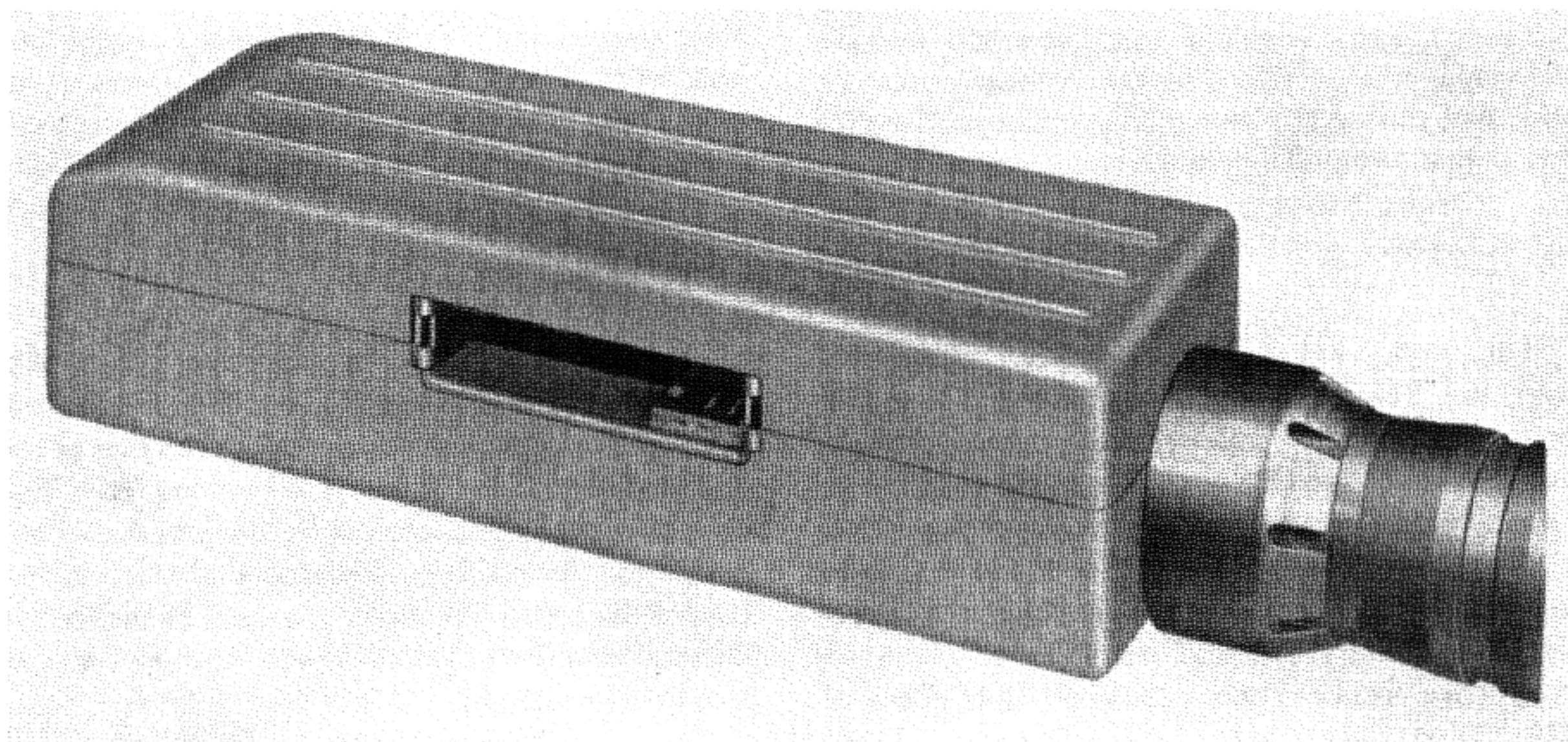


Figure 4-34. Wooden mockup of Caliber .60 T51 Machine Gun, view of receiver portion.

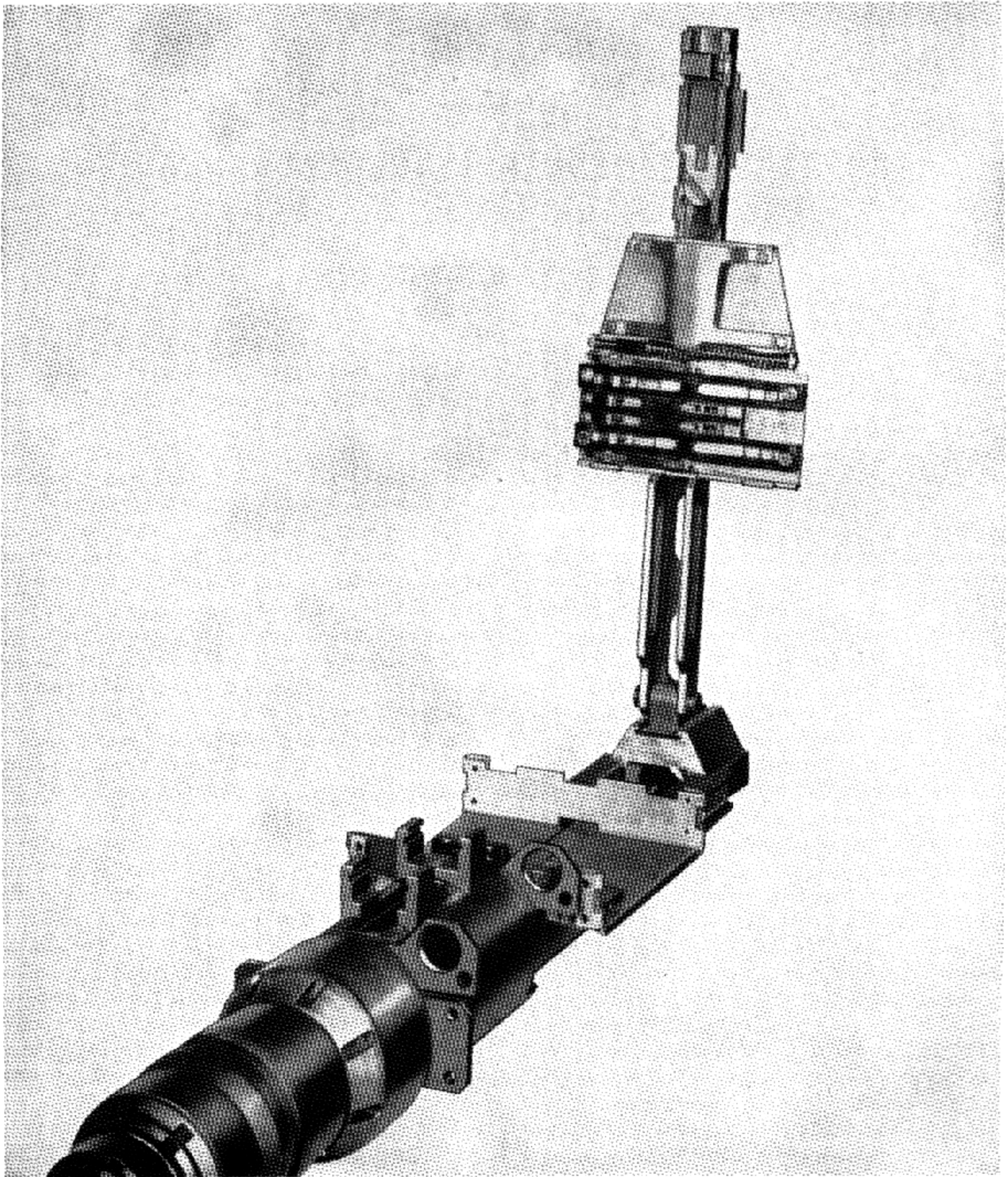


Figure 4-35. Wooden mockup of Caliber .60 T51 Machine Gun. Casing removed and feed hinged up.

Chapter 5

75-MM AMERICAN AIRCRAFT CANNON DEVELOPMENT

SECTION 1. HISTORY AND BACKGROUND

The military characteristics for airplane cannon approved in January 1937 called for an experimental cannon not to exceed a caliber of 75 mm, which would be capable of firing time and impact fused shells.

By October 1938, the Ordnance Corps expressed a desire to push with all possible speed the project for mounting a 75-mm gun and its necessary fire-control equipment in a suitable airplane. Thorough study of the problem by the Ordnance Corps revealed that the simplest possible solution should be attempted first. From an artillery point of view, this meant mounting the 75-mm as a fixed gun with limited movements in elevation and traverse. The gun should be capable of firing at a predetermined range with fuses set to burst at a chosen distance.

Two months later, a project was initiated, known as 75-mm airplane gun mount T1, for mounting a French 75-mm gun, model 1897, in a B-18 airplane together with a telescopic sight and a range finder. The Army Air Corps cooperated with the Ordnance Corps in the development of this improvised unit, which was tested by Ordnance Corps personnel on the ground and in the air. When firing tests for accuracy were conducted against aerial targets, the results obtained were far better than had been anticipated. The airplane successfully withstood the shock resulting from firing the 75-mm cannon, proving conclusively that the mounting of a 75-mm gun in an airplane was feasible from both an engineering and a tactical point of view.

The first 75-mm aircraft cannon, standardized as the 75-mm gun M4, with airplane gun mount M6, was essentially an adaptation of the 75-mm gun M3 designed for tanks. Subsequent research and development resulted in lighter guns known as the 75-mm gun M5, with airplane gun mount M9, and

the 75-mm gun M10, with aircraft gun mount M10. These installations weighed approximately 500 pounds less than the M4 gun with the M6 mount, a reduction in weight made possible by the use of high-strength alloy steel and the design of concentric recoil mechanisms. The saving in weight permitted the installation in aircraft of additional forward-firing caliber .50 machine guns.

Much of the variation in design of the 75-mm gun and its supplemental equipment was a result of space limitations and other characteristics of the airplanes into which it was to be installed. Up to the end of 1944, the M5 gun had been placed in the A-20, XA 38, XP-58, P-71, XA 26B, and B 25H airplanes, while during the same period the M5 gun was also installed in the light tank M24.

In October 1940 approval was given for the Ordnance Corps, in cooperation with the Air Corps, to proceed with the design and manufacture of a combat unit consisting of a 75-mm gun, an aircraft mount, a stereoscopic rangefinder, and a fire control system, as well as an airplane designed and built to carry this combat unit. The Ordnance Corps was to design and manufacture the gun, mount, and fire-control system immediately, while the Air Corps was to start the design and manufacture of the airplane when facilities became available, but not later than fiscal year 1942.

Plans were made to mount the 75-mm gun M2 in the nose of an XP-71 plane, with a bulkhead separating the gun and the crew. Although this type of plane was to be primarily a high-altitude fighter, requirements had also materialized for a plane with a large cannon whose primary mission was to destroy ground targets. Consequently, it was planned to mount the 75-mm Gun M3 in the XA-26B plane then under development.

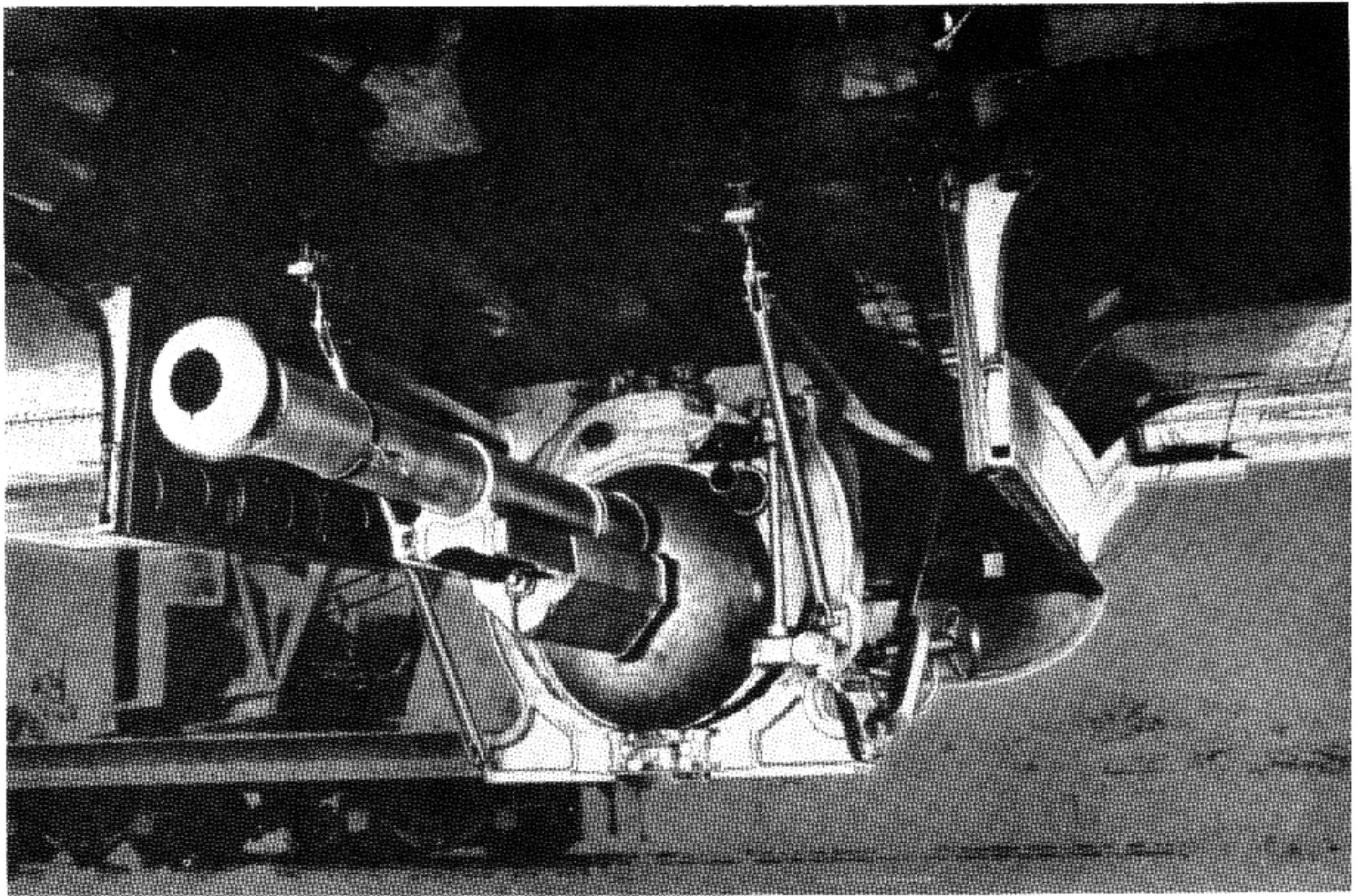


Figure 5-1. 75-mm Gun M1897A5E1 mounted in the B-18 Airplane. This mounting was used in 1939.

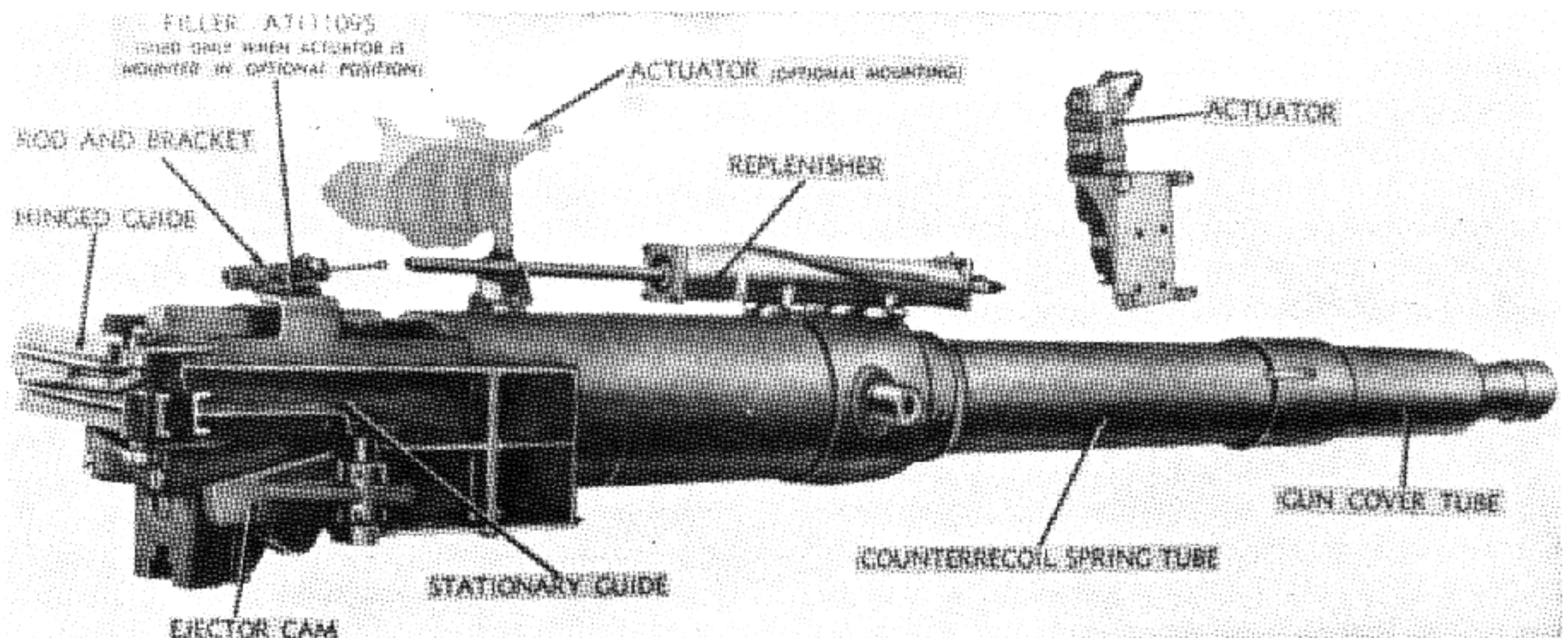


Figure 5-2. Ordnance Corps 75-mm Gun M5.

The 75-mm guns M2 and M3 were derived from the 75-mm gun T6. The Ordnance Corps originally planned to use the T6, a low-velocity anti-aircraft gun, as armament for the medium tank. Later it was found that the T6 gun would have to be modified to make it suitable for use in tanks, and the modified design was designated 75-mm gun T7.

The firing mechanism of the T7 gun used a trigger type with provision for the use of a solenoid, instead of the lanyard type of trigger actuation as used on the T6 gun. Its recoil mechanism was rotated 90 degrees about the barrel. With the addition of an operating handle for initial opening of the breech, the T7 gun was standardized in April 1941, designated 75-mm gun M2, as part of the armament of medium tank M3.

Improvements in tank design required mounting the 75-mm gun in the turret rather than in the right sponson mount. When a gyrostabilizer was installed, the gun became out of balance, because of breech preponderance; however, this difficulty was overcome by lengthening the barrel from 28.47 calibers to 37.5 calibers. This modified M2 gun was standardized as 75-mm gun M3 in June 1941.

The M3 gun required two mounts: 75-mm airplane gun mount T3 without a muzzle cover, and 75-mm airplane gun mount T3E1 with an automatic muzzle cover.

The muzzle cover was designed to prevent flare-backs caused by the action of the air blast through the open gun tube, which might carry powder gas and unconsumed particles of burning powder rear-

ward into the airplane. In addition, the muzzle cover was to aid in the loading of the gun by reducing the force caused by the air blast through the tube while the airplane was in flight.

In June 1942 at a meeting of representatives of the Air Corps and the Ordnance Corps in California, it was decided to replace the 75-mm M3 gun in the production XA-26B airplane with the 75-mm T9 gun. Pending development of the T9 gun, however, production was authorized for 750 mounts using the M3 gun. The T3E1 mount was modified to facilitate manufacture after relocating trunnions in such a way that the T9 gun could be installed without further change in the production airplane. In August 1942 this mount was standardized as 75-mm airplane gun mount M6. To fit the M6 mount, the M3 tube had a seat machined on it to accommodate the muzzle cover spline ring. Standardization of this modified M3 gun as 75-mm gun M4 took place at the same time that the M6 mount was standardized.

In the fall and winter of 1942, the M4 gun on the M6 mount underwent firing tests using M72 and M61 projectiles against an M4E2 tank hull. Firings were also conducted with a towed target representing a submarine with the deck awash. In March 1943, trunnion reactions were measured and extensive tests of the muzzle cover were made under conditions simulating a plane at rest on the ground. By April 1943, slight modifications had been made to the muzzle cover, and the gun and mount were in production. Tests conducted at Eglin Field, Fla.,

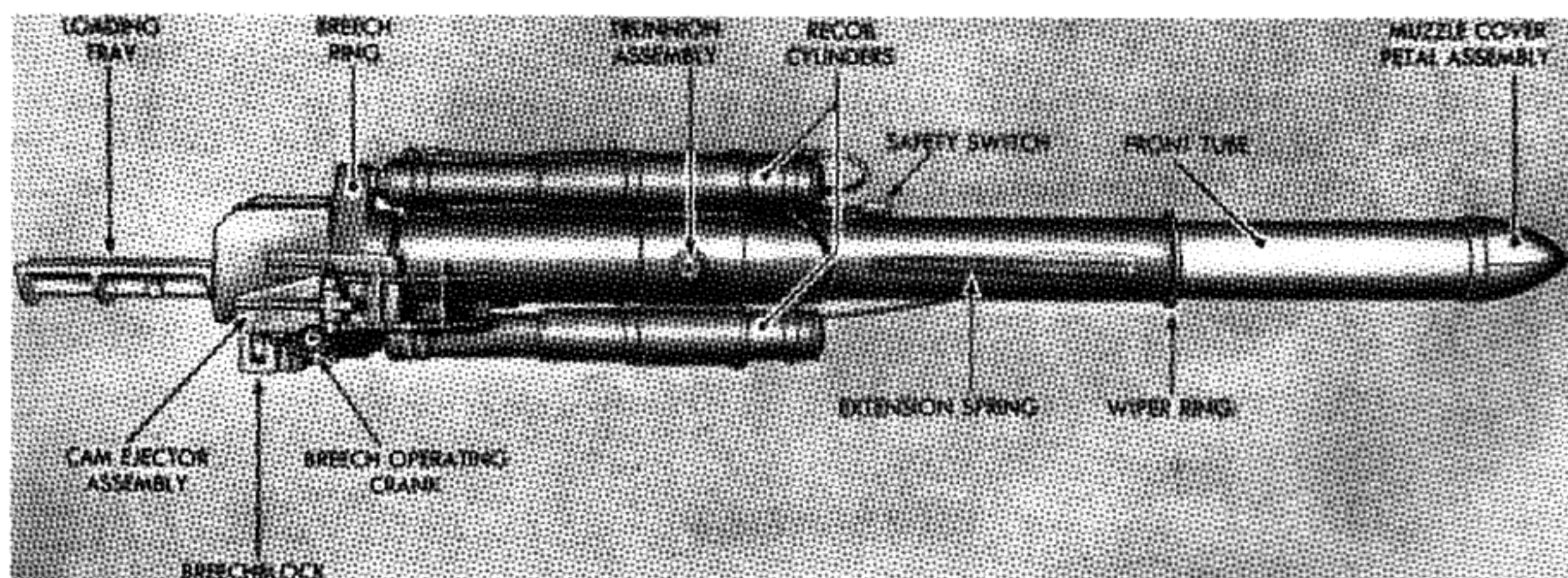


Figure 5-3. Ordnance Corps 75-mm Gun M4 on Mount M6. Right side view.

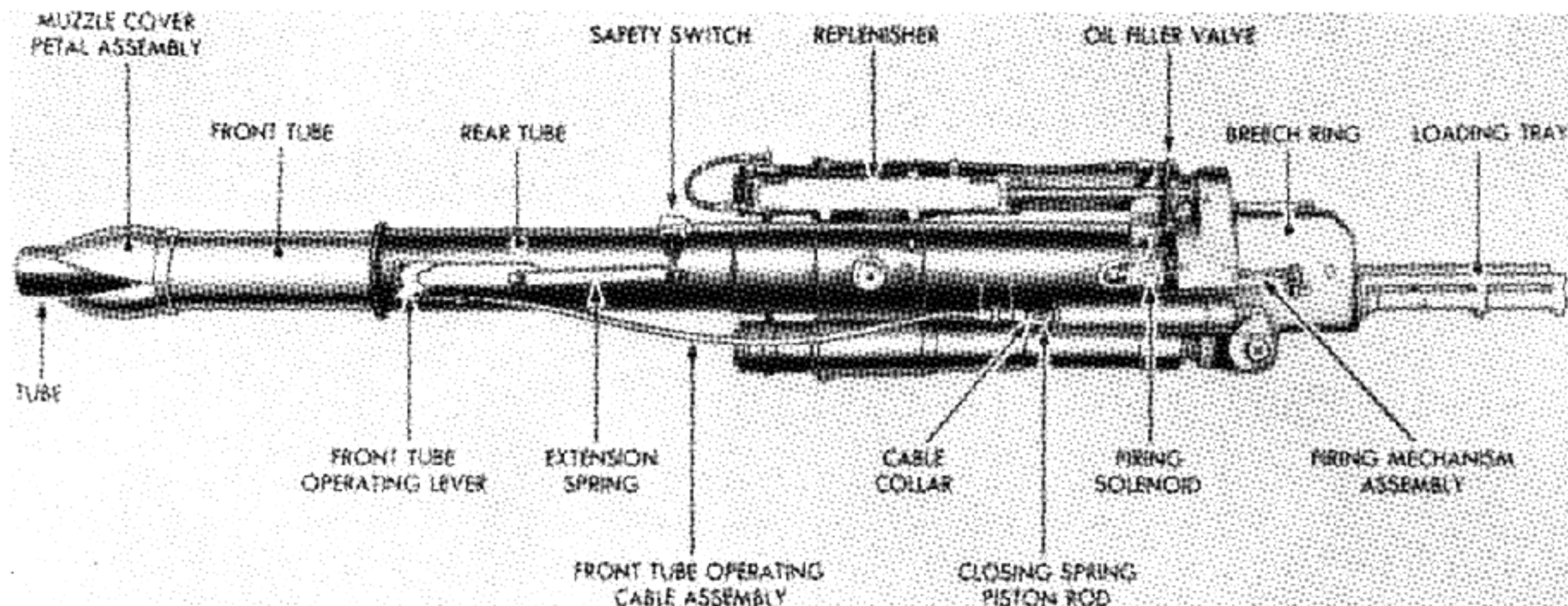


Figure 5-4. Ordnance Corps 75-mm Gun M4 on Mount M6. Left side view.

in May 1943, showed that the petals of the muzzle cover would not stay closed; accordingly, the Air Force abandoned the muzzle cover as a requirement.

Initiated in May 1942 75-mm gun T9, which was designed as a light weight 75-mm gun for aircraft use, had the same ballistic characteristics as those of 75-mm gun M4. Two pilot models were constructed; one had a closed and the other open breech ring. In December 1942 these pilots were redesignated 75-mm guns T9 and T13 respectively. The T9 gun was intended for use with mechanical loading devices and the T13 gun with hand loading installations. In November 1942 limited procurement was approved for 100 T9 guns, with 75-mm feed mechanisms T13 and 75-mm airplane gun mounts T15, all for installation in experimental aircraft.

In March 1943 during a preliminary test of the 75-mm feed mechanism T13 with the 75-mm gun T9, a power failure of considerable magnitude developed making it necessary to balance the breech

ring so that the center of gravity of the recoiling parts lay on the centerline of the bore. Because of the similarity between the breech rings of the T13 and T9 guns, this was also necessary for the T13 gun. These balanced guns were designated 75-mm guns T9E1 and T13E1.

Extensive tests were conducted at Aberdeen Proving Ground with production 75-mm guns T13E1, including extended firing at excess pressure, cold-room firing, and detonation tests. Examination of tubes at Watertown Arsenal showed that satisfactory tubes could be obtained only when the tube was heat treated after boring during the manufacturing process.

The prototype B-25H airplane with 75-mm gun T13E1 and 75-mm airplane gun mount T13E2 was subjected to service tests at Eglin Field, Fla. Following this test, standardization of the equipment at 75-mm gun M5, 75-mm airplane gun mount M9, and firing lock M15 was authorized in March 1944.

In May 1944 the Joint Aircraft Committee adopted the above unit with the nomenclature of

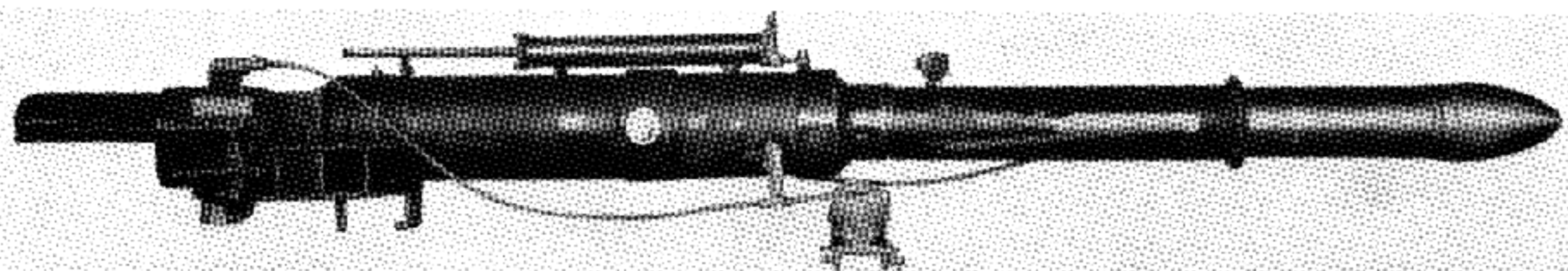


Figure 5-5. Ordnance Corps 75-mm Gun T13. Right side view.

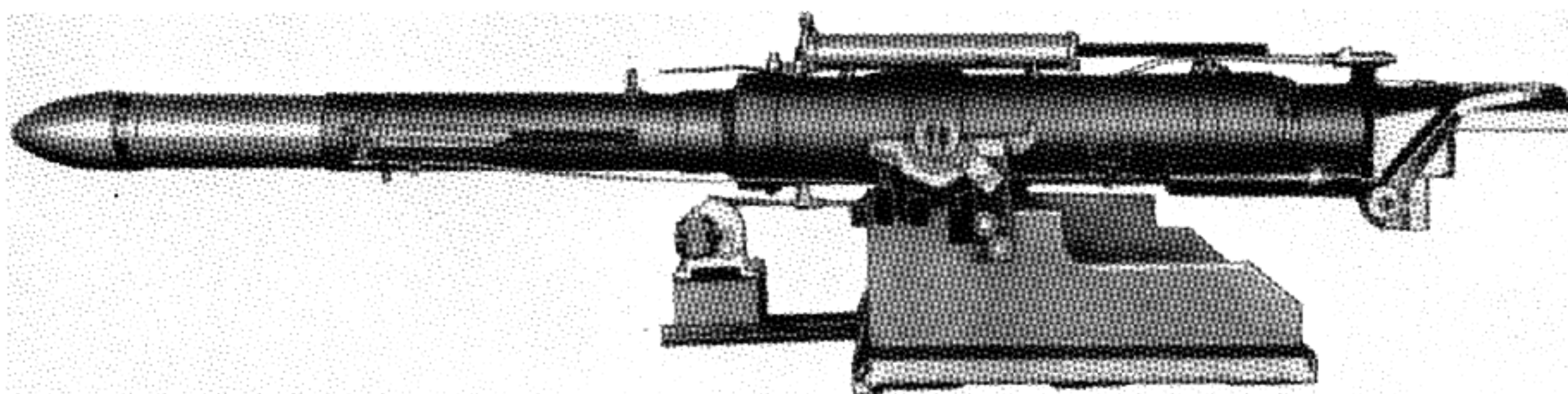


Figure 5-6. Ordnance Corps 75-mm Gun T13. Left side view.

75-mm gun AN-M5, 75-mm aircraft gun mount AN-M9, and firing lock AN-M15 as standard for use by the Army, Navy, and the British.

The 75-mm gun AN-M5 was mounted as a fixed installation in the nose of the plane. The vertical sliding wedge type breech mechanism of the AN-M5 gun was opened manually for the first round and closed by the action of the projectile, tripping the extractors and allowing the breech to close under pressure of the closing spring. During counter-recoil, the breech mechanism was opened automatically by action of the breech operating crank as it struck the breech operating cam on the mount. A collar on the forward end of the gun tube retained the counterrecoil spring.

The M9 aircraft gun mount consisted of a cradle which formed the outer cylinder of the concentric recoil mechanism. Two trunnions located on the cradle provided for mounting the gun, recoil mechanism, and cradle in the airplane. The cradle supported the replenisher and the recoil guide. The counterrecoil spring was located ahead of the cradle and was inclosed by the rear tube. A front cover was snapped in place on the front end of the rear tube. A hinged guide was provided on the rear right side of the cradle to guide the gun during recoil and counterrecoil. During inactive periods the guide could be swung across the rear face of the breech ring to conserve space.

The M15 firing lock was operated by a motor driven firing actuator, controlled by a cannon selector switch and firing button which were airplane equipment mounted in the pilot's compartment.

By the end of 1944, extensive research work had produced 75-mm guns of greater firepower than those the field artillery had used in World War I. Many differences were evident: The original field

artillery weapon weighed 1,015 pounds, but the modern airplane gun of the same bore weighed only 406 pounds. The M5 was three calibers longer than the French model. The hydropneumatic recoil system used by the French permitted a recoil of 46 inches, while the airplane gun hydrospring concentric recoil system limited the recoil to 21 to 23 inches.

The trend of 75-mm development was marked by reduction in weight and increase in firepower. Increased firepower was attained through the development of an automatic feed mechanism and a fuse setter-rammer. On 1 July 1944, for the first time, a 75-mm gun was fired automatically in bursts of three rounds from an airplane in flight. Personnel were released for other purposes than gun loading because power operation made possible use of the gun in aircraft where space was inadequate for manual operation. A cyclic rate of 30 rounds per minute and ammunition capacity of 20 rounds were achieved.

B-25G and the improved B-25H bombers armed with the 75-mm cannon sank lightly armored warships and destroyed enemy gun emplacements, shipping, and tanks. Extremely accurate attacks in the New Guinea area scored five direct hits on a Japanese destroyer, which was left in a sinking condition. In the Lanywa oil field of Burma, an oil storage tank was destroyed with 3 out of 4 shots put in the target. During operations in the Marshalls, the 75's were reported as extremely effective in silencing antiaircraft positions. In the Mediterranean, 75-mm aircraft cannon were used successfully against shipping.

While the French originated the 75 and its accompanying materiel, the Ordnance Corps adapted it to the needs of modern warfare. The 75-mm gun

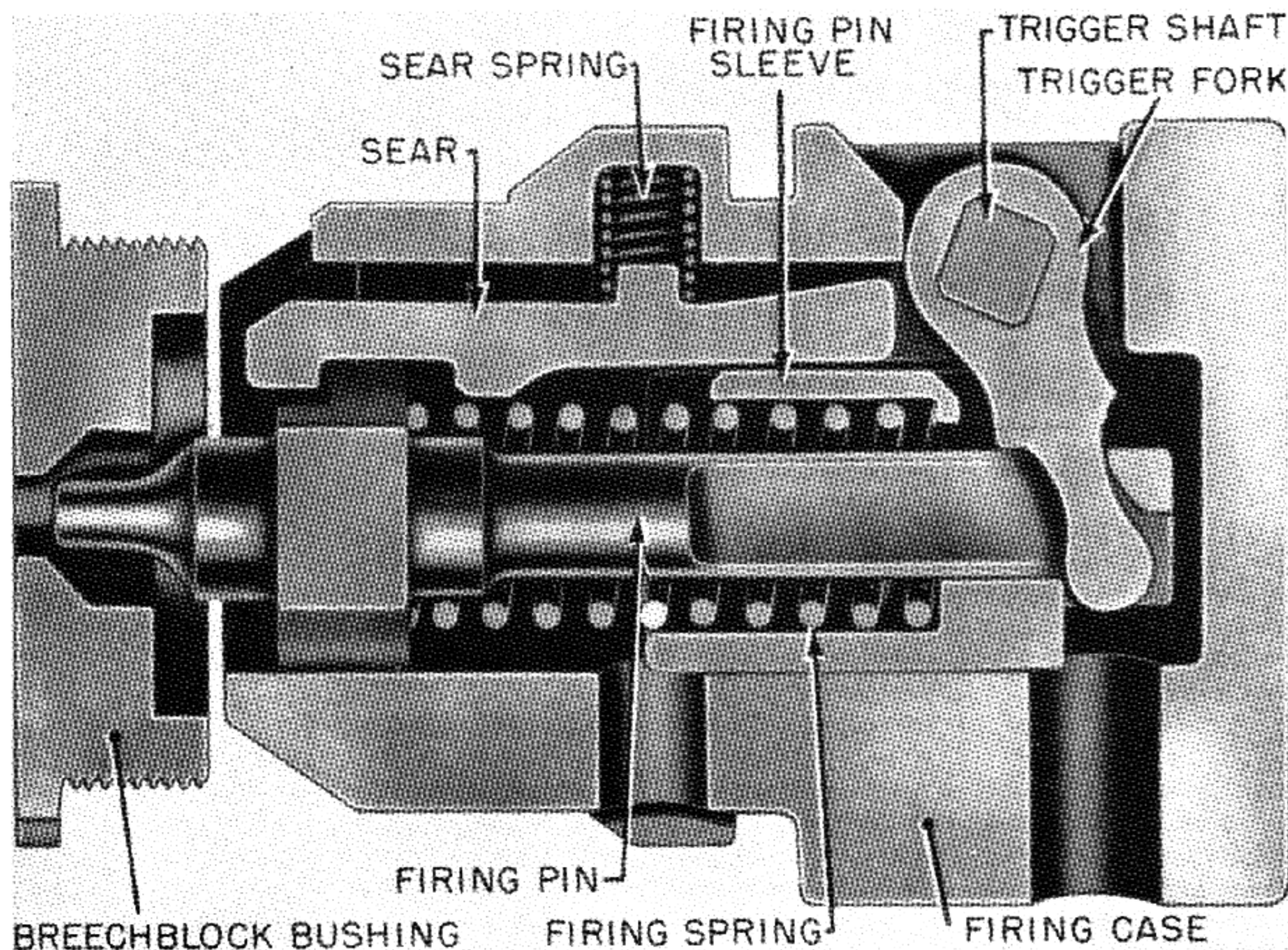


Figure 5-7. Ordnance Corps 75-mm Gun M5. Firing Lock M15 in firing position. Sectional view.

has been supplanted as a field weapon by an equally mobile 105-mm howitzer but was still an outstand-

ing weapon in World War II when used in its modern form in an airplane or tank.

SECTION 2. 75-MM GUN M4

General Description

The 75-mm gun M4 was a single-shot, hand-loaded, flat-trajectory weapon with an automatically operated vertical sliding wedge type of breechblock. A breech ring anchored two recoil mechanisms. The breech mechanism was composed of a breechblock percussion type mechanism, right- and left-hand extractors, breech operating shaft, breech and breechblock operating cranks, and a chain terminal crank connected to the breech closing mechanism.

The 75-mm airplane gun mount M6 consisted of a cradle in which the tube assembly was supported longitudinally in a large central boring. Bored sec-

tions of the cradle above and below the tube boring and parallel to the tube carried the two recoil cylinders. A replenisher mechanism was mounted on the left side of the upper section of the cradle; an electrical firing circuit was on the left rear side of the central section of the cradle, and a cam ejector mechanism was on the right rear side of the cradle.

The muzzle cover mechanism consisted of a rear tube, front tube, and muzzle cover petals, which opened automatically when a round was inserted in the chamber and then closed on counterrecoil of the gun. A safety switch, connected to the electrical firing device, prevented firing of the gun when the muzzle was closed.

General Data: 75-mm Gun M4

Gun length: 129.23 inches.
 Gun weight: 893 pounds.
 Rate of fire:
 Normal: 3 to 4 rounds/minute.
 Maximum: 30 rounds/minute.
 Muzzle velocity (average velocity with new gun):
 Shell, HE, M48, with supercharge: 1970 feet/second.
 Shell, APC, M61: 2030 feet/second.
 Shell, AP, M72: 2020 feet/second.
 System of operation: Long recoil (semiautomatic).
 System of locking: Sliding vertical block.
 System of feeding: Manual.
 Location of feed opening: Rear.
 Location of ejection opening: Rear.
 Method of charging: Manual.
 Method of cooling: Air.
 Breech mechanism: Vertical sliding wedge, semiautomatic.
 Type of firing mechanism: Percussion.

Barrel length: 110 inches.
 Length from muzzle to rear face of breech ring: 118 inches.
 Barrel weight: 628 pounds.
 Rate control: None.
 Chamber pressure: 38,000 p. s. i.
 Bore:
 Number of grooves: 24.
 Groove depth: 0.02.
 Groove width: 0.248.
 Direction of twist: Right hand.
 Form of twist: Uniform.
 Length of bore: 37.5 calibers.
 Length of rifling: 96.2 inches.
 Type of mount: 75-mm M6.

General Data: 75-mm Gun M5

Length of gun (muzzle to rear face of breech ring):
 116.375 inches.
 Weight of gun: 406 pounds.
 Muzzle velocity:
 Projectile APC, M61: 2,030 feet/second.
 Shell, HE, M48 (supercharge): 970 feet/second.
 Shot, AP, M72: 2,020 feet/second.
 Type of firing mechanism: Continuous pull, self-cocking.
 Breech mechanism: Vertical sliding wedge, semi-automatic.
 Length of barrel: 37.5 calibers.
 Weight of gun and mount (including recoil mechanism): 763 pounds.
 Length (muzzle to rear end of hinged guide): 129.25 inches.
 Type of mount: 75-mm M9.

Comparative Data: 75-mm M6 and M9 Gun Mounts

Mount	M6	M9
Recoil mechanism	Hydrospring, two separate recoil cylinders (recoil mechanism is considered part of mount M6).	Hydrospring concentric recoil mechanism counter-recoil springs are housed in separate cylinder ahead of cradle (considered part of mount M9).
Weight of recoil mechanism	334 pounds	
Maximum allowable recoil	23 inches	
Normal recoil	21 inches	
Breech ring guide	Solid construction	Folds against rear face of breech ring.
Loading tray	Swings up out of way	None.

SECTION 3. 75-MM GUNS M5, M5A1, AND AN-M5A1

The 75-mm gun M5 used the standard 75-mm gun rifling with a twist of 1 turn in 25.58 calibers. The stability factor of 75-mm HE shell M48 was 1.373 when fired on the ground; when fired from an airplane in flight (because of the increase in linear velocity with no increase in rotational velocity), the stability factor was reduced and reached a value of 1.000 for a true air speed of 228 miles per hour at sea level. At higher speeds, the stability factor was even less. This condition of instability precluded the application of adequate fire control and substantially reduced the effectiveness of the round.

To improve the stability of 75-mm HE shell M48 for aircraft firing, it was necessary to provide a gun with increased twist. Accordingly, two 75-mm guns M4 were made with a twist of rifling of 1 turn in 22 calibers.

With this increased twist, the stability factor for ground firing of 75-mm shell M48 was raised to 1.857, with a corresponding increase for aerial firing. Extended firings were conducted with one of these guns at Aberdeen Proving Ground, and the second gun was sent to Eglin Field, Fla., for aerial firing. The results of Eglin Field tests were in agreement with this and indicated satisfactory stability with HE shell M48 when fired from a gun with a twist of 1 turn in 22 calibers.

Two other tubes with twist of rifling of 1 turn in 22 calibers were built and tested at Aberdeen Proving Ground. One of these guns had the standard 75-mm gun form of rifling and the other, a modified 75-mm howitzer form of rifling (28 lands and grooves, 0.30 in. deep with a fillet radius of 0.03 inch).

SECTION 4. 75-MM GUN M10 (T9E2)

In July 1944 75-mm gun T9E2, with 75-mm feed mechanism T13 and 75-mm airplane gun mount T15E2, were installed in the XA-38 airplane and fired on the ground at Tulsa, Okla. This test was essentially a proof test of the airplane structure. At the same time the unit was fired from the XA-38 airplane in flight at Great Bend, Kans. Throughout this test, the mechanism functioned satisfactorily.

The 75-mm gun T9E2 differed slightly from the 75-mm gun M5A1, but was used with the T15E2

One gun of each type was fired approximately 1,000 rounds at maximum rated pressure and ambient outdoor temperature, followed by 200 rounds at 115 percent maximum rated pressure and -50° F. Series of shell M48 and projectile APC M61 inert were fired for recovery and examination of the rotating bands at intervals of 500 rounds. In addition, spin measurements were taken with M48 shell fired from the standard gun contour of rifling to obtain comparative results of firing from a new gun and from one which had been fired approximately 1,800 rounds.

The results of these tests indicated that there was no appreciable loss of spin in a gun which had been fired 1,800 rounds. Accordingly, it was approved in July 1944 that the twist of rifling of 75-mm gun tubes for aircraft use be increased to 1 turn in 22 calibers, retaining the standard form of rifling for 75-mm guns. These guns were then designated 75-mm gun M5A1 and 75-mm gun T9E2, and the 75-mm gun M5 for aircraft use was reduced to limited standard.

In November 1944 the Joint Aircraft Committee considered further development of the M5A1 gun. It was pointed out that although the AN-M5 gun was satisfactory for firing from aircraft, such as the B-25, at speeds up to 230 to 250 m. p. h., it was unsatisfactory on the A-26 and in other aircraft having maximum speeds above 250 m. p. h. Consequently, the M5A1 gun was standardized as 75-mm gun AN-M5A1, and the AN-M5 gun reduced to substitute standard, with the understanding that the AN-M5 gun would not be procured for airplanes having speeds above 250 m. p. h.

mount and T13 feed mechanism. It was not interchangeable with the 75-mm gun M5A1 and M9 mount. The breech rings were made from the same castings and were alike except that provision was made on top of the breech ring of the T9E2 gun for mounting the feeder mechanism which started the operation of the feed mechanism. The T15E2 mount differed from the M9 mount only in the location of the trunnions and the provision of certain

bosses and pads for mounting the feed mechanism. Standardization of the T9E2 gun as 75-mm gun M10, the feed mechanism T13 as 75-mm feed

mechanism M4, and the T15E2 mount as 75-mm aircraft gun mount M10 was approved in October 1944.

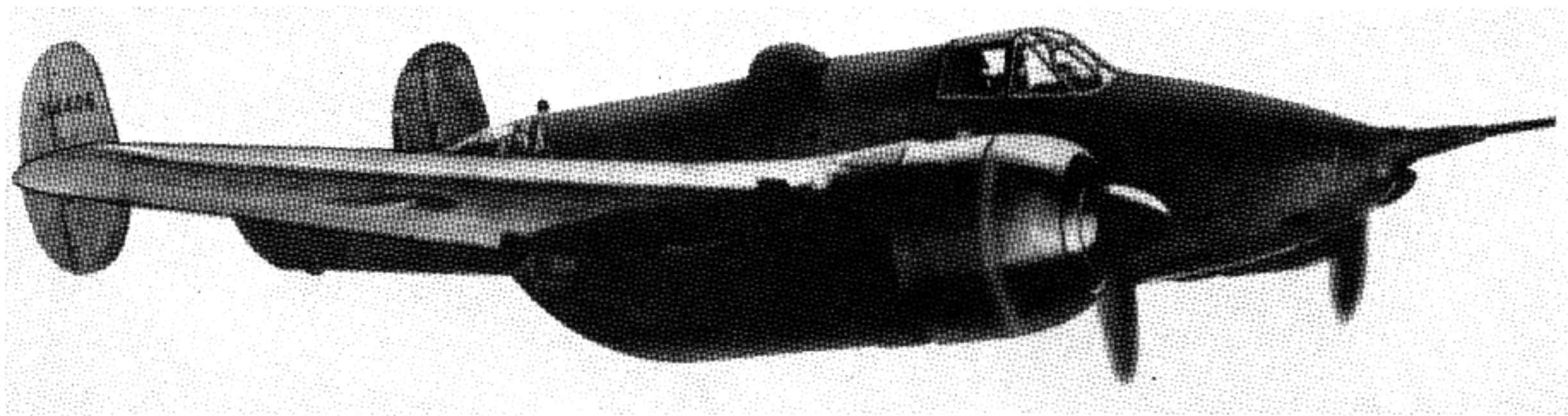


Figure 5-8. XA-38 Airplane armed with 75-mm Cannon M10.

SECTION 5. 75-MM GUN T9E3

In August 1944 a development program was authorized to reduce the installation weight of the combination T9E2 gun, T13 feed mechanism, and T15E2 airplane gun mount in the XA-38 airplane. The new gun, designated 75-mm gun T9E3, was to be provided with suitable bearing surfaces to guide it in recoil, to mount the piston of the recoil mechanism directly on the tube, and to have the standard 75-mm gun form of rifling with a uniform right-

hand twist of 1 turn in 22 calibers. The ballistic characteristics were to be identical with the 75-mm gun T9E2.

A new mount, designated 75-mm airplane gun mount T15E4, was to be used with the T9E3 gun. This mount, unlike its predecessors which were of the hydrospring concentric recoil type, embodied a hydropneumatic concentric recoil mechanism.

General Data: 75-mm Gun T9E1

Gun length: 116.375 inches. Gun weight: Without mount: 406 pounds. With mount: 763 pounds. Rate of fire: Maximum: 30 shots/minute. Average: 3 or 4 shots/minute. Muzzle velocity: 2,030 feet/second (when using projectile APM61). System of operation: Long recoil. System of locking: Vertical sliding wedge. System of feeding: Manual. Method of headspace: Locking wedge designed to take up any excessive headspace. Location of feed opening: Rear of breechblock. Location of ejection opening: Rear of breechblock. Method of charging: First round loaded by gunner. Method of cooling: Air.	Barrel length: 84 inches. Barrel weight: 178 pounds. Rate control: None. Barrel removal: Not designed for field removal. Bore: Number of grooves: 24. Groove depth: 0.020 inch. Groove width: 0.248 inch. Pitch: 7 degrees. (Equals 1 turn in 25.587 calibers and 1 turn in 20.137 inches.) Direction of twist: Right hand. Form of twist: Uniform.
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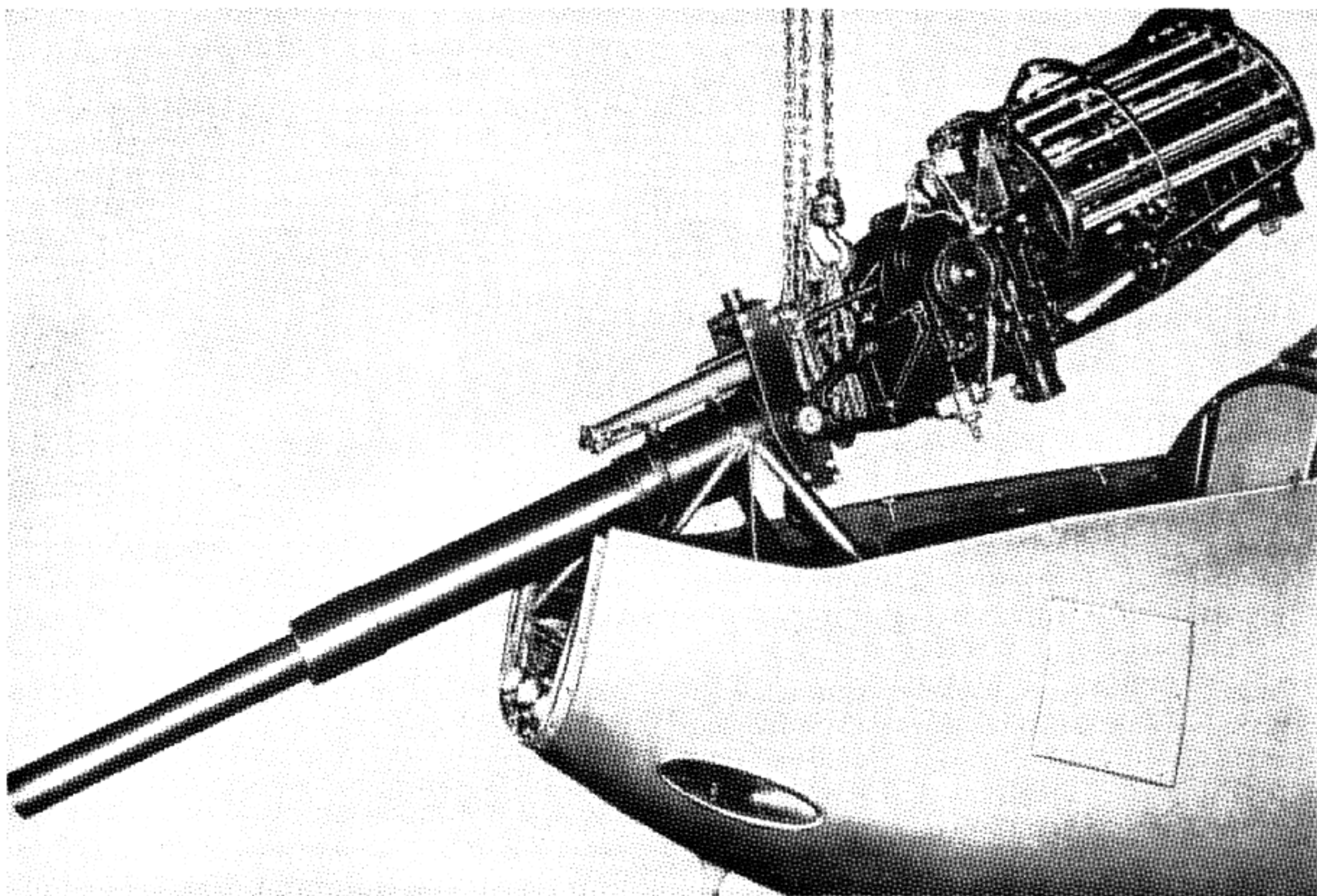


Figure 5-9. Ordnance Corps 75-mm Gun M10.

Modifications to the T13 feed mechanism were carried on with the designation 75-mm feed mechanism T13E1.

Tests of the gun, mount, and feed mechanism combination showed that excess impact load was caused by rapid ejection. A new ejector cam for the T15E4 mount was consequently required to slow

down the ejection. Before completion of this latest cam design, the Aberdeen Proving Ground was ordered to stop further testing.

The 75-mm aircraft weapon program came to a halt after the effectiveness of rockets was proved by their promoters, but not before the weapon had been successfully modified to fire full automatic.