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UNITED STATES ARMY AVIATION BOARD
Fort Rucker, Alabama

REPORT OF TEST

PROJECT NR AVN 2260 ✓

HELICOPTER-MOUNTED SS-11 ANTI-TANK GUIDED MISSILE SYSTEM (U)

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1. (C) AUTHORITY.

a. Directive.

(1) Letter, ATDEV-4 471.94/558(C) (20Nov58), Headquarters, USCONARC, 20 November 1958, subject: "Test Directive for User Service Test of an Anti-tank Guided Missile System (U)."

(2) DF, ATDEV-4, Headquarters, USCONARC, 22 January 1959, subject: "User-Service Test of an Anti-Tank Guided Missile System (U)."

(3) Letter, ATDEV-4 471.94/119(C)(30 Mar 59), Headquarters, USCONARC, 30 March 1959, subject: "Test Directive for User Service Test of an Anti-tank Guided Missile System (U)."

b. Purpose. To determine if the helicopter is a suitable vehicle from which to fire and control the SS-11 missile.

2. (U) REFERENCES.

a. Plan of Test, Project Nr 2011, "Test of SS-11 Anti-Tank Guided Missile System (DA Project Nr 516-05-015) (U)," US Army Armor Board, 22 July 1959.

b. Report of Test, Project Nr FA 1158 (Supplemental), "User Service Test of French Anti-Tank Guided Missile System, SS-10 (Helicopter-Mounted)," US Army Artillery Board, 19 December 1958.

c. First Partial Report of Project Nr 2011, "Test of SS-11 Anti-Tank Guided Missile System, Part I - Test of Basic Anti-Tank Guided Missile System Without Regard to Vehicle Mount," US Army Armor Board, 29 January 1960.

3. (C) BACKGROUND.

a. In 1958 the U.S. Army Aviation Board completed testing of the SS-10 Antitank Guided Missile (ATGM) installed on the H-13H Helicopter. It was concluded that the helicopter-mounted SS-10 system was suitable for Army use. It was recommended that it be classified Standard, Modernization Code B (STD-B), that certain deficiencies be corrected prior to procurement, and that organization and basis of issue be determined by the U.S.

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Army Aviation School. Subsequent to the service test the Aviation School conducted troop tests of the system at Ft. Rucker, Ala., Ft. Benning, Ga., and Ft. Knox, Ky. Procurement action on the helicopter-mounted SS-10 system was held in abeyance until the completion of the service test of the helicopter-mounted SS-11 system. Some of the factors considered were:

(1) Components of the SS-10 system peculiar to the helicopter installation were not in production. The French do not employ the SS-10 from aircraft.

(2) Major redesign of the launchers would be necessary to correct the deficiencies noted during the test (see paragraph 2b above).

(3) Information available on the SS-11 system indicated that it had the following advantages over the SS-10 system when considered as a helicopter-mounted system:

(a) In production and in operational use on both rotary- and fixed-wing aircraft in other countries.

(b) Maximum range of approximately 3200 meters compared to the 1500-meter maximum range of the SS-10.

(c) Maximum velocity of 425 m.p.h. compared to 179 m.p.h. for the SS-10 which would mean a reduction of the exposure time for the helicopter.

(d) A type of control system more suitable for air launching the missile.

(e) A wingspan of approximately 10 inches less than the SS-10 which would allow a more compact installation.

b. The HU-1 was selected as the most suitable helicopter for mounting the SS-11 system. Factors considered were:

(1) The HU-1( ) Helicopter is a standard item in production and will be organic to many Army tactical units.

(2) It should accept a six-missile SS-11 system without restricting the utility of the helicopter except for the added weight.

(3) The HU-1 carries a considerable payload, has a low noise level, and has a low silhouette.

(4) The high mounting of the main rotor would reduce or eliminate the possibility of its severing the missile control wires.

c. The Aviation Board SS-11 project officer and one other HU-1 helicopter pilot were trained as SS-11 gunners at the US Army Infantry School, Fort Benning, Georgia.

d. Engineering testing of the helicopter-mounted SS-11 ATGM system was conducted by the U.S. Army Rocket and Guided Missile Agency at Redstone Arsenal, Alabama, during the period 3 December 1959 through 24 March 1960. Thirty-five SS-11 missiles were fired from the HU-1 helicopter during the engineering test. The Aviation Board provided the helicopter and crew, including gunners, for the tests at Redstone Arsenal.

4. (C) DESCRIPTION OF MATERIEL. The SS-11 ATGM system was installed on an HU-1 helicopter (see figure 1). Ballast was required in this installation (see Test No. 7, appendix A). There is reason to believe, however, that ballast will not be required in production installations. (Items of the helicopter-mounted SS-11 ATGM system which are identical with those of the ground systems are not described in detail in this report.)

a. Six missile launchers (three on each side, mounted on horizontal booms) were installed on the helicopter. The launchers can be jettisoned from the helicopter individually or simultaneously in an emergency. The launcher booms can be readily removed or folded vertically to the stowed position (see figure 2).

b. The gunner's controls were installed on the copilot's side of the cockpit without removing the flight controls. The control box was mounted on the pedestal between the pilot's and copilot's seats in a position convenient to the gunner (see figure 3). Items on this control box were:

(1) A voltmeter for checking the supply voltage.

(2) A switch for remote operation of the signal generator.

(3) A rotary-selection switch for selecting the desired missile for firing.

(4) A firing button to fire the selected missile.

(5) A switch to jettison the control wires from the launcher after the missile reaches the target.

(6) A switch to jettison the individual launcher selected on the rotary selection switch.

(7) A switch to jettison all launchers simultaneously.

c. The gunner's missile control stick and the sight were located on a pole mounted on the front of his seat (see figure 4). The sight used was one developed by the University of Rochester for the P-61 "Black Widow" night fighter. It consisted of eight-power binoculars mounted in a frame and isolated from the helicopter vibrations in the horizontal plane by two dampers which employed a rubber diaphragm in a thin cylinder. Vertical vibrations induced to the sight by the helicopter were reduced to an acceptable level by mounting the sight on four vibration dampers. The mount for the sight and the control stick was fabricated and installed at the Aviation Board. A standard Mark 8 aircraft gunsight was installed on the pilot's side (see figure 5). The pilot's sight and the gunner's binoculars were aligned to enable the pilot to keep the target in the gunner's binoculars.

d. A heading control system for the helicopter, (see figure 6) designated as the Lear Millimin Automatic Control and Damper Heading Command (Lear MIIACON DHC), was manufactured by Lear, Inc., for this test. Item was comprised of components in production and designed to military specifications. The system weighed approximately four pounds. Two switches were provided on the cyclic stick for pilot operation of the system. Upon sighting the target in his sight the pilot would throw the engage switch to the ON position. This locked the helicopter on the heading to the target. By means of the two-way rate trim, the pilot was able to command small heading changes to correct for crosswinds on the firing run without disengaging the heading lock. This feature also enabled the pilot to track moving targets smoothly. The two operating switches were installed on the pilot's cyclic control stick (see figure 5) so that he could engage, operate, and disengage the heading control without diverting his attention from the target.

5. (C) SUMMARY OF THE TESTS.

a. Physical Characteristics. The six-missile SS-11 system installed on the HU-1 weighed 727 pounds including missiles, imposed only a small volume penalty upon the helicopter, and was suitable in configuration with one minor exception: the signal generator and the selection box should be relocated to one of the electrical compartments.

b. Reliability. The helicopter-mounted SS-11 system was 100-percent reliable. No failures or malfunctions occurred. No component required repair or replacement.

c. Accuracy. Overall accuracy obtained was 70 percent (28 hits out of 40 firings).

(1) Of 20 firings in cruising flight, 11 were hits (55 percent).

(2) Of 8 firings in hovering flight, 6 were hits (75 percent).

(3) Of 12 firings from the helicopter operating on the ground, 11 were hits (92 percent).

(4) Of 13 firings utilizing the Lear MIIACON DHC in its present configuration, 11 were hits (85 percent).

This sharp increase in accuracy is a direct result of the positive heading control provided by the MIIACON DHC.

d. Ruggedness. The helicopter was flown 202 hours with the -11 system installed. No failures or defects were noted in any compo ent of the system.

e. Climatic Effects. All components of the system functioned properly after operation in rain and dust. Only normal care and cleaning were necessary.

f. Readiness. It required 30 minutes for the pilot and gunner to unpack, check, and load six missiles. It required seven minutes for an experienced four-man ground-loading crew to load six prepared missiles.

g. Helicopter Missile Load. The HU-1 heli opter can carry a full load of fuel, pilot and gunner, the SS-11 system complete with six missiles, and 1267 pounds of cargo. This additional cargo capability permits carrying six SS-11's in shipping crates.

h. Minimum and Maximum Feasible Ranges.

(1) The minimum feasible rang was the same as that for the ground systems; however, the mobility of the airborne system enables the crew to fire at the most desirable ranges.

(2) The maximum feasible range was 3000 meters, the maximum range of the system. The helicopter flight speed and altitude had no apparent effect on the rang of the missile.

i. Maintenance nd Preflight Requirements. The helicopter crew chief could perform organizational maintenance and pre-firing checks of the system after approximately eight hours of instruction. The pre-firing system circuit check was similar to hat performed on the ground vehicle systems and required approximately 15 minutes.

j. Safety. Safety provisions of the system as installed were adequate with one exception: the missiles could not be jettisoned manually in the event of an electrical power failure. No incidents occurred which created a hazard to the crew or to the safe operation of the helicopter. Ballast had to be added to the tail of the helicopter to maintain the center of gravity if the helicopter was to be flown at airspeeds above 80 knots.

k. Suitability of the HU-1 Helicopter. The HU-1 equipped with an automatic heading control was a suitable vehicle from which to fire and guide the SS-11. The gunner's field of vision was good, and windshield distortion was not apparent. The missile system did not materially restrict the utility of the helicopter. Its configuration permitted firing in forward flight, at a hover or on the ground. An HU-1 on the alert line can be one mile away in less than 60 seconds after the pilot engages the starter. It had a low noise level and a low silhouette. The ease of operation allows the pilot to devote maximum attention to the tactical situation.

6. (C) DISCUSSION.

a. Sighting Devices.

(1) A sight was not provided as part of the helicopter-mounted SS-11 system. The French have not yet developed a suitable sight for use in the helicopter and, consequently, are unable to take advantage of the full range of the SS-11 when firing it from the air. Optical magnification is necessary for the gunner to guide the missile to tank-size targets at ranges beyond 1000 meters. Obstacles to providing suitable optical magnification for helicopter-borne sights have been the vibrations and the instability inherent in all helicopters.

(2) During the engineering test of the helicopter-mounted SS-11 systems at Redstone Arsenal, a wide variety of devices was tested in the search for a means of providing optical magnification to aid the gunner in guiding the missile to the target. Items tested included helmet-mounted binoculars and monocular, gyro-stabilized binoculars, chest-mounted binoculars with gyro stabilization, low-power binoculars worn like eyeglasses, a French tank sight in a variety of mounts, and a prototype sight developed for the P-61 night fighter.

(a) Only the P-61 sight proved suitable for use in the helicopter. This sight was developed at the University of Rochester for the P-61 "Black Widow" night fighter. It is not known if the sight was placed in operational use. Mounts for the sight were fabricated by Board personnel after many trial-and-error experiments. This sight provided the helicopter-borne SS-11 gunner a stable, magnified target image and a means of guiding the missile to tank-size targets at the maximum range of the system. The sight is rugged, reliable, simple to manipulate, and has no moving parts except for the rubber diaphragms in the two dampers.

(b) With some engineering research and design this basic sight could possibly be improved to eliminate all of the helicopter vibrations from the gunner's sight, to increase the field of view, and to increase the magnification. The production version of the sight should also be mounted from the roof of the gunner's compartment to allow out-of-the-way stowage when not in use and to remove a potential hazard.

(c) A means of enabling the pilot to keep the target in the gunner's sight had to be devised as the gunner could not guide the missile and adjust the sight simultaneously. A standard Mark 8 aircraft gunsight was installed for the pilot. The two sights were aligned prior to firing. Thus, by keeping the target in his sight, the pilot was able to keep the target in the gunner's sight.

b. Helicopter Instability.

(1) The slightest tendency of the helicopter to yaw, pitch, or roll caused movement of the target in the gunner's sight and usually resulted in a target miss. This problem became acute in turbulent and gusty air. Simulated firing runs revealed that the pilot could maintain the desired pitch and roll attitude but could not maintain yaw (heading) control as accurately as necessary; flight in turbulent air caused the helicopter to yaw to the point where the target would pass out of the field of view of the gunner's sight. A positive means of maintaining aircraft heading was necessary to eliminate misses caused by yaw movements of the helicopter.

(2) In mid-March 1960 the Aviation Board contacted Lear, Inc., Santa Monica, California, and requested the loan of a Lear Super ARCON (automatic rudder control), an item evaluated by the Board in 1958. A Super ARCON was not available but the Astronics Division of Lear, Inc., offered to fabricate a heading control system at no cost to the government. On 4 April 1960, a representative of the Astronics Division arrived at Fort Rucker with the equipment and installed it in the HU-1 helicopter equipped with the SS-11 system.

(3) Testing with the heading control system (Lear MIIACON DHC) began with service-test firing number 11 (see chart in appendix C). Initial test firings utilizing the Lear MIIACON DHC indicated several modifications were necessary to give the equipment more positive control. The changes were made as testing continued and, by service-test firing number 25, the equipment was functioning as desired. Subsequent to firing number 25, 17 missiles were fired of which 15 were hits, resulting in an accuracy figure of 89 percent. This high percentage of hits was a direct result of the positive heading control provided by the Lear MIIACON DHC.

c. SS-11 Kit for the HU-1. The SS-11 system as installed on the HU-1 could be readily adapted as a "kit" installation.

(1) The adoption of the SS-11 system in kit form would offer these advantages:

(a) All HU-1 series helicopters could be readily fitted with the SS-11 system in the field.

(b) The commander would have the option of varying the number of SS-11 equipped HU-1 series helicopters to fit each situation.

(c) SS-11 equipment on grounded aircraft could be used on other aircraft.

(2) Items which would be permanently installed on the helicopter are:

(a) Internal cables and wires.

(b) Hard points for launcher attachment.

(c) Brackets to accept the two sights, the control stick, the generator, the selection box, and the control box.

(3) Components of the "kit" would be:

(a) Launchers and support booms

(b) Two sights

(c) Control stick

(d) Control box

(e) Generator

(f) Selection box

(g) Automatic heading control (Lear MIIACON DHC).

7. (C) CONCLUSIONS.

a. The helicopter equipped with automatic heading control is a suitable vehicle from which to fire and control the SS-11 missile.

b. The HU-1( ) helicopter is suitable as a vehicle for the SS-11 system and so mounted, the system will provide tactical commanders with an airborne anti-tank weapon which is fast, rugged, reliable, accurate, ready, and easily operated by a two-man crew.

c. Accuracy in the order of 90 percent can be achieved if the P-61 and Mark 8 sights and the Lear MIIACON DHC are incorporated as essential components of the SS-11 system.

d. Discrepancies and shortcomings listed in appendix B should be corrected.

8. (C) RECOMMENDATIONS. It is recommended that:

a. Subject to incorporation of equipment outlined in paragraph 7c and correction of discrepancies outlined in section I, appendix B, the helicopter-mounted SS-11 antitank guided missile system be type classified Standard A. (This will replace no existing equipment.)

b. The HU-1( ) helicopter be utilized for mounting the SS-11 system.

c. The SS-11 ATGM system be adopted for helicopters in kit form.

William H. Byrd Jr.
1st Lt. Inf

JACK L. MARINELLI
Colonel, Artillery
President

APPENDIX A

Details of Test

1. (C) Test No. 1 - Physical Characteristics.

a. The SS-11 system as installed on the HU-1 helicopter mounted three launchers horizontally on each side of the fuselage near the center of gravity of the aircraft. The gunner's controls were installed in the copilot's side of the cockpit without removing the copilot's flight controls.

b. The SS-11 system installed on the HU-1 helicopter, including six missiles, weighed 727 pounds. The installed system imposed a small volume penalty upon the HU-1 helicopter since most of the components were mounted externally. Only the control stick, the control box, the T9C generator, the selection box, and the gunner's and pilot's sights were installed internally (see figure 7). (In future installations the selection box and the T9C generator should be installed in one of the radio or electrical compartments, since they are not manipulated in flight.) The installation of the system did not impair the ability of the helicopter to perform any of its normal missions.

c. With outboard missiles in place, the installation extended 4 feet 10 inches from the sides of the fuselage, and was easily stowed vertically by removing four bolts. With missiles installed on the launchers, minimum ground clearance was one foot six inches. The inboard missiles (numbers 5 and 6) cleared the fuselage by 11½ inches.

d. The launcher booms were adjustable through the range of 0 to 10 degrees elevation in relation to the longitudinal axis of the helicopter. Ordnance engineer testing determined that nine degrees' elevation was suitable for firing when the helicopter was on the ground, hovering at any altitude, or cruising at any altitude. No missiles were grounded because of low launches, and no control wires were cut by the rotor.

e. Each launcher was individually wired to the selection box and an inoperative launcher did not preclude utilization of the other launchers.

2. (C) Test No. 2 - Reliability. The helicopter-mounted SS-11 system was 100-percent reliable throughout the test. All of the components functioned properly throughout the test without repair or replacement. One missile received for the test was not fired because a test performed by Nord Aviation representatives indicated that it was probably defective.

3. (C) Test No. 3 - Accuracy. 40 missiles were fired from the HU-1 helicopter at stationary targets at ranges from 800 to 3000 meters, from flight altitudes of 0 to 500 feet, at airspeeds from 0 to 75 knots. Moving targets were not available. Missiles were fired while the helicopter was operated in three general flight regimes, i.e., in cruising flight at various altitudes and airspeeds, in hovering flight at various altitudes, and on the ground with the engine and rotors turning at operating r.p.m. (see figures 9, 10, and 11). Tank-type targets were used.

a. The overall accuracy obtained was 70 percent hits (28 hits out of 40 firings).

(1) The percentage of hits obtained from firings while the helicopter was operated on the ground was 92 percent (11 hits out of 12 firings).

(2) The percentage of hits obtained from firings while the helicopter was operated at a hover was 75 percent (6 hits out of 8 firings).

(3) The percentage of hits obtained from firings while the helicopter was operated in cruising flight was 55 percent (11 hits out of 20 firings).

b. Two firings were disqualified from accuracy computations. Firing number 4 (see chart in appendix C) was disqualified because the missile struck a sapling stump and crashed short of the target. This firing was conducted in moderate rain and the stump was not visible to the gunner because of the range and the rain. The missile was well stabilized on the target for 4 or 5 seconds prior to impact with the stump. One minute before this firing the same gunner got a good hit on the same target under the same conditions. Firing number 24 was disqualified because the gunner did not connect the control stick cable and the missile flight was uncontrolled. Detailed information on all firings is presented in appendix C.

c. The considerable improvement in accuracy which resulted when the Lear MIIACON DHC was utilized in its present configuration should be noted. The overall percentage of hits obtained from firings in flight using the Lear MIIACON DHC in its present configuration (see paragraph a) was 85 percent (11 hits out of 13 firings).

4. (C) Test No. 4 - Ruggedness. The HU-1 helicopter with the SS-11 system installed was flown 202 hours. All flights were made with all control components of the SS-11 system installed; the majority of the flights were conducted with a full missile load. The helicopter was operated at maximum gross weight approximately 75 percent of the test period. The helicopter was flown through all maneuvers considered normal for its type. These included autorotations, running landings, rapid decelerations,

steep turns and flights in moderate turbulence. Missiles were installed on the launchers in the "Ready-to-Fire" condition and flown for periods ranging from 1 to 6 hours prior to firing with no apparent effects. No replacement or repair was required by any system component, and no failures or defects were noted in the launcher booms, supports, braces or other hardware.

5. (C) Test No. 5 - Climatic Effects. The helicopter equipped with the SS-11 system was operated in the vicinity of Fort Rucker, Alabama, Redstone Arsenal, Alabama, Fort Knox, Kentucky, and Fort Benning, Georgia, during the period 1 November 1959 to 27 May 1960. The helicopter was parked outdoors the entire test period except for brief periods when it was hangared for maintenance which required shop facilities.

a. The helicopter was flown through light to moderate rain with missiles loaded in the "Ready" condition prior to firing. The missiles functioned properly with no adverse effects from the rain. The rain which accumulated on the windshield did not restrict the gunner's use of the P-61 sight. The gunner's side of the cockpit (copilot's side) was not equipped with a windshield wiper.

b. Frequently during the test the helicopter was operated in areas where sand and dust clouds were easily generated by the rotor wash and the wind. The SS-11 system, including missiles, functioned properly during exposure to this type of contamination. Only normal care and cleaning practices were required to maintain the system under all conditions encountered during the test period.

6. (C) Test No. 6 - Readiness.

a. Two tests were run to determine the preparations and time required to load the full complement (six) of missiles aboard the helicopter in the "Ready-to-Fire" condition.

(1) In one test, the helicopter was landed at an ammunition point where a ground loading crew and missiles ready for loading were available. The ground loading crew consisted of four men, two men to load each side of the helicopter. The missiles were assembled and checked prior to the arrival of the helicopter. Seven minutes were required for the loading crew to load the six missiles aboard the helicopter in the "Ready-to-Fire" condition.

(2) In the second test, the helicopter was landed at an ammunition "cache" where the missiles were stored in their shipping crates and ground personnel were not available to assist the helicopter crew. The helicopter pilot and the gunner performed the entire operation. This consisted of removing the missile components from the shipping crates, checking and installing the three dry cell batteries, fixing the warhead to the missile body, checking the jetavators (control spoilers at the

sustainer motor exhaust port) for proper operation, and loading the missiles on the launchers. It required 30 minutes for the helicopter crew to land, perform this operation, and take off.

b. The HU-1 helicopter possesses excellent readiness characteristics. An HU-1 on the alert line can be one mile away at 500 feet altitude in less than 60 seconds after the pilot engages the starter. Further, this "scramble" takeoff is accomplished without exceeding any of the operational limitations imposed upon the helicopter. This type of readiness materially enhances the suitability of the HU-1 helicopter as a platform for the SS-11 system.

7. (C) Test No. 7 - Helicopter Missile Load.

a. The HU-1 helicopter with the complete SS-11 system still retained considerable load-carrying capability. Test weight figures were:

HU-1A Helicopter

Maximum gross weight		7200 lb.
Helicopter empty weight	3975 lb.	
SS-11 system (less missiles)	365	
Six SS-11 missiles	378	
Fuel (full load)	825	
Crew (pilot and gunner)	400	
Ballast (may be eliminated in production version)	50	
Total	5993 lb.	
Total subtracted from maximum gross weight		5993 lb.
Load capability remaining		1207 lb.

HU-1B Helicopter

These figures are based on information available on the HU-1B and not on actual tests.

Maximum gross weight		8500 lb.
Helicopter empty weight	4400 lb.	
SS-11 system (less missiles)	365	

HU-1B Helicopter Chart (Continued)

Six SS-11 missiles	378 lb.
Fuel (full load)	936
Crew (pilot and gunner)	400
Total	6479 lb.

Total subtracted from maximum gross weight . . . . . 6479 lb.

Load capability remaining . . . . . 2021 lb.

b. These figures show that, weightwise, the HU-1A Helicopter, and the HU-1B Helicopter when it becomes available, possess the capability of carrying missiles in addition to the six carried on the launchers. If the missiles are transported in the shipping crates, six can be carried in the cargo compartment of the HU-1A. This load will require that ballast be placed in the helicopter tail boom to maintain the center of gravity within limits.

8. (C) Test No. 8 - Minimum and Maximum Feasible Ranges. During the test, missiles were fired at targets at a range of 800 meters to 3000 meters.

a. Minimum Range. It was determined that the same factors did not apply when determining the minimum range of the helicopter-mounted SS-11 system as those for the ground and other vehicle systems. The unique mobility of the HU-1 helicopter enabled the crew to fire the missile at the most desirable range without encountering the problems which may confront a ground system crew. Further, since the vulnerability of the helicopter increases as range decreases, the helicopter should avoid attacking targets at ranges less than 1000 meters. Should it ever be necessary for the helicopter to attack a target close in, the best minimum range applicable to the ground systems would apply since the gunner was never offset from the missile and the missile could always be launched directly at the target.

b. Maximum Range. The maximum feasible range for the helicopter system utilizing the P-61 sight was 3000 meters. The flight speed or the altitude of the helicopter had no apparent effect on the range of the missile.

9. (C) Test No. 9 - Maintenance and Preflight Service Requirements. Organizational maintenance and preflight servicing of the system was performed by the helicopter crew chief and the pilot-gunners. The crew chief was not school trained to maintain the system but received instruction and assistance from the Nord Aviation technical representatives during the test. The helicopter crew chief could perform organizational maintenance and

daily pre-firing tests of the system after approximately eight hours of instruction. The system required no repairs during the test. The crew chief inspected the system each day as part of the normal preflight inspection of the helicopter. The pre-firing test of the system circuits, which required 15 minutes, was similar to that performed on the ground vehicle systems with the addition of a check of the emergency jettison system. A defective signal generator, control box, control stick, or selection box should be replaced and repaired at a higher echelon maintenance facility.

10. (C) Test No. 10 - Safety.

a. Safety features provided were good. The missile motors could not be ignited and the warhead could not be armed unless the missile was free to lea· the launcher. A micro-switch on the launcher had to be activated by the missile locking lever going to the full unlocked position before the motors could ignite (see figure 8). If a missile had malfunctioned on the launcher during firing, it could have been jettisoned by pressing the "Individual" jettison switch on the control box. This would have jettisoned the launcher and missile selected on the rotary selection switch. All launchers and missiles could be jettisoned from the helicopter by pressing the "Total" jettison switch to be located convenient to the pilot. In the HU-1 this switch was located on the pedestal to the pilot's left, near the Mark 8 gunsight control (see figure 3). The jettison system provided was electrical and the missiles could not be jettisoned manually in the case of a power failure.

b. Safety procedures outlined in the Nord Aviation manual on the air-to-surface version of the SS-11 system were adequate. No incidents occurred which created a hazard to the crew or to the safe operation of the helicopter.

11. (C) Test No. 11 - Suitability of the HU-1 Helicopter. The HU-1 Helicopter equipped with automatic heading control proved to be a suitable vehicle from which to fire and guide the SS-11 missile. No flight regime of the helicopter adversely affected the proper functioning of any component of the missile system. Conversely, firing the missile did not affect the operation of the helicopter. The gunner's field of vision from the helicopter was good. Windshield distortion was not apparent, even when using the eight-power P-61 sight. The HU-1 helicopter has these advantages as a vehicle for the SS-11 system.

a. The six-missile SS-11 system did not limit the utility of the HU-1 except for the weight penalty. The HU-1 carried the complete six-missile SS-11 system, pilot and gunner, and a full load of fuel, retaining load capability of 1207 pounds and an unrestricted cargo compartment to carry it in.

b. The HU-1 configuration permitted the firing of the missiles while the helicopter was operated in forward flight, at a hover, or on the ground (see figures 9, 10, and 11). No missiles were grounded because of low launch, and no control wires were severed by the rotor. All launchers were set at the same elevation, nine degrees up.

c. The HU-1 readiness characteristics are excellent. An HU-1 on the alert line can be airborne and a mile away in less than 60 seconds after the pilot engages the starter (see paragraph 6b).

d. The HU-1 has a low noise level and a low silhouette.

e. HU-1 features such as abundant power, automatic r.p.m. and power control, a good flight control trim system, and overall ease of operation allow the pilot to devote maximum attention to the tactical situation. This is especially important since the method of employment devised during this test requires that the pilot keep the target in the gunner's binocular sight by maintaining a precise flight attitude on the target heading.

APPENDIX B

FINDINGS

Section I

This section contains discrepancies requiring elimination in order to make the item acceptable for use on a minimum basis.

Discrepancy	Suggested Corrective Action
1. No sights were provided with the helicopter-mounted system.	Adopt the P-61 sight evaluated during this test for the helicopter-mounted system. Adopt the standard Mark 8 gunsight for use by the pilot.
2. Yawing movements of the helicopter caused the gunner to lose the target and missile in the sight and miss the target.	Adopt the Lear MIIACON DHC, evaluated during this test, as a necessary component of the helicopter-mounted SS-11 system.
3. The mounting for the P-61 sight and missile control stick fabricated at the Aviation Board was satisfactory functionally but was cumbersome and a potential hazard to the gunner if a crash occurred.	Mount the P-61 sight overhead in the HU-1 installation in such a manner that it can be telescoped down before the gunner for firing and stowed when not in use. The mounting should be adjustable in the three axes and should provide vibration damping adequate to eliminate or substantially reduce the effects of helicopter vibrations. Mount the missile control stick on a small support which could be quickly inserted in a bracket on the front of the gunner's seat for firing and stowed near the gunner when not in use.
4. There were no provisions for manual jettisoning of the missiles in the event that the electrical jettison system failed.	Provide for manual jettisoning of the missiles and launchers.

Section II

This section contains shortcomings which are desired to be corrected as practicable, concurrent with elimination of discrepancies in Section I, or in production engineering or by product improvement.

Shortcomings	Suggested Corrective Action
1. The P-61 sight had a narrow field of view, characteristic of binocular-type sights.	Increase the field of view and the power of the optics.
2. The signal generator and the selection box were installed in the cabin just aft of the pedestal between the two pilots. These two items were not manipulated by the gunner and should have been installed out of the way.	Install the signal generator and the selection box in one of the aft electrical or accessory compartments.
3. The test installation was forward of the helicopter center of gravity requiring ballast in the helicopter tail boom to maintain the center of gravity within acceptable limits.	Install the SS-11 system at the helicopter center of gravity.

APPENDIX C

PHOTOGRAPHS AND CHARTS

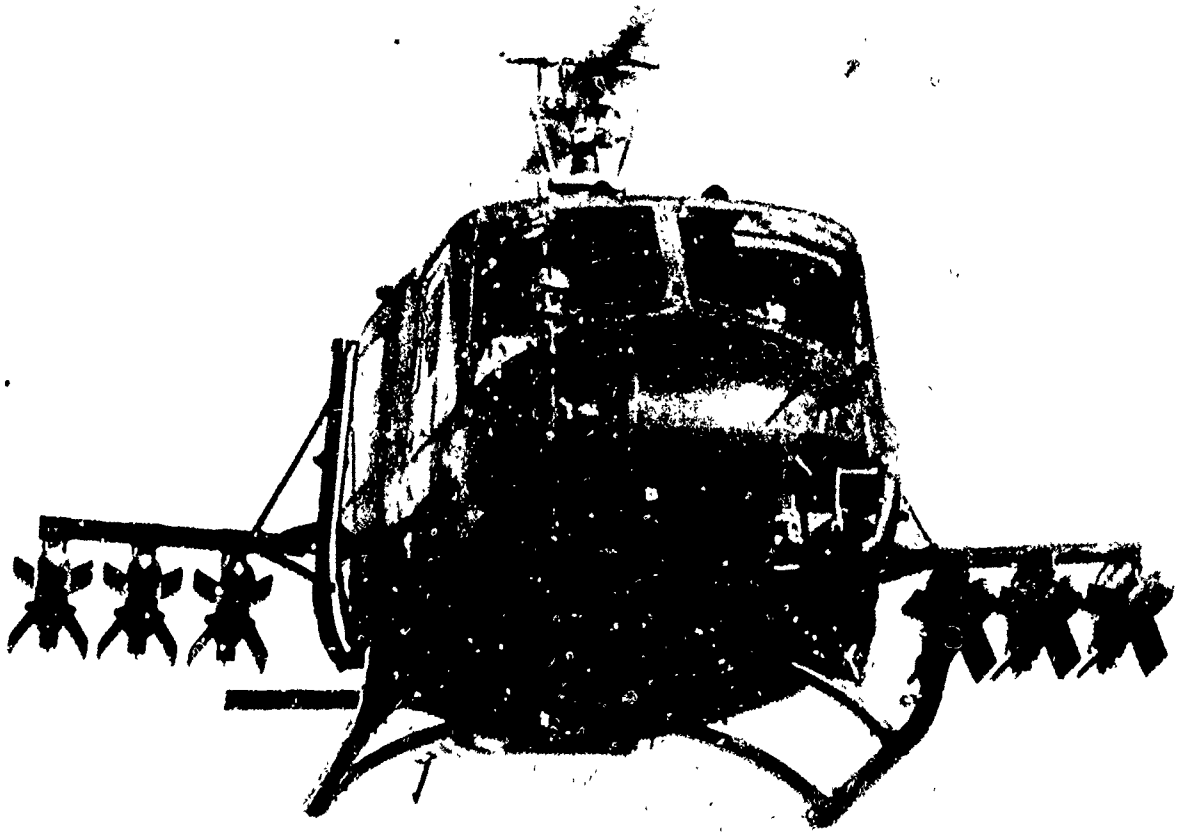

Figure 1. HU-1 helicopter with the SS-11 ATGM system installed

Figure 2. Launcher booms in the stowed position

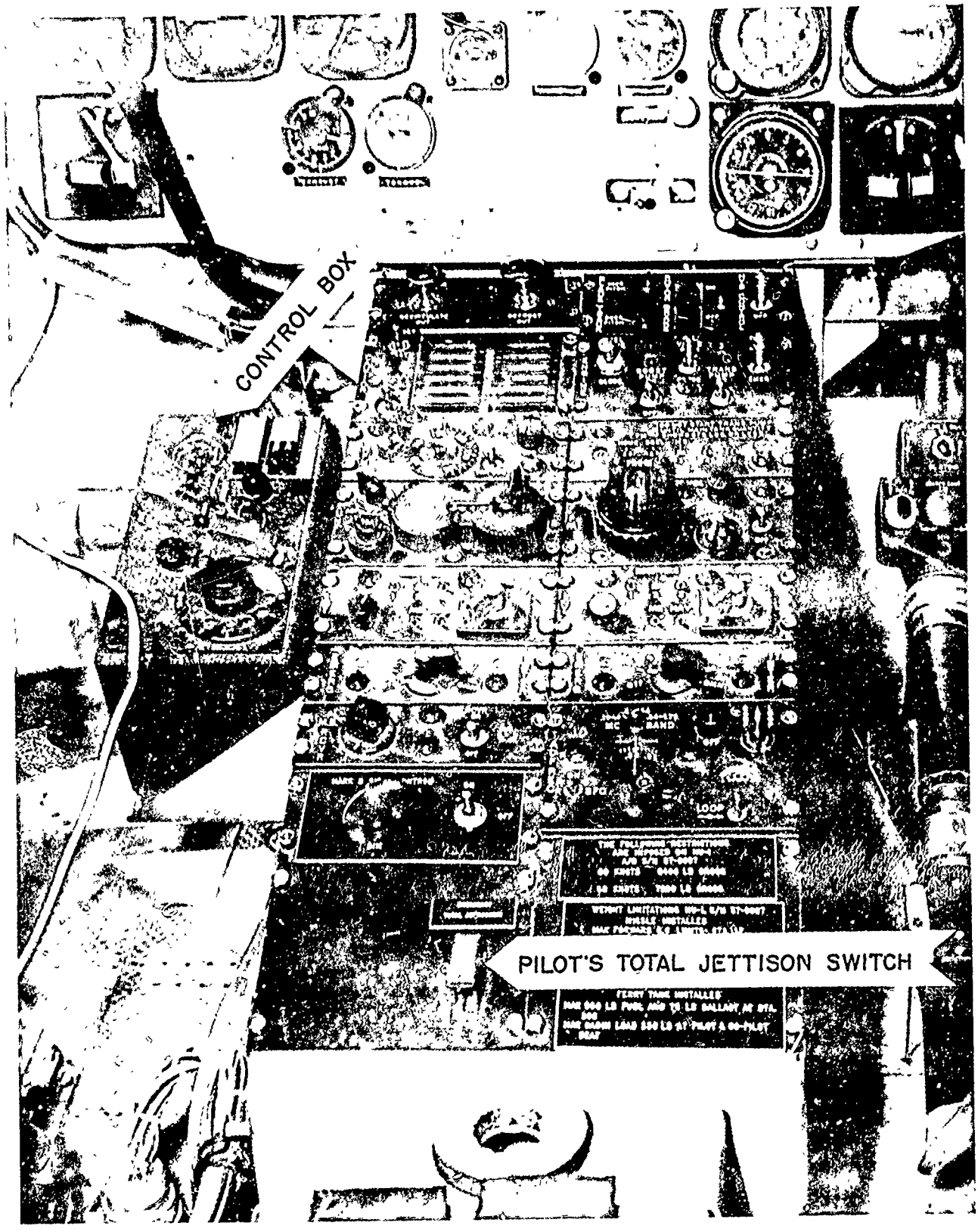

Figure 3. Location of the control box and the pilot's "Total" jettison switch

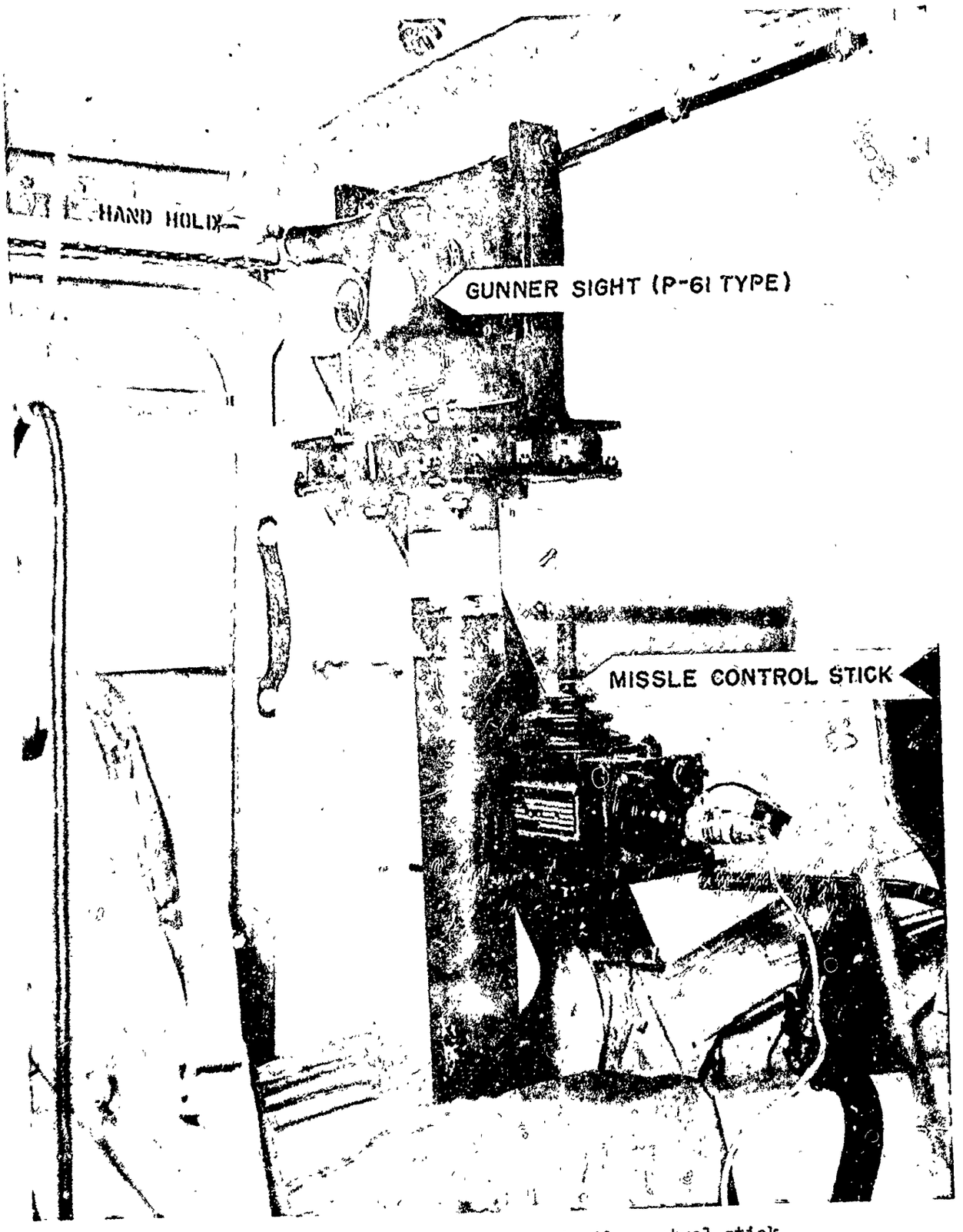

Figure 4. Gunner's sight and missile control stick

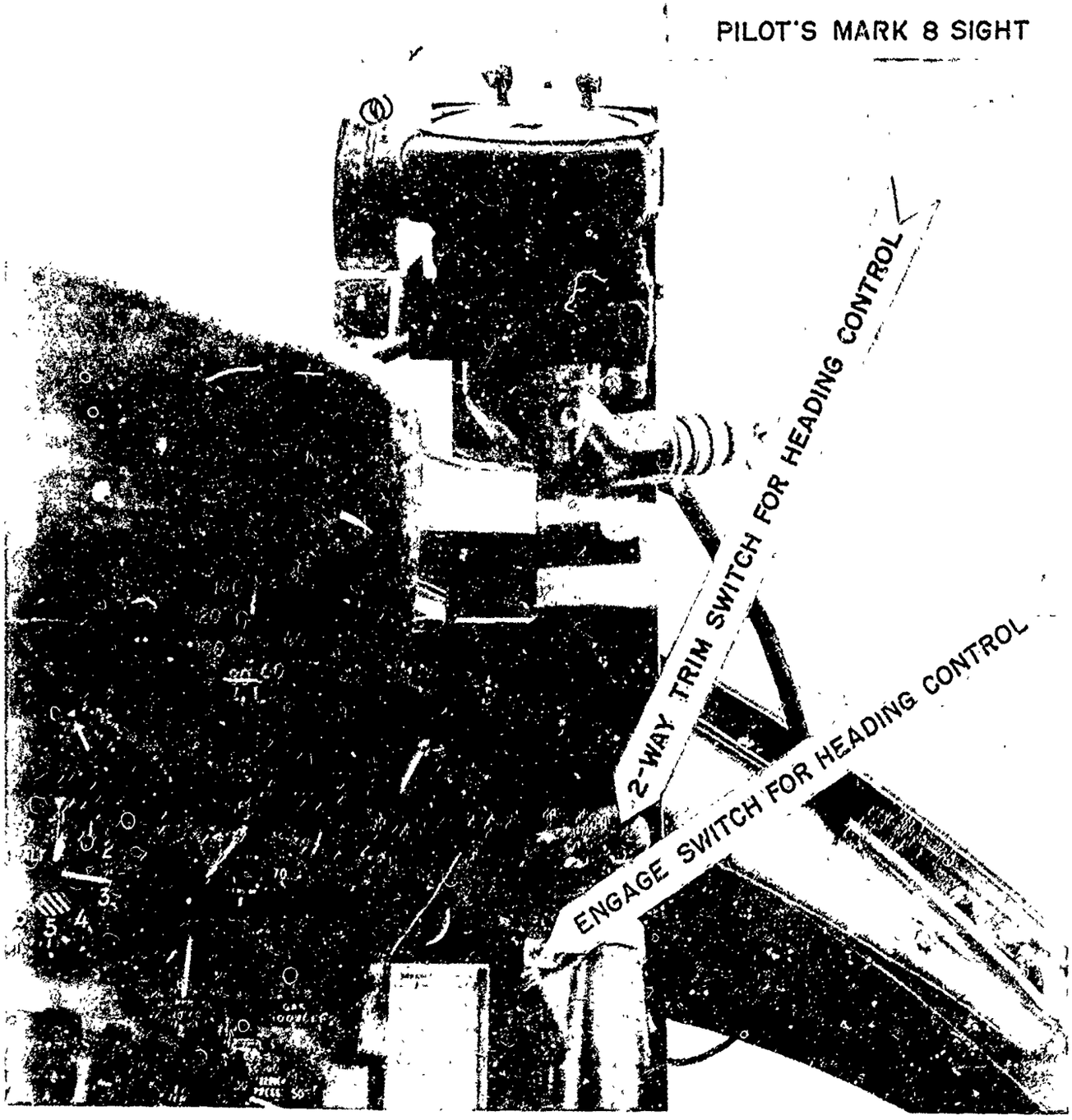

Figure 5. Pilot's Mark 8 sight showing illuminated reticle. Switches on the pilot's control stick for operating the Lear MIIACON DHC (automatic heading control)

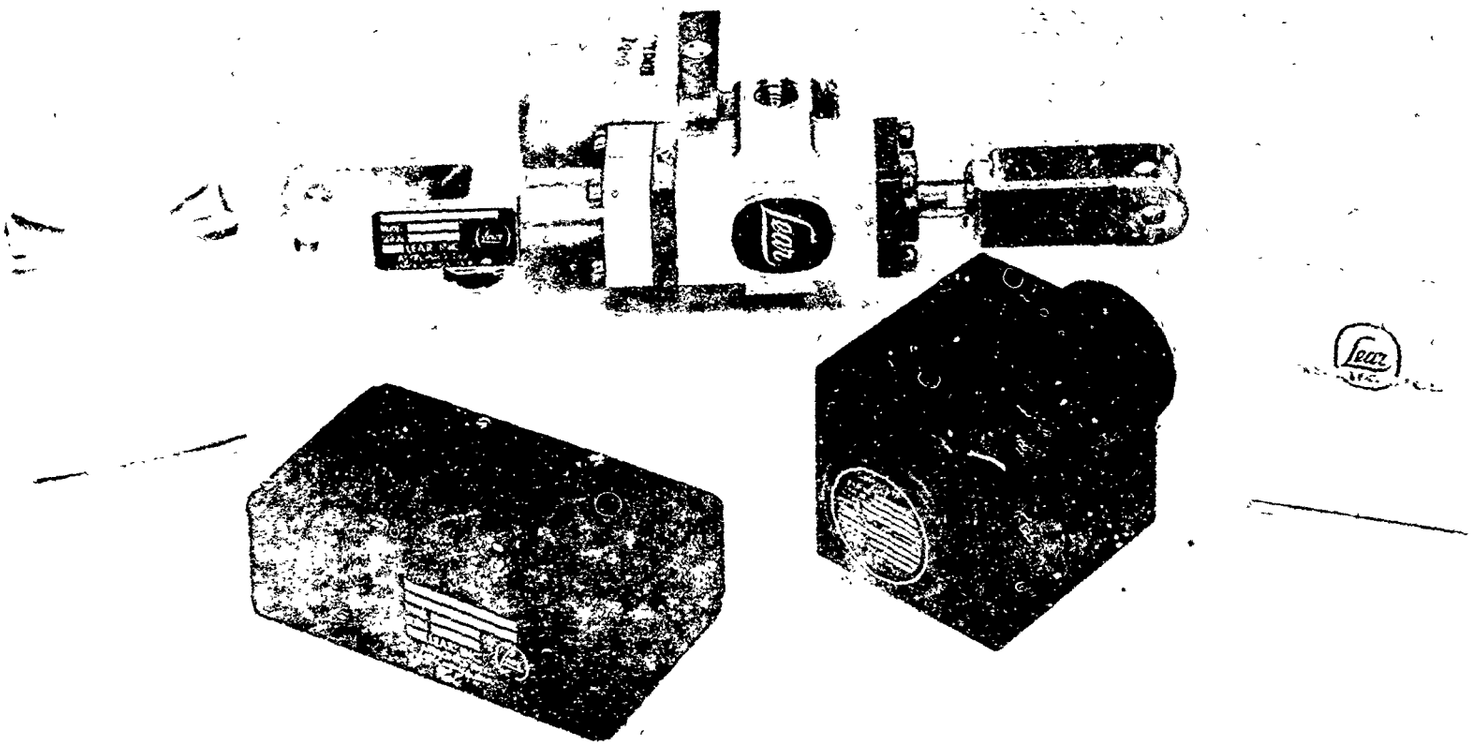

Figure 6. Components of the Lear MIIACON DHC (automatic heading control)

Figure 7. Location of the selection box and the signal generator in the test helicopter

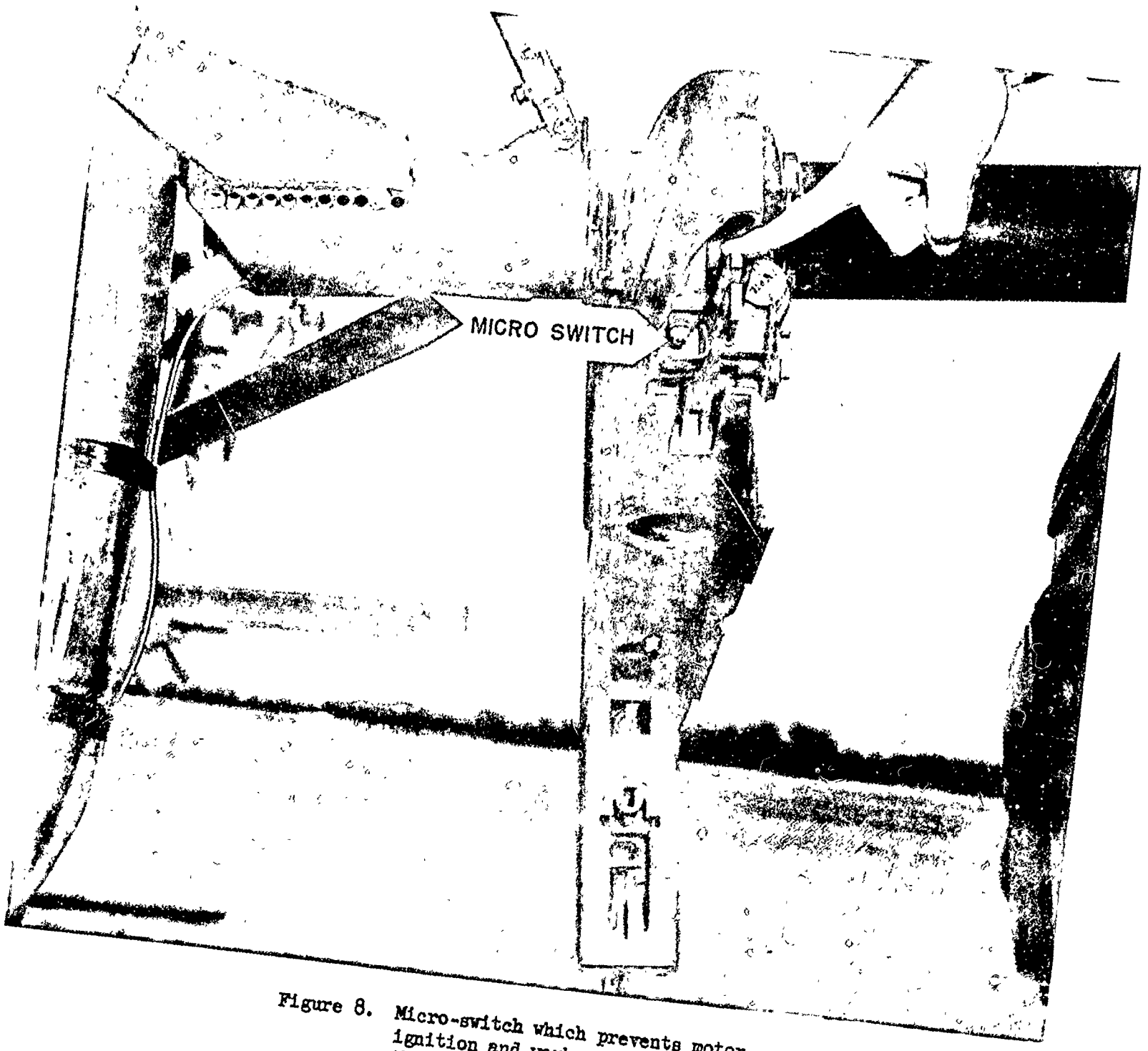

Figure 8. Micro-switch which prevents motor ignition and warhead arming in the event the missile-locking lever does not unlock

Figure 9. SS-11 firing from HU-1 helicopter in forward flight

Figure 10. SS-11 firing from HU-1 helicopter in hovering flight

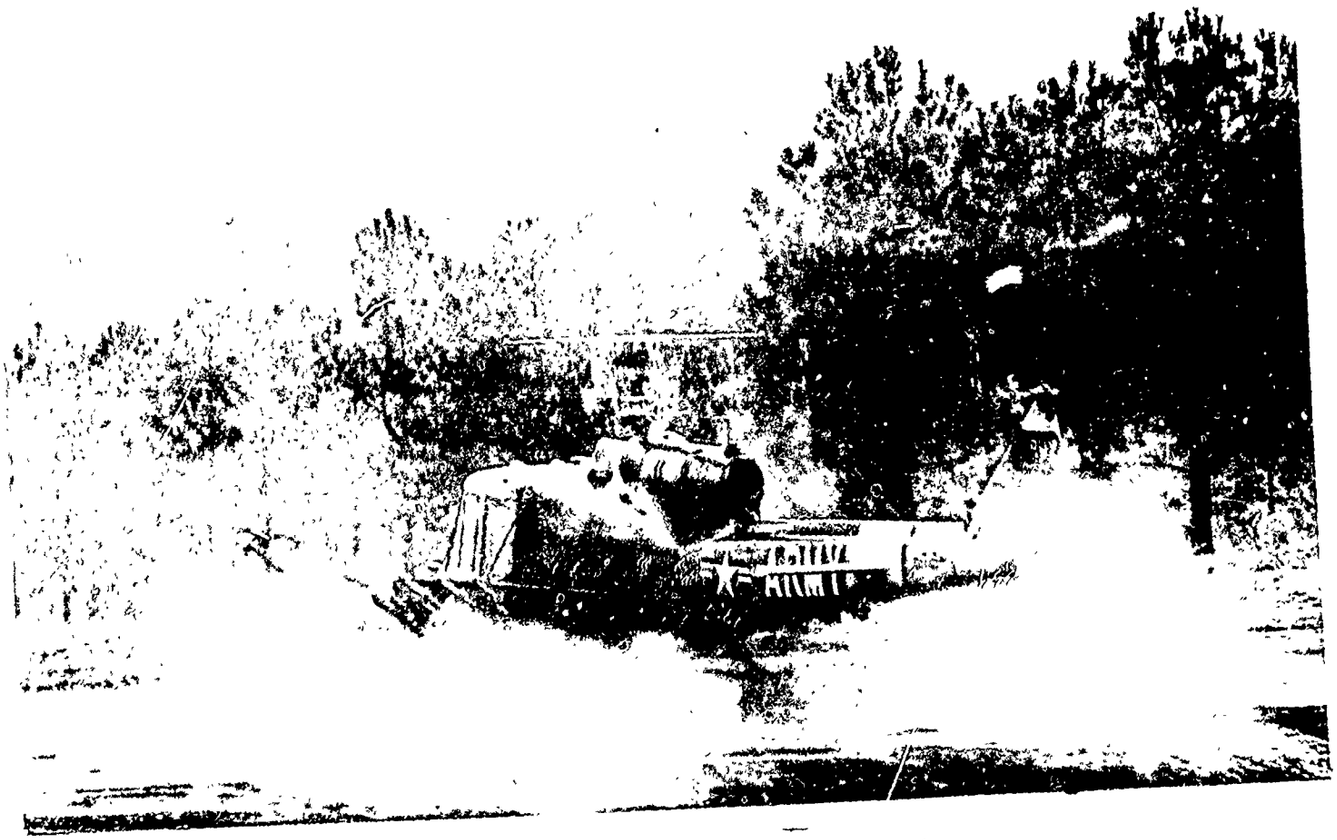

Figure 11. SS-11 firing from HU-1 helicopter operating on the ground

DETAILS OF SERVICE TEST FIRINGS

Firing Number	Weather	Helicopter Altitude/Air-speed (Ft/Kts)	Target	Target Range (Meters)	Type Warhead	Results	Remarks	Gunner/No. SS-11's Fired Previously
1	Overcast, cool; wind 10-15 mph	0/0 (On the ground)	M-4 tank hull, stationary	2100	Inert	Miss	Missile hit short, lined, ricocheted into tank. P-61 sight used.	Carroll/43
2	Overcast, cool; wind 10-15 mph	0/	M-4 tank hull, stationary	2100	Inert	Hit	Good flight. P-61 sight used.	Meyer/28
3	Overcast, rain; wind 18 to 20 mph	0/0	M-4 tank hull, stationary	2100	Inert	Hit	Very stable flight. P-61 sight used.	Meyer/29
4	Overcast, rain; wind 18 to 20 mph	0/0	M-4 tank hull, stationary	2100	125 mm. HEA	--	Missile stabilized well on target but crashed short of target after striking stump.	Meyer/30
5	Overcast, cool; gusty wind 20 to 32 mph	0/0	M-4 tank hull, stationary	2100	125 mm. HEAT	Hit	P-61 sight used.	Carroll/44
6	Clear; calm	30/60	M-4 tank hull, stationary	2100	Inert	Miss	Near miss. Passed just over turret. No sight used.	Meyer/31
7	Clear; calm	30/45	M-4 tank hull, stationary	2100	125 mm.	Hit	P-61 sight used.	Meyer/32

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Firing Number	Weather	Helicopter Altitude/Air-speed (Ft/Kts)	Target	Target Range (Meters)	Type Warhead	Results	Remarks	Gunner/No. SS-11's Fired Previously
8	Clear; calm	30/40	M-4 tank hull, stationary	2100	Inert	Hit	Helicopter yawing caused loss of target and missile in sight. Flight completed without sight.	Carroll/45
9	Clear; calm	30/40	M-4 tank hull, stationary	2100	125 mm. HEAT	Hit	Difficulty with helicopter yawing. Gunner lost target in sight, completed flight without sight.	Carroll/46
10	Clear; wind 5-10 mph	0/0	M-4 tank hull, stationary	2100	125 mm. HEAT	Hit		Carroll/47
11	Clear; wind 5 to 10 mph	40/40	M-4 tank hull, stationary	2100	125 mm. HEAT	Miss	Missile ricocheted into tank. Helicopter yawing caused loss of target in sight. 1st test of MIIACON DHC.	Carroll/48
12	Clear, warm; tailwind 6 to 8 mph	30/0 (Hover)	M-4 tank hull, stationary	2100	Inert	Miss	Near miss, stable lined flight. Passed just over target. Used P-61 sight and MIIACON DHC.	Meyer/33

Firing Number	Weather	Helicopter Altitude/Air-speed (Ft/Kts)	Target	Target Range (Meters)	Type Warhead	Results	Remarks	Gunner/No. SS-11's Fired Previously
13	Clear, warm; tailwind 6 to 8 mph	40/40	M-4 tank hull, stationary	2100	125 mm. HEAT	Hit	Impact near front of turret. Used P-61 sight and MIIACON DHC.	Meyer/34
14	Clear, warm; tailwind 8 to 10 mph	0/0	M-4 tank hull, stationary	2100	125 mm. HEAT	Hit	Good flight. Used P-61 sight.	Carroll/49
15	Clear, warm; tailwind 8 to 10 mph	40/45	M-4 tank hull, stationary	2100	125 mm. HEAT	Hit	Used P-61 sight and MIIACON DHC.	Carroll/50
16	Clear, warm; tailwind 8 to 10 mph	30/40	M-4 tank hull, stationary	2100	125 mm. HEAT	Hit	Good flight. Used P-61 sight and MIIACON DHC.	Carroll/51
17	Clear, warm; wind 15 to 25 mph	0/0	M-48 tank, stationary	2000	Inert	Hit	Used P-61 sight. Good flight. Target about 100' higher than helicopter. Missile knocked cupola off tank. Set tank afire inside.	Meyer/35
18	Clear, warm; wind 15 to 25 mph	0/0	M-48 tank, stationary	2000	Inert	Hit	Good flight. Missile off within 5 seconds after missile above hit. Used P-61 sight.	Meyer/36
19	Clear, gusty tailwind 16-26 mph	100/70	M-48 tank, stationary	2000	Inert	Miss	No sight used. Missile hit short.	Carroll/52

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Firing Number	Weather	Helicopter Altitude/Air-speed (Ft/Kts)	Target	Target Range (Meters)	Type Warhead	Results	Remarks	Gunner/No. SS-11's Fired Previously
20	Clear; gusty tailwind 16-26 mph	100/75	M-48 tank, stationary	2000	Inert	Miss	No sight used. Missile passed just over tank.	Carroll/53
21	Clear; gusty tailwind 16-26 mph	500/50	M-48 tank, stationary	3000	Inert	Miss	Used P-61 sight and MIIACON DHC. Difficulty with yaw.	Meyer/37
22	Clear; wind 10 to 15 mph	100/40	9' x 10' armor panel at 60 degrees obliquity	1800	125 mm. HEAT	Miss	Used P-61 sight and MIIACON DHC.	Meyer/38
23	Clear; wind 10 to 15 mph	100/40	9' x 10' armor panel at 60 degrees obliquity	1800	125 mm. HEAT	Miss	Near miss. Used P-61 sight and MIIACON DHC.	Meyer/39
24	Clear; wind 10 to 15 mph	100/45	Tank hull	1800	Inert	--	Gunner did not connect control stick. Missile flight was uncontrolled.	Carroll/54
25	Clear; wind 10 to 15 mph	100/40	Tank hull	1800	125 mm. HEAT	Miss	Good flight. Missile hit lined and just short of target. Used P-61 sight and MIIACON DHC.	Carroll/55
26	Overcast; gusty wind 15 to 20 mph	0/0	Stationary tank	2100	Inert	Hit	Used P-61 sight.	Carroll/56

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Firing Number	Weather	Helicopter Altitude/Air-speed (Ft/Kts)	Target	Target Range (Meters)	Type Warhead	Results	Remarks	Gunner/No. SS-11's Fired Previously
27	Overcast; gusty wind 15 to 20 mph	10/0 (Hover)	Stationary tank	2100	Inert	Hit	Good flight. Used P-61 sight and MIIACON DHC.	Carroll/57
28	Overcast; gusty wind 15 to 20 mph	30 to 100/45	Stationary tank	2100	Inert	Hit	Good flight. Used P-61 sight and MIIACON DHC.	Carroll/58
29	Clear; tail-wind 10-15 mph	0/0	Stationary tank	2100	125 mm. HEAT	Hit	Used P-61 sight.	Meyer/40
30	Clear; tail-wind 10-15 mph	10/0 (Hover)	Stationary tank	2100	125 mm. HEAT	Hit	Used P-61 sight and MIIACON DHC.	Meyer/41
31	Clear; tail-wind 10-15 mph	40 to 100/45	Stationary tank	2100	125 mm. HEAT	Hit	Used P-61 sight and MIIACON DHC.	Meyer/42
32	Clear; gusty tailwind 8 to 15 mph	0/0	Stationary tank	2100	125 mm. HEAT	Hit	Used P-61 sight.	Carroll/59
33	Clear; gusty tailwind 8 to 15 mph	5/0 (Hover)	Stationary tank	2100	125 mm. HEAT	Hit	Used P-61 sight and MIIACON DHC.	Carroll/60
34	Clear; gusty tailwind 8 to 15 mph	50 to 100/30	Stationary tank	2100	125 mm. HEAT	Hit	Used P-61 sight and MIIACON DHC.	Carroll/61
35	Clear; winds 5-10 mph	0/0	Stationary half-track	3000	125 mm. HEAT	Hit	Used P-61 sight.	Carroll/62

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Firing Number	Weather	Helicopter Altitude/Air-speed (Ft/Kts)	Target	Target Range (Meters)	Type Warhead	Results	Remarks	Gunner/No. SS-11's Fired Previously
36	Clear; winds 5-10 mph	6/0 (Hover)	Stationary half-track	3000	125 mm. HEAT	Hit	Used P-61 sight and MIIACON DHC.	Carroll/63
37	Clear; winds 5-10 mph	20/40	Stationary half-track	3000	125 mm. HEAT	Hit	Used P-61 sight and MIIACON DHC.	Carroll/64
38	Overcast; winds 5 to 10 mph	200/0 (Hover)	Stationary M-4 tank	1500	Inert	Hit	Good flight. Used P-61 sight and MIIACON DHC.	Meyer/43
39	Overcast; winds 5 to 10 mph	100/0 (Hover)	Stationary M-4 tank	1000	Inert	Miss	Good flight. Near miss. Passed just over turret. Used P-61 sight.	Meyer/44
40	Overcast; winds 5 to 10 mph	50/0 (Hover)	Stationary M-4 tank	1000	Inert	Hit	Used P-61 sight and MIIACON DHC.	Meyer/45
41	Overcast; winds 5 to 10 mph	50/45	Stationary M-4 tank	1000	Inert	Miss	Near miss. Passed just in front of turret. Gunner was late in shifting to sight. Used P-61 sight and MIIACON DHC.	Meyer/46
42	Overcast; winds 5 to 10 mph	30/40	Stationary M-4 tank	800	125 mm. HEAT	Hit	Very good flight. Center-of-mass hit. Used P-61 sight and MIIACON DHC.	Meyer/47

Firing numbers 1 through 16 and 38 through 42 were made at Matteson Range, Ft. Rucker, Ala.; 17 through 21, at Hays Flats Range, Ft. Knox, Ky.; 22 through 25, at Salt River Range, Ft. Knox, Ky.; 26 through 34 at Dorrets Run Range, Ft. Knox, Ky.; 35 through 37, at Underwood Range, Ft. Benning, Ga.