commands to make sure that the decision that the article is combat-worthy and ready to go in the inventory is not the decision of the developer alone.

The AF Cambridge Research Center, devoted mainly to research, this year specializes in electronics and geophysics. The latter has as its main current product weather techniques and systems. This includes meteorological studies and the upper atmosphere. Cambridge also supports Project Lincoln, the main Air Defense Laboratory for the ground electronic environment system. Lincoln is managed by the Massachusetts Institute of Technology.

At the Rome, N. Y., Air Development Center, missions were mainly in the area of ground electronics components. Developmental work, supervised and administered from there, resulted in actual hardware.

The Headquarters of the Research and Development Command is located on a temporary basis in Baltimore, Md.

The Wright Air Development Center, most familiar of USAF's research locations, is now devoted mainly to weapons systems and airborne equipment. The largest by far of the centers, it employs one-fourth of the total personnel of the Air Research and Development Command.

The Arnold Engineering Development Center, located near Tullahoma, Tenn., a complex of wind tunnels designed for very high mach numbers and high altitude flight, got its first tunnels in operation during 1955, and others are coming along on schedule.

The Missile Test Center at Patrick Air Force Base in Florida, base point of the long-range missiles testing ground across the Carribean and out into the south Atlantic, continued experimental testing on missiles with a range up to 5,500 nautical miles.

At Eglin Field, Fla., is located both the Air Proving Ground Command and the Air Force Armament Center.

The Proving Ground Command was active in testing the operational suitability of equipment. The Armament Center tested developmental equipment from the Armament Laboratory at Wright Field and other locations.

At San Antonio's Randolph Air Force Base, the School of Aviation Medicine concentrated its research on aero-medical problems for the most part in the high-altitude and mach-speed areas.

The division of the effort between the Research Division of the School of Aviation Medicine and the Aero-Medical Laboratory at Wright Field is that the former is primarily research on humans. At Wright Field this research is on hardware, such as the flying suits and bail-out equipment.

At Holloman Air Development Center, work continued on short-range missile testing.

The Air Force participated in research at the White Sands Proving Ground, part of the integrated Department of Defense organization under the administration of the Army. Holloman does the flying support for the work at White Sands and has its own missiles program and firing programs integrated into the total firing programs at White Sands.

At Kirtland Air Force Base, in Albuquerque, N. M., the Air Force

Special Weapons Center worked closely with the nearby Atomic Energy Commission developments at Sandia Base and Los Alamos.

Located at the base is also the Tri-Service Armed Forces special weapons project, Field Command, under Army administration.

The Special Weapons Center is the Air Force Research and Development home and permanent base for flight activities in support of the Atomic Energy Commission's test program, not only at Indian Springs, located close to Las Vegas, Nev., but also at Eniwetok.

Expanding activities went forward at the Air Force Flight Test Center at Edwards AFB, where early test work on new aircraft is done. Some missiles testing was also done there particularly suitable to Edwards' facilities, such as the early models of missiles which eventually will not have wheels, but in their early versions do, so one can land them and bring them back and use them over again.

Navy

Today, all funds for the Navy's research and development programs are combined in a single appropriation. The Chief of Naval Research is the man who combines the budget requests of the bureaus, the Marine Corps and the ONR into this single appropriation. ONR is responsible for administering the appropriation and for keeping the necessary control records.

The problem for ONR is to make sure that the Navy is using the latest and best of science and technology, in a way that really meets the Navy's needs. To do this, says Rear Admiral F. R. Furth, USN, Chief of Naval Research, "we must foster new knowledge through active support or research, especially in areas that don't get support as a result of normal commercial and industrial pressures."

With a 1955 fiscal budget of $60-million, ONR is sponsoring about 360 projects which it farms out to about 217 universities and industrial laboratories, in addition to keeping a 4,500 staff in its own laboratories and offices.

Support is given to proposals having the greatest scientific merit and that have important bearing on Navy problems.

Recognizing that basic research should not be slowed by security restrictions, ONR encourages workers in unclassified projects to share their ideas with their colleagues, and to publish their results in recognized journals.

In addition to its basic research program, ONR supports a major applied research program. The office is constantly looking for new ideas and principles that will lead to the development of new weapons or warfare techniques. It is general practice to carry a project based on such ideas to a point where the technical feasibility of the principles have been established. At this point, the projects are normally turned over to a Navy bureau for further development and production.

Navy research and development is carried out along the same organizational lines as those used by a private industrial organization. An example is the electronic counter-measures program. Vacuum tubes are being developed for frequencies that are important for naval operations. When

ONR gets the basic principles worked out and the tubes developed, the Bureau of Ships will use them in developing shipboard electronic equipment and the Bureau of Aeronautics to develop airborne equipment. The Bureau of Ordnance may use them in guided missiles or fire control mechanisms.

The bureaus are analogous to operating divisions or companies. They maintain laboratories and support contract research and development of equipment in their particular fields. ONR provides corporate across-the-board supporting research, exploratory development and coordinates the total research and development programs. The nature of the entire program stems from operational requirements that are prepared by the Chief of Naval Operations, and that reflect the functional needs of the fleet.

Meeting the needs of the operating forces poses many problems for any military research and development program. New developments must be closely tied to operating plans, to requirements, to logistics and to tactical developments. Also, military planning must take into account new weapons that might soon be available, or could be developed should a military need arise. With the new techniques of operations research the Navy is able to analyze some aspects of these problems on a quantitative and objective basis. In this way much of the guesswork is taken from military planning. Broad areas for research have been outlined by the Chief of Naval Research. These areas are being explored through ONR.

Basic research is being conducted in aerodynamics, in power, in metallurgy and in other basic fields that affect aircraft development by the aviation industry.

Aircraft are being developed to meet the threat of enemy air attack on troop transports or convoys. The two vertical rising and descending fighters, Convair's XFY-1 and Lockheed's XFV-1, are distinctly new and different types: they do not need catapults or long runways, and can be operated from carriers or even from merchant ships.

The Navy's rocket-powered aircraft *Skyrocket* is a flying laboratory for research in rocket propulsion. Further, the continuous push to higher altitudes has taken the ONR to a point where major progress must be accompanied by new knowledge of the upper atmosphere, which is virtually airless and is bombarded by cosmic rays. ONR is constantly gathering data about this region through high altitude balloon and rocket flights which are carefully instrumented.

Basic research is supported in areas such as solid state physics, electronics, electromagnetic radiation and communication theory. The material bureaus are emphasizing miniaturization and reliability in all electronic equipment. Such developments as the transistor and the printed circuit have proven most valuable in this effort.

Support given to mathematical research has yielded new knowledge of differential and integral equations. These equations have great value in solving problems concerned with guided missiles and aircraft. In addition, the equations have permitted studies that have revealed the cause of some rocket motor explosions, and suggested some possible remedies.

CHAPTER THREE

Department of Defense

THE YEAR 1955 SAW no wavering in U. S. determination to maintain its ability to meet and repel any aggression with crushing force, despite the hope of a breakthrough improving East-West relations and easing world tensions. The era of good feeling generated at the Geneva summit conference soon evaporated, leaving in its wake disappointments which only served to re-emphasize the need for a military defense system which, in quality and quantity, would be a convincing deterent to war.

In the realm of military aviation, charged with the responsibility of providing the retaliatory take-out punch against any opponent, the tenth year of the cold war was marked by many noteworthy achievements in the continuous search for more effective airpower. And the stepped-up pace of aeronautical research and development offered the promise that 1956 and the years immediately beyond it would bring still greater improvements in the nation's defensive-offensive capabilities.

President Eisenhower's State of the Union message on January 6, declaring the forthcoming military budget for fiscal 1955-1956 would emphasize new weapons of rapid and destructive striking power, was followed by aircraft and missile performances which underscored that objective.

New altitude and speed records were established and important new developments were made in design and production of turboprop transports, in the new generation of long-range jet bombers, in jet-powered helicopters and other vertical rising craft, in more powerful engines, and in the missiles art. All contributed to steady progress in the forward march of aeronautical technology.

The new generation of century fighters and interceptors began to reach production, bringing still closer the day when combat operational speeds in the Mach 1.5 to 2 range will be commonplace. Construction was begun on wind tunnels to test aircraft up to Mach 5.

The year 1955 also saw greater concentration on development of a nuclear powered aircraft, and investigation in this area was given tremendous impetus with announcement by the Atomic Energy Commission of a major breakthrough in reactor research.

Another project, one with a Buck Rogers flavor, was organized during the year to accelerate research on an earth satellite capable of orbiting at an altitude of 300 miles. And the space platform project was followed by a Defense Department decision to begin studies in the field of anti-gravitation.

As in the past, May Day fly-by demonstrations over Red Square in Moscow disclosed new aircraft types and spawned new questions concerning the comparative U. S.-Soviet air strengths. Defense Department, Air Force and industry spokesmen joined President Eisenhower in refuting charges that this country had lost leadership in the air.

Year's end found Administration leaders deep in studies to determine ways of trimming the 1956-1957 defense budget estimates without impairing airpower and supporting military strength. Simultaneously, came assurance from Air Secretary Quarles and Air Force Chief of Staff Twining that the goal of 137 wings would be maintained.

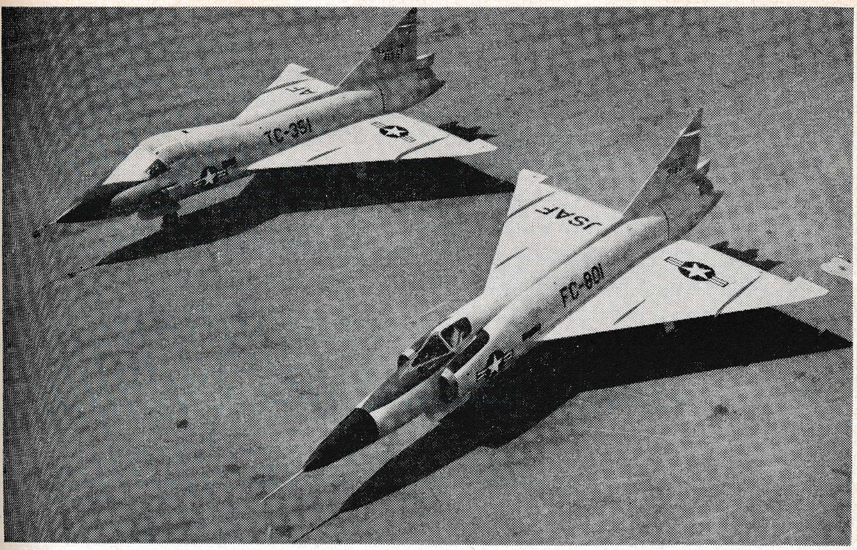
Air Force

The Air Force moved closer to its 137-wing objective during the year and, simultaneously, made significant progress in its long-range program of integrating unmanned missiles and conventional aircraft for maximum striking power.

Manned combat aircraft will continue to predominate in the Air Force defensive-offensive machine for years to come, but developments in the missiles art in 1955 defined more clearly than ever before the increasingly important role unmanned vehicles will play in defending the U. S. and the North American continent against air attack.

Trevor Gardner, Assistant Secretary of the Air Force for Research and Development, sketched in some of the details of the Air Force missiles and their roles in March and revealed that full use of high yield atomic warheads would be made to permit earlier availability of operational missiles. Atomic warheads, he said, reduce accuracy requirements, permitting an easing of guidance systems specifications. He grouped missiles into the following categories: air defense, tactical, strategic intercontinental, and strategic air-to-ground.

Earlier in the year, the Air Force announced accelerated development of three missiles with intercontinental range — North American Navaho, Northrop Snark and Convair Atlas—and by spring the Atomic Energy Commission had detonated the prototype of an air-to-air nuclear warhead missile more than 30,000 feet above the Nevada desert. Another milestone in missiles development was the start of construction on a new rocket test stand to withstand 1-million pounds of thrust.



Convair TF-102A combat proficiency trainer and the new F-102A all-weather jet interceptor

By the end of the year, the Air Force had been given responsibility for development of medium-range as well as long-range missiles, and Air Secretary Donald Quarles could report that the U. S. was ahead of the Soviet Union in the field of intercontinental missiles.

Research on a nuclear powered aircraft, a project severely criticized in the past for its slow rate of progress, was accelerated during the year and an important advance in reactor studies provided further impetus. The Navy also began work in this field, concentrating on the application of atomic power to large flying boats.

One of the more startling announcements by the Defense Department was the disclosure that an earth satellite would be sponsored jointly by the Air Force, the Navy and the Army, and that 1957 had been designated as target time for its launching. The Martin Company was awarded the prime contract for the satellite, which would orbit at an altitude of 300 miles, and General Electric was charged with responsibility of providing the rocket engine. Subsequently, the Martin Company announced that design techniques and components "are at hand" to create a multi-stage rocket required to launch the planned satellite.

The Air Force ordered a speed-up in production of the Boeing B-52 bomber, the first of which was delivered during the year, and Air Materiel Command reported that Phase I development contracts already had been prepared for the successor to this eight-jet aircraft. A similar speed-up also began on most of the F-100 series of jet fighters and interceptors.

Convair was awarded a multi-million dollar contract for production of the F-102A, which had reached a supersonic speed in level flight in shakedown tests at Edwards Air Force Base late in 1954, and for an undisclosed number of TF-102A's. That was followed by an AF order for the Convair F-102B interceptor powered by the Pratt & Whitney J57.

Other designers of "century" series aircraft sharing in production orders included McDonnell, F-101 and RF-101; North American, F-100C which established a new official world speed record of 800 mph-plus at Palmdale during the year; Lockheed, F-104, reported to have exceeded Mach 2 speed; Republic, F-105 and RF-105; and North America, F-107.

Convair, which received its first order for the B-58 delta-wing supersonic bomber in 1954, received the green light for stepped-up production and enlisted the aid of the following seven companies for the construction of major sub-systems: Sperry Gyroscope, Bendix's Eclipse-Pioneer Division, Bell Aircraft, Melpar, Emerson Electric, Sylvania, and Fairchild Camera and Instrument Corporation. Other subcontractors on this program include Magnavox, Bendix Radio, Hamilton-Standard, Ultrasonic Corp., Minneapolis-Honeywell, Motorola of Phoenix, Westinghouse Electric of Lima, Aerojet-General, and Federal Telephone & Radio.

Turboprop transports played an ever larger role in the Air Force in 1955, the largest being the Douglas XC-123, an 80-ton capacity plane with three times the load ability of the C-124B Globemaster. Other aircraft in this category which moved closer to operational duty during the year included the Lockheed C-130A and YC-131F. Boeing began extensive service tests of the P&W T-34 turboprop engine.

The year also was marked by several spectacular jet aircraft performance records. In January, a Republic F-84F made the longest non-stop flight for jet fighter-bombers, traveling 2,390 miles from George AFB in California to Langley Field in Virginia at an average speed of 605 mph. A month or so later, the Air Force activated its first squadron of parasite fighters, using Republic RF-84F's equipped to be carried, launched and recovered from an RB-36 in flight.

Early in April, NAA recognized a Republic Thunderstreak's speed of 3 hours 44 minutes 53 seconds between Los Angeles and New York as a new official mark. Pilot was Lieutenant Colonel Robert R. Scott. In May, a North American F-86 became the first aircraft to make a round-trip ranscontinental dash in daylight. And a few months later a North American F-100C hung up a new official world speed record over a measured course at Palmdale, passing the 800 mph mark.

General O. P. Weyland announced in May that all forthcoming combat planes of the Tactical Air Command — fighter-bombers, day superiority fighters and light bombers—must have refueling capabilities. A few months later the wisdom of that decision was demonstrated when 12 Republic F-84's used in-flight refueling to fly 5,116 miles, from England to Texas, in 10 hours 48 minutes.

Progress continued in the convertiplane field and in the design and production of helicopters. McDonnell's XV-1 convertiplane made its first successful in-flight conversion from helicopter to conventional plane, and Bell's XV-3 convertiplane made its first flight at Fort Worth. Sikorsky Aircraft received additional orders for its H-19D helicopter, Bell began tests of a flying wing helicopter with side-by-side rotors, Sikorsky dedicated a new Stratford, Conn., plant, and Ryan received a contract for development of the Air Force's first jet-powered vertical takeoff craft. It carries Air Force designation XF-109.

Jet power ratings continued to climb during the year and many engine production facilities were greatly expanded. Another notable development in this field was a Defense Department directive establishing policy governing development and application of gas turbine engines, followed by creation within the Air Force of an Aircraft Logistics Planning Board to make better forecasts of spare engine requirements.

General Electric's J79, earmarked for the Lockheed F-104 and the Convar B-58, was officially rated at 15,000 pounds of thrust, and Allison's J71 qualified for a 10,000 pound thrust rating. General Electric completed full-scale tests of a thrust spoiler for in-flight braking of the B-47 Stratojet, and Allison produced ahead of schedule its T56 turboprop engine for the Lockheed C-130A. General Electric, Pratt & Whitney and Curtiss-Wright expanded facilities for production and research in gas turbine and nuclear energy power fields.

Research, the cornerstone of aeronautical progress continued to keep pace with other advancements in aviation. NACA added new tools and exploratory aircraft in its never-ending search for methods of increasing aircraft performance, and the manufacturing industry added many new facilities to aid in the same common goal—qualitative air superiority.

General Electric announced a five-year, $40-million program of expansion for its aircraft gas turbine plant at Evendale, Ohio, where $60-million already has been invested. Boeing launched construction of a wind tunnel to test aircraft and missiles in the Mach 1.2 to 4 speed ranges. Convair earmarked $3.5-million for a "trisonic" tunnel for the testing of aircraft and missiles models up to Mach 4.5. Pratt & Whitney established a new nuclear propulsion facility at Middletown, Conn. Northrop chose El Paso as the site for a new guided missiles plant. Air Research and Development Command blueprinted a $1-million electronic testing and flight simulation laboratory for Wright-Patterson Air Development Center. Glenn L. Martin set up a new research lab to explore the frontiers of knowledge, including space travel and ways of overcoming gravity. NACA picked Sandusky, Ohio, as the site for a $5-million research reactor.

Other important Air Force developments during the year included: a Hughes-designed fire control system to enable the Northrop F-89D to use guided missiles . . . unveiling by Link of a simulator to train AF navigators for high speed, high altitude flight . . . award of a jet tanker contract to Boeing for the KC-135 and a Phase I contract to Lockheed for design of an advanced tanker . . . stepped-up orders for the Douglas F4D-2 . . . development by Sperry of an improved remote control for jet fighter aircraft . . . activation of the first AF unit equipped with Fairchild C-123B aircraft . . . delivery of the final Douglas C-124 Globemaster . . . delivery by Republic of its 1,000th F-84 . . . retirement of the B-36 intercontinental bomber . . . development of an improved downward ejection seat for the Douglas X-3 research aircraft.

Naval Aviation

Perhaps the most important development in Naval Aviation during the year was the decision to launch a vigorous program of exploration in the realm of nuclear powered aircraft.

A policy instruction issued by Navy Secretary Charles S. Thomas in May ordered a broad attack in the field of atomic power for application to all types of surface ships and sub-surface craft, as well as to aircraft. In June, Rear Admiral Frederick R. Furth, Chief of Naval Research, disclosed that the Office of Naval Research and the Bureau of Aeronautics had made "initial fesibility studies of nuclear powered seaplanes."

In October, James H. Smith, Jr., Assistant Secretary of the Navy for Air, announced that the Martin Company and Convair Division of General Dynamics Corporation—principal companies in the flying boat business—had been awarded high priority contracts "directed specifically toward the early development of nuclear powered seaplanes." At the same time, unidentified companies were given contracts for the Navy's A-engines.

Although the Air Force saw the proposed Navy atomic powered seaplane as suitable for strategic bombing, Navy Secretary Thomas declared firmly that the potential of the A-powered seaplane could be fully exploited by the Navy only. He pointed out that the modern seaplane must be supported and assisted by other ships and integrated with the other offensive team members of the new Navy.

On another front in the task of adapting new weapons to the Navy's roles and missions, the sea-going service made considerable progress in the field of guided missiles.

In November, Admiral Arleigh A. Burke, Chief of Naval Operations, declared that "the long dry spell in missiles development is over" and revealed that the Fairchild Petrel, air-to-underwater missile, had reached the operational stage. He also disclosed that the Sperry Sparrow, supersonic air-to-air missile, and the Chance Vought Regulus, for surface-to-surface duty, are being exploited in fleet units—subs, cruisers and aircraft carriers.

The U.S.S. Boston, commissioned in Philadelphia, became the Navy's first missile ship and by the end of the year a second vessel of that type, the U.S.S. Canberra, had been added to the fleet. The Boston is fitted with batteries of the Convair Terrier, surface-to-air missile which went into production in 1953.

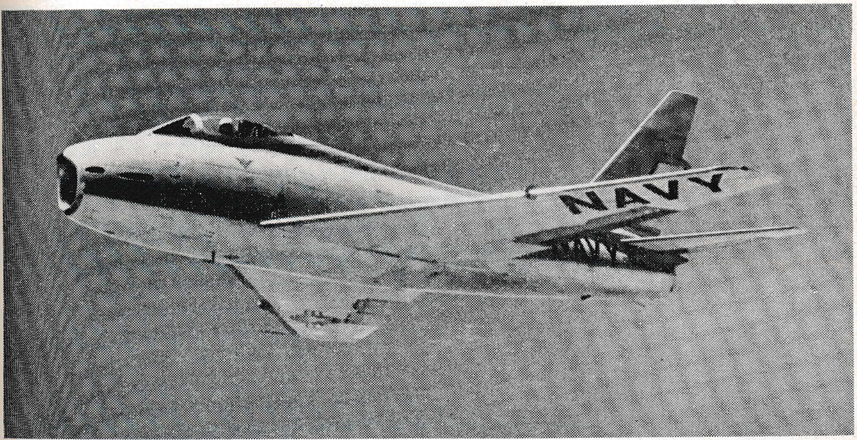
Chance Vought was given a $16-million Navy contract for the Regulus missile in January, and by August the company began to deliver the KDU-1 target drone version of the Regulus. Production continued on other missiles designed for the Navy.

The Martin Company received a $5-million contract to continue research and development on the XP6M-1 seaplane, capable of 600 mph-plus. Now fitted with four Allison J71 engines, this 15-ton payload aircraft also is being studied in connection with the nuclear power program. The Navy also joined the Air Force and the Army in the earth satellite project involving Martin and other companies.

The U.S.S. Forrestal, first of the new super carriers, made its first trial run at Newport News, Va., August 29, and in November the Navy awarded a contract for the fifth Forrestal-class carrier to New York Shipbuilding Corporation.

Among new aircraft designed for shipboard operations unveiled during the year was the Chance Vought XF8U-1, a supersonic fighter powered by a Pratt & Whitney J57-P-4 equipped with afterburner. It has a thin swept-back wing mounted high on the fuselage and set well back from the cockpit. Substantial weight reductions were made possible through the use of titanium in aft and mid sections.

An $8-million contract for the Douglas F4D-2 fighter was placed in February, and in March the first production FJ-Fury made its initial flight at the North American Columbus, Ohio, plant. The Navy also revealed that its first aircraft to incorporate the area rule design developed by NACA was the Grumman F11F-1.



North American FJ-4 Fury on active service with the Navy

An FJ-3 Fury established a new altitude climb record late in January, climbing to 10,000 feet in 83 seconds piloted by Lieutenant Commander R. H. Moor at Miramar Naval Air Station. A month later, Pilot Robert O. Hahn piloted a Douglas F4D-1 to the same altitude in 56 seconds. In October, an A4D, light-weight bomber, set a new 500-kilometer closed course speed record of 695 mph at Edwards Air Force Base.

Hiller Helicopter Company designed and delivered the first small wing-less flying platform, which combines the principle of weight shifting with the ducted fan, and began work on a new VTO-type aircraft and one-man helicopter (XROE-1) for Navy and Marine Corps. The Navy also revealed that it had placed an order for the Ryan vertical takeoff jet aircraft also ordered by the Air Force. The Navy continued to take delivery on several types of helicopters during the year from Bell, Sikorsky, Hiller and Piasecki.

The first of the Navy's new T2V-1 jet trainers designed for carrier operations rolled off the Lockheed assembly lines under a $14-million contract. First deliveries of the Beech T-34B trainer were made in January.

One of the largest Navy contracts during the year was the Bureau of Aeronautics $38.6-milion contract for an undisclosed number of Lockheed WV-2 radar picket planes. Lockheed also received a substantial order for P2V-7 patrol planes powered by two Wright R-3350's and two Westinghouse jets.

Bell Aircraft and the Navy tested an electronic landing system for aircraft carrier use which has since brought in several hundred aircraft in fully automatic, hands-off landings. John A. Attinello, head of the Bureau of Aeronautics division of supersonics, reported that low speed landings, coupled with thrust reversers, may soon eliminate the need for special airports with long runways.

The Navy's Bureau of Aeronautics spelled out during the year a new aircraft procurement policy under which aircraft delivered to operational squadrons would be as nearly combat-ready as possible and would require no major "fixes" in the field. Basically, the new procedures call for a low rate of production on a new plane during the first three years, with all production planes going immediately into the test program. The Navy's objective under the program was thorough evaluation of a new product before a commitment to large production funds.

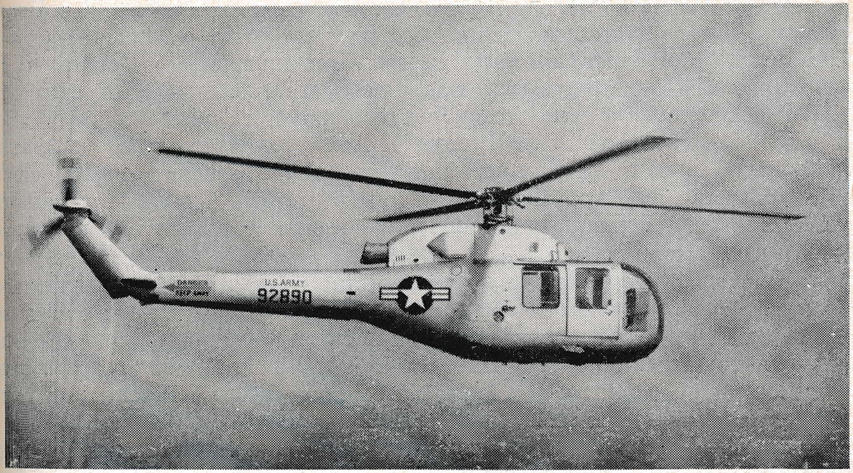
At year's end, the Navy was building toward its objective of 17 carrier air groups and 15 anti-submarine warfare squadrons.

Army Aviation

Greater air mobility for the ground forces continued to occupy much of the time of Army research and planning staffs in 1955, and near the end of the year two top Army generals spelled out the air transportability requirements.

General Maxwell D. Taylor, who succeeded General Matthew Ridgway as Chief of Staff, said that present requirements to plug gaps around the frontiers of the free world impose on the Army new requirements for mobility, requirements which can be met only by air transport. He pointed out that the need for airlift had caused the Army to restudy the weight and design of all of its equipment "in an effort to fit our combat units as rapidly as possible into the aircraft available for strategic movement of large bodies of troops."

Another former arborne commander, Lieutenant General James M. Gavin, chief of Army Research and Development, declared at Fort Ben-



Sikorsky S-59 Helicopter

ning, Ga., that to fight successfully in the future "our Army must be mobile not only on the ground but in the air." He said that most supplies for battle areas should be delivered by aircraft of the assault cargo and convertiplane types, while tactical transport of units into and within battle areas must be accomplished by basic reliance on planes and fast naval vessels. He advocated airlifting into battle zones all but the heaviest armored units.

Earlier in the year, Army spokesmen intimated the Defense Department might be requested to authorize formation of an Army Air Wing to provide Army-controlled transport and tactical air support. In October, the Army War College asked the Martin Company to explain the advantages of water-based aircraft, such as the XP6M-1, in transporting troops and cargo. In the same month, Defense Secretary Wilson vetoed an Army plan to procure jet aircraft on its own, and decided that the Air Force could lend a few jet trainers to the Army for evaluation as liaison and reconnaissance duty.

However, a responsibility previously handled by the Air Force was taken over by the Army when the latter ordered its first fixed-wing tactical transport company to be activated at Fort Riley, Kans. This laid the groundwork for the Army to begin airlifting and dropping its airborne units.

The transport company, known as the 14th Army Aviation Company, was assigned to the Fifth Army. It will use 21 de Havilland U-1 Otters, 90 of which have been ordered. Each can carry 3,000 pounds of cargo or 14 passengers, pilot and co-pilot. Their range is 1,100 miles at a cruising speed of 140 mph.

Another important Army development was a decision to train 900 helicopter pilots during fiscal 1956. Civilian flight training schools would be used for primary training for cargo helicopter pilots.

Major General Paul A. Adams, Deputy Chief of Staff, told a House Appropriations subcommittee in April that the Army was planning for a low-level, "tank killer" aircraft. At the same time, Major General K. F. Hertford disclosed the Army was investigating feasibility of extremely small helicopters for Army front line reconnaissance missions.

William H. Martin, new director of Army Research and Development, announced plans to increase spending for guided missiles. He said Army's research next year would emphasize missiles to kill airplanes and missiles and rockets to deliver atomic and conventional warheads on nearby and distant targets.

Helicopters continued to play important roles in Army activities and the service continued to explore the convertiplane field. By the end of the year, the Army had spent nearly $16-million on two experimental convertiplanes—the McDonnell XV-1 and the Bell XV-3. Bell won an Army competition for development of a light, closed cabin utility helicopter for front-line evacuation, utility missions and instrument training.

The Army set up a second source of supply for its Nike missile, letting a contract to the Douglas Marietta, Ga., division. A new missile for close support for the ground forces was developed during the year by Cornell Aeronautical Laboratory.

A novel Army development was a small camera-carrying drone to make still and motion pictures from altitudes ranging from several hundred feet to four miles. The drone is catapulted and parachutes to the ground.

Marine Corps Aviation

The Marine Corps continued its work on combat helicopter organization during the year, advancing toward the day when it will have the capability of landing an entire assault force of men and their weapons by rotary wing craft.

General Lemuel C. Shepherd, Corps Commandant, cited two distinct advantages in the use of helicopters for such assault operations: (1) They would make it possible to disperse transports and minimize the possibility of an atomic bomb destroying more than one ship. (2) They would make it possible to make landings anywhere on an enemy shore.

In pursuit of this objective, landing an entire assault force by air, the Marine Corps continued its experiments and practice maneuvers with such large helicopters as the Piasecki and the Sikorsky HR2S.

In addition to large helicopters, the Marine Corps also is planning to incorporate one-man helicopters into its operations and to continue experimentations with new high performance observation planes. And it was expected that by 1956 all jet fighters assigned to the Corps by the Navy would have in-flight refueling capability.

The Navy and the Corps anticipate delivery of 2,616 aircraft during fiscal 1956 and it was expected that orders would be placed for an additional 1,613 in the same period.

CHAPTER FOUR

Manpower

THE MOUNTING SHORTAGE OF ENGINEERS continued to plague the industry during 1955.

So grave was the problem that President Eisenhower established a cabinet committee to study the question of training scientists and engineers. The committee included the Secretaries of Commerce, of Labor and of Health, Education and Welfare, the Assistant Secretary of Defense for Manpower, and the Directors of the Atomic Energy Commission, of the National Science Foundation and of the Office of Defense Mobilization.

The critical shortage continued to grow. The number of engineers entering industry in 1954 was less than one-half the number required. Despite this fact, the rate of induction by Selective Service of engineering personnel showed a marked increase during the same year. Figures published by the agency disclosed that in 1954 the number of occupationally deferred registrants, excluding agricultural, had been reduced 35 percent.

The Selective Service took no definitive action in 1955 despite the ringing of new alarms. Particularly loud were the speculations appearing in the national press as to whether the Communists were overtaking the United States in the race for new and improved airborne weapons. Editorials emphasized that if we just hold our lead, we may be slipping towards defeat, for if we lose the cold war, we have no choice but to depend first and most heavily upon aerial superiority.

Congressman Carl Hinshaw of California recently pointed out that because of the fundamental issues involved in the critical shortage of scientific manpower facing the nation today—and for years to come—Congress is conducting a searching examination, which it is hoped will lead to overhaul of the Selective Service law through enactment of pertinent new legislation.

This proposed legislation would amend the present draft law to provide for the discharge and continuing deferment of certain persons of exceptional scientific, technical and engineering ability. It would provide that each individual inducted or enlisted in the armed forces "shall within 30 days from the date of his induction or enlistment be afforded an opportunity to apply to a Scientific Specialist Board . . . for suspension of his obligation for training and service in the armed forces."

This legislation would simultaneously create a Scientific Specialists Board, composed of five members appointed by the President, who would have the sole power of determining whether an individual's obligation to serve in the armed forces would be suspended.

The Board would be charged with the prompt examination of the inductee or enlistee applicant for technical ability or aptitude "to warrent suspension of his obligation to serve in the armed forces . . . because he is actually or potentially more valuable to the interests of the national security and defense as a scientist, technician, or engineer, than as a member of the armed forces."

The proposed legislation further provides that "Prior to the expiration of the eighty-fifth day from the date the applicant was enlisted or inducted, the Board shall notify him of its decision with respect to his application."

If the Board decides that an individual who has applied for a suspension is "actually or potentially" more valuable to the interests of the national security and defense as a scientist, technician, or engineer, then the Secretary of Defense will suspend the obligation of the individual to serve in the armed forces not later than the eighty-ninth day after the date on which he was inducted or enlisted.

The Board would be autonomous, with full power of decision. It would not act in an advisory capacity. It would decide whether an individual's obligation would continue to be suspended, and it would be up to the Board to decide whether an individual should be reinducted should he fail to fulfill the purpose that justified the suspension of his military obligation. The legislation further provides that an individual who receives such a suspension would remain liable for induction up to age 35.

Continuing industry reports show that engineers are vitally needed for design and development work in preliminary analysis, aerodynamics, aerothermodynamics, thermodynamics, structures, stress analysis, missile components, systems, and static and flight tests. Important in current electromechanical engineering programs is reducing through subminiaturizing the size and weight of electronic components. In advanced electro-mechanical programs, engineers are needed for design of guidance systems, fire and flight control for aircraft, component development, instrumentation, radar systems, computer systems and development of related systems.

Engineers most vital are those with majors in mechanical, aeronautical, electrical or electronic engineering. Much in demand are mechanical engineers with options in thermodynamics or aeronautics, civil engineers for stress work and design. Chemical engineers are finding a special niche in thermodynamic functions. Those with engineering physics degrees are readily being used in aerophysics or electro-mechanical systems projects. For materials research in connection with airframe and the broad propulsion program, the need is for chemists, physicists, metallurgists, chemical engineers and welding and ceramics engineers.

Late in 1955, an extensive study of Soviet professional manpower was issued by the National Science Foundation. The report states that in 1953, the Soviet had about 500,000 trained professional engineers, while in the United States there were about 530,000 trained engineers. Analysis of the Soviet professional labor force by occupational field, as well as certain comparisons made with professional personnel in the United States, suggests that Soviet higher education is still oriented primarily towards the training of specialists in scientific-technical and applied fields, and has succeeded over the past two and a half decades in reaching a level of close equivalence, and occasionally of numerical supremacy, to that in the United States.

Soviet secondary semi-professional education has provided a large supply of trained supporting personnel, which in the United States is obtained mainly through the automatic process of on-the-job training or through under-utilization of trained college graduates.

The Soviets over the last 25 years have made these substantial gains despite the disrupting effects caused by forced collectivization, purges, and war, as well as the radical experimentation that took place in education in the late 1920's. The growth of professional manpower has been considerably eased by the extensive employment of women, who comprise nearly half of all professionals.

Far from decreasing, the present shortage of engineers and scientists in the United States will become increasingly worse before it bcomes better. Fewer technically-trained men are being prepared by the colleges and universities. According to a report by the Teacher's College of Columbia University, between 1950 and 1954 the total number of students graduated by colleges and universities decreased about 34 percent, owing in part to the fewer number of students studying under G. I. Bills. The number of natural science graduates decreased about 51 percent, and the number of engineering graduates decreasd about 58 percent.

Figures show that the number of natural science graduates in 1950 was 59,000; in 1954, 29,000. The number of engineering graduates in 1950 was 52,000; in 1954, 22,000. In contrast, the best information indicates that the USSR doubled the number of its engineering graduates during the same period, from 28,000 in 1950 to 54,000 in 1954.

The United States trains three-fourths of its Ph.D's in the humanities; the USSR trains three-fourths of its doctoral condidates in science and related fields. At the present time there is reason to believe that the USSR is training 300,000 scientists in schools of university rank and 1,600,000 students in intermediate technical schools.

The Teachers College report concludes that the supply of scientists in the United States is drying up at the secondary school source because of (a) lack of an adequate corps of well-trained high school science teachers, and (b) lack of an adequate and challenging science and mathematics program in many schools.

Aviation industry consensus at the end of the year was that only a concerted effort on the part of everyone concerned to establish a long-term program could possibly meet the Russian challenge.

CHAPTER FIVE

Guided Missiles

UNITED STATES MISSILE SCIENCE in 1955 was highlighted, first of all, by the fact that decisive steps were taken toward development of space flight. On July 29 the White House announced that the first unmanned Earth satellites would be launched during the International Geophysical Year (July 1st, 1957-December 31st, 1958). The Defense Department, in cooperation with the National Science Foundation, went to work on the coordination of Project *Vanguard,* the official code name for the satellite project. An estimated 10 instrumented, spherical 30 to 40-pound satellites will be launched. The prime contracts were given to the Martin Company of Baltimore for the first stage of the three-step rocket vehicle. The General Electric Company received the contract for the engine of this stage. The contracts for the second stage was given to Aerojet General Corporation, which manufactured the Aerobee-Hi.

Actually, 1955 marked the end of the first decade of United States guided missile science; most of the missiles whose names are common knowledbe today have been developed and produced by the aircraft industry since in January 1945. Their speeds now extend from subsonic to supersonic and they have varying range capabilities and guidance systems. In function, they are described as surface, air-to-air, surface-to-underwater and ship-to-air weapons. And coming along behind these is a new family of missiles capable of adding new dimensions to warfare and national defense.

The Joint Chiefs of Staff made it clear in 1955 that the United States must do more than to maintain its strategic deterrent; it must also establish a tactical deterrent. It must be able to punish local aggressions with such speed and force that the enemy will call a halt before he has an opportunity to even consider large scale aggression. This is the concept of the so-called double deterrent to wars of tomorrow. It is based on an extensive use of guided missiles and, in particular, guided missiles with atomic warheads.

The aircraft industry has made great progress in missiles during the last few years, but our scientists are still fighting the basic engineering problems—the biggest of them all being how to more nearly approach perfect guidance systems. Progress has been made, and htere are several accepted systems currently in use.

Nevertheless, the fact that various guidance systems have been developed to the extent where one can talk about production missiles became apparent in 1955 and basic concepts of the systems in use and/or under development were discussed officially for the first time and ever since our missile industry was established.

The systems are divided into two general categories, those used against moving targets and those used against fixed targets. Guidance systems are further broken down into a number of basic types. Guidance systems most useful against moving targets are the *beam rider,* sometimes called *beam timer, homing* and *command systems.*

In the beam riding system a missile is directed along the line of sight which extends from the launching site to the target. A radar or other beam is laid along this line of sight, the beam being of such a character that the missile can sense its deviations from the beam and attempt to return to its center. Since the line of sight and consequnently the beam follow the motions of the target, the missile will, with a certain error owing to time lag in the system, eventually pass through or near the target. In beam riding systems, the information on where the target is goes from the target to the guidance station, which may be on the ground or in the launching aircraft, and then back up to the missile.

In the homing system the target position information goes directly from the target to the missile, the missile homer sensing changes in the direction of arrival of signals from the target. There are three types of homing systems, *passive, semi-active,* and *active.* The first of these relies on some type of disturbance emitted from the target. The most obvious of these is the radiation in the infrared region due to the generally higher temperature of the target compared to its background. If not relying on the target completely for location information, the missile can be guided by a target illuminated by a reflected source of energy. This is called semi-active homing. In active homing, the illuminator is in the missile itself.

The third type of guidance system useful against moving targets is the command system. With this system, target location is sensed at the guidance station by radar or other means. Computations are then made and flight directions sent to the missile.

For the command system, two radar sets are involved. As the target moves along, one radar set tells the location of the target. A missile is launched and is tracked by a second radar set. If the position of the target and the position of the missile at the same time are known, the necessary missile course can be computed.

Fixed targets present a different but not necessarily easier problem. Information about the location of the target is generally not measurable at the location of the guidance station, but must be obtained by some indirect means such as mapping techniques.

Other techniques, most of which are just automatic adaptations of navigation systems, include the *baseline* systems and the so-called *self-contained* systems. The baseline systems may be somewhat familiar in the form of Loran or Shoran. In these systems an artificial grid of lines in space is laid down above the ground in the target area.

One system consists of a grid of lines that measure specific distances from two ground stations. If a missile is to reach a target in a particular location, the missile flies out along a particular line and as it crosses the grids, it will come to one it recognizes and which represents the target.

The term self-contained guidance implies that a missile carries within it all the information that is necessary to reach the target, that is, the location of the target and an internal means for sensing deviations from an arbitrary path to the target. This definition is really fulfilled only by the type called *inertial.*

The simplest form of inertial system is the use of a purely ballistic path, where the forces acting on the missile are limited to inertial and gravitational forces. However, the system normally employs a technique denoted as *inertial space.* This technique is achieved by the use of two instruments. The first is the gyroscope which tells the direction in which the missile is headed and the second is the accelerometer which provides the information from which (by integration) the velocity of the missile and, therefore, the distance traveled, may be determined.

Information on target location with respect to the location from which the missile starts can be stored in the missile ahead of time, and since the missile knows at all times where it is, at least to some degree of approximation, from its history of heading and distance traveled, it can compute the course it still has to take to get to the target.

The Army's new artillery system, the Douglas *Nike* system, sometimes called the*Nike-1* has the ability to attack most aircraft type targets. There are indications that new and supposedly improved *Nike-type* missiles are being developed as replacements for the type currently in operation. To support its tactical mission in the field, the Army has the Douglas *Corpal,* which is in effect a moderate range, tactical, ballistic missile capable of carrying atomic warheads. It has a guidance system that is precise enough to make it effective in the sense that it has the necessary precision to deliver fire effective against tactical targets.

In addition to the *Corporal* guided missile, the Army has now put into the field here and abroad its unguided ballistic rocket, the Douglas *Honest John,* which is a considerably shorter range weapon, somewhat comparable with the longer range artillery, but capable of carrying a much larger warhead than any artillery, including atomic warheads.

The Army reached the testing stage of a longer range, ballistic type rocket, the Chrysler *Redstone* rocket, in 1955, the characteristics of which have not been released. The *Redstone* sometimes has been referred to as the modern V-2 but it is considerably more advanced than the V-2. Some of the German scientists who developed the V-2 have also been responsible for the *Redstone,* developed in cooperation with the Army's Missile Center, Huntsville, Ala.

The Navy has three missiles already deployed in support of its mission. The first of these is a ship-launched, anti-aircraft missile, the Convair *Terrier,* which has now been tested in fleet operational tests off the battleship *Mississippi.* Two of the Navy's cruisers were equipped operationally last year to defend the fleet with the *Terrier* missile system.

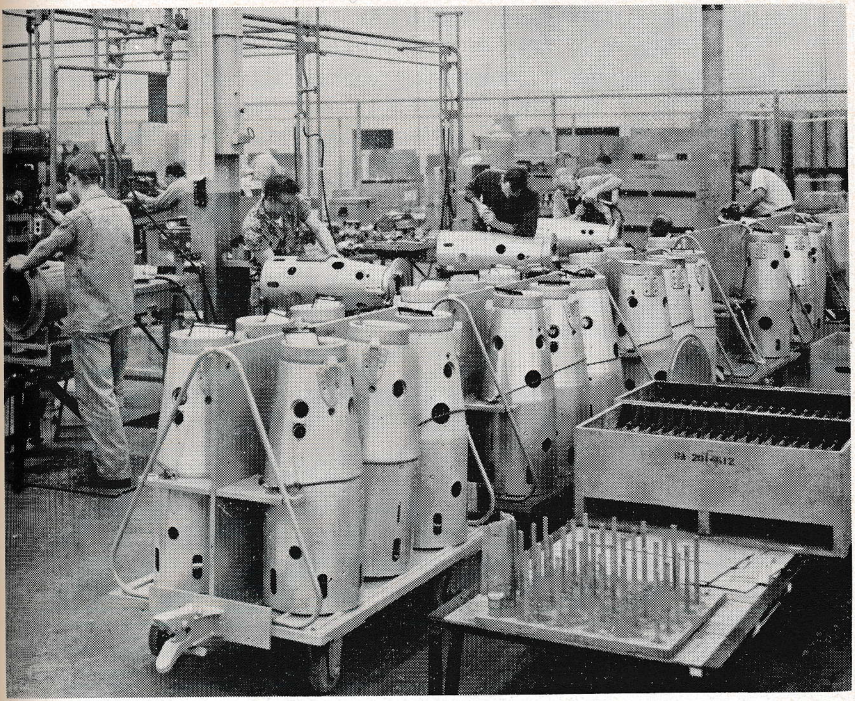
More than 30,000 inspections, tests and check-outs are made on a *Terrier,* primary armament of the *USS Boston* (CAG-1) before the completed surface-to-air guided missile is released from the factory. The *Terrier* is being produced in quantity for the Bureau of Ordnance at the government-owned Naval Industrial Reserve Ordnance Plant, operated at Pomona, Calif. for the Navy by Convair. Ground was broken at the 141-acre plant site in August, 1951, and limited operations were begun in the Engineering Building a year later. The finished plant, capable of complete missile design, manufacturing and testing, short of actual firing, was activated in January, 1953.

Second Navy missile—but first to attain combat-ready reliability in quantity production—is its air-to-air system, the supersonic Sperry *Sparrow* I. Years of tests and current fleet training have proved it effective against speedy jet aircraft of any size, and its range is far in excess of previous conventional aircraft weapons.

Both fleet and Marine air arms are evaluating two or more different *Sparrow* I guidance systems, also developed and produced by Sperry Gyroscope under that company's complete system program since 1947, originally termed "project Hot Shot." Current-model "birds" are quantity produced at a Navy facility, the Sperry Farragut plant in Bristol, Tenn.

The Navy's *Regulus* missile is in the surface-to-surface class and is designed for launching from Naval vessels. The versatile *Regulus,* developed by Chance Vought Aircraft, Incorporated, under the sponsorship of the Bureau of Aeronautics, has increased tremendously the striking power of the Navy's surface and submarine forces.

Designed for launching from submarines, surface ships and shore bases, *Regulus* is one of the most modern weapons in the nation's arsenal of defense. It is in full scale production at the company's Dallas, Texas, plant, where maximum effort is being devoted to increasing the performance and versatility of advanced missile types.



Convair Terrier guided missiles under construction at Pomona plant

Regulus can deliver a powerful warhead at transonic speeds over a range of hundreds of miles, guided along its course by a built-in electronic system.

The first Navy surface-to-surface guided missile to become fleet-operational, *Regulus* was conceived by Chance Vought in 1947. However, its existence was not disclosed publicly until March, 1953, when the Navy announced that the program had reached the stage where information concerning some of its earlier phases could be released to give the public information concerning engineering and technical progress made by the Navy Department and its contractors.

Regulus was designed in two versions: a recoverable test and training missile with a retractable landing gear and a non-recoverable tactical missile.

In addition to contracting for a tactical missile, the Navy had introduced an exceptional requirement: the basic missile configuration must contain provision for recovery. This meant that the missile, in its test and training versions, must be capable of landing intact after a mission so that it could be flown again.

The concept of recoverability paid off. Some *Regulus* missiles have been flown as many as 10 times and one missile has flown at least 15 times.

In addition to savings in money, the recoverability concept was responsible for much of the exceptional versatility of *Regulus*. It led to new developments in certain elements of the missile system that extended the usefulness of *Regulus* far beyond its original mission and extended development in simplified training.

The submarine *USS Tunny* was the first underwater craft specifically modified to launch *Regulus,* with other craft slated for similar conversion. Recommissioned on the West Coast in March, 1953, the *Tunny* was a converted World War II submarine, modernized by the addition of the snorkel and streamlining of hull and conning tower. A special tank for storing of the *Regulus* and a launching ramp also were installed.

Navy crews have successfully launched *Regulus* from cruisers, aircraft carriers, small surface ships, and from portable launchers ashore, as well as from submarines.

In the missile field, *Regulus* has transferred the research and development plans of many years into operational reality. Working closely with the Bureau of Aeronautics, the Bureau of Ships, and the Bureau of Yards and Docks, Chance Vought, in its *Regulus* program, did far more than develop a missile—it pioneered in developing the Weapons System Concept in the missile field.

This concept involved all phases of planning, development, manufacture, and utilization, not only for the missile but also for all necessary supporting elements to fulfill the operational role of the weapon.

Throughout its existence, the *Regulus* program has continued to meet the requirements laid out in the basic development plan to incorporate the missile as an integral part of the Navy's defense program.

It was the first surface-to-surface missile to be equipped with a landing gear and to be recovered successfully and the first to use a parachute brake. *Regulus* also was the first guided missile with which two flights were made in one day with the same missile and the first guided missile to fly 15 times (one vehicle). It was the first guided missile to be flown successfully from all of the following: an aircraft carrier, a cruiser, a guided missile ship and a submarine.

The Air Force is developing a surface-to-air interceptor type guided missile, the Boeing *Bomarc,* which was announced somewhat prematurely because "it is not the habit of the Defensee Department to announce weapons at the stage of development where *Bomarc* now is."

The Air Force announced actual production in 1955 of the Hughes *Falcon* air-to-air guided missile. Existence of the*Falcon* guided missile was originally announced by the Air Force on March 15, 1955, when it was revealed that tests indicated the *Falcon* packs the blast of a heavy artillery shell and every hit is a kill.

The *Falcon* is slightly over six feet long, is six inches in diameter and weighs less than the average man. It is small and light enough to be carried in quantity by a small interceptor, and can be fired in salvos. The Air Force said that this missile, launched at a range of miles, not yards, gives interceptor pilots better odds in combat than they have ever had before:

First, the *Falcon* can be launched from well beyond the reach of an enemy bomber's defense. Second, it can be launched on a climbing course from an interceptor that is far below the enemy bomber, thus saving time that the interceptor would need to gain the bomber's altitude. Third, the *Falcon* has an extremely high probability of kill, even against maneuvering targets.

Once the target has been pointed out to the *Falcon,* its electronics intelligence steers it to anticipate and strike the target no matter how the target maneuvers. The Falcon's computing devices give it a built-in habit pattern.

The Air Force has also developed and has put into operational use its surface-to-surface *Matador* missile. It takes off from a mobile launcher with a booster which puts it on its course and then a sustaining motor to carry it along very much the way an airplane would be carried on its course.

Engineers of the Martin Company recognized that a successful missile is not simply a warhead delivery wagon. *Matador* was designed as a comprehensive tactical weapons system in the rounded military sense. TM-61 embraces: (1) a transonic, high performance airframe, featuring interchangeable parts; (2) means of automatic guidance; (3) alternative warheads; (4) a zero-length launcher and booster rocket; (5) a full complement of ground-handling and transporting vehicles; (6) fully equipped squadron assembly, ordnance and launch areas; (7) complete systems check-out and testing apparatus; (8) depot, housing and maintenance facilities both at the factory and in the field (9) shipping containers for the seven major components; and (10) packaged spare parts ready for shipment and long-term storage.

Means for launching the *Matador* received early study. It was decided to employ a booster rocket that would hurl the *Matador* into the air from a stationary condition. The simple, mobile, zero-length launcher provided a basic part of the answer. The booster rocket is of the underslung type and burns a solid-propellant fuel. When expended, the booster is detached from the missile by a compressed air cylinder. Rocket alignment and launch angle are predetermined, so that speed and altitude at end of boost can be made consistent with flight requirements.

Prior to igniting the booster rocket, the launch crew revs up the missile's engine to full rpm. The missile has been raised to flight altitude. As the jet impulse takes effect, a hold-back bolt prevents the missile from nosing over. The bolt fails in shear as the rocket imparts added thrust.

The first *Matador* launcher was a goliath. It was fixed in position and took eight men 15 minutes to operate. It had no self-contained systems. Today it is a specially constructed semi-trailer of 35,000 pounds containing a d-c motor-generator, a blower for electronic cooling and a hydraulic pump. It raises the missile in a matter of seconds.

Considerable attention was paid to such problems as strength, clearance, blast protection, use of a tractor vehicle, missile hold-back during engine run-up and self-contained systems. Structurally, thought was given to the springiness of forward and rear support points, as these affect the launch of a missile. Of concern also, was the angular momentum imparted to the missile by the supports at the instant of separation from the launcher.

Successful tests at Aberdeen Proving Ground, in 1947-1948, verified the zero-length launching technique. Wooden dummies simulated the *Matador*. Last year, Martin launched a piloted F-84 from the zero-length platform.

Shipments of Allison J33 series centrifugal flow turbo-jet engines for use in surface-to-surface guided missiles increased in 1955 as a result of a step-up in military operational training programs.

In continuous production throughout 1955 were the J33-A-37, power plant for the TM-61 *Matador*, and the J33-A-18A which provides the power for the Chance Vought *Regulus*.

The J33-A-37 in the USAF's *Matador* is currently being replaced by a J33 engine with higher power, a conversion of an engine originally used with a piloted aircraft. The conversion was engineered by a modification of the fuel system; removal of afterburner, air inlet screens and emergency fuel system and the installation of lower cost but more durable turbine buckets to withstand increased temperatures and rpm.

First official disclosure that the 600-plus mph Ryan *Firebee* jet target drone also has potential tactical applications and could be used as a guided missile or for reconnaissance was made last year by Ryan Aeronautical Company, with Department of Defense approval. At the same time detailed performance characteristics of the swept-wing pilotless plane were released.

Designed originally as a high-speed target to provide the military services with a jet-fast flying bull's-eye which can realistically simulate attacking enemy aircraft, the *Firebee* has a maximum speed of 610 miles an hour at sea level, or 605 miles an hour at 40,000 feet. It is designed to fly under remote control from the ground, after air launching from a mother plane, for 1 hour and 20 minutes at 575 miles an hour and an altitude of 40,000 feet. Its service ceiling is approximately eight miles up—42,500 feet. Its rate of climb at sea level is a spectacular 8,500 feet per minute.

The *Firebee's* primary function, for which it is now being evaluated by the Air Force, the Navy and Army Ordnance, is as an evasive target for ground and air-to-air gunnery practice and as a high-speed bull's-eye to aid in evaluating the effectiveness of new weapons systems. Its production cost is approximately one-tenth that of piloted aircraft converted to pilotless drones. The *Firebee* has a parachute recovery system which permits repeated use of the drones for target practice.

For guided missile use, a warhead or other special equipment could be carried in the fuselage or in pods slung beneath the wing. Smaller pods could be mounted on the wing tips. As a versatile guided missile for a variety of applications, the *Firebee* could be ground launched from rail or zero-length launchers, or air-launched from a carrier plane in flight.

For tactical reconnaissance, a *Firebee* could be equipped with aerial cameras, radar, Reconofax and television installations to transmit intelli-