RESTRICTED

BOOBY TRAPS

Bureau of Naval Personnel
NAVY DEPARTMENT
WASHINGTON, D. C.

NAVPERS 16110

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Contents

Purpose

THIS pamphlet is a guide for naval personnel on booby traps and how to avoid them. Information is given on various types of traps which Germany and Japan have been using in the past and which they very likely will be using in the future.

The material in these pages was prepared with the cooperation of the United States Navy Bomb Disposal School, Washington, D. C.; the Mine Warfare Section, Base Maintenance Division, Naval Operations; M4 (Engineer) Section, Division of Plans and Policies, Headquarters, United States Marine Corps; and the Army Engineer Board, Fort Belvoir, Va.

It is intended that this information receive wide circulation among personnel concerned.

WHY YOU SHOULD KNOW ABOUT ENEMY BOOBY TRAPS

THERE'S no need to tell you that booby traps are concealed explosive devices to catch the unwary. They are laid in such a way as to be unintentionally set off by personnel, causing casualties. These fiendish mechanisms used by the retreating enemy are not new in warfare. The Trojan horse was certainly a bombshell, and it worked.

All the major wars have used booby traps. Their use in the strictly modern sense started near the end of World War I. Many of the trenches which changed hands rapidly were not only being mined, but mined in deceptive fashion.

In the interim between that war and the present one, gangsters became more resourceful. They did not stop by popularizing the submachine gun. If you did not pay your cut, you could step on the starter and the car would blow up; open the writing desk and be shot by your own cleverly concealed weapon; lift the lid of the cigar box and go to glory.

Our international gangsters have added more refinements, the Germans describing their intentions thus: "It should not be safe for him (meaning you and me) when in an occupied community to press a door latch, to move a wagon, to close a window, to clear away debris, to disturb a wire, to cross a street—without causing the explosion of a mine."

First report of use of booby traps in this war came in 1939. French patrols which had gone on scouting missions into enemy-held territory never returned. Several groups were annihilated before it was found that the Germans had strung thin wire traps through no man's land. Such devices are now widely used by Germany and to a considerable extent by Japan. Even a trained bomb disposal officer is a wary and cautious man until he is sure that every possible trap has been safely removed or exploded.

If you are an aviator forced down, a Seabee clearing a harbor, a member of a naval beach or shore party, or a wanderer upon a foreign strand, you should understand the whole subject of booby traps, so that the enemy's disastrous intent will be nullified to petty annoyance. You should be wary but not afraid.

You should gather confidence after you learn:

1. What mines and booby traps are.
2. How booby traps work.
3. Why they are used.
4. Common types employed by Germany and Japan.
5. Where to look for the booby trap.
6. How to detect booby traps.
7. What to do if you find one.

UNDERLYING PRINCIPLES OF BOOBY TRAP EMPLOYMENT

WHAT THEY ARE

First are *antivehicle mines,* designed for effect against tanks, trucks, boats, and other vehicles. Second are *antipersonnel mines,* designed for effect against personnel and used to perform definite military missions such as the laying of mines in wire entanglements. Third are *booby traps,* designed to function by themselves, to delay, confuse, and destroy individuals or small groups of the enemy.

While antipersonnel mines and booby traps use the same detonating devices and charges, they do differ in two respects. In the first place, booby traps are not used for tactical purposes. Secondly, in contrast with antipersonnel mines, they may involve all sorts of schemes and devices which are employed to set off the detonator.

The demolition expert will tell you, as we have just pointed out, that the mine is one thing, the booby trap another. It is true that there is nothing hit or miss about mines, which may be as close together as one every 5 yards, and laid in patterns

as geometrical as a French forest. But since the enemy booby-traps his own mines and even ours (if he knows they are temporary and soon to be lifted) and since such things as butterfly bombs and UXP's (unexploded projectiles to you) will kill you just as dead, let us not haggle. Let us discuss anything you should stay away from.

HOW THEY WORK

Booby traps and mines are explosive charges hooked to an igniter. The igniter is a cocked trigger which must be actuated in some manner, usually by:

1. *Pressing down.*—Stepping on a trigger (e. g., walking on a board under which an igniter is placed).
2. *Pulling trigger.*—Tripping a concealed wire or cord (e. g., opening a door to which a wire is attached).
3. *Releasing pressure.*—Lifting some apparently harmless obstacle which holds trigger down (e. g., moving an oil drum which holds down a trigger placed by the enemy in the road).
4. *Release of tension.*—Cutting a taut wire which fires the device (e. g., breaking a wire strung across your path).
5. *Automatic time device*—(*a*) *Mechanical.*—This actuates itself independently of any human agency, like an alarm clock, at a predetermined time (up to 50 days).

(*b*) *Chemical.*—This also actuates itself independently; breaking of a glass container releases acid which eats through wire releasing a striker.

To beat the booby trap you should not step on anything, pull or slide anything, or release anything. That is the general idea, but to be more specific:

1. Before opening doors or windows or making use of service facilities, careful search should be made of any building recently in the hands of the enemy.
2. Investigate both ends of all wires and cords.
3. Do not move furniture or equipment until a check has been made for concealed explosives.

4. Suspect loose boards and other movable objects under which pressure igniters might have been placed.

5. Examine carefully all equipment around a building, such as machinery or gasoline tins.

You can never be certain where traps have been placed.

Remember your first mistake will probably be your last. Develop suspicion of all harmless looking objects. And keep in mind that a booby trap may be actuated by any of a number of things—a concealed wire, an innocent piece of string, a phone cord, a light switch, a door, a table, a chair.

The illustrations in this pamphlet show you a number of the more common ways in which booby traps are set. Study these carefully and remember them. They will help you to locate these or similar traps when in enemy areas in which you may be travelling.

WHY BOOBY TRAPS ARE USED

The first reaction you will have to the booby trap is that it is a silly waste of time. Consider the pistol ground spike. If you step on it, one single bullet is sped upward. And ponder the five or more expensive mines one abandoned house may contain—surely the enemy can spend his powder to better advantage. What a waste of time!

YOUR time, yes; right into eternity. The first use of the booby trap is psychological; and here is about how it works—

(The squad leader comes across a nice German Luger pistol lying on the ground, just waiting to be picked up.)

SQUAD LEADER. "Do not touch it, men. It is booby-trapped. Watch me!" (He bends down, carefully attaches a cord to the tripper guard, and backs away toward a convenient foxhole.)

SQUAD LEADER. "Take cover, men. When I move the Luger, it will explode. Here we go!" (He is right. He steps into the foxhole, where the enemy, anticipating his line of reasoning, has put a couple of bounding mines set for pressure.)

Four purposes.—The whole purpose of these fiendish devices which Nazis and Japs are equally adept at using is fourfold:

1. To confuse and demoralize us all—by killing some of us—even when the enemy is miles away.

2. To slow our advance by making us clear the way before we proceed, whether we are demoralized or not.

3. To make us disclose our whereabouts by the noise of the explosion.

4. The fourth and last use is minor indeed, but you can defend a position better with booby traps than with sentries.

Notice that all of these uses are best suited for retreating, and that is just what we have got our enemies doing—retreating.

Psychological effect.—The effect on your state of mind is considered more important by the enemy than any bodily injury which might come to you. Traps are set so as to go off unexpectedly when you are relaxed or busying yourself with a routine job. And the only limit to their variety and location is the ingenuity of the enemy. Your best defense against these devilish devices is to learn as much as you can about them before going into enemy territory. If you desire more information than is contained in this pamphlet, read some of the references given in the bibliography at the back. Fortified with the facts, and alert to any evidence of trap installation by the enemy, you can move into newly captured territory with confidence.

Some idea of the effectiveness of mines and booby traps can be gathered from the testimony of the British 8th Army, whose advance from El Alamein to Tripoli was greatly slowed by the necessity of cleaning out mines and traps before proceeding. It took around 300 trained men to "delouse" 15 miles of road a day, lifting on the average 18 mines per mile. Each deserted airfield yielded around 450 tellermines and 250 "S" (for "Shrapnel") mines. In addition to the mines themselves, every fake mound of earth, as well as each bottle, can, or bit of iron found by the detectors, had to be investigated.

But slow or not, the job has to be done, and the more you know the better you can help.

COMMON TYPES USED BY GERMANY AND JAPAN

Elsewhere in this pamphlet all the known devices which are used to set up booby traps are shown in illustrations so that you can recognize them, report them, and pass by another way. For present purposes it will be sufficient to de-

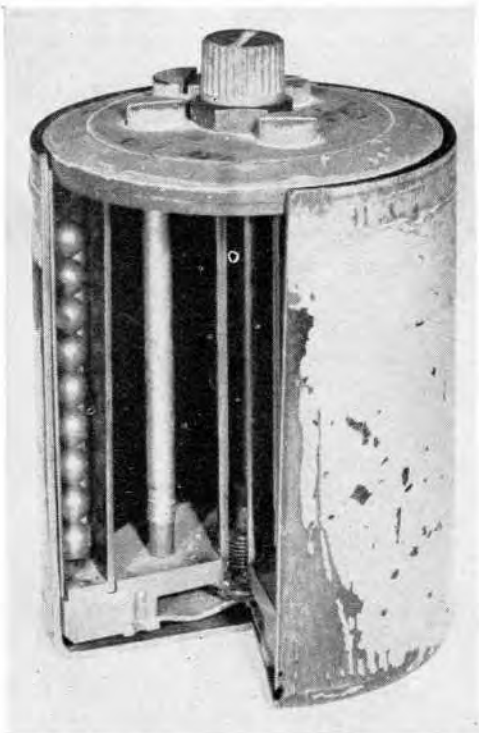

Figure 1. A cross section of an "S" mine revealing the interior of the mine. Notice the row of steel balls. These surround the entire mine, flying in all directions when the mine explodes.

scribe a few of the common varieties used by Germany and Japan. Unless you are a specialist in explosives, it may be as

well for you not to trade on your limited knowledge anyway, for the appearance of the traps will change from time to time. Furthermore, anything that can hold an explosive charge may be a booby trap: a piece of iron pipe, a hand grenade, one of our own unexploded bombs or one of our own projectile "duds," a wooden box with the lid slightly open waiting for you to step on it, a 40-gallon drum, a bottle of wine—even an old shoe.

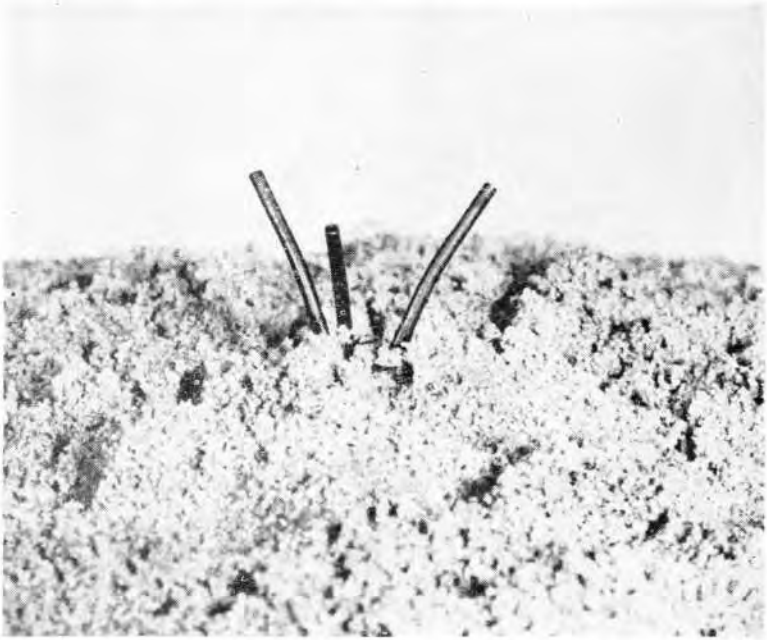

Figure 2.—"S" mine buried in ground with three-prong igniter projecting above surface. Pressure on the prongs causes explosion of mine. This is a commonly used trap. Watch out for it in shore or inland areas recently held by the enemy.

Remember your responsibility is to detect and avoid booby traps. The job of neutralizing and removing them belongs to the Navy bomb disposal man and the Army or Marine Corps engineer, or other authorized personnel.

"S" Mine

Of the manufactured varieties, the German "S" mine is the most deadly and most often encountered of the anti-personnel booby traps. It resembles in size and shape a family sized can of pork and beans. (See fig. 1.) The British

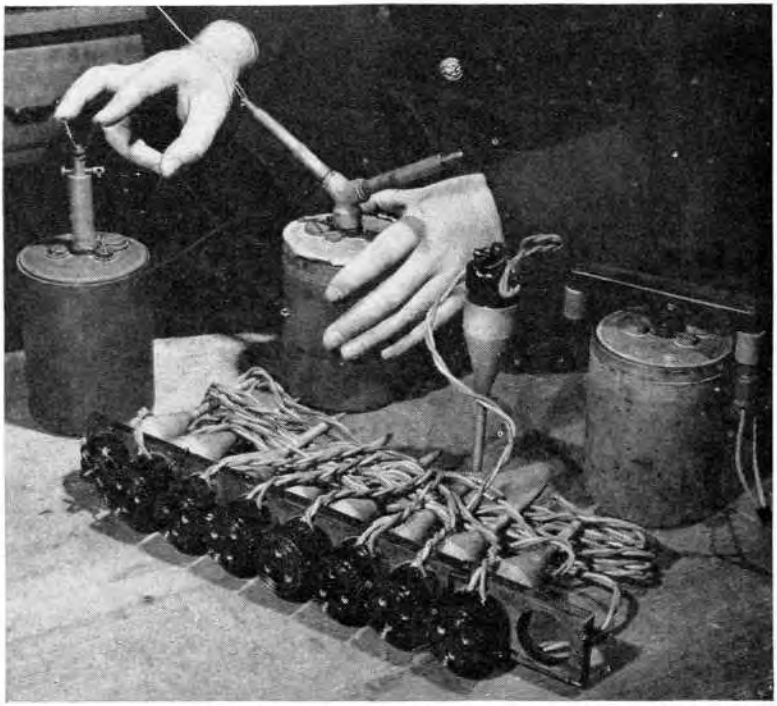

Figure 3. Three types of firing devices for "S" mines.

Mine on left of picture has three-prong pressure device as in figure 2.

Mine in center of picture has a Y adapter and two pull igniters.

Mine on right of picture has an igniter bridge, to which can be attached two strings of electric igniters (one in this picture). Each string consists of nine igniters connected in parallel. Pressure on any one igniter releases a striker which breaks a glass vial containing acid. The latter then comes into contact with two plates, creating an electric current, this firing an electric detonator in igniter bridge.

Remember the "S" mine is used as an antipersonnel device and is likely to be found in most all types of circumstances.

"shrapnel" mine, the American "bounding" mine, and the Italian B-4 are first cousins. Sometimes called the silent soldier, the "S" mine is made in two parts; the deadly portion is contained in a cylinder, the walls lined with 350 bullet-like slugs, the size of small steelies which boys treasure in their marble bags. The death-dealing cylinder fits smoothly into an outer case.

When the igniter of the "S" mine is set off, either by stepping on a hidden or partly hidden pressure-trigger (see fig. 2) or by tripping a pull-igniter in stumbling over a concealed wire, a charge of black powder underneath the cylinder will propel it upward (see fig. 3 for types of igniters). At the same time a charge of TNT will detonate the mine when it has jumped from 3 to 6 feet into the air. All together this takes about 3 or 4 seconds—just time enough for the mine to jump up, and for you, if you are caught, to proceed down. The pellets are shot outward laterally, showering annihilation to a range of 25 yards, and causing flesh wounds at 200 yards.

The German, British, and American varieties of these jack-in-the-box mines are buried, but the Italian cousin is usually laid above ground, so that it scatters its shrapnel without any pop-up. Painted green, the Italian one will quite likely be tied to a tree, a short stake or fence post, a telephone pole, or to the sides of entrances to dugouts.

There is one sure way to outwit the man-mowing mine. Let him who is nearest the mine itself, probably the one who set it off, listen for the swoosh, like the spewing sound of our Fourth of July rocket, the noise made by the black powder. In that moment of grace a wisp of gray smoke will arise from the ground. If any one yells "S mine!" drop like a shot before you *are* shot. The little bullets fly outward, rarely downward, so your chances are better if you are low to the ground.

Pistol Ground Spike

Another antipersonnel device called the pistol ground spike is the contrivance our boys have nicknamed the "castrator."

Actually this trap is British, but numbers were captured in Africa and are now being used by the Germans against the Allies. The device is easy to plant and hard to detect, as little ground is disturbed. (See figure 4.) The castrator is a miniature mortar. The six inch hollow spike is driven into the ground flush with the surface of the earth and a bullet dropped

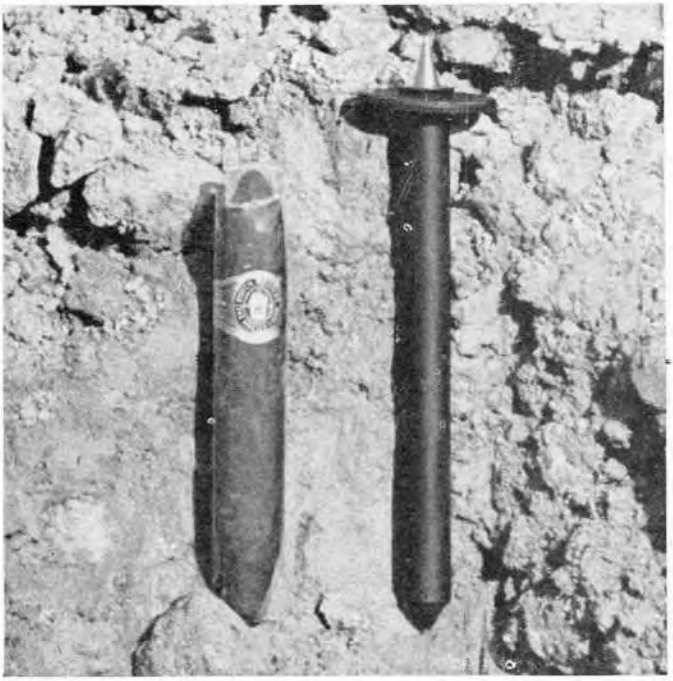

Figure 4. Keep your eyes peeled for the pistol ground spike. Pressure of your foot on the bullet which projects slightly above the ground will release a hammer which fires the bullet. Cigar at left shows relative size of ground spike.

in, nose up. Stepping on the bullet exerts enough pressure (4 pounds is the minimum) to release a spring that drives the striker hand against the cartridge cap. The bullet may travel upward through your foot or thigh. Anyway you look at it it is dirty business.

The Tellermine

The tellermine, named after the German word for *plate*, is the example of a dozen "mushroom" varieties. (See fig. 5 for three examples.) Even the British mines resemble the tellermines somewhat. All are similar in principle.

A tellermine is a German light anti-tank mine about a foot in diameter and 3 inches thick, and resembles the top of a garbage can, or more exactly, the top of an old-fashioned ice-cream freezer. Though it holds 11 pounds of TNT, it weighs only 20 pounds, which makes it easy to transport. You can expect

Figure 5. Tank mines used by the Germans. Watch for these on roads and along the sides of roads. Pull igniters of two mines in foreground are connected so that moving of either mine will set off both of them. Pressure igniters have been removed from two of the mines.

to find this tellermine anywhere, and set to be detonated in all sorts of ways.

As an example, a tellermine used by the Axis in the Mediterranean theater was found balanced on one branch of a tree by means of a long stick. A pull igniter was attached to a second branch, the idea being that someone would jar the stick that balanced the mine, thereby allowing it to fall and explode in the air.

Usually the tellermine is found in roadways or roadblocks, pressure-ignited as shown in figure 6. When set to catch vehicles, it takes 300 pounds weight on the lid to detonate it, but do not conclude therefore that a stroll through the minefield is indicated. Picking a tellermine up is always asking for it, because wells in the side and bottom give ample opportunity for

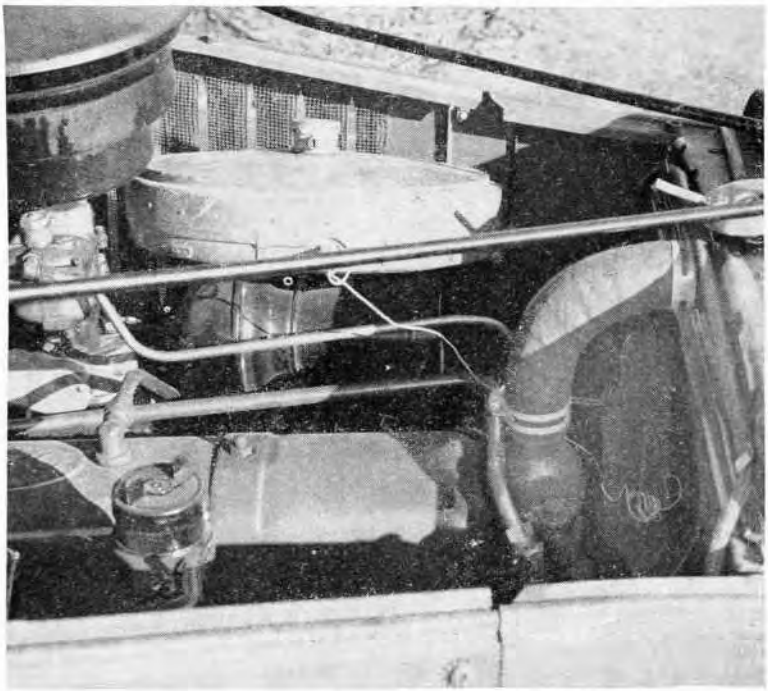

Figure 6. Tellermine located under hood of truck with trip wire attached to fan blade. When motor starts, revolving of fan belt will set off pull igniter, thus exploding the mine.

booby-trapping (that is, rigging it with a pull igniter fastened down below so that when you lift the mine you "pull the trigger".) Some wise guys have tried shooting at tellermines with rifle fire at close range (25 feet). If you are a good shot and hit

the mine right, you are likely to be rewarded, but only in heaven. Shooting at mines is something to outgrow right away.

The CVP (circular, variable pressure) is often considered to be an Italian mine used by the Germans. Actually it was man-

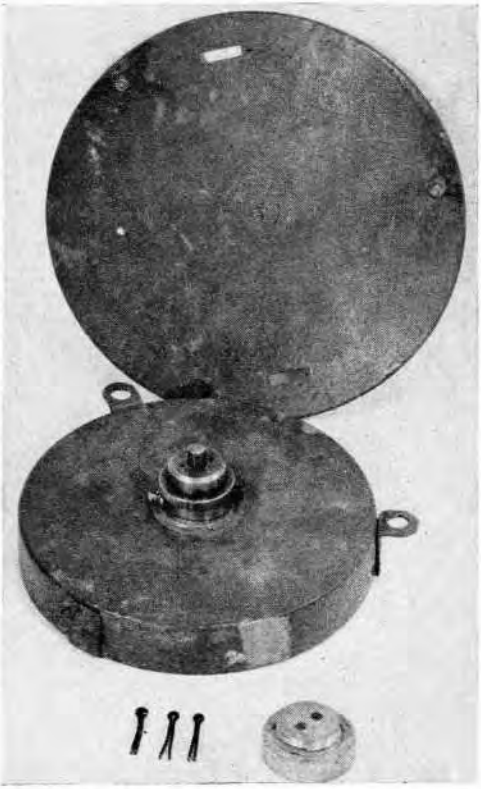

Figure 7. CVP is a Hungarian anti-tank mine used by the Germans. It can also be set as an antipersonnel mine. It is generally placed along roadways and in mine fields. Downward pressure at any point on the cover (thrown back in picture) will cause fuse to operate.

ufactured in Hungary. It resembles the tellermine very closely in appearance (see fig. 7), but a circular plate has been added on top. The CVP is smaller than the tellermine. Do not let

that lessen your respect for it. The mechanism may be touchy at 77 pounds pressure, which makes it antipersonnel, or sluggish at 777 pounds. It can also be used for booby-trapping by employing a trip wire.

Italian Long Metal Box Types

These two Italian mines are elongated metal boxes, usually gray-green in color. The B–2 is slightly over a yard long, 5 inches wide, and 5 inches deep. Though the N–5 is just as long, it's only half as wide and deep. The two of them are primarily intended for use against vehicles, but do not touch them. They are so dangerous to handle that the Nazis, who still use captured Italian material, employ them only if nothing else is available.

German "Butterfly Bomb"

The "butterfly bomb" is the German's favorite bomb against personnel on beaches, in camps, and against airfields. It is small and light, and can be dropped in great numbers from airplanes. One plane can carry several hundred of these deadly little devices with no trouble at all. As each bomb descends, the fist-sized iron ball full of explosives swings free at the bottom of a rod about the size of a lead pencil. The unfolded fins on the top of the pencil-rod are whirling in the air and turning the rod, thus arming the bomb.

Some "butterfly bombs" explode in the air just above ground, some on hitting the ground, and some incorporate delayed action (about 8 to 30 minutes) which makes everything just dandy for the persons who have to come out after the raid to fight fires. See figs. 8 and 9. That should be enough, but the end is not yet. Part of the crop of "butterflies" will not go off at all until someone disturbs them—picks them up, treads on the wings, or the like. Often the bodies of the bombs will have buried themselves in the soft earth. The only part visible will be the brightly colored (green and red, or green and yellow) upturned wings, like the lovely discarded shells of some crabs or lobsters. What a memento for the office desk back home—but pick it up and you won't get back home!

As an example of how the "butterfly" can let you down: One night last spring in North Africa the Germans raided a forward area of ours where there happened to be a P. O. W. (prisoner of war) cage full of Germans we had captured that

Figure 8. Danger lurks for the inquisitive in the form of the German anti-personnel bomb known as the "butterfly." Here is one of these bombs, lying as you might find it in the field.

day. Jerry dropped hundreds of "butterfly bombs" and one of them drifted into the P. O. W., settling to earth without going off. Naturally the German prisoners were greatly relieved and shied clear of their own infernal machine. But

next morning was a different story. Three of our allied soldiers guarding the P. O. W. came across the little yellow wings, and the pencil rod, and the iron ball.

"A–ha!" said one of the guards to his pals. "Something new has been added."

And while the other two held onto the little iron ball, he tried to unscrew the yellow wings, and up went all three— the German prisoners, watching from a distance, were delighted.

Figure 9. "Butterfly" in tree. Stay away from this kind of a situation. The bomb may explode through a time device or as a result of any disturbing pressure.

The "Thermos" Bomb

An Italian bomb in the shape of an ordinary thermos bottle. This type can be dropped from planes in great quantities. It can also be timed for delayed action. A dangerous feature is a little ball inside, which on being disturbed may roll in any direction and cause the charge to explode. The bomb is easy to detect. (See fig. 10.) Do not pick up or touch any quart-

Figure 10. More deadly even than the "butterfly," the thermos bomb is likely to be found around airfields, in evacuated cities, on roads, and in open fields. Keep your distance from this bomb for it is designed to go off on slightest movement or disturbance.

sized thermos bottle you may see lying about. It is a "thermos" bomb. And you had better mark it off and report it, for it is set to go off in a matter of hours, whether anyone touches it or not.

Japanese "Sandman" and Other Types Used by Japan

The Jap has used four types of mines in the Solomons, not counting improvised wooden traps. The first two he loves to hide in the sand of beaches, or under a palm leaf.

1. *Anti-vehicle type*, resembling the German tellermine but only about half as large, contains two pounds of high explosive. (See fig. 11.)

2. *Anti-personnel—Dutch*, captured in some quantities in Java, has a dome-shaped cover, is 8½ inches in diameter

Figure 11. Three types of mines used by the Japanese—(1) anti-vehicle type (left) (2) antipersonnel—Dutch (center) (3) antitank magnetized (right).

and 3½ inches thick as shown in figure 11. Fifty pounds of pressure will detonate it.

3. *Antitank magnetized* resembles a khaki hot water bag with its dun-colored cover, or possibly a snapping turtle with all four legs stretched out from under its shell. (See figs. 11 and 12.) These four legs are square magnets designed to hang on like a leech to any metal, whether tank or gun carriages. If a tank passes over a foxhole which contains one Jap and one magnetic mine, the tank will be crippled 5 seconds later.

4. *Bangalore torpedo.*—Any 2- to 4-inch section of pipe around 40 inches in length and filled with explosives is the Bangalore torpedo. The original purpose of this one is to blow up barbed-wire entanglements, but it may also be a snare if laid with a trip wire rigged up to a pull igniter.

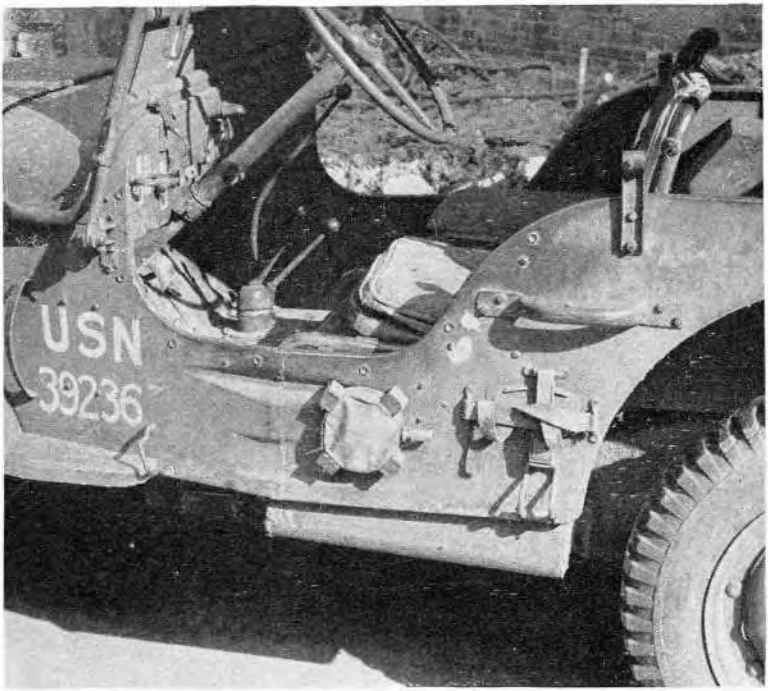

Figure 12. Antitank magnetized mine on side of jeep as enemy might place it on one of our vehicles if given a chance. When so placed as a trap, pressure is applied to ignite cap causing an explosion, within 7 seconds.

5. *Wooden box mine.*—That is all it is, a wooden box full of explosive with pressure, pull and tension release devices attached so that movement of any sort will cause an explosion. It represents a sort of triple threat.

Probably the most common types of booby traps used by the Japs in the South Seas were strings of grenades hooked to a

trip-wire to discourage anything in the nature of a bayonet charge.

By comparison with the Germans, the Japanese have employed very few mines except those captured from the Dutch. Those they did use were likely to be crude, home-made affairs. At Kiska, one trap was placed under a gramophone, and hooked up electrically to play its barbaric music. But the wire leading to the charge under the floor boards was only half concealed and our boys spotted it.

From New Guinea comes the 70-millimeter barrage shell (see fig. 13), a real invention of the devil. The shell does damage at low levels, but is even more effective as a decoy, shot over the heads of our troops. Out of that shell spills a parachute to check its course so that seven smaller canisters may be scattered without tangling. Each of these canisters has a cloth parachute attached (see fig. 13), which opens and flutters down. From the canisters delayed-action black-powder trains discharge the bombs themselves. If the parachutes open, the pull on the suspension lines will cause explosions simulating the noise of infantry fire. Our troops, hearing the shooting in the rear, may imagine themselves surrounded and retreat.

Whenever the tightly packed chutes do not open and the bombs plummet to earth, you may find the perfect pocket-sized souvenir painted black with a red band below the screw cap and some Japanese writing that means: "dangerous—don't touch." If you try to fly the pretty little thing, it will blow your head off. Unexploded projectiles and unexploded bombs, whether our own or the enemy's, are every bit as dangerous and tricky as ordinary booby traps. Avoid them. Do not touch them. If you can, put up a marker by them and notify the nearest bomb disposal officer immediately.

Panzi.—Needle-sharp bamboo spikes, called Panzi, are one of the most treacherous weapons employed in jungle warfare. They have been used by the Japanese as traps to impede the advance of an attacking force. They can be easily constructed from material available in the jungle and are difficult to see

against jungle background. But you feel them quickly, and you know when one has gone through your foot. Panzi are used as traps at narrow points in trails where a ledge or heavy brush on one side prevents you from escaping. They are also used in a pit or foot trap placed in a path at the crossing of a stream or other similar places.

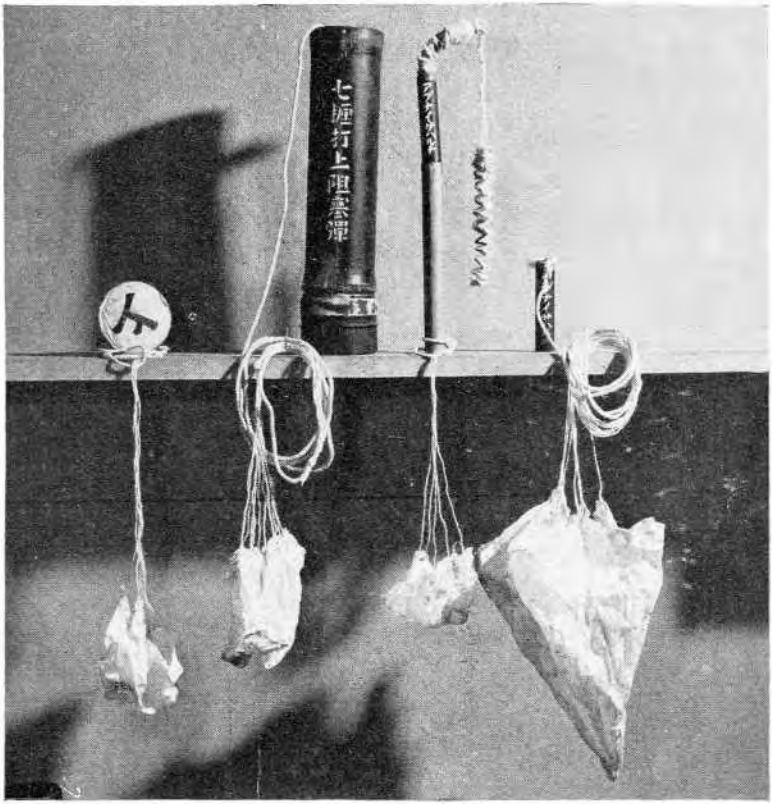

Figure 13. Japanese parachute barrage shells. The large container in the center has the propellant in the base and contains seven of the long container tubes shown center right. The small case on the extreme right, one of which is found in each of the long tubes, contains the explosive charge which is initiated by a friction igniter that operates on the jerk from its parachute. Figure at left shows top view of large container.

Japanese techniques.—There have been numerous reports of the Japanese use of booby traps in China and Burma and scattered reports of their use in the Pacific area. Since booby traps are principally weapons of retreating forces, it is probable that their use by Japan will occur more and more frequently as the United Nations' offensive in the Pacific area is extended.

Special instructions have been issued to Japanese engineers and other specialized troops emphasizing the importance of

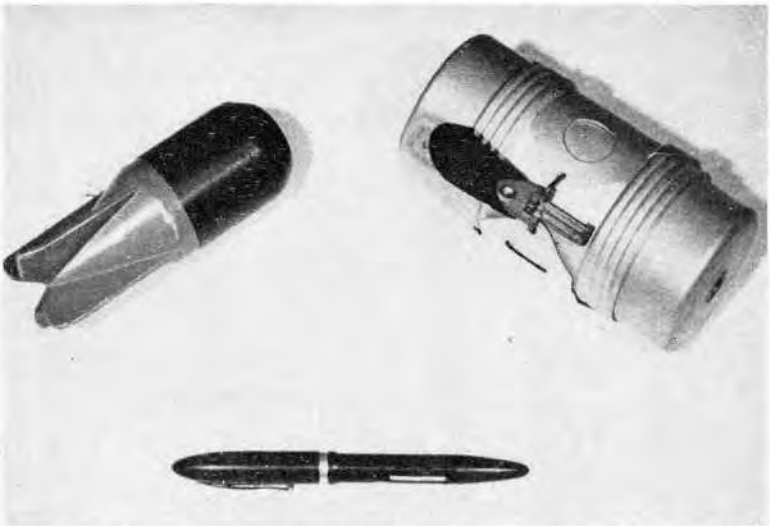

Figure 14. Italian mortar grenade (left) and hand grenade (right). Leave these grenades alone. They have fuzes which act in all directions.

ingenuity on the part of the individual soldier in preparing traps. These instructions include examples of use of trip wires attached to doors, windows, road blocks, souvenirs and corpses, and stretched across trails. Pressure drivers in the ground and under floor boards are described. Also included are instructions on making booby traps from bottles, trunks, empty tobacco tins, parasols, bamboo cylinders, canes, kerosene tins, flashlights, match boxes, clocks, vehicles, and other material that is to be left behind. There is nothing new or unusual about any of these

examples or about any Japanese booby traps that have been found. They employ familiar principles and methods. The difficulty lies in locating them. And this is a job which you must help perform when you are in territory which the Japanese have previously occupied.

Figure 15. British hand grenades. If the enemy gets ahold of these, he very likely will rig them up as booby traps.

Keep in mind that the Japanese have information and plans of German and Italian mines and booby traps, and since the "little men" are good at copying, it is probable that you will encounter numerous imitations. Also remember that extensive use of booby traps is to be expected of an enemy who has been highly deceptive and treacherous in many other respects.

Figure 16. German hand grenade—stick type. If you capture one of these, do not use it unless previously inspected by an ordnance man.

Figure 17. Japanese hand grenades. (1) Potato masher, patterned after the German stick grenade (left), (2) hand grenade (center), (3) "knee" mortar grenade (right).

Grenades

Most enemy grenades, like ours, can be left behind as booby traps. The German egg-shaped grenade with the gray body may be set for instantaneous firing. The Italian grenades (fig. 14—two types) become very dangerous when safety pins are removed. As booby traps they are often placed in a rubble heap or hidden in a large tin can. When disturbed even slightly, they explode. Suspect *any* grenade left behind by the enemy, whether it is an egg grenade, a mortar grenade, a shaving stick, or a bar of soap. In Northwest Africa, a bar of soap with the standard brand name "Bourjois" on one side and on the other "Made in England" turned out to have a different odor, a metallic core, and enough explosive to blow you to kingdom come.

The Japs have left hundreds of grenades behind them, too. Figure 17 shows three types. One American boy in Kiska had fun collecting these for souvenirs. He filled his pockets full; came in by the fireside to warm—until things got too hot for him—entirely too hot.

Remember that the Jap "booby traps" himself with his last grenade. Make him strip or shoot him.

WHERE TO LOOK FOR THE BOOBY TRAP

At this point it may appear that any advice about where to suspect the presence of booby traps is a waste of time, since they are everywhere. Nothing could be further from the truth. If a description of the traps has slowed you down to a walk, a knowledge of where they may be laid and how to avoid them should speed you up. Since one purpose of planting a few booby traps is to make everyone overcautious, let us not play into the enemy's hands.

You know what the things are like; if you know where they are most likely to be, you can keep your eyes open, recognize and avoid them, and still do your assigned job the way it should be done. If you know what you are likely to meet and where you are most likely to meet it, you can proceed without a whole lot of vague fears and wild doubts. You can be reasonably

confident you can avoid being hurt by these traps—either from (1) ignorance or (2) stupid curiosity. You can BE WARY BUT NOT AFRAID, and you can BE CONFIDENT BUT NOT COCKY.

Booby traps are laid where you will *have* to go and where you will be *likely* to go. Certain areas will contain few if any traps. A discussion of all three possibilities should qualify your freedom of action.

Where You Have To Go

Harbor.—The Navy will have the heaviest responsibility around harbors. It is true that the general may not take over from the admiral until the amphibious forces are well inland, but the harbor is the first place where the Navy should develop booby trap "*savvy*." A derelict ship, a barge half wrecked,

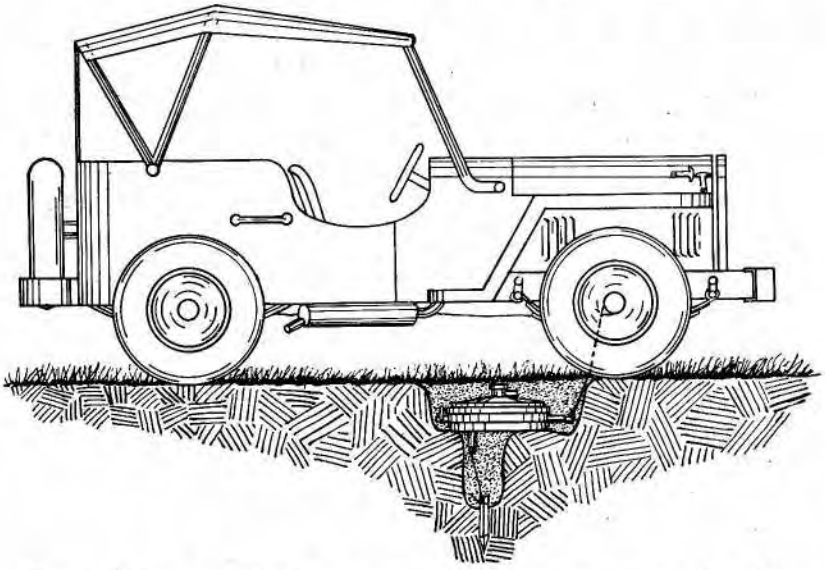

Figure 18. Any abandoned equipment should be checked thoroughly before any attempt is made to move it. Illustration shows placement of a mine under a jeep. If jeep is moved either forward or backward the mine will fire.

like a deserted truck sprawled across the highway (see fig.18), must be cleared out. Take it carefully here. *Suspect everything already wrecked by the enemy and impeding your progress.*

A *pier* which the enemy did not blow up may be waiting for you to set it off and make it a part of general carnage. (See fig. 19.)

The *rubble pile* which is right in the way and which must be moved, is easy to trap. No telltale signs of recent disturbance

Figure 19. This trap found at Tarawa is a high-explosive projectile (partly submerged in water) attached to a pressure firing device (shown by arrow) which is placed under boards of pier.

will tip you off, since all of it has been messed up. Make sure the engineers have cleared it of traps.

Roads which have to be traveled, like the one mountain pass, will be mined. Beware of any road obstruction. If it is a stone pile, the little stone may be removed and even the one slightly larger. But the big rock that takes several men to dislodge may release the mine. If the obstruction in the road

is not mined, the ground around it, where you will have to detour, will be.

Airfields need to be put in shape before our planes land. The enemy knows this too. Bomb craters on the field are good places for traps. Sometimes a spiked strip placed on the runway to rip tires is such an obvious hazard that you will want to lift it out. Better pull it with a long rope (50 yards). It may blow up.

To knock out his own airport at Tripoli, the Hun laid 100-pound bombs in 2-foot trenches up and down the runways. Then he blew up the bombs, and after that, he trapped the sides of the craters with "S" mines, so that our filling up the pits would set them off and blow up the trucks. Jumping into such a crater would be just the ticket to set off an "S" mine.

Deserted enemy planes are favorite haunts for the booby bird to lay her eggs—in the radio, under the pilot's seat, under the rumpled parachute lying on the cockpit floor, or hooked up electrically to the storage batteries. If the enemy has not destroyed his own wrecked plane, he is counting on your help. Remember he will also trap your planes if he has a chance. (see fig. 20.)

Will the field need enlarging? Then the bushes and the little trees outlining the field may have mines at the roots, just waiting for the guy who does not think.

Hangar doors, storage bins, fuel dumps, need a quick once-over.

Bivouac areas outside of big towns will be twice as dangerous as the big towns themselves, as the enemy is not likely to set many traps in the towns where the natives are still living and where few of our troops will actually go into the buildings. Houses which would make the best barracks get the most attention from the retreating enemy. Tokens will be left in the piano, the closet, the stove, the icebox, behind the pictures, under dishes and flower bowls and underneath the beds. They will be attached to windows (as shown in figure 21), doorknobs, cabinets, letters, shower faucets, telephones, to almost any fix-

ture or object that might seem harmless. While we are mentioning places you have to go, watch out for bombs in the "head." And if you happen to encounter a time mechanism (a commomly used German device is J-Feder 504) report it immediately. Figure 22 shows the 21-day clock type believed used in the Naples post office.

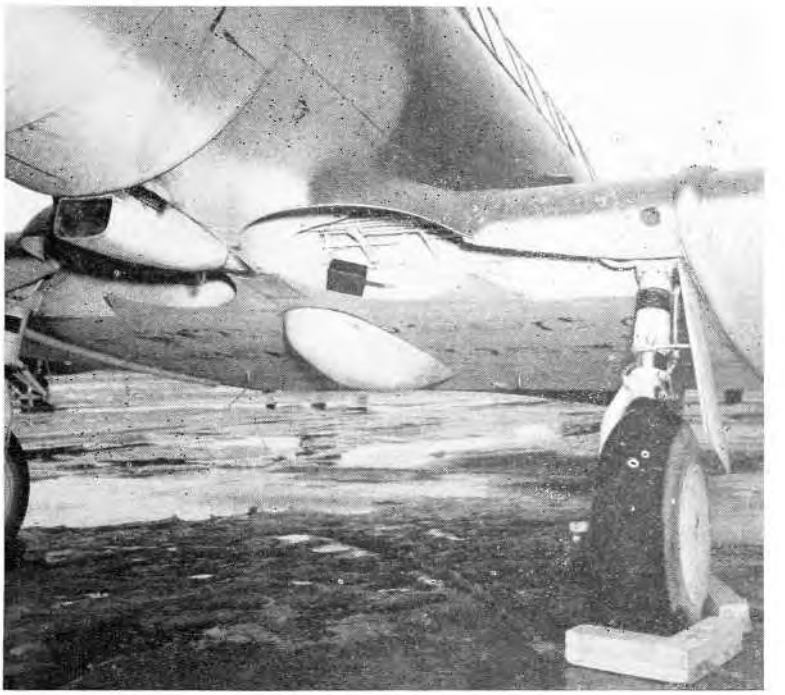

Figure 20. This plane has a tension release device attached to the landing gear and connected to a concealed explosive container. Device is fired, after take-off, as wheels are folded. The Japs placed traps in similar fashion on American planes at Guadalcanal.

Where you are likely to go

The enemy has been at pains to study your psychology in order to catch you napping. When you enter a house, what

are your natural reactions? You do not know? Well, at least give as much thought to preserving your life as the enemy has expended in trying to destroy it.

The enemy knows your human weakness. He knows the Americans go in for souvenirs. Do not pick up helmets, rifles (fig. 23), thermos bottles, or cameras left behind by the enemy.

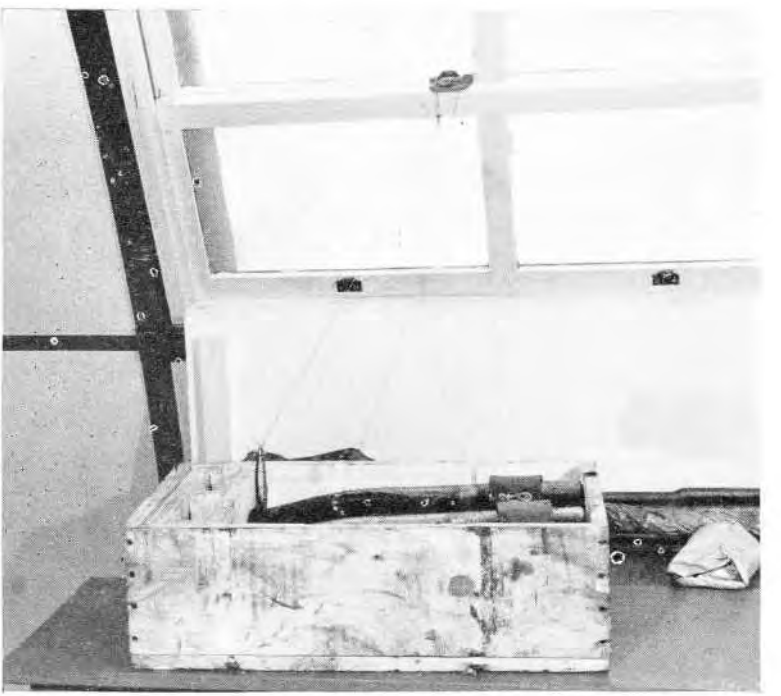

Figure 21. Pull type igniter with trip wire attached to lock on window. Raising window starts pull device which detonates projectile shown in box.

They very likely are connected up to some dynamite intended to blow souvenir hunters to shreds.

If you do not actually put the thing in your pocket, you will at least want to see what it looks like. Resist that impulse to find out: What are those obscured letters on the kilo stone

(milepost), which make you move those fatal three steps nearer destruction?

How would you look in that German helmet?

What is behind the picture?

What does the dead enemy soldier have in his pocket?

As to the last question, we do not know. But we can tell you right now what he has on his chest. It is a mine. During

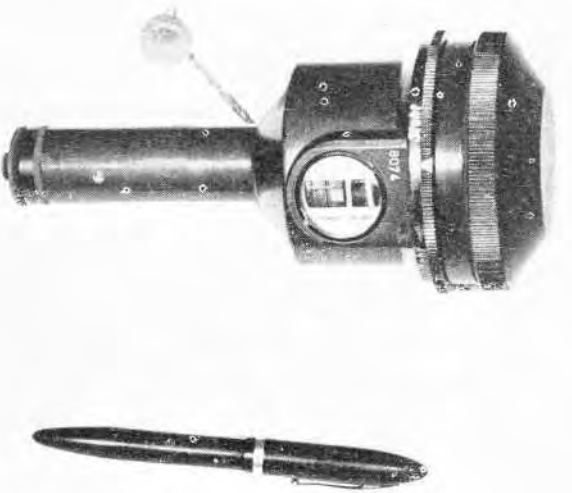

Figure 22. This German clock may be set to explode a charge any time from a minute up to 21 days, after starting.

World War I an allied propagandist worked out a story that the Hun used his dead for soap. In this war, both the Germans and the Japs have found a better use for their dead, and that is not any story.

The enemy knows that you are likely to take the road which is easiest for you to take. The mines invariably are placed in that road. If you want to be safe, take the hard way up and over.

He knows you are likely to be hurrying. Some men cannot wait for the boat to touch shore, but must jump into the water and dash up the beach. Do not do it unless you have to. Barbed wire entanglements with mines attached have been placed under water or on the beach to trap you as shown in fig-

Figure 23. The rifle is connected to the pull-igniter string of a German stick grenade by means of a cord. A pull on the gun will set off the grenade. This type of trap is generally placed in a shallow hole and then covered or concealed in grass or bushes.

ure 24. It is the same with the fellow who cannot bother to investigate both ends of the too-obvious wire. And both the Japs and the Germans booby-trap the handy repair material they have left on the sides of bomb craters.

Where You May Speed Up Without Danger of Encountering Traps

Obviously in warfare no place is safe. But when it comes to booby traps, you should know where they are least likely to be set. These safer places are:

1. *Areas occupied by civilians.*—Tunis, for example, contained practically no traps. The theory is that the natives will see them set and tell, and even if they do not tell, few

Figure 24. Here is a typical trap which you are likely to encounter on the beach. Notice the three trip wires hooked to the barbed wire. The explosive charge is buried under the sand. (This is a photograph of an actual trap found at Tarawa.)

of our troops will be billeted in houses still actually in use by civilians.

2. *Hard surfaced roads.*—It is so difficult to lay mines here that they are placed in the soft shoulders. The British 8th Army found that if they appeared in the roadway at all, they would be in "potholes in the tarmac." More popularly, "potholes in the tarmac" are "holes in the road."

The same applies to hard ground. Big stepping stones are safe, and hard ground is safer than soft.

3. *Where the enemy has not had time to set them, or not time to set them properly.*—If he leaves in a hurry, 20 houses in a row may be booby-trapped in the same unimaginative fashion. Or you may find he has left disturbed earth, obvious pull wires, empty mine containers—or even open mines on the surface.

4. *In territory which the enemy hopes to retake.*—Since the Japs were sure they would recapture Guadalcanal, traps there were relatively scarce.

So far we have discussed what booby traps are and where they are likely and not likely to be found. But how do you detect them, and if you find them what do you do about it?

HOW TO DETECT BOOBY TRAPS

What are the specific "on the spot" indications of a mine or a trap? Most indications are based upon evidence of disturbance. The successful trapper removes all signs, but since human beings are not machines, they make mistakes and leave clues. The British found that if their engineers arrived on the scene before a rain they could detect by eye 70 percent of all mines laid. So if you are early on the scene after the enemy has flown, keep your eyes peeled for:

1. *Disturbed ground.*—You are familiar with the dry, crisp look of ground separated from the main body of the moist earth.

2. *After a rain, ground slightly sunken* may be the giveaway, and concentric cracks often appear after the ground has dried.

3. *Vehicle tracks on landing grounds* may mean that heavy mines have been transported. Watch for irregular or unexplained tracks, whether vehicle or human.

4. *Withered grass or bushes* tell of vegetation placed there by the enemy to hide a trap.

5. *Traces of removed barbed wire fence* suggest mining.

6. *Empty mine boxes,* discarded or found hidden, will suggest the presence of mines nearby.

7. *Dark round patches on the ground at night* will indicate newly laid mines.

8. *Pronged igniters.*—"S" mines long buried in sand usually disclose the pronged igniter because the sand has blown away. Three-prong igniters often show up even in the light of a dim flashlight.

9. *Discarded wrappings, sawdust, nosecaps from shells, nails, electric leads, pieces of thread or wire or tape* may appear both outside and indoors to indicate the placing of traps.

10. *Indoors, a break in the continuity of dust, paintwork, or timberwork—even an empty nailhole*—may be an indication of dirty work afoot.

The enemy will attempt to disturb the surroundings as little as possible. He will use dummies freely. He will very likely lay many traps in one place so that there will be less chance of your finding all of them without springing some. He will mask a well-concealed trap with an easily recognized one. He may provide several ways of setting off a single trap as shown in figure 25. And you can be certain that he will use as many different types as possible in any one locality.

The guiding principle of all detection is to suspect anything that appears to be strange, out-of-place, *too* normal when it should be upset, or *too* convenient for you.

A keen eyesight plus a quick appreciation of the meaning of unnatural phenomena will stand you in good stead. Question local inhabitants. They may have valuable information about enemy-laid booby traps.

Use your God-given intelligence, keep cool, and do not blow your gaskets.

As one demolition expert put it, you need the caginess of an Indian fighter, the sensitiveness of a deer, and the skepticism of a man from Missouri.

WHAT TO DO IF YOU FIND ONE

If you find a mine, an igniter, or a trip wire, *leave it alone!* Get out of there. WALK, DO NOT RUN, TO THE NEAREST EXIT!

Before you leave, mark the danger spot for the mine expert or bomb disposal officer. Use any device that will attract attention. The British sappers and United States Army engineers use arrow-shaped red and white markers, strung on wire or placed on pickets, to indicate the presence of mines.

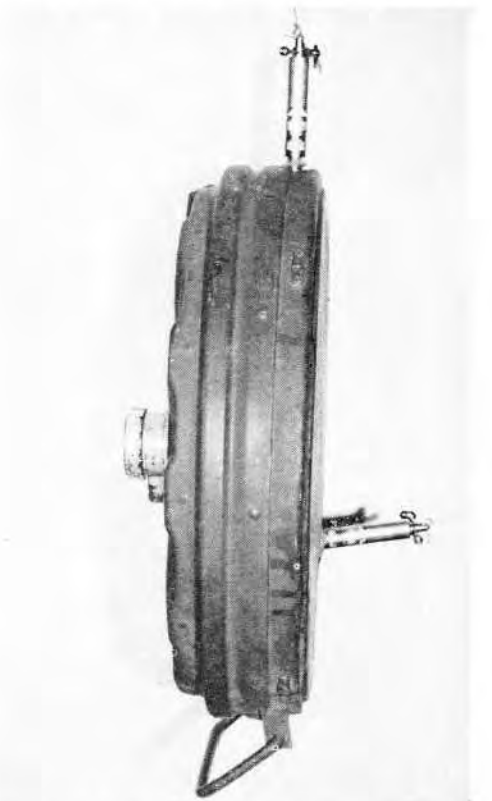

Figure 25. A tellermine with a main pressure igniter (center left) and two pull igniters (top and lower right) as secondary firing devices.

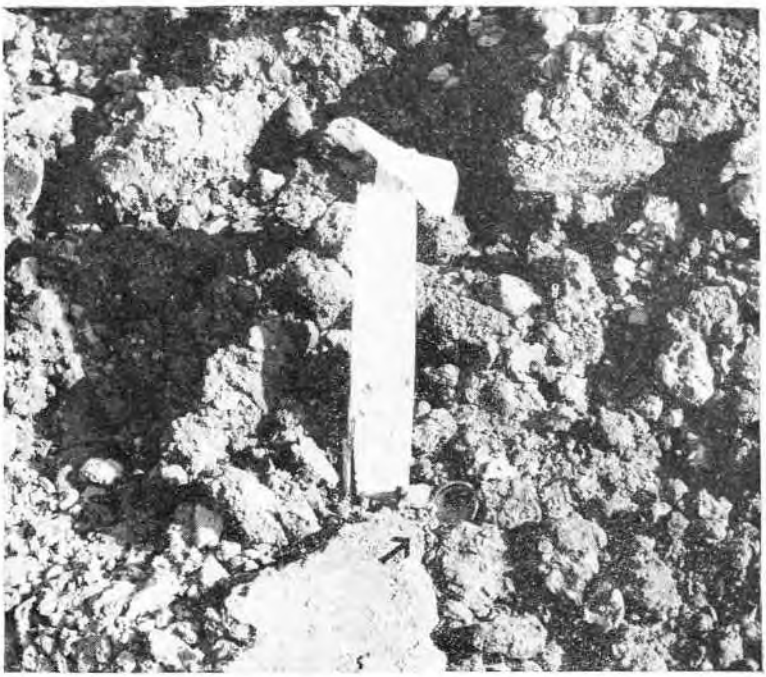

Figure 26. Before you leave a suspected booby trap, mark the danger spot for the bomb-disposal expert. A piece of paper attached to a stick and placed next to the trap will provide sufficient notice if you have no standard markers with you (arrow indicates top of buried mine).

The red half points to danger, the white to safety. The Americans and British also sometimes use white tape to mark-off parking places that have been cleared of mines, or "safe lanes." Maybe you will not have such equipment with you; if not, improvise. Mark traps by rags or paper streamers as shown in figure 26. Fence in danger areas with twine strung from stake to stake. A handkerchief on a stick, a message scratched on a piece of scrap paper or a stone, a bottle or can placed on a scooped-up mound of earth to attract attention, is better than nothing.

Do not cut wires, especially if they are taut. It may be a case of double bluff. "Double bluff" is a term for an obvious booby trap, which anyone will detect, rigged up to a cleverly hidden one.

Do not step over an obvious wire onto the loose board beyond.

In retracing your course, walk in your own footprints or drive in your own auto tracks. You have been over them once already and know they are O. K.

If you are looking for a new way and suspect that it, too, is unsafe, prod the ground you wish to set foot upon with a bayonet or long knife. Prodding should be done at an angle. Prod gently. All you are after is the scraping sound of steel upon metal—not rock. You will be able to tell the difference.

Do not get funny with neutralized enemy mines our engineers have left along the roadside. Sometimes they are hard to explode, sometimes easy. For instance, three AAF boys in Africa, using one of these neutralized tellermines for pistol practice, hit the thing and it blew up. They had to be carted off in the meat wagon.

The best rule for entering houses is to go in by a window. Do not hesitate to throw a rock through the pane from a safe distance, rather than raise it. Inspect the door from the inside for a booby trap.

SOME "RULES OF THUMB" ABOUT BOOBY TRAPS

Should you be required to cross an area or enter a building just abandoned by the enemy, and not yet inspected by the Army engineers or by the bomb-disposal squad, the following simple hints should be kept in mind. Indeed, keeping them in mind at all times when taking over from the enemy will not hurt.

ALONG ROADS

1. Keep off the *shoulders* of the road. That is where the mines are.

2. *Obstructions* in the road (oil drums, wrecked vehicles, etc.) will have traps behind or beneath them, to catch you when you try to remove the obstructions in a hurry.

3. A *crater* in the road will make you go off the road and around. Look carefully for mines in the ground you use for this detour. The enemy knew you would have to pull off at this spot.

4. *Sandbags* on the floor of an ordinary truck or car provide some protection for the driver and passengers in case a mine is hit. In vehicles with no cab, a bed or other bulky article behind the driver's head might stop the flying pellets of an "S" mine. But this does not apply if you are (*a*) in reverse or (*b*) following another vehicle closer than 100 yards (because you will drive into the pellets from the "S" mine which the vehicle ahead set off as he drove over it).

5. If your vehicle (or a neighbor's one) goes up on a mine, don't immediately jump out and run around to see what has happened. Where there is one mine there are probably others. But *the track marks of your vehicle are safe*, so walk back along them.

CROSSING OPEN GROUND

The first essential is not to tread on a trap. This is so simple a rule it is sometimes lost sight of, even by those who are otherwise on the look-out; but it is obviously better (for you) to find no trap than to find one under your foot.

Therefore, when on suspect ground, *always look at the piece of ground on which you are going to put your foot.*—A trip wire, a "mushroom" lid, or a bunch of little wire prongs sticking up can nearly always be detected by the eye.

1. Always put your foot on *hard* ground—if available. The man who always treads on a big, firm rock will never tread on a mine.

2. If no hard ground is available, put your foot on *bare* ground.

3. If you cannot find bare *or* hard ground—*prod* (with a bayonet or stick) the piece of ground on which you are going to put your foot.

4. If you suddenly see a mine unexpectedly—

(*a*) DO NOT turn around and run hurriedly away from it; you may be in the middle of a bed of them.

(*b*) DO NOT walk carelessly up to have a closer look, or lift it; there may be others on the way.

BUT

(*c*) DO stand stock still for a minute and look carefully for any other mines around you.

(*d*) DO warn others.

(*e*) DO either turn around on your own ground and walk back on your own footprints or if they are not visible, prod your way back.

(*f*) Mark the spot and inform your commanding officer and the nearest bomb disposal officer.

5. If you should, in spite of the above precautions, *set off* a German "S" mine, shout "'S' mine!" and crouch low—fast! With this type there is still a moment of possible escape, as the mine takes about 4 seconds to jump up out of the ground and explode. During the time between an "S" mine being set off and the mine jumping there is usually a small wisp of grey smoke to be seen coming out of the ground. With "S" mines long exposed to damp, the delay may be considerably longer than 4 seconds. Take no chances and stay down low for half a minute.

6. A thick overcoat or leather jerkin worn loosely is quite good protection against "S" mine pellets.

ENTERING BUILDINGS

1. Before opening a door have a look at the other side of it—(this can usually be done by looking through a win-

dow) to see if it is trapped (look for unexplained wire or cord or unusual objects that might contain an explosive charge). Do not raise window to get a better view; if necessary break the glass.

2. If you must open doors or window shutters without being able to look at both sides—pull them open with a long rope.

3. Because you have found one trip wire attached to a door or any object don't assume there isn't another one.

4. Look carefully where you are treading—loose tiles or floor boards, bits of carpet, etc., may have traps underneath with push igniters.

5. Don't move furniture, pictures, etc., without carefully examining for trip wires attached.

6. Don't open any box, cupboard, lid or drawer unless absolutely necessary. If necessary then make a careful examination for pull wires (usually inside).

7. Don't sit on any chair, sofa or bed until it has been looked over (and under).

8. The enemy tried to guess just what you'd be most likely to do on entering each room, so try to avoid doing the obvious or most natural thing until you are sure the enemy also wasn't expecting you to do it.

9. Because you don't find any traps at first glance, don't say "all right this house isn't trapped." Houses might contain only one trap.

PARTING WORD OF ADVICE

One final point: Don't assume familiarity with booby traps simply because you have studied this manual or because to date you have handled traps without trouble. Every new situation in territory recently held by the enemy should be viewed with caution and respect. Booby traps are a continuing hazard. Don't stop watching for them.

Healthy respect for the enemy is the point of this manual. Let's admit that the Jap is tricky, even if he is best at the tricks

his betters have taught him. Let's admit that the German is intelligent, even if Hitler has fooled him. But to hold either of them in fear and dread is fatal.

We don't need to let the thieves out of San Quentin to combat the booby trap. Good American boys with their background of cops and robbers are more than a match for Nipponese nastiness or Jerry jokes. And the more resolutely you push the enemy back, the less time you give him to lay, or lay well, his booby traps.

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NOTES

ON THE

AUTOMATIC TIME FUSE GRENADE

MODEL 1916

With Appendix 1

Translated from the French editions of August 22, 1916, and March 16, 1917, at Headquarters American Expeditionary Forces, France

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Reprinted by the

ARMY WAR COLLEGE

January, 1918

WAR DEPARTMENT
Document No. 731.
Office of The Adjutant General.

WAR DEPARTMENT,
WASHINGTON, *January 14, 1918.*

The following pamphlet, entitled "Notes on the Use of the Automatic Time Fuse Grenade, Model 1916, with Appendix I," is published for the information of all concerned.

[A. G. O., No. 062.1.]

BY ORDER OF THE SECRETARY OF WAR:

TASKER H. BLISS,
General, Chief of Staff.

OFFICIAL:

H. P. McCAIN,
The Adjutant General.

August 22, 1916.

FRENCH MINISTRY
OF WAR.

ARTILLERY.

NOTES ON
THE AUTOMATIC TIME FUSE GRENADE.
MODEL 1916.

I.

DESCRIPTION.

The 1916 model automatic grenade (F_1 or O F) is composed of a grenade body and an automatic fuse-plug, model 1916 B.

The fuse-plug is a tubular body, in which a slow fuse is placed, and on the inner end of which a detonator is set.

The head of the plug contains a widened cavity that is closed by an inserted cover.

Inside this cavity are two primers on either side of the end of the fuse. Between the two primers is a spring shaped like a pair of tongs, the branches of which have a tendency to separate so as to strike simultaneously each primer. A lug that passes through the cover of the firing-plug engages the two branches of the spring and keeps them in place.

This lug is actuated by a spiral spring placed on the outside of the plug; it is held down by an outside lever that is fastened first to a stud on the plug, and, secondly, by a safety split pin with a ringed head.

When this safety split pin is withdrawn by pulling it out by its ring, the outside lever is pushed up by the bolt, which is forced up by its spring.

At that moment the spring striker is freed and hits the primers. Even if one of the primers refuses to act, the other is sufficient to ignite the fuse. The fuse burns during five to seven seconds, then ignites the detonator that explodes the grenade.

II.

TRANSPORT OF THE GRENADES.

The fuse-plugs are sent to the army parks in cardboard boxes containing 50 plugs.

At the army parks the plugs are placed on the grenade bodies and the grenades packed in boxes with hinged cover, locks, and handles for carrying.

The empty boxes are returned to the parks. If these boxes are lacking, the grenades can be wrapped in paper and carried in any box, packed in with sawdust or wood fiber.

Carrying loose grenades in boxes or sacks must be avoided as much as possible. The soldiers must carry the grenades in the special boxes or in the 1916 model grenade belts.

III.

THROWING.

First—Take the grenade **fully** in the right hand, the plug up, the ring turned towards the chest and even with the root of the thumb. (Figure 1.)

The outside lever is then resting on the palm of the hand, and is easily held tight without effort.

Second—Put the first finger of the left hand in the ring and tear out the safety split pin. (Figure 2.)

The grenade is thus armed (cocked), and the hand must be kept closed to prevent the outside lever from springing off.

Third—Aim at the target with your left hand at arm's length and throw the grenade as prescribed in the "Instructions on Grenade Combat" of April 7, 1916. (Figure 3.)

Remarks—The grenade must be held as close to the plug as possible, so as to have the outside lever well in hand. Remove the safety split pin only at the time of throwing. After the safety split pin is out, hold the grenade firmly, but without straining; the strength needed to maintain the outside lever is insignificant, but must be continuous from the moment the grenade is "cocked" or "armed."

It is absolutely forbidden to hold the grenade when lighted, under the pretext that the time of combustion is too long.

Figure 1.

The grenadier will avoid keeping a "cocked" grenade too long in his hand, and, **above all, will not walk with** one, as the grenade might be inadvertently dropped in stumbling.

The normal functioning of the grenade is calculated for an elevation of 25 millimeters (1 inch) of the tail of the outside lever, but it may work exceptionally at a much lower elevation because of the tolerance allowed in manufacture. This is why it is recommended to hold the hand closed, and **not to play the lever up and down to ascertain if it will work well.**

Figure 3.

Figure 2.

The grenadier will soon learn that this grenade is easy to work, and is not dangerous unless it is treated carelessly. **If by inadvertence a grenadier should drop a "cocked" grenade, he must keep cool, pick up the grenade, and throw it far away before it explodes.**

The instructor, by developing the presence of mind of his grenadiers, may avoid a great part of the accidents always to be feared on account of unskillfulness.

During the practice he may, as an example, drop unexpectedly an unloaded grenade and count out loud from second to second; the grenade must be picked up, thrown, and all the men be in the dugouts before he reaches the number "five."

UNEXPLODED GRENADES.

All unexploded grenades must be considered as dangerous to the same degree as a fired and unexploded shell. Leaving unexploded grenades on the practice grounds must be avoided.

Because of the length of combustion of the fuse there is no danger in picking up an unexploded grenade as long as one takes the necessary precautions and throws it far away if it should ignite.

If a body of troops happens to camp on a place where there are unexploded grenades lying about, they must be removed as soon as possible.

To do this, all the men must take cover while one man proceeds to remove one grenade after another, possibly marking them beforehand by a twig or any other object.

Usually the failures come from non-ignition of the fuse or from non-ignition of the detonator; sometimes from a misplaced fuse-plug, and less frequently from unexploded primers.

When the hole of the lug is not filled with mud, it is easy to see if the caps have been fired, because in that case the tube is blackened. If so, the grenade is no more dangerous to handle than an ordinary grenade.

If the sides of the tube are white and shining, on the contrary, then the primers have not been exploded, and in that case the spring striker being in contact with the primers, a shock may be expected to ignite them. As a matter of fact, when a practice grenade, the primers of which have failed to work, is struck against a rock or a hard body, it is possible to break the plug in pieces before the primers will explode, and this is explainable by the small mass of the striker spring.

Be that as it may, when it is uncertain as to whether the primers have gone off, it is best to carry off the grenades by hand, one at a time, watching them so as to be ready to throw any that might become ignited.

The unexploded grenades are placed in a pile and exploded by a petard.

It is advantageous to use unexploded grenades in loading a fougasse.

It is absolutely forbidden to unscrew the firing-plug of a loaded grenade without using the special apparatus made to that effect with an arrangement to protect the operator from fragments.

If more than six (6) per cent failures are noted, it is best to report the fact, indicating the marks stamped on the fuse-plugs, so that the fabrication service can watch more thoroughly the machine shops whose products are defective.

PRACTICE GRENADES.

For grenade practice, use can be made of inert grenades, of grenades weighted and supplied with active detonators, or of regular war-loaded grenades.

To prevent confusion, the following conventions are established:

Grenades painted **grey** are war-loaded grenades.

Grenades painted **white** are weighted and supplied with active fuse-plugs.

Grenades painted **red** are provided with inert detonators (bored through) o without detonators (from condemned "lots").

"Lots" of fuse-plugs not satisfying the receiving conditions can be used for practice with weighted grenades, but not on war-loaded grenades. They will be stamped with a cross.

The firing-plugs that can be taken apart, that are furnished to instructors, are provided with inert detonators and bored through to prevent any uncertainty.

Note.—The outside levers and the fragments of tin that remain on the ground after a grenade practice represent a considerable value (about 25 centimes per grenade), and must be sent to the nearest artillery establishment when there is time to pick them up.

March 16, 1917.

MINISTRY OF
ARMAMENTS AND
WAR FABRICATIONS.

NOTES ON

THE AUTOMATIC TIME FUSE GRENADE.

MODEL 1916.

Approved August 22, 1916.

FIRST APPENDIX.

The aim of the present appendix is to bring to the attention of the grenadiers the danger that is run during the transport of automatic time-fuse grenades in which the safety split pin has not been sufficiently opened.

Some badly manufactured pins are, as a matter of fact, difficult to extract, and grenadiers may be tempted to close more or less the ends of the split pin before placing them in their grenade belt so as to suffer no interruption during an engagement and to obtain a maximum rapidity in throwing.

Such a proceeding is to be avoided, as the split pin, too far shut, may fall out at the slightest push, almost by itself, and provoke an unexpected explosion of a grenade.

It is necessary to leave the split pin just as it was placed at the factory until the very moment of throwing.

The transportation of grenades on which the branches of the split pins are less than seven millimeters (.28 inch) apart must be considered as dangerous.

As a precaution against the possibility that the safety split pins have not been properly opened at the factory, lifting grenades out of the packing cases and belts by their rings will be avoided.

N. B.—Mention of the present appendix will be made in red ink at the head of the "**Notes.**"

Paris, March 13, 1917.
The General of Division
Inspector of Technical Studies and Experiments
of the Artillery.
GOSSOT.

APPROVED:
Paris, March 16, 1917.
For the Minister and by his order
The General in charge of the Artillery.
SIGNED: RONNEAUX.

TM 9-227

WAR DEPARTMENT

TECHNICAL MANUAL

20-MM AUTOMATIC GUN M1 AND 20-MM AIRCRAFT AUTOMATIC GUN AN-M2

1 JUNE 1943

TECHNICAL MANUAL
No. 9-227

U.S. WAR DEPARTMENT
Washington, 1 June 1943

20-MM AUTOMATIC GUN M1 AND 20-MM AIRCRAFT AUTOMATIC GUN AN-M2

Prepared under the direction of the
Chief of Ordnance

(with the cooperation of the Chief of the Bureau of Ordnance, Navy Department)

CONTENTS

*This manual supersedes TM 9-227, 19 November 1942; TB 227-4, 6 November 1942; TB 227-5, 5 May 1943; TB 227-6, 12 May 1943; Ordnance School Manual (OS) No. 9-3, 15 August 1941; and Ordnance School Manual (OS) No. 9-45, December 1942.

20-MM AUTOMATIC GUN M1 AND 20-MM AIRCRAFT AUTOMATIC GUN AN-M2

Section I

INTRODUCTION

1. SCOPE.

a. This manual is published for the information and guidance of the using arms and services. It contains information of a technical nature required by the personnel of the Army and Navy for the identification, use, care, and preservation of the 20-mm Automatic Gun M1 and 20-mm Aircraft Automatic Gun AN-M2, and of the accessories and ammunition used therewith.

b. This manual differs from TM 9-227 of 19 November 1942 as follows:

(1) The material has been arranged to conform with gun type designations.

(2) The table of data has been enlarged.

(3) The material has been enlarged to cover the adapters, chargers, and electric trigger.

(4) Instructions for the disassembly and assembly of the 20-mm feed mechanism AN-M1 have been revised and simplified.

2. CHARACTERISTICS.

a. Description.

(1) The 20-mm Automatic Gun (figs. 1 and 2) is a combination blowback and gas-operated aircraft weapon. The gun is air-cooled and has a cyclic rate of fire of 600 to 700 rounds per minute. It is designed for mounting as a fixed gun in the wing or fuselage of an airplane. It may also be mounted to fire through the hub of the propeller, and may be mounted as a flexible gun in a turret. The gun cannot be synchronized to fire between the propeller blades of an airplane.

RA PD 66716

Figure 1 — Basic Gun — Right Side

RA PD 66717

Figure 2 — Basic Gun — Left Side

Figure 3 — Breechblock Modifications

(2) The gun can be fed by a drum type magazine or a feed mechanism using a disintegrating link belt. The name and serial number of the gun and name of manufacturer are stamped on the top of the receiver just to the rear of the magazine slide. The serial number of the tube, name of gun, and name of manufacturer are stamped on the tube just ahead of the gas cylinder bracket. The serial numbers of the gun and of the tube will usually be different. The serial number on the receiver is the actual serial number of the gun. Any reports sent in should, however, give both serial numbers.

b. Current Modifications. Several modifications of the gun described in TM 9-227, 19 November 1942, have been adopted by the Army and Navy. These modifications (figs. 3, 11, and 12), which do not affect troop use, are as follows:

(1) The inertia blocks with plungers and springs have been replaced by solid inertia blocks which do not have oil grooves.

(2) The coil extractor spring has been replaced by a cantilever (pin) spring.

(3) The transverse slot in the firing pin has been elongated by about $\frac{1}{16}$ inch to permit movement of the firing pin on the breechblock slide key.

(4) The breechblock lock has been filleted on the sides.

(5) The breechblock slide springs are heavier than those of early manufacture.

3. MODEL OF GUN USED BY THE NAVY.

a. The Navy uses the AN-M2 model, type E only (fig. 24).

4. MODELS OF GUN USED BY THE ARMY.

a. The army uses both the M1 and AN-M2 models, types A, B, C, and D (figs. 23 and 24).

b. Differences Between Models. The differences between the AN-M2 and M1 Guns are in manufacture only; these do not affect troop use or care, but are useful as means of identifying the different models. The guns are identical with respect to the construction of the tube and the working parts, the only differences being in the dimensions of some of the receiver parts. The AN-M2 receiver is 0.2 inch longer. Each receiver slide of the AN-M2 Gun has a projection which fits into a slot in the side of the receiver, and the receiver slide bolts are locked by cotter pins (fig. 4). In the M1 Guns, the receiver slides have no flanges and are riveted instead of bolted to the receiver. The shoulders on the bottom faces of the receiver sides serve as further

20-MM AUTOMATIC GUN M1 AND 20-MM AIRCRAFT AUTOMATIC GUN AN-M2

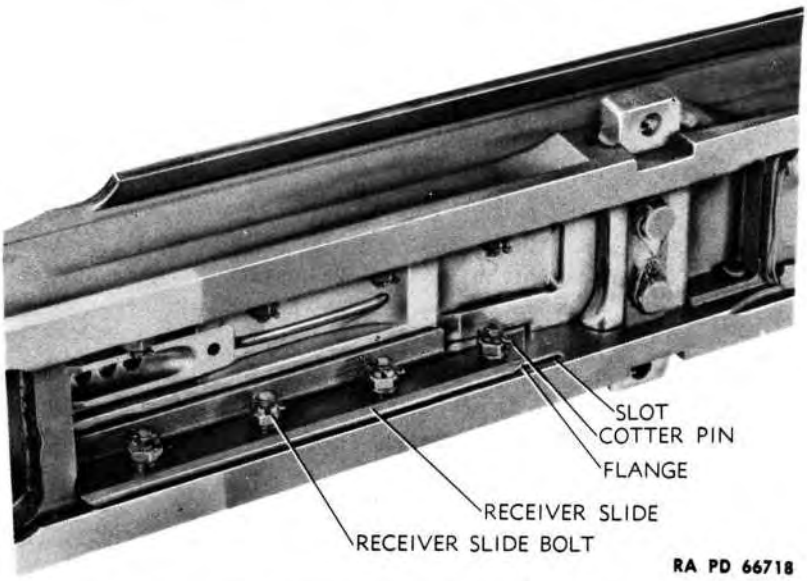

Figure 4 — Identification Marks on the AM-M2 Gun

means of identifying the M1 Gun (fig. 5). In some M1 Guns each receiver slide has a flange which overlaps the side of the receiver and the receiver slide bolts are locked by locking wire.

NOTE: The designations M2 and AN-M2 refer to the same gun. The name AN-M2 has been standardized by the Army and Navy for the M2 Gun.

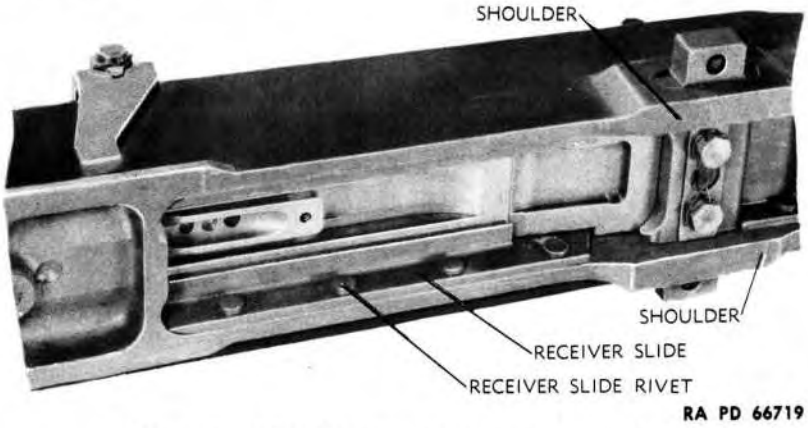

Figure 5 — Identification Marks on the M1 Gun

INTRODUCTION

5. DATA.

Weight of basic gun M1 or AN-M2 (approx.)	102 lb
Over-all length of basic gun (approx.)	93.7 in.
Weight of tube	47.5 lb
Length of tube	67.5 in.
Weight of 20-mm adapter AN-M1	11.3 lb
Weight of electric trigger AN-M1	5 lb
Weight of hydraulic charger M1	2.6 lb
Weight of 20-mm feed mechanism AN-M1	18 lb
Weight of 20-mm adapter M6	14 lb
Weight of 20-mm adapter M7 (thread protector)	7.5 lb
Weight of 20-mm adapter M7 (muzzle brake)	10.7 lb
Weight of muzzle brake M1	4.6 lb
Weight of sear mechanism M1	1.3 lb
Weight of manual charger M2	1.5 lb
Weight of 60-round 20-mm magazine M1 (empty)	22 lb
Muzzle velocity (HE-I or Ball ammunition)	2,850 ft per sec
Muzzle velocity (A.P. ammunition)	2,950 ft per sec
Rate of fire	600 to 700 rounds per min
Rifling:	
Number of grooves	9
Depth of grooves	0.015 in.
Width of grooves	0.205 in.
Width of lands	0.068 in.
Twist, uniform, right-hand, slope	7 deg
Length	63.08 in.
Bore of tube:	
Across rifling lands	0.787 in.
Across rifling grooves	0.817 in.
Chamber pressure (max.)	42,000 lb per sq in.
Travel of projectile in tube	63.68 in.

6. PRECAUTIONS.

a. All rounds should be lubricated just before they are inserted in the magazine or belt. Dip a cloth in OIL, lubricating, preservative, special. Then wring it out and wipe the cartridge case with it, applying a light film of oil. Extreme care must be taken to avoid oiling the primer (base of the case) or the joint where the case is crimped to the projectile.

20-MM AUTOMATIC GUN M1 AND 20-MM AIRCRAFT AUTOMATIC GUN AN-M2

b. Place the breechblock in the most forward (locked) position whenever the gun is to be disassembled. This is to reduce the tension on the driving spring and prevent possible injury when removing the driving spring guide.

c. Do not keep gun charged for any extended period of time.

d. Make certain that the gun is charged before take-off on all planes not equipped with remote-control chargers.

e. When checking the gun after assembly never allow the breechblock to go forward home under the pressure of the driving spring unless there is an empty shell or dummy round in the chamber. The empty shell acts as a cushion to prevent damage to the breechblock or tube.

f. Inspect all guns to see that the rear buffer threaded sleeve is staked to the housing at three places. This is done to prevent the sleeve from unscrewing during firing. Extreme caution must be exercised, however, not to overstake, as difficulty may be experienced in removing the stake when it is necessary to replace the rear buffer spring.

Section II

DESCRIPTION, FUNCTIONING, AND INSTALLATION

7. BASIC GUN.

a. Tube (figs. 6 and 7). The principal components of the basic gun are the receiver which houses most working parts, and the tube. The tube is threaded at both ends and has a radial gas port about 20 inches from the breech end. The breech end is screwed into the receiver and is secured with a locking pin to prevent the tube from vibrating loose during firing. The breech face of the tube is recessed to clear the lip of the extractor. The tube serves to accommodate the front mounting arrangements.

b. Gas Cylinder and Sleeve Group (figs. 8 and 79). The function of this group is to assist in unlocking the breechblock. It consists of a piston integral with a sleeve extension terminating in the form of a yoke which engages two push rods projecting through the front of the receiver. The gas cylinder piston is contained in and guided by the gas cylinder, the front end of which fits into the gas cylinder bracket and is secured by the threaded gas cylinder vent plug. The bracket is shrunk-fit over the gas port on the tube and is closed at the top by the gas cylinder bracket plug. The plugs are secured by a gas cylinder lock plate, washer, and locking wire. The vent plug has an opening through which a portion of the propellant gases is bled from the tube to force the piston and sleeve back. The sleeve is free to slide on the gas cylinder guide and force the two push rods against the breechblock slides. This action unlocks the breechblock. A piston spring, housed in the sleeve, returns the piston and sleeve to the forward position.

c. Receiver Assembly (fig. 9).

(1) The receiver houses most of the working parts. It consists of the receiver body and the receiver plate which is riveted to the rear under side.

(2) At the front end, the body is threaded internally to receive the tube; a vertical hole is drilled from the under side to accommodate

20-MM AUTOMATIC GUN M1 AND 20-MM AIRCRAFT AUTOMATIC GUN AN-M2

Figure 6 — Tube of Gun

Figure 7 — Tube — Front Portion

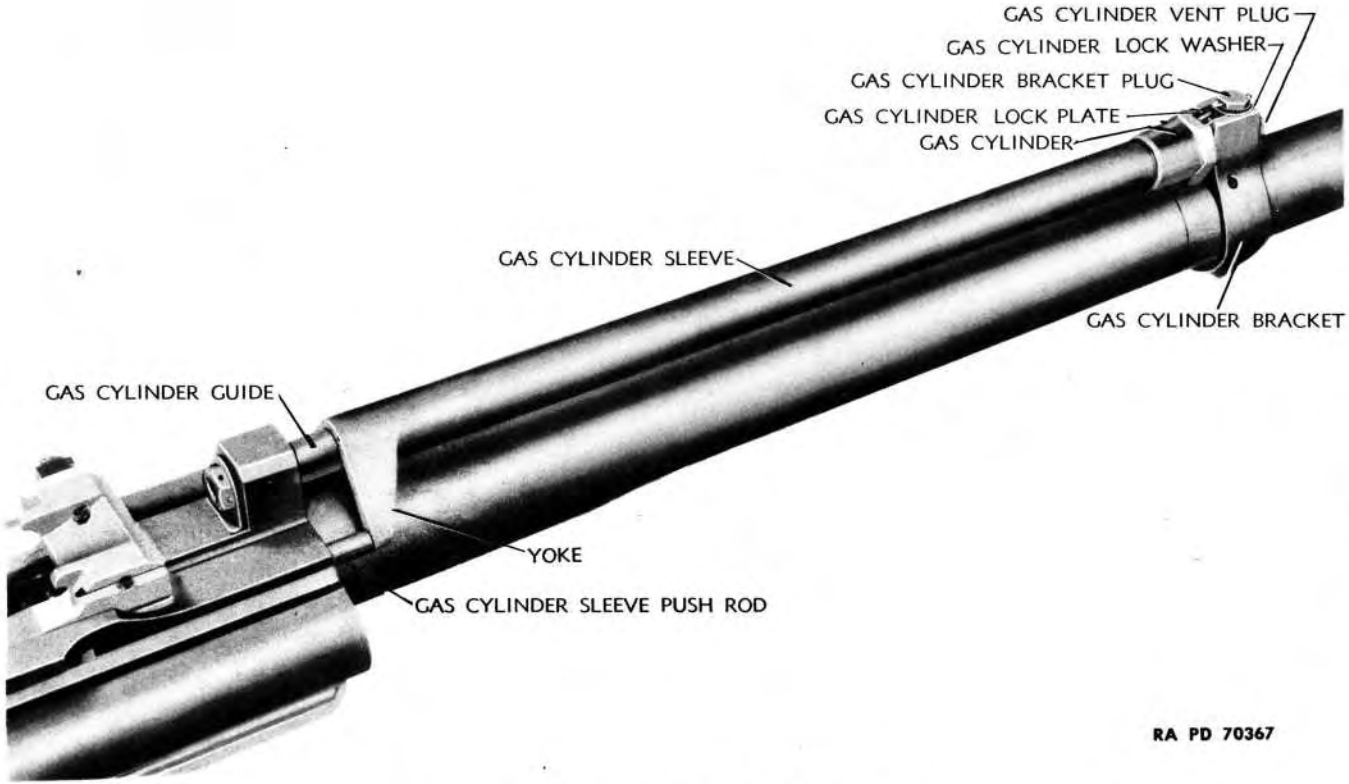

Figure 8 — Gas Cylinder and Sleeve Group

the tube locking pin. On top of the body is a lug which is threaded internally to receive the gas cylinder sleeve guide.

(3) On each side below the lug, longitudinal holes are drilled through the front of the body to house the push rods which push the breechblock slides to the rear. This action unlocks the breechblock lock.

(4) Integral with the right side of the receiver is a cylindrical charger housing which can be fitted with a manual or hydraulic charger for retracting the breechblock. A slot in the rear half of the charger housing permits the lug on the right breechblock slide to protrude into the housing so it can be engaged by the charger.

(5) The front under side of the body is open to permit ejection of empty cartridge cases. Above the ejector opening are two receiver slides which are bolted or riveted to the sides of the receiver and serve to support the breechblock in its forward movement. The slides have cammed surfaces at the rear which engage corresponding cams on the breechblock lock so as to cam it into the locked position, with the assistance of the camming action of the breechblock slides, as described in subparagraph e (3) below. To the rear of the ejector opening, a transverse slot is cut in each side of the receiver body to accommodate the breechblock locking key. The breechblock locking key engages the breechblock lock when the lock is cammed down into the locked position.

(6) At the rear, the under side of the receiver is partially closed by the receiver plate. The plate is designed to house the sear block group and to accommodate a firing mechanism.

(7) The rear of the body has vertical dovetail grooves for attaching the rear buffer assembly. Two guideways on top of the receiver body accommodate the magazine slide group. The magazine slide group mounts the ejector and provides a means for securing a feed mechanism to the gun.

d. Magazine Slide Group (figs. 10 and 78).

(1) The magazine slide has a guide on each side which provides for sliding engagement with corresponding guideways on the receiver body. Two longitudinal grooves are provided at the rear of the slide to accommodate the ejector and magazine latch. The magazine latch fits in the two upper grooves of the slide. The latch houses two springs which abut the magazine slide back plate and keep the latch under tension. The latch is operated by means of the magazine slide lever which is supported on two ears on the magazine slide by means of the magazine slide lever pin and bushing.

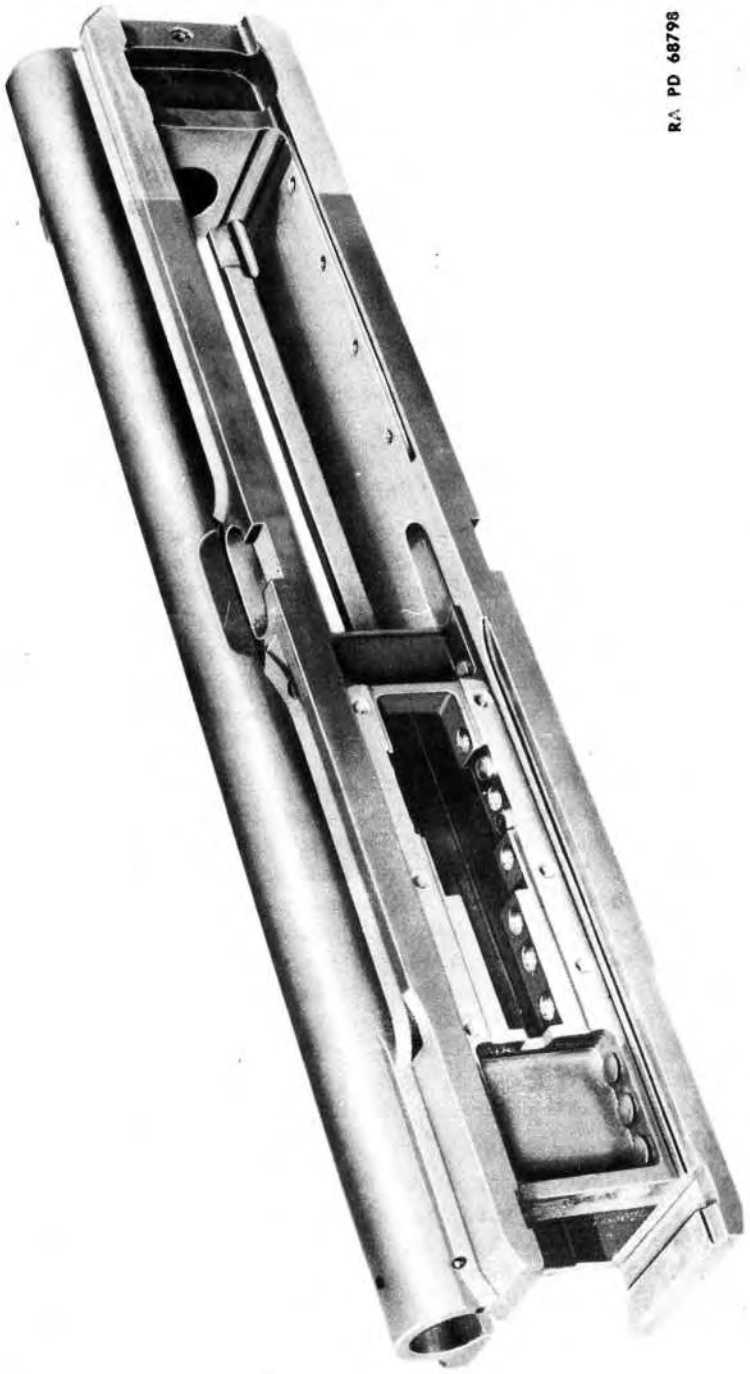

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Figure 9 — Receiver Assembly

(2) The feed mechanism is secured to the magazine slide at the front by the two hook-shaped projections on the slide, and at the rear by the magazine slide latch.

(3) The ejector fits into the lower two grooves in the magazine slide beneath the latch. It consists of two prongs projecting from a steel plate. The ejector plate houses two springs which contact the magazine slide back plate, and is fitted with a threaded stud. The stud passes through the back plate and is attached by a nut.

(4) The upper inner surfaces of the prongs are shaped to center the incoming round into the path of the breechblock as it moves forward. The top shoulders of the bolt move between the two prongs of the ejector. The prongs deflect the empty cartridge case downward as the breechblock moves to the rear.

e. **Breechblock Assembly** (figs. 11, 12, and 77).

(1) The breechblock assembly consists of the bolt assembly, two breechblock slides with springs and guides for the springs, a breechblock slide key, inertia blocks, firing pin, breechblock lock, and extractor, extractor spring, and breechblock slide key. The whole group is housed in the receiver. Its function is to carry the round from the mouth of the feed mechanism into the chamber, fire the round, extract and eject the empty case, and support it until it is deflected out of the receiver by the ejector.

(2) The bolt is bored from the rear to receive the firing pin, driving spring guide plunger, and driving spring. The upper shoulders of the bolt are cut away to clear the horns of the ejector, while the front face is recessed to accommodate the base of the cartridge case. The bottom of the bolt is recessed at the rear to receive the breechblock lock and at the front for securing the extractor. The extractor is attached by means of the extractor pin. A spring between the extractor and the bolt forces the claw at the forward edge of the extractor toward the face of the bolt. The extractor supports the empty shell from the chamber during the rearward motion of the bolt and supports it until it strikes the two prongs of the ejector. The extractor is then pivoted downward to allow ejection of the shell.

(3) Flanges along the lower edges of the bolt provide surfaces for guiding the breechblock slides. The slides are keyed together by means of a slide key passing through a slot near the forward end of the bolt. The breechblock slide key passes through a transverse slot in the firing pin with a clearance of approximately $\frac{1}{16}$ inch so that the firing pin can slide on the key. The lug on the rear end of the right breechblock slide extends through a slot into the charger housing for

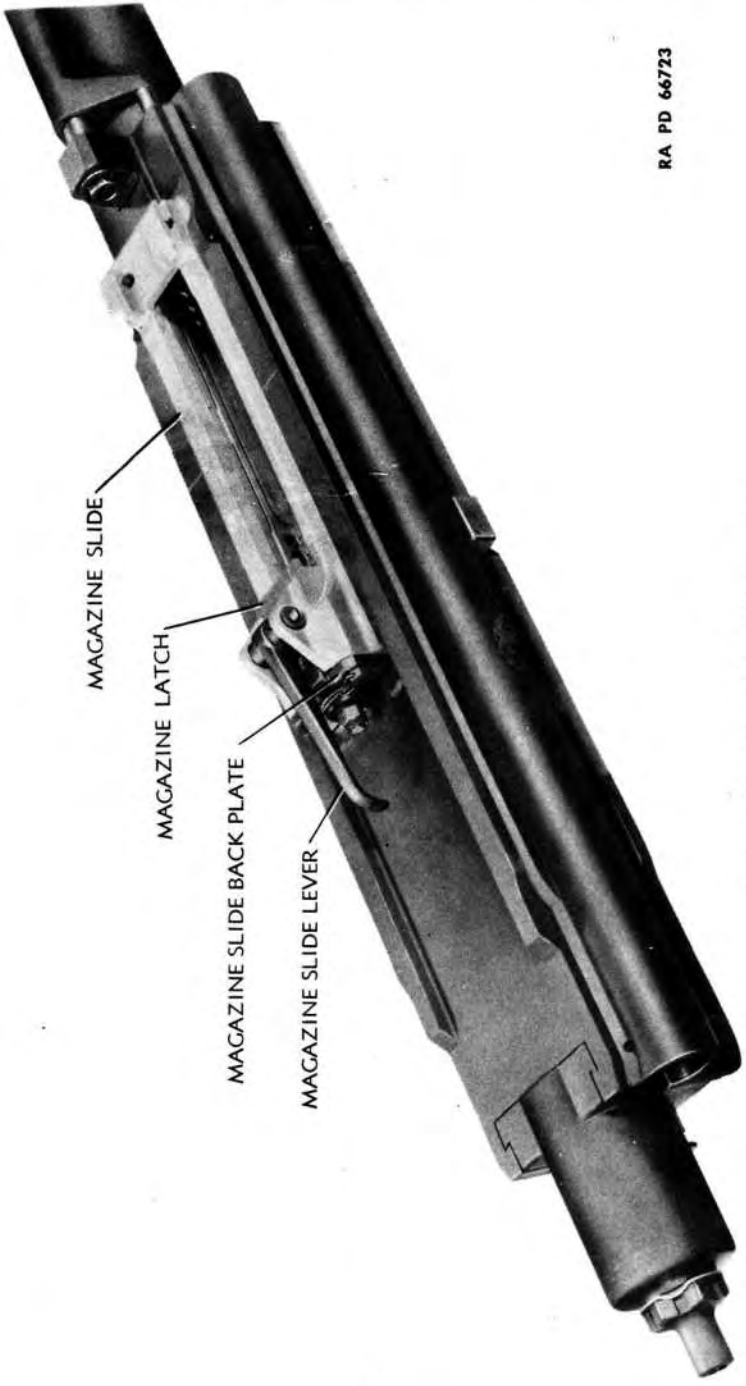

Figure 10 — Magazine Slide Group

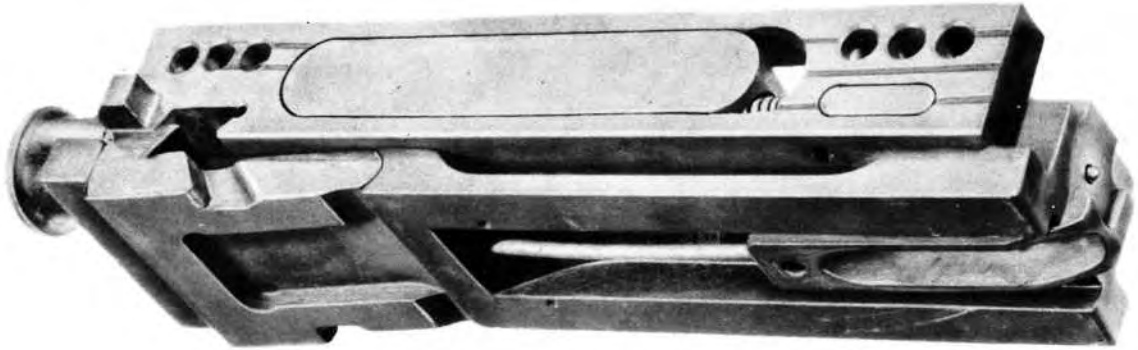

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Figure 11 — Breechblock Assembly — Present Manufacture

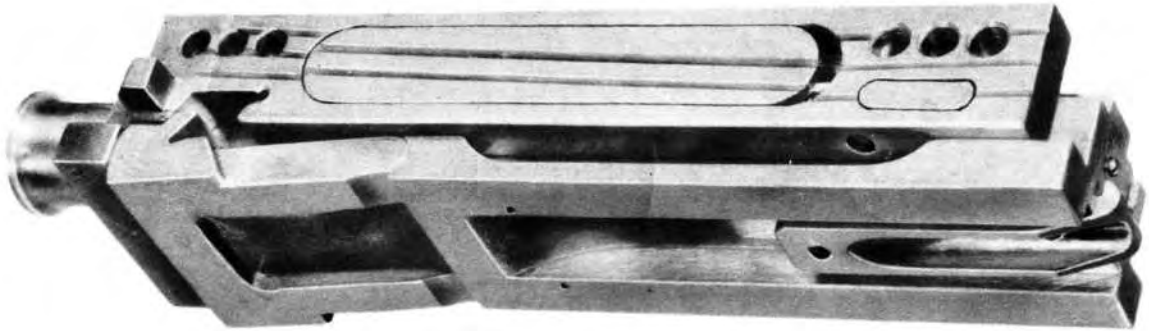

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Figure 12 — Breechblock Assembly — Early Manufacture

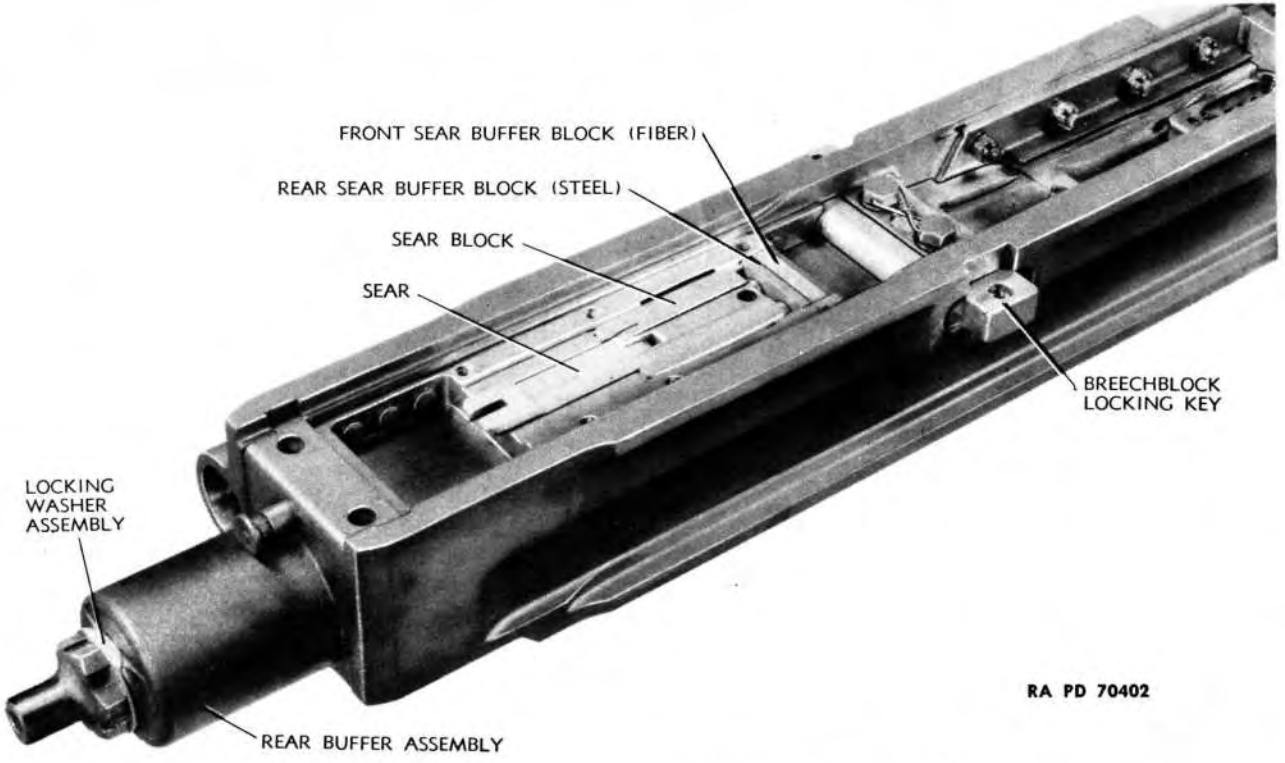

Figure 13 — Sear Block Group and Breechblock Locking Key

engagement with the charger. The rear of each breechblock slide spring guide passes through the hole in the breechblock pin and the front ball of the guide bears in a recess in the slide. The spring, which is mounted around the guide helps to drive the slides forward into the firing position and to prevent rebound of the slides. The bottom edges near the rear of the slides are cut to form cam surfaces. The foremost cam surfaces contact corresponding cam surfaces on the breechblock lock to unlock the breechblock lock. The rearmost cam surfaces act against the level at the rear of the breechblock lock during the forward motion of the slides, and assist the locking action of the receiver slides in lowering the lock into the locked position.

(4) A large slot in each breechblock slide accommodates an inertia block. The inertia blocks are cut away on the under side to accommodate the breechblock slide springs and guides. The function of the inertia blocks is to prevent rebound of the breechblock slides. The shallow grooves in the breechblock slides serve to distribute the lubricant and to collect any foreign matter.

(5) The breechblock lock is a flat plate with cams projecting from each side of its top surface. The rear surface of the lock is designed to engage the breechblock locking key. The rounded front edge of the lock hinges in the recess on the under side of the bolt. The bottom of the lock is recessed to engage the sear.

NOTE: In guns of earlier manufacture the breechblock assembly differs from the one described above as follows: The inertia blocks are provided with plungers and springs; the firing pin fits snugly over the breechblock slide key; the extractor spring is coiled; the inertia blocks have shallow grooves to distribute lubricant and collect foreign matter.

f. Breechblock Locking Key (fig. 13). The breechblock locking key passes through the transverse slots in the sides of the receiver. It is prevented from moving laterally by the plate positioned between the sides of the receiver body and secured to the key by screws and lock washers. The screws are locked by locking wire. The top front face of the key is beveled to permit engagement by the breechblock lock when it is cammed down into the locked position. Two tapped holes are located in the ends of the key which protrude past the sides of the receiver. These two outside holes provide a means for mounting the rear of the gun in some airplane installations. Below the bevel are two projections which support the breechblock lock when it is lowered to the locked position.

g. Sear Block Group (figs. 13 and 82). The sear block group consists of the sear and sear block, together with sear buffer springs, plungers, and blocks. The sear is hinged to the rear of the sear block

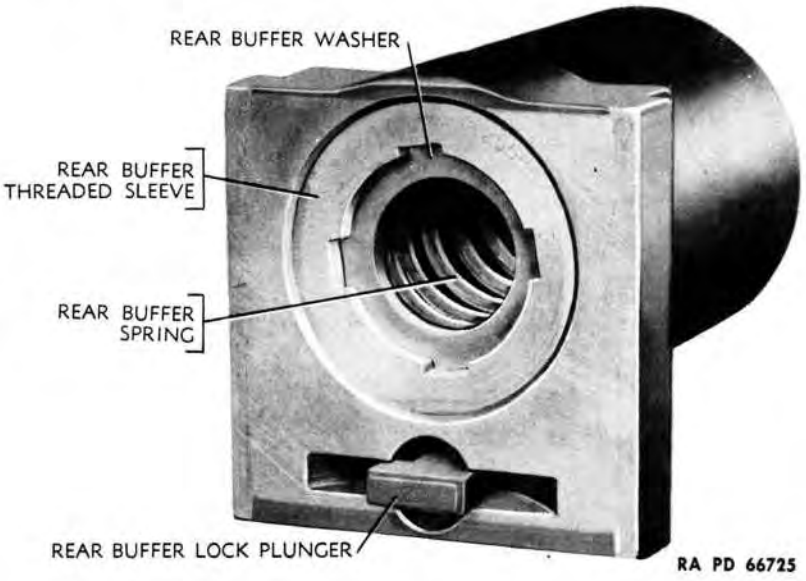

Figure 14 — Rear Buffer Assembly

by a pin. The rear of the sear is forked for engagement with the shaft of a firing mechanism. The sear is operated by the shaft of a firing mechanism and its function is to retain the breechblock in the retracted position by engaging the recess in the bottom of the breechblock lock. The sear block is drilled through the front to house the sear buffer springs and plungers. The sear buffer blocks, one of steel and one of fiber, provide a front abutment for the sear buffer springs and plungers. The steel block should be adjacent to the plungers; the flat surface of the fiber block should be adjacent to the steel block. The function of the sear buffer springs is to absorb the shock when the sear and breechblock engage. Any pressure on the sear is taken on the radial bearing surfaces of the sear and sear block and not on the pin itself. The vertical hole near the front of the sear block is for inserting the sear buffer spring retaining tool. The tool engages the circumferential grooves on the plungers and holds the springs under compression when the group is removed or replaced (fig. 80).

h. Rear Buffer Assembly (figs. 13, 14, and 72).

(1) The rear buffer assembly is joined to the receiver body by means of a dovetail connection and a lock plunger which engages a slot in the receiver plate and prevents vertical sliding of the rear buffer. The function of the rear buffer is to cushion the shock of the recoiling breechblock assembly, stop the recoil, and start the breech-

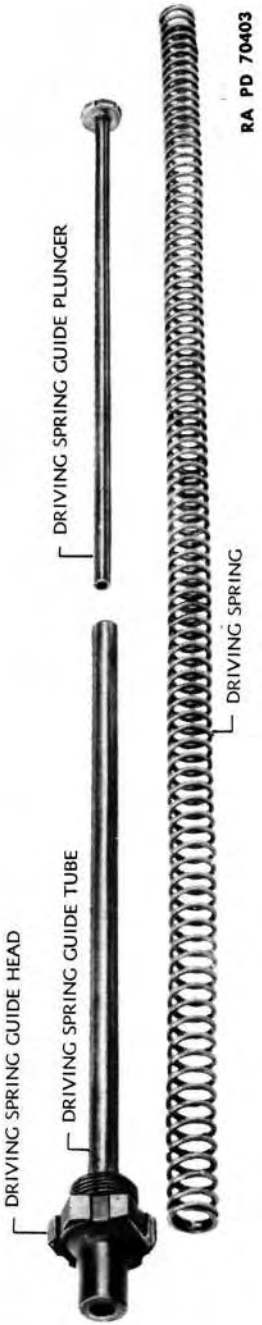

Figure 15 — Driving Spring Guide Group

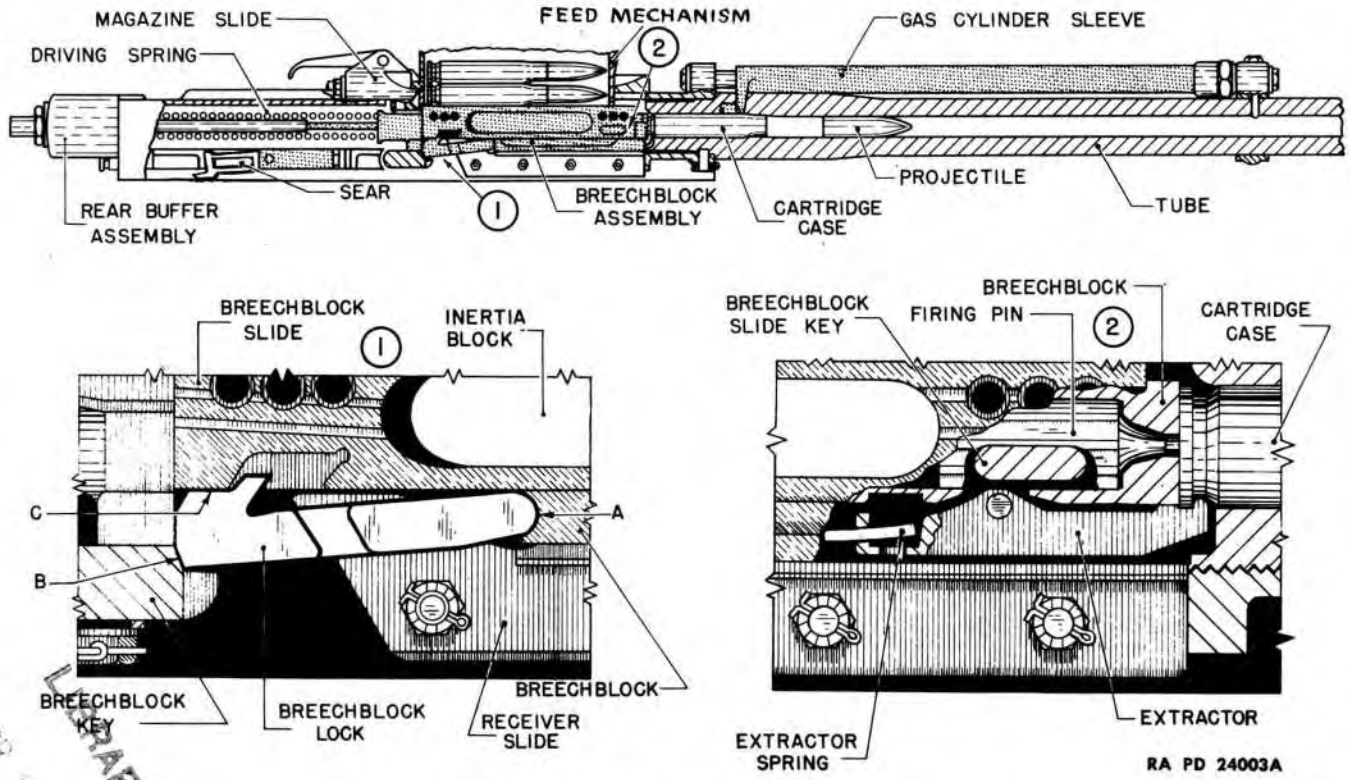

Figure 16 — Gun Mechanism Shortly After Firing

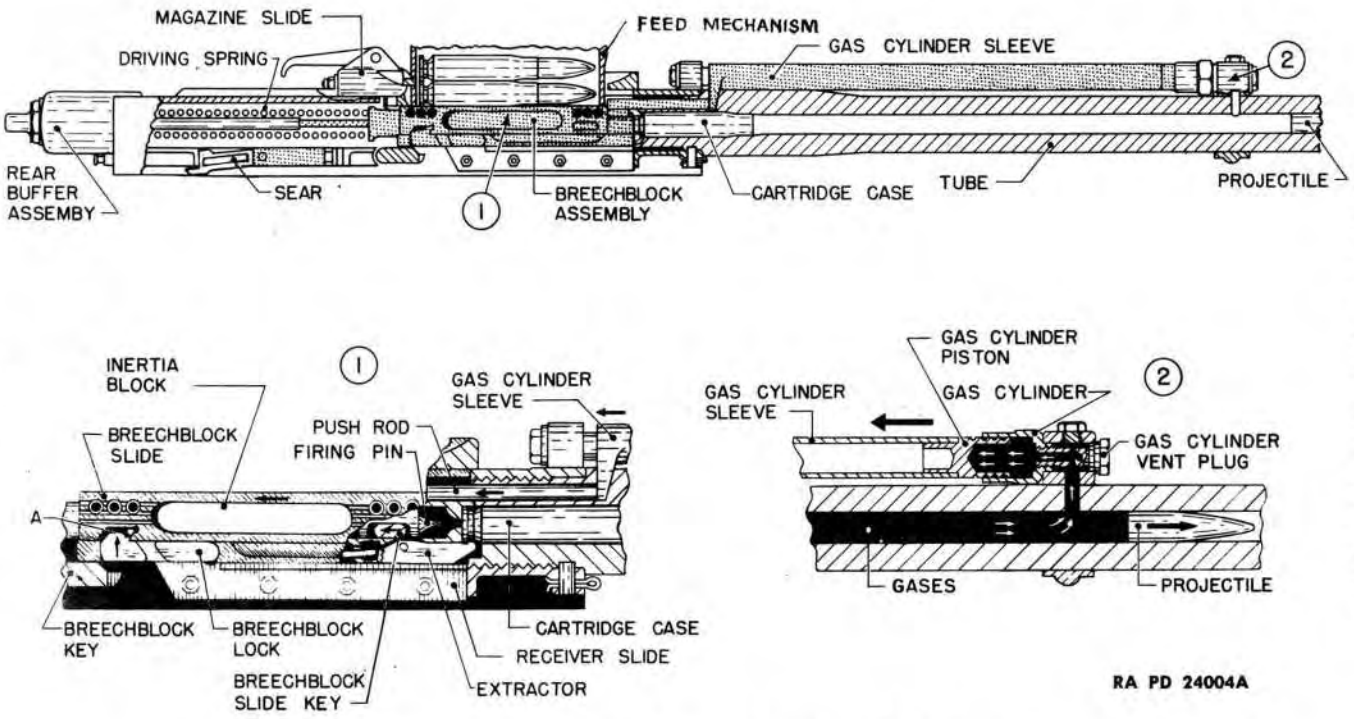

Figure 17 — Gun Mechanism During Breechblock Unlocking

block assembly on its forward movement. This action, plus the action of the driving spring, accelerates the breechblock assembly rapidly on the start of its forward motion, and thus maintains firing speed. The rear buffer houses a spring which is placed under initial compression by screwing the rear buffer threaded sleeve into the housing until it bottoms. Between the spring and flange of the sleeve is a washer which transmits the shock of recoil to the spring when the breechblock is driven to the rear on the recoil stroke. The rear face of the buffer housing is threaded to receive the driving spring guide head.

(2) The rear buffer is provided with a retainer assembly which prevents the driving spring guide head from unscrewing. The assembly is a washer with a flange and a pin projecting from the face. The pin engages a hole in rear buffer housing and the flange engages a recess on the housing. In assembling, the rim of the washer is bent over a flat of the driving spring guide head to lock it.

i. Driving Spring Guide Group (fig. 15). The driving spring guide group consists of the driving spring, guide, and plunger. The plunger fits into the interior of the bolt and the head rests against the back of the firing pin while the rear end slides in the driving spring guide tube. The driving spring is positioned between the head of the plunger and the head of the driving spring guide. The function of the driving spring is to drive the breechblock group forward to fire an initial round and assist in firing all rounds. It also retards the rearward motion of the bolt.

8. FUNCTIONING OF THE GUN AS A WHOLE.

a. The following is an account of a complete firing cycle from the explosion of one propelling charge to the next.

(1) At the moment of firing, the projectile starts down the tube, propelled by the expanding gases. The firing pin is in its forward position, having struck the primer of the cartridge. The breechblock is held in its forward position by the action of the breechblock lock. The lock engages the breechblock at point "A," figure 16, and bears against surface "B," figure 16, of the breechblock key. The breechblock slide engages the lock at point "C," figure 16, preventing the lock from being forced upward prematurely.

(2) As the projectile moves forward, it passes the gas port (fig. 17). A portion of the expanding gases enters the gas port, passes through the gas cylinder vent plug, enters the gas cylinder, and exerts pressure on the gas cylinder piston. This piston moves rearward, carrying with it the gas cylinder sleeve. The yoke on the rear end of the gas cylinder sleeve engages the push rods and carries them rearward. The push rods, in turn, contact the breechblock slides. The slides are connected

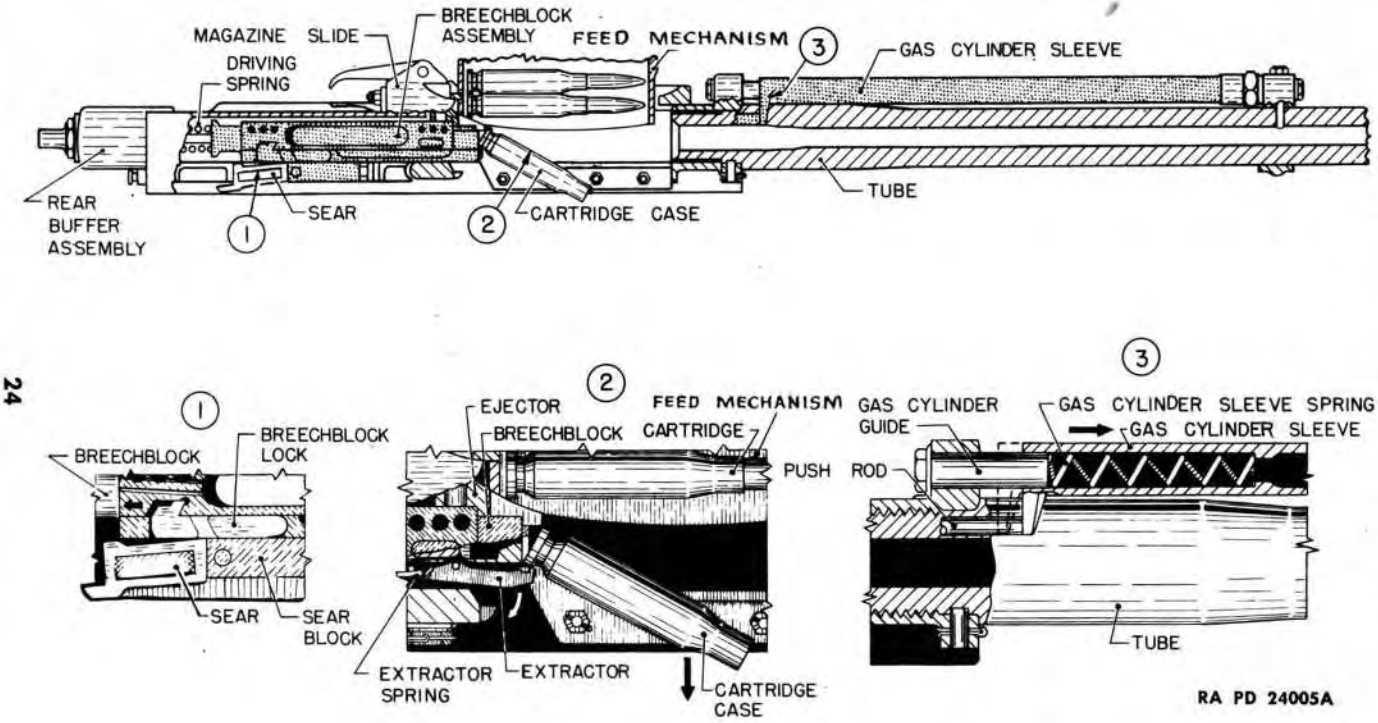

Figure 18 — Gun Mechanism — Cartridge Being Ejected

by the breechblock slide key, which also engages a slot in the bottom of the firing pin. As the breechblock slides are forced rearward by the push rods, the key carries the firing pin rearward. When the lock has been brought to a horizontal position the breechblock is forced to the rear by direct blowback.

(3) When the breechblock assembly is moved to the rear, the empty cartridge case which has been forcing the bolt back by blowback action is contacted on the upper edge by the two prongs of the ejector (fig. 18), forcing the cartridge case to pivot about and force downward the forward end of the extractor. The cartridge case leaves the lip of the extractor and moves through an opening in the bottom of the receiver, completing the ejection of the empty cartridge case (fig. 18). When the cartridge case frees itself from the extractor, the extractor is returned to its normal position by the action of the extractor spring. By this time the gas cylinder sleeve has been returned to its forward position. The gas cylinder sleeve spring, which was compressed during the rearward movement of the sleeve, expands when the gas pressure drops, forcing the sleeve and piston forward.

(4) When the breechblock is sufficiently far to the rear to clear the feed mechanism, a new round is forced downward into the mouth of the feed mechanism by a spring in the mechanism that maintains pressure on the new rounds. In recoiling, the breechblock compresses the driving spring. As the breechblock nears the end of its rearward movement, it strikes the rear buffer and compresses the buffer spring, which absorbs the remaining force of recoil and brings the breechblock to a stop (fig. 19). As the breechblock comes to a stop, the inertia blocks continue to move rearward in their slots in the breechblock slides until they reach the end of the slots. By this time the breechblock has started forward again and the inertia blocks remain in a rearward position with respect to the breechblock slides during the forward motion of the breechblock. The function of the sear will be described later, but it should be noted at this point that it is held in a downward position during automatic fire, allowing the breechblock to move through its cycle without being caught and held at the rear.

(5) The rear buffer spring and the driving spring expand, forcing the breechblock forward (fig. 20). During this motion the breechblock engages the new cartridge which has been positioned in the mouth of the feed mechanism. As the cartridge is forced forward, it drops into the recess in the bolt where it is gripped by the lip on the extractor as it enters the chamber.

(6) As the breechblock reaches the end of its forward motion (fig. 21), it seats against the end of the tube, closing the chamber. The momentum of the slides and the action of the slide springs cause the slides

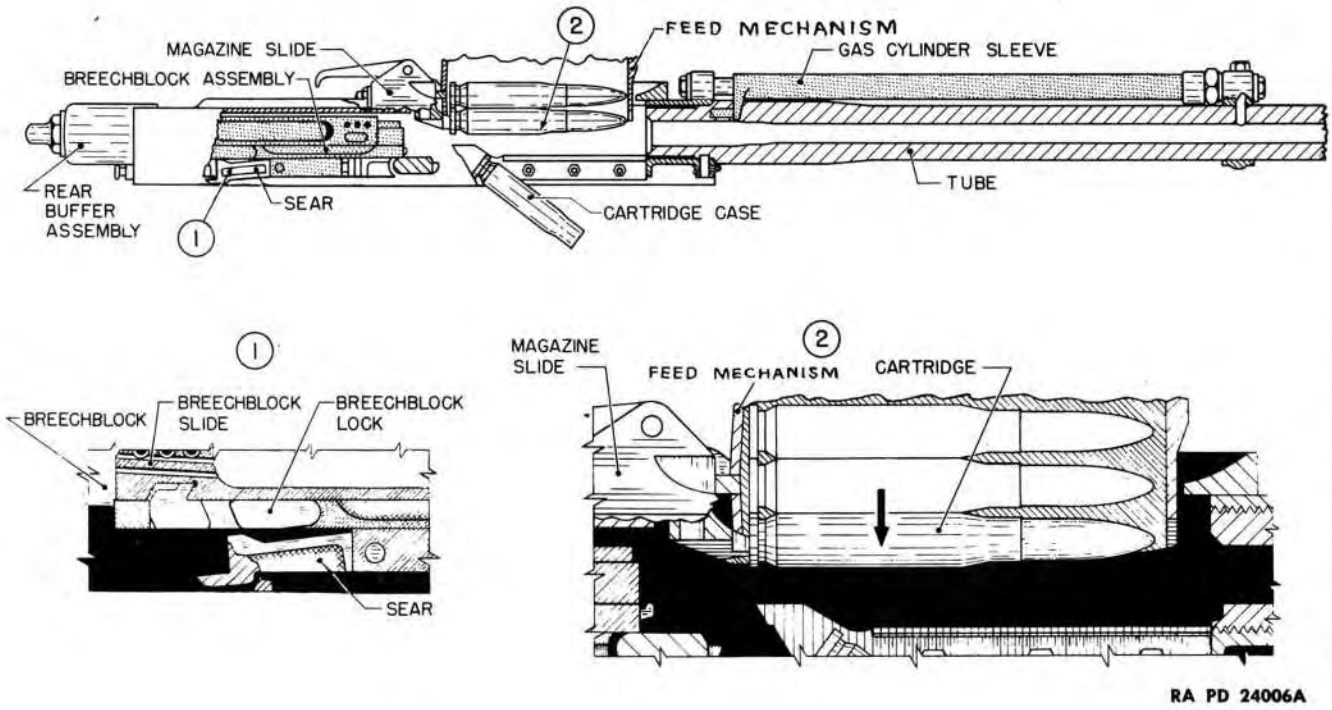

Figure 19 — Gun Mechanism — Breechblock in Rearmost Position

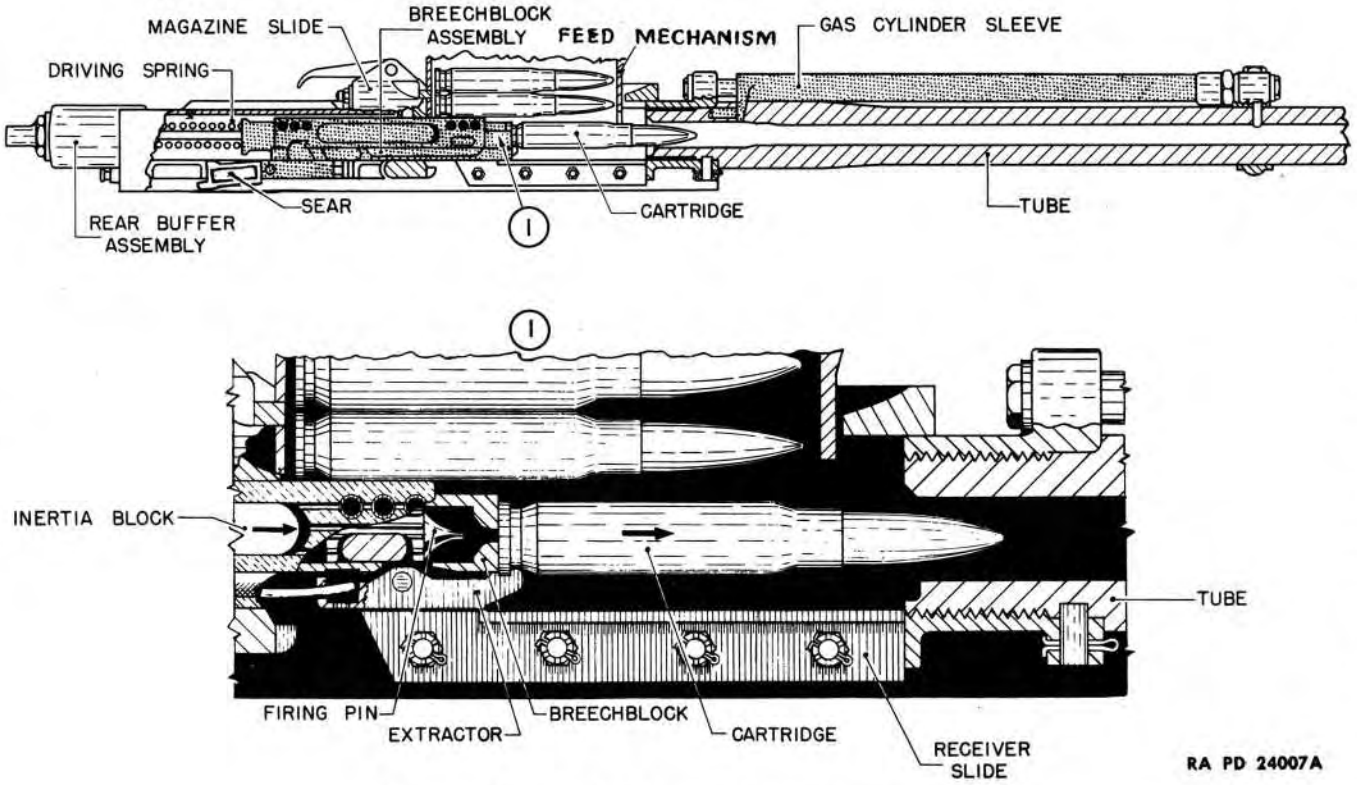

Figure 20 — Gun Mechanism During Ramming

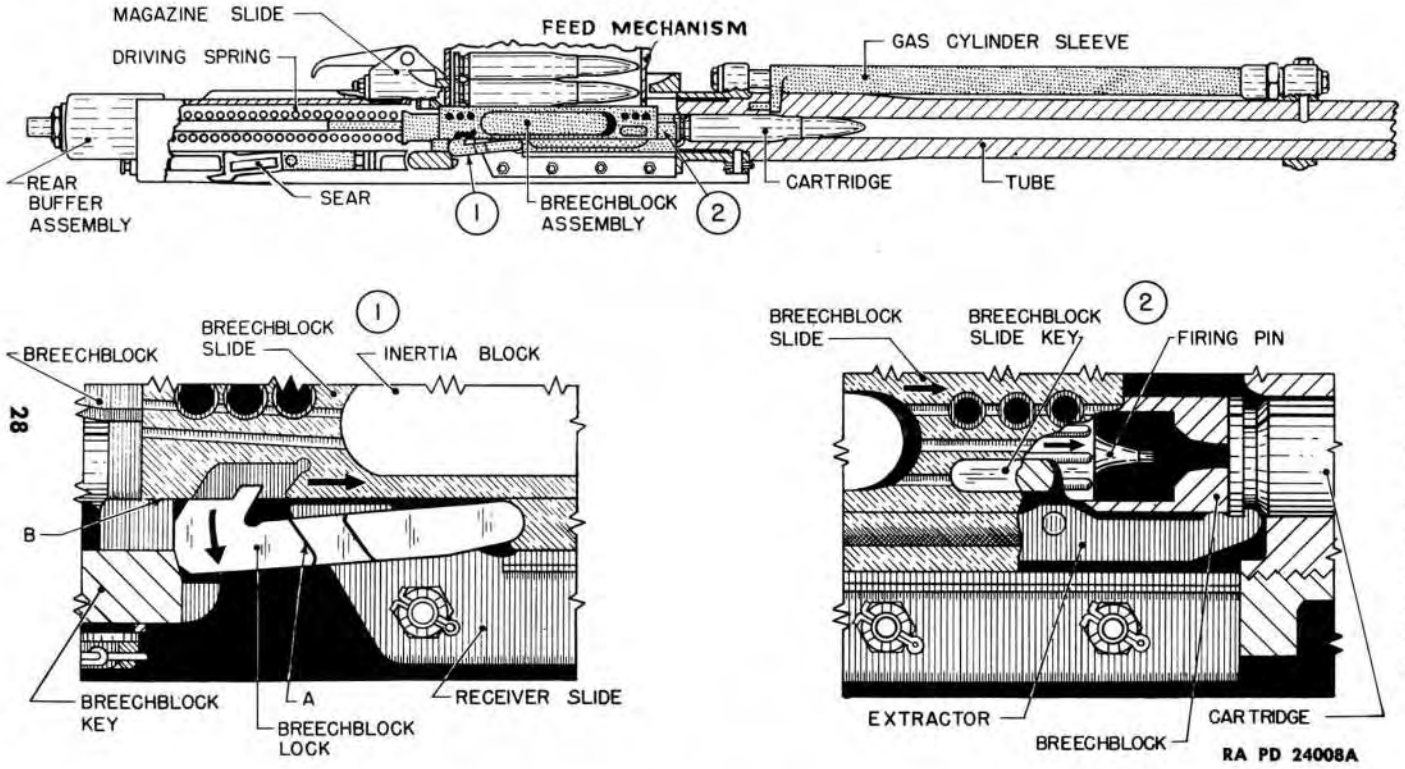

Figure 21 — Gun Mechanism Ready to Fire

to continue to move forward, releasing the breechblock lock. At the same time, projecting cams "A," figure 21, of the lock are engaged by cam surfaces on the receiver slides which, together with the action of the breechblock slide cams on the level of the lock, cam the lock downward. The lock seats against the breechblock key and is locked in its downward position by the lower surface "B," figure 21, of the slides which move over the end of the lock. When the slides reach the end of their forward motion, the inertia blocks continue to move forward for a short distance, counteracting any tendency that the slides might have to rebound. As the breechblock slides continue forward, they carry the firing pin with them on the breechblock slide key. The firing pin is free to move on the breechblock slide key and will continue forward under the force of its inertia. Thus the firing pin will strike the primer even though the breechblock slides may rebound slightly. As the firing pin strikes the primer of the cartridge, it fires it and starts the cycle all over again.

(7) To stop firing of the gun, the firing mechanism is released (fig. 22) and the sear is forced upward. As the breechblock moves rearward, it forces the sear down. As the breechblock moves forward, the sear rises again and enters a recess on the under side of the breechblock lock, engaging the lock at point "A," figure 22, and stopping the forward motion of the breechblock assembly. The shock is taken up by the sear buffer springs and plungers in the sear block.

9. GUN TYPE DESIGNATION.

a. The following gun type designation is based on the kind of adapter, sear actuating mechanism, and charger used with the basic M1 or AN-M2 Gun.

(1) Type A is used by the U.S. Army Air Forces. It consists of the basic M1 or AN-M2 Gun with AN-M1 adapter, AN-M1 electric trigger, and M2 manual charger (fig. 23).

(2) Type B is used by the U.S. Army Air Forces. It consists of the basic M1 or AN-M2 Gun with M6 adapter, AN-M1 electric trigger, and M2 manual charger (fig. 23).

(3) Type C is used by the U.S. Army Air Forces. It consists of the basic M1 or AN-M2 Gun with the M7 adapter (with thread protector), AN-M1 electric trigger, and M2 manual charger (fig. 24).

(4) Type D is used by the U.S. Army Air Forces. It consists of the basic M1 or AN-M2 Gun with the M7 adapter (with M1 muzzle brake), AN-M1 electric trigger, and M2 manual charger (fig. 24).

(5) Type E is used by the U.S. Navy. It consists of the basic AN-M2 Gun with the AN-M1 adapter, AN-M1 electric trigger, and M1 hydraulic charger (fig. 24).

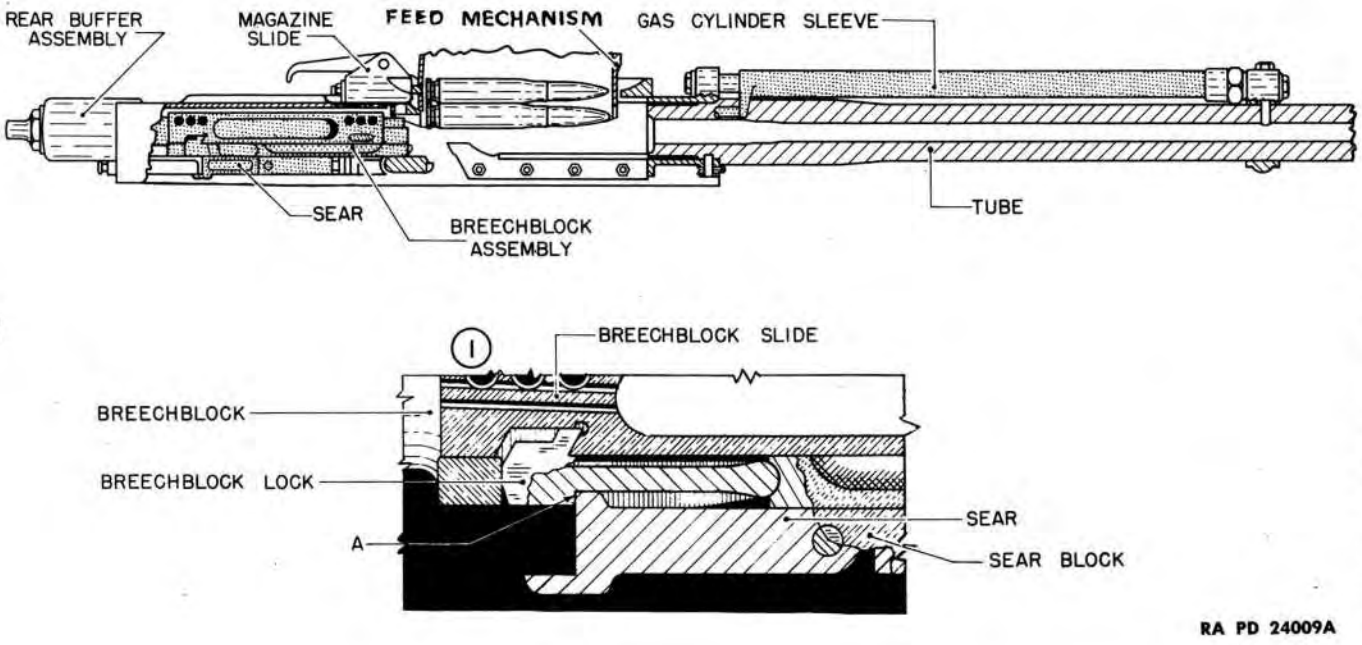

Figure 22 — Action of Sear

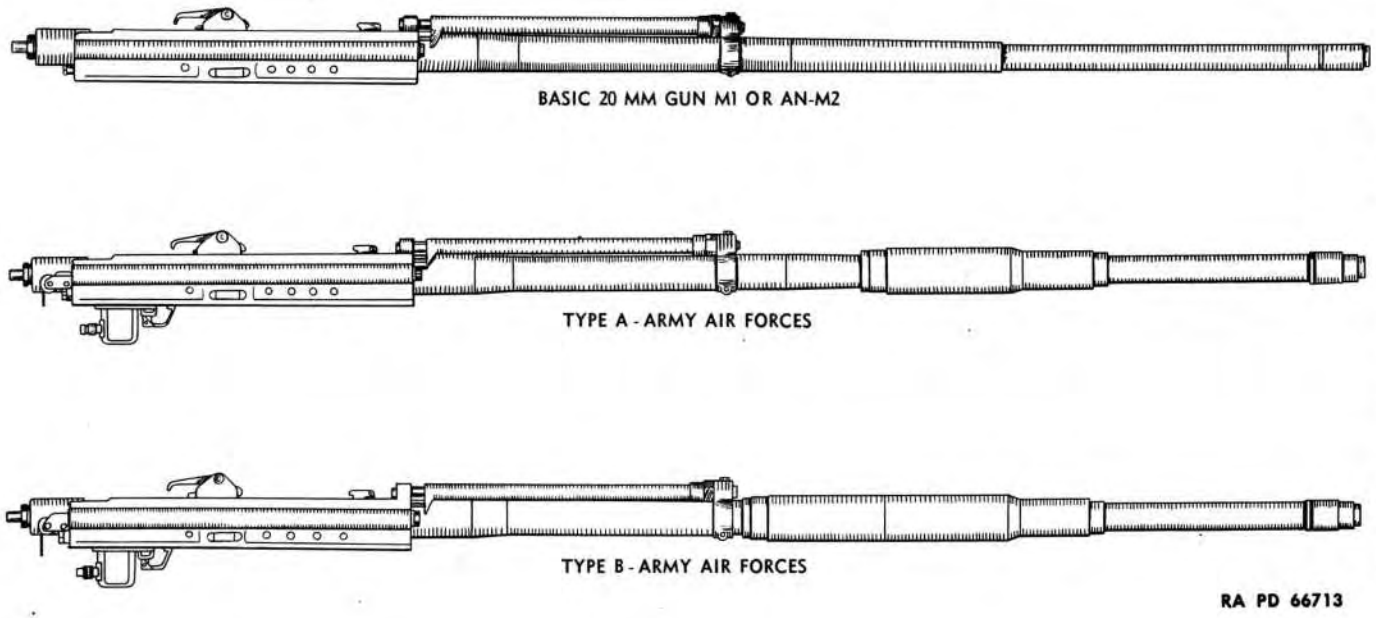

Figure 23 — Gun Type Designation Chart

20-MM AUTOMATIC GUN M1 AND 20-MM AIRCRAFT AUTOMATIC GUN AN-M2

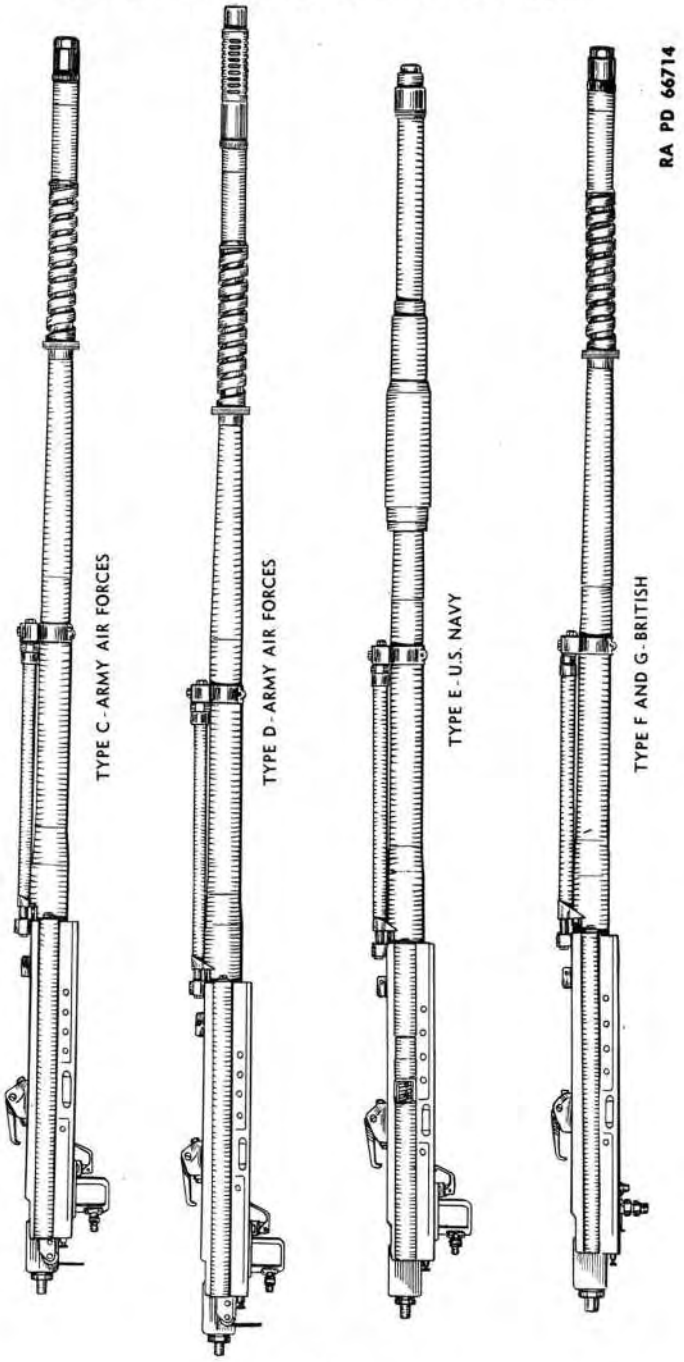

Figure 24 — Gun Type Designation Chart

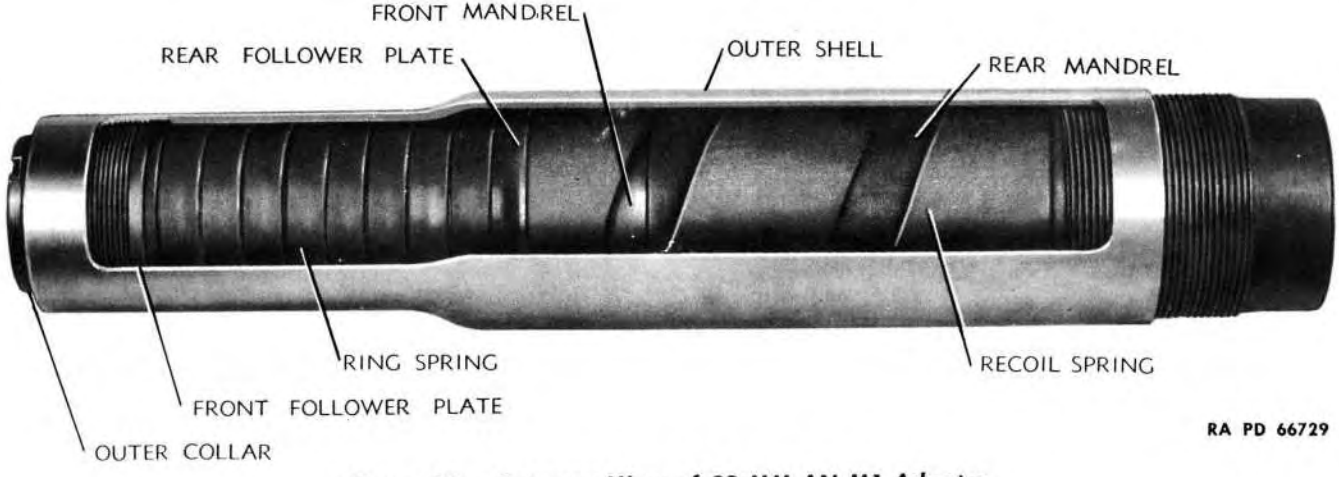

Figure 26 — Cutaway View of 20-MM AN-M1 Adapter

(6) The recovery of the springs returns the gun to battery. The adapter will act as a counterrecoil buffer if the gun should travel past its battery position. The ring springs will be compressed in the same manner as on the recoil motion of the gun, but the action of the parts will be exactly reversed to return the gun to battery. Thus, the energy of counterrecoil is absorbed and the gun is returned to battery.

b. Installation of 20-mm Adapter AN-M1.

(1) Installation of the adapter on the gun must be accomplished in conjunction with installation of the gun in an airplane. A mounting bearing assembly (figs. 27 and 28) is used to secure the adapter, and thus the gun, to the airplane structure. (The mounting bearing assembly is furnished by the airplane contractor.) It consists of a mounting bearing which screws onto the front mounting collar or the rear mandrel of the adapter, a bearing support, which is secured to the airplane structure, and a bearing support retaining screw which screws into the bearing support to secure the assembly. The bearing assembly can be mounted on the adapter in several different positions (fig. 29). When the correct point of mounting has been determined, the procedure described below should be followed:

(a) Slide the bearing sleeve onto the tapered portion of the tube with its smallest inside diameter forward. (The paint should be removed from the tube where the sleeve is installed to insure a tight fit.) Drive the sleeve onto the tube firmly with a soft hammer and tighten the three setscrews with the Allen hexagonal key wrench supplied with the adapter. Stake the setscrews in place and stone down any burs raised by staking so that the adapter will slide freely over the bearing sleeve.

(b) Screw the appropriate bearing tightly onto the adapter and stake it in place. If the rear mounting extension is used, it should be screwed tightly onto the adapter and staked in place at the V-joint.

(c) Install the adapter and assembled bearing in the bearing support, which is secured to the plane structure, and screw in the bearing support retaining screw handtight.

(d) Install the gun in the adapter by sliding the tube through the adapter until the shoulder on the tube abuts its flange in the adapter, at the same time engaging the flanges on the side of the receiver in the rear mounting yoke. Slip the tube sleeve over the end of the tube and secure it by screwing up the tube sleeve nut tightly with the special adapter combination wrench.

(e) After boresighting the gun, tighten the bearing support retaining screw into the bearing support with the special spanner wrench and secure it with locking wire.

Figure 27 — Typical Installations of 20-MM Adapter AN-M1 and Mounting Bearing

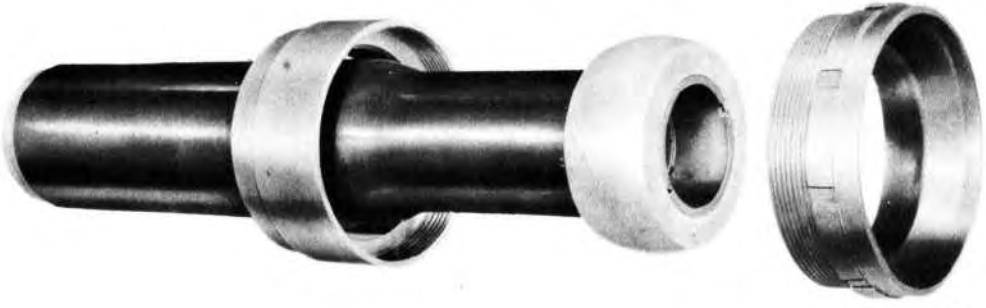

Figure 28 — Typical Bearing Assembly — Parts

20-MM AUTOMATIC GUN M1 AND 20-MM AIRCRAFT AUTOMATIC GUN AN-M2

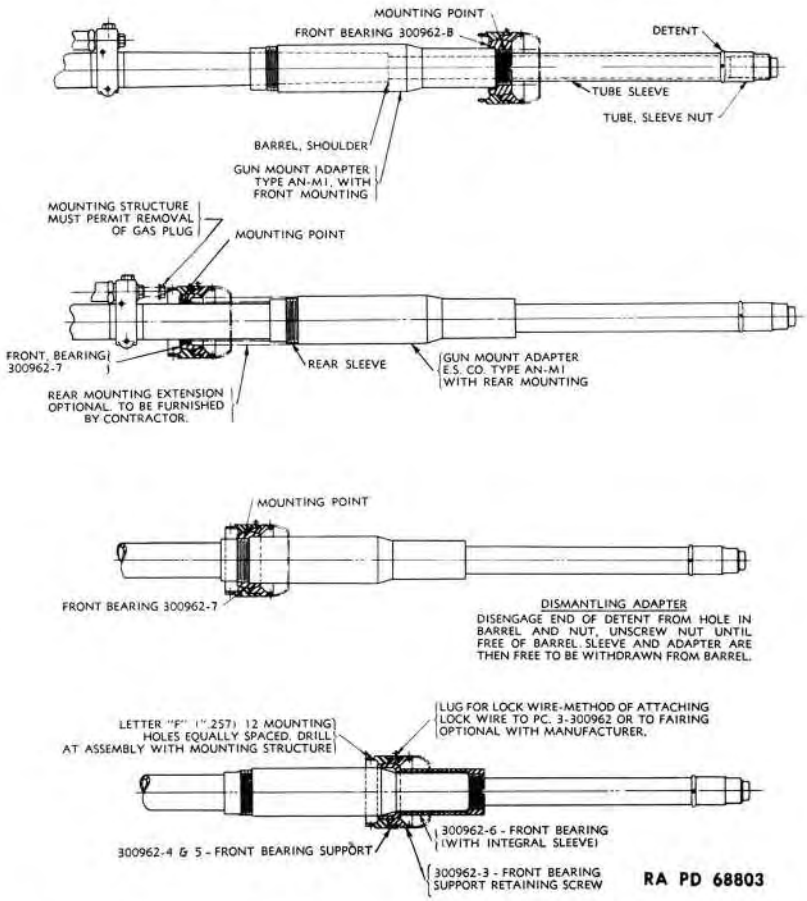

Figure 29 — Mounting Arrangements of 20-MM AN-M1 Adapter on Naval Installations

NOTE: The special adapter combination wrench and the special spanner wrench will be furnished in the 20-mm Aircraft Gun AN-M2 tool and accessory set.

(2) On some installations, when the feed and link chutes do not aline with the feed mechanism, minor adjustments (about 3/8 inch) of the position of the gun may be made by reversing the bearing on the adapter. This adjustment can be made with most bearings by unscrewing the bearing, turning it end for end, and reinstalling it.

(3) When removing a gun from an airplane, it is important to

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Figure 30 — 20-MM Adapter M6

disconnect the feed and link chutes, if necessary, from the feed mechanism, remove the feed mechanism, disconnect the electric trigger and the hydraulic charger, and disconnect the magazine slide from the front mounting structure to which it is attached.

c. Functioning of 20-mm Adapter M6 (fig. 30). This adapter consists of the AN-M1 adapter as described in subparagraph **a** above, to which a rear extension body has been added in order to increase the over-all length of the adapter by $8\frac{1}{16}$ inches to suit some mounting requirements. The rear extension is not staked prior to shipment, in order that it may be removed in the field and the adapter converted to the AN-M1 model. This flexibility is provided to take care of cases where the mounting requirements are indefinite at the time of shipment or where they may be changed. Before the M6 adapter is installed, the rear extension body must first be staked by peening the outer shell of the adapter at a point adjacent to the V-shaped notch at the front edge of the extension body.

d. 20-mm Adapter M7 with Thread Protector (fig. 31). The M7 adapter fits on the tube between the tube shoulder and the muzzle end. It consists of the dashpot piston, recoil spring with a recoil spring filler sleeve, recoil spring sleeve, a muzzle brake lock, and a thread protector. The short end of the piston abuts the shoulder on the tube while the long end rides against the rear of the recoil spring filler sleeve. The sleeve serves as a lining for the recoil spring. The recoil spring bears between the flanged recoil spring sleeve and a stationary mounting. In a typical installation (fig. 34) the front mounting has an inside circular shoulder which fits in front of the dashpot piston washer on the long end of the piston. In this manner the front face of the shoulder within the mounting serves as an abutment for the rear end of the recoil spring. The recoil spring sleeve is held in position by the muzzle brake lock and the thread protector. The muzzle brake lock is prevented from rotating by splines on the tube which mate with splines on the inside of the lock. The muzzle brake lock and thread protector are locked by mating teeth. As the gun recoils, the recoil spring is compressed against the shoulder in the mounting, thus reducing the force of recoil on the airplane structure.

e. 20-mm Adapter M7 with Muzzle Brake M1 (fig. 32). This adapter is the same as that described in subparagraph **d** above, except that the thread protector has been replaced with muzzle brake assembly which counteracts some of the recoil. A typical installation is shown in figure 35. The muzzle brake assembly consists of a front ferrule, body assembly locking washer, and rear ferrule. The body assembly is composed of a sleeve and eight baffles staked in place. It has 36

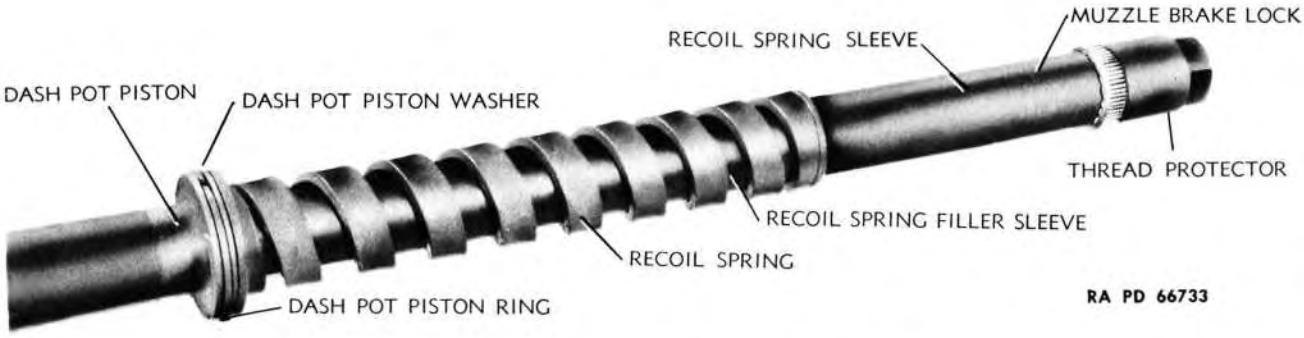

Figure 31 — 20-MM Adapter M7 with Thread Protector

Figure 32 — 20-MM Adapter M7 with Muzzle Brake

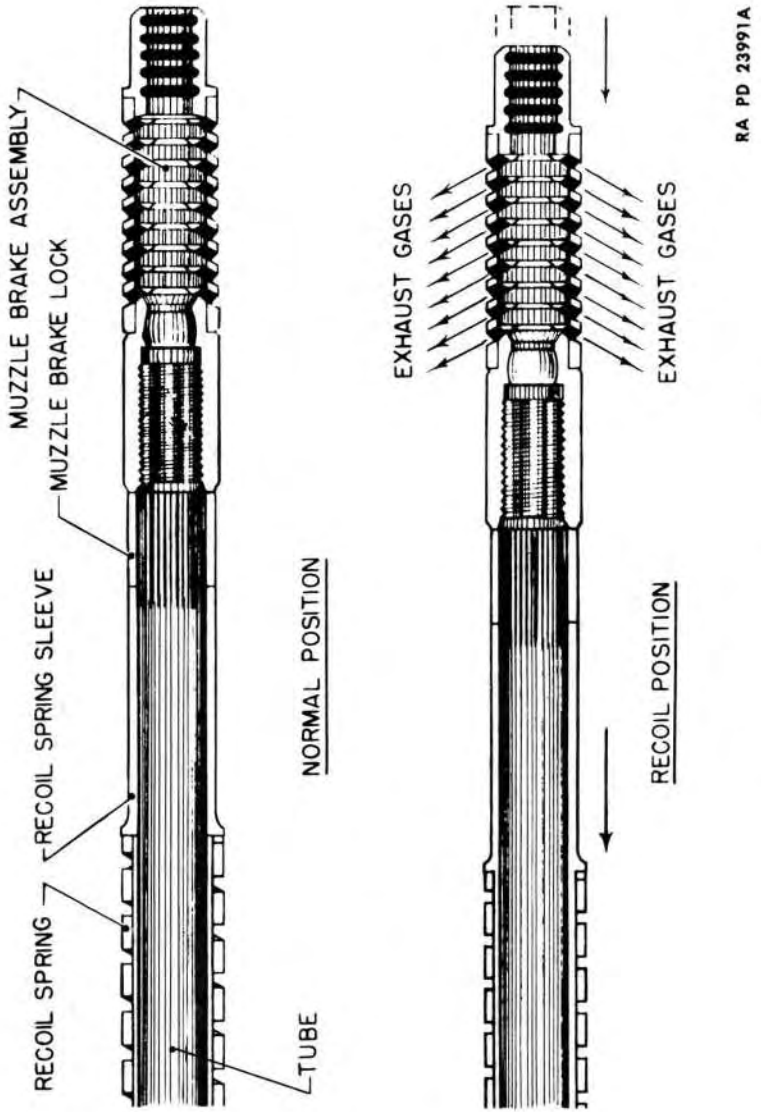

Figure 33 — Action of Muzzle Brake

Figure 34 — Typical Installation of 20-MM Adapter M7 with Thread Protector

Figure 35 — Typical Installation of 20-MM Adapter M7 with Muzzle Brake M1

equally spaced ports cut at an angle of 45 degrees to the axis of the bore. This construction causes a portion of the blast gases to be deflected to the rear, thus absorbing about 35 percent of the recoil action (fig. 33). This adapter is used only with the 60-round magazine which does not utilize the recoil energy of the gun for its operation.

11. SEAR ACTUATING MECHANISMS.

a. Electric Trigger AN-M1 (figs. 36 and 37).

(1) The electric trigger AN-M1 is a remote-control device designed to fire the 20-mm guns in airplanes that are equipped with 24-volt electrical systems. Prior to standardization as the electric trigger AN-M1, this device was known in the Navy as the Electric Trigger Control Mk. 6 Model 1 and in the Army as G17 Solenoid.

(2) The electric trigger is attached to the receiver plate of the gun. It consists essentially of the mounting plate assembly and solenoid body.

(3) The solenoid body is secured to the mounting plate by means of dovetail connections and the cam lever lock mechanism. The mounting plate assembly is secured to the bottom of the receiver plate by six cap screws and provides a means for rapidly mounting and dismounting the electric trigger. The mounting plate assembly incorporates the following:

(a) A solenoid alinement pin which fits into the slotted hole in the base plate of the solenoid body so as to aline the sear shaft with the sear of the gun.

(b) A sear spring pin and spring, housed in the solenoid clamping stud and protruding on the inside face of the mounting plate to act on the sear which engages the breechblock lock.

(c) A cam surface on the inside face of the plate just to the rear of the sear spring pin which insures positive engagement of the sear with the breechblock lock by its camming action against the mating surface of the sear when the sear is forced forward against the sear buffer spring by the breechblock.

(4) The solenoid assembly consists of a solenoid mounted on a base plate by a yoke. A plunger and a pinned sear shaft extend through the base plate and are free to move within the solenoid. There is an AND 10066-10S-2P receptacle mounted on the rear end of the yoke for connecting the trigger to the electrical system of the airplane. The solenoid draws a maximum of eight amperes from a 24-volt system.

(5) When the solenoid is energized, a magnetic field is set up which acts on the solenoid plunger and on the attached sear shaft to

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Figure 36 — Electric Trigger AN-M1 on Gun

Figure 37 — Electric Trigger AN-M1 — Installation

draw them into the solenoid against spring tension with a force of approximately 75 pounds. This force is large enough so that the gun will be fired regardless of the altitude of the plane in which the gun is installed.

b. Installation of Electric Trigger AN-M1 (fig. 37).

(1) Secure the mounting plate to the receiver plate with the six cap screws provided with the gun, using lock washers on the two rearmost screws. Lock the other four screws with locking wire. Proper lock wiring of this component is essential and should not be neglected for any reason.

(2) Attach the solenoid by raising the locking lever and slipping the solenoid on from the rear in such manner that the locking shoulder is slipped beneath the clamp which is actuated by the locking lever.

(3) Rotate the locking lever until the end abuts the plate and lock wire to the small screw in the plate.

(4) Connect solenoid to the electrical system of the airplane by mating the male and female electrical receptacles.

c. Sear Mechanism M1 (fig. 38). The sear mechanism is secured to the receiver plate by means of six cap screws; the two cap screws nearest the rear end require lock washers, and the other four cap screws and the sear housing are locked by locking wire. A hardened insert is fitted into a recess on the inside face of the plate. The purpose of this insert is to assure positive engagement of the sear with the breechblock lock by its camming action against the mating surface of the sear as the latter is forced forward against the sear buffer springs. To the front of the insert, the plate is drilled and tapped to receive the sear spring housing with the spring and plunger. The sear spring forces the sear spring plunger upward against the sear so that the latter can engage the breechblock lock. To the rear of the insert, the plate is drilled and tapped to receive the bowden shaft housing nut. The bowden connection shaft is a shouldered cylindrical shaft which slides vertically within the spring in the bowden connection nut. The upper end of the shaft has lugs for engaging the forked end of the sear. The lower end of the shaft is drilled and slotted for connecting the bowden control cable. A groove in the shaft is for engagement with the safety trigger pin which is operated by the safety lever. The pin has two notches which, in conjunction with the spring and ball, hold the lever in the "SAFE" or "FIRE" position. The lower end of the bowden shaft housing nut has the bowden connection nut which houses the inner and outer bowden connection bushings.

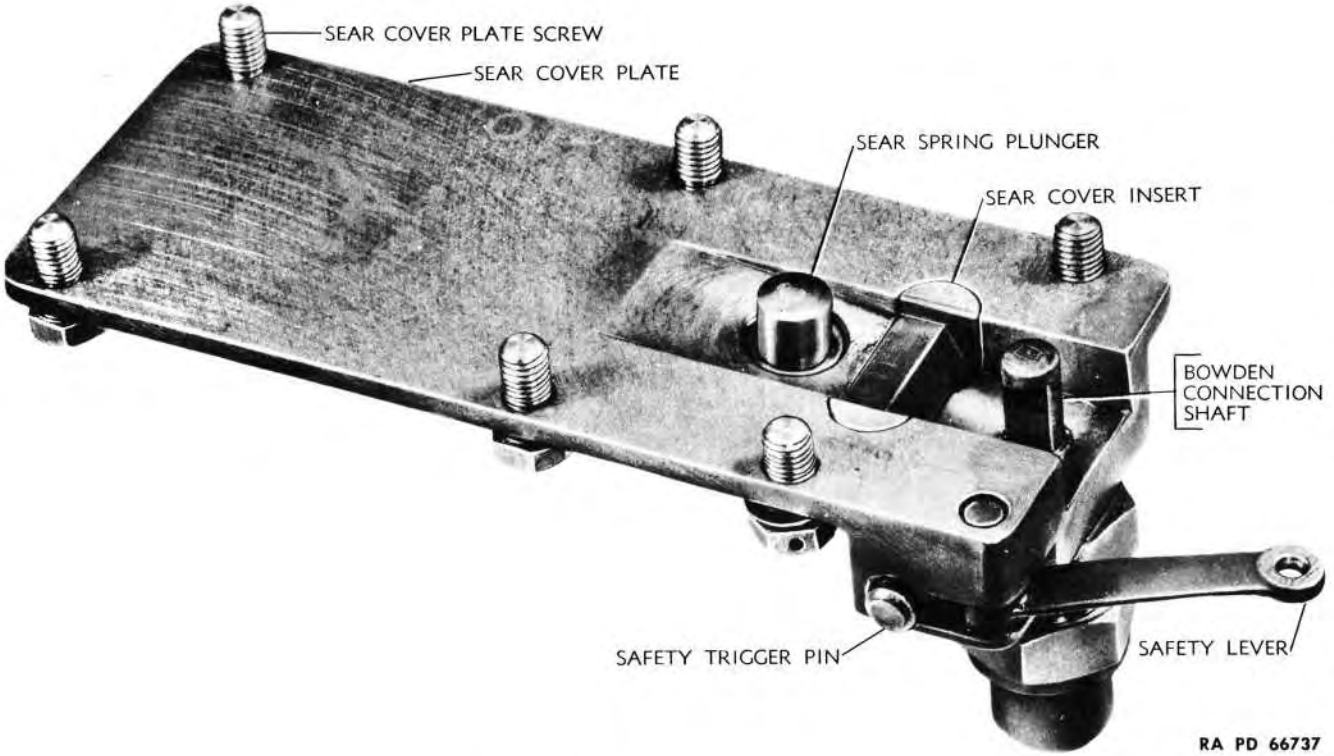


Figure 38 — Sear Mechanism M1

12. CHARGERS.

a. Functioning of Hydraulic Charger M1 (fig. 39).

(1) Naval installations of the 20-mm Aircraft Gun AN-M2 are equipped with the 20-mm hydraulic charger M1 which provides a means of charging or safetying by remote control 20-mm guns in an airplane. The charger consists of a spring guide assembly, a piston spring, and a cylinder and piston assembly, all of which are assembled within the cylindrical charger housing on the right-hand side of the gun. A charger housing end is attached to the spring guide by a press fit, and the assembly is inserted in the charger housing of the gun from the rear, with the slotted portion of the housing end toward the bolt of the gun, to allow clearance for the charging stud as the bolt is removed from the receiver. The spring guide assembly is secured to the cylindrical charger housing by a taper pin and the housing end serves as a stop for the travel of the charger piston. The piston return spring fits over the spring guide in the rear end of the housing and fits within the cylinder and piston assembly.

(2) The cylinder and piston assembly consists of a piston tube fitted within a highly polished cylinder. The forward end of the cylinder is threaded externally so that it can be screwed into the forward end of the charger housing, using a special spanner wrench furnished with the hydraulic charger. A piston head assembly which fits tightly in the cylinder, is secured to the forward end of the piston tube. It consists of two composition V-shaped packings held in place by a seat, a follower, and a castle nut (fig. 40).

(3) A cylinder end adapter is screwed into the forward end of the cylinder assembly to provide a means of connecting the charger to the hydraulic system of the airplane.

(4) When the charger control valve is actuated, hydraulic fluid is forced into the cylinder chamber forcing the piston tube to the rear. The piston contacts the lug on the bolt after a short rearward motion, and carries the bolt with it during the remainder of the rearward movement. The piston carries the bolt rearward far enough so that the sear can lock the bolt in the rear position. Further movement of the piston tube to the rear is stopped by the cylinder end housing. During this rearward motion of the piston tube, the hydraulic pressure in the system increases to about 350 to 600 pounds per square inch, depending on the setting of the release valve in the charger control valve.

(5) After the piston tube has completed the rearward motion, the pressure in the system continues to increase to about 800 to 1,100 pounds per square inch, depending upon the setting of the release valve in the charger valve. Pressure in the system actuates the release valve

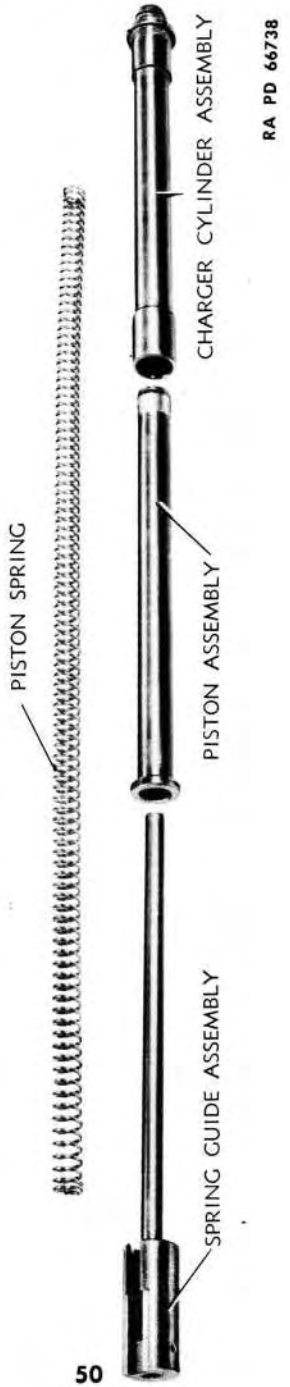


Figure 39 — Hydraulic Charger M1

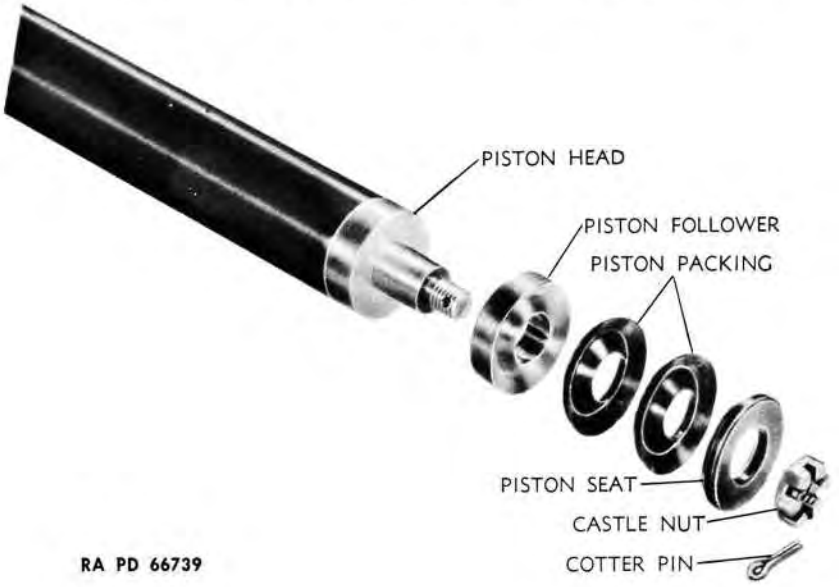


Figure 40 — Piston Head Details

in the charger control valve, resulting in the control valve handle "popping out." If the control valve is set on "SAFE," the hydraulic fluid is locked in the charger system, thus holding the piston tube and the bolt in the rear position. If the control valve is set on "FIRE," the hydraulic fluid in the charging system can flow into the return line and to the hydraulic fluid reservoir. When the hydraulic fluid in the cylinder is released to the return line in the airplane hydraulic system, the spring in the charger forces the piston tube forward to its original position ahead of the lug on the bolt, thus leaving the bolt free to move forward and fire if the trigger is actuated. If the control valve is originally set on "SAFE," a rotation of the control valve handle to the position marked "FIRE" will result in releasing the pressure in the charging cylinder and permit the gun to fire if the trigger is pressed.

CAUTION: Do not stand in back of the gun when the hydraulic charger is actuated. If the taper pin becomes loosened, the high pressure acting on the charger housing end may force the housing end out of the housing at high velocity and result in injury to personnel.

b. Installation of Hydraulic Charger M1. Guns may be shipped with the hydraulic charger M1 installed in them. If the charger is shipped separately, or if a new charger is to be installed in the gun, the following procedure should be followed:

Figure 41 — Manual Charger M2

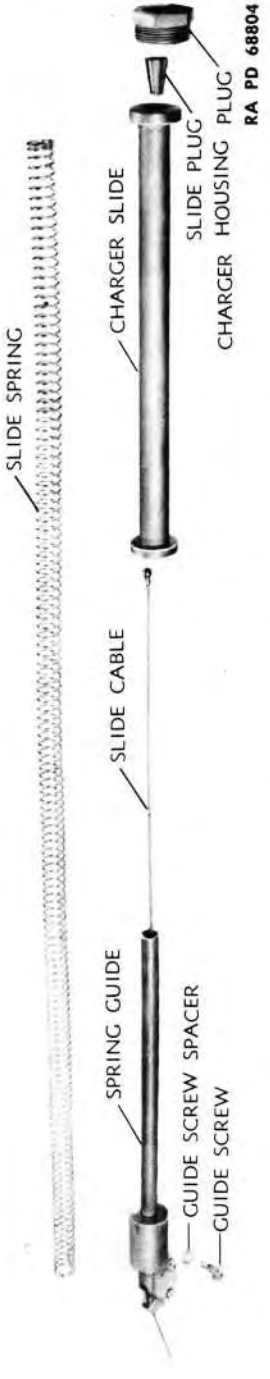


Figure 42 — Manual Charger 20-MM M2 — Installation

(1) Insert the spring guide in the piston spring and slide the assembly into the rear of the charger housing with the slotted portion of the spring guide toward the breechblock assembly to allow for clearance of the charging stud as the breechblock assembly is removed from the receiver.

(2) When the hole in the spring guide is lined up with the holes in the charger housing of the gun, the hole should be reamed through for a No. 3 taper pin.

(3) Drive the taper pin into the hole firmly, and stake the pin securely to the charger housing.

(4) Place the cylinder and piston assembly over the spring, which will protrude from the front end of the charger housing. Push the assembly into the charger housing and screw the threaded end of the cylinder into the housing with the special spanner wrench provided with the charger.

NOTE: When removing the charger from the gun, remove the cylinder and piston assembly first. When removing the cylinder and piston assembly, care must be taken to prevent the assembly from flying out under the action of the piston spring.

(5) Connect the charger to the hydraulic system of the airplane.

c. Functioning of Manual Charger M2 (fig. 41). The manual charger M2 was previously designated as the B6 charger by the U.S.A.A.F. The charger consists essentially of a flanged charger slide for engaging and retracting the breechblock, a slide spring for returning the slide to its forward position, and a spring guide which closes the rear end of charger housing. The slide is actuated manually by pulling the slide cable. The cable is anchored in the slide plug in the front of the slide and passes out through the spring guide and over a pulley. The front of the slide spring rests in the slide and the rear fits around the slide spring guide. The front of the charger housing is closed by a charger housing plug. As the cable is pulled against the spring pressure, the slide moves to the rear, engaging the projection on the right-hand breechblock slide and retracting the breechblock. In the fully retracted position, the sear will engage the breechblock lock and hold the breechblock assembly until the gun is fired. The cable is then released, thus allowing the spring to return the slide to its front position. Thus, when the firing mechanism is actuated, the bolt will move forward at its normal rate unimpeded by the slide.

d. Installation of Manual Charger M2 (fig. 42).

(1) Before installation of manual charger, the breechblock must be removed from gun. To facilitate installation, the M2 manual charger should be assembled before placing in charger housing of gun. To do

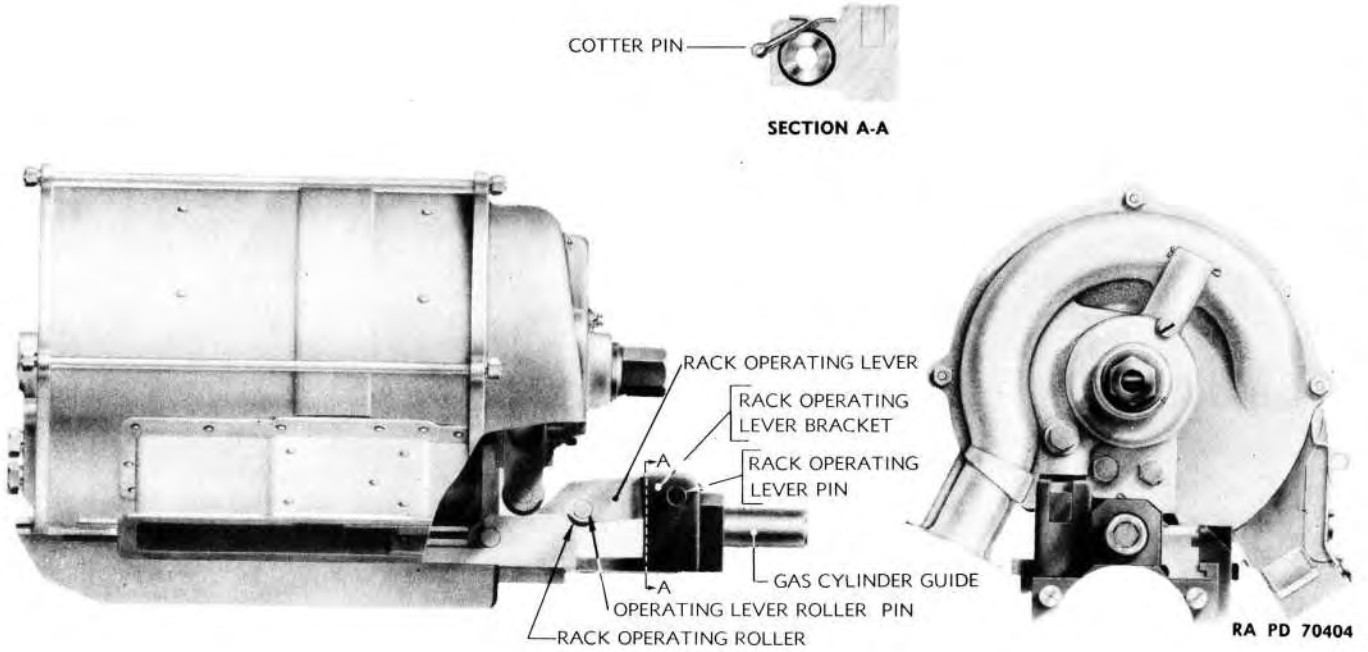


Figure 43 — 20-MM Feed Mechanism AN-M1 and Charging Cam Assembly

this, force cable out from end of spring guide as far as possible. Slip slide spring over cable and on to the guide. Hold guide plug and guide against a solid support and compress the spring on the guide. Slip the charger slide over the spring and guide until the swaged ball fitting protrudes from front end of the slide. Install the slotted swaged slide plug over the cable at swaged ball end and release the spring gradually.

(2) To install in the gun, screw the charger housing plug into the front end of the charger housing. With charger slide and compressed spring on spring guide, pull cable out through pulley end of slide until slide plug seats itself at front end of slide. Holding the cable taut at the guide plug to keep the spring compressed, insert the charger into the charger housing of the gun. Secure guide by screwing guide screw (with spacer assembled) through hole in side of charger housing and into guide plug.

13. FEED MECHANISMS.

a. 20-mm Feed Mechanism AN-M1.

(1) DESCRIPTION OF 20-MM FEED MECHANISM AN-M1 (figs. 43, 44, 45, and 46).

(a) The 20-mm feed mechanism AN-M1 is a device which utilizes the recoil energy of the gun to feed rounds to the gun. The rounds are assembled into a belt with links, and the function of the feed mechanism is to draw up the belt to the gun, separate the rounds from the links, and feed the rounds, one at a time, into the breech of the gun. There are two distinct mechanisms, one for right-hand and one for left-hand feeding.

(b) The feed mechanism consists of a cylindrical metal case, the ends of which are closed by front and rear covers held by three tie rods. Inside the case is a rotatable central shaft supported by the covers. Three sprockets, with hubs keyed on the shaft, form an assembly which rotates as a whole. A link ejector bracket is mounted on the hub of the front sprocket. A front feed lever, carrying a last round retainer, is mounted on the hub of the center sprocket. A rear feed lever is mounted on the hub of the rear sprocket. Riveted to the front sprocket is a driving spring case within which is a spiral driving spring. A rack mounted in the front cover engages a ratchet actuating segment which rotates a tensioning ratchet to maintain the tension of the driving spring. A pawl in the front cover engages teeth on the tensioning ratchet to prevent unwinding.

(c) The case is cylindrical with three circumferential guides riveted inside. The belt guide is riveted over a slot in the case and permits a feed chute to be attached. Three belt guide packings, which serve as link guides, are riveted inside the belt guide. The link chute is riveted

20-MM AUTOMATIC GUN M1 AND 20-MM AIRCRAFT AUTOMATIC GUN AN-M2

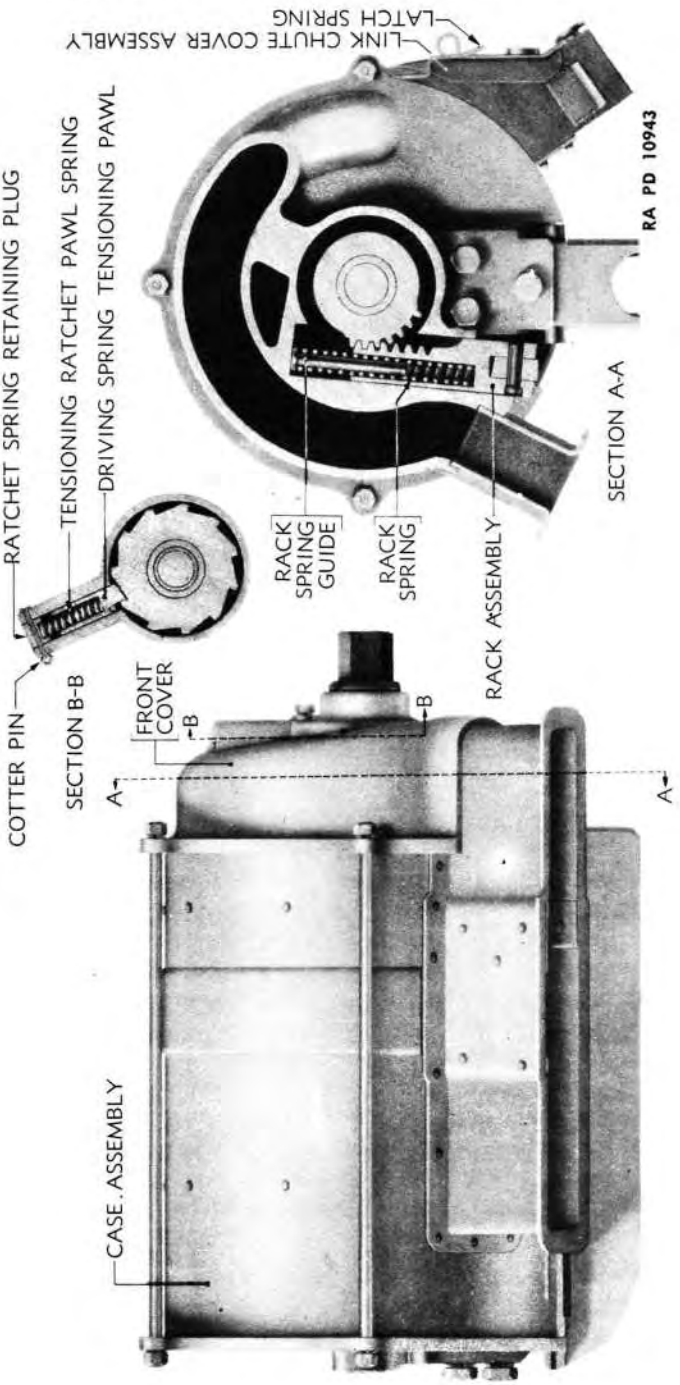


Figure 44 — 20-MM Feed Mechanism AN-M1 — Front Cover Sectional Views

over a slot in the case and is provided with a cover. The cover is hinged to one of the tie rods and is held in place by side flanges on the chute. A latch is riveted to the cover and retains it in the closed position by engaging a stud on the outer end of the chute. A ramp is secured inside the cover, and a flat spring is riveted to the inner end of the ramp to facilitate ejection of the links. A lug welded to each side of the link chute permits attachment of the link chute to convey the links away from the gun.

(d) The mouth has a vertical lug at each end which secures the front and rear covers by three screws on each end. Grooves along each side of the mouth receive the edges of the case assembly. At the rear of the mouth is a shoulder to be engaged by the magazine latch. On each side, at the front of the mouth, is a pin to engage the hook-shaped projections of the magazine slide. A small lip along part of the lower edge of the mouth supports the round in the path of the breechblock until it is pushed forward by the breechblock.

(e) In the front cover is formed the cam groove by which the noses of the rounds are guided and forced back as they are carried through the mechanism. A hollow boss on the front cover accommodates the driving spring mechanism, and recesses are provided for the actuating rack and pawl. A cartridge ramp is riveted to the rear cover and limits the rearward movement of the rounds. A pin protruding from the rear cover serves as the feed lever stop.

(f) The driving mechanism consists of a rack with a spring and spring guide, a ratchet actuating segment, a tensioning ratchet with spring actuated pawl, a ratchet thrust spring, a driving spring hub, and a driving spring.

(g) The rack has six teeth to engage the teeth on the actuating segment. A hole in the upper end accommodates the rack spring with its guide. At the lower end of the rack is a roller which rotates on a pin, the ends of which are peened. A longitudinal slot in the rack is engaged by the rack retaining screw. Another slot diametrically opposite the other makes it possible to use the rack for either a right-hand or left-hand feed mechanism. The actuating segment fits on the driving spring hub, and is housed inside the hollow boss of the front cover. Eight teeth on a part of its periphery engage with the teeth of the rack. On the front face of the segment there are 11 ratchet teeth to engage with the ratchet teeth of the tensioning ratchet. A ratchet thrust spring forces the actuating segment against the tensioning ratchet to maintain contact between the two sets of teeth.

(h) The tensioning ratchet fits over the front end of the driving spring hub, to which it is secured by a pin. The driving spring hub rotates on the front end of the shaft, and the boss of the tensioning

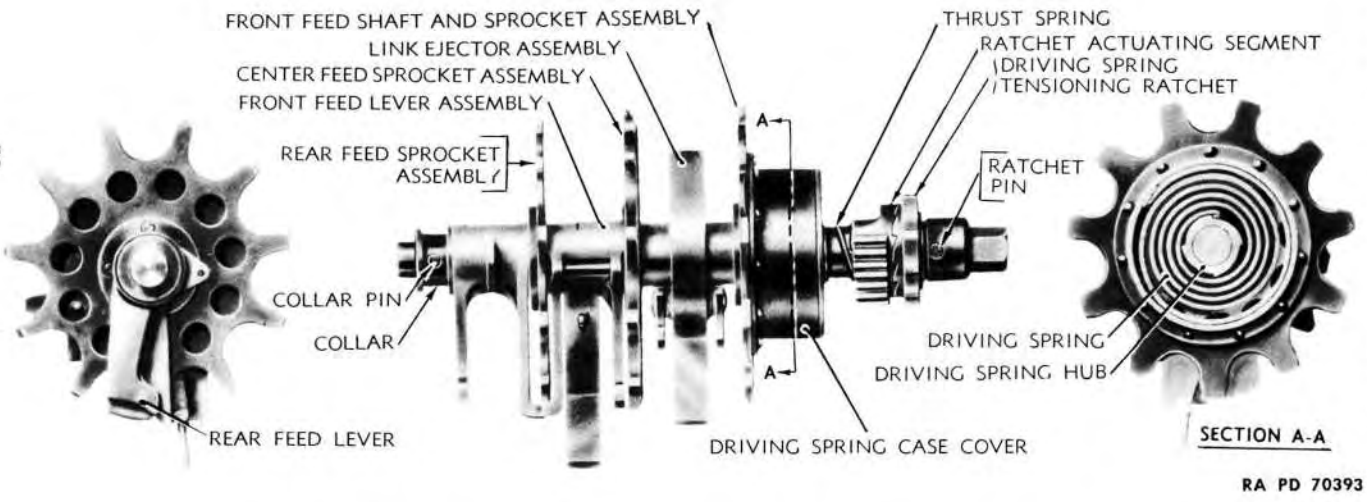


Figure 45 — 20-MM Feed Mechanism AN-M1 with Cover Removed

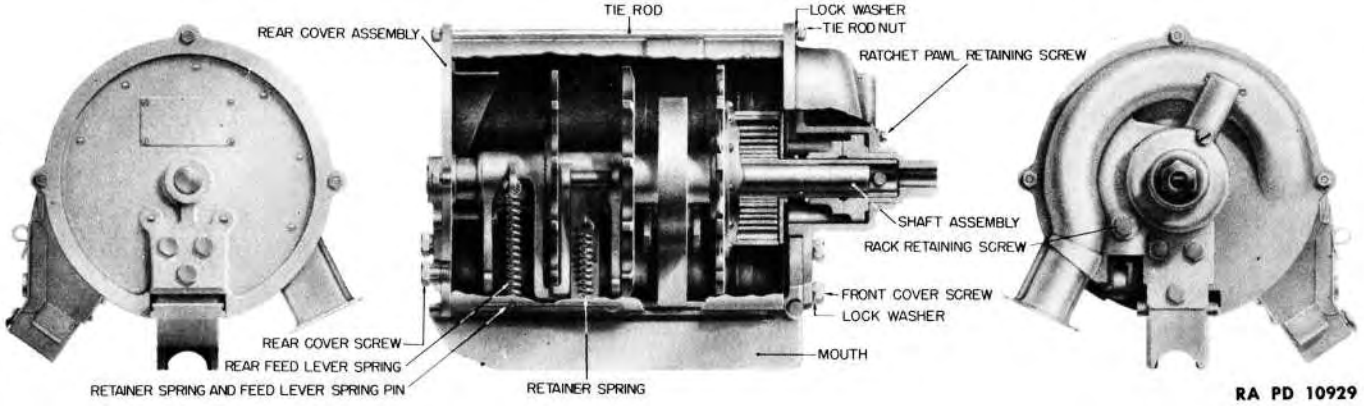


Figure 46 — 20-MM Feed Mechanism AN-M1 — Sectioned View

ratchet rotates in the bearing formed in the front cover. The tensioning ratchet thus forms the front bearing for the shaft, but each is free to rotate independent of the other. The boss of the tensioning ratchet projects through the front cover and is hexagonal to permit use of a wrench for applying the initial tension to the driving spring. One of the flat faces of the pawl is extended partly along the side and engages the flat portion of the retaining screw, thus preventing the pawl from rotating while allowing it to reciprocate.

(i) The driving spring hub has four ratchet teeth on the periphery, any one of which can engage the inner end of the driving spring. The driving spring is a flat coiled spring. At the inner end it is bent to engage one of the four teeth on the driving spring hub. The outer end engages the driving spring case.

(j) The front, center, and rear sprockets are provided with hubs which are keyed to the shaft. Each sprocket has 11 teeth. The driving spring case is riveted to the front face of the front sprocket. The center sprocket prevents axial movement of the links while the rounds are pushed out of them towards the rear.

(k) The link ejector (fig. 47) consists of two four-toothed sprockets rotatably mounted on a bracket which is maintained stationary between the front and center sprockets. The sprockets are mounted on a square shaft. A spring-actuated plunger is located in the bracket and bears against the flats of the shaft to hold the link ejector in the correct position to be engaged by each round. The link ejector bracket is mounted on the hub of the front feed sprocket, which is free to rotate within the bracket. To prevent the bracket from rotating, a forked arm engages the top edge of the mouth on the belt feed side. The upper side of the arm is curved and helps to guide the rounds into the mouth.

(l) The front feed lever has two arms and is mounted on the hub of the center sprocket. The front arm has a projection to push on the upper side of the second round in the mouth, and the rear arm has an extension which projects towards the rear and mates with a projection on the rear feed lever. Normally the two feed levers operate as one unit, but one can turn relative to the other in one direction, thus preventing damage if a round should enter the mouth obliquely. Two lugs are formed on the front feed lever, the last round retainer being hinged between them.

(m) The purpose of the last round retainer is to prevent the last round from dropping all the way down into the mouth of the feed mechanism. If the last round should drop into the path of the bolt,a stoppage would result. The last round retainer is a flat lever which projects into the mouth. On its outer side is a stud to which the last round re-

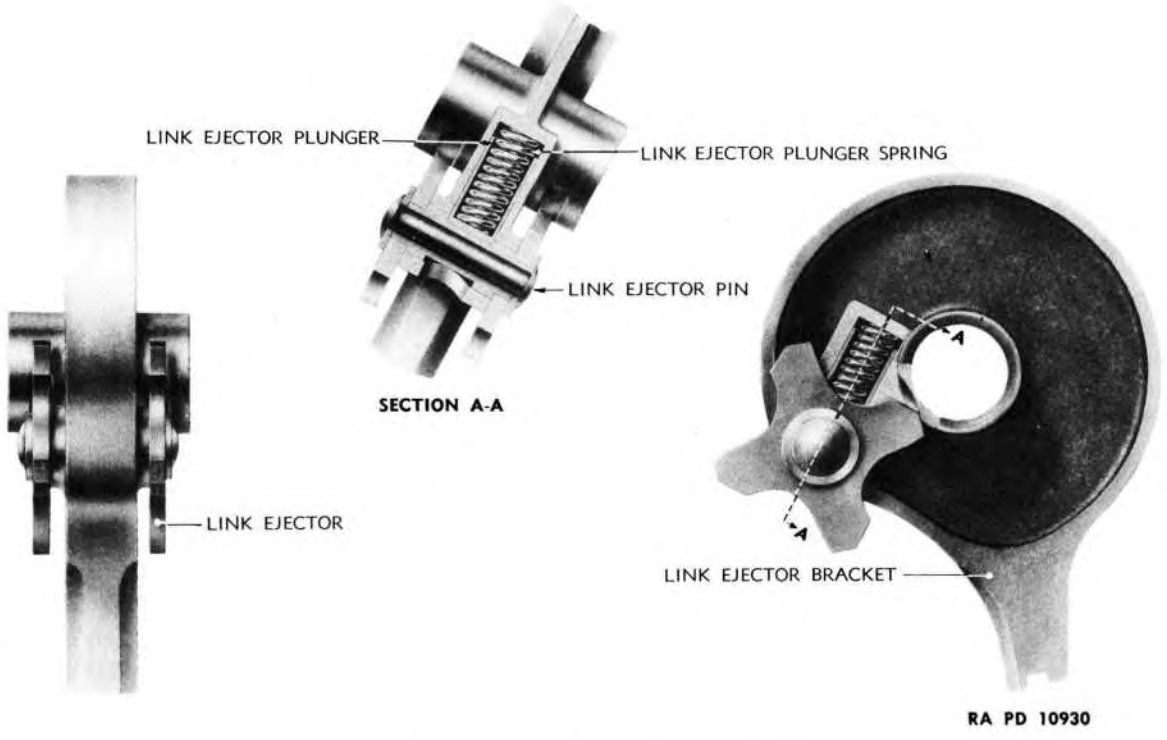


Figure 47 — Link Ejector Assembly

tainer spring is secured at one end. The other end of the spring is formed into a loop which passes through a hole in the case and is secured by a pin. The spring holds the retainer against the side of the mouth and tends to pull the retainer further into the mouth. When the last round leaves the sprocket, the feed lever moves up against the stop in the rear cover, moving the retainer into the mouth. This prevents the last round from dropping all the way down into the mouth.

(n) The rear feed lever has two arms and is mounted on the hub of the rear sprocket. The rear short arm has a projection at its lower end to steady the rounds in the mouth. Incoming rounds force the lever away from the stop in the rear cover and thus withdraw the retainer from the mouth. A lug on the rear feed lever serves as an anchorage for one end of the rear feed lever spring; the other end of the spring passes through a hole in the case and is secured by a pin. The spring tends to rotate the lever in the opposite direction to that in which the shaft rotates, but the rear feed lever stop, inside the rear cover, engages the rear arm of the lever to prevent it from rotating too far. The collar is secured to the shaft by a pin and bears against the rear cover.

(o) The mechanism is operated by the tension of the initially wound driving spring, but the tension is maintained by the recoil of the gun which actuates the charging cam assembly (fig. 43). It takes a recoil of approximately $^{13}/_{16}$ inch to operate the feed properly, depending on the setting of the magazine slide and the temperature of the gun. The charging cam mechanism consists of a special gas cylinder guide A25940 which mounts a bracket with a lever having an inclined surface at the rear. A roller is pinned to the lever below the inclined surface. The feed mechanism and magazine slide remain stationary, and the charging cam lever recoils with the gun. During this motion, the charging cam roller rides up the inclined face on front of the magazine slide while the rack roller rides up the inclined surface on the charging cam lever. This combined movement actuates the tensioning ratchet to maintain the tension of the driving spring. Unwinding of the spring is prevented by the ratchet tensioning pawl in the front cover.

NOTE: The description above is applicable for either left- or right-hand feed mechanisms. Left-hand parts are of the same dimensions and shapes as right-hand parts, but their positions in the feed mechanism are reversed.

(2) FUNCTIONING OF 20-MM FEED MECHANISM AN-M1 (figs. 48, 49, and 50).

(a) The belt is inserted into the belt guide with the bullets pointing toward the front. The links should be entering the belt guide, with

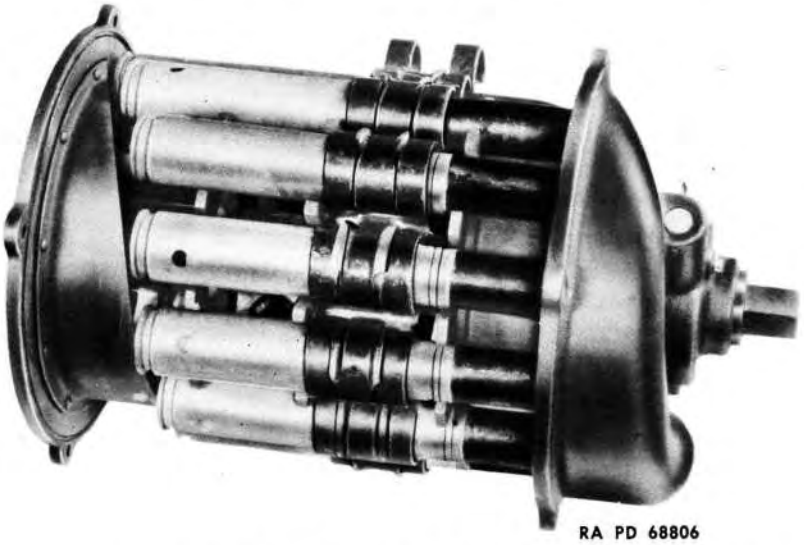


Figure 48 — Separation of Links from Rounds in 20-MM Feed Mechanism AN-M1 — Right Side View

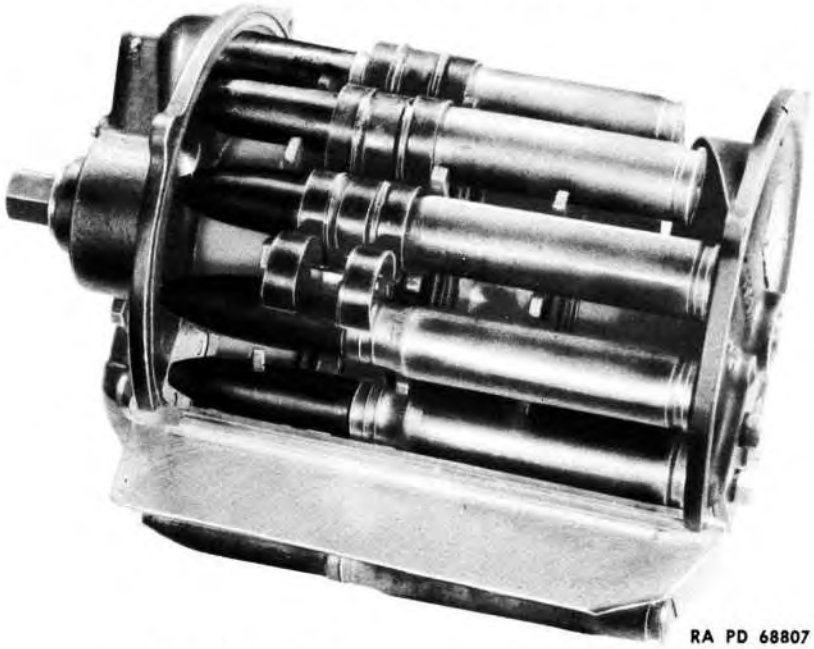


Figure 49 — Separation of Links from Rounds in 20-MM Feed Mechanism AN-M1 — Left Side View

their double loops leading and the open sides of the loops facing towards the mouth. The belt is fed by hand into the mechanism and the rounds engage the feed sprockets. The tensioning ratchet is rotated by wrench to pull the belt into the mechanism. Rotation of the tensioning ratchet winds up the driving spring which then reacts in the spring case and rotates the shaft and feed sprockets, thus drawing the belt further into the mechanism.

(b) As the belt is carried round by the feed sprockets, the noses of the bullets are in contact with the bottom of the cam groove formed in the front cover, and the rounds are pushed towards the rear. The links are prevented from moving towards the rear by engagement with the teeth of the center feed sprocket, and when the rounds have been pushed back through a distance equal approximately to the width of a link, the links are freed from the rounds. As the rounds are carried past the link ejector, they cause the link ejector sprockets to rotate so that the teeth engage the middle portion of each link as it becomes free and push it outwards. The double loops of the link, which are leading, engage the ramp inside the link chute cover with their closed sides and the ramp causes the link to tilt on the teeth of the ejector sprockets so that the single loop is moved clear of the round. Continued movement of the main sprockets carries the round further around, and the link ejector sprockets rotate so that the single loop of the link engages the ramp inside the link chute cover and the double loops are cleared from the round. The pivotal movement of the link is limited by the engagement of first the double loops and then the single loop with the ramp, so that the single loop cannot re-engage the round and the link falls away through the link chute. After the ejection of the link, the spring-actuated plunger in the link ejector bracket acts on the flats of the link ejector shaft and holds the link ejector sprockets in the correct position to be engaged by the next round in the mechanism.

(c) Each round, after passing the link ejector, comes into contact with the feed levers and the curved surface of the link ejector bracket. The feed levers are pushed aside against the action of the springs and this movement withdraws the last round retainer so that it does not obstruct the passage of the rounds into the mouth. After each round passes the feed levers, the latter are partly returned by their springs to hold the rounds firmly in the mouth. After the first round has been seated in the bottom of the mouth, further rotation of the ratchet winds up the driving spring until it reaches maximum tension.

(d) When the gun is fired, the breechblock travels forward, hits the base of the round, and drives the round forward out of the mouth of the feed mechanism into the chamber of the gun. As each round

(6) Type F is used by the British. It consists of the basic M1 Gun with the M7 adapter (with thread protector), and M1 sear mechanism (fig. 24).

(7) Type G is used by the British. It consists of the basic AN-M2 Gun with M7 adapter (with thread protector), and M1 sear mechanism (fig. 24).

10. ADAPTERS.

a. Functioning of 20-mm Adapter AN-M1 (figs. 25 and 26).

(1) The adapter is a self-contained tubular unit which slips over the tube of the gun. The purpose of the adapter is to reduce the effective recoil and counterrecoil forces of the gun on its supporting structure and accurately control the amount of recoil travel within definite limits (0.875 inch to 1.17 inches). It provides a front mounting arrangement for the gun and also permits the gun to recoil the required distance to operate the AN-M1 feed mechanism or any other feed mechanism that derives its operating power from the recoil movement of the gun.

(2) The adapter consists essentially of a ring spring in series with a coil spring (fig. 26). The ring spring is assembled under compression. The ring spring is fitted around the front mandrel and the recoil spring is fitted around the rear mandrel, both springs and their mandrels being assembled in the outer shell.

(3) The ring spring consists of nine conically shaped inner rings which are positioned between and bear upon eight conically shaped outer rings.

(4) The adapter is held firmly in place on the gun tube by means of a tube sleeve and tube sleeve nut. The nut is prevented from unscrewing by means of a tube sleeve nut detent. The outer shell is fastened securely to the supporting structure. The front mandrel abuts the shoulder on the gun tube and moves with the tube. The bearing surfaces between the recoiling and non-recoiling components of the adapter are between the front and rear mandrels and between the front inner collar and front mounting collar.

(5) When the gun is fired, the tube sleeve moves to the rear with the gun barrel. Inasmuch as the initial compression of ring spring is greater than the final force of the coil spring, the ring spring holds the rear follower plate against the shoulder of the moving sleeve. It can thus be seen that during this phase of the recoil stroke, the coil spring alone is offering resistance to the rearward motion of the gun. This action continues until a distance of $\frac{7}{8}$ inch has been traversed, at which time the front mandrel abuts the rear mandrel. At this instant compression of the coil spring stops, the remainder of the impact being absorbed by the ring spring.

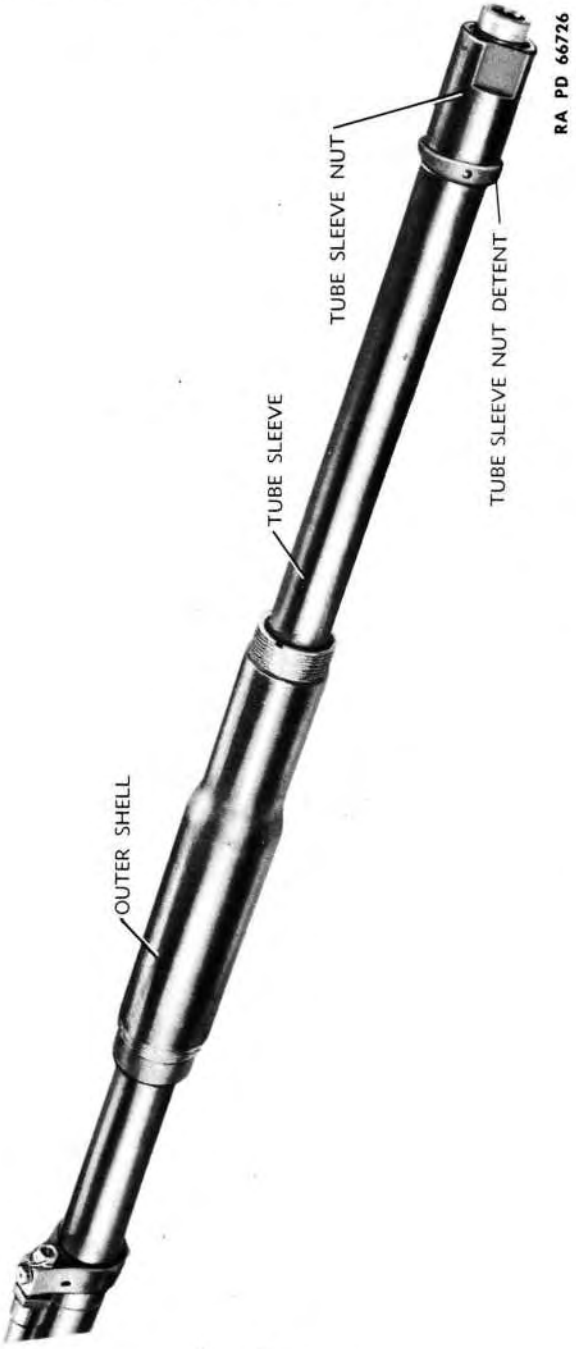
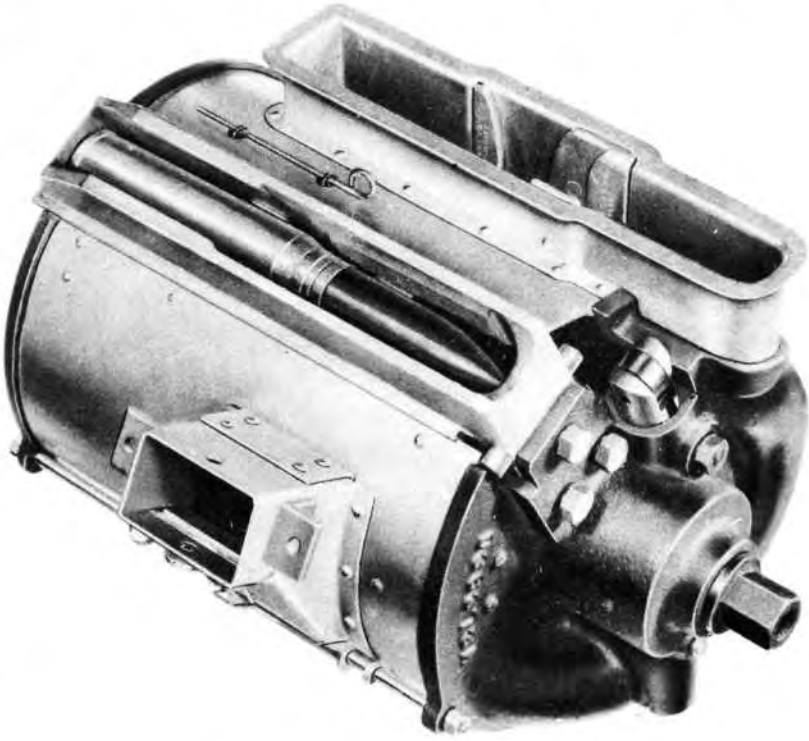


Figure 25 — AN-M1 Adapter on Gun



RA PD 68805

Figure 50 — 20-MM Feed Mechanism AN-M1 — Last Round Held by Retainer

leaves the mouth, the driving spring acts in the driving spring case to rotate the shaft and the feed sprockets, thereby feeding another round into the mouth.

(e) After the last round but one has been pushed out of the mouth by the breechblock, the last round begins to move downward. This permits the two feed levers to move to their maximum extent through the action of the springs so that the rear feed lever abuts its stop on the rear cover while the last round retainer projects into the mouth and prevents the last round from reaching the loading position (fig. 50). If a fresh belt is fed into the mechanism while the last round of the previous belt is still in the mouth, the first round of the fresh belt becomes the second round in the mouth and the last round of the previous belt can be fired in the normal manner.

(3) HAND-LOADING OF BELTS FOR RIGHT-HAND FEED (fig. 51).

(a) Inspect all links for rust, dirt, or deformed links.

RA PD 66742

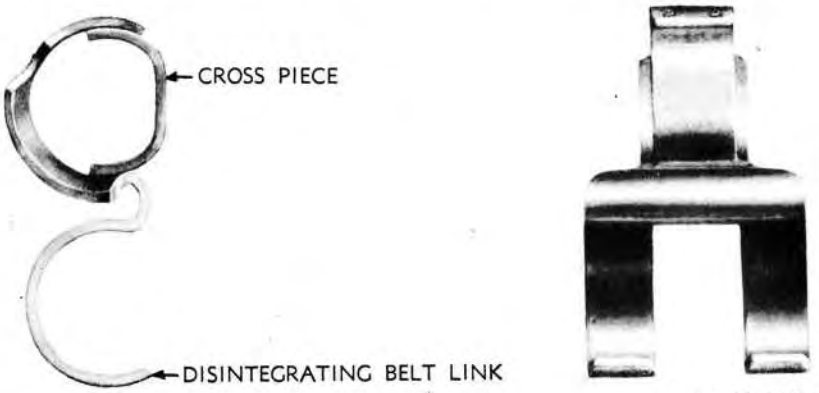
Figure 51 — 20-MM Round in Links for R.H. Feed

(b) Dip all links in OIL, lubricating, preservative, special, and drain off excess oil just before using.

(c) Dip a clean lintless cloth in OIL, lubricating, preservative, special, wring it out, and oil the cartridge cases with it, being careful not to oil the primers of the joint where the case is cramped to the projectile.

(d) Lay the links along the bench, with their open sides up, double loops to the right, and single loops positioned between the double loops.

(e) Insert a round into each loop, including the leading double loop, and push it forward.



RA PD 10931

Figure 52 — End Link

RA PD 66743

Figure 53 — 20-MM Rounds in Links for L.H. Feed

(f) The last link at the left end of the belt of ammunition to be fired by means of the feed mechanism must be of the closed single loop type (fig. 52) to prevent the last link from jamming or catching within the feed mechanism.

(g) Check the position of the cartridges relative to the links. The distance from the base of the cartridge case to the front edge of the double loop should be 3.80 inches.

(h) Test the belt for flexibility by lifting the left end loop and drawing along the top of the belt to the right. Any faulty link will cause the belt to "kink" instead of folding over smoothly. Any link which does not hinge freely must be replaced by another and the test repeated.

(i) Repeat the above test, starting with the right end loop and drawing it to the left. If a stiff link is found, it must be replaced by another and both right end and left end tests repeated.

(j) Test the belt for oversize links by suspending it from one end and twisting the lowest link until resistance is felt. If the belt breaks, the faulty link must be replaced by another and all tests repeated.

(4) HAND-LOADING OF BELTS FOR LEFT-HAND FEED. The procedure is the same as in subparagraph a (3) above, except that the position of the links is reversed (fig. 53). The double loops are to the left, and the special end link is at the right end.

(5) JOINING A NEW BELT TO A PARTLY EXPENDED BELT.

(a) Remove the special link from the end of the partly expended belt.

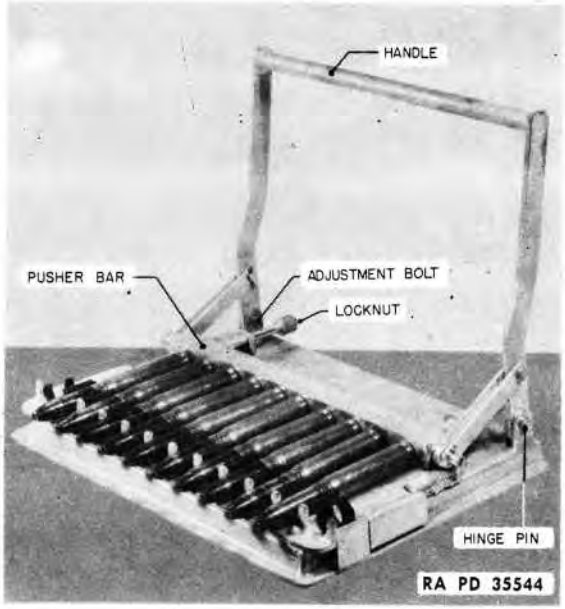


Figure 54 — Position of Links and Cartridges in Machine

(b) Join the two belts by means of an ordinary link.

(c) Check the position of the round which has been inserted to join the belt.

(d) Be sure that the last round in the ammunition container has the special end link.

(6) LOADING OF BELTS WITH 20-MM AMMUNITION LINKING MACHINE M4 FOR RIGHT-HAND FEED.

(a) Inspect and lubricate links and lubricate rounds as described in subparagraph a (3) *(a)*, *(b)*, and *(c)* above.

(b) Place 11 links in a continuous row along the link guide, with their open sides up, double loops to the right and single loops positioned between the double loops. The left end link must be of the closed, single loop type (fig. 52).

(c) Place 10 cartridges in the 10 central grooves of the cartridge guide, with their noses resting in the links (fig. 54).

(d) Push forward on the handle with steady pressure until the stroke is stopped by the lock nuts on the adjustment bolts (fig. 55).

(e) Pull back the handle. Lift out the 10 cartridges which are now

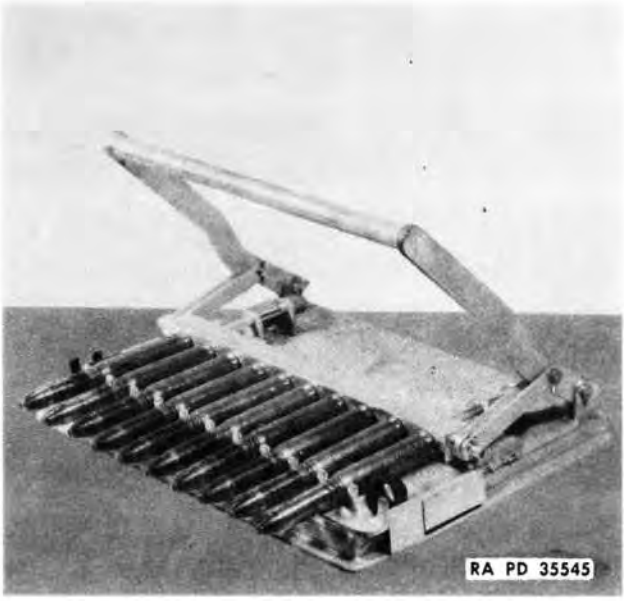


Figure 55 — Cartridges and Links Assembled by Machine

linked together and place the right end cartridge in the left end groove. Place additional links and cartridges in the guides and repeat the operations until the belt is of the desired length (fig. 56).

(f) Test flexibility of belt as directed in subparagraph a (3) *(h)* above.

(7) ADJUSTMENT. The machine is provided with lock nuts and two adjustment bolts on the pusher bar to regulate the length of the stroke. These should be set so that when the pusher bar is in its forward position, the distance between the face of the bar and the link stop should be 3.80 inches.

(8) LOADING BELTS WITH AMMUNITION LINKING MACHINE FOR LEFT-HAND FEED.

(a) Place 11 links in a continuous row along the link guide, with their open sides up, double loops to the left and single loops positioned between the double loops. The right end link must be of the closed, single loop type (fig. 52).

(b) Place 10 cartridges in the 11 central grooves of the cartridge guide, with their noses resting in the links.

(c) Push forward on the handle with steady pressure until the stroke is stopped by the lock nuts on the adjustment bolts.

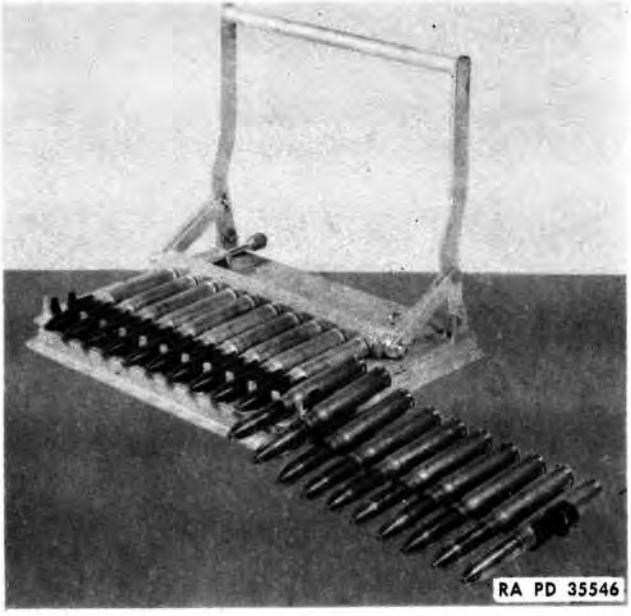


Figure 56 — Forming Continuous Linkage

(d) Pull back the handle. Lift out the 10 cartridges which are now linked together and place the left end cartridge in the right end groove. Place additional links and cartridges in the guides and repeat the operations until the belt is of the desired length.

(e) Test the flexibility of the belt as instructed in subparagraph a (3) *(h)* above.

(9) UNLOADING. Set the locknuts so as to increase the stroke about ½ inch. Place the belt in the machine, in reversed position, and gently force the cartridges out of the links.

(10) LOADING THE 20-MM FEED MECHANISM AN-M1.

(a) If the feed mechanism is not assembled to the gun, insert a loaded belt of 18 rounds into the belt guide of the right-hand feed mechanism with the double loop of the link leading, cartridges pointing toward the front cover, and the open sides of the links toward the mouth. Position the sprocket by hand so that the first round can enter freely and then push the belt in as far as possible. Turn the tensioning ratchet with a wrench (fig. 57) until the driving spring is solid, strip the first round, and hook the single loop of the last link around the edge of the link chute (fig. 58). This provides for easy handling of the feed mechanism before being installed on an airplane. If the feed mechanism is assembled to the gun, close the breechblock, load the feed

Figure 57 — Loading R.H. Feed Mechanism

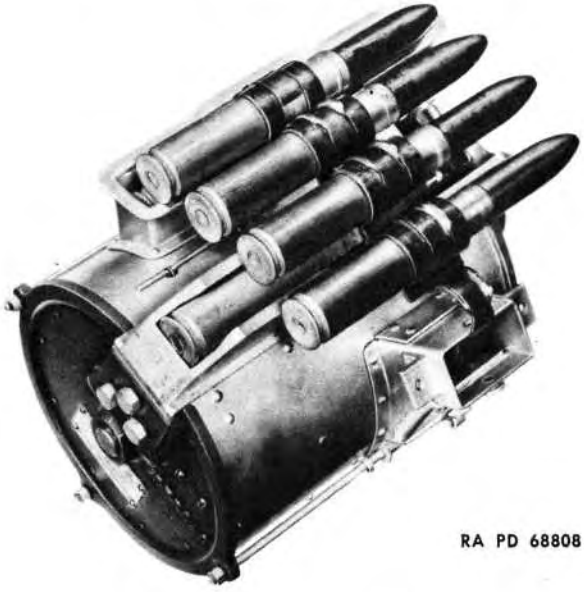
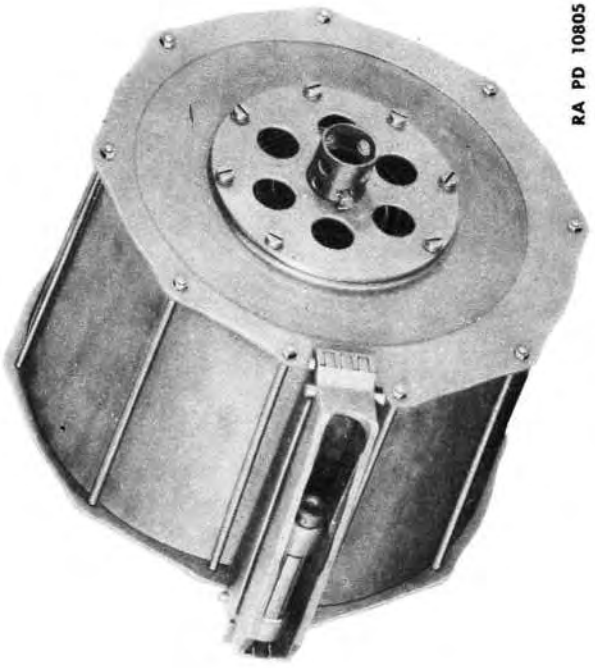


Figure 58 — Loading Feed Mechanism

RA PD 10804

Figure 60 — 60-round Magazine — Rear View



RA PD 10805

Figure 59 — 60-round Magazine — Front View

RA PD 10811

Figure 61 — Loading 60-round Magazine

RA PD 10812

Figure 62 — Round in Loaded Position

mechanism, and wind the driving spring until solid. Cock the gun.

CAUTION: Be extremely careful not to exert more torque than is necessary to wind the driving spring solid. Excessive torque applied against a tightly wound driving spring will result in breakage of the driving spring. If any difficulty is experienced in pulling the belt through the feed mechanism before the desired initial torque is obtained, the belt should be examined for defective links.

b. Description and Functioning of 20-mm 60-round Magazine M1 (figs. 59, 60, and 92).

(1) The 20-mm 60-round Magazine M1 consists essentially of an outer casing closed by front and rear plates and containing a tensioning spring in a spring casing in the front plate. A hole in the rear plate accommodates the feed arm axis tube. The inner end of the spring is attached to the tensioning tube. On the inside of the plates are spirals which act as guides for the ammunition.

(2) The magazine is operated by the spring tension. Initial tension is applied during assembly. Further tension is applied progressively during the loading operations. The tensioned spring acts through the tensioning tube, feed arm axis tube, and feed arm to maintain the platform or follower in contact with the last round. Thus a round is always in position in the magazine mouth. As soon as this round is loaded, the next round is brought into position by the spring.

c. Loading the 20-mm 60-round Magazine M1.

(1) If the magazine has been disassembled, apply initial tension as follows:

(a) Place the magazine in the magazine holder or in any other suitable retaining device.

(b) Remove the cotter pin and tensioning tube pin, if necessary.

(c) Rotate the magazine until the follower is in the mouth.

(d) Insert the tensioning tube bar through the end of the tensioning tube and turn it counterclockwise three-quarters of a turn.

(e) Insert the tensioning tube pin and secure it with a cotter pin.

(f) Insert the bar through the hole in the tensioning tube and turn it slightly counterclockwise to lower the platform, so as to allow a round to be inserted.

(g) Insert a round, base first, into the mouth of the magazine and push it against the rear plate (fig. 61). Ease the bar, and see that the round is flush against the rear plate (fig. 62).

(h) Turn the bar slightly counterclockwise to lower this first round, and then insert a second round in the same manner.

(i) Repeat the operation until the magazine contains not over 55 rounds, taking care that the first round inserted contacts the platform or follower. No further tension must be applied. It is advisable not to load the magazine with more than 55 rounds.

Section III

OPERATION

14. INSTALLATION OF MAGAZINE SLIDE.

a. Secure the magazine slide to the magazine slide anchoring mechanism.

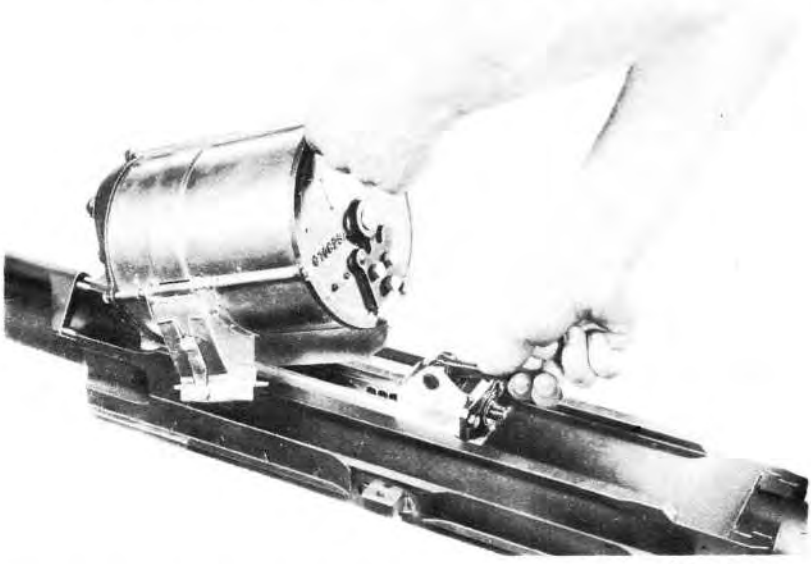
b. If the 20-mm feed mechanism AN-M1 is to be used, adjust the magazine slide anchoring mechanism so that the engraved lines on the magazine slide are $\frac{1}{16}$ inch to the rear of the engraved lines on the receiver. This adjustment must be made when the gun is cold. With this adjustment, the maximum advisable length of burst is 75 rounds.

c. If the 20-mm 60-round magazine M1 is to be used, adjust the magazine slide anchoring mechanism so that the engraved lines on the magazine slide match the engraved lines on the receiver.

15. INSTALLATION OF 20-MM FEED MECHANISM AN-M1 ON THE GUN.

a. Charge the gun. Hold the feed mechanism, loaded with 17 rounds (par. 13 **a** (10)), above the magazine slide with the tensioning ratchet pointing toward the muzzle. Carefully lower the mechanism so that the mouth enters the opening of the magazine slide and the latch plate at rear of the mouth rests on the magazine latch. Push the mechanism forward until the transversely projecting pins at the front of the mouth engage the hook-shaped projections at the front of the magazine slide (fig. 63). Lift the magazine slide lever and engage the magazine latch with the latch plate at the rear of the mouth. If the mechanism is properly secured, as described in paragraph 14 **a**, there will be approximately a 0.05-inch clearance between the operating lever and the rack roller (fig. 64).

b. Join the belt in the feed mechanism to the belt in the ammunition container by inserting a round and joining the link of the last round in the feed mechanism to the first link of the belt in the ammunition container. Make certain that the belt in the feed mechanism and the belt in the ammunition container are linked for feeding in the



RA PD 68809

Figure 63 — Installation of 20-MM Feed Mechanism AN-M1 on the Gun

same direction, that the round used to join the belts is properly positioned, and that the special end link is on the last round in the ammunition container.

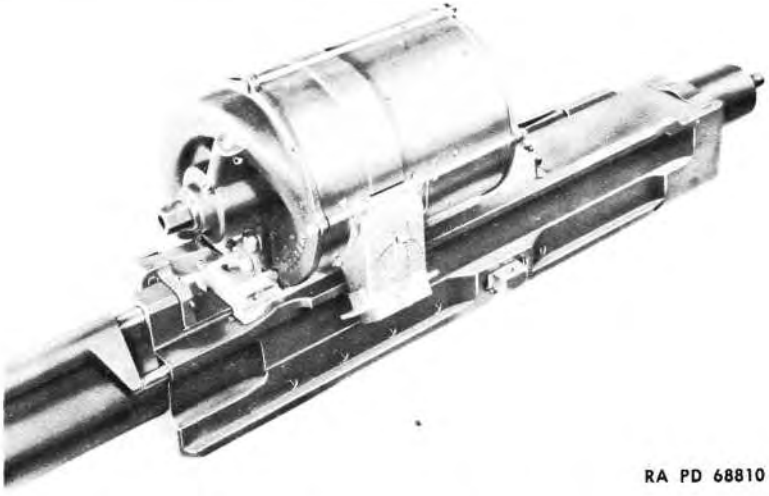


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Figure 64 — Feed Mechanism in Position on Gun

Figure 65 – Removal of Last Round

c. Attach the link and feed chutes to the feed mechanism.

d. Test the rack operating assembly for vertical movement before the gun is fired. If rack cannot be raised, turn tensioning ratchet until a single click is heard.

e. Recoil of the gun must be checked with a fully wound mechanism containing at least five rounds of ammunition. If the recoil is less than 7/8 of an inch, washers must be placed in front of the sleeve to lengthen the height of the recoil spring to obtain the 7/8-inch recoil. If the recoil is more than 7/8 inch, washers must be placed in front of the spring to shorten the spring to obtain the 7/8-inch recoil.

NOTE: When the 20-mm feed mechanism AN-M1 is used with adapter AN-M1 or M6, no special adjustments are made to adapters. When the M7 adapter is used, the muzzle brake must be replaced with the thread protector.

16. FIRING THE GUN.

a. **Firing.**

(1) Charge the gun.

(2) Actuate the firing mechanism to fire the gun.

b. **To Cease Firing.** Discontinue actuating the firing mechanism.

c. The same method of firing is employed, regardless of the type of feed mechanism used.

RA PD 10809A

Figure 66 — Installation of 20-MM 60-round Magazine M1 on Gun

17. UNLOADING THE GUN (20-MM FEED MECHANISM AN-M1).

a. Point the gun in a safe direction.

b. Disconnect the link and feed chutes from the feed mechanism if necessary.

c. Break the belt near the belt guide by withdrawing a round from the links if there.

d. Lift the magazine slide lever to disengage the magazine latch from the feed mechanism.

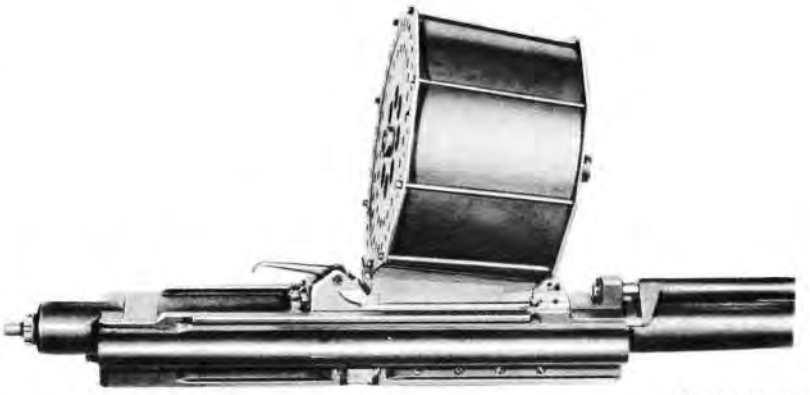
e. Pull the feed mechanism upward and rearward and remove it from the gun.

f. If the breechblock is retracted, be sure the chamber is clear and then actuate the firing mechanism. If the breechblock is in the forward position, charge the gun, be sure the chamber is clear, and then actuate the firing mechanism.

g. Remove the rounds from the mouth of the feed mechanism by pushing them forward with a blunt wooden instrument, such as a hammer handle. Do not drop the cartridges as they are removed. Keep fingers clear of the working parts of the mechanism.

h. To remove the last round from the mouth, open the link chute cover and, with a screwdriver, push the lower end of the front feed lever so that it rotates and the last round retainer is displaced (fig. 65) allowing the last round to drop down into the mouth.

i. Push the last round forward in the mouth and remove it.



RA PD 10808A

Figure 67 — Loaded Magazine in Position on Gun

18. INSTALLATION OF 20-MM 60-ROUND MAGAZINE M1 ON THE GUN.

a. The magazine should be used with M7 adapter and muzzle brake only.

b. Place a fully loaded magazine on top of the magazine slide and engage the two pins at the front of the mouth with the hook-shaped projections at the front of the slide (fig. 66). Lift the magazine slide lever to engage the magazine latch with the rear of the magazine (fig. 67).

19. UNLOADING THE GUN (20-MM 60-ROUND MAGAZINE M1).

a. Point the gun in a safe direction.

b. Lift the magazine slide lever to disengage the magazine latch from the magazine; then pull the magazine upward and rearward and remove it from the gun.

c. If the breechblock is retracted, be sure the chamber is clear and then actuate the firing mechanism. If the breechblock is in the forward position, charge the gun, be sure the chamber is clear, and then actuate the firing mechanism.

20-MM AUTOMATIC GUN M1 AND 20-MM AIRCRAFT AUTOMATIC GUN AN-M2

Section IV

DISASSEMBLY AND ASSEMBLY

20. GENERAL.

a. Disassembly and assembly as described in the following paragraphs are intended for instruction, detailed cleaning and lubrication, detailed inspection, and replacement of parts. The gun should always be kept on wooden supports during disassembly and assembly in order to prevent it from falling and being damaged. In order to avoid damage which may result in malfunctions, parts should not be forced during disassembly and assembly.

21. SPECIAL TOOLS.

a. Special tools to be used in disassembly and assembly are listed in section IX and illustrated in figure 99.

22. DISASSEMBLY OF THE BASIC GUN.

a. Driving Spring Guide Group.

(1) Make certain the breechblock is in its most forward position before proceeding any further.

(2) With a blunt chisel, straighten the rim of the retainer washer so that it does not engage the flat on the driving spring guide head (fig. 68).

(3) Insert the driving spring assembling tool through the driving spring guide head. Push the tool forward until it engages the driving spring guide plunger (fig. 69).

(4) Unscrew the driving spring guide assembly using the special rear buffer wrench (fig. 70). Remove the assembly together with the driving spring assembling tool and plunger.

RA PD 10932A

Figure 68 — Straightening the Retainer

(5) Withdraw the driving spring assembling tool. Remove the driving spring guide plunger and the driving spring.

(6) The driving spring guide and head are attached by a staked screw and a sweated joint, and should not be disassembled.

b. Rear Buffer Group.

(1) Retract the rear buffer lock plunger and remove the rear buffer group by sliding it out of the dovetail grooves in the receiver.

(2) Drift out the rear buffer lock plunger pin. Remove the plunger, spring, and collar.

(3) Secure the rear buffer assembly in a vise with soft jaws. Unstake the rear buffer threaded sleeve and unscrew the sleeve with the special rear buffer wrench (fig. 71). Remove the rear buffer washer and spring (fig. 72).

RA PD 10938A

Figure 69 — Inserting the Driving Spring Assembling Tool

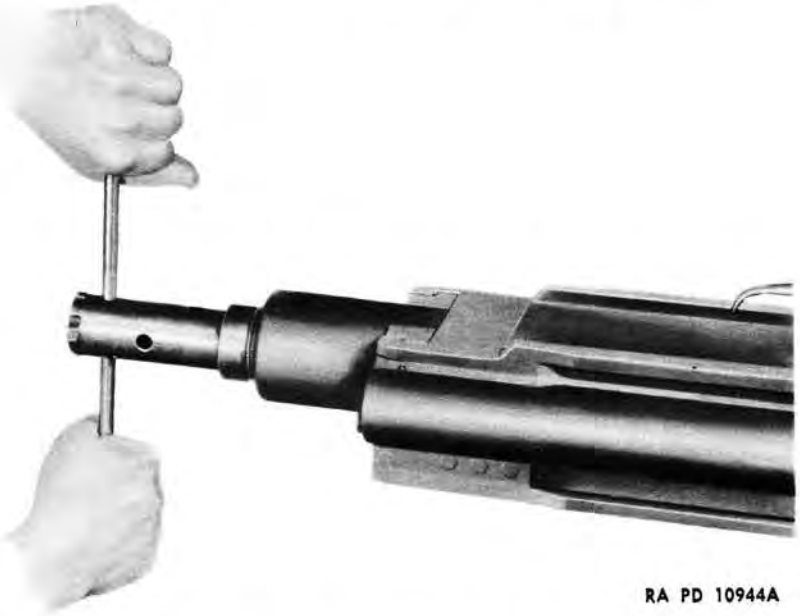


Figure 70 — Unscrewing the Driving Spring Guide Assembly

(4) The completely disassembled rear buffer group is shown in figure 72.

c. Breechblock Group.

(1) Engage the projection on the arm of the breechblock unlocking tool with the front face of the right breechblock slide (fig. 73).

(2) Place the other arm of the tool along the top of the breechblock with its end against the receiver (fig. 74).

(3) Press the lever of the tool forward to unlock the breechblock (fig. 75).

(4) Move the breechblock assembly to the rear of the receiver. As soon as it starts to come out, grasp the breechblock lock and hold it in the unlocked position (fig. 76). Failure to do this may cause the breechblock to get jammed in the rear portion of the receiver as it is being pulled out. Do not drop the breechblock lock.

NOTE: If the special tool is not available, use the hand charger to retract the breachblock. If hydraulic charger or manual charger is installed the breechblock may be unlocked by prying the push rods back with a screwdriver.

Figure 71 — Unscrewing the Rear Buffer Sleeve

(5) Remove the breechblock lock. Remove the left and right inertia blocks (fig. 77).

(6) Withdraw the left breechblock slide and then the right breechblock slide with the slide key assembled, being careful not to let the breechblock slide spring and guides fly out (fig. 77). Do not remove the breechblock slide key except for replacement.

(7) Press the extractor against the extractor spring and drift out the extractor pin. Withdraw the extractor and extractor spring (fig. 77). Lift the front end of the bolt assembly and allow the firing pin to slide out through the rear. Do not drop the firing pin.

d. Magazine Slide Group.

(1) Remove the cotter pin, unscrew the ejector stud nut, and remove the washers. Withdraw the ejector with the springs (fig. 78).

(2) Remove the locking wire, unscrew the magazine slide back plate screws, and remove the back plate with the magazine latch springs. (The magazine slide back plate should never be removed except when it is being replaced.) Remove the magazine slide lever pin and bushing, slide lever, and latch (fig. 78).

(3) Remove the magazine slide by sliding it to the rear.

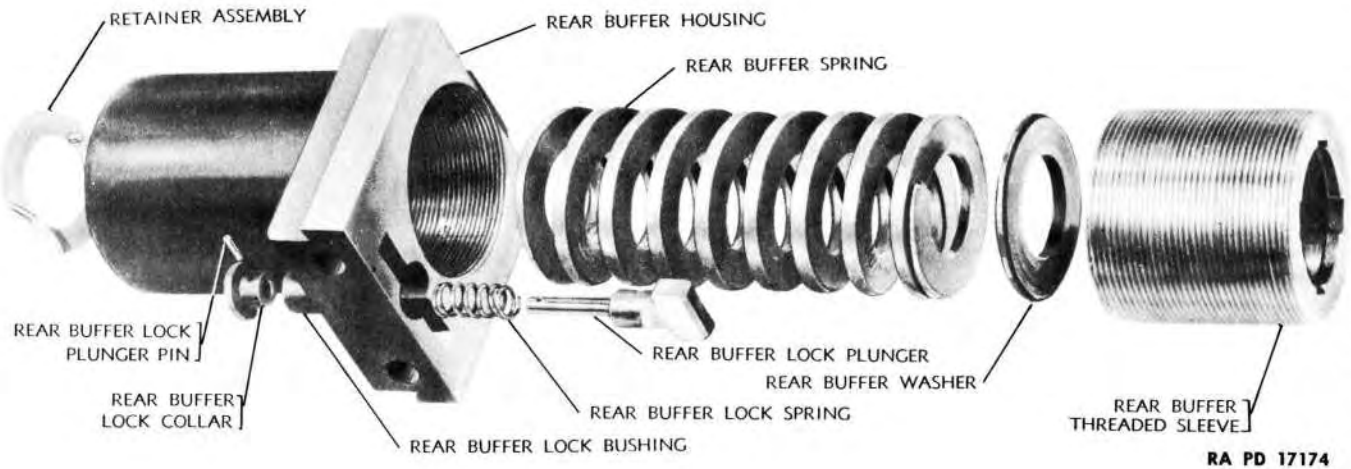


Figure 72 — Rear Buffer Group — Parts

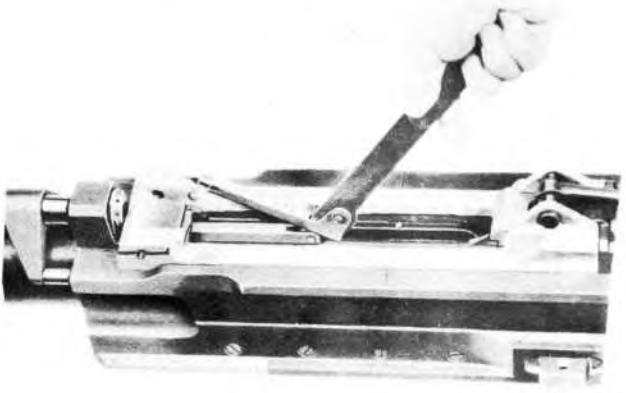


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Figure 73 — Placing the Breechblock Unlocking Tool in Position

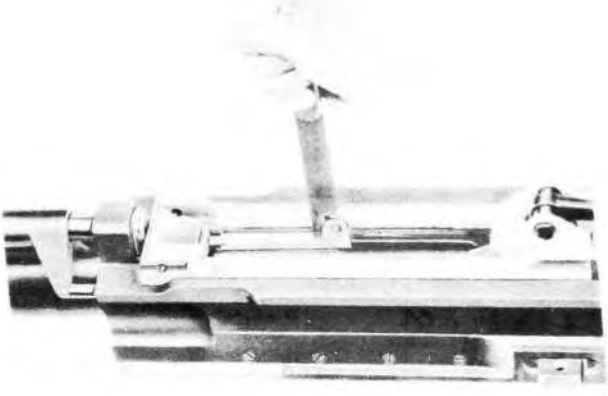

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Figure 74 — Breechblock Unlocking Tool in Position

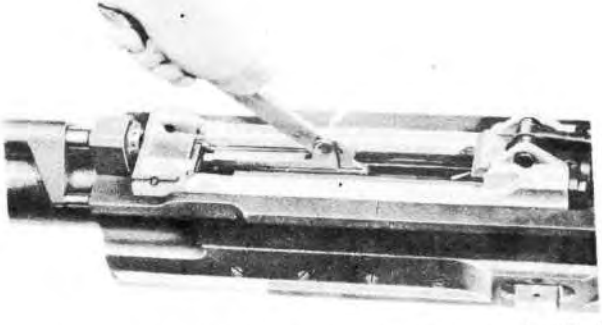

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Figure 75 — Unlocking the Breechblock

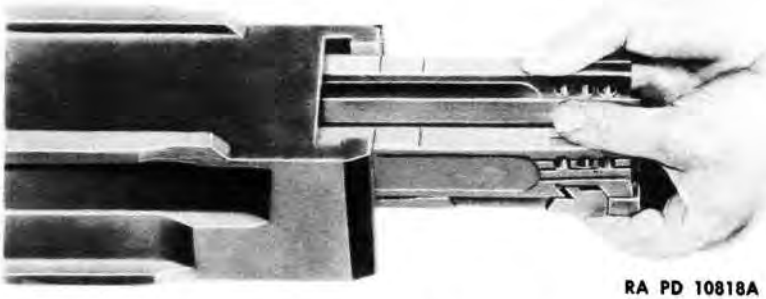

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Figure 76 — Removing (or Replacing) the Breechblock

e. **Gas Cylinder and Sleeve Group** (fig. 79).

(1) Remove cotter pin and lock washer from gas cylinder guide and unscrew the gas cylinder guide.

(2) Remove the gas cylinder sleeve spring.

(3) Remove locking wire from the gas cylinder bracket plug and then the gas cylinder lock washer. Unscrew gas cylinder bracket plug and remove gas cylinder lock plate. Unscrew gas cylinder vent plug.

(4) Remove the gas cylinder and the sleeve from the gas cylinder bracket by sliding the assembly toward the rear of the gun.

(5) Remove the gas cylinder from the sleeve.

(6) Remove the gas cylinder sleeve push rods.

f. **Receiver Slides.** Turn the gun upside down. Remove the receiver slides from their slots in the receiver body by removing the cotter pins, nuts, and lock washers from the eight slotted head bolts that hold the two slides in position.

g. **Sear Block Group.**

(1) Insert the sear buffer spring retaining tool into the hole in the sear block. Push the tool through the sear block so that it fully engages the circumferential grooves on the sear buffer spring plungers.

(2) Carefully lift the sear block and sear out of the receiver with the retaining tool in place (fig. 80). Remove the steel and fiber sear buffer blocks from the receiver.

(3) Withdraw the sear pin to detach the sear from the sear block.

(4) Place the sear block in the sear block assembling tool so that the radial bearing surface of the sear block contracts the jaw of the tool while the plungers which protrude from the sear block engage the hook-

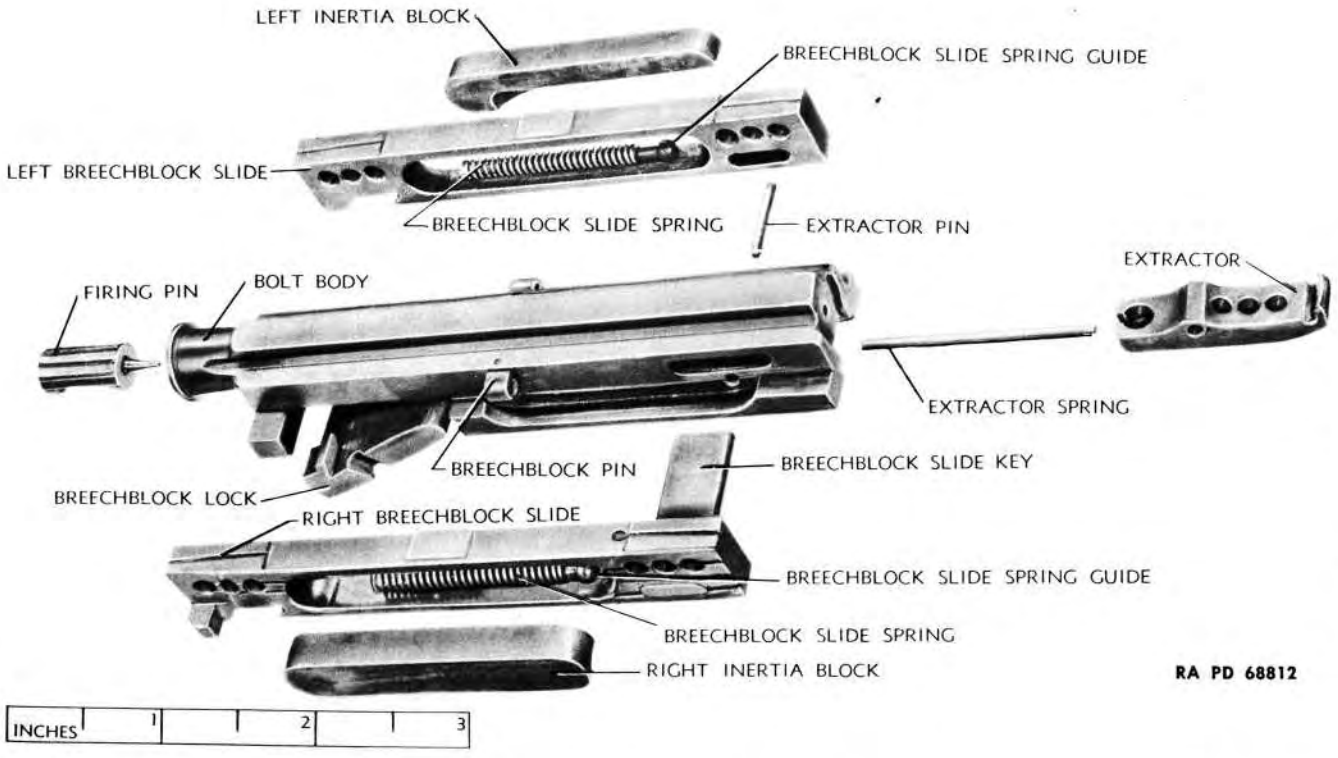
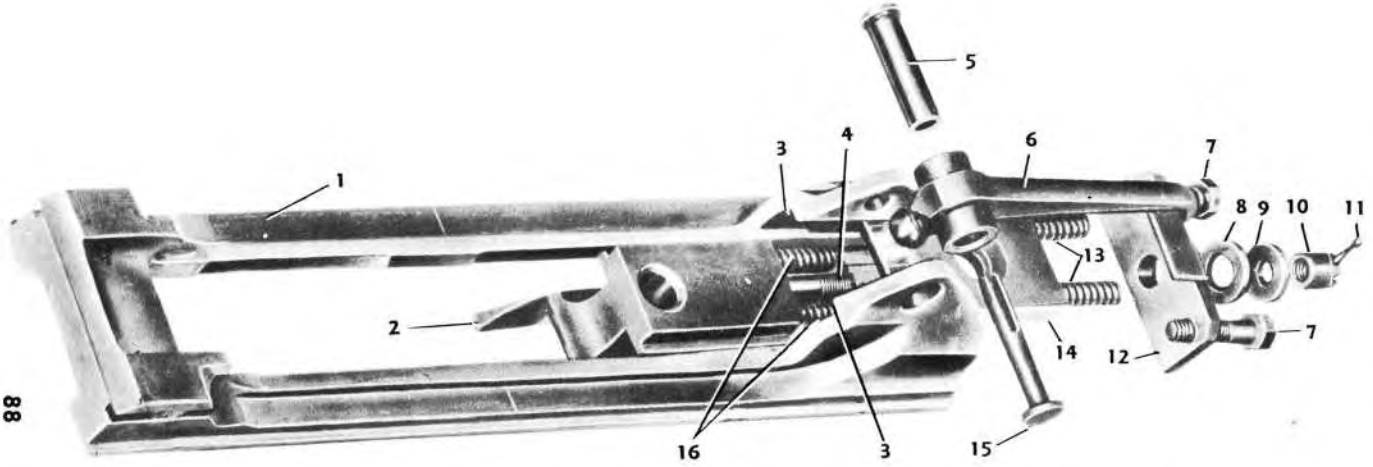


Figure 77 — Breechblock Group — Parts



1 — MAGAZINE SLIDE
2 — EJECTOR
3 — MAGAZINE LATCH GROOVES
4 — EJECTOR STUD
5 — MAGAZINE SLIDE LEVER PIN BUSHING
6 — MAGAZINE SLIDE LEVER
7 — MAGAZINE SLIDE BACK PLATE SCREW
8 — EJECTOR STUD WASHER
9 — EJECTOR STUD NUT WASHER
10 — EJECTOR STUD NUT
11 — COTTER PIN
12 — MAGAZINE SLIDE BACK PLATE
13 — MAGAZINE LATCH SPRING
14 — MAGAZINE LATCH
15 — MAGAZINE SLIDE LEVER PIN
16 — EJECTOR SPRING

RA PD 68813

Figure 78 — Magazine Slide Group

A — GAS CYLINDER SLEEVE SPRING
B — GAS CYLINDER SLEEVE
C — GAS CYLINDER PISTON
D — GAS CYLINDER
E — TUBE
F — GAS CYLINDER VENT PLUG
G — GAS CYLINDER BRACKET PLUG
H — GAS CYLINDER BRACKET
J — GAS CYLINDER TAPER PIN
K — GAS CYLINDER GUIDE
L — SPLIT COTTER PIN
M — GAS CYLINDER GUIDE LOCK WASHER
N — GAS CYLINDER LOCK PLATE
P — GAS CYLINDER LOCK WASHER

RA PD 70368

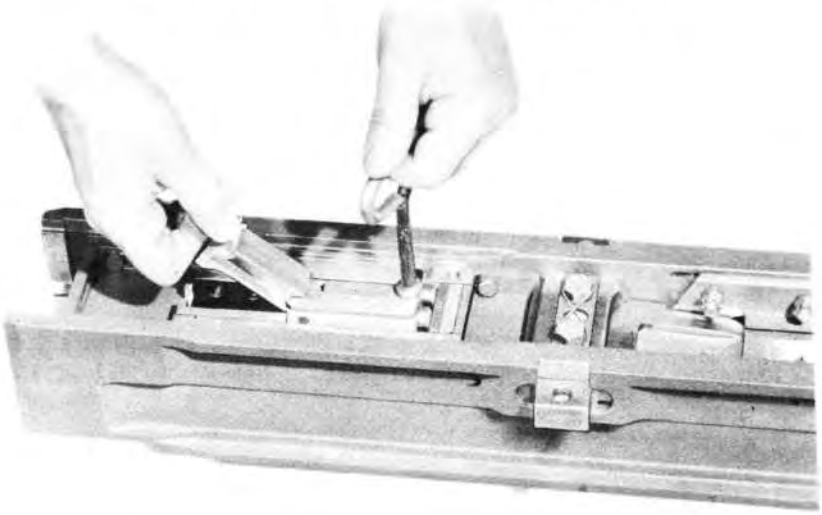
Figure 79 — Gas Cylinder and Sleeve Group

shaped projection at the front of the tool (fig. 81). The sear buffer spring retaining tool should enter the hole in the sear block assembling tool.

(5) Turn the handle of the sear block assembling tool sufficiently to take the tension off the sear buffer spring retaining tool. Remove the retaining tool. Gradually turn the handle of the tool to release the tension of the springs. Remove the plungers and springs (fig. 82). If the special sear block assembling tool is not available, an ordinary vise will serve. If the retaining tool is not available, use a slightly tapered steel rod which nearly fills the hole.

h. Breechblock Locking Key. Remove the locking wire and unscrew the breechblock locking key plate screws. Remove the lock washers and the plate. Drive out the key with a soft hammer.

NOTE: The breechblock locking key is to be removed only for replacement.



RA PD 10933

Figure 80 — Removing Sear Block Group from Receiver Plate

23. ASSEMBLY OF THE BASIC GUN.

a. Prior to assembly, all parts must be free of dirt, rust, and other extraneous matter. Metal parts in contact must be covered with a light film of lubricating oil. Assembly and replacement are in the reverse order of disassembly. However, the following instruction pertaining to certain assembly operations should be noted:

RA PD 10937

Figure 81 — Sear Block Group in Position in the Tool

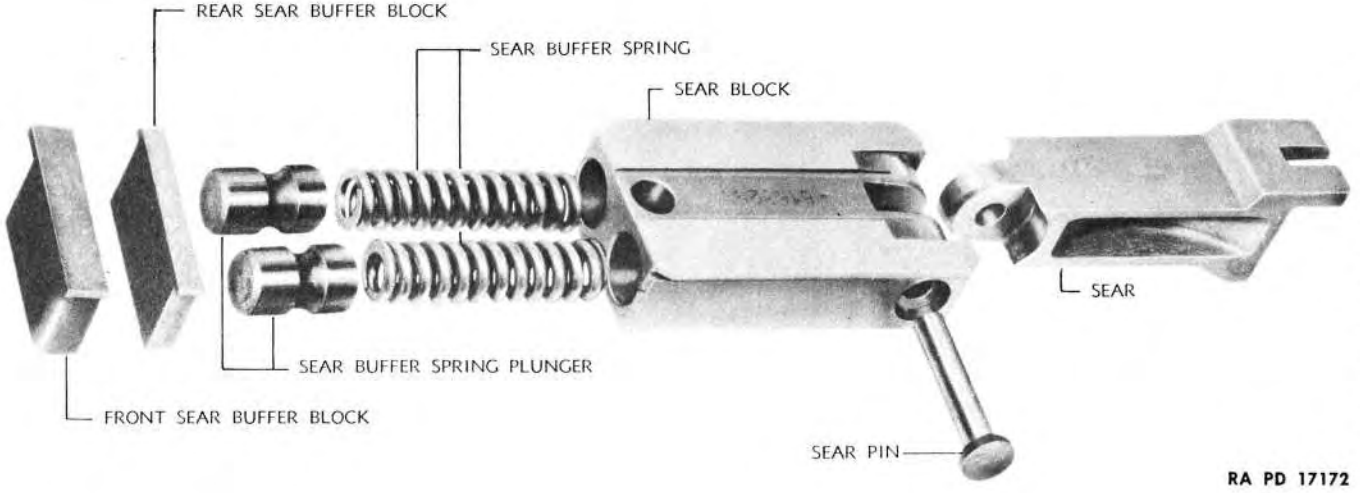


Figure 82 — Sear Block Group

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Figure 83 — Inserting the Driving Spring Group

(1) The breechblock lock must be assembled to the breechblock by forcing the breechblock slides rearward and, at the same time, exerting pressure against the lock until it is in the unlocked position. Hold the breechblock firmly in this position and push into the receiver as far as it will go so that the lock will not spring out of position (fig. 76).

(2) In assembling the rear buffer group, stake the threaded sleeve to the housing at three points. Extreme caution should be exercised, however, not to overstake, as difficulty may be experienced in removing the stake when it is necessary to replace the rear buffer spring.

(3) To assemble the driving spring and driving spring guide, push the breechblock forward to the locked position. Insert the driving spring assembling tool into the driving spring guide plunger. Slip the driving spring over the tool and plunger. Insert the driving spring guide into the spring so that the tool telescopes the guide tube. Insert the entire group into the receiver (rear buffer in place) (fig. 83), so that the head of the plunger rests against the back of the firing pin. Compress the driving spring and tighten the guide securely, using the special rear buffer wrench. Remove the driving spring assembling tool.

(4) In assembling and replacing the sear block group, proceed as follows: Insert the sear buffer springs in their recesses in the sear block. Replace the plungers with their hollow ends against the springs. Place the unit on the sear block assembling tool with the flanged side of the sear block up and with the radial bearing surface against the jaw of the tool. Compress the springs until the sear buffer spring retaining tool can be inserted to engage the grooves of the plungers (fig. 81). Remove the sear block and retaining tool from assembling tool. Attach the sear to the block so that the forked end of the sear is on the same side as the flanged side of the block. Do not remove the retaining tool until the group has been replaced in the gun.

(5) Assemble the gas cylinder group first without the spring and test for free movement of the piston in the cylinder. When this has been done, remove the gas cylinder guide, and install the spring.

DISASSEMBLY AND ASSEMBLY

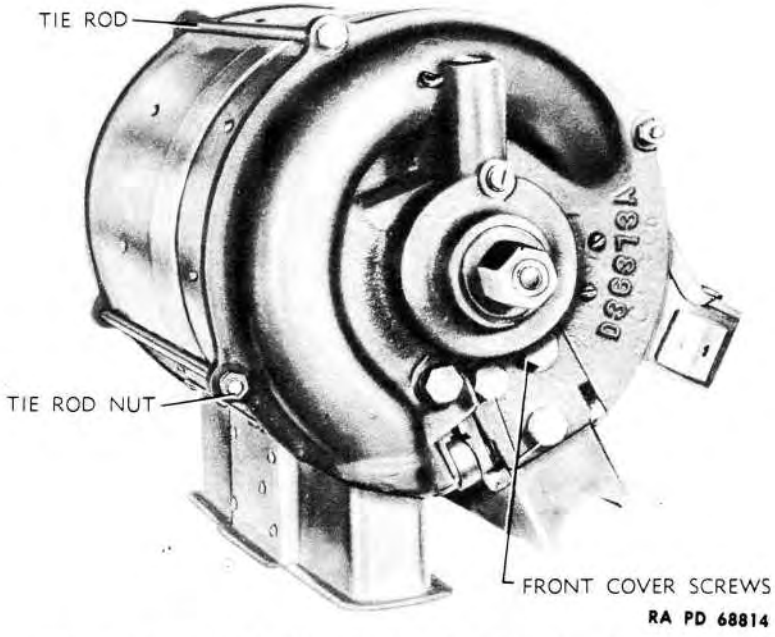

Figure 84 — 20-MM Feed Mechanism AN-M1 — Front View

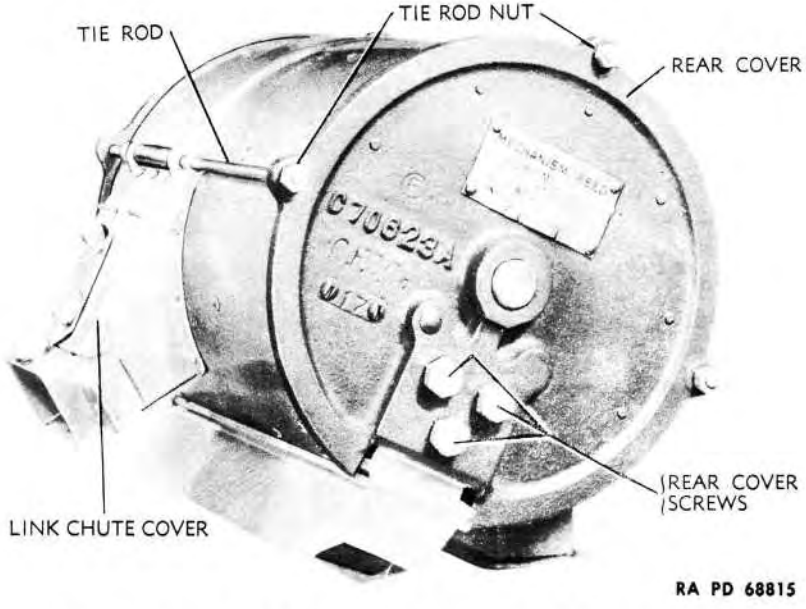

Figure 85 — 20-MM Feed Mechanism AN-M1 — Rear View

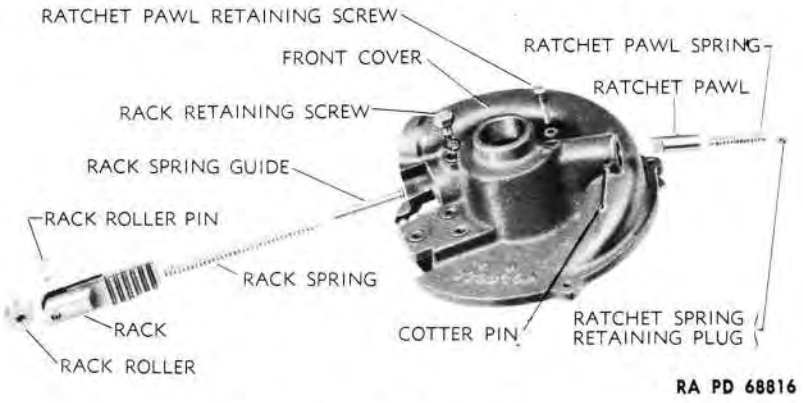

Figure 86 — Front Cover Group

(6) The gas cylinder should have at least a 0.01-inch clearance between the hexagonal shoulder and the top of the tube to allow for heat expansion. This is best done with a 0.010-inch shim or feeler gage.

24. DISASSEMBLY OF 20-MM FEED MECHANISM AN-M1.

a. Remove the front and rear cover screws and the washers. Remove the tie rod nuts. When the tie rod above the link chute is pulled out, the link chute cover and spring will be released (figs. 84 and 85).

b. Carefully loosen rear cover and remove it, taking care not to damage any of the parts. Remove the pin which secures the last round retainer spring and rear feed lever spring. Carefully loosen the case from the front cover. Pull the ends of the case out of the grooves in the mouth and withdraw the mouth. Remove the shaft assembly.

c. While holding the rack in place in the front cover, unscrew the rack retaining screw, and gradually release the rack assembly, rack spring, and the rack spring guide. Withdraw the hub with the driving spring case cover, the thrust spring, the ratchet segment, and driving spring ratchet from the front cover.

d. Remove the cotter pin, which secures the ratchet spring retaining plug, from the upper side of the front cover. Withdraw the plug and the tensioning ratchet pawl with the spring. Unscrew the tensioning ratchet pawl retaining screw (fig. 86).

e. Drift out the ratchet pin and remove the ratchet, ratchet segment, thrust spring, and driving spring case cover (fig. 87).

f. Drift the collar pin out of the shaft and slide off the following in the order listed:

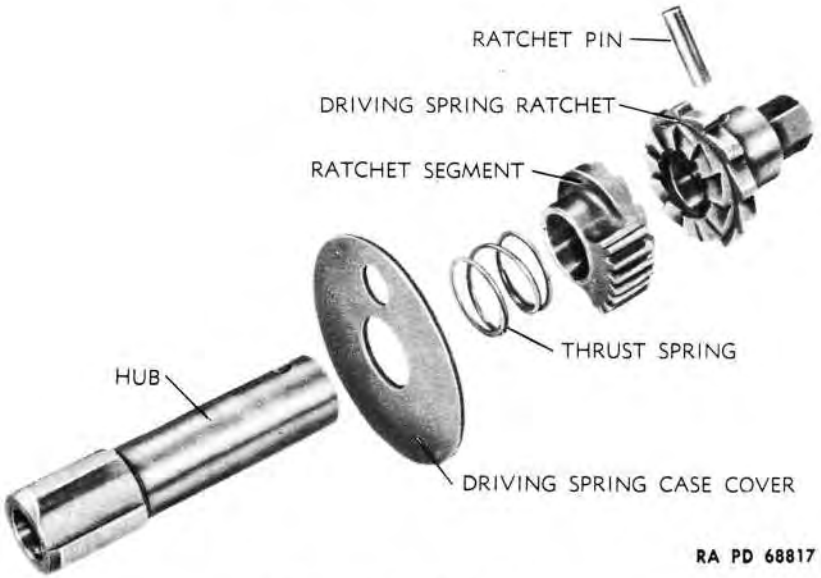

Figure 87 — Hub Group

(1) Collar.

(2) Rear feed lever.

(3) Rear feed sprocket assembly.

(4) Front feed lever assembly.

(5) Center feed sprocket assembly.

(6) Link ejector assembly.

g. Drift out the front feed sprocket bushing pin and slide off the front feed sprocket assembly.

h. Shaft assembly parts are shown in figure 88.

25. ASSEMBLY OF 20-MM FEED MECHANISM AN-M1.

a. Slip the driving spring case cover on the hub, placing it flat against the face of the bossed surface at one end of the hub. Follow with the thrust spring and ratchet segment. The flat of the segment should bear against the thrust spring. Place the ratchet on the hub and engage its teeth with the teeth on the segment. Aline the ratchet pin hole with the hole in the hub and drive in ratchet pin.

b. Replace rack spring together with rack spring guide within the recess in the rack provided for it Place this unit in the recess located

Figure 88 — Shaft Assembly

RA PD 68819

Figure 89 — Engaging Rack to Ratchet Segment

in the front cover. Position the rack so that the teeth face the central hole in the front cover. Insert the hexagonal end of the ratchet into the central hole of the front cover from the rear of the cover. Engage the rack and segment so that the first tooth on the rack goes between first and second teeth of the segment. This operation can be most advantageously accomplished by looking through the hole in the driving spring case cover (fig. 89). Fasten the rack assembly to the front cover with the rack retaining screw.

c. Insert the tensioning ratchet pawl into its recess in the top of the cover. The cut-out portion must face to the same side as the rack teeth. Aline it by replacing the tensioning ratchet pawl retaining screw. Insert the tensioning ratchet pawl spring into the hollow rear end of the pawl. Close the recess with the pawl spring retaining plug and secure the plug with the cotter pin.

d. Slip the driving spring case over the hub so that the hub engages the driving spring. Insert the shaft key into the keyway on the shaft. Insert the front end of the shaft (end with bronze bearing) into the front feed sprocket bushing. With one hand aline the hole of the front feed sprocket bushing with the hole of the hub, and with the other hand push in the shaft so that the shaft key alines with the keyway in the bushing (fig. 90). Aline the hole in the shaft with the hole in the bushing and insert the front feed sprocket bushing pin.

RA PD 68820

Figure 90 — Inserting Shaft into Hub

e. Slip the following onto the shaft in the order listed:

(1) Link ejector assembly. In the right-hand feed mechanism, the ejector should be to the left and the notched arm on the bracket should be down when looking forward along the shaft. In the left-hand feed mechanism the position is reversed.

(2) Center feed sprocket assembly with bushing to the rear (the center feed sprocket is thicker than the rear feed sprocket).

(3) Front feed lever assembly. In the right-hand feed mechanism the last round retainer is to the right. In the left-hand feed mechanism it is to the left.

(4) Rear feed sprocket assembly with bushing to the rear.

(5) Rear feed lever with flat arm to the rear.

(6) Collar with larger face adjacent to the flat arm of the rear feed lever. Drive in the collar pin to secure the collar to the shaft.

f. Attach last round retainer spring (smaller) to stud on last round retainer and rear feed lever spring (larger) to stud on rear feed lever.

g. Place the case over the shaft assembly, front end first. Slip the ends of the last round retainer spring and rear feed lever spring through

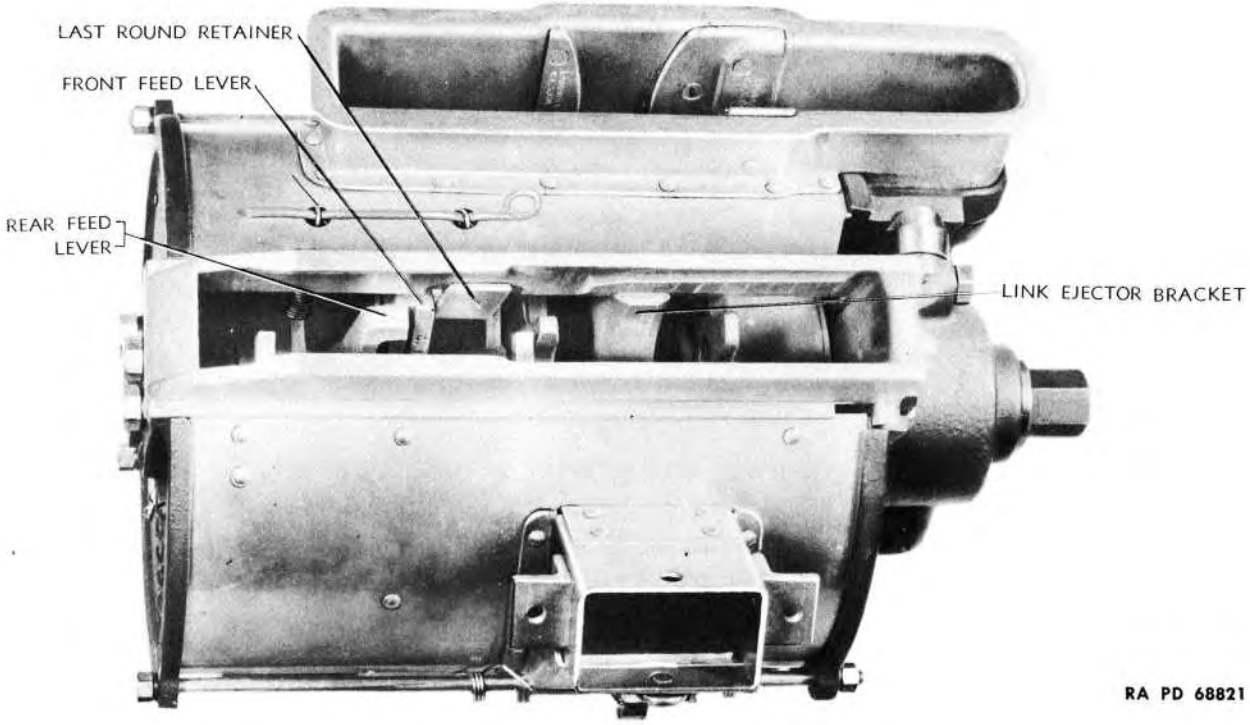

Figure 91 — Details in Assembling the Feed Mechanism

the small holes located in the rear of the case below the belt guide. Fasten the springs with the pin. The loop of the pin should be to the front.

h. Slip the mouth into position in the case, with the slanted end to the rear. Compress the case to hold the mouth securely. The last round retainer should extend downward within the mouth (fig. 91). The notch on the end of the link ejector should engage the right edge of the mouth in the right-hand feed mechanism and the left edge in the left-hand feed mechanism (fig. 91). The rear feed lever should be placed in a position whereby the lug on its front arm will mate with the lug of the adjacent arm of the front feed lever when the rear feed lever is turned in the direction of feed (fig. 91). Tap the case forward until the edges enter the grooves in the front cover. Place the rear cover on the rear end of the shaft. The rear feed lever should extend downward to the right of the rear feed stop in right-hand feed mechanism (and to the left in left-hand feed mechanism) when looking into the case with the mechanism right side up. Insert the tie rods through the front and rear covers. Attach first the tie rod that acts as a hinge for the link chute cover and spring. Compress the case until the edges enter the grooves in the covers. Fasten the tie rods with lock washers and nuts. Fasten the nuts gradually and uniformly. Fasten the mouth to the covers with lock washers and front and rear cover screws. The screws have the same diameter but differ in length. Use the *longer* screws for the *front* cover.

26. DISASSEMBLY OF 20-MM 60-ROUND MAGAZINE M1.

a. Remove all rounds from the magazine. Place the magazine in the magazine holder with the mouth up and the nut on the lower tie rod in the locating hole in the holder. If no magazine holder is available, use any other suitable retaining device.

b. Remove the cotter pin from the tensioning tube pin. Place a bar in the end of the tensioning tube and turn it to take the load off the tension tube pin. Remove the tube pin and carefully release the spring.

c. Unscrew the seven fixing screws and remove the front plate disk. Remove the spring casing with the spring and tensioning tube. Disengage the tensioning tube from the spring.

d. Remove the pin and collar from the rear of the feed arm axis tube. Turn the feed arm axis tube through a right angle so that the follower clears the hole in the front plate and remove the tube with feed arm and follower (fig. 92).

27. ASSEMBLY OF 20-MM 60-ROUND MAGAZINE M1.

a. Proceed in reverse order of disassembly.

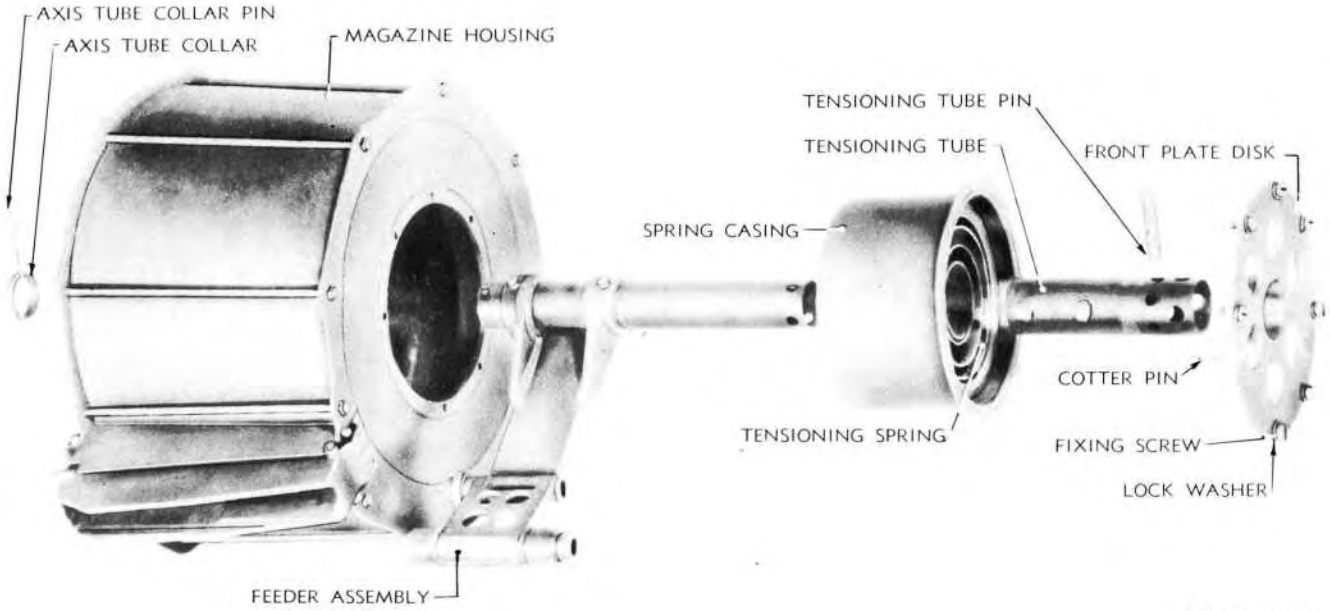

Figure 92 — 20-MM 60-round Magazine M1

Section V

MALFUNCTIONS AND CORRECTIONS

28. GENERAL.

a. Proper care of the gun before and after firing will usually eliminate most stoppages. Stoppages or other malfunctions should be dealt with in accordance with instruction described in the following paragraphs. These instructions should be studied before any firing is done.

b. Immediately after flight, unload the gun and, if the breechblock is home, retract it by charging the gun. If a round is extracted during the charging, it indicates that the gun failed to fire. If a hydraulic charger is used, leave the pressure on so that there will be no risk of the breechblock moving forward until the pressure is released.

29. MISFIRE.

a. All stoppages will be considered misfires if the receiver is not visible. Immediately after the occurrence of a misfire, proceed as follows:

(1) GROUND TESTING. Wait 30 seconds from the time of occurrence of the misfire. Recharge the gun and remove the round from the vicinity of the aircraft.

CAUTION: If the gun is hot and the round cannot be removed from the chamber, the breechblock or bolt should be closed. It should not be opened until the hand can be placed on the breech or barrel without discomfort.

(2) AIR TESTING. If the weapon can be recharged, either manually or remotely, wait 30 seconds and then recharge. If the weapon cannot be recharged, no corrective action is possible.

(3) COMBAT FIRING. If recharging is possible, recharge immediately and continue firing.

NOTE: The possibility of a hangfire of more than 30 seconds after an attempt to fire is very remote in guns using fixed ammunition. The possibility of the propellant or the high-explosive filler being fired

by the heat absorbed from a hot gun barrel increases with the length of time the round is in the gun. The safest time to remove a misfire is between 30 and 45 seconds after its occurrence.

30. OTHER MALFUNCTIONS AND THEIR CORRECTIONS.

a. Failure to Feed.

(1) CAUSES:

(a) Loss of tension in the feed mechanism driving spring due to insufficient recoil of the gun, improper magazine slide adjustment, broken driving spring in the feed mechanism, or broken parts in the anchoring mechanism of the magazine slide.

(b) Round jammed in the mouth of the feed mechanism due to loss of tension in the feed mechanism driving spring, deformed feed mouth, excessive friction in feed mechanism, or a belt jam in the feed chute or ammunition container.

(c) Link jammed or belt broken, due to defective links.

(d) Insufficient recoil of bolt caused by faulty unlocking or defective ammunition.

(2) REMEDIES.

(a) Check the tension of the feed mechanism driving spring with a torque wrench if available. If the tension has dropped from the original setting, check the magazine slide setting which should be $\frac{1}{16}$ inch to the rear of the scribe mark on the receiver. Inspect the anchor mechanism for loose or broken parts. Check tension of the rack spring and replace if broken or weak. When testing the tension of the driving spring determine whether the driving spring of the feed mechanism is broken. If it is, replace the feed mechanism. If the feed mechanism has lost tension and the loss in tension cannot be attributed to any of the above causes, it may be assumed that there was insufficient recoil of the gun to operate the feed mechanism. In this case, the front and rear mountings should be carefully inspected for any signs of binding or restricted movement of the gun in recoil. If it is impractical to test-fire the gun to determine the resulting recoil travel, replace the adapter with a new one.

(b) If a round is jammed in the mouth of the feed mechanism, it may have been caused by a loss of tension in the feed mechanism. Check as described in subparagraph a (1) above. If the tension has not dropped, inspect the mouth of the feed mechanism for burs, dents, or other deformations. If the mouth of the feed mechanism is in good shape, check the link chute for jammed links which may be caused by a weak or broken link chute cover spring, or by weak and defective links. Remove jammed links with screwdriver.

20-MM AUTOMATIC GUN M1 AND 20-MM AIRCRAFT AUTOMATIC GUN AN-M2

CAUTION: Do not insert finger in link chute to clear jammed link as unwinding of spring may result in injury. Excessive friction in the feed mechanism may be caused by improper lubrication of the feed mechanism and of the links and rounds (par. 13 a (3) and 33 g). Check the feed chute for free motion of belt. Check the ammunition container. Friction or jams in the feed chute or container may prevent feeding.

(c) If the gun fails to pick up a new round, it may be caused by a jam as described in step (2) above. Also it may be caused by faulty ammunition, which provides insufficient recoil energy, or by faulty unlocking of the breechblock. Check the bore to see that there is no projectile in the tube. Check the gas cylinder and piston for free operation. If the piston is bent or deformed on the end, replace parts to insure free unlocking action. Broken belts are usually caused by defective links. If the breechblock remains in the retracted position when the firing mechanism is actuated, inspect the electric trigger and all connections thereto.

b. Failure to Fire Chambered Round.

(1) CAUSES. Failure to fire may be caused by:

(a) Defective firing pin.

(b) Defective ammunition.

(c) Insufficient protrusion of firing pin.

(2) REMEDIES.

(a) Examine the firing pin for breakage or cracks (indicated in figure 93). If firing pin is cracked or broken, it should be replaced.

(b) Examine the extracted round. If the primer of the round is deeply indented, it must be treated as a misfire and immersed in water. If the primer is not indented or only slightly indented, examine the firing pin as above, inspect the driving spring and breechblock slide springs, and examine the receiver for foreign matter. Also examine the breechblock slides for swaging (fig. 93) which may produce "light hits" by interfering with bolt action.

c. Failure to Extract.

(1) CAUSES. Failure to extract is generally caused by:

(a) Broken extractor or extractor spring.

(b) Carbon deposit in chamber.

(c) Dirty ammunition.

(2) REMEDIES.

(a) When failure to extract occurs, the bolt may be found fully closed with a spent case in the chamber. Generally, most failures to

extract can be remedied by charging the gun except when the extractor, extractor spring, or extractor pin are broken. When this occurs, the case should be pushed out from the muzzle end. The broken extractor, spring or pin should be replaced.

(b) Sometimes the empty case will be left in the chamber with the extractor ripping through the base of the cartridge case. When this occurs, the bolt will generally attempt to feed a fresh round into the chamber. It will then be necessary to remove this round before the spent case can be removed. If the jammed round is broken, be sure to remove all powder that may be strewn around in the receiver.

(c) A dirty chamber can be caused by carbon deposit from the oil film on the rounds. If this occurs, clean the chamber.

(d) Failure to Eject. This is caused by a broken ejector stud or ejector which should be replaced.

(e) Run-away Gun. This may be caused by a broken sear spring or sear which should be replaced. To stop a run-away gun on a ground test, jam a screwdriver in the belt; to stop a run-away gun in an airplane in the air, activate the charger on "SAFE" or pull back rapidly on the control stick.

Section VI

CLEANING AND LUBRICATION

31. GENERAL.

a. Proper functioning and accuracy of firing depend largely on care, cleaning, and oiling. The weapon should be checked daily for cleanliness and lubrication. The following instructions should be carefully observed:

(1) Use OIL, lubricating, preservative, special, for the lubrication of all aircraft guns under all service conditions, regardless of the temperatures to be encountered. The oil is preferably applied by means of a cloth dampened with the oil. On guns other than aircraft, OIL, lubricating, preservative, light, may be used.

32. CLEANING OF GUNS RECEIVED FROM STORAGE.

a. Guns which have been stored in accordance with instructions given in paragraph 35 will be coated with either OIL, lubricating, preservative, medium, or COMPOUND, rust-preventive, light. Guns received from storage will usually be coated with a COMPOUND, rust-preventive, heavy. Use SOLVENT, dry-cleaning, to remove all traces of the compound. Apply the solvent with rag swabs to large parts, and as a bath for small parts. Take care to remove the compound from all recesses in which springs or plungers operate. Be careful to remove all traces of compound from the gas part in the tube and the gas cylinder plug. After removing all traces of the compound, allow the parts to dry and then wipe with a clean dry rag.

b. Persons handling parts after such cleaning should wear gloves to avoid leaving finger marks which are usually acid and start corrosion. SOLVENT, dry-cleaning, will attack and discolor rubber gloves.

33. CARE PREPARATORY TO FIRING.

a. Before the day's firing, the following instructions should be carefully followed in order to insure proper functioning of the gun.

b. Remove the breechblock.

c. Run clean patches through the bore and chamber to remove all dirt and oil.

d. Thoroughly clean all metal parts and lightly oil with OIL, lubricating, preservative, special.

CAUTION: Do not oil the bore and chamber before firing because dangerous pressures may develop.

e. Lubrication should be applied lightly because oil has a tendency to collect dirt which may act as an abrasive on the operating parts.

f. After the gun has been cleaned and oiled as described above, assemble the gun and wipe all outer surfaces with a lightly oiled rag.

g. Feed lubrication. Before installing feed mechanism on the ground, dip the whole mechanism in OIL, lubricating, preservative, special, and allow to drain, being sure to get oil in the specified filter on the front of driving spring hub.

34. CARE AFTER FIRING.

a. Thorough cleaning after firing is extremely important and shall be performed as soon as possible. The bore and other portions exposed to primer fouling, such as the front end of the bolt and receiver portions to the rear of the chamber, shall be thoroughly cleaned of primer salts using CLEANER, rifle bore. The corrosive primer salts are water soluble, and are not soluble in petroleum distillates.

b. Immediately after firing or as soon as possible, run several wet patches impregnated with CLEANER, rifle bore, through the bore from the breech end. If the CLEANER, rifle bore, is not available, use warm soapy water or warm water alone. Remove the patch from the cleaning rod and attach the cleaning brush. Run the brush through the bore several times. Make certain the brush goes all the way through before reversing the direction. Remove the brush and run several patches wet with clean water through the bore and chamber again. Follow this with dry patches until they come out clean and dry. Failure to remove all traces of bore cleaner from the receiver and bolt is apt to result in malfunctioning of the gun at low temperatures because the cleaner contains water. Other methods of cleaning primer salts, such as the use of steam or hot solutions may be employed if proper control is maintained to complete removal of moisture from all parts of the gun, and the bore is lubricated immediately thereafter.

c. After the bore and chamber have been cleaned, remove the breechblock and clean with SOLVENT, dry-cleaning. Clean the receiver with SOLVENT, dry-cleaning. Then wipe dry and oil as described in paragraph 31.

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35. PREPARATION FOR STORAGE.

a. OIL, lubricating, preservative, special, has rust-preventive properties, but is not recommended as a rust-preventive for guns stored for extended periods, since frequent inspection and reoiling is required. Where guns must be maintained ready for immediate installation or use, it may be used subject to the following periodic inspection and reoiling:

(1) The gun shall be inspected every 4 days if installed in aircraft stored outdoors, and every 7 days if installed in aircraft stored indoors. Adverse weather conditions may require more frequent inspection. Guns having parts treated with protective coatings require less frequent inspection. If inspection reveals signs of corrosion the preservative coating should be renewed.

b. When installed guns are not to be fired for a month or more, they shall be removed, disassembled, cleaned, and dipped in OIL, lubricating, preservative, medium. Guns thus oiled shall be inspected at least every 7 days if stored outdoors and every 20 days if stored indoors. More frequent inspection may be necessary under adverse climatic conditions.

c. For the preservation of guns over very long storage periods when frequent inspection is impractical the guns shall be removed, disassembled, and thoroughly coated with COMPOUND, rust-preventive, light. This compound is applied by heating to temperature from 150 F to 180 F and briefly dipping the parts therein. Reassemble and store, applying the compound to spots where it has been removed during handling. Complete removal of all traces of this compound prior to reoiling for use is essential. Removal by vapor methods and immersion in SOLVENT, dry-cleaning, is prescribed.

d. **Specifications and Stock Numbers of Lubricants and Preservatives.**

(1) OIL, lubricating, preservative, special, Navy Specification OS 1361; US Army Specification AXS 777; ASO Stock No. R14-O-2852 (1-qt container); ASO Stock No. R14-O-2856 (5-gal container).

(2) OIL, lubricating, preservative, medium, Navy Specification OS 1363; US Army Specification AXS 674; ASO Stock No. R14-O-2832 (1-qt container); ASO Stock No. R14-O-2834 (5-gal container).

(3) COMPOUND, rust-preventive, light, US Army Specification 2-84B; ASO Stock No. R14-C-260 (5-lb container); ASO Stock No. R14-C-261 (25-lb container).

(4) CLEANER, rifle bore, US Army Specification RIXS 205; ASO Stock No. R51-S-4794 (6-oz container); ASO Stock No. R51-S-4796 (1-qt container).

(5) SOLVENT, dry-cleaning, Federal P-S-661a.

Section VII

INSPECTION

36. GENERAL.

a. The purpose of inspection is to determine the condition of the gun and any repairs, adjustments, or replacements that may be required to maintain the gun in proper condition for efficient operation. Thorough, systematic inspection at regular intervals is the best insurance against an unexpected gun break-down at the critical moment when maximum performance is absolutely necessary. Never let your materiel run down; keep it in first class fighting condition by vigilant inspection and prompt maintenance.

37. INSPECTION OF GUN.

a. These inspections are routine and should be performed after every firing session without removing the gun from the airplane.

b. General Condition of Gun. Experience has shown that certain parts of the gun are subject to failure more frequently than others. Complete inspection should be carried out periodically, but the following parts and assemblies must be carefully cleaned and inspected after every day's firing. The exterior of the gun should be inspected for any scoring, evidence of binding in recoil travel, or broken locking wire or cotter pins which would result in loose parts or assemblies.

c. Functioning of the Gun. Remove the feed mechanism from the gun. Charge the gun and actuate the firing mechanism several times, using a dummy or empty shell in the chamber to cushion the shock. If any binding or sluggish movement of parts is noted, determine the cause and stone or replace parts as necessary to produce free motion. Use only a fine stone on parts and do not remove any more metal than is absolutely necessary.

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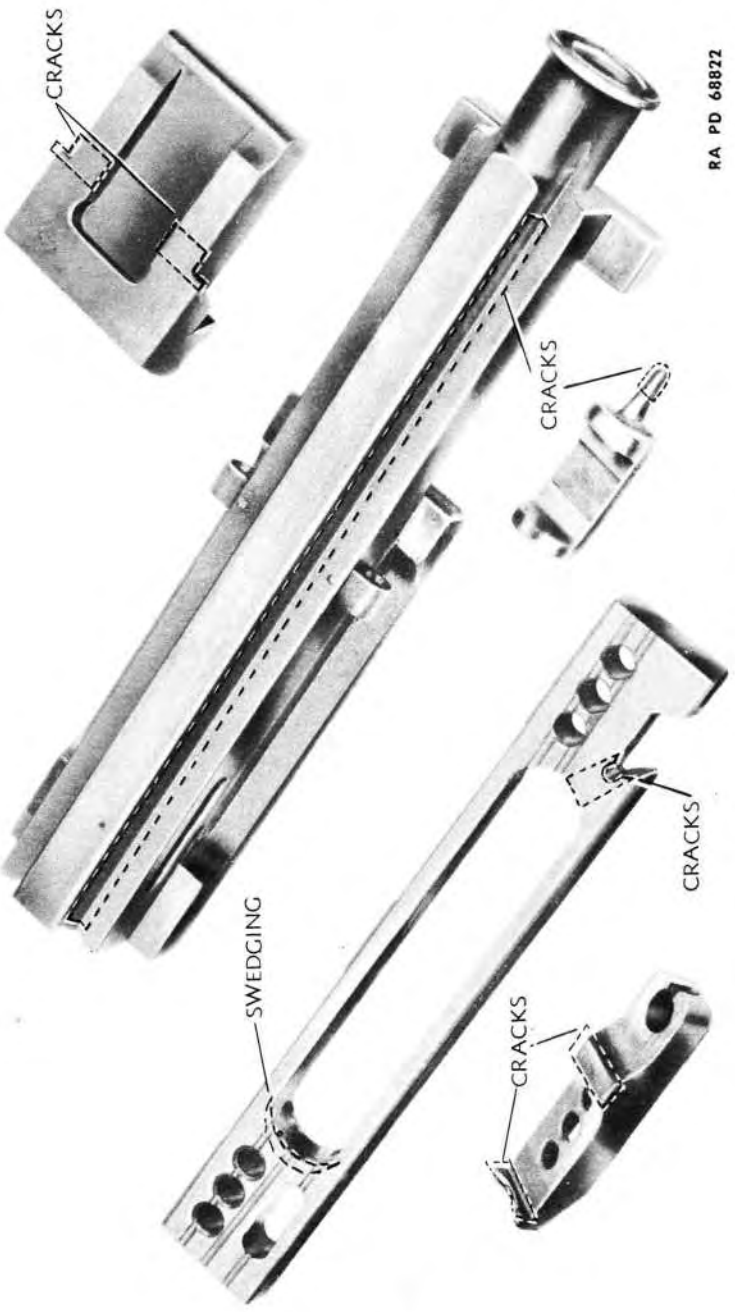

Figure 93 — Defects in Breechblock Parts

d. Driving Spring. Test tension of driving spring and examine for sharp kinks or offset of coils. Measure free length (26.5 in.). If free length is less than 23.5 inches, the spring should be replaced.

e. Rear Buffer. Examine rear buffer for rough or bruised surfaces on washer, threaded sleeve or dovetail connections.

f. Breechblock. Disassemble the breechblock and clean it with SOLVENT, dry-cleaning. Examine front face of bolt for erosion and wear, and note condition of firing pin hole. Look for cracks on the shoulders of the bolt (fig. 93). Examine breechblock slides for burs or rough surfaces on cam. Look for swaging and cracks (fig. 93). Note condition of breechblock slide key. Examine firing pin for pitting, deformation, or cracks (fig. 93). Examine the extractor for signs of cracks over extractor pin hole, and chips or burs on the lip (fig. 93). Examine breechblock lock for condition of cams on both sides, and for wear or roughness on locking surface. Check under side of lock for wear and cracks (fig. 93).

g. Magazine Slide. Check whether magazine slide is correctly adjusted (par. 14). Check for free motion of the slide in the guideways.

h. Gas Cylinder and Sleeve Group. Check for carbon or rust on gas cylinder and sleeve, bracket, and plugs. Note if gas cylinder vent plug is loose.

38. INSPECTION OF FEED MECHANISMS.

a. Examine exterior of feed mechanism for loose or broken parts. Test whether the tie rods and nuts are tight.

b. If the case or covers are dented or damaged, and if the lips on the mouth are bent, the feed mechanism is unserviceable.

c. Remove any burs from the mouth, from the pins at the front of the mouth, and from the latch plate at the rear of the mouth.

d. If the feed mechanism has been disassembled, check the cam in front cover for burs and scores. Test whether the feed sprockets rotate freely. Then, raise the link chute cover and see if spring is broken. Check whether rack roller rotates freely.

39. INSPECTION OF CHARGERS.

a. Hydraulic Charger M1. See that the taper pin which retains the spring guide assembly is firmly staked to the charger housing. Check for leakage around charger cylinder. If the charger cylinder leaks excessively around the piston, the packings should be replaced. This is done by removing the cylinder and piston assembly from the charger housing on the gun with the special spanner wrench provided with the charger. Separate the piston from the cylinder and remove the pack-

ings by unscrewing the nut on the end of the piston tube. Install new packings between the follower and the seat, and fasten with the nut and a cotter pin. The nut should be tightened until the packing swells sufficiently to prevent leakage around the piston, but not too tight so that excessive binding will result. (In an emergency, the nut may be tightened to swell old packings enough to stop leakage, but the packings should be replaced as soon as possible.) Exercise care to keep all parts free from dirt. If dirt is permitted to get into the cylinder chamber, the highly polished wall surface may become scored and cause excessive wear of the packings and eventual leakage. In assembling the piston to the cylinder, special care should be taken to guide the packings into the cylinder so that the sealing edge of the packings is not damaged, as this will cause leakage at low pressures.

40. INSPECTION OF SEAR ACTUATING MECHANISMS.

a. Electric Trigger AN-M1.

(1) The Electric Trigger AN-M1 is manufactured as an integral unit, and if any malfunction occurs, the whole unit should be replaced and the damaged unit returned to ordnance maintenance personnel or to the nearest supply point for replacement.

(2) When the trigger control is removed from the gun, be sure that the base plate is clean and free from burs before assembling the trigger to the gun.

b. Sear Mechanism M1.

(1) Check fit of mechanism to receiver of gun. Check sear spring housing for looseness, and examine interior of housing for foreign matter or rough edges on the opening.

(2) Test tension of sear spring.

(3) Test functioning of safety lever.

(4) Remove the two nuts from bowden connection shaft and examine the parts for wear, rust, and broken or cracked bushings.

(5) Test tension of bowden connection shaft spring.

41. INSPECTION OF ADAPTERS.

a. It is important to check the tube sleeve nut which may be loose even though a detent is used. Remove the detent and tighten the nut securely. If the detent shows signs of wear, replace it with a new one.

b. 20-mm Adapter AN-M1 or M6. Since this adapter itself is constructed as a unit, there are no adjustments or repairs that can be made. If the adapter fails to function properly, replace it with a new adapter and return the damaged adapter to ordnance maintenance personnel or to the nearest supply point for replacement.

Section VIII

AMMUNITION

42. GENERAL.

a. The ammunition for these guns is issued in the form of fuzed complete rounds of fixed ammunition. The term "fixed," used in connection with ammunition, signifies that the propelling charge is not adjustable and that the round is loaded into the gun as a unit. The propelling charge is assembled loosely in the cartridge case which is crimped rigidly to the projectile. A complete round comprises all the ammunition components used to fire a weapon once. After firing, the cartridge case is extracted and ejected; then the next round is loaded into the gun, all automatically.

43. NOMENCLATURE.

a. Standard nomenclature is used herein in all references to specific items of issue. Its use for all purposes of record is mandatory.

44. CLASSIFICATION.

a. Dependent upon the type of projectile, the ammunition is classified as high-explosive-incendiary, armor-piercing, or ball. The high-explosive-incendiary projectile contains both a high-explosive and an incendiary filler. The armor-piercing projectile is a solid shot, containing a tracer element for observation of fire, that is, for showing the gunner the path of the projectile in flight. The ball projectile is inert, and is provided for use against personnel and light materiel targets.

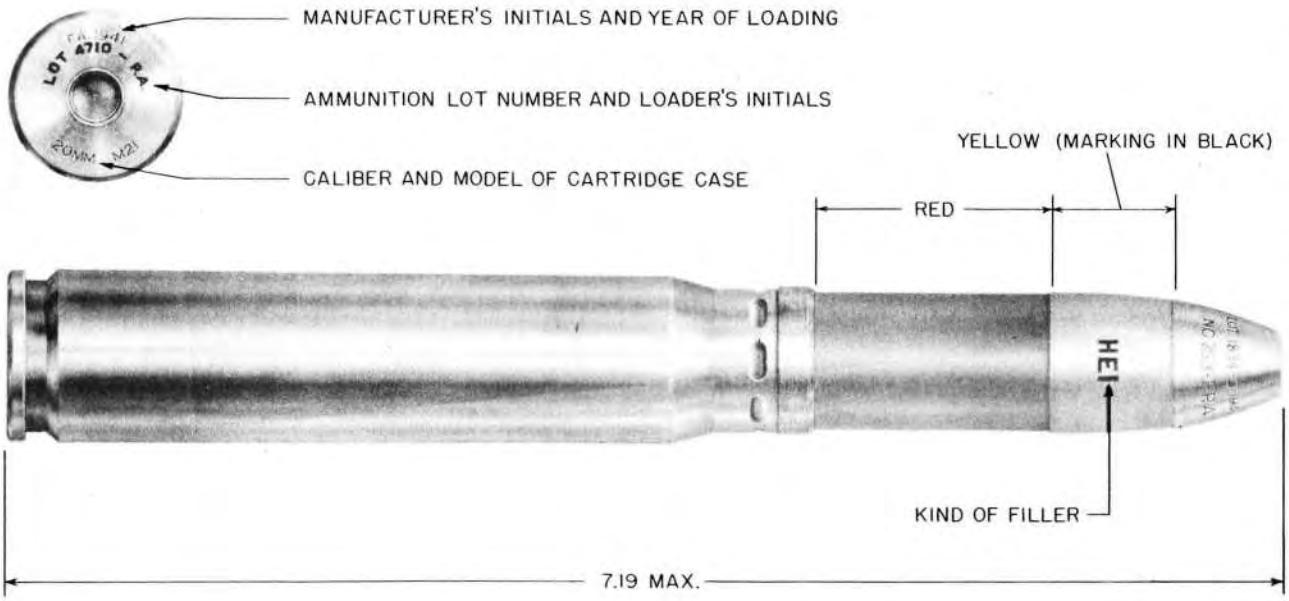

Figure 94 — Cartridge, HE-I, MK. I, W/Fuze, P.D., 253 MK. I-II, 20-MM Guns M1, AN-M2, and Br. H.S. /A/

45. IDENTIFICATION.

a. General. Ammunition, including components, is completely identified by means of painting and marking (including ammunition lot number). Other essential information may be obtained from the marking. See figures 94, 95, and 96 and the paragraphs below.

b. Mark or Model. To identify a particular design, a model designation is assigned at the time the design is classified as an adopted type. This model designation becomes an essential part of the standard nomenclature of the item, and is included in the marking of the item. The model designation consists of the letter "M" followed by an arabic numeral. Modifications are indicated by adding the letter "A" and the appropriate arabic numeral. Thus, "M1A1" indicates the first modification of an item for which the original model designation was "M1." An exception exists in the case of some models of 20-mm ammunition which are designated "Mark," abbreviated "Mk.," followed by a Roman numeral. The unusual nomenclature of some rounds is due to the fact that some of the names have come from the British, some from the U. S. Navy, and some from U. S. Army Ordnance.

c. Ammunition Lot Number.

(1) When ammunition is manufactured, an ammunition lot number, which becomes an essential part of the marking, is assigned in accordance with pertinent specifications. This lot number is stamped or marked on every complete round and on all packing containers. It is required for all purposes of record, including reports on condition, functioning, and accidents, in which the ammunition is involved. To provide for the most uniform functioning, all of the rounds of any one lot of affixed ammunition consists of:

(a) Projectiles of one lot number.

(b) Fuzes of one lot number.

(c) Primers of one lot number.

(d) Propellent powder of one lot number.

(2) Therefore, to obtain the greatest accuracy in any firing, successive rounds should be from the same ammunition lot whenever practicable.

d. Painting and Marking.

(1) PAINTING. Projectiles are painted to prevent rust and, by the color, to provide a ready means of identification as to type. The projectiles of the ammunition described herein are painted as follows:

High-explosive-incendiary ... Yellow ogive, red body; marking in black
Armor-piercing ..... Black; marking in white
Ball (inert) ..... Black; marking in white

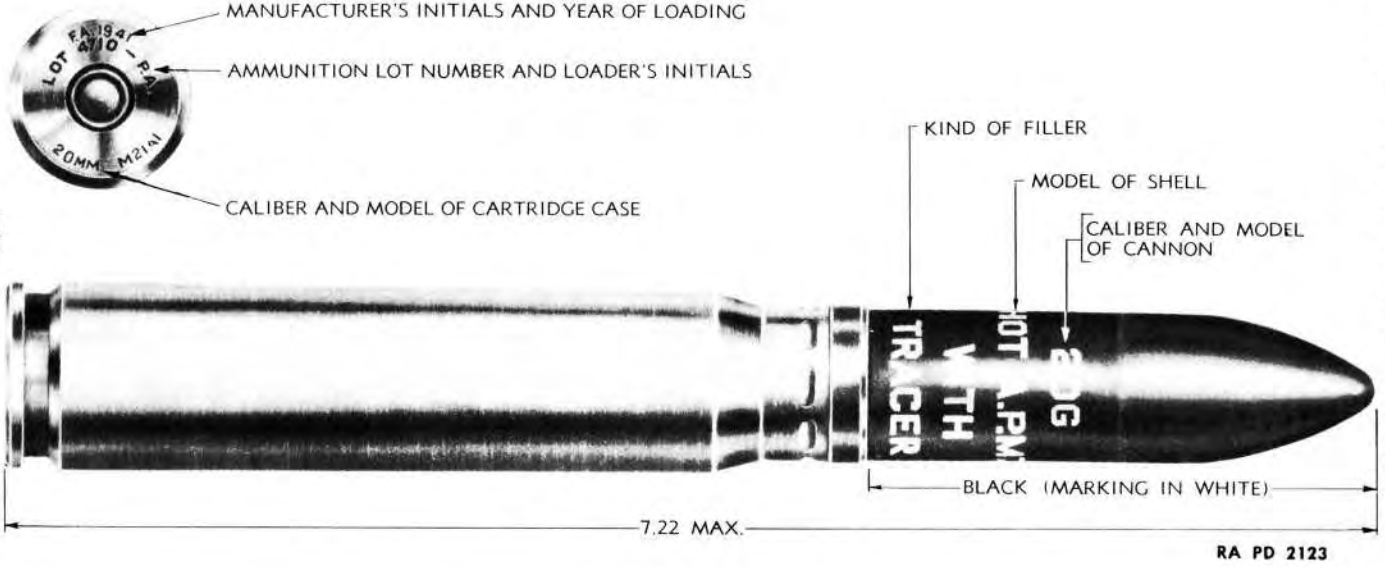

Figure 95 — Cartridge, AP-T, M75, 20-MM Guns, M1, AN-M2, and Br. H.S. /A/

NOTE: The above color scheme is not wholly in agreement with the basic color scheme described in TM 9-1900.

(2) MARKING. For purpose of identification, the following is marked or stamped on the components of each round of fixed ammunition described herein.

(a) On the Projectile (Stenciled):

On the H.E.I. projectile: Kind of filler.
On the A.P. projectile:
Caliber and type of weapon in which fired.
Model of projectile.
"WITH TRACER."

(b) On the Projectile (Stamped in the Metal):

On the H.E.I. and practice projectiles (on the body):
Manufacturer's initials or symbol.
Lot number of empty projectile.
Month and year of manufacture.

On the A.P. projectile (on the base end):
Manufacturer's initials or symbol.
Lot number projectile.
Year of manufacture.
Caliber and designation of shot.

(c) On the Head of the Cartridge Case:

Stenciled:
Ammunition lot number.
Loader's initials.

Stamped in the metal:
Designation and caliber of case.
Manufacturer's initials or symbol.
Year of manufacture, in full.

(d) On the Fuze (Stamped in the Metal):

Model and designation of fuze.

Manufacturer's initials or symbol.

Loader's lot number.

Year of loading.

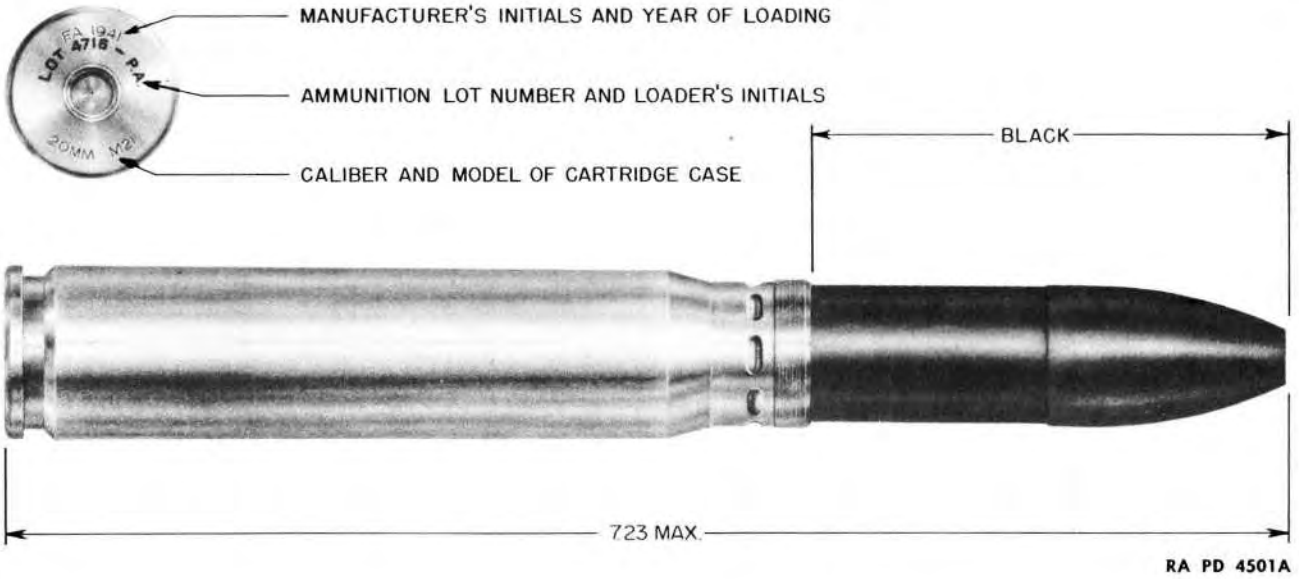

Figure 96 — Cartridge, Ball, 20-MM Guns, M1, AN-M2, and Br. H.S. /A/

AMMUNITION

46. CARE, HANDLING, AND PRESERVATION.

a. Complete rounds are packed to withstand conditions ordinarily encountered in the field. Ammunition for the 20-mm automatic guns is packed in cartons (10 per carton), which in turn are inclosed in metal-lined wooden boxes. Since explosives are adversely affected by moisture and high temperature, the following precautions should be observed:

(1) Do not break moisture-resistant seals until ammunition is to be used.

(2) Protect ammunition, particularly fuzes, from high temperatures, including the direct rays of the sun. More uniform firing is obtained if all the rounds are at the same temperature.

b. Handle ammunition with care at all times. The explosive elements in primers and fuzes are highly sensitive to shock and high temperature.

c. Do not attempt to disassemble any complete round or fuze.

d. The complete round should be freed of foreign matter such as sand, mud, grease, etc., just before loading into the magazine or belt. If it gets wet or dirty, it should be wiped clean at once.

e. Although the use of oil or grease on ammunition is generally prohibited, in the case of ammunition for these guns it is necessary to oil the cartridge case in order to prevent jamming. By means of a cloth wrung out of OIL, lubricating, preservative, special, spread a light film of oil evenly over the body of the cartridge case just prior to insertion of the round into the magazine or belt. Extreme care should be taken to prevent oil from getting on the primer or joint at the mouth of the cartridge case. If OIL, lubricating, preservative, special, is not available, use OIL, lubricating, preservative, light. Preferably, only one day's supply of ammunition should be lubricated at a time. Rounds oiled for firing and not fired at the same day, should be wiped dry to prevent the accumulation of dust and grit, and the seepage of oil around the primer and mouth of the cartridge case. Such rounds will be used first in subsequent firing; they must be oiled again before use.

f. Do not handle duds because their fuzes are armed; they will not be moved or turned but will be disposed of in accordance with TM 9-1900.

47. AUTHORIZED ROUNDS.

a. The ammunition authorized for use in these guns is shown in the following table. The M1, AN-M2, and Br. H.S. /A/ Guns are chambered alike; hence, fire the same ammunition. The nomenclature (standard nomenclature) completely identifies the round.

20-MM AUTOMATIC GUN M1 AND 20-MM AIRCRAFT AUTOMATIC GUN AN-M2

Table 1
Ammunition for the Gun,
20-mm, M1, AN-M2, and Br. H.S. /A/

Nomenclature	Action of Fuze	Approximate Weight of Projectile as Fired
Service Ammunition		
CARTRIDGE, HE-I, Mk. I, w/ FUZE, P.D., 253 Mk. I-II, 20-mm guns, M1, AN-M2, and Br. H.S. /A/	Superquick	0.29 lb
CARTRIDGE, AP-T, M75, 20-mm guns, M1, AN-M2, and Br. H.S. /A/	None	0.37 lb
CARTRIDGE, ball, 20-mm guns, M1, AN-M2, and Br. H.S. /A/	None	0.29 lb

HE-I, High-explosive-incendiary; AP-T, armor-piercing, w/tracer P.D., point-detonating.

48. PREPARATION FOR FIRING.

a. As issued, the complete rounds are ready for firing after removal of packing; however, it is necessary to oil the rounds as described in paragraph 46 e and to load the rounds into the feed mechanism or the magazine

49. CARTRIDGE, HE-I, MK. I, W/FUZE, P.D., 253 MK. I-II, 20-MM GUNS M1, AN-M2, AND BR. H.S. /A/.

a. This complete round (fig. 94) is for use from aircraft against light materiel targets, functioning with both explosive and incendiary effect. After the shell penetrates the target, the high-explosive filler is detonated, the shell is shattered, and the incendiary composition is ignited. The round consists of a primer and a propelling charge, contained in a brass cartridge case which is crimped rigidly to the projectile, and a fuze which is of the superquick type. The projectile contains a total of 0.03 pound of high-explosive and incendiary fillers. The round is 7.19 inches long and weighs 0.57 pound. The propelling charge, weighing 0.07 pound, consists of loose flashless nonhygroscopic (FNH) smokeless powder contained in the cartridge case.

50. CARTRIDGE, AP-T, M75, 20-MM GUNS M1, AN-M2, AND BR. H.S. /A/.

a. This complete round (fig. 95) is for use from aircraft against armored targets. It consists of a primer and a propelling charge contained in a brass cartridge case which is crimped rigidly to the projectile. The projectile is a solid steel shot, and contains a red tracer

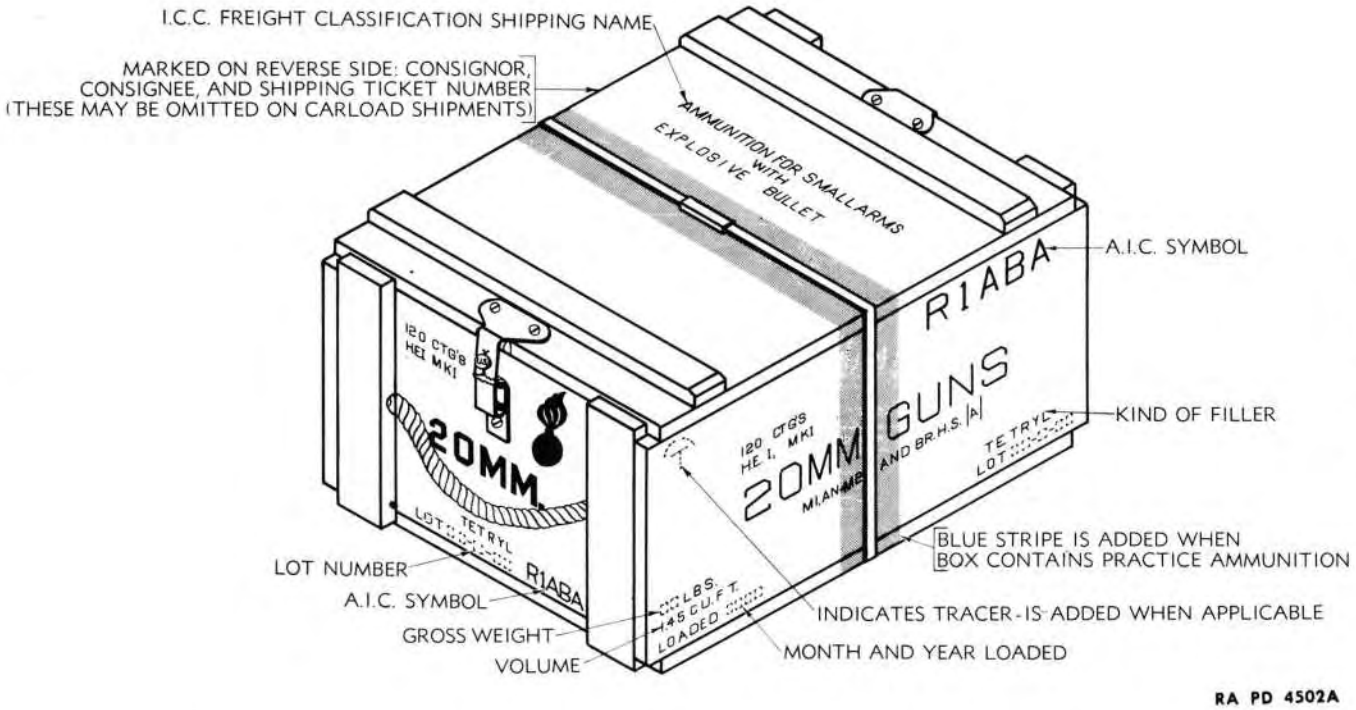

Figure 97 — Packing Box for Ammunition for 20-MM Guns M1, AN-M2, and Br. H.S. /A/

composition in its base. The round is 7.22 inches long and weighs 0.64 pound. The propelling charge, weighing 0.07 pound, consists of loose flashless nonhygroscopic (FNH) smokeless powder contained in the cartridge case.

51. CARTRIDGE, BALL, 20-MM GUNS M1, AN-M2, AND BR. H.S. /A/.

a. This complete round (fig. 96) is for service firing from aircraft against personnel and light materiel targets and for practice. It consists of a primer and propelling charge contained in a cartridge case which is crimped rigidly to the steel projectile. The projectile contains no explosive and has no fuze. It is similar in shape and ballistic properties to the point-fuzed high-explosive incendiary projectile. The round is 7.23 inches long and weighs 0.57 pound. The propelling charge, weighing 0.07 pound, consists of loose flashless nonhygroscopic (FNH) smokeless powder contained in the cartridge case.

52. FUZES.

a. A fuze is a mechanical device used with a projectile to explode it at the time and under the circumstances desired. A fuze designed to function upon impact with a target is classified as the impact type. Fuzes designed to function on impact with a light material target, such as an airplane wing, are further classified as superquick fuzes.

CAUTION: Fuzes will not be disassembled. Any attempt to disassemble fuzes in the field is dangerous and is prohibited except under specific direction of the Chief of Ordnance.

53. FUZE, P.D., 253 MK. I or MK. II.

a. These are instantaneous percussion fuzes of the impact type, for penetration of light armor and functioning on heavier armor of aircraft. Like some fuzes used with small caliber ammunition, these fuzes do not come within the definition of boresafe. They are used with 20-mm high-explosive aircraft ammunition and are issued assembled to the high-explosive incendiary projectile of the fixed complete round described in paragraph 49 and shown in figure 94. The MK. II /A/ fuze is similar to the MK. I /A/ except that the MK. II /A/ is more sensitive. It contains a washer type disk whereas the MK. I /A/ contains a solid disk.

54. PACKING AND MARKING.

a. Packing. The ammunition for the GUN, automatic, 20-mm, M1, AN-M2, and Br. H.S. /A/ is packed 10 rounds per fiber carton,

12 cartons (120 rounds) per sealed metal-lined packing box (fig. 97). The following data are considered suitable for estimating weight and volume requirements:

	Weight	Volume
Complete round, HE-I, w/o packing material	0.57 lb	—
Complete round, A.P., w/o packing material	0.64 lb	—
Complete round, Ball, w/o packing material	0.57 lb	—
120 HE-I or Ball rounds in fiber cartons in metal-lined packing box	94.8 lb	1.48 cu ft
120 A.P. rounds in fiber cartons in metal-lined packing box	103.0 lb	1.48 cu ft

Over-all dimensions of packing box (in.): $18\frac{11}{16} \times 13\frac{3}{16} \times 10\frac{11}{32}$

b. Marking for Shipment.

(1) Packings for shipment are marked as follows (fig. 98):

(a) Name and address of consignee (or code marking).

(b) List and description of contents.

(c) Code symbol (A.I.C.) as published in standard nomenclature lists and OFSB 3-14.

(d) Gross weight in pounds; displacement in cubic feet.

(e) The number of the package.

(f) Ordnance insignium and escutcheon.

(g) Name or designation of consignor preceded by the word "FROM."

(h) Lot number.

(i) Month and year loaded.

(j) Inspector's stamp.

55. FIELD REPORT OF ACCIDENTS.

a. When an accident involving the use of ammunition occurs during training practice, the procedure prescribed in section VII, AR 750-10, will be observed by the ordnance officer under whose supervision the ammunition is maintained or issued. Where practicable, reports covering malfunctions of ammunition in combat will be made to the Chief of Ordnance, giving the type of malfunction, type of ammunition, the lot number of the complete rounds or separate-loading components, and conditions under which fired.

Section IX

ORGANIZATIONAL SPARE PARTS AND ACCESSORIES

56. ORGANIZATIONAL SPARE PARTS.

a. These are extra parts provided with the materiel for replacement of those parts which are most likely to become unserviceable through breakage or wear. Organizational spare parts are for use by the using arms in making minor repairs. The sets of organizational spare parts should be kept as complete as possible at all times and kept clean and oiled to prevent rust. The allowances of organizational spare parts are prescribed in SNL A-47.

57. ACCESSORIES.

a. **General.** Gun accessories are those required for operating, disassembling, assembling, and for cleaning, care, and preservation. They also include covers, tool roll, etc., necessary for storage and protection when the equipment is not in use. Accessories should not be used for purposes other than as prescribed. Those accessories, the names or general characteristics of which indicate their use, are not described in detail here. Accessories embodying special features or having special uses are described in the following paragraphs and illustrated in figure 98.

(1) 20-MM LINK LOADING MACHINE M4. The ammunition linking machine provides a quick and accurate means of combining 20-mm cartridges and disintegrating links to form a continuous belt. The machine consists essentially of a base with guides for 11 links and 10 cartridges. A handle operates a pusher bar which pushes the cartridges into the links to form a belt of 10 rounds.

(2) CLEANING STAFF M13 (20-MM). The rod consists of four metal sections threaded to each other and provided with a T-shaped handle at one end and a brush assembly at the other end (bore brush M25 or M28). The brush assembly can be replaced with a plug end for use with a patch, or a loop end for a flannelette or other cleaning rag.

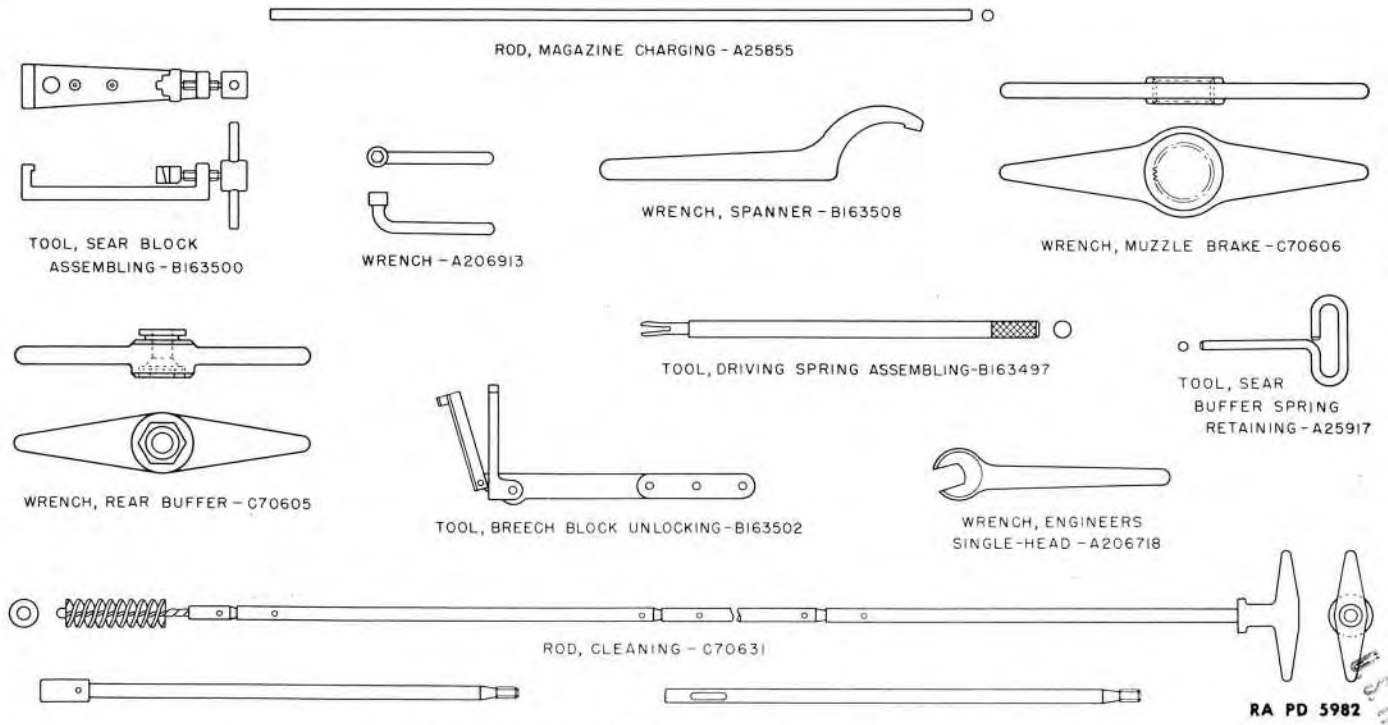

Figure 98 — 20-MM Automatic Gun Accessories

20-MM AUTOMATIC GUN M1 AND 20-MM AIRCRAFT AUTOMATIC GUN AN-M2

(3) DRIVING SPRING ASSEMBLING TOOL. This is a steel rod with a split stud at one end. The studded end is inserted through the driving spring guide tube into the recess in the outer end of the driving spring guide plunger, to aid in removing and replacing the plunger in the bolt.

(4) SEAR BLOCK ASSEMBLING TOOL. This vise-like tool is used for compressing and releasing the sear buffer springs in disassembly and assembly of the sear block group.

(5) SEAR BUFFER SPRING RETAINING TOOL. This is a rod bent to form an oval handle at one end, and slightly tapered at the end of the straight portion. The tapered end is inserted into the hole of the sear block to engage the grooves on the sear buffer spring plungers, and thus hold the sear buffer springs under compression. The sear block group can then be removed or replaced in the receiver as a unit.

(6) BREECHBLOCK UNLOCKING TOOL. This lever with two arms pivoted at one end is designed to place on top of the bolt body in the receiver. The hook on one arm engages the front face of the right breechblock slide so that when the lever is operated, the slides are forced rearward to unlock the breechblock.

(7) ENGINEER'S SINGLE-HEAD WRENCH. This open-end wrench is provided to fit the gas cylinder guide and gas cylinder vent plug.

(8) REAR BUFFER WRENCH. One face of this tool has a hexagonal socket to fit the driving spring guide head; the other face has four equally spaced projections to engage keyways in the flange of the rear buffer sleeve.

(9) SPANNER WRENCH. This spanner wrench is used to turn the mounting sleeve nut in adjusting the compression of the recoil spring.

(10) MUZZLE BRAKE WRENCH. This wrench has internal splines to engage the external splines on the muzzle brake when disassembling and assembling. The tool can also be used for removing and replacing the muzzle thread protector.

(11) SOCKET HEAD WRENCH ($\frac{7}{16}$-INCH). This wrench is used for removing or tightening the screws on sear mechanism M1 or electric trigger AN-M1.

Section X

STORAGE AND SHIPMENT

58. PREPARATION FOR STORAGE AND SHIPMENT.

a. Preparation of Parts. If the gun is provided with the sear mechanism M1, prepare the gun for storage and shipment by inverting the inner bowden connection bushing so that this inner bushing fits into the outer bowden connection bushing (figs. 99 and 100). This is to prevent the bowden connection shaft from being operated and to prevent the bushing from being damaged. Remove the muzzle brake and place the thread protector in position. Remove the electric trigger AN-M1 if it is secured to the gun.

b. Cleaning. Clean the gun with SOLVENT, dry-cleaning, or with soapy water so as to remove shop coating, dirt, and other foreign substances from all surfaces. Thoroughly dry the gun before application of COMPOUND, rust-preventive, light.

c. Application of Rust-preventive Compound. Immediately after the gun is cleaned, brush or slush lightly on the outside of the gun COMPOUND, rust-preventive, light.

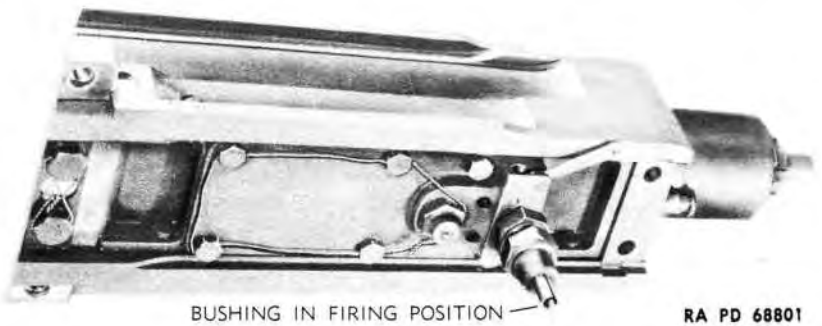

Figure 99 — Bushing in Firing Position

20-MM AUTOMATIC GUN M1 AND 20-MM AIRCRAFT AUTOMATIC GUN AN-M2

59. PACKAGING.

a. Pack the gun in a box similar to that shown in figure 101. Make this box of 1-inch lumber to the following dimensions:

Length	95 in.
Width	7¾ in.
Depth	8⅜ in.

b. The weight of the box with contents will be 158 pounds. The box shall be lined with waterproof paper and shall be strapped with either three-round wire straps (No. 14 gage) or three flat steel straps (⅜- x 0.020-in.).

60. REMOVAL OF PRESERVATIVES.

a. Remove preservatives by cleaning all surfaces with SOLVENT, dry-cleaning.

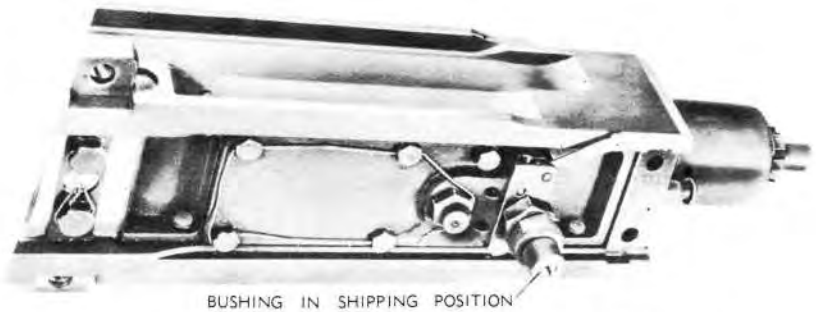

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Figure 100 — Bushing in Shipping Position

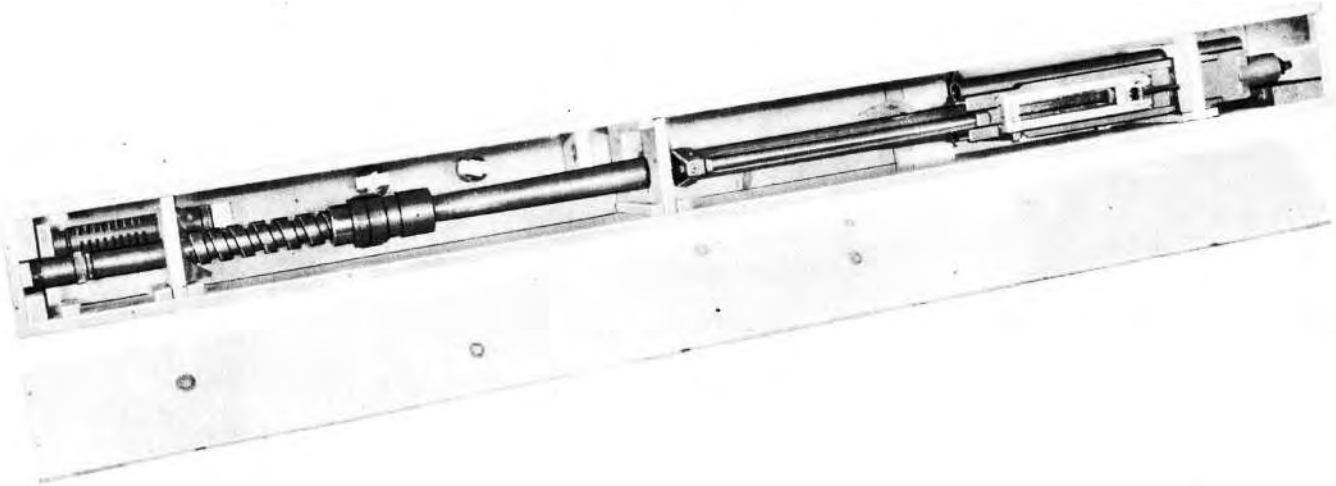

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Figure 101 — Method of Packing a 20-MM Gun

Section XI

MAINTENANCE UNDER UNUSUAL CONDITIONS

61. GENERAL.

a. When operating under unusual conditions such as tropical or arctic climates, severe dust or sand conditions, and near salt water, the precautions listed below should be scrupulously observed.

62. CARE IN ARCTIC CLIMATES.

a. In temperatures below freezing, and particularly in arctic climates, it is essential that all moving parts be kept absolutely free of moisture. It has also been found that excess oil on the working parts will solidify to such an extent as to cause sluggish operation or even complete failure. Metal parts should be cleaned with SOLVENT, dry-cleaning, and oiled as prescribed in paragraph 31.

b. Immediately upon being brought indoors, the gun should be thoroughly oiled, using OIL, lubricating, preservative, special, because moisture condensing on the cold metal in a warm room will cause rusting. After the gun has reached room temperature it should be wiped free of condensed water vapor and oiled again.

(1) If the gun has been fired, it should be thoroughly cleaned and oiled. The bore may be swabbed out with an oiled patch and when the weapon reaches room temperature, thoroughly cleaned and oiled as prescribed in paragraph 34.

(2) Before firing, the gun should be cleaned and the oil removed as prescribed in paragraph 33. The bore and chamber should be entirely free of oil before firing.

MAINTENANCE UNDER UNUSUAL CONDITIONS

63. CARE IN TROPICAL CLIMATES.

a. Tropical Climates.

(1) In tropical climates where temperature and humidity are high, or where salt air is present, and during rainy seasons, the gun should be thoroughly inspected at frequent intervals and kept lightly oiled when not in use. The groups should be removed at regular intervals and, if necessary, disassembled sufficiently to enable the drying and oiling of parts.

(2) Care should be exercised to see that unexposed parts and surfaces are kept clean and oiled.

(3) In hot climates, OIL, lubricating, preservative, special, should be used for lubrication.

b. Hot, Dry Climates.

(1) In hot, dry climates where sand and dust are apt to get into the mechanism and bore, the gun should be wiped clean daily or more often, if necessary. Groups should be removed and disassembled as far as necessary to facilitate thorough cleaning.

(2) Oiling and lubrication should be kept to a minimum, as oil will collect dust which will act as an abrasive on the working parts and foul the bore and chamber. OIL, lubricating, preservative, special, is best for lubrication where temperatures are high, and should be lightly applied only to the surfaces and working parts showing signs of wear.

(3) Perspiration from the hands is usually acid and causes rust. Metal parts should therefore be wiped dry frequently.

(4) In dusty climates the breech and muzzle should be kept covered.

20-MM AUTOMATIC GUN M1 AND 20-MM AIRCRAFT AUTOMATIC GUN AN-M2

Section XII

REFERENCES

64. STANDARD NOMENCLATURE LISTS.

a. Ammunition, fixed and semifixed, all types for pack, light and medium field artillery including complete round data ..... SNL R-1

b. Cleaning, preserving and lubricating materials; recoil fluids, special oils, and miscellaneous related items ..... SNL K-1

c. Gun, automatic, 20-mm, M1 and AN-M2 (aircraft) SNL A-47

d. Soldering, brazing and welding material, gases, and related items ..... SNL K-2

Current Standard Nomenclature Lists are as tabulated here. An up-to-date list of SNL's is maintained as the "Ordnance Publications for Supply Index" OPSI

65. EXPLANATORY PUBLICATIONS.

a. Air corps technical order ..... T.O. 11-1-21

b. Ammunition, general ..... TM 9-1900

c. **Army Regulations.**

Ordnance field service in time of peace ..... AR 45-30

Range regulations for firing ammunition for training and target practice ..... AR 750-10

d. Bureau of Ordnance circular letter (Navy) V-3-43

e. Chemical decontamination materials and equipment ..... TM 3-220

f. Cleaning, preserving, lubricating, and welding materials and similar items issued by the Ordnance Department ..... TM 9-850

g. Defense against chemical attack ..... FM 21-40

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20-MM AUTOMATIC GUN M1 AND 20-MM AIRCRAFT AUTOMATIC GUN AN-M2

[A.G. 300.7 (6 May 1943)
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BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

J. A. ULIO,
Major General,
The Adjutant General.

DISTRIBUTION: IB 1(2); IR 1(2); R 9(4); IBn 1(5); Bn 9(2); IC 1(2); C 9(8)

(For explanation of symbols, see FM 21-6)

PUBLICATIONS DEPARTMENT, RARITAN ARSENAL

TM E9-369A

*RESTRICTED

WAR DEPARTMENT

TECHNICAL MANUAL

&

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

29 JUNE 1943

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TECHNICAL MANUAL
No. E9-369A

WAR DEPARTMENT
Washington, 29 June 1943

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

Prepared under the direction of the
Chief of Ordnance

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GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

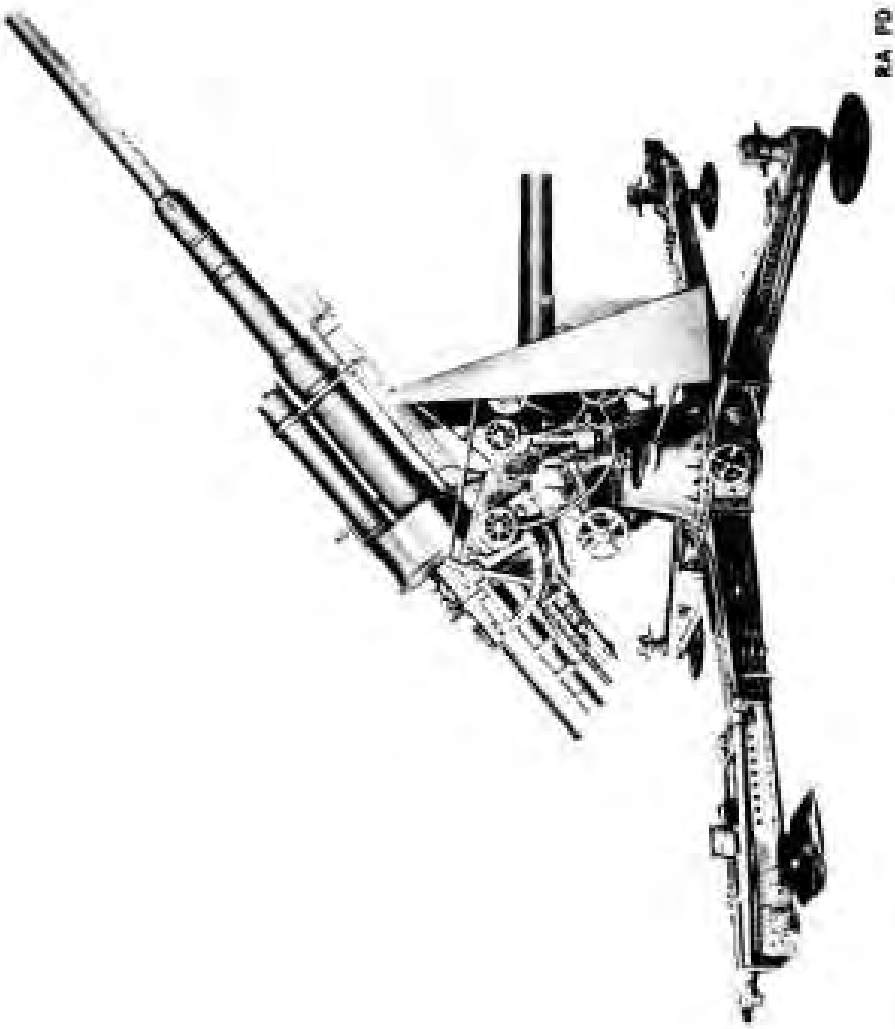

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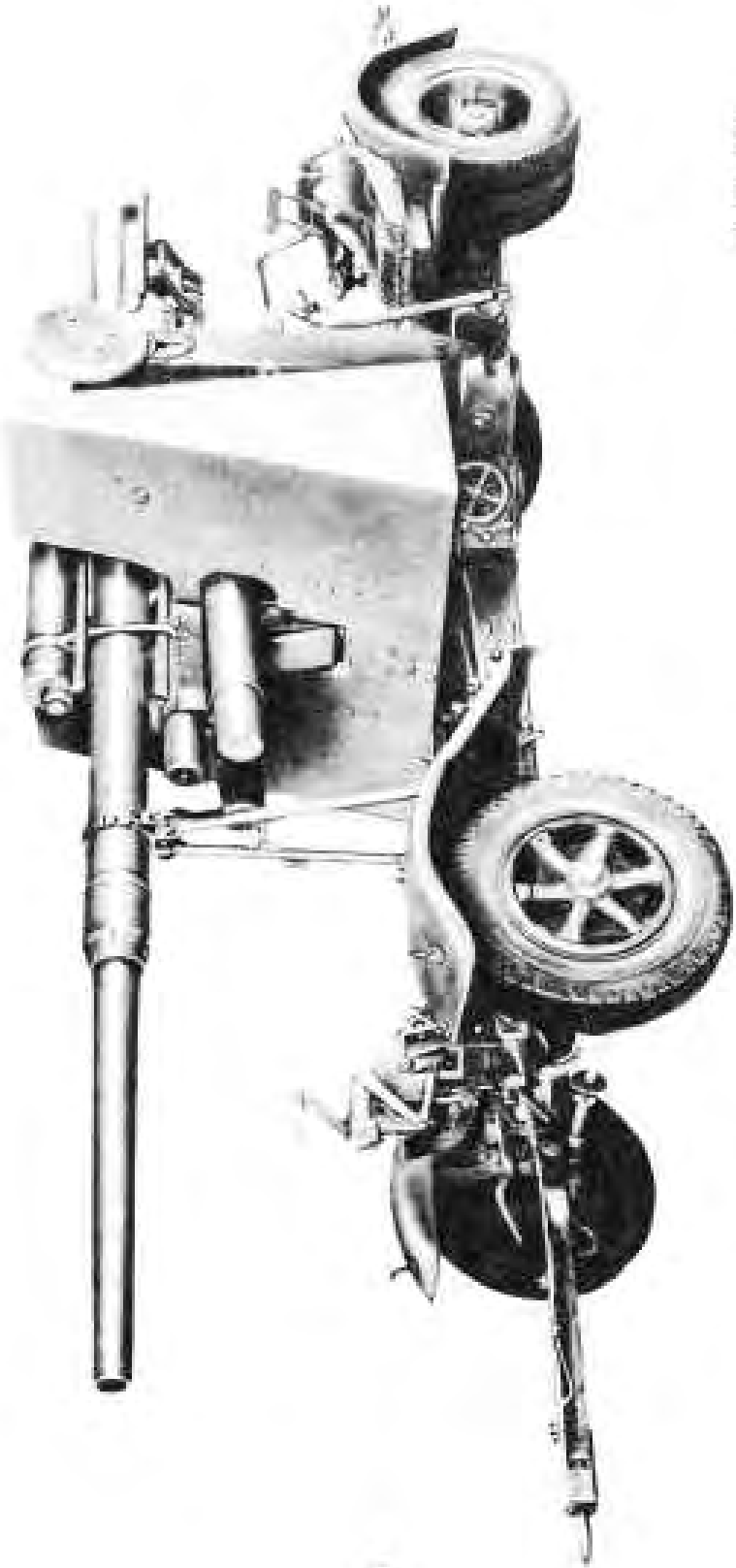
Figure 1 — German 88-mm Antiaircraft Gun — Firing Position



RA PD 71175

Figure 2 — German 88-mm Antiaircraft Gun — Traveling Position

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

CHAPTER 1

INTRODUCTION

1. SCOPE.

a. This manual is published for the information and guidance of the using arms and services.

b. There is included as much technical information required for identification, use, and care of the German 88-mm antiaircraft gun as can be ascertained from printed matter and the materiel on hand. Corrections and additions to this manual will be published as the information becomes available.

c. In all cases where the nature of the repair, modification, or adjustment is beyond the scope or facilities of the unit or beyond the scope of this manual, the responsible ordnance service should be informed so that proper instructions may be issued.

2. CHARACTERISTICS.

a. The mount is a circular pedestal antiaircraft type suspended from two bogies when in traveling position. The mount is equipped with a data transmission indicator for antiaircraft fire. There are also provisions for installing a direct laying sight for antitank fire and a dial sight for indirect fire. A hand driven fuze setter is fitted to the left side of the top carriage. The traversing and elevating mechanism data transmission indicators and direct laying sight are on the right side.

b. Normally, the bottom carriage is in contact with the ground during firing and is stabilized by outriggers. There are four leveling jacks, one at each extremity of the outriggers for leveling the bottom carriage. The top carriage is leveled by two handwheels located 45 degrees from either side of the center line of the front outrigger on the bottom carriage. The leveling system has a range of 9 degrees. The front of the mount is protected by a flat shield of armor plate.

3. DATA.

a. Gun.

Type	Tube and loose 3 section liner
Total weight	2,947 lb
Weight of removable components:	
Breech ring	505.5 lb

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Outer tube	785 lb
Inner tube	805.5 lb
Liner (muzzle section)	600 lb
Liner (center section)	199 lb
Liner (breech section)	58 lb
Retaining rings	34 lb
Over-all length of tube	185 in. (470 cm)
Over-all length of gun and tube	194.1 in. (493.8 cm)
Length in calibers	56
Distance from center line of trunnions to breech face	6.5 in.
Travel of projectile in bore	157.4 in. (400 cm)
Volume of chamber	226 cu in.
Rated maximum powder pressure	33,000 lb per sq in. (approx.)
Muzzle velocity	2,690 ft per sec
Maximum range:	
Horizontal	16,200 yd
Vertical	39,000 ft
Maximum effective ceiling	25,000 ft (at 70-deg elevation)
Rifling:	
Length	157.4 in. (400 cm)
Direction	Right-hand
Twist	Increasing 1 turn in 45 calibers to 1 turn in 30 calibers
Number of grooves	32
Depth of grooves	0.0394 in. (1 mm)
Width of grooves	0.1969 in. (5 mm)
Width of lands	0.1181 in. (3 mm)
Type of breech mechanism	Semiautomatic horizontal sliding block
Rate of fire	15 rounds per min (practical rate at a mechanized target) 20 rounds per min (practical rate at an aerial target)

b. Recoil Mechanism.

Type	Independent liquid and hydropneumatic
Total weight	524 lb
Weight of recuperator cylinder	285 lb
Weight of recoil cylinder	239 lb
Weight of recoiling parts in recoil mechanism	108.5 lb
Total weight of recoiling parts (with gun and tube)	3,159 lb
Type of recoil	Control rod type with secondary control rod type regulating counterrecoil

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

Normal recoil:	
0-degree elevation	41.5 in. (105 cm)
25-degree elevation	33.46 in. (85 cm)
Maximum elevation	27.75 in. (70 cm)
Capacity of recoil cylinder	2.5 gal
Capacity of recuperator cylinder	4.5 gal

c. Mount.

Weight (less cannon and recoil mechanism)	8,404 lb
Maximum elevation	85 deg
Maximum depression	minus 3 deg
Traverse	360 deg
Loading angles	All angles
Height of trunnion above ground (firing position)	5.2 ft
Height of working platform (firing)	0.8 ft
Height of trunnion above working platform	4.4 ft
Leveling	Pivots located 45 deg from either side of center line of front outrigger (total of 9 deg each)
Number of turns of handwheel to elevate from 0 to 85 degrees:	
High gear	42.5
Low gear	85
Elevation for one turn of elevating handwheel:	
High gear	2 deg (35.4 mils)
Low gear	1 deg (17.7 mils)
Number of turns of handwheel to traverse 360 degrees:	
High gear	100
Low gear	200
Traverse for one turn of handwheel:	
High gear	3.6 deg (63.8 mils)
Low gear	1.8 deg (31.9 mils)

Effort required at elevating handwheel (in.-lb):

To Elevate	High Gear	Low Gear
0 deg	55	110
20 deg	110	160
40 deg	192	110
60 deg	214	55
80 deg	209	50
To Depress	**High Gear**	**Low Gear**
0 deg	275	220
20 deg	193	28
40 deg	138	50
60 deg	110	77
80 deg	165	77

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Effort required at traversing handwheel (in.-lb):

To Traverse Left	High Gear	Low Gear
0 deg	55	39
90 deg	28	6
180 deg	11	11
270 deg	22	17

To Traverse Right	High Gear	Low Gear
0 deg	10	6
90 deg	44	17
180 deg	61	44
270 deg	20	17

Time to elevate from minus 3 to plus 85 degrees:
- High gear ..... 15.02 sec
- Low gear ..... 25.90 sec

Time to depress from plus 85 to minus 3 degrees:
- High gear ..... 21.44 sec
- Low gear ..... 34.90 sec

Time to traverse 360 degrees:
- High gear ..... 33.90 sec
- Low gear ..... 69.79 sec

Over-all dimensions in firing position:
- Length ..... 19 ft
- Height ..... 6.9 ft
- Width ..... 16.87 ft w/outriggers

Over-all dimensions in traveling position:
- Length ..... 25.5 ft w/drawbar
- Height ..... 7.9 ft
- Width (front) ..... 7.20 ft
- Width (rear) ..... 7.60 ft

Length of outriggers ..... 4.8 ft
Number of bogies 2
Type of bogies ..... Single axle. Single wheels on front; dual wheels on rear
Weight of front bogie ..... 1,825 lb
Weight of rear bogie ..... 2,645 lb
Pneumatic tire size ..... 32 in. x 6½ in. (6½ extra 20); also marked 7:50 x 20
Wheel base ..... 13.75 ft
Type of brakes ..... Vacuum air brakes on all wheels; hand-operated parking brakes on rear wheels also

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

Type and number of jacks	4 jacks integral with mount for leveling bottom carriage; one on each end of outriggers and carriage
Leveling	4.5 deg leveling either side of horizontal
Road clearance	1.14 ft
Tread (front)	5.8 ft
Tread (rear)	6 ft
Height of axis of bore above ground (firing)	5 ft
Time to change from traveling to firing position	2½ min with 6-man crew (approx.)
Time to change from firing to traveling position	3½ min with 6-man crew (approx.)
Weight of entire carriage	16,325 lb
Rear wheel reactions	9,830 lb
Front wheel reactions	6,510 lb
Type of equilibrators	Spring type with built-in spring compressors

d. Essential Translations.

Schnell	Quick
Normal	Normal
Automatik	Automatic
Hand	Hand
Wiederspannen	Recock
Los	Loose
Fest	Tight
Linksgewinde	Left-hand thread
Mundung	Muzzle
Feuer	Fire
Sicher	Safe

CHAPTER 2

GERMAN 88-MM ANTIAIRCRAFT GUN AND MOUNT

Section I

DESCRIPTION AND FUNCTIONING OF GUN

4. GERMAN 88-MM ANTIAIRCRAFT GUN.

a. The German 88-mm antiaircraft gun consists of a detachable breech ring with a half-length outer tube, a half-length inner lock tube, and a loose three-piece liner.

b. The liner separates into three sections, one division being two-thirds of the rifled length back from the muzzle, and the other division being approximately 6 inches to the rear of the origin of rifling. Instead of replacing the entire length of liner as is the practice in this country, economy is achieved by replacing just that section of the liner which receives the most wear, i.e., the forcing cone section.

c. The front and center sections of the liner are keyed in place so as to aline the rifling and prevent relative rotation. This joint does not have any seal other than that provided by close tolerance machining. The center and rear sections are merely overlapped and not keyed in place as there is no rifling to aline (fig. 3).

d. The three sections are alined end to end and then fitted into the inner tube (fig. 4). This tube serves to prevent lateral move-

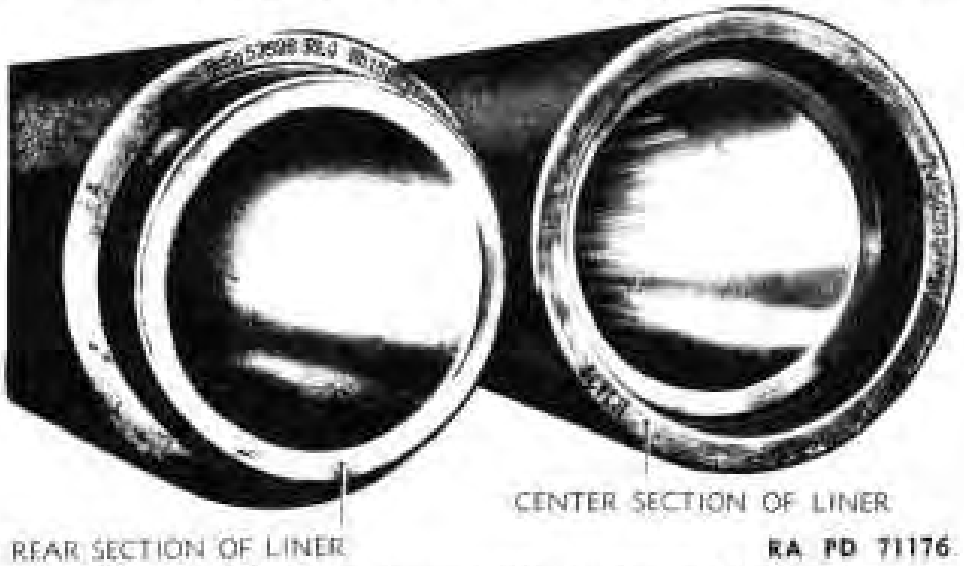

Figure 3 — Center and Rear Sections of Liner

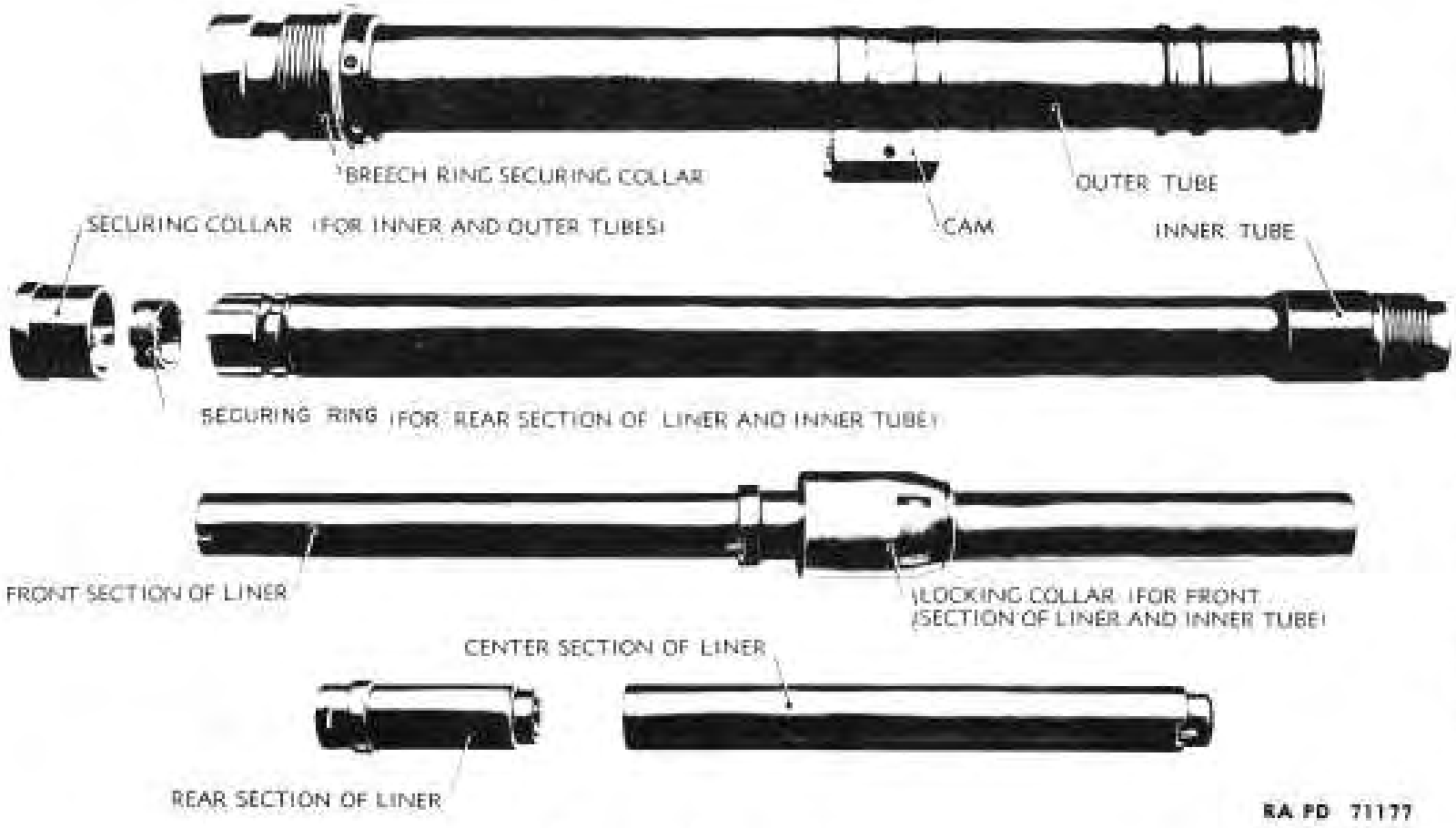

Figure 4 — Tube and Liners

DESCRIPTION AND FUNCTIONING OF GUN

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Figure 5 — Method of Securing Chamber Sections of Liner to Inner Tube

ment and to prevent rotation between the rear of chamber sections and other sections of the liner. The locking collar (fig. 4) prevents forward movement, and the locking ring (fig. 4) prevents movement to the rear. See figure 5 for method of fastening the chamber sections of liner to the inner tube. When the locking ring and collar are fully tightened, the liner sections are drawn up snugly and the joints offer little or no resistance to the passage of the projectile. The female threads in the locking collar are left-hand as indicated by the word "LINKSGEWINDE" (fig. 6). The collar is rotated in the direction of "LOOSE" ("LOS") for removing and in the direction of "TIGHT" ("FEST") for tightening.

AMERICAN	GERMAN
LEFT HAND THREAD	LINKSGEWINDE
LOOSE	LOS
TIGHT	FEST

RA PD 71179

Figure 6 — Markings on Locking Collar

RA PD 71180

Figure 7 — Method of Securing Inner and Outer Tubes

e. The inner tube which contains the liner sections is slipped into the outer tube (fig. 4). The latter tube has fastened to it the forward end of the slides. The breech ring also fits on the outer tube. The inner tube is secured by the locking collar (fig. 4) to prevent forward and rearward motion. See figure 7 for the method of securing the inner tube to the outer tube.

f. The breech ring does not screw on the tube as is the practice in this country. Instead, the breech ring slides over the tube until it is seated and then the securing collar (fig. 4) draws it up tightly. This eliminates the need for rotating the tube or breech ring. In order to prevent rotation of the outer tube and the two locking collars, keys are provided. See figure 8 for installation of the keys.

5. BREECH MECHANISM.

a. The breech mechanism is of the horizontal sliding breechblock type actuated by a breech operating spring permitting semiautomatic or manual operation (fig. 9). The breechblock slides in a rectangular breech ring which is bored to receive the outer tube and the breechblock. Channels are machined into the bottom of the ring to permit installation of recoil slide pads. The recoil piston rod lug is made an integral part of the breech ring.

b. With the breech mechanism set for semiautomatic operation, a round of ammunition, when pushed in the breech recess of the gun, will trip the extractors and allow the breechblock to close under the action of the breech actuating spring. When the gun is fired, and recoils, the breechblock actuating shaft, which is operated by the breech operating crank, is rotated by the cam on the side of the cradle (fig. 10). This action winds up the lower breech opening spring and draws the intermediate plate away from its stop.

DESCRIPTION AND FUNCTIONING OF GUN

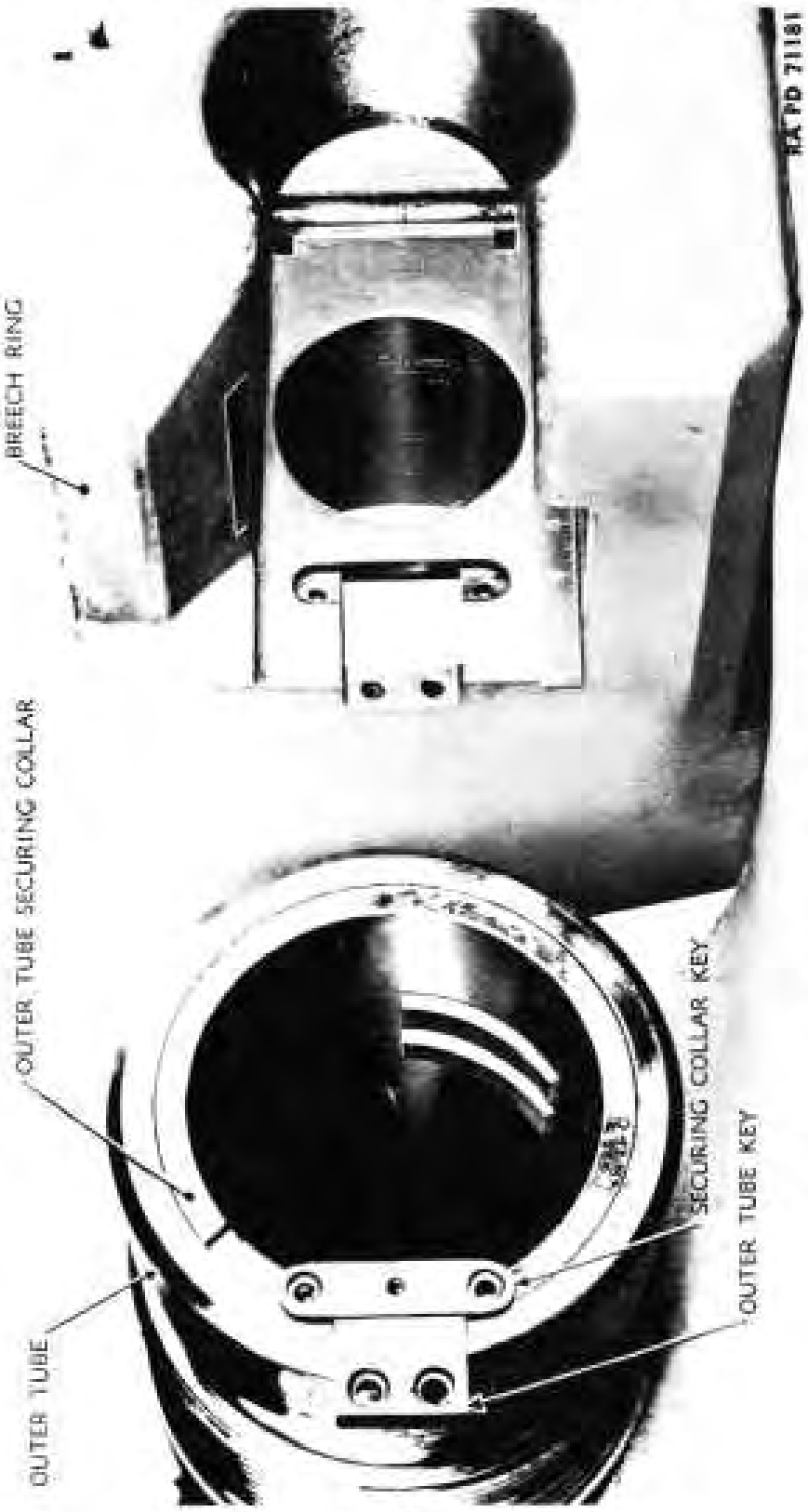

Figure 8 — Method of Fastening Breech Ring to Outer Tube and Securing Collar

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

Figure 9 — Breech Mechanism

A — BREECH OPERATING CAM
B — AUXILIARY TRIGGER
C — ELEVATION QUADRANT
D — ELEVATING ARC
E — ELEVATING HANDWHEEL
F — TRAVERSING HANDWHEEL
G — DIRECT SIGHT BRACKET
H — ELEVATING MECHANISM CLUTCH
J — DATA TRANSMISSION INDICATOR (ELEVATION)
K — PANORAMIC SIGHT BRACKET
L — BREECH ACTUATING LEVER
M — DIRECT SIGHT ELEVATION INDICATOR

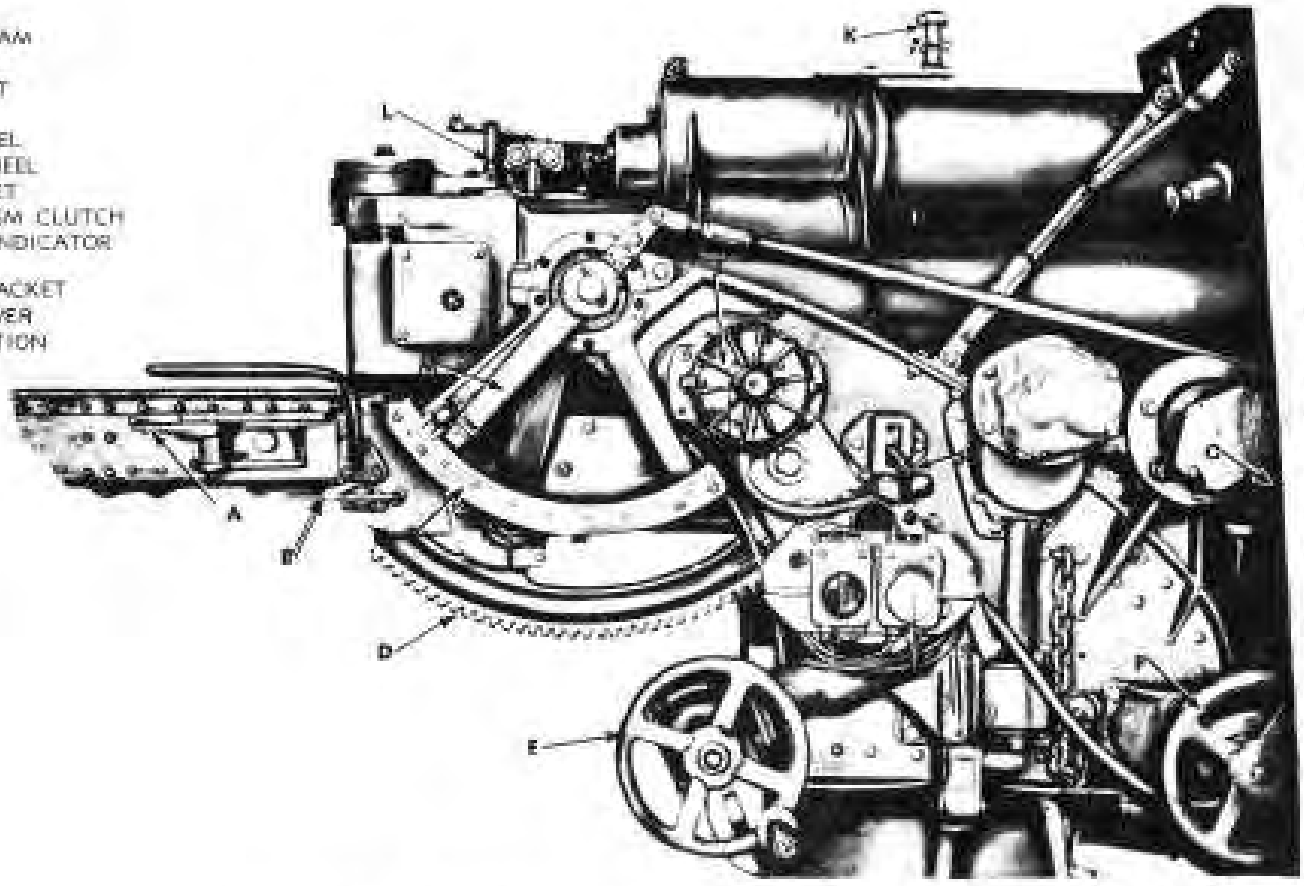

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Figure 10 — Breech End — Right Side

c. When the breech operating crank is in the straight position of the cam path, the catch on the top spring cover disengages the lug retaining the breech actuating mechanism closed. Then the actuating shaft is free to rotate to the open position under the action of the breech opening spring, taking the crank with it and so opening the breechblock by the action of the breechblock actuating lever. The extractors are tripped and the empty case is ejected.

d. In the full open position, the compression of the breech opening spring is taken between the lug on the intermediate plate and its mating step. Any further opening motion of the breechblock is then taken up by the breech closing spring which, at this stage, acts as a breechblock buffer stop.

e. The breechblock is held open by the action of the extractors hooking on the recesses in the breechblock against the action of the upper spring which has been further wound up during recoil.

f. With the breech mechanism set for hand operation, the springs are disengaged from the breech actuating mechanism and the breechblock may then be opened or closed with no spring influence.

g. The breechblock may be closed without loading a round by the action of the extractor actuating shaft. This is a splined shaft extending through both extractors. The extractors are tripped and removed from the recesses in the breechblock by rotating the shaft by hand (fig. 11).

6. FIRING MECHANISM.

a. The firing mechanism is composed of the percussion mechanism, percussion mechanism release assembly, the cocking lever assembly, and the cradle firing mechanism.

b. The percussion mechanism is composed of the firing spring retainer, firing spring, firing pin, and firing pin holder (fig. 12). This group is held in the axial hole of the breechblock by a lug on the firing spring retainer engaging a mating groove in the breechblock. The percussion mechanism is operated through the percussion mechanism release assembly.

c. The percussion mechanism release assembly is located in various recesses of the breechblock. This assembly is composed of the cocking arm, operating rod, operating rod spring, safety stop lever, operating rod guide, sear, sear spring, and sear operating lever. Through this assembly, the percussion mechanism is cocked either automatically or normally.

d. Cocking of the percussion mechanism automatically is accomplished during opening of the breech, with the cocking lever in the "FIRE" ("FEUER") position. As the breechblock slides to the right in recoil or hand operation, the cocking arm is engaged by the breechblock actuating lever. As the actuating lever rotates on the actuating shaft, the cocking arm is also rotated. The cocking lug on the firing

DESCRIPTION AND FUNCTIONING OF GUN

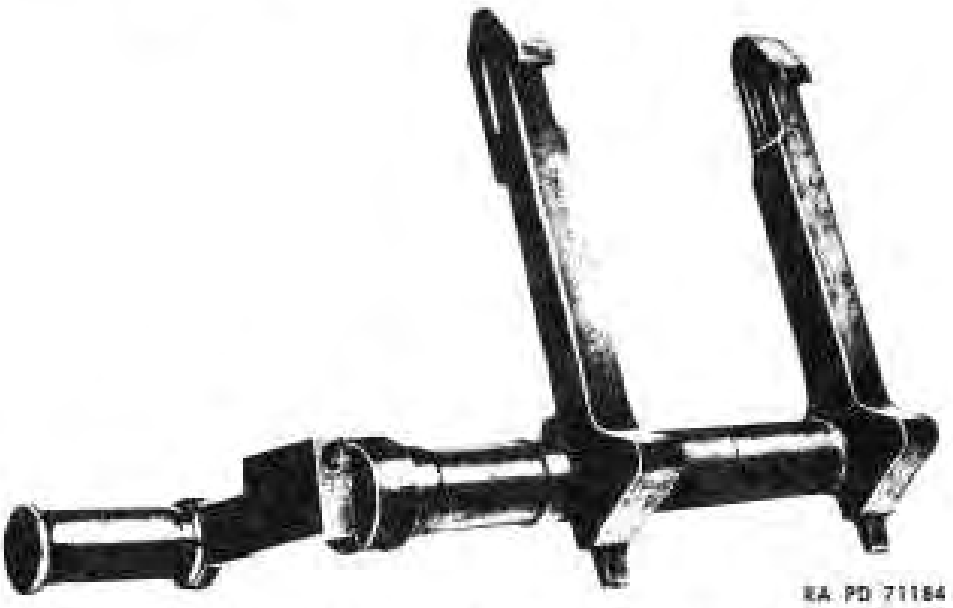

Figure 11 — Extractors and Actuating Shaft

pin holder is engaged and slid to the rear, compressing the firing spring. When the holder reaches the cocked position, the sear lug on the holder is engaged by the notch of the sear, which holds the mechanism cocked.

c. Manual cocking of the percussion mechanism is accomplished by the cocking lever (fig. 13). This lever is located on top of the breech ring. The breech must be closed when manual cocking is performed. The cocking lever serves the same purpose as the actuating lever, i.e., to rotate the cocking arm. However, in this case, if the cocking lever is kept in the rear, the firing mechanism will not operate but will be on "SAFE" ("SICHER") (fig. 13) because the lug on the cocking arm will not have cleared the lug on the firing pin holder.

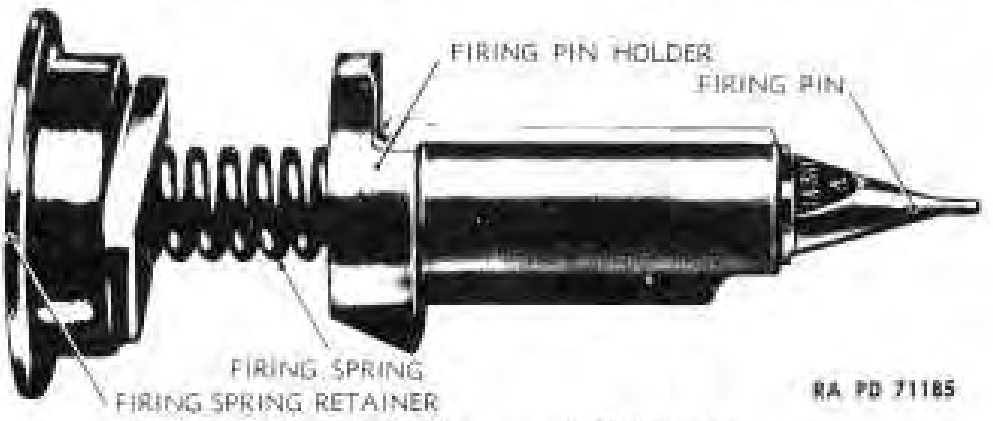

Figure 12 — Percussion Mechanism

Figure 13 — Breech Mechanism — Top View

Thus the cocking lever also serves as a safety. The arc described by the cocking lever during manual cocking of the percussion mechanism is marked "WIEDERSPANNEN" which, freely translated, means "recock."

DESCRIPTION AND FUNCTIONING OF GUN

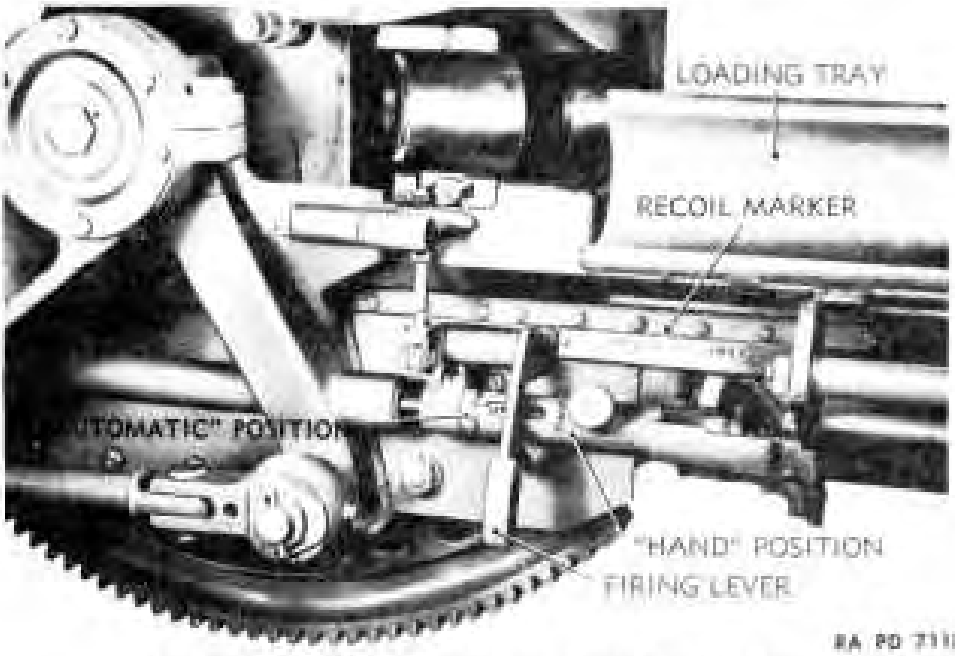

Figure 14 — Loading Tray Interlock Mechanism

f. The cradle firing mechanism is located on the left side of the cradle. Raising the firing lever (fig. 14) of the cradle firing mechanism forces the lug up at the end of the sear operating lever. This, in turn, pushes the sear down against the sear spring disengaging the sear lug. The firing pin holder and firing pin, thus released, are driven forward by the compressed firing spring to fire the primer in the cartridge.

g. The firing mechanism will not operate unless the breechblock is fully closed. If the breechblock is not fully closed, the operating rod will not be fully in position against the compression of the operating spring rod. This will prevent the safety stop lever from rotating, and hence will not permit clearance for the firing pin holder to move forward, thus rendering the firing mechanism inoperative.

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

CHAPTER 2

GERMAN 88-MM ANTIAIRCRAFT GUN AND MOUNT (Cont'd)

Section II

DESCRIPTION AND FUNCTIONING OF RECOIL MECHANISM

7. DESCRIPTION AND FUNCTIONING OF RECOIL MECHANISM.

a. **General.** The recoil mechanism is an independent hydropneumatic system. The recuperator cylinder, which is entirely separate from the recoil cylinder, is filled and charged with gas and liquid in direct contact. The recoil cylinder is of the control rod type with a secondary control rod regulating recoil length. Both recuperator and recoil cylinders are supported by the cradle, and the pistons are connected to the top and bottom of the breech ring, respectively.

Figure 15 — Recuperator Cylinder

b. **Recuperator Cylinder.**

(1) The recuperator cylinder (fig. 15) is secured to the cradle above the piece. A liquid cylinder is fitted eccentrically in the bottom of the outer gas cylinder. The center lines of both cylinders are parallel. The liquid cylinder is completely filled with a glycerine-water solution, and the rest of the mechanism is charged with nitrogen to the proper pressure.

DESCRIPTION AND FUNCTIONING OF RECOIL MECHANISM

RA PD 71189

Figure 16 — Recoil Cylinder

(2) Upon recoil, the recuperator cylinder rod and piston are brought to the rear by the recoiling gun; and the liquid is transferred, by the piston, from the liquid cylinder into the gas cylinder. The gas is compressed by the decreased volume in the cylinder, thus opposing the energy of recoil. While the recuperator cylinder controls a portion of the recoiling energy, the recoil cylinder controls the remainder of the recoiling energy in addition to controlling the length of recoil. In counterrecoil, the motivating force is the expanding gas tending to force the liquid back into the liquid cylinder, thus activating the recuperator cylinder piston. The force of counterrecoil is dampened by the recoil cylinder. After several rounds have been fired, the gas and liquid have emulsified. This condition, however, does not alter the volume pressure relationship, and the liquid is still effective for its original purpose of supplying an adequate pressure seal. The ports in the end of the liquid cylinder are not throttling orifices, and the state of emulsification has no effect on the recoil action.

(3) The piston rod is hollow to eliminate the vacuum which would be caused by the sealed cylinder and plug. This hollow opening also permits exit of the atmospheric air in back of the piston head. The washers are of U-shaped leather and use U-shaped brass spacers. The whole is secured by a large lock nut.

c. Recoil Cylinder.

(1) The recoil cylinder (fig. 16) is located beneath the gun inside the cradle. The cylinder is filled with liquid at atmospheric pressure. The cylinder and the control rod remain stationary. In recoil, the piston rod and counterrecoil control rod move with the breech ring. As the weapon recoils, part of the fluid is forced through the orifices in the piston head and through the control grooves in the recoil control rod. Another portion of the fluid passes through the valve in the control bushing and fills the increasing hollow space behind the head of the recoil control rod. The pressure of the liquid through the constantly narrowing grooves takes up most of the force of recoil and gradually brings the gun to a standstill. Part of the force of recoil is also taken up in the increase of air pressure in the recuperator cylinder.

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

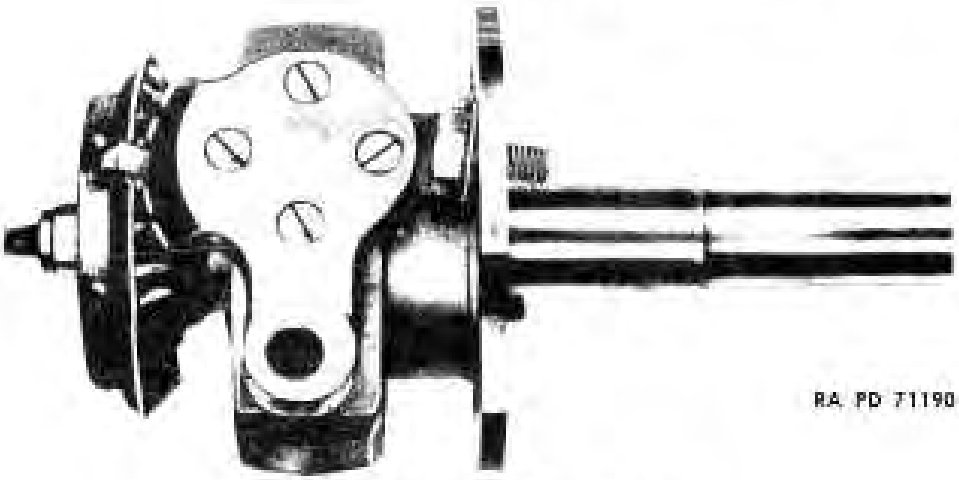

Figure 17 — Recoil Control Linkage

(2) The counterrecoil action is activated by the expanding air in the recuperator cylinder. The braking liquid which is now in front of the recoil piston head runs back through the control bushing of the recoil control rod. The piston rod slides back over the recoil control rod and the counterrecoil control rod penetrates deeper into the recoil control rod, displacing the liquid in the latter. The valve being closed, the fluid is forced through the grooves in the counterrecoil control rod and the holes in the head. The force of counterrecoil is thus reduced, and the gun comes to rest without shock.

(3) To change the length of recoil as required by high angle fire, the recoil control rod is rotated by the length of recoil control linkage (fig. 17). The linkage is operated when the cradle is elevated and serves to rotate the throttling grooves, thus varying the port area over the whole length of recoil.

CHAPTER 2

GERMAN 88-MM ANTIAIRCRAFT GUN AND MOUNT (Cont'd)

Section III

DESCRIPTION AND FUNCTIONING OF MOUNT

8. GENERAL.

a. The German 88-antiaircraft gun mount is a mobile unit carried in traveling position by two bogies (fig. 18). This gun is a dual-purpose weapon. It can be fired from the bogie wheels as an antitank weapon, or the bogies can be removed to emplace the weapon for antiaircraft fire (figs. 19 and 20). The mount consists mainly of the bottom carriage, side outriggers, leveling jacks, top carriage leveling mechanism, pedestal, top carriage, cradle, equilibrators, traversing mechanism, elevating mechanism, bogies, and rammer.

9. BOTTOM CARRIAGE.

a. The bottom carriage is of box-section type construction, welded, and riveted. The bottom carriage is designed to form a chassis for connection to the bogies in traveling. For stability during firing, a large base area is incorporated into the design of the bottom carriage, with front and rear outriggers being integral (fig. 21). Greater stability is obtained by hinging side outriggers to the bottom carriage. The interior of the bottom carriage provides space for storing tools and accessories and for housing the electrical wiring.

b. The pedestal is bolted to the enlarged central portion of the bottom carriage. This portion also houses the handwheels used to level the top carriage. The data transmission junction box is located at the rear end of the bottom carriage (fig. 22). The gun muzzle rest for road transportation is supported at the front end. Two lugs at each end of the bottom carriage are provided to suspend the mount from the bogies. Hooks at each end of the bottom carriage are provided to engage the bogie chains (fig. 21).

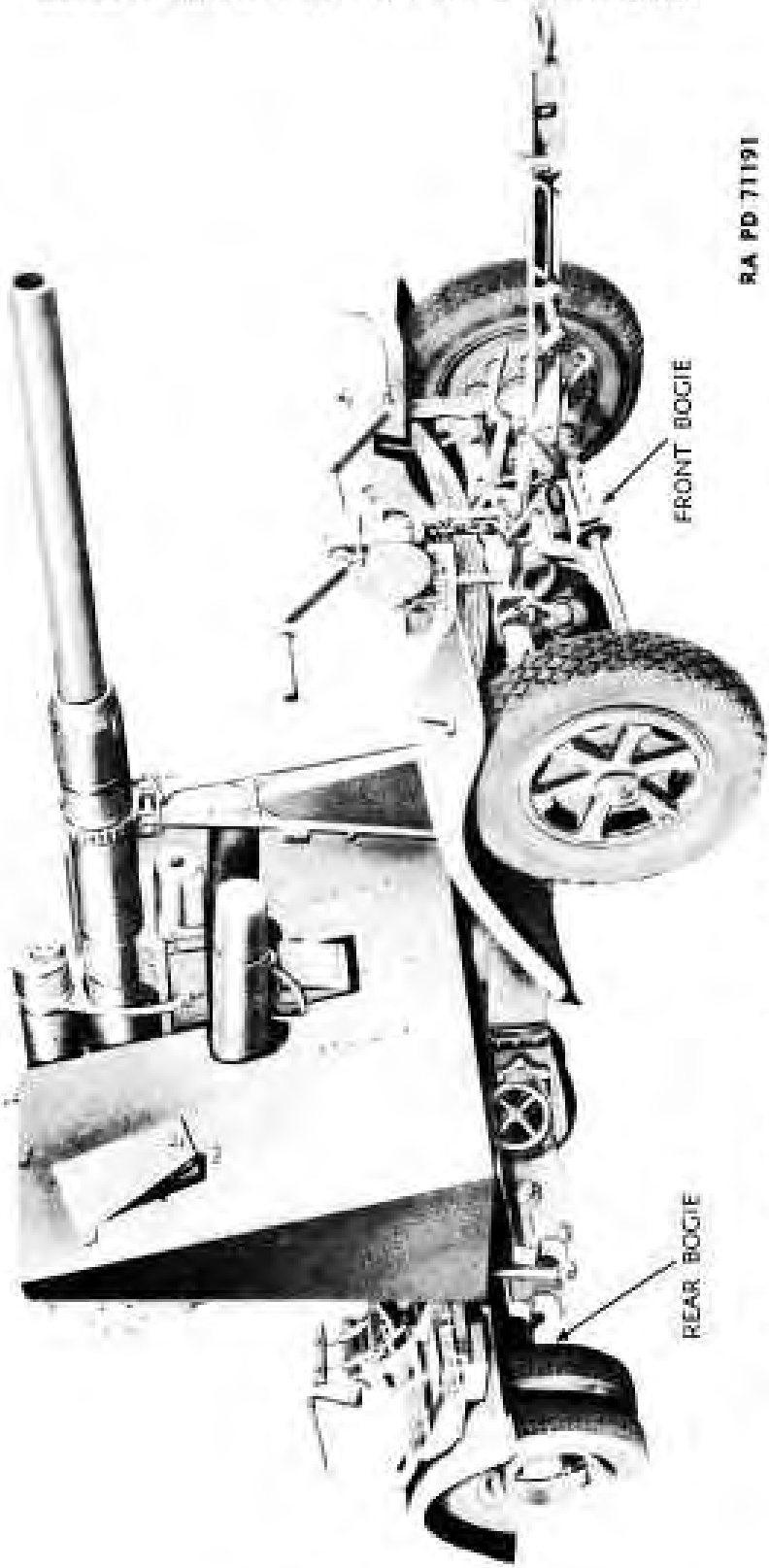

Figure 18 — German 88-mm Antiaircraft Gun — Right Side — Traveling Position

DESCRIPTION AND FUNCTIONING OF MOUNT

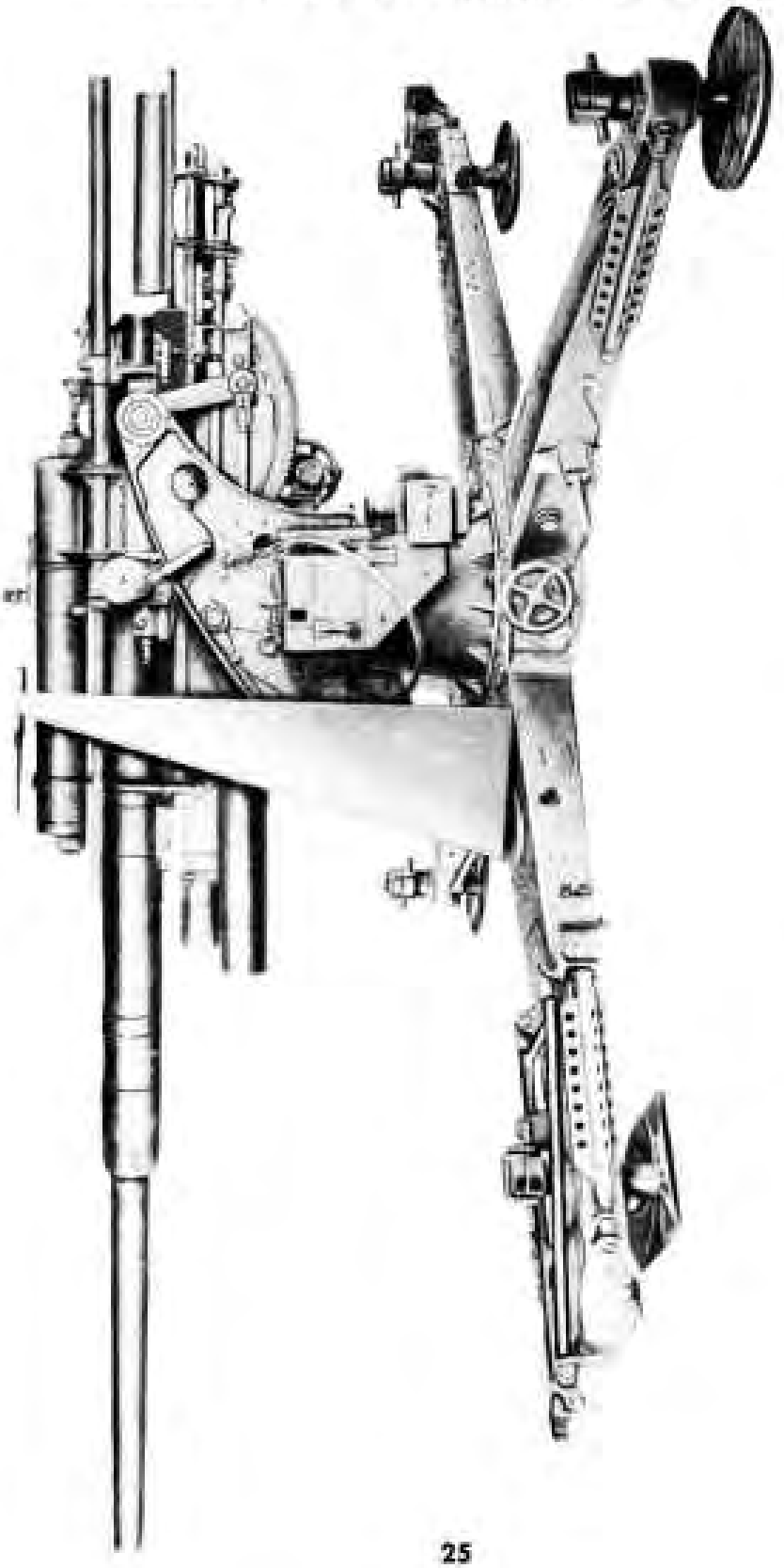

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Figure 19 — German 88-mm Antiaircraft Gun — Zero-degree Elevation

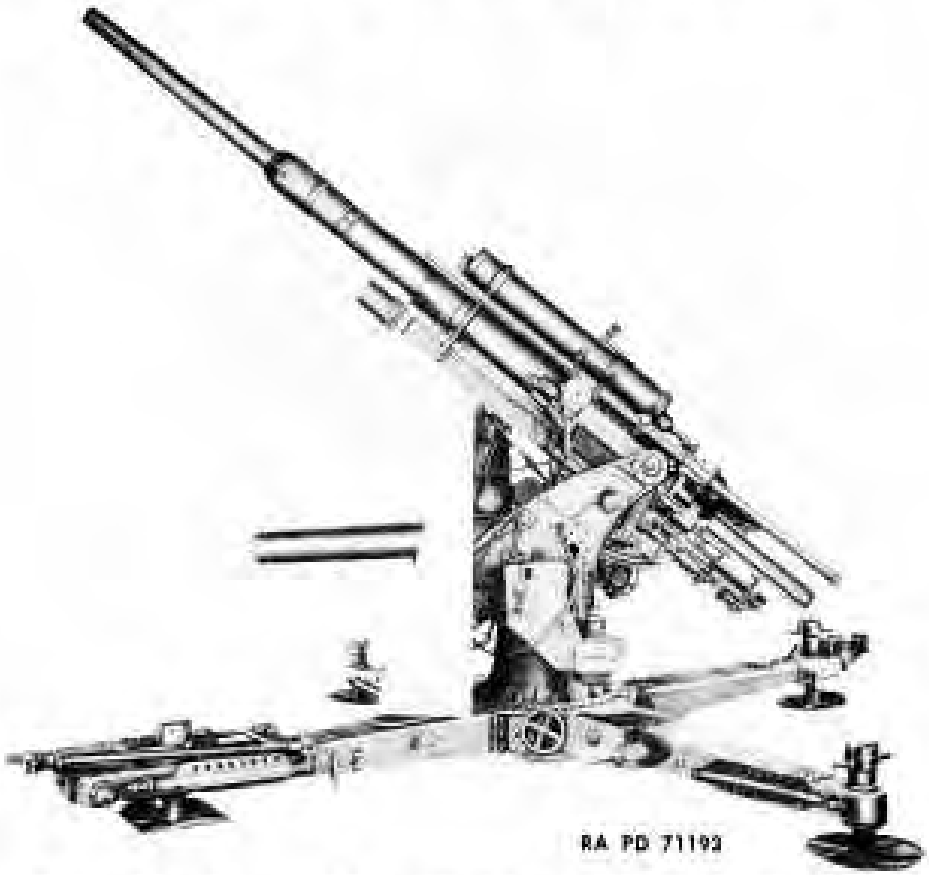

Figure 20 — German 88-mm Antiaircraft Gun — Left Side View

10. SIDE OUTRIGGERS.

a. The side outriggers are of the same construction as the bottom carriage, i.e., welded and riveted. They hinge to the bottom carriage and provide stability when firing in traverse other than directly to the rear or front. In traveling position, they are swung to a vertical position and secured against the mount. In firing position, the side outriggers are let down and secured in position by half-round locking pins (fig. 23). The side outriggers are provided with leveling jacks and stakes at the extremities as are the outriggers of the bottom carriage (fig. 24).

11. LEVELING JACKS.

a. The leveling jacks (fig. 25) are of a simple lead screw construction. Four leveling jacks are provided, one at the extremity of each of the side outriggers (fig. 24) and of each of the bottom carriage outriggers (fig. 21). They serve to distribute firing loads evenly when the mount is on uneven ground.

DESCRIPTION AND FUNCTIONING OF MOUNT

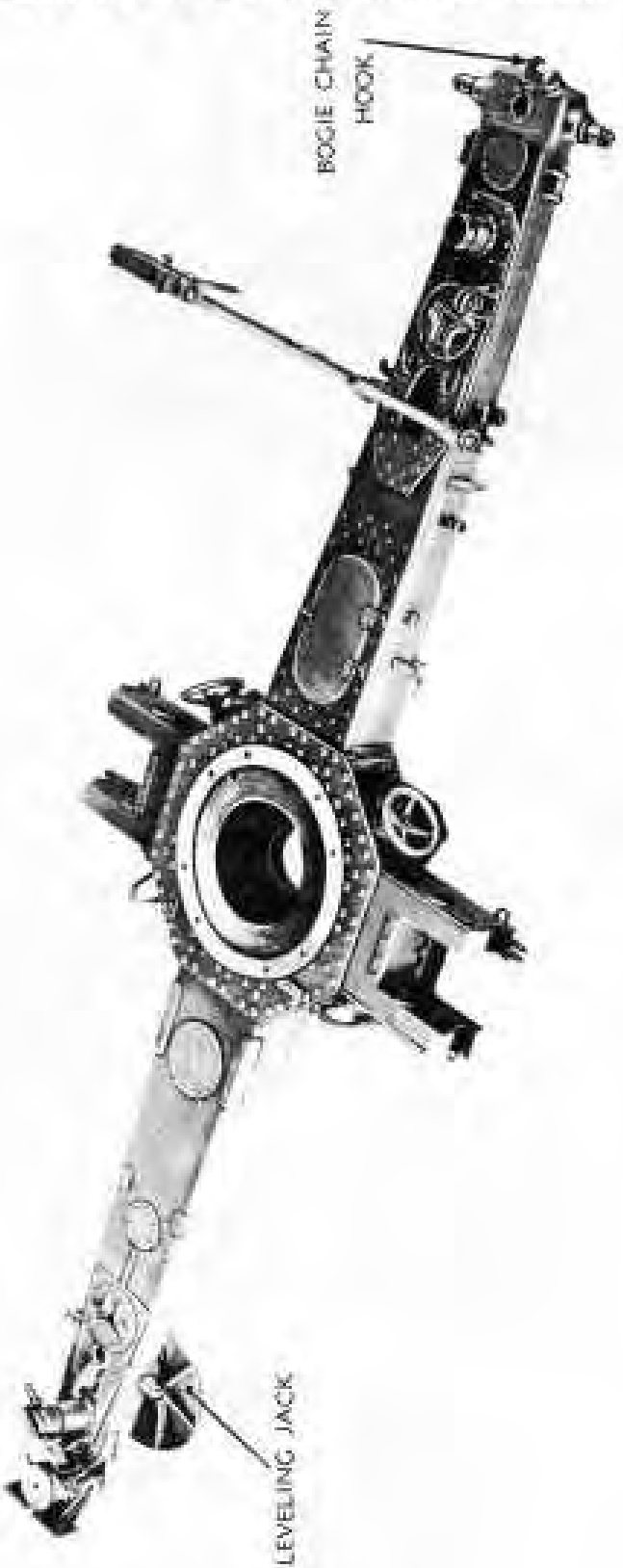

Figure 21 — Bottom Carriage

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

Figure 22 — Rear End of Bottom Carriage

DESCRIPTION AND FUNCTIONING OF MOUNT

Figure 23 — Bottom Carriage Outrigger and Connecting Pins

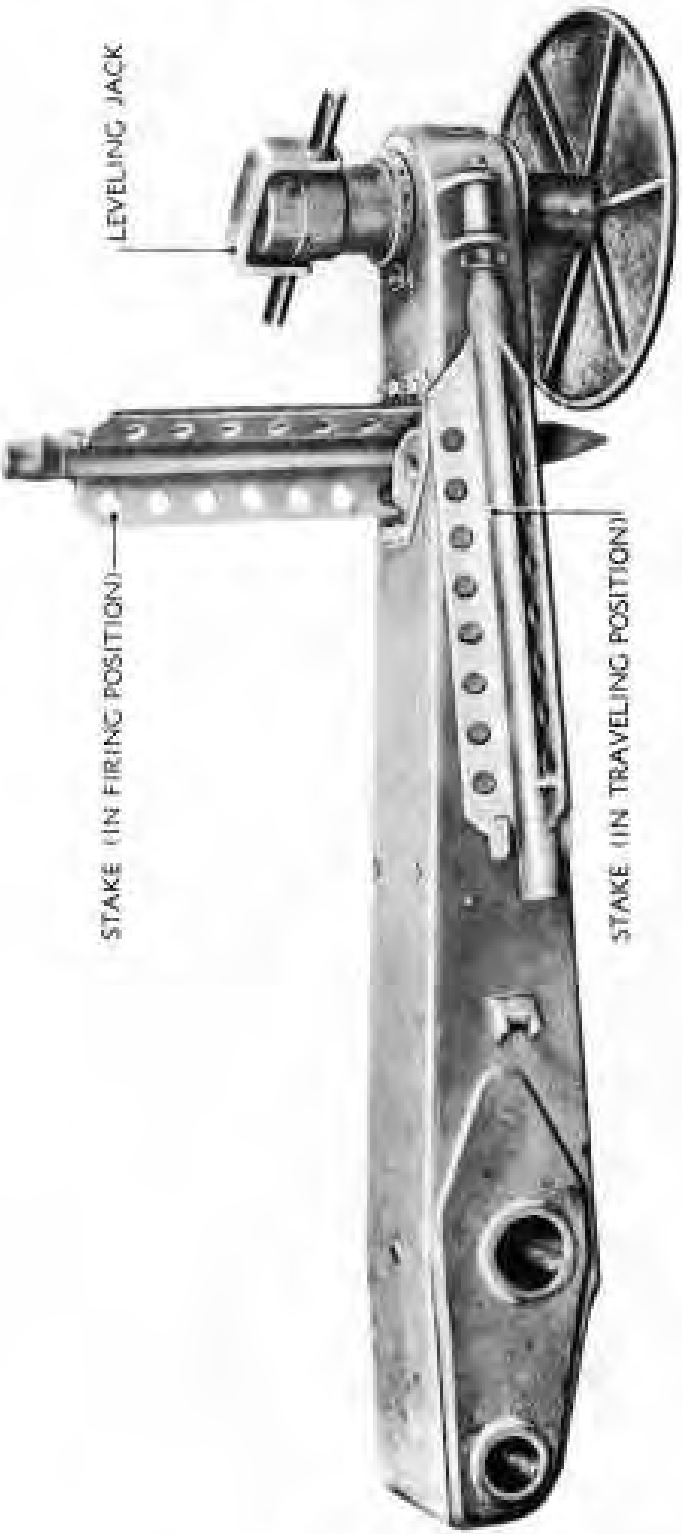

Figure 24 — Outrigger, Showing Position of Stakes in Firing and Traveling Position

DESCRIPTION AND FUNCTIONING OF MOUNT

Figure 25 — Details of Firing Jack

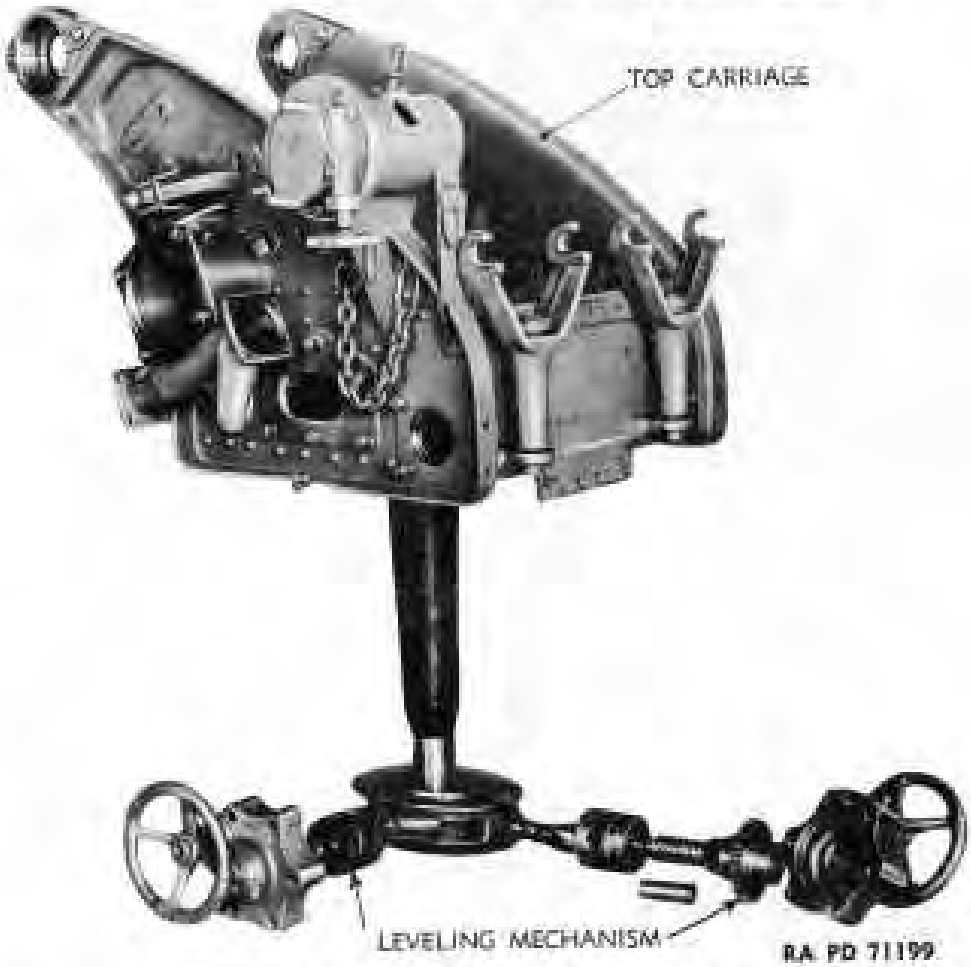

Figure 26 — Top Carriage Leveling Mechanism

12. TOP CARRIAGE LEVELING MECHANISM.

a. The top carriage leveling mechanism (fig. 26) is operated by handwheels in the enlarged central portion of the bottom carriage. The mechanism operates the linkages that tip the top carriage about the two centers of rotation, thereby alining the gun trunnions at a horizontal position. A level indicator is provided on the pedestal (fig. 39).

13. PEDESTAL.

a. The pedestal (fig. 27) is made in three sections, namely, the pedestal, leveling universal, and traversing ring. The pedestal is of welded construction. The leveling universal is suspended in the pedestal trunnion bearings by trunnions and is tipped about the trunnions and secondary pivots. The traversing ring is bolted directly to the top of the leveling universal. The pedestal is bolted to the bottom carriage and supports the top carriage.

DESCRIPTION AND FUNCTIONING OF MOUNT

Figure 27 — Components of Pedestal Assembly

b. An adjustable azimuth scale is provided for the orientation of the weapon. The leveling universal houses the self-alining roller bearing gimbal and ball thrust bearing on the pintle of the top carriage (fig. 28).

14. TOP CARRIAGE.

a. The top carriage (fig. 26) is of welded construction. The forged hollow pintle is welded to the top carriage and houses the data trans-

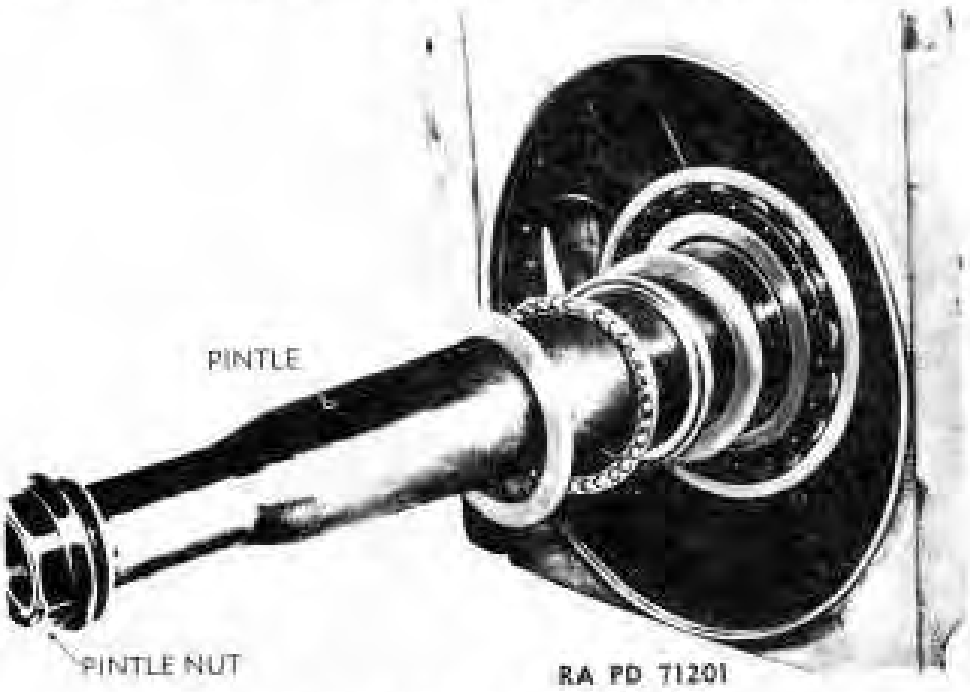

Figure 28 — Pintle and Bearing Arrangement

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

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Figure 29 — Cradle

DESCRIPTION AND FUNCTIONING OF MOUNT

Figure 30 — Details of Equilibrator

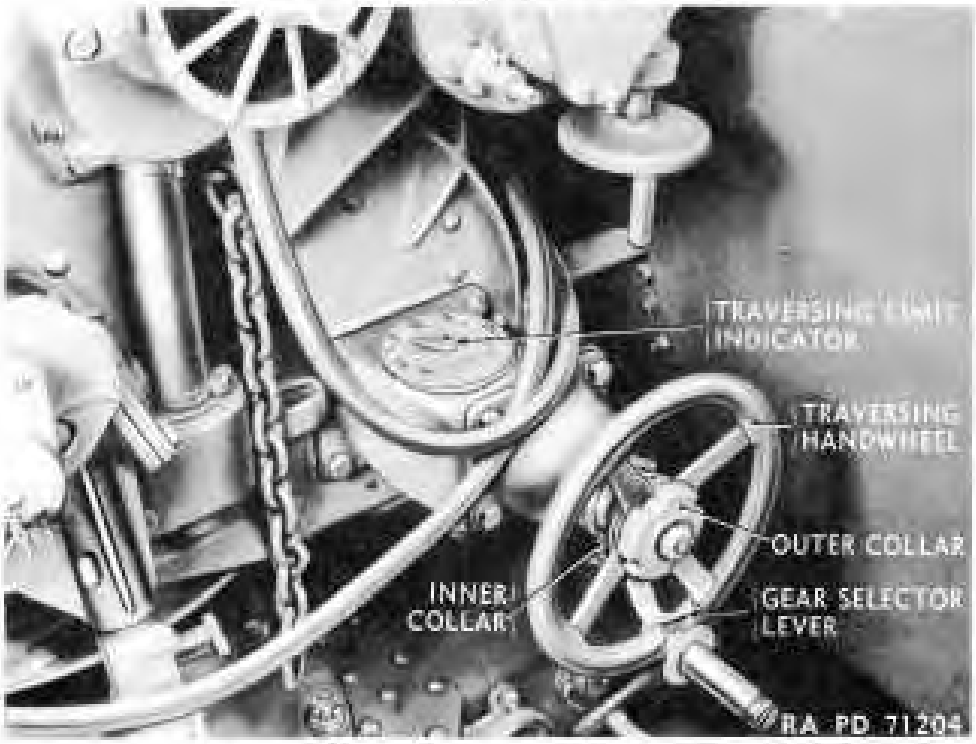

Figure 31 — Traversing Limit Indicator

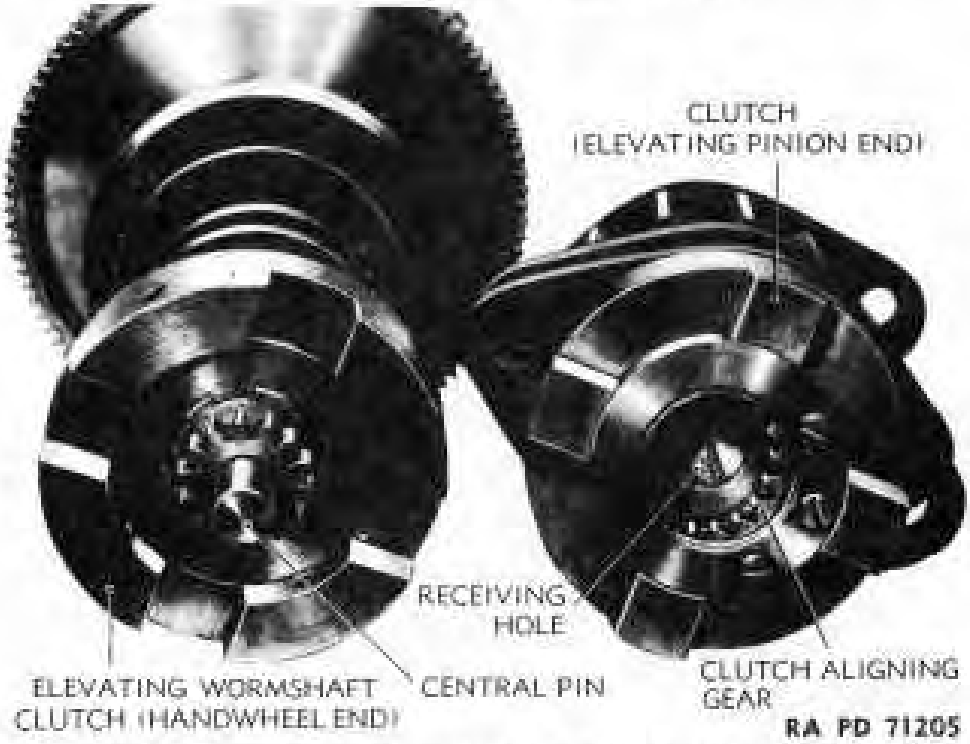

Figure 32 — Elevating Mechanism Clutch Disassembled

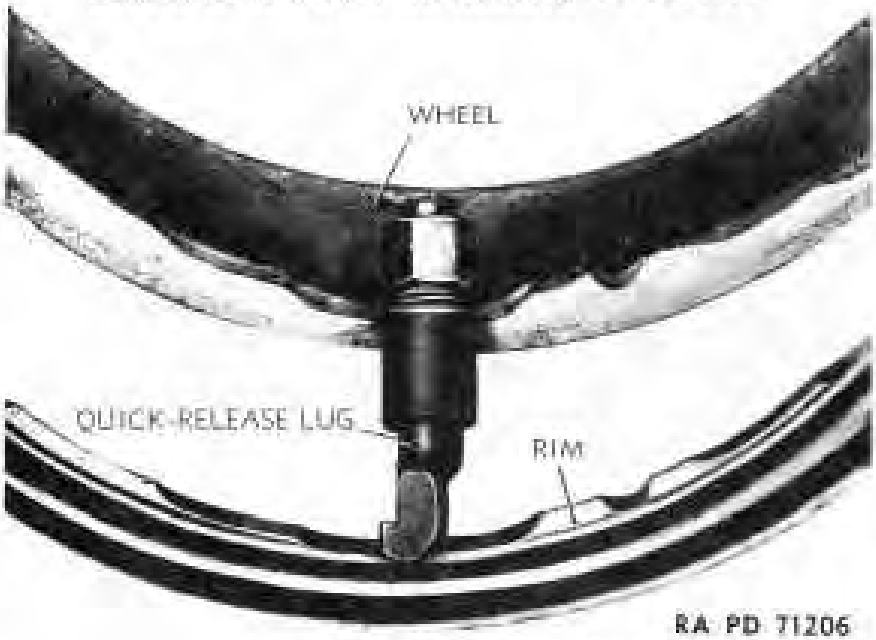

Figure 33 — Quick-release Lug

mission cable. The top carriage rests directly on the leveling universal of the pedestal and is kept in place by the gimbal bearing. The nut at the end of the pintle (fig. 28) prevents any vertical motion.

b. The cradle trunnion housings, azimuth and elevation mechanism housings, direct sight elevating housing, and equilibrator

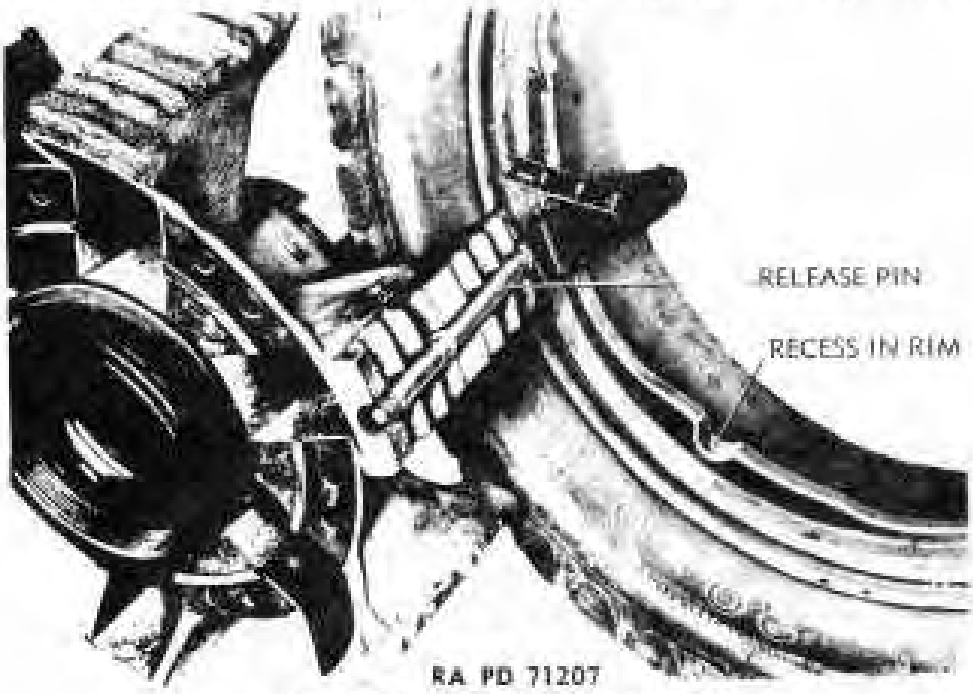

Figure 34 — Quick-release Device

trunnion supports are all welded to the top carriage. The leveling mechanism is fastened to the roller bearing at the lower end of the pintle.

15. CRADLE.

a. The cradle (fig. 29) is of rectangular-trough type section, welded, and riveted. The slides of the cradle support and guide the gun during recoil and counterrecoil. Trunnions are welded directly to the side frames and support the self-alining roller bearings. The equilibrator rod is fastened to the rear and below the trunnions by means of two clevis joined by a pin running through the cradle. The single elevating arc is fixed beneath the cradle by means of the equilibrator clevis pin and another pin just forward. Thus the arc is fastened to the cradle at two points and is readily replaced by removing the two pins. The breech operating cam and the auxiliary trigger mechanism are both fixed to the rear right side of the cradle. The loading tray is fastened to the rear left side as are the firing lever and recoil marker (fig. 14).

16. EQUILIBRATORS.

a. Two spring equilibrators are used to balance the muzzle preponderance of the gun. The equilibrators are suspended from the top carriage by trunnions and are fastened to the cradle by a clevis. In each unit there are three rectangular cross-section wire springs separated by spacers. The equilibrator rod also serves as a spring compressor and adjusting screw. Each unit is encased in a telescoping housing (fig. 30).

17. TRAVERSING MECHANISM.

a. The traversing handwheel is located on the right side of the mount (fig. 10). The traversing mechanism may be operated in either high or low speed. For changing from one speed to the other, a gear selector lever is provided at the handwheel (fig. 31).

b. A 360-degree traverse is permitted by the traversing ring. An indicator, located above the traversing handwheel, shows when the mount has made up to two complete revolutions in either direction (fig. 31). A Belleville spring stop at the left side of the top carriage prevents rotation in excess of two complete turns in any one direction. This is to prevent tangling of the data transmission cable. The azimuth data transmission indicator is geared directly to the circular rack just above the traversing ring.

18. ELEVATING MECHANISM.

a. The elevating handwheel is located on the right side of the carriage (fig. 10). Motion is transmitted from the handwheel, through gears, to the elevating pinion which engages the elevating rack, thereby elevating or depressing the gun. The elevating mechanism may be operated in either high or low speed. For changing from one speed

to the other, a gear selector lever is provided at the handwheel similar to the one on the traversing handwheel.

b. A clutch (fig. 32) is provided as a means of disengaging the elevating mechanism (fig. 10) from the elevating arc to prevent transmission of road shocks to the elevating gear system during traveling. The clutch mechanism is designed to prevent excessive wear on the edges of the clutch teeth when improperly meshed. The operational design of the clutch prevents meshing until the teeth are correctly alined. The clutch alining gear is always in contact with the spur gear as the clutch fork moves the clutch body on; the central pin moves forward at the same time. The clutch teeth will not engage until this pin enters the receiving hole in the clutch alining gear. This hole is properly concentric in only one position. At this position the pin will properly seat and the clutch will engage. When both sides of the clutch engage, there is no relative rotation between the alining gear and the clutch, and the holes remain alined until the clutch is disengaged for traveling position.

19. BOGIES.

a. The front and rear bogies are of welded construction, single axle type. The front bogie is fitted with 7-leaf transverse spring and has single wheels. The rear bogie is fitted with conventional 11-leaf suspension springs and has dual wheels.

b. The wheels are of cast spoke construction with twin detachable rims on the rear bogie and single detachable rims on the front bogie. The wheel spoke casting is fastened to the brake drum. The brake shoes are castings with the lining riveted to the outer surface. The shoes are actuated by a cam as is the practice in this country. The rims are fastened to the wheels by means of quick-release lugs (fig. 33). The lugs are loosened and then moved along the rim to bring them in line with recesses provided for the purpose and then removed. The wheels are removed from the spokes by another quick-release device (fig. 34). The release pin is pulled out until the recessed shoulder permits a quarter turn of the wheel and then the wheel may be removed by pulling straight off.

c. The mount is equipped with air brakes on all wheels. The rear bogie is provided with a seat from which the hand brake lever may be operated in case of emergencies. The stop lugs (fig. 22) on the German air hose connections must be filled slightly to allow the ones on American prime movers to be inserted. At best, only a loose connection is possible, thus resulting in a leakage of air.

d. The adjustable height drawbar is fastened to the front bogie axle projection and also controls the action of the radius bars (fig. 46). The lunette on the drawbar is large enough to fit the pintle on American prime movers. The bogies are equipped to take a single tube transporter bar to connect the two bogies when removed from the mount so as to make an improvised trailer.

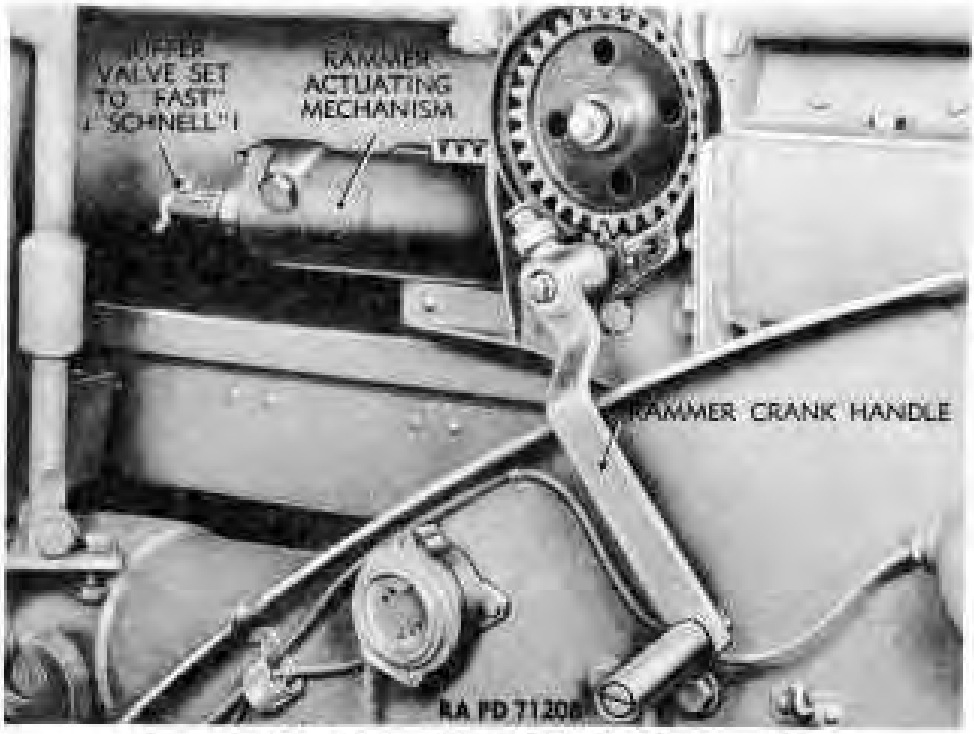

Figure 35 — Rammer Mechanism

20. RAMMER.

a. To facilitate the loading of rounds at high angles of elevation, an automatic rammer is provided (fig. 35). This rammer is mounted on the left top of the cradle and is actuated by a hydropneumatic cylinder. The rammer head is cocked automatically during counterrecoil and is released by the action of the hand-operated loading tray.

b. The actuating mechanism (fig. 36) utilizes gas and liquid in direct contact as in the recuperator cylinder. In this instance the cylinder is movable and the piston is fixed to the cradle. The cylinder has a removable inner liner, eccentrically located, but with its axis parallel with the axis of the outer cylinder. The system is filled with liquid to the level of the top of the inner cylinder and with nitrogen under pressure. A gas check valve is used for buffer action.

c. As the gun returns to battery in counterrecoil, a cam on the outer tube (fig. 4) engages a catch on the cylinder. The force of counterrecoil forces the cylinder forward until the gun returns to battery. At this point the cam on the tube is disengaged and the loading tray interlock prevents the cylinder from returning the position. The motivating force for ramming is now the mixture of liquid and gas under pressure.

DESCRIPTION AND FUNCTIONING OF MOUNT

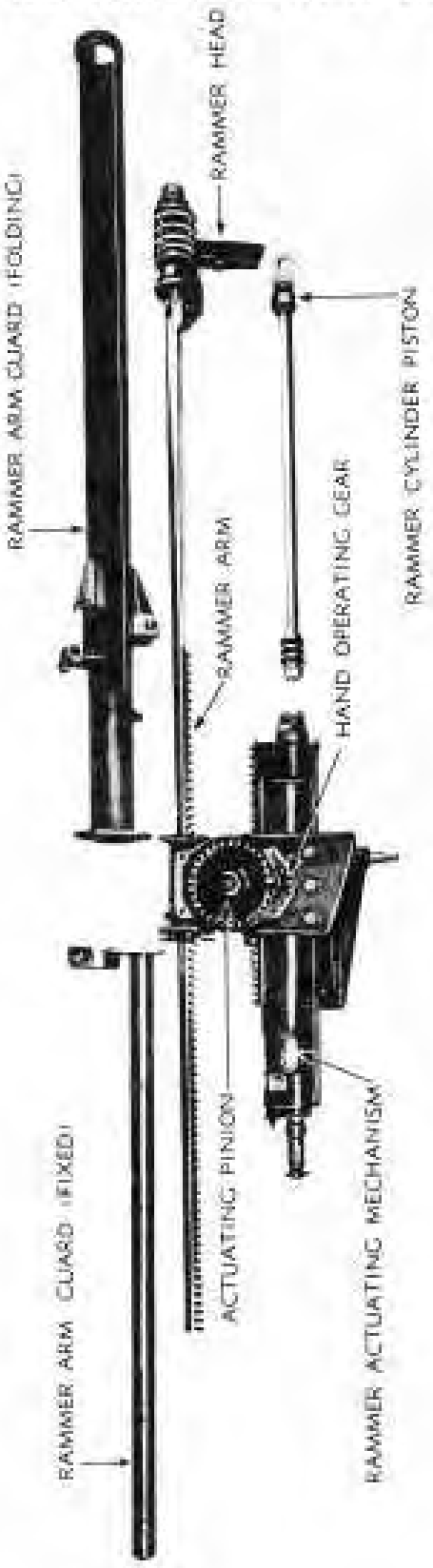

Figure 36 — Automatic Rammer Assembly

d. As the cylinder moves forward with the gun in counterrecoil, the rack and pinion linkage (fig. 36) actuates the ramming arm in the opposite direction. Thus, when the gun is in battery and the cylinder fully cocked, the ramming arm is fully extended and the mechanism is in ramming position. The loading tray is hand-operated and is mounted on two supporting lugs on the left side of the cradle. When the gun is fired, the loading tray is outboard of the cradle slides, and the new round may be placed on the tray at any time. As the gun returns to battery and the rammer head is fully cocked, the round is placed in loading position by grasping the handles on the side of the tray and pushing the tray over on its pivot until the axis of the round is on the same line as the axis of the bore. At this point the loading tray interlock (fig. 14) is released and the expanding gas forces the rammer cylinder back along the piston; thus the rammer arm is rapidly withdrawn seating the round. The loading tray interlock will not permit the trigger mechanism to operate until the loading tray is returned to the outboard position. There is an "AUTOMATIC" ("AUTOMATIK") position (fig. 14) on the interlock that will permit the trigger mechanism to function automatically when the loading tray is returned to the loading position. When the interlock is on "HAND," the trigger handle must be operated manually in order to fire the piece.

e. The rammer head (fig. 36) is permitted to swivel on the rammer arm. Thus, in order to ram the round, the rammer head is returned by hand to a position in which the base of the round may be engaged. When the round is rammed, the horizontal sliding breechblock strikes the end of the head and throws it over into a position that will enable the recoiling gun to clear.

f. The rammer arm is protected in all positions by a folding guard which also serves as a guide. When the gun has been fired for the last time before preparing for a change of location, the loading tray interlock may be operated without a round in the tray, thus releasing the pressure on the rammer and permitting the end of the guard to be folded back. In order to cock the rammer before the first round is fired, a removable handle (fig. 35) is available to rotate the rack and pinion linkage and thus force the cylinder back until the loading tray interlock will take effect. From this point on, all operations are the same as previously noted.

g. At elevations above 45 degrees the air buffer operation is reduced to obtain additional energy for ramming by permitting the air to escape at a faster rate. This is accomplished by setting the buffer valve, at the front of the rammer cylinder (fig. 35), to "FAST" ("SCHNELL"). For elevations below 45 degrees, the valve should be set to "NORMAL" ("NORMAL").

CHAPTER 2

GERMAN 88-MM ANTIAIRCRAFT GUN AND MOUNT (Cont'd)

Section IV

OPERATION

21. TO PLACE THE WEAPON IN FIRING POSITION.

a. The piece may be fired from the wheels but must be emplaced for high angle fire. To fire from the wheels:

(1) Unlimber the prime mover from the drawbar.

(2) Set the hand brakes on the rear bogie.

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Figure 37 — Engaging Elevation Gear Clutch

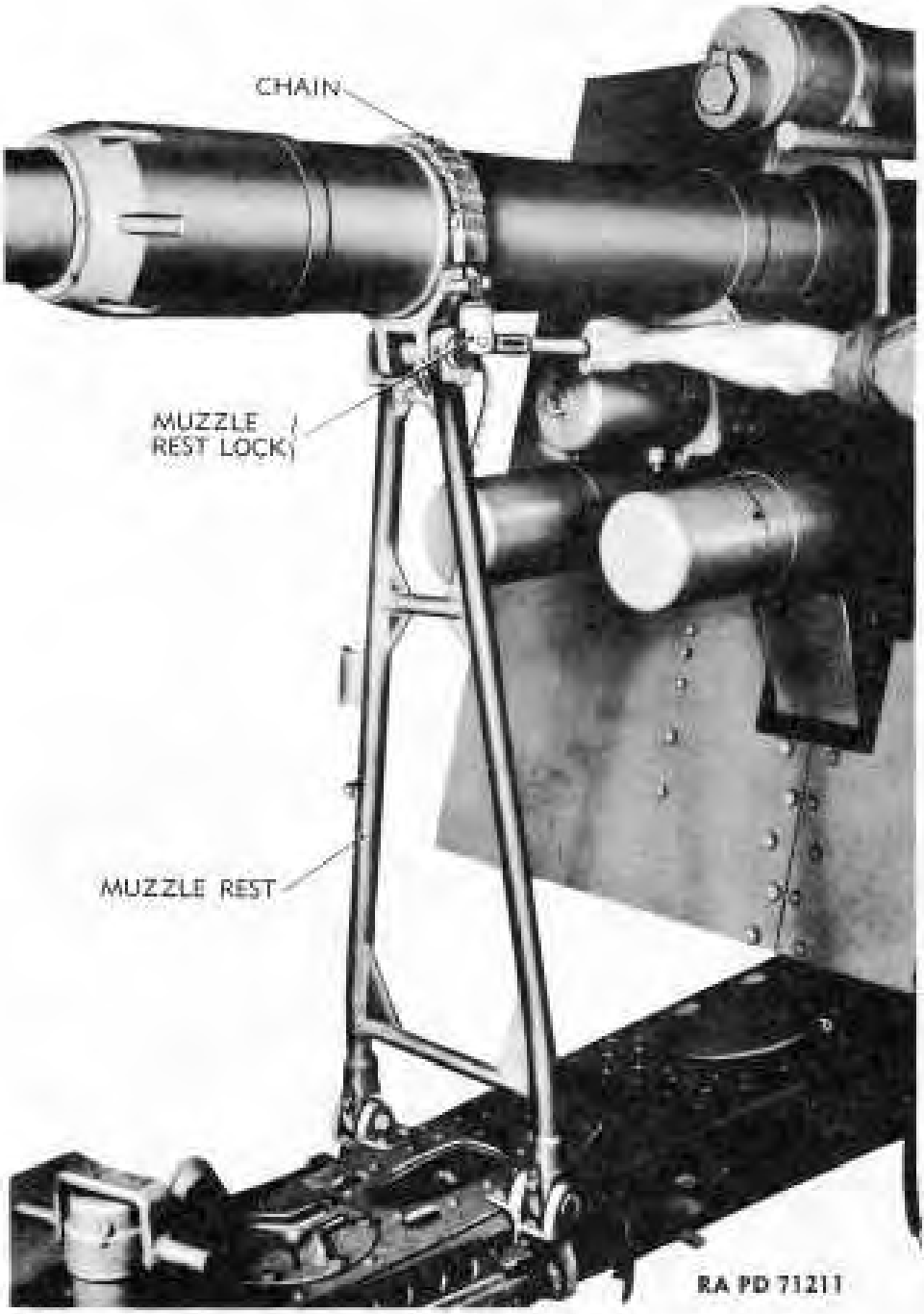

Figure 38 — Releasing Muzzle Rest

Figure 39 — Leveling Top Carriage

RA PD 71213

Figure 40 — Unfolding Rammer Guard

(3) Engage the elevating gear clutch by pulling the clutch lever to its downward position (fig. 37).

(4) Release the muzzle rest (fig. 38) by:

(a) Unscrewing the muzzle rest lock so that the chain may be swung over the barrel.

(b) Elevating the gun slightly so that the muzzle rest may be pushed forward and down onto the bottom carriage.

(5) Level the top carriage by cross-leveling handwheels, using the level indicator for reference (fig. 39).

(6) Unfold the rammer guard (fig. 40) to the operating position (fig. 41).

(7) Cock the rammer assembly by rotating the rammer crank handle in a counterclockwise direction (fig. 41).

b. To Emplace the Mount.

(1) Unlimber the prime mover from the drawbar.

NOTE: The operation of disconnecting both bogies is identical.

(2) Operate the winch until the chain takes all the weight from the locking jaws (fig. 42).

(3) While one man steadies the winch, disengage one locking jaw at a time by raising handle (figs. 42 and 43). Repeat for the other locking jaw on the bogie.

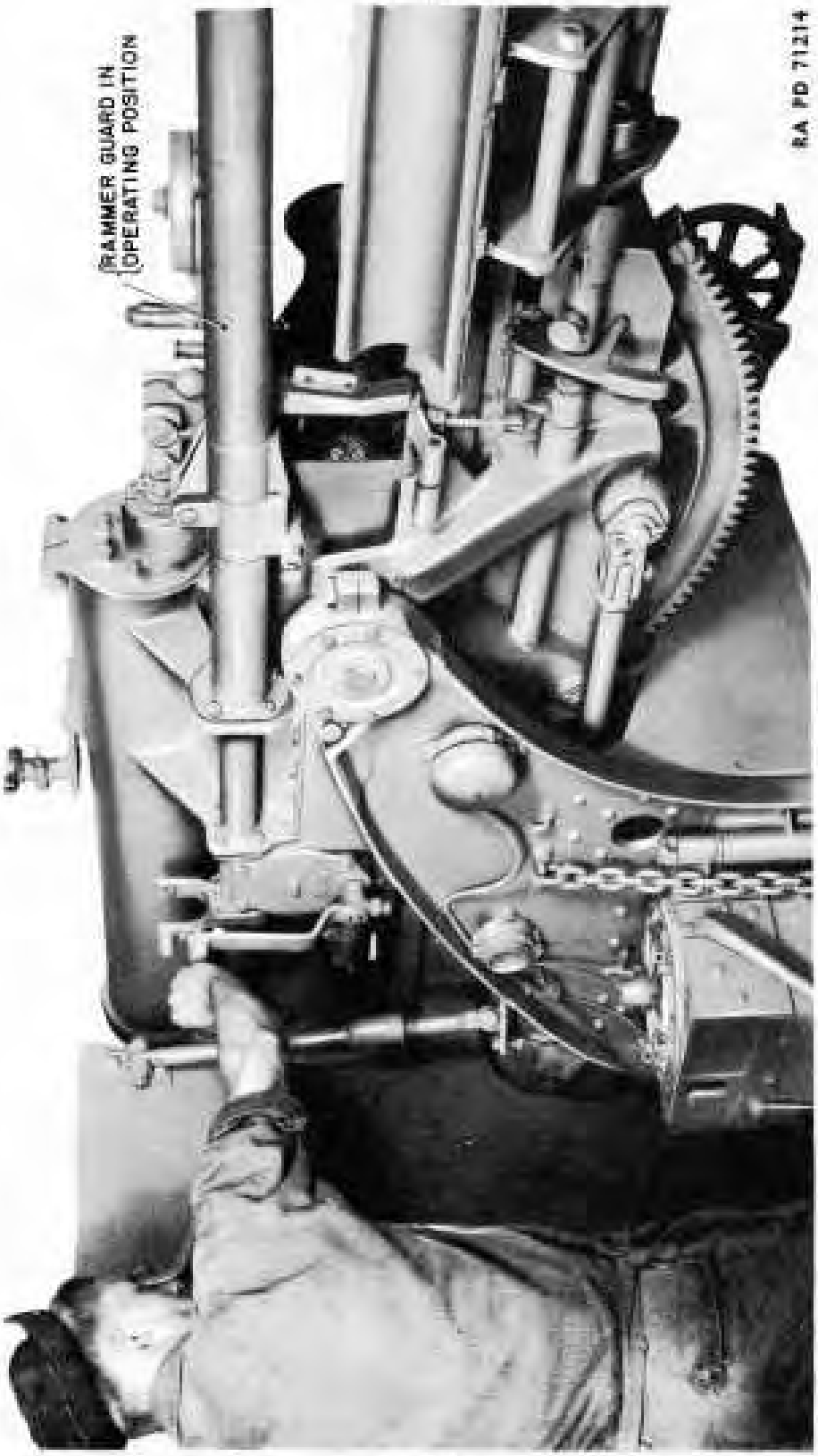

Figure 41 — Cocking Automatic Rammer

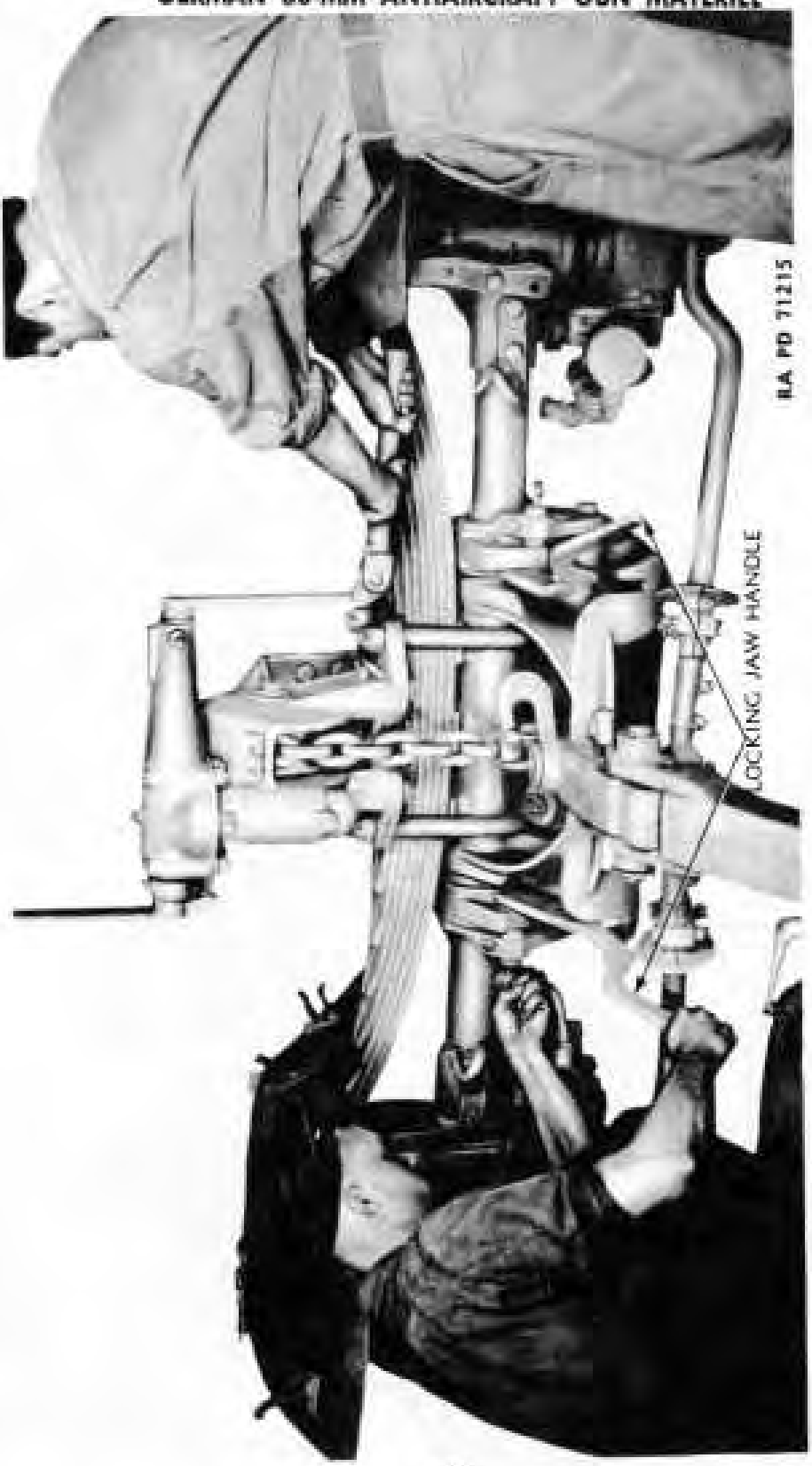

Figure 42 — Unlocking Front Bogie from Bottom Carriage

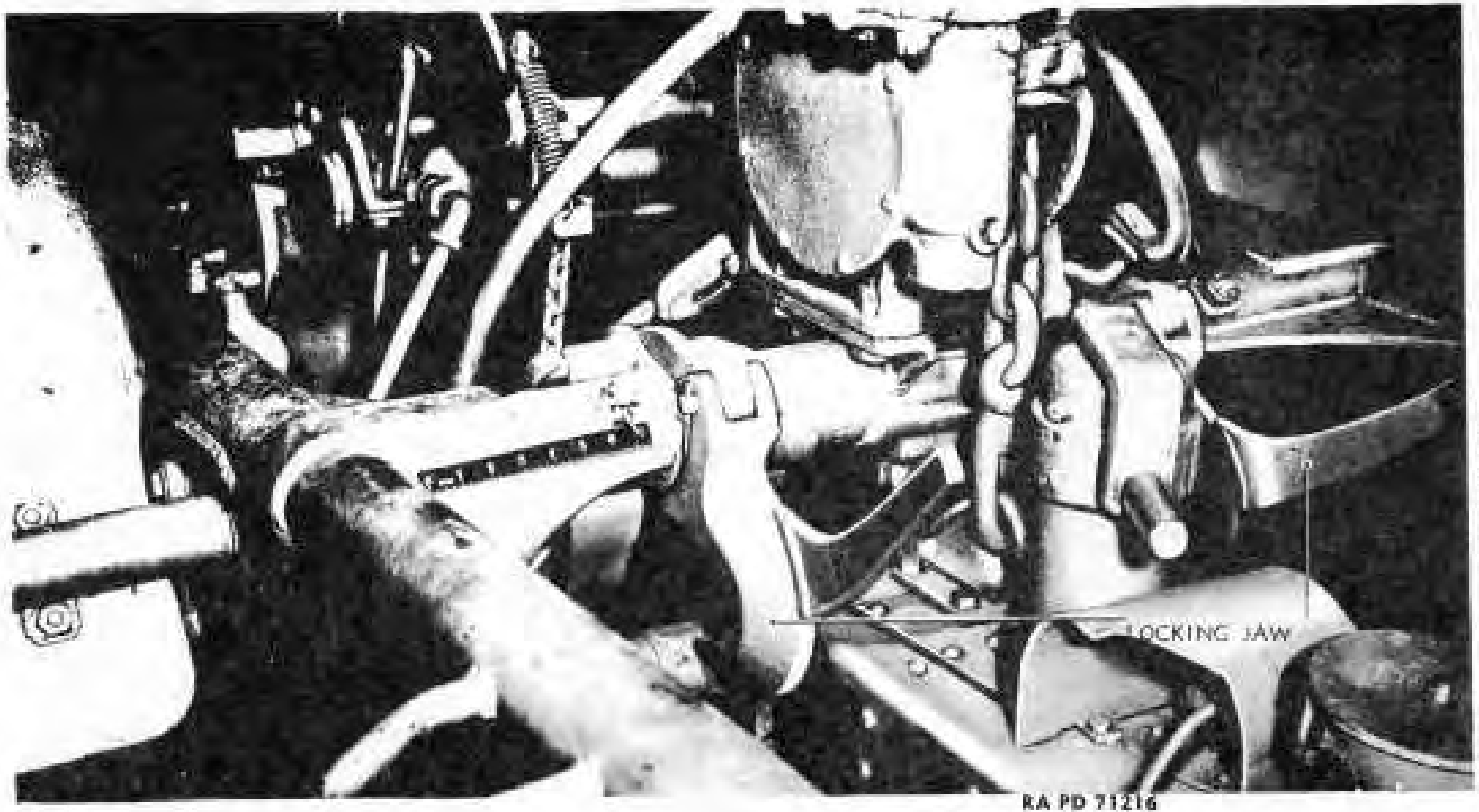

Figure 43 — Rear Bogie Locking Jaws

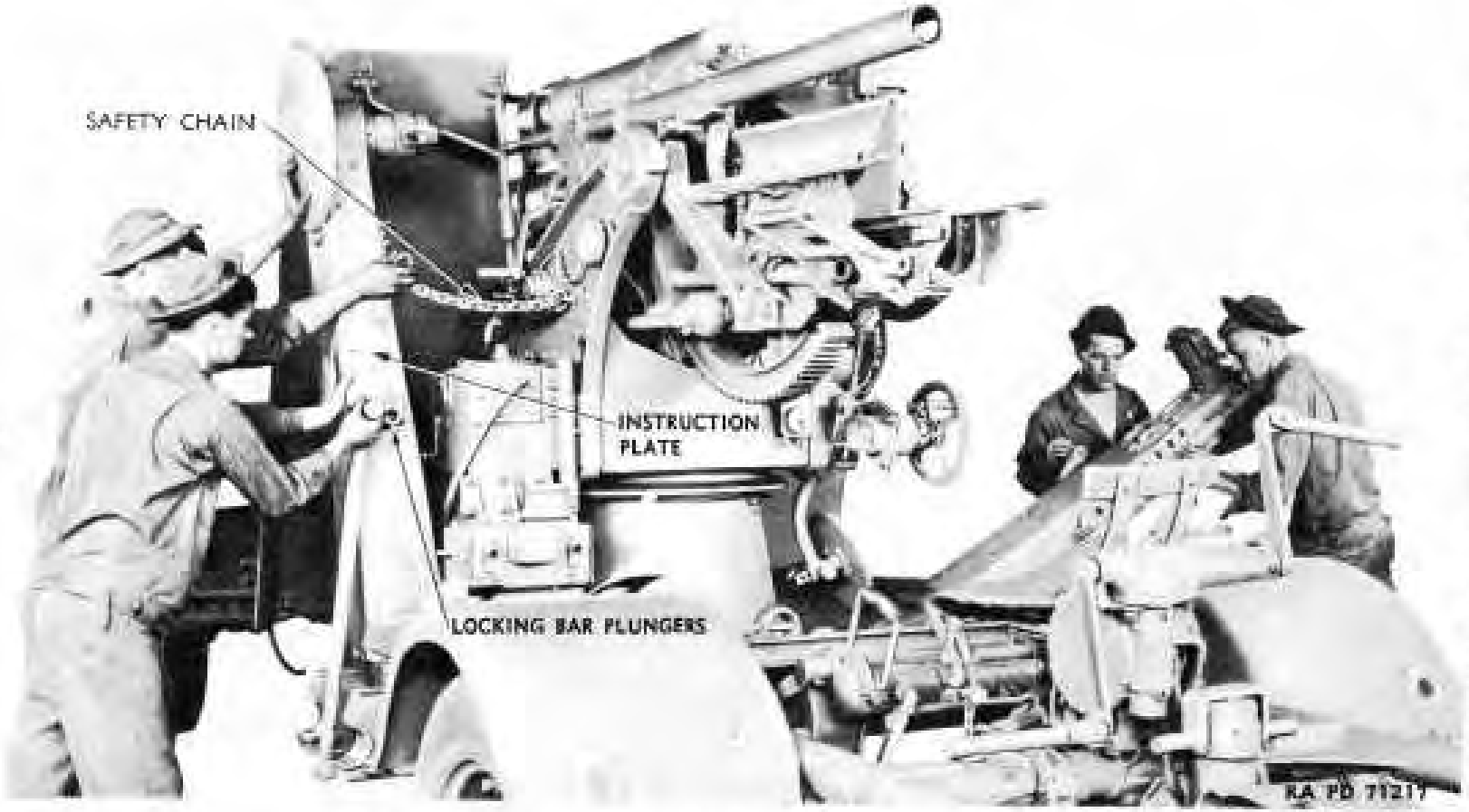

Figure 44 — Releasing Locking Bar Plunger and Removing Safety Chain

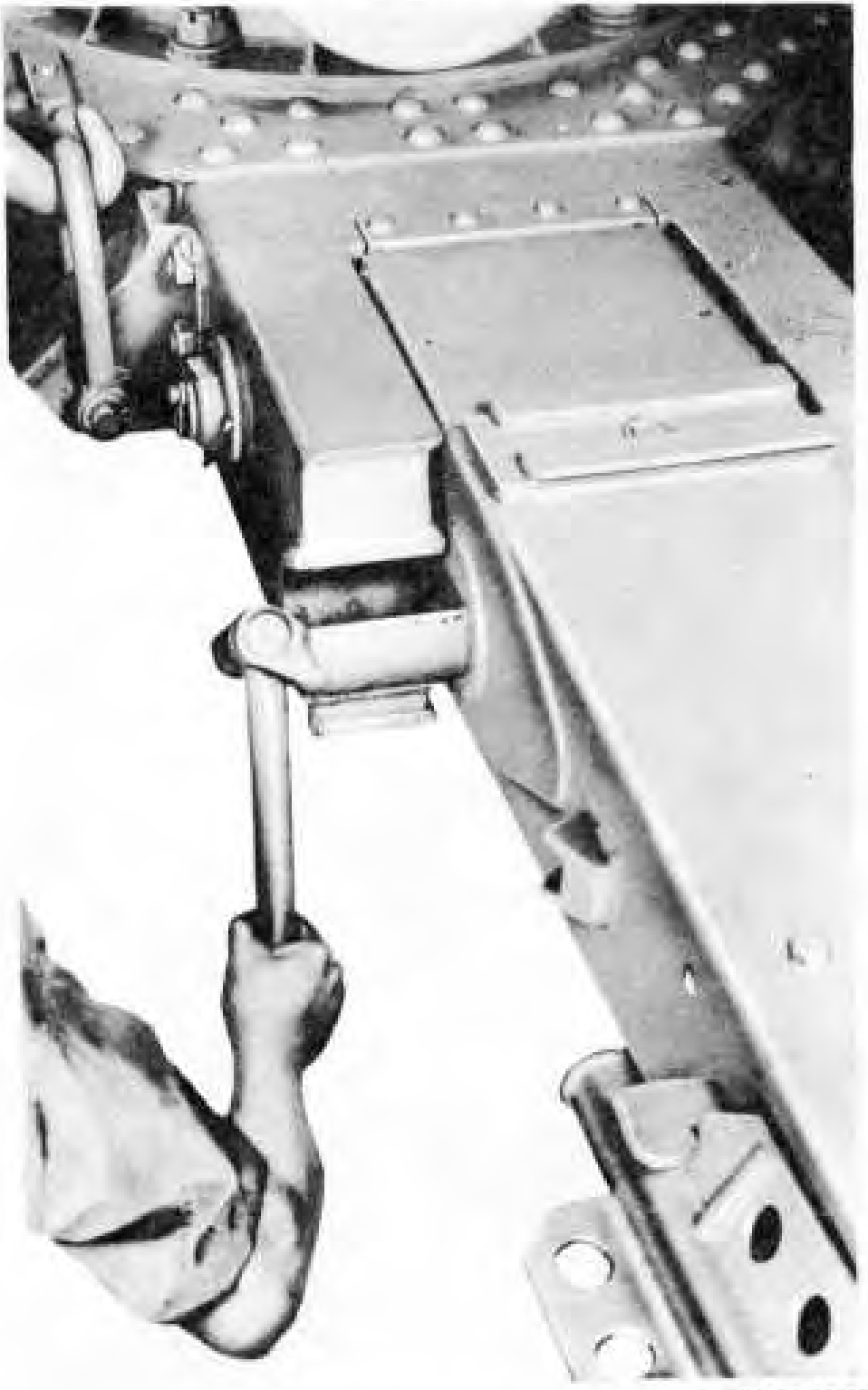

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Figure 45 — Locking Outriggers in Place

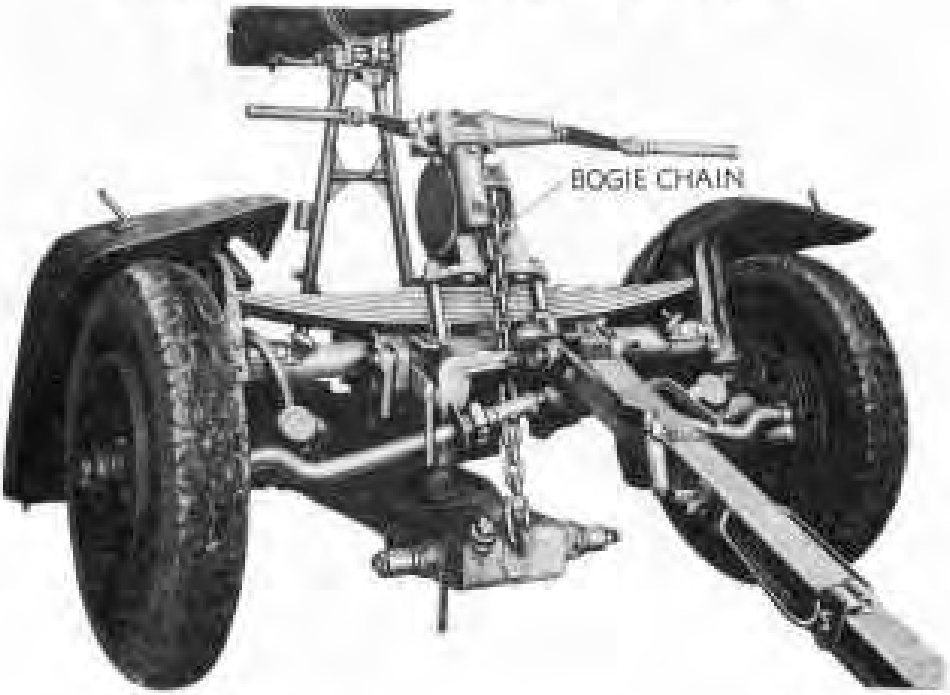

Figure 46 — Mount Lowered to Ground

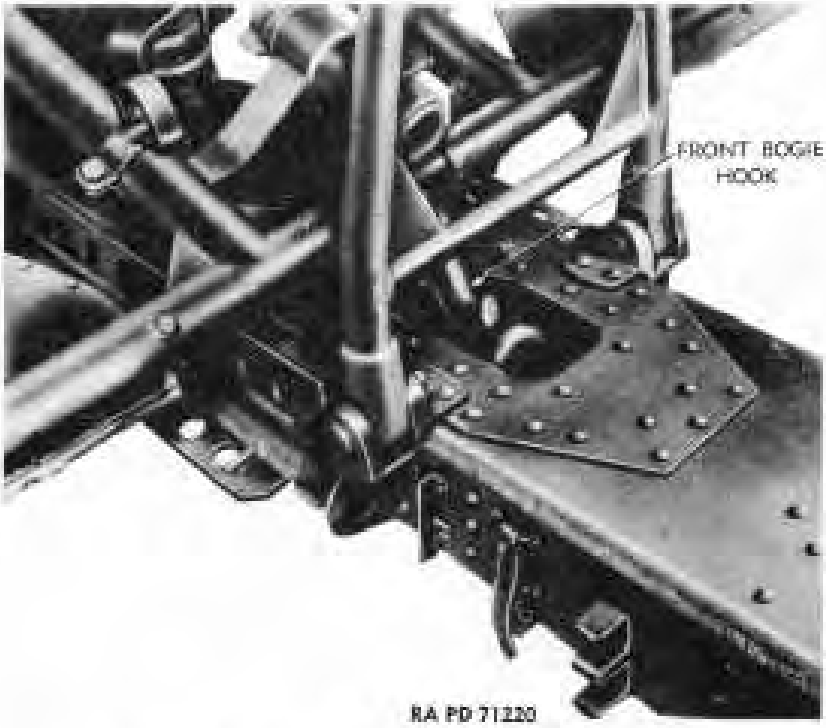

Figure 47 — Front Bogie Hook Disengaged

OPERATION

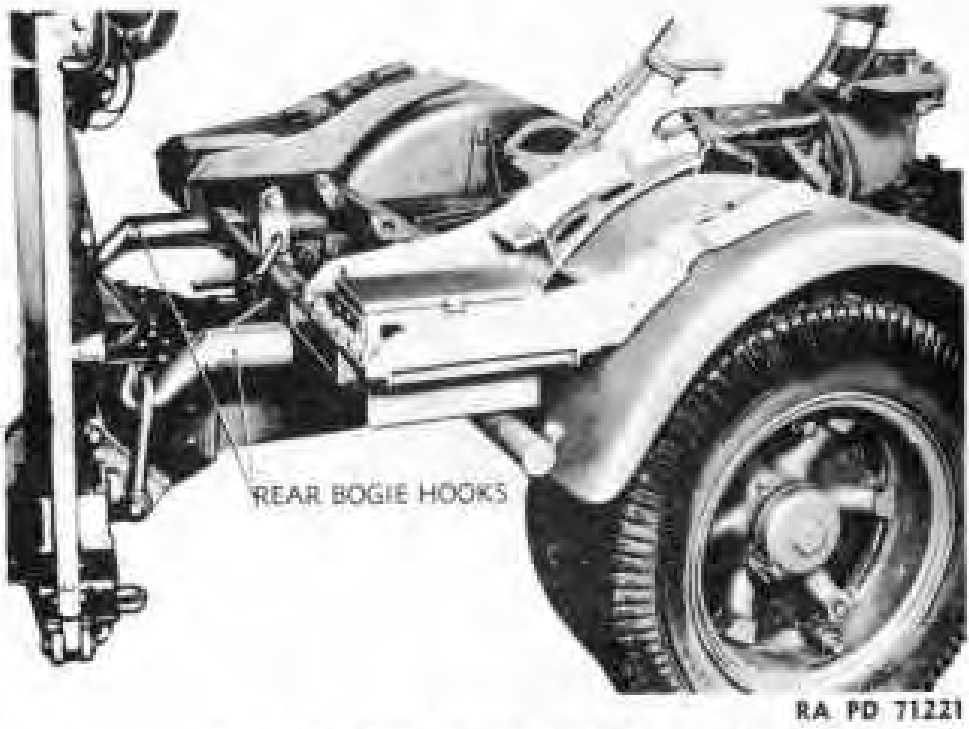

Figure 48 — Rear Bogie Hooks Engaged

Figure 49 — Supporting Mount and Outriggers on Leveling Jacks

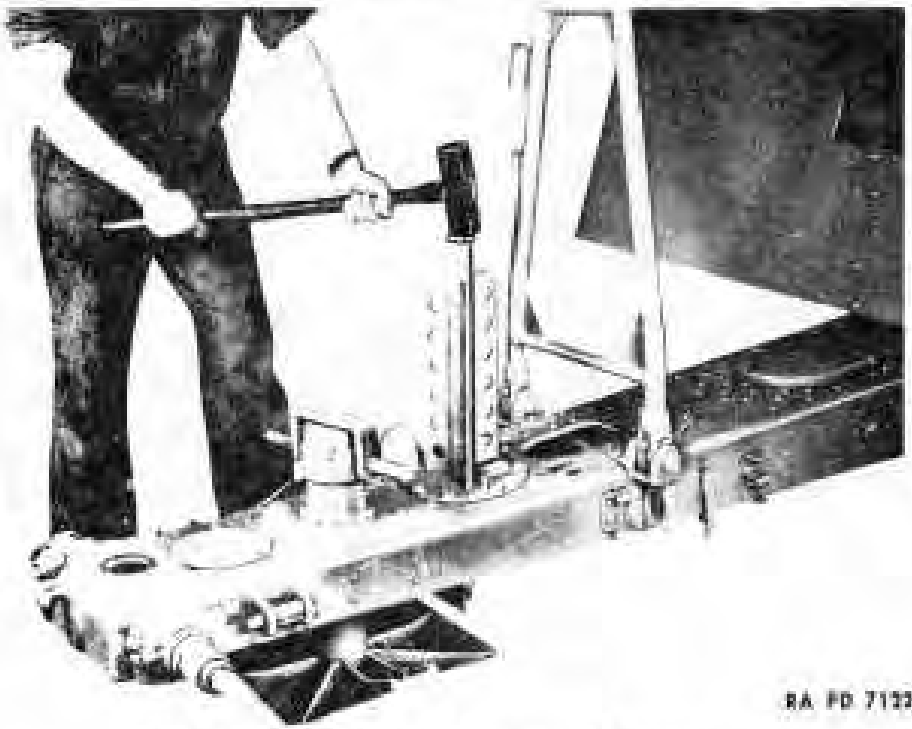

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Figure 50 — Staking Mount and Outriggers

(4) Simultaneously with the above, lower the side outriggers by performing the following steps. NOTE: The instruction plate (fig. 44) on the left outrigger reads "VOR AUSLOSEN DER STUTZEN SEITENHOLM DURCH 2 MANN FESTHALTEN," which translated means, "Before releasing the side outrigger supports, steady (the outriggers) by 2 men."

(a) Releasing the locking bar plunger (fig. 44).

(b) Removing the safety chains (fig. 44).

(c) Swinging the outriggers down.

(d) Locking the outriggers in place by rotating the locking pins (fig. 45).

(5) When the mount is completely lowered, unhook the bogie chains (fig. 46).

(6) Disengage the hooks securing the bogies to the mount (figs. 47 and 48). NOTE: Unhook the front bogie first.

(7) Remove the bogies, connect them together with the transporter bar, and wheel them away as a complete trailer unit.

(8) Engage the elevating gear clutch by pulling the clutch lever to its downward position (fig. 37).

(9) Release the muzzle rest (fig. 38) by:

(a) Unscrewing the muzzle rest lock so that the chain may be swung over the barrel.

(b) Elevating the gun slightly so that the muzzle rest may be pushed forward and down onto the bottom carriage.

(10) Support the bottom carriage and side outriggers with the leveling jacks (fig. 49).

(11) Secure the mount in position by driving the stakes through the bottom carriage and outriggers as shown in figure 50.

(12) Level the top carriage by the cross-leveling handwheels, using the level indicator for reference (fig. 39).

(13) Unfold the rammer guard (fig. 40) to the operating position (fig. 41).

(14) Cock the rammer assembly by rotating the rammer crank handle in a counterclockwise direction (fig. 41).

22. TO TRAVERSE.

a. The traversing handwheel is located on the right side of the carriage (fig. 10). Rotate the handwheel clockwise for right traverse and counterclockwise for left traverse, either in high or low speed.

(1) To Traverse in Low Speed. Trip the gear selector lever (fig. 31) toward the mount so that the lever will engage one of the four notches on the inner collar on the traversing handwheel shaft.

(2) To Traverse in High Speed. Trip the gear selector lever away from the mount so that the lever will engage one of the four notches on the outer collar on the traversing handwheel shaft.

23. TO ELEVATE.

a. The elevating handwheel is located on the right side of the carriage (fig. 10). Rotate the handwheel clockwise for elevation and counterclockwise for depression, either in high or low speed.

(1) To Elevate in High Speed. Trip the gear selector lever away from the mount so that the lever will engage one of the four notches on the outer collar on the elevating handwheel shaft.

(2) To Elevate in Low Speed. Trip the gear selector lever toward the mount so that the lever will engage one of the four notches on the inner collar on the elevating handwheel shaft.

24. TO OPERATE THE BREECH MECHANISM.

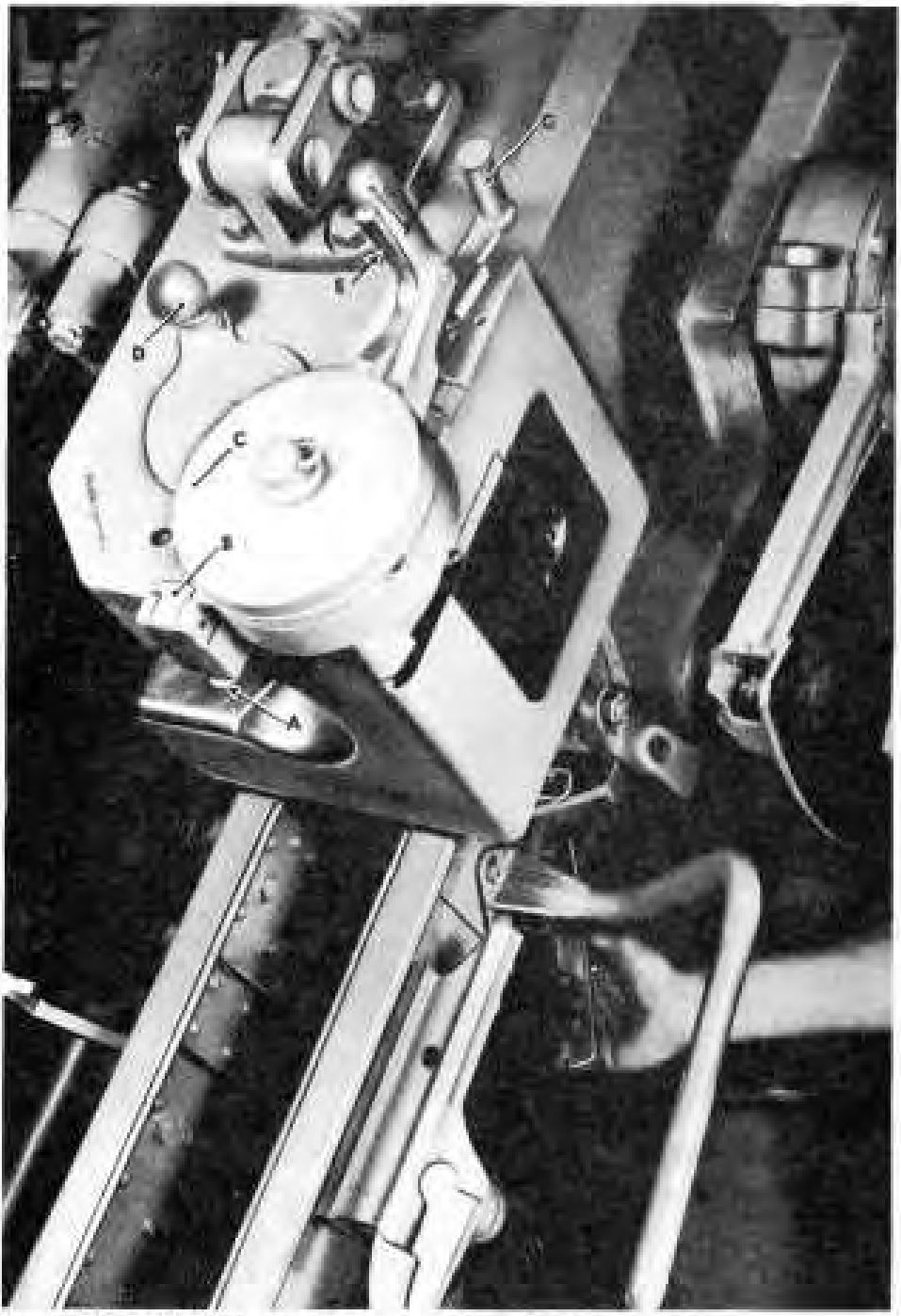
a. **To Open.**

(1) Normally, in action, the breech is opened, percussion mechanism cocked, and cartridge case extracted during counterrecoil of the gun.

(2) To open the breech manually before inserting the initial round of ammunition, grasp the breech actuating lever and squeeze the trigger to release the retaining catch (fig. 51). Rotate the breech actuating lever clockwise as far as it will go.

(3) Opening the breech manually may be performed either during the engaged or disengaged position of the "SEMIAUTOMATIC-

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL



A — CATCH PLUNGER
B — CATCH
C — BREECH ACTUATING MECHANISM
D — COCKING LEVER IN "FIRE" / "FEUER" POSITION
E — TRIGGER
F — BREECH ACTUATING LEVER
G — EXTRACTOR ACTUATING LEVER

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Figure 51 — Firing the Gun Manually

OPERATION

RA PD 71235

Figure 52 — Disengaging "SEMIAUTOMATIC-HAND" Catch

HAND" ("SEMIAUTOMATIK-HAND") catch. With the catch engaged, a strong pull to rotate the breech actuating lever is necessary. To engage the catch, pull down on the catch plunger and raise the catch in front to engage the breech actuating mechanism (fig. 51). The catch is disengaged when it is pressed down in front (fig. 52).

b. To Close.

(1) Normally, in action, the breech is closed by the cartridge base tripping the extractors, thereby releasing the breechblock, which closes due to the force of the spring in the breech actuating mechanism.

(2) After the firing period, it is necessary to close the breech. This is accomplished by rotating the extractor actuating lever in a clockwise direction (fig. 51) or operating the loading tray interlock without a round in the tray.

25. POINTS TO BE OBSERVED BEFORE FIRING.

a. Lubrication. All points should be thoroughly lubricated as prescribed (par. 33). The recoil, recuperator, and rammer cylinders should be filled to proper oil levels (pars. 37, 38, and 39). The recuperator and rammer cylinders should be charged to proper gas pressure (pars. 37 and 39).

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

26. POINTS TO BE OBSERVED DURING FIRING.

a. If the gun fails to fire, the following safety precautions must be observed:

(1) Stand clear of the path of recoil.

(2) Keep the gun at firing elevation. Do not depress the piece.

(3) Keep the gun directed in traverse either on the target or on a safe place in the field of fire.

(4) The breech will not be opened until at least 10 minutes after the last unsuccessful attempt to fire the piece.

27. TO LOAD.

a. Place the shell on the loading tray and swing the tray in line with the axis of the bore of the gun. At this point the loading tray interlock is released and the expanding gas forces the rammer cylinder back along the piston; thus the rammer arm is rapidly withdrawn, seating the round (fig. 53). Swing the empty loading tray back to its original outboard or loading position.

Figure 53 — Shell Partially Rammed

b. When firing at angles above 45 degrees, set the buffer valve to "QUICK" ("SCHNELL") (fig. 35) by turning the valve clockwise. At angles below 45 degrees, the valve is set to "NORMAL" ("NORMAL") by rotating the valve counterclockwise.

OPERATION

28. TO FIRE.

a. With the loading tray interlock set at "AUTOMATIC" ("AUTOMATIK") (fig. 53), the gun will fire as soon as the loading tray clears the path of recoil and is returned by hand to its outboard or firing position.

b. With the loading tray interlock set at "HAND" ("HAND"), the gun must be fired by performing either one of the following steps:

(1) Raising the firing lever on the left side of the cradle (fig. 53).

(2) Pulling the auxiliary trigger on the right side of the cradle (fig. 51).

29. TO RECOCK.

a. In case of a misfire, it will be necessary to recock the percussion mechanism by rotating the cocking lever in a counterclockwise direction as far as the word "WEIDERSPANNEN," which means "RECOCK." Then return the cocking lever to its original position at "FIRE" ("FEUER") (fig. 51). Fire the gun as described in paragraph 28 again; and if the gun again misfires, wait 10 minutes and then unload as described in paragraph 30.

30. TO UNLOAD.

a. Open the breech. If the extractor does not eject the shell, grasp the shoulder on the cartridge base and withdraw it from the breech recess. Then reload the gun.

31. TO PLACE THE WEAPON IN TRAVELING POSITION.

a. To place the weapon in traveling position after having been fired from the wheels:

(1) Release the pressure on the rammer by operating the loading tray interlock without a round in the tray. The rammer guard may now be folded back.

(2) Swing the muzzle rest up to vertical position and secure the gun to it.

(3) Disengage the elevating gear clutch.

(4) Release the hand brakes.

(5) Connect the prime mover to the drawbar.

b. To place the weapon in traveling position after having been fired from emplacement:

(1) Release the pressure on the rammer by operating the loading tray interlock without a round in the tray. The rammer guard may now be folded back.

(2) Withdraw the stakes and secure them in their places on the outriggers.

(3) Swing the muzzle rest up to vertical position and secure the gun to it.

(4) Disengage the elevating gear clutch.

(5) Remove the transporter bar from between the bogies.

(6) Secure the bogies to the mount by engaging the hooks provided for the purpose.

(7) Connect the bogie chains to the bottom carriage.

(8) Place the side outriggers in traveling position by:

(a) Unlocking the outriggers by rotating the locking pins.

(b) Swinging the outriggers up against the mount.

(c) Engaging the locking bar plungers.

(d) Securing the safety chains.

(9) Operate the winch to raise the bottom carriage high enough to engage the locking jaws.

(10) Lower the bottom carriage until its weight settles in the locking jaws.

NOTE: Use steps (9) and (10) with the front bogie first.

(11) Connect the prime mover to the drawbar.

CHAPTER 2

GERMAN 88-MM ANTIAIRCRAFT GUN AND MOUNT (Cont'd)

Section V

LUBRICATION

32. INTRODUCTION.

a. Lubrication is an essential part of preventive maintenance, determining to a great extent the serviceability of parts and assemblies.

33. LUBRICATION GUIDE.

a. **General.** Lubrication instructions for this materiel are consolidated in the lubrication guides (figs. 54 and 55). These specify the points to be lubricated, the periods of lubrication, and the lubricant to be used. In addition to the items on the guides, other small moving parts, such as hinges and latches, must be lubricated at frequent intervals.

b. **Supplies.** In the field it may not be possible to supply a complete assortment of lubricants called for by the lubrication guides to meet the recommendations. It will be necessary to make the best use of these available, subject to inspection by the officer concerned, in consultation with responsible ordnance personnel.

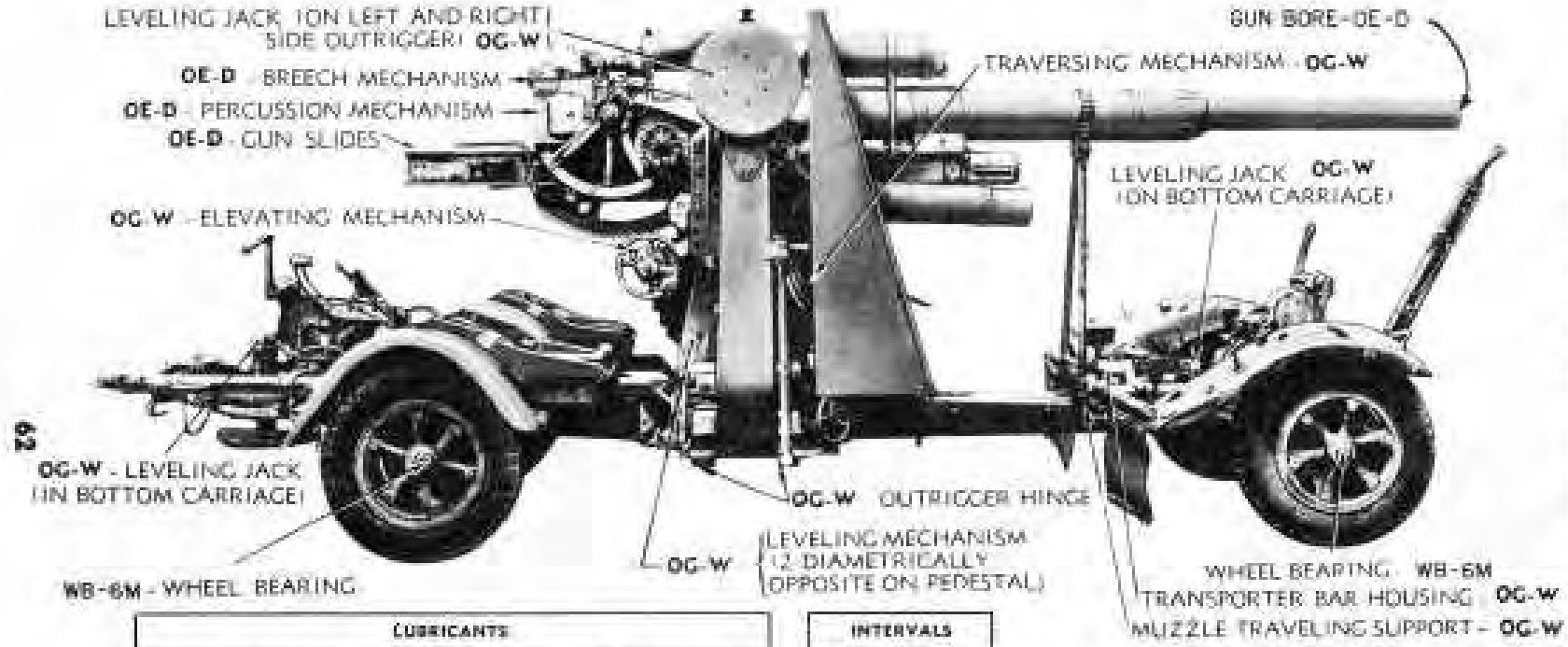
c. Oilholes and lubrication fittings are painted red for easy identification.

d. American lubrication guns and couplets will fit most German lubrication fittings.

e. American and German lubrication fittings are interchangeable.

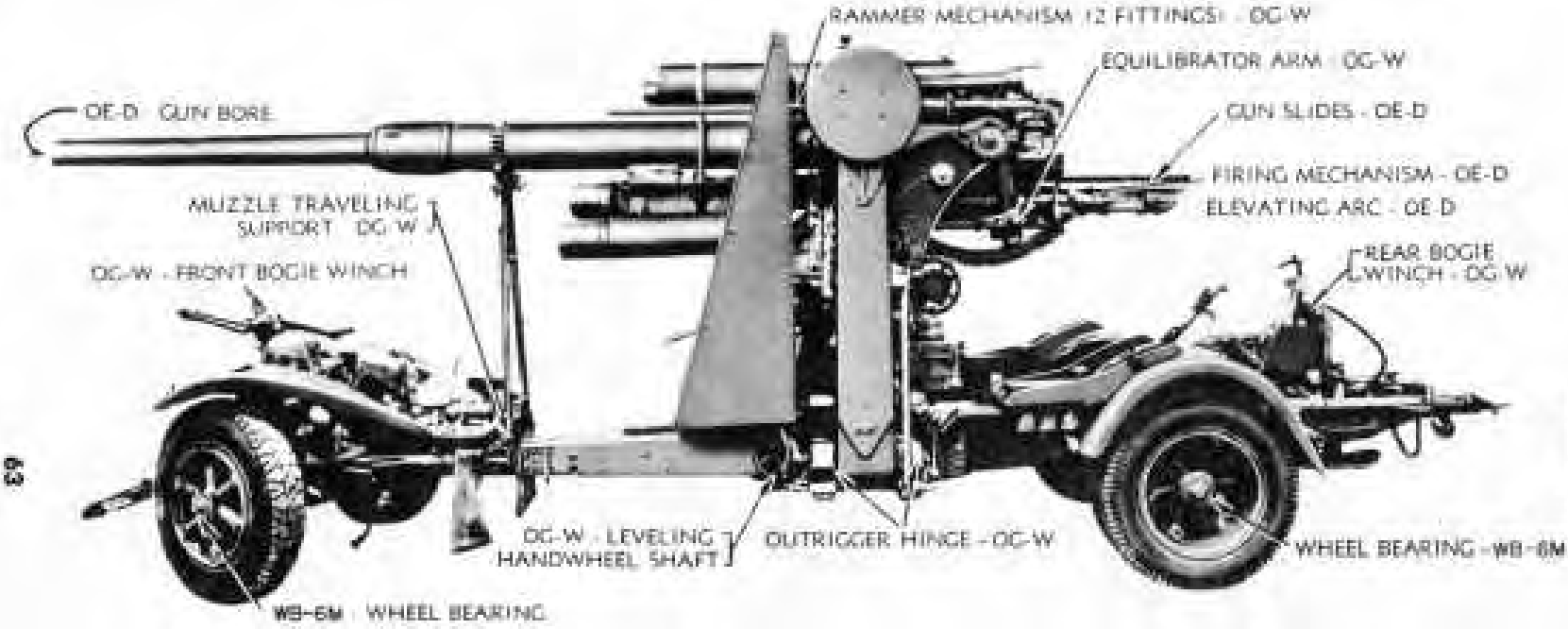
f. All gear cases should be disassembled, cleaned, and lubricated with GREASE, O.D. (seasonal grade), by ordnance personnel at the earliest opportunity available, and every 6 months thereafter.

g. **Wheel Bearings.** Remove bearing cone assemblies from hub and wash spindle and inside of hub with SOLVENT, dry-cleaning. Wet the spindle and inside of hub and hub cap with GREASE, general purpose, No. 2, to a maximum thickness of $\frac{1}{16}$ inch only to retard rust. Wash bearing cones with SOLVENT, dry-cleaning. Inspect and replace if necessary. Lubricate bearings with GREASE, general purpose, No. 2, with a packer or by hand, kneading lubricant into all spaces in the bearing. Use extreme care to protect bearings from dirt, and immediately reassemble and replace wheel. Do not fill hub or hub cap. The lubricant in the bearings is sufficient to provide lubrication until the next service period. Any excess might result in leakage into the brake drum.



LUBRICANTS		INTERVALS
OE — OIL, engine SAE 30 (above + 32° F) SAE 10 + 32°F to 0°F	OG — GREASE, G.O. NO. 0 (above + 32° F.) No. 00 (below + 32° F.)	D — Daily
OG — Below 0°F use OIL, lubricating, preservative, light.	WB — GREASE, general purpose No. 2	W — Weekly 6M — 6 Monthly

Figure 54 — Lubrication Guide



LUBRICANTS		INTERVALS
OE — OIL, engine SAE 30 (above + 32° F.) SAE 10 (+32° to 0° F.) Below 0° F use lubricating, preservative, light	OG — GREASE, G.O. NO. 0 (above + 32° F.) No. 00 (below + 32° F.) WB — GREASE, general purpose No. 2	D — Daily W — Weekly 6M — 6 MONTHLY

RA PD 71228

Figure 55 — Lubrication Guide

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

CHAPTER 2

GERMAN 88-MM ANTIAIRCRAFT GUN AND MOUNT (Cont'd)

Section VI

CARE AND PRESERVATION

34. GENERAL.

a. **Gun.**

(1) The cannoneer will examine the bore before each loading to ascertain and remove, if necessary, portions of powder bag or unburned powder remaining in the bore.

(2) In cleaning after firing, wash the bore with a solution of ½ pound of SODA ASH in 1 gallon of water. Wipe dry with the bore sponge covered with clean white rags. Oil the bore with OIL, engine, SAE 10, if temperature is between plus 32 F and 0 F. Use OIL, engine, SAE 30, above plus 32 F.

(3) Lubricating instructions are given in paragraph 33.

(4) When the materiel is not in use, covers must be used.

b. **Breech Mechanism.** The breech mechanism should be kept clean and the parts well lubricated. Disassemble daily or after firing, clean with SOLVENT, dry-cleaning, and oil with OIL, engine (seasonal grade).

c. **Firing Mechanism.** These parts require the same attention as the breech mechanism. Therefore, frequent disassembly for the purpose of cleaning and lubrication according to the lubrication guides (figs. 54 and 55), is required.

35. MOUNT.

a. Attention should be given to cleaning, lubricating, and to loose or broken parts. Lubrication, with the method and frequency of application, is carried in detail in paragraph 33.

b. The mount should be given a daily general inspection by the chief of section of the gun crew.

Figure 56 – Filling the Recuperator Cylinder with Liquid

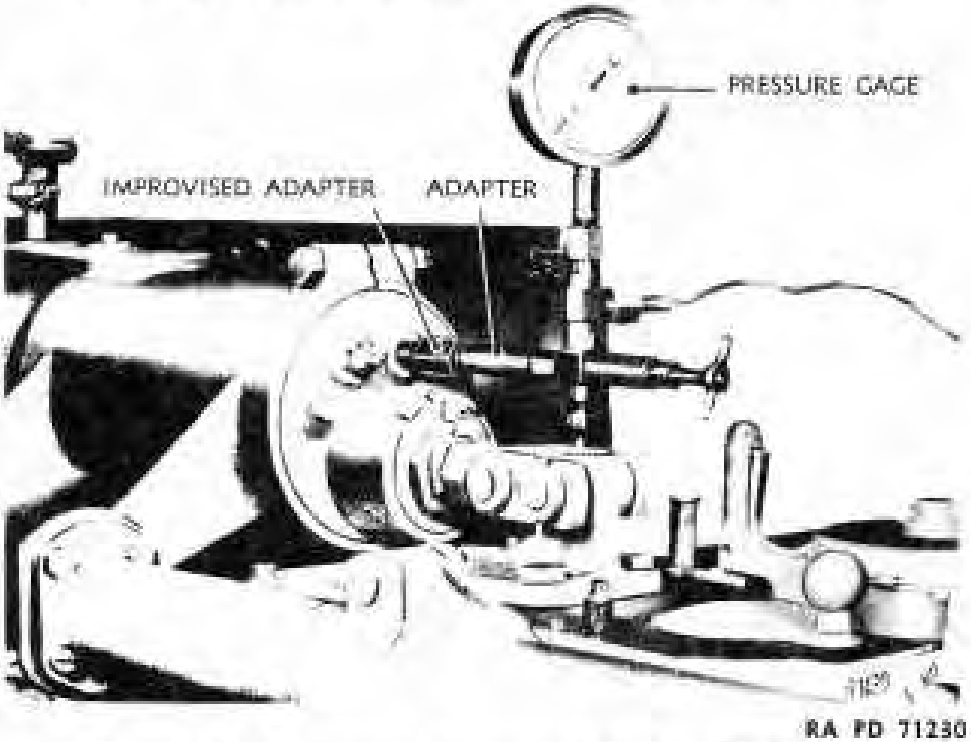


Figure 57 – Charging Recuperator Cylinder with Nitrogen

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

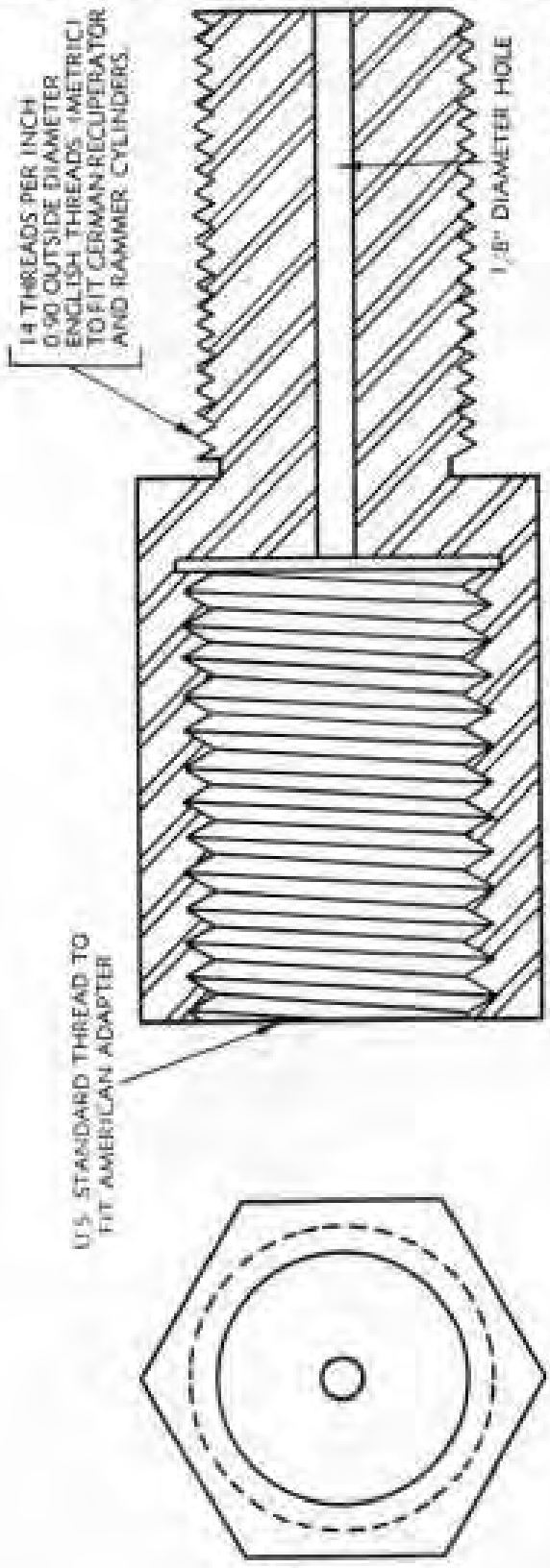


Figure 58 — Improvised Adapter

CARE AND PRESERVATION

36. RECOIL LIQUID.

a. The recuperator, recoil, and rammer cylinders are filled with the same liquid. The liquid used is 60 percent glycerine and 40 percent distilled water by volume with 1 ounce of caustic soda per 3 gallons of liquid. This mixture, while not a duplicate of the German liquid, is entirely satisfactory as a substitute. If the recommended liquid is not available, COMPOUND, antifreeze (ethylene glycol type), may be used in the same proportion as glycerine with the same gas pressures as when using liquid.

37. FILLING AND CHARGING THE RECUPERATOR CYLINDER.

a. Remove the liquid and gas filling plug and the drain plug at the rear end of the recuperator cylinder. Open the gas valve at least three full turns (fig. 56).

b. Place the gun at a zero-degree elevation and a zero-degree cant. Using a funnel, pour in recoil liquid at the gas and liquid filling hole (fig. 56) until it overflows at the drain hole. Approximately 4½ gallons will be required. Replace the drain plug.

c. Screw adapter and pressure gage into the gas and liquid filling hole (fig. 57) and connect to nitrogen supply. NOTE: To make the American adapter fit the liquid and gas filling hole in the recuperator cylinder, as shown in figure 57, an adapter must be improvised. The male threads at one end of this improvised adapter are 14 threads per inch and the outside diameter is 0.900 English thread. The female threads will receive the American adapter. An ⅛-inch diameter hole runs through this adapter to allow passage of the gas (fig. 58).

d. Close the gas valve on the recuperator cylinder and check the gas line for leakage.

e. If the gas line is tight, open the gas valve on the recuperator cylinder about two turns and charge with gas until approximately 600 pounds per square inch are recorded on the pressure gage. Close the gas valve on the recuperator cylinder and disconnect the gas line. Replace the gas and liquid filling plug.

38. FILLING THE RECOIL CYLINDER.

a. Elevate the gun to approximately a 2-degree elevation and a 0-degree cant.

b. Remove the two liquid filling plugs at the top front end of the recoil cylinder. Also remove the two overflow plugs, one at the front end and one at the left side of the cylinder.

c. Using a funnel, pour in recoil liquid at one of the liquid filling holes (fig. 59) until it overflows at the front overflow plug (fig. 59). Approximately 2½ gallons are required. Replace the front overflow plug.

d. Continue to pour until the liquid overflows at one of the top filling holes. As entrapped gas will cause the liquid to overflow, it is

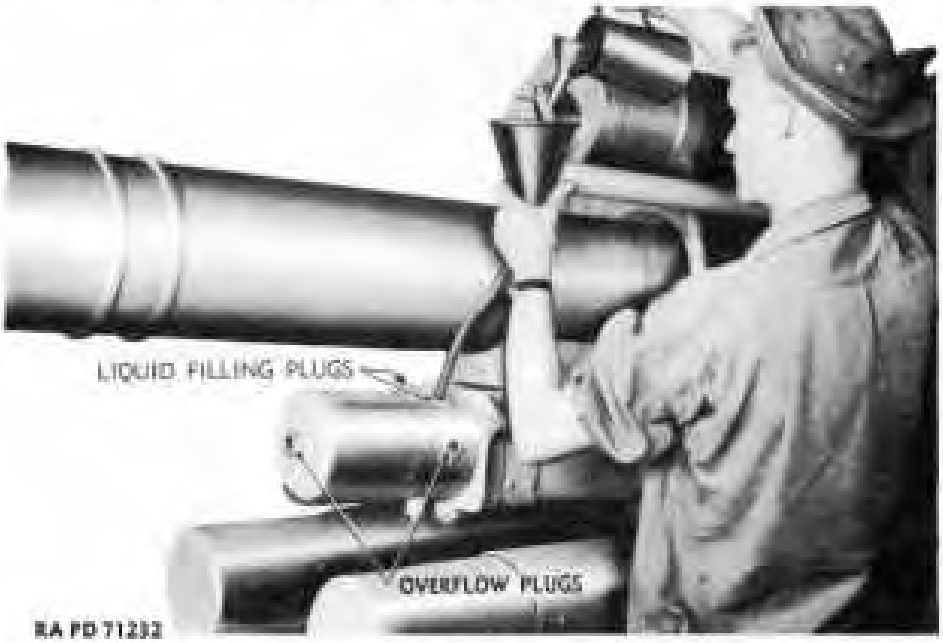


Figure 59 — Filling Recoil Cylinder with Liquid

Figure 60 — Filling Rammer Cylinder with Liquid

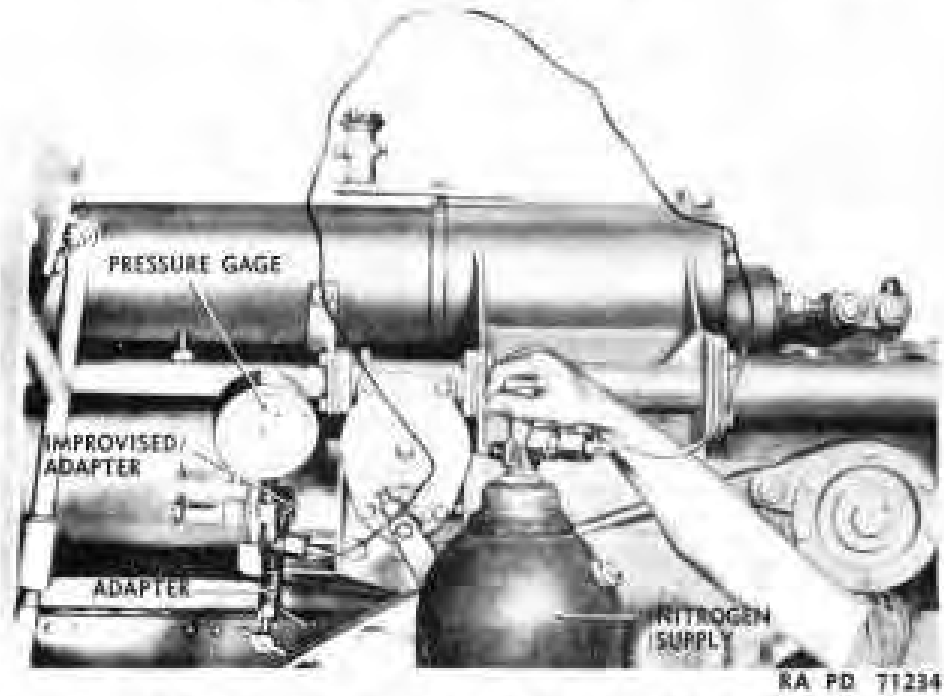


Figure 61 — Charging Rammer Cylinder with Nitrogen

desirable to wait until the turbulence subsides; then continue to fill. Replace the liquid filling plugs.

e. Depress the gun to the horizontal and pour recoil liquid in the side overflow hole until it overflows. Replace the plug.

f. Elevate and fully depress the piece at least three times to free the entrapped gas, and then elevate to a 2-degree elevation. Remove the liquid filling plugs again and add liquid if necessary.

39. FILLING AND CHARGING THE RAMMER CYLINDER.

a. Place the gun at a zero-degree elevation and a zero-degree cant.

b. Remove the liquid and gas filling plug.

c. Open the gas valve about two turns (fig. 60).

d. Using a funnel, add recoil liquid until the liquid overflows at the gas and liquid filling hole.

e. Screw adapter and pressure gage into the gas and liquid filling hole (fig. 61) and connect to nitrogen supply. NOTE: Use the same improvised adapter described in paragraph 37 e (fig. 58).

f. Close the gas valve on the rammer cylinder and check the gas line for leakage.

g. If the gas line is tight, open the gas valve on the rammer cylinder about two turns and fill with nitrogen until approximately 225 pounds per square inch are recorded on the pressure gage. Close the gas valve fully and disconnect the gas line. Replace the gas and liquid filling plug.

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

CHAPTER 2

GERMAN 88-MM ANTIAIRCRAFT GUN AND MOUNT (Cont'd)

Section VII

INSPECTION AND ADJUSTMENT

40. GENERAL.

a. Inspection has as its purpose the detection of conditions which cause improper performance. Such conditions may be caused by:

(1) Mechanical deficiencies resulting from ordinary wear and breakage.

(2) Faulty or careless operation.

(3) Improper care (servicing and lubrication). Inspection should always be accompanied by corrective measures to remedy any deficiencies found. When properly carried out, inspection and necessary corrective maintenance will insure the maximum reliability and performance of the materiel. The following inspection should be made at regular intervals not to exceed 30 days during both active and inactive seasons.

b. Before making a detailed inspection, the gun and mount should be inspected in general for evidences of faulty operation, care, and maintenance. Any unusual conditions which might result in improper operation or damage to the materiel, must be immediately remedied. Untidy appearance and evidences of rust or deterioration must be corrected. Missing or broken apparatus must be replaced.

41. INSPECTION OF GUN.

Inspection	Adjustment
Note condition of bore. Look for rust. Note lubrication of bore.	Remove any rust. Clean and slush. Wipe dry and lubricate.

INSPECTION AND ADJUSTMENT

42. INSPECTION OF BREECH MECHANISM.

Inspection	Adjustment
Note smoothness of operation of the breech mechanism in opening and closing.	If the mechanism does not operate smoothly, disassemble, clean, examine the parts for wear or breakage, and replace unserviceable parts. Lubricate the mechanism and reassemble. If it is still difficult to operate, notify ordnance maintenance personnel.
Examine the breechblock and breech recess for burs, indentations, rust, pitting, and other evidence of erosion.	If not possible to smooth or clean with CLOTH, crocus, notify ordnance maintenance personnel. Do not use any other abrasive.

43. INSPECTION OF FIRING MECHANISM.

Note the action of the firing mechanism by pulling on the firing lever. Then open the breech and note whether the percussion mechanism has been cocked during the operation of opening the breech. Close the breech again and operate the firing mechanism. With the breech closed, cock the percussion mechanism using the cocking lever assembly.	Repair or replace parts of the percussion mechanism release assembly, percussion mechanism, and cradle firing mechanism which may be worn or broken.

44. INSPECTION OF TRAVERSING MECHANISM.

Operate the traversing mechanism to determine smoothness of operation and whether there is any backlash or play in the mechanism.	Lubricate. If this fails, notify ordnance maintenance personnel.
Inspect for defective or broken parts.	Notify ordnance maintenance personnel.
Examine for proper lubrication.	Lubricate if necessary.

45. INSPECTION OF ELEVATING MECHANISM.

Operate the elevating mechanism to determine smoothness of operation and whether	Lubricate. If this fails, notify ordnance maintenance personnel.

Inspection	Adjustment
there is any backlash or play in the mechanism.	
Inspect for defective or broken parts.	Notify ordnance maintenance personnel.
Examine for proper lubrication.	Lubricate if necessary.

46. INSPECTION OF RECOIL AND RECUPERATOR MECHANISMS.

Check recuperator cylinder for proper amount of gas pressure and liquid.	To check the gas pressure: See that the gas valve on the recuperator cylinder is closed. Remove the liquid and gas filling plug and install the pressure gage securely. Open the gas valve and read the pressure registered on the gage. The normal pressure is 600 pounds per square inch. If the recorded pressure is less than normal, proceed as in paragraph 37. The gas pressure may also be checked without the use of the gage, by elevating the gun to maximum elevation and then jacking it out of battery and blocking in the recoil position. If the gun slides into battery rapidly when the block is knocked out, the gas pressure is sufficiently high for proper operation. To check the liquid level: Depress the gun to minus 1 degree. Gently open drain plug not more than one turn and note whether liquid flows. If it does, there is sufficient liquid. If no liquid flows, the cylinder must be purged of gas and refilled with liquid as described in paragraph 37.

INSPECTION AND ADJUSTMENT

Inspection	Adjustment
Check the recoil cylinder for proper amount of liquid.	To check liquid: Elevate the gun to a 2-degree elevation. Remove the liquid *filling* plugs. The liquid should be up to the level of the filling holes. If it is necessary to add liquid, proceed as in paragraph 38.
Exercise the weapon using a block and tackle to determine the amount of recoil, which should be 41½ inches at a 0-degree elevation and 27¾ inches at maximum elevation.	If necessary, check the gas and liquid content of the recuperator cylinder, should the weapon recoil in excess of the prescribed distances (par. 46 a). If cylinder is full, notify ordnance maintenance personnel.
The gun should not jump or slam into battery. The gun should ease into battery smoothly against the action of the recoil mechanism.	If necessary, refill the recoil cylinder. If this does not remedy the condition, notify ordnance maintenance personnel.
Note whether or not the recoil and recuperator piston rods are properly secured to the breech ring.	Tighten if necessary.
Inspect for any leakage of liquid around the recoil or recuperator cylinders.	Notify ordnance maintenance personnel.

47. INSPECTION OF RAMMER ASSEMBLY.

Check the rammer cylinder for proper amount of gas pressure and liquid.	To check the gas pressure: See that the gas valve in the rammer cylinder is closed. Remove the liquid and gas filling plug at the air filling vent and install the pressure gage securely. Open the valve and read the pressure registered on the gage. The normal pressure is 225 pounds per square inch. If the recorded pressure is less than normal, proceed as in paragraph 39.

Inspection	Adjustment
	To check the liquid level in the rammer cylinder. Depress the gun to minus 1 degree. Gently open the gas and liquid filling plug not more than one turn and note whether liquid flows. If it does, there is sufficient liquid. If no liquid flows, the cylinder must be purged of gas and refilled with liquid as described in paragraph 39.
Check the smoothness of the rammer tray for burs or rust.	If not possible to smooth or clean with CLOTH, crocus, notify ordnance maintenance personnel. Do not use any other abrasive.
Inspect for any leakage around the rammer cylinder.	Notify ordnance maintenance personnel.
Operate the rammer assembly by cocking the mechanism; then release the pressure on the rammer to determine smoothness of operation.	Lubricate if necessary. If this fails, notify ordnance maintenance personnel.

48. INSPECTION OF MOUNT.

Inspect the pintle bearing for lubrication.	Lubricate if necessary.
Inspect the trunnion bearings for cleanliness and lubrication.	Clean and lubricate.

49. INSPECTION OF BOGIES.

Examine the winches for broken parts, smoothness of operation, and lubrication.	Repair any damage or replace broken parts. Lubricate if necessary.
Check to see that the leaf spring clips are tight and that the spring center bolts are not worn.	Tighten the spring clips or replace spring center bolts, if necessary.

50. INSPECTION OF BRAKES.

a. **Power Brakes.** Inspect the power brake mechanism at frequent intervals to discover air leaks. All air line connections must be tight.

In case leakage test shows a 2-inch diameter soap bubble in 5 seconds, notify ordnance maintenance personnel.

b. Hand Brakes. A hand brake lever is mounted on the rear bogie. The lever is retained in position by a latch engaging a toothed segment. If the hand brake does not hold, notify ordnance maintenance personnel for any necessary adjustment.

51. INSPECTION OF EQUILIBRATORS.

a. If the elevation handwheel is difficult to operate, it is possible that the equilibrators are not compensating for the unbalanced weight of the gun. Notify ordnance maintenance personnel for any adjustment necessary.

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

CHAPTER 2

GERMAN 88-MM ANTIAIRCRAFT GUN AND MOUNT (Cont'd)

Section VIII

MALFUNCTIONS AND CORRECTIONS

52. MALFUNCTION OF GUN.

a. Fails to Fire; No Percussion on Primer.

Cause	Correction
Broken or weak firing spring. Broken or deformed firing pin.	Remove firing spring retainer, firing spring, and firing pin holder assembly. Replace broken or deformed parts. Clean and lubricate; then replace in breechblock.
Sear not retaining the firing pin in cocked position.	Remove the sear and sear spring. Clean and lubricate; then replace.

b. Fails to Fire Until After Several Percussions on Primer.

Percussion mechanism and percussion mechanism release assembly parts not working freely.	Disassemble and examine carefully for burs, or rough surfaces. Smooth with CLOTH, crocus, or an oil stone. Clean, lubricate, and reassemble.
Weak firing spring.	Replace.

c. Fails to Fire When Proper Pressure on Primer is Obtained.

Defective primer.	After three percussions, wait 2 minutes before opening breech; then insert another round of ammunition.

d. Fails to Extract Empty Cartridge Case.

Broken extractor.	Carefully remove the case by operating from the muzzle end. Examine the edge of the chamber for deformation or burs which might cause difficult extraction. Disassemble mechanism. Replace extractor, if necessary.

MALFUNCTIONS AND CORRECTIONS

e. **Misfire.**

Cause	Correction
Defective ammunition.	In case of a misfire, at least two or three additional attempts to fire the piece should be made. The breechblock will not be opened until at least 10 minutes after the last unsuccessful attempt to fire the piece. The gun will be kept directed in elevation and traverse either on the target or on a safe place in the field of fire.

f. **Breechblock Unable to Be Brought to Full Closed Position.**

Improper chambering of cartridge case.	Attempt to close the breech. If the breech will not close, open the breech and insert another round. If the malfunction recurs, notify the ordnance maintenance personnel.
Breechblock seized.	Notify ordnance maintenance personnel.

53. MALFUNCTION OF MOUNT.

a. **Gun Returns to Battery with Too Great a Shock.**

Excessive amount of recoil liquid in recuperator cylinder.	Drain and recharge the recuperator cylinder with liquid and air pressure, as described in paragraph 37.
Insufficient amount of liquid in recoil mechanism.	Fill recoil mechanism, as described in paragraph 38.
Recoil mechanism out of order.	Notify ordnance maintenance personnel.

b. **Gun Fails to Return to Battery.**

Excessive friction at stuffing boxes.	Notify ordnance maintenance personnel.
Damaged recoil slides, piston rod, or piston.	Notify ordnance maintenance personnel.
Insufficient amount of liquid and gas pressure in recuperator.	Charge the recuperator with liquid and gas pressure, as described in paragraph 37.
Recoil mechanism out of order.	Notify ordnance maintenance personnel.

Cause	Correction
Lack of lubrication, or scoring or "freezing" of sliding surfaces.	Notify ordnance maintenance personnel.

c. Spasmodic Counterrecoil.

Lack of lubrication or scoring of sliding surfaces.	Notify ordnance maintenance personnel.

d. Gun Recoils More Than the Maximum Distance Allowed.

Insufficient amount of liquid and gas pressure in recuperator cylinder.	Charge the recuperator cylinder with liquid and gas pressure, as described in paragraph 37.

e. Gun Slides Out of Battery When Slightly Elevated.

Insufficient amount of liquid and gas pressure in recuperator cylinder.	Charge the recuperator cylinder with liquid and gas pressure, as described in paragraph 37. If trouble repeats, notify ordnance maintenance personnel.

CHAPTER 2

GERMAN 88-MM ANTIAIRCRAFT GUN AND MOUNT (Cont'd)

Section IX

DISASSEMBLY AND ASSEMBLY

54. GENERAL.

a. Wear, breakage, cleaning, and inspection, make necessary the occasional disassembly of various parts of the gun and mount. This work comes under two headings, that which may be performed by the battery personnel with the equipment furnished and that which must be performed by trained ordnance personnel.

b. The battery personnel may, in general, do such dismounting as is required for battery use. Such work should be done in the manner prescribed herein. Any difficulty which cannot be overcome by the prescribed method must be brought to the attention of ordnance personnel.

c. The battery personnel will not attempt to disassemble any part of the recoil mechanism not authorized in this manual, nor do any filing on the sights or gun parts; and only by order of the battery commander on any mount part.

d. The use of wrenches that do not fit snugly on the parts should be avoided. They will not only fail to tighten the part properly but will damage the corners of the nuts and bolt heads. There is also danger of spreading the wrenches and rendering them useless.

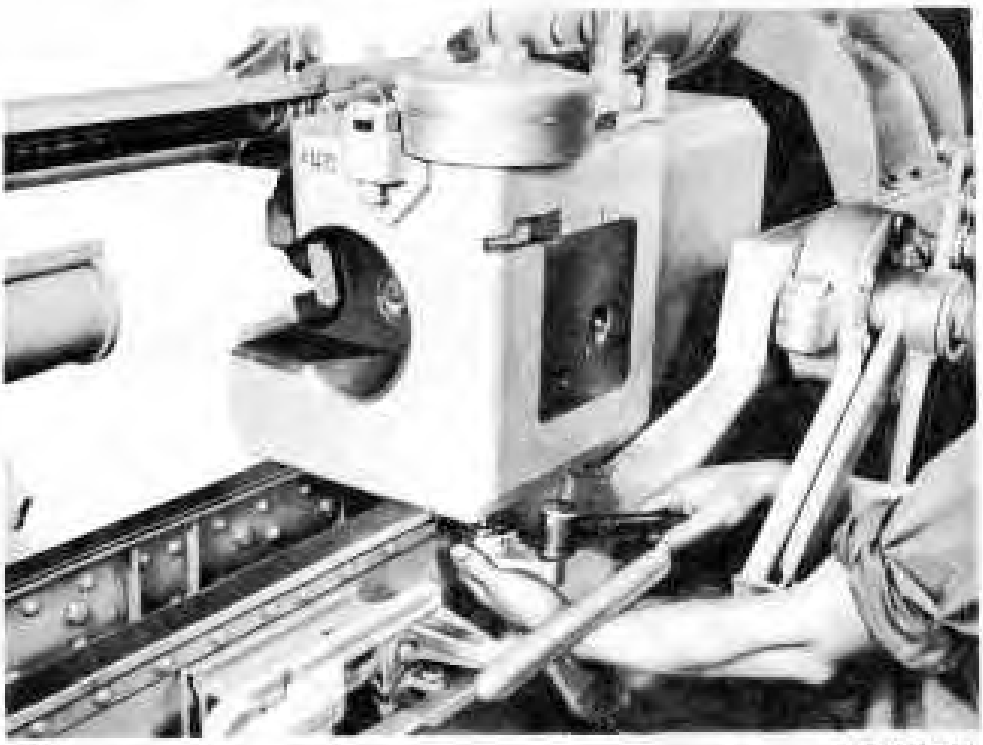
e. Before attempting the assembly of the larger mechanisms, the assembly of the subassemblies should be completed. In all assembly operations, the bearings, sliding surfaces, threads, etc., should be cleaned and lubricated.

55. TO DISASSEMBLE THE BREECH MECHANISM.

a. Set the gun at a 0-degree elevation and close the breech. Remove the locking pin (fig. 13) and remove the breech operating crank (fig. 62).

b. Disengage the "SEMIAUTOMATIC-HAND" ("SEMIAUTOMATIK-HAND") catch from the breech actuating mechanism (fig. 52). Then remove the breech actuating mechanism as a unit (fig. 63).

c. Rotate the extractor actuating lever and remove it from the breech ring (fig. 64).

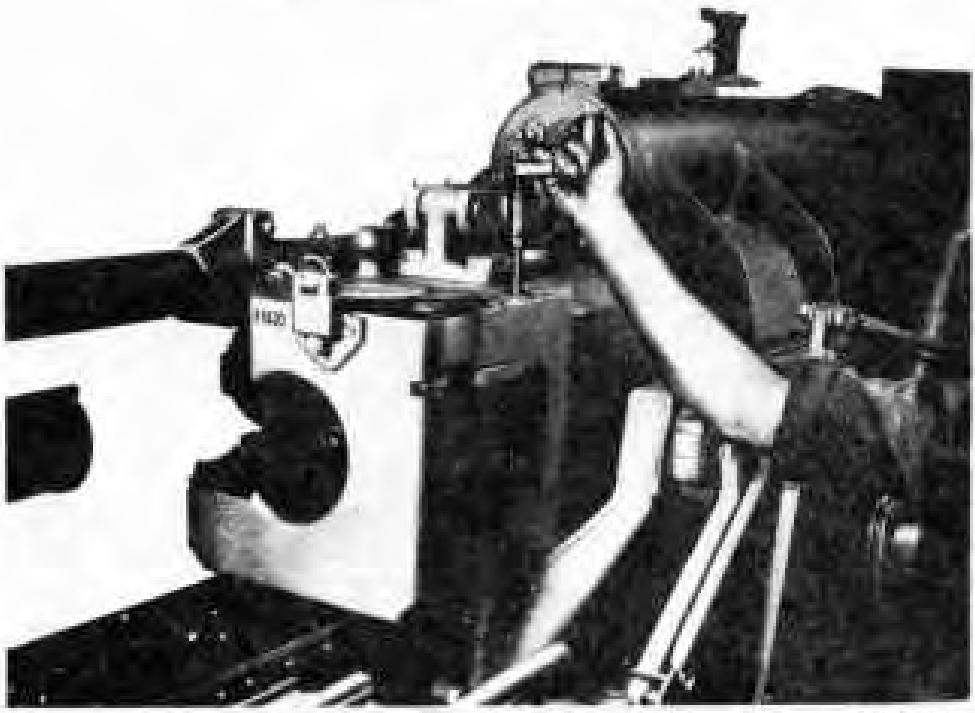


RA PD 71235

Figure 62 — Removing Breech Operating Crank

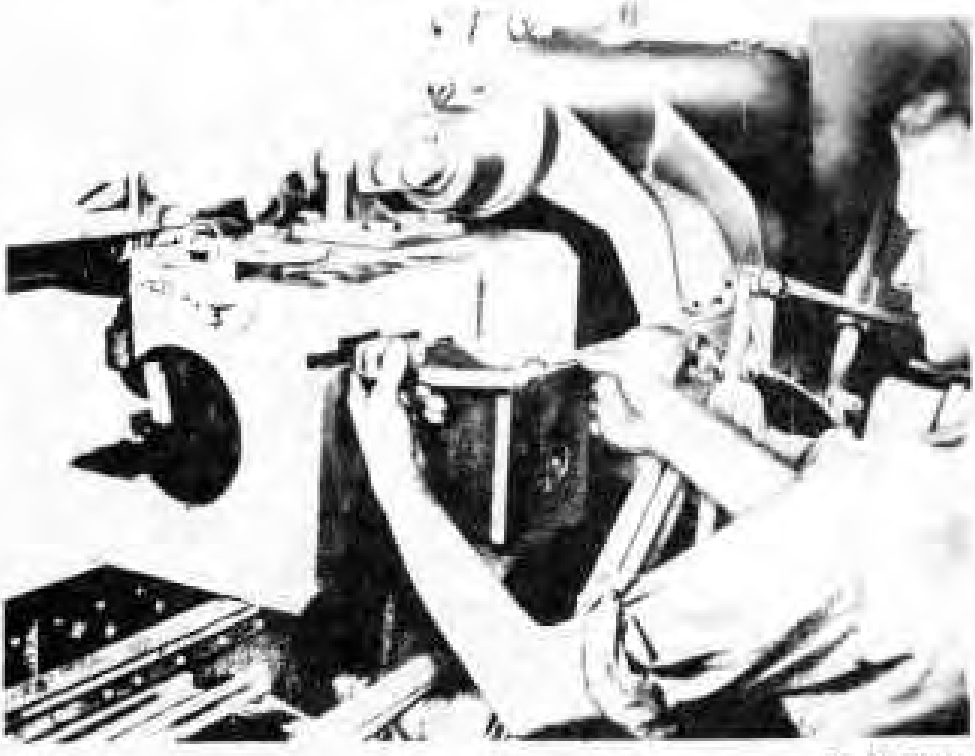
RA PD 71236

Figure 63 — Removing Breech Actuating Mechanism



RA PD 71237

Figure 64 — Removing Extractor Actuating Lever



RA PD 71238

Figure 65 — Removing Breechblock Actuating Lever

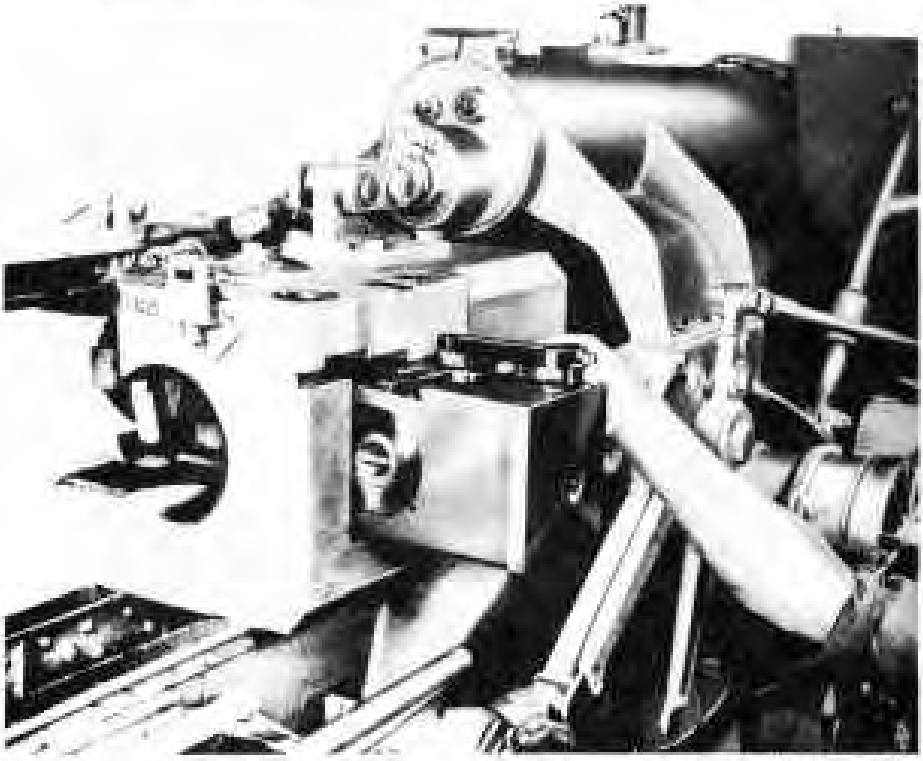


Figure 66 — Removing Extractor RA PD 71239

RA PD 71240

Figure 67 — Removing Cocking Lever

DISASSEMBLY AND ASSEMBLY

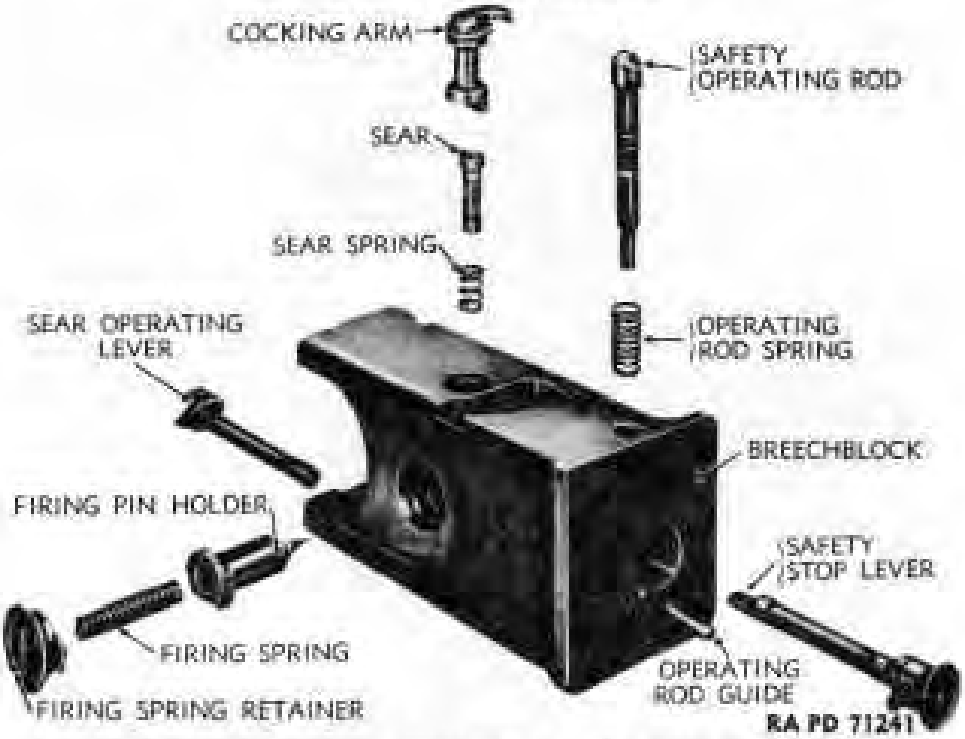


Figure 68 — Breech Mechanism — Exploded View

d. Open the breech sufficiently and remove the breechblock actuating lever (fig. 65).

e. With the breechblock open 2 inches, press the heels of the extractors into the recesses of the breechblock.

f. Open breech sufficiently and remove the extractor (fig. 66).

g. Rotate the cocking lever counterclockwise until the handle is toward the muzzle. The lever may now be lifted out (fig. 67).

h. Remove the breechblock.

i. Fire the percussion mechanism by depressing the operating rod and rotating the sear operating lever (fig. 68).

j. Press in and rotate the firing spring retainer through 90 degrees. Remove the retainer and firing spring (fig. 68).

k. Rotate the cocking arm and remove the firing pin holder to the rear (fig. 68).

l. Lift out the cocking arm.

m. Depress the operating rod and remove the safety stop lever (fig. 68). The operating rod with spring may now be removed (fig. 68).

n. Press the sear down and remove the sear operating lever (fig. 68). The sear and spring may now be removed (fig. 68).

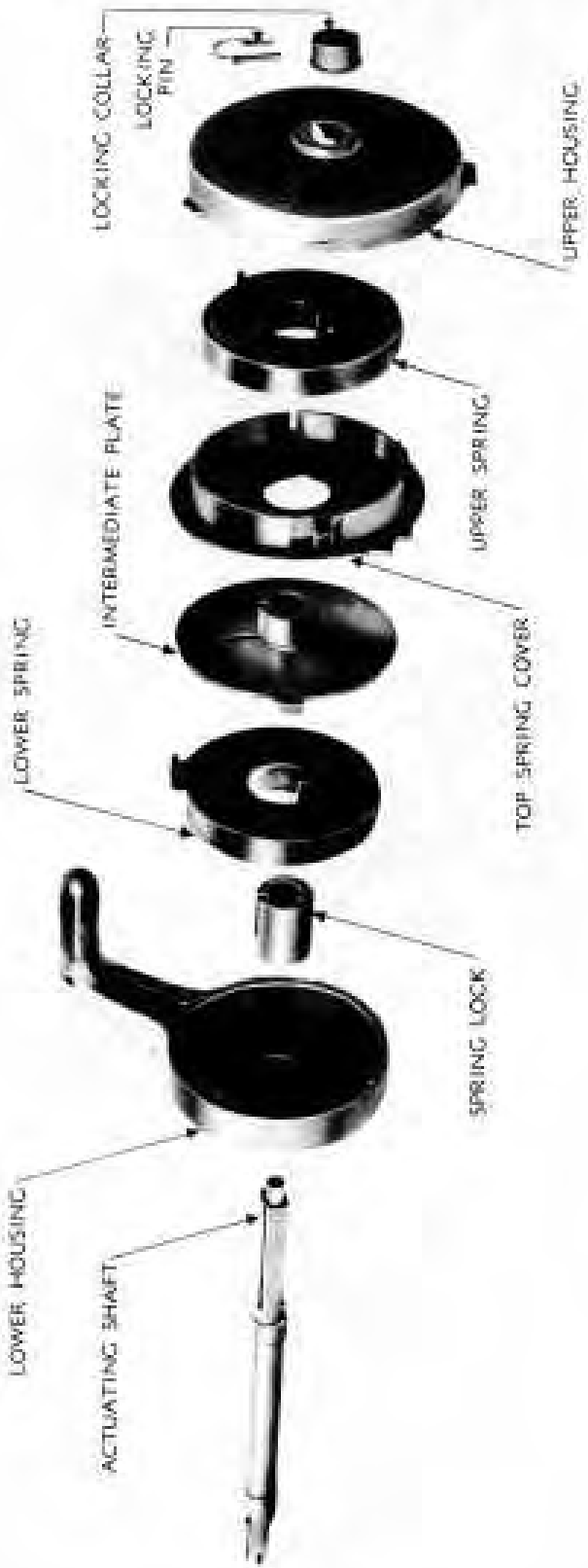


Figure 69 — Breech Actuating Mechanism — Exploded View

DISASSEMBLY AND ASSEMBLY

56. TO ASSEMBLE THE BREECH MECHANISM.

a. To assemble the breech mechanism, perform the steps necessary to disassemble the breech mechanism in the reverse order.

57. TO DISASSEMBLE THE BREECH ACTUATING MECHANISM.

a. With the breechblock removed, replace the breech actuating mechanism as a unit in the breech ring, with the breech mechanism actuating lever and breech operating crank assembled.

b. Engage the "SEMIAUTOMATIC-HAND" ("SEMIAUTOMATIK-HAND") catch to the breech actuating mechanism.

c. Remove the locking pin and locking collar from the actuating shaft (fig. 69).

d. Rotate the breech mechanism actuating lever slightly towards the open position and remove the actuating mechanism upper housing (fig. 69). Allow the lever to rotate beyond the closed position until all spring pressure is lost. Remove the upper spring and top spring cover (fig. 69).

e. With the actuating mechanism in closed position, set the actuating lever and rotate the mechanism beyond the closed position and hold while the intermediate plate (fig. 69) is lifted up and removed; then gently ease the lever beyond the open position until all spring pressure is released. Remove the lower spring and the actuating mechanism lower housing.

f. Remove the spring lock (fig. 69).

58. TO ASSEMBLE THE BREECH ACTUATING MECHANISM.

a. To assemble the breech actuating mechanism, perform the steps necessary to disassemble the breech actuating mechanism in the reverse order.

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

CHAPTER 3

AMMUNITION

59. GENERAL.

a. Ammunition for the German 88-mm antiaircraft gun is similar to U. S. fixed 90-mm rounds (fig. 70). However, the German 88-mm rounds may be identified, as described in paragraph 64, by markings and appearance. The 88-mm multipurpose (8.8 cm. Flak 36), the 8.8 cm. Pak, and the 8.8 cm. Flak 18 guns are chambered alike and may use the same ammunition.

60. FIRING TABLES.

a. These are not available, except for the range table for firing the armor-piercing projectile in paragraph 64.

61. CLASSIFICATION.

a. The German 88-mm gun ammunition is classified according to type of projectile (Granate, Gr.) as high-explosive or armor-piercing. The high-explosive shell (Sprenggranate, Sprgr.) contains a relatively large charge of high explosive and any one of the following types of point fuzes:

(1) Combination superquick and delay fuze.

(2) Inertia-operated mechanical time fuze.

(3) Spring-wound mechanical time fuze.

NOTE: The armor-piercing projectile (Panzergranate, Pzgr.) is provided with an armor-piercing cap, to aid in penetration of armor plate, and a windshield, to improve the ballistic properties. It contains a relatively small explosive charge and a base-detonating fuze, having a tracer element in its base.

AMMUNITION

62. AUTHORIZED ROUNDS.

a. The following rounds may be found for use in the German 88-mm guns.

TABLE 1. GERMAN 88-MM ROUNDS

Nomenclature of Complete Round*	Action of Fuze	Weight of Projectile as Fired (Pounds)	Muzzle Velocity (Feet per Second)
8.8 cm. Spgr. Patr. L/4.5 (kz.) m. Zt. Z. S/30 (8.8 cm. fixed H.E. shell, with spring-wound mechanical time fuze)	Time (30 sec.)	20.06	2,690
8.8 cm. Spgr. Patr. L/4.5 (kz.) m. Zt. Z. S/30 Fg' (8.8 cm. fixed H.E. shell, with inertia-operated mechanical time fuze)	Time (30 sec.)	20.06	2,690
8.8 cm. Spgr. Patr. L/4.5 (kz.) m. A.Z. 23/28 (8.8 cm. fixed H.E. shell, with percussion fuze)	Superquick or delay (0.11 sec.)	20.34	2,690
8.8 cm. Pzgr. Patr. m. Bd. Z. (8.8 cm. fixed A.P.C. shell, with base-detonating fuze)	Nondelay	20.71	2,657

63. PREPARATION FOR FIRING.

a. Complete rounds, when they have been removed from their packing containers (par. 66), and their fuzes properly adjusted, are ready for firing.

b. Should it be necessary to fuze or unfuze projectiles, authorized personnel only will do this work. A spanner wrench labeled "A.Z. 23 and Zt. Z. S/30" should be used if available. The fuze setter for "A.Z. 23 and Zt. Z. S/30" may also be used to screw and unscrew fuzes.

c. Fuzes are adjusted for the desired action as described in paragraph 65.

64. DESCRIPTION OF ROUNDS.

a. **General.** The components of a complete round of German 88-mm ammunition are shown in figure 71. A comparison of the 88-mm armor-piercing and high-explosive complete rounds with a U.S. 90-mm high-explosive round is illustrated in figure 70. The double rotating band on the German 88-mm projectiles immediately distinguishes these from the U.S. round, as does the double 360-degree crimps of the cartridge case to the projectile. Markings and labels on

*For an explanation of German abbreviations, see paragraph 72.

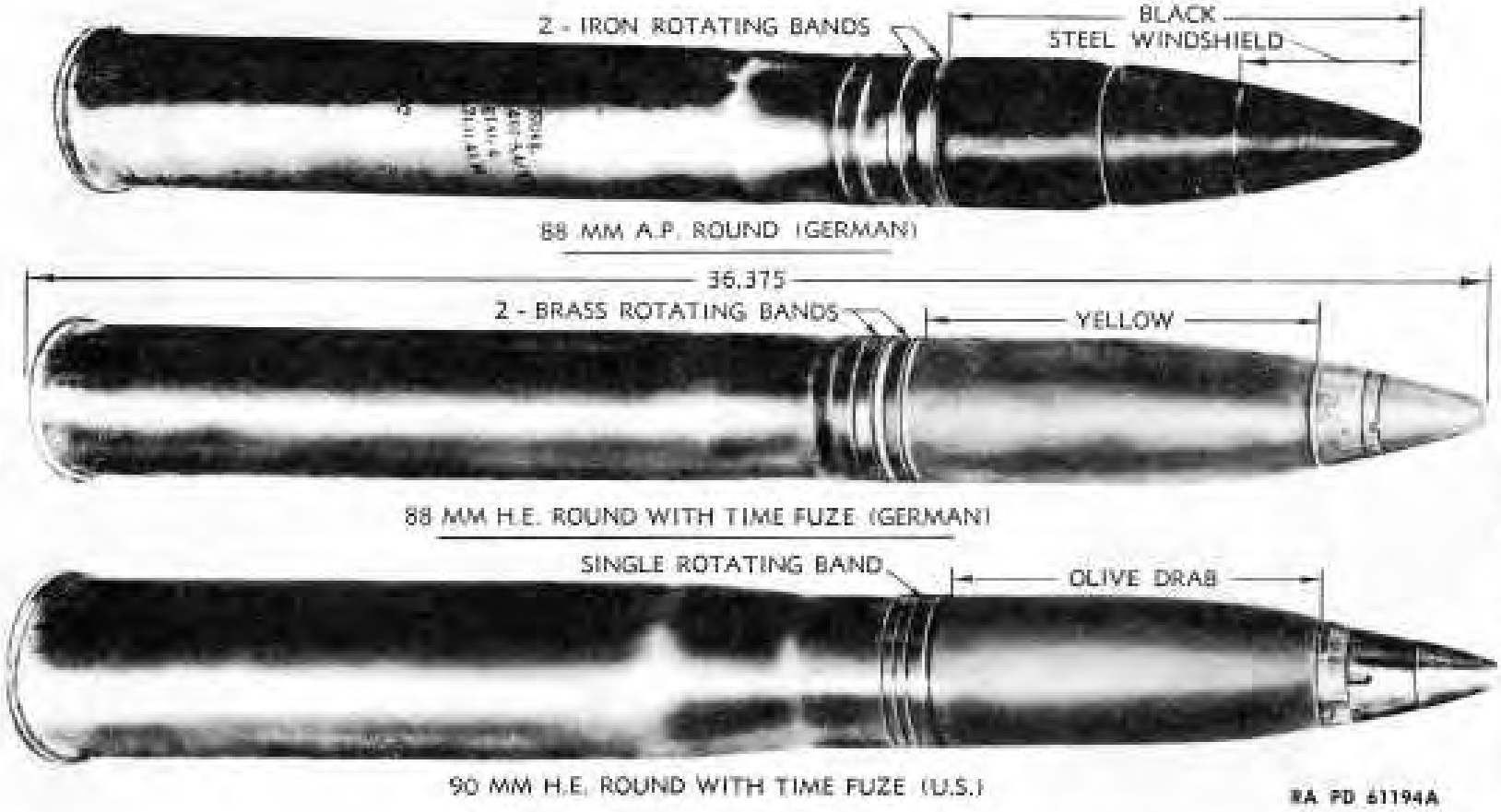


Figure 70 — Comparison of German 88-mm Armor-piercing Round, German 88-mm High-explosive Round, and U.S. 90-mm High-explosive Round with Time Fuze

shipping containers and crates (par. 66, figs. 77 and 78) serve as a means of identification. Further identification may be made by means of markings on the ammunition as described in subparagraph h, below, and is illustrated in figures 72 and 73.

h. **Identification.**

(1) GENERAL. The following identification markings may be found on projectiles. These markings may vary, dependent upon the particular lots found in the field. German abbreviations and terminology, and their English equivalents are given in paragraph 72.

(2) ON THE PROJECTILE. Armor-piercing projectiles are painted black above the rotating bands; high-explosive projectiles are painted yellow. In addition, the following markings may be present:

(a) Weight-zone Marking (Gewichtsklasse). The weight-zone marking is a roman numeral in black. The numeral "III" generally indicates "standard" weight; no weight corrections in the firing tables are necessary in firing shells which are in weight-zone III.

(b) Shell Number. In the case of 88-mm shell, the number 28.

(c) Date of assembly and manufacturer's initials or symbol.

(d) A number indicating type of high-explosive filler, for example: "1" indicates TNT; "2" indicates picric acid. Other number designations will be found in paragraph 72.

(e) Abbreviations denoting type of shell, for example:

1. Tp (Tropen), for the tropics.
2. Ub (Ubung), practice.
3. Nb (Nebel), smoke.

(3) ON THE SIDE OF THE CARTRIDGE CASE. Markings on the side wall of the cartridge case are shown in figure 72. Their English equivalents are given in Table II.

(4) ON THE BASE OF THE CARTRIDGE CASE. The principle marking for identification on the base of the cartridge case is the number "6347," which appears on all the cartridge cases of the German 88-mm complete rounds. For other markings, see figure 73. It will be noted that the primer design marking is "C/12nA St." The caliber and model of the gun may also appear on the base, for example, "8.8 cm. Flak. 18."

TABLE II. MARKINGS ON SIDE OF CARTRIDGE CASE

German Marking	English Equivalent
2.700 kg.	2,700 kilograms
Digl. R.P.—8 (495-5. 4 2.75)	Diglycol powder, number (grain size)
tgl. 41 P	Manufacturer, date, delivery number
Lu. 14. 5.41 K.	Manufacturer, date, work mark
P.T. plus 25 C (in red)	Powder temperature (pulvertemperatur), plus 25 C

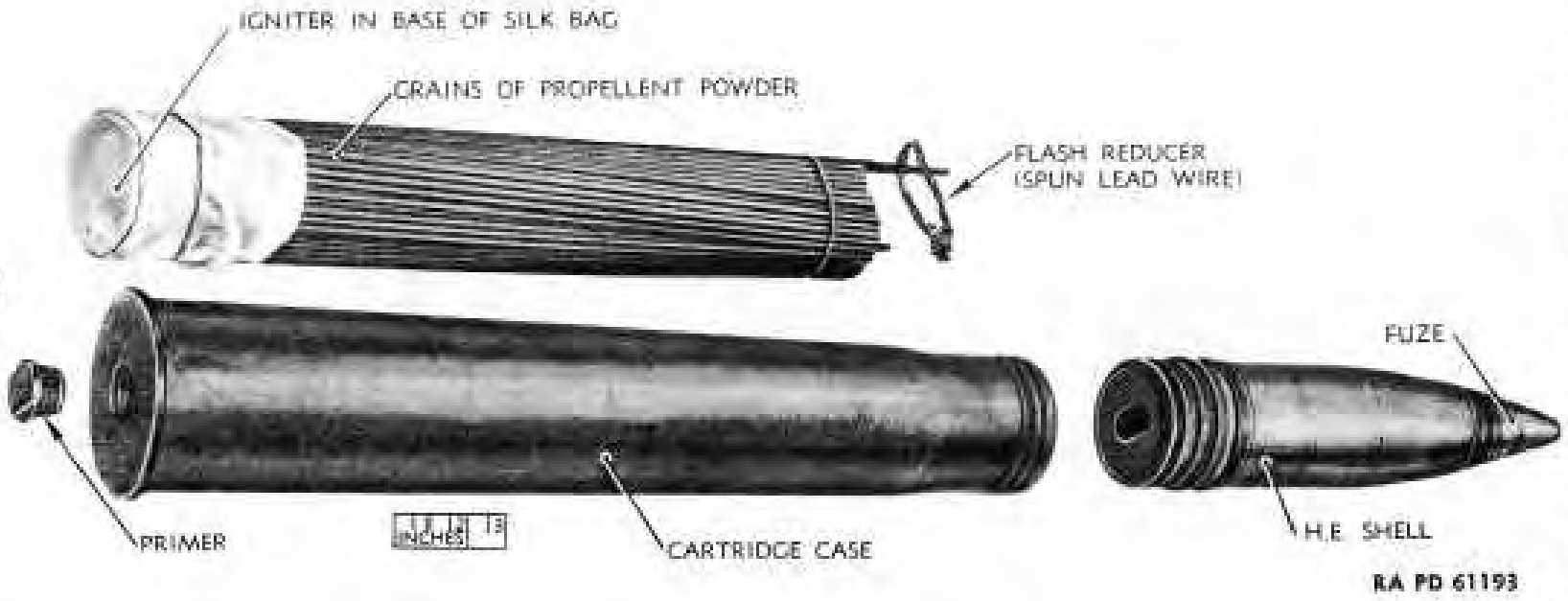


Figure 71 — Components of German 88-mm High-explosive Complete Round

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c. 8.8 cm. Sprgr. Patr. L/4.5 (kz.) m. Zt. Z. S/30 (8.8 cm. High-explosive Fixed Shell, with Spring-wound Mechanical Time Fuze).

(1) COMPLETE ROUND. This complete round, illustrated in figure 70, consists of cartridge case No. 6347, containing the primer and propelling charge, crimped to a high-explosive projectile which is fuzed with a 30-second spring-wound mechanical time fuze. It is identified as indicated in subparagraph b, above. The complete round weighs 31.69 pounds and is 36.69 inches in length. The maximum horizontal range is 16,200 yards, the vertical range being 32,500 feet. Muzzle velocity and weight of projectile are given in Table I. Packing of this round is described in paragraph 66.

(2) PROJECTILE. The two rotating bands on the projectile are fashioned from powdered iron impregnated with wax. The German high-explosive projectiles differ from those of U.S. manufacture, in that a base plug is screwed into the base. A lead gasket seals the base assembly against possible penetration of the hot gases of the exploded propellant. The German projectile has a square base and is 15.55 inches in length. The bursting charge consists of 2.19 pounds of TNT or 40/60 amatol.

(3) PREPARATION FOR FIRING. This round is ready for firing when removed from its packing, except that the mechanical time fuze must be set as described in paragraph 65.

d. 8.8 cm. Sprgr. Patr. L/4.5 (kz.) m. Zt. Z. S/30 Fg[1] (8.8 cm. Fixed High-explosive Shell with Inertia-operated Mechanical Time Fuze). This complete round is the same as the fixed high-explosive round described in subparagraph c, above, except for the time fuze, which functions by different means. However, the timing of the fuze for this round is also 30 seconds. See paragraph 65 for description of fuzes.

e. 8.8 cm. Sprgr. Patr. L/4.5 (kz.) m. A.Z. 23/28 (8.8 cm. Fixed High-explosive Shell, with Percussion Fuze). This complete round is the same as the fixed high-explosive round described in subparagraph c, above, except for the fuze, which is a combination super-quick and delay (0.11 second) fuze similar in action and setting to the U.S. FUZE, P.D., M48, or FUZE, P.D., M51. See paragraph 65 for description of fuzes. This complete round weighs 32 pounds, the weight of the projectile being 20.34 pounds.

f. 8.8 cm. Pzgr. m. Bd. Z. (8.8 cm. Fixed Armor-piercing Capped Shell, with Base-detonating Fuze).

(1) COMPLETE ROUND. This complete round, illustrated in figure 70, consists of cartridge case No. 6347, containing the primer and propelling charge, crimped to an armor-piercing projectile which contains a high-explosive filler, base-detonating fuze, and a tracer. It is identified as indicated in subparagraph b, above. The complete round weighs

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Figure 72 — German 88-mm Cartridge Case, Showing Stenciled Markings

Figure 73 — German 88-mm Cartridge Cases — Base End Views

32.74 pounds and is 34.21 inches in length. Muzzle velocity and weight of projectile are given in Table I. Packing of this round is described in paragraph 66.

(2) PROJECTILE. The two rotating bands are bimetallic, being composed of copper electroplated on an iron band. Another type of rotating band may be of ductile iron. The projectile contains a bursting charge of TNT which is approximately 1.8 percent of the total weight of projectile. Weight of the tracer composition is 13 grams. The windshield is attached to the armor-piercing cap by spot welding at 12 places. The projectile has a square base and is 14.49 inches in length. The fuze is described in paragraph 65.

(3) PENETRATION AGAINST HOMOGENEOUS ARMOR PLATE.

TABLE III. PENETRATION DATA OF A.P.C. PROJECTILE AGAINST HOMOGENEOUS PLATE

Range in Yards	Thickness of Plate in Inches	
	Normal Impact	Impact at 30 Degrees
500	5.07	4.33
1,000	4.68	3.97
1,500	4.33	3.62
2,000	3.93	3.30

(a) In addition to Table III above, the armor-piercing ammunition is effective against smaller concrete emplacements, particularly if they have exposed perpendicular walls. Eight well-grouped armor-piercing shells at 800-meter (8.75-yd) range is sufficient to penetrate 2 meters (2.2 yds) of reinforced concrete.

(4) PREPARATION FOR FIRING. This round is ready for firing when removed from its packing.

65. FUZES.

a. **General.** The point fuzes used with the German 88-mm high-explosive shells consist of the following:

Zt. Z. S 30 Time fuze (30-second) with spring-wound action
Zt. Z. S/30 Fg[1] Time fuze (30-second) with inertia-operated action
A.Z. 23/28 Percussion fuze, superquick or delay (0.11 second) action

(1) These fuzes, and their markings, are shown in figures 74 and 75. With the armor-piercing capped shell, a base-detonating (Bodenzunder, Bd. Z.) fuze is used. It appears that none of these fuzes are boresafe. The diameter over the threads of the point fuzes is 1.96 inch, and the pitch of the threads is 3-mm or 0.12 inch.

CAUTION: Fuzes will not be disassembled. Any attempt to disassemble fuzes in the field is dangerous, and is prohibited except under specific directions from the Chief of Ordnance.

Figure 74 — Spring-wound Time, Percussion, and Inertia-operated Time Fuzes for German 88-mm High-explosive Shell — View Showing Setter Grooves and Selector Element

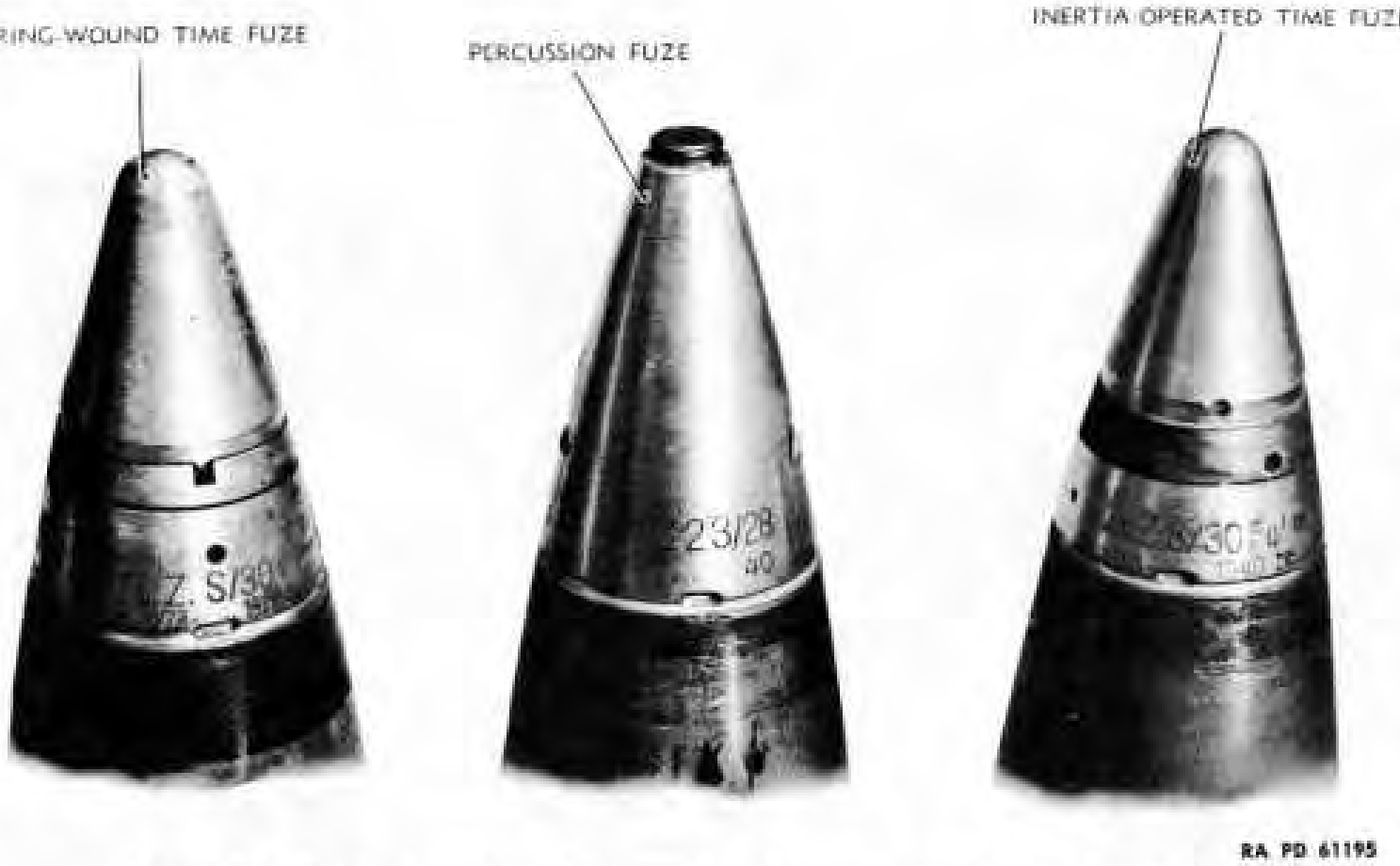

Figure 75 — Spring-wound Time, Percussion, and Inertia-operated Time Fuzes for German 88-mm High-explosive Shell — View Showing Fuze Markings

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b. German Fuzes, Zt. Z. S/30 and Zt. Z. S/30 Fg[1].

(1) DESCRIPTION. These fuzes, shown in figures 74 and 75, are 30-second time fuzes. These do not have impact elements. It will be noted that there are no graduations on the time ring. For use, the fuze must be set by means of the fuze setter provided. The zero setting of the fuze is "recess over recess;" on the fuze setter, the indicator (arrow) is at zero. The fuze setter is set at the fuze setting found in the firing table and the fuze is then set as described in chapter 4, section III. A time-safety feature in the fuze prevents time action below 2 seconds of flight. The Zt. Z. S/30 has a spring-wound mechanical time mechanism, whereas the Zt. Z. S/30 Fg[1] has an inertia-operated mechanical time mechanism similar to U. S. FUZE, time, mechanical, M43.

(2) PREPARATION FOR FIRING. The fuzes are prepared for firing as described in subparagraph b (1), above. Fuzes which have been set on rounds prepared for firing but not fired, must be reset at zero. This resetting is accomplished in the same manner as in setting, but with the fuze setter indicator at zero.

c. German Fuze, A.Z. 23/28.

(1) DESCRIPTION. This fuze, shown in figures 74 and 75, is similar to the A.Z. 23 used with the German 105-mm howitzer high-explosive shell. The number "28" apparently identifies this fuze for use with German 88-mm shell. The fuze contains two actions, superquick (ohne versögerung, O.V.) and delay (mit versögerung, M.V.). Although both actions are initiated on impact, the functioning of the shell depends upon the setting of the selector of the fuze. Unlike the U.S. FUZE, P.D., M48, it should be noted that there is only one firing pin; should this fail, the projectile will become a dud. However, it appears that the firing assembly is more sensitive to impact than the U.S. FUZE, P.D., M48. Also, unlike the Fuze M48, the German fuze, is not a boresafe fuze. As shipped, the fuze is set for superquick action; that is, the slot on the setting sleeve of the selector is parallel to the axis of the fuze and is thus alined with the registration line marked "O." To set the fuze for delay action, the slotted setting sleeve is turned 90 degrees so that the slot is alined with the line marked "M" on one side of the setting sleeve and with "V" on the other side. The delay action is provided by a delay pellet of 0.11 second delay. The setting may be changed at will with a screwdriver or with "SETTING KEY A.Z. 23" (Stellschlüssel Für A.Z. 23) at any time before firing. This can be done even in the dark by noting the position of the slot. The slot is parallel to the fuze axis for superquick ("O") action, or at right angles thereto for delay action ("M" and "V"). Figure 77 illustrates the internal parts of the fuze.

(2) PREPARATION FOR FIRING. As shipped, the fuze is ready for firing with superquick action. To set the fuze for delay action, the setting sleeve is turned with the setting key or screwdriver, as de-

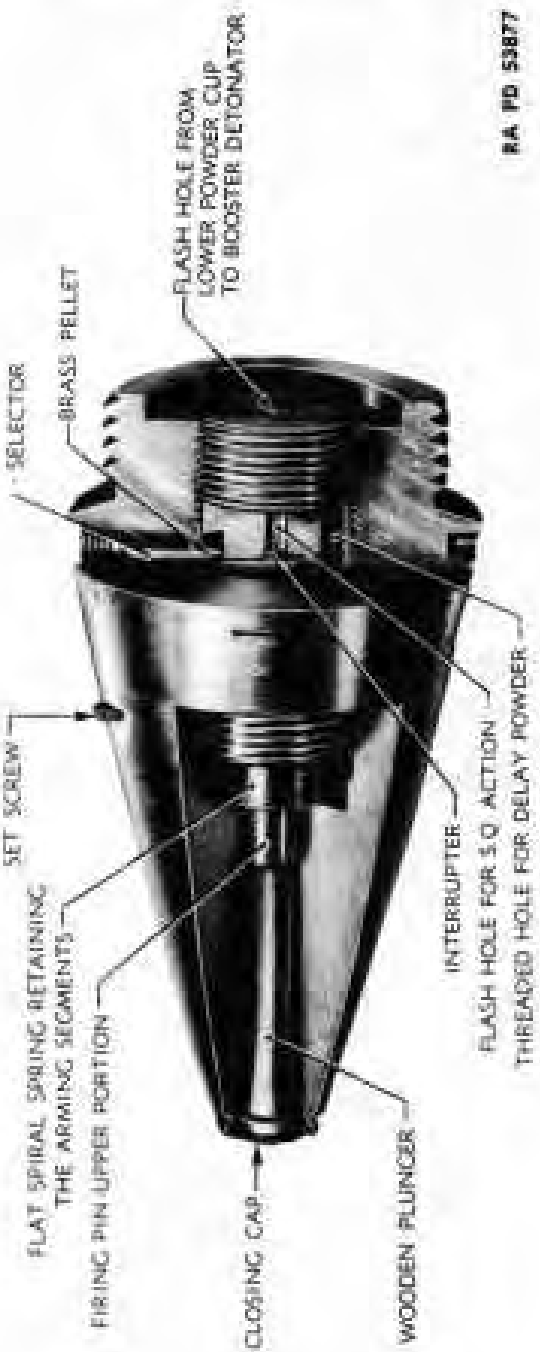


Figure 76 — German A.Z. 23 Fuze — Sectional View

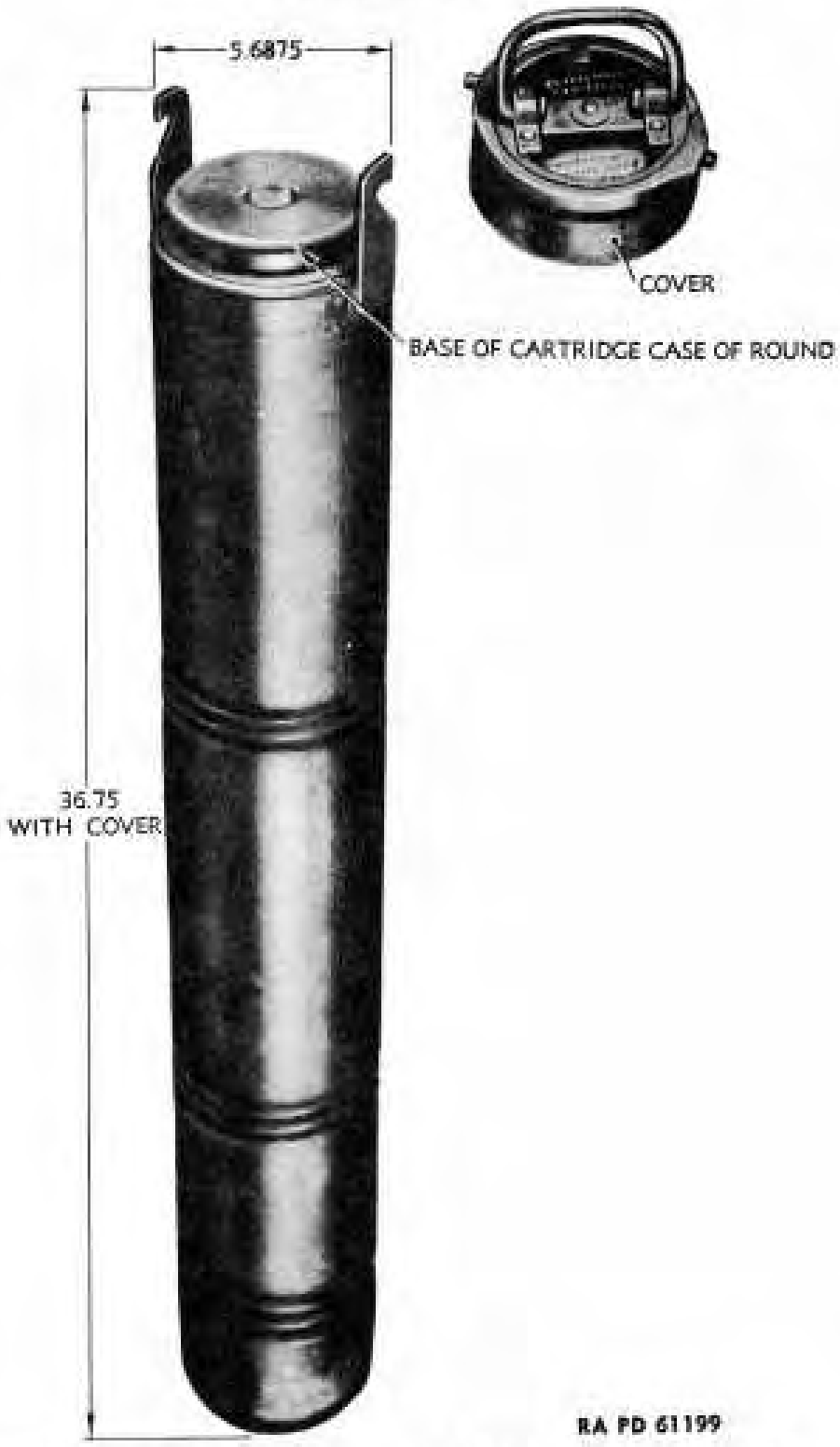


Figure 77 — 1-Round Metal Container for German 88-mm Round

scribed in step (1), above, through 90 degrees so that the slot on the setting sleeve is alined with the letters "M" and "V." Fuzes which have not been fired should be reset to superquick or "O.V." The slot will then be in line with "O."

d. German Base-detonating Fuze, Bd. Z. This fuze which is assembled in the base of the armor-piercing capped projectile, is a nondelay type. The fuze mechanism is standard for use with other caliber armor-piercing projectiles, such as in the German 7.5 cm., 8.8 cm., and 10.5 cm. rounds. However, the body of the fuze differs depending upon the caliber. The complete fuze weighs 2.18 pounds. The tracer assembly is threaded into the base of the fuze body and the detonator assembly is threaded into the forward portion. The safety feature consists of five brass safety blocks, which are held in the unarmed position by a flat, circular spring, and which engage the shoulder of the primer housing to restrain it against forward movement. Upon rotation of the projectile, centrifugal force causes the safety blocks to move outward against the flat spring, thereby arming the fuze. Upon impact, the primer moves forward, impinging the primer against the firing pin. The resulting primer flame passes into a retaining jet which directs the gases into the detonator initiating the charge. It is believed that a *short delay* is obtained through the plunger action of the primer assembly and also by retardation of the gases by the jet, which prevents the gases from functioning the detonator until considerable pressure has been developed.

66. PACKING.

a. General. German 88-mm rounds are packed in individual sealed steel containers (fig. 77) particularly for use in the tropics or three per wicker basket (fig. 78).

b. Steel Containers. The steel container (fig. 77) is hermetically sealed by a rubber gasket under a removable steel cover. As shipped with one complete round, it weighs approximately 47 pounds and its calculated volume is approximately 2.2 cubic feet. It is painted a slate gray color. Two tags are pasted on the cover.

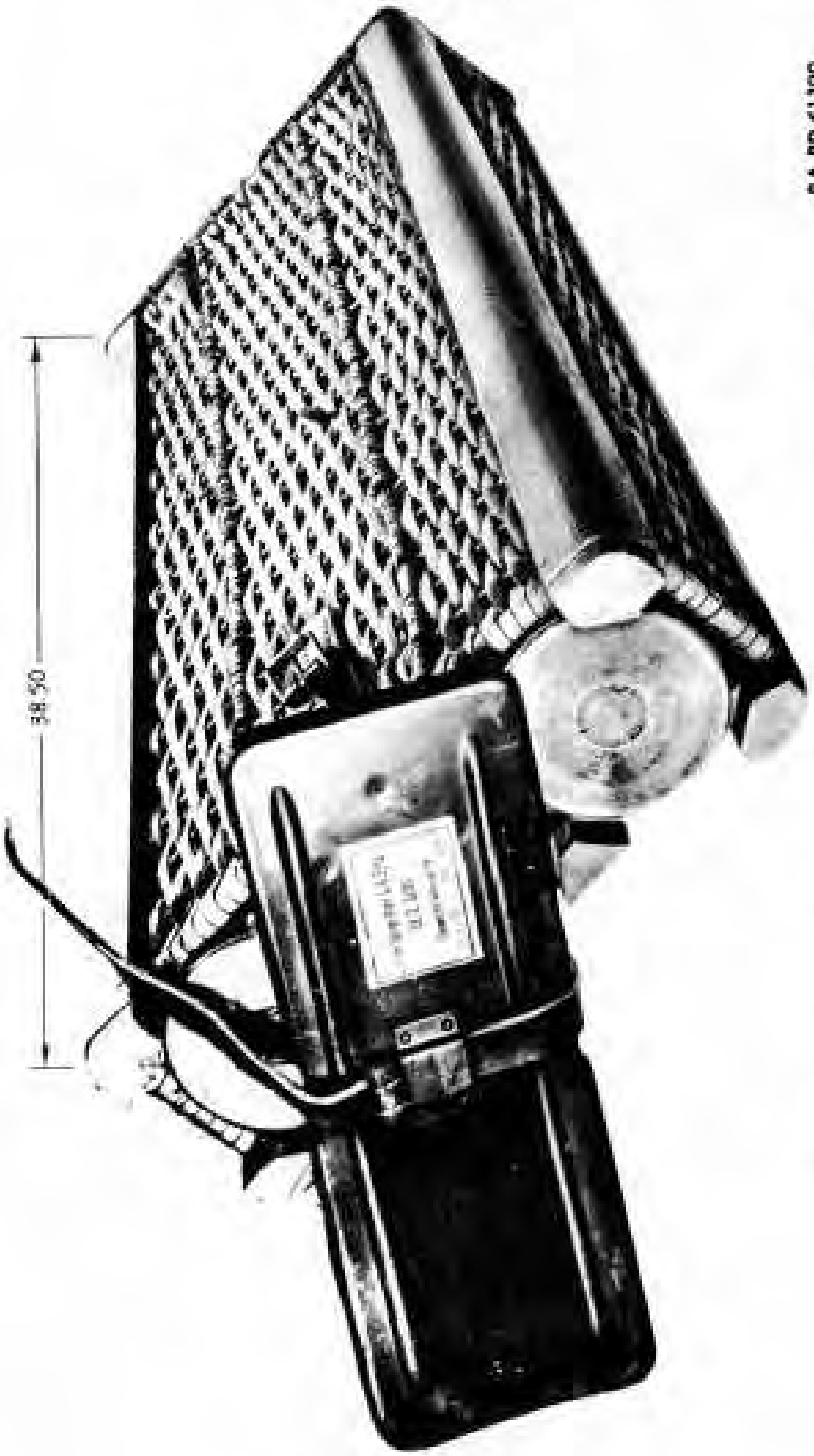
(1) One tag, of black paper is printed with white ink as follows:

"8.8 cm. Pzgr. Patr.
Bd. Z. f. 8.8 cm. Pzgr."

(2) The other tag of white paper is printed in red as follows:

"Fur Tropen!
Normale Pulvertemperatur
+25° C."

(a) The cover is constructed of several parts arranged so that when the cover is placed in position against the two hooks, and its handle is turned in a clockwise direction, pressure is applied to a rubber gasket between the cover and container body to effect a seal.



RA PD 61200

Figure 78 — 3-Round Wicker-type Container for German 88-mm Rounds

A hair felt disk is used as a cushion between the head of the cartridge case and the cover.

c. **Wicker-type Container.** The wicker-type container (fig. 78) contains three rounds. A metal cover is held in place by a leather strap. The base is also of metal. Round rubber stops at the bottom of the container protect the fuzes against jarring. The rest of the container is of wood and wicker construction. The dimensions of the container are 38½ by 14¾ by 5½ inches.

67. INTERCHANGEABILITY OF AMMUNITION ITEMS.

a. The British No. 18 primer for 40-mm ammunition is interchangeable with the German primer, C/12nA. In addition, other calibers of German ammunition, such as German 105-mm howitzer ammunition, have the German C/12nA primer as a component of the cartridge case.

68. TROPICAL AMMUNITION.

a. Ammunition for use in the tropics is marked in red lettering, as follows: "P.T. +25 C." This marking appears on the side of cartridge cases. Shell for use in the tropics may be marked "Tp."

b. Containers for tropical ammunition have the following marked in red on white labels:

"Fur Tropen
Normale Pulvertemperatur
+25° C."

c. Tropical ammunition has reduced weight of propellant and gives normal range table performance at +25 C (77 F). Where tropical ammunition has not been issued or manufactured, special range tables are provided for use in the tropics with standard ammunition. The temperature taken as normal for standard ammunition is 10 C (50 F).

69. PRECAUTIONS IN HANDLING CAPTURED AMMUNITION.

a. *All* captured ammunition should be examined by qualified personnel as soon as practicable. Loose ammunition may be dangerous and is rarely worth the trouble of collection.

b. Ammunition may be dangerous because of:

(1) Deliberate "booby traps" laid by the enemy.

(2) Having been subject to fire or shelling.

(3) Removal of safety devices from fuzes, etc. (either deliberate or accidental).

(4) Exposure rendering explosive elements unreliable.

c. Ammunition known or suspected of being dangerous will not be moved or touched, but destroyed in accordance with directions in TM 9-1900.

d. Destroyed ammunition should be salvaged for brass parts. In addition, all enemy airtight containers should be returned to the base. This also applies to timber and to wooden boxes suitable for use as dunnage or for remaking ammunition boxes.

e. Ammunition should be recovered by complete rounds; for example, unfuzed shell are useless without the appropriate fuzes.

f. Personnel handling captured ammunition should keep in mind the fact that although two types of ammunition appear to have identical measurements, they are not necessarily interchangeable. Experiments to ascertain interchangeability are forbidden except by special authority.

g. No unauthorized modifications or experimentation will be carried out on any ammunition.

70. CARE, HANDLING, AND PRESERVATION.

a. In addition to the precautions and care in handling U.S. ammunition as given in TM 9-1900, the following apply particularly to German 88-mm ammunition.

(1) The fuze A.Z. 23/28 is particularly sensitive; hence, it is important that the path of flight before the muzzle be free of all obstructions, including small branches and leaves. Otherwise, premature burst may occur.

(2) Components of ammunition prepared for firing but not fired will be returned to their original condition and packing.

(3) Projectiles with impact fuzes (A.Z. fuzes) whose top or forward closing disk has been so damaged that the firing pin is pressed down or has fallen out, will not be fired. They are, however, safe to transport.

(4) Projectiles with time fuzes (Zt. Z. fuzes) may not be fired when the rotatable closing cap of the fuze is bent, dented, or damaged, or cannot be turned by the fuze setter. However, they are safe to transport.

(5) Rounds which have fallen and have not been damaged may be fired.

(6) After each round is fired, it is necessary to examine the bore of the weapon to determine whether any foreign matter remains in the bore. All particles or obstructions should be removed to prevent jamming of the weapon upon firing the next round.

(7) The primer must be hit dead center or it may not function.

71. FIELD REPORT OF ACCIDENTS.

a. When an accident involving the use of ammunition occurs during training practice, the procedure prescribed in section VII, AR 750-10, will be observed by the ordnance officer under whose supervision the ammunition is maintained or issued. Where practicable, reports covering malfunctions of ammunition in combat will be

made to the Chief of Ordnance, giving the type of malfunction, type of ammunition, the lot number of the complete rounds or separate-loading components, and condition under which fired.

72. GERMAN ABBREVIATIONS AND TERMINOLOGY OF AMMUNITION ITEMS.

a. General. The following abbreviations, symbols, and terms may be found on labels or in communications and literature pertaining to the ammunition items described herein. Certain general terms are also included.

b. Abbreviations.

TABLE V. GERMAN AMMUNITION ABBREVIATIONS

A.Z.	Aufschlagzünder	percussion fuze
A.Z. m. V.	Aufschlagzünder mit versögerung	percussion fuze with delay action
Bd. Z.	Bodenzünder	base percussion fuze
Bl.	Blindgänger	dud
Bl. P.	Blättchenpulver	flaked gunpowder
Bz.	Brennzünder	time fuze (powder train type)
Digl. / Dgl.	Diglycol	diglycol
Dopp. Z. / D.Z.	Doppelzünder	combination fuze
Ex. Mun.	Exerziermunition	dummy ammunition; blank ammunition
f	Für	for
Flak	Flugabwehrkanone	antiaircraft gun
Flb.	Flugbahn	trajectory
Fp.	Füllpulver	high explosive
Gesch	Geschoss	projectile; shell
G. Gr.	Gasgranate	gas shell
Gr.	Granate	shell
Grf.	Granatfüllung	bursting charge of shell
Gr. m. p.	Granate mit Panzerkopf	armor-piercing shell
Gr. Z. / G.Z.	Granatzünder	shell fuze
H	Hexagen	cyclonite, R.D.X.
Kl.	Klein	small
Kp	Krupp	Krupp
Kz.	Kopfzünder	point-detonating fuze

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TABLE V. GERMAN AMMUNITION ABBREVIATIONS (Cont'd)

Ldg. / L.	Ladung	charge; propelling charge; load
Leggr.	Langgranate	long shell
Lv.	Ladungsverhältnis	ratio of charge to weight of projectile
m.	mit	with
Mun.	Munition	ammunition
m.v.	mit versögerung	with delay (fuzes)
Nb.	Nebel	smoke
Nbgr.	Nebelgranate	smoke shell
Ngl. / Nigl.	Nitroglyzerin	nitroglycerin
Np.	Nitropenta	P.E.T.N.; penthrite
Nr.	Nummer	number
o.	ohne	without
o.v.	ohne versögerung	without delay (superquick)
Pak.	Panzerabwehrkanone	antitank gun
P. K.	Pulverkasten	ammunition box
P. S. Gr.	Panzerstahlgranate	steel armor-piercing shell
P. T.	Pulvertemperatur	ammunition temperature
Pzgr. / Pz. Gr.	Panzergranate	armor-piercing shell
Pz. Spr. Gr.	Panzersprenggranate	high-explosive armor-piercing shell
Sch. Tf.	Schusstafel	firing table
Sch. Z. Schr.	Schlagzündschraube	threaded base percussion fuze
Sonderkart	Sonderkartusche	special charge
Sprgr. / Spr. Gr.	Sprenggranate	high-explosive shell
St.	Stahl	steel
Tp.	Tropen	Tropics
Ub.	Ubung	practice
Ubgr. / Ub. Gr.	Ubungsgranate	practice shell
v.	versögerung	delay (fuzes)
Z.	Zünder	fuze
Zdschr.	Zündschraube	threaded percussion primer
Zt. Z. / ZZ.	Zeitzünder	time fuze

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c. Glossary.

TABLE VI. GERMAN AMMUNITION TERMS

Aufschlagzünder (A.Z.)	percussion fuze
Aufschlagzünder mit versögerung	percussion fuze with delay action
Blättchenpulver (Bl.P.)	flaked gunpowder
Bleidraht	lead wire
Blindgänger (Bl.)	dud
Bodenzünder (Bd. Z.)	base percussion fuze
Brennzünder (Bz.)	time fuze (powder train type)
Brisanz	high-explosive
Brisanzgeschoss	high-explosive shell
Brisanzmunition	high-explosive ammunition
Diglycol (Digl.; Dgl.)	diglycol
Doppelzünder (Dopp. Z.; D.Z.)	combination fuze
Exerziermunition (Ex. Mun.)	dummy ammunition; blank ammunition
Flugabwehrkanone (Flak)	antiaircraft gun
Flugbahn (Flb.)	trajectory
Füllpulver (Fp)	high explosive
Für (f)	for
Gasgranate (G. G.)	gas shell
Geschoss (Gesch.)	projectile; shell
Gewichtsklasse	weight class shell
Granate (Gr.)	shell
Granate mit Panzerkopf (Gr. m. P.)	armor-piercing shell
Granatfüllung (Grf.)	bursting charge of shell
Granatzünder (Gr. Z.; G. Z.)	shell fuze
Haube	ballistic cap
Hauptladung	propellant (lit; main charge)
Hexagen (H.)	cyclonite, R.D.X.
Holzkasten	wooden box
Hülse	cartridge case
Hülsenbezeichnung	cartridge case designation (number)
Kartusche	cartridge case
Kartuschhülse	cartridge case
Kartuschkorb	ammunition basket
Kartuschvorlage	cartridge case wad; flash reducer
Kennbuchstabe	identification mark
Klein (Kl.)	small
Kopfzünder (Kz.)	point-detonating fuze
Ladung (Ldg.; L.)	charge; propelling charge; load
Ladungsverhältnis (Lv.)	ratio of charge to weight of projectile
Langgranate (lggr.)	long shell
Lieferungsnummer	delivery number
mit (m.)	with
mit versögerung (m.v.)	with delay (fuzes)
Munition (Mun.)	ammunition
Nebel (Nb.)	smoke
Nebelgranate (Nbgr.)	smoke shell
Nebelgeschoss	smoke shell
Nitroglyzerin (Nigl.; Ngl.)	nitroglycerin
Nitropenta (Np.)	P.E.T.N.; penthrite
Nummer (Nr.)	number
ohne (o.)	without
ohne versögerung (o.v.)	without (superquick)

AMMUNITION

TABLE VI. GERMAN AMMUNITION TERMS (Cont'd)

Panzerabwehrkanone (Pak.) ..... antitank gun
Panzergranate (Pzgr.; Pz. Gr.) ..... armor-piercing shell
Panzersprenggranate (Pz. Spr. Gr.) ..... high explosive armor-piercing shell
Panzerstahlgranate (P. S. Gr.) ..... steel armor-piercing shell
Pulver ..... powder
Pulverkasten (P.KK.) ..... ammunition box
Pulverladung ..... powder charge
Pulvertemperatur (P. T.) ..... powder temperature
rauchloses Pulver ..... smokeless powder
rauch-schwaches Pulver ..... smokeless powder
rohrsicherer Zünder ..... bore-safe fuze
Schusstafel (Sch. Tf.) ..... firing table
Schlagzündschraube (Schl. Z. Schr.) ..... threaded base percussion fuze
Sonderkartusche (Sonderkart.) ..... special charge
Sprenggranate (Sprgr.; Spr. Gr.) ..... high-explosive shell
Stahl (St.) ..... steel
Stellschlüssel ..... setting key (fuzes); hand fuze setter; adjusting wrench
Tropen (Tp.) ..... Tropics
Ubung (Ub.) ..... practice
Ubungranate (Ubgr.; Ub. Gr.) ..... practice shell
Verzögerung (V.) ..... delay
Vorlage ..... flash hider
Zünderstellung ..... fuze setting
Zünderschlüssel ..... hand fuze setter
Zünderstellmaschine ..... fuze setter
Zünderstellschlüssel ..... hand fuze setter
Zündschraube ..... threaded percussion primer
Zeitzünder (Zt. Z.; ZZ.) ..... time fuze

d. Index Numbers on German Shell Indicating Type of High-explosive Filler.

TABLE VII. NUMBERS ON GERMAN SHELL INDICATING TYPE OF H. E. FILLER

No. on Shell	Type of Filler
1	Fp 02 (TNT) in paper or cardboard container
2	Grf 88 (picric acid) in paper or cardboard container
10	Fp 02 plus Fp 5 plus Fp 10 (TNT fillers) in paper or cardboard container
13	Fp 40/60 (40-60 amatol, poured)
14	Fp 02 (TNT), poured
32	Np 10 (P. E. T. N. filler) in paraffin-waxed paper wrapping
36/38	Np 40 plus Np 60 (P. E. T. N. fillers) in paraffin-waxed paper wrapping
91	H 5 (Cyclonite; R.D.X.) in paraffin-waxed paper wrapping

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

e. German Explosives, Abbreviations.

TABLE VIII. GERMAN EXPLOSIVES, ABBREVIATIONS

Abbreviation	German Nomenclature	English Equivalent
Fp 02	Füllpulver 02	TNT
Fp 5	Füllpulver 5	TNT with 5 percent montan wax
Fp 10	Füllpulver 10	TNT with 10 percent montan wax
Fp 40/60	Füllpulver 40/60	40-60 amatol, poured
G of 88	Granatfülling 88	picric acid
H	Hexagen	cyclonite, R.D.X.
H5	Hexagen 5	cyclonite with 5 percent montan wax
Np	Nitropenta	P.E.T.N.; penthrite
Np 10	Nitropenta 10	P.E.T.N. with 10 percent montan wax
Np 40	Nitropenta 40	P.E.T.N. with 40 percent montan wax
Np 65	Nitropenta 65	P.E.T.N. with 65 percent montan wax

CHAPTER 4

SIGHTING AND FIRE CONTROL EQUIPMENT

Section I

INTRODUCTION

73. INTRODUCTION.

a. The sighting and fire control equipment for the 8.8 cm Flak 18 or 36 varies, depending on the use to which the weapon is put. The gun may be used for direct fire as in antitank work, for indirect fire, or for antiaircraft fire.

b. For direct fire the telescopic sight ZF.20E (Zielfernrohr 20E) is used for laying the gun in azimuth and elevation. This sight, consisting of elbow telescope, telescope mount, and range drum is mounted on a bracket geared to the elevation quadrant on the right-hand size of the top carriage. The gun is laid in elevation by matching its pointer on the elevation quadrant against a pointer controlled by the telescopic sight.

c. The gun may be laid in azimuth and elevation against aircraft, moving ground or sea targets in accordance with data obtained from a director. Either of two directors may be used. The stereoscopic director Kdo. Gr. 36 (Kommandogerät 36) connects electrically to the on-carriage equipment for blackout dial matching. The auxiliary director Kdo. Hi. Gr. 35 (Kommandohilfsgerät 35) develops data which are telephoned to the gun crew. It is much lighter than the Kdo. Gr. 36 and is intended for mobile use. It is designed to be carried by porter bar.

d. When the stereoscopic director Kdo. Gr. 36 is used, the off-carriage equipment includes a distribution box; a switchboard with battery source of power for telephone and transmission of data; cables connecting the director to the distribution box, switchboard, and guns. The on-carriage equipment includes the instruments listed below:

(1) The panoramic telescope Rbl. F. 32 (Rundblickfernrohr 32) which is placed in a telescope holder on the top of the recuperator for initial orientation of the guns with the director.

(2) The azimuth indicator.

(3) The elevation indicator.

(4) The fuze setter.

(5) On-carriage wiring and boxes.

e. When the auxiliary director Kdo. Hi. Gr. 35 is used, a 4-meter range finder (separately connected) furnishes slant range.

f. Information is not available on the switchboard, the off-carriage cables, or the height finder telescopes of the Kdo. Gr. 36.

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

CHAPTER 4

SIGHTING AND FIRE CONTROL EQUIPMENT (Cont'd)

Section II

SIGHTING EQUIPMENT

74. TELESCOPIC SIGHTS (ZF.20E OR ZF.20) WITH ELEVATION QUADRANT FOR DIRECT FIRE.

a. Description of Telescopic Sight (ZF.20E).

(1) The telescopic sight Flak ZF.20E (ZF, Zielfernrohr, meaning telescopic sight) (figs. 79 to 81) is used for direct fire. It includes an elbow telescope, angle of site mechanism, range quadrant and elevation mechanism, and deflection mechanism.

(2) ELBOW TELESCOPE. The elbow telescope is of fixed focus type, has 4X magnification and a field of view of 17 degrees 30 minutes. The image remains erect during the rotation of the telescope. The filter knob and detent positions each of the filters: clear, green, light neutral and very dark neutral. A window and a dovetail surface permit attachment of a lamp for illumination of the reticle. The reticle pattern (fig. 81) permits rapid centering of reticle on target in desert glare and has indications for estimating lead.

(3) ANGLE OF SITE MECHANISM. The angle of site mechanism rotates the telescope and deflection mechanism within the main housing. The angle of site scale is graduated in 100-mil intervals from plus to minus 200 mils. Zero is normal. The angle of site micrometer is graduated in 1-mil intervals from 0 to 100 mils. Stop rings limit motion within the limits of the scale.

(4) RANGE QUADRANT AND ELEVATION MECHANISM. The range and elevation knob rotates the entire telescope and angle of site mechanism in the housing. On each end of the worm is a drum and pointer. One drum indicates elevation in degrees and is graduated from 0 to 12 degrees in $\frac{1}{10}$-degree intervals. The other drum is graduated in 100-meter intervals from 0 to 94 meters.

(5) DEFLECTION MECHANISM. Deflection may be set into the sight by rotation of the deflection knob. The deflection scale is graduated from 250 mils left to 250 mils right.

(6) A blank eyeshield is provided to rest the observer's eye. The shield may be adjusted for interpupillary distance.

(7) The telescopic sight has two trunnions and a clamp for installation on the telescopic sight bracket of the mount.

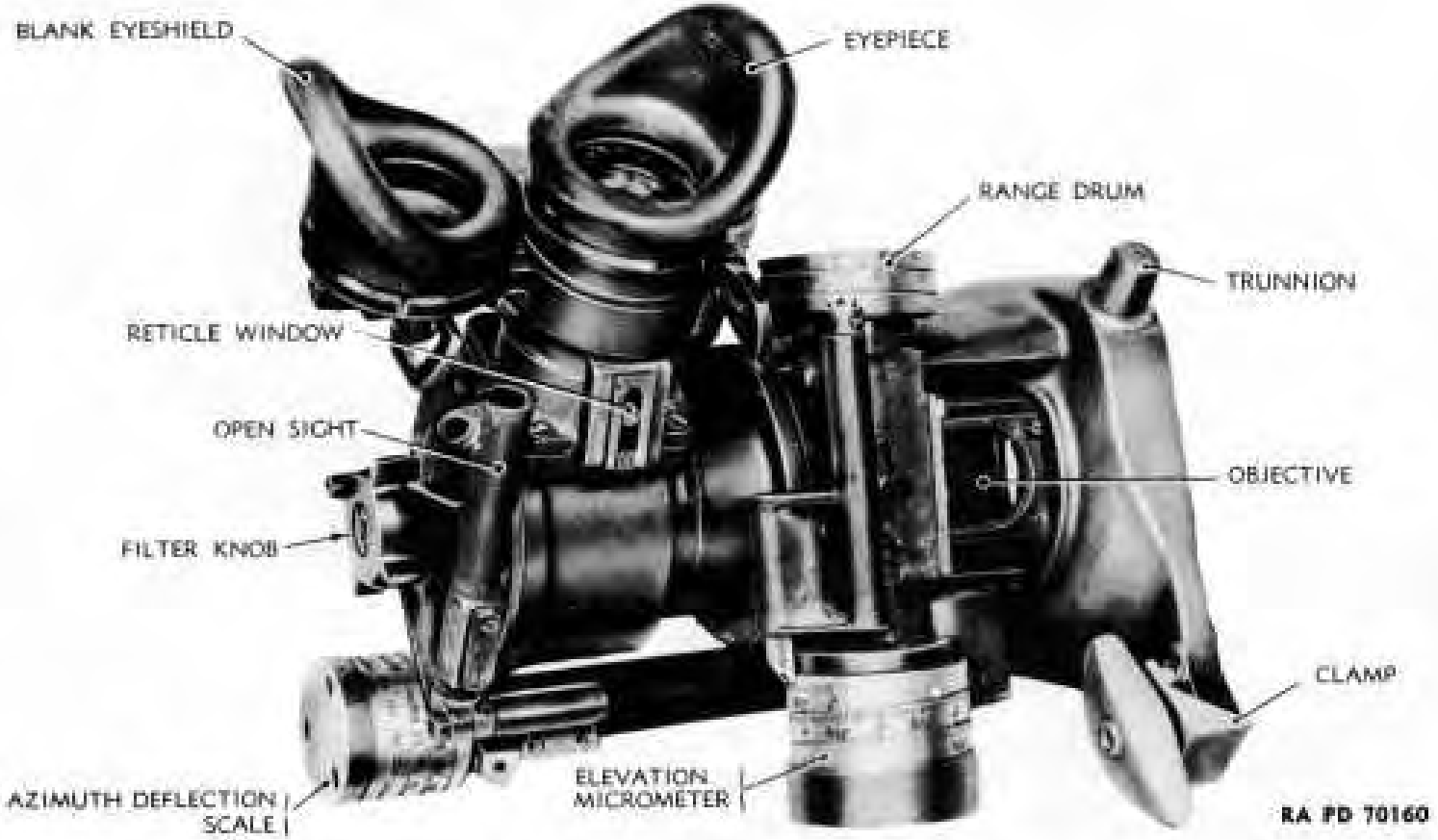

Figure 79 — Telescopic Sight ZF.20E — Front View

Figure 80 — Telescopic Sight ZF.20E — Top View

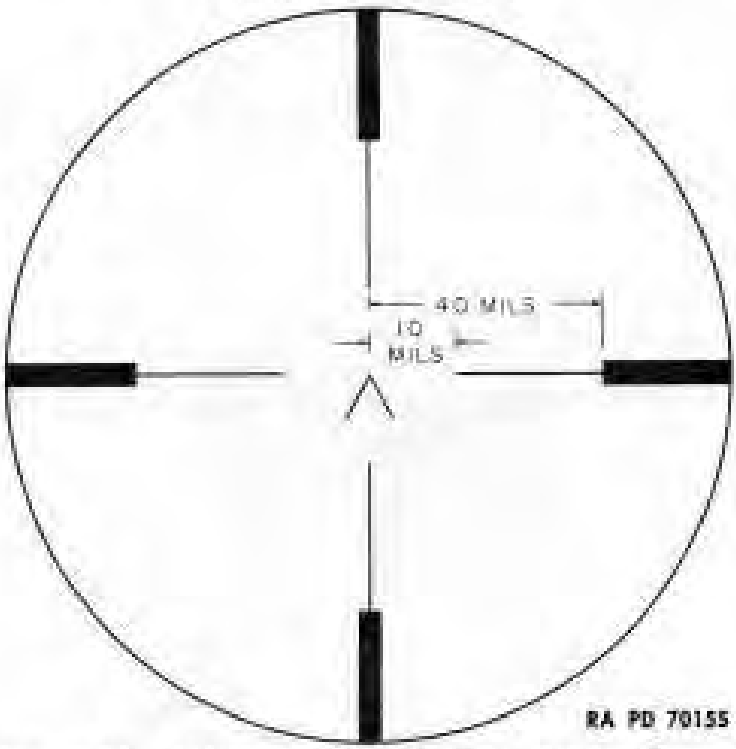

Figure 81 — Telescopic Sight ZF.20E — Reticle Pattern

b. Description of Telescopic Sight (ZF.20). The telescopic sight (ZF.20) (figs. 82, 83, and 84) is similar to the telescopic sight (ZF.20E) but lacks the range drum. The gun commander must memorize the range equivalent to some of the elevation scale readings.

c. Elevation Quadrant.

(1) The elevation quadrant (fig. 85) is used in direct fire sight (ZF.20E or ZF.20) for laying the gun in elevation. The elevation quadrant includes a quadrant, an outer pointer, an inner pointer, and a link to the telescopic sight bracket.

(2) The quadrant is centered on the cradle trunnion and is fastened to the mount. In operation the quadrant remains stationary. The quadrant is graduated in 0.25-degree intervals from minus 3 degrees in depression to plus 85 degrees in elevation.

(3) The outer pointer (quadrant elevation pointer) is fastened to the cradle trunnion. It bears an index which alines with the quadrant scale, indicating the elevation of the gun.

(4) The inner pointer (direct sight elevation pointer) pivots on the cradle trunnion and moves with the bracket of the telescopic sight. The pointer has an index line which alines with the index of the outer pointer.

(5) The link connects the inner pointer with the bracket of the telescopic sight and has a turnbuckle for alinement of the sight with the gun bore.

Figure 82 — Telescopic Sight ZF.20 — Front View with Eyeshields Swung Down and Forward

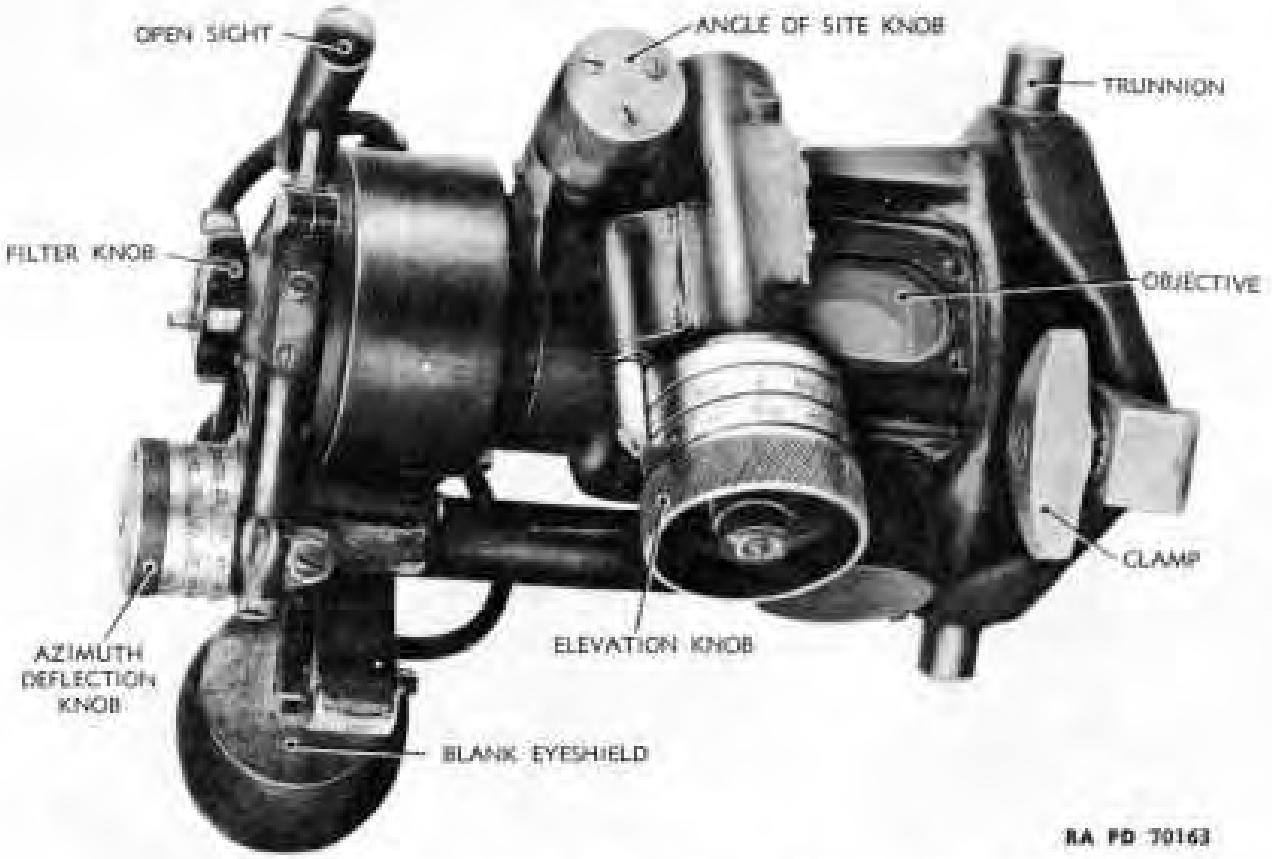

Figure 83 — Telescopic Sight ZF.20 — View of Bottom from Front

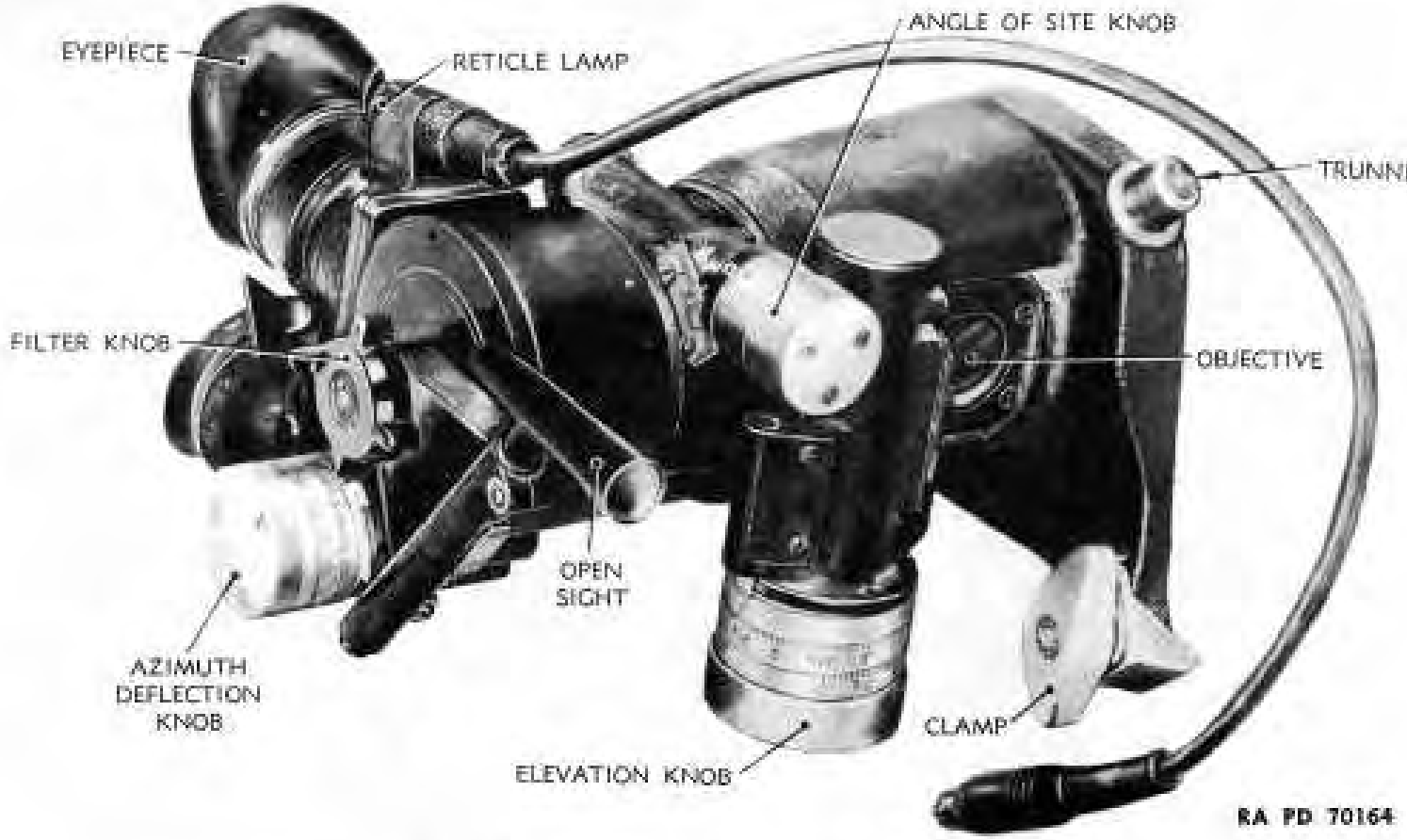

Figure 84 — Telescopic Sight ZF.20 — Side View

SIGHTING EQUIPMENT

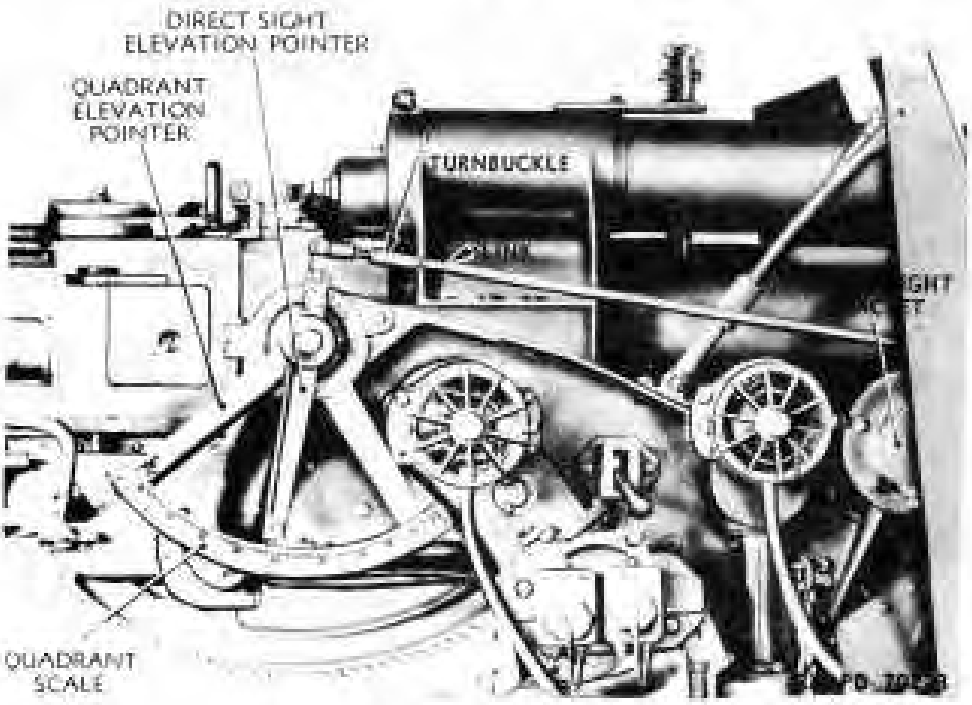

Figure 85 — Elevation Quadrant

(6) When the elevation quadrant, the link, and the telescopic sight are in adjustment, the gun may be laid in elevation by setting the desired elevation or range in on the telescopic sight and matching the pointers on the elevation quadrant.

d. Operation.

(1) INSTALLATION. Examine trunnions and mating surfaces for nicks and burs. Set the trunnions of the telescopic sight in the proper slots of the telescope bracket and clamp the telescopic sight firmly in place.

(2) BORE SIGHTING.

(a) Remove the firing pin and use the firing pin hole as the breech bore sight. Improvise the muzzle bore sight by fastening two pieces of cord or wire across the muzzle face, locating the cord in the horizontal and vertical grooves on the muzzle face and securing with a strap around the barrel close to the muzzle.

(b) Lay the gun on a well defined distant aiming point by sighting through the bore. Turn the handwheel of the telescopic sight bracket (just below the bracket) to match the direct sight elevation pointer with the quadrant elevation pointer. Set the range scale, the angle of site scale, and the deflection scale of the telescopic sight to "0." The telescope sight should now be on the distant aiming point.

(c) If error in elevation exists, lengthen or shorten the link bar by adjustment of the turnbuckle.

(d) Errors in azimuth may be corrected by turning the telescope deflection micrometer until the telescope alines in azimuth with the distant aiming point, then loosening the three screws in the end of the micrometer, slipping the scale to zero, and reclamping.

(3) DIRECT FIRE OPERATION.

(a) The azimuth gun pointer sits behind the telescopic sight with the traversing handwheel at his left.

(b) The angle of site scale and micrometer should be set at zero.

(c) The elevation for range in degrees and $\frac{1}{16}$ degrees is set in on the elevation scale or in meters (on ZF.20E only) on the range drum.

(d) The deflection in mils, if large, is set in on the deflection drum. (Red graduations bring the piece to the left.)

(e) Small deflections may be estimated on the reticle (fig. 81).

(f) The gun is laid for elevation by matching both pointers of the elevation quadrant.

(g) The azimuth gun pointer tracks the target with the traversing handwheel.

CHAPTER 4

SIGHTING AND FIRE CONTROL EQUIPMENT (Cont'd)

Section III

FIRE CONTROL EQUIPMENT

75. COMPONENTS.

a. The fire control equipment consists of the stereoscopic director 36 (Kommandogerät 36), or the auxiliary director 35 (Kommandohilfsgerät 35); the azimuth and elevation indicators; the fuze setter; the necessary on-carriage wiring; and the cables.

b. When the stereoscopic director is available, it transmits data electrically to the indicators and fuze setter. These have dials, each containing 3 concentric circular rows of 10 lamps each. The data are indicated by the lighting of lamps and matched by operating the gun until the 3 blackout indexes of each of the 2 indicators and the fuze setter cover the lighted lamps. The gun is then alined on the target indicated by the director.

c. When the auxiliary director is used, slant range is obtained from a separate 4-meter range finder (information not available) and is manually set into the director. The computed values are read off on dials and scales visible in the sides of the director and then telephoned to the gun crew.

d. Information is not available on the cables used to connect the directors with the guns.

76. PANORAMIC TELESCOPE 32 (RBL. F. 32).

a. Description of Panoramic Telescope 32 (Rbl. F. 32).

(1) The panoramic telescope used for orienting with the stereoscopic director is the Rundblickfernrohr 32 (figs. 86 and 87). The

Figure 86 — Panoramic Telescope 32 (Rbl. F. 32) in Telescope Holder

telescope is clamped in the telescope holder on the top of the recuperator. The holder is located at the pintle center of the mount.

(2) The panoramic telescope (fig. 88) is a 4-power, fixed focus type with a field of view of 9 degrees. The line of sight may be raised or lowered by rotation of the angle of site knob. The angle of site scale is graduated from 100 mils to 500 mils (300 mils is normal). The angle of site micrometer is graduated in mils from 0 to 100 mils. The azimuth scales on the vertical barrel of the telescope are graduated in 100-mil intervals; the upper scale, 0 to 64; the lower scale, 0 to 32, 0 to 32. A knurled portion permits adjustment. The center index is locked in place by a lug at the front of the telescope. The azimuth micrometer includes 2 scales graduated in mils from 0 to 100 mils. The index between the scales is fixed. It is believed that one scale is used for setting in corrections and the other for setting in fine azimuth values. A throw-out lever is provided for rapid setting in azimuth. A locking lever locks the azimuth micrometer in any setting. The reticle pattern is shown in figure 87.

(3) The telescope holder is of conventional design. It is welded to the top of the recuperator and is in the vertical plane through the axis of bore. It is also at the pintle center. The telescope holder lever operates a cam which engages a notch in the body of the telescope. Two screws with jam nuts permit adjustment in azimuth of the telescope in the holder.

FIRE CONTROL EQUIPMENT

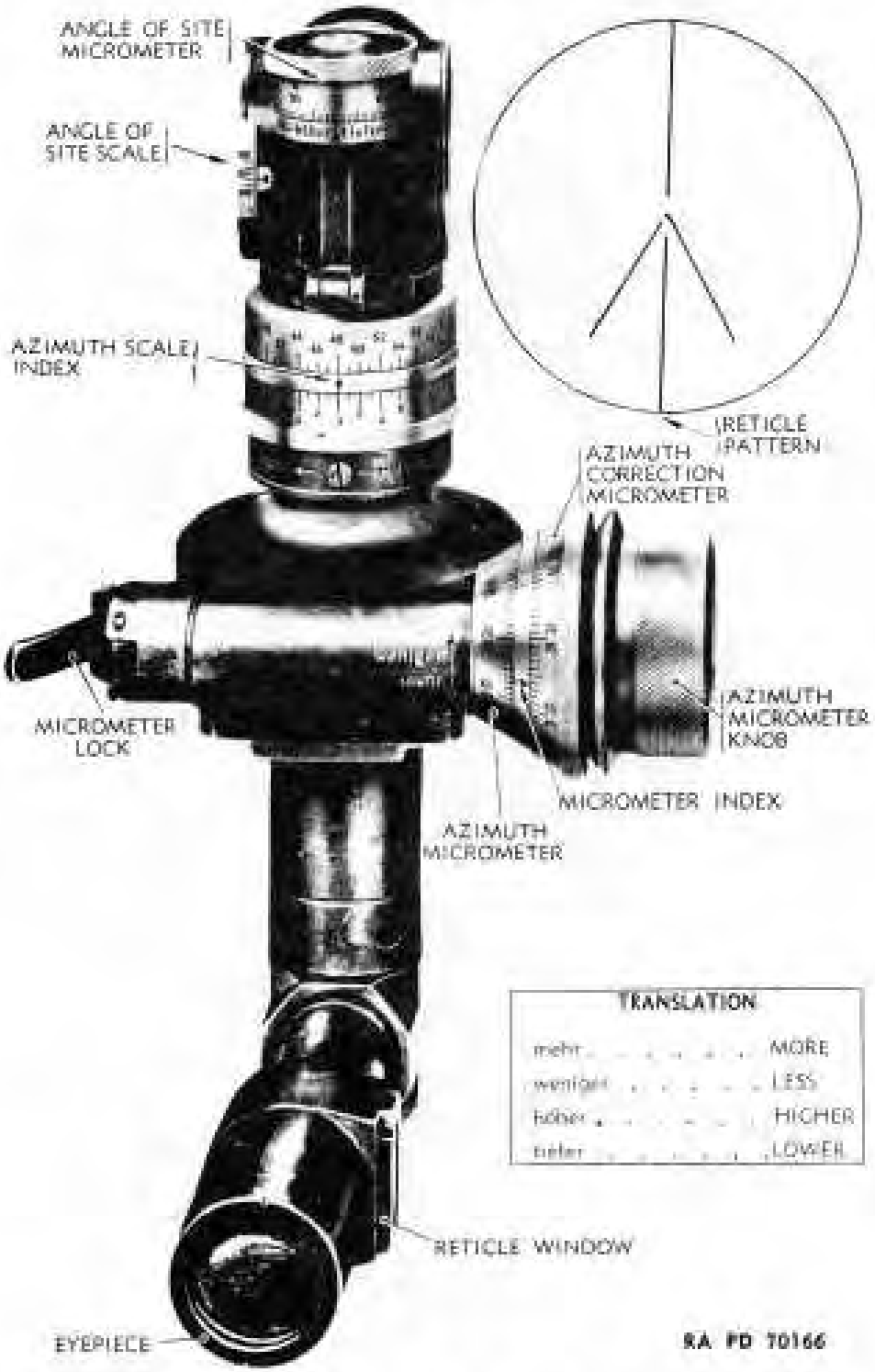

Figure 87 — Panoramic Telescope 32 (Rbl. F. 32) - Rear View

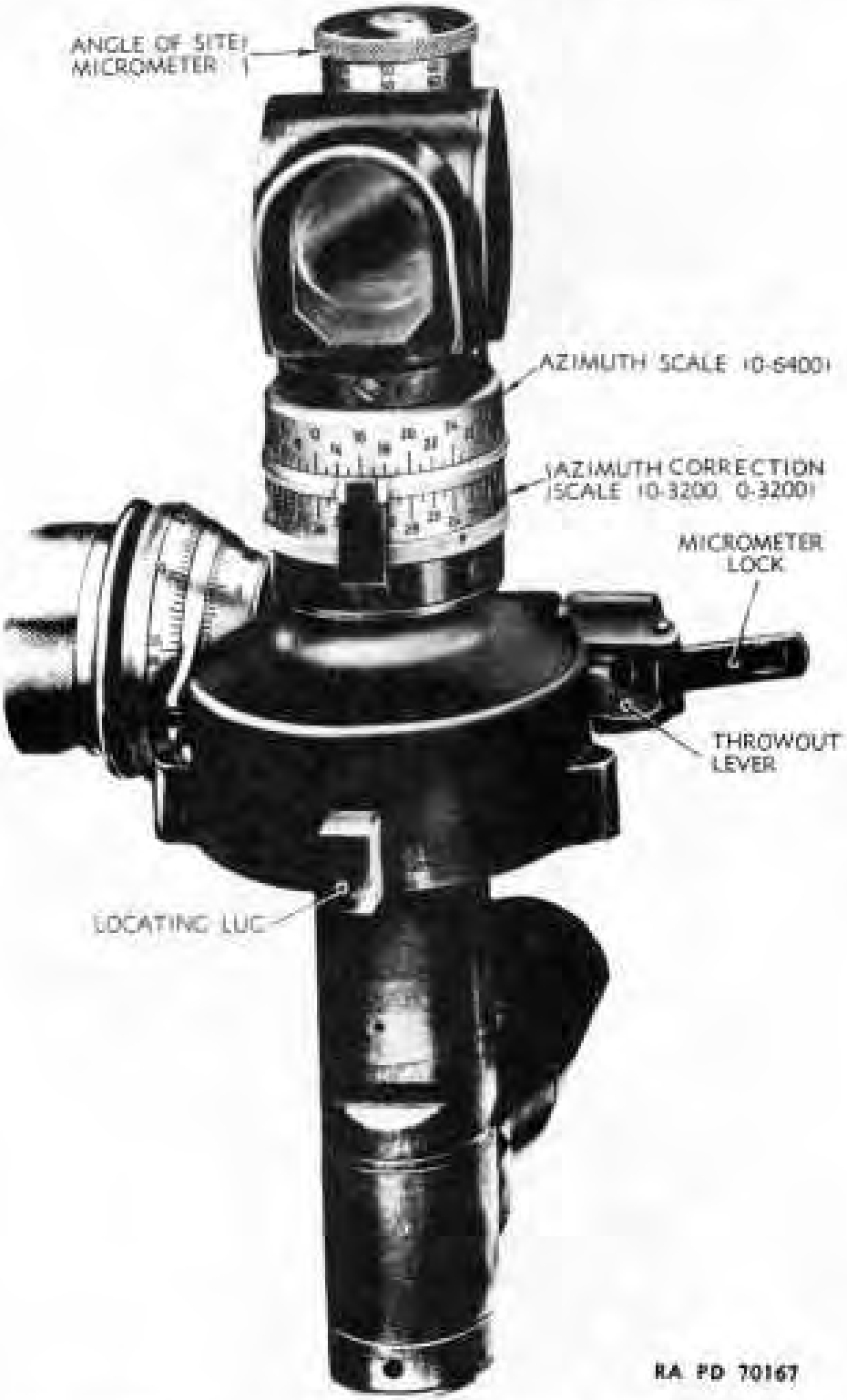

Figure 88 — Panoramic Telescope 32 (Rbl. F. 32) — Front View

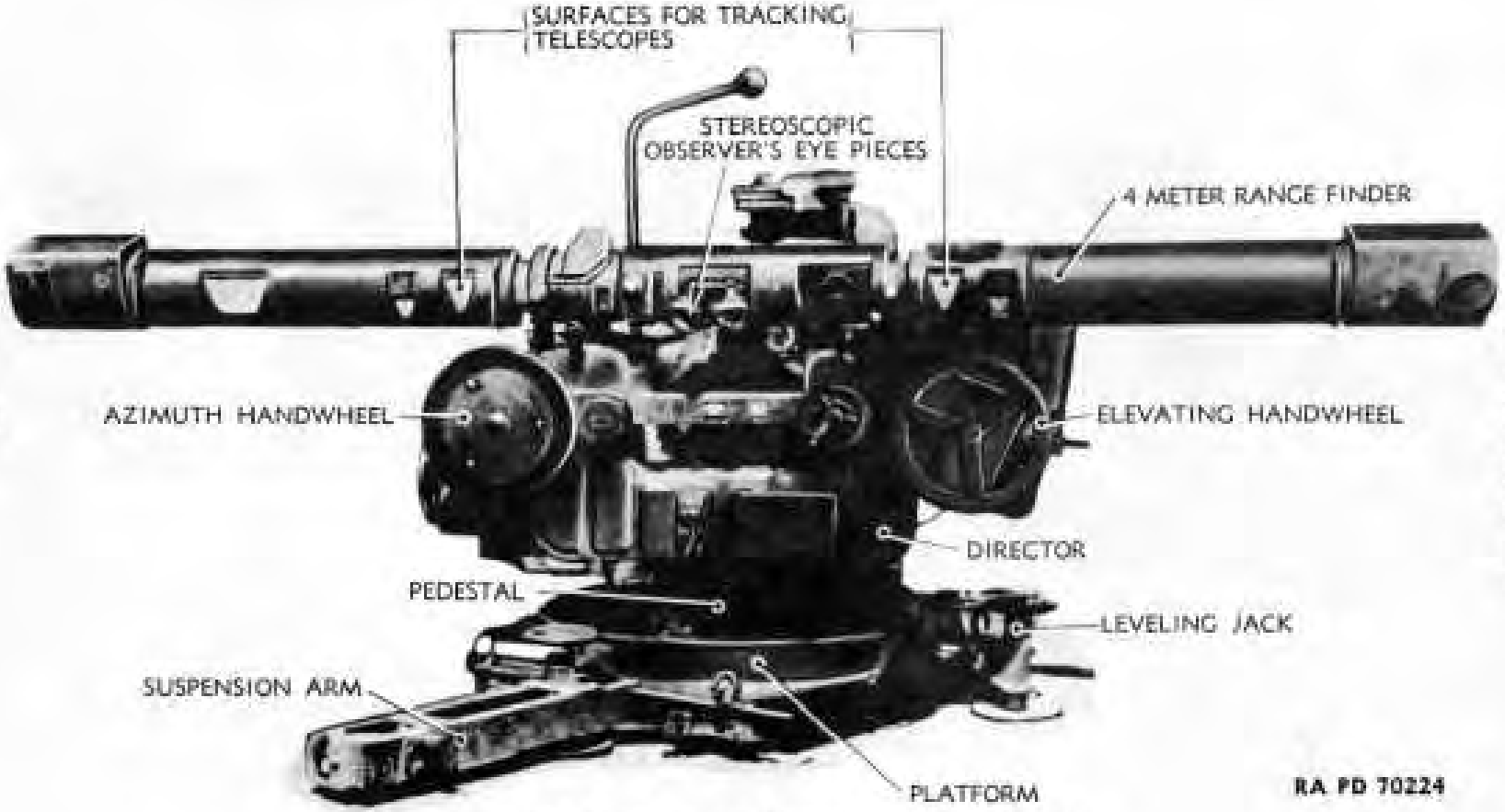

Figure 89 — Stereoscopic Director 36 (Kdo. Gr. 36)

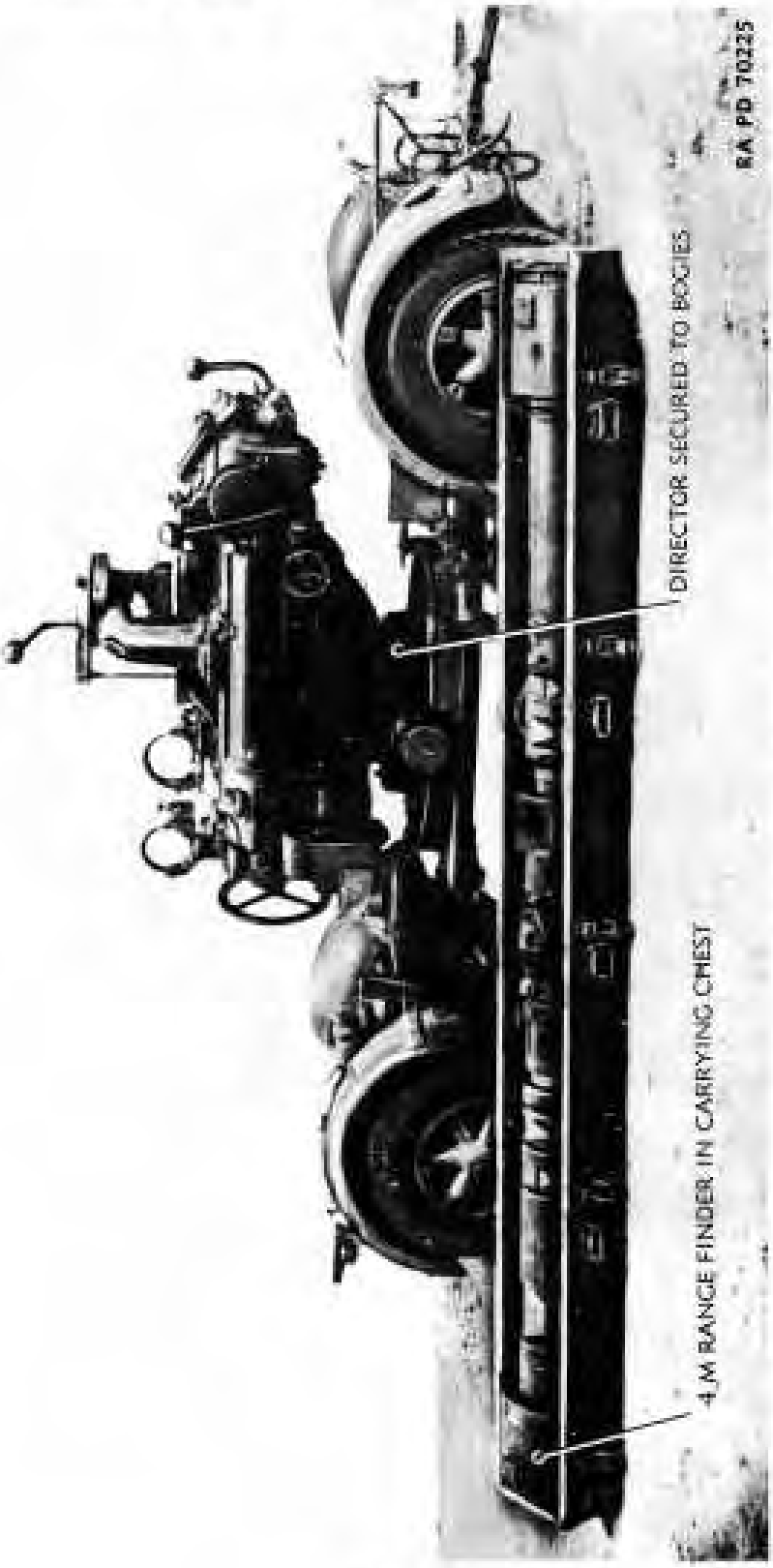

Figure 90 — Stereoscopic Director 36 (Kdo. Gr. 36) — Range Finder Removed from Director

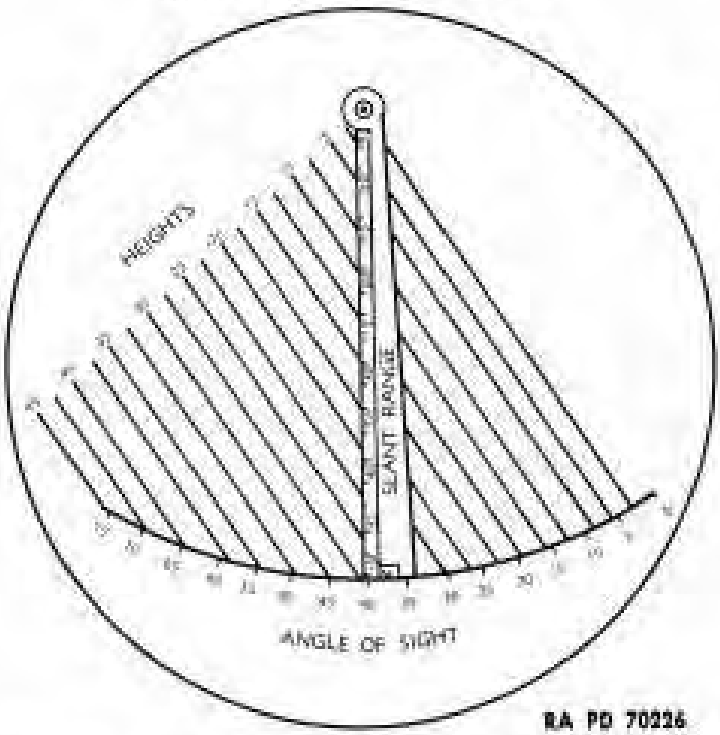

Figure 91 — Stereoscopic Director 36 (Kdo. Gr. 36) — Height Scale

77. STEREOSCOPIC DIRECTOR 36 (KDO. GR. 36).

a. **General.** The stereoscopic director 36 (Kommandogerät 36) (figs. 80 to 86) is the standard director used with the 8.8 cm. flak 36. It is a combined stereoscopic range finder and director, supported on a pedestal which has three leveling feet and two suspension arms for securing to front and rear bogies for travel. The bogies are similar to those used for carrying the gun mount.

b. **Range Finder (Em. 4m. R. (H)).**

(1) The 4-meter base stereoscopic range finder (Raumbildentfernungsmesser (Höhe)) adapted for height finding has magnification of 12x and 24x and a range scale reading from 500 meters (550 yd) to 50,000 meters (55,000 yd). It is clamped by two rings to the director for use and in travel is carried in a chest fitted with hand grips.

(2) A device for obtaining approximate height is fitted on the right end of the range finder tube. This consists of an arm pivoted at one end and engraved with a scale of ranges. A series of parallel lines graduated to the value of height are engraved on the disk to which the arm is pivoted. As the instrument is elevated, the disk carrying the scale rotates with the instrument. The arm, however, remains vertical, and the height line corresponding to the range on the range arm indicates target height (fig. 91).

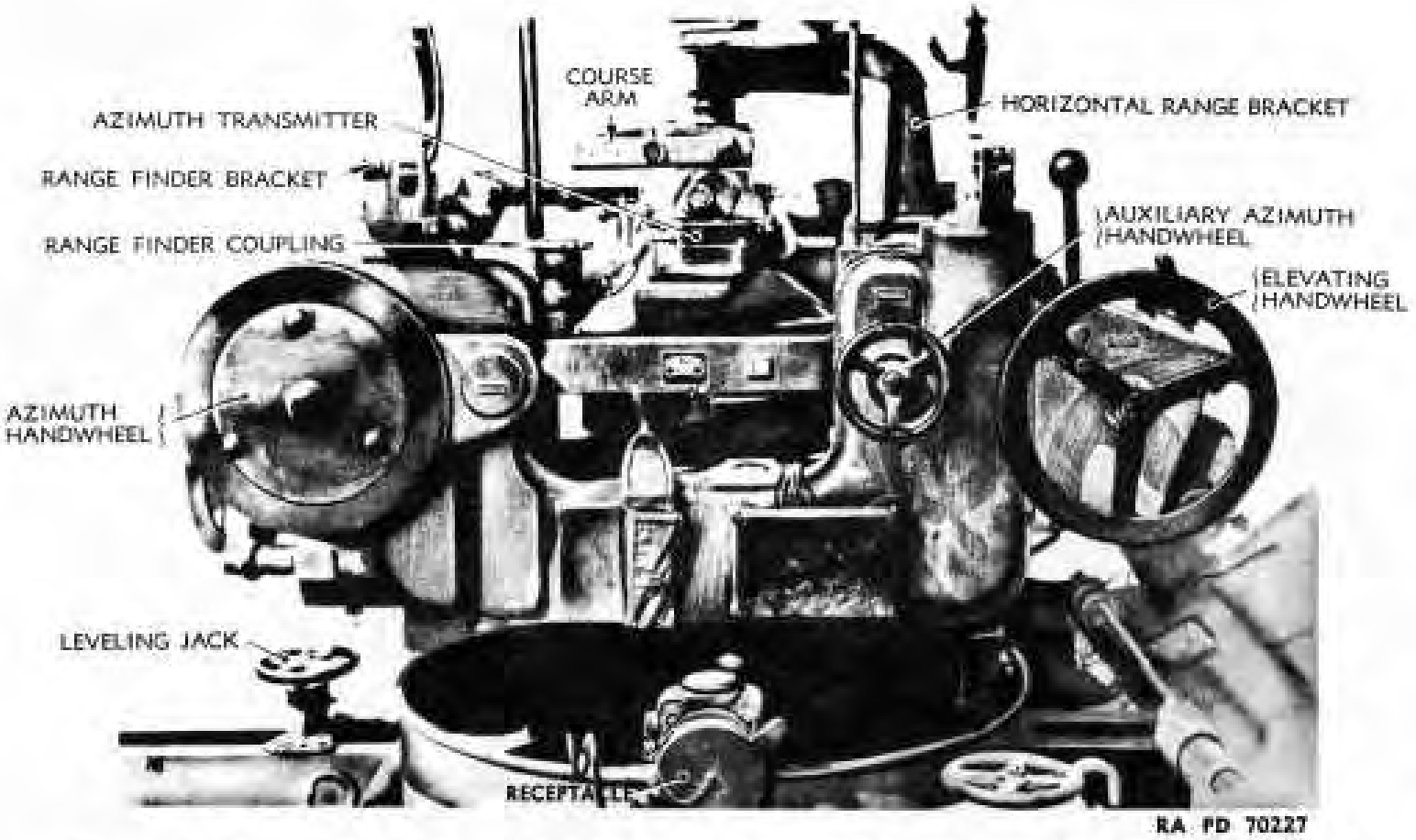

Figure 92 — Stereoscopic Director 36 (Kdo. Gr. 36) — View of Traversing and Elevating Handwheel

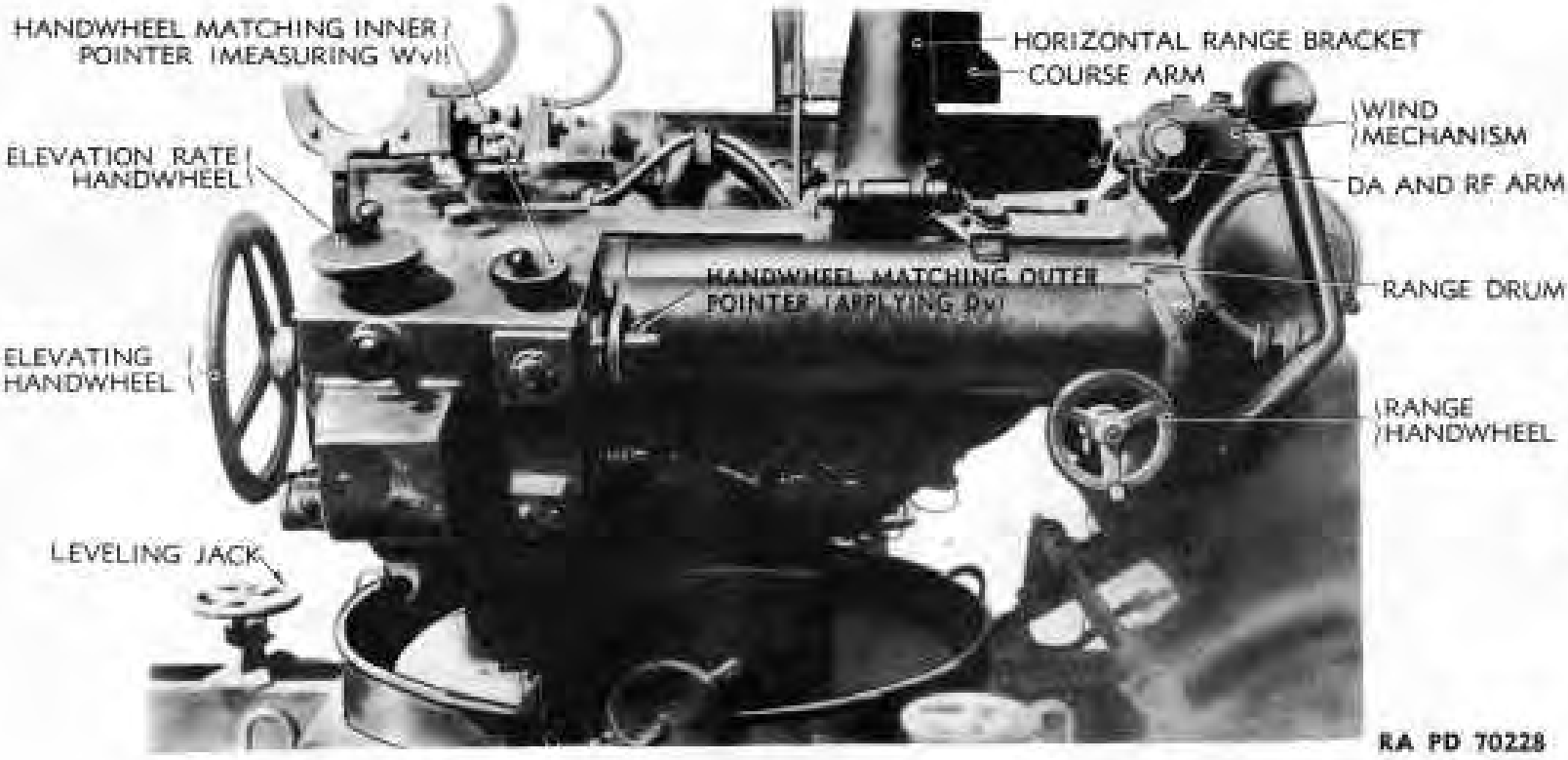

Figure 93 — Stereoscopic Director 36 (Kdo. Gr. 36) — View of Range Drum

(3) Two tracking telescopes are fitted on the range finder tube to the right and left of the stereoscopic eyepiece. These are employed for keeping the range finder on the target and have a cross wire reticle pattern.

(4) The range finder is turned in elevation by rotation of the elevating handwheel which is connected by gearing to a gear between the range finder tube and the left bearing ring.

(5) An optical lath is provided. When it is suspended on the supporting brackets, it provides an artificial infinity for test and adjustment of the range finder.

c. Director.

(1) The director includes a main casting, supported on a pedestal, and supporting a number of box enclosed mechanisms (figs. 92-95). The director determines and transmits the following data to the battery.

(a) Quadrant elevation.
(b) Future azimuth.
(c) Time of flight of projectile, expressed in fuze units.

(2) The values set into the director are:

(a) Present angular height.
(b) Present azimuth.
(c) Present slant range.

d. Setting Up.

(1) Uncouple the carriage supporting the director from its towing vehicle and lower the platform from the front and rear bogies (fig. 90). Open the cases containing parts and accessories.

(2) Open the range finder clamp rings of the director. Remove the range finder from its case and clamp it to the director. Couple the range finder to the director. Place the two tracking telescopes and the four other telescopes on their respective mounting surfaces on the range finder. Check against a distant aiming point to make sure that the telescopes are aimed with the range finder.

(3) Level the director by adjusting the three leveling jacks (fig. 89). Level the range finder using the range finder leveling screw and lock nut until the bubble of the level is centered.

(4) Turn the handwheel for angular height to the left until the zero reading of the angular height graduation of the horizontal range to datum point drum is exactly under the horizontal range to datum point index. Then turn the upper part of the coupling which transfers present angular height to the director until the zero-degree reading of present angular height is visible in the aperture of the present angular height instrument attached to the range finder.

(5) Remove the range finder eyepiece protector and hang it under the range finder. Set the head rest in the correct position. Hang the arm strap on the knob to the right of the eyepiece. Set the interpupillary distance and focus the eyepieces. If necessary, use the filters.

(6) Bring the panoramic telescope, which is on the top of the recuperator of the gun, to bear on the director. Set this value on the telescope of the director and bodily slew the director to lay on the red stem of the panoramic telescope on the gun.

(7) With the director alined on the gun telescope, set the graduated lateral deflection ring at zero. Set the graduated deflection ring of the course plate at zero.

(8) Screw the counterweights into the range finder and remove the cover from the correcting apparatus. If necessary, install the telescope extension tubes (rain protection) on the range finder.

(9) Adjust the range finder stereoscopically and check alinement of tracking telescopes and observing telescopes and binoculars with the range finder. Detailed information on this is not available at this time.

(10) Wind up the clockwork of the horizontal speed indicator.

(11) Connect the cables between the director, the switchboard, the distribution box, and the guns. Plug in the head and chest set telephones. Detailed information on this is not available at this time.

(12) Set in average values for future azimuth, Q.E., and fuze. Turn on the switch in the receptacle box at the director. Turn on the power with the transmission switch at the switchboard. Check the lamps in the indicators and fuze setter, noting broken or weak lamps. Check the future azimuth, Q.E., and fuze values obtained at the guns with that set in at the director. The director is now ready for operation.

c. Stereoscopic Director Operation.

(1) FUNCTIONS OF OPERATORS. It is believed that 11 operators are required.

(a) Elevation Tracker. Keeps reticle of elevation tracking telescope (mounted on right range finder tube) laid on the target by turning the elevating handwheel.

(b) Azimuth Tracker. Keeps reticle of azimuth tracking telescope (mounted on left range finder tube) laid on the target by turning the azimuth handwheel. An auxiliary elevation handwheel close to the azimuth handwheel enables the azimuth tracker to track in both azimuth and elevation when necessary.

(c) Stereoscopic Observer. Tracks the target stereoscopically, indicating slant range on range drum.

(d) Range or Height Reader. Reads off elevation figures on the range drum of the range finder to both the horizontal range operator and the target course and speed operator. When range only is being taken, the reader gives these to the horizontal range reader only.

(e) Horizontal Range Operator. By operation of the horizontal range handwheel keeps the center circle of the cursor (attached to horizontal range bracket) on the curve indicated on the range drum by the stereoscopic observer.

Figure 94 — Stereoscopic Director 36 (Kdo. Gr. 36) — View of Course Plate

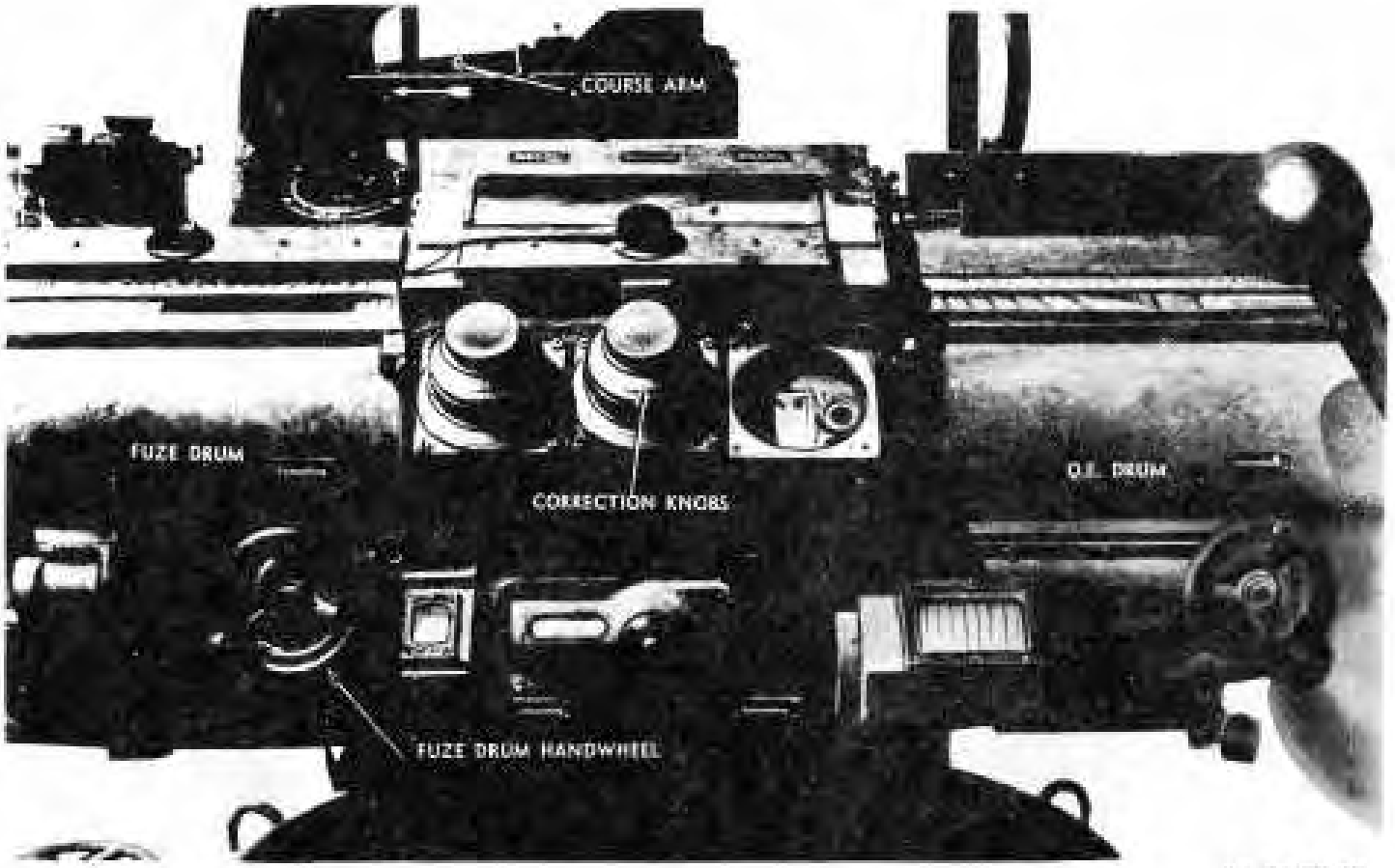

Figure 95 — Stereoscopic Director 36 (Kdo. Gr. 36) — View of Wind Correction Knobs

(i) Target Course and Speed Operator. Watches the trace made by the course pointer over the course plate (fig. 94) and rotates the course bearing disk to keep the parallel lines in agreement with the target course. Keeps the pointer of the horizontal speed scale in agreement with the speed registered on the horizontal speed indicator, or watches the dial of the horizontal speed mechanism, and keeps the colored disk rotating at the same speed as the pointer and the parallel lines of the speed plot in agreement with the track of the plot by turning the handwheel below the course plate.

(g) Present Angular Height Operator. Takes readings from present angular height scale on range drum and sets these in on the present angular height scale of the rate multiplying mechanism. This is done either by direct rotation of the handwheel or by clutching in the variable speed drive and turning the handwheel to control the rate of change. Watches the elevation speed indicator, keeping the inner index matched to the pointer by one handwheel and the outer index matched to the main index by the second handwheel.

(h) Operator for DA and Rf Arm. Matches pointer of DA and Rf arm against pointer moving along course arm by turning the two handwheels mounted on the DA and Rf arm. One handwheel traverses the arm and adds deflection in azimuth to the present azimuth set into the future azimuth transmitter.

(i) Fuze Drum Operator. Reads the future angular height scale (to the right of the drum) and sets the curve indicated on this scale under the center of the cursor by turning the fuze handwheel. This also sets the fuze transmitter.

(j) Quadrant Elevation Operator. Reads future angular height scale (to the left of the drum) and sets the curve indicated on the scale under the center of the cursor by turning the tangent elevation handwheel. This also sets the quadrant elevation transmitter.

(k) Correction Operator. Reads off from the respective registers the drift adjustment, elevation corrections, and fuze setting corrections as shown under the cross threads and sets these in on the respective dials (fig. 95).

f. Operation by Telephone. When transmission of data from the stereoscopic director is desired by telephone, three additional operators are required to telephone the values (Q.E., future azimuth, fuze) to the gun crew.

g. Standby Settings. When firing has ceased, the following settings should be made:

(1) Traverse the director to zero.
(2) Bring the present angular height reading to zero.
(3) Set target height in range finder to 2,500 meters.
(4) Set horizontal range to 5,000 meters.
(5) Set horizontal velocity to 50 meters per second and bring the pointer under its arm.

(6) Set correction for drift to zero.
(7) Set future horizontal range to 5,000 meters.
(8) Set gun elevation to 60 degrees.
(9) Shut off power.

78. AUXILIARY DIRECTOR 35 (KDO. HI. GR. 35).

a. Description.

(1) The auxiliary director 35 (Kommandohilfsgerät 35) (figs. 96 to 99) is a portable director, smaller and less complicated than the Kdo. Gr. 36. Data computed in the director is telephoned to members of the gun crew, who then set in elevation, azimuth, and fuze time. The slant height or range scales are calibrated for use with the 8.8 cm Flak 18 and 10.5 cm Flak 38. Provision is made for two tracking telescopes although information is not available at this time on these.

(2) The slant range prediction is approximated by adding range rate times future time of flight to the present slant range which is obtained from a 4-meter stereoscopic range finder set up nearby. The super elevation and fuze are taken from three-dimensional cams, positioned by future angular height and future slant range. Lateral, vertical, and range rates are measured by tachometers and are manually matched. Deflections are computed by multiplying present angular velocity by present time of flight.

(3) The instrument and stand are carried in a two-wheeled trailer. The stand is collapsible for traveling. Three leveling screws on the head of the stand support the director. The director has four porter bars which form an integral part of the instrument and telescope within each other when the instrument is emplaced. The director weighs about 450 pounds.

(4) The only electric current required is for the telephone system. The 10-pole receptacle in the center of the bottom provides constant contact throughout complete traversing of the director because of the slip rings in the bottom of the director. The receptacle has colored dots: black, white, yellow, brown, brown, respectively for adjacent pairs of terminals. A key prevents incorrect positioning of the mating plug. The receptacles on the gun mount use colors in accordance with this color system. The two receptacles also at the bottom, but on either side of the center, move with the director and permit connection to the telephone sets for the director operators.

b. Operation.

(1) Limits of operation are:

Range of target	12,000 meters (39,360 ft)
Height of target	10,000 meters (32,800 ft)
Fuze time	37 seconds
Lateral deflection	± 600 mils (33.75 deg)
Vertical deflection	± $^{300}/_{16}$-degrees (18.75 deg)
Rate of change of range	± 150 meters per second (492 ft per sec)

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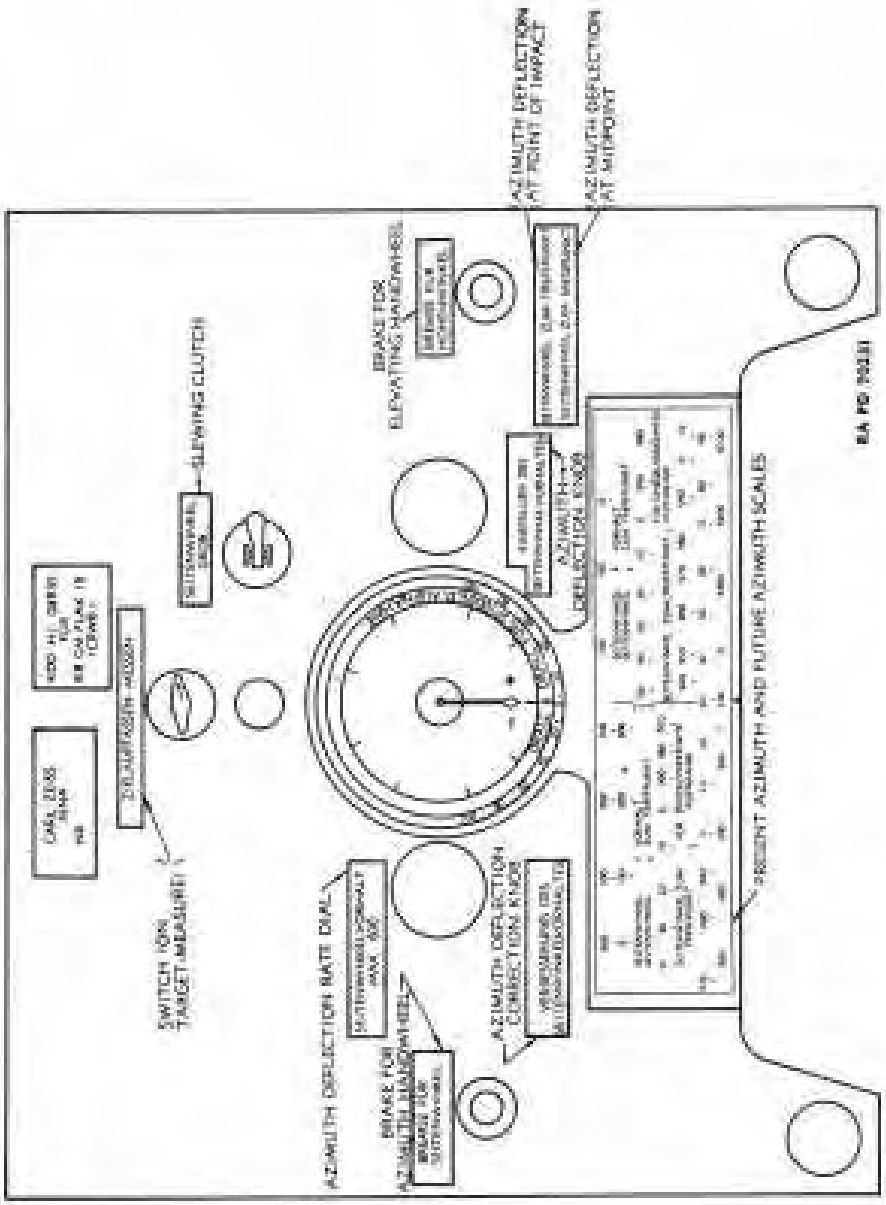


Figure 96 — Auxiliary Director 35 (Kdo. Hi. Gr. 35) — Rear Panel

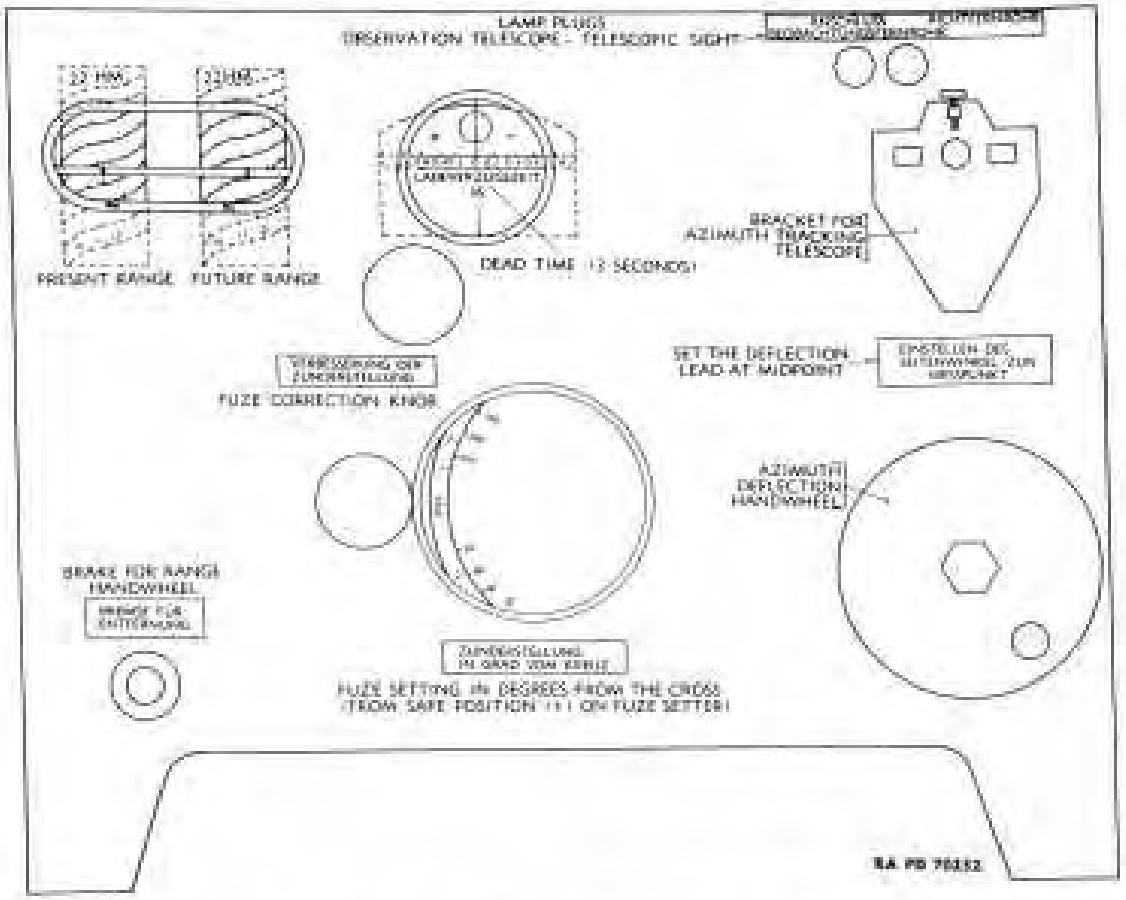


Figure 97 — Auxiliary Director 35 (Kdo. Hi. Gr. 35) — Left Side Panel

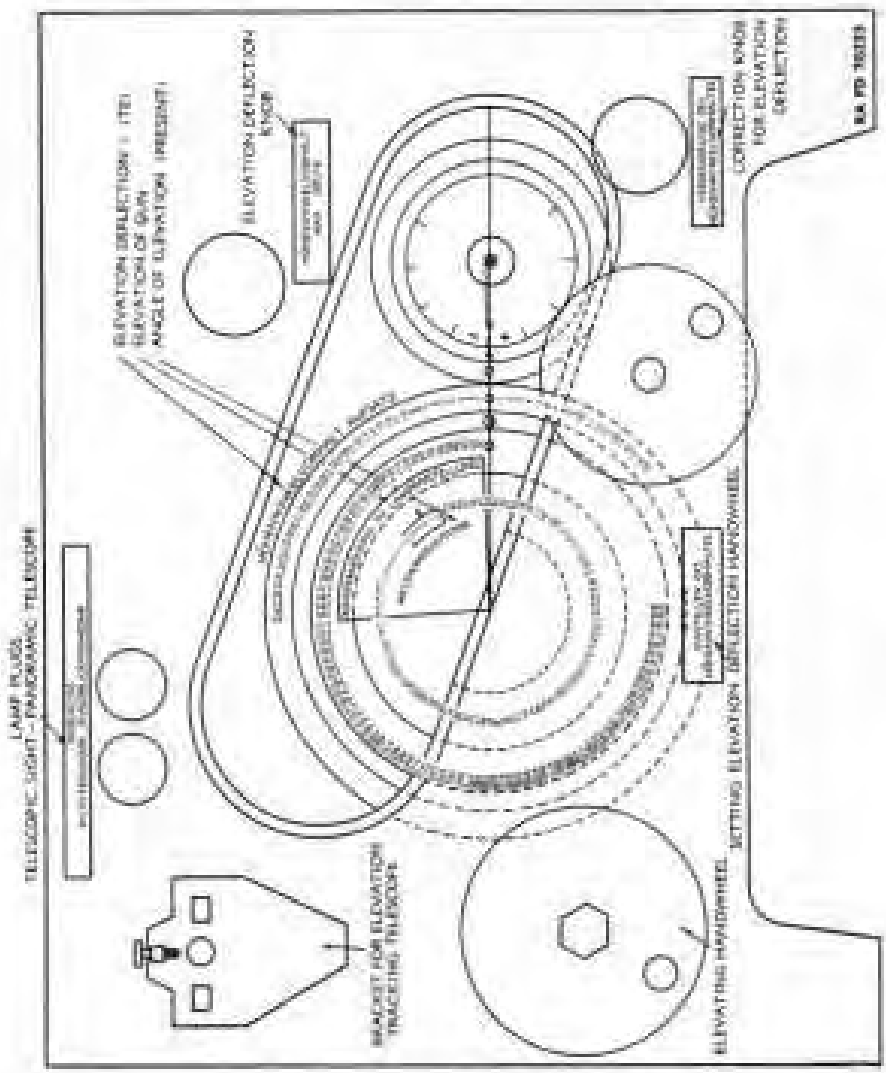


Figure 98 — Auxiliary Director 35 (Kdo. Hl. Gr. 35) — Right Side Panel

FIRE CONTROL EQUIPMENT

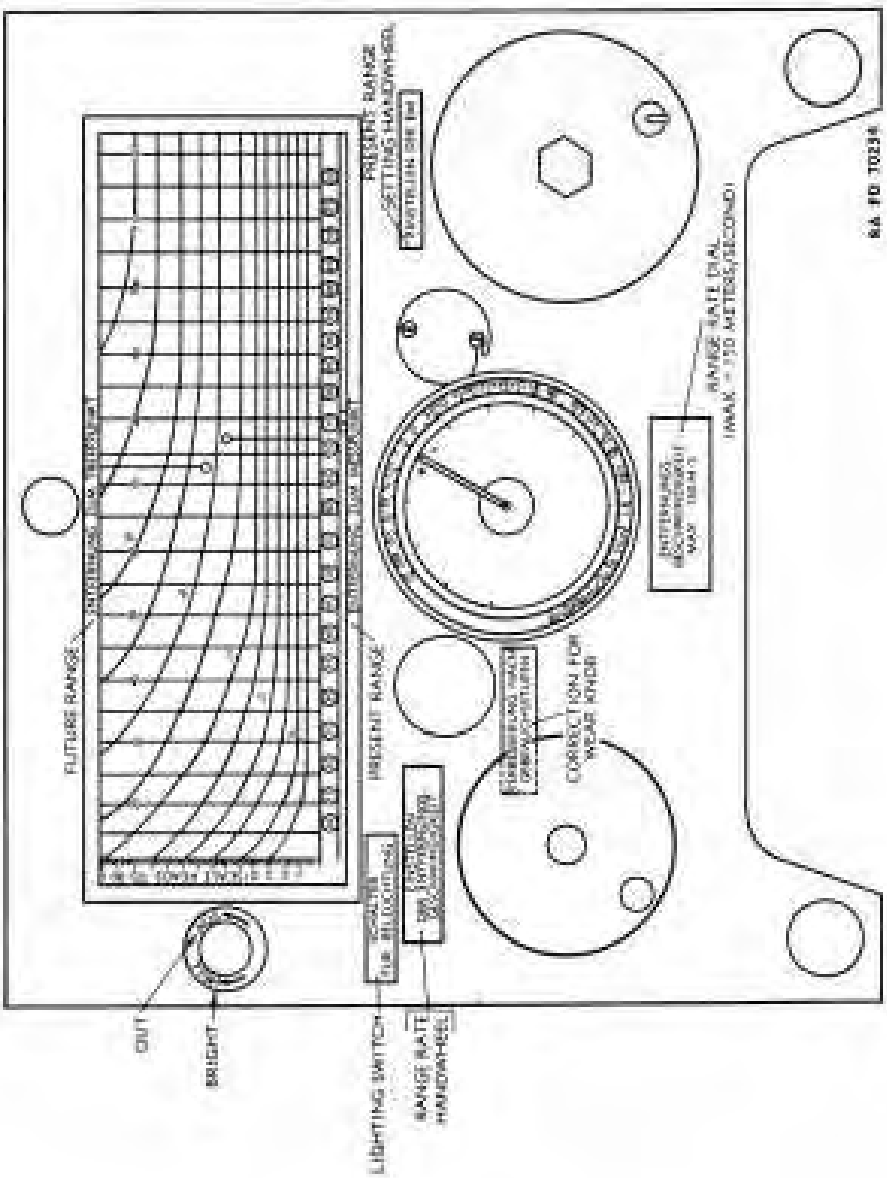


Figure 99 — Auxiliary Director 35 (Kdo. Hi. Gr. 35) — Front Panel

(2) It is believed that nine operators are required:
(a) Azimuth tracker.
(b) Elevation tracker.
(c) Range operator.
(d) Azimuth rate setter.
(e) Elevation rate setter.
(f) Range rate setter.
(g) Future azimuth reader.
(h) Future elevation reader.
(i) Fuze reader.

(3) The azimuth and elevation trackers keep their telescopes on the target by operating their respective handwheels. The range operator sets in range values obtained from the 4-meter stereoscopic range finder nearby.

(4) The azimuth rate setter keeps the azimuth rate indicator alined with its index (at 6 o'clock relative to the rate dial for zero correction) by turning the azimuth deflection knob. He also applies correction by turning the azimuth rate knob.

(5) The elevation rate setter alines the elevation rate pointer with its index (positioned under the white line for zero corrections) and applies corrections by turning the elevation rate correction knob.

(6) The range rate setter keeps the range rate pointer alined with the index (at 6 o'clock for zero correction) and applies corrections by turning the range rate correction knob.

(7) The future azimuth reader observes the future azimuth scale and telephones the values indicated to the guns. The future elevation reader observes the future elevation scale on the right side panel and telephones the values indicated to the guns. The fuze reader observes the fuze dial on the left side panel and telephones the values to the guns.

(8) Each input handwheel has a flywheel mounted within the case which tends to give a steady rate of change. Brakes operated by push buttons permit quick stopping.

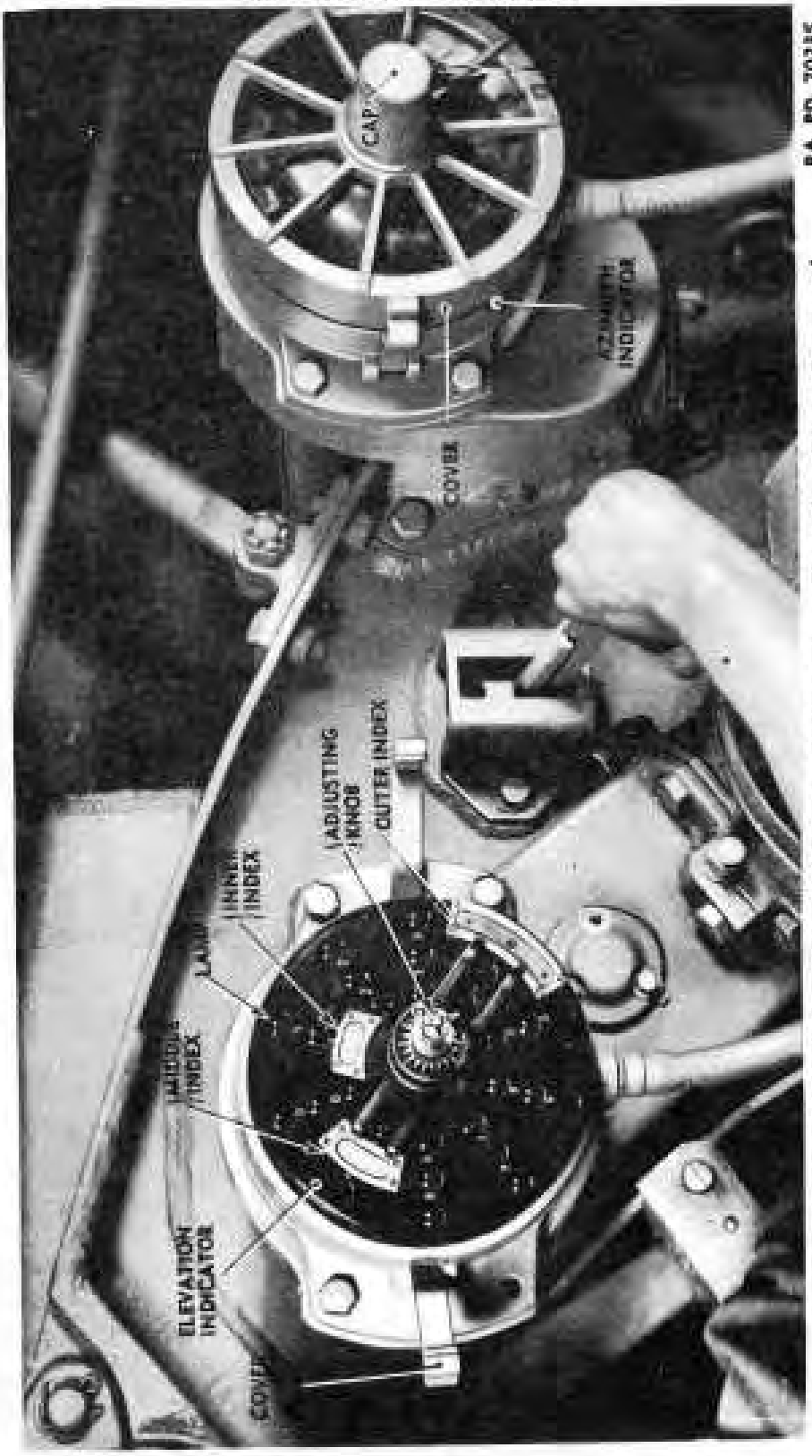
(9) Clutches are provided for driving in azimuth or elevation.

79. AZIMUTH AND ELEVATION INDICATORS.

a. Description.

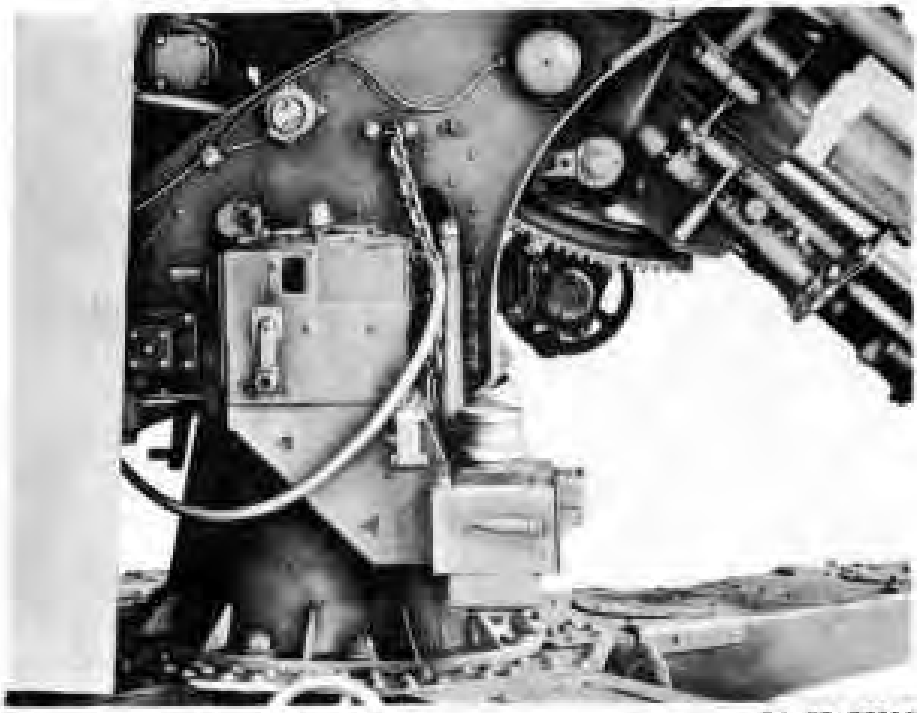
(1) The azimuth and elevation indicators on the gun carriage are identical (fig. 100). Each indicator consists of a cylindrical case containing three concentric rings of 10-volt electric lamp sockets. Each socket has an individual positive electrical connection. All sockets in each indicator have a common negative connection.

(2) Three pointers are pivoted at the center of each indicator, one for each circle of lights. At the end of each pointer is a translucent index. The two inner indexes are each wide enough to cover one light. The outer pointer can span two lights. The pointers are



RA PD 70235

Figure 100 — Azimuth and Elevation Indicators — Elevation Cover Removed



RA PD 70236

Figure 101 — Fuze Setter on Carriage

geared together at a ratio of 1:10:100; the shortest pointer moving 1 turn to 100 of the target pointer. The pointers are mechanically coupled to the azimuth and elevation drives of the gun carriage. A knob at the center of each indicator is used for synchronizing the indicator arms with the gun prior to operation.

(3) The case is bolted to the top carriage and has a cover which consists of a 10-armed spider which supports a translucent plastic sheet cupped within the spider. A dowel on the case fits a hole in the rim of the spider, permitting assembly in only one position. This assures maximum visibility of the lights. Two spring clips clamp the cover in place. At the center of the spider is a chained cap which protects the adjusting knob of the indicator.

b. Operation.

(1) Sight the range finder of the stereoscopic director on a distant aiming point (a distant terrestrial object or a celestial body) and bore sight the guns of the battery on this target. If the lighted lamps of the azimuth and elevation indicators of each gun cover the lighted lamps the gun is oriented with the director. If adjustment is necessary, remove the metal cap and engage the knob with the cross piece in the shaft, turn until the dial is blacked out, and release the knob.

(2) The gun is thereafter operated as the lights flash on around the circle by turning the elevating and traversing handwheels to keep the lamps blacked out.

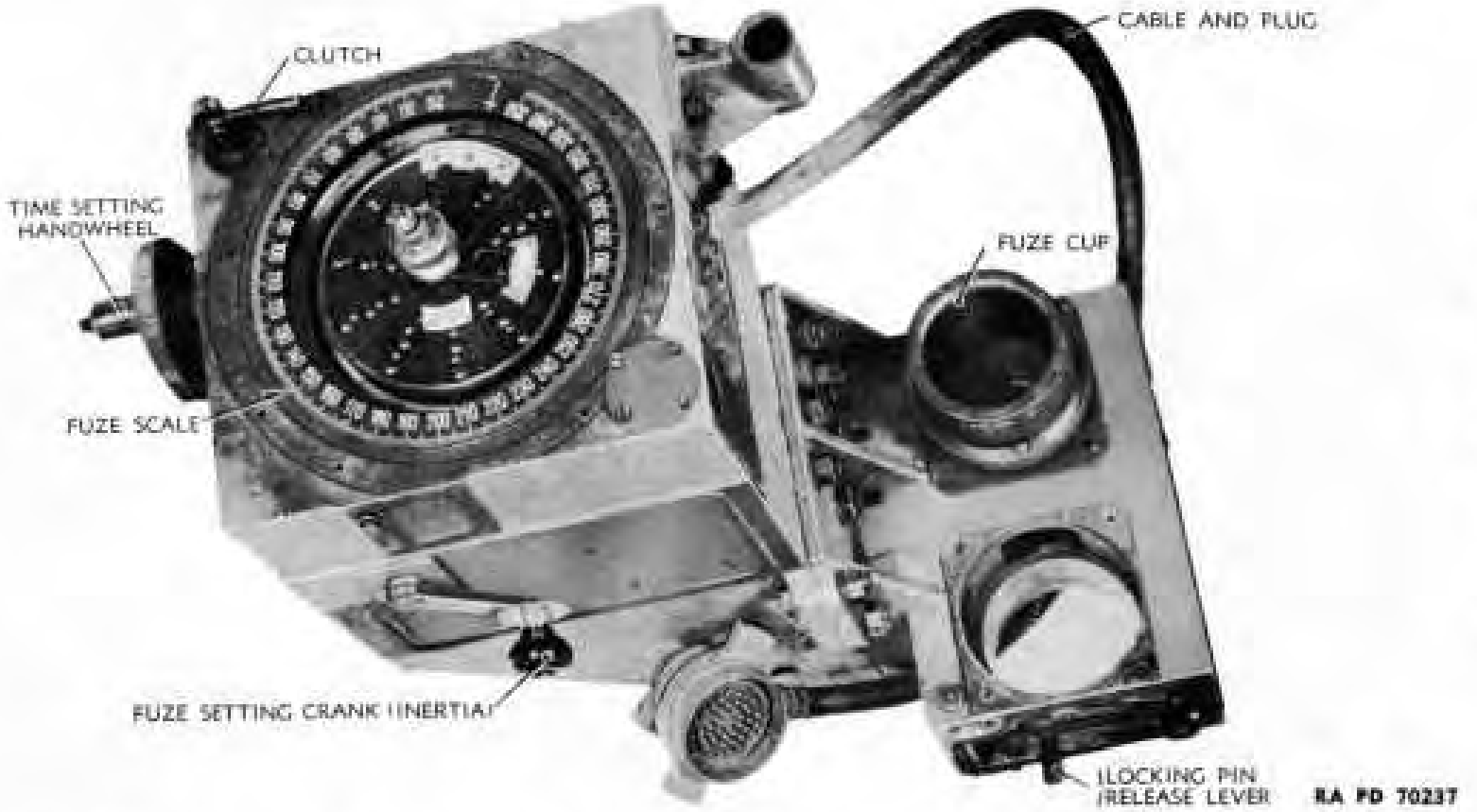


Figure 102 — Fuze Setter — Close-up, Showing Cover Removed and One Fuze Cap Disassembled

80. FUZE SETTER.

a. Description.

(1) The fuze setter is mounted on the left side of the top carriage (fig. 101). It is manually operated and is capable of cutting two fuzes at a time. It may be used with either the stereoscopic director or the auxiliary director.

(2) For use with data electrically transmitted from the stereoscopic director, the fuze setter has a system of lights similar to that employed in the azimuth and elevation indicators. In the top of the fuze setter is a plate containing three concentric rings of 10-volt electric lamp sockets. Each socket has an individual positive electrical connection. All the sockets have a common negative connection. Three pointers are pivoted at the center of the circles, one for each circle of lights. At the end of each pointer is a translucent index. The two inner indexes are each wide enough to cover one light. The outer pointer can span two lights. The pointers are geared together at a ratio of 1:10:100, the shortest pointer moving 1 turn to 100 turns of the longest pointer. The pointers are geared to the fuze dial and to the setting ring of the fuze setter.

(3) For use with data telephoned from the auxiliary director, the fuze setter has a scale graduated from 15 to 350 degrees (fig. 102). The safe position is marked with a cross. (American fuze setter dials are marked in fuze seconds. A conversion scale is necessary for converting from American fuze seconds, with corrector values set in to the degree markings on this fuze setter.)

(4) The setting crank at the front of the fuze setter turns the pointers and the fuze dial. The crank at the side of the fuze setter turns the inertia flywheel which stores up mechanical energy for cutting the fuzes. The release lever releases the round after the fuze is cut. The cable receptacle from the fuze setter extends to the terminal box at the front of the top carriage.

b. Operation.

(1) Turn the setting handwheel to black out the lights (in operation with the stereoscopic director) or to aline the fuze scale in accordance with the values announced by telephone (in operation with the auxiliary director). Turn the power crank, thus storing up energy in the flywheel, and keep the crank turning at a uniform rate.

(2) Thrust the round sharply into one of the cups of the fuze setter, thereby engaging a toothed clutch which rotates the adjusting pin. This makes two complete turns before being automatically disengaged. The round is held in position by a key which rides in a circular groove at the bottom of the fuze. This key is tripped by a lever at the top of the setter and the round is released. Two fuzes may be cut at one time.

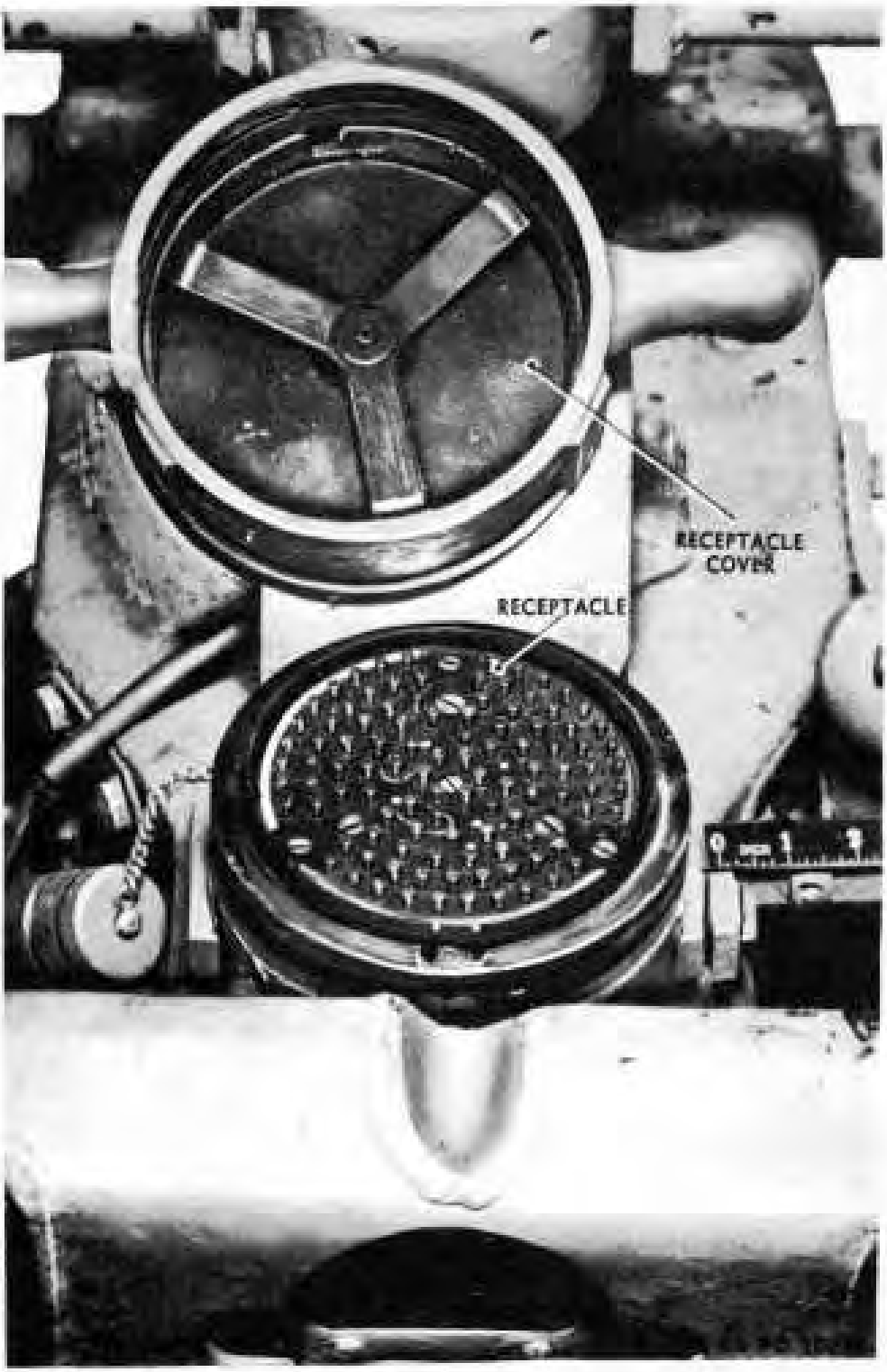


Figure 103 — Data Transmission Receptacle on Rear Trail

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

81. ON-CARRIAGE WIRING.

a. A receptacle containing 104 pins is at the end of the rear trail and is intended for connection to either of the directors (fig. 103). Each pin is numbered and groups of pins are identified by colored dot inserts. Conductors are brought from the end of the trail to a receptacle box at the front of the top carriage. The arrangement of wiring permits traversing the gun a maximum of two turns in either direction. Stops limit further travel and a dial (marked "MUNDUNG," meaning muzzle direction) just over the traversing handwheel is graduated to indicate the number of turns made.

b. Cables and plugs from the azimuth and elevation indicators, the fuze setter and the receptacle, adjacent to each, plug into the receptacle box.

c. The bell just above the fuze setter may be sounded to indicate that the director is on target or may serve as a time interval bell.

d. Conductors are carried in loose flexible coverings throughout the gun carriage and are not armored.

82. AIMING CIRCLE.

a. **General.** The aiming circle (figs. 104 to 107) is used for measuring angle of site, for declinating and determining azimuth angles, and for spotting. The instrument, removed from the tripod, may be used on a plane table for topographic survey. The aiming circle consists of a periscope, a telescope having 4- or 5-power magnification, an angle of site mount, an azimuth mount, and a tripod. The tripod is the same as that of the battery commander's telescope. Carrying cases for the instrument and the tripod are provided. A trench mount is furnished which can be embedded in the ground or in wood for use in place of the tripod. A lamp bracket and portable battery supplies light for the telescope reticle. Graduations are in mils.

b. **Description of Components.**

(1) The periscope raises the line of sight, but has no magnifying power. It is attached, to the aiming circle by a dovetailed slide, but is not locked in place. The aiming circle may be used without the periscope.

(2) The telescope has an adjustable focusing eyepiece. Horizontal and vertical cross lines and a deflection scale are on the reticle of the telescope. On top of the telescope body is a level used with the angle of site mechanism. On the left of the telescope is a circular level. A sun shade is provided for use when the periscope is not attached.

(3) The angle of site mount supports the telescope and includes a graduated elevation scale and micrometer, a magnetic needle, a circular level, and clamping devices.

(a) The elevation scale, graduated from 0 to 1,400 mils, and the micrometer 0 to 100 mils. The normal setting is 300 mils.

FIRE CONTROL EQUIPMENT

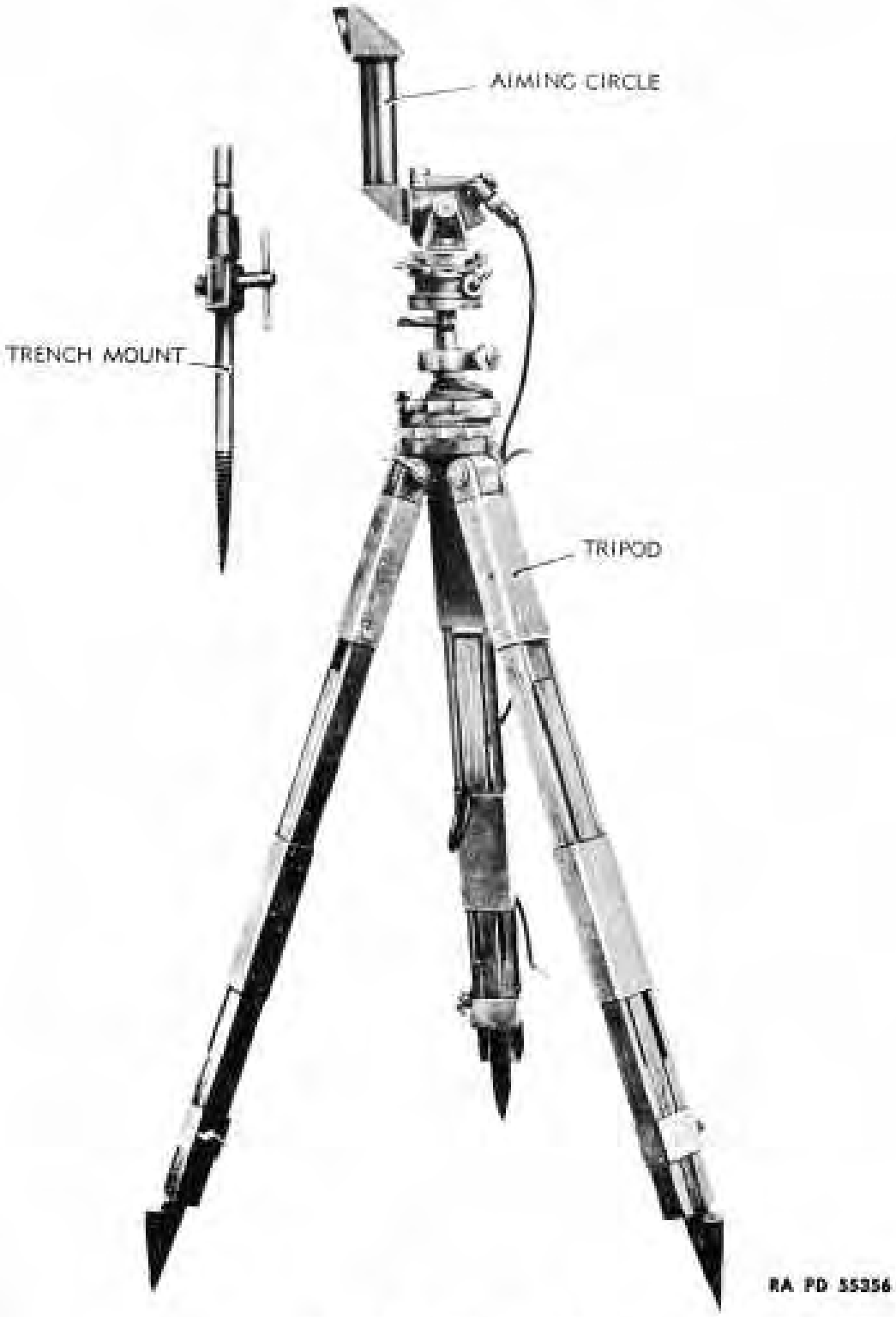


Figure 104 — Aiming Circle

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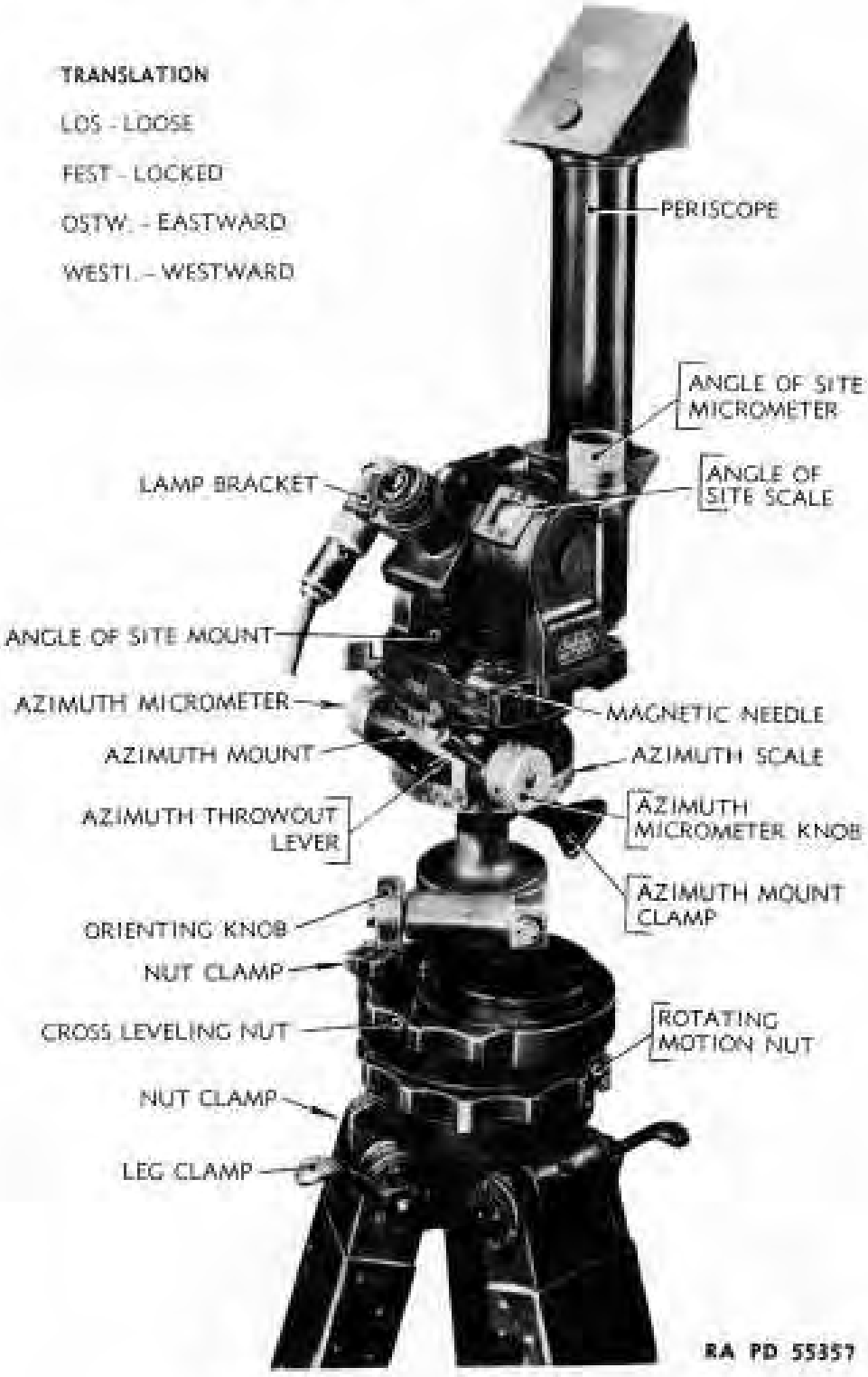


Figure 105 — Aiming Circle — Close-up

FIRE CONTROL EQUIPMENT

Figure 106 — Aiming Circle Components

Figure 107 — Aiming Circle — Angle of Site Mount

(b) The magnetic needle has a visible range of 10 degrees on either side of the magnetic north line. A knob below the window marked "N" locks the needle when it is not in use. A window at the "S" end permits observation from the rear of the instrument.

(c) The circular level is used with the compound head of the tripod for leveling the instrument.

(d) Clamping levers lock the angle of site mount on the azimuth mount.

(e) The folded 10-centimeter ruler (fig. 107), is for use when the telescope and angle of site mount, disengaged from the traversing mechanism, is in use on a plane table in topographic survey.

(4) The azimuth mount has a tapered stud which supports the angle of site mount, an azimuth scale, graduated from 0 to 6,400 mils in 100-mil intervals, and a micrometer, graduated from 0 to 100 mils in 1-mil intervals. A throw-out lever permits rapid traversing of the instrument. The azimuth mount is clamped to the spindle of the tripod.

(5) The tripod is used for both the aiming circle and battery commander's telescope. The tripod includes a spindle, a worm and worm wheel mechanism, a ball and socket joint, and individually clamped legs. The spindle supports the instrument and is attached to the worm and worm wheel mechanism which is used for orientation.

The ball and socket joint includes the ball at the end of the spindle, two clamping nuts, one of which permits cross leveling and the other, circular oscillation. The tripod legs have clamping levers at the head for locking each leg to the head. At the foot of each leg is a steel point and foot rest which facilitate embedding in the ground.

(6) The carrying case is provided for the instrument. The table of contents pasted in the cover includes one lamp bracket and four lamps, a dry cell battery holder, a dust brush, a cleaning cloth, and an impregnated cloth to be used in decontaminating parts of the instrument which may have been subjected to gas attack.

c. Operation.

(1) To set up the instrument, clamp the tripod legs at the desired length and embed them firmly in the ground. Level the instrument using the circular level and the ball and socket joint. Tighten the clamping nuts. Focus the telescope as required, using the sleeve on the eyepiece to set in the correction necessary for the observer's eye.

(2) To orient the instrument, a datum point of known azimuth or a magnetic bearing may be used.

(a) To orient on a datum point of known azimuth, set the main azimuth scale (100-mil intervals) and micrometer (1-mil intervals) to the azimuth of the datum point and turn the orienting knob until the datum point appears on the vertical cross line of the reticle. The instrument may also be relocated on the tripod spindle using the orienting clamping screw for large angular changes. The telescope may be elevated or depressed as required to center the point in the field of view.

(b) To orient on magnetic north, set the main azimuth scale and micrometer to indicate zero. Press the plunger releasing the magnetic needle and turn one of the orienting knobs until the north-seeking end of the magnetic needle appears approximately opposite the "N" index at the front of the instrument; then refine the setting so that the south-seeking end of the needle is centered in the reticle. The instrument may also be relocated on the tripod spindle using the orienting clamping screw for large angular changes. The aiming circle will then indicate magnetic azimuths.

(c) To orient on grid north, proceed as for magnetic north but set the azimuth to the magnetic declination of the locality (subtracting west declinations from 6,400 mils) instead of to zero. The instrument will then indicate grid azimuths.

(d) When orientation by magnetic bearings has been completed, turn the knob to clamp the magnetic needle.

(3) To read azimuth, bring the object on the vertical cross line of the reticle using the azimuth knob; the throw-out lever may be depressed for making large azimuth changes rapidly. Azimuths from

RA PD 55360

Figure 108 — Range Finder 34 with Harness

0 to 6,400 mils are read directly on the azimuth scale; the scale is graduated at 100-mil intervals and the micrometer is graduated at 1-mil intervals.

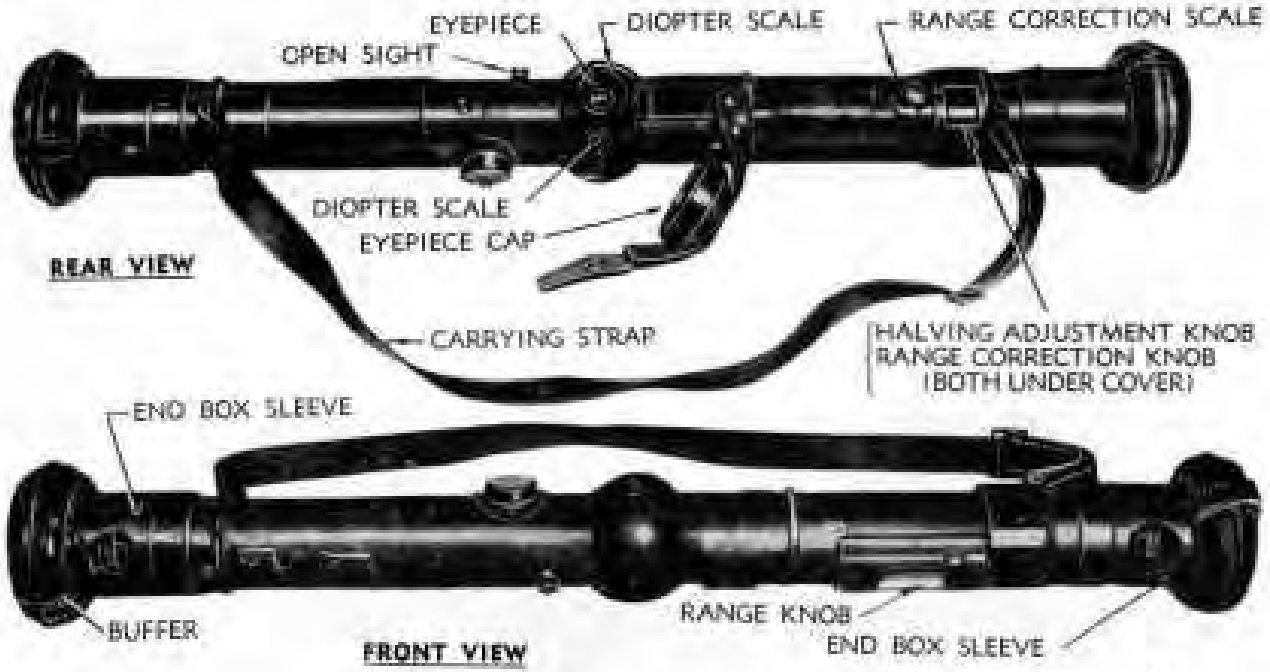
(4) To read angle of site, first make sure that with the telescope level bubble and the circle level bubble centered the angle of site scale and micrometer read normal. Then center the object in azimuth. Raise or depress the angle of site micrometer to center the object on the reticle cross lines and read the angle of site on the scale and micrometer.

(5) To prepare the instrument for traveling, place it in the carrying case provided.

d. Tests and Adjustments.

(1) The azimuth micrometers should read "0" when the azimuth scale indicates zero. The screw in the end of the azimuth micrometer may be temporarily loosened for this adjustment.

(2) The line of sight as determined by the center of the reticle should be horizontal when the bubble in the telescope level is centered. This may be verified by sighting on a distant point at the same level as the telescope, the error, if any, being read on the reticle. No corrective adjustment by the using arms is permitted.



TRANSLATION

EM 34 - (ENTFERNUNGSMESSER) - RANGE FINDER 34
ENTFERNUNGSUERICHTIGUNG - RANGE CORRECTION
VERGR - 11X - MAGNIFICATION 11X
SPERREN - SHUT
NUR IN STELLUNG "ZU" SPERREN U. OFFEN - OPEN OR CLOSE ONLY IN "TOWARD" POSITION
BERICHTIGUNG DER HOHE - ADJUST FOR HEIGHT
BERICHTIGUNG DER ENTFERNUNG - ADJUST FOR RANGE
GEBR. WICHMANN M.B.H. - WICHMANN BROS. LTD.
ENTFERNUNGS-TEILUNG IM EINBLICK ABLESEN - RANGE SCALE - READ OFF IN EYEPIECE

RA PD 55361

Figure 109 — Range Finder 34 — Assembled Views

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

Figure 110 — Range Finder 34 with Adjusting Lath

FIRE CONTROL EQUIPMENT

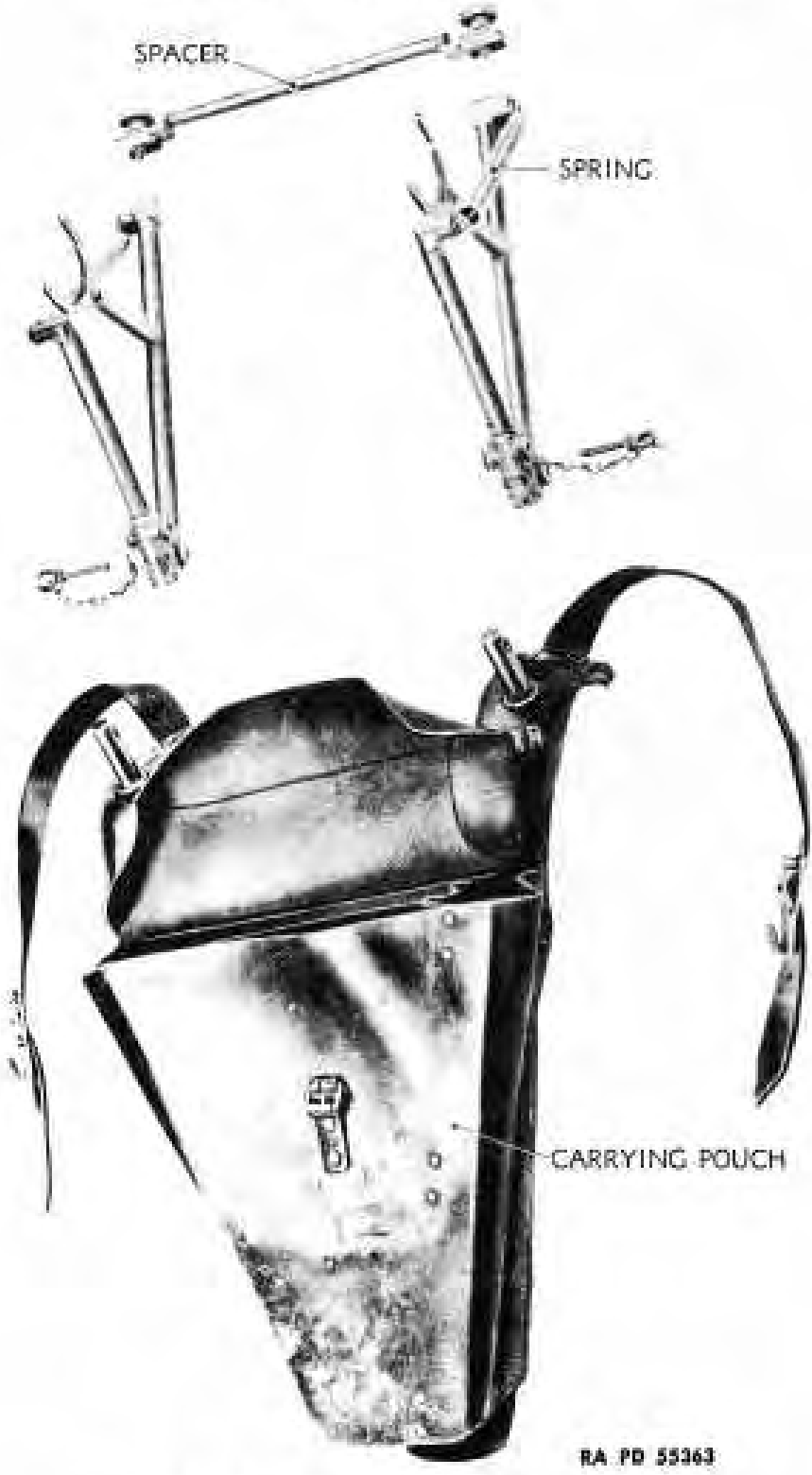


Figure 111 — Range Finder 34 — Harness

(3) To check the accuracy of the declinator, it is necessary to set up the instrument in a position not subject to local magnetic attraction and sight on one or (preferably) more points of known azimuth. The average error should be noted and the necessary correction recorded. No adjustment by the using arms is permitted.

e. **Care and Preservation.** Refer to paragraph 87 for general instructions pertaining to the care and preservation of instruments.

83. RANGE FINDER MODEL 34.

a. This instrument (figs. 108 to 111) is used primarily for measuring distances by triangulation. Range values are read in the field of view.

b. **Description.** The instrument includes an internal 70-centimeter base line, all power optical system with two objectives, a common eyepiece of the coincidence type, and a scale on which the distance is indicated. It is furnished complete with a carrying strap, an eyepiece cap and strap, a shoulder harness with carrying pouch, and an adjusting lath with carrying case.

c. **Operation.**

(1) To set up the instrument, adjust the harness on the observer. See figure 108. The carrying pouch should hang on the back; the spring mounted holders for the range finder should extend in front of the observer. Carefully place the range finder in the holders and in line with the eye of the observer.

(2) Focus the eyepiece by rotating the diopter scale to produce a sharp image; if the operator knows the value for his own eye, the setting may be made directly on the scale.

(3) To measure the range of a target, aline the instrument on the target, using the open sight. Select a clearly defined part, perpendicular if possible to the halving line. Center the target in the field of view. Turn the range knob until the images of the target appear in coincidence. Read the range value centered in the field of view.

(4) To prepare the instrument for traveling, remove the instrument from the harness, close the end box covers, and cover the eyepiece. Disassemble the harness and put it in the carrying pouch.

d. **Tests and Adjustments.** Information on this is not available at this time but will be published when available.

e. **Care and Preservation.**

(1) Refer to paragraph 87 on general instructions pertaining to the care and preservation of instruments.

(2) Keep the end box sleeves closed and eyepiece covered when the instrument is not in use.

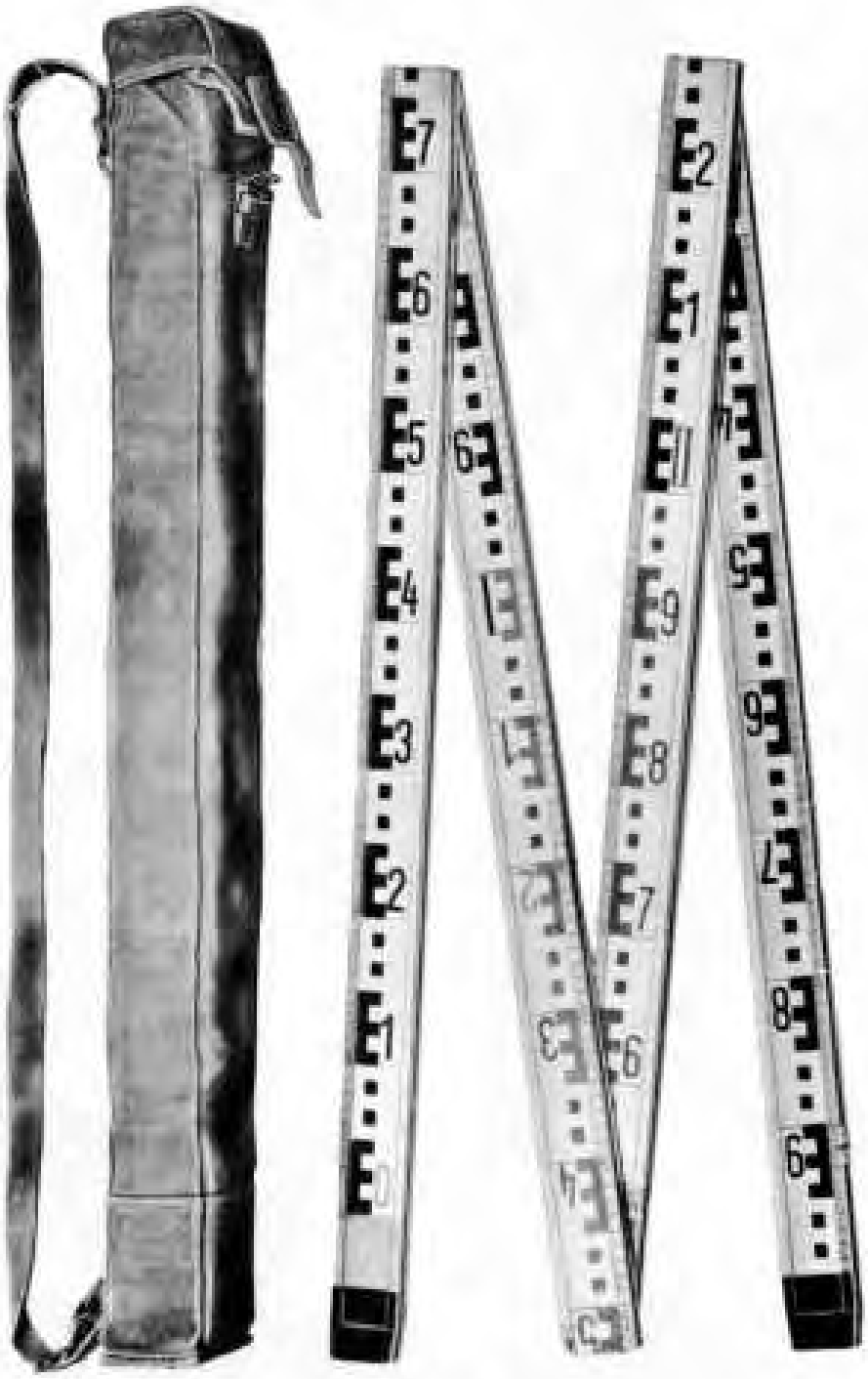


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Figure 112 – Surveying Rod and Carrying Case

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

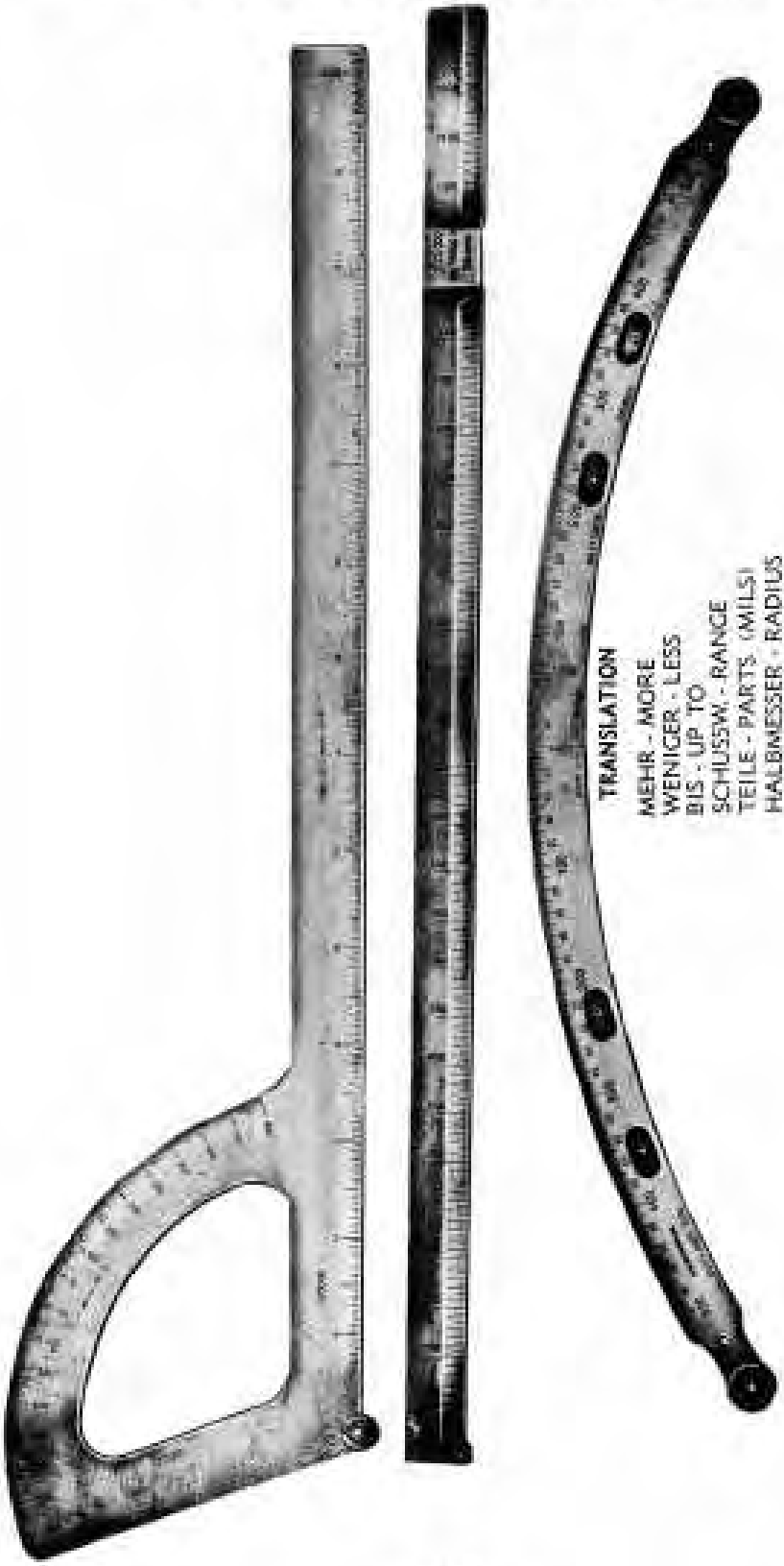

Figure 113 — Plotting Rules

FIRE CONTROL EQUIPMENT

84. SURVEYING ROD.

a. A 3-meter surveying rod (fig. 112), graduated in 1-centimeter divisions, is provided for orientation of the battery. The rod is hinged to reduce its length to about three-quarters of a meter for storage and travel. The folded rod is carried in a canvas case fitted with a sling strap.

85. PLOTTING RULES.

a. Three rules are furnished as plotting board accessories.

b. One steel rule (fig. 113) bears a linear scale, graduated from 0 to 14 kilometers in 5-meter intervals, and a quadrant, graduated from minus 800 mils to plus 800 mils in 50-mil intervals. At the zero end is a center for pivoting. This rule may be used for plotting azimuth and range values on a topographic map with a scale of 1:25000.

c. The steel protractor is graduated from minus 500 mils to plus 500 mils in 2-mil intervals. The radius of curvature is 480 milimeters. Two points permit pinning the protractor to a board.

d. The other steel rule bears a linear scale graduated from 0 to 14,600 meters in 50-meter intervals and a center at the zero end. At about 11,800 meters is a raised section. When this rule is set up with the protractor on a deflection chart, the raised section clears the protractor. The rule and protractor are used for plotting deflections on a chart with a scale of 1:25000.

86. BATTERY COMMANDER'S TELESCOPE.

a. Description.

(1) The battery commander's telescope is a 10-power binocular instrument used for observation and for measuring azimuths and angles of site. The instrument consists of a telescope and an azimuth mount, tripod, carrying case, and accessories. The tripod includes an orienting mount. A trench mount is furnished, which can be embedded in the ground or in wood, for use in place of the tripod.

(2) The telescope arms may be positioned vertically (fig. 114) or they may be swung horizontally (fig. 116) to increase the steroscopic effect. The reticle, which remains erect in any position of the telescope arms, is illuminated by the removable lamp on the slide near the reticle.

b. Operation.

(1) To set the instrument, clamp the tripod legs at the desired length, embed them firmly in the ground, and tighten the leg clamping levers. Using the spring plunger, clamp the telescope on the vertical spindle extending from the orienting mount. (The tripod has a mount which permits cross leveling and orienting.) Level the mount by cen-

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

Figure 114 — Battery Commander's Telescope with Cases

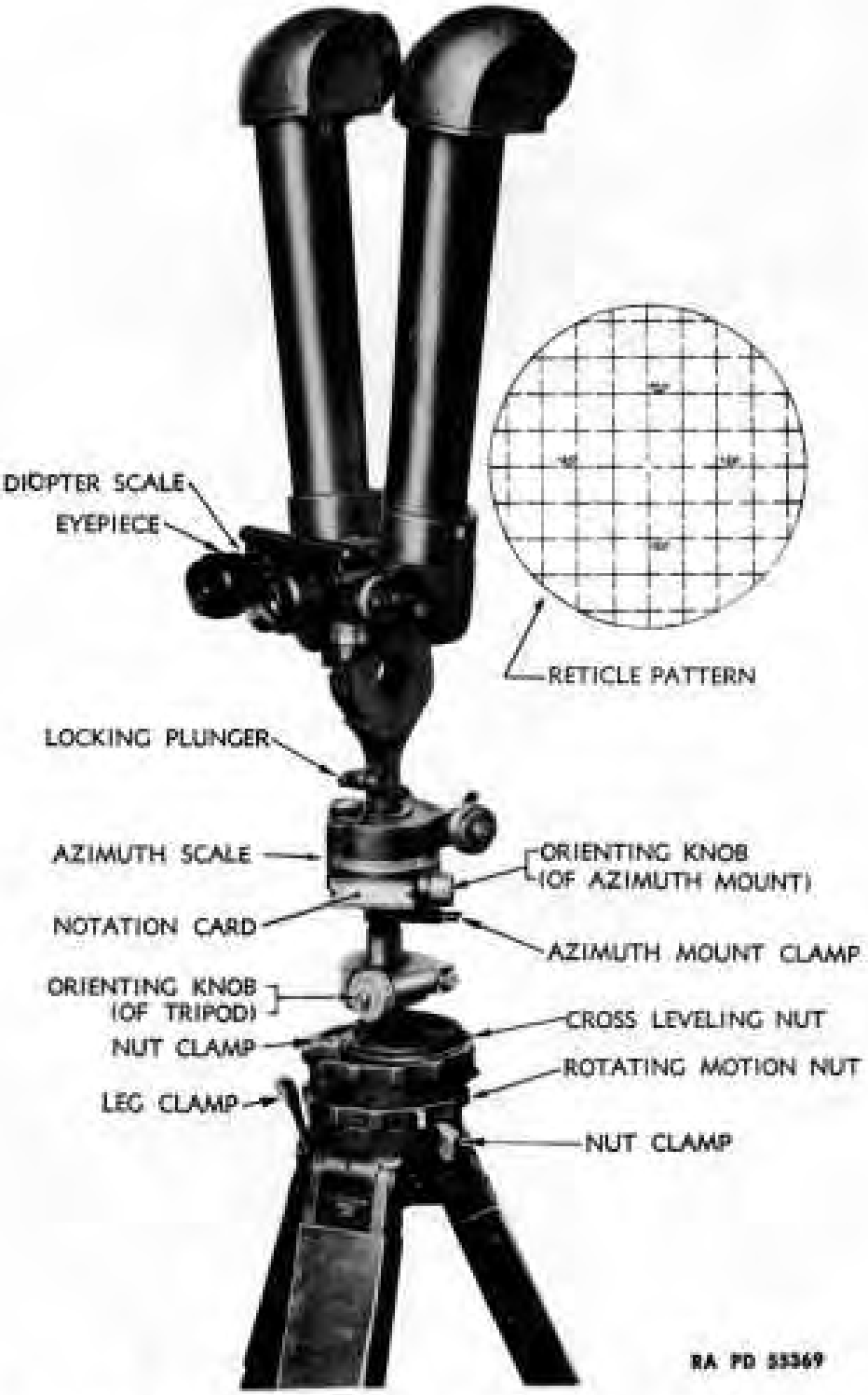

Figure 115 — Battery Commander's Telescope — Close-up

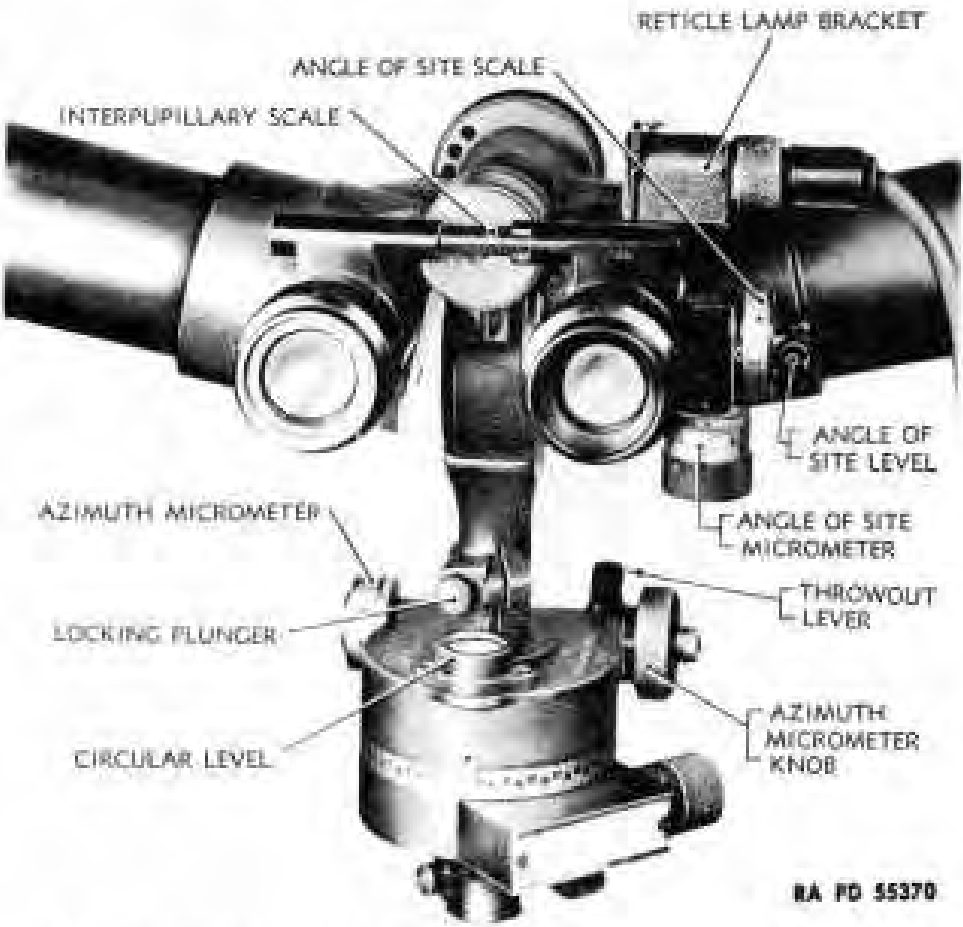

Figure 116 — Battery Commander's Telescope — Interpupillary Scale and Angle of Site Mechanism

tering the bubble in the circular level. When the bubble is centered, clamp the ball and socket joint on the lower mount.

(2) To prepare the telescope, release the telescope clamping knob (fig. 114) and turn the telescope arms to the vertical or horizontal position, as required. Set the proper interpupillary distance on the interpupillary scale (fig. 115), graduated from 55 to 75 milimeters, and tighten the interpupillary clamp knob. If the interpupillary distance for the observer is not known, it may be found by observing the sky and moving the eyepiece apart or together until the field of view changes from two circles or two overlapping circles to one sharply defined circle. The interpupillary wing knob is then clamped. Focus each eyepiece independently by covering one of them and looking through the telescope with both eyes open at an object several hundred yards away; turn the diopter scale until the object observed appears sharply defined. The diopter scale on each eyepiece permits

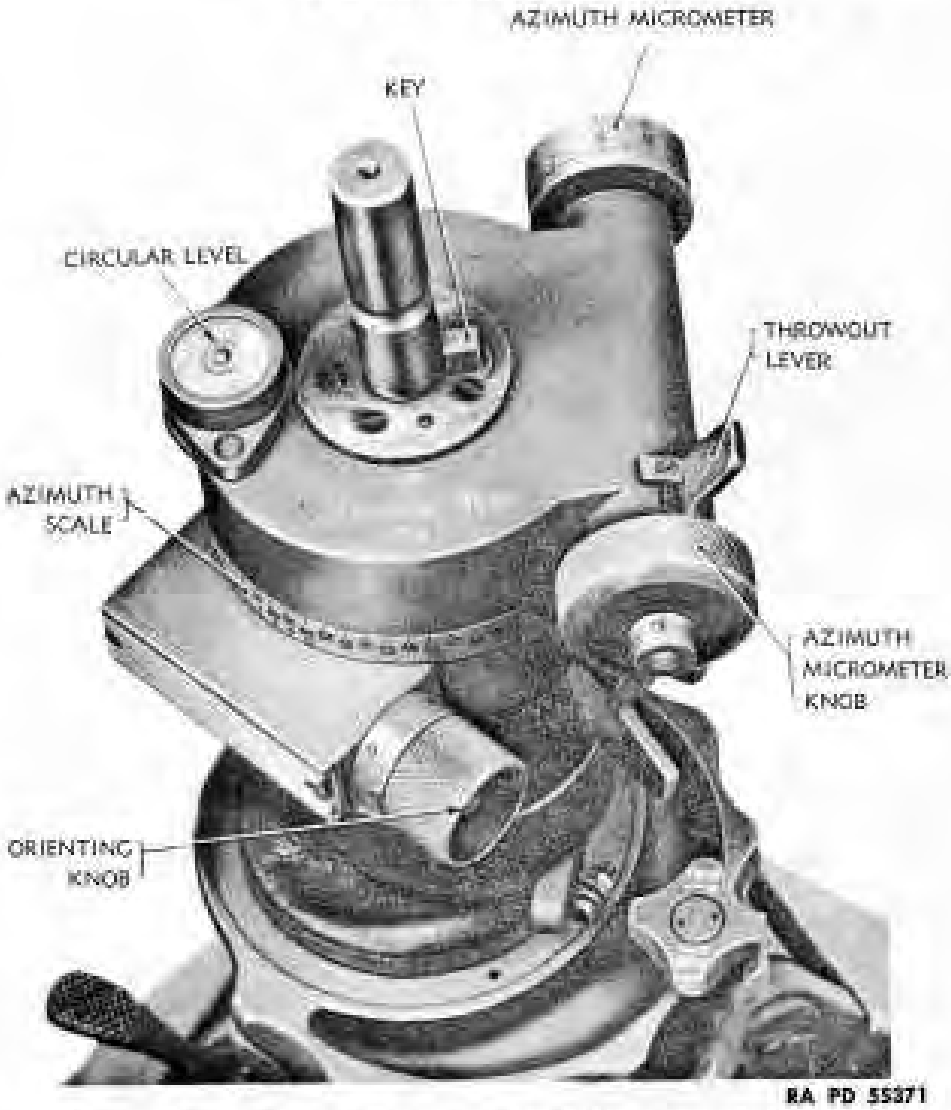

Figure 117 — Battery Commander's Telescope — Azimuth Mount

immediate adjustment for each eye if the observer knows his own eye corrections. If required, place the light or dark filters over the eyepieces and the metal sunshades over the objective lenses. Tubular sections, about 8 inches long, can be attached to the sun shades for protection against rain.

(3) To orient the instrument, select a datum point of known azimuth and set this value on the azimuth scale (100-mil steps) and micrometer (1-mil steps). The throw-out lever may be used for making large changes in azimuth rapidly. Turn the telescope with the orienting knob until the datum point appears at the center of the reticle of the right-hand telescope. The orienting clamping knob may be temporarily released for making large angular changes rapidly. Thereafter, use

only the azimuth knob, or, for large changes, the azimuth throw-out lever, and the correct azimuth of the point observed will be indicated. For azimuths in the 3,200- to 6,400-mil region additional numbers (0 to 3,200 mils) are provided, corresponding to the azimuth scale on the panoramic telescope.

(4) Direct the telescope on the object and rotate the elevating knob until the object appears at the center of the reticle. Center the angle of site level bubble by adjusting the angle of site knob. The angle of site is then read on the angle of site scale. It is not known whether the graduations on the angle of site scale are in mils or in $\frac{1}{10}$ degrees. An indication of 300 corresponds to a horizontal line of sight.

(5) The reticle (fig. 115), located in the right eyepiece, is a grid, the horizontal and vertical axis of which are graduated in 100-mil intervals.

(6) A throw-out mechanism is provided for rapidly traversing the telescope. A circular level is provided for leveling the head. The traversing head is graduated from 0 to 64 in 100-mil divisions with a micrometer adjustment from 0 to 100 in 1-mil divisions.

(7) To prepare the instrument for traveling, remove the sun shades and filters, if used. Loosen the telescope clamping knob and place the telescope arms in a vertical position. Disengage the telescope from the mount and place the instrument in the wooden carrying case.

c. Tests and Adjustments.

(1) The azimuth micrometer and azimuth scale should read zero simultaneously. The screw in the end of the micrometer may be temporarily loosened to permit adjustment.

(2) The angle of site mechanism may be checked by observing a datum point of known angle of site. Small errors may be corrected by temporarily loosening the screw in the end of the knob and slipping the micrometer and knob to the correct position. Should the angle of site scale and micrometer then fail to indicate "300" and "0" respectively, the instrument should be turned in for adjustment by authorized ordnance personnel.

d. Care and Preservation.

(1) Refer to paragraph 87 for general instructions pertaining to the care and preservation of instruments.

(2) Always release the telescope clamping knob before rotating the telescopes in a vertical plane. Failure to do this often results in damaging the instrument and causes double vision.

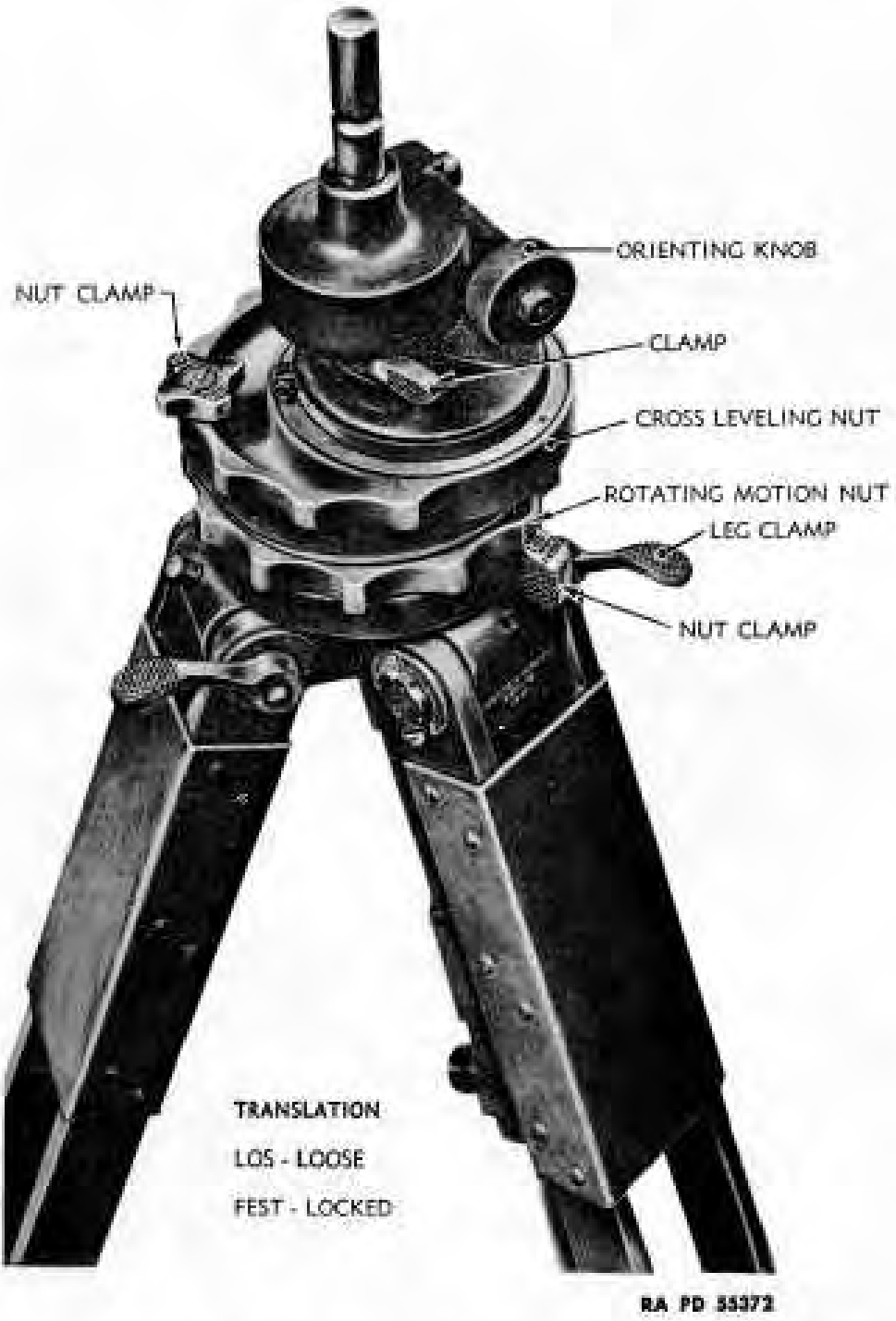

Figure 118 — Battery Commander's Telescope and Aiming Circle — Tripod Head

GERMAN 88-MM ANTIAIRCRAFT GUN MATERIEL

87. CARE AND PRESERVATION.

a. General.

(1) The instructions given hereunder supplement instructions pertaining to individual instruments included in preceding paragraphs.

(2) Fire control and sighting instruments are, in general, rugged and suited for the purpose for which they have been designed. They will not, however, stand rough handling or abuse. Inaccuracy or malfunctioning may result from such mistreatment.

(3) Unnecessary turning of screws or other parts not incident to the use of the instrument is expressly forbidden.

(4) Keep the instruments as dry as possible. Do not put an instrument in its carrying case when wet.

(5) When not in use, keep the instruments in the carrying cases provided, or in the condition indicated for traveling.

(6) The maintenance duties described are those for which tools and parts have been provided the using personnel. Other replacements and repairs are the responsibility of maintenance personnel, but may be performed by the using arm personnel, when circumstances permit, within the discretion of the commander concerned.

(7) No painting of fire control or sighting equipment by the using arms is permitted.

(8) Many worm drives have throw-out mechanisms to permit rapid motion through large angles. When using these mechanisms, it is essential that the throw-out lever be fully depressed to prevent injury to the worm and gear teeth.

(9) When using a tripod with adjustable legs, be certain that the legs are clamped tightly to prevent possibility of collapse.

(10) When setting up tripods on sloping terrain, place two legs on the downhill side to provide maximum stability.

(11) Dry cell batteries should not be kept in the battery boxes when the instrument is not in use. Dry cell batteries when weak deteriorate rapidly and will cause corrosion and other damage to containers.

(12) Data transmission cables should be protected against crushing by vehicles.

b. Optical Parts.

(1) To obtain satisfactory vision, it is necessary that the exposed surfaces of the lenses and other parts be kept clean and dry. Corrosion

and etching of the surface of the glass can be prevented or greatly retarded by keeping the glass clean and dry.

(2) Under no condition will polishing liquids, pastes, or abrasives be used for polishing lenses and windows.

(3) For wiping optical parts, use only lens paper specially intended for cleaning optical glass. Use of cleaning cloths in the field is not permitted. To remove dust, brush the glass lightly with a clean camel's-hair brush and rap the brush against a hard body in order to knock out the small particles of dust that cling to the hairs. Repeat this operation until all dust is removed. With some instruments an additional brush with coarse bristles is provided for cleaning mechanical parts; it is essential that each brush be used only for the purpose intended.

(4) Exercise particular care to keep optical parts free from oil and grease. Do not wipe the lenses or windows with the fingers. To remove oil or grease from optical surfaces, apply ALCOHOL, ethyl, grade 1, with a clean camel's-hair brush and rub gently with clean lens paper. If alcohol is not available, breathe heavily on the glass and wipe off with clean lens paper; repeat this operation several times until clean.

(5) Moisture due to condensation may collect on the optical parts of the instrument when the temperature of the parts is lower than that of the surrounding air. This moisture, if not excessive, can be removed by placing the instrument in a warm place. Heat from strongly concentrated sources should not be applied directly, as it may cause unequal expansion of parts, thereby resulting in breakage of optical parts or inaccuracies in observation.

c. **Lubricants.**

(1) Where lubrication with oil is indicated, use OIL, lubricating, for aircraft instruments and machine guns.

(2) Where lubrication with grease is indicated, use GREASE, lubricating, special.

(3) Exposed moving points should be oiled occasionally. Interior parts are not to be lubricated by the using arms. Wipe off any excess lubricant that seeps from the mechanisms to prevent accumulation of dust and grit.

(4) The tripod pivots should be carefully oiled at frequent intervals.

(5) Do not oil optical parts.

CHAPTER 5

FIRING TABLES

*Kz—Kopfzünder = Nose fuze.

88. FIRING TABLE FOR THE 8.8 cm FLAK 18 AND 36 WITH 8.8 cm H.E. SHELL L/4.5 (Kz)* WITH TIME FUZE S/30 OR P.D. FUZE 23/28 (TABLE I).

M.V. 820 m/s or 2690 ft/sec. Weight of shell 9.00 kg or 19.8 lb Weight of air at ground level = 1.22 kg/m³ or 533 grains/cu ft

Range		Quadrant Elevation	Drift	For S/30 Fuze Only Fuze Setting at 0 Meters Remaining Flight	Time of Flight	Maximum Ordinate		1/16 deg Changes the Point of Impact by	Means (50 percent) Dispersion			Angle of Impact	Velocity
						Distance	Height		Range	Width	Height		
yd	m	deg	mils	deg from cross	sec	m	m	m	m	m	m	deg	m/s
	1	2*	3	4	5	6	7	8	9	10	11	12*	13
109	100	0 1	0	—	0.13	50	0	147	—	—	—	0 1	810
219	200	0 1	0	—	0.26	100	0	145	68	0.1	0.2	0 1	800
328	300	0 2	0	—	0.39	150	1	143	68	0.1	0.3	0 2	789
437	400	0 3	0	21	0.52	201	1	140	69	0.1	0.3	0 2	779
547	500	0 4	0	22	0.65	252	2	138	69	0.2	0.4	0 3	769
656	600	0 4	0	24	0.78	303	2	136	69	0.2	0.4	0 4	759
766	700	0 5	0	25	0.91	354	3	134	69	0.2	0.5	0 5	749
875	800	0 6	0	27	1.05	406	3	131	69	0.3	0.6	0 6	739
984	900	0 7	0	28	1.18	458	4	129	69	0.3	0.7	0 7	729
1094	1000	0 8	0	30	1.32	510	5	127	69	0.3	0.7	0 8	720
1203	1100	0 9	0	31	1.46	562	5	125	69	0.4	0.8	0 9	710
1312	1200	0 9	0	33	1.60	614	6	122	69	0.4	0.9	0 10	700
1422	1300	0 10	0	35	1.74	667	7	120	69	0.5	1.0	0 11	691
1531	1400	0 11	0	36	1.89	720	8	118	69	0.5	1.0	0 12	681
1640	1500	0 12	0	38	2.04	773	9	116	69	0.5	1.1	0 13	672

*Numbers in column 2 are in degrees, and in column 5 in 1/16 degrees.

Range		Quadrant Elevation	Drift	For S/30 Fuze Only Fuze Setting at 0 Meters Remaining Flight	Time of Flight	Maximum Ordinate		1/16 deg Changes the Point of Impact by	Means (50 percent) Dispersion			Angle of Impact	Velocity
						Distance	Height		Range	Width	Height		
yd	m	deg	m/s	deg from cross	sec	m	m	m	m	m	m	deg	m/s
	1	2*	3	4	5	6	7	8	9	10	11	12*	13
1750	1600	0 13	0	40	2.19	826	10	114	69	0.6	1.2	0 14	663
1859	1700	0 14	1	41	2.34	879	11	111	69	0.6	1.2	0 15	653
1968	1800	0 14	1	43	2.49	933	12	109	69	0.7	1.3	1 1	644
2078	1900	0 15	1	45	2.65	987	13	107	69	0.7	1.4	1 2	635
2187	2000	1 0	1	47	2.81	1041	14	105	70	0.8	1.5	1 3	626
2297	2100	1 1	1	48	2.97	1095	15	103	70	0.8	1.6	1 5	618
2406	2200	1 2	1	50	3.13	1150	16	101	70	0.9	1.7	1 6	609
2515	2300	1 3	1	52	3.29	1205	17	99	70	0.9	1.9	1 7	600
2625	2400	1 4	1	54	3.46	1260	19	97	70	0.9	2.0	1 9	592
2734	2500	1 5	1	56	3.63	1316	20	95	70	1.0	2.1	1 10	583
2843	2600	1 6*	1	58	3.80	1372	21	93	70	1.0	2.2	1 12*	575
2953	2700	1 7	1	60	3.97	1429	23	91	70	1.1	2.3	1 14	567
3062	2800	1 8	1	62	4.15	1486	24	89	70	1.1	2.4	1 15	558
3172	2900	1 10	1	64	4.33	1543	26	87	70	1.1	2.6	2 1	550
3281	3000	1 11	1	66	4.51	1601	28	85	70	1.2	2.7	2 3	542
3390	3100	1 12	1	68	4.70	1659	30	83	70	1.2	2.8	2 5	534
3500	3200	1 13	1	70	4.89	1717	32	81	70	1.3	3.0	2 7	526
3609	3300	1 14	1	72	5.08	1775	35	79	70	1.3	3.1	2 9	518
3718	3400	2 0	1	75	5.28	1834	37	78	70	1.4	3.3	2 11	510
3828	3500	2 1	1	77	5.48	1893	40	76	70	1.4	3.5	2 13	503

3937	3600	2 2	1	79	5.68	1952	42	74	70	1.5	3.7	2 15	495
4046	3700	2 4	2	82	5.89	2011	45	73	71	1.5	3.9	3 2	487
4156	3800	2 5	2	84	6.10	2071	48	71	71	1.6	4.1	3 4	479
4265	3900	2 6	2	86	6.31	2131	51	70	71	1.6	4.3	3 7	472
4374	4000	2 8	2	89	6.52	2191	54	68	71	1.7	4.6	3 10	464
4484	4100	2 9	2	91	6.74	2252	58	67	71	1.7	4.8	3 13	457
4593	4200	2 11	2	94	6.96	2313	61	65	71	1.8	5.1	4 0	450
4703	4300	2 12	2	96	7.18	2374	65	64	71	1.8	5.3	4 3	442
4812	4400	2 14	2	99	7.41	2436	69	62	71	1.9	5.6	4 6	435
4921	4500	3 0	2	101	7.64	2498	73	61	71	1.9	5.9	4 10	428
5031	4600	3 1	2	104	7.87	2560	77	60	71	2.0	6.1	4 13	421
5140	4700	3 3	2	107	8.11	2622	81	58	71	2.0	6.4	5 1	414
5249	4800	3 5	2	109	8.35	2685	86	57	71	2.1	6.7	5 4	407
5359	4900	3 6	2	112	8.60	2748	91	56	71	2.1	7.0	5 8	400
5468	5000	3 8	2	115	8.85	2811	96	55	71	2.2	7.3	5 12	393
5577	5100	3 10*	3	118	9.11	2874	102	53	71	2.3	7.6	6 1*	387
5687	5200	3 12	3	121	9.37	2937	108	52	71	2.3	8.0	6 5	381
5796	5300	3 14	3	124	9.64	3001	114	51	72	2.4	8.4	6 10	375
5905	5400	4 0	3	127	9.91	3065	121	50	72	2.5	8.8	6 14	369
6015	5500	4 2	3	130	10.18	3129	128	49	72	2.5	9.2	7 3	363
6124	5600	4 4	3	133	10.46	3193	135	48	72	2.6	9.7	7 8	358
6234	5700	4 6	3	136	10.74	3257	143	47	72	2.7	10	7 13	353
6343	5800	4 8	3	140	11.03	3321	151	46	72	2.7	10	8 2	348
6452	5900	4 11	3	143	11.32	3385	159	45	72	2.8	11	8 7	344
6562	6000	4 13	3	146	11.62	3450	168	44	72	2.9	11	8 12	340

*Numbers in column 2 are in degrees, and in column 5 in 1/16 degrees.

Range		Quadrant Elevation	Drift	For S/30 Fuze Only Fuze Setting at 0 Meters Remaining Flight	Time of Flight	Maximum Ordinate		1/16 deg Changes the Point of Impact by	Means (50 percent) Dispersion			Angle of Impact	Velocity
						Distance	Height		Range	Width	Height		
yd	m	deg	mils	deg from cross	sec	m	m	m	m	m	m	deg	m/s
	1	2*	3	4	5	6	7	8	9	10	11	12*	13
6671	6100	4 15	3	150	11.92	3515	177	43	72	3.0	12	9 1	336
6780	6200	5 2	3	153	12.22	3580	187	42	72	3.0	12	9 6	332
6890	6300	5 4	4	157	12.53	3645	197	41	72	3.1	13	9 12	329
6999	6400	5 7	4	160	12.84	3710	207	40	72	3.2	13	10 1	326
7108	6500	5 9	4	164	13.15	3775	218	39	72	3.3	14	10 7	323
7218	6600	5 12	4	167	13.47	3840	229	39	73	3.4	14	10 13	320
7327	6700	5 15	4	171	13.79	3905	240	38	73	3.4	15	11 3	317
7437	6800	6 1	4	175	14.11	3970	252	37	73	3.5	15	11 9	314
7546	6900	6 4	4	178	14.44	4035	264	36	73	3.6	16	11 15	312
7655	7000	6 7	4	182	14.77	4100	276	35	73	3.7	16	12 5	309
7765	7100	6 10	4	186	15.10	4165	289	35	73	3.8	17	12 12	307
7874	7200	6 13	4	190	15.43	4230	302	34	73	3.9	17	13 2	305
7983	7300	7 0	5	193	15.77	4295	316	33	73	4.0	18	13 9	303
8093	7400	7 3	5	197	16.11	4360	330	33	73	4.1	18	14	301
8202	7500	7 6	5	201	16.45	4424	345	32	73	4.2	19	14 7	299
8311	7600	7 9*	5	205	16.80	4488	360	32	73	4.3	19	14 14*	297
8421	7700	7 12	5	209	17.15	4552	376	31	73	4.4	20	15 5	295
8530	7800	7 15	5	213	17.50	4616	393	30	73	4.5	21	15 13	293
8640	7900	8 3	5	217	17.86	4680	410	30	74	4.6	21	16 4	291
8749	8000	8 6	5	221	18.22	4744	428	29	74	4.7	22	16 12	289

8858	8100	8 10	6	225	18.59	4808	446	29	74	4.8	23	17 3	287
8968	8200	8 13	6	230	18.96	4871	465	28	74	4.9	24	17 11	286
9077	8300	9 1	6	234	19.33	4934	485	28	74	5.0	24	18 3	284
9186	8400	9 5	6	238	19.71	4997	505	27	74	5.1	25	18 11	282
9296	8500	9 8	6	242	20.09	5060	526	27	74	5.2	26	19 3	281
9405	8600	9 12	6	247	20.47	5123	548	26	74	5.3	27	19 11	279
9514	8700	10 0	6	251	20.86	5185	570	26	74	5.4	27	20 4	278
9624	8800	10 4	6	255	21.25	5247	593	25	74	5.6	28	20 12	276
9733	8900	10 8	7	260	21.64	5309	616	25	74	5.7	29	21 5	275
9842	9000	10 12	7	264	22.04	5371	640	25	75	5.8	30	21 13	273
9952	9100	11 0	7	269	22.44	5432	665	24	75	5.9	31	22 6	272
10061	9200	11 4	7	274	22.85	5493	690	24	75	6.1	31	22 14	271
10171	9300	11 9	7	278	23.26	5554	716	23	75	6.2	32	23 7	269
10280	9400	11 13	7	283	23.67	5615	743	23	75	6.3	33	24 0	268
10389	9500	12 2	8	288	24.09	5676	770	23	75	6.5	34	24 9	267
10499	9600	12 6	8	292	24.51	5737	798	22	76	6.6	35	25 2	266
10608	9700	12 11	8	297	24.93	5797	827	22	76	6.7	36	25 11	265
10717	9800	12 15	8	302	25.36	5857	857	22	76	6.9	37	26 4	264
10827	9900	13 4	8	307	25.79	5917	887	21	76	7.0	38	26 14	263
10936	10000	13 9	8	312	26.22	5977	918	21	76	7.2	39	27 7	262
11045	10100	13 13	9	317	26.66	6037	950	21	77	7.3	41	28 0	261
11155	10200	14 2	9	322	27.10	6097	983	20	77	7.5	42	28 10	260
11264	10300	14 7	9	327	27.55	6156	1016	20	77	7.6	43	29 3	259
11374	10400	14 12	9	332	28.01	6215	1050	20	77	7.8	44	29 13	259
11483	10500	15 1	9	337	28.46	6274	1085	19	78	7.9	45	30 6	258

*Numbers in column 2 are in degrees, and in column 5 in 1/16 degrees.

Range		Quadrant Elevation	Drift	For 5/30 Fuze Only Fuze Setting at 0 Meters Remaining Flight	Time of Flight	Maximum Ordinate		1/16 deg Changes the Point of Impact by	Means (50 percent) Dispersion			Angle of Impact	Velocity
						Distance	Height		Range	Width	Height		
yd	m	deg	mils	deg from cross	sec	m	m	m	m	m	m	deg	m/s
	1	2*	3	4	5	6	7	8	9	10	11	12*	13
11592	10600	15 6	10	—	28.92	6333	1121	19	78	8.1	47	31 0	257
11702	10700	15 12	10	—	29.39	6392	1158	19	78	8.3	48	31 10	257
11811	10800	16 1	10	—	29.87	6450	1196	19	79	8.4	49	32 3	256
11920	10900	16 7	10	—	30.35	6508	1235	18	79	8.6	51	32 13	256
12030	11000	16 12	10	—	30.84	6566	1275	18	79	8.8	52	33 7	255
12139	11100	17 2	11	—	31.34	6624	1316	18	80	9.0	54	34 1	255
12248	11200	17 7	11	—	31.84	6681	1358	18	80	9.1	55	34 11	255
12358	11300	17 13	11	—	32.35	6738	1401	17	81	9.3	57	35 5	254
12467	11400	18 3	11	—	32.87	6795	1445	17	81	9.5	59	35 15	254
12577	11500	18 9	12	—	33.39	6852	1490	17	82	9.7	61	36 9	254
12686	11600	18 15	12	—	33.92	6908	1537	16	82	9.9	62	37 3	254
12795	11700	19 5	12	—	34.46	6964	1585	16	83	10	64	37 13	254
12905	11800	19 12	13	—	35.00	7020	1635	16	84	10	66	38 7	254
13014	11900	20 2	13	—	35.55	7076	1686	16	84	11	68	39 1	253
13123	12000	20 9	13	—	36.11	7131	1739	15	85	11	70	39 11	253
13233	12100	20 15	13	—	36.67	7186	1794	15	86	11	73	40 5	254
13342	12200	21 6	14	—	37.24	7241	1850	15	86	11	75	41 0	254
13451	12300	21 13	14	—	37.82	7296	1908	14	87	11	77	41 10	254
13561	12400	22 4	14	—	38.40	7351	1968	14	88	12	80	42 4	254
13670	12500	22 11	15	—	38.99	7406	2029	14	89	12	83	42 15	254

13779	12600	23 3	15	—	39.59	7461	2092	14	90	12	83	43 9	254
13889	12700	23 10	15	—	40.20	7516	2157	13	91	12	85	44 4	255
13998	12800	24 2	16	—	40.82	7571	2224	13	92	12	91	44 14	255
14108	12900	24 10	16	—	41.45	7625	2293	13	93	13	94	45 9	255
14217	13000	25 2	16	—	42.09	7679	2364	12	94	13	98	46 3	256
14326	13100	25 10	17	—	42.74	7733	2437	12	95	13	101	46 14	256
14436	13200	26 3	17	—	43.41	7787	2513	12	96	13	105	47 9	257
14545	13300	26 12	18	—	44.10	7841	2592	11	97	14	109	48 4	257
14654	13400	27 5	18	—	44.81	7895	2674	11	99	14	114	48 15	258
14764	13500	27 14	19	—	45.54	7949	2760	10	100	14	118	49 10	259
14873	13600	28 8	19	—	46.29	8003	2850	10	102	14	123	50 6	260
14982	13700	29 2	20	—	47.06	8056	2945	10	103	15	128	51 2	261
15092	13800	29 13	20	—	47.86	8109	3045	9	105	15	134	51 14	262
15201	13900	30 8	21	—	48.69	8162	3151	9	107	15	140	52 10	263
15311	14000	31 4	21	—	49.56	8215	3264	8	109	16	147	53 7	264
15420	14100	32 0	22	—	50.47	8268	3385	8	111	16	154	54 4	265
15529	14200	32 14	22	—	51.43	8321	3515	7	113	16	162	55 1	267
15639	14300	33 12	23	—	52.45	8374	3655	7	115	17	171	55 15	268
15748	14400	34 11	23	—	53.54	8427	3806	6	118	17	181	56 14	270
15857	14500	35 12	24	—	54.76	8480	3970	6	121	18	193	57 13	272
15967	14600	36 15	25	—	56.13	8531	4158	5	125	18	206	58 14	274
16076	14700	38 6	26	—	57.76	8583	4387	4	129	19	222	60 2	276
16185	14800	40 4	27	—	59.87	8613	4692	2	135	20	245	61 11	280

*Numbers in column 2 are in degrees, and in column 5 in 1/16 degrees.

89. FIRING TABLE FOR THE 8.8 cm FLAK 18 AND 36 WITH 8.8 cm A.P. SHELL WITH BASE FUZE (TABLE II).

Table II

Muzzle velocity = 810 m/s or 2657 ft/sec Weight of shell 9.65 kg or 20.75 lb
Weight of air at ground level = 1.22 kg/cu m or 533 grains/cu ft

Range	Quadrant Elevation	Drift	Time of Flight	Angle of Impact	Terminal Velocity	Means (50 percent) Dispersion Height	Width
m	deg	mils	sec	deg	m/s	m	m
1	2*	3	4	5	6	7	8
—	—	—	—	—	810	—	—
100	0 1	0	0.12	0 1*	800	—	—
200	0 1	0	0.25	0 2	790	0.2	0.1
300	0 2	0	0.37	0 2	780	0.2	0.1
400	0 3	0	0.49	0 3	770	0.3	0.2
500	0 3	0	0.62	0 3	761	0.3	0.2
600	0 4	0	0.74	0 4	752	0.4	0.2
700	0 5	0	0.86	0 5	742	0.5	0.3
800	0 6	0	1.00	0 6	733	0.5	0.3
900	0 6	0	1.12	0 7	725	0.6	0.3
1000	0 7	0	1.25	0 8	716	0.7	0.4
1100	0 8	0	1.39	0 9	708	0.7	0.4
1200	0 9	0	1.52	0 10	700	0.8	0.5
1300	0 10	0	1.65	0 11	691	0.9	0.5
1400	0 11	0	1.80	0 12	683	1.0	0.5
1500	0 12	0	1.94	0 13	676	1.1	0.6

1600	0 12	0	2.08	0 14	668	1.2 0.6
1700	0 13	0	2.23	0 15	660	1.3 0.7
1800	0 14	1	2.37	1 0	652	1.4 0.7
1900	0 15	1	2.52	1 1	645	1.5 0.7
2000	1 0	1	2.68	1 2	637	1.6 0.8
2100	1 1	1	2.83	1 3	629	1.6 0.8
2200	1 2	1	2.98	1 5	623	1.8 0.9
2300	1 3	1	3.13	1 6	615	1.9 0.9
2400	1 4	1	3.30	1 7	608	2.0 0.9
2500	1 5	1	3.46	1 8	602	2.1 1.0
2600	1 6	1	3.62	1 9	595	2.2 1.0
2700	1 7	1	3.79	1 10	588	2.3 1.1
2800	1 8	1	5.96	1 11	581	2.4 1.1
2900	1 9	1	4.13	1 13	575	2.6 1.2
3000	1 10	1	4.31	1 15	569	2.7 1.2
3100	1 11	1	4.49	2 1	562	2.9 1.2
3200	1 12	1	4.67	2 3	557	3.1 1.3
3300	1 13	1	4.86	2 5	551	3.3 1.3
3400	1 15	1	5.05	2 7	544	3.5 1.4
3500	2 0	1	5.24	2 9	539	3.7 1.4
3600	2 1	1	5.44	2 11	533	3.9 1.5
3700	2 2	1	5.64	2 13	527	4.2 1.5
3800	2 3	1	5.84	2 15	521	4.4 1.6
3900	2 5	2	6.05	3 1	516	4.7 1.6
4000	2 6	2	6.25	3 3	510	5.0 1.7

*Numbers in column 2 are in degrees, and in column 5 in 1/16 degrees.

90. CONVERSION TABLES.

Yards to Meters
1 yard = 0.91440183 meters

YARDS	0	10	20	30	40	50	60	70	80	90
0	.00	9.14	18.29	27.43	36.58	45.72	54.86	64.01	73.15	82.30
100	91.44	100.58	109.73	118.87	128.02	137.16	146.30	155.45	164.59	173.74
200	182.88	192.02	201.17	210.31	219.46	228.60	237.74	246.89	256.03	265.18
300	274.32	283.46	292.61	301.75	310.90	320.04	329.18	338.33	347.47	356.62
400	365.76	374.90	384.05	393.19	402.34	411.48	420.62	429.77	438.91	448.06
500	457.20	466.34	475.49	484.63	493.78	502.92	512.07	521.21	530.35	539.50
600	548.64	557.79	566.93	576.07	585.22	594.36	603.51	612.65	621.79	630.94
700	640.06	649.23	658.37	667.51	676.66	685.80	694.95	704.09	713.23	722.38
800	731.52	740.67	749.81	758.95	768.10	777.24	786.39	795.53	804.67	813.82
900	822.96	832.11	841.25	850.39	859.54	868.68	877.83	886.97	896.11	905.26
1000	914.40	923.55	932.69	941.83	950.98	960.12	969.27	978.41	987.55	996.70

Meters to Yards
1 meter = 1.0936111 yards

METERS	0	10	20	30	40	50	60	70	80	90
0	.00	10.94	21.87	32.81	43.74	54.68	65.62	76.55	87.49	98.42
100	109.36	120.30	131.23	142.17	153.11	164.04	174.98	185.91	196.85	207.79
200	218.72	229.66	240.59	251.53	262.47	273.40	284.34	295.27	306.21	317.15
300	328.08	339.02	349.96	360.89	371.83	382.76	393.70	404.64	415.57	426.51
400	437.44	448.38	459.32	470.25	481.19	492.12	503.06	514.00	524.93	535.87
500	546.81	557.74	568.68	579.61	590.55	601.49	612.42	623.36	634.29	645.23
600	656.18	667.10	678.04	688.97	699.91	710.85	721.78	732.72	743.66	754.59
700	765.53	776.46	787.40	798.34	809.27	820.21	831.14	842.08	853.02	863.95
800	874.89	885.82	896.76	907.70	918.63	929.57	940.51	951.44	962.38	973.31
900	984.25	995.19	1006.12	1017.06	1027.99	1038.93	1049.87	1060.80	1071.74	1082.67
1000	1093.61	1104.55	1115.48	1126.42	1137.36	1148.29	1159.23	1170.16	1181.10	1192.04

Angular Conversion Table — Degrees to Mils

Degrees	0	1	2	3	4	5	6	7	8	9
00	0	18	36	53	71	89	107	124	142	160
10	178	196	213	231	249	267	284	302	320	338
20	356	373	391	409	427	444	462	480	498	516
30	533	551	569	587	604	622	640	658	676	693
40	711	729	747	764	782	800	818	836	853	871
50	889	907	924	942	960	978	996	1013	1031	1049
60	1067	1084	1102	1120	1138	1156	1173	1191	1209	1227
70	1244	1262	1280	1298	1316	1333	1351	1369	1387	1404
80	1422	1440	1458	1476	1493	1511	1529	1547	1564	1582
90	1600	(Conversion Factor, 1 deg = 17.77778 mils)								

CHAPTER 6

REFERENCES

91. STANDARD NOMENCLATURE LISTS.

a. Cleaning, preserving and lubricating materials; recoil fluids, special oils, and miscellaneous related items ..... SNL K-1

92. EXPLANATORY PUBLICATIONS.

a. Ammunition, general ..... TM 9-1900

b. Chemical decontamination materials and equipment ..... TM 3-220

c. Cleaning, preserving, lubricating, and welding materials and similar items issued by the Ordnance Department ..... TM 9-850

d. Defense against chemical attack ..... FM 21-40

e. Product guide ..... OFSB 6-2

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BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
J. A. ULIO,
Major General,
The Adjutant General.

DISTRIBUTION: X

(For explanation of symbols, see FM 21-6)

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