LIGHTNING!

What it is, what it does, and – better still – how to avoid it

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■■ For as long as man has walked the face of the earth, lightning has been a source of terror. The spectacular streaks of fire and their accompanying thunderclaps have sent humans scurrying for shelter in near-panic for centuries, and even today nature's fireworks inspire awe and trepidation.

For pilots, the phenomenon can be particularly terrifying, not only because there's no shelter available, but also because lightning is the ultimate symbol of violent weather at its worst. It's also faster than the mind can comprehend (one-tenth the speed of light), it's totally unpredictable, and its electrical strength staggers the imagination (up to 250,000 amps and 100 million volts).

Lightning isn't uncommon, either. At any given moment, some 1,800 thunderstorms bombard the earth with an average of 100 cloud-to-ground lightning strokes a second. With this kind of energy running amok in the atmosphere, it's no wonder that many pilots consider the possibility of surviving a lightning strike to be virtually nonexistent. Most pilots, however, know little or nothing about their chances of being struck.

Just how real that possibility is has been a subject of scientific study for years. Although the major thrust of research has been in predicting and preventing strikes on airliners, many of the findings apply equally well to light aircraft.

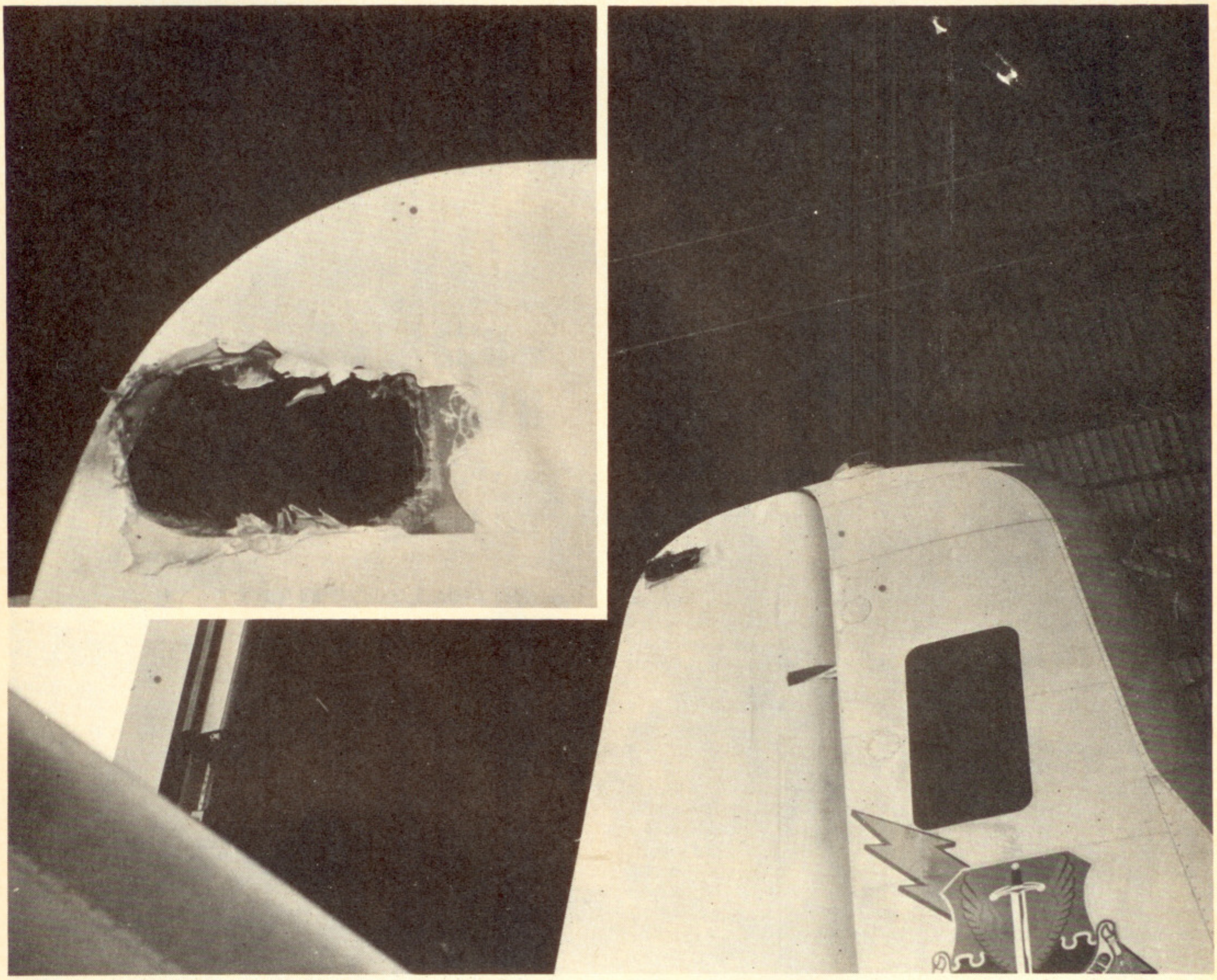
The first problem in lightning research is understanding the enemy. While the electrical structure of thunderstorms isn't fully defined, most scientists agree that the warmer, lower part of a storm cell usually contains a negative charge while the upper portion is most often positively charged. It is this difference in electrical charge that causes the violent discharges known as lightning, most of which occur within the storm itself. Occasionally, strokes reach from cloud to cloud or from cloud to ground, and these represent the most serious threat to aircraft—assuming, for the moment, that most pilots are sane enough to avoid flying *through* a thunderstorm.

Cloud-to-cloud lightning is probably the most troublesome to aircraft. This form is most common in desert and mountainous terrain, where the bases of the thunderstorms are higher than in flat, moist areas. Discharges from cloud to ground are less likely, because the distance from one cloud to another often is shorter than the distance to the earth.

Wherever it originates, a lightning strike consists of more than one discharge. Each visible flash is made up of a series of strokes, usually three but often as many as fourteen. The whole process takes less than a second, and an individual stroke is over in a few millionths of a second.

The first stroke is called the "stepped leader" because it advances in a series of jagged, 150-foot steps, zigzagging crookedly across the sky by the path of least electrical resistance. Subsequent strokes follow along the same path in rapid succession, causing tremendous heat and electrical disturbance. (One research study by Westinghouse indicates that a typical discharge generates enough electricity to supply a small home's power needs for a month.)

Because more and more general aviation airplanes are flying IFR at altitudes formerly frequented only by transport



A lightning strike left this hole in the rudder of an Air Force C-118. Photos courtesy of FAA.

LIGHTNING continued

jets, lightning has become a factor to be understood and respected by all.

Actually, it's not necessary to climb to FL 380 to find the ultimate sparklers. The USAF Air Weather Service made an extensive study of strike data over an eight-year period and determined that nearly 95% of contacts occurred below 22,000 feet. This means that high-flying jets are more immune to strikes than are light aircraft.

According to Air Force research, a majority of strikes were concentrated between 3,000 and 15,000 feet. These altitudes roughly correspond with the isothermal layer of air within ± 10°C of the freezing level. Aircraft flying below 1,000 feet were rarely struck.

Other studies show that most strikes occur in rough air while the aircraft is in clouds and precipitation, during climb or descent. There's also some evidence that indicates large, fast transport aircraft are struck more often than lightplanes. Strikes occur most frequently in April and August, when thunderstorm activity is at its peak.

Temperature appears to be the main key in the spawning of lightning. Airplanes operated near the freezing level stand the greatest chance of being struck. The great majority of strikes at the 0°C altitude indicates a definite relationship between lightning formation and the negative-charge center, which also resides at this altitude. Aircraft flying at altitudes at which temperatures are far above or below freezing rarely encounter lightning discharges. Of course, there's always the possibility of intercepting an air-to-ground bolt beneath a storm.

Fortunately, all-metal airplanes and their occupants generally fare well in the event of a strike. A 19th-century British physicist named Michael Faraday first demonstrated that electrical discharges won't harm the contents of a grounded metal box, and the "Faraday Cage" principle today helps protect passengers. Aluminum is an especially good conductor of both heat and electricity.

Though many lightplanes aren't made of aluminum, and are therefore more susceptible to lightning damage, the least common but most spectacular danger is that of fuel ignition. All fuel tanks are vented to the atmosphere, and the airspace within the tanks contains an ever-changing ratio of gas, so there is a potential for explosion.

Because of the precise 15:1 fuel/air mixture necessary to support combustion, explosive ignition of a fuel tank is rare—but not unknown. In December 1963, a Boeing 707 over New Castle, Del., lost a wing when a reserve tank was struck by lightning and exploded. Several earlier accidents also were attributed to spontaneous static discharge resulting in fuel ignition.

According to official records, general aviation has been comparatively free from fatal lightning accidents. The National Transportation Safety Board has theorized that lightning may have been a contributing factor in several lightplane accidents but has never pinned the blame specifically on a lightning strike.

Fact is, the chances of lightning sending any airplane into its final descent are minuscule. The data gathered up to now indicates that lightning's bark is far worse than its bite. Damage to aircraft usually is minimal and generally amounts to pitting or the burning of small holes in the aircraft skin, in which case the metal is actually vaporized by the 15,000°C heat. Pencil-size holes are common, and half-dollar-size burns are not uncommon.

Most strikes occur at parts of the aircraft where sharp curvature, points, or reduced air pressure exist. Antennas and wingtips are the most popular targets, though the capricious nature of lighting allows no set rules on contact points. According to one research study of nearly 1,000 strikes, 20% were to some point on the fuselage, 17% to the wing, and the remainder distributed over the rest of the airplane.

Radios and compasses are particularly susceptible to lightning damage. The spectacular jolts can cause insidious compass errors by magnetizing steel and iron alloys in the cockpit. Radios and autopilots don't necessarily blow out all at once. A strike can cause a slow current overload that eventually shuts down the component or causes a malfunction.

Nonmetal airplanes often fare poorly in the event of a direct strike, because wood and fabric are poor conductors of heat and electricity. While few manufacturers still rely on spruce and ceconite for new aircraft construction, there are thousands of lightplanes that utilize nonconducting materials, such as fiberglass, in susceptible components such as wingtips, tailcones, spinners and gear fairings. Certainly, no pilot should hinge his go/no go decision on the possibility of being struck by lightning, but it might be extra-wise for pilots of nonmetal airplanes to steer clear of lightning-conducive conditions.

There's no record of anyone ever having been fried in flight by a lightning bolt, but then there probably wouldn't be. On rare occasions, pilots experience electrical shock through metal components or see sparks in the cockpit.

In 1959, one crewman of a Navy P2V patrol bomber flying over San Francisco received a memorable hotfoot as he sat in the airplane's clear-plastic nose. The bolt hit just below the bubble, traveled up the man's right leg, across his back, and into the metal of the seat. The crewman was reported as saying, "I didn't know what hit me . . . all I know, my feet hurt all of a sudden, and I looked down and saw my right shoe burning." Fortunately, minor burns and shock were his only injuries.

It's not necessary for lightning to actually strike an airplane to cause problems. The flash itself is a very real hazard, especially at night when a pilot's eyes are adjusted to darkness. At least one accident in the early 1940s was attributed to a lightning flash that blinded the pilot.

Temporary blindness has lasted as long as ten minutes, but perhaps ten seconds is average. A pilot's best protection against blinding is to keep his eyes well away from the windows and turn up instrument lights to maximum brightness.

Many pilots and some airline passengers have experienced a less spectacular and generally harmless form of electrical discharge known as "St. Elmo's fire." This is a gradual static buildup that sometimes results in formation of a blue or red corona around the prop tips, wingtips and antennas of the aircraft. St. Elmo has yet to bring down an airplane, but fuel leaks or improper venting through even a light static charge could cause ignition.

Lightning research in both the public and the private sectors continues, in the hope that someday a method will be found to control nature's magnificent light displays. In the meantime, the message is clear. If you're penetrating a cumulonimbus in your wooden airplane, above the desert in August at the freezing level, you're asking for it. If you're smart enough to avoid that situation, you may never have to worry about a lightning strike.

This doesn't mean you should ignore the danger of a lightning strike in day VFR between a pair of thunderstorms. In such cases, no amount of cure will offset even an ounce of knowledge. □