Chapter 18

30-MM BRITISH AIRCRAFT CANNON (ADEN)

SECTION 1. HISTORY AND BACKGROUND

The 30-mm British Aircraft Cannon (Aden) is a revolver type weapon of British design similar to the German MK 213 gun. The designation "Aden" stands for "Armament Development Enfield."

The first six Aden guns were made in 1949. Numbers assigned to these guns were A1 to A6. At this time, a change was made in the link, and 35 guns of this second model were made (numbers A7 through A41).

In February 1950, the Ordnance Corps requested the United Kingdom to lend one 30-mm Aden aircraft gun for test. In September 1950, one gun of the second model (gun number A37) and 5,000 rounds of ball ammunition were shipped to Aberdeen Proving Ground where functional and performance tests were conducted from 20 December 1950 to 30 November 1951. One additional gun was received from Wright-Patterson Air Force Base, Dayton, Ohio, to furnish replacement gun components as required. A summary of the results of these tests is given in section 3 of this chapter.

Refinements were continued in Britain until a satisfactory preproduction model had been fabricated and subsequently the gun was put in production at a royal ordnance factory.

SECTION 2. DESCRIPTION OF THE 30-MM ADEN GUN

General Description

The 30-mm Aden gun is a heavy caliber revolver type machine gun with a high rate of fire and is designed for use in a fixed position in aircraft. The gun is fired electrically, and cooling is effected by air flow over the barrel. The weight of the gun is approximately 193 pounds.

Ammunition is fed to the gun in a belt, which may be of any length depending on the stowage space available. Provision is made for left- or right-hand feed, and the change from one feed to the other can be carried out by repositioning certain components.

The gun is gas operated. The slide and feed slide are forced to the rear by the gas piston, compressing

General Data: 30-mm Aden Gun

Gun length: 116 inches.	Barrel length: 52 inches.
Gun weight: 176 pounds.	Barrel weight: 64.2 pounds.
Rate of fire: 1,150–1,200 rounds/minute.	Rate control: None.
Muzzle velocity: 2,000 feet/second.	Barrel removal: Not quick disconnect.
System of operation: Gas operated, revolver principle.	Chamber pressure: 40,700 p. s. i., maximum.
System of locking: Stationary breech.	Bore:
System of feeding: Gas actuated.	Number of grooves: 16.
Method of headspace: Stationary anvil (set headspace).	Groove depth: 0.0177 inch.
Location of feed opening: Ammunition enters from lower left side of receiver.	Groove width: 1.45 inches.
	Pitch: 5 degrees 30 minutes.
Method of charging: Electro-pneumatic.	Direction of twist: Right hand.
Method of cooling: Air.	Form of twist: Progressive.

258970°—54——35

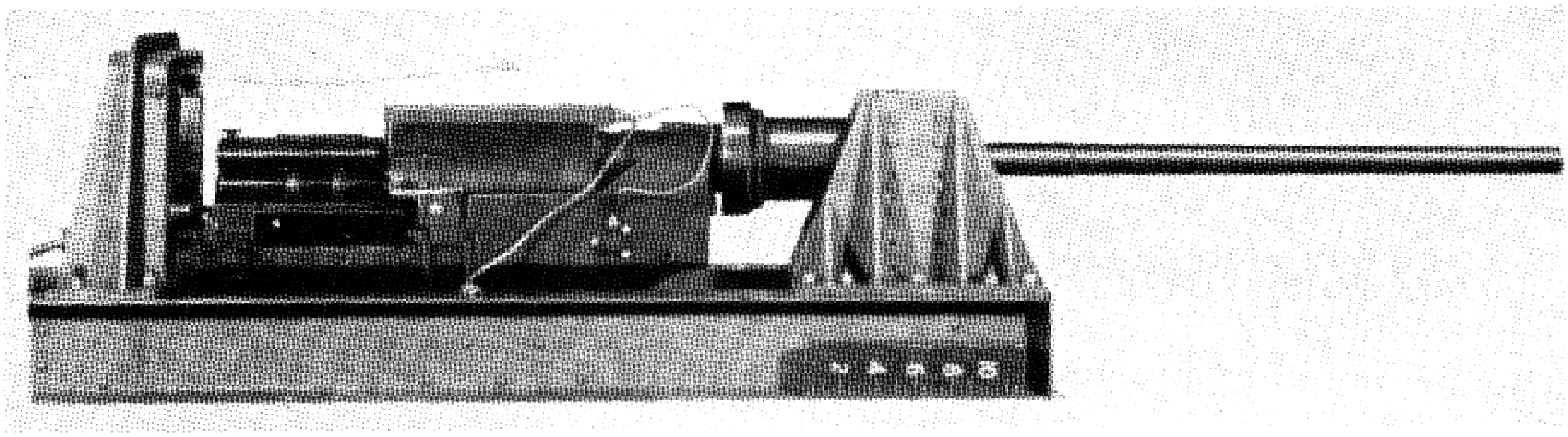

Figure 18–1. 30-mm British Aden Gun.

the return springs between the slide and the rear of the cradle, at the same time rotating the breech cylinder. The combined efforts of the expanding return springs reasserting themselves and the inertia of the breech cylinder camming upon the slide carry the slide and feed slide forward completing the 72-degree rotation of the breech cylinder and firing a round. During the counterrecoil of the feed slide, a round is stripped from its link, a second round is chambered, and the empty case of the round originating the cycle is ejected.

When a round is fired, the barrel, breech cylinder housing, and breech cylinder recoil a maximum of three-fourths of an inch. The feed mechanism is coupled to the breech cylinder and rotates with it. At the moment of ejection, the feed mechanism sprockets are clear of the ejection opening. The rounds are driven through the links by the rammer face of the feed slide, the links being ejected through the feed mechanism link ejection opening.

The gun may be divided into two groups, the nonrecoiling portions and the recoiling portions. The nonrecoiling portions are: Cradle and fittings; feed mechanism; and buffer housings. The recoiling portions are: Barrel; breech cylinder; breech cylinder housing; gas cylinder; buffer spindle; slides; and feed slide.

Description of Components

The Cradle. The cradle is the fabricated framework of the gun. Provision is made on the sides of the cradle for mounting the breech cylinder housing. At the rear of the cradle is a lug in which the feed mechanism anchorage pin engages. At the front of the cradle are two holes for anchoring the buffers. The cradle also accommodates the block, the cam lever guide, the return springs and rods, the feed mechanism, and the buffers.

THE BLOCK. This part is riveted to the bottom of the cradle and houses the cam lever guide. It also provides a surface for the slide and feed slide to work upon.

THE CAM LEVER GUIDE. This part is positioned in a recess in the forward end of the block and is secured to the cradle by two bolts. Machined in the cam lever guide are a track in which the cam lever plunger travels and the alternative positions for housing the cam lever springs which are pinned at their forward end to the cam lever guide.

RETURN SPRINGS AND RODS. The return springs and rods are positioned between the return spring rod seatings in the rear of the cradle and the recesses in the rear of the slide. The return spring rods pass through the return springs and are pinned to the return springs knurled knobs by means of locking pins. These locking pins engage the locking screws in the rear of the cradle.

FEED MECHANISM. Operation of the feed mechanism is automatic in that its rotation is governed by the rotation of the breech cylinder. It is fabricated, having a front casing and outer casing welded as one component. The casing accommodates the feed opening and is slotted for ejection of the links. It is also formed to allow for empty case ejection. The front and rear casings incorporate bearings for the feed mechanism spindle. On the spindle are mounted two sprockets positioned by a distance piece and collar. The front end of the spindle is machined to engage the slot in the breech cylinder. At the rear of the mechanism on top of the casing is a spring-loaded plunger which engages the feed mechanism spindle.

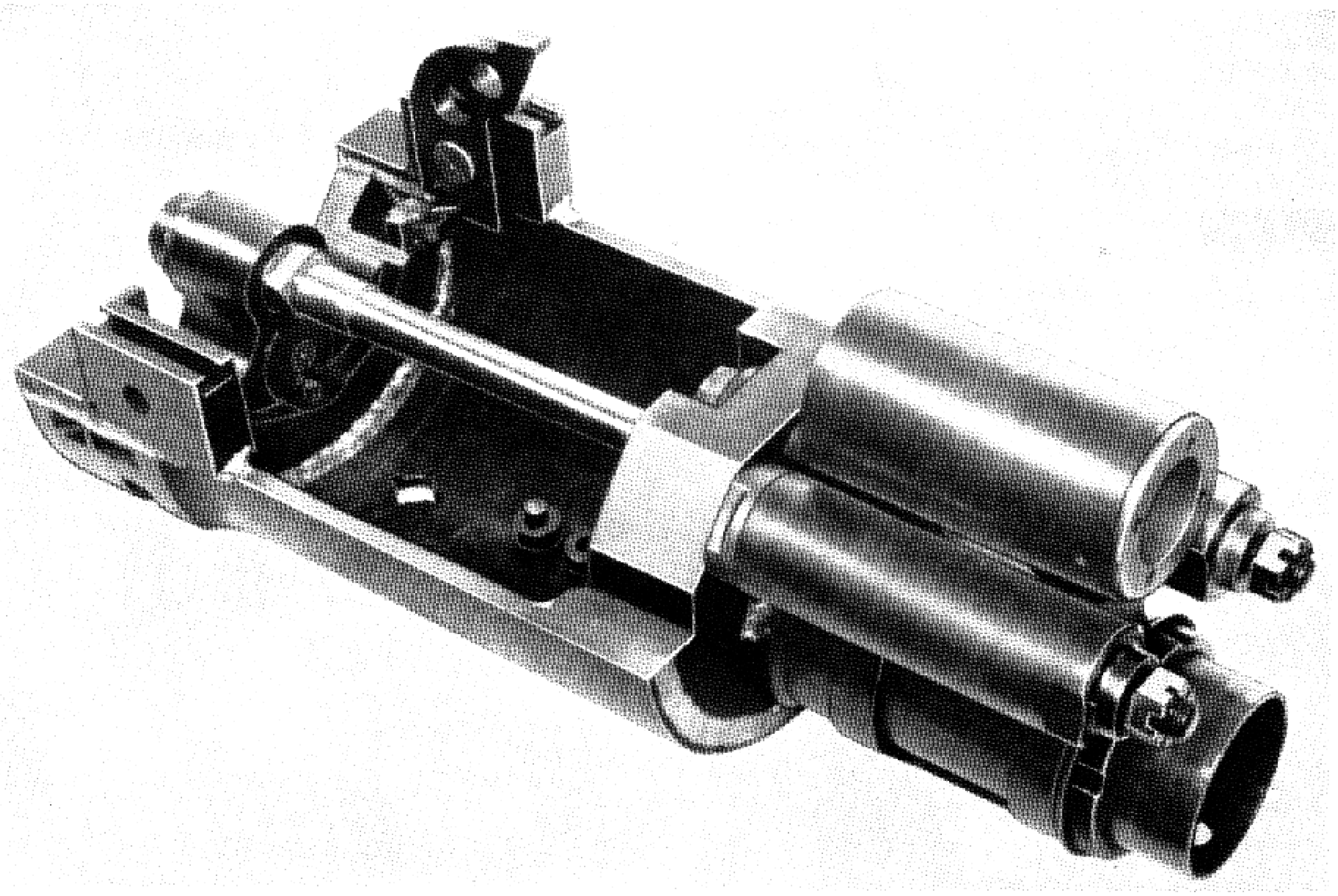

Figure 18–2. 30-mm British Aden Gun. Cylinder housing

BUFFERS. The buffers are situated between the front of the cradle and the front face of the breech cylinder housing. Assembled on the buffer spindle is the buffer housing. Between the spindle washer and the buffer housing plug are 29 Belleville washers, each 0.090 inch thick, in pairs. A single Belleville washer at one end is placed with its concave surface facing outward.

Barrel. The barrel is ribbed at the breech and has an interrupted thread to engage a corresponding thread in the breech cylinder housing, and there is a slot forward of the interrupted threads for the engagement of the barrel catch. A gas hole is drilled in the underside of the barrel connecting with the gas cylinder.

Breech Cylinder. The breech cylinder has five chambers 72 degrees apart. The cylinder rotates on a spindle which is supported in bearings at each end of the breech cylinder housing, the rear end of the spindle being slotted to engage the feed mechanism spindle. Machined into the front end of each cylinder is a recess to accommodate a gas scaling sleeve. This component forms a gas-tight seal between the breech cylinder and barrel face when the round is fired.

On the circumference of the cylinder are five rollers, equally spaced between the chambers, which engage the slide and cause rotation of the breech cylinder. Machined into the circumference are two sets of ten recesses which are engaged by the anti-rotation plunger. The front set are utilized for left-hand feed and the rear set for right-hand feed.

Breech Cylinder Housing. The breech cylinder housing provides front and rear bearings for the breech cylinder spindle. The housing is attached to the cradle by means of two trunnions which engage ribs on the cradle side plates. At the top front of the housing is the barrel catch. Also at the front are two tapped holes into which screw the buffer spindles and a bracket which supports the gas cylinder. At the rear of the housing are recesses which contain the cartridge retainer and a housing for the

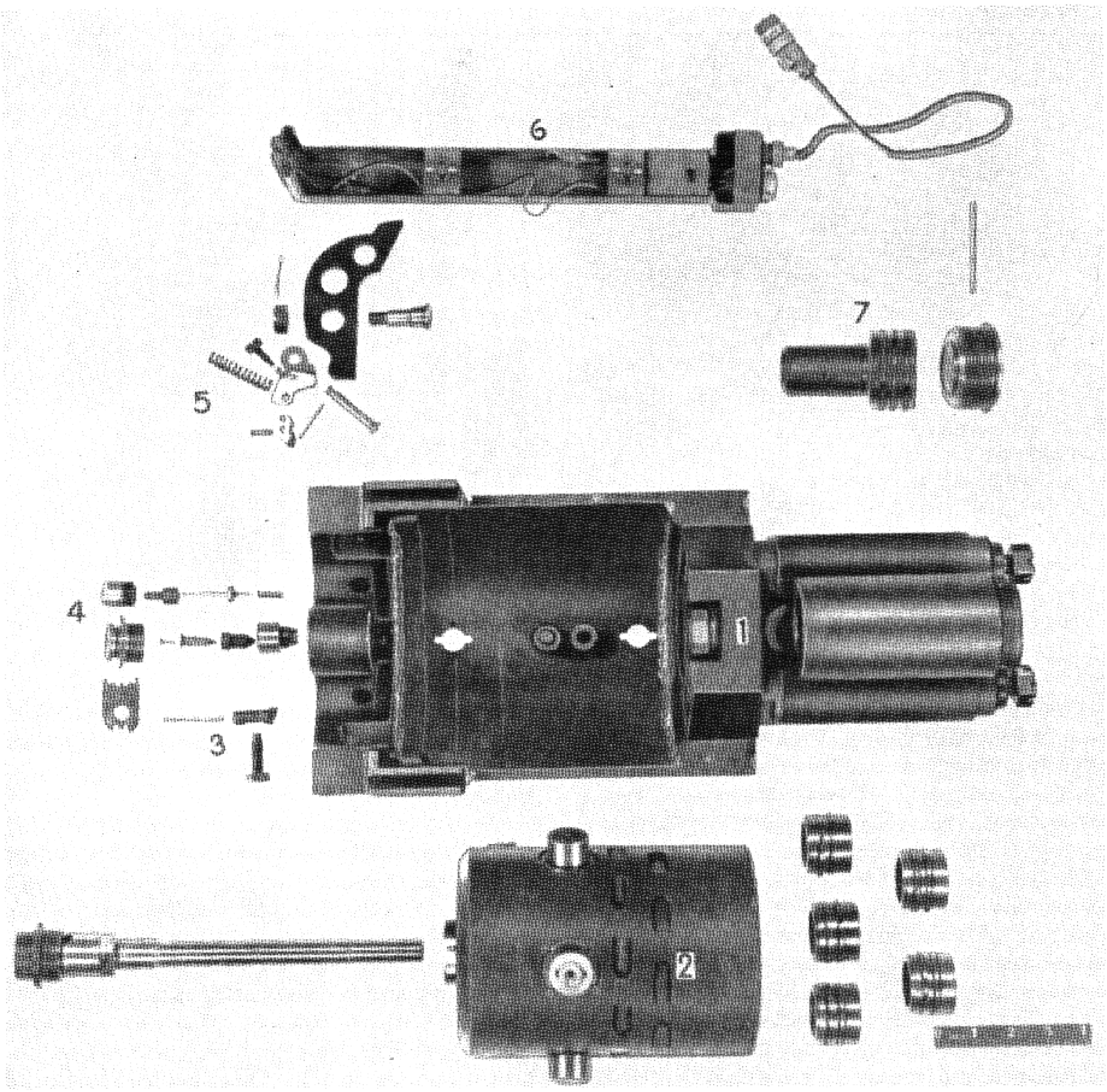

Figure 18–3. 30-mm British Aden Gun. Disassembled view of cylinder housing group. (1) Cylinder housing. (2) Cylinder group. (3) Round retainer assembly. (4) Firing pin assembly. (5) Extractor assembly. (6) Electric housing unit. (7) Gas piston and plug.

firing unit. Machined into the sides are seatings for the ejection assembly and the stud for the ejector actuating arm. The breech cylinder spindle is locked into position by the firing unit nut, which is, in turn, positioned by the tap washer and the cartridge retainer bolt. In the top of the housing are two recesses for the breech cylinder anti-rotation plunger and spring. One of the contact firing boxes is attached to the top of the housing by two quick-release studs, and at the rear of the box is the switch which contacts the firing unit plunger. The firing contact of the firing unit is insulated from the cylinder breech housing. At the front and rear of the top of the housing are the recesses for the barrel plunger switch and the round in chamber plunger, respectively.

Gas Cylinder. The gas cylinder houses the gas piston. At the front end of the cylinder is a plug which is locked in position by a pin passing through the plug and the cylinder body. The gas piston has three piston rings. The gas from the gas port in the barrel passes along a channel in the bracket to the gas cylinder and piston.

Slide. The slide is the mechanism which rotates the cylinder. The feed slide is connected to the slide by a connecting rod and pin. Slots are machined in the top of the slide to take either the plate right or left according to the feed required. At the front of the slide is an axis pin for the cam lever. Under the cam lever is the cam lever plunger, which protrudes through the slot in the slide and engages the cam lever guide.

Feed Slide. The feed slide is attached to the slide by a connecting rod and pin. The movement of the feed slide is governed by the movement of the slide. The feed slide travels under the feed mechanism. The curved pusher at the rear of the feed slide contacts the base of the rounds and drives them out of the links into the breech cylinder, and the pusher face forces them fully home into the cylinder. Feed slides are left- or right-handed.

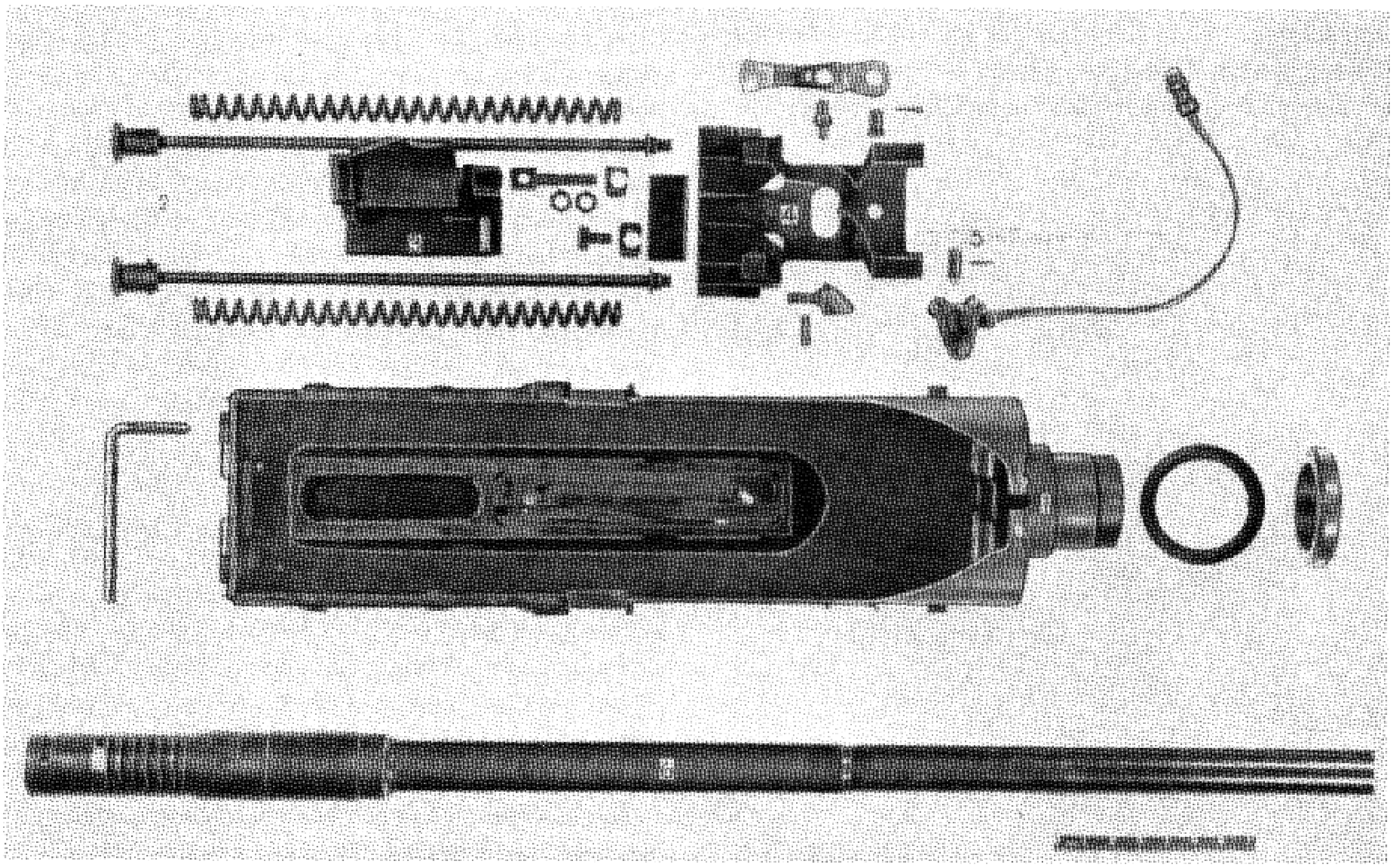

Figure 18–4. 30-mm British Aden Gun. Disassembled view. (1) Receiver. (2) Return springs and guides. (3) Feed slide unit. (4) Slide unit. (5) Receiver slide electrical contact. (6) Barrel.

Functioning of the 30-mm Aden Gun

Recoil Action. Assume that a belt is in position and a round is in the firing chamber of the breech cylinder. When the firing switch is operated, the firing circuit is completed and the round is fired.

The projectile passes from the chamber into the barrel and the driving band forces the gas-sealing sleeve hard against the rear face of the barrel, thus sealing the chamber and preventing loss of gas pressure. When the base of the projectile has passed the gas vent in the barrel, some of the gases pass along the gas channel to the gas cylinder emptying upon the head of the gas piston and driving it to the rear.

On the firing of the round, direct recoil moves the barrel breech cylinder housing and breech cylinder to the rear a maximum distance of approximately three-fourths inch, the breech cylinder housing running on guides on the side of the cradle and the bearing in the barrel trunnion housing. The buffers are anchored between the front of the cradle and the front of breech cylinder housing. As recoil takes place, the buffer spindles are withdrawn and compress the Belleville washers between the head of the spindles and the buffer housing end cap.

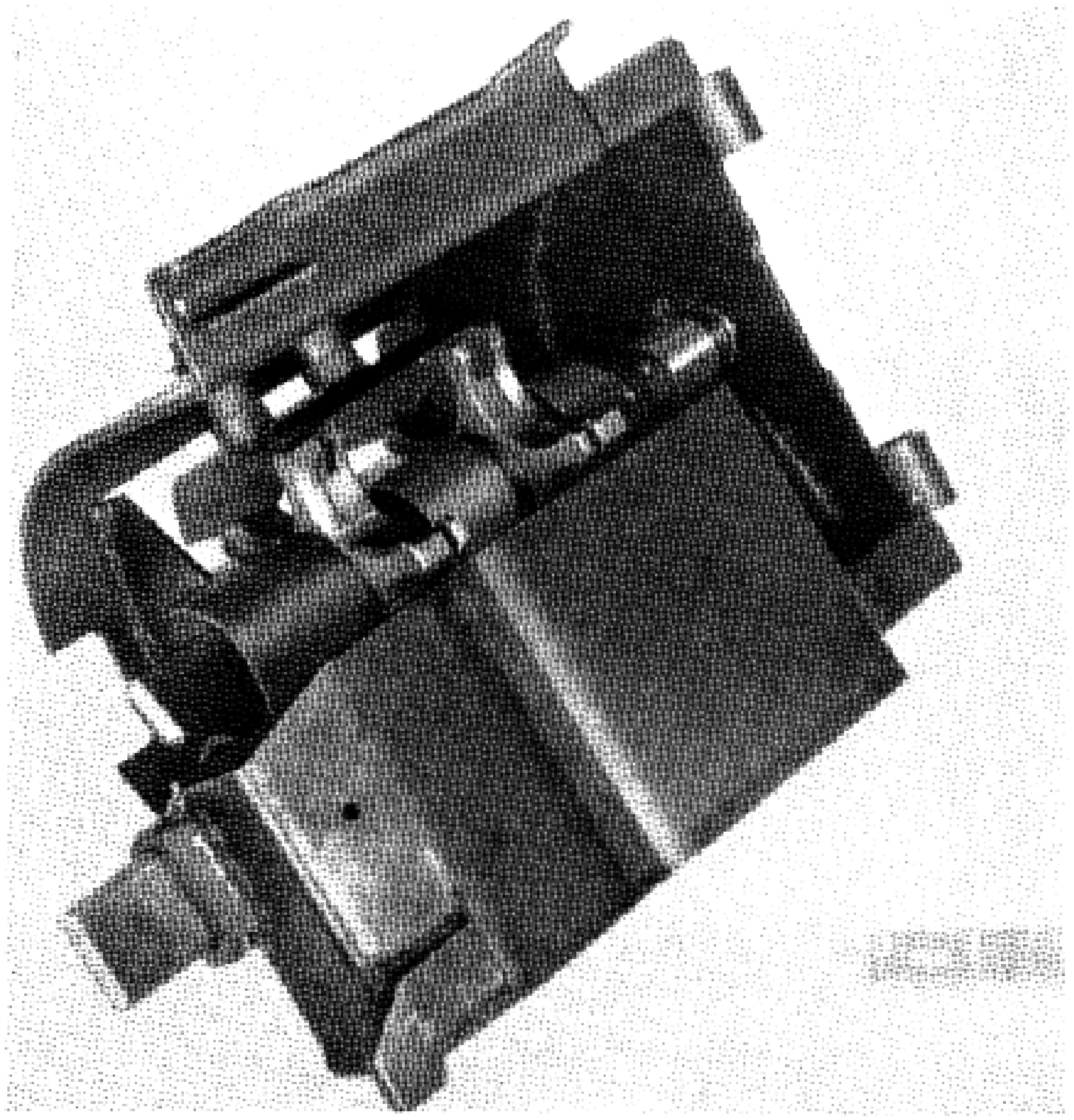

Figure 18–5. Feed mechanism of 30-mm British Aden Gun. Bottom view showing feed sprockets and link chute guide.

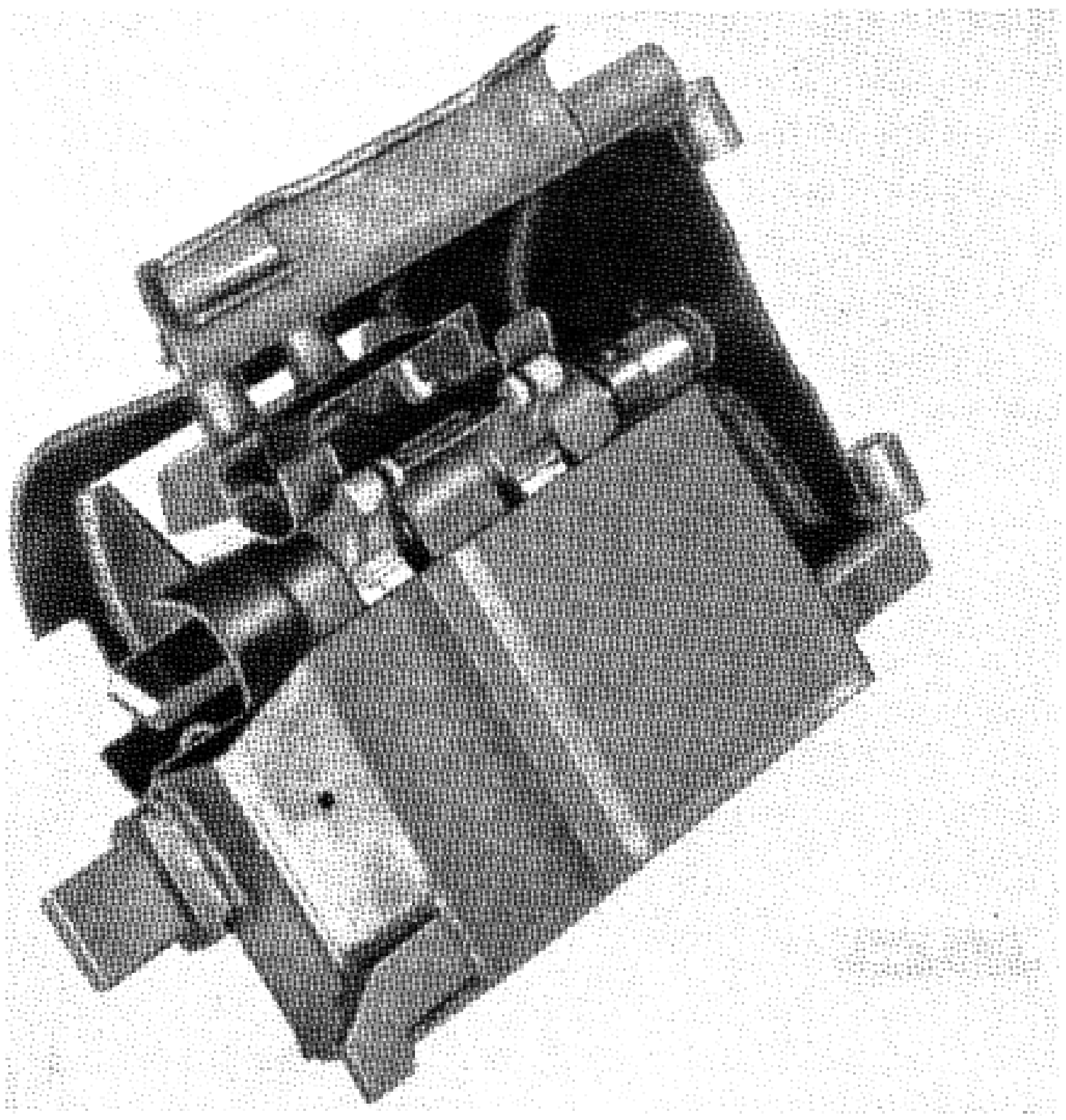

Figure 18–6. Feed mechanism of 30-mm British Aden Gun. Bottom view showing a link entering the feed chute guide.

As the gas piston moves to the rear, it comes into contact with the front face of the slide, drives it to the rear and compresses the return springs. During this movement, the breech cylinder is prevented from rotating until the slide has recoiled 1¾ inches. The cam lever plunger is running in the track of the cam lever guide, and when the slide has recoiled 1¾ inches, the roller is free to move. A further movement of the slide brings the curved face of the cam lever in contact with the roller, rotating the breech cylinder 36° and bringing the next roller into contact with the ramp at the front of the slide. At this stage, the two rollers are engaged by ramps on each side of the slide, the cam lever plunger is forced by the springs to move across the slide, and the cam lever is moved. The feed slide is linked to the slide by means of the connecting rod; and, as a result of the action just described, the feed slide has moved to the rear and the rammer faces have been positioned behind the rounds to be fed from the feed mechanism into the breech cylinder.

As the slide moves to the rear, the ejector actuating arm disengages from the ejector ramp on the slide. The ejector, which is in contact with the actuating arm, is returned to its housing by the

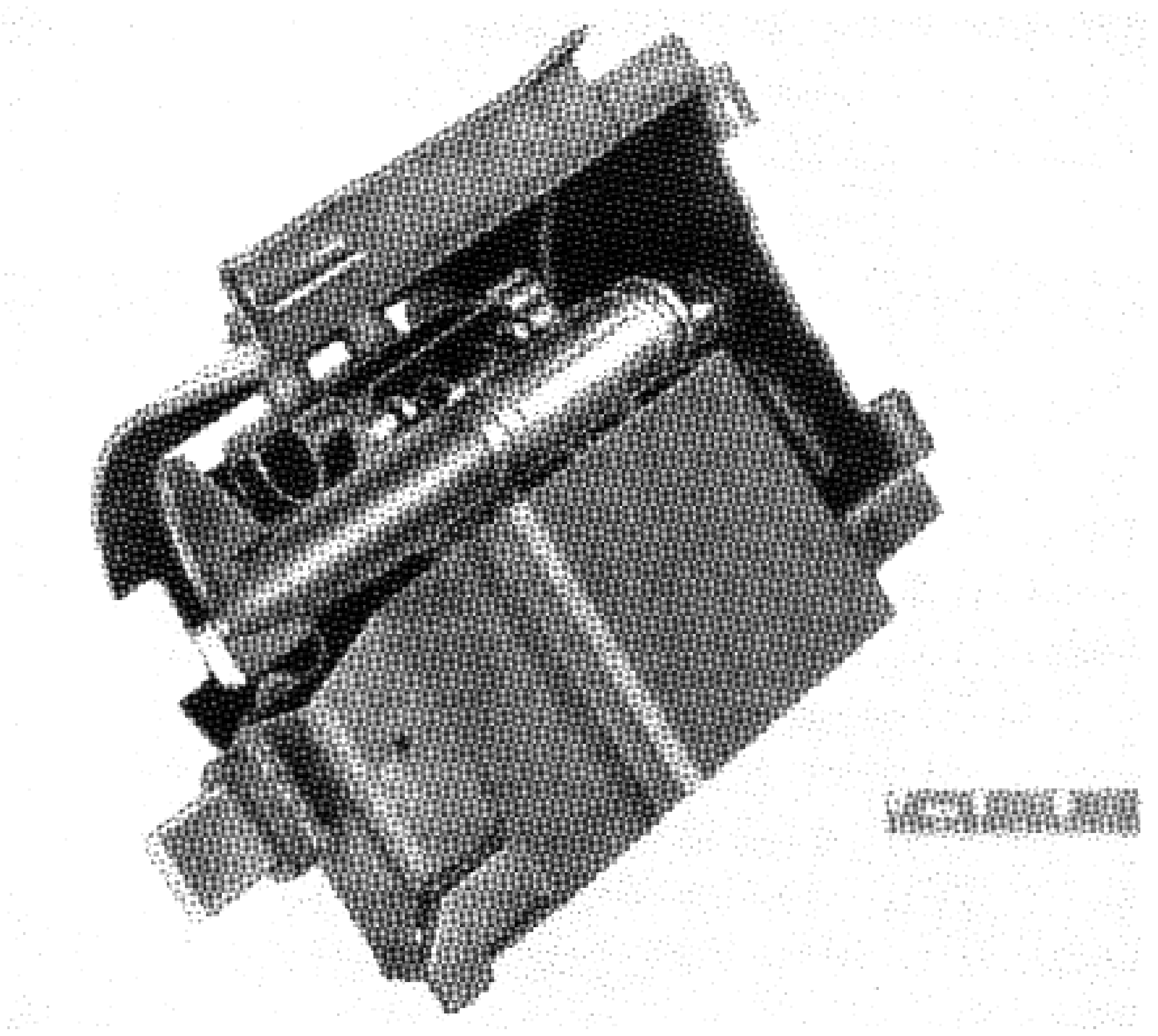

Figure 18–7. Feed mechanism of 30-mm British Aden Gun. Bottom view showing a round in position for stripping.

ejector spring, forcing the actuating arm to its lowest position.

The feed mechanism spindle is connected to the breech cylinder spindle; therefore, as the cylinder rotates, the feed mechanism sprockets will also rotate and feed into the ammunition belt. At all times, the feed mechanism sprockets are in alinement with the breech cylinder chambers.

The breech cylinder housing recoils; and the round in the chamber of the breech cylinder which will, on completion of the gun cycle, be in the firing position, is retained in the chamber by the cartridge retaining plunger, engaging behind the base of the round. This action prevents the base of the round from fouling the rear of the cylinder housing as the cylinder rotates.

Counterrecoil Action. The return springs force the slide and feed slide forward. The curved pusher face of the feed slide is positioned behind a round in the feed mechanism. As the feed mechanism moves forward, it pushes the round out of the link into a chamber of the breech cylinder. On the next forward movement, the front rammer face will ram the round further home into the chamber and the cartridge retainer will engage behind the base of the round.

The Belleville washers, under compression, exert themselves and return the breech cylinder housing, breech cylinder, and barrel to the runout position.

The inertia of the cylinder in rotation acting through the cylinder roller as it cams along the cam lever, together with the efforts of the compressed return spring, drive the slide forward. As the slide counterrecoils, the cam lever plunger is engaged in the track of the slide. The cylinder continues to rotate an additional 36°, and the roller is guided into the straight slot at the rear of the slide by riding along the cam lever. The plate, in guiding the roller during firing and during charging, rotates the cylinder through the remaining 36° of its cycle. As the cylinder rotates, the next round to be fired is brought into position with the barrel and firing unit. When the roller has entered the slot at the rear of the slide, the cam lever plunger has traveled along the track in the cam lever guide and is at that point deflected by the curved ramp on the track. This moves the cam lever on its axis to the opposite side of the slide. The front face of the slide comes into contact with the rear face of the gas piston, forcing it fully forward into the gas cylinder.

When the slide has almost completed its forward movement, the ejector ramp on the slide contacts the ejector actuating arm, which, in turn, rotates the ejector on its axis. The ejector claw engages the rim of the empty case, which has been brought into engagement with it by the rotation of the cylinder, withdraws the case from the chamber, and ejects it to the rear between the sprockets of the feed mechanism.

The links are retained by the feed mechanism link guides and fall away from the link ejection opening at the top of the feed mechanism.

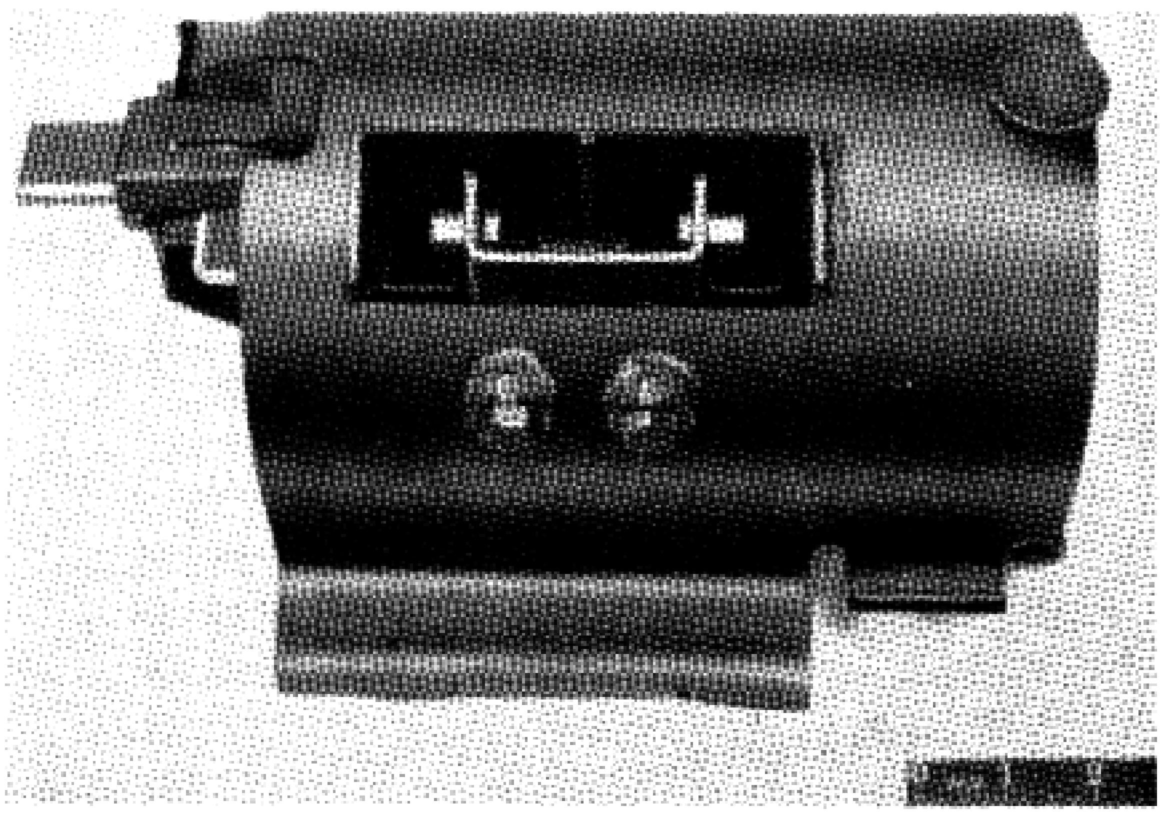

Figure 18–8. Feed mechanism of 30-mm British Aden Gun. Top view showing a link in the feed chute guide.

The barrel, when correctly in position, raises the barrel operating plunger, which closes a switch in the top contact box. When the slide enters its battery position, contact is made which completes the circuit and fires another round, provided the firing switch remains closed.

SECTION 3. TESTS CONDUCTED AT ABERDEEN PROVING GROUND, MARYLAND

Objectives

The object of these tests was to obtain functional and performance information concerning the 30-mm Aden gun and other information of value to ordnance gun designers.

Summary of Test Results

A total of 1,106 rounds was fired to obtain basic functional data such as muzzle velocity, rate of fire, target dispersion, trunnion reaction, and time-displacement of moving parts. High-speed movies of certain gun actions were taken. Muzzle velocities were slightly above the 2,020 feet per second specified in British reports. However, the rates of fire obtained were below the 1,200 rounds per minute rated for the gun. Stoppages were excessive, and parts failures high. Target dispersion, though initially extremely high, was improved somewhat by modification of the mount.

Details of Test Procedure

After inspection and repair of the gun, as received from England, testing was started. The procedures followed are discussed by test item or subject as follows:

Rate of Fire. Individual and overall rates of fire were recorded by camera chronograph during all test phases. Rounds were magnetized and fired through 20-inch solenoid coils.

Dispersion and Yaw. Dispersion and yaw were taken at 1,000 inches by firing through cardboard targets during all phases. A plastic scale prepared from measurements of a projectile was used for determining yaw in degrees.

Attempts were made to reduce dispersion through the use of a barrel stabilizer.

Muzzle Velocity. Muzzle velocity was recorded by camera chronograph on approximately 100 rounds during burst fire and 17 rounds single shot. The rounds were magnetized and fired through solenoid coils.

Physical Measurements and Calibrations. Weights and measurements of the gun and gun components were taken.

Time-Displacement, Time-Pressure (Gas Cylinder) Trials. A time-displacement (revolving drum) camera was utilized in recording travel versus time of recoiling parts. Reflectors were mounted on the cylinder housing and the feed slide, and sufficient light was focused on their path of travel. A slot was cut longitudinally in the feed mechanism and a link deflector provided. The travel of the reflectors was recorded on film records containing time calibrations. The distance calibrations were placed on the same film by an additional step using a calibration bar with reflectors spaced at 2-inch intervals.

Time-pressure of the gas cylinder chamber was recorded on film record by means of C–AN pressure-resistance gages. Timing markers were synchronized with the time-displacement camera for simultaneous records that could be plotted with the same time constant. The gas cylinder plug was replaced with an adapter for installing the gage. Only the base of the gage housing, which contains the ferrule, was utilized. Considerable difficulty was experienced with existing C–AN pressure-resistance gages due to gun shock. The principal point of breakage was at the junction of the fine wires of the ferrule and the lead-off wires. The porcelain-like insulation was discarded and the single-lead wires replaced with multistrand fine ductile copper wires. Gages fabricated in this manner were able to withstand the shock. Piezo-electric gages were found unsatisfactory. Two gages were damaged in test trials. A neoprene washer approximately ⅛-inch thick was placed in the cylinder to act as a buffer in eliminating the shock of contact between the piston and the metal shoulder of the cylinder at the rearmost point of piston travel.

Trials were made with the standard Aden gas piston and three gas pistons supplied by Armour Research Foundation. The latter had diameters of 2.147 inches, 1⅝ inches, and 1⅛ inches, respectively. The trials were then repeated with a gas-port restriction plug containing an orifice of 0.140-inch diameter, thereby reducing the cross-sectional area of the gas port by one-half.

Velocity of Ejected Cases. A 16-mm ultra-high-speed-motion picture camera was utilized. The velocity was taken between the centers of the feed-sprocket slots.

Recovery of Projectiles. Several rounds were fired for recovery in cotton waste for examination of rotating bands.

Chamber Pressure. Ten rounds were disassembled and each reloaded with a copper crusher gage, for determining chamber pressure. A spring-wire clip was utilized to retain the gage in the base of the case. The round was fired through burlap to retard the gage in the event it left the tube. Alternate rounds without gages were fired for comparison of muzzle velocities.

Piezo-electric chamber pressure was recorded on 18 rounds fired from a Mann barrel, utilizing an instrument trailer with cathode ray oscilloscopes and recording cameras. Approximately one-half the rounds were fired with the British converter firing circuit and the remaining with the 250-volt condenser unit. The firing circuit output was also recorded on the film record.

A strain patch was placed on the firing cylinder of the 30-mm Aden gun during one phase of the trunnion-reaction test for use in the study of gun action. This gave a film record of the powder pressure curve that could be tied in with other time-displacement data. However, magnitude could not be determined in this manner.

Time-Travel of Firing Cylinder Rotation. A 16-mm ultra-high-speed motion picture camera was utilized to photograph the action. A graduated steel tape was fastened to the outside circumference of the firing cylinder, and a hole was cut in the cylinder housing through which the tape could be photographed.

Time-Travel of Muzzle. A stylus was attached to the gun barrel, 1 inch from the muzzle. A grid was positioned on one side of the muzzle and the motion of the stylus recorded on motion picture film through the use of an ultra-high-speed camera.

Gas Leakage. Access to the supposed points of leakage was obtained by cutting holes in the cylinder housing (junction of cylinder sleeve and tube) and in the receiver (junction of gas cylinder and slide). The ultra-high-speed camera was utilized in recording the gas leakage.

Comparison firing was accomplished with and without gas check rings. Rates of fire and muzzle velocities were recorded. The "A" gas piston of 2.147-inch diameter was modified locally to simulate the characteristics of the Aden piston. The weight of the "A" piston was reduced by 3½ ounces, the piston face edges chamfered and gas escape ports drilled in the piston shaft. One burst was fired with the modified unit in this test phase.

Effects of Feeding, Stripping, and Chambering upon the Round. In these trials, the firing switch was released during the bursts and the unfired rounds remaining in the chambers and feed were inspected and photographed.

High-Speed Movies. High-speed movies of the following gun actions were recorded in addition to those previously referred to:

Path of ejected cases.

Action within feed mechanism.

Action of ammunition belt within feed chute.

Impact of projectiles upon target.

Comparison of Firing Circuits. British Joint Services Mission, Technical Services (Air) Washington, D. C., Report dated 19 January 1949 states that British electric primers have resistances between 20 and 200 ohms; that firing circuits have frequencies of 1,500 cycles per second using a "square" wave; that approximately 1,500 microjoules of energy are required to insure functioning (however, no time limitation specified); and that British primers should work satisfactorily with electrical firing arrangements envisaged by the United States.

No information is available as to the method of obtaining the above requirements nor is a diagram of the Aden gun firing circuit available.

Firing was accomplished with the locally assembled 1,500-cycle a. c. circuit and the 250-volt condenser discharge circuit, and rates of fire were recorded. Efficiency of the units in firing low resistance primers was observed. Very little firing was accomplished with the British converter unit, since it was not available until the test was nearing completion.

To determine the suitability of the gun for controlled fire, a burst (10 rounds) was attempted with the 250-volt condenser discharge fire control unit set at 800 rounds per minute.

Primer Resistance. A standard ohmmeter was used to obtain primer resistance of 12 complete rounds and six rounds with projectile and propellant removed. With the gun in full battery position and the round in the chamber, readings were recorded from the gun lead wires, the resistance of the gun circuit being deducted from the meter reading.

Trunnion Reaction Test. The gun was mounted in the trunnion reaction mount, assembled with strain resistance gages. Recordings during single and burst fire were made on film record in the instrument trailer equipped with cathode ray oscilloscopes. Displacement-time records of the motion of pertinent moving parts, as previously described, were obtained to aid in the interpretation of the force records.

The gages were bridged individually to scopes for recording strains on the individual gages both with and without the key in the front-mounting adapter. The purpose of the key in the adapter was to introduce maximum torque to be picked up by the gages.

The three pairs of gages, front horizontal, front vertical, and rear vertical, were each bridged oppositely, utilizing only three scopes in attempts to pick up torque forces directly with and without the adapter key.

In reducing the records, because of the difference in speed of the various cameras, it was necessary to enlarge the pressure records and then reduce them to the required size. When the records were reduced directly to the required scale, considerable difficulty in reducing the records to a common time constant was experienced. For the final charts, the pressure records were increased 8 to 1. Then the curves were traced on the record sheet to the desired scale with the aid of a pantograph. The reduction was accomplished on a round-to-round basis, since the speed of the individual camera increased during the burst. The time scale of the 35-mm pressure records was adjusted to coincide with that of the time-travel records.

In order to increase accuracy, the forces listed on the tabulation sheet were computed from direct film readings at 15 to 1 enlargement.

Belt-Pull. Trials were attempted with the common weight and pulley arrangement for adding loads to a 10-round belt (followed by 5 dummy rounds) with and without a spring in the linkage.

Another and seemingly more successful method was the use of a 50-round tray placed at a 16° incline from ground to gun. Varying and increasing loads of linked dummy rounds were added to a 10-round belt, and the rate of fire of the gun observed.

Results of Tests

Rate of Fire. The rate of fire has been summarized as follows for bursts of 10–20 rounds.

Circuit	Number rounds considered	Rate (Rds/Min)	
		Highest	Average
1,500 cycles a. c. circuit	139	1, 154	1, 114
250-volt Cond. d. c. circuit	59	1, 197	1, 138

A summary of individual and overall rates with gas pistons of various sizes follows.

	Overall rounds per minute	High individual rounds per minute	Low individual rounds per minute
Four-round burst with standard Aden gas piston	1,176	1,176	1,126
	1,169	1,182	1,144
	1,161	1,169	1,086
Four-round burst with "A" gas piston of 2.147-inch diameter	1,118	1,120	1,079
	1,098	1,110	1,036
	1,078	1,098	1,048
Four-round burst with "A" gas piston of 1⅝-inch diameter with adapter	989	1,022	974
	951	1,009	892
Four-round burst with "A" gas piston of 1⅝-inch diameter with gas-port restriction plug (orifice area reduced by ½ inch)	896	909	865
Four-round burst with "A" gas piston of 2.147-inch diameter with gas-port restriction plug	968	972	972

Dispersion and Yaw. This information is summarized as follows:

Target Dispersion of 1,000 Inches (Bursts of 10–20 Rounds)

Type of mount	*Average extreme spread (inches)*
Navy mount (British drawings)	22.0
Navy mount, single shot, 10 rounds	3.3
Navy mount, rear supports locked with clamps	14.4
Rigid front adapter and rear slides	34.4
Navy front socket support and rear slides	14.3

Note. Yaw at 1,000 inches. Amount of yaw ranged from 0° to 6° from the target checked. No excessive yaw (15° or greater) was noted.

Dispersion at 1,000 inches for 10-Round Burst Without the Tube Stabilizer

Horizontal spread (inches)	Vertical spread (inches)	Extreme spread (inches)	Main point of impact
13.65	19	19	Low and right.

Dispersion at 1,000 Inches for 10-Round Burst with Tube Stabilizer

	Horizontal spread (inches)	Vertical spread (inches)	Extreme spread (inches)	Main point of impact
Mounted 33⅞-inches from muzzle	5.10	15.15	15.20	Center and high.
Mounted 28½-inches from muzzle	9.36	7.52	10	Center.
Mounted 9¾-inches from muzzle; tube held in center of ⅜-inch vertical play	8.21	5.65	8.85	Low.
Mounted 9¾-inches from muzzle; tube held at top of ⅜-inch vertical play [1]	7.41	4.05	7.80	Center.

[1] Vibrations were introduced in the receiver when stabilizer was mounted near the muzzle during firing.

Muzzle Velocity. A summary of single and burst fire rounds follows.

	Number of rounds fired	Muzzle velocity (feet/seconds)		
		High	Low	Average
Bursts of approximately 10 rounds	66	2,073	[1] 1,986	2,042
Bursts of approximately 4 rounds	47	2,076	2,014	2,044
Single rounds	17	2,055	2,015	2,037
Aggregate	130	2,076	1,986	2,042

[1] Only 1 round below 2,000 feet per second.

Physical Measurements and Calibrations. The total weight of the gun was 192 pounds 12 ounces. Weights of the recoiling gun assemblies were as follows:

Cylinder housing, tube, cylinder assembled: 125 pounds 12 ounces.

Slide and feed slide: 14 pounds 4 ounces.

Time-Displacement, Time-Pressure (Gas Cylinder) Trials. The time-travel records are tracings from the original film while the pressure curves are plotted from film records. The following is a brief summary of the slide cycle time and gas cylinder pressure.

Velocity of Ejected Cases. The average velocity of the ejected cases for the three inches of travel between the centers of the feed sprocket slots was 45 feet per second, computed from the eleven cases which encountered no interference. Six of 17 cases struck a feed sprocket or the feed sprocket cover.

Recovery of Projectiles. No sheared bands were found during this test phase. However, one rotating band was found imbedded in a velocity coil during the latter part of the firing program.

Chamber Pressure. Average pressure in ten trials with three combinations of gages and copper cylinders was: 26,800 p. s. i. obtained with non-precompressed coppers and 30,200 p. s. i. with precompressed coppers.

Round numbers	Gas piston type	Slide		Gas cylinder pressure	
		Time required for 4 cycles (milliseconds)	Shortest cycle (milliseconds)	Average of 4 rounds (p. s. i.)	High Ind. (p. s. i.)
306–309	Standard Aden	211	51	1, 568	1, 765
318–321	"A" of 2.147-inch diameter	230	56	1, 836	2, 198
326–329	"A" of 1⅝-inch diameter with adapter	[1] 253	60	1, 991	2, 439
331–334	"A" of 1⅝-inch diameter with gas port restriction plug.	272	65	1, 354	1, 489
335–338	"A" of 2.147-inch diameter with gas port restriction plug.	248	60	1, 316	1, 420

[1] A seven-milliseconds delay of second round primer deducted.

It was anticipated that addition of the gage would increase pressure and therefore velocity, in view of the change in density of loading. However, it appears that the pressure of the gage is suppressing, possibly through ignition interference, since an average velocity decrease of approximately 25 feet per second was obtained with the gage round. The reduced bullet-pull caused by disassembly and reassembly of the round could also affect the velocity and pressure.

Time-Travel of Firing Cylinder Rotation. The velocity of the firing cylinder at full momentum is approximately 3,000° per second. The cylinder is in full battery position at least five milliseconds before and after firing.

Time-Travel of Muzzle. Muzzle movement was within the limits of 0.4 inch above and 0.2 inch below (approximately) the before-firing position. The muzzle completed approximately one and one-half cycles between rounds. The second round of the burst fired near the peak of the second muzzle cycle. This resulted in a very irregular cycle pattern since further upward movement was restricted. The third round fired near the original position and a fairly regular cycle followed.

Gas Leakage. Since inherent variations exist in rates and velocities, these data were not extensive enough to be conclusive. In general, the gun rates and velocities were maintained under each condition except for a slight drop in cyclic rate with the rings removed from the Aden piston. Removal of the breech cylinder sleeve insert rings appeared to have little effect upon gun operation. Performance of the "A" piston, which contained gas-check grooves, after modification, was comparable with that of the standard piston.

Review of the high-speed movies of gas leakage revealed that there were two points of leakage. They are, firstly, the junction of the tube and the cylinder sleeve and, secondly, the junction of the tube gas-vent hole and the channel leading to the gas cylinder. This gas escapage was in the form of high-speed jets and varied in intensity from round to round. In the former, since the gases were in jet form and varied widely in intensity, they evidently emitted from between the junction of the tube and the sleeve rather than around the sleeve by the rings.

The gas escapage from the gas cylinder (around the gas piston) appeared negligible. The accumulation of gases was not of a sufficient quantity to obscure vision of the slide movement.

In all cases the gases quickly dissipated, and the view of the gun was not obscured.

The amount of gas leakage of the two points previously discussed depends upon how well two metal surfaces mate. The barrel whip test indicate a vertical movement of 0.4 inch above the original muzzle position and 0.2 inch below. The degree of mating depends greatly upon the position of the barrel at the time of firing.

Effects of Feeding, Stripping, and Chambering Upon the Round. The rounds remaining in chambers and feed are referred to as No. 1 through No. 5 in counterclockwise order from the round in firing position.

ROUNDS No. 1 AND No. 2. Projectiles were found to be from zero inch to 0.060 inch forward of original position in the case. Any looseness present was within the above limits of movement. These rounds were fully chambered and contained markings on the base of the case made by the forward face of the rammer.

ROUND No. 3. This round had been stripped from the link in the initial stage of ramming and was found to be approximately three-eighth inch out of battery in each case. The projectile contained impressions from impact on the chamber mouth as did the first two rounds.

ROUNDS No. 4 AND No. 5. These rounds remained in their links within the feed mechanism and contained neither looseness nor markings. Cases and rotating bands of stripped rounds were found scratched. One band scratch was fairly deep. One sheared rotating band was observed. It was possible that a heavy link scratch contributed to the failure. The projectile remained secured by the crimped case in all instances.

Comparison of Firing Circuits. A total of seven stoppages caused by misfires were encountered, all of which occurred while utilizing the locally assembled 1,500-cycle circuit. The resistance of the primers checked ranged from 10 to 45 ohms. The 250-volt condenser circuit fired all primers including 1 primer with 10 ohms resistance which failed to fire with the former circuit.

A cyclic rate of 755 rounds per minute was attained (fire control set at 800 rounds per minute) in controlled fire. A stoppage occurred after eight rounds when the slide and feed slide separated due to the right segment of the feed slide breaking after the connecting rod belt drifted partly out. This resulted from cotter pin failure. It appears that controlled fire is too harsh on gun parts since the slide must strike battery position and bounce (no locking arrangement present) after each round with metal-to-metal contact. In uncontrolled fire, the buildup of gases in the gas cylinder probably affords some cushioning.

Primer Resistance. Results of trials are summarized as follows:

Component Tested	Number of Items	Resistance (ohms)		
		High	Low	Average
Complete round	12	215	50	103
Case with primer	6	80	30	52

Resistance of circuit, 5 ohms.

Trunnion Reaction Test. A summary of forces from the trunnion reaction test is presented below. Two tables summarize the test results, as follows:

Gages Bridged Oppositely, Gage Force 100 Pounds

	Gage pair	Tension		Compression	
		High	Average	High	Average
Unkeyed	Front horizontal	46	33	32	30
	Front vertical	26	22	37	33
	Rear vertical	15	15	15	14
Keyed	Front horizontal	45	32	32	29
	Front vertical	28	25	37	30
	Rear vertical	31	31	26	20

Gages Wired Individually, Gage Force 100 Pounds

	Gage pair	Left				Right				Total			
		Tension		Compression		Tension		Compression		Tension		Compression	
		High	Average	High	Average	High	Average	High	Average	High	Average	High	Average
Unkeyed	Front horizontal	38	31	76	68	30	26	73	59	68	57	149	127
	Front vertical	34	34	21	18	39	37	22	19	73	71	43	37
	Rear vertical	32	29	27	19	28	18	18	17	60	47	45	36
Keyed	Front horizontal	44	34	73	67	31	29	84	80	75	63	157	147
	Front vertical	33	27	23	15	19	16	22	22	52	43	45	37
	Rear vertical	24	24	22	17	36	28	22	22	60	52	44	39

Stoppages and Parts Failure. A total of 40 stoppages was encountered. The principal ones were: failure to eject, misfire, failure to chamber, and link separation.

A total of 47 parts failures occurred during the test. The principal ones were: Cam lever; circlips and cotter pins; slide electrical contact; cam lever plunger and firing pin spring; rollers and firing cylinder.

CAM LEVER. The slide was found binding in the slideway several times during the test. This condition was caused by battering of the rollers against the lever near the pivot point. It was necessary to grind down the uneven surfaces and remove burrs.

CIRCLIPS AND COTTER PINS. Failures of these items in the slide and feed slide caused stoppages and failures of larger gun parts.

SLIDE ELECTRICAL CONTACT. Excessive set in the contact wires resulted in unsatisfactory contact. Breakage of the wire loop was the primary cause for failure; the first breakage occurred after 558 rounds.

CAM LEVER PLUNGER AND FIRING PIN SPRINGS. The former was found broken after 481 rounds, and the latter was noted to register excessive set after 731 rounds, allowing the firing-pin assembly to become loose.

ROLLERS, FIRING CYLINDER. All rollers contained indentations and scoring. One roller unit was found binding, caused by excessive wear. The remaining contained excessive play.

CONTACT POINT OF THE FIRING PIN. This was worn considerably after 1,088 rounds of firing. Firing pin protrusion measured 0.036 inch as compared with 0.052 inch protrusion of the firing pin from a comparatively new gun.

Observations

The following observations were made:

1. Extractor adjustment appears critical, not only from the standpoint of properly ejecting the empty case, but also from the pressure exerted upon the slide by the extractor arm. Adjustment is difficult since the extractor spring must be removed and is subject to breakage during this operation.

2. The extractor arm engages the slide during counterrecoil at the extreme right side. Since the slide has a certain amount of play on its rails, which increases with wear, these parts have a tendency to bind when engaged by the extractor arm and accordingly the rate of fire is slowed down.

3. The forward face of the cylinder housing and the buffer housing contact each other when the gun is in battery position. Upon recoil these units separate at that point. There is no provision for buffering when these parts meet after counterrecoil. The metal-to-metal contact results in severe gun shock.

In addition, there appears to be no positive buffering as the slide returns to battery. The slide including feed slide, which weighs 14 pounds 4 ounces, returns to battery position with a momentum of approximately 175 p. s. i. The only possible buffer action is perhaps some gas buildup in the gas cylinder before the slide makes actual metal-to-metal contact with the gas cylinder. This condition probably contributes greatly to the increased dispersion during burst fire.

4. In the conventional gun due to accelerated rates of fire, the breechblock occasionally unlocks before all the powder has burned. This unburned powder is ignited to produce breech flash or burning in the receiver. This is not probable in the revolver-type gun since the case continues to perform obturation until all the powder has burned and the gases dissipated. The case remains in the chamber after firing for almost a complete cycle before being ejected as the slide returns to battery. Only a very small amount of the gas escapes with the ejected case. The rest of the gas comes out of the gas mechanism, obturating sleeves, and the cartridge case; when firing at 1,400 rounds per minute, this latter amount is considerable.

5. Since the receiver is fabricated of light metal, there is a certain amount of flexing possible during firing. The cylinder housing, which mounts the tube, recoils within the receiver which is supported by two short rails in the rear and the tubular neck in the front. There is considerable looseness in this assembly. The loose fit of the tube in the cylinder housing provides another source of wide dispersion. The method of securing the tube which permits quick changing does not provide for a firm fit. The muzzle end can be moved freely three-eighth inch in the vertical plane.

6. A certain amount of looseness in the assembly of the projectile and case is present in some rounds after chambering. However, this evidently has little adverse effect upon gun operation in view of the fairly consistent muzzle velocities obtained. A small amount of projectile separation occurs during initial ramming and stripping. However, the greater loosening effect comes with final ramming and chambering. The projectile ogive strikes the chamber mouth wall during initial ramming. However, since the windshield of the ball round is of soft metal, the impressions made probably do not represent a serious deficiency.

Conclusions

The following conclusions were reached:

1. The rate of fire is slightly lower than the 1,200 rounds per minute indicated for the gun.

2. Barrel whip is excessive, causing high target dispersion. The loose fit of the barrel and recoiling assemblies contributes to the high dispersion. There is a lack of positive buffer arrangements to provide smooth action as the cylinder housing and the slide units return to battery position; this condition induces excessive shock in the gun, contributing to the high dispersion during automatic fire and causing premature failure of parts.

3. Because of the light structure of the gun and the loosely fitting assemblies, a certain amount of flexibility in the mount as provided by the front socket assembly is necessary.

4. The slide rear supports are preferable to the link suspended supports, in view of the improved accuracy with the slide arrangement.

5. The muzzle velocity is slightly greater than the 2,020 feet per second indicated for the gun.

6. Tube wear and driving spring loss of efficiency are negligible after the firing of approximately 1,000 rounds.

7. Bullet pull requirements are high in this weapon. Since no forcing cone is present, the cartridge case performing the seating function, particular emphasis must be placed upon the crimping of the rounds.

8. Chamber finish is excessively rough, necessitating oiling rounds for proper extraction.

9. Chamber pressures appear somewhat greater than indicated by British drawings.

10. Improvement of slide camming angles to provide smoother firing cylinder deceleration before entering battery position is desirable to reduce the wear of critical components.

11. The principal points of gas leakage are at the junction of the firing cylinder sleeve and the tube, and at the junction of the tube gas vent hole and the channel leading to the gas cylinder. The gas check rings do not play a direct role in these points. The loose fit of the "quick-change" barrel contributes to the gas leakage.

12. The 250-volt condenser discharge circuit is satisfactory for use with the gun. However, the gun is unsuitable for controlled rate fire. A buffer and/or locking unit for the slide would be necessary if controlled fire were desired.

13. Primer resistance in the British round is considerably lower than that of small caliber American rounds (M52A3 primer).

14. Trunnion forces of approximately 7,000 pounds in tension and 15,000 pounds in compression can be expected. Torque loads of approximately 4,500 pounds in tension and 3,500 pounds in compression appear to exist.

15. Existing test equipment is not adequate to record belt pull in this gun.

16. The revolver principle offers good possibilities in the field of heavy caliber machine guns. However, certain design changes and fabricating techniques appear necessary in the Aden gun to insure proper functioning in sustained firing.

17. The circlips and cotter pins used in securing components of the slide and feed slide are unsatisfactory.

18. The existing method of adjusting connecting rod clearance is unsatisfactory.

19. Stoppages involving jammed and deformed rounds or cases require excessive efforts to clear; this condition would be extremely difficult in a plane installation.

20. Utilization of spring tension to secure the firing pin assembly internally is unsatisfactory.

21. The strength and wearing quality of the cam lever and firing cylinder roller units are unsatisfactory.

22. Gun electrical switches and wiring are not substantial enough to withstand sustained firing.

23. Although the stoppage rate experienced in this test was excessively high, it may be reduced somewhat in future tests when the emphasis may be placed upon gun performance rather than special test phases.

24. From the limited firing accomplished in these tests, it appears that the 30-mm Aden gun is unsatisfactory in its present stage of development. Numerous improvements in the design and durability of components are necessary to insure gun dependability.

Recommendations

The following recommendations were made:

1. That looseness in the mounting of recoiling assemblies be reduced and that additional support be provided for the barrel.
2. That the receiver be strengthened through the use of light metal alloys.
3. That the strength and wearing quality of the slide switch lever and the cylinder rollers be improved.
4. That slide camming angles be redesigned.
5. That cotter pins and circlips be replaced in the slide with more adequate securing devices.
6. That finer adjustments in the connecting rod be provided.
7. That a more positive means of locking the firing-pin assembly internally be provided.
8. That a positive means of locking the buffer shafts after preset adjustment be provided.
9. That chamber finish be improved to decrease the necessity of oiling rounds.
10. That provision be made for releasing the antirotation plunger of the firing cylinder housing from the exterior of the gun to facilitate clearance of gun stoppages.
11. That the electric system be simplified and more durable electrical switches provided.
12. That development work be expedited on the Navy magnetic-clutch, belt-pull apparatus for possible use in recording belt pull with guns of this type.

258970°—54——36

Chapter 19

25-MM HOTCHKISS AUTOMATIC GUN

SECTION 1. HISTORY AND BACKGROUND

At the conclusion of World War I, the French Air Ministry was faced with deciding on an improved aircraft cannon to arm France's outstanding Air Force. The choice was not easy, but attention was eventually focused on the reliable Hotchkiss system that had served France so faithfully throughout the years. In the opinion of the French, this automatic firing mechanism when made in rifle caliber resulted in the most dependable machine gun in the world, and they could see no logical reason why it would not prove to be just as successful if scaled up to handle a larger cartridge. All development work done on this aircraft cannon version was carried on in the greatest secrecy.

After a decision was reached to produce a weapon using a 25-mm cartridge, it was next decided that the prototype should be demonstrated and tested as an antitank or antiaircraft version. The French thought that they could get in the necessary function firing without revealing to foreign observers their intended use for the weapon.

Work progressed very slowly on the weapon because of lack of finances. It was as late as 1928 when a prototype made its appearance on a French proving ground, a huge weapon weighing 237 pounds and capable of being mounted on shipboard as an antiaircraft gun.

The gas orifice was purposely set so as to deliver a rate of fire between 150 to 200 rounds a minute. In armor piercing tests, 1½ inches of the best armor plate was pierced at 700 yards as was ¾-inch plate at 2,000 yards. After satisfying themselves that the operating principles were sound, French engineers proceeded with the refinement of the bulky pilot model and engineered a low-silhouette, highly streamlined, light-weight, well-balanced automatic firing mechanism capable of producing an acceptable rate of fire. This gun showed great promise; however, all work on it stopped when the Germans overran France in the early days of World War II.

SECTION 2. DESCRIPTION OF THE WEAPON

This 25-mm automatic gun is gas-operated, magazine and belt-fed, and is designed for both antitank and aircraft use. The breech bolt has a mechanical linkage-operated positive lock.

Tube

The tube is screwed into the receiver and held by a locking screw. This type of assembly results in very slow tube changing. A flash hider extends from the muzzle. The tube has a sleeve with the conventional fin arrangement that furnishes increased area for radiation. The gas cylinder that houses the gas piston is also secured to the tube.

Receiver

The receiver has an opening in the top to accommodate the feeder. The device for attaching the feeder is held in the front by a projection extending into the receiver and at the rear by a pin. The ejection slot is machined in the bottom of the receiver to allow the empty cases to be ejected downward and out of the gun.

The backplate is fastened to the receiver by a pin and acts in the dual capacity of buffer and housing for the sear. Two rods extend forward from the backplate to act as a guide and support for the driving springs.

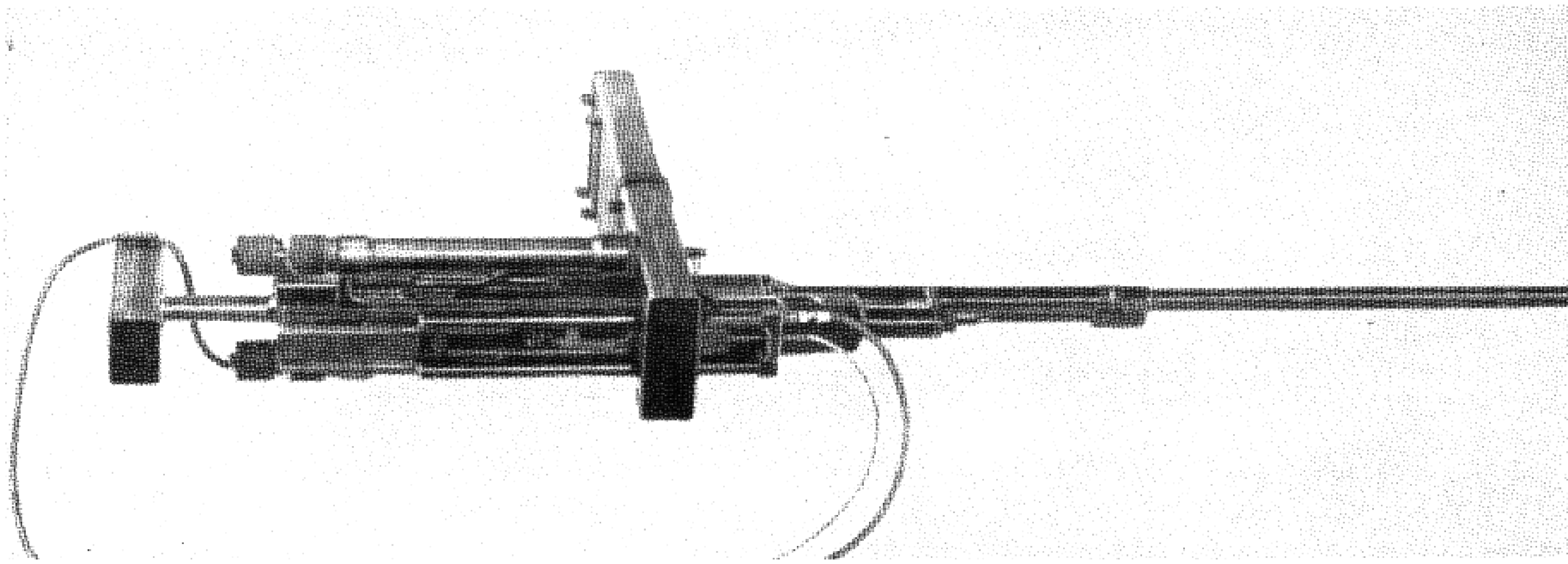

Figure 19–1. 25-mm Hotchkiss Automatic Gun.

The helical driving springs are made in two sections and are held together by a short rod. The springs ride in slots in the side walls of the receiver.

The actuation slide has a projection on each side to engage the drive springs. The front of the slide is the gas piston which operates the gun. About a third of the distance from the rear is the platform which engages the breech bolt and carries it rearward after unlocking. The actuator slide has a vertical opening to accommodate the link which connects the locking dogs and the actuator slide. The rear of the slide has a hole with a slot to hold the firing pin.

The breech bolt rides on the actuator slide and has a projection on the bottom to engage the platform of the slide on unlocking. The two locking dogs are pinned to the bolt, and the firing pin rides in the bolt.

The top of the bolt is grooved to allow passage of the ejector. The bolt has a claw extractor which is pivoted and spring loaded.

General Data: 25-mm Hotchkiss Automatic Antitank Gun (French)

Gun length, overall: 96.25 inches.	Barrel length: 59 inches.
Gun weight, total: 135 pounds.	Barrel assembly weight: 80 pounds 10 ounces.
Rate of fire: 600–700 rounds/minute.	Rate control: None.
Muzzle velocity: 2,700 feet/second.	Barrel removal: Not quick disconnect.
System of operation: Gas piston actuated.	Bore:
System of locking: Swinging lock (with linkage).	Number of grooves: 8.
System of feeding: Actuated by gas piston; employs metallic links.	Groove depth: 0.022 inch.
Method of headspace: Factory established.	Groove width: 0.145 inch.
Location of feed opening: Top of receiver.	Pitch: 5°30′.
Location of ejection opening: Bottom of receiver.	Direction of twist: Right hand.
Method of charging: Pneumatic and hydraulic.	Form of twist: Constant.
Method of cooling: Air.	Projectile weight: 0.7 pound.
Muzzle energy: 39.6 foot-tons.	Weight of round: 1.8 pounds.
Barrel assembly weight: 80 pounds 10 ounces.	Magazine:
Bolt weight: 9 pounds 4 ounces.	Weight empty: 14 pounds 15 ounces.
Actuating slide weight: 21 pounds 2 ounces.	Weight filled (10 rounds): 34 pounds 6 ounces.
Driving springs weight: 1 pound 11 ounces.	
Recoil springs length: 46 inches.	
Recoiling parts weight: 32 pounds 1 ounce.	
Receiver length: 32.75 inches.	

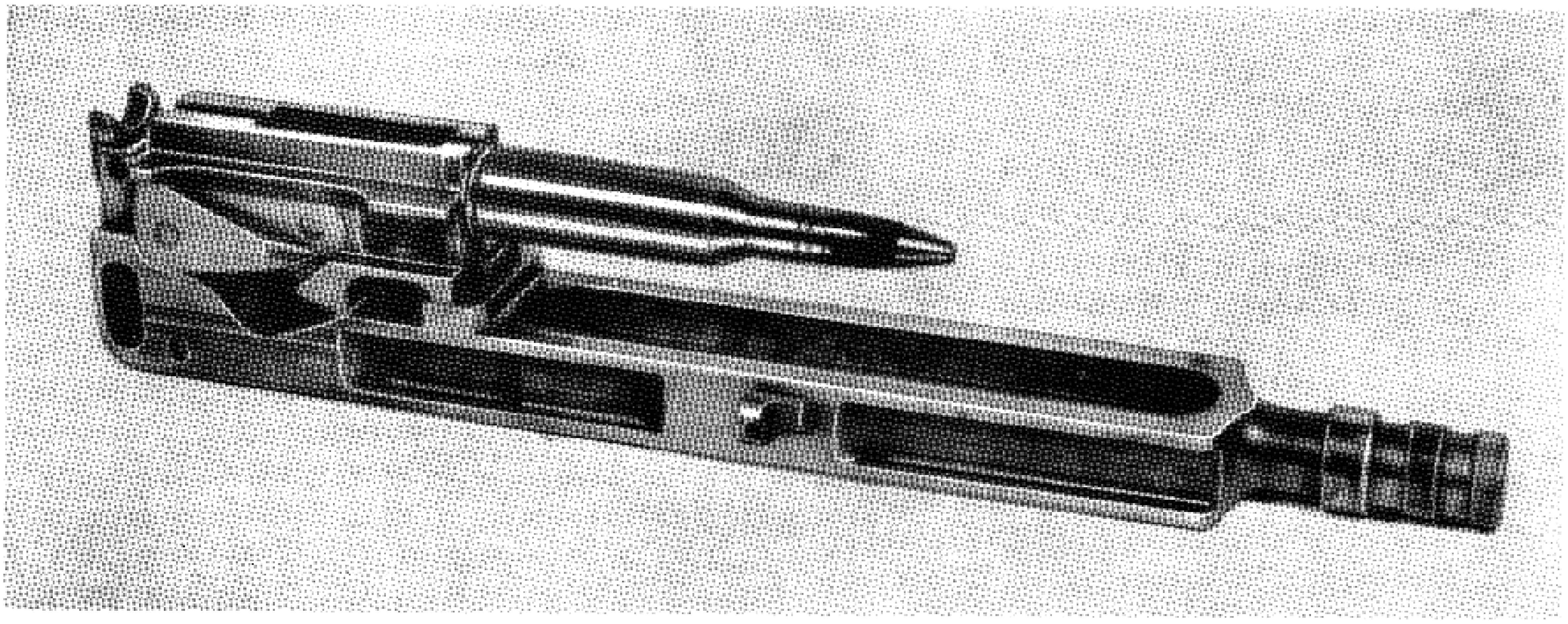

Figure 19–2. 25-mm Hotchkiss Automatic Gun. Breechblock and operating slide showing lock in locked position.

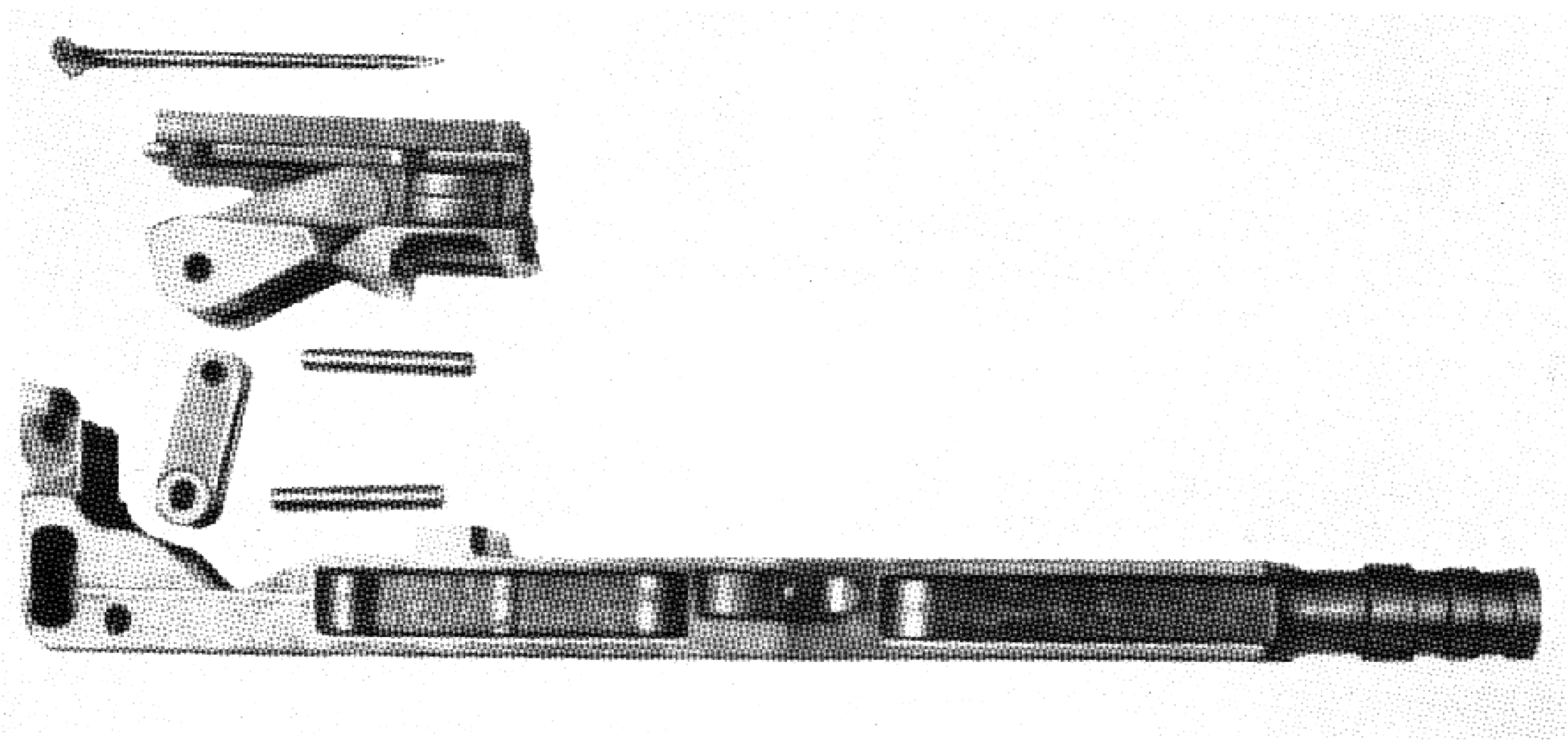

Figure 19–3. 25-mm Hotchkiss Automatic Gun. Operating group, disassembled, showing relationship of link, lock, slide, and breechblock.

Feeder

Cartridges are contained in a vertical box-type feeder with a 10-round capacity. As a round is stripped from the feeder by the bolt on its forward movement, the succeeding round is positioned by means of a follower and a spring contained in the feeder. The feeder is held in position in its housing by a latch attached to the top of the receiver.

SECTION 3. CYCLE OF OPERATION

Initial Charging

A gear rack rides in the slot on the bottom right side of the receiver and engages a driving spring lug on the side of the actuator slide. As the charging handle is drawn back, the rack draws the actuator slide also, compressing the driving springs until the spring-loaded hook sear in the backplate engages the actuator slide. The charging handle is returned to the original position.

Actuation

The trigger is pulled, depressing the sear and releasing the actuator slide. The breech bolt assembly moves forward under power of the compressed driving springs.

Loading

As the breech bolt passes under the feed mouth, a cartridge is stripped from it and carried into the chamber. As the round is seated into the chamber, its base is forced on the spring-loaded, pivoted extractor in the bottom of the face of the breech bolt.

Locking

After the bolt comes to rest against the face of the breech, the actuator slide continues to move forward a distance of 2¼ inches, causing the link, connected to the slide, and locking dog to be rotated. This action cams the locking dogs up, in front of the locking abutments, securely locking the bolt in its forward position.

Firing

A rigid firing pin is mounted in a slot in the top of the actuator slide and rides in its tunnel in the breech bolt body. The final forward movement of the slide, after the bolt is locked, forces the firing pin forward, exploding the powder charge. The firing pin cannot protrude through the hole in the face of the bolt until the slide is 0.16 inch from being fully forward; the bolt, however, is completely locked when the slide has advanced 0.53 inch from the forward position.

Unlocking

As the projectile passes a point 33¾ inches from the breech end of the barrel, a portion of the gases is metered through a port into a cylinder beneath the barrel. These gases impinge on the head of the piston of the actuator slide and force the slide to the rear. As the slide moves aft, the link is rotated in the opposite direction, pulling the locking dogs down from in front of the locking abutments. At the same time, the firing pin is withdrawn from the primer. The entire breech mechanism is driven to the rear by the force brought to bear on the piston, compressing the driving springs. The final rearward movement of the slide and bolt is arrested by the buffer, putting the operating parts into counterrecoil.

The velocity at which this assembly moves to the rear is controlled by ports of different sizes in the gas regulator, which is attached to the front end of the gas cylinder. Turning the regulator counterclockwise permits gas to be metered to the face of the piston in varying amounts through a controlled orifice located in the front end of the piston.

Extraction

As the breech bolt is driven rearward, the extractor engages the lip of the empty case and withdraws it from the chamber.

Ejection

The ejector, attached to the top of the receiver, and riding in a slot in the top of the bolt, collides with the rim of the empty cartridge case, kicking the empty cartridge case down and out through an opening in the bottom of the receiver.

Magazine Interlock

The magazine latch is an accessory of the magazine housing. If a magazine type of feed is used, when the last round is stripped from the feed mouth, a lug on the follower trips the latch and releases the magazine. Release of the latch causes a stop to be projected down in front of a clearance cut in the top of the bolt. As the bolt starts forward, it is arrested by this stop at a position slightly to the rear of that required for the slide and sear to become engaged. Installation of a charged magazine withdraws the stop and allows the mechanism to move forward and engage the sear. Both the magazine latch and the bolt stop are equipped with levers so that they may be operated by hand at will.

Chapter 20

HISPANO-SUIZA AIRCRAFT CANNON DEVELOPMENT IN SWITZERLAND AND GREAT BRITAIN

SECTION 1. DEVELOPMENT BY THE PARENT HISPANO-SUIZA CO.

History and Background

The Hispano-Suiza Co. of Geneva, Switzerland, has had great international influence on the development of aircraft armament. Founded early in the century as an automobile plant with factories in Switzerland, Spain, and France, it branched into aircraft engine and automatic weapon design. The story of the development of the Hispano-Suiza type 404 aircraft gun and its adoption as a basic weapon by Great Britain and the United States in World War II is given in The Machine Gun, volume I, chapter 14, pages 562–590. Since World War II, the firm has centered its research activities in its Swiss headquarters.

Post-World War II Weapon Design

After World War II the outstanding machine gun design of the parent Hispano-Suiza Co. was the 20-mm Hispano (Birkigt) type 404 aircraft gun.

Postwar development work included not only refinement of standard models and the usual pursuit of the new patentable ideas but also an intent perusal of captured German documents for ideas that might be used in future development. For example, the Rheinmetall MG–151 attracted the interest of the Hispano-Suiza Co. as well as of American ordnance engineers. Both the Hispano-Suiza Co. and the United States armed services developed weapons bearing a close resemblance to the German gun.

20-mm Hispano-Suiza Type 804

The following description of this weapon was taken from a brochure of the Hispano-Suiza Co.

The AA cannon type 804 is a weapon of automatic fire with mechanical locking of the breech. The recoil is taken up by the whole of the weapon. Before starting to fire, the breechblock must be pulled to the rear and is then held back with the sear. The return spring is thus compressed. When starting to fire and as soon as the trigger is moved, the breechblock with its percussion and locking system incorporated in it is driven forward by the return spring and starts the cartridge toward the chamber. At the moment of locking, the locking pieces move downward and release the unlocking slides, driving the firing pin forward. Continued movement of the firing pin with respect to the now stationary breechblock stops the locking pieces and locks the breech. Ignition is produced at the end of the movement by the unlocking plates. During the interval when the projectile is in the barrel, the recoil of the rearward traveling mass is checked by a heavy spring which also assures the return into position of the weapon. An oil cushion checks the last movement forward and thus avoids abnormally heavy shocks. The moment the projectile leaves the gun barrel, a powerful muzzle brake absorbs a great part of the kinetic energy of the recoiling mass. A gas piston unlocks the breechblock. The remaining gas pressure drives it to the rear at high speed, the cartridge case then driving the breechblock rearward. The ejection of the cartridge case takes place during the recoil of the breechblock as the rim of the case strikes the ejector. The recoil of the breechblock is checked in part by the return spring, and at the end of the travel by the large buffer spring. The accumulated energy in the spring alters the movement of the breechblock and drives it at very great speed forward with the aid of the driving spring. This is a very important feature in connection with obtaining a high rate of fire with the weapon. The magazine or feeder fixed on the weapon does not recoil with the action. The interrupted threaded joint of the barrel permits the latter being changed rapidly.

20-mm Hispano-Suiza Type 820

Engineers of the Hispano-Suiza Co. developed a more powerful cartridge for a 20-mm cannon and a more rugged mechanism to fire it, giving this version the official designation type 820. It was based, however, on the same principle as the well known and thoroughly seasoned original Hispano-Suiza action. The most important features on the refined weapon are an initial velocity of 3,400 foot per second and a rate of fire in the neighborhood of 1,000 rounds a minute. These improvements were obtained with little increase in weight, the new gun weighing 112 pounds or 20 pounds more than the original model.

The barrel is 85 calibers long and weighs 52 pounds, and with certain exceptions it is possible to change the length of the barrel and to adapt the gun to different needs of aircraft. The weapon can be fed either from a magazine or by belt of the disintegrating link type with the aid of a powered belt-feed mechanism.

The Hispano-Suiza Co. improved considerably the striking effect of the 20-mm ammunition intended for use in type 820. The original ammunition (standard) can also be used in the British Mark V, the French 404, and the American M3 gun. New types of projectiles included (1) high-explosive incendiary with high-blast effect, (2) double-effect shell incendiary type Mark IDA, and (3) incendiary and armor piercing incendiary shell type Mark ORC.

General Data: 20-mm French Hispano-Suiza Type 804

Gun length: 100 inches.	Barrel length, with muzzle brake: 87 inches.
Gun weight, without magazine: 99.2 pounds.	Barrel weight: 53 pounds.
Rate of fire: 750–800 rounds/minute.	Rate control: None.
Muzzle velocity: 2,785 feet/second.	Barrel removal: Quick disconnect.
System of operation: Retarded blowback.	Bore:
System of locking: Swinging lock.	Number of grooves: 12.
System of feeding: Drum, or spring-actuated feed employing links.	Groove depth: 0.015 inch.
Method of headspace: None.	Groove width: 0.205 inch.
Location of feed opening: Top of receiver.	Pitch: 7° (equals 1 turn in 25.587 calibers and 1 turn in 20.137 inches).
Location ejection opening: Bottom of receiver.	Direction of twist: Right hand.
Method of charging: Pneumatic, manual.	Form of twist: Constant.
Method of cooling: Air.	Length of rifling: 80 inches.

General Data: 20-mm French Hispano-Suiza Type 820

Gun length: 98 inches.	Barrel length: 68 inches.
Gun weight: 112 pounds.	Barrel weight: 52 pounds.
Rate of fire: 1,000 rounds/minute.	Rate control: None.
Muzzle velocity: 3,280 feet/second.	Barrel removal: Quick disconnect.
System of operation: Gas and retarded blowback.	Bore:
System of locking: Swinging lock.	Number of grooves: 9.
System of feeding: Drum or spring-actuated continuous feed.	Groove depth: 0.015 inch.
Method of headspace: None in weapon design.	Groove width: 0.205 inch.
Location of feed opening: Top of receiver.	Pitch: 7° (equals 1 turn in 25.587 calibers and 1 turn in 20.137 inches).
Location of ejection opening: Bottom of receiver.	Direction of twist: Right hand.
Method of charging: Pneumatic.	Form of twist: Constant.
Method of cooling: Air.	

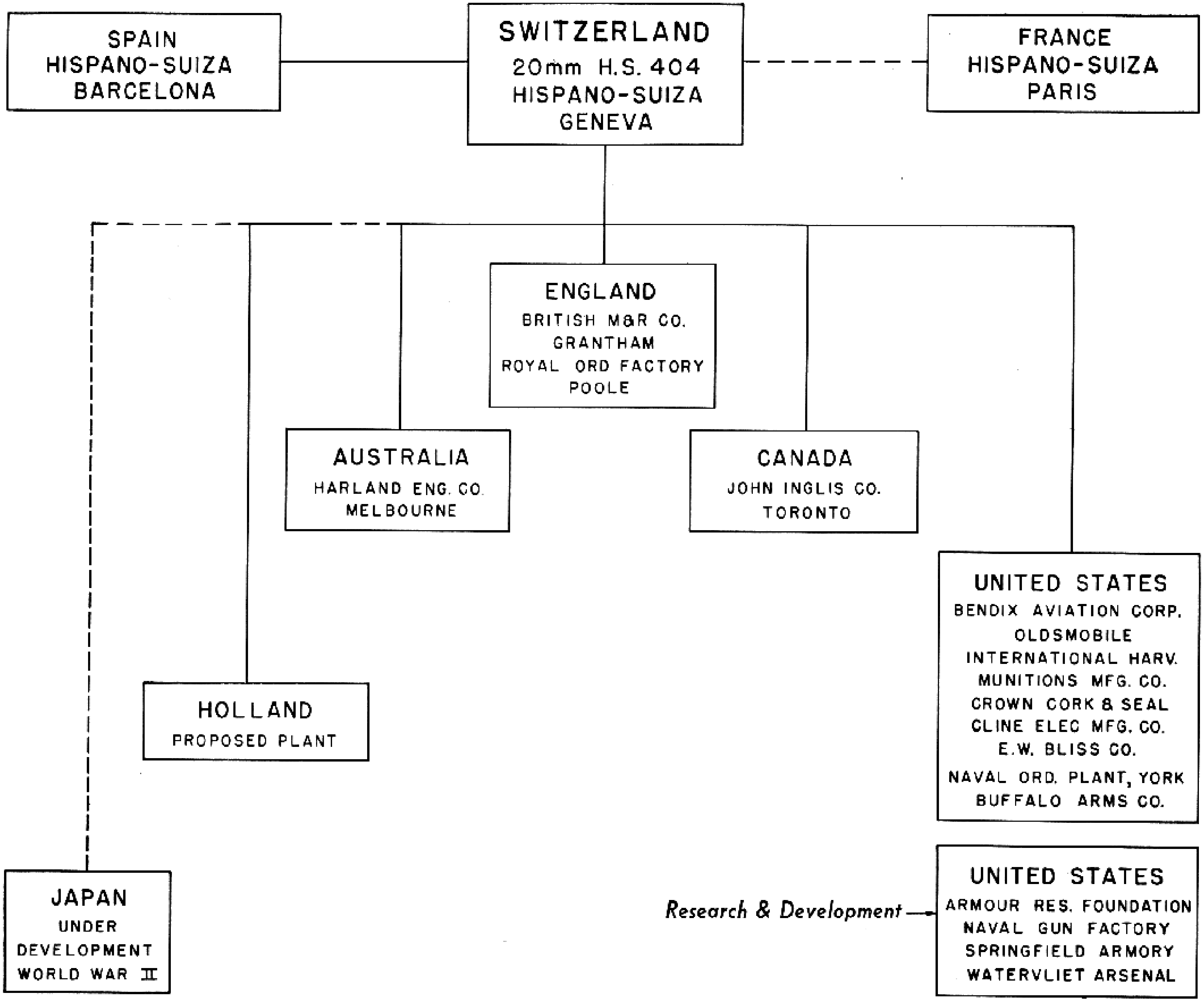

Figure 20–1. Facilities for manufacture of Hispano-Suiza Guns.

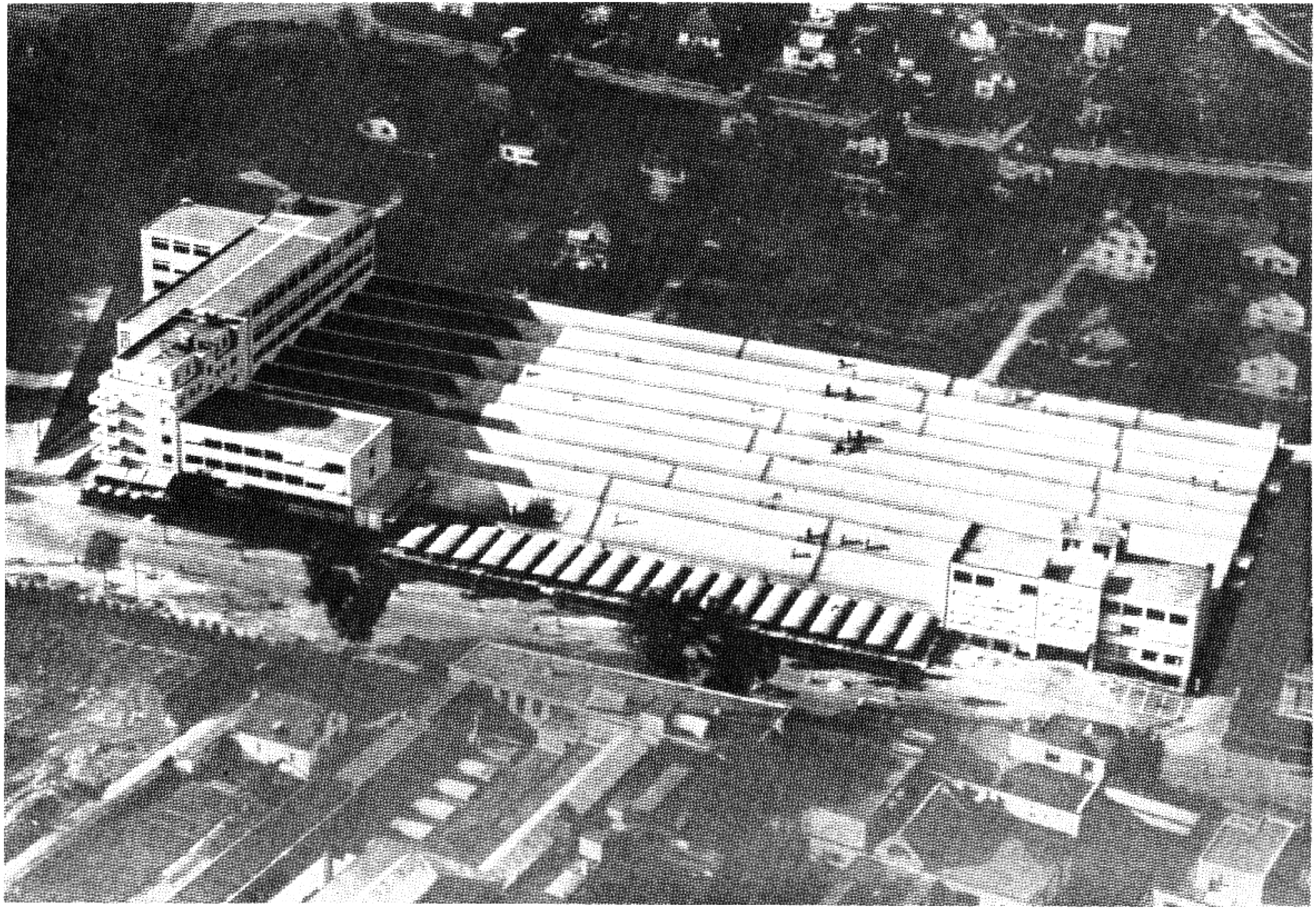

Figure 20–2. Aerial view of the Hispano-Suiza factory in Switzerland.

CONFIDENTIAL

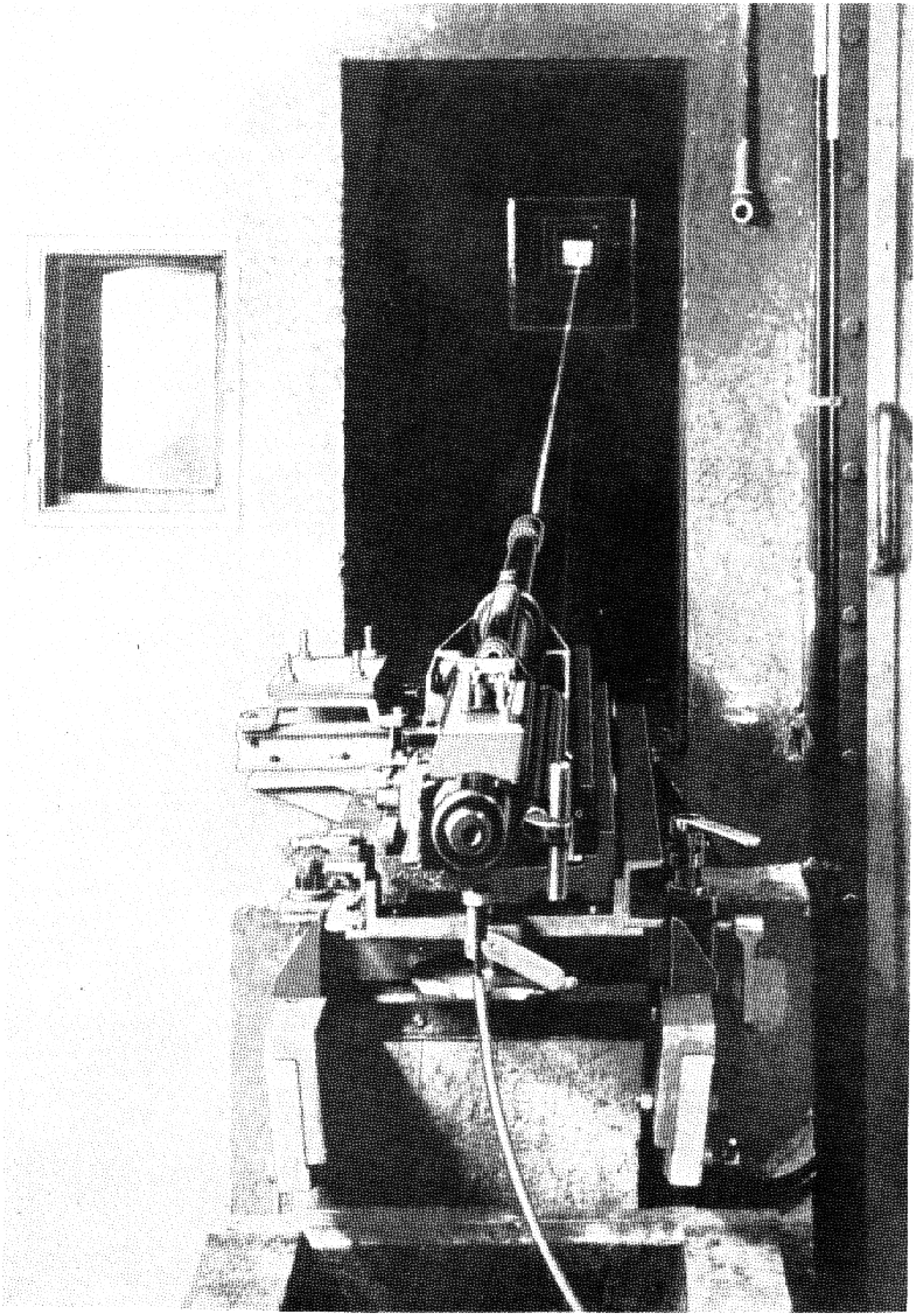

Figure 20–3. Automatic cannon undergoing proof testing at the Hispano-Suiza factory in Switzerland.

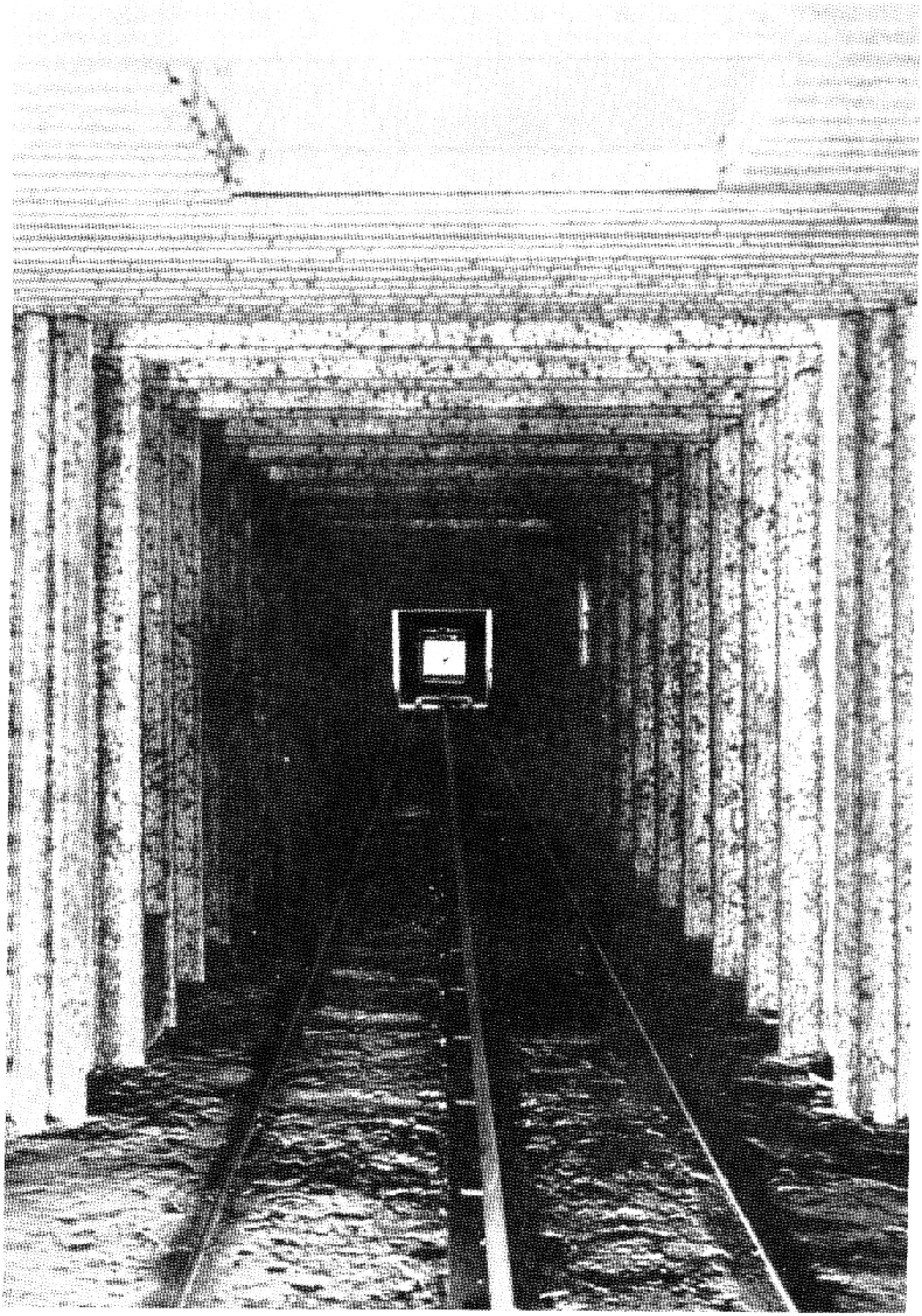

Figure 20–4. Firing tunnel at the Hispano-Suiza factory.

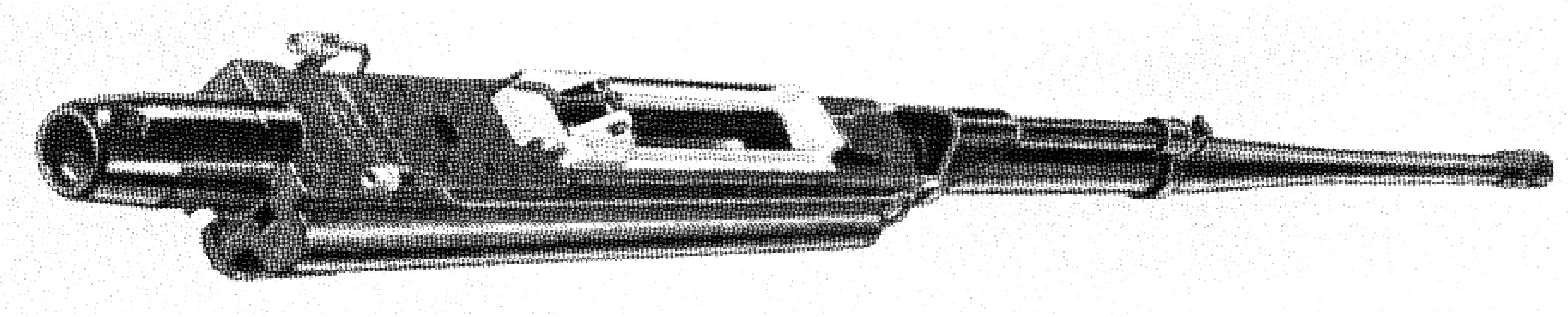

Figure 20–5. 20-mm Hispano-Suiza Aircraft Cannon Type 804. This is a wing gun with pneumatic charging.

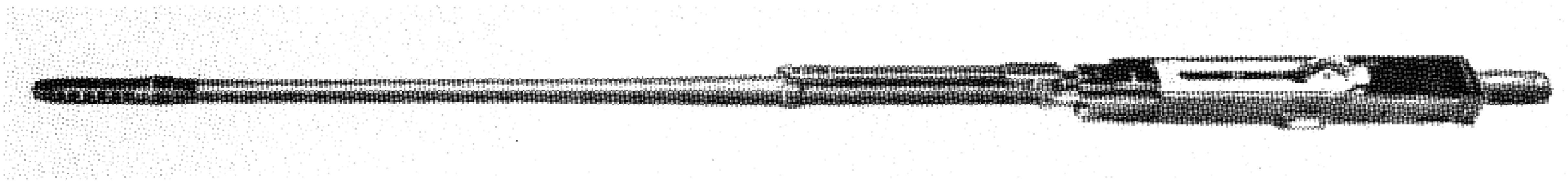

Figure 20–6. 20-mm Hispano-Suiza Antiaircraft Cannon Type 804.

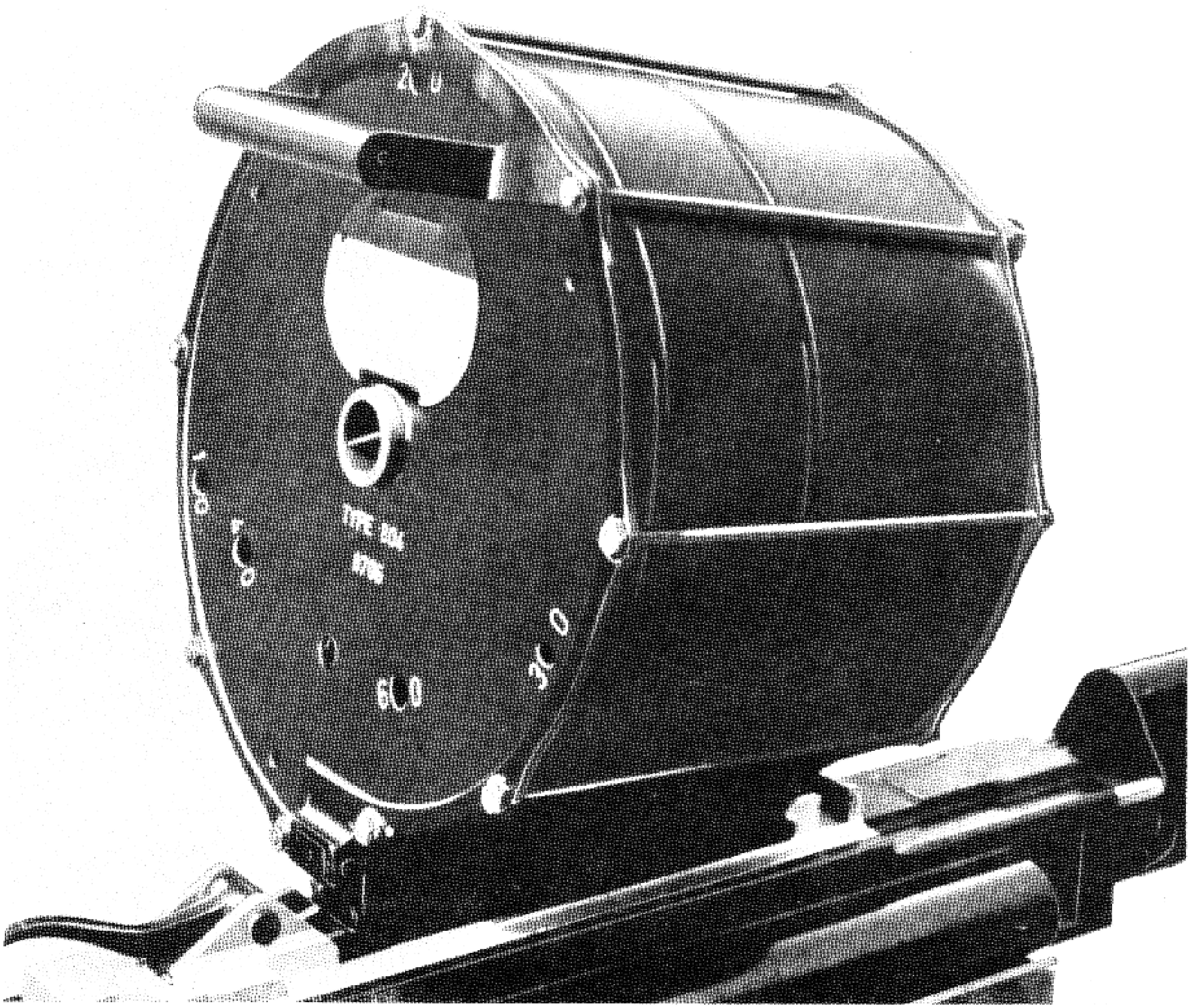

Figure 20–7. 20-mm Hispano-Suiza Aircraft Cannon Type 804 with drum feed attached. Closeup view.

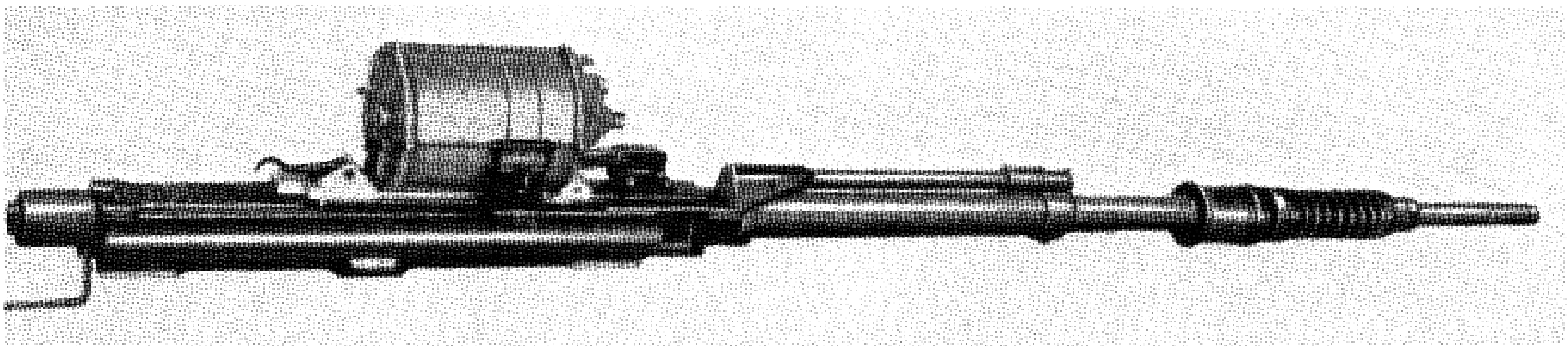

Figure 20–8. 20-mm Hispano-Suiza Aircraft Cannon Type 804. Barrel length, 65 calibers with manual charger.

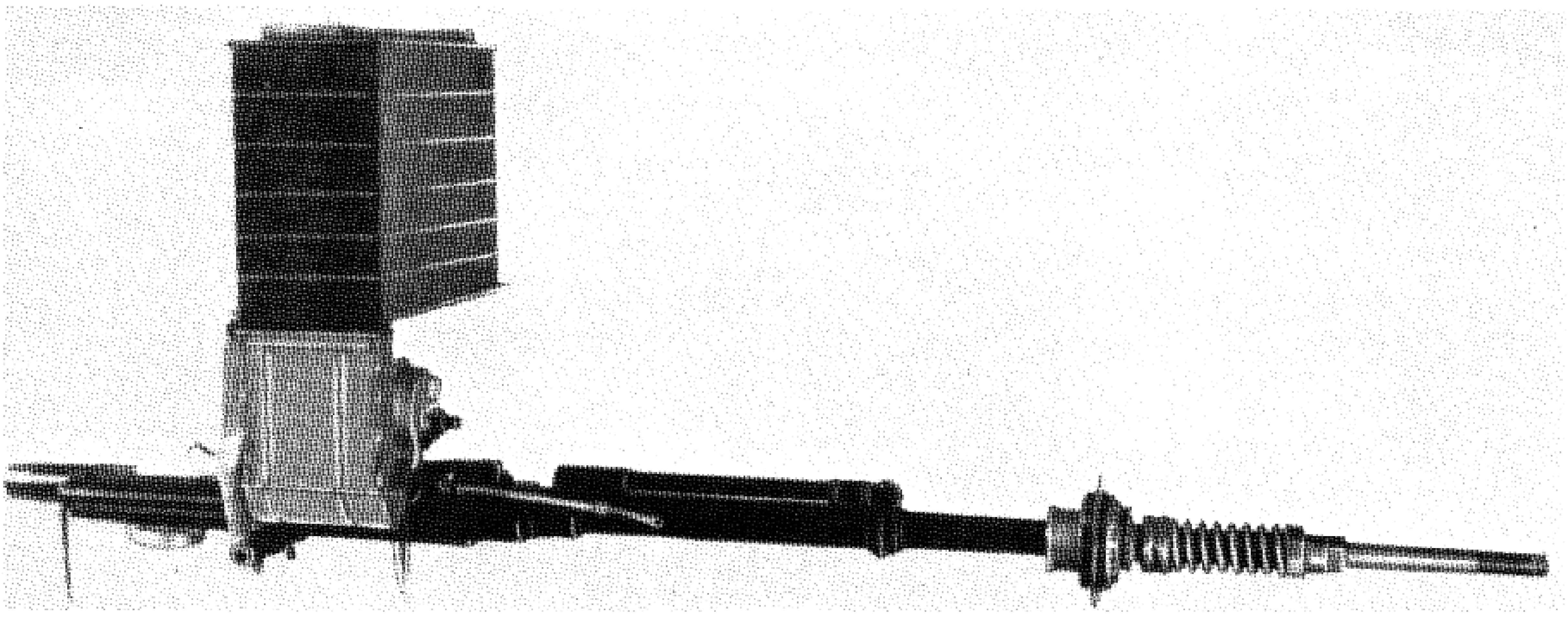

Figure 20–9. 20-mm Hispano-Suiza Aircraft Cannon Type 804. Barrel length, 70 calibers with feeder.

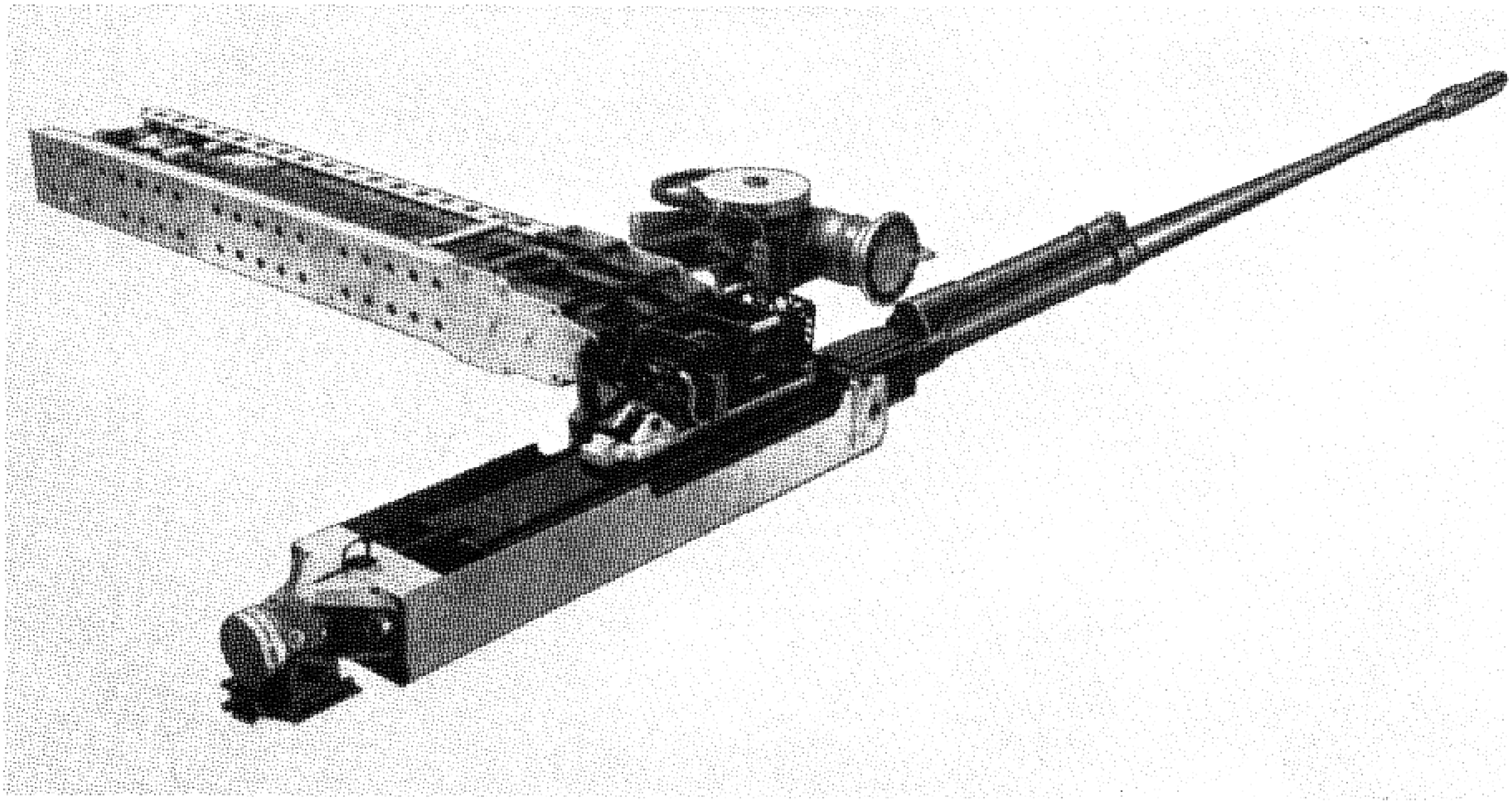

Figure 20–10. Wing magazine holding 200 rounds for 20-mm Hispano-Suiza Automatic Gun Type 804.

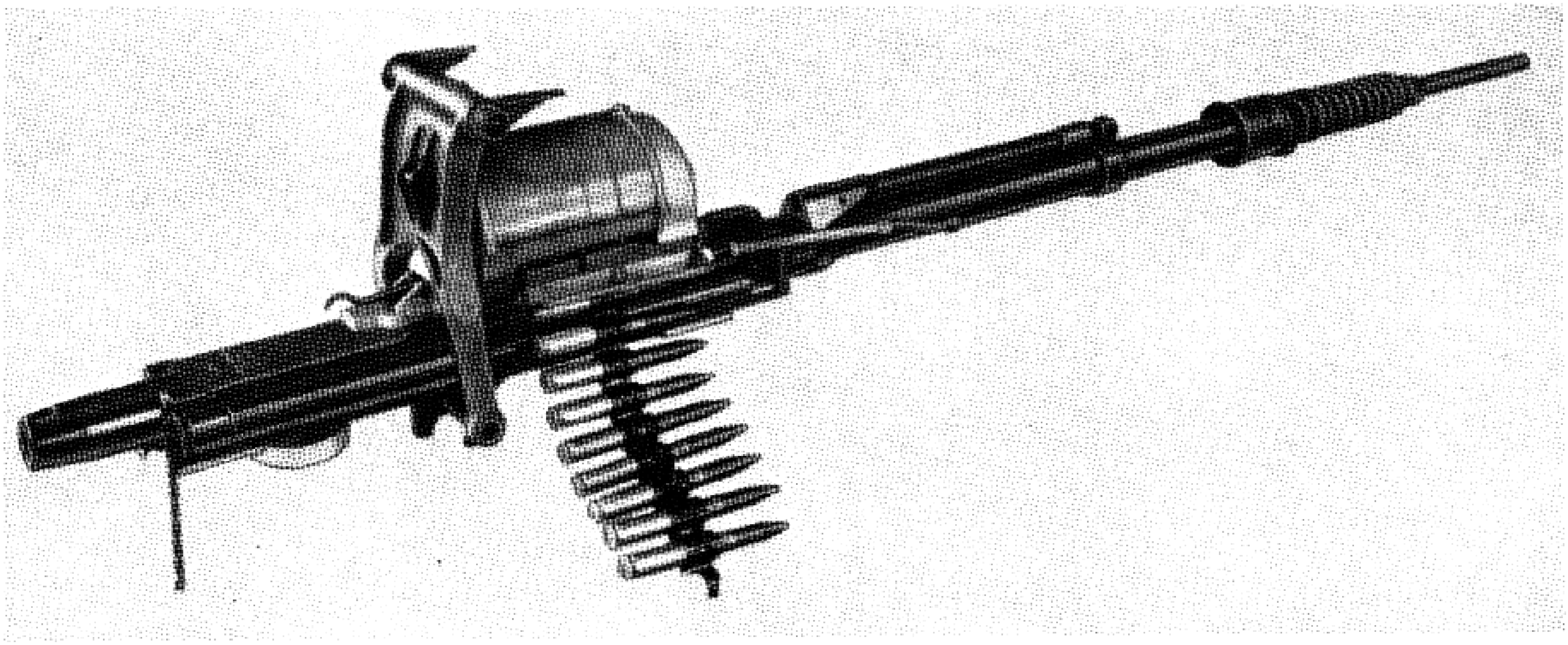

Figure 20–11. 20-mm Hispano-Suiza Aircraft Cannon Type 804, showing front and rear mountings.

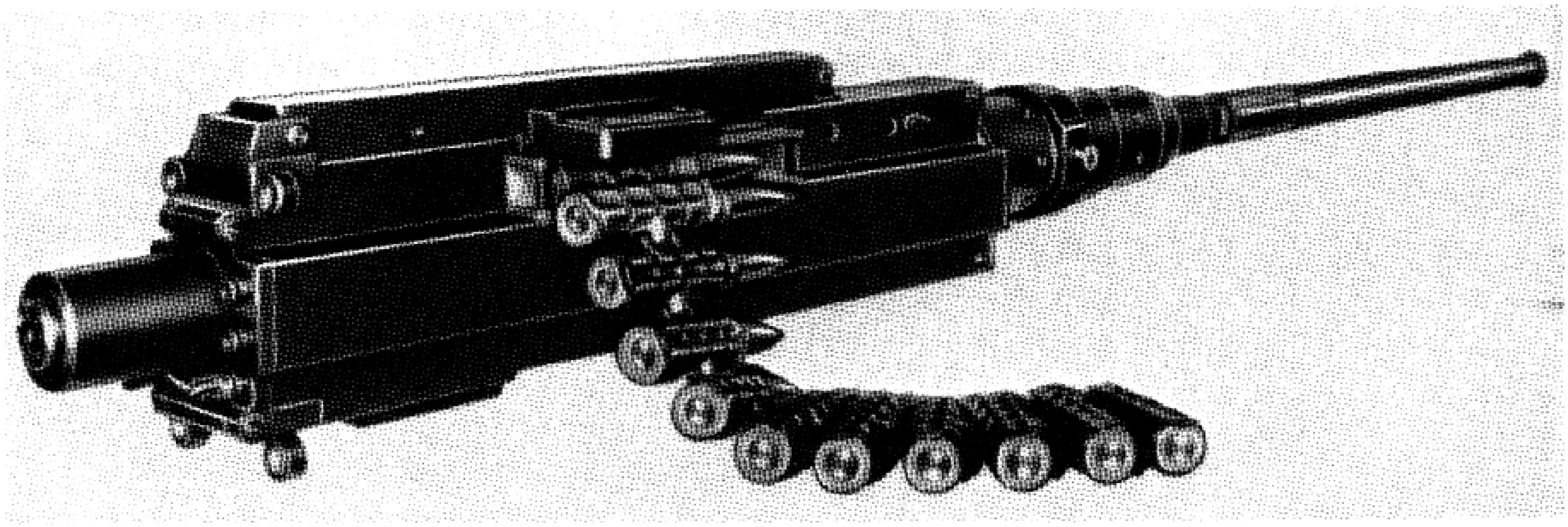

Figure 20–12. 37-mm Hispano-Suiza Automatic Cannon Type 606.

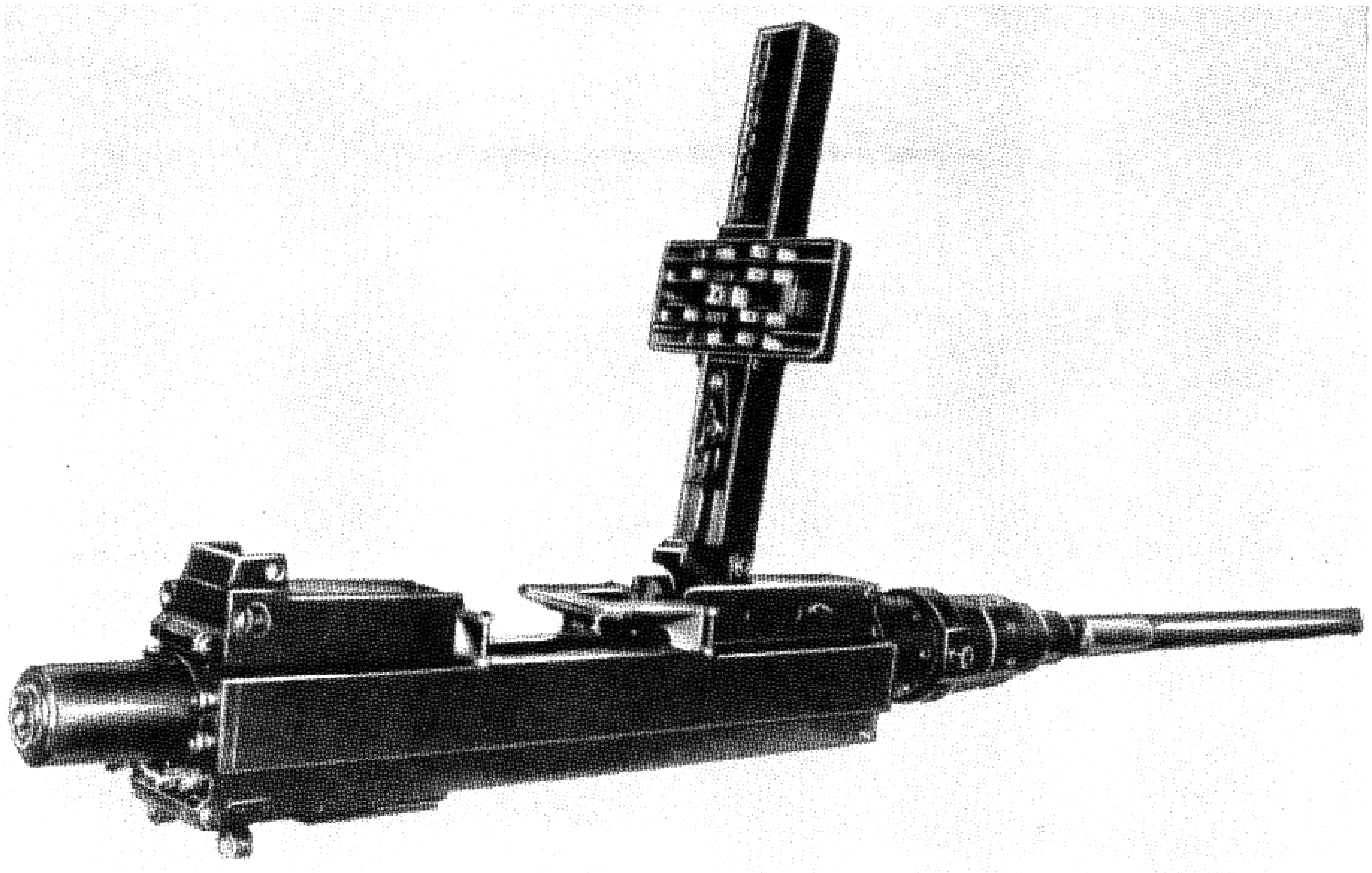

Figure 20–13. 37-mm Hispano-Suiza Automatic Cannon Type 606, with cover open.

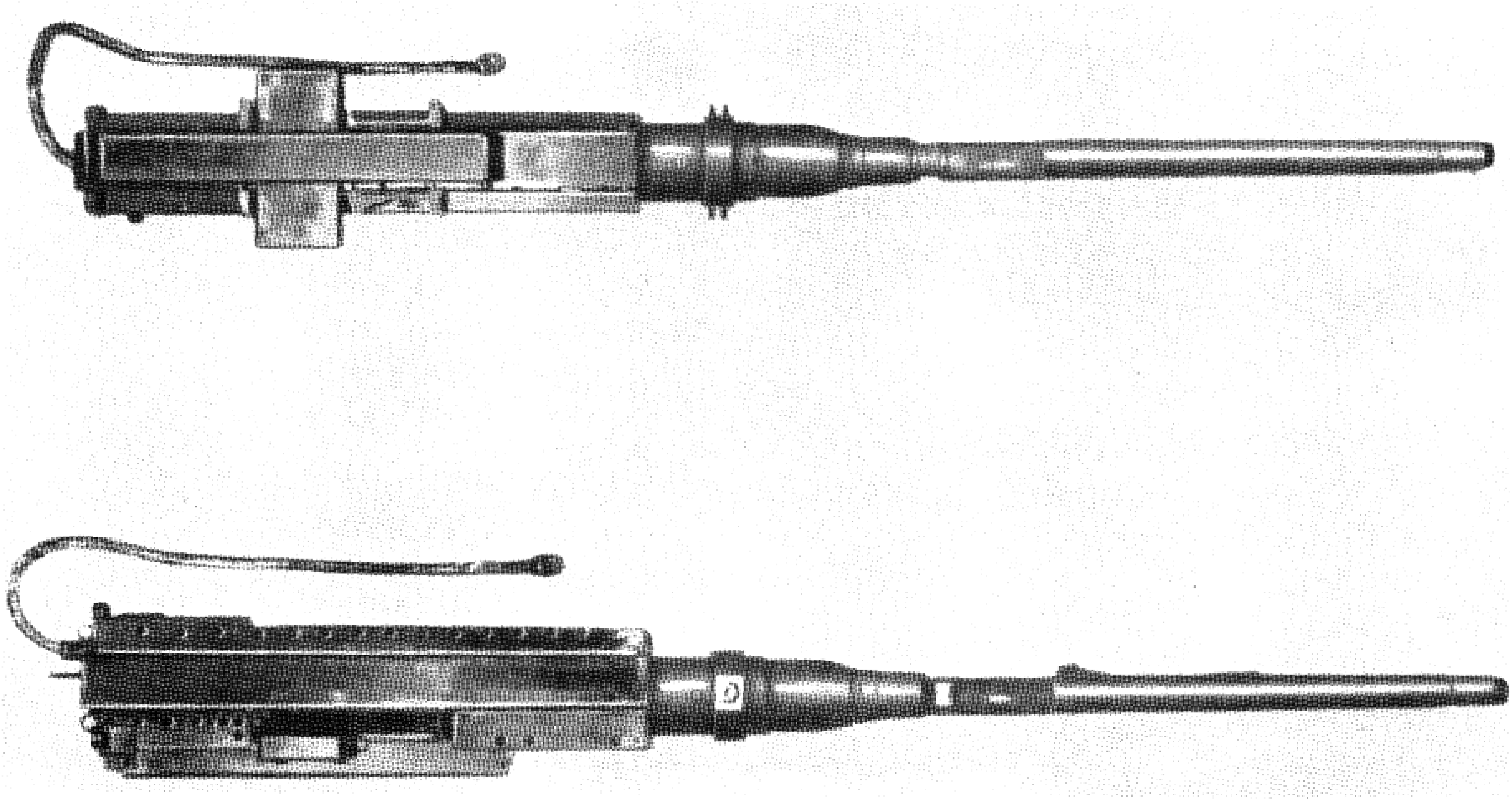

Figure 20–14. 30-mm Hispano-Suiza Automatic Cannon Type 603.

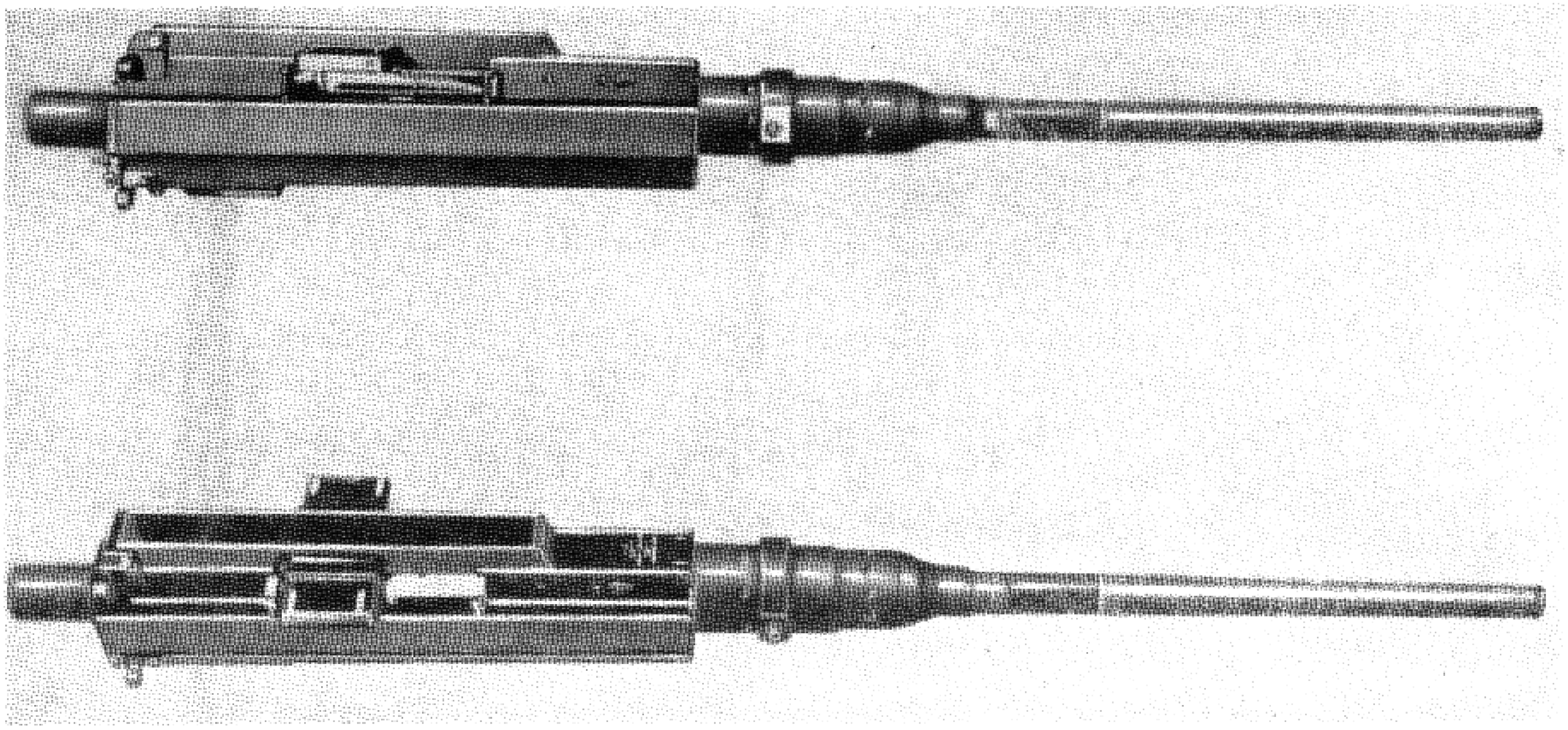

Figure 20–15. 30-mm Hispano-Suiza Automatic Cannon Type 603.

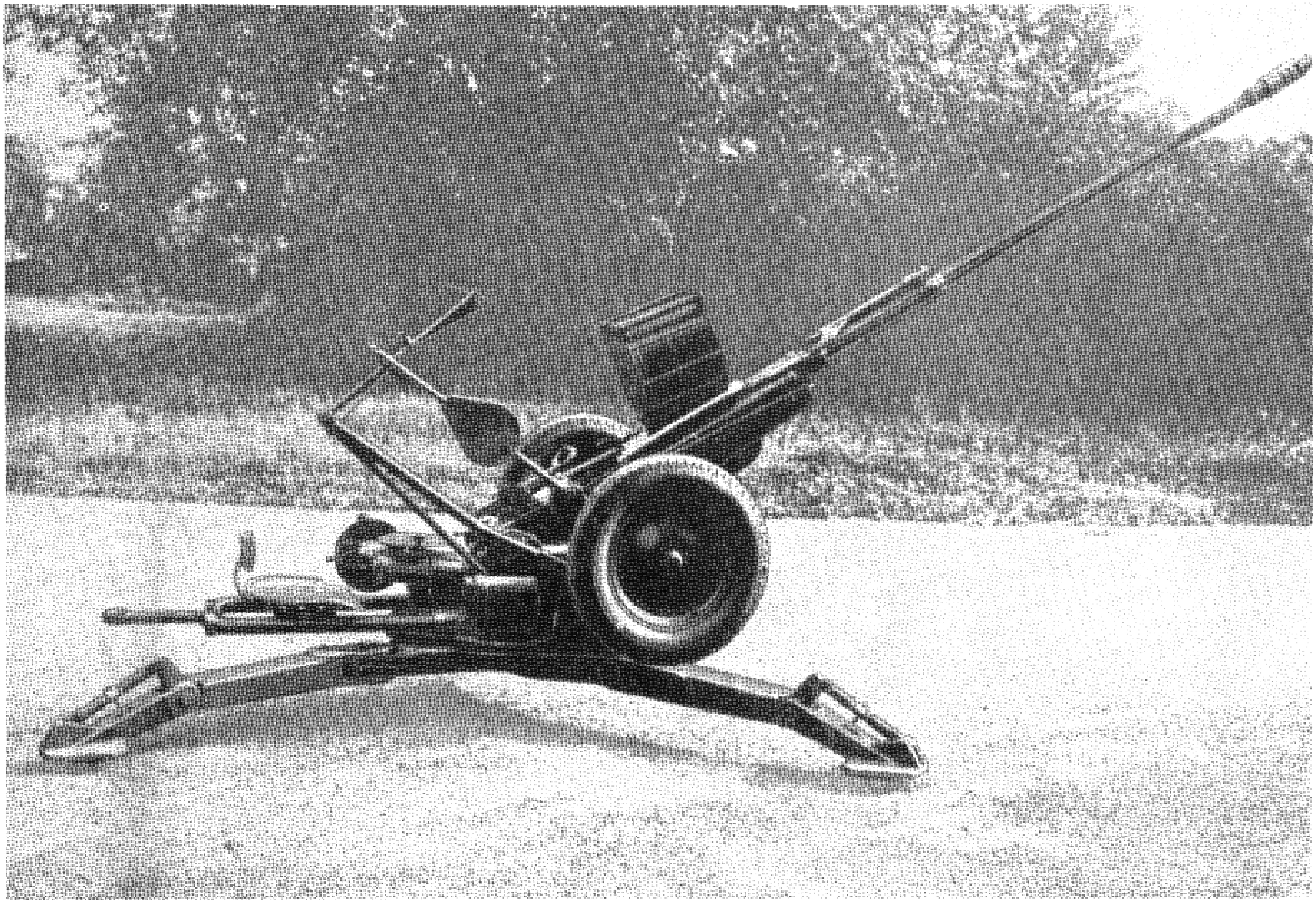

Figure 20–16. 30-mm Hispano-Suiza AA Cannon Type 830.

258970°—54——37

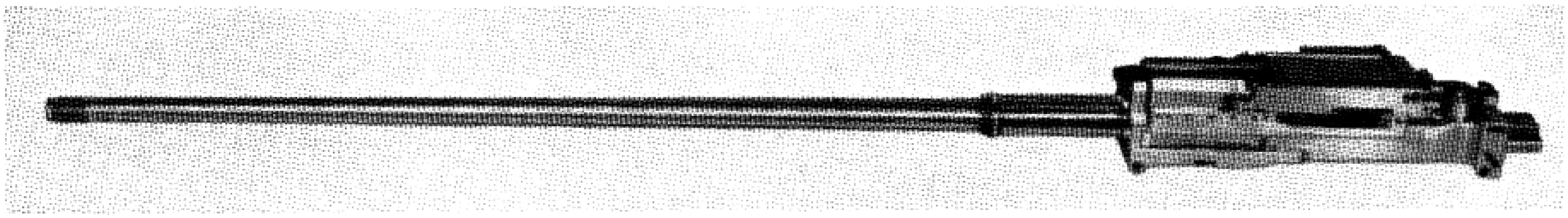

Figure 20–17. 30-mm Hispano-Suiza Aircraft Cannon Type 825. Left side view.

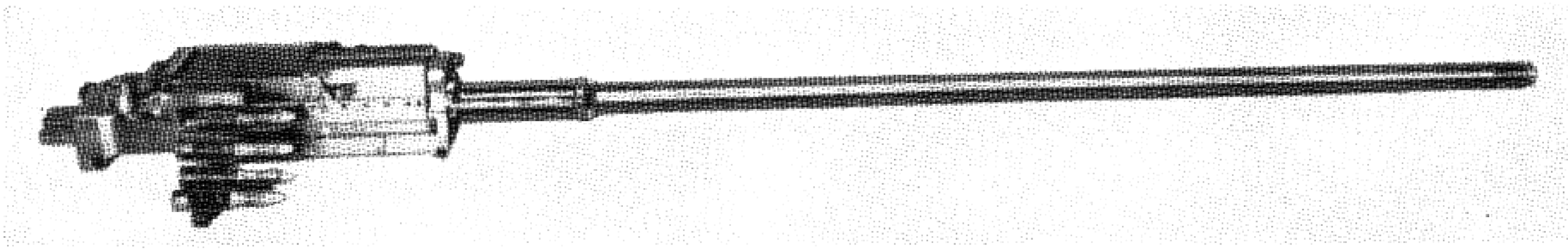

Figure 20–18. 30-mm Hispano-Suiza Aircraft Cannon Type 825. Right side view.

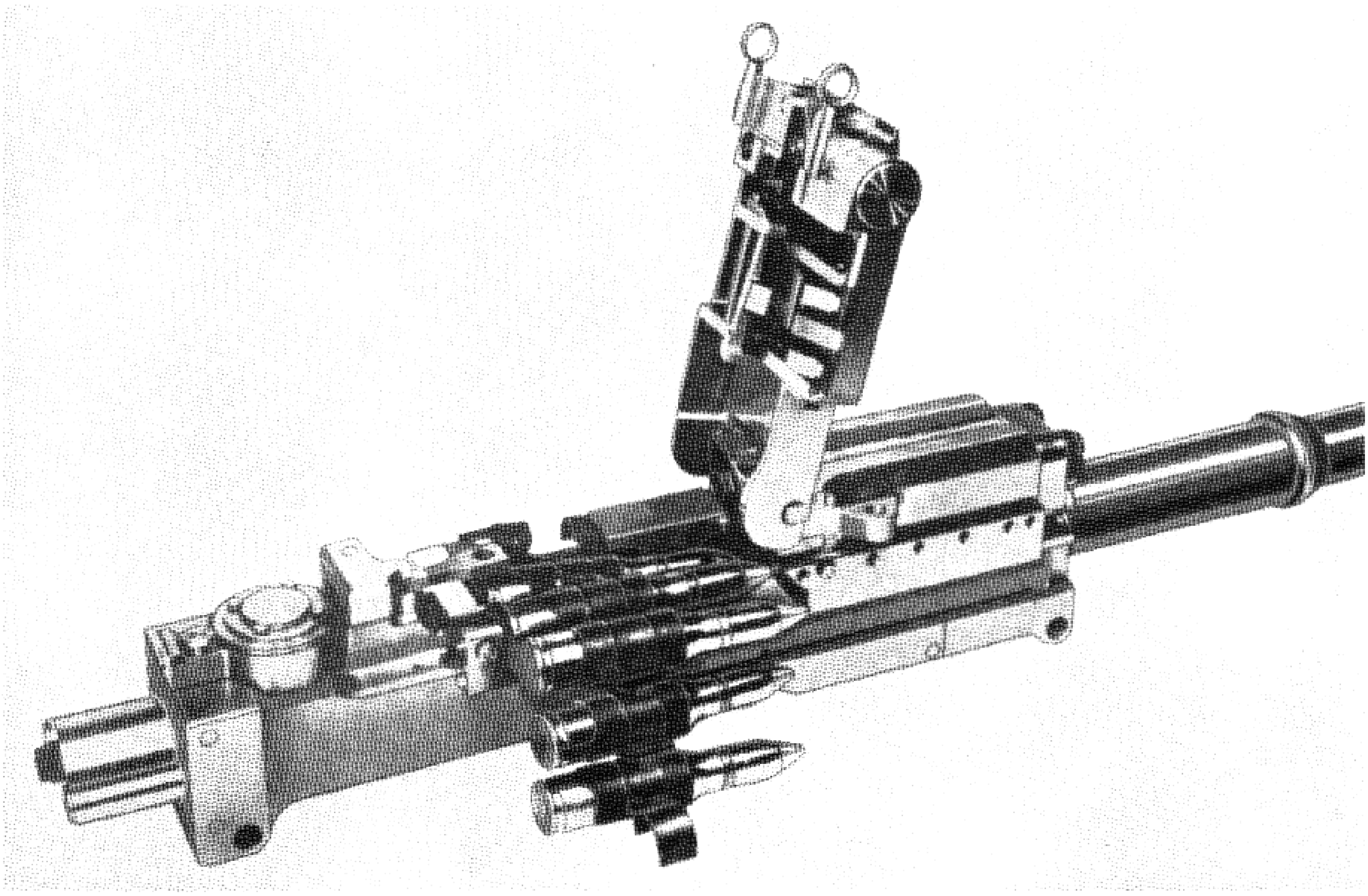

Figure 20–19. 30-mm Hispano-Suiza Automatic Cannon Type 825. Closeup of feedway.

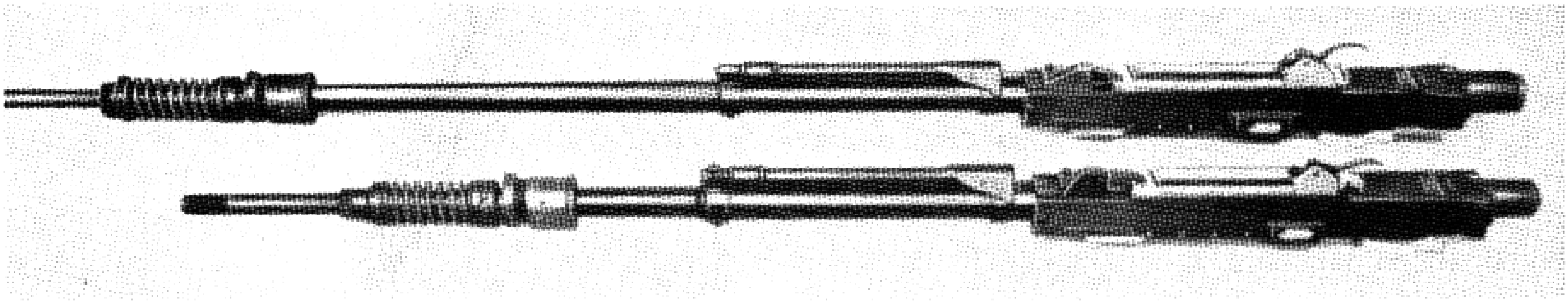

Figure 20–20. 20-mm Hispano-Suiza Type 820 Aviation Gun (above) and 20-mm Hispano-Suiza Type 804 (below).

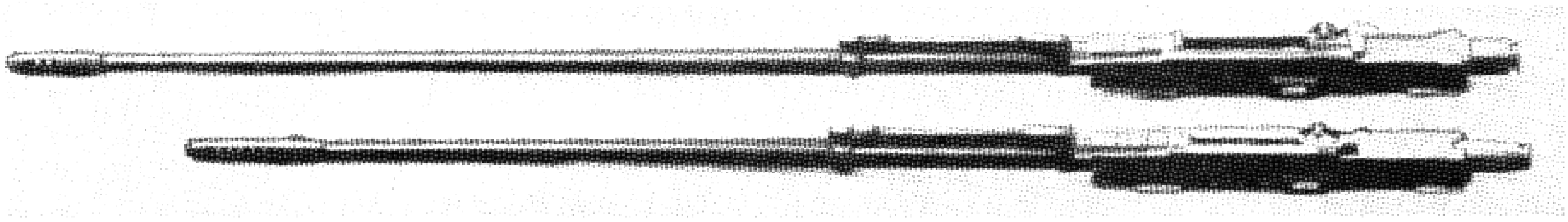

Figure 20–21. The basic 20-mm Hispano-Suiza Type 820 Gun (above) and the basic 20-mm Hispano-Suiza Type 804 Gun.

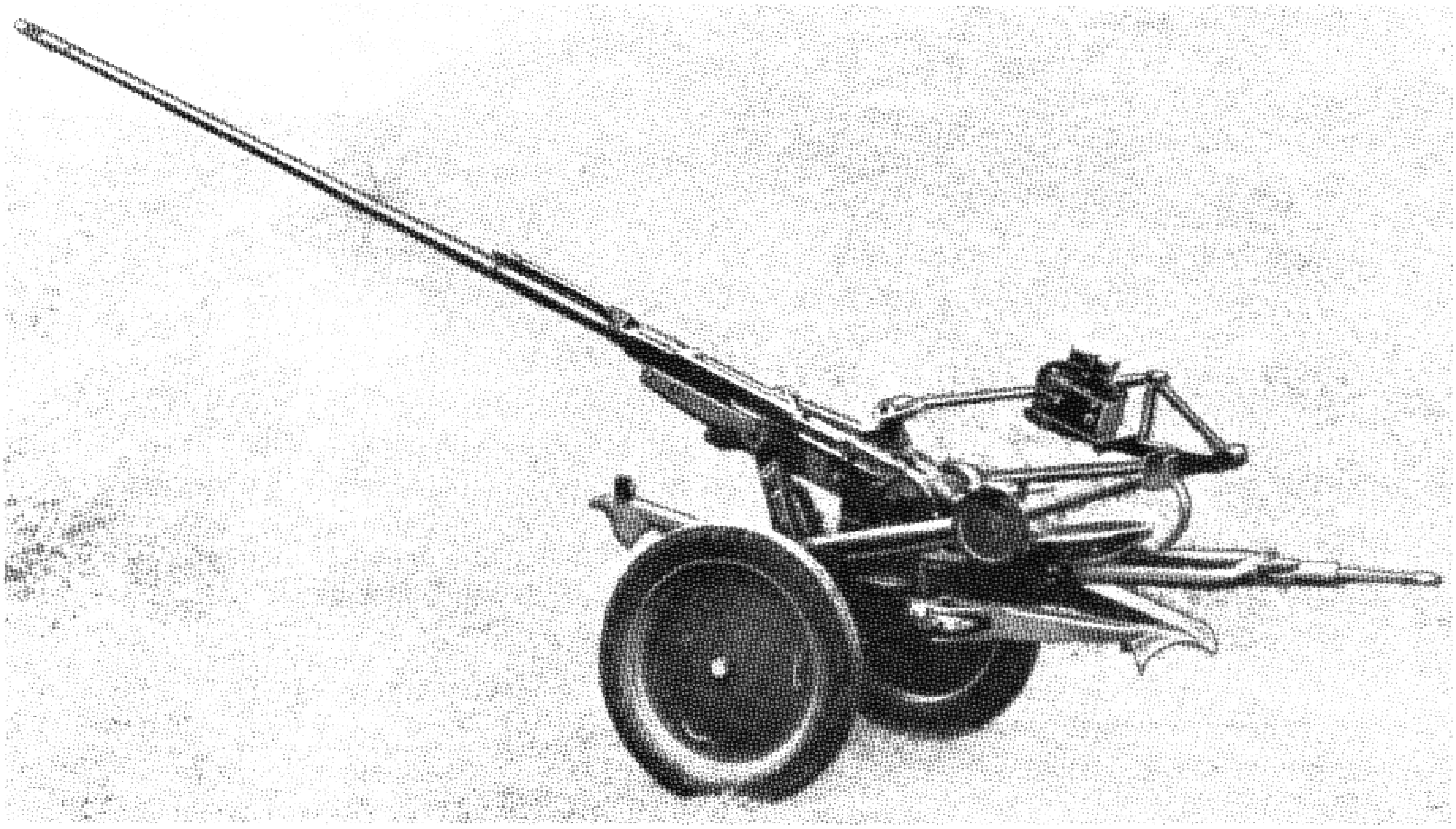

Figure 20–22. 20-mm Hispano-Suiza Type 820 Gun in traveling position.

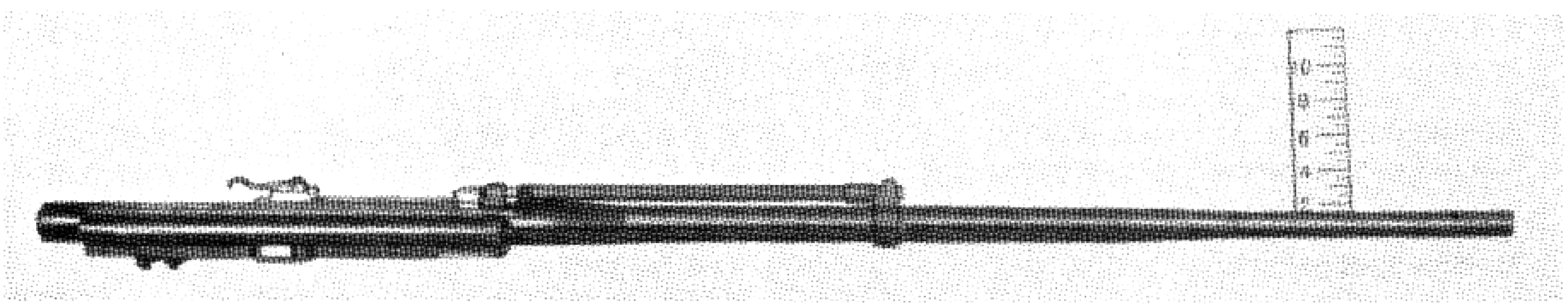

Figure 20–23. 20-mm Hispano-Suiza Cannon Type 404, manufactured for the French Government in World War II.

SECTION 2. BRITISH DEVELOPMENT AND PRODUCTION PROGRAM

History and Background

In 1936 the British commission became interested in the Hispano-Suiza Birkigt type 404. Negotiations for the purchase of six of these cannon by the British were completed in 1936, and the first gun was delivered in January 1937.

Early in 1937 the Hispano-Suiza Co. proposed the establishment of a Hispano-Suiza plant in England if given a token order for 400 cannons. This plant was opened in December 1938 under the name of British Manufacture & Research Co. The British produced gun was called the Hispano-Suiza type 404 in contrast to the designation identifying the model made in France, which was the Hispano-Suiza Birkigt type 404.

The initials of the British company were utilized to form the short identification "Mark" for the British-produced gun, and subsequent manufacture of the gun and development work to improve it were carried on under the designation "Mark" followed by a suitable Roman number.

In Canada, the Hispano-Suiza was manufactured under license by the John Inglis Co. of Toronto.

The story of the development of the Mark I and the Mark II is given in some detail in The Machine Gun, volume I, chapter 14.

There follows a short description of Mark I through Mark V for the purpose of identifying them.

20-mm Automatic Gun Mark I

This was the gun as first manufactured in Great Britain from the original French drawings. It was manufactured on a small scale because of production difficulties with the original drawings.

20-mm Automatic Gun Mark II

This gun was first manufactured in Great Britain to a new set of British drawings to suit large-scale production. It included a number of minor improvements such as: return spring guide to prevent buckling of the spring; triple strand breechblock return spring; inertia blocks in breechblock to prevent breechblock bounce; increased overrun to rear by 5 mm for breechblock, for the purpose of increasing energy on feed stroke and increasing time for feeding of round into feed lips; improved firing pin and sear; and continuous ribs on the gun body.

20-mm Automatic Gun Mark III

This was a design having a fabricated gun body to cheapen production and reduce weight. This design never went into production.

20-mm Automatic Gun Mark IV

The design of this weapon was identical to the Mark II except that the barrel was 12 inches shorter and a shoulder was 9 inches further to the rear. It was intended chiefly for turret guns and never went into large-scale production.

20-mm Automatic Gun Mark V

This design represented the stage of development of the 20-mm Hispano-Suiza gun reached by the end of World War II. It was 25 percent lighter than the Mark II and had a rate of fire up to 50 percent greater, and the barrel was 12 inches shorter. It saw service as a fixed gun and in turrets.

General Data: British 20-mm Automatic Guns Marks I through IV

Gun length: 93.7 inches. Gun weight, without feeder: 102 pounds. Rate of fire: 600–650 rounds/minute. Muzzle velocity: 2,850 feet/second. System of operation: Gas unlock, blowback assist. System of locking: Swinging locks. System of feeding: Drum and later Chatellerault automatic spring-wound feeder. Method of headspace: Cannot be adjusted. Location of feed opening: Top of receiver. Location of ejection opening: Bottom of receiver. Method of charging: Manual and hydraulic. Method of cooling: Air.	Barrel length: 67.5 inches. Barrel weight: 47.5 pounds. Rate control: None. Barrel removal: Not quick disconnect. Bore: Number of grooves: 9. Groove depth: 0.015 inch. Groove width: 0.205 inch. Pitch: 7° (equals 1 turn in 25.587 calibers and 1 turn in 20.137 inches). Direction of twist: Right hand. Form of twist: Constant. Cartridge: 20-mm Hispano-Suiza (M75 series). Rifling length: 63.08 inches.

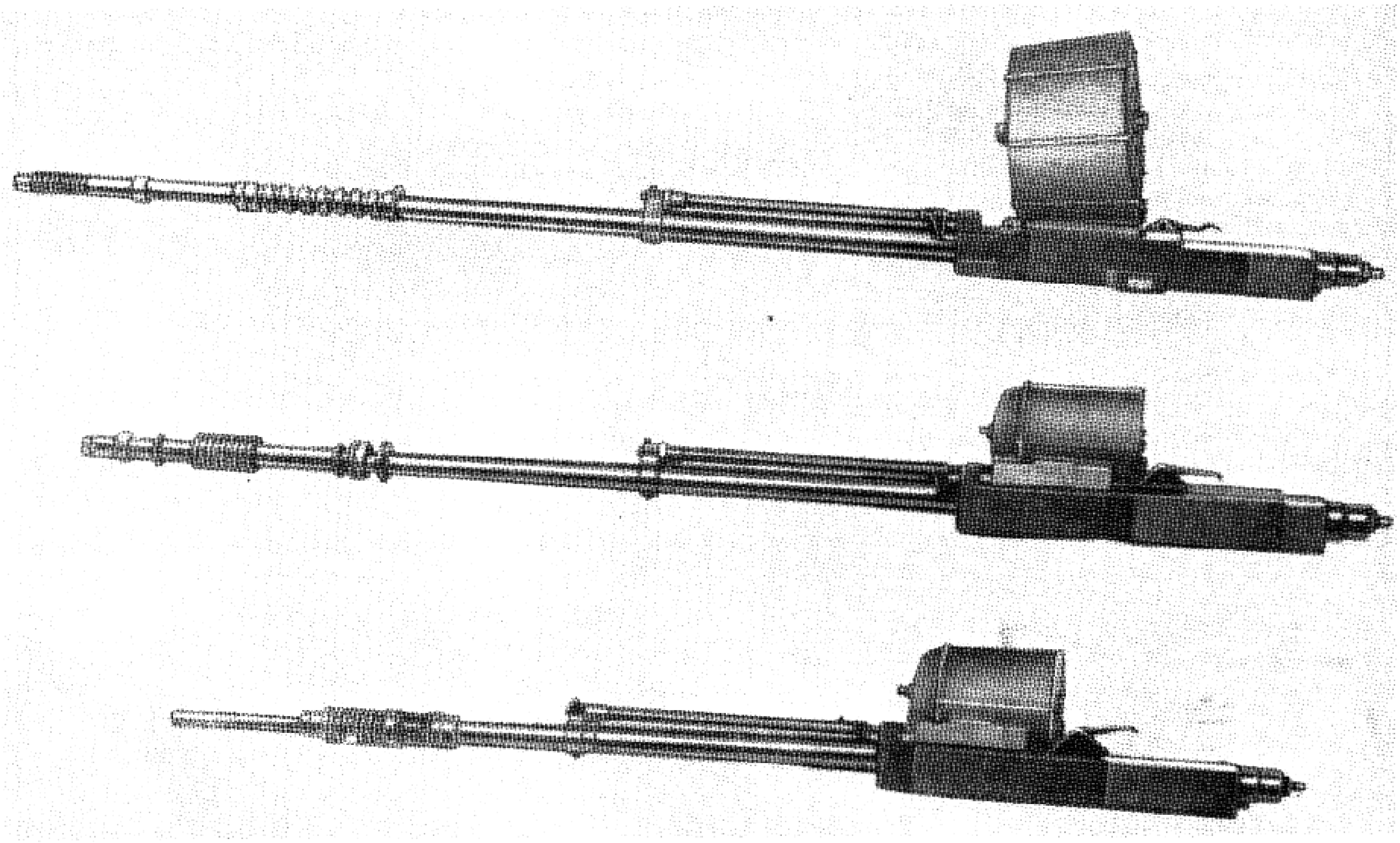

Figure 20–24. British Hispano-Suiza Guns, top to bottom: Mark I, Mark II, Mark V.

General Data: British 20-mm Automatic Gun Mark V

Gun length: 77 inches. Gun weight: 99.5 pounds. Rate of fire: 700–750 rounds/minute. Muzzle velocity: 2,850 feet/second. System of operation: Gas unlocked, blowback assist. System of locking: Swinging lock. System of feeding: Automatic spring-wound feeder employing metallic links. Method of headspace: No provision made for adjustment. Location of feed opening: Top of receiver. Location of ejection opening: Bottom of receiver. Method of charging: Hydraulic, pneumatic, manual. Method of cooling: Air.	Barrel length: 52.5 inches. Barrel weight: 26¾ pounds. Rate control: None. Barrel removal: Cannot be removed easily in field. Chamber pressure: 42,000 p. s. i. Bore: Number of grooves: 9. Groove depth: 0.015 inch. Groove width: 0.205 inch. Pitch: 7° (equals 1 turn in 25.587 calibers and 1 turn in 20.137 inches). Direction of twist: Right hand. Form of twist: Constant.

John Inglis Gun

Figure 20–25. The John Inglis 20-mm Gun. Left side view.

General Data: Canadian 20-mm John Inglis Gun

Gun length, with flash hider: 97 inches.	Barrel length: 67.5 inches.
Gun weight, with feeder attached: 155 pounds.	Barrel weight, without flash hider: 47½ pounds.
Rate of fire: 750–800 rounds/minute.	Rate control: None.
Muzzle velocity: 2,750 feet/second.	Barrel removal: Quick disconnect type.
System of operation: Gas unlocking, blowback assist.	Bore:
System of locking: Swinging lock.	Number of grooves: 9.
System of feeding: Gas operated, employing metallic disintegrating link.	Groove depth: 0.015 inch.
Method of headspace: Governed by tolerances of components.	Groove width: 0.205 inch.
Location of feed opening: Top of receiver, either right- or left-hand side.	Pitch: 7° (equals 1 turn in 25.587 calibers and 1 turn in 20.137 inches).
Location of ejection opening: Bottom of receiver.	Direction of twist: Right hand.
Method of charging: Hydraulic.	Form of twist: Constant.
Method of cooling: Air.	Cartridge: 20-mm Hispano-Suiza (M90 series).

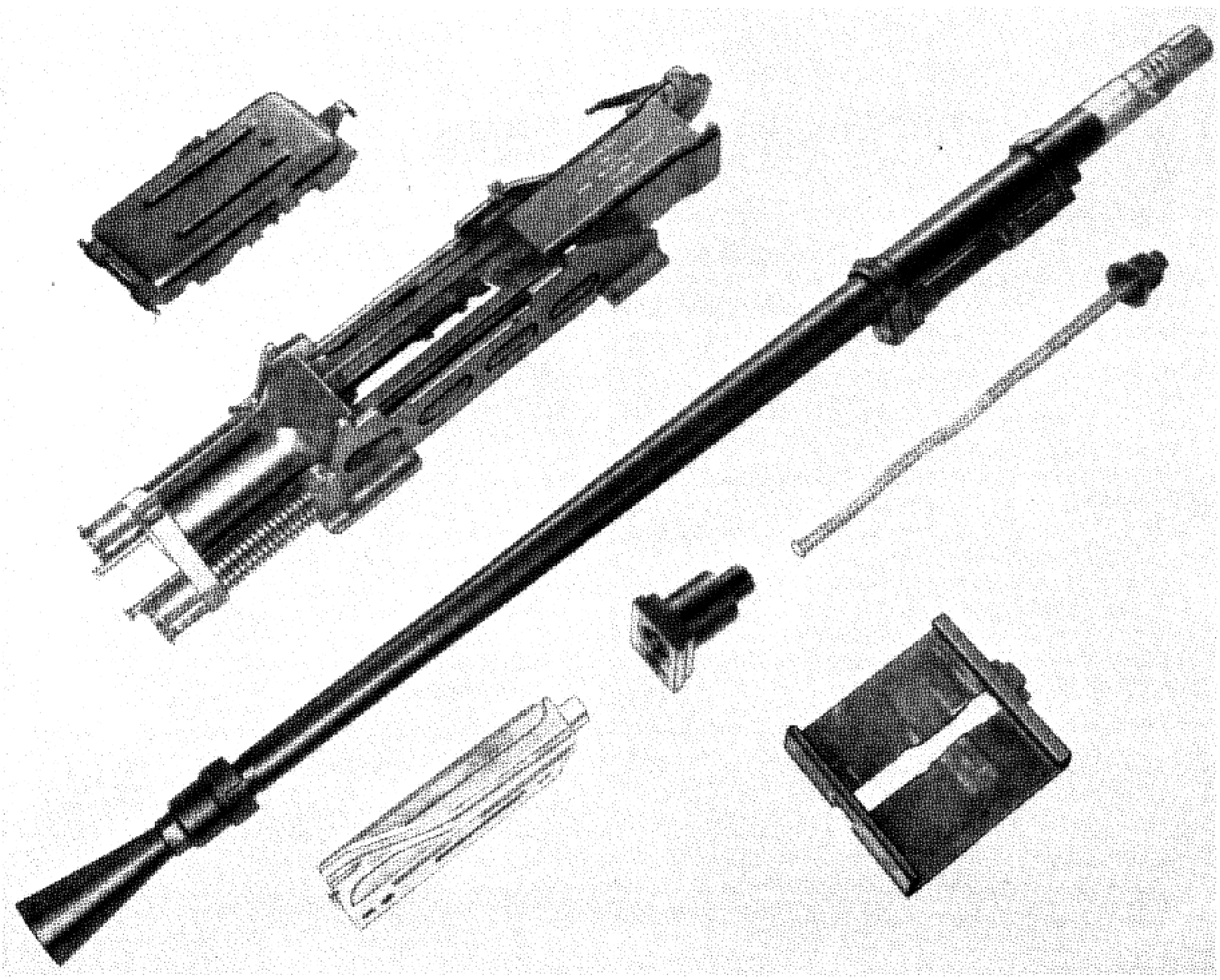

Figure 20–26. The John Inglis 20-mm Gun. Disassembled view.

Chapter 21

OERLIKON AUTOMATIC CANNON DEVELOPMENT

SECTION 1. HISTORY AND BACKGROUND

For more than a century, the town of Oerlikon, Switzerland, has been known in the engineering and machine tool fields.

In the early 1900's, the firm built the first electric railway in Switzerland. Electrical engineering became the primary business; the machine-tool section, which was much older, was separated from the Oerlikon Engineering Works and set up as an independent company known as the Oerlikon Machine Tool Works. The production of machine tools was the main endeavor of the tool works, but in 1911 the first Swiss aircraft engine was built. The project was a financial failure and engine building was dropped. In World War I, the company stepped up its production of machine tools; but with the termination of hostilities, demand fell off sharply and the tool works was in financial difficulties.

In October 1923, the Oerlikon Machine Tool Works was purchased by a German firm, the Magdeburg Machine Tool Co. The new manager was Emil Georg Buehrle, onetime officer of a machine-gun unit in the army of the Kaiser. Financial retrenchment was his first order of business. The firm's books were weighted with an inventory of finished tools for which there was little demand. The number of workers was 80.

Buehrle continued the production of machine tools, but he was also alert to the need of diversifying the output of the plant. He recognized the inherent potentialities of a machine gun of which Germany had produced several prototypes toward the close of World War I and which had been flown in combat. The gun was the 20-mm Becker machine cannon. The gun was currently undergoing development at another Swiss firm, Maschinenbau A. G. Seebach. However, this firm also met financial difficulties and went into bankruptcy. In 1924, Buehrle purchased the patent rights for the SEMAG, the name the Becker gun had been given. In the 3 years that followed, Buehrle's faith in the Becker gun had begun to be vindicated. Gune had been shipped to many countries, although no major power had purchased a large quantity of guns.

Figure 21–1. Emil Georg Buehrle, the proprietor of the Oerlikon Co.

At the end of the hostilities of World War I, the victorious Allies had examined German weapons, among them the 20-mm Becker machine cannon. They made a superficial check of the gun at Puteaux and relegated it to the museums.

In 1927, Buehrle began buying into the Oerlikon Machine Tool Works. By 1929, he was the principal stockholder and the number of employees had increased considerably.

In the early 1930's, interest in cannon armament for aircraft was reviving, and Buehrle saw an opportunity to push the development of the 20-mm SEMAG. A German designer, Fritz Herlach, was hired to work on a new version of the gun. A salesman was employed to introduce the gun to foreign governments. The man selected for this work was Antoine Gazda, an Austrian who had served as a pilot in World War I. In the capacity of "Export Manager, Oerlikon Works" he sold 40 guns and a license to the Japanese Navy. In the same year, 1935, he sold several guns to the United States Navy for test.

When a representative of the United States Ordnance Corps visited Oerlikon in 1935, he reported that the plant employed 800 persons—10 times as many employees as in 1923, when Buehrle assumed management. Two hundred of these workers were engaged in weapons manufacture. The new FF types were then appearing. These were designed primarily for mounting in aircraft having radial air-cooled engines for installation in or under the wings. The old F type, on the other hand, had been intended for engine mounting.

In 1936, Buehrle became sole owner of the company, which was renamed Werkzeugmaschinenfabrik Oerlikon, Buehrle & Co. The Swiss Federal Government stopped the shipment of production equipment to Japan in 1937, but the Dai Nippon plant was already in production. The Japanese license agreement was an important factor in the continued solvency of the Oerlikon Co.

About the same time, the British Army conducted tests of the Oerlikon as an antitank gun, but the War Office was critical of the blowback action and doubtful of the success of guns requiring greased ammunition. Then came the Spanish Civil War, where the nations rushed their new developments to the front for the ultimate test. Competent observers agreed that the gun was excellent when handled with reasonable care. The French Army of the Air liked the gun and put a quantity of 400 into service. At the opening of World War II, the Axis Powers had some of these weapons.

In 1937, the British Royal Navy considered this gun for shipboard AA defense. Tests were conducted of this and other weapons for the defense of merchant vessels, trawlers, minesweepers, and similar craft against dive bombers and close range air attack. One of the other weapons tested, the Hispano-Suiza, failed to meet the requirement that the gun be capable of operation by nonspecialist personnel such as merchant seamen and fishermen. Following the tests, a contract was negotiated with the Oerlikon plant for the manufacture and supply of guns, but only a small number of guns were delivered to the British from this source. Records indicate that only 100 guns were at sea in November 1940. The fall of France cut off the supply from Switzerland, but the Admiralty had anticipated such a possibility and had concluded a license agreement providing that Oerlikon would supply complete data for the manufacture of guns and ammunition in any part of the empire.

In June 1940, shortly before the German success in France, the British had decided to establish a facility for the manufacture of Oerlikon guns in the United States. In 1939, the Oerlikon company had appointed Alfred Altman of New York as its representative in the United States. He was to receive a 5 percent commission on guns, mounts, and ammunition sales, and a 10 percent commission on all license transactions. The latter transactions were limited to use in and for the United States. It was further provided that extension of any license agreement after the last day of 1940 was contingent upon Altman's concluding "transactions amounting to at least 500,000 United States dollars."

In May 1940, Gazda returned to the United States. He entered into negotiations with officials of the British Purchasing Commission, proposing to manufacture at a rate of 2,000 guns per year by establishing an assembly plant and using subcontractors as needed to maintain this production rate. Gazda was successful in finding a New York banking firm to back his organization.

While both Altman and Gazda were United States representatives of the Oerlikon Machine Tool Co., Gazda had power of attorney for the company. Accordingly, he negotiated a license agreement for the manufacture in and for the United States and export to the United Kingdom of the Oerlikon guns type SL and SS and ammunition types HL, SG, UL, and UG.

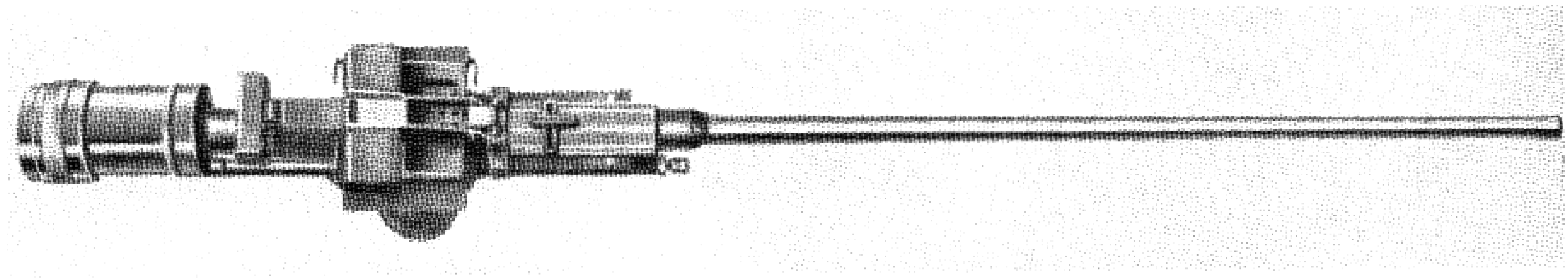

Figure 21–2. United States Ordnance Corps Caliber .60 Automatic Gun T31, an Oerlikon type developed by Gazda. Top view.

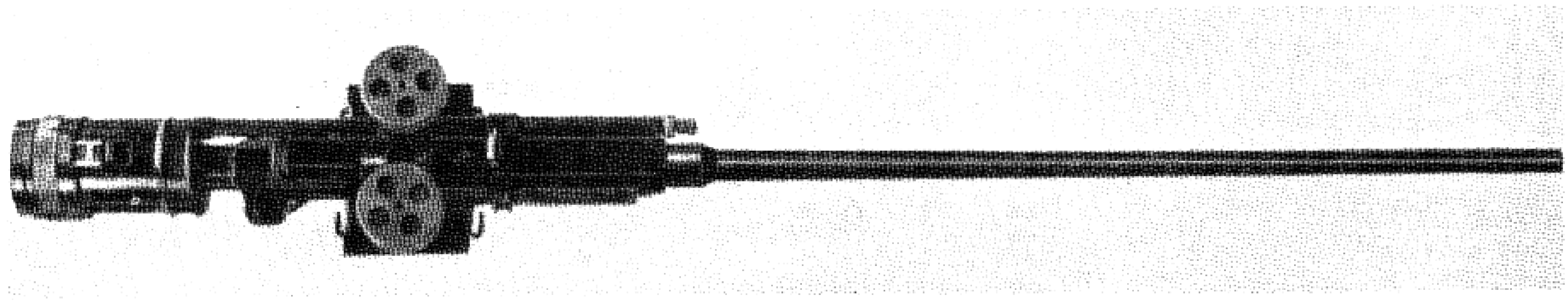

Figure 21–3. Caliber .60 Automatic Gun T31. Bottom view.

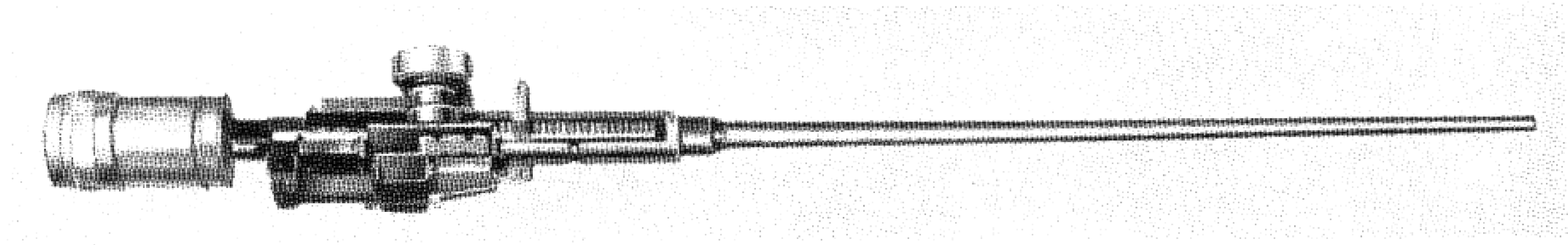

Figure 21–4. Caliber .60 Automatic Gun T31. Left side view.

This agreement was preceded by disagreement between the British Admiralty and the President's Liaison Committee on the relative merits of the Oerlikon and the Hispano-Suiza AA weapons. The difference of opinion came to an end when, on 9 November 1940, the United States Navy adopted the Oerlikon as its light shipboard AA defense. By the end of World War II almost 150,000 guns had been produced. This astronomical figure makes the 20-mm AA gun program the greatest single ordnance project in the building of the world's largest Navy.

The Axis Powers fought with Oerlikon aircraft guns using a shorter case with a reduced powder charge. Some Oerlikon weapons used by Japan were made in Switzerland, but the majority were of domestic manufacture. After the fall of France, the pressures of political, geographic, and military expediency brought about a closer liaison between Oerlikon and the Wehrmacht. This situation put the company on the Allied blacklist and resulted in the tying up of Oerlikon financial resources in the international banks. After 1943, shipments to the Axis Powers tapered off.

The international character of the production of Oerlikon guns is seen in the accompanying chart showing the main plant, its subsidiaries, and other firms which manufactured certain versions of Oerlikon weapons throughout the world. For additional details, see The Machine Gun, volume I, pages 512 to 521.

At the end of World War II, the Oerlikon plant had some thousand 20-mm guns in stock. Most of these were disposed of to governments engaged in minor military activities in various parts of the world before the Swiss Federal Council curtailed the munitions export trade by an embargo. This measure became effective in 1946. The main reason for

Figure 21–5. Test of the Oerlikon Type SS Gun at the Naval Proving Ground, Dahlgren, Va., in 1940.

this was to avoid the political embarrassment that the arms trade with Germany and Italy caused during World War II and with the U. S. S. R. in the postwar period.

The curtailment order did not completely hamstring the arms industry in Switzerland, however. Provision was made for the Federal Military Department to grant permits for export of certain classes of munitions. The most important of these, as far as the Oerlikon plant was concerned, were AA defense weapons up to 35-mm bore. The effect of this policy has been to permit shipment of trial orders to such countries as Great Britain, the United States, Sweden, Norway, and Canada—countries which have adequate arms industries and which are more interested in acquiring manufacturing rights to new Swiss weapons than in purchasing large quantities of Swiss-made guns.

With this incentive to continue weapon development, the Oerlikon plant turned its attention to new designs. Although guns with blowback action had played an important part in World War II, it was obvious that something better was needed. The competition of Hispano-Suiza was, no doubt, an important incentive at this time. The universal demand for a high rate of fire led to the setting of a requirement of one thousand rounds per minute in any new gun mechanism. Thereupon, the chief engineer of the firm proposed a method of operation which he named "power reserve loading." The gun produced to this design was called the 5TG. Although it seemed promising at first, it failed to meet fully the current requirements for an aircraft and antiaircraft high-speed cannon. The Oerlikon Co.'s progress seemed stymied, when new life was injected into the design department from outside sources.

About this time the impact of the defeat of the Axis powers was beginning to be felt. The victorious nations claimed all military inventions as

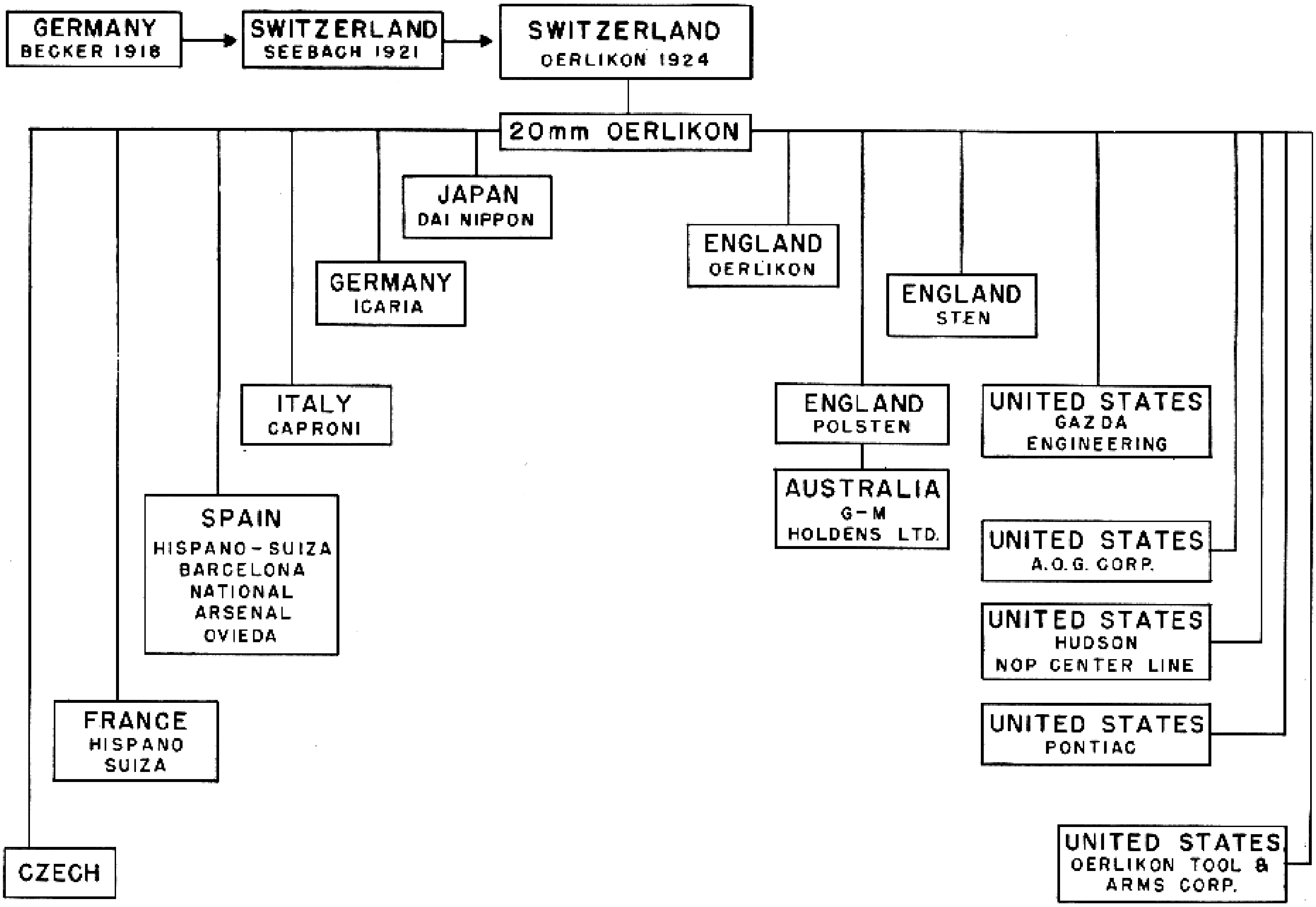

Figure 21–6. The present Oerlikon designs stem from the Becker gun of World War I. Adaptions from this parent mechanism are indicated in this chart.

booty of war. German gun models and data were evacuated by the Allied Technical Intelligence services and many German gun-design personnel became employees or prisoners of the victors. Others left Germany for neutral countries, and, of these, an important group went to the Oerlikon works. Among this group were Linder and Herlach—the same Fritz Herlach who had been hired by Buehrle to work on a new version of the 20-mm SEMAG in the thirties. These two men and others, who were hired, had worked on advanced designs which Germany was preparing when she collapsed.

Under the guidance of these men, hit-and-miss methods in research and development were replaced by more efficient procedures geared to produce more certain results. Several of the later designs which had been in the prototype stage in Germany were revived. In addition to development of 20-mm guns, design studies were made in the field of 30-mm weapons. Among these are the 30-mm automatic aircraft gun type 301 FK, shown in an accompanying figure, the 30-mm revolver gun 302 RK, and the 40-mm caseless gun HO 301. Important projects were also undertaken in the field of ammunition, rockets, and guided missiles.

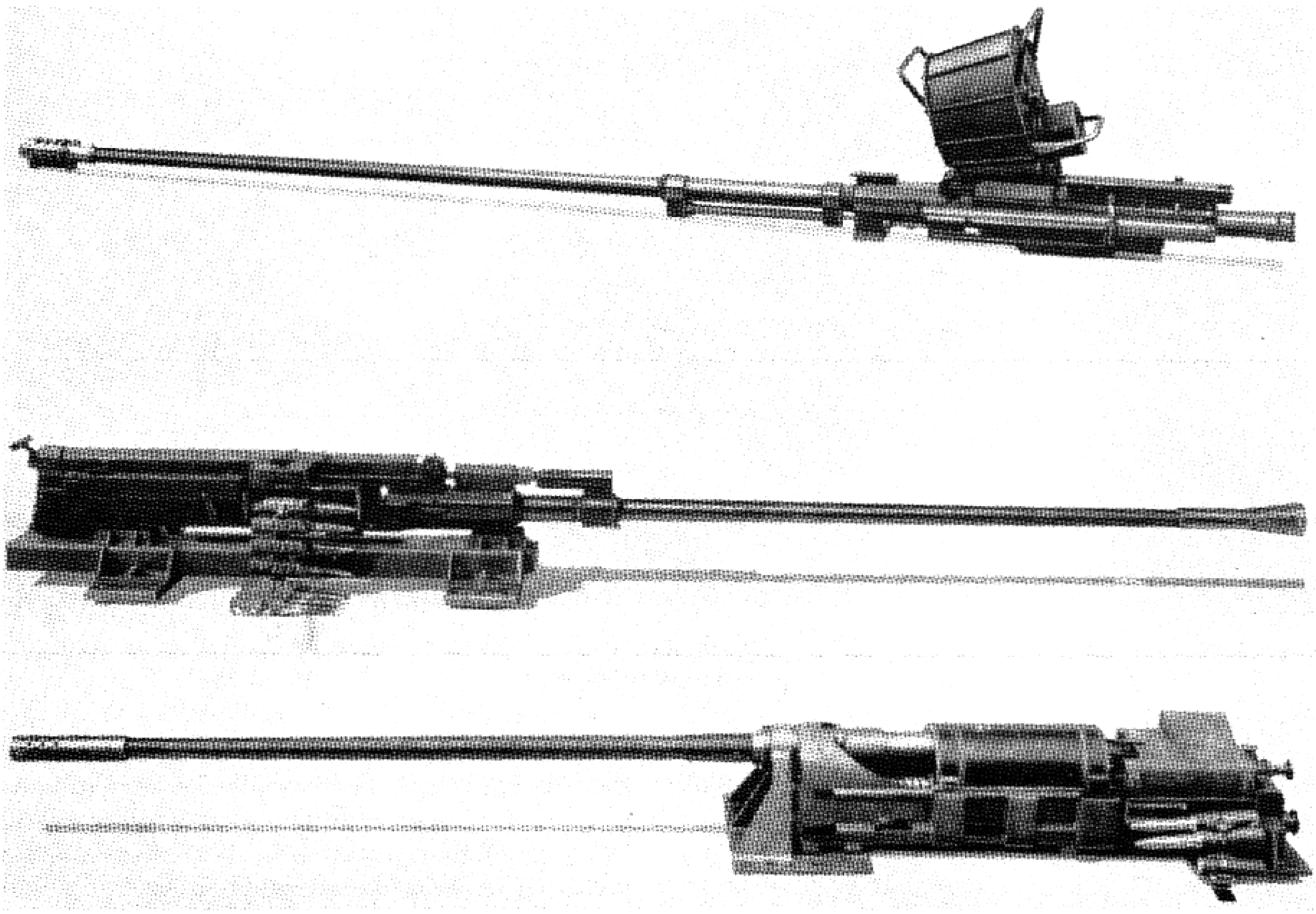

Figure 21–7. Automatic Cannon Types under development at the Oerlikon Factory since World War II. Top to bottom: 20-mm Automatic Gun Type 5TG; 20-mm Antiaircraft Gun Type 204 GK; 30-mm Revolver Cannon 302 RK.

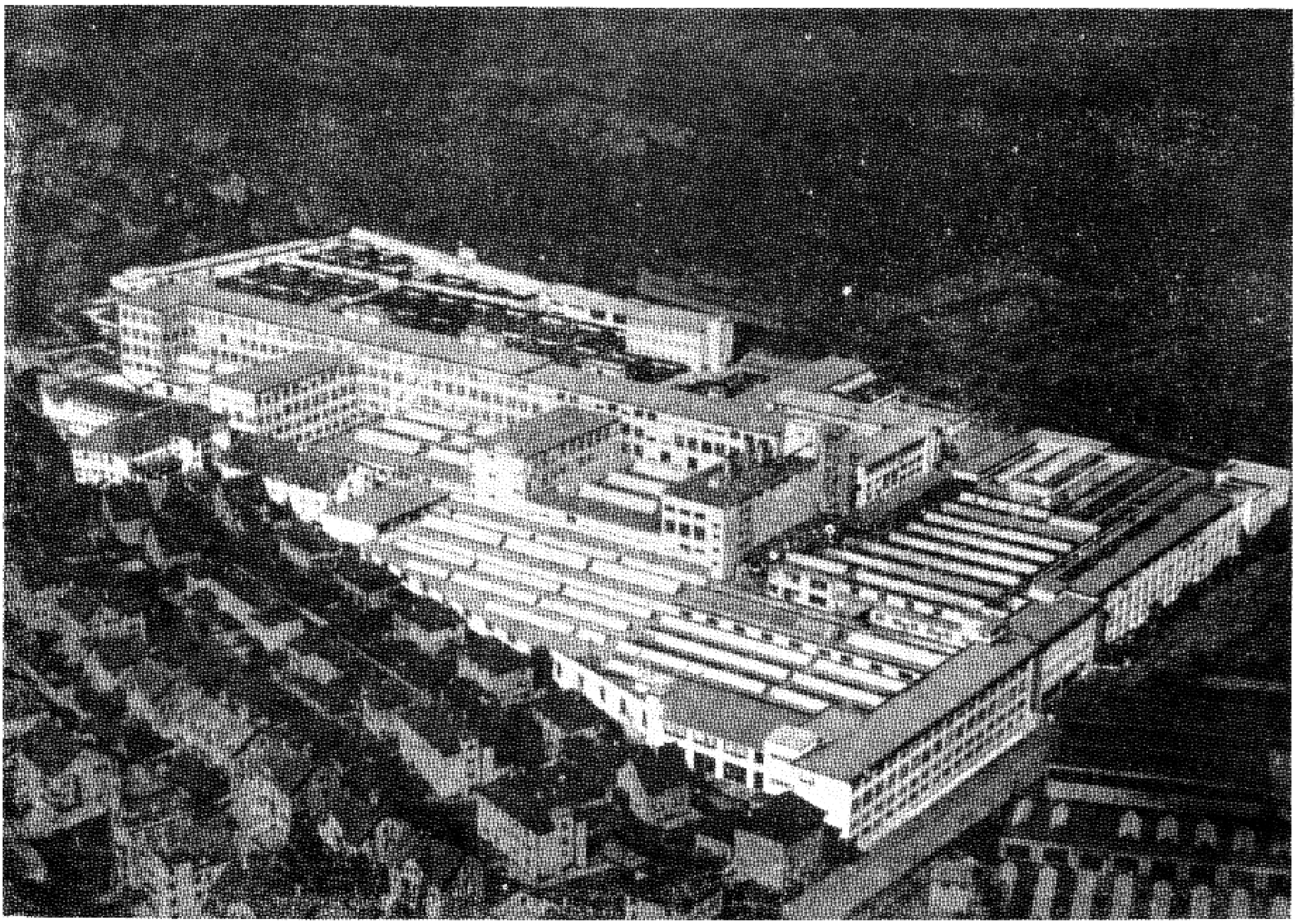

Figure 21–8. Aerial view of the Oerlikon factory in Switzerland.

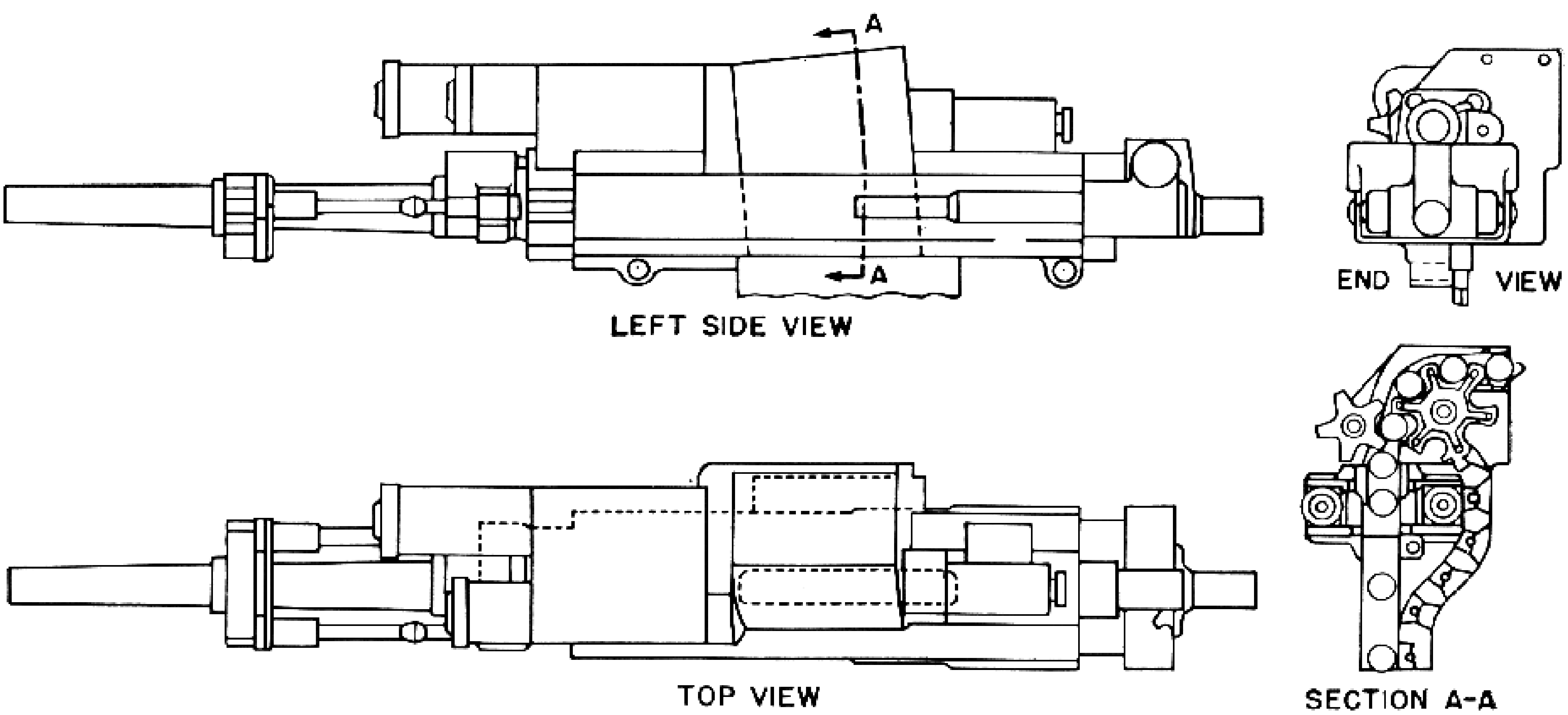

Figure 21–9. Oerlikon 30-mm Automatic Cannon Type 301 FK, a postwar design that was discarded in the development stage.

SECTION 2. 20-MM AUTOMATIC GUN TYPE 5TG

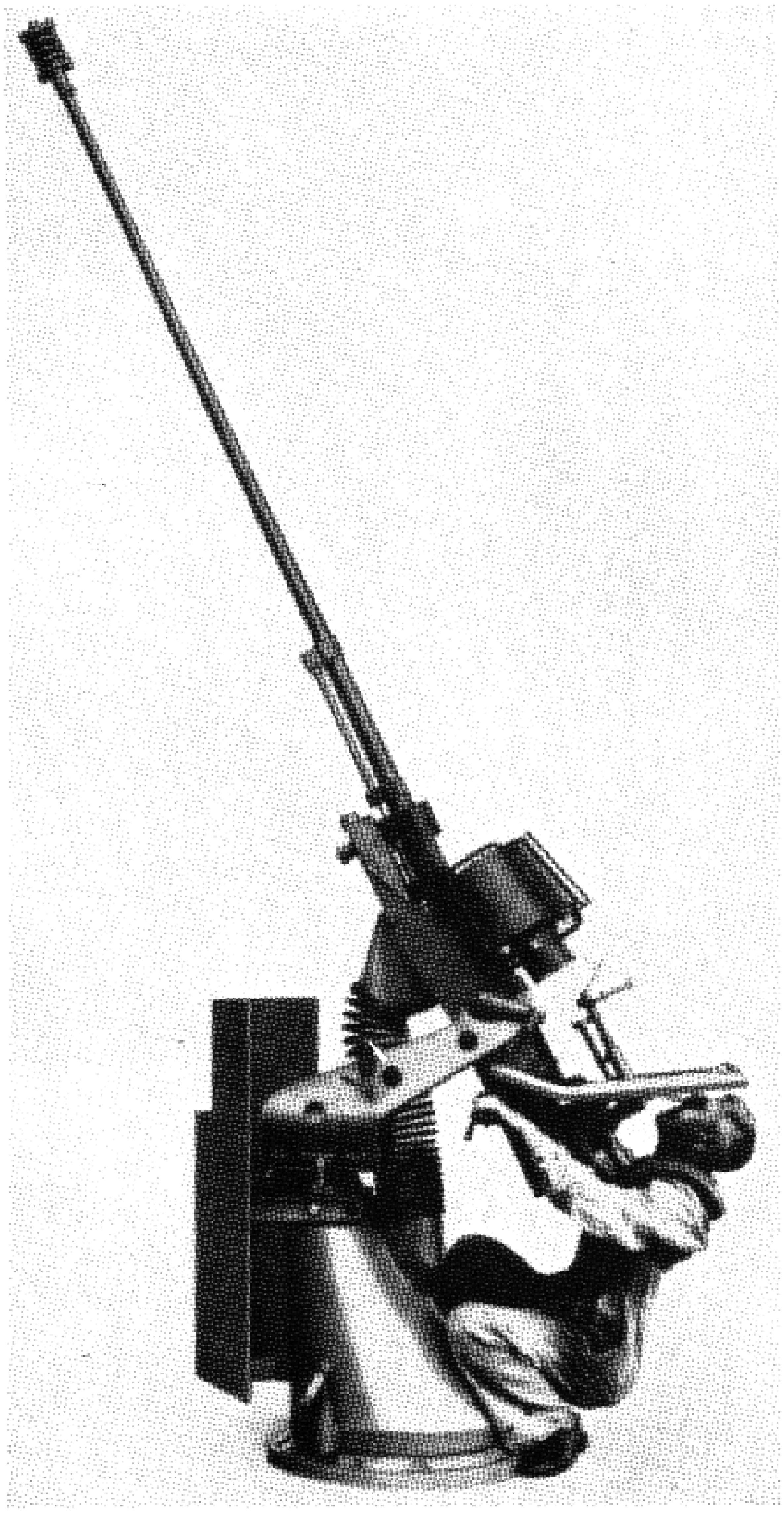

Figure 21–10. 20-mm Automatic Gun Type 5TG on a cone mount, for use as a light AA gun.

The 20-mm automatic gun type 5TG, developed after the close of hostilities of World War II, was the first Oerlikon gun design that differed radically from the original Becker design. The 5TG was first made with a drum feed. An Oerlikon Co. brochure describing the gun states that the gun can be adapted for pneumatic or electric-driven feeder, pneumatic or electric charger, and that searing and ignition can be made electrical. Available information indicates that the prototypes are still drum fed. The following quotation presents observations on 20-mm guns for firing against aircraft as given in the brochure just mentioned.

"The destructive power of a single 20-mm shell is comparatively small. Several hits are therefore required to down an airplane. The initial velocities and trajectory times encountered with the usual 20-mm automatic guns require intolerable prediction distances when firing against fast jet-propelled aircraft.

"The density of the cone of fire with the conventional rates of fire is no longer sufficient because of the high airplane speeds. The probability of hitting thus becomes very small.

"When low-flying aircraft are to be fought, the time available for firing is very short. Apart from the small probability of hitting, with the conventional rates of fire this time is mostly too short to fire a sufficient number of shells into the target to effect its destruction."

Based on these propositions, Oerlikon designed the 20-mm 5TG for a rate of fire of 1,000 rounds per minute and a muzzle velocity of 3,700 feet per second. It is noteworthy that during a demonstration in England held from 6 to 8 May 1949, a rate of fire of only 800 rounds per minute was attained although the muzzle velocity was recorded at 3,600 feet per second.

The improved performance of the 20-mm 5TG over the conventional automatic guns of the same caliber naturally had some constructional consequences. The increase in the muzzle velocity from the customary 2,790 feet per second to 3,700 feet per second—practically tantamount to twice the muzzle energy—necessitated on the one hand a longer barrel and on the other, a heavier propelling charge and consequently a larger and heavier cartridge. The barrel length of 7.88 feet—equivalent to 120 caliber—could be kept at the size permissible for operational and technical reasons. Yet, in order to obtain the desired high rate of fire in spite of the larger and heavier cartridge, a different approach had to be tried in the design and construction of the breech system. Only by reducing all oscillating

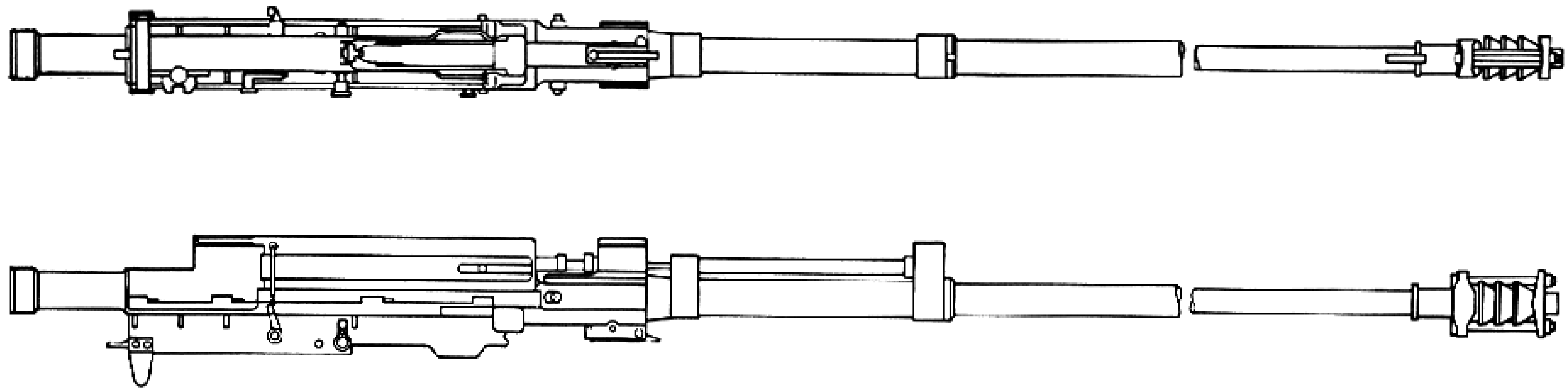

Figure 21–11. Oerlikon 20-mm Automatic Gun Type 5TG. Assembled view.

masses to a minimum and by designing all parts as simply as possible in regard to shape and action, could the high rate of fire of 1,000 per minute be reached.

The 5TG gun has a one-part breech which, during firing, is rigidly supported by a lock located in the breech casing. The energy necessary for locking is taken from a spring tensioned by the breech during the last part of its forward run. As the energy thus won during the breech's forward movement cannot be utilized immediately for actuating the bolt, it has to be stored for a short time in the spring acting as a power reserve. Since this function is an outstanding feature of the new gun, the breech system was given the name of "power-reserve-loader."

When the forward moving breech has reached its foremost position, the power reserve spring expands and by transferring its energy to the locking bar, swings the bolt into the locking position and finally actuates the firing pin. In this way the danger of premature ignition, with the breech unlocked, is wholly eliminated. The breech is unlocked by a gas piston operated by powder gases expelled through a vent in the barrel. The gun is triggered with the breech in open position, that is, rear seared.

The breech is kept in the rear position by the trigger catch lever against the pressure of the recuperation spring. The lock is secured in its lower position by the two rebound slides. The latter are acted upon by the accumulator springs, resting against the locking slides. The locking slides are held in place by the bolt through the locking bar. On activating the trigger, the catch lever rotates around its pin and releases the breech, which is now

General Data: 20-mm Automatic Gun Type 5TG

Gun length: 132.04 inches.
Gun weight: 208.37 pounds.
Rate of fire: 1,000 rounds/minute.
Muzzle velocity:
- Of HE shell, 4.16 ounces: 3,708 feet/second.
- Of armor-piercing shell, 5.29 ounces: 3,282 feet/second.

Barrel length:
- With muzzle brake: 100.67 inches.
- With cartridge chamber: 94.48 inches.

Barrel weight, with muzzle brake: 91.51 pounds.

Overall height of gun less magazine: 7.28 inches.
Overall width of gun less magazine: 5.0 inches.
Weight of 50-round drum magazine, empty: 48.51 pounds.
Weight of 50-round drum magazine, full: 85.99 pounds.
Weight of one cartridge with HE shell: 0.7497 pounds.
Weight of one cartridge with armor-piercing shell: 0.8159 pounds.
Flight time of HE shell at 3,282 feet: 0.5 second.
Flight time of HE shell at 4,923 feet: 1.1 seconds.
Flight time of HE shell at 6,564 feet: 3.0 seconds.

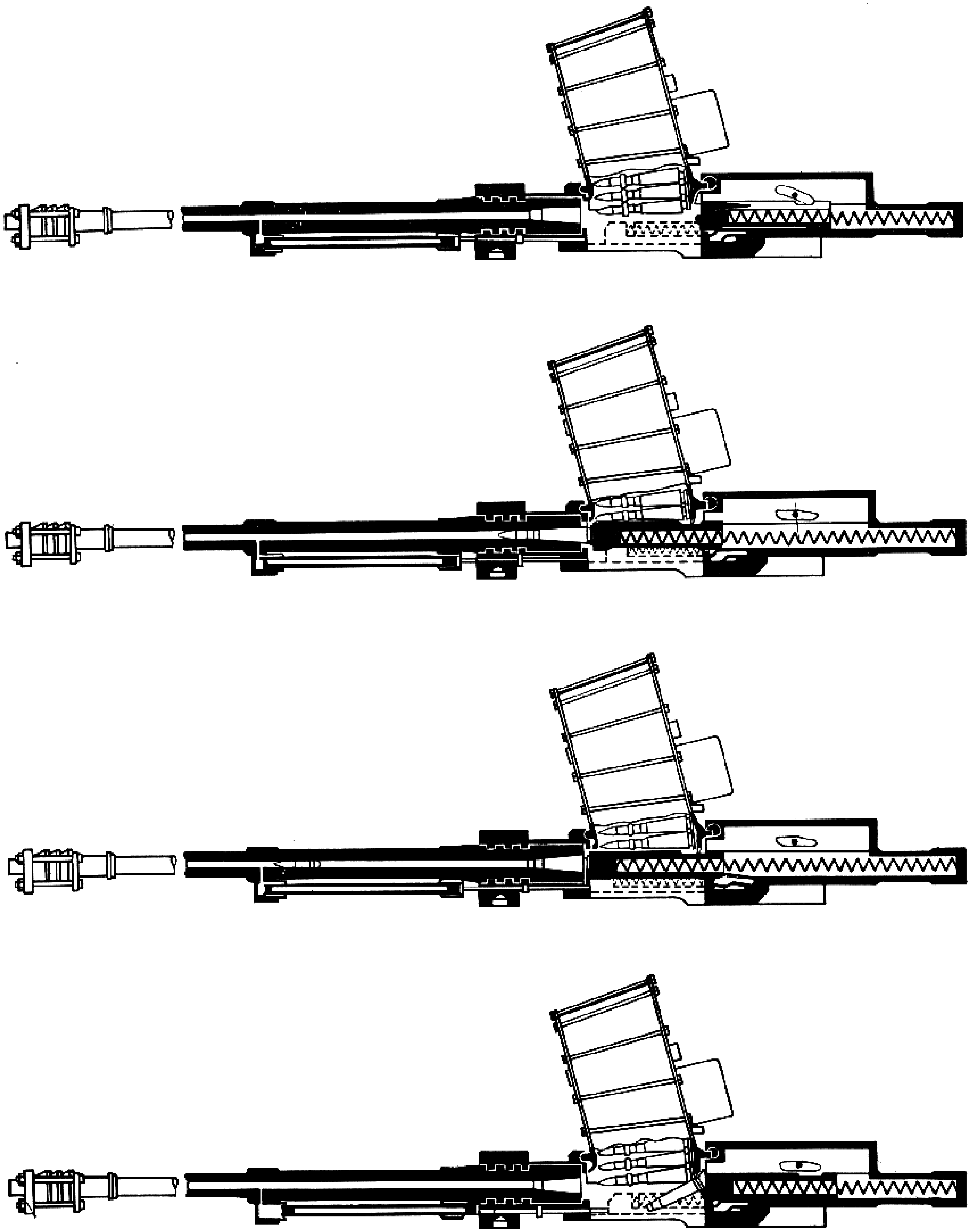

Figure 21-12. Cycle of operation of 20-mm Automatic Gun 5TG. Top to bottom: cocked; counterrecoil and feed; ignition recoil and eject.

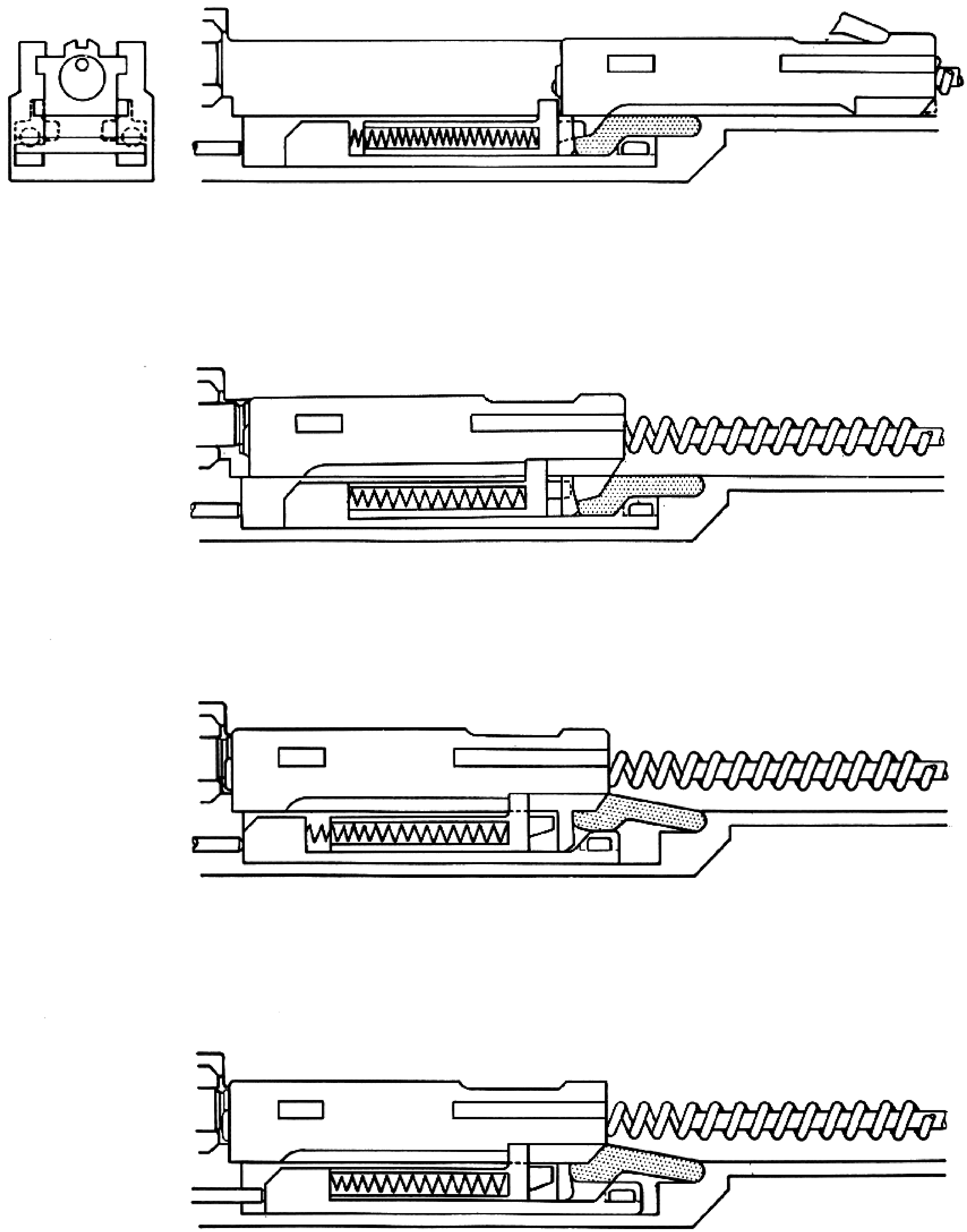

Figure 21–13. Locking action of 20-mm Automatic Gun 5TG. Top to bottom: bolt cocked; bolt advances; lock rises; unlockin commences.

258970°—54——38

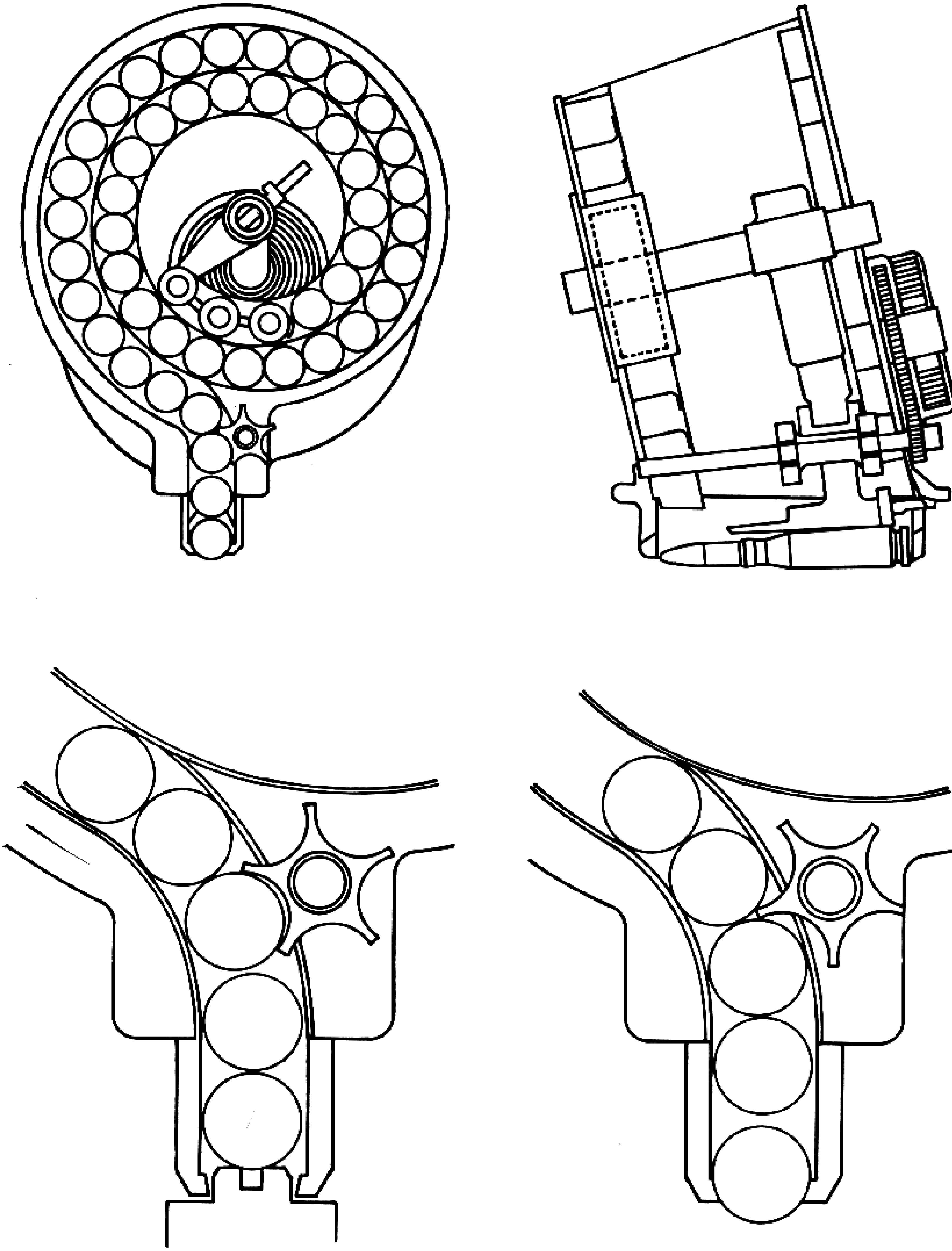

Figure 21–14. Drum magazine of 20-mm Automatic Gun Type 5TG.

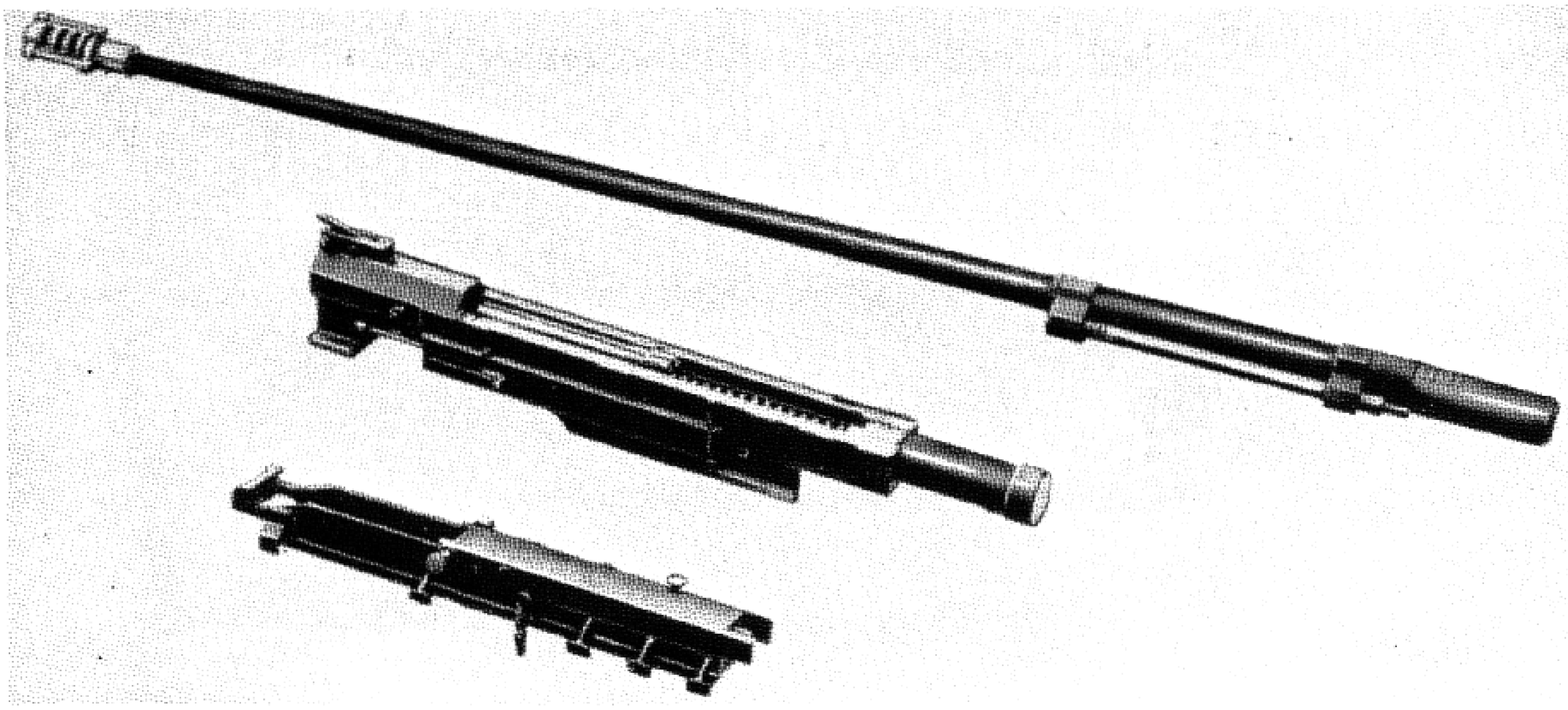

Figure 21-15. 20-mm Automatic Gun 5TG, partially disassembled.

driven forward by the recuperation spring. During its forward run, the breech seizes the lowermost cartridge in the magazine lips and pushes it into the chamber of the barrel. Shortly before reaching its foremost position, the breech's lateral noses impact upon the rebound slides, throwing them forward. Since the locking slides are still held in place by the lock, the accumulator springs are compressed by the motion of the rebound slides. On advancing, the latter release the lock which is, however, still secured in its lower position by the breech. Only when the rebound slides strike the locking slides, the lock is released by the breech. The locking slides now advance together with the breech, thereby pressing the lock upward through the locking bar.

After the breech has reached its foremost position, the locking slides continue to move forward under the action of the expanding accumulator springs. The lock is thereby brought into locking position, secured, and finally when the locking slides have arrived in their foremost position ignition is effected.

During firing the breech is connected rigidly to the breech casing by the lock. The cartridge chamber of the barrel is thus completely enclosed. The design of the breech system entirely eliminates the danger of premature opening of the breech.

As soon as the shell has passed the orifice in the barrel, the gas piston is pushed backward by the powder gases. The gas piston drives the locking slides to the rear against the pressure of the accumulator springs. The locking bar moving backward together with the locking slides ceases to secure the bolt in its top position. Under the action of the residual gas pressure, the breech can now push the lock downward and begin its recoil motion. The rebound slides are pressed back by the accumulator springs and secure the bolt once more in its lower position. The breech now recoils unhindered, thereby compressing the recuperation spring. The empty cartridge case is pulled out of the chamber by the extractor and ejected downward when striking the nose of the ejector. After reaching its rearmost position, the breech is moved again into firing position by the recuperation spring, the process repeating itself as long as the trigger is operated and there are cartridges in the magazine.

To reduce the strain on the gun, the mount, barrel, and breech casing are movable against a recoil spring. A muzzle brake of high efficiency reduces the recoil energy and thus the spring forces and recoil distances. The trigger casing carrying the drum magazine is connected rigidly to the cradle and therefore remains stationary during firing.

Cocking is effected by means of a cocking gear placed upon the gun and is performed by two lever movements.

For maintenance, the gun can easily be disassembled without tools. The complete disassembly

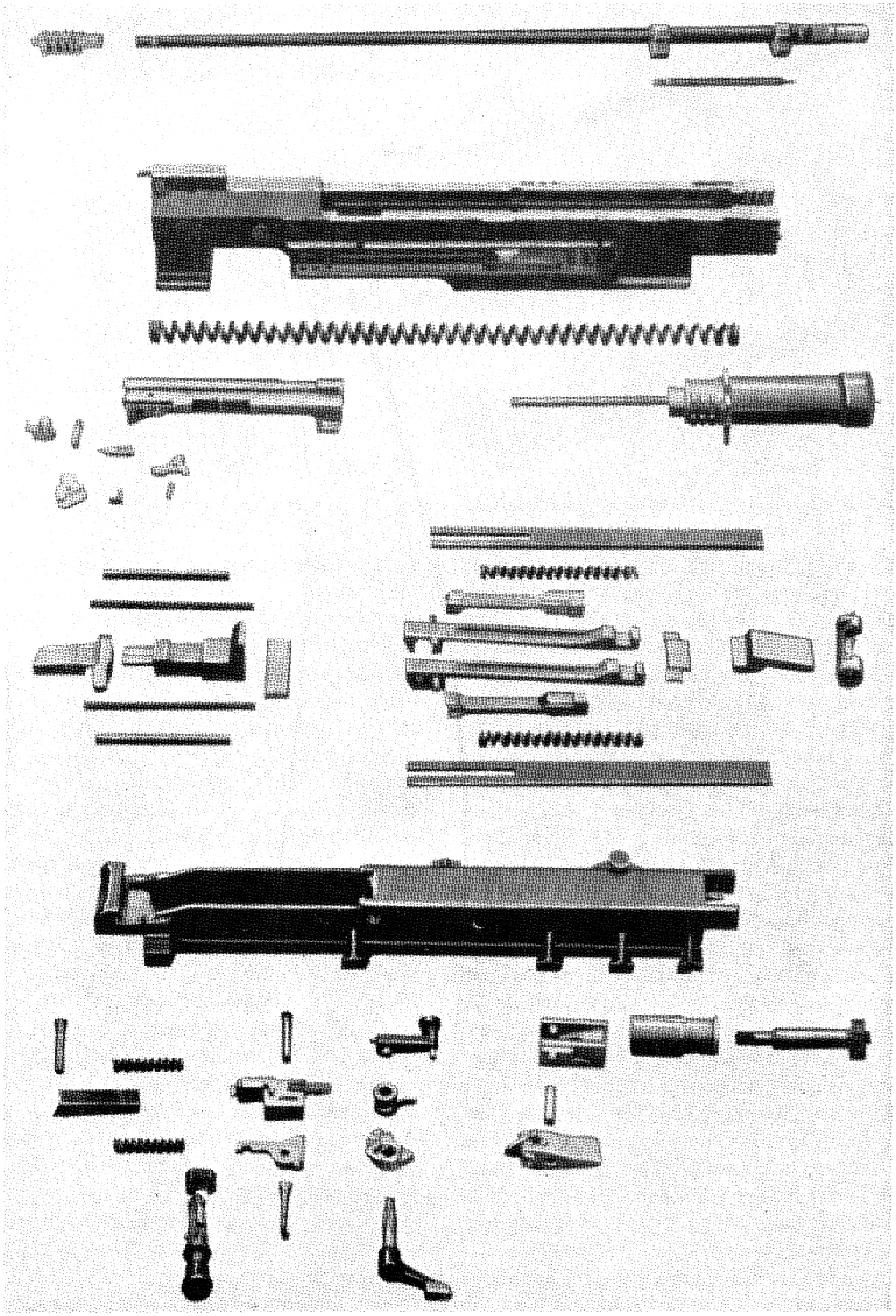

Figure 21–16. 20-mm Automatic Gun STG, completely disassembled (barrel not to scale).

can also be performed almost without tools. The few tools necessary for removal of a small number of parts (one lever, some wrenches and mandrels) are contained in the kit for tools and spare parts that is furnished with each gun.

Cartridge feed is effected by means of a drum magazine having a capacity of 50 rounds. A spiral spring arranged on the drum axle drives the feeder which moves the cartridges towards the magazine exit. At the exit there is a spring-driven star wheel which accelerates the foremost few rounds independently from the rest of the cartridges. Trouble-free ammunition feed is thus assured. When the magazine runs empty, the breech is automatically held in its rear position. After changing the magazine, no recocking is therefore necessary.

SECTION 3. 20-MM ANTIAIRCRAFT GUN TYPE 204 GK

The Oerlikon 20-mm antiaircraft gun type 204 GK is gas operated and features a centrally locked breechblock and belt feed. The belt can be fed into the gun as desired from the left or the right. The cartridge cases are ejected obliquely to the rear during the forward third of the breechblock travel.

General Data: 20-mm Antiaircraft Gun Type 204 GK

Gun length (without barrel): 39.4 inches.
Gun length (including flame muffler): 103.4 inches.
Gun weight: 154.35 pounds.
Rate of fire: 1,000 rounds/minute.
Muzzle velocity: 3,446 feet/second.

Barrel length: 66.92 inches.
Barrel weight (with flame muffler): 52.9 pounds.

Weight of shell: 4.23 ounces.
Weight of the parts recoiling in the mounting: 105.8 pounds.
Weight of the parts fixed with respect to the mounting (gun top with cartridge feed and trigger): 48.5 pounds.
Ammunition for the 204 GK gun.
Length of the cartridge: 8.01 inches (maximum).
Length of the cartridge in belt: 8.01 inches (maximum).
Length of cartridge case: 5.0 inches (maximum).
Maximum diameter:
- Of case: 1.25 inches.
- Of case at the belt link: 1.25 inches.

Length of belt link: 4.33 inches.
Maximum diameter of belt link: 1.32 inches.
Maximum diameter of belt link with cartridge: 1.35 inches.
Weight of belt link: 2.22 ounces.
Maximum diameter of guide rollers: 2.37 inches.
Number of cartridges required for twisting the belt through 90°: 7.
Inner radius of cartridge belt:
- With case bottoms inside: 6.5 inches.
- With shells inside: 1.97 inches.

Weights	Pointed explosive shell	Armor-piercing shell
	Ounces	*Ounces*
Cartridge	11.8	13.05
Shell	4.2	5.35
Empty case	5.39	5.39
Propellant charge	2.18	2.29

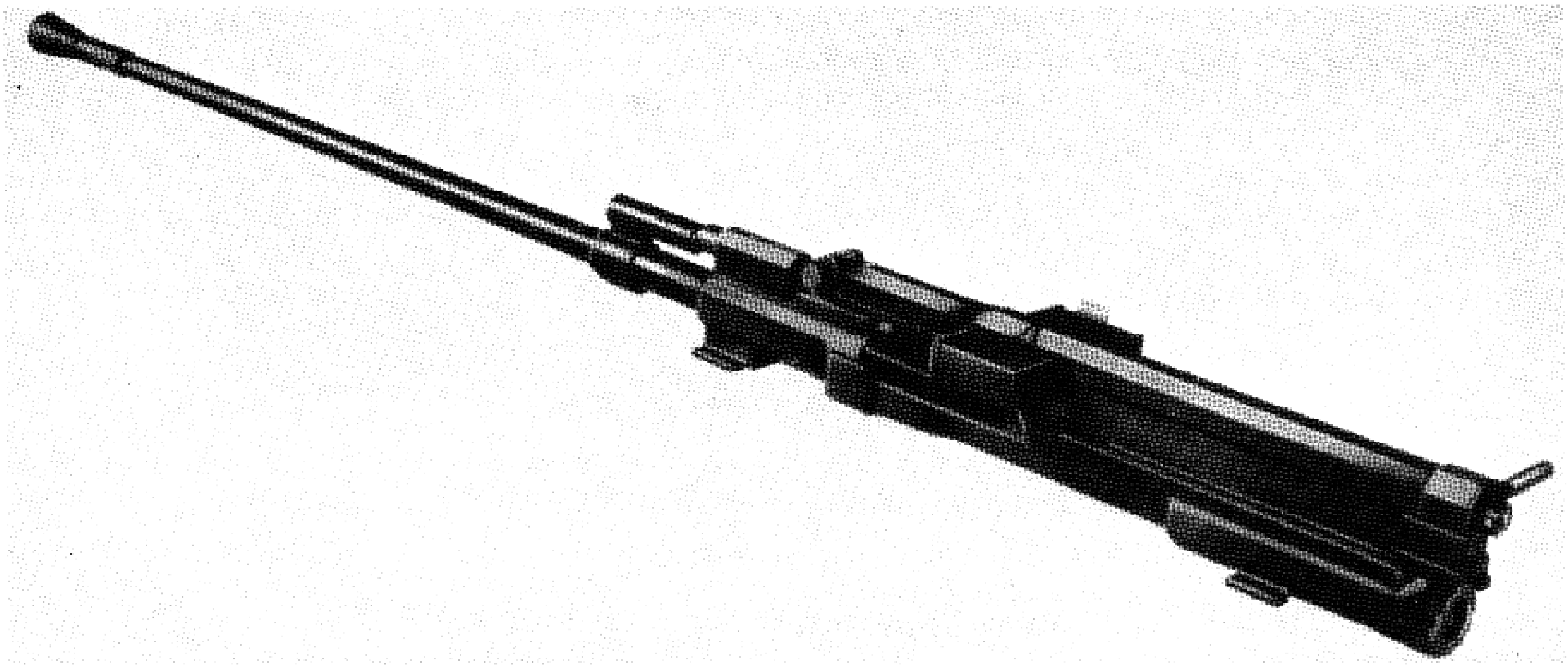

Figure 21–17. 20-mm Antiaircraft Gun Type 204 GK. Left side view.

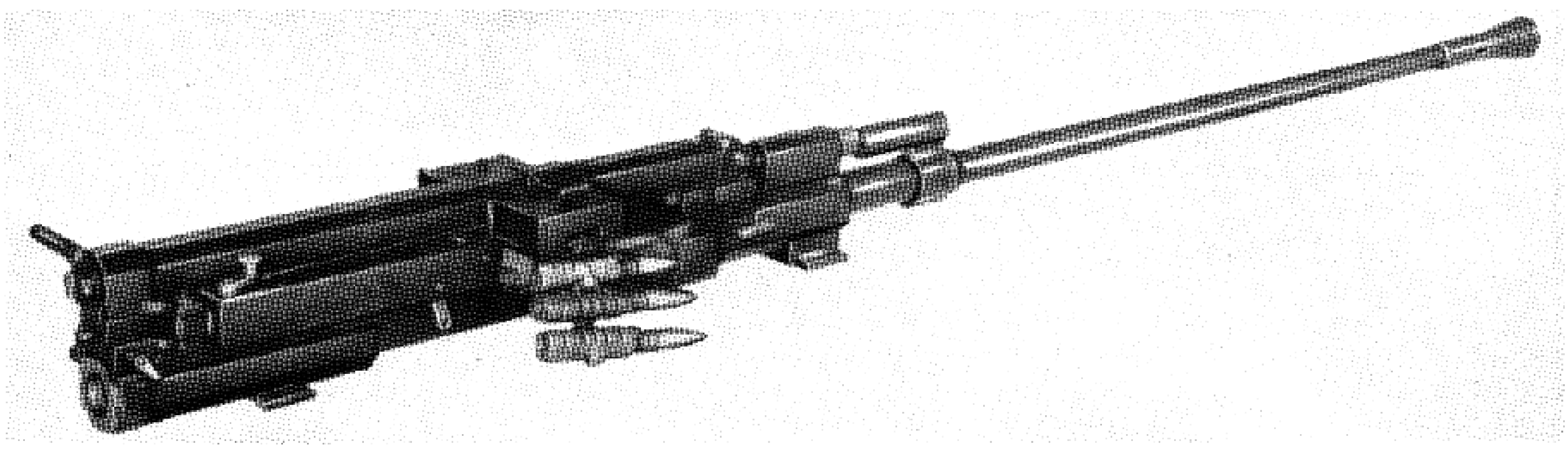

Figure 21–18. 20-mm Antiaircraft Gun Type 204 GK. Right side view.

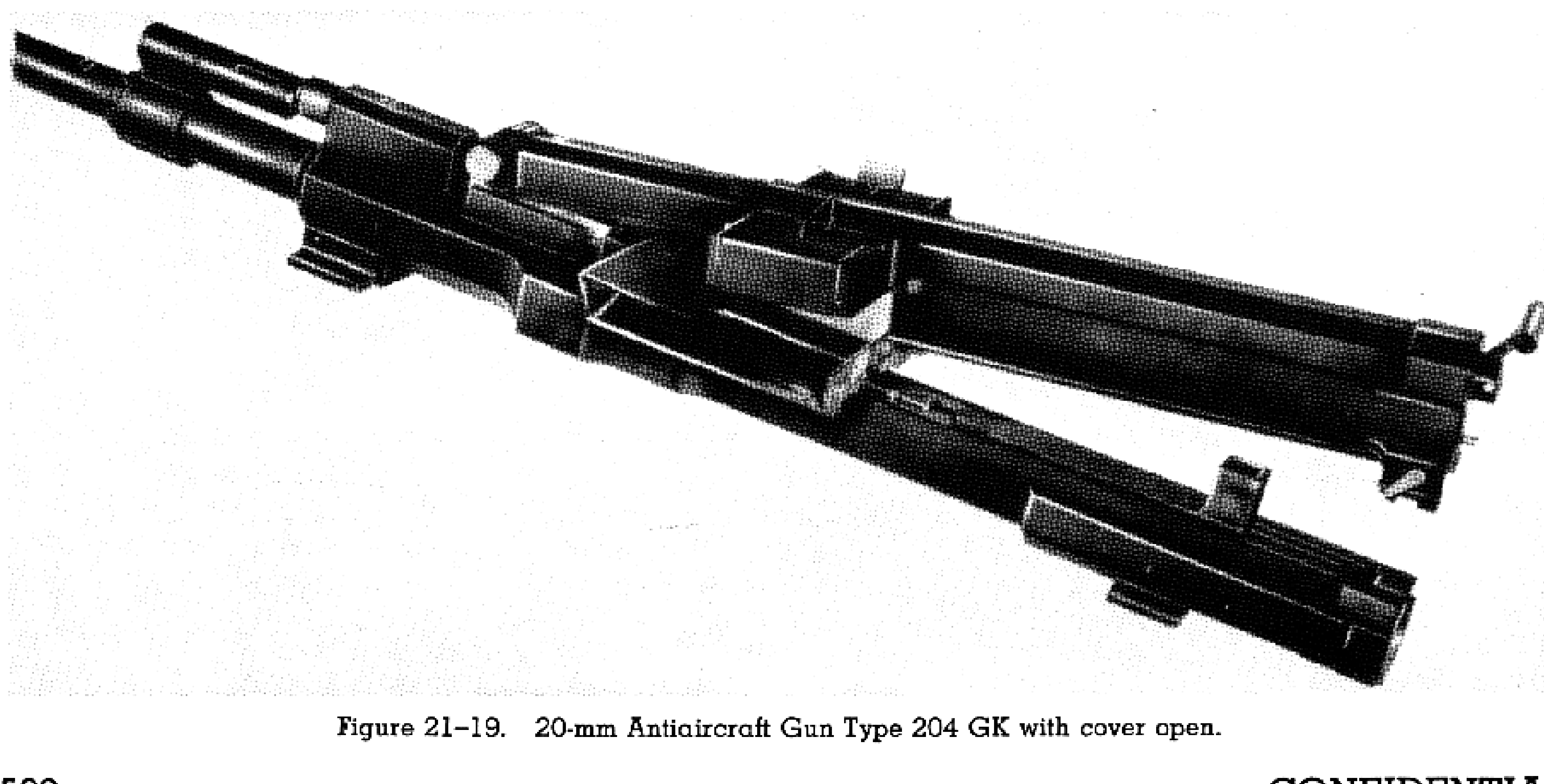

Figure 21–19. 20-mm Antiaircraft Gun Type 204 GK with cover open.

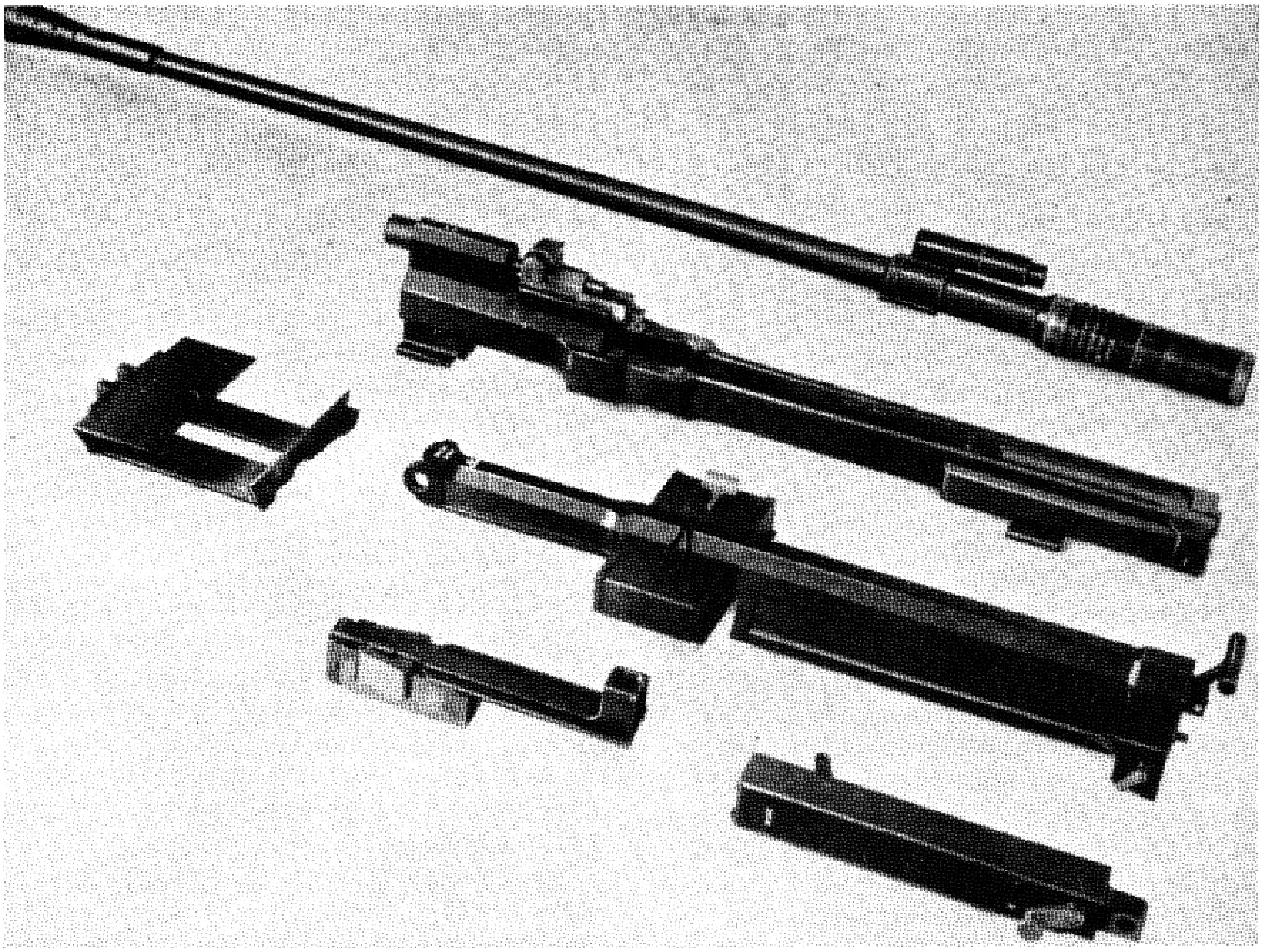

Figure 21–20. 20-mm Antiaircraft Gun Type 204 GK partially disassembled.

The belt links drop out of the feed mechanism on the side opposite the belt entry.

In the mounting there are two slide lugs which allow the gun to recoil during firing. The front slide lug is connected with the slide supported by the recoil springs. The recoil travel amounts to 20 mm. The top of the gun, which contains the cartridge feed devices, does not take part in the movement of the gun. The cartridge feed device is thus also fixed with respect to the mounting. The gun top is connected to the mounting at its rear end on the left or on the right side. The maximum trunnion thrust, acting only for a very short time, has the following values: If a flash hider is used, 4,410 pounds; if a muzzle brake is used, 2,646 pounds.

The breechblock is retracted by hand. The retracting device, which does not incorporate any gearing, is permanently built into the gun. The force necessary for retracting ranges from 55 to 110 pounds. Over a short distance, of approximately 2 inches, an additional resistance of 22 to 33 pounds (moving the cartridge belt) must be overcome. This additional resistance is hardly noticed if the retracting device is actuated with a strong pull. A charger can be installed on the gun, but this is not yet provided. The trigger mechanism for automatic fire is arranged inside a casing on the right side of the gun top. The safety is also located in this position.

The belt can be introduced into the gun with the breechblock closed as well as when the breechblock is in its open position. After the last round has been fired from the belt, the breechblock remains to the rear. To establish firing readiness of the gun, it is unimportant whether the belt is introduced first and the breechblock cocked afterwards or vice versa.

Since the design of this weapon is largely the work of Linder, who had worked on the MG 151 in World War II, the weapon has sometimes been described as derived from that well known German gun. There are certain external resemblances, but the locking action is completely different.

SECTION 4. 20-MM REVOLVER GUN 206 RK

General Description

The Oerlikon 20-mm revolver gun 206 RK is a high-performance aircraft gun, featuring a high muzzle velocity and an exceptionally high rate of fire. Ammunition is fed to the gun in belts, either from the right or from the left side. The feed direction may be changed by exchanging parts. The empty belt links are ejected laterally on the side opposite the feed side. The empty cases are ejected to the rear.

Principle of Operation

At the rear end of the barrel is the rotatable cylinder, which contains five cartridge chambers. During firing, cartridges are fed into the chambers of the cylinder. The cylinder is rotated in steps by means of the gas-operated slide so as to successively aline the chambers with the barrel. The cartridges are fired electrically when they reach the firing position behind the barrel. After the drum has been rotated by another pitch, the empty cartridge case is ejected to the rear.

Behind the drum is the star wheel, which rotates with the cylinder. The star wheel pulls the cartridge belt into the gun. From the star wheel, the cartridges are moved into the chambers of the cylinder in two steps, by means of a ram connected to the gas-operated slide. The empty belt links are ejected sideways from the star wheel. Cocking of the gun is effected by means of two pneumatic rams. When firing is interrupted, one cartridge is left in firing position.

The gun casing is rigidly attached to the airframe. The cylinder carrier, which carries the barrel, is inside the gun casing and recoils against two springs during firing. The cartridge feed mechanism is attached to the gun casing and therefore does not move during firing. The star wheel and cylinder are connected in such a way that they can move axially relative to each other.

General Data: 20-mm Revolver Gun 206 RK

Gun length; (with flash reducer): 94 inches.
Gun weight: 198 pounds.
Rate of fire: 1,650 rounds/minute.
Muzzle velocity: 3,600 feet/second.
Barrel length: 63 inches.
Length of cylinder: 7.95 inches.
Length of cartridge: 8 inches.
Weight of cartridge: 0.85 pound.
Weight of cartridge with belt link: 0.92 pound.
Weight of shell: 0.275 pound.
Mean reaction force on mounting: 3,850 pounds.
Frontal area of 1,000 belted cartridges: 2.3 square feet.

Description of the Principal Components

Casing. The cylinder carrier slides inside the casing and is guided on the latter by means of guides at the rear, engaging guide faces of the casing, and by the cylindrical guide face, which is supported in the front wall of the casing. At its front end, the cylinder carrier is fitted with a bracket which carries two recoil springs.

The spring supports are fastened to the front wall of the casing by means of castle nuts. Two rubber buffers arranged inside the bracket coaxial with the recoil springs damp the runout of the gun. They are held in place by the spring supports. The bracket is held on the cylinder carrier by the ring.

The barrel is held in the cylinder carrier by means of bayonet lugs and secured against rotation by the spring-supported lever. For removal of the barrel, the lever must be actuated, whereupon the barrel can be rotated and withdrawn. Either a perforated flash reducer or a muzzle brake can be fitted to the barrel muzzle. On actuation of a flat spring, the flash reducer or muzzle brake can be unscrewed and removed.

The barrel is fitted with a gas port which is alined with a bore in the bracket leading into the gas cylinder. The latter contains the spring-loaded piston. The gas cylinder with its sleeve is screwed into the bracket and secured by a plunger.

Cylinder. The cylinder carrier has two transverse walls, in which the cylinder is supported by means of its shaft. The shaft is held axially by the spring-loaded plunger, which engages with a groove of the shaft. The cylinder has five cartridge chambers. Each chamber carries, in its front part, a sealing sleeve which, under the action of the gas pressure, seals the gap between the cylinder and the barrel. The cylinder is fitted with five spring-loaded rollers which engage with the cam grooves of the slide. The latter moves in the casing and slides in guides. The slide rests against the wire rope springs which are arranged on the two rods and supported in the casing by knobs with bayonet lugs.

The cam groove through which the rollers of the cylinder pass first is fitted with an insert which prevents the rollers from reentering this groove. On passing over this insert, the rollers are lifted against the action of their springs.

The upper part of the rear cylinder carrier wall carries the firing mechanism. The electric firing pin is spring-loaded. Immediately after the firing of a round, the firing pin is withdrawn to prevent its tip from scratching on the rotating cylinder. To accomplish this, two levers are rotatably mounted on the cylinder carrier by means of pins. When the gun recoils after a round has been fired, the rear arm of the first lever is lifted by the cam on the fixed feed cover and is rotated, thus pulling the firing pin back against the action of the spring. Meanwhile the cylinder has begun to rotate and the second lever which, in firing position, engages a notch in the rim of the cylinder has been lifted by the cylinder and holds the first lever in rotated position. When the next cartridge chamber is alined with the barrel, the second lever engages another notch in the cylinder rim and thus releases the first lever, whereupon the firing pin is returned to operating position by its spring.

Feed Mechanism. The feed star wheel is arranged coaxial to the cylinder in the rear part of the casing. The star wheel is supported by a shaft mounted in the feed casing. The latter is seated on the casing and held in place by the shaft passing through a bore in the rear wall of the casing. The shaft is held axially by a spring-supported lockpin arranged in the rear part of the feed casing. The front end of the shaft is connected to the rear end of the cylinder shaft by means of a coupling which permits an axial movement of the two shafts with respect to each other. The feed casing is provided with a removable cover, which is held in place by two lugs engaging notches on one side of the feed casing and by a spring-loaded pawl and the spring-loaded rod at the opposite side of the cover and engaging lugs and on the casing.

The feed casing is fitted with a cartridge belt inlet. The feed cover carries a case ejection duct and a belt link outlet.

The cartridges are moved from the star wheel into the chambers of the cylinder by means of a feed ram which moves in the lower part of the casing and is guided by ledges. The ram is connected to the slide by means of the two control rods. The rods are fastened to the slide and the ram by means of two pins. The ram is fitted with two projections which serve for pushing the cartridges into the chambers of the cylinder. From the lowermost position in the star wheel, the cartridge is moved halfway into the drum by one projection. In this intermediate position, the cartridge is prevented from moving rearwards because of the recoil by the small spring-supported pawls of the star wheel. During the next stroke of the ram, the same cartridge is pushed fully into the chamber by the other projection. It is then held in this position by the spring-loaded pawl in the rear wall of the cylinder carrier.

The axial movement of the cartridges takes place while the cylinder and the star wheel are rotating. The empty cartridge case is ejected to the rear by the ejector, which rotates about the pin on the cylinder carrier. The movement of the ejector is controlled by the cam faces on the control rod.

Cocking Device. The gun is fitted with an electropneumatic cocking device. It consists of a valve on the left side of the casing and two cylinders at the front end of the casing. The pistons in the cylinders act upon the slide and push it rearward for the cocking movement. The cocking gear must be supplied with compressed air.

For cocking the gun, the button of the control box must be actuated after the switch has been brought into the ON position. Compressed air is then admitted to the cocking cylinders, and the slide is pushed back to its rear position and released. The slide is then returned to its initial position by the slide springs.

During this movement of the slide, the cylinder rotates by one pitch. If the gun is to be cocked repeatedly, the button must be actuated again only after the slide has returned to its front position.

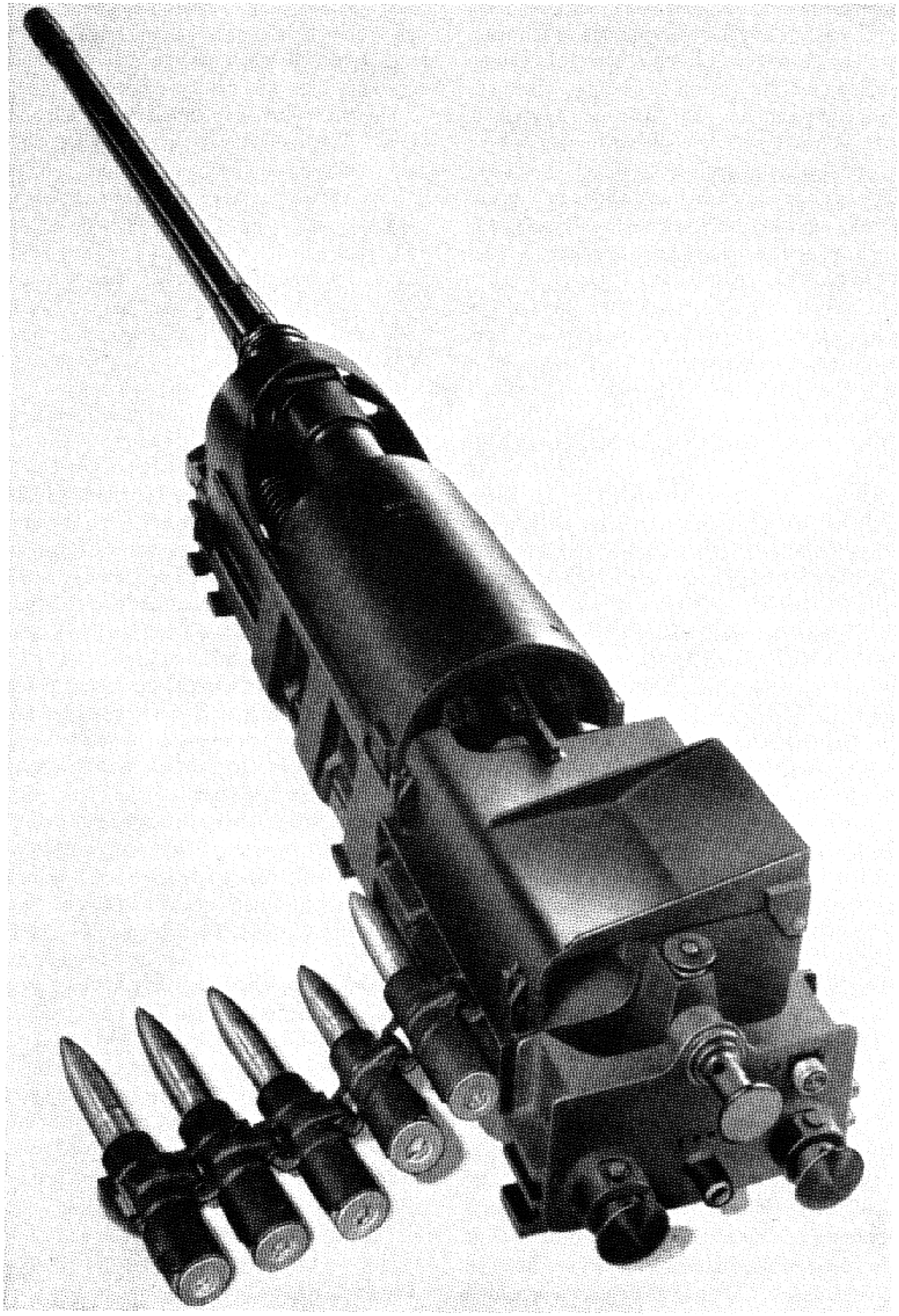

Figure 21–21. Oerlikon 30-mm Revolver Cannon 302 RK. This weapon has the same action as the 20-mm version, the 206 RK.

The gun may also be cocked by hand. For this purpose a spindle with a crank is provided, which is inserted through the bore in the rear wall of the casing and screwed into the bore of the ram. Then the nut has to be screwed into this bore over the spindle. The ram and the slide can then be moved rearward and forward again by rotating the crank. In the rear position, the shaft must be rotated in order to allow the roller to overcome the neutral position of cam groove in the slide with which it engages. It is important to remove the cocking spindle after the cocking operation is complete.

30-mm Version of the Revolver Gun

The 30-mm version of this mechanism is designated 30-mm revolver cannon 302 RK. Similarities to the 20-mm 206 RK are indicated in the accompanying technical data and illustration.

SECTION 5. JAPANESE VERSIONS OF OERLIKON MECHANISMS

Background

In World War II, armed forces on both sides used Oerlikon automatic weapons. Most of these guns were based on the original Becker mechanism, although some details had been varied. In this group of weapons are the 14-mm Mod 14 Mark 1, the 20-mm type 99, and the 30-mm type 2. In the course of World War II, there was one notable attempt to modify the Becker action, the caseless 40-mm HO 301, which was developed by Japan for her air force.

Records indicate that beyond establishing the factory and supplying engineering know-how to the Japanese Government for the conventional Oerlikon guns, the Swiss factory was not involved in Nipponese research and development. The caseless Oerlikon gun HO 301 with its unorthodox features, is a measure of the ingenuity of Japanese ordnance engineers. These prototype weapons were fabricated under poor conditions in a nation beset by shortages of manpower and materiels, and under persistent attack from the skies.

The following description of the gun HO 301, and the report on functional tests are extracted from documents originating in the Development and Proof Services, Aberdeen Proving Ground, Aberdeen, Md.

General Description of the Japanese Caseless Gun

The Caseless 40-mm HO 301 is simple and compact, considering its caliber. The weight is 107 pounds 9 ounces, the overall length is 58.48 inches. The elements performing cartridge case extraction and ejection have been eliminated by locating the propelling charge in a rear compartment of the projectile body. This feature is combined with straight blowback operation (without locking the breechblock when firing), with searing at the rear end of the receiver, and with the locating of the recoil spring elements around the tube.

The breechblock and the elements which serve to compress the recoil springs form a rigid structure and constitute the recoiling parts. The firing pin

General Data: 30-mm 302 RK Gun

Gun length: 117 inches.	Barrel length: 78 inches.
Gun weight: 400 pounds.	Barrel weight: 66 pounds.
Rate of fire: 1,100–1,200 rounds/minute.	Rate control: Rheostat.
Muzzle velocity: 3,600 feet/second.	Barrel removal: Not quick disconnect.
System of operation: Gas operated, revolver principle.	Bore:
System of locking: Stationary breech with rotating cylinder.	Number of grooves: 16.
System of feeding: Metallic link; feeder is powered by gas.	Groove depth: 0.0177 inch.
Method of headspace: Factory established.	Groove width: 0.145 inch.
Location of feed opening: Left rear side of receiver.	Pitch: 8°30′.
Location of ejection opening: Right upper side of receiver.	Direction of twist: Right hand.
Method of charging: Electropneumatic.	Form of twist: Constant.
Method of cooling: Air.	

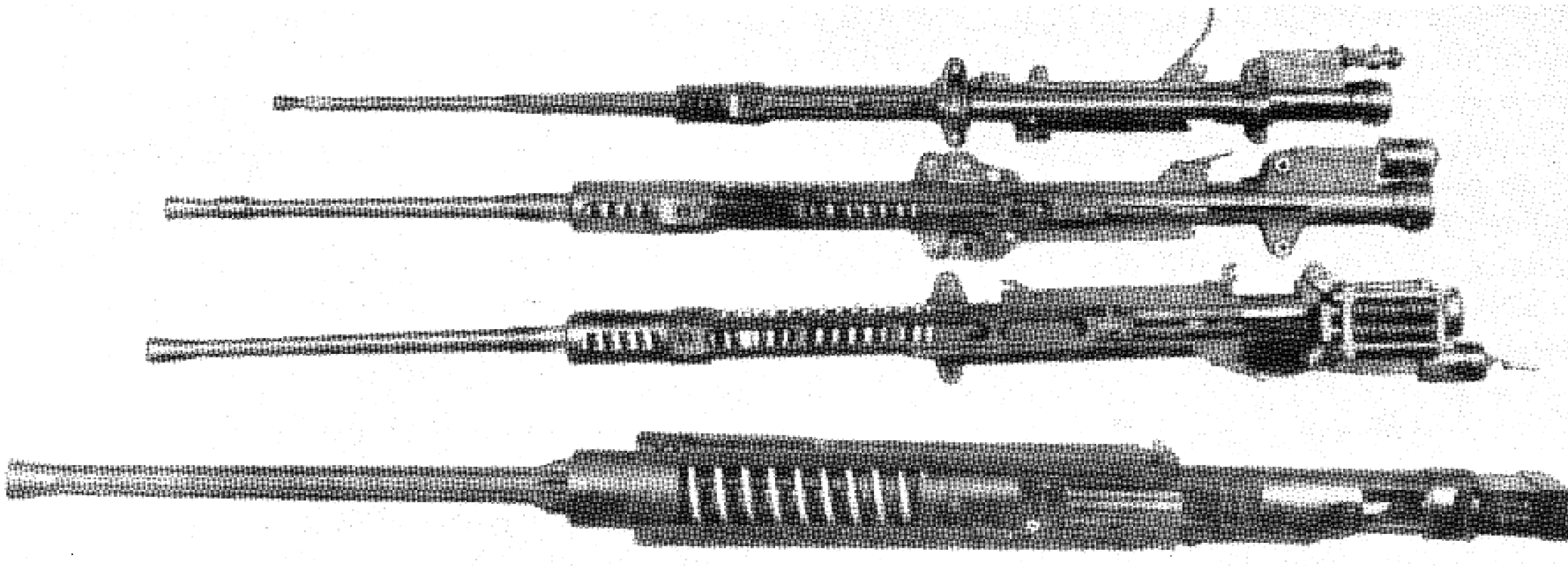

Figure 21–22. Japanese Oerlikon Type Aircraft Cannon, top to bottom: 14-mm Mod 14 Mark 1; 20-mm Type 99; another 20-mm weapon; and 30-mm Type 2.

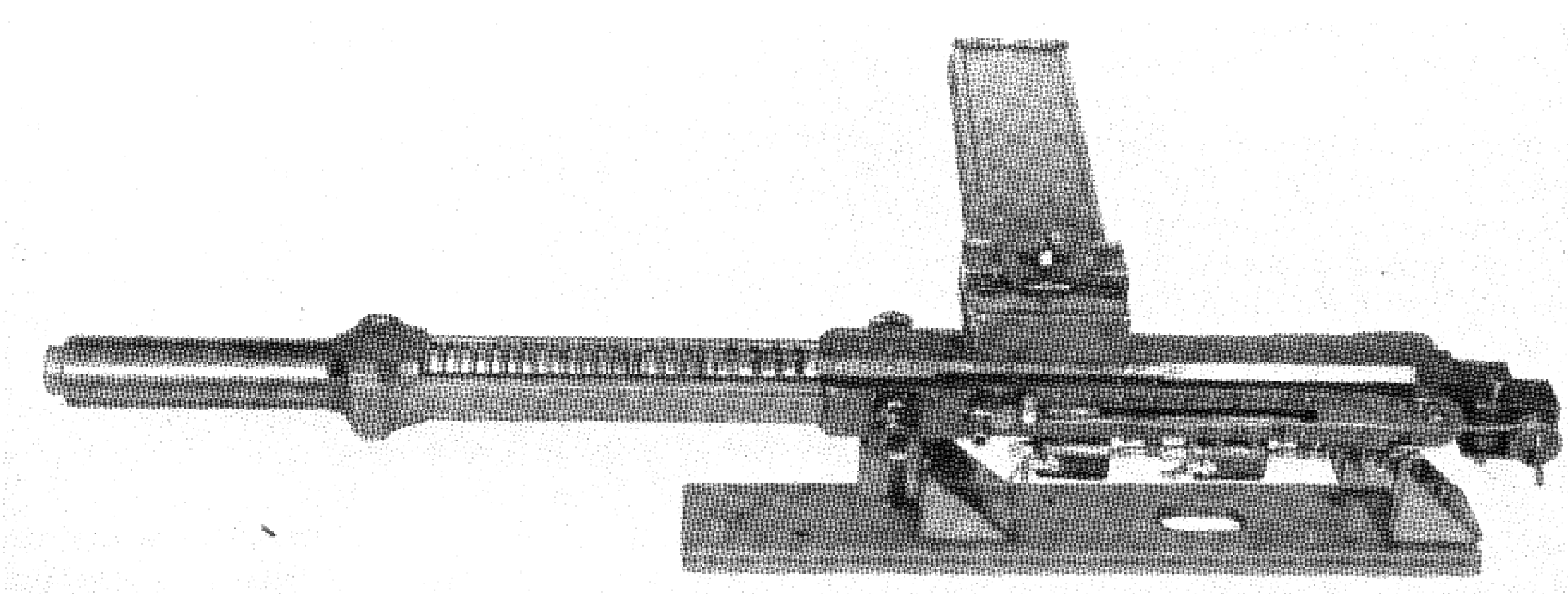

Figure 21–23. Japanese 40-mm Aircraft Cannon, HO–301, a modified Oerlikon blowback design.

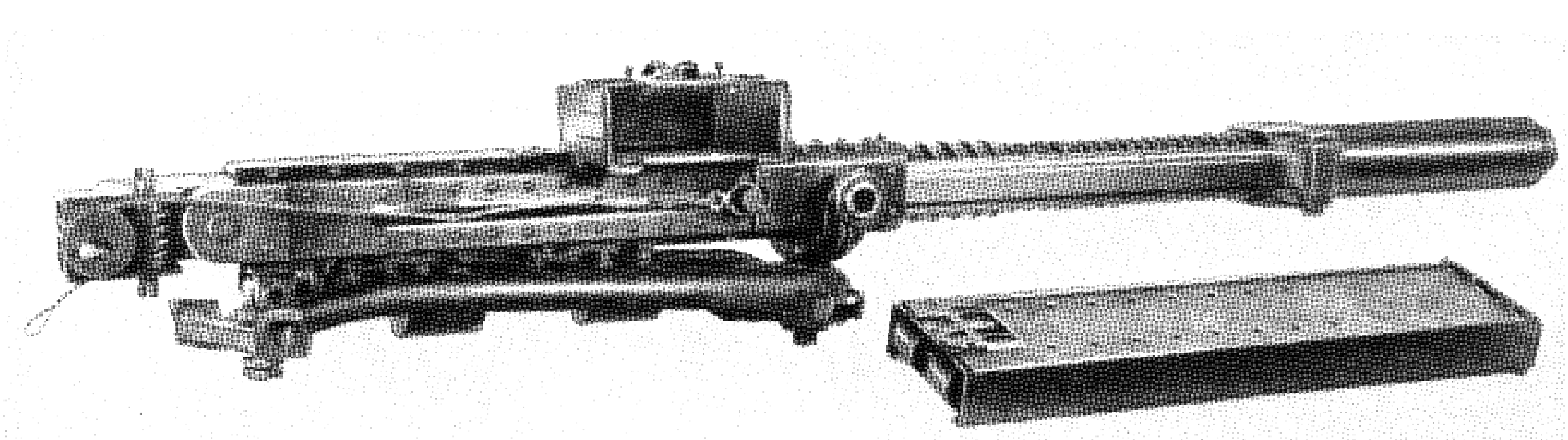

Figure 21–24. Japanese Caseless 40-mm HO–301. Right side view, with magazine removed.

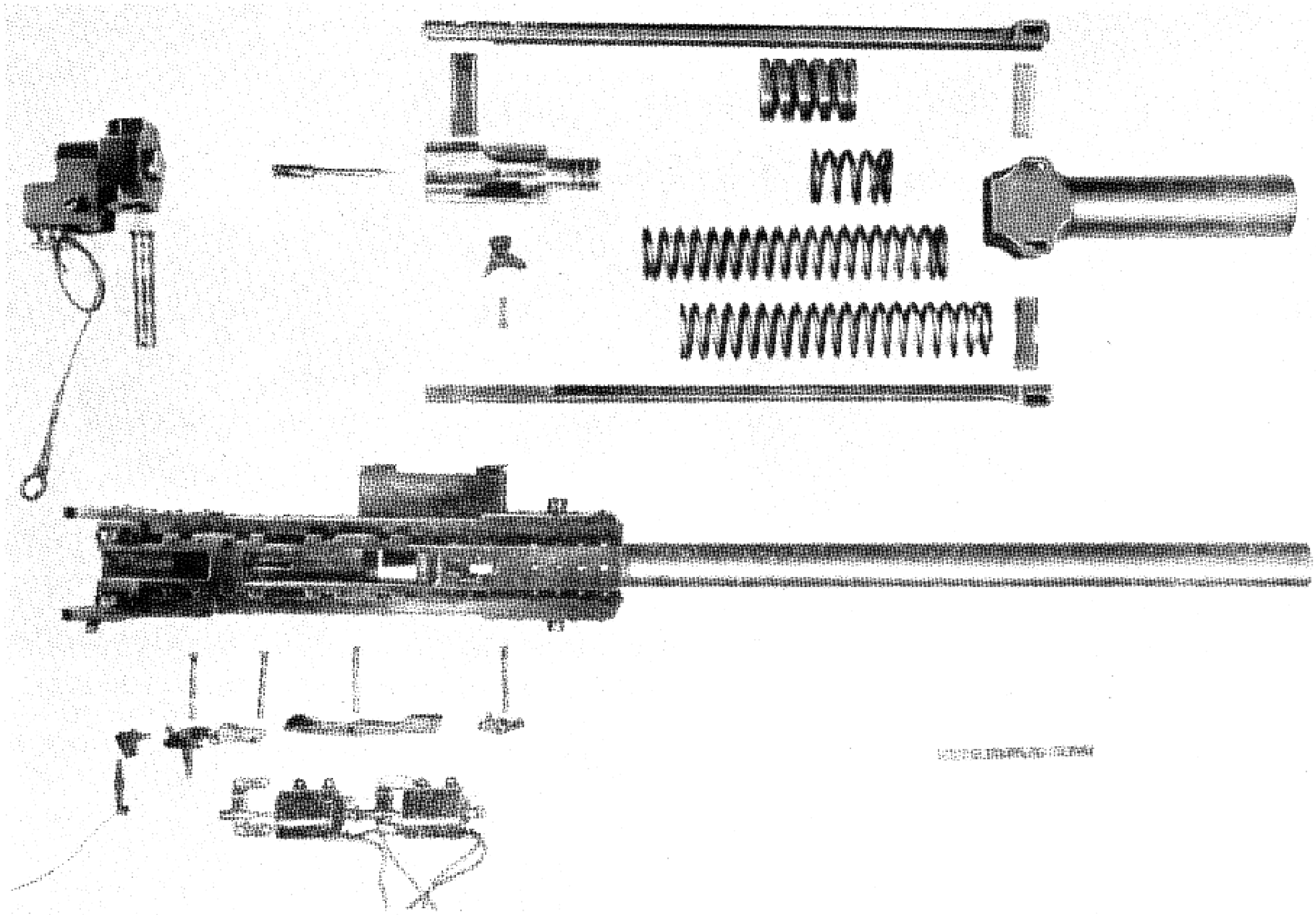

Figure 21–25. Japanese Caseless 40-mm HO–301. Disassembly of gun.

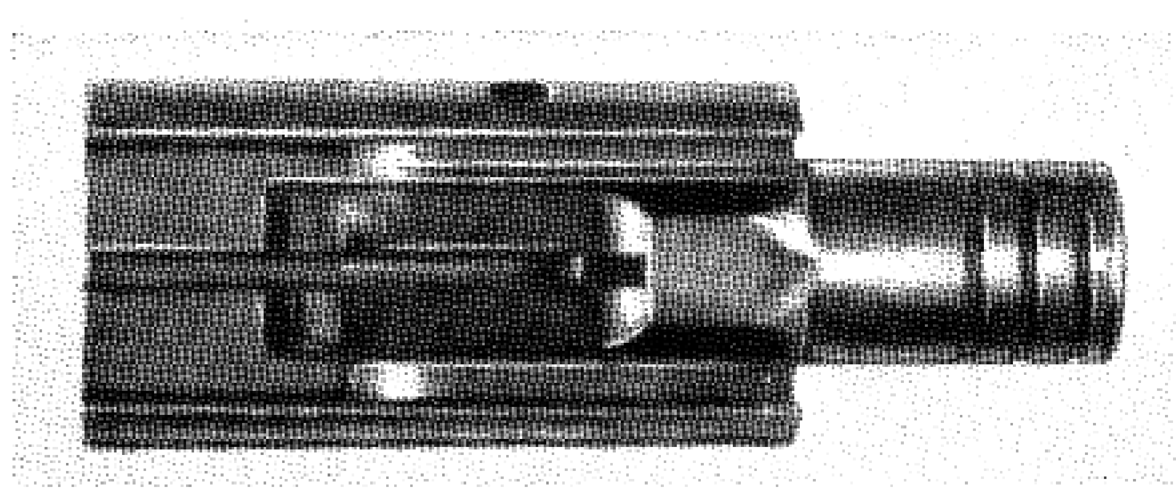

Figure 21–26. Japanese Caseless 40-mm HO–301. Bottom view of bolt.

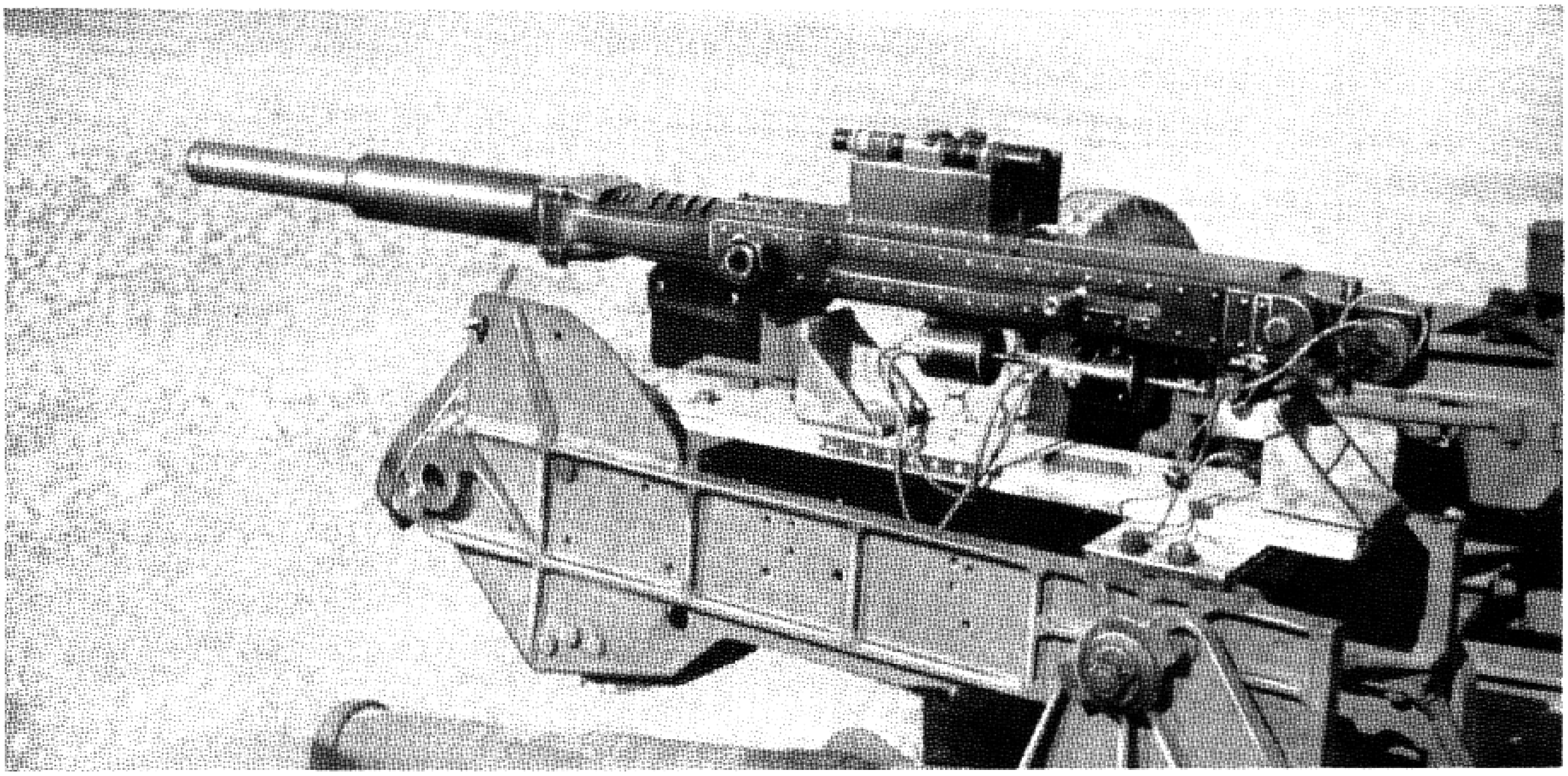

Figure 21–27. Japanese Caseless 40-mm HO–301. Left side view of the gun while undergoing test in the United States.

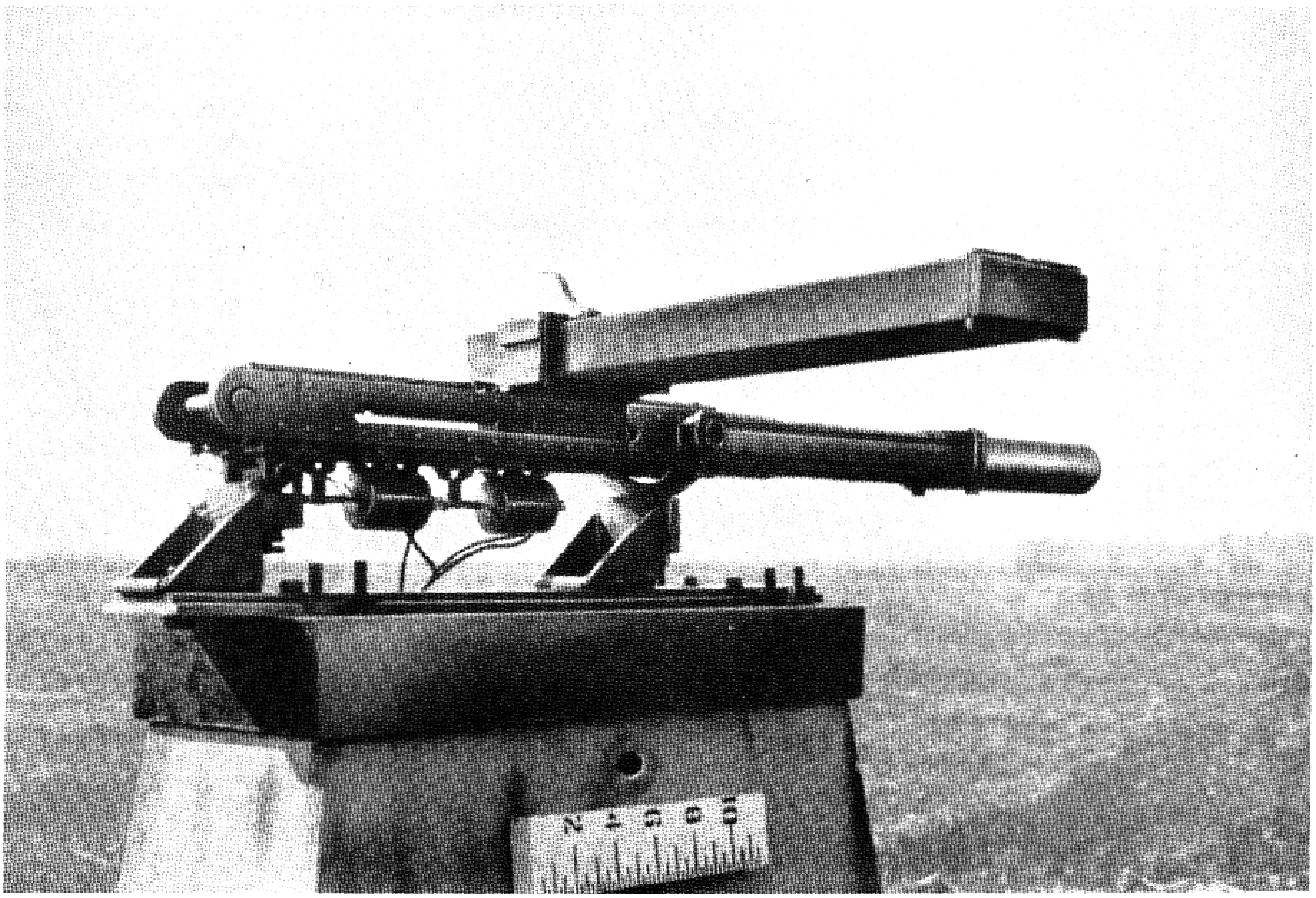

Figure 21–28. Japanese Caseless 40-mm HO–301. Right side view of the gun while undergoing test in the United States.

is actuated mechanically at the proper point of breechblock travel. In these two respects the weapon resembles the Oerlikon antiaircraft 20-mm guns.

The principal departure from conventional gun design consists of the application of a piston breechblock face. This piston section enters the breech and acts as a partial seal when the round is fired. Three annular rings cut into the piston walls were probably intended to reduce leakage. No piston rings are used.

Another novel feature is a "loading tray" or "round positioner" which consists of two pivoted lever pieces which are located in the floor of the forward section of the receiver. The breechblock rides over these levers, depressing the rear ends in turn and raising the front ends. The loading round enters the receiver and rests on these levers, and the motions of the levers insure that the round is properly engaged by the breechblock and chambered.

The gun charger operates mechanically. The forward end of the charger cable is looped over the breechblock retracting pin. The rear end of the cable is wound around a drum located on the rear buffer plate. The drum is rotated by the worm gear, the ends of the worm gear shaft providing seats for a removable crank.

A 10-round, spring-actuated, clip-type feed magazine is utilized, which fastens to the receiver by means of spring-loaded pins. The mechanism includes a stop pawl on the gun end, which prevents more than one round from entering the receiver at a time. This construction is rigid, and, accordingly, requires an excessive amount of space in an aircraft installation, considering the capacity.

The gun sear is a spring-operated lever located in the rear floor of the receiver, pivoted at the front end. The rear end engages the breechblock. A spring is employed to hold the sear in its engaging position. Sear release is effected by two 24-volt solenoids connected in tandem. The sear mechanism contains a mechanical locking device, probably included to insure that rounds are not fired during takeoff and landing. This gun safety was necessary because no provision for charging the gun in flight was included.

The gun fires automatically when the sear is released. Firing may be interrupted by opening the solenoid switch, which permits the sear to rise to the holding position. The breechblock retracts on each round and strikes a buffer element located in the backplate. This buffer consists of a steel block backed by two square wire springs.

The gun was originally equipped with a mounting adaptor constructed of welded tubing. The mount adaptor permitted slight adjustments in deflection and elevation after the gun was mounted, thus making possible the proper sighting of the piece.

When the gun was received at Aberdeen Proving Ground, the receiver cover plate and the breechblock retracting pin were missing. These components were improvised before tests were carried on. A mounting plate was also fabricated to provide a means of using available ground mount facilities.

Ammunition Used for Functional Tests of the Japanese Caseless Gun

Only HE loaded ammunition was available; no other type is known to exist. The ammunition appeared to be in a satisfactory state of preservation, although some rounds were slightly rusty adjacent to the base ends. Some verdigris had formed on the primers, but not enough to interfere with the functioning. The rounds were contained in a wooden box. Each round was provided with a plastic nose and metal base protector. The fuzes were located in holes bored in a tray bore in the box. Each fuze was wrapped in wax paper.

It was observed that the metallic sealing cups for successive rounds were not identical. Some were drawn with smooth walls, some with overlapping walls, the latter apparently cut before drawing to permit the overlapping. Also, it was observed that 2 lengths of booster cavity were represented, although only 1 length of booster was present. The reason for the latter discrepancy is unknown.

The fuse depends on centrifugal force for arming. Three elements move during the arming period. Two spring-loaded safety plungers are seated in holes in the third element, a spring-loaded sliding fork. The firing pin is restrained by the tines of the fork. The firing pin moves rearward to strike the fuse primer when impact crushes the comparatively thin nose section.

The 0.35-ounce propelling charge consists of graphited flake powder contained in a silk bag.

An aluminum cup holds the charge in place. This cup contains a hole which permits admission of primer flame when the primer functions. The primer, a percussion type, is threaded into the heavy steel base plate. This base plate contains 12 holes 0.162 inch in diameter arranged in a circle around the primer. These holes serve to vent the powder gases from the rear end of the projectile. The base plate is assembled to the projectile body by threads.

The explosive charge consists of two cylindrical blocks and one hemispherical block of TNT. The cylindrical blocks are wrapped in one piece of waxed paper, the hemispherical piece in another. One of the cylindrical blocks contains the booster cavity. The explosive charge weighs 2.015 ounces. The complete projectile, fused, weighs 1.31 pounds.

Details of the Test

Procedure. Preparation consisted of studying available reference material, of obtaining photographs and physical dimensions of the weapon and ammunition, and arranging for mounting the weapon. The first phase of the test consisted of 37 rounds fired both single shot and in bursts, principally to obtain records of target dispersion. During this phase, three different ground mounts were used. The first, a converted carriage, antiaircraft, 37-mm, M3, proved unstable, as did the second, a Frankford Arsenal rest on a concrete pedestal. The third was a concrete pedestal for the mount, Universal, T118, which proved satisfactory. Following this phase, nine rounds loaded with explosive were fired to observe fuze function. The final phase consisted of 10 rounds fired in darkness to observe breech and muzzle flash and, incidentally, fuze function.

During the phase concerned with target dispersion, the gun was realined after each single shot or each burst to a sighting mark on the target. A bore sight was utilized with the elevation checked by using a clinometer. Also, this phase was fired using rounds loaded with inert material substituted for the HE charge. Since the original charge is contained in waxed paper, it may be easily removed from its compartment.

The sealing cup, which is included in the rear cavity, may occupy various positions ranging from snug against the charge to back against the inner side of the base plate. Some difference in propellant ignition was possible, caused by the position of the cup. To discover the effect of the cup position on performance, rounds 1 to 20 were fired with the cup pressed snug against the charge, and rounds 21 to 37 with the cup against the base plate.

Recovered inert projectiles were examined to observe engraving and sealing at the band, the completeness of combustion of the powder charge, and variations in powder deposits at the vent holes in the base plate. Fuses were usually destroyed by recovery media.

Suitable safety precautions were observed with the ammunition, as directed.

The weapon and sufficient ammunition were delivered to the Ballistic Research Laboratories for a kinematic study and determination of trunnion reactions and tube pressures.

Results

The Gun. The mechanical reliability of the gun was satisfactory during the 56 rounds fired. The principal mechanical deficiency was the slamming which caused difficulty in keeping the gun fastened to the mount. Evidently the recoil springs did not cushion the recoil sufficiently. The backplate buffer compression was recorded by placing paint on the exposed sides of the buffer block before firing and then observing the distance between the front of the backplate and the paint line formed when the paint was removed as the buffer was compressed. The compression was found to be complete on every round. Since the buffer compression is complete, the backplate must receive considerable impact.

When the recoil springs were calibrated and assembled in the weapon, as the breechblock was retracted each coil in turn would bind on the recoil spring housing. This caused a frictional load on this stroke which was not present during the forward stroke.

The only parts which failed were two setscrews, which sheared. One was located in the rear buffer plate; the other was a solenoid mounting screw. The only undue interference noted was the burring of the breechblock piston by the front positioning lever.

It was not found practicable to determine any reliable values for the obturation efficiency of the breechblock piston. Only an indication could be obtained by observing the frequency and intensity of breech flash. Only five occurrences of breech flash were observed. On three of these rounds, photographic records were attempted. The flash recorded with low intensity on the negatives, and did not "print over." The breech smoke was also observed. The smoke was more pronounced when single rounds were fired than when bursts were fired.

During bursts, the overall average rate of fire was 476 rounds per minute. The lowest recorded was 341 rounds per minute, the highest 573. The instrumental velocity remained within the limits of 764 and 860 feet per second, with an overall average of 807 feet per second.

Most of the dispersion was in the vertical plane, and maximum variations as high as 9 mils in this plane were recorded. Mean variations as high as 4.61 mils were recorded. All rounds tended to drift to the right from the aiming point. Dispersion was definitely increased during burst fire.

The Ammunition. Evidently the propelling charge is consumed while the projectile is in the tube. During night firing a blue-white "trace" (there is no tracer element included) of very short duration was observed. Muzzle glow of low intensity was produced.

The principal deficiency appears to be the low efficiency of HE ammunition. Nineteen rounds with HE charge were fired, of which 8 exploded high order, 6 low order, and 5 failed to function. Obviously the blunt ogive presented by the fuse contributes to the deficiency. It was established by reference to "Handbook on Japanese Explosives" that the booster element is usually employed in 20-mm ammunition. If so, it is probably overmatched by this charge. Recovery and examination of dud HE ammunition was not attempted.

All recovered rounds passed through a 0.25-inch plywood screen before impacting sand or other recovery media. The recovered fuses were in such condition that it was probable that impact with the plywood would have caused function had the explosive been present. The engraving on the rotating bands appeared shallow, and some evidence that gases escaped forward past the bands was found. Some paint was removed by such escaping gases. The engraving was not of uniform depth. No bands failed or slipped. There was a marked tendency for the primer cup to separate from the primer body. The sealing cups were found in various positions, usually badly battered. Only one cup was found adjacent to the nozzle plate. A gray ash was found in all base cavities and usually particles of the cloth containers, sometimes uncharred.

Two primer misfires were encountered, both of which had been struck fairly by the firing pin.

The initial position of the aluminum sealing cup did not affect performance of gun or ammunition to any noticeable extent.

Observations on the Japanese Caseless Gun

A study of this weapon arouses speculations with reference to the practicability of muzzle disposal cartridge cases. The problem would consist in designing a cartridge case which would remain rigidly attached to the projectile during feeding, chambering, and firing, which would be released by some positive means at some safe point on the trajectory. A concurrent problem would be the designing of a fully obturated breechblock which would perform as efficiently as the conventional cartridge case in this respect.

As opposed to the thick walls and perforated base of the rear compartment of the projectile for the HO 301 (required because of the highest pressures develop in the compartment and because the rotating band is located over the walls), the cartridge case could consist of a perforated container which would tend to equalize pressures on the exterior and interior. The strength of the material could depend on the rigidity required to prevent deformation in feeding and chambering and to position the primer for firing. The volume for the charge, severely restricted in the weapon under test, could be increased to provide the velocity level desired. However, the diameter of the case would necessarily remain less than the diameter of the projectile.

258970°—54——39

The uncoupling of projectile and cartridge case along the trajectory would require precise timing and reliable functioning. An explosive separating element might be utilized, with a delay train initiated by the burning of the propelling charge.

A fully obturating breechblock for automatic operation will be required if and when chamber-consumed cartridges are developed, both to prevent breech flash with its fire hazard and to increase the efficiency of propulsion. Such a breechblock should not present insurmountable difficulties to the designer, since such breechblocks have been used for many years in guns using separate-loading ammunition.

Chapter 22

BOFORS AUTOMATIC CANNON

SECTION 1. HISTORY AND BACKGROUND

History and Background of the Bofors Plant

The Bofors Arms Co. is one of the oldest arms producing plants in the world. The name first appeared in the Swedish public records in November 1646, when one Paul Horsman was granted permission to erect a forge and hammermill in the mining district of Bofors, located in central Sweden. This forge was typical of many such places that were later to bring fame to the Swedish steel industry.

There was nothing outstanding about this particular establishment until the middle of the 19th century when changing world events enlarged the sphere of activity. As early as 1870, this plant was rated the largest manufacturer of roll bar stock in Sweden; in 1873, the mill was converted into a joint stock company, AB. Bofors-Gullspång. During the late 1870's, Bofors succeeded in producing a new kind of steel that was considered highly suitable for the manufacture of cannon barrels. This made the company a serious competitor to the mighty Krupp Works in Germany. In 1883 the Bofors Co. built its own workshop for the manufacture of war material and in 1888, the initial order was received from Switzerland for 28 cannon with a bore diameter of 12 centimeters.

In 1894, outright ownership of the company was acquired by the famous explosives inventor, Alfred Nobel, who immediately stressed the importance of specialization and erected the company's first research laboratory at Björkborn. The manufacture of gunpowder was started and later armor plate was added to the items produced.

In spite of keen competition, Bofors prospered and after 1900 began the manufacture of ammunition and fuses. The company made money but had no need for added factories until World War I, when huge orders made the existing facilities inadequate and necessitated considerable enlargement of the plant.

After the defeat of Germany, the dismemberment of the Krupp plant by the victorious Allies not only removed a big competitor but also allowed Bofors to make under license many Krupp guns that could not be produced in Germany. Otto Krupp obtained a sizable portion of the stock in the Bofors Co. Personnel and equipment from the Krupp Works were eventually moved to Sweden to furnish technical aid and manufacturing know-how. Through the nineteen twenties and early thirties, the company manufactured the few weapons that were demanded by the various powers during this peaceful period in world history.

In the 1930's, when a law was passed in Sweden prohibiting foreign ownership of munitions within the borders of Sweden, control of the Bofors Co. passed to Axel Wenmergren, a local financier.

History of the Bofors 40-mm Automatic Gun

The Bofors 40-mm antiaircraft cannon gained a reputation for efficiency during the Spanish Civil War. The development of this weapon is outside the scope of this volume, since its use is limited to shipboard installation, however, the weapon holds interest for readers of this volume for several reasons. Its design features are the basis for the design of the Bofors 57-mm aircraft cannon and the Bofors 20-mm antiaircraft cannon. The interest of both the Navy Bureau of Ordnance and the Army Ordnance Corps was attracted to the Bofors 40-mm shortly before Pearl Harbor.

The design of the Bofors 40-mm appears to have originated at the Krupp Works in Germany shortly after the end of World War I. During the 1930's, when the Krupp activities had been transplanted to

Figure 22–1. Evert Wijkander, managing director of Bofors since 1936.

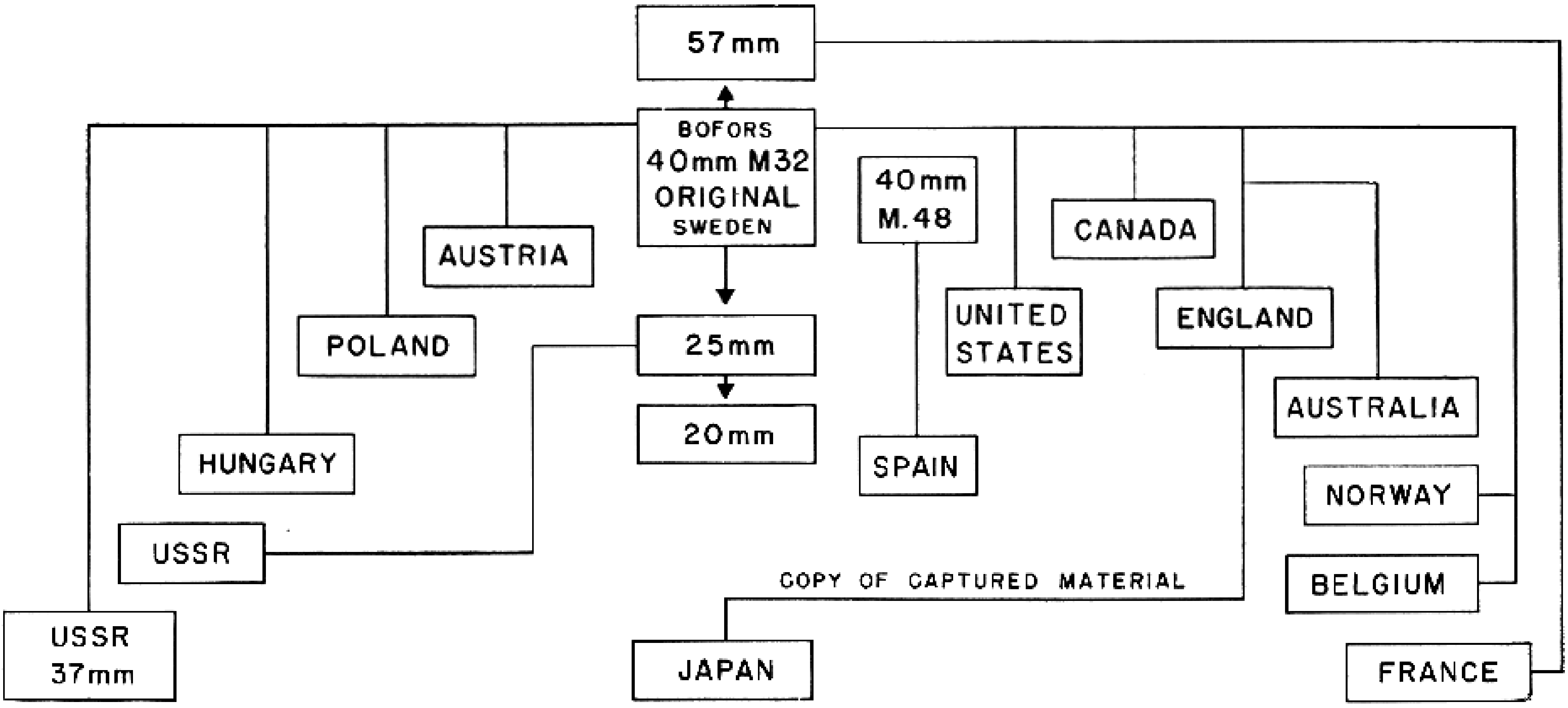

Figure 22–2. The spread of the Bofors mechanism throughout the world.

the Bofors Arms Co., the latter company became interested in the perfection of a 40-mm gun that could be used on shipboard as a defense against aircraft. The gun that was developed stemmed from the 40-mm cannon originated by the Krupp Works.

The Chief of the Bureau of Ordnance became interested in this gun through the efforts of an American businessman, Mr. Henry Howard, who had witnessed a firing demonstration in Sweden in 1939. The Bureau of Ordnance purchased one gun for test and evaluation; and when it arrived in New York along with 3,000 rounds of ammunition, it was sent to the Naval Proving Ground at Dahlgren, Va., for evaluation.

Coincidental with this transaction, the Bureau of Ordnance received a communication from the York Safe & Lock Co. of York, Pa., informing the Bureau that the York Co. was considering the possibility of obtaining a license to manufacture the gun in the United States. However, events moved too fast; before this transaction could be completed, the invasion of Norway stopped the plan.

Several years before the Navy showed interest in the 40-mm gun, the Army had sought to procure a single gun. In 1938, the Bofors Co. offered to send a pilot gun and one technician to the United States free of cost. They offered to supply 2,600 rounds of shell of several types for 6 to 12 dollars a round, the total cost figuring $20,200; and asked that the tests be concluded quickly and the gun returned. Evidence is now available indicating that the Bofors cable was misread and that the total amount involved was believed to be $243,600. Lack of punctuation in the cablegram, failure to mention the word "dollars" except toward the end of message, and the belief of the recipient that "10 1000" was the sender's method of writing 10,000 caused the error. The cablegram was as follows: "Referring conference 26/4 Ordnance Department Commander Bostroem stop 40 M/M pilot gun and ammunition can be sent about 15/6 costs of freight to be paid by Bofors stop FOB price New York City 500 rounds high explosive tracer shells 10 1000 tracer drill shells 8 1000 drill shells 6 100 armour piercing tracer shells 12 100 ditto uncharged 12 dollars a piece stop please cable confirmation." Consequently, the quantities of shell were read, respectively, as 500, 10,000, 8,000, 600, and 1,200, or a total of 20,300 shells at a common cost of 12 dollars each. Actually, the pertinent portion was meant to read: "500 rounds high explosive tracer shells 10 dollars apiece, 1000 tracer drill shells 8 dollars apiece, 1000 drill shells 6 dollars apiece, 100 armor piercing tracer shells 12 dollars apiece, 100 ditto uncharged 12 dollars apiece."

Before a confirming letter from Bofors could arrive or an answer be obtained to the letter, the Office of the Chief of Ordnance wrote to the Berlin Military Attaché asking his check on this unreasonably large quantity of ammunition for a test of one gun, the decision had been made to continue with the 37-mm Browning.

On September 1940, the Naval Proving Ground at Dahlgren completed tests which were, in every sense of the word, successful. Witnessing the trials were representatives of the Bureau of Ordnance, Army, and Naval Gun Factory. Even before this test, the Chief of the Bureau of Ordnance flew to Trinidad to witness the firing of a Swedish-made Bofors gun on a Dutch war vessel. The demonstration was so impressive that there was no longer any question of the suitability of the gun for Navy shipboard use.

From that time on, production of the gun was the only problem. Holland was now occupied, but the Navy Department was informed that a set of prints could be obtained from Java. In January 1941, additional drawings were obtained from British sources in Canada; manufacture had already commenced at Hamilton, Ontario. In November 1940, the Ordnance Department obtained a single British Army 40-mm Bofors gun, and tests were witnessed by officials of the Navy. Two months later suitable drawings were obtained and were turned over to the Chrysler Corp. for conversion to American measurements. In acquiring manufacturing rights, the Navy acted for the Army and the latter agreed to pay half the cost, which amounted to $500,000.

On 21 June 1941, the Navy through the naval attaché at Stockholm concluded a contract permitting the manufacture of the gun in this country "for United States use". An early draft of the contract had read "for United States Forces only". Interpretation of the phrase is still the subject of litigation.

Standard Navy drawings were prepared at York, Pa., from Bofors, Dutch, and British drawings. On 19 February 1941, a letter of intent was sent to York calling for the construction of 500 guns. In April 1941, the Navy took over administration of Chrysler for both Army and Navy production.

In the early part of the program, there was little interchangeability between Army and Navy guns, one reason being that the drawings converted at York were converted in decimals and those made by Chrysler had been calculated in fractions. The 200 items originally causing trouble in interchangeability were finally reduced to 10, not including components for water cooling. Soon after the interchangeability of parts was extended, Pontiac manufacturing division of General Motors in Pontiac, Mich., became the principal producer of this weapon for Army use.

Other Bofors Weapons Developed in the Thirties

Events leading up to World War II stimulated the arms industry greatly during the 1930's, and many countries placed large orders with Bofors. Its machinery was thoroughly modernized, and production leaned toward heavy automatic weapons development. However, aircraft armament was not overlooked, and several experimental models were produced and tested in its modern range. The Bofors Co. designed two types of 20-mm cannon, one for antiaircraft use which was nothing more than a scaled-down version of its successful 40-mm weapon.

In designing all of its automatic firing mechanisms, Bofors worked downward instead of taking a machine gun design and working up to a larger caliber as is generally the practice. The scaled-down version of the 40-mm gun was capable of both single shot or full automatic fire and employed the circular drum-type feed, as did the heavier version.

The aircraft cannon was announced for sale in 1938. It was different in design, being belt fed and using the short-recoil principle to operate the mechanism.

Branches of AB. Bofors-Gullspång and International Adaptations

The company itself has confined its manufacturing activities to Sweden, but the internationalization of the Bofors system has proceeded rapidly since the success of the 40-mm antiaircraft gun.

The spread of this mechanism is indicated in an accompanying figure, showing those countries which at one time or another have set up facilities for making guns of the Bofors pattern. The Japanese copy was made from a British gun captured at Singapore but only six guns had been produced by the Kokura Army Arsenal before hostilities ended. In Canada, the producer in World War II was the Dominion Bridge Co. at Vancouver, British Columbia. The Australian facility was the Government Ordnance

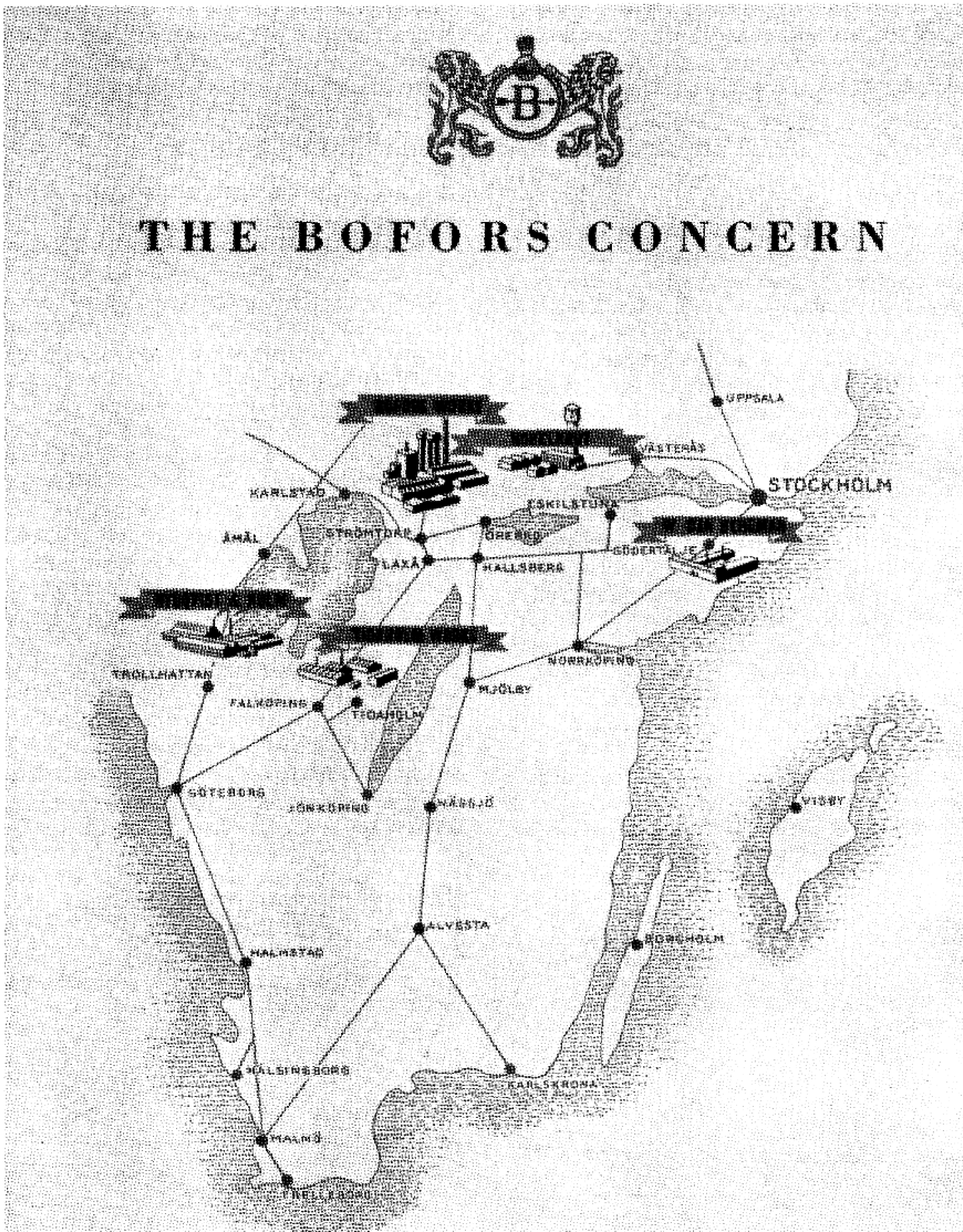

Figure 22–3. The affiliated concerns of the Bofors group.

Factory at Maribyrnong, Victoria. The Kongsberg Kanonfabrik, a Norwegian Government arsenal, produced for that Government. American production by York, Chrysler, and Pontiac is summarized in this chapter. Another facility engaged in the production of this system is at the Puteaux Arsenal in France, which has produced the 57-mm gun for antiaircraft use in the French Fleet.

SECTION 2. 20-MM BOFORS AIRCRAFT CANNON

Description

The 20-mm Bofors aircraft cannon, sometimes known as the L/70, operates with short recoil, is air cooled and belt fed, and uses a metal disintegrating pushout-type link that is streamlined in design.

A muzzle booster is sometimes used to speed up the action to 700 shots per minute. A hinged cover permits inspection of components for visual check or replacement of broken parts.

An air charger located directly on top of the cover group contacts the bolt by means of a ringed member that protrudes through a slot in the center of the receiver, permitting manual operation.

A large buffer using Belleville washers is used to absorb shock and give a faster return to the recoiling parts. The barrel is quickly detachable and is housed in a slotted barrel jacket.

The feed can be made to function from right or left merely by the repositioning of parts. The sear can be released either by air or manually, air being used when the weapon is mounted for remote control firing.

The links are of thin spring steel and cover half of the cartridge case from the base to the shoulder of the cartridge. A portion of the link snaps into the cannelure of the round. This arrangement keeps the cartridge in calibration once it is belted.

The barrel and bolt recoil securely locked together for a distance of 20 mm; at this point the bolt is unlocked from the barrel and continues to the rear, accelerated by a pivoted lever. Two projections at the point of unlocking hold the barrel and barrel extension to the rear against the barrel return spring, and the bolt continues to compress the driving spring. The fired cartridge case is extracted by a T-slot on the face of the bolt, and the empty brass travels with the bolt to the extreme rear position. It is ejected on counterrecoil by the introduction of the incoming round in the T-slot plus contact with the gradual angle that engages the empty case during this part of its forward movement. The round is chambered in its first position by a movement of a sliding bolt face similar to that of the Maxim.

When the counterrecoiling bolt is three-fourths inch from battery, it strikes the pivoting breechblock, simultaneously releasing the barrel and barrel extension, which continue toward battery as a unit. If the trigger is held back, the firing pin is automatically released just before the entire recoiling mass makes contact with the receiver. The safety feature

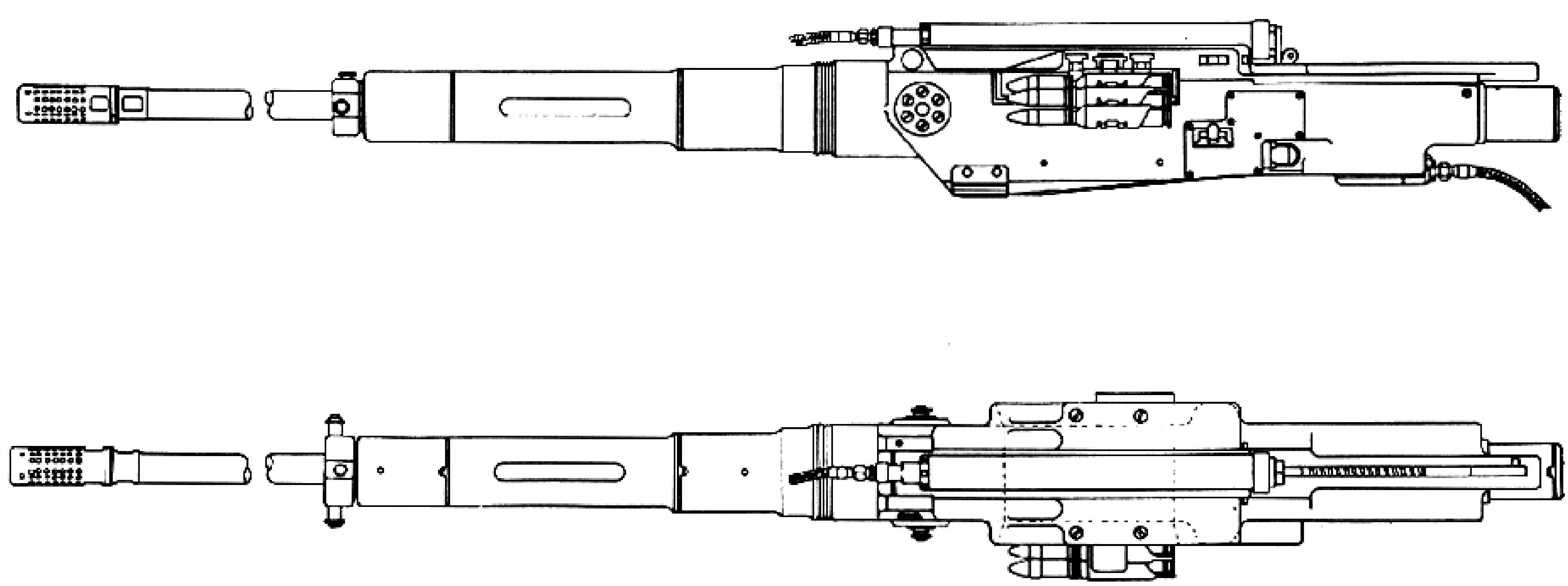

Figure 22–4. 20-mm Bofors Aircraft Cannon.

is also controlled with a breech lock, which serves as an adequate obstruction in the path of the firing pin until the firing mechanism is securely locked.

A fire regulator is located on the left side of the weapon. It permits the operator to choose automatic or single fire. Because of the gradual camming effect on the empty cartridge case while partially ejected, extraction is accomplished in a manner that prevents the empty cartridge from being thrown forcefully from the gun.

The barrel is provided with a muzzle brake and booster and is screwed onto the breech mechanism in such a way that it may be readily changed. The recoil and recuperating springs encircle the barrel. The breech mechanism is entirely automatic.

This gun is considered especially suited to mounting in modern fast aircraft because of its light weight, smallness in size, and its rate of fire.

SECTION 3. 20-MM BOFORS ANTIAIRCRAFT CANNON

Description

The mechanism of the 20-mm Bofors Antiaircraft cannon is identical with that of the 57-mm Bofors aircraft cannon. The 57-mm is a scaled-up version of the battle-tested shipboard 40-mm antiaircraft cannon, while the 20-mm antiaircraft cannon is a scaled-down version of the same 40-mm weapon.

Cycle of Operation

The 20-mm Bofors Antiaircraft cannon has the same cycle of operation as the 57-mm aircraft model.

SECTION 4. 57-MM BOFORS AIRCRAFT CANNON

Description

The success of the 40-mm automatic mechanism for antiaircraft use lead to its being scaled to a 57-mm model for aircraft use. This larger bore was thought to be necessary for the specific purpose the weapon was designed, namely, antitank work in close ground support by heavily armored planes. The gun was designed for ground attack use in the Swedish B. 18 aircraft, a type similar in appearance to the British Mosquito. The weapon's unusually large size and heavy weight limit its installation to a few types of aircraft. The components of the 57-mm model are heavier than those of the 40-mm to compensate for the greater shock of the larger round.

General Data: 57-mm Bofors Aircraft Cannon

Gun length, with muzzle brake attached: 16.85 feet.
Gun weight, with 41-shot drum feeder loaded: 1,620 pounds.
Rate of fire: 180 rounds/minute.
Muzzle velocity, with AP projectile: 2,250 feet/second.
System of operation: Long recoil.
System of locking: Vertical sliding wedge.
System of feeding: Drum holding 41 rounds.
Method of headspace: Factory established.
Location of feed opening: Top.
Location ejection opening: Bottom.
Method of charging: Pneumatic or hydraulic.
Method of cooling: Air.
Barrel length:
- with muzzle brake: 130.1 inches.
- without muzzle brake: 89.7 inches.

Barrel weight, complete with springs: 450 pounds.
Rate control: None.
Barrel removal: Not quick disconnect.
Length of recoil: 1.1 inches.
Bore:
- Number of grooves: 12.
- Length of rifle bore: 10.26 inches.
- Groove depth: 0.0225 inch.
- Groove width: 0.270 inch.
- Pitch: 1 turn in 45 calibers at breech to 1 turn in 30 calibers at muzzle.
- Direction of twist: Right hand.
- Form of twist: Progressive.

Recoil force:
- with muzzle brake: 5,500 pounds (approximate).
- without muzzle brake: 6,600 pounds (approximate).

Length of recoil:
- minimum: 10 inches.
- maximum: 12 inches.

Air pressure required to cock the gun: 425 p. s. i.

The weapon is operated by short recoil and employs a nonreciprocating bolt. It is air cooled, drum fed by a 25-round magazine, and its rate of fire is 100 rounds per minute.

A very efficient recoil system is employed to cushion the shock resulting from this unusually large round of ammunition. The recoil assembly consists of a spring and a cylinder. In counterrecoil the spring provides the force necessary to return the gun mechanism to battery position, cock the rammer, and feed a new round.

The recoil cylinder controls the length of recoil and the velocity of counterrecoil. As the piston rod is drawn to the rear in the recoil cylinder, liquid is forced from the front of the piston through eight holes in the piston head. Through the ports, the liquid passes to the rear. This effective and controlled flow sets up a fluid resistance that adequately retards recoil.

In full automatic fire, six operations make up a complete cycle. A live round is fed into the loading tray. The rammer is cocked. The round is rammed into the chamber. The breech is closed. The round is fired. The empty case is ejected.

The large drum-type feeder indexes each round by spring pressure. While efficient and simple in operation, the system of feeding made mounting in aircraft difficult and relegated the weapon to fuselage installations only. The manufacturers of the gun have pointed out that this was no hardship since it was for a specific purpose that required a minimum number of rounds to accomplish a mission.

The magazine is fixed permanently to the gun and is charged by hand by inserting single rounds from the rear while winding the magazine with a crank and applying pressure to the spring which operates the magazine during firing. The magazine is filled by hand before takeoff.

The breech mechanism is identical with that of the 40-mm model. The vertical sliding wedge is designed in such a way that when operated automatically the rounds are fired before the recoiling parts have completely run out. The firing mechanism is

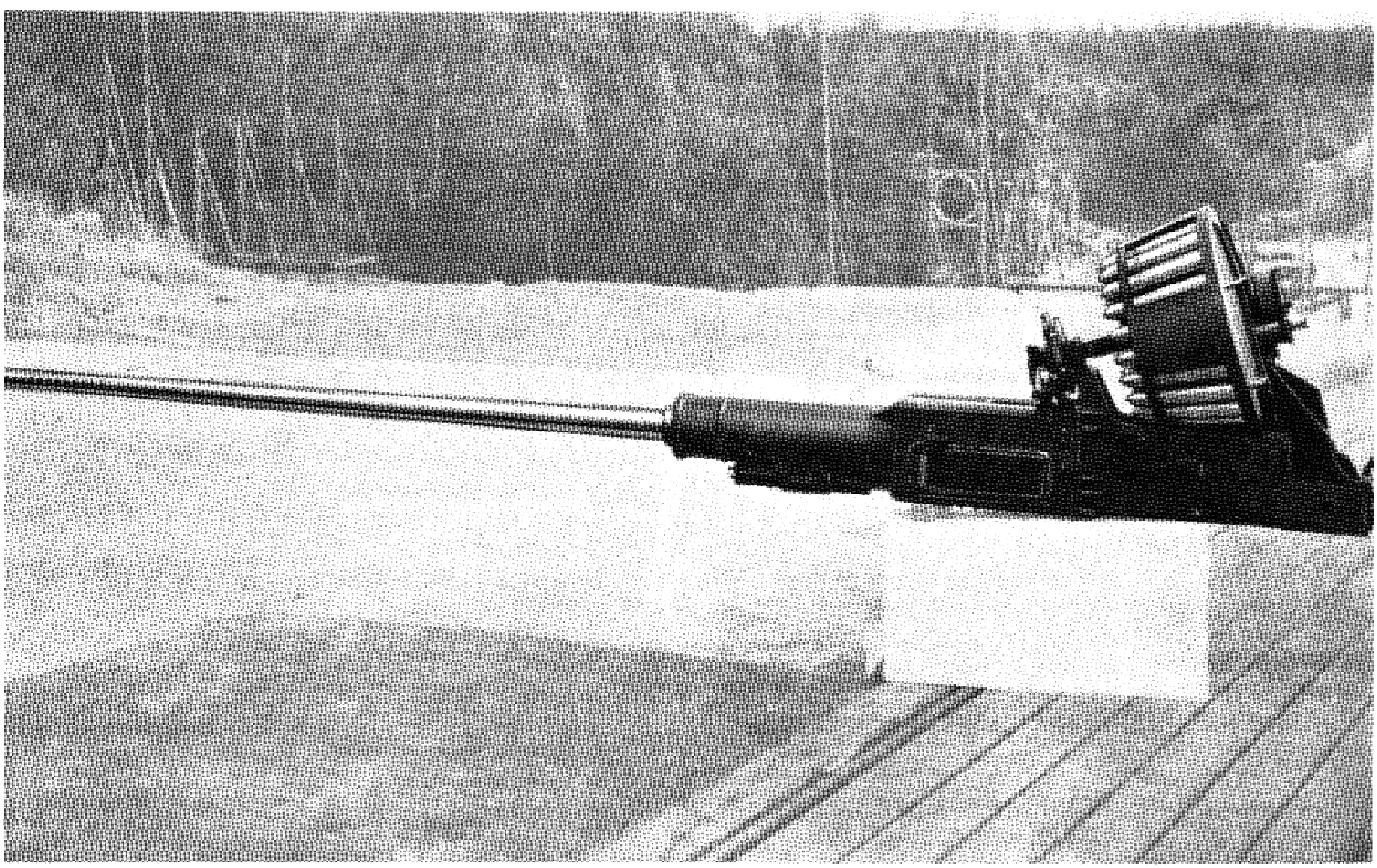

Figure 22–5. 57-mm Bofors Aircraft Cannon on the Proving Ground at the Bofors Plant.

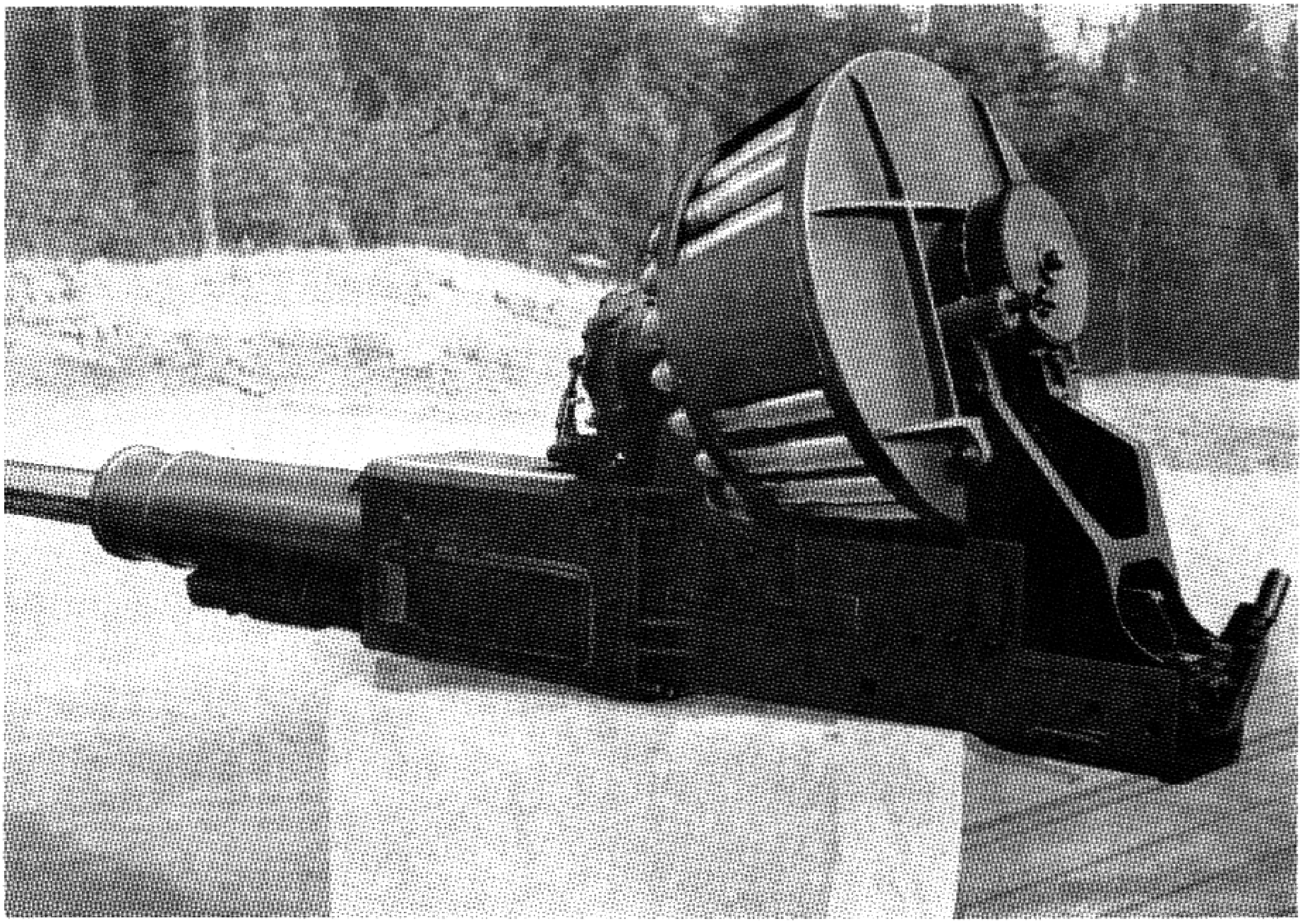

Figure 22–6. 57-mm Bofors Aircraft Cannon. Closeup view of feed.

discharged pneumatically. A pneumatic firing device can be operated electrically by means of a push button installed in the pilot's cabin or elsewhere. The weapon functions at all angles of elevation.

The recoil brake has an electric heating device allowing the gun to function at a very low temperature. The barrel is screwed into the breech ring in such a way that if it were not for its unusually heavy construction it could be readily exchanged. The recoil brake is hydraulic, and the recuperator consists of a spring which encircles the rear part of the barrel.

Cycle of Operation

To fire the Bofors 57-mm aircraft model in flight, the operator has only to throw the selector switch from SAFE to FIRE and press the firing button. By means of a solenoid, a cam forces the sear inward and releases the inner cocking lever and firing pin, which strikes the primer and explodes the cartridge's propellant charge.

During recoil, the cams on the side act on the outer crank to rotate the crankshaft and the inner cranks. The latter's first movement retracts the firing pin and unlocks the breechblock after 2⅞ inches of travel. At this time the projectile has safely cleared the bore, and continued rotation of the inner cranks lower the breechblock into contact with the toes of the extractors, accelerating them in their housing. The empty cartridge case is thrown down through the opening in the top of the breechblock and clear of the working mechanism of the gun, until it hits a deflector.

During the remainder of recoil, the rammer and feed pawls of the loader are raised above the incoming round, being held in position by the stop pawl. This action is brought about by movement of the

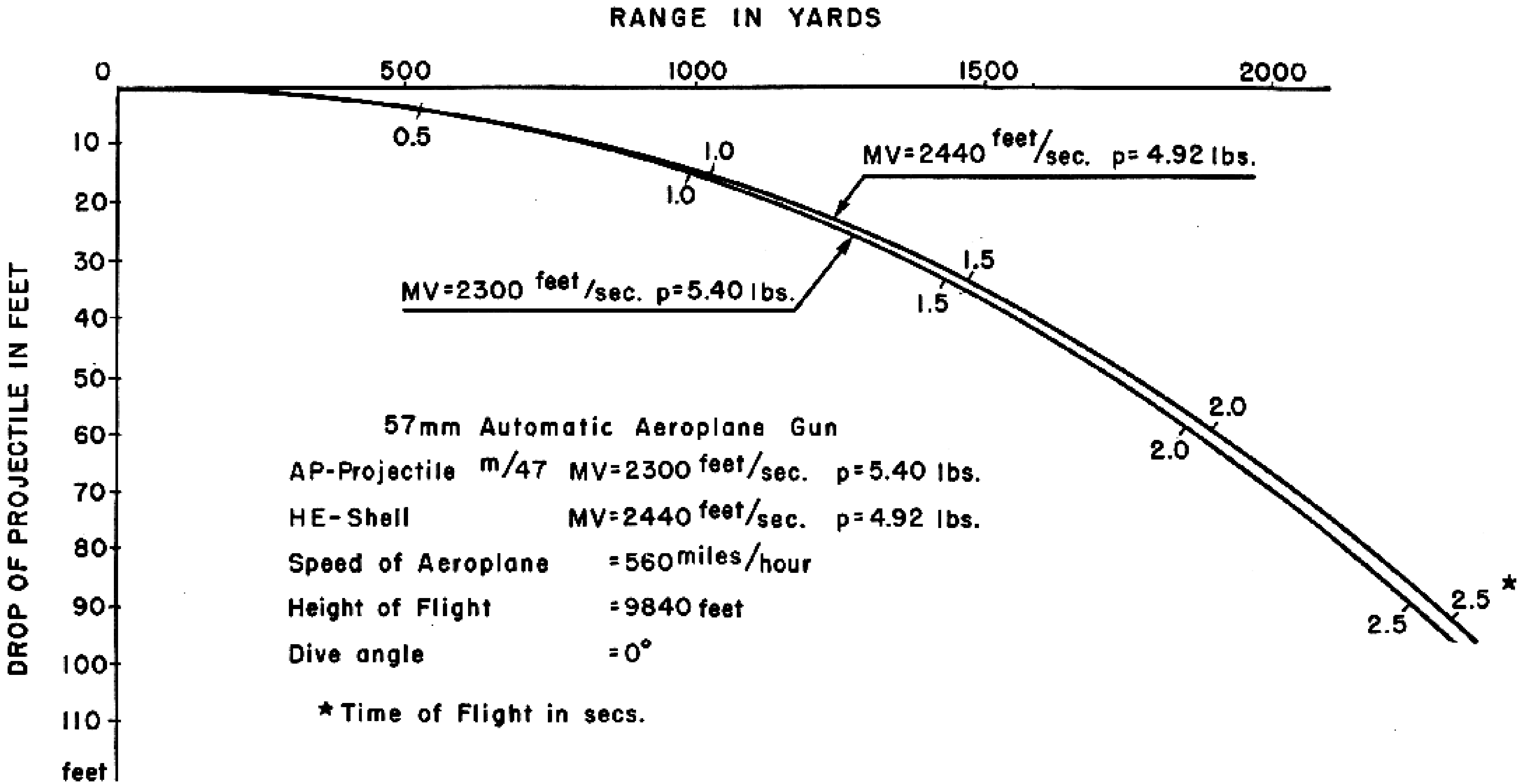

Figure 22–7. Performance of 57-mm Bofors Aircraft Cannon according to Bofors. Speed of plane has been added to muzzle velocity in computing time of flight.

CONFIDENTIAL

roller on the feed rod by means of the guides on the sides of the tray.

Counterrecoil begins after full compression of the driving spring. The breech-locking spring acts to move the breechblock to the closed position; but this motion is stopped as the breech is latched open by the hooks on the extractor. Consequently, the outer crank is carried clear of the side cam. As the tray moves forward, the pawls on the top surface rotate the star wheel in the feeder. This action forces a loaded round on the tray up to the point where the rammer shoe is latched to the rear by the tray catch lever. When an inch from battery position, the cam on the bottom of the tray trips a rocker arm. This in turn fires the tray catch lever, releasing the rammer to start the round into the chamber. At the end of this stroke, the ramming levers are spread by the slots in the tray. The live round, released at a high rate of speed, is literally catapulted into the chamber.

At the completion of this action, the breechblock closing spring is free to raise the breechblock to the closed position as the extractors are unhooked from the block by the rim of the cartridge in the act of chambering. While the block rises, pressure on the left inner cam is removed from the cocking lever and firing of the round is accomplished.

Chapter 23

23-MM MADSEN AUTOMATIC AIRCRAFT CANNON

SECTION 1. HISTORY AND BACKGROUND

In 1902 an 8-mm machine gun mechanism was developed by the Dansk Rekylriffel Syndikat of Copenhagen, Denmark. This automatic firing mechanism has been manufactured from that time to the present with little change in the basic design. The weapon is universally known as the Madsen, this title being derived from the name of the Danish Minister of War of that period as a tribute to his enthusiasm for the weapon at the time of its adoption by the armed services of his country.

Throughout the years, the mechanism has been made to fit practically every rifle cartridge in existence. In 1926 the Danish company announced that they had successfully scaled up the weapon and now had a 23-mm automatic aircraft cannon suitable for both wing and flexible mounting. In 1937, the United States became interested in this type of aircraft armament and bought four guns with ammunition and accessories. By this time, the Danish company was known as Dansk Industri Syndikat.

The four guns were sent to Wright Field and to the Naval Proving Ground at Dahlgren, Va. The

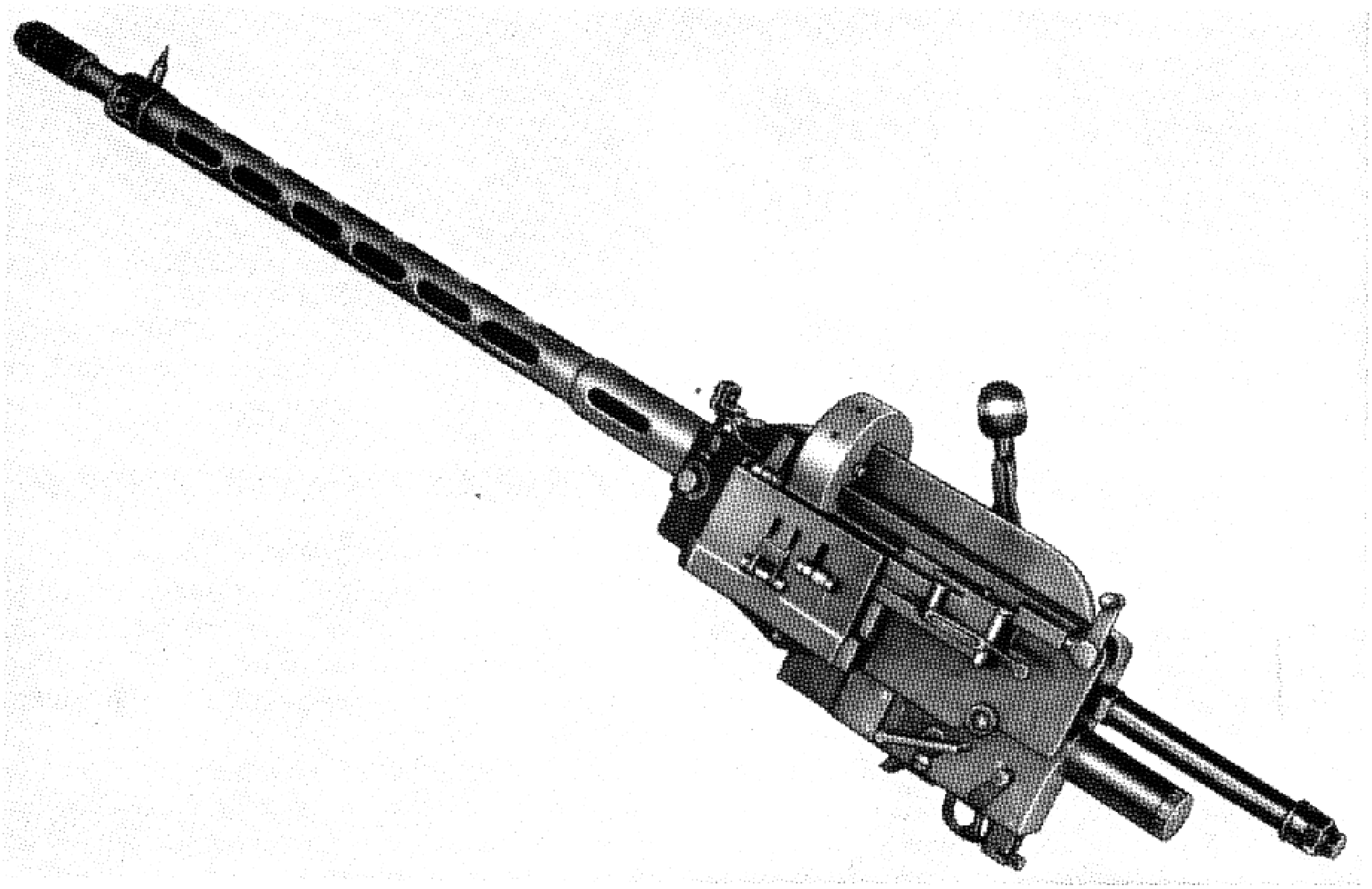

Figure 23-1. 23-mm Madsen Automatic Aircraft Cannon.

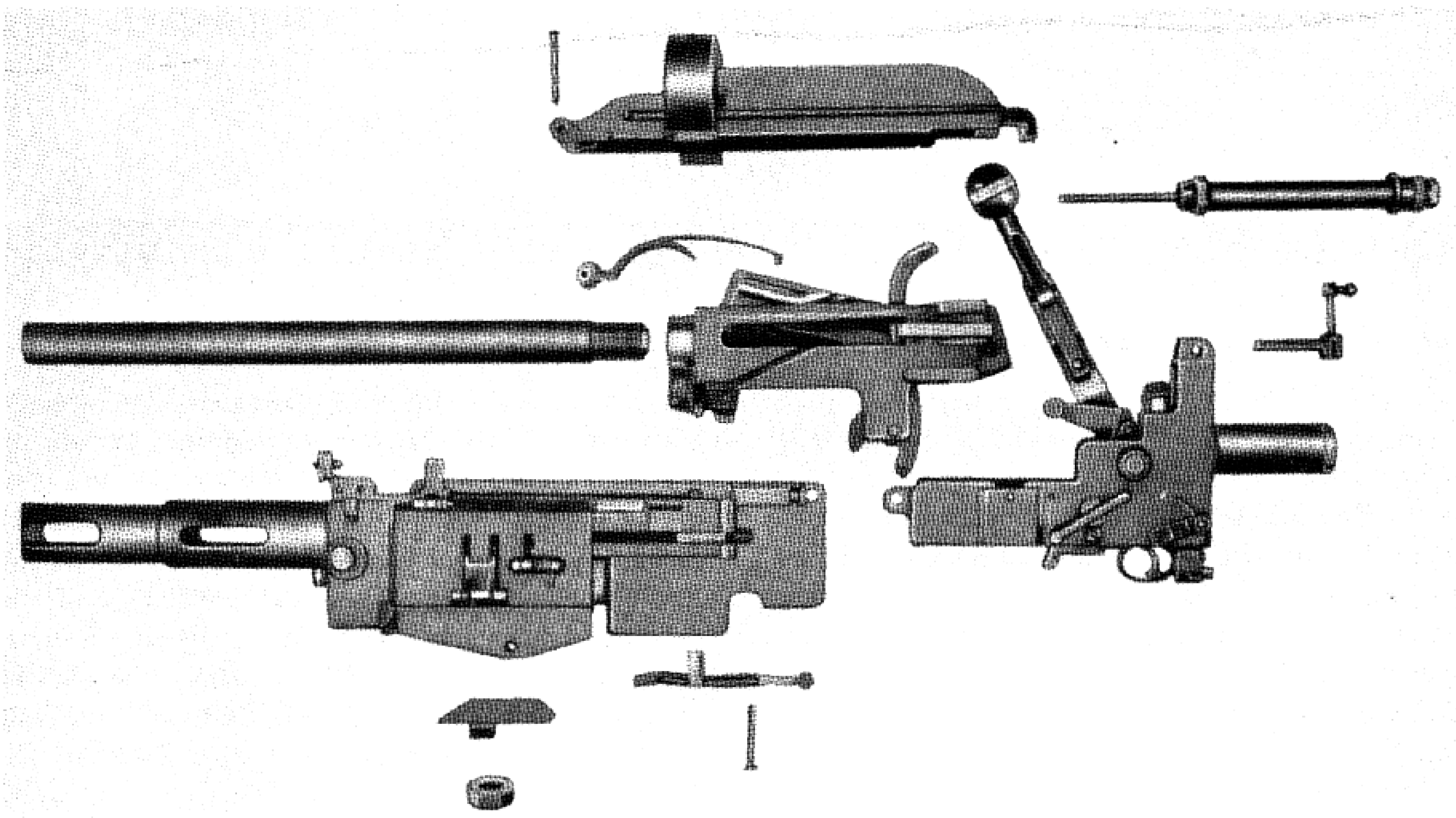

Figure 23–2. 23-mm Madsen Automatic Aircraft Cannon. Disassembled view.

tests at both places were discouraging, and the United States Government lost interest. Illustrations and discussion of developments to this date are included in The Machine Gun, volume 1, pages 537–541 and 570.

It is reported through official channels that after World War II this Danish company experimented with captured German weapons that had been under development at the Mauser and Rheinmetall manufacturing activities.

Unofficial reports indicate that in the post World War II period the Danish company has taken considerable interest in improvements in a 20-mm aircraft gun. Although there are many unofficial reports concerning this "new" 20-mm gun, a search of available records does not reveal that it has been exhibited in the United States.

Up to the time of going to press with this volume, photographs of the "new" 20-mm gun had not been received from the Danish company.

SECTION 2. DESCRIPTION OF THE 23-MM AUTOMATIC AIRCRAFT CANNON

General

The Madsen 23-mm automatic gun is air-cooled, short-recoil-operated, belt-fed, and percussion-fired. The weapon can be fired semi- or full automatic.

The distinguishing feature of this gun is its breechblock which, pivoted at its aft end, assumes three different positions for firing, ejection, and chambering.

The components are easily disassembled and assembled, but all recoiling parts must be removed from the rear before the barrel can be changed.

The Nonrecoiling Parts

The principal components which are nonrecoiling are: The barrel casing and the frame, which are attached together; and the trigger plate assembly. The trigger plate is fastened to the frame by a screw and bolt.

The cartridge-feeding mechanism is mounted on the frame. The trigger plate accommodates the trigger mechanism and the spring housing, which contains the recoil and return spring and assists in braking the mechanism when moving backward and in sending it forward again. The frame is closed by the frame cover.

The Recoiling Parts

In this portion, the essential parts are: the barrel, the breech, and the breechblock.

The barrel, which is screwed onto the breech, is in the form of a long frame which accommodates the breechblock. The fore end of the breechblock can move up and down in the breech, turning on the horizontal breechblock bolt.

The fixed and movable portions are connected by means of the recoil arm, which turns on the horizontal crank bolt. The head of the recoil arm engages in a groove in the link, which is made fast to the breech.

The Trigger Mechanism

The trigger mechanism is inside the trigger plate. The trigger guard has a seating for the trigger bolt upon which the trigger turns. The finger-grip of the trigger extends down into the trigger guard; and the trigger itself has 2 arms, 1 pointing forward, the other pointing upward. The forward-pointing arm is held up by a trigger spring, and to its extreme end is bolted a trigger rod depressor. The trigger rod moves on a bolt at its rear end between the upper ends of the trigger-guard flanges. The trigger rod points forward, and in its forward end has a notch into which the trigger rod depressor fits. On its rear end, the trigger rod depressor has a hook which engages over the trigger rod. The trigger rod spring forms a spring connection between the trigger rod depressor and the trigger rod, pulling the upper end of the trigger rod depressor backward and the fore end of the trigger rod upward. On its upper side, the trigger rod has a lug for the notch in the percussion arm, while on the lower side of the fore end, it is cut away so that the safety catch can be turned in under it. On the right side of the trigger rod is a sliding pawl which engages downward over the upturned arm of the trigger, so that movement of the trigger causes the pawl to move backward and forward in relation to the trigger rod.

In the trigger plate is a changeover lever, which can be turned so that the trigger cannot be moved all the way back, but only enough so that the lug of the trigger rod is withdrawn from the notch in the percussion arm, and not enough that the sliding pawl moves so far forward that the firing cam of the recoil arm can press on it.

Recoil and Percussion Arms

The recoil of the movable portion and its return after completing the recoil are governed by means of the muzzle brake and the recoil arm in conjunction with the recoil spring, the percussion arm with the percussion spring, and the return spring.

The recoil arm is mounted on the crank bolt, which at this point is four sided, whereby the two parts conform to each other's movements. At its top, the recoil arm has a head which engages in a channel in the link, thus forming the connection between the fixed portion and the movable portion of

General Data: 23-mm Madsen Automatic Gun

Gun length: 87 inches. Gun weight: 115 pounds. Rate of fire: 500–600 rounds/minute. Muzzle velocity: 2,300 feet/second. System of operation: Short recoil. System of locking: Pivoting bolt. System of feeding: Continuous feed is an integral part of gun. Method of headspace: Factory established. Location of feed opening: Left side of receiver. Location of ejection opening: Bottom of receiver. Method of charging: Manual or mechanical. Method of cooling: Air.	Barrel length: 61.5 inches. Barrel weight, with muzzle brake: 42 pounds. Rate control: None. Barrel removal: Not quick disconnect. Bore: Number of grooves: 8. Groove depth: 0.020 inch. Groove width: 0.215 inch. Pitch: 5°. Direction of twist: Right hand. Form of twist: Constant. Weight of cartridge: 0.75 pound. Weight of 1 belt with 100 cartridges: 83 pounds. Weight of projectile: 0.37 pound. Muzzle energy: 14.0 foot tons.

258970°—54——40

the gun. On the boss of the recoil arm is a firing cam as well as a face for the trigger rod depressor.

The percussion arm is also mounted on the crank bolt but can turn freely on it. It has a notch for the lug of the trigger rod and a head which, when the trigger is pressed, strikes against the hammer.

At their rear ends, both recoil arm and percussion arm have seatings for two pins, one the recoil spring pin and one the percussion spring pin on which the recoil spring and the percussion spring work. The springs are compressed between a spring base in the trigger plate and a collar on the spring pins.

The return spring is placed in the return spring housing. By means of the return spring plunger, the fore end of which rests against a seating on the back of the link, the return spring helps the recoil spring to brake the recoil of the movable portion after each round and to send the mechanism forward again.

The Safety Device

The safety catch consists of a transverse bolt and catch. On the bolt, opposite the end of the trigger rod, is a radial collar which, when the catch is set at "S", engages under the end of the trigger rod and prevents it from being depressed, thus stopping the gun from firing.

The Breechblock

On its lower right-hand side, the breechblock has a guide pin, and above at the rear it is drilled for the breechblock bolt on which the fore end of the block can swing up and down.

The breechblock track is in the right-hand side of the frame, and on its inner side has four cams which altogether form a track serving to guide the movements of the breechblock during the recoil and return action.

The guide pin rests between the two foremost cams of the breechblock track. When the round is fired, recoil begins. The barrel and the breechblock retain their mutual positions (that is, the chamber remains closed) until the guide pin strikes against the middle cam of the track. The ejector prevents the breechblock guide pin from running under the middle cam. The guide pin moves along a runway and the fore end of the breechblock is raised, whereby the chamber is opened. As the recoil proceeds the guide pin moves along another runway, which keeps the breechblock raised and permits the empty case to be ejected.

When the guide pin has passed, the breechblock spring inserted in the frame cover will press the breechblock down, and as the recoil is simultaneously at an end and the return movement begins, the guide pin will slide along so that the chamber is open during the forward movement. In the course of the latter movement, the cartridge is fed into the chamber, which is closed by the movement of the breechblock. During the final part of the forward movement, the guide pin is carried back to the starting point between the two foremost cams.

The breechblock is drilled longitudinally for the firing pin; when the chamber is closed by the breechblock, the whole is in alinement with the percussion cap.

On its fore end the hammer has a face which rests against the firing pin, which projects a little way out of the rear end of the breechblock; the rear part of the hammer serves as an anvil for the percussion arm. When the latter is released by a pressure on the trigger, it strikes the hammer which transmits the blow to the firing pin and through it to the percussion cap.

The Feeding Mechanism

The cartridge feeding mechanism consists of the feeder house, which is comprised of the feed funnel cab with its dividing pawl and stop pawl, feed funnel and slide with spring driving pawl and right and left stop pawls, cartridge distributor, cartridge-hook stop block, cartridge hook, and cartridge feeder.

A cartridge belt can be fixed to the feed funnel on the frame in such a manner that the stop pawls engage under the first cartridge and prevent it from sliding downward. The slide with its spring driving pawl has on its inner side a pin which moves in an oblique track on the left side of the breech, so that during the recoil movement it moves downward, moving upward again during the return movement. This draws the cartridge belt upward, and the stop pawls prevent it from sliding down again, in order that the driving pawl of the slide can reach the next cartridge in the belt when the slide moves down. The dividing pawl directs the cartridge while it is being drawn from the belt and during its introduction to the chamber. The cartridge distributor

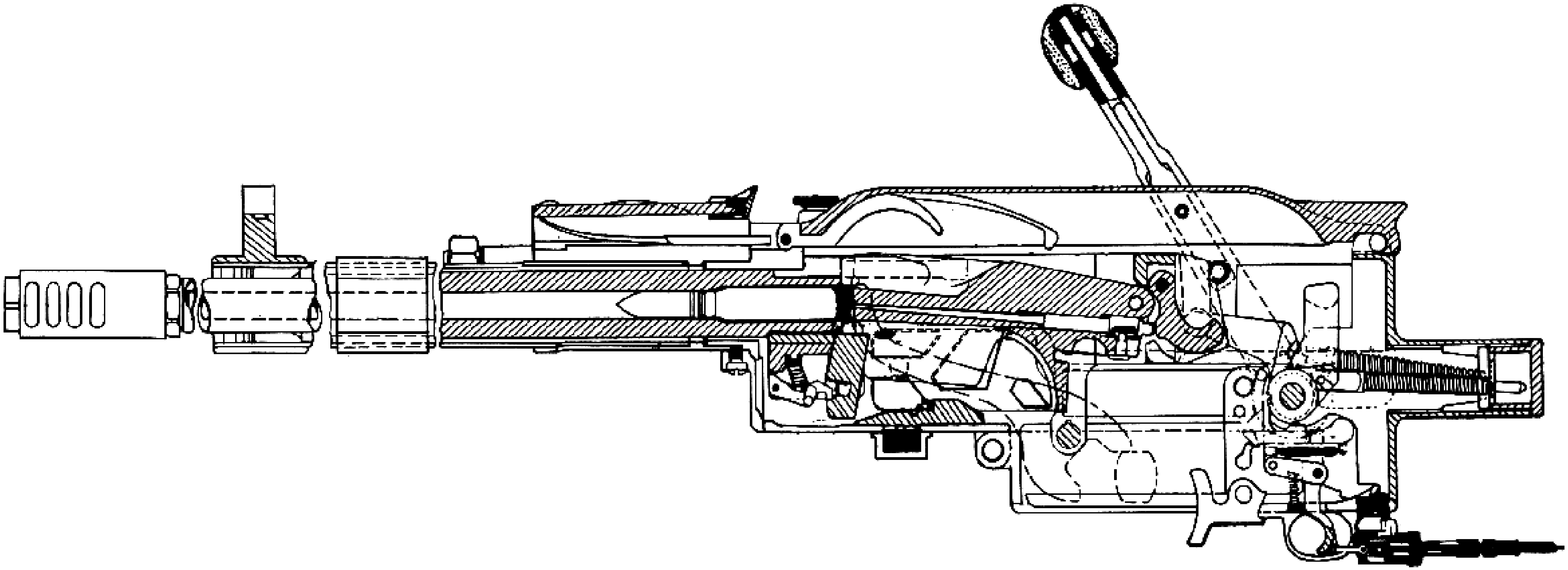

Figure 23–3. 20-mm Madsen Cannon. Longitudinal sectional view.

presses the cartridge into the breech with its forward-pointing arm.

The cartridge hook, which works on the left side of the breech, engages the flange of the cartridge and draws it back during the recoil movement. At the moment the cartridge hook strikes against the stop block the cartridge is released, the cartridge hook being pressed into the breech by the stop block, thus disengaging it from the cartridge flange, and the spring pawl on the stop block throws the cartridge forward into the cartridge seating in the breechblock.

The cartridge feeder is a three-armed lever working on the cartridge feeder bolt placed between the two lower flanges of the breech, so that it works between the left side of the breechblock and the wall of the breech, which is cut away to receive the cartridge.

The cartridge feeder is actuated by the passing of the two short arms over the cartridge feeder block, which is placed in the trigger plate, whereby its long arm moves forward during the return action and pushes the cartridge into the chamber. During the recoil, the long arm of the cartridge feeder is turned back so far that it comes behind the next cartridge placed into the breech by the cartridge distributor and, under the pressure of the cartridge feeder and the spring pawl of the cartridge stop block. This positions the incoming cartridge and seats it first in the breechblock and then in the chamber.

The cartridge opening in the left side of the breech is so placed that only when the breech is in its rearmost position does it give access to the cartridge released from the cartridge hook.

Ejector Mechanism

The ejector mechanism consists of the ejector, ejector pawl, and ejector pawl spring which is placed in the forward lower part of the breech, and the ejector block on the bottom of the frame.

When the movable portion moves backward, the ejector is raised, gliding up the forward ramp of the ejector block. It is retained in the vertical position by the ejector pawl, the nose of which engages in the notch in the ejector; when the ejector has moved up the ramp, its claw moves up in front of the cartridge flanges. Simultaneously, the breechblock is raised as already described, and by means of a ramp on the ejector block, the ejector pawl is so lifted that the ejector is released.

While the breechblock is up, the rear lower corner of the ejector trips against an upright edge on the ejector block so that it is thrown backward and lies flat. By this movement the claw of the ejector extracts the cartridge case, which follows the ejectionway of the breechblock and is thrown out through a hole in the bottom of the trigger plate. During the return action of the movable portion, the breechblock, which is then in its lowest position, will keep the ejector in its recumbent position; but when the breechblock moves up into the firing position, the ejector is released; the ejector pawl, actuated by the ejector pawl spring, will then move the ejector into its vertical position again.

SECTION 3. CYCLE OF OPERATION OF THE 23-MM AUTOMATIC AIRCRAFT CANNON

Loading

To load, the gunner inserts the cartridge belt into the feedway until the stop pawls engage under the first cartridge, then loads the gun by performing two loading movements.

During the first movement, when the gunner draws the crank back, the slide with its withdrawing pawl moves down and catches the first cartridge. When the crank moves forward, the slide moves up again and moves the cartridge belt over with it; the stop pawls engage under the second cartridge in the belt; the dividing pawl is pressed up and out by the first cartridge; the cartridge hook comes forward and seizes the rim of the first round.

During the second loading movement, when the gunner draws the crank back, the cartridge hook draws the first cartridge back (that is, out of the cartridge link and in behind the cartridge distributor, which presses it in toward the cartridge way in the left side of the breech); the dividing pawl, which is now free, springs forward; the slide moves down again, and the driving pawl moves in under the second cartridge; the cartridge hook, just before the movement comes to an end, is pressed back by the stop block on the side of the frame, whereby the first cartridge is set free; the cartridge distributor presses the cartridge in toward the middle of the gun, in front of the cartridge feeder which is then in its rearmost position; the spring pawl of the stop block at the same time throws the cartridge forward a little.

When the crank moves forward, the cartridge feeder pushes the cartridge into the chamber, while the dividing pawl insures that the point of the bullet is in the right direction; the slide moves the cartridge belt up, and another cartridge is thus ready to be drawn back by the cartridge hook, which then engages its flange.

Firing

Single-Shot Firing. Set the change-over switch at "E."

Every round is fired by a separate pressure on the trigger. A pressure on the trigger forces the trigger back so far that it strikes against the changeover switch, whereby the forward-pointing arm of the trigger draws the trigger rod depressor down by means of its hook. The trigger rod depressor draws down the trigger rod, disengaging the trigger rod lug from the notch of the percussion arm. The percussion arm, under the influence of the percussion spring, strikes against the hammer, which transmits the stroke to the firing pin, thus firing the round.

The recoil takes the movable portion back. During this movement, the breechblock guide pin glides in the breechblock track, whereby the breechblock is raised, the firing pin being withdrawn prior to this movement. Furthermore, the empty case is ejected and the cartridge feeder is turned to its rearmost position, while the cartridge hook releases the cartridge which has been placed in front of the cartridge feeder by the cartridge distributor. At the same time, the slide moves down and catches the next cartridge.

The recoil arm and percussion arm are pressed back by the movable portion, which at the same time compresses the return spring, recoil spring, and percussion spring. During the final part of the movement of the recoil arm, the firing cam points forward, whereby the trigger rod depressor is pressed forward and its hook is disengaged from the trigger rod, which is then forced by its spring so that its lug engages in the notch of the percussion arm, which is then prevented from striking.

When the movable portion has gone right back, the recoil spring and return spring press it forward again. During the forward movement, the breechblock moves down, and when it reaches its lowest position, the cartridge feeder will feed a cartridge into the chamber; this completed, the breechblock moves up and closes the chamber. The ejector, which during the final part of the recoil and the first part of the return movement has laid flat, will be raised by the ejector pawl during the last part of the return movement. The slide lifts the cartridge belt up and the cartridge hook seizes the flange of the next cartridge.

Automatic Firing. For automatic firing, the gunner will turn the changeover switch to "A," which means that it is so turned that the trigger is not restricted in its action.

When the trigger is forced back, its upward-pointing arm moves farther forward than in single-round firing. The upward-pointing arm is accompanied by the sliding pawl which is carried farther forward, the result being that the firing cam of the recoil arm presses on the sliding pawl during the end of the movement. The sliding pawl, and with it the trigger rod, are pressed down, and the round is fired.

Chapter 24

KRIEGHOFF EXPERIMENTAL CANNON

SECTION 1. HISTORY AND BACKGROUND

During World War II, the Krieghoff Waffenfabrik, of Suhl, Germany, devoted its time mainly to the production of the Parabellum (Luger) pistol. (See volume 1, pp. 310–311.) This company turned out large quantities of the famous weapon and the management took great pride in stating that the workmanship was of better construction than the well-known Oberndorf product.

7.92-mm FG–42

Early in World War II, the Krieghoff establishment was given the job of designing and producing a weapon to arm airborne infantry, a method of warfare that had never been attempted before this time. The specifications laid down demanded an extremely light-weight weapon employing the standard 7.92-mm cartridge and having a high rate of

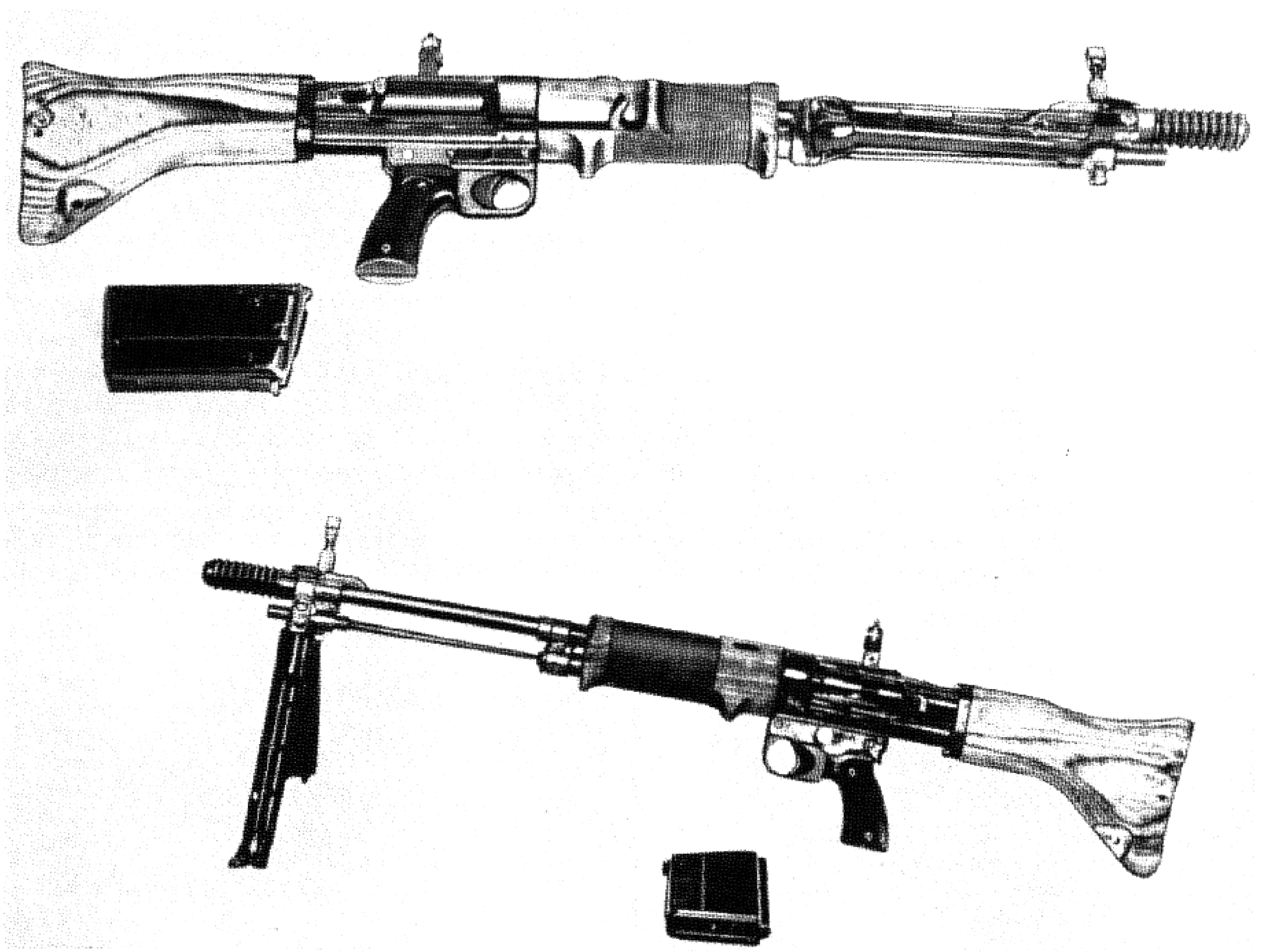

Figure 24–1. Machine Gun, 7.92-mm Model FG–42.

fire if needed but, if the occasion demanded, capable of firing single shot with the accuracy of an infantry rifle. The result of this order turned out to be one of the outstanding ordnance accomplishments of the Germans in World War II, and the finished product was given the official designation of 7.92-mm FG–42. The letters represent the initials of the Fallschirm Jaeger Gewehr (paratroop machine gun), and the numerals indicate the year of adoption. Shortly after the gun had been issued, the Germans used it in the invasion of Crete. This was the first time a military objective had been taken by soldiers parachuted from troop-carrying planes and the FG–42 played no small part in the success of the campaign. The FG 42 was a gas-operated, rotating form of lock, air-cooled, bipod-supported weapon that had an unusually large ventilated forearm grip. The overall weight of the gun was only 14 pounds with bipod and loaded clip that held 20 rounds. (See volume 1, pp. 489–491.)

For an American light machine gun developed from the FG–42, see this volume, chapter 14, pp. 423–433.

SECTION 2. DEVELOPMENT OF A UNIQUE LOCKING SYSTEM IN VARIOUS CALIBERS

General Description

Before World War II the Krieghoff company had in the development stage a gun design with a unique feature of locking by means of cams cut in the receiver sides to raise and lower the lock. This feature was incorporated into guns of various calibers ranging from 7.92-mm to 30-mm.

These weapons are all gas-operated, cam-locked, air-cooled, belt-fed aircraft machine guns and cannon. The receivers are fabricated by welding. The top of the receiver is open to accommodate the feed tray, which is held in the receiver by the feed assembly. The rear of the receiver has vertical slots cut to mate with the projection on the sides of the backplate. In the inner front sides of the receiver are two rollers that engage the cam track and support the slide assembly.

The first of this series was a 20-mm experimental aircraft cannon, and it is believed by many ordnance technicians that it was designed as early as 1938 and that all other experimental models of similar design are direct outgrowths of this 20-mm 1938 version. The translation of a German report which follows describes the action of these weapons regardless of the caliber.

Description of Components

Receiver Housing. The receiver is of fabricated welded construction and houses the barrel, barrel-recoil springs, slide assembly, drive spring, guide rod and rear buffer, and sear assembly. The barrel charging assembly is fixed on the left side of the receiver. The slide charging assembly is at the bottom front of the housing. The feed assembly and the tube lock assembly are hinged to the receiver. The top of the receiver is open to accommodate the feed tray, which is held in the receiver by the feed assembly. The inner sides of the receiver have longitudinal slides cut to mate with the projections on the rear of the slide assembly. The rear of the receiver has vertical slots cut to mate with the projections, or lands, on the sides of the backplate. In

General Data: 20-mm Krieghoff Experimental Aircraft Cannon

Gun length, with muzzle brake in barrel: 126 inches.	Barrel length: 89 inches.
Gun weight: 114 pounds.	Barrel weight: 47 pounds.
Rate of fire: 600–700 rounds/minute.	Rate control: None.
Muzzle velocity: 2,850 feet/second.	Barrel removal: Quick disconnect.
System of operation: Gas piston actuated.	Bore:
System of locking: Pivoting lock.	Number of grooves: 9.
System of feeding: Actuated by bolt extension.	Groove depth: 0.015+0.002 inch.
Method of headspace: Factory established.	Groove width: 0.205+0.010 inch.
Location of feed opening: Top right side of receiver.	Pitch: 7° (equals 1 turn in 25.587 calibers and 1 turn in 20.137 inches).
Location ejection opening: Bottom.	Direction of twist: Right hand.
Method of charging: Electropneumatic.	Form of twist: Constant.
Method of cooling: Air.	

the inner front sides of the receiver are two rollers which engage the cam track and support the slide assembly.

Barrel, Breech Ring and Breechblock. The barrel has to be assembled to the receiver from the rear. The barrel is held to the breech ring by interrupted threads. The barrel is prevented from rotating from the locked position by a retaining lug in the breech ring. This retaining lug is engaged by the receiver tube retainer which, when pulled out, allows the tube to be unlocked, leaving it free to rotate for disassembly. The barrel and breech ring are held in the receiver by a retaining sleeve, which is threaded onto the barrel after assembly in the receiver. The retaining sleeve bears against the upper section of the gas cylinder which, in turn, bears through another sleeve against the barrel recoil spring housed in the receiver. The breech ring bears against a collar in the receiver, preventing the barrel from escaping in the forward direction. The rear of the recoil spring bears against the front of the same collar. The barrel has a port through which gases escape to the gas cylinder to operate the slide assembly. The barrel is equipped with a muzzle brake.

The breechblock, which is of the vertical sliding type, does not cover the entire base of the cartridge case. The breech is open when the block is in the "up" position and closed when the block is in the "down" position. There are two rollers on the inside of the block, which ride in the cam track of the slide assembly to raise and lower the block. The firing pin is spring-loaded in the retracted position. It is actuated by the pin in the block, which in turn is operated by the pin in the ring. The gun fires on counterrecoil. As it is driven forward, the firing pin cam in the receiver is struck by the pin in the ring which operates the pin in the block; thus the firing pin is driven forward. During recoil, the receiver firing pin cam overrides the breech pin.

Slide Assembly. The slide assembly has at its forward end a gas-operated piston which drives the slide rearward during the firing cycle. The sides of the slide have cam tracks in which ride two sets of rollers. One set is secured to the breechblock and functions to close and open the breech. The other set is secured to the receiver and acts as a guide to support the front of the slide in its movements. At the rear of the slide assembly are 2 projections, 1 on each side, which ride in the slides of the receiver, supporting and guiding the rear of the slide. At the top rear of the slide is the feed operating cam, which engages the feed cam to operate the feed assembly on recoil of the slide assembly.

The rammer block is held in its forward position by the rammer-block spring and is locked in that position by the rammer-block lock. The lock is depressed by the breech ring when the round is rammed; this releases the rammer block so that the slide continues forward, compressing the rammer block spring. The rammer head is fixed to the rammer block. The extractor is pivoted at the rear of the rammer block and is spring loaded to hold it in the "up" position. The extractor has two cam surfaces which bear against the extractor operating cams on the feed tray, forcing the extractor down when the empty case is being reinserted into the link. The rammer block is buffered front and rear by banks of flat springs.

General Data: 30-mm Krieghoff Experimental Aircraft Cannon

Gun length: 116 inches.	Barrel length: 57 inches.
Gun weight: 390 pounds.	Barrel weight: 88 pounds.
Rate of fire: 400–600 rounds/minute.	Rate control: None.
Muzzle velocity: 2,850 feet/second.	Barrel removal: Not quick disconnect.
System of operation: Gas piston actuated.	Bore:
System of locking: Sliding block.	Number of grooves: 20.
System of feeding: Metallic link.	Groove depth: 0.02945 inch.
Method of headspace: Factory established.	Groove width: 0.01692 inch.
Location of feed opening: Top left.	Pitch: 2°30′.
Location ejection opening: Top right; expended case is placed back into link.	Direction of twist: Right hand.
Method of charging: Electropneumatic.	Form of twist: Constant.
Method of cooling: Air.	

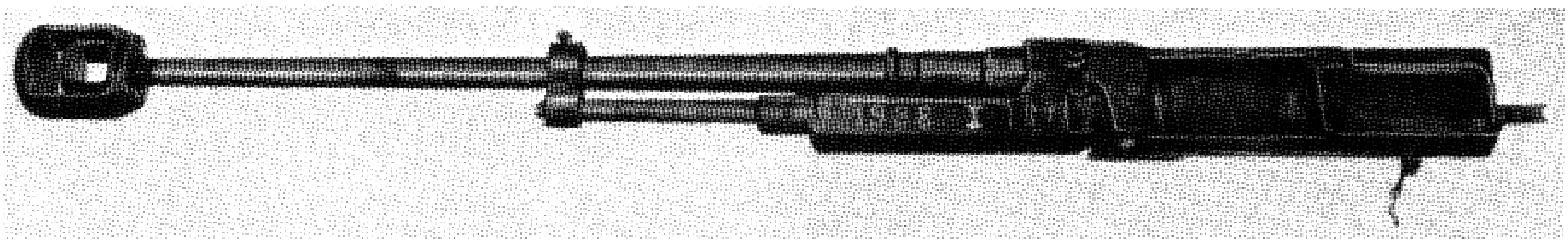

Figure 24–2. Early version of Krieghoff Experimental 20-mm Aircraft Cannon. Assembled view.

Feed Assembly. The feed assembly is hinged to the receiver and contains the mechanism for feeding and disintegrating the linked belt after the empty case is reinserted into the links. The feed cam is pivoted by means of a pin secured to the cover and is spring-loaded by a leaf spring. The feed pawl is spring-loaded so that the links will depress it on the return stroke. It slides in ways and is driven by the other end of the feed cam, which lies in a longitudinal slot of the feed pawl support. A lever which actuates the holding pawls projects from the face of this longitudinal slot.

As the feed cam arm is operated, the arm contacts the lever and the holding pawls are drawn down to permit the feed pawl to place the next link and round in line for ramming. Belleville springs absorb some of the feed shock. A holding pawl keeps the links stationary on the return stroke of the feed pawl. The feed body has transverse grooves machined in it to guide and support the links as they are fed through. A link disintegrating cam is set in the rear grooves to drive the link disintegrating pin. This pin in turn drives the other two connecting pins, so that the connecting hinges are no longer pinned together, and the links part.

Barrel Lock and Buffer Assembly. The barrel lock and buffer assembly is hinged to the receiver. The barrel lock is pinned at one end and spring loaded to hold it in the "down" position when assembled. The barrel lock buffer absorbs the force

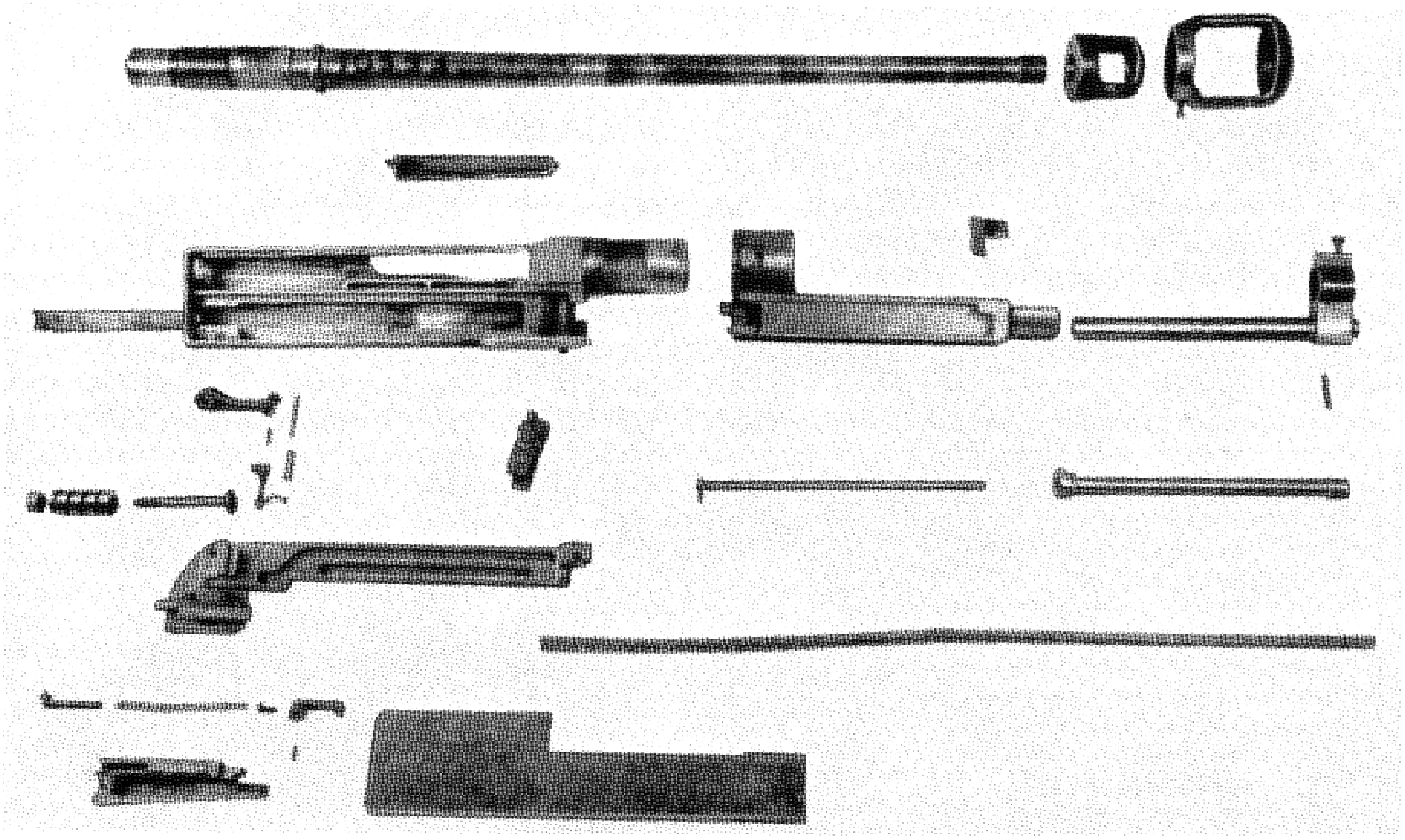

Figure 24–3. Early version of Krieghoff Experimental 20-mm Aircraft Cannon, completely disassembled.

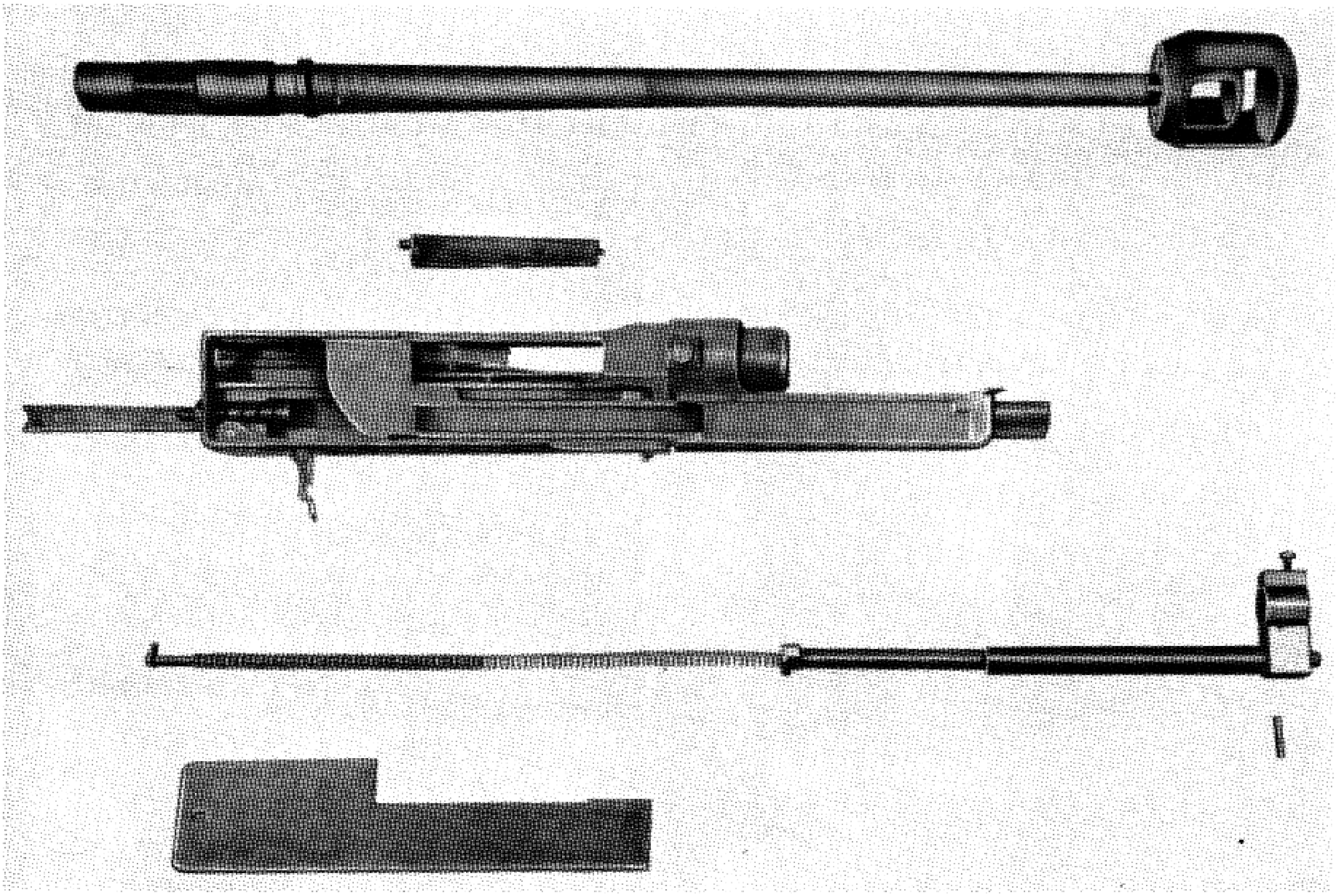

Figure 24–4. Early version of Krieghoff Experimental 20-mm Aircraft Cannon, partially disassembled.

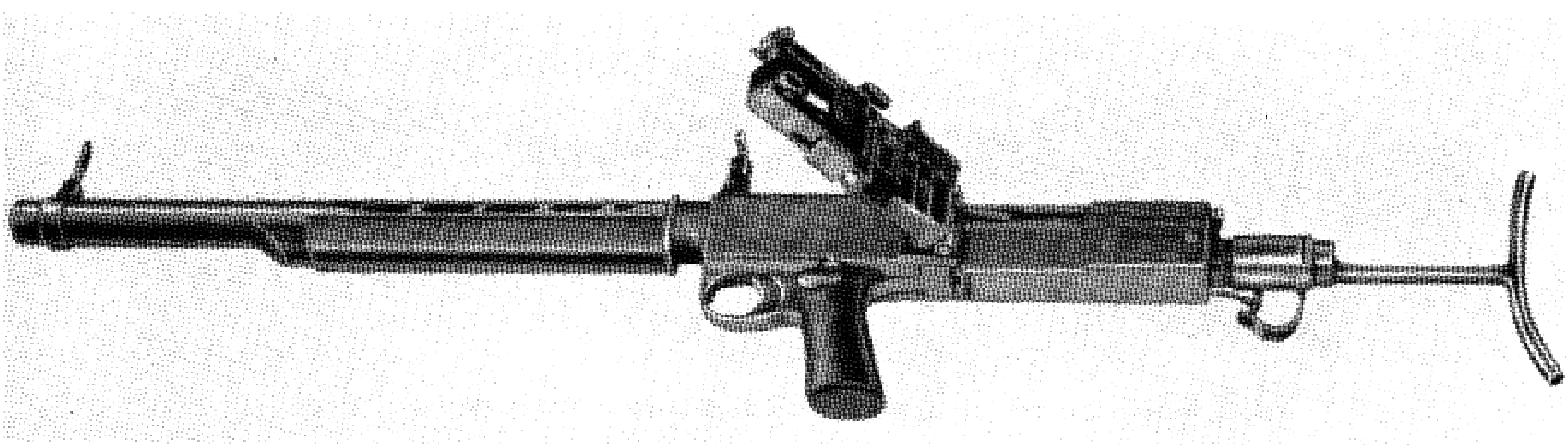

Figure 24–5. Krieghoff Experimental Aircraft Machine Gun, 7.92-mm Model 1940, with feed open.

Figure 24–6. Krieghoff Experimental Aircraft Machine Gun, 7.92-mm Model 1940. Right side view.

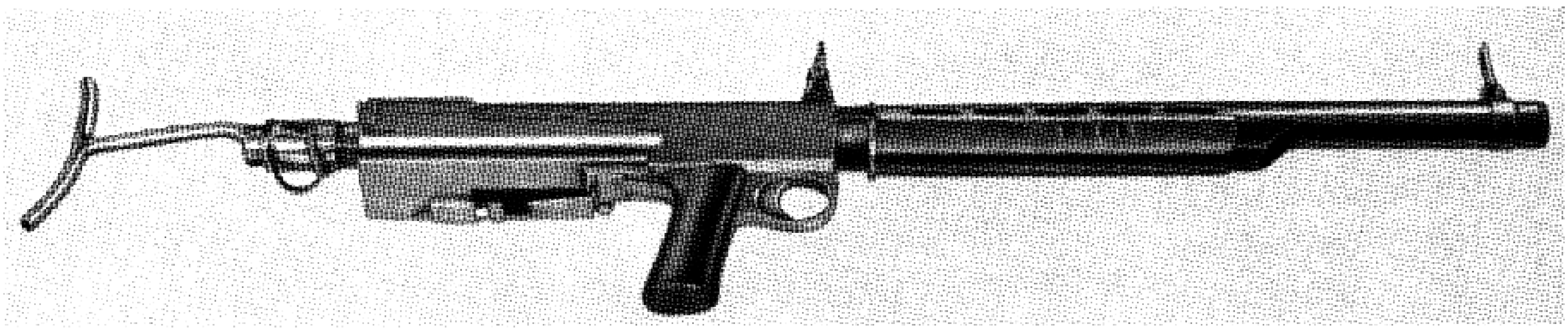

Figure 24–7. Krieghoff Experimental Aircraft Machine Gun, 7.92-mm Model 1940. Left side view.

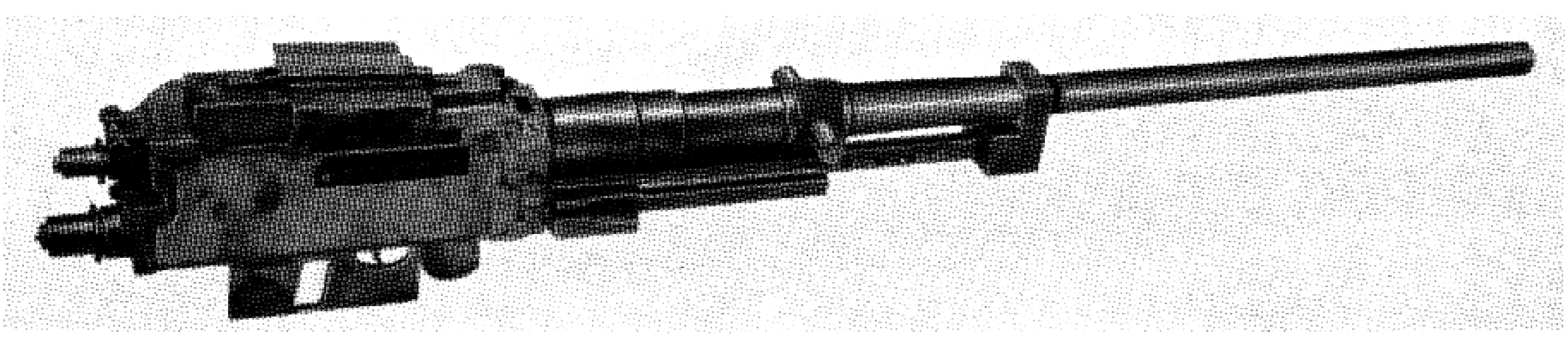

Figure 24–8. Second version of Krieghoff Experimental 20-mm Aircraft Cannon.

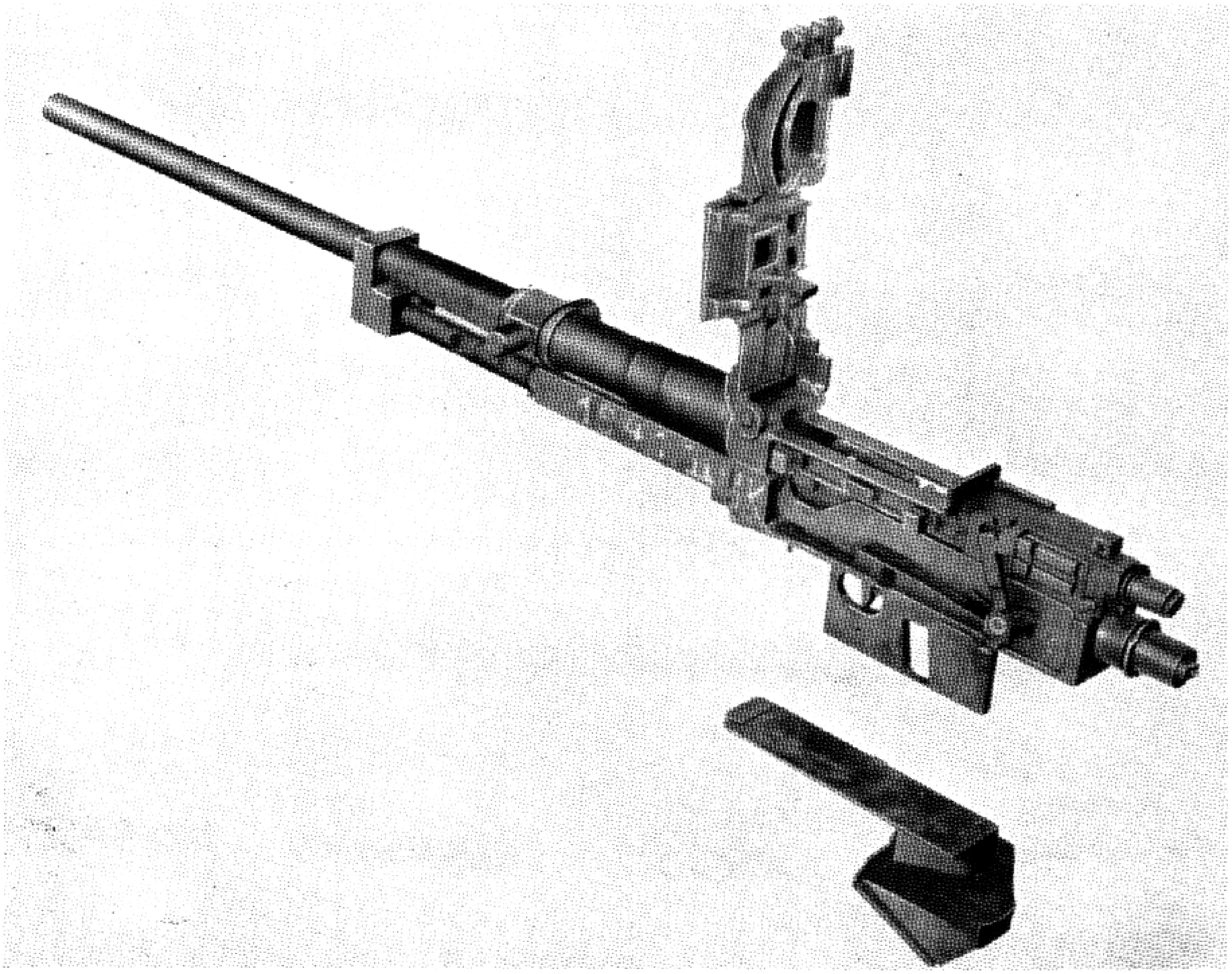

Figure 24–9. Second version of Krieghoff Experimental 20-mm Aircraft Cannon, with feed open.

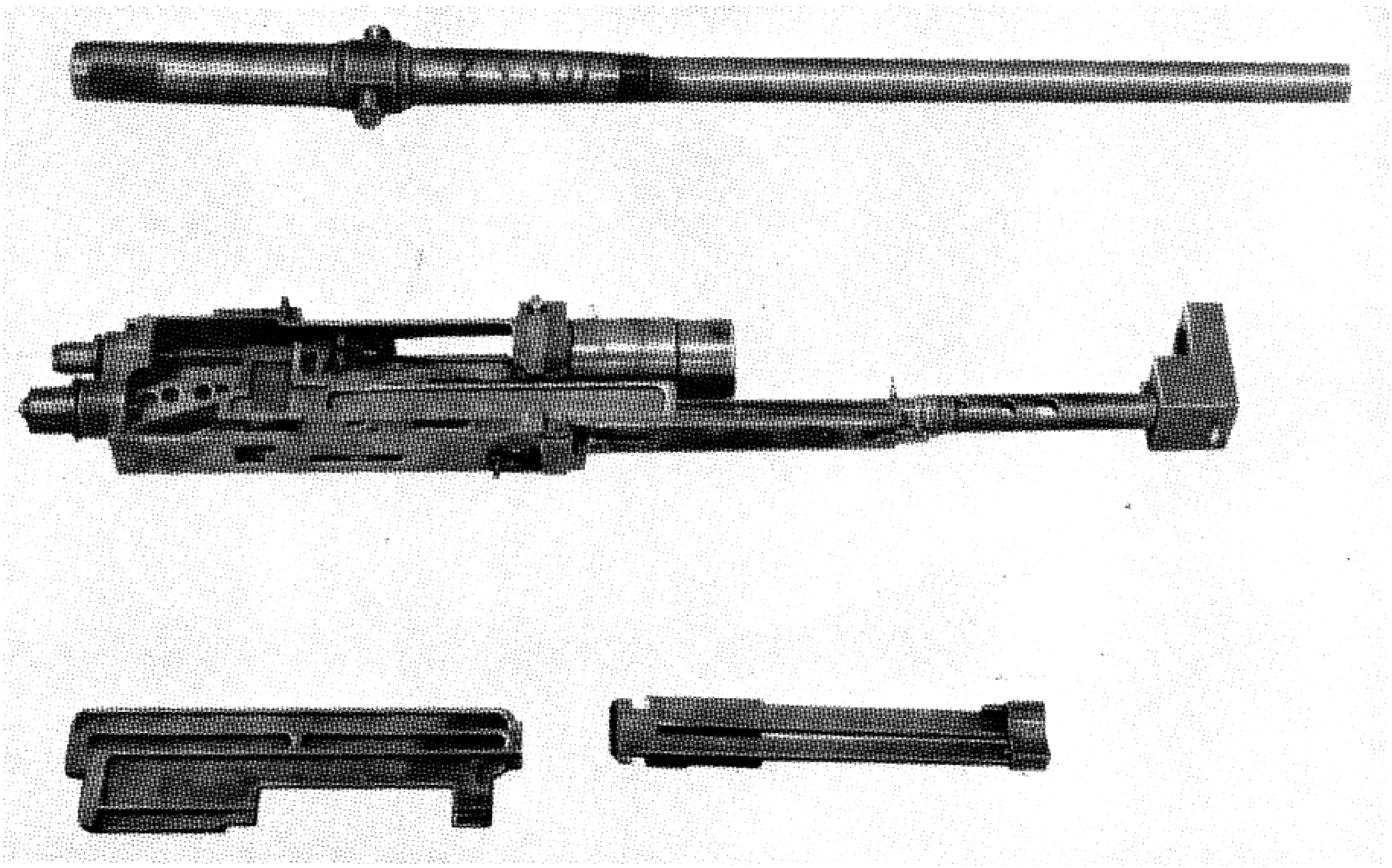

Figure 24–10. Second version of Krieghoff Experimental 20-mm Aircraft Cannon, partially disassembled.

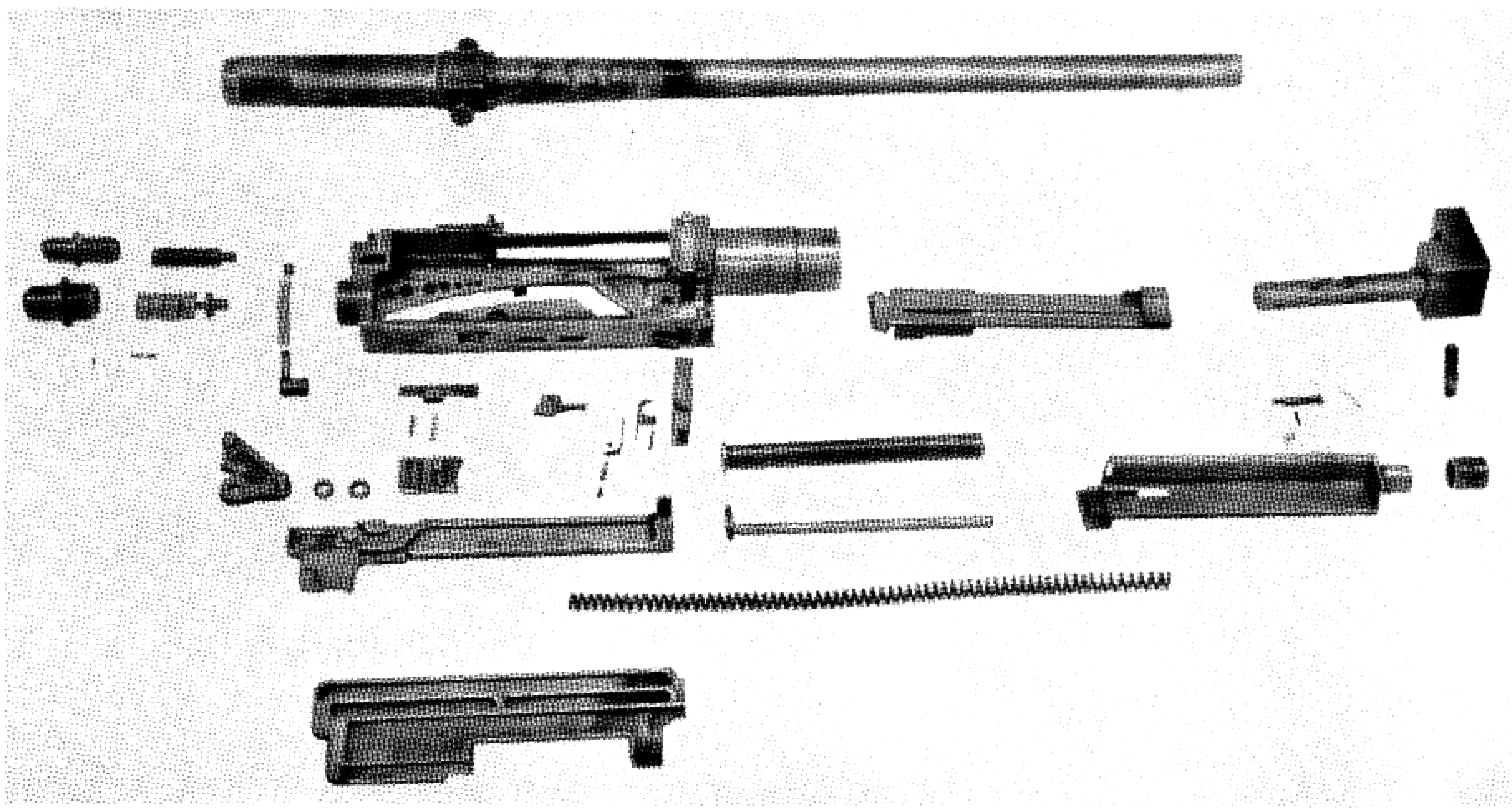

Figure 24–11. Second version of Krieghoff Experimental 20-mm Aircraft Cannon, completely disassembled.

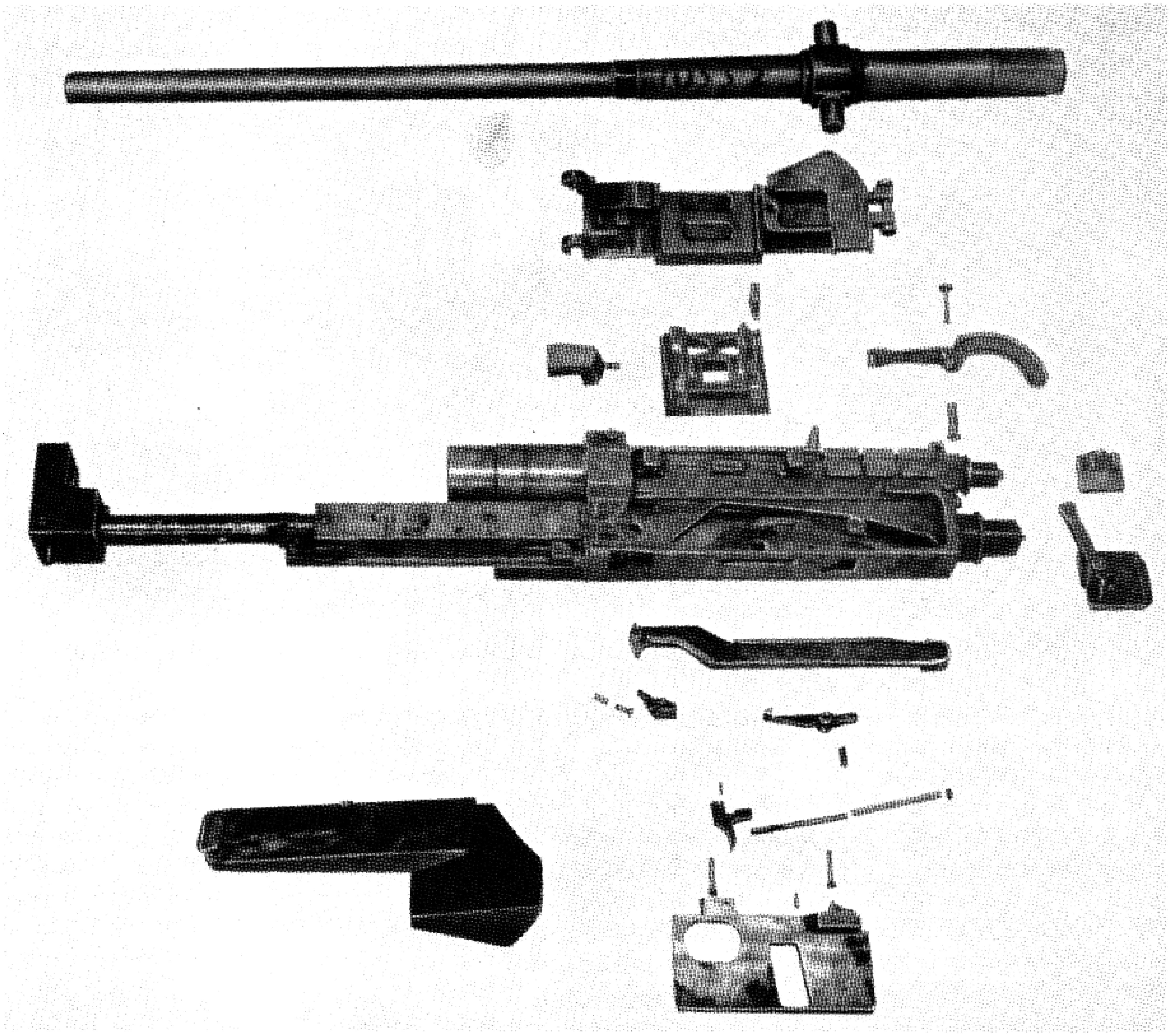

Figure 24–12. Second version of Krieghoff Experimental 20-mm Aircraft Cannon. Exploded view of feed elements.

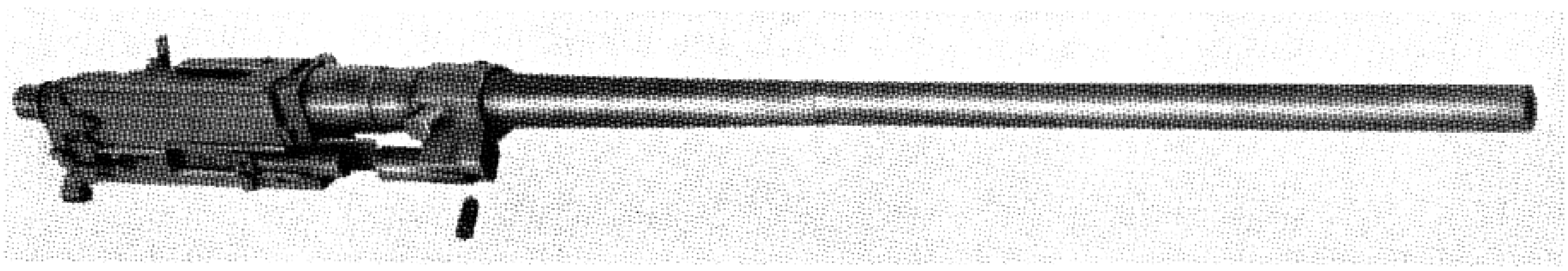

Figure 24–13. Third version of Krieghoff Experimental 20-mm Aircraft Cannon.

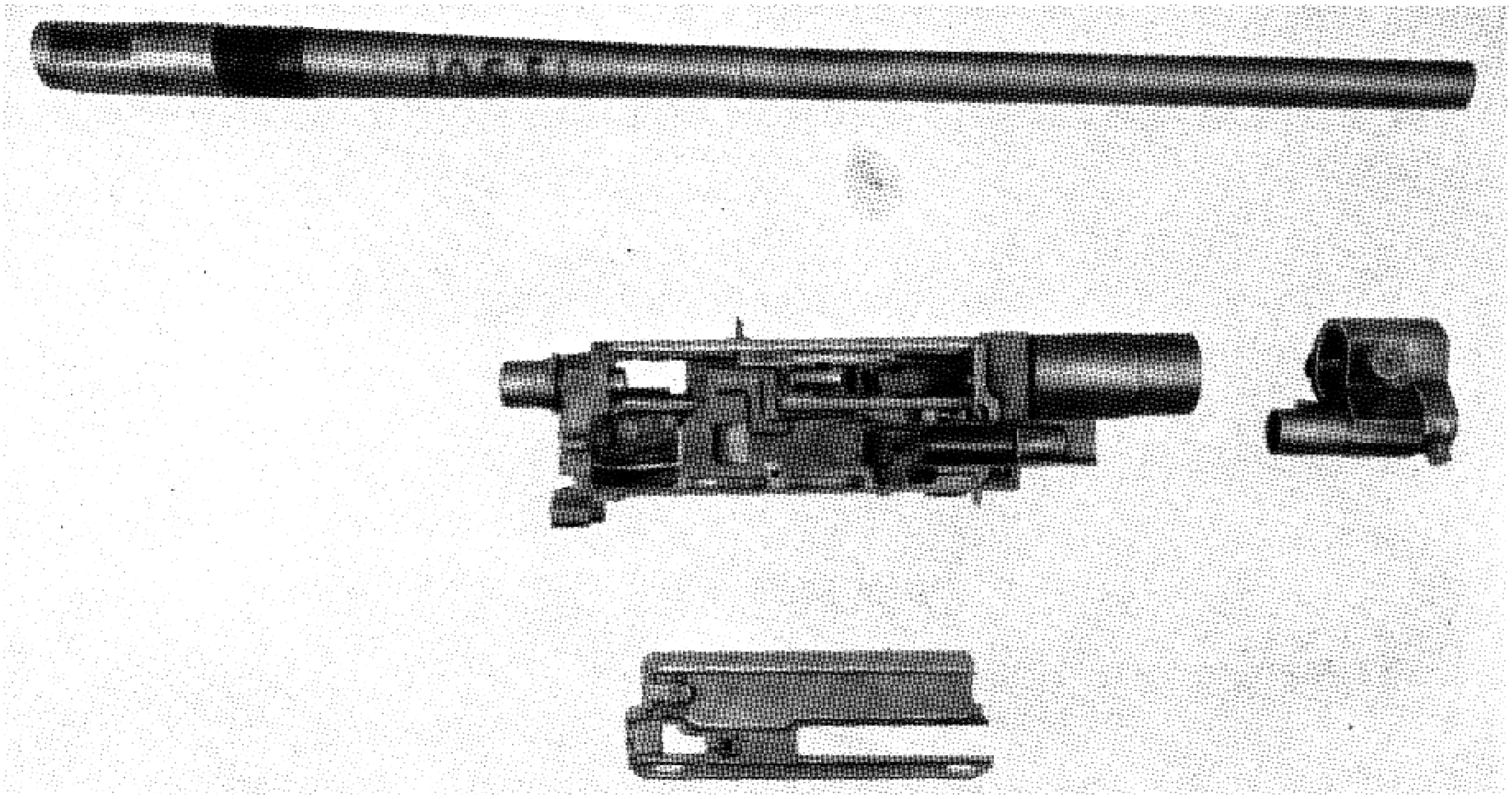

Figure 24–14. Third version of Krieghoff Experimental 20-mm Aircraft Cannon, partially disassembled. Right side view.

of the recoil springs as they attempt to return the barrel to firing position, and the open breechblock is engaged by the barrel lock.

Feed Tray. The feed tray, which guides the linked ammunition belt, has a longitudinal slot to permit the rammer to project up to contact the rounds. At the rear of the tray are two extractor cams which engage the extractor and lower it to enable the extractor to release the empty case after reinserting it into the link.

Operation

Charging. After the feed belt has been inserted into the feedway, compressed air is admitted to the front of the slide charging cylinder and the piston is driven rearward. The rod engages the slide assembly and it is forced rearward, compressing the drive spring until the sear engages the slide assembly. Compressed air is also admitted to the barrel charging cylinders. These cylinders (two in number) have a catch which engages a depression in the breech ring through a slot in the left side of the receiver. As the air is allowed to enter the charger, the breech ring and barrel are driven rearward by the catch, and the raised breechblock engages and raises the barrel lock. Further rearward movement allows the breechblock to clear the lock, and the lock snaps down and engages the front face of the raised breechblock, which holds the barrel rearward against the force of the compressed barrel recoil springs.

Cycle of Operation. After the feed belt has been inserted into the feedway and the gun charged it is ready for automatic firing. The trigger mechanism is operated; and by means of a lever system in the backplate, the sear is depressed, allowing the slide assembly to be driven forward by the compressed drive spring. The feed cam and feed pawl are returned by force of the leaf spring to their original position. The holding pawl prevents the links from being retracted from the feedway by the returning feed pawl. As the rammer head approaches the feed tray, the extractor is lowered by its cam and contacts the extractor cams on the feed tray. The rammer head contacts the base of the round and strips it from the link. The extractor, no longer held down by the extractor cams, is forced up by its spring and the lip of the extractor engages the rim of the cartridge case. The round is rammed into the chamber.

During the final movement of the round entering the chamber, the rammer-block lock is depressed by

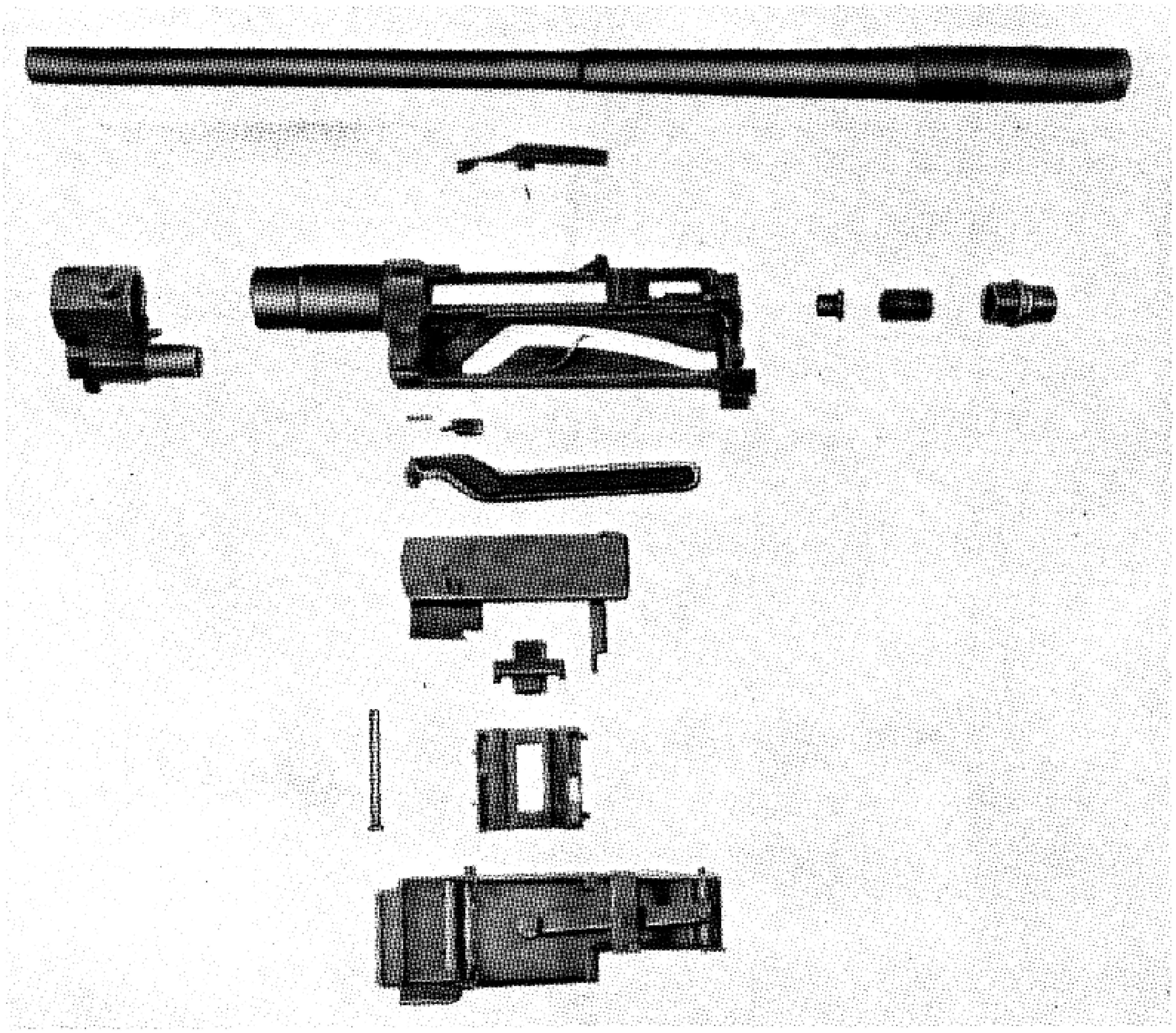

Figure 24–15. Third version of Krieghoff Experimental 20-mm Aircraft Cannon, completely disassembled. Left side view.

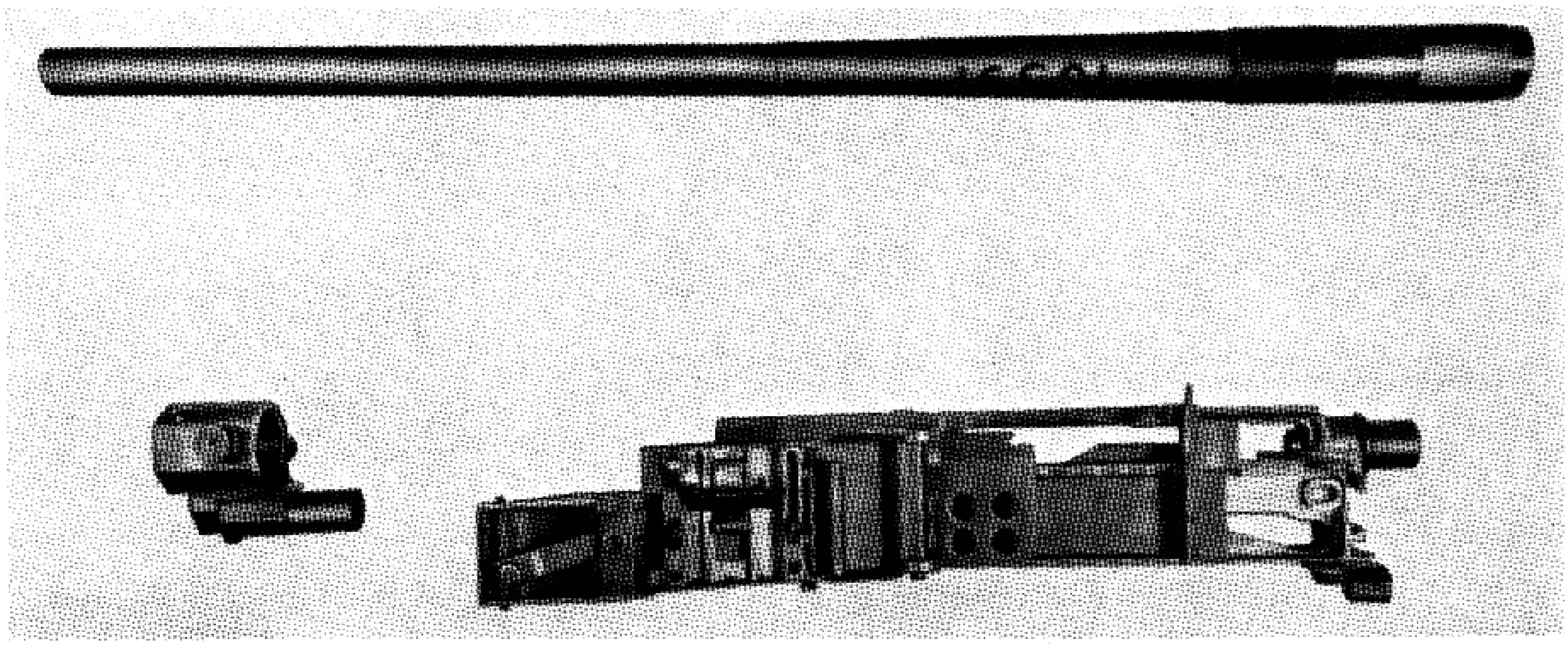

Figure 24–16. Third version of Kreighoff Experimental 20-mm Aircraft Cannon, partially disassembled.

258970°—54——41

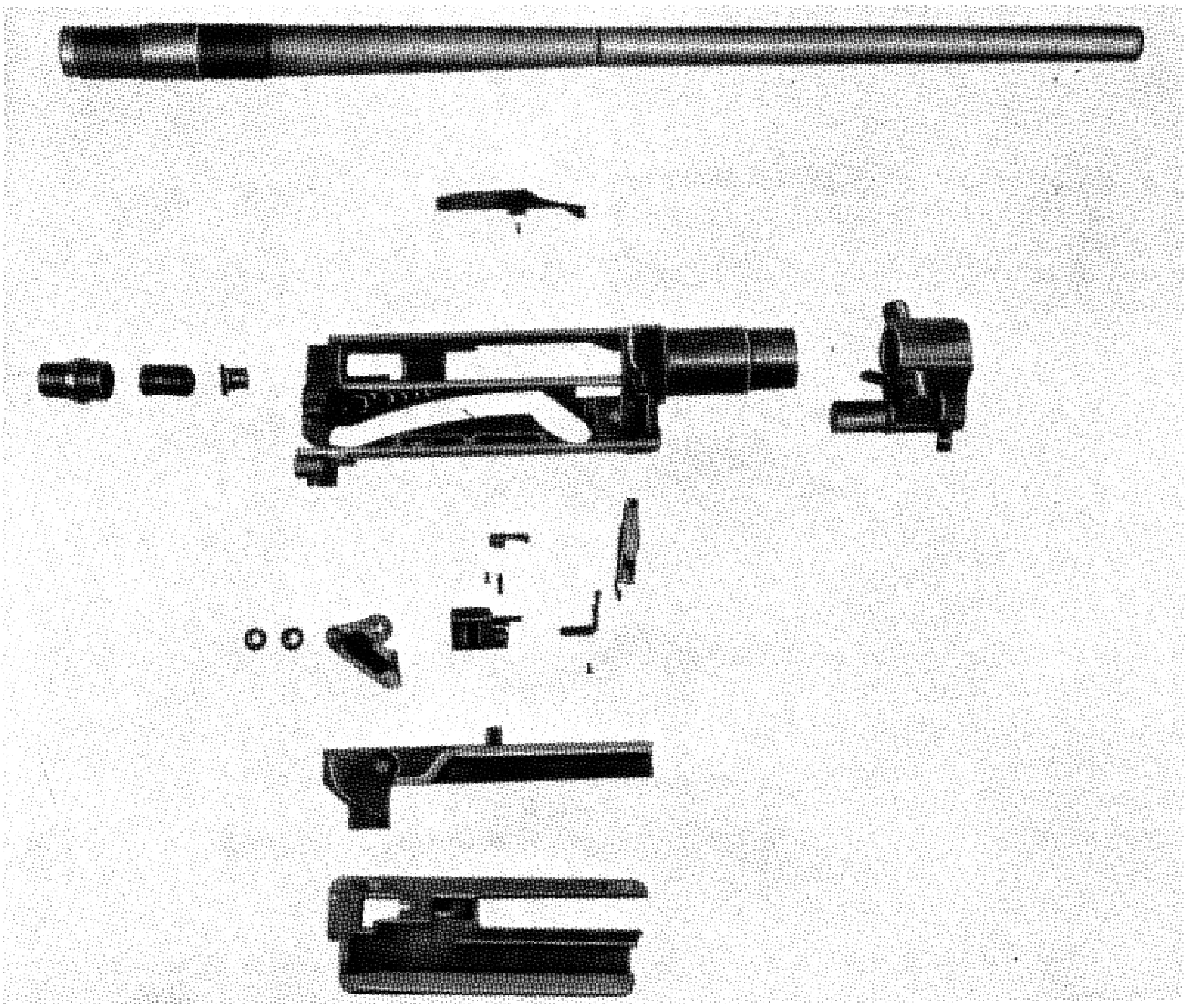

Figure 24-17. Third version of Krieghoff Experimental 20-mm Aircraft Cannon, completely disassembled. Right side view.

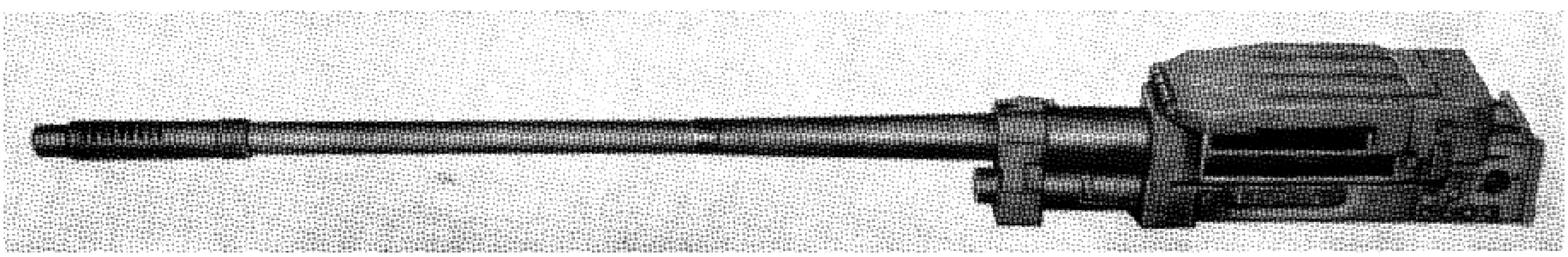

Figure 24-18. The final version of Krieghoff Experimental 20-mm Aircraft Cannon. This design was later scaled up to 30-mm.

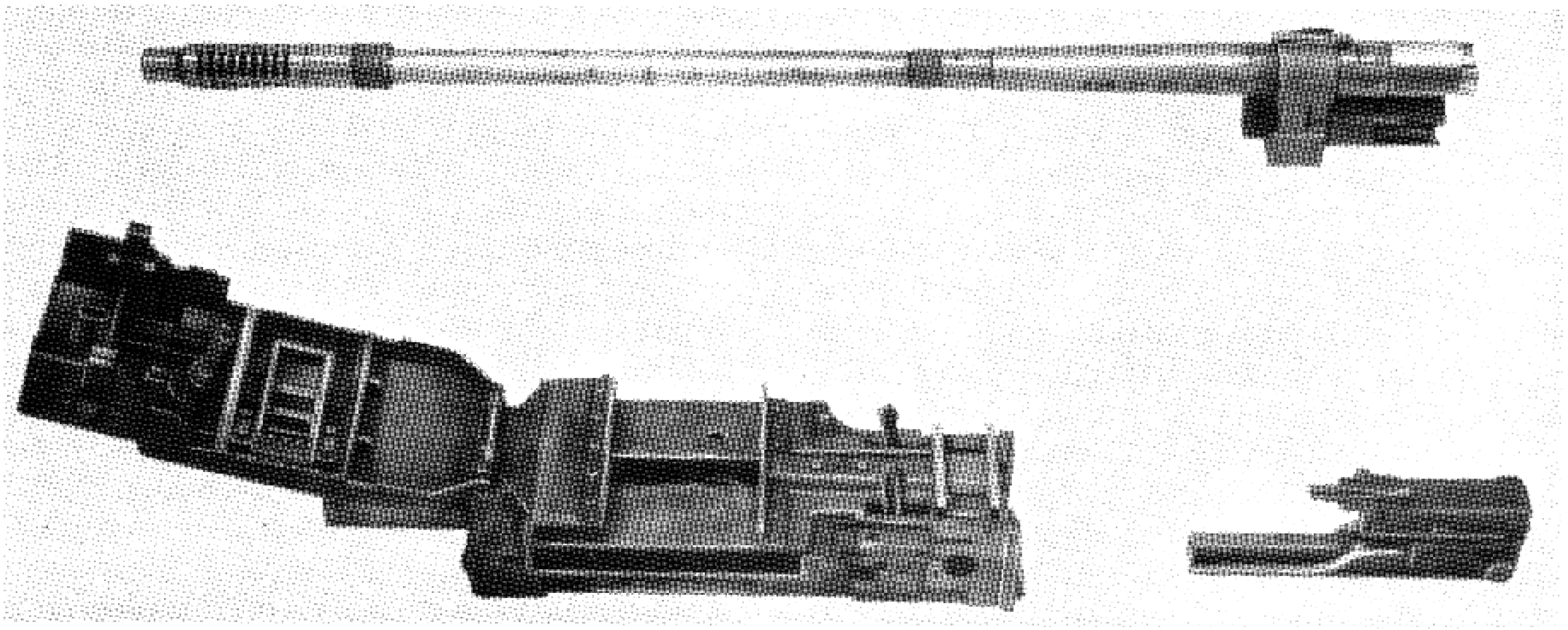

Figure 24–19. Final version of Krieghoff Experimental 20-mm Aircraft Cannon, partially disassembled.

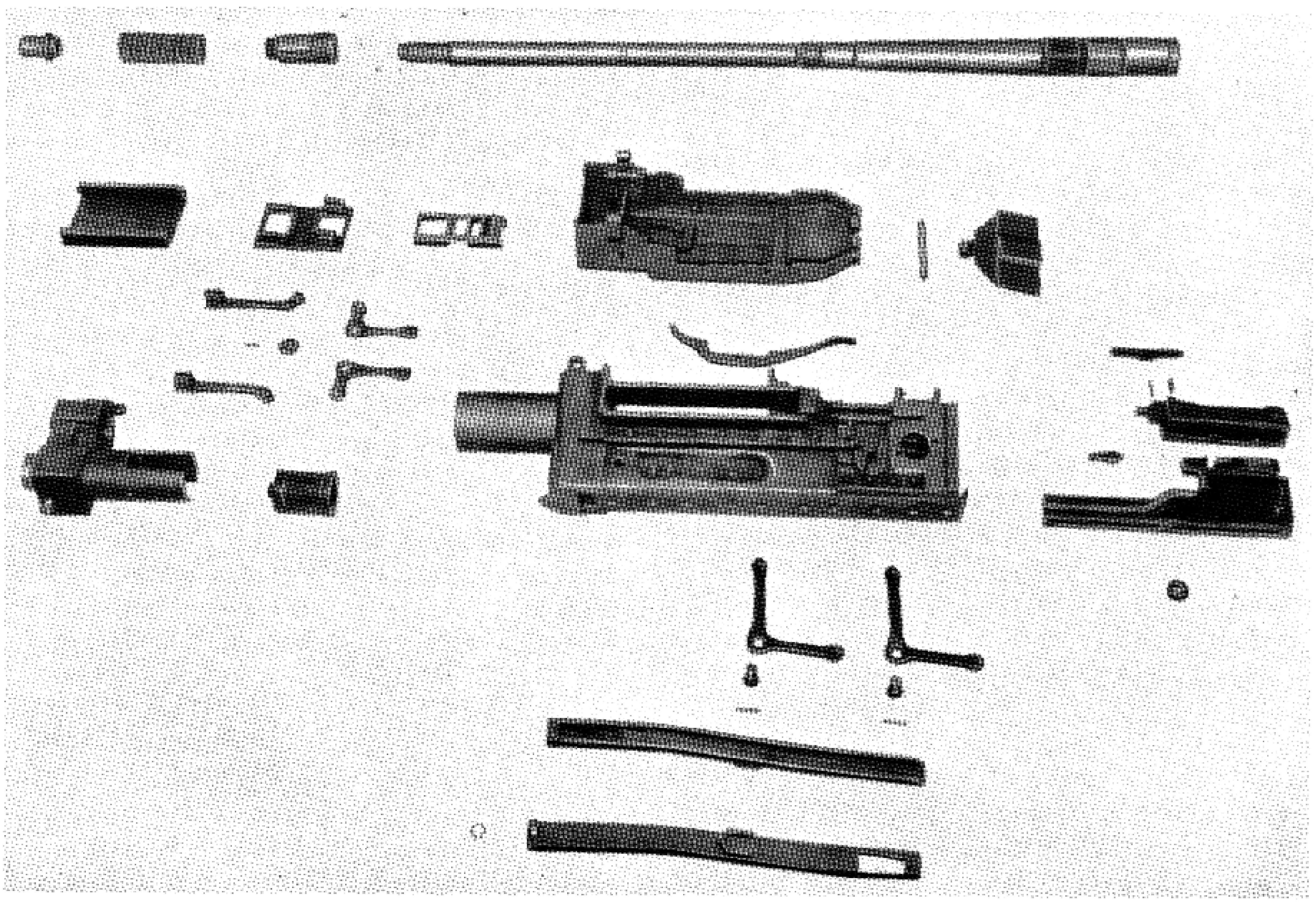

Figure 24–20. Final version of Krieghoff Experimental 20-mm Aircraft Cannon, completely disassembled.

the breech ring and relative movement between the slide assembly and rammer block results. The slide assembly continues to be driven forward by the drive spring. The rammer block is held by the face of the breech ring; thus, the rammer block spring is compressed by the continued forward run of the slide. The breechblock rollers engage the downward portion of the cam track in the sides of the slide, and the breechblock is drawn down. The gas piston of the slide enters the gas cylinder. The downward movement of the breechblock disengages the block from the barrel lock, and the gun is allowed to run forward under the combined force of the drive spring and the compressed recoil springs. As the gun runs forward, the receiver firing pin cam engages the ring firing pin actuator and depresses it. This in turn depresses the block firing pin actuator, the spring-loaded firing pin is driven into the primer, and the round is fired.

The barrel starts to recoil. Powder gases are led through a port in the barrel to the gas cylinder. The gases drive the slide assembly rearward and the cam track raises the breechblock; this action enables it to engage the barrel lock to hold the barrel in the recoil position. Further rearward movement of the slide results in the extractor's withdrawing the empty case from the chamber and reinserting it into the link. As the case is reinserted into the link, the extractor cam depresses the extractor to disengage the lip from the empty case and to allow continued rearward movement of the slide. After the empty case has been reinserted into the link, the feed operating cam is engaged by the feed cam. The cam is rotated about its pivot point, engages the holding pawl operator, and the pawls are depressed. Further movement of the feed cam results in the feed pawl's driving the links across the feedway and positioning a new round for ramming. As the links are forced across, the link disintegrating cam surface engages the link disintegrating pin and drives it inward. This pin in turn drives the other pins in the link connecting hinge, and the links part. The slide assembly strikes the rear buffer, and, if the sear is still held depressed, the cycle is repeated.

Chapter 25

CAPTURED RHEINMETALL AIRCRAFT WEAPONS

SECTION 1. HISTORY AND BACKGROUND

Early History

The history of Rheinmetall-Borsig A. G. may be traced back to the establishment of a modest company named Rheinische Metallwaren und Maschinenfabrik A. G., which began making bullets in 1889. Early in the history of the company it began to be spoken of as "Rheinmetall." At the outbreak of World War I, Rheinmetall was second only to the firm of Friedrich Krupp A. G. in the manufacture of German munitions.

After Germany lost World War I, Rheinmetall was placed under the control of the occupying forces through a group called the Inter-Allied Control Commission, which governed the manufacture of all arms producing plants in Germany.

Curtailment Following World War I

The commission laid down the activities that were permitted in the field of armaments. The curtailment imposed caused a lean time for the firm even though it turned to the manufacture of agricultural machinery. Some of the personnel went to Switzerland to firms such as Oerlikon and Solothurn.

In 1929, Rheinmetall established a subsidiary company in neutral Holland under the name of Hollandische Industrie and Handels Mattschaps (HIH). This venture turned out to be unsatisfactory; however, in the same year the firm acquired ownership of the Waffenfabrik Solothurn A. G. in Solothurn, Switzerland. This venture was the second attempt to activate Rheinmetall in a neutral country.

The Solothurn plant was originally developed for watchmaking, but the German owners obviously had other ideas. As soon as the company's presence was accepted by Switzerland, financial support was forthcoming from Germany, by loans and by the purchase of shares in the company. In the early 1930's, this support had become so unwieldy that the Reichskredit Bank was formed to administer the aid to industry. In addition, money was continuously forthcoming from the Reich Luftfahrt Bank.

Design Procedure

Among the engineers in the newly acquired factory were some of Germany's most talented automatic cannon specialists.

The genius of Fritz Herlach and Theodor Rakula is shown in a unique approach to the design of weapons as well as in their own professional skill in developing actual working principles. Herlach's excellent work in designing automatic arms won him the presidency of the company; he succeeded the world-famous Heinrich Ehrhardt, designer of artillery and other types of military ordnance. Others occupying prominent places in the design and development branch were the internationally known Dr. Walter F. Grasse and Dr. Richard H. Braun.

The need for a design was originated by a military request or by the firm. The design of the new weapon to meet the need was developed through conferences of the gun and ammunition designers.

Once the design had been approved, it was first ascertained if normal methods were to be used or whether metal stampings would be employed in the manufacture of the receiver and other components.

The specification was reviewed, and tentative ideas were suggested for meeting the various requirements such as caliber, muzzle velocity, rate of fire, and weight of gun.

The ammunition branch was called in and asked to design the round. In consultation with the ballistics branch, the ammunition branch settled upon the length of the projectile, its weight, and the chamber pressure. The latter group were also responsible for the design of the cartridge case.


SCIENTIFIC AMERICAN

Proprietor of the Rheinische Metal Fabrik, with his immediate staff, at the gate of the plant

the American manufacturer to consider the situation and frame anti-dumping laws accordingly. In reviewing the German industrial field the following plants

Figure 25–1. The page from "Scientific American" reproduced here indicates the more than local interest in the Rheinmetall Co. early in the 1900's. Third from the left of the photograph is Heinrich Ehrhardt, the proprietor. In 1889, when the company started operations in Dusseldorf, Ehrhardt became its technical adviser and vice chairman of the board of directors.

At this stage, the gun designer could voice an objection, such as to the shape of the base of the case in an instance where it would not suit his various components. This procedure was allowed to continue for as much as three or four months; during this period, the gun designer had time to think out the design in its entirety and solve his side of the problem.

For the setting up of the various systems, designers with comprehensive experience were always sought for the prototype of basic design. Production experts were responsible for the best production procedure dependent upon available raw material and for suggesting ways to simplify a system so as to obtain the most plausible manufacture with the least effort.

The hardening and surface technicians had not only to harden the unit produced but also to discover the particular use of various materials or metals. Pattern-shop men produced various wooden mock-ups of different systems mounting, so that a first test could be made from these models for clearance, serviceability, and visual inspections for details that could have been overlooked in the drafting stages.

Preliminary calculations were made to ascertain the time required for manufacture and to work out the quantity and quality of materials available for mass production. By these methods the time required was reduced to a minimum from the day of development to the day of mass production.

It was, of course, important that the finished experimental unit should resemble in every respect the future mass produced article. It was on this account necessary that the experimental plant should have at its disposal first class machines by means of which various kinds of production could be realized. Rheinmetall was well equipped with physical, chemical, metallographical, and X-ray laboratories, and equipment for testing durability. Benches for hot and cold weather testing were at the disposal of the scientists. For aircraft armament testing, there was available a special aviation section at the Tarnewitz Proving Ground. The sections were assisted by expert engineers in examination of drawings, measurements, and material. Special engineers furnished the technical descriptions and servicing instructions.

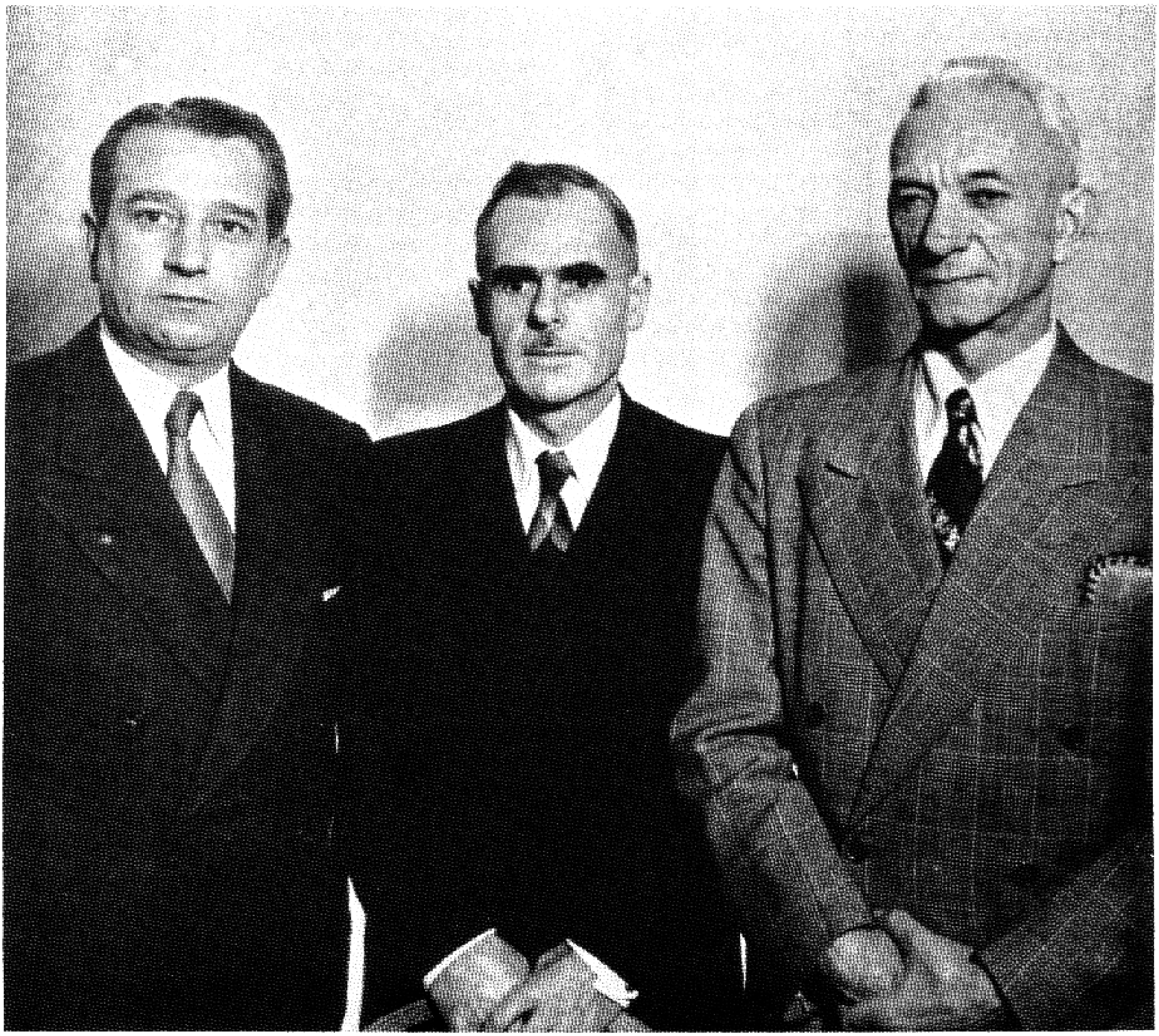

Figure 25–2. Dr. Walter F. Grasse, Dr. Richard H. Braun, and Mr. Theodor Rakula (from left to right). These men held positions of responsibility in the Rheinmetall-Borsig company during World War II, and deserve credit for the designs of much of the aircraft armament used by the Luftwaffe.

The experience obtained from the experimental laboratories and field tests were made known at certain times so that they could be applied to other developments. The originators of the prototype, who were known in the department as creative designers, were sometimes engineers and sometimes not. In most instances, they were men with considerable background in weapon design or firing.

A special department was established by the company in which designers continuously scrutinized foreign patents and foreign mechanisms; by this method, the management had a general survey of the degree of efficiency not only of their own designs but of any potential enemies.

As soon as a complete prototype was ready, range trials were arranged. Usually mass production was anticipated within 3 to 4 years. Questions of fitting of components in air frames or engines were handled at the levels that dealt with construction of fighter aircraft; decisions were in turn relayed direct to the manufacturers of the various components as well as of the plane itself. Liaison for questions dealing with the weapon's construction and installation in aircraft was established among the various design and production departments.

In order to aid the factory in shortening the time to get into full production, an arrangement existed whereby the design section detached a certain number of its personnel to work at the factory in a supervisory capacity during the early stages of production planning and production.

In the 20 years between World War I and World War II, specialists in various fields had been developed through the design procedure just described. These men felt that it was only through the close cooperation of design, science, and production that the highest performance could be expected. The field of automatic cannon placed the highest demands on material and was recognized as one of the most difficult fields of weapon development.

Expansion Preceding World War II

By 1935, the Rheinmetall firm was again expanding its activities. Negotiations had been started with the bankrupt Borsig works, which had a well-equipped heavy steel fabrication plant at Tegal, a suburb of Berlin. In January 1936, the two firms were merged and Rheinmetall-Borsig A. G. came into existence.

The Rheinmetall plant at Unterlüs was enlarged from a group of ranges to include a fairly large machine shop for developing machine guns, a filling factory for loading, a number of laboratories, and auxiliary buildings for administration.

About 1937, a research group was set up. Later on, as a direct result of World War II, the headquarters of the development organization was evacuated to Unterlüs and the moving of various kinds of equipment and documents from other sections followed.

The workers at Rheinmetall-Borsig had a slogan to which much of their superior work was attributable: "We do not know that this will not work; let us try it," rather than the stultifying converse, "We do not think this will work; we will not try it." Examples of this attitude, among many, are the Munchausen 56-centimeter recoilless gun, made on the Davis principle and designed to be carried on aircraft, and the work on bent barrels designed to shoot around corners. The quality of the workmanship on weapons is what mattered the most, and at no time during World War II did the organization allow quality to become debased by wartime conditions. On the other hand, no effort was wasted in applying an unnecessary degree of finish in places where it did not matter.

The firm was willing to expend considerable sums of money for power machinery, tools and fixtures, especially press tools for making the prototype. The idea behind this plan was that the effectiveness of the design could not be determined unless the prototype was carefully constructed with suitable tools. If the weapon should be acceptable, these tools would be of use for the initial production. If the weapon was not acceptable and there was no further use for the tools, the firm was prepared to write off their cost as a necessary development expenditure.

The development of all types of automatic cannon intended for installation in aircraft was undertaken from the point of view of the effectiveness of the weapon against its intended target. It was recognized that the most effective result could be obtained by the detonation of a high-explosive charge inside the enemy plane. With this requirement, it was also recognized that the employment of thin case projectiles holding a maximum of explosive would be the most suitable for use in firing from air to air.

The quantity of high explosive required for effective destruction depended upon the area of surface to be destroyed. In the earliest period of development, a quantity of 75 grams of explosive was considered to be quite sufficient. This quantity could be housed in a projectile having a minimum diameter of 3 centimeters. This knowledge was soon confirmed by experience gained in combat, and the poor effect of 20-mm ammunition upon 4-engine bombers was proved at the same time. The 3-centimeter high explosive projectile weighing 330 grams and holding 72 grams of high explosive was considered the optimum caliber. In order to put an opponent out of combat, it was estimated that 1 hit against a fighter plane and 4 hits against a 4-engine bomber could be reckoned upon as sufficient. The 3-centimeter high-explosive shell was accordingly designed for two weapons that were under construction, namely the MK–103 and the MK–108.

The Rheinmetall engineers came to the conclusion that the gunner's aim was influenced by the instability of the plane in relation to the horizontal and vertical axes, making accurate pinpoint fire next to impossible. The rigid firing method gave a raking fire. In this form, it was not dependent on ballistics but governed by the directional properties of the plane.

The effectiveness of raking fire becomes greater the denser the cone of fire; in other words, with a higher firing rate and a larger number of guns, combat action with rigidly armed fighters against bombers remained limited to medium distances of approximately 3,300 feet. At longer distances, the dispersion became so large that a sufficiently high density of fire could not be obtained, at least not with the gun weights of existing weapons. With these facts in mind, the Rheinmetall experts designed the MK–108. Its origin dates back to the Becker automatic cannon of World War I; however, it was revived in 1941 and put into production in 1944. The slowness in getting into production is accounted for not by inability to start production but by the fact that the German Air Force suddenly realized that it was on the defensive. To combat the heavy bombing raids that were then being carried out by both British and American forces, the automatic cannon offered by Rheinmetall was designed for one purpose only—air-to-air combat against big bombers.

Designation System for Weapons

When World War II began, so much automatic cannon development work was under way in Germany by different plants that the designations given to prototype and already adopted weapons became highly confusing. By the end of 1942, a system was instituted of identifying each of the four plants which were handling 90 percent of all experimental and development work. Rheinmetall-Borsig was allotted the number 1; Mauser, 2; Kreighoff, 3; and Krupp, 4.

To identify a weapon, a three digit number was assigned, the first digit representing the plant that developed it, and the last two standing for the order or sequence in which it was developed. As several firms were given the same problem in design, the company credited with the solution had its number assigned to the project. This number was carried all the way through to adoption. For instance, if Rheinmetall developed a prototype for the thirteenth type of weapon specified by the military authorities, the official designation of the finished product would be MK–113. If Mauser were first to succeed in this development, the nomenclature would be MK–213.

Unterlüs Plant

At the end of World War II, the Rheinmetall-Borsig organization at Unterlüs comprised a large range area with seven main firing points and the factory area, which included work shops, laboratory, and other buildings. The organization was one of the leading firms in research, design, and development of weapons for modern warfare in Germany. Many weapons were under development and in manufacture; among them were the models identified in the following paragraphs and described in later sections of this chapter.

Aircraft Machine Gun 13-mm MG–131

In 1938, when Germany was on the threshold of war, the 13-mm MG–131 made its debut. The gun was developed by the Rheinmetall-Borsig firm as a result of a directive from Herman Goering to produce a weapon to fill the need of the German Air Force for a high-speed light machine gun chambered for a caliber larger than the standard rifle cartridge. (See volume I, pp. 457–460.)

Automatic Aircraft Cannon 30-mm MK–101

This weapon was made by the Rheinmetall-Borsig firm about 1942. It was the first weapon to be designed under the new system of designation devised to identify each of four plants developing automatic cannon for Germany. The weapon was used by the German Luftwaffe, mostly on the Russian front, in the Heinkel 129, a heavily armored plane especially designed for ground attack. The weapon was also used for tank-destroying purposes. (See volume I, pp. 555–556.)

Automatic Aircraft Cannon 30-mm MK–103

The 30-mm MK–103 was designed to meet a need of the German Air Force for a gun effective against tanks and heavily armored vehicles. Although some work had been done on the design of such a weapon as early as 1940, it was the Russian front reverses that pointed out to the German high command the need for development of a higher rate of fire and higher velocity 30-mm aircraft cannon. This requirement eliminated some of the successful but lower velocity and slower firing 30-mm cannon already in operation. Production of the 30-mm MK–103 was begun early in 1943. Although it was reasonably satisfactory as a gun, the MK–103 was not used extensively in airplanes. Operational tactics had been altered to meet the attacks of the Allied heavy bombers, and fighter aircraft were required to attack at short range inside the defending fighter screen. This use required a lighter gun with a lower pressure, higher capacity, high explosive shell, and higher rate of fire. The answer to this need was the MK–108, and the MK–103 was relegated to antiaircraft use on the ground.

365-mm Recoilless Cannon G–104

This weapon was designed on order from the German Air Ministry for a recoilless gun similar to the MK–113 but capable of firing a 1,400-pound projectile from an airplane. Three guns in all were to have been built, but only one was completed and partially tested before the order for the weapon was withdrawn.

Automatic Aircraft Cannon 30-mm MK–108

Design work on the MK–108 was commenced in August 1941, but the gun was not given a high priority in production until 1944 when the German high command realized that they were on the defensive. The MK–108 was designed for one purpose only, air-to-air combat against big bombers. One direct hit from its unusually large projectile was expected to bring down any plane.

Aircraft Cannon 5.5-cm MK–112

As a result of the satisfactory performance of the 30-mm MK–108, a larger caliber weapon of the same type was requested by the German Air Force. The new gun was to be constructed of plain carbon steel, and sheet metal used wherever possible to facilitate manufacture and lower the cost of production.

The engineers of the Rheinmetall-Borsig firm decided that it was feasible to manufacture the weapon with available material, and undertook the work.

SECTION 2. 30-MM MK–101

Description and Principles of Operation

The MK–101 is a 30-mm automatic aircraft gun, scaled up from the 20-mm semiautomatic antitank gun designated MK S 18 1000. (See volume 1, pp. 554–556.) The MK–101 has a very long chamber and an extremely high velocity cartridge for this type of gun.

The barrel, which is fitted with a muzzle brake, recoils and counterrecoils within the recuperator housing. A stepped piston is rigidly attached over the front guide surface of the barrel. When the barrel recoils, the piston moves within the piston sleeve, which is fitted in the front end of the recuperator housing. Both ends of the stepped piston are fitted with piston rings. The front end of the piston slides inside the piston cylinder, while the rear end slides inside the recuperator housing.

In the recuperator housing, in the top of its front end, is an air inlet for admitting air between the rear end of the piston sleeve and the step in the piston. Air admitted here forces the barrel rearward during charging.

Between the rear end of the step piston and the shoulder inside the recuperating housing are the recuperating springs and the buffer spring, which are compressed by recoil of the barrel. The recuperator housing is assembled to the front end of the main housing by means of interrupted threads on the outside of the cam sleeve, which is rigidly attached to the rear end of the recuperator housing by wedges.

Inside the cam sleeve is a locking sleeve with rollers which ride in cam slots in the cam sleeve. The locking sleeve has interrupted threads in the front end for receiving the barrel and in the rear end for receiving the bolt. A coupling sleeve fits over the rear end of the locking sleeve and is held by interrupted threads after completing 60° of rotation. The barrel is held by the interrupted threads in the front end of the locking sleeve and is prevented from rotating during firing of the barrel lock, which rides in a groove in the barrel during recoil.

When the barrel is forced rearward either by compressed air acting on the stepped piston or by recoil, the cam slots in the cam sleeve—acting on the rollers attached to the locking sleeve—cause the locking sleeve to rotate and disengage the interrupted threads on the bolthead from those in the locking sleeve.

The rotation of the locking sleeve is insufficient to disengage the interrupted threads on the barrel in the coupling sleeve from their mating threads on the locking sleeve. The coupling sleeve is prevented from rotating during recoil by a lug extending from the rear of the sleeve at the right side. This lug carries the coupling slide, which is actuated by the spring loaded coupling lever.

The lever is spring loaded in such a way that the coupling slide is normally being forced outward; thus, when the gun recoils, the coupling slide is forced behind the catch plate (which is mounted in the extractor plate on the right side of the receiver) and holds the barrel in recoil position. Forward thrust of the coupling slide against the catch plate is absorbed by ring springs.

When the bolt moves forward into the locking sleeve and against the face of the chamber, a cam surface on the right side of the bolt engages the rear end of the coupling lever and cams the coupling slide out of engagement with the catch plate.

The barrel locking sleeve and coupling sleeve move forward under the force of the recuperator spring, and the bolt moves forward with them under the force of the driving spring. As the bolt and barrel move forward together, the rollers on the locking sleeve follow the cam slots in the cam sleeve and rotate the locking sleeve. This action locks the bolt in firing position.

The bolthead is flat on the top and bottom and is provided with locking lugs on both sides, which engage mating lugs or interrupted threads in the locking sleeve. A spring-loaded extractor is located in the under side of the bolt, and the spring-loaded rammer is located in the top of the bolt.

The firing pin is cocked against the spring by a cocking lever, which is actuated by contact with the cam in the left side of the receiver. The firing pin is held in the cocked position by a sear, which is actuated by a spring-loaded lever.

Pressure on the firing plunger located in the left side of the receiver actuates the sear lever against the spring and disengages the sear from the grooves

General Data: 30-mm Automatic Aircraft Cannon MK–101

Gun length: 116 inches.	Barrel length: 53.1 inches.
Gun weight: 396.9 pounds.	Barrel weight: 88.2 pounds.
Rate of fire: 260 rounds/minute.	Rate control: None.
Muzzle velocity: 2,734 feet/second.	Barrel removal: Quick disconnect.
System of operation: Reciprocating (short recoil).	Bore:
System of locking: Locking ring.	Number of grooves: 16.
System of feeding: Magazine, 6 rounds; drum, 30 rounds.	Groove depth: 0.0177 inch.
Method of headspace: Factory established.	Groove width: 0.205 inch.
Location of feed opening: Top of receiver.	Pitch: 8° 30′.
Location ejection opening: Bottom of receiver.	Direction of twist: Right hand.
Method of charging: Electropneumatic.	Form of twist: Constant.
Method of cooling: Air.	Muzzle energy: 49.2 foot-tons.

in the firing pin. This action allows the firing pin to move forward.

A firing safety lock can be positioned to prevent depressing the firing plunger. The bolt moves on guideways in the receiver. It recoils with the barrel until unlocking occurs, then it is thrown back by the accelerator.

The accelerator, located in the bottom of the receiver, is rotated to the rear about its pivot pin by recoil of the coupling sleeve against it. When the accelerator rotates rearward, it compresses a return spring which returns the accelerator to its forward position after the barrel moves forward.

In a tubular housing in the bottom of the receiver is a bolt drive spring. The rear end of the spring bears against the receiver backplate; the front end enters a sleeve. The top of this sleeve is recessed to engage a lug on the bottom of the bolt. When the bolt recoils, it forces the sleeve rearward and compresses the drive spring.

The guide rod extends from the backplate into the spring. In the receiver backplate is a ring spring buffer which is struck by the bolt during recoil.

Magazines. Two removable magazines are provided for the weapon. One is the flat type; the other is a drum. In both magazines, the ammunition is fed by spring pressure. The magazine is held in the magazine holder by a pin at the front and by a spring-loaded latch at the rear. In the rear end of the magazine holder, the spring-loaded bolt sear which extends through the top of the receiver engages an abutment in the top of the bolt when the bolt is in the cocked position.

The pressing lever lifts the sear out of engagement with the bolt. The lever is held in the depressed position by a spring-loaded latch as long as ammunition is in the magazine. When the last round leaves the magazine, the ammunition feeder in the magazine strikes the latch, disengaging it from the sear lever and allowing the sear to drop into position to engage the bolt. Thus the bolt is held in the cocked position after the last round is fired from the magazine.

In the top of the receiver and on the rear end of the magazine holder, is a spring-loaded ejector. When the bolt recoils with the empty case held against the bolt face, the base of the case strikes the end of the ejector, is pivoted downward over the extractor, and is ejected through the ejector opening in the bottom of the receiver. This opening is uncovered by the bolt drive spring during recoil when the spring is compressed by the bolt.

Bolt Charger. The bolt can be charged manually or pneumatically by the charger, which is located on the bottom of the recuperator housing. The charger consists of a pneumatic cylinder, a piston, and a piston rod which has racked teeth cut on the bottom.

A retractable, hand-cocking pin engages the teeth on the piston rod. The piston rod extends through the rear end of the cylinder and contacts the sleeve which connects the bolt and driving spring. Cranking the cocked pinion shaft runs the piston rod rearward and cocks the bolt.

When cocking is accomplished pneumatically, air is admitted through an air line in the cylinder head, and the piston and rod are forced rearward to cock the bolt. The piston and rod are returned to their forward position by the bolt when the bolt is released. Release of the bolt is caused by the sear being disengaged.

The charging piston and rod are held in their forward position by a locking piston and plunger which engages a recess in the charging piston rod. The locking piston is located in the hand cocking pinion housing and is disengaged by air pressure when charging is accomplished pneumatically.

When the bolt is cocked manually, the hand-cocking pinion forces the locking piston out of engagement with the charger piston rod as the pinion is manually pressed into engagement with the rack teeth on the piston rod.

Firing System. On the left side of the gun near the firing plunger there is a firing solenoid. When the solenoid is energized, it actuates a lever which strikes the firing plunger, causing the gun to fire. Firing continues automatically as long as the solenoid is energized. Firing is interrupted by opening the solenoid circuit, which leaves the bolt forward with a round in the chamber. The firing circuit is arranged to permit single automatic fire.

Cocking. Air from an air cylinder is admitted to the charging mechanism through an electric solenoid valve. The compressed air which flows through the elbow connector into the pinion housing forces the charging locking piston against the spring to the right until the plunger in the locking piston disengages the recess in the charging rack.

The compressed air flows through the air lines against the charging piston of the compressed air cylinder and forces it and the rack to the rear. The rack, whose end is pressed against the sleeve, forces the bolt mechanism, which is coupled with the sleeve, back until the bolt sear engages the bolt mechanism. Simultaneously, compressed air passes through a compressed-air line attached to the line fitting of the recuperator housing into the space between the piston sleeve and step piston of the recuperator.

Pressure exerted by the air against the piston forces the gun barrel to the rear against the recuperator spring and the buffer spring to a point where the coupling slide of the coupling sleeve is engaged by the catch plate of the striking plate. After the contact button of the charger has been released, the air imprisoned in its cylinder escapes through the release opening in the piston housing. After the bolt sear is released by pressure on the release lever, the bolt moves forward and brings the cocking rack forward again.

Under the effect of the driving spring, the plunger of the charging rack locking piston engages the depression in the charging rack and locks it forward. In order to cock the weapon by hand, the cocking crank is placed on the hand-cocking pinion shaft and the hand cocking pinion is pressed in toward the right with the cocking crank. The teeth of the hand-cocking pinion engage those of the charging rack, and the catch on the hand-cocking pinion forces the rack-locking piston against its spring until the piston plunger is disengaged from the charging rack.

When the cocking pinion is rotated, the rack moves back and pushes the sleeve back until the bolt, which is coupled to the sleeve, is engaged by the sear. Simultaneously, the barrel, which is locked with the bolt by means of the locking sleeve, is forced back with the coupling sleeve by mechanical means until the coupling slide engages its mating part in the striking plate. The recuperator spring and the buffer spring are now compressed.

Release of the Bolt Mechanism. The bolt mechanism, which has been brought back into its cocked position by means of the rack in the compressed air cylinder, is released after a loaded magazine has been inserted. The bolt moves forward under the pressure exerted by the driving spring, feeding the cartridge into the chamber of the barrel.

Chambering of the Round and Locking of the Bolt. As the bolt moves forward, a cartridge which projects into the path of the bolt mechanism is struck by the rammer, stripped from the magazine, and rammed into the chamber. The claw of the extractor engages the rim of the cartridge.

Shortly before the bolt mechanism strikes the locking jacket, the coupling lever is lifted by a cam surface of the bolt. The coupling lever disengages a coupling slide from the catch plate and the striking plate.

The coupling jacket is released, and the compressed recuperator spring and buffer spring bring the barrel, the locking jacket, and the coupling jacket forward together. The rollers of the locking jacket, which follow the cam grooves in the cam sleeve, rotate the locking sleeve, causing the interrupted threads in the locking sleeve to engage those of the bolt, the barrel, and the locking jacket. The coupling jacket and the bolt mechanism move to their most forward position. The weapon is now loaded and ready for firing.

Firing. Firing is accomplished by depressing the firing button, which energizes the electric solenoid. The lever of the solenoid presses against the trigger plunger, which moves the firing lever against its spring. The firing lever moves the firing pin sear out of engagement with the groove of the firing pin.

Under the action of the cocked firing-pin spring, the firing pin moves forward and strikes the primer, exploding the powder charge.

Unlocking, Recoil of Bolt Mechanism, Ejection of Cartridge Case. The barrel and the bolt mechanism are firmly locked together until after the projectile has cleared the muzzle. The barrel, the locking jacket, the coupling jacket, and the bolt mechanism, all rigidly locked together, recoil approximately 32-mm.

In the meantime, the cocking lever of the bolt mechanism strikes the cocking cam, causing the firing pin to be retracted by means of a lever. This lug engages a slot in the body of the firing pin until the sear is placed under spring pressure. The sear then engages the groove in the firing pin, holding it to the rear. In the course of further recoil in the barrel, the locking sleeve, whose rollers are guided in the cam slots to the cam sleeve, is now rotated. This action unlocks the bolt from the locking sleeve.

After unlocking, the bolt mechanism is accelerated rearward by the accelerator lever, which is motivated by the coupling sleeve. The accelerator lever is returned to its forward position by its return spring.

During recoil of the barrel, which amounts to a maximum of 150 mm, the recuperator spring and the buffer springs are compressed. These springs absorb the excess recoil force. Both springs move the barrel, the locking sleeve, and the coupling sleeve forward.

After a short counterrecoil, the coupling slide, which is pressed outward by spring force of the coupling lever, is engaged by the catch plate in the striker plate. The barrel, the locking sleeve, and the coupling sleeve are held stationary while the recuperator spring is still somewhat compressed. The impact of the coupling slide on the catch plate is absorbed by the friction ring spring in the striker plate.

While the barrel is still in counterrecoil, the bolt mechanism moves farther back with the cartridge case, which has been caught by the extractor. The ejector strikes the face of the cartridge case, tips the cartridge case about the extractor, and throws it out below. During recoil, the bolt compresses the drive spring and strikes the bolt buffer.

Counterrecoil Movement. After the bolt mechanism strikes the bolt buffer, the bolt moves in counterrecoil under force of the driving spring and puts the bolt in reverse motion. After the magazine has been emptied, the bolt is automatically engaged by the bolt sear. At the same time, a device in the magazine presses the sear release lever latch out of engagement with the sear release lever, allowing the lever to move into the path of the bolt and stopping it on counterrecoil. The bolt is held in its rearmost position. After a filled magazine has been inserted, the bolt is again released by pressure of the release lever and the weapon is ready for firing again. At this time, charging is not necessary.

Cycle of Operation

To fire the MK–101, a loaded drum is attached in its fastening latches on top of the receiver. Air from a cylinder is admitted to the charging mechanism through an electric solenoid valve. Compressed air enters the piston housing against the charging piston, forcing it back with the bolt assembly until it engages a rear-searing device. The release of air depresses the sear and allows the bolt assembly to be driven forward under the energy of the compressed driving springs.

The bolt face picks up a round from the mouth of the feed and chambers it, at the same time the rotating sleeve locks the piece in battery. Firing is accomplished by depressing the button that engages the solenoid; this action moves a lever that in turn disengages the front sear from the firing pin grooves. At this time, a heavy spring drives the firing pin into the primer to fire the chambered round. The barrel, bolt, and locking sleeve are all firmly joined while the projectile is traveling through the bore; they remain joined until an inch and a half of recoil takes place.

During the first movement rearward the cocking lever is pivoted, at first withdrawing the firing pin within the bolt face and then compressing the firing pin spring tightly until it is seared back fully cocked.

The locking sleeve, the roller of which is guided in the cam slots, is now rotated, unlocking the bolt. At this point, the accelerator speeds the bolt rearward. The barrel and locking sleeve are held in a retracted position while the bolt starts into recoil. At this instant, the empty cartridge case is held firmly against the bolt face by means of the extractor claws. The claws continue to grip the expended round until the ejector makes contact with the rim of the case and kicks it out through the ejection slot in the bottom of the receiver.

Further recoil compresses the driving spring, and the bolt hits the buffer. This action causes an opposite movement to begin. As the bolt moves forward, the first round in the magazine is started toward the chamber. At the same time, the extractor claw is cammed over the rim of the cartridge.

Shortly before the bolt strikes the locking ring, the coupling lever is lifted by an inclined ram on the bolt body. This action releases the retracted barrel and locking ring at the exact instant the bolt lugs are opposite their mating threads in the ring.

The rollers in the locking ring follow the camming grooves which rotate the sleeve, quickly locking the entire assembly. If the solenoid is still actuated, the firing lever moves the sear out of engagement with the button on the firing pin. The latter flies forward to fire the propellant charge in the cartridge.

SECTION 3. 30-MM MK–103

Description of the Weapon

The MK–103 is a 30-mm automatic aircraft cannon that is gas operated and air cooled. A steel cartridge belt feeds the weapon from the top. A metal disintegrating link is employed. The locking action is practically identical with that of the experimental American automatic cannon that never advanced beyond the limited-service use, namely, the Navy's 1.1.

The weapon was made in two different types. One is an engine-mounted gun with a shrunk-on inner liner, which is assembled from the rear; the other is a flexible gun with a monobloc barrel which is assembled from the front. With the exception of the barrel mounting, the two types are identical. The first weapons made were fitted with a magnetic trigger, and the latest type was equipped with an electropneumatic trigger. For the engine-mounted installation, a reinforced friction brake and barrel-recuperator spring were used because the engine-mounted gun was fired without the muzzle brake.

While the official rate of fire was between 420 and 450 rounds per minute, numerous attempts were made to increase the rate of fire of this weapon to 600 rounds per minute. However, all such attempts resulted in poor performance of several parts.

The weapon housing, feed, and several other parts were stamped out of sheet metal.

The barrel brake and barrel extension constitute the recoiling parts. The barrel extension is so constructed that it helps restrain the barrel during recoil. The feed mechanism is powered by means of the lug engaging the top of the barrel lock during recoil.

The breech bolt mechanism is unlocked by the gas-operated piston. Gas is admitted from a barrel port, which is located just to the rear of the shoulder. The gases are trapped in the space between the outer wall of the gun barrel and the inside of the forward portion of the receiver extension. A cylinder houses and guides the operating parts of the plunger assembly. The plunger thus is forced to strike the breech bolt slide, which is located on the bottom of the breech bolt assembly; the slide is forced rearward by gas pressure on the piston, causing the locks to move inward and to release the breech bolt.

The breech bolt assembly is now free to move rearward in full recoil. The rear end of the firing pin loses contact with the post on the slide as the bolt unlocks. This action restrains the current from reaching the primer until the breech bolt is locked.

The slide is provided with slots by which the charger lug on the left side and the driver spring lug on the right side are fastened to the breech bolt assembly. The driving spring and charger with the sear are assembled into the one unit at the bottom of the receiver. The charger lug is equipped with a

General Data: 30-mm Automatic Aircraft Cannon MK–103

Gun length: With muzzle brake: 91 inches. Without muzzle brake: 80 inches. Gun weight: 319.7 pounds. Rate of fire: 420 rounds/minute. Muzzle velocity: 2,822 feet/second. System of operation: Gas-operated reciprocating system. System of locking: Two swinging locks. System of feeding: Barrel-recoil-operated; metallic link belt. Method of headspace: Factory established. Location of feed opening: Top portion of receiver, either left- or right-hand side. Location of ejection opening: Bottom of receiver. Method of charging: Electropneumatic. Method of cooling: Air.	Barrel length: 52.3 inches. Barrel weight: 57.3 pounds. Rate of control: None. Barrel removal: Quick disconnect. Bore: Number of grooves: 16. Groove depth: 0.002 inch. Groove width: 0.146 inch. Pitch: 8° 30′. Direction of twist: Right hand. Form of twist: Constant. Muzzle energy: 45.5 foot-tons.

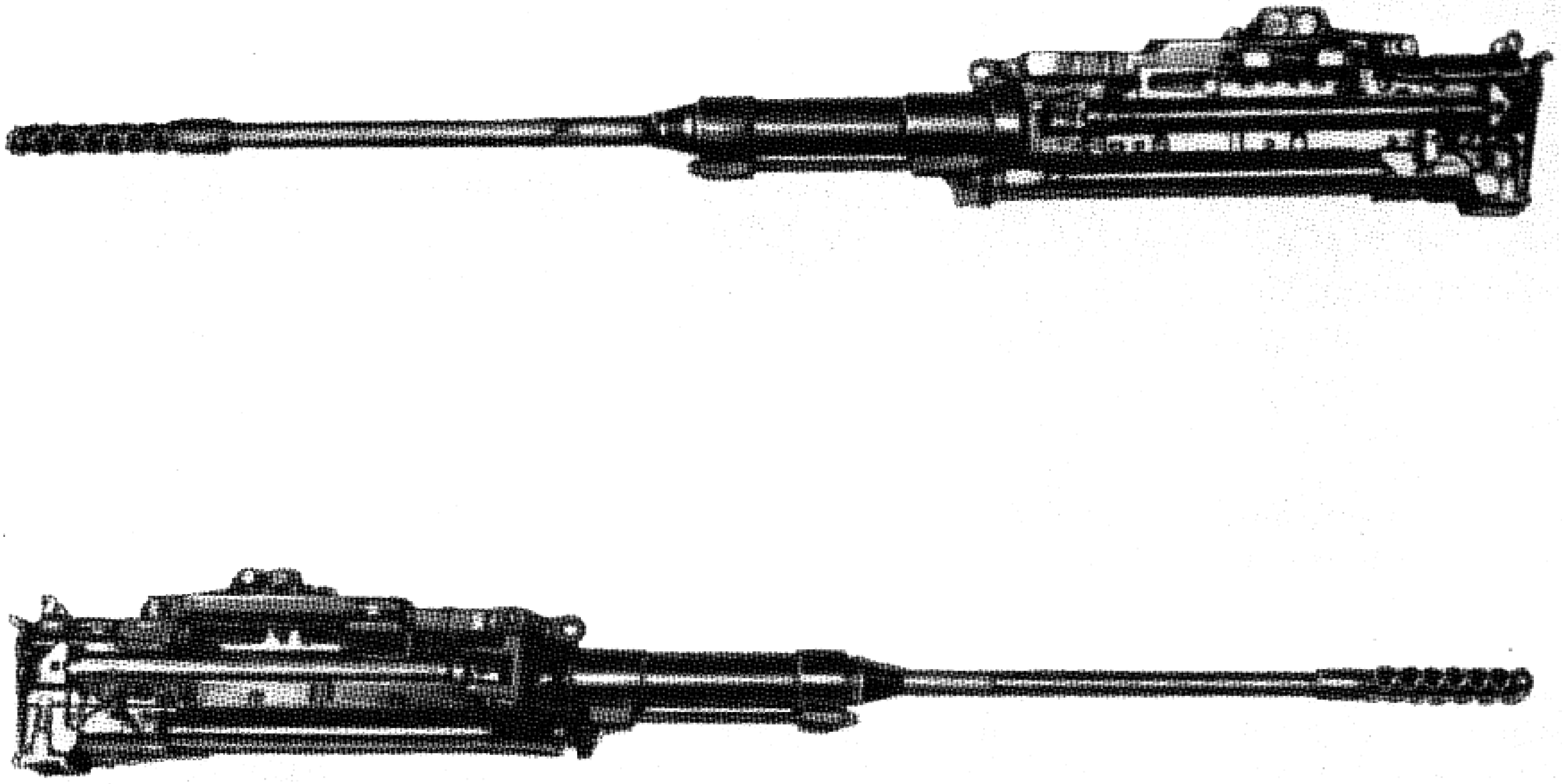

Figure 25–3. Automatic Aircraft Cannon 30-mm MK–103. Right- and left-side views.

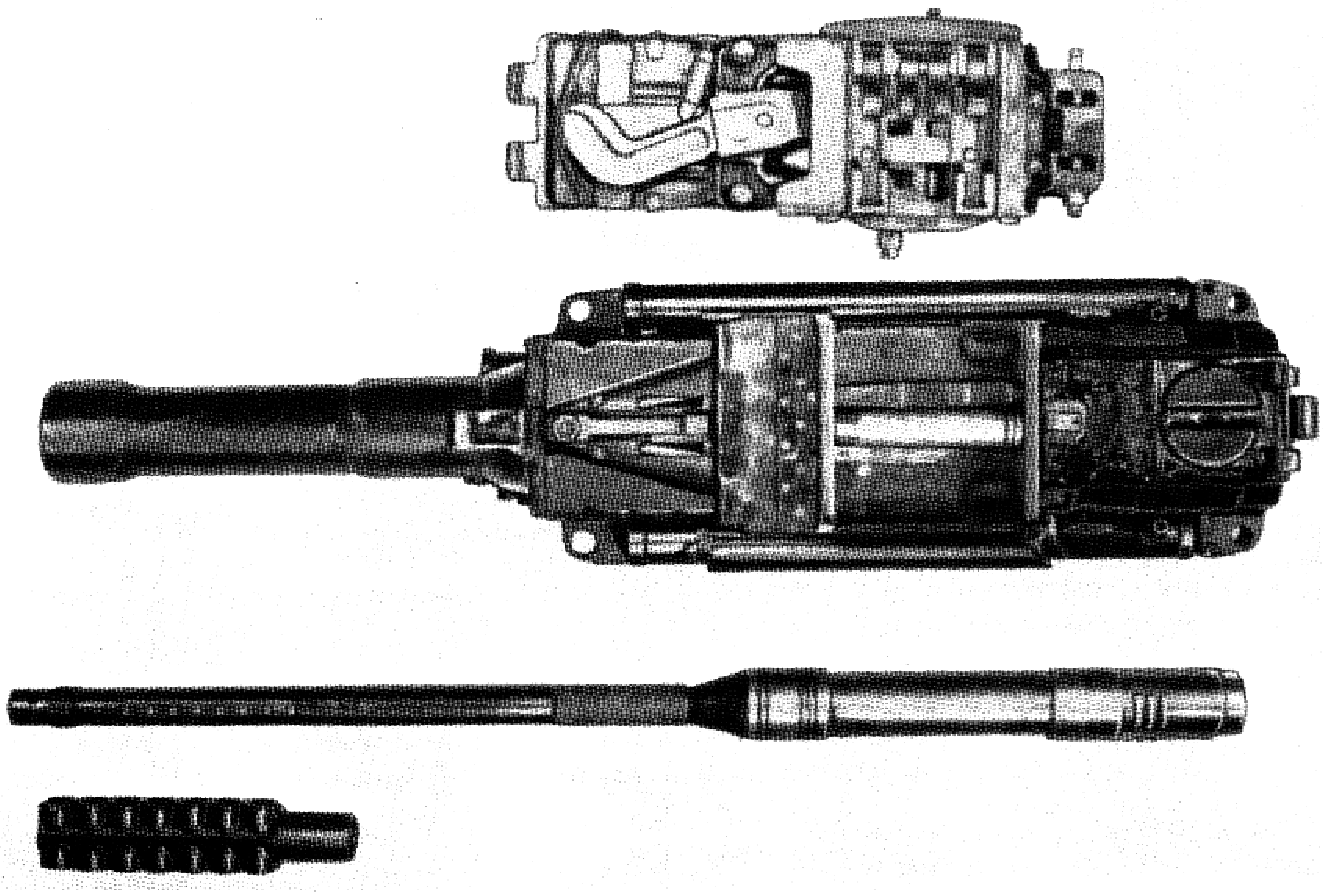

Figure 25–4. Automatic Aircraft Cannon 30-mm MK–103. Major assemblies.

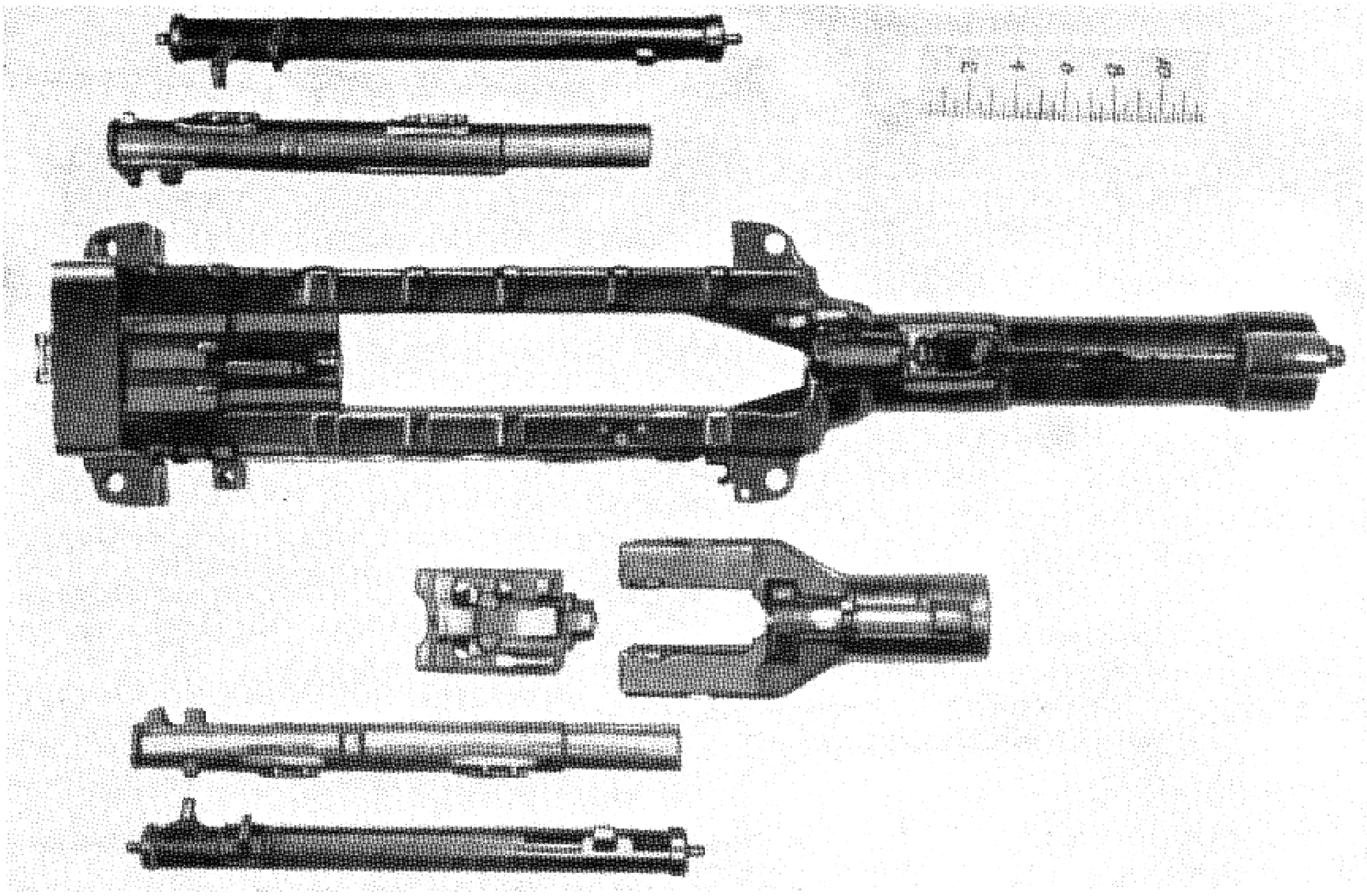

Figure 25–5. Breech mechanism of Automatic Aircraft Cannon 30-mm MK–103. Disassembled view.

spring latch, which must be released before the lug can engage the breech bolt. The rear end of the latch must be pushed inward for release.

The construction and location of these parts indicate that in the original installation a solenoid might have been utilized for the unlatching.

The sear consists of a blade arrangement which projects upward and rearward into the receiver.

The exterior electric connections are brought into the container mounted on the left side of the receiver. Two indicating circuits are included, one of which is completed when the breech bolt is seared, the other when the breech bolt is closed and locked. A third circuit provides the firing current.

Cycle of Operation

The operator places a loaded belt in the feedway with the first cartridge behind the belt holding pawl. Compressed air is released into the charging mechanism. The center feed pawls then index the incoming round.

The air entering the connection at the front of the driving spring and charging assembly drives the charging piston rearward. The charging piston has a lug which engages the slide of the breech bolt and drives the bolt assembly rearward, compressing the driving spring.

The sear engages the breech bolt assembly and holds it in the rearward position until the solenoid operating the pneumatic piston is energized and the sear is released. Upon release of the sear, the drive spring sends the bolt assembly forward. As the bolt is driven forward, the rammer, which projects up through the slot in the feed box, engages the rim of the positioned round and strips it from the link.

As the round is rammed forward, the nose is forced down toward the line of bore by a guide in the forward top of the feed box, while the rim is held from rotating up by the link in the roof of the feed box. The gradual widening of the slot in the bottom of the feed box assists in alining the round with the chamber.

258970°—54——42

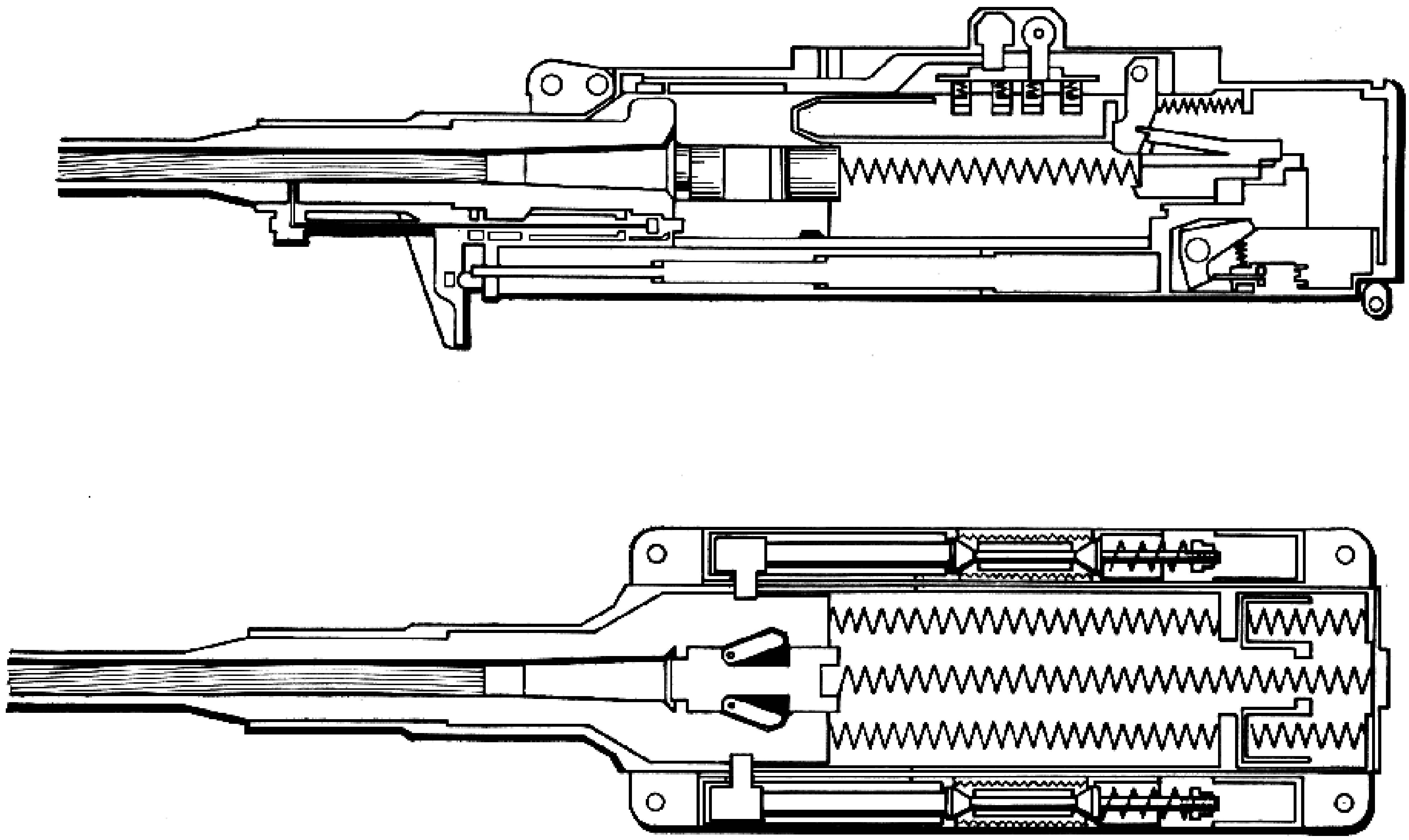

Figure 25–6. Automatic Aircraft Cannon 30-mm MK–103. Sectional view.

As the round enters the chamber, the claw extractor engages the rim of the case. The upper part of the bolt assembly is abruptly stopped as it strikes the face of the breech, while the slide continues in its path. This relative movement causes the locking plates, which are pivoted in the upper block, to be swung outward by the camming surfaces in the slide. The locking plates seat in two lock abutments in the tube extension. Further forward movement of the slide causes the electric contact to be made which fires the round.

On recoil of the tube extension, the feed cam roller engages the feed crank-cam, rotates the feed cam about its pivot, and compresses the feed cam return plunger spring. Upon rotation of the feed crank, the feed pawls are moved. They engage the cartridge links and place another round in position for stripping and ramming.

On counterrecoil, the feed crank is rotated to its original position by the feed cam roller, assisted by the feed return plunger spring. The spring-loaded feed pawls are depressed by the following round as the feed slide is drawn back to its original position. Two stop pawls prevent movement of the cartridge belt during return of the feed pawl slide.

After the projectile has passed the gas port, pressure is led to the gas cylinder assembly by the gas tube. The gas piston is forced rearward by the gas pressure and strikes the slide, driving it rearward. The movement of the slide cams the lock plates inward; the bolt assembly is driven rearward, assisted by the remaining pressure in the tube.

The claw extractor extracts the empty case from the chamber, and the bolt assembly carries it rearward. The projector at the rear of the feed box strikes the top of the case, and the cartridge is pivoted down and out of the receiver. The driving springs are compressed on recoil of the bolt assembly.

Continued recoil fully compresses the driving springs, and the movement ends with the bolt striking the buffer. The first phase of counterrecoil places the cartridge-holding pawl in the feeder over the next round. The rest of the forward travel is used to strip and chamber the new round and to lock the action into battery. The cycle is repeated if the electric circuit is still energized.

SECTION 4. 365-MM RECOILLESS CANNON G–104

Description of the Weapon

Design requirements for the G–104 (*Gerat–104* or *Device–104*), which were set up by the German Air Ministry, specified that it be a recoilless gun somewhat similar to the MK–113 but capable of firing a 1,400-pound projectile from an airplane. The principle of this recoilless system involves making the weight of the cartridge case equivalent to the projectile and discharging the heavy case from the rear of the gun.

The tube is rifled its entire length with a right-hand twist, and the projectile and cartridge case are preengraved. The effect of the gas exhaust is minimized by muzzle brakes which direct the gas sideways away from the aircraft parts.

General Data: 365-mm Recoilless Cannon G–104

Muzzle velocity:
- Projectile: 1,034 feet/second.
- Case: 1,050 feet/second.

Pressure: 1,700 to 2,000 p. s. i.
Recoil: 0.3937 inch.
Bore:
- Form of twist: Right hand.

The weapon was designed to be mounted beneath the aircraft and to be hydraulically lowered into the firing position.

Tube With Muzzle Brake and Reinforcements. The tube is rifled its entire length with a uniform, right-hand twist. The electric firing mechanism is located in the center of the tube on a reinforced area. Muzzle brakes are assembled on both ends of the tube and are so designed that the gases are guided and distributed as far as possible away from the aircraft.

Electric Firing System. The firing system consists of two main parts: The housing and the stop pin. The housing is assembled to the reinforcement on the tube and takes the gas pressure. The stop pin presses against the housing and has a spring which touches the contact rings through the current that flows to the primer. The stop pin holds the round in place by its position in the groove between the shell and the case.

Projectile. The projectile is a base-fused, armor-piercing shell with a soft iron preengraved rotating band. The rear of the base plate contains a contact ring in its circumference, through which the

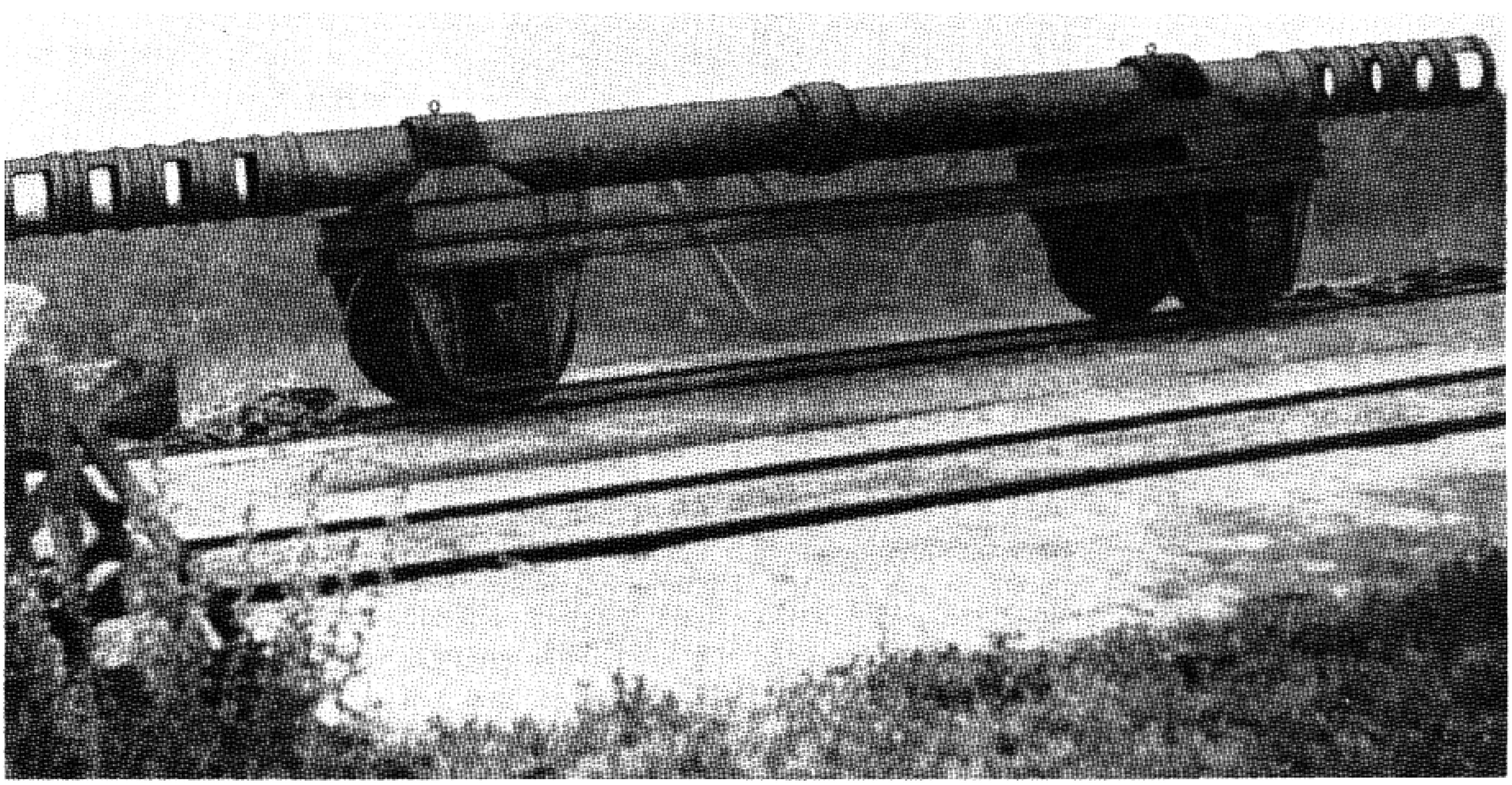

Figure 25–7. 365-mm Recoilless Cannon, G–104.

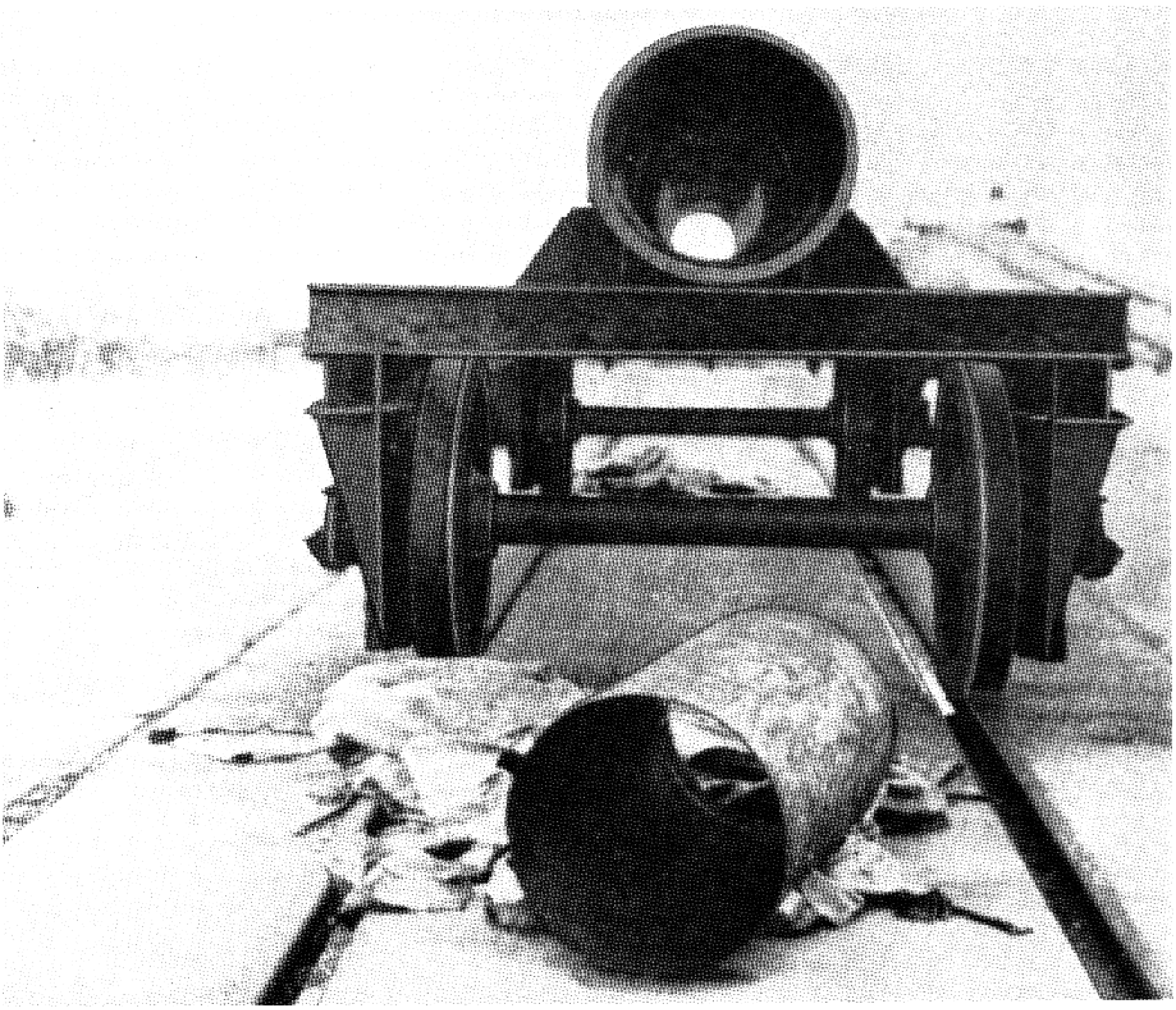

Figure 25–8. 365-mm Recoilless Cannon, G–104. View through bore.

ignition circuit is transmitted to the electric igniter located in the center of the base plate.

Cartridge Case and Propelling Charge. The cartridge case contains a propelling charge which is ignited by two igniter pads. At the front end of the cartridge case is a preengraved rotating band by means of which compensation can be made for variations in weight due to manufacturers' tolerances. This is done by replacing the balance plate at the rear of the cartridge case.

The shell and cartridge case are assembled and fired as a fixed round. They are held together by means of three shear pins in the cartridge case which catch in a groove in the shell and are held in place by means of screws. The complete round is held in a tube by the firing system.

Functional Tests

Tests were made to determine whether the weapon was recoilless. In these tests, the weapon was mounted on a moveable mounting. Forward and backward movement of about 10 mm was obtained. The results varied significantly. Upon mounting under an aircraft, slight damage to the aircraft occurred in the vicinity of the muzzle brake. The steering mechanism was also slightly damaged.

These defects were eliminated by strengthening the aircraft. The strengthening was not completed, as the order for the weapon was withdrawn by the Air Ministry. Only 15 rounds were fired altogether.

SECTION 5. 30-MM MK–108

Description of the Weapon

The MK–108 is blow-back operated, rear-seared, and belt fed. It uses electric ignition and is charged and triggered by compressed air. The most unusual feature of this weapon is the extremely short barrel with its resulting low muzzle velocity. The term "headspace" in its ordinary sense is not applicable to this gun.

American ordnancemen nicknamed the weapon "the paving buster" because of its appearance and its steady rate of slow fire, which sounds very much like the common pneumatic paving tool.

Another unusual feature of this efficient weapon is its construction. More than 80 percent of the parts are stampings; accordingly, the manufacture is both easy and cheap.

When installed in aircraft, no method of adjustment for harmonization was incorporated in the mount.

On the ME–109 plane, the gun is mounted on its side and fired through the hub of the propeller. Sixty rounds of ammunition can be fed by means of a metal disintegrating link belt from an ammunition can located directly above the gun. The system of operation employed in the MK–108 closely resembles the original Becker Oerlikon method. It has been brought up to date and uses a larger cartridge with a steel case.

The receiver is a metal stamping to which certain fixtures are joined by welding, for example, locking lugs for securing the backplate hinges to accommo-

General Data: 30-mm Automatic Aircraft Cannon MK–108

Gun length (overall): 45 inches.
Gun weight: 135 pounds.
Rate of fire: 450 rounds/minute (maximum).
Muzzle velocity:
  1,600 feet/second.
  1,640 feet/second.
System of operation: Blowback.
System of locking: Inertia.
System of feeding: Belt fed.
Method of headspace: Fixed.
Location of feed opening: Top side.
Location of ejection opening: Top side.
Method of charging: Air.
Method of cooling: Air.
Barrel length: 23 inches.
Barrel removal: Permanently fastened.
Bore:
  Direction of twist: Right hand.
Muzzle energy: 15.2 foot-tons.
Receiver:
  Length: 26½ inches.
  Width: 8 inches (approximate).
  Depth: 8 inches (approximate).

NOTE. This weapon can be fired only from the rear seared position, since it utilizes the forces of inertia for locking.

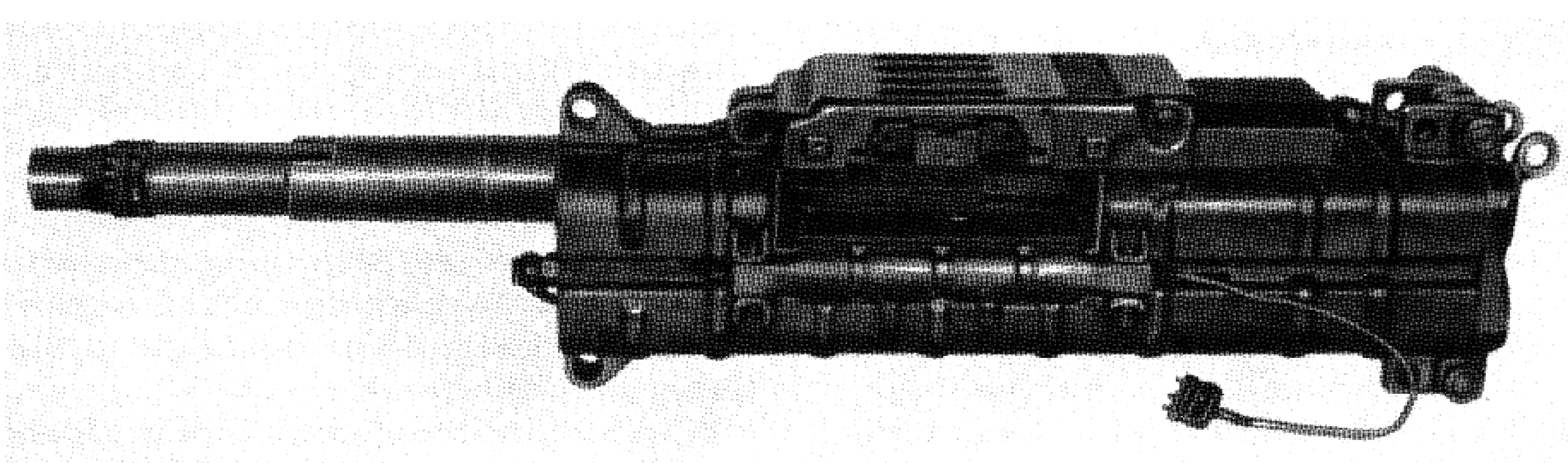

Figure 25–9. Automatic Aircraft Cannon 30-mm MK–108. Left side view.

date the sear housing, cover pin mounting lugs by which the cannon is bolted to the aircraft, and the guides for the ammunition of the feedway. Although the belt feed slides appear to have been forged, the feed mechanism is welded to a stamped cover. The bolt, sear mechanism, and backplate can be either forged or cast. The bolt and the charging cylinder seem to have considerable machine work on them and are well finished. However, the feed mechanism, the sear mechanism, and the backplate except for the bearing surfaces are roughly constructed.

The principal assemblies consist of the receiver, the cover which contains the entire feed mechanism, the sear assembly, an electrical firing device located on the left side of the receiver, the bolt assembly, driving spring assembly, a compressed air operating assembly built into the forward part of the receiver directly below the barrel, and the barrel proper.

The receiver is roughly 26½ inches in length and slightly over 8 inches in depth and width. The sides of the receiver are stamped so as to provide guides for the belt. Viewed from the rear, the receiver assumes a slightly oval shape.

The feedway is built into the receiver starting approximately 11 inches from the rear of the receiver. It is approximately 1¾ inches in depth and extends for nearly 8¼ inches. When viewed from the side, the receiver has a flat appearance.

Because the operational power is straight blowback and the system of feeding also requires slow movement, the weapon was expected to have a rate of fire of 600 rounds per minute maximum.

Its construction makes it adaptable for use in fuselage, wings, and engine. It has been experimentally mounted in a rotating mount.

The barrel is affixed to the receiver by threading and locked in place by means of a split pin driven vertically through a round opening in the top of the receiver so as to engage a locking groove in the barrel. The headspace on this weapon is fixed. The cover is attached to the receiver by means of a bolt nine-sixteenths of an inch in diameter and 3⅛ inches long, which is held in place by a spring. The cover is hinged just forward of the feedway in the center of the top of receiver, so that, when it is in a closed position, it supports the feed mechanism in its proper relation to the feedway.

The sear mechanism is affixed to the top of the receiver in a housing 1¾ inches to the rear of the feedway. The bolt is machined so as to fit the guides in the receiver, and it is bored through its entire length 3 times. The central and largest opening accommodates a charging cylinder, while the other small openings accommodate the driving spring assemblies. The top of the bolt is affixed to the housing which contains the firing electrode and the extractor. Two grooves milled into the top of the bolt operate the belt feed levers of the feed mechanism.

These groups or assemblies are easily removed from the receiver without the use of special tools. The only assemblies which present difficulties in assembly and disassembly are the driving springs; this difficulty is due to the pressure required to compress the springs upon their guides.

The cannon is initially charged by compressed air through the medium of a charging cylinder, or piston. The air is metered to the piston from a supply consisting of two interconnected air bottles. Initial charging simply forces the bolt to the rear of the receiver, compressing the driving springs. It is held to the rear by two dogs which extend downward through the top of the rear of the receiver from the sear mechanism. Alining of the round with the chamber is accomplished on the first few inches of forward motion of the bolt.

Ejection of the used cartridge case and link is also accomplished during the forward motion of the bolt. When the bolt reaches full battery position, electrical contact is made and the round is fired.

Since there is no breech-locking device other than the weight of the spring-loaded bolt, the recoil of the cartridge case forces the bolt to the rear. As long as air pressure is maintained in the sear mechanism the weapon will continue to fire automatically. The valves of the air metering system are apparently electrically operated by means of solenoids incorporated in the valve housing.

Cycle of Operation

To prepare the MK 108 for firing, the operator places a loaded belt of cartridges in the ammunition container and inserts the first round under the belt-holding pawl with the bolt forward.

When readying the weapon for combat, the pilot gunner pushes in on the charger button. The electric-powered solenoid opens an air valve on the charging device, and the belt is thrown rearward until it engages the sear and holds the assembly in a cocked position.

The valve now releases the air, permitting the charger to return home from its own spring tension. On this recoil stroke of the bolt, the belt feed lever, which is actuated by lugs riding in grooves in the bolt body, moves a cartridge over to the edge of the feed mouth. The gun is now cocked and the cartridge positioned for the next phase of operation.

When the sear is released, the heavy bolt starts home under compression of the driving spring. Its first forward movement causes the incoming round to be moved over the necessary distance to be indexed. The bolt face, which is narrower than the cartridge width, contacts the base of the cartridge, pushing it through the link into the chamber. Before final movement is halted by complete chambering, an electric contact is made that energizes the firing pin. This action detonates the electric primer, but the time delay is enough to allow the bolt to go still farther into battery.

Actual explosion of the propellant takes place while the bolt is still traveling at full speed forward, allowing the projectile to clear the bore of the weapon before the heavy bolt can begin counterrecoil movement.

The lubricated cartridge case is free to exert full blowback pressure on the face of the bolt, which starts recoiling immediately after the projectile clears. The cartridge case is supported by the extractor until the bolt face clears the rear end of the link. At this time, the dog rises to stop travel of the empty case, leaving it in its link. Continued movement of the bolt to the rear causes the feed arms to move the belt over halfway, shoving the empty case and link outside the receiver. This principle is known as two-stage feeding. The feed may be operated from left to right or vice versa by repositioning parts.

The bolt recoil is stopped by compression of the two strong driving springs, which then drives the assembly into counterrecoil to repeat the cycle if the solenoid remains actuated.

SECTION 6. 5.5-CM MK–112

Description of the Weapon

This gun was built at the suggestion of the German Air Force.

The new weapon was to have the following characteristics: Caliber, 5.5 cm; blowback operated having a muzzle velocity of 1,950 feet per second; total weight, not to exceed 600 pounds; overall length, 80 inches; muzzle energy, 97.5 foot-tons; rate of fire, a minimum of 300 rounds per minute. The projectile was to weigh 3.3 pounds, have an overall length of 8.8 inches, and contain an explosive charge of 14.8 ounces.

In the earlier stages of development and testing, a total of 10 weapons were fabricated for trial. Five more weapons were held back for improvement on the basis of test results. Seven of the completed weapons representing the original design, weighed 660 pounds, and three improved models weighed 605 pounds. Records indicate that reducing the weight was a critical problem because of the shortage of metals in Germany at that time.

In order to test individual parts for duration of functioning, extended firing tests were performed with the prototype design. One weapon was tested with approximately 1,300 rounds. The firing tests were made at a temperature range from 15° F. to 185° F. Smooth operation of the weapon was not

General Data: 5.5-cm Aircraft Cannon MK–112

Gun length (overall): 80 inches.
Gun weight:
- 600 pounds (maximum).
- 660 pounds (for original design).
- 605 pounds (for improved model).

Rate of fire: 300 rounds/minute.
Muzzle velocity: 1,950 feet/second.
System of operation: Blowback.
System of locking: Inertia.
System of feeding: Belt fed.
Method of headspace: Fixed.
Location of feed opening: Top side.
Location of ejection opening: Top side.
Method of charging: Air.
Method of cooling: Air.
Barrel removal: Permanently fastened.
Bore:
- Direction of twist: Right hand.

Muzzle energy: 97.5 foot-tons.

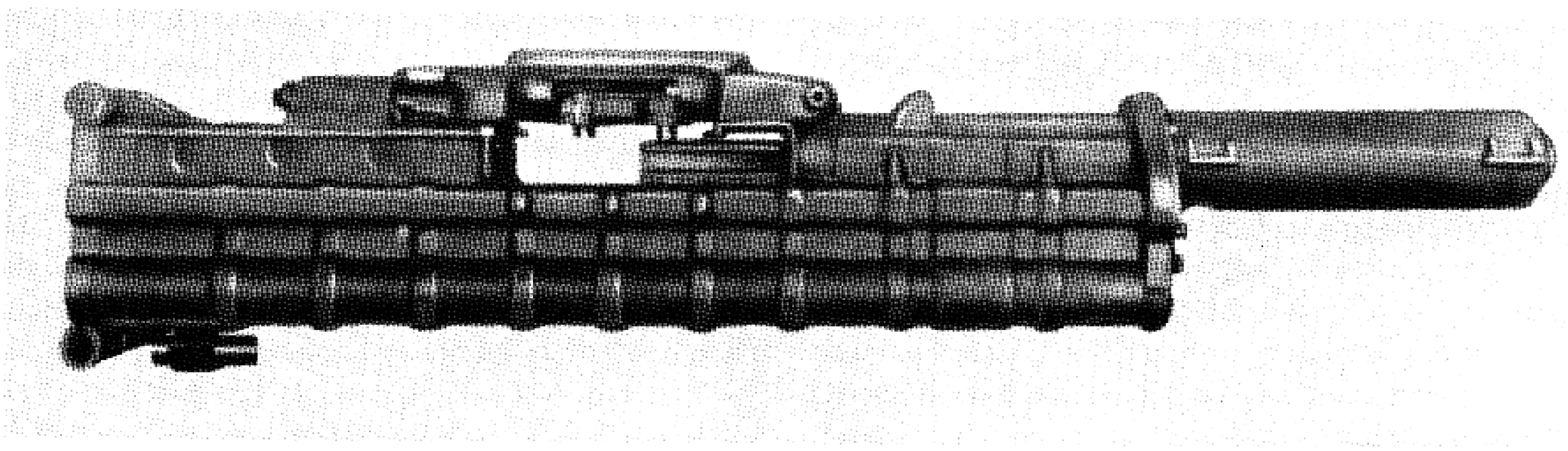

Figure 25–10. Aircraft Cannon 5.5-cm MK–112. Right side view.

achieved at high temperatures. The performance of the ammunition belt was not satisfactory in the early design. Further experimental tests were performed and the required firing rate of 300 rounds a minute was achieved. Also a belt lift of 2 meters was obtained. Bursts of fire to 20 rounds were fired in the initial firing.

Increasing the rate to 360 rounds per minute brought on further complications with the cartridge belt, hence the rate of fire was finally standardized at 300 rounds per minute.

Cold weather tests performed at —58° F. demonstrated the weakness of plain carbon steels, and it was necessary to redesign many of the parts for use in these low temperatures.

Difficulties with the electric ignition system and the connections between the firing lever and the ignition bolt were experienced in practically all early

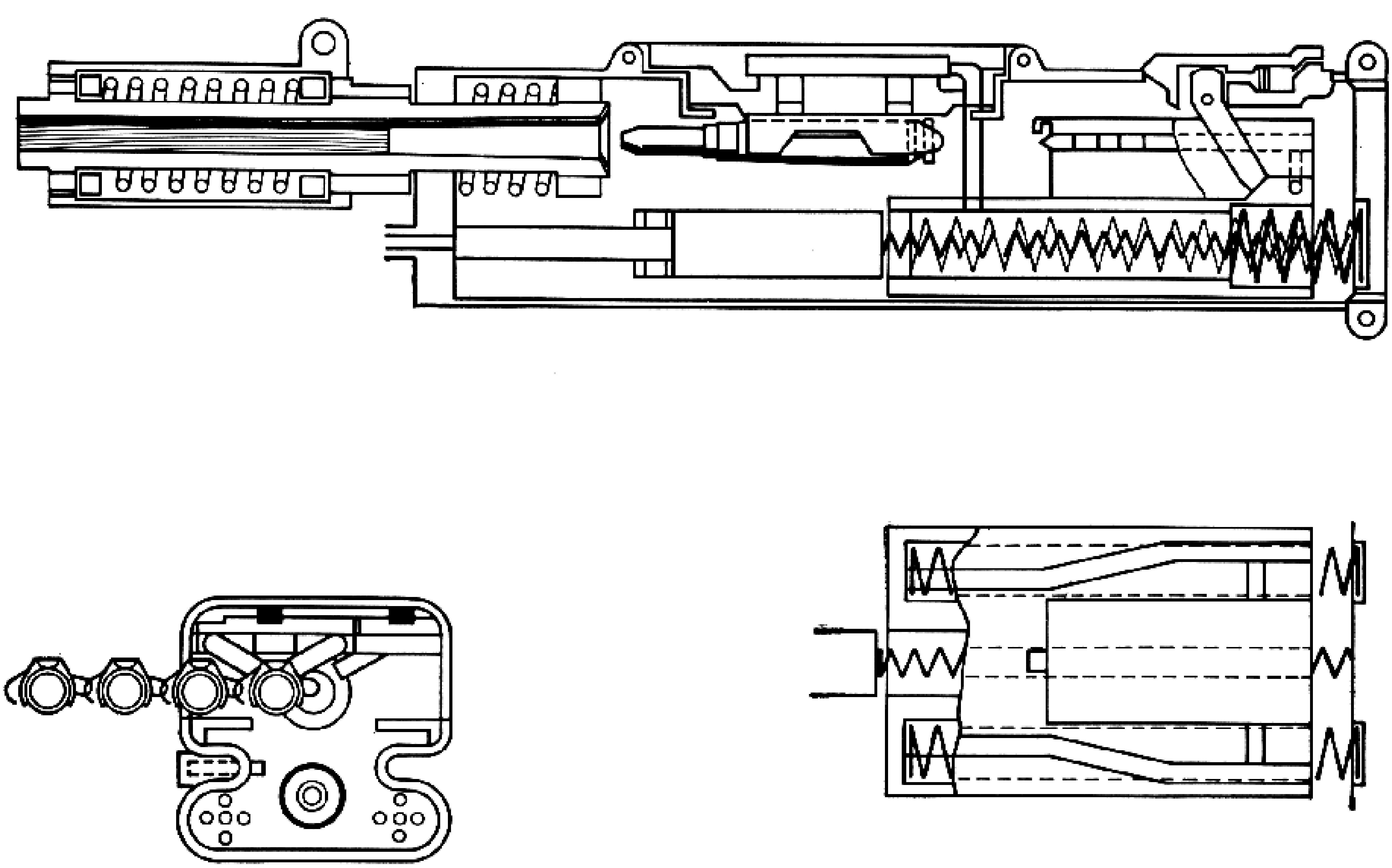

Figure 25–11. Aircraft Cannon 5.5-cm MK–112. Longitudinal and transverse sections.

firing. A hydraulic cocking mechanism was designed to replace the original pneumatic cocking mechanism.

Description of Principal Components

Tube, Electric Firing System, and Recoil Mechanism. In the forward part of the cradle is the tube, which is held in place with a set of buffer springs. A recoil mechanism, comprised of ring springs, is located around the front part of the tube, housed in a steel tubing and provided with a trunnion hole for installation in an aircraft mount.

Weapon Cradle. The cradle of the MK–112 is formed out of sheet metal, as are the slides for the breechblock. Two holes are located on the upper part of the cradle for the installation of the feed mechanism, and two other holes are provided for the electropneumatic trigger mechanism. Two holes are located in the rear section of the cradle for the mounting of the rear plate. The cocking mechanism is mounted on the front plate, and a filling plug is provided for connection with the pneumatic system. On the left side of the cradle and below the breechblock, the electric switch lever is mounted.

Breechblock Mechanism, Buffer, and Electric Firing Mechanism. The breechblock is a forged monobloc, the front section of which is provided with a removable hardened steel bushing, held in position with a bayonet joint and secured with a pin. The extractors are also located in the breechblock and operated with springs. The electric firing pin is placed in a horizontal groove, and the electric wiring is mounted on the left side of the breechblock. On the bottom part of the breechblock are holes provided for the buffer springs. On the upper part of the breechblock, a catch plate is provided for the pneumatic trigger. Feed cam grooves are located on both sides of the plate.

The Counterrecoil Springs and the Breechblock. The counterrecoil mechanism consists of 2 sets of 4 springs, left- and right-hand turns, assembled in telescopic manner.

Feed Mechanism. The housing for the feed mechanism is fabricated from sheet metal and contains two transport slides which move in opposite direction to the feed fingers and the safety pawls. The transport slides are connected with two transport levers which are encased in the feed housing and mesh with the breechblock. The controlling grooves which regulate the transport catches are also located in the feed mechanism. The feed mechanism is connected to the cradle by means of a bolt which may be quickly disengaged by hand.

Electropneumatic Cocking Mechanism. A cocking bolt is mounted on the front wall of the cradle cover over which a cocking piston slides horizontally. A horizontal helical spring, located in the bottom of the cradle, returns the cocking piston to battery.

Electropneumatic Trigger. The electropneumatic trigger is located in the top rear section of the cradle and rests against two ring springs, which act as a buffer to absorb forces developed by the breechblock. The trigger housing retains a trigger latch which locks the breechblock in the recoiled position. The trigger latch is controlled by an air-operated piston.

Rear Plate. The rear plate is connected to the cradle by means of a bayonet-type bolt. The rear plate limits the maximum recoil travel of the breechblock and acts as a retainer for the springs and the cocking mechanism.

Electric Firing Lever. The firing lever is formed out of sheet metal and is connected to the cradle by means of a bolt. An electric contact, located within the cradle, energizes the firing system when the breechblock passes over its surface. In case of a misfire, a lever in the rear section of the firing lever initiates firing mechanically through the breechblock.

Ammunition Feed Belt. The cartridge belt is punched out of sheet metal. It is provided with slots and hooks. The rounds hold the links together to form a belt assembly, and the links disintegrate into parts when the rounds are rammed into the gun.

Cycle of Operation

This weapon is operated on the blowback principle. When the electropneumatic trigger is released, the breechblock is rammed into battery by the action of the counterrecoil springs. The breechblock indexes the feed mechanism by cam action between the grooves located in the breechblock and transport levers in the feed system. The belt is indexed by half a pitch, and the round is alined with the center of the tube when the breechblock rams the cartridge into the gun. At the same time, the extractor engages the rim of the case.

Electric ignition takes place before the breechblock reaches the forward dead end of travel. Gas pressure pushes the breechblock beyond the length of the case and extraction occurs. The surplus energy of the breechblock is absorbed by a buffer mechanism, which is located in the breechblock and rests against the cradle.

When the electropneumatic trigger is not operated, the breechblock is locked in recoil position. In case of a misfire, the counterrecoil forces are absorbed by a spring buffer. The electropneumatic cocking mechanism pushes the breechblock beyond the locking trigger, and the cocking mechanism is returned by a helical spring. The ammunition may be fed from either right or left side of the weapon.

In order to keep the recoil forces within certain limits for the installation in aircraft, the weapon is equipped with a mechanism to absorb surplus forces developed in firing.

SECTION 7. SG SERIES OF RECOILLESS AIRCRAFT CANNON (113A, 116, 117, AND 118)

Description of the Weapons

Known officially as the SG series (*Sonder Gerat* or special purpose equipment), these weapons were developed at the Herman Goering Werke at Brunswick. They never advanced beyond the developmental stage.

These weapons were designed in various calibers on the principle of the Davis gun and were recoilless. The most popular version was the 7.5-cm sabot type projectile having a 4.5-cm AP core that was fired out of one end, and an equal weight that was shot out of the other. The two elements were fastened together by a rod with the weakened section arranged so that the two halves would part at a predetermined chamber pressure.

The SG–113A was mounted vertically, muzzle downward, and fired by some echo impulse from tanks on the ground as the aircraft passed over them. Radar was the means of obtaining the echo. Other types were mounted to fire straight up for use against heavy bombers, while still others were designed for forward firing.

General Data: 7.7/4.5-cm Gun SG–113A

Gun length: 62.2 feet.
Gun weight: 105.6 pounds.
Muzzle velocity: 2,112 feet/second.
System of operation: Recoilless, single loader.
Barrel length: 62.2 feet.
Barrel weight: 105.6 pounds.

General Data: 30-mm Cannon SG–116

Gun length: 63 inches.
Gun weight: 70.56 pounds.
Rate of fire: Single shot.
Muzzle velocity: 2,822 feet/second.
System of operation: Recoilless, loaded from muzzle with self-consuming cartridge case; propellant force kicks counterweight to rear.
System of locking: None.
System of feeding: Manual.
Method of headspace: Factory established.
Location of feed opening: None.
Location ejection opening: None.
Method of charging: None.
Method of cooling: Air.

Barrel length: 52.68 inches.
Barrel weight: 46.53 pounds.
Rate control: None.
Barrel removal: Not quick disconnect.
Bore:
- Number of grooves: 16.
- Groove depth: 0.0177 inch.
- Groove width: 0.1456 inch.
- Pitch: 8° 30′.
- Direction of twist: Right hand.
- Form of twist: Uniform.

General Data: 30-mm SG–117 and 30-mm SG–118 [1]

Gun length: 63 inches. Gun weight: 61.74 pounds. Rate of fire: 10,000 rounds/minute. Muzzle velocity: 1,641 feet/second. System of operation: 7 barrels grouped together, fired electrically. System of locking: Rigid. Whole unit glides back and fires by contacts along rail that is mounted perpendicular. System of feeding: Manual. Method of headspace: Factory established. Location of feed opening: Rear. Location of ejection opening: None. Method of charging: None. Method of cooling: Air.	Barrel length: 21.46 inches. Barrel weight: 4.85 pounds each. Rate control: None. Barrel removal: Not quick disconnect. Bore: Number of grooves: 16. Groove depth: 0.0177 inch. Groove width: 0.138 inch. Pitch: 4° 30′ up to 8° 30′. Direction of twist: Right hand. Form of twist: Progressive.

[1] These two weapons differ only in the method of mounting. Data tabulated are identical for both guns.

Figure 25–12. Experimental installation of SG–116 in German fighter plane.

Figure 25–13. SG–116 installation as seen from wing tip.

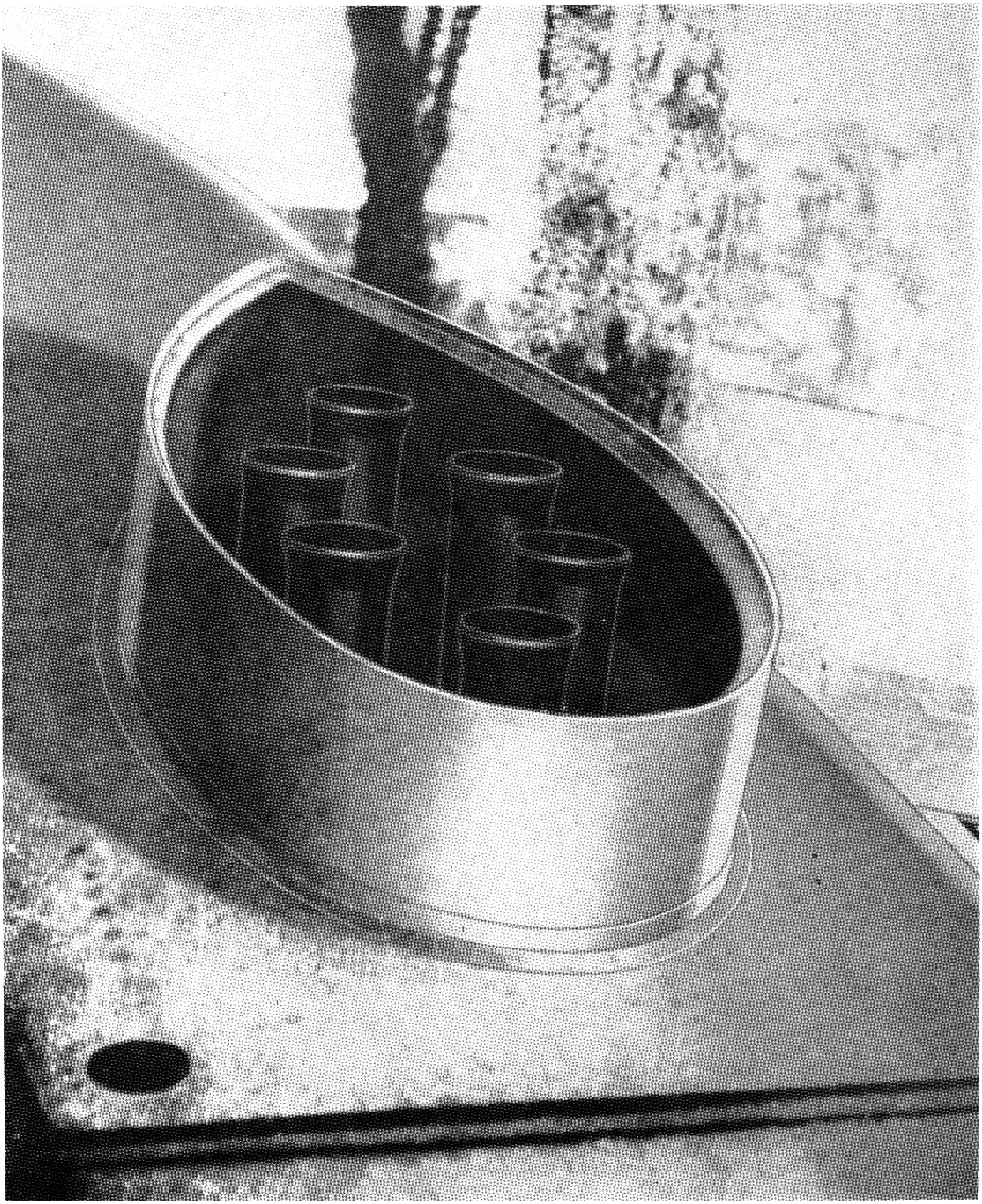

Figure 25–14. SG–116 installation from front, showing shape of fairing around muzzles.

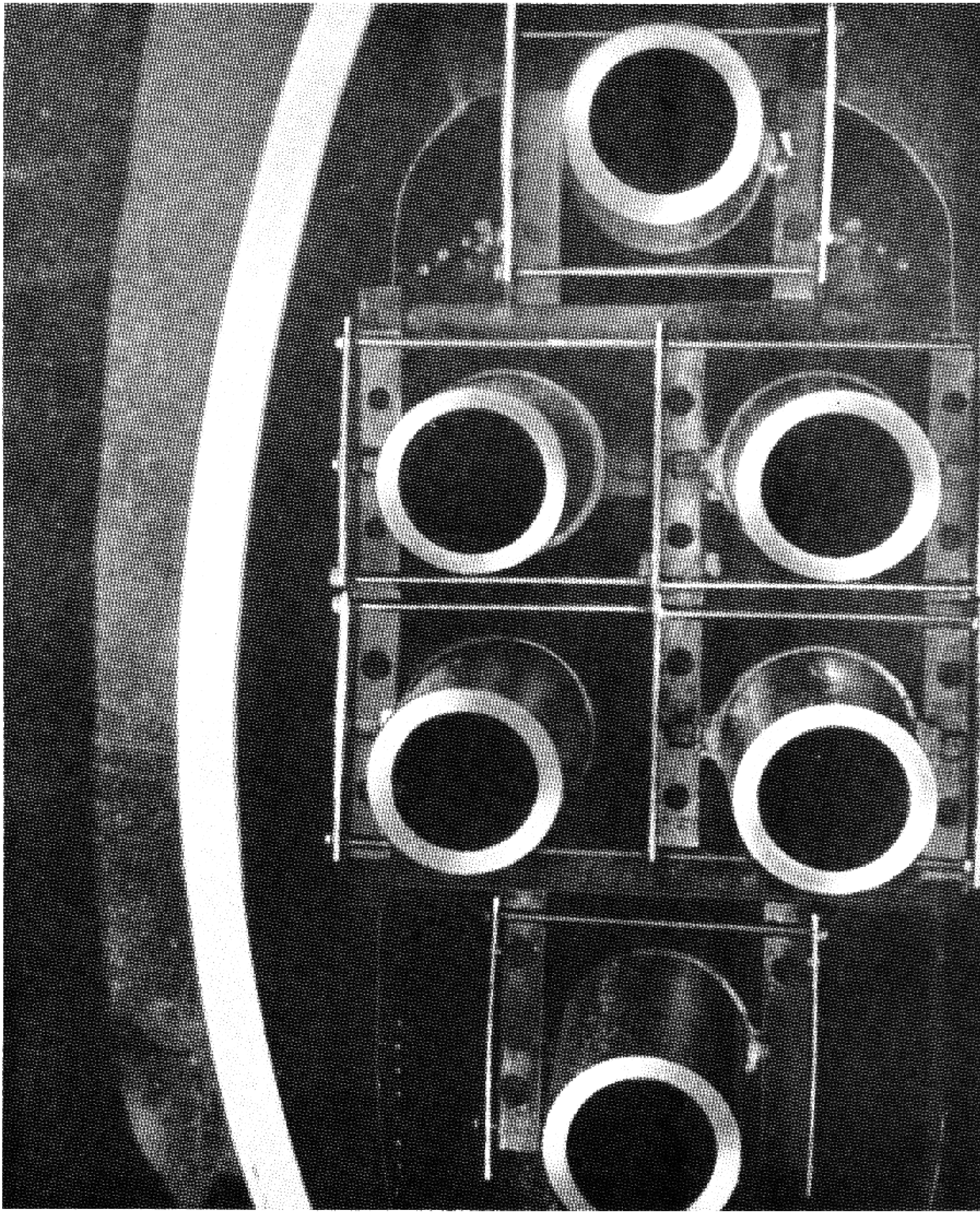

Figure 25–15. SG–116 installation. Top view.

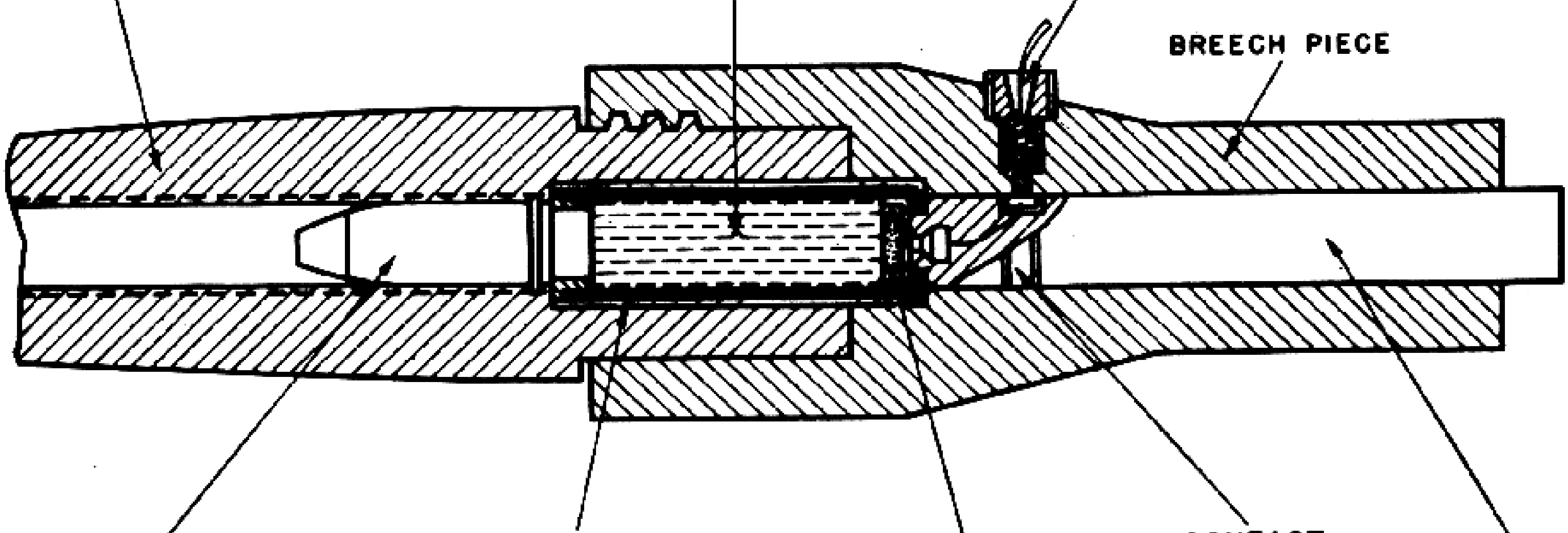

Figure 25–16. Section through one of the barrels of an SG–116.

SECTION 8. 5.5-CM AUTOMATIC CANNON MK–114

Description of the Weapon

The Ordnance Bureau of the Air Ministry set up the following requirements for the development of this automatic cannon: caliber, 5.5 cm; muzzle velocity, 3,250 feet per second; shell weight, 4.4 pounds; explosive, at least 0.88 pound; cyclic rate, at least 150 r. p. m.; weight to be not over 2,200 pounds; no alloy steels to be used; simple construction; electric firing; remote control; for use either as fuselage or engine-mounted gun. In order to keep the recoil force down, a recoil mechanism with a brake was to be provided.

The ammunition for the 5.5-cm flak device 58 was to be used. The gas-pressure loading system with fixed bolts was to be used.

The Rheinmetall-Borsig firm undertook the design of the gun, which was quite difficult. The specified total weight of not over 2,200 pounds allowed a gun weight of about 1,540 pounds. The use of nonalloyed steel seriously compromised the design. The various models that were completed came close to the requirements in their general structure but never met the main requirements fully.

Development work was stopped in the fall of 1944 by order of the Air Ministry.

General Data: 5.5-cm Automatic Cannon MK–114

Gun length: 137 inches.	Method of cooling: Air.
Gun weight: 1,543.5 pounds.	Barrel length: 165.7 inches.
Rate of fire: 150 rounds/minute.	Barrel weight: 551.25 pounds.
Muzzle velocity: 3,446 feet/second.	Rate control: None.
System of operation: Gas operated.	Barrel removal: Not quick disconnect.
System of locking: Sliding vertical wedge.	Bore:
System of feeding: Gas-operated feeder.	Number of grooves: 20.
Method of headspace: Factory established.	Groove depth: 0.0295 inch.
Location of feed opening: Top portion of receiver; may be fed from left or right.	Groove width: 0.197 inch.
Location of ejection opening: Bottom.	Pitch: 8° 30′.
Method of charging: Electropneumatic.	Direction of twist: Right hand.
	Form of twist: Uniform.

SECTION 9. 5.5-CM AUTOMATIC RECOILLESS CANNON MK-115

Description of the Weapon

The German High Command ordered the Rheinmetall engineers to explore the possibilities of developing a belt-fed automatic aircraft cannon based on the recoilless principle. At the end of hostilities, allied engineers found a device well along in the development stage. Officially called the MK-115, this unique weapon employed a locked breech; but by means of diverting gases through an orifice, the recoil forces were cut to practically zero. A combustible cartridge case was used by this weapon.

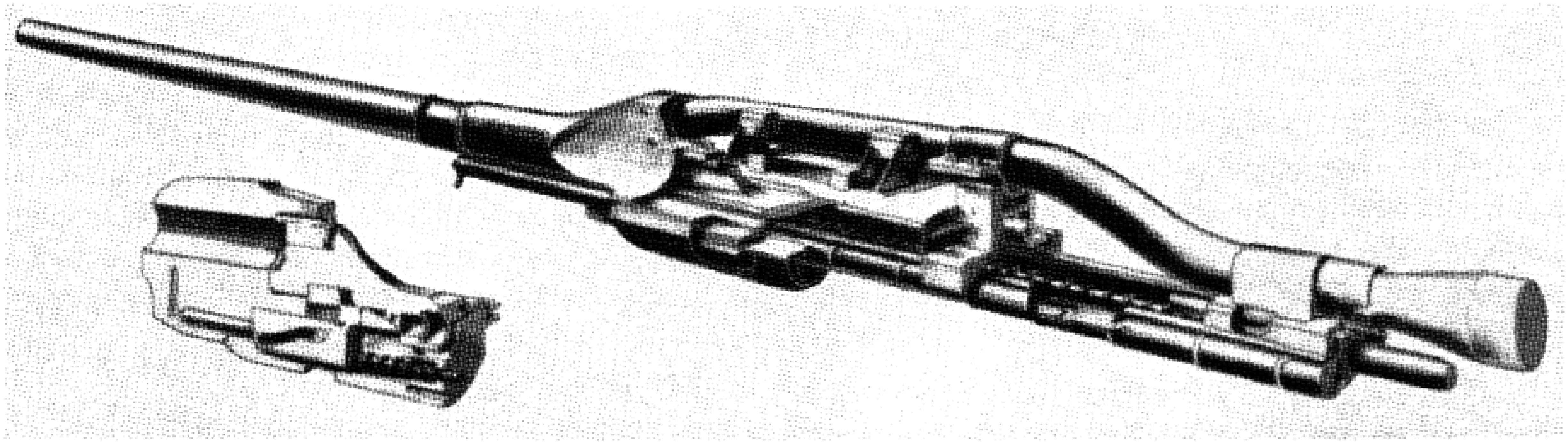

Figure 25-17. Artist's conception of 5.5-cm Automatic Recoilless Cannon MK-115.

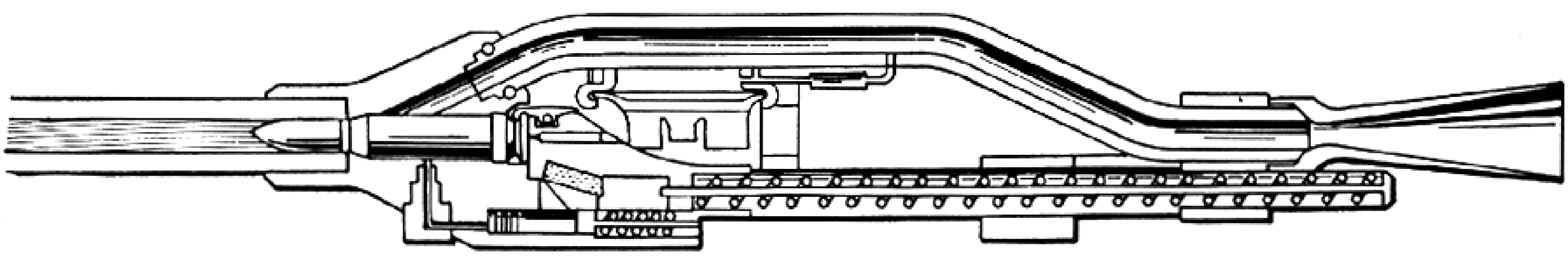

Figure 25-18. 5.5-cm Automatic Recoilless Cannon MK-115. Longitudinal section.

General Data: 5.5-cm Automatic Recoilless Cannon MK-115

Gun length: 129.9 inches.	Barrel length: 51.97 inches.
Gun weight: 396.9 pounds.	Barrel weight: 83.9 pounds.
Rate of fire: 300 rounds/minute.	Rate of control: None.
Muzzle velocity: 1,969 feet/second.	Barrel removal: Not quick disconnect.
System of locking: Swinging lock.	Bore:
System of feeding: Gas-operated belt.	Number of grooves: 20.
Method of headspace: Factory established.	Groove depth: 0.0295 inch.
Location of feed opening: Top of receiver, either left- or right-hand side.	Groove width: 0.197 inch.
Location of ejection opening: Rear portion of case is pulled back into link and ejected from the side opposite to that from which it is fed.	Pitch: 8° 30′.
Method of charging: Electropneumatic.	Direction of twist: Right hand.
Method of cooling: Air.	Form of twist: Uniform.
	NOTE: This weapon used a combustible cartridge case, leaving only the base to dispose of.

258970°—54——43

SECTION 10. 5-CM BK AUTOMATIC AIRCRAFT GUN

Description

The 5-cm BK automatic aircraft gun is a recoil-operated mechanism having an electrical firing system. The gun is fed and rammed by a series of air-operated pistons. The system is interlocked by electrical switches which, through solenoid-operated valves, control the compressed air supply to the pistons. The ring-shaped magazine has a capacity of 22 rounds. The recoil system is of the hydro-pneumatic type.

The tube and breech ring are housed and ride in the cradle. The recoil mechanism and counterrecoil mechanism are mounted on the cradle and secured to the breech ring. The ring magazine encircles the cradle and contains an endless belt of links with a capacity of 22 rounds. The links ride on a strip fastened to the inside of the outside shell of the magazine. The rounds are loaded in the belt through an opening in the magazine at the left rear. The endless belt is moved by the feed mechanism which is mounted on top of the drum magazine.

The feed mechanism is operated by the compressed air supply. At the proper time during the cycle, the air enters the cylinder and drives the piston which carries the cross piece and feed pawls. The holding pawls are cammed downward and return to the holding position on the return stroke of the feed piston. The return of the piston is caused by the feed springs, which are compressed on feeding. The positioning of the round by the feed system is indicated for the continuing of the cycle by operation of a switch.

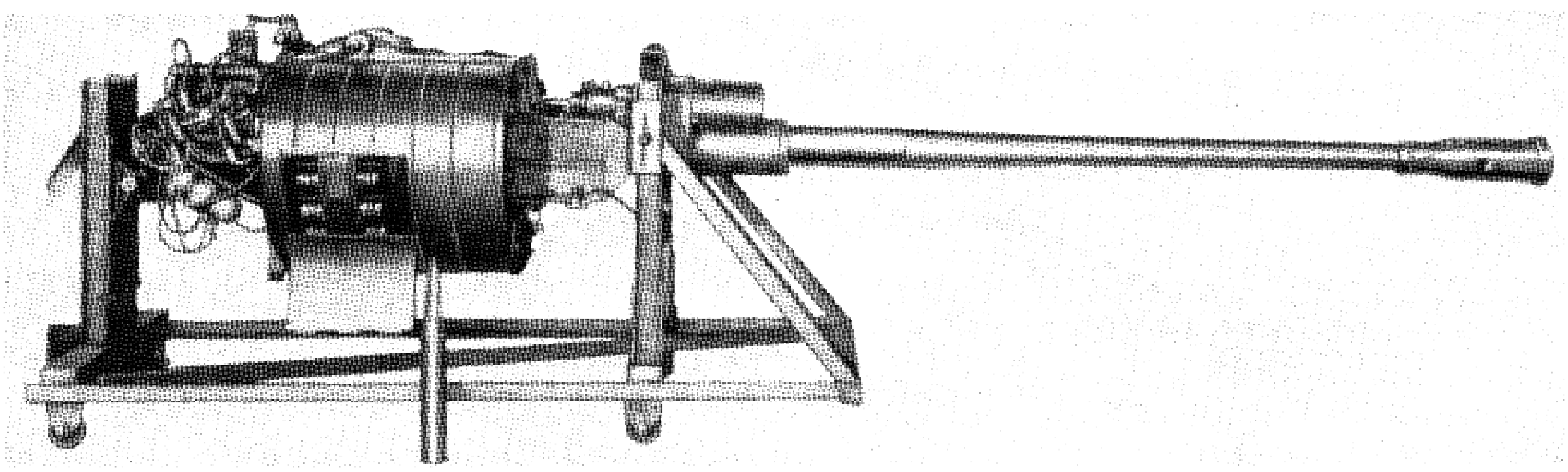

Figure 25–19. 5-cm BK Automatic Aircraft Gun, mounted in test stand. Right side view.

General Data: 5-cm BK Automatic Aircraft Gun

Gun length: 149 inches.	Barrel length, without muzzle brake: 94 inches.
Gun weight: 1,170 pounds.	Barrel weight: 480 pounds.
Rate of fire: 45–50 rounds/minute.	Rate of control: None.
Muzzle velocity: 3,010 feet/second.	Chamber pressure: 40,000 p. s. i.
System of operation: Long recoil.	Bore:
System of locking: Sliding vertical block.	Number of grooves: 20.
System of feeding: Circular automatic feeder holding 22 rounds.	Groove depth: 0.75 mm.
	Groove width: 5.0 mm.
Method of headspace: Sliding block constructed with sloping face so as to insure perfect headspacing.	Pitch: 8° 30′.
	Direction of twist: Right hand.
Location of feed opening: Rear of breech.	Form of twist: Constant.
Location ejection opening: Rear of breech.	Muzzle energy: 238 foot-tons.
Method of charging: Electropneumatic.	Capacity of ring magazine: 22 rounds.
Method of cooling: Air.	

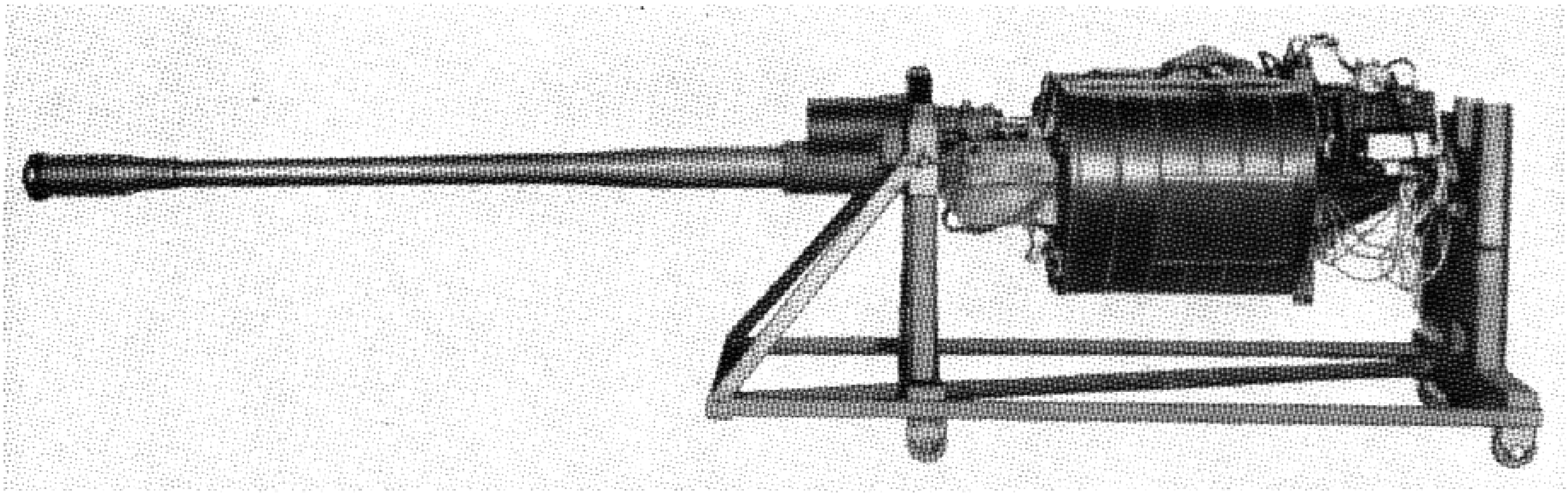

Figure 25–20. 5-cm BK Automatic Aircraft Gun, mounted in test stand. Left side view.

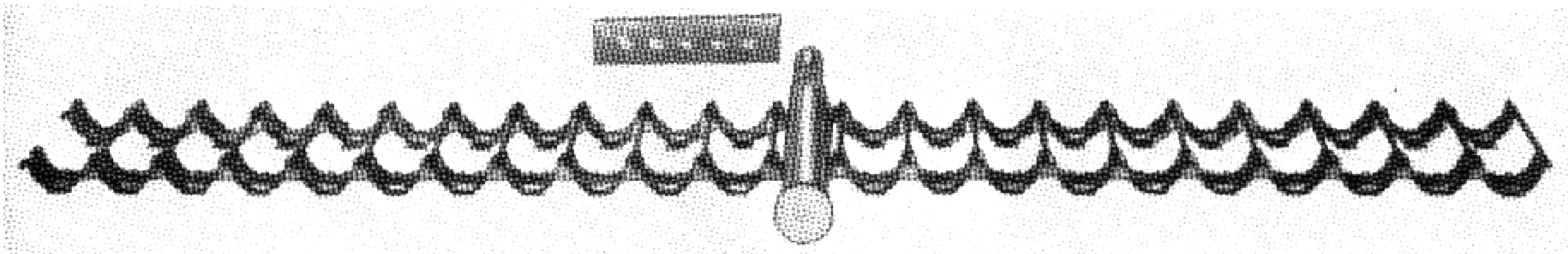

Figure 25–21. Feed belt of 5-cm BK Automatic Aircraft Gun.

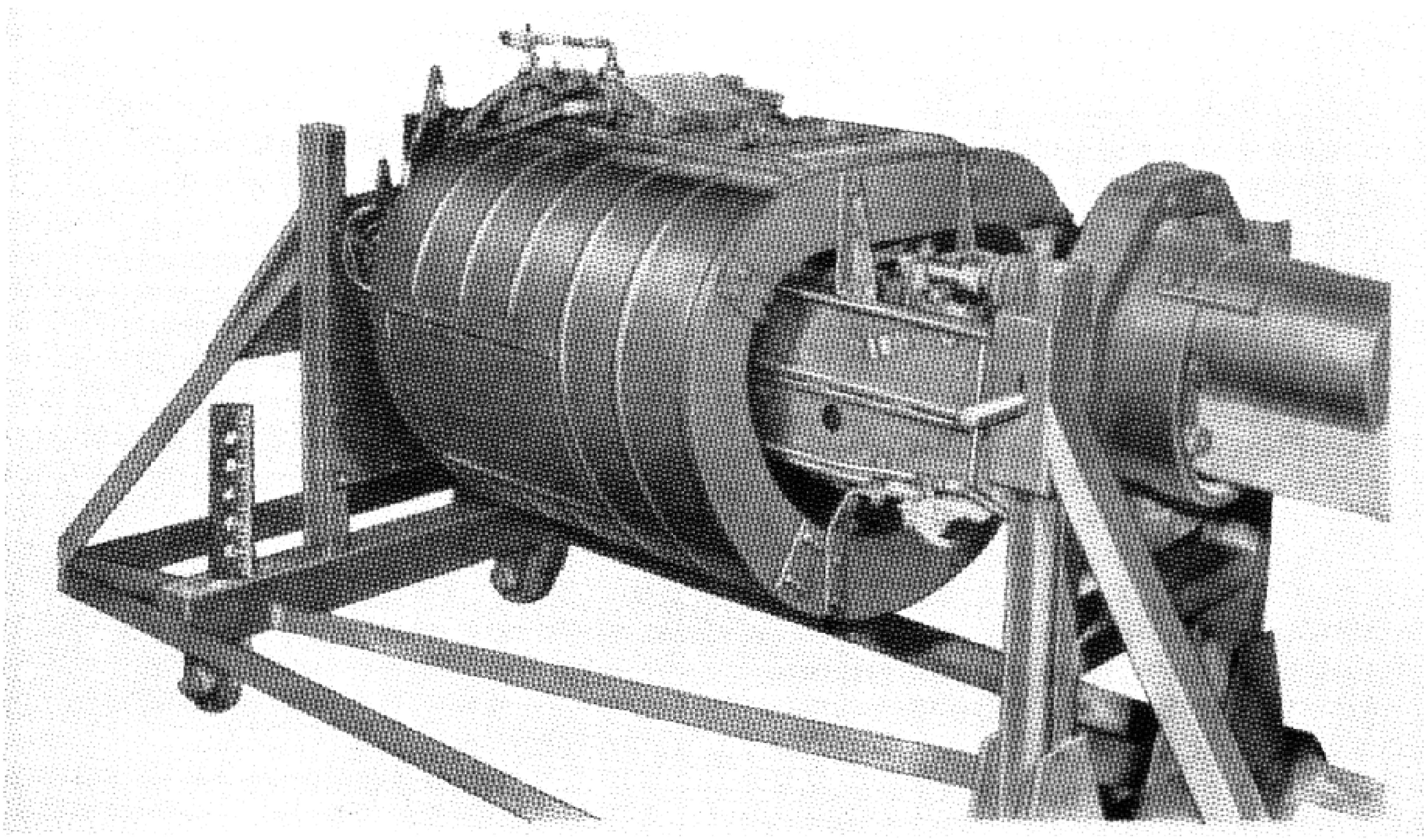

Figure 25–22. Receiver of 5-cm BK Automatic Aircraft Gun. Closeup view.

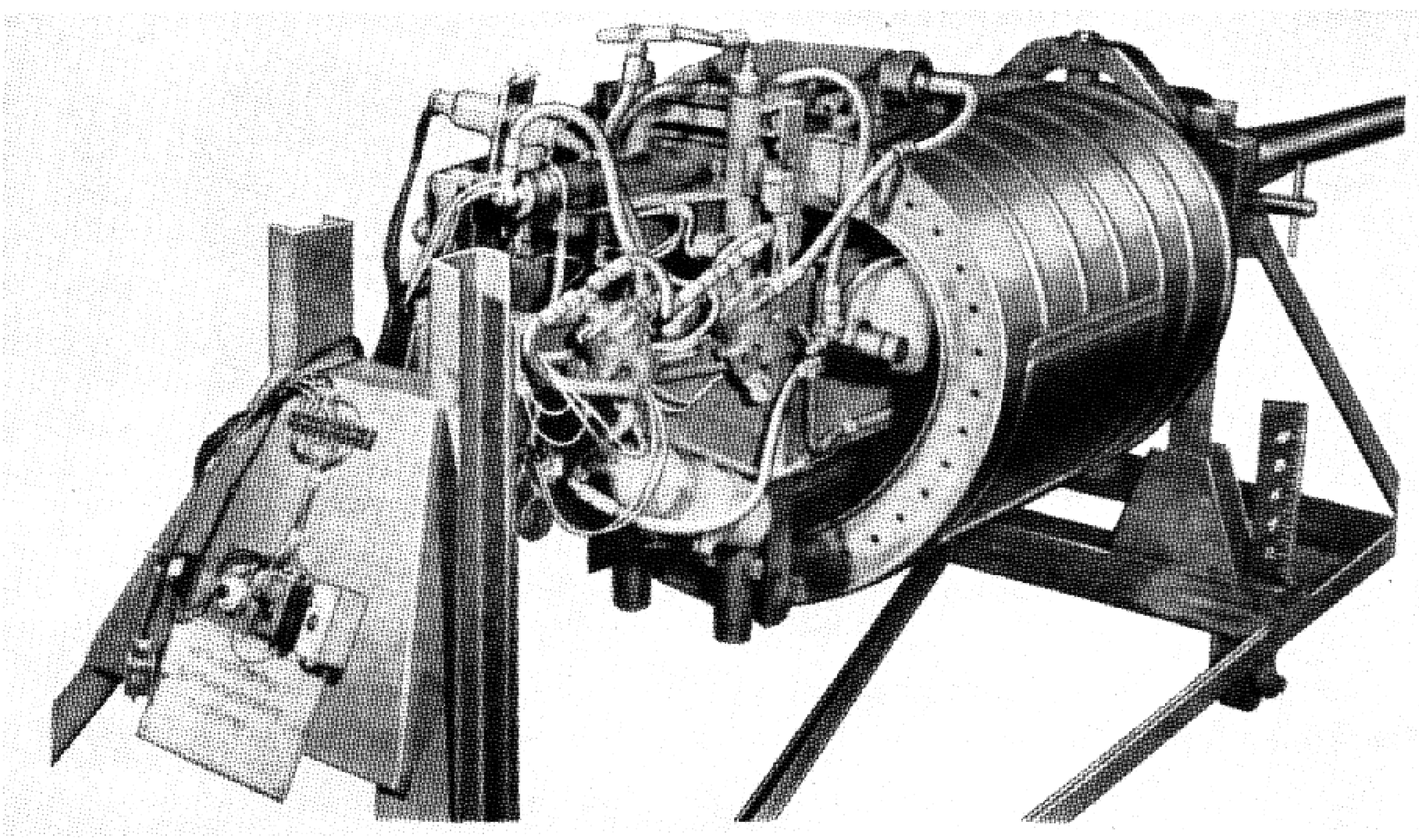

Figure 25–23. 5-cm BK Automatic Aircraft Gun. Right rear view.

On each side of the cradle and beneath the magazine, there are air bottles which contain the compressed air supply to operate the gun. The air is metered to the proper piston through one of three electrically-operated valves. There are six electric switches which complete the circuits to operate the valves at the proper time.

The main switch is operated by a lever in the rear of the loading tray. The lever is depressed by the round as it is positioned on the tray. This lever is operated by the rammer head moving forward and rearward. A switch is operated when the breechblock is in the down, or open, position, to prevent ramming of the round on a closed breech.

The loading tray is secured to two spring-loaded, air-operated pistons riding in cylinders. At the proper time in the cycle, the air is applied to the cylinders to drive the pistons down, compressing the springs so that the tray may return to its upward position on release of the air pressure. At the front of the tray is a spring-loaded holding pawl. When the round is pushed on the tray from the right side by the feed mechanism, the holding pawl is rotated upward and then snaps down, holding the front of the round under the bridge. As the round is rammed forward, the holding pawl accommodates the larger diameter of the case by rotating upward. As the rear end of the round enters the tray, it depresses a spring-loaded retaining catch which snaps out again after the round is in its seat. This action prevents the rear end of the round from escaping. A small vertical plate engages the front of the rim, thus preventing it from being driven forward by the face of the holding catch as the round is moved into position on the tray. The ramming head is secured to the air-operated piston in the ramming cylinder. The rammer piston, when being driven forward, compresses a spring to return the rammer upon release of the air pressure. The rammer head has an extension on the top and left side to hold the round when the tray is moving down, and to stop the round when it is being put on the tray by the feed mechanism.

The breechblock is practically the same as that used in the MK–214. The operating shaft rotated by the operating cam fits into the operating crank.

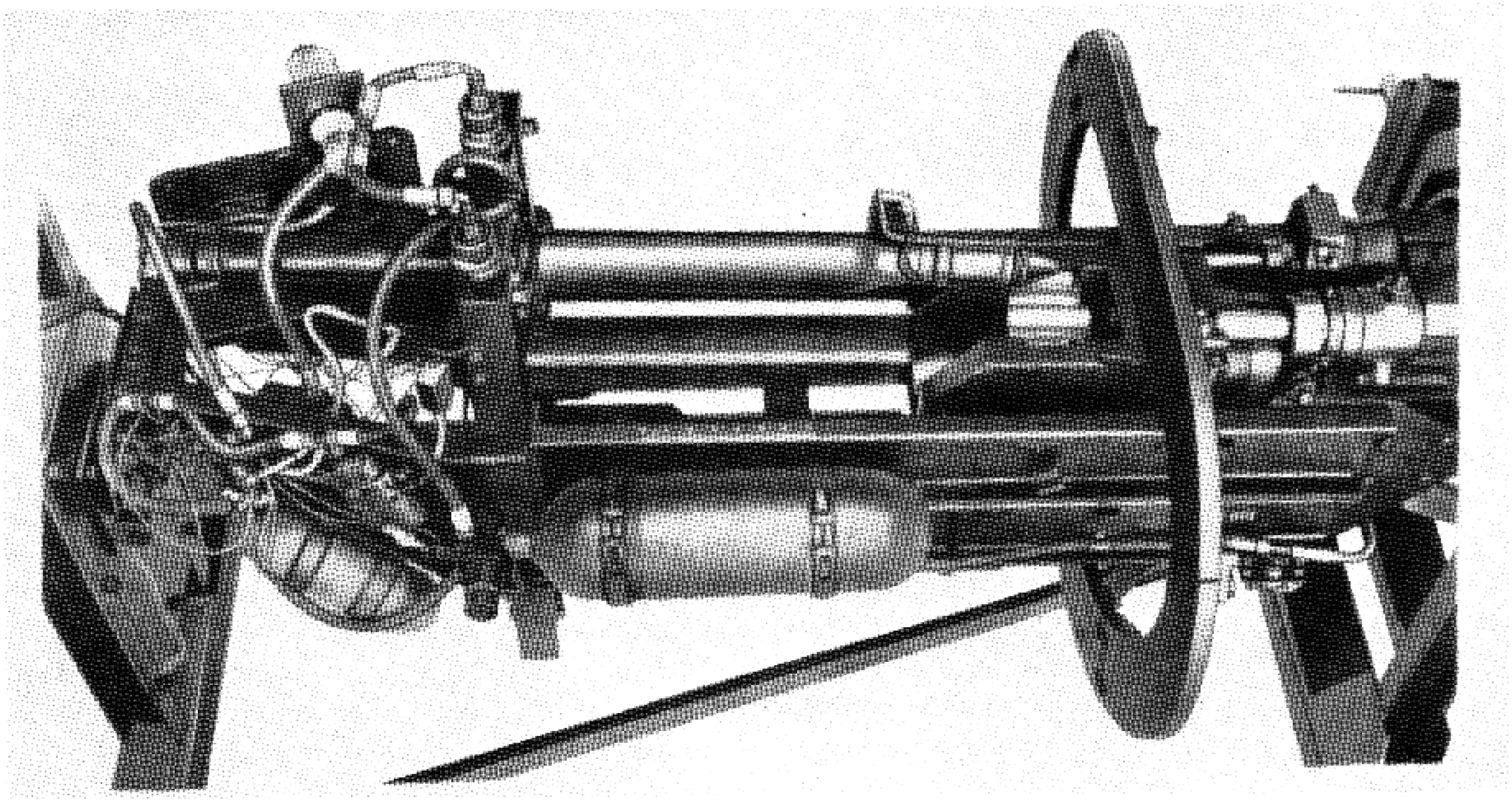

Figure 25–24. Receiver of 5-cm BK Automatic Aircraft Gun, with cover removed. A round is about to descend for ramming.

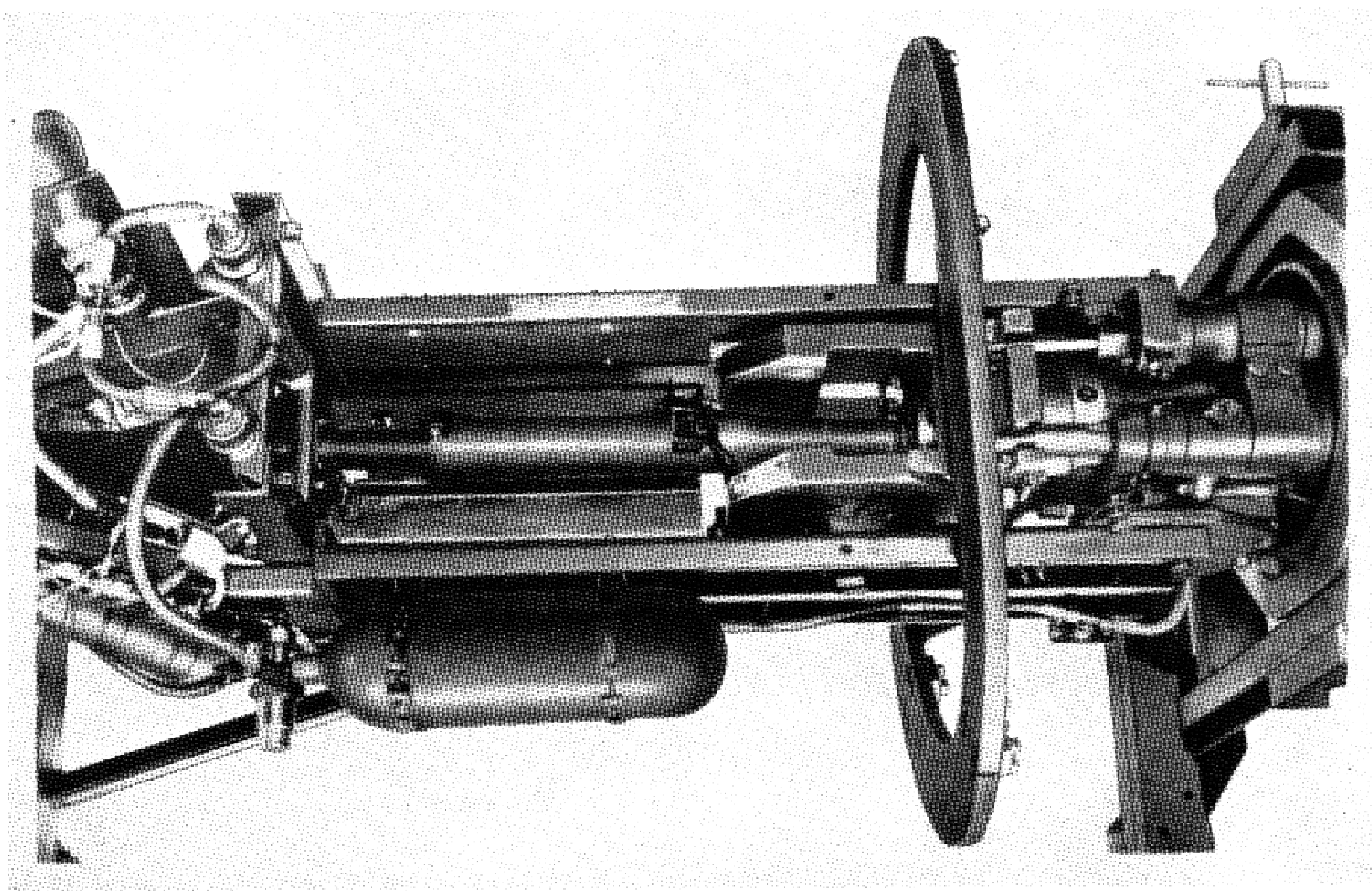

Figure 25–25. Receiver of 5-cm BK Automatic Aircraft Gun, with cover removed. A round is being rammed.

The cam is straight, but it is pivoted and spring-loaded in such a way that the roller on the crank of the operating shaft strikes the back of it on recoil and the cam rotates out of the patch of the roller. However, in counterrecoil when the roller strikes the cam, the cam will not rotate. Instead, the operating shaft and crank rotate and the breechblock is opened. The extractors strike the extractor cam on the block and extract the empty case; then they catch on the holding lips of the block to keep it open until the next round trips the extractors. When the lips are open, the closing spring is compresssd. On closing the block, the last travel of the operating crank engages the firing pin actuator and rotates it to allow the firing pin to ride forward and make contact with the chambered round. The insulated conductor contacts the insulated firing pin. When the block has closed, the firing circuit is completed by the conductor's making contact with the source of electricity, provided the rest of the circuit is completed by the operator and the tray is in the up position. When the block begins to lower, the firing pin is retracted.

The recoil system is of the hydropneumatic type, the same as that used on the MK–214. The counterrecoil cylinder consists of a steel cylinder and piston rod. The counterrecoil cylinder contains 0.9 liter of recoil oil under 882 p. s. i. of nitrogen pressure. The recoil cylinder consists of a steel cylinder, a hollow piston rod, and a throttling rod. The cylinder is completely filled with recoil oil. When firing takes place the tube and breech ring are forced to the rear, taking the recoil and counterrecoil pistons with them. The nitrogen in the counterrecoil cylinder is compressed and at the same time the oil in the recoil cylinder is forced through the orifices in the head of the recoil piston, through the main throttling orifice, and past the stationary throttling rod. In this way, the fluid resistance necessary to retard and stop recoil is set up. Then recoil ceases, since the throttling rod has almost blocked off the orifice, and the compressed nitrogen forces the tube and breech ring back into battery. The tapered section at the

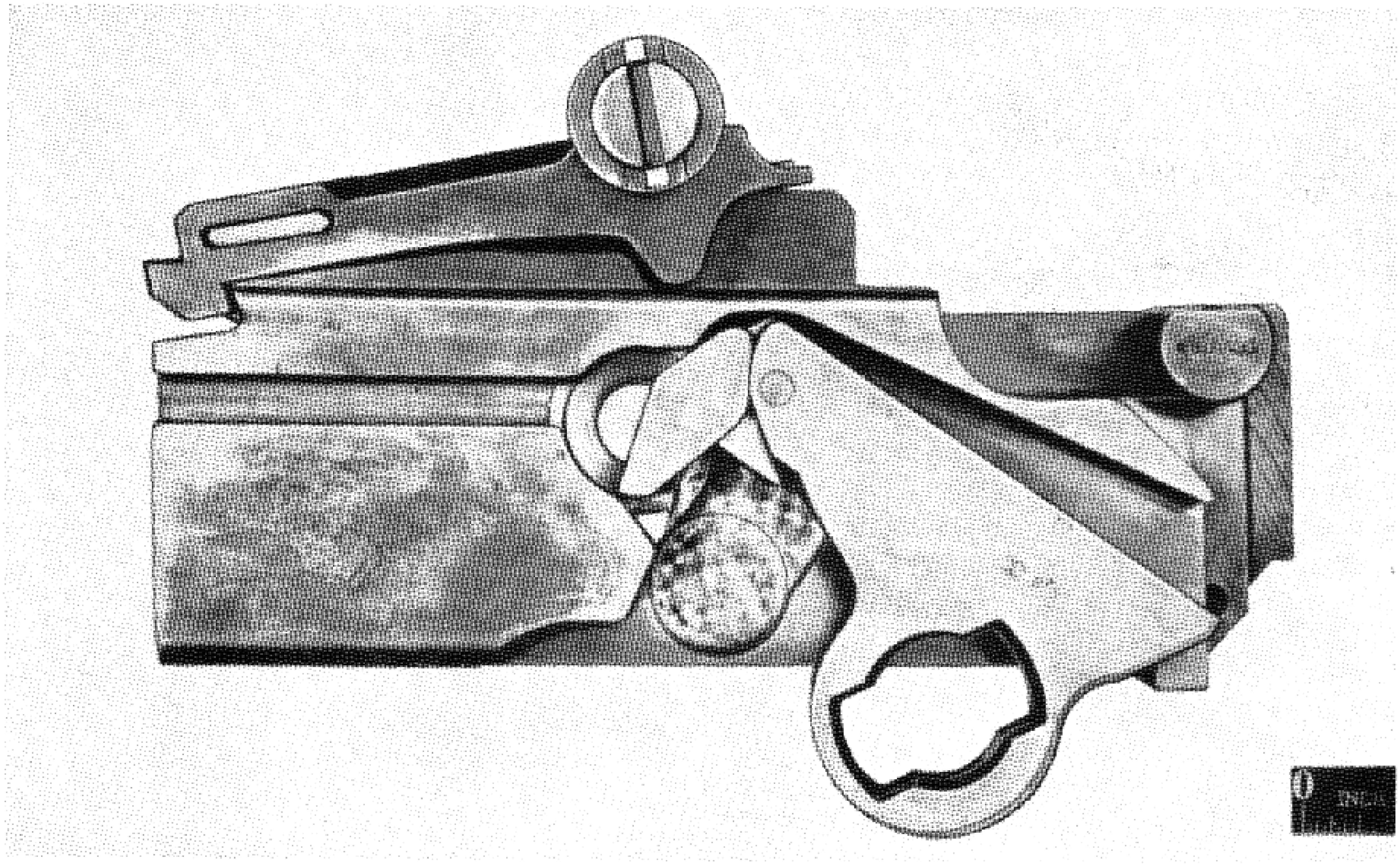

Figure 25–26. Breechlock of 5-cm BK Automatic Aircraft Gun. Assembled view.

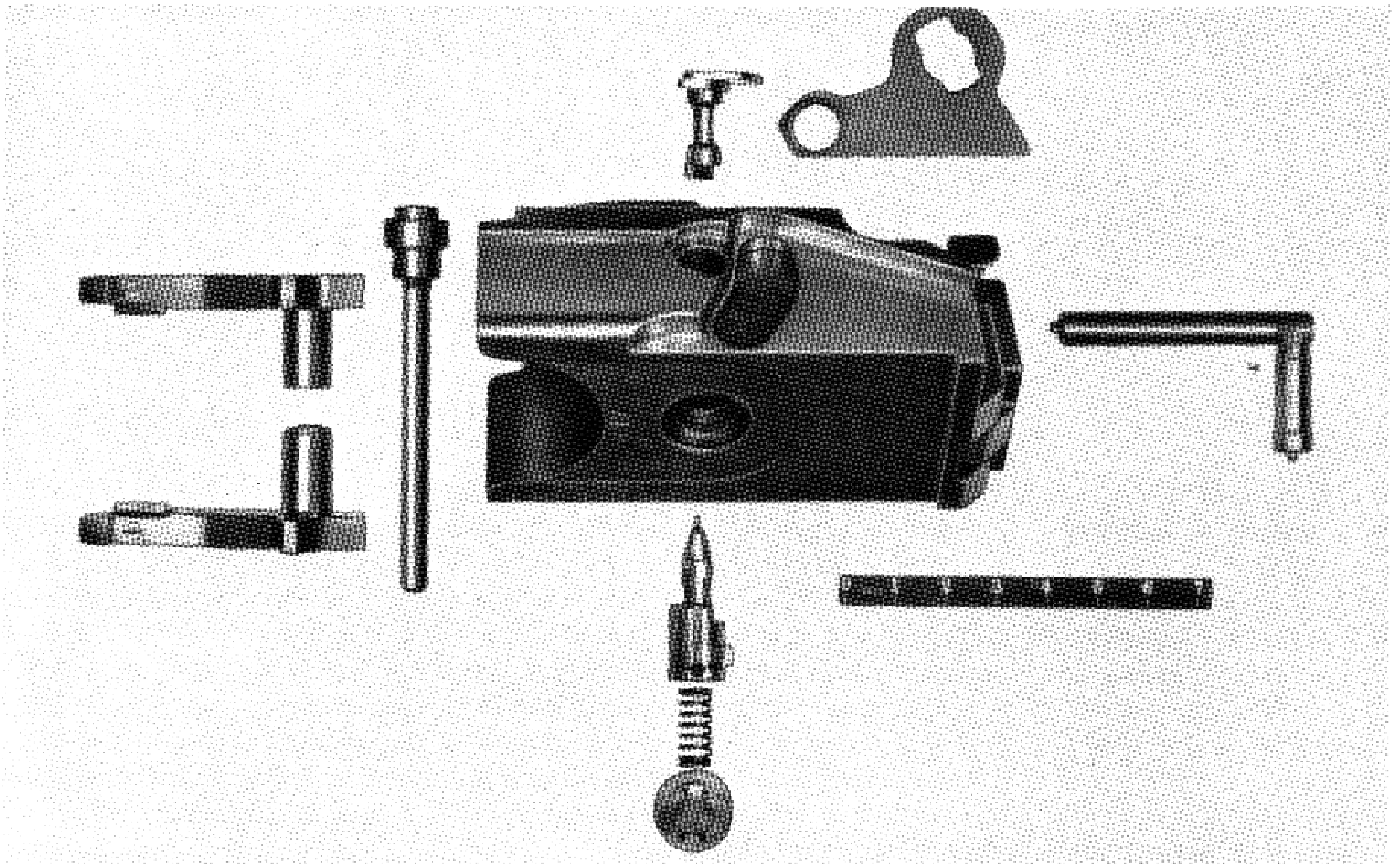

Figure 25–27. Breechlock of 5-cm BK Automatic Aircraft Gun. Disassembled view.

back of the throttling rod offers resistance to fluid flow and acts as a counterrecoil buffer.

Operation

When there is a round in the chamber, the operator can complete the electric firing circuit and thus fire the gun. The tube and breeech ring recoil rearward, the force of recoil being absorbed by the recoil cylinder. As the gun recoils, the roller on the crank of the operating shaft overrides the breech opening cam. The recuperator then draws the barrel back into battery through the force of the compressed nitrogen.

As the gun goes into battery, the roller on the crank of the operating shaft strikes the breechblock opening cam and the shaft is rotated, drawing the breechblock down and compressing the breechblock closing spring. When the block reaches the end of its travel, the extractors strike the extractor cam on the block and the extractors pivot. The empty case is extracted by this action. When the gun is in battery, air pressure is allowed to enter the tray cylinders, forcing the tray down and compressing the tray springs. The rammer head and the yoke at the front of the tray strip the round from the linked belt. When the tray carrying the round is at the bottom of its travel, air pressure is allowed to enter the rammer cylinder and the rammer head is driven forward, compressing its spring and driving the round into the breech.

The extractors are tripped by the rim of the case and the block is closed by action of the compressed breechblock spring. The rammer head is allowed to return to its position by action of its compressed spring, and the tray is allowed to return to its upward position by the force of the compressed tray springs. The firing circuit is completed as the block rises, the tray being in the up position. When the tray is in this position, the feed mechanism moves the linked belt to the left, putting a new round on the tray. The round is held by the rammer head and the front holding pawl, ready to be moved into the line of the bore.

Chapter 26

EXPERIMENTAL 47-MM AIRCRAFT MACHINE GUN (ITALIAN)

SECTION 1. HISTORY AND BACKGROUND

In World War II, the collapse of Italy brought to Allied hands a 47-mm experimental aircraft machine gun that proved interesting mainly because of its similarity to the not-too-successful United States Baldwin 37-mm aircraft automatic cannon model 1917. (See The Machine Gun, volume 1, pp. 526–530.) The main difference between the Italian experimental cannon and the Baldwin gun is the placing of the recuperator spring housing beneath the barrel, instead of on top as was the case with the Baldwin.

The Italian engineers designed their weapon with a bore diameter of 47 mm for reasons of economy. Barrels and ammunition could be made with machinery and dies that had previously been used in the manufacture of the universally used Hotchkiss revolving cannon of the same caliber.

The operation of the experimental Italian gun is novel; however the weapon contributes little toward the advancement of aviation ordnance. The method of firing, locking and unlocking the breech mechanism is not new. The feed mechanism and method of empty case ejection is interesting, as a directly vertical feed when using clips or metallic strip is advantageous. A point may be gained as concerns the ejection spring loaded lug on the face of the breechblock. The trigger and sear mechanisms are almost identical with the type used on the 40-mm Bofors gun.

The arrangement of the recoil springs is somewhat unusual; however, similar variations have been made on other guns. The counterrecoil cylinder is conventional and is very similar to the counterrecoil cylinder used on several 37-mm guns. The method of returning the breechblock carrier to the sear levers is conventional. The carrier is moved from its extreme forward position at firing to its extreme rearward position when cocked. This is accomplished by both recoil and counterrecoil of the gun barrel.

SECTION 2. DESCRIPTION OF THE WEAPON

General

The Italian 47-mm aircraft machine gun C. 102 is a long-recoil operated, metallic strip fed type of automatic gun.

Breech Locking Mechanism

This gun has a positive locking rotating breechblock. The external circumference of the breechblock has a three-section French interrupted screw that locks in the gun barrel when rotated. When a complete round of ammunition is placed in the gun chamber, the breechblock has completed its forward movement. However, the firing pin which is attached rigidly to the breechblock carrier, continues to move forward for a short distance and stops when the forward end of the firing pin protrudes from the face of the breechblock about 0.110 inch. The firing pin has a "speed thread" on its external circumference that rotates the breechblock when the breechblock has seated in the gun. Firing of the gun occurs when the firing pin protrudes from the face of the breechblock. After about 5 inches of recoil, the breechblock is unlocked by a cam guide secured to the bottom of the slide. The breechblock has secured to it an arm and roller. The roller runs in the cam guide on the bottom of the slide.

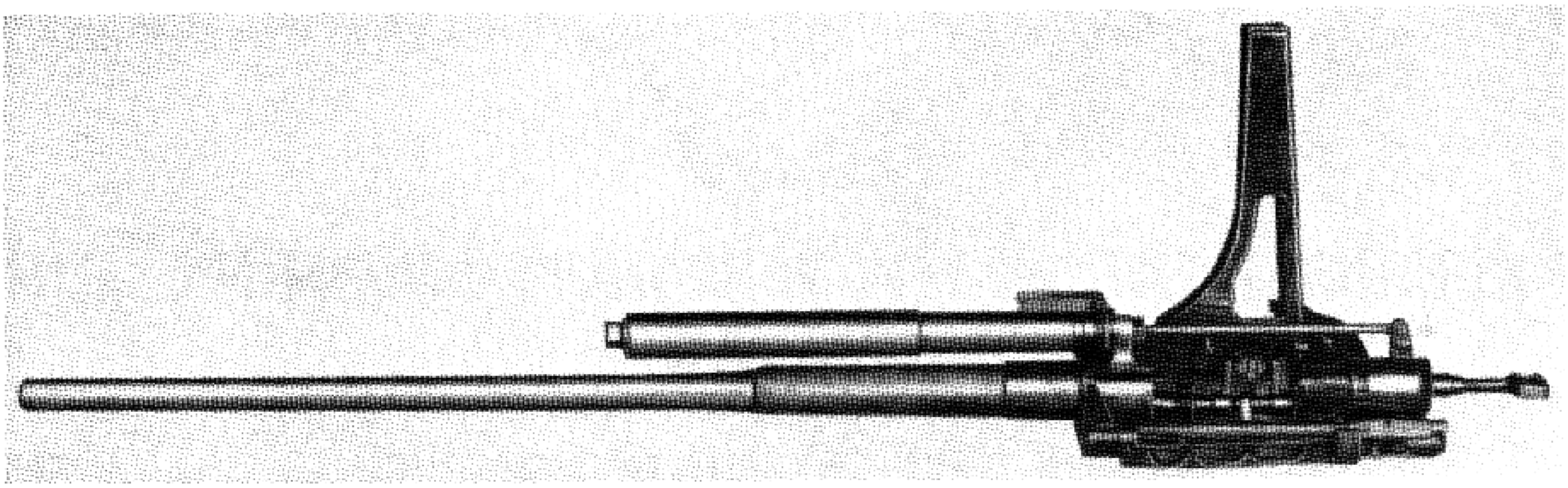

Figure 26–1. The American Baldwin 37-mm Aircraft Cannon.

Feed Mechanism

Automatic operation of the feed mechanism is accomplished by a long rod, sliding block, and safety buffer connected to a bracket on the right underside of the gun barrel. When the gun barrel recoils, it pushes to the rear the rod, sliding block, and buffer. Attached to the sliding block, which is at the rear of the assembly, is a lever arm that operates vertically over about 30°. On the aft end of this arm is a heart-shaped cam that rides under and over a lug about one-fourth inch in width and located on the inside of the gun slide. The metallic feeding strip is pulled down in its guide by the forward end of the lever operated by the heart-shaped cam when the gun is in recoil. The buffer is a safety device in the event of overtravel of the gun in recoil.

Ejection of an empty case is coincident with feeding. A small spring-loaded lug on the bottom of the breechblock face holds the empty case to the face of the breechblock. When a new round is fed to the breechblock face by the vertical action of the feed mechanism lever arm, the new round pushes down the empty case thereby retracting the spring-loaded lug. The empty case is then released from the breechblock face and continues down through an opening in the bottom of the gun slide.

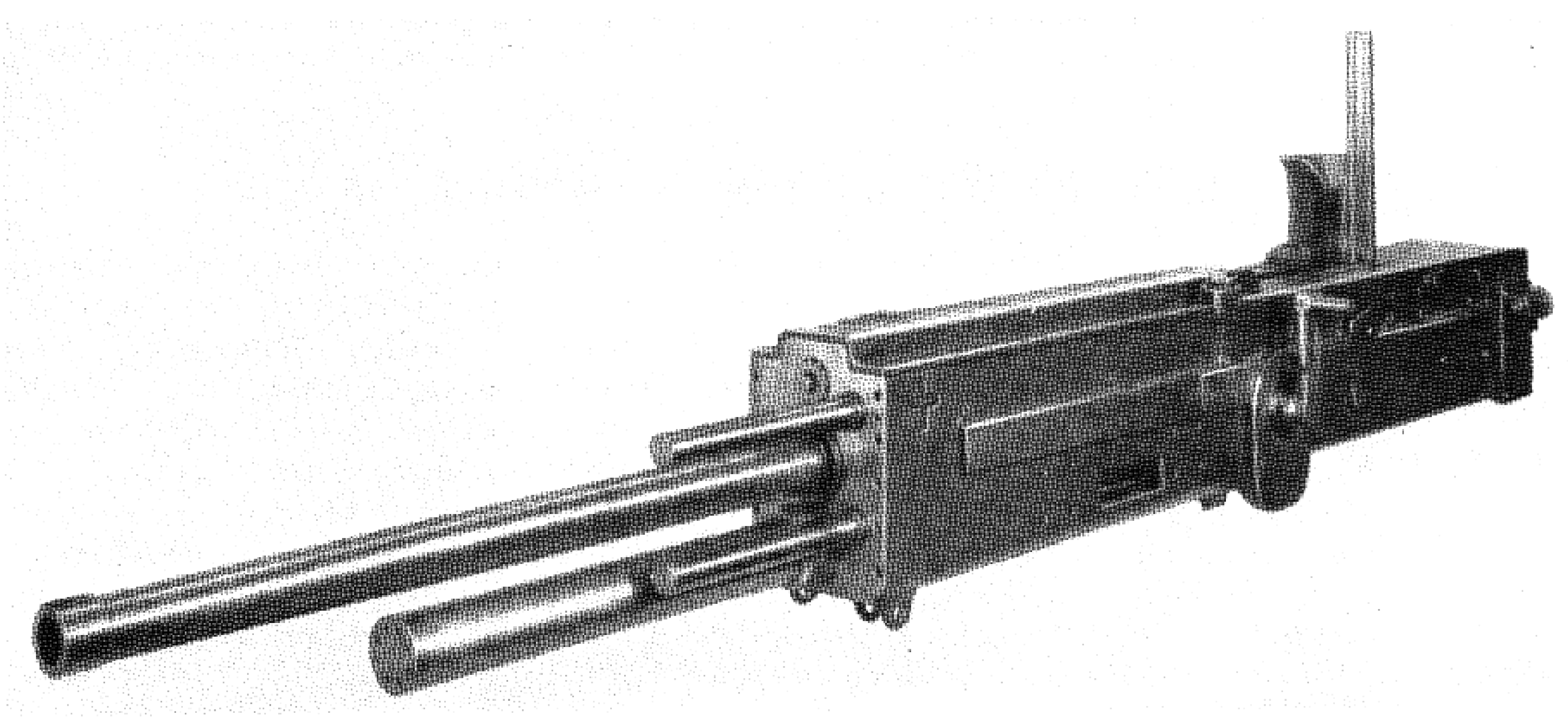

Figure 26–2. Experimental Italian 47-mm Aircraft Machine Gun. Left front view.

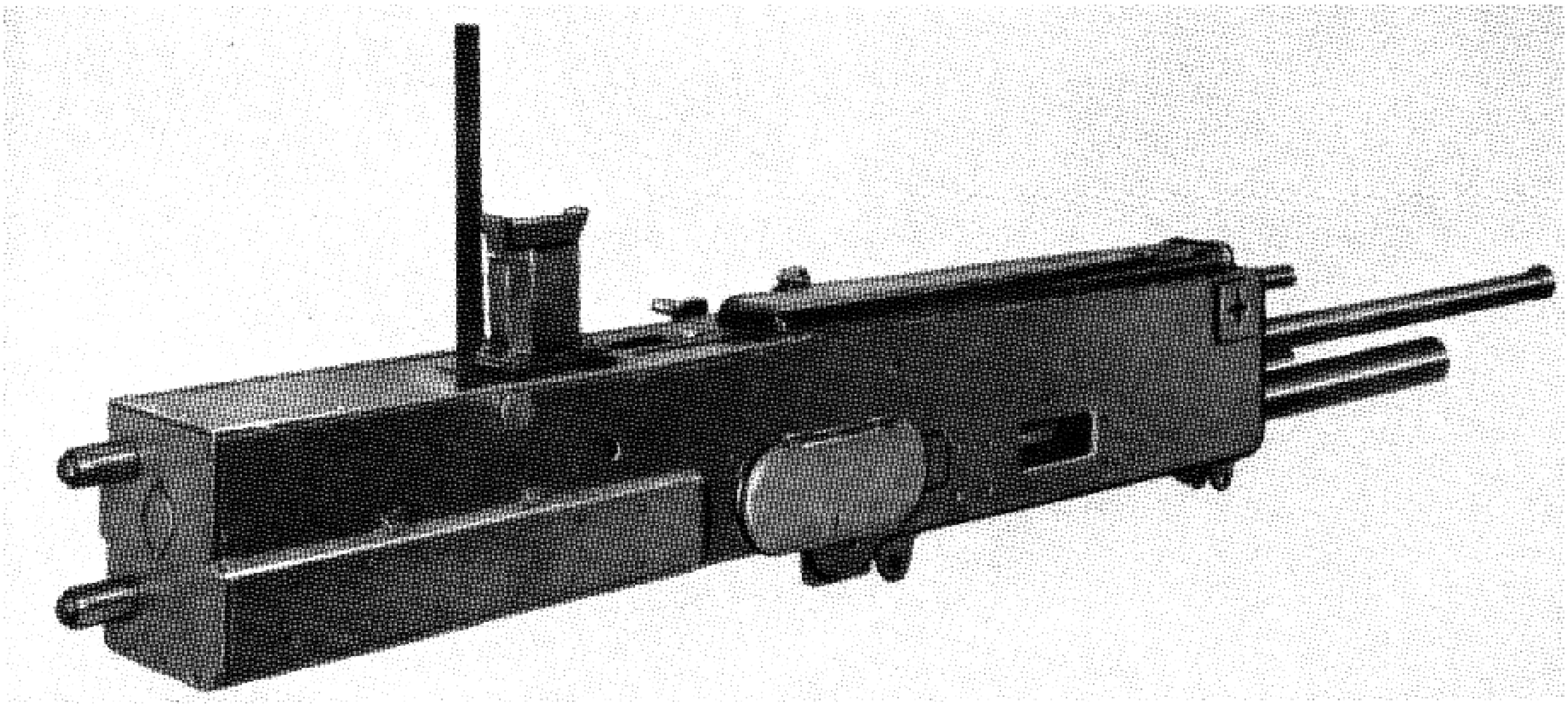

Figure 26–3. Experimental Italian 47-mm Aircraft Machine Gun. Right rear view.

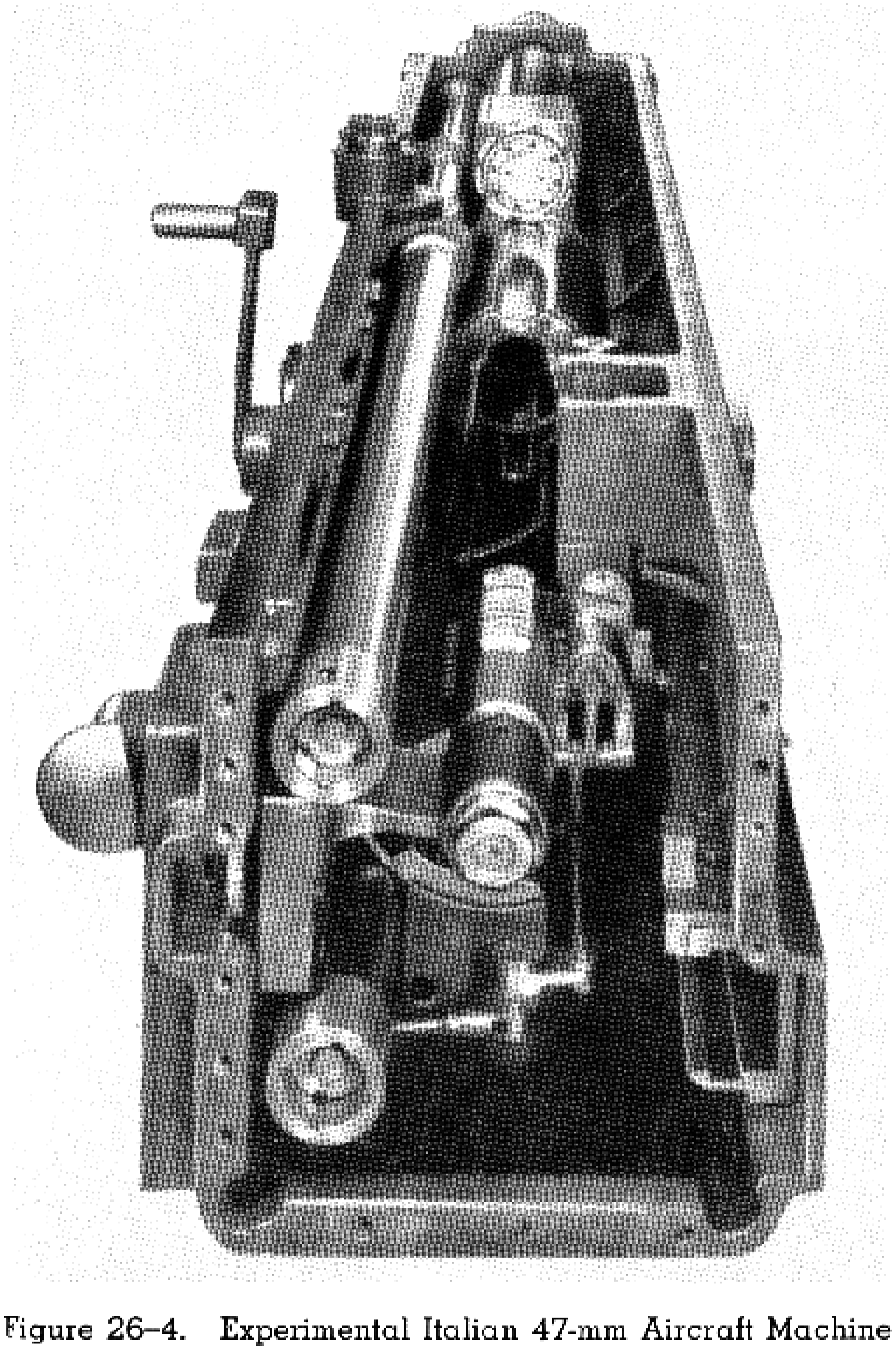

Figure 26–4. Experimental Italian 47-mm Aircraft Machine Gun. Rear view of operating mechanism.

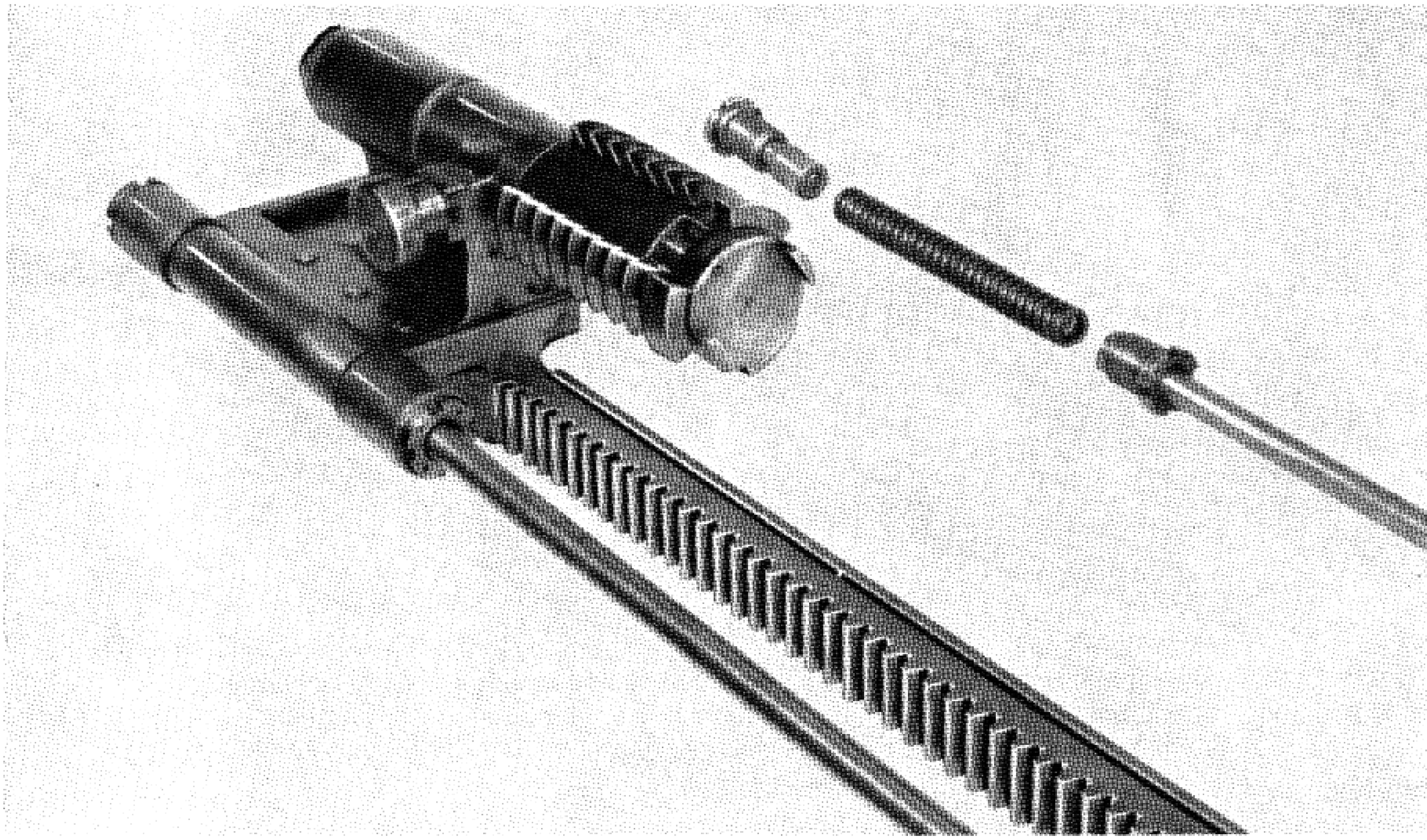

Figure 26–5. Experimental Italian 47-mm Aircraft Machine Gun, showing breechblock carrier with breechblock affixed.

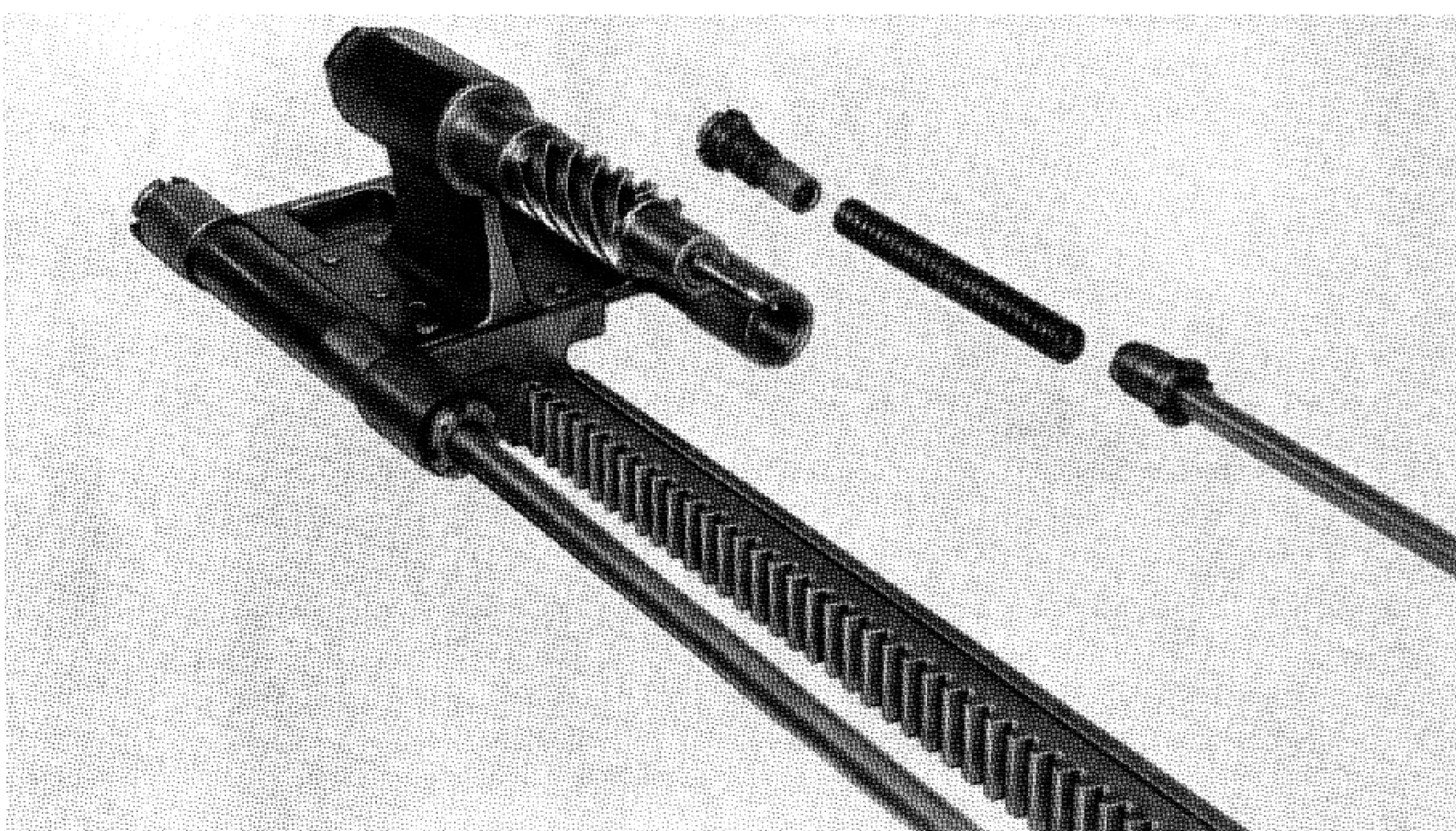

Figure 26–6. Experimental Italian 47-mm Aircraft Machine Gun, showing breechblock carrier.

Trigger and Sear Mechanism

The trigger and sear mechanism consists basically of a spring-loaded hand-operated plunger on the outside of the slide and three sear levers on the inside of the slide. All three sear levers may together or singly hold back the breechblock carrier in the cocked position. The first sear lever is actuated by the feed mechanism; when the last round passes a plunger in the feed guide, the feed mechanism sear lever is raised up and catches the breechblock carrier at the end of the firing cycle. The second sear lever is operated by a rod that runs along the inside bottom of the slide. This rod is connected to a lever that is depressed by a cam bracket on the left underside of the gun. When the gun barrel returns to battery position, the sear lever is depressed thereby allowing automatic firing. Therefore, in this case, the breechblock carrier will not be held in the cocked position. The third sear lever is operated manually. When the trigger plunger is depressed by hand, the sear lever is also depressed, allowing the breechblock carrier to go forward. Full automatic firing results only when ammunition is being continually fed to the mechanism and at the same time the trigger plunger is kept depressed.

Recoil and Counterrecoil Mechanism

The recoil cylinder contains four springs. There are two sets of springs, one set placed behind the other, with a separator collar in between. Each set of springs consists of one small-diameter spring within a large-diameter spring.

The counterrecoil cylinder is of the self-contained hydraulic type, of conventional design. However, there are no means of adjustment to regulate the return of the gun to battery position. The fluid contained therein is a mixture of water and glycerine.

SECTION 3. CYCLE OF OPERATION

Assuming that the breechblock is locked in the gun and the chamber is empty, the breechblock carrier must be brought to the rear and cocked. This is done manually by turning the hand operating crank in a clockwise direction. A pinion gear on the hand operating crank shaft meshes with a long rack in the upper left side of the slide. To this rack is connected the breechblock carrier which is supported by the driving spring tubes. When the carrier is brought to the rear of the slide, it is held there by the feed mechanism and manual trigger sear levers. With the carrier in this position, the upper and lower driving springs are compressed. When feeding the initial rounds of ammunition into the mechanism, the feed mechanism sear lever is disengaged from the carrier. A cycle of operation may now begin.

When the manual trigger plunger is depressed, the manual sear lever disengages from the carrier. Due to the action of the driving springs, the carrier and breechblock with the first round are driven forward. Upon seating of the round and breechblock in the gun, the carrier and firing pin continue to move forward, thereby locking the breechblock in the gun and firing the round.

When the gun barrel recoils to about 5 inches, the breechblock is unlocked since its arm and roller follow the cam guide on the bottom of the slide. The maximum recoil of the gun barrel is about 12 inches. At this point, the feed mechanism is pulling another round down. Although the gun barrel has reached its maximum recoil, the breechblock and carrier have yet to travel rearward about an additional 12 inches. As the gun barrel returns to battery position, a spring-loaded pawl attached to a bracket on the right underside of the gun barrel engages a sliding rack on the bottom of the slide. This rack meshes with a pinion gear that is on a shaft which has a gear on its opposite end (left side of slide) that meshes with the pinion gear on the hand operating crank shaft. This gear then meshes with the rack that is connected to the breechblock carrier to the rear where it is caught and held by the manual trigger sear lever.

It is not possible for the carrier to go into counterrecoil if the gun barrel is out of battery because of a ratchet and pawl on the bottom of the gun-operated rack. This pawl will keep the rack from moving rearward until the gun barrel is in battery position. The gun-operated rack on the bottom of the slide moves in the direction opposite to that of the driving-spring-operated carrier rack.

Chapter 27

JAPANESE AUTOMATIC AIRCRAFT CANNON DEVELOPMENT

Post World War II Study of Japanese Weapons

When the United States Army occupied Japan after World War II, a study was made of automatic guns which the Japanese had under development at the close of hostilities. Unfortunately, many of the actual model guns had been destroyed, either during bombing raids or by the Japanese themselves to prevent capture. However, evidence that was gathered indicated that virtually all known gun systems had been copied by the Japanese. In addition to the designs borrowed from other countries, the Japanese had several unconventional designs in the developmental stage. In the latter category is a group of so-called "recoilless" guns, produced by the foremost Japanese designer of automatic guns, Mr. Shiro Kayaba. The inventor had retained photographs which enabled the United States ordnance team to reach certain conclusions concerning the various models.

13-mm, 20-mm, and 37-mm Models

The two 13-mm guns, the 20-mm model and the 37-mm design operate on an improved Maxim principle, wherein the single major spring acts as barrel return, bolt return, and buffer. This action is accomplished by forming the accelerator as an extension of the rear arm of the toggle joint, which is pivoted on the rear of the barrel extension. An anchor, pivoted in the receiver is linked to the accelerator. An important advantage of this design

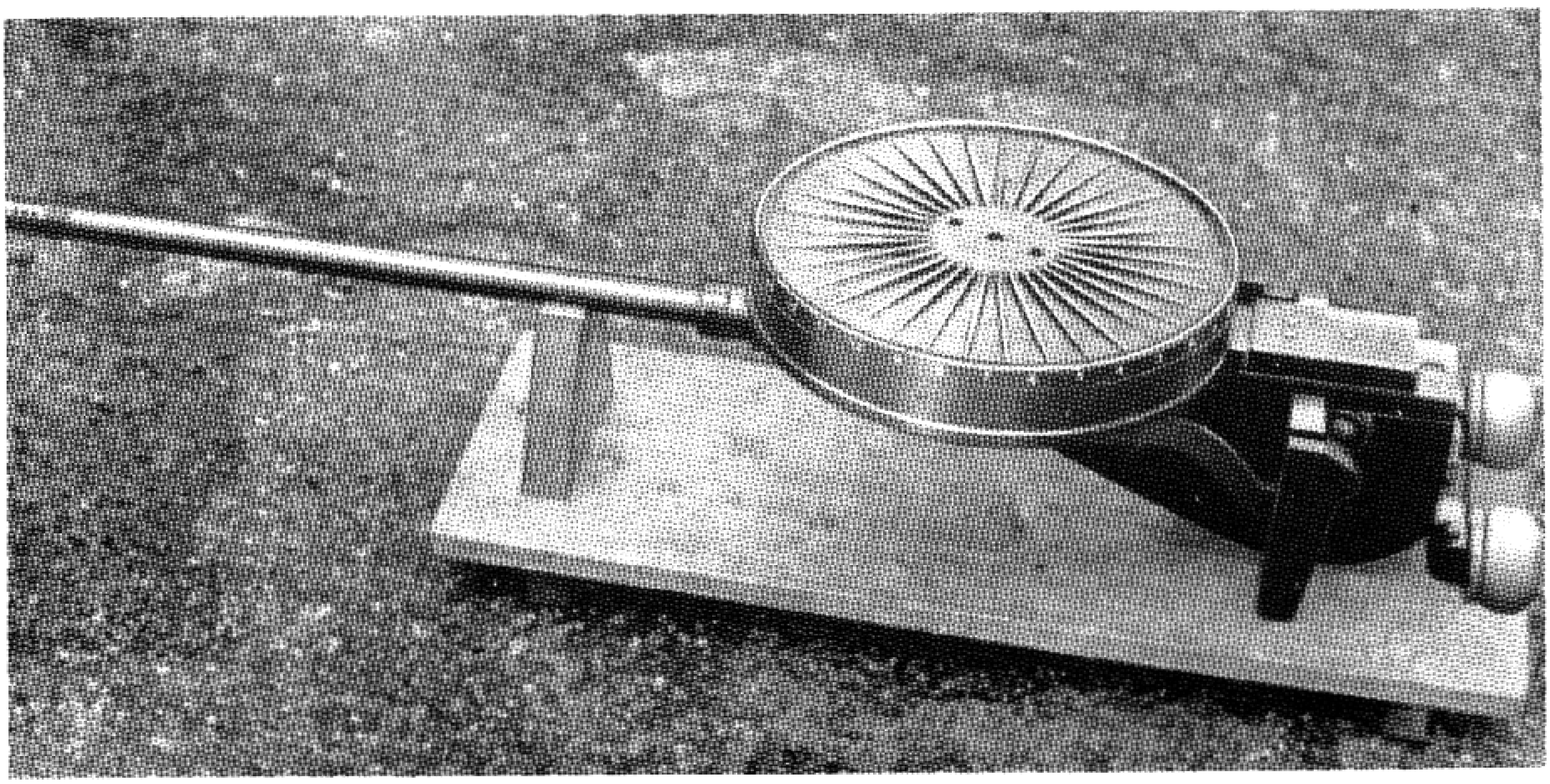

Figure 27–1. Japanese 13-mm Drum-Fed Machine Gun.

is the complete mechanical timing of the bolt and barrel extension which is incorporated in the toggles and linkages.

40-mm "Recoilless" Machine Gun

The 40-mm gun appears to be designed to discharge a blast of gas to the rear when fired, in order to counteract the recoil force. This action, in conjunction with the action of a cradle having recoil and counterrecoil springs, would permit a high degrees of recoil-damping. In all probability the 40-mm gun was designed around the caseless round of ammunition for the Japanese HO–301 gun.

80-mm Recoilless Gun

The 80-mm gun is nonautomatic and, like the 40-mm design, discharges gas to the rear. It is a simple affair and apparently was intended for some type of free suspension. This gun incorporated no radically new ideas.

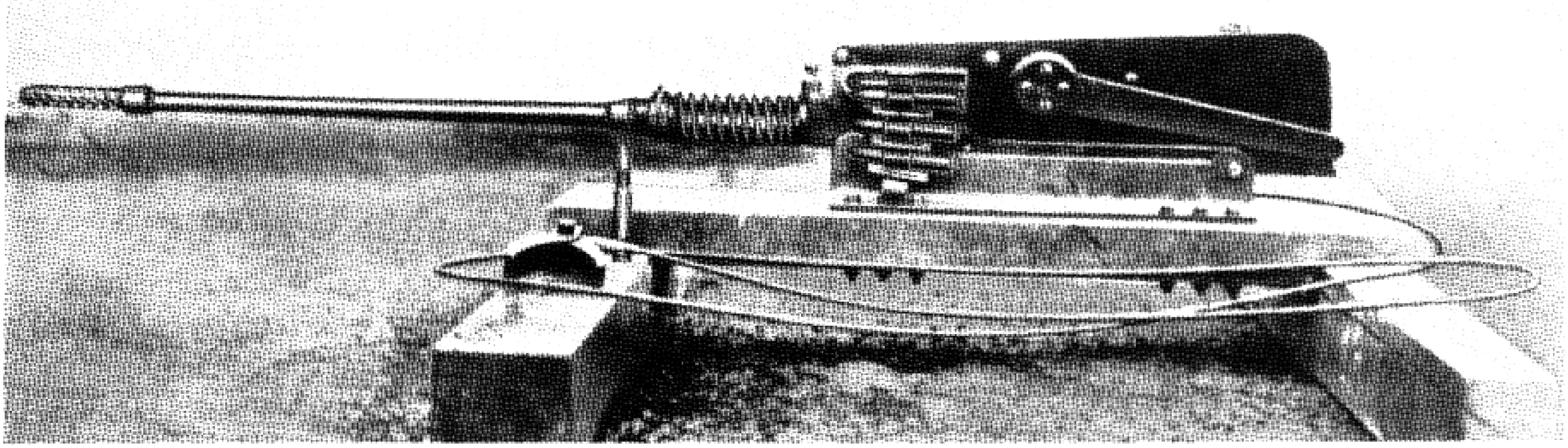

Figure 27–2. Japanese 13-mm Belt-Fed Machine Gun.

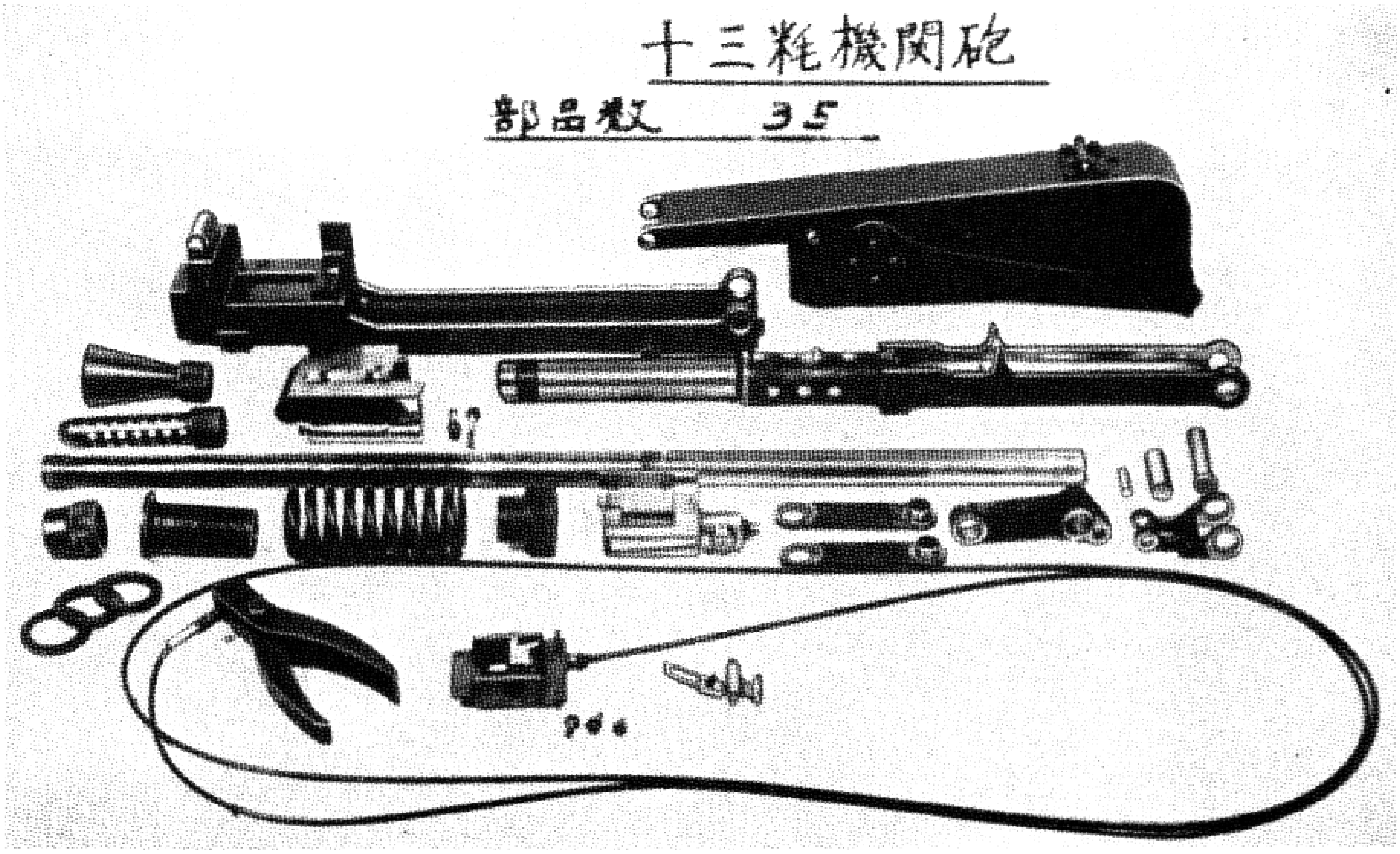

Figure 27–3. Japanese 13-mm Belt-Fed Machine Gun, stripped.

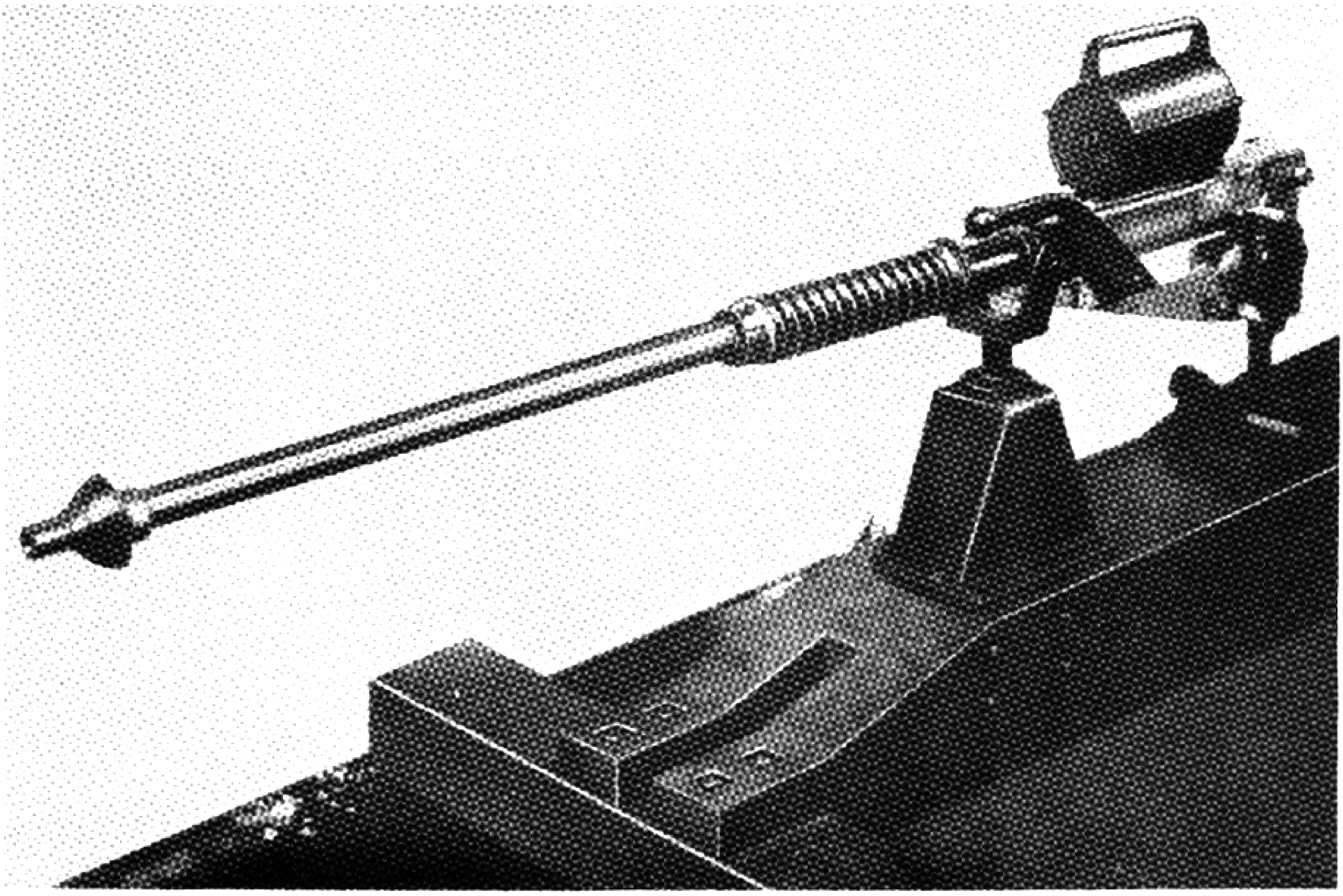

Figure 27–4. Japanese 20-mm Drum-Fed Machine Gun.

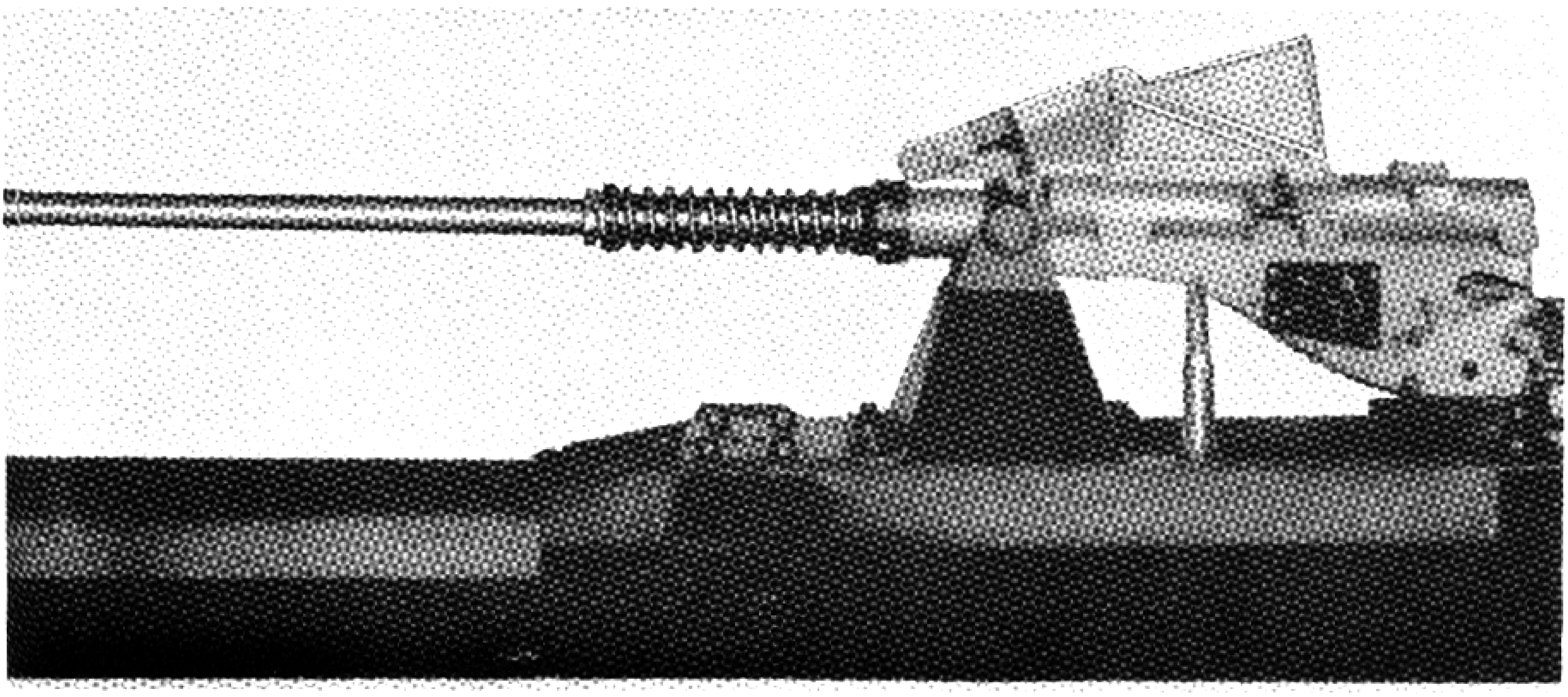

Figure 27–5. Japanese 37-mm Magazine-Fed Machine Gun.

258970° 54— 44

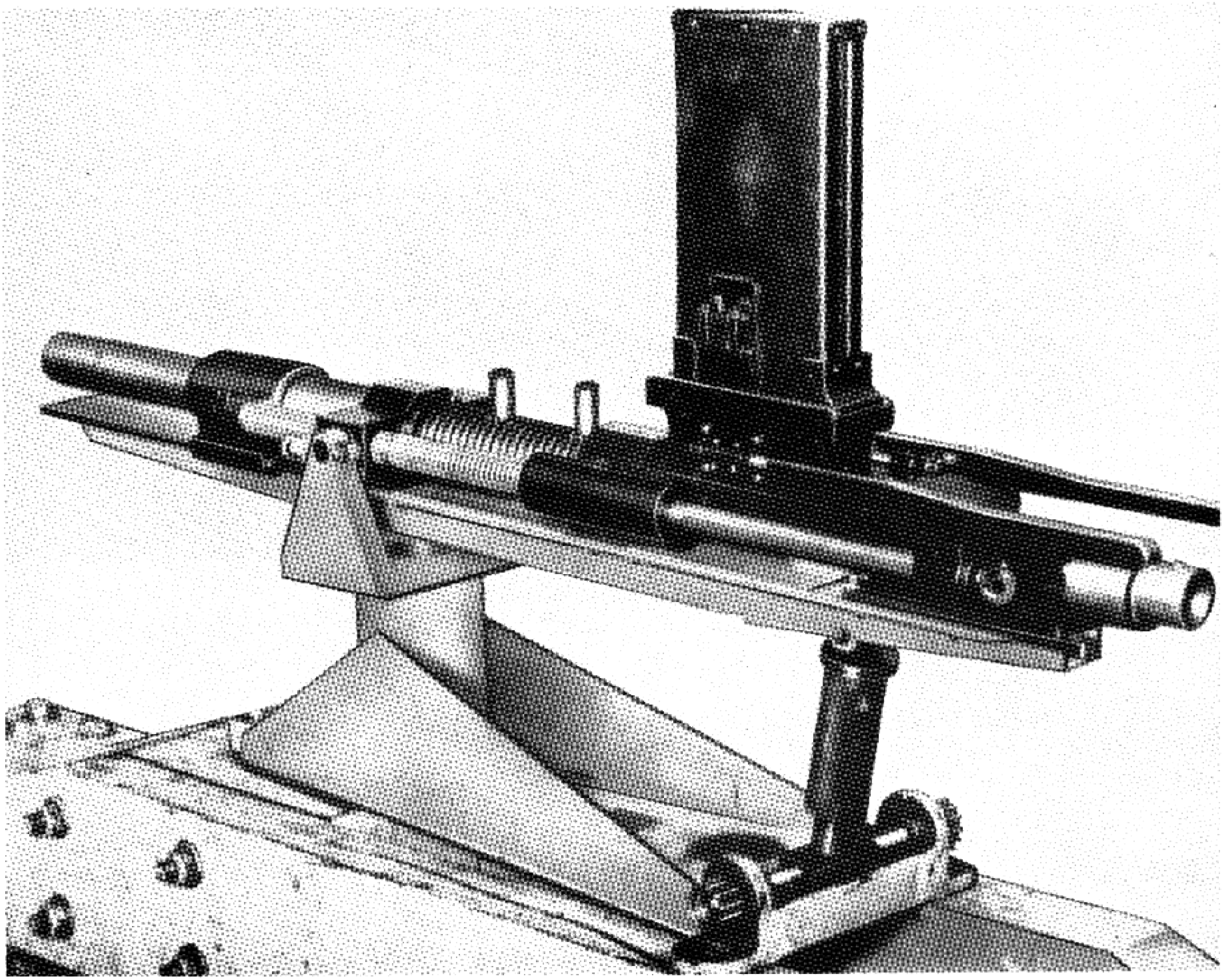

Figure 27–6. Japanese 40-mm "Recoilless" Machine Gun.

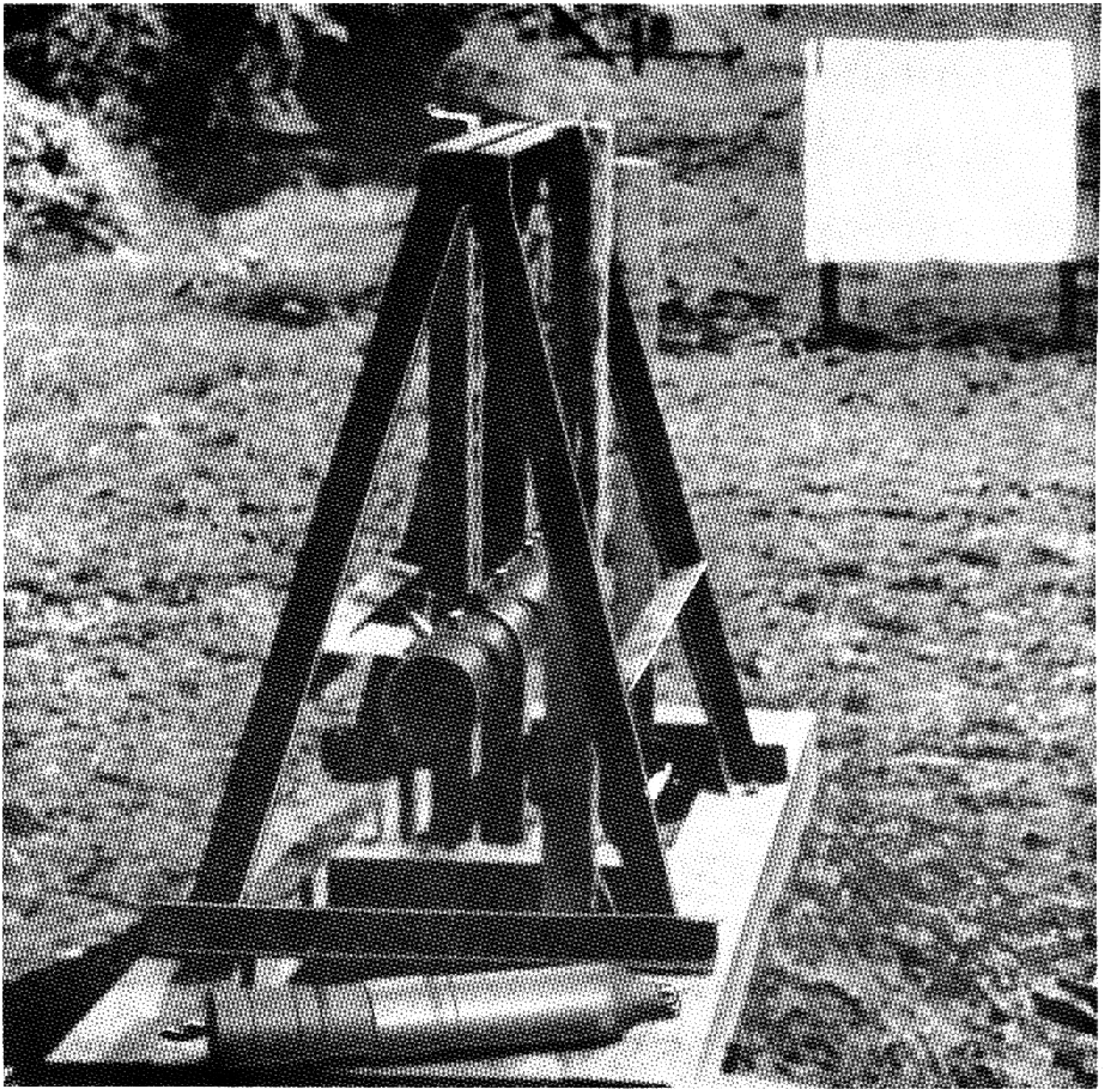

Figure 27–7. Japanese 80-mm Recoilless Gun on test stand.

INDEX

258970°—54——43

U. S. GOVERNMENT PRINTING OFFICE: 1954