Aviation Week

A McGraw-Hill Publication

and Space Technology

RAYTHEON'S HAWK

Reprinted From AVIATION WEEK And Space Technology

December 4, 11, 1961

THREE HAWK MISSILES are carried to launcher and loaded, ready for firing, by tracked loader/transporter vehicle.

Army Hawk Anti-Aircraft Missile—Part I:

Rapid Tactical Mobility Stressed in Hawk

By David A. Anderton

Andover, Mass.—Army's Hawk anti-aircraft missile system, developed and in high-volume production at Raytheon Co., is well into its second year of service with 13 Army battalions deployed in West Germany, the Panama Canal Zone and the island of Okinawa in the Pacific.

U. S. Marine Corps fielded its first Hawk systems more than a year ago, using a "stripped-down" battery concept that makes all components air-transportable by helicopter.

Within the coming months, five NATO countries—West Germany, Italy, France, Belgium and Holland—will activate a total of 22 battalions among them.

Hawk—which conveniently is an acronym for Homing All-the-Way Killer—is being developed and produced under a prime contract between Army's Boston Ordnance District and Raytheon Co. The Northrop Corp. is the single major subcontractor; but the system draws on components manufactured by about 3,500 active suppliers.

Technical direction of the program is the job of Army Rocket and Guided Missile Agency, working with Raytheon's Missile and Space Div. at Bedford, Mass.

First exclusive details and photographs of the Hawk system at a field level are presented here; a second article will describe production of the weapon system at Raytheon's Aero/Weapons division.

Primary mission of the Hawk system is defense against low-flying attack aircraft. Past thinking has generally bracketed this task in terms of subsonic planes and altitudes from ground level to about 1,000 ft.

But Hawk capabilities have been stated by military sources to cover a much wider range. Hawk, they say, can engage targets flying at speeds up to Mach 2 at altitudes from ground level to 50,000 ft. They point to successful intercepts by Hawk of tactical missiles—Honest John, Little John, and Corporal—to emphasize the quick response of the Hawk system, even when the target is supersonic and has a small radar cross-section. Little John, for example, is just over one foot in diameter.

Typical targets knocked out by Hawk during test firings in the missile development program included an XQ-5 drone—hit at a speed of 1,400 mph. above 30,000 ft.—and a QF-80 drone, engaged at less than 100 ft. altitude.

Major characteristic of the system is its ability to maintain a high rate of fire against single, massed or widely separated targets.

The low-altitude capability of Hawk originally led to Army plans to use it as a weapon complementary to Nike-Hercules for area defense. Hawk would engage low-flying attackers, while Nike-Hercules would take on the high-altitude targets. But the Joint Chiefs of Staff rejected the idea early in 1959, and since then there has been no work on fixed-site installations for Hawk.

Instead, Hawk is a field-army weapon, designed to be rapidly and easily transportable by a variety of current cargo aircraft, helicopters or wheeled vehicles. It can be set up anywhere that provides line-of-sight between its radar and the missiles on their launchers. No prepared sites are necessary, and the only preparation—once the battery has rolled into position—is to level the various trailers and lay the cables connecting power supply to the components of the firing sections.

Each Hawk battery consists of two firing sections commanded from a single battery control central station. The battery has two acquisition radars. One of them, the AN/MPQ-35 pulse acquisition radar, gives coverage of long-range, high-altitude and large-volume targets. The other is an AN/MPQ-34 cw acquisition radar, for picking up targets practically at treetop level.

Both these radars feed target information to the battery control central, where targets are identified and selected for action from a conventional plan-position indicator (PPI) presentation. Each of the firing sections is tied to battery control through its AN/MPQ-33 cw illuminator radar, which receives a target azimuth from battery control and then searches in an elevation box to find and lock on the target. After lock-on, the search procedure continues automatically.

Each firing section has three launchers, each pre-loaded with three Hawk missiles. The battery control central receives information as a display which tells the status of each missile. Battery control then selects the missile to go. The missile looks at its target, which is illuminated by the cw radar, and also looks at the illuminator radiation for reference.

When the target is in range, the section operator in the battery control central fires the Hawk. Its internal guidance system solves the intercept equation during the flight out and directs the missile to the strike.

Normal operations of the Hawk system are under the direction of five

HAWK battery equipment includes AN/MPQ-34 cw acquisition radar (above) and AN/MPQ-33 cw illuminator radar (upper right). Three Hawk missiles, ready for transport as a unit to launcher, are mounted on pallet attached to wheeled trailer (below). Crane beam has been added to loader (lower right).

men, once the site has been readied. These five, stationed in the battery control central, include the tactical control officer and his assistant, who work from a situation presentation and a plan-position indicator display of the local area.

Crew Functions

These men identify and select targets for the missile system.

The cw acquisition radar, which picks up low-flying targets while ruling out returns from ground clutter and slow-moving traffic, is operated by a third man. The two remaining men sit at two consoles, one for each firing section, and observe target displays. They finally fire the Hawks when the marked target comes within striking range.

Tied into the control system is the crew chief distribution box, which interrupts the lines between the cw illuminator radars of each firing section and the Hawk launchers. The crew chief can use this box to remove any launcher in his section from action for reloading or correction of malfunctions. This box also is the terminal for telephone lines from battery control central so that handling crews and firing crews can have voice contact if necessary.

Basic complement of the battery just described is five officers and 68 men; that organization is the one being used by U. S. Army Hawk units. But the Marines, with a different emphasis on use of the weapon during an assault operation, have chosen to operate a "stripped-down" Hawk system that is completely transportable by helicopter. This basic choice rules out the larger components of the system, such as the battery control central, in favor of smaller and lighter units.

Heart of the Marine system is the AN/TSW-4 assault fire command console, a 450-lb. case that can be brought to the site by helicopter and manhandled into final position if necessary. This unit functions as the battery control central. But because this is a stripped-down system, the Marine Hawk batteries do not have the large pulse acquisition radar; instead, they work with the cw acquisition unit and radar, a single cw illuminator and a single firing section of three launchers.

Even this system can be reduced one step further by eliminating the acquisition radar on the assumption that there will be no need to go looking for targets —they'll be there. For this minimum assault weapon, a single launcher is tied to the assault fire command console through the crew chief distribution box and a single cw illuminator radar.

Hawk batteries which will enter service with NATO countries will use a table of organization like that of the Army batteries. One of the major criteria for the NATO Hawk system is that all components be completely interchangeable with those for the U. S.

Army system, so that logistics and operations within the NATO areas are simplified.

System Design

Fundamental requirement for Hawk design, other than those criteria determined by the enemy threat, was that the entire system had to be quickly and easily transportable in existing road and airborne vehicles. This meant that everything had to be sized to minimum dimensions and weights, yet still be consistent with the Army's concept of field operations. Both Army and Marines specified that major wheeled units had to be able to float. For the Army, over-the-road means fording rivers as well. For the Marines, as one officer said, "If everything else fails, we want to be able to put a man on the launcher and have him paddle the thing ashore!"

Further requirements for the Hawk system were determined by Army policy on field maintenance. There is neither the time nor the place to perform any repair work, however simple, on system components in the field, says the Army. Therefore, basic circuits in operational and checkout gear had to be boxed in small, light modules that could be freed from their chassis by a quarter-turn of a handle, pulled out and replaced with a new unit within seconds.

Environmental Stresses

Army field operations imply rugged terrain ranging from deserts through rain forests to Arctic tundra and polar icecaps. This range of environmental conditions imposes the expected requirements on a weapon system designed for Army use. Hawk is expected to take the same kinds of environment as a hand weapon or a half-tracked vehicle.

The missiles are expected to work after being bounced behind prime movers during movements over open terrain, soaked with water while crossing a river or dropped off a moving truck at an advance supply point. After they enter the logistics pipeline, Hawk rounds may sit out in open storage without any extra protection; they may get rained on, covered with snow, pounded with hailstones or abraded by wind-driven sand. But when they go from there to the launchers for pre-flight check, they are expected to work. This also poses design problems.

Basic element of the system is the Hawk missile, a dart-shaped vehicle 198 in. (16 ft. 6 in.) long. The 14-in. diameter body mounts a cruciform of four truncated-delta aerodynamic surfaces, spanning 47.4 in. Weight of the complete missile, ready to fire, is approximately 1,295 lb.

A glass fiber radome of ogival shape forms the nose contour of the Hawk. Directly aft of the radome is a cylindrical section containing the entire guidance package and the auxiliary power units. The seeker dish is mounted at the forward end of this package and extends into the base of the radome.

The warhead compartment is located behind the guidance section. Field units have a choice of warheads depending on the expected threat.

Rocket Powerplant

Fuselage space from the leading edge of the wings to the end of the tail cone is filled by an Aerojet-General XM-22E8 solid-propellant rocket encased in a thin-walled shell made of 4130 steel. The rocket engine uses two different propellants to provide two thrust levels for the missile. The boost phase delivers a high thrust for a short duration to accelerate the missile clear of the launcher and to flight speed as rapidly as possible. The sustainer then takes over and provides a lower thrust level until burnout or intercept.

Wings of the Hawk are double-wedge section surfaces, built from all-aluminum alloy honeycomb structural components, skin and fittings. The wing skin is formed from 0.051-in. 7075-T6 aluminum alloy and bonded to the internal structure consisting of two sheet metal ribs, two 0.003-in. foil honeycomb cores and some machined fittings. Three rivets are used. The wings and elevons are being delivered by Ling-Temco-Vought and Northrop, through the latter company which is Raytheon's only major subcontractor.

Control actuators and elevons are mounted in a small ring structure around the necked-down section of the rocket motor nozzle.

Raytheon production here turns out the guidance section, complete with nose cone and elevon control ring. These units are shipped in a standard container (XM417E2) to go either to a field unit as a repair part or to the Raytheon assembly site at the Army's Red River Arsenal, Texarkana, Tex. At this site—designated HAMCO for Hawk Assembly and Missile Check-Out—the complete Hawk round is assembled with its Aerojet-General motor, the LTV-Northrop wings, and the government-furnished warhead. After a checkout, the missile is disassembled and transferred to the XM430 shipping and storage container for shipping either to a storage area or a tactical site.

Parallel to this movement of the missiles themselves, the various items of supporting equipment are sent to Ft. Bliss, Tex., where they are checked out as a system at a Raytheon site. From there, the Army takes over and ships them to a field user.

At the tactical site, a Hawk round is removed from its container to a handling dolly. Assembly of the wings follows. From there, the complete round goes to a check-out area, where 45 min. of testing certifies it as either a go or a no-go round. From there, the missile can be sent either to a pallet for storage or a launcher for ready status.

The XM1E1 pallet is a simple truss-work structure that holds three missiles in the same position as the launcher holds them. The pallet can be used trailer- or truck-mounted, or stand free. Attachment points can be used for pickup gear or for helicopter sling attachments.

Three tracked XM501-E2 loader-transporter vehicles are assigned to each battery. These units can carry from one to three missiles from checkout and storage areas to the launcher, and load the rounds in a matter of seconds after arrival at the launcher.

The XM-78E3 zero-length launcher is a wheeled, trailer-mounted unit that can be towed behind one of the six M36 cargo trucks assigned to each battery. An electronic control system in the launcher slaves it to the cw illuminator radar for initial pointing before final data is fed to the missile just prior to launching.

Mobile Radars

The big pulse acquisition radar, over the unit weight limit for helicopter transport, is palletized so that the electronic unit can be separated from its trailer and air-lifted under a helicopter. The paraboloid reflector breaks down into five pieces for transport.

The smaller and lighter cw acquisition radar is transported as one unit on its two-wheeled trailer. Like the pulse acquisition radar, it can be towed behind an M36 prime mover vehicle.

Finally, the cw illuminator radar—which is recognized easily by its two circular antennas—is also a single unit, mounted on a two-wheeled trailer.

The AN/TSW-2 battery control central is a single shelter containing all the monitoring, plotting and fire control equipment. It is within the helicopter weight-lifting limits.

Power supply for the entire battery comes from three trailer-mounted 45kw. electrical generators. A fourth unit supplies power for the missile test and check-out area; a fifth generator is held as a spare. Two crew chief distribution boxes and 31 sets of electrical cable assemblies make up the rest of the power supply system.

Finally, a towable, trailer-mounted AN/MSM-43 organizational maintenance shop goes along with each battery.

Part of the Hawk missile system not attached to the batteries at the field sites is a series of field maintenance shops, normally transported on a flat-bed M36 truck to an ammunition supply point or a field-maintenance depot. Each shop is geared to one specialized form of maintenance on the system.

Ready to roll, the Hawk battery makes up into a convoy of 23 vehicles which carry system components for two firing sections equipped with a total of 36 missiles. Over-all system packaging and transport has been planned so that the sections can be ready for firing within minutes after arriving at the battery site.

SIMULATED Hawk battery site aids development

Hawk Anti-Aircraft Missile–

Production

By David A. Anderton

HAWK RADOMES are checked for final contouring (above) before being finished on engine lathes in the background. Final assembly area for Hawk missiles at Raytheon Andover plant handles guidance section, radome and elevon control ring assembly. Hawk is in large-volume production for U. S. Army.

Andover, Mass.–Raytheon Hawk missile system, continuing at peak production level for the U. S. Army, draws on more than 3,500 active suppliers of parts in a program whose costs since inception are climbing toward the $900-million mark.

More than half these allocated funds have been spent outside the company, Raytheon says, and about $200 million have gone to the many small businesses associated with the Hawk project.

Raytheon has had more than 5,200 direct suppliers to the program to date. Including all sub-contractors, the company estimates the total number of manufacturing firms associated with the Hawk at a "conservative" 25,000.

As prime contractor for Hawk to Army through the Boston Ordnance District, Raytheon Co. has systems responsibility for the missile. Technical direction of the project is in the hands of the Army Rocket and Guided Missile Agency at Redstone Arsenal, Huntsville, Ala.

Systems engineering in the research and development sense, plus flight test work on complete systems, is under Raytheon Missile Systems Division at Bedford, Mass. Work on continuous wave and pulse acquisition radars was done by the company's Equipment Division at Wayland, Mass. Production of the system is the responsibility of Aero/ Weapons Division here.

First exclusive details and photographs of the Hawk system appeared in AVIATION WEEK Dec. 4, p. 74, as the first article of this two-part series.

Raytheon management adapted most of the standard approaches of large-scale, complex-system production to the Hawk. It should be pointed out that Raytheon is not in a strange field;

testing of missile system. Engineer enters battery control central (left); cw acquisition radar is in left foreground.

Part II:

Pace for Hawk Is Set by Quality Control

although traditionally associated with the manufacture of electronic equipment, the company has versatile manufacturing capability across the spectrum. In addition, Raytheon is prime contractor to the Navy on the Sparrow 3 air-to-air missile, a weapon of a different sort but involving many of the same approaches in design, engineering and manufacturing philosophies.

The company relies heavily on subcontractors and suppliers of parts and hardware. In the Hawk missile there are about 3,500 separate parts of about 1,500 different kinds. Only 113 of these are made by Raytheon; the rest are purchased outside the company. Including raw materials, more than $6.5 million worth of purchased parts comes in every month for Hawk.

Parts with a high direct-labor cost are, in general, manufactured by Raytheon.

Peak production scheduling is based on one-shift operation, with some second-shift time for maintenance and to fill in at trouble spots. This gives flexibility for any sudden need for extra production; by adding a full second and third shift, Hawk output could be nearly doubled or trebled.

Raytheon managers talk about two basic manufacturing philosophies which they apply to the Hawk:

- **Versatility**, so that changes or modifications can be put into production missiles as rapidly as possible, without dependence on a vendor's lead time.
- **Capability**, so that every critical part in the system could be manufactured, if necessary, by the company. This eliminates long line shutdowns if a subcontractor runs into trouble.

But most impressive to the engineering observer is Raytheon's insistence on the importance of quality control, and the elevation of quality control engineering to a position just below top plant management. This change from the usual scheme of things was born out of the Hawk program and, according to company officials, is a major factor in obtaining and keeping a high rate of delivery of complete systems.

The quality control system starts at a shop level when any purchased part arrives at the Raytheon plant here. More than 250 inspectors in three areas —mechanical, electrical and microwave —augmented by Army Ordnance inspectors check almost everything as if it were to go on a flight missile. In spite of the quantities of materials involved, there is very little sampling; almost 100% testing is done on incoming parts. They are put through drop, shake, shock and life-cycle testing before being released to production.

At an engineering level, quality control starts with personnel from the group in research and development engineering offices at Bedford. From initial design to final delivery, they are never far out of sight of every part that makes up the Hawk system.

A major share of the quality control job is assigned to its engineering department which is responsible for a variety of jobs usually assigned to many different engineering groups. For example, quality control engineers develop all functional system parameters to define the limits of operation. They develop all test procedures and tell both production test and quality control test per-

AEROJET-GENERAL solid-propellant rocket engine for Hawk missile fires at two thrust levels: boost (above) and sustaining for cruise (below).

sonnel just how those tests will be run.

The group also designs and develops the equipment to make the tests in the first place, and then is responsible for documenting those tests for the customer. Maintenance and calibration of all test equipment is also under the quality control group.

Only two Raytheon managers have the authority to stop the Hawk production line: one is the Andover plant manager and the other is the chief quality control manager. There is no time wasted in the action, either. One engineer remembered a time when some trouble developed in production of the Hawk. It was reported by the line foreman to the responsible quality control engineer who in turn went to the manager with the story. "We shut the line down in 10 minutes' elapsed time from the discovery of the trouble," the engineer pointed out.

This kind of decision-making machinery in the hands of quality control personnel is unusual. But the company says it pays off in many ways that would be difficult to achieve otherwise.

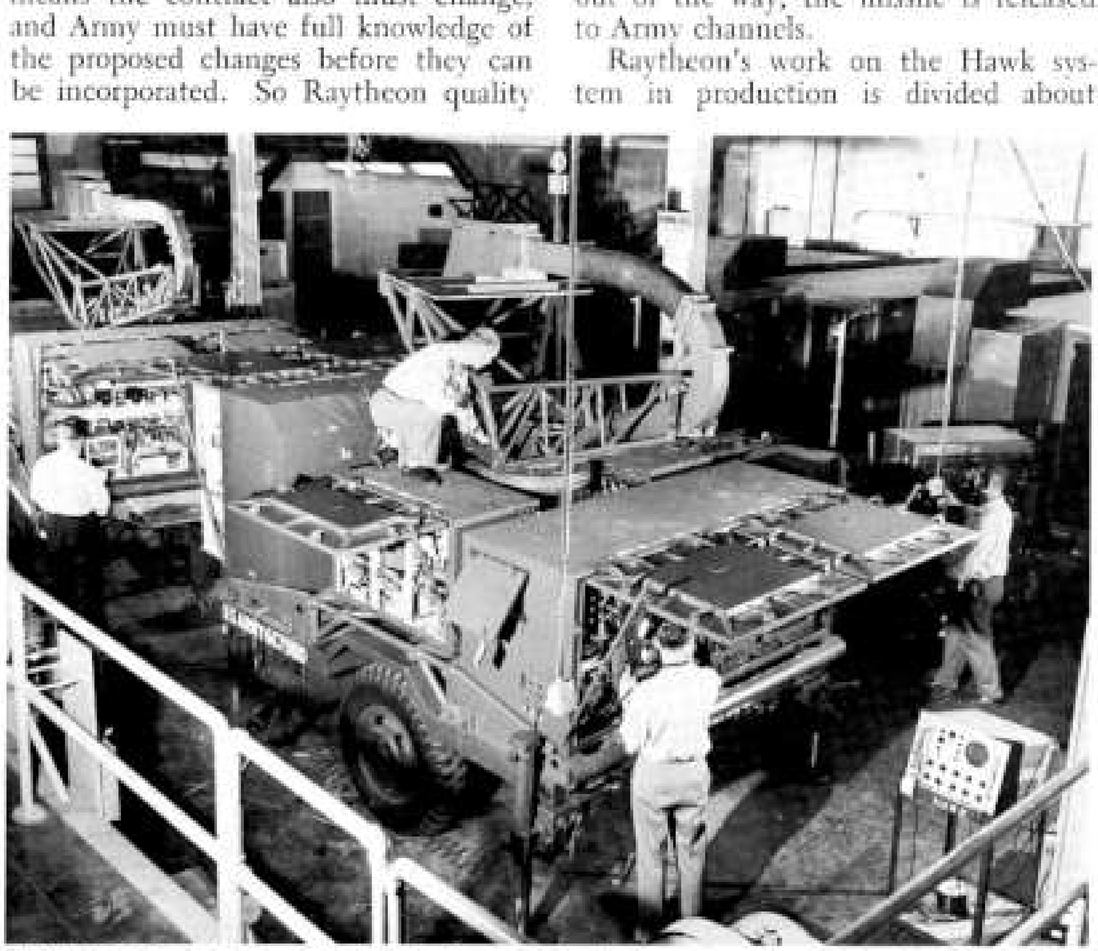
Once the line has been stopped for cause, the quality control manager gets systems engineers to dig into the difficulty. When the problem is solved, there is a routine procedure involving Army Ordnance permission that has to be completed before the line can start again. The reason involves contractual obligations.

If a part has to be changed, that means the contract also must change, and Army must have full knowledge of the proposed changes before they can be incorporated. So Raytheon quality control engineers test the new change or new part, document that test and report it to the local representative of Army Rocket and Guided Missile Agency. If he approves, he forwards the report to the Contracting Officer of Boston Ordnance District, who has the authority to tell Raytheon to get going again. There is no way of short-circuiting this procedure to speed up production, except of course by hand-carrying documents through the channels instead of sending them by mail.

One detail of the change system is worth noting. Even the EO (Engineering Order) forms, which are generally used to make small changes on a production drawing and which eliminate the need to correct the main drawing every time there is a small change, follow tight procedures. They have a space for the dates on which repair parts will be available and on which technical manual pages will be ready. There is no EO sent out without this information, so that there should never be a case of a missile arriving in the field when the troops don't have the necessary information in drawings or documents, or parts to complete it.

Finally, when a missile system is ready for delivery, quality control signs the final certificate of inspection. Units are still subject to a further check at the option of the Boston Ordnance District. Their inspectors can ask for spot checks of warehoused items in a so-called Verification Test. With these out of the way, the missile is released to Army channels.

Raytheon's work on the Hawk system in production is divided about equally between the 1.2-million-sq.-ft. plant here and the Waltham plant. Most of the parts associated with the missile airframe–guidance system, radome, and final assembly of the nose and tail packages–are handled here. Waltham is responsible for heavy equipment production such as the battery control central and the ground radars.



AN/MPQ-35 pulse acquisition radar for Hawk missile system gets electronic check during final assembly at Raytheon's Waltham plant. Dummy load replaces paraboloid antenna on top of palletized radar assembly. Unit is wheeled for over-the-road towing, breaks into two sections for helicopter transport.

A tour of the factory shows that the aims of manufacturing management–versatility and capability–seem to have been carried out. The machinery is varied in size and function; there are no endless ranks of the one-type machines usually found in high-volume machine shops. Instead there seems to be one each of every type and size of machine tool, giving the observer the impression of a large experimental or prototype shop rather than a gear works.

The other noticeable feature of a factory tour is the large number of quality-control stations. The over-all factory average works out to about one quality control man per seven workers; their positions are dotted all over the factory floor. In the section where deft-fingered women fabricate the complicated guidance "platters," every few stations along the line is an inspection position, where the work of the previous few operators is carefully checked and verified.

Actual rate or quantity of Hawk production is not known; but the number of components stored waiting to go on final assembly confirms the impression that this is one of the largest missile production jobs in the industry. Everywhere the observer looks in the factory he sees rows of radomes, scores of guidance sections waiting for test and calibration, dozens more under test in a series of alcoves and cells.

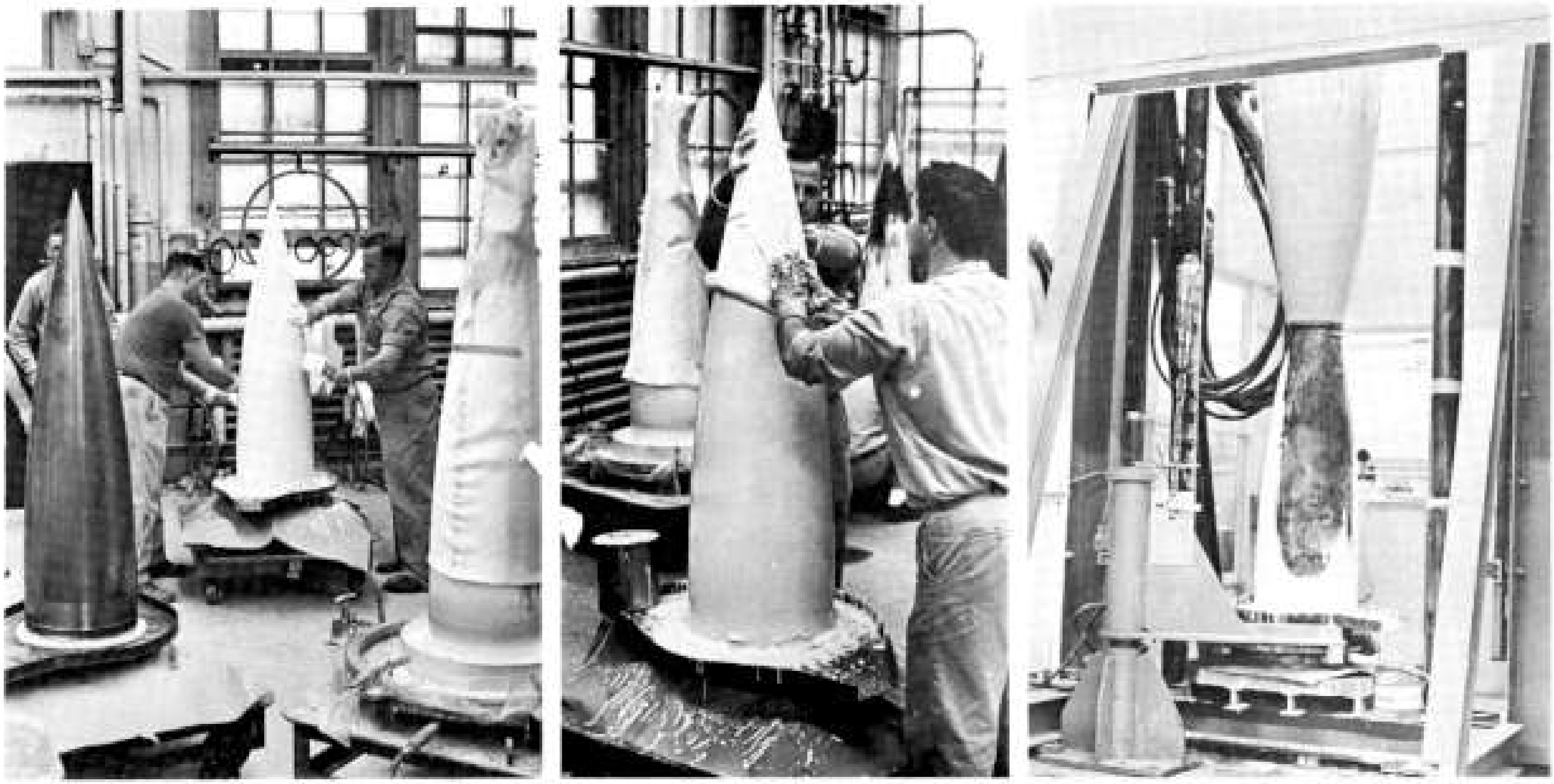
Finally all the parts come together in one of the shortest production lines yet seen. This relatively small area, tucked away in one corner of the plant, takes the guidance package with its seeker head, covers it with the radome, adds the elevon control ring and package, and sends it out to final checking.

Most of the production techniques are straightforward. Hawk is meant to be a rugged missile built to withstand the rigors of Army operation and to be easily repairable or maintainable in the field. This in many ways dictates an unsophisticated design using minimums of exotic materials or fabrication methods.

But a few of the production techniques used are somewhat different. One of these is the production of the glass fiber radome that covers the seeker head and forms the aerodynamic fairing for the front of the Hawk missile.

Radome Production

The glass fiber layup that finally



HAWK RADOME is made from layup of 28 glass cloth "socks" pulled over a steel form and hand-worked to eliminate wrinkles and impregnate the cloth. Final step is forcing excess binder out with Hydrosqueegee and curing the layup with heated rubber bag drawn over the built-up form. Cycle takes about one hour per radome.

emerges as a finished radome for the Hawk starts in Raytheon shops as 28 "socks"—patterned and sewed glass cloth formed into shapes approximating that of the radome—pulled on a metal form.

Two men work at each mandrel, pulling the tight-fitting "socks" down over the contoured mold form, smearing the creamy curing plastic over each layer and working out the wrinkles with their gloved hands.

With the rough layup completed and covered with a polyvinyl chloride sheet, the mandrel is positioned in a Hydrosqueegee, the shop name for a fixture which squeezes out the excess binder, smoothes the wrinkles in the "socks" and cures the piece in one operation that lasts about one hour. The Hydrosqueegee is a hot-water-filled conical bag of rubber suspended from an overhead support. The work piece is located so that it and the bag are point-to-point in the vertical position, like two radomes nose to nose. The bag is then lowered slowly over the form, and the hydraulic pressure of the water inside the bag squeezes out the excess binder as the bag slowly lowers to cover the entire radome layup. It goes on like a "sock," put on inside out and starting at the point of the radome nose.

After curing, the nose radomes are routed to a machine shop for final contouring on a lathe with an automatic tracer to meet minimum tolerances.

Finally each radome is checked electronically to determine its dielectric properties before being routed to final assembly for installation on the guidance package.

Raytheon makes the rate gyroscopes and accelerometers used in the Hawk's internal guidance package. Production techniques are conventional; work is done in the usual "clean" room, largely by women workers and inspectors.

Production Techniques

The gyro starts out as a motor stator, around which is the rotor which doubles as the inertia flywheel of the gyro. The rotor-stator combination is gimbal-mounted, then pickoffs—which have been made as a separate assembly—are added. Finally the case seals off the gyro assembly.

Gyro and accelerometers are on the order of two inches long and about one

Hawk Missile System Suppliers

Item	R&D	Production
Hawk missile:		
Guidance	Raytheon	Raytheon
Powerplant	Aerojet-General	Aerojet-General
Wings, elevons	Northrop	Northrop/Temco (now L-T-V)
Warhead	Picatinny Arsenal	Government Furnished Equipment
Ground guidance group:		
Battery control central	Raytheon	Raytheon
CW acquisition radar	Raytheon	Raytheon
CW illuminator	Raytheon	Raytheon
Pulse acquisition radar	Raytheon	Raytheon
Assault fire command console	Raytheon	Raytheon
Ground support equipment:		
Launcher	Northrop	Northrop
Launcher electronics	Raytheon	Raytheon
Loader/transporter	Northrop/Food Mach.	Northrop/Food Mach.
Pallet	Fruehauf	Fruehauf/Portland Copper & Tank
Guidance container	Applied Design	Williamson Mfg. Co.
Single tactical container	Applied Design	Williamson Mfg. Co.
Test equipment:		
Missile test shop	Raytheon	Raytheon
Ground equipment test shop	Raytheon	Raytheon/G. F. E.
Shelters	Craig	Craig
Electronic test equipment	Raytheon/RCA	Raytheon/RCA
Hydraulic-mechanical test equip.	Raytheon/Kidde	Raytheon/Kidde

HAWK GYROS and accelerometers are assembled in a clean room at Raytheon's Andover plant. Production techniques are conventional; accent is on quality control and careful inspection following every few steps of assembly.

inch in diameter.

The insistence on quality control, prevalent throughout Raytheon Hawk manufacture, is almost the dominant factor in gyro production. One estimate by an engineer is that money spent on inspecting and testing of gyros is as much as that spent on their production.

Most of the elements of a field battery are sprawled out on a few acres of rolling terrain a short drive from the Raytheon plant here. At least one unit of each operational type is in working condition and is used almost continually in a severe test of Hawk capabilities.

Hawk rounds stand out in the open, snowed on in winter and sunburned in summer, as working missiles to be carried from supply point to a launcher, tested and checked either alone or as part of a system, and then taken back to storage again. Some of the Hawks show handling marks, their paint has been chipped and the steel has rusted; but on the launcher they behave just like new missiles off the factory line under test.

Air traffic in the pattern for Boston's Logan Airport and Raytheon test aircraft based at USAF's Hanscom Field in nearby Bedford furnish practice targets for Hawk acquisition and illuminating radars.

This field site serves several purposes:

- **New developments in the Hawk** system can be checked here in a simulated operational environment.
- **Updated installations** or modifications originating in field service reports can be checked for performance.
- **Training of key NATO personnel** is done here.
- **Trouble reports from field** service representatives pass through the test site for solution, if a field-level solution is indicated.

ENVIRONMENTAL TEST of Hawk missile airframe is one of rigorous set of checks made on system components during manufacture.

Hawk History

Raytheon's initial work in the missile field began near the end of World War II when the company's engineers were developing a target-seeking system for the Navy's Lark anti-aircraft missile, then being built in parallel programs by both Consolidated-Vultee Aircraft Corp. (now General Dynamics) and the Ranger-Lark division of Fairchild Engine and Airplane Corp. (now Fairchild Stratos Corp.).

From this program came an active cw radar seeker, and later a pulse seeker which Raytheon wanted to fly in a General Dynamics Lark airframe. But the Lark program, like many others in the early postwar proliferation of projects, was cut back and Consolidated-Vultee's portion was canceled.

But there were some spare Lark airframes around, and Raytheon got some, installed the company's pulse-radar seeker and added a mid-course guidance system, thus replacing the original beam-riding system that guided the Lark.

First target intercept with the Raytheon system in the Lark airframe was made in January, 1951. Shortly after that, the Navy's Bureau of Aeronautics directed the work toward a semi-active system to increase effective range.

The experience gained in working in the various phases of the Lark program led directly to the Raytheon prime contract on the Navy's Sparrow 3 air-to-air missile. While that system was being developed, the Army evolved a missile requirement for defense against low-altitude targets.

From Army Ordnance Corps, Raytheon received a contract to develop a ground-based illuminating radar to go with an unchosen low-altitude missile system using cw radar techniques. Parallel with this task were a number of other study contracts placed with industry and intended to lead to the low-altitude defense missile system.

Raytheon decided to risk a company-funded proposal and submitted an unsolicited design for a complete missile system to Army. In July, 1954, Army told Raytheon the contract was theirs; one year later, the Army asked for a year's acceleration of the program. In 1956, there was a further acceleration in the program when Army asked Raytheon to increase system capabilities and still maintain the same delivery schedules.

In 1956, technicians fired the first Hawk against a target. It was the first flight with a full guidance system operating and it was the first target intercept for Hawk.

During subsequent test flights, Hawk missiles have been fired against low-flying, high subsonic speed drones like the Lockheed QF-80, against the Corporal tactical ballistic missile, and the Honest John and Little John heavy artillery rockets. In all cases the closure speeds were supersonic, varying from below Mach 2 to well above Mach 3. The missiles also presented a considerably smaller radar target for the Hawk system than conventional target drones; Little John, for example, is just over a foot in diameter and is actually smaller than the Hawk itself.

In some quarters this kind of performance has been equated enthusiastically with anti-missile capabilities for the Hawk. But Raytheon engineers are the first to point out that this is not universally true. Anti-missile capabilities are inherent in the missile system, they say, but obviously there is a great deal of difference between being able to kill a short-range, relatively slow battlefield ballistic missile or artillery rocket and being able to stop a hypersonic ICBM.

They'd be willing to tackle the former, but defense against ICBMs is a long way beyond the Hawk system.

As an over-all program, Hawk ranks among the few really high-volume production missiles ever to be built. It has reached out through extensive subcontracting to thousands of small firms throughout the world. It is now on station in dozens of batteries in the U.S., the Panama Canal Zone, Western Germany with the U.S. Army, and the islands around Okinawa. The U.S. Marine Corps has adopted the Hawk system for defense against enemy air during their vertical envelopment assaults. Within months it will be adding significant strength to the defense of five NATO countries in Western Europe.

"We're still a first-line battlefield weapon," said one engineer. "Even in the days of massive retaliation, Army kept this program going. Lately we've had ample proof that the kind of threat we designed against still plays a large part in the enemy's offensive power. We expect that that threat, plus the capability of the Hawk system in limited wars or the special problems the Marines may have to face, will keep us in the Army inventory for quite a while."

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