JPRS-CST-91-016
1 AUGUST 1991

Foreign Broadcast Information Service
50 ANNIVERSARY 1941 - 1991

JPRS Report

19981210 055

Science & Technology

China

TACTICAL MISSILES & AIR DEFENSE SYSTEMS

JPRS-CST-91-016
1 AUGUST 1991

SCIENCE & TECHNOLOGY

CHINA

TACTICAL MISSILES & AIR DEFENSE SYSTEMS

CONTENTS

IV. The Missile

The HY-2 is a cruise missile which contains the following segments: the fuselage segment, the guidance and control system, the power system, the electrical system, and the warhead and fuse segment.

1. Exterior Profile and Aerodynamic Configuration

The HY-2 missile has a conventional aerodynamic configuration with planar symmetry; the left and right wings are attached to the mid section of the fuselage. The three tail fins are spaced 120° apart.

The nose section of the missile is an elliptic body of revolution, the mid section is a cylinder and the tail section is a contracting cone. The wing and the three tail fins have a triangular design with small aspect ratio and large leading-edge back sweep.

2. Guidance and Control System

The HY-2 missile uses an autonomous post-launch guidance scheme which consists of autonomous control during the initial flight segment followed by automatic steering during the terminal segment. The onboard autopilot is an automatic control/regulator system with three independent control circuits. The system contains the following components: the free gyro control assembly, the damping gyro, the electric rudder, the integration mechanism and the altimeter; its main function is to provide flight stability and control.

The onboard active terminal-guidance radar system has the following subsystems: the antenna, the transmitter, the receiver, the range discriminator, the automatic discriminator, the power supply, and the control subsystem. Its main function is to radiate the high-frequency, high-power signal generated by the transmitter in a focused narrow beam, and to receive the return signal reflected by the target, from which the angular offset to the target can be measured. It then sends the bearing and altitude control voltages to the autopilot to control the flight path according to a specified steering law until the target is hit. During the acquisition process, the target can be discriminated based on range.

3. Power System

The power system of the missile includes the solid-propellant booster rocket and the liquid-propellant rocket engine and its fuel supply system. The main engine has a single combustion chamber and an automatic regulator system; it uses a natural bipropellant and can operate under two-stage thrust conditions. The propellants are stored in the fuel tank and the oxidizer tank located in the forward section of the missile. The onboard compressed air bottle, the detonator valve, the pressure reducer, and the membrane assembly are used to ensure that the required propellant pressure is achieved at the intake of the turbo-pump of the engine.

4. Warhead and Fuse Segment

The warhead of the HY-2 missile is a cluster-energy blast-type warhead which contains high-energy composite explosives; its nose section is a hemispherical metallic cluster-energy shield which forms a high-temperature metallic jet stream.

There are two electrical fuses and one mechanical fuse, all of which are full-safety contact fuses with remote safety release.

5. Fuselage and Compartment Layout

To facilitate manufacturing, parts replacement, inspection and maintenance, the fuselage of the missile is divided into two sections. The forward fuselage contains the radome, and is further divided into six compartments which include the forward terminal-guidance compartment, the fuel tank, the warhead compartment, the oxidizer tank, the autopilot compartment and the rear terminal-guidance compartment. Four of the equipment compartments have large, removable covers to facilitate inspection and maintenance. The rear fuselage is a compartment that contains the liquid-propellant rocket engine.

6. Flight Trajectory and Post-Launch Operation

The flight trajectory of the HY-2 missile can be divided into two segments: an autonomous control segment and an automatic steering segment. An illustrative plot of the trajectory is shown in Figure 5.

At the time of launch, the missile is ejected by the booster rocket along the guiderails, and begins climbing and accelerating; at the same time, the main engine begins operation. When the booster completes its burn, it is separated from the missile while the missile continues climbing for a period and then turns into horizontal flight. When the velocity reaches Mach 0.9, the engine switches from first-stage thrust to second-stage thrust operation. Before activation of the onboard radar, the missile is under autopilot control, and follows a trajectory which is determined by the instantaneous launch direction and the specified cruising altitude. Once the radar is activated, the terminal-guidance radar begins searching for the target in both range and azimuth. When a target is detected, the radar issues an acquisition command, and enters the target tracking mode; at this point, the missile switches into automatic steering operation. Based on the measured angular error signal relative to the target, the control system steers the missile toward the target. During the post-launch period, the three-stage safety mechanism is released according to a particular sequence; when the missile hits the target, the contact of the fuse sensor is closed, and the warhead is detonated.

7. Improvements and Developments

In an effort to improve the penetration capability and the anti-jamming performance of the missile, three improved models of the HY-2 have been developed.

(1) The HY-2G missile has an improved design of the altitude circuit of the guidance and control system; by using a high-precision, low-altitude altimeter, the cruising altitude is reduced to 30-50 m.

(2) The HY-2A missile not only has the improved altitude circuit design, but also has a passive infrared steering unit in place of the terminal-guidance radar. The infrared detector operates at liquid-nitrogen temperature and has a long action range. The concealed infrared steering unit provides good anti-jamming capability. A second-generation infrared steering unit which has higher sensitivity and superior acquisition performance has also been developed; it is capable of launching an omnidirectional attack on the target within the steering range.

(3) The HY-2B missile also has the improved altitude circuit design; in addition, it has replaced the concealed terminal-guidance radar by an advanced monopulse radar. The monopulse radar is equipped with a special anti-jamming device which can reject interference caused by ocean waves and many forms of electronic interference.

V. Launch-Site Facility

The ground facilities of the HY-2 missile system include the launch-site facility, the technical-site facility, and the common base facility.

1. Components and Functions of the Launch-Site Facility

The launch-site facility consists of the ground radar station, the firing command unit, the launch structures, the mobile power station, the transport and loading vehicles and the electric cable transport vehicles. Its main function is to perform launch control operations for the HY-2 missile, which include: target search and track, guidance computations and aiming, pre-launch inspection and remote-controlled launch operation.

The ground radar station consists of an antenna vehicle and a display vehicle; although primarily designed to track targets on the ocean surface, it can also perform the target-search function. Under normal conditions, it carries out the mission of target search, discrimination and detection in coordination with the coastal warning radars.

The firing command unit consists of a command vehicle and two identical pre-launch inspection vehicles; it is the center of the fire-control system.

There are four launchers, each of which can accommodate one missile. Eight loading and transport vehicles are used to load the missiles onto the launchers to ensure that four missiles are always in ready position at the launch site.

Power to all the site equipment is provided by four mobile power stations. These vehicles are connected to one another by multi-core rubber cables for transmitting command and communications signals. When the vehicles are on the march, the cables are carried by four cable transport vehicles.

2. Operation of the Launch-Site Equipment

Once a target is detected by the coastal warning radar, the command center takes action by assigning the ground radar of a particular HY-2 launch site to begin searching and tracking the target. The radar continually transmits the target coordinates to the firing command unit, where a dedicated computer uses this information, in conjunction with the pre-assigned launch-site parameters and the real-time meteorological parameters, to determine the aiming angles and the autonomous-control flight times from the hit equation. The computer also controls the four launchers and the missiles to aim at a point which leads the target motion. The autonomous-control flight times are loaded into the missile to control the termination time of the autonomous control segment and the initiation time of the automatic steering segment.

The pre-launch inspection vehicle performs the function of missile inspection prior to launch; if the onboard control system is normal, and there are no induced voltages in the launch circuit or the booster circuit, the commander issues an order to push the firing button, and provided that the system satisfies all six launch conditions including checking the firing corridor and the battery conditions, the missile would be ignited, lift off from the launcher, and fly toward the target.

Since the system uses an autonomous post-launch guidance scheme, once a missile is launched, the launch-site facility can immediately prepare for the next launch; it may also be moved to a different site for another combat mission, or the ground radar can continue to monitor the status of the engagement.

3. Developments and Improvements

In order to meet the requirements of modern warfare and to improve the survivability of the missile system, the following improvements have been made to the HY-2 launch-site facility.

The firing command unit has been modified to accommodate all four models of the HY-2 family; also, it has evolved from a transistor-based unit to a solid-state unit controlled by a microprocessor; these improvements have resulted in greatly improved reliability and maintainability, and enhanced capability.

To improve the anti-jamming capability of the ground radar, its single-band "electronic scan" operation has been replaced by the double-band "electronic scan" plus "monopulse" operation and "electronic scan" plus "frequency agile" operation. Special anti-jamming circuits have also been implemented to further improve the combat effectiveness and survivability of the launch-site facility.

In order to reduce the number of pieces of equipment and the number of electric cables, the cables have been replaced by an advanced data transmission system for signal transmission and communications between the vehicles. As a result, the accuracy of the fire-control system and the survivability and mobility of the missile system are also greatly improved.

VI. Technical-Site Facility

The HY-2 technical-site facility consists of 13 vehicles which include the integrated test vehicles and oxidizer filling vehicles. They are used to provide proper maintenance and technical preparation of the missiles so they can be shipped to the launch site in a timely manner.

The main functions of technical preparation include: inspecting the onboard propellant system and the compressor system for airtightness; inspecting the onboard control system for open circuits (unit test and coordinated inspection); filling propellants and compressed air into the missile and installing the warhead and the booster rocket.

The common base facility includes the missile-transport vehicle and the fuel truck which are used for filling and transporting different types of fuel and for transporting the missiles.

The HY-2 missile system and its improved models have passed various ground tests and flight tests; the test results show that their performance meets all design and operational requirements. The family of HY-2 missiles have been classified as superior products by the state, and they participated in the national parade on 1 October 1984 celebrating the anniversary of the establishment of the People's Republic.

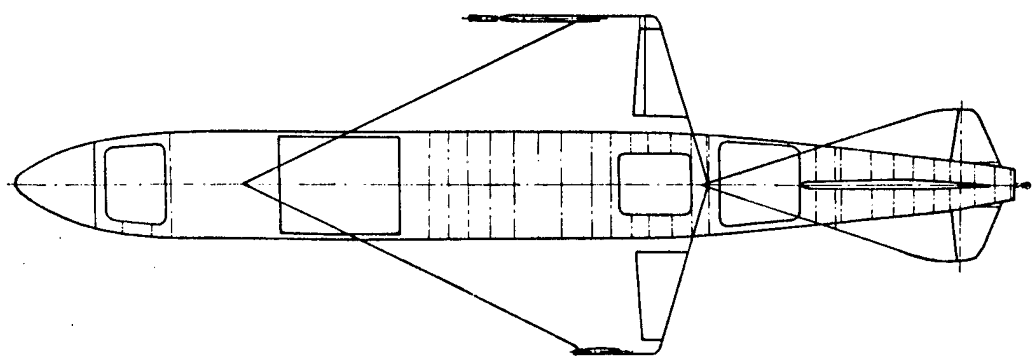

Figure 2. Top View of the HY-2 Missile

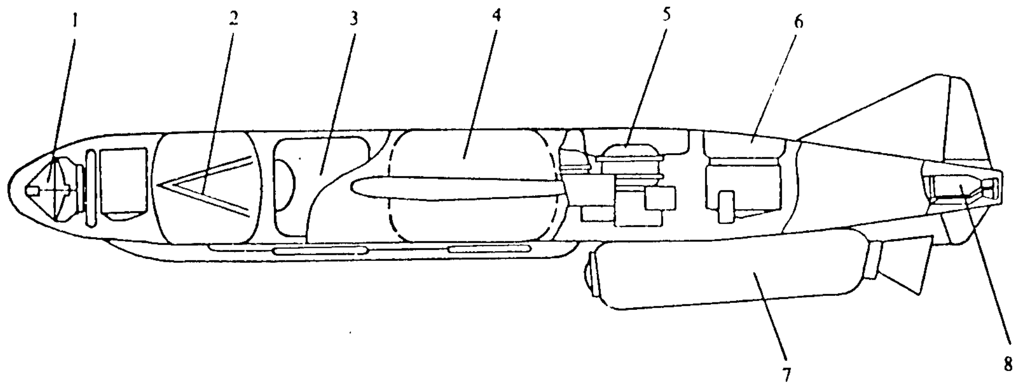

Figure 4. Layout of the HY-2 Missile

1. forward terminal-guidance compartment; 2. fuel tank; 3. warhead compartment; 4. oxidizer tank; 5. autopilot compartment; 6. rear terminal-guidance compartment; 7. booster engine; 8. liquid-propellant rocket engine

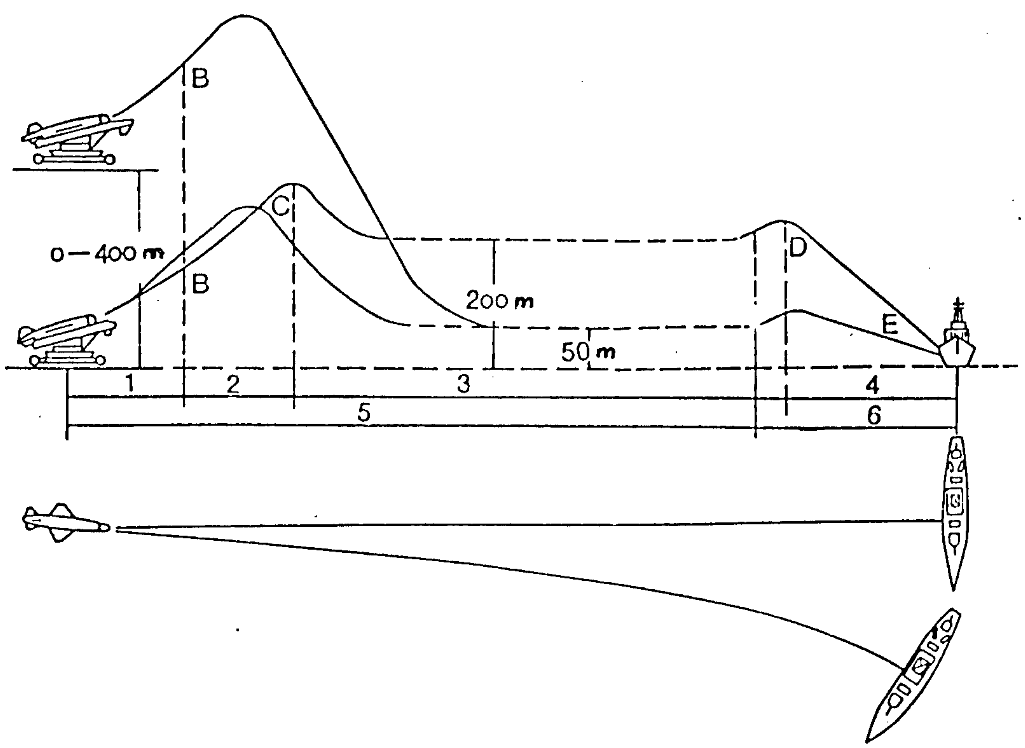

Figure 5. Flight Trajectory of the HY-2 Missile

1. the launch segment; 2. the climb segment; 3. the horizontal-flight segment; 4. the dive segment; 5. the autonomous-control segment; 6. the automatic-steering segment

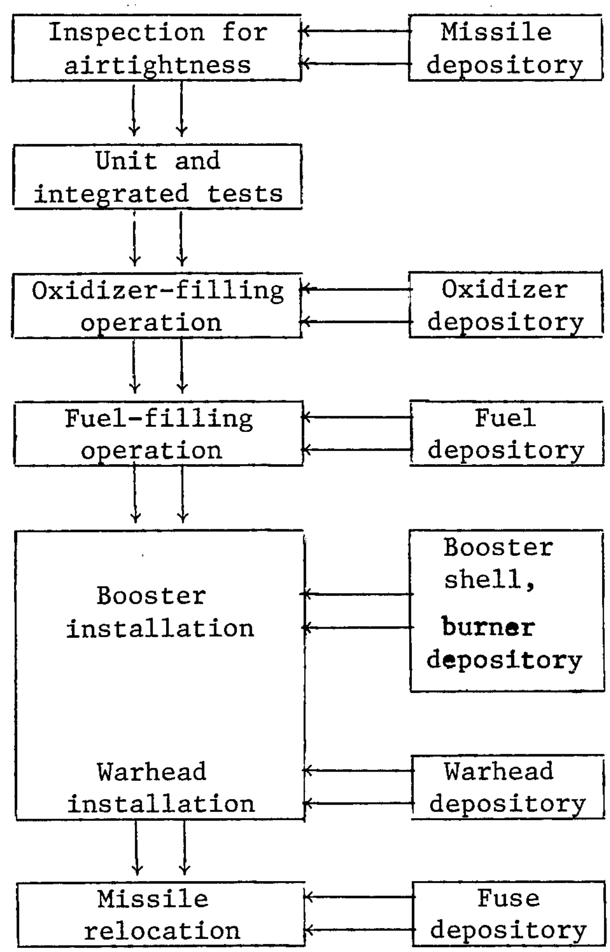

Figure 8. Technical Preparation Procedure for the HY-2 Missile

HQ-2B SAM System

91FE0271B Beijing SHIJIE DAODAN YU HANGTIAN [MISSILES & SPACECRAFT] in Chinese No 5, May 90 pp 28-31

[Article by Xu Pingao [1776 0756 7556] of the Jiangnan Industrial Co., Ministry of Aerospace Industry: "China's HQ-2B Surface-to-Air Missile Weapon System"]

[Text]

Abstract

The HQ-2B (Hong Qi-2B) is a strategic-base-defense missile weapon system developed by this country. A brief description of the important features, the main functions, the tactical and technical performance, and the components of the missile system are given. The improvements to the missile and the guidance and control station that have been incorporated in the HQ-2B system over the HQ-2 missile system, as well as the newly developed launch equipment, are also described.

I. Introduction

The HQ-2B surface-to-air missile (SAM) system is a highly effective, all-weather, omnidirectional strategic-base-defense system; it has been developed based on the HQ-2 SAM system to meet the requirements of modern air defense. In the HQ-2B SAM system, the desirable features of the HQ-2 system are retained, while improvements have been made to overcome the latter's short-comings and deficiencies. By making extensive use of modern technologies and redesigning most of the subsystems and components of the missile, the guidance station and the launch system, the capability of the missile system has been greatly enhanced. [The HQ-2B SAM on launcher and the system's antenna transceiver car are shown in Figures 3 and 4, respectively, of the special photograph section below.]

II. Important Features of the HQ-2B

To evade attack by surface-to-air missiles, modern airborne targets use a variety of counter-measures such as deploying active and/or passive interferers, executing horizontal and vertical evasive maneuvers, and penetrating the defense at very low altitudes or high altitudes. For this reason, a SAM system must employ effective anti-interference measures to enhance its capability against different targets and to expand its battle airspace; also, it must improve its survivability by having increased system mobility on the ground. The HQ-2B SAM system has been developed to achieve these objectives. Compared to the HQ-2 missile system, the HQ-2B has many enhanced capabilities:

1. Expanded battle space;

2. Extended target velocity range;

3. Enhanced capability against horizontally moving targets and new capability against vertically moving targets;

4. Significantly improved anti-interference capability;

5. Improved ground mobility;

6. Higher degree of automation;

7. Extensive use of digital circuits and implementation of computerized command, guidance and control system.

III. Main Functions of the HQ-2B SAM System

The HQ-2B is a mobile SAM system. It is designed primarily for strategic-base defense; however, it can also be used as an autonomous defense system, or be linked with other defense systems to form a wide-area lattice defense network, or to form a circular defense network against a single target.

The HQ-2B system is highly effective against airborne targets such as bombers, fighter-bombers, fighters, reconnaissance aircraft and helicopters; it can also defend against air-to-ground missiles provided they can be tracked by the guidance station. It can defend against single or multiple targets, high-speed or low-speed targets; it can launch one missile in a single-shot mode, or launch two missiles simultaneously.

The HQ-2B SAM system is one of the few air-defense systems in the world that has a capability to defend against targets with such a wide range of velocities and altitudes; it is a powerful defense system that provides effective protection of China's airspace.

IV. Important Tactical and Technical Performance Aspects of the HQ-2B System

1. Battle Space. The HQ-2B is a SAM system with omnidirectional battle capability. It not only has the capability of head-on engagement as with conventional SAM systems, but also has side-attack and tail-chase capabilities. This is a very important advantage that HQ-2B has over other SAM systems in defending against maneuvering targets and targets with end-run penetration capability.

The HQ-2B has an engagement altitude that matches the maximum flight altitude of most modern aircraft; it also has a kill radius with sufficient depth to effectively destroy invading airborne targets.

2. Target Velocity Range. The HQ-2B SAM system can attack targets whose velocities are within the velocity range of all modern aircraft. For target velocities below Mach 2.5, the system has a very high kill probability; for target velocities of Mach 3.3, a sufficiently high kill probability can still be achieved. This is another capability of the HQ-2B seldom matched by other SAM systems.

3. The single-shot kill probability P_1 under normal conditions is higher than 0.92.

4. The maximum missile flight speed M_D is greater than Mach 4.2.

5. Anti-Interference Performance. The HQ-2B system has incorporated 10 new anti-interference measures beyond those of the HQ-2 system; these measures represent a collection of state-of-the-art anti-interference technologies. The missile system can operate in an interference environment that contains clutter interference, target-return interference, and passive interference.

V. Components of the HQ-2B SAM System

The HQ-2B missile system consists of the missile, the guidance station, the launch equipment and the technical support equipment. All the equipment in the system is fully compatible, and the system is easy to maintain and to operate; an operator can use the system in an air-defense battle with only a short period of training.

A basic battle unit of the HQ-2B system includes the following:

1. Twelve missiles, which are transported and launched by 12 mobile launch vehicles; or they can be launched by six launchers which are pulled by six tractors, while the missiles are transported by 12 transport and loading trucks. The launch configuration depends on the mobility requirement of the missile system.

2. A guidance station, which consists of an antenna transmit/receive vehicle, a display and command vehicle, a coordinate-computation vehicle, a command-transmission vehicle, a power-generation vehicle and an electrical-equipment vehicle.

3. The launch equipment, which consists of 12 mobile launch vehicles and a launch-control vehicle. The launch equipment may also consist of six launchers and their support equipment.

The technical support equipment may vary depending on battle requirements. For an autonomous battle unit, each unit will have a complete set of equipment; for densely deployed battle units, several units may share the same set of equipment.

VI. The Missile

The HQ-2B missile is similar to the HQ-2 missile only in its aerodynamic configuration; all the onboard instruments and equipment have essentially been redesigned.

The HQ-2B missile consists of two stages connected in series: the main stage and the booster stage. The missile is 10.80 m long; the booster stage has a diameter of 0.65 m and the main stage has a diameter of 0.50 m; its launch weight is 2,322 kg.

Compared with the HQ-2, the following improvements have been incorporated in the HQ-2B SAM system:

1. The Use of a High-Kill-Power Fuse-Warhead System

The HQ-2B missile uses a newly designed anti-interference phase-comparison fuse whose detonation time can be adjusted according to the relative velocity between the target and the missile; this allows the warhead to be detonated at the optimum position for maximum kill effect. Test results show that the much higher kill power of the HQ-2B missile provides the capability to meet the enhanced battle requirements of engaging high-velocity targets. During several development tests, the target aircraft were hit by only one round of missile firing; some targets were shattered by the missile. The HQ-2B has a large warhead for assurance of target destruction. The warhead is a newly designed fragmentation warhead which contains a considerably larger number of fragments than the HQ-2 warhead; the fragments have very high scattering velocities and armor-piercing capability.

2. Improved Propulsion System

Both the main-stage engine and the booster engine of the HQ-2B missile have been improved in comparison with the HQ-2 propulsion system. The main-stage engine has a variable-thrust design and uses higher-specific-impulse propellant; the booster engine also has a higher total impulse. The improved propulsion system has provided the required trajectory characteristics to accommodate the enhanced battle space and the increased target velocities.

3. The Use of Anti-Interference Digital Codes for Command Transmission

In the HQ-2B SAM system, anti-interference measures in the transmission of commands and signals between the missile and the guidance station have been implemented. Specifically, anti-interference digital codes are used in the transmission of control commands and in the onboard radio controller. Compared with the HQ-2, the signal transmission is more accurate, more reliable, and has higher interference-rejection capability.

4. A New Onboard Power-Supply System

The power-supply system of the HQ-2B missile has been redesigned; the battery-inversion converter system of the HQ-2 missile has been replaced by a battery-static converter system. The improved power-supply system is much lighter in weight and its operation is simplified.

The HQ-2B uses a new self-activated battery design which allows the battery to be operated under any ambient temperature without heating.

5. Increased Usable Overload

By using a redesigned digital autopilot and by increasing the rudder offset, the usable overload of the HQ-2B missile is significantly increased.

VII. The Guidance Station

The guidance station of the HQ-2B SAM system retains the integrated search, track and illumination design of the HQ-2 guidance station. However, except for the scanning antenna, most of the subsystems and components have been redesigned. Its main features include:

1. Extensive use of digital circuits and computerization of command computation and fire control. The old technologies used in the HQ-2 guidance station are almost completely replaced by modern digital technologies. This results in a higher degree of automation and higher accuracy in command computation, which in turn improves the performance of the guidance and control circuits and increases the guidance accuracy and kill probability.

2. The scanning radar is supplemented with a high-frequency ranging radar and television tracking and monopulse system, which significantly improve the anti-interference capability of the target channel.

3. Missiles launched from a single-salvo launch (1-3 missiles) can be guided using different guidance laws to engage different types of targets: high-velocity targets, maneuvering targets, targets with jamming devices and low-altitude targets.

4. A large-screen graphic display unit is used for battle command; it can automatically display such information as the kill radius, the predicted encounter point between the missile and the target, and the optimum launch time.

5. A new moving-target indicator is implemented to discriminate enemy targets from friendly targets.

6. The tractor-pulled type of power station of the guidance station has been replaced by a self-propelled type.

VIII. Launch Equipment

The HQ-2B launch equipment is newly developed. The launch control vehicle can simultaneously control six mobile launch vehicles and issue control commands to six other vehicles; i.e., it has control over 12 mobile launch vehicles.

The new launch vehicles greatly enhance the mobility of the missile system. The main features of the launch equipment are:

1. The HQ-2B mobile launch vehicle is a self-propelled, track-driven vehicle; it can be used for both launching and transporting missiles. Compared with the HQ-2 launchers, the number of pieces and tonnage of the new launch equipment have been significantly reduced, and ground mobility is greatly enhanced.

2. Upon arrival at the launch site, the HQ-2B launch vehicle can begin operation without anchoring or adding supporting structures. A large amount of test data shows that the launch equipment has an excellent record of safety and reliability.

3. The HQ-2B launch vehicle uses colloid-protected track belts so that it not only has good field performance but can also travel on paved roads without damaging the surface.

4. The HQ-2B launch vehicle is equipped with its own power supply and does not require external power sources; consequently, the launch deployment and retrieval times are reduced.

The mobility of the HQ-2B launch vehicle is particularly suited for air-defense units whose launch sites require frequent changeovers; however, the vehicle can also be used with HQ-2-type launchers by users who do not have high mobility requirements.

IX. Technical Support Equipment

The technical support equipment includes the propellant-filling equipment, the powder-packing equipment, the missile-test equipment, and the missile lifting and transport equipment.

Most of the technical support equipment of the HQ-2B system has been redesigned to improve performance, facilitate operation, and reduce weight.

X. Experimental Research on the HQ-2B System

In developing the HQ-2B SAM system, a large number of simulated and actual tests have been conducted over a wide range of target altitudes and velocities; the results of actual tests are shown to be in good agreement with the simulated results in terms of dynamic characteristics and target-kill probabilities. The kill probabilities from both tests are in full compliance with design requirements and are significantly higher than those of the HQ-2 system.

Red Arrow-73 Antitank Missile System

91FE0271C Beijing SHIJIE DAODAN YU HANGTIAN [MISSILES & SPACECRAFT] in Chinese No 6, Jun 90 pp 32-34

[Article by Wen Zhonghui [2429 0112 6540] of Beijing Science & Engineering University: "China's Red Arrow-73 Antitank Missile System"]

[Text]

Abstract

A general description of the components, the tactical and technical performance and the various subsystems of China's first-generation antitank missile system, the Red Arrow-73, are given. The deployment, operation and improvements of the missile system are also presented.

I. Introduction

The Red Arrow-73 is China's first-generation antitank weapon system first developed and deployed in the 1970's. The system is primarily used by Army units to attack tanks and other stationary or mobile targets within a range of 500-3,000 m. The missile is launched from a ground-based launcher; it has a manually operated visual sighting and tracking system, and uses lead-wire communication for command transmission. The weapon system can also be launched from a tank or an armored vehicle.

The basic components of the weapons system include the missile, the launcher, the control box, and the sighting device (see Figure 1) [shown as Figure 5 in the special photograph section below]; when not deployed, the system is stored in two separate backpacks.

II. Important Tactical and Technical Parameters

Target	Tanks, armored vehicles and military structures
Maximum effective range	3,000 m
Minimum range	500 m
Average flight velocity	120 m/sec
Launch rate at maximum range	2 per minute

Attack zone	±9° at a range of 500 m ±22.5° at a range of 1,500-3,000 m
Hit probability	60% at maximum range
Armor-piercing power	Vertical penetration depth for homogeneous armor > 60 mm; at 65° angle, the probability of penetrating a 150-mm homogeneous armored steel plate is > 90%
System reliability	Greater than 90%
Total missile weight	11.3 kg
Warhead weight (including fuse)	2.5 kg
Length	0.84 m
Diameter	0.12 m
Wing span	0.349 m
Guidance system	Manually operated visual sighting and tracking, cable transmission of commands, three-point steering
Propulsion	Two-stage solid-propellant rocket engine, takeoff engine thrust 2290N, cruise engine thrust 740N
Battle preparation time	From march to battle condition 1 min 35 sec, from battle condition to march 2 min 0 sec
Total system weight	In packaged state, 30 kg; in deployed state, 26.5 kg
Operating life	Launchers 10 rounds Control box 2,000 rounds Battery units 20 cycles

III. The Missile

1. Configuration

The missile has a tailless aerodynamic configuration (Figure 2); the wings serve both as lifting surfaces and as stabilizers; the four wing surfaces are arranged in a "cross" configuration and are installed at a 3° 10' offset angle to maintain a 6-8-rps rotation of the missile during flight. To facilitate storage, the wings can be folded along the wing span. The nose section of the missile is a cone, the mid section is a cylinder, and the tail section is a contracting cone with a contraction ratio of 0.56.

The structural layout of the missile is shown in Figure 3. The assembled missile is divided into two compartments: the warhead compartment and the transport compartment. The transport compartment contains the engine, the guidance unit, the wings and the wing barrels. To facilitate packaging and shipping, the warhead compartment and the transport compartment are stored separately; at the time of deployment, the two compartments are connected together by the quick-link mechanism. The takeoff engine and the cruise engine are connected in series; the guidance unit is located on the side of the cruise engine. The backstay-type gyroscope is located at the tail section of the missile to facilitate starting by bracing-wire tension during takeoff. The gas generator and its operating mechanism are located near the jet nozzle of the cruise engine. Four guide blocks located on the outside of the missile are used to attach the missile to the launcher and to guide its direction of motion during takeoff. At the base of the upper left wing is a tracer tube which is ignited simultaneously with engine ignition; during flight, the operator uses the light emitted by the tracer to visually track the missile.

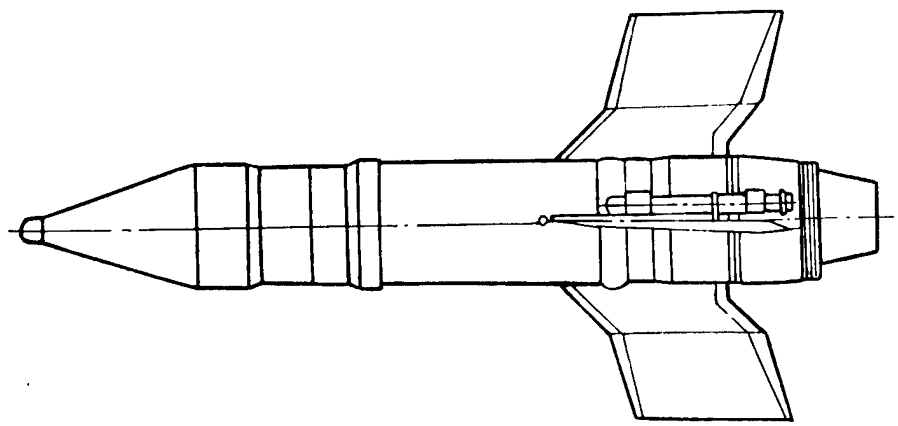

Figure 2. Aerodynamic Configuration of the Red Arrow-73 Missile

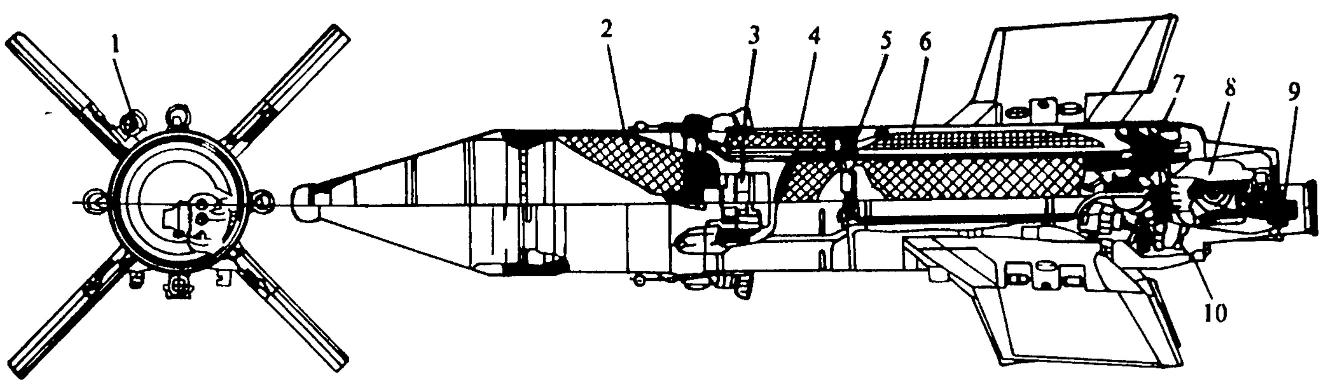

Figure 3. Structure and Layout of the Red Arrow-73 Missile

1. tracer tube; 2. warhead; 3. fuse; 4. engine; 5. wing barrel; 6. cable tubes; 7. steering engine; 8. gyroscope; 9. tail guidance unit; 10. electric receptable

2. The Engine

The basic parts of the engine include the combustion chamber, the powder grain, the jet nozzle, the ignition unit and the engine support.

Both the takeoff engine and the cruise engine use double-base powder; the takeoff engine burns for approximately 0.5 second until all the powder is exhausted, and accelerates the missile to a velocity of 110-120 m/sec. The takeoff engine has four jet nozzles whose axes are tilted relative to the missile plane of symmetry to provide the initial rotational velocity. The cruise engine has an end-burning powder grain whose surface contains circular grooves designed to increase the initial combustion area and to adjust the thrust velocity characteristics so that the missile maintains maximum velocity as it approaches the target.

3. Guidance and Control

The guidance loop of the missile system consists of the launch operator, the ground-control equipment, the onboard guidance unit, the missile and its dynamic components. The guidance equipment includes the ground-control equipment and the onboard guidance unit. The guidance system has a single-channel control system which makes use of the slow rolling motion of the missile during flight; it uses the thrust-vector controller as its executive unit. Detection of errors in the relative motion between the target and the missile and the formation of control commands are performed by the ground-control equipment. Therefore, the onboard guidance unit is relatively simple.

After the missile is launched, the operator uses the visual sighting device to determine the line-of-sight to the target, and tracks the missile to measure its deviation relative to the target line-of-sight. He then manually operates the stick on the control box to issue control commands based on the three-point steering law. The control commands are received by the ground control box where they are converted into control signals by a comparison with the signals sent back from the onboard reference gyro; the control signals are transmitted to the onboard guidance unit where they are processed and distributed to the steering engine to control the thrust-vector controller. The controller produces control forces in pulse-modulated form to steer the missile along the target line-of-sight.

4. Warhead and Fuse

The Red Arrow-73 missile uses a cluster-energy, armor-piercing warhead, which is a conventional hollow cone filled with explosives; the cone angle is approximately 60°. In an effort to enhance the cluster-energy armor-piercing effect, a partition is placed behind the primary powder grain. The structure of the warhead is shown in Figure 4; the front section is a cone-shaped wind shield (which serves as a fairing), whose tip has an anti-slip cover. The warhead housing is not only filled with explosives but also equipped with a piezoelectric crystal lead to the fuse. The fuse is a full-safety-type fuse with a safety release distance of 70-200 m behind the launcher.

IV. Launch Guidance System

The launch guidance system includes the launch system and the ground guidance equipment. The launch system consists of the launcher, the electric cables and the backpacks. The launcher is used to support the missile and to provide the initial launch direction. The electric cables are used for connecting the ignition circuit onboard the missile to the control box.

The backpacks are normally used to store the disassembled missile; they are also used as the base for the launcher at the time of launch. The ground guidance equipment consists of the control box, the sighting scope and the battery; its function is to convert the signal given by the launch operator into a control signal and to transmit the signal to the missile through the lead-wire. The sighting scope is used to monitor the deviation of the missile trajectory from the target line-of-sight, and to steer the missile toward the target.

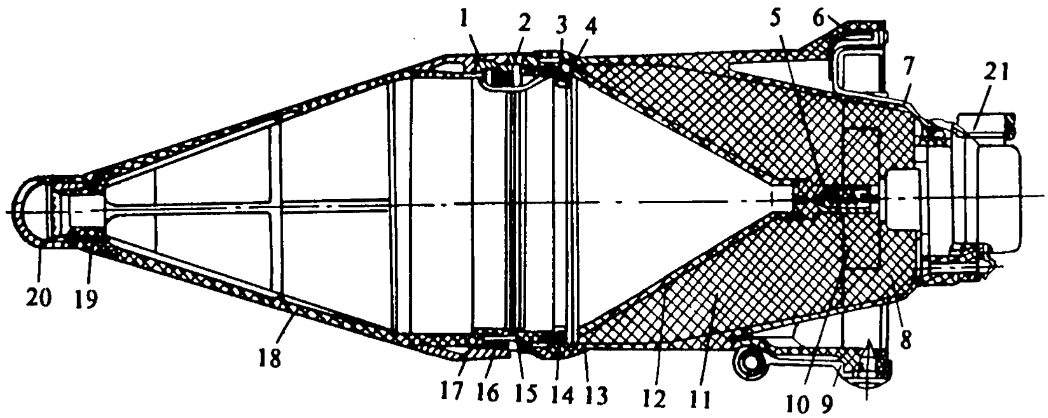

Figure 4. Structure of the Warhead

1. electrical connecting ring; 2. screw; 3. conductive ring; 4. washer; 5. spring; 6. receptacle; 7. lead-wire; 8. secondary powder grain; 9. hook; 10. shield plate; 11. primary powder grain; 12. explosives cover; 13. insulating sleeve; 14. warhead housing; 15. connector; 16. piezoelectric plate; 17. pressure bolt; 18. wind shield; 19. anti-slip cover; 20. protective cover; 21. fuse

V. Combat Operation

The missile systems are directly supplied to the Army combat units for deployment; each combat unit consists of three soldiers.

During the initial stage after launch, the operator uses direct visual observations to determine the deviation of missile trajectory and issues correction commands accordingly to steer the missile along the target line-of-sight. After the missile enters cruise flight, the operator uses the sighting scope to determine the deviation and issues correction commands so that the missile maintains a cruise altitude 3-5 m above the target. When the missile approaches a distance 300-500 m from the target, it gradually descends to the same altitude as the target until the target is hit.

The Red Arrow-73 missile system is fully equipped with test instruments which can monitor the performance of the control box, the battery, the control circuits, the onboard circuits and the launch equipment; it can also measure the parameters of the control box, the resistance of the cable insulator, and the launch angle of the launcher.

VI. Developments and Improvements

Technical improvements of the Red Arrow-73 include the following areas:

1. The armor-piercing capability of the warhead has been enhanced by changing the constituents and proportions of the explosives without altering the shape of the warhead or the missile; the total mass of the explosives has been increased from 1.2 kg to 1.5 kg. This results in a 20 percent increase in the kill power of the warhead.

2. The analog circuits in the control box have been replaced by digital circuits. This improvement not only increases the speed of signal processing, but also reduces the size and weight of the ground-control equipment.

3. The manually operated visual sighting and tracking unit has been replaced by an infrared semi-automatic guidance system which uses visual sighting, infrared goniometry and automatic tracking and formation of control commands.

The improved Red Arrow-73 antitank missile not only has enhanced kill power, higher accuracy and higher probability of hit, but can also travel at slightly higher speed. While the improved missile is 0.3 kg heavier, the total system weight is reduced to make transportation and launch from an armored truck feasible.

C601 Air-to-Ship Missile System

91FE0271D Beijing SHIJIE DAODAN YU HANGTIAN [MISSILES & SPACECRAFT] in Chinese No 7, Jul 90 pp 31-34

[Article by Yang Jingqing [2799 4842 0615] and Xu Zimou [1776 2737 5399]: "China's C601 Air-to-Ship Missile Weapon System"]

[Text]

Abstract

A general description of the components and important features of China's C601 air-to-ship missile system is given; in particular, the capabilities of the onboard equipment and the launch procedure are described in detail. The technical-site equipment and airfield facilities of the weapon system are also briefly described.

I. Introduction

The C601 missile system is a Chinese-built air-to-ship tactical missile system. These missiles are carried under the wings of the Chinese-made long-range bomber, the B6-D. Their mission is to attack large or medium-size surface ships that invade China's territorial waters. The basic components of the C601 missile system include the C601 missile, the sighting and launch equipment on board the aircraft, and the ground-based technical support equipment. This weapon system is a product of sophisticated systems engineering which incorporates many advanced technologies and high-quality equipment; the system operation is well coordinated and highly accurate. Test results show that the C601 is a practical, reliable, versatile and effective defensive anti-ship weapon system. [The C601 missile under the wing of a B6-D bomber is shown as Figure 6 in the special photographic section below.]

II. Important Features of the C601 Missile System

1. High Mobility

The C601 missile can be launched from an altitude of 1,000-9,000 m above sea level. Since the B6-D aircraft has a combat radius of 1,800-2,000 km, a single air base armed with B6-D aircraft and C601 missiles can defend an ocean area of 5-6 million square kilometers with a high degree of mobility.

2. Extended Range

The maximum effective range of the C601 is 100-110 km, and the maximum dynamic range is 150 km. The launch corridor of the missile is ±12°.

3. Autonomous Control After Launch

Once the missile is launched, it can fly toward the target autonomously based on a pre-programmed flight sequence without guidance from the ground or from the aircraft; the aircraft can either leave the combat zone or continue to carry out its support mission. This feature not only ensures the safety of the aircraft and its flight crew, but also enhances the combat capability of the weapon system.

4. Low-Altitude Penetration Capability

The C601 missile can cruise at an altitude of 50, 70, or 100 m with a cruising velocity of M = 0.9. Its long duration of autonomous flight provides good concealment and low-altitude penetration capability during an attack. The missile is also highly accurate: within the maximum effective range, it has a target-acquisition probability of 98 percent and a hit probability above 90 percent.

5. High Kill Power

The fully loaded warhead of the C601 missile has a very high kill power and cluster-energy armor-piercing capability; specifically, it has sufficient destructive power to severely damage or sink a 3,000-ton-class destroyer or a 10,000-ton-class cargo ship. Depending on combat conditions, the missile can be launched one-at-a-time or in salvo pairs, which greatly enhances its combat effectiveness.

6. Anti-Interference Capability

The terminal-guidance unit of the C601 missile uses a monopulse active radar which has strong anti-interference capability against ocean waves and other types of interference.

7. Simple System Design

For ease of operation, the sighting and launch equipment of the missile system are located in the flight cabin of the B6-D aircraft. The ground-based technical support equipment is mostly carried on motor vehicles to facilitate deployment, retrieval, and relocation. The airfield facilities consist of only three vehicles which can load the missiles on the aircraft and prepare the aircraft for takeoff in only 30 minutes.

III. The C601 Missile

The C601 missile is a cruise missile whose basic components include the missile body, the guidance and control system, the propulsion system, the electrical system, and the warhead-fuse system. The missile is 7.36 m long and has a maximum diameter of 0.76 m; its wing span is 2.4 m and its launch mass is 2,440 kg.

1. Aerodynamic Configuration and Missile Body

The C601 missile is a high-subsonic aircraft which has a conventional symmetric aerodynamic configuration with a large backsweep delta-wing design and a semi-rigid structure. The nose section is an elliptical body of revolution, and the mid section is a cylinder; the converging tail section has three tail fins placed at 120° intervals. The overall missile has good dynamic and static stability and control characteristics to accommodate a wide range of flight missions.

2. Guidance and Control Equipment

The guidance system of the C601 missile uses a post-launch autonomous control and automatic terminal-steering strategy; the autopilot is designed to perform independent stability and control functions for all three angle channels. It also coordinates with the onboard Doppler navigation radar, the radio altimeter and the command unit to perform the functions of center-of-mass control and range control. The automatic steering function is carried out based on the steering signal received from the active terminal-guidance radar.

The terminal-guidance radar is a special-purpose radar whose components include the antenna, the receiver/transmitter, the signal processor, the automatic discriminator, the controller, the ECM unit, and the power supply. It provides target information in the pitch and yaw planes which are used to steer the missile toward the target based on a pre-selected steering law.

In order to maintain the temperature of the radar compartment above -25°C so that the terminal-guidance radar will function properly at high altitudes, high-temperature gas is bled from the compressor of the aircraft engine to the radar compartment.

3. Propulsion System

The propulsion system of the C601 missile includes a liquid-propellant rocket engine, the propellant-supply system, the oxidizer-blowoff system, the oxidizer tank, the fuel tank, and the high-pressure gas bottle. The oxidizer-blowoff system is primarily used to release the oxidizer carried by the missile on its return journey in order to ensure the safety of the aircraft, the missile and the flight crew during landing. The missile can be saved for future use.

4. The Warhead and Fuse

The warhead of the C601 missile is a cluster-energy armor-piercing fragmentation-type warhead packed with high-energy composite explosives. Its nose section has a hemispherical metallic cover which upon explosion would produce a sufficiently-high-temperature metallic jet to penetrate a 1-m-thick armored steel plate.

Working in conjunction with the warhead are two electrical fuses and one mechanical fuse. All fuses are contact-type fuses with three-stage safety devices to ensure complete coordination with the warhead and to achieve maximum effect of penetration.

[The layout of the C601 missile is shown in Figure 3.]

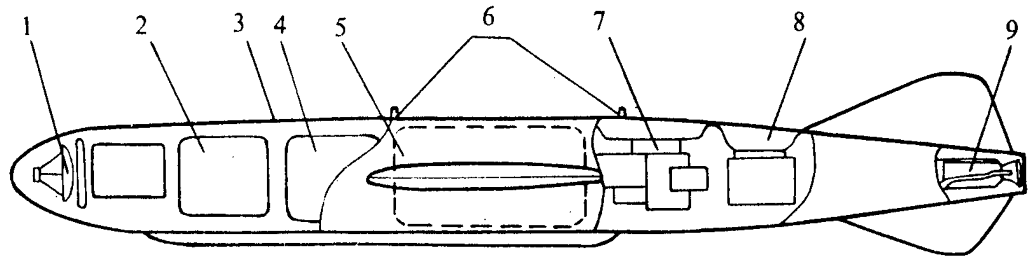

Figure 3. Layout of the C601 Missile

1. terminal-guidance radar; 2. fuel tank; 3. missile body; 4. warhead; 5. oxidizer tank; 6. front and rear suspension ring; 7. autopilot; 8. Doppler radar; 9. liquid-propellant rocket engine

5. Missile Trajectory and Post-Launch Operation

The flight trajectory of the C601 missile is shown in Figure 4; it consists of two segments: the autonomous-control segment and the automatic-steering segment.

Prior to launch, the sighting and launch equipment loads various launch parameters into the C601 missile. Once launched from the aircraft, the missile first flies along an unpowered glide trajectory according to a designated pitch sequence. When it reaches an altitude of 850 m, the propellant tank becomes pressurized, igniting the engine, and powered flight begins. When the missile velocity accelerates to a specified value, the second stage of the engine is ignited, and the missile is propelled to continue flying at constant velocity. As the missile drops further to an altitude of 500 m, it flies along a power-law glide path to its designed cruising altitude. Finally, when the missile reaches firing range, the onboard Doppler radar is turned off, and the terminal-guidance radar is activated and begins searching, acquiring and tracking the target; at this point, the guidance system automatically makes the transition into an automatic steering mode which guides the missile along a diving trajectory toward the target. At the same time, the safety locks of the electrical and mechanical fuses are released, thus allowing the fuses to detonate the warhead and destroy the target upon impact.

6. Improvements and Developments

In an effort to enhance the missile performance and to increase its range, improvements have been made in the propulsion system, the electrical system and the terminal-guidance radar of the C601. Specifically, the improved model, which is renamed the C611 air-to-ship missile, uses new high-energy fuel to increase its range to 200 km. Improvement has also been made in the sighting and launch equipment on board the aircraft so that both the C601 missile and the C611 missile can be launched by the B6-D aircraft.

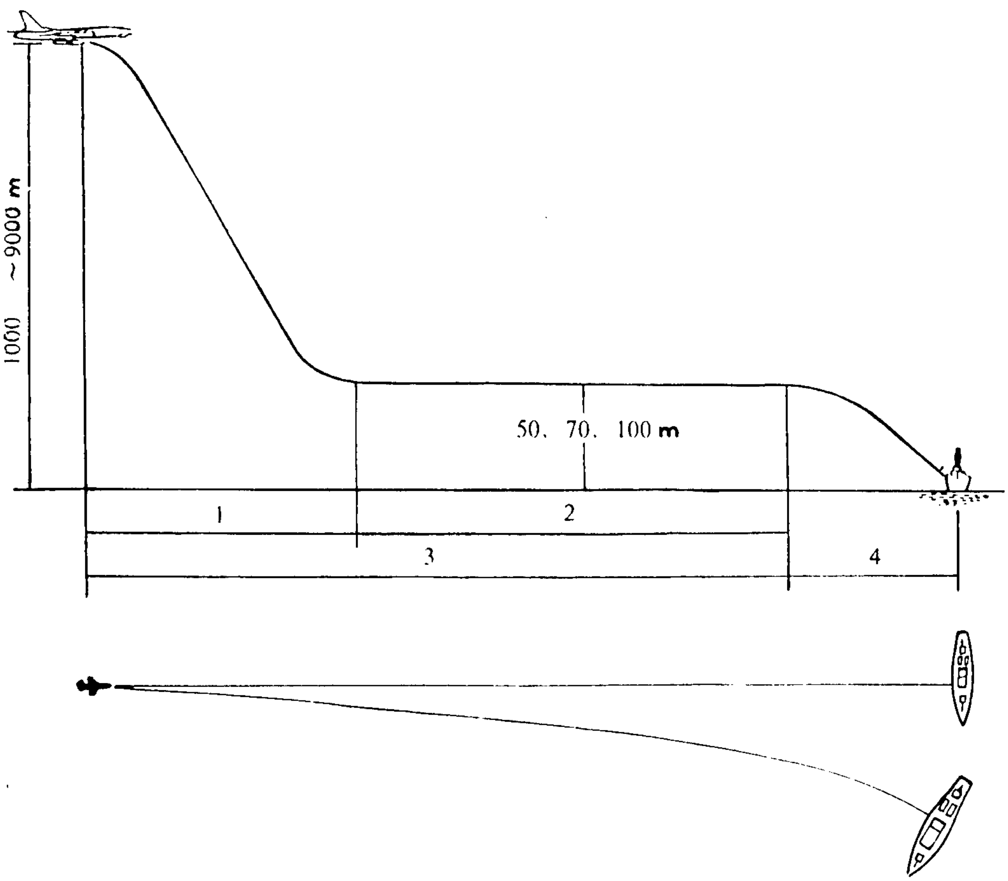

Figure 4. Schematic Diagram of the C601 Missile Trajectory

1. glide segment; 2. cruise flight segment; 3. autonomous-control segment; 4. automatic-steering segment

IV. Sighting and Launch Equipment On Board the Aircraft

1. Components and Functions of the Sighting and Launch Equipment

The sighting and launch equipment of the C601 missile are located on the B6-D aircraft. They include: the target-search radar, the firing-command unit, the launch-control console, the missile-support frame, and various sensing units. The sensing units consist of the yaw reference gyro, the air-pressure-type altitude sensor, the yaw attitude system, the Doppler navigation radar, the inertial navigation unit, the fuselage gyro platform and the wing gyro platform.

2. Operation of the Sighting and Launch Equipment

When a surface ship on the ocean is discovered by the onboard search radar, the navigator first tries to lock on the target by adjusting the tracking gate on the radar screen, then switches into automatic tracking mode. Based on information provided by the sensor measurements, the command unit computes various launch parameters such as the autonomous flight distance, the launch angle, etc., using the hit equation; these parameters are then filtered, smoothed, and loaded into the C601 missile. When all the launch conditions are satisfied, the readiness indicator on the control console is turned on, and the missile is ready for launch.

V. Ground Technical Support Equipment

The main function of the ground technical support equipment is to ensure that the C601 missile system is always in sound technical condition. The technical support equipment is divided into two segments: the technical-site equipment and the airfield facilities.

The technical-site equipment consists of 10 vehicles which include a test-equipment vehicle for conducting tests of various missile subsystems, a maintenance equipment vehicle, a mobile power station, an air-supply vehicle, an air-filling vehicle, an air-cleaning vehicle, a spray-wash vehicle, a lift-equipment vehicle, a propellant-filling vehicle and a transport vehicle.

During missile tests, the mobile power station provides a 27-volt power supply to the missile; the air-supply vehicle and the air-filling vehicle are used to test the propulsion system for airtightness and to fill the high-pressure bottle with compressed air. Then the missile is filled with two different types of propellants and finally the warhead is installed. At this point, the technical-site preparation procedure is complete, and the missile is ready to be deployed on the aircraft.

The airfield facilities of the C601 missile system include two missile deployment vehicles and one command-unit test vehicle. The missile deployment vehicle is a self-propelled vehicle which has the capability of carrying one missile and moving it vertically and laterally as well as rotating it in the yaw, pitch and roll directions; it is easy to use and has a high degree of mobility and versatility. The command-unit test vehicle is used to perform tests of the onboard command unit and to participate in pre-flight ground tests and simulated in-flight tests prior to launch.

The results of numerous development flight tests and actual firings of the missile show that the performance of the C601 missile system has exceeded its design and technical requirements; the system also received the nation's First Prize Award in science and technology achievements. The successful development of the C601 missile system greatly enhances China's defensive strength over its territorial waters.

HQ-61 SAM System

91FE0271E Beijing SHIJIE DAODAN YU HANGTIAN [MISSILES & SPACECRAFT] in Chinese No 8, Aug 90 pp 29-32

[Article by Tang Zhiliang [0781 1807 5328] of the Shanghai Institute of Electromechanical Engineering: "China's HQ-61 Surface-to-Air Missile Weapon System"]

[Text]

Abstract

The system components and the tactical and technical performance parameters of China's HQ-61 missile system, as well as the aerodynamic configuration, the propulsion system, the fuse-warhead segment, the control system and the electrical system of the missile, are described. The components and functions of the launch-site and technical-site facilities and the operational procedures of the weapon system are also described.

I. Introduction

The HQ-61 (Hong Qi-61) missile system is a Chinese-built, all-weather surface-to-air missile (SAM) system designed to attack invading subsonic and supersonic aircraft flying at medium or low altitudes. It has two different models with basically the same components and performance: the surface-to-air model and the ship-to-air model. The ship-to-air model is deployed on moderate size ships for sea-based air defense. The surface-to-air model is carried by wheel-driven all-terrain vehicles for tactical and strategic-base air defense. The missile system consists of three segments: the launch-site facilities, the technical-site equipment and the missile. Because of its many desirable features such as structural simplicity, high guidance accuracy, high kill power, high mobility, good anti-interference capability, and ease of maintenance and operation, the system is considered to be one of the most effective air-defense systems in the world. During target-shooting tests and actual combat tests, the target is generally destroyed by the first round of missile firing. [The ground-launched and ship-launched versions of the HQ-61 system are shown in Figures 7 and 8, respectively, of the special photographic section below.]

II. Important Tactical and Technical Parameters

Maximum range	10 km
Maximum altitude	8 km
Single-shot kill probability	64–80%
Guidance system	Full-course semi-active homing guidance using corrective proportional navigation law
Launch mode	Double guide-rail tilted launch
Missile length	3.99 m
Missile diameter	0.286 m
Wing span	1.166 m
Missile weight	300 kg
Maximum speed	M3

[The kill zone in the vertical plane is shown in Figure 1.]

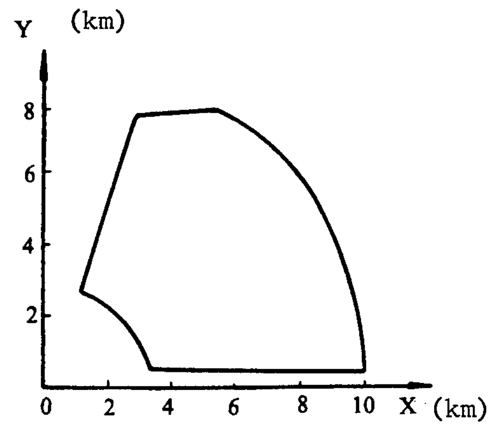

Figure 1. Kill Zone in the Vertical Plane

III. The Missile

The basic components of the missile include the missile body, the guidance and control system, the propulsion system, the electrical system and the warhead-fuse segment.

1. Appearance and Configuration

The missile has an axially symmetric aerodynamic configuration with cross-shaped rotary wings located at the mid section; the cross-shaped tail fins are installed at a 45° angle relative to the wing orientation.

The missile body has a slender cylindrical shape and consists of the radome and five separate compartments: the guidance compartment, the control compartment, the warhead compartment, the engine compartment and the converging compartment (see Figure 2). The radome is made of non-metallic materials and houses the antenna of the steering unit. The guidance compartment contains the steering unit, the fuse and the power supply. The control compartment contains the autopilot-equipped control and stabilization unit and the hydraulic control system. The warhead compartment contains the warhead and the safety mechanism which is located in the center tube of the warhead. The converging compartment contains the engine nozzle which extends outside the compartment. The triangular wings are attached to the control compartment and the triangular tail fins are attached to the converging compartment.

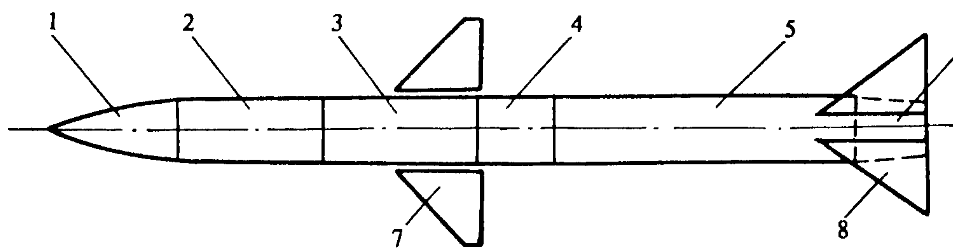

Figure 2. Configuration of the HQ-61 Missile

1. radome; 2. guidance compartment; 3. control compartment; 4. warhead compartment; 5. engine compartment; 6. converging compartment; 7. rotary wings; 8. tail fins

2. Guidance and Control System

The HQ-61 missile uses continuous-wave (CW) full-course terminal guidance; the onboard steering unit includes the following components: the direct-wave feed, the return-wave antenna, the direct-wave receiver, the return-wave receiver, the information processing system and the antenna control unit. Its function is to generate control commands by processing the target return signal and the direct signal from the ground radar; the control signals are transmitted to and used by the autopilot to steer the missile toward the target using corrective proportional navigation guidance law.

3. Propulsion System

The propulsion system of the HQ-61 missile is a single-stage solid-propellant rocket engine. Its basic components include the ignition device, the combustion chamber, and the propellant grain.

The ignition device is a miniature engine used to ignite the primary grain of the main engine; it consists of the jet nozzle, the combustion chamber, the ignition grain box, the grain and the electrical detonator.

The combustion chamber is an argon-welded cylinder made of high-strength plate material. The exhaust nozzle has a titanium-alloy outer shell and its throat section is lined with graphite; the nozzle is threaded to the combustion chamber.

The propellant grain is made of composite explosives with high specific impulse, and is poured into the combustion chamber; it has a six-sided star-shaped hole at the center.

4. Electrical System

The onboard electrical system is designed to perform the functions of transmitting information between various onboard units and between the missile and the ground; supplying electric power to the onboard equipment; generating timing signals; and providing safety switch for the electrical detonation circuit.

5. Warhead-Fuse Segment

The warhead is a continuous thin-rod-type warhead where the thin rods are argon-welded into a single unit; after detonation of the warhead, the rods unfold into circular rings which cut and destroy the target. There are two types of fuses on board the missile: one is a radio-activated proximity fuse; the other is a contact fuse.

IV. Launch-Site Facilities

The launch-site facilities for the HQ-61 SAM system include the target-indication radar vehicles, the tracking and illumination radar vehicle, the computer and launch-control vehicle, the launch vehicle, the power-supply vehicle, and the transport and loading vehicle. They are designed to perform the functions of target search and tracking, computation and sighting, supplying power to the missile, as well as inspecting and launching the missile.

The target indication radar unit, which consists of the antenna vehicle and the display vehicle, is used to provide target indication to the tracking radar. It performs the functions of target identification and discrimination, and has good anti-interference capability.

The tracking radar uses a monopulse system and the illumination radar uses a CW system; both radars share the same antenna. The antenna can be folded into the vehicle storage compartment when the launch site is being relocated. The vehicle is also equipped with a television tracking system; its camera is attached to the antenna base and shares the same antenna servo system with the radar. The main functions of this radar are to track the target and estimate its coordinates, and to illuminate the target and the missile with continuous waves.

The computer and launch-control vehicle is a command and control vehicle which contains a firing-command unit, launch-control equipment, and communications equipment.

The firing-command unit uses an 8086 microprocessor to compute target parameters, launch parameters, and pre-loaded parameters of the steering unit, and to send these parameters to the launch vehicle, the steering unit, and the command-display unit. It also has data-recording and trouble-shooting capabilities.

The launch-control equipment consists of a set of automated remote-control equipment which is used to supply electric power to the missile and to inspect and launch the missile. The equipment can drive two launchers simultaneously, and can operate in either the single-shot mode or the dual-shot salvo mode.

The launcher is a guide-rail-type launcher with two step-ladder sections. The launch elevation and azimuth angles are controlled by a hydraulic servo system with automatic leveling capability.

The power-supply vehicles consist of a 75-kW power-generation tractor and an intermediate-frequency power supply vehicle; they provide the electricity for all equipment at the launch site as well as the power for illumination.

V. Technical-Site Equipment

The technical-site equipment of the HQ-61 missile is used to perform the functions of unwrapping and testing the missile, filling propellant and air, assembling, and delivering the missile to the launch site. The equipment includes the test vehicle, the oil-supply vehicle, the air-supply vehicle, the power-supply vehicle, the missile transport and loading vehicle, and the tools truck.

VI. Combat Operation of the Weapon System

1. Deployment Configuration

Based on the defense requirements and the launch-site conditions, the four launchers can be deployed in two different configurations: a pie-shaped configuration and a circular configuration.

The pie-shaped deployment configuration is used where the direction of approach of the invading target is relatively fixed and where multiple sites operate in a coordinated defense scenario. Since all four launchers are distributed along the front border of the pie-shaped region, each launcher can attack the target approaching from the front.

The circular deployment configuration is used where the direction of approach of the invading target is uncertain or where a single launch site must carry out the defense mission on its own. In this case, the four launchers are distributed along the circumference of a circle centered around the tracking radar and the launch-control vehicle; therefore, there are always two or three launchers within the target range regardless of the direction of approach of the target.

In either deployment configuration, the target indication radar is located far away from the center of the launch site. If the target indication radar is shared by two different launch sites, then it should be positioned between the two sites.

2. Operational Procedure of the Weapon System

The target indication radar is activated by intelligence on enemy targets, and begins searching for the target. Once a target is detected, all other equipment at the launch site is turned on, and self-test procedures are initiated. When the target enters the operating range of the tracking radar, the target indication radar sends the target information to the tracking radar, which immediately begins tracking the target, and transmits information on target coordinates to the firing-command unit. The firing-command unit computes the target parameters, the launch angles and the pre-loaded parameters of the steering unit, and sends the data to all the equipment and the command-display unit.

When the target enters the firing zone, the missile is automatically connected to the CW transmitter, which begins illuminating the target and the missile. As the missile approaches the target, the final stage of the safety lock of the fuse is released, and when the distance between the missile and the target drops below a certain threshold value, the fuse detonates the warhead, thereby destroying the target. If a direct hit occurs, then the warhead is detonated by the contact fuse. If the closest approach between the missile and the target is greater than a specified value, then the missile will self-destruct after passing over the target. [Combat operation is depicted in Figure 5.]

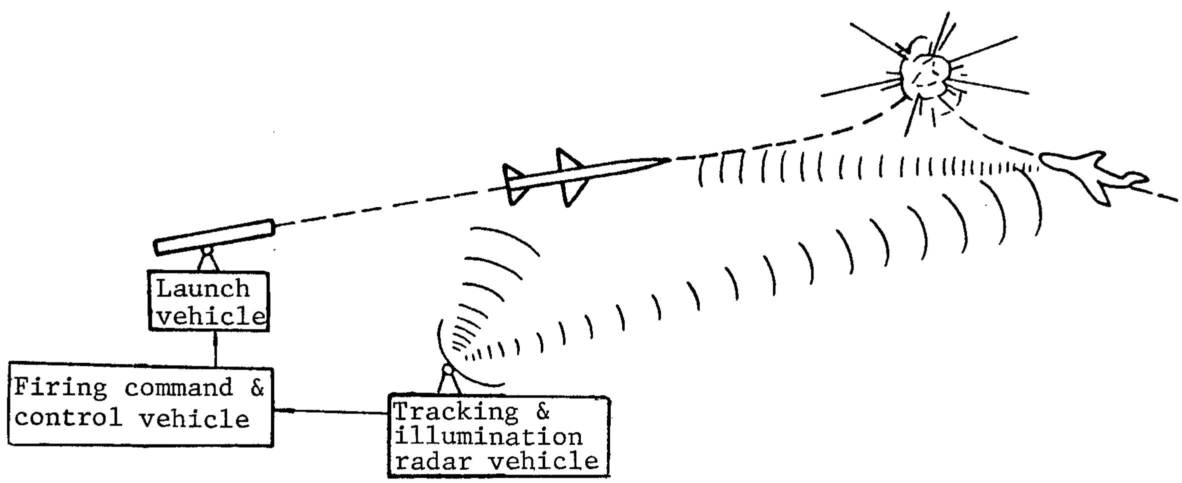

Figure 5. Combat Operation of the HQ-61 Missile System

VII. The HQ-61 Ship-to-Air Missile System

The components and operation of the HQ-61 ship-to-air missile system are basically the same as those of the surface-to-air system. The main differences between the two are:

1. The launch-site facilities are not carried on vehicles but are installed on ships.

2. The missiles are normally stored in a warehouse; at combat time, they are quickly retrieved and delivered to the launchers by a special transport mechanism.

3. The technical-site equipment is stored in bunkers or warehouses near the docks, where missile testing and assembly are carried out.

HN-5C Short-Range Air Defense System

91FE0271F Beijing SHIJIE DAODAN YU HANGTIAN [MISSILES & SPACECRAFT] in Chinese No 9, Sep 90 pp 30-33

[Article by Wang Wei [3769 4850] of the Beijing General Research Institute of Electronic Engineering: "China's HN-5C Short-Range Air Defense System"]

[Text]

Abstract

A brief description of the HN-5C short-range mobile air defense system is given. In particular, the components, the capabilities and the main features of the missile system are described in detail. Also, important technical improvements to the HN-5C are introduced.

I. Introduction

The HN-5C is a short-range mobile air defense system developed by China's Chang Feng Science and Technology Industrial Group. It is primarily used by field combat units, airports, communications centers and important military facilities to defend against the threat of subsonic low-altitude fighters and armed helicopters. As a high-mobility point-defense system, all its combat equipment can be carried on a light-weight all-terrain vehicle, and can be rapidly deployed to any combat region on demand.

A complete HN-5C weapon system consists of a target indication radar and several fire units; the target indication radar is used for target sighting, acquisition and tracking. The system can also perform local search to provide autonomous combat capability. The prototype of an HN-5C fire unit was first developed in early 1986, and actual tests against stationary targets were conducted in June 1986 to verify the performance of the system. The test results clearly demonstrated the validity of the system design concept and the feasibility of the structural design. In November 1986, the prototype was unveiled at the First Asian Defense Exposition in Beijing and attracted wide attention from domestic and foreign news media and arms trade groups.

Currently, the HN-5C is undergoing design improvement and development; the key technical improvements include the use of advanced target detection and tracking sensors and design modifications to provide compatibility with foreign portable missiles such as the "Stinger" and the "Northwest Wind" [i.e., the Mistral] and with different types of carrying vehicles. These improvements will greatly enhance the combat capability of the HN-5C system.

II. Brief Description of the Missile System

The HN-5C system consists of the following components:

--All-optical target detection and tracking sensor;
--Rotary tower;
--Fire-control computer and launch-control electronics;
--Missile launcher;
--Power-supply system;
--Wireless data transmission and position/direction determination system.

All the combat equipment is carried on a light-weight terrain-crossing vehicle; the total system weight including the two launch operators (eight ready-to-launch missiles and eight back-up missiles without the carrying vehicle) is 2.2 tons. The maximum speed for transporting the system is 60 km/hr on paved highways and 30 km/hr on dirt roads. The carrying vehicle is equipped with four leveling devices to ensure that the vehicle remains in a level position during combat. However, since the servo gimbals of the detection and tracking sensor uses a rate gyro for stabilization, level adjustment is not required on a flat combat field. A photograph of the HN-5C fire unit is shown in Figure 1 [see Figure 9 of the special photographic section below].

III. Target Detection and Tracking Sensor Module

The optical target detection and tracking sensor module consists of the infrared goniometer, the television steering unit and the laser ranging device. [The module is shown as Figure 10 of the special photographic section below.]

The infrared goniometer is a liquid-nitrogen-cooled indium-antimonide light-sensitive device operating in the 3-5 μm band; under good weather conditions with visibility greater than 10 km, its detection range for a jet-aircraft target exceeds 7 km. Its main function is to detect and acquire the target, then switch to automatic tracking mode and hand over to the steering unit. Its maximum tracking speed is 20 deg/sec, and the tracking accuracy is higher than 2.4 arc-minutes. The sensor can also perform local target search over a search space of 15° x 9° (elevation x azimuth); this capability ensures a high probability of target detection even when the accuracy of target indication may be poor. This infrared sensor is designed for good-weather and nighttime operation.

The television steering unit has two operational modes. During search and detection, it uses the wide field-of-view (FOV) mode; after target acquisition, it switches to the narrow-FOV mode and guides the missile until the target is acquired by the infrared goniometer.

The two sensors can also be used by the launch operator to perform manual target tracking by using the stick on the control console.

The laser ranging device is used to measure the distance between the target and the fire unit in order to allow accurate calculation of pre-launch parameters and to determine the launch conditions. Its pulse repetition frequency is 5 Hz; its optical axis is accurately aligned with the axes of the infrared goniometer and the television camera. For the purpose of concealment, the laser ranging device begins operation only after the target is acquired by the steering unit.

The optical segment of the above sensors is located on the upper section of the rotary tower; it is equipped with independent servo mounts which are operated by torque motors to perform target search and track in both azimuth and elevation directions. It can operate either synchronously with the rotary tower (during track) or independently (during search). Therefore, when the rotary tower is being reconfigured for launch, it can continue to track the target without losing it. Its electronic control circuits are located in the operator's compartment, and information exchange between the control circuits and the optical segment is accomplished using multi-channel bus bars. During combat operation, the optical sensor provides the required data such as target elevation, azimuth, range, and rates of change of elevation and azimuth to the fire-control unit to generate launch-control commands.

IV. Rotary Tower and Missile-Launch Box

The rotary tower is a support structure for the missile-launch box and the target detection and tracking sensor. The structure consists of the elevation/azimuth motor, the servo amplifier, the amplidyne (the improved model of HN-5 uses a transistor amplifier), the differential bus bar and the main body. It has three operating modes which are controlled by the fire-control computer and signals from the target detection and tracking sensor; these modes are: initial-turn adjustment, synchronous tracking, and advance-turn adjustment.

On each side of the rotary tower is a launch box which contains four ready-to-launch missiles. The launch box is designed to orient the missile in the direction of launch and to facilitate reloading after launch; it is equipped with a pneumatic retrieval mechanism which takes the place of the manual operation done on a shoulder-launched missile. Each launch box also has a missile sequencer whose function is to power the missile, control the initial spin of the steering gyro, and to unlock and release the missile pin in accordance with commands received from the fire-control computer.

The operating range of the rotary tower is:

Azimuth	360°
Elevation	-2° to +85°
Angular rate	0.25 to 50 deg/sec
Tracking accuracy	< 4 m

V. Fire-Control Computer

The fire-control computer is the control center of the weapon system during an engagement. Through the A/D, D/A conversion interfaces, the advance angle unit, and the software and hardware of the display control console, it can perform the following functions:

--Carry out coordinate conversion based on information provided by the target indicator and the vehicle bearing, calculate the initial-turn adjustment of the target detection and tracking sensor and the launcher, and generate the initial-turn adjustment signals;

--Generate the control commands for target search and track and for synchronization of the laser pulses;

--Process the target parameters using a smoothing filter, determine the launch conditions, and calculate the advance-launch parameters and advance-turn adjustment signals for the rotary tower;

--Issue control commands for powering the missile, unlocking the steering unit, and launching the missile;

--Display the current status of the missile.

The fire-control computer is also equipped with software for self-diagnosis, monitoring combat operation and for printing the computed parameters; it can be operated in either automatic or manual mode with manual-interrupt capability.

VI. Launch Operator's Compartment

There are two passengers in the launch operator's compartment: the captain and the launch operator; one of them is also the driver. The captain uses the control console and the CRT display to carry out the command and control tasks of target detection, tracking, discrimination and communications with the main station (i.e., the target indication radar station). Discrimination can be accomplished either by using the discriminator or by visual observation. At the fire units, the discriminator is an optional piece of equipment because the targets identified by the main station have already been through the discrimination process; furthermore, for close-range combat, an experienced operator can effectively perform the discrimination function by examining the target image on the CRT screen. The launch operator has his own control console and display unit. His duty is to key into the computer the bearing data of the vehicle relative to the main station in order to apply coordinate conversion to the target data; at the same time, he also monitors the display unit and controls the combat operation.

VII. Target Indication

Based on user requirements, target indication can be accomplished by a target indication radar or by using existing equipment. A typical target indication radar station or a C^2 system is required to perform the following functions:

--Monitoring targets in the defended zone;
--Target search;
--Target discrimination;
--Provide target indication to the fire units;
--Provide communications between fire units;
--Provide network capability with other C^2 and C^3 systems.

Therefore, the target indication radar and the fire units must have compatible wireless data transmission and communications equipment and position/direction determination equipment.

VIII. Main Features of the HN-5C System

1. Passive operation. The passive mode of operation provides good concealment and greatly reduces the probability of detection by enemy aircraft.

2. High combat efficiency. In comparison with a shoulder-launched missile system whose typical detection range is 3-5 km, this missile system has a target detection range of 7 km; also, by eliminating the effect of human interaction, the system response time is reduced by half and the kill probability is increased by 200 percent.

3. High mobility. The HN-5C is compatible with a wide range of carrying vehicles and has rapid deployment capability.

4. Nighttime combat capability.

IX. System Improvements

A major technical improvement of the HN-5C system is to replace the original point-source infrared target detection and tracking sensor by an imaging target detection and tracking system; the system consists of a dual-FOV forward-looking infrared [FLIR] imaging device, a CCD (charge-coupled device) television camera with continuous focusing capability, and a video-frequency tracking device. By digitizing the target image, the video tracking device forms an error signal between the center of the target image and the tracking axis which drives the servo system. The improved system has many desirable features such as omnidirectional detection, low atmospheric attenuation, and strong interference-rejection capability; it also provides good discrimination capability. The video device is compatible with both television tracking, which can be used for daytime operation, and infrared-image tracking, which can be used under poor visibility conditions (e.g., dust and fog) and during nighttime operation. At present, the system has been field-tested and its performance has been certified. Its head-on detection capability is of particular importance against missiles in a frontal attack. Test results show that for a typical jet aircraft, its head-on detection range is 8-10 km, which is adequate for any existing portable missile system.

A typical carrying vehicle for the future HN-5C system is a wheel-driven armored vehicle, which provides superior terrain-crossing capability and better protection for the launch operator. [Such a vehicle is shown as Figure 11 of the special photographic section below.]

The steering unit of the HN-5 missile uses a 1-3 μm short-wave infrared detector, which is sensitive to heat radiated from a jet engine; therefore, it is effective only in a "tail-chase" combat situation but ineffective against a frontal attack. The new HN-5 missile will have 3-5 μm medium-wave detector with head-on defense capability; the improved HN-5C missile system will be equipped with these new missiles to expand its combat zone.

Airborne Radar Altimeters

91FE0271G Beijing SHIJIE DAODAN YU HANGTIAN [MISSILES & SPACECRAFT] in Chinese No 10, Oct 90 pp 44-47

[Article by Cai Shixue [5591 0013 1331] of the Beijing Institute of Remote Sensing Equipment: "Development, Applications of Domestically Made Radar Altimeters"]

[Text]

Abstract

The development and application of airborne radar altimeters is discussed. Specifically, the performance and technical parameters of the non-coherent radar altimeter, the dual-function coherent radar altimeter, the ocean satellite radar altimeter, the low-altitude FM CW altimeter, the ceramic triode pulsed radar altimeter and the multi-function radar altimeter developed by the Beijing Institute of Remote Sensing Equipment are presented.

I. Introduction

Radar altimeters can be used to accurately measure not only the relative altitude between the carrier vehicle and the ground or ocean, but also surface roughness, scatter coefficients of different ground objects, and the height of ocean waves. Therefore, radar altimeters are being increasingly used by aircraft for a wide range of different applications. For example, they play an important role in automatic landing of airplanes, terrain following and terrain evasion, bombing control, automatic navigation of manned and unmanned aircraft, terrain guidance in cruise missiles, measurement and correction of trajectories in long-range strategic missiles, mid-air detonation of warheads, landing of space shuttles, satellite orbit determination, attitude sensing, measurement of geodetic reference surface, and mapping of ocean conditions.

Based on the mode of operation, radar altimeters can be divided into two types: continuous-wave (CW) and pulsed altimeters. The CW altimeter is simple, inexpensive and provides accurate measurement at very low altitudes; it is primarily used for low-altitude (0-10 km) measurement systems such as aircraft landing systems. But its application is limited due to inherent problems with FM CW systems such as poor interference-rejection capability, difficulties in making high-altitude measurements and associated poor accuracies. Therefore, the pulsed radar altimeter has become the main-stream airborne altimeter because it is capable of obtaining highly accurate altitude measurements ranging from zero to over 1,000 km. In certain special applications such as the measurement of ocean waves, its performance is unmatched by other systems.

Airborne radar altimeters can be divided into two categories: aircraft altimeters and spacecraft altimeters. An aircraft altimeter generally operates in the 0-20 km range, and is required to provide accurate low-altitude measurements and fast response; it is mostly used for automatic landing, terrain following and terrain evasion, and bombing control. For example, the U.S. APN-194, the British 0101, and several Chinese-built aircraft and cruise-missile altimeters are all designed for the above applications. In the early days, most of these applications used FM CW radar altimeters; the range of operation varied between 0 and 1-2 km, and the measurement accuracy was approximately 3 percent of the altitude range. Later, the CW radar altimeters were replaced by pulsed radar altimeters; as a result, the range of operation was greatly increased, and the measurement accuracy was improved to 1-5 m, which was independent of the altitude. In terrain-matching precision navigation (or guidance) systems, the radar altimeter is required to generate real-time high-resolution terrain maps in order to achieve terrain-matching positioning and navigation.

A spacecraft radar altimeter is used on long-range missiles and satellites; its operating altitude generally ranges from several hundred km to over 1,000 km. Its design features vary with the application. For example, altimeters used for trajectory estimation of long-range ballistic missiles such as the U.S. 520 Saturn altimeter and a series of Chinese-built altimeters can operate to a maximum range of over 1,000 km with a certain response speed; their measurement accuracy is of the order of 1 m. However, satellite radar altimeters which are used for wide-area ground or ocean surveying require an operating altitude of over 1,000 km and a measurement accuracy of ±10 cm. In order to achieve this accuracy, radar altimeters used on the U.S. Geosynchronous Environment Observation Satellite C (GEOS-C) and the Skylab satellite have adopted new technologies such as high-compression-ratio pulse compression techniques, 1-second signal storage time, and 10-nanosecond narrow pulse techniques. The radar altimeter of the Seasat satellite uses a 3-nanosecond pulse width to achieve high measurement accuracy and high resolution; the problem of processing extremely narrow-pulse signals has been solved using full deramp altitude measurement techniques.

During the past decade, this institute has been engaged in the development and testing of airborne radar altimeters. These altimeters cover an altitude range of 0 to over 1,000 km, and can be used for a variety of different applications; the measurement accuracy is of the order of 2-3 meters. The radar systems used are primarily pulsed systems, with a few exceptions where FM CW systems are used. The transmitter designs include magnetrons, traveling-wave tubes, ceramic triodes, and solid-state circuits. The receiver designs include non-coherent receivers and pulse-compression coherent receivers. The antenna designs include single-antenna systems and dual-antenna systems. In short, this institute has been involved in numerous in-depth studies on a wide range of topics in radar altimeter technology.

II. Development and Application of Spacecraft Radar Altimeters

1. Non-Coherent Radar Altimeter Used on Ballistic Missiles

During the period 1976-1980, a radar altimeter used on long-range ballistic missiles for accurate trajectory measurement was developed. This altimeter measures missile altitude data along its trajectory, which are transmitted back to the ground via telemetry and used in estimating impact-point deviations. The accuracy of impact-point estimation using this technique was much higher than the accuracy achieved by other external measurement techniques. Of course, one can also use this altimeter for estimating trajectories during powered flight; the improved powered-flight data can be used to correct engine cut-off parameters and to achieve more accurate guidance. It is estimated that this technique can reduce the longitudinal impact-point error by a factor of 3-10, equivalent to an improvement in circular error probable (CEP) by a factor of 1.5-2. The radar altimeter can be used to measure missile altitude continuously over the entire trajectory or just at a few selected points. The measurements should be taken along the ascending arc or descending arc of the trajectory in order to minimize the maximum range requirement of the altimeter.

This radar altimeter has been subject to a full range of routine tests including high- and low-temperature tests, low-pressure test, shock test, overload test, transport test, and numerous field tests; during 1978 and 1980, two flight tests were also completed. The test results show that all the technical parameters of this altimeter have met design requirements. The important technical parameters of this radar altimeter are listed below:

System	Non-coherent pulsed system
Frequency band	X band
Transmitter	Magnetron
Pulse power	80 kW
Operating altitude	100-1,000 km
Altitude measurement accuracy	3 m (rms)
Weight	43 kg

2. Dual-Function Radar Altimeter Used on Missiles

Since the non-coherent radar altimeter provides only high-altitude measurements, it can only improve trajectory estimation in the longitudinal direction. In order to improve the overall accuracy of trajectory estimation, it is also necessary to make accurate measurement of the lateral deviations of the trajectory. For this reason, during the period 1979-1985, a dual-function radar altimeter was developed. This is a pulsed radar which can measure both altitude and slant range at the same time; when operating in the ground-reflection mode, it can measure the relative missile altitude to a maximum range of over 1,000 km; when operating in the transponder mode (i.e., the target is not the ground but a cooperative transponder), it can measure the slant range to a maximum range of 2,500 km. There are several ways to improve the accuracy of trajectory estimation by combining altitude and slant range measurements. By using several altitude measurements along the ascending arc and one slant-range measurement from a ground transponder, it is possible to improve the CEP of the impact-point error by a factor of 3-4. If two slant-range measurements from two different transponder stations are used, then the impact-point error can be further reduced. For example, the estimated CEP for a long-range missile is 200-300 m; for a medium-range missile, it is 80-120 m; and for a short-range missile, it is 50-80 m.

The dual-function radar altimeter is a coherent pulsed radar which uses a traveling-wave tube (TWT) transmitter; it uses linear FM pulse-compression techniques to reduce the peak power of the transmitter. The high measurement accuracy is achieved by using a digital range finder. The important technical parameters of the dual-function radar altimeter are listed below:

System	Linear FM pulse compression
Frequency band	X band
Transmitter	TWT
Pulse power	1 kW
Pulse width	25 μs
Pulse compression ratio	125
Operating altitude	200-1,000 km (altitude measurement) 200-2,500 km (range measurement)
Altitude measurement accuracy	3 m (rms)
Weight	< 20 kg

3. Development of the Ocean Satellite Radar Altimeter

In order to measure the profile of the time-varying water level over land and over the ocean, and to map the ocean conditions, stringent requirements are imposed on ocean satellite radar altimeters. The measurement error must be less than 10 cm, and the resolution must be sufficiently high to measure the wave height which is contained in the leading-edge slope of the reflected signal. In addition, it is also necessary to measure the scatter coefficients of the ocean surface, which are used for research in oceanography and for other engineering applications. The development work for this radar altimeter began in 1988. In order to meet the high-resolution and high-accuracy requirements, a 2.5-nanosecond pulse width is used. The problem of signal processing for such a narrow pulse is solved by using the full deramp (or stretch) technique. This technique involves selecting a linear FM pulse signal whose pulsewidth-bandwidth product is equal to 4,000; a time-frequency transform is applied to the signal and a single-chip digital signal processor is used to measure the water level, the wave height, and the scatter coefficients of the ocean surface. The transmitter is a traveling-wave tube. In order to improve the reliability of the radar altimeter, not only the design of each component and circuit has incorporated reliability considerations, but the entire unit has a redundant structure which can be tested and switched by a microcomputer. Communications with the ground are also controlled by a microcomputer. The important parameters of the satellite radar altimeter are listed below:

Height measurement accuracy	±10 cm (wave height < 20 m, 1-sec smoothing)
Terrain resolution	37 cm
Measurement accuracy of effective wave height	±10% of 0.5 m (effective range of wave height 1-20 m)
Measurement accuracy of ocean scatter coefficients	1 dB
Operating altitude	700-1,000 km
Radar system	Full deramp pulsed radar
Frequency band	Ku band
Transmitter	TWT
Pulse Power	260 W
Pulse width	10 μs
Pulse compression ratio	4,000
Compressed pulse width	2.5 ns
Weight	< 95 kg

III. Development and Application of Aircraft Radar Altimeters

1. Low-Altitude FM CW Altimeter

During the period 1986-1987, a small FM CW radar altimeter was developed for making accurate measurements on aircraft and missiles at low altitudes. It can be used for aircraft landing, maintaining constant-altitude flight for cruise missiles, and for activating altitude-measuring fuses. Altitude measurement in a FM CW altimeter is accomplished by converting the time delays of the signal to frequency deviations. This altimeter is simple in structure, inexpensive, and provides good measurement accuracy at very low altitudes. The main disadvantages are: poor interference-rejection capability and degradation of measurement accuracy with increasing altitude. The important technical parameters of this altimeter are listed below:

System	FM CW
Frequency band	X band
Transmitter	Gunn diode
Transmitter power	50 mW
Operating altitude	0-40 m
Weight	3 kg

2. Ceramic Triode Pulsed Radar Altimeter

In order to satisfy the needs of altitude measurement and automatic navigation for aircraft and cruise missiles, a low-altitude radar altimeter was developed during the period 1983-1985. This altimeter uses a ceramic triode transmitter and a zero IF [intermediate frequency] receiver. Altitude measurement is accomplished using a 30-nanosecond narrow pulse to ensure that sufficiently high resolution can be achieved to meet the requirements of constructing terrain maps in real time for terrain-matching guidance systems. The important technical parameters of this radar altimeter are listed below:

System	Nanosecond pulse system
Frequency band	C band
Transmitter	Ceramic triode oscillator
Pulse power	100-200 W
Pulse width	30 ns
Operating altitude	60-1,500 m
Altitude measurement accuracy	2-3 m (rms)

This altimeter was flight-tested in 1985 and 1986. However, because it has many undesirable features such as large size, short life span (due to the use of vacuum components), and high-voltage requirements, it was replaced by a miniaturized, highly reliable, solid-state pulsed radar altimeter.

3. Miniature Solid-State Nanosecond Pulsed Radar Altimeter

Radar altimeters which are used for altitude measurement, navigation and guidance on aircraft and cruise missiles not only must have good electrical performance but must also meet the requirements of high reliability, small size, light weight and low power consumption. In view of the above-mentioned deficiencies of the ceramic triode altimeter, this institute has developed a new solid-state nanosecond pulsed radar altimeter during the period 1988-1990. This altimeter uses a power field-effect-amplifier transmitter, which has an output power of 3-4 W. In order to meet the maximum measurement altitude, ground resolution and measurement accuracy requirements, linear FM pulse-compression techniques are used to achieve an approximately 20-nanosecond narrow pulse. Miniaturization of the unit is accomplished by using a CMOS high-precision digital range finder. This altimeter has been successfully field-tested and flight-tested in 1989 and 1990. The important technical parameters of this radar altimeter are listed below:

System	Linear FM pulse compression
Frequency band	C band
Transmitter	Field-effect tube
Pulse power	3-4 W
Pulsewidth-bandwidth product	300
Transmitted pulse width	6 μs
Operating altitude	25-7,000 m
Altitude measurement accuracy	2-3 m (rms)
Mean time between failure	> 200 hours
Weight	4.1 kg (excluding antenna)
Power consumption	< 28 W

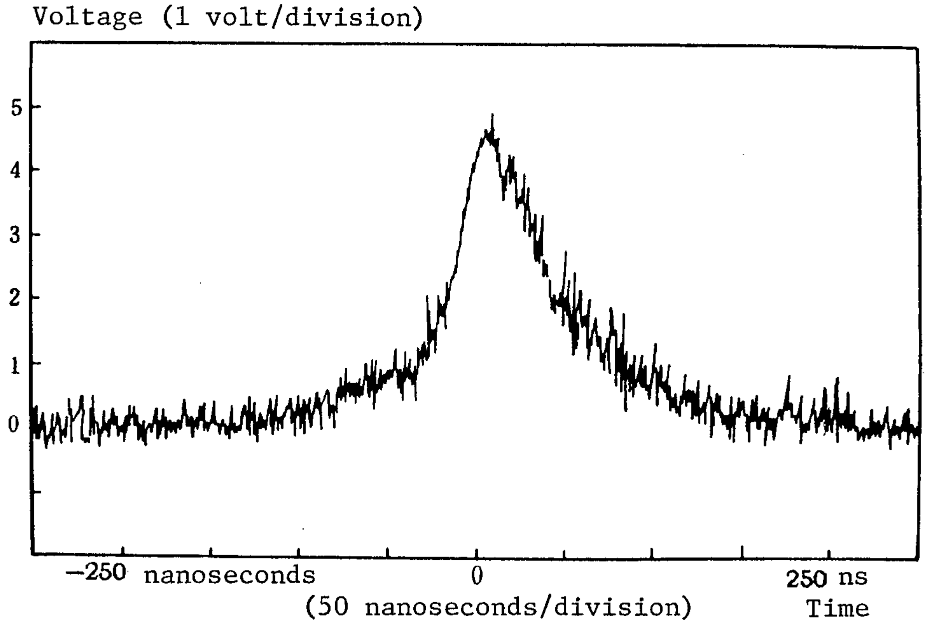

Figure 1. Ground Returns of the Miniature Solid-State Nanosecond Pulsed Radar Altimeter at an Altitude of 1,190 m

4. Development of the Multi-Function Radar Altimeter

In an effort to extend the range of application of the miniature solid-state radar altimeter, a multi-function airborne radar altimeter is under development. This altimeter can be used for automatic landing, automatic navigation, terrain-following and terrain-evasion, and bombing control on manned aircraft, and for altitude measurement, automatic navigation or terrain-matching guidance on unmanned aircraft or cruise missiles. The operating altitude of this radar altimeter is 20 km; its measurement error is less than 2-3 m at high altitudes and 1-3 percent of the altitude range at very low altitudes; the measurement error in ground-object scatter coefficient is of the order of 0.5-1 dB. This altimeter is small in size, reliable, durable, and easy to operate and maintain. It uses a large-compression-ratio linear FM pulse-compression nanosecond pulse system, a digital pulse range finder and a digital signal processor which combines both the stretch technique and altitude measurement technique. It also uses a solid-state amplifier transmitter and an arched antenna array.

IV. Concluding Remarks

Airborne radar altimeters have evolved from the early single-function systems to the multi-function, multi-purpose systems. In terms of performance, measurement accuracy has improved from tens of meters to the current 10-cm range; the operating altitude has increased from low altitude to several thousand km. In terms of measurement technology, the early CW systems have been replaced by pulsed systems; the transmitted pulse width has been reduced from the microsecond range to the nanosecond range; pulse-compression techniques and solid-state components are being used extensively in transmitters; in addition, integrated circuits, digital signal processing techniques and microprocessor techniques are also widely used in radar altimeters. In short, with the continuing advancement in high technologies, airborne radar altimeter technology will also continue to evolve and develop.

C101 Supersonic Anti-Ship Missile System

91FE0271H Beijing SHIJIE DADAN YU HANGTIAN [MISSILES & SPACECRAFT] in Chinese No 11, Nov 90 pp 34-38

[Article by Zhou Zhizong [0719 1807 1350] and Zhang Changgen [1728 7022 2704]: "China's C101 Supersonic Anti-Ship Missile Weapon System"]

[Text]

Abstract

A description of the components and main features of China's C101 supersonic anti-ship missile system is given; in particular, the aerodynamic configuration of the missile, the layout of the compartments, the guidance and control system, the propulsion system, the warhead and fuse, the electrical and hydraulic control systems, and the flight trajectory are described in detail. In addition, the fire control system, the launch system, the ground equipment and the operating procedure of the weapon system are also introduced.

I. Introduction

The C101 missile is an ultra-low-altitude, supersonic tactical anti-ship missile developed by this country. It has two different models: the aircraft-launched model and the ship-launched model. Its mission is to attack large or medium surface ships such as destroyers.

The basic components of the C101 missile system include the missile, the fire control system, the launch system and ground equipment. The system is structurally simple and has rapid launch capability. It has a rather small and light-weight missile with a powerful warhead and good penetration capability. It is one of the advanced weapon systems of the 1990's. [A photograph of the missile during launch preparation, Figure 1, is shown as Figure 12 in the special photographic section below.]

The C101 missile uses liquid-propellant ramjet engines as its primary propulsion unit and solid-propellant rocket engines as boosters. After being launched from its carrier vehicle, it is accelerated by the booster engine to a velocity of Mach 1.8; once the booster engine completes its operation, it is separated from the missile. At this velocity the liquid-propellant ramjet engines begin operation and continue to accelerate the missile to its cruising velocity of Mach 2.0. During the autonomous-control flight segment, the onboard autopilot system turns the missile into level flight in accordance with a specified flight program. At a pre-designated instant of time, the terminal-guidance radar is activated by the onboard command unit to acquire and track the target. Finally, the radio altimeter controls the missile on a descending trajectory during its final approach to the target until it reaches an altitude of 5 m above sea level.

The rapid maneuver of the missile is accomplished by the onboard hydraulic system, which in conjunction with the high-precision control system carries out attacks on the target. The fire control system of the missile is designed to perform either instantaneous point attack or advance point attack.

II. Weight and Dimensions of the C101 Missile

Lift-off weight	
Ship-launched model	1,850 kg
Aircraft-launched model	1,500 kg
Length	
Ship-launched model	6.5 m
Aircraft-launched model	7.5 m
Diameter	0.54 m
Wing span	1.62 m

III. Main Features of the C101 Missile

In the 1980's, western countries began developing high-penetration fourth-generation anti-ship missiles--oceanic supersonic cruise missiles. These include the French supersonic anti-ship missile, the French and German ANS, the British supersonic Sea Eagle and the Italian Otomat-2. In the 1990's, the volume of subsonic anti-ship missiles is expected to drop drastically; they will be replaced by the growing number of supersonic missiles.

In comparison with foreign supersonic anti-ship missiles, the C101 has the following special features:

1. High penetration capability

(1) The C101 has a cruising altitude of 50 m, and it dives to an altitude of 5 m at a distance of approximately 3 km from the target for its final approach. By flying close to the ocean surface during the attack, the missile is able to remain concealed from the target.

(2) The C101 maintains supersonic flight at M = 2.0 from cruise flight to hitting the target. The concealed trajectory and the high speed of the C101 ensure its high penetration capability. The diving attack at 3 km from the target is chosen because it is the engagement point of ship-based terminal intercept weapons; the sudden maneuver greatly reduces the enemy's intercept probability.

For example, if a Crotale or Sea Wolf terminal-interception guided missile is used to defend against the C101 missile, and assume that under ideal conditions, infrared sensors are used to detect and track the missile, and the interceptor is capable of operating in the high-speed response mode, it would have only one intercept opportunity, and the engagement point would be at the position where the C101 initiates its diving maneuver. If a ship-based gun is used as the defensive weapon, then the response time becomes only 1-2 sec. Clearly, using a hard weapon to defend against the C101 would be totally ineffective.

(3) The C101 missile uses a 2-cm monopulse terminal-guidance radar with multiple anti-jamming capabilities. Also, because of its supersonic, low-altitude flight trajectory, enemy electronic countermeasures (ECM) would be ineffective as the operating time is only around 10 seconds.

2. The high-precision guidance and control system, the high-power fast-response hydraulic servosystem, the single-plane steering and good maneuverability ensure that the C101 missile can achieve a very high hit probability. Repeated flight tests of the C101 show that it can always hit the target near the water line.

3. The C101 missile uses a supersonic, high-energy semi-armor-piercing fragmentation-type warhead and a delay trigger fuse; the 300-kg warhead is larger than most warheads used in foreign missiles of similar class. A single hit by the warhead can sink or severely damage a destroyer-class surface ship.

4. The C101 missile is totally autonomous after launch. During the autonomous-control flight segment, it is controlled by the onboard control system; during the automatic steering segment it is controlled by the terminal-guidance radar to follow the target. Thus, once the missile is launched, the carrier vehicle can immediately maneuver away from the engagement zone and silence the onboard radar.

5. The C101 uses conventional kerosene aviation fuel which is safe, non-toxic and easy to handle and maintain.

IV. The Missile

The basic components of the C101 missile include the missile body, the guidance and control system, the propulsion system, the warhead and fuse, the electrical system, and the hydraulic control system.

1. Aerodynamic Configuration

The missile has two stages. The second stage has a canard-type aerodynamic design; the two liquid-propellant ramjet engines are attached symmetrically to two sides of the missile via the forward and aft wings; the tail section of the second stage has a pair of vertical tails which are equipped with differential rudders to control the yaw and roll motions; the forward section of the missile has a pair of horizontal canard wings to control the pitch motion. The configuration of the first stage varies depending on whether it is a ship-launched model or an aircraft-launched model. For the ship-launched model, two solid-propellant boosters are attached in parallel to the lower sides of the second stage; a pair of "X"-shaped stabilizers and a pair of trailing-edge ailerons are used to control the first-stage roll motion. For the aircraft-launched model, one solid-propellant booster is attached in series to the rear section of the second stage; there is also a pair of "X"-shaped stabilizers and trailing-edge ailerons.

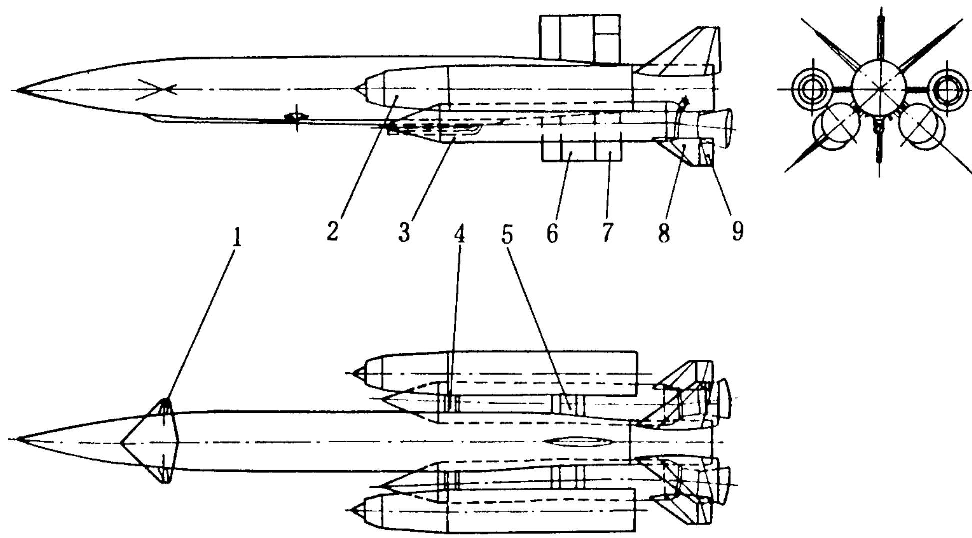

Figure 2. Three Views of the Ship-Launched C101 Missile

1. canard wing; 2. ramjet engine; 3. booster; 4. forward wing; 5. aft wing; 6. vertical tail; 7. differential rudder; 8. first-stage stabilizer; 9. first-stage trailing-edge aileron

2. Missile Compartments and Layout

The C101 missile has seven compartments.

(1) The radar compartment contains the terminal-guidance radar; the nose section has a non-metallic radome.

(2) The warhead compartment contains a semi-armor-piercing warhead and fuse system.

(3) The fuel tank contains 200 kg of kerosene aviation fuel.

(4) The load-bearing short compartment is the primary support member of the missile body; on top of this compartment is a suspension joint, and on its two sides are connecting joints for the engines and the booster.

(5) The autopilot compartment contains the control system, the propulsion system and the electrical system. A turbo-pump inlet is located below this compartment.

(6) The equipment compartment contains the hydraulic control system and the differential rudder mechanism; on two sides of this compartment are the rear engine connectors.

(7) The connecting short compartment is the load transmitting member of the first and second stages. A rear booster connector is located below the compartment.

(8) The ventral fin contains the electric cables and conduits etc.

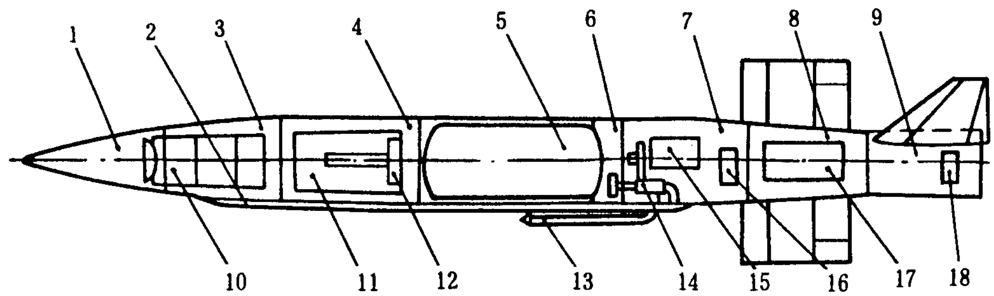

Figure 3. Layout of the C101 Missile

1. radome; 2. ventral fin; 3. radar compartment; 4. warhead compartment; 5. fuel tank; 6. load-bearing short compartment; 7. autopilot compartment; 8. equipment compartment; 9. connecting short compartment; 10. terminal-guidance radar; 11. semi-armor-piercing warhead; 12. fuse system; 13. turbo-pump inlet; 14. fuel regulation system; 15. control equipment; 16. electrical equipment; 17. hydraulic control system; 18. first-stage control system

3. Guidance and Control System

Control of the missile is accomplished by the autopilot, which is an automatic control and regulator system with three mutually-independent control loops. It consists of the controller, the damping gyro unit and the altimeter, and is used for attitude stabilization. Its main function is to ensure that the missile reaches the designated altitude during the autonomous-control flight segment, and that it is controlled by the radar signal to automatically follow the target during the automatic steering segment.

The terminal-guidance radar consists of the antenna, the transmitter, the receiver and the power supply module; its function is to perform search, acquisition and tracking of targets over the ocean surface, and to send control signals to the autopilot.

4. Propulsion System

(1) Main Engine

The main propulsion unit of the C101 missile consists of two liquid-propellant ramjet engines connected in parallel. These engines are structurally simple, easy to operate, and very reliable. The relay Mach number of the ramjet engine is 1.8; after the boosters are dropped off, the missile is accelerated by the ramjet engines to a cruising speed of Mach 2.0. The amount of fuel supplied to the engine is controlled by the onboard fuel regulation system. During cruise flight, the engine thrust is approximately 18 kN, which is sufficient to overcome the aerodynamic drag to maintain the cruising speed at Mach 2.0.

(2) Booster Engine

The booster engine is a solid-propellant rocket engine with a hexagonal internal combustion chamber. It uses poly-sulphur composite propellant and is equipped with a safety ignition mechanism.

The aircraft-launched C101 uses a serially connected booster engine, whereas the ship-launched model uses two booster engines connected in parallel. The nominal thrust levels for the two boosters are 18 kN and 26 kN respectively. Once the missile reaches a speed of Mach 1.8, both the booster engine and the connecting short compartment are separated from the missile.

5. Warhead and Fuse

The missile has a supersonic, high-energy semi-armor-piercing fragmentation-type warhead; it relies on the high kinetic energy generated by the missile motion to penetrate the armored plate of the ship; the detonation inside the ship produces huge kill power.

A delay-trigger fuse is used to control the detonation time of the warhead inside the ship. The fuse is equipped with a remote release mechanism and several stages of safety locks of different designs.

6. Electrical System and Hydraulic Control System

The electrical system consists of the electrical equipment and the onboard electric cable network. The electrical equipment includes the batteries, the various switches, relays and release sockets. The electric cables are used to link all the onboard equipment into a single network. The electrical system is designed to perform the functions of supplying power to the electrical equipment as well as transmitting and testing electrical signals.

The hydraulic control system is used to provide pressurized oil to the rudder drive mechanism in order to move the rudder surface under autopilot control.

7. Flight Trajectory

The flight trajectory of the C101 missile varies depending on whether it is a ship-launched model or an aircraft-launched model. The flight trajectory of the ship-launched model can be divided into two segments: the autonomous-control segment and the automatic steering segment, as shown in Figure 4.

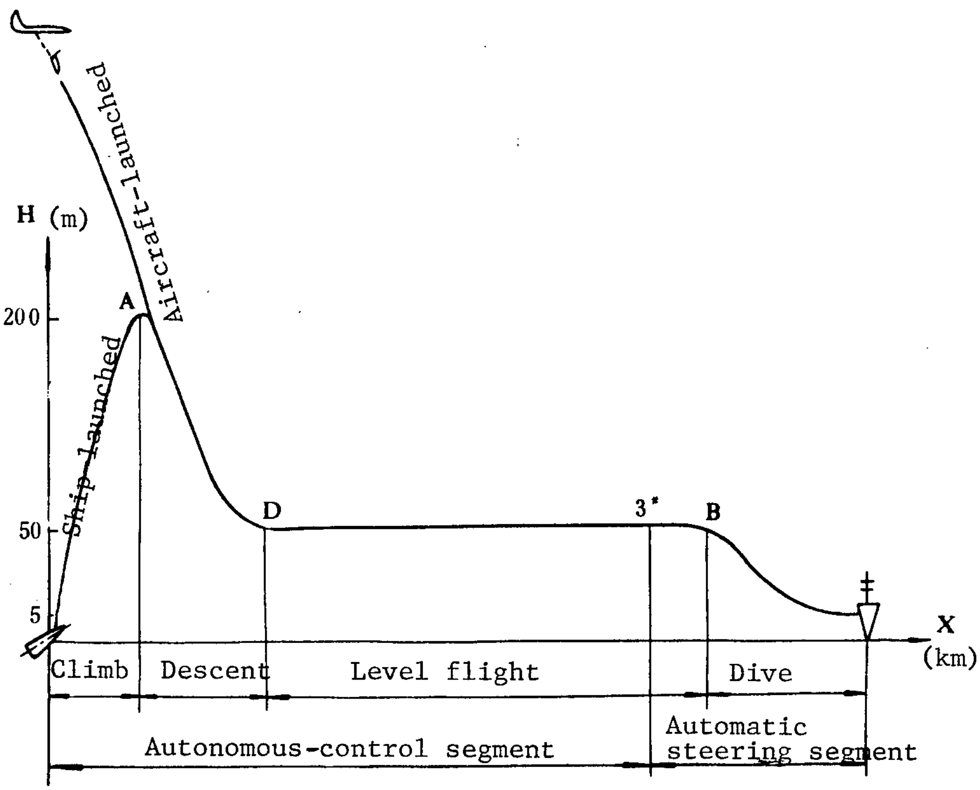

Figure 4. Flight Trajectory of the C101 Missile

(1) The autonomous-control segment can be further divided into three stages: climb, descent, and level flight. During the climb stage, the missile is launched from the carrier ship at a specified launch angle, quickly climbs upward under the action of the booster engine, and accelerates to a velocity of Mach 1.8, at which point the booster separates from the missile body. During the descent stage, the onboard command unit issues a descent command, and the missile begins its descent along a power-law trajectory until it reaches an altitude of 50 m, as indicated by the curve between point A and point D. During the level-flight stage, the missile flies at a constant altitude of 50 m.

(2) The automatic steering segment begins when the onboard command unit issues a 3# command, which turns on the terminal-guidance radar. The guidance radar begins searching for the target, and transmits acquisition signals and acquisition commands; it also sends combat commands to the autopilot to control the flight azimuth of the missile. At the same time, the

missile continues to maintain level flight based on altitude signals provided by the altimeter. When it reaches a distance approximately 3 km from the target (point B in the figure), the radar issues a dive command, and the missile initiates a dive maneuver and again follows a power-law trajectory until it hits the target at an altitude of 5 m.

The flight trajectory of the aircraft-launched model differs from that of the ship-launched model only during the climb stage: once the missile is launched from the mother aircraft at a specified altitude, it first glides along an unpowered flight path over an altitude range of 60 m, at which point the booster engine is ignited; the booster engine burns for approximately 3-4 seconds, during which time the missile is accelerated to a velocity of Mach 1.8, then it separates from the missile body. The missile continues to descend until it reaches point A, then it follows the same trajectory as that of the ship-launched model.

V. Fire Control System

The fire control system on board the aircraft or the ship consists of the attack radar, the command unit, the gyro platform and the power supply. Its main functions are to search and track enemy targets, perform real-time measurements of the attitude and motion parameters of the carrier vehicle, compute and load the target motion parameters and missile firing parameters into the missile, conduct pre-launch inspection and control the launch operation.

The attack radar is the main observation unit on board the carrier vehicle; it is used to perform wide-area search over the ocean surface, identify the target to be attacked and initiate target track, calculate target motion parameters and transmit the data to the command unit.

The command unit is the control center of the fire control system; its functions include: calculating the flight time of the autonomous-control segment and deviations in the flight azimuth of the carrier vehicle, loading the required parameters and commands into the missile, conducting pre-launch inspection, controlling the launch operation, and providing a missile simulator for training purposes.

VI. Launch System

The ship-launched C101 uses a tube-launch design; the launch system has two parts: the launch tube and the launch frame. The launch frame is rigidly mounted on the ship deck at a fixed azimuth angle and elevation angle; the missile is loaded into the launch tube and the whole unit is lifted onto the launch frame. Therefore, the launch tube serves both storage and launch functions.

The launch system of the aircraft-launched C101 consists of the transition beam and a special suspension frame. The transition beam is attached to the lower side of the wing and can be used as suspension frame for bombs, cruise missiles, and guided missiles. Below the transition beam is a special suspension frame which has two hooks to which the C101 missile is attached. When the launch conditions are satisfied, the hooks automatically open to release the missile.

VII. Ground Equipment

The ground equipment of the C101 missile includes the technical-site tractor, the missile-loading vehicle, the fuel-supply vehicle, the hydraulic fluid-supply vehicle, and the booster interface vehicle. They perform the functions of technical preparation and maintenance of the missile so that it is always in good technical condition to be delivered to the launch site.

VIII. Operational Procedure of the Weapon System

When a target is detected by the attack radar, it is first identified and discriminated; once the target is selected for missile attack, the radar immediately begins tracking the target, and the missile enters the pre-launch preparation mode which includes pre-heating the magnetron of the onboard radar.

As the attack radar tracks the target, it automatically computes the target motion parameters and sends the information to the command unit; the command unit analyzes the launch elements and loads the combat parameters and commands into the missile; it also performs pre-launch inspection and controls the launch operation. There are two launch modes: single-missile launch and salvo launch.

Prior to launch, electricity is supplied to the missile by the power source on board the carrier vehicle. Once the launch conditions are satisfied, the battery becomes activated, the gyro is unlocked, and the booster engine is ignited (for the aircraft-launched missile, the booster engine is ignited only after a 60-m unpowered glide); at the same time, the power source on board the missile begins to supply its own electricity. After the missile leaves the launcher, it follows the pre-programmed trajectory of climb, descent, and level flight. At the designated time of autonomous-control flight, the onboard radar is turned on and begins searching and tracking the target. At the same time, the safety locks of the fuse are released stage-by-stage according to a specified sequence. When the missile reaches the target, the fuse detonates the warhead and destroys the target near the water line.

IX. Concluding Remarks

Through a large number of ground tests and repeated flight tests, a series of difficult technical problems have been solved; these problems include: matching the thrust-to-drag ratio of the ramjet engine, developing a reliable separation mechanism for the booster engines, designing onboard equipment to operate under severe vibrational conditions, ensuring electromagnetic compatibility, and developing precision control technology.

Flight test results show that the C101 missile has met all its design specifications, and its performance complies with the advanced standards of the fourth-generation anti-ship missiles of the 1990's.

Red Arrow-8 Antitank Missile System

91FE0485A Beijing SHIJIE DAODAN YU HANGTIAN [MISSILES & SPACECRAFT] in Chinese No 1, Jan 91 pp 38-41

[Article by Wen Zhonghui [2429 0112 6540] of Beijing Science & Engineering University: "China's Red Arrow-8 Antitank Missile System"]

[Text]

Abstract

A general description of the components and the tactical and technical performance of China's Red Arrow-8 antitank missile system are given. In particular, the aerodynamic configuration, the propulsion system, the guidance and control system and the missile warhead, as well as the launch guidance equipment and combat operation of the missile system are described in detail.

I. Introduction

The Red Arrow-8 missile system, a second-generation antitank missile system with infrared semi-homing guidance, was developed by China in the late 1970's to early 1980's. It is a medium-to-long-range antitank weapon system that can be carried either by Army units or by motor vehicles or helicopters. Its main function is to attack targets such as tanks, armored vehicles, military forts and other hardened structures at a range of approximately 3,000 m.

A large amount of test data shows that the Red Arrow-8 system has many desirable features including high guidance accuracy, high reliability, high probability of hit, strong armor-piercing power and ease of operation. Specifically, the data indicates that 58 of 60 launches were reliable; 109 of 113 launches hit the target; and 58 of the 60 rounds that hit the target penetrated the 180 mm/68° homogeneous steel plate. These results show that the Red Arrow-8 missile has the capability to inflict damage on modern third-generation or fourth-generation main battle tanks.

The basic components of the Red Arrow-8 missile system include: the combat operation segment (the weapon segment), the launch operator training simulator and test instruments, and the maintenance equipment. The combat operation segment consists of the missile (ammunition), the control box, the infrared goniometer and sighting device, the launch equipment and the first-stage test instruments. The successful development of a sophisticated weapon system such as the Red Arrow-8 has demonstrated the advanced level of technology achieved by this country in antitank missile design and research.

II. Important Tactical and Technical Parameters

Target	Tanks, armored vehicles and hardened military structures
Maximum effective range	8,000 m
Minimum range	100 m
Maximum velocity	230 m/s
Initial velocity	70 m/s
Launch rate at maximum range	8 rounds per minute
Hit probability	Over long range (500-3,000 m) > 90%, over short range (100-500 m) > 80%
Armor-piercing power	Vertical penetration depth for homogeneous armor > 850 mm; for a 180 mm/68° homogeneous alloy steel target, probability of penetration > 90%
Firing zone	
Elevation	+10°, -8°
Azimuth	360°
System reliability	> 95%
Missile (takeoff) weight	11.2 kg
Missile plus container weight	22.5 kg
Total system weight	85.5 kg
Length	0.875 m
Diameter	0.120 m
Wing span	0.320 m
Initial spin velocity	7-8 r/s
Guidance system	Optical sighting and tracking, infrared semi-homing three-point guidance, command transmission via cable
Sighting device	Magnification factor 12, field of view (FOV) ±3°
Goniometer	Acquisition FOV ±50 mrad, tracking FOV ±7 mrad
Propulsion	Two-stage solid-propellant rocket engine
Operating environment	Temperature range -40° - +50°C, humidity (+40°C) 95%
Storage period	5-10 years

III. The Missile

1. Configuration and Structure

The Red Arrow-8 missile has a tailless aerodynamic configuration; the wings serve both as lifting surfaces and as stabilizers. The wing surfaces are arranged in a "cross" configuration around the circumference of the missile, and they are interleaved 45° with the four takeoff engine nozzles located ahead of the wing surfaces. The wings are foldable and have a projected trapezoidal shape; the leading edge backsweep is 45°, and the aspect ratio is approximately 1.3. The missile has a cylindrical body and an elliptical nose section. In order to maintain a steady spin velocity during flight, the four wing surfaces are installed at an offset angle. The control force is provided by the gas vortex vanes. The axially symmetric aerodynamic configuration of the missile results in identical aerodynamic characteristics in the pitch and yaw directions. The missile's aerodynamic exterior is shown in Figure 1.

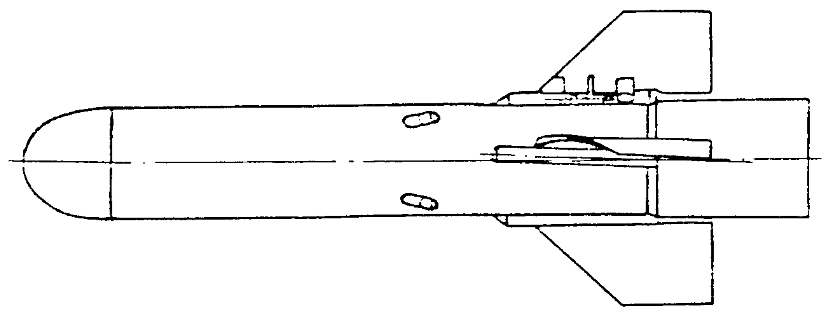

Figure 1. Aerodynamic Configuration of the Red Arrow-8 Missile

The structural layout of the missile and the locations of its components are shown in Figure 2. The forward section of the missile contains the warhead; the mid section contains the takeoff engine and the cruise engine. There is no separate compartment for the guidance equipment; the components of the guidance system are installed between two conduits of the cruise engine in the tail section. A gas steering engine and its execution mechanism are located at the tail of the missile; the ring-shaped infrared radiator is also located at the tail. The outer shell of the tail section consists of the wing stowage tube and the guidance cable tube. The wing seat and its connecting mechanism are assembled into an integrated unit before it is attached to the wing. The overall missile structure is highly compact with efficient use of space; this design provides easy access for the technicians and also facilitates assembly and adjustments.

2. Propulsion Unit

The propulsion unit of the Red Arrow-8 missile includes the takeoff engine and the cruise engine. The takeoff engine uses tube-loaded double-base propellants whose inner and outer surfaces are burned simultaneously; this produces a sufficiently large thrust to accelerate the missile from an initial velocity of 70 m/s to the maximum velocity of 200-300 m/s. The cruise engine uses end-burning grain to maintain relatively high cruise velocity. The takeoff engine and the cruise engine are built as an integral structural unit but separated by a base plate. The combustion chamber of the cruise engine has a long slender tube which feeds the hot gas to the exhaust nozzle. The four tilted nozzles of the takeoff engine are located at the front of the engine;

the gas first travels in a reverse direction before it flows through the nozzles. The axes of the nozzles are tilted 15° relative to the missile axis; they are also tilted 50° in the tangential direction to provide the initial spin velocity of the missile. The propulsion unit is structurally simple, light-weight, and has good dynamic performance.

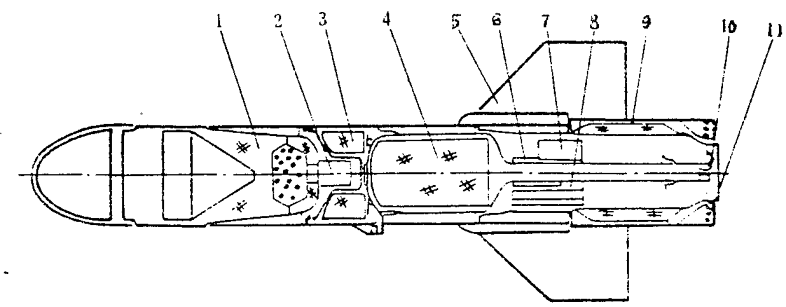

Figure 2. Structure and Layout of the Red Arrow-8 Missile

1. warhead; 2. fuse; 3. takeoff engine; 4. cruise engine; 5. wing mechanism; 6. gyro; 7. onboard battery; 8. onboard units; 9. guidance cable; 10. steering engine; 11. infrared radiator

3. Guidance and Control System

The Red Arrow-8 missile has an infrared semi-homing guidance system which includes an optical sighting and tracking device, an infrared goniometer for measuring angular deviations, a ground control box to form control commands, and cables for transmitting the commands. The optical system is used by the launch operator to track the missile and the target; at the same time, the infrared goniometer automatically measures the angular deviation between the missile and the target line-of-sight, and transmits this information to the control box. The control box compares this error signal with the reference signal measured and transmitted by the onboard gyro to form control commands. The control commands are transmitted via the cables to the onboard receiver, where they are interpreted and sent to the steering engine; the steering engine controls the motion of the vortex vanes to generate the control force which guides the missile toward the target.

The onboard guidance equipment includes the onboard receiver interpreter-converter, the reference gyro, the guidance cable tubes, the steering engine, the infrared radiator, and the power supply. These components are attached to the tail cover and the conduit support of the cruise engine which are located in the tail section of the missile. The gyro, the battery, and the electronic components are located on the printed circuit board which is attached to the tail cover.

4. The Warhead

The warhead of the Red Arrow-8 missile is a cluster-energy armor-piercing warhead which consists of the wind shield, the housing, the primary grain, the secondary grain, the partition, and the shaping cover. The weight of the warhead grain is approximately 1.5 kg and the total weight is approximately 3 kg; the static armor-penetration depth at an explosion height of 300 mm is approximately 900 mm. This warhead has a superior design, stable performance, and has incorporated many advanced technical features; its capability far exceeds that of similar antitank missiles currently being deployed.

The warhead uses an electrical fuse whose components consist of the contact switch, the fuse element, the detonation unit, the clock mechanism, the ignition unit, and electronic parts. The fuse element, which is a completely sealed unit, is located on the bottom side of the warhead, and is separated from the takeoff engine by a reinforced plate. The nose fairing of the warhead is divided into an inner section and an outer section which serve as two electrodes for the fuse switch. When the missile hits the target, the collision of the fairing (or wind shield) closes the circuit to activate the fuse, which in turn detonates the warhead.

IV. Launch Guidance Equipment

The Red Arrow-8 antitank missile uses a high- and low-pressure throw-back ejector as the launcher. The basic components and the structure of the hand-carried weapon system are shown in Figure 3.

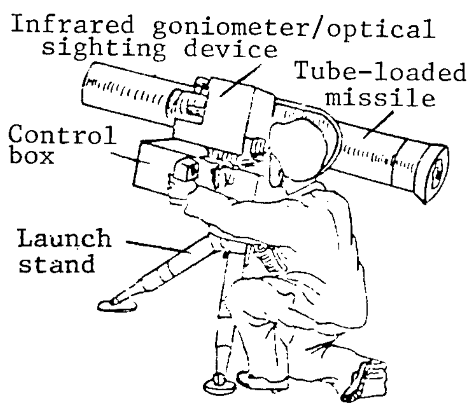

Figure 3. The Red Arrow-8 Antitank Missile System With a High- and Low-Pressure Throw-Back Launch System

The launch guidance equipment refers to all the launch equipment and guidance equipment of the system other than the onboard guidance unit. Specifically, it includes the ejector, the launch structure, the ground power supply, the lock release mechanism, the infrared goniometer, the optical sighting device and the control box. The launch equipment varies with the type of carrying vehicle. If an armored vehicle or helicopter is the carrying vehicle or the launch platform, then it must include an additional drive mechanism or stabilizing platform. Hand-carried launch equipment must include a manually operated drive and damping equipment. The ejector is a key element of the launch equipment; it consists of the high-pressure chamber, the launch tube, the missile carriage and the arresting mechanism. The main function of the ejector is to provide the initial velocity and initial spin, and to ensure that as the missile is ejected, the lead-wires are disconnected and the launch tube is thrown backwards. The basic operation of the high- and low-pressure ejector is as follows. When the operator acquires the target and squeezes the launch handle, the launch sequence begins, and at a pre-designated time, the locking mechanism is released, igniting the grain and generating very-high-pressure gas in the high-pressure chamber. When the pressure reaches a certain level, the membrane of the high-pressure nozzle is broken, and the gas flows through the nozzle into the low-pressure chamber. When the pressure in the low-pressure chamber reaches a specified value, the missile begins to move forward along the launch tube, propelled by the missile-carriage drive belt. At the same time, the launch tube is thrown backward along the guide rail. As the launch tube is moving backward, the missile continues to move forward inside the launch tube. When the forward positioning block hits the arresting ring at the mouth of the launch tube, the shock wave of the impact shears off the positioning block. As the missile continues to move forward, the embracing ring at the base of the wing hits the arresting ring, a second shock wave from the impact breaks the shear pin, and stops the embracing ring. Finally, when the missile carriage reaches the arresting ring, it is also stopped at the mouth of the launch tube. At this point, the missile quickly exits the launch tube, while the launch tube continues its backward motion, and eventually falls to the ground. As the missile is leaving the launch tube at a particular initial velocity, it is also given a small spin velocity by the spin mechanism located on the missile carriage.

The basic components of the ground guidance equipment include the infrared goniometer and the optical sighting device. The onboard goniometer produces frequency-modulated error signals and reference signals through the nutational motion of the metallic modulation disk of the optical head. The optical sighting device and the infrared goniometer are structurally integrated into a single unit. The error signal processed by the infrared goniometer is transmitted in the form of a sine wave to the control box where it is synthesized. Specifically, the error signal and the reference signal are frequency discriminated, detected, filtered and converted from analog to digital signals; then they are sent to the computer to form control commands which are transmitted through the cables to the missile.

V. Combat Operation

This missile system can be directly deployed as a tactical weapon system by a combat unit which carries two tube-loaded missiles and the launch guidance equipment. At the launch site, the combat unit assembles the missile system on a tripod which is supported on the ground; then it is ready for launch.

After the missile is launched, the operator keeps it within the FOV of the infrared goniometer and uses the optical sighting device to track the target as well as the missile. The deviation between the missile and the target line-of-sight is measured by the infrared radiator and transmitted to the signal generator (control box) where it is synthesized and interpreted to form control commands. The command signal is transmitted via the cables to the onboard receiver which steers the missile toward the target.

The Red Arrow-8 antitank missile system can also be launched from a helicopter or an armored vehicle. For these launches, the operator uses a periscopic sighting device to control and track the missile. The missile can be carried by either a wheel-driven or a tracked vehicle. The launch equipment carried by vehicles can be deployed singly or in pairs, and it can be loaded automatically or semi-automatically with manual assistance. The launch equipment carried on helicopters is an advanced and sophisticated system, but its performance has been satisfactory.

VI. Discussion of System Features

The Red Arrow-8 antitank missile system is one of the high-performance weapon systems being deployed today. Its features compare favorably with those of the U.S. TOW system and the European HOT system (see Table 1).

Table 1. Comparison of the Red Arrow-8 With the TOW and the HOT Antitank Missile Systems

Missile type / Performance parameters	TOW		HOT		Red Arrow-8
	Proto-type	Improved model	Proto-type	Improved model	
Maximum range (m)	3,000	3,750	4,000	4,000	3,000
Minimum range (m)	65	65	75	75	100
Takeoff weight (kg)	18	18.5	23	23	11.2
Tube-loaded missile weight (kg)	24	24.5	32	32	22.5
Diameter (mm)	127	150	136	150	120
Length (mm)	1,160	1,160	1,270	1,270	875
Static armor-penetration depth (mm)	600	950	800	1,130	>900
Hit probability (%)	80-85	80-85	80-90	80-90	>80-90
Reliability (%)	~85	~85	~90	~90	>95
Initial velocity (m/s)	65	65	28	28	70
Terminal velocity (m/s)	140	140	240	230	230

From the point of view of overall system performance, the Red Arrow-8 system is superior in terms of weight, reliability, and hit probability. In terms of armor-piercing capability, the Red Arrow-8 is more powerful than the TOW and the HOT prototypes, but less powerful than their improved models; however, the diameter and the takeoff weight of the Red Arrow-8 are smaller than both systems. Therefore, one may conclude that the performance of the Red Arrow-8 falls between the prototypes and the improved models of the aforementioned U.S. and the European antitank missile systems.

C301 Supersonic Anti-Ship Missile

91FE0567A Beijing SHIJIE DAODAN YU HANGTIAN [MISSILES & SPACECRAFT] in Chinese No 2, Feb 91 pp 33-36

[Article by Jiang Junliang [5592 0193 5328] and Huang Taian [7806 3141 1344]: "China's C301 Supersonic Anti-Ship Missile"]

[Text]

Abstract

The main features, components and combat effectiveness of China's C301 anti-ship missile system are described. The C301 missile can provide good penetration capability by flying at supersonic speeds and very low altitudes during an attack. It is an advanced shore-based weapon system of the 1990's.

I. Introduction

The C301 missile weapon system is a new anti-ship weapon developed by this country. It has good penetration capability and high destructive power. The missile has a very long range and can fly at supersonic speeds and very low altitudes. It is an advanced shore-defense weapon system of the 1990's.

The C301 missile is designed to attack large and medium-size surface ships such as destroyers; its primary mission is to protect harbors, military bases, and to defend against enemy landing craft.

II. Main Features of the C301 Missile Weapon System

1. Penetration Capability

Penetration capability is an important design issue for anti-ship missiles, and considerable effort has been devoted to the study of this problem. Generally speaking, there are two approaches to enhance penetration capability. One is low-altitude penetration, where subsonic missiles flying at extremely low altitudes are used to approach the target; this minimizes the reflected signals from the missile and effectively reduces the probability of detection by ship-borne radars. The other is supersonic penetration, where high-speed missiles are used to reduce the response time of enemy defense systems and to minimize the intercept zone of ship-to-air missiles. An important trend in the development of anti-ship missiles is to combine the two approaches to provide low-altitude, supersonic penetration. The C301 missile has good penetration capability and high survivability because it can fly at a cruising altitude of 100-300 m with a velocity of Mach 2.

2. Extended Range

The C301 missile has a range of 130 km, which is longer than the range of similar anti-ship missiles in existence today. Because of its ability to fly at supersonic speeds and very low altitudes, it can attack enemy ships far away from shore, thereby effectively controlling the coast line and a wide area of territorial waters.

3. Anti-Interference Capability

The high velocity of the C301 missile during the final phase of its trajectory significantly reduces the response time of the electronic surveillance systems on board enemy ships. Therefore, the effectiveness of enemy electronic countermeasures (ECM) and intercept missiles is greatly mitigated.

The terminal-guidance radar of the C301 missile is a monopulse radar with anti-interference capability against ocean waves and electronic jamming. Like other components of the C301 missile system, it is designed to operate under different environmental and weather conditions.

4. High Hit Accuracy and High Destructive Power

The fire control system and the onboard guidance and steering system of the C301 missile are designed to minimize the position scatter at the end of the autonomous-control segment, thereby increasing the probability of target acquisition and hit accuracy.

The warhead of the C301 missile is a high-explosive cluster-energy fragmentation warhead which weighs 512 kg. The inherent power of the warhead plus the huge kinetic energy upon collision with target gives the C301 sufficient destructive power to sink a destroyer or severely damage a cruiser with one hit, and sink a cruiser with two hits.

5. Safety and Economy

The liquid-propellant ramjet engine of the C301 missile uses kerosene fuel, which is plentiful, low-cost, non-toxic and safe; these features make kerosene a very attractive fuel.

6. Mobility and Concealment

The C301 missile can be quickly transported from one missile base to another within a certain area. Also, its launch point can be concealed in a trench which makes it difficult for the enemy to detect.

III. Components of the C301 Missile Weapon System

The C301 missile system has the following components: the missile, the fire control system and ground equipment. A basic fire unit of the C301 system includes the following equipment:

1. 8-12 missiles, which are carried by 8-12 transport vehicles;

2. 4 tractors, which are used to pull 4 launch structures;

3. 1 fire control vehicle;

4. 1 detection and tracking radar;

5. 1 power-supply vehicle;

6. The technical-site equipment includes the integrated test vehicles, air-supply vehicles, hydraulic power-supply vehicles, filling vehicles, lift trucks and tractors. Each technical site can service one or more fire units.

IV. The C301 Missile

The C301 missile consists of the missile body, the guidance and control system, the propulsion system, the fuse and warhead system, the electrical system and the hydraulic power-supply system.

1. Missile Body

The C301 missile has a symmetric canard-type aerodynamic configuration. The canard rudder located in the forward section of the missile controls the pitch motion; a pair of differential rudders located on the vertical stabilizers in the rear are used to control the yaw and roll motions. Two engines are located on the outside of the wings, and four cluster booster engines are distributed around the circumference of the tail section; each booster has its own stabilizer.

Missile length	1st stage	9.85 m
	2nd stage	9.46 m
Missile diameter	0.76 m	

An exterior view of the missile is shown in Figure 1 [see Figure 13 of the special photographic section below; Figure 14 of special section shows a rear view (from front cover of magazine) of missile], while its configuration is shown in Figure 2.

The C301 missile body has a rigid shell structure which is divided into eight compartments: the radome, the radar compartment, the forward fuel tank, the warhead compartment, the center fuel tank, the instrument compartment (which contains the control equipment, the battery, the propulsion system, and the hydraulic power-supply system), the rear fuel tank, and the tail compartment (which contains the rudder and the control mechanism of the ailerons). The layout is shown in Figure 3.

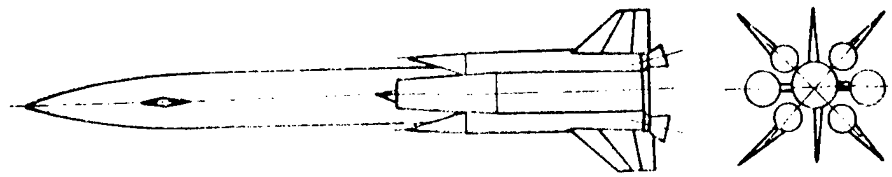

Figure 2. Configuration of the C301 Missile

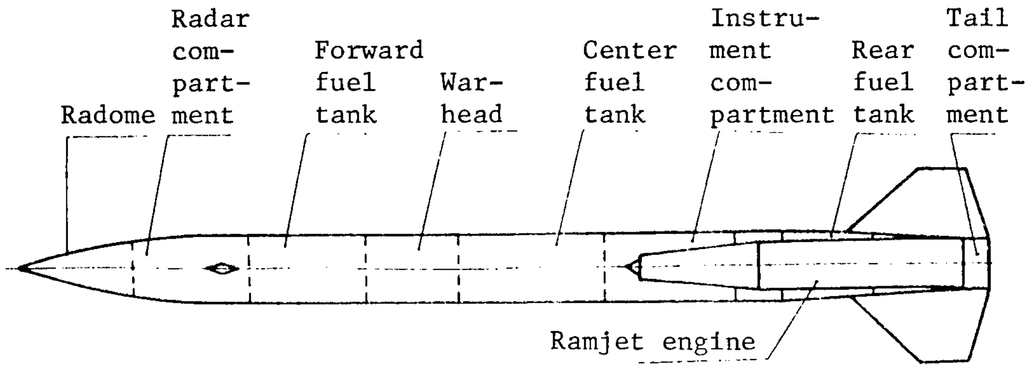

Figure 3. Layout of the C301 Missile

2. Flight Trajectory

The flight trajectory of the C301 missile is divided into three segments: climb, level flight, and final approach, as shown in Figure 4. The level-flight segment is approximately 100-300 m above sea level. From lift-off to activation of the terminal-guidance radar, the missile flies autonomously under the control of the autopilot; subsequently, the missile is steered automatically by the radar until it hits the target.

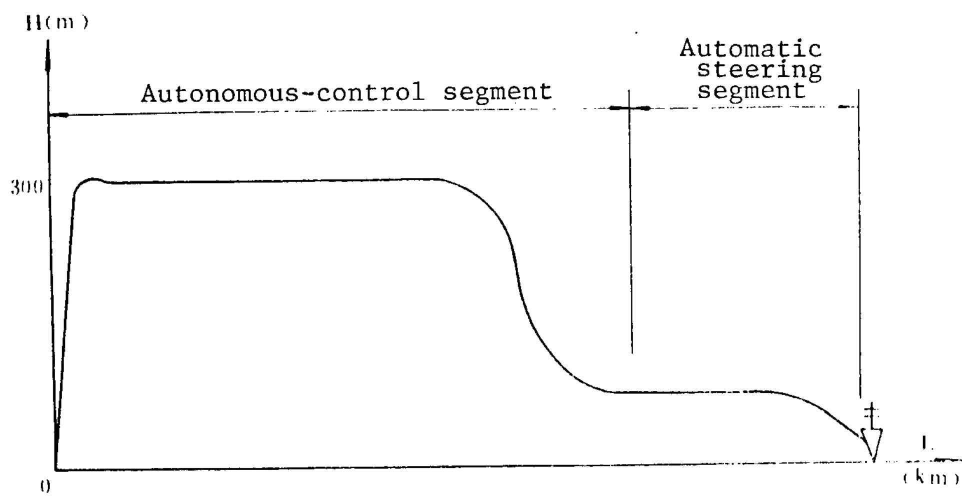

Figure 4. Flight Trajectory of the C301 Missile

3. Guidance and Control System

The autopilot of the C301 missile consists of the following components: the control unit (which includes three high-precision gyros), the radio altimeter, and the command unit. It is designed to perform the functions of attitude stabilization, center-of-mass control, and range control. Target information is provided to the autopilot by the terminal-guidance radar (which includes the following subsystems: the antenna, the signal processor, the automatic discriminator, the control unit, the ECM unit, and the power supply), and the autopilot steers the missile toward the target according to a specified steering law.

The drive mechanism is a high-power hydraulic servo system which has a relay hydraulic power supply.

4. Propulsion System

The propulsion system of the C301 missile consists of four solid-propellant booster engines, two liquid-propellant ramjet engines and the fuel supply system.

The four booster engines operate synchronously for several seconds until the missile is accelerated to a sufficiently high Mach number to activate the ramjet engines, then they are separated from the missile body.

The two liquid-propellant ramjet engines which begin operation at the relay Mach number are the main engines of the missile. They accelerate the missile to Mach 2.0, and continue to thrust to maintain this cruising speed. They use conventional aircraft kerosene fuel which is stored in the soft fuel tank on board the missile; the fuel tank uses natural pressurization to ensure timely supply of fuel to the engines.

5. Fuse and Warhead System

The C301 missile has three different fuses: the electrical fuse, the mechanical fuse and the laser fuse. The laser fuse is a non-contact fuse which can be used to detonate the warhead in the vicinity of the target in case the missile fails to score a direct hit.

6. Electrical System

The electrical system of the C301 missile is a unified network which includes the battery, the contact trigger, the relay, the fuse box and electric cables. The battery is a high-performance silver/zinc chemical battery which provides 27-volt d.c. current to the various onboard systems.

V. Fire Control System

The fire control system of the C301 missile consists of the target detection and tracking radar, the firing command system and the launchers.

1. Target Detection and Tracking Radar

The primary function of this radar is to perform search, detection, target tracking and accurate position determination; the target information is then transmitted to the ground firing command system.

2. Firing Command System

The primary functions of this system are: 1) to calculate in real time the flight distance (or time) of the missile during the autonomous-control segment and the launch angle based on data provided by the detection and tracking radar; 2) to load the calculated launch parameters and commands into the missile; and 3) to perform pre-launch inspection of the missile and launch control.

3. Launcher

The launcher of the C301 missile has a short guide rail whose pie-shaped front rail can rotate about a fixed axis in accordance with the motion of the missile.

VI. Operation of the C301 Missile System

The target information obtained by the ground radar of the fire control system is processed by the intelligence processing system, which shows four of these targets on the display screen. The commander determines which target to attack, and issues a command to the operator; the operator then locks onto the selected target and initiates target track. At the same time, on the basis of input data (e.g., instantaneous position, meteorological parameters, and launch-site parameters), the firing command system calculates the launch parameters in real time, and continuously sends the information to each of the launchers and the missiles.

Once the pre-launch inspection is completed and the launch conditions are satisfied, the operator pushes the launch button, which activates the onboard battery to replace the ground power supply. The booster engines are then ignited, lifting the missile off the guide rail, and accelerating it upward until it reaches the relay Mach number, when the liquid-propellant ramjet engines are activated; at this point, the four booster engines are automatically separated from the missile body, and the first-stage safety lock of the fuse is released. The ramjet engines continue to accelerate the missile until it reaches a velocity of Mach 2.0, then provide sufficient thrust to maintain this constant velocity. Once the missile begins level flight, it automatically adjusts its flight direction, and several seconds later, the second-stage safety lock is released. Under the action of preloaded commands, the missile switches from level-flight to a descending glide. The onboard terminal-guidance radar is turned on at a pre-set time, and begins searching for the target; once the target is acquired, it switches to the automatic tracking mode, and steers the missile until it hits the target.

VII. Development and Improvements

Improvements can be made to the missile to enhance its performance and increase its range to approximately 180 km. In addition, the onboard control system can be modified to use an inertial guidance platform for improved system accuracy, and the ground detection and tracking radar can be modified to use the onboard target indication system. These improvements can not only extend the target detection range, but also increase the missile's hit probability.

The C301 missile can also be modified to become a supersonic ship-to-ship missile, a cruise missile for attacking ground targets, or an ultra-low-altitude supersonic missile. In short, with the appropriate improvements, the performance of the C301 missile can be further enhanced and its applications further extended.

HG-252 IR-Optical Measuring System for Missile-Range Use

91FE0567B Beijing SHIJIE DAODAN YU HANGTIAN [MISSILES & SPACECRAFT] in Chinese No 3, Mar 91 pp 30-32, 37

[Article by Su Qishun [5685 0796 7311] of the Beijing Institute of Remote Sensing Equipment: "China's HG-252 Infrared Optical Measuring System"]

[Text]

Abstract

The HG-252 infrared (IR)-optical measuring system is a small, van-carried system used for missile range measurement. The system is capable of automatic or manual operations for missile tracking, real-time collection of angle data, and wireless data transmission using the communications system. It uses special software to calculate the missile trajectory, the impact point and the target miss distance.

In this paper, the main components, the operational procedure and the technical specifications of the system are presented; the basic techniques used in measuring the trajectory and the target miss distance are also discussed.

I. Introduction

The HG-252 IR-optical measuring system is a small van-carried system designed to measure missile trajectories, target miss distances and to predict impact points. There are two models of the HG-252: the HG-252A is primarily used for measuring missile trajectories and predicting impact points at strategic bases and combat units; the HG-252B is primarily used at tactical bases and target ranges. In addition to providing measured and calculated data, the HG-252 can provide television pictures and recordings of target tracking data for subsequent analysis; it can also provide IR signatures of the target for analyzing the thermal radiation characteristics of the missile, from which one can determine the operating conditions and detect any abnormalities of the engine.

This system can be used in either a manual or automatic mode for tracking missiles and aircraft. Its computer subsystem can be used to collect angle data in real time, and its communications subsystem can be used to perform wireless data transmission between two or more units; it is also equipped with special software for calculating trajectories, impact points and target miss distances.

II. Components of the System

The components of this system include the test vehicle, the detection and tracking unit, the diesel generator, the antenna and support equipment. Figure 1 shows a photograph of the deployed system [see Figure 15 of the special photographic section below].

The detection and tracking unit consists of the IR sensor, the long-focal-length camera, the variable-focus camera, the telescopic lens, the servo-mechanism and the support frame. Its configuration is shown in Figure 2 [see Figure 16 of the special photographic section below].

Figure 3 [see Figure 17 of the special photographic section below] shows the test-vehicle electronics rack, which includes four modules: the IR module, the control module, the display module, and the power-supply module. They contain the following units: the main amplifier, the error-signal processor, the timer, the detector, the simulated-signal generator, the timing generator, the communications unit, the correction unit, the azimuth and elevation digital display, the power amplifier, the computer, the storage oscilloscope, the television monitor, the magnetic recorder, the video recorder, the printer, the pen recorder, the control console, the redundant power supply, the electrical distribution equipment and electric cables.

III. Operation Procedure of the System

As a passive detection and tracking system, this system uses the video image of the missile taken by the television camera for monitoring and guidance; it also uses the IR sensor to detect the IR radiation from the missile to form error signals; the processed error signals are used to drive the servo-mechanism and the control circuit in search and tracking operations. The angle data are provided by the inductor-type circular synchronizer located on the azimuth and elevation axes of the detection and tracking unit; this information is displayed on the digital display unit of the test vehicle. The timer is triggered by the external or internal timing reference (lift-off signal). The angle and timing data are collected by the computer and used in mission calculations; the calculated results (e.g., trajectories, impact errors, target miss distances) are transmitted to the users. The data transmission is accomplished by the communications subsystem which can perform either wireless or wired transmissions between two stations. During the missile tracking process, the television images are recorded by the video recorder. The IR signatures can be displayed on the storage oscilloscope, or be recorded by the magnetic recorder; they can also be plotted on a pen recorder for subsequent signal analysis. The self-diagnosis subsystem is designed to test key parameters of the system and to monitor signal waveforms. The system can be powered by a diesel generator in the field or by conventional a.c. supply. The power distribution unit performs the functions of primary power distribution and switching protection. The redundant power supply provides the secondary power source for all electronic equipment of the system.

IV. Important Technical Specifications

1. IR Sensor

1) Operating band and noise equivalent illumination (NEI)

HG-252A: operating band 3-5 μm; NEI $\leq 2.5 \times 10^{-12}$ W/cm^2
HG-252B: operating band 1-2 μm; NEI $\leq 2 \times 10^{-11}$ W/cm^2

2) Field of view: 1.3° x 1.3°

2. Television Camera Lens

1) Focal length of the variable-focus camera lens: 12-58 mm

2) Focal length of the long-focus camera lens: 600 mm

3. Servo Control System

1) Operating range

Azimuth: ±135°
Elevation: -5° to 85°

2) Maximum angular velocity ($\dot{Q}_m$) and angular acceleration ($\ddot{Q}_m$)

HG-252A: $\dot{Q}_m = 10°/s$; $\ddot{Q}_m = 14°/s^2$
HG-252B: $\dot{Q}_m = 16°/s$; $\ddot{Q}_m = 25°/s^2$

3) Tracking accuracy: 100" (when $\dot{Q}_m = 4°/s$ or $\ddot{Q}_m = 2°/s^2$)

4) Angle measurement accuracy: 30"

5) Axis system accuracy: 5"

4. Computer System

1) Main unit: IBM PC or COMPAQ

2) Data acquisition and resolution:

Azimuth and elevation data (to arc seconds);
error in azimuth and elevation data (12-bit A/D);
time (to 1/100 sec)

3) Acquisition frequency (data arrays/sec); 1, 5, 10, 25, 50 (each data array contains all the data described in 2).

4) Special software: data acquisition software, wireless data communications software, software for trajectory and miss distance calculations.

5. Wireless Communications System

1) Operating frequency: 430 MHz-450 MHz

2) Output power: 5W, 25W

3) Communications range: > 20 km with omnidirectional antenna
> 40 km with directional antenna

4) Functions: can be selected among voice, synchronization and data transmission.

6. Power Supply

1) Total power consumption < 600W

2) Gasoline generator power: 1.9 kW

V. Applications

1. Trajectory Measurement

A single station provides only angle measurements of the missile. However, if angle measurements are obtained from two different stations whose earth coordinates are known, then the missile coordinates and its trajectory can be calculated. The missile coordinates in the measurement system can be further transformed to coordinates in the launch system to provide points along the trajectory.

Trajectory calculations must be based on data collected at the same instant of time, i.e., synchronized data collected by two different stations. In a relative time synchronous system, this function is accomplished by using an external signal (e.g., the lift-off signal) or an internal signal to synchronize the timer of the two stations; at the same time, the time counter in the computer is also initiated and begins taking data at equal intervals. Each station has a sufficiently accurate timing unit to ensure that time synchronization is maintained.

In general, the two stations may be far apart with no cable links between them; however, data between the two computer systems and communications systems can be transmitted using a wireless system. This ensures that calculations of the impact point, the target miss distance, and the trajectory can be completed in a timely manner.

2. Measurement of Target Miss Distance

Another important function of the system is to measure the target miss distance of a tactical missile. It is known from the previous section that the position of the missile can be measured using two stations. The measurement of target miss distance involves measuring the relative positions between two points (the target and the detonation point) or between a point and a line (the target and the missile trajectory). The basic principle is illustrated in Figure 4.

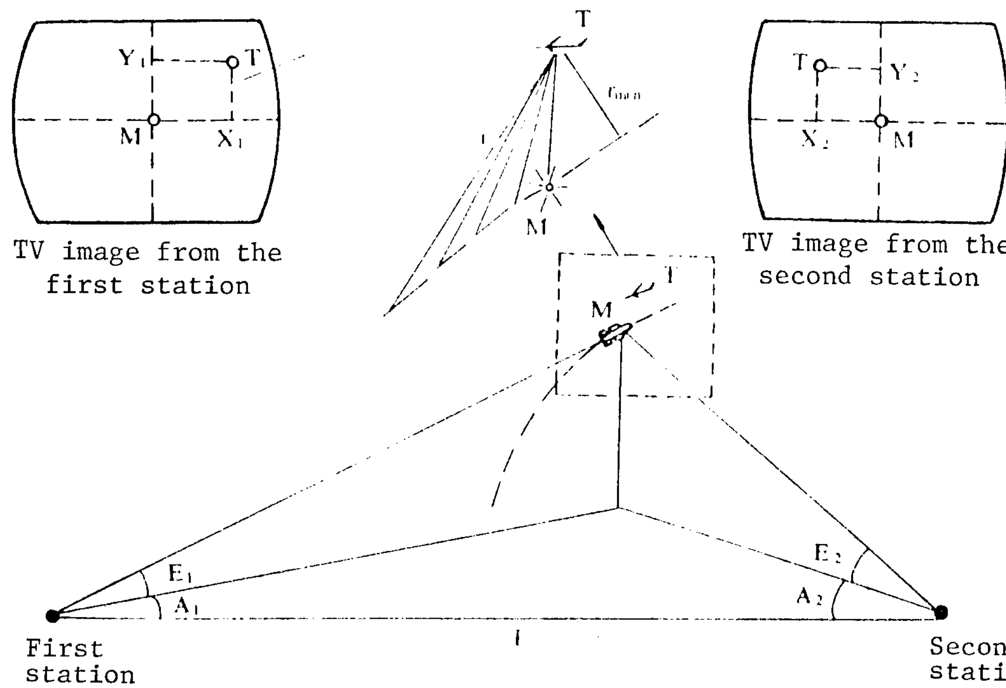

Figure 4. Schematic Diagram Illustrating the Measurement of Target Miss Distance (M: missile position, T: target position)

The HG-252 detection and tracking system has a long-focal-length television camera. By using the TV cameras from two stations to take simultaneous pictures of the missile and the target before and after the encounter, and analyzing the video images frame by frame, it is possible to estimate the relative deviations between the missile and the target in both the horizontal and vertical directions, as indicated by X_1, Y_1, X_2, Y_2, in Figure 4. Based on the functional relationships between the target-to-missile distance r and A_1, E_1, X_1, Y_1, A_2, E_2, X_2, Y_2, and L, one can compute the distance between the two points at any given time. By repeating the process for different picture frames, the values of r can be calculated as a function of time, and the minimum value of r, r_{min}, can be determined. By definition, r_{min} is the target miss distance. Of course, the functional relation of r provides not only the magnitude but also its direction, i.e., it provides the vector $\vec{r}$.

It is not difficult to see that the distance vector between the detonation point and the target can be similarly determined. One of the important factors affecting the measurement accuracy is the motion of the detonation point. It should be pointed out that the motion of the detonation is completely different from that of the missile. The detonation point seen on the video image is actually the residual smoke from the explosion; although the center of mass of the fragments from the explosion still moves with the original missile velocity, the residual smoke (i.e., the detonation point) moves with a much slower speed. Therefore, the motion of the detonation point only has a minor effect on measurement accuracy; in most cases, the resulting errors would be acceptable.

The measurement accuracy of target miss distance depends primarily on the measurement accuracy of the missile-target separation on the video image, the measurement accuracy of the missile slant range, the frame frequency, and the synchronization accuracy of the initial frame point; it only has a minor dependence on the randomness of the frame time and the detonation time. As in trajectory measurement, the position error can be reduced by strategically placing the measurement stations, and the measurement accuracy can be improved by taking full advantage of the resolution of the TV image (i.e., let the relative deviation fill the video screen as much as possible).

VI. Special Features of the System

1. Once the system is disassembled, all its components can be loaded in the test vehicle and be rigidly attached to fixtures supported with shock absorbers. They can be transported over long distances on highways. The system is easy to deploy and to retrieve; the total preparation time is less than 30 minutes.

2. The system has its own power supply, signal simulator, and self-diagnosis equipment. Under field conditions, it can perform the functions of self-diagnosis and calibration, tracking, measurement, recording, data transmission, voice communications, and printing of measured and calculated results. The recordings include television pictures, video images, magnetic recordings of simulated signals, as well as data and document files.

3. The system is equipped with a high-precision gimbal system which is matched with the goniometer to produce highly accurate angle measurements. The television system has sufficiently high resolution to meet the accuracy requirement of measuring target miss distance.

4. The data processing speed of this system is much higher than that of conventional optical measuring systems. Equipped with computers, wireless data communications systems and full-function recording and analysis devices, this system can transmit and process the data as soon as tracking is completed, and the calculated results can be distributed in a timely manner.

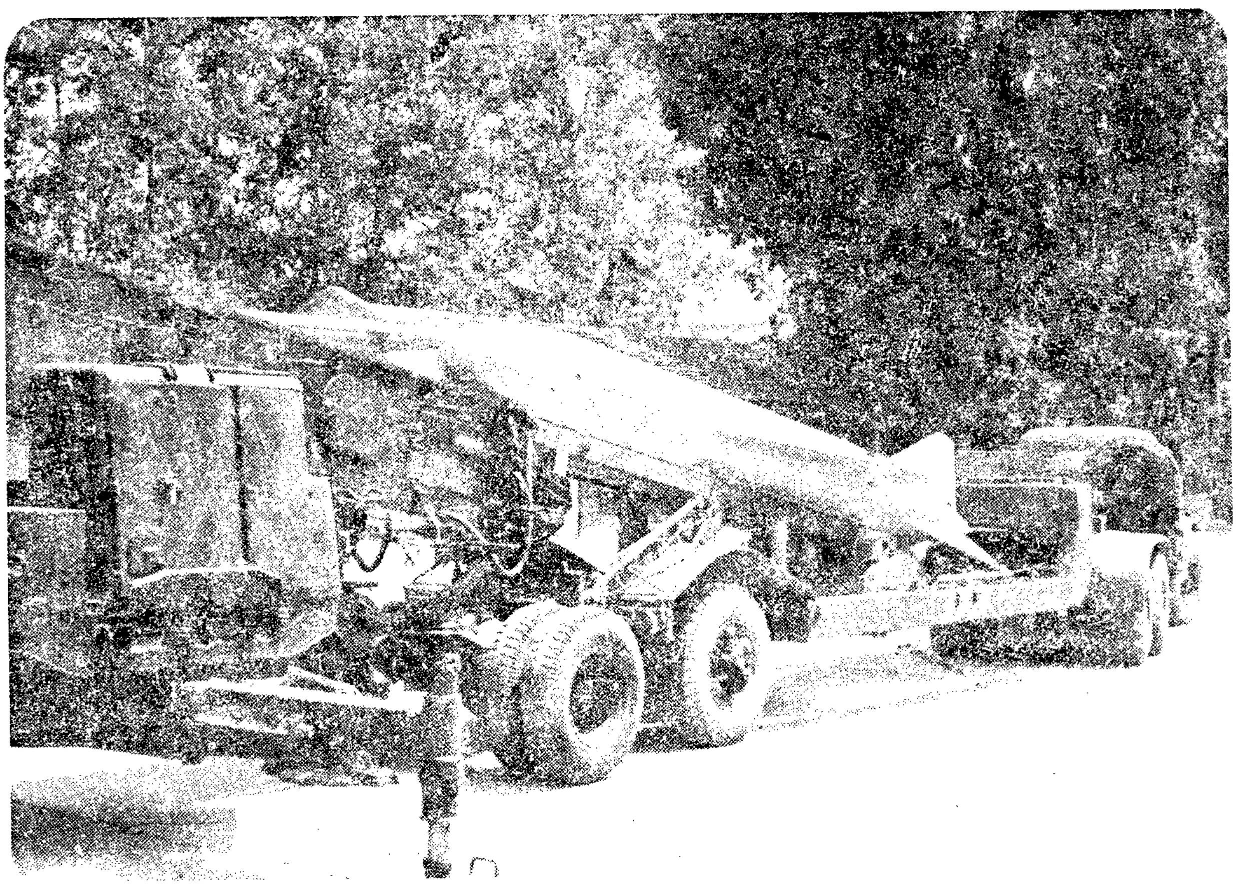

Figure 1. HY-2 Shore-to-Ship Missile on Launcher

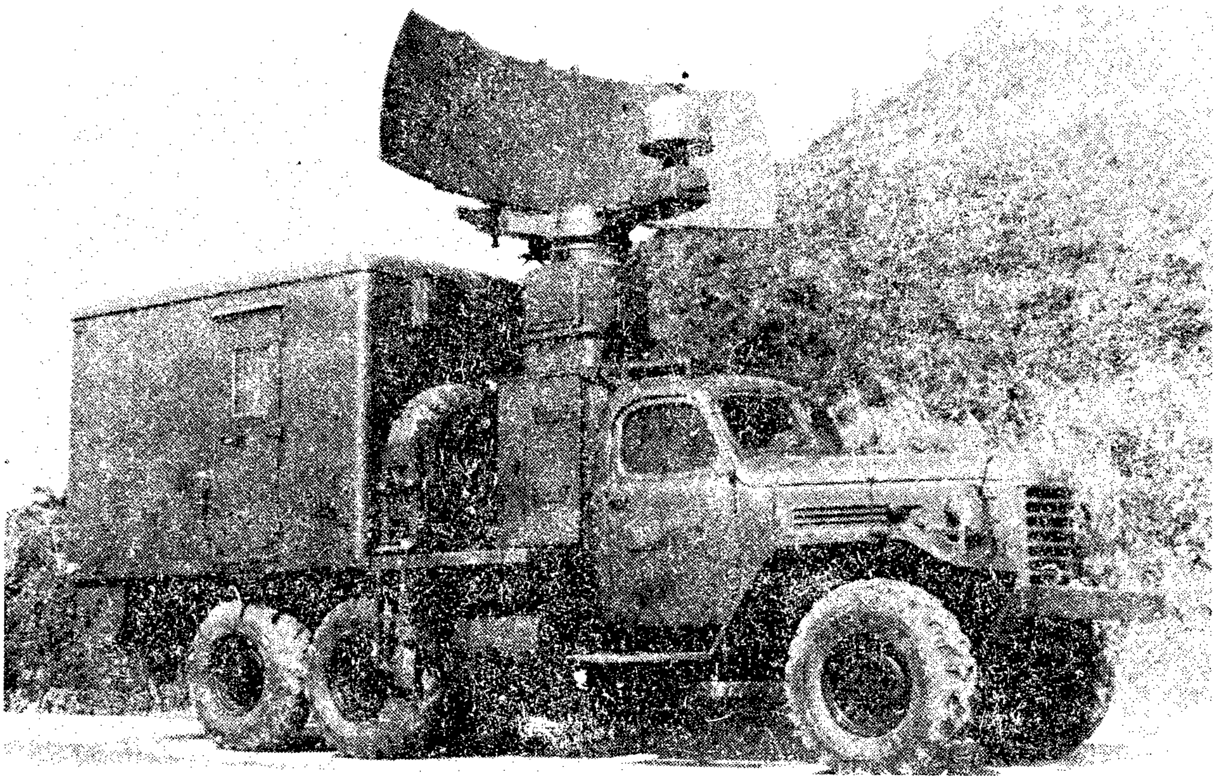

Figure 2. Ground Radar Antenna Truck for HY-2 Missile

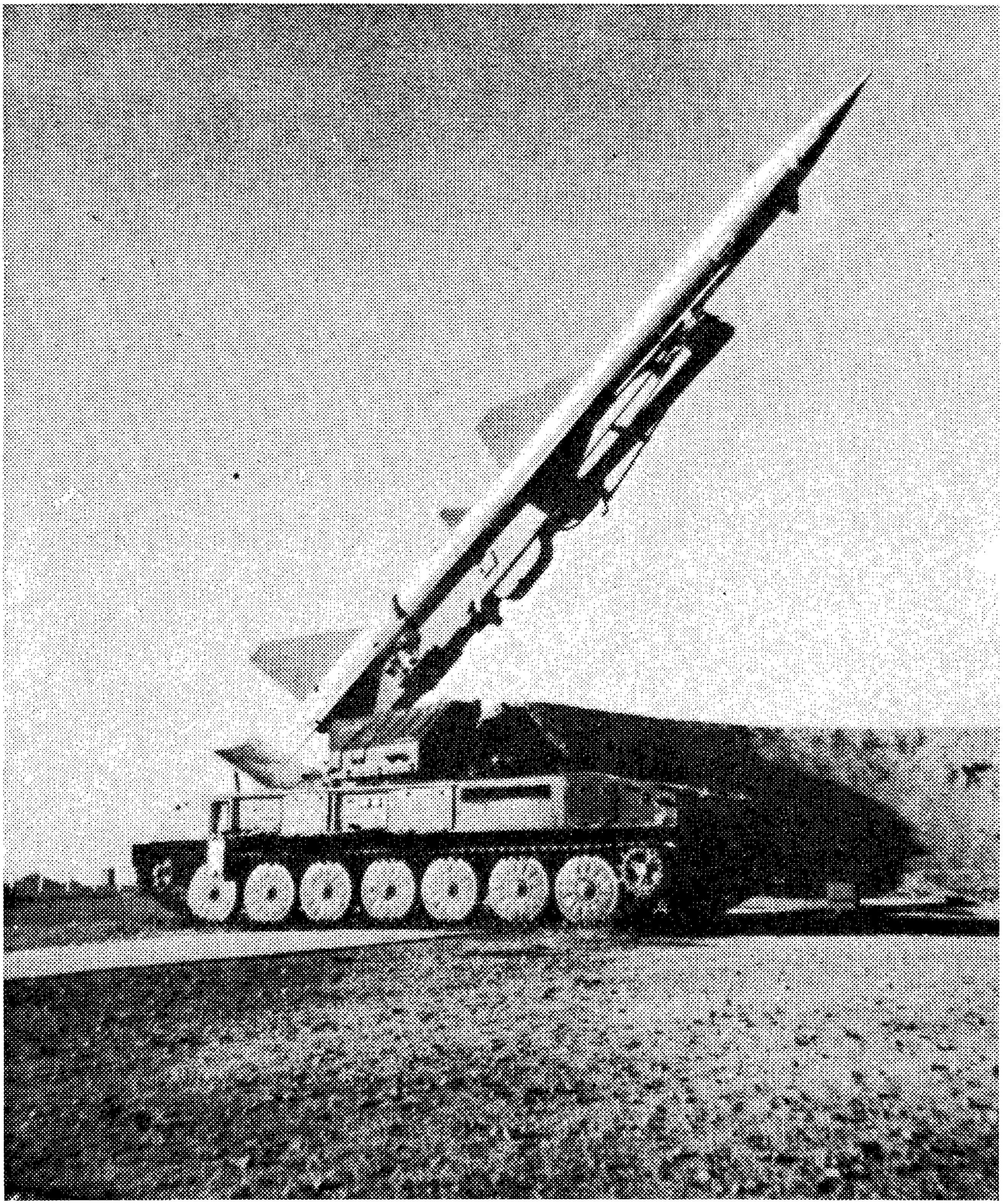

Figure 3. HQ-2B SAM on Launcher

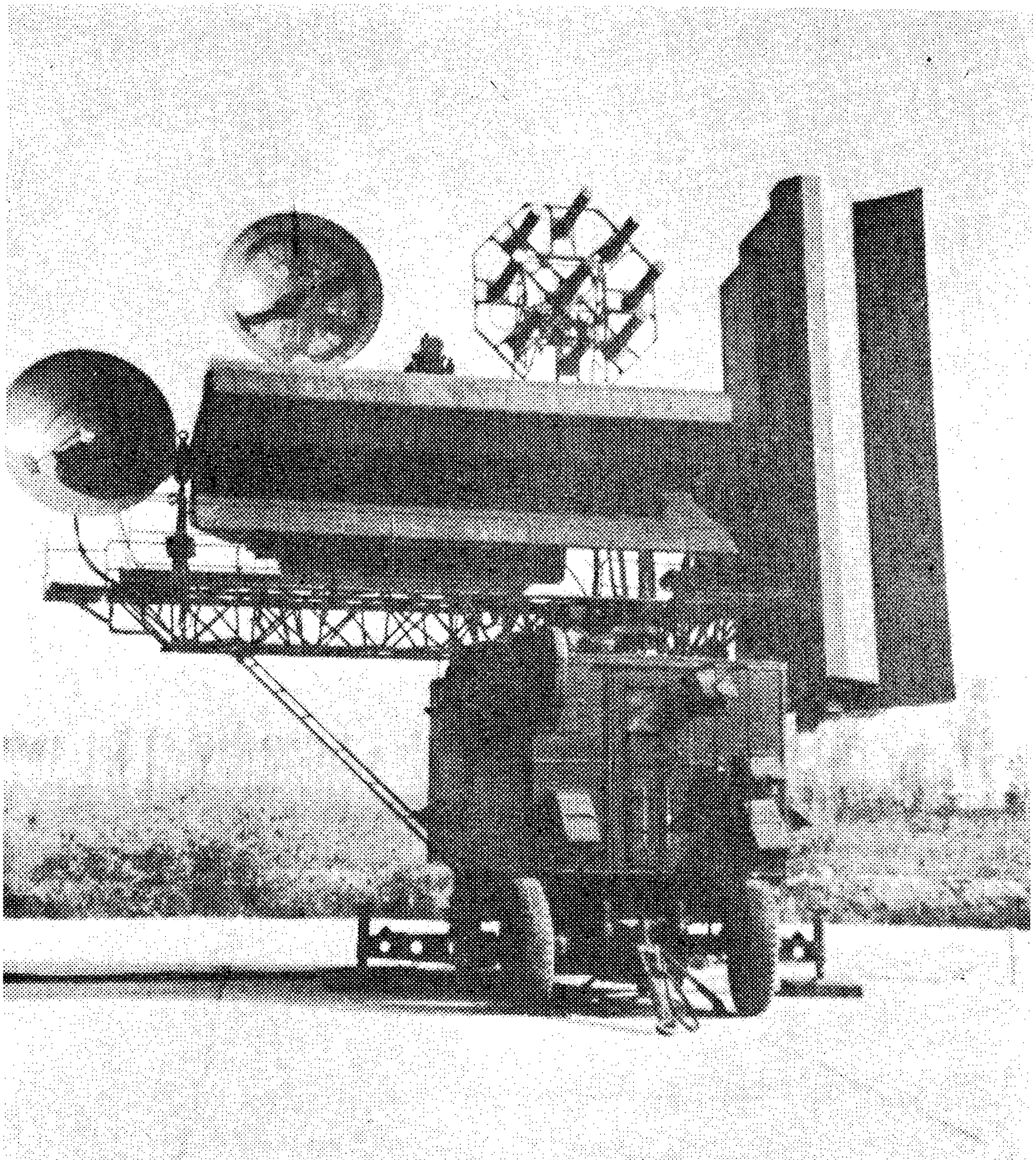

Figure 4. Antenna Transceiver Car for HQ-2B SAM

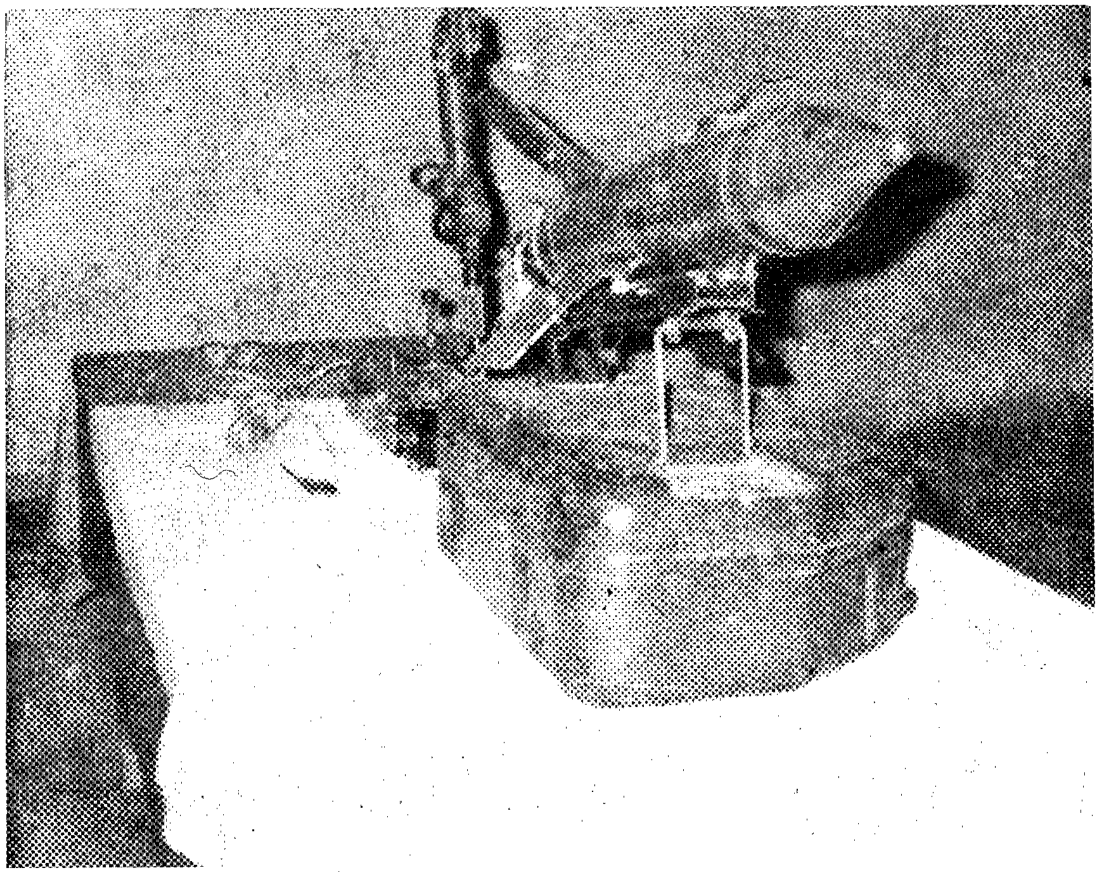

Figure 5. Red Arrow 73 Antitank Missile System

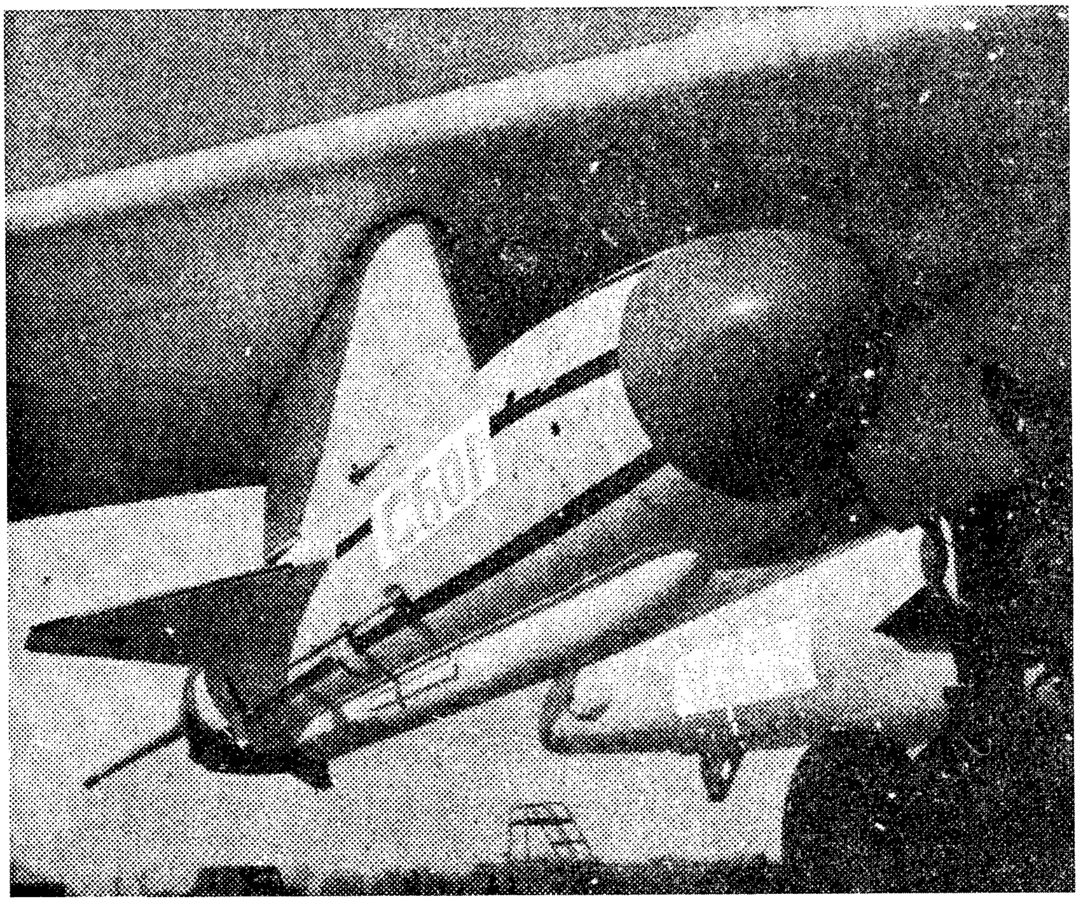

Figure 6. C601 Air-to-Ship Missile Under Wing of B6-D Bomber

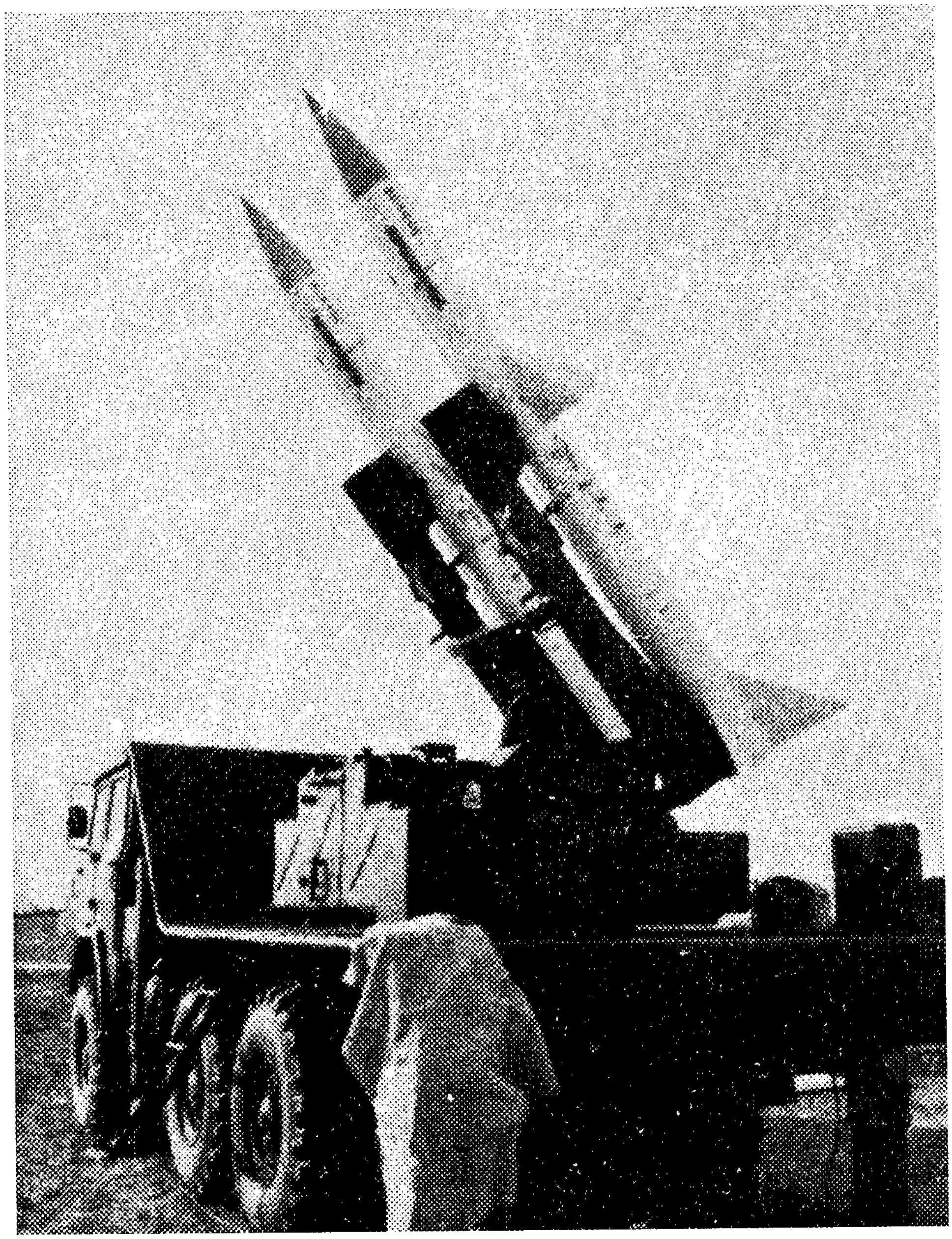

Figure 7. Ground-Launched HQ-61 SAM System

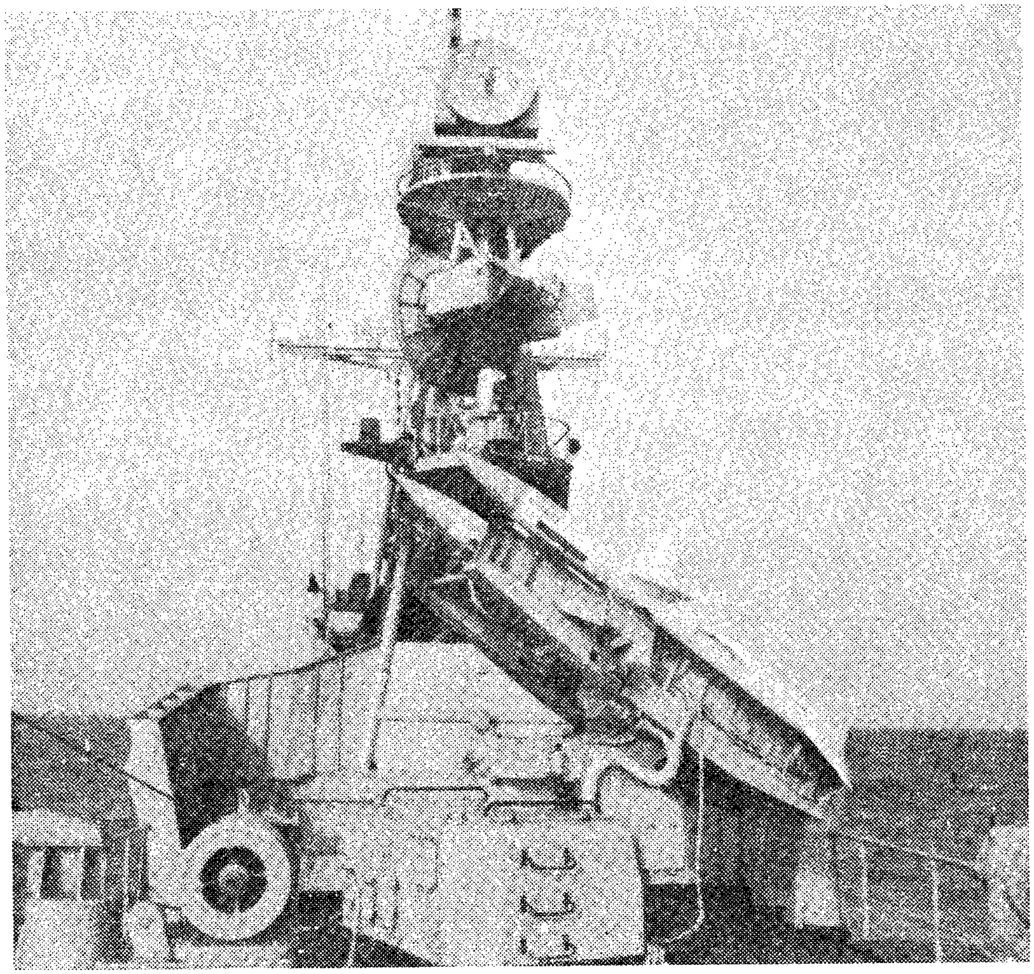

Figure 8. Ship-Launched HQ-61 SAM System

Figure 9. Exterior View of HN-5C System

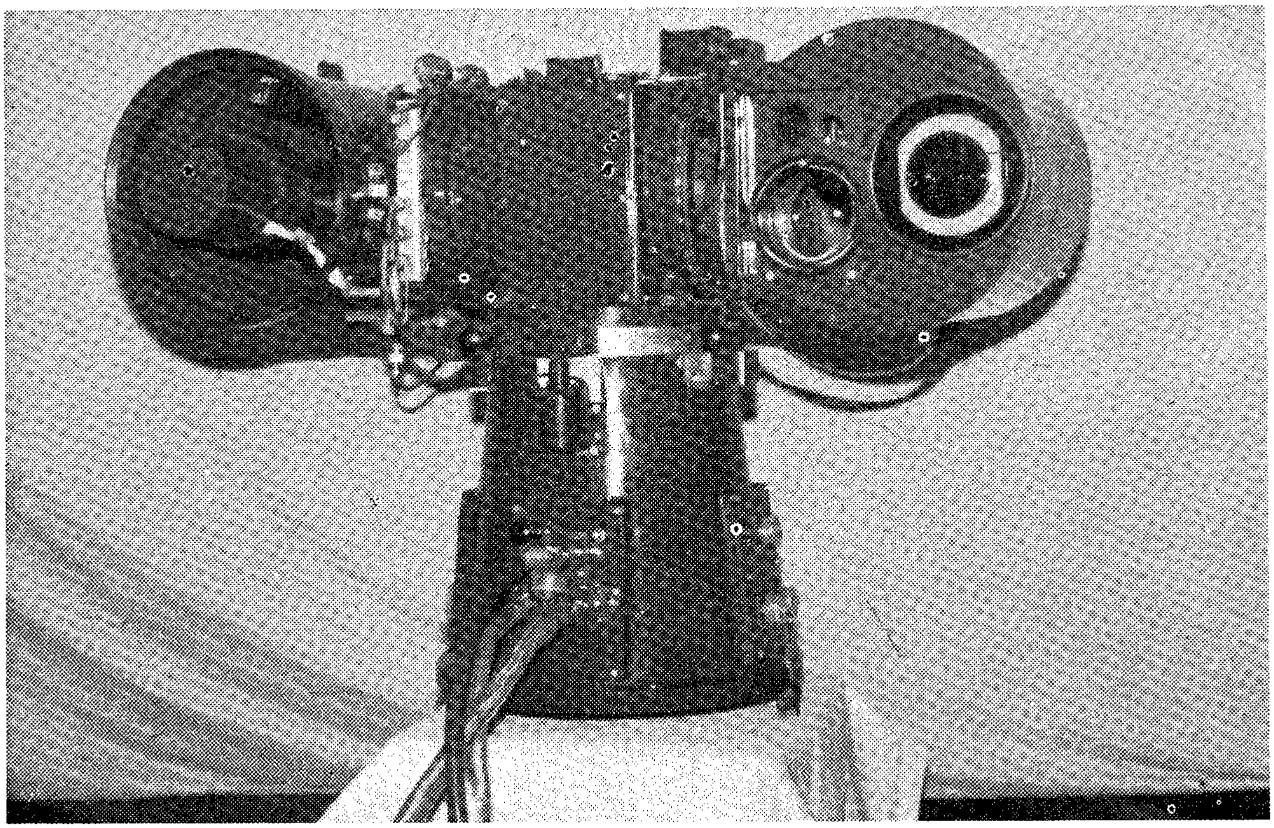

Figure 10. Target Detection and Tracking Module of HN-5C

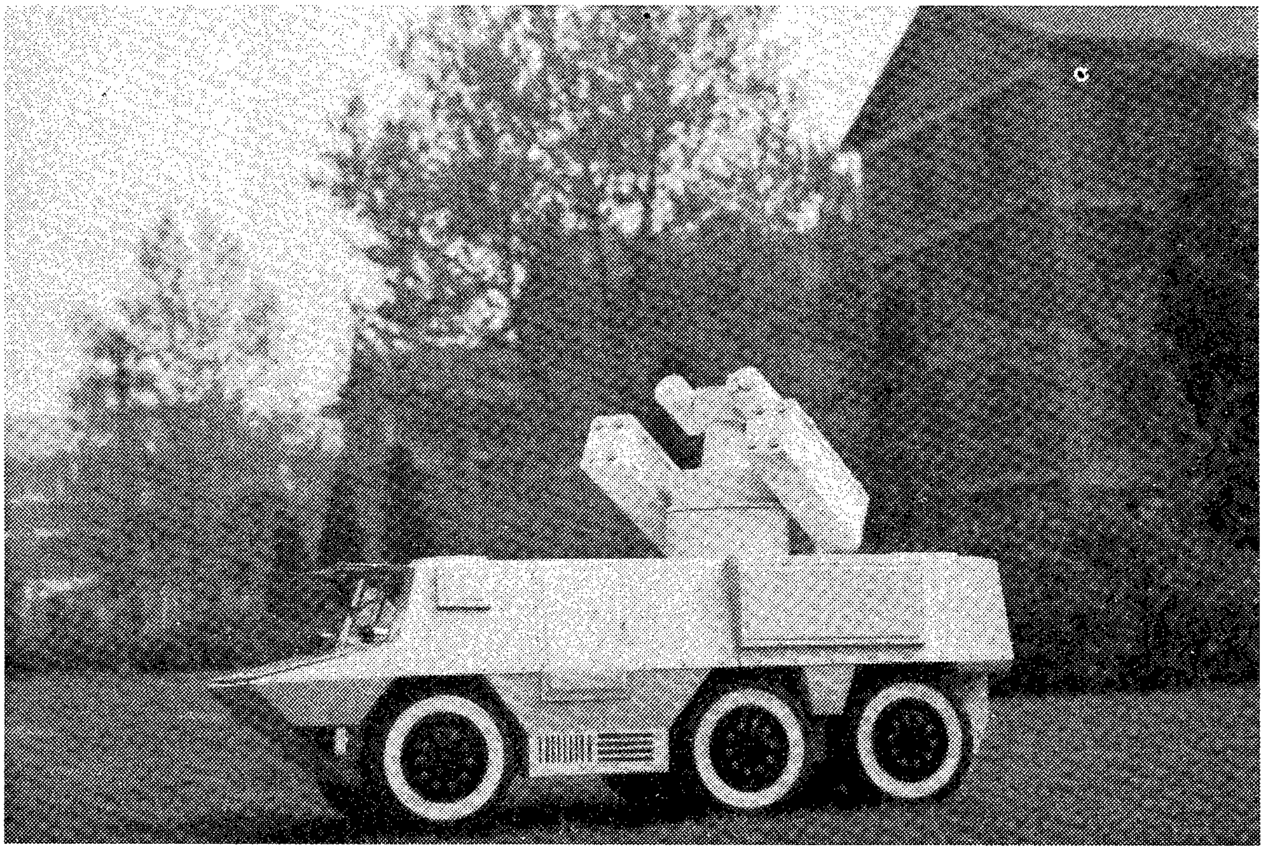

Figure 11. Armored-Car Version of HN-5C

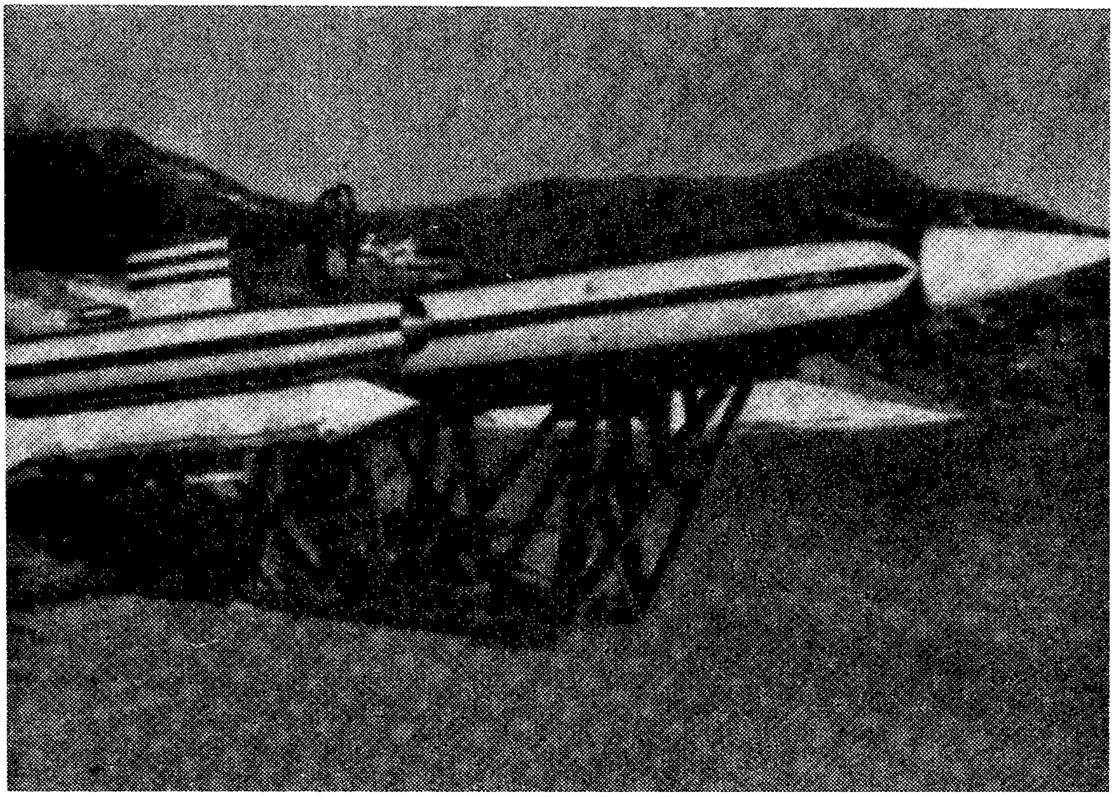

Figure 12. C101 Missile Launch Preparation

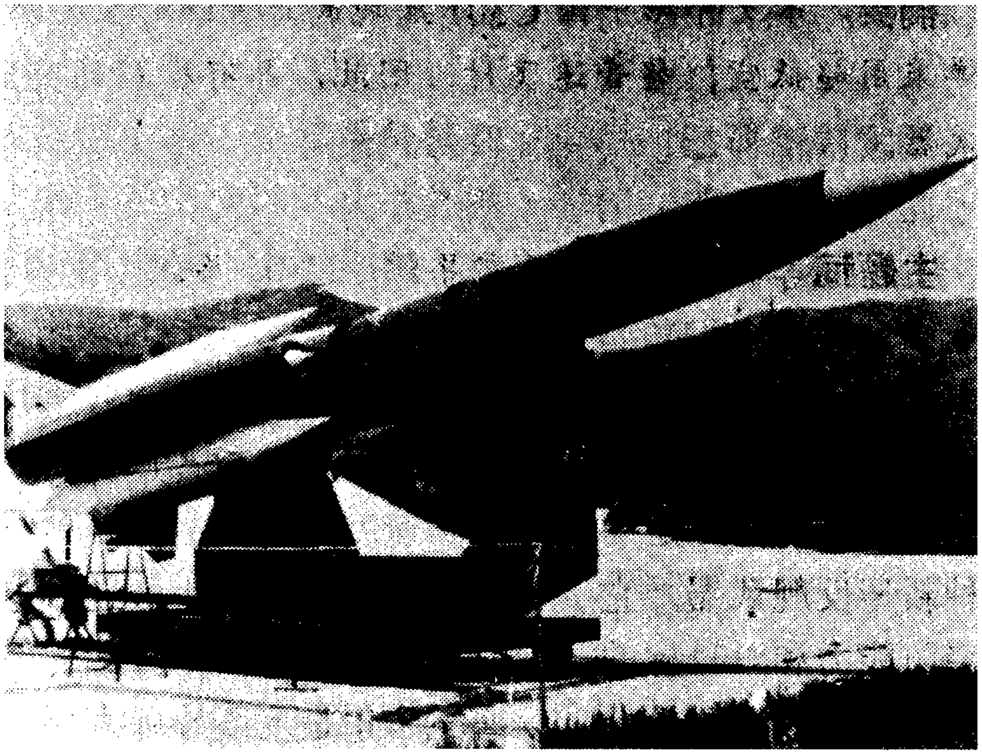

Figure 13. Exterior View of C301 Anti-Ship Missile on Launcher

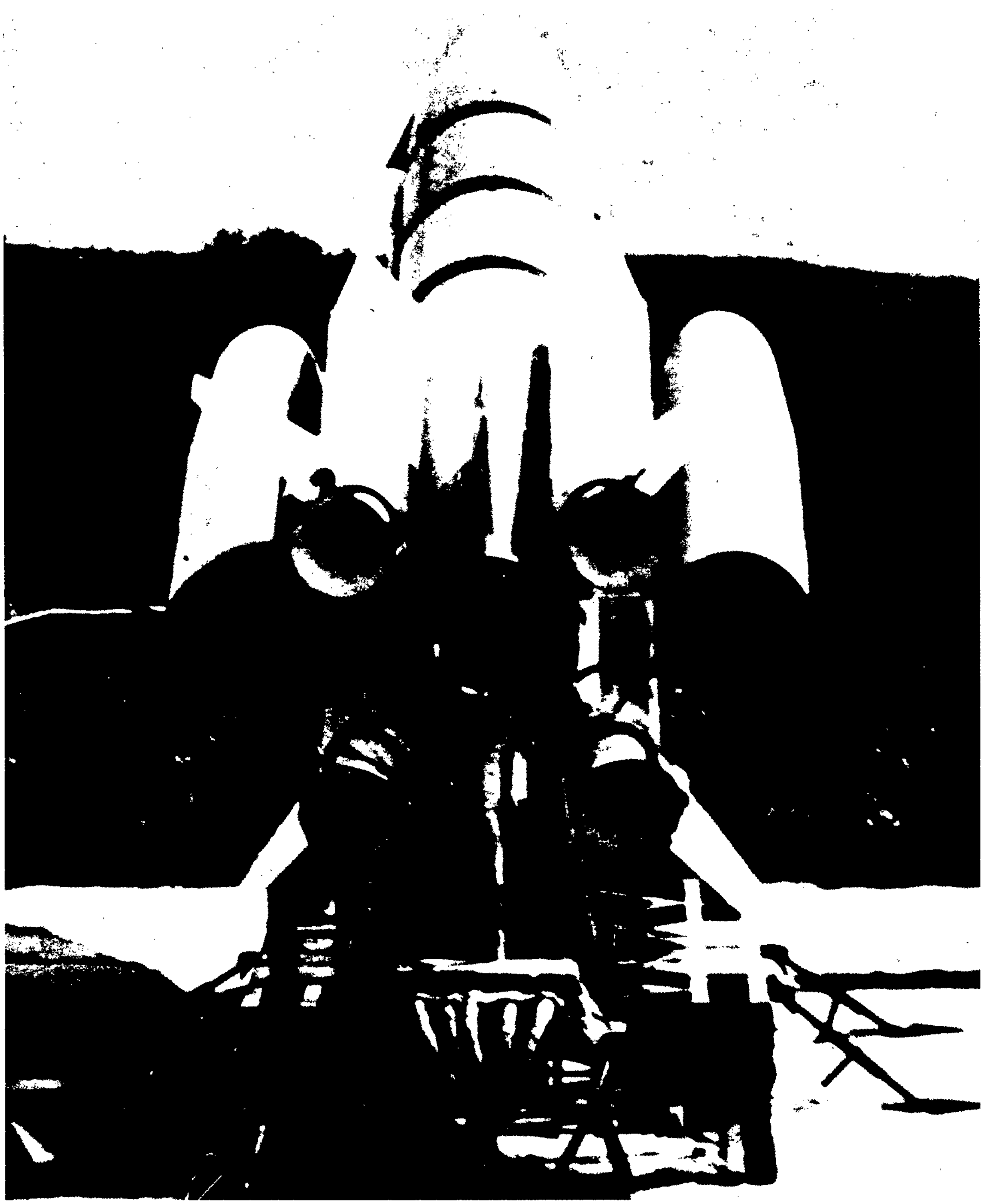

Figure 14. Rear View of C301 Anti-Ship Missile on Launcher

Figure 15. Overall View of HG-252 IR-Optical Measuring System
1 — Van; 2 — Detection & Tracking Mechanism;
3 — Oil-Engine Generator; 4 — Antenna

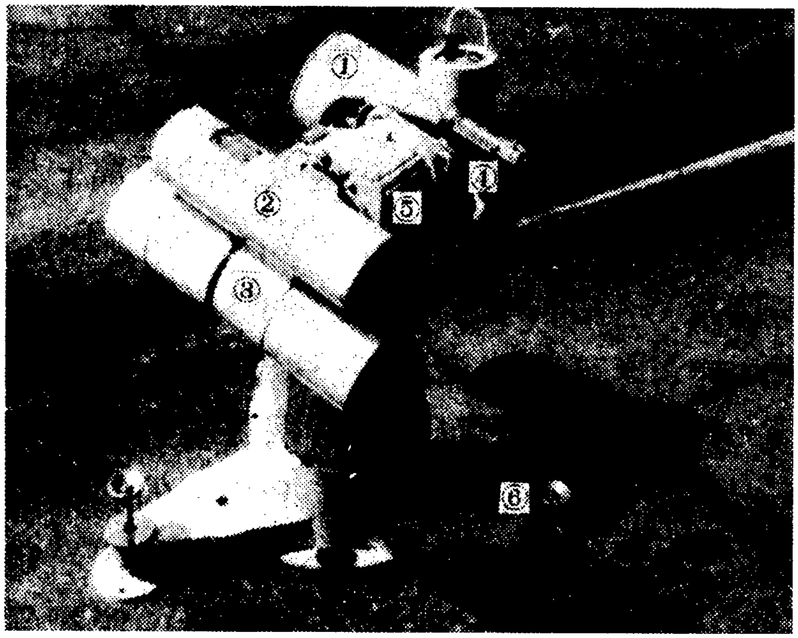

Figure 16. Detection & Tracking Mechanism
1 — IR Head; 2 — Long-Focal-Length Image Pickup Head; 3 — Zoom Image Pickup Head; 4 — Telescope; 5 — Follow-Up Mechanism; 6 — Support

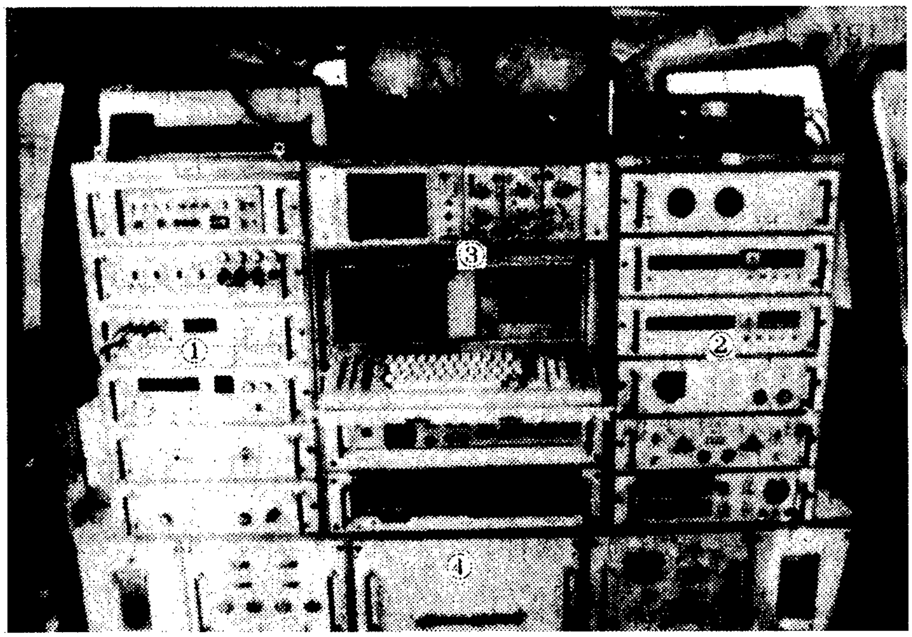

Figure 17. Electronics Rack for HG-252 System
1 — IR Rack; 2 — Control Rack; 3 — Display Rack;
4 — Power-Supply Rack

NTIS 2
ATTN: PROCESS 103
5285 PORT ROYAL RD
SPRINGFIELD, VA 22161

Foreign Broadcast Information Service (FBIS) and Joint Publications Research Service (JPRS) publications contain political, military, economic, environmental, and sociological news, commentary, and other information, as well as scientific and technical data and reports. All information has been obtained from foreign radio and television broadcasts, news agency transmissions, newspapers, books, and periodicals. Items generally are processed from the first or best available sources. It should not be inferred that they have been disseminated only in the medium, in the language, or to the area indicated. Items from foreign language sources are translated; those from English-language sources are transcribed. Except for excluding certain diacritics, FBIS renders personal names and place-names in accordance with the romanization systems approved for U.S. Government publications by the U.S. Board of Geographic Names.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by FBIS/JPRS. Processing indicators such as [Text] or [Excerpts] in the first line of each item indicate how the information was processed from the original. Unfamiliar names rendered phonetically are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear from the original source but have been supplied as appropriate to the context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by the source. Passages in boldface or italics are as published.

SUBSCRIPTION/PROCUREMENT INFORMATION

The FBIS DAILY REPORT contains current news and information and is published Monday through Friday in eight volumes: China, East Europe, Soviet Union, East Asia, Near East & South Asia, Sub-Saharan Africa, Latin America, and West Europe. Supplements to the DAILY REPORTs may also be available periodically and will be distributed to regular DAILY REPORT subscribers. JPRS publications, which include approximately 50 regional, worldwide, and topical reports, generally contain less time-sensitive information and are published periodically.

Current DAILY REPORTs and JPRS publications are listed in *Government Reports Announcements* issued semimonthly by the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161 and the *Monthly Catalog of U.S. Government Publications* issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

The public may subscribe to either hardcover or microfiche versions of the DAILY REPORTs and JPRS publications through NTIS at the above address or by calling (703) 487-4630. Subscription rates will be provided by NTIS upon request. Subscriptions are available outside the United States from NTIS or appointed foreign dealers. New subscribers should expect a 30-day delay in receipt of the first issue.

U.S. Government offices may obtain subscriptions to the DAILY REPORTs or JPRS publications (hardcover or microfiche) at no charge through their sponsoring organizations. For additional information or assistance, call FBIS, (202) 338-6735,or write to P.O. Box 2604, Washington, D.C. 20013. Department of Defense consumers are required to submit requests through appropriate command validation channels to DIA, RTS-2C, Washington, D.C. 20301. (Telephone: (202) 373-3771, Autovon: 243-3771.)

Back issues or single copies of the DAILY REPORTs and JPRS publications are not available. Both the DAILY REPORTs and the JPRS publications are on file for public reference at the Library of Congress and at many Federal Depository Libraries. Reference copies may also be seen at many public and university libraries throughout the United States.