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THIS IS THE THIRD and final volume of the 2W151B, *Aircraft Armament Systems Journeyman*. It covers general aircraft fundamentals. Unit 1 delves into aircraft and flight line safety and maintenance practices you must know when working as an armament systems apprentice. Unit 2 covers basic aircraft armament systems components and suspension equipment. Unit 3 gives you a look at aircraft guns and gun systems you'll probably encounter at some point in your career. Unit 4 wraps things up with weapons loading principals and unique loading situations.

A glossary is included for your use.

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This volume is valued at 15 hours and 5 points.

NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

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Unit 1. General Aircraft Maintenance

AIRCRAFT MAINTENANCE IS extremely important to the Air Force's mission. Maintenance must be done in a way to minimize the hazards to people and equipment as much as possible. In your job, you will come across many types of hazards each day. You need to clearly understand the dangers awaiting you around the aircraft and on the flight line. This unit addresses those dangers. The more aware you are of these hazards, the less likely you are to become a statistic or become the topic of a safety briefing.

1–1. Aircraft Safety

Because of the nature of the work itself, you are exposed to a variety of hazards in aircraft maintenance. The Air Force has safety features built into every piece of equipment it acquires in order to prevent accidents from happening. However, by disregarding or not being aware of these features, we create hazardous situations for others and ourselves. You must become familiar with the hazardous areas of aircraft. And, of course, you must be able to identify and work in and around these areas, taking all precautions necessary to avoid injury to yourself and others. This section will acquaint you with some of the general hazards common to the environment in which you will work.

401. Aircraft danger areas and hazards

Working around aircraft can be dangerous especially when we do not comply with safety items. Some of these safety items pertain to specific aircraft and some are common to all aircraft.

Fixed aircraft surfaces

Many times, our job requires us to walk on the aircraft while doing a particular task. A typical example of a task that requires walking on the aircraft include removing the F–15 or F–16 gun system. All aircraft have designated walkways designed specifically to accommodate the weight distributed by a person walking on the wing or fuselage. They are reinforced to give you a sure-footed, sturdy place to walk while you maintain the aircraft. You will find the walkway construction gives better footing than the rest of the aircraft surface, especially during inclement weather. Surfaces other than the designated walkways are not reinforced. If you step on them, you may damage other systems or components beneath the wing's skin. These areas may also become very slick during rain, snow, ice, or even after the aircraft has just been cleaned. When you walk on the surface of an aircraft, always use the walkways.

Other areas of an aircraft that present physical hazards include wing tips, antennas, inspection doors, static dischargers, refueling probes, and pitot tubes. These items have sharp or pointed surfaces and pose a special problem as you move around and under the aircraft. You should be extremely careful when working around these areas to avoid cuts, bruises, or even a concussion.

Power-actuated surfaces and equipment

Aircraft with power-operated (hydraulic, pneumatic, or pneudraulic) devices, such as flight control surfaces, bomb bay doors, and landing gear present a potential danger. These systems are designed to operate quickly against heavy loads with close tolerances leaving little room in the stowed or closed position; thus, they can be quite dangerous unless you observe all safety precautions involving these systems. They can easily act like a giant pair of scissors, trash compactor, or a club. They are capable of amputating limbs, crushing people or equipment, or simply delivering crushing blows to anything unfortunate enough to be in their way as they move. If you operate them carelessly, the possibility is high you will damage equipment or cause personal injury.

Before going into a bomb bay to work, make sure you have safed or disabled the system or installed the proper strut supports. If you are operating a bomb bay door system for the purpose of checking it out, make sure all personnel and equipment are cleared from the area of operation, and have someone stand by to make sure everyone stays clear of the area.

The control surfaces of aircraft may have sharp edges. When you work near these edges, be especially cautious. During prolonged maintenance periods, make sure such edges have protective covers. If they do not, then you must tape the sharp edges. To indicate an area is dangerous, always make sure red streamers are attached to whatever type of protective cover you use.

Jet engines

A running jet engine is a main hazard you must be aware of when working on the flight line. The major danger areas are (1) the engine intake, (2) the engine exhaust, (3) and the engine turbine plane of rotation.

Engine intake

The engine intake and exhaust blast areas are the two primary sources of serious and sometimes fatal flight line injuries. The suction effect created by a running jet engine intake is powerful enough to cause fatal injury to personnel and extensive damage to equipment in its danger zone. Normally, an intake's danger zone extends forward and to the sides of the engine intake for about 25 feet. Anything beyond this distance is considered relatively safe, although on some of the more advanced aircraft, the technical order (TO) cautions that a danger also exists in an area extending up to five feet beyond of the intake lip.

Engine exhaust

Engine exhaust is another primary source of serious and sometimes fatal flight line injuries. The high velocity and high temperature of the jet engine's exhaust blast makes it particularly hazardous to flight line personnel. A safe distance is considered about 200 feet to the rear, but the exhaust area is not the same for all aircraft. Make sure you check the proper TO for the aircraft you are working on.

Engine turbine plane of rotation

Always stand fore or aft of the engine's plane of rotation. There have been instances when the turbine wheel inside a jet engine has disintegrated during operation. For this reason, you should always be aware of where you are standing when an aircraft's engine is running. To make this danger area easy to find, a painted RED stripe may mark the danger point on the engine cowling. If there is no red stripe, you can check the applicable TO to determine exactly where the plane of rotation for the engine is located. You should know that if a turbine wheel disintegrates while you are standing in the plane of rotation, you might be seriously injured (i.e., cut or impaled) by flying parts traveling at speeds far above the muzzle velocity of a rifle projectile.

Rotor blades

Helicopters pose a completely different type of hazard. You must stay clear of the rotor blade travel area whenever the main rotor blades are turning because of what is known as a "droop stop malfunction." This particular malfunction permits the blades to droop to within five feet of the ground while they are turning. Imagine what would happen if you were standing within this danger area and the malfunction occurred.

Tail swing is another hazard presented by these aircraft. Tail swing occurs during quick takeoffs and windy conditions. During these conditions, the tail of the helicopter swinging around could hit you even if you are standing outside the danger area. The rotor blade can also injure you during the swing. The only way to protect yourself from tail swing is to position yourself and your equipment at least a distance equal to the length of the helicopter away from these areas.

High-intensity sound

Being around aircraft exposes you to extremely hazardous noise. The noise endangers your hearing and makes it hard to talk with and hear others during maintenance tasks. The noise also leads to fatigue, and fatigue leads to faulty maintenance, which can cause an increase in the number of accidents attributed to maintenance errors. As a result, there is a general increase in the number of ground accidents.

The intensity of sound is measured in decibels (db). Noise levels of 110 to 120 db and above are common in the vicinity of operating jet aircraft engines. Multi-engine jets frequently exceed 130 db. You may suffer physical injuries at these levels unless your ears are adequately protected. Noise levels of 85 db and below are considered relatively safe.

Ear protection, selection of aircraft run areas, noise suppression devices, and other precautions protect us against noise hazards. The noise intensity of jet aircraft is greatest in the rear of the engines and at an angle of 45° on either side. Do not work or stand in these high-intensity noise areas unless absolutely necessary. Ear defenders alone will not give you enough protection at levels of 130 to 140 db. When you work in these areas, wear a headset in addition to earplugs. If possible, minimize the time you are exposed to noise.

A person who has worked too long in areas with high db levels will show symptoms of sickness or injury. The individual may have pain; a feeling of fullness; a ringing or burning sensation in the ears; dizziness; impairment of mental concentration; and occasionally nausea, vomiting, or weakness of the knees. Also, emotional irritability is often a sign of noise fatigue. When a person shows any of these symptoms, immediately take them from the noise area so they can be examined by a medical officer.

Radio frequency radiation

Radio frequency (RF) transmissions are dangers beyond our ability to see or hear. “Electromagnetic radiation” is another name applied to this hazard. High-frequency radio transmitters, radar, or electronic countermeasure devices give off this radiation. These radiation-causing devices are often hidden behind the nose cone or in other places on an aircraft. The energy radiated by these transmitter antennas can cause items such as impulse cartridges to ignite or explode up to as far as 100 feet away.

RF radiation emissions can cause burns beneath your skin and to the lenses of your eyes causing cataracts to form. The presence of RF energy may not be apparent; however, the injuries may occur before any pain is felt. When electromagnetic energy is absorbed in the tissues of the body, heat is produced. If the heat cannot be displaced as fast as it is produced, the internal temperature of the body rises. Internal organs are not cooled by an abundant flow of blood. Therefore, these organs can easily be damaged by heat from excessive exposure to radiation.

To avoid this danger, don’t stand in the beam of a nearby radar antenna. Because you can’t tell that your internal organs are being heated, serious damage can occur before you know it. Whenever possible, in a maintenance situation, everyone should avoid the area of radiating power from radar antennas. Try to get your work rescheduled after the radar is turned off.

Radiation hazards depend on many variables, such as time of exposure, strength of emission, weather, and the number of units operating in the area. You must use common sense, good judgment, and your experience to evaluate these variables.

Hot brake areas

When an aircraft traveling at speeds in excess of 200 knots touches down on the runway, it normally requires the use of drag chutes and power brakes to help it stop. If a drag chute fails to operate upon landing, extra use of the brakes are required to stop the aircraft before it reaches the end of the runway. This extra brake usage could cause the brakes to become overheated and cause the tires to explode. The end of runway (EOR) crew is most likely to be affected by this event. EOR crews must immediately, after the aircraft lands, go under the aircraft to install safety devices on all munitions items that were not released during a sortie. You must always approach an aircraft with hot brakes with extreme care. If you suspect, or the pilot informs you, the aircraft has hot brakes, approach the aircraft only if it is absolutely necessary. If you must go near the tire area, only approach it directly from the front or back of the tire. Never approach from the sides, because the tires could explode causing debris to fly out from the sides.

Racks, pylons, and launchers

Racks, pylons, and launchers are a combination of explosive, high-pressure pneumatic, pneudraulic, and mechanical designs. They may be found under the wings and are either installed in the fuselage or attached to it. Depending on the type of aircraft being flown, or the mission, it could be carrying munition items, electronic equipment, or fuel tanks. All of these items can be jettisoned from the aircraft and must be safed before you work on an aircraft. You must know the safing procedures in your tech orders. Anybody who is standing beneath, in front of, or to the rear of these items could be in danger.

Aircraft gun systems

Guns are found in the leading edges of the wings or fuselage, in the nose, and in the sides or rear of the fuselage of the aircraft. They are designed to fire ammunition ranging in sizes from 7.62 mm to 105 mm, depending on the system. The ammunition for the gun systems is carried within the aircraft, and positioning depends on the particular aircraft. One safety practice you should always remember when working around loaded gun systems is *never* walk in front of the gun. Regardless of how long you have worked with a crew or an individual, remember—we all make mistakes.

Emergency egress systems

Emergency egress systems contain explosive charges and rocket motors to eject the seat and jettison the canopy from any aircraft. This escape equipment is designed to make sure you can evacuate from the aircraft regardless of its speed, altitude, or attitude. Extreme heat or unintentional movement of any of the actuating mechanisms can fire off the ejection seat or canopy. These items should receive the same respect given an armed fuze or loaded gun system since, indirectly, they are types of munitions.

To give you an idea of the force you are dealing with, you should know that ejection charges normally are capable of hurling 300 pounds at an initial rate of 60 feet per second. Your job requires you to enter the cockpit on a daily basis; therefore, if you fail to follow safety regulations, standard operating procedures (SOP), and tech orders, you could become an ejection seat mishap.

402. Armed and explosive loaded aircraft

Many fatal accidents and extensive aircraft damage have resulted from maintenance personnel working on “armed” aircraft. By “armed” we mean the aircraft have explosive munitions, such as bombs, rockets, impulse cartridges, missiles, or ammunition installed.

Armed aircraft

Normally, the maintenance performed is limited when an aircraft is in an armed configuration. If you have to perform maintenance on an armed aircraft, use extreme care in applying external electrical power, because you could easily jettison or fire a munition. Here are a few other ways you can determine the status of an aircraft:

1. Armed aircraft generally are identified with safety pins with red streamers attached. These are installed at the loaded stations or on the applicable armed munitions items.
2. The AFTO Form 781H, Aerospace Vehicle Flight Status and Maintenance Document, may have an entry in block 11 (Munitions/Gun Status) on the status of the aircraft.
3. The AFTO Form 781A, Maintenance Discrepancy and Work Document, will have an entry identifying the types and quantities of munitions loaded on the aircraft.
4. Refer to either Integrated Maintenance Information System (IMIS)/Autonomic Logistics Information System (ALIS) depending on which 5th generation aircraft you may be assigned to determine the loaded aircraft status.

Explosive loaded aircraft

TO 11A–1–33, *Handling and Maintenance of Explosive Loaded Aircraft* refers to the designation of explosive loaded aircraft. Although you probably already know how to identify explosive loaded aircraft, it never hurts to refresh your memory. You can easily recognize one because it will be carrying munitions or explosives, either internally or externally. Munitions or explosives in this instance could be impulse cartridges, rockets, bombs, and so forth. However, there are times when an aircraft's explosive loaded condition is not so easy to recognize, for example, when the pyrotechnics are stored in survival and rescue kits and when other pyrotechnics used by aircrew personnel are found on board. An aircraft in which the cockpit seat and canopy systems are armed is not, for maintenance purposes, considered an explosive loaded aircraft. As an aircraft armament systems specialist, you are often required to safe an aircraft for maintenance. These procedures vary slightly from aircraft to aircraft, but their results are basically the same. When working on an aircraft, follow the safety procedures outlined in the specific aircraft TO.

Aircraft safe for maintenance procedures are procedures performed before you start any maintenance related task on an aircraft loaded with munitions. These procedures ensure the aircraft is in a safe condition before you do maintenance. Although we discuss some generalities in the next few paragraphs, you can find more specifics in your aircraft's job guides.

Safe for maintenance procedures

Before you start any safe for maintenance procedure, first check the aircraft's forms to determine its status. Next, do an aircraft walk around. This includes making sure the aircraft is properly positioned, chocked, grounded; the proper fire-fighting equipment is available for use; and your support equipment is positioned properly. Now make sure all of the required safety devices are installed. Your TOs specify the devices required for your particular operation and aircraft. Safety devices found on aircraft come in the form of ground safety locks and pins. Use these devices to safe the aircraft system or their potential hazards. Some of the more common areas requiring safety locks and pins are listed below:

1. Cockpit canopies and seats.
2. Horizontal stabilizers.
3. Pylons and bomb racks.
4. Arresting hook.
5. Landing gear struts.
6. Speed brakes.
7. Guns.

8. Installed suspension equipment.
9. Weapons bay doors.
10. Chaff and flare dispensers.

Also, safety devices must be installed on all munition items. Munition items that cannot be safed must be removed from the aircraft. For example, an operational Air Intercept Missile (AIM)–9 missile equipped with an ARM/SAFE key installed and positioned in the SAFE position need not be downloaded when you are performing maintenance on an aircraft, even if electrical power must be applied. There are many other precautions taken to double and even triple safe some munition items, depending on the aircraft in which they are installed. We won't go into particular munition and aircraft precautions here, but TO 11A–1–33 and your aircraft's 33–1–2 or 33–2–1 TO can clarify any questions you may have in this area. Once you are this far in your aircraft safe for maintenance procedures, your last step takes you into the cockpit.

Safing in the cockpit

Earlier, we addressed the dangers associated with the cockpit. As a safety precaution, ejection seat and canopy safety pins or struts, with red streamers, are installed immediately after an aircraft's flight and remain installed while the aircraft is on the ground. You must make sure these safety pins or struts are installed properly and all cockpit switches are in an OFF, SAFE, or NORMAL position.

The modern aircraft cockpit, like a loaded gun, is deadly in the hands of the inexperienced. Located in the cockpit are the controls for explosives, wing tanks and canopy jettison, ejection seats, flaps, landing gear, and arresting hooks, plus numerous other controls that can cause serious injury or death if operated by untrained personnel. Any of these controls, positioned wrong, can be "killers." Make sure all cockpit switches are properly positioned before performing any maintenance on an aircraft.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

401. Aircraft danger areas and hazards

1. Why should you use only the walkways when you have to walk on an aircraft?

2. What can happen if you carelessly operate aircraft power-actuated devices?

3. What are the major danger areas that exist around a running jet engine?

4. What condition causes the danger area around a running jet engine intake?

5. What conditions make the engine exhaust blast particularly dangerous?

6. Why is the plane of rotation of the engine turbine wheel considered dangerous?

7. How can you determine where the plane of rotation of the engine turbine is located?

8. On the average, what is a safe distance to keep yourself and your equipment from the danger areas posed by helicopters?

9. Where is noise intensity greatest around operating jet aircraft engines?

10. In addition to ear plugs, what protective device should you wear when working in high-intensity noise areas?

11. State the effects RF can have on your body?

12. How should you approach the tire area of an aircraft with hot brakes?

13. What safety practice should you adhere to when working with loaded gun systems?

14. Why should ejection seat catapults/rockets or canopy removers receive the same respect as armed fuzes or loaded guns?

402. Armed and explosive loaded aircraft

1. When you approach an aircraft to perform maintenance, how can you determine whether or not the aircraft is armed?

2. Which block of AFTO Form 781H tells you whether or not an aircraft is in an armed configuration?

3. What is main reason for performing aircraft safe for maintenance procedures?

4. Normally, what type safety devices do you find on aircraft?

5. What must be done to munitions that cannot be safed before performing maintenance on an aircraft?

6. When are the canopy and ejection seat safety pins installed, and how long do they stay installed?

7. In what positions are aircraft cockpit switches normally placed during aircraft safe for maintenance procedures?

1–2. Flight Line Safety and Hazards

You will be involved in just about every situation imaginable, from operating vehicles to firefighting. What we discuss in this section will broaden your knowledge in areas of flight line safety.

403. Flight line firefighting

~~Air Force Instruction (AFI) 91–203, *Air Force Consolidated Occupational Safety Instruction;*~~ Air Force Manual (AFMAN) 91–201, ~~*Explosive*~~ *Safety Standards* and local base directives govern normal flight line operations and maintenance. These publications guide your behavior while performing maintenance on the flight line. Fires and explosions are an ever present hazard in aircraft maintenance and munitions handling operations. Occasionally, you may have to become involved in fighting an aircraft fire. Therefore, you need to know as much as you can about the causes of fires, fire fighting procedures, and the equipment used in firefighting.

Causes of aircraft fire

Aircraft fires can be caused by numerous situations. But an aircraft is *most* susceptible to fire when the engine(s) is/are running depending on the aircraft. These fires are usually in the engine or engine bay area. They are generally traceable to a collection of residual fuel in the engine, extreme fuel enrichment, and not enough drainage. Fires may also start because fuel is leaking from lines or fittings, and is especially volatile because of the high-pressure vaporization. You may encounter this situation during pylon or fuel tank uploads. Hydraulic fluid leaks are equally volatile when pressurized.

Some other sources of fire are improper electrical grounding of the aircraft, hot brakes, fueling tasks, and fuel lines being disconnected while electrical power is on the aircraft. Fuel vapors coming from or near the aircraft require constant precautionary measures since the slightest spark could start a fire. Munitions or munitions operations are seldom the cause of an aircraft fire.

Aircraft fire fighting procedures

Before a fire starts, it’s extremely important that you familiarize yourself with the procedures involved in fighting a fire on your particular aircraft. If you wait until the need arises, then it is too late. When fighting a fire, comply immediately with the prescribed procedures in order to prevent injury to yourself, others, and damage to equipment.

There are two sets of procedures to fight fires. One set addresses nonexplosive loaded aircraft and the other addresses action to take if munitions are involved in an aircraft fire. Load crew personnel are more apt to be involved in fighting fires on aircraft loaded with munitions; however, all personnel must be thoroughly familiar with these procedures.

Nonexplosive-loaded aircraft

Normally, when an aircraft with no munitions installed is involved in a fire you will not be involved. However, there may come a time when you will be involved, so you need to know three things:

1. Fight the fire, if possible, from the upwind side of the aircraft. Keeping the wind at your back while fighting the fire will cause smoke, fumes, and the majority of the heat to travel away from you.
2. Do not put yourself in a position where you could become trapped by fire or fumes.
3. Be especially concerned during brake fires because of possible flying debris resulting from tire blowout.

Explosive-loaded aircraft

Normally, aircraft fires involving munitions occur under a set of circumstances making it impossible to know immediately the specific model of missile, bomb, or cluster bomb unit (CBU) installed on the aircraft. Naturally, this hampers fire fighting capabilities. Knowing the specific model of missile, bomb, or CBU is absolutely essential, because this information tells you three very important things:

1. How long you have before the munitions are expected to function (explode).
2. How much time you have to evacuate the area.
3. How far from the area you should evacuate.

If, at any time, you are involved in a situation where the specific model of munitions involved in a fire is not known, follow these criteria for firefighting and withdrawal for aircraft that contain bombs, CBUs, missiles, and rockets.

Bombs

General purpose bombs normally detonate within two to four minutes of being engulfed in flames. Fuzes and boosters may be ejected and function as separate explosions. After two minutes, the environment becomes a major hazard, and fire fighting capabilities decrease. When you need to withdraw from the area, take whatever cover is available; however, personnel and equipment should be at least 2,000 feet from the burning aircraft.

Cluster bomb unit

A CBU can be expected to detonate within one minute with some munitions (bomblets) being expelled by the force of the explosion up to 1,000 or more feet. These bomblets can detonate upon impact. Again, after one minute, the environment becomes a major hazard, and fire fighting capabilities decrease. When withdrawal is necessary, re-enter the area only after explosive ordnance disposal’s (EOD) personnel approval.

Missiles and rockets

In a fire, missiles and rockets normally propel or detonate, or both, within 45 seconds to two minutes. A propulsion hazard occurs within 45 seconds. After one minute, the environment becomes hazardous and fire fighting capabilities decrease. Approach the fire, if possible, from the side of the aircraft.

Loading crew responsibilities

Fire fighting procedures for explosive-loaded aircraft include those covered for nonexplosive-loaded aircraft. They also include designated responsibilities for each load crewmember. Load crews normally consist of three or four people, and each has different responsibilities.

The number one person, or crew chief, removes the munitions from the aircraft or area, if possible. The weapons load team chief also records the time the fire engulfs the munitions. Recording this action is required to determine the time left to evacuate the area before the munitions propel or detonate. Withdraw all personnel to the specified distance within the applicable time limits after the fire overtakes the munitions or after the arrival of the fire department, whichever occurs first. The recorded time must also be given to the fire fighting supervisor. He or she also has the added responsibility of evacuating all nonessential personnel from the area.

The number two person notifies the fire department and gives the location of the fire and the tail number of the aircraft involved. After notifying the fire department, the number two person ***must*** return to the aircraft and assist in fighting the fire. The number three person is the primary firefighter. If your crew consists of four people, person number four would assist the weapons load team chief in removing the munitions from the aircraft, if possible. If, during the downloading process, flames were to engulf the munition(s), **ALL** personnel would evacuate the area.

These procedures, although fairly concrete, could vary according to your major command (MAJCOM), base of assignment, or specific loading situation. Familiarize yourself with the local procedures before the need arises.

Fire fighting equipment

Several types of fire extinguishers may be used when fighting aircraft fires. The most commonly used fire extinguisher is the 150-pound Halon 1211. The 150-pound Halon 1211 is the primary flight line fire extinguisher and is distributed either one per aircraft, one per two aircraft, or one per three aircraft, depending on the size of the aircraft.

404. Foreign object damage—classification, causes, and prevention

Since jet engines have been developed, foreign object damage (FOD) has been an ever-present threat. Although FOD is usually associated with jet engines, it can also be a threat to other portions of an aircraft. Aircraft tires, for example, are extremely vulnerable to FOD. Each time an incident involving FOD happens, literally thousands of dollars are wasted.

Foreign objects can be bolts, nuts, safety wire, tools, rags, rocks, pens, hats, and so forth. When ingested into a jet engine, these objects can destroy the engine completely. Also, if they are dropped in an aircraft's cockpit, other foreign objects, such as pins, keys, and other items found in a person's pockets, can prevent the ejection system from functioning. So, you can see why it is essential to recognize foreign objects and prevent them from causing damage. This lesson will help you do both.

Exactly what is FOD? For the most part, it is the damage to jet turbine engines caused by objects being drawn into the engine compressor. Now you'll want to know how it affects you. Well, it could affect you both financially and personally. For instance, when aircraft equipment is damaged or destroyed, the Air Force must repair or replace it. Who supplies this money to the Air Force? As taxpayers, we all do; however, you alone may have to supply the money if the damage or destruction is due to your carelessness. Now, let's assume a screwdriver enters the engine compressor section, the turbine wheel blades disintegrate, and a friend of yours is seriously injured or killed from the fragmented turbine wheel. Or, assume an ejection system failed to operate during an emergency because of something you dropped in the cockpit—killing the pilot. How would you feel if you had to go through life knowing your carelessness caused a death?

Classification

Generally, foreign objects are hazardous to aircraft engines and fall into one of three basic categories: (1) metal, (2) stone, or (3) miscellaneous. The metal category contains aircraft and engine fasteners (nuts, bolts, washers, safety wire, etc.) and extra flight line metals (nails, personnel badges, pens, pencils, etc.). The stone category contains natural stone (pebbles, gravel, sand, etc.) and unnatural stone (concrete, cinders, etc.). The miscellaneous category contains wood, organic matter (animal or vegetable matter), wearing apparel, hard plastics, ice (hailstones, frozen or hard-packed snow), and even large pools of water. These classes and types of foreign objects cause the most damage to turbine engine compressors. In most FOD preventive programs, there has been a tendency to consider all FOD a single problem. Some problems, however, cannot be corrected when they are considered as a whole, but only when they are broken down into categories. Therefore, in taking preventive action, it is better to assign FOD damage to the basic classifications and then decide how to correct problem situations.

Causes

One primary cause of FOD is carelessness. It is imperative all personnel use extreme care when doing work in and around an aircraft. Too often, specialists fail to keep track of items used on the job or items in their pockets. Many engines have been destroyed because of a misplaced wrench, a pair of pliers, or bits and pieces of hardware. There have also been accounts of malfunctioning ejection systems because of items being dropped in the cockpits and jamming linkages of ejection systems.

Today's jets have more efficient engines and produce more intake suction; therefore, these engines are capable of ingesting objects from even greater distances. This makes it very important for maintenance and run-up areas to be free of debris at all times. Failure to keep these areas clean is another cause of FOD which is why you should give special attention to these areas after inclement weather. Loose objects may have been blown or washed on to taxiways, runways, or parking ramps and is probably the greatest hazards to aircraft engines.

Prevention

The Air Force's initial effort to prevent FOD was the establishment of the FOD prevention program. The objective of this program is to find and correct potential hazards and to eliminate causes of FOD. AFI 21–101, *Aircraft and Equipment Maintenance Management*, establishes the minimum requirements for a FOD prevention program, while AFI 36–2650, *Maintenance Training*, dictates the requirements for FOD prevention training.

All maintenance personnel must do their part if the FOD prevention program is to be effective. Many supervisors, especially on the flight line, set aside a few minutes each day for an organized inspection and physical pickup of foreign objects. This is more commonly known as a "FOD Walk." Other methods we can use to prevent FOD include inventorying tools before and after each job, policing the work area after the job is done, and placing debris in special FOD containers. Usually, the containers are stenciled "FOD" and placed in strategic locations on the flight line. Such FOD containers actually serve a dual purpose. They provide a receptacle for debris and remind workers to practice FOD prevention. Ways of preventing FOD include using intake screens when working around operating jet engines and securing or removing from pockets personal effects (hats, gloves, pens, cigarette lighters, etc.) when working near intakes or in cockpits.

As flight line personnel, you are not the only people involved in FOD prevention. Flight crews are usually briefed, well in advance, on such things as taxiway and runway construction projects and any concentration of birds in the vicinity of the runway. As you can see, FOD prevention is a combined effort of all personnel.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

403. Flight line firefighting

1. When is an aircraft most susceptible to fire?

2. From which side of an aircraft should you fight a fire?

3. When bombs are on board an aircraft, how far away from the aircraft do personnel and the equipment have to be?

4. Within how many minutes are CBUs expected to detonate if involved in a fire?

5. How do missiles normally react in a fire?

6. Who is the primary firefighter on a weapons load crew?

7. What fire extinguisher is considered to be the primary flight line fire extinguisher?

404. Foreign object damage—classification, causes, and prevention

1. What are some of the items classified as metal FOD?

2. What are some items classified as stone FOD?

3. What are some items classified as miscellaneous?

4. What is a primary cause of FOD?

5. What areas should receive special attention during inclement weather?

1–3. Corrosion Control Procedures

Corrosion control is of major importance in all areas of aircraft maintenance. Our national security depends on the reliability of our weapon systems. Corrosion can weaken structural supports of the aircraft, components of the weapon systems, and even electrical wiring enough to destroy a system's reliability. This weakening can result in a major repair or replacement of the entire system. Such repairs and replacements are costly and time consuming.

In technical training, you learned about the types of corrosion, the actual corrosion process, and basic methods of controlling corrosion. You have the basics—now consider this: (1) What does corrosion look like on different metals? (2) When and where do you look for corrosion? (3) What do you do about it when you find it? This section answers these questions.

405. Identification of corrosion on metal surfaces

Corrosion is visible in many forms and various colors, depending upon the type of corrosion and the type of metal used. Each metal has its own peculiar indications of corrosion. Since you'll work with equipment constructed of different metals, you need to know what corrosion looks like. Generally, corrosion takes form by the dulling of a polished surface and sometimes appears rough and frosted. It may also be found as a white or gray powdery deposit that blotches the metal surface. It can also be red or brown deposits. Normally, when these deposits are cleaned away, you'll find pits or holes. Now, let's look at what corrosion does on various metals in particular situations.

Magnesium

Anytime you see magnesium, it will always be primed and top coated due primarily to its low resistance to corrosion. Corrosion appears only where breakdown occurs or the finish is removed. Damaged areas of paint may show a gray powdery corrosion product. If the area has been moist, the color of the corrosion may change to green or black.

Aluminum

A lot of your equipment is constructed of aluminum. Aluminum appears high in the electrochemical series of elements, and for this reason it is expected to corrode very easily. However, the formation of a tightly adhering oxide film offers increased resistance under mild corrosive conditions; basically, as aluminum corrodes, it provides its own protective coating. Aluminum can be used bare, primed, or painted. Each condition has its own evidence of corrosion.

Bare

Normally, bright aluminum becomes dull and coated with a whitish powdery residue. Blackened areas and pitting may appear where the residue is removed. Large volumes of white-gray corrosion products may appear on cut edges or corners.

Primed

Corrosion shows up where there is a scratch, gouge, or a blister in the primer. In the early stages, a white-gray corrosion product grows in the damaged area. As the corrosion advances, the aluminum appears etched or mottled around the damaged area.

Painted

Corrosion appears as a white-gray corrosion product where there is a break in the finished coat. When the paint flakes, it leaves the aluminum with a spotted, mottled, or etched appearance.

Carbon and alloyed steel

If left unprotected, ferrous metal surfaces corrode easily when moisture is present. As shown in the table below, each type of metal surface treatment has a different appearance of corrosion.

Types of Metal Surfaces	Appearance of Corrosion
Bare steel surfaces	Bare steel rusts over its entire surface. A severe form of rusting is indicated by a red-to-black scale which may flake off.
Primed steel surfaces	Rust appears in areas where the primer becomes damaged either mechanically or by exposure to moisture. Since primers used for steel are nearly the same color as rusted steel, light rust is difficult to identify. An easy way to check for corrosion is to wipe any areas of suspected rust lightly with a clean cloth; the removed rust will leave evidence on the cloth. If it is not removed, further corrosive attack will cause a scale to form.
Primed and painted steel surfaces	Rust appears where a paint system has been damaged mechanically or by exposure to moisture, chemicals, or solvents. The underlying steel may be blackened as well as rusted. Again, if the corrosion is allowed to continue, scale forms.

Types of Metal Surfaces	Appearance of Corrosion
Cadmium-plated steel	Corroded cadmium forms a dull-gray product that can be wiped off. Corrosion attacks steel only if the cadmium is destroyed.
Zinc-plated steel surfaces	Corroding zinc or galvanized coating forms a white corrosion product more voluminous than that of cadmium. Corrosion attacks the steel only where the coating has been destroyed.
Nickel- or chrome-plated steel surfaces	Rust appears as small spots on the plated surface if there are small pores in the plating. If corrosion is allowed to continue, pitting results.
Phosphate-coated and greased steel surfaces	Phosphate coatings are applied to steel to hold oil or grease on the surface. Corrosion starts uniformly over the part. It appears as red-black and is darker than common rust.

Corrosion-resistant steel

Stainless steels are basic alloys of chromium in iron and are resist to common rusting, chemical action, and high-temperature oxidation. This metal blackens as it corrodes. The black corrosion product is very tightly bound to the surface and will not rub off. Corrosion on the surface may appear as pits. If the steel has been plated or painted, the surface exhibits the same type of corrosion product as described for painted or plated carbon and alloy steels.

Copper and copper alloys

These metals are quite resistant to atmospheric corrosion. Protective paint coatings are seldom required because of the inherent resistance of the metal.

Bare copper surfaces

Unfinished copper and its alloys normally take on a darkened copper color. Corroded copper is greenish white. If the corrosion is caused by an acid environment such as un-removed solder flux, the corrosion products tend to be more grayish-white and quite voluminous. Corrosion forming on products of copper alloys forms a bluish-green coating on the surface of the product.

Primed and top-coated copper

When the coating system is damaged, the exposed copper darkens. After a time, the exposed copper may turn black and becomes partly covered by a green corrosion product.

Tin-plated copper

As the tin corrodes, a white-yellow corrosion product appears on the exposed copper. This corrosion is accelerated because tin is sacrificial to copper.

Cadmium-plated copper

If the cadmium plating is removed or damaged, the normal white corrosion products grow at a rapid rate on the exposed copper. The green colored corrosion of copper shows up only when the cadmium plating is completely destroyed.

406. Surfaces susceptible to corrosion

The external and internal surfaces discussed here include most of the surfaces common to aerospace equipment.

External surfaces

Some of the common corrosion problem areas may be grouped under general types of external surfaces.

Magnesium surfaces

You should include in any inspection for corrosion the location and inspection of all magnesium skin surfaces with special attention given to edges, areas around fasteners, and to cracked, chipped, and missing paint.

Aluminum alloy surfaces

When you are inspecting external skin surfaces such as pylons, look for corrosion around the heads of counter sunk fasteners on panels, especially riveted areas and areas where fairings overlap. Figure 1–1 identifies areas to check.

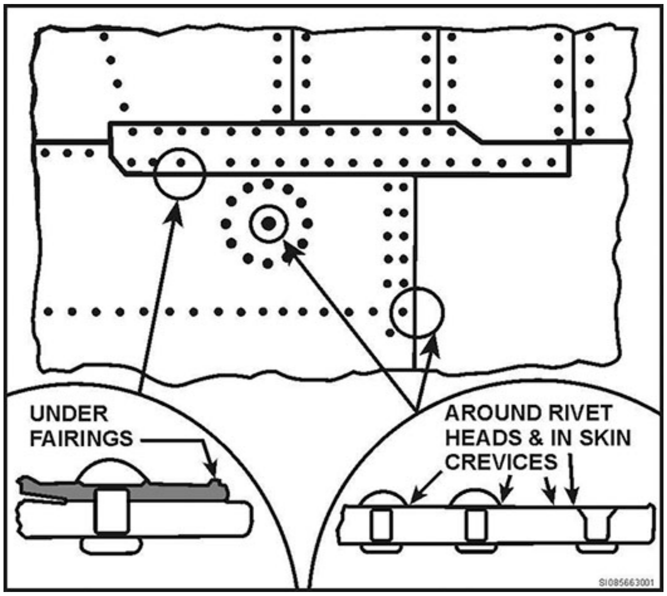


Figure 1–1. Typical panel corrosive areas.

Rocket and gun blast areas

Surfaces located in the path of rocket and gun blasts are particularly subject to corrosive attack and deterioration. These surfaces include gun compartment venting systems, spent ammunition collection chutes, and jet assist rocket and missile exhaust paths. In addition to the corrosive effect of the gases and exhaust deposits, the protective finish is very often blistered by heat, blasted away by the high-velocity gases, and abraded by spent shell casings and solid particles from gun and rocket exhausts. Watch these areas for corrosion, and clean them carefully after firing operations. Gun bay areas are also potential water traps and should be kept sealed to prevent water entrapment.

Spot welds

Spot welds are found on various components throughout the weapons system. They are more prominently known for being at certain points on gun housings or supports. The main cause of the corrosion of spot welded metals is corrosive agents entering and becoming entrapped between the layers of metal. The original cause of some of the corrosion is from the fabrication process, when moisture worked in through open gaps and seems (fig. 1–2).

The first evidence of this type of corrosion is the appearance of corrosion at the crevices where corrosive agents have entered. Corrosion may appear at other external or internal laying surfaces, but it is usually more prevalent on external areas. Advanced corrosion causes skin bulging and eventual spot weld fracture.

You can detect skin bulging in its early stages by looking along the spot weld seam or by using a straightedge. The only technique that prevents this condition is keeping potential moisture from entering points, gaps, seams, and holes created by filling broken spot welds with a sealant or a suitable preservative compound.

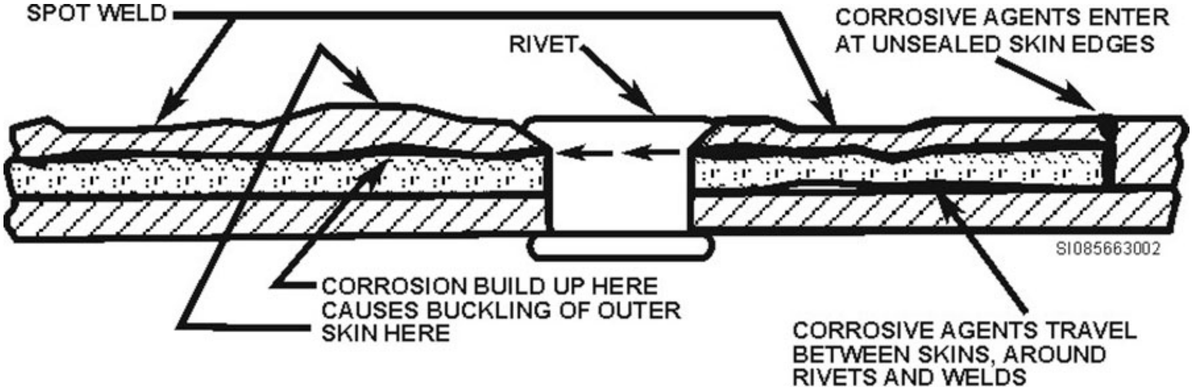


Figure 1–2. Corrosion of spot welded metal.

Piano hinges

The effect of corrosion on piano hinges is also a problem on aircraft. These are not only prime spots for corrosion because of the dissimilar metal contact between the steel pin and the aluminum hinge tangs, but are also natural traps for dirt, salt, and moisture. The areas where hidden corrosion occurs are shown in figure 1–3. When such hinges are used on access doors or on plates that are actuated only during periodic checks, they tend to freeze in place between inspections. Inspections should include lubricating and actuating these hinges for several cycles to ensure the lubricant has completely penetrated the hinges.

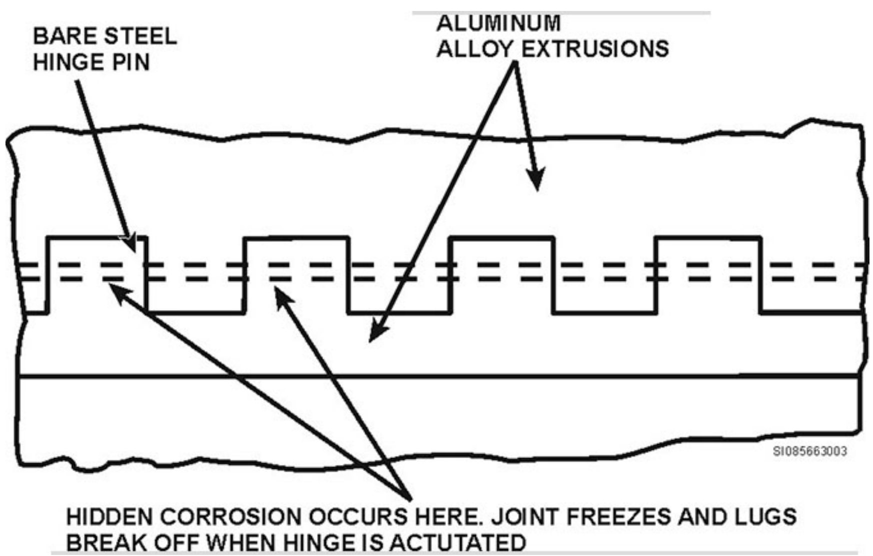


Figure 1–3. Corrosion of piano hinges.

Internal surfaces

Internal surfaces are just as susceptible to corrosion as external surfaces and should be inspected just as diligently.

Electronic compartments

Electronic and electrical package compartments, cooled by ram, compressed, or bleed air are subject to the same conditions as engine and accessory cooling vents and engine frontal areas. The degree of their exposure is less because a smaller volume of air passes through the compartments, and special design features prevent water from forming or collecting in the enclosed spaces. Nevertheless, these compartments are still trouble areas that require special attention.

Because circuit breakers, contact points, and switches are extremely sensitive to moisture and corrosive attack, inspect for these conditions during routine checks as thoroughly as their design permits. If design features hinder the examination of these items while they are installed, corrosion control specialists should inspect the items carefully when the components are removed. Corrosion in an electrical or electronic component should be treated only by corrosion control personnel since conventional corrosion treatments that you can perform may not be applicable depending upon the extent of the corrosion found.

Water entrapment areas

With the exception of sandwich structures, aircraft design requires a drain hole in every area where water can collect. However, in many cases, these drains are ineffective because they are either not properly located or because they are plugged. These areas are natural sumps or collection points for water, hydraulic fluids, dirt, loose fasteners, drill shavings, and other debris. Residual oil quite often masks small quantities of water that set up hidden corrosion cells. Daily inspection of water entrapment areas should be a requirement.

As you grow proficient in performing corrosion inspections, you'll be able to look at a piece of equipment and form a mental picture of where the corrosion deposits are on both its internal and external surfaces. Remember, corrosion deposits may be found on surfaces where contaminants, stagnant water, and hydraulic fluids are allowed to collect.

407. Maintenance measures used to combat corrosion

Most metals are subject to corrosion. However, corrosion can be reduced by the use of corrosion-resistant protective finishes. Although some equipment has a protective coating, accumulated soil, salts, industrial fumes, and moisture causes coatings to break down and allow corrosion to set in. Preventive maintenance is the most effective method of combating corrosion. Some preventive maintenance functions include:

- An adequate cleaning program.
- Inspecting for corrosion.
- Treating corrosion as it occurs (touch-up, paint, sealant, etc.).
- Cleaning up corrosive chemical spills immediately.
- Lubricating periodically.
- Applying preservative coating as necessary.
- Handling and storing removed parts properly.
- Protecting equipment from moisture and dust.

All of these functions are important—some of these you'll be exposed to almost daily in your shop or on the aircraft. Since you need to better understand these preventive maintenance measures, we will discuss them in more detail.

Inspection

An important part of corrosion control is detecting and treating corrosion when it's in the earliest stages. Such early detection is possible only through frequent and thorough inspections. In addition to brief service inspections, a more comprehensive inspection must be performed periodically. In all of your inspections, watch for indications of beginning or potential corrosion as well as corrosion in advanced stages. If you find corrosion in any area, remove the corrosion and apply preventives.

Cleaning

Clean and wash equipment to prevent corrosion. Dust, dirt, acid spills, or waste materials can provide the electrolyte (agent), which accelerates corrosion. An accumulation of moist or oily dust in a unit may cause a short in a vital electrical circuit or eventually weaken a support structure.

There are several methods of cleaning equipment and each one has certain hazards. Keep in mind cleaning agents may react to certain metals or synthetic materials differently, thereby causing additional deterioration or damage. For instance, a cleaning solvent with an oily base can cause an accumulation of dust or dirt if final rinsing isn't properly done. If steam cleaning compounds and steam is used in electrical compartments, they'll cause corrosion of relays and deterioration of wiring. Cleaning is essential to corrosion control, and you must adhere to proper cleaning or washing procedures at all times. So, before starting a cleaning procedure, make sure you know exactly what must be done and how to do it properly.

Treating

Although corrosion cannot be completely stopped, it can be controlled by coating the surface with another metal or a corrosion resistant compound. Painting is the most common method of slowing corrosion. However, paint does not work in certain areas because it chips and cracks. When chipped or cracked, exposed metal may be protected (from moisture, salt, etc.) by spot painting. Spot painting is an effective means of controlling corrosion when treating small areas.

Depending on the directives of your assigned base and squadron, you may or may not be involved in corrosion removal and treatment. Most Air Force bases have corrosion control specialists; however, since some do not. You may be called upon to handle your own systems, components, and general equipment corrosion problems.

TO 1–1–8, *Application and Removal of Organic Coatings, Aerospace and Non-Aerospace Equipment*, contains detailed information on removal procedures and application of preventives for the various types of metals used during aircraft manufacturing. Methods, materials, and equipment used in preventive maintenance painting are also discussed in TO 1–1–8.

Once you determines it is necessary to remove and treat corrosion, follow the instructions outlined in the TO. If, during your inspection, you find corrosion so severe that it necessitates removing the damaged component or part, follow repair procedures as outlined in the specific TO for the aircraft.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

405. Identification of corrosion on metal surfaces

1. Why is magnesium always primed and top coated?

2. Where does corrosion attack zinc-plated steel?

3. How does corrosion appear on bare copper surfaces?

406. Surfaces susceptible to corrosion

1. Cite some points to check for corrosion when looking at external aluminum alloy surfaces.

2. What area of a weapon system is a potential water trap and should be sealed to prevent corrosion?

3. What is the first evidence of corrosion of a spot weld in a gun housing?

407. Maintenance measures used to combat corrosion

1. What is the most effective measure in preventing corrosion?

2. During an inspection, what are the two things you must do if corrosion is found?

3. What can happen to electrical compartments if steam cleaning compounds and steam is used?

4. What is a common method of slowing corrosion?

Answers to Self-Test Questions

401

1. They are reinforced to give you a sure-footed, sturdy place to walk while you maintain the aircraft. They are constructed to give better footing than the rest of the aircraft surface, especially during inclement weather.
2. Damaged equipment and personnel injury.
3. The engine intake, engine exhaust, and engine turbine plane.
4. Engine intake and exhaust blast.
5. The high velocity and high temperature it produces during operation.
6. Because if the turbine wheel disintegrates while you are standing in this plane, flying parts of the blade could seriously injure you.
7. It is normally marked by a painted RED stripe on the engine cowling. If there is no red stripe, you can check the applicable technical order.
8. A distance of at least the length of the helicopter.
9. At the rear of the engines and at an angle of 45° on either side.
10. Head set.
11. Burns beneath the skin and cataracts in the eyes.
12. Directly from the front or back of the tire.

13. Never walk in front of a loaded gun system.
14. Because they are a type of munition item and can be set off by extreme heat or unintentional movements.

402

1. Armed aircraft generally are identified with safety pins, with red streamers attached, installed at the loaded stations or on the applicable armed munitions items.
2. Block 11.
3. To make sure the entire aircraft is in a safe condition before you do any maintenance on it.
4. Safety locks and pins.
5. They are removed.
6. They are installed after an aircraft's flight and remain installed as long as the aircraft is on the ground.
7. OFF, SAFE, or NORMAL.

403

1. When its engine is running.
2. The upwind side.
3. 2,000 feet.
4. One minute.
5. By propelling or detonating, or both.
6. The number three person.
7. The 150-pound Halon 1211.

404

1. Aircraft and engine fasteners (nuts, bolts, washers, safety wire, etc.) and extra flight line metals (nails, personnel badges, pens, pencils).
2. Natural stone (pebbles, gravel, sand) and, unnatural stone (concrete, cinders).
3. Wood, organic matter (animal or vegetable matter), wearing apparel, hard plastics, ice (hailstones, frozen or hard-packed snow), and large pools of water.
4. Carelessness.
5. Maintenance and run-up areas.

405

1. Its low resistance to corrosion.
2. Only where the coating has been destroyed.
3. Greenish-white.

406

1. Around the heads of countersunk fasteners, on panels, riveted areas, and in fairing overlap areas.
2. Gun bay areas.
3. The appearance of corrosion at the crevices of the spot weld.

407

1. Preventive maintenance.
2. Remove the corrosion and apply corrosion preventives.
3. Corrosion of relays and deterioration of wiring.
4. Painting.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

1. (401) Before operating bomb bay door systems for check out, you *must* make sure
   a. the system has been safed or disabled.
   b. the proper strut supports have been installed.
   c. the system safety pins and rigging stops have been installed.
   d. all personnel and equipment have been cleared from the area of operation.

2. (401) The noise intensity of jet aircraft is *greatest*
   a. anywhere within a 25-foot radius around the aircraft.
   b. anywhere within a 100-foot radius around the aircraft.
   c. in the rear of the engines at an angle of 10° on either side.
   d. in the rear of the engines at an angle of 45° on either side.

3. (401) What symptom can a person expect to experience before suffering organ damage from radio frequency radiation exposure?
   a. Blurred vision.
   b. Profuse sweating.
   c. Loss of balance/vertigo.
   d. There are no symptoms before damage occurs.

4. (402) Which Air Force Technical Order (AFTO) form has an entry identifying the types and quantities of munitions loaded on an aircraft?
   a. 781A, Maintenance Discrepancy and Work Document.
   b. 781F, Aerospace Vehicle Flight Report and Maintenance Document.
   c. 781H, Aerospace Vehicle Flight Status and Work Document.
   d. 781J, Aerospace Vehicle—Engine Flight Document.

5. (403) What information is the topic of Air Force Manual (AFMAN) 91–201?
   a. Explosive safety standards.
   b. Aircraft and equipment maintenance management.
   c. Equipment inventory, status and utilization reporting.
   d. Conventional munitions maintenance and management.

6. (403) From which side of an aircraft do you fight a fire when possible?
   a. Upwind.
   b. Crosswind.
   c. Downwind.
   d. Any position.

7. (403) General purpose bombs normally detonate within how long after being engulfed in flames?
   a. 30 seconds.
   b. 45 seconds to one minute.
   c. Two to four minutes.
   d. Five to 10 minutes.

8. (404) Personnel line badges are classified as what type of foreign object damage (FOD)?
   a. Metals.
   b. Papers.
   c. Plastics.
   d. Miscellaneous.

9. (404) What is the foreign object damage (FOD) walk?
   a. Any walkway for storing debris temporarily.
   b. An inventory of tools before and after each job.
   c. An organized inspection and physical pickup of foreign objects.
   d. A place to store personal effects while working on the flight line.

10. (405) Anytime you see magnesium, how will it *always* appear?
    a. Primed and top coated due primarily to its low resistance to corrosion.
    b. Heavily lubricated due primarily to its low resistance to corrosion.
    c. Free from lubricants due to its high resistance to corrosion.
    d. Bare due primarily due to its high resistance to corrosion.

11. (405) Aluminum's formation of a tightly adhering oxide film
    a. prevents it from being primed and top coated.
    b. offers reduced resistance under all corrosive conditions.
    c. provides increased resistance under mild corrosive conditions.
    d. requires heavy lubrication to prevent further degradation of structural integrity.

12. (405) How does corrosion appear on nickle- or chrome-plated steel surfaces?
    a. Small spots on the plated surface.
    b. A dull-gray product that can be wiped off.
    c. A bluish-green coating on the surface of the product.
    d. A white-yellow corrosion product appears on the exposed surfaces.

13. (406) Piano hinges are prime spots for corrosion because they are natural traps for dirt, salt, and moisture and
    a. dissimilar metal contact between the steel pin and the aluminum hinge tangs.
    b. residual oil quite often masks small quantities of water that set up hidden corrosion cells.
    c. their constant actuation by maintenance personnel results in excessive wear of their finishes.
    d. their protective finish is very often blistered by heat, blasted away by the high-velocity gases, and abraded by spent shell casings and solid particles from gun and rocket exhausts.

14. (407) An important part of corrosion control is detecting and treating the corrosion when it is in what stage?
    a. Final.
    b. Severe.
    c. Earliest.
    d. Endothermic.

Please read the unit menu for unit 2 and continue ➔

Unit 2. Aircraft Armament Systems

AS AN AIRCRAFT ARMAMENT SYSTEMS SPECIALIST, you are responsible for performing an unlimited amount of maintenance on an aircraft's armament system. Doing this kind of maintenance requires you to know all aspects of an aircraft's armament system. Unfortunately, it is beyond the scope of this course to cover all the aircraft you may have to work on during your career. However, there really is no need to cover each system, because they all are designed basically the same. They may have different names for different components, or because of modernization and miniaturization, one panel may do what four or five used to do. But their overall end product is the same—the controlled and efficient release of munitions from an aircraft.

In this unit, we will cover the basic armament systems controls, stores management systems (SMS), and munitions suspension equipment. These are the three basic components incorporated into the design of all armament systems, regardless of how old or new the aircraft. Finally, we will take a look at the complete armament system, focusing briefly at its subsystems operation and certain maintenance aspects affecting us as armament systems specialists.

2–1. Armament Systems Controls

This section discusses the basic components that make up an aircraft armament system—the cockpit armament panels and the various display and related control items. As you know, aircraft are designed with everything from conventional type switches, pushbuttons, and lamps, to having computers and integrated keyboards in their cockpits to control the armament system. Depending on the particular aircraft, these controls, as we mentioned before, vary in their placements in the cockpits, names they are given, and their electrical and physical designs. As we go through this section, relate the items discussed to your aircraft, and remember all aircraft have more or less the same components, although they may be disguised as or called something else.

408. Aircraft cockpit armament panels

The aircraft cockpit switches must be in the proper position to be safe and to make the armament system work properly. We'll go over the general placement of controls and switches involved in cockpit operations.

Aircraft power panels

Panel switches must be positioned properly before external power is applied to an aircraft. Once the switches on the panel are properly positioned and an external power source is applied, the circuitry of the panel allows electrical power to be distributed throughout the entire aircraft electrical system. On some aircraft, the aircraft power panel also controls the central computer power and may also monitor the entire aircraft, turning things on and off as programmed by the computer system. These panels are used and monitored each time you apply external power to the aircraft.

Main armament control panel

The entire weapons system receives its power through the main armament control panel. This does not mean every subsystem is automatically armed through this panel. It only means power is normally distributed to the subsystem controls through this panel and its switches. Numerous other functions are done through this panel by positioning its switches or selecting certain pushbuttons, depending on the panel's design characteristics. Some of the more common armament systems functions performed through this type of panel are:

- Selective jettison of munitions and related suspension equipment.
- Selection of gun firing rates on aircraft equipped with gun systems.
- Energizing and deenergizing of bomb rack arming solenoids at selected stations.
- Selection of wing, fuselage, pylon, and armament bay stations for munitions release.
- Selection of a particular type of weapons release mode (i.e., single, ripple, triple, etc.).
- Selection of release interval pulses for computed munition release.
- Selection of electro-optical/insulation resistance (IR) guided bomb system power.
- Opening and closing of aircraft weapons bay doors.
- Nuclear weapons prearm and unlock functions.

You may also find many weapons system indicators on the main armament control panel. The indicators tell you information like the number of rounds remaining in a gun system, fuzing options selected for loaded munitions, selected release intervals (normally shown in feet or milliseconds), and weapons stations selected for a particular purpose. There may also be other indicators to give you information you need to know about other armament subsystems.

Subsystem control panels

The subsystem control panels are used to control (ready and arm) individual portions of the armament system. They are found in various locations in the aircraft cockpit. Let's look at the more common ones found in an aircraft and their functions.

Audio/communication control panels

Audio/communication control panels are used during ground functional checks. Personnel are required to be in the cockpit and on the ground during most types of system functional checks. Communications between crewmembers is essential and made possible through these panels.

Another function of the audio/communication control panel, depending on the aircraft, is the capability to vary missile tone during ground functional checks of the missile system. This function is found on aircraft capable of carrying the AIM–9 missile.

System override panels

System override panels provide a circuit to bypass the need for the landing gear to be in the UP position before the armament system is able to receive power.

Chaff and flare panels

The chaff and flare panels contain the controls and indicators necessary to ready an aircraft's chaff and flare dispensing systems. The actual dispensing of the munitions is done through the controls, which are usually located on the engine throttle grips on fighter-type aircraft and at the electronic warfare officer station or defensive systems operator station on bomber-type aircraft.

Missile control panels

The circuitry through the mission control panels is used to activate an aircraft's radar set functions to their fully operational status so ground checkout of certain missile systems may be done. It may also provide for arming and prearming other missiles along with the selection of their launch and release modes. Additionally, you may find lighted indicators on these panels providing you with a status of loaded missiles.

Emergency jettison control panels

The emergency jettison control panels have the controls necessary to do the emergency release of conventional and nuclear weapons (internal or external), and all external jettison-capable munitions suspension equipment. In the case of nuclear weapons, emergency jettison is usually done through this panel in conjunction with the special weapons control panels. Additionally, certain aircraft have provisions for emergency manual release of special weapons.

Special weapons control panels

Special weapons control panels control and monitor an aircraft's nuclear weapons delivery system. Controlling and monitoring is further defined as the features of selecting, monitoring, prearming, enabling, arming, disenabling, safing, and releasing.

The panels are positioned within the aircraft in such a manner to make sure the aircrew personnel follow the two-person concept even during weapon delivery. In the case of a single cockpit aircraft, the aircraft's permissive action link (PAL) system and ground monitoring make sure the two-person concept is still used. These special weapons control panels work in conjunction with the main armament system control panels to facilitate all of the functions needed to release a special weapon. The special weapons control panels also contain various indicators and displays to show information such as station location of weapons, locked and unlocked status of bomb racks, the condition of weapons bay doors, status of the weapon, and when the weapon is released. The switches on these panels are guarded in the SAFE position by a red cover guard and are safety wired with either 0.020 copper or steel safety wire. You may also find a lead seal attached to the safety wire. The seal is distinctively marked so you can easily detect tampering.

409. Armament displays and related control items

Many of the displays we use provide us with information about the status and location of weapons loaded on the aircraft.

Video displays

Video display "monitors" are used to display information about the status of the aircraft's weapons system and the munitions installed on the aircraft. In most aircraft, they have replaced many of the older control panel systems discussed in the earlier lesson. Push button type switches are positioned around the edge of the display screen. These switches are used to control the display of system data and input data into the system. You are required to input and monitor information through these displays and their controls during various maintenance tasks. Usually, upon system initialization, a main menu is displayed on the display screen allowing you to select the appropriate subsystem menu or function you need to perform the task. The content of the display you call up is software controlled and stored within the aircraft's computer system. Most aircraft have more than one display, and they all may operate and look exactly the same. The additional screens only allow you to view the status of an additional system at the same time. Familiarize yourself with your particular aircraft and the proper procedures for their operation.

Armament advisory light panels

Along with video displays, you may encounter armament advisory light panels on older aircraft. Armament advisory light panels contain lights to advise you, or the pilot, of the status of the weapons system. Normally, the function of each panel is self-explanatory when illuminated. There is a light for every munition carried on an aircraft's armament system. You may, in some instances, find one light may be used to monitor more than one munition. This depends on the munitions functioning characteristics and the design of the armament system. These lights tell you everything from the selected stations to what type of munition is selected for release.

Master caution light panels

Most aircraft are equipped with a master caution light panel. The master caution light panel contains lights to advise you or the pilot of the status of all aircraft systems. The function of each light on these panels is self-explanatory when illuminated. Also, there is a light for every emergency that might occur during system operation.

Heads-up displays

Heads-up displays (HUD) are designed to display flight data to the pilot while in-flight. These displays are transparent so the pilot or crewmembers can watch where they're going and see the flight data at the same time. The HUD also displays weapons targeting data and sights. You will use the HUD during some of your missile checks.

Helmet mounted displays

One of the newest displays available on combat aircraft is the joint helmet mounted cueing system (JHMCS). JHMCS combines a magnetic head tracker with a display projected onto the pilot's visor, giving the pilot a targeting device that can be used to aim sensors and weapons wherever the pilot is looking. With JHMCS, the pilot can aim the radar, air-to-air missiles, infrared sensors, and air-to-ground weapons merely by pointing his or her head at the target and pressing a switch on the flight controls. Additionally, the pilot can view any desired data (airspeed, altitude, target range, etc.) while using the "heads-up" feature, eliminating the need to look into the cockpit during visual air combat.

Armaments system circuit breakers

When external power is applied to an aircraft, it doesn't just go straight to the various systems controls. It must first pass through circuit controlling devices called *circuit breakers*. You may find these items placed on various panels or grouped together on a single panel in the aircraft cockpit. They are normally pulled out to prevent electrical power from being applied, and pushed in to allow power to flow through the circuits. You will find circuit breakers controlling all aspects of the armament system.

Stick grips

The pilot's stick grip normally contains two basic armament system controls. They are the trigger switch and the armament release switch, better known as the pickle or bomb button. The trigger switch usually controls camera operation and gun firing at the first and second trigger detents, respectively. The armament release switch releases munitions from the aircraft.

Throttle grips

Sometimes, again depending on the aircraft, you will find armament controls located on the engine throttle controls. These controls may be used to select different weapons system modes of operation such as guns, missiles, or chaff and flare dispensing.

Integrated keyboards

Presently, there are four aircraft in our inventory with integrated keyboards: the B–52, B–1, B–2, and the AC–130. They contain numerous keys and display switches through which the operator may input information into the aircraft computers. The keyboards allow you, the operator, to select information for display on the video displays and provide a way for you to modify information, such as changing the number of weapons to be dropped on a target.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

408. Aircraft cockpit armament panels

1. On some aircraft, what aircraft panel is responsible for controlling central computer power?

2. What panel allows for the selection of gun firing rates?

3. On what aircraft panel can selected weapons system indicators normally be found?

4. What function is provided by system override panels?

5. What aircraft panels are used in conjunction with each other to facilitate emergency jettison of nuclear weapons?

6. What are the eight controlling and monitoring functions performed by the special weapons control panel?

409. Armament displays and related control items

1. What is the function of video display monitors in an aircraft's cockpit?

2. What switch in an aircraft is used to release munitions?

3. What type of armament related controls might you find on an aircraft's throttle grips?

4. Which four aircraft in the inventory are using integrated keyboards in their cockpits?

2–2. Stores Management Systems

An aircraft's SMS, as its name implies, manages and controls weapons loaded on the aircraft. All aircraft have various forms of these systems. The design features of the components and component operation are the only differences between the various aircraft systems. If we were to inventory all the aircraft we work on today, we could safely say their systems can be divided into three design types: analog, digital, and hybrid. Let's take a look at these systems and other related systems of stores management.

410. Types of systems and their basic operation

We work with three types of systems in today's aircraft. The analog system is the older of these systems. The digital system is the newest of these and is seen on all the newer aircraft. The third system, the hybrid, is just a combination of the first two.

Analog

Legacy analog-based armament release systems are only found in older aircraft, like in some of the systems found in the B–52. These systems have the same capabilities as our newer aircraft systems but with some exceptions. One difference is they have fewer options available during weapons delivery. Newer systems are capable of functions such as aircraft stores inventory, computed weapons release, and weapons release priority sequencing, which analog systems normally are not capable of these higher functions. They contain only the basic system functions of weapons selection, arming, and release.

Other differences are the type of components analog systems use and their component and system design. Typically, analog systems are hardwired. This means wiring is run back and forth between analog components that make up the electrical circuits to facilitate weapons delivery. They are wired so each function of the armament system has individual circuit breakers, wiring, relays or relay packages, and switches. Consequently, each function is more or less a system itself. Each operates independently of the other, except for sharing the main armament controls, including the system MASTER ARM switch, and various aircraft components tied in as main controls of the armament system. The design of the analog system components is more primitive. The relays, relay packages, and resistors they use are not small; they are the conventional electromechanical type. Some components of these systems are contained in line replaceable units (LRU), which are found in the form of black boxes. These boxes contain the large, can-type relays. Normally, the boxes can be removed and replaced, but not repaired. The operation of the analog system is illustrated in a functional block diagram in figure 2–1. Refer to it as we work our way through its operation.

When external power is applied to an aircraft with an analog type system, 28 volts direct current (VDC) is applied to a primary bus. The primary bus then distributes power to a monitored bus or the aircraft's main armament circuit breaker panel. If the armament system circuit breakers are pushed in (energized), power is then routed through the MASTER ARM switch and various aircraft components tied together as part of the system's controls. At this point, if you flip the MASTER ARM switch you apply power to the entire armament system. When this switch is positioned correctly, power is initially routed to an armament bus relay. As long as this relay is energized, power is sent to the main armament bus and distributed to all of the aircraft armament system switches. The armament bus relay normally remains energized as long as electrical power to the aircraft is not interrupted or the MASTER ARM switch is not switched OFF.

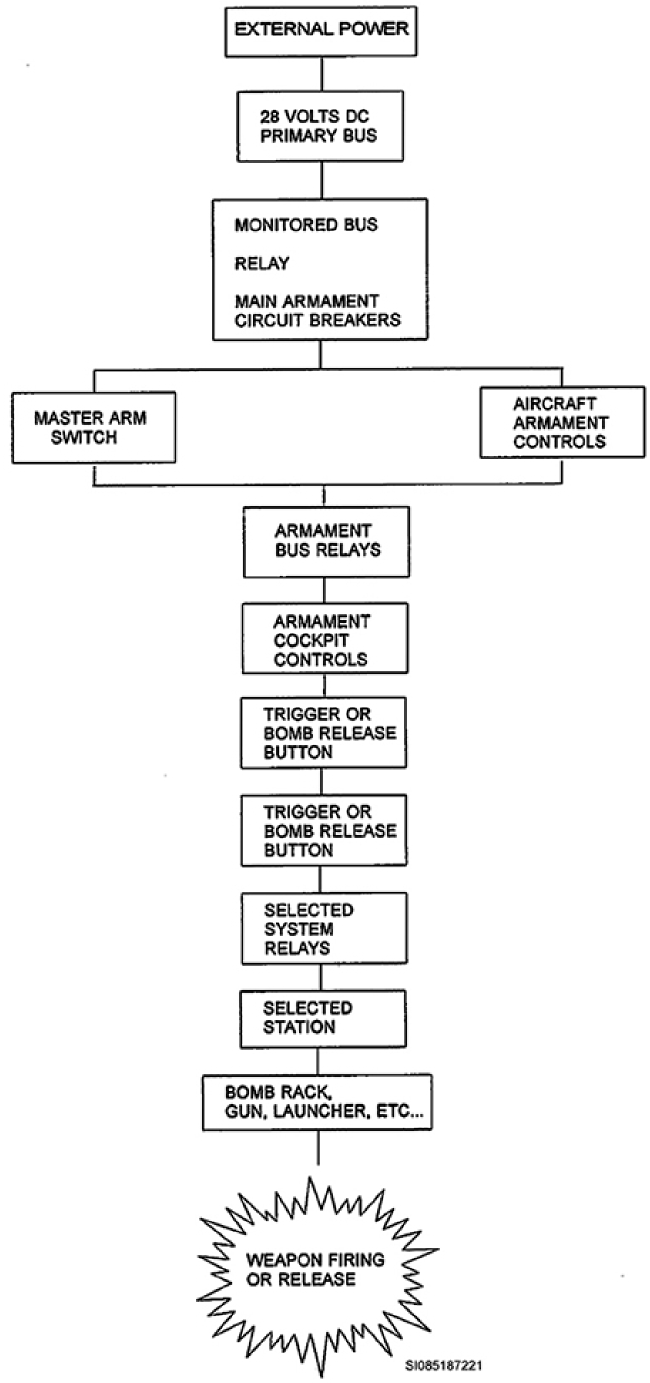


Figure 2–1. Analog-type SMS flow chart.

Once electrical power reaches the cockpit switches, it remains there until the switches are properly positioned to facilitate a particular weapons release function. For example, if a release function is selected, power is automatically distributed to the system relays, relay packages, or black boxes. After that, the power then splits into one of two different routes. One route would lead the power directly to the trigger switch or bomb release button, depending upon the function selected. The other route would guide power to the selected station or stations and finally to the bomb rack or launcher, to await the final relayed signal from the trigger or bomb button to activate the function.

Digital

In a digital system, the big relays and resistors of the analog system are replaced with circuit cards. Digital systems are complex computerized systems made up of many components. Basically, they convert cockpit control switch settings to electrical signals, process the signals, and transmit them to the various integrated components within the armament system and aircraft. This provides for the release or firing of various weapons.

Digital systems also provide a variety of functions, such as stores identification, inventory/status, activation/control, release, launch, jettison, sequencing and delivery rates, verification, and armament system integrity. This type of system works closely with, and is dependent upon, the aircraft's avionics systems. The SMS is usually divided into sections to perform certain functions. For example, if a system had a Controls and Displays section, it might be responsible for reading all signals leaving the cockpit and converting them into understandable data for other sections. It may also receive return data and status signals from other sections and use it to update various displays in the cockpit. Each section normally contains its own data processor to process system data and then transfers it to a central computer or set of computers by multiplex (MUX) buses, which are dedicated wires for communication.

Each SMS has at least one main computer and may have up to four depending on the aircraft. These components store, send, and compute the data used by the entire SMS. Most systems also have an additional computer or some type of interface unit used to backup the system's constant flow of data in case computer failure. All these computers are programmed by software to control their own functions and process their own data. These computers tie everything together between the aircraft's cockpit and its weapons stations.

The computers are linked to the various weapons stations through the use of an additional interface unit. These additional interface units are normally referred to as remote interface units (RIU), station logic units (SLU), missile interface units (MIU), release matrixes, or something similar. Essentially, these interface units are a multiplex terminal and switching center for power, control, release, stores status, and signals being sent to or coming from the weapons stations. We call them passive devices. They are constantly under the control of the central computer system. They are incapable of transmitting data except when called upon by the computer system. They also serve as an electrical interface between the stores, launchers, and bomb racks at the weapons stations. You will find various units of this sort in the systems and sometimes incorporated into individual pieces of suspension equipment.

The primary means of monitoring and controlling the digital system is normally done through various cockpit and aircraft-related controls. The functions of a digital system are initiated by the operator through inputs by way of switches or integrated keyboards. Data is transferred from computer to computer or throughout the SMS. As mentioned earlier, multiplexing refers to the ability of a system to send more than one message or signal over the same wire at the same time.

MUX buses are the most common mode of interfacing and transferring digital data within an SMS. The data or messages sent out through the MUX buses have a transmit or receive code attached to them. Receive codes allow the system components to receive input data from the other computers onboard the aircraft. A transmit code allows the components to send data to the central computer system. This process is quite common among our newer aircraft. The inputs are accepted and implemented by the controlling computer system and finally completed by the RIU, SLU, release matrixes, or MIU at the respective weapons stations. Figure 2–2 illustrates the typical digitally designed SMS and its components. Notice the data always flows back and forth between the various SMS components. Look at figures 2–1 and 2–2 and compare the components used in the various aircraft and their operational sequences. You may be surprised at the similarities of the aircraft systems.

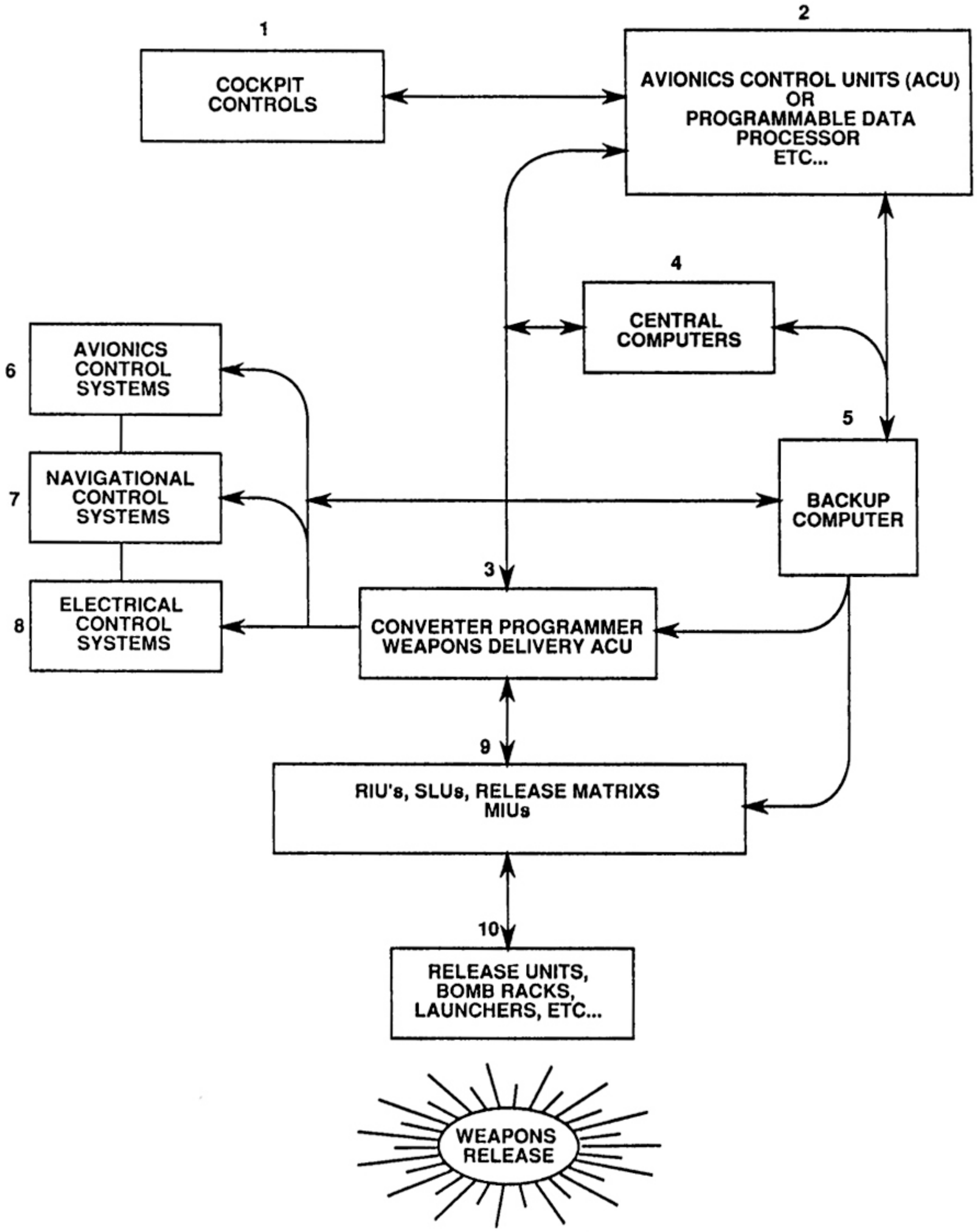


Figure 2–2. Digital SMS flow chart.

Hybrid

Hybrid systems employ both digital and analog circuits to control aircraft stores such as bombs, rockets, flares, dispensers, and missiles. They provide a means of selecting, arming, and releasing weapons in various computed and manual release modes. They also provide for selective jettison of specific weaponry and a redundant emergency jettison circuit to jettison all aircraft stores in an emergency situation.

Hybrid systems normally have one main control unit. It is capable of receiving, decoding, and transmitting to other control units either digitally or in analog signals. These control units are the heart of the entire armament system. They normally have the capability to perform a self-test or built-in-test (BIT) to ensure they operate properly. If so equipped, these units normally have go/no go indicators of some type to allow you to determine their status after the test. You will find these units contain plug-in and pullout-type circuit cards so they can be removed, repaired, and replaced.

Normally, this main control unit monitors the entire system for any analog and digital input signals. It is constantly looking for signals to tell it what weapons function is to be carried out. When it finds or receives the necessary inputs, it reads them and sends output signals to various systems and units and awaits return messages. These return messages can be sent by the push of a button in the cockpit, flip of a switch, or as a return message from an associated component. This control unit needs these signals to finalize its set up for the weapons operation. Once the necessary inputs are received and noted by the control unit, it generates the required release pulse(s) needed to accommodate weapons release. Next, it sends the release pulse(s) to the relay packages at the various selected weapons stations and weapons release will be accommodated.

If a computed mode of release is selected through the main control unit, it may or may not generate a release pulse, depending on the particular aircraft. Some aircraft are equipped with computers needed to interface with the main control unit before release pulses can be generated. The computer is the component used to calculate the drop interval of the weapons based on the settings of the interval switches, normally found in the cockpit. Another function of this computer is to generate a portion of the release pulses each time the aircraft has flown the distance indicated by the interval switches, then working in conjunction with the control unit, release pulses are sent to the appropriate weapons stations. This computer is not present on all aircraft having this type of hybrid system because some of the aircraft's main control units are capable of performing these functions alone.

We stated earlier the release pulses are sent from the main control units to relay packages at the selected weapons stations. These packages are also known as station program units (SPU), station control units (SCU), and agreement matrixes. Most aircraft using the hybrid-type system require these units. The SPUs are essentially switching devices consisting of relays to isolate the arming and release signals from the bomb racks and launchers. The SPUs are the interface between the system, pylons and bomb racks, and installed suspension equipment. SPUs may also be used to control other functions such as opening and closing weapons bay doors, if the aircraft is so equipped. The main control unit or the computer controls these units. Figure 2–3 illustrates the typical hybrid-designed SMS and its components.

System variations

There are variations in all of the designs we have talked about thus far. Extreme variations in the hybrid system employ the use of several black boxes to perform all of the functions of a main control unit. The computer may or may not be used in systems configured in this manner. The black boxes also contain circuit cards, as do the main control units. This segregation of control between several boxes does not affect their capability to handle digital signals as inputs or outputs. It's just not as convenient as having everything controlled through one box or unit. Yet, another variation of the hybrid system is demonstrated by the B–52 computed release portion of the conventional and free fall nuclear systems. This particular B–52 hybrid design uses the combination of a computer and the original analog.

If you really look close at the aircraft systems, you will probably see more variations or combinations of these types of systems than you are aware of. One example is the B–52, which has all three systems in use: the analog in the manual portion of its conventional and free fall nuclear system, a hybrid variation in its automatic conventional and free-fall nuclear system, and the digital in use in the offensive avionics system (OAS). Explore the aircraft you are presently working on and become familiar with its variations, if any.

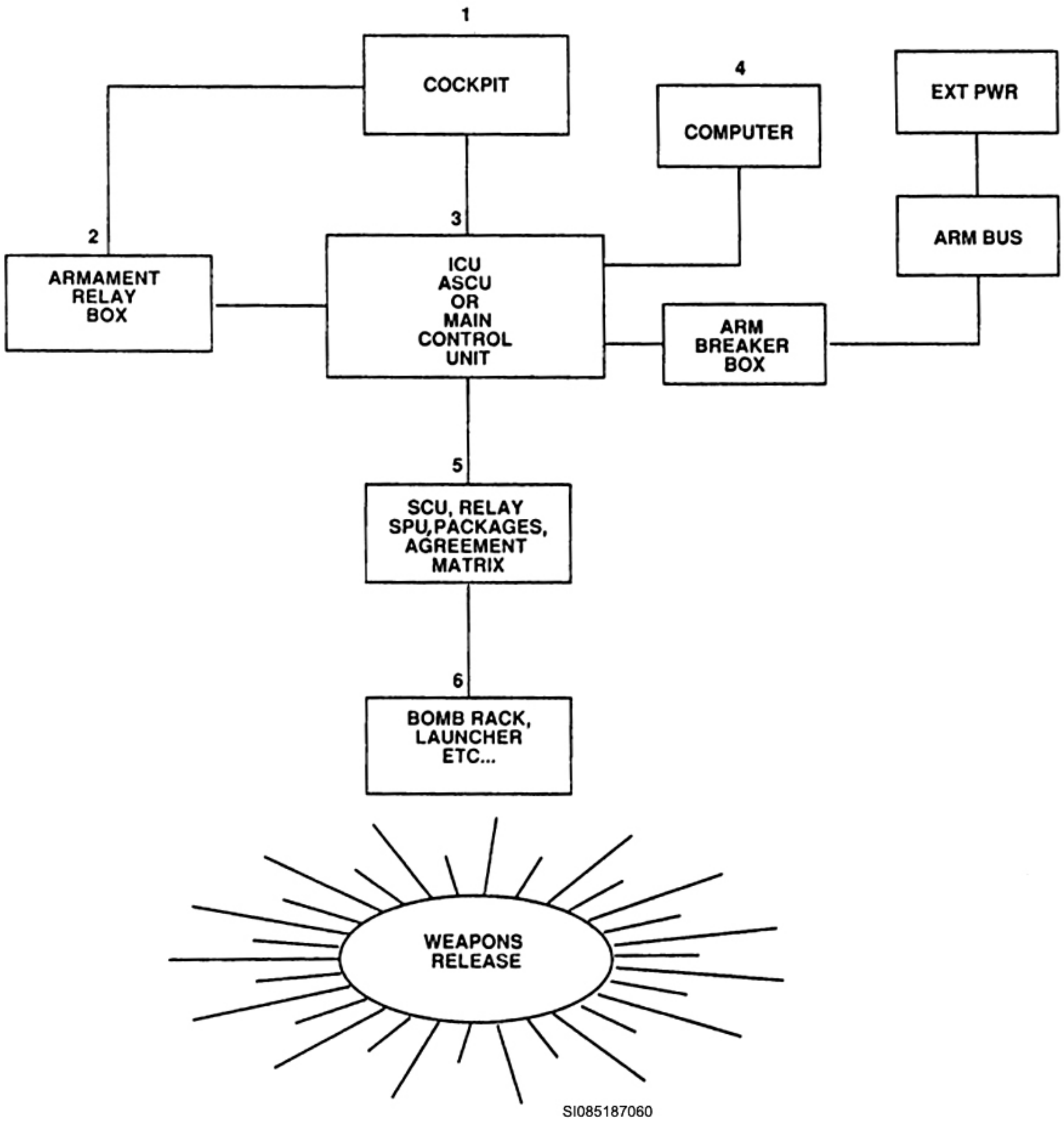


Figure 2–3. Hybrid type SMS flow chart.

411. Stores management system related systems

Systems related to SMSs are there to help carry out conventional or nuclear weapons delivery. In certain aircraft, they also assist in fault isolation. Not all of the systems we cover here apply to the aircraft you currently work on, but to be a well-rounded aircraft armament systems specialist, you need to be aware of their existence and have some knowledge of their purposes. As you study this lesson, keep in mind the names used are not specifically tied to any aircraft; the system concepts are basically the same regardless of the aircraft they are found on. You should also try to relate the concepts behind this information to the aircraft you are presently working on.

Controls and displays

The controls and displays system normally accepts and decodes commands from various control panels in the aircraft cockpits. It responds to these commands by displaying information on the aircraft's multifunctional displays (MFD). It primarily provides the operator-machine interface between you and the SMS.

Release priority systems

Some type of a release priority system is built into every aircraft. It controls the sequencing of weapons releases when more than one station is selected for weapons delivery. These systems determine the proper weapons stations release sequences by the information they receive from the SMS. They normally function automatically once they receive SMS information. When weapons release pulses are generated, these systems send the first release pulse to the station having the highest release priority, as determined by system design or preprogramming.

Release priority systems may also vary in their sequencing according to the type of release being accomplished through the weapons system. Sequencing normally takes place automatically, but as the differences in aircraft comes into play, so do the differences in the priority sequencing. Some weapons stations may have to be individually selected and released, again depending on the design of the aircraft. Once the munitions from these stations are released, the automatic sequencing once again resumes operation. There may be times when multiple releases are desired at more than one weapons station. Let’s assume, for example, triple ejector racks (TER) are loaded at stations on the opposite sides of an aircraft. Sequencing in this situation occurs alternately, back and forth, between the two stations until all of the munitions have been released. In a situation where only a single release is being done, the system would not be operable. These systems not only affect the normal release or firing of weapons but may also affect their jettisoning. The release priorities of aircraft stations usually change as the options of release change.

Fault isolation systems

Fault isolation (FI) systems are found only in newer, more advanced aircraft. The purposes of these systems are to monitor an aircraft’s system and to indicate or report its status to the aircrew and ground maintenance technicians. FI systems are designed and programmed to monitor all aircraft and weapons-related subsystems and to determine exactly what system area, subsystem, or component caused, or is causing a malfunction. They range in design from the basic BIT type to almost an artificial intelligence type system.

The BIT is one of these types of fault isolation systems. These checks are automatically set into operation as soon as the aircraft computer system receives electrical power. Maintenance personnel may also manually initiate them. This system performs self-tests on certain system components and displays the results either on a MFD or at a common display point. Once the results of a BIT check are displayed, you should know what system or subsystem is causing a problem if the test is not successful. Thus, as maintenance personnel, you have a starting point to begin your fault analysis of the aircraft. Using the test equipment is normally required with this type of FI system.

The second type of system you will encounter performs continuous, noninterruptive self-tests for constant monitoring of the aircraft systems. This type of system provides malfunction data, displayed on an MFD in the form of codes, and must be interpreted by aircrew or maintenance personnel. It also has the capability to provide you with a recorded history and description of system failures. The system normally takes you to a point where your fault analysis is minimal. It carries you one or two steps further than the BIT check. Your work will probably begin at the subsystem or LRU level.

Although this type of system is more advanced than the BIT check, it still will not always lead you directly to a faulty LRU. Depending on the system it is checking, you may only be lead as far as the faulty system or subsystem. These systems also require the use of test equipment to finalize your fault analysis.

The third and final type of FI system is a highly advanced computer system. This particular system actually allows the aircraft to tell you where the problem lies. It constantly monitors the entire aircraft and its systems while the aircraft is flying or even taxing on the runway. It basically listens in on all the aircraft systems and reports its findings on MFDs, and then records the faults found into system memory for technician analysis. This allows you to gain access to the information when the aircraft returns from flight or in our newest aircraft before it returns. This type of system is programmed to monitor all LRUs in all subsystems. It takes you deeper into fault analysis—to a point where it normally isolates the fault encountered to a single LRU. In some cases, if a fault cannot be isolated to the single LRU stage, the system isolates the fault(s) to a group of LRUs.

The fault isolation system may also be activated on the ground during operational tests of aircraft subsystems. The options available for use with the FI system are requested or selected by you through data input at an integrated keyboard. This system, as you can probably guess, has a full range of parameters it monitors on each system. These parameters include everything from voltage levels to the condition of certain devices (i.e., is a circuit breaker open or closed?). This function can save you valuable maintenance time during fault analysis. If the system tells you the problem and where to find it, you no longer have to crawl around the aircraft with multimeter taking voltage readings because you already know this data. Consequently, you can immediately find the faulty item, then remove and replace it—a considerable change from the past.

FI systems also monitor certain individual components along with all major systems data busses. They compare the information received with a stored list of correct information. If the two sets of information are the same, everything is GO as normal. If not, the system declares a malfunction and stores the information.

Up to this point, the only thing this system cannot do is fix the faulty items or components. Let's compare it to your car to get a better understanding of how it works. If you hear a strange noise coming from your car, your brain remembers it and compares it to how your car normally sounds. If the two sounds do not compare, you declare the unfamiliar sound a problem and take the car to be fixed or fix it yourself.

To help identify the faulty LRU or shop replaceable unit (SRU), you have to refer to a system's technical order and go through a flow chart answering a series of questions about the problem. The system may indicate a problem does not exist, although you have noticed one. What do you do? You must go back to conventional troubleshooting methods.

Nuclear systems

Nuclear systems are used by our nuclear-capable aircraft to prevent accidental or unauthorized prearming of nuclear weapons and, if necessary, to accommodate their delivery. These systems also control the jettisoning nuclear weapons. You have probably heard them referred to as PAL, aircraft armament and control (AMAC), nuclear enable, or special weapons systems. They are all responsible for monitoring and controlling nuclear weapons installed on an aircraft.

Nuclear systems are electrically connected into the aircraft arming systems between the cockpit controls and weapons stations. They normally do not allow any release commands or firing pulses to pass through their circuits and gain access to a nuclear weapon until they are properly enabled. Usually, they are software controlled and enabled by properly positioning cockpit controls and inputting a numbered code through a PAL panel, a coded switch set controller, or a similar device. This enabling system is safe in itself, because there are approximately 16,000,000 different possible input codes. Once these codes are input into the system, they are checked electronically for validity by various system components. If they do not match, then the system is not enabled. These systems adhere to the two-person concept, regardless of the aircraft they are installed in.

Communication systems

You might be wondering how the communication system is connected with the SMS. Well, on aircraft capable of carrying the sidewinder missile, the communication system is used to transfer missile tone from the missile to the cockpit. These tones are heard when the missile detects a heat source or when an applicable tester is hooked up and used to functionally check the sidewinder missile system.

Radar navigation systems

Radar navigation systems provide navigational aids and flight data from the onboard radar sets to various aircraft systems. On computerized aircraft, this system sends signals to the computer system specifically to facilitate the computerized release of onboard missiles.

Global positioning system

The global positioning system (GPS) provides specially coded satellite signals processed in a GPS receiver, enabling the receiver to compute position, velocity, and time for target acquisition. GPS satellite signals are used to compute positions in three dimensions for time to target and release sequence.

Electro-optical guided munition control systems

Electro-optical guided munition control systems provide the control signals necessary to select, arm, and release electro-optical (EO) guided munitions. An MFD in the cockpit normally is used to provide a picture of the target on the aircraft's radar indicator. This assists in the alignment and lock on of the bomb guidance unit. Most of the time, the only connection this system has with the SMS is during weapon and station selection and release activation. Release activation is normally carried out through the bomb button or weapons release switch.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

410. Types of systems and their basic operation

1. What aircraft contains analog type SMS?

2. What are the basic system functions of analog type SMS?

3. What type of SMS is typically a hard-wired system?

4. For the primary armament bus relay to remain energized in an analog SMS, what conditions must be met?

5. What are the functions provided by a digital SMS?

6. What component of a digital SMS stores and sends information used by the entire system?

7. Which components of the digital SMS serve as a multiplex terminal and switching center for power, control, release, stores status, and signals being sent to and from the weapons stations?

8. What type of SMS may or may not employ the use of a computer?

9. How does the hybrid system vary from the analog and digital systems?

411. Stores management system related systems

1. What SMS related system responds to commands by displaying information on an aircraft's MFD?

2. What is the purpose of release priority systems?

3. What type of fault isolation system only takes you as far as the system or subsystem point in troubleshooting?

4. What type parameters are monitored by more advanced FI systems?

5. What is the purpose of the nuclear system on nuclear capable aircraft?

6. Normally, what is the only connection an EO guided bomb control system has with the SMS?

2–3. Bomb Carriage Suspension Equipment

Bomb carriage suspension equipment provides the carrying and releasing capabilities for a multitude of items from our aircraft. Depending on the aircraft, it may be used to carry weapons and other suspension equipment items, such as launchers and dispensers. Suspension equipment includes bomb racks, clip-in racks, cluster racks, bomb modules, multiple ejector racks, and pylons. Let's discuss each one separately.

412. Basic bomb racks

Bomb carriage and release items are found on all attack, fighter, and bomber aircraft in inventory today. Their purpose is to provide a point which to carry and release a variety of weapons both conventional and nuclear, as well as, subracks, launchers, dispensers, and so forth. This lesson covers all types of bomb racks, including some related miscellaneous items.

Mechanical bomb racks

There is only one mechanically operated bomb rack in use today. It is more commonly referred to as the B–11 bomb shackle (fig. 2–4). The B–11 was designed for internal installation and is presently being used with the B–52 aircraft cluster rack system. It can suspend bombs and munitions items weighing up to 1,600 pounds, if the munition has 14-inch suspension lugs.

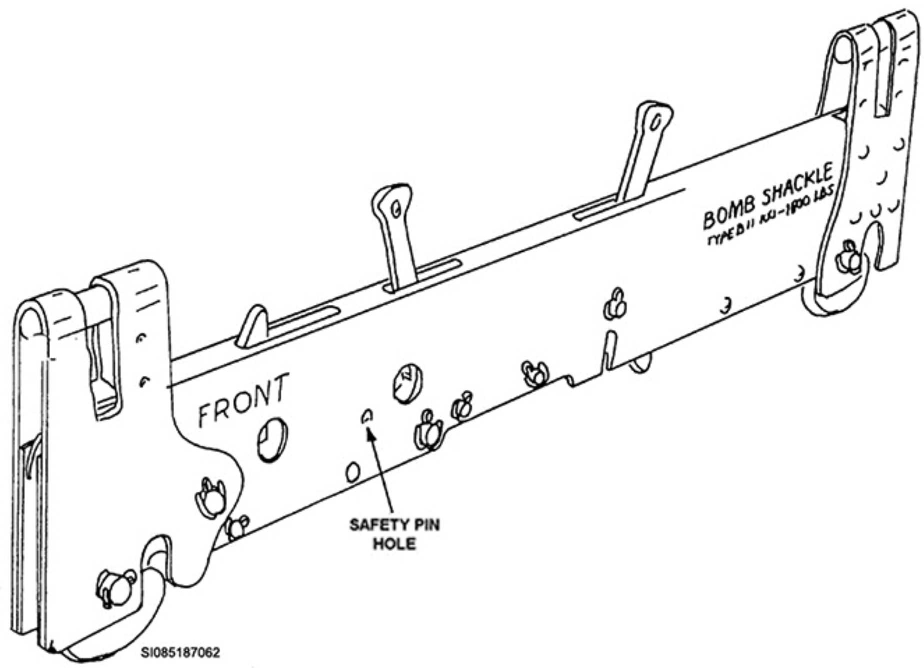


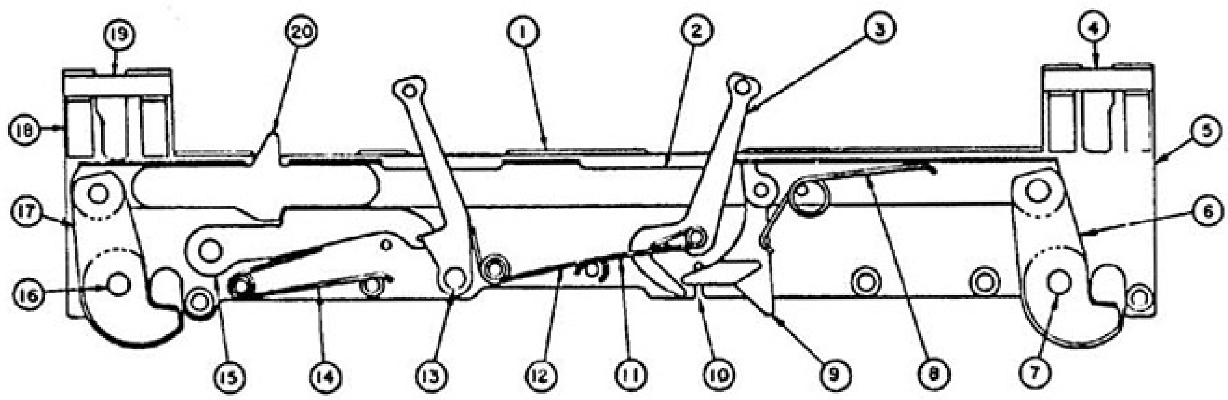
Figure 2–4. B–11 bomb shackle.

The major components of this bomb rack (shackle) are shown in figure 2–5. Its operation is fairly simple and, when installed in the aircraft, it is dependent upon a release unit covered later in this section. Refer to figure 2–5 as we discuss the shackle's operation.

The bomb shackle's stirrup rods are attached to hooks on the cluster rack assembly. The shackle supports bombs and munitions items with two hooks when the shackle is cocked. When installed in the aircraft, the two levers protruding from the rack fit into slots of an electrically operated release unit. These two levers and the release unit are responsible for operating the shackle's hooks and arming mechanism. Figure 2–5 shows the shackle in a "cocked" position with the arming lever in the "safe" position. These are the positions they would be in when carrying a bomb.

The bomb's arming wire would be held in the slot (10) by the arming wire retainer. Installing an arming wire loop into the shackle is done by pulling back the arming retainer against its spring pressure and inserting the arming loop into the slot. To release a bomb "armed," the latch and arming hook are rotated towards each other for their full travel by the release unit. The motion of the latch releases the tumbler and is forced down against its spring by the weight of the bomb acting through the hooks, link, and tumbler stop. The link is then free to move to the right and the hooks are free to rotate to the open position. The arming wire loop is caught by the arming hook and pulled from the fuze. The fuze arms as the bomb is released.

You can see from this example that the operation of this type of unit is extremely simple. But now, let's move on and see how it compares to the other types of bomb racks.



1. CHANNEL
2. LINK
3. ARMING HOOK
4. STIRRUP ROD
5. STIRRUP, REAR
6. HOOK
7. HOOK PIN
8. ARMING WIRE RETAINER SPRING
9. ARMING WIRE RETAINER
10. ARMING WIRE SLOT
11. ARMING HOOK SPRING
12. LATCH SPRING
13. LATCH
14. TUMBLER SPRING
15. TUMBLER
16. HOOK PIN
17. HOOK
18. STIRRUP, FRONT
19. STIRRUP ROD
20. TUMBLER STOP

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Figure 2–5. B–11 bomb shackle components.

Gas-operated bomb racks

The gas-operated bomb rack is the most commonly used bomb rack today. There are a lot of variances in the types used, but their basic design and operation have not changed. Gas-operated bomb racks include the MAU–12; MAU–40 and 50; BRU–44, 46, 47, 56; and the 14-inch ejector racks.

The table below lists compatibility of the aircraft carrying these bombs and figures 2–6, through 2–8 show you the various bomb racks. They are all designed to suspend from an aircraft and eject or free-fall release nonnuclear air munitions and suspension equipment items. Only the MAU–12, BRU–44 and 47 are nuclear capable. The BRU–56 contains all of the necessary components for nuclear release, but it is no longer certified to do so.

Aircraft	Bomb rack(s)
A–10	
Wing outboard 2 pylon stations	MAU–50/A
All other stations	MAU–40/A
B–1B	
Conventional bomb module	14 inch ejector racks
180-inch rotary launcher	BRU–56/A (A.K.A. 30-inch ejector racks)
B–2	
Rotary launcher assembly	BRU–44B/A
B–52	
External stores	MAU–12 C/A or D/A
Common strategic rotary launcher	BRU–44 or Modified MAU–12 D/A
F–15	
Pylon stations	MAU–12 C/A or D/A
F–15E	
Inboard and centerline pylon stations	BRU–47/A
Conformal fuel tank inboard stations	BRU–47/A
Conformal fuel tank outboard stations	BRU–46/A
F–16	
All pylons	MAU–12 C/A or D/A

Aircraft	Bomb rack(s)
F–22	
Center weapons bay	BRU–46/A
F–22A pylon	BRU–47/A

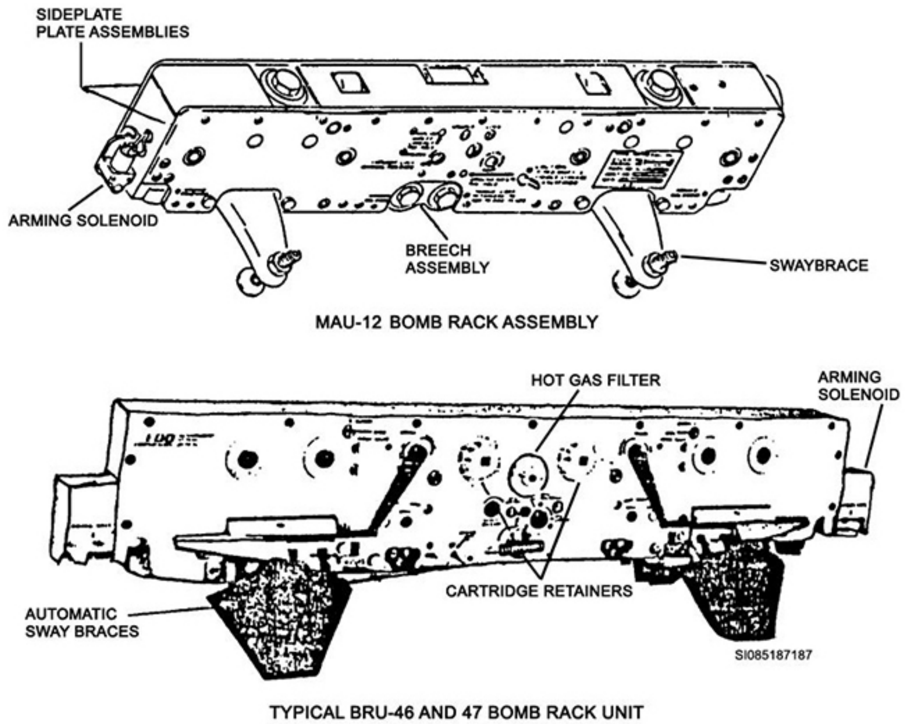


Figure 2–6. Typical gas-operated bomb racks.

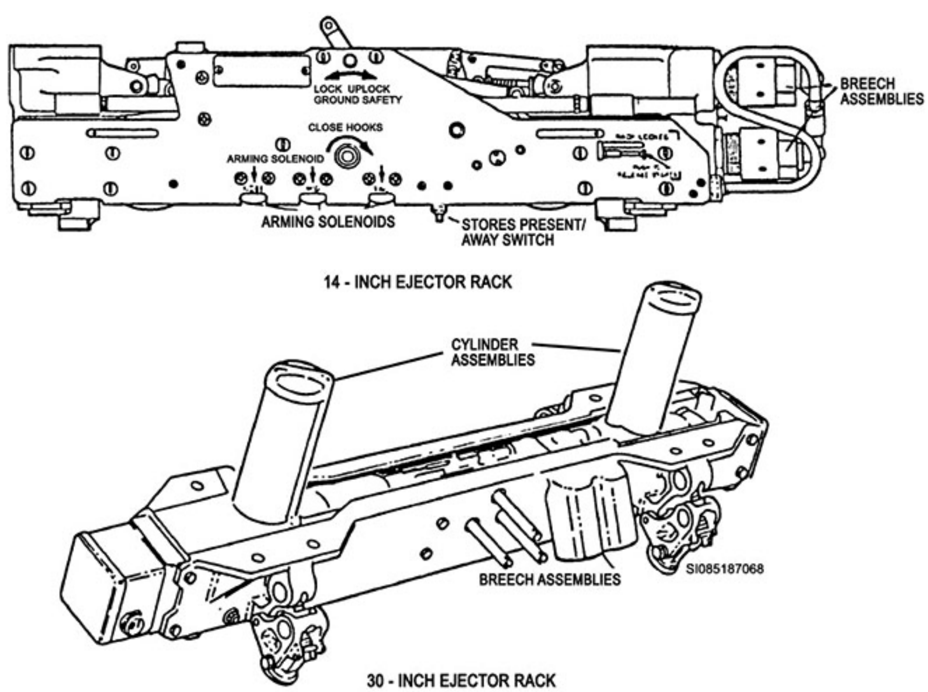


Figure 2–7. Typical gas-operated bomb racks (cont'd).

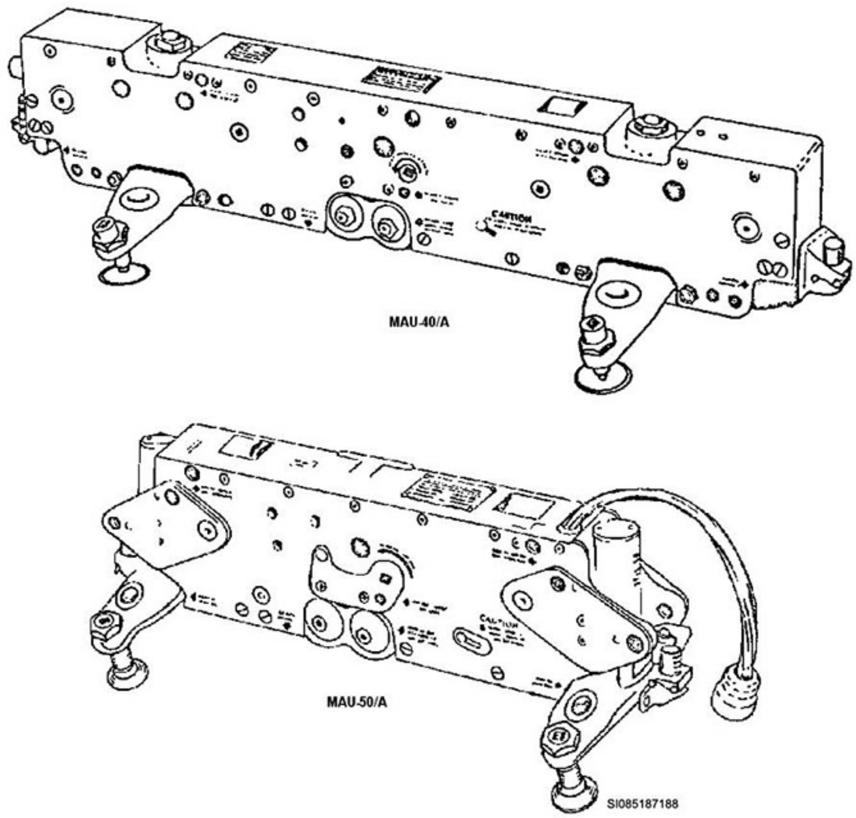


Figure 2–8. Typical gas-operated bomb racks (cont'd).

All gas-operated bomb racks have similar components. If you were to disassemble any of these racks, you would find that there are four basic sets of components to each one. We base our discussion on these sets of components.

Framework

A set of components form the framework of the bomb racks. These components vary with each bomb rack, but basically you will find two designs in use. The first uses side plates, channel assemblies, and cylinder assemblies to form the framework. If this is the case, you will find the two side plate assemblies, one left hand and one right hand, bolted to channeling assemblies or cylinder assemblies to form the rack's framework. The left-hand side plates are easily identified by a cutaway portion normally in their lower edges; the cutaway portion allows access to both a cartridge breech assembly and the cartridge retainers or the rack's arming solenoids. Holes are located in the side plates to accept the mounting bolts, manual release tools, and ground safety pins.

Gas ejector system

The second set of components comprises the gas ejector system. The gas or ballistic components are used to force a store installed on the bomb rack away from the aircraft. Each of the individual racks has a breech assembly into which impulse cartridges are installed. The impulse cartridges, once installed, are held in place by either cartridge retainers or screw-on type breech caps. The breeches are where the internal gas pressure is created by firing the impulse cartridges. This gas pressure is used to unlock the hooks by over centering a bell crank type mechanism. When the hooks are unlocked, the weight of the bomb actually opens the hooks to release the bomb. The ejector pistons are used to push the bomb out into the air stream nose first.

On the BRU–46 and BRU–47, an internal hot gas filter has been incorporated into the breech assembly to help cut down the amount of carbon entering the gas system components. When impulse cartridges are fired, a carbon residue is created and pushed throughout a bomb rack's entire gas system. This residue can build up inside the components. If the components are not cleaned properly, the residue eventually restricts the amount of gas pressure being delivered within the system to a point where the rack may not eject a store. This new development greatly reduces the amount of carbon entering the system so cleaner internal operation is possible. Consequently, it also reduces the amount of maintenance required on the bomb rack itself.

The gas pressure leaving the breech assembly is ported through holes to a tube or passageway into gas-pressure limiting devices. These limiting devices may be built into the system or changeable. Their overall effect is to regulate the amount of ejection force used to push a store away from the bomb rack or aircraft. Changeable limiting devices are more commonly referred to as orifice assemblies. The BRU–46 and BRU–47, as examples, use devices called pitch control valves that have been incorporated to serve the same purpose. The pitch control valves are multi-positional controls adjusted using a flat blade screwdriver. The valves allow a selection from near zero to full gas flow. Orifice assemblies must be changed to obtain these results. Each bomb rack normally has two of these devices. Their sizes or adjustments are varied according to the type of store being carried on the bomb rack.

The suspension hooks and linkages on bomb racks are also opened and closed manually. Some hooks may close independently, but they normally open interdependently. Either one or two sets of suspension hooks are found on a bomb rack. They are set at spaces of either 14 or 30 inches apart.

Each bomb rack is also equipped with one or two cylinder blocks or assemblies. Inside each of these are a variety of parts, from o-rings and springs to ejector pistons. These cylinders are normally manufactured to close tolerances; they are also highly polished on the inside to ensure a smooth ride for the ejector pistons without any gas pressure escaping. Gas pressure enters the cylinder blocks or assemblies and pushes the ejector pistons down. The ejector pistons then exert pressure against an installed store to ensure a nose down attitude. To minimize drag, ejector pistons automatically retract to their stowed position after a store is released. Some ejector pistons have ejector feet assemblies screwed into the bottom of them. They are the portions of the piston actually touching the store being ejected.

Electrical wiring harness

The third component provided in each bomb rack is the electrical wiring harness. It completes the electrical circuitry throughout the entire bomb rack. Located at the rear of the bomb racks is an electrical connector. It provides an electrical connection point between the bomb rack and the aircraft's umbilical cable.

The electrical components of every bomb rack play a major role in how, and if, a release is accomplished. All the electrical components in a bomb rack provide for some portion of control and release of a loaded store. All of the bomb racks we've discussed so far have three arming solenoids. They may be found clustered together in the center portion of the bomb rack, or one at each end and one in the center of the racks.

At present, there are two types of solenoids in use, but most often you will find the newer hook-type solenoids installed on most bomb racks. The arming solenoids are designed to release the arming wire of munitions whenever their hooks are open (deenergized) and hold the wires if they are closed (energized). This provides for a significantly improved and fail-safe arming operation. The arming solenoids are named for their position on the bomb rack—NOSE, CENTER, and TAIL. The nose and center solenoids are usually wired in parallel and must work in conjunction with each other. The tail solenoid is wired individually and may work independently of the other two, depending on the capability of the aircraft's bomb arming system.

You will also find a sensing switch or stores present/stores away switch. It is a spring-loaded switch found on the bottom side of the bomb racks. It provides a signal to the cockpit when a store is installed on or ejected from the bomb rack. To prevent damage, a guard is installed on the switch when removing or installing a bomb rack or during other maintenance tasks.

Nuclear capable bomb racks are equipped with an inflight-safety lock of some type to prevent inadvertent opening of the rack hooks when a nuclear weapon is installed. Switches in the aircraft cockpit are used to activate a solenoid attached to this locking system. When the switches are positioned properly, the solenoid is electrically energized and moves the locking system to the unlocked position. The solenoid holds the locking system to the unlocked position until the weapon is released.

Sway brace

The last components that comprise gas-operated bomb racks are the sway brace components. Four sway braces are provided on each bomb rack. Bomb racks presently use two types of sway bracing components: automatic and manual. Automatic sway bracing capabilities are found on the 14-inch ejector racks and the BRU–46 and BRU–47 bomb racks. The 14-inch ejector racks use a fully automatic spring loaded wedge sway brace. The sway braces automatically cock when the rack releases. When the next store is installed, the sway braces are automatically driven to their locked position (down against the munition) and are tightened by shaking action either by the load crew or by the motion of the aircraft. The BRU–46 and –47 automatic sway bracing mechanisms use independently locking and pivoting sway brace arms. Each sway brace may be pivoted manually using a ⅜-inch square drive. This system has a built-in preload limiting device in each sway brace arm. It ensures the rack linkages are not excessively loaded to prevent damage to the sway bracing system. These sway braces must be manually retracted before loading a store and automatically sets when the store is loaded.

All of the other bomb racks have manual sway braces. The four sway braces mentioned earlier are found on each side of the two-cylinder block assemblies. They are screwed down against a loaded store according to tech order procedures, and lock nuts are tightened against them to prevent the sway braces from backing off during flight.

413. Fixed bay bombing systems

The three heavy bombers in the inventory have large internal bomb bays to hold their ordinance. The most efficient way to fill these bays with large numbers of weapons is through the use of fixed bay bombing systems. These systems consist of a large structure or framework in which multiple small capacity bomb racks are arranged. Each of the heavy bombers uses different bombing systems that we will now briefly cover.

Cluster bomb rack description and operation

The cluster bomb rack assembly (fig. 2–9) is designed to carry many types and weights of nonnuclear bombs in the B–52 aircraft. Only a few selected important components labeled in figure 2–9 are discussed here. Each cluster bomb rack assembly consists of three bomb racks: left, right, and center. A forward support beam and an aft support beam support the bomb racks. An electrical harness interconnects the racks and is mounted on the aft support beam with clamps. Each rack has three pairs of hooks to support the B–11 shackles (we discussed these earlier). A–6 type release units (one for each B–11 shackle) are mounted on the cluster bomb rack assemblies, and are used to actuate the B–11 shackles. Figure 2–10 gives you a closer look at the hooks for the shackles, the A–6 release unit, and how the release units and B–11 shackles mate to the cluster bomb rack.

The three bomb grid assemblies are operationally identical. Stores equipped with B–11 bomb shackles are hoisted into position and the bomb shackle is secured to the rack by the suspension hooks. The levers on the B–11 bomb shackle mate with corresponding levers on the A–6 bomb release units. Stores release is initiated through electrical actuation of the A–6 release unit. The release unit has two levers on top of the box—one is the release lever and the other is the arming lever. Both levers are electrically actuated during normal (armed) release and only the release lever is actuated during stores jettison (safe release). A trip screw on the front of the release unit permits manual tripping of the two levers or manual release of the unit.

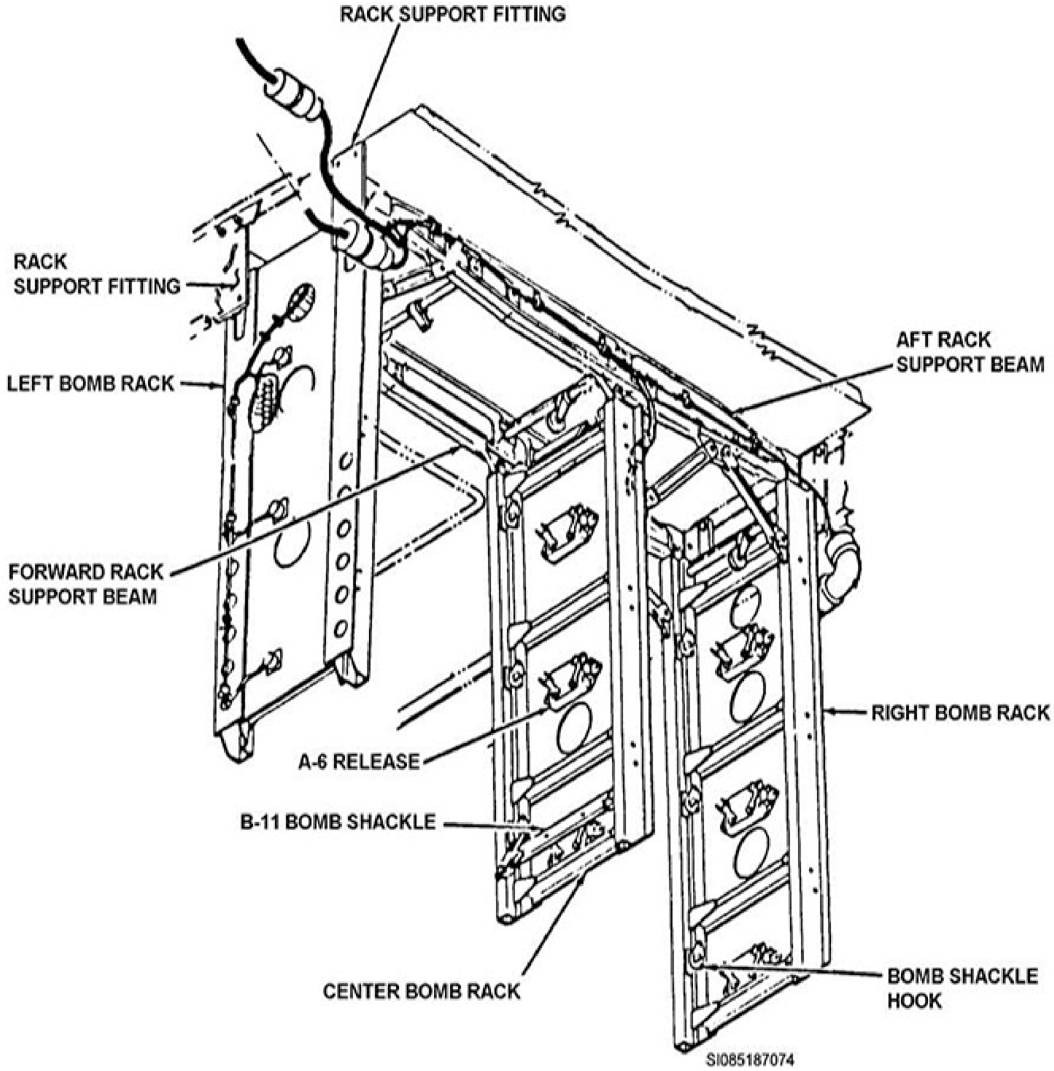


Figure 2–9. Cluster bomb racks.

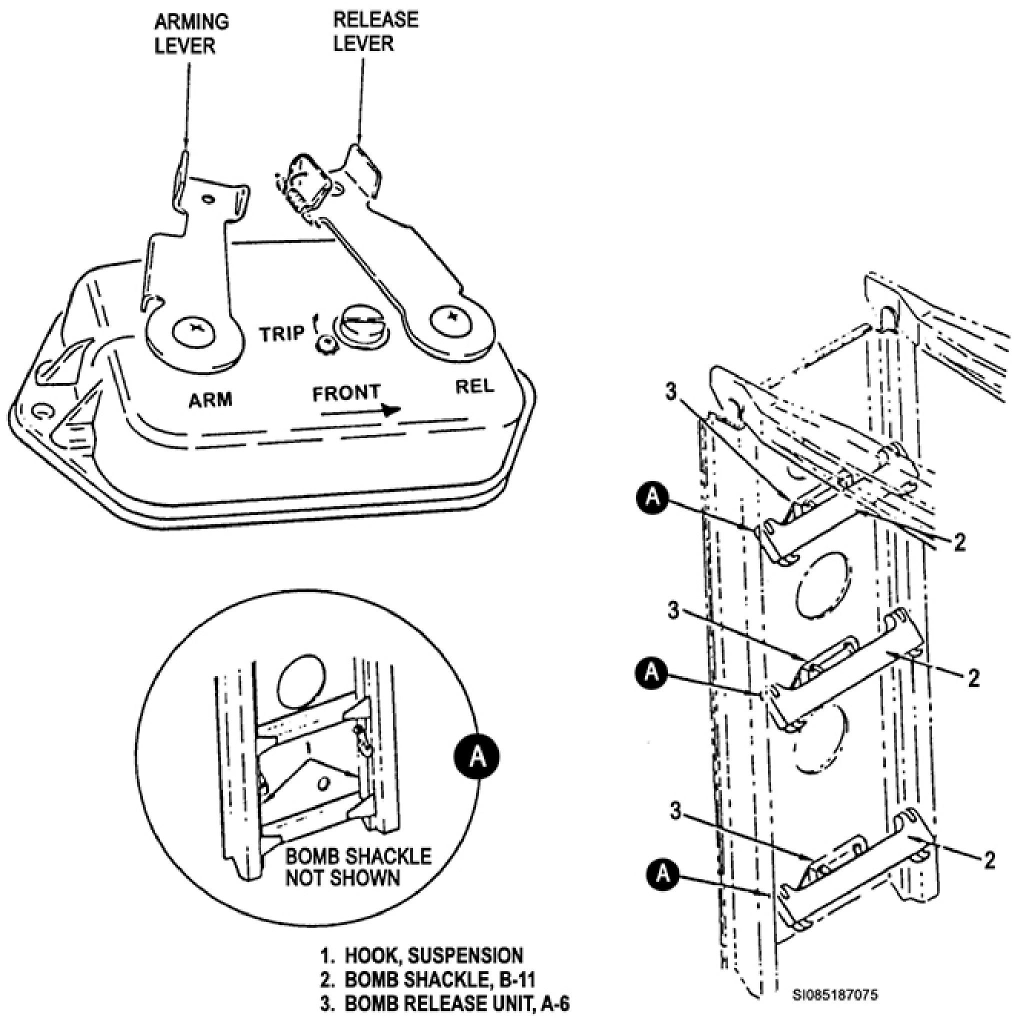


Figure 2–10. Cluster bomb rack components.

Bomb modules description and operation

There are currently two different conventional bomb modules used in the B–1B. The first is the 28-carry conventional bomb module and the more recent addition to the inventory is the military standard (MIL-STD)–1760 standard enhanced conventional bomb module (SECBM). While these modules share many of the same structural components, they differ substantially in their capabilities and configurations.

The conventional bomb module provides the capability for suspension and release of 28 MK–82 air bombs or MK–36 destructors. A module may be installed in any of the three aircraft weapons bays (forward, intermediate, and aft). The module (fig. 2–11) consists of a shell structure containing the supporting structure and swing arms for mounting 14-inch ejector racks.

The module is divided into a forward and aft bank (fig. 2–12) with each bank capable of carrying 14 stores. Each bank contains two swing arms—one carries two stores and one carries three stores. Each swing arm is capable, by means of a cartridge-powered actuator, of rotating to a position to allow stores located above them to be ejected from the module. The swing arm actuator assemblies are mounted on the shell structure of the module and use impulse cartridges to create the pressure needed to actuate the swing arms. Each module is divided into three support structures: left, center, and right. These differ in their store support capabilities because of the design of the module (i.e., a forward bank and an aft bank). The important thing to remember here is, between the three support structures and the swing arms of each bank, the store carrying capacity is 14. A safety lock mechanism has been incorporated into the module. It provides a means to lock all of the ejector racks to prevent inadvertent release of stores during ground handling.

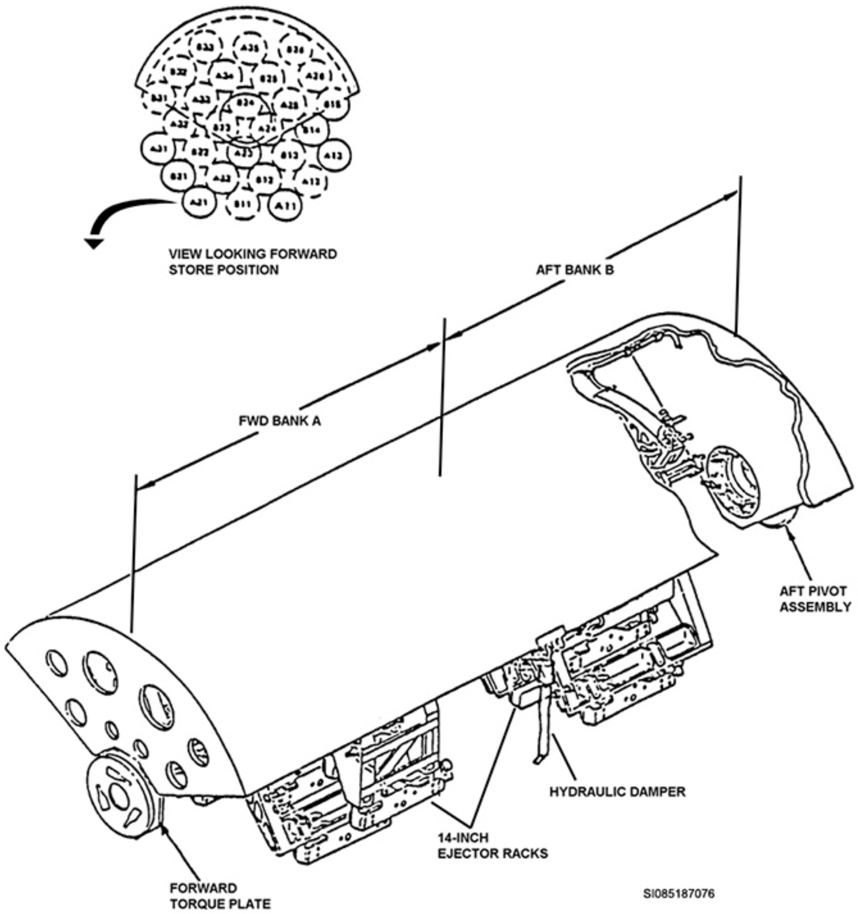


Figure 2–11. Conventional bomb module.

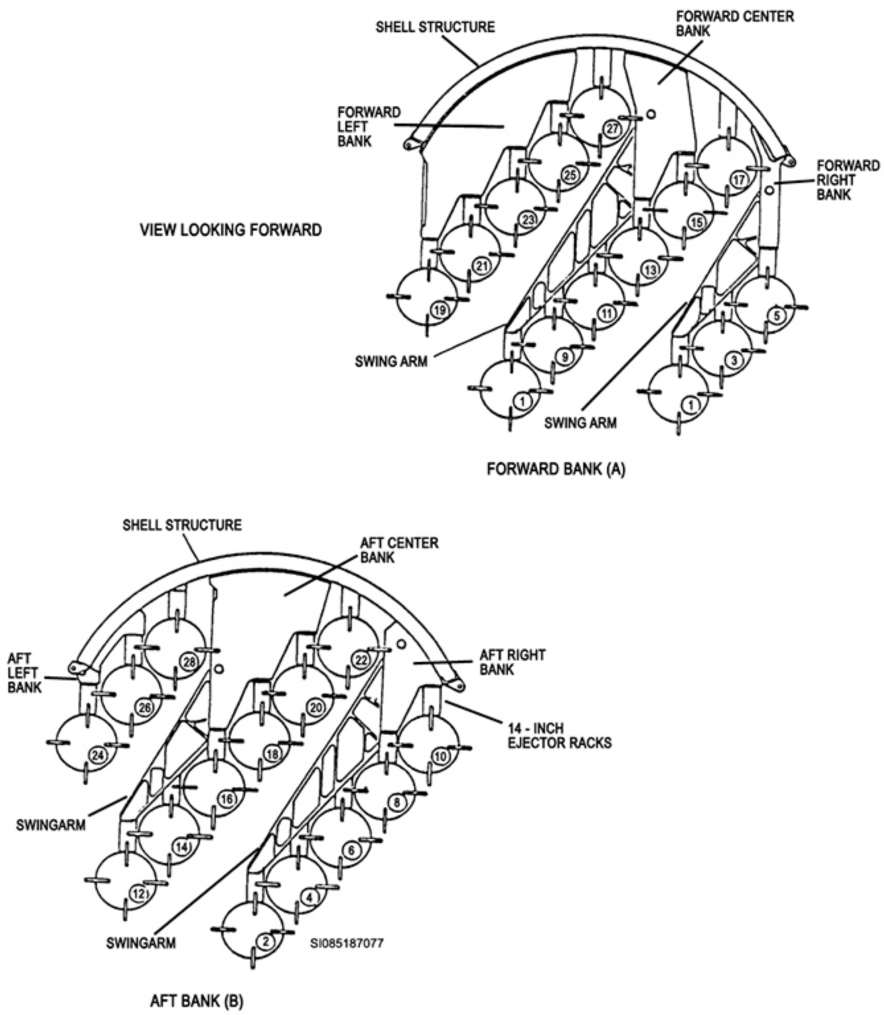


Figure 2–12. Conventional bomb module banks.

The new SECBM (fig. 2–13) differs from the standard conventional bomb module in a few critical ways. It was designed with fewer racks to allow it to carry larger diameter munitions than the conventional bomb module. It also incorporates MIL–STD–1760 LRUs allowing it to carry a much wider variety of munitions than the older design. The 10-Carry SECBM consists of the shell structure with attached frames for mounting 10 each, 14-inch bomb ejector racks. The 10-Carry SECBM is designed to carry and release 10 CBU, either CBU–87, 89, 103, 104, or 105 (fig. 2–14). The SECBM is also certified to carry and release the guided bomb unit (GBU)–38 500-pound Joint Direct Attack Munitions (JDAM), with six in the forward, six in the intermediate, and three in the aft bay.

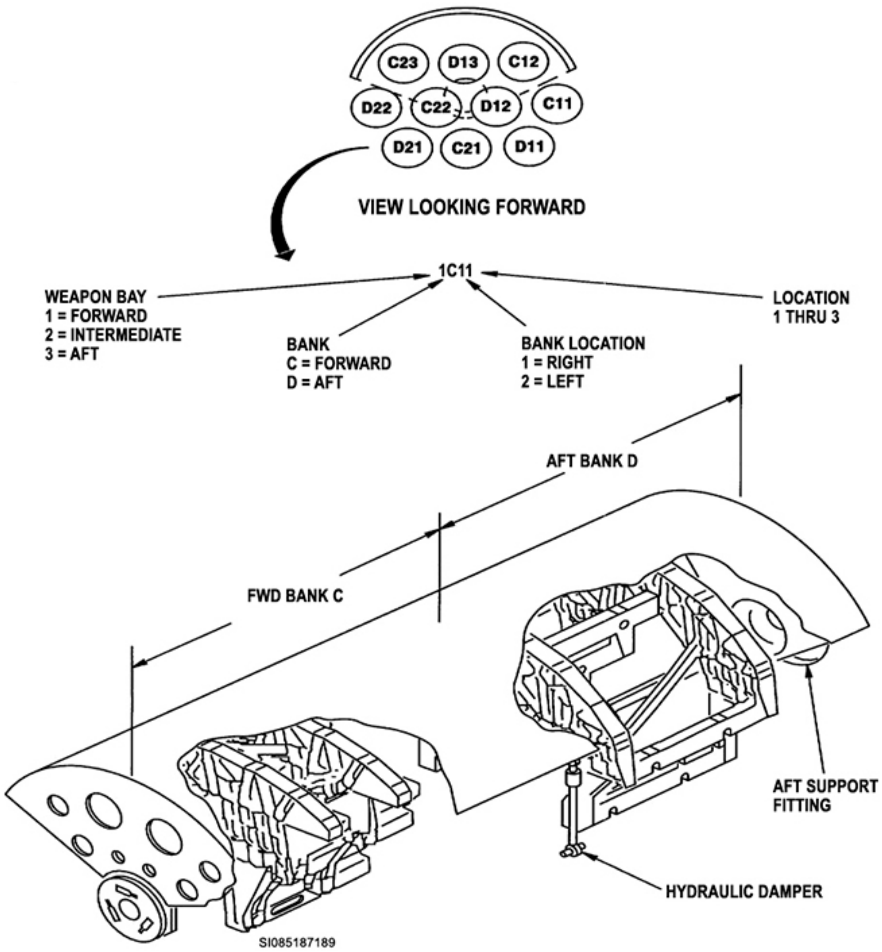


Figure 2–13. Enhanced conventional bomb module banks.

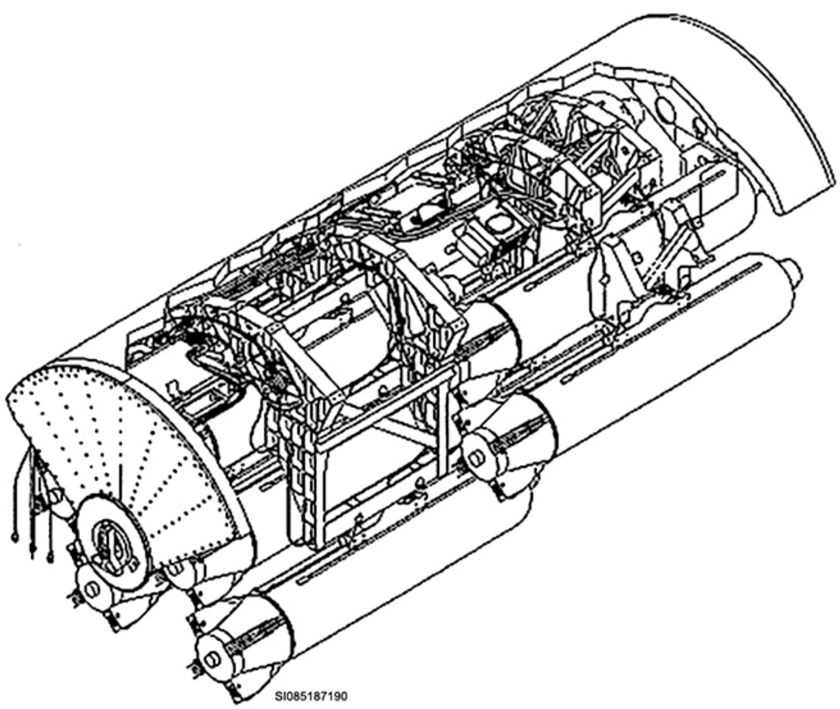


Figure 2–14. Loaded enhanced conventional bomb module.

Both modules are supported at the forward end by the forward torque plate and at the aft end by the aft pivot point. These assemblies exhibit universal joint characteristics preventing aircraft fuselage stress from transferring to the module shell to prevent binding of the load. The forward torque plate assembly, by means of a triple link combination, allows the module to vary in length to accommodate any change in length of the aircraft's weapons bay. The aft pivot assembly acts as the interface between the modules and the aircraft's environmental control system (ECS) and power supplies. The modules are also equipped with two hydraulic dampers—one on each side of the structure. The dampers are used to transmit torque movement caused by store ejection to the aircraft frame rather than to the module's attach points.

Bomb rack and smart bomb rack assemblies

The bomb rack assembly (BRA) provides the mechanical interface between the B–2 aircraft and conventional weapons (fig. 2–15). Depending on the type of weapons, the BRA is configured in two ways (fig. 2–16, A and B). In configuration A, the BRA can support a partial or full load of 20 MK–82 high-drag or low-drag general purpose bombs, MK–36 destructors, or MK–62 naval mines.

In configuration B, the BRA can support a partial or full load of nine CBU–87 or 89 cluster bombs. Weapon mixes are not allowed on the BRA. Two A or B configured BRAs can be installed in each of the B–2's weapons bays. Release units are arranged in four columns. When the BRA is in configuration A, weapons may be loaded on all four columns. When in configuration B, weapons are loaded on columns one, three, and four only.

The smart bomb rack assembly (SBRA) is a modified BRA with the addition of a left and right wired junction box assembly, a smart bomb release controller, and umbilical cables that allow the SBRA to support a partial or full load of 20 MIL-STD–1760 weapons in addition to the load configurations of the BRA (fig. 2–17).

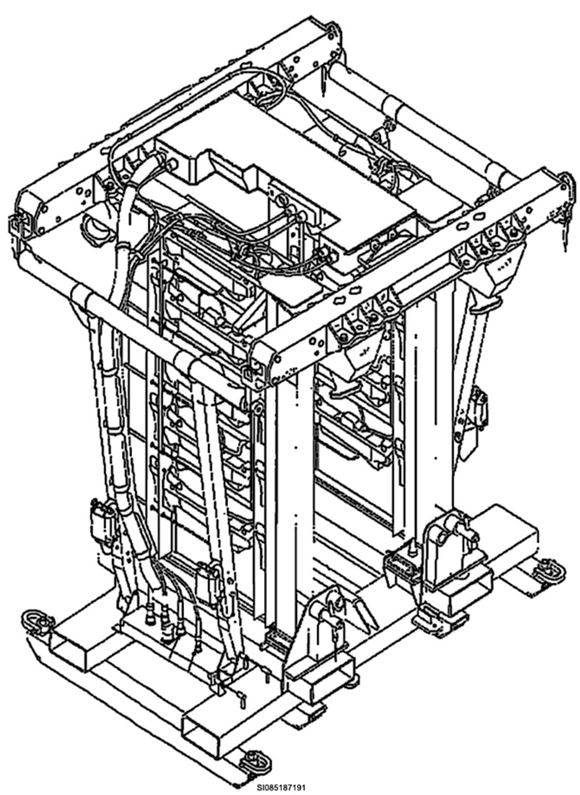


Figure 2–15. Bomb rack assembly.

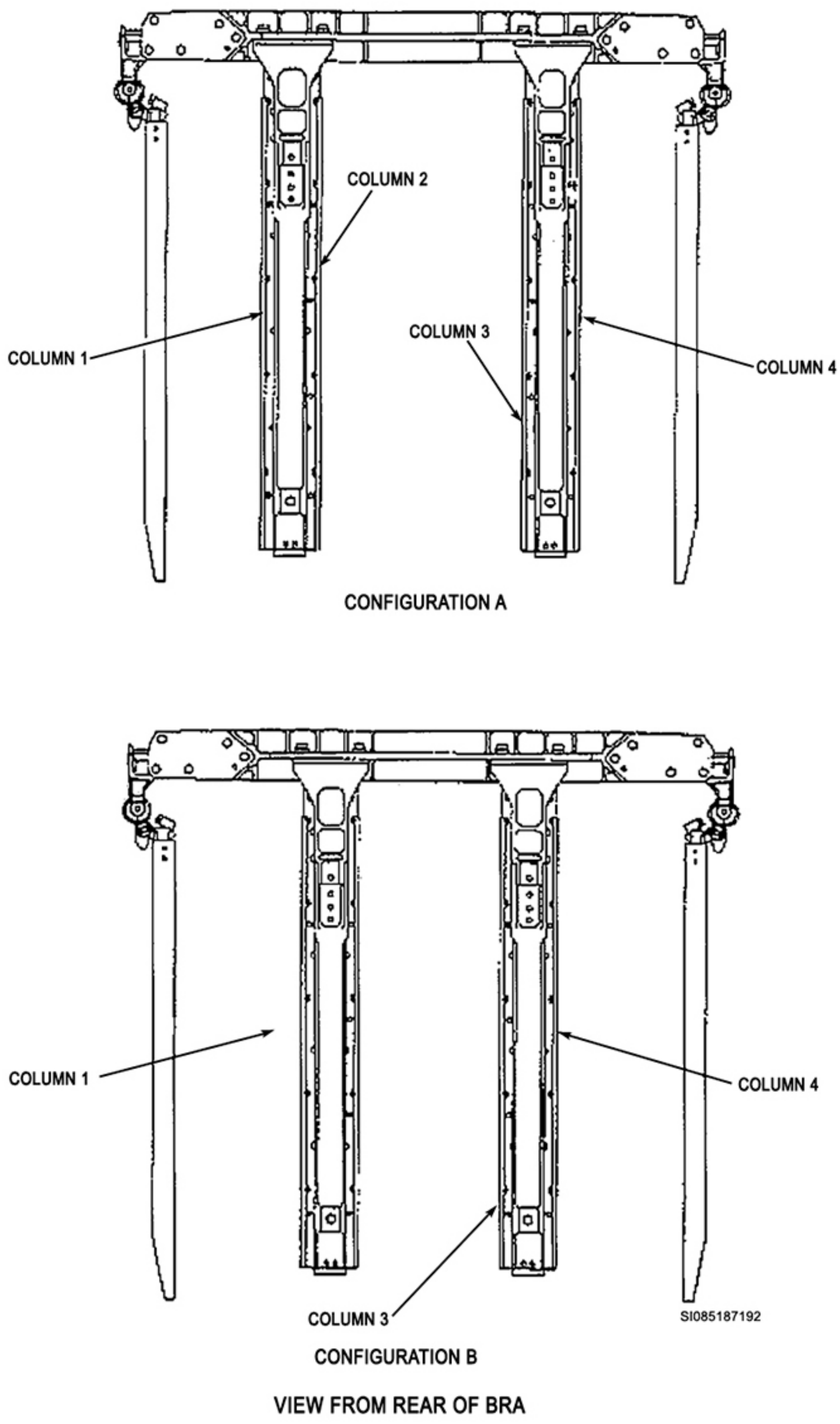


Figure 2–16. Bomb rack assembly configurations.

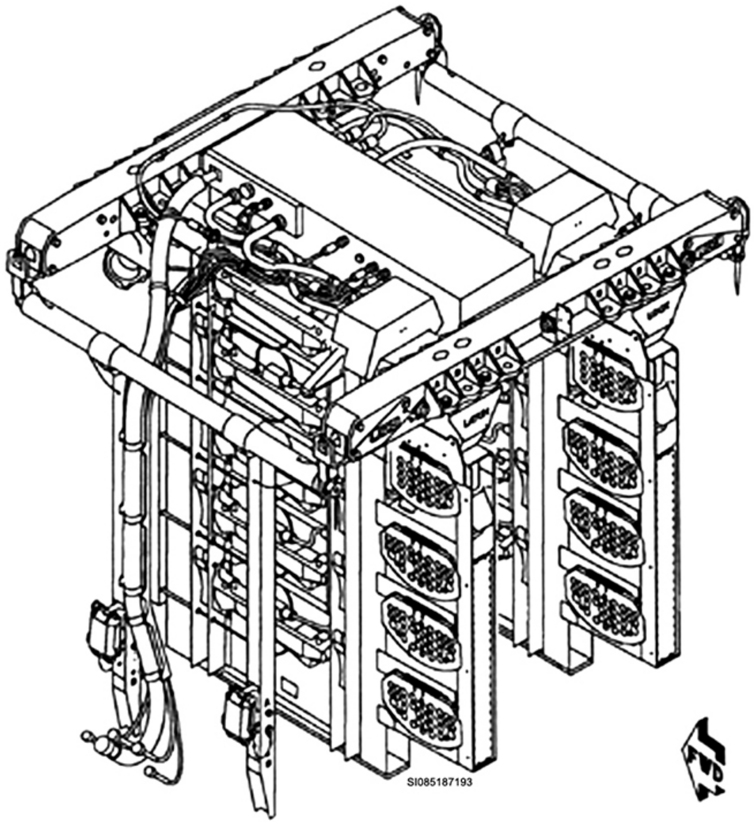


Figure 2–17. Smart bomb rack assembly.

414. Rotary launchers

Rotary launchers are used on our bomber aircraft to carry heavy stores in their bomb bays. There are three types of rotary launchers used today. The first is the multipurpose rotary launcher, also known as the 180-inch rotary launcher, that's used on the B–1. The B–2 uses the advanced application rotary launcher or rotary launcher assembly (RLA). Finally, the B–52 uses the aircraft guided missile and bomb rotary launcher, which is most commonly referred to as the common strategic rotary launcher (CSRL).

Rotary launchers

The rotary launchers shown in figures 2–18, 2–19, and 2–20 are capable of carrying, monitoring, controlling, and launching various types of nuclear and conventional missiles and bombs.

Each rotary launcher contains electronic and pneumatic subsystems. The launcher subsystems are provided to support the operation of the launchers and the various munitions they are capable of carrying. Each launcher is electronically controlled. Depending on the particular launcher and how it is configured, the launcher's electronic subsystems are made up of items such as decoder-receivers, relay assemblies, nuclear station logic units, and associated nuclear hardened wiring and cable assemblies. All of these components plus the aircraft avionics system are responsible for electrical interface between the stores, launcher, and aircraft. They also work in conjunction with the hydraulic subsystem, or various mechanical components, to allow the launchers to rotate to the proper position for stores release. Each of the launchers can carry a maximum of eight stores that are ejected one at a time from the six o'clock position.

The CSRL interfaces to an aircraft power drive unit to receive its rotational power. The multipurpose launcher (used with the B–1B) requires the use of the aircraft's systems for operation. During ground rotation, this launcher rotates at ⅛ the normal rotation speed. The launchers pneumatic subsystems or

ECS distributes cooling air to loaded missiles and various launcher electronic components. The aircraft supplies the cooling air to the launcher's pneumatic subsystems.

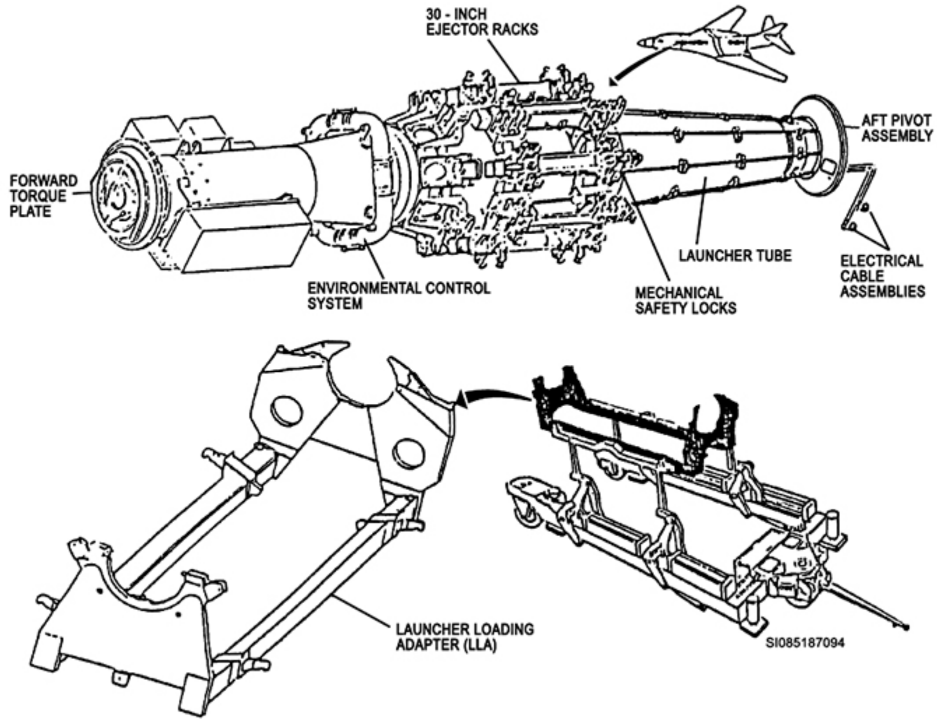


Figure 2–18. Multipurpose rotary launcher.

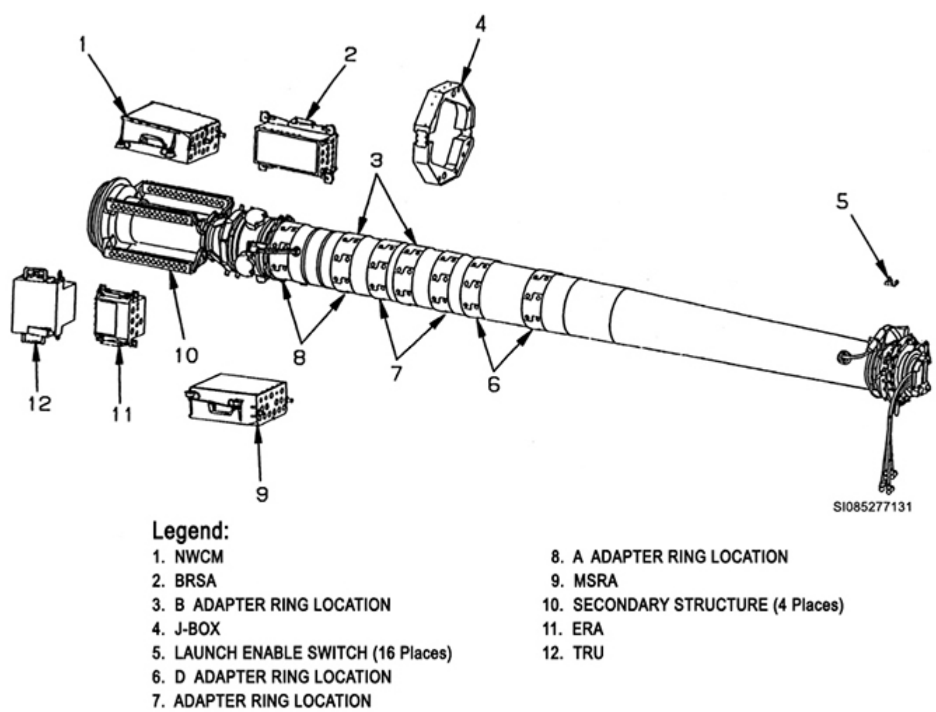


Figure 2–19. Rotary launcher assembly.

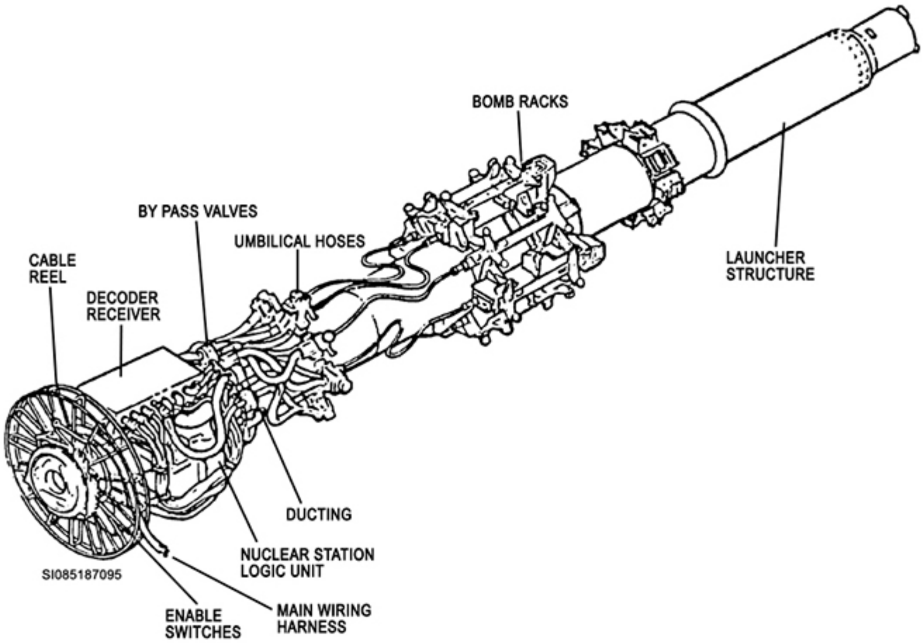


Figure 2–20. Common strategic rotary launcher.

As with all suspension equipment, the missiles and bombs carried by these launchers are suspended from some type of bomb rack. The CSRL uses up to eight MAU–12 or BRU–44 bomb racks; the RLA exclusively uses the BRU–44B/A bomb rack, and the 180-inch launcher uses the BRU–56/A (a.k.a. the 30-inch) ejector racks. The missiles or bombs to be loaded on these launchers are mated to the bomb racks and then installed on the launchers while they are attached to a loading frame. Loading these units onto the aircraft requires the use of either the munitions handling unit (MHU)–204 or 196/M lift trailers and their individual loading adapters. Single missile or bomb exchanges are normally mated or demated to these launchers using either the MJ–40 or MHU–83 series lift trucks with the applicable adapters.

415. Multiple ejector rack systems

Multiple ejector rack systems are auxiliary suspension racks used to increase the number of munitions carried on hard points on almost all of our aircraft. They are, in essence, a way to transform a single high-weight capacity bomb rack into multiple lower weight capacity racks. There are currently three systems in use by the Air Force—the TER, BRU–57, and BRU–61.

Triple ejector rack components

A TER consists of a strongback with one cluster of three ejector units and an interconnecting wiring harness (fig. 2–21). The TER has provisions for suspension, sway bracing, sensing, mechanical arming (arming solenoids), and ejection of munitions. The strongback has two suspension lugs with 30-inch spacing and four sway brace pads for suspension from and sway bracing by the MAU–12 or MAU–40 bomb rack. A fairing around the strongback encloses the interconnecting wiring harness. A control panel at the aft end of the TER has an electrical safety pin installed. One mechanical safety pin can be installed at each loaded ejector unit.

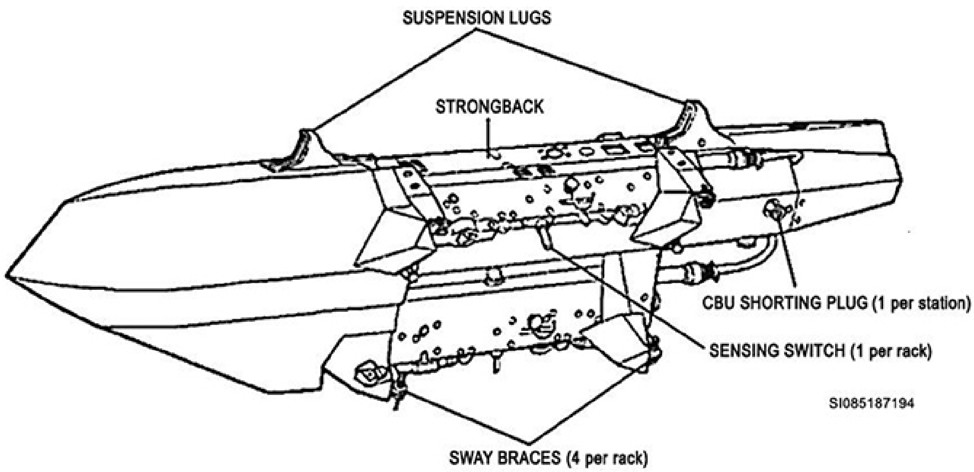


Figure 2–21. Triple ejector rack.

Operation

In the bomb release mode, the TER receives mechanical arming power and breech cap fire pulses from the aircraft. The mechanical arming power is routed to the appropriate solenoid(s) in each ejector unit. The breech cap fire pulses are routed to the loaded ejector unit breech cap in the appropriate release sequence. Empty ejector units are automatically bypassed and do not receive a fire pulse. The sequencing happens by an electrical stepper switch and operates in a fire-and-step order. When an ejector unit receives a fire pulse, the switch automatically steps to the next loaded ejector unit. When the stepper switch has completed one cycle (steps past the last ejector unit), it provides a TER empty signal to the aircraft resulting in aircraft station transfer. The stepper switch takes approximately 70 milliseconds to step from one ejector unit to the next unit in order, and an additional 15 milliseconds is required for each empty ejector unit to be stepped past.

The TER automatically steps to the first loaded ejector unit in the release sequence when MASTER ARM power is applied to the aircraft. In the rocket/CBU select mode, 28-volt direct current (DC) power supplied by the aircraft causes the TER to reroute the aircraft fire pulses from the ejector unit breech caps to the rocket or CBU adapter harnesses. The CBU position is used only with CBU dispensers. The ROCKET position is used with rocket pods and flare dispensers. The TER stepping and sensing circuits operate identically in the rocket/CBU select mode and in the bomb release mode. However, when the TER is in the "CBU" mode, it provides a CBU empty signal to the aircraft, resulting in aircraft station transfer.

In the bombing mode, the CBU shorting plug must be installed in empty ejector units. This shorting plug provides a CBU empty indication to allow the TER stepper switch to step past an empty ejector unit. When loaded with rocket pods or flare dispensers, the interconnect cable between the pod or the dispenser connects to the connector exposed when the shorting plug is removed. After all flares, markers, or other munitions have been fired, the launchers/dispensers may be jettisoned through the aircraft jettison system.

Accessories

There are several TER accessories used on the bomb dummy unit (BDU)–33: sway brace adapter, short piston, tension spring, and the yoke adapter. The TER sway brace adapter is used to adapt the TER ejector unit for bomb dummy unit (BDU)–33 practice bomb carriage (fig. 2–22).

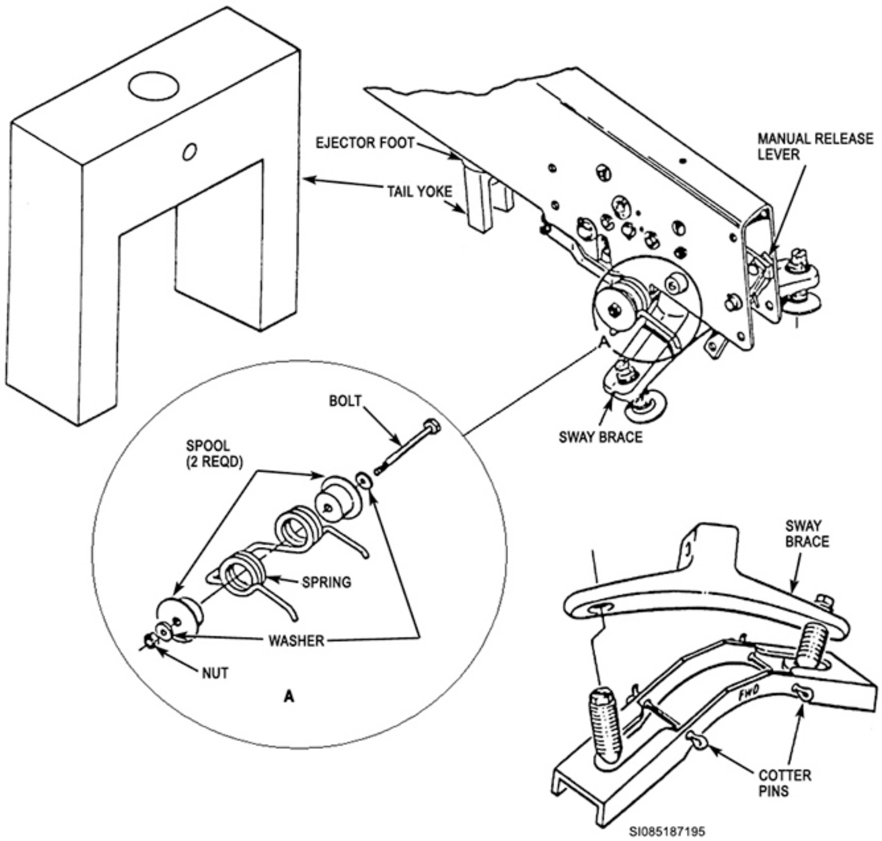


Figure 2–22. TER accessories for practice bombs.

You must remove the normal long ejector piston of each rack and install a short piston. When the TER is used to carry BDU–33 practice bombs, a tension spring is usually installed on the TER sway brace arm to stabilize the BDU–33 practice bomb during aircraft flight and to assist in ejection from the rack upon release. Another TER accessory is the BDU–33 yoke adapter. It is used to provide alignment and maintain contact of the BDU–33 with the TER sensing switch. It is also used to stabilize the BDU–33 when it is loaded.

BRU–57 Smart Rack

The BRU–57 Smart Rack is the newest subrack for the F–16 (fig. 2–23). The BRU–57 is suspended from a MAU–12 on stations three, four, six, or seven. It uses two BRU–46 bomb racks to carry stores weighing up to 1,000 pounds. The stores carried by the BRU–57 use the MIL–STD 1760 cable. The BRU–57 carries two JDAMs or two wind corrected munition dispensers (WCMD) tail-kit equipped cluster munitions. The BRU–57 also can carry any munition previously carried from 14-inch hooks, such as a 500-pound MK–82 general purpose bomb or the LAU–l31 rocket launcher. The parts of the BRU–57 are detailed below.

Strongback

The strongback is the main structural part of the BRU–57 Smart Rack. It provides a mounting point for the two BRU–46 bomb racks and houses the electronics that control the BRU–57. The strongback also holds the two 30-inch suspension lugs that attach to the MAU–12.

Electronic control assembly

Located under the strongback is the electronic control assembly. It is responsible for routing signals to and from the BRU–46 bomb racks, as well as sending data back to the aircraft’s weapons system.

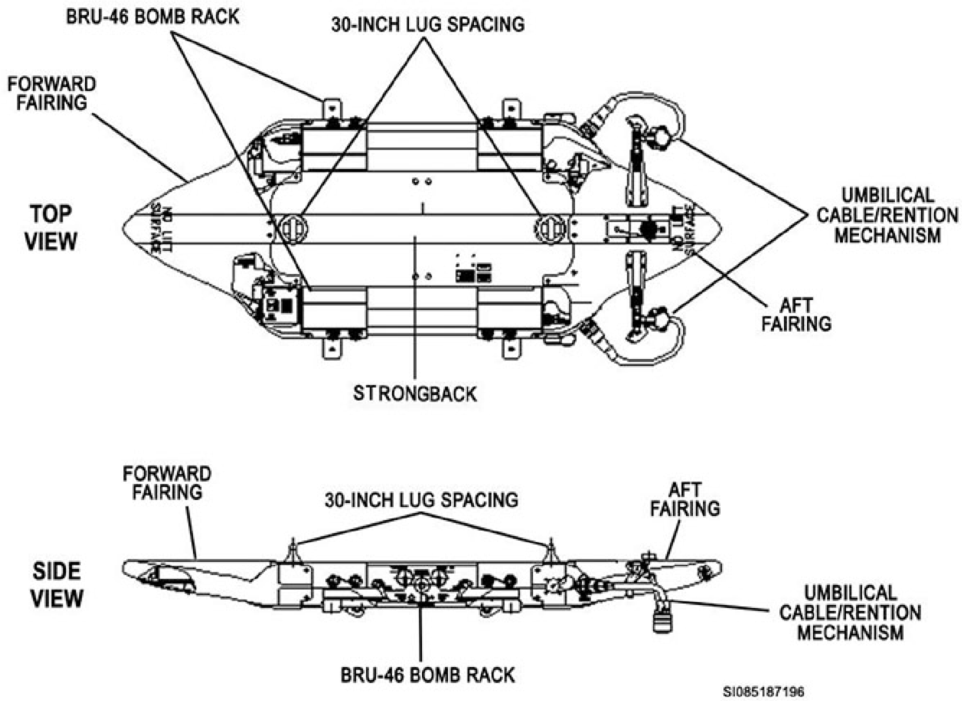


Figure 2–23. BRU–57 smart rack.

Fairings (forward and aft)

The fairings on the BRU–57 are located on both ends. The fairings are easily identified as the area marked “NO LIFT SURFACE.” The fairings are primarily used to improve the aerodynamics of the BRU–57. The aft fairing also contains the MIL-STD–1760 receptacle. A MIL-STD–1760 cable connected between this receptacle and the wing weapons pylon allows the BRU–57 to communicate with the aircraft. The sides of the aft fairing also contain two receptacles, which allow cable harnesses to communicate with each individual munition carried from each BRU–46 bomb rack.

Umbilical cable/retention mechanism

The umbilical cable/retention mechanism is located on the aft fairing. These protrusions properly retain and route the cable harnesses to each individual munition. Never lift the BRU–57 by the umbilical cable/retention mechanism.

BRU–46

The BRU–46 is the bomb rack used on the BRU–57 Smart Rack as the component that actually holds and ejects the munitions from the BRU–57. The BRU–46 bomb rack only carries conventional stores and forcibly ejects them from the aircraft in either armed or unarmed condition. The BRU–46 has one pair of hooks spaced 14 inches apart. The weight capacity for the 14-inch hooks is 1,000 pounds.

BRU–61/A

The BRU–61/A (fig. 2–24) is a departure from the previous systems in this lesson in two very prominent ways. First, unlike the TER and BRU–57, which are capable of carrying a wide variety of stores, the BRU–61/A is only capable of carrying a single type of store—the GBU–39 small diameter bomb. Second, it contains the Air Force’s only non-pyrotechnic-based pneumatically operated bomb rack. This system uses compressed air delivered by an onboard compressor to eject munitions from the rack.

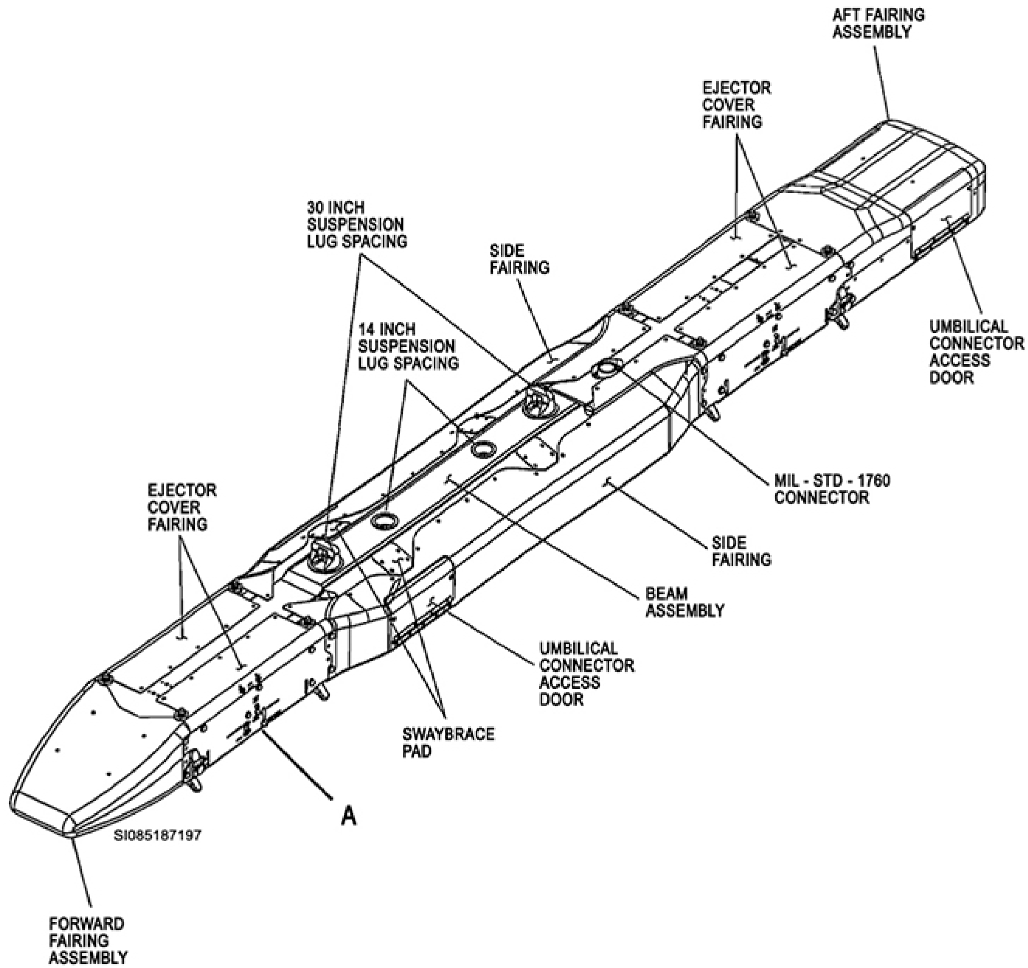


Figure 2–24. BRU–61/A.

System overview

The BRU–61/A has four suspension lug mounting locations to attach the BRU–61/A to the aircraft pylons. Lug wells are provided at 14- and 30-inch spacing. The BRU–61/A provides four positions to carry miniature munitions. There are also four pairs of hooks spaced 14 inches apart. Each pair of hooks latch, lock, and release independently of the remaining three hook pairs. This provides an easy way to load munition and ensures positive munition release.

Internal components of BRU–61/A are protected by a number of external fairings. The fairings are constructed from aluminum sheet stock and provide aerodynamic characteristics for the BRU–61/A. A MIL-STD–1760 connector is located on the top of the BRU–61/A to provide interface with the host aircraft. Four weapon umbilical harnesses provide interface between munitions and the BRU–61/A.

System operation

The BRU–61/A is readied by control signals from the aircraft. These signals command the BRU–61/A to pressurize the pneumatic system using the internal onboard compressor. During flight, munition release is accomplished by signals sent from the host aircraft. The carriage system control electronics (CSCE) sends a signal to the ejector unit to release and eject the munition.

When the CSCE signals to eject the munition, a solenoid in the ejector unit unlocks the hooks. The ejector then releases the hooks from the munition, while compressed air is simultaneously forced into the ejector piston forcing the piston to extend. The combined weight of the munition and the force of the ejector pistons cause the munition to be released and ejected.

As the munition is released, the ejector pistons extend, and the force of the ejector pistons causes the munition to be ejected away from the aircraft. The pitch valves, which are manually set before flight, vary the ejection force of each ejector piston. This controls the pitch of the munition as the munition is ejected away from the BRU–61/A.

Carriage system control electronics
The CSCE operates as the brains of the entire system. It is designed to direct aircraft power and commands from a single aircraft store station interface to the appropriate munitions carried by the BRU–61/A. It monitors the commands from the host aircraft and determines how to best perform those commanded operations. It selects the appropriate munition for use based on the number and position of munitions available on the BRU–61/A. It initiates that munition's operation and determines the operational status of not only the munition, but of the BRU–61/A as well. It controls the release of the munition through the BRU–6I/A ejector units. In addition, it provides the BRU–61/A status to the aircraft stores management system.

Compressor assembly
The BRU–61/A uses a compressor assembly designed for cold gas munition ejection. The compressor assembly is a compact miniature high-pressure air compressor and air drying unit designed to provide the high-pressure dry air for cold-gas munition ejection. The compressor assembly contains a drive motor and gearbox, a four-stage high-pressure compressor, a filter unit, a coalescer, and an electronic control unit (ECU). It uses 115 volts, alternating current (VAC), 400 Hz, 3-phase power to control its operation. The compressor assembly ECU uses a 28-VDC signal provided by the CSCE to control its operation.

Filter assembly
The pneumatic system, or the BRU–61/A, includes a filter assembly to remove moisture from the system. The filter assembly is a simple tubular filter with pneumatic fittings at either end and is secured to BRU–61/A beam assembly using two mounting blocks.

Weapon umbilical harness
There are four joint miniature munition interface (JMMI) weapon umbilical harnesses located on the BRU–61/A; one for each munition location. The JMMI cable provides the interface between the munition JMMI connector and the BRU–61/A electrical harness missile status control indicator (MSCI) receptacle. The JMMI cable connects to the munition JMMI connector by way of a MIL-C–38999 lanyard release plug.

MIL-STD–1760 connector
The MIL-STD–1760 connector located on the top of the BRU–61/A provides a standard interface between BRU–61/A and host aircraft.

416. Aircraft pylons
The last suspension component we discuss in this section is the aircraft pylon. Up to now, we've covered a variety of bomb carriage suspension equipment, but we have not discussed the aircraft pylon.

Description
Pylons are streamlined castings with side panels and access doors (fig. 2–25). They all look pretty much the same with the exception of those used on the B–52 aircraft (fig. 2–26). They provide the electrical wiring and mounting points for bomb racks, various other subracks, and suspension equipment. Pylons are installed at a particular point on an aircraft, usually referred to as a station. You will find, depending on the aircraft, pylons may or may not be interchangeable, and may or may not be jettisonable.

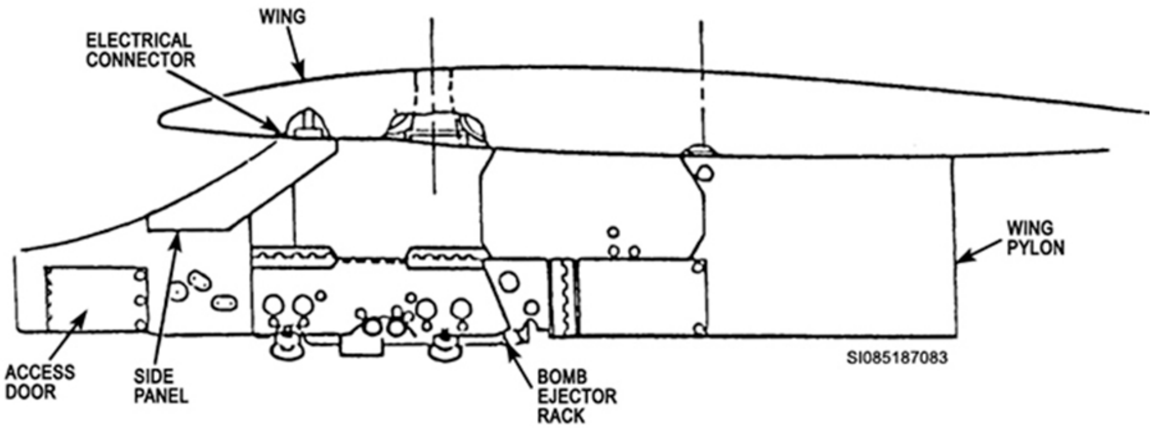


Figure 2–25. Aircraft pylon (generic).

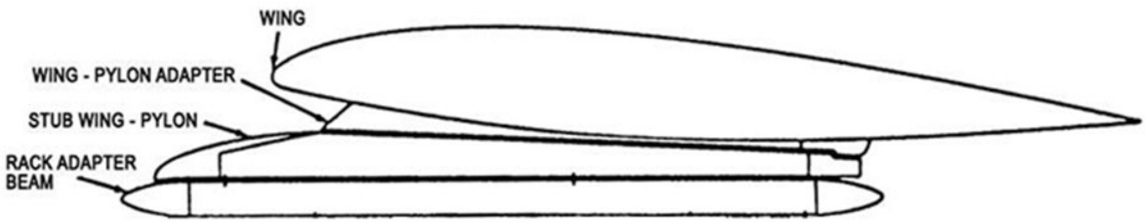


Figure 2–26. B–52 wing pylon.

An interchangeable pylon is one capable of being installed at any wing position or station. Noninterchangeable pylons are just the opposite. They fit in one particular position on the aircraft and, if removed, must be reinstalled in the same position.

Jettisonable pylons are not new creations. They have been in existence for quite some time. We presently have three aircraft with this capability—the F–15, B–52, and F–22. These types of pylons do not look substantially different from regular pylons, even though they are installed very differently from the conventional “bolted on” pylons.

They usually have an aft pivot point to provide an initial nose-down pitch for the pylon when it is jettisoned. This feature also ensures the pylon is safely separated from the aircraft. It allows the pylon to be punched down safely away from the aircraft wing. Once the pylon has pivoted so far, the pivot disengages and the pylon free falls clear of the aircraft.

Jettisonable pylons normally have either a safety pin installed or (in the case of the F–22) a safety clutch located on the pyrotechnic and arming unit actuated by a ⅜-inch drive during ground operations. The safety pins mechanically and electrically safes the pylon, preventing accidental jettison. The safety clutch on the F–22 pylon electrically safes the pylon only.

A major difference between jettisonable and non-jettisonable pylons are the electrical connectors or cables, and fuel fitting (if applicable) inside of the pylons. Because of the nature of jettisonable pylons, these fittings and connections need to automatically disconnect to prevent damage to the aircraft if it jettisons the pylon(s). On each pylon, you normally find a ground receptacle used as an aircraft grounding point, if necessary.

Locations

Pylons attach to hard points on an aircraft’s wings and sometimes to fuselage areas (fig. 2–27). Normally, they are found installed on both the left and right sides of the aircraft. Typically, most aircraft have four external positions, two on both sides of the aircraft, where a pylon may be installed. These positions are referred to as inboard and outboard stations. They also have centerline positions on the belly of the aircraft. Fuselage pylons may be found attached to an aircraft's center section (positions to the outside of the centerline pylon).

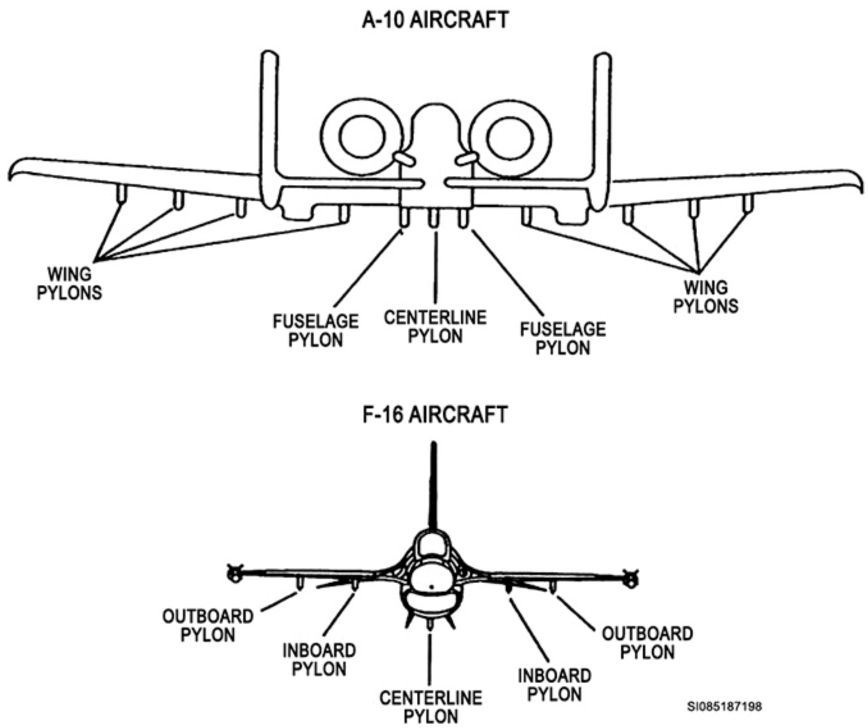


Figure 2–27. Aircraft pylon attach points.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

412. Basic bomb racks

1. What is the only mechanical bomb rack in use today?

2. How is the B–11 bomb shackle supported in the aircraft?

3. What is responsible for the B–11 bomb shackle's operation?

4. What is the purpose of the gas or ballistic components of the gas-operated bomb racks?

5. On the BRU–46 and BRU–47 bomb racks, what is the purpose of the internal hot gas filter?

6. What bomb rack component is designed to hold or release the arming wire attached to munitions?

7. What are the two types of sway bracing components used on bomb racks?

413. Fixed bay bombing systems

1. How many bomb racks comprise a cluster rack assembly?

2. What type of release unit and bomb rack is used on cluster rack assemblies?

3. How is stores release initiated on cluster bomb racks?

4. How many 28-carry conventional bomb modules may be loaded in the B–1B?

5. What causes rotation of the swing arms of the 28-carry conventional bomb module?

6. What is the purpose of the safety lock mechanism that has been incorporated into the 28-carry conventional bomb module?

7. How does the SECBM differ from the standard conventional bomb module?

8. What conventional bomb module assembly acts as the interface between the modules and the aircraft's system and power supplies?

9. How many cluster bombs can be loaded into a BRA or SBRA in configuration B?

414. Rotary launchers

1. What is the purpose of rotary launchers?

2. How are rotary launchers controlled and rotated?

3. What bomb racks are carried by the RLA?

415. Multiple ejector rack systems

1. What is the purpose of multiple ejector rack systems?
2. How many ejector units are installed on a TER?
3. What component of a TER is responsible for release sequencing?
4. What components must be installed on a TER when BDU–33 practice bombs are carried?
5. What type and how many bomb racks are carried on the BRU–57 Smart Rack to carry stores?
6. What is the purpose of the umbilical cable/retention mechanism found on the BRU–57?
7. What munition is supported by the BRU–61/A?
8. What BRU–61/A component varies the ejection force of each ejector piston?

416. Aircraft pylons

1. What is the purpose of aircraft pylons?
2. What is meant by interchangeable pylons?
3. State the three positions where pylons are normally installed on an aircraft.

2–4. Launcher- and Dispenser-Type Suspension Equipment

Bombs are not the only type of munitions our aircraft carry. Missiles and rockets are also in our inventory, and they require special types of suspension equipment to function. We cover this equipment in this section.

417. Missile launchers

Missile launchers provide our aircraft with the capability to carry, launch, and in some cases jettison various air-to-air and air-to-ground munitions. There are launchers designed for all of our aircraft. There are three distinct types of missile launchers: gas operated, pneudraulically operated, and rail launchers. Let's take a look at each of them.

Gas-operated launchers

The only gas-operated launcher used today is the LAU–106A/A. The LAU–106A/A launcher is a self-contained, gas-operating mechanism capable of suspending, launching, and ejecting AIM–120 missiles. LAU–106A/A launcher is found mounted inside the fuselage structure of the F–15 A/B/C/D or as optional equipment on the conformal fuel tank stations of the F–15E (figs. 2–28 and 2–29).

The LAU–106 is constructed with five basic sets of components:

- Ejection components.
- Gas tube system.
- Linkage mechanisms.
- Structure assembly.
- Electrical components.

The ejection components are responsible for launching, ejecting, or pushing the missile away from the aircraft. They typically consist of the forward and aft ejection pistons and the breech assembly. The gas tube system is made up of the breech assembly, forward and aft gas tubes, and possibly a center gas tube, depending upon the launcher. They route the gas pressure to the ejector pistons as they do in the gas-operated bomb racks. Linkage mechanisms consist of forward and aft hooks to mate with the lugs on the missiles. The hooks are mechanically linked to the forward and aft linkage assembly and bellcranks. This set of components also is really quite similar to those of the gas-operated bomb racks. The structure assembly is what keeps the complete set of launcher components together. The electrical components typically consist of electrical cable assemblies or harnesses, two cartridge firing pins, possibly a stray voltage receptacle, and some type of switch to relay signals when a missile is ejected from a launcher.

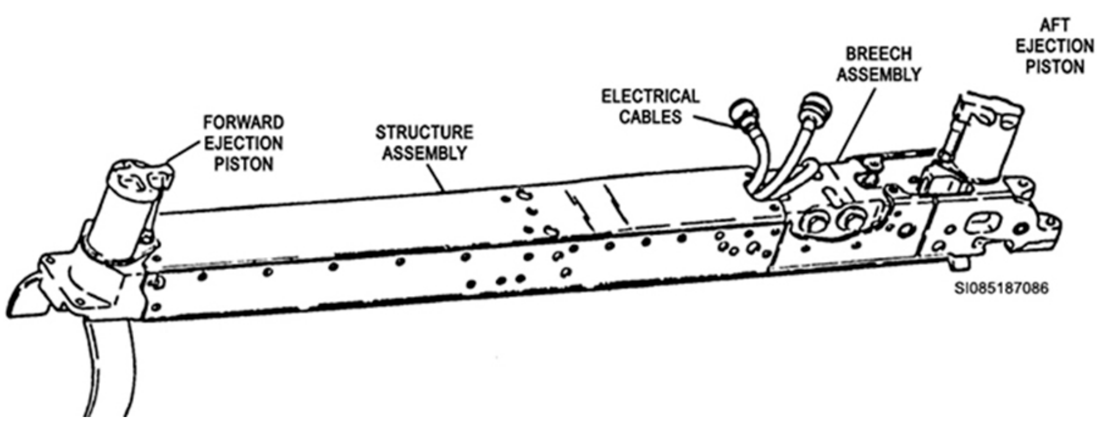


Figure 2–28. LAU–106 launcher.

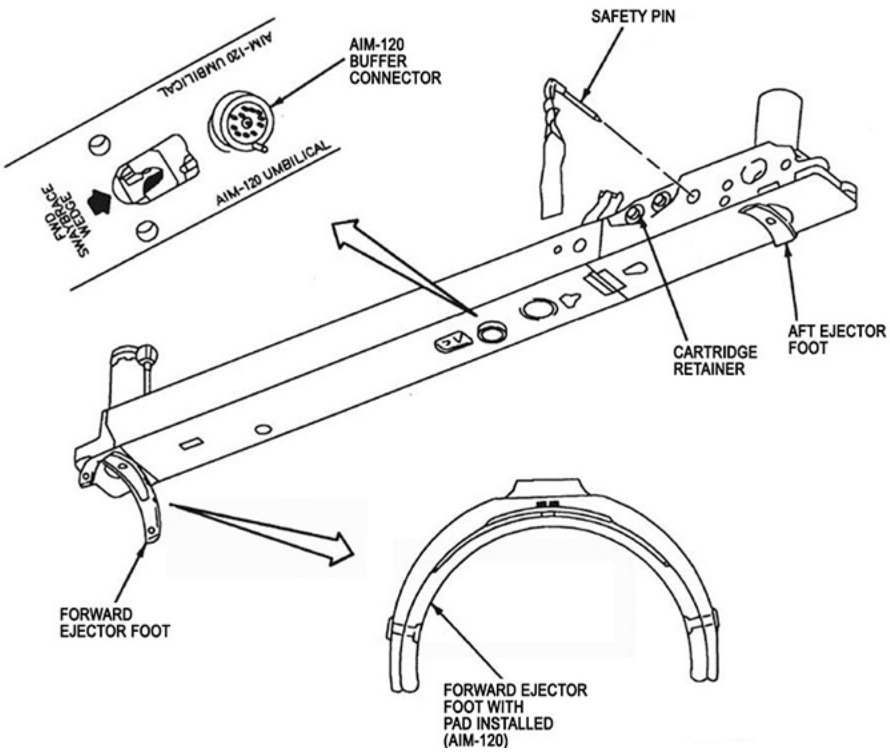


Figure 2–29. LAU–106 launcher components.

LAU–106A/A launchers have two basic operating modes: latching and unlatching. Latching is always a manual process. A manual release nut or socket using the appropriate tool is rotated clockwise to activate the latching mode of operation. This clockwise rotation closes the forward and aft hooks. Rotating these items counterclockwise opens the hooks. A missile launcher safety pin may be installed when the hooks are locked or closed. When the safety pin is installed, a switch is activated inside the launcher, which interrupts electricity to the ejector cartridges and the missile motor firing circuits. The safety pins also mechanically safes the launcher by blocking the movement of the linkage inside the launcher.

The unlatching mode of operation for gas launchers has two methods of operation—operate the hooks manually and firing the impulse cartridges. If the launcher safety pin is installed, it must be removed before manual unlatching can be done. With the firing option, gas pressure is produced when the impulse cartridges are ignited. It is routed to a slave piston within the launcher. This slave piston rotates the bellcrank to over center the linkage and unlock the hooks. Gas pressure is also routed through gas tubes to the forward and aft ejector pistons to eject the missile. Missile motor fire is not completed until after the missile is pushed away from the aircraft.

Pneudraulically operated launchers

Pneumatic systems use gases under pressure to perform mechanical work, while hydraulic systems use liquids under pressure to perform mechanical work. Pneudraulics simply means that a system contains both pneumatic and hydraulic components. The LAU–142/A found in the F–22 is currently the only pneudraulic missile launcher system in use by the Air Force (fig. 2–30).

The LAU–142/A is carried internally on the F–22. Depending on mission requirements, the F–22 can carry up to six LAU–142/A launchers arranged in two groups of three in each of the center weapons bays. The LAU–142/A missile launchers can only support the AIM–120 series missiles; there is currently no capability to support other missile systems.

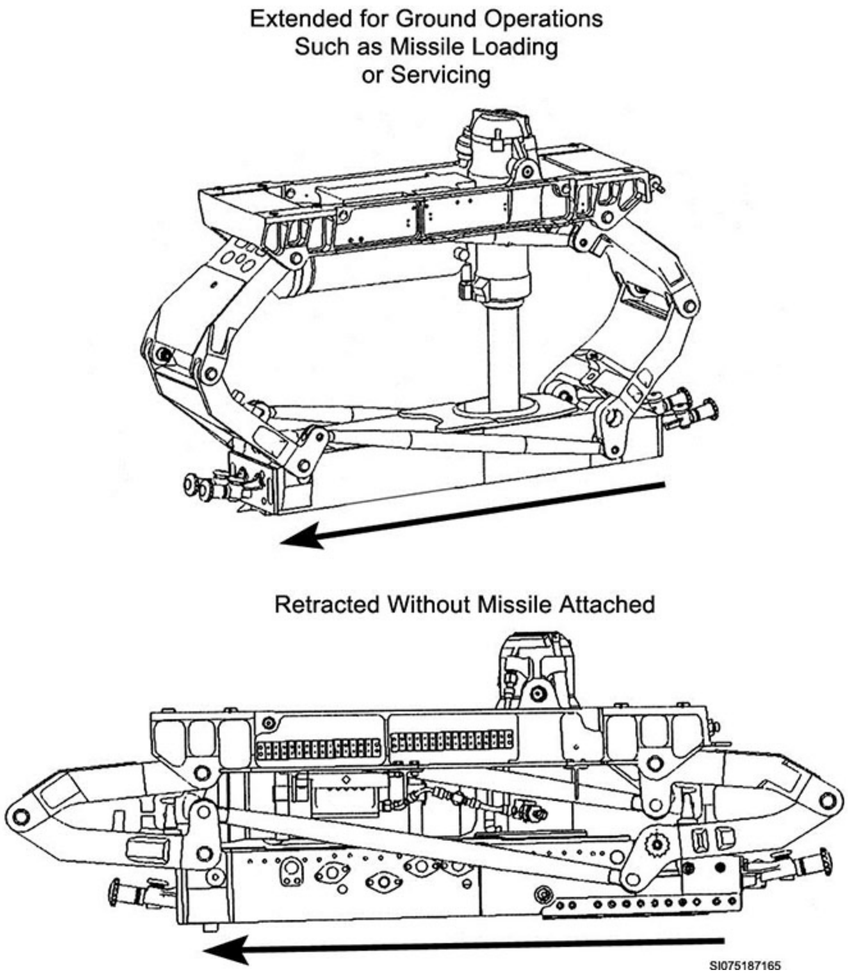


Figure 2–30. LAU–142/A launcher.

The launcher consists of three assemblies: the upper and lower assemblies and the linkages. The upper assembly contains all of the interfaces to the aircraft (hydraulic, electrical, and mechanical, the nitrogen pressure tank, and all of the actuating machinery). The lower assembly interfaces electrically with the missile and contains the hooks and snubbers that hold on to the missile hangers. The linkages have two scissor-like armatures that connect the upper and lower assemblies together.

The launcher has two distinct positions: retracted and extended (fig. 2–30). The launcher uses compressed nitrogen gas to extend the launcher from its retracted position in the bay to its fully extended position for launch or loading. Hydraulic pressure is used to return the launcher from the extended position to the stowed position. The LAU–142/A does not use conventional safety pins. It uses a ground safety lever located on the right side of the lower assembly. The handle has three settings: FLT (flight), GND (ground), and HK RLSE (hook release). You must take great care when extending a loaded launcher during ground operations; unless the ground safety lever is in the “GND” position, the launcher will automatically release the missile hangers as soon as it reaches full extension. During a missile launch, the launcher uses nitrogen gas stored in the onboard container to power a pneumatic actuator. During ejection, the pneumatic actuator travels approximately 9 inches, at which point it develops the required velocity to safely separate the missile from the aircraft. The LAU–142/A ejects the missile out of the bay at more than 25 feet per second with a force of 40 Gs at peak acceleration; the entire process from start to the closing of the bay door takes three seconds.

Rail launchers

Rail launchers are used to suspend and launch a variety of missiles. They are also found in the single, dual, and triple rail or track designs. They are attached directly to hard points on tactical aircraft, bolted to the side of pylons, or suspended from bomb racks. Most of these installations require the use of an adapter, depending on the aircraft. Refer to figures 2–31 through 2–39 and you see the different types of launchers and the typical aircraft that carries them.

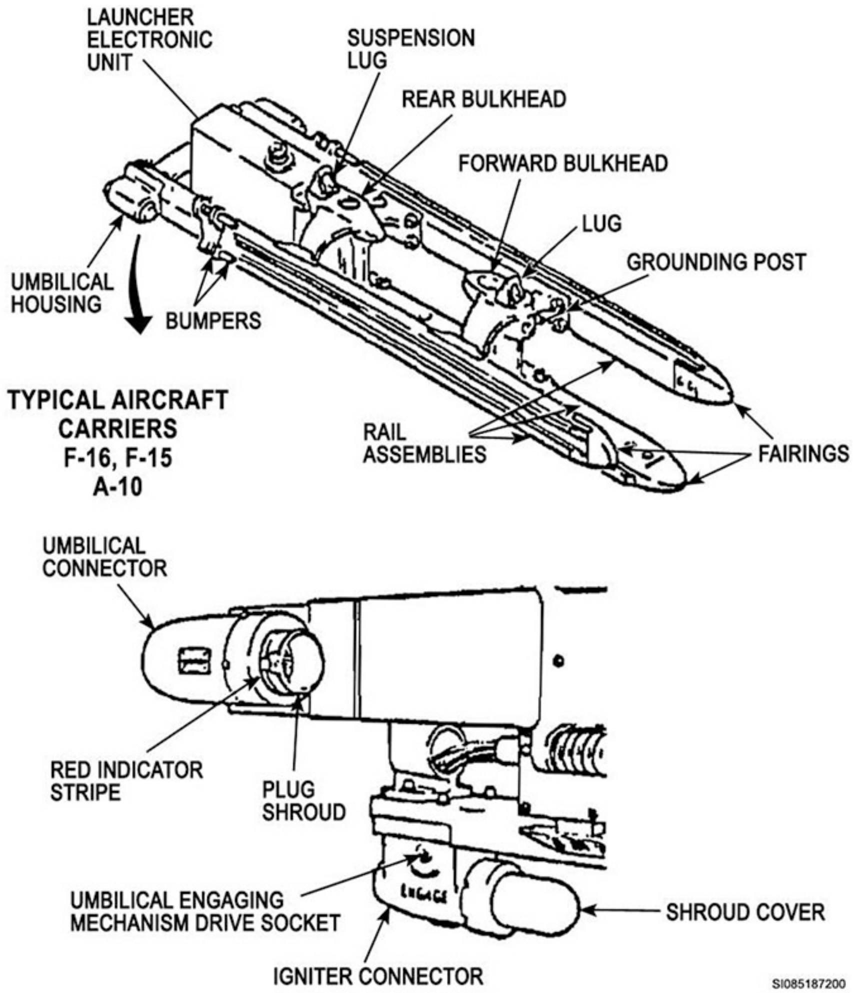


Figure 2–31. LAU–88 missile launcher.

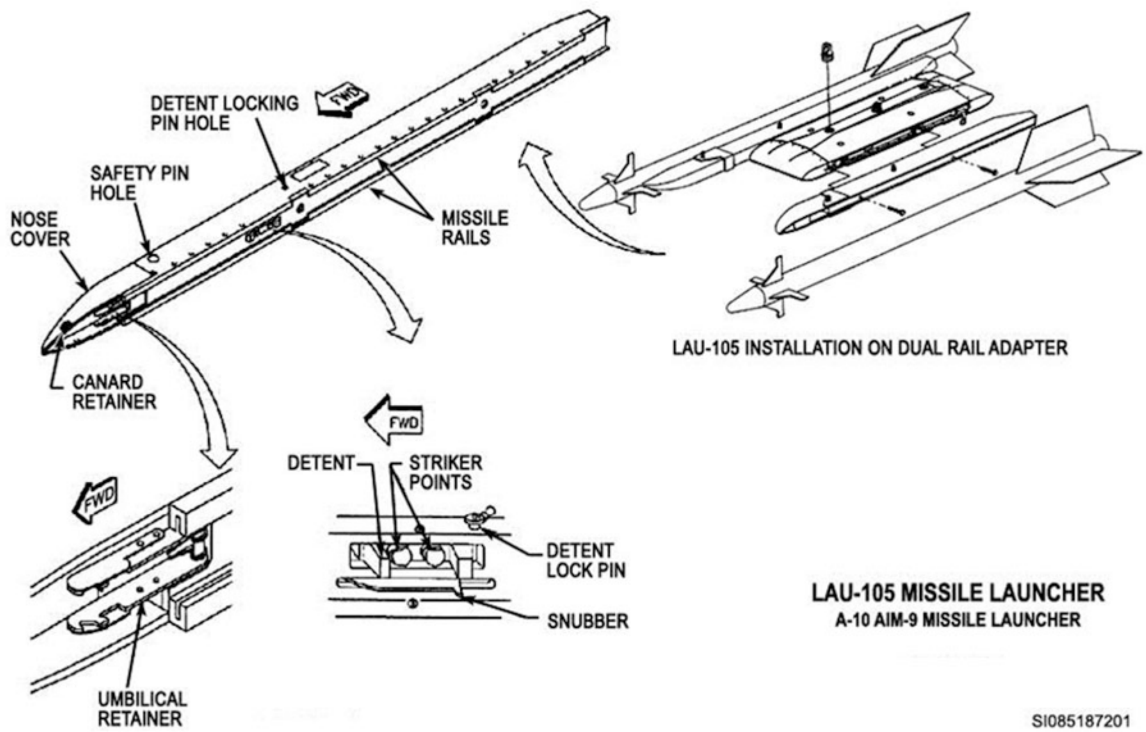


Figure 2–32. LAU–105 missile launcher.

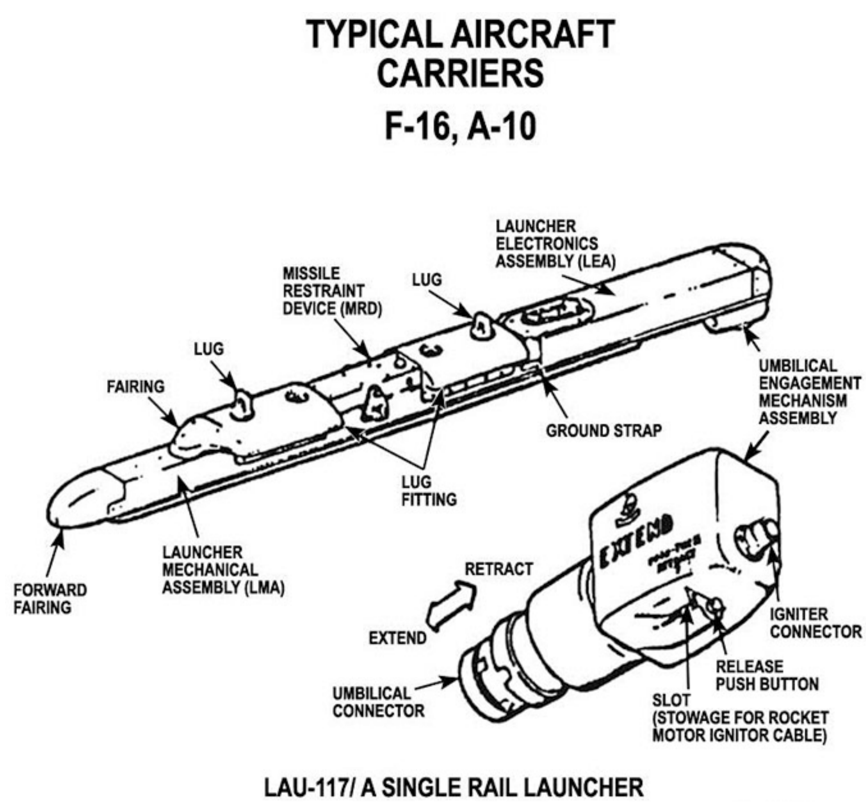


Figure 2–33. LAU–117 missile launcher.

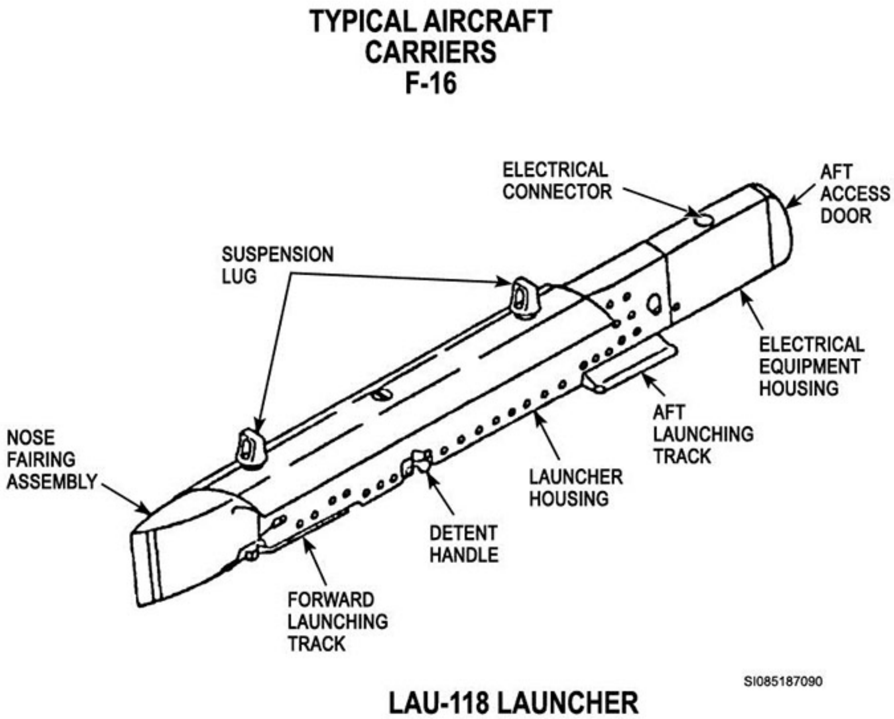


Figure 2–34. LAU–118 missile launcher.

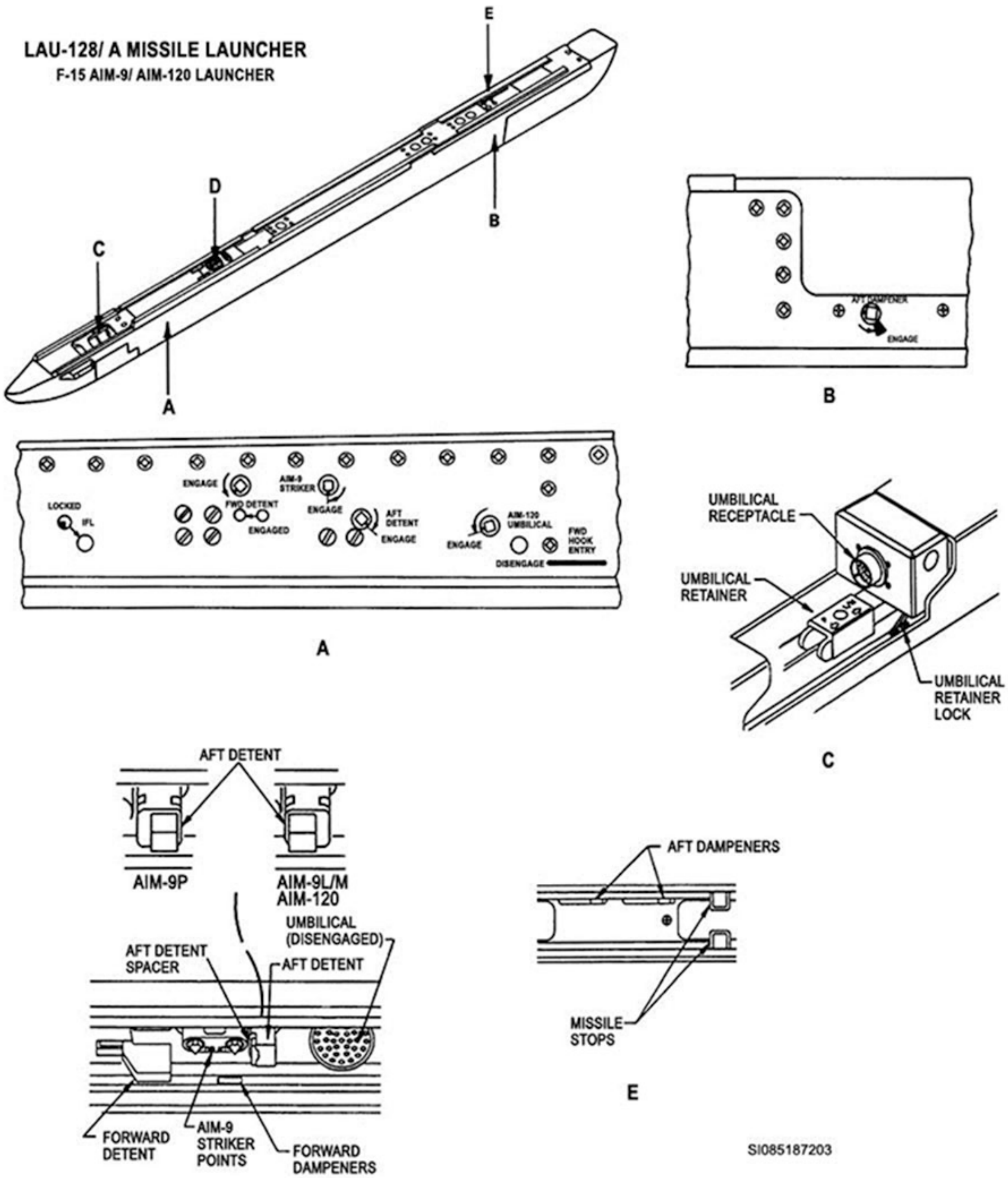


Figure 2–35. LAU–128 missile launcher.

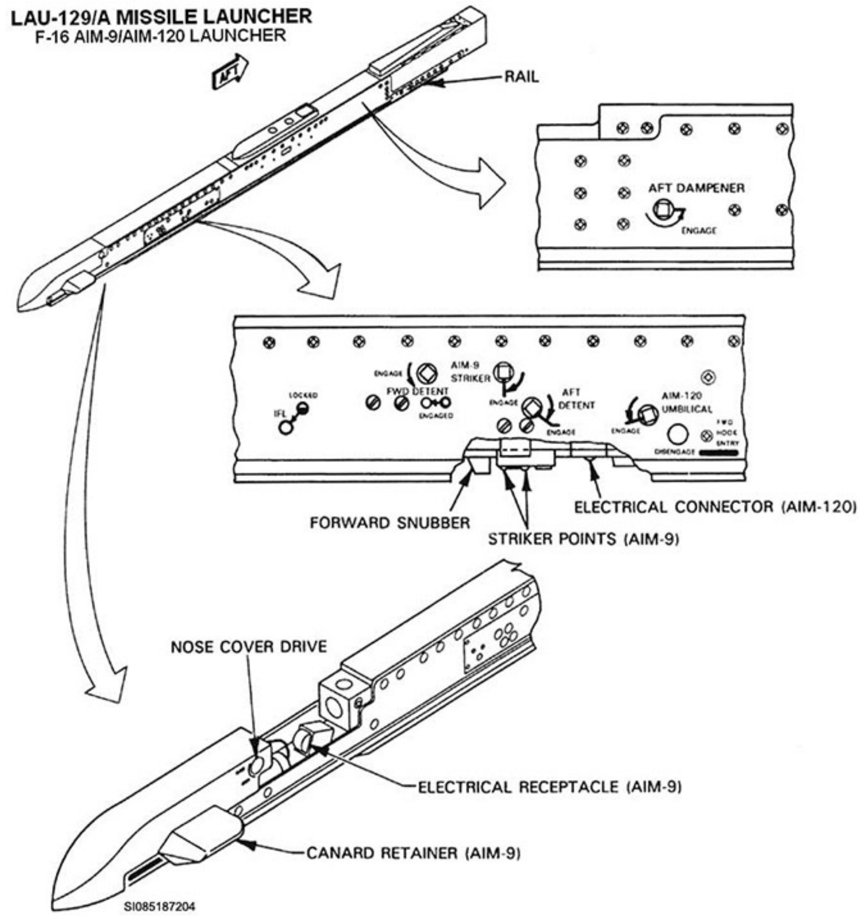


Figure 2–36. LAU–129 missile launcher.

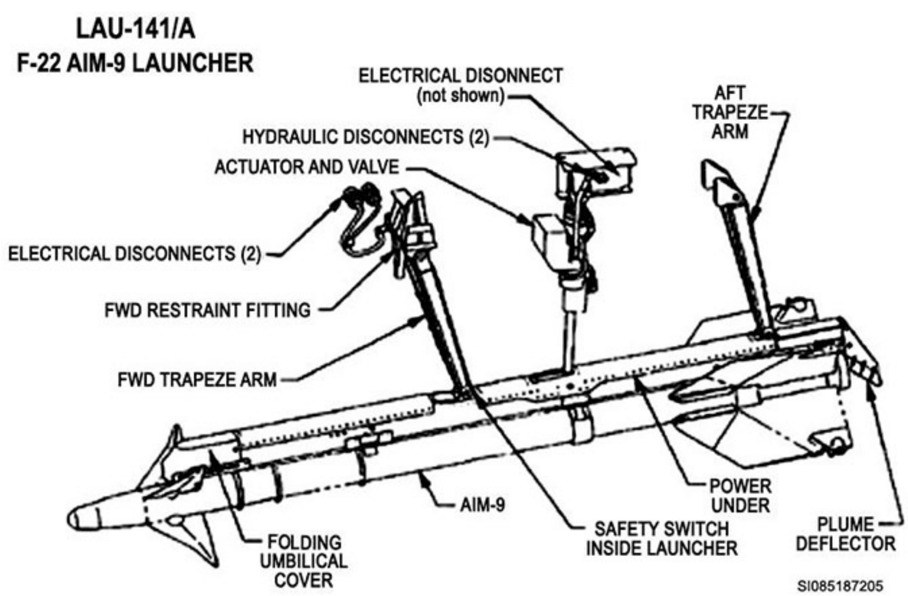


Figure 2–37. LAU–141 missile launcher.

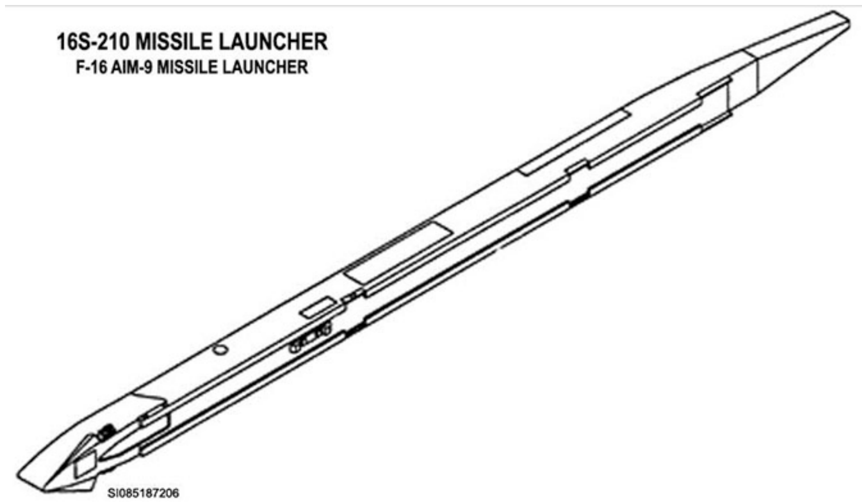


Figure 2–38. 16S–210 missile launcher.

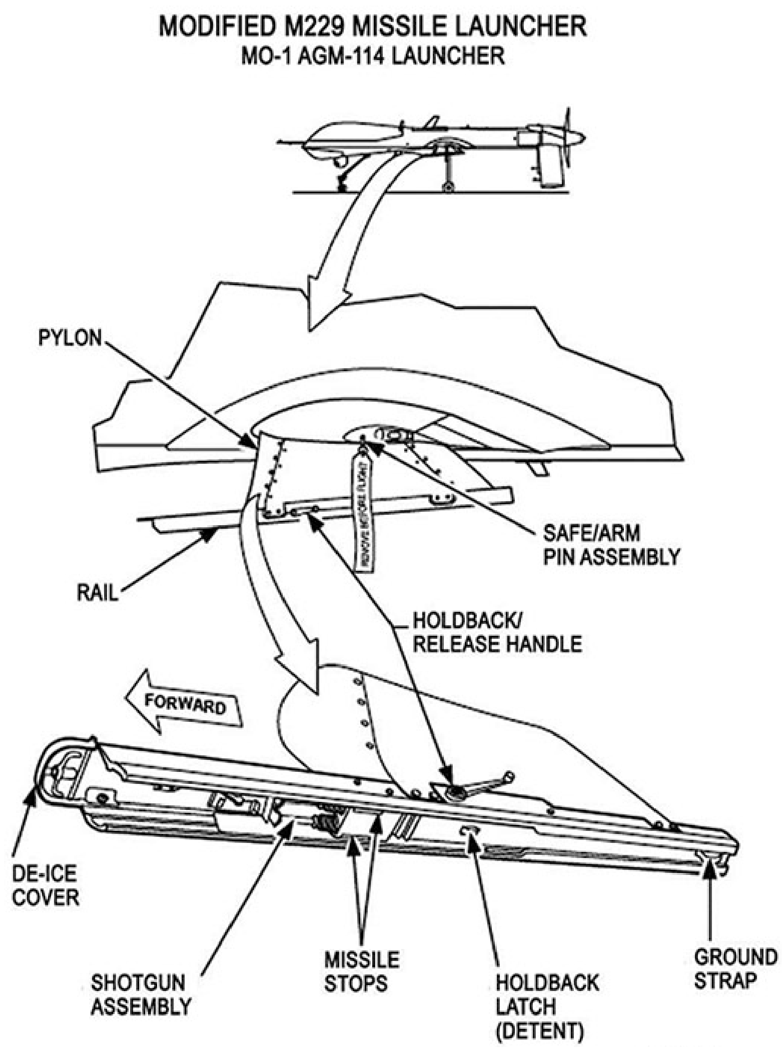


Figure 2–39. Modified M299 missile launcher.

Structure assembly

All of these launchers have a structural support built up around the rail. The structure assembly purpose is to provide an attach point for the rail assemblies and to house the various components of the launchers. Some structure assemblies have holes in them to install suspension lugs. Others have holes for attach bolts. These bolts and suspension lugs provide a means of attaching the launchers to the aircraft. The suspension lugs attach to the launchers and, in turn, are used to attach the launchers to an aircraft bomb rack. Depending on the launcher, the suspension lug spacing may be 14 or 30 inches.

Mechanical assembly

The second set of components common to all rail missile launchers is their mechanical assemblies. They normally consist of the rails themselves, some type of missile restraint and stabilization device or devices, and various other miscellaneous items. The rails of the launchers provide a track for the missile hooks. The surfaces of the rails on all launchers are normally anodized and coated with molybdenum disulfide (dry lube). The rails of the launchers are either a one-piece solid unit or two-piece tracks. These items basically serve two purposes: first, they act as a support for the missile, and second, they guide the missile at initial missile launch. They may be found with stops machined into them to prevent the missile from sliding forward or aft on the launcher rail.

The missile restraint devices range in design from shear pins to different types of detent mechanisms and missile restraint devices. These devices are installed internally on the launchers. The LAU–88 missile launcher uses a shear pin as its missile restraint device. The shear pins are threaded shafts screwed through the rail into the missile once it is installed on the launcher. The pin is then torqued and a lock nut is installed against it to keep it from backing out during flight. It holds the missile in place until the missile's motor fires, then it is sheared off as the missile is propelled from the rail.

A missile restraint device is used on the LAU–117 missile launcher. It is an internal component that is engaged and disengaged manually by loading personnel and electrically disengaged during the firing sequence. It incorporates a shear or holdback pin designed to engage a bushing in the missile when the device is engaged. The LAU–118 uses a retention mechanism assembly that is operated manually or electrically. It incorporates a detent shaped to fit into the detent rib recess located in the upper motor body of the AGM–88 (HARM) missile. The modified M299 used to carry the AGM–114 uses a manually retracted missile hold-back that operates similarly to the LAU–118's design, which contacts the forward part of the intermediate shoe/hanger on the missile. It is not automatically disengaged during missile firing like the LAU–118; it is overridden by the force from the missile's rocket motor.

Detent mechanisms are also types of restraint devices found on AIM–9 and AIM–120 capable launchers. The detent mechanisms on these launchers are located at the forward hook locations of the launchers.

On AIM–9 (only) capable launchers, the detent assembly extends through the launcher rail and straddles the forward hanger of the rocket motor. It prevents forward and aft movement of the missile during aircraft flight. Most of these launchers incorporate a detent locking pin to keep the detent from moving during flight turbulence and high "G-force" maneuvers, and prevents the missile from being lost inadvertently. Located in the center of the detent mechanism are two contact points. These contact points make contact with contact buttons on the forward hanger of the AIM–9 missile. Power flows through these contact points to activate the missile motor firing and influence fuze and target detector circuits. The detent mechanism is held in place against the missile by detent spring pressure and must be raised and lowered using a $^3/_8$-inch square drive tool when loading and unloading the missile. When the rocket motor is fired, its forward thrust overcomes the pressure of the detent spring and pushes it up into the launcher so the missile can clear the rail.

The AIM–9 and AIM–120 capable launchers detent mechanism is designed similar to the AIM–9 (only) capable launchers. Although it basically serves the same purpose, there are some differences we should address. The detent assembly incorporates a forward and aft detent. Both detents manually operated, as was the detent assembly previously discussed. However, the difference is each detent is, or can be, operated independently of each other to accommodate loading either the AIM–9 or the AIM–120 missiles. The forward detent of this type of mechanism, even though held in place by spring tension, is also locked by a solenoid called the in-flight lock (IFL). When the IFL is engaged, it prevents the forward detent from moving so the missile will not leave the rail even if the rocket motor fires inadvertently. When the IFL disengages, the forward detent is free to rotate upwards. It releases when the missile motor thrust is sufficient to compress the spring mechanism.

Other items included in rail launcher mechanical components are umbilical connectors serving as electrical interfaces between the missiles and launchers, forward and aft snubbers (AIM–9 missile launchers), or dampeners (on AIM–9 and AIM–120 missile launchers) to prevent the missile from moving side-to-side, umbilical retract mechanisms, and canard springs used to secure AIM–9 missile canards in a straight ahead position when the missile is loaded. Lists of this type could go on and on. If you need more information on launcher components, consult the appropriate technical order.

Electrical components

All rail launchers have a set of electrical components. Power supplies, electronic assemblies, and harnesses are all typical of launcher electronic components. They all provide an electrical interface between the aircraft, launcher, and missile. They may be located inside the structural cover assemblies or bolted to the launchers themselves. Each launcher has some type of umbilical connection point or buffer to the loaded missile.

The connection of the missile umbilical is made in four different ways, depending on the missile being loaded and launcher being used. When loading the AIM–9 missile, you must connect and disconnect the umbilical cable attached to the missile by hand. For the AIM–120 missile, once the missile is positioned and aligned, the connector and umbilical engage by rotating a $^{3}/_{8}$-inch square drive wrench point connected to a bellcrank mechanism inside the launcher. This type of connector is withdrawn to initiate missile motor firing and may also be retracted by pressing a manual release button on the launcher. When the AGM–65 missile is loaded on the LAU–117 or LAU–88, it requires the umbilical connector to be engaged manually. This is done by rotating an umbilical engaging mechanism drive socket located on the launcher as shown in figure 2–31. The last method is used when loading the AGM–114 on the modified M299 missile launcher. As the missile is slid onto the rail, the fixed pair of electrical connecters located on the top of the missile automatically engages the shotgun assembly's connector covers and engages the two fixed connectors on the rail's shotgun assembly (fig. 2–40).

Additional electrical components may consist of receptacles for stray voltage testing, solenoids and relays; BIT units automatically checking for proper voltage tolerances and stray voltage; and electrical power supplies or launcher electronic units (LEU) through which control to the missile is initiated. The operation of these launchers is pretty much the same since most carry one missile at a time. The exception is the LAU–88. The LAU–88, since it is a triple rail launcher, has missile firing priority controlled through its LEU. The firing priority is as follows: (1) outboard missile, (2) bottom missile, and (3) inboard missile. It also has a manual override capability to select the next missile in priority if single missile firing is desired.

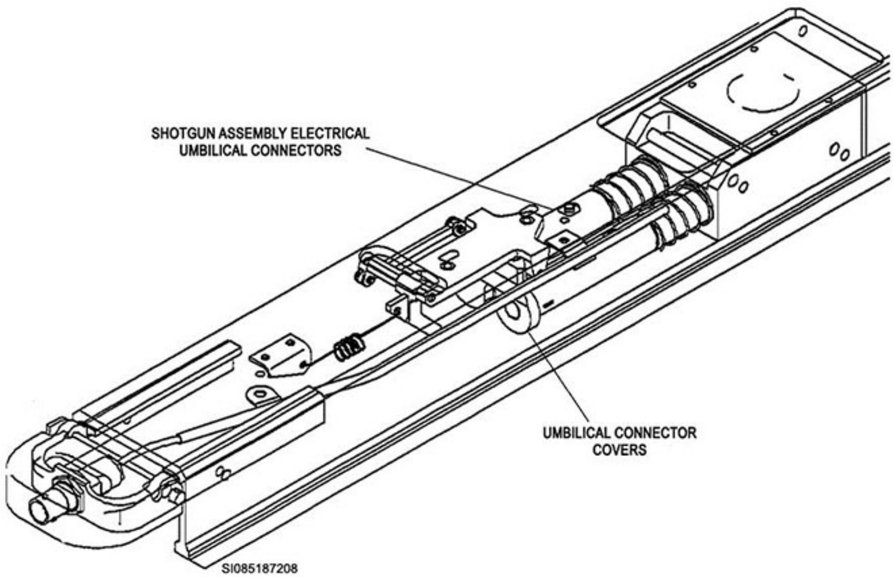


Figure 2–40. Modified M299 missile launcher shotgun assembly.

418. Rocket launchers

The LAU–131 rocket launcher is presently being used to carry and launch the 2.75-inch series aircraft rockets. These launchers are capable of being loaded with seven 2.75-inch series rockets. The LAU–131 accommodates all of the 2.75-inch series aircraft rockets.

These launchers are reusable and consist of a center section with streamlined fairings installed and locked onto the forward and aft ends (fig. 2–41). The front fairing is constructed so that upon rocket firing, it shatters. The aft fairing is constructed to accommodate the funneling of rocket debris away from the aircraft when the rocket fires. It is constructed of aluminum and can be reused at least six times. The center section of the launcher is constructed of seven metal tubes clustered and bonded together to form one integral unit. This structure is then wrapped with a thick aluminum outer skin. Detents within the tubes restrain the rockets against normal flying loads. Ignition voltage is applied to the 2.75-inch rockets by the firing contacts at the aft end of each of the launcher tubes. Two electrical receptacles are located on the top of the launcher center sections and serve as a point of electrical connection between the aircraft and launcher. A connector or cable assembly connects the launcher electrically to the aircraft armament system. A shorting pin is also on the aft portion of the center section. It is used to safe the firing circuit of the launcher.

Two additional components are located on the aft end of these launchers: the intervalometer and a single/ripple switch. The single/ripple switch selects the launcher-firing mode. Single selection allows one rocket firing for every release pulse received by the launcher. Ripple allows rockets to fire continuously at predetermined intervals (depending on which part number for the intervalometer is used) between each release pulse received by the launchers. This switch must be set before the aircraft takes off.

The intervalometers have an “L” (load) and “A” (arm) position. They also have positions ranging from 1 to 7. The intervalometer is also set before the aircraft takes off. Setting it at the “A” and “1” positions allows firing to start at the number 1 rocket tube and continue through tube number 7, as long as the launcher receives firing impulses from the aircraft. Setting the intervalometer at any other position allows firing to start at the selected position and to stop after the firing of tube number 7. Even if a full load of rockets were installed in the launchers, the intervalometer does not have the capability to bypass the “L” and “A” position to continue firing. The last components found on these launchers is a set of suspension lugs spaced 14 inches apart.

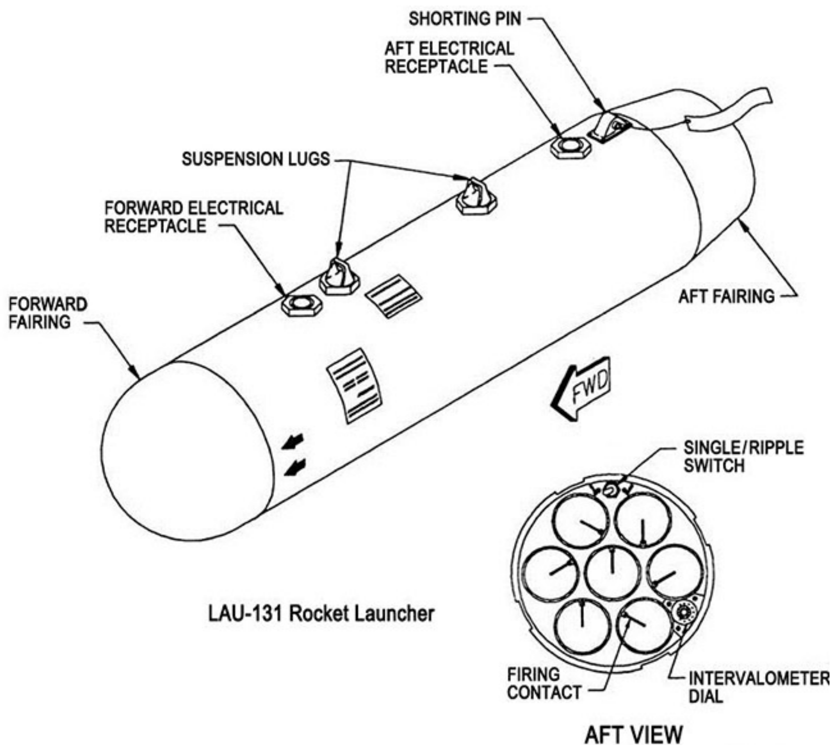


Figure 2–41. LAU–131 rocket launcher.

419. Dispensers

As is true of CBUs, there are numerous types of suspension utility units (SUU). We already know a certain type of SUU plus bomblets produce a CBU. But these are not the only type of SUUs. There are SUUs designed to carry practice bombs and flares, or in other words, dispensers. Our discussion in this lesson covers those dispensers.

Suspension utility unit–20 bomb dispenser

The SUU–20 bomb dispenser is an externally mounted pod with both practice bomb ejection capabilities and rocket launching tubes. (We no longer use the rocket launching tubes.) The dispenser is designed to carry six BDU–33 series practice bombs. The six practice bombs are carried in a recessed open bay and held in individual bomb ejector racks by retention arms, sway braces, and ejector pistons.

The SUU–20/A and the SUU–20A/A are identical in external appearance. Their most distinguishable feature is an externally mounted (welded) strongback running the length of the dispenser top surface. The SUU–20B/A is functionally identical to the SUU–20/A and SUU–20A/A. Physically, the SUU–20B/A differs in that the strongback is enclosed within the skin of the dispenser, the relative positions of the intervalometers have been reversed, and the method of sway bracing the practice bombs has been changed (fig. 2–42).

The practice bomb ejector racks consist of bomb retaining arms, sway braces, and an ejector piston assembly. The bomb retaining arms are adjustable for 3- or 4-inch bombs. The forward sway brace is a bolt with a metal inverted V on the lower end. On the SUU–20/A and SUU–20A/A, the aft sway brace is a spring-loaded wedge. The forward sway brace is screwed down to level the bomb horizontally, and the aft sway brace is moved forward to wedge the bomb snugly in place.

On the SUU–20B/A, one sway brace is a bolt with an inverted V on the lower end, and the other sway brace is a bolt with a saddleback pad on the lower end. Both sway braces are screwed down until the bomb is horizontal and held snugly in place with the legs of the inverted V and the legs of the saddleback pad straddling the bomb. The bomb ejector racks are rotated 180° from each other so that the cartridge holder is always on the outboard side of the dispenser. This rotation places the saddleback sway brace pad aft on the right side and forward on the left side of the dispenser. The practice bomb ejector racks of the SUU–20B/A are replacing the racks of the SUU–20/A and SUU–20A/A by attrition. However, mixing the two types of ejector racks on the same dispenser is not authorized.

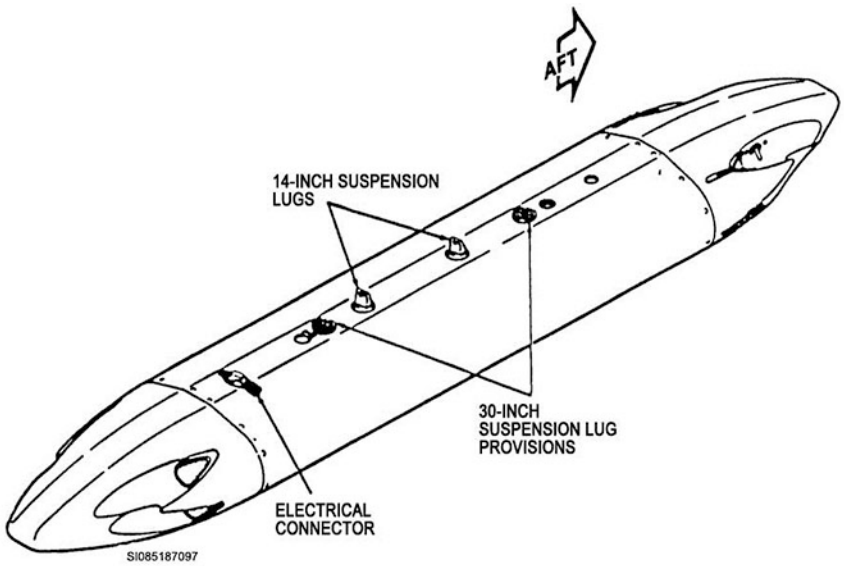


Figure 2–42. SUU–20 practice bomb dispenser.

On both types of ejector racks, the ejector piston assembly operates within the breech housing and is driven by gas pressure generated when a single impulse cartridge is electrically fired. Each ejector rack uses one ARD 863–1 impulse cartridge. An index pin on the ejector piston fits into a corresponding hole in the bomb to prevent the piston from sliding off the side of the bomb during ejection. Impulse cartridges are installed in the breech housing and retained by a cartridge holder. The cartridge holder is torqued and pinned in place to ensure it does not vibrate loose in flight.

The dispenser has one intervalometer located at the forward end of the recessed bomb bay in front of the practice bomb racks. On the SUU–20B/A, the intervalometer has single, ripple, and salvo release modes with an ARM position and a SAFE position for each mode. Before loading, the intervalometer is placed in the SAFE position immediately in front of the release mode to be used. For example, if the bomb single release mode is to be used on the next flight, the bomb intervalometer is placed in the SALVO SAFE position. This ensures the intervalometer does not have to be cycled through any loaded stations during arming area checks.

Ground safety is provided by a mechanical safety pin in each bomb rack, a circuit disconnect safety spring to open the dispenser firing circuits, and the SAFE positions of the dispenser intervalometers. All safety pins and the safety spring are tagged with red "REMOVE BEFORE FLIGHT" streamers.

Suspension utility unit–25 flare dispensers

Flare dispensers are designed as reusable, externally mounted, pyrotechnic launching devices (fig. 2–43). The dispensers are loaded with eight high-intensity illumination flares or colored pyrotechnic target markers. These dispensers are always delivered in a pre-loaded configuration by munitions personnel.

This dispenser is a tubular shaped, all-metal constructed body consisting of four tubes assembled together and enclosed by an outer skin with a bulkhead at each end. Located at the top center of the dispenser are two electrical receptacles that connect with the aircraft electrical system. Each receptacle is equipped with a dust cap. Only one electrical receptacle connects to the aircraft for dispenser operation. An intervalometer and breeches are located on the forward bulkhead. A pyrotechnic protection cover (nose cone) is installed on the forward end for protection. The cover also aids the dispenser aerodynamically.

The intervalometer sequences the dispensing of the flares only allowing one munition to be dispensed at a time. However, if the aft flare fails its launching sequence, the forward flare firing sequence purges the tube, launching both munitions together. On the right side of the dispenser in the center section is a jack where a shorting pin is inserted to interrupt the electrical circuit between the two electrical receptacles and the breeches. This pin electrically safes the dispenser. At the aft end of the dispenser in each tube, the end of the flare can be seen with a yellow sealing cap ring installed around the munition.

At the lower inboard area of each tube is an L-shaped retaining link positioned against the sealing cap with a shear pin inserted through the retaining ring and bracket. The split end of the shear pin spreads to lock the retaining link in position. Installed on top of the dispenser are two suspension lugs, adaptable to all 14-inch bomb racks. The area around the lugs is reinforced with a strongback to permit sway bracing and forced ejection. The SUU–25E/A and SUU–25C/A are similar, except on each side in the center of the SUU–25E/A dispenser is an access door with a notch at the top and bottom to allow the forward retaining link shear blocks to extend outside the dispenser.

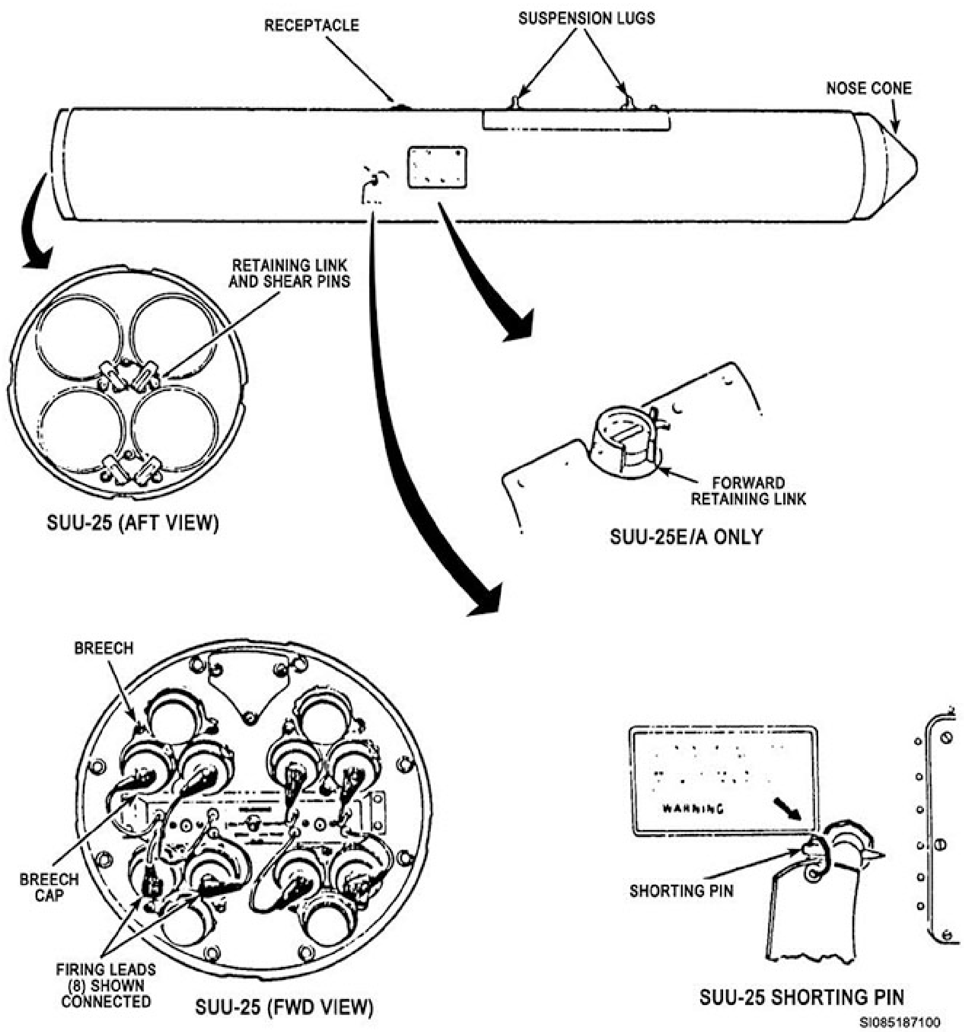


Figure 2–43. SUU–25 flare dispenser.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

417. Missile launchers

1. Name the three types of missile launchers used on our aircraft.

2. What missiles are gas-operated launchers capable of carrying?

3. Where are gas-operated launchers normally found mounted on an aircraft?

4. What are the five basic sets of components that make up a gas-operated launcher?

5. What are the two basic operating modes of gas-operated launchers?

6. Which mode of operation of gas-operated launchers is always a manual process?

7. How does the launcher safety pin safe gas-operated launchers?

8. In what two ways may gas-operated launchers be unlatched?

9. When is missile motor fire initiated upon missile ejection from a gas-operated launcher?

10. What is currently the only pneudraulic missile launcher system in use by the Air Force?

11. How is the LAU–142/A safed?

12. What three designs do rail launchers normally consist of?

13. What is the purpose of the structure assembly of rail launchers?

14. In what two ways are rail launchers normally attached to aircraft?

15. What are the two purposes of the rail or tracks on rail launchers?

16. What component acts as the missile restraint device on the LAU–88 missile launcher?

17. Where are the detent mechanisms located on AIM–9 and AIM–120 capable missile launchers?

418. Rocket launchers

1. How many rockets are the LAU–131 rocket launchers capable of carrying?

2. What components of the rocket launchers restrains the rockets against normal flight loads?

3. What is used to safe the firing circuit of the LAU–131 launchers?

4. If the single/ripple switch is positioned to ripple, how will rockets be fired from the LAU–131 rocket launchers?

419. Dispensers

1. The SUU–20 series dispenser is designed to carry what munitions?

2. What ejector cartridge is used in the SUU–20 series dispensers?

3. How is the SUU–20 cartridge holder held in place?

4. How many flares are loaded into the SUU–25 flare dispenser?

2–5. Armament Subsystems Operation and Maintenance

There are four basic subsystems used to accomplish weapons release. They normally are referred to as the bombing, missile, jettison, and chaff and flare systems. This section discusses these subsystems, the operations they provide or their release options, and the maintenance we might be required to perform on them.

420. Subsystems operation

The bombing system of an aircraft has one purpose: to facilitate the release of conventional and/or nuclear bombs. There are two types of systems used in our aircraft today.

Bombing systems

The two types of bombing systems used on our aircraft are most commonly referred to as internal and external systems. Internal bombing systems are found on the B–1B, B–2, F–22, and B–52 aircraft. The B–52 and F–22 aircraft actually have both internal and external systems. All other aircraft in our inventory are equipped exclusively with external conventional bombing capabilities. Figures 2–44 through 2–49 show the aircraft presently in use and the aircraft stations used in this subsystem.

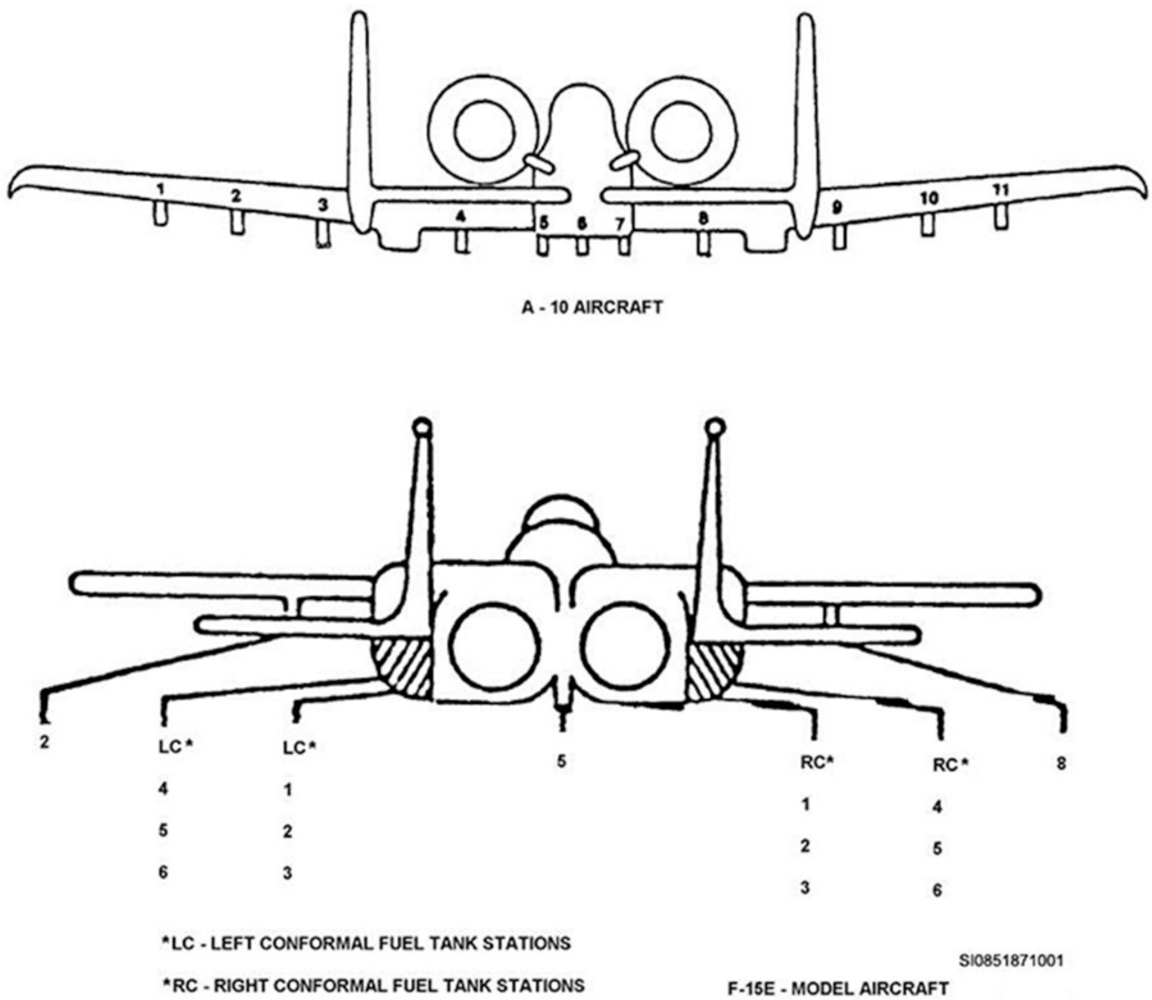


Figure 2–44. Aircraft bombing system configuration.

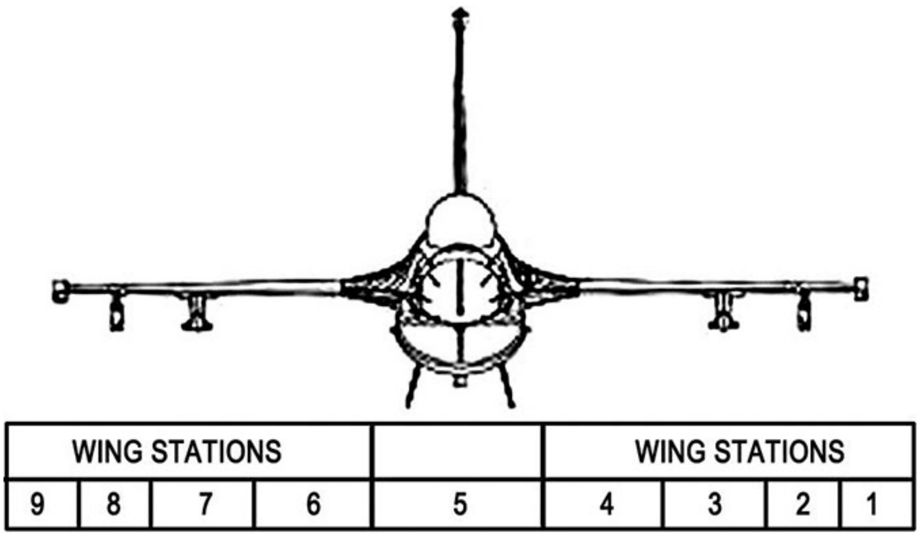


Figure 2–45. Aircraft bombing system configuration (cont'd).

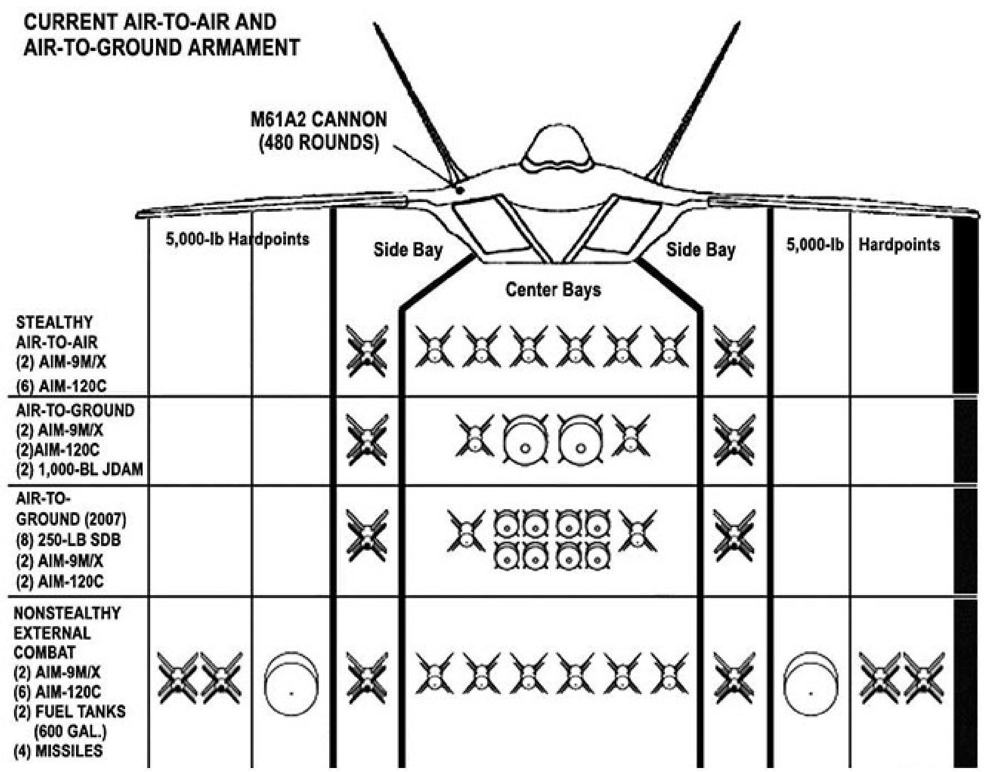


Figure 2–46. Aircraft bombing system configuration (cont'd).

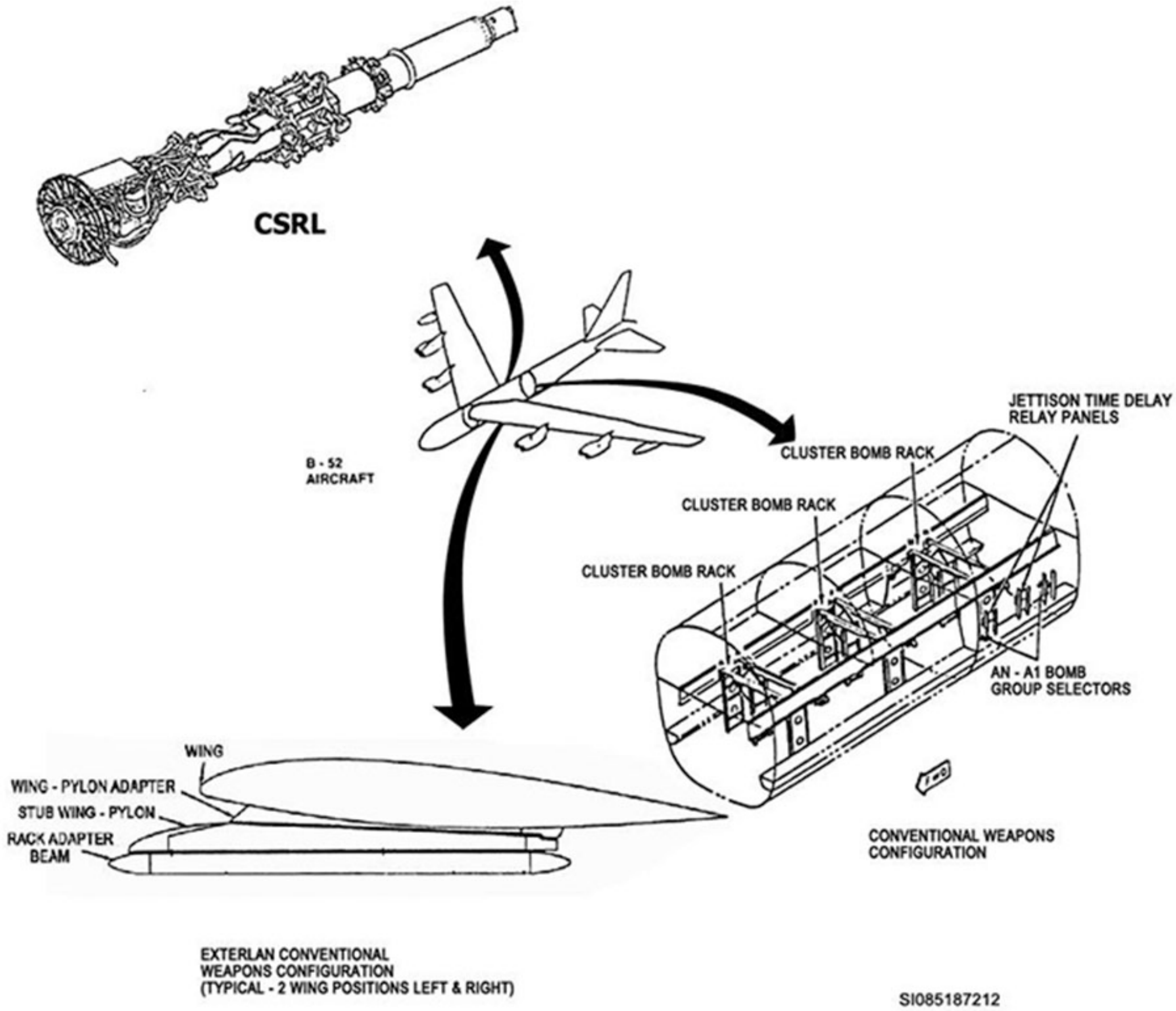


Figure 2–47. Aircraft bombing system configuration (cont'd).

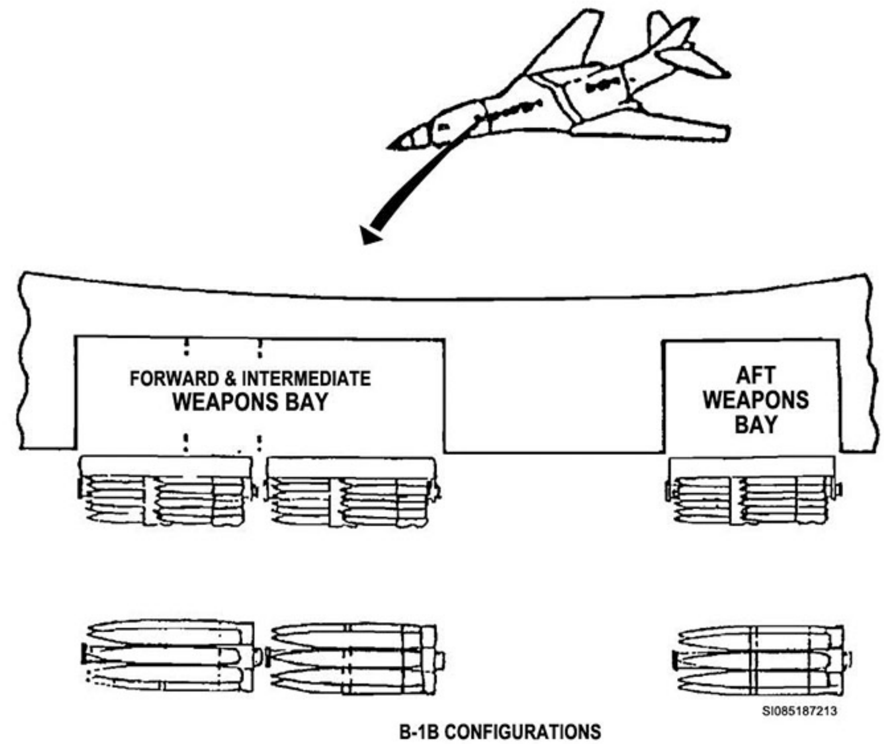


Figure 2–48. Aircraft bombing system configuration (cont'd).

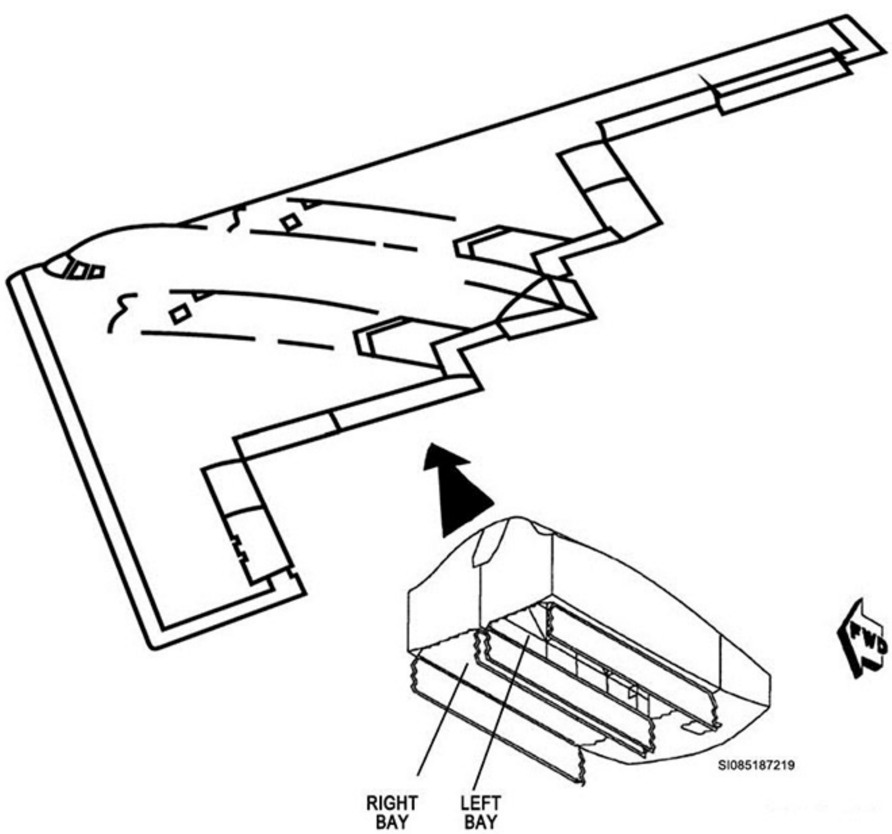


Figure 2–49. Aircraft bombing system configuration (cont'd).

All conventional and nuclear bombing systems offer different types of release options for selected weapons. Depending on the aircraft, you may encounter release options such as normal, single, rapid, pairs, salvo, emergency armed, and so forth. All of these options are categorized into three types of releases: manual, manual-computed, and automatic (computed).

Manual release

Manual release is equated to a single selected weapons release. In other words, one push of the weapons release switch, or generation of one release pulse, affects the release of one bomb from one station. When using this type of release, most systems require the individual selection of stations, various cockpit controls, and activation of the weapons release switch, bomb release switch, or some other comparable bombing system control component to accommodate weapons release. Multiple stations may be selected during this type of release, but only one station releases for each depression of the weapons release switch. When multiple stations are selected, the weapons release priority system determines the drop sequence of the individual stations and directs the generated release pulse to the appropriate station.

Manual-computed

The second type of release is the manual-computed release option. When using this type of release option, you can select a ripple, salvo, or train (multiple weapons release) mode-type release. Once the proper control selections are made in the cockpit, the system generates a preselected number of release pulses and holds those until the manual input is received (usually the depression of the weapons release switch). When manual input is received, release pulses are distributed to the various selected weapons stations and weapons release begins. Weapons release ends when the selected number of release pulses has been used up by the system. Again, the weapons release priority system determines the station sequences. Unless this option is deselected, it continues to generate weapon release pulses. One important thing to remember here is the pulses can only be distributed to the weapons stations by depressing the weapons release switch or other comparable bombing system manual release control. The pilot must give the computer consent to release the weapons.

Automatic

The automatic or computed release option is extremely similar to the manual-computed option. Depressing the weapons release does not cause release pulses to be distributed to selected weapons stations. It actually serves as consent by the system operator for the aircraft's computer system to release the munitions when a certain set of predetermined parameters has been reached. This allows the system to release weapons at very precise times that a person could never hope to estimate. For instance, if a weapon needed to travel at a precise trajectory to hit the target, this method of release would allow the computer to calculate the precise moment to release the weapon for mission completion.

Missile systems

Missile systems have two basic modes of operation: air-to-air (A/A) and air-to-ground (A/G). Not all of our aircraft are capable of carrying both A/A and A/G missiles; therefore, they all will not have both modes of operation incorporated into their systems. Figures 2–50 through 2–54 show our major aircraft's configurations and capabilities of missile carriage (conventional and nuclear). When reviewing the illustrations, notice the B–1, B–2, and B–52 do not have A/A missile capabilities.

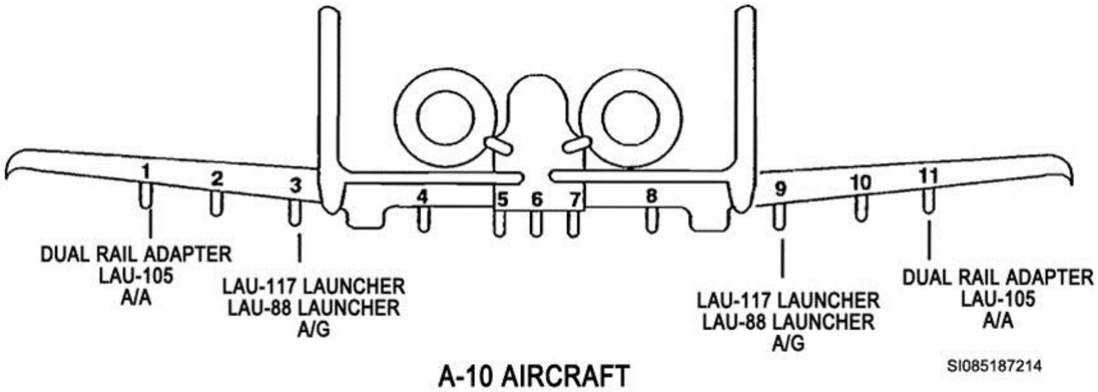


Figure 2–50. Aircraft missile systems configuration.

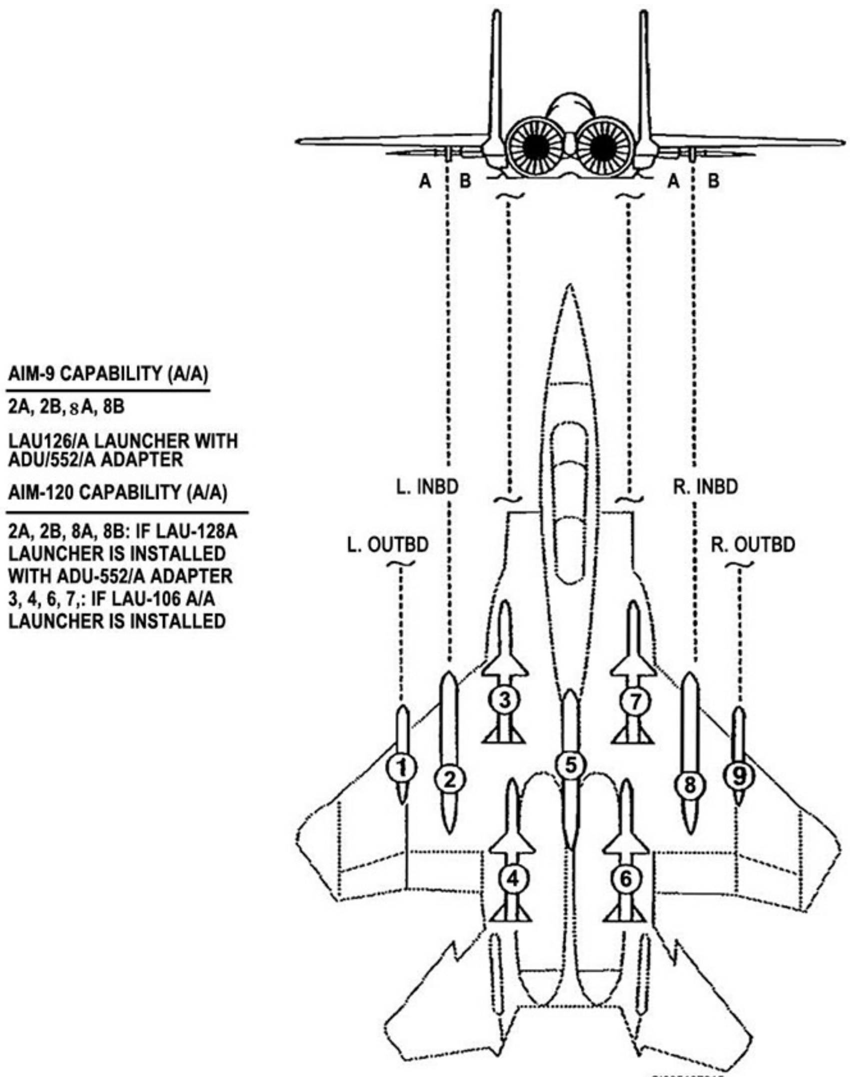


Figure 2–51. Aircraft missile systems configuration (cont'd).

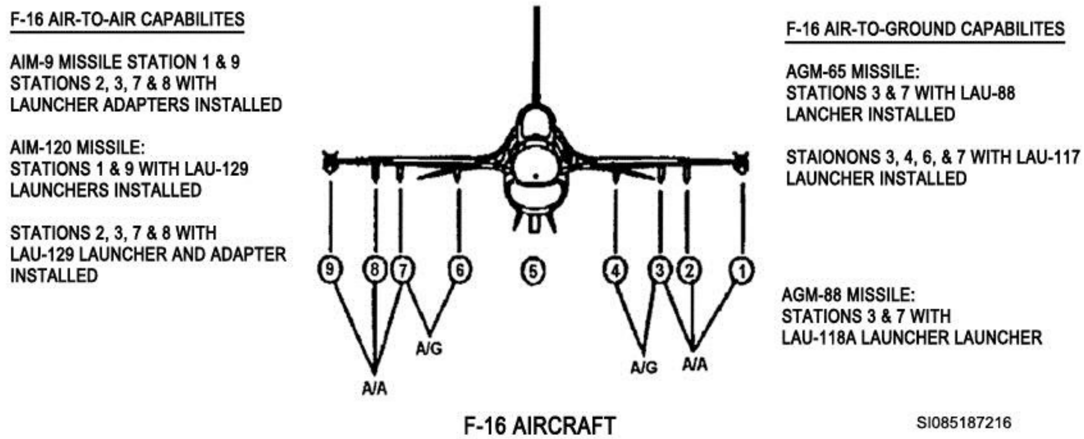


Figure 2–52. Aircraft missile systems configuration (cont'd).

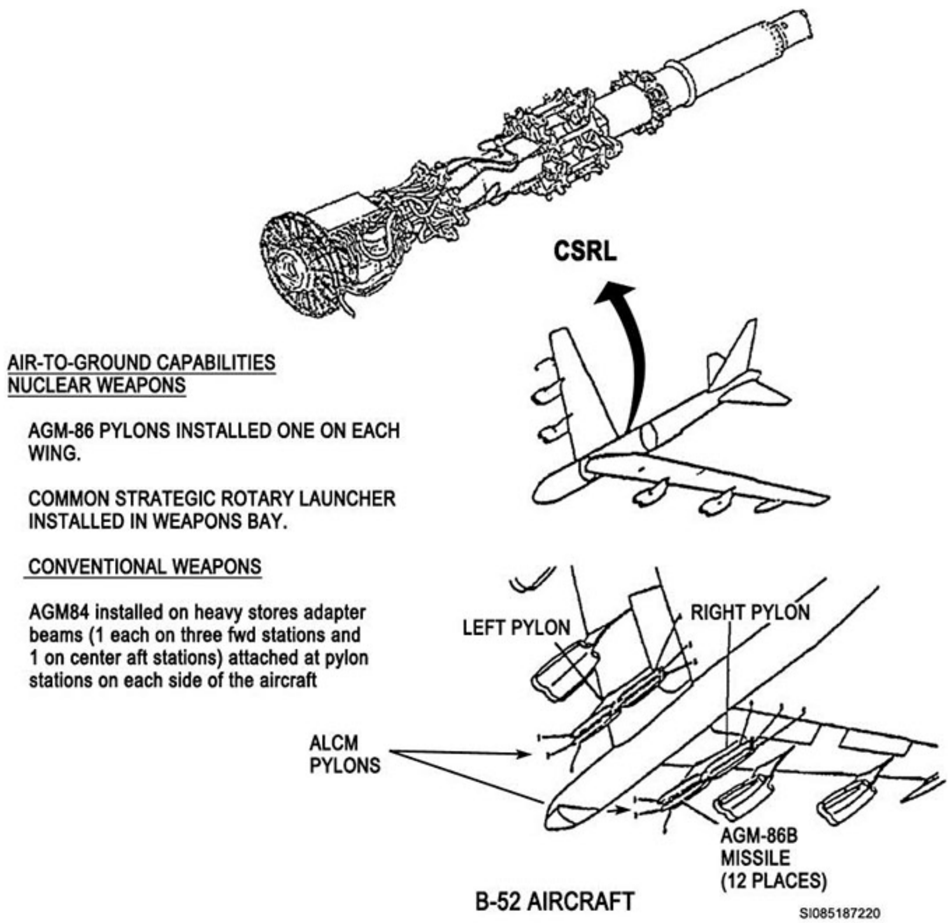


Figure 2–53. Aircraft missile systems configuration (cont'd).

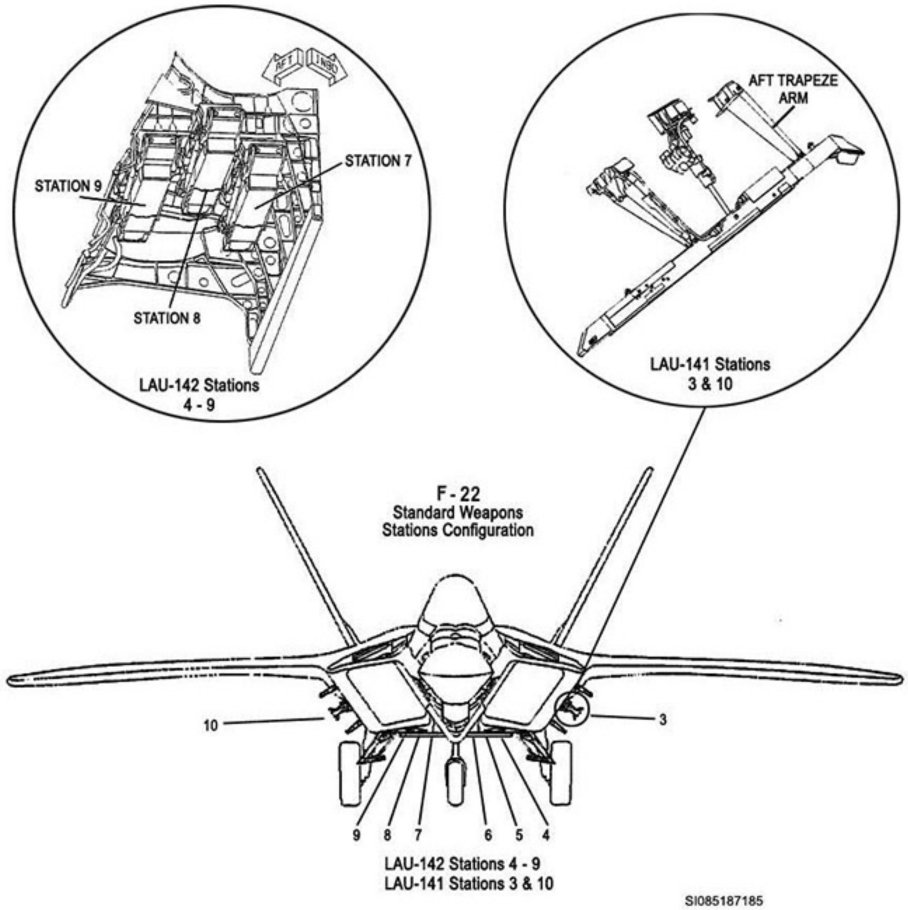


Figure 2–54. Aircraft missile systems configuration (cont'd).

Air-to-air release

A/A missile release, depending on the aircraft, is done after the selection of the appropriate cockpit switches. This includes depressing the weapons release switch or trigger switch. A/A missiles, such as the AIM–120 and AIM–9, are always fired individually. There are no provisions for multiple or simultaneous release of these missiles from any capable aircraft. If all A/A stations are selected, the aircraft system normally selects the missile at the station with the highest priority. In the firing sequence, stations not selected are automatically passed over, regardless of their initial launch priority. The launch sequence for A/A missiles is started when the appropriate displays, normally ready (RDY) on systems with MFDs or RDY lights on other systems, are displayed and the weapons release switch or trigger switch is depressed. At the start of the launch sequence, signals are sent to the launcher and to the missile through the launcher umbilical. These signals are required for missile launch preparation and for missile guidance after launch. At this point, deviations start to occur, depending on whether the AIM–9 or AIM–120 missile is selected.

In the case of the AIM–9, the first uncage signals are sent to all selected AIM–9 missiles to uncage the missile seeker heads and enable the IR detection system. When the missile detects a heat source, an audio signal from the missile is amplified in the launcher, routed to the aircraft's computer system and intercommunication system, again amplified, and routed to the pilot's headset. This audio signal or missile tone is used by the pilot as a missile lock-on indication. The volume of the tone depends on things like target range, size, and temperature. During this initial AIM–9 initiation, the aircraft missile system also monitors the status of all selected stations, the seeker scan, and cool status of the missiles.

When the actual firing circuit is energized, voltage from the launcher power supply ignites the missile gas grain generator through the umbilical cable. Sufficient buildup in the generator circuit closes a firing relay in the power supply and sends power to the striker points of the launcher causing missile arming and missile motor firing. Missile motor thrust overrides the restraining effect of the launcher detent and the missile moves forward along the launcher rail. Forward thrust of the missile shears off the umbilical block, opens a power interlock relay, and removes power from the block. The retract hook found in the launcher's nose fairing pulls the block and cable inside the nose fairing of the launcher. The missile is now free of all restraints and leaves the launcher for its target.

Launching an AIM–120 from a rail launcher is similar to the AIM–9 missile. Of course, the AIM–120 is not a heat-seeking missile, so there are some differences. Once the radar of the AIM–120 is homed in on a target and the weapons release switch is depressed, the aircraft computer system generates a release consent signal and forwards it to the missile. This signal, along with aircraft power, allows the missile to begin its launch cycle. After completing a series of internal checks, a commit to launch signal is issued by the missile back to the aircraft's missile system. Once the aircraft receives this signal, it issues an umbilical retract signal to the missile launcher. When the umbilical has retracted, the missile completes the launch cycle by igniting the rocket motor. Missile motor thrust, as it did with the AIM–9 missile, now pushes the missile down the launcher rails, overrides the detent assemblies and leaves the launcher headed for its target. If for some reason the umbilical does not retract into the launcher, the missile will not complete the launch cycle or fire the rocket motor.

The AIM–120 missile, being supported and launched by LAU–106 launchers, is launched somewhat different from the rail-type launchers. It does, however, receive its launch signals through the launcher umbilical just as the other missiles do. The first signal through the umbilical activates the missile's battery and hydraulics. The next set of signals from the aircraft computer system initiates missile control before launch. When the missile receives these signals, it sends back a battery-activated signal. Then, approximately 1.3 seconds later, a missile eject signal is sent to the launcher. The launcher then sends the eject signal to the launcher impulse cartridges; they fire causing the hooks to open and the ejector feet to extend downward. The downward push exerted by the ejector feet pushes the missile away from the aircraft. The missile motor is fired after the missile is a certain distance away from the aircraft.

Air-to-ground release

A/G missile release must be discussed in two aspects: conventional and nuclear release. When loaded, most A/G missiles are installed on launchers attached to bomb racks, but some missiles are attached directly to the bomb racks. With the exception of having to use the nuclear weapons control systems to enable and release nuclear missiles, their launching sequences are basically the same. Once the appropriate cockpit switch selections are made and the weapons release switch is depressed, the launch cycles begin. Aircraft power is routed through the A/G portion of the missile system to the selected weapons station.

Before power reaches the missile to be launched or the bomb rack used to eject the missile, the power is routed through some type, or even several types, of electronic control units. As you already know, these units are found on all launchers and in all pylons. They are the signal receiving and sending point between the central aircraft system and weapons station. The unit, depending on the particular configuration and aircraft, may be used to establish firing orders for loaded missiles, to provide missile arming and enabling voltages, to send return signals so the launcher can rotate, and to provide empty station signals when all missiles have been fired.

After passing through the electronic control units, power normally is routed two different ways. Power may be routed directly into the cartridges of a bomb rack for missile ejection and into the missile to accommodate missile arming and motor firing. Power may also be routed straight into the missile, bypassing the bomb rack, for missile arming and firing. The first route normally is applicable to nuclear missiles; the second to conventional missiles. If multiple external stations are selected for missile release, the systems release priority system selects, as with other systems, the highest priority station to accommodate the first missile release. A closed-circuit video system may also be provided in the aircraft to provide a picture of the target to assist in alignment and lock-on of missile guidance circuits.

Jettison systems

Throughout this unit we have mentioned jettisoning munitions, subracks, and pylons. But exactly what is jettison? It's nothing more than releasing any of the items we've discussed from an aircraft. There are times, such as in-flight emergencies or malfunctioning munitions, when items installed on an aircraft must be released in flight by using the jettison system. These systems have basic circuit characteristics incorporated into all aircraft, regardless of system design. They normally have two basic modes of operation—selective and emergency jettison. Their capabilities are also very similar and they will jettison missiles, stores (munitions), subracks, and even aircraft pylons if the aircraft has the capability. If the aircraft is nuclear capable, these systems also provide for jettison of nuclear weapons. On aircraft using internal bombing systems, the jettison system also provides a method for electrically controlling the opening of the bomb bay doors when munition items are being released.

Selective

The selective jettison mode of operation, as its name implies, is used to jettison weapons or related suspension equipment from specifically selected weapons stations. When this operational mode is used, all of the aircraft's mechanical fuzing circuits are normally disabled to accommodate a SAFE munitions release. In the normal selective jettison operation, once a station is selected for release and the appropriate switch is depressed (selective jettison switch, push to jett switch, etc.), circuit power is routed to the selected station. Then, either the subrack and munition or just the munition is released. Normally, all stations on an aircraft can be selected, but only one release is affected with each depression and release of the appropriate switch. If all stations are selected, they normally are released by depressing and holding the appropriate switch, and letting the aircraft's release priority system step through the stations. Usually, there is a time delay anywhere from 250 milliseconds to 1.1 seconds between release pulses to individual selected stations.

One variation of selective jettison you may encounter is found in bomber-type aircraft. In operation, all internally and externally installed munitions are released together in a SAFE condition. Conventional weapons are released from all rack locations at the same time. Nuclear weapons are released as simultaneously as the system's transfer circuits allow.

Emergency

Emergency jettison can be equated to an override mode of operation. It normally is a one-switch operation to accommodate the jettison of all subracks and installed munitions, regardless of the mode of operation of the aircraft's armament system. Emergency stores jettison normally is the highest priority input into the armament system. All weapons jettisoned in this mode are jettisoned SAFE. The power for emergency jettison usually comes from the essential bus of the aircraft and has an automatic transfer to the aircraft battery bus for reliability.

Again, as with selective jettison, depressing the appropriate switch (emergency stores jettison switch, salvo jettison switch, etc.) distributes power to the system. Unlike selective jettison, power into the emergency jettison circuit is routed to all stations, regardless of stations selected to accommodate the release of everything on board the aircraft. The aircraft's mechanical fuzing circuits are disabled and the aircraft's release priority system establishes the stations release sequence with a time delay between station releases. Emergency jettison circuits are always HOT. Within these circuits, variations such as emergency-armed release (bomber-type aircraft) can be found. These operate the same as the selective jettison circuits, except all munitions leave the aircraft armed.

While we are discussing jettison systems, we should mention the jettisonability and nonjettisonability of certain munitions and suspension items. AIM–9 and AIM–120 missiles jettisoned from the F–15 aircraft remain attached to the launchers and pylons. They are jettisoned as a complete package. From the A–10 aircraft, AIM–9 missiles are also jettisoned as a complete package—missiles, launchers, and adapter. However, currently this capability is not being used in the A–10 world. The F–16 aircraft presently has no AIM–9 missile jettison capability. AIM–120 missiles loaded on LAU–106 launchers are usually selectively jettisoned one at a time and emergency jettisoned simultaneously. Their status of release is unarmed, unguided, and with no motor fire.

The AGM–65 missile may be jettisoned in two ways, depending on the aircraft carrier. The first is by jettisoning the launcher and missile together; the second is by firing the missile unarmed and unguided. Nuclear missiles like the air-launched cruise missile (ALCM) are normally jettisoned unarmed, unguided, and with no motor fire. The ALCM may also be jettisoned attached to its pylon as the carrier aircraft (the B–52) has that capability. Just as subracks and launchers can be jettisoned, so can pylons. At present, only three aircraft have pylon-jettisoning capabilities of this sort—the B–52, F–22, and F–15.

Chaff and flare systems

Aircraft chaff and flare systems are used to dispense radar reflective material (chaff) and infrared flares. The purpose of these items is to counteract or deceive attacking enemy missile threats. The system ejects chaff and flares either individually or in groups from dispensers installed in the aircraft. The ejection process is made possible by either chaff and flare programmer or the aircraft's computer system. All data concerning the type of payload (chaff or flares) is normally set up through the system's aircraft control panel and processed by the programmer. In the case of computerized systems in aircraft like the B–1, programs are preloaded into the computer system to control firing or dispersing the payloads. The system also contains a provision for sending signals back to the aircraft when the payloads have been depleted. This may be found in the form of a sequencing switch or other comparable component.

An additional design feature of this system, found on the B–1 aircraft, is overheat detection. This feature monitors the heat of the dispenser as flares are ejected. If it detects an overheating condition, it causes the system to automatically eject all remaining flares. Chaff and flare quantities are displayed on the aircraft's cockpit chaff/flare panel displays or its MFD depending on how the aircraft is designed. Each system has some type of safety device found in the form of a safety pin installed in an electromagnetic interference (EMI) filter—a door activated micro switch, a safety plate, or handle. Whatever the type of safety device, the important thing to remember is they all are used to isolate or SAFE an aircraft's chaff/flare system critical circuits.

Two basic modes of operation are normally available with all chaff and flare systems: manual and automatic. The manual mode of operation is operated by aircrew personnel and provides for single or multiple chaff and flare dispensing as the need arises. The automatic mode of operation normally provides for the same type of release. However, in this mode of operation, the time intervals between release pulses and actual payload releases are initiated by preprogrammed sequences or by the aircraft's defective computer system. One variation of the automatic mode is demonstrated by the systems in use on the B–1B and the F–22. In the automatic mode, the aircraft system can automatically determine what countermeasures to dispense, in what pattern, and how frequently in regards to what type of threat is detected by the aircraft's defensive radar system. The automatic mode may always be overridden by the manual mode should the aircrew determine it a necessity.

A chaff and flare system is normally armed by positioning the appropriate system controls. Power, in the form of a dispense command signal, is routed to the programmer or aircraft's controlling computer system. These items process the signals and then sends them to the safety device (EMI filter, safety handle, door controlled micro switch, etc.). If these items are activated, power is contained at this point in the system. If not, power flows through the safety device to some type of firing sequencing device. The sequencing device routes the power to a particular contact pin in the dispenser breech plate. Here, power flows to the cartridge squib, making contact with the contact pin.

The squib fires the cartridge and chaff or flares are dispersed. When all the cartridges are fired, the sequencing device sends an empty signal back to the controlling system and kills power to the chaff/flare system.

421. Subsystem maintenance

Systems used to release or monitor weapons delivery are critical to accomplishing the mission. A system is tested periodically or after maintenance to make sure the system functions when the mission calls for it.

Operational/functional testing

Operational tests or checks are detailed procedures used to functionally verify the reliability and safety of an aircraft's weapons release systems. The procedures for these tasks are found in various aircraft TOs, job guides, or system TOs.

Operational checks are normally performed on a regular basis. According to the applicable aircraft –6 inspections requirements TO, these checks are performed on a 30- or 60-day basis. These time constraints may be changed by the local commander, if necessary, for local operating conditions. Under such conditions, usually time is decreased between checks and almost never increased. Operational checks are also required when the release system or any component of the system has malfunctioned, is repaired or replaced, or has been modified.

Functional checks are performed in conjunction with a loading operation and are completed after the aircraft preparation or safe-for-maintenance procedures. These checks are essential in determining the operational status of an armament system's electrically controlled circuit before loading or reconfiguring an aircraft.

All of the subsystems we addressed in the previous section may be operationally or functionally checked for the following parameters: release capability, stray voltage or current, jettison capability, and insulation resistance.

Test equipment usage

Now that we know the parameters checked in operational and functional checks, we need to know something about the equipment used to test these parameters. The test equipment used can range from a complete weapons release system tester or simulator to a multimeter. The particular test being performed and aircraft being worked on are the driving factors for the type or piece of equipment needed to perform these checks. Commonality between the various armament systems test equipment is limited to the fact that they check the same parameters. For the most part, each aircraft has its own test equipment, and very seldom is it interchangeable among different aircraft. Let's briefly look at some of the more common types of test sets.

Stray voltage adapters

Stray voltage adapters range in design from analog units to units with digital readouts. They both must be used in conjunction with a multimeter. A shunt adapter is used in conjunction with the 8025 multimeter to perform stray voltage tests. Some voltage adapters may be manufactured locally.

Armament circuit test

All of our aircraft have an armament circuit test set or comparable test set. This unit is a flight line test set. The armament circuit test set performs system confidence tests at ejector rack breeches, pylon disconnects, and pylon weapons disconnects. Also, depending on the model, it may test for nose and tail arming voltages, stray voltage, and eject and jettison voltage. It normally contains a variety of items such as adapter cables, voltage detector shorting devices, circuit selectors, and plug assemblies, as shown in figure 2–56. All of the accessories provided with this unit normally have a self-test capability if used in conjunction with the voltage detector. The voltage detector is an important part of the tester. It is a solid-state device used to test for all types of voltages (stray, release, jettison, and so forth). Its indicators and controls are located on the front panel. Some display results in digital form (fig. 2–56) or by a light type indicator (fig. 2–55).

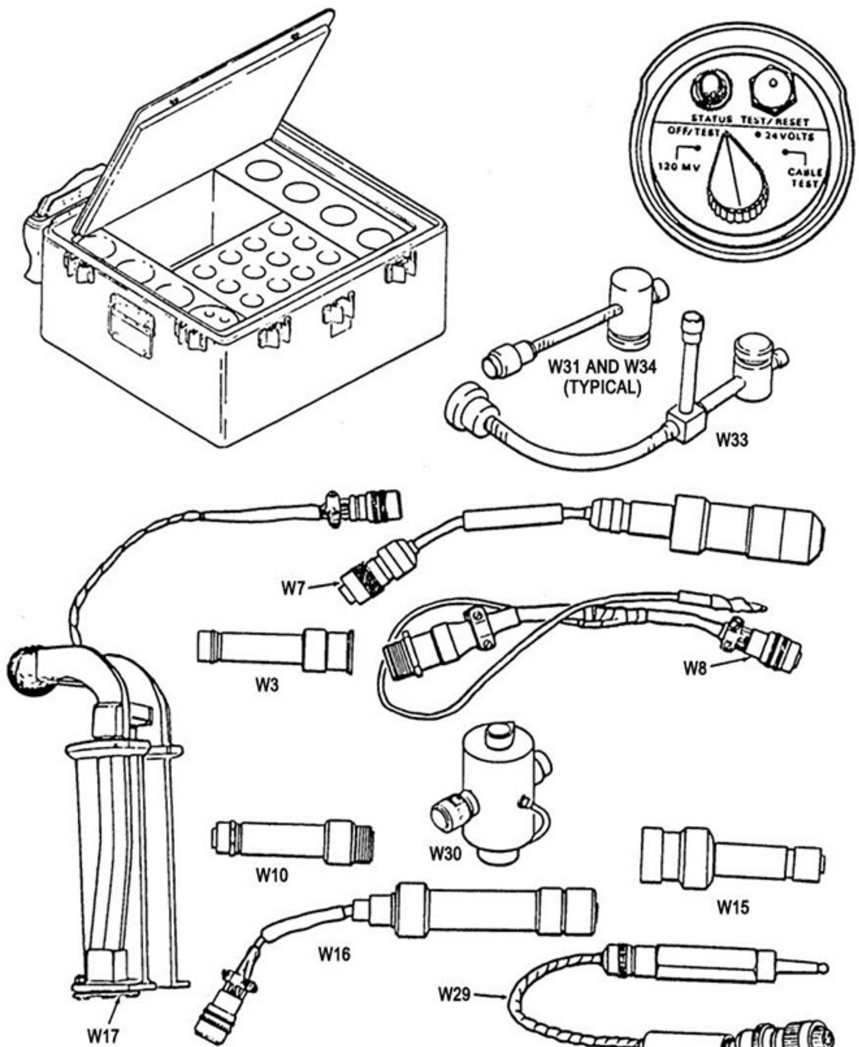


Figure 2–55. Armament circuit test sets and components (typical).

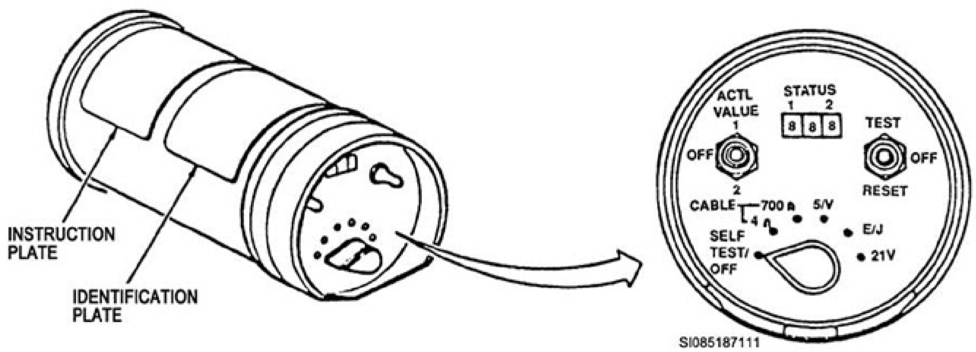


Figure 2–56. Voltage detectors (typical).

Missile system test sets

These types of testers are basically used to check voltage tolerances of the standby and firing power supplied to the AIM–9 missile (fig. 2–57). They also check missile firing sequences for correctness and firing circuits for safety.

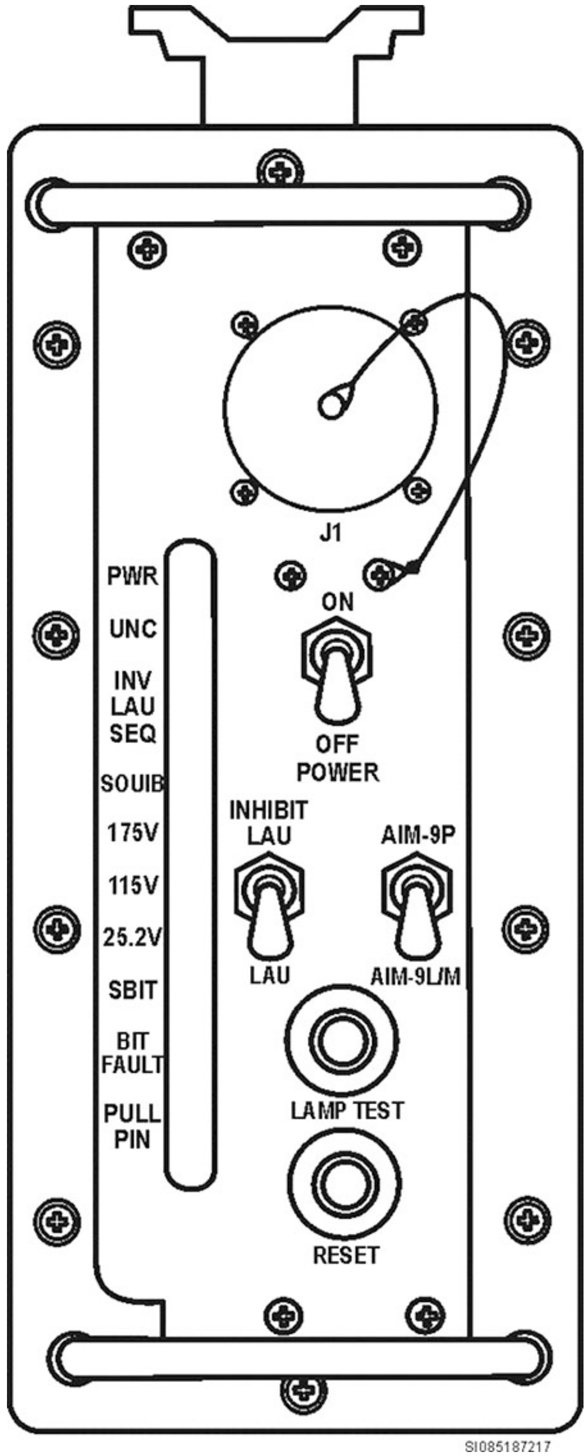


Figure 2–57. Missile systems test sets (typical).

Nuclear system testers

The nuclear system tester tests a multitude of items within an aircraft's nuclear weapon system. Some of the more common items are AMAC signals, lamps on nuclear control panels, aircraft indicators, normal release circuits, jettison circuits, and emergency release circuits.

The overall purpose of these units is to check the aircraft wiring to make sure it is an electrically reliable nuclear weapon release system. These test sets test the control and monitor group system (DCU panels) for insulation resistance (IR) and circuit continuity; they also detect faulty circuits. The nature of the fault is also displayed by the tester.

Fault isolation/troubleshooting

When a problem arises with a system, you normally end up spending a major part of your aircraft maintenance time troubleshooting for faults. In this realm of expertise, experience is a great teacher and probably the best you can have. However, regardless of your expertise, you will not be the best troubleshooter unless you know the system you are working on. You must be thoroughly familiar with the traditional and logical steps performed for every malfunction detected, isolated, and repaired. There are really three phases to troubleshooting: (1) recognizing the problem, (2) analysis, and (3) repair (fig. 2–58). The first and last phases of the process are the easiest to work through. Phase two, analysis, is the toughest area.

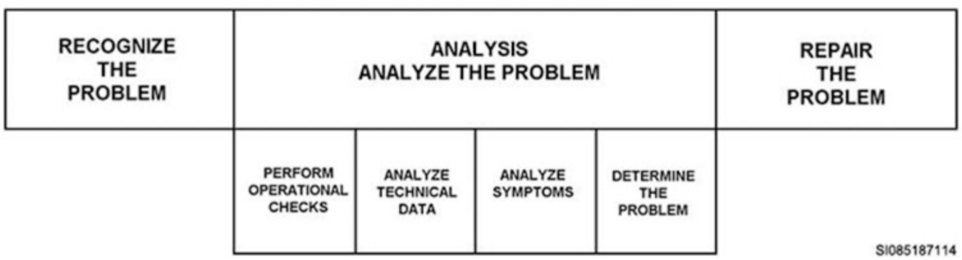


Figure 2–58. Troubleshooting phases.

Phase one, recognize the problem, consists of checking aircraft forms, talking to aircrew personnel, and so forth. Use all the resources available to you to understand the problem. Understanding the exact problem eliminates troubleshooting the wrong problem, can not duplicate (CND), and gives you a point to start your fault isolation process.

Normally you begin fault isolation procedures by first determining whether you have a mechanical or electrical problem, or a combination of the two. Usually making a physical check of the system lets you make this determination. Most times, if the problem is mechanical, you can fix it right away. Electrical problems require you to check for the obvious first, such as loose cannon plugs, corrosion, cut wires, and so forth. At any rate, whether you determine the problem is mechanical or electrical, you must perform an operational check. For instance, if a gun system is jammed and the gun jam is cleared, it would still require an operational check to ensure reliability. A good general rule to follow at this point is not to assume you have successfully solved all existing problems just because you located and corrected one problem. An operational check of the system reveals if there are any further troubles. When you perform an operational check, you must look for clues to tell you how the system is operating. There are always indications to give definite clues where the trouble may be.

When troubleshooting, you must use all available resources to solve the problem. These resources include specific data on the systems (found in TOs), personal experiences of fellow workers, assistance from other work centers, and sometimes even factory representative assistance. The analysis of technical data for a system, subsystem, or component provides you with an explanation of the theory of operation. It also provides you with block diagrams, wiring diagrams, locations of test points, and the readings (voltage and resistance) that should be present during a check. Troubleshooting analysis charts and minimum performance checks are also found in the TO. Block diagrams show the mechanical and electrical interrelationships between various units of the systems. You must become thoroughly familiar with these items in order to properly apply troubleshooting principles. Troubleshooting analysis charts in the TOs cover the malfunctions expected to occur over and over again in a particular system.

In addition to the common troubles shown in the TO troubleshooting charts, you will find many troubles peculiar to the specific system you are working. Troubleshooting procedures are provided only as a guide to the possible remedies of a peculiar malfunction. Knowing the conditions at the time of the malfunction and your past experience with the system may dictate troubleshooting in a direction other than indicated in the guides. In the process of troubleshooting, it is sometimes difficult to locate components. The illustrated parts breakdown of the system can provide you with a pictorial view of all the units.

You must be able to recognize symptoms of troubles (detected through routine checks or as reported). Failure to do so may cause you to lose many man-hours. Without close observation of equipment, you may overlook the first indication of a problem. Be aware of the indicators and research your equipment records so you will know the history of system failures. This allows you to correct discrepancies before they turn into major problems.

Troubleshooting is a process of elimination, and every malfunction requires a thorough analysis as a part of troubleshooting procedures. Once you have completed all the analyses we’ve talked about, you should be able to define the problem with the system you are checking. To effectively perform trouble detection and fault isolation, you must understand equipment performance standards, know how the equipment is operating, and be able to recognize symptoms. Trial and error maintenance must be avoided at all costs.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

420. Subsystems operation

1. What are two types of bombing systems used in our aircraft?

2. What are the three types of releases incorporated into all aircraft bombing systems?

3. How is manual release equal to a single selected weapons release?

4. What is produced by a manual input to the bombing system during manual-computed weapons release?

5. In what type of release will the proper weapons release time be calculated using predetermined parameters?

6. What are the two basic modes of operation in missile systems?

7. Which three aircraft presently have no A/A capabilities?

8. Refer to figure 2–50. What stations of the A–10 aircraft are capable of A/A missile system operation?

9. How are AIM–120 and AIM–9 missiles fired?

10. What happens to nonselected aircraft missile system stations during missile release?

11. What supplies the pilot with a missile lock-on indication when the AIM–9 missile is selected for firing?

12. What does the aircraft missile system monitor during initial AIM–9 initiation?

13. Through what launcher component is voltage supplied to ignite the missile gas grain generator?

14. What launcher component pulls the umbilical block and cable inside the launcher nose fairing during missile launch?

15. What happens during firing sequence of the AIM–120 if the launcher umbilical does not retract?

16. State the two routes of power flow during A/G missile release after it flows through the electronic units.

17. What are the two basic modes of operation in aircraft jettison systems?

18. What additional function is included in jettison systems for aircraft using internal bombing systems?

19. During selective jettison, what circuits are normally disabled?

20. What range of time delays are normally found in aircraft selective jettison circuits?

21. What type of operation can emergency jettison be equated to?

22. What is the normal condition of aircraft emergency jettison circuits?

23. What three aircraft presently have pylon jettison capabilities?

24. What is the purpose of an EMI safety pin (device)?

25. What are the two modes of operation normally available with a chaff/flare system?

421. Subsystem maintenance

1. What is the purpose of an operational/functional test?

2. When are functional checks normally performed and completed?

3. What system parameters are checked during operational/functional testing?

4. What is the purpose of an armament circuit test set?

5. What common items of an aircraft's system are checked by nuclear system testers?

6. Name the three phases of troubleshooting.

7. How do you normally begin fault isolation procedures?

8. What available resources should you use during troubleshooting procedures?

Answers to Self-Test Questions

408

1. Aircraft power panels.
2. Main armament control panel.
3. Main armament control panel.
4. They provide a circuit that bypasses the need for the landing gear to be in the UP position before the armament system is able to receive power.
5. Emergency jettison control panels and the special weapons control panels.
6. (1) Selection.
   (2) Monitoring.
   (3) Prearming.
   (4) Enabling.
   (5) Arming.
   (6) Disenabling.
   (7) Safing.
   (8) Release.

409

1. They display information about the status of the aircraft's weapons system and the munitions that are installed on the aircraft.
2. The armament release switch.
3. Controls that select the different modes of operation for guns, missiles, or chaff and flare dispensing.
4. The B–52, B–1, B–2, and the AC–130 aircraft.

410

1. The B–52.
2. Weapons selection, arming, and release.
3. Analog type systems.
4. Electrical power to the aircraft must remain energized and the MASTER ARM switch must not be switched OFF.
5. Stores identification, inventory and status, weapons activation and control, weapons release, launch, stores jettison, stores sequencing and weapons delivery rates, verification of stores and weapons, and armament system integrity.
6. The main computer or computers.
7. RIUs, SLUs, and MIUs.
8. Hybrid-type systems.
9. This system uses a combination of black boxes to perform all of the functions of a main control unit.

411

1. Controls and displays.
2. They control the sequencing of weapons release when more than one station is selected for weapons delivery.
3. BIT check type systems.
4. Everything from voltage levels to the condition of certain devices.
5. To prevent accidental or unauthorized prearming of nuclear weapons and, if necessary, accommodate their delivery.
6. Weapon and station selection and release activation.

412

1. B–11 bomb shackle.
2. The bomb shackle's stirrup rods are attached to the hooks on the cluster rack assembly.
3. An electrically operated release unit.
4. They are used to force a store installed on the bomb rack away from the aircraft.
5. To help cut down the amount of carbon entering the gas system components.
6. Arming solenoids.
7. Automatic and manual.

413

1. Three.
2. The A–6 release unit and B–11 bomb shackle.
3. By electrical actuation of the A–6 release unit.
4. Three.
5. A cartridge-powered actuator.
6. It provides a means to lock all of the ejector racks to prevent inadvertent release of stores during ground handling.
7. It can carry larger diameter munitions and it incorporates MIL–STD–1760 LRUs.
8. The aft pivot assembly.
9. Nine.

414

1. To carry, monitor, control, and launch various types of nuclear and conventional missiles and bombs.
2. All are electrically controlled and work in conjunction with the hydraulic subsystem or in various mechanical components to provide rotation.
3. BRU–44B/A bomb rack.

415

1. They are used to increase the number of munitions that can be carried externally on almost all of our aircraft.
2. Three.
3. The stepper switch.
4. Sway brace adapter, a short piston, tension spring, and yoke adapter.
5. Two BRU–46 bomb racks.
6. To properly retain and route the cable harnesses to each individual munition.
7. The GBU–39 small diameter bomb.
8. The pitch valves.

416

1. They provide the interconnecting electrical wiring and mounting points for bomb racks, various other subracks, and suspension equipment.
2. One that may be installed at any wing position or station.
3. (1) Both wing inboard and outboard.
   (2) Aircraft centerline.
   (3) Sometimes fuselage positions.

417

1. (1) Gas operated.
   (2) Pneudraulically operated.
   (3) Rail launchers.

2. The AIM–120.
3. Inside the fuselage structure of the F–15 A/B/C/D or as optional equipment on the conformal fuel tank stations of the F–15E.
4. (1) Ejection components.
   (2) Gas tube system.
   (3) Linkage mechanisms.
   (4) Structure assembly.
   (5) Electrical components.
5. Latching and unlatching.
6. Latching.
7. Electrically and mechanically.
8. Operate hooks manually and by firing impulse cartridges.
9. When the missile is pushed away from the aircraft.
10. LAU–142/A.
11. It uses a ground safety lever located on the right side of the lower assembly.
12. Single, dual, or triple rail or track design.
13. It provides an attach point for the rail or track assemblies and houses the various components of the launchers.
14. Bolting and suspended by suspension lugs.
15. (1) They act as an aft support for the missile.
    (2) They guide the missile at initial launch.
16. A shear pin.
17. At the forward hook locations.

418

1. Seven.
2. Detents.
3. A shorting pin.
4. Rockets fire continuously at predetermined intervals between each release pulse received by the launchers.

419

1. Six BDU–33 practice bombs.
2. ARD 863–1 impulse cartridges.
3. Torqued and pinned.
4. Eight.

420

1. Internal and external.
2. (1) Manual.
   (2) Manual-computed.
   (3) Automatic (computed).
3. Manual release allows the release of one bomb from one station.
4. Manual input (depression of the weapons release switch) allows computed release pulses to be distributed to the various selected aircraft bombing system weapons stations.
5. Automatic or computed.
6. Air-to-air and air-to-ground.
7. B–1, B–2, and B–52.
8. Stations 1 and 11.

9. Individually.
10. They are automatically passed over during the firing sequence.
11. An audio signal or missile tone.
12. The status of all selected stations, the missile seeker, and cool status.
13. The launcher power supply.
14. The launcher retract hook.
15. The missile will not complete the launch cycle or fire the rocket motor.
16. It may be routed directly into the cartridges of a bomb rack for ejection and into the missile to accommodate missile arming and motor firing, or straight into the missile for arming and firing.
17. Selective and emergency jettison.
18. A method for electronically controlling the opening of the bomb bay doors.
19. The mechanical fuzing circuits.
20. Anywhere from 250 milliseconds to 1.1 seconds.
21. An override mode of operation.
22. HOT (active).
23. The B–52, F–15, and F–22 aircraft.
24. It isolates or safes an aircraft's chaff/flare system critical circuits.
25. Manual and automatic.

421

1. They are detailed procedures used to functionally verify the reliability and safety of an aircraft's weapons release system.
2. In conjunction with a loading operation; they are completed after the aircraft safe-for-maintenance procedures.
3. Release capability, stray voltage or current, jettison capability, circuit continuity, and insulation resistance.
4. To perform system confidence tests at ejector rack breeches; pylon disconnects; pylon weapons disconnects; and, depending on the model, nose and tail arming voltages, stray voltage, and eject and jettison voltage.
5. AMAC signals, lamps or nuclear control panels, aircraft indicators, normal release circuits, jettison circuits, and emergency release circuits.
6. (1) Recognizing the problem.
   (2) Analysis.
   (3) Repair.
7. By determining the type of problem, either mechanical or electrical, or a combination of the two.
8. Specific data on systems, personal experiences of fellow workers, assistance from other work centers, and possibly factory representative assistance.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

15. (408) Which cockpit panel allows electrical power to be distributed throughout the entire aircraft electrical system?
   a. Aircraft power panel.
   b. Main armament control panel.
   c. Emergency jettison control panel.
   d. Ground operations power override panel.

16. (408) The energizing and de-energizing of bomb rack solenoids at selected weapons stations normally is performed through the
   a. special weapons control panels.
   b. main armament control panels.
   c. subsystem control panels.
   d. jettison control panels.

17. (408) What panel works in conjunction with the special weapons control panels to facilitate all of the functions needed to release a special weapon?
   a. Missile control panel.
   b. Subsystem control panel.
   c. Visual display control panel.
   d. Main armament control panel.

18. (409) What display or panel contains lights to advise you or the pilot of the status of all aircraft systems?
   a. Heads-up display.
   b. Master caution light panel.
   c. Audio/communication control panels.
   d. Joint helmet mounted display system.

19. (409) Which aircraft use integrated keyboards to select information for display on the video displays?
   a. B–52, F–15E, B–1B, and AC–130.
   b. B–52, B–1B, B–2, and AC–130.
   c. F–22, AC–130, B–52, and B–1B.
   d. AC–130, F–22, and B–52.

20. (410) Basic system functions contained in the analog stores management system are arming,
   a. release, and weapons selection.
   b. release, and aircraft stores inventory.
   c. weapons selection, and computed weapons release.
   d. weapons selection, and release priority sequencing.

21. (410) How would you *best* describe the typical analog system?
   a. Wireless.
   b. Hardwired.
   c. Multiplexed.
   d. Software controlled.

22. (410) What component of an analog system is responsible for distributing power to the aircraft's main armament circuit breaker panel?
    a. Master arm relay box.
    b. Armament bus relay.
    c. Master arm switch.
    d. Primary bus.

23. (410) In digital stores management systems, what component acts as a multiplex terminal for signals being sent to or coming from weapons stations?
    a. A transfer unit.
    b. An interface unit.
    c. A microprocessor.
    d. An electromechanical relay box.

24. (410) The functions of a digital stores management system are initiated by the
    a. operator.
    b. interface unit.
    c. main computer.
    d. back up computer.

25. (410) Which aircraft employs all three stores management systems (SMS)?
    a. B–1B.
    b. B–52.
    c. A–10.
    d. F–15.

26. (411) In a fault isolation system using built-in-test (BIT) checks, the results of the test should narrow a fault down to a
    a. subsystem or system.
    b. circuit card or component.
    c. subsystem or line replaceable unit.
    d. circuit card or line replaceable unit.

27. (411) Radar navigation systems associated with the weapons systems normally facilitate the computerized release of onboard
    a. rockets.
    b. missiles.
    c. nuclear bombs.
    d. conventional bombs.

28. (412) Which mechanical bomb rack is the *only* one presently in use?
    a. B–11.
    b. MB–3A.
    c. BRU–44.
    d. MAU–12.

29. (412) During release, what component of the B–11 bomb shackle caught by the arming wire?
    a. Arming hook.
    b. Retention lever.
    c. Arming solenoid.
    d. A–6 release unit.

30. (412) Which gas-operated bomb racks are nuclear capable?
    a. MAU–12, BRU–44, and BRU–47.
    b. MAU–12, BRU–56, and BRU–61.
    c. MAU–40, MAU–50, and BRU–47.
    d. MAU–40, BRU–46, and BRU–47.

31. (412) How many arming solenoids are *normally* found on gas-operated bomb racks?
    a. One.
    b. Two.
    c. Three.
    d. Four.

32. (412) Nuclear capable bomb racks are equipped with
    a. an in-flight safety lock.
    b. center arming solenoids only.
    c. umbilical connectors for the installed weapon.
    d. separate electrical and mechanical safety pins.

33. (413) What permits the release units used on cluster bomb racks to be released manually?
    a. Trip screw.
    b. Trip lever.
    c. Release lever.
    d. Release knob.

34. (413) The conventional bomb module may be installed in which B–1B weapons bay?
    a. Forward and aft only.
    b. Aft and intermediate only.
    c. Forward and intermediate only.
    d. Forward, aft, and intermediate.

35. (413) Rotating of the bomb module swing arms is enabled by
    a. electrical actuators.
    b. hydraulic actuators.
    c. pneumatic actuators.
    d. cartridge-powered actuators.

36. (413) How many MK–82 500-pound bombs can be carried by the bomb rack assembly?
    a. 8.
    b. 10.
    c. 20.
    d. 28.

37. (414) Which rotary launcher is used in the B–52?
    a. 180 in rotary launcher.
    b. Rotary launcher assembly.
    c. Multipurpose rotary launcher.
    d. Common strategic rotary launcher (CSRL).

38. (414) The multipurpose rotary launcher is controlled
    a. pneumatically.
    b. mechanically.
    c. hydraulically.
    d. electrically.

39. (414) During ground rotation of the multipurpose rotary launcher rotation, speed is
    a. $^{1}/_{8}$ normal rotation speed.
    b. $^{1}/_{4}$ normal rotation speed.
    c. $^{1}/_{2}$ normal rotation speed.
    d. the same as normal rotation speed.

40. (415) When power is initially applied, a loaded triple ejector rack (TER) will step to the
    a. last station of the unit.
    b. first station of the unit.
    c. last loaded station position of the unit.
    d. first loaded station position of the unit.

41. (415) When BDU–33s are carried on a triple ejector rack (TER), to provide alignment of the bomb, you *must* install a
    a. short piston.
    b. yoke adapter.
    c. tension spring.
    d. set of rear sway braces.

42. (415) The BRU–57 bomb rack is electrically connected to the aircraft by a
    a. MIL-STD–1760 cable.
    b. station wiring harness.
    c. station interconnect harness.
    d. station interconnect wiring harness.

43. (415) Which munition is the BRU–61/A bomb rack capable of carrying?
    a. BDU–33.
    b. GBU–39.
    c. CBU 87/89.
    d. Any munition or dispenser with 14 inch lug spacing.

44. (415) How many munitions is the BRU–61/A bomb rack capable of carrying?
    a. Two.
    b. Three.
    c. Four.
    d. Six.

45. (415) How are the pitch valves set on a BRU–61/A bomb rack?
    a. Manually.
    b. Electrically.
    c. Hydraulically.
    d. Pneumatically.

46. (416) What does the aft pivot point provide on a jettisonable pylon?
    a. Initial nose-up pitch.
    b. Initial nose-down pitch.
    c. Fuel system connection.
    d. Quick disconnect capability.

47. (417) Which operating mode of a LAU–106 is *always* a manual process?
    a. Ejection.
    b. Jettison.
    c. Latching.
    d. Unlatching.

48. (417) What launcher is the *only* pneudraulically operated missile launcher?
   a. LAU–88.
   b. LAU–106.
   c. LAU–117.
   d. LAU–142.

49. (417) What system is the *only* missile system supported by the LAU–142 missile launcher?
   a. AIM–9.
   b. AIM–120.
   c. AGM–65.
   d. AGM–129.

50. (417) Normally, what do you use to anodize and coat launcher rail surfaces?
   a. Spray paint.
   b. Silicone spray oil.
   c. VVL–800 (dry lube).
   d. Molybdenum disulfide (dry lube).

51. (417) On the LAU–88 missile launcher, what component keeps the shear pin from backing out during flight?
   a. Lock nut.
   b. Spring pin.
   c. Cotter pin.
   d. Lock washer.

52. (417) On AIM–9 and AIM–120 capable rail launchers, what component prevents the missile from leaving the rail if the rocket motor fires inadvertently?
   a. Dampners.
   b. An in-flight lock (IFL).
   c. Detent spring pressure.
   d. Electrically operated snubbers.

53. (417) What missile launcher is the *only* rail launcher that automatically engages the missile umbilical during loading?
   a. LAU–88.
   b. LAU–117.
   c. LAU–118.
   d. Modified M299.

54. (417) Built-in-test (BIT) units in rail launchers automatically check for
   a. proper ampere inputs to launcher control units.
   b. ground circuits in the launcher and electrical units.
   c. proper voltage tolerances in the launcher electrical units.
   d. proper resistance tolerances in the launcher electrical units.

55. (418) What number is the rocket capacity of the LAU–131 rocket launcher?
   a. 5.
   b. 7.
   c. 13.
   d. 19.

56. (418) What mechanism within the LAU–131's tubes restrains the rockets against normal flying loads?
    a. Detents.
    b. Snubbers.
    c. In-flight locks.
    d. Rocket retainer assemblies.

57. (418) How is the LAU–131 rocket pod safed?
    a. Electrically with a shorting pin.
    b. Electrically with a safing clutch.
    c. Mechanically with a safing cover.
    d. The pod has no safing mechanism.

58. (419) How many flares are contained in the SUU–25 flare dispenser?
    a. 4.
    b. 6.
    c. 8.
    d. 12.

59. (420) What aircraft-generated computer signal allows the AIM–120 missile to begin its launch cycle?
    a. Umbilical retract.
    b. Infrared lock-on.
    c. Release consent.
    d. Radar lock-on.

60. (420) What armament system circuits are normally disabled during selective jettison?
    a. Mechanical fuzing.
    b. Armament buss.
    c. Electrical fuzing.
    d. Essential buss.

61. (420) Which aircraft *does not* have pylon jettisoning capability?
    a. B–52.
    b. F–15.
    c. F–16.
    d. F–22.

62. (421) How often are operational and functional checks *normally* done?
    a. 15 or 30 days.
    b. 30 or 60 days.
    c. 60 or 90 days.
    d. 90 or 120 days.

63. (421) Who has the authority to change time constraints of operational/functional checks?
    a. Flight chief.
    b. Division chief.
    c. Shop supervisor.
    d. Local commander.

Please read the unit menu for unit 3 and continue ➔

Student Notes

Unit 3. Aircraft Guns and Gun Systems

THE AIR FORCE REQUIRES flexible, cost-effective weapons capable of high-sortie rates and maximum kills per sortie. It also requires maintenance on its aircraft weapons systems. One of these weapon systems is the aircraft gun system. As an aircraft armament systems specialist, you are required to perform all aircraft gun systems maintenance. You must have a thorough knowledge of the guns and the maintenance you perform on them.

In this unit, we discuss the various guns and their theories and specifics of their operation, the different types of internal and external gun systems, and the maintenance you must perform on these systems.

3–1. Automatic Gun Theory

It is critical for you to understand not only the specifics of gun systems but also the history and theory behind the operation of the equipment that you will be working with. The Air Force implements two distinct theories of automatic gun systems in aircraft applications: multiple-barrel rotary and the single-barrel automatic. This section will provide you a better understanding on the basics of how gun systems actually work.

422. Multi-barrel rotary gun systems

Very early gun systems suffered from a low firing rate because of the inability of the operator to rapidly reload fired barrels. The primary firearms of the day were single-shot, breech-loading rifles. The operator would open the rear of the barrel (the breech) and place a single round into it, close it, fire, and then re-open the breech to recover the expended casing. This manual process, while an improvement over the old black powder designs, was still very slow. Two systems were already developed to partially overcome this limitation—the revolving cylinder guns and the multi-barrel guns.

The first kind was the revolving cylinder that you may be familiar with from the small revolver pistols. This system uses multiple chambers preloaded by the operator for firing as or when needed.

The advantage of the system was that with all of the breeches preloaded, the operator could fire multiple shots without reloading. The system was also compact because you only needed to have a single barrel to fire all of the rounds contained in the cylinder. The disadvantage was that it took a considerable amount of time and effort to reload the cylinders after firing was complete.

The second type of system used was the French Mitrailleuse (fig. 3–1). In this system, a large number of barrels (anywhere from 5 to 37 depending on the model) were arranged on a gun carriage with each barrel having its own breech and trigger mechanism locked into place to the rear. This configuration arranged a large number of single-shot-type rifles into a single unit that the gunner could point at the enemy and fire as needed. The disadvantages of this system included the fact that the guns weighed up to 2,000 pounds and required a significant amount of time to reload after firing.

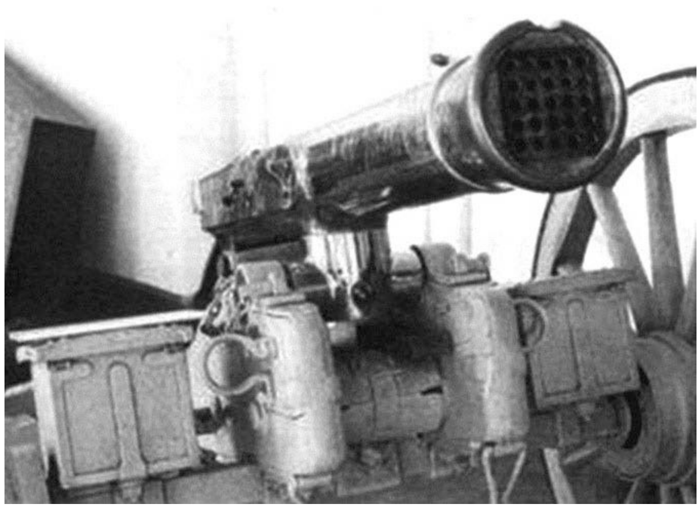


Figure 3–1. Mitrailleuese.

To overcome the limitations of those early gun designs, Dr. Richard Gatling (fig. 3–2) developed the multi-barrel rotary gun system in 1861.

Figure 3–2. Dr. Richard Gatling.

Dr. Gatling's primary innovation was a rotary gun in which the cylinder equipped with individual barrels rotated around a central point. This system allowed the rotation action of the revolving cylinder to be linked with a feeding system for barrels not in a firing position. This divided the gun into five basic components:

Component	Description
Housing	Serves as a mount for the entire gun, this component does not move during operation. It provides a mount for the rotor to turn inside and also contains an oval track machined onto its inner surface that the breech bolts ride in, forcing them to move fore and aft as the rotor turns.
Rotor	The rotating inner rotor serves as a mount for the barrels and has tracks mounted on it for the bolts. These tracks allow the bolts to move forward and aft to follow the track machined into the housing, but keep the bolts aligned with the barrel in which their rounds fire.
Breech bolts	Breech bolts travel fore and aft along the tracks on the rotor to transport rounds into and spent cases out of the barrel's breeches. They also contain the firing pins for firing the rounds.
Barrels	The barrels are mounted to the rotor assembly. They contain a breech for containing gas pressure when the round is fired.
Power source	Provides rotational force to the rotor. It can take many different forms from a hand crank to an electric or hydraulic motor.

As a rotary system is turned, tracks on the inside of the outer housing cause the breech bolts to travel forward and back on the track located on the rotor. As the bolts travel forward and backward along this track, they can perform all of the required actions to load, fire rounds, and then extract the expended brass.

The rotary based system's use of the rotational force applied to the rotor allows for a much higher rate of fire over either revolver-based or non-rotating-based multi-barrel systems as all steps of the firing cycle take place simultaneously. While one bolt is picking up a round, another is forcing its round into a breech, another is firing a round, and yet another is extracting an expended brass, all depending on the bolt's position on the track in the housing.

Another advantage of rotary based guns is the fact that the rate of fire is divided over the number of barrels in the system. While a six barreled system may be firing 6,000 rounds a minute, each barrel is firing at only 1/6 the rate or 1,000 rounds per minute. The advanatage of this is that each barrel does not heat up as much as a single-barrel firing at a faster rate. This buildup of heat causes two distinct problems—excessive wear and warping. First, as the barrels get hot, the metal becomes softer and subject to greater wear as they fire rounds. Second, as the barrels get hot, they expand in unpredictable ways causing them to bend ever-so slightly; this causes a more erratic pattern of rounds at the impact point.

While rotary based systems found initial popularity in the militaries of many countries, they fell into disuse because of their high cost and the complexity of the systems involved. This caused aircraft designers to use multiple single-barrel recoil and gas-operated designs starting in World War 1 (WWI) through Korea as these systems were capable of engaging the aircraft of the day at a far lower cost. Rotary based systems use, however, was to be reintroduced as the jet age arrived. In the 1960s, aircraft became *much* faster and capable of literally flying between the bullets of the single-barreled guns due to their low rate of fire rendering them ineffective in the air-to-air role. Using Gatling's concepts and modern materials and processes, engineers were able to construct rotary guns capable of firing up to 6,000 rounds per minute with ammunition handling systems containing from hundreds to thousands of rounds to feed them through sustained fire. This high sustained rate of fire allowed gun systems to effectively engage air-to-air targets successfully even if they were traveling at high speeds.

423. Single-barrel automatic guns

While the guns using Dr. Gatling's principles are effective weapons, they are not the right tool for every job. Their advantage of high-firing rate must be balanced against their size, complexity, and their need for massive ammunition handling systems to keep them supplied with rounds for sustained firing at high rates of fire. The Air Force uses a second type of gun where the needs for lower firing rate and a simpler construction are needed—the single-barrel automatic gun.

The single-barrel repeating automatic guns use a single barrel and bolt design, where all of the steps of the firing cycle happen sequentially during the fore and aft movement of the single bolt assembly. These systems are generally of a much simpler and compact design that requires significantly less maintenance and room in the airframe.

The travel of the bolt is carried out by one of two methods. The first involves recoil force applied to the bolt during the firing of the round. As the round fires, the powder rapidly burns and applies pressure not only to the round to push it down the barrel but it also exerts a significant amount of force to the face of the bolt. Recoil-operated guns use this force to move the bolt backwards. This rearward motion of the bolt extracts the expended brass from the breech, ejecting it from the housing of the gun, and compresses springs located in the rear of the gun. When the spring is fully compressed, it expands driving the bolt forward stripping a round off of the feeding belt and forcing it into the breech to begin the cycle over again.

The second method of operating the bolt in the single-barrel systems is the gas-operated method. In this system, after the round fires, the expanding gasses from the cartridge push against the locked bolt at the end of the breech and against the projectile. Since the bolt is locked into the breech, this pressure forces the round down the barrel. When the round reaches a particular point in the barrel, it allows gas pressure to be vented into a hole machined into the barrel itself. This pressure is routed to an expansion chamber positioned directly under the hole in the barrel. The chamber contains a piston that is driven by the high-pressure gas. Connected to the back of the piston is an operating rod that travels back down along the outside of the barrel to the bolt assembly. The force transferred by the rod from the piston unlocks the bolt from the breech and drives the bolt backwards removing the expended brass from the breech, ejecting it from the weapon, and compressing a spring. The energy stored in that spring will be released by the trigger mechanism sending the bolt forward to strip a round off of the feed belt and driving it into the breech to begin the cycle over again.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

422. Multi-barrel rotary gun systems

1. When and why did Dr. Gatling develop his theories?

2. What component of a Gatling gun serves as the mount for the entire gun?

3. What is the advantage of dividing the total rate of fire between multiple barrels?

423. Single-barrel automatic guns

1. What are the two methods of operation of single-barrel automatic guns?

2. In recoil-operated guns, what forces the bolt back forward after firing?

3. In gas-operated guns what component transfers power from the piston back to the bolt?

3–2. Multi-Barrel Rotary Aircraft Gun Systems

At present, we have four different types of multi-barrel rotary guns installed on aircraft to load, unload, and maintain. They range in sizes from 7.62 mm to 30 mm. They are installed in tactical fighter aircraft, helicopters, and the AC–130 gunship. These guns are used for everything from close air support of ground troops to aerial dogfights. In our lessons, we will move from our smallest caliber rotary gun, the GAU–2, to our largest, the GAU–8.

424. GAU–2 automatic gun

The GAU–2 is an air-cooled, 7.62 mm, electrically driven, automatic multi-barrel gun (fig. 3–3). The weapon has six barrels and six bolt assemblies, which revolve around the longitudinal axis of the rotor. The minigun is capable of firing rates of 2,000 rounds per minute (rpm) low rate and 4,000 spm high rate. It is used primarily as a hand-operated gun mounted on helicopters.

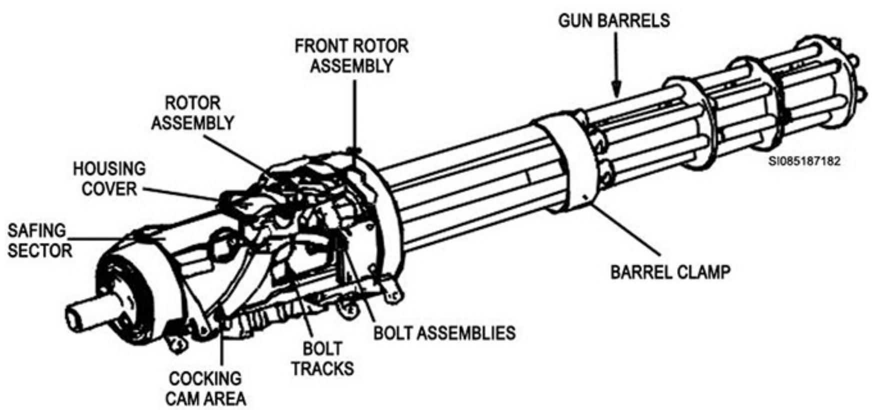


Figure 3–3. GAU–2.

The following table lists the specifications of the GAU–2:

Caliber	7.62 mm
Rate-of-Fire	2,000 rpm (low)/4,000 rpm (high)
Effective Range	1500 meters
Muzzle Velocity	2750 ±30 ft/sec
Drive	Gear (external electric gun drive)
Rotation	Counterclockwise as viewed from breech
Length	29.5 inches
Weight	35 pounds
Number of Barrels	6

Feeding cycle

The feeding cycle begins when mechanical power is applied to the forward gear of the rotor assembly. This power is transferred through the aft gear of the rotor assembly (or through the clutch assembly when installed) to the delinking feeder, which is a rotary type, gear-driven device that serves as a delinking mechanism as well as a bypass clearing mechanism. The link-belted ammunition is fed into the delinking feeder by a stripper sprocket located forward of the push rod guide. The rounds are stripped from the links by the pushrods, cammed forward by a fixed helical cam, and fed into the gun guide bar. The stripped links are conveyed to the exit side of the delinking feeder through a link ejection chute. Unless the trigger circuit is energized, the solenoid-actuated clearing mechanism, when installed, automatically prevents transfer of rounds from the delinking feeder to the gun. The feeder is an integral part of the minigun ammunition feeding and hand-off system.

After dwell, the gun housing cam interacts with the rotor rotation to pull the bolt body aft to rotate the bolt head out of lock. This action rotates the firing pin and retracts it from the primer. Firing pin reset occurs when the forward cross pin reacts with the cross-slot in the bolt head. During the last unlocking action of the bolt head, the aft cross pin interacting with the bolt body cams the firing pin in a clockwise rotation to its reset position. The two cross pins then transmit the extract load.

At the end of the forward dwell of the elliptical cam path, the bolt assembly roller enters the reverse segment of the path that unlocks the bolt head. Further travel of the bolt assembly roller along the reverse segment moves the bolt assembly to the rear and extracts the spent cartridge case from the barrel. A lip on the face of the bolt head holds the spent case until it is cammed out by the guide bar and ejected. The bolt assembly continues to follow the elliptical cam path into position to receive another cartridge.

At this point, the bolt assembly has completely cycled through the elliptical cam path. All six bolt assemblies repeat this cycle while power is applied to the front gear of the rotor assembly.

Clearing cycle

The clearing cycle begins when trigger power is removed from the system. The gun drive motor remains energized for a short time (400 milliseconds) to allow the automatic gun to fire out all ammunition remaining in the gun.

At the end of each firing burst (when trigger is released), electrical power is removed from the solenoid causing it to disengage the clutch. When the clutch disengages, mechanical drive power from the aft gear of the gun rotor is removed from the feeder and the feeder stops rotating. This, in turn, stops the flow of ammunition into the gun from the feeder as well as into the feeder from the ammunition system. The machine gun continues to turn (for 400 milliseconds) and fire out any live rounds that remain in the rotor.

For application without the clutch assembly, the clearing solenoid is mounted on the feeder. When the trigger is released, the electrical power is removed from the solenoid causing it to engage the clearing guide and prevent the transfer of rounds from the feeder into the gun. As long as the machine gun continues to turn (400 milliseconds), live rounds are released out of the feeder and ejected overboard.

GAU–2 components

The major components of the GAU–2 gun are shown in figures 3–4, 3–5 and 3–6. They include the rotor assembly, six bolt assemblies, six removable tracks, the gun housing, safing sector, housing cover, guide bar, aft gun support, barrels, and barrel clamp assembly.

Rotor assembly

The rotor assembly is supported in the gun housing by annular ball bearings. The rotor supports the gun barrel cluster, removable bolt tracks, and bolt assemblies. It has six S-shaped triggering cams machined into it to serve as a path for the firing pin tang to follow until it reaches the cocking shoulder.

Bolt assembly

The bolt assembly has a rotary head and fixed extractor design. It engages the bolt tracks on the rotor assembly. Each bolt assembly contains a firing pin to fire rounds. It also has extractor lips to transport rounds through the gun and extract empty cases after round firing. A bearing roller on top of the bolt is used to keep it in the cam path of the gun housing during gun operation.

Safing sector

A safing sector is attached to the gun housing with two quick-release pins. It is a safing device for the gun. Its inner surface forms the dwell segment of the cam path. This segment brings the bolt assemblies into the firing position. When the safing sector is removed, the bolt assemblies cannot be cammed into the firing position by manual or mechanical rotation of the barrels, nor can the firing pins be cocked and released by the triggering cam on the rotor assembly.

Housing cover

The housing cover is secured to the safing sector and gun housing by two quick-release pins. It provides you with a point of access to the rotor and bolt assemblies for inspection and service. There is a guide bar held to the housing assembly by a permanently installed pin at the front and a screw at the rear. This guide bar directs cartridges from a feeder assembly into the extractors. It also cams spent cartridge cases out of the extractors into an ejection chute. The gun also has an aft gun support attached to the rear of the rotor assembly. The gun barrels (fig. 3–6) are supported by the front part of the rotor assembly. They have a barrel lock flange on the breech end of the barrel to lock them into place in the rotor. A barrel clamp assembly is inserted over the muzzle end of the barrels to keep them from spreading apart as the gun turns.

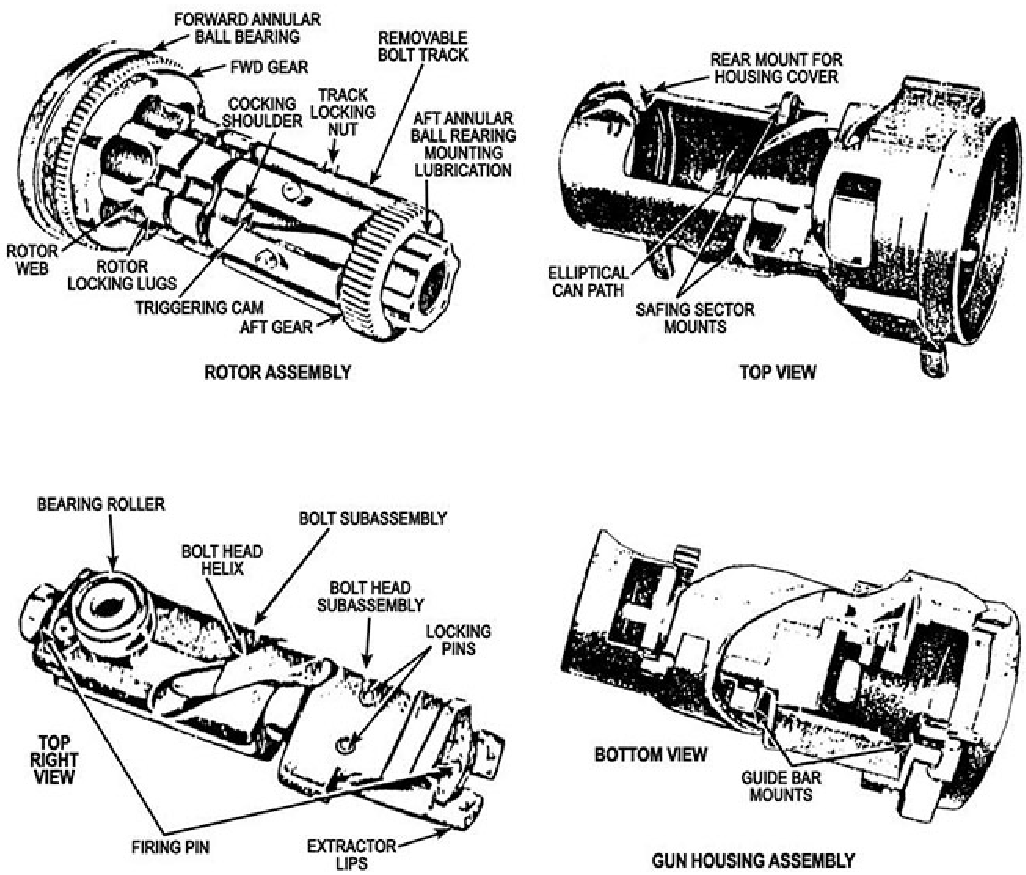


Figure 3–4. GAU–2 components.

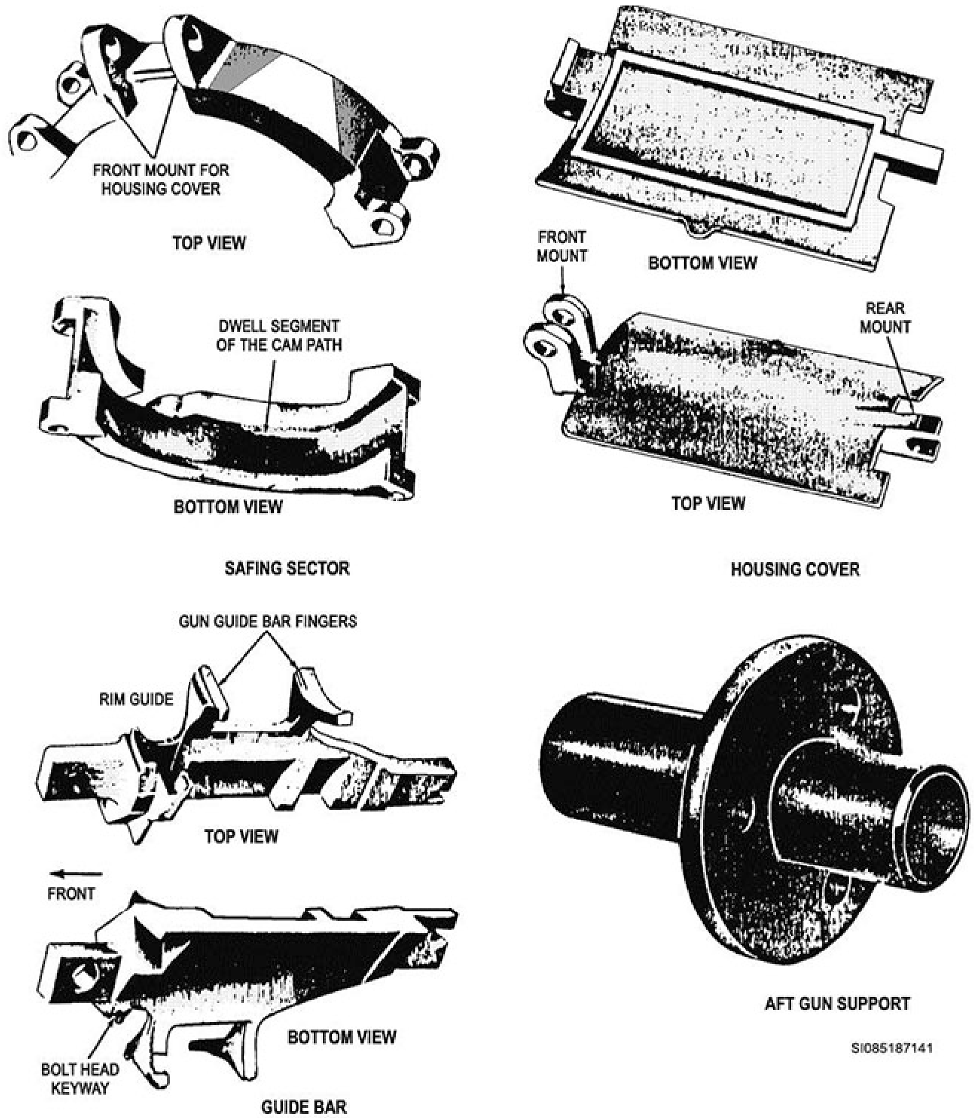


Figure 3–5. GAU–2 components (cont'd).

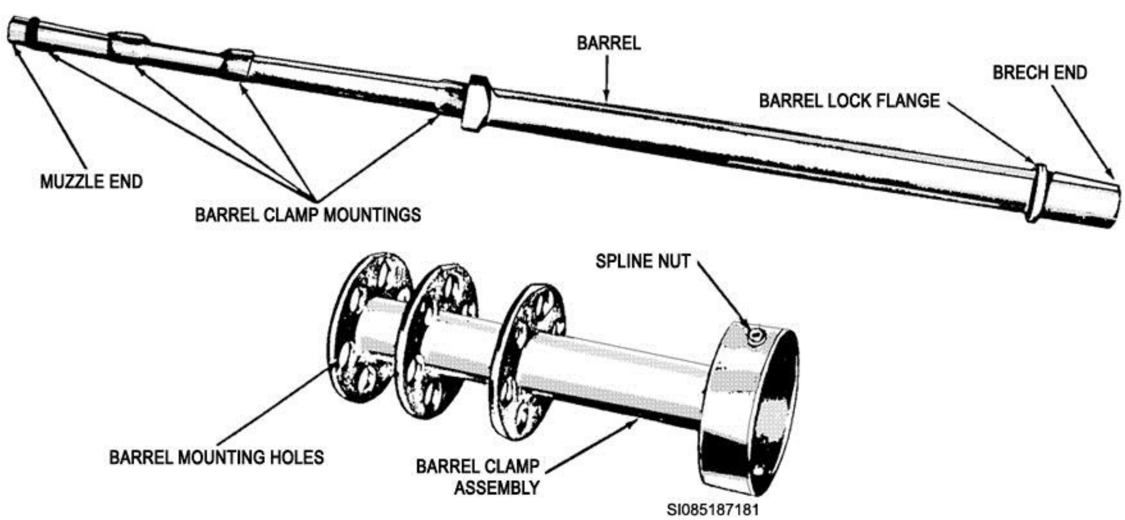


Figure 3–6. GAU–2 components (cont'd).

425. The M61A1 and M61A2 20 millimeter guns

As the speed of an aircraft increases, the time a pilot can keep it sighted on the target decreases. As a result, the M61A1 was created to deliver the tremendous firepower needed during the extremely short interval an aircraft is on the target.

M61A1 20 millimeter gun

The M61A1 is a rotary gun firing 20 millimeter (mm) electrically primed ammunition with a rate of fire from 4,000 to more than 7,000 shots per minute (spm), depending on what type of external power (electric or hydraulic) is available in the aircraft (fig. 3–7). The M61A1 gun is not too complex from a maintenance standpoint, but it does have problems found in no other weapon. The number of parts and the tolerances in the gun cannot be checked after assembly. This means you must be competent and conscientious when maintaining this gun. The consequences of incorrect maintenance or maladjustment are usually severe and would certainly mean loss of the weapon. We'll first describe the function of the assemblies of the gun and then its operation.

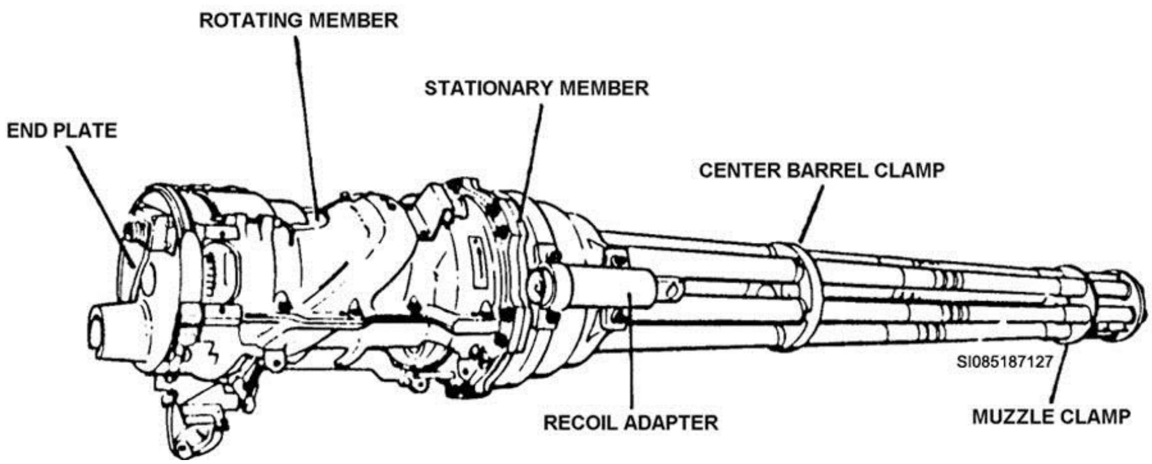


Figure 3–7. M61A1 20 mm gun.

Function of the gun assemblies

The M61A1 gun consists of a housing assembly used to support a rotating rotor. The stationary housing, with the installed recoil adapters, is attached to the gun mounts in the aircraft. The rotor is driven with an electric or hydraulic drive unit. The rotor's rotation causes the gun to feed, chamber, lock and fire, unlock, extract, and eject the cartridges. An automatic gun lubricator (not shown on fig. 3–8) is mounted on the top left of the gun. Its purpose is to provide lubricant to the gun during operation. As the gun recoils, a pump in the lubricator forces lubricant to the gun. With this in mind, let's begin our discussion of the gun by outlining the function of various assemblies shown in figure 3–8.

Rotor assembly

The rotor assembly is the major unit of the gun (fig. 3–9). An electric motor or hydraulic drive unit attached to the drive gear drives it. The front support for the rotor is a double-row thrust bearing, and the rear support is needle bearings located inside the rotor. The end plate provides the needle bearings with a stationary inner race for rear support of the rotor. These units are attached to the rear end of the housing by a clamp. Six sets of rotor tracks are attached to ribs along the rotor body. Each set includes a front, a center, and a rear removable track. The removable track can easily be taken out to permit removal of the bolt assemblies for servicing.

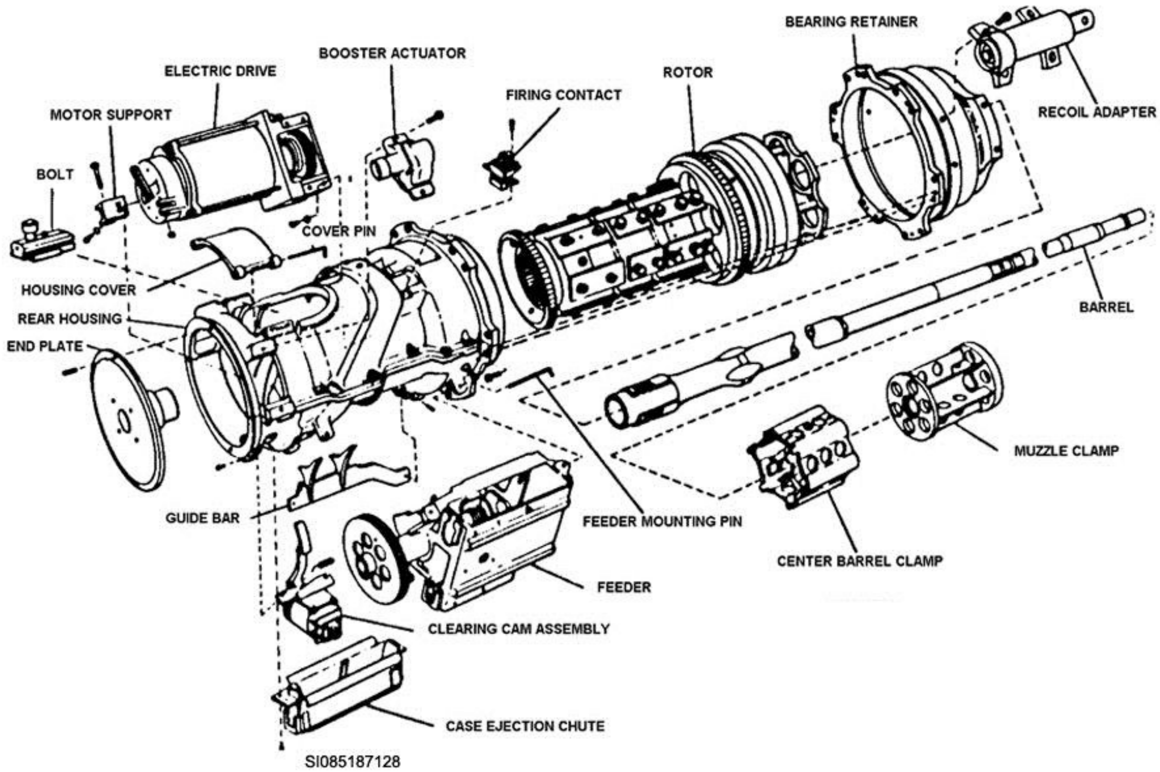


Figure 3–8. M61A1 exploded view.

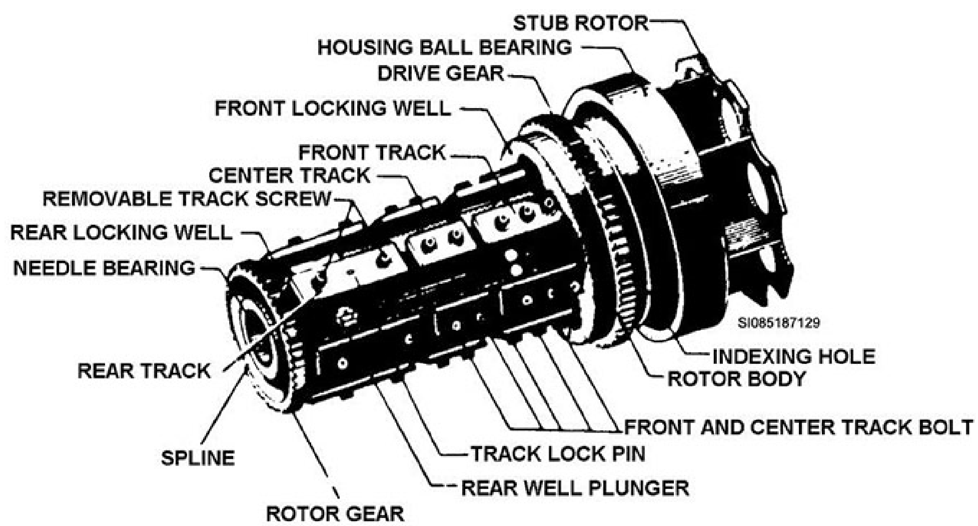


Figure 3–9. M61A1 rotor assembly.

Bolt assemblies

The bolt assemblies transport the round through the gun to the firing chamber, lock the bolt in the firing position, transmit firing voltage to the primer of the round, and transport the empty case to the guide bar for ejector. Figure 3–10 shows the bolt assemblies in the locked and unlocked positions.

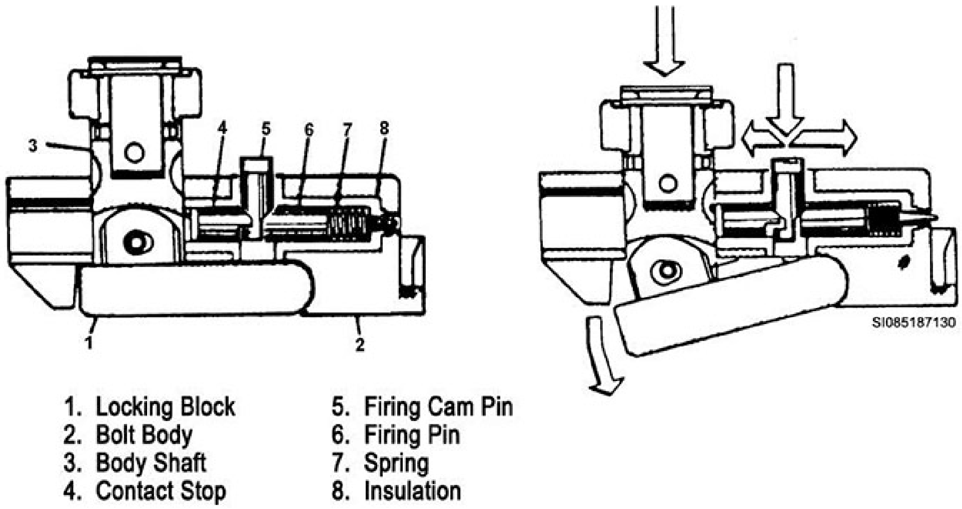


Figure 3–10. M61A1 breech bolts in unlocked and locked position.

An extractor lip on the front of the bolt subassembly engages the rim of a round and supports it during the cycling operation. The rim of the round remains in the bolt extractor lip until it is cammed out of the weapon by the guide bar and ejected. Tracks on the sides of the bolt assembly engage the rotor tracks and permit the bolt assembly to slide back and forth on the rotor. The position of the bolt on the rotor is determined by the bolt shaft assembly engaging the main cam or the clearing cam path in the housing. Just before the weapon is fired, the shaft of the bolt assembly is forced down by a locking cam; this action causes the locking block to drop into the locking well of the main rotor, thus, locking the bolt in firing position.

The firing circuit components of the bolt body assembly are the firing pin, the firing pin spring, firing cam pin, and contact stop assembly. Molded insulation in the bolt subassembly insulates the components. The contact stop assembly engages a slot in the firing cam pin to hold it in the body. When the firing cam pin is depressed, the firing pin moves forward to make electrical contact with the primer of the round. The six barrels are supported by a stub rotor attached to the rotor assembly. The three rows of interrupted locking lugs on the barrel mate with similar locking lugs on the rotor body secure the barrels. Three knurled bands near the middle of the barrels provide a convenient gripping surface for the installation and removal of the barrels from the rotor.

Barrel and muzzle clamps

The center barrel clamp assembly locks the barrels into position (fig. 3–8). It consists of a clamp body and locking ring assembly to secure the barrels. The muzzle clamp assembly consists of a muzzle clamp subassembly, muzzle clamp lock, spring pin, and self-locking nut. The muzzle clamp lock is secured on the beveled shoulder of three of the barrels and is secured by tightening the self-locking nut.

Housing assembly

The housing assembly consists of an upper and lower section assembled as a unit. It provides main and clearing cam paths to guide the bolt assemblies. The main cam path is elliptical in shape and provides a path for the breach bolts in the firing cycle. A circular clearing cam at the rear of the housing provides a path for the bolt assemblies when the weapon is being cleared. The housing cover is a part of the clearing cam path when in the CLOSED position (fig. 3–8). When OPENED, it provides access to the bolt assemblies so they may be removed without disassembling the weapon. The guide bar guides the rounds as they are fed into and ejected from the extractor lips of the bolt assemblies.

Clearing cam assembly

The clearing cam assembly forces the breach bolts into the clearing cam path. It is actuated electrically or manually.

M61A2 20 mm gun

The only variant of the M61A1 currently in service is the M61A2 in use exclusively on the F–22. This weapon is functionally identical to its predecessor. The systems are so similar that the guns share 80 percent of all parts. The only major difference between the two systems is the weight of the system. The decrease in weight is mostly due to thinner and shorter barrels. The rotor and housing assemblies also went through a weight saving process to remove all unnecessary weight. As a result, the M61A2 weighs approximately 80 percent less than the original M61A1 but still maintains the original rate of fire and reliability rate.

426. GAU–12/U 25 millimeter gun systems

The GAU–12/U Gatling gun is a 25 mm trainable/mounted gun used to provide air-to-ground firing capability. The system includes a 3,000 round ammunition storage and handling system (ASHS) and controlling electrical and hydraulic equipment and a gun gas purge system.

GAU–12/U

The gun fires percussion-primed 25 mm ammunition at a rate of 1,800 ±100 spm (fig. 3–11). It can be driven in either a clockwise or counterclockwise direction, with the clockwise direction being the firing direction. Drive power is provided by the flexible drive shaft from the ASHS. The flexible drive shaft turns the gun drive gear box mounted to the back of the gun.

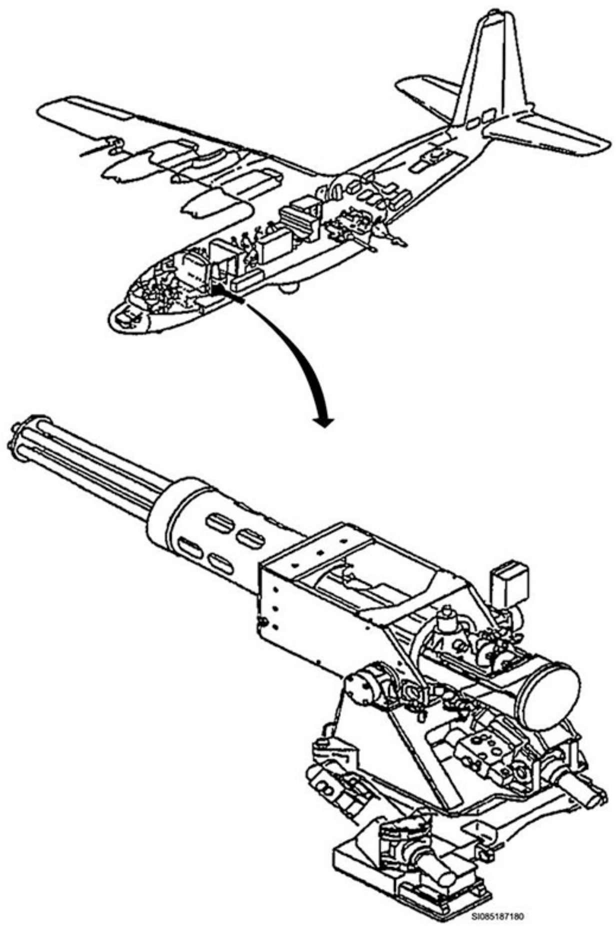


Figure 3–11. GAU–12/U 25 mm Gatling gun.

25 mm gun

The 25 mm Gatling gun is an externally powered five-barrel, automatic, Gatling-type gun. A stationary housing assembly supports the aft end of the gun on rollers. The gun housing also has mounting surfaces for the lock/unlock cam, the cartridge guide bar, the load/unload guides, the gun drive gear shaft, and the firing/safing cam. You will see in figure 3–12 some of the system components.

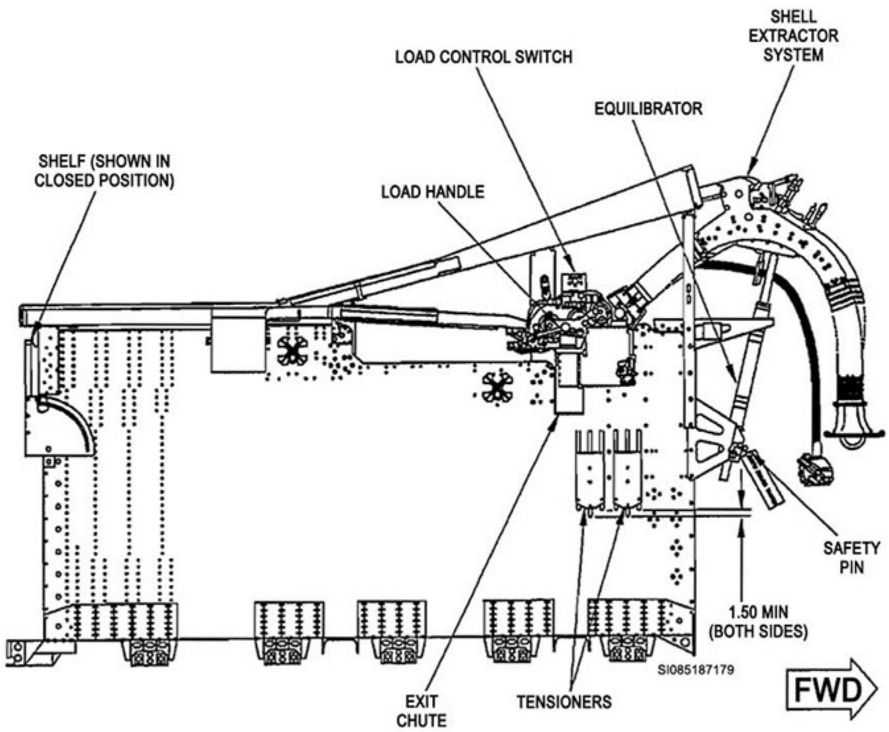


Figure 3–12. GAU–12/U systems components.

Ammunition storage and handling system

The 25 mm gun ASHS provides storage for ammunition and spent cases (fig. 3–13). A hydraulic motor receives power from the utility hydraulic system, and the hydraulic motor drives the magazine. The ASHS can also be powered by the auxiliary hydraulic system for ammunition loading and downloading on the ground.

The ASHS magazine is a linear linkless feed system consisting of two 1,500 round bays. Since the system draws from both bays simultaneously, the ammunition in these bays moves at ½ the gun speed. The ammunition is moved within the magazine by an endless chain ladder. Two tensioner assemblies inside the magazine always keep tension on the chain ladder.

Hydraulic drive assembly

The hydraulic drive assembly consists of a servo valve, hydraulic pressure switch, tachometer, delta pressure transducer, ASHS mounted gearbox flexible drive shaft, and gun drive box. When the ASHS is commanded to move, the servo valve is commanded to open allowing hydraulic pressure fluid to turn the hydraulic motor. The hydraulic pressure switch sends a signal to the ECU showing pressure is present. The hydraulic motor turns the ASHS mounted gearbox to drive the magazine and the flexible drive shaft. The flexible drive shaft drives the gun drive gearbox and, in turn, drives the gun.

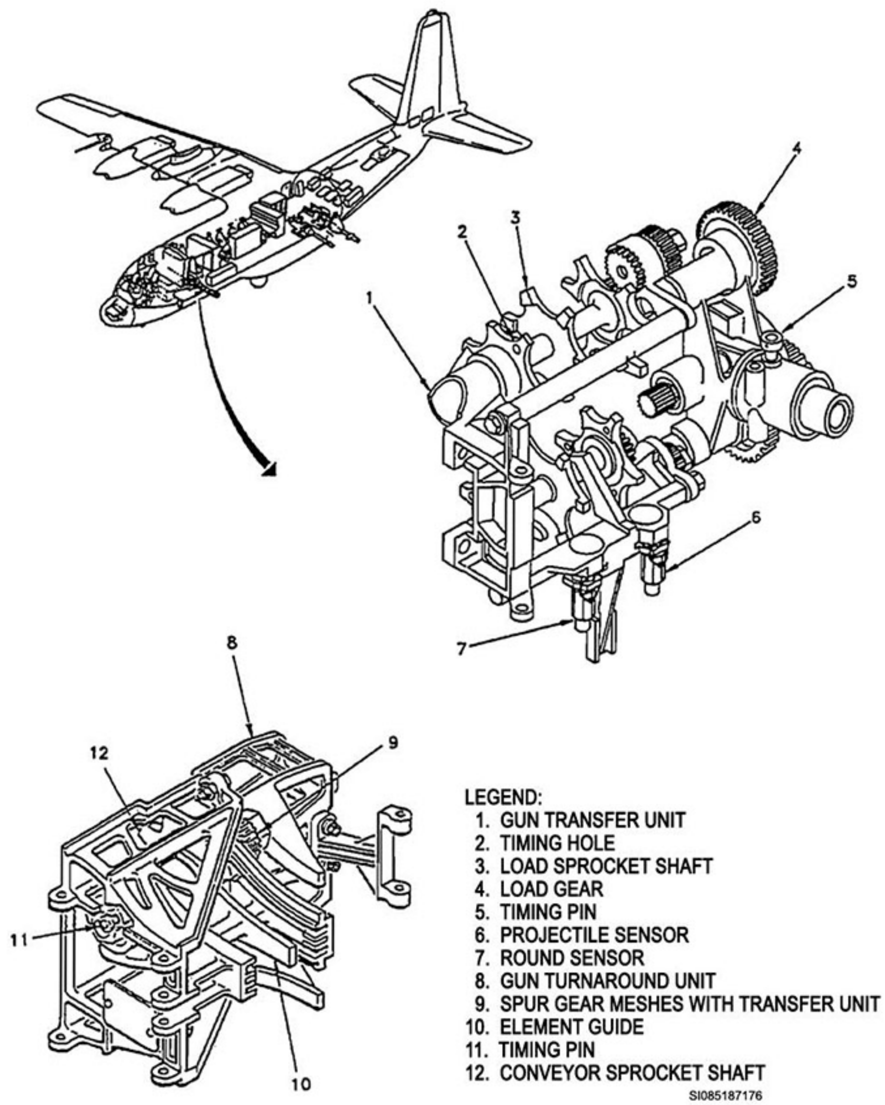


Figure 3–13. ASHS.

427. The GAU–8/A 30 millimeter gun

The GAU–8/A gun is the firepower behind the A–10 aircraft. The role of the A–10 in close air support has made the 30 mm an integral part of mission success. This seven-barrel, air-cooled, Gatling-type weapon is capable of firing 4,200 rpm, but is limited to 3,900 rpm when installed in the A–10 aircraft (fig. 3–14). The major components consist of the gun housing, rotor assembly, seven bolt assemblies, midbarrel support assembly, seven barrels, and muzzle clamp assembly.

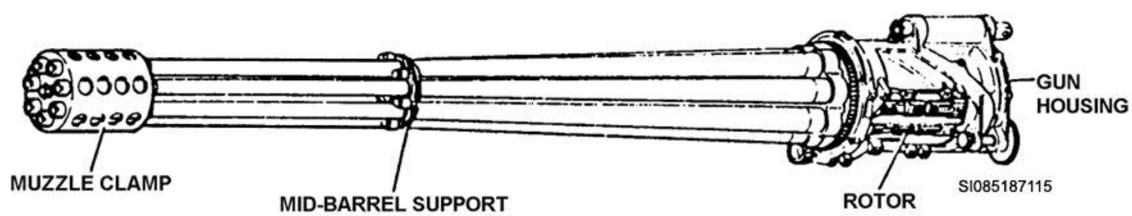


Figure 3–14. The GAU–8/A 30 mm gun.

Gun housing

The gun housing contains an offset oval cam path to control the movement of the bolt assemblies during gun rotation (fig. 3–15). The gun housing has two recoil spindles to absorb the recoil and counter recoil produced by the gun when it's firing. The spindles also act as attach points for the aft gun mount. An indexing pin is available for timing of the gun. A lock/unlock cam is also bolted to the housing. Its purpose is to lock the breech bolt for firing and unlock it to accommodate extraction of the expended shell. Two other cams are attached to the gun housing—the firing and safing cams. The firing cam allows the cocking lever of the breech bolt to fall forward and fire rounds. The safing cam, controlled electrically by a solenoid assembly, either lets the firing cam work or holds it in the SAFE position so rounds cannot be fired.

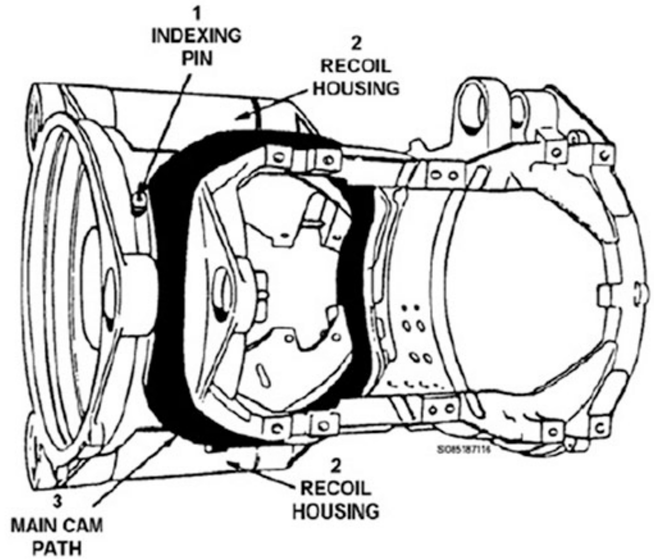


Figure 3–15. GAU–8/A gun housing.

Rotor assembly

The rotor assembly is divided into two parts: the forward rotor and mid rotor (fig. 3–16). Gun drive power (hydraulic) is applied to the forward rotor main drive gear. Interrupted locking lugs in the forward rotor engage similar lugs on the barrels to secure them in position. A forward bearing is fitted on the forward rotor to center it inside the gun housing and provide for easy rotation. A locking well (not shown) is located just behind the interrupted locking lugs. It is where the breech bolt locks in position for round firing. On the midrotor, there are several rows of rotor tracks used to guide the breech bolts forward and aft in the gun housing as the rotor rotates. Relief cuts at the rear of the midrotor permit disassembly of a jammed gun by removal of the gun housing to the rear.

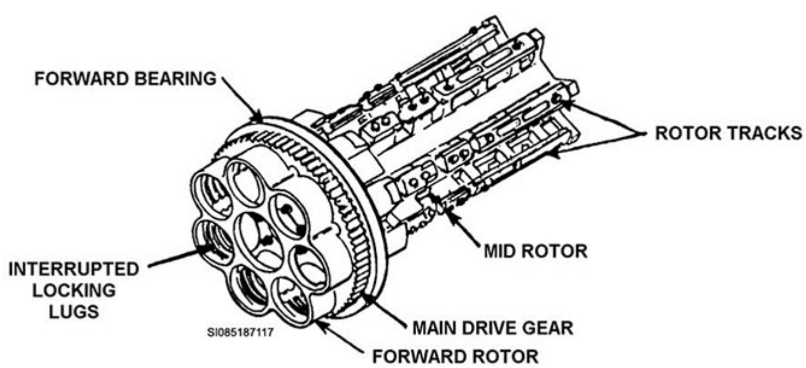


Figure 3–16. GAU–8/A rotor assembly.

Breech bolt assemblies

Seven breech bolt assemblies are used in the gun to transport rounds from the transfer unit through the gun for firing and eventually out of the gun again (fig. 3–17). Each breech bolt has nine parts: the bolt carriage, extractor lip, cam follower, linear-motion rollers, bolt cap and roller, cocking pin, helical compression spring, and firing pin. The bolt carriage rides in the rotor tracks during gun rotation. The bolt body and linear-motion roller locks the bolt assembly in the firing position. The cocking pin cocks the firing pin, and then the firing pin detonates the percussion-primed ammunition. The gun bolt roller determines the position of the bolt assembly as it follows the cam path in the gun housing assembly.

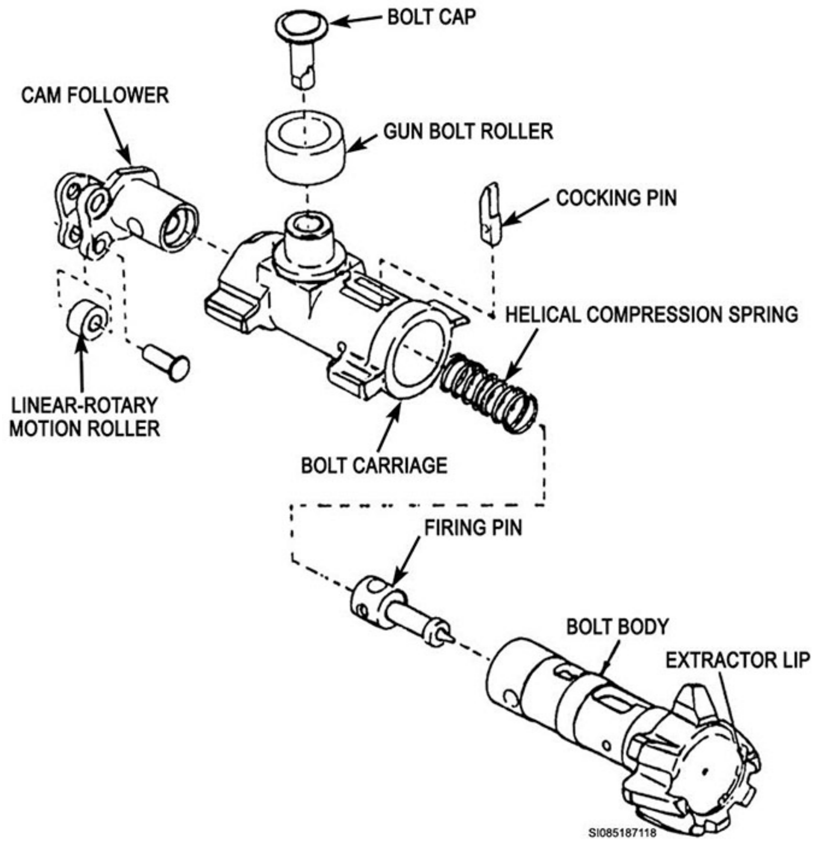


Figure 3–17. GAU–8/A breech bolt assembly.

Barrels

The gun has seven rifled barrels in a circular cluster. Interrupted locking lugs on each barrel engage similar interrupted locking lugs in the rotor to secure the barrels.

Mid-barrel support assembly

A mid-barrel support assembly locks the barrels in the rotor and supports and stabilizes the barrel cluster (fig. 3–18). It also serves as a front mount for the gun.

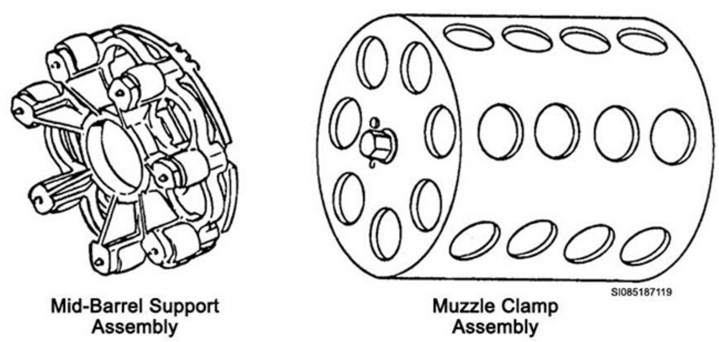


Figure 3–18. GAU–8/A barrel cluster components.

Muzzle clamp assembly

A muzzle clamp assembly is positioned at the muzzle end of the barrel to restrain individual barrel movement during gun rotation (fig. 3–18). The diverter is nothing more than a modified muzzle clamp. It serves the same purpose as the muzzle clamp except it is designed to divert gun gasses and smoke below the belly of the aircraft.

Additional components

In addition to those major components of the GAU–8/A gun, there are two other items important to gun operation: the transfer unit and lubricator assembly.

Transfer unit

The transfer unit is bolted to the gun and feeds ammunition to the gun. It also removes spent cases or unfired rounds from the gun.

Lubricator assembly

The lubricator assembly has a gear-driven pump to automatically provide lubrication to the gun during rotation. The reservoir of the lubricator must be refilled at intervals determined by its level indicator.

Operation

With power applied, the rotor and barrel cluster rotate in a counterclockwise direction, as viewed from the rear of the gun. Ammunition is supplied to the gun by the transfer unit. Guide bar fingers, the controlling surfaces of the gun housing, and the transfer unit guide the round into the extractor lip of each bolt assembly. As rotation continues, the gun bolt roller follows the cam path in the inner surface of the gun housing. This action cams the bolt assembly forward in the rotor tracks. The cam action applied to the gun bolt roller moves the bolt assembly and round forward to chamber the round (fig. 3–19). The linear-motion roller enters the lock and unlock cam and is guided by the cam's control surfaces. This causes the breach bolt body to rotate and the locking lugs of the bolt body to engage with similar locking lugs of the rotor. The bolt assembly remains locked while the gun bolt roller travels through the front dwell of the gun housing cam path.

The cocking pin contacts the firing cam as the bolt assembly approaches the front dwell of the gun housing cam path (fig. 3–19). The solenoid raises the safing sector to allow firing pin drop. The rotation of the rotor assembly causes the bolt assembly to move forward. During this forward movement, the firing cam moves the cocking pin rearward to compress the firing pin spring. Continued rotation causes the cocking pin to be released from the cam at the sear point. After the cocking pin is released, the compressed firing pin spring drives the firing pin forward to detonate the primer of the round. As the bolt assembly nears the end of the front dwell of the gun housing cam path, the linear-rotary motion roller and unlock cam cause the bolt body to rotate and the locking lugs of the bolt body to disengage from the locking lugs of the rotor. After unlocking occurs, the gun bolt roller enters the reverse segment of the cam path. The bolt assembly extractor lip extracts the spent case or unfired round from the barrel chamber as the bolt assembly moves rearward. The bolt assembly continues to move rearward along the rotor tracks until the spent case or the unfired round is cammed out of the bolt extractor lip by the guide bar and is ejected from the gun into the transfer unit.

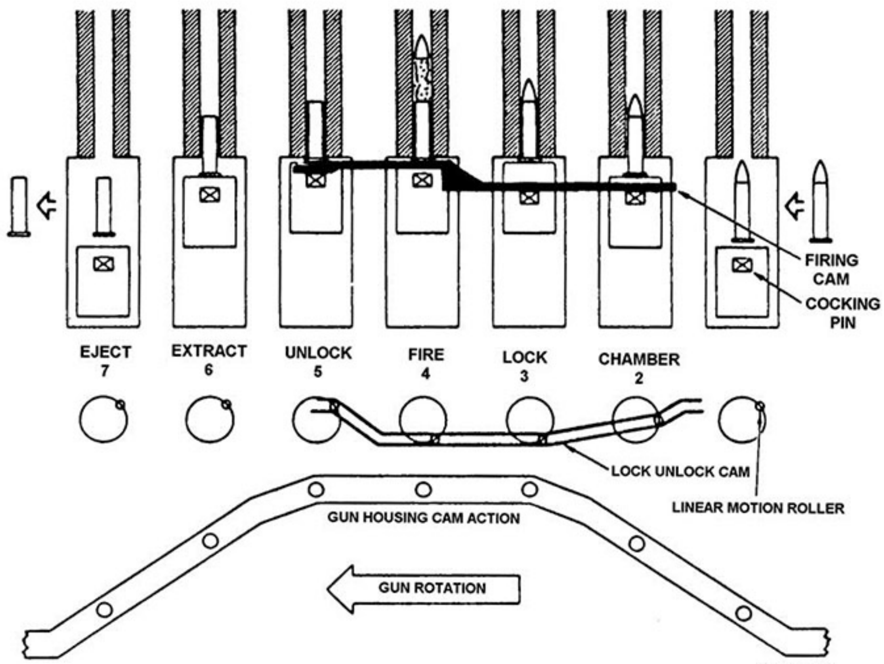


Figure 3–19. GAU–8/A cycle of operation.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

424. GAU–2 automatic gun

1. What is the primary use of the GAU–2?

2. When does the GAU–2 feeding cycle begin?

3. When does the GAU–2 clearing cycle begin?

425. The M61A1 and M61A2 20 millimeter guns

1. How is the rotor assembly driven?

2. What purpose does the extractor lip on the bolt assembly serve?

3. What determines the position of the bolt on the rotor?

4. What supports the six barrels in the gun?

5. How is the clearing cam assembly actuated?

6. What is the only major difference between the M61A1 and the M61A2?

426. GAU–12/U 25 millimeter gun system

1. What is the firing rate of the GAU–12/U gun system?

2. What drives the GAU–12/U gun?

3. What does the 25 mm ASHS store?

4. What is the ASHS magazine?

5. How fast does the ammunition move in the ASHS?

6. How is ammunition moved in the ASHS?

7. How is the ASHS driven?

427. The GAU–8/A 30 millimeter gun

1. Where is the cam located that controls movement of the bolt assemblies?

2. Where is gun drive power applied to the gun?

3. Where does the breech bolt lock into position for firing?

4. What locks the bolt assembly in the firing position?

5. What serves as a front mount for the gun?

6. After what operational step of the gun does the bolt roller enter the reverse segment of the cam path?

3–3. Aircraft Single-Barrel Gun Systems

While the multi-barrel rotary systems provide the vast majority of the number of the gun systems in use by the Air Force, they are by no means the only systems in use. Single-barrel systems make up a large number of the number of systems maintained by armament systems personnel. There are currently four single-barrel systems in use today ranging from the 7.62 mm M240 to the massive M137A1 105 mm Howitzer. In this section, we give an overview of the systems in use and the basics of their parts and functions.

428. M240 machine gun system

The M240 is a gas-operated single-barrel, 7.62 mm machine gun. The primary use of the M240 is as the flight engineer’s window weapon on the HH–60 (fig. 3–20). The weapon is configured to feed ammunition from the left-hand side in all Air Force applications. The spent cases are ejected from a port on the bottom of the gun and are caught in a bag attached to the cradle mount using snaps.

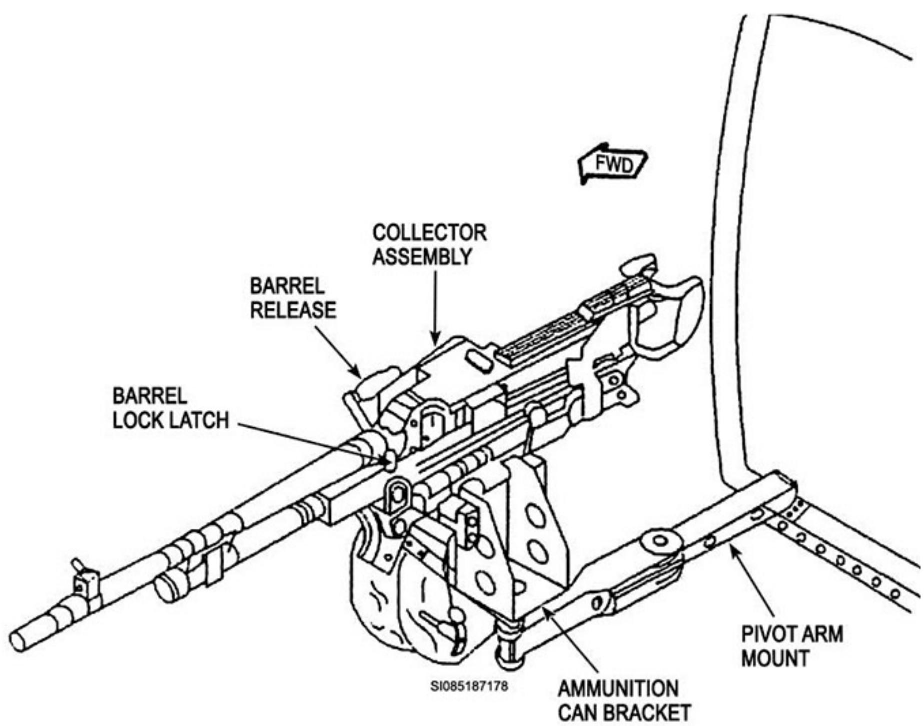


Figure 3–20. Mounted M240D.

The aircraft configuration, designated the M240D (butterfly thumb triggers, spade grips, special trigger guard, and butterfly handles) (fig. 3–21, top) can be configured by the operator in less than one minute to a ground assault weapon designated the M240G (pistol-grip trigger, wooden or metal butt stock, and bipod) (fig. 3–21, bottom).

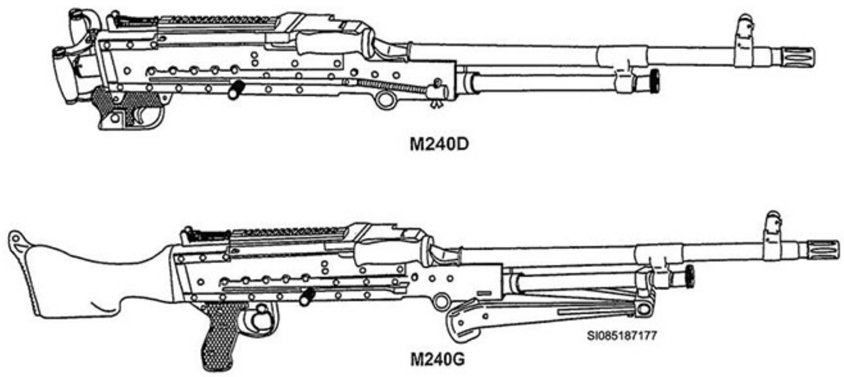


Figure 3–21. M240D and M240G.

The following table lists the specifications of the M240 machine gun:

Weight M240D	22.9 lbs.
Weight M240G	25.8 lbs.
Rate of fire	650 to 950 spm
Maximum effective range	800 meters
Maximum range	3,725 meters

Loading the weapon is performed by pulling the charging handle which locks the bolt to the rear. The weapon is placed on safe and the charging handle is pushed forward. The feed tray cover is then lifted and rounds are laid inside the feed tray. The feed tray cover is then closed and the weapon is ready for operation.

It is critical to understand the M240 operates under the open bolt concept. When the weapons charging handle is pulled, the bolt assembly is locked to the rear of the weapon and is placed under considerable spring pressure. You must take care to prevent exposing your fingers to the area of travel of the bolt assembly during this time. Any action inadvertent or deliberate allowing travel of the bolt can result in severe damage to your hands.

Clearing the weapon is performed by making sure the bolt is locked to the rear and the weapon is on safe. The feed tray cover is then lifted, the remaining belt (if any) is swept out of the feed tray, and the feed tray is lifted to visually inspect the rear of the barrel and the face of the bolt. Any links or brass casings are removed. The weapon is now clear. In the unlikely event that a live round is on the bolt face, it is knocked loose with a cleaning rod or another rigid object, keeping the operator's hands clear of the travel path of the bolt.

Cycle of operation

The M240 machine gun will fire automatically as long as ammunition is fed into it and the trigger is pushed. Each time a cartridge is fired, the parts of the gun function in a given sequence. This is known as the cycle of operation. It begins when the trigger is pushed, releasing the sear from the sear notch in the operating rod. The cycle stops when the trigger is released and the sear again engages the sear notch in the operating rod.

The cycle of operation can be separated into eight steps:

1. Feeding—Positioning of a round in the feed tray groove.
2. Chambering—Stripping a round from the belt and sliding it into the chamber.

3. Locking—Rotation and locking of the bolt inside the barrel socket.
4. Firing—The firing pin striking and detonating the cartridge primer.
5. Unlocking—Unlocking the bolt from the barrel socket.
6. Extracting—Pulling the empty case from the chamber.
7. Ejection—Expelling the empty cartridge from the receiver.
8. Cocking—The operating rod yoke engaging the firing pin, compressing the firing pin spring, and withdrawing the firing pin into the bolt.

Feeding

Feeding begins as the bolt moves to the rear when the cocking handle pulls it back or after a round is fired. The cam roller on the top of the bolt forces the feed cam to the left causing the feed cam lever to pivot. This action moves the belt feed pawl to the right placing a round in the feed-plate groove. As the bolt begins to move forward, the feed cam is forced to the right causing the feed cam lever to pivot in the opposite direction. When this occurs, the belt feed pawl is forced over the next round in the belt ready to place it in the feed plate groove when the rearward action occurs again.

Chambering

Chambering a round begins with the bolt in the rearward position. When the trigger is pulled, the rear of the sear is held down so it cannot engage the sear notch. This allows the operating rod and bolt to continue forward. As the expanding driving spring rod assembly drives the operating rod and bolt forward, the upper locking lug of the bolt contacts the extraction rim of the cartridge. The pressure of the front and rear cartridge guides holds the round down so that positive contact is maintained by the upper locking lug of the bolt. The front cartridge guide prevents the link from moving forward as the bolt strips the round from the belt. As the bolt pushes the round forward, the nose of the cartridge contacts the chambering ramp in the receiver and the barrel socket. This action causes the round to go down and forward into the chamber. When the round is fully seated in the chamber, the extractor snaps over the extractor rim of the cartridge and the ejector in the face of the bolt is depressed.

Locking

Locking occurs as the round is chambered and the bolt enters the barrel socket. The upper and lower lugs contact the bolt locking cams inside the barrel socket and begin to rotate the bolt clockwise. Locking is then complete.

Firing

Firing occurs once the bolt is fully forward and locked. The striker of the firing pin protrudes through the hole in the face of the bolt striking the cartridge primer and igniting it. The primer ignites the powder within the cartridge driving the bullet through the barrel.

Unlocking

Unlocking begins as the operating rod contacts the curved bolt camming slot and ends as the bolt clears the end of the barrel socket. After the cartridge is fired and the bullet passes the gas port, part of the expanding gas enters the gas cylinder through the port forcing the gas piston to the rear. The operating rod, being in contact with the piston, is pushed to the rear. This causes the bolt to rotate counterclockwise. The upper and lower locking lugs of the bolt, which contact the bolt locking cams inside the barrel socket, cause the bolt to complete it’s one quarter turn rotation counterclockwise, unlocking the bolt from the barrel socket.

Extracting

While unlocking is going on, extraction is beginning. Rotation of the bolt (unlocking) loosens the cartridge case in the chamber. As the operating rod and bolt move to the rear, the extractor (gripping the rim of the cartridge) pulls the cartridge case from the chamber.

Ejection

As the case is withdrawn from the chamber, the ejector spring expands. The ejector presses on the base of the cartridge case forcing the front of the spent case against the right side of the receiver. As the bolt continues to the rear, the action of the ejector pushing against the base of the cartridge case and the extractor gripping the right side of the case causes the cartridge case to be spun from the gun as the case reaches the ejection port. The empty link is forced out of the link ejection port as the rearward movement of the bolt causes the next round to be positioned in the feed-plate groove.

Cocking

As the expanding gases force the gas piston to the rear, the operating rod is initially moved to the rear, camming the bolt to the unlocked position. After an initial movement of approximately two inches, the bolt assembly and operating rod move rearward together. At the same time, the operating rod yoke acts against the rear firing pin spool withdrawing the firing pin from the primer of the spent cartridge case. The action of the operating rod continues to the rear against the rear firing pin spool fully withdrawn and the firing pin is compressed, the gun is cocked.

429. GAU–18 machine gun

The GAU–18 .50 caliber machine gun (fig. 3–22) is an automatic, recoil-operated, belt fed, air-cooled unit that fires 750 to 850 rounds per minute (rpm). It is designed to be installed on helicopters. The gun is 56.25 inches long and weighs 65 pounds. This lesson covers the gun's major components and cycle of operation.

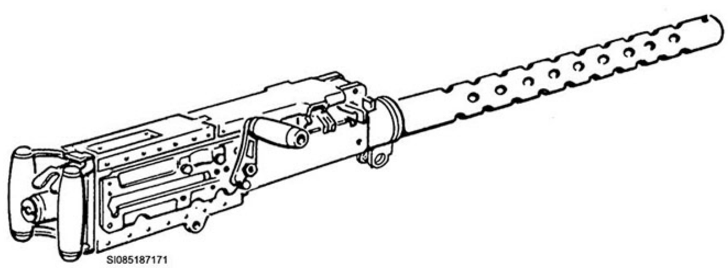


Figure 3–22. GAU–18 .50 cal. machine gun.

Firing cycle

Unlike the M240 machine gun, the GAU–18 machine gun is a recoil-operated gun; gas pressure does not assist in the operation. To avoid any confusion during this discussion, don't try to relate the steps of the
GAU–18 to the M240. The cycle of operation of the GAU–18 machine gun can also be separated into eight different operations:

1. Firing.
2. Recoiling.
3. Cocking.
4. Counter recoil.
5. Feeding the round.
6. Extracting the brass.
7. Ejecting the brass.
8. Chambering.

Firing

To fire the first round, the gun must be loaded and manually cocked by charging the bolt to the rear. With the firing mechanism cocked, the firing pin spring is compressed and the firing pin extension engages the sear. When the trigger is operated, it contacts the rear end of the trigger bar and forces it upward. As the trigger bar is actuated, it rotates about its pin and forces the front end down to depress the sear, thereby disengaging the cocking lever to engage the sear from the firing pin extension (fig. 3–23). This allows the compressed firing spring to force the firing pin and firing pin extension forward to fire the round in the chamber.

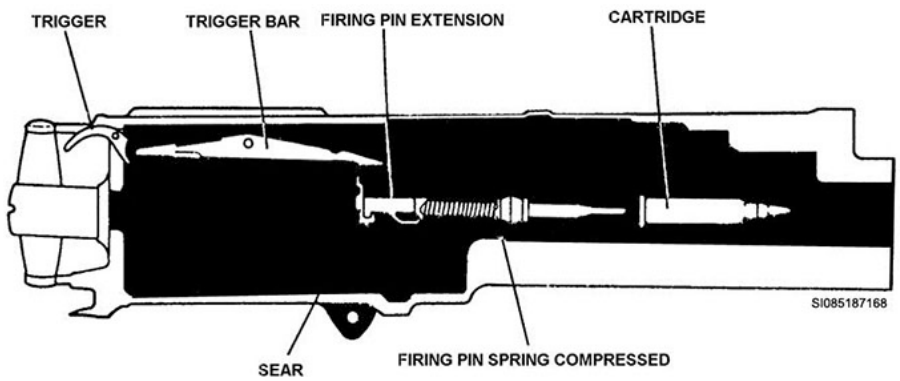


Figure 3–23. GAU–18 firing components.

Recoiling

Recoiling starts at the instant of firing with the recoiling parts, the barrel, barrel extension, and the bolt in the fully forward (battery) position. When the round is fired, these parts begin to move toward the rear of the gun.

Cocking

The act of cocking the gun begins immediately after firing. As the bolt moves rearward, the tip of the cocking lever is forced forward and the lower end is forced rearward. As the bolt moves rearward, the firing pin extension and firing pin move rearward and compresses the firing pin spring against the accelerator stop. Figure 3–24 shows the cocking action of the bolt and its components during recoil. During the forward movement of the bolt, the cocking lever acts as a safety device to prevent the cartridge from firing before the bolt has gone forward sufficiently. Figure 3–24 shows the action of the cocking lever during counter recoil.

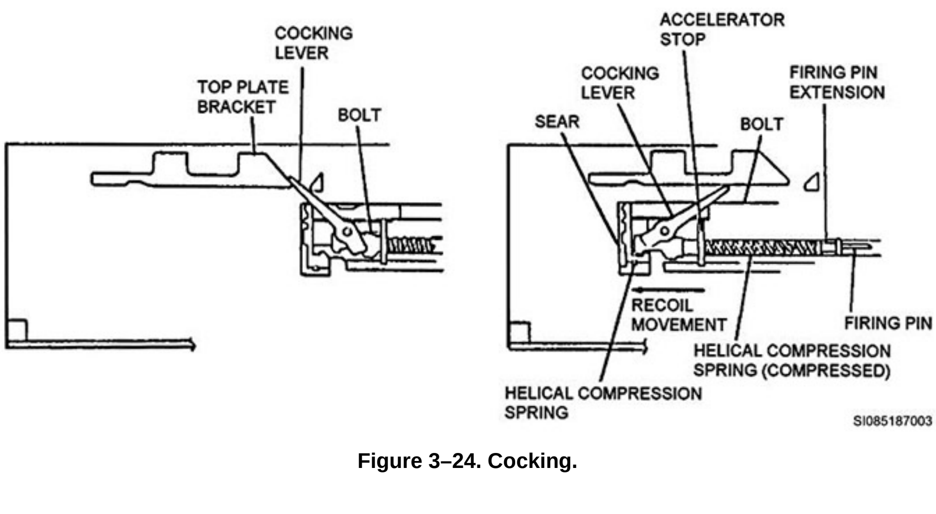


Figure 3–24. Cocking.

Counter recoil

After completing the recoil movement, the bolt is forced forward by the energy stored in the recoil buffer assembly’s helical compression drive springs and the buffer tube disc. This energy forces the bolt, barrel, and barrel extension forward (battery position) as shown in figures 3–25 and 3–26.

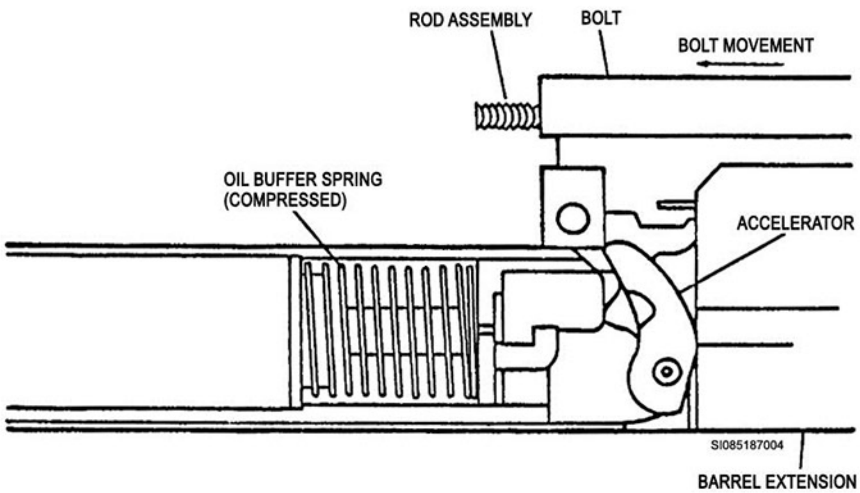


Figure 3–25. Counter recoil components.

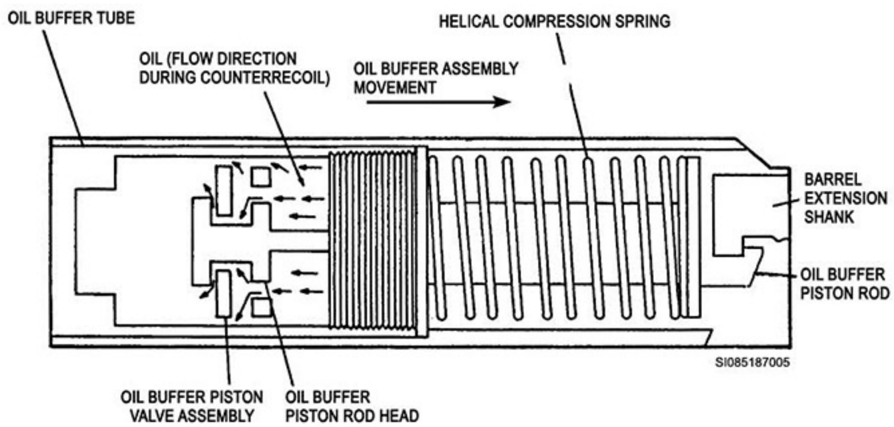


Figure 3–26. Oil buffer components and operation.

Feeding the round

Feeding is the process of extracting a live cartridge from the ammunition belt, extracting the belt element from the gun, and positioning the round for the chambering in the appropriate step in the firing cycle. This step in the firing cycle *does not* place a round into the breech for firing; this takes place during chambering.

Extracting the brass

Extracting is the process of removing the fired cartridge from the chamber by the breech bolt. As the breech bolt moves to the back of the gun during recoil, it brings the empty brass with it.

Ejecting the brass

After the breech bolt has moved aft, counter recoil begins. The breech bolt moves forward to chamber another round. As it does this, the spent case is ejected through the bottom of the gun.

Chambering

The movement of the live cartridge ejecting the spent brass positions the live cartridge into its correct position in the T-slot. The extractor stop lug on the side of the bolt limits the downward travel of the extractor so that the cartridge, guided by the ejector, enters the chamber of the barrel. When the cartridge is partly chambered, the extractor rides up the extractor cam on the left side plate where it contacts and compresses the cover extractor spring which forces it down into the extractor groove of the next cartridge in the belt. The partly chambered cartridge has meanwhile been completely chambered by the bolt as it moves to the battery position.

GAU–18 nomenclature and function of parts

The major components that make up the GAU–18 machine gun, shown in figures 3–27 and 3–28 are the:

1. Barrel and barrel extension assembly.
2. Back plate assembly.
3. Rod assembly.
4. Breech bolt assembly.
5. Recoil buffer assembly.
6. Cover assembly.
7. Retracting slide assembly.
8. Receiver assembly and barrel jacket assembly.

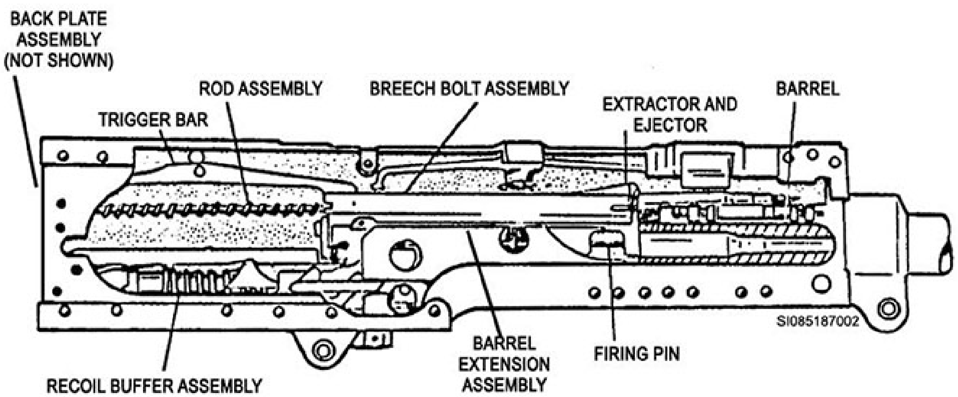


Figure 3–27. GAU–18 cutaway.

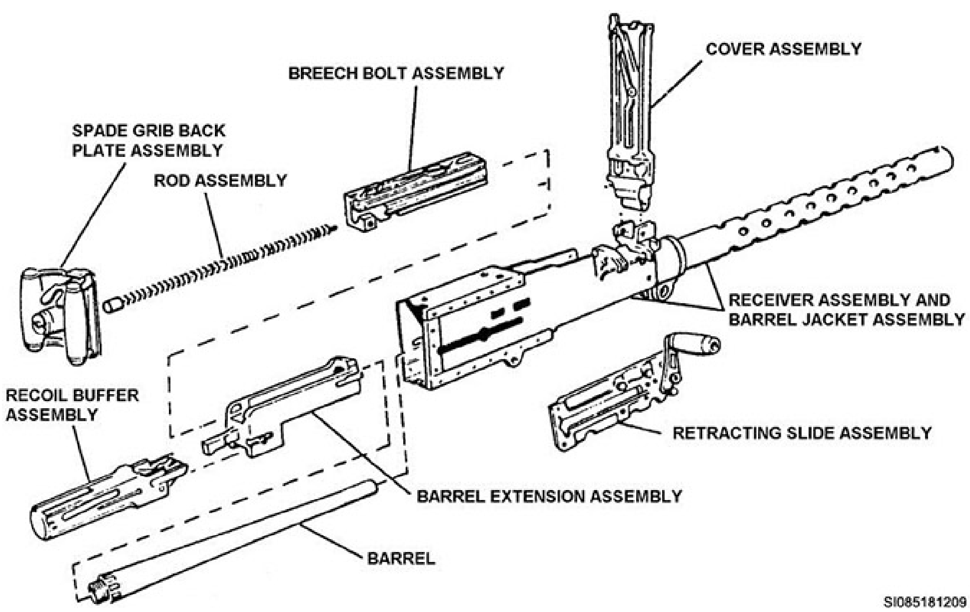


Figure 3–28. GAU–18 exploded view.

Barrel and barrel extension assembly

At the heart of the GAU–18 machine gun is the barrel extension assembly (fig. 3–29). This component joins the recoil buffer, breech bolt, and barrel together. A shank on the rear of tile barrel extension joins the buffer and barrel extension. The breech cam lock locks the breech bolt into the barrel extension. The back end of the barrel is threaded and fits into the front of the barrel extension. A barrel lock spring is installed to prevent the barrel from turning during operation.

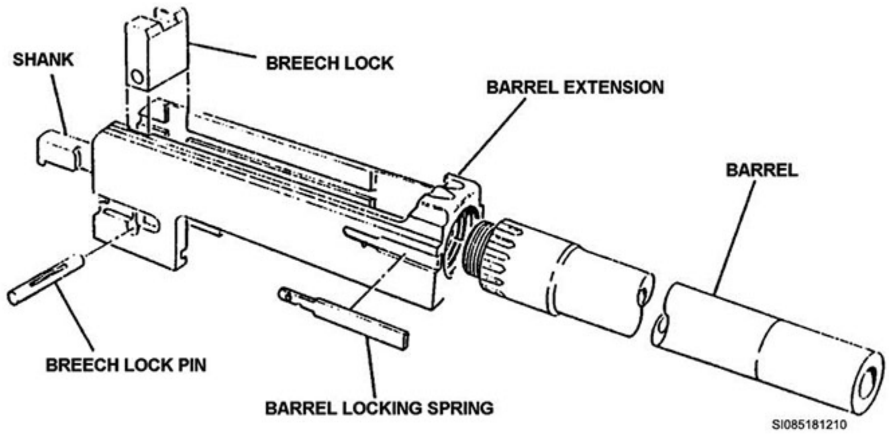


Figure 3–29. Barrel extension assembly exploded view.

Back plate assembly

The back plate assembly is installed on the rear end of the receiver. The spade grip is made up of handle grips and trigger. The back plate encloses the rear portion of the receiver and serves as a backstop for the breech bolt and recoil buffer. It may be configured with a spade grip or other user and/or trigger interface depending on application.

Rod assembly

The rod assembly is composed of a spring and rod that assists the return of the breech bolt to the battery (forward) position after a round has been fired. As the breech bolt moves to the rear of the gun during recoil, the spring compresses. The energy stored in the compressed spring is released to drive the bolt back forward.

Breech bolt assembly

Located in the barrel extension assembly is the breech bolt assembly (fig. 3–30). The breech bolt assembly and its components work together to guide and fire rounds of ammunition.

Recoil buffer assembly

The recoil buffer assembly (fig. 3–31) is used to cushion the recoil of the breech bolt caused by firing the weapon.

Cover assembly

The cover assembly is a cover fitted to the receiver assembly by a pin, which allows it to open like a door. The components located in the cover assembly assists the gun in feeding ammunition to the breech bolt assembly.

Retracting slide assembly

The retracting slide assembly is used to charge the weapon to begin its firing cycle. The round fired first is the round charged into the path that the breech bolt assembly takes. The retracting slide assembly can be mounted to either the left- or the right-hand side of the weapon depending on the required direction of ammunition feed.

Receiver assembly and barrel jacket assembly

The receiver assembly and barrel jacket assembly supports and protects the barrel assembly. The receiver assembly also serves as a housing and support for various assemblies of the gun.

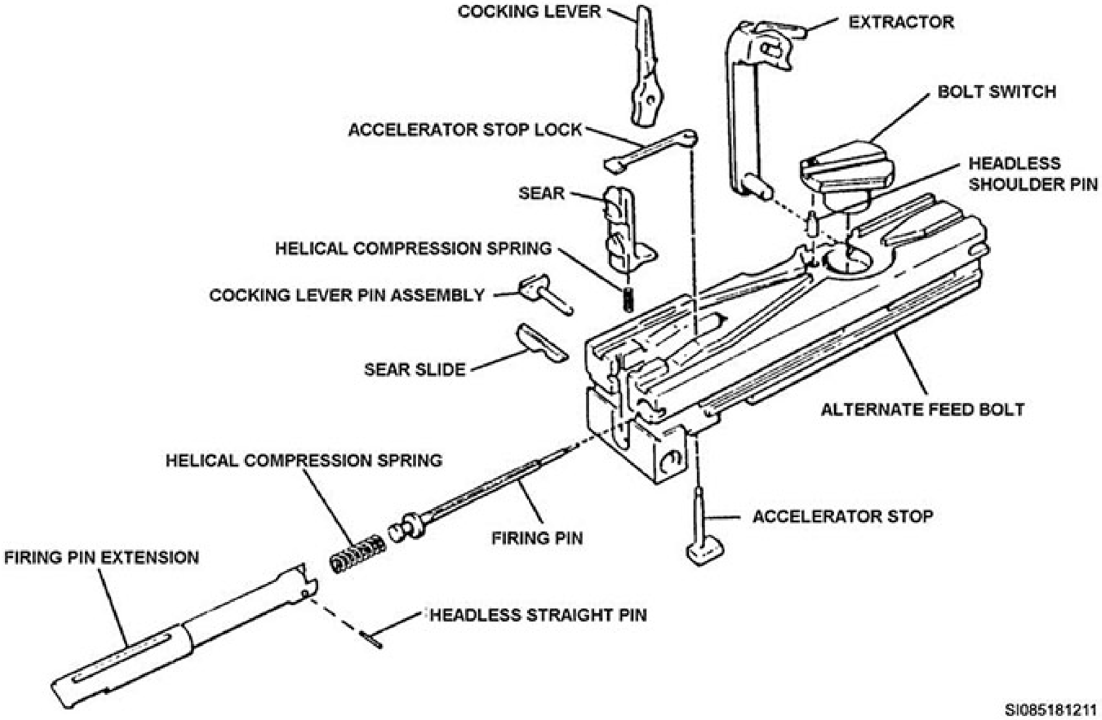


Figure 3–30. Breech bolt assembly exploded view.

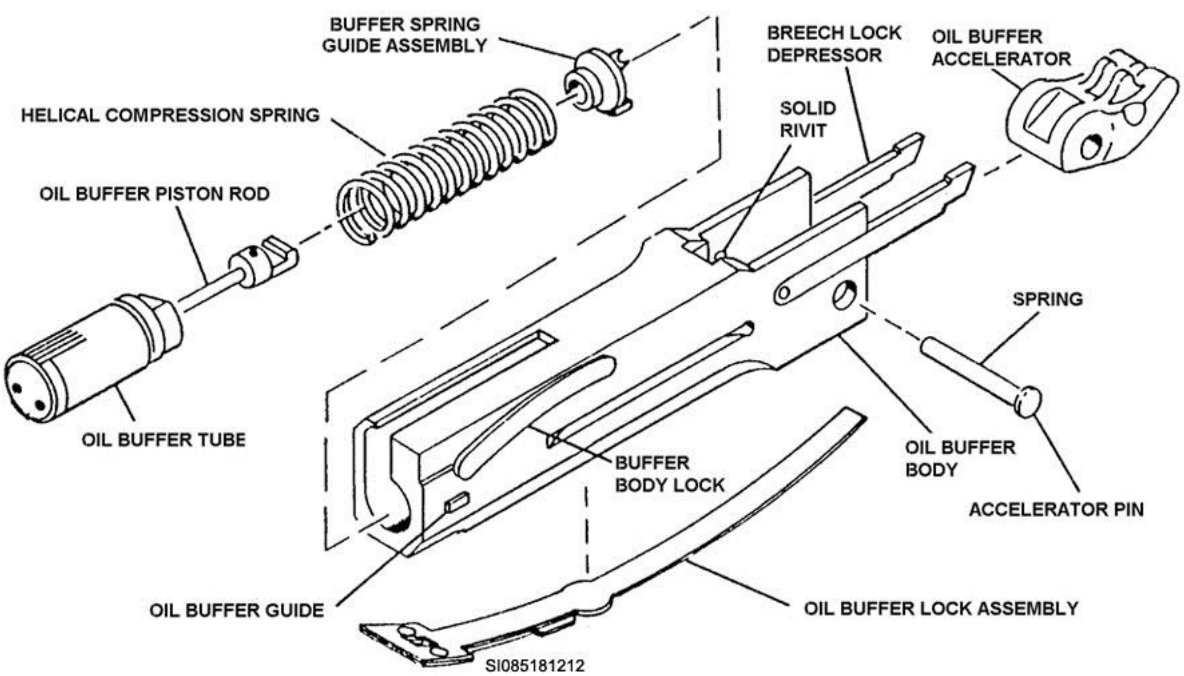


Figure 3–31. Recoil buffer assembly exploded view.

430. The M2A1 40 millimeter automatic gun

The M2A1 40 mm automatic gun was originally an Army gun the Air Force modified to use on the AC–130 gunship. The gun is a clip-fed, recoil-operated, air-cooled cannon (fig. 3–32). It weighs about 975 pounds and can fire up to 120 rounds per minute. The major components of this gun include the barrel assembly, a breech casing assembly, a breech ring assembly, an automatic loader assembly, and a recoil cylinder assembly.

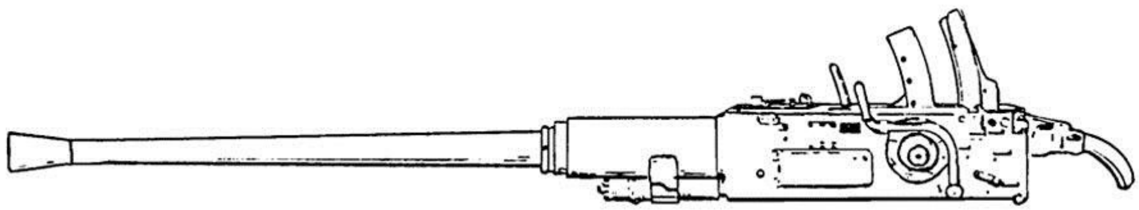


Figure 3–32. 40 mm automatic gun.

The barrel assembly is made up of a flash hider, barrel tube, recuperator spring, and necessary mounting devices (fig. 3–33). The flash hider is on the muzzle end of the barrel and was designed for two purposes. First, it minimizes the operator's temporary blindness caused from fire flash by diffusing the flash. Secondly, it reduces the hazard of being accurately observed by the enemy during night operations.

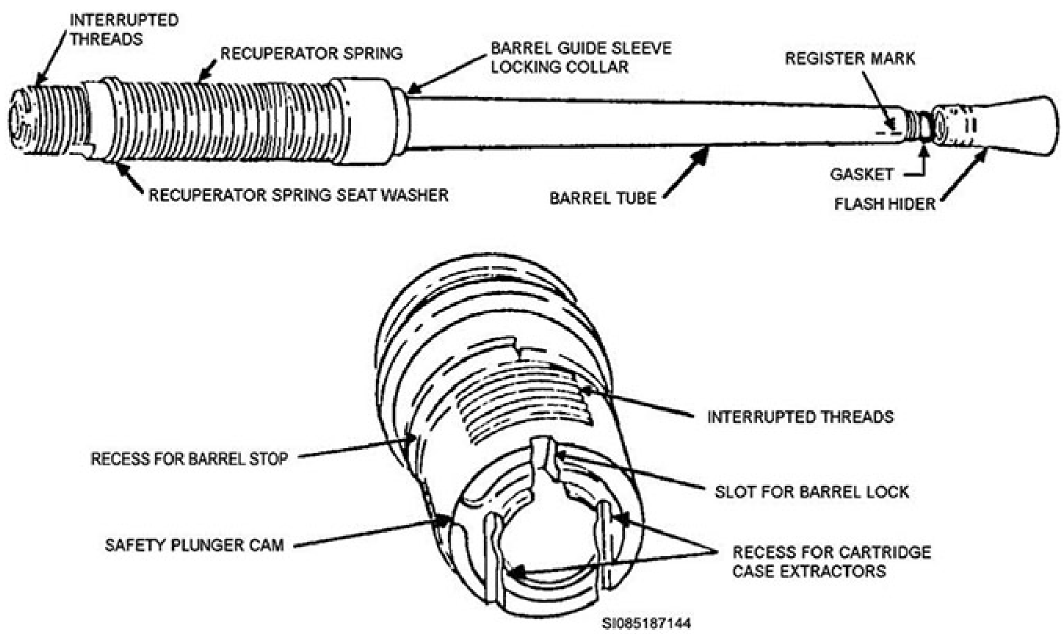


Figure 3–33. 40 mm gun barrel assembly.

A recuperator spring, installed near the breech end of the tube, working with the recoil cylinder, absorbs a portion of the rearward thrust caused by firing the gun. The spring is compressed during recoil. Energy stored in the spring is expended during counter recoil to force the gun back into battery position. The recuperator spring is held in compression against the recuperator spring seat washer and a surface inside the breech casing by a barrel guide sleeve and a barrel guide sleeve locking collar. The sleeve centers the barrel assembly in the breech casing and provides a bearing surface for movement during recoil and counter recoil. The recuperator spring seat washer is positioned on the tube by a shoulder, forward of the interrupted threads.

Interrupted threads at the breech end of the tube are screwed into mating threads in the front end of the breech ring. A vertical slot, cut in the breech face of the tube, is provided for the breech ring and barrel catch. The breech ring and barrel catch ensures the assembly corrects and provides a means for locking the barrel assembly in the breech ring. Vertical recesses on the breech face of the tube at each side of the chamber provide clearance for operation of the cartridge case extractors.

The breech casing assembly is made up of a breech casing and a firing mechanism (fig. 3–34). The breech casing is the housing or supporting unit of the various subassemblies of the gun. The recoiling parts of the gun slide in recoil and counter recoil in the breech casing. Four hinged or detachable covers provide access to the interior of the casing. The breech case firing mechanism consists of parts mounted on the left and right walls and the bottom sides of the breech casing. The breech case firing mechanism also includes a firing selector lever used to actuate the firing linkage. The mechanism also can be positioned to prevent gun firing or select single or automatic firing. A hand-operated lever, on the side of the casing, must be cocked to open the breech and prepare the gun for its first round.

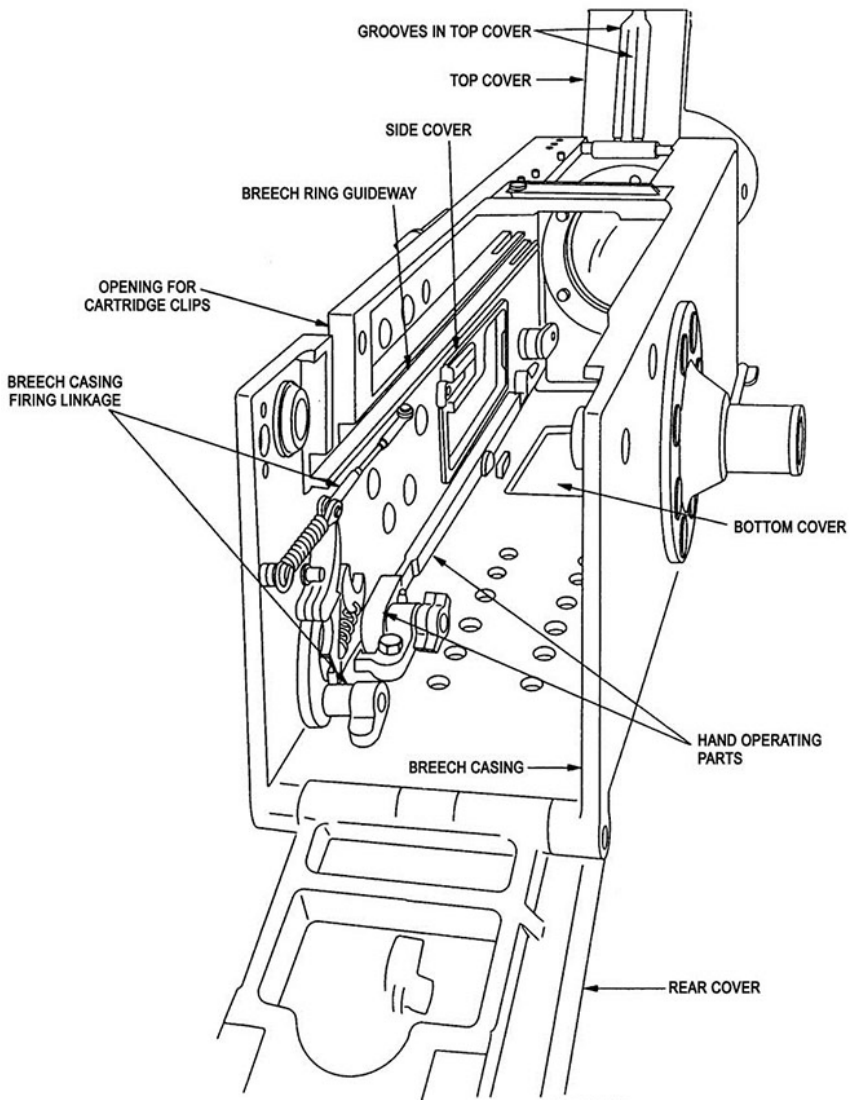


Figure 3–34. 40 mm breech casing assembly.

The breech ring assembly (figs. 3–35 and 3–36) and its components are responsible for holding the barrel assembly in the gun, keeping it in a position where it cannot be rotated or removed, and acting as a safety device to prevent gun firing whenever the barrel assembly is removed or improperly installed. By moving up and down inside the breech casing (working from recoil action), it also locks and unlocks rounds for firing and provides for their extraction and ejection.

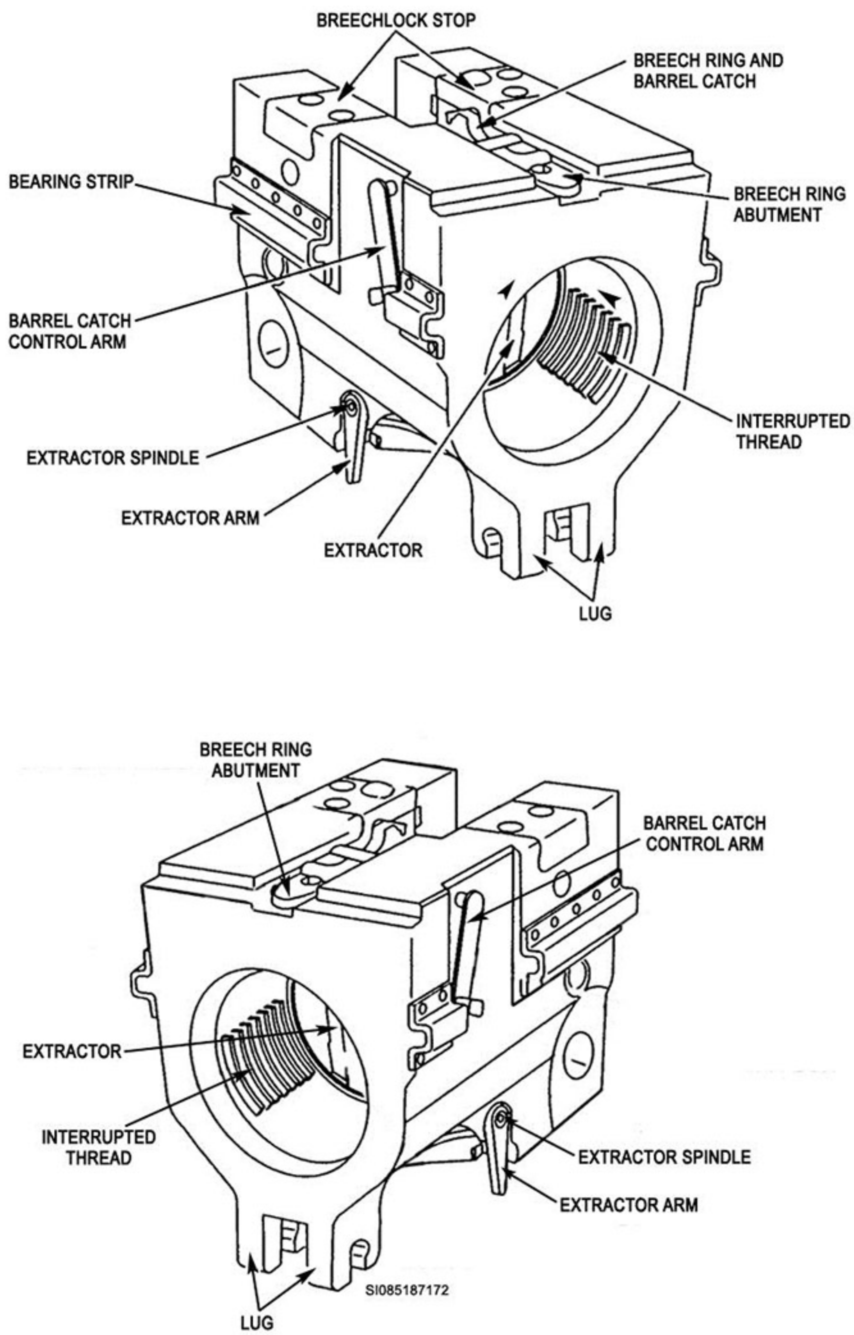


Figure 3–35. 40 mm gun breech ring assembly.

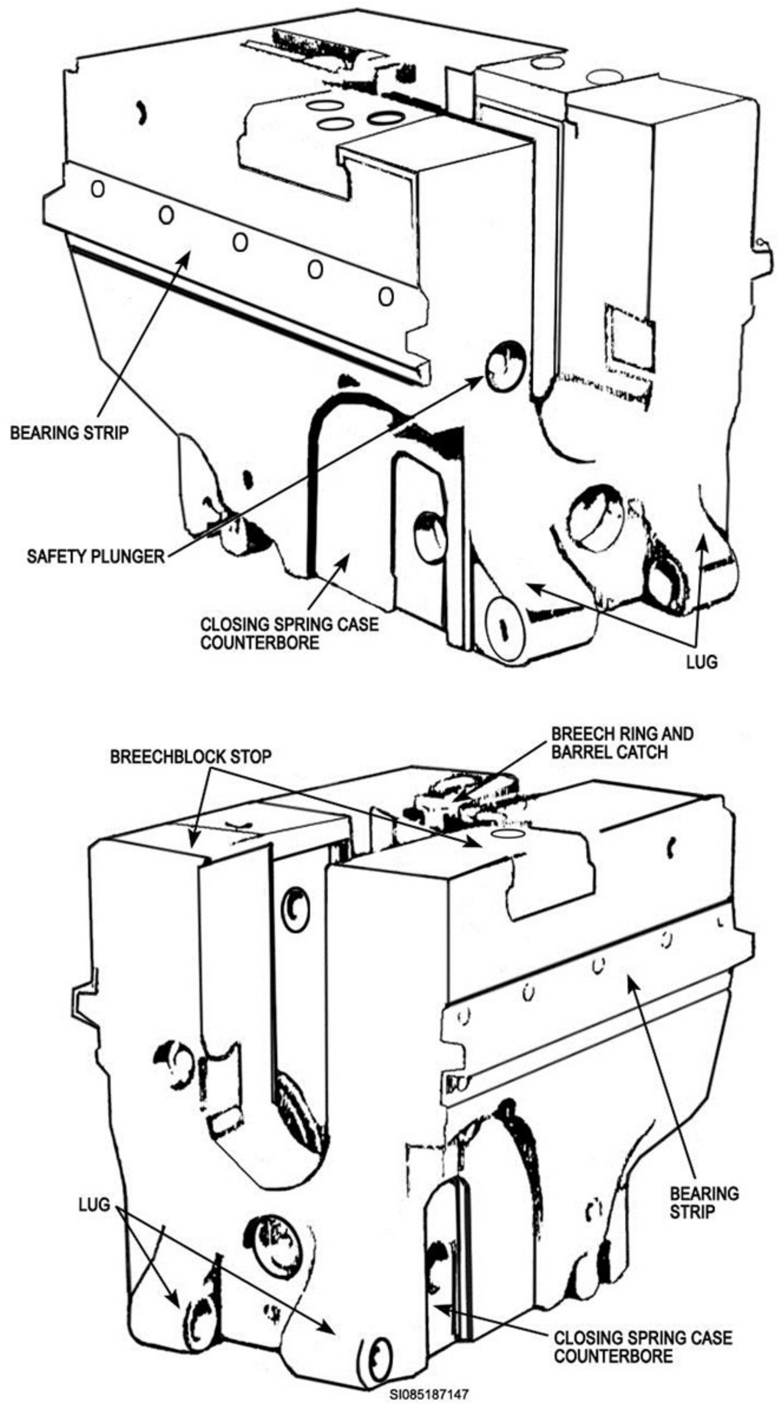
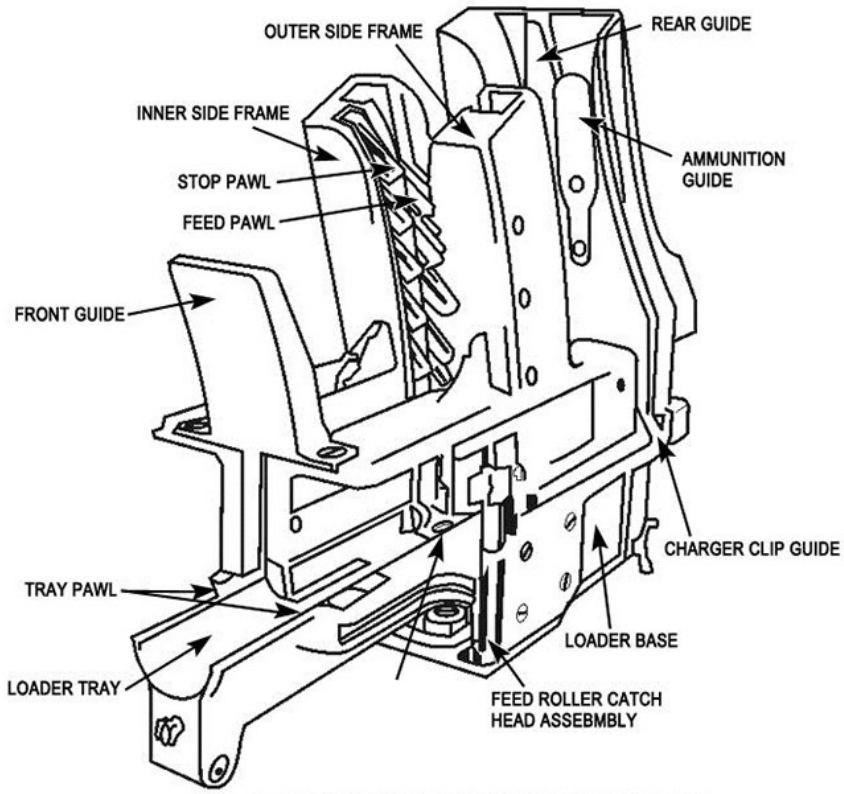


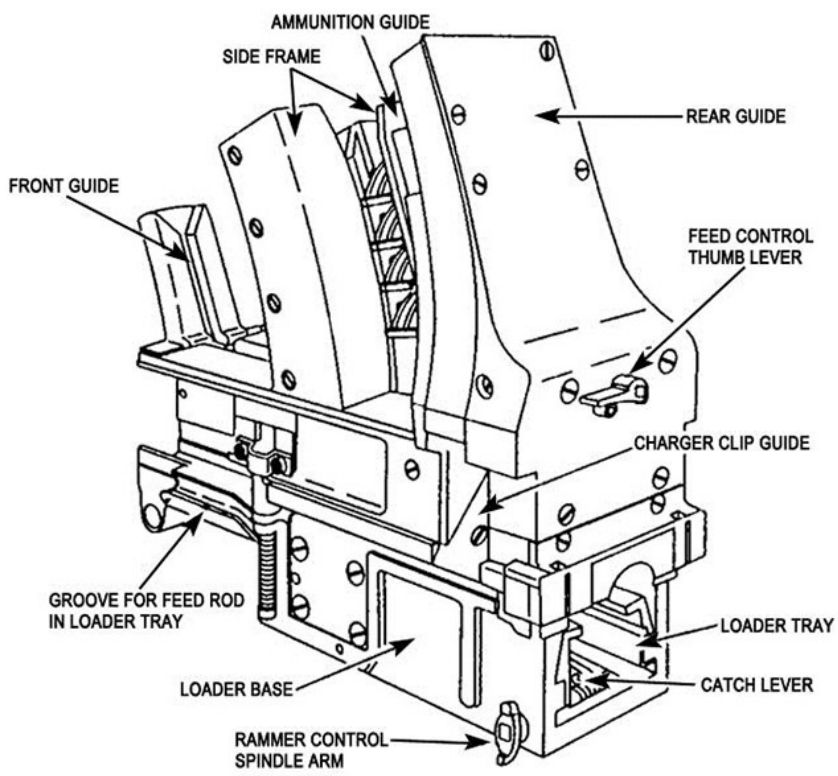
Figure 3–36. 40 mm gun breech ring assembly (cont'd).

The automatic loader assembly is both a cartridge magazine and a loading device (fig. 3–37). Cartridges in clips of four rounds are inserted in the top of the loader. After the clips are stripped from them, rounds are fed individually to a loader tray where they are rammed into the chamber of the barrel to be fired.

The recoil cylinder is mounted under the tubular front end of the breech casing. It works in conjunction with the recuperator spring on the barrel assembly to absorb the energy of the recoil, thereby slowing down and controlling rearward movement of the gun.



LEFT AUTOMATIC LOADER ASSEMBLY, FRONT VIEW



LEFT AUTOMATIC LOADER ASSEMBLY, REAR VIEW

Figure 3–37. 40 mm gun automatic loader (left front and rear view).

431. The M137A1 105 millimeter howitzer

The M137A1 105 mm howitzer is used only in a trainable mount, mounted in the AC–130 gunship to provide air-to-ground support during combat operations (fig. 3–38). This weapon is the only gun in the Air Force inventory that is a manually fed, single-shot weapon. Each round is individually placed in the breech at the back of the gun before firing. Once it has fired, an aerial gunner must manually unlock the breech and remove the expended round from the gun. The massive size of the weapon and the size limitation of an aircraft mount preclude the use of an automatic loading system. The 105 mm gun consists of three major components—the cannon assembly, recoil mechanism, and cradle assembly.

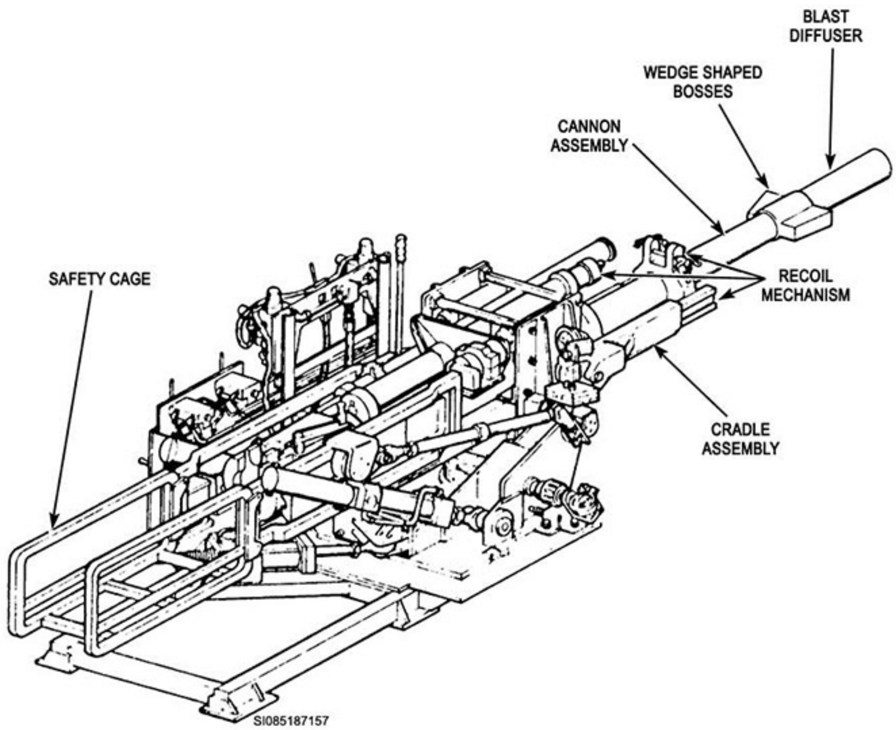


Figure 3–38. 105 mm howitzer.

Cannon assembly

The cannon assembly consists of a tube, breech mechanism, and blast diffuser. The rifled tube is threaded on the muzzle end to accept the blast diffuser and on the breech end to accept the breech mechanism. The blast diffuser is used to suppress the muzzle blast created when the gun is fired. It is also equipped with wedge-shaped bosses to act as secondary recoil stops in the event of a recoil mechanism failure. The breech mechanism holds the round of ammunition, fires it, and extracts it.

Recoil mechanism

The recoil mechanism is composed of a sleigh assembly, recuperator assembly, and recoil cylinder. These three components along with the cannon assembly are known as the recoiling parts of the gun. The sleigh assembly is what holds all of the components together, and its rails hold everything in the cradle assembly. The recuperator assembly is at the top, the cannon in the center, and the recoil cylinder at the bottom of the sleigh assembly. The recoil mechanism absorbs the energy and shock of firing by gradually checking and stopping the rearward motion of the recoiling parts. It returns them into the battery position during counter recoil, provides proper buffing action to prevent “slamming,” and holds the parts in the battery position with the force of compressed nitrogen gas in the recuperator cylinder.

Cradle assembly

The cradle assembly is simply a welded aluminum framework where all of the recoiling parts are installed. It also adapts the gun components to the trainable gun mount. This gun is recoil operated and its operation is similar to that of the 40 mm gun. If you need more information on the 105 mm gun, refer to TO 11W1–33–7–2.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

428. M240 machine gun system

1. Which side is ammunition fed from when using the M240 machine gun?

2. How would you clear a loaded M240?

3. How many steps are there to the M240 firing cycle, and what are they?

429. GAU–18 machine gun

1. How many steps are in the GAU–18 firing cycle and what are they?

2. During the counter recoil step of the firing cycle, what component forces the bolt, barrel extension and barrel back to the battery position?

3. What is the function of the barrel lock spring?

4. What component is used to cushion the recoil of the breech bolt caused by firing the weapon?

5. What component serves as a housing and support for various assemblies of the gun?

430. The M2A1 40 millimeter automatic gun

1. How is the 40 mm automatic gun fed?

2. What gun components absorb a portion of the rearward thrust caused by firing the gun?

3. What types of firing modes can be selected on the gun?

4. What assembly holds the barrel in the gun?

5. What actions are the six stages of gun operation divided into?

431. The M137A1 105 millimeter howitzer

1. What are the major components of the gun?

2. What is the purpose of the blast diffuser?

3. What are all of the recoiling parts installed?

3–4. Gun Associated Aircraft Systems

Guns are no different than any other major component of the weapons system of an aircraft. They do not operate independently; they require associated support and control systems to perform their functions so that the guns can serve their functions within their aircraft's weapon system. In this section, we are going to look at the peripheral support systems critical to aircraft mounted guns operation.

432. Aircraft ammunition handling systems

Aircraft ammunition handling systems do exactly what their names imply; they handle an aircraft's gun ammunition. They are responsible for the storage and feeding of unfired rounds to the aircraft guns. Depending on the particular system, ammunition systems may also provide storage for spent cases and stripped links. In this lesson, we take a look at the different system designs, find out where they are used, and learn about their operation.

Currently, there are three types of internal systems in use: link-fed, linkless, and linear-linkless. Linkless systems have been around for some time and are used in all of our tactical fighter aircraft. The newest of the three is the linear-linkless system, used in the F–15E, F–22, and AC–130 aircraft. Let's begin this discussion the link-fed system.

Link fed

Link-fed systems normally consist of ammunition stowage boxes or cans and feed chutes such as the one shown in figure 3–39. Ammunition boxes or cans normally hold 100 to 4,500 rounds of ammunition, depending on the particular system. They are normally loaded by hand, opening from the top or side to accommodate ammunition loading. You can also see some systems have their ammunition laid in rows—one on top of the other. This, too, depends on the system.

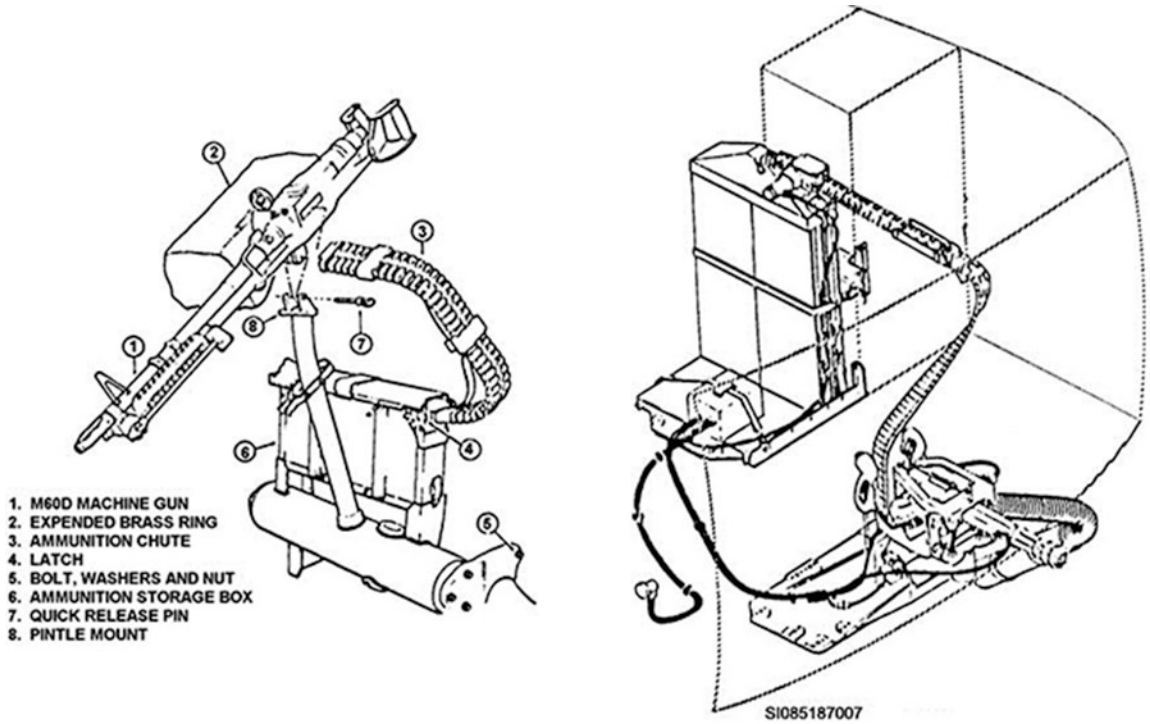


Figure 3–39. Link-fed system (typical).

Linkless

As we mentioned earlier, linkless ammunition systems are contained in all tactical fighter aircraft. The purpose and design of these systems is basically the same. They are normally comprised of an ammunition drum and conveyor system. The system's ammunition drums (fig. 3–40), just as ammunition cans, come in various sizes and have different capacities. They provide storage for both live rounds and spent cases. Ammunition is stored in the drum in longitudinal partitions and is moved longitudinally from the entrance unit to the exit unit by action of the inner drum. Entrance and exit covers, or end covers, contain the necessary gearing and sprockets to transfer ammunition into and out of the drum. These covers may or may not be interchangeable, depending on the particular system. The drum is driven by a flexible or rigid shaft from a gear box or by the exit cover being meshed to a drum drive.

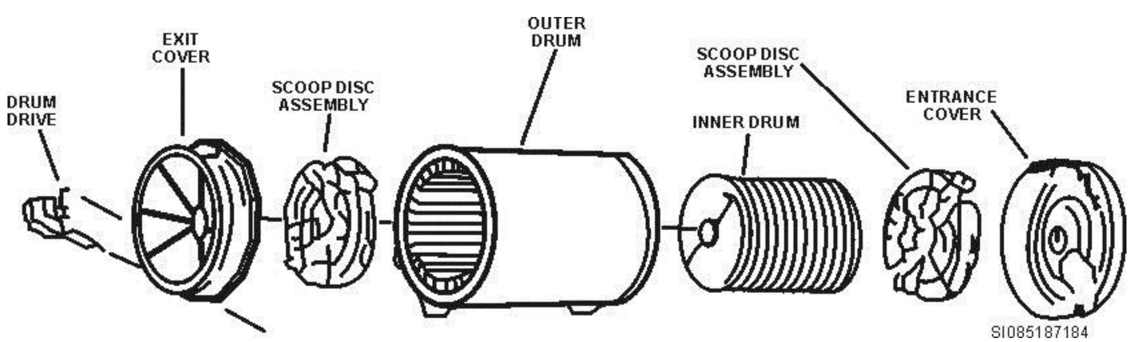


Figure 3–40. Ammunition drum (typical).

The conveyor system transports rounds from the drum to the gun and back to the drum (fig. 3–41). This system is made up of the ammunition chutes and various units attached to both the gun and drum. The ammunition chutes and the various units facilitate system loading and unloading, moving live rounds and spent cases, and conveyor element movement throughout the system. The ammunition chutes are constructed in interlocking segments like the chutes of the link-fed systems.

Depending on the particular system, you may find several of these chutes in a single system. They all serve as routes for empty conveyor elements or elements carrying live rounds and spent cases to follow during loading/unloading and gun firing operations.

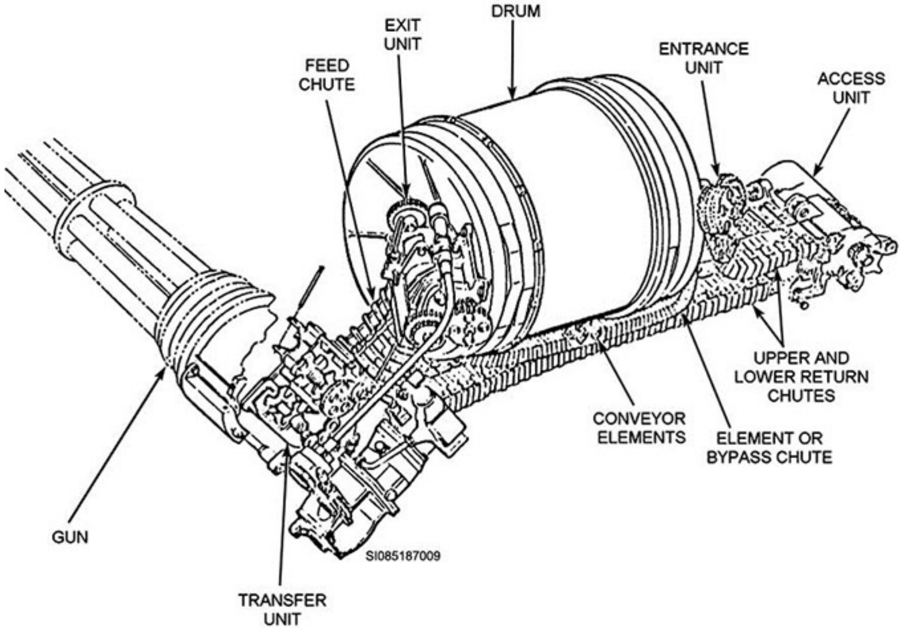


Figure 3–41. Conveyor system (typical).

No matter how many chutes are in a system, they can be divided into three types with their names depicting their functions: a feed chute, return chute, and element or bypass chute. Feed chutes are connected between the drum and gun. Theses feed chutes provide the path for the conveyor elements to transport rounds from the drum to the gun. The functions of return chutes may vary, but basically, they guide rounds and spent cases from the gun back to the drum. Systems with two return chutes use the second chute to guide rounds from an access unit to the drum during loading operations (fig. 3–42).

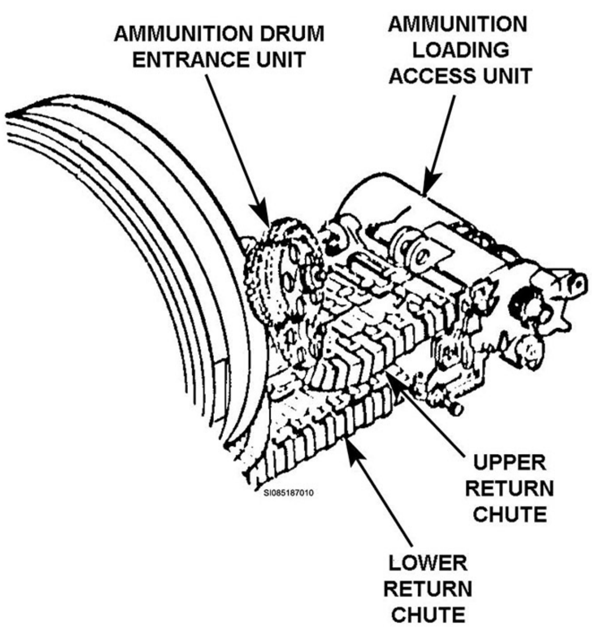


Figure 3–42. Dual return chute.

The element or bypass chute is connected between the entrance and exit units and provides a path for conveyor elements only to bypass the drum. These elements are *never* pass through the drum. The elements are shaped to cradle the rounds and are normally joined together by removable hinge pins or by bolts and nuts to form a continuous belt of elements throughout the entire system (fig. 3–43). The elements are kept in line in the chutes by tabs used to engage guides in the chutes and various units. Some systems have a tension equalizer that keeps the belt of elements at the same tension throughout the entire system.

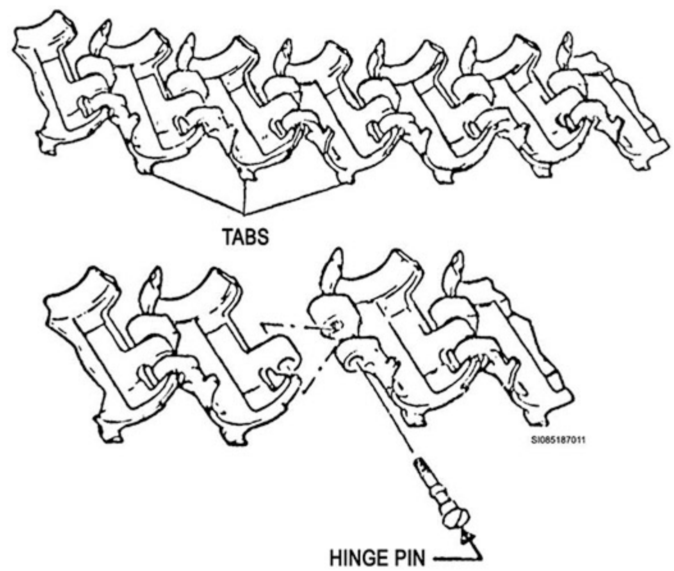


Figure 3–43. Linkless system conveyor elements.

The remainder of the conveyor system is composed of various units with specific functions. The entrance unit is attached to the aft end of the ammunition drum. It transfers ammunition, being loaded or cleared and spent cases, from the system conveyor elements into the drum assembly. It is gear driven by the drum. An exit unit attaches to the opposite end of the drum, and its purpose is to remove rounds from the drum and place them in the conveyor elements heading for the gun. On most systems, a last-round switch is mounted on this unit. This switch is tied into the gun firing control circuits. As long as live ammunition is passing the switch, it remains CLOSED and permits system operation. When the system is nearly fired out and spent cases, normally two or three, start to reach the exit unit, the switch is triggered by missing ammunition projectiles and OPENS to prevent further system operation. The F–15 aircraft system has a loader adapter attached to its exit unit to facilitate ammunition loading and unloading. It was designed in this fashion because of the way the system is oriented in the aircraft. Additionally, its last-round switch is located on the handoff unit.

Two systems, namely the F–16 and A–10, are equipped with access units. These units are located where loading and unloading of the gun system takes place. Also on the F–16 is a ground mechanical power receptacle and gear box used for cycling the ammunition handling system during loading.

Another unit found in most gun systems is the transfer unit. On the A–10, it is referred to as the turnaround or transfer unit. This unit normally removes rounds from the conveyor elements and feeds them into the gun. It will also pick up unfired rounds and spent cases and place them back in conveyor elements for their return trip to the drum. The A–10’s turnaround unit removes rounds from elements and puts them in the transfer unit to make sure the rounds get into the gun. On the return trip to the drum, the transfer unit picks up rounds from the gun and gives them to the turnaround unit to put them into conveyor elements.

The F–15 makes use of both the transfer and feeder units. Their functions are as their names imply. The transfer unit transfers rounds from the conveyor elements to the feeder so they may be fed into the gun. In addition to these two units, the F–15 also has interface and handoff units. Both of these units are in the return route of cleared rounds or spent cases. The interface unit lifts spent cases or unfired rounds from the conveyor belt and hands them off to the handoff unit where they are placed in an element and routed to the entrance unit. Figures 3–44 through 3–46 show the guns and ammunition handling systems installed in particular aircraft configurations.

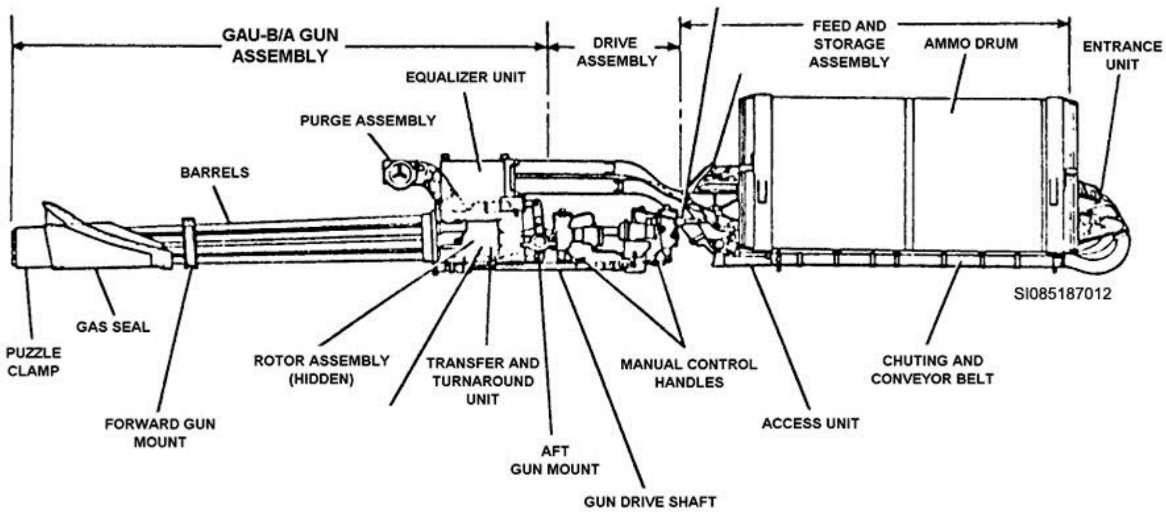


Figure 3–44. A–10 internal gun system.

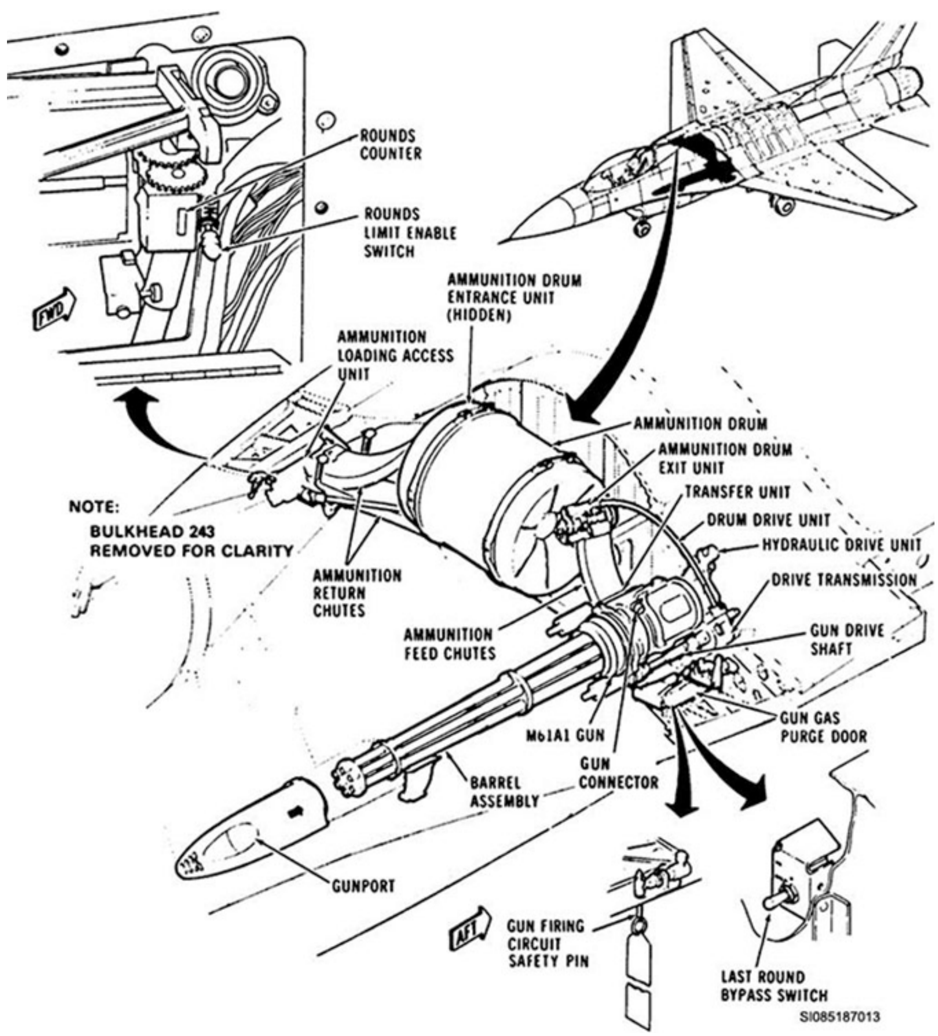


Figure 3–45. F–16 internal gun system.

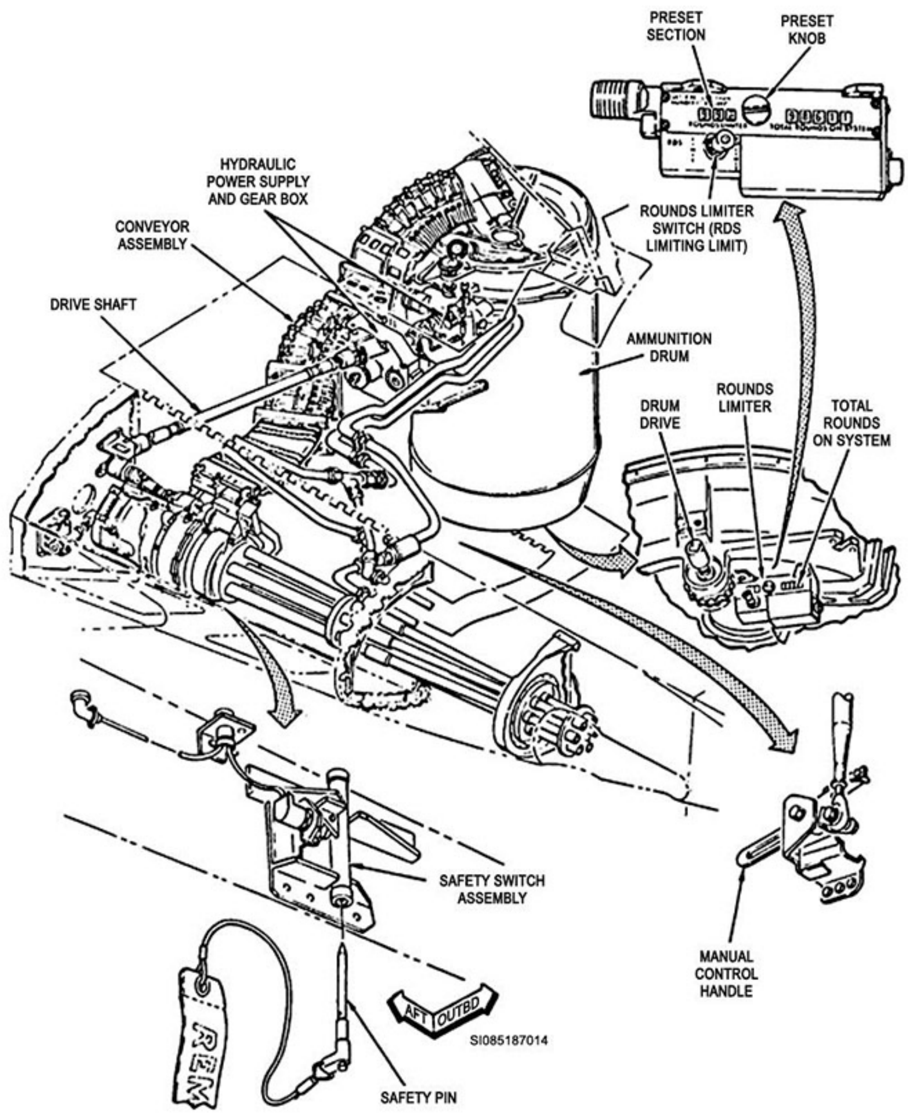


Figure 3–46. F–15 internal gun system.

Linear-linkless

Traditional drum systems use a round drum where rounds ride in tracks and are pushed along by use of a double helix auger. In some aircraft applications, this kind of system is not a viable option so engineers developed the linear linkless system. In these systems, the rounds are stored in a large serpentine trackway inside of a large outer container. The F–15E, F–22, and the AC–130 use a linear linkless system (fig. 3–47) to store live and expended rounds. The mechanical portions of these systems were designed very similar to (in most areas) the original drum fed systems. The method of ammunition storage is the main difference between the linear-linkless and the original linkless systems. Chuting in the conveyor systems are basically the same as other systems.

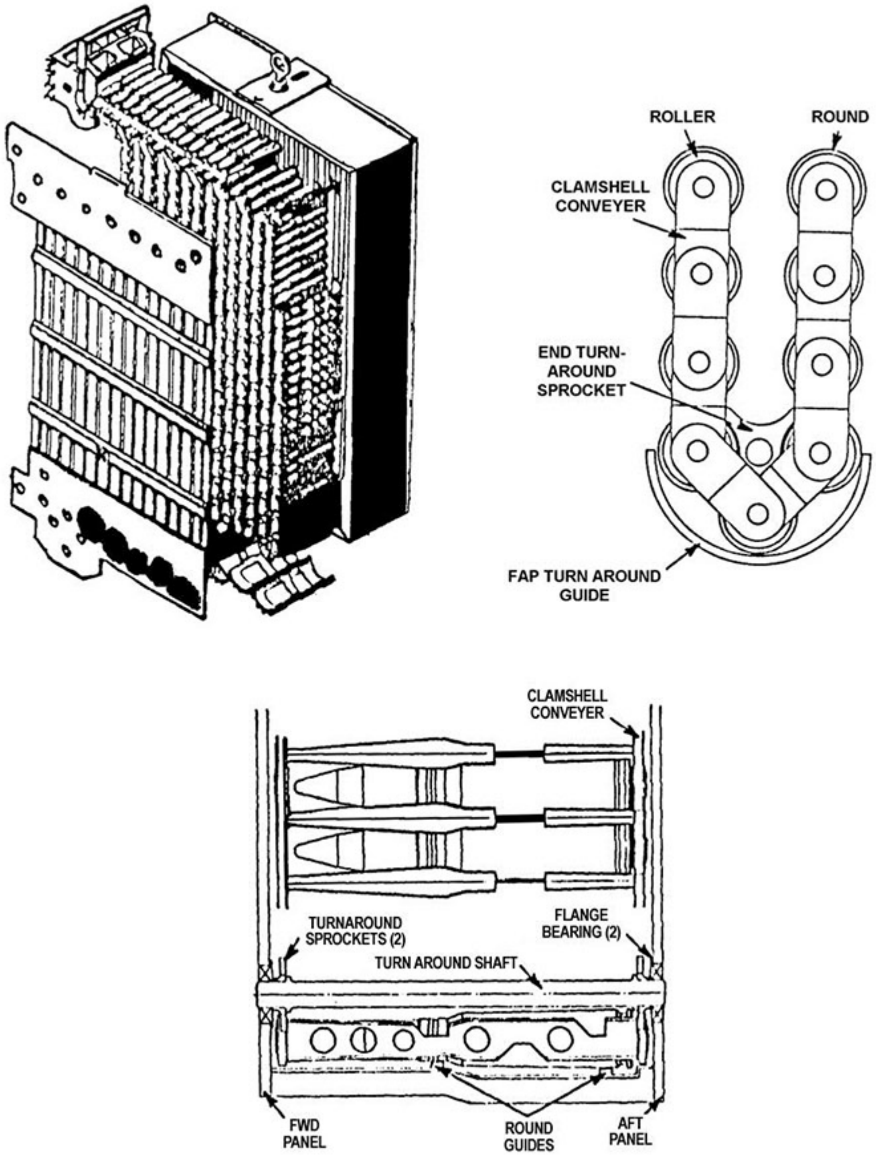


Figure 3–47. F–15E linear linkless system.

433. Gun system controls

We've looked at aircraft guns and ammunition handling systems and their operation. Now we need to take a look at the four aircraft systems used to control gun system functioning: the hydraulic system, the gun gas purge/scavenge system, gun firing ports, and the electrical control system.

Hydraulic system

Almost all aircraft gun systems operate from hydraulic power converted to mechanical power through a hydraulic gun drive system. The gun drive system causes the gun and its ammunition system to rotate. The initial hydraulic power is usually derived from the aircraft's utility hydraulic system. The hydraulic pressure is controlled by the trigger activation (aircraft with single fire rates) or a gunfire rate switch selection (aircraft with dual fire rates) in the aircraft cockpit. This gunfire rate switch, normally HIGH and LOW positions, controls a two-speed flow control valve in the hydraulic system. The positioning of the switch directly relates to the amount of hydraulic pressure applied to the gun hydraulic drive system. The hydraulic system may also control the opening of the gun gas purge/scavenge doors or the gun firing port door, depending on the design of the system.

Gun gas purge/scavenge systems

During the operation of aircraft gun systems there is a buildup of "gun gas." These gasses are the result of burning propellant in the cartridges and vaporized lubricants from the gun itself. These gases pose two problems—an explosive and a corrosion hazard.

Hazard	Problem
Explosive	Without adequate ventilation, the collection of gun gases could ignite and result in serious damage to the aircraft.
Corrosion	The gasses themselves are corrosive to certain metal alloys and electrical equipment. They also contain vast quantities of soot and carbon compounds that can become trapped in lubricants, degrading their effectiveness.

The gun gas purging and scavenge systems provide ventilation to eliminate these gases from the gun bay and ammunition handling systems compartments.

Gun gas scavenge systems have two different designs. With the first, air enters the gun compartment through an air scoop to collect ram air to force gun gas to be expelled through strategically located louvers in and around gun and drum bays. The second type uses a scavenge door opened by hydraulic pressure, and airflow is used to clear gases. The door is designed so the application of hydraulic pressure will close it. Spring tension is used to retract the actuator piston to open the door. A loss of electrical signal or utility hydraulic pressure will cause the door to open, providing fail-safe gun compartment scavenging. The door is maintained in a closed position at all times when electrical power and utility hydraulic pressure are applied to the aircraft. The door opens when the trigger is depressed and remains open for approximately 30 seconds after the trigger is released to make sure all accumulated gas is venting.

Gun firing port

The F–22 makes use of a moveable door covering the firing port for the projectiles to exit the aircraft (fig. 3–48). The door remains closed during normal flight and is opened only during operation of the gun. This port door serves two equally vital purposes—maintaining aerodynamic and low observance integrity.

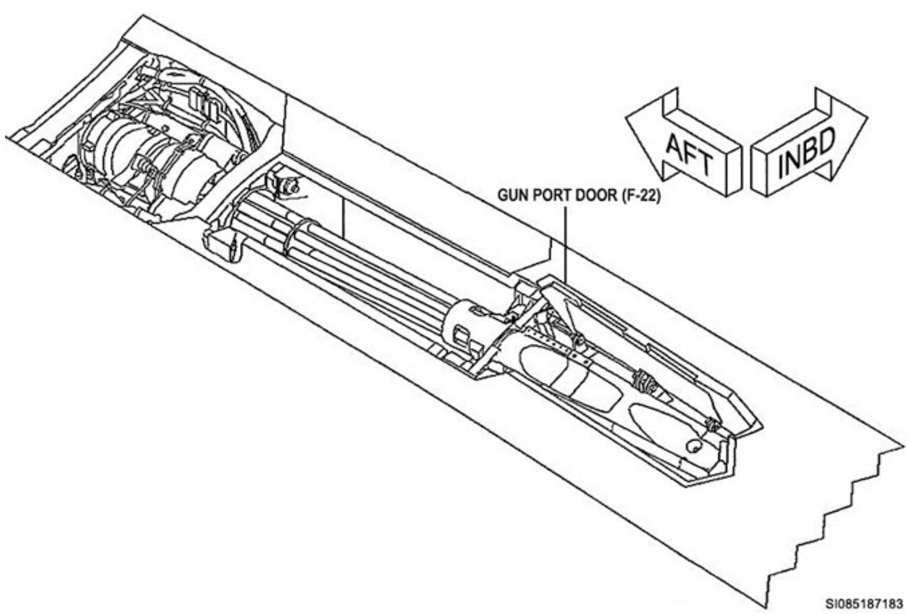


Figure 3–48. F–22 gun port door.

All aircraft gun systems obviously require an exit path for rounds to travel to their targets. These usually take the form of a “gun port” or a hole in the surface of the aircraft. These structures, while necessary for the weapons to function, can cause a great deal of aerodynamic drag. One of the advantages of the F–22 the ability to super-cruise since this is vital for the aircraft to have as aerodynamic a shape as possible to maximize performance. The gun port door optimizes the aerodynamics of the aircraft by covering the gun port when the gun is not in use. The second function of the gun port door is to maintain low observance integrity. The barrels of gun systems and the clamping systems used to keep barrel clusters aligned are excellent reflectors of radar energy. In a stealthy aircraft, it is unacceptable to expose these radar reflective surfaces to enemy observation. The gun port door covers these components to eliminate their ability to compromise the low radar observability of the F–22.

Like the gun gas purge and scavenge systems, if this door fails to operate properly, it will prevent the gun system from operating.

Electrical control systems

In this electrical control system, an electronic control unit, sometimes referred to as a gun control box, provides the circuitry for safe control, operation, and clearing of the gun. It also provides power and sensing for all electrical components of a gun system. Electrical power is supplied from the aircraft’s 28 VDC system and, in the gun control box, may be converted to VAC, depending upon the particular aircraft system. Gun system operation is initiated by making the appropriate cockpit switch selections plus activation of the MASTER ARM switch to ARM and depression of the trigger switch. Depressing the trigger will cause activation of the gun hydraulic drive system, and generated output signals are sent to the gun for firing. When the trigger is released, the gun firing cycle will stop and the clearing cycle will begin. The electrical control system may also provide for limiting the number of rounds to be fired from a gun system.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

432. Aircraft ammunition handling systems

1. Name the three types of internal ammunition handling systems.

2. What are the major components of link-fed ammunition handling systems?

3. How are link-fed systems normally loaded?

4. What are linkless ammunition handling systems composed of?

5. How is ammunition stored and moved in an ammunition drum?

6. What are the purposes of ammunition chutes in a linkless ammunition system?

7. When do the elements in linkless systems pass through the drum?

8. Where are the interface and handoff units of the F–15 ammunition handling system located?

9. What is the main difference in the linear-linkless and original linkless systems?

433. Gun system controls

1. From where is the gun's hydraulic power usually derived?

2. What is the purpose of gun gas purge/scavenge systems?

3. How long do purge doors normally stay open after trigger release?

4. What are the two primary purposes of the gun firing port door on the F–22?

5. What normally happens if a gun gas purge door fails to open?

3–5. Gun System Maintenance

Maintenance of aircraft gun systems falls into two categories—preventive and corrective. Preventive maintenance, as the name implies, is the maintenance performed to prevent an unsatisfactory condition from occurring. Corrective maintenance is the maintenance required to correct an unsatisfactory condition. Any failure to perform the required maintenance on a gun system can result in a malfunction. The maintenance required to return a malfunctioning gun system to serviceable condition is usually greater than the normal maintenance required to prevent the malfunction in the first place. Granted, all malfunctions cannot be prevented by maintenance, but the majority of them can. Therefore, in this section we take a look at both maintenance concepts so you know the type of maintenance necessary for the job you are doing.

434. Preventive maintenance

Tools, equipment, and spare parts are issued to each using organization to keep guns and gun systems in a serviceable condition. Gun systems must be inspected for serviceability, cleanliness, and proper lubrication and function.

Inspecting

Systematic inspection is a part of preventive maintenance and we must inspect our gun systems regularly to prevent operational failures. Normally, a visual inspection is done to determine the general condition of a gun or system before beginning the actual TO inspection. The first thing you must do before beginning gun system maintenance is to make sure the gun is cleared of all live rounds of ammunition and in a safe condition. This is normally done by depressing the gun clearing sector or safety sector and rotating the barrel cluster a number of times as designated by the TO. Some guns will require you to cock them a number of times; it depends on the design of the gun. Normally, a safety device such as a clearing sector hold-back tool is installed during this operation.

After safing the gun and system, you should look over the interior and exterior portions. Your objective is to spot and make a note of any item damaged, missing, or needing lubrication. Next, you will disassemble, clean, and inspect the major subassemblies of the system. When you complete this inspection, you will have a list of parts identified as worn, bent, broken, missing, wrong part number, or needing lubrication. In addition to having inspected the systems for the things we just mentioned, you will also need to check other inspection points regularly. They include:

- All parts for cracks, burrs, wear, cleanliness, and proper lubrication.
- All electrical components and connectors for looseness, wear, corrosion, and breaks in soldering.
- Bolts, screws, and quick-release pins for serviceability.
- Mounting holes for elongation.
- Gears for chips, wear, improper tooth contact, and lubrication.
- Springs for weakness and other damage.
- Bearings for pitting, damaged races, wear, and lubrication.
- Applicable units for proper timing, adjustments, and clearances.

Cleaning and lubricating

Cleaning is a part of preventive maintenance and must always be done on specified time schedules or after firing, and *before* inspecting the individual parts. Rust, dirt, grit, gummy oil, and moisture will cause the parts to wear very rapidly, thereby leading to an unserviceable system or gun. To prevent wear, you should understand the approved methods of cleaning and lubricating the gun and system. Cleaning must be done according to the applicable TO. The TO specifies the type of cleaning materials to be used on the various parts of the weapon, the method of application, and the parts not to be cleaned because of certain peculiarities in manufacturing. Immediately after cleaning, dry parts thoroughly to remove the cleaning solutions or residual moisture and then apply a light coat of preservative lubricating oil.

Lubrication, like cleaning and inspecting, is also considered preventive maintenance. You should lubricate the larger portion of the gun with preservative lubrication, being sure to apply it sparingly. Excessive oil holds grit and foreign matter to the gun. As a result, it may cause a malfunction or stoppage. In any case, the abrasive action of the grit and foreign matter will cause excessive wear of the moving parts. Excessive oil or grease left in the chamber will raise the breech pressure to a hazardous point when the gun is fired and will result in excessive wear at the breech face of the barrel. Failure to lubricate components as required will eventually lead to extensive corrective maintenance.

The gun system can be kept in top operating condition with proper maintenance and servicing. All parts or assemblies not meeting the inspection requirements as outlined in the applicable maintenance TO must be replaced with a like serviceable part. Parts such as self-locking nuts, bolts, screws, cotter pins, and spring pins are replaced after one-time use. The only modification you will probably perform is installing new and/or improved parts when directed to do so by time compliance technical orders (TCTO). Actual changes in the design, machining, and modification of parts and accessories are normally made by depot personnel or the manufacturer.

Operational and functional testing

In Unit 2, we emphasized that these tests or checks are detailed procedures used to functionally verify the reliability and safety of an aircraft's weapons system. Remember, each subsystem has its own operational and functional check procedures. These checks, when performed on gun systems, are of two types: mechanical and electrical. Because of the extremely fast acceleration and stopping and the tolerances of certain system components, checkout must be done to keep the systems operating properly. To check for mechanical functioning of the gun systems, you normally load them with dummy rounds. Then cycle the rounds through the entire system, at the same time checking for proper system mechanical functioning. Cycling the system may be done manually or hydraulically, depending on the TO procedures. If any binding occurs or any abnormal symptoms are encountered during the cycle test, you must stop immediately, isolate the cause of the malfunction, and then correct it. Another cycle test will be required after repairs are made.

Electrical checkout of gun systems uses gun system test sets, multimeters, and voltage detectors. These types of checkouts are normally completed on a scheduled basis and when performing troubleshooting or fault isolation procedures. Their frequencies are established in the applicable aircraft –6 inspection requirements TO. When using an electrical test set, its operation is outlined in the TO and you are cautioned to follow each step carefully and completely. Failure on your part to do so can result in damaging the equipment or possibly even injuring yourself. During these checks, you are checking for proper operation of the gun electrical control system and all associated electrical components, the hydraulic control system, and the operable portions of the gun gas purge/scavenge systems. The applicable TO gives you step-by-step procedures. Follow them!

435. Corrective maintenance

When using any gun, it is very important to make sure it hits its intended target. Aircraft guns are no exception.

Harmonization

It is essential that a gun system provide the most accurate on-target delivery of ammunition possible. Boresighting makes this possible. Boresighting is not an everyday occurrence on the flightline. Basically, the requirement for performing boresight procedures are based on four main conditions: (1) aircraft hard landings, (2) excessive "G" loads placed on the aircraft or unusually violent maneuvers with the aircraft, (3) replacement of certain gun components, (4) and pilot reported discrepancies. To aim the guns, the pilot must aim the aircraft at the target. If the guns were installed in such a way they did not point along the same axis the aircraft flies, it would be impossible to hit a target by pointing the aircraft. Sometimes the guns move out of alignment and do not hit the target when fired. It is our job to realign the gun so it will fire true. This alignment is referred to as harmonization or boresighting. There are three distinct methods of gun harmonization used to align the guns. They are boresighting, gun firing, and laser alignment; however, here we will only discuss boresighting.

Using the boresight method, harmonization can be done inside a hangar or on any suitable hard surface providing the necessary space for setting up the boresight target. The aircraft must be elevated and leveled using aircraft hydraulic jacks. With the aircraft in position, the boresight target is placed in front of the aircraft, 1,000 inches from the nose wheel axle. The aircraft and target must be aligned with each other. Normally, the fire control specialist does this. After this is completed, you attach a boresight telescope to the gun and adjust the gun mounts in azimuth and elevation until the gun is properly aligned on the target. Some aircraft do not require the use of a target like we just discussed. The alignment is accomplished by attaching boresighting fixtures to the aircraft at key points, determining a boresight reference point, and making the necessary adjustments at the gun mounts. The procedures just discussed are used with both internal and external gun systems.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

434. Preventive maintenance

1. What is the first thing you must make sure of before performing maintenance on a gun?

2. What should be applied to gun parts immediately after cleaning and drying?

3. What can result if excessive oil or grease is left in the chamber of a gun?

4. Name the types of operational and functional checks performed on aircraft gun systems.

5. How do you check the mechanical functioning of a gun system?

6. What test items are used to perform electrical checks of gun systems?

7. What specifically are you checking during gun system electrical checks?

435. Corrective maintenance

1. Why do we harmonize gun systems?

2. The requirement for performing boresight procedures are based on what four conditions?

3. Where can the boresight method of harmonization be accomplished?

4. How is gun alignment accomplished?

Answers to Self-Test Questions

422

1. In 1861 to overcome the limitations of early gun designs.
2. The housing.
3. Each barrel does not heat up as much as a single-barrel firing at a faster rate.

423

1. Gas and recoil.
2. Force applied to the face of the bolt from firing the round.
3. A rod that travels back down the barrel to the bolt assembly.

424

1. As a hand-operated gun mounted on helicopters.
2. When mechanical power is applied to the forward gear of the rotor assembly.
3. When trigger power is removed from the system.

425

1. By an electric motor or hydraulic drive unit.
2. It supports the round during cycling operations.
3. The bolt shaft assembly engaging the main cam or the clearing cam path in the housing.
4. The stub rotor.
5. Electrically or manually.
6. The weight of the system.

426

1. 1800 (±100) SPM.
2. Flexible drive shaft from the ASHS.
3. Ammunition and spent cases.
4. A linear linkless feed system consisting of two 1,500 round bays.
5. One half the gun speed.
6. An endless chain ladder.
7. Hydraulically.

427

1. Gun housing.
2. Forward rotor main drive gear.
3. A locking well on the rotor assembly.
4. The bolt body and linear-motion roller.
5. The midbarrel support assembly.
6. Unlocking.

428

1. The left hand side.
2. The bolt is locked to the rear and the weapon is on safe. The feed tray cover is then lifted, the remaining belt (if any) is swept out of the feed tray, and the feed tray is lifted to visually inspect the rear of the barrel and the face of the bolt.
3. Eight.
   (1) Feeding.
   (2) Chambering.
   (3) Locking.

(4) Firing.
(5) Unlocking.
(6) Extracting.
(7) Ejection.
(8) Cocking.

429

1. Eight.
   (1) Firing.
   (2) Recoiling.
   (3) Cocking.
   (4) Counter recoil.
   (5) Feeding the round.
   (6) Extracting the brass.
   (7) Ejecting the brass.
   (8) Chambering.
2. The recoil buffer assembly’s helical compression drive springs and the buffer tube disc.
3. It prevents the barrel from turning during operation.
4. The recoil buffer assembly.
5. The receiver assembly and barrel jacket assembly.

430

1. By clips.
2. Recuperator spring and recoil cylinder.
3. Single and automatic.
4. Breech ring assembly.
5. Recoil and counter recoil.

431

1. The cannon assembly, recoil mechanism, and cradle assembly.
2. It is used to suppress the muzzle blast created when the gun is fired.
3. The cradle assembly.

432

1. (1) Link-fed.
   (2) Linkless.
   (3) linear-linkless.
2. Stowage boxes or cans and feed chutes.
3. By hand.
4. An ammunition drum and conveyor system.
5. Ammunition is stored in the drum in longitudinal partitions and moved longitudinally from the entrance unit to the exit unit by action of the inner drum.
6. They facilitate system loading and unloading, movement of live rounds and spent cases, and conveyor element movement throughout the system.
7. Never.
8. In the cleared rounds and spent cases return route to the ammunition drum.
9. The method of ammunition storage.

433

1. The aircraft’s utility hydraulic system.

2. They provide the ventilation to eliminate gun gasses from the gun and ammunition handling compartments.
3. Thirty seconds.
4. Maintaining aerodynamic and low observance integrity.
5. It will prevent the gun system from operating.

434

1. Make sure the gun is cleared of all live rounds of ammunition and in a safe condition.
2. A light coat of preservative lubricating oil.
3. The breech pressure rises to a hazardous point when the gun is fired, and excessive wear results at the breech face of the barrel.
4. Mechanical and electrical.
5. First, load dummy cartridges into the system; then cycle the cartridges through it, checking for proper mechanical functioning.
6. Test sets, multimeter, and voltage detectors.
7. The gun electrical control system and all associated components, the hydraulic control system, and the gun gas purge/scavenge system.

435

1. To provide the most accurate on-target delivery of ammunition possible.
2. (1) Aircraft hard landings.
   (2) Excessive "G" loads placed on the aircraft or unusually violent maneuvers with the aircraft.
   (3) Replacement of gun mounts.
   (4) Pilot reported discrepancies.
3. Inside a hangar or on any suitable hard surface that provides the necessary space for setting up the boresight target.
4. By attaching boresighting fixtures to the aircraft at key points, determining a boresight reference point, and making the necessary adjustments at the gun mounts.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

64. (422) A rotary-based gun system allows for a much higher rate of fire over either revolver-based or non-rotating-based multi-barrel systems because *all* steps of the firing cycle take place
    a. sequentially.
    b. repetitiously.
    c. systematically.
    d. simultaneously.

65. (422) Which condition is a detrimental effect of barrel heating?
    a. Reduced barrel pressure.
    b. Excessive barrel pressure.
    c. Excessive barrel wear and warping.
    d. Increased susceptibility to corrosion.

66. (423) To complete the firing cycle, recoil operated guns use force applied to the
    a. detent.
    b. face of the bolt.
    c. breech housing.
    d. recuperator spring.

67. (423) In gas-operated, single-barrel automatic guns, the force from the expansion chamber is transferred to the bolt face by the
    a. regulator.
    b. transfer rod.
    c. operating rod.
    d. gas tube assembly.

68. (424) How is the GAU–2 automatic gun driven?
    a. Electrically.
    b. Hydraulically.
    c. Mechanically.
    d. Pneumatically.

69. (424) What number of rounds is the *maximum* firing rate of the GAU–2 automatic gun?
    a. 1,500 rounds per minute (rpm).
    b. 2,000 rpm.
    c. 4,000 rpm.
    d. 6,000 rpm.

70. (425) On the M61A1 rotary gun, the position of the bolt on the rotor is determined by the bolt shaft engaging the
    a. feeding cam or locking/unlocking cam path.
    b. clearing cam or locking/unlocking cam path.
    c. main cam or clearing cam path.
    d. main cam or feeding cam path.

71. (425) What component of the M61A1 rotary gun breech bolt makes electrical contact with the primer of the round?
    a. Firing pin.
    b. Firing tang.
    c. Firing contact.
    d. Electrical contact.

72. (426) What number of rounds is the firing rate of the 25 millimeter (mm) gun?
    a. 1,100 (±100) rounds per minute (rpm).
    b. 1,200 (±100) rpm.
    c. 1,800 (±100) rpm.
    d. 2,100 (±100) rpm.

73. (426) The ammunition in the ammunition storing and handling system (ASHS) moves at what speed compared to the gun?
    a. ¼ the gun speed.
    b. ½ the gun speed.
    c. ¾ the gun speed.
    d. Same as the gun speed.

74. (427) What number of rounds is the firing rate of the GAU–8/A 30 millimeter (mm) gun when it is installed in the A–10 aircraft?
    a. 2,000 rounds per minute (rpm).
    b. 3,900 rpm.
    c. 4,200 rpm.
    d. 6,000 rpm.

75. (427) Into how many parts is the GAU–8/A 30 millimeter (mm) gun rotor assembly divided?
    a. Two.
    b. Three.
    c. Four.
    d. It’s one complete assembly.

76. (427) What GAU–8/A 30 millimeter (mm) gun component secures each barrel into the rotor?
    a. Stub rotor.
    b. Muzzle clamp.
    c. Midbarrel support.
    d. Interrupted locking lugs.

77. (427) During the GAU–8 30 millimeter (mm) gun firing cycle, what should happen when the cocking pin is released from the cam at the sear point?
    a. This action cams the bolt assembly forward in the rotor tracks.
    b. The firing pin spring drives the firing pin forward to detonate the primer of the round.
    c. The breach bolt body rotates and the locking lugs of the bolt body engage with similar locking lugs of the rotor.
    d. The breech bolt body rotates and the locking lugs of the bolt body disengage from the locking lugs of the rotor.

78. (428) Which direction does the M240 machine gun eject expended brass?
    a. Top.
    b. Bottom.
    c. Left.
    d. Right.

79. (428) The M240 machine gun operates under the
    a. Gatling principle.
    b. open bolt concept.
    c. closed bolt concept.
    d. recoil operated concept.

80. (428) How many steps are there in the M240 machine gun cycle of operation?
    a. 5.
    b. 6.
    c. 8.
    d. 12.

81. (429) The GAU–18 machine gun is operated
    a. by gas.
    b. by recoil.
    c. electrically.
    d. pneudraulically.

82. (429) Which direction does the GAU–18 machine gun eject expended brass?
    a. Top.
    b. Bottom.
    c. Left.
    d. Right.

83. (430) What ammunition feed system is used to supply the M2A1 40 mm automatic gun?
    a. Clip.
    b. Linked.
    c. Linkless.
    d. Linear linkless.

84. (431) What M137A1 105 millimeter (mm) howitzer assembly component acts as a secondary stop in case of recoil mechanism failure?
    a. Sleigh assembly.
    b. Recuperator spring.
    c. Recuperator assembly.
    d. Wedge-shaped bosses.

85. (431) What component of the M137A1 105 millimeter (mm) howitzer is composed of the sleigh and recuperator assemblies?
    a. Recoil mechanism.
    b. Cannon assembly.
    c. Cradle assembly.
    d. Housing assembly.

86. (432) Depending on the particular system, the ammunition boxes of the link-fed system *normally* hold
    a. 100 to 4,500 rounds.
    b. 150 to 2,500 rounds.
    c. 246 to 1,000 rounds.
    d. 500 to 6,000 rounds.

87. (432) How are the ammunition cans of link-fed systems normally loaded and unloaded?
    a. By hand.
    b. By manual hoists.
    c. By electric hoists.
    d. Using bomb lift trucks.

88. (432) Which aircraft *does not* make use of a linear linkless ammunition storage system?
    a. F–22.
    b. F–16.
    c. F–15E.
    d. AC–130.

89. (433) How many different gun gas scavenge designs are used on aircraft?
    a. One.
    b. Two.
    c. Three.
    d. Four.

90. (433) What aircraft makes use of a moveable door covering the firing port for the projectiles to exit the aircraft?
    a. F–15E.
    b. F–16.
    c. F–22.
    d. AC–130.

91. (434) What two types of operational/functional checks are used for gun systems?
    a. Mechanical and hydraulic.
    b. Pneumatic and hydraulic.
    c. Pneumatic and electrical.
    d. Mechanical and electrical.

92. (435) When using the boresight method of harmonization, the boresight target *normally* is placed
    a. 1,000 inches from the nose wheel axle.
    b. 1,000 feet from the nose wheel axle.
    c. 2,250 inches from the nose wheel axle.
    d. 2,250 feet from the nose wheel axle.

93. (435) Where is the adjustment made on the gun when boresighting?
    a. Barrels.
    b. Gun mounts.
    c. Nose mount.
    d. Heads up display.

Please read the unit menu for unit 4 and continue ➔

Student Notes

Unit 4. Weapons Loading Principles

YOUR LAST AND MOST often performed duty is weapons loading. Weapons loading has its own peculiarities—more so than any other task you will perform. It has its own safety requirements and procedures. You will find they stay fairly constant no matter what aircraft you are working on. There are unique loading situations you may encounter—for example, dual loading operations (DLO) and chemical munitions loading. These and other areas of weapons loading are what we cover in this last unit.

4–1. Weapons Loading and Unloading Safety Precautions

There are two sets of loading safety requirements where we are concerned. First, there are general requirements applied to all loading situations regardless of the aircraft or weapon you are loading. Second, there are unique requirements applied only to special loading situations. Everyone must comply with these safety requirements during all operations, especially during weapons loading. Because you are involved directly with weapons loading, you must be completely aware of all the hazards explosives may present. Thinking safety and working safely must become a firmly established habit of yours. In this section, we look at the safety requirements for particular weapons loading procedures.

436. Safety requirements for loading and unloading aircraft munitions

These requirements can be applied to any weapons loading or unloading situation. You must always start every loading task by complying with the general safety.

General requirements

General requirements are listed in a section of the loading TO or checklist for the aircraft you are working on. In addition, you must also follow the guidance given in AFMAN 91–201, ~~*Explosive*~~ *Safety Standards*. We look at these general requirements from three aspects: (1) those directly affecting positioning of an aircraft, (2) those affecting functional checks, and (3) those affecting munitions handling during loading and unloading operations. Remember one thing as we go through these requirements: the absence of a safety requirement in this career development course (CDC) or the TO does not necessarily indicate *no* safeguards are needed in a particular situation. In such instances, you must rely on your judgment and training.

Aircraft positioning

Positioning the aircraft always plays an important role in any weapons operation. Any aircraft we work on must always be positioned in a direction presenting the minimum hazard to personnel, buildings, and equipment in the event forward firing munitions (rockets, missiles, or guns) are inadvertently released. Sometimes a commander may elect to enhance an aircraft's alert posture by calling for a quick turn. If so, the aircraft must be positioned in an approved and controlled entry alert area during loading operations.

Always remember the proper fire protection equipment must be available to use during emergency situations. If you are unsure of what is required, consult TO 00–25–172, *Ground Servicing of Aircraft and Static Grounding/Bonding*. Minimum requirements will be one 150-pound Halon 1211 extinguisher. During mass weapons loading and unloading (three or more B–1, B–2, or B–52 aircraft simultaneously), in addition to the normal fire extinguisher requirements, a fire department standby vehicle must be present.

A concentrated amount of Halon, when applied to a fire, can also produce toxic byproducts. If this situation arises, try to avoid inhaling these materials by evacuating and ventilating the area. Never use the extinguishers mentioned here on fires involving pyrotechnics or magnesium incendiaries. These extinguishers can only be used to protect surrounding materials exposed to these fires until the fire department arrives.

Functional checks

Normally, performing functional stray voltage or confidence checks is done after the aircraft is positioned. Also, weapons bay doors are opened and closed after positioning the aircraft. When you perform these operations, the use of ground interphones is mandatory. Strictly for safety reasons, these checks are not done on aircraft loaded with munition. But functional stray voltage or confidence checks may be performed if all applicable release and jettison circuits have been electrically and mechanically safed or if impulse cartridges have been removed. If these requirements cannot be met, the munitions must be downloaded before the checks are performed.

During these checks, you'll use such items as the Fluke meter and the voltage detector. These items have special safety measures you must be aware of. The lack of meter readings on the Fluke meter (stray voltage indication) does not mean the circuit is safe because dangerous levels of voltages of other polarities may be present. If the overload circuit of the Fluke meter activates, it must be checked before you can safely conclude no dangerous voltage is present in the circuit under test. Always place voltage detectors in the OFF/TEST position before disconnecting them from a circuit under test. There are numerous other factors governing functional checking of an aircraft with munitions, so be sure to check your loading TOs and local maintenance operating instructions (MOI) to ensure you are working within proper guidelines.

Handling munitions

Loading and unloading munitions from aircraft is the area you find the most safety precautions. This area can be broken down into precautions pertaining to personnel and actual maintenance operations. There will be occasions when you will be required to load or unload aircraft when the engines are running. Aircraft with engines running are never approached until either the aircraft flight crew places both hands in full view or verbal communication takes place between you and the crew. Normally, these types of situations only occur during EOR operations.

You must be especially careful when working near the aircraft's intake area, because you or your equipment could be drawn into the intake in a split second. Some aircraft, especially the A–10, you must be extremely cautious during loading because the aircraft has a tendency to drop suddenly, compressing the struts. This could cause someone to be severely injured or killed.

Practically every loading operation requires you to install or remove impulse cartridges. While performing this task, never stand or place any part of your body directly in front of any bomb rack breeches or exhaust ports or under the ejection rams. If the impulse cartridges were to inadvertently detonate, you could end up dead or severely injured. Also, unless it is absolutely necessary, never stand in front of or in back of loaded missiles, rockets, flare dispensers, or guns after their electrical connections have been made. Before handling any electrically primed munitions, you must ground yourself so any buildup of static electricity is dissipated. As you know, most of our loading and unloading operations are done using bomb lift trucks. Many injuries have occurred from carelessness around these pieces of equipment; so, unless you have to, do not stand under bomb lift tables or place your hands between a munition and bomb rack or munition and bomb lift table.

Handling other munitions and special equipment

Certain munitions such as flares, white phosphorus (WP) items, and spotting charges also pose special hazards during loading operations. If flares have ignited inadvertently, you must not look directly at them because their burning intensity can damage the eyes. You will have to use special procedures and equipment when handling white phosphorus and plastic white phosphorus munitions. You may need to apply field treatment to WP burns. If burning particles strike and stick to clothing, take off the contaminated clothing quickly before the phosphorus burns through to the skin. If burning particles strike the skin, smother the flame with water, a wet cloth, or mud. keep the phosphorus covered with wet material because phosphorus continues to burn unless it is deprived of oxygen. Try to remove the burning particles with a knife, stick, or other available objects. It may be possible to remove some of the particles by rubbing them with a wet cloth.

If the eyes become contaminated, flush them immediately with water. Tilt the head to one side, pull the eyelids apart with the fingers, and pour water slowly into the eye so the water runs off the side of the face to avoid spreading contamination. You must seek medical attention as soon as possible. Make sure first aid and protective equipment are readily available at the aircraft being loaded or unloaded. This includes asbestos or flameproof gloves, nonflammable face shield, gauze sponges, two sponges, and five gallons of water. If leaking WP is evident, submerge the munition in a container of water or smother it with sand, dirt, or foam.

Spotting charges (titanium tetrachloride, CXU–1/B, –2/B, and –3/B) are found in practice bombs, and, as with WP handling, there are special precautions to take, and certain equipment must be available for use during handling. You may again need to apply field treatment for exposure to these items. Prolonged exposure to, or breathing of, the concentrated vapors when reacted with air can cause inflammation of the respiratory system or eye irritation. If the vapors are released in a closed space, immediately ventilate the space and evacuate. Any area of the body exposed to the liquid or its vapors must be wiped immediately with a dry cloth, and then washed with water. If the eyes become contaminated, the victim should immediately flush them with water and report to a medical facility as soon as possible. Remove contaminated clothing as soon as possible and wash with soap and water.

Any equipment contaminated can be cleaned by washing it with water. Always make sure your protective equipment is available at the loading site. This includes a protective mask, butyl rubber gloves, and a 5-gallon container of clean water. Always wear the mask when smoke is present, and wear gloves when handling leaking contaminated munitions.

Maintenance

During maintenance operations of loading and unloading munitions, if you ever run into an abnormal condition and the TO does not specifically address it, you must stop and get technically qualified guidance before continuing the operation. As the saying goes, it is always better to be safe than sorry. If you ever encounter an immediately dangerous explosive—for example, a leaking WP container—you must shut down all operations in the immediate area, evacuate everyone to a safe location, and call EOD. Never resume work in an area until the hazard has been completely eliminated.

If loading and unloading operations are done at night, adequate lighting is mandatory. Whether the lighting is in the form of flightline ball park lights or portable floodlight units, make sure it is adequate for use. In all operations where arming and/or fuze safety devices are used, do not remove them until after the munition containing them is loaded on an aircraft. They also must be installed before downloading operations. These restrictions do not apply to FMU-type electronic fuzes because they are armed by a power source driven by air travel. Some examples of these include the FMU–139A/B fuze with the FZU–48/B initiator.

There are numerous maintenance tasks involving impulse cartridges, but generally local commanders establish MOIs pertaining to their use and handling. During turnaround operations, installed impulse cartridges are authorized provided electrical power is not applied to the aircraft. If power is to be applied, all applicable stations must be electrically and mechanically safed or the impulse cartridges must be removed. Any substitution of physically disconnecting connectors for electrical safing is not authorized. Impulse cartridges may also be installed before munitions loading, provided the appropriate check—normally, stray voltage—has been performed and no aircraft external power is applied. You may at times find breech cartridge retainers installed, safety wired, or sealed. This certifies the cartridges are not installed. The certification is considered void when the wire or seal is broken.

Two additional items we must mention here: (1) you will not load mixed loads of live and training munitions—it is not authorized, and (2) always remember good housekeeping is essential to safe operations—keep your area clear of unnecessary tools and equipment at all times.

Unique requirements

These safety requirements come into play when you are dealing with nuclear munitions. Keep in mind, in addition to the unique requirements for these munitions, you must also comply with the general safety requirements we just covered. In dealing with nuclear weapons, your loading crews must comply with the two-person concept to gain access to any aircraft loaded with, or to be loaded with, even a single nuclear weapon. If an accident or incident occurs, you must follow the procedures defined in your Base Disaster Control Plan. Reporting a nuclear incident or accident must be done according to AFI 91–204, *Safety Investigations and Reports*. You must be aware of what types of conventional munitions are authorized to be loaded with nuclear weapons on an aircraft.

If conventional weapons are loaded with nuclear weapons on the same aircraft, the conventional munitions are loaded before nuclear weapons. Normally, in this situation, no conventional configuration changes can be made until after nuclear weapon loading is completed. Any changes made after nuclear loading is limited to conventional upload and downloads, provided power is not applied to the aircraft and weapons systems functional checks are not required.

437. Weapons loading and unloading procedures

Weapons loading and unloading are performed more or less in the same manner, regardless of the aircraft or munition being loaded. There may be different loading equipment and adapters involved in the process, but the end result is the same—a mission-capable aircraft. Both loading and unloading operations are composed of various steps performed each time one of these operations is completed. These steps, along with how to do them, are your concern, so let’s explore the procedures in more detail.

Loading

Most loading operations have seven basic steps. These basic steps include: aircraft preparation, munitions preparation, loading, cartridge installation, postloading inspection, delayed flight or alert, and immediately prior to launch. The number of steps included in this process may increase or decrease by one or two, depending on what munition is being loaded. Aircraft preparation begins the loading process. This process includes safing the aircraft, installed accessory preparation, and functional or stray voltage tests you need for a particular loading operation. Safing the aircraft includes making sure the aircraft is properly positioned, chocked, and grounded; the proper firefighting and support equipment is positioned correctly; all applicable safety pins and devices are installed; all impulse cartridges are removed; the aircraft forms (AFTO Form 781) are checked for aircraft status; all armament-related cockpit switches are positioned to OFF, SAFE, or NORMAL; and the necessary armament system circuit breakers are pulled.

The next portion of aircraft preparation is installed accessory preparation. This includes checking the serviceability, security, and proper configuration of pylons, bomb racks, gun systems, TERs, or any previously installed armament component that need to be loaded. The last portion of aircraft preparation includes performing any functional or circuit confidence checks required to make sure the system is properly functioning before munitions loading.

Before any munitions can be loaded on an aircraft, they must be prepared. This brings us to the second step of the loading process—munitions preparation. You always want to make sure you are loading the right munition, so the first step in munitions preparation is to make sure that the munition matches the mission requirements. Each munition has its own serviceability requirements you must check before loading. Make sure each requirement is met by 100 percent; there is no room for tolerances or deviations in the loading process.

Reject any munition when a questionable condition exists and the effect on reliability and/or safety cannot be determined. If any munition is dropped, do not load it until it has been inspected for serviceability. Any munition item dropped a distance equal to or greater than its drop criteria must not be loaded under any circumstances. If you are working with fuzes and they have safety devices missing, or if an armed indication is present, the fuze must be considered armed or partially armed. Armed or partially armed fuzes and munitions are hazards waiting to become accidents; do not install the fuze into a munition or load a munition in this condition. If you encounter such a condition, notify the appropriate personnel. Remember, disassembling any munition without specific authority is not allowed.

We are now at the point in the loading operation where you actually load the munition(s) onto the aircraft. Loading some munitions, as you already know, is done by hand, and some by using various adapters, lift trucks, and lift trailers. Ensure the serviceability of all the equipment before using it to pick up or transport any munition item. When you use this equipment to pick up a munition, make sure you have the munitions center of gravity properly positioned on the equipment and secure it with a load binder assembly or tie down strap so you don't accidentally drop it. If your task is to load GP bombs or any other bomb, this step allows you to lock the bomb in position, insert arming wire swivel loops in the bomb rack solenoids, and sway the munition down. If you are loading soft-shelled munitions or launchers, use an adapter or set of extra-long rollers to protect the munition from damage. Loading aircraft wing stations are normally done alternately from one wing to the other to maintain aircraft stability, but check your loading TO for proper loading sequences.

When loading large aircraft, such as the B–1, B–2, and B–52, you must be very careful when working in winds over 30 knots. The load crew chief is the determining authority in these situations, but for the most part, loading under these conditions is done only in emergency situations. The B–1, in respect to aircraft stability, is the most complex as far as loading goes, so we leave a word of caution here. **NEVER** load the aft weapons bay before loading either the forward or intermediate weapons bay. The B–1 has proven itself as being capable of using its main landing gear as a fulcrum allowing the aircraft to tip over, literally sitting itself on its tail (fig. 4–1). Therefore, you must NEVER unload both the forward and intermediate weapons bays before unloading the aft bay. A fully loaded fuel tank loaded in the forward bay satisfies the center of gravity requirements for loading or unloading the aft weapons bay.

Figure 4–1. B–1 accident.

At this point during the loading operation, variations start to occur. If you have loaded GP bombs, your next step is to fuze them. This is done by removing the fuze safety pins or devices, cutting off any excess arming wire and installing the fin access cover if it was removed. You now install the impulse cartridge if it was not installed previously. Also, if stray voltage checks were not done at the same time as functional checks, you must do them before this point. Impulse cartridges installed in bomb rack breeches must always be torqued. Refer to your loading TO for the specific torquing requirement.

After cartridge installation, a postloading inspection must be performed. The postloading inspection is performed by the load crew chief and is an inspection of your work to make sure loading the aircraft was done correctly. The crew chief must check for proper installation of munitions, safety pins and devices, and impulse cartridges. He or she must also check for the security of all panels and access doors, ensuring all tools and equipment have been removed from the area and are accounted for, making a placard entry (if applicable), and making all appropriate AFTO Form 781 entries.

The delayed flight or alert step may or may not be performed during loading procedures. This step may be omitted from operations by the local commander. If it is performed, it constitutes one more check to make sure all applicable safety pins and devices are installed. The *last step* in the loading process is called immediately before launch. This step is performed at the end of the runway (EOR) by a weapons load crew. Their job is to remove all the munitions safety pins and devices and arm the munitions before aircraft takeoff.

Unloading

Unloading or downloading procedures are usually broken down into three steps: safing, preloading, and unloading. Safing is the first step and is performed at EOR as soon as the aircraft lands. It may be omitted if authorized by the local commander, but omission is normally not the case. As you can guess, this step is the complete opposite of the one done immediately before the launch step performed during loading. In this step, all applicable safety pins and devices are reinstalled and munitions are safed or dearmed. After safing, the aircraft is allowed to taxi back to its flightline parking space. Once the aircraft is parked, preunloading begins. Preunloading ensures the aircraft is safe to work on. You check for proper aircraft positioning; fire fighting equipment placement and serviceability, chocking, and grounding; installation of all applicable aircraft and munition safety pins and devices; proper positioning of aircraft switches; and any write-ups in the aircraft forms affecting the maintenance you are about to perform. Removing impulse cartridges (if applicable) is also done during this step. Remember, each type of munition load has its specific procedures, so use your tech data.

You are now ready to unload or download the aircraft. Downloading is actually just the opposite of loading. You may again require various pieces of loading equipment to remove the munition(s) from the aircraft. Once you have removed the munition(s), make sure all access doors and panels are secured, remove all tools and equipment from the area, clear the placard entry (if applicable), and make any necessary AFTO Form 781 entries. If you have downloaded bombs requiring fuze removal, this is the time to do it. Since all the safety devices were installed during preunloading, what is required here is to remove the arming wire from the fuze, the fuze from the bomb, and the delay element from the fuze. You must also reset the fuzes to what is considered their safe position for storage. Do not forget to install the pads and plugs in the bombs if applicable. What you must remember is, regardless of what type of weapon is being downloaded, all of the basic steps have to be performed. The peculiarities of each individual process vary, but the basics are always the same.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

436. Safety requirements for loading and unloading aircraft munitions

1. What Air Force instruction gives guidance on explosive safety standards?

2. What are the minimum fire extinguisher requirements for loading munitions?

3. What should you do before handling electrically primed munitions?

4. What action should you take if a munition is leaking WP?

5. What protective equipment must be available at a loading site where practice bombs with CXU–1/B, –2/B, or –3/B spotting charges are being loaded?

6. What is the purpose of installing empty breech cartridge retainers and safety wiring, and sealing them?

437. Weapons loading and unloading procedures

1. How many steps comprise an aircraft munitions loading operation?

2. What step begins a loading operation?

3. What major tasks are included in aircraft preparation?

4. In what loading step would you reject a munition for loading?

5. Normally, how is an aircraft's wing station loaded?

6. When loading the B–1's weapons bays, what precautions must you take?

7. At what point in loading procedures may stray voltage checks be done if they were not done during aircraft preparation?

8. What must be done to impulse cartridges once they are installed during the loading process?

9. Who is responsible for performing the postloading inspection?

10. In what loading step are all safety pins and devices removed and munitions armed?

11. Name the steps involved in the unloading process.

4–2. Unique Loading Situations

Not all loading situations take place under the calm and controlled conditions that you encounter in a load training facility. Unique loading situations arise because of our need to be prepared for all types of contingency situations.

438. Rapid aircraft "turning" methods

Contingency could most certainly create the need for us to turn around fighter and bomber aircraft for additional sorties in a minimum amount of time. Therefore, in this section we discuss the concept of DLO and concurrent servicing operations (CSO).

Combat turnaround

Based on unit tasking, the commander determines the need to conduct combat turnaround operations. Weapons standardization is the focal point for the combat turnaround program. This program is designed to rapidly turn an aircraft defined in combat turnaround operations procedures. The primary methods of munitions loading used during combat turnarounds are the DLO and the CSO.

Dual loading operations

Generally, when a loading operation takes place there is one crew working by itself on an aircraft conducting all loading operations. This method of loading is normally sufficient for daily operations; however, there may be a time when the munitions need to be loaded more quickly than a single crew can accomplish. Because of this, the Air Force developed the DLO. DLO basically means there are two load crews working on the aircraft at the same time to load it more quickly than a single crew could possibly could. DLOs are the primary method for rapid munitions loading/unloading on bomber aircraft. DLO can be used when both the external and internal (B–52) or dual bay (B–1, B–2) loading is required. Both load crews ensure the aircraft is safe for loading by checking the forms and aircraft for proper configuration. The cockpit safety must be verified by both load crew chiefs and both load crew chiefs check off their checklists as they perform these checks. Both of the load crews perform independently and from separate trailers or load stand and each crew performs their power-on checks after all operations are completed.

Concurrent servicing operations

Normally, when an aircraft returns from a mission, the various flightline expeditors will coordinate through the production superintendent a deconflicted servicing schedule where different shops will be able to work on aircraft, in turn, to prepare them for their next flight. Sometimes it is necessary to "turn" aircraft as quickly as possible to complete the mission. To do this, the Air Force produced a series of procedures and guidance called the CSO. A CSO is defined as the simultaneous loading/unloading of munitions, fueling, aircraft reconfiguration, and may include aircraft –6 inspections, and other aircraft servicing. Other servicing may include oil, nitrogen, and hydraulic fluid. Oxygen servicing is *never* done during fuel servicing. CSO provides units operational flexibility in managing resources and a rapid means of generating mission ready aircraft. A DLO will not be conducted during CSO. Any time fueling is being done during a CSO, a concurrent servicing supervisor (CSS) is required to be present.

The CSS is the person responsible for on-site supervision of all aspects of fuel servicing, munitions loading/unloading, and aircraft reconfiguration while being performed concurrently. The key function requiring the CSS is fueling. When no fueling is taking place, a CSS is not required. The CSS must be at least a 7-level with a maintenance (2AXXX or 2WXXX) Air Force specialty code (AFSC). The CSS must have at least one year of experience on the airframe. Also, the CSS must be a safety supervisor who will supervise only one CSO at a time and will perform no other functions.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

438. Rapid aircraft "turning" methods

1. What is a DLO?

2. On what aircraft is the DLO accomplished?

3. What is a CSO?

4. What are the requirements to become a concurrent servicing supervisor?

Answers to Self-Test Questions

436

1. AFMAN 91–201.
2. One 150-pound Halon 1211 extinguisher.
3. Ground yourself.
4. Submerge the munition in a container of water or smother it with sand, dirt, or foam.
5. A protective mask, butyl rubber gloves, and a 5-gallon container of clean water.
6. This certifies that impulse cartridges are not installed at a particular station.

437

Seven.

2. Aircraft preparation.
3. Safing the aircraft, installed accessory preparation, and functional or stray voltage tests.
4. Munitions preparation.
5. Alternately, from one wing to the other.
6. Never load the aft weapons bay before loading either the forward or intermediate weapons bay.
7. Before cartridge installation.
8. They must be torqued according to the applicable tech data.
9. Load crew chief.
10. Immediately before launch or EOR.
11. Safing, preunloading, unloading.

438

1. Two load crews working on the aircraft at the same time.
2. External and internal (B–52) or dual bay (B–1, B–2).
3. The simultaneous loading/unloading of munitions, fueling, aircraft reconfiguration, and may include aircraft –6 inspections, and other aircraft servicing.
4. The CSS must be at least a 7-level with a maintenance (2AXXX or 2WXXX) AFSC with at least one year of experience on the airframe.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

94. (436) The use of ground interphones during aircraft functional checks is
    a. preferred.
    b. mandatory.
    c. suggested.
    d. optional.

95. (436) In addition to a 5-gallon container of clean water and butyl rubber gloves, what *must* be available at a loading site where practice bombs with CXU–1/B spotting charges are being loaded?
    a. A protective apron.
    b. A protective mask.
    c. Telephone.
    d. Radio.

96. (436) If you find breech cartridge retainers installed, safety wired, or sealed this certifies the
    a. station cannot be loaded.
    b. station is not nuclear capable.
    c. impulse cartridges are installed.
    d. impulse cartridges are not installed.

97. (437) In what loading step is the serviceability of the munition loading stations determined?
    a. Safing.
    b. Loading.
    c. Aircraft preparation.
    d. Munitions preparation.

98. (438) Which load crew performs aircraft safe for maintenance procedures during a dual loading operation (DLO)?
    a. Primary.
    b. Secondary.
    c. Both.
    d. Squadron lead crew.

99. (438) During a concurrent servicing operation, what servicing action *cannot* be performed while refueling?
    a. Oil.
    b. Oxygen.
    c. Loading.
    d. Nitrogen.

100. (438) During a concurrent servicing operation, a concurrent servicing supervisor (CSS) is *not* required when
    a. engines are not running.
    b. no loading is taking place.
    c. fueling is not being performed.
    d. no oxygen servicing is taking place.

Student Notes

Glossary Abbreviations and Acronyms

A/A	air-to-air
A/G	air-to-ground
ADU	adapter unit
AFI	Air Force instruction
AFMAN	Air Force manual
AFOSH	Air Force Occupational Safety and Health
AGM	air-to-ground missile
AIM	air intercept missile
ALCM	air-launched cruise missile
ALIS	Autonomic Logistics Information System
AMAC	aircraft armament and control
ASHS	ammunition storage and handling system
BDU	bomb dummy unit
BIT	built-in-test
BRA	bomb rack assembly
BRU	bomb rack unit
CBU	cluster bomb unit
CDC	career development course
CND	can not duplicate
CSCE	carriage system control electronics
CSO	concurrent servicing operation
CSRL	common strategic rotary launcher
CSS	concurrent servicing supervisor
db	decibel
DC	direct current
DLO	dual loading operations
ECIU	enhanced central interface unit
ECS	environmental control system
ECU	electronic control unit
EMI	electromagnetic interference
EO	electro-optical
EOD	explosive ordinance disposal
EOR	end of runway

FI	fault isolation
FOD	foreign object damage
GAU	gun automatic unit
GBU	guided bomb unit
GPS	global positioning system
HUD	heads up display
IFL	in-flight lock
IMIS	Integrated Maintenance Information System
IR	insulation resistance
	infrared
JDAM	Joint Direct Attack Munitions
JG	job guide
JHMCS	joint helmet mounted cueing system
JMMI	joint miniature munition interface
LAU	launcher adapter unit
LEU	launcher electronic unit
LRU	line replaceable unit
MAJCOM	major command
MAU	munitions adapter unit
MFD	multifunctional display
MHU	munitions handling unit
MIL-STD	military standard
MIU	missile interface unit
mm	millimeter
MOI	maintenance operating instruction
MPCD	multipurpose color display
MSCI	missile status control indicator
MUX	multiplex
OAS	offensive avionics system
PAL	permissive action link
PBAR	practice bomb adapter rack
PDU	power drive unit
QA	quality assurance
RDY	ready
RF	radio frequency

RIU	remote interface unit
RLA	rotary launcher assembly
RPM	rounds per minute
SBRA	smart bomb rack assembly
SCU	station control unit
SECBM	standard enhanced conventional bomb module
SEL JETT	selective jettison
SLU	station logic unit
SMS	stores management system
SOP	standard operating procedures
spm	shots per minute
SPU	station program unit
SRU	shop replaceable unit
SUU	suspension utility unit
TCTO	time compliance technical order
TER	triple ejector rack
TO	technical order
VAC	volts, alternating current
VDC	volts, direct current
WCMD	wind corrected munition dispensers
WP	white phosphorus
WPN REL	weapon release switch
WW1	World War 1

Student Notes

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