AMERICAN HERITAGE HISTORY OF FLIGHT

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THE WONDER OF WINGS

For half a million years at least, we lived at the bottom of an ocean of air without using it - except to breathe. We knew that the invisible envelope around us had substance, that it could move, that it could be rough or gentle, cold or warm. We saw it drive clouds, ruffle waters, stir grasses, and uproot trees. Groping for cause and effect, we must have reasoned the wind was the breath of some gigantic god - invisible, unpredictable, and potentially hostile like everything else in our frightening world.

All about us at the same time were clues to the secret of flight. When we watched smoke drift upward, when we hurled our boomerangs or loosed feathered arrows, and when the squid leaped away from us in tropical seas, we were witnessing the phenomena that we would one day utilize in our own mastery of the air: the lift of lighter-than-air substances; air pressure against wing surfaces; jet propulsion. We saw these things, but we did not comprehend them.

Nor did we comprehend the grace with which birds performed their aerial acrobatics. We could only observe their flights with incredulity and admiration, and observing, we came to speculate about the origin of their wondrous gift. Birds were a constant source of inspiration to those of us who dreamed of imitating them - as well as a constant irritant because the imitation seemed so unattainable.

The force of this stimulus was perhaps never better expressed than by a forty-one-year-old American addressing a society of French aviation enthusiasts in 1908. “I sometimes think that the desire to fly after the fashion of birds is an ideal handed down to us by our ancestors who, in their grueling travels across trackless lands in prehistoric times, looked enviously on the birds soaring freely through space, at full speed, above all obstacles, on the infinite highway of the air.” The tribute he was receiving that night for the success he and his brother had achieved five years earlier, Wilbur Wright said, was really a tribute to “an idea that has always impassioned mankind.”

But as the millenia passed and the sky still arched above us, enormous and challenging, our imagination began to fill with a host of strange creatures and objects: demons and dragons, angels and devils, flying carpets and flying chariots. Some of these fantasies were foolish, but they expressed our wonder at - and defiance of - the incomprehensible mysteries that surrounded us.

Wherever people walked, they invented gods and devils, but there was something more urgent and fascinating about the denizens of the sky. The idea of soaring, of rising up from earthly cares had such an irresistible appeal that wings and their significance became inextricably entwined with our aspirations.

Almost as soon as forms of expression appear - carving, painting, and writing - the theme of wings is there. From the winged bulls guarding the halls of ancient Persia to the winged horse Pegasus of Greek mythology, the thought is clear and unmistakable: to fly is to conquer, to be a god.

Into this savage company people came slowly and hesitantly. The early history of human attempts to fly is legend. A few faint echoes of disasters may just possibly have been based on fact, but the traditions of successful flight certainly are not. No one seems to have learned anything from the failures; there was nothing to be learned from the improbable successes.

The earliest recorded story of human flight is Chinese. Some 4,000 years ago, according to the ancient *Annals of* *the Bamboo Books,* the Emperor Shun escaped from captivity as a boy by “donning the work-clothes of a bird.” On another occasion, the versatile Shun became a flying dragon. Two stories are told about Shun’s adventure. The first is that his father ordered Shun to the top of a tall granary and then set it on fire. The young Shun escaped by seizing two wide-brimmed reed hats and floating safely to the ground. Such hats sometimes were three feet wide. The second story is that Shun's jealous half-brother Xiang set a barn on fire and convinced Shun to climb onto the roof to extinguish the flames. Then Xiang took away the ladder, trapping Shun on the burning roof, so Shun made a parachute out of his hat and cloth and jumped down to safety. Both stories show that Shun may well have been the first successful parachutist.

The Chinese possess many other aerial legends, Lei Kung, the god of thunder and lightning, had the wings of a bat. In the eighteenth century B.C., one Ki-kung-shi supposedly invented a flying chariot; the old drawings show him sailing through the heavens with a satisfied smirk and no visible means of support. Some 1,600 years later, an eager experimenter named Liu An concocted an elixir that gave him the power of levitation. As he rose on high, he dropped his flask into a barnyard, whereupon the animals that sampled the spilled contents took off, too.

The folklore of virtually every early civilization had its flying heroes or demigods. Kai Kawus, an ancient king of Persia, was said to have had a flying throne drawn by four hungry eagles that flapped frantically in an effort to reach slabs of meat impaled on spears just beyond their beaks. (Other legends credit Alexander the Great with a similar device, a cage drawn by winged griffins.) In northern Europe, it was Wayland the Smith and his shirt made of feathers. In Africa, it was a great warrior, Kibaga, who flew invisibly over his enemies and dropped rocks on them until they finally brought him down by shooting their arrows blindly into the air.

The best-known of all the flying legends is the story of Daedalus and Icarus, who fashioned wings of feathers and wax with which to escape from the labyrinth of Cretan King Minos; the flight ended in disaster for Icarus when he flew too close to the sun and melted the waxed wings. The plunge of Icarus has fascinated generation after generation. This story may be pure myth, perhaps, yet sometimes legend is a shimmering cloak for truth. Daedalus, the “cunning artificer,” knew of the sail that reaches for the restless wind, captures it, and converts it into power. The updrafts where a steep cliff rises from the sea can be very strong, and Crete has such cliffs. Moreover, the principal components of a glider - light wood and cloth - were just as available in the Age of Bronze as they are now.

Could Daedalus, watching the soaring gulls, actually have attempted a glider large enough and strong enough to carry a man? H. G. Wells thought so. (Or perhaps it was Wells-the-novelist rather than Wells-the-historian speaking.) Suppose Daedalus did construct some such device; suppose his son was killed in some gallant and foolish experiment. The embroidery of the poets and the epic-singers is understandable. Beyond the miracle of flight is conflict, drama, and the wicked king posting guards by land and sea. Ovid has Daedalus saying dramatically, “We’ll go through air; for sure the air is free.” And then came the moral with pride going before a fall.

Not all the inventions were simply legends. The windmill, an ancestor of the propeller, was known and used in ancient Rome. The Chinese introduced the kite long before the Christian era and were using it for military signaling at least as early as the third century B.C. Tradition has it that by the Middle Ages the Chinese had developed monster kites capable of lifting men, and it seems possible. The Chinese also invented gunpowder about 900 A.D. and hit upon the idea of the rocket about 1100.

The identity of the first man-made object to fly under its own power is shrouded in mist and silence. Several centuries before Christ, according to Chinese records, a contemporary of Confucius named Kung-shu Tse built a wooden and bamboo magpie that “flew for three days.” It was, quite simply, a kite.

The mysterious wooden “pigeon,” a bird-shaped self-propelled flying device designed and built by Archytas, astounded observers in southern Italy in about 400 B.C.; however, it cannot so easily be dismissed as a kite. According to Aulus Gellius, a gossipy Roman who told the story in his *Attic Nights,* a collection of anecdotes written in the second century A.D., the dove or pigeon was caused to fly by means of “hidden and enclosed air” that, in turn, was activated by “some lamp or other fire within it.” Puzzling over these and other descriptions, some modern historians believe Archytas had his bird suspended by wires from a revolving arm that was turned by some sort of steam-reaction device. In any case, he seems to have had something more than a kite or a hand-propelled toy.

Actually, the first toy that flew was almost certainly invented by the Chinese. By inserting feathers in a lightweight spindle and rapidly rotating it, they achieved momentary flight using the helicopter principle. But it is impossible to assign a date to these spinning tops. They are doubtless far older than Kung-shu Tse’s magpie or Archytas’s dove.

Both legend and history have a good deal to say about the early "tower-jumpers," daring or demented souls who launched themselves from high places equipped with magical spells, homemade wings, or a hopeful combination of both. One of the earliest was Bladud, the legendary tenth king of Britain, who supposedly reigned in the ninth century B.C. According to medieval chroniclers, Bladud went to Athens and studied "Necromanticke Arts," came back to Britain, and was killed while attempting to fly with a pair of artificial wings over the ancient site of London. He was also the father of King Lear; perhaps madness ran in the family.

Ancient Rome had its tower-jumpers, too, one being the sorcerer Simon Magus who allegedly flew around until Saint Peter shot him down by well-directed prayers. One jump that seems to have been quite accurately reported took place in Constantinople in the eleventh century. There a Saracen climbed to the top of a tower overlooking the hippodrome. He wore a long white garment stiffened with willow poles and leaned experimentally into the wind while an impatient crowd urged him on from below. At length, he did attempt to glide, but, according to one account, "the weight of his body having more power to drag him down than the wings had to sustain him, he broke his bones and his evil plight was such that he did not long survive."

Far from discouraging imitators, these disasters seemed to encourage them. A contemporary of the Saracen, an English monk-astrologer-mechanic known as Oliver of Malmesbury, fashioned some wings and flew "more than a furlong" before breaking his legs. After the flight, he announced crossly that the only reason he fell was that he had forgotten to fit a tail to his "hinder parts."

Some 500 years later, an Italian adventurer named John Damian, having talked King James IV of Scotland into giving him the job of court physician, decided that whatever Bladud had done, he could do better. In 1507, according to John Lesley, Bishop of Ross, “he causet mak ane pair of wingis of fedderis, quhilkis beand fessinet apoun him, he flew of the Castell wall of Striveling, but shortlie he fell to the ground and brak his thee bane.” Damian, who seems to have retained his sense of humor despite the broken thigh bone, blamed his fall on the fact that he had used chicken feathers which, he said, had more affinity for the barnyard than for the sky.

The first man credited with anything like a scientific approach to flying was Roger Bacon, an English philosopher and Franciscan monk whose lifetime spanned most of the thirteenth century. Actually, such credit is overgenerous. Bacon’s contributions to heavier-than-air flight are limited to a few vague remarks about “instruments to flie withall, so that one sitting in the middle of the Instrument, and turning about an Engine, by which the wings being artificially composed may beate the ayre after the manner of a flying bird.” He knew of a man who invented such a thing, he said, although he had never seen it.

There is no evidence, however, that Bacon grasped the notion that the air was a substance that could be made to support a properly designed aeronautical machine just as water buoys up a ship, although this concept of the atmosphere as a kind of sea with a well-defined upper surface was not completely unknown. Albertus Magnus, another thirteenth-century scholar and a Dominican friar and Catholic bishop, toyed with the idea. So did another German philosopher, Albert of Saxony, and others.

For 150 years after Bacon, there is little evidence of experimentation or speculation. Then, the intellectual and artistic sunburst of the Renaissance cast new light into many dark corners, and the age saw the first great scientific pioneer in the field of aeronautics. Unfortunately, he had no direct influence on the subsequent development of aviation.

Leonardo da Vinci - artist, musician, architect, mathematician, the “universal man” of the Renaissance - left his fabulous collection of manuscripts and drawings to a friend who never bothered to make them public. It was not until the late nineteenth century that Leonardo’s astounding material received serious notice. By that time, the march of science had overtaken most of his ideas.

However, Leonardo was a towering genius. In one almost casual notation, about the year 1500, he suggested a design for the parachute specifying “a tent made of linen of which the apertures have all been stopped up.” He sketched a pyramid-shaped parachute, giving the measurements that would enable a man to “throw himself down from any great height without sustaining any injury.”

He also designed a model helicopter with a helix, or spiral screw, driven by a spring mechanism and seems to have flown it. But he was well aware that no adequate propulsive unit was available to launch a full-scale machine. There is a tradition that he experimented with hot-air balloons - more likely they were small kites. But he certainly knew that heated air rises, and it is possible that he was the first man to put this principle to work by designing the smokejack, a propeller worked by the hot air in a chimney which turns a roasting spit.

Leonardo was fascinated by birds - too fascinated, perhaps, for he devoted a tremendous amount of time and effort to the study of ornithopters, or flapping wing devices. It is curious: A man of Leonardo’s intellect must have known that the muscle-to-weight ratio in man differs so sharply from the birds as to make a human-powered ornithopter a virtual impossibility. (It was only in the twentieth century - in the full light of modern knowledge of mechanics and aerodynamics - that some engineers were willing to hazard that an ornithopter might, just conceivably, work for a minute or two.) Nevertheless, Leonardo's notebooks show dozens of drawings of ornithopters with the operator in various positions. Had he applied a tenth of this attention to a fixed-wing glider, he might well have anticipated Otto Lilienthal, the nineteenth-century "father of gliding," by a full 400 years.

Oddly enough, there is some evidence that a contemporary of Leonardo's did fit himself with flapping wings and attempt to fly. He was Giovanni Danti, a mathematician of Perugia credited with several faltering glides over Lake Trasimeno about 1490. According to an account written nearly two centuries later, an iron brace in Danti's left wing gave way as he was trying to glide from a tower in Perugia. He fell and was badly injured.

Leonardo's stature seems all the greater when compared to some of the solemn nonsense that followed him. One theory of flight, for example, involved eggshells and dew. Since dew was thought to be "drawn up by the sun," and since eggshells are undeniably light, a dew-filled eggshell, it was stated, might very well fly - and enough of them might very well carry something, or somebody. The French author Cyrano de Bergerac used this notion of a dew-suspended airship in some lighthearted science fiction in the mid-seventeenth century. Other imaginative writers toyed with the idea of using giant magnets or lodestones to defeat the pull of gravity.

Fantastic though their tales were, the early yarn spinners deserve some credit for keeping the interest in flying alive.

In 1638, for example, a fantasy by Francis Godwin, Bishop of Hereford, was published with the somewhat long-winded title of *The Man in the Moone, or a Discourse of a Voyage thither by Domingo Gonsales the Speedy Messenger.* This "speedy messenger" was an enterprising Spaniard who trained twenty-five geese to pull him to the moon on a sort of flying trapeze.

The tale was of no significance in the history of flight, but it did fire the imagination of another bishop, John Wilkins of Chester, who did some serious thinking on the subject of flight, "than which there is not any imaginable invention that could prove of greater benefit to the world or glory to the author."

Writing in 1648, Wilkins classified previous attempts to fly under four headings, by spirits or angels, by the help of "fowls," by wings fastened to the body, and by a flying chariot which he regarded as "altogether as probable, and much more useful than any of the rest."

Wilkins made no attempt to build such a device, as he clearly understood how difficult the basic problems were, wondering "whether an engine of such capacity and weight may be supported by so thin and light a body as the air" and "whether the strength of the persons within it may be sufficient for the motion of it." In any case, he said firmly, "if [a] Fowl . . . can so very easily move it self up and down in the Air, without so much as stirring the Wings of it, certainly then it is not improbable, but that when all the due Proportions in such an Engine are found out and when Men by long Practice have arrived to any Skill and Experience, they will be able in this (as well as in many other Things) to come very near unto the imitation of Nature."

There is some evidence that a friend of Wilkins's, the English physicist Robert Hooke, constructed small ornithopters and a helicopter "which, by the help of springs and wings, rais'd and sustain'd itself in the air." This happened - if it happened - about the time Thomas Cromwell became Lord Protector, and nothing more was heard of it.

Through the whole history of man's quest for flight runs one persistent and mysterious thread, the phenomenon of levitation, or human flight with no mechanical contrivances whatever. Various mystics and saints allegedly have had this power, the most famous being the "flying monk," Saint Joseph of Cupertino. It is difficult to say where mythology ends and the supernatural begins, but Saint Joseph's case was well-documented by the sworn statements of those who witnessed his amazing feats.

It is perfectly true that something in the modern mind balks at the notion of Saint Joseph taking gracefully to the air "with his customary cry of 'Oh!'" But it is difficult to read the biographies of this unassuming little Franciscan friar without becoming half-convinced - momentarily - that he actually *did* fly. And not only in the obscure village of Cupertino, but in Assisi, in Naples, even in Rome before the astonished eyes of Pope Urban VIII.

Here is a description of one of Joseph's seventy recorded "flights" that were sworn to under oath by eyewitnesses after his death. The writer is Father Rossi of the Franciscan Order: "While the Lord High Admiral of Castile, Ambassador of Spain at the Vatican, was passing through Assisi in the year 1645, the custodian of the convent commanded Joseph to descend from the room into the church, where the Admiral and his lady were waiting for him, desirous of seeing him and speaking to him. To whom Joseph replied, 'I will obey, but I do not know whether I shall be able to speak to her.’ And, as a matter of fact, hardly had he entered the church and raised his eyes to a statue . . . situated above the altar, when he threw himself into a flight in order to embrace its feet at a distance of twelve paces, passing over the heads of all the congregation; then, after remaining there some time, he flew back over them with his customary shrill cry, and immediately returned to his cell. The Admiral was amazed, his wife fainted away, and all the onlookers became piously terrified.”

Toward the end of his life, Joseph became so famous that his superiors had to confine him in the convent of Osimo so that his life should “not be disturbed by the concourse of the vulgar.” After his death, the Church studied his case and weighed the evidence for ninety years before proceeding with his canonization.

Leaving supernatural intervention aside, a more scientific attempt to achieve flight was made by a contemporary of Saint Joseph’s, Francesco de Lana. In 1670, this Italian Jesuit proposed a vacuum-balloon ship to be lifted by four paper-thin copper globes, each twenty feet in diameter, from which the air was to have been evacuated. De Lana, who came close to determining the actual weight of air at sea level, was the first to grasp the concept of controlling a balloon by carrying ballast to govern the rate of ascent and readmitting air into the spheres in order to descend - but he underestimated the atmospheric pressure that would have instantly crushed his spheres.

The pious de Lana doubted, however, that God would ever allow such a machine to fly, “since it would cause much disturbance among the civil and political governments of mankind.” His prophecies of aerial warfare were devastatingly accurate. An aerial ship, he said, could swoop down on conventional naval vessels and cut their rigging, "Or even without descending so low, iron weights could be hurled down to wreck the ships and kill their crews, or the ships could be set on fire by fireballs and bombs. Not only ships, but houses, fortresses and cities could thus be destroyed, with the certainty that the airship would come to no harm as the missiles could be thrown from a great height."

It was exactly this prospect that moved a British prime minister, Stanley Baldwin, to remark in 1935, two and a half centuries later: "I wish for many reasons flying had never been invented . . . somehow we have got to Christianize it."

Ten years after de Lana's proposals held out some hope of lighter-than-air flight, another Italian scientist threw some cold water on the tower-jumpers or would-be birdmen who still believed that muscle-operated wings could sustain human beings in the air. In his 1680 treatise *De Motu Animalium,* G. A. Borelli demonstrated forcibly that pectoral muscles, even combined with leg muscles, were too weak to enable people to imitate the birds. "It is impossible," he wrote, "that men should be able to fly craftily by their own strength," and he added rather sourly that he had "no faith in any invention designed to lift man from the earth."

Borelli may have had in mind the claims of a French locksmith named Besnier, who two years earlier, in 1678, insisted that he had achieved flight through muscle power. Besnier's apparatus was said to consist of two light rods which he balanced on his shoulders, holding one end with his hands, the other end being attached with cords to his ankles. Each rod was equipped with cloth panels that were hinged so as to close on the upstroke and open on the downbeat. According to Besnier, he jumped from higher and higher places until he finally flew over a barn. But few of his contemporaries believed him, and Borelli certainly did not. In fact, when the German philosopher Gottfried William von Leibniz and other distinguished men of the day endorsed Borelli's conclusions, the whole idea of heavier-than-air flight was virtually abandoned for the next 100 years.

And yet this was the decade in which Isaac Newton, having stated his Third Law of Motion (to every action there is opposed an equal reaction), prophesied with remarkable foresight, "This is the principle which will enable mankind in later centuries to undertake flight to the stars."

After de Lana and Borelli, the dream of lighter-than-air flight was not only kept alive but seems actually to have been realized, in a small but impressive way, by a Brazilian-born Jesuit, Father Lourenço de Gusmão. In 1709, Gusmão requested the King of Portugal to grant him a patent for a flying machine, and the request was granted. Early engravings of Gusmão's *Passarola,* or "great bird," show a weird-looking contrivance with a bird's beak and tail, a billowing sail, and totally inadequate wings. But the pictures were the work of a misinformed artist. Gusmão's model - by no means as grotesque as it had been depicted and actually displaying a rather advanced design for its day - may have been successfully flown as a glider. If he did build a full-size, man-carrying ornithopter, it certainly never flew.

British historian Charles H. Gibbs-Smith rescued Gusmão from centuries of ridicule by presenting evidence that he made and flew a miniature hot-air balloon seventy-three years before the famous experiment of brothers Joseph and Etienne Montgolfier. He flew it, according to separate accounts from two eyewitnesses, on August 8, 1709, in the presence of the Portuguese king and nearly set His Majesty's furnishings on fire in the process.

Gusmão's device, according to a manuscript dated about 1724, "consisted of a small bark in the form of a trough which was covered with a cloth of canvas. With various spirits, quintessences, and other ingredients, he put a light beneath it and let the said bark fly in the Salla das Embaixadas before His Majesty and many other persons. It rose to a small height against the wall and then came to earth and caught fire when the materials became jumbled together. In descending and falling downwards, it set fire to some hangings and everything against which it knocked. His Majesty was good enough not to take it ill."

There is some indication that the Inquisition was not very pleased with this demonstration, the idea of flight still being widely associated with witchcraft or sorcery. In any case, no one in Portugal was inclined to follow up Father Laurenço's experiments.

It is extraordinary that the hot-air balloon was not invented long before Gusmão. For thousands of years, people had watched smoke rise from a fire, and for centuries, they had possessed in silk a material capable of capturing and holding that smoke.

But as the decades of the eighteenth century rolled by, progress in aeronautics seemed virtually at a standstill. In fact, contemporary comment often shows a marked degree of disillusion with the whole subject. Writing in 1713, the English satirist Joseph Addison said that as far as he was concerned, he would discourage "any person from flying in my time," primarily because of the baleful influence it would have on love affairs. "You should have a couple of lovers make a midnight assignation upon the top of the Monument, and see the cupola of St. Paul's covered with both sexes like the outside of a pigeon-house. . . . or a gallant giving chase to his mistress, like a hawk after a lark.”

Fiction writers continued to endow man with wings, but there was little serious scientific speculation. The Swedish mystic Emanuel Swedenborg offered some ideas for an ornithopter with wings “to be worked up and down with a spiral spring,” But he never got past the idea stage. Neither did Joseph Galien, a Dominican friar, whose vivid imagination conceived of an enormous cube-shaped aerial transport. Galien said buoyed up by “rarefied air,” he said, the airship would be capable of transporting whole armies of men to Africa, or anywhere else. But he recommended that its construction be left to “experienced engineers,” virtually the only sensible suggestion he made.

About 1742, one of the last of the hardy breed of tower-jumpers appeared in the form of a misguided French nobleman, the Marquis de Bacqueville, who attracted a large crowd of Parisians by announcing that he was going to fly across the Seine. With some sort of wings attached to him, he leaped from the roof of his riverside mansion, came plummeting down onto a washerwoman’s barge in the river, and broke his leg. The shades of Danti, Damian, and the rest must have smiled.

It was the French, in the latter half of the eighteenth century, who showed the most sustained interest in the idea of flight. Even as the storm clouds gathered around the ill-fated Louis XVI, his subjects continued to experiment with *voitures volantes* (flying cars), but their ornithopters left the hopeful inventors rather firmly planted on the ground.

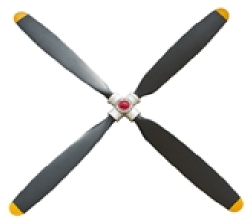
Meanwhile, across the Channel, the English chemist Henry Cavendish had succeeded in determining the weight of hydrogen, then called “inflammable air.” Describing its properties in a paper read before the Royal Society in 1766, he announced that “inflammable air” was considerably lighter than ordinary air.

The aeronautical significance of this seems to have escaped Cavendish entirely, or perhaps he simply was not interested. But Joseph Black, a chemistry professor at Glasgow University, realized that a very light container filled with hydrogen would be lighter than air and would rise. Believing that a demonstration would amuse his students, he made arrangements to obtain the lightest bladder that he could think of - the allantois (part of the umbilical cord) of a calf. But by the time one was made ready, he was teaching another part of his course and never got around to carrying out his plan.

Hearing of this intended experiment, Tiberius Cavallo, an Italian scientist who had settled in England, decided to follow through with it. But none of the containers that he tried seemed light enough. In the end, “tired with the expenses and loss of time,” he gave up - having come as close to the invention of the balloon as was possible without actually achieving it. Ironically, the dawn of the air age was only a year away.

The isolation of hydrogen made the development of lighter-than-air craft possible. But strangely, the final leap of imagination came from two men who had no experience at all with hydrogen. It was a far older phenomenon that finally carried man into the air.

It came in the form of a question so simple that no one had thought to ask it before. If sparks fly upward, why couldn’t the power that raised them be used to lift other things? In 1782, an inquisitive pair of brothers came up with the question.



EXPLORE

By the time the Greek poet Hesiod compiled the first genealogical history of the gods about the eighth century B.C., the belief that they possessed the power of flight was well established. It was taken for granted that the immortals could span time and distance at will; only when the plot of a particular story required winged steeds or aerial chariots were such dramatic devices added.

To explain the course of the sun, the Greeks gave their sun god Helios a golden chariot, drawn by fire-breathing horses. Other gods in the crowded Greek pantheon possessed simpler aids to flight: Hermes (who later reappeared as the Roman god Mercury) sped his messages with the help of winged sandals; Eros (the Roman Cupid), capriciously aiming his arrows of love, was a winged child; the handsome youth Ganymede ascended Mount Olympus astride an eagle. And the hero Perseus, after slaying the serpent-tressed Medusa, made his retreat on the winged horse Pegasus that had obligingly sprung from Medusa's bleeding neck.

The power of flight which the Greek and Roman storytellers bestowed on the immortals was a happy literary device also, for it permitted the gods' many interventions in the affairs of man - especially at crucial moments in a battle - and usually brought the amorous adventures of the deities to a swift and successful conclusion.

The Image of Heaven

Through the ages and around the world, wings appeared and reappeared as supernatural attributes in the different religions of man.

The legends of the Near East, India, and the Orient - like those of Greece and Rome - contain numerous references to winged creatures, aerial chariots, and flying gods. When Christianity replaced paganism in the West, wings - far from being abandoned - were incorporated with renewed emphasis in much of the art and literature of the young religion.

Jewish law had prohibited the making of graven images, but when Christianity assimilated the Old Testament, it also borrowed from Greco-Roman art to depict angels as human figures with wings. At first, they were decorously clothed in flowing robes - a departure from the anatomical frankness of classic art. Eventually, however, even Eros-Cupid, the messenger god of love, reappeared in Christian form as a plump, innocent, and unclothed cherub, complete with the wings that were an indispensable part of man's image of divinity.

Flying Carpets and Chariots

The folklore and legends of people everywhere provide an unbroken record of man's envy of birds and his desire to get up in the air himself. Often, he achieved success (in his mind) with the help of elaborate and ingenious aerial contrivances.

Chinese tales credit the Emperor Shun (*circa* 2200 B.C.) with the world's first flying chariot. Shun's successors, unfortunately, proved incapable of copying his vehicle, and later fliers had to rely on winged dragons. By the third century B.C., the Chinese had kites, an invention that might have turned their minds to practical methods of achieving manned flight. But a kite was too modest a device to satisfy the needs of storytellers, and twelve hundred years later travelers in the *Arabian Nights* relied on flying carpets for aerial trips.

Leonardo da Vinci

When he died in 1519 at the age of sixty-seven, the great Renaissance man, Leonardo da Vinci, left nearly 5,000 pages of manuscript notes, revealing the extraordinarily wide range of his interests and imagination. Even the possibility of human flight - and practical inventions to attain it - had occupied his curiosity.

Because of his fascination with birds, Leonardo combined his observations of their motions in flight with his knowledge of physics and mathematics and worked out flapping wing devices to bear men aloft. And about 1500, he drew detailed designs for a helicopter and a parachute. His notebooks, in all, contained some 150 sketches of flying machines.

Unfortunately, this treasure was forgotten for more than 300 years. Had his work been known, the course of aviation history might have been advanced by centuries.

Dreamers and Visionaries

For a century and a half after Leonardo's death, there were few practical contributions to aeronautical progress. Then, beginning in 1670, several visionaries appeared, proposing ideas that showed, at least, the searching work of serious minds.

The aerial boat designed by the Italian Jesuit Francesco de Lana in 1670 contained at least the germ of truth: the lifting power of a vessel lighter than air. But his scheme of draining air from hollow copper globes was wildly impractical. In 1709, another Jesuit, Laurenço de Gusmão, was granted a Portuguese patent for a man-carrying ornithopter that combined the use of flapping wings and a sail. Later that year, Gusmão seems to have bolstered his aeronautical reputation by experimenting with small hot-air balloons.

Though scientifically unsound, the work of these men helped to stir a new interest in flight.

Aerial Fantasies

The theme of air travel fascinated many seventeenth- and eighteenth-century European writers who wove exciting plots about heroes who flew not only across the earth but to the moon and sun as well.

One of the early science-fiction fantasies, *The Man in the Moone,* was written by Francis Godwin, Bishop of Hereford, and published posthumously in 1638. Godwin's hero, Domingo Gonsales, harnessed twenty-five geese to his flying apparatus, devising a system of pulleys and weights that distributed the load equally and thus enabled him to reach the moon.

Gonsales commented that it is "farre more honour to have been the first flying man, than to bee another Neptune that first adventured to sayle upon the Sea" - an early appreciation of the fame that awaited the first man to fly.

Cyrano de Bergerac, the French author, was another who wrote tales of solar and lunar flights. His stories, which appeared from 1657 to 1662, told of aerial journeys accomplished with the help of dew-filled flasks and small rockets.

The vogue for fictional ascensions reached a peak in the eighteenth century, when more than fifty different works on the subject appeared in England and France. Imaginative as well as entertaining, the romances often contained references to equipment that one day would become practical realities. Crude parachutes, rocket ships, and electrical flying machines were described, and most of the vehicles employed in these adventures were heavier than air.

Jonathan Swift's *Gulliver's Travels,* published in 1727, foreshadowed today's satellites in its description of a flying island. The people of this "vast opaque body," powered by a giant magnet, intimidated nations by hovering above them, excluding the sun and rain, by flinging great stones down, or even "letting the island drop directly upon their heads."

Glums and Gawrys, strange winged creatures inhabiting an island near the South Pole, peopled *The Life and Adventures of Peter Wilkins,* written in 1751 by Robert Paltock. As a reward for helping them defeat their enemies, the hero of Paltock's book married and lived happily ever after with one of the winged ladies, of whom the English critic Leigh Hunt later wrote, "A sweeter creature is not to be found."

On the Eve of Flight

The late eighteenth century saw a quickening of interest in aeronautics. Some experimenters were misguided, and others unlucky. But work in all branches of science provided a foundation for historic breakthroughs that were soon to come.

In 1772, a French priest, Canon Desforges, built a wicker car with wings and a parasol to protect him against unexpected descents. Manual operation of the wings proved too great a labor for the inventor who failed to make good his claim of a seventy-five-mile-per-hour speed in the air.

In the next decade, C. F. Meerwein, a German architect, made a nearly correct calculation of the wing surface necessary to support a man; but he, too, clung to an impractical flapping-wing device and got nowhere. The same year, 1781, Jean-Pierre Blanchard designed an equally unrealistic flying machine that received wide publicity.

While such schemes were capturing the interest of the public, better-trained and more practical scientists were quietly at work on studies that would lead eventually to successful flight. By 1766, the English chemist Henry Cavendish had determined that hydrogen weighs less than oxygen. Joseph Black, a Scottish professor, concluded soon afterward that hydrogen-filled vessels would rise through the heavier air.

Twenty years passed before man acted successfully on this conclusion to create the balloon.

2

BALLOONING

In all the folklore of flying, only one fairy tale seems to foreshadow the principle that first lifted man from the earth. According to ancient Arabian legend, a jinni, or spirit-demon, was able to fly “by swallowing air.” Here is a faint indication that some long-forgotten watcher of the desert sands knew that heated air rises and that it might conceivably lift something as insubstantial as a jinni.

It is doubtful that Joseph or Etienne Montgolfier, French papermakers of Annonay, near Lyon, ever heard the legend - or paid much attention to it if they did. They were well-educated eighteenth-century gentlemen who did not let their paper mill interfere too much with scholarly pursuits. Science in particular intrigued them. As children, they had heard of Benjamin Franklin’s famous electrical experiment with a kite. Later, they read a translation of Joseph Priestley’s treatise on the properties of air. The elder Montgolfier, in fact, constructed a parasol-type parachute in 1779, and tested it successfully with a sheep.

Joseph Montgolfier, gazing pensively into his fireplace a couple of years later, asked himself why he could not capture the “gas” or whatever it was that was lifting the smoke and sparks and use it to elevate something more interesting. If clouds could float in the sky, he reasoned, why not capture a cloud and enclose it in a bag?

Cloud capturing was not very feasible, but anyone could build a fire and trap the smoke. Joseph first tried it with an oblong bag made of fine silk. When he burned paper beneath an opening in the bottom, the bag swelled into an awkward sphere and sailed to the ceiling of the room, much to the “great surprise” of his landlady who had supplied the silk.

This indoor experiment took place at Avignon in November 1782. To his brother Etienne at Annonay, he wrote excitedly, “Prepare promptly a supply of taffeta and ropes, and you will see one of the most astonishing things in the world!” At Annonay, the brothers repeated this experiment out of doors. This time the bag rose about seventy feet before losing its buoyancy and descending gently.

Still unwilling to announce their discovery, the Montgolfiers made two larger “aerostatic machines,” as they called their balloons, tested them, and found the lift strong enough to break the cords that held them down. The second aerostat rose to a height of more than 1,000 feet and came down almost a mile away. By now, the inventors were using a fire made of chopped wool and straw that produced great quantities of noxious smoke and left them more convinced than ever that their “flying globes” were being lifted by some hitherto unknown gas. The notion that heated and, therefore, rarefied air alone could exert such an upward pressure did not occur to them.

By the early summer of 1783, the brothers were ready for a public demonstration. Their aerostat, a paper-lined linen bag, had a circumference of more than 100 feet. On June 4, in the presence of “a respectable assembly, and a great multitude of people” they lit a fire in the marketplace of Annonay and began to inflate their strange contrivance. Soon, to the astonishment of the onlookers, it required eight strong men to hold it down. When Joseph finally gave the release signal, it shot into the air, soared to an altitude of 6,000 feet, according to careful measurements made with “philosophical instruments,” and finally landed more than a mile away.

When news of this triumph reached the Academy of Sciences in Paris, it caused great excitement. The members promptly invited the Montgolfiers to come to the capital and demonstrate their aerostat. They also authorized a young French physicist, Jacques Charles, to carry out further research.

A cool-headed scientist, Charles realized from the start that the lifting agent of the Montgolfier machine was not nearly as effective as Professor Henry Cavendish's "inflammable air." He decided, therefore, to use hydrogen for his experiment. Paper and linen, he knew, would be too porous to retain the gas. But he had heard of a pair of engineering brothers Anne-Jean and Micolas-Louis Robert who had devised a method of coating silk fabric with rubber. (The brother team appears with curious regularity in the history of aeronautics.) From them, Charles ordered a small "flying globe" some thirteen feet in diameter.

On August 23, 1783, the balloon was judged ready for a trial. Charles had endless difficulty in generating enough hydrogen to keep the balloon filled, but on the night of August 26, the balloon was partially inflated and ready for transport to the Champ-de-Mars, where it was to ascend. By this time, popular excitement was so great that the balloon's sponsors decided to move it before daybreak, hoping to avoid the crowds. But the Parisians turned out anyway, and the occasion became a spectacular torchlight parade. Why the open flames did not explode the 22,000 cubic feet of hydrogen in the leaky envelope is a mystery, but they did not.

All the next day, a crowd of more than 50,000 eager people waited while Charles struggled to inflate the silken bag. Finally, at five in the afternoon, in a "copious shower of rain," the balloon was released and rose into the low-hanging clouds. Craning his neck among the spectators was Benjamin Franklin, envoy from the infant United States.

“Interesting,” some skeptic remarked to him as the balloon vanished, “but what use is it?” To this, the old genius Franklin growled, “What use is a newborn baby?” Franklin hastened to inform scientific colleagues in London, Vienna, and Philadelphia of the new invention, stressing to them its military potential.

In the meantime, Etienne Montgolfier had come to Paris and was completing a handsomely decorated aerostat some seventy-four feet high. Etienne demonstrated his new creation so successfully before members of the Academy that a royal summons arrived to repeat the performance before Louis XVI and Marie Antoinette at Versailles on September 19, 1783.

Etienne built a new balloon in four days (the other one had been damaged by rain). To determine if the upper air could sustain life, the brothers decided to attach to the balloon a cage containing a sheep, a rooster, and a duck. Up rose the first aerial menagerie, soared for eight minutes, then drifted to a landing a mile and a half away. The king was delighted, awarded both brothers the Order of Saint Michel, and ordered a gold medal to be struck bearing their profiles and the proud accolade: *“Pour avoir rendu l’air navigable”* (for having rendered air navigable). Soon, hot-air balloons were to be called *montgolfières* to distinguish them from the hydrogen-filled *charlières.*

When the cage of animals came down intact, the first man to reach it was Jean-François Pilâtre de Rozier, a young physician from Metz. Within a few weeks, his curiosity and enthusiasm were to make him the first balloon pilot in history - and within two years the first aerial fatality.

Full of confidence, the Montgolfiers now set to work to construct a third giant balloon so that it could carry aloft not only a fire, but a two-man crew to stoke it. In view of the risks involved, the king was inclined to order a pair of condemned criminals to make the first ascent, their lives being their reward if they came down in one piece. But others felt that the honor of being the first men to fly should not thus be wasted, and in the end this view prevailed. Since the most articulate and persistent volunteer was the eager Pilâtre, he was chosen.

In October, Pilâtre made several tethered ascents, twice taking passengers with him. Going up in a captive balloon sounds tame enough today, but it required the courage of any first step into the unknown. And the flimsy linen-and-paper balloon, with an open fire blazing beneath it and no means of directional control, was much less predictable than a modern space rocket. Then, as now, the rewards were the soaring sense of adventure and achievement and the heady acclaim of the crowd.

The first free flight took place on November 21, 1783, when Pilâtre and the Marquis Francois Laurent d'Arlandes, an infantry major, stationed themselves on opposite sides of a wicker gallery attached to the straining montgolfière and "at fifty-four minutes past one o'clock passed safely over some high trees and ascended calmly and majestically into the atmosphere," waving their hats triumphantly to the gaping crowds below.

The journey, lasting some twenty-five minutes, took them more than five miles across Paris. At one point, sparks from the grate scorched holes in the balloon and threatened to set the cordage on fire. The gallant Marquis (who later was cashiered for cowardice in the French Revolution) met this emergency with a wet sponge. When the balloon finally settled gently to the ground, the dream of the ages was a reality at last. And the glory belonged to France.

Ten days later, the methodical and scientific Professor Charles made the first flight in a hydrogen balloon. Having raised enough funds by private subscription, he had designed a big charlière that incorporated most of the essential features of modern balloons. With one of the Robert brothers as a passenger in a car well equipped with food, extra clothing, scientific instruments, and even bags of sand for ballast, he took off from the Tuileries Gardens on the afternoon of December 1.

The voyage was a resounding success; Charles himself described it as “delightful.” In the first two hours, the wind carried them to Nesle, some twenty-seven miles from Paris. Robert got out there, and Charles decided to make another ascent without him. With only one passenger, the balloon leaped from the shadows and rose to 9,000 feet, giving Charles the unique experience of seeing the sun set twice in one day. Somewhat troubled by the cold and a sharp pressure-pain in his ear, he came back down, making an expert landing.

The excitement created throughout the civilized world by these early flights was extraordinary. Balloons and ballooning became a craze: Montgolfières and charlières appeared in science fiction and in cartoons, on plates, vases, and snuffboxes. Amid all the acclaim, a few gloomy voices were heard. Former British Parliament member Horace Walpole wrote darkly, “I hope these new mechanic meteors will prove only playthings for the learned and the idle and not be converted into new engines of destruction to the human race as is so often the case of refinements or discoveries in science.”

The Montgolfiers evidently had no such qualms. On January 19, 1784, the largest hot-air balloon yet made went up at Lyon with seven persons aboard, including the first airman, Pilâtre de Rozier, and Joseph Montgolfier. It was the inventor's first and only flight.

In September, the craze came to London when a handsome Italian, Vincent Lunardi, took time off from his duties as secretary to the Neapolitan ambassador to popularize ballooning in England. His balloon balked at lifting another intended passenger, George Biggin, so Lunardi left him behind. He did, however, carry a dog, a cat, a pigeon, a bottle of wine, and some food that he could not eat because it fell into his sand ballast.

He also took a pair of aerial oars but soon dropped one of them. According to Lunardi, a young lady saw the oar fall and thought it was the balloonist himself. She was so upset, he wrote, that she suffered "a seizure" and died. However, balancing this tragedy, he also claimed to have saved a life. At another point along his route, he said, a jury deliberating the fate of a criminal heard of his approach, reached an instantaneous verdict of not guilty, and rushed outside to see the spectacle.

After a brief descent at North Mimms where Lunardi put out the cat ("the poor animal had been sensibly affected by the cold"), he flew on to Standon in Hertfordshire, where he landed to find himself a hero - to everyone but the glum Horace Walpole. "One Lunardi," Walpole wrote, "is the first *airgonaut* that has mounted into the clouds in this country. So far from respecting him as a Jason, I was very angry with him: He had full right to venture his own neck, but none to risk the poor cat."

Lunardi's balloon was a charlière; he considered montgolfières with their open fires too hazardous. His second aerostat became almost as famous as his first. The next summer it carried aloft the first Englishwoman to fly.

Mrs. L. A. Sage was a statuesque beauty weighing close to 200 pounds. With Lunardi's friend George Biggin as companion (the balloon, under the circumstances, balked at carrying three), she took off from London on June 29. The flight was uneventful except for one small scientific disaster when Mrs. Sage knelt on the barometer. After a satisfying lunch of chicken, ham, and wine, she and Biggin landed safely in a field near Harrow to the huge delight of the Harrovian schoolboys and the fury of the farmer who owned the land and objected violently to the sight of the massive Mrs.Sage tramping all over his beans.

Lack of directional control was to plague balloonists for more than a century. From the beginning, they tried to achieve some degree of control with aerial oars, paddles, and revolving fans that were the crude forerunners of propellers. But these hand-operated devices were useless in the face of the pressure exerted by the wind on the balloon itself.

Two other problems became vividly apparent in that first breathless year of ballooning. Once hydrogen was valved off to check an ascent, there was no way to get the lost buoyancy back except by jettisoning valuable ballast. Furthermore, if expanded hydrogen were released at high altitudes, the balloon tended to lose its shape as it came back down. Pondering this, a French lieutenant in the corps of engineers proposed the inclusion of a smaller sac within the main envelope that could be filled with ordinary air by means of a pump. This *ballonet* could be used to some extent in varying the weight of the whole balloon. It could also help the airship retain its shape after any loss of gas.

This young lieutenant, Jean-Baptiste Marie Meusnier, was one of the first great geniuses of aeronautics. He realized that to be "dirigible," or steerable, a balloon should have an elongated shape, with a bow and a stern like a ship. In 1785, with astonishing prescience, he designed an airship that was almost a century ahead of its time. The gas envelope, football-shaped, was to be 260 feet long. Slung below it was to be a car powered by three propellers and steered by a rudder in the form of a sail. The propellers were to be worked by man power. Meusnier even sketched a hangar to house his brain child at its home base and a portable canvas shelter to protect it in the field. Nine years later, having risen to the rank of general, he was killed at the Battle of Mayence.

One of the most dramatic events of that dramatic year of 1785 was the first aerial crossing of the English Channel. The pilot was a courageous if somewhat waspish little Frenchman named Jean-Pierre François Blanchard. His passenger was an American-born doctor, John Jeffries, who - disapproving of the recent and successful rebellion against King George III - had made his home in England.

Blanchard’s interest in aeronautics went back a long way. According to his own story, as early as 1777, he was experimenting with parachutes. In 1784, he designed and built a “flying chariot” with four beating wings that, like the other man-powered ornithopters, never flew. With the success of the first charlière he turned eagerly to lighter-than-air craft, and soon made successful ascents in both France and England.

This brought him to the attention of Dr. Jeffries, surely one of the most ardent amateurs in the history of flying. So determined was Jeffries to go on the voyage across the Channel that he organized the flight, provided all the money, and even agreed to “get out of the car” at any point if lightening the ship became necessary - no small pledge for any sort of flight.

Blanchard, apparently reluctant to share with his patron the honor of being first to cross the Channel in a balloon, did all he could to discourage the eager doctor. At one point, he secretly weighted himself with lead in an attempt to demonstrate the balloon's limited lifting capacity. This resulted in a quarrel that was settled only by the personal intervention of the Governor of Dover Castle. Finally, on January 7, 1785, with a favorable wind, the balloon took off with both men.

Blanchard had with him some aerial oars and a hand-cranked *moulinet*, or propeller. In addition, the balloon carried thirty pounds of sand ballast, two anchors, two cork jackets in case of a forced landing at sea, a bottle of brandy, provisions, and a large parcel of pamphlets to scatter over France.

At first, all went well; the balloon sailed serenely over ships in the Channel, which saluted by dipping their colors. But at about 2,000 feet it became necessary to release some of the expanding hydrogen. In the process, the balloon lost too much gas and went into a terrifying series of ups and downs. The ballast went overboard first, then the pamphlets, then everything movable except the life jackets. The two men managed to unscrew the *moulinet* and throw that out. Next went the two anchors; then the aeronauts began to cast away their outer garments, Blanchard even discarding his "trowsers."

At last, near the French coast, their lightened balloon went into a slow up-run. Shivering in the frigid January wind, they found themselves plunging down again - this time into a forest. They tossed out the now useless life jackets, and Dr. Jeffries reported candidly that in desperation they resorted to one last "curious" expedient to lighten the ship. When the car bounced through the treetops, they managed to pull it along to an open space where they opened the valve and sank gratefully to the ground some twelve miles inland from Calais.

On both sides of the Channel, they were acclaimed as heroes, which, indeed, they were. Blanchard made many more flights in Europe, and one notable ascent in Philadelphia on January 9, 1793, under the watchful eye of President Washington. It was the first aerial voyage in the United States, though thirteen-year-old Edward Warren of Baltimore had risen into the air in a captive balloon nine years earlier.

For more than two years after the Montgolfier brothers had first demonstrated their *globe volant* (man-navigating balloon) in 1783, no one, miraculously, was killed. But this remarkable safety record could not go on forever. The end came when a misguided attempt was made to combine the merits of the hot-air montgolfière and the hydrogen charlière in a single airship. This deadly hybrid was designed by the first man ever to achieve flight - Pilâtre de Rozier.

Impressed by - and perhaps a little jealous of - the praise showered upon Blanchard and Jeffries, Pilâtre decided to attempt an east-to-west Channel crossing. To avoid the loss of hydrogen that had almost brought Blanchard to disaster, he would use both hydrogen and hot air. Underneath the spherical charlière would be a cylindrical montgolfière with the usual open fire. The pilot would be able to vary the total lift simply by controlling the fire. Such was the theory behind Pilâtre's balloon.

Some historians have claimed that Pilâtre was ignorant of the hazards involved, but this hardly seems credible. The explosive properties of hydrogen were well known. Besides, that clear-minded scientist, Professor Charles himself, told Pilâtre that, in effect, he was trying to mix fire and gunpowder. What is more likely is that Pilâtre, having obtained a grant from the French government to build the balloon, got himself so far out on a limb that he could not go back.

He was anything but optimistic about the voyage. He told friends that he was "certain of meeting with death" and vowed that if he did reach England, he would give up ballooning for the rest of his life.

His qualms, apparently, were not shared by two of his countrymen who competed furiously for the honor of going with him. One was Pierre Romain, manufacturer of the balloon. The other was the impetuous young Marquis de Maisonfort, who offered 200 gold louis for a place in the balloon. Pilâtre objected so strenuously that, in the end, the Marquis grudgingly withdrew. It was well for him that he did.

Early on the morning of June 15, 1785, with what seemed to be a favorable wind, the balloon took off from Boulogne with Pilâtre and Romain aboard. In half an hour, it had risen to 3,000 feet but was making little progress toward England. Watchers on the ground saw the occupants doing something to the fire basket that swung below the montgolfière. Instantly, a blue flame appeared, a muffled explosion was heard, and the car came hurtling down, trailing smoke and shreds of silk. It struck the rocks near the coast at Wimereux. Pilâtre was dead when the would-be rescuers reached him; Romain was breathing but died in a few minutes. The air had claimed the first of many victims.

The tragedy marked the beginning of the end of the hot-air balloon. Montgolfières continued to fly (particularly to carry aloft stunting parachutists), but confidence in them was badly shaken. Four years later, when the French Revolution burst in all its fury, even the charlières went into partial eclipse. Between 1783 and 1790, seventy-six lighter-than-air ascents were recorded in France. In the next decade, the number of civilian flights dropped to six.

The significance of these new toys had not escaped the military, however. In 1793, the French government authorized an air arm, and the next year, the Revolutionary armies began using captive hydrogen balloons for reconnaissance. But in 1802, Napoleon disbanded the balloon corps.

By the beginning of the nineteenth century, a certain amount of disillusionment with balloons had set in. The "cloud enclosed in a bag" had liberated man from his bondage to earth, but it had proved an intractable creature, a plaything of the winds. For the next 100 years, the history of lighter-than-air flight is the story of people's struggle to make their cloud-in-a-bag go where they wanted it to go. This proved to be so difficult that as the decades passed, some of the best scientific minds in both England and France turned back to the ancient dream of wings as the most promising means of flight. But the balloonists, both in Europe and America, kept doggedly on.

One of the greatest was the Englishman Charles Green, who made his first flight in 1821, using coal gas instead of hydrogen because it was more readily available and considerably cheaper. Green was the first to make practical use of the guide rope, a long rope designed to act as automatic ballast. Trailing below the balloonist's car, it regulated lift in proportion to the amount of its weight dragging along the ground. At night, it could warn the balloonist of rising terrain. It could also, on occasion, cause considerable havoc on the ground, from bowling over unsuspecting lovers to demolishing haystacks.

The most famous of Green’s flights took place in 1836. With two companions, he took off at noon from Vauxhall Gardens in London, flew all night over France and Belgium, and landed the next day near Weilburg in the German Duchy of Nassau, a record distance of 480 miles.

One of Green’s two passengers was Thomas Monck Mason, a flutist of note who later became one of the first air historians. His description of night ballooning thrilled his contemporaries: “An unfathomable abyss of darkness visible seemed to encompass us on every side; and as we looked forward into its black obscurity . . . we could scarcely avoid the impression that we were cleaving our way through an interminable mass of black marble . . .”

Mason was more than just a passenger or a reporter; he was also a designer. A few years later, he constructed a model dirigible forty-four feet long with a propeller driven by clockwork. It was exhibited in the Strand and traveled short distances at a speed of about six miles per hour.

Charles Green’s counterpart in America was John Wise, whose long career in the air covered more than forty years. His greatest contribution was the invention of the ripping panel that allowed balloonists to deflate their gasbags instantly on landing and thus not be dragged all over the countryside on windy days.

Wise also saw clearly the immense potential of aerial warfare. In 1846, with the United States at war with Mexico, he proposed that a captive balloon on a long cable be positioned over the Mexican fortress at Vera Cruz, where it could drop bombs and torpedoes on the garrison while soaring out of range of any counterfire. The War Department looked askance at his proposal, but it was not so farfetched as it seemed. Three years later, in 1849, the Austrians had the dubious honor of carrying out the first air assault in history. Besieging Venice, they sent small hot-air balloons over the city, each carrying a thirty-pound bomb with a time fuse. Damage was slight, but Father de Lana's grim prophecy of over two centuries before had come true.

By the middle of the nineteenth century, however, balloonists were still vainly struggling for directional control of their capricious craft. As some anonymous rhymer had put it, back in 1786:

To Montgolfier the Invention's due

Unfinished as it lies,

But his will be the glory who

Direction's art supplies.

Again the glory, such as it was, fell to France. In 1852, nine years after Monck Mason's little clockwork model dirigible had sailed sedately around the Royal Adelaide Gallery in London, the famous French engineer Henri Giffard slung a small, three-horsepower steam engine under an elongated balloon. He hooked his crude little engine to a huge three-bladed propeller. Then, tugging down his flowered waistcoat and settling his top hat firmly on his head, he chugged off through the air at five miles per hour and did not come down until he had covered seventeen miles. Although the man-carrying, dirigible airship was thus realized, nothing much came of it, principally because steam engines were too heavy to be practical.

Observation balloons came back into use during the American Civil War and again, nearly a decade later, during the 1870-71 siege of Paris in the Franco-Prussian War. Still, lighter-than-air travel languished for lack of a powerful, lightweight engine. In 1872, another Frenchman, Henri Dupuy de Lôme, built a well-designed dirigible, but he had to rely on human muscle power to spin the propeller. In the same year, a German, Paul Haenlein, flew a dirigible powered - just barely - by an internal combustion engine that ran on coal gas.

Next, the designers turned to electric motors, and in 1884, two Frenchmen, Charles Renard and A. C. Krebs, flew their dirigible around a five-mile course. But electric motors, like steam engines, were too heavy for successful adaptation to aeronautics.

It was not until 1885 - more than a century after the invention of the balloon - that the solution appeared. In that year, a German, Karl Benz, built the first practical gasoline-powered automobile. Even so, thirteen more years elapsed before anyone arranged a successful marriage between the gasoline engine and lighter-than-air craft.

The man who did it was Alberto Santos-Dumont, a rich Brazilian living in Paris. He was one of the city’s first automobile enthusiasts, and, in 1898, he decided to see if the sputtering engine of one of his tricycle motorcars could be made to drive a balloon. His persistent attempts to build a practical dirigible were plagued with bad luck: One airship collapsed upon landing; a second rammed into trees and was damaged; a third was destroyed by vandals; the wind from another’s propeller gave the inventor pneumonia. Before he was through, however, this fearless little man with the high, stiff collars and odd Panama hats designed and flew twelve small airships.

In Germany, a former cavalry general, Count Ferdinand von Zeppelin, was planning the first of his great dirigibles, to be over 400 feet long; by comparison, Santos-Dumont's creations were little more than flying bicycles.

The airship came of age as a practical vehicle with the successful flights of the 190-foot-long, semi-rigid *Lebaudy,* named for her sponsors, Paul and Pierre Lebaudy, and designed by Henri Julliot. The first ascension was made at Moisson, near Mantes, on November 13, 1902. The following May, the *Lebaudy* traveled twenty-three miles. In June, it easily covered sixty-one miles in two hours and forty-six minutes; in November, it completed a thirty-eight-and-one-half-mile flight from Moisson to Paris. These voyages, made at respectable speeds of up to twenty-six and twenty-eight miles per hour, were the first long-distance flights by a powered airship.

Parisians admired the achievements of the *Lebaudy,* but Santos-Dumont remained their pet. One pleasant June morning in 1903, he sailed across Paris in dirigible number nine, his "little runabout," he called it. "I might have guide roped under the Arc de Triomphe," he wrote solemnly afterward, "had I thought myself worthy." Down the Champs Elysées, he flew to his own handsome house where servants drew the little runabout to earth and held it steady while their master went into the house for coffee and *croissants.* After breakfast, he sailed off again.

That same summer, in Dayton, Ohio, two methodical and persistent brothers were hard at work. Before the year was out, another dream, the ancient one of flying with wings, was also to come true.

EXPLORE

On a drizzly summer day in 1783, French peasants near Annonay were startled to see a globe sailing through the sky toward them. Many of the frightened people thought it must be the moon suddenly detached from its place in the firmament. When the sphere finally settled to earth and news of what it actually was raced across the countryside to Paris, all France - and the world - hailed the event as a great scientific triumph.

Throughout the eighteenth century, wits and satirists had had fun treating aerial navigation as an amusing fantasy and a dream of idiots. But it was an age of reason, also, in which serious students and investigators carefully pondered the phenomena of nature. Science had become a religion, and anyone with an inquisitive mind was enrolled in the cult.

In the exciting atmosphere of inquiry, it was not surprising that someone at last would conclude that ascending smoke might be able to lift man from the earth. Late in 1782, the notion occurred to Joseph Montgolfier, the forty-two-year-old son of a French provincial paper maker.

A brilliant and impatient man, Joseph enlisted the interest of his brother Etienne, five years younger and the more methodical of the two. Working without publicity, the brothers succeeded in sending aloft small silk bags filled with hot air. That was in November 1782. They next experimented with larger vessels, and on June 4, 1783, invited a group of observers to witness their first public demonstration - the ascension that frightened the peasants.

Not even the Montgolfiers understood the principle that made their balloon rise. The lifting power of smoke was attributed to electricity - the rage of the day - or to a mysterious gas that science had not yet discovered. But there was no doubt that the Montgolfiers had harnessed the force - whatever it was.

Within a month, the scientific community of Paris was agog with excitement. Everyone wanted to meet the brothers from Annonay and witness for himself the newest example of man's progress. The Academy of Sciences invited the Montgolfiers to repeat their demonstration in Paris, and the brothers accepted the summons. However, before they could send a second balloon aloft, another man, working from a different principle, had duplicated their success.

Man Goes Aloft

Spurred by news of the Montgolfiers' success, Faujas de Saint-Fond, an eminent French geologist, raised a subscription in the summer of 1783 to finance further aeronautical work. His bid to conduct research was immediately accepted by J.A.C. Charles, whose experiments in various fields of physical sciences had gained him some renown.

Charles did not know that the Montgolfiers had used smoke in their balloon, but he was aware of the lifting power of hydrogen, which for the past seventeen years had been known to be lighter than air. Foreseeing the difficulty of containing the gas in a porous envelope, he turned the problem over to two mechanics, Anne-Jean and Nicolas-Louis Robert. Within a short time, they fashioned a small, rubber-coated, silk balloon, and on August 27, 1783, Charles sent it aloft filled with hydrogen.

Charles's first unmanned balloon, launched on the Champs de Mars in Paris and watched by a crowd that included Benjamin Franklin, came to an ignominious end in a village a short distance away when it descended and villagers attacked it with pitchforks. Startled by the rush of escaping hydrogen, they tied the balloon to the tail of a horse that dragged it to shreds on the country roads.

There were now two methods for ascensions, and the stage was being readied for man's first aerial trip. By mid-October 1783, Etienne Montgolfier, having successfully demonstrated his hot-air balloon to the French Academy of Sciences and King Louis XVI, was conducting captive ascents with a passenger - a bold young doctor named Jean-François Pilâtre de Rozier.

The first free flight in the Montgolfiers' hot-air balloon finally occurred on November 21 when two men went aloft. The daring pioneers, Pilâtre de Rozier and the Marquis d'Arlandes, received the acclaim of Paris. But Charles and his hydrogen-filled balloon were right behind them. On December 1, with Nicolas-Louis Robert as passenger, Charles, too, made a successful flight, bettering by far the distance and time in the air set by his competitors.

Up in the Clouds

Even before Jean-Pierre Blanchard's epochal Channel flight, the excitement of ballooning was spreading across Europe.

Italy was the first country after France to witness an ascension when Paolo Andreani went up in a hot-air balloon near Milan on February 25, 1784. The following July, four Austrians unintentionally made the first aerial voyage over Vienna when the cord holding their captive balloon suddenly snapped.

The first woman balloon passenger anywhere was a Madame Élisabeth Thible, who went up in a montgolfière at Lyon on June 4, 1784. One observer noted that "she seems to have shown much greater courage" than her male companion, a painter named Fleurant. During the voyage, the lady sang a comic-opera aria, "Oh, to travel in the clouds."

Vincent Lunardi, a young Italian adventurer noted for his good looks and dashing charm, made the first ascent in England on September 15, 1784, and seemed genuinely surprised that so many young ladies courageously offered to accompany him on subsequent voyages. Nineteen days later, on October 4, James Sadler, whose aeronautical career was to last until 1815, became the first English balloon pilot.

Three was a crowd on June 29, 1785, when Mrs. Letitia Sage became the first Englishwoman to dare an ascent. The historic moment was dampened momentarily when the balloon could not lift Mrs. Sage, her companion George Biggin, and Vincent Lunardi. But the day was saved when Lunardi gallantly offered to allow the other two to ascend without him.

Attempting to cross the Channel on June 15, 1785, Pilâtre de Rozier fell to his death when his ill-conceived combination of the hot-air and hydrogen balloons burst into flames. But even this first aerial fatality did not dampen popular interest in the spectacle of ballooning.

The indefatigable Blanchard did most to foster the mania. During the summer and fall of 1785, he made the first ascents in Holland, Germany, and Belgium. Later, he was the first aerial voyager in Switzerland, Poland, and Czechoslovakia.

When the French Revolution plunged all Europe into turmoil after 1789, Blanchard traveled to the New World with his balloon and introduced the new sport to America.

Waving a flag decorated on one side with the Stars and Stripes and on the other with the French Tricolor, the veteran balloonist Blanchard made the first ascent in the United States on January 9, 1793, with a small dog who came along as company.

The Balloon Goes to War

In June 1793, with most of Europe united against it, the French Republican government took the unprecedented step of adding an air arm to its military forces. The new organization would make use of captive balloons from which "observers, placed as advanced sentries high in the air, could observe the movements of the enemy."

On April 2, 1794, the first company of French *aérostiers* was formed under the command of Colonel Jean-Marie-Joseph Coutelle. Exactly two months later, Coutelle made his first military ascent at Maubeuge, a besieged city some 125 miles northeast of Paris.

Impressed by the distress which the balloon caused the enemy - and by the lift in morale it gave to their own forces - the French created a second company of balloonists.

During the German campaign of 1796, the first unit was taken prisoner, and its balloon was sent as a prize to Vienna. But the following year, Napoleon employed balloon observers during his siege of Mantua in Italy. When he took a balloon corps to Egypt in 1798, its equipment soon fell into the hands of the enemy, and the balloonists were employed in other fields for the remainder of the campaign. Returning to France early in 1802, they received notice that their corps had been disbanded.

All the Rage

The military debut of the balloon led men to consider other uses for the new invention. Without the ability to steer, however, a balloon seemed ill-suited for commercial transportation or for any other practical function of government or business.

And yet balloons had become a rage. They offered thrills and amusement - both to those who sailed them and to watching multitudes. Painted and decorated with flags and gaudy embellishments, they provided the basis for increasingly spectacular displays that included fireworks, ascents on horseback, and parachute drops. Their lovely shapes inspired fashion designers, and their fashions, in turn, gave cartoonists a new source of merriment. But more important, they gave the public, for the first time, a feeling of familiarity with the air - once considered unattainable.

André-Jacques Garnerin made the world's first parachute descent on October 22, 1797, in Paris. Five years later he repeated the feat in London.

Green and Wise

Two of the nineteenth century's most celebrated aeronauts - Charles Green in England and John Wise in America - shared a desire to make the first transatlantic balloon flight.

Charles Green's best-known journey - 480 miles from London to the German Duchy of Nassau - was made on November 7-8, 1836, in a giant, striped balloon. One of the loveliest balloons ever to grace the skies, it was called the *Nassau* after the flight and was used by Green to publicize his later ascents.

Encouraged by the success of his record-breaking flight to Germany, Green proposed an aerial journey to America in a balloon equipped with propellers operated by clockwork and with a guide rope to regulate ascent and descent. Green spoke knowledgeably of westerly air currents, yet he never made the attempt. Instead, he devoted his last public years to completing an astonishing number of ascents - 500 before he retired in 1852, at the age of sixty-seven.

Despite many setbacks, John Wise never gave up his dream of flying to Europe. Still attempting to set endurance records at seventy-one, the Pennsylvanian disappeared over Lake Michigan in 1879 in a tragic end to his forty-four-year career.

Power and Ability to Steer

From the beginning, the usefulness of the balloon depended on providing it with dirigibility. By late 1783, the cafés of Paris were buzzing with suggestions for supplying direction and movement to aerostats. Most of the plans, though, seemed designed only to reveal the ignorance of the inventors.

Yet on January 24, 1784, a French physicist, M. J. Brisson, proposed the elongated balloon shape that eventually was to be used in successful dirigibles. That summer, the Robert brothers, who had helped Charles with his first hydrogen balloon, constructed a cylindrical vessel. Five parasol-shaped oars of blue taffeta, whose opening and closing were intended to propel the vehicle, proved ridiculously inadequate; and, after two unsuccessful trials, the Roberts sensibly abandoned their project.

Other efforts to achieve dirigibility with sails, paddle wheels, flapping wings, and oars served only to prove to the experimenters that such methods were unrealistic - if not totally ludicrous. In March 1785, the Academy of Lyon received 101 entries in a contest for the best dirigible design. They were all so impractical that the prize was not awarded.

Balloons in Fun and Fancy

Infinitely the most magnificent and astonishing discovery made . . . perhaps since the Creation," wrote one enthusiast five years after the first balloon had soared into the air. The excitement of the new sport continued to capture the public fancy through the nineteenth century. And for those who scoffed, the balloon - inflated as it was by hot air and sometimes falling straight back to earth again - was a rich subject for satire.

A dolphin-shaped balloon with painted eyes and gills, a pair of oars, and a sliding box of sand for ballast was the first proposal for a dirigible in England. The scheme was suggested in 1816 by two Swiss armorers in London, S. J. Pauly and Durs Egg, and was known as "Egg's Folly."

In 1785, Lieutenant Jean Baptiste Meusnier of the French corps of engineers conceived an elliptical airship. His advanced design - never executed - included a rudder and three propellers, as well as an anchor for effecting safe landings.

Military Use In America and France

On April 20, 1861, a New Hampshire meteorologist, Thaddeus S. C. Lowe, went up in a balloon in Cincinnati and came down in South Carolina - where he was arrested by secessionists as a Union spy.

Lowe was released as soon as he proved that his flight was a scientific venture and had nothing to do with the Civil War. But two months later, he was in Washington urging the

Federal Government to employ military observers in captive balloons.

In a demonstration ascent on June 18, Lowe dispatched to President Lincoln the world's first air-to-ground telegraph message. Lincoln was impressed and soon afterward authorized the creation of an army balloon corps with Lowe in command.

Patriotic Southern women donated silk dresses for a balloon corps for the Confederates, but only the North actually employed a unit during the war. For two years, Lowe's observers hovered over the smoke and roar of battlefields in Virginia, trying to play the role of eyes for the Union armies. Their assistance did not seem worth the expense, however, and when Federal commanders in the field showed little interest in continuing the use of balloons, the North abandoned its air arm in 1863.

The experience of the French during the Siege of Paris in the Franco-Prussian War of 1870-71 was an entirely different one. On September 23, 1870, only four days after German troops completed their encirclement of the French capital, a balloon soared aloft from Paris, flew over the Prussian lines, and landed safely in French-held territory fifty-five miles to the northwest.

Thereafter, the French used balloons effectively throughout the siege to maintain contact between the surrounded city and the provinces. Workshops in the capital's railroad stations built balloons at assembly-line speed, and of the sixty-six that were constructed and flown out of Paris during the four-month siege, only six were captured by the Germans, and two others were blown out to sea and lost.

The balloons carried more than 100 people out of Paris. In addition, they took to the provinces 2,500,000 letters and many carrier pigeons that later flew back to the city with messages reduced on microfilm.

Fairground and Carnival Days

A huge captive balloon, built by Henri Giffard, was the sensation of the Paris Exposition of 1867. Thrill seekers bought tickets and took rides, experiencing the exhilarating adventure of rising high into the air over the exposition grounds.

The following year, Giffard took his attraction to London, and for the next forty years, in both Europe and America, balloon ascensions were an indispensable feature of almost every fair, carnival, and exposition. Few, if any, of the captive balloons equaled the record of 35,000 passengers carried by a Giffard aerostat at the 1878 Exposition in Paris. But over the years, fairground ascensions spread an interest in flight among thousands of people who previously had viewed the subject with skepticism or indifference.

After the turn of the century, new thrills were added by free balloonists who awed carnival-goers with stunts and record ascensions. By 1913, balloonists had remained aloft for eighty-seven hours, made flights of nearly 2,000 miles, and gone as high as 35,000 feet.

By that time, the new achievement of flying with wings had overshadowed lighter-than-air ascensions. But many airplane pilots had received their aerial baptism in balloons, and others had first had their imaginations fired by the thrill of ballooning at an exposition or county fair.

A Polar Tragedy

On July 11, 1897, a balloon rose from the barren shores of Spitsbergen, bounced above the gray waves of the Arctic Ocean, and disappeared into the northern skies. It was the start of an audacious attempt to reach the North Pole in a free balloon - an adventure with a tragic ending, details of which only came to light thirty-three years later.

The project was conceived in 1894 by a forty-year-old Swedish engineer, Salomon August Andrée. Financed in part by Alfred Nobel, the inventor of dynamite and founder of the Nobel prizes, Andrée had a balloon built for himself in France that was capable of retaining its gas for thirty days.

After an abortive attempt to launch the aerial assault on the North Pole in 1896, Andrée and two young companions, Nils Strindberg and Knut Fraenkel, reached Spitsbergen by boat the following May. Difficulties with the balloon, as well as foul weather, delayed them for six weeks, but on July 11 they finally soared away on their great adventure.

A message brought by a carrier pigeon and a letter in a buoy, found later, told of the first two days in the air. The rest was silence, unbroken for thirty-three years.

On August 6, 1930, Norwegian explorers on White Island, some 300 miles east of Andrée's starting point, stumbled on a silent Arctic camp. There they found the frozen bodies of the three balloonists, together with undeveloped films.

Andrée's pitiful diary and the developed pictures told what had happened: Three days out of Spitsbergen, the trio had come down on the ice. After abandoning their balloon and enduring the hardships of a two-and-a-half month trek, they had established the camp in which they had finally perished.

Andrée’s balloon had carried sails and trailing guide ropes, two inadequate navigating devices that the explorers had hoped would help them maintain a direct course to their goal.

In the Arctic sky, the balloon did not have enough ballast to dump when ice formed on the envelope. After three days of bumping across the frozen sea, the men had landed 400 miles from Spitsbergen, but 500 from the Pole.

Dirigibles

In the first years of the twentieth century, several men finally mastered the ability to steer engine-powered balloons. Among the best-known of the dirigible builders - who included Count Ferdinand von Zeppelin in Germany, the Lebaudys in France, and Thomas Baldwin in the United States - none was a better showman than Alberto Santos-Dumont, the heir to a Brazilian coffee fortune.

Santos-Dumont’s intriguing cigar-shaped aerial runabouts were familiar sights in Paris, skimming over rooftops and darting back and forth above the boulevards. His machines seemed little more than sports vehicles in the air, and his contributions to the development of the dirigible were outdistanced by those of Zeppelin. But his flashy feats (like flying from Saint-Cloud to the Eiffel Tower and back) helped arouse interest in the dirigible as a potential means of aerial transportation.

3
LEARNING TO FLY

Throughout the nineteenth century, while balloonists struggled with the problem of dirigibility or control, a dedicated handful of pioneers - and an engaging throng of crackpots - clung to the conviction that man's true destiny in the air was to fly with wings. These visionaries usually worked alone and endured endless setbacks and disappointments. Some lost their reputations, and a few lost their lives. Most of them failed even to understand the problem they were attempting to solve, but now and then, one would contribute something essential to the slowly rising tide of knowledge. However, few bothered to find out what their predecessors had done; as a result, progress was agonizingly slow.

In 1783, when word of the Montgolfier brothers' wonderful flying globe leaped across the Channel, no one in all England was more thrilled than a bright-eyed nine-year-old named George Cayley. Like countless other small boys, he began experimenting delightedly with paper balloons and lighted candles. With other youngsters the excitement soon faded, but George Cayley was different.

In his teens, he experimented with small contra-rotating propellers made of feathers stuck in corks and driven by a whalebone bow - a helicopter device that had been invented a few years before in France. And, like Leonardo, Cayley studied the birds.

In 1804, at age forty, Cayley built a whirling-arm device that enabled him to study the air pressure on a one-foot square plane set at various angles of incidence. Later, experimenting with small and full-size gliders, he found that setting the wings at a slight dihedral (or shallow V-shaped) angle to each other gave lateral stability, and that a tailplane set behind the main wings was necessary for longitudinal stability.

By the end of the first decade of the nineteenth century, George Cayley had completed his basic research and published his conclusions in scientific papers that laid the foundation of all modern aerodynamics. “The whole problem is confined within these limits,” he wrote in 1809, “*viz* - to make a surface support a given weight by the application of power to the resistance of air.” The steam engines of his day were too heavy to be used in flying machines, but when it came to understanding the action of air pressure against an inclined plane, this inquisitive young Yorkshireman was far ahead of his time.

Cayley knew that the secret of winged flight lay in the nature of air itself. He knew that this mixture of gasses offers resistance to objects moving through it, that its density can vary, and that its particles can be stirred into invisible currents or eddies. He knew that for millions of years this mixture had kept aloft bats and birds and insects - and he believed that someday this mixture would support human beings as well.

He believed this because he watched it support his gliders. A small model that he built and flew in 1804 had had a wing area of only 154 square inches, but in many respects it was the first true airplane device in history. It consisted of an ordinary diamond-shaped kite fastened to a light pole, set at an angle of about six degrees. The tail assembly, with vertical and horizontal stabilizers, was attached to the pole by a universal joint so that it could be set at any angle. “It was very pretty,” Cayley noted, “to see it sail down a steep hill, and it gave the idea that a larger instrument would be a better and safer conveyance down the Alps than even a sure-footed mule.”

Also Cayley did build larger ones - both monoplanes and triplanes. One of his notes mentions a glider that in 1849 lifted a ten-year-old boy "off the ground for several yards on descending a hill." In 1853, according to a story told years later by his granddaughter, Cayley coaxed his reluctant coachman into making a trial run in a glider that lifted him across a shallow valley and set him down in a cloud of dust. "Please, Sir George," that outraged retainer is said to have shouted, "I wish to give notice. I was hired to drive, and not to fly!"

However, Cayley's inquiring talents were not confined to manned flight. He invented, among other things, the caterpillar tractor, automatic signaling devices for railroads, and a self-righting lifeboat. But in aeronautics, his reputation is monumental. The long shadow he cast reaches all the way to the Wright brothers.

An Englishman who grew up in the age of steam carried on the work that Cayley began. William Samuel Henson worked in the lace trade at Chard in Somerset. He had seen the first public railroad become a reality in England and had watched the first steam-powered ships cross the Atlantic. Thus, when Henson decided to build a flying machine in 1841, he looked to steam as the means of propulsion.

Henson was fully aware of Cayley's experiments; in 1842, when Henson patented his plans for an "Aerial Steam Carriage," he followed many of Cayley's ideas. His design called for a monoplane with a wingspan of 150 feet, a tailplane shaped rather like a bird's tail, a vertical rudder, and a tricycle landing gear. This surprisingly modern-looking craft was to be powered by two steam-driven pusher propellers. This was Henson's brilliantly original concept. He was the first to envisage the modern propeller-driven airplane.

A full-size version of the *Ariel,* as the machine was called, never would have flown; for one thing, the weight of the steam engine alone would have made flight impossible. But it was the first rational and detailed concept of a powered airplane, and the inventor deserved a more sympathetic hearing than he got. By 1847, assisted by his friend John Stringfellow, Henson had completed and tested a model with a twenty-foot wingspan. But when it proved incapable of anything more than a descending, powered glide, Henson gave up in disgust, married, and moved to America.

The next year, working alone, Stringfellow built another, smaller model based on Henson's designs. With a tiny steam engine driving two four-bladed pusher propellers, his little monoplane seems to have achieved some sort of part-glide, part-powered flight after releasing itself from a launching cradle suspended on a wire. But it was clear that steam could be used successfully at this stage on small models only; and "finding nothing but pecuniary loss and little honour," Stringfellow gave up his experiments for the next twenty years.

With Stringfellow's withdrawal, the initiative shifted to France. In 1857, Felix Du Temple, a French naval commander, patented a design for a powered airplane that showed several improvements over Stringfellow's model; it had a forward-mounted tractor propeller that pulled it through the air and wings set at the dihedral angle that Cayley had recommended. A small model powered first by clockwork and later by a steam engine took off and flew successfully about 1857 or 1858, the first fixed-wing machine to raise itself unaided from the ground. Later, about 1874, Du Temple built a full-sized machine with a tractor propeller driven by a hot-air engine. In an attempted takeoff down an inclined ramp, it may have left the ground with a young sailor aboard. If so, it was the first powered, man-carrying leap, or hop. A similar claim was made for a steam-driven airplane built by a Russian naval captain, Alexander F. Mozhaiski, and launched down a long ramp near St. Petersburg in 1884 with I. N. Golubev as pilot.

In 1866, aviation achieved respectability with the founding of the Aeronautical Society of Great Britain. At its first meeting that year, an assemblage of its dignified and serious members listened attentively to a report by F. H. Wenham, a marine engineer whose observations of bird flight in Egypt had led him to the study of aerodynamics. His paper was to prove a milestone in the development of aviation. After much experimentation with models, Wenham had been able to prove that a cambered (slightly arched) wing was better than a flat surface and that the lift exerted by such a wing moving at an angle inclined to the wind was derived mainly from the front portion of the wing. He went on to demonstrate that a long narrow wing exerts more lift than a short, wide one. Since wings long enough to provide a markedly greater lift might prove unmanageable, Wenham proposed that several shorter wings, placed one on top of another, be substituted as a means of achieving the desired lifting area. It was this proposal that pointed the way to the development of the modern biplane.

Wenham also went on to become the first man to use a wind tunnel for experimentation with wing shapes. It is known today that an airplane’s lift results less from the pressure of air against the underside of the wing than from the negative pressure or suction above the wing, where the air is thinned as it rushes over the arched wing surface. Cayley had grasped this principle as early as 1809, but it was not established as a scientific fact until a few years after the first successful powered flight.

Intrigued by Wenham’s paper, John Stringfellow once more tried his hand at model airplane building. Following Wenham’s lead and Cayley’s published recommendation of a multiplane type, Stringfellow designed a model triplane that, although it was not successful, attracted much attention at the exhibition staged by the Aeronautical Society at the Crystal Palace in London in 1868.

In the decade between 1870 and 1880, a brilliant and tragic figure appeared in France. Alphonse Pénaud first read everything he could find on the subject of aeronautics. Then the imaginative young man built and flew beautifully balanced models of helicopters, ornithopters, and airplanes powered by twisted elastic bands. He had not read Cayley when he built his first *planophore,* as he called his little airplane, but he gave the wings a dihedral angle at the tips, and he set his tail assembly some distance behind the main wings at a negative angle. The combination gave his model both lateral and longitudinal stability. With a twisted rubber band spinning the little pusher propeller, the planophore flew more than forty yards in eleven seconds.

In 1876, Pénaud patented a design for an amphibious aircraft that showed a variety of brilliant innovations. These included a single control column to move both rudder and elevators (the first joystick), retractable landing gear, and a glass cockpit canopy. Power was to be supplied by two tractor propellers, with the engine enclosed in the fuselage. But there was no suitable engine available, and at the age of thirty, discouraged and depressed by the skepticism and ridicule that pioneers must endure, Pénaud took a revolver and put a bullet through his marvelous brain.

When Pénaud died in 1880, lack of lightweight power was still thought to be the major barrier to winged flight. Most would-be fliers assumed - a little too readily as it turned out

- that if something would just boost them into the air, they would know what to do when they got there. The result was an endless series of theories and proposals. Some thought that electricity might be the answer; others turned hopefully to compressed air. Still others sought a solution in jet propulsion, using steam rockets, “vaporized petroleum oil,” and so on.

As the nineteenth century drew to a close, two men came close to powered flight, and both relied on steam. The first was Sir Hiram Maxim, an opinionated, American-born inventor who transferred his citizenship to Britain. The second was a French electrical engineer named Clément Ader.

When he turned to aeronautics, Maxim was already rich and famous as a result of earlier inventions, notably the machine gun that bears his name. After many experiments with wing shapes and propellers, he laid out a half-mile railroad track at his estate in Kent and proceeded to build a giant flying machine powered by two enormous steam-driven propellers that at full throttle developed an unheard-of 360 horsepower. The main wing of the huge craft was 110 feet long and four feet wide; the total wing surface was more than 4,000 feet.

Maxim was interested only in measuring lift and thrust; he was not really interested in flying at all. To keep his monster down, he added extra wheels on outriggers that would engage secondary wooden guardrails if the machine rose more than a few inches.

In 1894, with his white beard whipping in the wind, the pompous little inventor drove his machine along the track, gradually increasing steam pressure until, despite a total weight of three and a half tons, it actually lifted clear of the track and broke through the restraining guard rails. Faced with the prospect of losing control altogether, Maxim shut off the steam, and his creation came to a stop, slightly damaged. At that point, apparently having done what he set out to do, Maxim gave up. “Propulsion and lifting,” he announced brusquely, “are solved problems; the rest is a mere matter of time.” His sweeping statement did not even mention the third requirement of successful flight: control in the air.

In 1889, five years before Maxim’s effort, a French electrical engineer, Clément Ader, completed a bat-winged, steam-powered machine that he christened the *Éole.* In 1890, he tested it and claimed that he left the ground in this odd-looking contrivance for a distance of about 164 feet. Later, with some financial backing from the French army, he made and tested other machines. At the 1897 trials of his *Avion III*, official observers noted carefully that it never left the ground. The War Ministry withdrew its backing, and Ader gave up in disgust.

In their preoccupation with the mechanics of propulsion and the dynamics of lift, men like Maxim and Ader contributed relatively little to the art of flying. Maxim talked of controlling airplanes in free flight with gyroscopes and of steering them by varying the speed of the propellers. But he totally lacked the vision and the touch of poetry that were to become the hallmark of the true airman. Ader, who had watched and admired the effortless soaring flight of vultures in Africa, nevertheless patterned his lifting surfaces on a wing-flapping creature, the bat. In the end, it was only when man began to imitate the birds that glide or soar on rigid wings that he truly learned to fly.

In 1881, Louis-Pierre Mouillard, a Frenchman who lived in North Africa, published a treatise on bird flight that was greatly to influence subsequent students of gliding. Mouillard had no great success with the fixed-wing gliders he constructed to amuse himself. But his insistence in his book, *The Empire of the Air*, that a bird can “sail indefinitely upon the wind without further flapping his wings” encouraged other men to attempt gliding experiments.

The greatest of these birdmen was Otto Lilienthal, Germany’s first and most brilliant contributor to the conquest of the air. As a child enviously watching the storks that were common in his native Pomerania, Otto became obsessed with the idea of flight. He read widely but accepted nothing until he had verified it himself. In 1891, when he finally began building a glider, his purpose was clear. He wanted to master the art of flying so that when a suitable means of propulsion was ready to be added to wings, man would be ready, too.

Lilienthal’s early gliders were monoplanes with cambered wings and a fixed tailplane. The pilot dangled like a marionette from these fragile craft, head and shoulders above the wings, body and legs below. It was by shifting weight, swinging hips and legs forward or back, or from side to side, that the operator achieved some degree of control.

Near Berlin, Lilienthal constructed a conical hill of earth so that he could take off downslope and into the wind, no matter which way it blew. Looking like an athletic mountain climber in his heavy shoes and close-fitting cap, this daring and methodical German radiated a burning intensity as he sought the secrets of controlled flight. Between 1891 and 1896, he made over 2,000 glides, some of them covering several hundred feet. Photographs of his flights appearing all over the world excited great admiration and led other adventurous souls to experiment with gliders.

By 1896, Lilienthal was ready to attempt powered flight. He had constructed a glider with flapping wing tips, and to power it he had built a small motor that operated on compressed carbonic acid gas. On August 9, in one of his standard gliders, he made what should have been a routine glide. The weather was blustery, and a gust of wind suddenly pitched his craft sharply upward. The glider stalled and crashed to earth from about fifty feet, breaking the great pioneer’s back. He died the next day.

The influence of Lilienthal can hardly be overestimated. He was the first to demonstrate beyond question that, with or without power, the air could support a man in winged flight. To those who tried to follow where he led, he was both an inspiration and a warning. If his life proved that man could imitate the birds, his death was a somber reminder that the air is an alien element and that man would have to master his wings before he could fly with confidence and safety. The price he paid to fly was the highest. But one feels he paid it gladly.

Directly inspired by Lilienthal’s early flights, a young Scotsman, Percy Pilcher, had built his first glider in 1895. Before testing the *Bat*, as he called it, he went to Germany to meet the man who knew more about gliding than anyone else in the world. Lilienthal listened patiently to the eager young man’s questions, let him try out his new biplane glider, and gave him much useful advice.

The news of Lilienthal’s fatal crash in 1896 must have been a blow to Pilcher, but he did not let it deter him. When his original *Bat* did not prove satisfactory, he rebuilt it, adding the tailplane that Lilienthal had recommended. In rapid succession, he built three more gliders: the *Beetle*; the *Gull*; and the *Hawk*, a highly successful machine fitted with a wheeled undercarriage. In the *Hawk*, during the summer of 1897, he set a gliding distance record of 250 yards.

By now, Pilcher was ready for powered flight. Still, no suitable lightweight engine was available, and so he decided to build his own. Designed to produce four horsepower, it was to drive a small pusher propeller. All through the year 1898, he worked on it.

Early in 1899, at a meeting of the Aeronautical Society in London, Pilcher met Lawrence Hargrave, an unassuming Australian who since 1884 had been experimenting in Sydney with every kind of mechanical flight. In 1887, Hargrave had devised the first rotary engine, a compressed-air motor in which the cylinders revolved around a stationary crankshaft. In 1893, he had invented the box kite, whose cellular construction - two cells arranged in tandem - made it by far the most stable kite flown up to that time.

Hargrave knew that in the box kite he had a basic structure that could easily be adapted to gliders or airplanes. When he displayed two of his kites in London and read a paper on them, he fascinated Pilcher. The young Scotsman borrowed the kites, tested them himself, and incorporated some of their features into a new triplane glider.

Late in September 1899, Pilcher scheduled a demonstration of the new glider and the *Hawk*. When rain soaked both machines, he decided to fly only the well-tested *Hawk*. He was soaring steadily, some thirty feet off the ground, when a tailplane brace snapped. The *Hawk* flipped over in the air, crashed, and Pilcher was fatally injured. His death was a tragic blow to aviation, for he was a great natural flier.

Octave Chanute, a warm, delightful man already in his sixties and one of America's most successful civil engineers, was captivated by Lilienthal's gliding experiments. A careful and devoted student of aeronautical history, he first attracted attention with a series of magazine articles called "Progress in Flying Machines." Published in 1894 in book form, this was the first factual and trustworthy history of man's attempt to fly and one of the great classics of aviation.

By 1896, Chanute was designing his own gliders, using his knowledge of bridge building to add structural strength to them. He was aided by another engineer, A. M. Herring, who acted as pilot. What Chanute was after was automatic stability - a built-in device that would cause his machine to right itself in the air. On the sand hills fringing windy Lake Michigan, he tested glider after glider with rear-positioned tailplanes like Lilienthal's. His 1896 biplane glider was his best, but his designs also included a triplane and even a five-winged model. None of these gliders had control surfaces; in all of them the pilot had to rely on body movement for control. However, Chanute's experiments with gliders were not nearly as important in aviation history as his subsequent role as collector and disseminator of information.

Of all these early trail blazers, one of the most controversial, and surely one of the most unlucky, was Samuel Pierpont Langley. This distinguished astronomer, the director of the Smithsonian Institution, was well into his fifties when the lure of the air gripped him. He began by making elastic-band-propelled models based on Alphonse Pénaud's little aircraft. Then, in 1889, a little aero steam engine designed two decades earlier by John Stringfellow was presented to the Smithsonian. Studying this historic curio, Langley realized that better steam engines could be built and decided that he could build them.

In 1891, he constructed the first of his model aerodromes, as he called them. The steel frame was too heavy; it would not fly. For the next five years Langley doggedly kept building models, trying to solve the power-to-weight problem. Finally, in 1896, he produced a steam-driven model - a sort of double monoplane with wings set in tandem - that flew for three quarters of a mile and then came down only because the fuel gave out.

This success did not bring Langley the acclaim he deserved. On the contrary, he was criticized and ridiculed for wasting his time with such useless toys. But he refused to be discouraged.

With dwindling funds and almost no encouragement, he had little hope of finding money to construct a full-size, man-carrying aerodrome. In 1898, the United States went to war with Spain, and suddenly the War Department showed considerable interest in a controllable, power-driven airplane. As a result, Congress granted Langley $50,000 and asked him to go ahead and build such a machine.

Langley was now convinced that a gasoline engine offered more promise of powered flight than steam. He went to one manufacturer after another, asking for an engine that would deliver twelve horsepower and weigh only 100 pounds. When these requirements proved too formidable, he turned the problem over to his gifted assistant, Charles M. Manly.

A frail, bespectacled little man, Manly chose an engine designed by Stephen Balzer of New York. Balzer’s engine was of a radically new type with the cylinders arranged around a crankshaft. Most of the parts, even the sparkplugs, had to be made by hand. Manly hoped that this radial gasoline engine might produce twenty horsepower. Actually, when finally tested, the five cylinders of the little power plant (it weighed only 125 pounds) produced fifty-three horsepower - an amazing achievement for the time.

The aerodrome itself followed Langley's favorite design - a monoplane with two main wings in tandem and a tailplane and vertical fin behind. To launch the device, he decided to use a catapult that he mounted on a houseboat in the Potomac River.

Before attempting a full-scale version, he built a quarter-size model which flew successfully - the first time a gasoline engine had actually driven an airplane. In October 1903, he was ready for what he confidently believed would be the first sustained, man-carrying, heavier-than-air flight in history.

At noon on October 7, with Manly at the controls, the engine was started. It ran perfectly: the twin propellers hurling back columns of air and the 730-pound machine straining for release.

The next day a reporter for the Washington *Post* told the remainder of the story. "A few yards from the houseboat were the boats of the reporters who for three months had been stationed at Widewater. The newspapermen waved their hands. Manly looked down and smiled. Then his face hardened as he braced himself for the flight, which might have in store for him fame or death. The propeller wheels, a foot from his head, whirred around him one thousand times to the minute. A man forward fired two skyrockets. There came an answering 'toot, toot,' from the tugs. A mechanic stooped, cut the cable holding the catapult; there was a roaring, grinding noise - and the Langley airship tumbled over the edge of the houseboat and disappeared in the river, sixteen feet below. It simply slid into the water like a handful of mortar . . .”

Langley believed that some part of the machine had fouled the launching gear. It should have been a warning to him to abandon the catapult altogether and to set his machine on wheels as Pilcher had done with the *Hawk.* But ignoring the jibes and caustic comments, he grimly salvaged the aerodrome, repaired it, and on December 8 tried again. Again the catapult fouled the aerodrome; again it crashed ignominiously into the river; again Manly was pulled out, dripping but unhurt.

This second failure crushed even Langley’s stalwart spirit. The press of the country, reflecting the curious sadism with which crowds had greeted aeronautical failures since the days of the Montgolfiers, broke into a chorus of jeers.

But the cynicism of the critics was ill-timed. Just nine days after Langley’s second and final failure, on a bleak North Carolina beach, a powered airplane ran along a track, sailed into the air, wavered along for twelve seconds, and then settled onto the sand. While the world was still laughing at Langley, the Wright brothers had flown.

Langley was a great pioneer, but - like Maxim and Ader - he was too concerned with power plants and wing surfaces. It was not enough. The line of endeavor that finally resulted in victory did not go through these ground-based engineers; rather it went through those men who had not only mechanical ingenuity but also the skill, imagination, and daring to seek, first of all, control in the air through gliding experiments: through Lilienthal, Pilcher, and Chanute to the Wright brothers.

Where there are heroes, there are usually legends, but the story of the Wright brothers is straight and unadorned. Sons of a United Brethren bishop, Wilbur and Orville Wright grew up in Dayton in the days when the Republican Party, the veterans of the Grand Army of the Republic, and the various denominations of the Protestant church were the forces to be reckoned with in Ohio.

The Wrights were a close-knit family, five children in all, with Wilbur and Orville the two youngest sons. They were taught early in life to be patient, painstaking, and methodical where any kind of effort was concerned. These qualities, plus creativity and integrity, were to bring them success in a field where more highly educated men had tried and failed.

In later years, the Wrights traced their interest in aeronautics to a toy helicopter that their father had brought home in 1878 when Wilbur was eleven and Orville seven. "A toy so delicate," they wrote, "lasted but a short time in the hands of small boys, but its memory was abiding."

As they grew older, the brothers experimented with toy helicopters of their own. Tiring of this, they turned to kite flying as a hobby. This was just for sport; like most sons of ministers, they had to earn a living. Together they produced a small newspaper, worked for a while as printers, then turned to bicycle repairing and manufacturing and built up a small business that was to finance their ventures into aviation.

During the 1890s, they were fascinated by Lilienthal's work with gliders and shocked by his death. In 1899, having heard of Langley's experiments with steam-driven models, they wrote to the Smithsonian and asked for a list of the best books on flying. Among those recommended was

Octave Chanute's *Progress in Flying Machines,* which so impressed the brothers that Wilbur wrote a letter to Chanute that marked the start of a warm friendship. Throughout their trial-and-error years, his friendship and encouragement meant much to the lonely experimenters at Kitty Hawk.

Wilbur's initial letter to Chanute expressed dissatisfaction with the Lilienthal gliding technique and listed his own observations of bird flight. Buzzards, he pointed out, seemed to maintain their balance chiefly by twisting the dropped wing; the increased air pressure on that wing restored the bird to level flight.

This trick of wing warping, borrowed from the birds, was the first of two great Wright techniques that were to lead to much greater control of gliders - and ultimately, to airplanes. They built a box kite five feet long and found that by warping the wing tips through four controlling strings, they could make it responsive to control from the ground.

From the start, the Wrights realized that there were three essential problems facing anyone who aspired to sustained mechanical flight: wing shape and resulting lift; the whole tricky and relatively unexplored business of balance and control in the air; and the satisfactory application of power to a tested wing shape. They also knew that to solve the control problem they had to get up in the air and practice as Lilienthal had done. It was with these things in mind that they began the construction of their first glider.

This was a biplane with a horizontal elevator in front, no tail unit, and wing tips that could be warped by means of cords operated by the pilot or worked from the ground. It was, in essence, a big kite, and the brothers knew they would need a lot of wind to fly it. They wrote to the Weather Bureau in

Washington and were advised to try the beaches of North Carolina, where the winds swept in from the sea, and there was plenty of open space.

In October 1900, the brothers assembled this first glider at Kitty Hawk. Though they made a few glides in it, lying prone on the lower wing, there was seldom enough wind for man-carrying experiments, and they had to content themselves with flying it as a kite.

Consequently, when they came back the next summer with a second glider, they had enlarged both the wing area and the curvature of the wings. This time they set up a camp at Kill Devil Hills, four miles south of Kitty Hawk. During the summer, Octave Chanute, now nearly seventy, made the first of several visits to see what these young bicycle makers were up to. He gave them the praise and encouragement they needed. Their second glider had many faults, and Wilbur in particular was depressed. “Nobody will fly for a thousand years!” he said gloomily.

In their approach to the basic problems of flying, the Wrights differed sharply from some of their predecessors. Maxim and Langley had sought “automatic equilibrium” in their aircraft with the pilot in the relatively passive role of driver of the machine. The Wrights decided to abandon this concept and build an intentionally unstable - and hence much more “flyable” -airplane in which the pilot’s skill would be the key factor in control. Therefore, they gave the wings of their glider no dihedral but relied on wing warping for lateral control and on the lever-operated front elevator for longitudinal control.

In this second Wright glider, the wires that controlled the wing warping were attached to a cradle in which the operator lay. If he wished to bank to port, he swung his hips and the cradle to the left. This tightened the cable attached to the outer strut of the starboard wing, warping the rear edge of the wing downward, whereupon increased air pressure would make the wing rise. At the same time, an auxiliary cable would give the port wing an up-warp that tended to lower it. This simultaneous down-warp on one side and up-warp on the other was an important feature of the Wright system.

What the Wrights really learned that second summer on the windy beach was how much they still did not know about aerodynamics and how much of the information on which they had been basing their work was inaccurate. “Having set out with absolute faith in the existing scientific data,” they commented at a later date, “we were driven to doubt one thing after another, till finally, after two years of experiment, we cast it all aside.”

Back at Dayton, they built a small wind tunnel six feet long and sixteen inches square. In it they began testing dozens of miniature wings. Comparing the lift of square and oblong surfaces, they rediscovered the importance of the “aspect ratio” of a wing - that is, the ratio of its length to its width. They learned what Wenham had discovered in England four decades earlier - most of the lift derived from a cambered wing comes from the front portion, so a long narrow wing (high aspect ratio) provides more lift than a short, wide one. They also found errors in Lilienthal’s wind-pressure tables that they had been using.

They built their new knowledge into a third glider, which they constructed with wings that were less curved and had an aspect ratio of six to one instead of three to one. They kept the forward elevator but added fixed vertical fins at the rear. When they tested this glider in September 1902, it flew magnificently. In two months at Kitty Hawk, the brothers made almost 1,000 glides, some of them covering 600 feet or more.

The glider seemed to have only one serious fault. They were able to fly it in winds up to thirty-five miles per hour, but they found that sometimes when the wings were warped, the glider did not turn as desired. Instead of turning, the raised (down-warped) wing would pull back, and the machine would go sliding down into the sand with its dropped (up-warped) wing shooting out ahead. Or else, when they tried to correct this by reversing the warping, the lowered wing would hang behind, causing the machine to go into a sudden spin.

Orville realized, finally, that in such cases increased air resistance was retarding the down-warped wing, slowing it down instead of allowing it to advance in a banked turn. Something had to be done to maintain the bank and take the machine around smoothly. It was Orville who suggested that they make their fixed rear fins into a single movable rudder and Wilbur who thought of interconnecting the rudder controls with the warping controls so that air pressure against the rudder would automatically counteract the drag of the down-warped wing.

This linkage of warp and rudder controls was the second of the two great Wright techniques that were to lead to success in the air. With their forward elevator, the brothers could rise or descend. With wing warping and rudder synchronized, they could turn smoothly to left or right or restore horizontal balance. By the time they returned to Dayton in October 1902, they had solved the major problems of control in the air. Now all they needed was a power plant to keep them going.

Like Pilcher and Langley, the Wrights found no lightweight gasoline engine on the market. Building one would have been a formidable challenge for almost anyone except these engineering geniuses. The four-cylinder water-cooled power plant they designed and built weighed over 200 pounds. But by now the brothers were sure of their calculations as to power and load. They were confident that the twelve horsepower produced by their simple engine would move their new flying machine forward fast enough to allow the wings to lift it into the air.

In addition to their work with wing models in the wind tunnel, the Wrights had also made a careful study of propellers. Almost no serious research had been carried out in this field; even the action of marine propellers was little understood. The Wrights found this their most difficult job. “What seemed at first a simple problem,” they wrote later, “became more complex the longer we studied it.”

In the end, they designed and built propellers that were far more efficient than either Langley’s or Maxim’s. These were driven by a pair of long bicycle chains connected to the engine. To counteract torque - the twisting force of the revolving propellers - they made the propellers revolve in opposite directions.

In September 1903, the Wrights crated up their new machine and shipped it to Kitty Hawk. But a series of mishaps caused delays. The bicycle sprockets kept slipping on the propeller shafts. They solved this finally by melting tire cement into the threads. A tubular shaft cracked; Orville had to go back to Dayton to make a new set. Finally, in mid-December, they were ready.

It has been stated that in its historic first flight the Wrights’ machine was boosted by a crude catapult. This is not true;

it took off under its own power. Like its predecessors, the 1903 flying machine was fitted with skids for landings on soft sand. The launching device consisted of a light wooden rail about eight inches high. On this rail ran a little trolley with a crossbeam fixed to it. The skids were placed on the crossbeam, and a wire held the machine back until the engine was running at full throttle. When the wire was released, airplane and trolley went running smoothly down the track until - hopefully - the machine was airborne, leaving the trolley behind. The track, which was in sections, could be laid out on level ground, facing into the wind.

By December 12, preparations were complete, but the brothers had to wait two days for a sufficiently strong breeze. They tossed a coin to see which of them would make the first attempt, and Wilbur won. The breeze had freshened, and they decided that if they laid the track down the slope of a dune, their machine might gain enough speed to take off.

They had invited the people of the neighborhood to be on hand, but few braved the chilly December wind. And those who came were disappointed. With Wilbur at the controls, the flying machine went clattering down the track, rose too steeply, stalled, and fell back into the sand.

Three days later, with the damage repaired, they tried again. This time the wind was so strong that they laid the track on a level stretch of sand. Again they hoisted the prearranged signal to alert the Life-Saving Station down the beach, and five men arrived to help them move the heavy machine from its hangar.

By now, the wind was blowing more than twenty miles per hour, whipping the sand from the top of the dunes. Orville fitted himself, face down, into the cradle on the lower wing.

Slowly he brought the engine up to full power. The restraining wire was released. The trolley moved down the track, slowly, then faster, Wilbur running alongside. Near the end of the track, Orville raised the forward elevator. The machine rose. For twelve seconds, it surged forward against the wind. Then, 120 feet from the launching track, it settled back onto the sand. It was 10:35 a.m. on December 17, 1903. The ancient dream was a reality at last.

Three more flights were made that morning. The final one, with Wilbur at the controls, was an extraordinary effort lasting fifty-nine seconds. In that time, he covered 582 feet over land, but since it was bucking a stiff wind, the plane actually flew half a mile through the rushing air - a feat that was to remain unequaled by anyone except the Wrights themselves for almost four years.

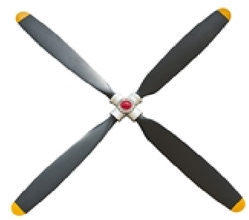
After the last flight, a gust of wind caught the machine, tumbled it over, and damaged it severely. However, the Wrights had their triumph. Lilienthal and Pilcher had glided; Maxim had left the ground; Ader had hopped. But as Orville wrote later, his flight was “the first in the history of the world in which a machine carrying a man had raised itself by its own power into the air in full flight, had sailed forward without reduction of speed, and had finally landed at a point as high as that from which it started.”

Back in Dayton, their father received a telegram from North Carolina, which, despite minor inaccuracies and telegrapher’s misspellings, summed it all up:

> SUCCESS FOUR FLIGHTS THURSDAY MORNING ALL AGAINST TWENTY ONE MILE WIND STARTED FROM LEVEL WITH ENGINE POWER ALONE AVERAGE SPEED THROUGH AIR THIRTY ONE MILES LONGEST 57 SECONDS INFORM PRESS HOME CHRISTMAS

ORVELLE WRIGHT

A message of fewer than forty words - but it marked a turning point in human history.



EXPLORE

In 1809-10 *Nicholson's journal,* a British technical periodical, published three articles "On Aerial Navigation." These articles marked the first solid step taken on a path that would lead, ninety-four years later, to powered flight with wings. The author, Sir George Cayley, had begun his aerial experiments in 1796, when, at the age of twenty-three, he built a helicopter device of cork and feathers. From then until his death in 1857 at the age of eighty-three, the problem of manned flight - and possible solutions to its many aspects - were never long out of his mind.

By 1809, Cayley had designed, built, and flown several small fixed-wing gliders - and one full-size but unmanned one – that were revolutionary departures from the flapping-wing devices favored by his predecessors. The conclusions he drew from his experiments regarding wing surfaces, control systems, aerial stability, and air pressure were incorporated in his 1809 essay. Often reprinted and widely read throughout the nineteenth century, Cayley's study of aerodynamics had an enormous influence on later inventors.

The brilliant Yorkshire baronet did not rest with this achievement but continued to change and develop his fixed-wing glider designs from 1804 to 1853. Nor did he confine his research to airplanes.

In 1816, he published the first of four papers on airships, proposing an elongated dirigible powered by steam-driven propellers. More clearly than any of his contemporaries, he realized that the larger the dirigible, the larger would be the percentage of its total lift available for carrying useful loads. And, in 1843, still inventing at seventy, Cayley designed a helicopter whose rotating blades could be converted into fixed wings for forward flight.

The lack of a lightweight engine was one barrier to Cayley's dream of achieving powered flight, but no serious student of aerodynamics who followed him could ignore his pioneering work.

Aerial Steam Carriage

George Cayley's suggestion for a fixed-wing airplane influenced William Samuel Henson, the English lace manufacturer and aviation enthusiast who in 1842 applied for a patent on a "Locomotive Apparatus . . . for conveying Letters, Goods, and Passengers from Place to Place through the Air . . ."

Henson's monoplane contained one far-sighted innovation: twin pusher propellers to be powered by a steam engine enclosed in a fuselage below the wings. He had already tested his design with clockwork-powered models, but the inadequacy of his steam engine plagued his further experiments. Working with a fellow industrialist and engineer, John Stringfellow, Henson built and tested a large model of the aerial steam carriage.

To finance the building of this giant steam-powered airplane, Henson tried to organize an "Aerial Transit Company" in 1843. Many widely-published illustrations showed the *Ariel* - as Henson called his machine - in effortless flight over China, India, and the pyramids of Egypt. Such grandiose and premature announcements subjected the inventor to great ridicule when his model failed to accomplish anything more than descending glides after leaving the inclined ramp from which it was launched. Although his scheme collapsed and he abandoned the project, the publicity did much to condition even a skeptical and indifferent public to the idea of fixed-wing, propeller-driven aircraft.

A smaller model built by Stringfellow in 1848 was also unsuccessfu, and the locomotive in the sky remained a dream recorded in fading photographs and models that became dusty museum curios.

French Progress

A decade after the failure of Stringfellow's model airplane in 1848, two French seamen helped reassert their country's lead, first established by the Montgolfiers, in the race to conquer the air. One of them, Felix Du Temple, based his work on scientific knowledge and scored two notable firsts; the other, Jean-Marie Le Bris, took a bold, empirical approach to the problem - and had less luck.

Before patenting a design for an airplane on May 2, 1857, Du Temple tested a scale model that rose into the air under its own power - the first airplane device ever to do so. Its propeller stopped in mid-air, but its wings, acting as a parachute, sustained the craft until in the words of Du Temple's brother, "The airplane settled to the ground on its wheels as a bird flutters down to land on its claws." A full-sized machine, built by Du Temple in 1874 and launched down a ramp, briefly carried a sailor through the air.

The seemingly effortless soaring of the albatross had fascinated Le Bris, Du Temple's brave contemporary, during his long years at sea, and the man-carrying glider he built in 1856, not surprisingly, took the shape of a giant bird with a wingspan of fifty feet. A system of pulleys and levers adjusted the wings to various angles of incidence. Launched from a horse-drawn cart, the device completed one short glide over a quarry. On a subsequent trial, Le Bris lost control of his vehicle and fell, breaking a leg. Ten years later, he built another glider, but when it was destroyed during a preliminary, unmanned test, Le Bris gave up his courageous attempts to imitate the birds. Later, at the age of sixty-two, he served in the Franco-Prussian war. In 1872, having survived the perils of the sea, the air, and land warfare, Le Bris was waylaid and killed by highwaymen.

When a hip disease prevented him from following his father's naval career, twenty-year-old Alphonse Pénaud turned to aviation in 1870 and began experimenting with model airplanes powered by twisted rubber bands. One of his model "planophores" was flown publicly in Paris on August 18, 1871. With its raised wing tips and negatively positioned tail plane incorporating a vertical rudder, it achieved inherent stability. In 1876, Pénaud patented the design for an amphibious airplane with retractable wheels, but with no suitable engine to drive its twin propellers, it was never built. Four years later, the depressed inventor committed suicide at the age of thirty.

Ornithopters and Helicopters

Despite the contributions of men like Cayley, Henson, and Pénaud, optimistic dreamers continued experimenting with ornithopters. Flapping-wing devices had been discredited by G. A. Borelli in 1680, but - though failure was predictable - patents were still being granted for such machines two centuries later.

In 1784, two Frenchmen - Christian de Launoy, a naturalist, and Bienvenu, a mechanic - had demonstrated the lifting possibilities of two pairs of contra-rotating steel blades made to spin about a vertical shaft by releasing a tightly-wound cord. This deceptively simple device bore the germ of the helicopter.

German philosopher and physician Jacob Degen (also known as Jakob Schegk) used a balloon for lift during numerous unsuccessful tests of his flapping-wing device at Paris and Vienna from 1806 to 1817.

About 1825, an English carpenter named David Mayer built a full-sized, man-powered helicopter and unblushingly described its failure to rise above the ground as “very flattering, if not perfectly successful.” In 1828, Italian cobbler Vittorio Sarti’s 1828 design for a helicopter had twin three-bladed propellers, a sail and a balancing rod to maintain the vessel’s equilibrium. Another Englishman, W. H. Phillips flew a model, steam-powered helicopter in 1842, and subsequent inventors never lost sight of this potentially profitable line of aerial experimentation.

Some Lessons From Nature

Contributions to aviation knowledge sometimes came from unexpected sources, and a new idea helpful to aviation sometimes also led to technological advances in other fields.

Hoping to find the answer to heavier-than-air flight by studying the motions of birds, Alphonse Pénaud, about 1873, proposed using a new method of instantaneous photography to record the actions of birds’ wings in flight. A contemporary French physiologist, Etienne Jules Marey, had already embarked on a lifetime’s study of muscular movement in men and animals. Putting Pénaud’s idea into practice, Marey illustrated his 1873 treatise *Animal Mechanism* with rapid-sequence photographs of birds that corrected centuries of misconceptions based on fallible human vision, and later, students of aviation turned repeatedly to his pathfinding work.

Marey himself went on to the study of aerodynamics, and in the 1890s constructed a wind tunnel. He photographed the action of wind against various shapes, and his methods, in time, contributed to the start of a brand-new field - motion pictures.

Fictional Flight

Slow scientific progress has never hampered visionary writers who through the ages have gone beyond the inventors to create their own flying machines. Even with successful aviation almost in sight, late-nineteenth-century authors continued to expand on the popular theme of flight, and none did so more persuasively than Jules Verne, the French master of science fiction.

A diligent researcher as well as a prolific writer, Verne spiced his adventure stories with enough technical details to make them sound almost convincing even today. His first great success, *Five Weeks in a Balloon,* published in 1863, capitalized on current interest in the attempt to achieve dirigibility. However, this was a comparatively tame effort for the seemingly clairvoyant Verne, who went on to envision helicopters, artificial satellites, and space capsules.

His 1865 tale, *From the Earth to the Moon,* took three men prophetically launched in a conical projectile from the Florida coast through weightlessness into orbit around the earth’s satellite. Five years later, he rescued his heroes from permanent oblivion in a sequel, *Around the Moon,* which brought the space vehicle back to earth, where it was retrieved after landing in the ocean.

Mastering the Glider

Most of the men working on the problem of winged flight concentrated on the design and construction of large, unwieldy flying chariots that they hoped to force into the air simply by adding a suitable lightweight engine. It was rather like attaching wings to an automobile in the belief that it would become airborne if driven fast enough.

Only the more clear-sighted aerial pioneers understood that there was another, closely related problem: control in the air. The first man to do anything about this problem was Otto Lilienthal, the pioneer German airman who blazed a new trail in the sky in 1891 by building and flying the first of several successful gliders.

Lilienthal’s death in an 1896 gliding accident shocked the aviation world, but by then there were others to carry on his important work. A young Scottish engineer, Percy Pilcher, perhaps Lilienthal’s greatest disciple, was on the point of adding power to his gliders when in 1899, he, too, met death in an aerial mishap.

The gliding career of John J. Montgomery, a science teacher at Santa Clara College in California, also ended in tragedy. Montgomery is said to have experimented with gliders on his family’s ranch near San Diego about 1883. Twenty years later, still interested in aviation, the Californian proposed launching manned gliders from a balloon. After several trials of this method, an assistant, Daniel Maloney, died in the crash of a Montgomery glider on July 18, 1905. In 1911, Montgomery himself was killed when one of his later models was upset on takeoff.

Powered Machines

Several ambitious aerial projects of the late nineteenth and early twentieth century created an erroneous impression that the problem of winged flight was all but solved. The notion was sometimes fostered by the prestige of the inventor himself or by the implied endorsement of government financing as in the case of Samuel Pierpont

Langley. Working partly with War Department funds, the eminent astronomer and Secretary of the Smithsonian Institution built a full-sized “aerodrome” that failed miserably in two 1903 trials.

Eleven years later, New Yorker Glenn Hammond Curtiss, a bicycle racer and builder who was a rival of Orville and Wilbur Wright, secretly modified the machine and retested it with limited success. The Smithsonian announced that Langley’s invention had been the first airplane capable of sustained, man-carrying free flight, an untenable position it maintained until 1942.

On the Brink of Success

Wilbur Wright was only thirty-two in 1899 when he and his brother Orville, younger by four years, began reading everything available on aviation. Intuitively scientific in method, they worked out new formulas where they found the old ones inadequate. With unflagging patience, they tested each new theory in three seasons of gliding experiments at Kitty Hawk.

By the end of October 1902, they knew the answers to most of the problems that had prevented men from flying with wings and only needed power to convert their gliders into airplanes. Weary from their two-month outing in North Carolina, they returned to Dayton, Ohio. As they set about building a power plant for their airplane during that winter and spring, the routine work of making bicycles for the summer trade dropped forever from their minds. The two brothers were standing on the threshold of history.

4

OFF WE GO

In many ways, of all the breathless aviation decades that have passed since Kitty Hawk, the first remains the most vivid. The Wrights' era began in obscurity and silence, and perhaps in the cold statistics of aeronautical achievement it had the least to offer. But in adventure and excitement, color and romantic episode, it stands alone.

One reason may be that while the number of people involved was small, the extent of their daring seemed limitless. In the perilous air decade before the First World War, to leave the comfortable earth on fragile wings demanded a blend of courage and curiosity, dedication and daring, fanaticism and fatalism. Regardless of nationality, these early fliers seemed linked as a fraternity accepting a common challenge. Most of the small band knew one another. Fierce rivalries flared among them, but there were few jealousies and little pettiness. When one of them failed and died, as many did, each felt the loss of a fellow adventurer who could never be replaced.

Perhaps it was because all of them faced a single great adversary, and all of them knew it. From the beginning, many noble themes have been woven into the fabric of flying, including man against gravity, man against distance, and man against time. But the basic theme of the early years was as old as the oldest flying legend: man against death. Each of the first fliers understood that the air was an alien element into which man ventured only at his peril. Far from shrinking from the challenge, they welcomed it. They played a dangerous game for the excitement of it - and accepted without bitterness the consequences of losing.

The beginnings of that decade were strangely quiet. In his triumphant telegram of December 17, 1903, Orville Wright requested his father in Dayton to "inform press" that powered flight with wings was achieved at last. Before

Bishop Wright could do so, a Norfolk, Virginia, newspaper published a fragmentary and misleading account based on a pirated copy of the telegram. To counteract further garbled reports, the Wrights issued a statement to the Associated Press on January 5, 1904. However, the nation’s press was skeptical and unmoved. Editors were weary of claims that had proved false and of flying machines that did not fly. Consequently, those papers that did print the dispatch ran it without comment, and news of the greatest aerial achievement of all times was greeted with appalling indifference.

The apathy was to last, incredibly, for more than four years. So little known was the Wrights’ accomplishment that in October 1906, when the irrepressible Alberto Santos-Dumont wavered off the soil of France, standing bolt upright in a clumsy tailless biplane, he was convinced that he was the first man in history to fly with powered wings.

The Wrights are popularly believed to have been secretive and averse to publicity. This might have been the case in later years when they felt that competitors were trying to steal their invention, but it was not so at first. If anything, they were anxious to show the world what they had done. In the spring of 1904, they invited the press to watch a demonstration of a new and improved version of their flying machine.

They were now using a cow pasture near Dayton for their work. Unfortunately, on the day the press showed up, a combination of unfavorable wind conditions and engine trouble made flying impossible. The next day, when a few persistent reporters came back, the engine failed on takeoff, and the machine sat down abruptly. After that, the press lost interest.

The Wrights stoically accepted the fact that they had more work to do. They were off the ground, but just barely. The low power and unreliability of their engine made them resort to an assisted takeoff, using a catapult device consisting of a tall derrick with a weight attached to their machine by a long rope. Control in the air was still primitive and difficult, and it was not until September 20 that Wilbur was able to make a circular flight. On November 9, he celebrated the election of Theodore Roosevelt by circling the field four times in a three-mile flight that lasted a little over five minutes.

The next year - 1905 - the Wrights designed and built another larger and improved flying machine that proved capable of turning, banking, doing figures of eight, and flying for distances that were astonishing. The problem of stalling on tight turns in their restricted practice field was overcome when the brothers learned to put the nose down and pick up additional speed, which gave greater controllability. They also unlinked their rudder controls from their wing-warping controls, thereby gaining much greater flexibility in their handling of the airplane. By the end of the summer, they were making flights that ended only when their fuel was exhausted - as on October 5 when Wilbur flew for more than thirty-eight minutes and covered more than twenty-four miles.

At this point, almost two years after their initial success, the Wrights were still the only human beings who had achieved powered flight with wings. Yet they still failed to receive the acclaim and encouragement that their accomplishment should have brought them. In January 1905, the brothers had offered their invention and scientific knowledge to the War Department, which flatly rejected three separate overtures without even bothering to investigate. Discouraged by the cold reception and by troubles with the

Patent Office, Orville and Wilbur settled on a policy of secrecy to ward off costly litigation with potential imitators. In 1906, they built no new planes and for two and one-half years did not even fly.

Hoping to find more interest among European governments, the Wrights crated one of their machines and took it abroad in 1907. No one there, however, would agree to pay their asking price of $250,000 for a machine that they were unwilling to demonstrate until a contract had been signed. As a result, the brothers went home, leaving the flying machine sitting forlornly in its crate at Le Havre.

By this time, the work of the Wrights had been the subject of considerable discussion, debate, and even imitation among European aeronautical pioneers, particularly in France. Word of their activities crossed the ocean as early as 1902 when Octave Chanute, that tireless disseminator of information, began a correspondence with Captain Ferdinand Ferber of the French army. Ferber had been making and testing gliders since 1899, following, without much success, Lilienthal's example. When Chanute gave him some information about the Wrights' experiments, he started building "Wright-type" gliders. Since the specifications Chanute sent were not complete, Ferber's imitations were failures, which led him to conclude - erroneously - that the Wrights were not making significant progress.

In April 1903, Chanute came in person to lecture at the Aéro Club in Paris. What was intended to be no more than a routine progress report became a turning point in the development of European aviation. The old man told of his own gliding experiments and described the Wrights' 1902 glider in considerable detail, not omitting the key fact that rudder and wing-warping controls were operated simultaneously. By these revelations, Chanute was handing French fliers a blueprint for success, and his words spurred a few of them to new efforts.

Of these, the most important were Robert Esnault-Pelterie, a gifted engineer, and Ernest Archdeacon, a wealthy automobile and balloon enthusiast. These men had already encouraged another engineer, Léon Levavasseur, to build a powered, birdlike, single-wing airplane, which, though it did not fly, pointed the way to later successful monoplanes. In 1904, to test the Wrights' design, Esnault-Pelterie attempted to copy their 1902 machine, and Archdeacon also built a "Wright-type" glider. Lacking complete specifications, they were unsuccessful and asserted that the reports of the Wrights' achievements were unfounded.

Esnault-Pelterie also came to the conclusion that wing warping was unsatisfactory and dangerous. This led him to the invention of the aileron. He fitted two "independent horizontal rudders" to the wing tips of a second "Wright-type" glider that he constructed in 1904, but this glider had no great success because of other shortcomings.

By now, new names and faces were appearing on the French aviation scene. An energetic manufacturer of automobile headlights, Louis Blériot, began to "occupy himself passionately with problems of aviation." Someone had conceived the idea of mounting a glider on floats and towing it behind a fast motorboat. So Blériot and Archdeacon ordered a pair of float gliders from a young architectural student who was also a glider pilot, Gabriel Voisin.

Voisin's float gliders kept the forward elevator and biplane configuration of the Wrights, but they also incorporated Hargrave's box-kite principle with a tail unit consisting of two large cells. This, again, reflected European preoccupation with built-in stability as opposed to the Wrights' emphasis on "flyability." These gliders had only limited success, but their design was most influential where early European biplanes were concerned - especially since Voisin and his brother Charles became, before long, the first professional airplane builders. Among the early buyers of their biplanes were two men whose names were soon to become famous, Henri Farman and Léon Delagrange.

In 1906, having built and flown twelve small dirigibles, Brazilian coffee heir Alberto Santos-Dumont turned his attention to heavier-than-air flight. In building his airplane, he set the box-kite wings at a pronounced dihedral, relying for power on an Antoinette engine made by Levavasseur and for control on another box-kite cell placed so far out in front that the machine - in such flight as it achieved - looked as if it were flying tail first.

After testing this creation, suspending it under one of his dirigibles, Santos-Dumont set out to capture the Archdeacon prize of 3,000 francs for the first person to fly twenty-five meters (about eighty feet). On October 23, 1906, at Bagatelle in Paris, he managed to leave the ground for nearly two hundred feet; two weeks later, on November 12, again at Bagatelle, he flew 722 feet to win the French Aéro Club's prize for the first flight of 100 meters. He thus achieved the first heavier-than-air, powered, man-carrying flights in the Old World. All Europe was electrified. Almost no one believed that 4,000 miles away, in Ohio, the air had already been conquered.

In 1907, having had little luck with biplanes, Blériot decided to experiment with powered monoplanes. That year he built three, all different. The third one - a direct ancestor of the monoplane as we know it today - had large forward wings, an enclosed fuselage, and tail unit comprised of a rudder and combined elevator and ailerons (“elevons”). It made five short flights before it crashed on landing.

In America, the Wrights were finally facing some homegrown competition. A young motorcycle racer named Glenn Curtiss had become interested in aeronautics. Lean, adventurous, obsessed with engines and speed, he typified the breed of men that was emerging to share in the conquest of the skies.

When he was not setting motorcycle speed records, Curtiss was building lightweight engines for Thomas Baldwin’s dirigibles. So successful were these that Curtiss attracted the attention of Alexander Graham Bell, the aging inventor of the telephone. In October 1907, Bell, Curtiss, and others formed the Aerial Experiment Association and began building airplanes with features borrowed from both the Wrights and the Voisins.

Their third airplane, the *June Bug*, attracted far more attention and acclaim than the Wrights had ever received. On July 4, 1908, several hundred people at Hammondsport, New York watched as Curtiss flew the plane more than a mile. This was the first wholly public flight in America.

The *June Bug* was fitted with wing-tip ailerons. This soon brought Curtiss into historic conflict with the Wright brothers who considered any form of movable wing section to be an extension of their wing-warping idea. Though previously generous in giving help to any amateur flier who asked for it, the Wrights sued Curtiss for infringing their patent. The issue, bitterly fought through the courts, was finally settled in favor of the Wrights.

Meantime, in England, such pioneers as S. F. Cody, J. W. Dunne, and A. V. Roe were struggling to lift themselves into the air. Cody, an American-born adventurer who fascinated the British by dressing like an Arizona sheriff, built a biplane for the War Office that was called officially *British Army Aeroplane No. 1*. At Farnborough, on October 16, 1908, he made the first powered flight in Great Britain. He kept on flying until 1913, when he was killed.

Like Cody, Dunne was employed at the Government Balloon Factory at Farnborough, designing and building flying machines. He was something of a mystic who later wrote a best seller called *An Experiment with Time.* In 1907, he added an engine to a revolutionary tailless biplane glider with swept-back wings, a configuration he thought might solve the elusive goal of built-in stability. Lack of an adequate power plant held him back and through 1908 he made little more than powered hops.

A. V. Roe, a former Merchant Navy officer, was experimenting with both biplanes and triplanes. He crashed so often that, at one point, he was prosecuted as a menace to public safety. He went on to found the Avro Company, whose planes distinguished themselves in both World Wars.

The important year 1908 saw the complete vindication of the Wrights both at home and abroad. In February, the U.S. Army finally accepted their bid to build an airplane for military use. The machine, said the Army, would have to be able to carry two men and fuel for 125 miles and fly at least ten miles nonstop at an average speed of forty miles per hour. The next month, the brothers sold their French patent rights to a syndicate for $100,000. This meant that Wilbur would have to go to France to demonstrate the machine that was still crated there while Orville worked at home to carry out the commitment to the United States government.

Since neither brother had flown for more than two years, they went back to Kitty Hawk to regain their skill with their slightly-modified 1905 machine. The changes allowed them to fly sitting up, instead of the uncomfortable prone position that had minimized air resistance but had given them painful cricks in the neck. They were still using a catapult device for launching and, unlike Curtiss and the European pioneers, still preferred skids to wheels.

In May, Wilbur sailed for France where he was met with unconcealed skepticism from both the public and the press. But on August 8, when his machine slid easily down its track and into the air, the critics were silenced, and European fliers were astounded. Where the Europeans had been forcing their clumsy machines to become grudgingly airborne through engine power, here was this soft-spoken American darting and soaring like a bird. “Marvelous!” cried the press. “Glorious! Sensational!” “We’re beaten,” confessed Leon Delagrange. “We don’t even exist.” The chorus of cheers went on and on while Wilbur set record after record. Blériot conceded instantly that the Wright biplane was far superior to any European machine - a generous admission from a man now wedded to monoplanes. Looking to the future, an Englishman, Major B. F. S. Baden-Powell, made a memorable pronouncement: “That Wilbur Wright is in possession of a power which controls the fate of nations is beyond dispute.”

During the rest of the year, Wilbur stayed in France, revolutionizing European aviation and captivating everyone with his modesty, good humor, and willingness to share his knowledge and skill. He tried - not always successfully - to avoid banquets and speechmaking. “I only know,” he said on one such occasion, “of one bird, the parrot, that can talk, and it doesn’t fly very high.”

At home, Orville finally broke through the barrier of governmental and public apathy that had surrounded the Wrights' remarkable accomplishments. His series of test flights for the Army at Fort Myer, Virginia, dumbfounded official Washington. On September 3, flying solo, Orville Wright demonstrated his new two-seater with brilliant success, banking effortlessly around the parade ground while the spectators below "went crazy." In the following days, he repeatedly broke his own endurance records. But on the last day of the test series, September 17, tragedy overtook him. During a flight with a passenger, Lieutenant Thomas Selfridge, a twenty-six-year-old West Pointer who had worked with Curtiss and Bell in the Aerial Experiment Association, a cracked propeller led to a chain reaction of mechanical failures, and the plane crashed. Orville was badly injured, and Selfridge was killed, the first man to lose his life in an airplane. Within ten months, however, Orville was flying again at Fort Myer, and by the end of July 1909, he completed the tests, demonstrating a new machine that easily met the Army's requirements.

This year, 1909, was even more memorable than 1908. Dr. Henry W. Walden, a Massachusetts dentist and inventor, designed, built, and flew the first American monoplane. J. T. C. Moore-Brabazon became the first British subject to fly in Britain. First flights were made in Canada, Austria, Sweden, Rumania, Russia, Turkey, and Portugal, and Europe continued to heap honors on the Wright brothers. In October, the Crown Prince of Germany presented a diamond and ruby stickpin to Orville after he had made the first flight of over 1,000 feet in elevation. Returning to America, Wilbur thrilled over a million New Yorkers with their first sight of an airplane when he flew up the Hudson River from Governors Island to Grant's Tomb during the Hudson-Fulton celebration. But, earlier in the year, the first flight across the English Channel had already given aviation a tremendous boost.

The *Daily Mail* of London had offered a prize of £1,000 to the first aviator to fly the Channel, and a half-English, half-French airman, Hubert Latham, set out to capture it. Latham was a chain smoking daredevil who had taken up flying because he feared he had tuberculosis - and preferred a sudden death (he said) to a lingering one. Strangely, his health seemed to improve with every crash. (Ironically, he did not die in a plane crash. Three years later, at age twenty-nine, Latham was killed by a wounded buffalo while he was big game hunting in Africa.)

Latham had made his first Channel attempt from Sangatte, not far from Calais, on July 19. His slender Antoinette monoplane, designed and built by French powerplant engineer and inventor Léon Levavasseur, had flap-type ailerons and a fifty-horsepower engine. This engine failed when Latham was about a third of the way across the Channel. Fortunately, his Antoinette floated nicely, and Latham, calmly puffing a long cigarette, patiently waited for rescue by a French destroyer that had been ordered to trail him. Levavasseur, a more-than-interested spectator, and immediately ordered that another plane be made ready.

After Latham’s failure, Louis Blériot decided to make the same attempt in his latest monoplane. He set up headquarters at Les Baraques, a few miles nearer Calais. Bad weather held him up until Latham had time to return with his new Antoinette to his base at Sangatte.

Now began a nerve-racking vigil in which each flier kept one eye on the weather and the other on his rival. On Saturday night, July 24, Latham went to bed leaving strict orders to be called at 3:00 a.m. if the wind dropped. The wind did drop, but Latham's friends let him sleep serenely on.

Louis Blériot, however, was wakeful. A burn on his foot was troubling him. At 2:30 a.m., noticing that the wind had slackened somewhat, he climbed into an automobile, drove to the field where his plane was sheltered in a tent, and had it brought out and made ready. For the next half hour, he hobbled around on his crutch, watching the night sky. At 3:30, in the cool, pre-dawn grayness, he took off and flew a couple of circles to test his three-cylinder, twenty-five-horsepower Anzani engine.

This engine had a tendency to overheat. Now it seemed to be running smoothly, so Blériot landed before the overheating process could begin. "Replace the fuel," he said to his mechanic. "In ten minutes I start for England."

It was 4:35 a.m. when he took off and pointed his tractor propeller out over the choppy Channel. Latham's friends, watching from a distance, had assumed that Blériot was merely making practice hops. When they saw him head out to sea, they rushed to wake their airman, who struggled into his flying clothes and had his Antoinette brought out. But, by now, the wind was too strong, and Latham could not take off.

Blériot had no compass, no instruments of any kind. He sat hunched over the controls, the air stream from the propeller whipping past his helmeted head. On he flew, holding to what he hoped was the right course until he saw the great chalk face of Shakespeare Cliff rising from the sea. A cross wind had pushed him to the east; he was nearer Deal than Dover. He swooped down to a rough landing near Dover Castle, nearly at the spot where Blanchard and Jeffries had started their cross-Channel balloon flight in 1785. Blériot had covered the twenty miles in thirty-seven minutes.

Two days later, Latham made his second attempt, but his engine failed again, and he crashed into the sea less than a mile from the English coast, this time cutting his face rather badly.

Blériot was lionized and feted; Latham was hailed as a gallant and courageous loser. Certainly France was now far ahead in the game, with airplane builders like the Voisins, Henri Farman, Levavasseur, Esnault-Pelterie, and Blériot, and such daring airmen as Latham, Delagrange, Ferber, Eugène Lefebvre, Louis Paulhan, and others. Santos-Dumont was also still active; his latest aircraft was the smallest monoplane yet. Christened the *Demoiselle,* it had a wingspan of only eighteen feet and a two-cylinder engine. Some wag remarked that it looked like an infuriated grasshopper, but Santos-Dumont flew it with his customary skill and gusto.

If a date can be selected when this wonderful new sport of flying came of age, it was probably the fourth week of August 1909, when the first great air meet was held at Reims, France. The Wrights were not there, but some of their aircraft were - and virtually every other aviation pioneer.

It was a colorful and exciting week. The first day the field was so soggy that some of the fliers could not get off the ground. Those who did, took off with great gobs of mud clinging to their wheels.

Blériot covered one leg of the speed course and was forced down with grit in his carburetor. Latham, his face still scarred from his Channel plunge, flew airplane *No. 13* and also had engine trouble. Lefebvre, the chief pilot for the French Wright Company, recklessly braved a stiff wind to circle the six-and-a-quarter-mile course in nine minutes.

Day after day, records were set and then broken. Piloting a new biplane of his own design, Henri Farman won the endurance prize with a flight of more than three hours. He also thrilled the crowd by carrying two passengers. This airplane combined many of the best features of both the Wright and Voisin types and became very popular.

Glenn Curtiss also had a new biplane, derived from his famous *June Bug.* Brown-faced and intense, he captured for America the speed prize offered by New York *Herald* publisher James Gordon Bennett, averaging forty-three miles per hour. Latham flew as high as he could and claimed the dizzy altitude of 1,200 feet. The judges awarded him the prize, but said he had been no higher than 500 feet.

No one was killed, though there were close calls. On the last day, Delagrange's propeller flew apart in mid-air, and he was lucky to make a forced landing without serious injury. Henri Fournier wrecked his airplane but walked away from it as did Louis Bréguet. Blériot was badly burned when trying to set a new speed record, a fuel line broke and caught fire, and the gas tank exploded.

Despite such mishaps, there was a spirit of excitement, adventure, freshness, and enthusiasm that people long remembered. Before Reims the practicality of flight was in doubt; after Reims it was a demonstrated fact.

Contemporary reports of the Reims meet speak constantly of "aviator's luck" or of the "charmed lives" of the fliers. With the very first balloonists, a kind of beginner's luck did seem to prevail. Between 1891 when Lilienthal's first glider flew and the Reims meet, only four men had been killed in heavier-than-air accidents - three of them in gliders. But with no safety devices of any kind, not even seat belts, this record could not long be maintained.

Lefebvre became the first person to die while piloting a powered airplane. He was killed in a Wright machine soon after Reims. Ferber died two weeks later in a Voisin crash. Within a few months, flying a Blériot, Delagrange fell to his death. Altogether, in 1910, thirty-two men were killed - grim notice that the air would not easily forgive man for conquering it.

Even so, 1910 was another year of progress. In January, the first international air meet in the United States was held at Dominguez Field, Los Angeles. The setting was 6,000 miles from Reims, but the cast of characters was familiar. Glenn Curtiss, this time earning a passenger, topped the speed that had won him the Gordon Bennett trophy in France and set a new world's record of fifty-five miles per hour. Louis Paulhan, a French pilot soon to become world-famous, set an altitude record of 4,165 feet. People came from hundreds of miles to view such marvels.

The London *Daily Mail* shrewdly realized that the glamor of flying could be converted into paying circulation, a theory amply proven by Blériot's Channel flight in pursuit of a *Mail* prize. As early as 1906, it had offered a prize of £10,000 to the first person to fly from London to Manchester, a distance of almost 200 miles, in twenty-four hours. Not to be outdone, one competitor made its own offer: £10,000 to the first person to fly to Mars and back within a week; another gaily offered £10,000,000 to anyone who could fly five miles out from London and back again. But the *Mail's,* offer was a serious one, and after the Reims air show, it was inevitable that within weeks, or months, some of the birdmen, as they were beginning to be called, would be after it.

The first long-distance, cross-country airplane race in history took place in England in April 1910. It was followed breathlessly by hundreds of thousands of people, and, even more than Blériot's flight, served notice upon the world that aviation was no longer a dream or a madman's sport but a new and revolutionary form of travel.

At dawn on April 23, a young Englishman, Claude Grahame-White, set out from Park Royal in an effort to win the *Daily Mail* prize. His Farman biplane was powered by a Gnome rotary engine producing fifty horsepower with a pusher propeller. Grahame-White flew for two hours and landed, half-frozen, at Rugby, a record-breaking cross-country flight of eighty-five miles.

After refueling and thawing himself out, he took off again and got as far as Lichfield, more than halfway to Manchester, before a combination of gusty winds and engine trouble forced him to abandon his attempt to beat the twenty-four-hour deadline. Next day, the wind flipped his Farman over, damaged it, and the disappointed airman had to take it back to his base near London for repairs.

By Wednesday, April 27, Grahame-White was ready for another attempt. But now a foreign competitor had appeared in the person of Louis Paulhan, fresh from his triumph at the Dominguez meet in Los Angeles. Paulhan, who also flew a Farman, had had it shipped to Hendon, near London. All that day, he was busy assembling it, with the help of Henri Farman himself. At 5:00 p.m., it was ready, and without even a trial flight the Frenchman announced that he intended to take off and fly as far as he could before darkness set in. This he proceeded to do, following a special train chartered to guide him, and he got as far as Lichfield before the long twilight ended.

Grahame-White, meanwhile, having reached the conclusion that it was too windy to fly, had settled himself for an afternoon nap. When word came at 6:00 p.m. that Paulhan had started, he flung himself into his Farman, took off despite the wind, and flew some sixty miles before darkness forced him down. This left him still fifty-seven miles behind his rival, and in a frantic effort to close the gap he decided to risk an almost unheard-of thing: a night takeoff. At 2:30 the next morning, despite his friends' protests, he soared away from a field feebly illuminated by automobile headlights and vanished into the dark.

By this time, the whole country – and much of the world - was wild with excitement. On the route to Manchester, people sat up all night hoping to catch a glimpse of either flier. French and British newspapers put out extras. Bulletins were posted in New York and Berlin.

Grahame-White, who knew that a landing in the dark could be fatal, was having his problems. "A great difficulty presented itself in not knowing in the darkness whether I was ascending or not . . . but I soon became accustomed to watching closely the movements of my elevating plane, which was silhouetted before me against the sky. . . . On I flew. The weirdness of the sensation can scarcely be described. I was alone in the darkness with the roar of my engine in my ears."

A friend had agreed to shine his automobile headlights on the wall of an inn on his line of flight. Grahame-White managed to spot this primitive air beacon and then picked up a freight train and followed it into Rugby.

When the Englishman landed, he was only a dozen miles behind Paulhan, who had just left Lichfield. But no one appeared to help him in his struggle against a fierce wind on the ground, and his Farman was nearly wrecked for the second time. Meanwhile, Paulhan flew straight to Manchester where a huge crowd cheered him deliriously.

The growing list of accomplishments in the air made for an era of wonderful achievement and sometimes wonderful nonsense. Backyard airplane builders began to appear everywhere, putting together weird-looking contraptions, few of which ever left the ground.

In England, Moore-Brabazon, holder of Pilot Certificate No. 1, took a pig for a ride in order to put an end to the old ironic expression of unlikelihood, "when a pig can fly." In France, the first women pilots were publicized. In America, barnacled admirals stirred slightly when a young civilian pilot, Eugene Ely, flew his Curtiss off the deck of a cruiser at Hampton Roads, Virginia, on November 14, 1910. Two months later, he performed the considerably more difficult feat of landing on a wooden platform built over the afterdeck of the USS *Pennsylvania.* Curtiss himself continued to make news, flying down the Hudson River from Albany to New York to win a prize of $10,000 offered by the New York *World.*

Engines and airframes improved, and so did performance. At Boston Harbor in September 1910, a huge crowd watched British and American fliers compete for prizes totaling almost $100,000. England's Grahame-White won the speed race - and $10,000 - with a flight around Boston Light. Later, he took his Farman to Washington and astonished the populace by landing and taking off from a street alongside the White House.

Both Curtiss and the Wrights by now had established flying schools, and the number of pilots was slowly rising. Future generals and admirals were learning to fly, including Benjamin D. Foulois, Frank Lahm, Thomas Milling, H. H. Arnold, John H. Towers, and Marc Mitscher. Harry Houdini, the renowned magician, was one of the first showmen to exploit the publicity value of airplanes. In 1910, he was flying his own Voisin from one theatrical engagement to another. In October of that same year in St. Louis, ex-President Theodore Roosevelt eluded his aides and went for an aerial ride, alarming his pilot, Arch Hoxsey, by refusing to hold on - he was too busy waving with both hands.

This was also the beginning of an age of daredeviltry in the skies, when a handful of young adventurers thrilled crowds by performing seemingly impossible stunts in their flimsy kites. Curtiss and the Wright brothers had formed exhibition teams that toured the country, giving small-town America its first glimpse of the fledgling airplane. At fairgrounds, race tracks, and farm pastures all over the country, crowds watched in shuddering expectation to see if these madmen would tear the wings off their planes - and sometimes they did.

The most spectacular of the stunters was San Franciscan Lincoln Beachey, a dirigible pilot who joined Curtiss in 1910. He promptly wrecked two planes but went on to become, in Orville Wright's opinion, "the greatest aviator of all." Neatly dressed, with celluloid collar and jeweled stickpin, Beachey on the ground looked as sedate as a deacon, but in the air he was a wild man. He could - and did - scoop handkerchiefs from the airfield with his wing tip. He liked to seesaw along a row of hangars, sticking a wing casually into each one as he flew by, and he enjoyed flying under bridges. In 1911, he set an altitude record of 11,600 feet by the simple expedient of filling his gas tank to the brim and climbing until he ran out of fuel whereupon he sailed down to a graceful dead-stick landing.

In 1913, a French stunt flier, Adolphe Pégoud, made the loop-the-loop famous. Chagrined because he had not thought of it first, Beachey became a fanatical looper, often attempting it at dangerously low altitudes. Death was more patient with him than with many of the other early stunt fliers, but in 1915 at the Panama-Pacific International Exposition in San Francisco, the wings of his plane collapsed, and he was hurtled into San Francisco Bay. More than 50,000 people saw Beachey's death dive.

By the end of 1910, the range of airplanes was increasing dramatically, thanks more to pilot persistence than to any built-in reliability. Flights were made from Florida to Cuba, and over the Swiss Alps. In 1911 in the United States, Calbraith P. "Cal" Rodgers made the first transcontinental flight, leaving Sheepshead Bay, New York, on September 17, 1911, and arriving in Pasadena, California, on November 5, 1911, after making seventy stops. Rodgers's flying time was actually eighty-two hours and two minutes, but strong winds, lightning, accidents, and darkness extended the trip's duration.

But a far more significant American achievement of that year was the introduction by Glenn Curtiss of the first practical seaplane. To make water-based takeoffs and landings possible, Curtiss simply fitted a large float beneath the center section of his standard landplane and added smaller auxiliary floats to the wings.

By the beginning of the second decade of the century, there were some 350 certified pilots in France. Great Britain ranked next with about sixty. Then came Germany, Italy, and Belgium, with the United States a poor sixth. Important new names in airplane design were being heard from: Sopwith, de Havilland, Vickers, Bristol, and Handley Page in England; Fokker in Holland; Deperdussin in France; Sikorsky in Russia and then the United States. Within a few years, war was to etch these names deeply into men's minds.

While aviation was spreading its appeal, lighter-than-air travel was by no means forgotten. During the first decade of the twentieth century, ballooning made a comeback as a sport, and the Gordon Bennett Cup for balloon races attracted much attention. But more important, in France the Lebaudy brothers after 1902 sponsored a series of successful dirigibles that proved the practicability of powered airship flights. In England, keeping an uneasy eye on the shifting balance of power in Europe, the government also experimented with airship building. But by far the most spectacular developments in lighter-than-air craft came from Germany, where Count Ferdinand von Zeppelin was building the great dirigibles that bore his name.

Zeppelin's first dirigible, launched in 1900, had reached a speed of about sixteen miles per hour in some of its trials. The *LZ-2 (Luftschiff Zeppelin 2),* built in 1905, was equipped with much more powerful engines but was wrecked by the wind after completing only two voyages. However, now the government was becoming interested. After the *LZ-3* had made several successful flights, Zeppelin was told that the German army would buy an airship if it could fly for twenty-four hours and make a round trip of 435 miles from her base to an assigned goal.

On August 4, 1908, Zeppelin's newest dirigible, the *LZ-4*, set out to pass the twenty-four-hour test. After an eleven-hour journey, an engine failure compelled the airship to land. Repairs were soon completed, and it ascended a second time, only to be forced down again by further motor trouble. During this second stop for repairs, the craft was struck by a squall and dragged along the ground until it exploded in a sheet of flame. Zeppelin and his aides were in despair, but the catastrophe roused the German people to such a pitch of patriotism that within a few weeks they had contributed nearly $1,500,000 to a Zeppelin fund. The government thereupon decided to accept the *LZ-3* and launched a great airship-building program that lasted until the closing days of World War I.

By 1910, public confidence in dirigibles had risen to a point where the first aerial passenger service became possible. Zeppelin himself piloted his craft, the *Deutschland,* on her maiden voyage. She was wrecked a few days later, but four sister ships continued to carry passengers for the next four years without loss of life. These civilian airships were comfortably fitted with carpets and wicker armchairs, cold lunches and wine were served aloft, and thousands of passengers bought tickets to sail in comfort through the skies at about forty-five miles per hour.

But it was a risky form of travel. Hydrogen was just as explosive as it had been in Pilâtre de Rozier’s day, and the huge bulk of the dirigible made it vulnerable to storms and high winds. Zeppelin’s fourteenth airship, which had been assigned to the German navy, was wrecked over the North Sea, and the crew of thirteen drowned. Three weeks later, his eighteenth ship exploded in mid-air, killing its crew of twenty-five. Of the twenty-six dirigibles that Zeppelin built by 1914, more than half came to a violent end.

American experience with airships was not much happier. In 1907, Walter Wellman, a journalist and explorer, set out to fly over the North Pole in the *America,* a much smaller dirigible than the giant Zeppelins. He took off from

Spitsbergen on September 2. Bad weather forced him to land on the ice, deflate the airship, and salvage what he could. Another attempt in 1909 was equally unsuccessful.

When Admiral Robert Peary's dash to the Pole with dogsleds destroyed the novelty of Arctic exploration for him, Wellman decided to rebuild the *America* and attempt to fly the Atlantic. He increased her length, gave her two engines, and added a detachable lifeboat to her equipment. He also devised a steel guide rope that weighed two tons, with drums of gasoline spaced at intervals as extra ballast. He called it an "equilibrator," certainly a classic misnomer. With a crew of six and a small gray cat as a mascot, he set out from Atlantic City on October 15, 1910.

Almost from the beginning, nothing went right. Eighty miles out, one engine quit. At night, the hydrogen contracted and the dirigible descended so low that it was almost rammed by a schooner. The next morning when the wind rose, the "equilibrator" began to jump from wave crest to wave crest, threatening to shake the gondola loose from the gas bag. Finally, after an erratic flight of several hundred miles, the weary airmen sighted a steamer, and Wellman decided to abandon ship. Valving hydrogen, he descended as low as he dared and released the lifeboat. As the *America* soared away, the "equilibrator" struck the little boat and stoved in one side, but all hands were saved, including the cat.

Despite such episodes, the faith of lighter-than-air men in their fragile craft was virtually indestructible. The engineer of the *America,* Melvin Vaniman, put months of work into building another dirigible, the *Akron,* with which he planned to succeed where Wellman had failed. But in July 1912 on a trial run near Atlantic City, the *Akron* burst into flames in mid-air, and the crew of five was killed.

Less than ten years had now elapsed since “the miracle at Kitty Hawk,” but already airplane designers were beginning to dream of transoceanic flight. In 1913, a landplane piloted by Roland Garros, a French musician-turned-pilot, flew 453 miles across the Mediterranean in less than eight hours. In Russia, Igor Sikorsky was designing giant multi-engine airplanes capable of carrying as many as fifteen passengers. These were the precursors of all large multi-engine craft.

In 1914, the *Daily Mail* offered a prize of $50,000 for the first successful nonstop transatlantic flight, and the directors of the Panama-Pacific Exposition offered three times that much for the fastest round-the-world flight in less than ninety days. Airmen were eager to meet the challenge. In America, Rodman Wanamaker, a department store magnate in Philadelphia, New York City, and Paris, commissioned Glenn Curtiss to build a trimotor seaplane for the transatlantic attempt. The flight, he announced, would be made in July.

But the flight was not made in July. In the struggle to conquer the air, from the very beginning death had been man’s great adversary. This had given flying its intensity, its honesty, and its innocence. Now death was to have an ally in the skies, and that ally was man himself.

On June 28, 1914, the age of innocence in the air came to an end. The pistol shots at Sarajevo ended it.

EXPLORE

When news of the Wrights' gliders crossed the Atlantic in 1902 and 1903, Ferdinand Ferber, Robert Esnault-Pelterie, and Ernest Archdeacon unsuccessfully tried to build imitations in France. Unwilling to concede that America had the lead in winged flight, European aviation pioneers generally discounted further reports from the United States.

Wilbur Wright flew a distance of twenty-four miles in October 1905, but Alberto Santos-Dumont's far more modest flights a year later were nevertheless acclaimed in Europe as the world's first. By early 1908, Henri Farman and Léon Delagrange were making flights of more respectable distances in Voisin airplanes (designed and produced by fellow aviation pioneer brothers, Gabriel and Charles Voisin of France) airplanes, but aviation in Europe still lagged behind that in America.

The Big Year

In 1908, the Wright brothers ended two and a half years of secrecy to make public flights that won for them the overdue plaudits of an amazed world. Their sudden triumph was scored on two continents.

Wilbur made his public debut in France on August 8 while Orville began tests for the U.S. Army at Fort Myer, Virginia, on September 3. Although an accident cut short Orville's flights, Wilbur continued to astonish European observers with performances in France.

The record for European fliers that year was set by Henri Farman on October 2, but his twenty-five-mile flight failed to equal marks already set by the Wrights. Wilbur completed his European trials on December 31 with a seventy-seven-mile flight lasting two hours and twenty minutes - an achievement that Europe was unable to surpass for eight months. And the first European to fly for over an hour, Paul Tissandier, did so in a Wright machine.

Glenn Curtiss

Unlike the Wrights, who preferred to work alone, Glenn Curtiss enjoyed the stimulus of teamwork. His first plane, the *June Bug,* was built for the Aerial Experiment Association, a research organization founded in late 1907 by Alexander Graham Bell. Flying this plane on July 4, 1908, Curtiss won the *Scientific American's* prize for the first public flight in America of over one kilometer.

Curtiss captured the prize a second time on July 17, 1909, with a fifteen-mile flight in another plane built for the Aeronautical Society of New York. Then, on May 31, 1910, the dynamic young aviator went even farther with a spectacular flight down the Hudson River from Albany to New York.

Curtiss's contributions to aviation went far beyond record-breaking flights. Late in 1910, he established a flight training school near San Diego, California, where the first U.S. Navy pilot, Lieutenant Theodore G. Ellyson, learned to fly. For more than two years, Curtiss had been experimenting with float planes, and on January 26, 1911, in San Diego, he launched his first practical hydroplane. In May, impressed by the designer's further achievements, the U.S. Navy ordered its first two planes from Curtiss.

Blériot Flies the English Channel

By mid-1909, French airplane builders were closing the gap in aviation development between America and Europe that Wilbur Wright's stunning 1908 flights in France had revealed. Nothing dramatized the European resurgence more than the first flight across the Channel, made by Louis Blériot on July 25, 1909.

Blériot had built his original monoplane in 1907. Although he steadily perfected the design in subsequent models, the No. XI monoplane in which he set out from Calais was still a frail, unproven aircraft. The resolute Frenchman was determined, however, that the honor of the first winged Channel flight should come to his country - just as Blanchard's balloon crossing had brought glory to France 124 years earlier.

"For ten minutes," he recalled of the tense moments after he had left the French coast, "I was alone, isolated, lost in the middle of the foamy sea, seeing nothing on the horizon, not even a boat. . . . These ten minutes seemed long to me, and, truly, I was happy to catch sight of . . . a gray line which detached itself from the sea . . . It was the English coast."

Among the first persons to greet Blériot after his landing near Dover were British officials who went through the solemn ritual of a customs inspection. In London, 120,000 people flocked to see his airplane, and orders for monoplanes deluged the elated Frenchman.

Perceptive observers saw the flight as a grim portent of the future. "The day that Blériot flew the Channel," the British aviator Sir Alan Cobham later wrote, "marked the end of our insular safety, and the beginning of the time when Britain must seek another form of defense besides ships."

Men and Machines

Many new figures - some destined to play important roles in the future of flying - appeared on the European aviation scene in 1909 and 1910.

Paced by Blériot, Farman, and Léon Levavasseur, designer of the Antoinette V-8 engine, France held the lead over other countries in air progress, but England was now moving to catch up. Many of Britain's first pilots went to France for flying instruction, and the work of early British builders often reflected the influence of French designs. Frederick Handley Page's successful 1910 monoplane was derived from Blériot's famous model, and Geoffrey de Havilland's first practical airplane, built that same year, was patterned after a Farman. Impressed by his design, the British government hired de Havilland as its first official test pilot and designer.

A. V. Roe was a youthful British designer of the 1909 triplane, who called his creations "avroplanes." He built the first enclosed-cabin airplane in 1912 and another model, his 1911 biplane, led to the famous Avro 504 trainer of World War 1.

A former artist and automobile racer, Henri Farman was Europe's first successful pilot. Through 1908, he continued to modify a box-kite biplane that the Voisins had built for him, and in 1909 he began producing his own influential planes.

Reims Air Meet

Apart from its success as a social gathering and a grand spectacle," an observer noted of the Reims air meet of August 22-29, 1909, "[the event marked] an awakening to the world of the practicability of human flight."

So rapid was aviation's progress in 1909 that scarcely a month elapsed between Blériot's daring solo flight across the English Channel on July 25 and the opening of the French tournament in which more than thirty planes were entered. The Wrights had just completed their second series of Army trials at Fort Myer and did not attend, but six of their planes flown by European pilots competed with the best designs of European builders.

There were many stars at the meet, including Henri Farman, who set a distance record of 112 miles. His feat of carrying two passengers easily around the six-mile course also proved that the airplane was no longer merely a sports vehicle for a lone pilot.

One of Léon Levavasseur's Antoinettes, flown by Hubert Latham, set the Reims altitude record of 508 feet.

Buzzing horses and diving at the stands, Eugène Lefebvre was the Reims clown. One week later, he became the first pilot killed in a crash.

The popular Claude Grahame-White captured the Gordon Bennett Trophy at Belmont on October 29 by flying his Blériot twenty laps around the three-mile course at a 61-mile-per-hour speed. Alfred LeBlanc of France was flying 68 miles per hour when he ran out of gas.

Crowds at the tournament were fascinated by the spectacle of different types of planes performing in the air simultaneously.

Almost disguised by his helmet and goggles, Orville Wright was at the controls of the "Baby Grand," the Wright entry in the Gordon Bennett race at Belmont. Orville tested the plane at 70 miles per hour, but Walter Brookins, a member of the Wright exhibition team, smashed it during the takeoff for the speed contest.

America's top aviation event of 1910 was the international air meet held the fourth week of October at Belmont Park.

Crowds of up to 25,000 people came to the New York race track to watch daily contests.

The meet reached a breathless climax on October 30 with a $10,000 elapsed-time race between Belmont and the Statue of Liberty, a round trip of thirty-three miles. By 3:30 p.m., England's debonair Claude Grahame-White had completed the circuit in 35 minutes, 21 seconds. Having wrecked his own plane, the American flier John B. Moisant borrowed a French machine and set out a few minutes past 4:00. When Moisant returned shortly after 4:30, everyone assumed that he had not completed the course.

The announcement that Moisant had done so - and beaten Grahame White's time by 43 seconds - brought charges of technical violations, and the tourney ended in controversy.

Across America

Late in 1911, William Randolph Hearst offered a $50,000 prize for the first coast-to-coast flight across America. With little chance of meeting Hearst's thirty-day deadline, but determined to reach California anyway, Calbraith P. "Cal" Rodgers, a rangy motorcycle racer with only sixty hours of flying experience, took off from New York on September 17.

Rodgers had christened his specially-built Wright biplane the *Vin Fiz,* after a soft drink made by his commercial sponsors. A three-car train carrying his wife and mother, mechanics, and $4,000 worth of spare parts followed - and sometimes led - him as he doggedly crossed the nation in a series of short hops.

People waited in suspense all along Rodgers's route and watched as aides rushed to extricate Rodgers from the wreckage of his plane after one of the nineteen crashes that marked his halting progress westward. The *Vin Fiz* was repaired so many times that at journey's end, only the rudder and a single strut of the original frame remained. Cal himself completed the trip with his leg in a cast.

Pushing his fragile aircraft to the limit of endurance, he reached Pasadena on November 5, where a crowd of 20,000 hailed the successful completion of the flight and draped the modest airman with a flag. Unfortunately, he was nineteen days too late to qualify for the prize. During an exhibition flight four months later, he crashed into the Pacific and was killed.

Backyard Builders

By 1910, aerodynamic principles tested by the Wrights, Curtiss, Farman, and Blériot were more or less standardizing the basic shapes of planes, and anyone who wanted to fly could imitate their proven designs. Nevertheless, many persons who had caught "the flying bug" worked on their own ideas and turned out a stream of weird and wonderful contraptions that they hoped would bring them fame and fortune. Most of these machines were unflyable and remained in the backyards and empty fields in which they were built. Strange as they seem today, they are a testament to the many unremembered pioneers whose energies and dreams, though doomed to failure, were an important part of the early feverish, do-it-yourself days of aviation.

Exhibition Fliers

In the years before 1914, teams of exhibition fliers thrilled crowds across America with aerial stunts, set new records of speed and endurance, and - in the case of the Curtiss and Wright teams - promoted the aircraft of rival builders. At Belmont Park in October 1910, John and Alfred Moisant enrolled a group of French and American aviators to tour the United States and Mexico.

Flying during those years was also something of a family affair; Matilde Moisant, John and Alfred’s sister, was the second American woman to win a pilot’s license. In 1912, sixteen-year-old Katherine Stinson learned to fly, and later, her two brothers, Edward and Jack, and her sister, Marjorie, set up a flying school in Texas.

Growing Up

The military potential of the airplane, though underrated, was not entirely overlooked in the first years of the twentieth century. The French decided to buy war planes in 1909 but were not sure whether to assign them to the artillery or the engineers. Great Britain’s Royal Flying Corps was established in April 1912.

After the U.S. Army had purchased a flying machine from the Wrights on August 2, 1909, the brothers trained the first Army pilots, Lieutenants Frederic E. Humphreys and Frank P. Lahm. A third young officer, Benjamin D. Foulois, was about to solo when the airplane - the Army’s sole machine - was damaged on November 5. Humphreys and Lahm were transferred back to their original units, and Foulois was sent to Fort Sam Houston, Texas, to complete his training on his own.

5
WORLD WAR I

At the outbreak of war in 1914, the airplane was still a toy, though potentially a deadly one. Planes had been built that could fly at speeds of more than 125 miles per hour. Others could reach altitudes of 25,000 feet or fly nonstop for more than 1,000 miles. These were highly specialized aircraft: High performance in one area usually ruled out capability in others. But it was inevitable - with war as a spur to technology - that the airplane would emerge from its first conflict not only a more sophisticated machine but also a highly versatile weapon.

As always, there were those who shrank from the pain of a new idea. In 1910, for example, the British War Secretary announced serenely: “We do not consider that aeroplanes will be of any possible use for war purposes.” Others, including even the Wright brothers, took the optimistic view that the airplane - seeing all and knowing all - would actually abolish war. “When my brother and I built and flew the first man-carrying flying machine,” Orville sadly wrote in 1917, “we thought that we were introducing into the world an invention which would make further wars practically impossible.”

However, in every major European country during the prewar years, a few realists struggled against government inertia and lack of funds to develop warplanes that they felt certain would be needed. As a result, when hostilities began, the adversaries were fairly evenly matched: roughly 1,200 German combat planes to 1,000 for France and Britain.

The British, who had organized the Royal Flying Corps in 1912, had varieties of the BE-2, a steady and reliable reconnaissance biplane made by Captain Geoffrey de Havilland, a designer and test pilot who later founded his own aircraft company. His plane could carry two men, guns, and a camera at speeds up to seventy-five miles per hour and stay up for three hours. The English also had the Avro 504, they soon began to use for light bombing, and the Bristol Scout and the Sopwith Tabloid, single-seater planes capable of speeds of over ninety miles per hour. The French had similar types, notably the Morane-Saulnier monoplane and the Nieuport biplane for scouting, and the slower Farman Aviation "pusher" biplane for observation. Germany had several different heavy biplanes for artillery spotting and reconnaissance, and for scouting adopted the Albatros biplane and the Taube ("Dove"), a monoplane whose swept-back wings had given it its name.

The war began in August 1914, and as the visionaries had foreseen, planes were in it from the beginning. When the British hurried Lord Kitchener's little expeditionary force to France, thirty-seven combat planes went with it. Only one of them had a machine gun. On his own initiative, one of the British pilots, Lieutenant L. A. Strange, mounted a Lewis machine gun on a French Farman and on August 22 attempted to chase an enemy aircraft. The German got away from him because the Farman could not rise above 3,500 feet. Deciding that the weight of the gun was the main reason for this shortcoming, Strange's commander ordered him to leave such weapons to the infantry where they belonged.

At first, the principal use of planes by both sides was for observation of the enemy's positions and activities, and the demand was for slow, stable aircraft from which fliers could study and photograph the ground. For a time, this concept guided official thinking; the German High Command actually tended to restrict production of the faster planes because greater speed made good camera work difficult. Few of the observation planes carried arms; if an Allied spotter met a German reconnaissance plane, the pilots were quite likely to wave companionably to each other and go on about their business.

There were a few attempts at bombing, but they were crude and ineffective. Only weeks after the war began, a German lieutenant hand-dropped two four-pound bombs while he was flying over the outskirts of Paris. Another pilot, in what was probably the first attempt at psychological warfare from the skies, dropped a note tied to an old cavalry boot stating that the German army was at the gates of Paris and urging the people to surrender.

As the war progressed, the Allies, too, began to use bombs, sending some planes over German-occupied Brussels. The first long-range strategic strike in history came in November 1914 when the British daringly sent three Avro 504s to bomb the Zeppelin sheds at Friedrichshafen on Lake Constance in southern Germany. Little damage was done to the Zeppelin base, and one of the British planes was downed, but the surprised Germans retaliated by forming a bombing squadron that they called the “Ostend Carrier Pigeons.” By January 1915, they were raiding Dunkirk, France, behind the Allied line, flying in formation and - surprisingly - flying at night.

Inevitably, single-seater scouts of both sides were given the assignment of driving off enemy bombers and reconnaissance planes. But for months, their armament remained incredibly primitive. Late in July 1915, Captain Lanoe Hawker of the Royal Flying Corps took off in his Bristol Scout armed with a cavalry carbine mounted on the starboard side of the fuselage and pointed at an outward angle so that the bullets would clear the propeller. Over the Ypres salient, flying with one hand and firing with the other, Hawker attacked three German two-seaters in succession and shot down two - an exploit considered so remarkable at the time that he was awarded England's highest military decoration, the Victoria Cross.

Such accurate shooting from a moving platform at a moving target was beyond the marksmanship of most gunners. What was needed was a gun that could fire straight forward so that the whole airplane could be aimed at the enemy, thus eliminating one of the variables. Ironically, a device to enable a machine gun to fire through a rapidly spinning propeller had been patented in England before the war and sent to the War Office, where it vanished in the fogs of officialdom. The French had also tried the idea and abandoned it, mainly because the gun they used was not satisfactory.

In February 1915, French fighter pilot Roland Garros mounted a forward-firing automatic rifle on his Morane monoplane close behind the propeller. The rear of the propeller was armored with triangular steel plates designed to deflect such bullets as might hit it. It was a potentially suicidal device, but Garros went into battle with it and within sixteen days had scored five victories over Germans who did not bother to take evasive action when they saw him coming at them. Garros thus became the first Allied "ace" of the war, acquiring a name that was already widely used in France to describe an outstanding performer in any field of endeavor. The advantage that Garros gained with his forward-firing gun lasted until April 19, 1915, when engine trouble forced him to land behind enemy lines. Both the pilot and his plane were captured (Garros eventually escaped), and the armored propeller was closely examined.

Early in the war, the Germans had been wise enough to employ a Dutch airplane designer named Anthony Fokker. Now, with Garros's captured plane in their hands, the Germans called Fokker from his factory at Schwerin, where he was building his first warplane, the *Eindecker I.* They showed him the Garros device and told him to duplicate it or come up with something better.

Fokker, who had never seen a machine gun at close range, returned to Schwerin with the propeller from the captured French plane and a standard German Parabellum machine gun. His solution to the problem was essentially a simple one. Garros had fired through his propeller blades at random - a kind of airman's Russian roulette, since a bullet at any time might strike the flier's own propeller. Fokker realized that the firing of the weapon must be synchronized with the revolving of the propeller blades; this he did - in two days - by connecting the gun and engine with a rod-and-lever mechanism which allowed the gun to fire only at safe intervals. This "interrupter gear" was far from foolproof (later, the German ace Max Immelmann shot off his own propeller twice while using it), but Fokker installed it on one of his own monoplanes and demonstrated it successfully to a group of German officers.

The skeptical military men insisted that Fokker personally test the weapon in action. Under protest - as a Dutchman he was technically a noncombatant - Fokker took off from a front-line airfield a few days later, got a French Farman in his sights, and then abruptly decided that, as he later said, "the whole job could go to hell . . . I had no wish to kill Frenchmen for Germans. Let them do their own killing!"

This the Germans were eager to do. The first Fokker Eindecker equipped with the new interrupter gear went to Lieutenant Oswald Boelcke, a schoolteacher-turned-pilot who was then Germany's leading ace. The second went to Lieutenant Max Immelmann, who shot down the first plane at which he fired.

Immelmann, whose moody arrogance contrasted sharply with Boelcke's sunny amiability, was already famous for an aerial combat maneuver that bore his name - a half-roll at the top of a steep climb in which the controls were momentarily reversed, the elevators acting as rudder and the rudder as elevators. Actually, this "Immelmann turn" had been known to stunt fliers before the war. But the "Eagle of Lille," as Immelmann was called, remained the idol of Germany until his death in 1916.

Thanks to Fokker's ingenuity, the Germans were dominant in the air for several months. In an effort to halt the "Fokker scourge," as the Allied press soon began calling it, the British stepped up production of planes with pusher propellers, like the Vickers Gunbus, in which the gunner could fire forward. After several of their pilots had shot themselves down using the Garros deflector device, the French tried mounting a machine gun on the top wing of their Nieuports and firing over the propeller. It gave them a clear forward field of fire but slowed down their fighters by increasing drag. Meanwhile, no Allied reconnaissance plane dared to fly without heavy escort. On February 7, 1916, one British BE-2 survey plane alone was assigned an escort of no less than twelve fighters.

The Germans were so jealous of their secret weapon that they forbade pilots flying Fokkers equipped with the new gear to cross into enemy territory. But in April 1916, one hapless German, lost in a fog, landed by mistake behind the Allied lines. The plane was captured, the gun examined, and the device instantly copied for Allied use. Later, a much more efficient hydraulic synchronizer was introduced by the British.

In time, new Allied war aces began to make a mark: Georges Guynemer and Jean Navarre for France; Lanoe

Hawker and Albert Ball for England. Guynemer, a frail-looking youngster suffering from tuberculosis, was shot down seven times before he finally disappeared on a mission in 1917. Navarre, who wore a woman's silk stocking for a helmet, was a wild and impulsive fighter. On one occasion, when Zeppelins were reported over Paris, he took off clutching a butcher knife "to disembowel the monster." Closer inspection revealed the monster to be nothing more than a cigar-shaped cloud. Badly wounded in 1916, he did not recover for two years.

In November 1916, Hawker went down under the guns of Manfred von Richthofen, who was to become the top-ranking ace of the war. In a savage, dramatic battle, the two men fought from 10,000 feet down to 150 in plain view of the troops in the German and British trenches. Finally, a bullet from Richthofen's red Albatros creased Hawker's skull, and the unconscious pilot crashed to his death.

Albert Ball, a dreamy-eyed youth who raised rabbits and vegetables around the airfield to keep his mind off the war, was a deadly killer in the air. He ran his score up to forty-four victories before - like Guynemer - he disappeared. One version of his death is that having developed a casual habit of buzzing a church tower in German-occupied territory to see what time it was, he was shot down by a machine gun that the enemy had cunningly planted in the tower.

Ball believed in closing in on an enemy plane almost to the point of collision before opening fire, a tactic used by most of the great air fighters. When Richthofen, then an unknown, first met Oswald Boelcke, he asked him how he had achieved his string of victories. Boelcke smiled. "I fly close to my man," he said, "aim well, fire, and then he falls down."

There was more than that to air combat, and Boelcke knew it. He made detailed studies of airplanes, their capabilities, strengths, and weaknesses. He handpicked his pilots and painstakingly taught them combat tactics: deflection shooting, use of cloud cover, decoys, wind direction, and attacks from out of the sun or from the enemy's blind spots. It was Boelcke who first suggested that fighters be formed into attack squadrons instead of being limited to escort duty. It was he who organized and trained the "flying circus" that Richthofen later took over, and it was he who on June 23, 1916, shot down Victor Chapman, the first American airman to die in the war. Chapman was one of the original members of the Lafayette Escadrille, a volunteer unit of American fliers fighting under the French flag.

Boelcke seemed immune to enemy bullets, and his squadron-mates considered him invincible in the air. But, on October 28, 1916, in an attack on two British de Havillands, Erwin Bohme, one of his best pupils, brushed the wing of his plane against Boelcke's. The Albatros fell out of control, and Boelcke was killed. Even his enemies were saddened. The Royal Flying Corps flew over his grave and dropped a wreath inscribed to "our brave and chivalrous foe."

The adjective was not ill-chosen; there *was* chivalry in air combat in those days. The risks were so appalling - wings could come off in a dive, a single bullet could turn a gasoline tank into an inferno - that fliers felt a kinship that transcended nationalism.

For the fighter pilots, war in the air was strangely intimate. Often, thanks to the personal insignia emblazoned on most planes, they knew exactly who their opponent was, and air duels were often likened to clashes between armored knights of medieval romance. Occasionally a victor would spare his adversary's life. A story is told that when

Guynemer and the German ace Ernst Udet met in 1916, they fought for eight minutes - until Udet's guns jammed. The Frenchman flew close, watched the German hammering futilely at his useless weapons, waved a sympathetic hand, and flew away. Udet survived two combat parachute jumps in World War I to become a high-ranking Luftwaffe officer under Hitler - and eventually a suicide.

Many pilots unafraid of bullets were terrified of fire. The pack parachute had been invented by an American showman before the war, and spotters in observation balloons were equipped with chutes packed in leather tubes. But no Allied pilots and - until near the end of the war - few Germans carried them. The excuses were both cruel and stupid. It was claimed that parachutes were not sufficiently reliable to justify mass production and that if pilots had them, they might be tempted to bail out without a fight. As a result, numerous lives were lost unnecessarily. It was not unusual for airmen to jump from blazing planes, preferring quick deaths to being roasted alive.

By the summer of 1916, the Fokker Eindecker was obsolescent, inferior to the Nieuport and to two new Allied fighters, the British Sopwith Pup and the French Spad, whose initials stood originally for *Société pour la Production des Appareils Deperdussin,* led by engineer Louis Béchereau, the company's technical director. When Blériot, head of the consortium that bought the company's assets in 1913 after Armand Deperdussin's bankruptcy, took over production, the company was renamed *Société pour Aviation et ses Dérivés.*

It was clear now to the high command of both sides that to attain air supremacy was to blind the enemy. Great air battles raged over Verdun and the Somme salient, but neither side was able to maintain a decisive advantage. The tide of victory ebbed and flowed as Allied and German designers produced new and more effective weapons. Tracer bullets made their first appearance in air combat in July 1916, when the bloody struggle on the Somme was at its height. Fighter planes began to be armed with rockets to shoot down observation balloons. The first crude flying bombs were discussed and some experiments were made, but none was ever flown operationally.

Decisions regarding the most effective use of available aircraft began to plague the top commanders. Unable to match the air power massed by the Germans for the assault on Verdun, the French ordered their planes to attack the German rear in other sectors. Anguished cries from field commanders for air protection put so much pressure on the German General Staff that they sacrificed their air supremacy over Verdun - and the fortress did not fall.

The war in the air was not limited to the western front. In the south, Austrians fought Italians in the skies, and a fiery Italian officer named Giulio Douhet was court-martialed for criticizing his superiors’ failure to exploit air power properly. In the east, the Russians tried to make up for inferior equipment and organization with suicidal courage. Their first victory was scored less than a month after the war began - and by an unarmed plane. When his airfield was raided by three German planes, Captain P. N. Nesterov took off in a French Morane and deliberately rammed the German leader. Both planes crashed, and both pilots were killed. A. A. Kazakov, the top-ranking Russian ace with seventeen victories, also destroyed his first Albatros by ramming it with the undercarriage of his own fighter. With the collapse of the Russian war effort in 1917, he joined the British fighting in northern Russia.

A. P. de Seversky, the most famous Russian naval flier, was shot down on his first night-bombing flight early in the war and lost his right leg when the bomb his seaplane was carrying exploded. Later, with special permission from the Czar, he returned to active service and became Chief of Fighter Aviation for the Baltic area. In fifty-seven operational flights, he shot down thirteen German planes and proved that a missing leg was no handicap. He was in the United States when the Bolsheviks seized power in 1917, and he remained in America to continue a distinguished career as a test pilot, aircraft designer, and tireless advocate of air power.

Though seaplanes and flying boats never received the publicity or acclaim that was showered on land-based fighters, they were widely used by both sides for reconnaissance, bombing, and torpedo attack. In May 1915, a British patrol seaplane warned Admiral David Beatty of the approach of the German fleet at Jutland, and by the end of the war, the British had developed long-range seaplanes that could cross the North Sea and kill Zeppelins patrolling the German coast.

Bombers, too, evolved rapidly from the first slow reconnaissance two-seaters whose primitive missiles were hand grenades, steel-tipped darts, or sometimes simply bricks. The effective British light bomber, the de Havilland DH.4, was replaced in later years by the DH.9 and the DH.9A, which could carry a bomb load of 450 pounds under the wings. For a heavy bomber Great Britain had the Handley Page 0/400, a twin-engine machine that could carry 1,800 pounds of bombs; the Germans relied mainly on the Gotha that had similar performance. By the end of the war, the British had produced a number of giant four-engine bombers capable of carrying 7,500 pounds of bombs. They were designed to bomb Berlin and were ready to do so when the Armistice was signed.

Probably the single-most significant aeronautical innovation that appeared during the war came from a German engineer, Hugo Junkers. In 1915, Junkers produced an all-metal monoplane with a fully-cantilevered wing - no external struts or bracing. The cantilever idea was applied with great success to the excellent Fokker fighters of 1917 and 1918.

While revolutionary advances were being made in Europe, aviation in the United States was lagging badly. Almost no progress had been achieved in the development of military aircraft. For three years after the Army had accepted its first Wright machine in 1908, that lone airplane had been the United States’ air force. Each year the Signal Corps had tried in vain to get additional aviation funds. Not until March 1911, was money finally appropriated for the purchase of five more planes.

By the end of 1913, nine of the twenty-eight aircraft purchased by the Army had crashed. Of some forty Signal Corps officers trained as pilots, eleven had been killed. The survivors grew restless and dissatisfied with what they considered indifference and poor leadership in the higher echelons. Feeling that they had nothing to lose, they stated their grievances in a sharply written round-robin letter and fired it off to Washington. This out-of-channels maneuver did not endear them to the top brass. The infuriated Chief Signal Officer described the fliers as “deficient in discipline and the proper knowledge of the customs of the service and the duties of an officer.” It was an accusation that was to go echoing down through the years.

When tension arose along the Mexican border in 1914 and 1915, detachments of the 1st Aero Squadron were sent to Texas. In March 1916, after the revolutionary leader Pancho Villa crossed the Rio Grande and killed seventeen Americans, eight planes were assigned to General John J. Pershing to aid in his pursuit of the Mexican. As things turned out, it was the planes that needed help; battered by dust storms, windstorms, and snowstorms, unable to fly over the Mexican mountains, they were finally given the meek task of carrying messages.

By April 1916, only two Army airplanes were left, and these were declared unfit for service. The fiasco prodded Congress into appropriating $13 million for the expansion of military aviation, but the lawmakers were soon to learn that dollars could not be converted into aircraft overnight. Of the 366 machines ordered in 1916, only sixty-four were delivered - and most of the manufacturers simply could not build the planes and asked to be relieved of the assignment.

When America entered the war on April 6, 1917, the Aviation Section of the Signal Corps had 131 officers, most of them pilots; about 1,000 enlisted men; and fewer than 250 aircraft. This in itself was frightening, but the overall picture was worse. There was only one airplane plant - Curtiss - that could be called a factory; the rest were hardly more than shops. There were perhaps a dozen aeronautical engineers of sound reputation, but none was even remotely qualified to design an up-to-date fighting airplane. Tight censorship in Europe had prevented such knowledge from crossing the Atlantic, and the Allies had steadfastly refused to allow American air observers in Europe to visit the fighting fronts.

The deficiencies were not recognized at first. Within days after the American declaration of war, military missions were arriving from Europe clamoring for planes. Grandiose plans and dazzling promises were made. One program called for “22,625 airplanes, plus 80 percent spares and 44,000 engines” - this from a nation that had produced fewer than 1,000 planes in the thirteen years since Kitty Hawk. The original plans also promised 263 American squadrons in action by June 1918. But when the war ended in November, only forty-five American squadrons were at the front, and not a single American-designed combat plane had been used in the fighting.

Inevitably, the goals had to be scaled down, with much recrimination, faultfinding, and bitterness. One decision, made fairly early, was to mass-produce only a few well-tested types of aircraft, Curtiss was given a large order for its JN-4Ds and for flying boats. The JN-4D, better known as the Jenny, became the standard training plane. The British DH.4 was selected for American mass production; later, the Handley Page 0/400 bomber and a three-engine Caproni bomber were also built in the United States. But only the DH.4 was produced in quantity, nearly 5,000 being turned out by the end of 1918.

These DH.4s and the Handley Page 0/400s were powered by Liberty engines, America’s most significant technical contribution to the air war. Two automobile engineers, Jesse G. Vincent and E. G. Hall who also had some experience with aircraft power plants, are often credited with designing the Liberty engine during one forty-eight-hour session in a Washington hotel room. Actually, a number of engineers from private industry and the government contributed ideas to the project. The initial design, presented at the end of May 1917, called for a V-8 engine with light steel cylinders that would deliver up to 300 horsepower. Within a month, the first handmade engines were ready for testing. When the eight-cylinder engine did not prove sufficiently powerful, the Liberty was redesigned for twelve cylinders, raising the output to 400 horsepower. Mass-produced, this engine became the backbone of American military aviation and remained so until the mid-1920s.

All advanced training of American flying personnel was carried out in Europe where experienced instructors and combat aircraft were available. About 2,500 American pilots received this advanced training, most of them in France. It was not until April 1918 - a full year after the United States entered the war - that American fliers were in combat, and even then, they had to fly French planes.

For the last seven months of the war, however, the Americans carried an ever-increasing share of the aerial offensive. Their first daylight bombardment squadron began operations in June 1918. The next month, reorganized as the First Brigade under command of Colonel William Mitchell, the Americans were given responsibility for a sector of the front in the Chateau-Thierry area. Here, outnumbered by more experienced German squadrons, they met their first fierce opposition and suffered fairly heavy losses.

Billy Mitchell, the American commander, was a flamboyant falcon of a man. Son of a Wisconsin senator, he had enlisted as a private in the Spanish-American War and later served as a Signal Corps officer in the Philippines and Alaska. In 1915, when he was thirty-six years old, he took up flying and was in Europe as an observer when the United States declared war on Germany. He was the first pilot wearing an American uniform to fly over the enemy lines. His reports on the Allies’ conduct of the war were so thorough and penetrating that his selection as combat commander was assured.

Mitchell was greatly impressed by the British air strategist, General Hugh “Boom” Trenchard. Trenchard conceived of the airplane as an offensive weapon that could, if properly exploited, play the decisive role in any war. He told Mitchell that heavy bombing could wreck the Ruhr and cripple the German war machine, but added dryly that this was difficult to achieve when the bombers were at the beck and call of ground commanders. Concentration of air power was the essential thing. Massive air formations responsible only to air commanders were the key to victory. The age of the individualist in the air, Trenchard insisted, was over.

Mitchell’s imagination soared even higher than Trenchard’s. Mitchell dreamed of a great airborne assault in which an entire American infantry division would be lifted over the stalemated trenches, “ten men in each plane,” and dropped by parachute behind the unsuspecting enemy. There, as he visualized it, ground-strafing Allied planes would hold off the Germans until the paratroopers could organize and launch their attack.

When the war ended, such an airdrop was actually being planned for the winter of 1919. But in the spring of 1918, when Mitchell first conceived it, the Germans were far from beaten in the air. In June 1918, the best of all the Fokker designs - and probably the best fighter plane of the war – reached the front: the Fokker D.VII. The new German Pfalz D.XIIs and Albatros D.Vs were almost as good.

By early summer, American names were being added to the list of aces. Lieutenant Eddie Rickenbacker, a former automobile racing driver now with the 94th Aero Squadron, scored his first victory on April 29, and his sixth on May 30. During June, he was hospitalized by an ear infection and was out of action through July and August. But, in

September and October, he shot down twenty more planes and ended the war with a total of twenty-six.

Perhaps the most colorful American combat flier was Frank Luke, the “balloon buster from Arizona.” With a strange combination of shyness and aggressiveness, he antagonized some of his fellow pilots by his boastfulness and contempt for authority. But no one ever questioned his courage. Five times he brought his plane back so full of holes that it had to be retired from combat, and by late September, he was the leading American ace. But his refusal to obey orders became so intolerable that on September 29 his commanding officer told him that he would be grounded until he could learn the rudiments of discipline.

Angered, Luke took off in his French Spad without permission and headed for enemy territory. An order was issued for his arrest, but it was never put into effect. Late that afternoon, having refueled at a forward field, Luke flew over an American balloon headquarters and dropped a note: “Watch three Hun balloons on the Meuse. Luke.” He destroyed the first, was wounded badly in shooting down the second, but kept on and brought the third down in flames. He then strafed German troops in the village of Murvaux before something - probably faintness from loss of blood - forced him to land. Surrounded by German soldiers, who called on him to surrender, he fought with his pistol until rifle fire killed him. For such gallantry - however undisciplined - he was awarded posthumously the Medal of Honor, the only World War I airman so honored while fighting was still going on.

In the years that have passed since the end of this “war to end wars,” the legend has taken root that the men who fought in the skies were somehow different from those who fought on land and sea. Perhaps this was true. The aces had to be men of great skill and valor. They had to possess superb vision and lightning-quick reflexes. They had to have that marvelous mixture of geometry and prescience that makes a deadly marksman - or they did not long survive.

Individually, they were so different that no generalization fits them all. Some were war-lovers who killed with ferocity and satisfaction. Others killed equally well, but always with regret. Some were sportsmen who despised the twisted rules of the game. There were hunters - killers like Richthofen who presented himself with a silver cup after every victory. There were God-fearing teenagers like Albert Ball, who assured his parents in his letters that he always remembered to say his prayers - and who died before he was twenty.

Others were cool, calculating perfectionists like René Fonck, France's top-ranking ace who ended the war with an official score of seventy-five enemy planes. There were fanatics like France's Charles Nungesser and Germany's Rudolf Berthold, who carried into battle wounds that would have hospitalized lesser men. There were Willy Coppens, the Belgian ace, who once - incredibly - landed on a German observation balloon and took off again, and the great Canadian ace, Billy Bishop, who won the Victoria Cross for singlehandedly attacking an enemy airfield. Where such men were concerned, there was no common denominators except courage and a pair of fragile wings.

Each warring nation praised and publicized her pilots in different ways. In France, anyone who shot down five enemy planes became an ace, and aerial exploits were given wide publicity. The sterner Germans doubled the requirements; not until a flier had scored ten victories was he hailed as a *Kanone.* Britain took the traditional tight-lipped attitude that heroism should not be unduly publicized; a hero's war record was made public for the first time at the solemn occasion of his decoration. American headlines were full of brilliant feats in the air.

All the combatants had fairly strict requirements for verification of victory claims - three eyewitnesses were usually necessary. As a result, many of the great aces on both sides undoubtedly scored more kills than their records show.

Despite the legendary accomplishments of the aces, air power during the first three years of the struggle was more romantic than decisive. Reconnaissance was the most important function, and it became steadily more efficient as coordination with the ground forces improved, and more effective cameras were developed. But static trench warfare tended to reduce the value of air observation. So did camouflage. Besides, night movement of troops could easily be carried out unobserved. For twelve hours out of every twenty-four, the airplane was blind.

Tactical use of the airplane - ground strafing, artillery spotting, and troop support - was limited by vulnerability to ground fire although armored planes made their appearance early in the war. If the pilot were brave and determined, considerable damage could be done. Ernst Udet was once credited with destroying a British tank, having dived on the armored giant six times until the tank went out of control and turned over. But low-level strafing was a hazardous business. A German infantryman's random bullet brought down Edward Mannock, Britain's highest-ranking ace. Francesco Baracca, top-ranking Italian ace, was killed while machine-gunning Austrian trenches.

Until late in the war, strategic bombing from airplanes was generally too inaccurate and too sporadic to be effective.

But from the outset, the Allies were highly apprehensive about the German dirigible fleet. The English knew that both Count Zeppelin's monsters and the somewhat smaller Schutte-Lanz airships had the range and lift to carry impressive bomb loads to any point in the British Isles. The only defensive measures in the early months of the war were air strikes against the Zeppelins' home bases - ineffective with the primitive bombers then available - and blackout of targets at night. As the struggle lengthened, exaggerated claims of damage done in England by the Zeppelins gave the German people an unjustified sense of optimism. But far from destroying British morale, the damage wrought by these giants of the sky tended to anger the victims and harden their will to resist.

Most of the Zeppelins that raided England belonged to the German Naval Airship Service, whose commander was Peter Strasser, a man of great courage and ability. Strasser was convinced that the primary mission of his airships was scouting - sea patrol and spotting for the German navy. He tried to send two or three Zeppelins aloft each day on twelve- to twenty-hour patrols over the North Sea. But such searches were at the mercy of the weather. A cross wind of more than twelve miles per hour made it impossible for the big ships to leave or enter their hangars.

The first raids against England were limited to minor attacks on coastal areas, but by August 1915, "squadron raids" on London had begun - always at night and always in the dark of the moon. The most daring and successful Zeppelin commander was Heinrich Mathy, who made 120 war flights, including thirteen raids against England. He took the *LZ-13* over London on September 8 and dropped some two tons of bombs, setting fires that did $2,500,000 worth of damage in the most destructive raid of the war.

By the summer of 1916, British planes were armed with incendiary and explosive ammunition. Early in September, one of these night fighters shot down a German army airship in flames. Three weeks later two other airships that tried to attack the capital were brought down. On October 1, Mathy himself perished when his airship was hit over England.

By this time, the Kaiser was convinced that the raids should be halted. Strasser and his supporters argued that the Zeppelin raids kept at home English forces needed on the western front. Airships capable of reaching greater altitudes, they pointed out, would be immune to the punishing blows of the Royal Flying Corps. Modifications enabling the Zeppelins to fly at altitudes up to 20,000 feet were introduced in 1917, but they brought new problems of inefficient engine performance and oxygen starvation to the crews.

In the last mass raid of the war, made on October 19, 1917, eleven Zeppelins reached England, but only seven returned safely to Germany. Three months later, five more ships were lost in a series of explosions at the Ahlhorn Zeppelin base. Two more were destroyed on the ground the following July when seven British Camels from the carrier *Furious* hit the Zeppelin sheds at Tondern, near the Danish border - the first time carrier-based airplanes had attacked a land-based target.

Still Strasser refused to concede defeat. On August 5, 1918, he led five Zeppelins against England. His flagship was the new *LZ-70,* a giant that had recorded speeds of eighty-two miles per hour on her trial runs. The British had heavily armed aircraft ready and waiting. Before she could even reach the English coast, the *LZ-70* went down in flames under the guns of a DH.4. With Strasser's death, the Zeppelin organization virtually disintegrated.

In September 1918, a month after Strasser's death, the great drive against the Saint-Mihiel salient was under way. To support this offensive, nearly 1,500 Allied warplanes, including day and night bombers, observation squadrons, and more than 700 fighters, were assembled under the command of Billy Mitchell, now a brigadier general. For the first time, the outnumbered Germans were put on the defensive and kept there. About a third of the Allied air force was used to support ground troops while the rest carried out long-range bombardment or sought to whittle down German fighter strength.

Always sensitive to rear-area attack, the Germans tried desperately to halt the Allied bombers but often found themselves trapped and outnumbered by Allied fighters. On October 9, when the Germans tried to launch a counterattack in the Meuse-Argonne area, the Allies smashed at their concentration points with 200 bombers escorted by over 100 fighters. From this operation, probably the largest raid of the campaign, only one American aircraft failed to return. Five weeks later, the war was over.

At the Armistice, despite a painfully slow start, American front-line air strength consisted of 740 combat airplanes, nearly 800 pilots, and 500 observers. Losses in seven months of increasingly violent fighting had been 289 planes and forty-eight balloons, as against confirmed claims of 781 enemy aircraft and seventy-three balloons destroyed by American air fighters.

Despite these impressive statistics and the enduring legend of heroism left by the air fighters of World War I, it is impossible not to categorize this first sustained military use of air power as more spectacular than effective. No airplane or dirigible, for example, ever succeeded in sinking or seriously damaging a surface warship. No war industry was ever put out of action by bombing. In no major engagement was victory ever won or lost exclusively by air power - or lack of it. Giant technical strides were made in aviation, but looking back, it is the men who are most vividly remembered and not the machines.

Through most of World War I, infantry was still the queen of battles and artillery was king. Only in the closing weeks of the struggle - as hundreds of Allied bombers hammered German troop concentrations, railroad junctions, and supply depots; as swarms of Allied fighters battered down aerial opposition and made daylight movement of enemy troops more and more difficult - did it become evident that a new military doctrine was being forged. Ground commanders varied in their degree of perceptiveness, but during the furious fighting of September and October that led to Germany's collapse, this precept was written in blood and fire for those who had eyes to see: If you hold the air, you cannot be beaten; if you lose the air, you cannot win.

EXPLORE

As World War I began, the visions of air-minded prophets soared above the realities of contemporary aviation. General Pierre Ruffey of the French 3rd Army dreamed of an independent, offensive air force of 3,000 planes. However, at the time France and Great Britain combined could bring only 220 combat-ready machines to the western front to oppose Germany’s 260, and with only about a dozen aircraft factories on each side, it was unlikely that these numbers could be rapidly increased.

At the outset, the novel air war in an uncrowded sky was fought with chivalry. The catalyst of war would change both the planes and the men.

The notion that dirigibles were useful only for reconnaissance was short-lived. Although scouting remained the primary function of airships, Peter Strasser, commander of German Naval Airships, outfitted Zeppelins for bombing raids.

Filled with highly combustible hydrogen and with their flights severely hampered by adverse weather conditions, the ponderous ships in the sky were far from ideal bombers. If the delicate balance of ballast and lift was upset, Zeppelins would soar to heights where lack of oxygen and extreme cold incapacitated the crew. Also during “valving off” - the release of gas which enabled the dirigible to lose altitude - Zeppelins were especially vulnerable to incendiary fire.

Strasser armed the gondolas below the balloon and the platform on the bow with machine guns, but the airships were almost defenseless against attack from above. To lessen the chance of outright explosion, he had the Zeppelins built with many separate gas compartments. Nevertheless, dirigible commanders were often so unnerved by the sight of another Zeppelin in their squadron plummeting in flames that they would abandon the objective, drop out their bombs, and quickly run for home.

Despite the risks, Zeppelins in 159 sorties over England dropped 220 tons of bombs, causing damage worth $7.5 million. By 1918, however, excessive losses to Allied firepower had all but ended the raids of the awesome airship-bombers.

Over the Front

During the Allied retreat from Mons in August and September 1914, aerial reconnaissance played an important role for both sides. From then on, a determined struggle began to dominate the air and keep enemy observers out of the sky.

The new air fight raged with increasing intensity. Soldiers in muddy trenches and shellholes watched the dogfights over the lines and cheered the planes of their own fliers, many of whom they knew by name. When an ace fell, even the enemy felt the loss - a gallant contender had departed from an arena of sportlike combat.

The Americans Get Ready

Impatient with United States' neutrality, a number of Americans volunteered for service with the Allies during the first years of the war. By April 1916, so many of them were in French aviation that France authorized the formation of a squadron of American fliers under Captain Georges Thenault.

Two lion cub mascots, "Whiskey" and "Soda," epitomized the flair and bravado of the group, called the Lafayette Escadrille. Within a month, on May 20, 1916, Kiffin Rockwell scored the squadron's first victory. Courageous and skillful fliers like William Thaw, Norman Prince, and James N. Hall soon added more triumphs.

The unit became a nucleus for 180 American volunteers serving in ninety-three French squadrons. Nearly a third of them were killed, but they accounted for 199 German planes lost.

In March 1911, when Congress voted $125,000 for the Army Signal Corps air branch, just one military training plane existed in the United States - Lieutenant Foulois's dilapidated Wright at Fort Sam Houston, Texas. As more planes became available, mishaps increased, and the accidents hurt the cause of those who sought more money for military craft. Finally, in July 1914, the Army purchased both Wright's and Curtiss's models improved by aircraft manufacturer Grover C. Loening and a new "TT" trainer designed by Glenn Martin.

Naval aviation, meanwhile, had been prodded by men like Washington Irving Chambers, the first officer to have oversight of the Navy's aviation program, and Artemus Gates, who became assistant secretary of the U.S. Navy for air in World War II. But their efforts had little better success against public and governmental apathy.

Because of this indifference, the United States, when it finally entered the war in April 1917, ranked fourteenth among world air powers.

In the War

Although lack of planes, pilots, airfields, and technicians restricted American war efforts at the outset, U.S. instructors gave 15,000 American pilots their preliminary training in this country. Advanced instruction was conducted abroad, and the 1st Aero Squadron, under Major Ralph Royce, arrived in France in September 1917. In April 1918, Lieutenants Alan Winslow and Douglas Campbell scored the first American victory. Some U.S. fliers like Elliott White Springs and Clayton Knight flew with British squadrons part of the time or throughout the war, and others, including Fiorello LaGuardia, who led a bomber group, served in the Italian theater.

American Air Service commanders in France - Mason Patrick, William Mitchell, Benjamin Foulois, Frank Lahm, and Thomas Milling - organized and led the last big air battles of the war.

Trial by Fire

Behind the drama of dogfights and dawn patrols, aviation was rapidly learning many new lessons to leap ahead faster during the war than it had ever done before.

Technological developments were piled one upon another. European and American manufacturers, responding to military appeals for planes and engines with improved performances, dropped old models and labored around the clock to produce revolutionary new designs. Specialized aircraft were developed for bombing, pursuit, and attack.

Navies shaped aviation to their own needs. The American Navy produced, besides its ace David Ingalls, two future statesmen, Robert Lovett and James Forrestal, whose World War I experience with planes served the nation well in later years.

The Fraternity of the Brave

Romantic writers have often likened the aces of World War I to chivalric knights. Their trade held them together, and though they were as diverse as any other group of men, they looked upon themselves as a special breed of fighters, different from the soldiers and sailors below.

Those who survived did so because of luck and because they combined with their daring a deadly skill that marked them as the new men of war, flying free and brave above all obstacles.

The Allied Edge

After the summer of 1917, the sheer numbers of Allied craft began to overwhelm the German air forces. Sopwith Camels, Spads, and SE-5's appeared in such quantity that the Germans - to maintain any offensive position - were forced to combine their *Jastas* (fighting units originally composed of no more than fourteen planes) into large squadrons.

The Allied edge in production was matched by a new Allied sense of how to organize and use air forces. In August 1917, General Jan C. Smuts completed a report on British air organization that led to the formation, on April 1, 1918, of the Royal Air Force. General Hugh "Boom" Trenchard then organized the Independent Air Force with a mission of long-range bombing, a development that came too late to make a real showing in this war - though Trenchard's ideas were to carry forward powerfully to World War II.

At the time of the last German offensive, in March 1918, the British had 1,232 planes in France. And still production was expanding; by war's end, eight months later, the RAF had 1,799 planes at the front. The Americans, too, overcame their initial un-preparedness and by the Armistice were producing DH-4's in the United States at the rate of 1,100 per month. Conversely, the Germans built 4,000 planes fewer in 1918 than in 1917.

The growing might of the Allied air fleets and their control of the sky were not the most critical factors in the war, but they did undermine the Germans’ will to fight.

In the last two air offensives of the conflict, the Allies employed formation flying, strategic bombing, and saturation attack. Aviation had traveled an immeasurable distance from the days when gentlemen on reconnaissance missions waved to one another in friendly greeting.

6

THE TWENTIES

At the end of hostilities in 1918, aviation, like many a war hero, found itself abruptly unemployed. Surplus warplanes, ill-suited for civilian use, were dumped on the market at a fraction of their original cost, leaving manufacturers with little demand for new aircraft. Military airfields, too, were deactivated rapidly, resulting in a shortage of landing fields that further discouraged production. Why build planes when there were no facilities to handle them?

In addition, where flying was concerned, a curious psychological reaction set in. During the fighting, the airplane had been heroic and glamorous, but now, grim associations of violence and death clung to it. There was in the American public's mind an added sense of humiliation and uneasiness about the country's failure to "darken the sky with clouds of planes." Almost $1 billion had been appropriated for the purpose, yet General Billy Mitchell had come home raging that as a combat commander he had received exactly 196 American warplanes - and none had ever been flown in combat. Where had the money gone? Was it true that the DH.4 was obsolete even when American production of it had been ordered? Why had the United States tried to fit American engines to European airframes instead of building its own planes?

The country worked off its frustrations in typical fashion: a series of investigations that captured a few headlines but proved essentially nothing. America quickly forgot the questions of the past in its glorious enjoyment of the present, for these were the golden twenties.

In 1920, a wholesale reversion of military personnel to peacetime rank was ordered, striking a blow to service fliers' pride, prospects - and pocketbooks. And those American pilots who tried to make aviation a career in civilian life did so at considerable sacrifice. "What's the most dangerous thing about flying?" someone once asked Dick Depew, a war pilot-turned-barnstormer. "The risk," growled Depew, "of starving to death."

Even so, a lot of adventurous young men were willing to chance it. Flying war-surplus DH.4s and Curtiss Jennies and sleeping in open fields under the wings of their weather-beaten craft, they hopped from town to town, from carnival to county fair, giving exhibitions of stunting, wing-walking, parachute jumping - anything that would attract a crowd. Then, from the audience, they hoped, a few brave souls would hesitantly step forward to go for a ride at prices that averaged about fifty cents a minute.

No nervous groundling who tried it ever quite forgot the heart-thumping assortment of sensations that came from being strapped into an open cockpit: the bewildering array of gadgets; the oily, unfamiliar smells; the shattering roar of the engine; the rush of wind over the mud-speckled windscreen; and the stomach-shriveling first steep bank. The wild-eyed passenger would glance backward to see if the pilot had lost his mind - or perhaps had tumbled out - and would receive a reassuring nod from the goggled, helmeted creature of the sky. Then followed a gradual relaxing and the soaring exultation of actually *flying,* of becoming a member - however humble - of one of the most exclusive fraternities in the world.

These flying gypsies were remarkable men. Casual and rakish though they looked, they were often skilled mechanics and almost always first-rate pilots. They had accidents and forced landings, but they usually managed to survive. In addition, they treated their customers with an honesty and a friendly good humor that did much to recapture the public's interest in planes and restore its faith in the future of aviation.

And they brought romance back to flying.

As the years passed, some of the barnstormers abandoned their dangerous and unpredictable way of life for more prosaic jobs. Others went back into the Army or Navy so that they could continue to fly at government expense. A few hoarded their money, set up flying schools, or undertook the first tentative efforts to haul freight or passengers that led, in some cases, to the eventual establishment of commercial airlines.

In Europe passenger-carrying airlines had sprung up immediately after the war. The defeated Germans, of all people, were first to enter the field. The Deutsche Luft-Reederei was operating between Berlin, Leipzig, and Weimar less than three months after the Armistice. By the end of 1919, both the British and the French had organized London-to-Paris service. Having fled to Holland, the energetic Tony Fokker was busy setting up new factories, and KLM, the Dutch airline, was started that same year.

America, with its special problems of terrain and distance, got off to a slower start. In August 1919, a company called Aero Limited was organized to fly vacationers and summer commuters from New York to Atlantic City. Soon afterward, observing the melancholy changes wrought by the new Prohibition Act, Aero Limited moved its headquarters to Miami and began ferrying thirsty Americans to various oases in the Bahamas. Another company with the same objective was the Aeromarine Sightseeing and Navigation Company, operating between Miami and Havana.

In those days, the carrying capacity of commercial planes was so limited that passenger revenues alone could not cover operating costs. Recognizing this, most European countries were paying subsidies to their fledgling airlines.

The French government, for example, contributed up to 1,000 francs of each commercial pilot's annual pay. It took the British a little longer to learn the lesson. Not until April 1924 - after the failure of several independent airlines in that country - was Imperial Airways formed with a government subsidy to sustain its operation.

In America, opponents of such subsidies warned that they invariably led to excessive governmental control and tended to stifle private initiative. But it was obvious that without some help, private operations could not succeed. The solution, eventually, took the form of government airmail contracts to private airlines.

Beginning in 1918, however, the United States Post Office tried to fly the mail itself. During the war, the Army had organized a mail run between Washington, Philadelphia, and New York. Before hostilities ended, the Post Office Department took over with seventeen planes of its own and with pilots recruited mostly from civilian instructors at Army bases.

Almost at once, plans were made for a mail route from New York to Chicago over the storm-plagued Allegheny Mountains. By the summer of 1919, mail pilots were flying this "graveyard run" in open-cockpit, rebuilt warplanes under incredible conditions: no radio beams, no weather stations, no blind-flying instruments, not even lighted air beacons. Carrying the mail over the mountains was fully as hazardous as combat flying. Of the first forty pilots hired by the Post Office Department, thirty-one were killed before the operation was turned over to private airlines.

Despite its misfortunes in the east, the Post Office gradually pushed its operations westward and opened new routes, letting a few contracts to private fliers. In Seattle, enterprising aviator Edward Hubbard persuaded postal authorities to let him run the airmail across Puget Sound to Victoria, British Columbia. He made his initial flight in 1919 in a pontoon-equipped biplane, the first aircraft built at the new Seattle factory of William E. Boeing, an air-minded member of a wealthy lumber dynasty.

In the public mind, these tentative commercial airlines and the beginnings of airmail were overshadowed by the first dramatic transatlantic flights. Soon after the end of the war, the United States Navy decided to demonstrate the range and power of its new Curtiss flying boats by sending three of them under Commander John H. Towers to England via Newfoundland, the Azores, and Portugal. On May 6, 1919, the *NC-1* (Navy Curtiss-1), *NC-3*, and *NC-4* left Newfoundland on the first leg of the transoceanic journey. The *NC-1* became lost in the fog and landed some 200 miles west of the Azores where her crew was picked up and the plane abandoned. The *NC-3*, skippered by Towers, landed on seas so rough that she could not take off again. With no aid in sight, Towers masterfully half-sailed, half-taxied the plane, by now severely damaged, the final 205 miles to the Azores - a tour de force of navigation.

From the start, the *NC-4* under the command of Lieutenant Commander Albert C. Read, proved faster - and luckier - than her sister ships. Fog blanketed the sea near the Azores, but the *NC-4* made it to Horta without difficulty, covering the 1,380 miles at an average speed of 74.8 knots. From there she went on triumphantly to Portugal and England.

This feat still left the London *Daily Mail's* 1913 offer of £10,000 for the first nonstop flight between the British Isles and the New World unclaimed. More than 1,800 miles of stormy ocean lay between Newfoundland and Ireland. Even with a tail wind, a loaded plane could not make much more than 100 miles per hour. Cockpits were still open. Air-to-ground communications were so primitive that radios were frequently discarded to lessen weight.

These hazards did not deter a pair of Britons who tried the nonstop transatlantic flight a month after the trip of the *NC-4.* Captain John Alcock and Lieutenant Arthur Whitten Brown (whose parents were American) had both been prisoners of war in Germany. Flying a twin-engine Vickers-Vimy remodeled bomber, they took off from St. John's, Newfoundland, on June 14, flew for sixteen hours and twenty-seven minutes through appalling weather, and at last claimed the *Daily Mail* prize when they made a crash landing the next morning in an Irish bog.

The last great flight of 1919 was an 11,000-mile race against time from London to Australia. Again a prize was the incentive: £10,000 was offered by the Australian government to any Australian pilot who completed such a flight within thirty days from the start in an all-British-built airplane.

In a Vickers-Vimy biplane similar to the one used by Alcock and Brown, Captain Ross Smith, an Australian war flier, left England on November 12. Reasonably good airfields were available as far as Calcutta, but for the last stages there were virtually no facilities at all. A combination of bad weather and bad luck plagued Smith and his three-man crew most of the way. Yet, twenty-seven days and twenty hours out of England, they landed at Port Darwin - with fifty-two hours to spare - and were able to claim the prize.

These record flights, however, did little to lift military aviation in America out of its postwar doldrums. Yet, ever since the Armistice, the indefatigable Billy Mitchell - who was now Assistant Chief of the Army Air Service in Washington - had been a driving force behind Army air activity. In October 1919, acutely aware of the publicity received by the Navy for the *NC-4*'s triumphant crossing of the Atlantic five months earlier, he sent seventy Army pilots across the continent in both directions in what was termed an air race. Actually, it was a badly needed survey flight that pointed up the inadequacy of the nation's air facilities. Mitchell also organized an aerial forest-fire watch on the West Coast, a flying border patrol along the Rio Grande, and urged mass Army flights to Alaska and around the world. In 1920, Captain St. Clair Streett, commanding four DH.4s, successfully executed the Alaskan flight.

However, such Army aircraft as the DH.4s had become dangerously obsolete. In a twelve-month period, from midsummer 1920 to midsummer 1921, the Air Service suffered 330 crashes and sixty-nine fatalities. The Army fliers complained bitterly about the de Havillands and called them "flaming coffins." But the mood of the country was one of financial retrenchment and a "return to normalcy." There was little government support for spending money on new military planes.

In the face of official indifference, Mitchell raised his voice with increasing passion. One of his principal arguments, certain to arouse hostility from many Naval leaders, was that the bomber and torpedo planes had rendered surface warships obsolete. Mitchell clamored ceaselessly for a chance to prove that he was right. Publicly, he produced embarrassing magazine articles and gave out uninhibited newspaper interviews calling for a stronger air force. Privately, he expressed his conviction that behind the resistance to his views lurked sinister big business groups interested primarily in the profits to be made from building battleships.

Undoubtedly, Mitchell had courage, energy, and the historic position of being right. But he did not suffer fools gladly, and he had an unfortunate tendency to consider anyone who differed with him a fool. Some of his charges, moreover, were unfair. His statements to the press made it sound as if the struggle were basically between a hidebound Navy and an eager young Air Service. This was not so; many top Navy experts agreed with him.

He was supported strongly by Admiral Bradley Fiske, who as far back as 1912 had pioneered the torpedo plane. Admiral William S. Sims, who had commanded American Naval Forces in European waters during the war, came out flatly for aircraft carriers as opposed to battleships. One of the Navy's most brilliant strategists, Admiral W. F. Fullam, prophesied that "sea power, or fighting power, in the future will be largely dependent upon control of the air."

The same controversy was raging in England. Jack Fisher, who had been a wartime First Sea Lord of the Admiralty, joyously sank his fangs into colleagues who kept clamoring for more battleships. "There is only one thing to do to the ostriches who are spending these vast millions on what is as useful for the next war as bows and arrows," he roared. "Sack the lot." The real battle was not so much between the Navy and the Army Air Service as it was between air-minded and non-air-minded officers everywhere.

Finding his recommendations consistently blocked or ignored, Mitchell felt justified in appealing to Congress or the public over the heads of his superiors. By the beginning of 1921, the uproar he had stirred reached national proportions. Mitchell kept insisting that his bombers could sink any warship afloat - and he kept offering to prove it.

In June and July, Mitchell got his chance. The targets were former German warships, anchored some seventy-five miles off the mouth of Chesapeake Bay. First, Naval seaplanes sank a German submarine, the *U-117.* Next, a destroyer and the light cruiser *Frankfurt* went down under a rain of bombs from Army planes. However, the critical target was the "unsinkable" dreadnought *Ostfriesland,* which had survived severe mine damage and gunfire at the Battle of Jutland and was one of the most heavily armored ships in the world.

Attacks carried out on July 20 by Naval, Marine, and Army fliers with light bombs made little impression on the German giant. On the morning of July 21, the Army's first assault, made with 1,000-pound bombs, was equally ineffective. But under Mitchell's fierce prodding, Army Ordnance had developed a new bomb weighing 2,000 pounds, and now, flying at about 2,500 feet, a formation of eight Martin bombers - each carrying one of these giant bombs - sank the pride of the German navy in just twenty-five minutes.

There was a lesson to be learned from the bombing tests, and some high-ranking Naval officers were quick to admit it. "We must put planes on battleships," announced Rear Admiral William A. Moffett, the new Chief of Naval Aviation, "and get aircraft carriers quickly." Within eight months, he got his first carrier; on March 20, 1922, the USS *Langley* was commissioned at Norfolk, Virginia.

By 1921, the Navy had been assigned the principal lighter-than-air mission and was building a great rigid dirigible, the *ZR-1*, in Philadelphia. Although a sister ship being built in England crashed on her final test, Admiral Moffett stoutly reaffirmed his confidence in lighter-than-air craft and announced that work would continue on the *ZR-1,* eventually to be christened the *Shenandoah.*

The hazards of hydrogen-filled airships were brought home to the Navy even more vividly in 1922 when the semi-rigid dirigible *Roma,* purchased from the Italian government, struck high-tension wires near Langley Field, Virginia, and exploded in a sheet of flame. Eleven men saved themselves by jumping. Thirty-three were lost. After that, hydrogen was abandoned as the lifting agent in American dirigibles. The substitute to eliminate the risk of fire was helium, an inert gas only slightly heavier than hydrogen.

While lighter-than-air men struggled with such ancient problems, Billy Mitchell continued to plot aerial feats that would capture public attention and help buttress his arguments for an independent air force. In May 1923, after two unsuccessful Army attempts to fly nonstop across the country, Lieutenants John A. Macready and Oakley G. Kelly took off from Roosevelt Field, Long Island, in a single-engine Fokker T-2. Almost twenty-seven hours and more than 2,500 miles later they landed at Rockwell Field, San Diego. Next year, in a heavily publicized "dawn-to-dusk" race against the sun, Army Lieutenant Russell A. Maughan streaked from Long Island to San Francisco in seventeen hours, fifty-two minutes. Flying a new Curtiss pursuit plane, he averaged 150 miles per hour, including refueling stops. He landed just at sunset and proudly handed the Mayor of San Francisco a copy of *The New York Times* printed that same day.

While Maughan was racing the sun, three Army airplanes on the other side of the planet were nearing the halfway point in the most ambitious aerial exploit yet undertaken - a mass flight around the world. On April 4, 1924, eight of the Air Service's best pilots had taken off from Seattle in four “world cruisers” - single-engine biplanes designed to fly both as landplanes and seaplanes. Two of them completed the 26,000-mile circuit of the globe at Seattle on September 28.

Such a series of triumphs might have mellowed almost any man except Billy Mitchell, but he was far from satisfied. A tour of Europe had convinced him that German militarism was very much alive and that the Germans were already planning to exploit air power in a war of the future. A visit to the Far East had also left him highly critical of American defenses, especially at Pearl Harbor. “If our warships there were to be found bottled up in a surprise attack from the air and our airplanes destroyed on the ground,” he wrote, “nothing but a miracle would enable us to hold our Far East possessions. It would break our backs. The same prediction applies to the Philippines . . .”

By now, official patience with the self-appointed prophet was wearing thin. “That man,” fumed President Calvin Coolidge to Secretary of War John W. Weeks, “has talked more in the last three months than I have in my whole life.” The result of presidential displeasure was that when Mitchell’s tour of duty as Assistant Chief of the Air Service ended, he was not reappointed but was sent instead to what his superiors hoped would be the obscurity of an air base in Texas.

In the summer of 1925, partly to counteract Mitchell’s criticisms, the Navy sent a seaplane on a hazardous nonstop flight from San Francisco to Hawaii. It also ordered the dirigible *Shenandoah* to make a series of “public relations” appearances in Midwestern states. Both decisions were disastrous. The seaplane, *PN-9 No. 1,* ran out of fuel short of Hawaii, and was forced to land at sea. For ten days, Commander John Rodgers and his crew struggled to sail the craft the remaining distance. Suffering from hunger and thirst, they were finally picked up by a submarine within sight of land.

On September 3, 1925, two days after Rodgers had disappeared, the Navy's proud *Shenandoah* was caught in a violent line squall near Marietta. Ohio, and came apart in mid-air, killing fourteen men.

Forty-eight hours after this second disaster, Mitchell issued a blistering statement accusing the War and Navy Departments of "incompetency, criminal negligence, and almost treasonable administration" of aviation affairs. He followed this up with a blast calling for an investigation of the "disgraceful" situation by a board to be composed of "representative Americans instead of representatives of the army and navy-bureaucracies." By such actions, Mitchell made his trial by court-martial inevitable, and his conviction on charges of "insubordination and conduct unbecoming to an officer" a foregone conclusion. When President Coolidge confirmed his conviction on January 25, 1926, Mitchell promptly resigned from the Army.

During the trial itself, public sentiment was with Mitchell. "He has done more for the cause of aviation than any other man in the nation's history except the Wright brothers," wrote Frank Tichenor, editor of *Aero Digest.*

At the other extreme was Admiral Moffett's furious denunciation of Mitchell as a man "of unsound mind and suffering from delusions of grandeur." In the middle were those inclined to agree with General Charles P. Summerall, who pronounced Mitchell "one of that damn kind of soldier who is wonderful in war and hell in peace."

Perhaps the sharpest indictment that can be brought against Mitchell is that for all his fireworks - and even with truth on his side - he did not get what he was after, namely a strong and independent air force. Far from winning acceptance for his ideas, his tactics tended to alienate the very people who might have implemented his theories. As a result, his prophecies were disregarded, and his contributions outweighed by the bitterness he aroused.

While the Mitchell controversy dominated the headlines, men in the background were working on proposals that would set the pattern of development for military aviation in this country for the next two decades. In September 1925, President Coolidge, nettled by Mitchell's criticism, appointed a commission to study, among other things, the "best means of developing and applying aircraft in national defense." As chairman of the board he named Dwight Morrow, a partner in the banking firm of J. P. Morgan. On November 30, just after Mitchell had rested his defense and while he was awaiting the verdict of the court-martial, the Morrow Board submitted its report that flatly rejected some of Mitchell's arguments. Air power, the report noted, was not sufficiently developed to justify creation of an independent air arm; building up a strong air force, at the expense of naval armaments limited by international treaty, would be a disservice to the cause of world disarmament. "The next war may well start in the air," the Morrow Board glibly predicted, "but in all probability it will wind up, as the last one did, in the mud."

To pacify the less violent military critics of America's defense establishment, the Morrow Board suggested that the Air Service be renamed the Air Corps to give it more prestige, but it failed to recommend that its status within the War Department be changed.

The essential provisions of the report were incorporated in the Air Corps Act, passed by Congress on July 2, 1926. This law dutifully changed the name of the Air Service to Army Air Corps and created the post of Assistant Secretary of War for Aeronautics. Similar provisions were written for the Navy. A more positive aspect of this new legislation was the authorization given to the War and Navy departments to begin a five-year expansion plan. Although lack of funds delayed the start of this program until 1927, the new orders for military planes, in time, assured the development of a domestic aircraft industry.

Along with its study of military aviation, the Morrow Board had considered problems of commercial aviation in America, As far back as 1922, Secretary of Commerce Herbert Hoover had drafted legislation covering this subject, but for three years his suggestions were ignored by Congress. Not until February 1925 did Congress pass the Kelly Bill "to encourage commercial aviation and authorize the Postmaster General to contract for airmail service." Only private operators with adequate experience and equipment were given consideration, and as an incentive to bidding, they were promised up to four-fifths of the revenue derived from the mail they carried. Within two months, the Postmaster General had received more than 5,000 inquiries from applicants whose eagerness to gain the rewards obviously exceeded their ability to meet the requirements.

In October 1925, the Post Office asked for bids on eight small "feeder" routes. Contract Air Mail Route Number 1 between Boston and New York went to Colonial Air Transport. Colonial's operations were directed by a dynamic, twenty-six-year-old Yale graduate, Juan Terry Trippe, who promptly bought two Fokker trimotor planes capable of carrying six passengers in addition to the mail. National Air Transport received the contract for the Chicago-Dallas-Fort

Worth run and later took over the eastern section of the transcontinental route from New York to Chicago. The western section, from Chicago to San Francisco, was awarded to the Puget Sound airmail pioneers, William Boeing and Edward Hubbard, who formed Boeing Air Transport and put into service twenty-five new Boeing 40s that could carry two passengers in an enclosed cabin.

Actually, the first domestic airmail flown by a private airline was carried in planes owned by Henry Ford. Impressed by William Stout's early experiments with thick-wing, all-metal airplanes, Ford purchased five of his single-engine monoplanes and early in 1925 started a freight service between Detroit, Cleveland, and Chicago. Later, when Stout redesigned his plane and powered it with three Wright Whirlwind motors, Ford bought him out altogether and announced that he would carry passengers as well as freight.

Carrying the mail was so much more profitable than carrying people that most airlines with mail contracts made little effort to attract passengers. But small, struggling operators who had no mail subsidy had to find cash customers or go out of business. Often these "independents," as they were called, acted as salesmen for new airplanes that were gradually superseding the war-surplus types.

With the spur given to commercial aviation by passage of the Kelly Bill, it became apparent that a greater degree of governmental control and supervision of the air was imperative. Realizing that "the foundation for military aviation was a strong commercial service," Secretary of Commerce Hoover insisted that the Morrow Board give its attention to this problem. The committee's conclusions led, in May 1926, to the passage by Congress of the Air

Commerce Act that has been called the “legislative cornerstone for the development of commercial aviation in America.” The act created a Bureau of Aeronautics in the Department of Commerce that was authorized to license all American planes and pilots, set up and enforce rules for air traffic, investigate accidents, test new engines and aircraft for safety - in short, assist, guide, and police the development of civil aviation in all possible ways.

During these years of controversy and compromise over the future of military and civilian aviation in the United States, a number of important technological breakthroughs were scored by both European and American scientists. Even before the end of the war, Hugo Junkers was building his first all-metal airplanes in Germany. In 1919, realizing that the corrugated metal being used in airplane construction produced high drag, another German builder, Adolph Rohrbach, began producing planes with smooth metal surfaces - thus originating the modern “stressed-skin” concept in which the covering of the wing adds to its strength and load-bearing capacity.

The cantilevered wing requiring no external bracing had also been pioneered by Junkers in the last years of the war. Further development of this principle by Junkers and by Anthony Fokker, who extended his operations to the United States in the twenties, for the first time brought the monoplane into serious competition with the more familiar biplane, especially in the field of transport airplanes.

Convinced that biplanes wasted too much power overcoming drag, William B. Stout in 1920 designed an unorthodox American monoplane that he described as “nothing but a wing with control surfaces.” A further step toward the flying-wing concept was taken by Vincent J. Burnelli, an American designer who in 1924 built a biplane in which the fuselage enclosing the engine contributed to the wing lift. Meanwhile, the Handley Page slotted-wing device and Orville Wright's invention of the split flap began a long series of control-surface improvements.

These years also saw the introduction or development of such aviation refinements as the pressurized cabin, retractable landing gear, mid-air refueling, reversible and variable pitch propellers, a radio-controlled pilotless airplane, and radial air-cooled engines as a substitute for the heavier water-cooled models. And airplanes were first used for crop-dusting, cloud-seeding, and the gathering of weather data.

"Progress in aeronautics is being made at so rapid a rate," the National Advisory Committee for Aeronautics report of 1923 concluded, "that the only way to keep abreast of other nations is *actually to keep abreast,* year by year, *never falling behind."* The Committee, composed of distinguished military and civilian air authorities, had been established by act of Congress in 1915 to "supervise and direct the scientific study of the problems of flight, with a view of their practical solution." Conducting its own research at the Langley Memorial Aeronautical Laboratory in Virginia and ceaselessly encouraging and reporting on the work of others, NACA played an increasingly larger role in American aviation up to 1958 when it was reorganized and renamed the National Aeronautics and Space Administration with an exciting new role to play in the developing space age.

The Daniel Guggenheim Fund for the Promotion of Aeronautics, established in 1926, gave aviation another shot in the arm. The air-minded New York philanthropist had founded the School of Aeronautics at New York University in 1925, and his $2.5 million fund extended the program of aviation education across the country with generous grants that enabled several universities to build experimental wind tunnels. In succeeding years, the fund sponsored the Safe Aircraft Competition, encouraged private flying clubs, and endowed a national aeronautical collection at the Library of Congress. A continuing spur to scientific progress, the fund also fostered commercial aviation by urging the development of a practical air transport vehicle, instituting a national program of roof-markings as navigation aids, and setting up the first aeronautical weather reporting service on a model airline operated by Western Air Express between Los Angeles and San Francisco.

In another area, the ultimate decline of the airplane as a military weapon was foreshadowed by the work of an American scientist, Dr. Robert H. Goddard, of Worcester, Massachusetts. On March 16, 1926, Goddard fired the first rocket propelled by liquid fuel. In a treatise published in 1920, he had suggested that it was theoretically possible to send a rocket to the moon, and if the rocket carried a pound or two of photographic flash powder, it might even be possible - with a big telescope - to see it hit a dark area on the moon. Far ahead of his time, Goddard received skeptical and often jeering publicity in the United States, and most Americans soon forgot about him. But Germans and Russians read his writings with interest, and in those countries his influence helped shape rocket development that by World War II was ahead of the rest of the world.

Back in the twenties, however, the airplane alone provided the public with enough thrills to appease its hunger for sensation and novelty. And world interest in aviation rose with each new attempt to set records of distance and speed in the air. In 1924, Britain's Alan Cobham flew from London to Rangoon, Burma, and back; the next year he made the round trip from London to Capetown. His pioneering survey flights would one day help to tie the British Empire together in a commercial air network. Lieutenant Commander Richard E. Byrd and his pilot Floyd Bennett earned for America the glory of the first flight over the North Pole on May 9, 1926. Two days later, the Norwegian explorer Roald Amundsen crossed the Pole in an Italian-built dirigible, the *Norge.*

On May 22, 1919, seven years before these flights over the Pole, a prize of $25,000 had been offered by Raymond Orteig, a New York hotel owner, "to the first aviator who shall cross the Atlantic in a land or water aircraft (heavier-than-air) from Paris or the shores of France to New York, or from New York to Paris or the shores of France, without stop."

For seven years, this prize had gone unclaimed, not because wings were fragile or men lacked courage, but because airplane engines could not be counted on to run continuously for such a distance. But now the new 220-horsepower, air-cooled Wright Whirlwind engine, was proving itself unexcelled in lightness, reliability, and efficiency for long distances.

Three of these radial engines, designed by Charles L. Lawrance and developed by the Wright Aeronautical Corporation, had taken Byrd to the Pole. In September 1926, an airmail pilot employed by the Robertson Aircraft Corporation in St. Louis began to wonder if such an engine might not pull a carefully designed monoplane across the tremendous 3,300-mile arc of land and sea that stretched from New York to Paris.

Twenty-four years old and looking even younger, Charles Augustus Lindbergh had already logged almost 2,000 hours in the air. An ex-barnstormer, wing walker, survivor of emergency parachute jumps, captain in the Missouri National Guard, he had all the flying experience needed, but little money. He took his idea - and $2,000 of his own savings - to a group of businessmen in St. Louis. Hesitantly, they agreed to raise another $13,000 to buy a long-range monoplane equipped with a Whirlwind engine. They had qualms about a single-engine airplane, but Lindbergh convinced them that extra engines simply increased the chances of engine failure. Besides, he pointed out, they could not afford a multi-engine plane.

Other men with greater financial backing had their eyes on the Orteig Prize and the glory that would go with it. Already the French war ace René Fonck had come to grief in an attempt to fly the Atlantic when his Sikorsky trimotor crashed on takeoff at Roosevelt Field, Long Island, killing two members of the crew. A new Fokker trimotor was being built for Commander Byrd, and a Bellanca monoplane capable of carrying two men over the ocean was being made ready by the Columbia Aircraft Corporation. Lieutenant Commander Noel Davis and Lieutenant Stanton Wooster of the U. S. Navy were testing a big Keystone Pathfinder biplane with three Whirlwind engines. In France another war hero, Charles Nungesser, was planning an east-to-west Atlantic crossing with François Coli. Lindbergh and his backers knew there was no time to lose.

When negotiations with Fokker and other leading manufacturers got nowhere, Lindbergh turned to a small, relatively unknown company, Ryan Airlines, Inc., of San Diego. On February 23, 1927, Lindbergh arrived in San Diego, and the next day he wired his St. Louis backers that the California builders could produce the plane, complete with engine, for $10,580. What was more, they thought they could do it in sixty days. For two months, he and the small Ryan factory staff worked feverishly on the new plane.

Exactly sixty days after the business negotiations had been settled, the *Spirit of St. Louis* was airborne.

On May 10, with all tests completed, Lindbergh flew nonstop to St. Louis in fourteen hours and twenty-five minutes - a new record from the Pacific Coast. Two days later, he was in New York.

Meanwhile, things had been going badly with the big multi-engine ships. Byrd's Fokker had crashed on landing with Fokker himself at the controls, seriously injuring Floyd Bennett. The plane was still being repaired. Davis and Wooster had been killed when their Keystone crashed in a marsh. On May 8, Nungesser and Coli had disappeared over the Atlantic. Even the Bellanca had been involved in a crack-up.

Reports of weather conditions over the Atlantic were discouraging. For a full week Lindbergh waited. His competitors - Byrd, Giuseppe Bellanca, and Clarence Chamberlin - were kind and helpful, but he acquired a permanent distaste for the intrusive tabloid press. Most of the time Lindbergh spent checking his plane, peeling off every ounce of surplus weight. There would be no radio in the *Spirit of St. Louis* and no parachute.

On the night of May 19, Lindbergh had planned to see *Rio Rita,* a musical hit. It was raining in New York; the tops of the skyscrapers were lost in mist. On the way to the theater, a call was made to the weather bureau. Now the forecast for the North Atlantic was suddenly more favorable. Forgetting the theater, Lindbergh made plans to leave early the next morning.

At the moment of takeoff, conditions were anything but favorable - a soft, rain-soaked runway; an overloaded plane; an engine whose tachometer registered thirty revolutions too low; a maddening breeze that shifted from a light head wind to a five-mile-per-hour tail wind just after the little plane had been placed in position; and a propeller set for cruising, not takeoff. But something whispered to Lindbergh that he could get his ship off the ground, and he did, clearing a web of telephone wires by twenty feet and vanishing into the misty grayness on a compass heading of 65 degrees - the heading he had worked out for the first 100-mile segment of his great circle route to Paris.

The story of that flight has been told many times, twice by Lindbergh himself. His first account, published in 1927 and titled *We,* was a stiff and unadorned account that gave little but the bare facts, "Being young, and easily embarrassed," he wrote years later, "I was hesitant to dwell on my personal errors and sensations. Also, believing in aviation's future, I did not want to lay bare, through my own experience, its existing weaknesses." In 1953, he told the whole story in a fine book, *The Spirit of St. Louis.*

Twenty-seven hours after takeoff, Lindbergh spotted fishing boats, circled low, cut his engine, and shouted futilely, "Which way is Ireland?" Actually, he was exactly on course and two hours ahead of schedule. Across the southern tip of Ireland, he flew, across the south of England, across the Channel. Then he landed in the dark at Le Bourget field at Paris, with the huge, stampeding, hysterical crowds. "Everyone had the best of intentions," he wrote with a flicker of humor in *We,* "but no one seemed to know what they were."

In the days that followed, Lindbergh's stature as a hero grew. No one has ever fully explained the outpouring of admiration and affection that came from all over the world. Granted it was a magnificent flight, splendidly marked by simplicity and perfection. Granted Lindbergh’s subsequent performance was faultless: He was modest, composed, and seemed to have an infallible instinct for saying and doing the right thing. Still there had been other great flights, and other personable and modest fliers.

Perhaps it was because something in Lindbergh - his integrity, his courage, his indifference to money, the hint of Puritanism about him, of monasticism almost - touched the spark of nobility that glows, however faintly, in human beings everywhere, reminding his admirers that man’s spirit can also soar on wings above materialism, above the dark waters of selfishness.

The symbolism of the flight was irresistible. As Ambassador Myron T. Herrick said of Lindbergh, “He started with no purpose but to arrive. He remained with no desire but to serve. He sought nothing; he was offered all.”

EXPLORE

Aviation, the romantic military branch of the war, found itself regarded as a useless curiosity in peacetime. Barnstormers drew crowds at county fairs in America, and stunt fliers enlivened the movies. Gliding was a popular sport in Europe, and the exploits of the first transatlantic fliers made exciting reading. But to many people, the airplane was a frivolity that could never earn its keep.

Two new developments began to change some minds. In Europe commercial airlines sprang up soon after the Armistice, and although the planes were uncomfortable and expensive, they usually reached their destinations safely.

In the United States, airplanes were flying the mail. Scheduled mail flights had been inaugurated even before the end of the war. Delays were frequent, and fatalities high, but routes were expanded, and in February 1921, the mail was flown from San Francisco to New York for the first time, in thirty-three hours and twenty minutes.

Although it sometimes promised more than it could deliver, the airplane had gone to work.

Across the Ocean

Although two successful flights across the Atlantic were made in 1919, transoceanic trips were a perilous business for airplanes. The Navy's *NC-4* flew safely to Europe via the Azores in May, but her two sister ships were forced down into stormy waters by bad weather. In June, fog and ice almost turned Alcock and Brown's nonstop flight into a disaster.

That same summer, however, a dirigible crossed the Atlantic and made it look easy. Britain's *R-34* left Scotland on July 2, and although constant head winds reduced her speed, she reached Mineola, Long Island, four and a half days later. Her return trip to England took only seventy-five hours. Lighter-than-air men were jubilant, and the dirigible's reputation for safety and reliability in the next decade rose higher than was deserved.

The Lean Years

The end of war prosperity had brought a critical period to America's budding aviation industry. Seattle's William Boeing assessed the situation in a letter to his staff soon after the Armistice: "I look for a splendid future in peacetime, but there is going to be a gap of six months to two years when it will be a hard struggle. In the meantime we should keep our shop occupied with other work. Comb the field and see what we might go into. I can suggest showcase work and interior woodwork."

Boeing was correct in his prediction of a doldrums period. But he was overly optimistic concerning the duration. With only a minimum of government military orders and practically no demand for commercial planes, American builders experienced a long period of lean years.

During that time, many of them never stopped dreaming - and working at planning boards. Great names of the future stayed in the business - men like Boeing, Donald Douglas, Lawrence Bell, James Kindelberger, Claude Ryan, Igor Sikorsky, Eddie Stinson, William B. Stout, and Sherman Fairchild. Along with established pioneers like Glenn Curtiss, Glenn Martin, and Grover Loening, they competed for the occasional government order and eagerly sought the rare private sale.

Financing was a constant problem, and shops were often half-empty or temporarily shut down. Sometimes designers left their employers and gambled with shops of their own.

In the end, those with staying power and ability - who had kept their favorite planes flying while constantly testing and improving them - were rewarded. As activity picked up, they won bids and expanded operations that, in some cases, boomed eventually into huge plants.

Speed and Comfort

Europe's fledgling airlines struggled to survive in the early 1920s. The converted bombers being used for passengers were too small for profit, and there were too many airlines for too few customers.

Government subsidies and more efficient aircraft solved the problem. Following the example of Holland's KLM, Germany and England merged their anemic private airlines into state-supported Lufthansa and Imperial Airways. And multiple-engine airliners that could carry up to twenty passengers in their sumptuous cabins were designed by builders like Anthony Fokker, Hugo Junkers, and Frederick Handley Page.

Passenger totals for the world's airlines, excluding China and Russia, soared from 5,000 in 1919 to 434,000 a decade later in 1929. It was not yet self-supporting, but aviation had become a big business.

Billy Mitchell

Naval officers were stunned when General Billy Mitchell's bombers sank the supposedly impregnable *Ostfriesland* on July 21, 1921. Some wept openly as they watched the huge German battleship go down under a quick and deadly hail of 2,000-pound bombs.

Diehards pointed out that the ship was neither defended nor moving when it was attacked, and the joint Army and Navy report of the event signed by General John Pershing stated that the battleship was still the “bulwark of the nation’s sea defence.” But Mitchell had tasted victory, and he became even more uncompromising in his crusade for a stronger air corps.

Mitchell’s appointment as Assistant Chief of Air Service was due to expire in 1925, and he was determined to make the most of his tenure. He exposed the vulnerability of American cities with a series of mock air attacks, and he proved again, in further demonstrations at sea, that battleships were no match for bombers. Mitchell knew that the future of air power rested on civilian as well as military support and understanding, and so he set out to reawaken the nation’s interest in aviation.

Army Triumphs

Under Mitchell’s ceaseless prodding, U. S. Army Air Service pilots smashed world records and made flights that pressed both men and planes to the limit of endurance. Most spectacular were the first nonstop flight across the continent made in 1923 by Lieutenants John Macready and Oakley Kelly and the round-the-world flight of 1924. But there were other triumphs, too.

In September 1922, Lieutenant James Doolittle became the first person to fly across the United States in less than a day. With only one stop, he flew from Florida to California in twenty-one hours and twenty minutes. In May 1923, Lieutenant H. G. Crocker raced from Texas to Ontario, Canada, in less than twelve hours nonstop. And in June 1924, Lieutenant Russell Maughan beat the sun from New York to California as he flew 2,670 miles in less than twenty-two hours including refueling stops.

Speed records fell as men like Maughan, H. R. Harris, Ralph Lockwood, and Cyrus Bettis - all Air Service lieutenants - increased the performance of their planes. And endurance records toppled when a pioneering aerial refueling device helped Lieutenants Lowell Smith and John Richter to remain aloft for more than thirty-seven hours in August 1923. Each month saw new Army Air Service successes - and new ammunition for Mitchell's crusade.

The Navy Flies

American Naval aviation was partially eclipsed in the 1920s by the more sensational exploits of the Army Air Service pilots. Nevertheless, progress was made in adapting aviation to the Navy's mission.

Naval pilots and engineers pioneered in the refinement of aerial torpedoes, air-cooled radial engines, all-metal airplanes, and catapults for launching planes from ships. An accurate high-altitude bombsight was developed for the Navy by Carl Norden. Seaplane tenders were put into service, and the first aircraft carriers were built. Despite these advances and the fact that Navy pilots broke many records, some Naval leaders were criticized, often unfairly, for inefficiency and shortsightedness. To counteract any impatience with Naval progress, two highly-publicized flights were ordered in 1925. The first, a nonstop flight to Hawaii, was a failure. And two days later, the second, a good-will tour by the dirigible *Shenandoah,* ended in disaster.

Great Air Races

Competition for two coveted racing trophies gave tremendous impetus to aviation in the 1920s. Pitting nation against nation and the Army against the Navy, the

Schneider and Pulitzer Races capitalized on the natural rivalries of the fliers to encourage technological progress.

The Schneider Trophy Race, established in 1913 by Jacques Schneider of France, was open to seaplanes of all nations. The first pure racing planes appeared in the 1923 contest that the United States won with a Curtiss CR-3, the first plane to fly with a metal propeller. Its pilot was Lieutenant David Rittenhouse of the Navy, whose speed was 177 miles per hour. Each subsequent Schneider Race was marked by innovations in designs and engines, culminating in the great Supermarine aircraft, forerunners of the Spitfire fighters of World War II. British pilots, flying Supermarines at speeds up to 343 miles per hour, won the Schneider Race three consecutive times, and retired the trophy in 1931.

The Pulitzer Races were first held in 1920, when the Pulitzer brothers of St. Louis donated the trophy to spur the progress of American aviation. From that first year when Lieutenant Corliss Moseley of the Army beat out thirty-six other entries in a Verville-Packard racer, to 1925 when Lieutenant Cyrus Bettis won with a record-breaking 249 miles per hour, the Pulitzer Races excited the imagination of American designers and pilots and gave a new competitive spirit to the growing aviation industry.

Over the Pole

Shortly after midnight on May 9, 1926, a Fokker trimotor, the *Josephine Ford,* took off on skis from a snow-packed runway at King’s Bay, Spitsbergen. Commanded by Richard E. Byrd, and piloted by Floyd Bennett, the plane flew across the forbidding arctic waste toward the North Pole.

Navigation without landmarks of any kind was perilous, and tension was increased by the discovery that one of the engines was leaking oil. But the plane stayed aloft, and the pilots kept their bearings. At 9:02 a.m. May 10, they became the first men to fly over the top of the world.

Sixteen hours after takeoff, they returned triumphantly to King’s Bay. Among those who greeted them was Roald Amundsen, the Norwegian explorer, who himself was to fly over the Pole in the dirigible *Norge,* three days after Byrd’s success.

Charles Lindbergh

Early on the morning of May 20, 1927, the *Spirit of St. Louis* was towed by a truck from Curtiss Field, Long Island, to adjoining Roosevelt Field, which had a smooth runway. As the airplane was hauled backward through the rain, Lindbergh thought the scene looked “more like a funeral procession than the beginning of a flight to Paris.” But a beginning it was; at 7:52 a.m., he made a successful takeoff.

Parisian police tried to hold back the ecstatic crowd at Le Bourget airport when Lindbergh landed, but their efforts were futile. The mob broke through the barricades, and while some ripped pieces of fabric off the *Spirit of St. Louis* as souvenirs, others dragged Lindbergh from the cockpit and carried him away on their shoulders. Enthusiastic crowds also greeted Lindbergh in Brussels and in London.

At first, Charles Lindbergh was too busy to think of sleep. Pleased with his successful takeoff, he checked his instruments carefully and followed the geography of the land below him on his maps. He also discovered unexpected sources of annoyance. Clumps of mud, for instance, had been thrown onto the wings during takeoff. Lindbergh had been ruthless in eliminating excess weight; how ironic that uninvited chunks of dirt should now add to the plane’s load.

By the fourth hour of flight, his body began to cry for rest. But there were squalls over Nova Scotia to buffet the plane and shake him back to alertness, and later, over the hazy Atlantic, there were ominous ice cakes on which to concentrate. During the twelfth hour, he flew low over St. John’s, Newfoundland, and saw the weather-beaten faces of men on the ground looking up at him in amazement.

North America was behind him now, and Lindbergh flew on through fog and darkness. When he shined his flashlight on the wing, he saw that there was some icing. But sleep was still his deadliest enemy. He cupped his hands into the slipstream to direct the icy wind against his face; he stamped his feet and bounced up and down in his seat. And sometimes, during the endless night, he had to hold open his eyelids with his thumbs.

Then it was morning. Lindbergh settled his plane low over the turbulent ocean. He knew that the land he saw was a mirage, and he continued onward as if in a daze. In the twenty-sixth hour, he saw a porpoise, and then birds, and later, boats. Excitement conquered his need for sleep. He flew over Ireland and, now fully awake, on toward France and into the pages of history.

7

THE THIRTIES

The impact of Lindbergh's achievement on American aviation was explosive. From May 21, 1927, onward, men knew that the airplane was actually capable of all that the dreamers and pioneers had claimed for it. It could span oceans, shrink the globe, compress time, unite people with goods and services - or destroy them with bombs and bullets wherever they might be on earth. Man had truly conquered the air, and it was merely a matter of time - and money - before full-fledged commercial and military air power would come into being.

Like the first four-minute mile in foot racing, the flight broke through an invisible psychological barrier and touched off a whole series of record-breaking performances. Within six weeks of Lindbergh's arrival in Paris, two more planes had spanned the Atlantic. On June 4, Clarence D. Chamberlin, accompanied by his financial backer Charles A. Levine, made a record-breaking nonstop flight of over 3,900 miles from New York to Germany where he was forced down by fog only 118 miles short of his goal, Berlin. On June 29, Commander Richard E. Byrd and a crew of three finally set out for Paris in their Fokker C-2 trimotor, the *America.*

Taking off in the rain, with Bert Acosta and Bernt Balchen as pilots and George O. Noville as radio operator, the *America* followed the trail that Lindbergh had blazed. For much of the distance, they flew through fog. Climbing at times as high as 10,000 feet, and steering only by the luminous compass dials, Byrd repeatedly noted in his log: "Impossible to navigate."

The fog lifted briefly as they reached the French coast but then closed in again. With fuel running low, the fliers' only chance was to make a landing on water. Dropping flares into the ocean, they ditched the big landplane just off the

Normandy beach and paddled dejectedly ashore in a rubber boat.

At almost the same time another C-2, the *Bird of Paradise*, was making an even more remarkable flight from Oakland, California, to Honolulu, Hawaii. The hazard faced by two Army fliers, Lieutenants Lester G. Maitland and Albert F. Hegenberger, was obvious: The slightest navigational error would cause them to miss the islands altogether. They were aided to some extent by a radio beacon - the first use of this device in overseas flight - but their receiver worked only intermittently. Adding to their anxiety was the apparent absence of their food supply, which had actually been put aboard but had been stowed away so carefully that the fliers could not find it until they had covered the 2,400 miles to Hawaii in twenty-five hours and fifty minutes of faultless flying and navigating.

Again the pioneers did a better job than some of their imitators. In July, a pair of civilians, Ernest L. Smith and Emory Bronte, barely made it to the island of Molokai from Oakland before running out of fuel. In August, the first transoceanic air race in history took place when James D. Dole, a planter in Hawaii, offered prizes totaling $35,000 for a flight from Oakland to Wheeler Field on the island of Oahu.

The Dole “Pineapple Derby,” as it was called, was not one of aviation’s more illustrious events. It was not an attempt to advance the science of aeronautics; some of the airplanes entered were little better than homemade crates. There was not even the challenge of a great new adventure; the flight to Hawaii had already been made twice. The chief motives of the contestants were simply publicity and money.

Of the sixteen original entries, two crashed on their way to the small, single-runway airfield at Oakland. Trying to forestall further disasters, the government inspected the remaining planes and tested the competence of the pilots and navigators. Six planes were eliminated. Of the remaining eight, only one - the *Woolaroc,* a single-engine, Travelair monoplane - carried a radio capable of both sending and receiving. Four of the contestants either crashed on takeoff or turned back. Only two of the other four - the *Woolaroc* and the *Aloha,* a Breese monoplane - completed the flight. The others disappeared. An Air Corps search plane that went out to look for them spun into the sea, killing two Army fliers.

The following year, however, in one of the most successful and daring flights of all time, four men conquered the Pacific completely. A pair of Australian fliers, Squadron Leader Charles Kingsford-Smith and Flight Lieutenant Charles P. T. Ulm, were convinced that a flight from the United States to Australia was possible. With limited funds, they came to the United States, and for about $15,000 managed to buy a secondhand Fokker trimotor that had been used by Sir Hubert Wilkins for arctic exploration.

With three new Wright Whirlwind J-5 engines, Kingsford-Smith and Ulm carried out a number of preliminary endurance flights. Authorities in Australia, worried by the “Pineapple Derby” disasters, tried to dissuade them from their transpacific plans, and their financial problems seemed endless. But on May 31, 1928, with two Americans, Harry W. Lyon and J. W. Warner, as navigator and radio operator, they took off from Oakland and flew to Hawaii without difficulty. From there they made a spectacular flight of 3,000 miles through headwinds, rain, and turbulence to the Fiji Islands. A third hop of 1,762 miles brought them to Brisbane, Australia, on June 9.

Eight days later, the first woman to fly the Atlantic became an international heroine overnight. On June 17, 1928, Amelia Earhart made a flight from Newfoundland to Wales as a passenger in another Fokker C-2, piloted by Wilmer Stultz, with Louis Gordon as mechanic. When people praised her courage, she demurred. “The bravest thing I did,” she said with disarming modesty, “was to try to drop a bag of oranges and a note on the head of an ocean liner’s captain - and I missed the whole ship!”

By 1929, transoceanic flights had lost much of their novelty although the publicity given them helped stir new interest in the airplane as a passenger-carrying vehicle. Commercial aviation in the United States, however, still had a long way to go. In the period 1919-27, European lines had moved ahead of their American counterparts. About 1924, a series of amalgamations of small European pioneer companies had resulted in stronger airlines, such as Aero-Lloyd in Germany, Air Union in France, and Imperial Airways in Britain. Encouraged and partially underwritten by their governments, the lines were energetically pushing air routes around the globe to overseas possessions: the Dutch out of Batavia in the East Indies; the British to India and Australia; and the French down through Africa to Madagascar. American airlines during those years tended to be small, mail-carrying companies with little capacity for (or interest in) passenger travel.

The Lindbergh flight acted like adrenalin in the bloodstream of American aviation. In a single year after Lindbergh’s flight, applications for pilot licenses in the United States jumped from 1,800 to 5,500. In 1928, the nation’s airline operators doubled their mileage, trebled their mail load, and quadrupled the number of passengers they had carried in 1927. And airline stocks boomed. In 1929, before the stock market crash, the public bought aircraft manufacturing securities to the tune of $400 million.

Fortunately, technological developments kept pace with the public's quickening interest. In 1927, the famed Lockheed Vega had appeared. Designed by Allan H. Longhead (who used a simplified spelling in his company name) and John Northrop, it was a brilliant adaptation of the Fokker type of high-wing monoplane. Capable of carrying a pilot and six passengers at speeds up to 135 miles per hour for a distance of 500 to 900 miles, it served as America's challenge to the lead in transport design so long held by Fokker and Junkers. In engines, the more powerful 425-horscpower Pratt and Whitney Wasp was replacing the old reliable 225-horsepower Wright Whirlwind. In 1928, the National Advisory Committee for Aeronautics developed an engine cowling that increased airspeed with no increase in horsepower, and the following year instrument flying became a reality with Jimmy Doolittle's first completely blind takeoff and landing in a trainer equipped with a hooded cockpit. Another development that was to insure safe, practical all-weather commercial flying in the years to come was the introduction in 1929 of the use of two-way voice radio.

But the key factor in the sudden expansion of American commercial flying was the growing awareness of big business that there was money to be made in it - if the necessary mergers were made and the right men given the right kind of backing.

Whenever the magic combination of cash and courage appeared, things happened quickly. In July 1927, the aggressive and far-sighted Juan Trippe had won a contract to carry mail between Key West and Cuba. Within a year, he had secured two more foreign mail contracts to Puerto Rico and the Canal Zone, which meant that his brash young Pan American Airways would be receiving about $2.5 million a year in mail revenues alone. Within three years, Trippe's Fokker amphibians and Sikorsky flying boats had thrown an aerial loop around South America, "just in time," he liked to say, to keep foreign competition - mainly French and German - from dominating that continent.

After a long, complicated, and often bitter struggle among a welter of rival companies, three major transcontinental air systems began to take shape in the United States. In 1929, Lindbergh agreed to lend the enormous prestige of his name to Transcontinental Air Transport, which soon became known as "the Lindbergh line." It offered a combined rail-and-air service across the central part of the nation to transcontinental passengers who could sleep all night in Pullmans while crossing the Alleghenies or the Rockies and transfer to planes over safer flying country. This hybrid form of travel was never a great success. It offered relative safety but not much in terms of time-saving. In October 1930, Transcontinental merged with Western Air Express to become Transcontinental and Western Air (TWA) and inaugurated an all-air service from coast to coast.

The preceding March, United Airlines, operating between the West Coast and Chicago, had bought out National Air Transport and extended its service to New York. A third great airway system sprawled across the southern section of the nation. Composed of a jumble of minor airlines, this cumbersome organization, American Airways, eventually developed into one of the most profitable lines in the country.

In March 1929, these three big systems came under the penetrating eye of Walter F. Brown, Postmaster General of the new Hoover Administration. Like his predecessors, Brown felt that the Post Office Department should encourage commercial aviation in the interests of national defense. But he also felt that rapid expansion would never take place so long as government subsidies made it more profitable for the airlines to carry mail than to carry passengers.

Consequently, he sought an amendment to the original Kelly Act that would eliminate the old pound-per-mile rate and pay operators according to how much cargo space they made available. Brown figured that this would encourage the airlines to place orders for larger airplanes; then, if mail did not fill the extra space, the operators would carry passengers rather than fly half-empty. The new proposal, passed as the McNary-Watres Bill, also attempted to reward progressive operators by providing for extra payments to airlines using multi-engine planes equipped with the latest navigational aids. The whole point of the new law, Brown said, was to develop aviation in the broad sense and to stimulate manufacturers "who would compete with each other and bring their aeronautical industry up to the point where it could finally sustain itself."

This approach meant, inevitably, that when it came to bestowing mail contracts, Brown would tend to disregard the small, struggling, independent airlines in favor of the larger companies with better financing and more experienced personnel. After a series of meetings, later known sardonically as the "Spoils Conferences," the big operators did walk off with most of the contracts. Brown's motives were sincere enough, but almost from the start of the Hoover regime, the independents were sharpening their knives and looking eagerly at the scalp of the Postmaster General.

When Brown assumed office, all transcontinental mail was being carried by United Airlines over the northern route. The new Postmaster General felt that there should be two other mail routes across the country. Given his preference for strong, experienced airlines, it was no surprise when American Airways won the southern route and TWA, the central route.

In addition to the three big transcontinental routes, a host of independents were competing strongly with one another. This competition, working back to the factories, soon produced some revolutionary aircraft designs. In February 1933, Boeing brought out a low-wing, all-metal monoplane, the 247 that in many ways was the first modern airliner. It was also a demonstration of the superiority of all-metal construction; the 247 clearly antiquated the part-wood, part-metal planes of the twenties and early thirties. Carrying ten passengers and powered by two Wasp radials, the new plane was designed to fly on one engine if necessary. Cowled engines, appearing for the first time on an airliner, greatly reduced drag. This airplane, derived from the Boeing B-9 bomber of 1931, strongly influenced European designers. The British Bristol 142, the German Junkers Ju-86, and the Heinkel He-111 all owed a debt to Boeing.

Ordinarily such an airplane might have outdistanced its competition for several years, but within a few months, an even more remarkable plane was in the skies.

In 1932, like many other corporations battling the Depression, the aircraft manufacturing firm of Donald Douglas had fallen upon lean times. Douglas himself had been passionately interested in aviation ever since 1908 when, as a wide-eyed youngster, he had watched Orville Wright demonstrate his marvelous flying machine for the

Army at Fort Myer. Later he had worked as Glenn Martin's chief engineer. In 1921, he had formed his own company in back of a barber shop in Santa Monica, California.

In August 1932, a query came to Douglas from Jack Frye, vice president of TWA. Could Douglas build an all-metal, trimotor monoplane capable of carrying a crew of two and at least twelve passengers at a speed of 150 miles per hour and with a cruising range of 1,000 miles? Douglas designers set to work and the result, less than a year later, was the DC (Douglas Commercial)-1.

The DC-1, of which only one was built, was a twin-engine, all-metal, stressed-skin monoplane somewhat larger than the Boeing 247 and slightly faster. It was powered by two Wright R-1820 Cyclone engines which drove fixed-pitch propellers. When the DC-1 was modified into the DC-2, variable-pitch propellers became standard equipment and gave much improved performance. The DC-1 was also equipped with flaps that made low-speed approach and landing possible. Another important innovation was the long-chord cowling around the radial engines, a vital factor in the DC-1's excellent drag characteristics.

Tests carried out with the DC-1 were so successful that TWA ordered twenty-five aircraft of the same type, with a few changes. Douglas sold these DC-2s, as they were called, for $65,000 apiece and lost money on the order. But the age of the modern airliner had begun.

The capabilities of both the Boeing 247 and the Douglas DC-2 were dramatically demonstrated to the world in October 1934 in a race from England to Australia. The Boeing was flown by Colonel Roscoe Turner, the Douglas by a KLM Dutch crew. The 11,000-mile race was won by a de Havilland Comet, a twin-engine military airplane that flew the last two and one-half hours of its run on one engine. But the "sedate" American transports were right behind the Comet. The DC-2 landed at Melbourne just over seventy-one hours after leaving England. The Boeing was third, another Comet racer was fourth, and the other entrants were strung out behind. By the end of the year, Douglas was turning out ten DC-2s per month. Altogether it produced 220 of these fine aircraft for airlines all over the world.

The year 1934 also saw the appearance of the Lockheed L-10 Electra. Smaller and faster than the Boeing 247 and the DC-2, it carried only eight passengers, but its low operating costs made it popular, and Lockheed built about 150 of them.

By this time, American Airways had inaugurated a transcontinental sleeper service, using Curtiss Condor biplanes. These were reliable, but slow; the company wanted a plane that could leave New York at sundown, fly through the night with three or four refueling stops, and land in California the next day. They, too, brought their problem to Douglas. Trying to stretch the DC-2 to include berths for overnight passengers, Douglas engineers finally came up with a new airplane, the DC-3 that could be used as a twenty-one-passenger day plane or a fourteen-passenger "Skysleeper." The new plane went into service with American on June 26, 1936, powered by two 900-horsepower Wright Cyclone engines. It turned out to be the most successful transport ever built, answering for the first time the three basic requirements of speed, safety, and economy.

One reason for its popularity was its great durability. The multi-spar construction of wing and tail made the airframe highly resistant to fatigue or structural failure. Some DC-3s flew as many as 70,000 hours without being rebuilt. Carrying more passengers than its predecessors, its operating costs represented a 25 percent improvement over the Boeing 247, and brought the airline operators much closer to the break-even point. Before the appearance of the DC-3, domestic airlines in the United States were covering less than two-thirds of their total costs. The new airplane made it possible for them to cover more than 80 percent. By 1939, the DC-3 was carrying about three-fourths of all domestic air traffic.

While technology was making such spectacular advances, political problems were darkening the aviation horizon. In Washington, the Hoover regime had been replaced by Franklin D. Roosevelt's New Dealers. Thirsting for blood, the independent airline operators were clamoring that the recent Republican Postmaster General had been guilty of favoritism in his allocation of mail contracts to the big operators. Not at all averse to pinning charges of misconduct on their political rivals, the New Dealers launched a Senatorial investigation under the chairmanship of Hugo L. Black of Alabama. The findings seemed damaging at the time - although later a court held there had been no discrimination or collusion - and the Administration was prompted to take a drastic step.

On February 9, 1934, President Roosevelt instructed Postmaster General James A. Farley to cancel all domestic airmail contracts and ordered the U. S. Army to fly the mail effective February 19. Believing that the airmail flights would give his peacetime fliers valuable training under emergency conditions similar to war, Major General Benjamin D. Foulois, Chief of the Army Air Corps, promptly accepted the assignment.

The Army agreed to maintain fourteen routes connecting eleven major cities with total daily runs of 41,000 miles. The job, Foulois estimated, would take 500 officers and 148 airplanes; he had just ten days to prepare for it. Foulois immediately set up airmail headquarters in Washington; divided the country into three zones with zone commanders at Newark, New Jersey, Chicago, and Salt Lake City; asked the National Guard for additional airplanes; ordered Army planes stripped of military equipment to make room for the mail sacks; installed radios and additional navigation aids in these converted planes; and initiated familiarization flights in which Army pilots received training in blind and radio-beam flying. When three pilots were killed during these trials, Foulois strengthened the safety requirements, emphasizing that lives and property would not be sacrificed to keep the mail going.

Commercial operators were skeptical of these preparations - and bitter because they had been cut off from the subsidy that had nourished them for so long. In a last-ditch effort to prove to the public that the job of flying the mail belonged in experienced, private hands, TWA staged a sensational flight on the night of February 18. Flying a brand-new DC-2, rushed to completion just before the fatal deadline, vice president Frye and Captain Eddie Rickenbacker, now vice president of Eastern Air Transport, flashed across the country together to deliver the last load of mail from Los Angeles to Newark before noon on February 19. Their time of thirteen hours and four minutes was an unheard-of performance for a transport airplane. The next day, the Army took over.

Although plagued by bad weather and hampered by lack of adequate training, the military pilots made a brave try. By March 10, however, ten men had been killed - either in training or actual airmail flights - and Foulois temporarily halted the program. After a thorough inspection of men and equipment, the mail flights were resumed on March 19. As the weather improved, the Army began to do a creditable job. But by now, the tide of public opinion was running strongly against the entire unfortunate experiment. By May, the job of carrying the mail was back in private hands.

As a face-saving gesture, Postmaster General Farley - who had never relished his role of Lord High Executioner - decreed that no airline could win a new contract if it had been represented at the so-called “Spoils Conferences” of 1930. As a result, some of the major lines submitted bids with their names slightly changed. American Airways became American Airlines. Eastern Air Transport turned up as Eastern Airlines. Transcontinental and Western Air submitted its bid as TWA, Inc. - apparently all the camouflage needed. On May 8, with hustling Jack Frye flying a powerful new Northrop Gamma, TWA set a new coast-to-coast record, delivering the mail from Los Angeles to Newark in less than twelve hours. Nevertheless, it took the airlines several years to recover from the financial losses and dislocations that had been caused by the suspension period.

Meanwhile, record-breaking flights had continued; even in the grim years of the Depression, the public had not lost interest in them. In 1931, a one-eyed ex-parachute jumper, Wiley Post, and his Australian-born navigator, Harold Gatty, had thrilled the country by flying their Lockheed Vega, the *Winnie Mae,* around the world in eight days, fifteen hours, and fifty-one minutes. Two years later, in July 1933, Wiley Post’s second dash around the world in the *Winnie Mae* - this time alone -furnished the decade with perhaps its most remarkable display of flying endurance. The Sperry Gyroscope Company in the fall of 1932 had perfected an automatic pilot that made it possible for the pilot to relax in the cockpit while the plane flew itself. Equipped with this and other new devices - notably a radio direction finder - Post succeeded in slashing almost a day from his previous record. He was killed two years later in a tragic crash - near Point Barrow, Alaska - that also took the life of his flying companion, newspaper columnist, social commentator, and actor Will Rogers.

Two months after Post's death, a tall, intense young Texas millionaire named Howard Hughes set a new speed record for landplanes, flying his Hughes *Special* at 325 miles per hour. Three years later, with four companions, Hughes flew a Lockheed 14 around the world in the remarkable time of three days, nineteen hours, and fourteen minutes. Powered by two Wright Cyclones, the plane was a flying laboratory that cost $300,000.

Hughes paid all expenses himself, and he did not claim any special credit. "Please remember," he said, "that I am but one of five persons who made that trip, and being taller than any of them kept getting in the way and making a nuisance of myself. If you must praise anyone, save your shouts for Wiley Post, for by flying around the world alone, in the time he did, and with but one eye, he made the most amazing flight that has ever occurred."

It was an attempted round-the-world flight that cost Amelia Earhart her life in 1937. Unlike Wiley Post and Howard Hughes who had followed the relatively short northern route, she planned a 27,000-mile flight close to the bulge of the equator. This, she said, would be her last long-distance effort. Flying a Lockheed Electra, with Fred Noonan as navigator, she reached New Guinea late in June. Her next scheduled stop was tiny Howland Island, 2,556 miles across the South Pacific. Noonan was uneasy about his chronometers; he was having trouble setting them accurately. Nonetheless, on July 2, they took off. A United States Coast Guard vessel, the *Itasca,* was stationed near the island. It received radio messages from the plane that told of head winds and heavy fuel consumption. A final fragmentary call seemed to indicate that the Electra was off course - lost. After that, there was silence.

That same year, the most harrowing and spectacular of all air disasters wrote a fiery finish to passenger-carrying airships. On May 6, 1937, nosing down through the sultry dusk to a landing at Lakehurst, New Jersey, the giant Zeppelin *Hindenburg*, largest dirigible ever built and pride of Nazi Germany, exploded in a sheet of flame that killed thirty-five of the ninety-seven persons aboard.

Up to that point, confidence in dirigibles had somehow managed to survive an almost unbroken series of failures and tragedies. The tremendous size of the great ships, their apparent stability, their lack of dependence on fragile wings - these had lent an air of majesty to their flights and had given a false sense of security to those who rode in them.

In 1928, returning to the Arctic, General Umberto Nobile had piloted the dirigible *Italia* to the North Pole and then crashed on the ice pack on his way back to Spitsbergen. Faint radio signals touched off massive rescue efforts. Roald Amundsen disappeared, trying to save his former companion. Finally, after weeks of misery, the survivors were picked up - some by airplanes, some by a Russian icebreaker.

This was just one more link in the chain of lighter-than-air tragedies. In 1930, outward bound for India, the big British dirigible *R-101* crashed in flames in France. Of the fifty-four aboard, only six survived. England abandoned her dirigible experiments, but America and Germany kept on.

The German-built *Los Angeles* was retired after a dozen years of docile flying, and the reliable *Graf Zeppelin* made a round-the-world flight in 1929 and later safely ferried passengers across the Atlantic. But these were happy exceptions to a grim rule. In 1933, on her fifty-ninth flight, the American-built *Akron* crashed at sea in a storm off the New Jersey coast. Seventy-three out of seventy-six men aboard were lost, including Admiral Moffett, the Navy's staunchest dirigible enthusiast. Two years later, the *Akron's* sister ship, the *Macon,* was wrecked off the California coast. Only two lives were lost - a pair of crewmen who jumped too soon. After the *Hindenburg* disaster, Hitler grounded the *Graf Zeppelin,* and another monster airship under construction - the *LZ-170* - was never allowed to make a commercial flight.

Even before this final tragedy, the advent of the long-range airliner was already robbing the great sky ships of such value as they had. Like the dinosaurs, they fell victim to their own huge bulk and lack of adaptability. After the death of the *Hindenburg,* they became extinct.

One reason Hitler grounded the *Graf Zeppelin* was his intense dislike for her commander, Dr. Hugo Eckener. For years, Eckener had been forthrightly urging his passengers to beware of the Nazis. "These madmen are after you," he would say to complacent British or American travelers. "They mean to conquer Europe - yes, the whole world!"

His colleagues would smile tight-lipped smiles and say that, after all, Herr Doktor was an airman, not a statesman. But the grizzled little German was right. Throughout the turbulent 1930s, some of the great powers were preparing for another big war by fighting little wars.

Militaristic nations never lack excuses to justify their aggression. In January 1932, the so-called “Shanghai Disturbances” touched off a war in Asia. At first, the Japanese suffered sharp and unexpected reverses at the hands of the Chinese 19th Route Army. But by sending two aircraft carriers equipped with Nakajima and Mitsubishi fighters, they were able to control the air over the combat zone. The value of this air superiority impressed the Japanese so deeply that they initiated a tremendous program of air-power expansion that continued right up to Pearl Harbor.

Nor were the aggressors in Europe idle. In Italy, after Mussolini came to power, the neglected air force was made autonomous - a policy advocated as early as 1921 by Guilio Douhet. In print and speech, this Italian officer had insisted that future wars would be won by those nations that possessed independent air forces capable of carrying out massive bombing of enemy cities as opposed to selective bombing of industrial targets in order to cripple an enemy’s morale. Douhet’s theories were studied by military leaders throughout the world, and in 1935, they were tested with grim results by his own countrymen.

In October, Italy invaded the primitive African kingdom of Ethiopia. The Italian Regia Aeronautica promptly went into action. More than 300 combat airplanes, mostly three-engine bombers, were used to harass the enemy and supply the Italian ground forces. Against virtually no opposition, they tested every weapon in their arsenal, including poison gas - a mode of annihilation which Douhet had stressed in preference to conventional bombs.

The next year, when civil war broke out in Spain, Mussolini sent both fighter and bomber squadrons to aid Franco’s rebels. When that fierce and bitter war ended almost three years later, more than 700 Italian warplanes had been in action, carrying out some 5,000 bombing missions and claiming a total of 903 Loyalist planes destroyed. The Germans, too, seized the opportunity to test their rapidly expanding Luftwaffe under combat conditions. In August 1936, six Heinkel fighters and twenty Junkers bomber-transports were given to Franco, and in November, sending combat personnel to Spain disguised as "strength-through-joy" tourists, the Germans organized the Condor Legion, a miniature air force complete with fighters, bombers, dive bombers, seaplanes, and even antiaircraft batteries.

One squadron of Heinkels was commanded by an aggressive young officer, Adolf Galland, who had learned to fly gliders in "de-militarized" Germany, and who had later been given secret pilot training in Italy. In Spain, Galland's squadron specialized in ground attack and developed tactics that were later to characterize the *blitzkrieg* against Poland and France. It was found as the war went on that the Heinkels could not hold their own against the fighters that the Loyalists were receiving from the Russians, and they were gradually replaced by the new and deadly Messerschmitt Me-109s.

The war in Spain also saw the first operational use of the Junkers dive bomber, a form of flying artillery that the Germans had developed after studying some early American experiments. In December 1937, three of these Ju-87 As screamed down upon Loyalist gun positions at Teruel with such spectacular results that the Germans promptly sent more of them into action. These gull-winged "Stukas" were relatively slow and were vulnerable both to conventional fighters and to ground troops seasoned enough to stand firm and shoot at them. But in 1938 - as in the early stages of World War II - they were a terrifying and demoralizing weapon.

By 1938, German airplane production was on a wartime basis, and the Condor Legion was methodically testing two new bombers, the Heinkel He-111 B-1 and the Dornier Do-17E-1. These flew successfully in unescorted raids against the weakening Loyalists and led the German High Command to think that they could protect themselves. It was an expensive illusion; the same tactics were to prove disastrous two years later in the Battle of Britain.

Against these Italian and German warplanes in Spain were ranged some of Soviet Russia's best fighting aircraft. As early as October 1936, twin-engine bombers flown by Soviet "volunteers" were raiding Seville, Granada, and other rebel-held cities. These were SB-2s (SB standing for *Skorostnoi Bombardirovshchik,* or "fast bomber") designed by A. N. Tupolev, who had been turning out planes for the Soviets since 1919. The Russians also poured more than 1,000 fighters into Spain, chiefly Ilyushin Il-15s and Il-16s that were equal or superior to most of the Fascist fighters. In the end, the Loyalists lost the war, but the reports sent to Moscow on the performance and limitations of their planes under combat conditions were of great value to Soviet strategists.

Spain was not the only testing ground for the Russians. When fighting again broke out between Japan and China in 1937, Il-15 and Il-16 fighters with Chinese insignia were soon flying against carrier-based Mitsubishi fighters - and holding their own. Russia had long regarded Japan's conquests in China with alarm, and in the summer of 1939, tension along the Mongolian border broke into an unofficial but savage war in which both the Russian and Japanese air forces were heavily engaged. For the first time, the Japanese found themselves up against a strong modern air force and were roughly handled. Only Soviet preoccupation with the growing Nazi menace in the West prevented a major Japanese defeat.

This came as a shock to the Japanese, who had been testing and improving military planes ever since the “Shanghai Disturbances” of 1932. Gradually long-distance bombing had become the province of their naval air force, the army air force being used primarily for ground support. Japanese naval fliers had had to learn some lessons the hard way - as when they attempted an unescorted daylight raid on Hankow in April 1938 and lost thirty-six out of forty-bombers. But gradually they had pushed the defenders inland. By July 1940, they were sending bombers over Chungking - almost at will. Flying escort on these missions was a new fighter, the Mitsubishi A6-M2 Type O Model 11. This was the famed Zero-Sen. Light, maneuverable, heavily armed, it was so superior to anything else in the skies that the Chinese air force virtually disappeared. By the end of 1941, the only opposition of any consequence was being offered by ninety Curtiss P-40s flown by a group of American volunteers commanded by General Claire Chennault and known as the Flying Tigers.

While the totalitarian nations were testing their warplanes and toughening their pilots in actual combat, the Western democracies were slowly shaking off the military lethargy that had gripped them since the end of World War I.

In the United States, the growth of air power had been thrown out of balance by a national policy based on the belief that weapons would be needed only to fight a defensive war against an invader. In such an attack against the United States proper, the Navy would fill its traditional role as the first line of defense, and land-based bombers would provide support by flying out to sea and helping to sink the invader. Air Corps doctrine, based on offensive strategic bombing rather than continental defense, ran opposite to this, but using national policy to justify the building of bombers, Air Corps planners concentrated on the development of a long-range bomber that could, among other things, intercept a hostile fleet far offshore. In the early 1930s, this mission was entrusted to twin-engine planes like the Boeing B-9 and the Martin B-10. The B-10, with its enclosed cockpit, gun turrets, and retractable landing gear, was almost as fast as the best pursuit planes and helped foster faith in the bomber.

Unfortunately, as a result, fighter plane design and production lagged in the prewar days. A few fighter enthusiasts like Chennault protested, vigorously but in vain. The Lockheed P-38, Bell P-39, and Curtiss P-40, designed in 1936 and 1937, were not ready when war broke out in Europe. At that point - September 1939 - the Air Corps had only obsolescent Curtiss P-36s - and no night fighters at all.

But it did have the most powerful bomber in the world as a result of the vision and persistence of men like General Foulois. In July 1935, the XB-17, a revolutionary four-engine long-range bomber, designed by Boeing, had been test-flown. In August, it made a nonstop flight of 2,100 miles at an average speed of 232 miles per hour, which put it in a class by itself. Even before this, the Air Corps had asked for a bomber with a range of 5,000 miles, capable of flying to Hawaii, Alaska, or the Canal Zone without having to stop en route. This had resulted in the XB-15, an airplane that proved too large for any power plants then in existence. It was not put into mass production, but it was the direct ancestor of the B-29.

Interservice rivalry raised its head in 1938 when the Air Corps, demonstrating its range at halting an enemy offshore, sent a flight of B-17s to “intercept” the Italian liner *Rex*, 725 miles at sea. The Navy viewed it as an invasion of an area entrusted to itself as guardian of the sea approaches, and the Air Corps shortly found its combat range restricted to 100 miles off the coast. In addition, the Air Corps was instructed to limit itself to the number of B-17s completed or on order. The ruling was handed down, incredibly, on the eve of Munich.

The Navy itself was hampered to some extent in building up a carrier force by dissension in its ranks over the value of naval air power. By 1936, the original carriers, the *Langley, Lexington,* and *Saratoga* had been reinforced by the *Ranger,* the *Enterprise,* and the *Yorktown,* with the *Wasp* under construction. During the mid-1930s, the number of naval aircraft was held to about 1,000, but in May 1938, Congress authorized the Navy to treble that number.

By this time, too, both Great Britain and France were rearming frantically. The British had been jolted into action in 1935 by Hitler's boast that the Luftwaffe, which had been in existence officially only two weeks, had already attained parity with the RAF. By 1936, Britain had set up a "shadow factory" system, with small plants feeding parts to the great airplane production centers. By 1937, a chain of twenty radar warning stations was being built - a piece of foresight that was to save England. Airfield construction was also stepped up drastically.

In the summer of 1938, Chamberlain's appeasement of Hitler at Munich was bitterly criticized, but the year thus bought was invaluable to the RAF. At the time of Munich, Great Britain had only forty-three Hurricane fighters - and three Spitfires - with which to oppose some 1,200 battle-ready German bombers. A year later, the RAF had more than 500 modern fighters ready to meet the invader.

France, which for years had had the largest air force in the world, was unable to rise to the same challenge. Governmental instability, lack of funds, a sentimental fondness on the part of some commanders for outdated types of aircraft, all acted as a drag on the Armée de l’Air at a time when to delay was to guarantee disaster.

By 1938, awake at last to its own shortcomings and its peril, France was feverishly ordering warplanes from abroad. But before any substantial deliveries could be made, the storm broke. On September 1, 1939, having hitherto used his Luftwaffe mainly for intimidation, Adolf Hitler sent 1,600 warplanes slashing into Poland above his racing panzers. Ahead of the world now lay six flaming years of war.

EXPLORE

Charles A. Lindbergh's epochal flight to Paris opened a dramatic era of long-distance flying. In the twelve months following his triumph, thirty-one planes set out to span the perilous Atlantic. Only ten of them succeeded, and the failures cost twenty lives. But neither those disasters nor similar ones in the Pacific discouraged other pilots who hoped to break records and attain instant fame.

Determined pilots like Charles Kingsford-Smith, Dieudonné Coste and Maurice Bellonte, Russell Boardman and John Polando, James Mollison and his wife Amy Johnson, and colorful personalities like Douglas "Wrong Way" Corrigan became popular heroes and kept aviation on the front pages of the world's press.

Many of the transoceanic, flights were foolhardy, but the pilots who had the skill and luck to succeed made valuable contributions to aviation's growth. They spurred the development of new planes and navigational devices, and they made clear to the world that commercial airlines would soon follow the routes that they had blazed across oceans and around the globe.

New Horizons

In January 1929, an Army C-2, appropriately named *Question Mark* during a period of searching for answers to new questions, broke all world endurance records by remaining in the air over California for more than 150 hours. Forty-three times during the historic flight, a second plane hovered less than twenty feet above the Fokker and passed down to it more than 5,000 gallons of fuel, as well as supplies and food for the five Army Air Corps fliers aboard. Only when plugged grease outlets stopped one of the Wright Whirlwind engines did the plane return to the ground.

The dramatic flight of the *Question Mark* was just one of many exploratory projects conducted by the Air Corps and Navy in the late 1920s and early 1930s. Congress had approved expansion of the two air branches, and both of them strove to develop new equipment and new techniques.

Altitude records fell to men like Lieutenant Apollo Soucek of the Navy who flew his Wright Apache to 43,166 feet in 1930. Lieutenant James Doolittle made the first takeoff and landing on instruments in September 1929, and his work was carried on by the Air Corps's Captain Albert Hegenberger and by the Navy's Lieutenant Frank Akers who made the first blind landing on an aircraft carrier in July 1935.

It was a period of tests and exploration as military fliers worked steadily to find out just what they and their airplanes could do.

Racing Thrills

America's best pilots convened each year at the National Air Races to display their skills and compete for cash awards. Huge crowds packed the grandstands and watched spellbound as the fliers cut pylons with incredible sharpness and flirted, sometimes too closely, with disaster.

The two most-coveted prizes were the Thompson Trophy, given for the fastest speed in a closed-course race, and the Bendix Trophy, awarded to the winner of a transcontinental derby. In these races, great pilots like Jimmy Doolittle, Roscoe Turner, Harold Neumann, Rudy Kling, James Haizlip, Jacqueline Cochran, and Frank Fuller, Jr., set new records and thrilled the crowds with their bravado. And it was the Air Races that gave impetus to the development of retractable landing gear, new fuels, and better engines -

technological advances that were to be of great importance to the nation in the coming years of World War II.

A highlight of the 1928 Air Races at Los Angeles was the inverted flying of Navy pilots D. W. Tomlinson, W. V. Davis, and A. P. Storrs, known as the "Sea Hawks". Military observers who saw them fly upside-down in Boeing F-2B's with modified Wasp engines realized the combat potential of such maneuvers.

The barrel-like Granville Gee Bee won the 1932 Thompson Trophy for Jimmy Doolittle who sped around the ten-lap, ten-mile course at a record-breaking 252 miles per hour. The Gee Bee, designed by Bob Hall, was dangerous as well as fast. Lowell Bayles and Russell Boardman were both killed flying Gee Bees.

Posters advertising the 1930 Air Races at Chicago promised thrills but did not foresee the tragedy that was to mar the meet. In the Thompson Trophy Race a Curtiss Hawk flown by Captain Arthur Page of the Marines crashed, fatally injuring the pilot. The event was won by Charles Holman who flew 201 miles per hour in a plane designed by Matty Laird.

Speed Kings

Lieutenant Alford Williams was one of the Navy's greatest pilots. Winner of the 1923 Pulitzer Race with a record-breaking speed of 244 miles per hour, he was awarded the Distinguished Flying Cross in 1929 for his work as a test pilot. In a series of research flights, Williams studied the effects on aircraft of inverted flying maneuvers and correctly assessed their potential value in military combat.

Frank Hawks earned the title "Meteor Man" with a series of record-smashing flights in America and Europe. Hawks, who was an Air Service pilot and then a barnstormer, was hired by the Texas Company in 1927 to promote its aviation products. He did so by flying from city to city and coast to coast, breaking speed records wherever he went.

“Records of today,” Frank Hawks said, “are the commonplaces of tomorrow.” He and the other fast pilots of the 1930s made his statement come true.

When Hawks flew from California to New York in 1929, his time of eighteen hours and twenty-one minutes was considered astonishing. But by 1937, the transcontinental record was cut to seven and a half hours by Howard Hughes. Similarly, a speed of 194 miles per hour was good enough to win the 1929 Thompson Trophy for Douglas Davis, but a decade later, Roscoe Turner won the 1938 race by flying his Turner-Laird Special around the closed course at 283 miles per hour.

Thus, records fell with amazing rapidity as daring pilots, who knew that their triumphs would be short-lived, vied for the right to claim the momentary title of fastest flier.

Infant Industry

A first, fitful boom in American commercial aviation arrived at last in the late 1920s. Government support of the airmail, the sudden interest of big business in aviation, and the public’s response to the long-distance record flights all combined to encourage commercial expansion. There were forty-four scheduled airlines in the United States by 1929, and although airmail routes had totaled only 2,800 miles in 1926, the figure had jumped to 30,000 miles only four years later in 1930.

The trouble, however, was that it was mail and not passengers that was providing the revenue. The vast majority of the public hung back, still unwilling to fly. New, safe, and economical planes were badly needed to induce enough air travel for profitable operations.

Queens of the Sky

The modern airliner was born in 1933, when the Boeing 247 and the Douglas DC-1 made their initial flights. Both airplanes were the forerunners of a series of rapidly developed, all-metal aircraft that featured cowled, air-cooled radial engines, retractable landing gear and variable-pitch propellers. They could carry passengers with safety and with speed, and - most important for their operators - they made commercial aviation a profitable business.

Most successful was the DC line produced by Donald Douglas and his dynamic chief engineers, James H. ("Dutch") Kindelberger and Arthur Raymond, who succeeded Kindelberger in 1934. The DC-1, a two-motor plane that could fly safely even if one engine failed, cost $307,000 to develop and produce. Only one was built, but the next version, the DC-2 of 1934, was reproduced more than 200 times. Its multi-spar wing construction and split flaps allowed it to outperform all competition, and when a larger model, the DC-3, was built in 1935, it became the most popular airplane in the world. By 1946, when the last DC-3 was produced, 10,926 had been built, and by 1960 DC-3's had carried 600,000,000 passengers.

As domestic air travel boomed with the new planes, Pan American Airways began to push an air track across the Pacific, using Hawaii, Midway, Wake Island, and Guam as steppingstones to the Philippines. By 1936, graceful Martin M-130 Clippel's were carrying mail and passengers to Manila, and by 1937, the route was extended by Sikorsky

S-42's to Hong Kong, linking the United States to the Asiatic mainland more than 8,500 miles away.

Boeing's 307-B Stratoliner, a civilian version of the B-l7 bomber, began carrying passengers for TWA in April 1940. The first pressurized airliner, the four-engine transport could carry thirty-three passengers at 246 miles per hour. Aviation was growing at a fantastic pace, and domestic airlines in the United States, which had carried only about 6,000 persons in 1926, fifteen years later in 1941 were transporting almost 3 million people annually.

Pioneering

As the growth of commercial aviation spurred the development of conventional aircraft, men of new ideas and visions continued to explore and experiment.

The first rocket-propelled glider flight was made in Germany in 1928 while in America Dr. Robert Goddard steadily improved his equipment and fuel until he was able to launch a rocket to 7,500 feet in 1935. The first practical delta-wing aircraft was designed in 1931 by Dr. Alexander Lippisch of Germany, and the same nation saw the first flight of a practical helicopter in 1936. Frank Whittle of England and Hans von Ohain of Germany worked doggedly during the 1930s to design a workable jet engine.

Other pioneering efforts of the period included high-altitude balloon flights made by Auguste Piccard of Switzerland and by Captains Orvil Anderson and Albert Stevens of the U.S. Army Air Corps, who soared to 72,394 feet in the gondola of the *Explorer II* in 1935.

The Fate of the Hindenburg

Ten times during 1936, the giant Zeppelin *Hindenburg* made the round trip between Germany and the United States. Cruising quietly at seventy-eight miles per hour, it gave its passengers, who paid $720 apiece for the round trip, a voyage of the utmost smoothness and luxury.

The demand for reservations aboard the hydrogen-inflated airship was so great that eighteen flights had been scheduled for the 1937 season, and extra cabins had been built to accommodate more passengers. There were ninety-seven persons aboard on May 3, 1937, when the *Hindenburg* left Germany for its first voyage to North America that year.

Head winds prolonged the flight, and thunderstorms delayed the landing. But shortly after 7:00 p.m. on May 6, the 804-foot Zeppelin prepared to moor at Lakehurst, New Jersey. Cables were lowered and the *Hindenburg* came down to less than 200 feet. Then, suddenly, disaster struck.

Flames burst from between two cells of the upper stern, and within seconds, sheets of crackling fire enveloped the tail section. As spectators watched in dumb horror and screaming passengers leaped from the ship, the Zeppelin fell to the ground in twisted, flaming wreckage. Thirty-six lives were lost in the holocaust, and many of those who survived were horribly burned.

The cause of the disaster was never definitely established. There were many theories, but all that seemed certain was that free hydrogen had somehow escaped and had been ignited. The *Hindenburg* tragedy, which brought to an abrupt end the era of the great Zeppelins, remains an unsolved mystery.

Rehearsal for World War

As aggressor nations plunged into limited wars in China, Ethiopia, and Spain in the 1930s, people slowly came to recognize that air power would undoubtedly be the decisive factor in any future world conflict. The stunning successes of new planes and techniques tested by the Germans, Italians, and Japanese served to convince the Axis powers of their own superiority. Only in time did these tragic examples strike home to shatter the complacency of unprepared, peaceful countries.

The small wars of the 1930s made it painfully clear that civilian populations would no longer be exempt from the horrors of conflict. In Ethiopia, Mussolini's son Vittorio observed with pleasure the bombs from his Caproni plane bursting "like flowers" among the thatched huts of primitive tribesmen. In Spain, Nationalist bombs killed 1,654 inhabitants of Guernica, whose anguish was later immortalized in a painting by Pablo Picasso. And in China, Japanese planes made flights of more than 1,200 miles over land and water to their targets and demonstrated that distance no longer afforded security from long-range bombers.

These ruthless displays of air power frightened and shocked the observing world. The Germans had announced in 1935 that their air force was already equal to Great Britain's and was approaching that of France, which still had the greatest number of planes, though many of them were obsolete. The British and French, aware at last of the crucial role of air power, began to try to regain aerial supremacy, but their potential enemies moved at an even faster pace, continuing a military build-up that, for the first time, included powerful fleets of airplanes.

A Giant Stirs

With war clouds darkening Europe and the Far East, Generals Henry H. Arnold, Frank Andrews, and others fought hard for a stronger American air force. But not until September 1938, when President Franklin D. Roosevelt called for an enlarged Air Corps of 10,000 planes, did expansion really begin. The Air Corps, Arnold said, had finally "achieved its Magna Charta."

Although still hampered by isolationist sentiment and shortsightedness in Congress and elsewhere, the Air Corps was able to speed the production of new designs. America was not ready when war finally broke out in 1939, but the great Army Air Forces of the future were being forged.

8

WORLD WAR II

At first light on September 1, 1939, the Luftwaffe struck a hail of blows against the airfields of Poland. In forty-eight hours, German He-111 bombers, Me-110 “destroyers,” and Ju-87 Stukas decimated the Polish air force, most of it on the ground; in ten days, the Polish army had all but ceased organized resistance. Hitler’s uneasy ally, Soviet Russia, sent its hordes across the eastern border, and at the end of a month, all Poland lay prostrate.

Britain and France, honoring their treaty obligations to the Poles, had meanwhile declared war on Germany. In time-tried opening moves, the French army took up positions in and behind the Maginot Line. Britain dispatched to the Continent a small expeditionary force, with an air component of one fighter wing, one bomber-reconnaissance wing, and a token independent air striking force. For seven months on the western front, nothing happened. Americans called it a “phony war.” Hitler, in his “Directive Number 1 for the Conduct of the War,” had stipulated that “the responsibility of opening hostilities should rest unequivocally with England and France.”

The later months of this “phony war” were overshadowed by a Russo-Finnish conflict. This “winter war” began on November 30 when the Soviets decided to take by force the Finnish bases they had been refused. Expecting little opposition, the Russians at first used obsolescent warplanes, holding back their newer designs. But the Finns put up a stiff resistance, and the 900-plane force originally committed by the Russians had to be expanded to nearly 2,000 before the little nation was finally overwhelmed in February 1940.

A British blockade, meanwhile, was threatening to cut Germany off from her Scandinavian supplies. In reaction, Hitler struck savagely on April 9, 1940, to seize both

Denmark and Norway. The Danes declined to fight. Norway's bravery cost her much. The German attack force, composed of warships, seven army divisions, 800 combat aircraft, and nearly 300 troop-carrier planes, moved with surprise and precision. By the second day, all of Norway's major ports - Oslo, Bergen, Trondheim, and Narvik - were occupied, and all her airfields in the south were taken over with nearly as great speed. As the RAF was unable to operate effectively in daylight at the distances involved, the Luftwaffe had control of the air and soon sealed the doom of the Norwegians.

The Finnish crisis, with Allied inability to bring military assistance to a harassed friend, had brought down the French government of Édouard Daladier. The Norwegian fiasco now had a similar effect in England, and on May 10, the old war dog, Winston Churchill, succeeded Neville Chamberlain as prime minister.

Perhaps no single day of the whole six-year war was as fateful as that May 10. Even as Churchill took up the burdens of office, Nazi tanks, motorized columns, screaming Stukas, and parachutists had begun a brutal invasion of Holland, Luxembourg, and Belgium.

Despite resistance by the northern French armies and the British Expeditionary Force, the Germans were able on the first day to attack not only Rotterdam and capture its airfield but to pierce the whole Dutch countryside in the direction of the Moerdijk bridges - the vital link in the waist between northern and southern Holland. When these were lost after four and a half days, the Netherlands, on May 15, capitulated. The *coup de grâce* was delivered in barbaric measure by the Luftwaffe in a mass bombing of Rotterdam. For four days, debate divided Churchill's newly formed War Cabinet, but with this murderous low-level daylight attack on the famous Dutch seaport, hesitation ended, and the RAF Bomber Command was ordered to operate against the Nazi homeland. That night, for the first time, Allied aircraft - ninety-nine in all - dropped their charges on oil and communications centers in the Ruhr. Symbolically at least, the strategic air offensive against Germany had begun.

Meanwhile, Franco-British land strategy, which called for a wait-and-see attitude while the Belgians attempted to hold on along the Meuse and the Albert Canal, was going badly. The enemy's first assault, which included airborne troops, had already leaped ahead of the intended Belgian line. Knowing well that the Maginot fortifications extended only along the frontier between Germany and France and not into Belgium, the panzers executed the main feature of German strategy and split the Allied front in two by a massive thrust between Belgium and France.

After the Nazi breakthrough, the Battle of France unfolded swiftly. The exhausted Belgians surrendered on May 27. The Germans, having turned toward the coast, methodically closed around the northern Allied forces a tight semicircle centered on Dunkirk. From that deadly noose, protected by RAF fighters the Royal Navy eventually saved the lives of more than a third of a million British, French, and other Allied troops.

With its now legendary lightning speed, the German war machine sliced deeper into France. On June 7, it reached the Somme; on June 9, Rouen fell; on June 10, it crossed the Seine. The "jackal, Mussolini," as Churchill dubbed him, chose that day to declare war and attack France in the south. Everywhere on the crowded, sunny French roads, the Luftwaffe bombed and strafed fleeing refugees and soldiers.

The inevitable fall of France came on June 20. The next day at Compiègne, scene of Germany's World War I surrender, Hitler, in satanic elation, personally exacted the armistice. Britain, clutching her own and others' escapees, stood at last alone.

All thoughts now turned to a German invasion of Britain that everyone supposed Hitler, as with his other plans of conquest, had long prepared. There were, in fact, neither plans nor preparations. Operation Sea Lion was still mostly talk. Almost as though the war had succeeded beyond his expectation, Hitler hung back, uncertain what the next best move might be. "I can see no reason why this war need go on," he told the Reichstag on July 19, hinting that England would find him ready to make terms. When Churchill brushed aside all suggestion of parley, Hitler's last remaining hope of avoiding a long war was to attack.

While the German generals and admirals were wrangling over how and where to get ashore, how to nullify the British navy, and how to keep reinforcements and supplies moving across the Channel, the battle for mastery of the air began.

The opposing air forces entered the contest realizing that they were "poised on the top of a huge wave of fate" - whichever way it fell, much would be decided. As of mid-July, Hermann Goering, on his side, disposed of three air forces: Luftflotte 2 in Belgium and the Low Countries with Albert Kesselring in command, Luftflotte 3 in northern France under Hugo Sperrle, and Luftflotte 5 in Denmark and Norway under Hans-Juergen Stumpff. The first two together possessed roughly 900 fighters (Me-109s and Me-110s), 875 bombers (He-111s, Ju-88s, and Do-17s), and 300 dive bombers (Ju-87s). Luftflotte 5 had only 157 aircraft, thirty-four of them fighters. On the British side, the RAF fighter force consisted of forty-six squadrons of Hurricanes and

Spitfires and two of Defiants. The total number of British single-engine fighters was between 600 and 700.

Since early June, the Luftwaffe had been skirmishing in night raids over England, testing the nerve of the people and the mettle of the RAF Fighter Command. Pressure against the defenders had so increased that by July 10, the British felt the main offensive to be imminent. The first phase of the battle actually started on July 2 with heavy pounding of the Channel ports and convoys and nightly bombing of towns and cities all over England, Scotland, and Wales. German tactics aimed at luring RAF fighters into combat prematurely, but Sir Keith Park, the great commander of No. 11 Group that was responsible for London and the South of England, wisely held his strength for heavier onslaughts to come.

From August 8, the attacks intensified, and the main targets now became airfields and radar stations on the south and east coasts. On August 13, which the Germans called Eagle Day and which marked the real beginning of the main offensive, the Luftwaffe flew 1,485 sorties and lost forty-seven aircraft but failed to inflict serious damage. RAF Fighter Command defended with 700 sorties, losing thirteen machines. On the fourteenth, a quiet day, the Germans lost nineteen planes, the British eight. The high tide of the battle thus far was reached on August 15 with the Germans making 1,786 sorties, the greatest number flown by either side at any time. During a day of widespread, incessant conflict, plotters in the RAF control center at Stanmore observed apprehensively that the attackers consistently outnumbered the defenders, but the Luftwaffe did not achieve a breakthrough. The British claimed 182 of the enemy shot down while the Germans reported 134 kills for a loss of thirty-four. After the war, it was learned that the actual totals were seventy-five German and thirty-four British aircraft lost.

To the Germans, it seemed that the British would have required three times the number of fighters they actually possessed to put up the defense that everywhere greeted them. The first secret was radar, primitive as it was, and the supporting communications that permitted effective, flexible control of the fighters from the ground. The Luftwaffe had no radar and no radio control of its aircraft. Each German mission was a set piece, planned in detail beforehand; there could be no improvisation during the battle. The second British secret was tactics. Sir Hugh Dowding, the Fighter Commander, and Park, his lieutenant in the south, decided to meet the enemy as close to the coast as possible, thereby exploiting the short range and superior eight-gun firepower of the Spitfire. Despite the opposition and later bitter criticism of formidable opponents, Park also insisted on using flexible squadron tactics rather than wing tactics in committing his forces to battle.

After a brief lull due to bad weather, the Luftwaffe, on August 24, returned to full-scale attack. It did so with apparent determination to smash the hard core of Fighter Command that thus far had eluded it. Realizing that failure to concentrate geographically and numerically had proved costly as well as ineffective, the Germans now attempted to breach the defense with hammer blows by close formations. Through the rest of August and the first days of September, Spitfire and Hurricane squadrons were confronted by masses of up to forty bombers escorted by more than 100 fighters as fighter airfields and the command posts of London’s defenses were hit in more than two-thirds of thirty-three attacks.

The German mass tactics now began to swamp the squadron tactics of Fighter Command, eating into replacements of pilots and machines. In two weeks, the RAF lost 277 aircraft as against 378 lost by the Germans. Worse still, the British lost 231 pilots, killed and wounded - a quarter of the available force. Just as the attrition was becoming intolerable, Goering again switched his plan of attack. This effect had a deeply ironic cause.

On the night of August 24, owing to a navigational error, Nazi bombs fell on central London for the first time. Believing the attack was deliberate, Churchill made a suggestion to Sir Charles Portal, the chief of Bomber Command. Hitler and Goering were astounded when, the following night, RAF bombers made a reprisal raid on Berlin. Eighty-one British planes did what Goering had boasted could never be done. After Berlin was attacked a second time on August 26, Hitler vowed to wipe Britain’s cities off the map.

Goering conferred with Kesselring and Sperrle at The Hague on September 3. As usual, opinions differed. Believing the RAF still had plenty of fighters, Sperrle favored continuing current tactics. Kesselring thought the RAF was finished. Goering stated that the British fighters were withdrawing beyond London, out of range of the German fighters, and that only if London, the heart of the Empire, were in mortal danger would England risk her last fighter reserves. Two against one: The switch to London was ordered.

The Reichsmarschall took command in person, his headquarters an armored train hidden in a tunnel at Cap Gris-Nez. Hitler had been told that the next phase of the battle would decide the air issue and make invasion possible or, as Goering thought, unnecessary. In Britain, the morning of September 7 began with a seemingly routine attack on airfields. By 4:00 p.m., radar plotters noticed several large enemy formations over Calais. Instead of splitting up as they usually did when the coast was reached, the German aircraft appeared to be stacking up in layers, much above their customary altitude. They hit London in two waves - 300 bombers with 600 fighter escorts employing new flexible tactics. The attacks went on throughout the night, with the populous East End and London Docks the principal targets. The fires burned into the dawn. Goering, elated, telephoned his wife: “London is in flames.” The blitz was on.

Many Londoners thought the invasion had started. Church bells were rung, road blocks thrown into place, and the Home Guards were alerted. Actually, what had begun was an ordeal of death and destruction that for length and intensity no city on earth had yet suffered. There were few more mass daylight raids, though for eighty-five nights London was pummeled and pounded. But the RAF and the ack-ack took a heavy toll of the intruders, and the “hearts of oak” of the people of London never faltered in courage nor wavered in defiance.

The blitz on London continued until spring, but long before that, it was clear that the Luftwaffe had failed miserably. Before September ended, Hitler had postponed Operation Sea Lion to October, and when October came, he put it off until the next year. In reality, it was put off forever. With the threat of invasion past, the British took stock of what had happened to them and what they must do in the future. By a very narrow margin, a hair’s breadth, they had escaped. The Germans had failed to achieve the first prerequisite to success against England - control of the air, on which the second prerequisite, control of the narrow seas, depended. Though it went on to other victories in other theaters, the German air force never really recovered from the experience of the Battle of Britain. For a while, Hitler still paid rhetorical tribute to his Eagles, but he never quite trusted Goering again: The Luftwaffe was not invincible, and the Reich was not invulnerable to enemy air action.

For a would-be world conqueror, Hitler's strategy was curious. He was a land animal and scorned both sea and air power because he could not understand them. He did not see that air power was an all-embracing, strategic power, truly analogous to the sea blockade of the days before the airplane but more potent because it was more direct. So, despite its seemingly independent position within the German armed forces, he subordinated the Luftwaffe to his land-minded strategy that depended for success upon interior lines of communication and upon commitment to but a single main tactical front.

The top leadership of the Luftwaffe - Goering, Erhard Milch, Udet, Kesselring, Hans Jeschonnek, Sperrle, Stumpff, and the others - did little to educate the Fuehrer in air doctrine because they were nearly as ignorant of the true nature of air power as he was. At no stage in the build-up of the Luftwaffe was there coordination of strategy and technology. The basic weaknesses of the Luftwaffe were lack of comprehensive thinking and planning and ineffective command for implementing decisions.

The German weakness in air technology was not merely a question of the selection and production of types of aircraft, of armor and armament, and of radar and other navigational aids. From the beginning to the end of the war, the Germans had on the drawing boards and in various stages of test and production some of the world's finest airplanes, including both a rocket-propelled fighter (the chunky Me-163 with a speed of 590 miles per hour but a rapid consumption rate of fuel that limited its time in the air) and the first jet-propelled plane, the He-178. Nor was it a question of prejudice for or against bombers. Hitler and Goering both wanted bombers. But whatever the types, Hitler was obsessed with what he called “offensive war” - by which he meant unceasing attack - and by incessant attacking without due regard to when, where, and how, he threw away the Luftwaffe and bled Germany to death.

The Battle of Britain may have been lost by Germany before it began. First, if it had come two months sooner, the RAF would have been far less well prepared. Second, if after Dunkirk, Hitler had turned at once and invaded England instead of pursuing the French army, Britain as well as France might have fallen, for at that moment the British had only one equipped division available for the island’s defense.

Fatal flaws in the Luftwaffe’s performance were detailed in a series of reports to Washington by an American observer, Colonel Carl Spaatz. Spaatz noted that German night bombers failed to close British ports on the Channel and on the east and west coasts, and thereby force shipping into the Clyde where U-boats could easily have sent it to the bottom. Many lucrative targets far from the main concentration of RAF fighter airfields could have been bombed with low losses, even if with some strain on the bombers’ range. Escorting day fighters were erroneously tied to the bombers for close support instead of being allowed to pursue RAF fighters in running combats. Consequently, bombers and fighters flying together in close packs became ready marks for the Spitfires and Hurricanes. Bombers employed singly or in threes were wasted in weak attacks on scattered, militarily unprofitable targets all over the country. The practice of having one experienced pilot lead a bomber formation otherwise manned by inexperienced crews was self-defeating because the RAF fighters soon learned that by shooting down the leader in head-on attack, they could often disperse a whole formation.

These lessons were lost least of all on the RAF, which, in the high tradition of its first chief, Lord Trenchard, was devoted to the development of true offensive air power. Vital though it was to the whole war, the Battle of Britain was defensive and, as such, an interruption of the RAF's determined plan for a strategic bombing offensive. From the moment Churchill had taken over from Chamberlain, bombing had been settled policy. The limiting factor was the unhappily small number, restricted range, and low payload capacity of Bomber Command's aircraft. It was also evident that, for the present, the Germans could prevent large-scale attack by unescorted bombers, and that at night, with existing navigation aids, darkness alone was enough to preclude the identification of precision targets.

There was some consolation, however. The Battle of Britain had made clear that Germany was not going to win the war in a matter of weeks. There would be time to improve the planes and accessory equipment and to apply a plan of systematic bombing.

The sweep of war, meanwhile, had been widening. Always anxious to extend his empire, Mussolini had invaded Egypt and Kenya on September 13, which forced Britain hastily to reshuffle her thinly spread land forces in India, Australia, and New Zealand to meet the threat to the vital link in her lifeline through the Mediterranean and Suez. On land, the Italians were checked by Archibald Wavell at Sidi Barrani while the British navy on November 11 won a resounding victory at Taranto and restored to itself supremacy in the Mediterranean Sea. Three of the six capital ships of the Italian fleet were put out of action by aircraft from HMS *Illustrious.* On December 11, Wavell moved against the

Italian army and in sixty-two days cleared Egypt and Cyrenaica. His little, poorly equipped army, spearheaded by the Desert Air Force, crushed Mussolini's legions and captured 130,000 prisoners.

The year 1941 began well, but before it was very old, Germany, with the acquiescence of Bulgaria and Rumania, put the torch of war to Yugoslavia and Greece. Yugoslavia was quickly subdued. The Greeks, aided by a small British expeditionary force, resisted for a fierce moment, but, virtually without air strength, were soon quelled. The British retired to Crete, the strategic key to the eastern Mediterranean, but their attempt to hold the island and its three airfields was hopeless without fighter defense. Under the hammering of the Luftwaffe, followed by paratroop assaults and landings of troop-carrying gliders and aircraft, the doom of the Cretan garrisons was sealed.

Meanwhile, in Libya, Wavell found himself between the mass of the Italian army in his rear in East Africa and a possible hop by the Germans across the Mediterranean into North Africa. Choosing to meet the nearer danger first, he attacked Eritrea from Khartoum and Italian Somaliland from Nairobi. By April 6, the capitals of both countries were in British hands. Though the mopping up took some hard fighting and lasted until the end of November, Mussolini's dream of an empire in Africa was demolished.

While Wavell was thus occupied, the Germans had planted a large contingent of the Luftwaffe on Sicily and of tanks in Libya. Faced with the latter, the British army had no choice but to fall back on Egypt, leaving a garrison on the coast at Tobruk. Under the constant blows of the Luftwaffe, the navy was hard put to keep open the Narrows between Sicily and Malta on which the life of Malta depended. The Mediterranean picture was darkening.

The war at sea took a dramatic turn when at the end of May the Germans sent out the fast new battleship *Bismarck* to prey on shipping in the Atlantic. A large force of British capital ships set forth in pursuit. In the first engagement, the *Hood* was hit by the *Bismarck* and blew up, but the *Bismarck* was also hit. Early the next morning, May 25, the *Bismarck* was lost to her pursuers. Some thirty-one hours later, she was found again by an RAF Catalina flying boat. On the evening of May 26, Swordfish planes from the carrier *Ark Royal* landed two, possibly three, hits on the *Bismarck* whereupon her steering went out of control. Destroyers continued to torpedo the wounded ship throughout the night. On the morning of May 27, British capital ships moved in for the kill.

The fate of the *Bismarck,* pride of the German navy, re-emphasized that land war offered Germany her only hope of victory. The successes in Greece and Crete, on the trail of her fading Axis partner, Italy, had proved extremely costly, with little glory and no booty. The path to India through the Middle East was still blocked by Britain and the little countries friendly to her, and seas and an ocean lay between. But there was an alternative theater and a more glittering prize, and Hitler decided to make a supreme effort to obtain it.

At dawn on June 22, 1941, the Wehrmacht, with the assistance of Finns, Hungarians, Rumanians, and later, Italians and Spaniards, smashed with 170 divisions across the 1,000 mile Russian frontier. As usual, the operation was spearheaded by the Luftwaffe with 2,770 planes.

Nazi successes came rapidly. Massed near the border on unprotected airfields, Russian planes were surprised and destroyed on the ground in hundreds during the opening attacks. In the air, battle-hardened German pilots swept the skies. Fantastic victory scores were reported. Even the slow Stukas once more came into their own. By the end of the war, Hans Rudel, the renowned dive-bomber pilot, was credited with destroying more than 500 Russian tanks, enough to equip a whole tank corps.

While the good summer weather lasted, the dazzling successes of the Luftwaffe continued. Russian fighters could not match the Messerschmitts, and their bomber forces were virtually wiped out. Their most effective air weapon was the Il-2, a new, heavily armored ground-attack plane that they used with great courage and determination.

Although by the end of 1941, more than 8,000 Soviet planes had been destroyed in the air and on the ground, the Nazis badly miscalculated the technical capacity and productive power of the Russian aircraft industry. While many of the western factories were overrun, new plants at Irkutsk and Semenovka, at Kazan and Novosibirsk, were beyond the reach of German two-engine bombers. Now Germany's lack of a long-range strategic air force began to hurt, for at the end of 1941, the battered Russian air force was beginning to recover its strength.

Hitler was sarcastically bitter in denouncing the Luftwaffe's technical capabilities and production. Goering, stung by his taunts, passed the buck to Ernst Udet, his old friend and a World War I ace who was unfortunately miscast in the role of inspector general and chief of the technical department of the Luftwaffe.

When the early Russian winter showed up the poor preparation of German aircraft for such conditions, Goering heaped blame on Udet. Patriotic, popular, and conscientious, Udet cracked under the strain. Late in November 1941, he put a pistol to his head and killed himself. Though Goering reported the suicide as a test-flight accident, many knew where the real fault lay and saw in Udet's death the nemesis that awaited the Luftwaffe and all of Germany.

All the assumptions on which German air power was built were proving wrong. The war was no longer limited to Europe only. The Fuehrer was no longer satisfied when the Luftwaffe beat up the enemy air force at the start of each campaign. The German air force of just before the war had not, as it then so confidently believed, attained all the capabilities it would ever need, and the cancellation order of August 1940 - which had stopped research and test on all aircraft that could not be put into production within one year - was now seen to have been a hideous mistake.

Aside from doctrine, the main reason for not developing long-range strategic bombers had been that such a program would have overtaxed the country's resources when reserves of oil and bombs and combat crews were already very short. Now the Russian war, though it pointed up the need for such aircraft, actually deferred, rather than spurred, their development. The thinking in the Luftwaffe at this point was that a strategic bomber fleet could only be created if the Russian campaign ended quickly and the terrible drain on the economy that it caused was halted. Still further changes in German air concepts were soon to be brought about by the growing threat posed by the bombing offensive from the British Isles against the Reich itself.

In line with Churchill's conviction in the fall of 1940 that "only the Air Force could win the war," the RAF, under its new chief, Sir Charles Portal, had set resolutely to work. Between October 1940 and March 1941, the main concern, apart from the Battle of the Atlantic, had been with precision bombing against oil and rail targets in the Ruhr and elsewhere.

The retired but still redoubtable Lord Trenchard and others protested that Britain was too nice in her bombing. Trenchard called for a massive bomber build-up and an offensive against every corner of the Nazi homeland. While his fiery views were not wholly endorsed by the RAF leadership, two basic policies were emerging. The principal bombing effort would be made at night, and the principal objective, though the targets themselves would be military, would be German morale.

Hardly had the night-bombing offensive gotten under way when a crisis developed that called the whole program into serious question. In June, the prime minister took alarm when night photographs disclosed that only one in four aircraft reporting attack on a German target actually got within five miles of it, and in heavily defended areas like the Ruhr, only one in ten. Then, on November 7, 1941, 400 bombers took off to strike at Berlin, the Ruhr, and other targets; thirty-seven did not come back. Annoyed and dismayed, Churchill “advised” that Bomber Command be “conserved” in order to “re-gather their strength for the spring.”

The war had now been in progress for two grim years. Though the people of the United States were not yet directly and formally engaged, they had already given many hostages to fortune.

On September 28, 1938, on the eve of Munich, President Roosevelt had directed that, in view of the deteriorating international situation, the national defense required an actual rate of production of 10,000 long-range airplanes a year, backed up by a production potential of 20,000 a year -

a decision that was called the “Magna Charta” of American air power.

Munich-time also brought to the top command of the U. S. Army air arm one of the country’s pioneer military aviators - a news writer somewhat ludicrously called him a “white-haired old gentleman” - Henry H. (“Hap”) Arnold, just turned fifty-two and now a brigadier general. Vigorous, bold, and far-seeing, he was one of America’s most dynamic war leaders and the man chiefly responsible for organizing and directing the greatest aggregation of air power the world had ever seen - an air force of nearly 2.5 million men and more than 75,000 aircraft.

As Arnold took over, the Air Corps was emerging from a doctrinal dispute that had been going on since 1917. The dominant view now was that bombing was the basis of air power, that daylight bombing was fundamental to precision as opposed to area attack, that bombers - because of the limited range of existing fighters - would have to fly without escort, and that bombers could achieve enough defensive firepower to enable them to operate without prohibitive losses. Fighter development had lagged behind bomber development due to the soon-discredited theory of “bomber invincibility,” overemphasis on the interception function as opposed to escort, and such technical misconceptions as the multi-seat fighter. Whatever the cause, when war broke out, no serious effort had been made in the United States to convert single-seat interceptors into escort fighters by extending their range.

Arnold was anxious to apply or adapt to the American air situation the lessons learned from friend or foe. In the spring of 1939, Charles A. Lindbergh, who had been living in England and France, returned to America. The day after he landed, he and Arnold had an important conference at

West Point where after lunch they sat unnoticed in the bleachers while a baseball game was in progress. Arnold later wrote: "Lindbergh gave me the most accurate picture of the Luftwaffe, its equipment, leaders, apparent plans, training methods, and present defects that I had so far received." What Lindbergh told him galvanized Arnold into redoubled activity.

With President Roosevelt's knowledge and approval, Arnold asked the flier to get into uniform and serve on a board to revise the military characteristics of all aircraft under consideration in the Air Corps expansion program. In assuring that America's air capabilities surpassed anything the Germans had or were planning on, the findings of this "Lindbergh board" were of inestimable value.

Though Lindbergh later got into a dispute with Roosevelt by opposing what he considered a dangerous drift toward intervention in the European war when the United States was still unprepared and had not been attacked, Arnold's opinion of him was not changed by the uproar. When war came, Lindbergh, no longer in uniform, continued to act as technical adviser to the Air Force, testing airplanes in combat in the Pacific and even shooting down a couple of Zeros.

The French debacle of May-June 1940, led the President Roosevelt to issue his famous call for 50,000 airplanes. By this, he meant that annual production should go to 50,000 and that the combined air strength of the Army and Navy should total 50,000 airplanes - 37,000 for the Air Corps, 13,000 for Navy aviation.

Arnold knew that, however high the goals, a large proportion of U. S.-produced aircraft would go to friendly countries already fighting. Still, he was determined to keep a balance between the procurement of airplanes and the training of combat and maintenance crews. By this means, whatever its size, the Air Corps would have the trainers, bases, buildings, transport, and gasoline that were as necessary for building air power as were combat planes.

At the same time, Navy aviation was being rapidly expanded. In 1938, the aircraft carrier tonnage limit had been 40,000 tons; in June 1941, this was increased by 79,000 tons, and in July, by another 200,000 tons. The ceiling on useful airplanes was simultaneously raised to 15,000. Attempts were even made to equip destroyers with catapults and planes, but the experiment was later abandoned.

Throughout 1940 and 1941, the defense picture in the United States was one of growing preparedness. Before one expansion program could be completed, a larger program would be called for. All these demands, foreign and domestic, rapidly converted the haphazard peacetime economy into a vast industrial machine - an "arsenal of democracy." The Battle of Britain brought the destroyer-bases deal. The blitz on London produced the Lend-Lease program inaugurated in March 1941. The disaster in Crete, the campaign in the North African desert, and the U-boat war led to the president's declaration of an "unlimited national emergency."

The military services had by now laid their plans for action in any eventuality. In July 1941, President Roosevelt asked for an estimate of the forces "required to defeat our potential enemies." The Air War Plans Division responded with a document known as AWPD/1, which turned out to be an accurate forecast of the peak air strength of the Air Force in World War II. The air mission, it stated, would be to destroy Germany's industrial war-making capacity, to restrict Axis air operations, and to prepare and support a final invasion of Germany. An accompanying map showed that of forty-two groups of heavy and medium bombers based on the British Isles, twelve bomb groups were to be B-29s, with another twelve B-29 groups based in the Middle East. Actually, these bombers did not become available soon enough and were never used against Germany.

Although the German attack on Russia drew the United States closer to the anti-Axis countries, it also stimulated the appetite of Japan for conquest. In July 1941, with the connivance of Vichy France, the Japanese took over Indochina. The United States, Britain, and Holland retaliated with economic sanctions against Japan. Throughout the fall, diplomatic talks were kept up between Washington and Tokyo, but the Japanese fleet, cut off from its oil sources, was burning up reserves. United States Secretary of State Cordell Hull demanded that Japan disgorge not only Indochina but also her gains on the Chinese mainland. This was asking the tiger to give up its kill. To the new, militaristic premier, Hideki Tojo, it seemed that his country must accept unbearable demands or resort to force to break the strangling blockade. On December 1, an imperial conference decided that Japanese honor demanded war.

Early on December 7, a powerful Japanese carrier force that had secretly left Japan on November 28 under Vice-Admiral Chuichi Nagumo reached a point some 200 miles north of the Hawaiian Islands. At dawn, a first wave of 183 planes roared off for Pearl Harbor, their mission to neutralize American air defenses. The American commanders in the Pacific, convinced that aggression, if it came, would start in the Far East, had taken no defensive measures, though they had been warned to expect “an aggressive movement in any direction.” The Japanese surprise was complete. At 7:55 a.m., the raiders struck, strafing and dive-bombing

American planes on the ground and leaving the air almost free for following waves of bombers and torpedo planes.

Protecting the first wave of bombers from the carriers *Akagi* and *Kaga* were forty-three Zeros, the best carrier-borne fighters in the world. They shot down four of twenty-five Air Corps planes that got into the air. Then 170 planes from Nagumo's other carriers roared in. Bombing and torpedoing almost without interference, they either sank or damaged all eight of the American battleships in the harbor. Twelve B-17s flying in from California found themselves in the middle of the battle with guns stowed away and no ammunition. By 9:00 a.m., the raiders were gone. At a cost of twenty-nine planes and fifty-five men, the Japanese had killed more than 2,000 Americans and virtually destroyed American power in the Pacific.

In the Philippines, the story was much the same. Despite advance warning, both Clark and Iba Fields were devastated, and rows of American planes were shot on the ground. By nightfall on December 9, only twelve out of thirty-five operational bombers and thirty fighters were left. American offensive air power on Luzon had ceased to exist.

On the tenth, in the Gulf of Siam where they were steaming without fighter escort, the British battleship *Prince of Wales* and the battle cruiser *Repulse* were sent to the bottom by Japanese land-based torpedo bombers. Of this loss Churchill wrote: "In all the war, I never received a more direct shock."

The ancient concept of the capital ship as mistress of the seas was shattered forever. In a classic test of air power against conventional sea power, the airplane had won. Billy Mitchell's old contention - that no surface ship, however powerful, could survive determined air attack unless protected by friendly aircraft - had been spectacularly vindicated.

Dominant in the air, Japan now had naval supremacy in the Pacific and in East Asian waters, and she used it to the hilt. With no effective air defense, the bastions of the Far East fell one after another. Hong Kong, Singapore, and Malaya, were all lost. The Dutch East Indies, Borneo, the Andamans, and Burma all were conquered. The Burma Road was cut, and China was left in isolation.

Their humiliation at Pearl Harbor left the American people stunned and infuriated. They got their first taste of revenge on April 18, 1942, when James Doolittle, now a Lieutenant Colonel, led a flight of sixteen B-25s off the aircraft carrier *Hornet*, and in the first attack on the Japanese homeland, bombed Tokyo.

Early in May, a far-ranging B-17 spotted a Japanese convoy moving south to occupy Port Moresby, the Allied base in New Guinea. The ensuing Battle of the Coral Sea was the first naval engagement in history fought without the opposing ships making contact. In two days of confused but vicious fighting, American Naval planes sank the light carrier *Shoho* and damaged the *Shokaku.* The Japanese sank the carrier *Lexington* and damaged the *Yorktown.* Strategically, the Coral Sea was an important American victory since the Japanese invasion fleet was turned back, and the threat to Port Moresby was averted.

Still Japan pushed on. The next move was a two-pronged offensive designed to capture Midway and establish bases in the Aleutians. Admiral Isoroku Yamamoto assembled a tremendous striking force of battleships, carriers, cruisers, destroyers, submarines, and supporting vessels - more than 150 ships and 1,000 carrier-based planes. The purpose was to push Japan’s defense perimeter farther from the home islands and to force the remnants of the U.S. fleet to fight a final, decisive battle.

Yamamoto’s first error was in dividing his air strength by consigning two of his carriers to the Aleutian task force. His second was in failing to detect soon enough the two American carrier task forces - under Rear Admirals Raymond A. Spruance and Frank J. Fletcher - that were converging on Midway from Pearl Harbor. After severe losses of American Brewster Buffaloes and Douglas TBD Devastators that were no match for Zeros, Dauntless dive bombers in less than five minutes smashed into flaming wrecks three Japanese carriers - the *Akagi, Kaga,* and *Soryu.* The fourth enemy carrier in action, the *Hiryu,* hit the *Yorktown.* Later, the *Hiryu* was set afire by planes and sunk by an American submarine. The crippled *Yorktown* was also finally lost to a submarine’s torpedo.

Robbed of his air power, Yamamoto was obliged to retire without achieving any of his objectives. His only gain was the occupation of Attu and Kiska, two chilly islands in the Aleutian chain. Though far from finished as a fighting power, Japan never recovered from the loss of the cream of her combat fliers and so many irreplaceable technicians and maintenance crews. When Yamamoto sent his withdrawal message, “Occupation of Midway is canceled,” he signaled in effect that, though the war in the Pacific was far from over, the decision was no longer in doubt.

EXPLORE

"Born of the spirit of the German airmen of the First World War, inspired by faith in our Fuehrer . . . thus stands the German Air Force today, ready to carry out every command of the Fuehrer with lightning speed and undreamed-of might."

Thus trumpeted Hermann Goering on September 1, 1939, as Germany invaded Poland. With overwhelming technical and numerical superiority, German planes wiped out 90 percent of Poland's air force. And on September 25, the first large-scale bombing of a major city began as Ju-87 Stukas, flying at 210 miles per hour, screeched down on Warsaw and bombed the Polish capital into submission in two days. It was a fast and heady first victory for Hitler's Luftwaffe - and a chilling preview of a terrifying new power.

The Germans, with a combat force of more than 1,500 planes, rapidly eliminated air opposition and used their unchallenged fighters for ground-strafing.

In Denmark, Norway, Luxembourg, Holland, Belgium, and France, the story was the same: Unprepared men, too late and with too little, were overwhelmed. As Hitler's armies rolled forward, fighters and bombers of the Luftwaffe paced the Nazi conquests.

For one triumphant moment only, in May 1940, the indomitability of man's spirit frustrated the juggernaut. Hemmed in at Dunkirk, shattered remnants of British and French units waited to be captured. For the moment, Hitler sent his armor elsewhere - and the miracle occurred. Every type of British ship raced across the Channel protected by every British combat plane available. The RAF "capped" the beaches, held off the Luftwaffe, and allowed more than 350,000 men to be saved from what had seemed certain surrender.

Battle of Britain

In the summer of 1940, the power of the Luftwaffe was turned loose on Great Britain. Certain that they could wipe out the RAF, the Germans bombed British airfields and installations and battled the outnumbered RAF pilots in the air. As the British people watched with pride and courage, English fliers in Spitfires and Hurricanes fought above the home island, giving the invaders more than they received. "Never . . . was so much owed by so many to so few," said Winston Churchill.

Still, British losses were great, and by September, the situation was ominous. Then Hitler changed tactics. Daylight raids dwindled, and the nighttime bombing of cities began. It was now the turn of British civilians, and they rose to their "finest hour." Night after night, the wail of sirens sent defiant populations into subways and shelters while firemen and volunteers steadfastly battled seas of fire set by Goering's planes. Overhead, the RAF continued to fight ferociously, downing German bombers and their fighter escorts.

Destruction was great; large parts of many cities were reduced to rubble. In London alone, more than 20,000 persons were killed and 25,000 seriously injured. But when failure led Hitler to end the blitz in May 1941, the English people knew they had beaten the Luftwaffe.

The Nazi Tide

In Africa and the Balkans, in the Atlantic and the Mediterranean, Axis aggressions steadily broadened the arena of war.

In April 1941, to secure his southern flank before attacking Russia, Hitler hurled his armies, supported by nearly 1,000 planes of Luftflotte 4, against Yugoslavia and Greece. Nine RAF squadrons, supporting the Greek forces, fought until they had only twenty-four airplanes left. These had to be evacuated to Crete when the Greeks were overwhelmed.

With Greece in their hands, the Germans decided to capture Crete with a massive airborne assault. The assignment was given to the 11th Air Corps whose parachute and glider-borne troops were an elite force. With almost complete air superiority, the Germans struck on May 20. More than 500 Ju-52s and 100 gliders ferried troops to the island where - according to the Daedalus legend - man first flew with wings. The defenders, mostly New Zealanders, resisted furiously. German casualties were heavy - more than 4,500 men were killed or missing and 200 Ju-52s were damaged or destroyed. But in the end, the Royal Navy was forced to evacuate the remnants of the garrison, suffering heavily from dive bombers as it did so.

It was a brilliant air victory for the Nazis, but an expensive one, for the island was of little use to them.

The Arsenal of Democracy

Stunned by the fall of France and the seemingly invincible might of the German Luftwaffe, the American people looked suddenly to the state of their own air power. Army and Navy aviation, for so long the stepchildren of the armed forces, were given what amounted almost to blank checks and directed to expand as fast as possible.

The needs seemed overwhelming. American aviation had to be built up, but overseas democracies, fighting with their backs to the wall, were desperate for American planes and equipment. Under Lend-Lease, commitments were made to Britain that had high priority. Existing American plants began operating round the clock, and new factories were built across the nation. Manufacturers of non-military products retooled to aviation needs, and the output of planes soared from 6,000 in 1940 to 19,000 in 1941.

Both the Army and Navy, meanwhile, rushed the completion of new training facilities. The draft brought in recruits, some of whom were soon on their way to new bases in Alaska, Iceland, and the Caribbean. The mere spending of funds could not fully compensate for oversights of the past, but by mid-1941, the United States was well embarked on an air program designed to meet the ominously-mounting crisis.

Attack in the East

"Russians," wrote Werner Baumbach, the Luftwaffe's General of the Bombers, "were simply regarded as subhuman." When the German military machine struck suddenly at Russia in June 1941, Hitler's ground and air forces treated the Russian people in that light, blitzing soldiers and civilians alike and alienating whatever anti-Communist elements might have existed within the country.

The Rising Sun

Since 1931, when they had first intervened in China, the Japanese had been marked as aggressors. But the rest of the world had done little to halt them, and by 1941, their shadow extended over much of Southeast Asia. Though there were many who still believed that an appeal to reason would pull them up short, it was far too late. Military leaders were firmly in power, and a well-oiled armed machine was on the march.

Among the keys to their power, underrated by western nations, were strong air arms of the army and navy that included many advanced types of planes, including the superb Mitsubishi carrier-based Zero fighter. The Zero had weaknesses - principally lack of armor - but in the days after Pearl Harbor, its firepower, range, and maneuverability made it more than a match for every fighter that the surprised and hard-pressed American Air Corps and Navy could bring into the struggle against it.

Japanese Victories

The days following Pearl Harbor produced shock after shock for the Allies. With little air opposition, Japanese planes paved the way for conquests in Southeast Asia and the Pacific. Americans cheered a gallant defense of tiny Wake Island, during which a handful of Marine Wildcats helped fight off the Japanese invasion fleet. Ten days later, a larger force with two carriers appeared and finally overwhelmed the island.

Elsewhere, Japanese planes and ships swept the Allies from one defensive position after another. American sea defenses were crippled at Pearl Harbor, and British sea power in the East all but disappeared as Japanese planes, in short order, sank the *Prince of Wales, Repulse, Cornwall, Dorsetshire, Hermes,* and *Vampire.* Only at the Coral Sea, in May, were the Japanese temporarily halted.

The Doolittle Raiders

Not until the aircraft carrier *Hornet* had taken them far out to sea did the fliers who had volunteered for Lieutenant Colonel James Doolittle's "dangerous and highly important mission" learn where they were going. On April 18, the *Hornet* would be 500 miles from Japan, and on that day, they would take off from the carrier in their sixteen B-25s and bomb Tokyo.

Unforeseen problems beset the daring raid. Early on the 18th, Japanese vessels spotted the *Hornet* and its companion carrier, the *Enterprise.* Doolittle and Vice-Admiral William F. Halsey, who commanded the carriers, decided on an immediate takeoff, though the ships were still some 670 miles from the target. From a deck that rose and fell with the rough sea, and off a runway only a third as long as the B-25s usually required, the raiders soared into the air and headed toward Japan.

Flying extremely low to avoid interception, thirteen of the B-25s swept in over Tokyo while three others headed for targets south of the capital. Led by Doolittle and by Major John Hilger, Captains David M. Jones and C. R. Greening, and Lieutenants Edward York and Travis Hoover, the Army fliers dropped their bombs and sped on unharmed, planning to land in China.

As darkness approached, the weather was bad, and their fuel ran low. One by one, they bailed out or made crash landings. Most of the fliers were found by friendly Chinese. One crew landed near Vladivostok, and the Russians interned them. Two planes came down in Japanese territory; three of the eight crewmen were shot, and five were imprisoned.

The bold raid did little actual damage to Japan. But American planes over Tokyo, even for "thirty seconds," rattled Japanese confidence and gave a boost to the morale of the United States.

Production Line

"Rosie the Riveter" and "graveyard shift" entered the American vocabulary as men and women worked side by side on the home front, turning out planes for the fighting fronts. Shifts came and went round the clock, producing in 1942 nearly 48,000 planes. Two years later the figure was more than 96,000.

The vastly expanded aircraft industry, much of it on the West Coast, was aided by automobile plants that converted to making planes. The Government altogether spent an estimated $45,000,000,000 for aircraft in World War II, and a total of 300,000 military planes were produced. The United States, said Lieutenant General William S. Knudsen of the Air Technical Service Command, "smothered the enemy in an avalanche of production the like of which he had never seen or dreamed of."

The Battle of Midway

From Japan, an armada of 200 ships and 700 planes bore in for the kill. Its mission: to seize Midway, destroy the remnants of the U.S. fleet, and win the war. Though heavily outnumbered, America had broken the Japanese naval code and knew the enemy was coming. As an ambush, Admiral Chester Nimitz flanked the invaders with the carriers *Enterprise, Hornet,* and *Yorktown* - and waited.

On June 4, 108 Japanese planes hit Midway's defenses, chewing up a Marine fighter squadron in antiquated Buffaloes. When island-based bombers and Devastators from the lurking carriers tried with desperate courage to attack the Japanese fleet, they were slaughtered. Thirty-five out of forty-one Devastators were lost. Then, while the battle raged at low level, the ambush suddenly worked. Out of the clouds screamed Dauntless dive bombers, destroying three Japanese carriers in five minutes.

Later, the Japanese lost another carrier and a cruiser, and the Americans lost the *Yorktown.* But pilots' heroism had won a decisive battle.

9

ALLIED TRIUMPH

American war strategy included two major premises: “Europe first” and the build-up of forces in Britain for an air offensive and the early recrossing of the Channel by Allied armies. Whatever hopes Allied air leaders may have had that Germany could be defeated by strategic bombing, it was clear that the air offensive would have to take place within a land-sea-air strategy. But with fires burning everywhere, the build-up of American bomber forces in the British Isles had to be slower than the pre-Pearl Harbor plans had envisioned.

On January 27, 1942, it was agreed that the first two heavy bomb groups available should form the nucleus of an American air command in Britain that would “operate independently in cooperation with the British Bomber Command.” On February 4, Brigadier General Ira C. Eaker left the United States to prepare for the reception of American air units in England, and early in June, Major General Carl Spaatz arrived with the first contingent and formally took command of the 8th Air Force.

At the same time, Churchill journeyed to Washington. Since Christmas, the Coral Sea and Midway had been the only bright spots in a gloomy world. The German summer offensive was underway in Russia. The Crimea had already fallen, and the Nazis were bearing down on the Caucasian oil fields and possibly the Middle East. In May in North Africa, Erwin Rommel had begun to move; on June 13, he had defeated the British at Knightsbridge. Now, on June 21, while Churchill was conferring with Roosevelt, a telegram arrived that the president silently handed to the prime minister: “Tobruk has surrendered, with 25,000 men taken prisoners.”

Churchill suggested that the Americans, who were anxious to be in some major action in 1942, might create a strategic diversion in northwest Africa. The American chiefs of staff resisted, arguing that even a small bridgehead in France would be preferable to anything that might be done in North Africa. Haunted by the memory of Dunkirk, the British refused to join in a cross-Channel operation in 1942. By the end of July, the Americans found themselves committed to invade North Africa, and on August 7, Lieutenant General Dwight D. Eisenhower, American commander of the newly formed European theater, was named to lead the new expedition.

In England, meanwhile, the first B-17E arrived on July 4, 1942. American faith in daylight bombing was still strong, despite early German and British failures. It had not really been tried - not with the high-level precision techniques that Americans believed essential. Confidence was based on two things: first, the Norden bombsight, held to be capable of “pickle-barrel” accuracy from great height; and second, two great bombers, the B-17 Flying Fortress and the B-24 Liberator. Their speed, range, and durability had already been proved in the Pacific; and in formation, armed with ten or more heavy machine guns each, they could bring tremendous firepower against attackers.

Some of the British were skeptical about daylight bombing. Others, like Trenchard, believed that whatever the problems, it was infinitely more desirable - even necessary - to bomb by day and by night, right around the clock, than to do either alone.

Unquestionably, area bombing at night by RAF Bomber Command had made great progress in 1942. The new bomber commander, Sir Arthur Harris, intended to wipe out Germany’s cities systematically, acre by acre. He believed that with existing equipment true precision bombing was impossible and, in any case, probably a meaningless refinement. The American idea of going for the jugular vein did not appeal to him; he felt the result was more certain - if less tidy - when the whole organism was smashed.

The striking power of Bomber Command was vastly increased in 1942. Older, slower, less capacious aircraft were replaced by more Halifaxes and the redesigned Manchester, now called the Lancaster. The weight of single bombs rose from 2,000 to 8,000 pounds. Average strength available per mission went up from forty-two bombers in January to 261 in December. Pathfinder navigation aids in the form of airborne radar now made it more nearly certain that targets could be found in overcast skies and at night.

The Ruhr was at last heavily bludgeoned in a series of mounting blows, culminating, on May 30, in a mass attack on Cologne, the first of three 1,000-bomber raids. The munitions towns of northern Italy were also hit, Turin being the first city to feel a full-scale attack with 8,000-pound bombs. On some operations, losses amounted to 10 percent and in a few instances rose even higher, but Harris believed the results justified the risks.

On July 4, the U.S. 8th Air Force went into action with borrowed RAF airplanes. On August 17, flying with strong Spitfire escort - and with Eaker, the bomber commander, in the lead ship of the second flight - twelve Fortresses bombed the railroad yards at Rouen while six others carried out a diversionary sweep. All returned safely, and the mission seemed a good omen for daylight precision bombing.

Through the first week of September, ten more attacks were made on targets within the operating radius of the fighters. Accuracy was so good that it looked as if the day bombers would be able to land 40 percent of their bombs in a 1,000-

yard circle around the aiming point. Luck changed abruptly on September 7 when the weather turned bad, and the bombing went wild. Still, losses were low - only two bombers in eleven missions.

A new phase of the American effort began on September 8 when Spaatz was ordered to strip the 8th Air Force of a good part of its still meager strength to provide units and planes for a new air force - the 12th, under Brigadier General James H. Doolittle – that would assist the forthcoming invasion of North Africa. The pared-down 8th, somewhat disheartened by the postponement of its own mission, flew three more operations in October. On the ninth, over Lille, German fighters shot down four out of 108 bombers. Worse still, only nine bombs were plotted within 500 yards of the aiming point. For the rest of the year and into the spring, the 8th Air Force and RAF Bomber Command were directed to give protection to Allied convoys bound for North Africa and were obliged to waste their effort in bouncing bombs off the twelve-foot-thick roofs of submarine pens in the Brest peninsula.

November 1942 marked three great climaxes of World War II. The first was the Battle of El Alamein, in which the British 8th Army, under its new commander, Lieutenant General Bernard L. Montgomery, broke the back of Rommel's Afrika Korps and sent it into retreat. In a series of stupendous actions from October 24 to November 5, Montgomery was mightily assisted by the RAF's Desert Air Force, under Sir Arthur ("Maori") Coningham, and the U.S. 9th Air Force, under Lieutenant General Lewis H. Brereton, who earlier had been in India.

The second November climax was the Battle of Stalingrad, a German disaster of the first magnitude. Furious fighting had been going on there since August. As the Russian winter closed in, a massive Soviet counterattack struck the Germans on November 19, hurled them back, and ultimately closed around the 6th German Army. During December 1942 and January 1943, nearly 500 aircraft were lost in a frantic attempt to deliver the 550 tons of supplies needed daily by the encircled troops. The Germans even tried using their new four-engine bomber as a transport. This was the Heinkel He-177, just coming into limited production after many design difficulties. Losses were unbearable: Within a few weeks, 1,000 highly trained airmen were sacrificed, and their efforts were wasted. In February 1943, the 6th Army surrendered.

The third climax occurred on November 8, 1942, with the Allied invasion of northwest Africa. Three well-timed task forces - two from England moving on Algiers and Oran and a third headed from the United States to Casablanca - caught the enemy off guard. Brief opposition was met from Vichy French forces, but by November 10, Algiers and Oran had been taken and all French units in Morocco had surrendered.

The Allied problem was to secure Tunisia before the Germans could build up enough strength to hold it. Supported by paratroops dropped at Bône and other key points, Allied troops got within twenty miles of Tunis on November 28, only to be driven back two days later by superior German forces. The high tide of Allied advance passed; supplies, reinforcements, and aircraft bogged down in mud.

Perhaps the unhappiest part of the operation was the air situation, in which responsibility for support was unwisely divided between the American 12th Air Force, under Doolittle, and the British Eastern Air Command, under Sir William Welsh. Units were strung out throughout the invasion areas, and local ground commanders assumed operational control of tactical aircraft, dissipating the meager air strength. Coordination was virtually impossible and could only be effected by the Allied Commander in Chief personally. Early in December, Eisenhower sent for Spaatz to come down from England and take charge. Tactical air commanders were restored to control of their own units, and a system of coordination between ground and air commanders was established. Spaatz emerged as Eisenhower's acting deputy for air.

In January 1943, Roosevelt and Churchill met at Casablanca and adopted the policy of "unconditional surrender." They also decided that when Tunisia had been won, Eisenhower should proceed to the capture of Sicily in order to re-establish Allied control of the Mediterranean. At the same time, Churchill also proposed to Roosevelt that the American air forces based in Britain abandon daylight bombing and join the RAF in night operations.

Called to the conference, Eisenhower and Spaatz resisted, knowing that the United States was already developing long-range fighters that would become available by the time the 8th Air Force had reached sufficient bomber strength to make deep penetrations into Germany. Long argument failed to convince the prime minister that daylight bombing was feasible. Eaker came down from England and in a private interview with Churchill made a point-by-point case for daylight bombing. Not without lingering doubts, Churchill at last withdrew his opposition. Before the conference ended, the Combined Chiefs of Staff issued a directive for a combined bomber offensive by the 8th Air Force and RAF Bomber Command, operating day and night against a common schedule of priority targets.

North Africa was now made a separate theater under Eisenhower. Spaatz was to command all the air forces in northwest Africa while Sir Arthur Tedder coordinated air activities throughout the Mediterranean, especially those eastward of Tunisia and thus beyond Eisenhower's jurisdiction.

On February 14, Rommel, retreating before Montgomery's British 8th Army, joined up with the Axis forces already in Tunisia and settled in the Mareth Line. The Germans struck the weak Allied center, breached the line in the bloody battle of Kasserine Pass, and were stopped only as they pressed into Algeria. This was the last great adventure of the Afrika Korps.

In March, operating from newly built forward airfields, Spaatz achieved control of the air in Tunisia. The 8th Army, moving in from Libya behind massive air and artillery preparation, took the Mareth Line, and Rommel went home to Germany pleading ill health. The Northwest African Air Forces now pounded the Sicilian ports and shipping to prevent the Germans from reinforcing or escaping. B-17s pulverized thirty acres of dock area in Palermo, and on April 18, four squadrons of American P-40s caught nearly 100 Ju-52s and their fighter escort over the Gulf of Tunis, shooting down more than fifty in ten minutes with the loss of only six Warhawks.

The final ground push began on April 22 supported by as many as 2,000 air sorties a day. Tunis and Bizerte fell on May 7. Huddled against the sea, cut off from escape by sea and air, the entire Axis force in Africa - 270,000 men - surrendered on May 13.

Before the invasion of Sicily could be supported by air, it was necessary to subdue the neighboring island of

Pantelleria and gain its bases for fighters too short-legged to operate from Tunisia. Bombed incessantly for a month, the island surrendered on June 11, the first instance of the conquest of territory by air power.

Sicily itself was given a similar pounding. A thousand planes and almost all thirty-one of its airfields were put out of action before D-Day, July 10. With the air over land and sea under Allied control, only a dozen of the armada of 3,000 ships were lost, mostly at night, and the American, British, and Canadian forces went ashore virtually unmolested by enemy air attacks. From July 14, Allied air supremacy was almost complete, and North African Air Force planes were free to bomb airfields in France and Italy and make strategic attacks against Italian rail centers.

After Casablanca, the commitments of American air power to other theaters had kept the strength of the 8th Air Force in England, now under Eaker, too low to damage the Reich. Until spring, its nominal force was from two to six groups, and only half of these were operational. A hundred-plane mission was a rarity. The idle commitment to invulnerable submarine pens continued to exact its toll. U-boats, nevertheless, gave the 8th Air Force its first opportunity to attack Germany when, on January 27, 1943, the construction yards at Wilhelmshaven were hit.

Even yet, there were no long-range fighters and no nose turrets to give protection against head-on attack. The development of the combat box, a tight stack of bombers with mutual defensive fire, helped somewhat. Still, losses above 10 percent were common, and in an attack on Bremen on April 17, sixteen of 106 bombers were lost.

By the summer of 1943, the 8th Air Force received six new heavy groups. Aircraft, ball bearings, and oil were the high-priority enemy targets, and the oil refineries at Ploesti, Rumania, were singled out to be hit. The 8th lent three of its B-24 groups, and the 9th, still based in North Africa, two of its groups, for a minimum-altitude, radio-silence, surprise attack, on August 1, 1943, on this supposed oil arsenal of the Reich. In the execution, the lead groups turned too soon and alerted the defenses. Fifty-four of 177 Liberators dispatched were lost, in return for about 40 percent of the capacity of Ploesti that in a few months was nearly back to its usual efficiency. The courage and devotion of the crews were by far the most important aspects of the mission.

The 8th Air Force realized that in 1943, owing to RAF Bomber Command's 1942 successes and the mere appearance of the new Flying Fortress weapon against Germany, the Luftwaffe would be waiting for revenge. In target planning, Ploesti oil had been a tossup with the Messerschmitt single-engine fighter works at Regensburg and Wiener Neustadt. The two attacks were finally made concomitant though the Ploesti task force was to bomb Wiener Neustadt and the 8th, Regensburg. Ball bearings being high on the target list, an attack on Schweinfurt was thrown in for good measure. Regensburg was to be hit first, and the force was to fly on to bases in Algeria - an early shuttle-bombing attempt. By striking after the Regensburg contingent, the Schweinfurt effort was expected to escape enemy opposition. Both operations could be given fighter support only part of the way.

The Regensburg wave of 146 bombers took off from England on the morning of August 17. As expected, the German fighters savagely attacked the top and bottom elements of the combat wing. Twenty-four bombers went down, but every building of the Messerschmitt plant was damaged, and the planes flew on to Africa unopposed. Bad weather held up the Schweinfurt wave for three and a half hours. Instead of the feeble resistance of spent German fighters, it encountered the Luftwaffe rested and refueled. In and out, the task force lost thirty-six bombers and more were crippled in exchange for eighty direct hits on the ball-bearing works.

A second raid on Schweinfurt on October 14 cost sixty of the 291 attacking Fortresses. Though no formation of American bombers was ever turned back, the worst that the opponents of daylight bombing had prophesied had come true. Heavily armed bombers, it was now seen, could not protect themselves against massive fighter attack. The German tactics of loosening up combat formations by firing long-range rockets from twin-engine "destroyers" and then having their single-engine fighters go after cripples or stragglers were effective and deadly. "Feathering a prop over Germany," said one American pilot, "is like writing to the boys at the mortuary for space on their slab!" It was the last deep daylight penetration attempted by the Allies until long-range fighter escort appeared four months later in February 1944.

After the second Schweinfurt raid, the Germans dispersed their ball-bearing plants. German industry, though severely battered, was showing remarkable recuperative powers; German fighter production in December 1943 was higher than it had been in June. Yet, the Nazis fully realized the potential disaster that awaited them. Invading Russia in 1941, the German army had been supported by 50 percent of the Luftwaffe. Now, at the end of 1943, only 20 percent stood behind the army; the bulk of the German fighter squadrons had wheeled around to meet mounting day and night bombing in the west.

The Allied invasion of Italy, meanwhile, had begun on September 3 with Montgomery's landing in Calabria. The

American 5th Army, in an attempt to cut off the supposedly retreating Germans, landed higher up the boot at Salerno, below Naples, on September 9. With Allied fighters operating at the limit of their radius, the going in the beachhead was rough. When the Germans counterattacked, American paratroops were dropped, and they stopped the advance. With the full weight of Allied air, naval, and ground fire assisting, General Mark Clark was able to make contact with Montgomery on September 16. Spaatz then turned his bombers against the remaining enemy airfields in the south and quickly rebased his own fighters on them as they became available. From then on, the Allies had control of the air over Italy.

Naples fell on October 1, and the 8th Army reached an equivalent point on the east coast, thus freeing the complex of airfields in the Foggia Plain. In a few weeks, the Allied advance found itself stopped by the rugged Italian terrain, bad weather, and a fortified barrier that the Germans called the Gustav Line. Here the Allies sat through the winter. The capture of the Foggia airfields, however, had provided bases from which strategic bombers could at last reach targets in central and southeastern Europe. To exploit the advantage, the United States formed a new strategic air force to be based in Italy - the 15th, under Major General Nathan F. Twining.

In November and December, Roosevelt and Churchill again met at Cairo and at Tehran. Closer cooperation with the Russians was attempted, and Stalin agreed to let the American heavy bombers have shuttle bases in the Ukraine. The war in Italy was to be curtailed, and all possible effort concentrated on the build-up for a cross-Channel invasion of the Continent in the summer of 1944. The command team developed in the Mediterranean was moved to London. Eisenhower was designated Supreme Commander, with Sir

Arthur Tedder as his deputy. Spaatz became commander of the U.S. Strategic Air Forces in Europe, controlling the operations of the 8th and the 15th. Eaker was sent from England to head the Mediterranean Allied Air Forces, and Doolittle replaced him as commander of the 8th. The war in Europe was about to enter its final phase.

On the eastern front, the summer of 1943 had spelled continued disaster for the Germans. Starting at Kursk, near the center of the long line, Soviet forces began a gradual but steady rollback of the invaders. Enormous battles of tanks and aircraft were fought at Orel, Smolensk, and finally Zhitomir. Day after day, cities and towns were liberated. By the end of the year, the whole front, from Leningrad to the Crimea, was rolling westward.

On the other side of the world, during all this period, a different kind of war had been raging fiercely. Daunted at Midway, the Japanese had pushed aggressively forward elsewhere. In July 1942, they had started a drive across the mountainous spine of New Guinea toward Australia, and on September 17 were only twenty miles from Port Moresby. Major General George C. Kenney at this point organized the U.S. 5th Air Force and, largely by knocking out enemy airfields, began systematically to gain control of the air over New Guinea. Allied troops, many of them airlifted from Australia, turned back the Japanese, who held on stubbornly at Buna until January 1943.

Admiral Chester W. Nimitz, Navy commander in the Pacific, had meanwhile begun a campaign to take Guadalcanal, where the Japanese were building an advanced airfield. The First Marine Division landed at Guadalcanal and Tulagi on August 7 and occupied the airfield, which soon came under heavy Japanese air and naval counterattacks. The small unit of Marines hung on gallantly, and from the airstrip, day after day, Marine Wildcats rose to battle Japanese bombers and fighters that swarmed down the Solomon Islands "slot" from Rabaul.

For weeks, the issue at Guadalcanal was in doubt. Four major naval battles were fought for possession of the island. Japanese reinforcements swarmed ashore, and on the night of October 13, shells from the battleships *Haruna* and *Kongo* reduced the airfield to a shambles. The Americans fought back with every type of combat plane available. On November 11, they smashed a desperate attempt by the Japanese to land new troops, sinking seven out of eleven transports and damaging the rest. Six thousand Japanese soldiers and all their supplies were lost.

After long, bitter fighting, the Japanese finally abandoned Guadalcanal in February 1943, and Marine and Army troops, under the direction of Admiral William F. "Bull" Halsey, moved on to capture other strongholds in the Solomons. The Japanese were dogged defenders and made island-hopping extremely costly to the attackers. It took two months to conquer New Georgia and longer to subdue the nearby islands, but once the tide of war turned, it began to ebb rapidly for the Japanese. In March, planes of the Royal Australian and United States 5th Air Forces smashed an entire Japanese convoy of eight transports and eight destroyers into flaming wrecks in the Bismarck Sea. The cost to the Allies was only six planes.

The Japanese suffered a dramatic blow of another sort in April. On the morning of the eighteenth, Admiral Isoroku Yamamoto, said to possess the best military mind in Japan, took off from Rabaul in a Betty bomber to inspect Japanese airstrips on Bougainville in the northern Solomons. American monitors, able to read and decipher enemy coded messages, knew where he was going and when; fifteen minutes before Yamamoto reached his destination, he was jumped by waiting Lockheed P-38s, shot down, and killed.

Salamaua and Lae, the main objectives of the Allied advance in New Guinea, held out against American and Australian troops under General Douglas MacArthur until mid-September. Gradually, it was realized that the most effective way to deal with the far-flung Japanese strong points was to strangle their long supply lines with air power. In the fall of 1943 and early in 1944, the 13th Air Force, Navy planes from the Solomons, and eventually the 5th Air Force did just that to Rabaul, neutralizing the anchor of the Japanese position in the southwest Pacific. Farther north, progress was also made. In November 1943 in the Gilbert Islands, the atoll of Tarawa was captured after a heroic and exceedingly bloody fight. Moving westward in February 1944, a landing was made in the Marshalls, and Kwajalein was taken with its harbor and airfield. Here, for the first time, the Japanese were deprived of territory they had held before the war. Its capture was a symbol that the power of the Rising Sun was soon to set.

Another threat to Japanese power was now building up in the United States and on airfields in central China. The threat was the Superfortress, the B-29, plans for which had been laid down in 1939-40. To operate the big planes from China required the building of huge air bases in India and China and airlifting supplies over enormous distances. The first B-29 attack of the war was made on May 27, 1944, from India against Bangkok. Full-scale use against the Japanese homeland from the advanced bases would come later. Meanwhile, C-46s - and, later, four-engine C-54s - of the 10th Air Force carried supplies to China over the "Hump" of the Himalayas. The pilots fought 100-mile-per-hour winds and blinding snowstorms, flew at night to avoid Japanese fighters, wrestled their heavily laden transports over mountain ranges 16,000 feet high, and faced the constant hazard of forced landings in remote and terrible terrain. “Five hundred and sixty miles of aerial dynamite,” one flier called the run over the Hump.

In Europe, the long-awaited invasion of France was about to take place. By early 1944, long-range P-51 fighters were beginning to arrive in England in significant numbers, and the range of the P-38s and P-47s had been extended by the use of droppable wing tanks. To gain control of the air over the invasion areas before D-Day, Spaatz’s bombers struck a major blow at the German aircraft industry in a “Big Week” of concentrated operations in February 1944. The RAF cooperated with five heavy night attacks. A large dent was put in German aircraft production when it was needed most. On March 4, 6, and 8, the daylight bombers, escorted by Mustangs, attacked Berlin in force. The whole of the Reich now lay open to the American heavies. Though losses were often severe, Spaatz relentlessly struck at important targets on every possible occasion. To cut down the Luftwaffe still faster, he ordered the fighters to skirmish ahead of the bombers to seek out and kill the enemy fighters. In February and March, the Luftwaffe lost 800 day fighters in the west. Though the planes might be replaced, the pilots could not, and the German air force began to decline rapidly.

In an effort to increase the firepower of their interceptors, the Germans weighed their warplanes down with rocket-firing devices, extra cannon carried in gondolas, and even air-to-air bombs. As a result, when the sleek, long-range Mustangs suddenly appeared over Berlin and other cities deep inside the Reich, the aging German fighters were completely outclassed.

Even if they had been able to match the Allies in quality, the Germans could no longer hope to stop the tidal wave of air power rolling over them. In 1944 alone, the United States produced 96,318 planes - more than twice the total American production in all the years prior to World War II. British factories were pouring out a stream of Lancasters, Halifaxes, Mosquitoes, Spitfires, Tempests, Typhoons, Beaufighters, and other combat types. When it came to hauling devastating bomb loads, the Lancaster was the war's most successful heavy bomber, but the British de Havilland Mosquito was also highly annoying to the Germans. Its great speed made it almost immune to fighter attack - until German jets became operational. Its wooden construction made it difficult to detect by radar. It was used for just about everything: bombing, photo-reconnaissance, night fighting, antisubmarine patrol, and "intruding" - following enemy aircraft back to their own fields and shooting them down as they tried to land.

In the planning phase before D-Day, a sharp difference of opinion arose among the Allied air commanders over target priorities. One group, led by Tedder, favored a concentrated campaign against communications. The other, for which Spaatz was spokesman, favored a smashing attack on oil. Eisenhower decided on the communications plan. In the end, the U.S. Strategic Air Forces, aided by the RAF Bomber Command's unremitting attacks on German cities, knocked out both target systems. The strategic bombing offensive may have been long in coming, but it was now beating the German homeland to pulp.

When the invasion was launched in the dark and windy hours before dawn on June 6, the Luftwaffe was able to fly only a few sorties in opposition. Over the invasion forces in 4,000 ships, 11,000 Allied planes formed an iron canopy. Three divisions of airborne troops were dropped into

Normandy before daylight. During the first day, the U.S. 8th and 9th Air Forces, between them, flew 8,722 sorties while the RAF, in daylight, flew 5,676.

In the following weeks, the Allies retained complete mastery of the air in Normandy. The interdiction campaign prevented rapid movement by German reinforcements into the combat area. Still, the German defense was stubborn, and the development of the battle was slowed. On July 25, for five miles along the Saint-Lô-Périers road, the 8th and 9th Air Forces blasted an enormous hole through which the American army was able to break out. Lieutenant General George S. Patton now began the first of his famous dashes across the French countryside. On August 7, when the Germans attempted to cut the American spearheads, they were caught in a British-American pincers movement at Falaise and the panzers were bombed and strafed into ruins. The remnants now headed for the Siegfried Line.

On August 15, France was invaded from the south by American and French troops after elaborate preparations by the 15th and 12th Air Forces. Pushing up the Rhône Valley, the invasion forces met up with the main body of Eisenhower's command on September 11. In this operation - as throughout the Battle of France - the American tactical air forces were writing a new page in the history of warfare through the intimate, powerful, almost omnipresent air support given the armies. Between these air forces and the ground forces they worked with, it was, as Patton said, a case of "love at first sight."

In a desperate attempt to split the Allied armies, Hitler in December launched a short but sharp offensive in the Ardennes. Known as the Battle of the Bulge, this maneuver carried the German armor fifty miles before it was stopped. For a week, bad weather prevented the Allied air forces from attacking, but when the skies cleared on December 23, the twenty-five German divisions in the Bulge were pounded unmercifully. The Luftwaffe tried to operate with its former sting, but it suffered heavy losses due to the inexperience of the crews. By New Year's, the Bulge was over.

The last twelve months of the war saw the introduction of Hitler's vengeance weapons, the V-1 and V-2, and the use of the first jet aircraft by both the British and the Germans. One week after D-Day, the V-1 flying bombs - in effect small pilotless jets with a speed of 390 to 410 miles per hour and a range of 150 miles - began to drone across the Channel, inflicting punishing damage on a horrified but unwavering London.

By August, the RAF had fifteen day squadrons and six night fighter squadrons assigned to V-1 interception. Seven of the new Gloster Meteor jet fighters went into action and destroyed thirteen buzz bombs. Revolutionary German fighters - the Messerschmitt Me-262 jet and the world's first rocket airplane, the Me-163 - came too late and in too few numbers to put a serious crimp in the Allied bombing offensive. Also too late to be of serious help to the Germans was the Junkers Ju-287, the first heavy jet bomber. Potentially more deadly was the V-2 missile which stemmed from earlier research with liquid-propellant rockets by the American scientist Robert H. Goddard. Carrying a 2,000-pound warhead, the V-2 had a range of 220 miles reached at speeds up to 3,600 miles per hour over an arched flight path sixty miles high at its peak.

Despite these spectacular developments, the whole German war machine by early 1945 was slowly and inexorably grinding to a halt. In January and February, the Western Allies knifed into the Rhineland. The Russians pressed westward from Warsaw to the Oder. In March, the Rhine was crossed. In April, the Ruhr was taken, and the last German defenses in the west collapsed. On April 16, Spaatz announced the end of the strategic air war - the bombers had run out of targets to destroy. On the twenty-fifth, American and Russian ground forces met at the river Elbe. At last, on May 7, Germany surrendered unconditionally. The captured Nazi leaders unanimously asserted that the war in Europe had been decided by air power.

The Pacific war was also slowly moving toward the climax. The final phase began in midsummer of 1944 with the Marianas operation against Saipan, Guam, and Tinian, only 1,500 miles from Japan. The invasion, preceded by neutralizing air attacks on Truk in the Carolines, was executed by a task force whose size dwarfed that of the whole Japanese navy. The amphibious assaults were provided heavy air support by U.S. Navy, Marine, and 7th Air Force planes.

Japanese commanders knew that if the Marianas were lost, massive bombing attacks on the home islands would begin. Still, they did not consider their position hopeless. In the Marianas, they had at least 500 land-based planes. In the Philippines, Vice-Admiral Jisaburo Ozawa had assembled a fleet of seventy-three vessels, including five battleships and nine aircraft carriers. Task Force 58 under Admiral Marc Mitscher was larger, and this time the volume of antiaircraft fire that American ships could deliver was almost unbelievable. Nevertheless, Ozawa hoped to exploit the superior range of his lighter aircraft, stay beyond the reach of the American carriers, and if necessary, run shuttle missions to Japanese land bases where his planes could refuel and rearm to strike the American fleet on their way back. After destroying the U.S. fleet, he could then whip the isolated invasion troops in the Marianas.

“The fate of the Empire,” said Premier Hideki Tojo, “rests on this battle.” Even as Army troops and Second and Fourth Division Marines fought for a foothold on grimly defended Saipan, and 3rd Division Marines stood by for a landing on Guam, a titanic sea and air battle commenced. For the Japanese, nothing went right. Before Ozawa’s fleet could reach the combat zone, Grumman Hellcats had shattered the Japanese land-based air force. When Ozawa hurled his planes at the American carriers in four separate waves, Hellcats clawed them to pieces. “If this plane could cook,” one ecstatic American pilot cried, “I’d marry it!”

Japanese losses were fantastic: 366 planes. In the Marianas Turkey Shoot, as it was called, some American fliers were credited with six victories on a single mission. American combat losses were twenty-six planes.

Submarines and air attacks from Mitscher’s carriers destroyed a large part of Ozawa’s fleet and sent the remnants reeling back, damaged and demoralized. From that victory, the American Navy turned toward the Philippines. In heavy strikes against Japanese bases on Okinawa and Formosa, Hellcats crippled the enemy’s land-based air power, then turned south to help protect landings on the east coast of Leyte.

Again while the beachhead battle was in progress, the Japanese fleet attempted a major disruption. The result was the Battle of Leyte Gulf, fought and won by the ships and fliers of the 7th and 3rd Fleets, commanded respectively by Admirals Thomas C. Kinkaid and William F. Halsey. Once more, the Japanese were overwhelmed. The giant battleship *Musashi,* hit by at least thirty bombs and twenty-four torpedoes, rolled over and sank. Two other battleships and four carriers went down. In the air, Zeros were slaughtered. In one engagement, Commander David S. McCampbell shot down nine enemy aircraft; he went on to become the Navy's top ace, with thirty-four confirmed victories. In the savage fighting that followed, Army Major Richard I. Bong brought his score up to forty confirmed kills and was withdrawn from combat, the number-one American ace of all time.

From Leyte, the action moved to Mindoro, and from there to Luzon, the invasion of which occupied much of January 1945. Corregidor was taken with a paratroop drop on February 16. By the beginning of March, Manila was in American hands.

A principal reason for the seizing of the Marianas had been to gain islands that could be used as bases for the long-planned B-29 very-heavy-bomber operations against Japan itself. The 20th Air Force, intended as a global air force and commanded personally by Arnold, controlled all B-29s. The Super-forts began to arrive on Saipan in October 1944 and flew their first mission - to bomb Truk – on October 28. Brigadier General Emmett "Rosie" O'Donnell of the 73rd Wing led 111 B-29s against Tokyo on November 24. The new strategic bombing force did not escape the usual operational problems - slow build-up, lack of fighter escort, bad weather, poor accuracy, and a low rate of operations. In the end, two answers were provided: LeMay and Iwo Jima. Major General Curtis E. LeMay, a division commander with the 8th Air Force, was sent out from England to take charge of the B-29s and put them in fighting shape.

Iwo Jima is a rocky island in the Bonins about halfway between Japan and the Marianas. Its value as a base for fighters and as an emergency landing field for B-29s limping back from Japan to the Marianas was inestimable. Before the operation, it was supposed that its capture would take four days. It took four weeks and one of the bloodiest battles of the entire war. For seventy-two days before the

Marines went ashore on February 19, 1945, planes and ships bombarded the rock - five and a half miles long and two and a half wide - almost round the clock, trying to soften it up. When the landing was made, the Japanese, hidden in underground defenses, fought like demons. But in terms of American fliers' lives eventually saved, the island was worth what it cost.

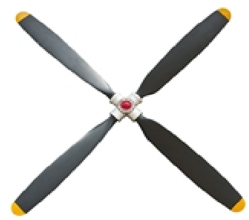
In the overall Pacific war, the next stage was to wrest the Ryukyus from the enemy, as these islands formed a natural springboard for an assault on Japan. The last and most violent amphibious campaign of the Pacific struggle began on March 18, with preparatory air strikes by Admiral Mitscher's Task Force 58. Okinawa, the main island, was invaded on April 1 by Army and Marine troops. As always, the Japanese garrison resisted fiercely, and the operation was not concluded until June 21.

No longer able to match American planes and fliers, the Japanese air force now turned to suicide tactics in which the *kamikaze* pilot crashed his explosive-packed plane onto a target, most frequently a ship. During the Okinawa operation, these kamikazes made about 1,900 attacks and caused the U.S. Navy some of the heaviest damage of the war.

In March, LeMay decided to break from standard Air Force practice and use his B-29s to bomb the cities of Japan at night in low-level attacks with incendiaries. The resulting devastation was spectacular. The first fire raid on Tokyo killed 80,000 people, destroyed a quarter of the city's buildings, and laid waste an area of fifteen square miles. Almost from the beginning of these attacks, the B-29s had mastery of the skies over Japan. Fighter escort was unnecessary; armament became a nuisance. Many of the bombers had their guns removed, and the space filled up with more incendiaries.

With their home islands a nightmare, further Japanese resistance was senseless. Nevertheless, they had seventy divisions of ground troops, and perhaps 5,000 combat planes of which at least 3,000 would be used as kamikazes. It was the knowledge on the American side that these forces could inflict untold additional casualties that led to the decision to use the atom bomb. On August 6, in a searing flash of flame, the city of Hiroshima disappeared. On August 9, Nagasaki was hit.

In the face of such appalling weapons, it was impossible for even the die-hards in the Japanese government to justify further resistance. On August 15, the Emperor accepted the surrender terms. Over the blackened ruins of Japan, the calm summer skies held terror no longer.



EXPLORE

General Henry H. Arnold had to cope with the logistical needs of eleven American air forces, each of which pleaded desperately for more planes and men. “A letter from [General William O.] Butler in Alaska,” Arnold wrote later, “summed up the mail from all of them: ‘I need everything.’” To add to the strength of any one commander “probably meant taking it away from some other theater, from some of your own people.”

American air power made its European debut during the summer of 1942. On June 12, Colonel Harry Halverson led thirteen B-24s on a first daring, long-distance raid against the oil refineries at Ploesti, Rumania. Taking off from Egypt, 1,000 miles from the target, the bombers surprised the enemy. All the planes got safely away though one B-24 crash-landed later.

The first American mission from England took place, appropriately, on the Fourth of July. Six aircrews, flying A-20 Boston bombers borrowed from the RAF, joined six British crews on a low-level raid against air bases in Holland. The Germans were warned by radio from a picket ship off the Dutch coast, and two of the bombers flown by Americans were shot down. The bombardiers of two of the other planes were so confused by the camouflaged targets that they failed to drop their bombs at all.

More auspicious was a raid on August 17 against the railroad yards at Rouen. A dozen B-17 Flying Fortresses loaded at an English base with 300-pound bombs completed their mission without losses. In the fall, the North African invasion diverted planes and men and temporarily stalled the build-up of U.S. air strength in England. But as the 8th continued to stab at the enemy, American crews matched the courage and ability of veterans.

On one occasion, for instance, nine B-17s, turning back from a canceled mission against Rotterdam, were jumped by more than twenty German fighters. The Americans fought their way back to England, but in one bomber the pilot was injured and the copilot was killed. The bombardier, who had been washed out of flying school, took over the controls and flew the plane back home on two engines.

On a Wing and a Prayer

During 1943, the Allies increased their air attacks on key points in Hitler's Fortress Europe. In July, British bombers turned Hamburg into an inferno. Dropping strips of tin foil to confuse the German radar system, the RAF dumped tons of incendiary and high-explosive bombs on the city. When the ten days of sustained raids were over, 70,000 people were dead, and Hamburg as a city had almost ceased to exist.

The Luftwaffe, however, was still able to inflict punishing losses on bombers that attacked strategic targets farther inland, beyond the range of escorting fighters. Almost one-third of the B-24s that made a low-level raid on Ploesti in August were shot down. Sixty planes and their crews were lost on August 17 in raids against Schweinfurt and Regensburg, and in October, 148 bombers were lost in six days. The Combined Bomber Offensive was damaging Germany, but the cost was high.

Global Bases

In the Pacific and the Far East, Japanese confidence was still high in the late summer of 1942. In their conquered territories were ample supplies of oil, rubber, minerals, and food. Only with submarines and a few remotely-based aircraft could the Allies interfere with Japanese access to these supplies.

Moreover, aggression and expansion were still proceeding. China's lifeline, the Burma Road, was cut. The Zero was still the best fighter plane in the Pacific, and under its air-cover the campaign to isolate Australia was moving ahead.

Serious reversals began to occur in August. In New Guinea, the Allies commenced to push back the Japanese, and on Guadalcanal in the Solomons an invasion by Marines turned into the start of an American counterthrust. Once the tide turned, Japanese difficulties mounted, particularly in the air. New U.S. fighters held their own against the Zero and gradually won control of the skies. And on the ground, in a growing number of locations that began to form links in a chain around Japan, bases were built for the increasing units of Allied planes that were arriving in the Pacific.

With an industrial technology and know-how that paled Japanese efforts, American engineers and Sea-bees constructed the bases in record time. Men and equipment poured from ships just behind invading forces or were flown in by air to clear, grade, and level airstrips. Where the Japanese had used steam rollers and manual labor, American engineers and Seabees utilized heavy trucks, bulldozers, graders, and draglines to knock down jungles.

Even before fields were finished, fighters would fly in, heralding the large air forces that would soon turn them into important offensive bases.

South Pacific

On a captured Japanese airfield at Guadalcanal, American forces established the first Allied air base in the Solomons. Henderson Field was, depending on the weather, either a gummy mudhole or a dust bowl, and the pilots who served there experienced all the hardships and tensions of jungle combat that characterized the torturous climb up the Solomons.

Living amid insects and tropical downpours, they suffered from dysentery, malaria, and fungus. Adequate equipment was often lacking. And as the pilots took to the air, they did so with the knowledge that the enemy's fighters were faster and more numerous than their own.

But under the command of Marine Brigadier General Roy Geiger, they shot down scores of enemy planes. "[They] fought on day after day, while their friends were killed around them," Australian Commander Eric Feldt said later, and "it was their unabated aggressiveness, taking to the air at every alarm, that began the decline of the Japanese Air Force."

When long-range fighters finally became available, the American Air Forces set out in earnest to accomplish General "Hap" Arnold's directive: "This is a MUST . . . *Destroy the enemy Air Force wherever you find them, in the air, on the ground, and in the factories."* The slogan, "Victory Through Air Power," which Major Alexander de Seversky had used in marshaling public opinion in the United States behind a strategic air offensive in Europe, began to come true.

On January 11, 1944, 800 American bombers, escorted by Mustangs, struck three major German aircraft factories. On the same day, the Mustangs claimed over 155 German planes in the air. On March 6, the Allies dropped over a thousand tons of bombs on Berlin and shot down 176 Luftwaffe fighters.

American losses were sometimes also high, but the savage poundings disrupted German transportation and communication, shattered military and industrial targets, and seriously set back Nazi production.

After D-Day, the attacks mounted in intensity, and in time, the offensive - hitting Germany from all sides - destroyed Hitler’s war might.

The commander of the U.S. Strategic Air Forces in Europe was Lieutenant General Carl Spaatz. After D-Day, his bombers concentrated on destroying the Nazis’ fuel supplies. By September 1944, gasoline production in Germany had fallen to 25 percent of the normal output. And by January 1945, enemy airfields were crowded with planes without fuel to fly.

The top American ace in Europe was Major Francis S. Gabreski. A member of the 8th Air Force’s 56th Fighter Group, the P-47 pilot was credited with thirty-one victories in the air, plus three planes destroyed on the ground.

Death in the Sky

While bombers blasted German aircraft plants and fuel supplies, Allied pilots overwhelmed the Luftwaffe in the air. In February and March 1944, the Germans lost 800 day fighters in battle, and by D-Day, the Allies had full control of the air over Normandy. After that, the Luftwaffe died fast.

Those who fought the German pilots never questioned their courage or competence. By the end of the war, twenty-nine German aces were credited with over 100 victories each. Major Erich Hartmann claimed 352 kills although many were no doubt “probables.”

Each of the Allies had its own heroes and aces. Russia's top flier, Ivan Kozhedub, claimed sixty-two victories. Britain honored many men, including Douglas Bader, who led a fighter squadron brilliantly although he had two artificial legs. American aces included Robert S. Johnson, George Preddy, John C. Myer, David Schilling, John T. Godfrey, and Francis S. Gabreski.

Carrier War

In the sparkling waters of the South and Central Pacific, carrier task forces and their men and planes fought a continuing series of sea-air battles that steadily destroyed Japanese power.

On November 11, 1943, as U.S. Navy planes from the carriers *Essex, Bunker Hill,* and *Independence* prepared to launch the day's second strike against Rabaul, more than 120 Japanese aircraft swooped down on the American fleet. A wild, forty-six minute melee followed, during which more than forty enemy planes were destroyed, and not one of the American ships was damaged.

The successful defensive action typified the direction the Pacific war was taking. Confidently, Admiral Nimitz announced: "Henceforth, we propose to give the Jap no rest."

Up the Ladder

As the Americans captured island after island from the Japanese, they perfected the strategic coordination of air, naval, and land forces that became the familiar pattern of the war in the Pacific.

An example was the campaign that seized the Marshall Islands. For weeks before the amphibious landings, Army and Navy pilots, based on the recently-captured Gilberts, pounded the enemy airfields with bombing and strafing attacks. Then, late in January 1944, Task Force 58 moved up, and planes from its twelve carriers gained control of the air over the Marshalls.

On January 31, troops landed on Kwajalein Atoll and took it with the support of tactical air power and gunfire from the ships offshore. On February 17, landings began on Eniwetok, which had been pounded by American planes for three weeks. And from February 14 to Febuary 22, planes of Task Force 58 and the 7th Air Force struck at Japanese bases in the Marianas and the Carolines, preventing them from sending aid to the Marshalls. By the end of the month, secure possession of the most important points in the Marshalls had been attained.

Kamikazes

During the last ten months of the war in the Pacific, at least 5,000 Japanese airmen sacrificed their lives in attempts to save their homeland by diving their planes into Allied warships. They accounted for 50 percent of American vessels damaged throughout the entire war.

One officer, J. [Joseph] Bryan III of the *Yorktown,* described how he felt during an attack: ". . . you try to keep your terror under cover. . . . You jump aboard the first train of thought that runs through your mind, to escape your imagination's conjury - the blast, the crumpled bulkheads, the pinioned leg, and the flames . . ." Kamikazes, however, were the last gasp of a dying air force.

The *Franklin*

On March 19, 1945, as planes from Vice-Admiral Marc Mitscher's Task Force 58 pounded targets on the Japanese home island of Kyushu, a single-engine enemy airplane swept out of the clouds and dropped two 500-pound bombs on the carrier *Franklin*. The fires and explosions that followed killed 772 men, but the survivors, many of whom had been on the carrier when a kamikaze gouged a forty-foot hole in her deck in October 1944, fought to save the listing ship. An unsuccessful follow-up attack did no additional damage, and the Franklin limped back to America under her own steam.

The Defeat of Japan

Congested cities, their buildings made mostly of wood, became tinder-boxes on the home islands of Japan during the last months of the war. From March 1945, B-29s of the 21st Bomber Command rained tons of jelly-gasoline incendiary bombs on sixty-nine major Japanese cities, razing almost 180 square miles and bringing death to more than 250,000 of the Emperor’s subjects.

Then on August 6, as Allied forces prepared to invade Japan, a single bomb, equivalent in force to 20,000 tons of TNT, was dropped on Hiroshima. This first atomic bomb, which destroyed 60 percent of the city, brought a fiery death to 80,000 persons and injured an equal number. Three days later, a second and more powerful A-bomb fell on Nagasaki. Terrible as they were, these weapons ended the war, and spared both sides the casualties of a bloody invasion.

10

POSTWAR

The months following V-J Day saw a drastic and dangerous decline in the air power of the free world. Taught by centuries of experience that global responsibilities outlast wars, the British were carefully slow in releasing their military aircrews. But the Americans, convinced that their monopoly of the atomic bomb gave them all the security they needed, joyfully began beating their swords into new automobiles and their spears into television sets.

As a result, American air strength simply melted away. So rapid was the demobilization that equipment worth millions of dollars rusted into junk overseas for lack of trained personnel to care for it. On V-J Day, the U.S. Army Air Forces had 2.25 million men. By the end of the year, fewer than 900,000 remained, and by the spring of 1947, the air force of the most powerful nation on earth had shrunk to a fraction over 300,000 men, of whom only 25,000 were flying personnel.

Since V-J Day, meanwhile, sentiment in the United States had been building for the creation of a unified national military establishment, with Army, Navy, and Air Force departments under a Secretary of Defense. Within this framework, the older services could at last agree to make absolute the independence of the Air Force, which, under the stress of conflict, had achieved actual if not statutory autonomy. These changes went into effect in September 1947 after passage of the National Security Act. In the new setup, James Forrestal became the first Secretary of Defense; Stuart Symington, Secretary of the Air Force; and General Carl Spaatz, the first Chief of Staff, United States Air Force.

“Unification,” as the reorganization was somewhat euphemistically called, was not a victory for Billy Mitchell’s concept of a single, unified national air force. As a matter of fact, each service - Army, Navy, Marine Corps, and Air Force - was now to a greater or lesser degree organized around air power and had its own air component. However, for all the compromises, there was little doubt that the Air Force had emerged as the dominant military service, and that air power had been confirmed as the nation's first line of defense.

Starved for consumer goods, the American people at the same time had been clamoring happily for more of everything - including air travel. The public no longer feared or distrusted flying. Some 13,000 DC-3s had been built; they seemed as reliable as rocking chairs. More than 1,100 DC-4s had come off the assembly lines. By the end of the war, the big four-engine Douglas transports, aided by a military version of the graceful Lockheed Constellation, were carrying 44 percent of all military air cargoes, daily spanning the Atlantic as casually as if it were a lake. At the end of hostilities, many of these airplanes became available for civilian use at a fraction of cost. With them, and with huge and newer cargo-carrying Curtiss C-46 Commandos, independent airlines like Slick, Riddle, Resort, and the Flying Tigers sprang up to help meet the demand for freight and passenger service. "Non-skeds" they were called, since often they adhered to no fixed schedules.

Fierce competition among American airplane builders, plus years of experience, made the postwar piston-engine American transport the most successful passenger-carrying aircraft in the world. While the major airlines raced to see which could be the first with nonstop transcontinental service, excellent short-haul aircraft like the Martin 404 and the Convair CV-240 appeared. In 1948, in an effort to attract still more customers, the major airlines offered reduced "air-coach" fares. By 1957, these "tourist" flights were accounting for almost 40 percent of all domestic passenger traffic and 65 percent of international traffic.

Meanwhile, the British were not idle. English engineers had become increasingly interested in the turboprop airplane, a compromise between the piston engine and the pure jet, that seemed to offer the best combination of speed and economy for the short-haul type of air traffic that prevailed in Europe. As a result, Britain was the first to build such an engine, the Rolls-Royce Trent, which was first tested in a Gloster Meteor in September 1945. Three years later, the British flew the first turboprop airplane in history, the Vickers V-630 Viscount.

The year after the war, the United States' armed services staged some dramatic flights that helped remind the public that military aircraft were still around - and still capable of great things. In October 1946, the *Truculent Turtle*, a twin-engine landplane designed by Lockheed and the Navy, flew nonstop and without refueling from Perth, Australia, to Columbus, Ohio - a distance record of 11,236 miles that remained unbroken for fifteen years (until January 1962 when an Air Force B-52H flew 12,519 miles, from Okinawa to Spain). Soon afterward, the Air Force sent a B-29 on a 9,500-mile flight from Hawaii to Cairo, Egypt, by way of the North Pole.

By this time, the spectacular B-36 was in the air. Ordered in 1941 as an intercontinental bomber that could strike Berlin from American bases in case of Hitler's conquering England, the huge plane weighed more than six times as much as a B-17 and was powered initially by six pusher propellers driven by conventional reciprocating engines. It could carry a 10,000-pound bomb load 10,000 miles.

Already it was obvious that such piston-driven monsters were headed for extinction; compared to the onrushing jets, they were cumbersome and slow. In the growing tensions between the East and West, the B-36 was a necessary interim aircraft and a deterrent to potential war-makers.

In fighter planes, the changeover from piston engines to jets was already well advanced. German and British pioneering in this direction had led to substantial progress during the war, but America was not far behind. The first jet airplane to fly in the United States was the experimental Bell XP-59A Airacomet. Powered by two General Electric turbojets based on a British model designed in the 1930s by Frank J. Whittle, it was rushed to completion in 1942. It was never put into production; its speed was too slow for a jet, and its range was too limited. But it was an important test vehicle and was followed by the faster Lockheed P-80, the Air Force's first operational jet fighter that was in the air by January 1944 - though it saw no combat until the Korean conflict.

In 1944, the Bell Aircraft Corporation had also been working on an experimental rocket plane to be known as the X-1. Douglas, too, had been developing a jet single-seater, the D-558 that was later to be powered with rocket engines and called the Skyrocket. Both these planes were designed to break through what had been considered a serious technological obstacle to aviation progress: the sound barrier. Early attempts to achieve supersonic flight were extremely hazardous. In Great Britain, Geoffrey de Havilland, son of the designer, carried out assaults on the invisible barrier with great courage and determination. On September 27, 1946, his swept-wing DH.108 disintegrated at or near the speed of sound, and he was instantly killed.

Just over a year later, on October 14, 1947, a twenty-five-year-old American combat veteran named Charles “Chuck” Yeager climbed into the tiny, needle-nosed Bell X-1 whose four rocket motors could gulp their entire fuel supply in two and a half minutes. Carried aloft by a B-29 and air-launched over Muroc Dry Lake in California, the X-1 zoomed above 37,000 feet and flashed through the critical transonic area to a speed of a little over Mach 1, the speed of sound. In September 1948, using a later version of the plane in which young de Havilland had met his death, the British also broke the sound barrier.

Unfortunately, however, in this postwar period, peaceful scientific research was not the prevailing urge throughout the world. In the summer of 1948, the Soviets moved to test the morale and unity of the Western Allies. With Berlin isolated deep in the Russian zone of occupied Germany, the Soviets imposed increasingly severe restrictions on the land routes used by the Western powers to supply their sectors of the city. By June 22, all surface traffic had been halted.

But the Allies had been guaranteed the use of three air corridors, each twenty miles wide, leading from West Germany to Berlin. Faced with the choice of abandoning the 2 million Berliners in their sectors of the city or attempting the task of supplying them by air, the British and Americans did not hesitate.

The Berlin airlift was a brilliant demonstration of technical competence and international and inter-service cooperation. American Navy tankers brought huge supplies of aviation fuel to Bremerhaven. Navy cargo planes joined the Air Force C-54s in round-the-clock flights to Berlin. The Army’s Transportation Corps trucked cargo to the planes. British air tankers took over responsibility for hauling all petroleum products to the beleaguered city. German civilians worked furiously to extend and maintain runways.

By January 1949, the airlift was providing enough food to permit the individual Berliner's food ration to be raised from 1,600 to 1,880 calories daily. As spring came and the weather improved, so did efficiency. On a single day in mid-April, in an effort that became known as the "Easter Parade," a total of 1,398 flights brought a record-breaking 12,940 tons into the city. Watching glumly, the Russians evidently decided that the airlift had become a Cold War victory for the Allies. The next month they ended the blockade.

Balked at Berlin, international communism looked for a more promising pressure area and found one in Korea. That country had been divided ever since the Soviet Union had occupied the northern portion to receive the surrender of Japanese troops in 1945. Beyond the strategic defense perimeter of the United States, South Korea was a tempting target for aggression. On June 25, 1950, backed by a small Soviet-equipped and Soviet-trained air force, Communist North Korean troops crossed the 38th Parallel.

American air power was almost immediately engaged. On June 27, flying from bases in Japan with orders to protect the evacuation of American citizens, long-range Twin-Mustang F-82 fighters intercepted a flight of five YAKs and shot down three of them. That same day, half a world away in New York, the Security Council of the United Nations approved a resolution urging members to "furnish such assistance to the Republic of Korea as may be necessary to repel the armed attack and to restore international peace and security in the area."

This made the defense of South Korea an international responsibility, and some of the members of the United Nations did "furnish assistance." Essentially, the struggle that followed was a clash between the forces of international communism and the United States. By June 29, American B-26s and B-29s were in action, plus a handful of F-80 jet fighters. By July, American carrier planes - Grumman F9F Panther jets and Douglas AD Skyraiders - were hammering enemy supply lines, and the USS *Boxer* was setting a transpacific speed record carrying a load of 145 Mustang fighters and other planes.

At first, such antiquated warplanes seemed adequate. The North Korean air force was virtually destroyed, and their ground forces driven back toward the Yalu River, which marked the Manchurian border. On November 1, six Russian-built MIG-15 jet fighters attacked a flight of Mustangs just below the Yalu. One week later, the first all-jet air battle in history took place between the MIGs and F-80s The Shooting Stars had difficulties against the newer swept-wing Russian fighters, but they destroyed one of the MIGs. The United Nations ground force advance and the unification of a free Korea were more than the Chinese Reds could tolerate. On November 26, they crossed the Yalu in force and confronted the United Nations with an entirely new war.

It was imperative that the American Far East Air Forces hold the initiative in the skies if the U.N. ground troops were not to be overwhelmed. Fighter-bombers gave close support, and airdrops of vital supplies helped the encircled Marines fight their way back from the Changjin Reservoir. In mid-December, the first F-86A Sabres arrived in Korea. Though they were a great improvement over the F-80s, they were still inferior in performance to the MIGs. But American pilots flying them proved to be more skilled and aggressive than their adversaries, and the Sabres made an effective record.

Both sides were hampered by political considerations that limited military operations. The United Nations forces could not bomb enemy supply bases in Manchuria without the risk of touching off another world war. The Reds could not fly combat missions from Manchuria without inviting reprisal; they had to stage their aircraft into North Korean airfields that were pounded constantly by U.N. bombers. Their efforts to keep these airfields operational were so unsuccessful that their ground offensive bogged down for lack of air support. In June 1951, the Soviet delegate to the United Nations suggested that ceasefire discussions begin.

They did begin, but the fighting went on for another two years. In the summer of 1952, American air commanders tried to break the stalemate by bombing North Korean power stations, including the great generating plant at Suiho on the Yalu River that was supplying electricity to war plants in Manchuria. Intelligence reports indicated that the Suiho strikes cost northeast China 23 percent of its power requirements.

Limited though it was geographically, the Korean struggle was a full-scale war. Red China’s twenty-two air divisions included some 1,800 aircraft and at least 1,000 jets. These were held at bay by improved F-86F Sabres that in the later months of the war established an overwhelming superiority in combat with the MIGs. In May 1953, Sabre pilots claimed fifty-six MIGs destroyed. Only one Sabre was lost, and the pilot was rescued. In June, seventy-five MIGs were claimed, and the Sabres had no losses at all.

In the spring of 1953, fighter-bombers of the 5th Air Force carried out a pair of attacks that may well have been decisive in bringing an end to the sullen war. The rice economy of North Korea depended on controlled irrigation from reservoirs that stored water for the rice-growing seasons. On May 13, fifty-nine F-84 Thunderjets attacked and damaged the massive irrigation dam at Toksan. That night, the waters broke through in a devastating flood, wiping out rail lines and highways. Three days later, ninety F-84s broke the dam at Chasan, dropping bombs into the reservoir and using the water itself to transmit the blast effect. Again there was a disastrous flood. Under such pressure, the Red negotiators at Panmunjom modified some of their previous unyielding attitudes, notably their demand that all prisoners of war be repatriated regardless of their wishes. At last, on July 27, an armistice was signed.

Neither side could claim total victory, but the United Nations' two main objectives were achieved: Naked aggression was halted, and South Korea's independence secured. For such limited success, air power could claim a large share of the credit. The Communists claimed repeatedly that if they had had the kind of air support on which the U.N. forces had relied, they would have driven their foe into the sea.

While the air battles had raged over "MIG Alley" in Korea, commercial aviation had put the first jet transport into operation. This was Britain's de Havilland Comet that appeared in 1952 on BOAC routes to South Africa, Ceylon, and the Far East. Some felt the plane had been rushed into service, but for the next two years the graceful Comets were queens of the skies. Then, in 1954, disaster struck.

On January 10, taking off from Rome in good weather and climbing to its flight-plan altitude of 36,500 feet, a Comet suddenly and inexplicably disintegrated, carrying thirty-five people to their deaths in the sea near Elba. No distress signal was heard. The pilot of the Comet was making a normal radio report; his voice ceased abruptly in mid-sentence. All Comets were grounded and subjected to rigorous inspection. Then, on April 8, the same thing happened to another Comet over the Mediterranean. Again, there was no warning - just instantaneous failure of a magnificent and proven airplane.

The Comet crashes shook the aviation world. But the whole history of aviation is the story of man's ability to recover - and learn - from disaster. The Comet accidents spurred the British to one of the most remarkable pieces of aerial detective work ever accomplished.

Groping in 400 to 600 feet of water with giant grabs and underwater television, salvage vessels recovered fragments of the airliner that had fallen near Elba. Meanwhile, back in England, three Comets were turned over to government engineers to serve as guinea pigs for exhaustive tests.

Two of the planes were flight-tested in every conceivable way. The fuselage of the third was encased in a huge tank containing 200,000 gallons of water. Every five minutes, by flexing the wings with hydraulic jacks and by raising and lowering water pressures inside the submerged cabin, engineers were able to reproduce stresses equivalent to a normal three-hour flight. Finally, after "flying" the equivalent of 9,000 hours in its watery tomb, the metal skin of the pressure cabin split open. Microscopic examination indicated that the cause of failure was metal fatigue, which occurred much earlier than any computation had indicated. Later, the critical piece of wreckage was recovered from the sea, revealing the same type of failure. The results of the investigation were made public in a candid and forthright report. Steps were taken to eliminate the weakness. Aviation moved on.

By now, it was moving at dizzying speed. Throughout the 1950s, experimental aircraft driven by increasingly powerful rocket engines leaped to one record after another. At the same time, supersonic military aircraft were becoming standard equipment, with designers in Britain, France, the U.S.S.R., and other countries advancing along parallel lines. With the lessons of the Korean War still fresh in mind, Americans scored the most firsts. In 1953, the Air Force put into production the Pratt & Whitney J-57 turbojet engine, whose thrust of some 10,000 pounds made Frank J. Whittle's original jet design seem almost like a toy. The first operational fighter to achieve supersonic speeds in level flight was the North American F-100 Super Sabre that set a world's speed record of 822 miles per hour in August 1955. The "Century" series of supersonic fighters continued with the twin-jet McDonnell F-101 Voodoo; the Convair F-102 Delta Dagger; the Lockheed F-104 Starfighter, capable of flying supersonic straight up; the Republic F-105 Thunderchief, a radar-equipped fighter-bomber designed to carry nuclear as well as high-explosive bombs; and the Convair F-106 Delta Dart. For the Navy, a Vought F8U-1 Crusader carrying full combat equipment won the Thompson Trophy in August 1956, with a speed of 1,015 miles per hour - an extraordinary performance for a plane capable of landing on an aircraft carrier.

One of the most significant aerodynamic discoveries of this period came from the laboratories of the National Advisory Committee for Aeronautics. Experimenting with transonic wind tunnels, NACA engineers found that air resistance could be significantly reduced by lengthening the nose of a supersonic aircraft and indenting the fuselage to give it a "wasp-waist," or "Coke-bottle" shape. Discovered and verified in 1952 by Richard T. Whitcomb, the "area-rule" concept was followed in the design of such fighter planes as the Navy's Grumman F11F-1 Tiger and the Air Force's F-

102. It was also incorporated into the world's first supersonic bomber, the Convair B-58 Hustler that first flew in November 1956.

While piloted aircraft were driving toward the outer limits of mechanical tolerance and human endurance, the descendants of the old German vengeance weapons were following an inexorable evolution of their own. In the United States, the Air Force developed the Martin Matador, and the Navy experimented with the Vought Regulus. These were subsonic, pilotless aircraft, carrying a warhead and driven by a turbojet engine after a rocket-assisted takeoff. The Air Force also worked on two long-range pilotless bombers, Northrop's SM-62 Snark and North American's SM-64 Navajo. Compared to the buzz bombs of World War II, the Snark had tremendous range: Its J-57 jet engine could keep it in the air for 4,000 or 5,000 miles. But its subsonic speed made it vulnerable to enemy countermeasures. Even the Navajo, which was designed to be faster, finally had to be canceled after more than $750 million had been spent on it - though it contributed considerable knowledge to future developments in guidance, rocketry, and aerodynamic configuration.

Another air-breathing, air-supported weapon was Boeing's IM-99 Bomarc, a pilotless winged missile designed to rise from the ground, seek out, and destroy incoming enemy aircraft. Launched by rocket power, the Bomarc was equipped with two ramjet engines that enabled it to climb to high altitudes at speeds up to Mach 2.5 and made it a threat to any conventional bomber.

But now the winged, manned aircraft itself was facing competition in the development of fearsome descendants of the V-2. At new and expanded research centers, manufacturing plants, and test sites in New Mexico, California, Alabama, Florida, and elsewhere, work progressed on both intermediate-range and intercontinental ballistic missiles. In September 1956, a U.S. Army rocket team headed by former German V-2 experts, including Wernher von Braun, fired a Redstone rocket with solid-fuel upper stages 3,000 miles down the Caribbean range from the missile test site at Cape Canaveral, Florida. This rocket carried a dummy fourth stage. If propellant instead of sand had been loaded aboard, the fourth stage could have been sent into orbit around the earth.

Thirteen months later, achieving the necessary escape velocity of some 18,000 miles per hour, the Russians hurled the first man-made satellite into space. The Russian *Sputnik,* a highlight of world-wide scientific activity in connection with the International Geophysical Year, aroused the American public's support for an accelerated program in the United States that would ensure an adequate supply of intercontinental ballistic missiles, as well as boosters that would put America ahead of Russia in the exploration of space.

Research and development were quickened in both fields, and in the fall of 1959, the Air Force added the first Convair Atlas ICBMs to its operational defenses. At the same time, work progressed on newer missiles and on the more powerful Saturn booster. The latter would be particularly important to the space program that was also taking large strides forward.

Despite Soviet firsts in orbiting the world, both with unmanned and manned vehicles (Yuri Gagarin circled the earth three times on April 12, 1961, and four months later Gherman Titov achieved seventeen orbits), the U. S. National Aeronautics and Space Administration's civilian-run Mercury Project, using Atlas carriers, thrilled the American people in February and May 1962. With full publicity so that no one could doubt their achievements, Lieutenant Colonel John H. Glenn, Jr., and Lieutenant Commander Scott Carpenter each orbited the earth three times.

The successes in outer space marked the dawn of a new era in the story of man's conquest of flight. Space medicine, metallurgy, physics, and a host of scientific fields faced a future of expanding horizons. Programs designed to orbit and probe the moon, establish space stations, and reach distant planets demanded more powerful boosters, complex satellite systems, and space vehicles capable of carrying crews that could navigate at will through space and in and out of the earth's atmosphere.

The spectacular rise of the long-range rocket and the first successes in space provided a new assessment, also, of the piloted aircraft as a military weapon. Ever since the formation of the United States Strategic Air Command in March 1946, the chief defense of the free world had been the retaliatory threat of its manned long-range bombers. Over the years, it had been built up into a magnificent force – by being disciplined, dedicated, and polished to split-second combat readiness.

In 1951, SAC began receiving its first B-47s, six-engine, jet-propelled medium bombers with swept-back wings and tail surfaces. Carrying a crew of only three men, the B-47 became for a time the workhorse of SAC; more than 1,300 were built by Boeing before production was discontinued. By August 1954, the production model of the B-52 was ready. These huge eight-engine jets cost $8 million apiece - as compared with an average cost of $315,000 for the old B-29 - but they could fly at speeds of more than 600 miles per hour and carry a formidable variety of weapons, including air-launched missiles. In 1956, the supersonic, delta-winged

B-58 medium bomber took to the air, and on March 6, 1962, dramatized its astounding capability when one of them flew round-trip from Los Angeles to New York in four hours and forty-two minutes, beating the sun, as it were, by covering the New York-Los Angeles leg in two hours, fifteen minutes, and twelve seconds.

To some fliers, the work with rockets and missiles had originally seemed to foretell a military "pushbutton" future, when manned aircraft - both the SAC bomber and the fighter plane - would be obsolete. Early warning radar lines, like the Air Force's Ballistic Missile Early Warning System (BMEWS), combined with retaliatory ICBMs carrying nuclear warheads and ground-launched antimissile defense missiles, seemed to preclude the usefulness of the military aviator. But it soon became apparent that strategic bombers would be needed for some time to complement ICBMs, and that an antimissile missile was still far in the future. Moreover, if manned military craft were approaching an end of usefulness within the atmosphere, they were just beginning a new chapter in the rarefied higher altitudes and in space.

The transition was vividly dramatized by the X-15, North American's experimental high-altitude plane. In 1959, the X-15 made its first free flight, released from under the wing of a B-52. By June 1962, this man-made needle with a volcano in its tail had reached an altitude of 250,000 feet. In November 1961, with air friction heating its skin to 1,100 degrees, it had exceeded its design speed of Mach 6, reaching Mach 6.04, or 4,093 miles per hour. And there was still plenty of "stretch" in it; engineers predicted that it would ultimately fly faster than Mach 7 and reach a height of 500,000 feet, almost 100 miles above the earth - or the area of satellites and orbiting space vehicles. Ultimately, the X-15 reached a peak altitude of 353,760 feet, or sixty-seven miles above the earth, on August 22, 1963. Its fastest manned flight, by U.S. Air Force test pilot William J. Knight on October 3, 1967, reached speeds of 4,519 miles per hour, or Mach 6.72 – a record that still held as of 2015.

At the same time, other aircraft showed the outlines of a future in which fighting men would continue to fly. The Air Force's RS-70 (originally the B-70) was planned to be a Mach 3 reconnaissance-strike bomber, able to cruise at more than thirty miles per minute - faster than the muzzle velocity of a rifle bullet. Weighing half a million pounds, this stainless steel and titanium monster would fly at almost 80,000 feet. It would be driven by six General Electric J-93 engines delivering 180,000 pounds of thrust. At Mach 3, the aerodynamic heating level would be around 550 degrees, yet inside the bomber the four-man crew would work in a shirtsleeve environment without having to wear pressure suits. Three prototypes were being built. The cost was something over $1 billion.

In the early 1960s, the United States Air Force moved also toward a total vault into space with another craft. Under the project name of the X-20, it planned an outer-space manned vehicle; here a giant multistage Titan III rocket would be used to boost a space glider that would reach speeds of Mach 25, or 17,500 to 18,000 miles per hour. The X-20 would represent a marriage of the ballistic missile and the winged aircraft and would be America's first truly maneuverable spacecraft.

Despite such attention to defense matters, progress in flight during the late 1950s was not limited to military and space activity. The first jet transport to fly in the United States was the Boeing 707, which made its initial test flight on July 15, 1954. In 1958, it was carrying passengers in almost vibrationless comfort at speeds of close to 600 miles per hour and at altitudes above 30,000 feet. The next year, it was joined by the Douglas DC-8, with similar performance. In Europe, by this time, the Russians had an all-jet transport in service, the Tu-104; the British had introduced their improved Comet 4; and the French had designed a twin-engine jet, the Caravelle, with the engine pods attached to the fuselage just in front of the tail surfaces - an innovation that reduced cabin noise and made possible an efficient, unencumbered wing. Such aircraft were a delight for the air traveler, despite high initial costs.

As aviation approached the sixtieth anniversary of powered flight, the scope and variety of air activities seemed almost limitless.

Less than the span of a person’s lifetime separated the epochal John Glenn’s orbiting of the earth and that day on the North Carolina shore when the Wrights, braving a freezing headwind, lifted the first airplane into the air for the first immortal flight. That realization makes almost anything seem possible.

EXPLORE

For generations, aviators and engineers been interested in the possibility of designing aircraft based on the principle of Sir Isaac Newton's Third Law of Motion (to every action there is opposed an equal reaction). In 1930, a first important step in this direction was achieved when a British patent was granted to Frank Whittle, a twenty-three-year-old RAF officer. His design called for a jet engine in which air, drawn in at the front, was mixed with fuel, ignited, and ejected from the rear in a violent reaction that propelled the airplane forward.

While Whittle worked to perfect his design, a German, Dr. Hans von Ohain, labored along parallel lines and developed an engine that powered the world's first jet plane. By 1942, the first jet combat plane, the Messerschmitt Me-262, appeared in Germany and was rushed into production. Although it was designed as a fighter, had no bombsight, and possessed too short a combat range to be effective, it went into service late in 1944 as a bomber.

Meanwhile, Britain's second jet, the Gloster Meteor, also appeared in combat; and a Whittle engine sent to the United States in 1941 served as the prototype for the power plant that boosted America's first jet, the XP-59A, into the air in 1942.

Jet craft appeared too late to affect the outcome of World War II. But in the postwar years, the new planes soon proved their superiority over conventional aircraft in speed, power, economy of fuel utilization, and simplicity of design.

The first jet plane, the Heinkel He-178, powered, by Hans von Ohain's centrifugal-flow turbojet engine, flew on August 27, 1939, at Rostock, Germany.

Frank Whittle tested a jet engine on the ground in 1937. On May 15, 1941, he had his initial success in the air with England's first jet, the Gloster E-28/39.

The Lockheed P-80, an American jet fighter first tested in 1944 with a power plant derived from a British de Havilland jet, later became the F-80 Shooting Star used in the Korean War.

Berlin Airlift

To the Communist world, the Berlin airlift of 1948-49 was a stunning setback. It was also a testament to heroic pilots and to the energies and initiative of the free nations of the West.

American and British cargo-carrying planes reached Berlin at intervals of three minutes, day and night. Pilots had one chance to land; if they missed, they left the area to avoid stacking. Unloading time was cut to forty-nine minutes per plane - enough pause for a cup of coffee before crews took off again. In the first six weeks, some pilots averaged as little as four hours of sleep per day.

Despite the huge traffic, expert planning by the Military Air Transport Service and other units kept accidents low. In fifteen months, there was only one mid-air collision.

The Korean War

In the first phase of the conflict in Korea, American air power quickly proved the lesson learned in World War II. A month after hostilities began, Lieutenant General George Stratemeyer, commander of the U.S. Far East Air Forces, commenced a systematic disruption of North Korean supply lines and the destruction of the Communists' sources of supply. Within two months, he announced that his bombers had knocked out “practically all of the major military industrial targets strategically important to the enemy.”

But the war was not ended. With one foe disposed of, a new one appeared. In November 1950, Chinese Communists entered action from a sanctuary that could not be attacked. Air Force, Navy, and Marine planes battled Russian-built MIG jets over the Korean peninsula; and with F-84 Thunderjets and F-86 Sabres as escorts, B-29 Superfortresses pounded strategic targets in North Korea and in the area of the Yalu River border. But the principal fountainheads of the Communists’ strength were protected, and the war dragged on, illustrating again - though this time by an inability to carry it out - the lesson of World War II.

Nevertheless, Americans controlled the air over the battlefields. “Without the support . . . of your air and naval forces,” said North Korean General Nam Il at the truce negotiations, “your ground forces would have long ago been driven out of the Korean peninsula.”

Supersonic Flight

In World War II, combat pilots making power dives approaching the speed of sound had found their controls freezing up and their planes being shaken by severe buffeting. The problem arose, basically, from the compressibility of air. When a plane flies through the air at the speed of sound (approximately 760 miles per hour at sea level and about 650 miles per hour above 35,000 feet), the air particles ahead do not have time to change their position and follow the shape of the oncoming wings or fuselage. Instead, they are compressed into a shock wave, or wall of “thick” air. Jet engines at first did not have enough power to push through this wall, and the problem of penetrating the sound barrier gave postwar aviation a dramatic challenge.

When planes began probing the sound barrier, engineers began measuring their speed in Mach numbers (named for Dr. Ernst Mach, an Austrian physicist who had experimented with supersonics). Under this system, Mach 1 equals the speed of sound at a given altitude, and Mach 2 is twice as fast. Speeds between Mach 1 and Mach 5 arc known as supersonic, and above Mach 5, hypersonic.

Charles Yeager's first supersonic flight (slightly above Mach 1) on October 14, 1947, in the Bell X-1 was followed by a string of further test flights in a variety of experimental craft. In August 1951, William Bridgeman flew a Navy Douglas D-558-II Skyrocket at Mach 1.89, and in December 1953, Yeager took a Bell X-1A to Mach 2.5 - 1,650 miles per hour. Almost three years later, after tests by Major Frank Everest and Captain Iven Kincheloe, a new plane, the X-2, also made by Bell, was flown at Mach 3.2 by Captain Milburn G. Apt, who was killed when the craft went out of control.

Other planes, flown by service and civilian pilots, pushed both speed and altitude records steadily higher; and by June 1962, test flights of the North American X-15 rocket plane had taken the heat-resistant craft to an altitude of 250,000 feet - about 47 miles - and a speed of Mach 6.04 - 4,093 miles per hour.

Years of Cold War

The peril to the free world, continuing after Korea, was clear for all to see: In a surprise attack, long-range bombers carrying thermonuclear weapons, could rapidly destroy a nation's ability to resist. Determined that there would never again be a Pearl Harbor, the American people looked to the Strategic Air Command to create an aerial force in readiness whose rapid and massive retaliatory striking power would deter the plans of a potential aggressor.

Under General Curtis LeMay, SAC flung a network of airfields in friendly countries around the world, berthing them with Convair B-36s.

The giant six-engine bomber, the biggest ever built, carried nuclear bombs and could reach any target on earth. Jet speed was added to SAC's deterrent force by the B-47 medium bomber, and in time, the B-36 was replaced by the faster and more versatile B-52 jet global bomber.

Fighters and Airlifts

On May 13, 1957, a unit of F-100 Super Sabres flew nonstop from London to Los Angeles, more than 6,700 miles, dramatizing the worldwide mobility of the U.S. Air Force's Tactical Air Command.

Rounding out an air power "second to none," urged by General Hoyt S. Vandenberg in 1953, TAC's family of supersonic fighters, reconnaissance aircraft, and mobile troop carriers and cargo planes was both a combat command and a supporting force. Air strike and airlift forces could move quickly to any "brushfire" war or trouble spot from Lebanon to Thailand. In support of NATO and tactical air units in Europe and the Pacific, TAG also provided fighter and troop-carrier squadrons.

Pioneer long-distance flights by jet fighters, troop-carrier maneuvers, intercontinental airlifts, and in-flight refueling all helped TAC develop its capabilities during the 1950s. By 1962, in a demonstration of their ability to cope with localized "hot spots," TAG personnel were training South Vietnamese in counter-guerilla air operations.

The New Navy

In an age when control of the sea meant control of the air above it, a progressive U.S. Navy experimented rapidly with new craft and new concepts. To deliver attack wherever necessary, carriers with angled decks and nuclear power were planned to provide far-ranging bases for fast, versatile planes.

In the Korean War and thereafter as guardians of peace in the Cold War, catapult-equipped carriers berthed planes like A3D Skywarriors (with a 3,000-mile range); A3J Vigilantes (with a Mach 2 speed); F3H-2 missile-launching Demons; and F8U supersonic Crusaders.

At the same time, the Navy added Polaris-firing, nuclear-powered submarines and furthered research in a variety of fields, including rocketry and high-altitude flights.

Hovering Craft

The meteoric development in the design and use of helicopters during the years since the start of World War II was due principally to the drive and vision of a single man, Igor Sikorsky.

In 1939, the Russian-born American, already famous for his giant living boats, designed and built the VS-300, the prototype of the modern helicopter. Fully operational by 1941, Sikorsky's machine had a single main lifting rotor, as well as a small vertical one at the tail to offset twisting effect and supply directional control - a combination used in 90 percent of current models. Three subsequent Sikorsky types were hurried into production, and more than 400 of them saw service in World War II. In postwar years, other builders, including Bell, Piasecki, Hiller, and Kaman, entered the field to compete with Sikorsky. In 1946, the two-seater Bell 47 became the first helicopter certified for commercial use. By 1956, large U.S. and European companies were operating big passenger-carrying helicopters between cities and outlying airports.

After the dramatic demonstration of the helicopter's military potential in Korea, Sikorsky developed the S-56, able to carry thirty-six fully-armed Marines, and the S-58, an effective craft for antisubmarine patrol.

"Flying bananas," "bubble-tops," and all shapes and sizes of what are familiarly tailed "whirlybirds" and "choppers" began to fill the air. Whether transferring a V.I.P. from an airport to the White House lawn, rescuing flood victims in Japan, exploring inaccessible canyons, opening up jungle wilds, or retrieving missile cones at sea, the helicopter has lived up to its boosters' claims that in time there would be almost no limit to the services it could perform in the air.

Travel by Air

Military transport aviation had familiarized air travel to thousands of servicemen and civilian officials during World War II, and in the postwar years international and domestic air transport boomed. Airports in America and overseas expanded and expanded again to handle passenger, freight, and mail business.

By 1961, the U.S. industry alone, with 49.6 percent of international traffic, had an annual payroll of over a billion dollars. There were fifty-six certified American lines, carrying more than 58 million passengers and some 885 million ton-miles of freight per year.

Jets, which made air travel even more attractive, heightened the problem of airspace. And still, in 1962, two-thirds of the American people had yet to make their first flight.

The Ramparts We Watch

On May 1, 1960, a high-flying Lockheed U-2 was downed in Russia while flying a reconnaissance mission for the U.S. Central Intelligence Agency. The episode again dramatized the use of the air as an arena for major moves in the Cold War.

But an aerial camera that could photograph large parts of Soviet territory with piercing sharpness from a plane flying in the neighborhood of supersonic speed at 60,000-feet altitude also symbolized the state that aviation had reached. Almost every branch of science contributed to opening new vistas for flight that the Montgolfiers and Wrights could not have imagined.

Defense necessities gave a military coloration to most of aviation's more startling advances. The triumph of a John Glenn, orbiting the earth, was part of the civilian Mercury Project, undertaken by the National Aeronautics and Space Administration. But as it launched America toward a new frontier of flight, it served also to remind the free world that all theaters of the heavens are still ramparts to guard.

The defenses of those ramparts are an increasingly complicated skein of supersonic bombers, missiles with nuclear warheads, radar warning lines, and sophisticated computer systems.

Someday, military use of the air may become unnecessary. Until then, however, men on peaceful missions must fly in the shadow of air forces and in regions dominated by missiles.

11

THE MODERN ERA

Space travel was not the only frontier in flight in the second half of the twentieth century. In 1969 - the same year American astronauts Neil Armstrong and Buzz Aldrin became the first men to set foot on the moon – the first "jumbo jet," capable of transporting more than 500 passengers, took off.

The Boeing-747 more than doubled the passenger capacity of its predecessor, the 707, and transformed air travel in the twentieth century. Featuring two levels of seating – with first-class accessible by a spiral staircase - the 747 was distinctive for both its look and comfort.

Air travel in the early 1960s was considered glamorous – a commodity of the rich and famous. As more people clamored for commercial flights, economy and business classes were added to make air travel more affordable as congested airports struggled to meet the demand. In 1965, Pan American World Airways (Pan Am) President Juan Trippe pressed Boeing President William Allen for a solution. The design of the 747 was assigned to forty-four-year-old engineer Joe Sutter.

The 747 was considered a temporary fix – a stopgap until supersonic aircraft took over passenger transport. Since the 1950s, engineers had been working to design a passenger plane that could travel faster than the speed of sound; an airliner that fast would not have to be as big as the 747 to carry as many passengers. In 1965, with aerospace companies on the verge of producing a supersonic passenger plane, the 747 was in danger of becoming obsolete before it got off the ground.

Sutter's design team at Boeing was challenged to build a plane that could be adapted to carry freight when the passenger model declined. The body, or fuselage, of the 747 was designed large enough to hold as many as twelve standard shipping containers (eight feet high and twenty feet long), stacked in pairs. The “hump” at the front of the plane – where the upper deck seated first-class passengers – functioned as a portal to load cargo through the 747’s nose.

To build its biggest plane, Boeing constructed the largest building in the world. The Everett Factory, about thirty miles north of Seattle, is more than 472 million cubic feet and sits on nearly 100 acres. In April 1966, Pan Am contracted with Boeing for twenty-five 747s, at a cost of $525 million. Boeing agreed to deliver the first 747 to Pan Am by the end of 1969, allowing twenty-eight months to complete it – about two-thirds of the typical design time. By late 1967, the project employed more than 4,500 people – including 2,700 engineers. Because of the fast-paced schedule, these people were nicknamed “The Incredibles.”

Boeing was spending an estimated $5 million a day to build the 747, and to finish, the company would sink more than $2 billion into debt. Head designer Joe Sutter was told to fire 1,000 engineers; instead, two months ahead of schedule, Sutter insisted on hiring 800 more. Boeing executives kept the project alive by spending their own money to manufacture parts.

Four massive turbofan engines were designed by the firm Pratt & Whitney to power the Boeing-747. The engines were thought to be twice as powerful as earlier turbojet models, while consuming a third less fuel. But engine stalls in early tests delayed delivery of the 747s. These and other design flaws were addressed between September 1968, when the first Boeing-747 rolled out of the assembly plant, and January 1970, when the planes began passenger service.

Five test planes were developed during this period. The first flight on February 9, 1969, was piloted by Jack Waddell and Brien Wygle and declared a success. But another test pilot, Ralph C. Cokely, crashed on December 13, 1969, by missing the short runway at Renton Municipal Airport at Boeing's Renton factory. The public got its first look at the 747 in June 1969 at the Paris Air Show, and late that year, it was cleared by the Federal Aviation Administration for service.

Pan Am's first 747 was christened on January 15, 1970, by First Lady Pat Nixon. At Washington's Dulles International Airport, the plane taxied onto the runway where it was sprayed with red, white, and blue water instead of the traditional champagne. A week later, it carried its first passengers from New York's John F. Kennedy International Airport to Heathrow Airport in London. The flight was delayed more than six hours – from the evening of January 21 to the early morning of January 22 – by an overheated engine. Pan Am's flight attendants were given a classier look for the 747 with pristine white gloves and stylish blue hats.

Critics had declared a plane as large as the 747 would never fly. Though twenty-five other airlines joined Pan Am in ordering the aircraft, some pilots refused to fly it over fears it wasn't safe. Others were concerned that it was too large to land at some airports. Boeing eventually put those concerns to rest, and subsequent models improved on the 747 design. By May 2015, the company put into service its 1,508th 747.

On March 2, 1969, a supersonic passenger jet - developed jointly by French and British aerospace companies – made its first test flight. The Concorde could reach Mach 2.04, twice the speed of sound, and seat as many as 128 passengers. It first went supersonic in October 1969, with

French test pilot André Turcat at the controls. Most commercial jets took eight hours to fly from New York to Paris. The Concorde could cover the same distance in less than half that time.

The public got its first look at the Concorde at the same Paris Air Show in 1969 that featured the Boeing-747, and sixteen airlines, including Pan Am, had placed orders for the Concorde by the spring of 1967. However, design delays kept the Concorde from entering passenger service until 1976, and by then, interest had waned.

The Soviet Union had developed a competing supersonic passenger plane, the Tupolev TU-144, which on June 3, 1973, crashed at the Paris Air Show. The crash killed all six people on board and eight more on the ground – including three children – and destroyed fifteen houses. Sixty other people were seriously hurt. This incident shocked potential buyers and raised public concerns over environmental issues – the sonic boom, takeoff noise, and pollution – presented by a supersonic jet. The TU-144 began passenger service in May 1978, but only sixteen were built, and the passenger model was grounded after only fifty-five flights. Many orders for the Concorde were cancelled; only twenty were made, six of which were prototypes, and in 2003, the design was retired. No other supersonic jet has been used regularly to transport passengers.

The recession in 1969 and 1970 also caused problems for the Boeing-747. In the first year and a half after the 747 entered service, Boeing only sold two; and after Pan Am, no American airline carrier placed an order for nearly three years. With fewer people flying, many airlines opted for smaller planes.

But that trend reversed by 1976, when Boeing introduced a 747 with higher passenger capacity and more powerful engines. During peak production in the 1980s, Boeing employed 10,000 workers, who churned out a new 747 every twenty-three days. In 1990, Boeing was building an average of six 747s a month. Though that number has dropped, Boeing-747s are still tranporting thousands of passengers a day in 2015 – making it one of the most successful commercial jetliners ever.

Other landmarks in modern-age aviation matched the spirit of the early pioneers. Ten years after the Boeing-747 first took off, a human-powered flying contraption - the Gossamer Albatross - successfully crossed the English Channel. Like a bicycle attached to a glider, its pedals powered a large, two-bladed propeller, with the cabin, sitting beneath long, tapered wings, wrapped in a thin, transparent plastic. Its designer, American aeronautical engineer Paul MacCready, and his company, AeroVironment, won the first two Kremer prizes – monetary awards established by industrialist Henry Kremer and given to pioneers of human-powered flight.

Bryan Allen, an amateur cyclist and self-taught hang glider pilot, first flew the Gossamer Albatross on a figure-eight course around two markers on August 23, 1977. Then, just before 6:00 a.m. on June 12, 1979, Allen crossed the English Channel, taking off near Folkestone, England, and landing two hours and forty-nine minutes later on a beach at Cape Gris-Nez, France. For more than twenty-two miles, the Gossamer Albatross flew at an average altitude of five feet, and achieved a top speed of eighteen miles per hour, which required Allen to pedal seventy-five revolutions every minute.

Boats accompanied the *Gossamer Albatross* across the Channel to monitor the flight, and as a safety precaution. At takeoff, weather and wind conditions were ideal, but there were complications. First, the aircraft's radio failed, which meant Allen had to communicate with the boats using only hand and head gestures. Because Allen only had enough water for a two-hour flight, he became dehydrated, and his legs cramped. Headwinds nearly caused the flight to end prematurely, but Allen was able to climb to a higher altitude and avoid turbulence.

The next year, another Gossamer model, the *Penguin*, flew for nearly two miles on an electric motor powered by a solar panel. Its test pilot was Janice Brown, who weighed slightly less than 100 pounds. Early test flights had been piloted by engineer Paul MacCready's thirteen-year-old son Marshall MacCready, who weighed eighty pounds.

Also in 1980, a balloonist from Oklahoma named Maxie Anderson and his son, Kristian, set a record by flying non-stop across North America in a balloon named the *Kitty Hawk*, in honor of the Wright brothers' first flight. That flight took off from Fort Baker, California, on May 8, 1980, and landed four days later in Quebec, Canada. Two years previously, Anderson flew another balloon, the *Double Eagle II,* from Presque Isle, Maine, to Miserey, France – setting records for distance (3,108 miles) and duration (137 hours). On the original *Double Eagle,* Anderson had to abort an attempt in 1977 to commemorate the fiftieth anniversary of Charles Lindbergh's transatlantic flight. In 1981, he attempted to circumnavigate the globe on the balloon *Jules Verne*, lifting off from Luxor, Egypt, on January 11 and landing forty-eight hours later in Hansa, India, after traveling 2,682 miles. Anderson died in a balloon crash on June 27, 1983, in West Germany.

The first balloonists to successfully circle the globe without stopping were Swiss psychiatrist Bertrand Piccard and English pilot Brian Jones in 1999. Their balloon – the bright-red, egg-shaped *Breitling Orbiter 3* – flew 25,361 miles from Switzerland to Egypt in nineteen days, twenty-one hours, and forty-seven minutes.

Other aviators were eager to see the shape of the world. In January 1982, a Gulfstream III business jet – manufactured in Savannah, Georgia, and owned by the National Distillers and Chemical Corporation in New York – flew around the world in a record-breaking forty-seven hours and thirty-nine minutes, stopping only to refuel. That same year, Henry Ross Perot Jr. – son of Texas businessman Ross Perot, who would become known for two failed presidential campaigns in the 1990s – co-piloted *The Spirit of Texas,* the first helicopter to complete a round-the-world flight.

In 1986, an experimental plane called the *Rutan Voyager* was the first to circle the globe without stopping or refueling. Its pilots were Air Force Lieutenant Dick Rutan and thirty-two-year-old Jeana Yeager (no relation to aviator Chuck Yeager). To reduce weight, the frame of the *Voyager* was made largely of fiberglass, carbon fiber, and Kevlar, the synthetic fiber used in body armor and racing boat sails. Still, fully loaded with fuel, it weighed more than 9,694 pounds. The *Voyager*'s front and rear propellers were powered by separate engines.

The *Rutan Voyager* took off from Edwards Air Force Base in California at 8:01 a.m. on December 14, 1986. It had a rough start, accelerating slowly and scraping its wings on the runway. Several times during the flight, the pilots had to maneuver around bad weather. But at 8:06 a.m. on December 23, 55,000 spectators witnessed *Voyager*'s safe landing at the same airfield it had departed nine days previously. As of 2015, this feat had been repeated by only one other plane – the *Voyager Atlantic GlobalFlyer* designed by Dick Rutan's brother, Burt - in 2005.

With each record achieved, new benchmarks were set. On September 20, 1993, eleven-year-old Vicki Van Meter from Meadville, Pennsylvania, became the youngest pilot to fly east to west across the continental United States. A year later, she set another record by piloting a single-engine, propeller Cessna 210 over the Atlantic Ocean. Her records will likely never be broken. In April 1996, seven-year-old Jessica Dubroff from Falmouth, Massachusetts, tried, but twenty-four hours into her quest, Dubroff was killed along with her father and flight instructor when their Cessna 177B Cardinal crashed shortly after takeoff in Cheyenne, Wyoming. Her death led to a law - the Federal Aviation Reauthorization Act of 1996 – making it illegal for student pilots to attempt to set aviation records.

Countless test pilots have sacrificed their lives to clear the way for advancements in aviation. In the 1950s, test pilots were killed at the rate of about one a week. With better technology, the risks dropped considerably. The development of Unmanned Aerial Vehicles (UAVs), or drones, has made it possible to test experimental aircraft features without the need for pilots. UAVs have been used by the military for training, combat and reconnaissance missions as early as World War I, but more commercial applications were found for the pilotless aircraft at the start of the twenty-first century.

Still, the skies continue to sing their siren song, beckoning more people to the clouds and beyond. In 2003, aerospace engineer Burt Rutan designed *SpaceShipOne,* a suborbital spaceplane that launched in-air off the back of another plane. On December 17, the 100th anniversary of the

Wright brothers' historic first powered flight, *SpaceShipOne*, became the first privately built aircraft to fly at supersonic speed. Taking off from the Civilian Flight Test Center in California's Mojave Desert, it reached Mach 1.6 in sixteen minutes and twenty-seven seconds. Six months later, it made the first privately funded human spaceflight – reaching the edge of space, more than sixty-two miles above the earth's surface, on June 21, 2004. In twenty-four minutes and five seconds, *SpaceShipOne* reached an average speed of Mach 2.9 – nearly three times the speed of sound. With this flight, South African/American pilot Michael Melvill became the first commercial astronaut. Ten years later, another test pilot, Michael Alsbury, was killed when the *SpaceShipTwo* broke up mid-air; a co-pilot managed to parachute safely to the ground.

After more than a century of aviation, the dream of flight is eminently attainable. The Federal Aviation Administration recorded more than 600,000 licensed pilots in the United States in 2010. For the first time ever, in 2013, more than 3 billion people worldwide flew on commercial airlines. On January 1, 2014, alone, an estimated 8 million people flew on nearly 100,000 flights.

Long before people took to the skies, writers and poets had cast their imaginations into the clouds. Why this ceaseless fascination with flight? Perhaps Mark Twain put it best when, in 1886, he wrote: "The air up there in the clouds is very pure and fine, bracing and delicious. And why shouldn't it be? – it is the same the angels breathe."

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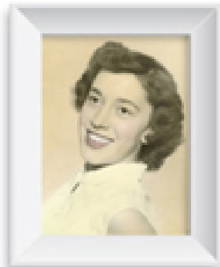

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