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Origins of Airpower

Hap Arnold's Early Career in Aviation Technology, 1903–1935

MAJ DIK DASO, USAF

HENRY HARLEY ("Hap") Arnold was not supposed to enter the Army.[1] His older brother, Thomas, was to attend West Point and continue the Arnold family tradition of American military service that began during the War for Independence. Henry Harley, Hap's namesake and great-great-grandfather, had been a private in the Pennsylvania militia. Another relative, Peter Arnold, fought with Gen George Washington's army. Thomas G. Arnold, his grandfather, had been a nail maker who fought at the Battle of Gettysburg during the Civil War. Herbert, Henry's father, had been a physician during the Spanish-American War, serving in Puerto Rico in 1898. Despite the military legacy, and after attending Penn State during the year prior to the West

Point admission tests, Thomas rejected his parents' persistent urging to attend West Point. So Henry Arnold, then called Harley, inherited the opportunity to carry on the family's military heritage, which he did with great distinction.[2]

Cadet Arnold entered the Military Academy in 1903, the same year the Wright Brothers flew at Kitty Hawk, North Carolina. However, horses, not airplanes, were his first love. He, along with many West Pointers in the class of 1907, yearned for a cavalry assignment. The dashing uniforms, the thunder of the charge, and the perceived class distinction between cavalry and every other branch of the Army, except the Engineering Corps, did not escape observation by members of the Corps of Cadets.[3] One of the youngest ever admitted to West Point at 17 years and one month, Arnold found a niche at the tradition-laden institution. He became a founding member, and eventually the leader, of the "Black Hand." This covert spirit squad was responsible for many of the most spectacular student pranks ever accomplished in West Point's history. Harley, called "Pewt" and "Benny" by his friends, had a fiery tongue and was frequently late for class. He earned far fewer demerits, however, than most classmates during his first three years at the Point (table 1). While leading the legendary Black Hand during his first class year, he amassed over one hundred "ticks" (demerits), nearly double his previous high for a class year, but still less than many of his friends. His future wife, Eleanor ("Bee") Pool, recalled that her first visit with Harley at the Point was through the window of his room. He had been confined to quarters for a disciplinary infraction.[4]

Arnold also channeled his spirit into sports. He saw frequent playing time as a second-string varsity football running back, put the shot for his class track and field team, and excelled at polo. Academically, Harley had an uncanny memory. He "specked" (memorized) several pages of logarithmic tables, which, although impressive, did not raise his final class standing any higher than 66 out of 111. His standing would have been much higher had it not been for a generally high number of military discipline marks. Cadet Arnold's last weeks at the Military Academy were perhaps typical for the soon-to-be lieutenant. During cavalry drill (cadets still rode horses regularly in those days), Arnold was given demerits for chewing tobacco during formation, an act strictly forbidden. Not only did this infraction keep him from many of the graduation festivities, but some believed that it provided the necessary leverage for the authorities in charge of graduation assignments to issue Arnold a ticket straight into the infantry. The cavalry, Arnold wrote, was "the last romantic thing left on earth."[5] His graduation standing was too low for engineering school and after a brief but high-powered struggle, arranged by his father and fought by the new lieutenant against his congressman, his senator, and the adjutant general of the Army, he accepted his commission and assignment as an infantryman. In later reflection, his wife, Bee, summarized the situation: "Those with brains got the engineers, but I don't think that Hap was the engineering type at all."[6]

Lieutenant Arnold "volunteered" for an assignment in the Philippine Islands. For the next two years, he worked hand in hand with engineering corpsmen mapping various islands. In 1909, his unit was transferred to Fort Jay on Governors Island, New York. There Arnold became aware of the airplane as more than just a curiosity. Although he had seen the Bleriot airplane briefly while in France on his round-about return from the Philippines, both the Wright Flyer, purchased in 1908 by the Army, and a Glenn Curtiss machine landed at Governors Island during his tour. Still trying to escape the infantry, Lieutenant Arnold took the entrance tests for the Ordnance Department, which held the most promise for early promotion (the lowest rank allowed in this department was first lieutenant). While waiting for the results of the exams, Arnold received a letter from the War Department which offered him the opportunity of a lifetime—the chance to learn how to fly.[7]

Against the advice of his commander, but recognizing an opportunity to free himself from infantry ties, he accepted orders for flight instruction. Arnold recalled his commanding officer's warning, "Young man, I know of no better way for a person to commit suicide!"[8] The young second lieutenent considered those words

ROBERT ARNOLD

Pewt Arnold, West Point sophomore, 1905

a challenge. By April 1911, Arnold was in Dayton, Ohio, to begin flying lessons at Simms Station, the home of the Wright Brothers' flying school. Arnold joined Lt Thomas DeWitt ("Tommy") Milling for an introduction given by the Wrights to the flying machine. Arnold and Milling together spent hours learning how the delicate machine was assembled, disassembled, greased, tightened, and repaired. Sharing the experience of becoming new aviators, the two young lieutenants developed a fast friendship. Arnold was grateful for the time spent in the factory because, although the Army had decided to train pilots, it had not begun training mechanics or crew chiefs. In 1911, every pilot was also a mechanic of sorts.

Orville and Wilbur Wright normally taught these ground lessons personally, but Lieutenant Arnold's flight instructor was a Wright employee named Al Welsh. In fact, it does not appear that Arnold ever took a flying lesson with Orville or Wilbur Wright. Between 3 May and 13 May, Arnold flew every one of his first 28 lessons with Welsh. An average flight lasted eight minutes. In practical terms, Arnold became a "pilot" on the day of his first solo, 13 May, a Saturday. Technically, his civilian airplane pilot certificate (*Fédération Aeronautique Internationale*— FAI) was awarded on 6 July 1911 and he did not receive his "official" Military Aviator rating until 22 July 1912, reflected in War Department General Order No. 40.[9]

Following initial flight qualification, Arnold and Milling crated up the Army's two newest Wright Flyers and followed them by train to College Park, Maryland, the home of the first Signal Corps flight school. The hours spent on the Wright factory floor began to pay off. Arnold and Milling assembled the craft themselves in preparation for the opening of the flight school. The Army's only two pilots were now its only flight instructors as well. Not only did they become skilled pilots, but skilled airplane mechanics and dedicated crew chiefs as well. They even created the first "Dash-1," the airplane technical manual, which included a picture of the craft with each of the parts meticulously labeled by hand.

Flight then was still a fair-weather game. As winter approached the Washington area, the aviators boxed up their planes and moved to Barnes Farm, near Augusta, Georgia, hoping for more temperate weather. Although the flyers endured the only blizzard to hit Augusta in 15 years, much flying and training, including wireless radio work, photography, and even bomb dropping were accomplished before returning to College Park in May 1912.[10]

For the rest of that year, tragedy seemed to stalk the flying community. Wilbur Wright died of typhoid fever on 30 May. Al Welsh died in a plane crash in June. In July, Arnold crashed off the coast of Massachusetts in a new Burgess/Wright "tractor" airplane. It was in that crash that Arnold received the scar on his chin which showed distinctively for the rest of his life. Two more Army aviators were killed in September, Lewis C. Rockwell and Corp Frank Scott (Scott was the first enlisted man to perish in an aircraft

accident). In November, it was Arnold who would once again face the hazards of early flight.[11]

The month of October was one of achievement rather than disaster. Arnold was awarded the first Mackay Trophy for the most outstanding military flight of the year. Arnold and Milling had been challenged to fly a triangular route between Fort Myer, Virginia, College Park, Maryland; and Washington, D.C., and pinpoint a "troop concentration." In winning the award, Arnold had completed the reconnaissance course and reported the strength and location of the simulated enemy troop concentrations to the event judges. In one respect, the "contest" was really not a contest at all. Milling, the only other participant, had aircraft problems that kept him on the ground. The flight did, however, demonstrate an actual mission for Army aviation, something the Army air arm was still struggling to define (as demonstrated by the variety of missions practiced while bivouacked in Georgia). Perhaps because of these circumstances, Arnold did not take himself or his accomplishment too seriously. The young lieutenant wrote Bee that "it [the trophy] certainly is handsome. I figure that it will hold about four gallons, so I cannot see how you can fill it with anything but beer."[12]

At the end of the month, Arnold, Milling, and the rest of the College Park airmen traveled to Fort Riley, Kansas, to participate in Army ground force exercises. Arnold's enthusiasm for flying was temporarily doused by a near-fatal airplane flight on 5 November 1912. Lieutenant Arnold and an observer, Lt A. L. P. Sands, were inexplicably thrown into a spin toward the ground. Arnold righted the craft and missed a violent crash by only a few seconds and tens of feet. The onboard altitude measuring device, a barograph, clearly recorded a drop of 300 feet in ten seconds, ending up just above the ground-zero line. It was too close a call for Arnold. He was so rattled that he immediately requested three weeks' leave and temporarily removed himself from flying status. "From the way I feel now," he explained, "I do not see how I can get in a machine with safety for the next month or two." By then, Arnold had earned several aviation firsts: winning the first Mackay Trophy, setting several altitude records, and accomplishing the first successful spin recovery in an airplane.[13]

Those few weeks of "grounding" grew into a few months, and then a year as a desk-bound Arnold served as the assistant to the officer in charge of aviation in the Office of the Chief Signal Officer, Brig Gen George P. Scriven. When the young lieutenant married Eleanor Pool in September 1913, he was effectively removed from the active flying roster. At that time, Army flyers were not permitted to marry and remain on flying status. Although this requirement would be softened by World War I, Arnold was relegated to ground duties until November 1916.[14]

Back in the infantry, Arnold never wavered in his belief in the importance of airpower. He recalled that in 1913 flyers fought a constant uphill battle for acceptance as well as for modern equipment. "At that time," Arnold said, "we in the Air Service looked to foreign countries for engines that might give us better performance."[15] Even as a lieutenant, Arnold looked for the best technology available, regardless of its origin.

Not only did the lieutenant look for the best new technology, he constantly sought improvements for the machines the Army already had. As early as 6 November 1911, Arnold had written Orville Wright about his concerns that aircraft did not carry enough weight or climb fast enough for military use. Arnold suggested increasing engine power and propeller revolutions to maximize performance. Brother Wilbur responded with a detailed explanation of how to fine-tune the engines, both new and old, and explained that the propellers and chains "have a large factor of safety and if sudden jerks are avoided, will easily carry 25% more power than our present motors give."[16] But Arnold was not satisfied with the response. On 18 November, he again wrote the Wrights:

> Could we put a 60 or 70 H.P. [horsepower] engine in the standard machine and put 2 or 3 more teeth in the engine sprocket? This would give us much more power when it was needed but for ordinary flying we could fly on less than the maximum power of the motor.[17]

Arnold was always pushing for improved equip-

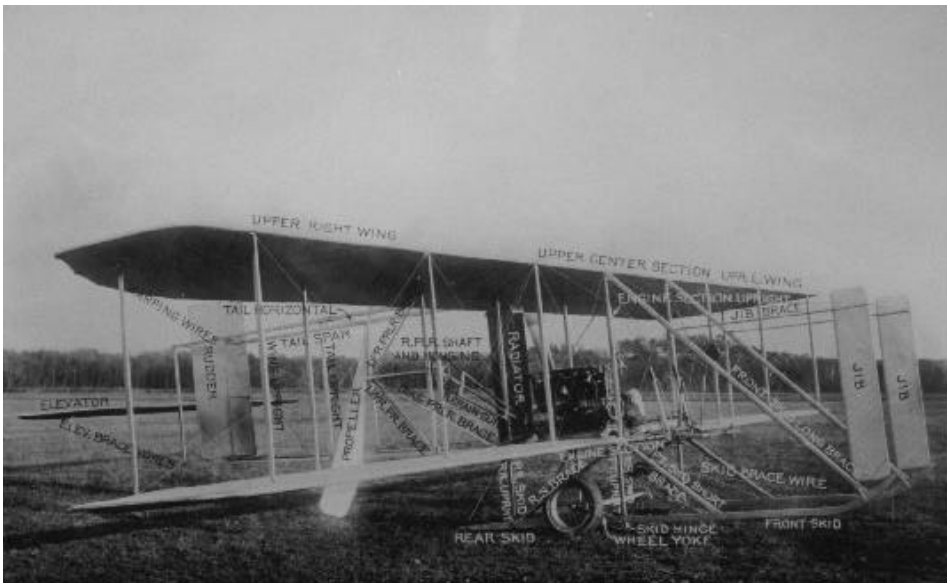
The Wrights instilled Arnold's "will to do" when it came to airpower. This early "bulb" exposure was taken of Orville Wright and Lieutenant Arnold after an early evening flight at College Park, Maryland, July 1912.

ment and maximum aircraft capability, whether it was available or not.

After his near-fatal spin, Arnold continued his inquiries, initially with a different emphasis. "If machines are inverted and given the sand test, what factor of safety should be required? What other tests could be given for determining the factor of safeties [sic] of any important parts?"[18] His concern with aircraft safety began after his spin and never wavered during his career.

Before long, Arnold was back to inquiries about performance and design directed at the Wrights. "As it is desired by this office to incorporate a stress test of some kind in our specifications for machines," he wrote, "we would greatly appreciate it if you would send to us . . . the chart showing the travel of the center of pressure for various speeds and weights." Or, "Will you kindly tell me what, if any, are the objections to having the propellers turn in the opposite direction to what they turn now in your machines?" And "The light scout machines have caused more or less controversy but I think the Signal Corps is at last persuaded as to the necessity of having them even though there is no one capable of flying them but Milling."[19] The Wrights always answered his letters in detail, but it seemed each response generated two more questions.

Arnold's constant inquisitive attitude about aircraft was a result of his pilot training and mechanical skills. He was not an aeronautical expert,



Arnold and Milling standardized the nomenclature for parts of the airplane. It was the first military aviator's technical manual—today's "Dash-1."

however, and did not always understand the science behind or the engineering problems associated with his queries. Changing prop direction, for example, would have required the Wrights to reverse nearly everything internal to the machine. Yet he was never fully satisfied with a machine as it stood. As a pilot, he wanted safer aircraft capable of higher altitude, better load capability, greater range, and faster speed. As a mechanic, he wanted interchangeable parts, peak engine performance, and substantial margins of safety in construction. Lieutenant Arnold wanted the best available equipment for the Air Service, and he did what he could to get it.

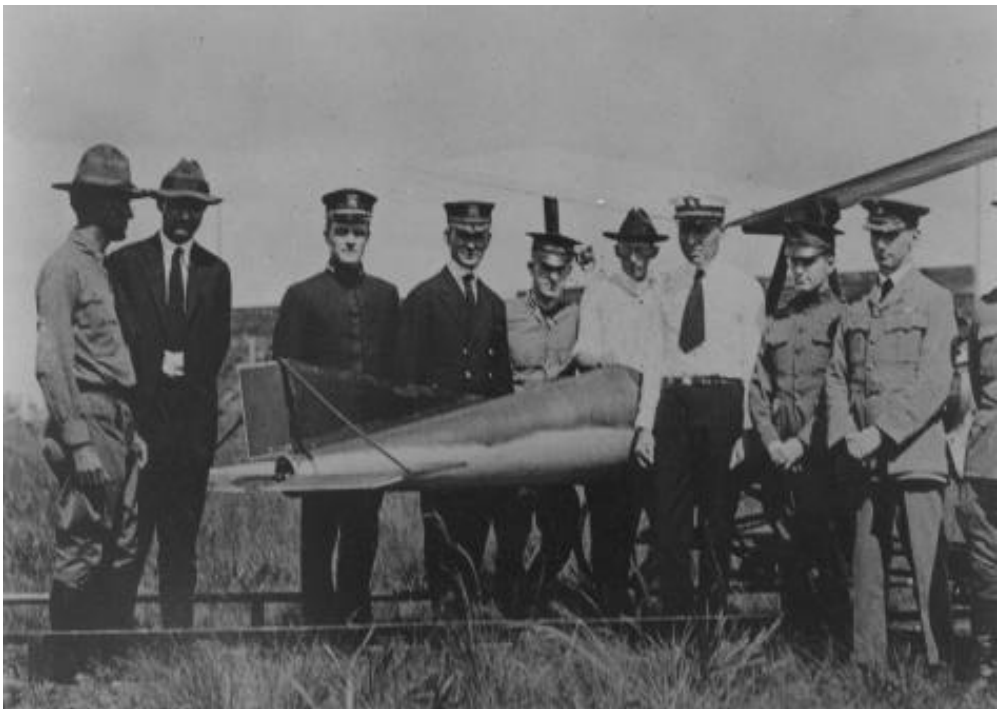
From December 1913 through 1915, Lieutenant Arnold participated in practicing ground attacks on different Philippine islands. During one of these exercises, Arnold watched a young lieutenant plan and execute a flawless attack at Bataan. He was so impressed that he told Bee upon his return that he had met a future Army chief of staff. This young man would become Arnold's friend, commander, and staunch supporter nearly a quarter century later. His name was George Catlett Marshall. Lieutenant Arnold was gaining experience and contacts that no other Army officer could match over a 50-year career. His experiences outside of the flying world became as valuable to future air forces as his personal aviation experiences. Then, as unexpected as his orders to join the Wrights in Dayton had been, he received orders to requalify into the Aviation Section of the Signal Corps.

Although joint Army-Navy aeronautical committees had existed before the National Advisory Committee for Aeronautics (NACA), they had no official status and even less authority over the progress of aeronautical science. The need for a committee with legitimate power to direct research and offer advice became apparent the following year while the Army was providing air support for Brig Gen John J. Pershing's punitive expedition into Mexico. One plane was lost before the operation even began, while another crashed a few days later, leaving only six of the original eight for operations. The craft in use, the Curtiss JN-3, had insufficient power to climb over the mountains and insufficient strength to withstand unpredictable winds and storms. Replacements were not immediately available.[20]

Arnold was adjusting to his new assignment as the supply officer at the newly established Aviation School at Rockwell Field near San Diego. He held the new Junior Military Aviator rating and wore a fresh set of captain's bars. Arnold arrived in May, but his requalification training did not begin until 18 November 1916 and was completed in six days when he soloed again for the first time in over four years.[21] Soon he was off to Panama as commander of a squadron there. In Panama, he was supposed to find an acceptable location for an air base before bringing his squadron to assist in the defense of the Canal Zone. No consensus could be reached on a location between the Americans—both Army and Navy—and the Panamanians, and he was sent back to Washington to take up the matter directly with Gen Leonard Wood, commanding general of the Atlantic Department. Arnold heard the news of America's entry into the Great War on the ship to Washington on 6 April 1917. He knew he would not be back to Panama any time soon.[22]

By August, Col (temporary) Henry Arnold was permanently assigned to his wartime post in Washington, D.C., as executive officer of the Air Division (the furthest up the chain of his "dozen jobs in one"). He had pressed for an assignment to Europe but was denied a transfer to the combat zone. Again, his assignment offered experience in the administration and, more importantly, the buildup of American air forces, which would pay off two decades later. Arnold rapidly became an indispensable aid to his superiors, who had little knowledge of air matters. While stuck in Washington, Arnold saw firsthand the immense problems facing the air division: lack of trained mechanics, lack of pilots, lack of funding, and lack of an aircraft production system (which Arnold considered the biggest headache of the war). Arnold spent most of his time traveling around the United States checking on aircraft production and development and keeping his superiors informed of the slow progress being made in these areas.[23]

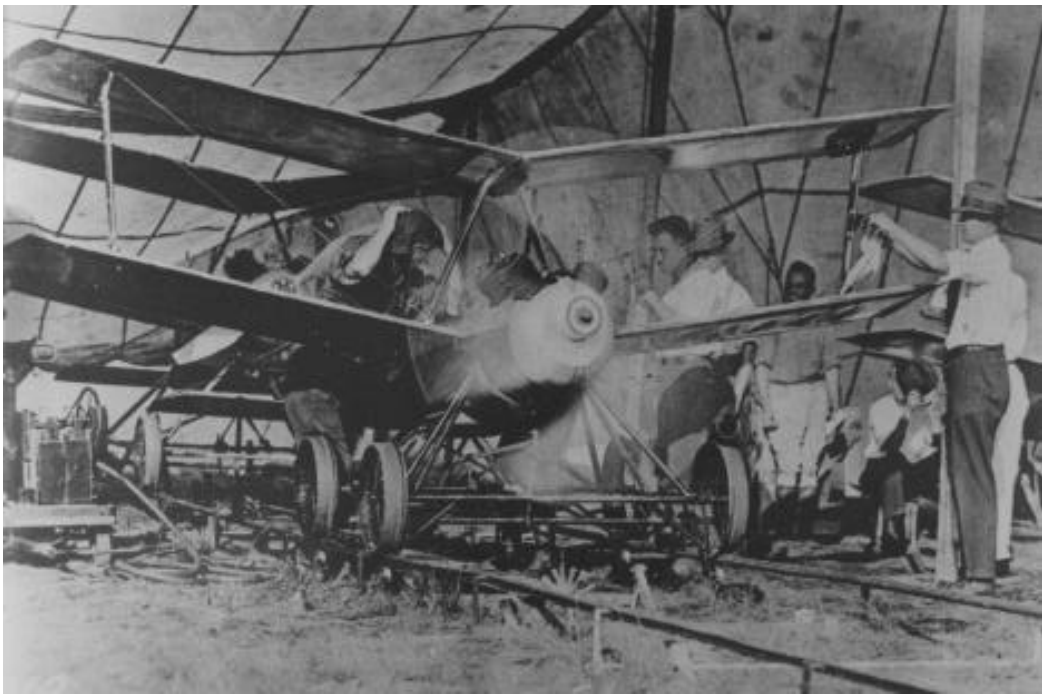
All of these problems resulted from America's policy of neutrality, which until February 1917 was



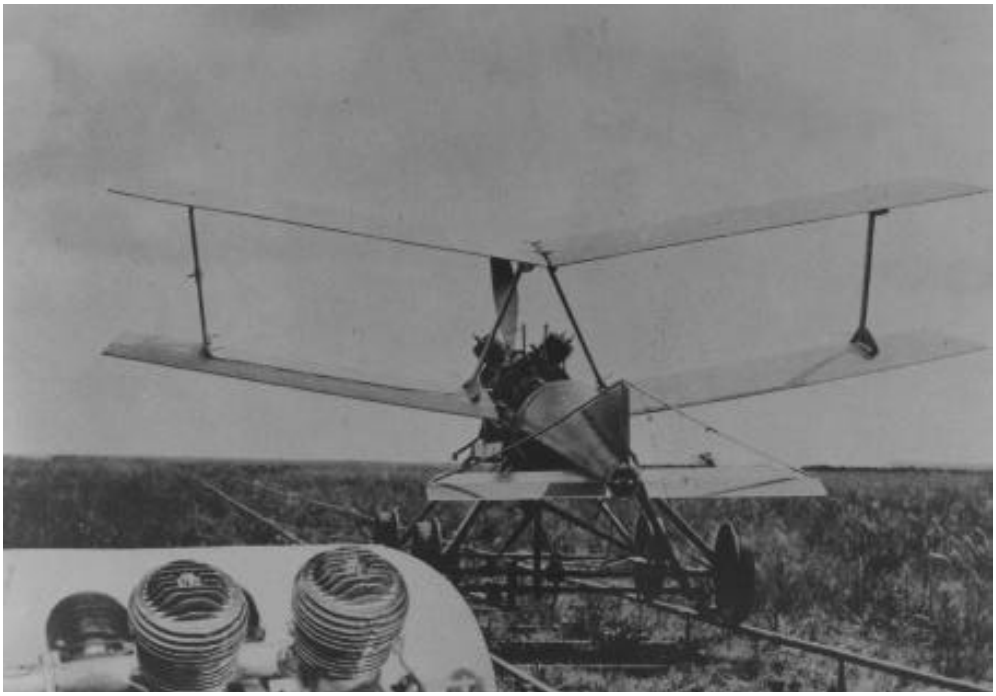
The "Flying Bug" was America's first guided missile. During the development of the weapon, Arnold met such notables as "Boss" Kettering, (the Bug's inventor), Elmer Sperry, Henry Ford, and Dr Robert Millikan. The team was composed of civilians and members of the other services as well. Arnold is at the far left.

publicly supported by President Woodrow Wilson. To build the American military in any form was to abandon neutrality as a policy. Not until German unrestricted U-boat warfare threatened American overseas trade with continental Europe had public opinion shifted dramatically to one of active intervention. The interception of the Zimmermann telegram, a memo from Berlin to Mexico City seeking a military alliance against the US, added insult to injury, but interventionist politics had already ensured funding for the military. Still, this funding came too late to build a fully functional Air Service.[24]

Arnold continued searching for improvements in planes and weapons. He teamed up with a task force of civilian scientists and produced the first "guided missile," dubbed the "Flying Bug," which was a beautiful wood-crafted, minibiplane. Early versions were simply made of papier-mâché. It housed a two-stroke, Ford engine and carried a "warhead" of 200–300 pounds of explosives. The Bug had no wheels and was launched from a wagon-like contraption that ran on a long section of portable track. The "missile" engine was started at one side of the track. When the engine was fully revved, the mechanical counter was engaged and the Bug was released. When it reached flying speed, it lifted off and flew straight ahead, climbing to a preset altitude controlled by a supersensitive aneroid barometer. When the Bug reached its altitude, the barometer sent signals to small flight controls, which were moved by a system of cranks and a bellows (from a player piano) for altitude control. A gyro helped maintain the stability of the craft, the barometer helped maintain altitude, but only the design of the wings assured directional stability. The Bug flew straight ahead until the mechanical



The Bug



counter had sensed the calculated number of engine rotations required to carry the weapon the intended target distance. A cam fell into place and the wings folded, looking much like a diving falcon swooping down on its prey. The Bug was rarely as deadly, and certainly not as fast, as a falcon.[25]

On the Bug team were Elmer Sperry, who had spearheaded the Navy's "aerial torpedo" project a few months earlier, Orville Wright, Robert Millikan, and the primary engineer, Charles Kettering. Most test flights were accomplished at Eglin Field, Florida, on the wide-open sand dunes that existed in that day. A first test, however, was attempted at Wright Field, Ohio, one that nearly ended in disaster as the errant missile narrowly missed crashing into the reviewing stands. After witnessing the initial test of the Bug, Arnold recalled that the gadget flew "like a thing possessed of the devil."[26] Lateral controls added shortly after these tests rectified the control problem that was the result of over-dependence on the dihedral of the wings for lateral stability. More important than the gadget itself were the members of the team, particularly Millikan, who would play a vital scientific role in the 1930s and during the Second World War. Arnold never forgot his experiences in production, administration, scientific experimentation, or testing. Nor did he forget the men who had helped create the fledgling force.

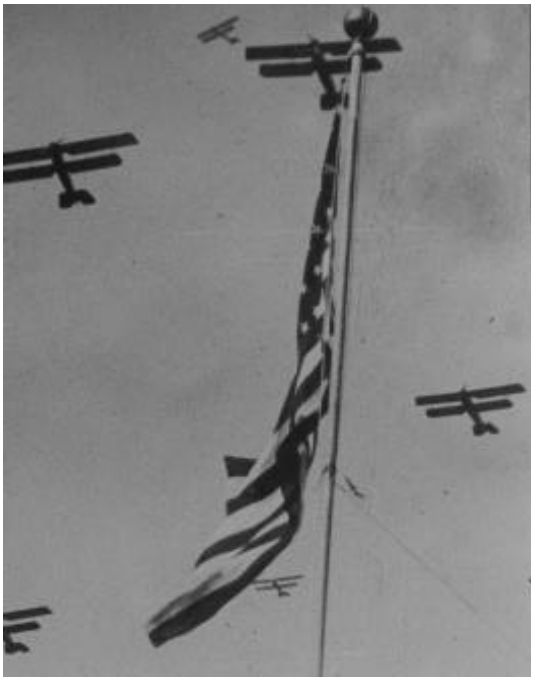
Arnold did, finally, make it over to Europe. He was convinced that General Pershing would want to bring the Bug into combat as soon as possible and was sent to convince him. Officially his orders were to sail by mid-October and become familiar with training organization methods in France and combat operations at the front.[27] His trip was not a success, however. He immediately fell victim to Spanish Flu, which was rampant on the East Coast. After recovery, he made it to the western front during November, shortly before the armistice went into effect. Because the weather was so terrible, however, he flew no combat missions. The Bug project died shortly thereafter.[28]

Arnold later recalled the importance of many advances that occurred in aviation during the war years. Some of the most significant were oxygen masks with communications devices all in one, air-to-ground radio communication sets, automatic cameras, armored pilot seats, increased firepower for strafing, the Bug, and improved aeronautical medical research equipment. Additionally, the establishment of the NACA held promise for the future of airplane research and development. Aircraft production, however, never reached acceptable levels. For example, even though Liberty engines were produced in great quantity, the United States never figured out how to build enough aircraft for the engines. By the end of the war, 1,213 American-built DH-4 aircraft had made it overseas but only about 600 had been sent to the front.[29] Arnold had witnessed the production bottlenecks firsthand and would remember the consequences of a failed production arrangement when he was in a position to do something about it.

After returning from Europe, and no longer being needed in D.C., Arnold received orders back to Rockwell Field. There he assumed the post of district supervisor, Western District of the Air Service. From January to June 1919, Arnold supervised the postwar demobilization of the Western District. Even while dealing with massive reductions in the size of the Army, Arnold promoted aviation as best he could. He held air shows and ordered his "Low Flying Team" to perform for California crowds. At one of these events, Arnold "decorated" movie star Mary Pickford with a banner making her an "Honorary Ace." The positive publicity generated by events such as these was desperately needed in the immediate postwar years.[30]

Arnold was well aware that public opinion was a powerful tool in maintaining support for the Air Service. When Rockwell Field closed temporarily, Arnold was transferred to San Francisco as air liaison officer for the Ninth Corps Area. A witness to the rapid drawdown, Arnold was determined to do what he could to bolster support for airpower. On his own initiative, Arnold established "fire patrols" over the western region. That not only saved thousands of acres of timber, but millions of dollars as well. His activities caught the public's attention. A peacetime

The Rockwell Field Low Flying Team included a young Lieutenant Doolittle (second from right). The team frequently performed for stars like Mary Pickford, "Honorary Ace" of the day. Its formations thrilled the California crowds.



use for military airplanes kept the shrinking service in the air, at least for a while.[31] Arnold the "politician" was developing during these early days in San Francisco.

It was during the years 1919 to 1924 that Arnold's working relationship with other Army officers began taking shape. William ("Billy") Mitchell's zealous approach to creating an independent air force taught Arnold how not to tackle a political hot potato. Arnold recalled that Mitchell himself had warned him away from the outspoken methods that he had been using. Mitchell realized that he was financially able to survive expulsion from the Army while most of his followers did not come from wealthy backgrounds. Carl A. ("Tooey") Spaatz and Ira C. Eaker served under Arnold during his next tour, again at Rockwell Field. These men became Arnold's right-hand and left-hand men over the next two decades. Eaker coauthored three books with Arnold, and Spaatz succeeded Arnold's command and become the first chief of staff of the independent Air Force in 1947. The amazing James H. ("Jimmy") Doolittle caught Arnold's attention after pulling off a dangerous flying stunt for a gathered crowd of onlookers. Arnold grounded the young second lieutenant for one month but later called on him to command the famous raid on Tokyo.[32]

While Arnold successfully pressed for publicity out west, Billy Mitchell held most of the headlines everywhere else. On 21 and 22 July 1921, Mitchell's bombers sank the ex-German battleship *Ostfriesland*, considered unsinkable by most naval officers. The wild publicity that followed marked the event as the Air Service's first major victory over the Navy in terms of service roles and missions. The seeds of strategic bombing had been sown. Another one of Mitchell's ideas was the Barling bomber, a six-engined behemoth capable of carrying a 10,000-pound payload. Although it seemed logical to build this monster in support of a "strategic" bombing mission, its performance was so poor that it could not fly over the mountains between Dayton and Washington while fully fueled. The Appalachians exceeded the bomber's service ceiling.

But the Barling was not a total loss. Valuable wind-tunnel data, parts design, and other aeronautical engineering problems were addressed and solved during the Barling's development. In that way, the Barling influenced the design of the B-17 and B-29, which were the American backbone of true strategic bombing in World War II. Although Arnold found the Barling operationally worthless, he realized that sometimes "the full-scale article must be built to get the pattern for the future."[33]

In the fall of 1924, Arnold was recalled to Washington by Gen Mason Patrick, then chief of the Air Service. Patrick, a classmate of Blackjack Pershing, had been so impressed with Arnold's California performance that he had added a commendation to Arnold's military record (201 file). Before joining Patrick's staff, however, Arnold attended the Army Industrial College in Washington. His World War I experience with aircraft production had been less than satisfying and now Major Arnold knew why. The Army planners were determined to utilize the American auto industry as the primary contractor to manufacture airplanes in time of crisis. Arnold lobbied for a different approach. He argued that the aircraft industry should remain the major contractor while using the auto industry for small parts and other subcontracting jobs. This short "college" assignment was one of the most valuable of his career, one which he said was to stand him in good stead in later years.[34] Not only did Major Arnold have a plan for future buildups in his mind, but he realized that his civilian industry contacts from earlier tours would be essential if a sizable production scheme had any hope of success. Glenn Curtiss, Elmer Sperry, Donald Douglas, and Larry Bell were only a few of those contacts.

During 1925 and much of 1926, Arnold served as Patrick's chief of information. In this function he was able to keep his eyes and ears open to new developments in foreign and domestic aviation in both the civil and military arenas. In a failed effort, he attempted to keep Billy Mitchell out of trouble by urging him to temper his language and writings while campaigning for an independent air force. Mitchell caused too much trouble and was "exiled" to Fort Sam Houston in San Antonio, Texas, in February 1925.

Brig Gen Billy Mitchell (center) stands under the Barling Bomber with the development team. Mitchell was instrumental in getting Arnold back into the flying game in 1916.

Arnold and Spaatz in November 1919. Arnold often reminded Spaatz of the importance of civilian scientists to the air forces.

Colonel Mitchell was not gone long. When he returned to face a military court-martial, Arnold was his Washington liaison officer. By Christmas 1926, with Mitchell "martyred," Arnold considered resigning but gained the resolve needed to endure his own punishment.[35] In the turbulence of Billy Mitchell's trial, Arnold was under the threat of a court-martial of his own. The official charge, made by Mason Patrick, was violation of the Articles of War for misappropriation of government supplies in an effort to sway legislators in support of Mitchell's viewpoint. Arnold himself was "exiled" to Fort Riley, Kansas, the Army's largest cavalry post.[36]

It was at Fort Riley in 1927 that Arnold made his choice to remain a military officer. Beyond the malice of his superiors, both personally and toward aviation, Arnold believed that he had suffered numerous career setbacks. He had never been assigned to the cavalry, even after repeated requests. He had been denied any opportunity to participate in the American war effort in Europe. He had testified on Mitchell's behalf despite warnings from his superiors that by siding with Mitchell he was jeopardizing his career. The national economic picture was very good. The New York Stock Exchange was higher than it had been on the same date for the previous five years. Cotton and coffee hit all-time highs on the market, and General Motors reported record profits during the week of 23–30 July 1927.[37] Additionally, Arnold had reached his 20th year of military service, which entitled him to half pay and full benefits if he were to retire.

John K. Montgomery, then president of American International Airways (a branch of Pan American Airways), had offered the major a lucrative position as the first president of Pan Am.[38] On 24 July, Arnold replied: "As much as I would like to tell you that I will resign and take up work with the company, I hesitate doing it on account of the obligations which I have with my family." Further, Arnold suggested that he might take four months' leave to work for Pan Am and then make his final decision.[39] This leave was apparently never taken even though Montgomery had called Jack Jouett, a mutual military friend of Arnold's now stationed in Washington, to expedite the leave request.[40] Thus, family concerns were foremost on Arnold's mind at the time his final decision was made. Remarkably, Maj Henry Arnold and his family remained in the Army.

Arnold never mentioned his family as a motive in his recollections. "I couldn't very well quit the service under fire," he said.[41] One of Arnold's biographers, Thomas Coffey, suggested that the frustrated major had many things to accomplish in the Air Corps, many ideas to test.[42] At that moment, however, there was no chance that Arnold would ever hold a position which would allow him to "test" anything. He had been banished within the Army, his reputation preceding him, and was sent to the "worst post" in the country as punishment for his clear violation of official regulations. Henry Arnold was lucky he was still an Army aviator at all.

He survived this tour and even attended the Army Staff College, despite the protests of the Staff College commandant, who had served on the court that had tried Billy Mitchell. After his tour at the Staff College, Arnold took command of the Fairfield Air Service Depot, near Dayton, Ohio, in the fall of 1928. In an expanded role during 1931, Arnold also served as executive officer to the chief of the Materiel Division at Wright Field, Brig Gen H. Conger Pratt. It was while in these assignments that Arnold developed his understanding of, and distaste for, the Army research and development (R&D) system.[43] Arnold was sickened by the lack of progress that he perceived at Wright Field. New in 1930, for example, the Douglas O-38 two-seat observation biplane was capable of only 130 miles per hour. "What the hell have we gained in twenty years?" he rhetorically asked his son Hank, "Nothing!"[44] These perceptions were etched deeply into his memory and stayed with him for the rest of his career.

By November 1931, Arnold assumed command at March Field near Los Angeles. Lieutenant Colonel Arnold's World War I associate, Dr Robert Millikan, was now president of the California Institute of Technology (Caltech), 40 miles away in Pasadena. Winner of a Nobel Prize for physics in 1923, he was continuing his cosmic

The Barling Bomber in flight. This six-engined behemoth did not even have enough power to fly over the Appalachian Mountains.

The DH-4 was used well after the First World War. Arnold never forgot the lesson of obsolete surplus after the war. Shown here is Mason Patrick's personal DH-4B (note the stars on the tail).

ray research in the face of a challenge to its validity by Karl Compton of the Massachusetts Institute of Technology. Arnold had little understanding of the nature of these experiments that involved moving a lead sphere to different altitudes and taking electronic measurements. Nonetheless, Millikan had no trouble convincing Arnold to lend him a Curtiss B-2 Condor bomber to complete his charged-particle experiments. Arnold had his mechanics build a special "bomb" rack for the sphere and affix it to the Condor. These experiments were carried out from Canada to Mexico over a period of months. As part of this project, measurements were also taken underground, in mines, and at a variety of elevations on the earth. On one occasion, Millikan transported the ball to Lake Arrowhead on top of a high mountain peak. Unfortunately, the ball was so heavy that it broke through the bottom of the rickety boat in which he was transporting the experiment. It sank to the bottom of the lake. Arnold recalled that the first time they met following the unfortunate mishap, he addressed the professor as "Admiral" Millikan.[45]

New Deal reforms, air shows, public relations campaigns, and exercises, as well as support of scientific research, kept Arnold's 1st Wing busy in the early 1930s. Even though the American economy had collapsed, Arnold did not forget the technical development of his airplanes. Military funding continued at forecast levels into 1934 but faded somewhat with the advent of President Franklin D. Roosevelt's reforms. Air shows at March Field were major public events in Southern California as they had been at Rockwell Field a decade before. Movie stars and celebrities of all sorts visited the field on show days. The inevitable result was a page of favorable publicity in several Southern California newspapers the following day. But perhaps Arnold's most impressive accomplishment during this tour of duty was not accomplished at March Field or even with his own airplanes.

Lieutenant Colonel Arnold won his second Mackay Trophy as commander of a flight of 10 new B-10 bombers conducting a round-trip flight from Washington, D.C., to Fairbanks, Alaska. The first all-metal low-wing monoplane, the Martin B-10 bomber, was the most technologically advanced airplane in the US inventory. After a solid month's preparation, Arnold took his planes on the 18,000-mile round-trip flight with only one major foul-up and no aircraft losses along the way. Planning was meticulous. A poor showing would have been a catastrophic embarrassment, particularly since the Air Corps was still stinging from its lackluster performance while carrying the US Mail in the spring of 1934.[46] The success of the mission brought Arnold a well-earned decoration, a trophy, and proof that long-range bombers could threaten once impenetrable and isolated territorial boundaries, both those of potential enemies and those of the United States.

But Arnold always pushed for improvement. His airplanes made the trip to Fairbanks, but now the route would have to be flown faster or higher. One of his favorite places to search for improvements in aeronautics was Caltech. There "Admiral" Millikan had gone a long way in fulfilling his dreams for American aviation. Caltech had the best wind-tunnel facilities in the western United States, and it had one of the finest academic faculties. The civil aviation industry was beginning to locate nearby in Southern California. Caltech had definitely aroused the interest of the commanding officer at March Field.[47]

By March 1935, Millikan, Brigadier General Arnold, and Professor Theodore von Kármán, director of the Guggenheim Aeronautical Laboratory, California Institute of Technology (GALCIT) wind tunnels had become well acquainted. Kármán recalled that he had first seen Arnold as a major, perhaps on one of Arnold's inspection tours to the Los Angeles area while still assigned to Wright Field. "Maj. Arnold," Kármán remembered, "came `alvays in the vind toonel' and asked me questions."[48] By 1930, Kármán, second in the field of aeronautics only to his former professor, Ludwig Prandtl, had come permanently to Caltech from Aachen, Germany, enticed by a Guggenheim Fund stipend. Arnold's association with the Hungarian professor provided him with a lifelong, personal tutor in theoretical aeronautical science and its application to airpower. During the first half of the 1930s, both Arnold and Kármán developed a similar vision

The O-38. "What the hell have we gained in twenty years . . . . Nothing!"

Arnold loaned World War I acquaintance R. A. Millikan a Curtiss B-2 Condor bomber like this one for use in his continuing cosmic ray experiments while he was commander at March Field, California.

for military aviation: the United States needed a cooperative aeronautics establishment that coupled civilian scientific and industrial expertise with the practical needs of the Army Air Corps.[49] To Arnold, this collaboration meant better Air Corps airplanes. To Kármán, it meant great possibilities for Caltech and the West Coast aviation industry. A decade later, with a five-star Arnold commanding the Army Air Forces (AAF), their vision would become a reality.

It was with the experience gained during his early career that General Arnold began to transform the AAF into a technology-minded service. His task was daunting but with the help of scientists like Kármán and Millikan, and associates like Marshall, Spaatz, and Eaker, he would influence the thinking of an entire generation of AAF leadership. That process had begun in earnest when Maj Gen Oscar Westover's plane crashed in September 1938. (Editor's note: *To be continued in Fall 1997.)* □

Notes

1. The origin of the name "Hap" is still a matter of dispute. Arnold's original West Point tag was "Pewt." Arnold's West Point diary, located at the USAF Academy Library, carries that name proudly across the front cover. *The Howitzer*, West Point's yearbook, also noted the nickname "Benny." One of these two tags is a reference to a cartoon character of the day. In his youth, Arnold was called "Harley," his middle name, by family members. One account claimed that his "perpetual smile" while flying as a stunt double on an early motion picture led a Hollywood producer, who probably could not remember his name, to call him "Happy." This was then shortened. Another suggested that Hap, when angry, would involuntarily tighten his lips in an insidious smile. This famous "smile" deceptively portrayed Arnold as "happy" when he was, in reality, quite the opposite. It is most likely that Hap is short for "Happy," the name which Bee, his wife, used for him in many of their personal letters. Hap's mother called him "Sunny," (not s-o-n-n-y) most of her life which indicated a cheerful appearance or sunny disposition. The name Hap did not catch on in his military/personal correspondence until about 1930. Until then, many classmates still addressed correspondence to Pewt, his West Point nickname.

2. Address by Brig. Gen. H. H. Arnold, Gladwyne, Pa., 30 May 1938. Papers of Ira C. Eaker, Library of Congress, Washington, D.C., box 38, Arnold speeches, 2; Mrs Barbara Arnold, interview with author, 6 April 1995, Washington, D.C. Mrs Arnold is the daughter of Donald Douglas and widow of the late William Bruce Arnold, General Arnold's son.

3. Maj Gen John W. Huston, USAF, Retired, to author, 22 February 1996. General Huston is currently editing Arnold's wartime diaries and is an authority on General Arnold and his military career.

4. Gen H. H. Arnold, Reminiscences of Friends and Acquaintances, Mrs. H. H. Arnold section, Special Collections, USAF Academy, Colorado(hereafter, Friends of Arnold); also see the *Biographical Register of the Officers and Graduates of the* USMA at West Point, New York, *supp. vol. 5, 1900–1910; and Official* Register of the Officers and Cadets of the USMA, June 1904; and *The Howitzer*, 1907, the student yearbook. All of these are available at the West Point Archives.

5. The Henry H. Arnold Collection, box 262A, Library of Congress, Washington, D.C. (hereafter Arnold Collection); also *The Howitzer*, 1907; also see Murray Green Collection (hereafter MGC), notes from the Columbia University Oral History Review (hereafter CUOHR); Henry H. Arnold, *Global Mission* (New York: Harper and Brothers, 1949), 7–8; a generally accurate but hard-to-find book by Flint O. Dupre, *Hap Arnold: Architect of American Air Power* (New York: Macmillan Co., 1972), 1–14, is a shorter version of *Global Mission*. Henry H. Arnold and Ira C. Eaker, *Army Flyer* (New York: Harper and Brothers, 1942), 40–41.

6. *New York Daily Tribune*, 13 June 1907. The article also displayed a marvelous, informal class picture of the graduates; also see Mrs H. H. Arnold, interviewed by Murray Green, n.d., transcript, MGC, USAF Academy, Colorado. Mrs Arnold was known by all as "Bee." Arnold titled his letters to "Beadle," a pet name. In the early 1900s, "B-e-a" was the short form of "Bertha," a name that Mrs Arnold would have likely found unacceptable.

7. Arnold Collection, box 3, folder 9; a copy of the flight log is also available at the National Air and Space Museum Archives, H. H. Arnold folder; also see *Global Mission*, 1–21. Arnold just barely failed the ordnance exam.

8. *Global Mission*, 15. Draft manuscripts of *Global Mission* are available in the Library of Congress, but book page references are used here as a convention.

9. Arnold's ratings were: FAI, airplane pilot certificate no. 29, July 1911; Military Aviator, War Department 1912–1914, July 1912; Expert Aviator, Aero Club of America no. 4, September 1912; and Junior Military Aviator, May 1916; see also Memorandum for Special Assistant to the JCS for Arms Control, 21 September 1970, USAF Historical Research Agency (hereafter USAFHRA), 168.7265-8. This document contains a study by the Office of Air Force History listing the first 22 military pilots and their license dates, verified in published War Department GO files at the Pentagon.

10. Arnold Collection, box 3; and *Global Mission*, 3038.

11. *Global Mission*, 35–41.

12. Arnold to Bee, 20 June 1913, MGC. Arnold loved to have fun, and a drink was never out of the question in his early career. His father had been rather strict about the use of alcohol and did not even permit it at Henry and Bee's wedding, a decision he later wished he had modified to allow champagne. Tommy Milling, Arnold's best man for the affair and a fellow pilot, smuggled some liquor up from the Arnold cellar during the reception anyway. It was interesting that after World War II, Arnold and Bee were both subjects of a Pabst Beer ad that showed them at their ranch in the Sonoma Valley. Robert Arnold, interview with author, 14–16 July 1995, Sonoma, Calif.

13. 2d Lt H. H. Arnold to commanding officer, Signal Corps Aviation School, 6 November 1912, Fort Riley, Kansas, USAFHRA, 168.65-38. The first portion of the letter describes the progress being made with the various airplanes at Fort Riley. Observation techniques were discussed in addition to mention of a number of engine problems. Arnold's disclosure of the near accident is added at the end of the report in a straightforward paragraph explaining the event. Letters from

The B-10 was a major advance in aircraft technology. Arnold took 10 of the first all-metal monoplanes from Washington to Alaska and back. The positive publicity helped salve the wounds of delivering the mail but also opened the eyes of America to the long-distance capabilities of airpower.

Table 1

The Military Career of Henry Harley Arnold (Cadet No. 4596)

Born: 25 June 1886, Gladwyne, Pa.
Died: 15 January 1950, Sonoma, Calif., age 63.

CADET RECORD (all numbers refer to class standing rather than a % grade)				
SUBJECT	**1903/04**	**1904/05**	**1905/06**	**1906/07**
Overall Ranking	82/136	63/119	61/113	66/111
Conduct	25	27	21	52
Demerits (actual)	45	66	36	105
Military/Drill	97	X	70	78
Engineering	X	73	X	47/62
Math	74	49	X	X
English	103	94	X	X
French	98	89	X	X
Spanish	X	94	X	X
Drawing	X	70	51	X
Philosophy	X	X	66	X
Chemistry	X	X	53	X
Hygiene	X	X	94	X
Law	X	X	X	100
History	X	X	X	89
Gunnery	X	X	X	54
Military Efficiency	X	X	X	76
Deportment and Discipline	X	X	X	60

CAREER ASSIGNMENTS	
1 Aug 1903	Entered West Point, the Military Academy
14 Jun 1907	Graduated
5 Dec 1907	Fort William McKinley, P. I.
9 Apr 1908	San Mateo, P. I., and various other temporary locations
18 Jun 1909	En route to US through Asia and Europe
1 Oct 1909	Governors Island, New York

CAREER ASSIGNMENTS	
20 Apr 1911	Aviation School, Dayton, Ohio, Simms Station
15 Jun 1911	College Park, Md. Aviation duty as instructor/supply officer
25 Nov 1911	Augusta, Ga. Same duty
15 Apr 1912	Fort Leavenworth, Kans.
1 May 1912	College Park, Md.
1 Jul 1912	Connecticut Maneuvers
5 Aug 1912	College Park, Md.
1 Oct 1912	Fort Riley, Kans. (near-fatal spin)
15 Nov 1912	Washington, D.C. Duty in Office of the Chief Signal Officer
1 Sep 1913	Fort Thomas, Ky. Infantry
25 Nov 1913	En route to Philippine Islands
5 Jan 1914	Fort William McKinley, P. I.
5 Jan 1916	En route to Madison Barracks, N.Y.
15 Mar 1916	Madison Barracks, N.Y.
20 May 1916	Aviation School at North Island, San Diego, Calif.
5 Feb 1917	Panama Canal Zone
20 Mar 1917	Washington, D.C. Asst. Executive and Executive Officer, Air Division, Signal Corps; Board Control Member; Asst. Director Military Aeronautics; Director of Military Aeronautics
10 Jan 1919	Rockwell Field, Coronado, Calif. District Supervisor, Western District, Air Service.
30 May 1919	Crissy Field, San Francisco, Calif. Air Officer, 9th Air Corps Area
17 Oct 1922	Rockwell Field, Calif. Commanding Officer, Air Depot
15 Aug 1924	Washington, D.C. Student, Army industrial College
Mar 1925	Graduated AIC, then assigned to the Office, Chief Air Corps
Mar 1926	Marshal Field, Fort Riley, Kans. ("Exile." Wrote Bill Bruce books)
Aug 1928	Fort Leavenworth, Kans. Student, General Service School
12 Jun 1929	Graduated, then to Fairfield Air Depot, Ohio. Commanding Officer; Chief, Field Service Section, Materiel Division, Air Corps; Executive Officer, Material Division
29 Oct 1931	En route to March Field, Calif.
26 Nov 1931	March Field, Calif. Commanding Officer
17 Jan 1936	Washington, D.C. Assistant Chief of the Air Corps
21 Sep 1938	Chief of the Air Corps
20 Jun 1941	Chief, Army Air Forces
9 Mar 1942	Commanding General, Army Air Forces; Member Joint Chiefs of Staff; Member Combined Chiefs of Staff
21 Dec 1944	General of the Army (5-star rank)

CAREER ASSIGNMENTS	
9 Feb 1946	Office of the Chief of Staff
3 Mar 1946	End tour
30 Jun 1946	Retired with disability (heart problems), 43 years service
7 May 1949	General of the Air Force

MILITARY RANK PROGRESSION	
1 Aug 1903	Cadet
14 Jun 1907	Second Lieutenant, 29th Infantry
10 Apr 1913	First Lieutenant of Infantry
20 May 1916	Captain, Aviation Section, Signal Corps
23 Sep 1916	Captain of Infantry
27 Jun 1917	Major, Aviation Section, Signal Corps
5 Aug 1917	Colonel, temporary, Signal Corps
15 Jan 1918	Major, temporary, Infantry
30 Jun 1920	Captain, permanent grade
1 Jul 1920	Major of Infantry (transferred to Air Service 11 August 1920)
1 Feb 1931	Lieutenant Colonel, Air Corps
2 Mar 1935	Brigadier General, temporary, Air Corps (one source: 11 Feb)
22 Sep 1938	Major General, Chief of Air Corps (30 October, Deputy Chief of Staff, Army, for Air Matters)
15 Dec 1941	Lieutenant General
19 Mar 1943	General
21 Dec 1944	General of the Army
30 Jun 1946	General of the Army (ret.)
7 May 1949	General of the Air Force

this period are also located in the Arnold Collection, box 3. The collection is now available on microfilm.

14. *Global Mission*, 41–43; Arnold Collection, box 222; also see Arnold 201, 94, National Archives, stack W-3; and CUOHR, B. Foulois. The safety statistics during the 1990–91 flying year for the US Air Force showed that less than two major accidents (not necessarily even a fatality) occurred every 100,000 flying hours. This included combat operations in the Persian Gulf War. In 1913, the safety rate equivalent would have been 950 deaths per 100,000 flying hours, not including major accidents where planes could not be repaired.

15. General of the Air Force Henry H. Arnold, USAF, Retired, interviewed by T. A. Boyd, 19 October 1949, El Rancho Feliz, Sonoma, Calif. Transcript in MGC.

16. Arnold to O. Wright, 6 November 1911 and W. Wright to Arnold, H. H. Arnold folder, 10 November 1911, Wright Brothers Papers (hereafter Wright Papers), box 9, Library of Congress, Washington, D.C.

17. Arnold to W. Wright, 18 November 1911, Wright Papers, box 9, H. H. Arnold folder.

18. Arnold to Mr Wright, 27 January 1913, H. H. Arnold folder, Wright Papers, box 9. The "sand test" was accomplished by flipping the aircraft over and loading the wings with sand until the wing spars began to crack. Thus, aircraft strength was determined by inverted sand weight, which simulated the forces of lift on the wings themselves. This test is still used today in modified form, most recently to test the wing strength of the C-17.

19. Arnold to Mr Wright, 1 February 1913, Arnold to O. Wright, 23 February 1913, and Arnold to Mr Wright, 15 March 1913. Orville tried to reassure Arnold that the scout ship was the "easiest machine that we build. Its high speed in landing is its only drawback. It is a very strong machine and has a larger factor of safety than any of the other models." Wright to Arnold, 22 March 1913, Arnold folder, Wright Papers, box 9.

20. Frank Walter Anderson, *Orders of Magnitude: A History of the NACA and NASA, 1915–1980* (Washington, D.C.: National Aeronautics and Space Administration, 1981), 1–15; Howard S. Wolko, *In the Cause of Flight: Technologists of Aeronautics and Astronautics* (Washington, D.C.: Smithsonian Institution Press, 1981), 18; and Robert F. Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force*, vol. 1, *1907–1960* (Maxwell AFB, Alabama: Air University Press, 1989), 19; and Wesley Frank Craven and James Lea Cate, *The Army Air Forces in World War II* , vol. 1, *Plans and Early Operations, January 1939 to August 1942* (Chicago: The University of Chicago Press, 1948), 7; and Maurer Maurer, *The U.S. Air Service in World War I*, vol. 1, *The Final Report and a Tactical History* (Washington, D.C.: Office of Air Force History, 1978), 75–89. The Air Service sent a few ill-prepared planes with Pershing as aerial observation platforms. Before long, many of them were destroyed, and several pilots killed due to crashes.

21. Arnold Papers, box 3, folder 13.

22. *Global Mission*, 46–47.

23. Arnold Papers, box 3, folder 13, Washington Service Diary, 1917–1918.

24. Dik Daso, "Events in Foreign Policy: The End of American Neutrality, 1917," (manuscript, University of South Carolina, 1993), 1–12. Copy in author's possession, Burke, Virginia.

25. USAF Museum, "Kettering Bug" folder. Many photos are included as well as many of the original documents describing the weapon and its construction. Interestingly, Elmer Sperry claimed that he had invented the Bug and quit the project in 1919, thoroughly disgusted with Kettering.

26. *Global Mission*, 74–76; Thomas P. Hughes, *American Genesis: A Century of Invention and Technological Enthusiasm* (New York: Penguin Books, 1989), 130–34; and Glenn Infield, "Hap Arnold's WW I Buzz Bomb," *Air Force Magazine* (May 1974).

27. General Huston to author, 22 February 1996.

28. Arnold Papers, World War I Diary.

29. Maurer, 88; also *Global Mission*, 63–64.

30. Arnold Papers, Photo Albums.

31. Global Mission, 92–93.

32. Ibid., 91–98. For an excellent tribute to "Jimmy" Doolittle, one should review the Winter 1993 issue of *Air Power History*, which was dedicated to the life of the aviation pioneer.

33. Alfred F. Hurley, *Billy Mitchell: Crusader for Air Power* (Bloomington, Ind.: Indiana University Press, 1975), 64–70. For a highly detailed account of the trial, see Michael L. Grumelli, "Trial of Faith: The Dissent and Court Martial of Billy Mitchell" (Ph.D. diss., Rutgers, The State University of New Jersey, 1991); and *Global Mission*, 109–12.

34. Arnold Papers, box 3, folder 17; *Global Mission*, 113.

35. *Global Mission*, 113–23; and Hurley, 100–105.

36. General Huston to author, 22 February 1996. General Huston was kind enough to clear up the circumstances of Arnold's "exile" in this correspondence.

37. *New York Times*, 23–30 July 1927, various pages.

38. Maj H. H. Arnold to John K. Montgomery, 15 and 22 July 1927, John K. Montgomery Papers, Caroliniana Library, **University of South Carolina, Columbia (hereafter Montgomery Papers); *Global Mission*, 123–28.**

39. Arnold to Montgomery, 24 July 1927, Montgomery Papers.

40. Montgomery to Arnold, 27 July 1927, Montgomery Papers. **Included in this letter are the specifics of the salary and "perks" offer to Arnold: (1) The presidency of Pan Am; (2) $8,000 per year salary; and (3) 300 shares of B stock (voting shares) and 1,200 more if he stayed on with the company. I cannot verify that the 300 shares offered were intended to be delivered had Arnold decided *not* to stay on, but he never went.**

41. *Global Mission*, 122.

42. Thomas M. Coffey, *Hap: The Story of the U.S. Air Force and the Man Who Built It, General Henry H. "Hap" Arnold* (New York: Viking Press, 1982), 126.

43. Lois E. Walker and Shelby E. Wickman, *From Huffman Prairie to the Moon: The History of Wright Patterson Air Force Base* (Washington, D.C.: Air Force Logistics Command, 1986), 59–61, 149. Arnold had commanded the Rockwell Air Depot in California from 1922 to 1924. He also wrote the history of Rockwell Field while he was there. A copy of the manuscript is located in the USAFHRA.

44. Gen H. H. Arnold, Jr., USAF, Retired, interviewed by Murray Green, Sheridan, Wyoming, 29–30 August 1972, MGC. *Huffman Prairie*, 218–19. Arnold appeared to be getting used to the system during these two years. He directed projects on flame suppression from engine exhausts and contrail dissipation. **The intent of both was to make American aircraft less** visible to enemy gunners. Maj Gen Donald J. Keirn, USAF, Retired, interviewed by Murray Green, **Delaplane, Virginia,** 25 September **1970, MGC.**

45. Brig Gen H. W. Bowman, USAF, Retired, interviewed by Murray Green, 23 August 1969. Transcript in MGC. Bowman flew several of Millikan's experimental missions. His task was to orbit a particular area with a 500-pound lead ball at various altitudes up to 21,000 feet. Bowman felt certain that Millikan introduced Arnold to Kármán at Caltech; also *Global Mission*, 139; and Robert H. Kargon, *The Rise of Robert Millikan* (New York: Cornell University Press, 1982) for a fair description of the Karl Compton challenge.

46. *Global Mission, 133–47; For some unknown reason, Arnold allowed an inexperienced B-10 pilot to take one of the birds out on a flight. The pilot ended up in Cook's Bay, and the B-10 was swamped in 20–40 feet of icy water. Remarkably, the other crews were able to save the plane and drain the water from the fuselage. It cranked up on the first try and flew the rest of the way to Washington, much to Arnold's relief.*

***47. William Rees Sears, interview with author, Tucson, Ari*zona,

8 July 1995. Since Clark Millikan, Robert Millikan's son, had joined the faculty at Caltech, Kármán used to differentiate the two by calling Robert "Old Millikan" to everyone but Old Millikan himself. Dr Sears is a former student, colleague, and friend of Theodore von Kármán, one of only a few who called him by his informal name, Todor; for an excellent summary of the Guggenheim influence, see Richard P. Hallion, *Legacy of Flight: The Guggenheim* Contribution to American Aviation (Seattle: University of Washington Press, 1977).

48. Theodore von Kármán, oral interview, 27 January 1960, USAF Academy Oral History Interviews, USAF Academy, Colorado; and Michael H. Gorn, *Universal Man: Theodore von Kármán's Life in Aeronautics* (Washington: Smithsonian Institution Press, 1992), 81; also, in the NBC newsreel that covered the Rose Garden ceremony (January 1963) in which Kármán was given the first Medal of Science by President John F. Kennedy, Kármán remembered Arnold and his inquisitive nature back in the early days; Arnold's flight logs carefully document his trips to California while he was at Fairfield Depot. On one trip, he spent nearly one month in the Los Angeles area during which he might have visited Caltech, Old Millikan, and, later, Kármán. A copy of these logs is located in both the Arnold Collection, Library of Congress, and the Arnold file at the USAF Museum, Wright-Patterson AFB, Dayton, Ohio. The fact that Kármán ranks Arnold as a major would date their initial meetings to sometime before 1 February 1931, when he was promoted to lieutenant colonel.

49. Gorn, 116, 158.