Chapter 5

BERESIN AIRCRAFT MACHINE GUN AND VYA AIRCRAFT CANNON

Weapons Included in This Chapter

Beresin Aircraft Machine Gun

Designation	Bore diameter	Use	Year of appearance
BS	12.7-mm	Fixed	1940
UBT	12.7-mm	Flexible (turret)	Early in World War II
UBK	12.7-mm	Fixed installation in Wings.	
UBS	12.7-mm	Synchronized through propeller arc.	

VYa Aircraft Cannon

Designation	Bore diameter	Use	Year of appearance
VYa	23-mm	Fixed	Early in World War II.

History and Background

Shortly after the invasion of Finland by the U. S. S. R., the Russian Air Force replaced the small-bore rifle caliber Shkas with the 12.7-mm Beresin Aircraft Machine Gun.

The Shkas was a comparatively intricate and well finished gun, the cost of which necessitated that it be kept in operating condition as long as possible by repair and replacement of parts. In contrast to the Shkas, the Beresin was deliberately expendable, that is, the Soviets' plan was to discard the entire gun after a short period of use during which one or another of the principal operating mechanisms became worn or broken.

The design of the Beresin machine gun was greatly influenced by a captured Lahti 20-mm machine cannon (see Volume 1, pages 596–597); many features of the Finnish gun appear in all models of the Beresin.

The earliest version was called the BS, which stands for Beresin Samolenti (Beresin Aircraft). Reports indicate that it was produced late in 1940.

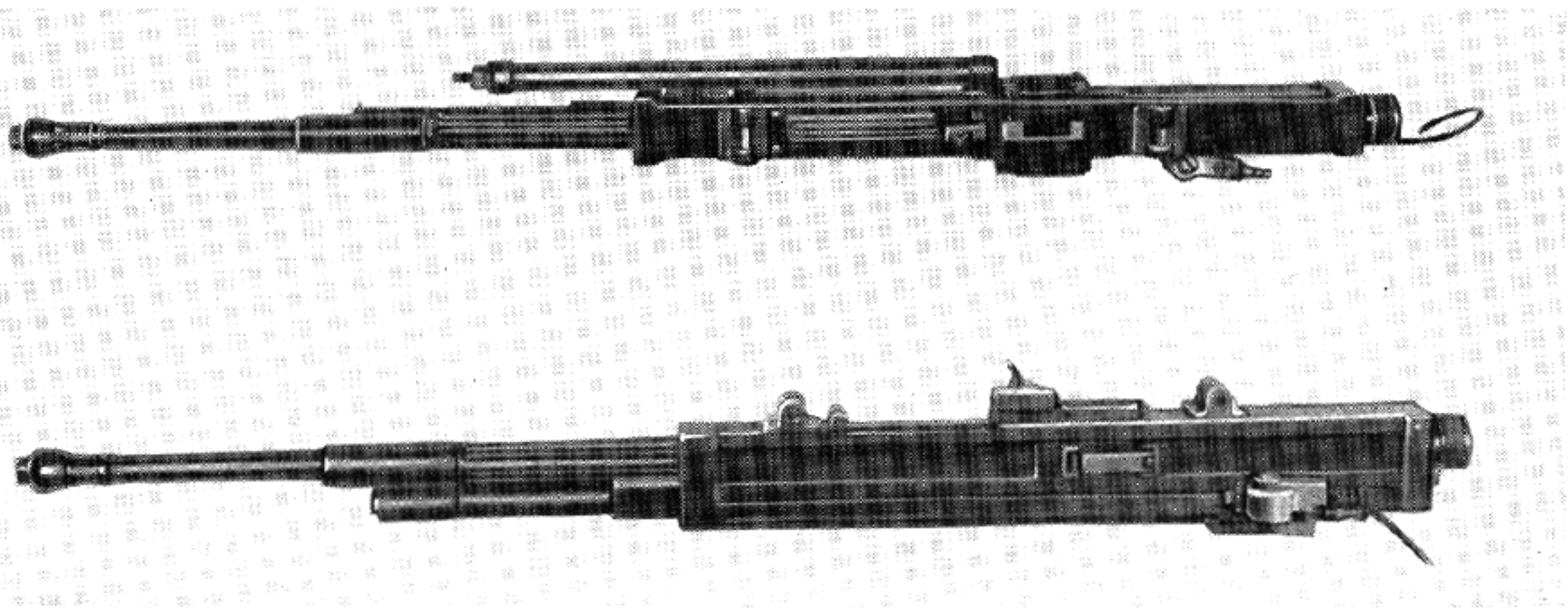

Figure 5–1. The Finnish Lahti Machine Cannon, top view (above) and left side (below).

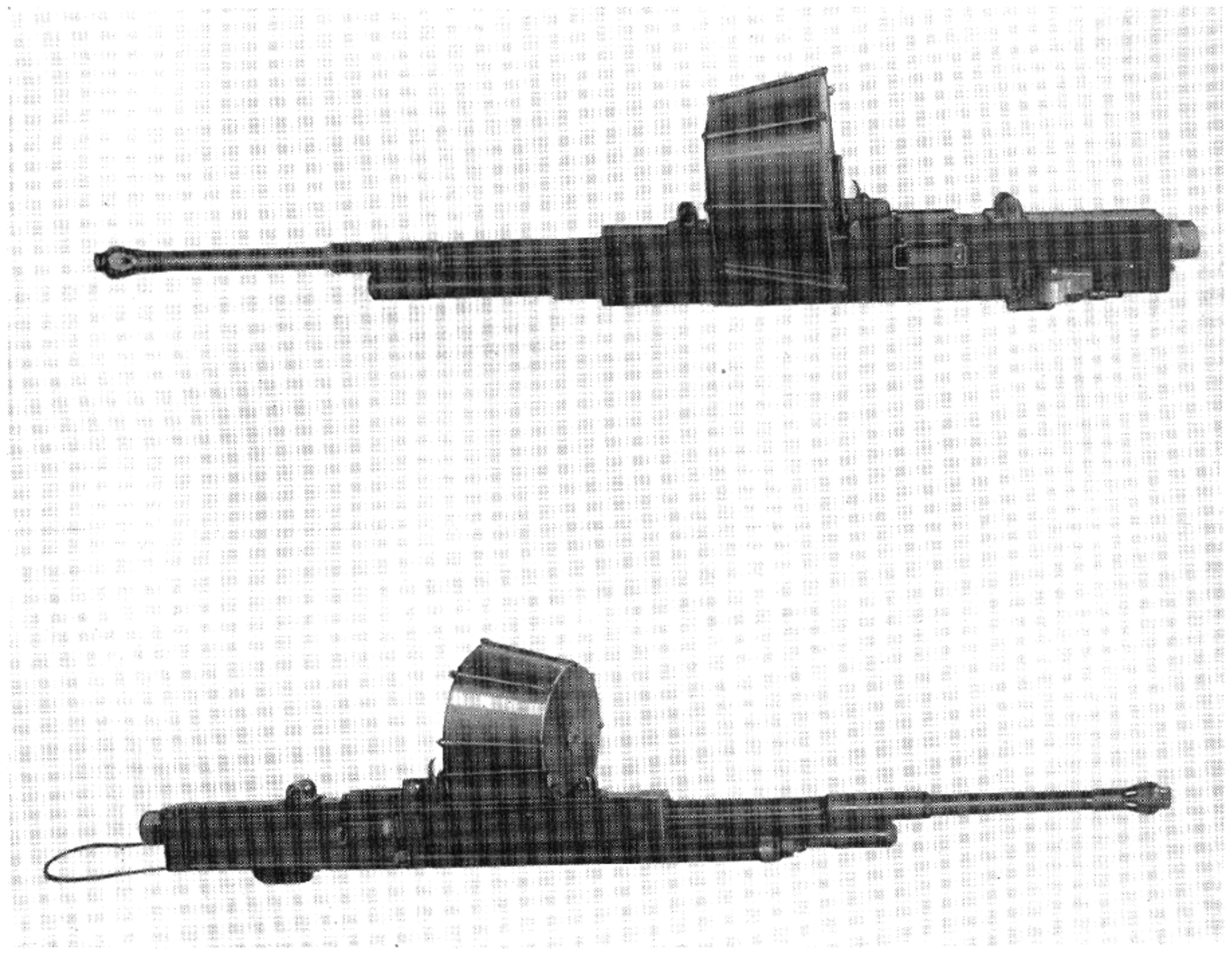

Figure 5–2. The Lahti Cannon with its feed drum, right and left side views.

The first instructors' manual put out for the field service was on what was known as the "Universal Gun" and appeared in 1941, a fact which seems to indicate that only a few of the BS type were made.

Later models were marked UBS, UBK, and UBT to show their intended method of mounting. The ones stamped UBT were for turret installations; the UBK guns were installed fixed in wings; while the synchronized weapons were given the designation UBS and fired through the propeller arc.

Since the larger caliber Beresin machine gun was designed to replace the rifle caliber Shkas in practically all aircraft, it was necessary to improvise a power system with an electrical servo unit to perform the lateral movement of the mid-upper turrets. Successful installation of two UBT 12.7-mm guns with ammunition boxes containing 500 rounds for each gun were made with this sort of arrangement.

This type of Russian offensive armament was not undertaken until well along in World War II. The Russian General Staff held that the low mental level of the masses would necessitate training that would be too expensive in both time and money to warrant construction of many such complicated devices.

VYa Aircraft Cannon. When it became apparent that rifle caliber machine guns were not adequate for the arming of aircraft, the Russian High Command, still following their fixed policy of using only proved and reliable weapons, ordered the engineering design team of Volkov and Yartsev to take the battle-tested Beresin automatic firing mechanism that was then being made in 12.7-mm only and scale it up to use a high velocity 23-mm cartridge.

Figure 5–3. F. N. Volkov, one of the two engineers whose initials appear on the 23-mm VYa Gun.

The Soviets' choice of engineers for this all-important job proved sound, for in a short time there appeared an automatic aircraft cannon that is identical basically with the well known Beresin. This weapon was the first-line aircraft cannon throughout World War II and was used extensively in close air support.

The identification VYa is derived from letters in the names of the designers.

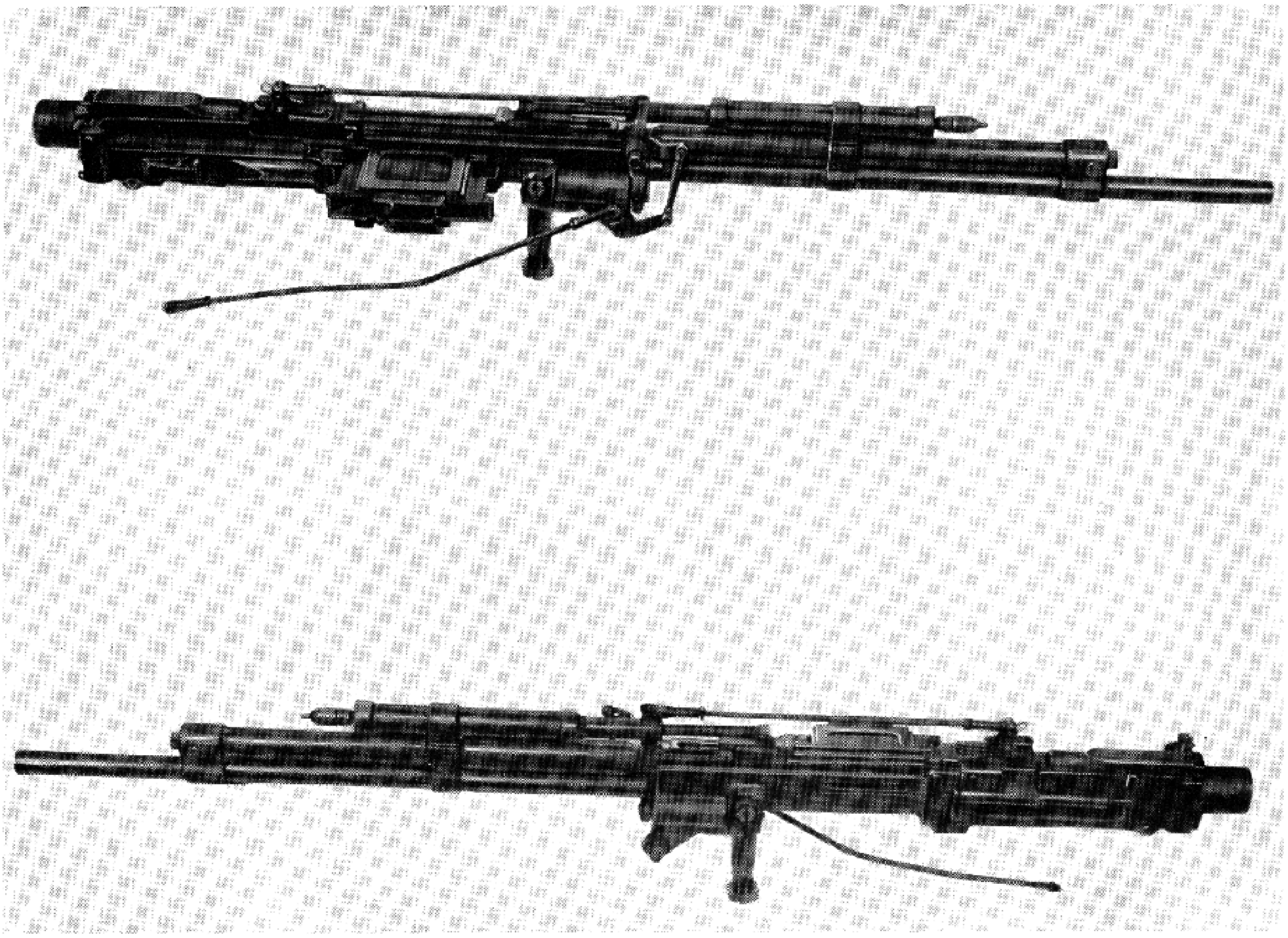

Figure 5 4. The 12.7-mm Beresin Aircraft Machine Gun.

SECTION 1. BERESIN AIRCRAFT MACHINE GUN

General Data

Caliber: 12.7-mm.
Rate of fire: 700–1,000 rounds/minute.
Muzzle velocity: 2,800 feet/second.
Gun length:
UBS and UBK: 53 inches.
Gun height: 6.3 inches.
UBT: 55 inches.
BS: Not standardized.
Gun weight: 47 pounds–56 pounds.
Gun width: 5.9 inches.
System of operation: Gas.
System of locking: Lateral stirrup-shaped piece moves across into recess in receiver.
System of feeding: Disintegrating belt.
Method of cooling: Air.
Method of charging: Pneumatic (manual on frec gun).
Barrel weight: 13.5 pounds.
Barrel length: Rifled part, 35 inches.
Barrel removal: Not quick change.
Chamber pressure: 44,000 psi.
Bore:
Number of grooves: 8.
Groove depth: 0.0066 inch.
Groove width: 0.11 inch.
Pitch: 6°02′27″.
Direction of twist: Right hand.
Form of twist: Constant.
Method of headspace: Barrel wedge.
Location of feed opening: Right side.
Location of ejection opening: Left side.

Description of the Weapon

The Beresin was designed primarily for aircraft use; however, the earliest model, the BS, was readily adaptable to antiaircraft use and was applied to a variety of ground armament, especially on armored vehicles.

The weapon is gas operated. The firing pin is not spring loaded. It protrudes beyond the bolt face just far enough to detonate the primer when it is driven by a pivoting piece striking the receiver. Removal of the empty cartridge case from the face of the bolt is accomplished by a rib running through the bolt body, camming the empty case clear of the receiving walls.

The guns designated UBS and UBK are charged pneumatically, while the UBT is loaded by a hand lever and has a much heavier and longer barrel than the other two guns.

The weapon is rear seared and there is no provision for single shots, firing being full automatic only. As an auxiliary safety device, if needed, the gunner can hold the bolt by the pneumatic or manual charger to the rear.

Feeding is always done by a metal, pull-out type link belt. The bolt always remains in a cocked position at the end of each burst to exclude the possibility of accidentally firing the cartridge due to a "cook off" in an overheated barrel or chamber. The Russians also went so far as to have a special alloy for their bullets, which they claim gives prolonged life to the barrel.

Feeding is performed from the right side only and is not interchangeable. A modern metal disintegrating link belt is used. The links fall from the right side of the receiver after the withdrawal of the cartridge, which is a very unusual feature. Ejection of the empty cartridges is done through a slot in the left side of the receiver, on the opposite side from which the gun is fed.

These peculiar characteristics no doubt were purposely incorporated in this weapon to give a cleaner installation, in harmony with the Russian practice of mounting aircraft guns beneath the engine cowling. In fixed installations, a heavy spring-loaded arrangement is invariably found, in which the forward part of the gun is supported flexibly by two

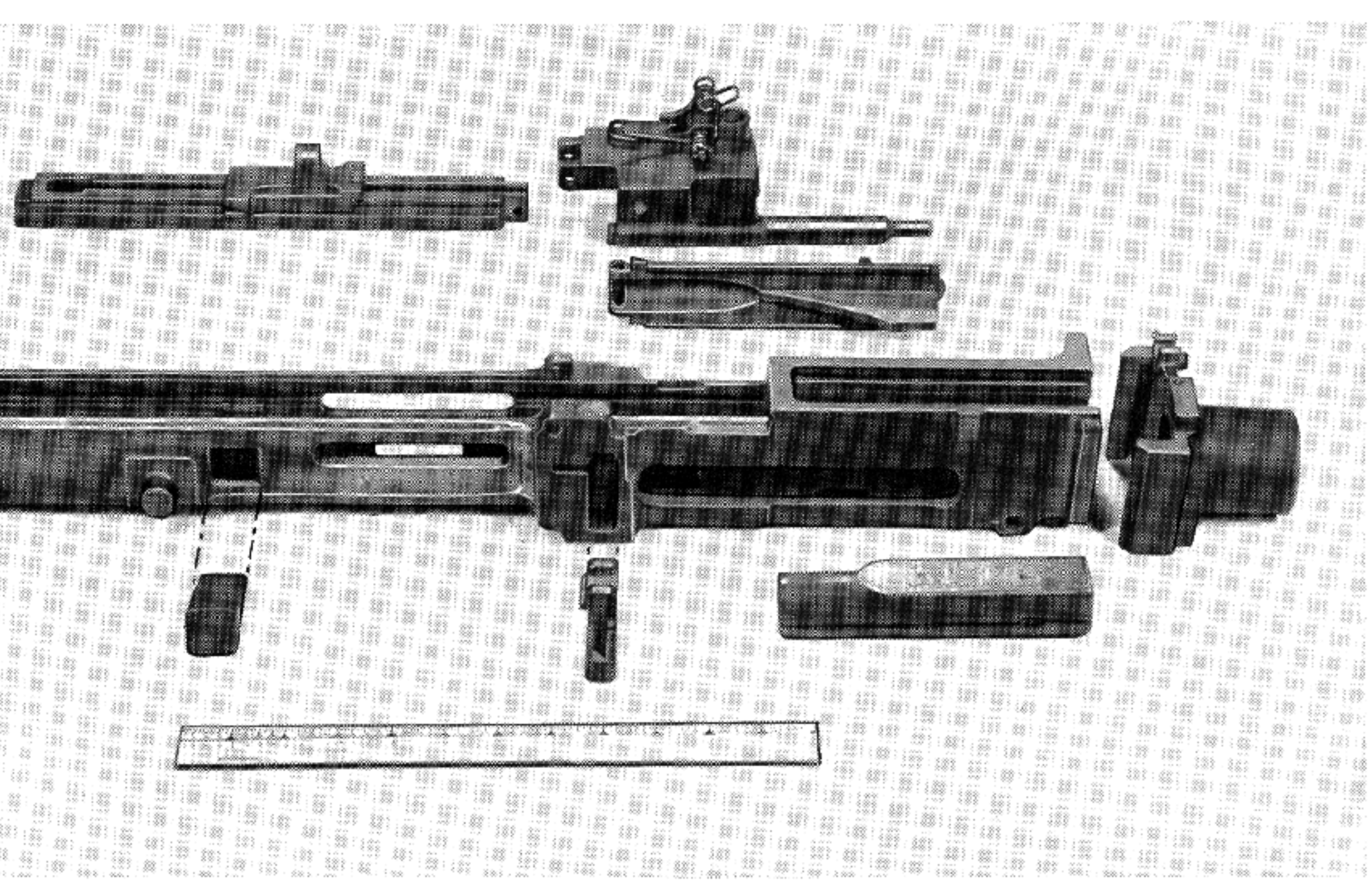

Figure 5–5. Receiver group of the Beresin, disassembled. In the foreground are the barrel retaining wedge (left) and the bolt lock (center), with dotted lines indicating their recesses in the gun body.

trunnions on the body casing, while the rear is fastened in a sliding plate that can move back and forth in a rigid yoke.

Locking of the Beresin is accomplished by forcing the U-shaped breech lock into its locking recess by advancing a sliding bar or bolt extension.

This weapon is sturdy in construction and follows the Soviet procedure of wasting as little effort as possible on the exterior appearance.

As with other Soviet mass-produced weapons, semi-skilled labor is used to the utmost on parts that do not have to be made with finesse or precision, whereas the operating components receive separate manufacture and intricate milling by qualified workmen. The whole weapon is assembled at a plant devoted solely to such activities. Where filing is required for fitting, no attempt is made to remove the marks, and no finish is employed solely to better the outward appearance of the gun.

At first, omission of hardening caused the weapon to have a quick drop in rates of fire after the soft metals began to burr and deteriorate from use. Correction of this flaw soon followed, but only the parts that were offending the most were hardened. However, the weapon, like so many of the earlier guns, was reliable regardless of its crude workmanship.

For aviation use, the Beresin uses both general and special types of ammunition such as tracer bullets, armor-piercing incendiaries, and explosive bullets which have sensitive and immediately reacting fuzes. The Beresin series uses one type of cartridge which is used in the DShK Degtyarev-Shpagin Heavy), but it will not employ the same type of ammunition belt.

The defensive armament of the first Russian aircraft equipped with this gun was very primitive. Gun positions and turrets were generally hand operated; this imposed heavy physical demands on the air gunners. The chance of scoring hits under these conditions was correspondingly impaired.

The UBT, UBK, and UBS include the following modifications of the original BS. Other changes were of a minor nature.

a. The weight was increased by 2 pounds.
b. Components could not be interchanged.
c. Improved belt feed mechanism.
d. Improved connection of the slide and piston.
e. Changes in the groove in the slides.

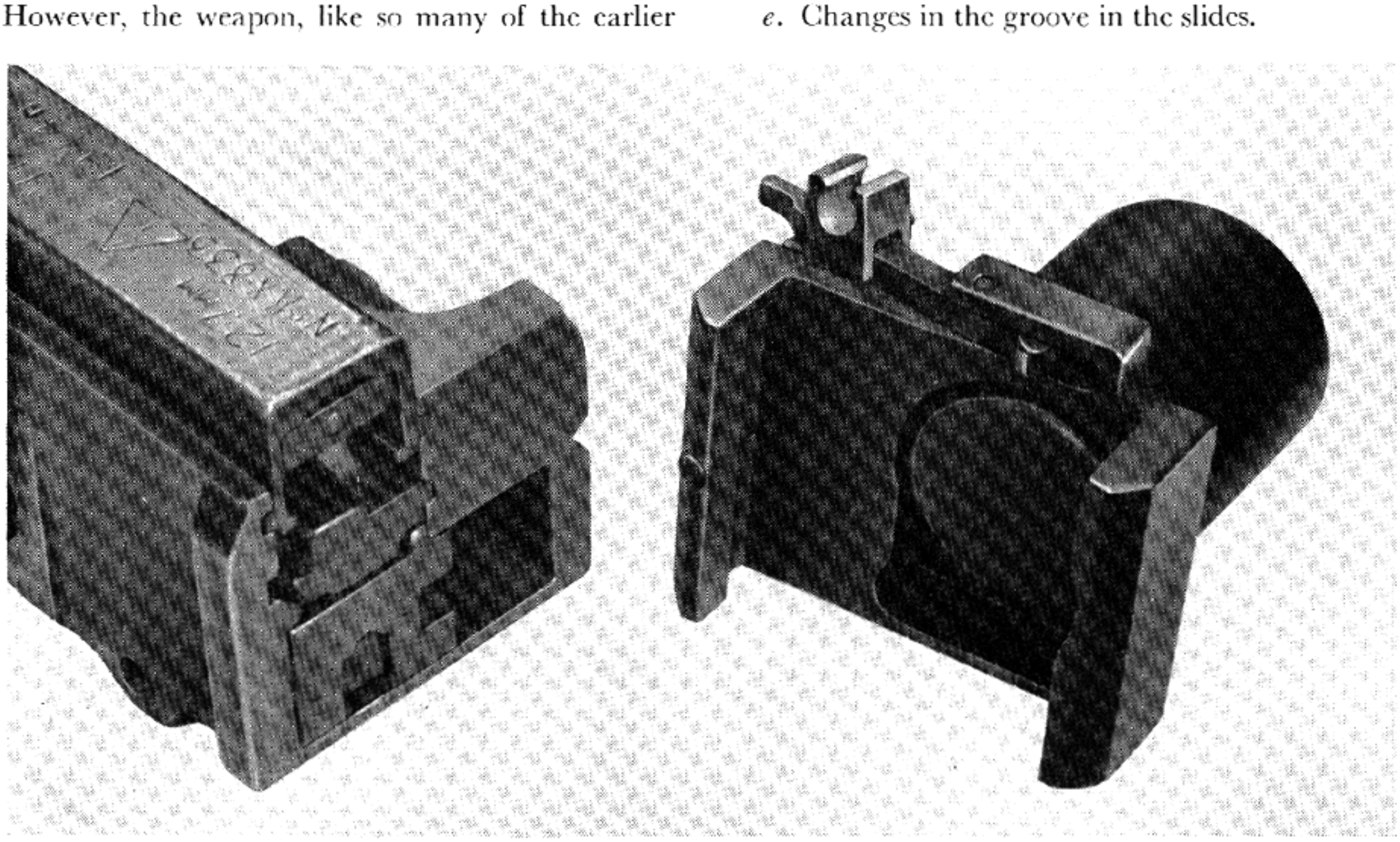

Figure 5–6. Rear of the receiver of the Beresin Machine Gun, showing backplate with buffer removed. This method of gun construction uses the backplate to prevent spreading tendencies of the sideplates.

f. Improved method of securing the firing mechanism to the receiver.

g. Change in the provision for fastening the buffer to the gun.

Cycle of Operation

To fire the Beresin, the operator pulls the first cartridge from a feed box on the right side of the receiver, and pushes the cartridge and its link under the belt-holding pawl. The bolt must be fully forward.

The charging handle is pulled all the way to the rear, and a T-slot on the bolt face, which is connected to the gas actuating piston, withdraws the cartridge from the belt and positions it farther down in the T-slot. The disintegrating link drops out of the right side of the receiver. The rear sear holds the operating mechanism back in the cocked position with the cartridge against the bolt face.

When the trigger mechanism is actuated, the bolt and gas piston are driven forward by the compressed driving spring. The bolt arrives in battery first and is now behind the chambered round with the locking piece directly over the cuts in the breech lock plate in the receiver. The gas piston is held to the rear by the lug engaging a small swinging portion resting in its recess in the bolt.

The gas piston now cams the U-shaped lock in the receiver and the lock then takes it place in the breech lock plate. At the same time, the pivoting member swings outward, permitting the gas piston to travel onward. As the face of the semicircular firing pin is freed by the raising of the U-shaped lock, the firing pin strikes the end of the receiver and pivots, thus driving the pin into the primer which in turn fires the cartridge.

The stirrup, or U-shaped locking piece, holds the bolt face securely behind the base of the cartridge in the chamber until the bullet passes the barrel's gas port. A certain amount of gas is then bled into a cylinder located on the barrel, and it starts the piston to the rear by the time the bullet has cleared the

Figure 5–7. A Beresin Machine Gun used for antiaircraft defense by Soviet ground troops in World War II. The light-weight barrel does not permit long bursts of sustained fire in such an installation.

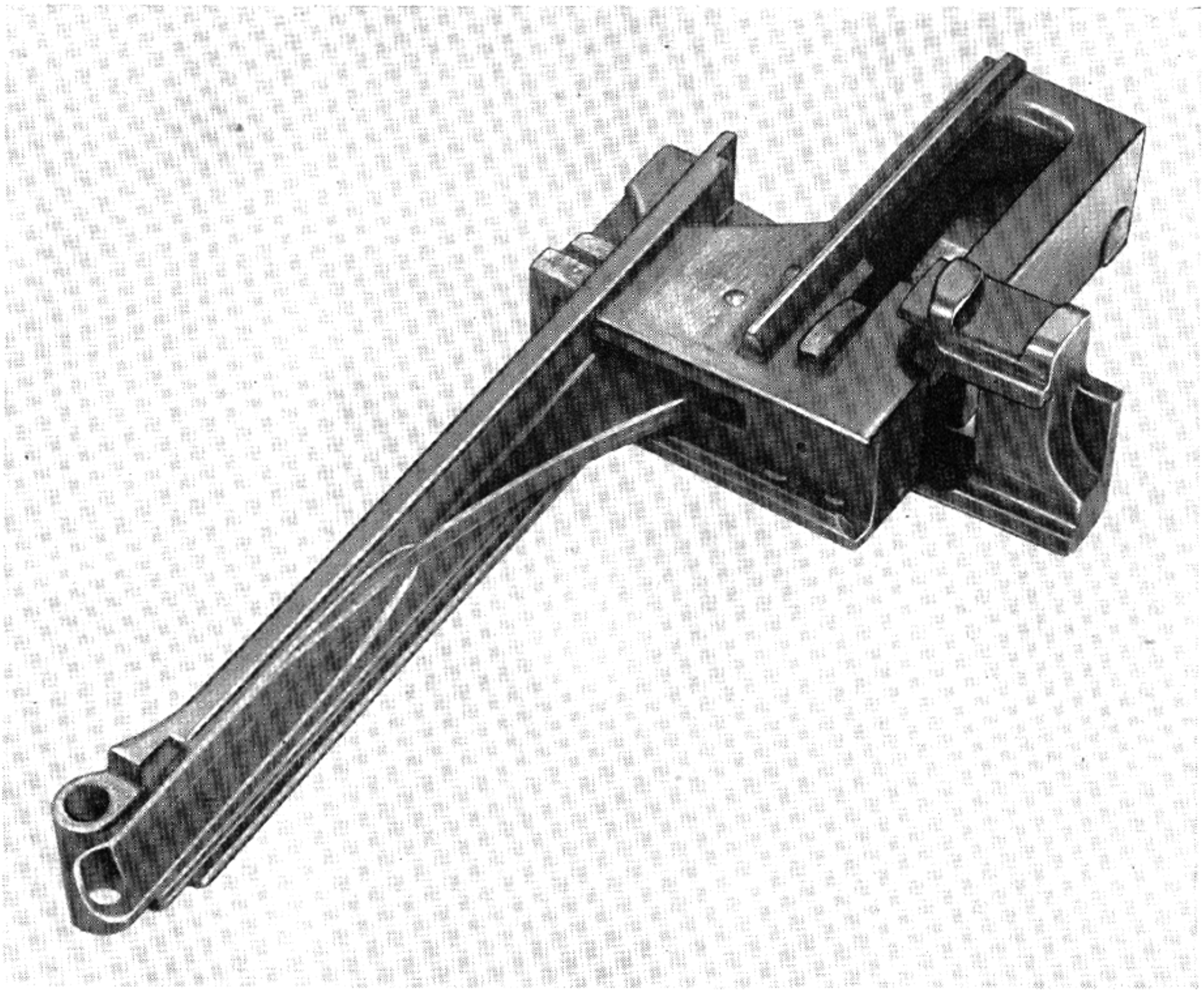

Figure 5–8. Important elements of the Beresin action. The bolt (center) slides between the fixed feed cam (left) and the bolt lock (right). The lock has only lateral motion in relationship to the receiver.

bore. In the first fractional part of its movement, the piston partially retracts the positioned cartridge in the feedway and places it into the T-slot, where complete recoil of the bolt assembly withdraws the round fully from the link and a ribbed arrangement cams it into the T-slot. In the first half inch of recoil, the lug of the gas piston releases the breech lock, which moves gradually to the left before totally unlocking.

This system of two-stage unlocking permits a gradual creeping of the bolt rearward to loosen the round, thereby performing a function known as initial extraction. By the time final unlocking of the bolt is acomplished, the cartridge has been fully loosened and the T-slot extractor needs only to hold the empty case in position for ejection. This takes place at a distance from the breech end of the barrel, which is greater than the over-all length of the loaded cartridge.

A rib enters its slot in the bolt body, causing the loaded cartridge to force the incoming round to the left and to drive the spent case through an ejection slot in the left and aft side of the receiver. This last act places the incoming cartridge in the T-slot, in position for chambering.

The base of the loaded cartridge cams back the free-floating firing pin. The rib causing this action is of very unusual shape, being uniform in width and

increasing in height at an accelerated rate. The gas piston and bolt asembly continue to recoil until it strikes an unusually heavy spring buffer deflecting it into counter-recoil. If the trigger is held down, the cycle of operation is repeated.

The cyclic rate of fire can be adjusted for use in a synchronized installation by means of four gas orifices marked 3.2 mm., 3.0 mm., 2.8 mm., and 2.6 mm.

Disassembly of the BS by Groups

1. Release the sear lever, unscrew the rotatable part 1¼ inches to 1½ inches to the rear of the rearmament cable. Release the cable and the movable parts, seeing to it that the spring does not fly up.
2. Drive out the bolt and pin that hold the pivot in the bottom of the synchro-mechanism box. This act disengages the components from the breech.
3. Prepare the barrel for changing by removing the pin with pliers and the bolt with a wrench or similar tool.
4. Separate the barrel from the breech by unscrewing and removing.
5. Separate the piston rod, the piston, and the recuperator spring from the slide. Remove the outer tube of the piston rod (by turning ¾ to ⅞ of an inch to the left).
6. To remove the rear plate, pull to the back the bolt which is holding the back plate. Remove the cotter pin, thus releasing the bolt. The back plate and the spring in the back plate must be removed carefully so that the spring will not fly up.
7. Release the trigger pull mechanism from the back along with the guide for the breech housing.
8. Remove the cover from the feed belt.
9. Remove the breech guide and the pins by using pliers.
10. Pull the breech bolt and its slide to the rear and separate one from the other.
11. Remove the breech and the breech bolt.
12. Remove the feed lever, and separate the plunger from the feed lever.
13. Disengage the cartridge belt.

Assembly of the BS by Groups

1. Replace the cartridge belt holding pawls.
2. Replace the breech bolt in the breech.
3. Start the removable slide breech into the breech block as follows: Place the movable breech in the guideways of the receiver. Completely couple the breech with the slide, then fit the guide into the breech.
4. During assembly, the breech spring is replaced in the slide.
5. Place the feed lever in the feeder collar, and check contact with the conduit breaker before the sear is placed in the breech.
6. Put the feed table in place.
7. Place the feed belt cover in the slide.
8. Assemble the piston rod with the slide. To raise the breech, adjust the spring by turning the lug of the rod to an angle of 30° or 40°. Connect the slot in the slide with the lug of the rod. The plunger bracket is placed to hold the cover securely. Turn the socket of the piston rod until it engages the receiver.
9. Assemble the barrel with the receiver. To operate properly, the barrel must be held securely. Care must be exercised to make sure that the barrel enters the enclosure of the receiver.
10. Place the locking device of the barrel into the receiver; position the barrel-holding wedge by pressing firmly toward the right until it fastens securely.
11. Place the trigger mechanism in the receiver by pressing it all the way into its groove guides.
12. In placing on the back plate, put the front wings of the buffer into the receiver in such a manner that the face of the disk is even with the front of the back plate.
13. Mount the synchronizer mechanism in the receiver. Place the half circular disk in position and press it into its housing, put the bolt toward the rear to serve as pivot point in the box. Release the bolt during the mounting. Be sure that the lever is engaged with the sear.

Other Procedures

Manuals issued by the Russian Army concerning the maintenance and operation of the Beresin machine gun indicate that hammering and filing of the parts is considered necessary for the fitting of components in the field.

The following quotation is taken from a Russian manual. "In inspecting the barrel, be perfectly sure there are no swelling or splits; if there are, the barrel must be replaced. The end of the barrel entering and locking in the breech must be cleaned with emery and a file. The brazes and scratches of

the rifled part of the barrel are removed with a very light emery. Clean with patches of cotton cloth on a ram rod, then with oil, passing the cotton patches through until they come out clean. Inspect the chamber for longitudinal small scratches. The transversal scours and scratches must be removed, as they cause jamming of the barrel; therefore, it is of the utmost importance to clean the bore well at all times. During the inspection of the chamber of the gun, make certain that there are no cracks or splits or swellings in this portion or any places where the movable parts would contact during firing. Be certain to use emery and polish the chamber and the parts inside. The bracket is released and cleaned separately."

This manual includes a check-out list for ordnancemen to use before a plane takes to the air. It is given here:

"Before combat flight, the machine gun must be lubricated and checked. Note that the barrel and breech bolt are correctly assembled. Note that the cartridge belt is started correctly, the pawl is in operating condition and the belt moves freely, and that there are no malformed cartridges in the belt. After the mounting of the machine gun in the airplane, it is necessary before feeding to verify the functioning as follows: by the aid of the pneumatic system of the re-arming lever, arm the machine gun. This type of machine gun cannot feed while the bolt is in battery. To feed, place the movable parts in a forward position engaging the first round in the belt. This positions the center pawl one space forward. Be sure that the feed pawls are operating correctly. Check the springs and their action. Check the sear and the actions of the scar. To arm the machine gun completely, it is necessary to retract the recoiling parts to the extreme rear. These parts are now against the sear, and the cartridge in the T-slot ready for chambering. The machine gun is ready to fire."

This manual also includes a table of malfunctions that were the most prevalent with this gun; the first one listed is the faint strike, or non-firing primer. The causes of this are listed as:

a. Bad quality of cartridge.
b. The spring too weak.
c. The percussion spring broken.
d. The firing pin badly worn or broken.
e. The breech lever worn out.
f. The sear release lever not in the receiver.
g. Disassemble and clean the removable breech.

The remedy given for each of these situations is as follows:

a. Reload the magazine and continue to fire.
b. Replace the percussion driving spring, afterwards making certain the cause of malfunction was a result of a bad spring.
c. Change the firing pin pivot pin.
d. Change the firing pin.
e. File the guides of the receiver.
f. File the breechblock so that the part enters its groove. The clearance should be as much as 0.005 inch. The plunger of the firing pin can now enter freely.
g. Disassemble and clean the removable breech.

The second most prevalent malfunction listed is "the cartridge stuck in the chamber." As in the No. 1 malfunction, the cartridge was named as the first cause. These statements suggest that there was considerable trouble with defective cartridges.

The causes of case seizure in the chamber are listed as:

a. Bad quality of cartridge.
b. Not adequately lubricating the weapon and its ammunition.
c. Friction of the belt in the feed guide.
d. Recuperative spring too weak.
e. Recoil incomplete.
f. Trigger badly worn.
g. Coupling worn out.
h. Cartridge extractor worn.

To remedy this fault, the following remedies are listed:

a. Reload the machine gun and continue to fire.
b. Disassemble and clean, and inspect all operating parts at regular intervals.
c. Inspect the belt, feed guide, and support.
d. Replace the recuperative spring.
e. Examine all movable parts.
f. Replace the lever of the automatic trigger.
g. Replace the coupler.
h. Replace the cartridge pawl.

This manual states that of the ten most common malfunctions encountered in the field, 85 percent were traced to bad cartridges; and, further, that when all the cartridges are fired and the last one is

not ejected, if the bolt is not caught on the sear it returns to battery forcing the empty cartridge case back into the chamber, which by now is overheated. The usual result is the cartridge stuck in the chamber, making it necessary to cool the gun for removal of the empty case.

SECTION 2. VYα

General Data

Caliber: 23-mm.
Rate of fire: 650–750 rounds/minute.
Muzzle velocity: 2975 feet/second.
Gun length: 84.53 inches maximum.
Gun width: 6.18 inches.
Gun height: 7.6 inches.
Gun weight: 145.2 pounds.
System of operation: Gas, piston operated.
System of locking: Lateral stirrup-shaped piece moves across receiver into locking recess.
System of feeding: Disintegrating belt.
Method of charging: Pneumatic (manual on free gun).
Method of cooling: Air.
Barrel length: 64.96 inches.
Barrel removal: Not quick change.
Chamber pressure: 47,200 psi.
Bore:
Number of grooves: 10.
Groove depth: 0.0138 inch.
Groove width: 0.205 inch.
Pitch: 5° 34′ 27″.
Direction of twist: Right hand.
Form of twist: Concentric (postwar models have progressive rifling 40/28 calibers).
Method of headspace: Barrel locking wedge.
Location of feed opening: Right side.
Location of ejection opening: Bottom.

Description of the Weapon

The Russian automatic aircraft cannon known as the VYa 23 mm is a scaled-up version of the 12.7 mm Beresin and, like the Beresin, is gas operated and depends on little or no blow-back force to assist in the cycle of operation. The weapon was designed primarily for aviation use. It employs a pneumatic charging system to retract the bolt assembly and index the first round. The design permits the cooling of the barrel only by air.

Feeding is accomplished by the use of metal disintegrating links that come apart when the loaded round is pulled toward the rear. The empty link is then guided through the remainder of the feed system and drops out of the left side of the receiver. There is no provision to reverse the feeding, it being from right to left only. The empty cartridge cases are cammed out through an opening in the bottom

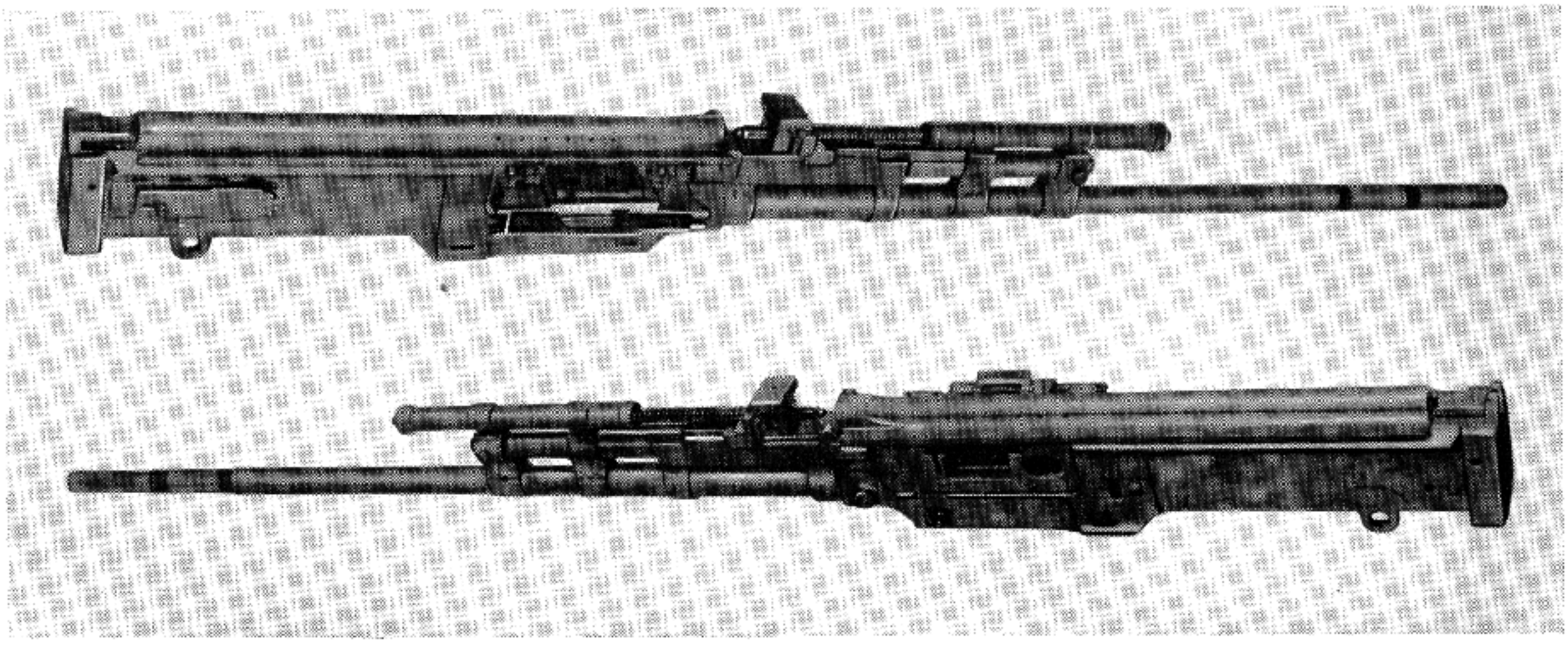

Figure 5–9. The 23-mm VYα Automatic Cannon.

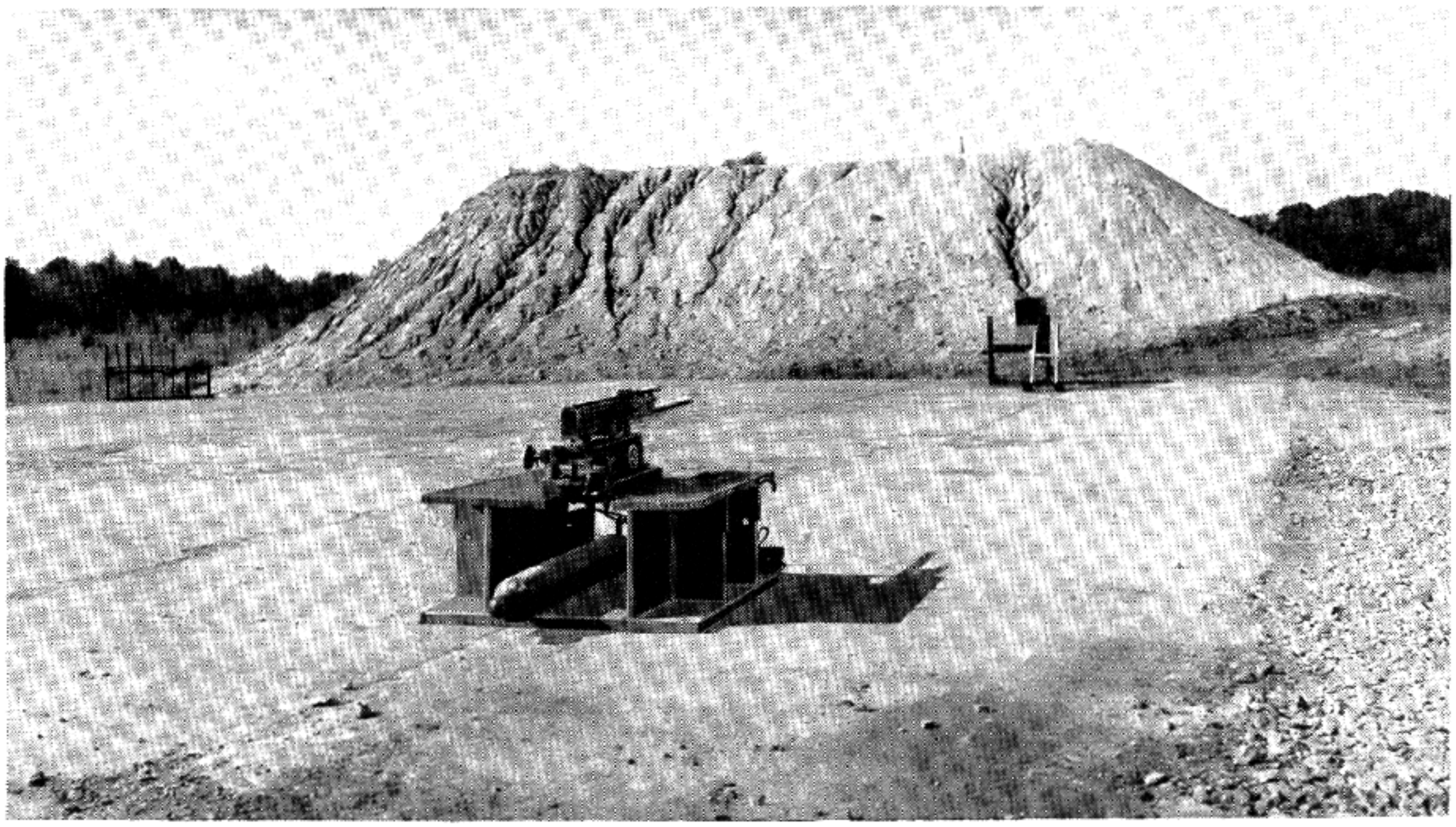

Figure 5-10. VYa Cannon undergoing firing tests at Aberdeen Proving Ground, Md.

of the receiver that is slightly rearward of the feed way.

The weapon operates from gas impact on the piston and has four different sized orifices to regulate the amount of gas required for different rates of fire. The dimensions are 3-mm, 3.5-mm, 4-mm, and 4.5-mm. The first or normal, setting is 3.5 and is reported to give a cyclic rate of 700 to 750 rounds per minute.

All loading and charging for the initial shot is done by the pneumatic system. This action is identical with the Beresin. One distinct difference between these two guns is that the VYa cannot be synchronized.

The components of this gun are not interchangeable, alterations to insure a workable fit usually being done in the field and accomplished by the simple method of filing or honing until the desired clearance is obtained. Like all its predecessors, its construction is rough and even the inside has a minimum of machining cuts.

Regardless of its external appearance, the VYa is a rugged, compact, hard-hitting gun. It was used successfully by the Soviet Air Force during most of World War II, principally for ground support. Its large-diameter high-explosive projectile has an unusually high velocity. This feature made the gun excellent in low-flying attack on light tanks and armored vehicles.

The gun consists of the following main groups, listed by the Russians as follows: barrel with gas cylinder and pneumatic cocking mechanism; breech with breech rail; receiver with buffer assembly; cover; feed system; trigger assembly.

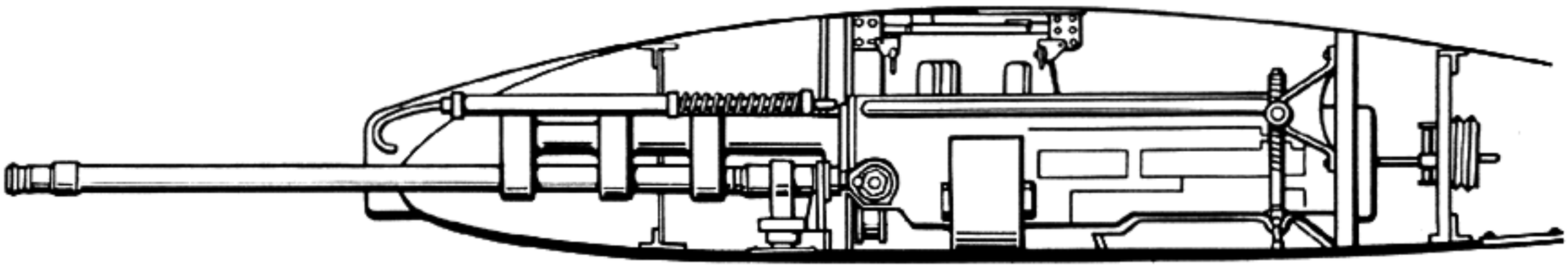

Figure 5 11. Method of mounting the VYα Gun in the wing of the Soviet IL-2 Airplane.

Figure 5–12. Armorers installing a VYa Cannon in a Soviet plane.

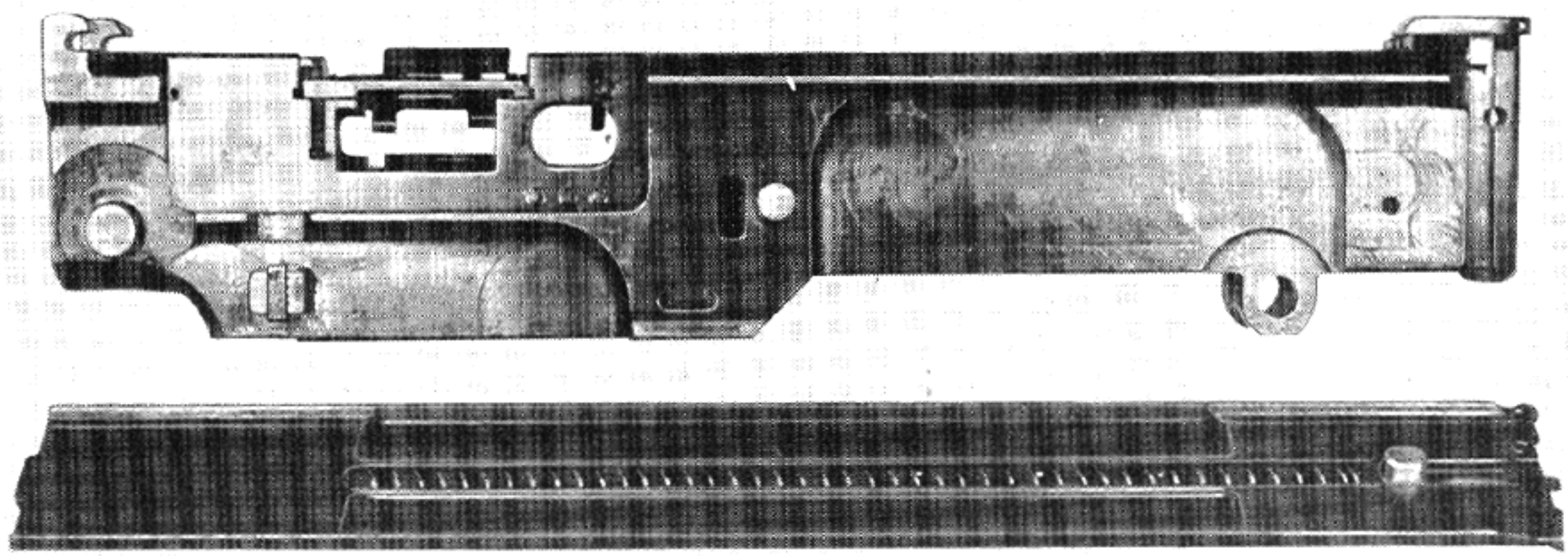

Figure 5–13. Receiver of 23-mm VYa Cannon. For similarities to the Beresin, see also figure 5–5.

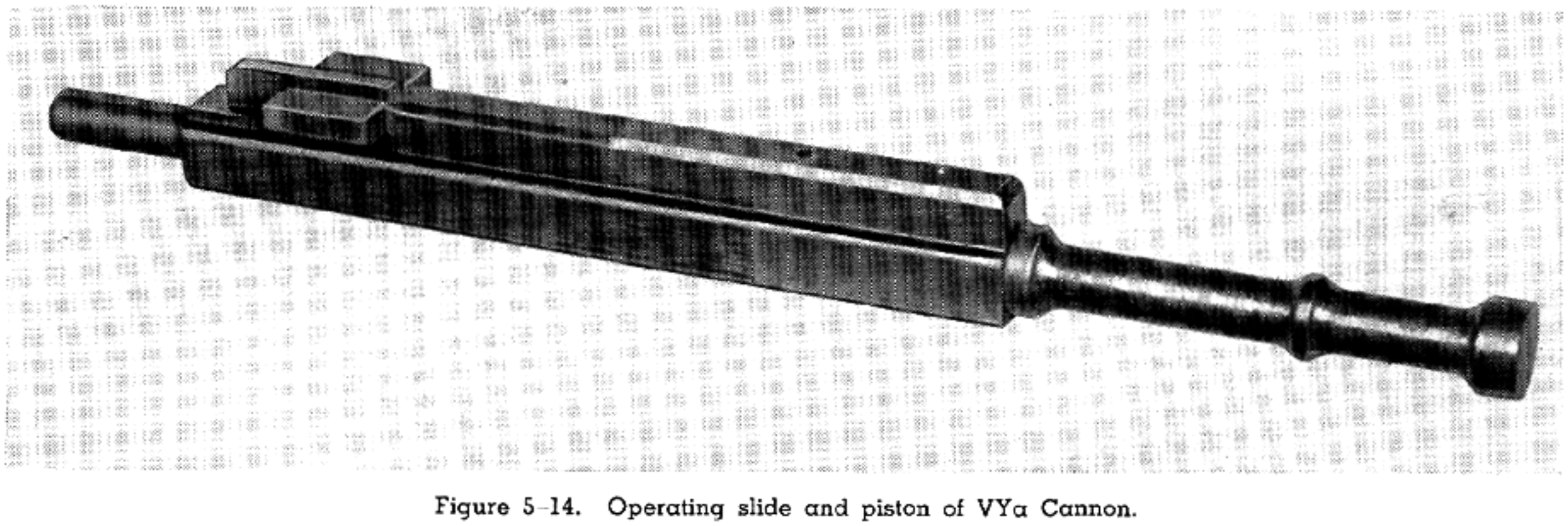

Figure 5–14. Operating slide and piston of VYα Cannon.

The barrel is 64.9 inches in length and is held rigidly to the receiver by the insertion and driving fast of a wedge-shaped piece that also serves the purpose of maintaining the headspace incorporated during manufacture.

The breechblock is attached to the breech rail. These parts move together as a single unit. The gas cylinder is attached to the barrel, together with the gas piston and the gas piston block. While the charging system is located above the gas piston assembly, one structural group is formed by the joining together of these parts.

Before the cartridge belt can be inserted, the gun must be cocked. As the jaws of the T-slot interfere with the passage of the cartridge, the feed slide is guided by a cam in such a manner as to index the incoming round in position to be picked up and started in the T-slot in the face of the bolt. The part known as the breech rail is guided in the receiver by its slots, and its front end is struck by the gas actuated piston. This force drives the rail to the rear, unlocking the breechblock. The gas piston itself is separate from the rail and serves only to give energy to the latter part.

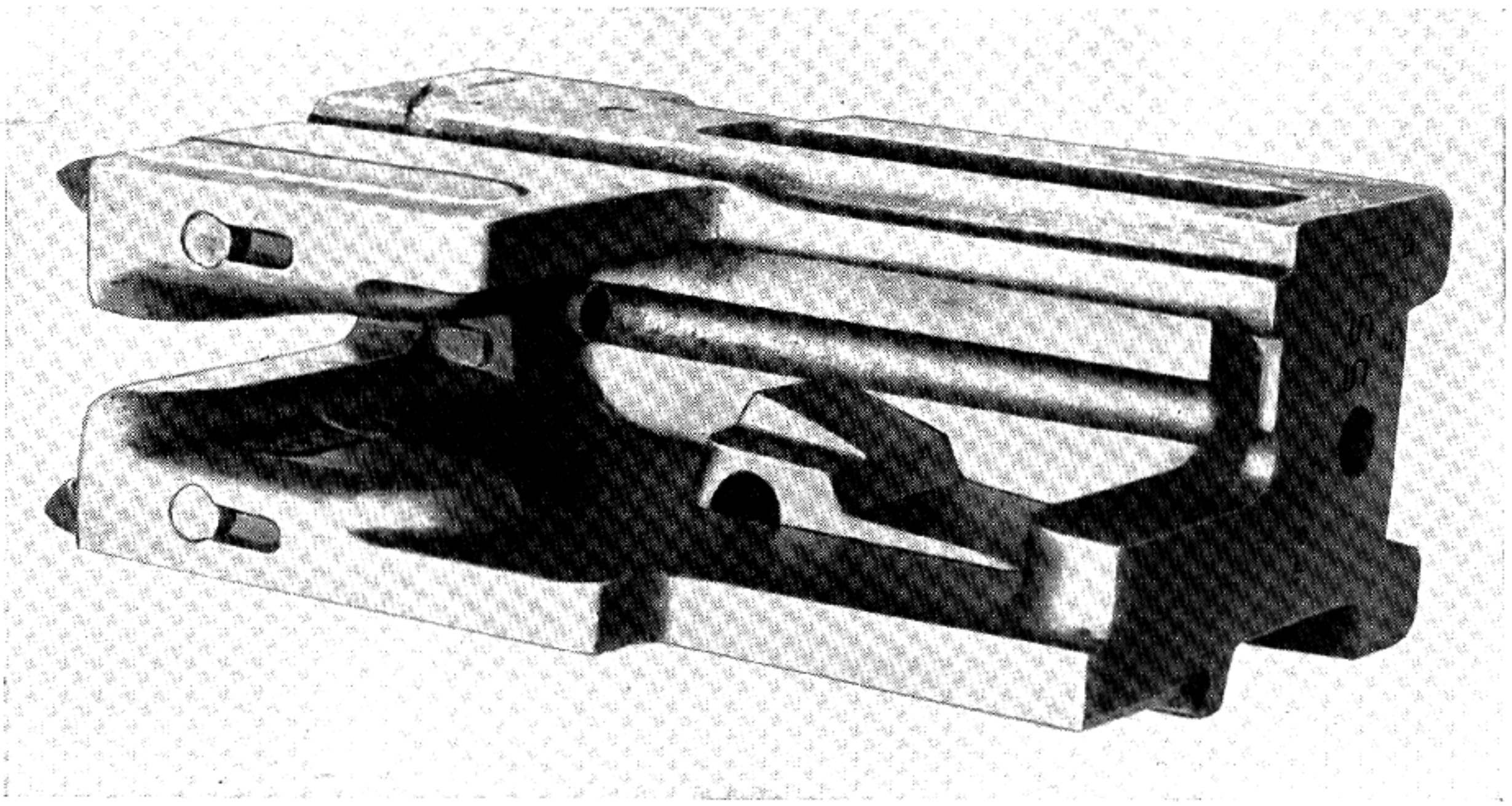

Figure 5–15. Top rear view of VYα bolt, showing "pincers" which extract round from belt and position it in T-slot for feed cam.

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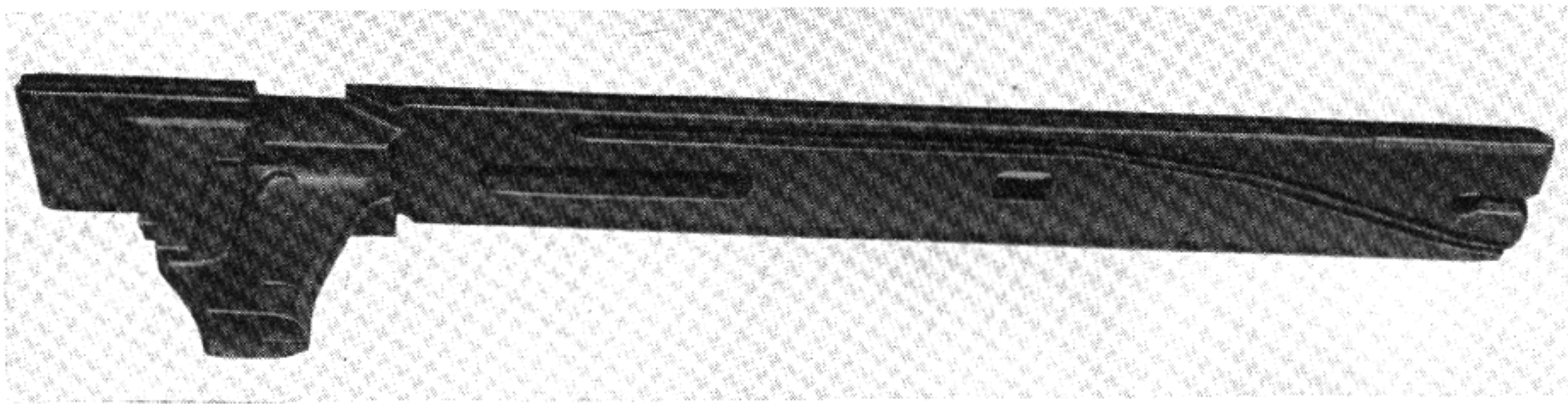


Figure 5–16. Operating slide of VYa Gun, showing groove for stud of belt feed. Large lug at left fits in hollow portion of bolt.

The breechblock is locked by a U-shaped wedge which moves in the casing vertically to the axis of the bore, the locking wedge being controlled by the fore-and-aft movement of the breech rail. The cam of the feed slide runs along a groove machined in the rail. An additional cut-out at the front end of the breech rail engages a piece that functions as an anti-bounce device.

Attached to and housed in the breechblock is the firing pin, which floats free until the receiver and breechblock are securely held together. At this time the breech rail has reached the end of its forward travel, and a lug on the rail strikes the firing pin. At the top of the breechblock, two spring-loaded jaws draw the incoming round from the belt.

Attached to the left-hand side of the bolt and housed in a recess is a small pivoting member. This piece holds the breechblock and breech rail together during recoil. The receiver is box-shaped in appearance and is equipped with longitudinal grooves for guiding the breech rail and breechblock. The front end of the receiver has a bore just large enough in diameter to admit the barrel. At the rear, sturdy ribs hold the bolt assembly securely. This portion is used as an abutment for the buffer assembly with the buffer plate and for the cartridge guide cam that has to be pushed into the rear end of the receiver when the parts are assembled.

The cover group is used for closing the receiver to keep out foreign matter and provide a ready opening for visual check and maintenance of parts. The feed mechanism is inserted from the top into its grooves and is secured in place by the cover that, in turn, is secured to the receiver by four screws. The feed slide and the feed catch fit into the upper part of the feed housing. The slide is controlled by a rib riding in a curved slot that is machined into the breech rail. The cartridge holding pawls are located in front and behind the feed slide. These pawls engage the cartridge from the top and hold

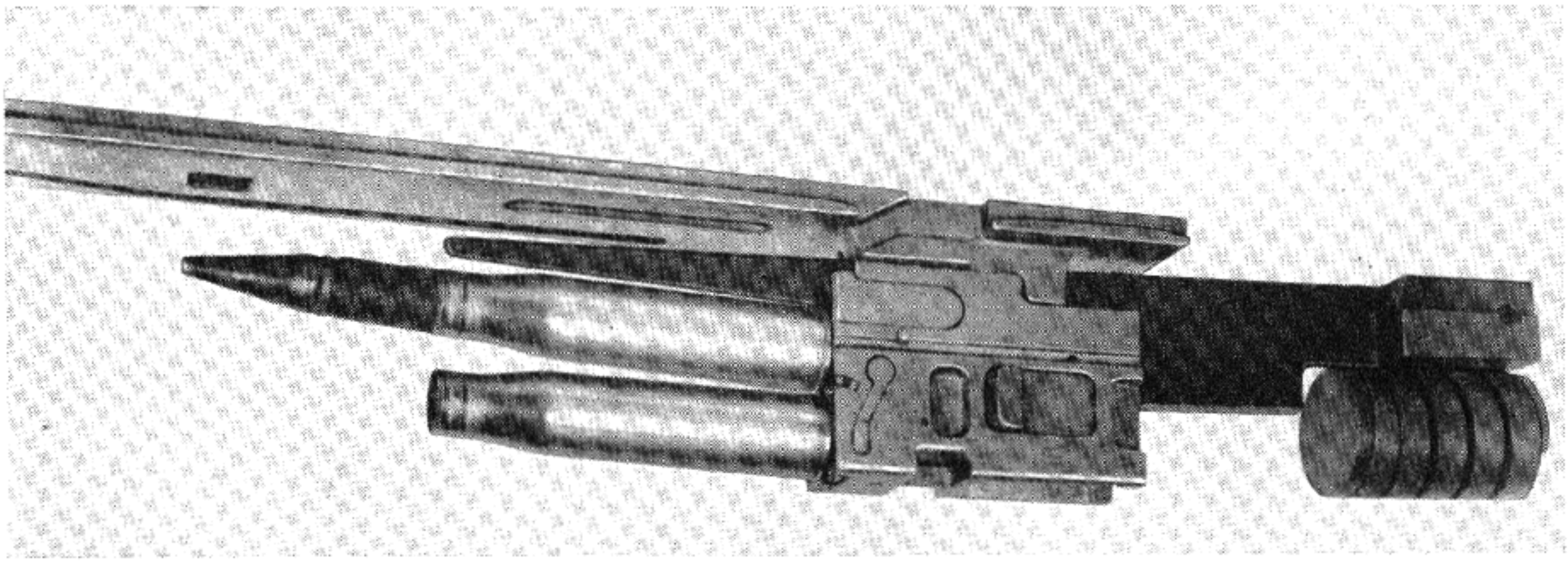


Figure 5–17. First phase of positioning incoming cartridge in T-slot of the VYa cannon. A live round, which was withdrawn from the belt by "pincers" at the top of the bolt, is being cammed downward in the T-slot and the empty case is being pushed out.

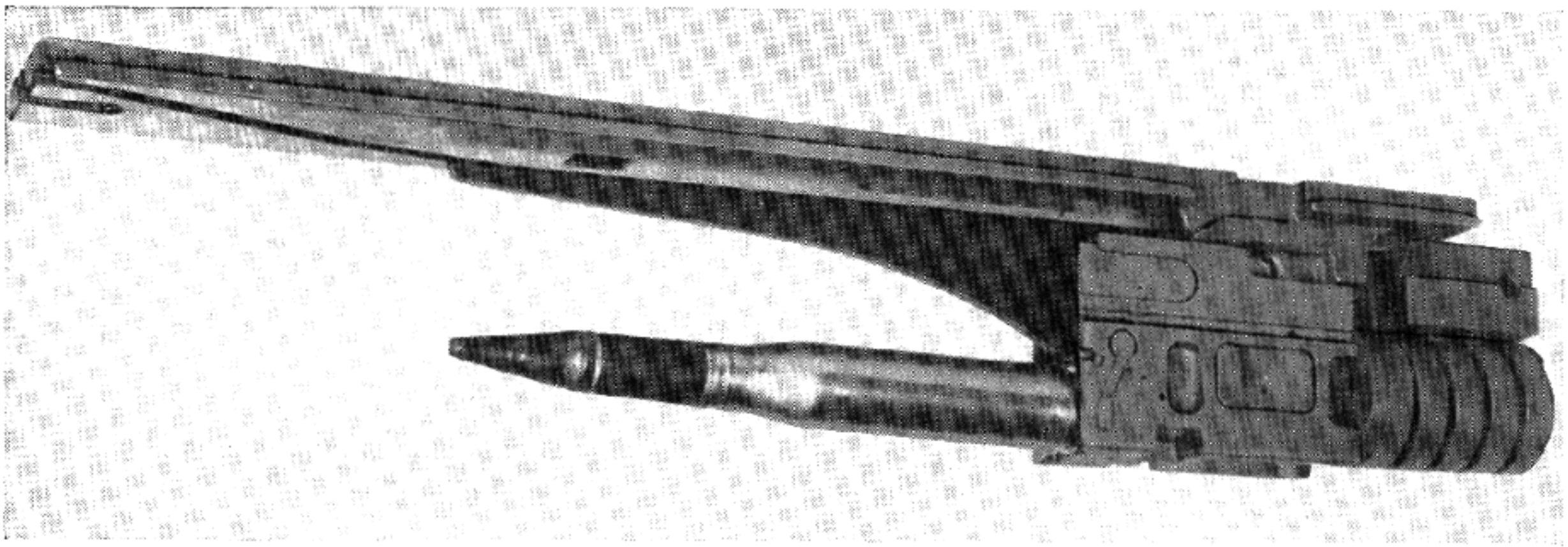


Figure 5–18. Final positioning of cartridge for chambering in the VYa cannon. The bolt has reached its buffer and the incoming round has been forced down to the centerline of the chamber.

it in position for being picked up and placed in the T-slot.

Cycle of Operation

To fire the VYa, the gunner first actuates the pneumatic charger, pulling the breechblock and breech rail to the rear until the sear is engaged. The cartridge belt is then inserted from the right side until the first round is behind the belt holding pawls and positioned so as to enter the spring-loaded jaws. The trigger is pulled, allowing the breechblock to fly forward and seize the rim of the first round.

The weapon is again cocked. This act withdraws the round from its link, the link falling from the left side of the feedway as the round is cammed down into the T-slot until it is in position for chambering. The weapon is now cocked and ready for firing.

Upon actuating the trigger, the breechblock starts forward, driven by the energy of its driving spring, the cartridge is chambered by the continued movement of the breechblock. At the farthermost travel forward, the U-shaped breechblock locking wedge rises vertically, cammed into its locking recess in the receiver by the last fraction of an inch of forward movement the breech rail can make after the breechblock is all the way home. This final travel brings the lug on the breech slide in contact with the firing pin driving it into the primer of the cartridge.

The barrel, breechblock, and breechblock lock remain securely fastened together until the projectile has cleared the bore. However, when the port in the barrel is passed by the projectile, a portion of the gas is metered onto the head of the piston, striking it a smart blow which in turn drives the breech slide rearward. The first movement of recoil allows the stirrup-shaped lock to disengage slowly at first before being totally unlocked.

This gradual withdrawal, with the T-slot holding fast to the cannelure of the fired round, causes the empty case to be jacked slowly rearward freeing it from the chamber walls. The lock has raised and the empty cartridge is free to ride back, held to the bolt face by the T-slot. A rib rides through a slot in the body and upper forward portion of the breechblock and cams down into the T-slot the incoming round, that has been picked up by the spring-loaded jaws and is now withdrawn from the link.

As the loaded round is forced into alignment with the chamber, the empty cartridge case is pushed out of the T-slot and through an opening in the bottom of the receiver. As the breechblock continues rearward it strikes the heavy spring buffer, compressing this piece and sending the firing mechanism back into counter-recoil. The recoil catch prevents further recoil of the breech rail. During backward travel of the breech rail, the bevel attached to the front end of this rail forces the recoil catch upwards. This catch then locks into the front cut-out under pressure of its heavy spring.

If the trigger remains depressed the firing cycle is repeated.

Disassembly by Groups

Remove the cover toward the top by depressing the locking bolt and pushing the cover latch backward. At the same time, the buffer assembly can be pulled downward. The cartridge cam and the breech buffer spring with the buffer plate can then be extracted toward the rear.

When the pneumatic cocking mandrel is pushed backward, the recoil catch is lifted and frees the breech rail together with the breechlock. After the trigger is pulled, both parts can be removed from the rear and the U-shaped wedge toward the top. After the trigger is pushed to the stop, the entire trigger assembly can be removed from the side. After the four screws are loosened, the entire feed mechanism can be taken from its guide grooves by lifting.

The barrel, that has fastened to it the carrier for the gas cylinder and for the pneumatic cocking device, is pulled toward the front after loosening the wedge. This frees the gas piston with the gas-piston block, which then can be disassembled toward the rear. After the threaded cap is unscrewed, the pneumatic cocking mandrel together with the piston and the spring can be extracted toward the front.

Disassembly of the gun into these parts is sufficient for cleaning. No special tools are required.

To Remove Barrel and Assembly:

1. From the left side of the receiver withdraw the receiver barrel lock retaining slide upward out of its recess, and push the receiver barrel lock to the right and out of the receiver.

2. Rotate the barrel and assembly to disengage the barrel lock from its recess in the receiver, and pull the barrel and its assembly out of the receiver.

Assembly by Groups

1. Replace the breech lock assembly by inserting it into its recess in the fore part of the receiver.

2. Place the belt holding pawl into the guideway of the feed assembly, and slide to the right.

3. Insert the device for camming down the cartridge into its guideway from the rear of the receiver.

4. Replace belt feed slide plate into the guideway in the top and rear of the receiver.

5. Before sliding the breechblock completely forward engage it on the under side of the breechblock feed slide plate.

6. Replace the breechlock receiver by pushing in on the lock projecting on the left side of the bolt.

7. Push the entire assembly forward until the sear within the right side of the receiver stops the bolt.

8. Pull back on the sear arm outside the receiver. This action withdraws the sear, allowing the bolt and belt feed slide plate to go forward.

9. The camming projection on top of the belt holding pawl must be in alignment with the guideway on the under side of the belt feed slide plate.

10. Replace the cover.

To Replace Barrel and Assembly. Reverse the procedure for removing barrel and assembly.

Chapter 6

NS AND N SERIES OF AUTOMATIC AIRCRAFT CANNON

Models Included in This Chapter

Designation	Bore diameter	Use	Year of appearance
NS 37	37-mm	Fixed	1943.
NS 23	23-mm	Fixed	1947.
N 37	37-mm	Fixed	Since 1947.

History and Background

In July 1943, the Russian Air Force introduced into service their first deviation from gas operation in automatic aircraft weapons, the NS. The gun proper was designed by Alexander Emmanuelovich Nudelman, one of Russia's top ordnance engineers. The pneumatic feed system was originated by A. Suranov, another armament specialist who was highly respected by the authorities of the U. S. S. R. The weapon is sometimes called the NS in honor of Nudelman and Suranov.

In World War II, the Russians stressed tactical support of ground action by their aviation. In operations against ground targets, it was well known that the 20-mm and 23-mm class of cannon were relatively ineffective. It was for this reason that the Nudelman-Suranov 37-mm gun appeared. It has been used successfully against armored vehicles and fortifications as well as more vulnerable targets, such as railroad trains and ordinary buildings.

The NS 37 is a 37-mm short recoil operated aircraft cannon with a rather slow rate of fire. The use of the short recoil principle in this weapon is a revolutionary step in aircraft armament development. Heretofore, the Soviet automatic weapon program, from light infantry machine guns to large caliber aircraft cannon, was designed to utilize the forces of gas for operation.

The NS and N guns use the same locking principle as the well-known German MG–151/20 aircraft cannon; namely, a two-piece bolt with a rotating bolt head. This part is so designed that the rear portion of the bolt is accelerated to the rear at the instant of total unlocking and timed so that the aft end is cammed rearward with great force, making contact at the instant of unlocking. This action speeds the recoiling movement of the whole unit and makes possible a high cyclic rate with a minimum of working parts.

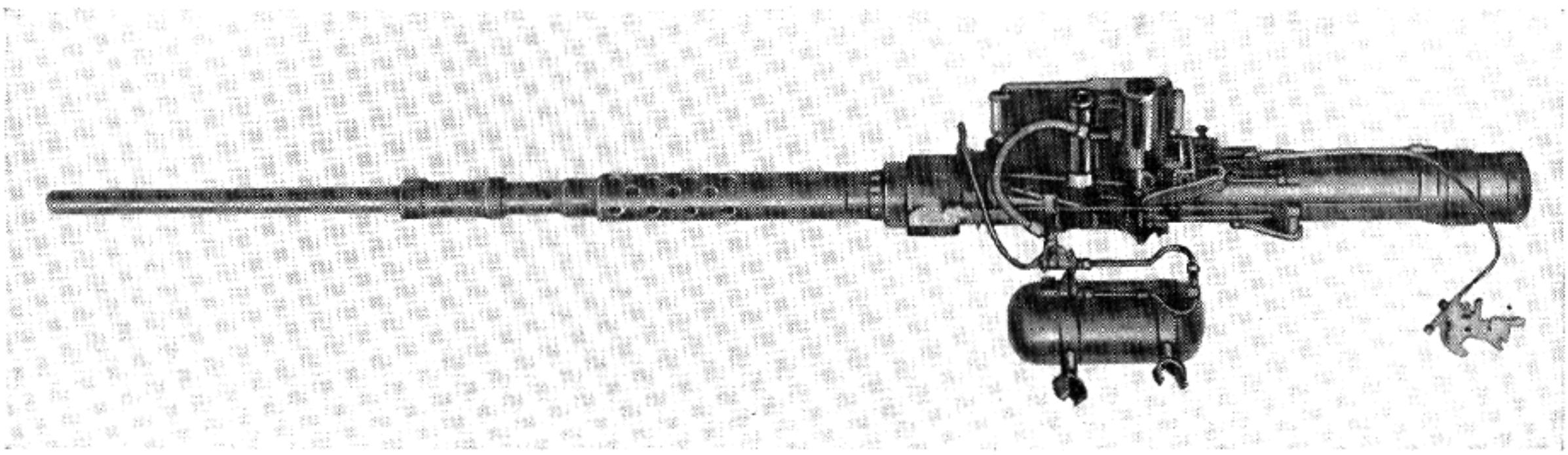


Figure 6-1. Left view of a 37-mm NS Cannon from underneath, showing the lines to the air flask and firing controls.

Figure 6-2. Soviet armament engineers who worked on the NS Series. Left to right: Gribkov, Bundin, Lebedev, Nudelman, Richter, Suranov.

In the late eighteen nineties, Ferdinand Mannlicher originated the rotating bolt head that unlocked the action of the weapon. He used it successfully in a military rifle that was named for him; however, it was the Mauser plant located at Oberndorf, Germany, that revived this system of locking just prior to World War II and applied it so well to automatic weapon design, both ground guns of rifle caliber (MG-81 and MG-34) and aircraft cannon (MG-151/20).

Since that revival, the system has been imitated in automatic weapon construction by practically

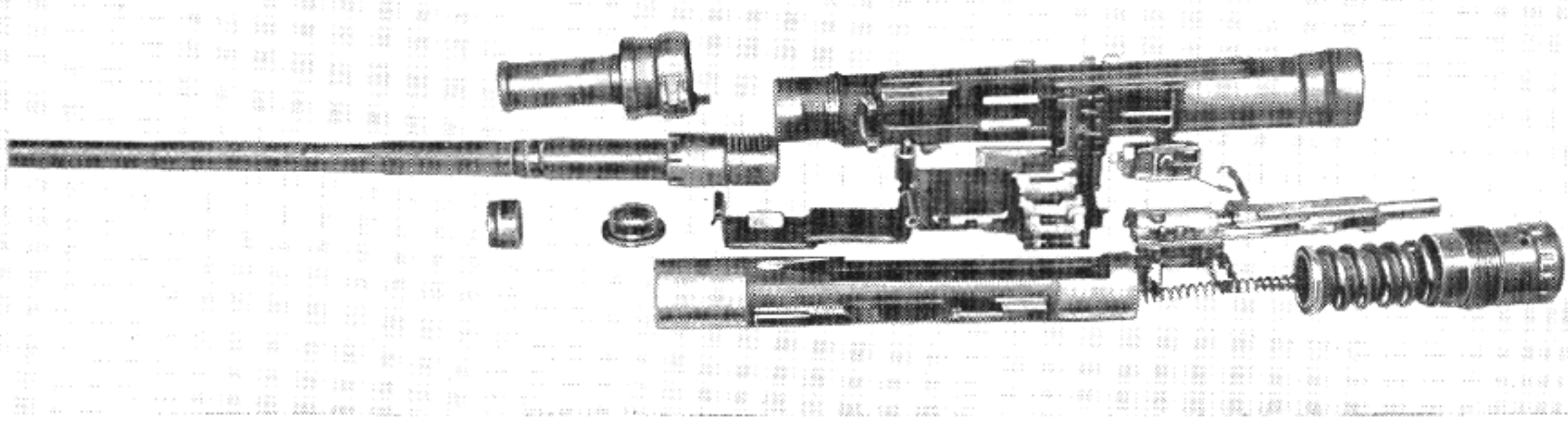


Figure 6-3. 37-mm NS Gun. Field stripped.

every major power. The family of Nudelman and Suranov guns was no exception.

In November 1943, an NS 37 gun fell into the hands of the Germans, who promptly put it under test at their Mauser plant. The detailed German reports on the weapon are available for studying the technical phase of the early guns.

The Germans had such a high respect for the original NS 37, they placed it on a chart and had it displayed prominently in ordnance establishments, in order that the armament personnel could familiarize themselves with the new design.

The NS 23 was designed by Nudelman for a cartridge having a 23-mm projectile. The designer retained the characteristics and the crude exterior of the NS 37, making improvements in the design in the process of scaling down.

The smaller caliber weapon was the last model to bear the official designation NS. The 37-mm cannon that appeared soon afterwards is referred to as the N 37, which implies, by Russian standards, that Nudelman had taken over the complete design of the weapon, even to the feed. The N 37, while employing a projectile of the same size as the earlier weapon, incorporates a drastic change in cartridge design, it being much shorter and having a smaller powder charge. The resulting muzzle velocity is 2700 feet per second. The rate of fire, however, is increased. The N 37 is far more refined in appearance, and the total weight with feeder and accessories is considerably less than the earlier version.

General Data for the NS 37

Caliber: 37-mm.
Rate of fire: 300–350 rounds/minute.
Muzzle velocity: 2,850 feet/second.
Gun length: 134¼ inches.
Gun weight: 375 pounds including feeder, charger, and external oil buffer.
System of operation: Short recoil.
System of locking: Rotating bolt head.
System of feeding: Pneumatic and spring.
Method of charging: Pneumatic.
Method of cooling: Air.
Barrel length: 90¾ inches.
Barrel removal: Not quick change.

General Data for the NS 23

Caliber: 23-mm.
Rate of fire: 600 to 700 rounds/minute.
Muzzle velocity: 2,850 feet/second.
Gun length: 78⅜ inches.
Gun weight: 121 pounds with all accessories attached.
System of operation: Short recoil.
System of locking: Rotating bolt.
System of feeding: Pneumatic.
Method of charging: Pneumatic.
Method of cooling: Air.
Rate control: None.
Barrel weight: 28⅞ pounds.
Barrel length: 57¼ inches.
Barrel removal: Not quick-change barrel.
Chamber pressure: 47,000 psi. (maximum).
Bore:
Number of grooves: 10.
Groove depth: 0.014 inch.
Groove width: 0.190 inch.
Pitch: 5° 12′ right, uniform.
Direction of twist: Right hand.
Form of twist: Concentric.
Method of headspace: Factory established.
Location of feed opening: Left side.
Location of ejection opening: Right side.
Across rifling lands: 0.910.
Across rifling grooves: 0.938.
Travel of projectile in barrel: 53 inches.

Description of the NS Series

Some features of this family of weapons deserve special note; one of these is the method whereby a smooth counter-recoil action is accomplished by oil

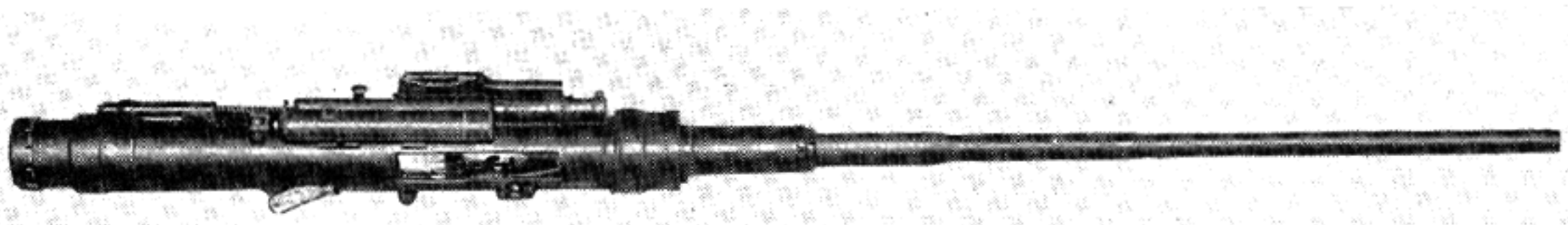


Figure 6-4. 37-mm NS Gun. Right side view.

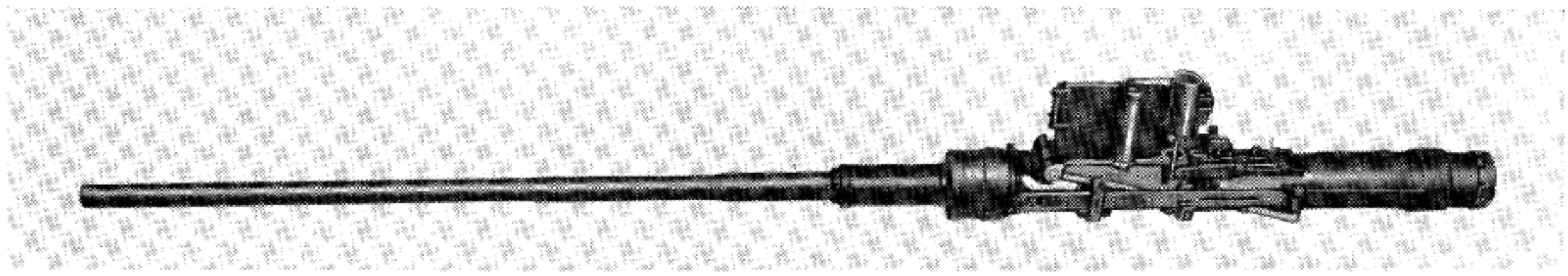


Figure 6–5. 37-mm NS Gun. Underneath view, from right.

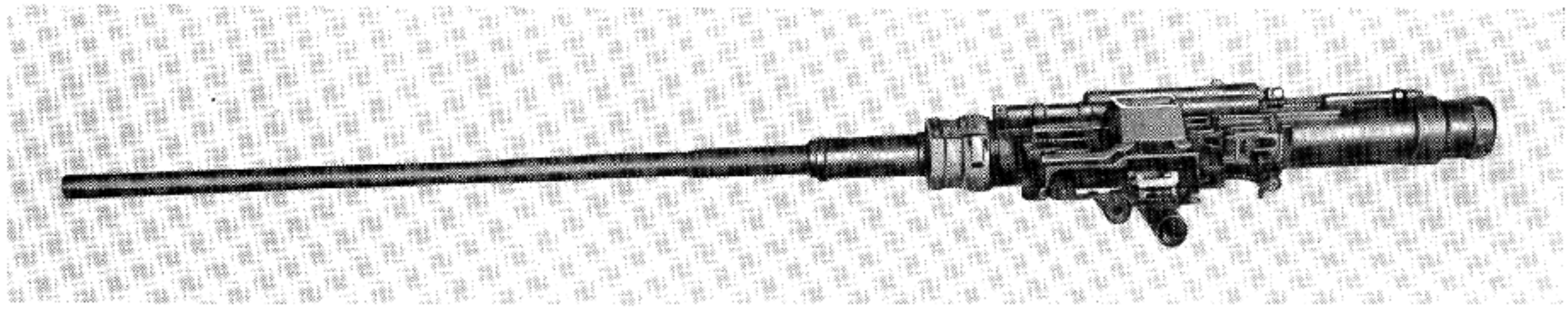


Figure 6–6. 37-mm NS Gun. Left side view.

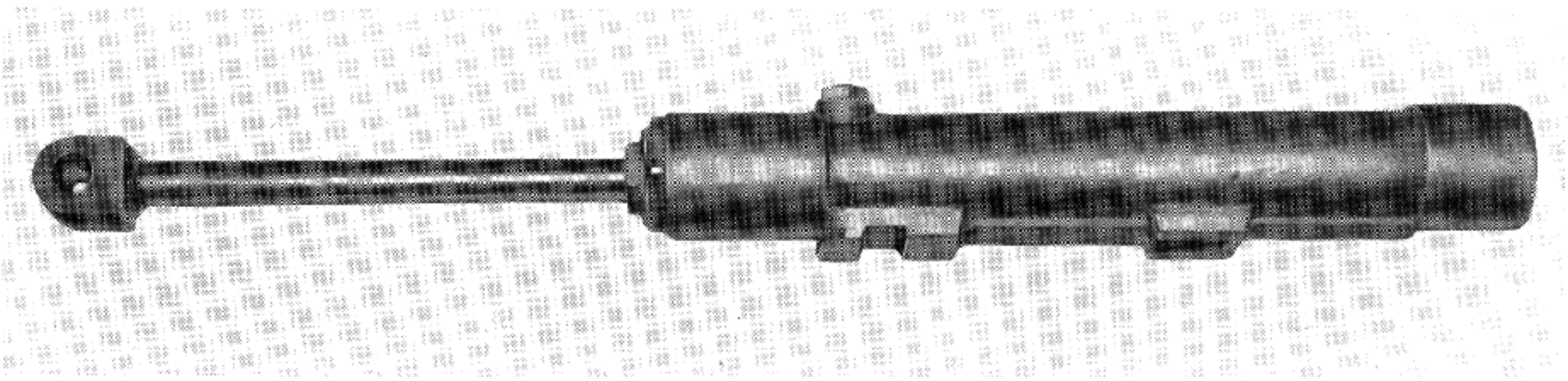


Figure 6–7. 37-mm NS Gun. Hydraulic counter-recoil control cylinder.

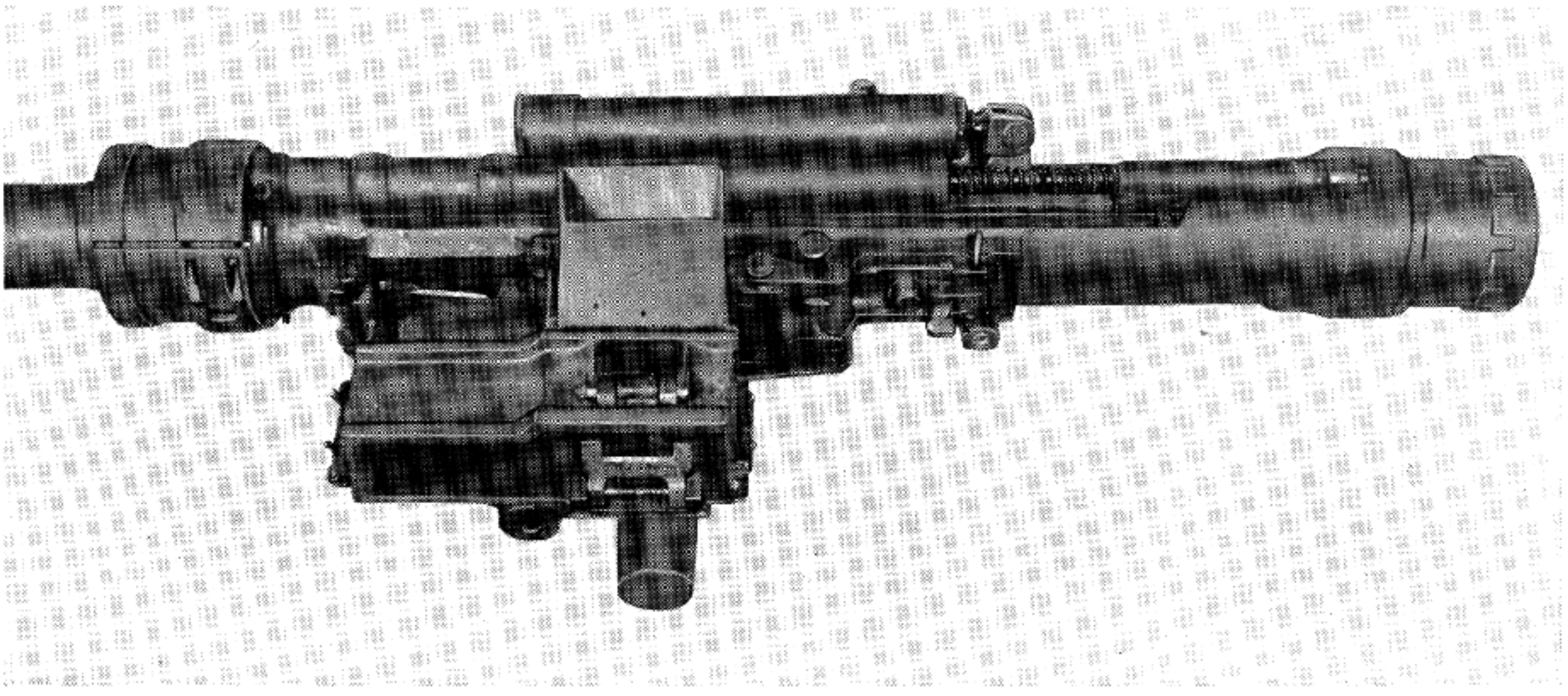


Figure 6–8. Close-up view of NS 37-mm gun from left. The shorter and thicker cylinder on top of the receiver is the hydraulic counter-recoil control. Link ejection chute is clearly visible on top of feed tray.

buffing without lowering the weapon's cyclic rate. Another good point is that some firing pin assemblies are so designed that the weapons can be converted from synchronized to inertia firing by the mere adding or taking away of components that go into the over-all assembly of the firing mechanism. The bolt, as it goes into the final movement to battery is rotated ¼ turn and locks by means of a lug on the bolt body following cams which are in the barrel extension. Simultaneously the firing pin, which is fixed to a portion of the aft end of the bolt body, is driven through the firing pin hole in the face of the bolt into the primer of the cartridge. This method is a common form of mechanics employed to produce percussion firing.

When necessary parts are assembled for synchronization, a firing pin spring and front sear are added. This arrangement permits the bolt to go all the way home and lock with the firing pin in a cocked position and to be released only when seared off by the trigger motor being actuated, causing a trigger bar to pivot up and release the sear. Each shot is fired at a predetermined time in the cycle since a mechanical obstruction has to be removed at each instant of discharge. This dual firing system also allows the weapon to be either front or rear seared as desired.

The bolt is energized by a compressed braided wire spring that is housed in the charging cylinder. Compressed air furnished to the gun through an electro-pneumatic valve operates both the built-in charger and feed system. When the retracting assembly is actuated, it simultaneously drives the bolt to the rear position and powers the feed pawl assembly, indexing the incoming round.

The feed slide assembly consists of three sets of spring loaded pawls so located that they index the incoming round while at the same time holding two other cartridges under control prior to positioning. The link employed is very similar to the German open type that was used by Rhinemetall-Borsig for the MK–108 Gun.

In the feedway, there is a chrome plated link stripper which separates the cartridge case from the links and then guides them between chromed surfaces to the link chute adapter. During the firing cycle, stripping is accomplished before the cartridges enter the main body of the receiver. The link chute adapter is secured to the top of the feedway by a hinge, an arrangement which allows instantaneous opening for visual inspection or maintenance. This piece is constructed of stainless steel which has been stamped or pressed and then spot welded, a type of construction known as "form

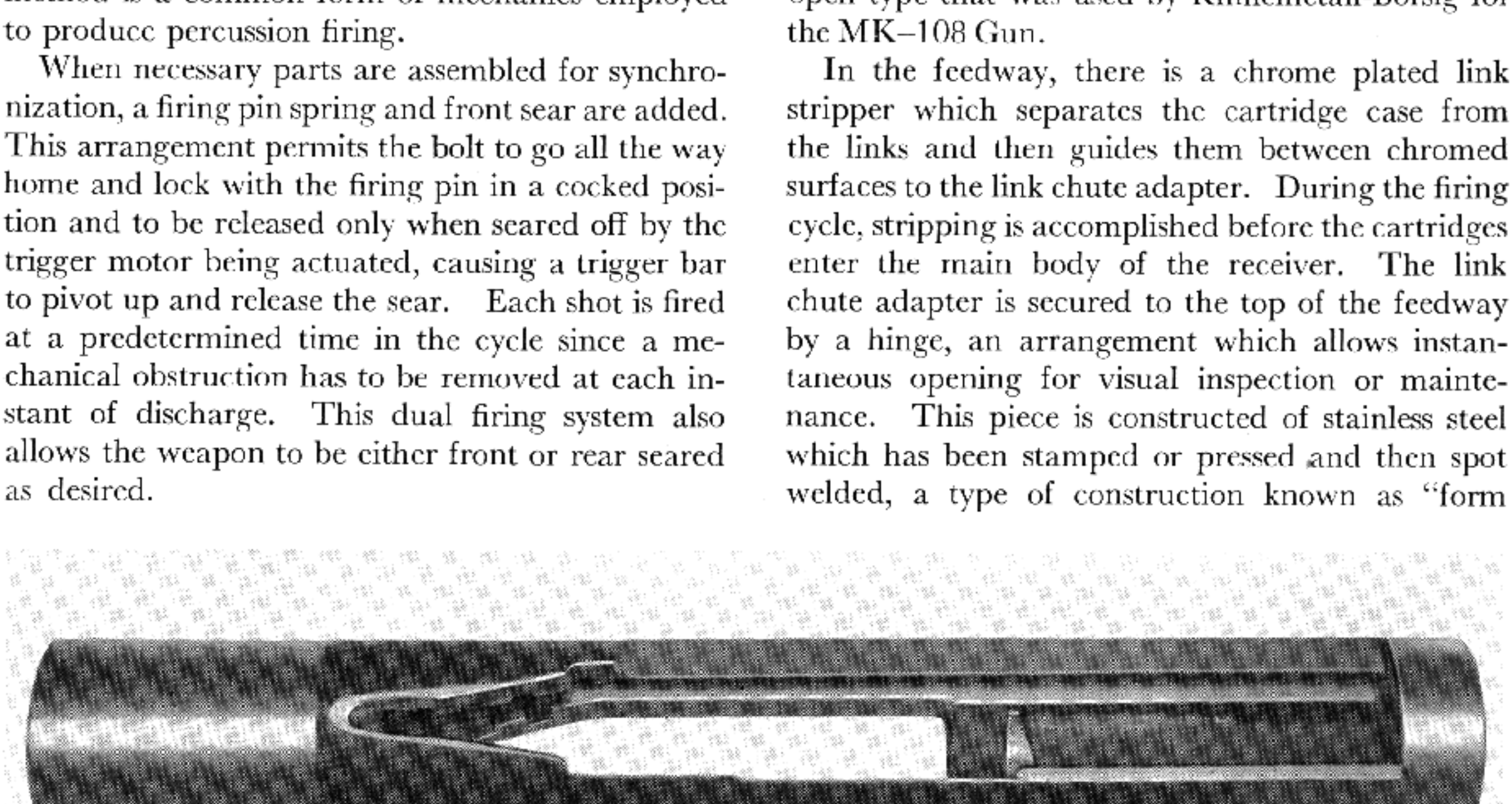


Figure 6–9. 37-mm NS Gun. Barrel extension and bolt.

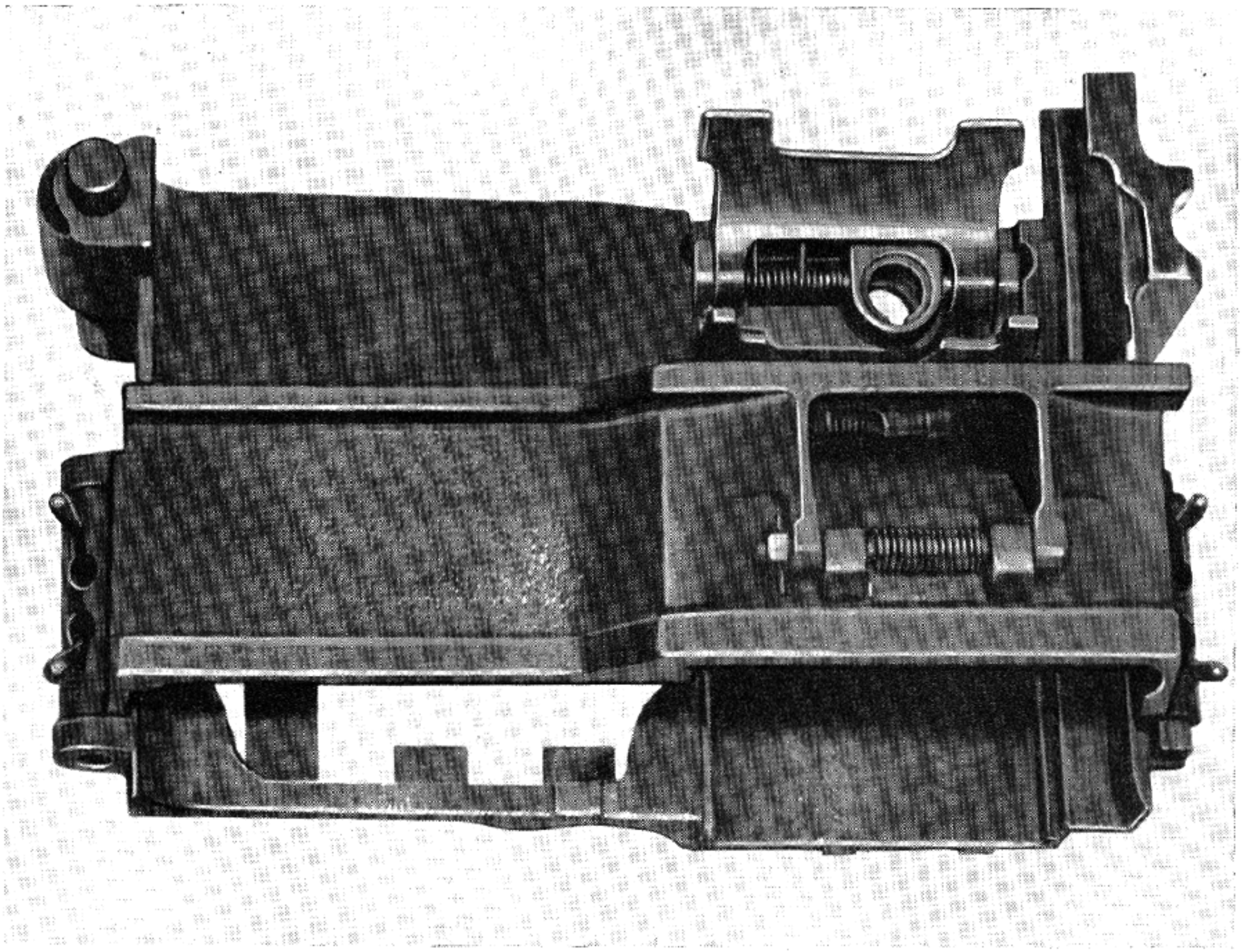


Figure 6-10. 37-mm NS Gun. Feed tray.

fitting." An extension of any reasonable length can be added to this piece; it is also made of stainless steel, fastened together by pin-locked piano wire hinges both fore and aft to make the necessary length to guide the expended links from the adapter to the ejection slots in the fuselage or wings of the plane.

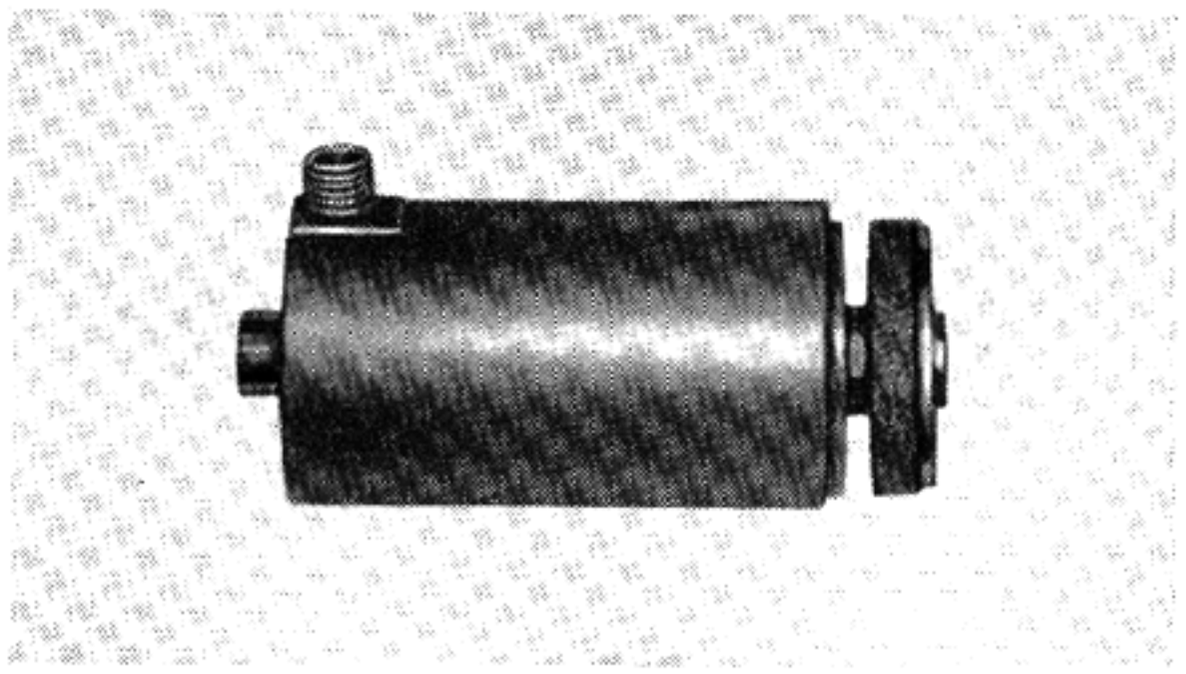


Figure 6-11. 37-mm NS Gun. Pneumatic feed pawl actuating cylinder.

When mounted to the airframe by a front and rear trunnion mount, the NS 23 has an adjustment for both azimuth and elevation. The front mount, which takes the major impact during firing, weighs 4 pounds 3 ounces and is provided with four mounting holes. The entire assembly consists of a hinged split ring with toggle bolt that fits snugly around the adapter at the forward end of the receiver. A sort of ball and socket joint allows movement necessary for bore sighting. The rear mount is a stud held in a solid metal block to which is attached a threaded post. By positioning the latter part and then moving the block to the desired degree away from the axis of the post, both vertical and horizontal adjustment can be accomplished.

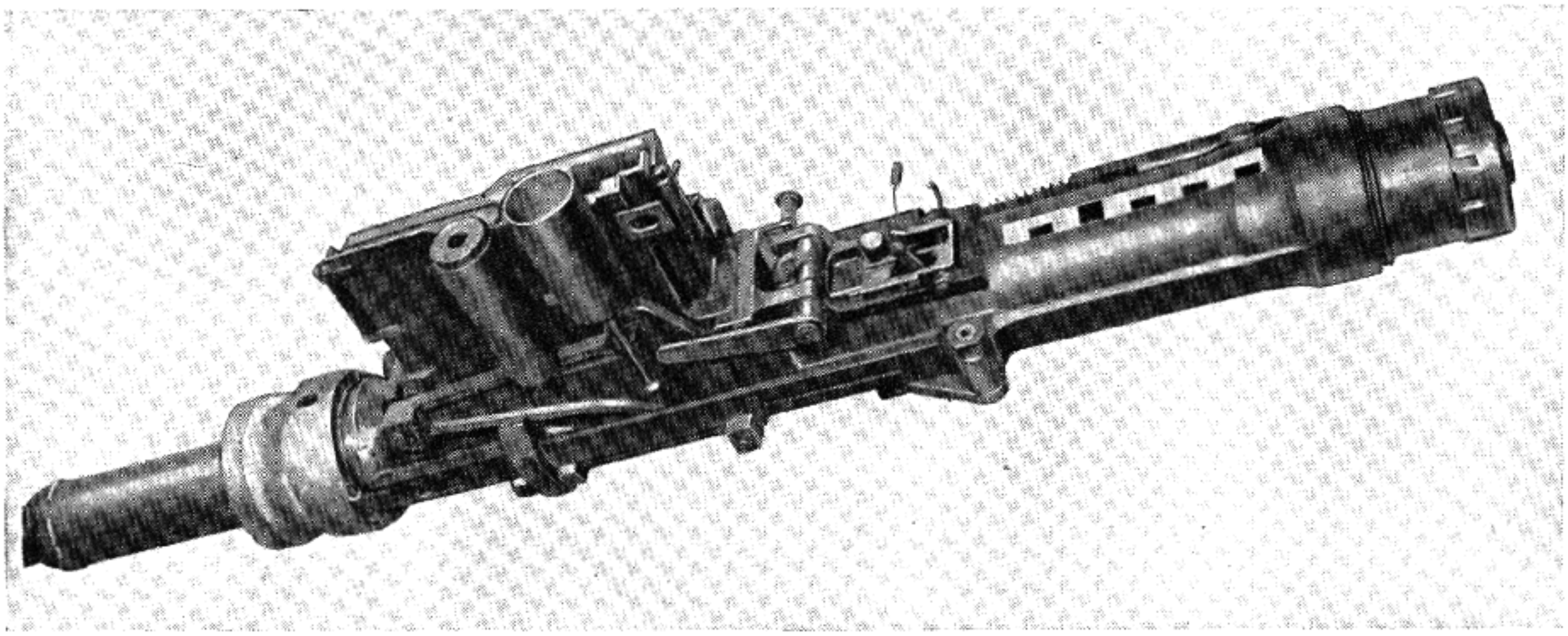


Figure 6–12. 37-mm NS Gun. View underneath feed from left of receiver. The larger of the circular recesses on the edge of feed tray is the seat for the pneumatic actuator (see fig. 6 11).

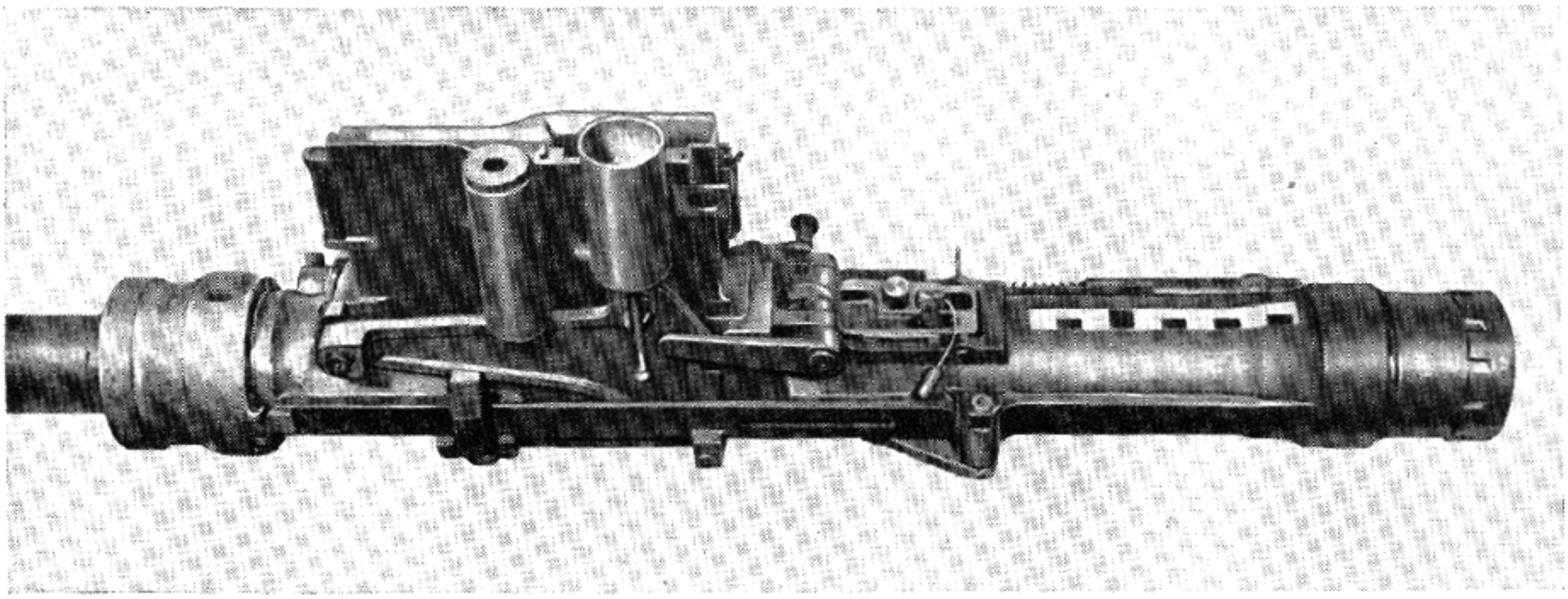


Figure 6–13. 37-mm NS Gun. View underneath feed from left of receiver. The smaller recess under the feed tray houses the feed cam return spring.

The 23-mm synchronized gun is mounted differently than the un-synchronized gun. The forward support consists of trunnions integral with a ring which is assembled to the front of the receiver. The rear support consists of a hinged clamp which is fastened around the rear of the receiver.

When the NS 37 was first introduced, it was mounted in the YAK–9 fighter plane and was bolted directly to the cylinder head of the engine.

It was later installed in the Stormovik, but in this case, it was mounted underneath the wings. This position did not prove satisfactory as the terrific impact from recoil made the plane unmanageable if during a burst of normal length one gun happened to malfunction. Failure to recognize the necessity of keeping plane design in step with weapon development resulted also in structural failures at other securing points.

The earlier method of fastening the weapon to the engine's cylinder block had another weakness; the unyielding engine frame caused cracked cylinder heads and mounting lugs. The Soviet engineers tried to overcome this by fashioning an adjustable mounting yoke that was rigidly fixed to the airframe. This later modification to the system of mounting supported the back plate buffer, but in

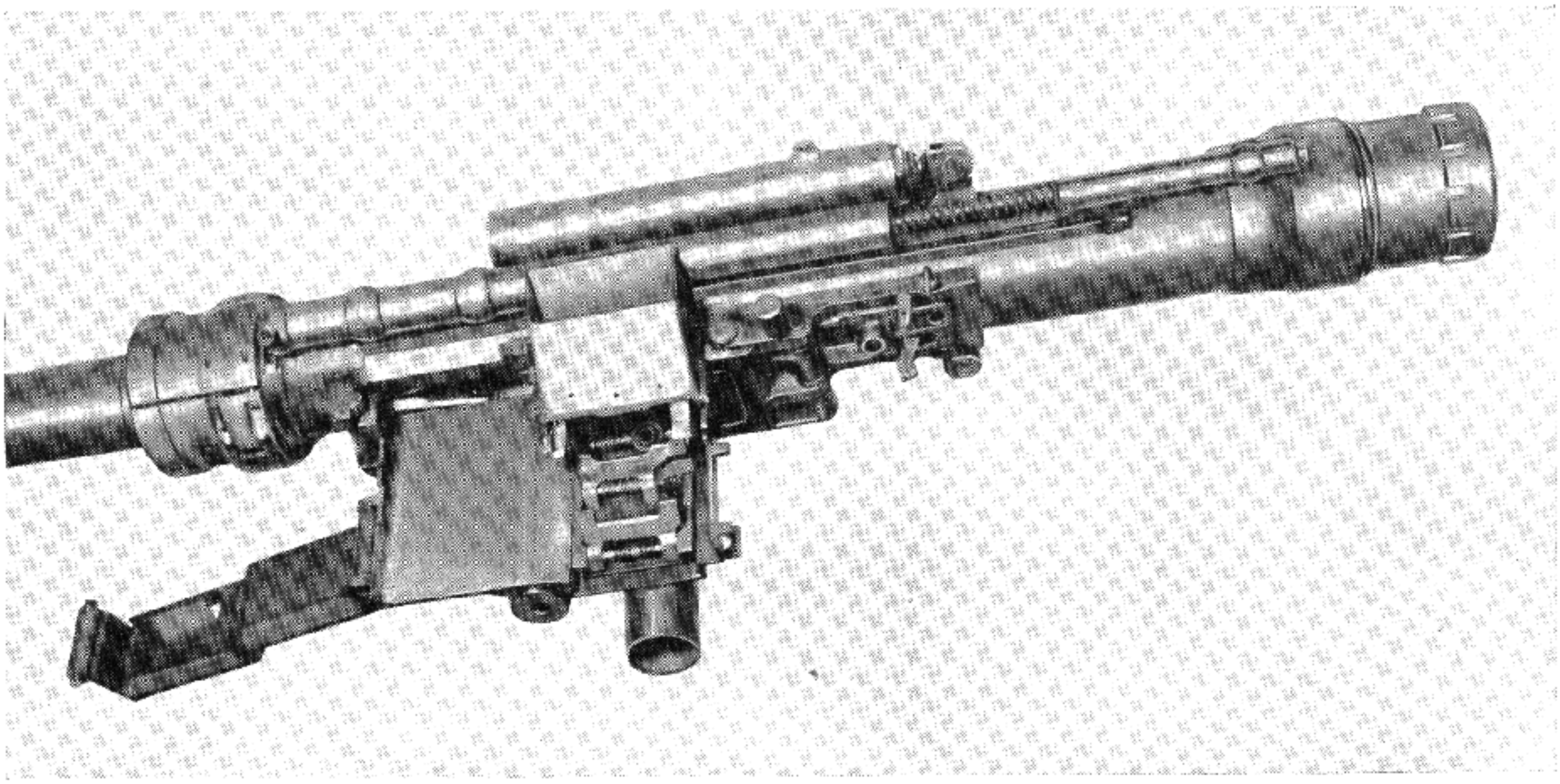


Figure 6–14. Close-up of feed-tray of 37-mm NS Gun. Feed cover which carries the belt holding pawl has been hinged to the left, exposing the belt-moving pawls.

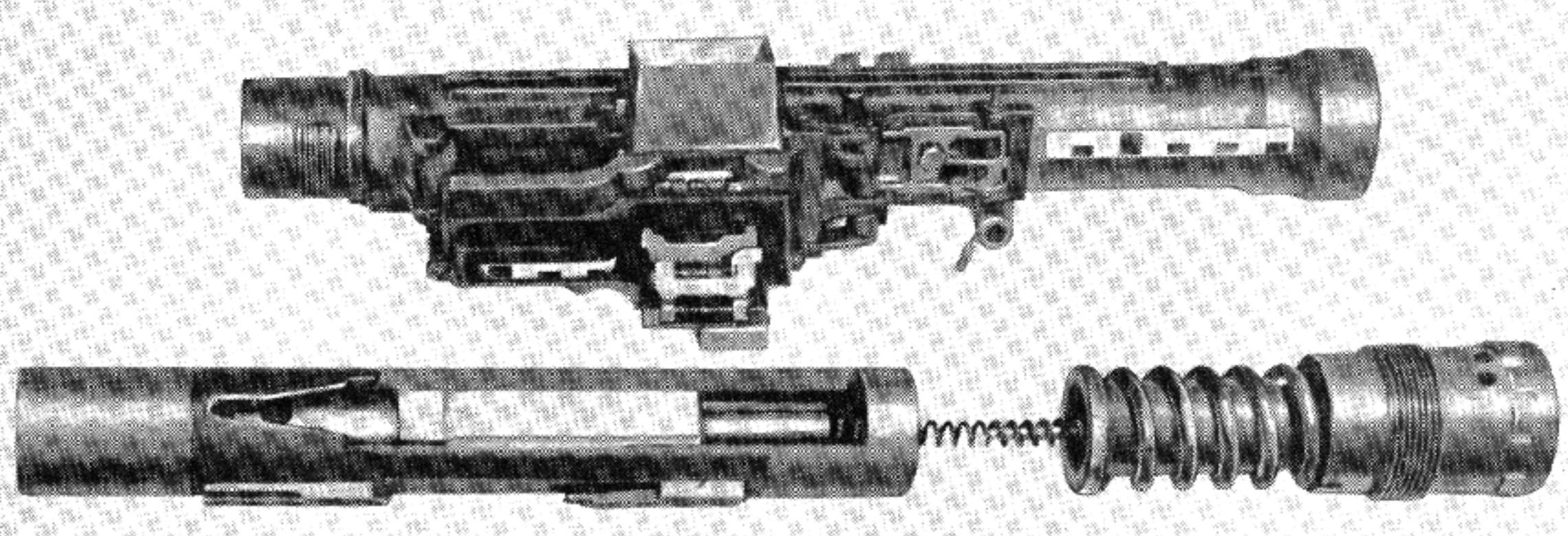


Figure 6–15. Receiver group of the 37-mm NS Gun. In the foreground is the barrel extension (which carries the bolt) and to the right of it, the recoil buffer.

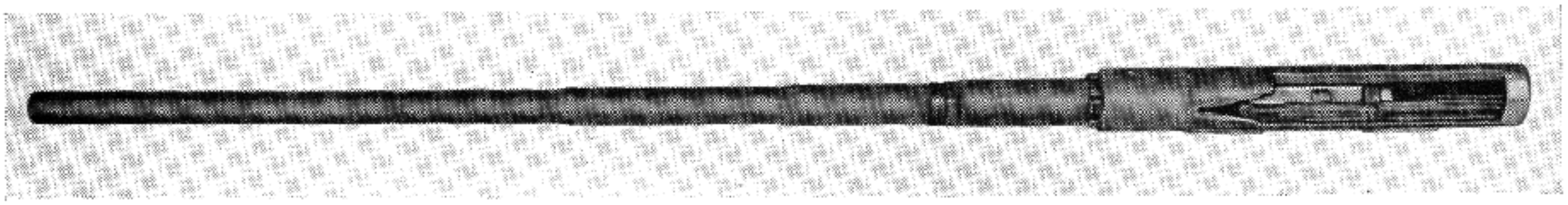


Figure 6–16. 37-mm NS Gun. Barrel and barrel extension, assembled.

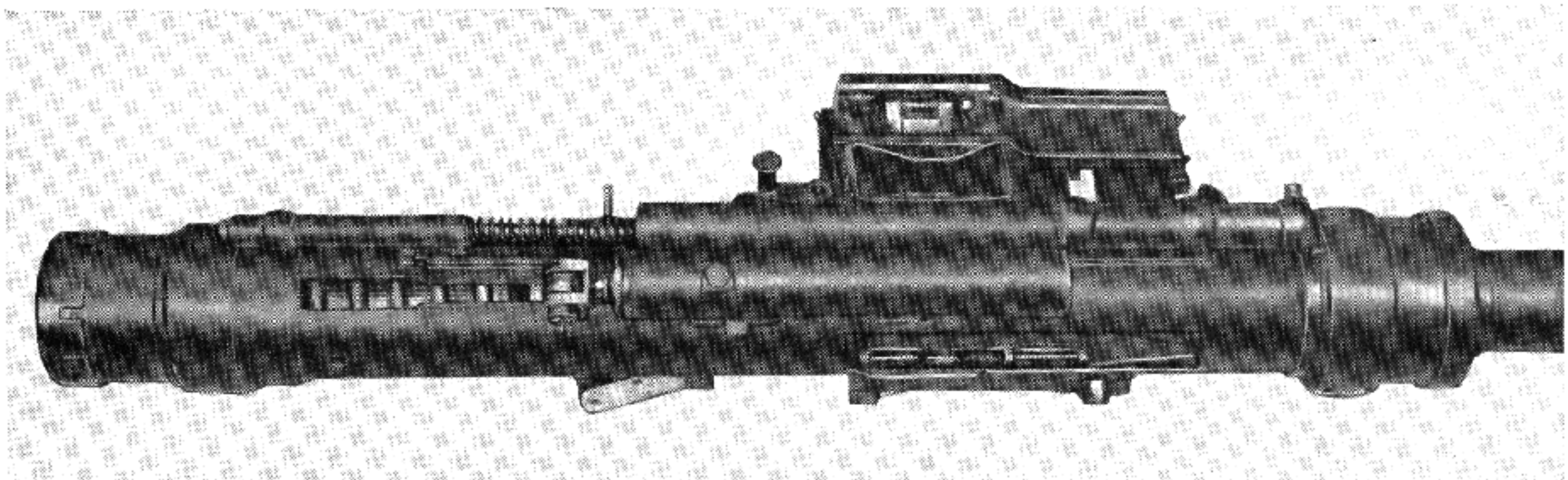


Figure 6-17. Close-up view of 37-mm NS Gun from right. The long thin cylinder on top of the receiver is the pneumatic charger.

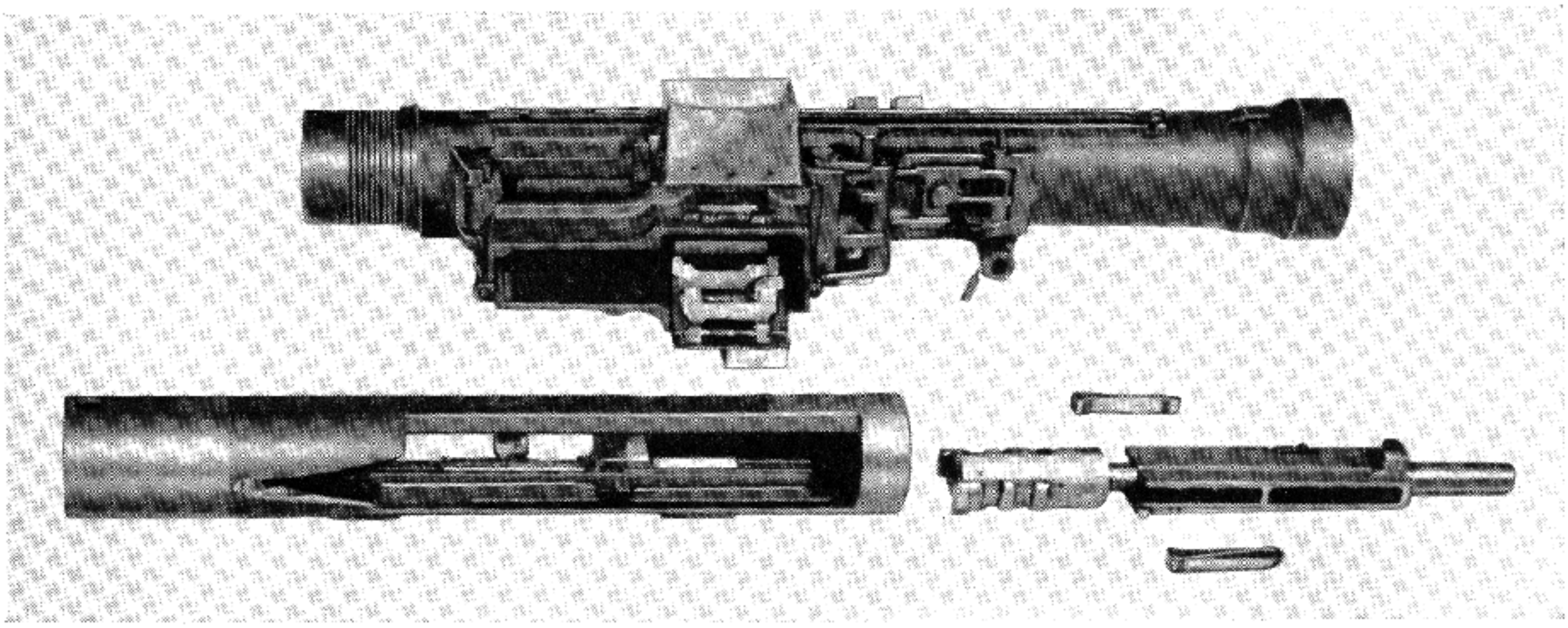


Figure 6-18. 37-mm NS Gun. Receiver Group. In the foreground is the barrel extension (left) and bolt group (right).

order to make this change, it was found necessary to move the pilot's seat position slightly farther to the rear. A male and female coupling type of mounting bracket was also fastened to the cylinder block and had splines cut in its body, to allow for the recoil movement of the gun. The forward part of the barrel was supported by a moderately close fitting sleeve or bushing that was housed in the hollow propeller hub.

The ammunition is carried in the plane in cans of the removable type. They are made of aluminum, weigh 9 pounds 2 ounces each, and come equipped with two small leather handles for carrying. The inside dimensions of the cans are 16 x 10½ x 8½. The back side of the container has a large hinged door, designed to facilitate loading and stacking of ammunition. One of the most distinguishing features about the smaller guns is the enclosed buffer, whereby the heavy peculiarly designed spring is housed inside the receiver, leaving the rear end of the gun minus the conventional protrusion that is on practically every machine gun that uses a mechanical means for buffing the recoiling parts.

The high muzzle velocity of 2,850 feet/second of the NS 37 gave the projectile a high penetration of armor when impact was at an angle that would not cause ricocheting.

The NS 37 showed the Russians that they were on the right track in turning to the short recoil principle for operational energy. It also pointed out that the weapon would have to be refined if it was to serve a useful purpose in the future. Before long another version of automatic aircraft cannon made its appearance, the NS 23.

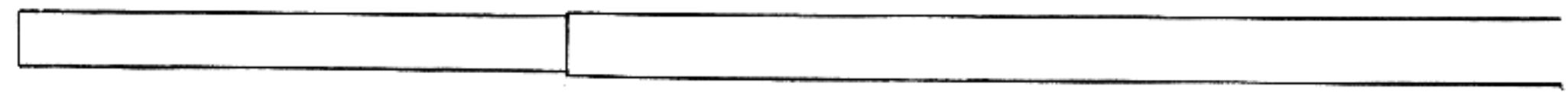


Figure 6–19. Assembly views of a Soviet 23-mm NS Cannon.

The NS 23 can be mounted in either the wing or fuselage. The latter mounting is more popular but necessitates synchronization, which causes a lower cyclic rate. The plane in which this gun is usually mounted will accommodate only three, or at the most four, guns. The fire power is, accordingly, inadequate for air-to-air combat. The gun is effective in close ground support, especially against armored vehicles.

The NS 23 aircraft cannon was used quite extensively with little or no change made in its construction; however, just as soon as the end of hostilities allowed them to do so, the Russians began an overall refinement program on both the 23-mm and 37-mm versions. While post-war models did not deviate basically from the original design, there have been refinements in these later versions.

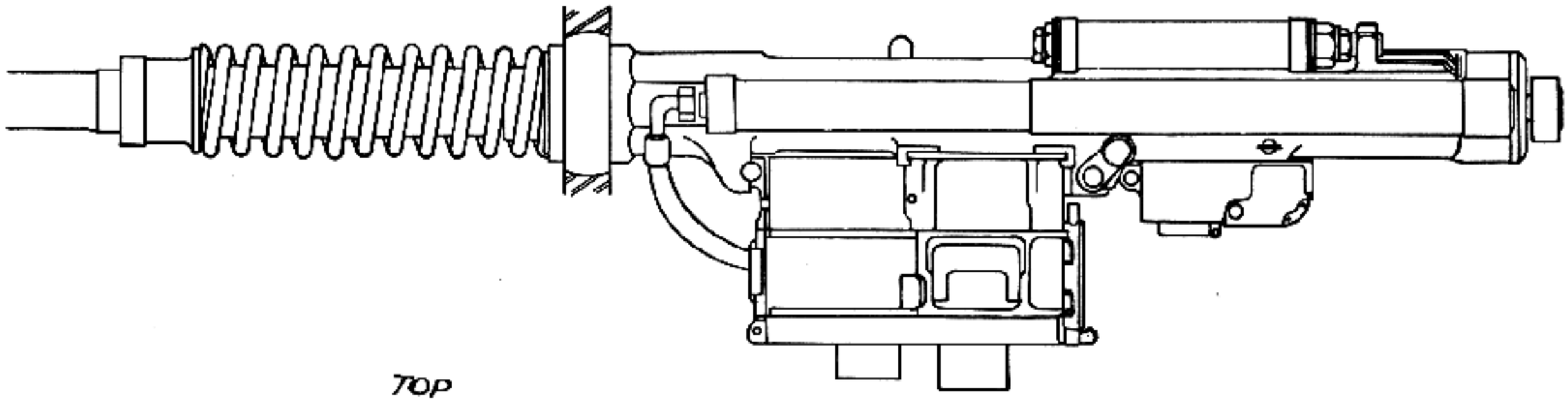
One of the main changes was to do away with the synchronizing of the firing mechanism. This did much to simplify construction of the bolt and its components. The rate of fire was stepped up. Also, every possible way to reduce the weight was attempted and so successful were the Soviets in this undertaking, that the post-war version designed for their jet fighter is approximately 33 pounds lighter than the type installed in the YAK–9, close air support plane.

Cycle of Operation for the NS Series

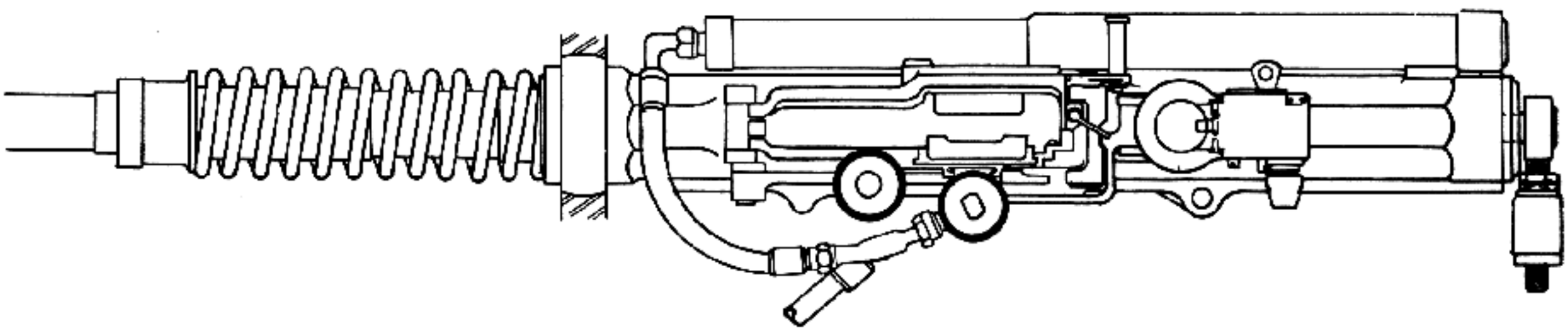
The cycle of operation for all guns of this series is similar and the following explanation which relates specifically to the 23-mm NS would apply to any of the other Nudelman designs.

Charging is accompilshed pneumatically through a system involving two cylinders, one to move the bolt rearward against its drive spring and one to charge the feeder springs. Both cylinders receive air under pressure simultaneously through a solenoid-controlled valve.

During charging, air under pressure acts on the charger piston assembly in the drive spring housing. Under this force the piston moves rearward, causing the drive spring guide to compress the drive spring. The bolt body is attached to the drive spring guide by a lug, causing the bolt body to move rearward with the drive spring guide. Simultaneous motion of the feeder cam plate depresses the bolt pawl allowing the bolt body to continue rearward under the force of the air acting on the charger piston assembly. The rearward motion of the bolt body rotates the bolt head lugs out of engagement with the recesses in the barrel extension, thus unlocking the bolt and allowing the air pressure to move the bolt completely rearward to the seared position.



TOP



LEFT SIDE

Meanwhile air under pressure enters the charger cylinder for the feeder exerting force on the charger piston assembly for the feeder. This force causes the feeder cam plate to be lifted, thus compressing the feeder springs, and moving the feeder slide outward. The feeder pawls are forced upward against their springs by the rounds in the ammunition belt during this motion. The rounds in the ammunition belt are held stationary during the outward motion of the feeder slide by the action of the holding pawl in the feeder cover plate. After the feeder slide and the bolt have completed their travel under air pressure, the solenoid-controlled valve reverses, venting the air on the high-pressure side of each piston. This causes the drive spring to move the bolt forward until it is caught by the sear, and causes the feeder springs to move the feeder slide in. The feeder pawls, which in the outward position moved up behind the rounds in the belt under the force of their springs, pull the belt into the gun and position a round in the T-slot in the face of the bolt. The feeder cam plate releases the mechanical sear at the end of its stroke, causing the bolt to be held rearward only by the solenoid-controlled trigger sear.

To load the gun the feeder cover plate and the link stripper assembly are removed. The link of the leading round in the belt is engaged with the link stripper and the link stripper assembly is reassembled. The feeder cover plate is then installed. After charging twice, the gun will fire upon release of the solenoid-controlled trigger sear.

In this ready state the feeder springs are expanded, and the cartridge is positioned in the T-slot in the face of the bolt. When the solenoid is actuated by the firing switch, the sear releases the bolt and the drive spring sends it home against the barrel, to chamber the round. The head of the bolt strikes the base of the barrel and stops. The body of the bolt continues forward, and a stud on the bolt head extension follows a cam groove in the bolt body, causing the head of the bolt to be rotated so that the locking lugs on the bolt head engage recesses in the barrel extension, thus locking the bolt to the barrel extension. Rebound of the bolt body is prevented by a spring-loaded pawl which snaps into a recess in the barrel extension.

As the bolt body nears the end of its forward

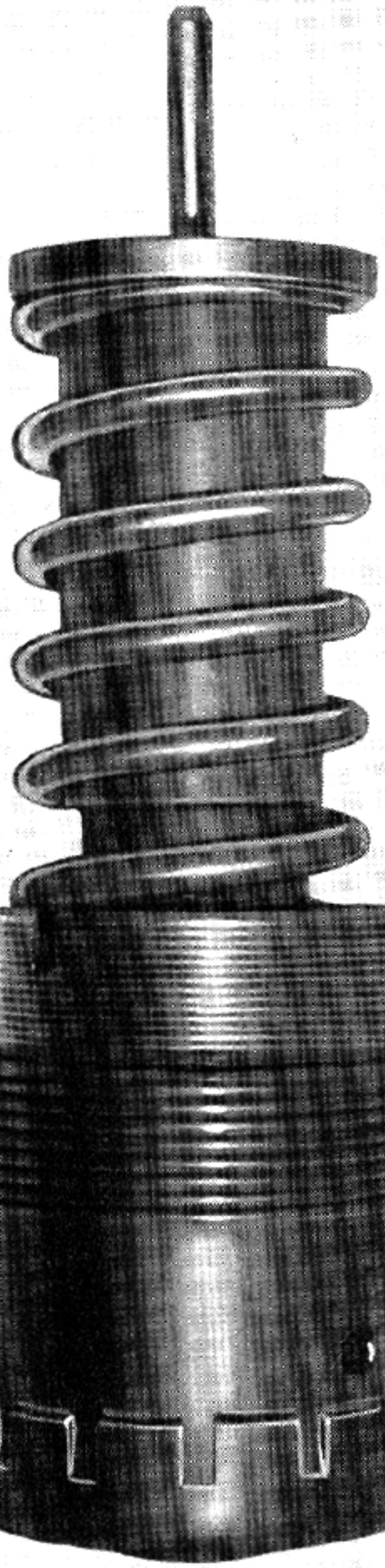


Figure 6–20. 37-mm NS Gun. Recoil buffer assembly.

travel, $\frac{5}{16}$ inch after the bolt head is locked, the firing pin is brought into contact with the primer, firing the round.

When the round fires, reaction against the bolt head causes the bolt assembly, barrel extension, and barrel to move rearward, since the bolt is locked to the barrel extension. After about $^{29}\frac{}{32}$ inch of recoil travel, the accelerator, pivoted in the receiver, starts to move the bolt body rearward at an increased velocity, causing it to cam the bolt head locking lugs out of engagement with the recesses in the barrel extension. This is possible because the pawl which prevents the bolt body from rebounding is disengaged from the barrel extension during recoil by the camming action of an intermediate lever between the receiver and the pawl. (During charging this pawl is disengaged by the motion of the feeder cam.) The unlocked bolt continues rearward until it strikes the buffer spring. It rebounds from the buffer, travels forward a short distance, and is stopped by a mechanically-operated sear, which is controlled by the feeder cam. This sear is side by side in the same housing with the electrical sear; either of them can hold the bolt in the rearward position. In the seared position the T-slot in the head of the bolt lines up with a T-slot in the feeder, which acts as a guide for the cannelure of the cases being fed.

As the barrel extension recoils, a shoulder on its side lifts the cam plate of the feeder, compressing the feeder springs. After the barrel extension has recoiled $2\frac{13}{16}$ inches, the feeder springs are compressed, and a spring-loaded latch, pivoted in the receiver moves under the feeder cam plate to hold these springs compressed. The barrel extension continues rearward a short distance further, until all of its remaining kinetic energy has been absorbed by the helical recoil spring. The total recoil travel of the barrel extension is about $3\frac{1}{4}$ inches. At the rear of the recoil position, the energy stored in the main recoil spring acts to return the barrel and barrel extension to battery.

The counter-recoil buffer starts to slow the counterrecoiling parts when they are $1\frac{13}{16}$ inches from the battery position, reducing the shock of stopping these parts.

When the barrel extension is 1⅛ inches from battery on its counter-recoil stroke, a cam on its side releases the latch holding the feeder cam plate, which allows the feeder springs to expand. The expansion of these springs operates the feeder slide, which forces a new round against the empty case held in the T-slot on the face of the bolt head (aligned by the sear) and pulls in the ammunition belt. This causes the empty case to be pushed off the face of the bolt and ejected through the side of the receiver, while the new round is positioned in the T-slot in the face of the bolt head. The links are stripped from the rounds in the feeder by the link stripper assembly and discharged through the bottom of the feeder. When the feeder cam plate is ⅛ inch from completing its feed stroke, it actuates a pin in the receiver which causes a stop pawl to be moved out into the path of the round being fed, causing it to stop in the proper position on the face of the bolt. A spring-loaded pin in the face of the bolt acts to retain the cartridge on the face of the bolt during ramming.

As the feeder cam completes its stroke, it releases the mechanical sear holding the bolt rearward and allows the drive spring to return the bolt to battery, initiating another cycle.

The synchronized 23-mm NS Gun probably fires the same ammunition and has the same performance characteristics as the free-firing gun, except that in synchronized firing, its cyclic rate would be slightly lower. The physical proportions and weights of the two guns are nearly identical.

Summary

The advantages and disadvantages peculiar to this design are general throughout the series but the following points apply particularly to the 23-mm guns.

Advantages. The advantages of this weapon appear to be as follows.

a. Mechanical ruggedness. It is probable that part breakages are rare in this weapon. The working parts are sturdy and apparently stressed only to reasonable levels.

b. Dependability. The method of feeding is positive throughout. Since the empty case is pushed out by the incoming round which, in turn, is positively positioned into the T-slots in the face of the bolt while the bolt is seared, feeding jams should be rare. Extraction and ejection are gentle and positive. In-line ramming contributes to dependability.

c. Low silhouette. This feature is of significance in fixed and flexible aircraft gun installations demanding minimum gun profiles.

d. Relatively high belt pull. It is probable that belts of considerable length can be fed without ammunition boosters.

e. Reliability. Operation of the weapon should be reliable under a wide range of climatic conditions.

Disadvantages. The disadvantages of the weapon are as follows: low cyclic rate, moderate muzzle velocity, rear sear or bolt after each round during automatic fire. Although this feature makes possible the positive feed and ejection feature and may be justified on this basis, it is an unusual principle in automatic weapons, and does reduce the cyclic rate.

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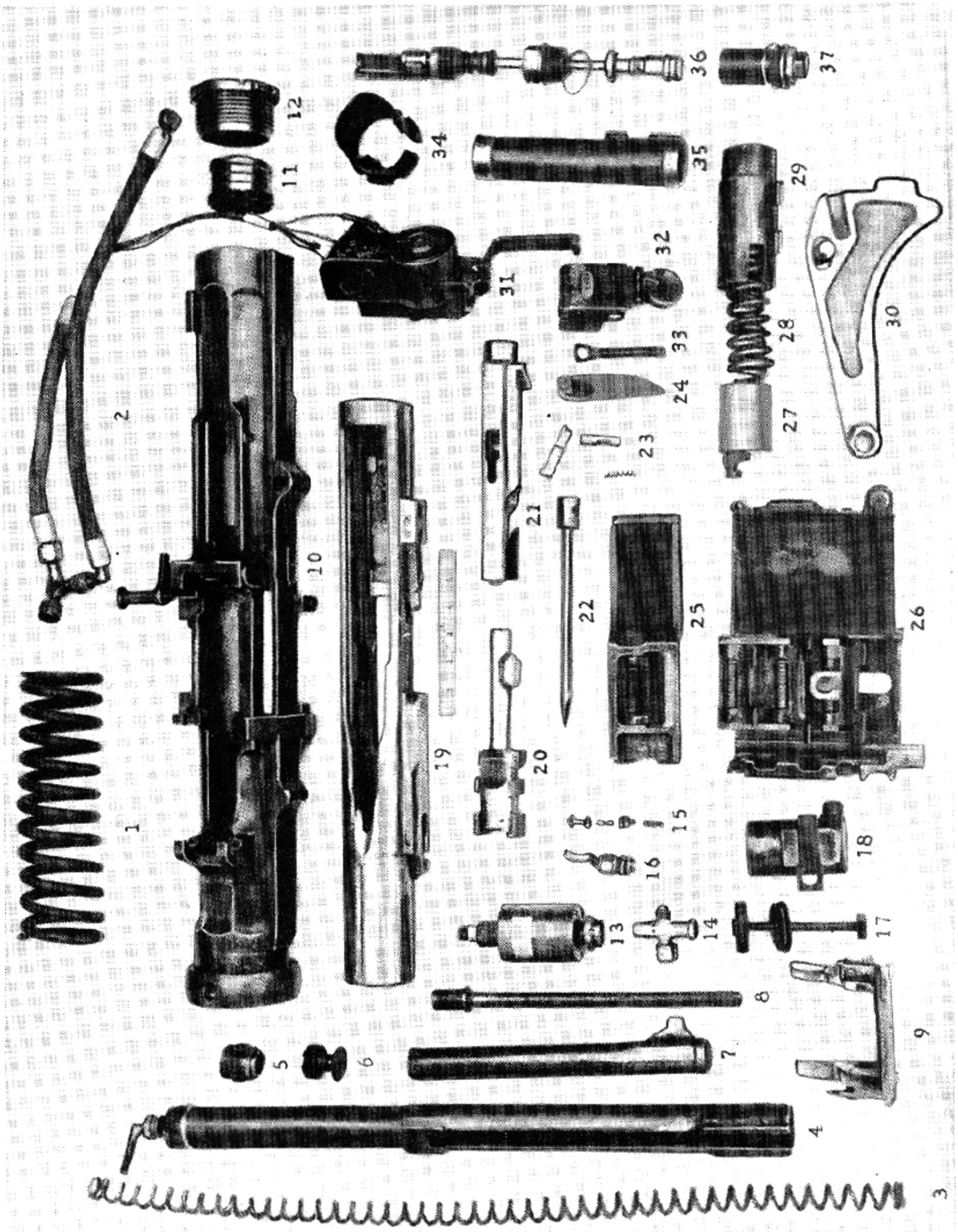

Figure 6–21. 23-mm NS Cannon, dismantled. The barrel is not shown.

1. Recoil spring.
2. Charger hose assembly.
3. Driving spring.
4. Driving spring housing.
5. Driving spring cap.
6. Charger piston assembly (bolt).
7. Driving spring sleeve.
8. Driving spring guide.
9. Link stripper assembly.
10. Receiver assembly.
11. Buffer spring.
12. Buffer housing.
13. Charger solenoid.
14. Charger valve housing.
15. Charger valve internal components.
16. Air connector.
17. Charger piston assembly (feeder).
18. Charger cylinder (feeder).
19. Barrel extension.
20. Bolt head.
21. Bolt body.
22. Firing pin assembly.
23. Bolt pawl components.
24. Accelerator.
25. Feeder cover plate.
26. Feeder assembly.
27. Feeder spring cap.
28. Feeder springs (inner and outer).
29. Feeder spring housing.
30. Feeder cam plate.
31. Sear assembly.
32. Sear cover.
33. Sear mounting pin.
34. Recoil spring retainer nut.
35. Counter-recoil buffer housing.
36. Counter-recoil buffer piston.
37. Counter-recoil buffer cap.

Figure 6–21.—Continued

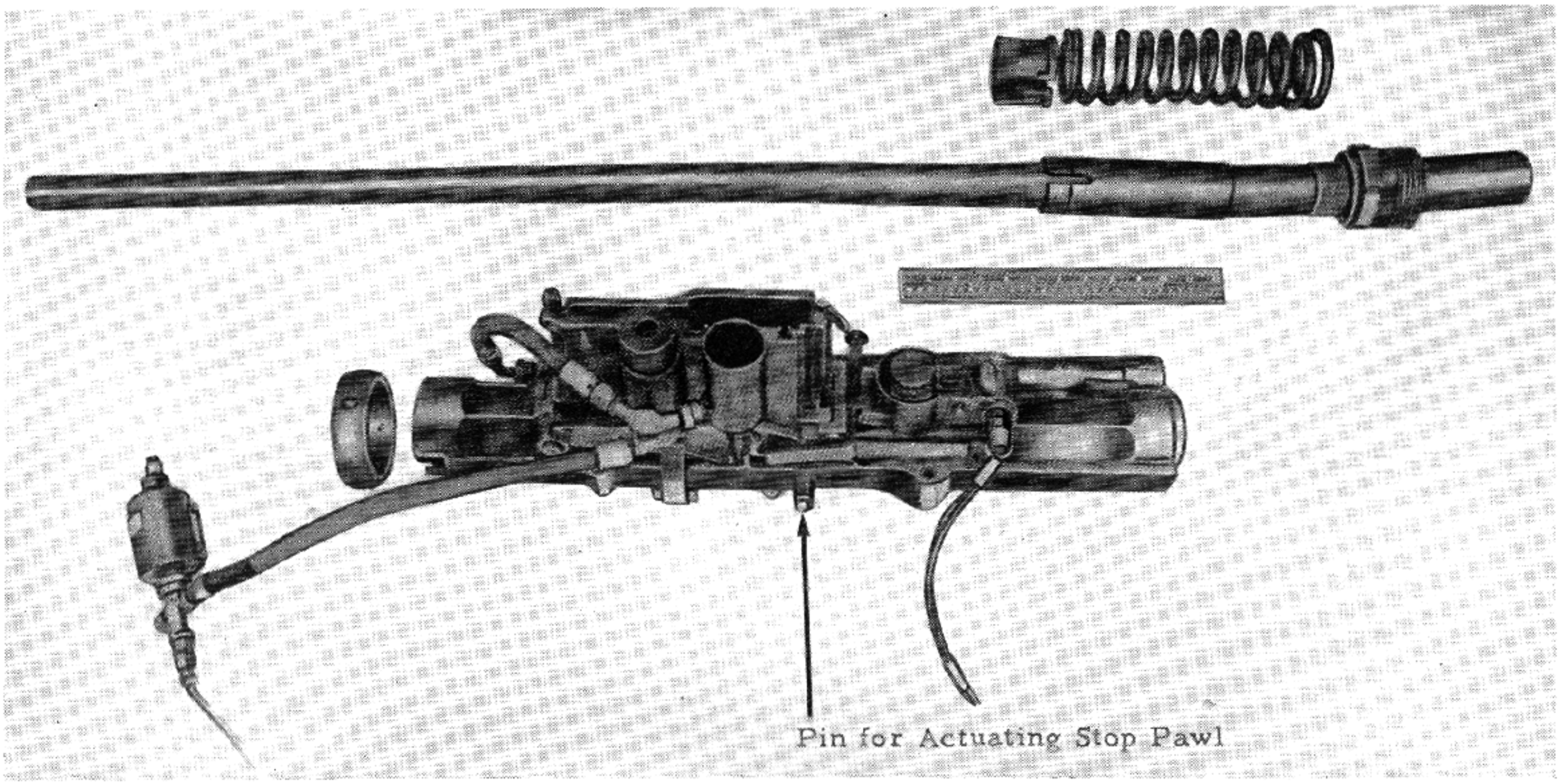

Figure 6–22. The two major assemblies of the 23–mm NS Gun.

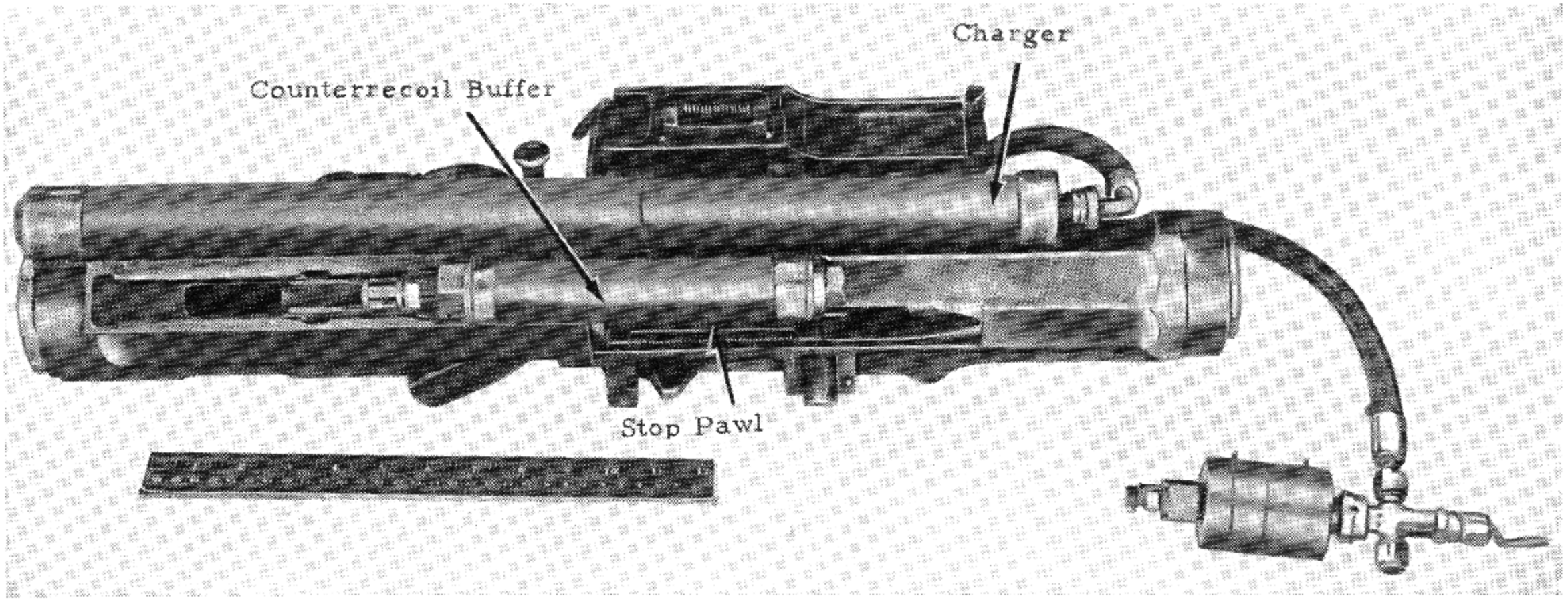

Figure 6–23. Receiver Assembly of 23-mm NS Gun, showing charger, counter-recoil buffer, and charger solenoid valve.

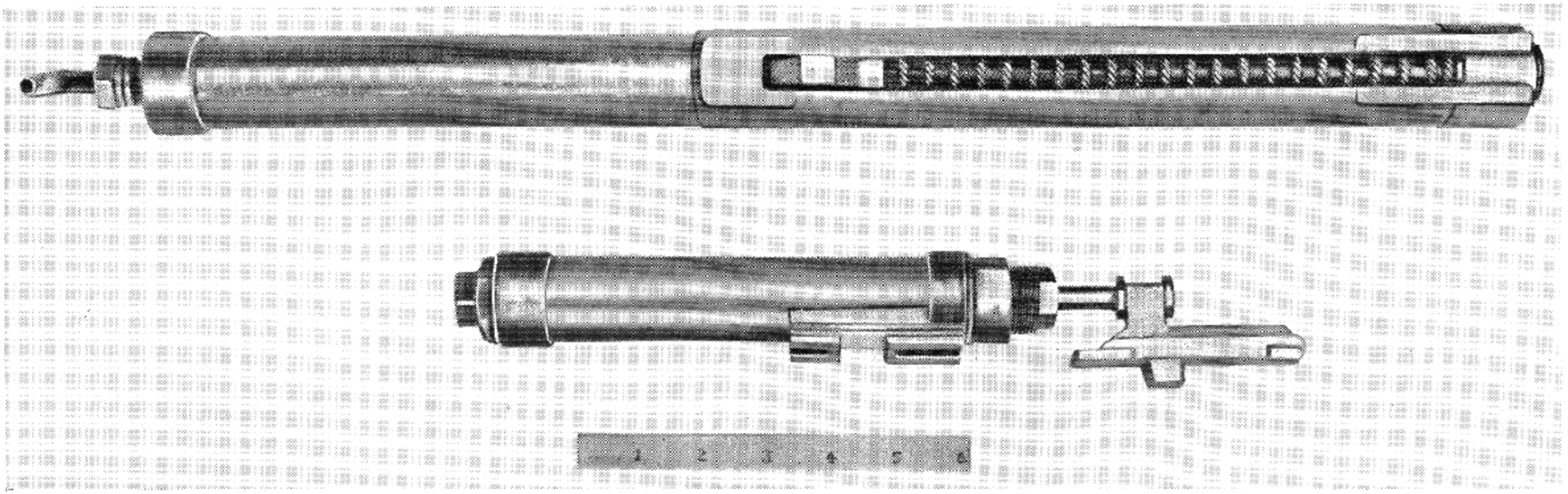

Figure 6–24. Charger and counter-recoil buffer for 23-mm NS Gun.

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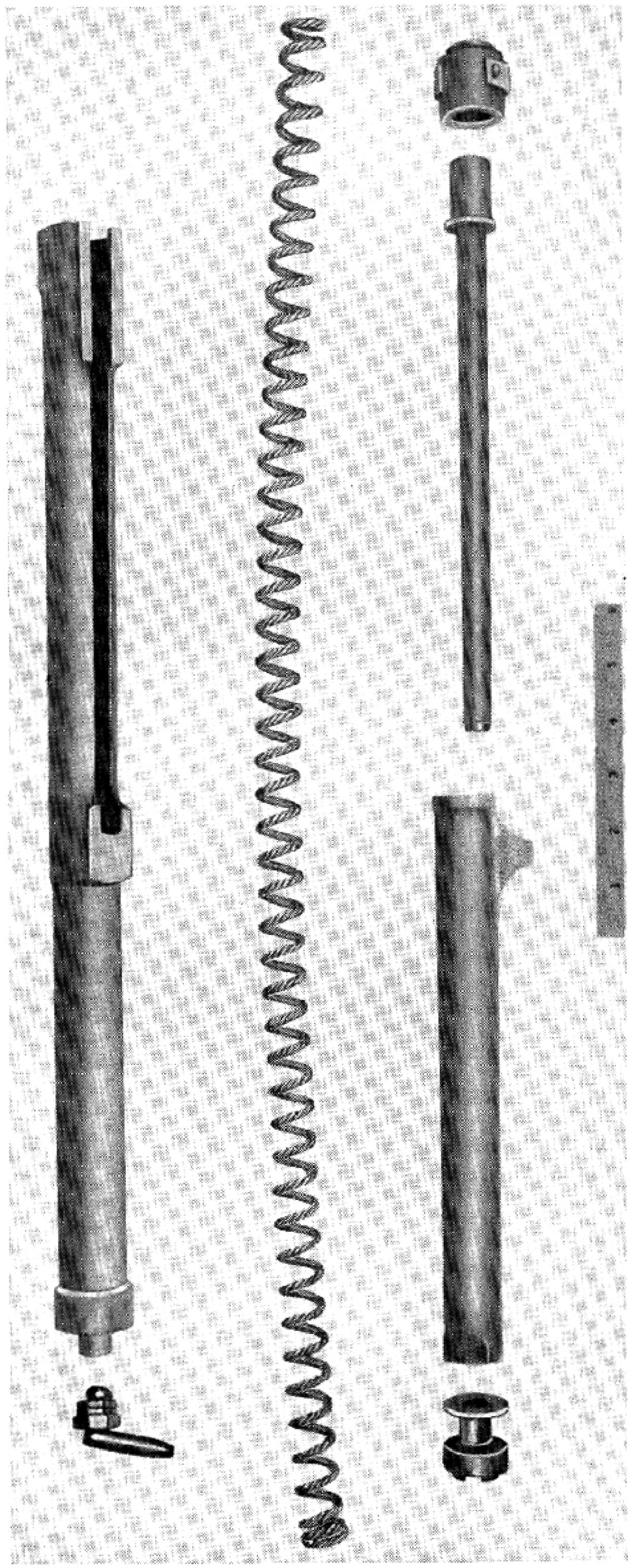

Figure 6 25. 23-mm NS Gun. View of disassembled charger.

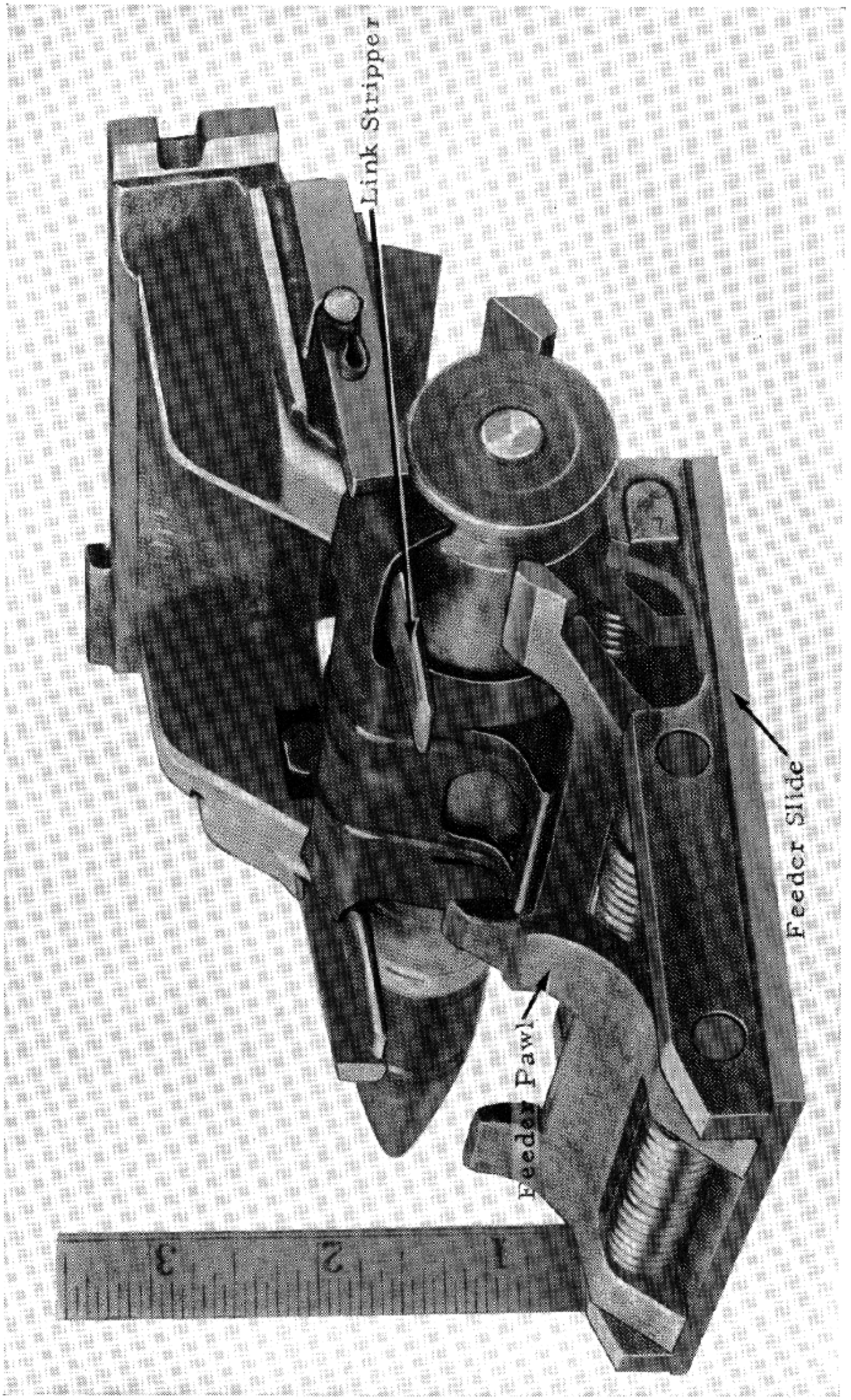

Figure 6–26. Feeder slide and link stripper for 23-mm NS Gun.

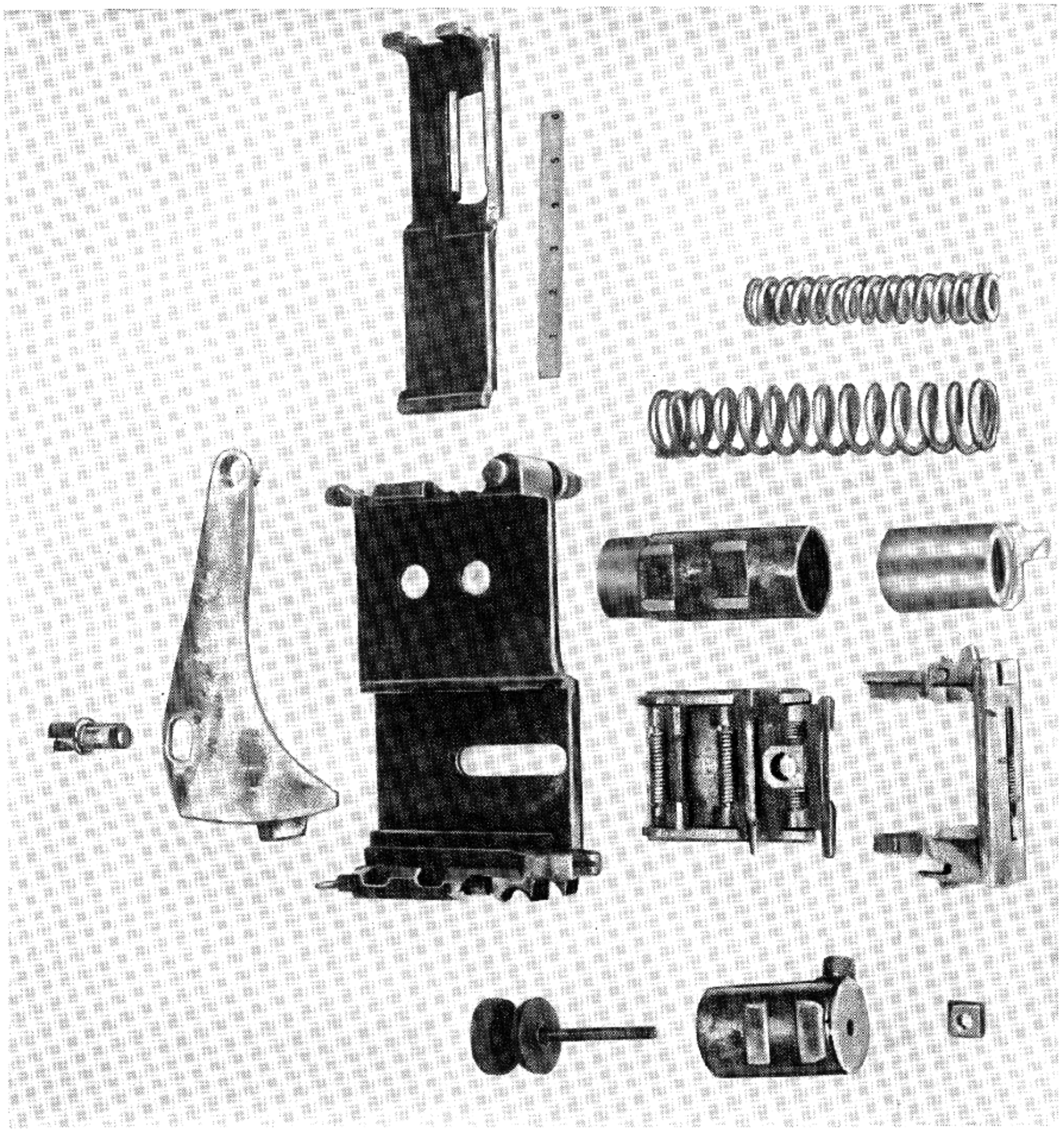

Figure 6–27. View of disassembled feeder for 23-mm NS Gun.

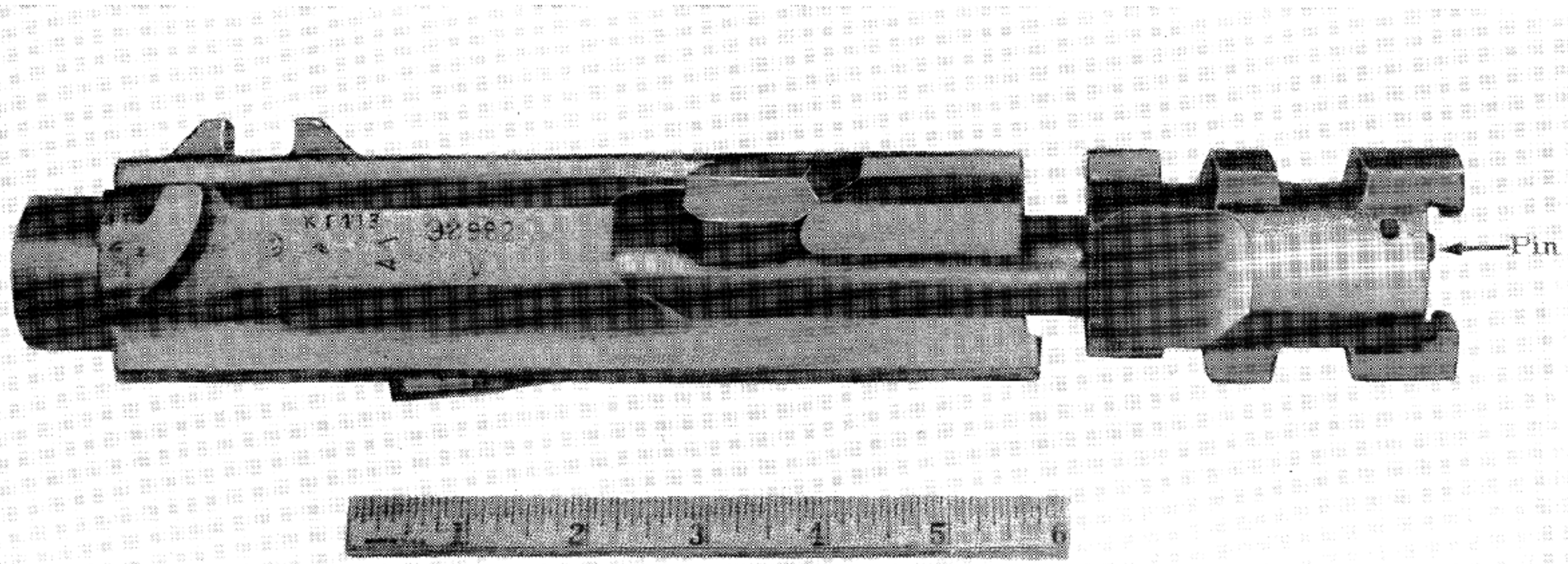

Figure 6-28. Bolt assembly for 23-mm NS Gun.

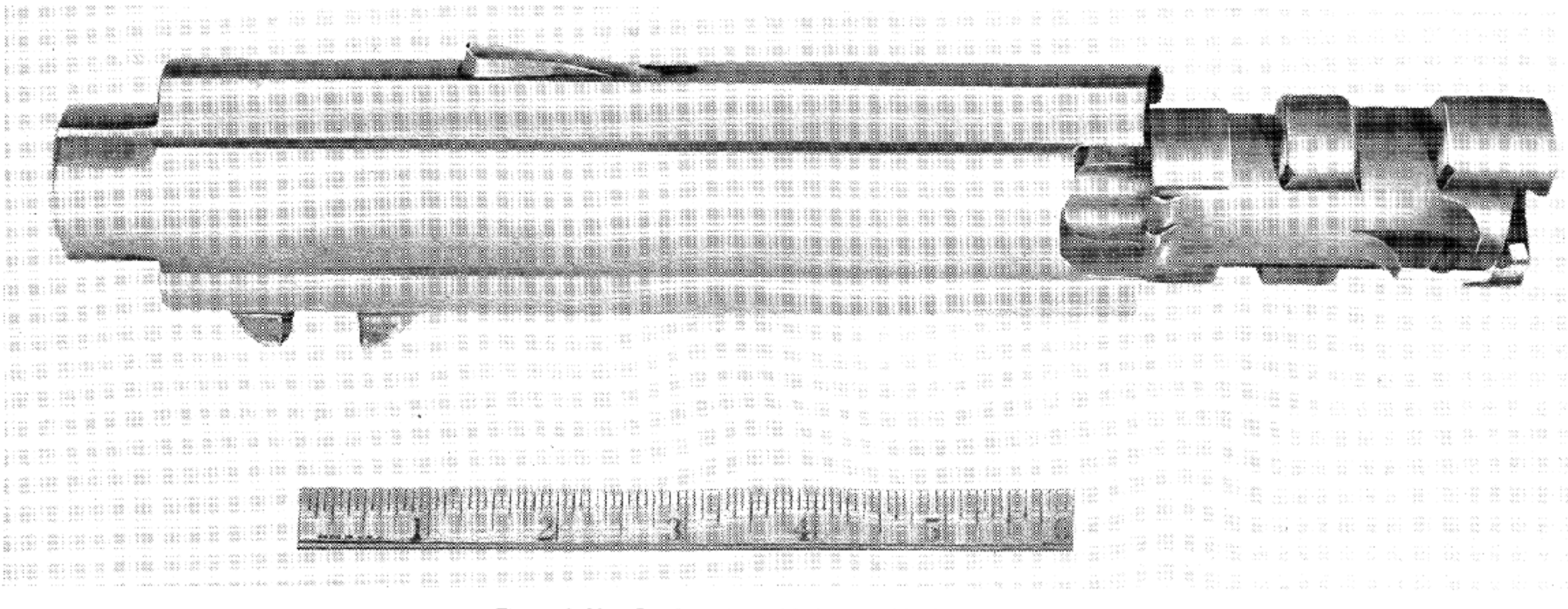

Figure 6-29. Another view of bolt assembly for 23-mm NS Gun.

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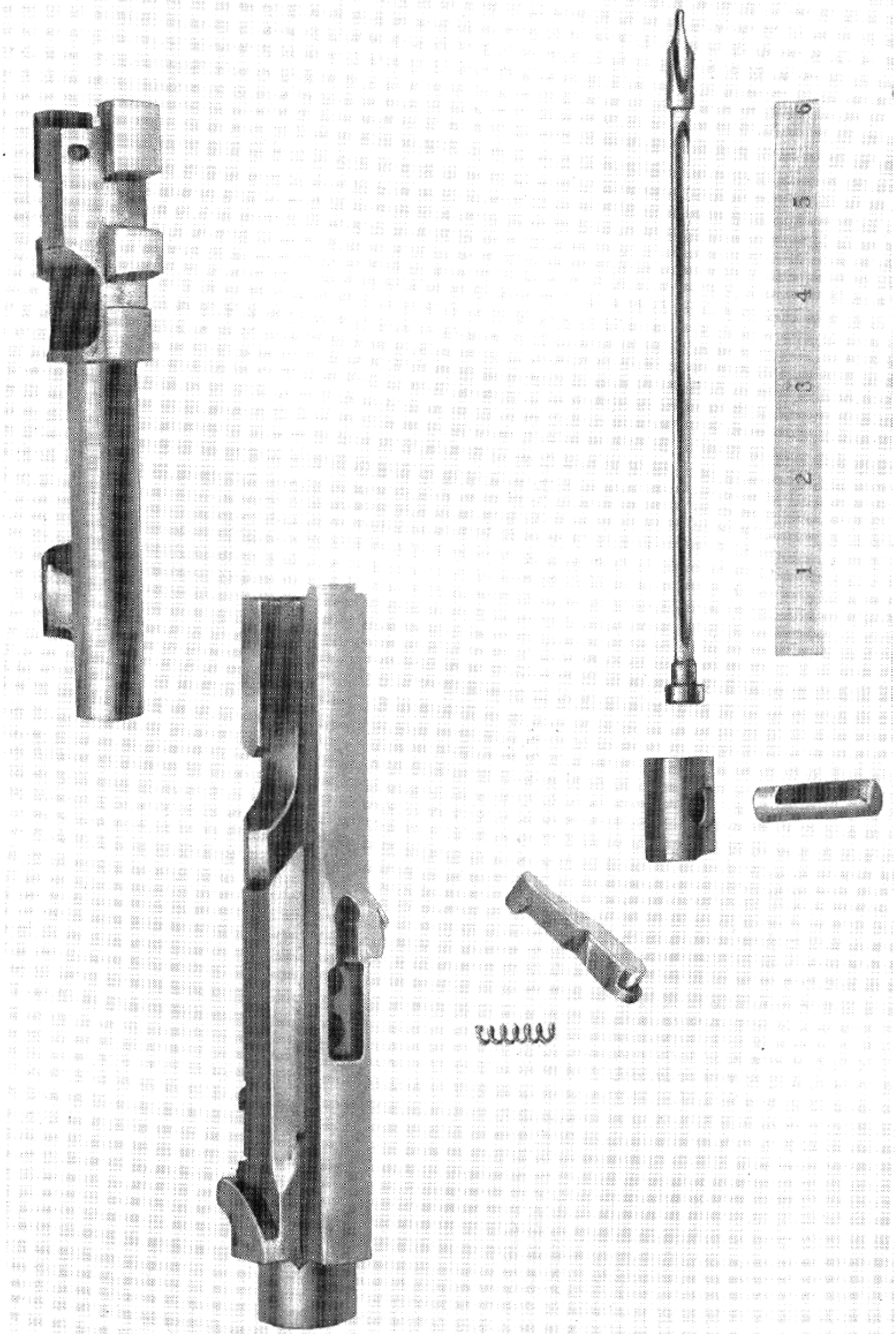

Figure 6-30. View of disassembled bolt for 23-mm NS Gun.

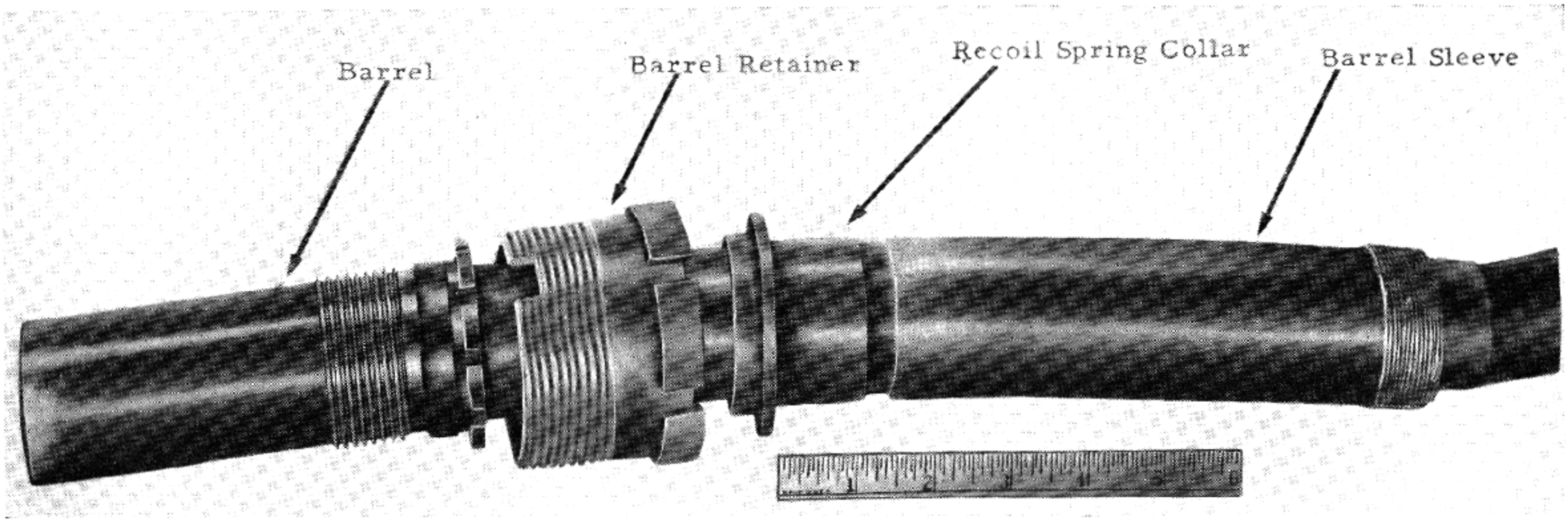

Figure 6 31. Barrel, barrel sleeve, recoil spring collar and barrel retainer for 23-mm NS Gun.

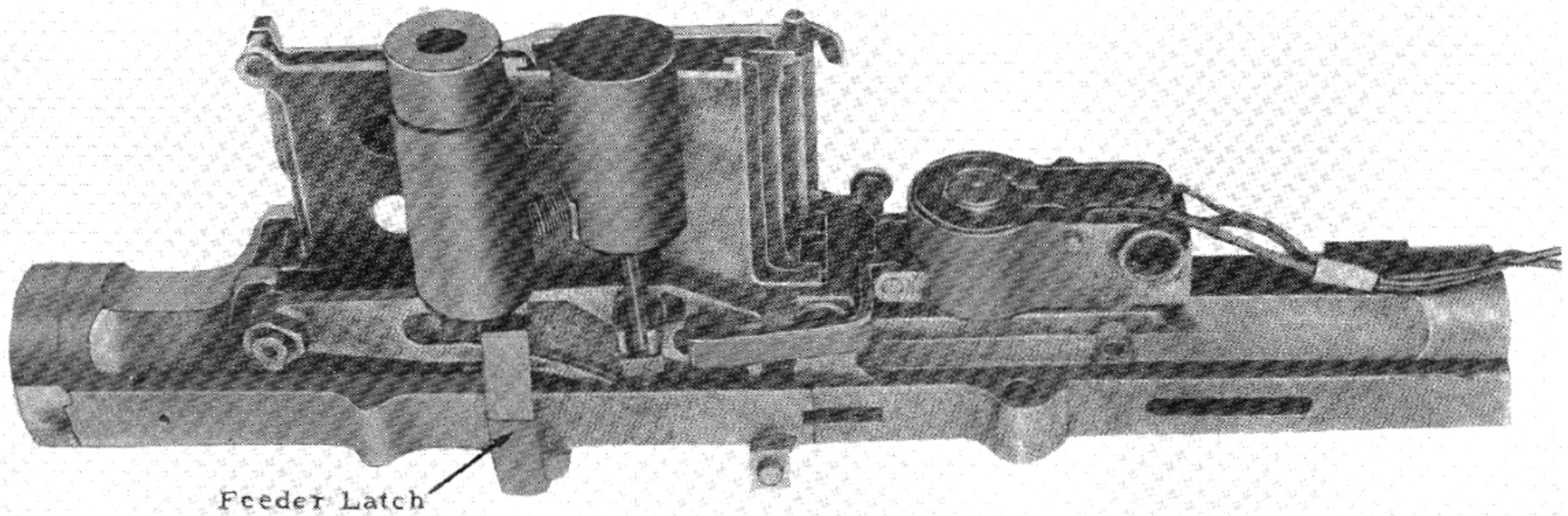

Figure 6–32. Receiver assembly of 23-mm NS Gun showing feeder cam plate and mechanical sear linkage.

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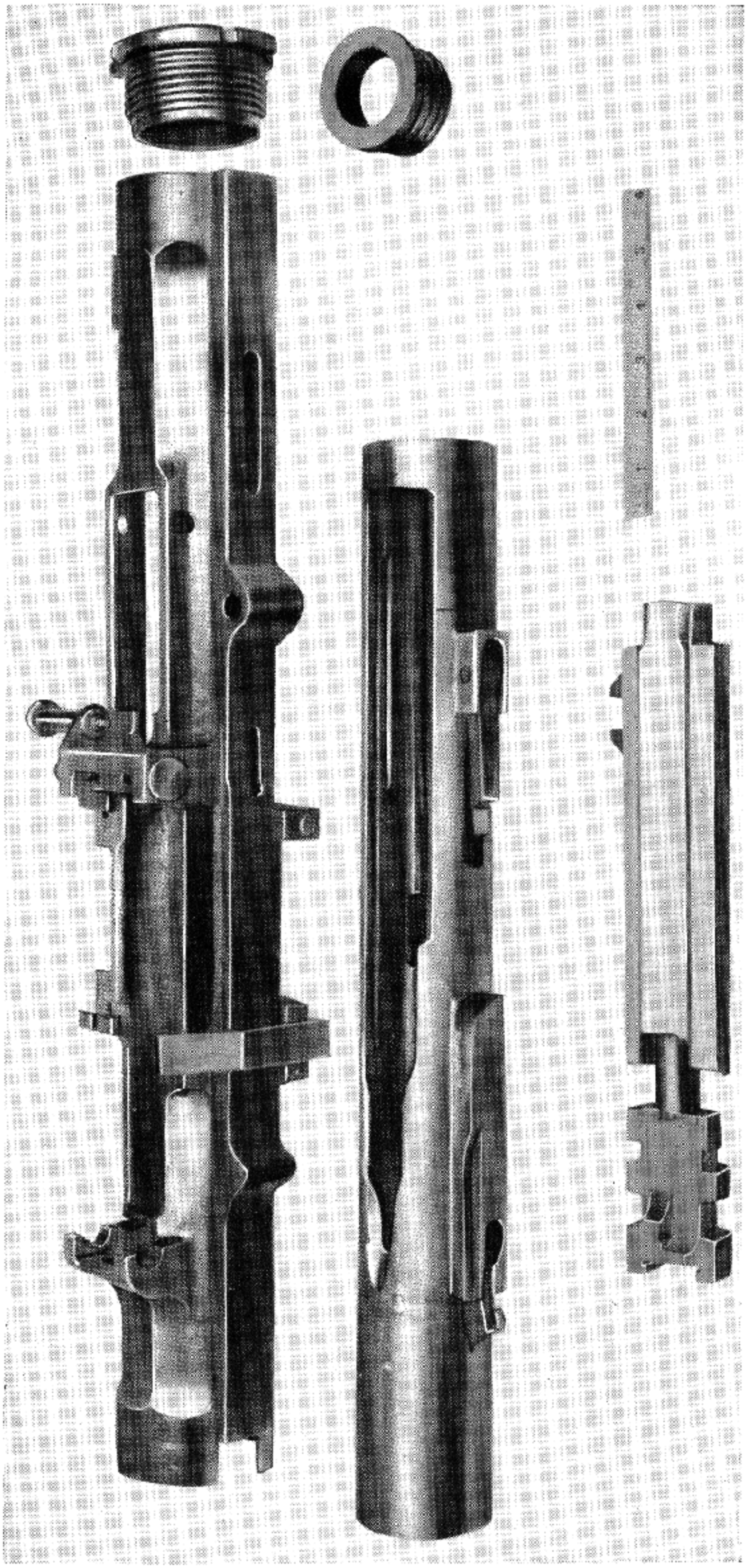

Figure 6–33. Receiver, buffer, barrel extension and bolt for 23-mm NS Gun.

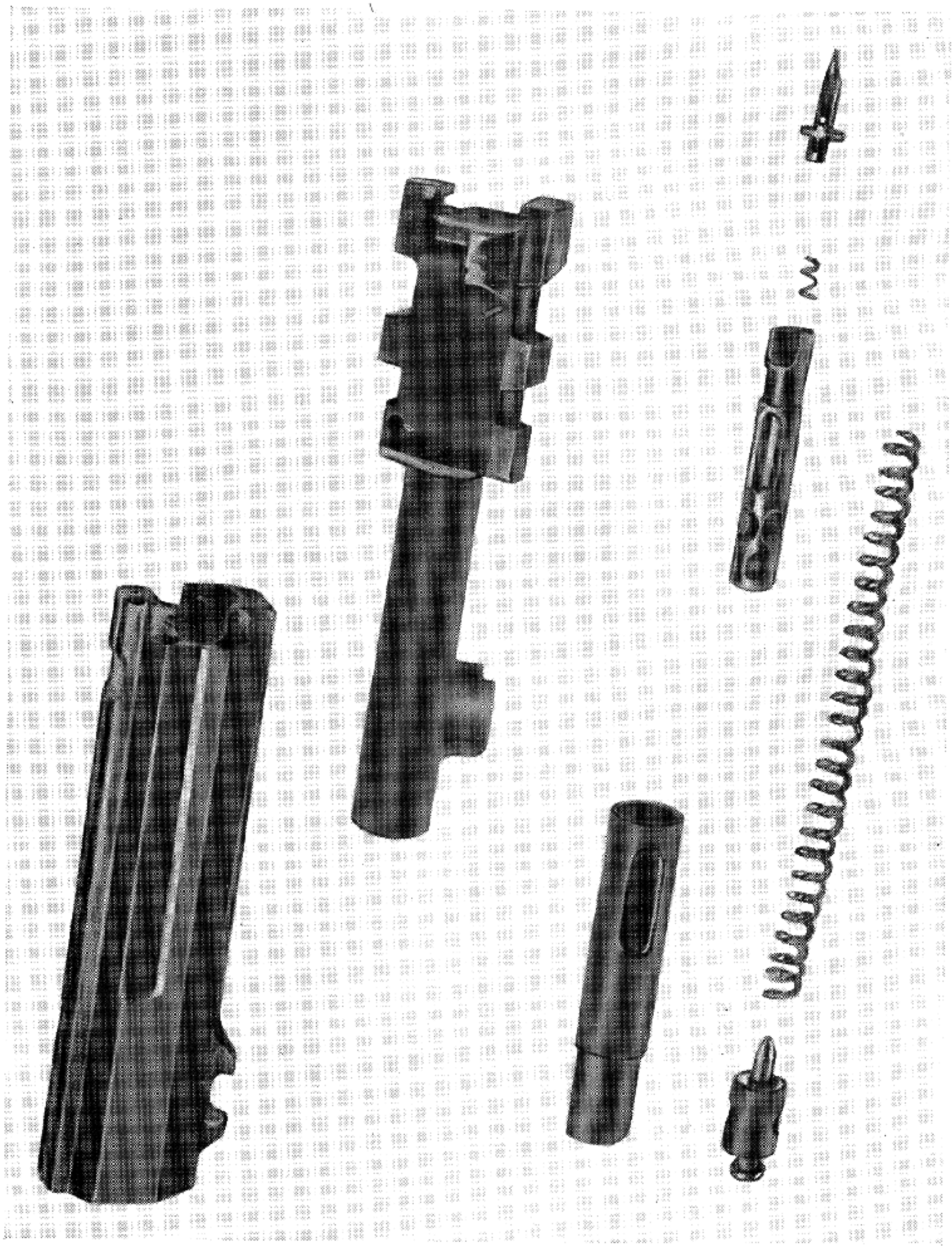

Figure 6-34. Synchronized version of 23-mm NS Gun. View of disassembled bolt.

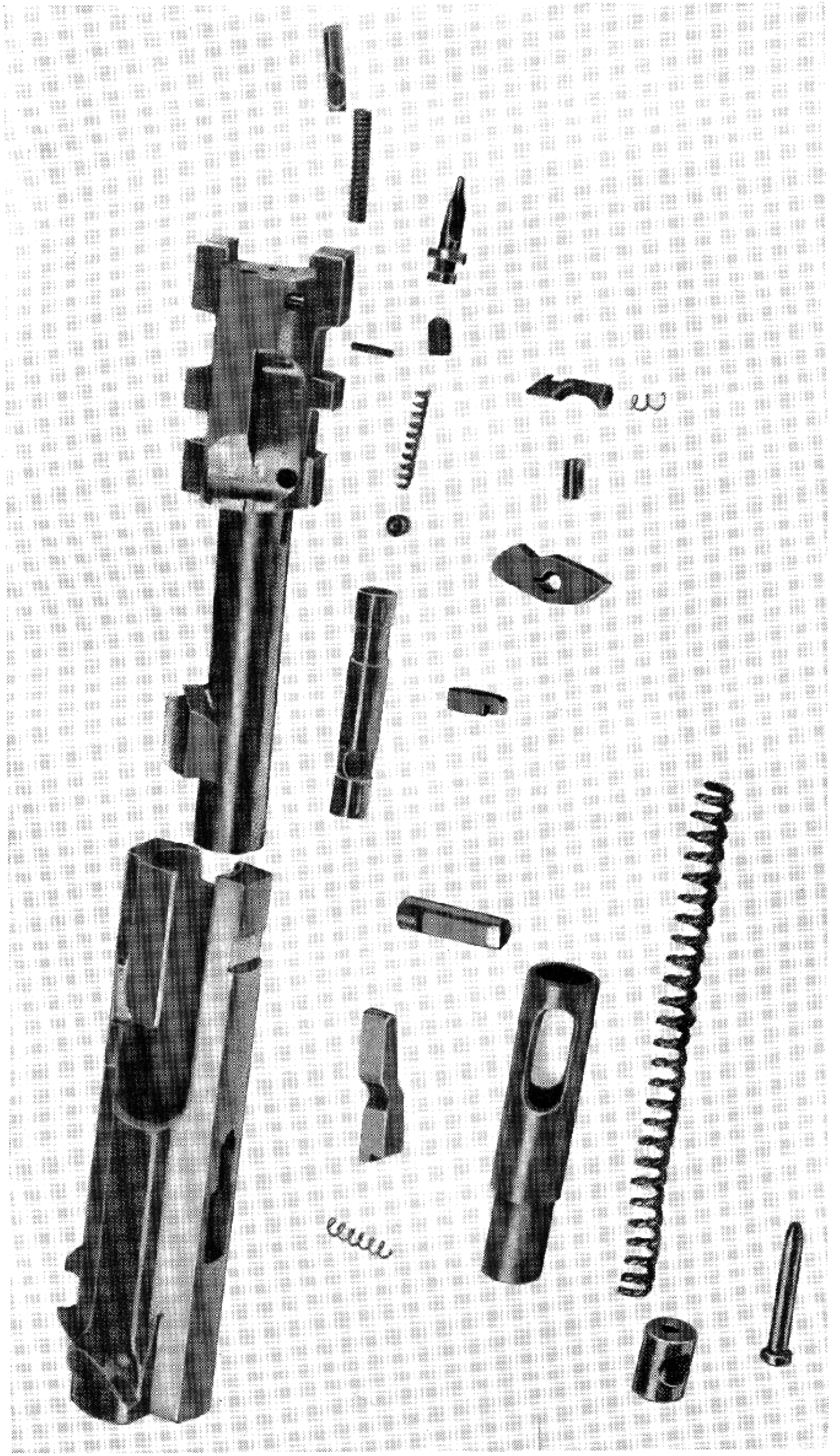

Figure 6–35. Synchronized version of 23-mm NS Gun. View of detail stripped bolt.

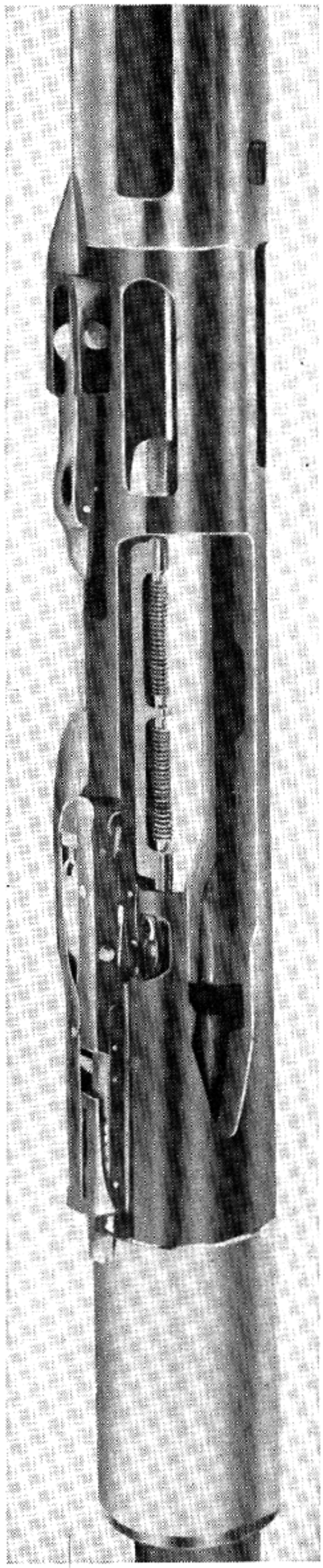

Figure 6-36. Synchronized version of 23-mm NS Gun. Barrel extension, viewed from the side.

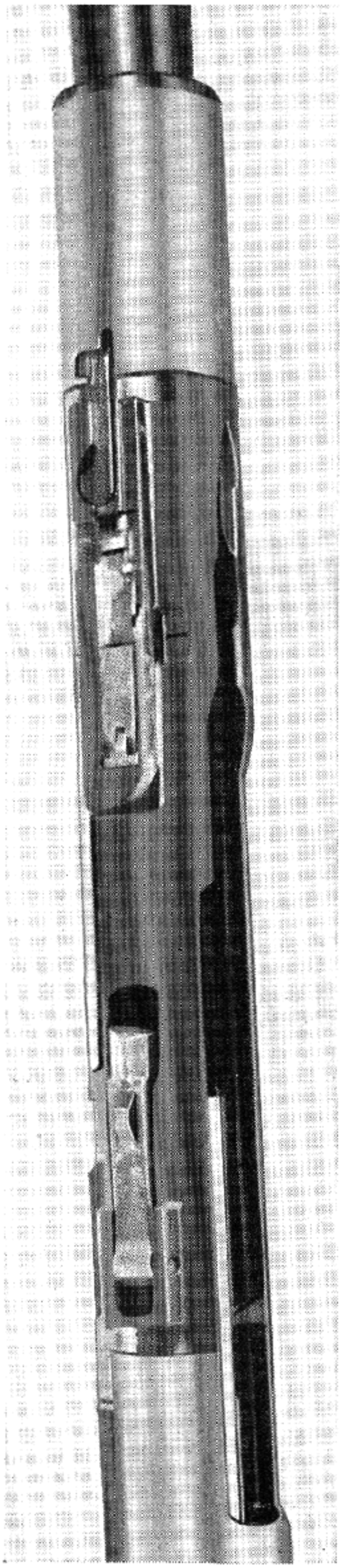

Figure 6–37. Synchronized version of 23-mm NS Gun. Barrel extension, viewed from below.

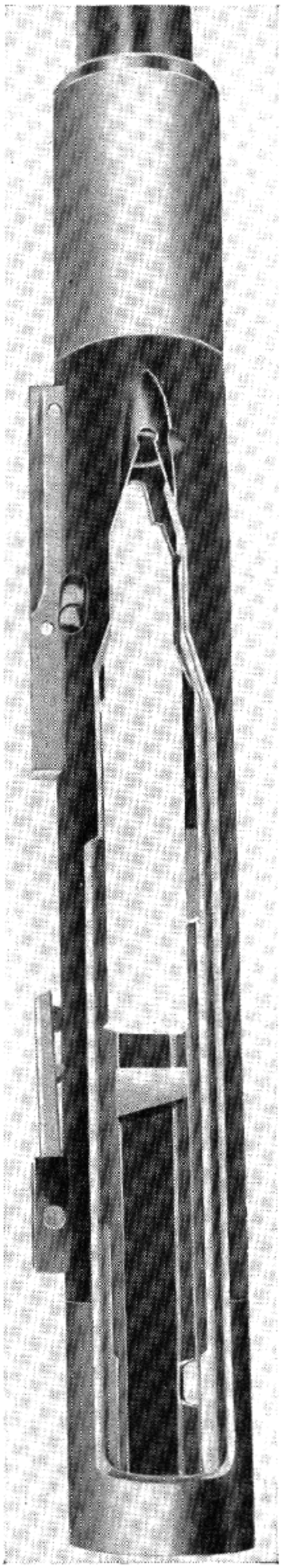

Figure 6–38. Synchronized version of 23-mm NS Gun. View of barrel extension from side to show recess for lateral movement of ammunition.

CYCLIC TIME=.1077 SEC.
CYCLIC RATE=557 ROUND/MIN.

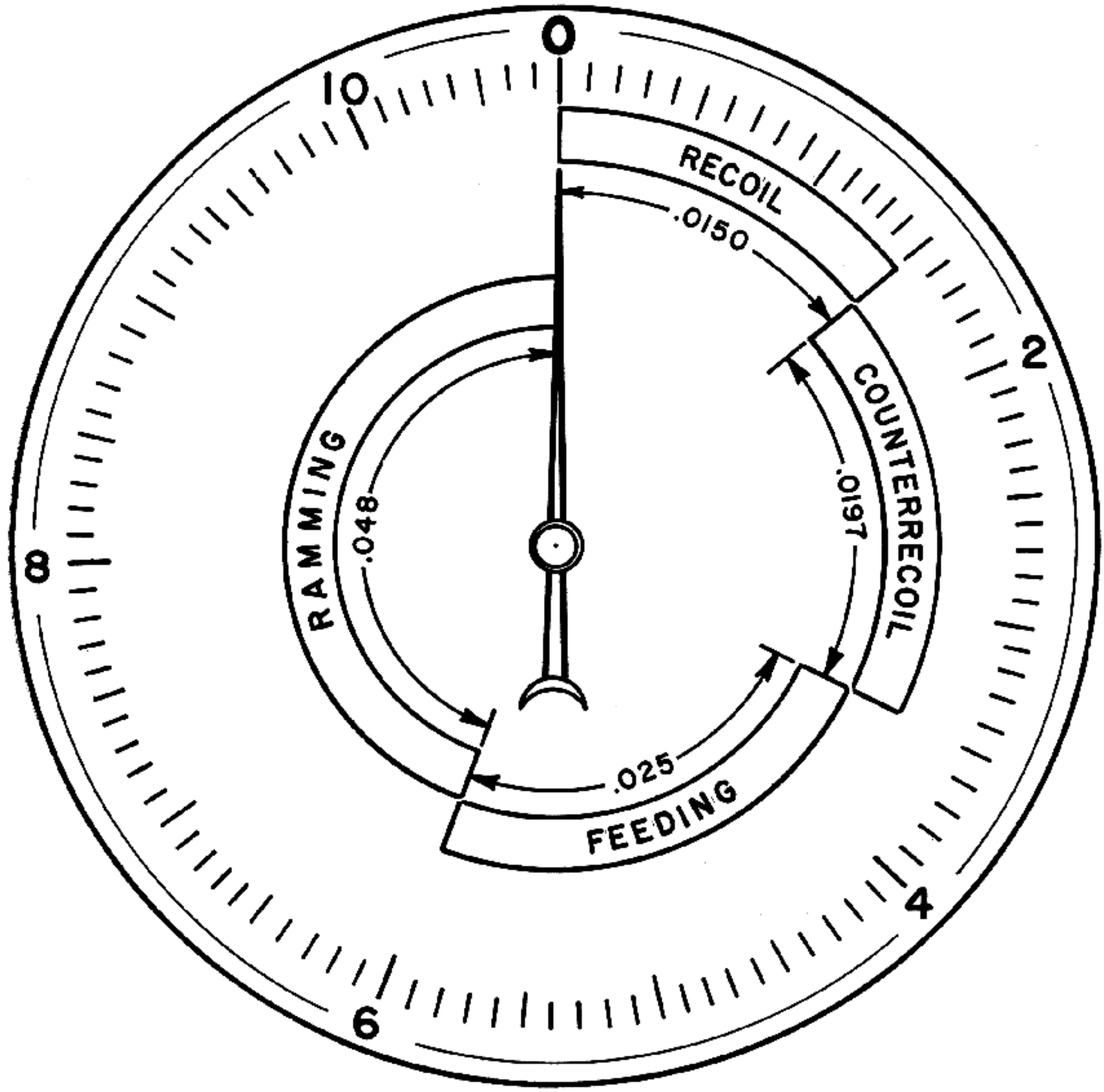

Figure 6–39. Time cycle for a 23-mm NS Gun.

Chapter 7

AUTOMATIC WEAPONS DERIVED FROM SKODA DESIGNS

Weapons Included in This Chapter

Designation	Use
30-mm FLAK Model A	Anti-Aircraft.
30-mm FLAK Model B	Anti-Aircraft.
50-mm PAK	Anti-Tank.
55-mm FLAK	Anti-Aircraft.
75-mm FLAK R4	Anti-Aircraft.
75-mm Recoilless	Aircraft.

History and Background

The world-famous Skoda Works was established in 1859 by the Count of Waldstein in Pilsen, then a city in Austria-Hungary. M. de Skoda became proprietor a few years later.

The factory engaged in various types of metal working and mechanical engineering, as well as the construction of war matériel.

The company's early record in the production of automatic weapons included the second successful automatic firing mechanism, which was patented in 1888 and appeared soon afterward. This weapon was preceded only by the Maxim gun. This 8-mm Skoda machine gun was invented by Grand Duke Karl Salvator and Colonel von Dormus, both of Austria, who sold their patent rights to the Skoda Works. After this venture, however, the company's interest turned to large-bore automatic weapons. In this field the company's products have been second to none throughout the years.

After the victorious Allies formed the independent country of Czechoslovakia at the close of World War I, the Skoda Works produced automatic weapons for not only the Czech Army but for other countries determined to encircle a defeated Germany. Very soon control of the Skoda plant was taken over by the French-owned Schneider Company, and in October 1919 the French Government appointed the French Military Mission to study the procedures developed by the Skoda plant and to impart to the management of the plant progressive French methods such as their advanced procedures in constructing experimental gun models.

The Mission was cordially received and collected extensive information about the ordnance designed in the Skoda plant as well as know-how valuable in the solution of various ordnance problems. Among those cooperating with the Mission were General Pelle who was made its head, his Chief of Staff, Colonel of Artillery Clausse, the organizer of the Czechslovakian Artillery; and Mr. Hasek, the manager of the Skoda Works, formerly an Austrian naval ordnance engineer.

Soon after the work of the Mission was completed, the Allies turned their attention to the need for creating a small-arms plant that would be on a par with the Skoda plant manufacturing facilities in the production of heavy armament. The location decided upon was Brunn, as a factory building was in existence there. The plant which was developed bears a Czechoslovakian name which has been shortened to the ZB Company. The following chapter is devoted to it.

Between World War I and World War II the Skoda Works continued to develop heavy armament. The weapons discussed in this chapter represent a portion of Skoda developments which have attracted the interest of many countries in the years since World War I, when Czechoslovakia became a nation. Access to these developments by various countries can only be suggested here. It is generally known, of course, that the facilities of the Skoda plant were used by the German forces after their occupation of the country in 1939.

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In the summer of 1945 when Allied ordnance teams visited the Skoda plant their study of interesting items was hampered by the lack of drawings and data which the company's officials accounted for as being destroyed by bombing. At that time the Russians were in control of Prague, and had access to copies of all drawings, designs, and technical data through the Skoda offices there.

In the period since World War II, the Skoda Works, like all Czech industrial enterprises employing more than 250 persons have been nationalized. After the Czech government obtained control, an attempt was made to begin moving munitions plants out of Bohemia and Moravia to the Eastern part of the country. Skoda development funds for the year 1947 were allotted to the restoration of the underground plant at Dubnica, which had been badly damaged in World War II. Two-thirds of the output of the eleven Skoda plants is earmarked for Russia.

Communist domination of Czechoslovakia in recent years is a matter of general information. It is known further that the weapons described in this chapter are in Soviet hands. Of particular interest in this field of automatic weapons are the contributions of certain individuals under Russian control to a development program which was under way in the Brunn plant at the time of German control. The fascination large-bore automatic armament holds for the Soviets indicates a trend which is tangent to Skoda developments under German supervision.

While the automatic cannon discussed here are somewhat officially referred to as anti-aircraft versions with a tremendous weight and low rate of fire, they are not to be dismissed without serious consideration of their basic features. They are all prototypes, and lightening them and speeding up the action for aircraft installation would be comparatively easy. One has only to remember that the Germans proved their famous 88 tank gun in the Spanish Civil War as an awkwardly designed anti-aircraft weapon that seemed so clumsy and inefficient that the Allied agents never called attention to its lethal potentialities. It was called a secret weapon at the beginning of World War II by Allied Ordnance men until it was revealed later by captured German documents that it had been in action for proving purposes all through the Spanish Civil War, but that its intended purpose was concealed by its use as an anti-aircraft gun.

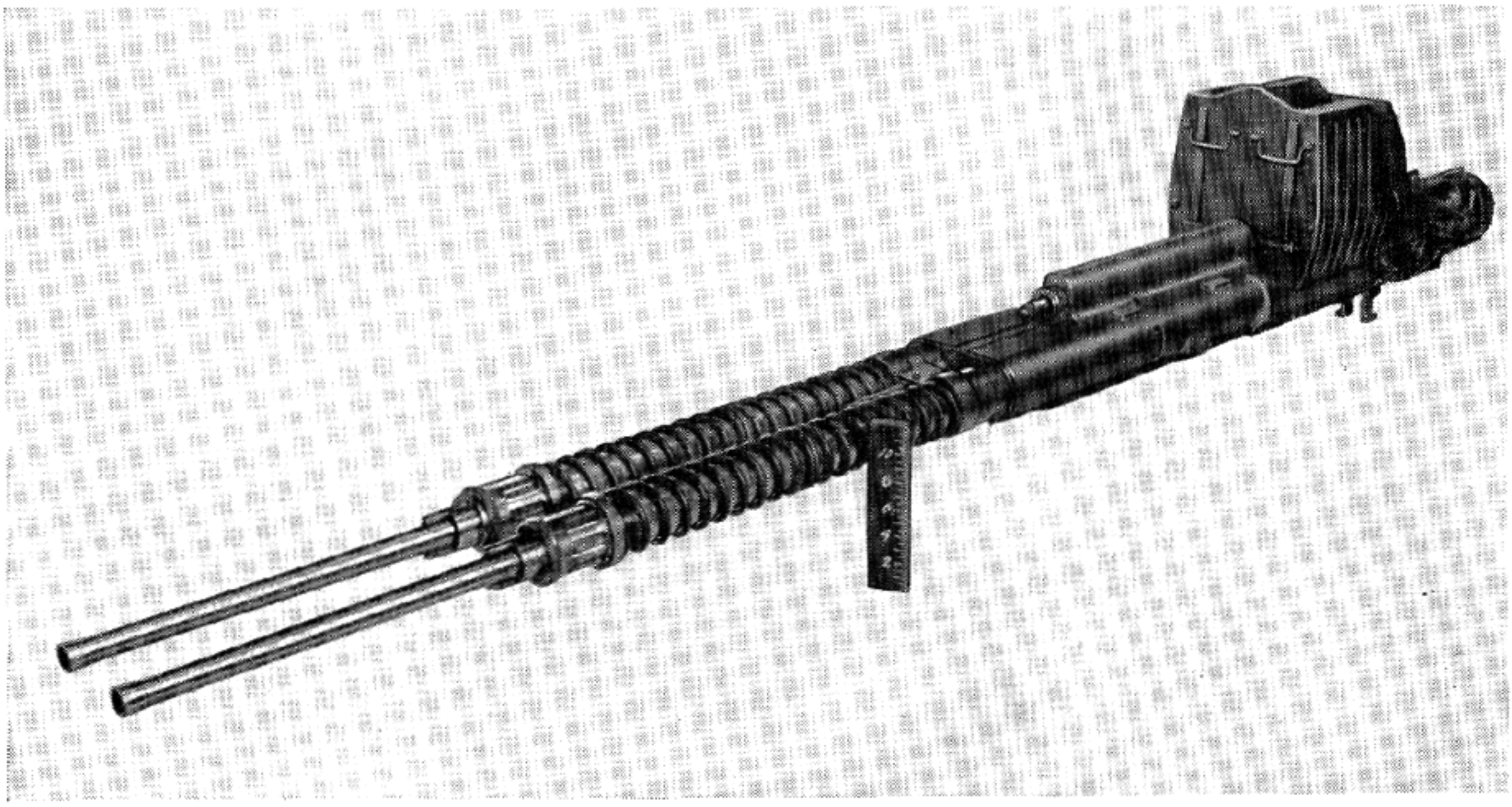

Figure 7–1. Skoda 30-mm Automatic Gun, FLAK Model B, three-quarter front view.

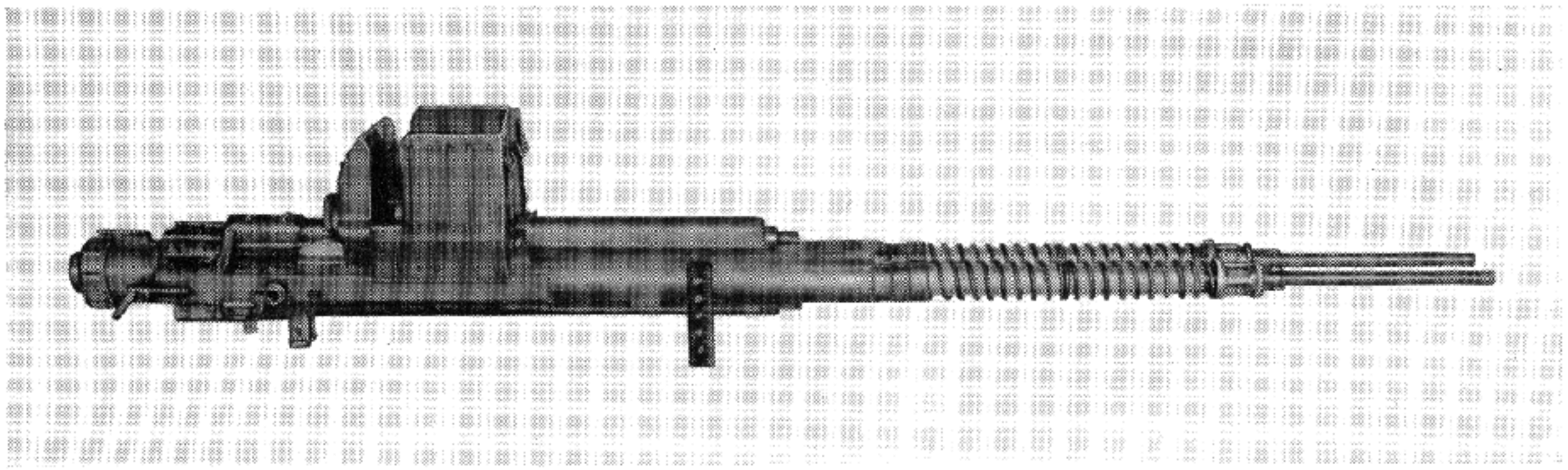

Figure 7–2. Skoda 30-mm Automatic Gun, FLAK Model B, right side view.

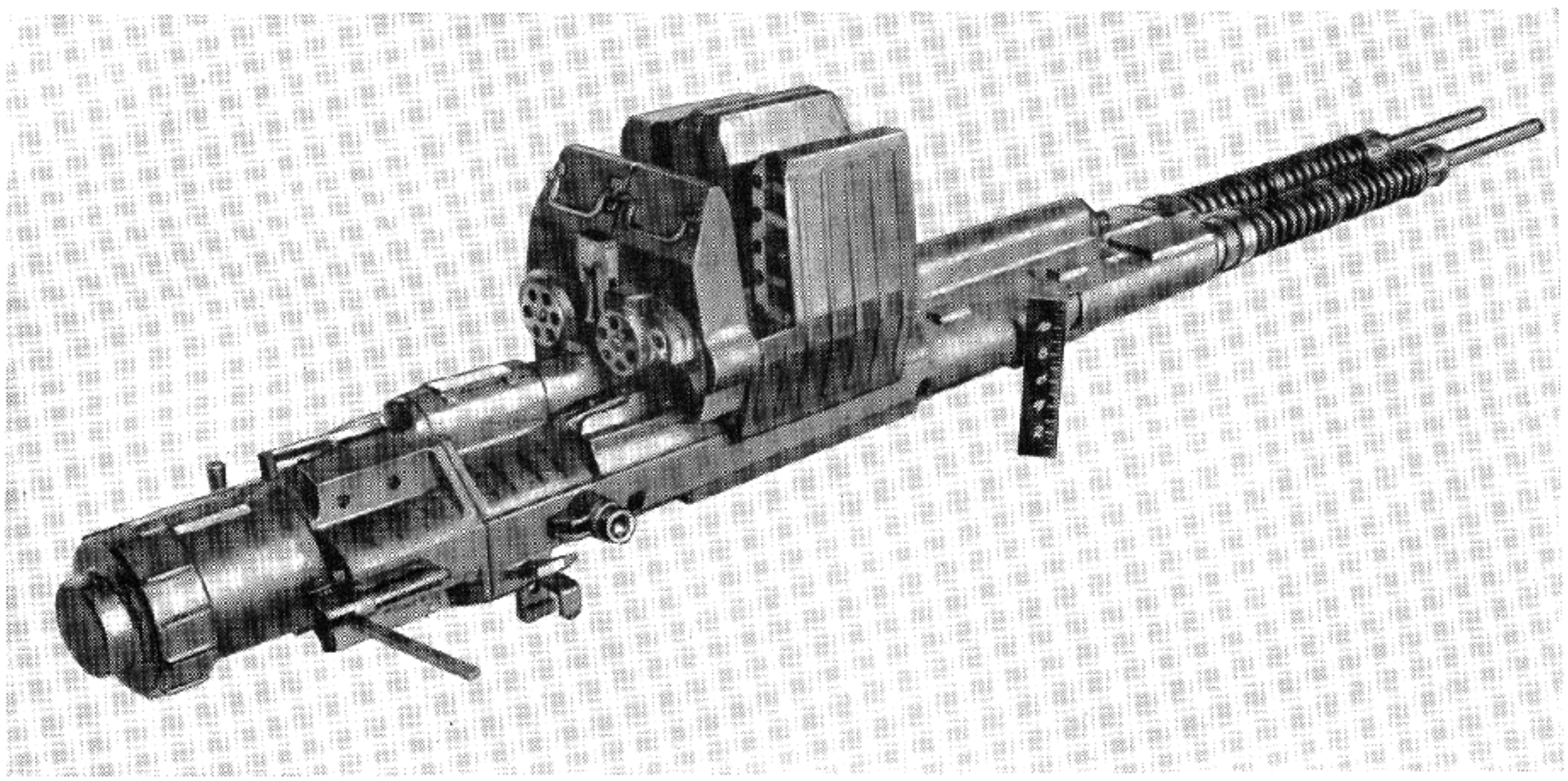

Figure 7–3. Skoda 30-mm Automatic Gun, FLAK Model B, three-quarter rear view.

SECTION 1. 30-MM FLAK MODEL A AND MODEL B

General Data on Model A and Model B

Caliber: 30-mm.
Rate of fire: 1,000 rounds/minute (approx.).
Muzzle velocity: 3,350 feet/second.
Gun length: 121.2 inches (approx.).
Gun weight: 1,380 pounds (overall weight of combined assembly).
System of operation: Blowback (retarded).
System of locking: Short recoil.
System of feeding: Magazine and metallic link belt.
Method of charging: Hydraulic on Model A (Manual on Model B).
Method of cooling: Air.
Barrel weight: 245 pounds.
Barrel length: 90.9 inches.
Barrel removal: Not quick change.
Bore:
  Direction of twist: Right hand.
  Form of twist: Standard constant.
Method of headspace: Factory established (not adjustable).
Location of feed opening: Top.
Location ejection opening: Bottom.

General Description of Model A and Model B

The design of this mechanism was begun in 1937 by the Skoda Works. It shows signs of having been inspired by both the Gast and the Becker, German guns of World War I which are described in Volume I of The Machine Gun.

This weapon is operated by short recoil and blow-back, is fed by twin loaders operated by bolt recoil, is fired by percussion firing mechanisms, and utilizes a hydro-spring recoil mechanism.

Unlike most twin guns, which fire independently, each gun is dependent upon the other, for the bolt of each gun is mounted integrally with the barrel of the opposite gun in order to increase the weight of the recoiling parts. Thus, if the left gun has fired, the bolt recoils by blow-back and carries with it the barrel of the right gun, and vice versa. Both guns must be in full recoil position in order to initiate firing, and each gun fires on the counter-recoil stroke of the other.

The guns are cocked simultaneously by hand operation of a crank, which mechanically retracts the firing mechanism.

Model A and Model B differ in the method of locking the gun in recoil position and releasing them at the proper time in the firing cycle. In the Model B this is done mechanically, while in the Model A it is done hydraulically. This difference is basic, causing many major and minor variations in the components and their operation. Comparison of the text for the two models points up these differences.

All illustrations show the Model B, which is the later model.

Detail Description of the Model A

A comparison of the detail descriptions of Model A and Model B points up an interesting difference in connection with the minimum burst for each model. Model A is fully automatic, being able to fire a minimum burst of two rounds by releasing the firing lever immediately after the bolt moves forward. The guns fire alternately until one of the loaders becomes empty or until the firing lever is released. Both guns are held in the full recoil position after the last round has been fired; thus the loaders may be recharged and firing resumed without cocking the guns, that is, locking them back in recoil position.

Recoiling Parts. The recoiling parts consist of two sets of similar parts, symmetrically arranged, each set being integral. One set consists of the left barrel, the left barrel recuperator spring, barrel extension, right bolt, and recoil piston rod. The other

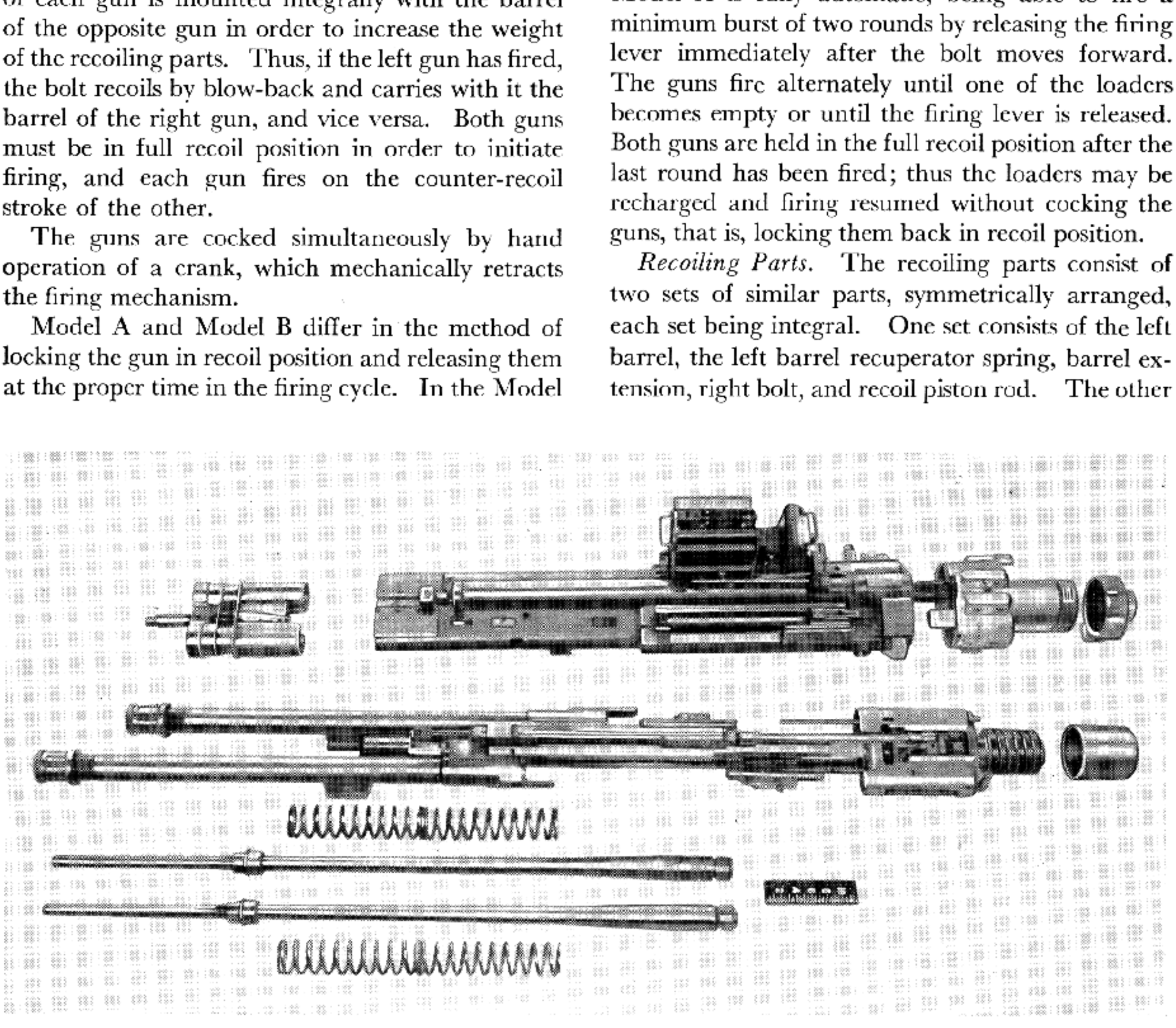

Figure 7–4. Skoda 30-mm Automatic Gun, FLAK Model B, stripped. Side view.

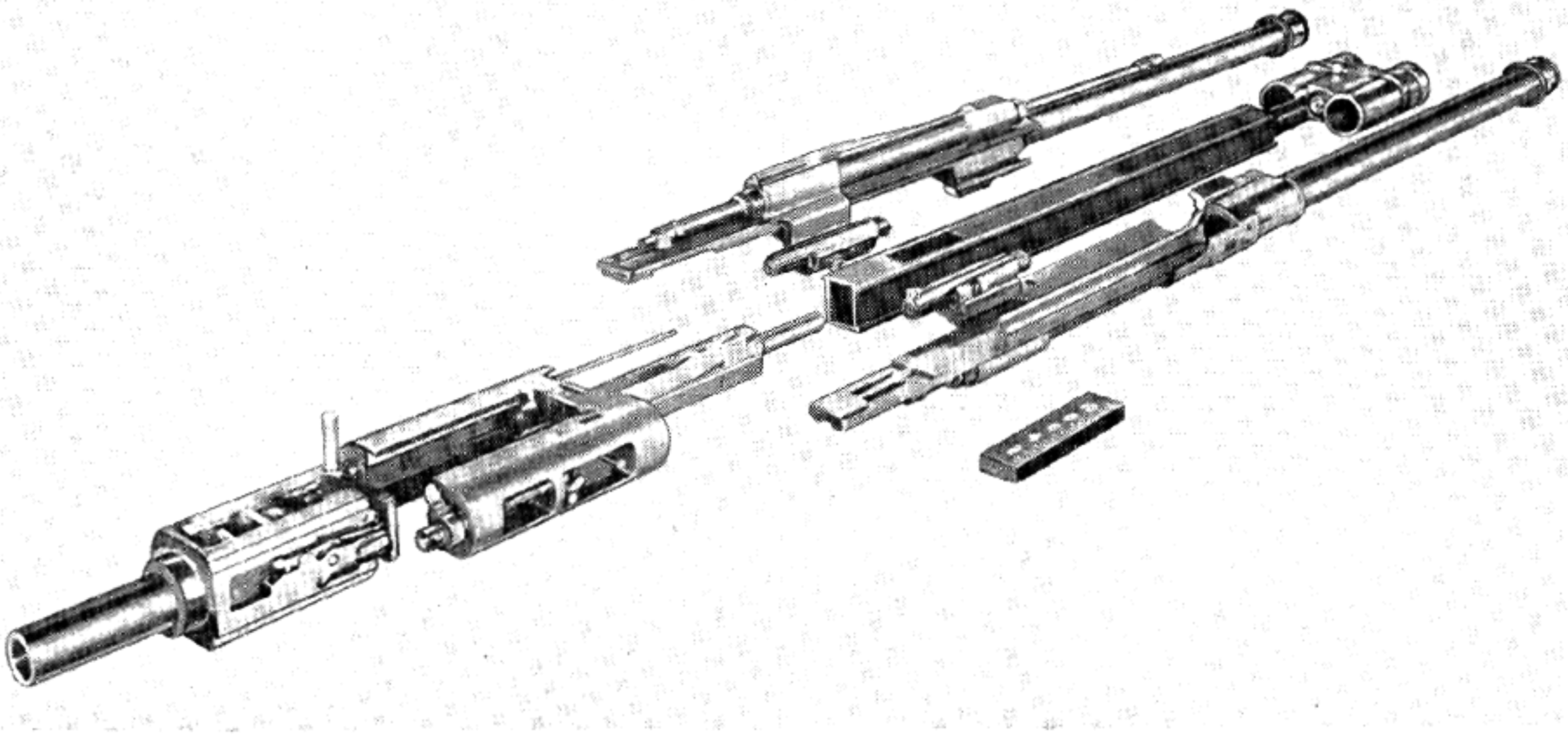

Figure 7–5. Operating parts of Skoda 30-mm FLAK Model B Automatic Gun.

set consists of the right barrel, the right barrel recuperator spring, barrel extension, left bolt, and recoil piston and rod.

Fixed Parts. The major fixed parts consist of the main housing; a recoil mechanism assembly which fits into the front end of the main housing and is secured by two wedges; a trigger assembly, sear assembly, and buffer assembly, which fit into the rear end of the main housing; a buffer housing, which fits into the rear end of the main housing and is secured by two wedges; a center guide on which the recoiling parts slide and which is held centrally between the recoil cylinder assembly and the trigger assembly; two ammunition loaders; two ejector and loader lock assemblies; charging mechanism with charging racks.

Barrels and Barrel Extensions. Each barrel has interrupted screw threads at the breech end, which mate with similar threads in the end of the barrel housing. Each barrel recoils through a sleeve in the front end of the recoil cylinder housing. A nut screws on the end of each barrel and permits adjustment of the initial compression of the recuperator springs.

Each barrel extension slides on a stationary central guide when the recoiling parts are in motion. The left barrel extension slides on the bottom and left side of the center guide, and the right barrel extension slides on the top and right side of the center guide. The surfaces interlock so that they cannot be disassembled except by sliding out the center guide.

A recoil piston rod is attached to a lug on each barrel extension and recoils with the extension. The top surface of the right barrel extension is inclined to form cam surfaces upon which cam followers ride to wind springs in the loader. On the inside of each barrel extension at the breech end is a sear plate which engages a sear in the sear assembly when the barrel is to be held in the full recoil position. Attached to each barrel extension just to the rear of the chamber is a firing cam which actuates the firing pin in the bolt as the bolt approaches the chamber.

Mounted on the right side of the left barrel extension and in line with the right barrel is the right bolt. Mounted on the left side of the right barrel extension and in line with the left barrel is the left bolt.

The recoil movement of each set of recoiling parts is limited by contact of the rear end of the barrel extension against the front end of the recoil buffer. Counter-recoil movement of each set of recoiling parts is limited by contact of the front end of the barrel extension against a surface in the recoil mechanism assembly.

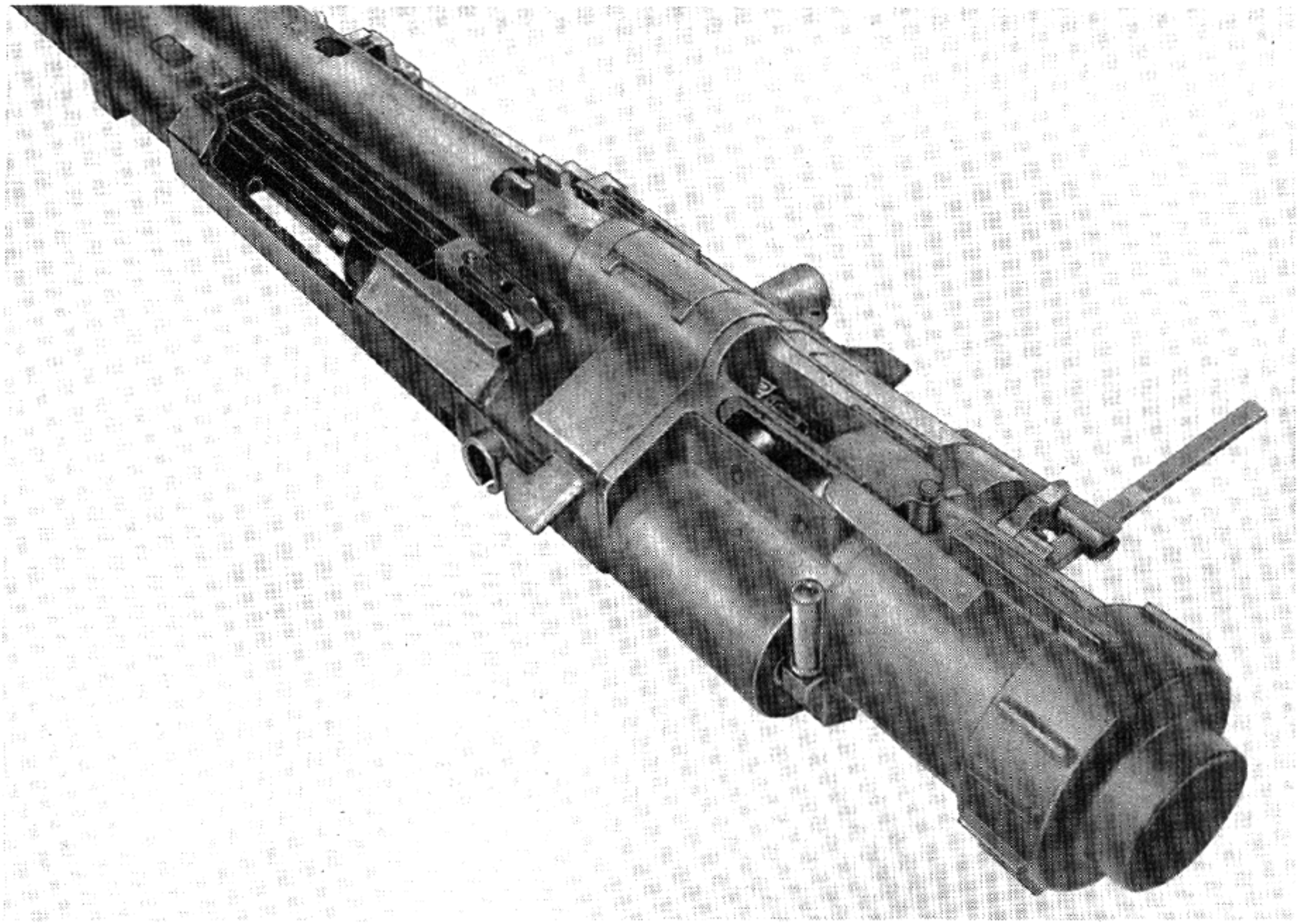

Figure 7–6. Top-rear of breech end of Skoda 30-mm Automatic Gun FLAK Model B.

When both barrels are fully forward, there is a distance of approximately 18 inches between each bolt and its corresponding chamber. Thus, a round can be chambered only when both barrels are initially in the full recoil position. Only one gun can be loaded and fired at a time, for if both bolts were released, both barrels would go fully forward and neither gun could be loaded. Therefore, the barrel in which the round is being fired must be in the full recoil position at the time the bolt, which is moving forward under the pressure of the recuperator spring on the opposite barrel, chambers the round.

Main Housing. The main housing is a fabricated structure of symmetrical design. Near the rear end on each side is a large opening over which a loader is mounted and through which ammunition is fed to the gun and expended cases ejected. On the top of the main housing and at the rear of the loader openings are two ejector and loader latch assemblies which strike the base of the case as the bolt recoils and force it downward through the opening in the main housing.

In the top of the main housing opposite the ejector and loader latch assemblies are openings under which the loader winding mechanism operating cam in the right barrel extension moves during the recoil and counter-recoil of the right barrel extension. Through these openings extend cam followers which transmit motion to the spring winding mechanisms of the loaders.

On the top and bottom of the main housing are long raised sections in which the recoil piston rods recoil. The rear ends of these raised sections permit movement of racks and are used in cocking the guns. The rear end of housing also houses two pinion shafts at the top and bottom, and three idler gears which drive the cocking racks. The

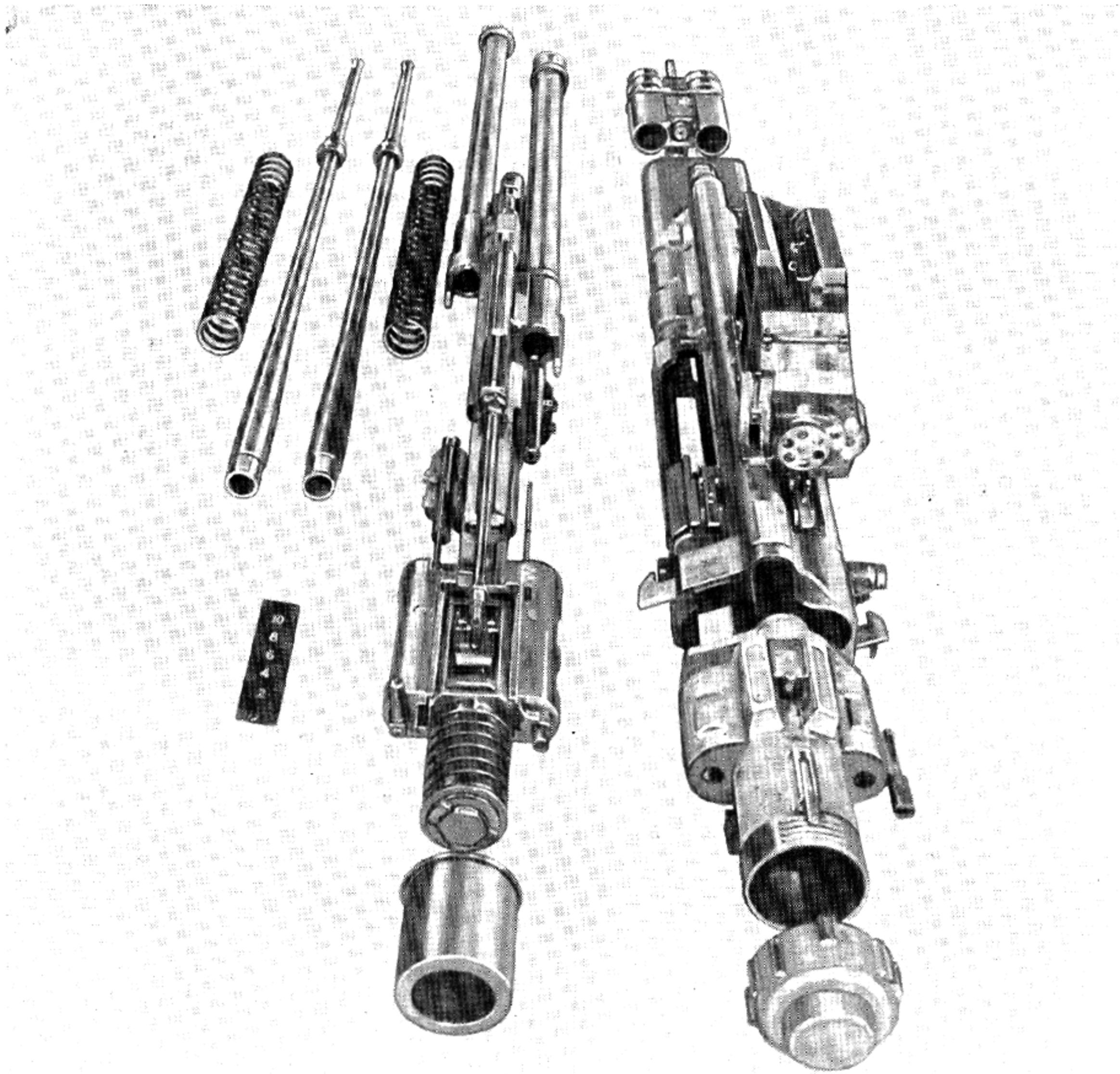

Figure 7–7. Skoda 30-mm Automatic Gun, FLAK Model B, stripped, rear view.

cocking mechanism bolts to the rear end of the housing on the left side.

In front of each loader is a spring-loaded plunger extending through the top of the housing. Pushing the plungers releases the barrel locks and permits the barrels to be turned and removed from the barrel extensions.

Recoil Buffer Housing. The recoil buffer housing fits into the rear end of the main housing and is held in place by two wedges. When in place, it holds the trigger assembly firmly against its seat in the rear end of the center guide. The recoil buffer housing also holds the buffer so that forward or rearward movement of the sear assembly within the trigger assembly compresses the buffer spring. Through the rear of the housing extends a handle

which actuates the sear lock. On the right side is a firing lever, firing lever safety lock, and a sear release lever.

Trigger and Sear Assemblies. The trigger assembly fits inside the hollow end of the center guide and is held in this position by the buffer housing. The sear assembly slides into the trigger assembly on guides and can move forward and backward against the pressure of the buffer spring which is mounted on the cylindrical extension at the rear of the sear assembly. The buffer housing is first assembled to the main housing, then the buffer components are assembled to the sear assembly and retained by two nuts. The cap on the rear end of the buffer housing holds the buffer in place within the housing. The spring can be compressed either by movement of the sear assembly rearward when the barrel extensions strike it upon recoil, or by movement of the sear assembly forward under the force transmitted to it through the bottom sear, which holds the left barrel extension in recoil position at the moment of firing.

The trigger and sear assemblies provide the means of holding the barrel extensions in the recoil position and the means of releasing them at the start of the firing cycle. After firing starts, locking of the barrel extensions in full recoil position and unlocking at the proper time in the firing cycle is accomplished hydraulically by the recoil system, as described in a later paragraph.

The top sear hinges upon a pin in the trigger assembly and bears against a spring-loaded plunger in the sear assembly. The finger of the top sear rests upon a flat in the sear trip shaft. The bottom sear hinges upon a pin in the sear assembly and bears against a spring-loaded plunger in the sear assembly. The finger of the bottom sear has a flat, which bears against a flat on the sear trip shaft, and a curved cam surface which bears against a dog. A spring-loaded plunger under the front end of the dog tends to keep the rear end depressed and bearing against the curved cam surface of the bottom sear finger.

On top of the dog is a spring-loaded slide which can be moved by a lever. When the slide is to the rear, it holds the rear end of the dog depressed. Thus, when the sear assembly is forced forward into the trigger assembly carrying with it the bottom sear, the finger of the bottom sear is cammed downward and the rear end of the sear, which engages the sear plate of the left barrel extension, moves up out of engagement with the sear plate and permits the barrel extension to move forward under the force exerted by the compressed barrel recuperator spring.

The top sear, which engages a sear plate in the right barrel extension, is moved out of engagement with the barrel extension when the sear trip shaft is rotated, allowing the barrel extension to move forward under the force exerted by the compressed recuperator spring of the right barrel. This is accomplished through the camming action between the sear finger and engaging flat on the trip shaft.

Further movement of the trip shaft will also cam the finger of the bottom sear downward to disengage the sear from the barrel extension. Further movement of the trip shaft is required for this because the end of the trip shaft which engages the bottom sear finger consists of two flats at an angle to each other. The second flat does not engage the finger until after the trip shaft is rotated sufficiently to trip the top sear. The trip shaft may be rotated by pulling the firing lever which, through linkage, turns the shaft which, in turn, pushes the plunger which is connected to the lever on the end of the sear trip shaft.

The firing lever can be removed just far enough to trip the top sear. However, one lever acts directly on another to rotate the trip shaft sufficiently to trip both sears. This lever is used, therefore, to release both barrel extensions and unload the barrel recuperator springs during a period of inactivity, and also serves as a safety to prevent accidental tripping of the sears by either the firing lever or sear lever.

The sear lock assembly fits into the round extension on the rear end of the sear assembly and is retained by a pin. Turning the handle rotates the lock shaft which moves forward under the camming action of the spiral grooves. When the lock shaft moves forward, its end engages mating recesses in the sear plungers (when the sears are in engagement with the barrel extension) so that the sears cannot be tripped. This is a safety feature to prevent accidental release of the barrel extensions on firing.

When the firing lever is operated to rotate the shaft, the link is pushed rearward, bringing the dog into engagement with the finger of the bottom sear.

Since the finger has not yet been depressed, the dog will bear against the side of the finger, and further movement of the firing lever will telescope the two plunger components within the connecting link. When the bottom sear finger is depressed by forward movement of the sear assembly into the trigger assembly, the dog will snap over the top surface of the bottom sear finger and hold it out of engagement with the barrel extension until the firing lever is released or until the link is moved out of engagement with the shaft by rotation of the lever.

Two levers are opposite a groove in the top left side of the trigger assembly, and one lever is opposite a groove in the top right side. When the gun is assembled, interlock rods extend rearward through these grooves from the rear ends of the ejector and loader latch assemblies. The interlock rods extending from the front ends of these assemblies are linked inside the assemblies to the rods extending from the rear in such a manner that when the front rods are pushed rearward, the rear rods are drawn forward. Each front rod contacts the lever in the loader, which is held depressed when ammunition is in the loader. Therefore, when ammunition is in the loader the rods extending rearward from the extractor and loader latch assemblies are held forward against springs in the assemblies.

When the last round leaves the left loader, a lever moves out and permits the read interlock rod to move to the rear and strike levers, disengaging the dog from the finger of the bottom sear and moving the slide forward out of engagement with the dog. The bottom sear then moves out to engage the left barrel extension, and since the dog is no longer held down against the cam surface of the sear finger by the slide, forward movement of the sear assembly cannot cam the sear out of engagement with the barrel extension.

When the last round leaves the right loader, a lever in the loader moves out and permits the rear interlock rod in the right ejector and loader latch assembly to move rearward and strike the lever, disengaging the link from the shaft and permitting the shaft to rotate. The top sear then springs out to engage the left barrel extension.

Assume that the loaders are full of ammunition and that both barrel extensions are in the full recoil position and engaged by the sears. Pulling the firing lever disengages the top sear and allows the right barrel extension and left bolt to move forward, strip a round from the left loader, and chamber it in the left barrel. As the round is chambered, the firing pin lever strikes the firing cam and fires the round. Blowback forces the left bolt, right barrel and extension rearward against the recoil buffer. The extension does not engage the top sear, as the sear is held out of engagement by the firing lever. The barrel and extension are held back, however, by hydraulic locking action in the recoil mechanism, as explained in a later paragraph.

At the time of firing, the force of friction between the moving projectile and the barrel forces the left barrel and barrel extension forward against the bottom sear which is assembled to the sear assembly. The sear assembly moves forward under this force, against the recoil buffer. This movement cams the bottom sear out of engagement with the left barrel extension and allows the left barrel, extension, and right bolt to move forward, strip a round from the right loader, and fire it in the right barrel. As the bottom sear is cammed out of engagement, the dog moves over the finger of the sear and holds it out of engagement, and the sear assembly and buffer resume their neutral position.

As the right bolt chambers and fires the round, the recoil piston of the left barrel causes the right barrel, extension, and recoil piston to be hydraulically unlocked. As the right bolt, left barrel, and extension recoil by blowback and strike the buffer and lock hydraulically in full recoil position, the left bolt, right barrel, and barrel extension move forward, and the bolt strips a second round from the left loader and fires it in the left barrel.

This cycle repeats until the firing lever is released or until one of the loaders becomes empty. If the firing lever is released, the top sear springs out to engage the right barrel extension, and the dog is pulled out of engagement with the bottom sear, which allows the bottom sear to engage the left barrel extension. Thus both barrels and extensions are held in full recoil position after firing ceases.

If the left loader becomes empty first, the left loader, interlock rod springs rearward from the left ejector and loader latch assembly, strikes levers, and allows the bottom sear to spring out to engage the left barrel extension as it recoils from firing the next to the last round from the right loader. When the last round from the left loader fires, the left bolt,

right barrel, and barrel extension recoil and are hydraulically locked in full recoil position, the top sear still being in the disengaged position if the firing lever is still held back. When the firing lever is released after firing ceases, the top sear springs out to engage the right barrel extension. Note that one round remains in the right loader after firing ceases.

Recoil System. The recoil system is a double hydro-spring system, consisting of a hydraulic recoil cylinder and piston rod, a replenisher, and a recuperator spring for each barrel. The hydraulic portion of the system is contained in the assembly. In addition to absorbing part of the recoil energy, the hydraulic system acts as a timing device, hydraulically locking each barrel and barrel extension in the full recoil position and unlocking them to permit them to go forward under the action of the recuperator spring at the proper time in the firing cycle.

The left cylinder contains a piston and a piston rod which is connected to the left barrel extension. The right cylinder contains a piston and a piston rod which is connected to the right barrel extension. The walls of the cylinders have throttling grooves of constant depth for the entire length, except approximately for 4 inches at the rear end where the bore is smooth.

The replenishers are smooth cylinders, each containing a spring-loaded piston. They serve to keep the system full of fluid and to permit expansion of the fluid. Two spring-loaded one-way valves are in the circuit connecting the left replenisher and the left recoil cylinder through lines. One valve has a stronger spring than the other valve. As the piston recoils into the smooth bore section of the cylinder, fluid is displaced to the front of the piston through lines and one-way valves. Flow of fluid into the replenisher is restricted by the small $\frac{3}{64}$-inch diameter orifice in the entrance to the replenisher. A one-way valve has a small $\frac{1}{32}$-inch diameter orifice through which fluid flows between the replenisher and recoil cylinder to compensate for leakage, expansion, and contraction of the recoil fluid. The one-way valve does not permit flow of fluid from the cylinder to the replenisher except through this orifice.

The piston of the left recoil cylinder is bypassed by the lines. This circuit is blocked by a spring-loaded valve, which is operated by a pressure differential in the lines leading from the valve to the front end of the right recoil cylinder. When the piston of the right recoil cylinder is moved forward, it passes the port of the line. Pressure ahead of the moving piston being greater than the pressure back of it causes the valve to open and connect the bypass lines. At this moment the piston of the left cylinder will normally be in the smooth bore section of the cylinder (full recoil position). Prior to opening of the bypass valve, the piston in the left cylinder cannot move forward under the force exerted by the barrel recuperator spring because fluid ahead of the piston cannot be displaced. As soon as the valve is open, however, fluid can be displaced from the front of the piston to the rear through the lines and valve. As soon as the piston enters the grooved section of the cylinder, fluid is displaced to the rear of the piston through the grooves. One valve closes when the forward movement of the piston in the right cylinder stops, as the pressures ahead of the piston is the same as the pressure back of it.

Assume that the left bolt, which is connected to the right barrel extension, is moving forward to chamber a round in the left barrel, which is in full recoil position. The right recoil piston rod, which is connected to the right barrel extension, is also moving forward, under the force exerted by the compressed recuperator spring on the right barrel. The left barrel, barrel extension, right bolt and left recoil piston are held in full recoil because the piston is in the smooth bore section of the cylinder and there is no path through which to displace the recoil fluid. As the piston in the right cylinder passes the port of the line, the differential pressure created in the lines opens the valve, allowing the piston in the left cylinder to move forward by displacing fluid to the rear through the valve. As the piston moves forward under the pressure exerted by the left barrel recuperator spring, the right bolt strips a round from the right loader and carries it forward. As the piston starts to move forward, the round being chambered in the left barrel fires. The left bolt, right barrel, and barrel extension are driven back by blowback, carrying the right recoil piston rearward into the smooth bore section of the cylinder. Fluid passes to the front of the piston through the throttling grooves until the piston reaches the smooth bore section of the cylinder. Fluid then passes to the front of the piston through lines and one-way

valves. The piston is held in this position until the piston passes the port of the line. The pressure differential created in these lines opens the valve, allowing piston to move forward by displacing fluid to the rear through the valve. This action repeats until one of the loaders becomes empty, or until the firing lever is released.

When the barrels are held in recoil position by engagement of the scars with the barrel extensions, the recoil pistons are probably just in front of the smooth bore section of the recoil cylinders. Thus hydraulic locking would not take place when the sears are released to allow the barrels to move forward for firing the first two rounds. Firing of the first two rounds and all subsequent rounds, however, causes the barrels to recoil past the position where the scars engage the barrel extensions. The recoil pistons then enter the smooth bore sections of the recoil cylinders and hydraulic locking takes place.

Since some clearance exists between the recoil cylinders and pistons, hydraulic locking cannot be maintained indefinitely. The piston will gradually move forward into the grooved section of the cylinder as oil is displaced to the rear of the piston through the clearance between the piston and cylinder.

Cocking Mechanism. The cocking mechanism provides means of retracting the barrels and barrel extensions until the extensions are engaged by the sears. It consists of racks, two pinion shafts which drive the racks, and a hand crank shaft and brake assembly which drives the pinion shafts simultaneously through three idler gears on the left side of the main housing. Each rack has a lug which engages a shoulder on the rear end of each barrel extension. After both barrel extensions are engaged by the sears, the racks are returned to their forward position by operating the hand crank shaft in reverse.

Loaders. The two loaders are similar in design to those for the Model B, differing only in the method of winding the loader springs. Each loader has a capacity of 9 rounds.

The rounds are fed downward by "star wheels" mounted on 8 shafts, all of which are driven by a common shaft which in turn is driven by a cross-shaft actuated by a spring in the housing. This spring is wound initially by hand by turning a knurled wheel, then both springs are wound simultaneously by action of cams in the top of the right barrel extension during recoil and counter-recoil of the extension. A cam follower rides in one of the cam grooves and moves up and down each time the right barrel extension recoils and counter-recoils. For each vertical movement of the cam follower the spring winding shaft is rotated one notch of the ratchet wheel, which is driven by the pawl in the follower shaft.

The lever is actuated by ammunition in the loader. When the lever is pressed into the end of the loader by the ammunition, it releases a ratchet which permits the star-wheel shafts to rotate under the power supplied by the loader spring. When the lever is released by the last round leaving the loader, it prevents unwinding of the loader spring. When the loader is in position, the interlock rod extending through the front end of the ejector and loader latch assemblies contacts the end of the lever. Thus when ammunition is in the loader, the lever pushes the interlock rod rearward, and when the last round leaves the loader, the lever permits the interlock rod to move forward.

Ejector and Loader Latch Assemblies. The ejector and loader latch assemblies are similar to those used on Model B. The assembly serves to latch the loader in position, eject expended cartridge cases, and house the loader interlock rods. Raising the lever on top of the assembly withdraws the latch and permits placing the loader in position.

The ejector, located under the end of the interlock rod, is spring-loaded to absorb the shock of striking the base of the empty case as the case is withdrawn to the rear by the bolt. The ejector rides in the groove in the top of the bolt as the bolt passes under it, and contacts the base of the case at the top, pivoting it downward over the extractor and through the opening in the main housing under the loader.

Extending through the front and read ends of the assembly are two interlock rods, one above the other. They are connected inside the assembly by a lever pivoted at its center. A spring maintains pressure on the rods to keep them in the extended position. If the front rod is pushed in, the read rod is withdrawn, and if the front rod is released, both rods are forced out by the spring.

Bolt. The bolts are similar to those used on the Model B. Each bolt consists of a bolt body, a spring-loaded extractor, two spring-loaded cartridge holding claws, a spring-loader firing pin, and a

firing pin actuating lever. There is no safety lock to be tripped to release the actuating lever, as in the Model B. The firing pin is normally held in the retracted position by its spring. It is moved forward to strike the primer by the actuating lever when the lever strikes the firing cam.

Cycle of Operation of the Model A

Preparation for Firing. Retract the barrels and barrel extensions by operating the retracting mechanism with a crank until both extensions are engaged by the sears. Then operate the retracting mechanism in reverse until the retracting racks are fully forward.

Turn the sear locking lever clockwise to lock the sears.

Turn the safety lever to the safe position.

Load a clip of rounds into each ammunition loader. Movement of the star-wheel shafts during loading is permitted by a clutch on each shaft. When the rounds are inserted in each loader, they press against levers and through the movement of the interlock rods in the ejector and loader latch assemblies, permit the levers to move forward and bring links in engagement with the lugs on the shaft. Movement of the firing lever which moves the shaft can then initiate firing.

Wind each loader spring by turning the knurled wheel.

Automatic Firing. Disengage the safety locks by turning the handle counterclockwise and the lever clockwise.

Pull back the firing lever to the limit of its travel, and hold it in this position until all rounds have been fired from one loader or until firing is to be suspended.

When the firing lever is pulled back, the bottom sear is disengaged, and the right barrel, barrel extension, and left bolt move forward under the force exerted by the right barrel recuperator spring. The bolt strips a round from the left loader and chambers it in the left barrel. Just before the round is completely chambered the bolt passes the firing cam, which engages the firing pin actuating lever in the bolt, causing the round to be fired. The left bolt, right barrel, barrel extension, and recoil piston rod all recoil under the force of the blowback, compressing the right barrel recuperator spring and throttling oil through the grooves in the recoil cylinder. The bolt extracts the expended cartridge case which is ejected when its base strikes the ejector near the end of recoil.

At the end of recoil the end of the barrel extension strikes the recoil buffer, and the recoil piston enters the smooth bore section of the cylinder, both of which absorb the remaining recoil energy. The barrel extension is not engaged by the top sear, as the sear is still held out of engagement by the firing lever, but the extension remains in full recoil position because recoil fluid cannot pass the recoil piston when it is in the smooth bore section of the cylinder. During recoil of the barrel extension the springs of both loaders are wound by the camming upward of followers by cam tracks in the top of the right barrel extension.

At the time the left bolt, right barrel, and extension are forced rearward by blowback force, the left barrel in which the round was fired and its extension are forced forward against the bottom sear by the force of friction between the moving projectile and the barrel. The sear assembly, under the action of this force, moves forward against the recoil buffer. This movement cams the bottom sear out of engagement with the left barrel extension and allows the left barrel, barrel extension, and right bolt to move forward under the force exerted by the recuperator spring, strip a round from the right loader, and chamber it in the right barrel. Just before the round is completely chambered the bolt passes the firing cam which engages the firing pin actuating lever, causing the round to be fired.

Also, just before the round is completely chambered, the left barrel recoil piston passes the control port of the right barrel recoil cylinder by-pass valve, causing the valve to open and allowing the right barrel, barrel extension, and left bolt to move forward under the force of the recuperator spring.

The right bolt, left barrel, barrel extension, and recoil piston all recoil under the force of blowback, compressing the recuperator spring and throttling fluid through the grooves in the recoil cylinder. The bolt extracts the expended case which is ejected when its base strikes the ejector near the end of recoil.

At the end of recoil the end of the barrel extension strikes the recoil buffer, and the recoil piston enters the smooth bore section of the cylinder, both of which absorb the remaining recoil energy. The

barrel extension is not engaged by the bottom sear, as the sear is held out of engagement by the dog. The extension does remain in full recoil position, however, because fluid cannot pass the recoil piston when it is in the smooth bore section of the cylinder.

While the left barrel and right bolt are recoiling as described in the preceding paragraph, the right barrel and left bolt move forward, strip a second round from the left loader and fire it in the left barrel. As the round is chambered, the left barrel and barrel extension are hydraulically unlocked by the opening of the left barrel recoil cylinder bypass valve, and allowed to move forward as the right barrel is recoiling.

The guns continue to fire alternately as just described as long as the firing lever is held in the firing position or until one loader becomes empty. If the firing lever is released, both sears spring out to engage the barrel extensions and hold them in the full recoil position. If one of the loaders becomes empty (the left loader becomes empty first if both are initially loaded with the same number of rounds) the loader interlock rod in the corresponding ejector and loader latch assembly strikes the corresponding interlock lever in the trigger assembly releasing the sear which engages the barrel extension of the barrel in which the last round is fired. The bolt, barrel, and barrel extension which recoil upon firing the last round are locked back hydraulically when the recoil piston enters the smooth bore section of the recoil cylinder. When firing ceases, the firing lever would normally be released, allowing the other sear to spring out in position to engage the barrel extension hydraulically locked in full recoil.

If no further firing is to be done, both barrel recuperator springs may be released by actuating the sear trip lever which disengages both sears and allows both barrels and their barrel extensions to move forward.

Detail Description of the Model B

A comparison of the detail descriptions of Model A and Model B points up an interesting difference in connection with the minimum burst for each model. Model B is fully automatic, but single shots can be fired by manipulation of the lever that serves as a disconnector. When individual rounds are fired, only the left gun can be fired, there being no means for firing the right gun singly. Since manually cocking the guns was not possible, it is assumed that some other means was provided in the design of the weapon.

Recoiling Parts. The recoiling parts consist of two sets of similar parts, symmetrically arranged, each set being integral. One set consists of the left barrel, left barrel recuperator springs, left barrel housing, and barrel extension, right bolt, recoil cylinder, and the loader winding mechanism operating cam. The other set consists of the right barrel, right barrel recuperator springs, right barrel housing, and barrel extension, left bolt, and a recoil cylinder.

Fixed Parts. The major fixed parts consist of the main housing; a counter-recoil buffer assembly which fits into the front end of the main housing and is retained by screws; a trigger assembly, sear assembly, and recoil buffer assembly which fit into the rear end of the main housing; a buffer housing which fits into the rear end of the main housing and is secured by two wedges; a center guide on which the recoiling parts slide and which is held centrally between the counter-recoil buffer and the trigger assembly; two recoil pistons and rods mounted in the two recoil cylinders; two ammunition loaders; and two ejector and loader lock assemblies.

Barrels and Barrel Extensions. Each barrel has interrupted screw threads at the breech end, which mate with similar threads in the breech end of the barrel housing. About ⅓ the length of the barrel from its muzzle end, there is a collar with spring-loaded detent locks which fit into the muzzle end of the barrel housing when the barrel is installed and prevent the barrel from turning. Screwed to the end of the barrel housing is a sleeve which bears against the end of the recoil spring when the spring is compressed during recoil.

Extending to the rear and on one side of each barrel housing is an extension which slides on a stationary central guide when the recoiling parts are in motion. The left barrel extension slides on the top and left side of the center guide, and the right barrel extension slides on the bottom and right side of the center guide. The surfaces interlock so that they cannot be disassembled except by sliding out the center guide. A recoil cylinder is mounted on the outside of each barrel extension and recoils

with the extension. On top of the recoil cylinder of the left barrel extension is a cam which recoils also and operates both loaders through the loader winding mechanism. On the inside of each barrel extension at the breech end is a sear plate which engages a sear in the sear assembly when the barrel is to be held in the full recoil position, two recesses to permit movement of the sear locks, and an abutment which actuates a slide in the trigger assembly. Just opposite the chamber on the outside of each barrel extension is a cam which actuates the firing pin in the bolt as the bolt approaches the chamber.

The right bolt is mounted on the right side of the left barrel extension and in line with the right barrel. The left bolt is mounted on the left side of the right barrel extension and in line with the left barrel.

The recoil movement of each set of recoiling parts is limited by contact of the rear end of the barrel extension with the laminated plates of the sear assembly located behind the sear. The recoil buffer absorbs the shock of this impact. Forward movement of each set of recoiling parts is limited by contact of the shoulder near the breech end of the barrel housing with the movable cylinders of the front buffer. When both barrels are fully forward, that is, when the shoulders on the barrel housings are in contact with the front buffer, there is a distance of approximately 18 inches between each bolt and its corresponding chamber. Thus, a round cannot be chambered by the bolt in this position. A round can be stripped from the loader and chambered only when both barrels are initially in the full recoil position.

Only one gun can be loaded and fired at a time, for if both bolts were released, both barrels would go fully forward and neither gun could be loaded. Therefore, the gun being fired must be held in the full recoil position while the other gun is released and allowed to move forward under the pressure of the recuperator springs on the barrel housing. The gun which is fired must be held in full recoil position until the other gun is blown back to full recoil position, where it is held. The gun just fired is then released, and allowed to move forward to charge and fire the other gun.

Main Housing. The main housing is a fabricated structure of symmetrical design. Near the rear end on each side is a large opening over which a loader is mounted and through which ammunition is fed to the gun and expended cases ejected. On the top of the main housing and at the rear of the loader openings, there are two ejector and loader latch assemblies which strike the base of the case as the bolt recoils, and forces the case downward through the opening in the main housing.

Located between the front ends of the loader openings in the top of the main housing is an opening under which the loader winding mechanism operating cam and recoil cylinder move during recoil and counterrecoil of the left barrel extension. The loader winding mechanism is mounted over this opening. A roller in the loader winding mechanism follows the cam through this opening and transmits power to both loaders simultaneously.

On the top and bottom of the main housing are long raised sections in which the recoil cylinders recoil. The recoil piston rods are attached to the main housing at the front ends of these raised sections by means of yokes and keys.

Recoil Buffer Housing. The recoil buffer housing fits into the rear end of the main housing and is held in place by two wedges. When in place, it holds the trigger assembly firmly against its seat in the rear end of the main assembly. It also holds the buffer so that forward or rearward movement of the sear assembly within the trigger assembly compresses the buffer spring. Through the rear of the housing on the left, extends a handle which releases the left barrel extension, and on the right, the firing plunger and lock. On the right side is a bracket for mounting a firing linkage mounted on this bracket. This lever is not an original component, but was added to improve the functioning of the mechanism. In the top and bottom and on each side, are four sets of rollers, two in each set, accessible by removing a slide cover. The top rollers bear against the beveled sides of the left barrel extension as it recoils over the sear, to make it engage the sear. The bottom rollers perform the same function in relation to the right barrel extension. Between the two top sets of rollers is a cover which provides access to the orifice adjusting screw for the left barrel extension recoil cylinder. A similar cover is on the bottom for the orifice adjusting screw of the right barrel extension recoil cylinder.

Trigger and Sear Assemblies. The long rectangular extension at the front of the trigger

assembly fits inside the hollow square section of the center guide and is held in this position by the buffer housing. The sear assembly slides into the trigger assembly on guides and can move forward and backward against the pressure of the buffer spring, which is mounted on the cylindrical extension at the rear of the sear assembly. The buffer housing is first assembled to the main housing, then the buffer spring within its cup-shaped sleeve is assembled to the sear assembly and retained by a large screw. The cap on the rear end of the buffer housing holds the buffer in place within the housing.

The sear and trigger assemblies are separated about 2 inches when the buffer spring is not being compressed. The spring can be compressed either by movement of the sear assembly rearward when the barrel extensions strike it upon recoil or by movement of the sear assembly rearward when the barrel extensions strike it upon recoil or by movement of the sear assembly forward under the force transmitted to it through the sear which holds the barrel (from which the round is being fired) in recoil position at the moment of firing.

The sear assembly provides the means of holding the barrel extensions in the recoil position and the means of releasing them at the proper moment in the firing cycle. On its top and bottom are two identical sets of parts. They consist of the sear, the sear spring and plunger, a pin upon which the sear pivots, the left sear lock, the right sear lock, a pin upon which the sear locks pivot, and two spring-loaded plungers which bear against lugs extending from the top of the sear locks to keep them engaged.

The upper left and lower right sear locks have rollers at their tips on the inside. These rollers are contacted by operating slides in the trigger assembly and permit automatic tripping of the sears. The barrel extension is held in the full recoil position by the sear in contact with the sear plate on the barrel extension. As the sear plate recoils over the sear assembly, it first contacts the levers of the sear locks and depresses them against their springs. This unlocks the sear so that it can be depressed. As the barrel extension recoils farther, it contacts the top of the sear and depresses it. The width of the sear plate is such that it depresses the sear while the sear locks are still depressed and disengaged from the sear.

As the sear plate recoils past the sear, the sear moves out under pressure of its spring-loaded plunger to engage the sear plate, and, at the same time, the sear locks move out under pressure of their plungers and lock the sear in place. The levers on the sear locks, upon moving out, enter the narrow slots in the barrel extension ahead of the sear plate. The barrel extension is then held in the recoil position until both sear locks are tripped. The pressure exerted by the compressed recuperator springs on the barrel housing is sufficient to depress the sear against the plunger, when the sear locks are depressed, and force the barrel extension forward over the sear. This action is identical for both barrel extensions.

The levers on each side of the sear assembly are for manually disengaging the sear locks from the sears. One lever trips the upper right sear lock, while another lever trips the lower right sear lock. These levers, along with another lever, turn upon a common shaft. The now fully depressing lever causes the rear end of the trip pawl to contact the edge of the sear housing and disengage it from its mating lever, which is operating the lower right sear lock. This permits another lever to spring up, out of engagement with the lower right sear lock, and allows the sear lock to engage the sear again.

If the lever is held down, the lower left and upper right sear locks are held out of engagement with the sears. The other two sear locks are the ones with rollers on their ends, and are automatically operated by the unlocking slides which extend through the back of the trigger housing into the opening in the front of the sear housing. The upper left sear lock, which has a roller on its end, is unaffected by movement of the lever. It can be tripped manually and is directly over the flat end of the lever when the sear assembly is assembled to the trigger assembly. The operating handle is turned, the left barrel extension, which is held back by the top sear, is free to move forward.

The guides in the trigger assembly engage the follower on the trigger lever, and when the sear assembly is assembled to the trigger assembly. These guides are free to move vertically on pins when interlock rods are in their rearmost position, for, in this position, a flat section on each rod is opposite a depression in the shank of each guide and

permits the guide to clear the rod. When both rods are forward, a round section of each rod engages the depression in the shank of each guide and locks the guide in the up position.

The firing plunger, when moved forward, forces the guide downward by means of the linkage, provided both interlock rods are rearward; unless the rod is held back, the guide which engages the follower on the lever will not be free to move. Pulling back the firing lever also pushes the firing plunger forward and causes the lever to be depressed. The accompanying action is explained in the three preceding paragraphs.

The interlock rods that extend through the ejector and loader latch assemblies, and the rectangular hole in the end of each rod engage the lever on the loader, which is connected by shafts and links to their respective levers. When ammunition is in the loader and the lever is pressed outward and the interlock rod is moved, the firing plunger cannot be moved forward unless ammunition is in the loaders, and the sears cannot be tripped to allow the bolts to move forward upon empty chambers except by moving both interlock rods back manually.

On each side of the rectangular extension of the trigger assembly is a slide which fits into a diagonal groove. The rear end of the slide is wedge shaped, the forward end carries a spring-loaded lever, and the central part contains a spring-loaded plunger assembly which bears against a shoulder in the trigger housing.

The left slide slopes upward to the rear, and the right slide slopes downward to the rear. The wedge-shaped ends of both slides extend through the back of the trigger housing and contact the rollers on the sear locks. The right slide actuates the lower right sear lock, and the left slide actuates the upper left sear lock; the spring-loaded lever in the end of the right slide extends through an opening in the top of the center guide. The corresponding piece on the left guide extends through the bottom side of the center guide.

As the right bolt and left barrel extension recoil by blowback after firing a round in the right chamber, the shoulder on the left barrel extension corresponding to the plate on the right barrel extension contacts the lever and pushes the right slide downward to the rear until the lever slides off the shoulder and under the barrel extension.

NOTE. During firing, the end of the extension never slides off the lever, so that the lever is always struck in counter-recoil by the slide-operating plate, and never by the sear plate.

The lever is then depressed, and permits the slide to move forward under pressure of the return spring which was compressed during the rearward movement of the slide. As the slide moves to the rear, its wedge-shaped rear end contacts the roller on the end of the lower right sear lock in the sear assembly and disengages it from the bottom sear, allowing the right barrel extension to move forward provided the firing lever is held back, which keeps the lower left and upper right sear locks disengaged.

In the meantime, the left barrel extension has been locked in full recoil position by the top sear. As the right barrel extension and barrel move forward under pressure of the recuperator spring on the right barrel housing, the left bolt, which is mounted integrally to the right barrel extension, strips a round from the left loader, chambers it in the left barrel, and fires. As the left bolt and right barrel extension recoil, compressing the right recuperator spring, the plate on the barrel extension strikes the lever on the left slide which extends through the bottom of the center guide, and pushes the slide upward to the rear. As the slide moves to the rear, the wedge-shaped rear end contacts the roller on the upper left sear lock, disengages it from the top sear, and allows the left barrel extension and right bolt to move forward.

In the meantime, the right barrel extension has been locked in the full recoil position by the bottom sear. As the left barrel and barrel extension move forward under pressure of the recuperator spring on the left barrel housing, the right bolt strips a round from the right loader, chambers it in the right barrel, and again fires. This cycle repeats as long as the firing lever is held back and until all ammunition is fired from both loaders.

Movement of the left loader interlock rod actuates the slide through a connecting lever, which in turn actuates the lock, the top of which slides in a slot of the slide. The lock extends through the front end of the trigger housing and underneath the right unlocking slide, where it can contact a hook extending downward from the lever in the slide. When the rod is pushed back, as is the case when ammunition is in the loader, the slide moves forward and with-

draws the lock to the left, disengaging it from the lever. The lever can then spring up again, after being depressed, as occurs on movement of the slide due to recoil of the left barrel extension. However, if the rod is moved forward, as is the case when the last round leaves the left loader, the slide moves to the rear and moves the lock to the right and in engagement with the lever, so that if the lever is depressed, it remains depressed. Thus, when the last round is stripped from the left magazine by the left bolt, which is integral with the right barrel extension, the interlock rod moves forward and the action just described occurs.

The right loader interlock rod acts similarly in locking the lever in the end of the left slide when the last round leaves the right loader.

After firing the last round from the left loader, the right barrel extension recoils, trips the upper left sear lock, and is locked in the full recoil position by the bottom sear. The left barrel extension moves forward over the slide and the lever to fire the last round from the right loader. Since the interlock rod is now forward and the lock is in engagement with the lever, the lever remains depressed. The left barrel extension, upon recoiling, then cannot move the slide to the rear and unlock the right barrel extension, which if unlocked, would carry the left bolt into an empty chamber. Both barrel extensions are then locked to the rear, and firing may be resumed after ammunition is placed in the loaders.

This is the action which normally takes place when firing automatically, for the right barrel extension is always released first when the firing lever is pulled, so that the first round fired is always from the left loader. The left loader will then become empty first, and the action just described will occur.

However, if fewer rounds are placed in the right loader, then the right loader will become empty first. The right interlock rod will then move forward, after the left barrel extension and right bolt have moved forward to fire the last round from the right loader. The lever in the end of the left unlocking slide then becomes locked down after the right barrel extension and left bolt move forward to fire the next round, and the right barrel extension, upon recoil, cannot move the left slide to the rear to trip the upper left sear lock and allow the left barrel extension and right bolt to move forward upon an empty chamber.

Firing of individual rounds might possibly be accomplished by pulling the firing lever (moving the firing plunger forward) and releasing it after the right barrel extension is released. This could be done for each round fired until all rounds have been fired from the left loader. Note that pulling the firing lever trips all sear locks except the upper left, and releases the right barrel extension. Releasing the firing lever permits the sear locks to re-engage the sears so that the left barrel extension will not be released automatically by recoil of the right barrel extension. Pulling the firing lever after the last round has been fired from the left loader, will allow the left bolt to move forward into an empty chamber. Thus, the firing of individual rounds from the right loader apparently cannot be performed.

Loaders and Winding Mechanism. The two loaders are identical in design, except that one is left-hand and the other right-hand. Each loader has a capacity of nine rounds. The rounds are fed downward by "star wheels" mounted on eight shafts, all of which are driven by a shaft through a common drive shaft. The shaft receives its power from a spring in the housing which is wound when the ratchet wheel is turned. The ratchet wheels on both loaders are turned one notch each time the left barrel recoils, by vertical movement of the ratchet wheel actuating pawls in the loader winding mechanism. The pawls are moved vertically by an arm whose roller rides on the cam.

The lever in the loader engages the loader interlock rod. Ammunition in the loader presses the lever outward and holds the lever rearward through the shaft. The shaft is also connected through linkages to the lever, which operates a pawl in engagement with a pawl wheel on the drive shaft. With ammunition in the loader, the lever is disengaged from the pawl wheel on the loader drive shaft, and the shaft is free to rotate. When the loader becomes empty, the lever engages the pawl wheel on the drive shaft, keeps it from rotating, and prevents the loader spring from unwinding.

Ejector and Loader Latch Assembly. The ejector and loader latch assemblies serve to latch the loader in position, as well as to eject the case. The long lever on top withdraws the latch and permits placing the loader in position. When the loader is in position, the latch engages a latch plate on the loader and holds it in position.

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The interlock rod extends through the round shank of the ejector and latch assembly. The lever engages a notch in the interlock rod and keeps the rod in its rearward position until the lever on the loader engages a hole in the end of the rod, when the loader is being placed in position. When the loader is in position, the lever is depressed and disengaged from the interlock rod, and allows the interlock rod to move forward.

The ejector is spring-loaded to absorb the shock of striking the case. The bolt has a groove in its top through which the ejector slides during recoil of the bolt. The nose of the ejector strikes the top edge of the base of the cartridge case and pivots it downward through the opening in the main housing under the loader.

Bolt. Each bolt consists of a housing, a spring-loaded extractor, two spring-loaded cartridge holding claws, a firing pin, firing pin spring, firing pin actuating lever, a pivot pin, and a safety lock. The firing pin is normally held in a retracted position by its spring. It is moved forward by the firing pin actuating lever, which engages the slot in the firing pin and pivots upon the pin. The firing pin actuating lever cannot be rotated upon its pivot pin until the safety lock is depressed sufficiently to disengage its lug from the firing pin actuating lever.

The left bolt is attached to the right barrel extension by means of a key. In this position, it is in line with the chamber of the left barrel. When the right barrel extension is disengaged from its sear, the left bolt moves forward under the left loader. The top edge of the bolt contacts the base of the cartrdige, strips it from the loader, and forces it into the chamber. As the cartridge enters the chamber, its base slides downward against the face of the bolt, and the rim engages the holding claws on each side of the bolt and the extractor on the lower side of the bolt. Just before the cartridge is fully chambered, the beveled surface of the safety lock contacts the firing cam on the side of the barrel housing. After the safety lock is fully depressed, the firing pin actuating lever strikes the firing cam and moves the firing pin forward to fire the round. When the bolt recoils, the firing pin is retracted by its spring, and the extractor, which is in engagement with the rim of the cartridge case, extracts the expended case.

Recoil System. Each barrel extension has assembled to it a recoil cylinder which recoils with the barrel extension over a fixed recoil piston and rod.

The piston rod and the piston are assembled in the recoil cylinder by means of a packing gland at each end of the cylinder. The cylinder is fixed rigidly to the barrel extension by a pin. The piston rod is hollow throughout its length. In front of the piston is a large orifice through the rod, and back of the piston is a long narrow orifice through the rod. An orifice control rod fits inside the rear half of the piston rod and is held in place by a fitting. Screwing the control rod through its retainer controls the size of the long narrow orifice behind the piston. In the front end of the piston rod there is also a fitting for attaching it rigidly to the main housing. The piston is fixed rigidly on the recoil rod and contains no orifices or valves. The oil is throttled through the orifices in the recoil rod during both recoil and counter-recoil.

Front Buffer. The front buffer consist of a fixed housing which fits into the front end of the main housing and through which a movable portion slides. A stationary piston rod, on which is mounted the piston, is attached to the housing and extends through the buffer cylinder. A packing nut screws into the packing gland. The return spring housing screws over the packing gland, which screws into the packing nut, which screws into the rear face of the movable portion.

A sleeve inside the return spring slides over the piston rod and is limited in travel by a shoulder on the piston rod. The piston contains orifices which are covered on the rear face of the piston by a spring-loaded plate which contains orifices smaller than those in the piston. During forward movement by the buffer, the plate is held against the piston. During rearward movement of the buffer, the plate is forced back against its spring, uncovering the piston orifices.

The movable portion consists of two cylinders through which the barrel housings and barrel extensions slide in recoil and counter-recoil. A shoulder at the rear end of each barrel housing strikes the rear end of the corresponding cylinder of the front buffer when both barrel extensions are released and allowed to move forward. The front ends of these cylinders bear against the ends of the barrel return springs. When the barrel housings strike the buffer, the movable portion of the buffer is forced downward over the recoil piston and

against the pressure of the return spring. Throttling of the oil in the buffer cylinder through the orifices in the spring-loaded plate retards the forward movement of the barrel extensions.

The buffer does not function during firing, but only when both barrel extensions are released to unload the recuperator springs for a period of inactivity.

Cycle of Operation of the Model B

Preparation for Firing. Load a clip of rounds into each ammunition loader. Movement of the star-wheel shafts during loading is accomplished by means of a clutch on each shaft. When the rounds are inserted in the loader, they press against the lever and move the interlock rods rearward through the action of the lever in the loaders. Movement of the interlock rods to the rear permit vertical movement of two guides when the firing lever is actuated.

Wind up each loader spring by turning the knurled wheel opposite the ratchet wheel.

Retract both barrel extensions until they are engaged by their respective sears.

Automatic Firing. Set the lever to the firing position. This permits the firing plunger to move forward when the firing lever is pulled back.

Pull back the firing lever to the limit of its travel and hold it in this position until all rounds have been fired from the loaders or until firing is to be suspended.

When the firing lever is pulled back, the sear locks are disengaged from the bottom sear, and the right barrel, barrel extension, and left bolt move forward under the force exerted by the right barrel recuperator spring. The bolt strips a round from the left loader and chambers it in the left barrel. Just before the round is completely chambered, the bolt passes the firing cam which engages first the safety lock and then the firing pin actuating lever in the bolt, causing the round to be fired. The left bolt, right barrel, barrel extension, and recoil cylinder recoil by blowback, compressing the right barrel recuperator spring and forcing oil through the orifices in the recoil piston rod. The bolt extracts the expended cartridge case, which is ejected when the base of the case strikes the ejector near the end of recoil. At the limit of its recoil, the barrel extension strikes the recoil buffer, which absorbs the remaining energy of recoil, and engages the bottom sear which holds the barrel extension in the full recoil position.

During the initial recoil movement of the right barrel extension, the plate on the extension strikes the lever on the left sear latch trip slide and moves the slide upward to the rear. The rear end of the slide contacts the roller on the upper left sear lock, disengages it from the top sear, and allows the left barrel extension and right bolt to move forward under the force exerted by the left barrel recuperator spring.

As the right bolt moves forward, it strips a round from the right loader and chambers it in the right barrel. The loader-operating cam on the top of the recoil cylinder moves forward with the barrel extension, forces the loader winding mechanism follower upward, and causes the winding ratchet pawls to move downward, to engage a notch in each loader spring winding ratchet wheel, and to wind both loader springs. Just before the round is completely chambered, the bolt passes the firing cam on the right barrel extension, which engages first the safety lock and then the firing pin actuating lever in the bolt, causing the round to be fired. The right bolt, left barrel, barrel extension, recoil cylinder, and loader-operating cam all recoil by blowback, compressing the left barrel recuperator spring and forcing oil through the orifices in the recoil piston rod. The bolt extracts the expended cartridge case when its base strikes the right ejector near the end of recoil. At the limit of its recoil, the barrel extension strikes the recoil buffer and engages the top sear which holds the extension in its full recoil position.

During its initial recoil movement, the left barrel extension strikes the lever on the right sear latch trip slide and moves the slide downward to the rear. The rear end of the slide contacts the roller on the end of the lower right sear latch, disengages the latch from the bottom sear, and allows the right barrel, barrel extension, and left bolt to move forward. During recoil of the left barrel extension, the loader-operating cam, upon which the loader winding mechanism follower rides, causes the winding ratchet pawls to move upward in position to engage the spring-winding ratchet wheels.

The cycle described above repeats as the left bolt, right barrel, and barrel extension move forward, and

continues to repeat as long as the firing lever is held in the firing position or until both loaders become empty.

When the last round leaves the left loader, pressure of the round against the lever is relieved, and the left interlock rod is allowed to move forward through the action of the lever of the loader. Movement of the interlock rod forward causes the lock to move into engagement with the lever on the slide. After the round is fired, the right barrel extension recoils, trips the upper left sear lock, and is locked in the full recoil position by the bottom scar. The left barrel extension moves forward over the slide and the lever to fire the last round from the right loader. Since the lever is held down by the lock when the left barrel extension recoils, the barrel extension does not strike the lever and move the slide rearward to trip the lower right sear lock. Both barrels and extensions therefore remain locked in the full recoil position after the last round is fired.

If no further firing is to be done, both barrel recuperator springs may be released by actuating both the firing lever and the lever which will trip all sear locks and allow both barrels to move forward against the front buffer.

SECTION 2. 50-MM PAK

General Data

Caliber: 50-mm.
Rate of fire: 80–120 rounds/minute.
Muzzle velocity: 2,740 feet/second.
Muzzle energy: 265 foot-tons.
Chamber pressure: 40,000 psi.
Gun weight (recoiling mass): 550 pounds.
System of operation: Recoil.
System of locking: Dropped breech.
System of feeding: Clip (can be converted to automatic feed using metallic belt).
Method of charging: Hydraulic.
Method of cooling: Air.
Barrel removal: Not quick change.
Bore:
Number of grooves: 8.
Direction of twist: Right hand.
Form of twist: Constant.
Method of headspace: Factory established.
Location of feed opening: Top.
Location ejection opening: Rear.
Projectile weight: 4.54 pounds.

General Description

The 50-mm Anti-tank Gun is air-cooled, recoil-operated, clip-fed, and uses percussion-primed ammunition. This gun was developed to provide a simple form of magazine-fed automatic gun utilizing the force of recoil to load the round on to a loading tray and to set a spring-loaded rammer.

During the firing tests a cyclic rate of 80–85 rounds per minute was obtained. The designer of the automatic loader stated that he hoped to obtain a rate of 100 rounds per minute and was confident that with further trials and redesign, the gun would be able to fire at a rate of 120 rounds per minute.

This gun is very simple and has a small number of parts which may be divided into two groups: the fixed parts and the recoiling parts. The breech operating mechanism is particularly interesting and was considered by the Germans to be worthy of further development.

Detail Description of the Nonrecoiling Parts

The principal fixed parts are: gun housing and cams, loading mechanism, rammer housing, and firing lever.

Gun Housing. The gun housing contains a mounting for the recoil system at the front end. The breech ring is pinned to the recoil system (hydro-pneumatic).

Loading Mechanism. The loading mechanism is fastened to the top of the open portion of the housing. The loading mechanism is actuated by the cam surface on the top right of the breech ring. As the gun recoils this cam surface causes the feed arm to move to the right while the magazine is held by the catches. During counter-recoil, the feed arm moves to the left under the action of the feed arm return spring and indexes the clip, stripping another round to the loading position. There is a safety catch located at the rear of the loader which prevents the rammer from moving forward when the last round has been fired.

Rammer. The rammer housing is fastened to the inside of the left wall of the housing. The rammer housing is tilted so that the rammer is clearly above the bore when it nears the rear end of its travel, thus affording clear ejection path.

The rammer is moved to the rear by the breech ring during recoil and is held there by the sear.

Sear. This sear has two catches. The front catch is operated by the firing lever. The rear catch is attached to the cam which is struck by the lowered breechblock as the recoiling parts come into battery. The rammer is held by the rear catch until the came is moved forward; it then moves forward until it is held by the front catch. This double catch system prevents a round being rammed unless the gun is forward and the breechblock lowered. The hand lever also operates the rear catch.

Firing Lever. The firing lever is connected by a long rod to the roller and is also keyed to the front catch operating mechanism. Operation of the firing lever draws the roller to the rear, moving the firing pin sear and releasing the firing pin. As the gun moves into battery, the breechblock is lowered and the roller strikes the front face of the block. The roller is spring-loaded and moves forward with the block until it is fully forward. When the block rises the roller moves rearward under the block and strikes the firing pin sear lever. Thus the firing pin cannot be released until the block is fully closed.

Single or Automatic Fire. Single and full automatic fire are controlled by a device located just to the rear of the firing lever, which governs the length of travel of the firing lever. For full automatic fire, the lever movement is limited in order to hold the front sear catch depressed. For single fire, the firing lever moves farther, depressing then releasing the front catch.

Detail Description of Recoiling Parts

The principal recoiling parts are: barrel, breech ring, breech-operating mechanism, breechblock, rammer, and loading tray.

Breech Ring. The breech ring is attached to the barrel receiver and contains the breech operating mechanism. The loading tray is attached to the rear of the breech ring.

The feed operating cam is located on the top right of the breech ring. The rammer buffer is on the rear left of the breech ring.

Breech - Operating Mechanism. The breech-operating mechanism is pinned to the bottom of the breech ring. The breech is spring-operated, both in opening and in closing.

The housing contains all the parts required to operate the breech. The gear rack and the breech closing spring slide over the shaft. The nut screws on the shaft, compressing the closing spring and forcing the gear rack to the rear against the shoulder. The nut bears against the housing and provides initial compression of the closing spring and also limits the travel of the shaft to the rear.

The breech opening springs fit inside the shaft. The bolt screws into the housing and forces the shaft and its shoulder against the gear, tending to move it forward and open the breech.

When the springs and rack are in the housing and the breechblock is raised, the shaft, the rack, and the closing springs are forward. The shaft then protrudes the maximum amount from the front of the housing.

As the gun comes into battery the shaft strikes a fixed pad on the gun housing and is held stationary as the breech ring continues to move forward. This causes the shaft to move rearward relative to the housing and compresses the breech opening spring. When the shaft is fully back, the catch slides down and bears against the forward face of the shoulder on the shaft. This locks the shaft to the rear and keeps the opening spring compressed.

Meanwhile, the breechblock has been held down by the extractors; therefore, the operating arm, the gears, and the gear rack have also been locked in position. Since the gear rack cannot move and the shaft and the collar have moved to the rear (relatively), the breech opening spring is compressed and stores the energy required to open the breech.

When a round enters the chamber and trips the extractors, the operating lever, gears, and gear rack are free to move under the action of the closing spring. The spring then forces the rack to the rear until it strikes the shoulder on the shaft. This causes the gear to rotate and turn the operating shaft, thereby raising the breechblock.

During recoil, the lug on the shaft of the catch strikes a cam on the bottom surface of the gun housing. This causes the lug to rotate and withdraw the catch from against the shoulder on the shaft. The breech opening springs which were held

compressed then force the shaft and the gear rack forward causing the operating lever to rotate and open the breech. The front end of the shaft then protrudes from the housing and is in position to be struck as the gun returns to battery.

Hand-Operating Mechanism. If the gun is in battery and the breech is closed, it may be opened by means of the hand crank. This hand crank is geared to a rack which in turn operates a gear having a lug that will bear against the cam. Rotation of the hand crank causes the gear to rotate and move its lug against the cam and cause it to rotate. This cam is keyed to the shaft of the operating lever and thereby lowers the breechblock. This rotation of the operating lever causes the gear to rotate and move the gear rack forward, compressing the breech closing spring since the front end of the shaft is against its pad.

Breechblock. The breechblock is of the vertical sliding type, having a percussion-type firing pin.

The internal breech operating lever is pinned to the breech operating lever located in the breech operating mechanism. As the breechblock is lowered the lever is caused to rotate first counter-clockwise and then clockwise. The counter-clockwise movement causes the cocking lever to rotate and withdraw the firing pin against the firing pin spring until it is caught by the firing pin sear.

The block is then raised and the lever goes through the same rotation (directions reversed). When the block is fully raised the sear lever is in position to be acted upon by the firing lever roller. The roller causes the sear lever to move to the rear which causes a rotation of the sear, raising the rear end and releasing the firing pin.

If the gun is firing full automatic, the lever is held to the rear. This causes the firing lever roller to be held to the rear. As the gun comes into battery the block is lowered and the roller strikes against the cam surface on the front of the breech block. The roller is spring-loaded and moves forward a short distance with the block. As the gun comes into battery the block is lowered and the roller strikes against the cam surface on the front of the breechblock. The roller is spring-loaded and moves forward a short distance with the block. As the block is raised the roller follows the cam until it strikes the sear lever and causes the gun to fire.

The cam surface is the part of the breechblock that strikes the cam which operates the rear catch of the rammer sear.

The cam surfaces are the surfaces which operate the extractors.

The firing pin may be hand cocked by rotation of the lever.

Loading Mechanism. The loading mechanism is of very simple design and is recoil-operated.

Manually Charging the Gun

When the gun is in battery and the breech is closed, it is charged by means of the hand crank. This hand crank is geared to a rack which in turn operates a gear having a lug that will bear against the cam. Rotation of the hand crank causes the gear to rotate and move its lug against the cam. This cam is keyed to the shaft of the operating lever and thereby lowers the breechblock. This rotation of the operating lever causes the gear to rotate and move the gear rack forward, compressing the breech closing spring since the front end of the shaft is against its pad.

Cycle of Operation

The operation of the weapon will be described in two parts, the recoiling and counter-recoiling movements.

Recoiling Movement. Upon firing of the round, the gun-barrel and breech ring move to the rear in recoil. The loading mechanism is actuated by the action of the cam surface on the feed arm causing a round to be indexed to the center position, during counter-recoil.

During recoil, the lug on the breech operating mechanism strikes the cam on the bottom surface of the gun housing and causes the breechblock to lower and eject the empty cartridge case. The firing pin is also cocked on this motion of the breech-block.

The rammer head is in contact with the breech ring during recoil and is forced back to the rammer catch by the breech ring.

The recoiling parts are then stopped by the recoil mechanism and start forward under action of the counter-recoil system.

Counter-Recoiling Movement. The gun barrel

and breech ring move forward and, as they approach battery, the shaft of the breech-operating mechanism strikes a fixed pad and charges the breech-operating springs.

The cam is struck by the cam on the lowered breechblock as the gun moves into battery. This releases the rear rammer catch and the rammer moves toward its front catch.

If the firing lever is on FIRE, the front catch is depressed and the rammer moves forward to ram the round. The firing lever roller is forced against the cam on the lowered breechblock.

As the round enters the chamber, it trips the extractors and the breech closes. The roller follows the cam path and strikes the firing lever and fires the round.

SECTION 3. 55-MM FLAK

General Data

Caliber: 55–mm.
Rate of fire: 100–140 rounds/minute.
Muzzle velocity: 2,740 feet/second.
Projectile weight: 4.54 pounds.
Muzzle energy: 265 foot-tons.
Chamber pressure: 40,000 psi.
Gun length (traversing mass): 257.9 inches.
Gun weight: 550 pounds.
System of operation: Recoil.
System of locking: Dropped breech.
System of feeding: Feed tray conveyor.
Method of charging: Manual.
Method of cooling: Air.
Weight of feed tray with 4 rounds: 57.2 pounds.
Barrel length: 185.13 inches.
Barrel removal: Not quick barrel change.
Direction of twist: Right hand.
Form of twist: Constant.
Method of headspace: Factory established.
Location of feed opening: Top.
Location ejection opening: Rear.

General Description

This 55-mm fully automatic anti-aircraft gun was initiated at the request of German authorities. It was designed to use a type of auto loader similar to that used on the 75-mm FLAK R4, described in the following section.

SECTION 4. 75-MM FLAK R4

General Data

Caliber: 75-mm.
Rate of fire: 75–100 rounds/minute.
Muzzle velocity: 2,950 feet/second with 13.9-pound projectile; 3,020 feet/second with 13.2-pound projectile.
Range: 53,500 feet.
Gun weight: 1,750 pounds.
System of operation: Recoil operated (hydraulic pressure stored during recoil).
System of locking: Horizontal sliding breech.
Recuperator system: Air.
System of feeding: Automatic.
Method of charging: Air or hydraulic.
Method of cooling: Air.
Barrel length: 172.2 inches.
Type of barrel: Jacket with removable liner.
Bore:
Direction of twist: Right hand.
Form of twist: Constant.
Method headspace: Established at factory.
Location of feed opening: Top.
Location ejection opening: Rear.

General Description

The 75-mm Flak R4, developed by the Skoda Works, is a fully automatic anti-aircraft gun, hydraulically operated and controlled by pressure created and stored during recoil. The breech is both opened and closed by springs charged during the final return to battery. The system incorporates a compact fuze setter.

Detail Description

Gun. The tube has a replaceable liner. The gun rides on ways and is retarded in its rearward motion by a constant force hydraulic recoil system and a compressed air recuperator. The breech is closed by a conventional horizontal sliding breechblock. The principle of operation of the breech-

block is the same as in the Skoda 50-mm PAK. The breech opening and closing springs are compressed by the charging rod striking the pad as the gun comes into battery. The extractors prevent the block from closing under pressure of the closing spring until the round is rammed. On recoil the

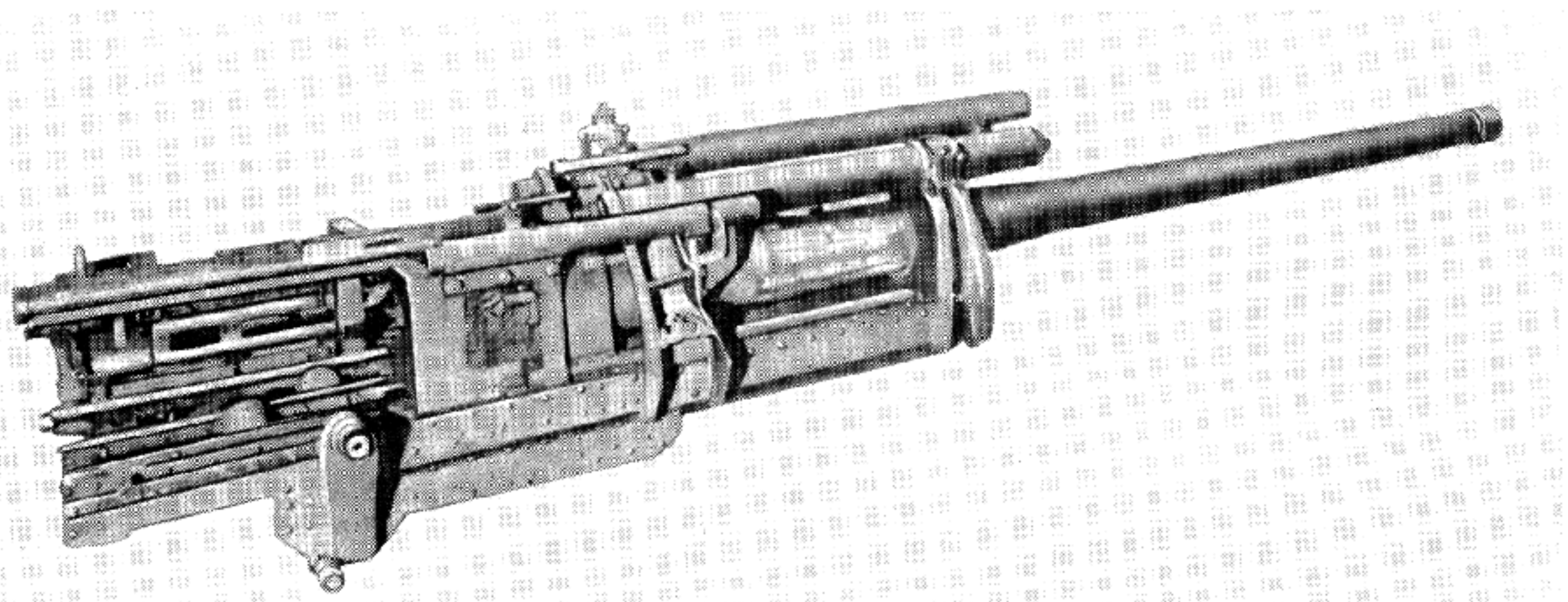

Figure 7–8. Right side view of the Skoda 75-mm Automatic FLAK R4.

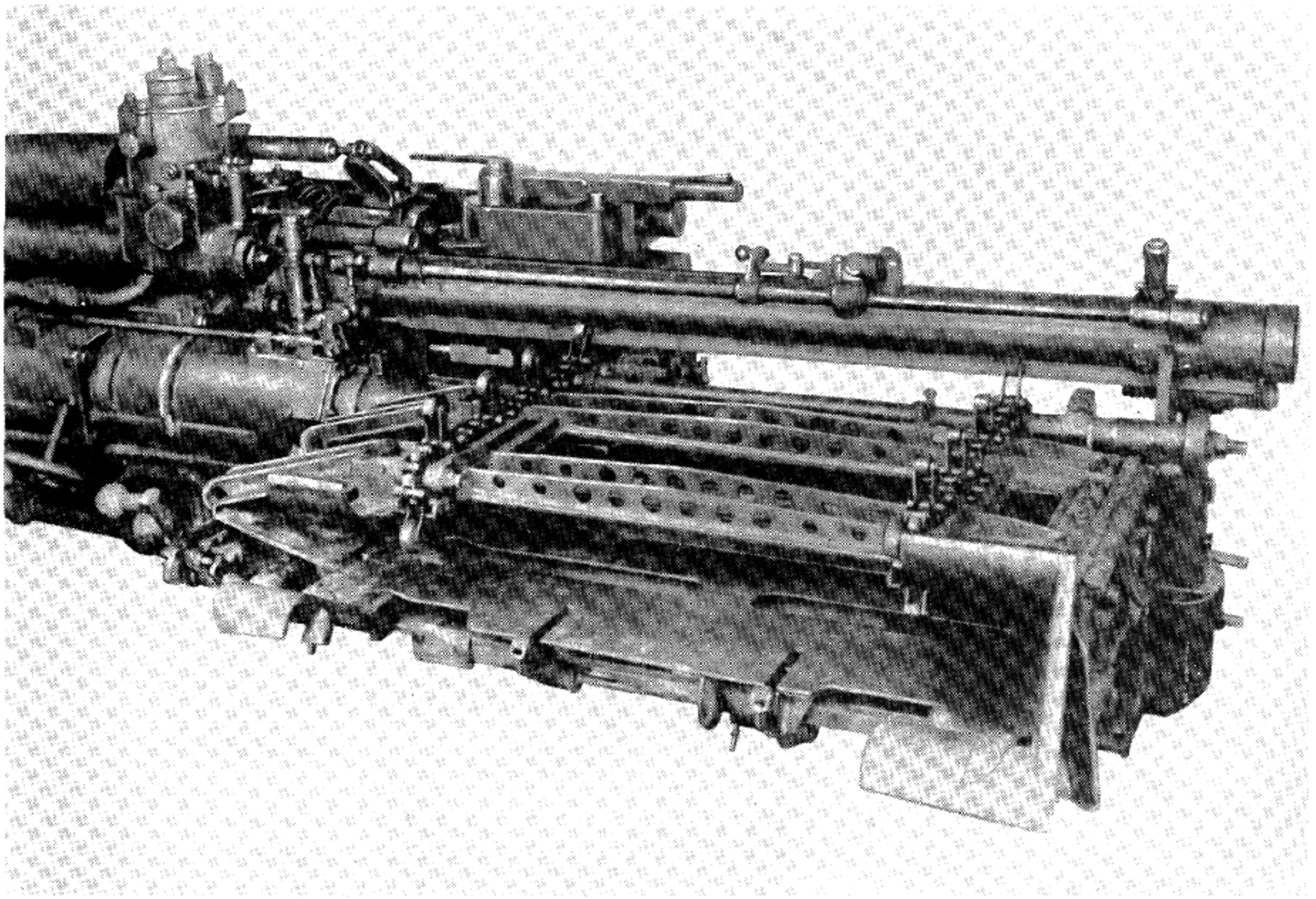

Figure 7–9. Skoda 75-mm Automatic FLAK R4. View of the feed device from the left.

breech-opening release lever overrides the breech-opening release cam. On counter-recoil the release lever contacts the release cam thereby unlocking the spring and opening the breech.

The breechblock may be hand operated by the lever, provided that the automatic fire plunger is depressed so the lever and operating gears are connected. A lever is provided to trip the extractors so rounds may be loaded and fired manually.

Feed Mechanism. The feed mechanism consists of a feedway, a feed tray, round conveyer and operating rack. The feedway is a guide for the rounds and has a capacity of three rounds which are indexed by the conveyer. Including the round in the feed tray, the total capacity is four rounds. The conveyer may be hand operated to load it initially. Under automatic operation the conveyer indexes a round onto the tray as the tray is returned outboard after ramming. The feed tray is hydraulically operated by the tray operating rack. When pressure is applied to the tray operating piston such that the rack is driven rearward, the tray is driven in line with the bore through a series of gears. The tray, fuze setter and rammer are interlocked so the operation of each occurs at the proper time during the cycle.

Rammer. The rammer is hydraulically operated. It consists of an arm secured to the end of a piston rod. The end of the rod rides on rollers in the rammer housing. The piston end of the rod is contained in the rammer cylinder and is driven rearward or forward by hydraulic pressure applied to the proper side of the piston through the control valve. The rammer arm is free to rotate through a limited

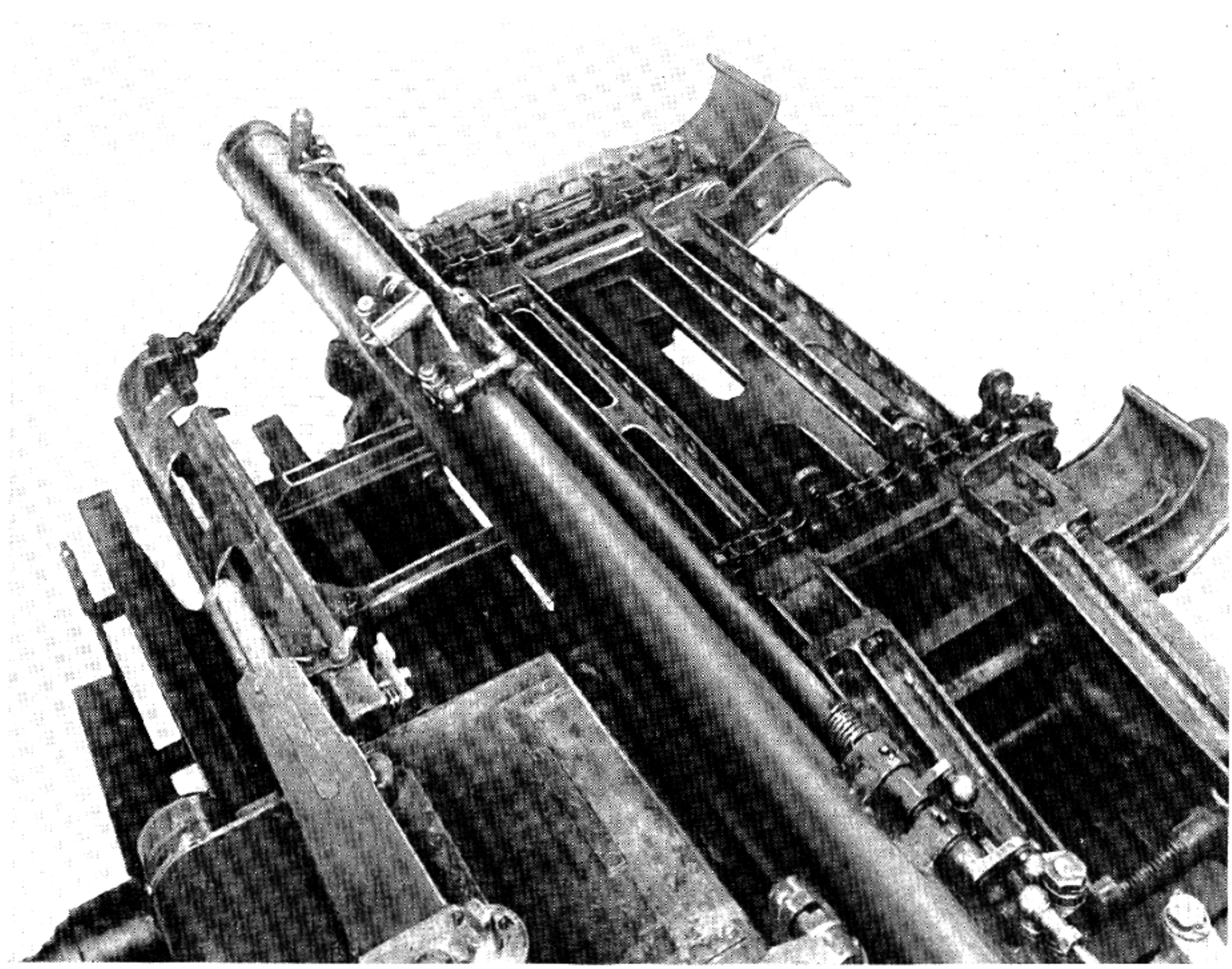

Figure 7–10 Skoda 75-mm Automatic FLAK R4. Top view of rammer and feed mechanism.

arc. As the tray moves in line with the bore a roller at the extreme rear of the tray engages the rammer arm and rotates it outward so the head is positioned behind the round. Upon reaching its "in line" position, the tray, through a linkage, operates the control valve and the round is rammed by the hydraulic pressure acting on the piston. Since the rammer and breech do not recoil together the rammer head must be positioned out of the way before firing. As the breechblock closes on the rammed round, a projecting rod on the breechblock contacts the rammer arm and rotates it out of the path of the recoiling gun.

Fuze Setter. The fuze setter is hydraulically operated by pressure through the control valve to the proper side of the piston. In setting the fuze, the fuze setter cup is driven rearward to engage the setting ring of the round. The cup then rotates the setting ring the required amount. The amount of rotation is preset by the handwheel and indicated by the dial. Each succeeding round will be set for the same time unless the handwheel is rotated.

Firing Mechanism. The rounds are percussion fired by a firing pin spring-loaded in the retracted position. The firing pin is operated by the firing pin actuator, which in turn is actuated by the spring-loaded firing plunger. As the gun comes into battery, the top projection of the sear engages the lower lip of the firing plunger and drives it forward compressing its spring. When the tray is returned to the outboard position, the sear actuator operating lug secured to the tray operating rack causes the operating linkage to rotate and depress the sear actuator. This actuator has an arm which engages the side projection of the sear and the firing plunger is released, firing the round.

Hydraulic Control System. The hydraulic control system is the heart of the weapon. The control system consists of an operating cylinder and piston, intermediate cylinder and floating piston, spring operated control valve which functions at the proper time during the automatic cycle. The cylindrical control valve properly controls the eight ports in each of four valve positions. In positions 1, port 6 is connected to port 5, and 1 is connected to 4. In position 2, port 6 is connected to port 7, and 1 is conected to 2. In position 3, port 2 is connected to port 3, and 7 is connected to 8. In position 4, port 3 is connected to port 4, and 5 is connected to 8. The valve allows the oil pressure to act upon the various operating pistons such that the resultant force (pressure time net area) acts to drive the piston in the proper direction. The valve is allowed to rotate through 90 degrees each time it is released. It is positively stopped in positions 1, 2, and 3. In position 4 it is stopped momentarily and then by the

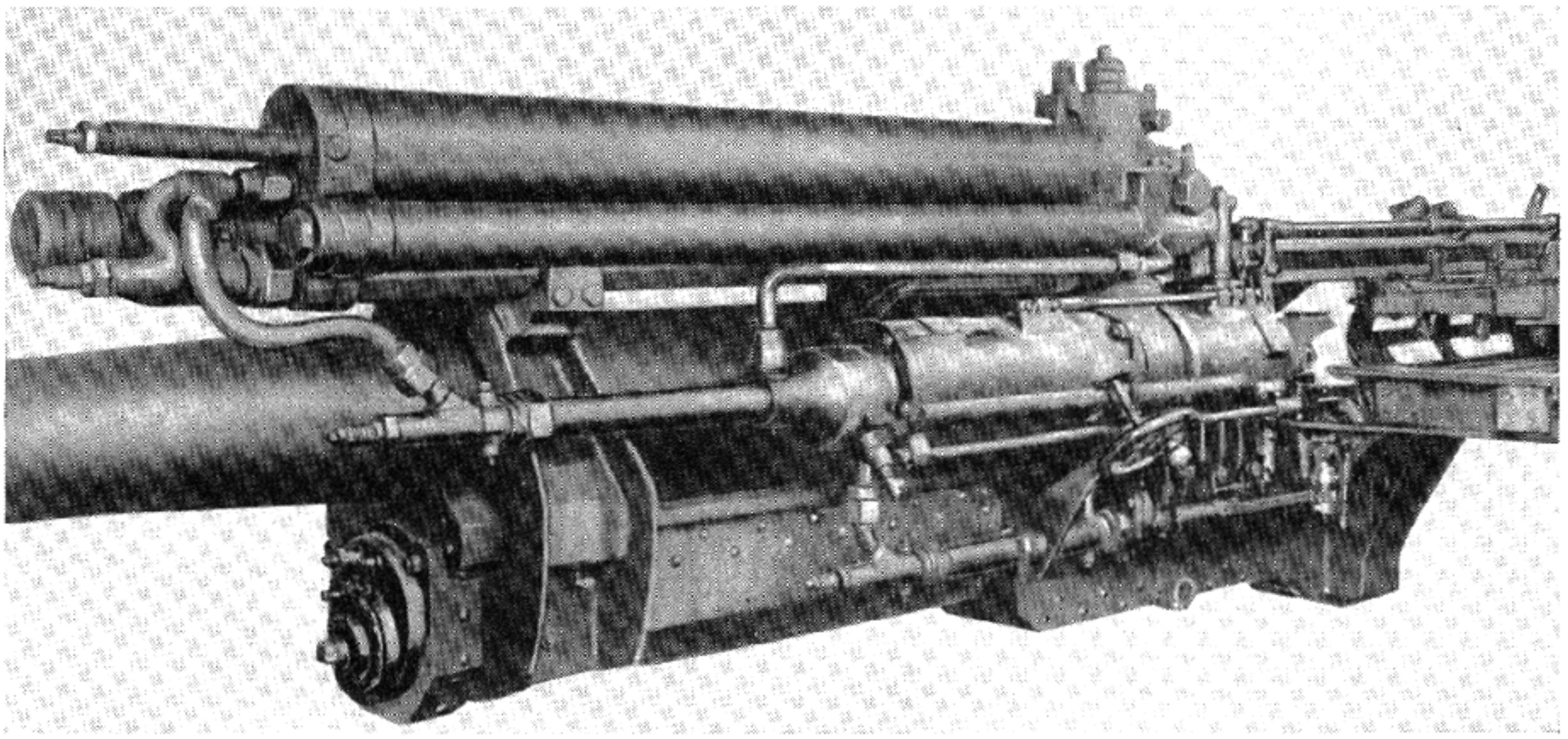

Figure 7-11. Skoda 75-mm FLAK R4. Close-up view of the hydraulic control system.

force of the coil spring, the valve slips on to position 1. The coil spring is initially wound manually. It is rewound each cycle by a rack and pinion arrangement. When the gun comes into battery the stop, secured to the breech-ring, contacts the control valve spring winding rack. This rack is geared to a pinion whose shaft operates to wind the control valve coil spring. At the same time the rack return spring is wound so upon recoil of the gun, the rack is returned to its original position.

The high pressure fluid which the control valve routes to the proper pistons is stored in the reservoir. The reservoir contains an initial supply of compressed air and oil. The reservoir is directly connected to the intermediate cylinder. The floating piston separates the actual operating oil from the compressed air and oil in the reservoir. The intermediate cylinder is connected through a one way valve to the operating cylinder. The operating cylinder contains a piston and rod. The front of the operating cylinder is equipped with a one way air valve which opens readily on rearward travel of the piston but acts as an orifice type brake on return of the piston. The rear of the operating cylinder piston rod is connected to the breech ring by a yoke. The gun will drive the rod rearward, but the rod is free to remain rearward while the gun returns to battery. On recoil of the gun after firing, the operating piston rod is driven rearward and the oil is displaced through the one way valve and into the intermediate cylinder driving the floating piston forward and further compressing the air supply in the reservoir. Thus a pressure supply is available for operation during the cycle. The

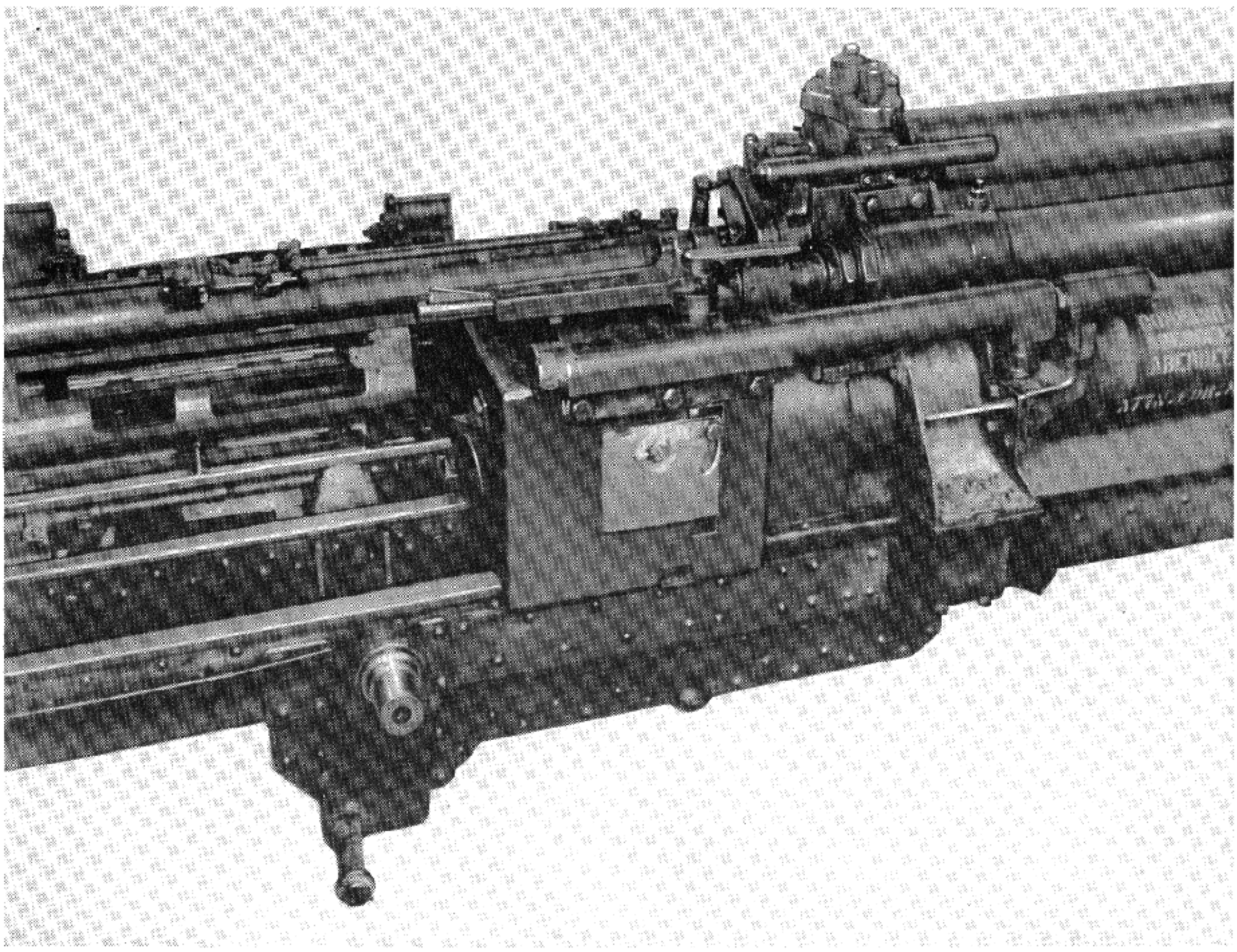

Figure 7–12. Skoda 75-mm Automatic FLAK R4. Close-up of breech from the right.

operating piston rod is retained rearward by the retainer until it is released to allow for return of oil to the operating cylinder.

Automatic Operation

The initial condition of the various elements of the gun just as it fires is as follows: The gun is in battery. The breechblock is closed upon the round and the breech opening springs are compressed. The feed tray is outboard with a new round held in it. The rammer piston is forward, and the rammer arm is rotated out of the path of the gun. The operating piston is forward and the floating piston is rearward. The fuze setter piston is forward. The control valve is in position to connect port 5 to port 6 and 1 to 4. After the round is fired, the gun recoils and the force is absorbed mainly by the constant force fluid recoil mechanism and the compression of the high pressure air in the recuperator. The operating piston rod is pulled rearward by the yoke secured to the breech-ring, and the retainer engages the head of the rod and holds it rearward while the gun returns to battery. As the gun returns to battery, the breech-opening release lever contacts the breech-opening release cam and the breech-opening spring is unlocked and the breechblock opens. The extractors are rotated and the empty case is ejected rearward. The breechblock spring charging rod contacts the pad as the gun comes into battery; the breech-opening and closing springs are compressed.

The oil in the operating cylinder is displaced by the recoil movement through the one-way valve and into the intermediate cylinder. The floating piston is forced forward and the compressed air in the reservoir is further compressed. The pressure also forces oil out of the intermediate cylinder through port 5, into the control valve and through port 6 to the front of the rammer and fuze setting pistons. The great area of the front of the pistons results in rearward motion. The rammer is thus driven rearward and held by the rammer catch. The fuze setter cup is also driven rearward until it engages the setting ring of the fuzed round at which time further rearward movement of the piston causes the cup to rotate the setting ring to the setting time as controlled by the handwheel. After the fuze is set the moving piston rod operates a yoke in the fuze setter which acts to drive the operating rod forward and to release the feed tray interlock. The operating rod engages and rotates the control valve operating shaft. Thereby the operating piston release linkage causes the operating piston retainer to release the operating piston rod. The return spring causes the operating rod and retainer to return to original position. The rotation of the control valve which rotates 90 degrees to position 2 which connects port 6 to port 7 and 1 to 2. Fluid under pressure in the intermediate cylinder goes through port 1, through the control valve, through port 2 and into the tray operating cylinder. The larger front area of the tray operating piston results in the tray operating rack moving rearward displacing the fluid back into the intermediate cylinder.

The control valve release linkage pivot overrides the lug on rearward movement of the operating rod. By means of the rack and pinion the feed tray, carrying the round held by locked spring clips, is moved into the line of the bore. The spring clips are unlocked by striking a projection of the breech ring. The rammer arm is rotated into the line of the bore by the moving feed tray. At the same time fluid pressure from the intermediate cylinder drives the fuze setter cylinder forward and the fluid is displaced through port 6, the control valve and port 7 and into the operating cylinder.

When the tray operating rod has moved the tray into the line of fire, the operating rod continues its rearward movement. This last movement causes the rammer release operating lug to engage a rod which rotates two pivots. The pivot raises the sear actuated so it is free to rotate inward (under its own spring pressure) to a position above the side lug of the sear. The other pivot rotates and through the linkage the rammer arm is released. The direct pressure from the intermediate cylinder acting on the rear of the rammer piston drives it forward and the fluid in front of the piston is displaced through the control valve, via ports 6 and 7, into the operating cylinder where the piston is free to go forward. The rammer arm drives the round, trips the extractors, and the breechblock is snapped closed by the compressed breech-closing spring. The rammer arm is rotated out of the path of the breech by the closing breechblock.

As the rammer head reaches the end of its forward travel, it contacts control valve operating plunger which rotates the control valve operating shaft and

the control valve is released to rotate 90 degrees to position 3. Pressure from the intermediate cylinder acts on the rear of the tray operating piston and drives it forward. The fluid is displaced through the control valve via ports 2 and 3 and into the operating cylinders.

The feed tray is driven outward by the rack and pinion. As the tray nears the end of its outward travel, the round conveyors index another round onto the feed tray. As the tray operating piston nears the end of its travel, the control valve release operating lug on the shaft engages and rotates the linkage and the control valve operating shaft is rotated allowing the control valve to rotate 90 degrees to position 4. Position 4 connects the intermediate cylinder with the operating cylinder through ports 5 and 8. This releases any pressure remaining in the rear of the intermediate cylinders. The valve is not positively positioned in position 4 and it slips into position 1.

The sear actuator operating lug on the tray operating shaft contacts the pivot arm which draws the sear actuator downward and engages the side projection on the sear and the spring loaded firing plunger is released. The firing pin actuator strikes the primer, firing the round.

SECTION 5. 75-MM RECOILLESS AIRCRAFT CANNON

General Data

Caliber: 75-mm.
Muzzle velocity: 2,535 feet/second.
Gun length: 187 inches.
Gun weight: 1,430 pounds.
System of operation: Recoilless principle.
System of feeding: Revolving drum.
Method of charging: Spring rammer.
Method of cooling: Air.
Bore:
  Number of grooves: 8.
  Direction of twist: Right hand.
  Form of twist: Constant.
Location of feed opening: Top.
Location ejection opening: Barrel pivots in center.
Type of ammunition: Fixed.
Type of charge: Ngl M. 36.
Projectile weight: 9.24 pounds.
Charge weight: 4.62 pounds.

General Description

This was a development project for a 75-mm high velocity gun for mounting in aircraft and to have automatic feed. In order to reduce recoil to a minimum, the design called for twin rear venturis, as in recoilless guns, and a muzzle brake.

The gun was to employ a revolving drum-type magazine and spring rammer operated by means of mechanical linkages and ratchet and spring assemblies, power being supplied by gas take-off from behind the rear part of the muzzle brake.

A conventional cartridge with electric primer was to be employed.

The venturis were to be at 30 degrees to the axis of the bore with the throats just forward of the front edge of the cartridge case.

Chapter 8

7.92-MM POWER-DRIVEN MACHINE GUN ZB–80

History and Background

For the design of the 7.92-mm power driven machine gun ZB–80, credit is due the Czechoslovakian arms producing company of Ceskoslovenska Zbrojovka Akciova Spolecnost v Brne, of Brunn, which is popularly known as Brno ZB or ZB because, obviously, of the unwieldy official name of the company. This plant was established after World War I when the victorious Allies were interested in the establishment of a small-arms manufacturing plant on a par with the Skoda facilities for making heavy armament. The location at Brunn was decided on as a factory already in existence there had previously made weapons and two-cylinder automobiles. In 1922, the plant was converted to small arms production by a combination of funds; 75 percent of the stock was held by the Czech Government, 20 percent by the Skoda Works and 5 percent by employees of the ZB plant.

France extended a helping hand, as the first machine gun built by the new firm was the Model 1922 light Hotchkiss built through the cooperation of French Ordnance engineers who had been ordered to turn over to the new company their latest drawings on this machine gun. In 1924, ZB introduced a prototype weapon (ZB 24) of their own design, officially identifying it by the year of its appearance. This weapon was a composite of many sound automatic weapon principles that had been proved by combat in other guns, such as Berthier, B. A. R. (Browning), Hotchkiss, and Chatellerault. A demand for a light machine gun by the Czech Army gave the company the needed opportunity for which it had been waiting, and from that time on the ZB Company has progressed in unbelievable strides.

Fortunately for the company, there was a wealth of skilled technicians available to assist in design and fabrication.

The modern and highly efficient ZB Plant was taken over by the Germans early in World War II and operated under the name Waffenwerke Brunn A. G. The Germans, long noted for their low regard for the professional skill of others, especially when compared with their own, admitted that the Czech engineers were producing weapons as fine as any in the world and paid them the unusual compliment of allowing them to continue their production without being completely restaffed by their own engineers. The Wehrmacht had acquired not only two huge manufacturing arsenals but also gun secrets of the Allies which had been developed in the ZB plant since 1922.

With the fall of Germany and the seizure of the Czech plants by the Russians, the Soviets for the first time had in their hands the one factor lacking in their automatic armament program all through World War II—the manufacturing "know how" whereby weapons could be mass produced to a close manufacturing tolerance, and metallurgy and heat treating could replace bulk or mass. Under the domination of the Soviet Union, the ZB facilities furnished arms to the Russians under the designation "Peoples' Enterprise," a suffix widely used for satellite war plants.

The ZB–80 was in the prototype stage at the time of the German invasion of Czechoslovakia. The model, pictures, and drawings had earlier found their way to the United States and a gun of this type had been demonstrated to American authorities. However, data given in this chapter are derived from brochures prepared in the ZB plant.

Evidence is conclusive that the ZB–80 prototype was designed with a 7.92-mm bore for the sole purpose of conducting tests with ammunition that was readily available and comparatively cheap. The prototype included all features necessary for scaling up the weapon to cannon dimensions.

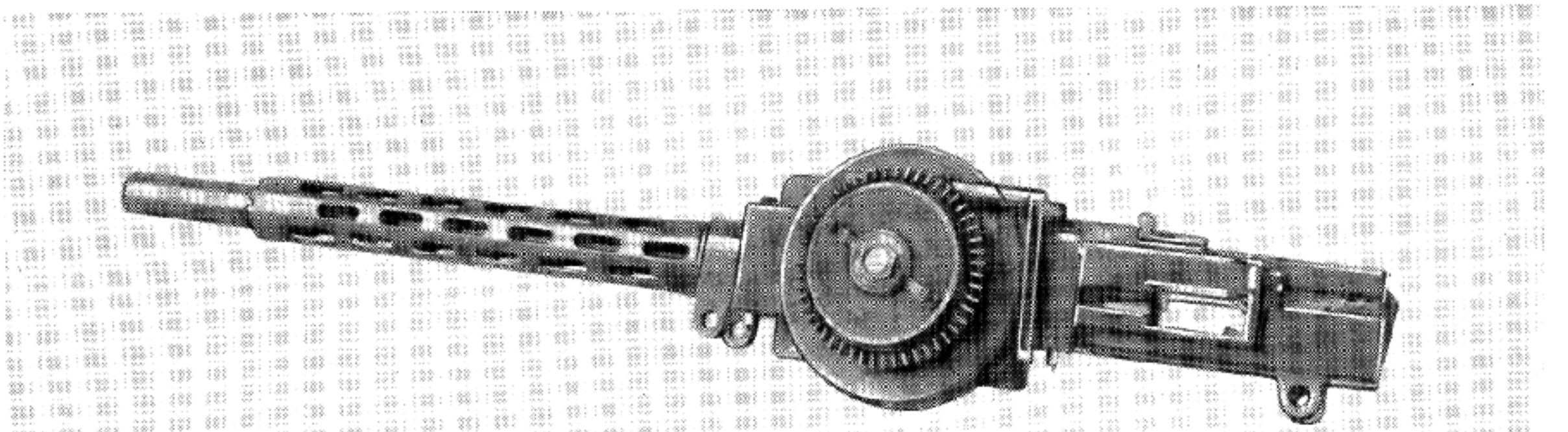

Figure 8–1. Left side view of ZB–80, power-driven machine gun.

General Data

Caliber: 7.92-mm.
Rate of fire: 1,200 rounds/minute.
Muzzle velocity: 2,750 feet/second.
Gun length: 31.1 inches.
Gun weight: 20.9 pounds.
System of operation: Power driven.
System of locking: Camming action (eccentric).
System of feeding: Link metallic belt.
Method of charging: Power derived from outside source.
Method of cooling: Air.
Rate control: Synchronization with airplane's motor.
Barrel length: 24.2 inches.
Weight of carrier frame and transmission: 5.5 pounds approx.
Barrel removal: Quick change.
Method of headspace: Fixed.
Location of feed opening: Top.
Location of ejection opening: Side (cartridge remains in belt during firing and also during ejection).
Weight of one complete belt link: 0.23 ounce.

Description of the Weapon

The ZB–80 represents a departure from the conventional automatic machine gun with synchronized control. This weapon is power driven and its operating energy is derived from an external power source (the airplane's engine) through a mechanical transmission.

Inasmuch as the gun is mechanically driven, it does not require warming up or an independent synchronizing device. These features increase the reliability of the action.

Furthermore, by the simple process of inserting the end of the belt into the belt guide block, the gun is made ready to fire, but there is no live cartridge in the barrel. It follows that there is no hand cycling device or charging movement required.

The belt links are simple pieces of machined steel and are very durable. They are not subjected to distortion or twisting strains and assure accurate functioning of the feed mechanism. The peculiar design of the link in the belt makes it possible to replace the ordinary functions of the breechblock and ejector, and the empty cartridges or misfires are mechanically carried out of the gun, thus eliminating the most common source of stoppage. When firing is interrupted, there can be only an empty cartridge in the barrel, so that pre-ignition by an overheated chamber is avoided.

The weapon cannot be damaged by delayed ignition, because if the delay exceeds the time lag, the barrel is moved off the cartridge and the latter explodes outside the chamber of the gun. Barring instances when unusual deformation of the cartridge case occurs through delayed ignition, it is carried out of the gun by the belt and no stoppage occurs.

The belt chamber has been generously proportioned, as a protection against damage to the main housing (receiver) of the gun by delayed ignition. In the event of the separation of the bullet and case,

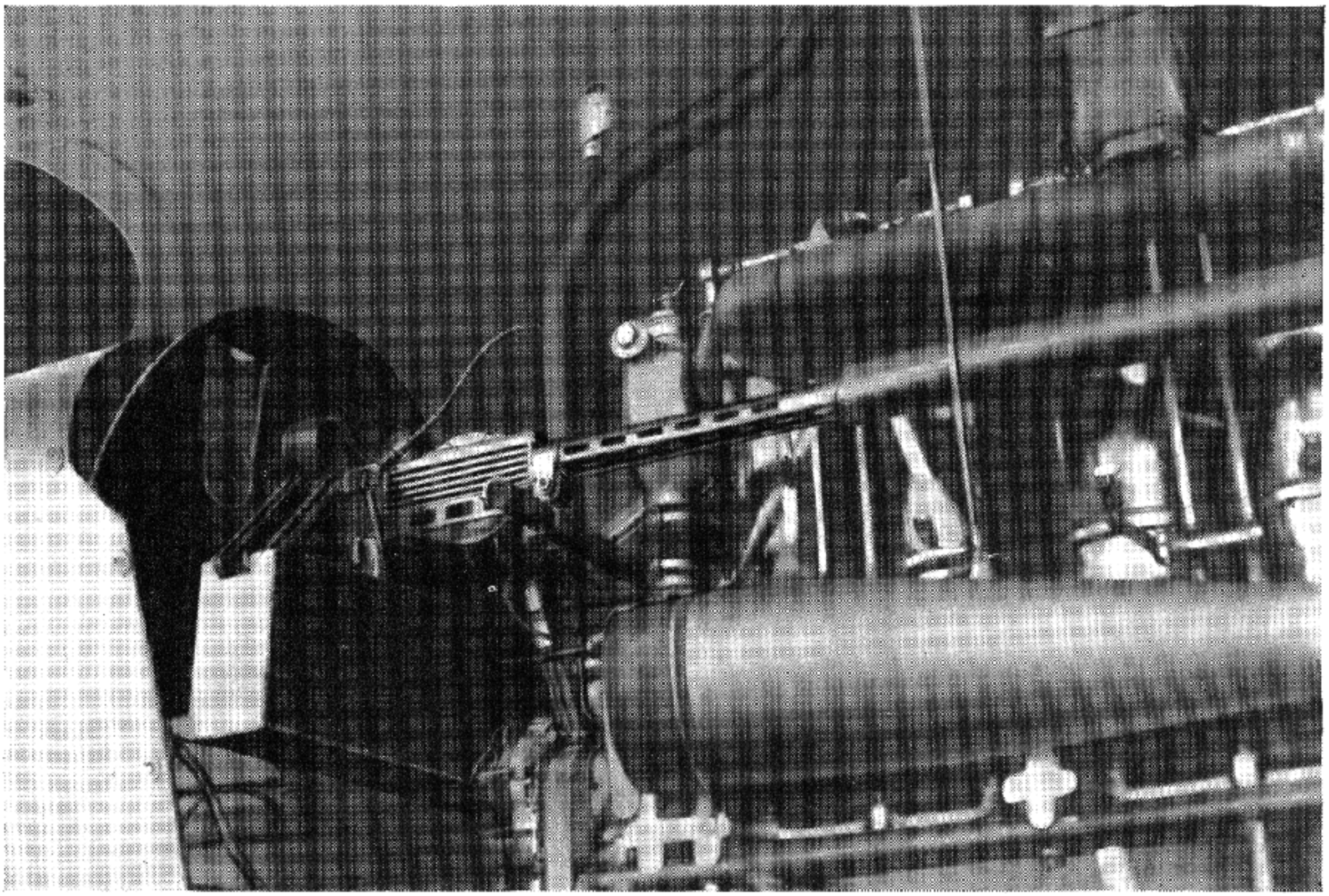

Figure 8-2. ZB-80 Power-driven Machine Gun.

the powder is immediately emptied out of the gun through openings at the rear end of the barrel.

A small angle of dispersion is accomplished by means of the mechanical drive principle, which fixes the firing point for the cartridge at a point which maintains a constant position regardless of the speed of the motor. The light weight and compactness of the gun permit installation in any type of airplane. The simple design permits rapid mounting in any position with respect to the plane. Dismantling the gun can also be accomplished with ease.

By selection of the proper gear ratio between the driving pinion and drive gear, the rate of fire may be brought up to the maximum of 1,200 shots per minute. The mechanical connection of the gun to the airplane engine guarantees uniformity and reliable operation with correct synchronization at all motor speeds.

This gun requires no breech locking mechanism. The mechanical drive connecting the engine to the gun imparts a longitudinal sliding motion to the barrel of the gun and simultaneously acts on the feeding and firing pin mechanism.

The cartridges are retained in a multiple unit flexible steel belt, which feeds them into and out of the gun. The individual units of this belt consist of but two parts, the bottom belt link and the top belt link, which are interconnected with a dowel pin. This pin is an integral part of the bottom belt link, and is locked after inserting the cartridges. After the belt is inserted in the machine gun, it is held in position by the belt holding powls.

The barrel moves on its horizontal axis, guided at the rear in the main housing and at the muzzle by a bearing surface located in the flash hider. The flash hider is connected with the main housing by the barrel sleeve. The flash hider locking spring locks the flash hider, and the barrel sleeve stud locks the sleeve.

This sliding block engages the angular grooves located at the rear of the barrel forming the con-

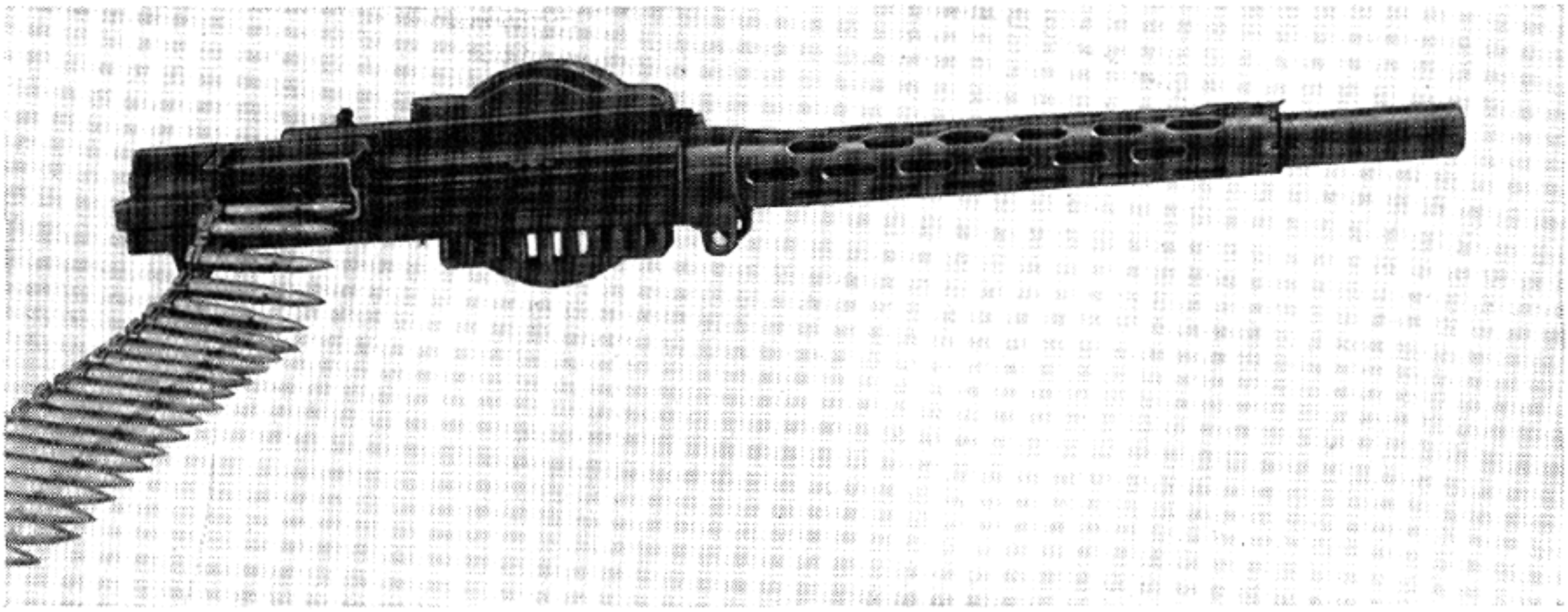

Figure 8–3. Right side view of ZB–80, showing the unusual design of the belt.

nection between the operating and drive mechanism, and imparting reciprocating motion to the barrel. The breech end is protected by the guard plate.

The crank pin drives the sliding block through the crank pin roller, which engages the crank pin roller bushing and runs in the sliding block slot.

The sliding block, that travels rearward and forward is an eccentric which is governed by the radius of the crank pin throw. After the barrel is locked, the crank pin moves 30 degrees before it starts to move the barrel again. This arrangement insures that the time lags is at least three times as long as the interval required for firing a round when the rate of fire is 1,200 rounds per minute. This type of action prevents pulling a hang-fire.

The drive gear of the ZB–80 is located on the side of the gun and is enclosed in the "crank housing" (receiver) which is attached to the "main housing" with two crank housing bolts which, in turn, are locked in position by the crank housing bolt catch. The roller bearing assembly for the crank disk consists of the crank disk roller bearing race, roller bearing rollers, roller cage, roller retaining plate, and roller retaining plate rivets. The roller bearing assembly contacts the periphery of the crank disk. This bearing, which is of large diameter, gives a considerable distribution of pressure during firing; thus reducing stresses and strains to the minimum.

The coupling for the crank disk is located in the center of the assembly and engages the clutch by means of slots in the clutch spindle, and the power connection is completed through the crank disc driver. One of the arms on the crank disc driver is a little longer than the other; improper assembly is thus less likely.

The clutch spindle ball bearings are enclosed in the crank case cover and held in place by the clutch spindle ball bearing retaining nut. They form the rear bearing for the clutch spindle. The front bearing of the clutch spindle consists of solid bushing. The crank spindle end plate is slipped over the square end of the clutch spindle and is held in position by the crank spindle nut.

The crank spindle end plate, as well as the timing plate which is attached with four timing plate dowels to the driving gear, has meshed gears. The connection between the drive gear and the clutch is by means of the timing ring, which slips over the crank spindle end plate and the timing plate. The drive gear, which is mounted in the drive gear bushing, rotates continuously as long as there is an application of power and transmits the rotation to the clutch through the timing plate dowels. Should an interruption in the functioning of the gun occur, the connection between the clutch and the drive gear is broken by the shearing off of the timing plate dowels.

The timing ring is used to adjust the timing of the gun when it is being mounted in the airplane. When this ring is slipped off in the direction of its axis, the connection between the driving gear and the clutch is broken; thereafter the drive gear and

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the clutch can be shifted in their relation to each other by any desired number of teeth. The timing ring is locked, as is also the clutch spindle nut, against turning, by the timing ring retainer.

The shaft bearings of the operating lever are secured to the crank case over and the crank housing, thus keeping the crank case cover from turning.

The operating yoke is secured to the spindle of the operating lever by means of the operating lever key and the operating yoke set screw. When the operating lever is shifted, the crank disc drive is pushed into contact with the crank disc by the operating yoke, and the machine gun starts to fire. The weapon may be controlled in two ways: (1) by manipulating the vertical arm of the operating lever, which engages and disengages the clutch; and (2) by moving a horizontal arm which engages and disengages the feed mechanism.

The feed mechanism is set in motion by the push rod, which lies on the main housing, and is guided by the main housing top cover. The forward movement is imparted by the sliding block, which is struck on its angled surface by the nose of the push rod, forcing the push rod forward. The return movement is accomplished by a push rod spring and a push rod spring plunger.

The push rod roller is mounted on the push rod and is prevented from falling out by the push rod roller guide, which projects into the slot in the belt feeder carrier driver.

The belt feed carrier drive turns on its shaft and transmits the reciprocating motion imparted by the nose of the push rod to the belt, feed carrier. The latter is mounted in the main housing at right angles to the axis of the barrel and has guideways in the form of slots, and protects the belt feeder.

The feed opening is located in the main housing and is a part of the guide block which is held by belt guide block studs. The belt holding pawl projects through a slot into the belt guide block and engages the cartridges. The belt guide pawl release and the belt stop pawl are located directly behind the bolt guide block. The pawls are attached to their springs by the release nuts and are retained by the release spring. The rear end of the push rod has a cam which operates the belt guide pawl, the release of which is accomplished with a vertical movement of the latch.

The cartridges are normally fed from right to left. To reverse the direction of feed, the belt guide pawl release and belt guide stop release are changed about, and three parts (belt feeder, belt feeder carrier, and belt feeder carrier driver) are replaced by parts of symmetrically reversed design.

Midway on the push rod, there is an elongated tooth which is caught by a projection when it has reached its extreme forward position. A slot in the push rod, into which the tooth on the horizontal arm engages, prevents premature disconnection of the clutch lever and also carries a lower arm, controlling the push rod latch, in which the push rod latch spring is mounted. The feed safety catch, located on the main housing top cover, disconnects the belt feed mechanism.

The firing pin with its main spring is housed in the firing pin tunnel, located along the axis of the barrel. A forked firing pin housing lever, which swivels on its shaft, is located under the firing pin housing. The right fork of the lever is in constant contact with the firing pin housing; the left fork, which has a lug, is in constant contact with the firing pin housing plunger. The firing pin housing spring returns the firing pin together with its component, to its initial position at the end of each burst.

The firing pin sear is located above the firing pin housing plunger, turning of the sear pin readies the firing pin. The firing pin safety device projects with its nose into the path of the sliding block. When the sliding block completes its rearward movement, it presses the plunger back, and the plunger forces the assembly forward through the motion of the firing pin housing lever. The tooth on the left arm of the sear holds back the firing pin, compressing the firing pin spring. When the plunger has completed its rearward movement, the lug on the firing pin housing lever trips the sear, releasing the firing pin. This arrangement greatly reduces the period during which the firing pin spring is compressed, and, of course, serves to lengthen its life.

The rear end of the main housing is closed by the main housing cover, which is locked in place by a spring loaded latch.

Mounting

A front bracket is attached on the framework of the fuselage of the plane.

The transmission for the machine gun drive mechanism consists of a drive pinion, mounted on the side of the bracket and engaging the drive gear of the machine gun. The drive pinion is connected to the engine through a flexible shaft. The gear ratio between the motor and the machine gun is determined by selecting the proper number of teeth on the drive pinion; the ratio in turn imparts the proper rate of fire in relation to the RPM of the power drive.

The trigger release is attached to the bracket in about the middle and is connected through a Bowden cable release to the master trigger on the flying controls. A slot is milled into the head of the trigger release.

The ammunition box is divided in two compartments. The live ammunition assembled in the belt is placed in the right hand compartment, while the empty cartridge cases, still held in the belt, fall into the left-hand compartment. In order to prevent danger to the live cartridges while the gun is firing, the box covers are cushioned with springs.

A blast tube is secured to the fuselage; the muzzle and flash hider of the machine gun project into this firing tube, which carries the powder gases away.

The machine gun is secured to the bracket by two bolts which pass through the front and rear bracket lugs on the weapon and are locked in position with safety catches.

The vertical end of the operating lever rests in the milled slot in the head of the trigger release, thus connecting the machine gun with the master trigger. To time the gun, the master trigger is depressed and locked with a suitable catch mounted on the flying control, and the clutch is turned by hand until the machine gun barrel is in the firing position. The timing ring is then taken off and the rotation of clutch is continued by hand until the desired tooth has advanced to the desired point. The gun is now in the actual firing position. The timing ring is slipped back into place, and the catch on the master trigger released. The clutch is turned a full revolution by hand, thus disconnecting the firing mechanism in order to prevent the possibility of accidental firing.

All that remains to be done is to insert the belt into the machine gun, and the weapon is ready to fire.

Cycle of Operation

The drive gear on the machine gun rotates continuously with the rotation of the airplane engine, as a result of a direct connection between these two parts. When the master trigger on the controls is depressed, the following sequence of actions takes place. The operating lever is shifted by the release on the gun and the operating lever yoke pushes the crank disk driver into engagement with the crank disk. This action completes the connection between the driver gear and the crank disk, which then commences to rotate counter-clockwise. The closing phase of the cycle is completed when the operating lever releases the push rod from the horizontal arm, causing the push rod to be returned to its previous position. The push rod roller then turns the belt feeder carrier driver on its shaft, forcing the belt feeder carrier to one side, and the belt feeder is brought into the engaged position. The crank pin, running in its slot in the sliding block, imparts a reciprocating motion to the sliding block, which is transmitted to the barrel.

As the barrel moves forward, the push rod is picked up by the sliding block, and the bolt guide pawl is depressed by the action of the cam on the push rod against the belt guide pawl release. This action releases the belt, and the feeding mechanism pushes a fresh cartridge into position behind the barrel. The push rod, which is retained in its end position by the horizontal arm on the push rod latch and the belt, is locked by the belt guide pawl and the belt stop pawl.

On the return movement of the push rod, the barrel is pushed over the live cartridge, thus closing the breech. The sliding block pushes back the firing pin housing plunger, and the firing pin housing lever of the firing pin housing, which is connected with firing pin housing plunger, moves forward; the firing pin is caught by the sear, and the firing pin main spring is compressed. Simultaneously, the sliding block engages the lower lever arm of the push rod latch, causing it to rock and release the push rod. The latter flies back and forces the feed mechanism into the ready position.

When the firing pin housing plunger reaches its in-battery position, the lug on the firing pin housing lever rotates the scar on its shaft, releasing the firing pin, which flies forward and detonates the cartridge.

The cycle is thus completed and continues as long as the master trigger is depressed.

When the master trigger on the controls is released, the trigger release forces the operating lever into neutral position. The horizontal arm on the operating lever remains engaged with the push rod until it reaches the slot on the push rod, drops into it and grips it. This action occurs only at the point where the barrel has reached front dead center. The operating lever is then locked in this position by the upper arm of push rod latch.

When the barrel reaches rear dead center, the cartridge in the chamber is fired and the sliding block twists the push rod latch, releasing the operating lever, and the operating lever yoke disengages the crank disk drive from the crank disk.

This action breaks the connection between the crank disk and the clutch of the machine gun.

For loading belts, a loading mechanism is employed, which takes the belt apart, ejects the empty cartridges, inserts live cartridges in the links, and reassembles the belt links.

SAFETY PRECAUTION. Before placing the cartridge belt in the gun it is mandatory that the cartridges be well greased in order to prevent rupturing of the cartridge cases at extremely high rates of fire. The procedure used in this function is to dip a brush in heavy oil or vaseline and oil or grease both sides of the ammunition by a painting process.

Disassembly

A special wrench is sent with each gun. This all-purpose tool together with a loaded cartridge are sufficient for the complete disassembly and assembly of ZB–80 Machine Gun.

The horizontal lever arm is turned until it projects out of the main housing top cover. If resistance is felt, the operating lever is pressed continually, and the drive gear is turned until the crank disk driver can be engaged in the crank disk and the operating lever turned. Then both crank housing studs are extracted and the crank housing detached from the main housing.

The sliding block is moved forward, thus moving the actuating rod in the same direction, and in position to be secured in position by the feed safety catch. The flash eliminator locking spring is turned and the barrel sleeve taken off. The sliding block is unscrewed and removed. The barrel is pulled out of the main housing.

To Disassemble the Belt Feeder. The main housing rear cover is taken off by pressing the main housing rear cover spring to the rear with the thumb of the left hand and pushing sidewise with the right hand until the cover falls off.

The main housing top cover is pushed to the rear as far as it will go and lifted off the main housing.

To free the feed mechanism the push rod pawl must be forced down until its locking projection releases the spring loaded latch. The feed is then lifted up and removed from the receiver. Now withdraw out of recess in the main top cover.

Now the push rod spring, push rod spring plunger, and the push rod are withdrawn out of the recess in the main top cover. The push rod roller cannot be removed from the push rod because the push rod roller guide is riveted. However, the push rod pawls and the push rod latch spring can be lifted out of their housing. Remove the belt feeder carrier.

To further dissassemble this piece, the belt feeder pin is pulled out of the belt feed carrier and the belt feeder is pushed upward. The belt feeder spring and the belt feeder are removed from the receiver.

The belt feed pawls are next released by unscrewing the studs holding them and are taken out in a downward direction. The belt guide releases, along with their springs, are removed by lifting them. After the belt guide lock screw is released, the belt guide block is taken out.

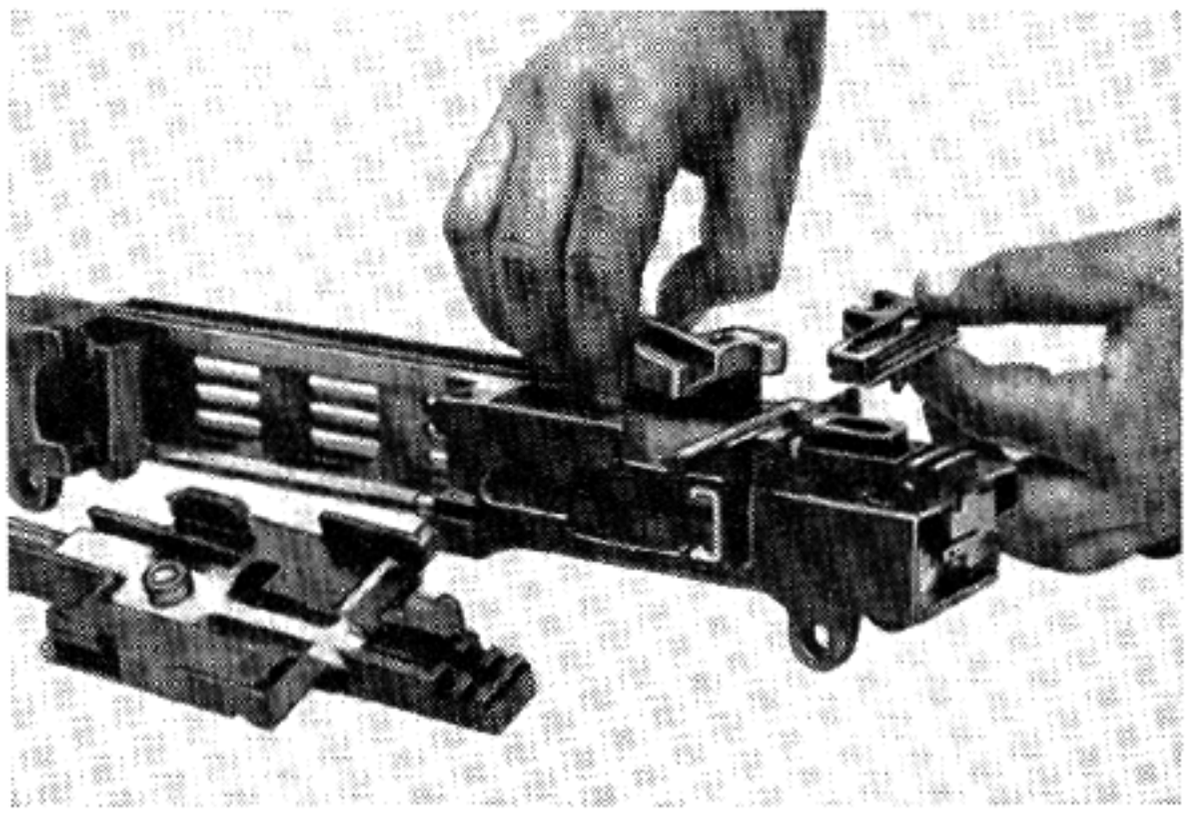

Figure 8–4. Disassembly of feed system of ZB–80 Power-driven Machine Gun.

To Remove the Firing Pin Assembly. To remove the firing pin spring, the firing pin bolt is unscrewed. The sear pin is then rotated and pulled upward. The firing pin housing plunger is forced to the rear and together with all relating components is removed from the main body of the receiver. The firing pin is lifted out of its tunnel and the firing pin spring removed from its housing.

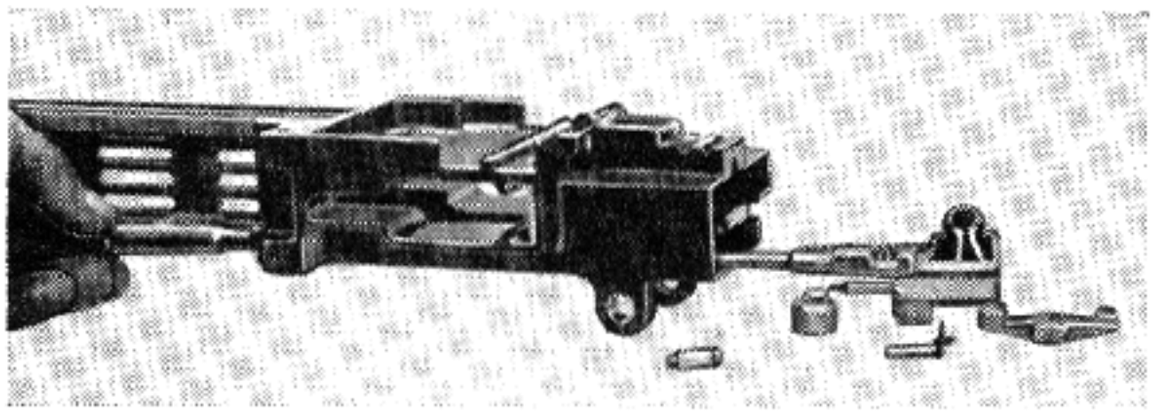

Figure 8–5. Removal of firing assembly of ZB–80 Power-driven Machine Gun.

After releasing the barrel sleeve stud, the barrel sleeve can be screwed off the main housing.

Disassembly of the Drive Gear. Both timing ring retainers are shifted in the direction of the clutch spindle axis. The crank spindle nut is unscrewed and the drive gear, crank spindle, plate, and timing ring are then detached. The operating yoke set screw is screwed out and the operating lever removed by pulling sidewise.

The operating yoke is then taken out with an upward motion. The crank case cover is screwed off, and the crank disk is removed from its housing. The clutch spindle and crank disk drive are taken out of the crank case cover. After the ball bearing retaining nut is released, the clutch spindle, along with its bearing, is removed.

Disassembly of the Drive Gear Bushing. Disassembly is not recommended as the bushing is fitted at the factory in such a manner that it would be next to impossible to duplicate the act in the field.

Preventive Maintenance

When the weapon is completely disassembled it is recommended that the guideways and bearing surfaces be lightly greased and a coating of thin oil applied to the operating parts. The drive gear should likewise be lubricated with vaseline at this time with particular attention paid to greasing the clutch spindle ball bearing, the crank disk, and the drive gear bushing. The recess in the rear bearing of the flash eliminator is filled with grease.

Assembly

To assemble the gun, the steps stated under Disassembly are reversed.

Malfunctions

As a safety precaution, this weapon has two plate dowels incorporated in its drive gear. In the event of a stoppage, these dowels are sheared off and must be replaced before firing can be resumed.

To replace the dowels, the crank spindle nut is unscrewed and the drive gear is removed. The several dowels are replaced by new ones, and the drive gear and crank spindle nut are put back.

If a cartridge becomes wedged because of the explosion of a hang-fire or a de-bulleted cartridge, the barrel is removed so that the belt guide pawl releases can be pressed down and the cartridge belt pulled out of the feedway.

In the event of split cartridge cases, the barrel is taken out and the remaining portion of the separated case is pulled from the chamber with a special tool.

A broken firing pin is replaced by screwing out the firing pin housing lever in the bolt body. This action frees the firing pin housing, which is taken out. Then a new firing pin is inserted in place of the broken one.

Chapter 9

SOVIET AMMUNITION

7.62-mm Ammunition

Soviet rifles, carbines, and rifle caliber machine guns fire a rimmed, bottle-necked 7.62-mm round. Rimmed ammunition is not well suited for use in automatic weapons, but clever gun designing has overcome the drawbacks of this old-style round. The basic cartridge is the Model 1908, or light ball, cartridge; the Model 1930, or heavy ball, cartridge is used for infantry machine guns. In addition to these types, explosive, tracer, incendiary, and other usual kinds of cartridges are made. Many varieties are available in each caliber; however, it is beyond the scope of this book to describe all the existing kinds.

Figure 9–1. Soviet armorers loading belts into a fighter plane.

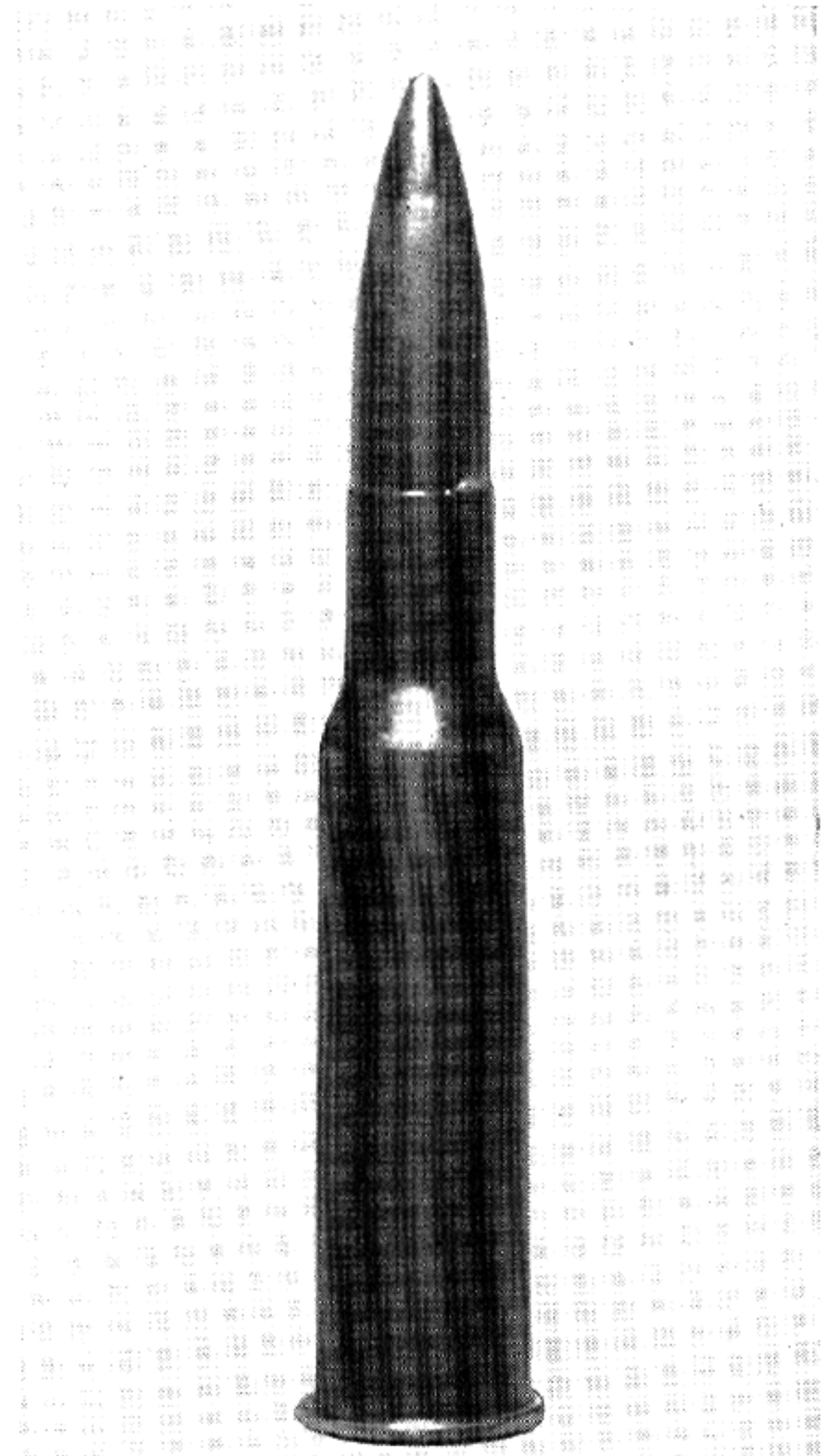

Figure 9–2. Soviet 7.62-mm cartridge.

Soviet small-arms ammunition has been notoriously poor in quality. Even before the desperate situations which developed in World War II, a drive was started to conserve materials by substituting a steel cartridge case with exterior copper wash for the normal brass cartridges. In the course of the war it was necessary in some instances even to substitute iron cases for those of steel.

12.7-mm Ammunition

The development of the Soviet 12.7-mm cartridge was influenced by the German T. u. F. 13-mm

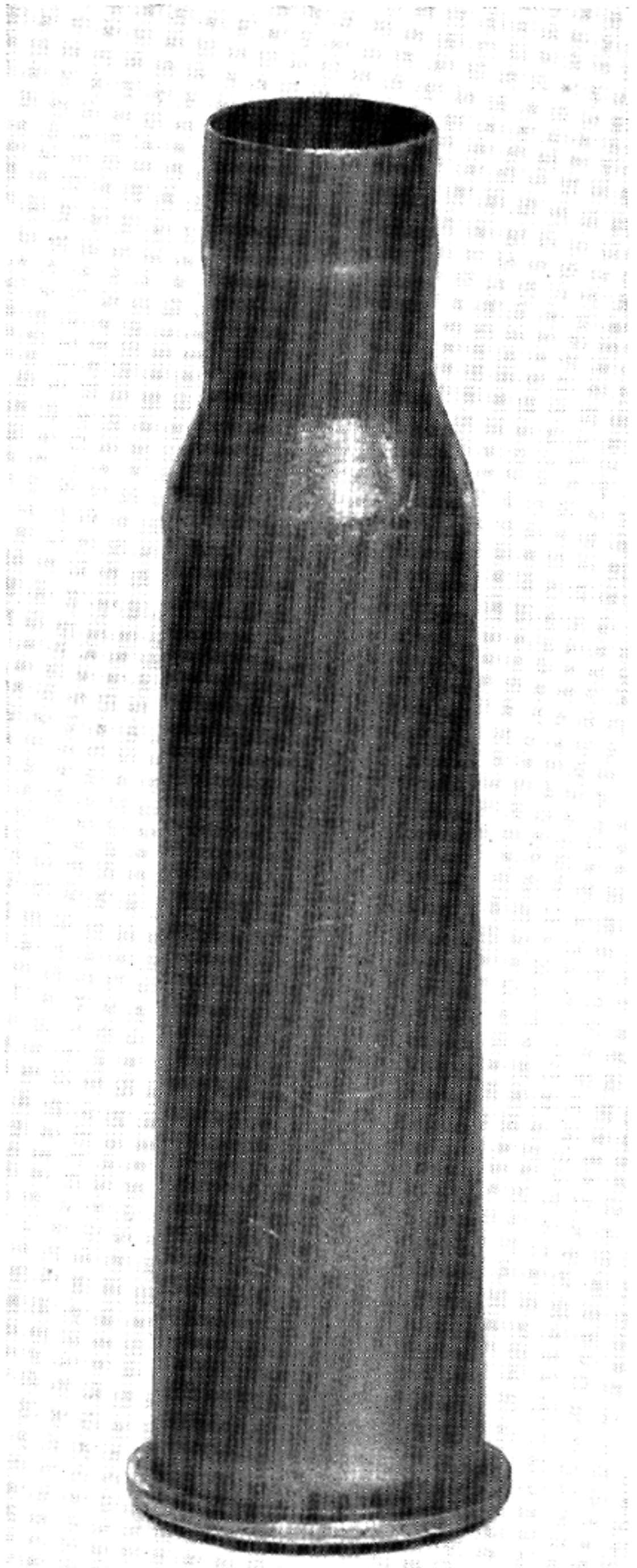

Figure 9–3. Close-up of a fired case from a Soviet 7.62-mm cartridge.

round used in World War I. The over-all design of the 12.7-mm is excellent. The outside world first became aware of it in connection with reports of the development of the 12.7-mm Degtyarev gun, about 1934. The use of this cartridge was adapted to the series of guns produced by Beresin; two distinct feed belts were developed. (See fig. 9–4.) Because of its introduction into the forces of various Soviet satellites, this cartridge ranks in importance second only to the American caliber .50 as far as world-wide use is concerned. Although nominally of the same projectile diameter, the American and Russian rounds are not interchangeable. The 12.7-mm rounds are produced with a variety of projectiles and are marked with a color code to distinguish them. The 12.7-mm round is shown in figure 9–5, and the fired case is shown in figure 9–6.

NOTE. It is important that personnel handling foreign ammunition obtain all available information on its color code and characteristics. Information compiled during World War II has been superseded in many cases.

The success of Shpitalny rifle-caliber aircraft machine guns led to larger calibers. (See ch. 4.) Because of features of this design, it could not be made to function with the rimless cartridge used in the Degtyarev and Beresin 12.7-mm guns. Accordingly the highly successful 12.7-mm rimless case was converted into a rimmed version having characteristics suitable to only one mechanism. (See fig. 9–7.) The rimless round was applied successfully to several models of two distinct systems of machine guns, but the rimmed round had very limited use in a single ill-fated gun. Whether the gun itself was a failure or the ammunition supply hopeless is not generally known, but the Shvak 12.7-mm played no important part in World War II. The rimmed 12.7-mm cartridge is quite rare, and the gun for which it was developed has passed from the scene.

One method of shipping bulk 12.7-mm ammunition is shown in figure 9–8.

Dual Ammunition Supply

The apparent explanation for the Soviets' use of a dual ammunition supply in wartime is the extraordinary prestige enjoyed by Shpitalny. It is a curious fact that ever since the introduction of firearms into military forces, Ordnance Departments have been stumbling into the dual-ammunition trap, usually in a situation involving a war or national emergency.

20-mm Ammunition

The cartridge case for the Shvak 20-mm ammunition is a Soviet ordnance item that shows evidence of desperate haste in design. It shows few of the outstanding characteristics of the American and European rounds designed for air-to-air combat.

The origin of this cartridge is open to discussion. It bears a physical resemblance to some of the old Gatling cartridges of the nineteenth century, one of

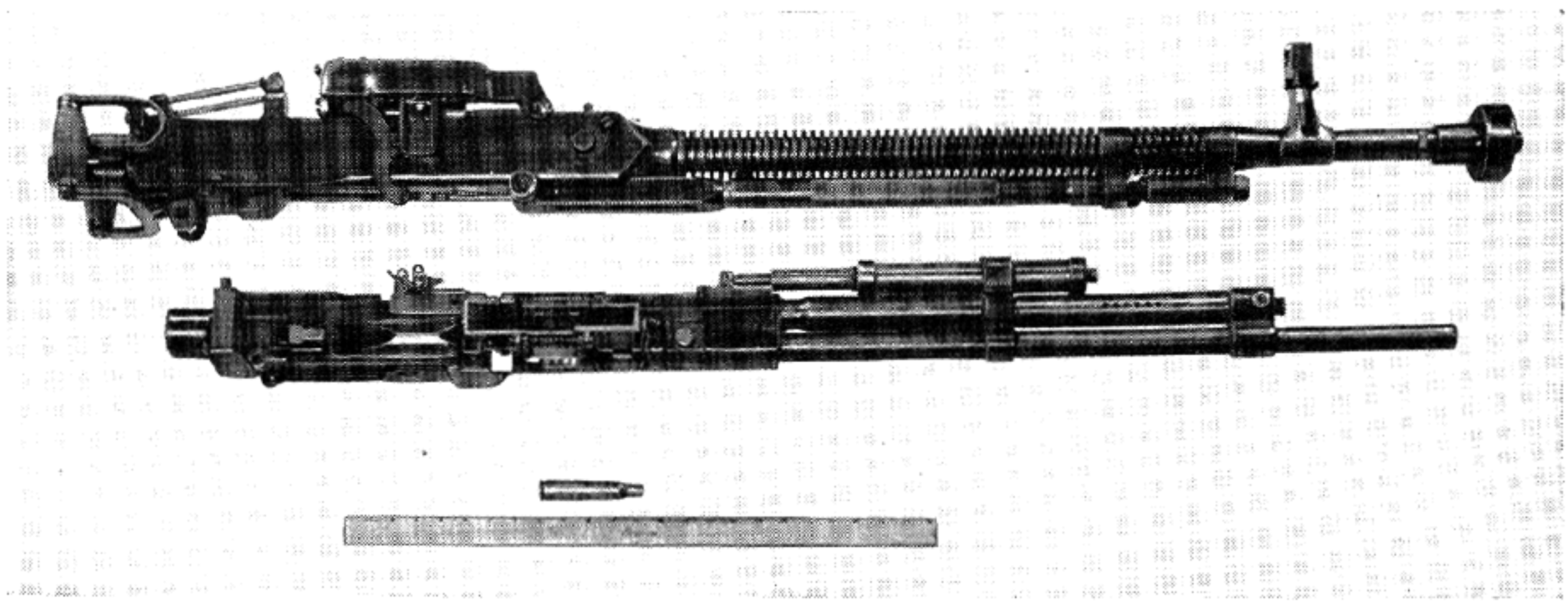

Figure 9–4. Comparison of Soviet 12.7-mm machine guns, Degtyarev (above) and Beresin (below). Although both fire the same cartridge, the feed belts are different.

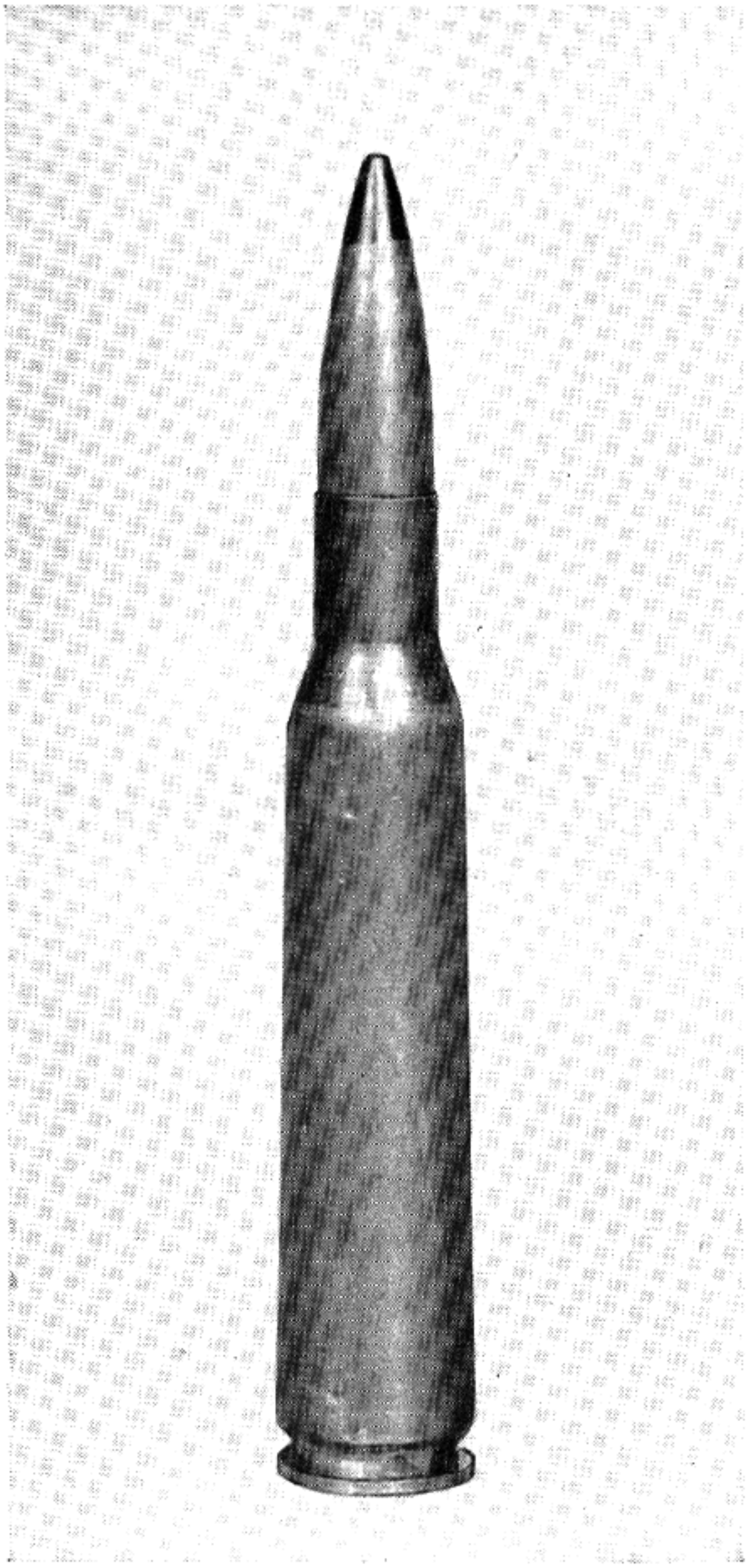

Figure 9–5. Complete round of Soviet 12.7-mm ammunition.

which is the caliber .75 shown in a catalogue of Kynoch and Co., of Witton, Birmingham, England, for the year 1882. Most of the Russian Gatling guns used the small arms ammunition but it is known that a few of larger caliber were tried. However, figure 9–12 shows the old caliber .75 Gatling round alongside a dimensional sketch of a complete round of 20-mm Shvak ammunition.

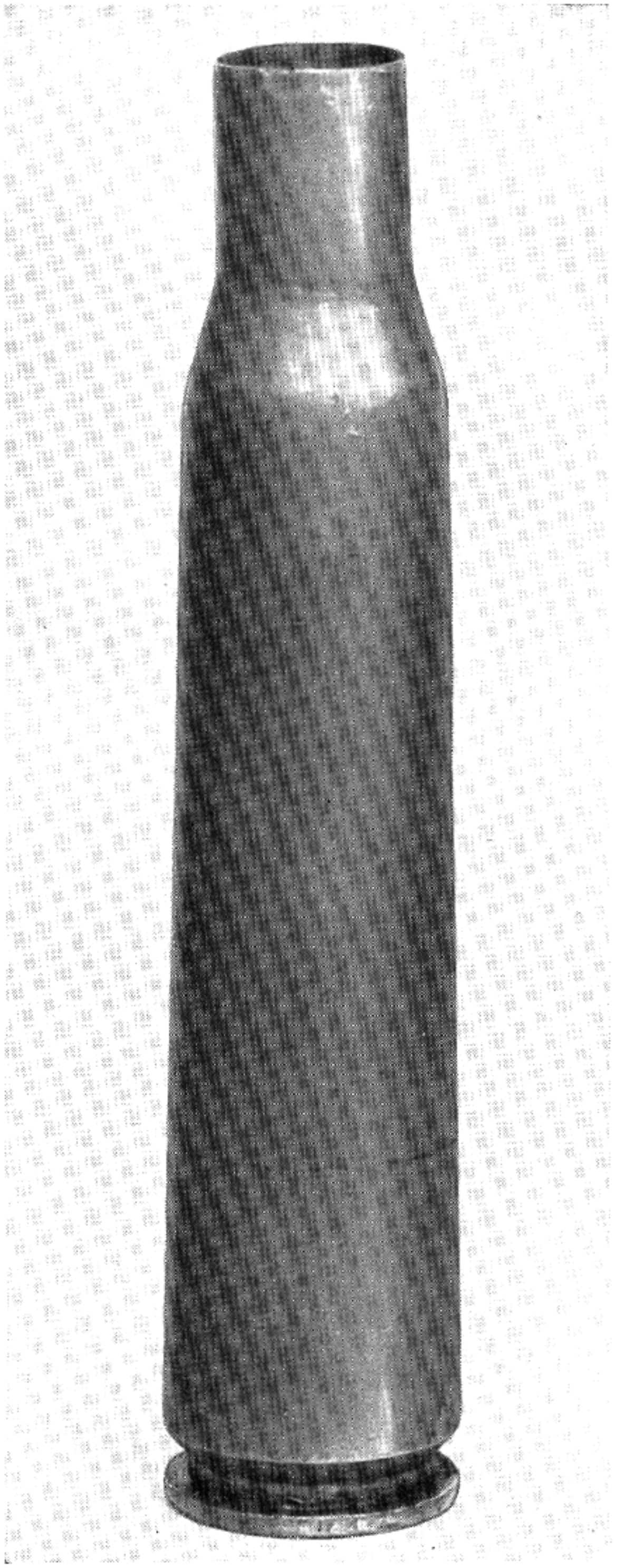

Figure 9–6. Close-up of a fired cartridge case from a Soviet 12.7-mm round.

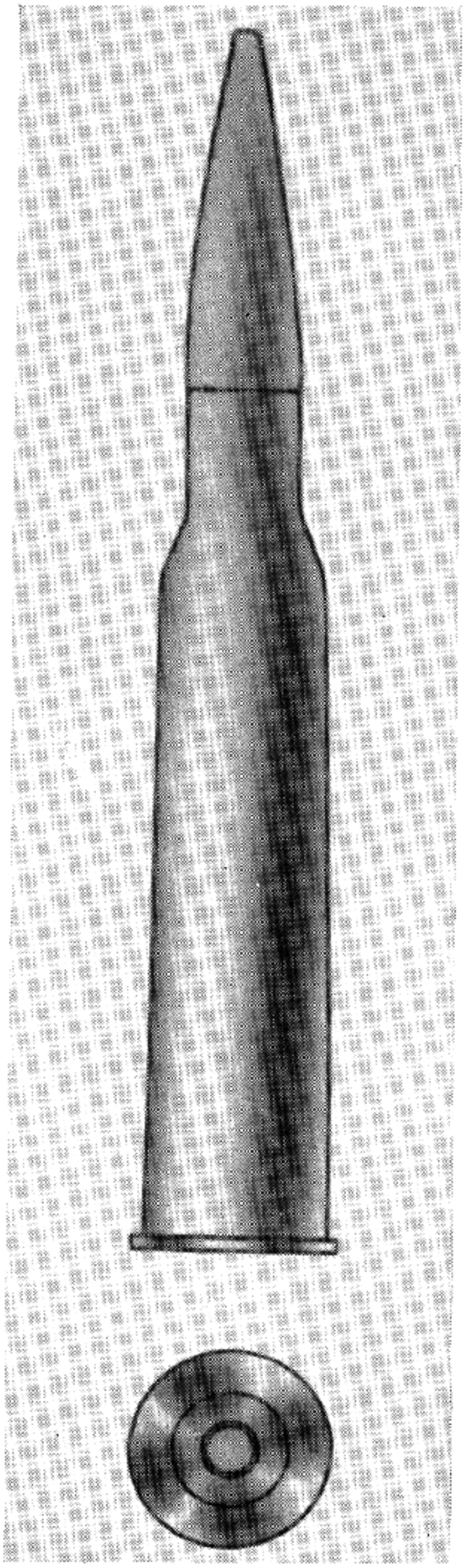

Figure 9–7. Artist's conception of the 12,7-mm rimmed cartridge used in the Shvak gun of that caliber.

23-mm Ammunition

There is a striking contrast between the Soviet 20-mm and 23-mm rounds used in World War II. The 20-mm was crudely designed and apparently produced in the utmost haste; the 23-mm exhibits features of refinement. The latter uses a bottle-necked case; and, although there is no distinct shoulder, the use of a belt just forward of the cannelure, or groove, serves to provide a mechanical stop to fix the extent that the round may enter the chamber. (See fig. 9–13.) The shape and dimensions of the groove itself follow the latest practice.

In the era just before World War II when emphasis began to be placed on increasing the explosive content of aircraft gun projectiles, several manufacturers produced 23-mm rounds which were merely versions of their 20-mm cartridges having the neck enlarged and fitted with a suitable projectile. Such changes generally had the result of lessening the effectiveness of the shoulder in positioning the round and adding materially to the possibility of lightly struck primers. The date of its appearance and its own physical characteristics indicate that the 23-mm VYa was designed specially for use with the 23-mm projectile and is not a converted 20-mm design. Figure 9–14 is a close-up of a fired case of this series.

In the years that followed World War II, the Russians produced a new gun in the 23-mm field, the NS. For this gun, the Soviets designed an entirely new series of ammunition with a case considerably smaller than that of the VYa. At the time this ammunition was designed, the major world powers were vigorously seeking higher velocities and increased performance, features which could not be credited to the NS round, with its absence of taper, poor shoulder, and lack of belt, shown in figures 9–15 and 9–16. The differences between the 23-mm rounds for the VYa and the NS are evident in figures 9–17 and 9–18. Unless the 23-mm NS cartridge is an interim round, it represents retrogression instead of progress.

37-mm Ammunition

The heavy load of propellant used in the original N 37 gun caused excessive stresses in engine and

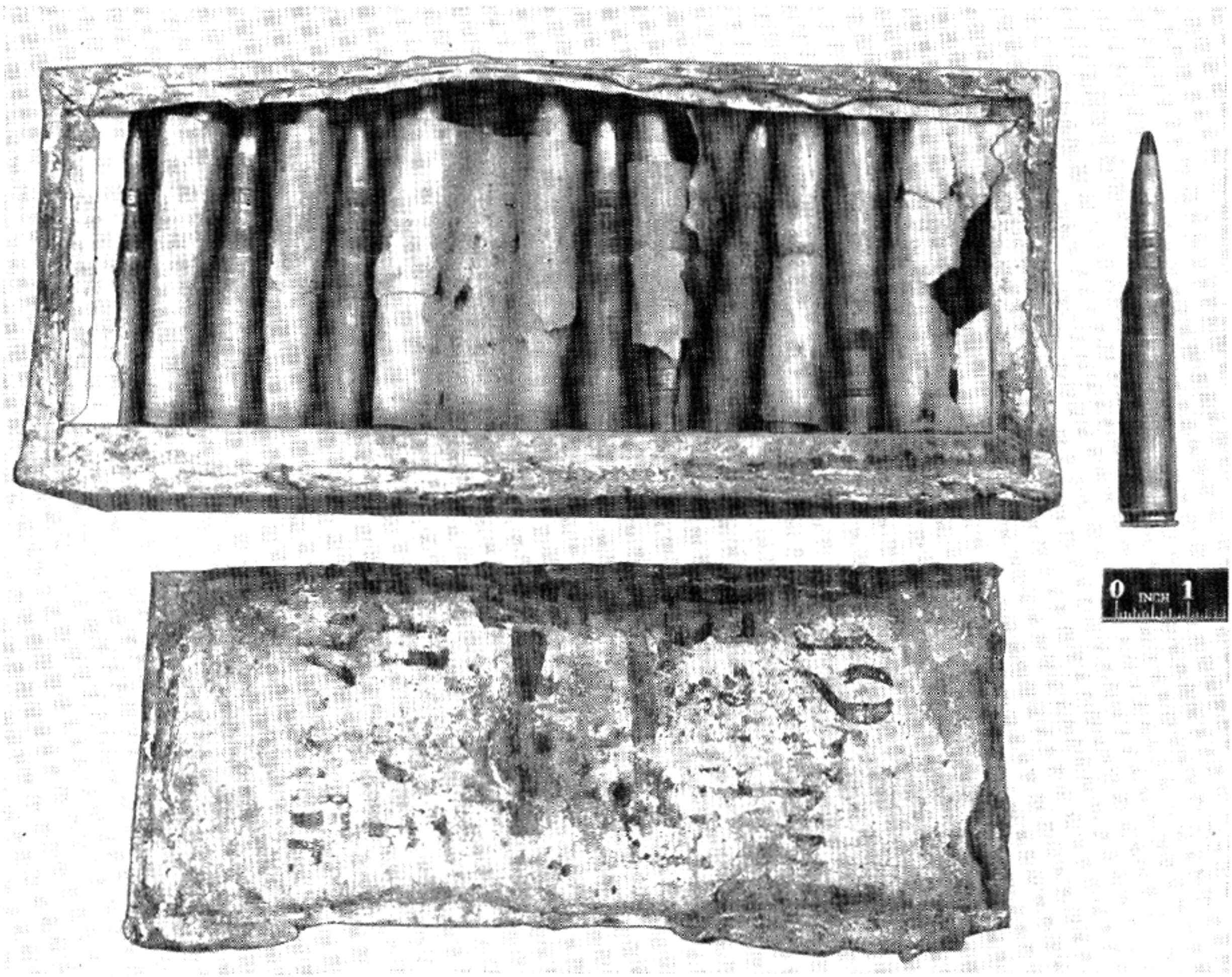

Figure 9–8. Method of packing Soviet 12.7-mm ammunition in bulk.

airframe. The dimensions of the NS 37 cartridge, shown in figure 9–19, indicate its unwieldy shape, which accounts for the stresses.

The refinement of the 37-mm gun which followed World War II included a reduction of the propelling charge, permitting the use of a smaller cartridge case. The smaller case, of course, permits shorter parts travel in the gun, but even more important it reduces the bulk of the ammunition. Figure 9–20 shows a fired case from an N 37 gun which was picked up in the Korean theater of operations.

Figures 9–21 and 9 22 are comparisons of base and profile of a representative group of Russian cartridge cases. The two specimens on the right, which are recent developments, indicate a trend toward a smaller cartridge. Although there is little taper and a rather vague shoulder, the construction of the base and the cannelure follow present trends. Design features of these cases indicate that they are the work of a single designer or group.

Links

The links used with these two rounds are the stripping type, as shown in figure 9–23. Withdrawal type links, shown in figure 9–24, are used in all the Shkas, Shvak, Beresin, and VYa aircraft guns. All four types illustrated were used in World War II. The rifle-caliber link used in the Shkas can be used in the DS and SG 43 ground guns as well as the aircraft gun for which it was designed.

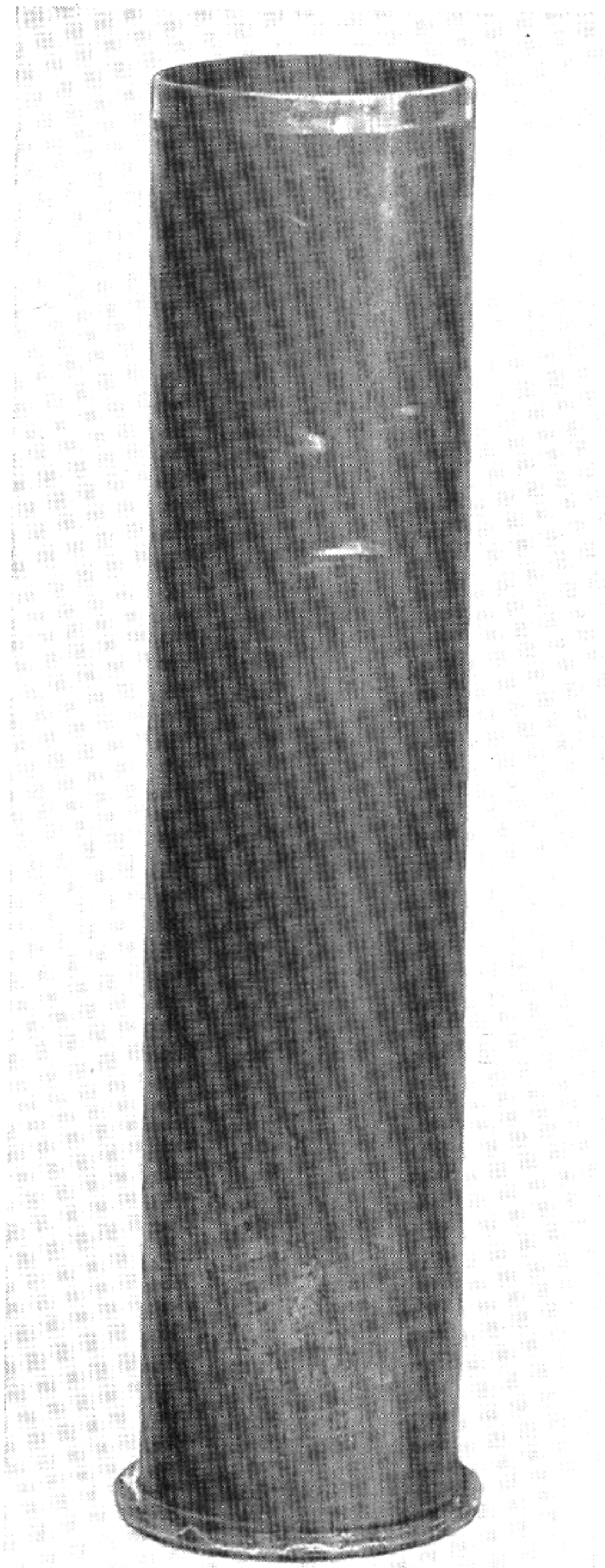

Figure 9–9. Close-up of a fired cartridge case for the 20-mm Shvak gun.

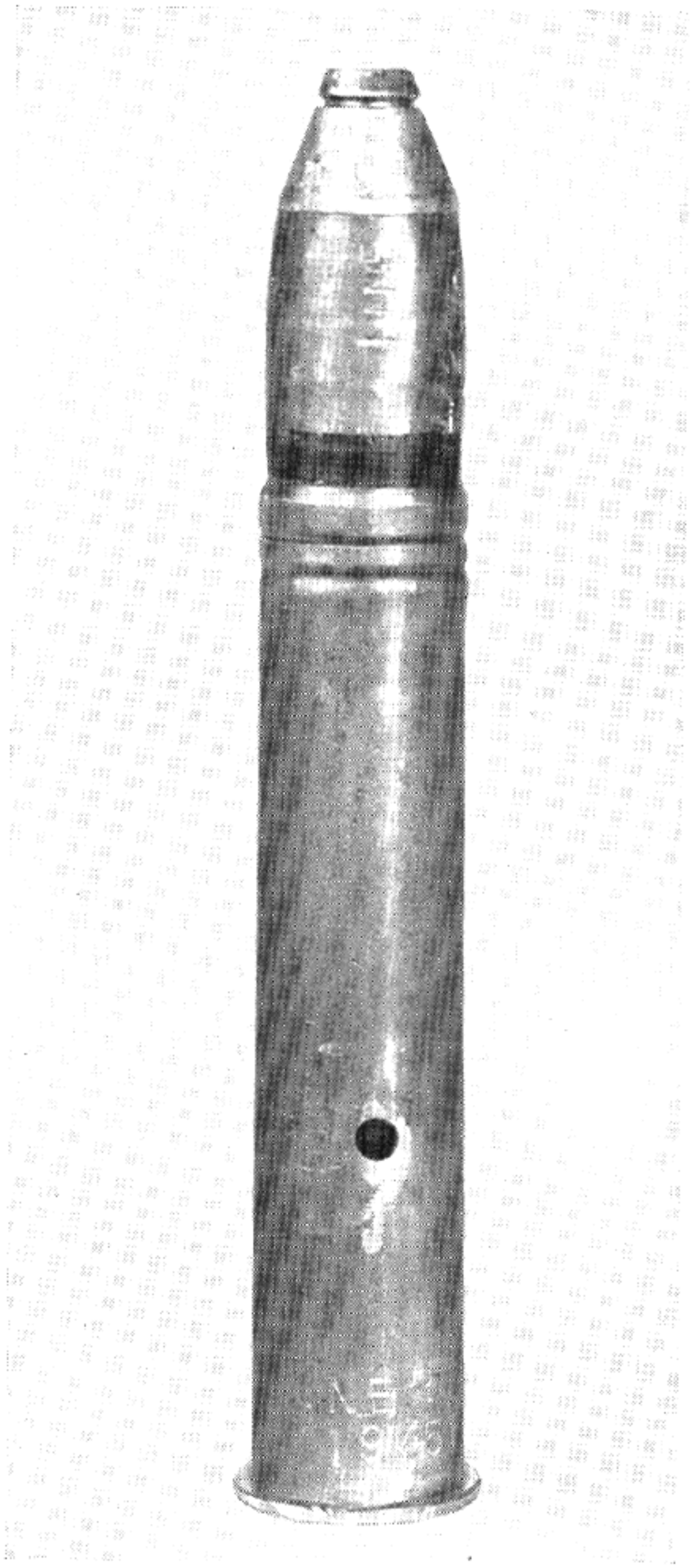

Figure 9–10. Soviet 20-mm complete round for Shvak cannon. (Round has been rendered inert at a U. S. proving ground.)

Figure 9–11. Bulk shipping containers for Soviet aircraft cannon ammunition. Top, 23-mm, and bottom 20-mm.

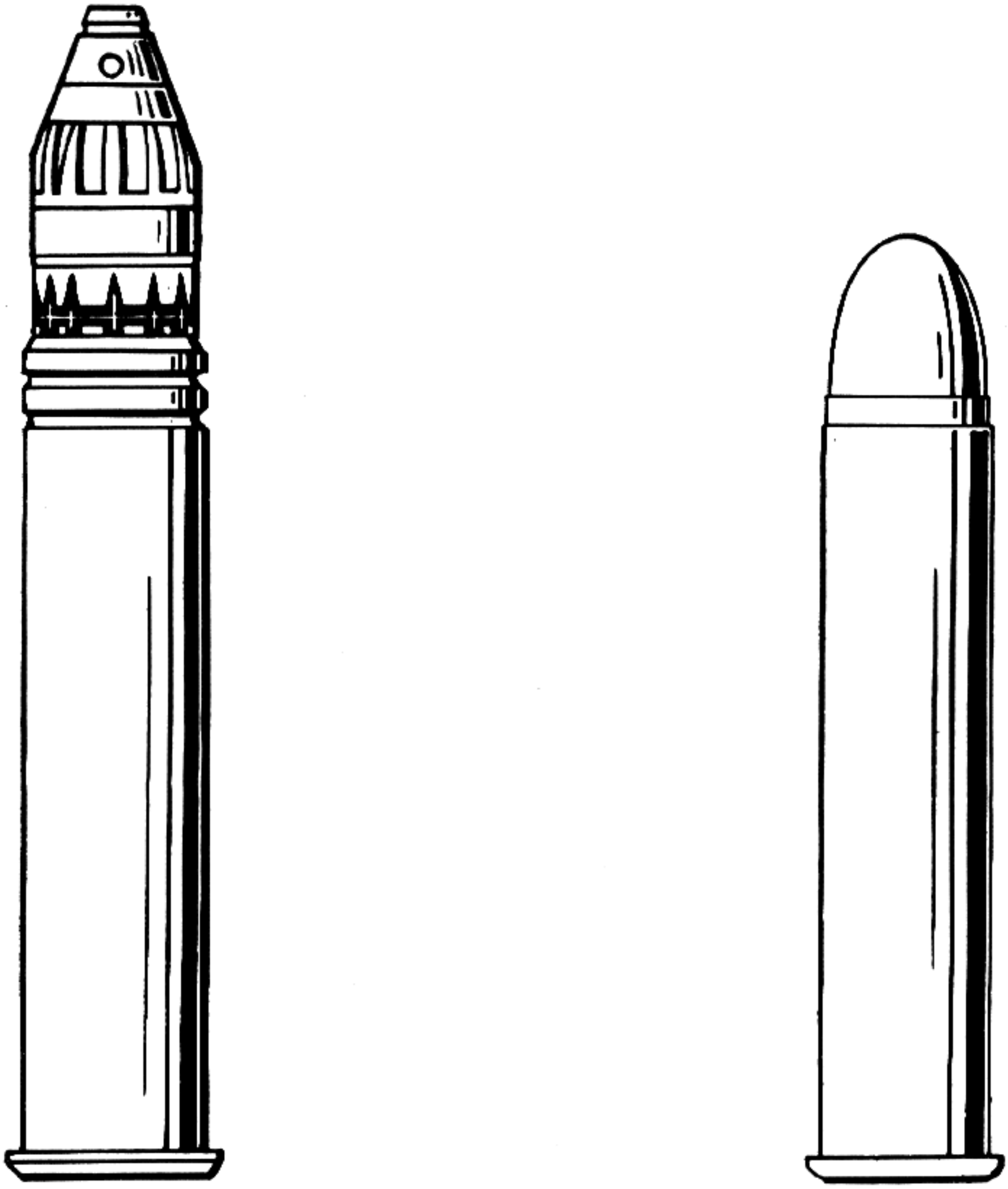

Figure 9–12. The 20-mm Shvak round compared with the old caliber .75 Gatling round.

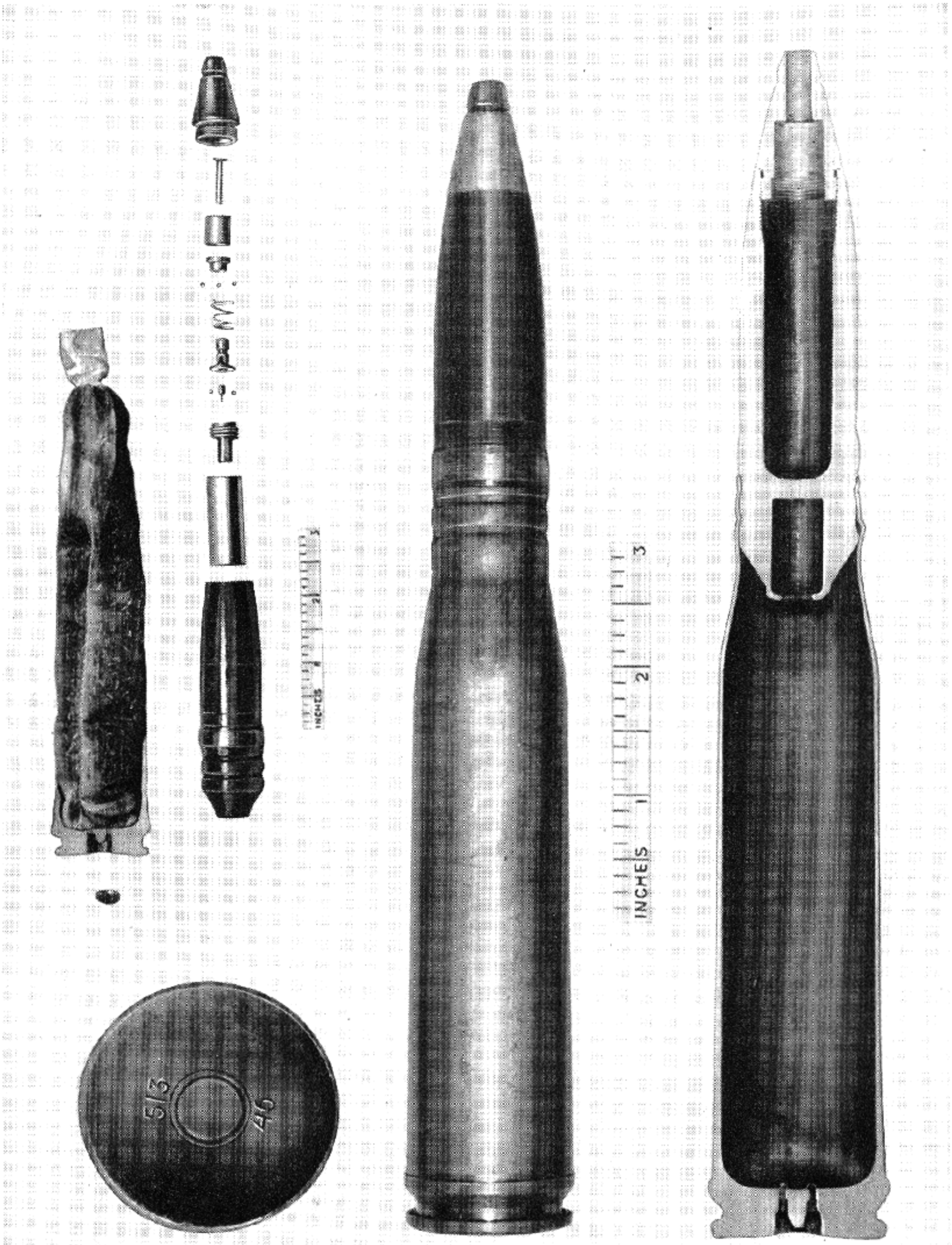

Figure 9-13. Study of a complete round for the 23-mm VYa cannon.

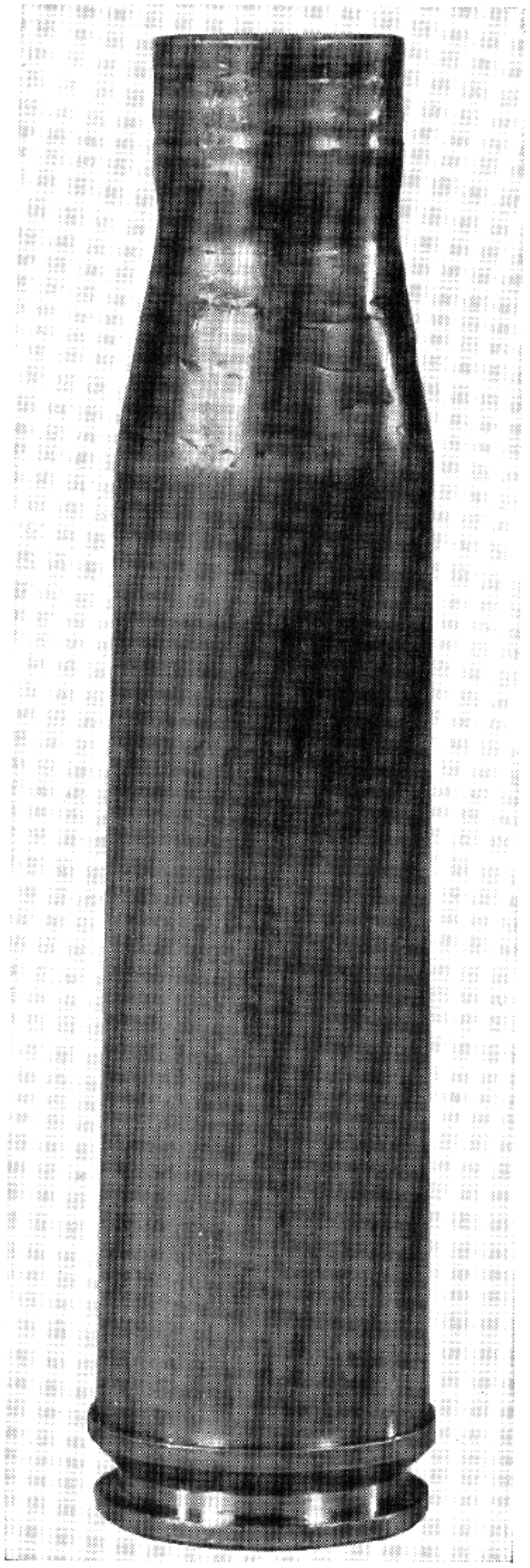

Figure 9–14. Close-up of a fired cartridge case for the 23-mm VYa gun.

Figure 9–15. Study of a complete round for 23-mm NS cannon.

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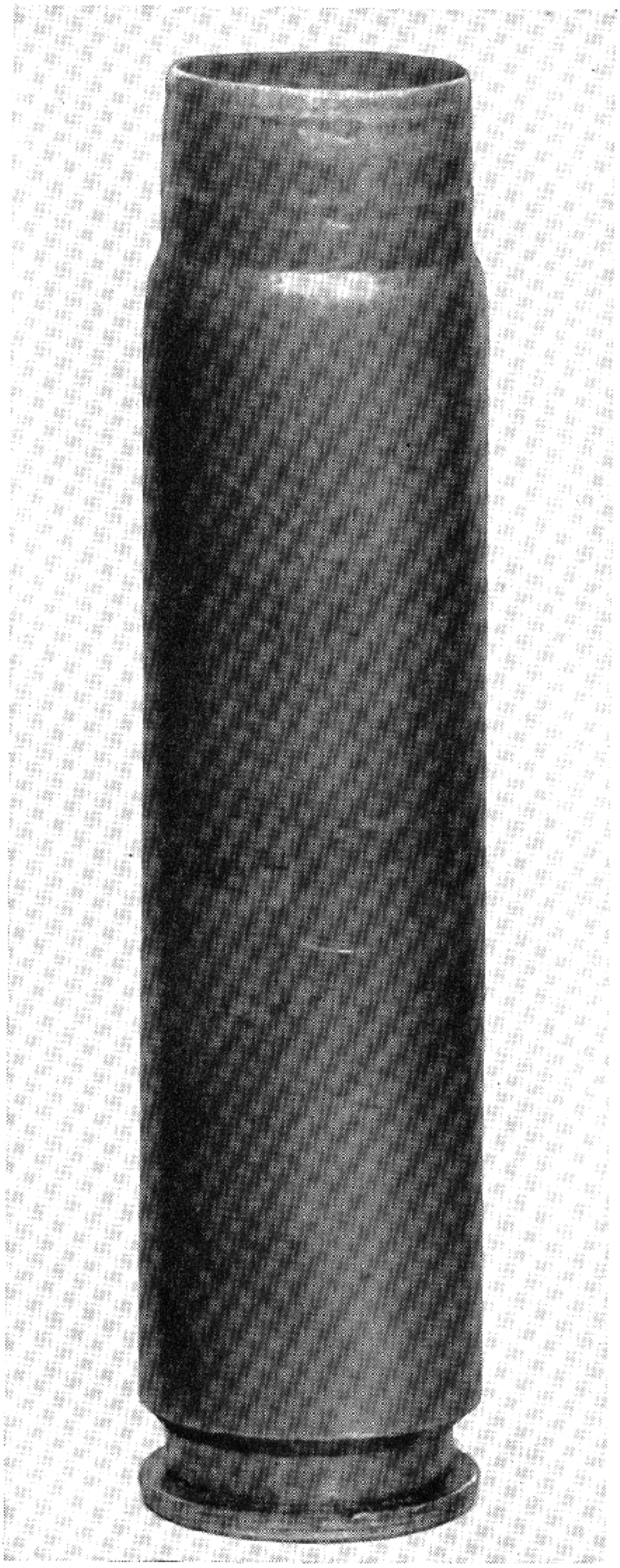


Figure 9–16. Close-up of fired cartridge case for 23-mm NS gun.

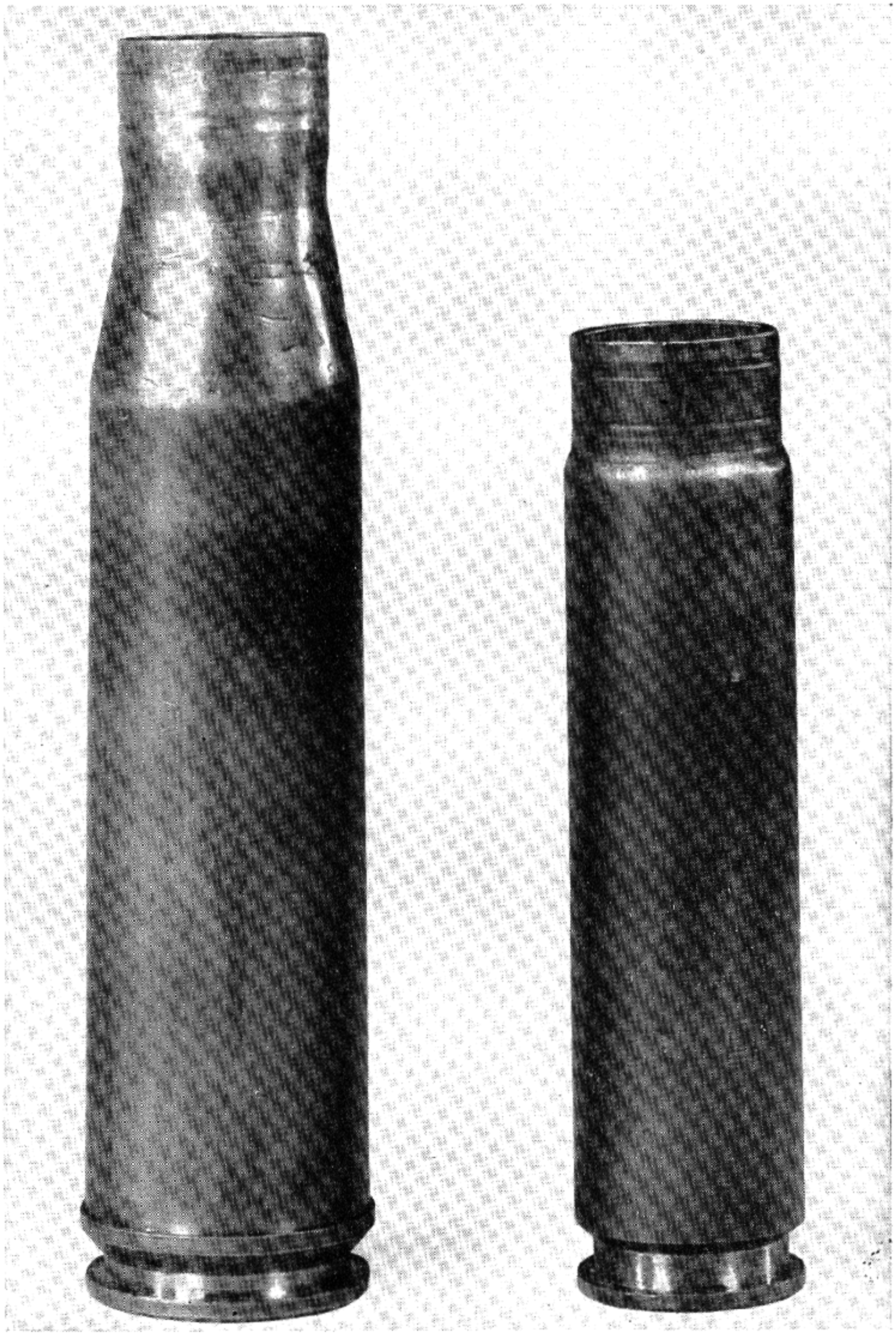


Figure 9-17. Comparison of Soviet 23-mm cartridge cases, both of which can use the same projectiles. Left case, old, for VYa type, right, new, for NS cannon.

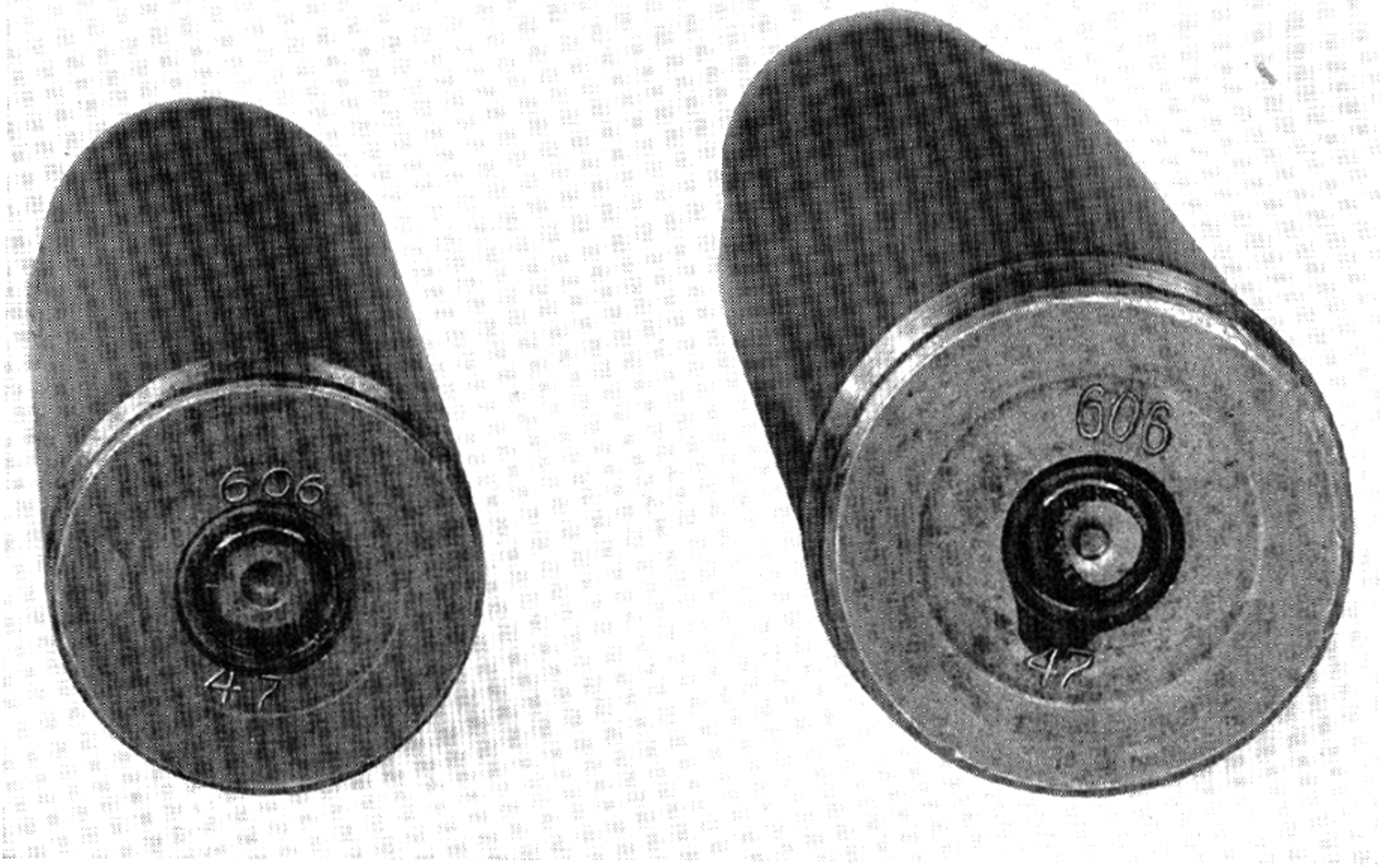


Figure 9-18. Markings on heads of Soviet 23-mm cartridge cases. Left NS, right VYa type.

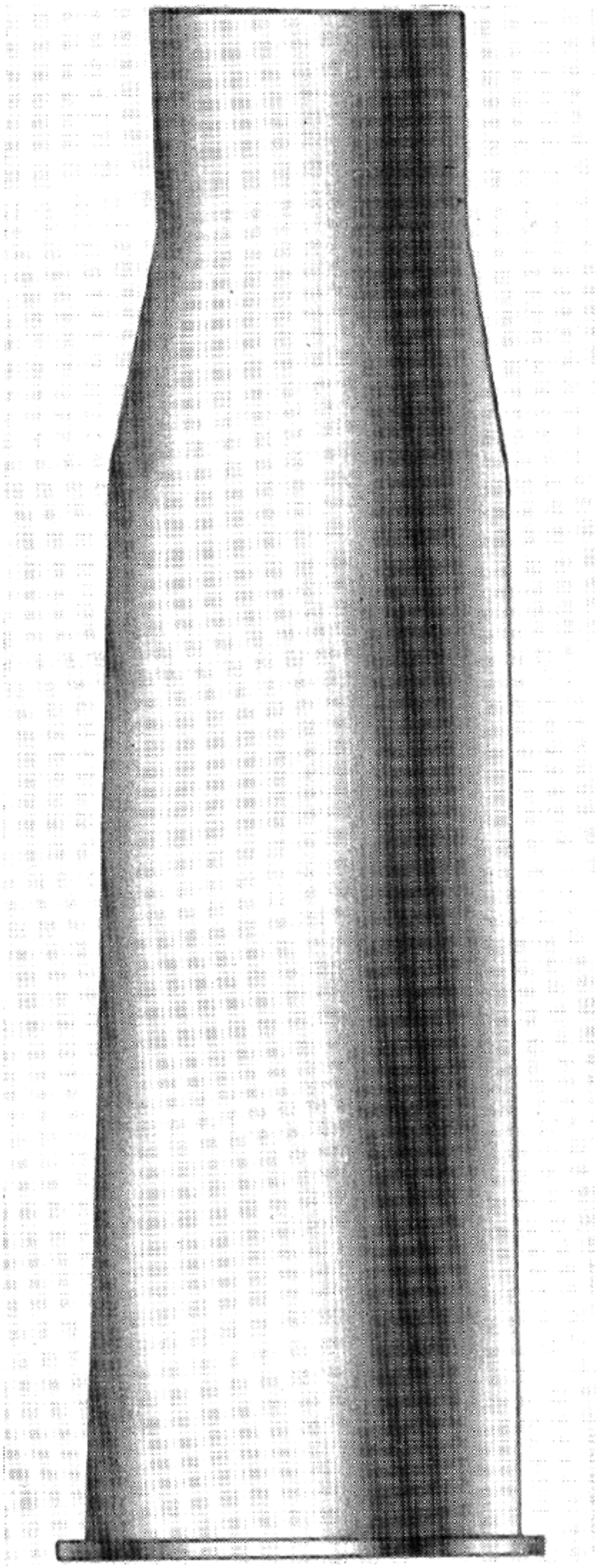


Figure 9-19. Artist's conception of cartridge case used in the old 37-mm NS cannon.

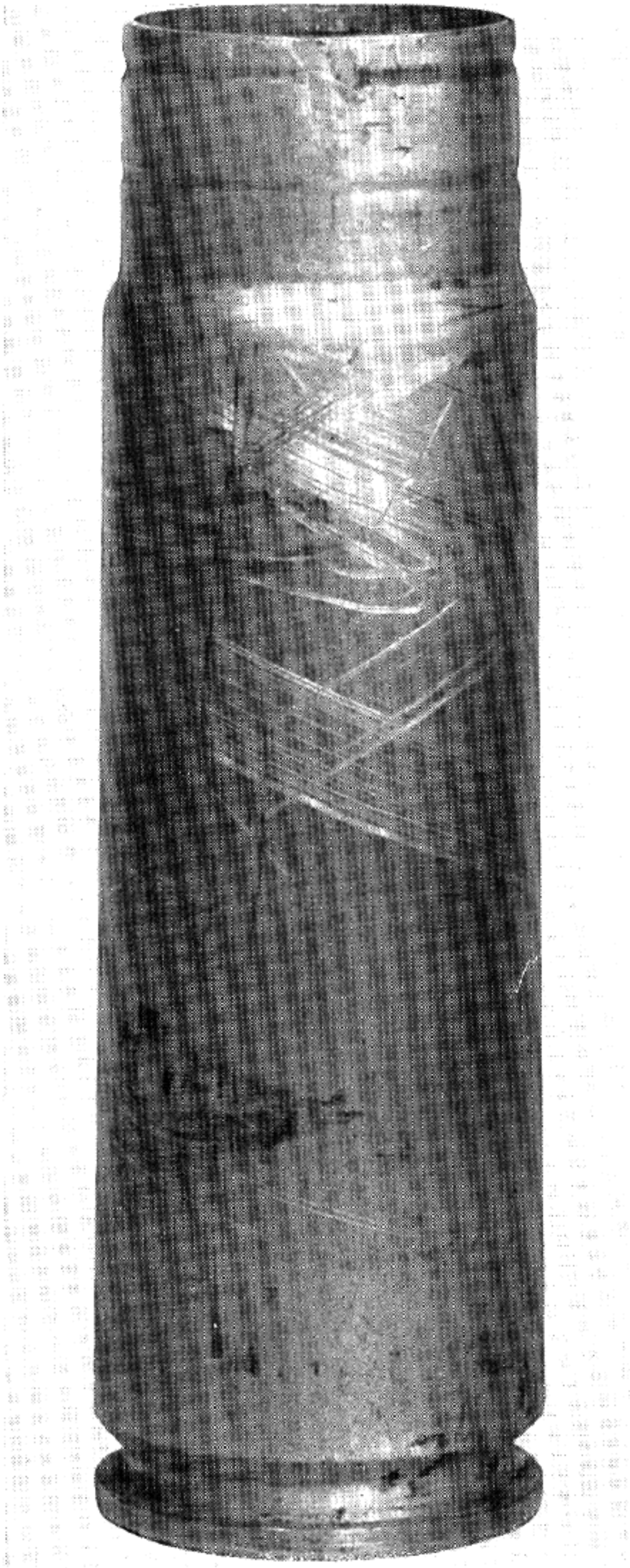


Figure 9 20. The new, smaller, cartridge case used in the 37-mm Soviet "N" gun.

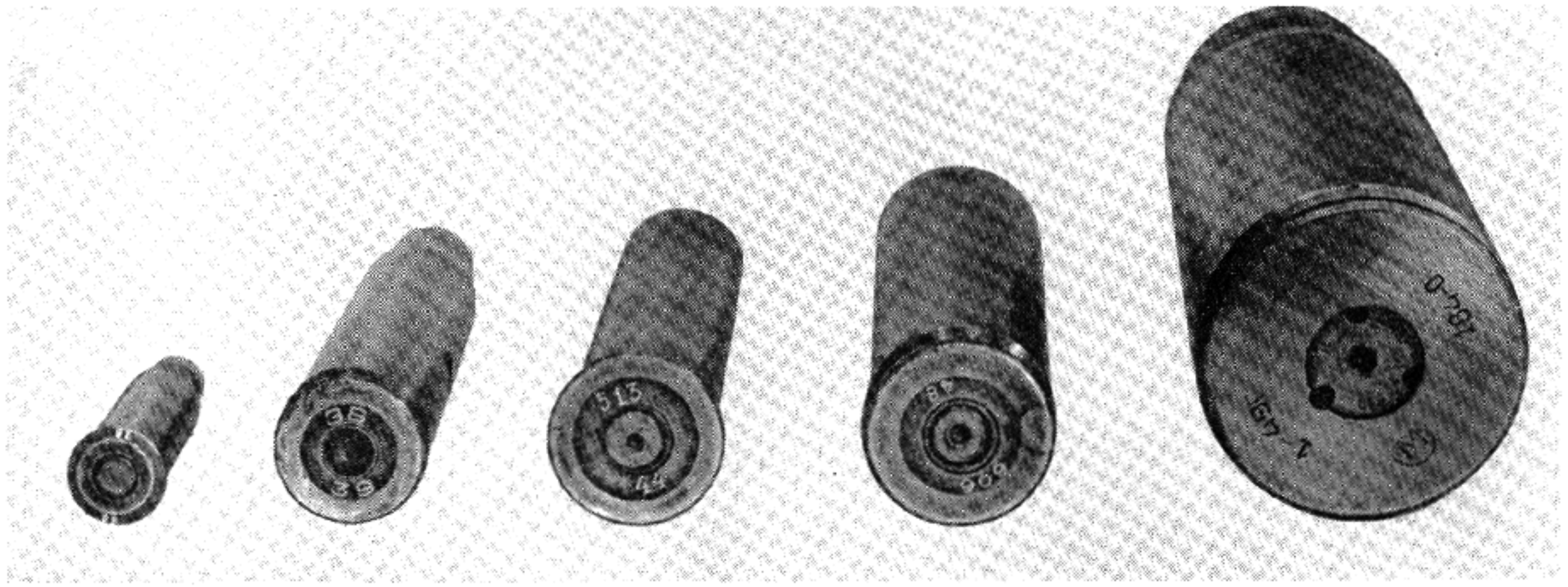


Figure 9-21. Comparison of typical Russian cartridge cases. Left to right: 7.62-mm, 12.7-mm, 20-mm, 23-mm (NS) and 37-mm (small).

Figure 9-22. Comparison of profiles of Russian cartridge cases. Caliber of each case is given in figure 9-21, above.

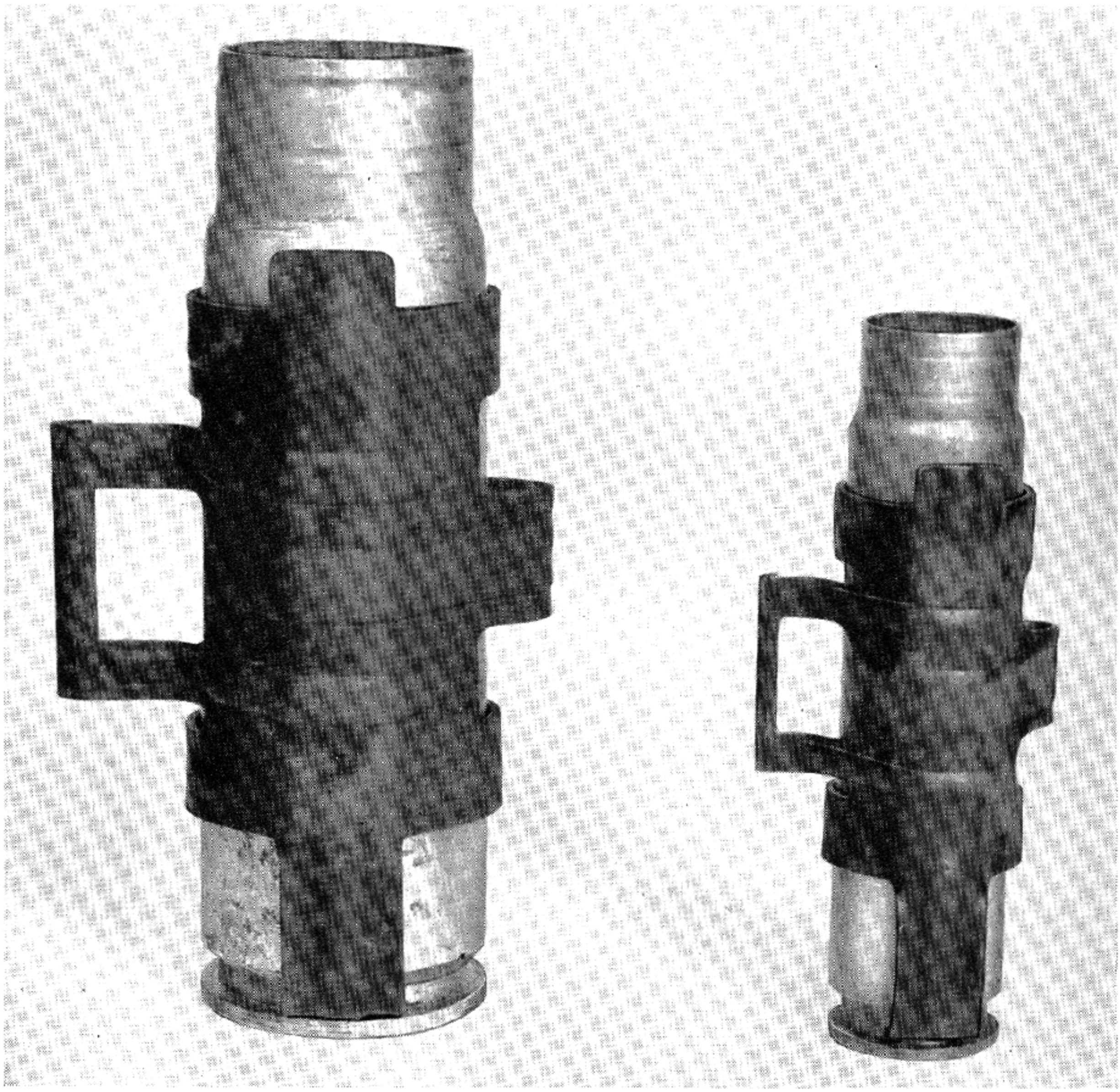


Figure 9–23. The cases and links for the new 37-mm and 23-mm Soviet aircraft cannon. Both cases are Nudelman designs.

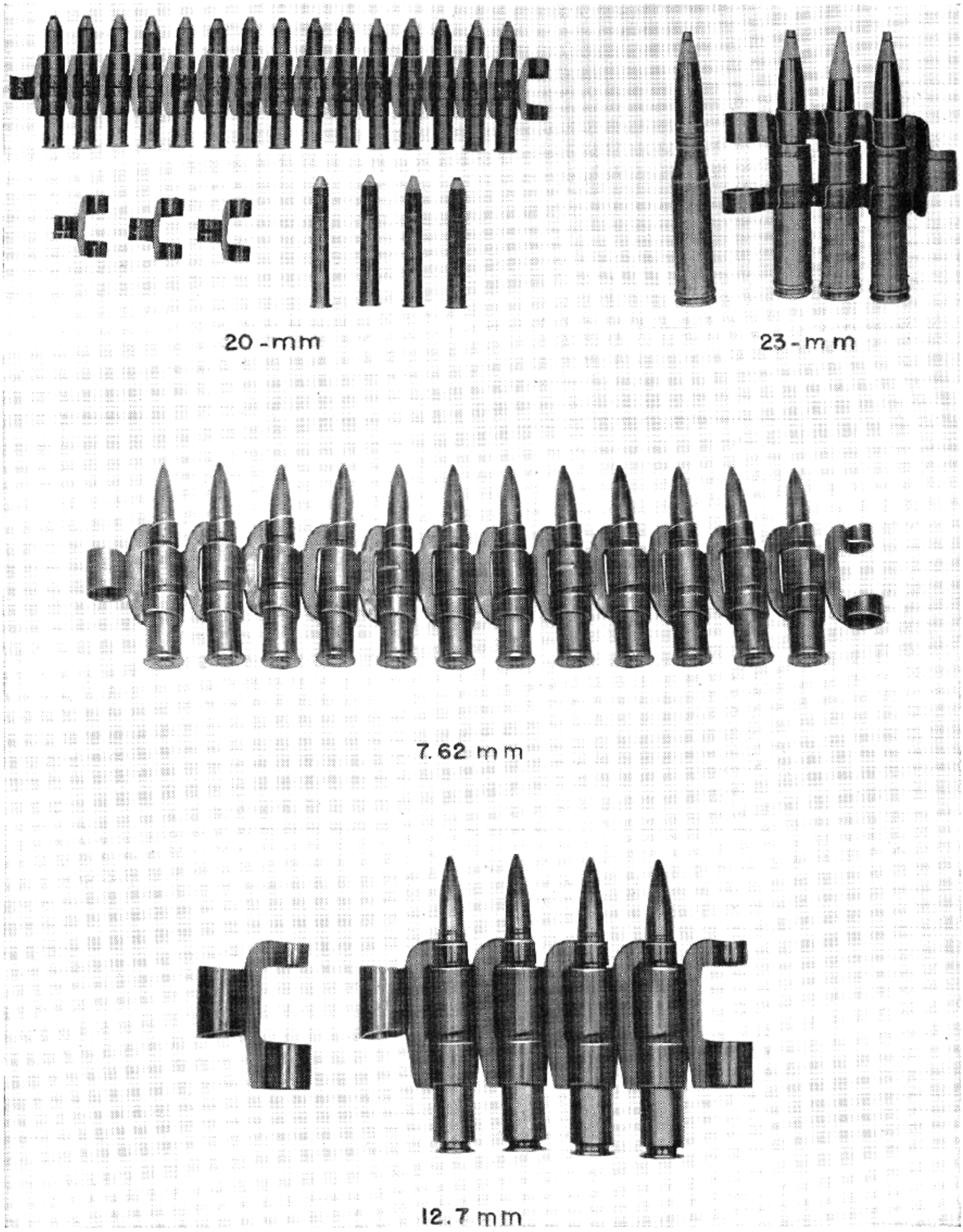


Figure 9-24. Various types of belts used in Soviet aircraft machine guns in World War II.

Chapter 10

SYMBOLS USED ON SOVIET MACHINE GUNS AND AIRCRAFT CANNON

Soviet machine guns and aircraft cannon are usually named for their designers. A short designation is devised by using letters from the name of the person credited with the design and some other identifying symbols, such as, some word or phrase from the name of the gun, arsenal mark, caliber, or year of manufacture. A table which follows explains some of the designations found on various Soviet machine guns, aircraft cannon, and related small arms.

This system was established after the Revolution and since the modern armament industry was established. Its flexibility has permitted it to remain unchanged as new weapons are added. In contrast, the system has been superseded in the West by the well-known number method of designation.

In the guns of the Degtyarev group, the serial number and the year may appear with letters of the alphabet. On most guns of this group, the marks are rather crudely stamped and are found on the top rear of the receiver.

The Shkas machine gun offers an interesting contrast. When it first appeared, in a peacetime period, high standards of finish prevailed. Each gun was carefully marked with the names of the inventors, the year of manufacture, the caliber, the serial number, the arsenal mark, and the type (such as wing, synchronized or flexible). Figure 10–1 shows this type of Shkas markings. Later guns, however, have been found with very poor standards of finish and markings crudely applied. On the other hand, the Shvak cannon (fig. 10–2), do not bear even the inventor's initials.

Code of Symbols Used on Soviet Machine Guns and Aircraft Cannon

Russian characters	English characters	Meaning in English
БС	BS	Beresin aircraft.
ДА	DA	Degtyarev aviation.
ДК	DK	Degtyarev heavy caliber.
ДП	DP	Degtyarev infantry.
ДПМ	DPM	Degtyarev infantry modified.
ДС	DS	Degtyarev heavy.
ДСхК	DShK	Degtyarev-Shpagin heavy caliber.
ДТ	DT	Degtyarev tank.
ДТМ	DTM	Degtyarev tank modified.
КП	KP	Wing machine gun (refers to Shvak).
МК	M–K	Maxim-Koleshnikov.
МТ	M–T	Maxim-Tokarev.
МП	MP	Motor machine gun (refers to Shvak).
НС	NS	Nudelman-Suranov.
ПМ	PM	Machine gun Maxim.
ПВ–1	PV–1	Machine gun Vickers.
ШКас	Shkas	Shpitalny-Komaritsky aircraft high-speed machine gun.
ШВак	Shvak	Shpitalny-Vladimirov.
СГ–43	SG 43	Heavy Goryunov 43.
СП	SP	Synchronized machine gun (refers to Shvak).
ТП	TP	Flexible machine gun (refers to Shvak).
УБК	UBK	Universal Beresin wing.
УБС	UBS	Universal Beresin synchronized.
УБТ	UBT	Universal Beresin flexible.
ВУа	VYa	Volkov-Yartsev.

Figure 10–1. Markings appearing on the top of a flexible Shvak machine gun.

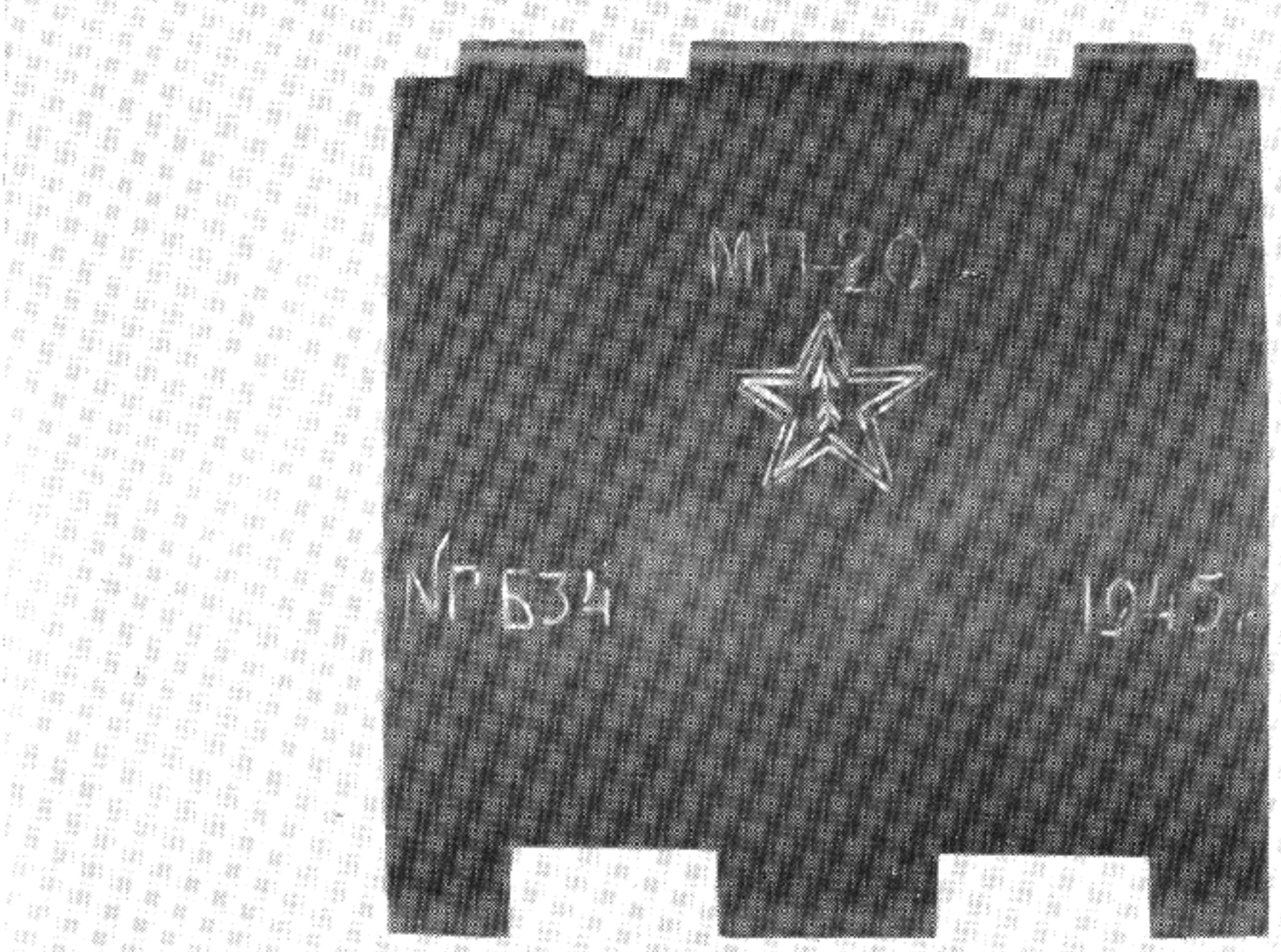


Figure 10–2. Identification markingson an engine-mounted Shvak cannon.

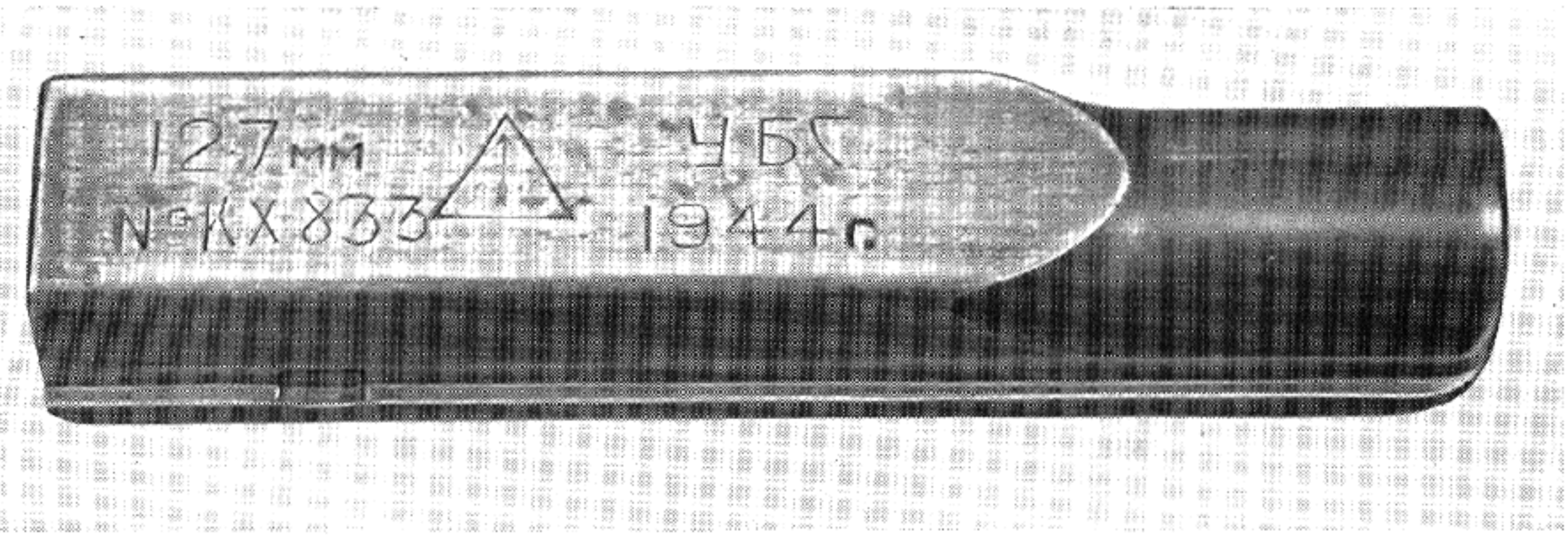
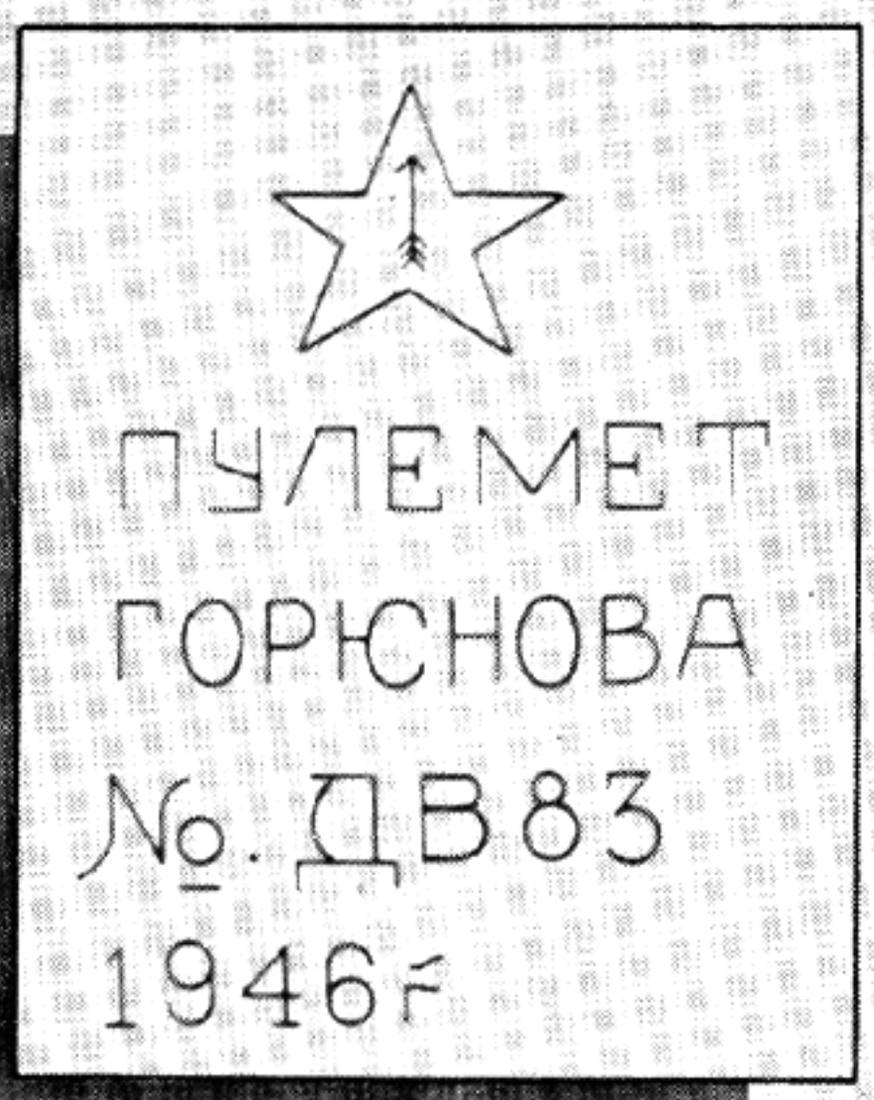


Figure 10 3. Markings on a 12.7-mm Beresin Aircraft Gun.



(ARSENAL MARK)

MACHINE GUN
GORYUNOV
No. DV83
1946 YR

NOTE: MARKINGS SHOWN ARE FROM AN APPROXIMATE SKETCH, NOT AN EXACT FACSIMILE.

Figure 10-4. Copy of markings appearing on a Goryunov infantry machine gun captured in Korea.

Figure 10–3 shows typical markings on a gun of the Beresin family. Marking on this particular gun was done in two stages. It is evidently the practice to place the letter indicating the use (synchronized, turret, or wing) and the serial number at a late stage in manufacture, while the letter for basic information is placed earlier.

The Goryunov ground machine gun (fig. 10–4) is marked inconsistently. Some guns show the full name, some have initials, and some omit the designers entirely. Attempts have been made to explain these facts on grounds of political favoritism, but it may be that local conditions dictate more or less care in the marking operation, and specifications may be less rigid than in the Western countries.

The marking of a VYa cannon is shown in figure 10–5. In the early appearance of this weapon in the Korean operations, attempts were sometimes made to obliterate the identification. Such an attempt is shown in figure 10–6. It is evident that the purpose was to conceal evidence of Soviet origin of the cannon. To accomplish this purpose, the arsenal mark was crudely removed and the initials of the gun system were scratched off. All letters and figures remaining are common to the Russian and English alphabets. In figure 10–7 we see an even more thorough job along the same lines.

The Nudelman-Suranov 37-mm cannon produced during World War II have not only the initials of the inventors' surnames included in its marking but also the surnames spelled out in full on another line. This duplication is typical of the variety to be found in Soviet machine gun marking. Figure 10–8 shows the marking on an NS 37 gun.

The NS 23 is stamped with the initials but not the names. The example shown in figure 10–9 includes the serial number, caliber, and year of manufacture. (The un-synchronized, fixed version is similarly marked except that KM replaces CM after the 23.)

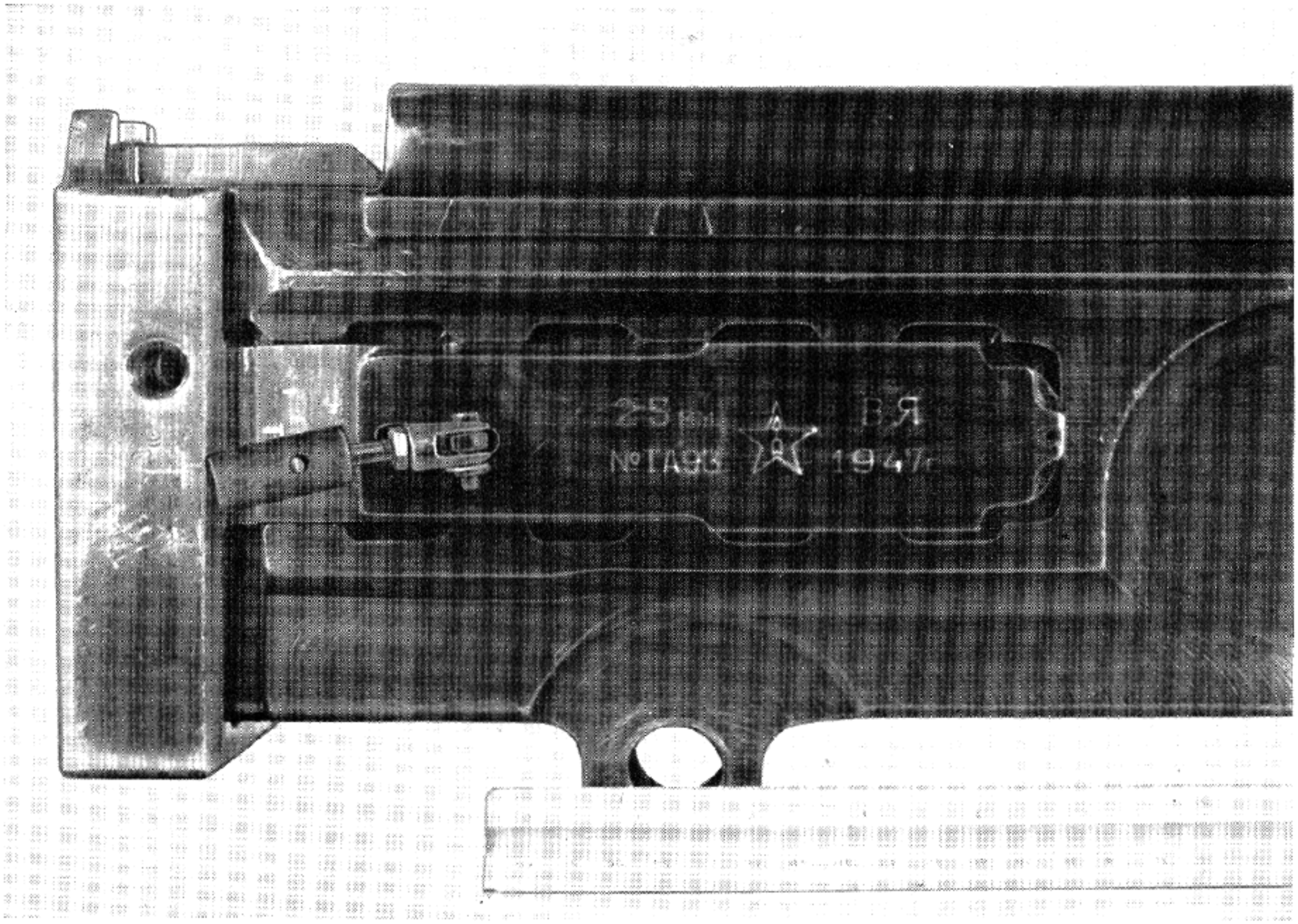


Figure 10–5. Complete marking from a 23-mm VYa cannon.

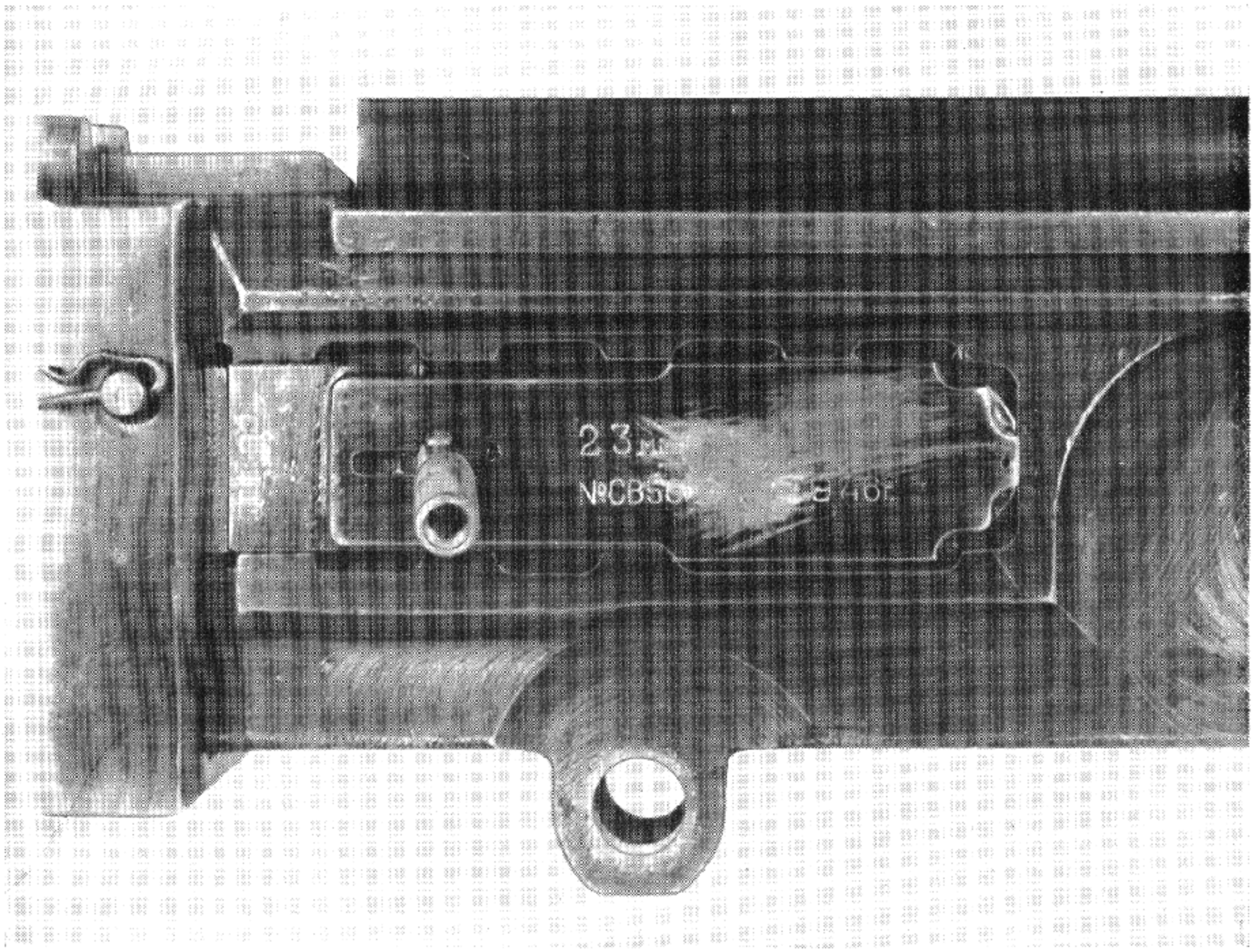


Figure 10-6. VYa cannon with marks crudely defaced. The arsenal mark and the initials have been obliterated.

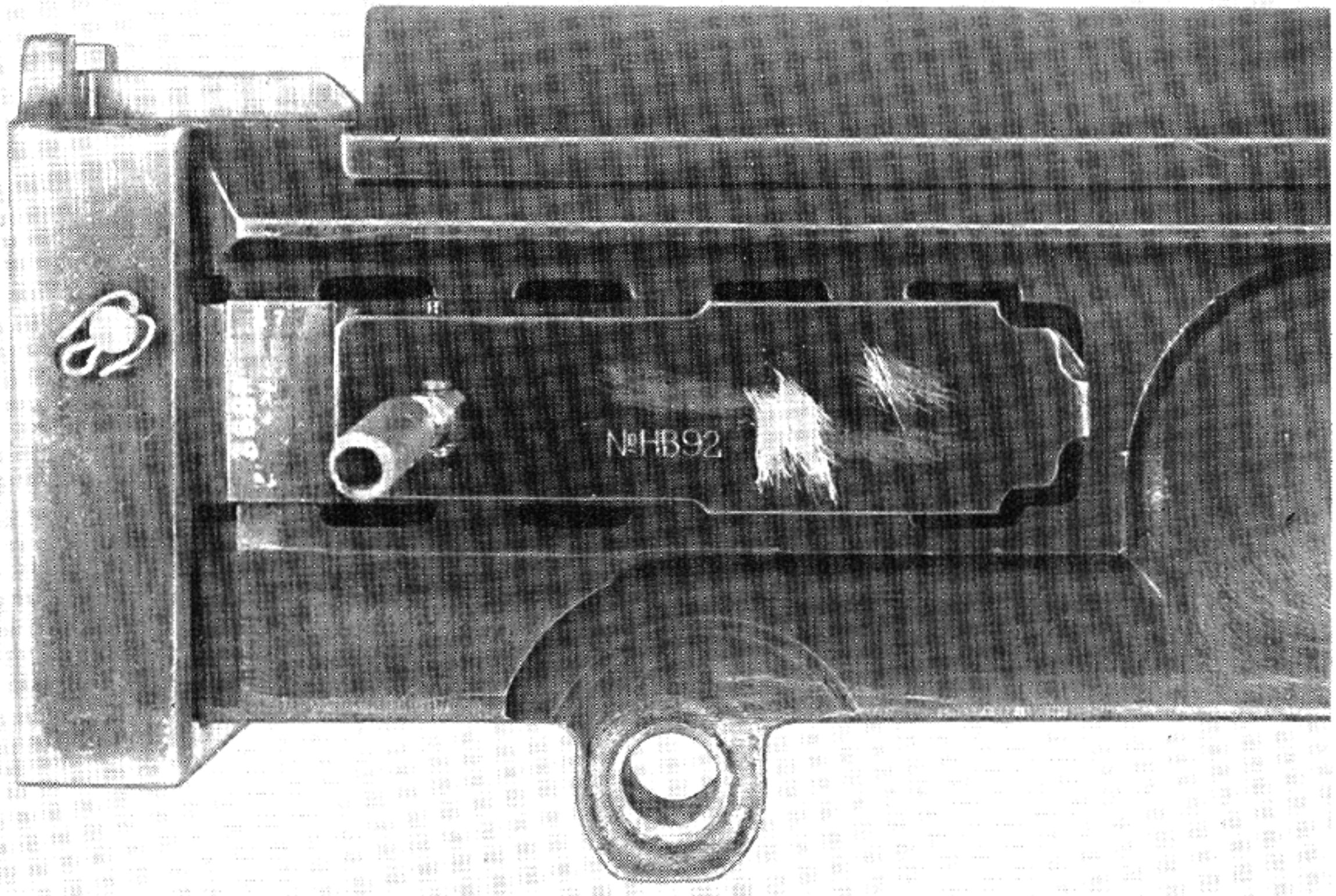


Figure 10–7. VYa cannon with all marks except serial number removed. As parts are not completely interchangeable, the serial number is critical for reassembly.

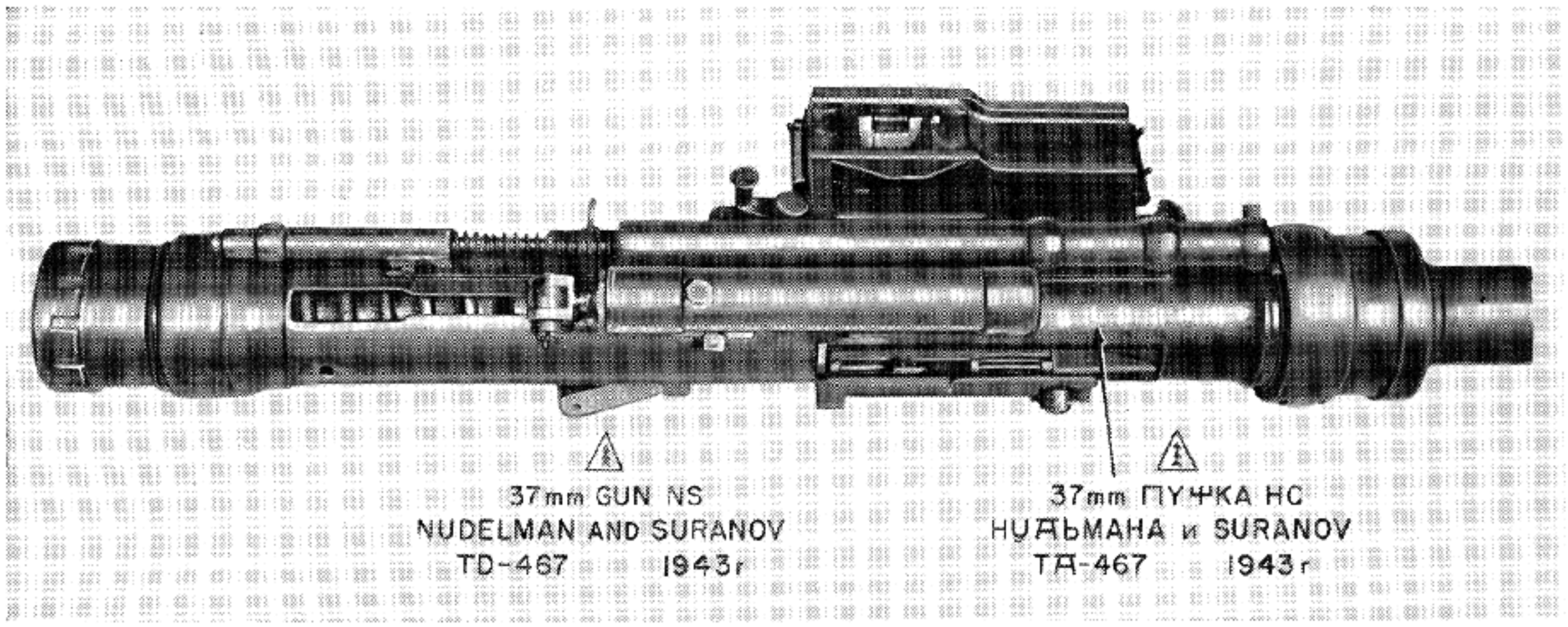


Figure 10 8. Typical marking of a 37-mm NS gun.

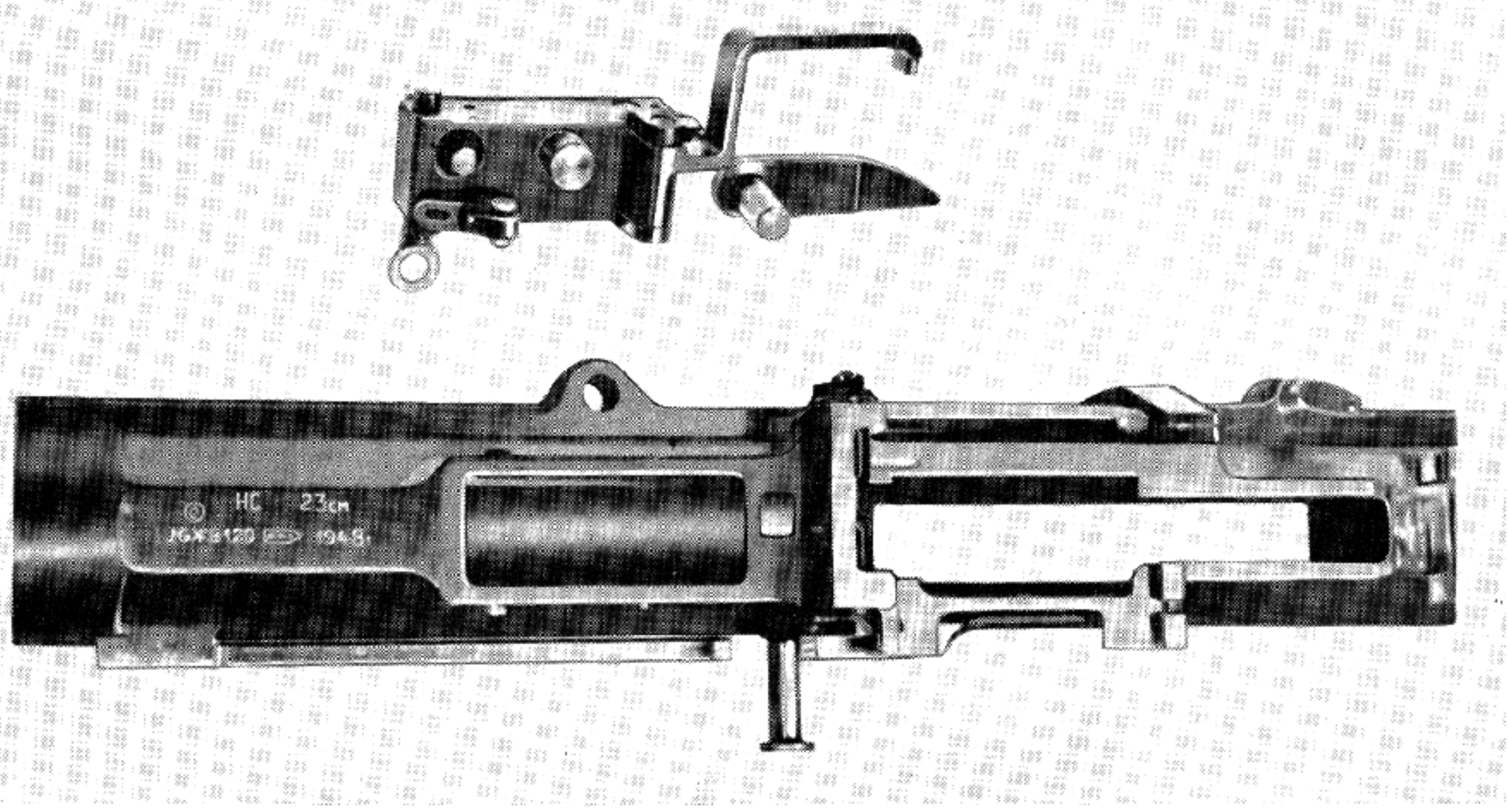


Figure 10–9. Mark of a 23-mm synchronized NS gun.

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Entries in this index refer to Russian guns, personalities, places, etc., unless identified otherwise.

References in italic type indicate pictures.

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