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Declassified in Part - Sanitized Copy Approved for Release 2012/03/13 : CIA-RDP92T00277R000500040024-2

Invisible bomber
—secrets of the plane that radar can't see

Airmen call them "stealth" planes. To enemy radar, they can look like hummingbirds

By JIM SCHEFTER
ILLUSTRATION BY DEAN ELLIS

Shaped like a broad, flat wing with only a smoothly blended windscreen revealing its cockpit, the bomber skimmed across barren polar terrain at nearly 600 mph. Barely 400 feet below, ice floes vibrated to the roar of its concealed jet engines. The early-warning radar fence lay behind, its operators unaware that the first line of defense had already been penetrated.

More radar waited ahead. Hugging the terrain to take full advantage of hills and valleys, the flying wing crossed

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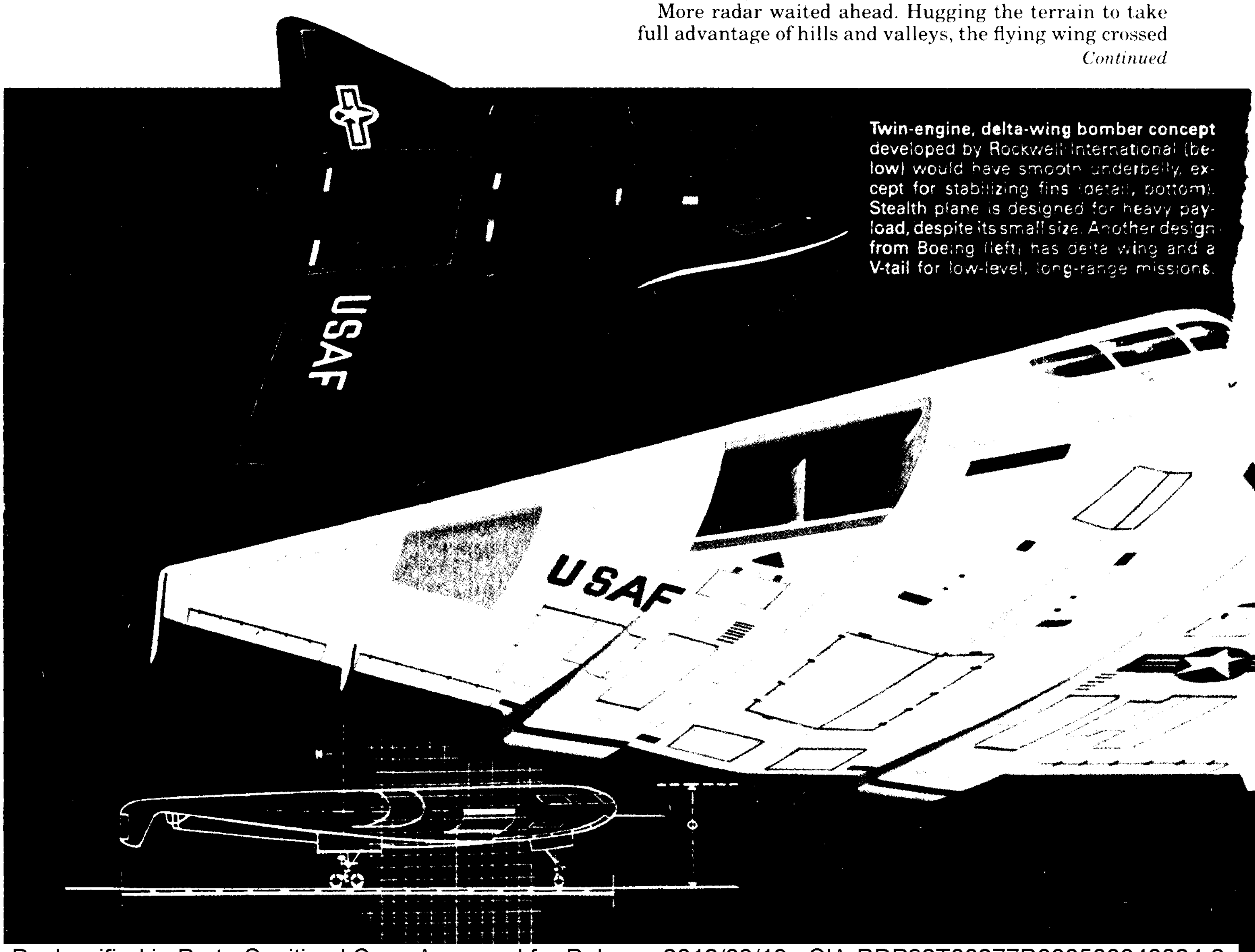


Twin-engine, delta-wing bomber concept developed by Rockwell International (below) would have smooth underbelly, except for stabilizing fins (detail, bottom). Stealth plane is designed for heavy payload, despite its small size. Another design from Boeing (left) has delta wing and a V-tail for low-level, long-range missions.

Ample window area on all sides of house is one advantage of HGE houses. This is southwest corner of the Heyd house.

reached 87 degrees F and the solarium rose to equal that, the living areas of the house ranged from 71 to 74, without auxiliary cooling. Certainly the outer shell, which shades the living area from the sun, contributed to this. But the cooling tubes, a standard feature of double-shell houses in some climates, didn't seem to help much. In cooling mode, hot air is supposed to rise from the solarium and exit through attic vents, pulling fresh air that has been cooled and dehumidifed by earth contact into the envelope through the cooling tubes. During part of the Mastin tests, air flow was in the wrong direction: It flowed from the house, through the cooling tubes, and out what was supposed to be the inlet.

(Actually, the Mastin house doesn't present much of a cooling challenge. It's about a mile from the Atlantic, and prevailing southwest winds bathe it in cool ocean air on most summer afternoons.)

After analyzing all the data collected, the Brookhaven team reached this conclusion: "The low energy needs of the Mastin house are attributable mainly to the excellent insulative value of its double shell." If cost were a simple overriding consideration, the report continues, "it would be difficult to rationalize the double envelope's use over the super-insulated house."

Super-insulated houses [PS, May '81] are exactly what the name implies. They are constructed to include an enormous amount of insulation. They conserve heat so well that internal heat gain—from people and appliances—is nearly enough to carry the house, even in a severely cold climate. They rely on solar heat very little, and hence have small windows, even on the south, since windows can be a large source of heat loss.

Hybridization

But, Mastin decided, why not have the best of both worlds? His current designs blend many aspects of a super-insulated house with some vestiges of the double-shell design. He calls the result a Hybrid Geotempered Envelope (HGE).

On a lovely wooded lot south of Boston, builder Robert Green is just completing an HGE house for Robert and Nina Heyd (see photo). Gary and Kathy Brennan and their five children have just moved into another near Little Compton, R.I. Both have solariums, but there's no air plenum forming a loop around these houses. Instead, a thermostatically controlled fan takes hot air from the top of the solarium and delivers it through ducts to the basement.

The attic, foundation, and the north, east, and west walls of these houses are super-insulated (see diagram). The north, east, and west windows, however, look much like the north windows in Mastin's own house: two sets of double-glazed units. There is an air plenum at each window, but it's only as wide as the window and ends at the top (which tends to comfort fire inspectors). It does, however, run all the way down to the basement. "The true effectiveness of the double-shell design is in reducing heat loss through glass," Mastin says. "When the air between the windows is colder than the air in the basement, it's going to drop and displace the warmer air there, which will rise.

"The plenum also reduces infiltration," he points out. "Yet when you need ventilation, you can open an interior window and get it, without a blast of cold air." This mitigates the need for an air-to-air heat exchanger [PS, Jan.], which super-insulated houses often require. And since the windows aren't horrible heat losers, HGE houses can have a good many, even on the north side.

Mastin is not alone in modifying the double-shell concept. In fact, a Pennsylvania designer, Christopher Shipp (R.D. 1, Box 331D, West Grove, Pa. 19390), has come up with an almost identical design, including both super-insulated walls and double windows with air plenums connected to the crawl space or basement. Shipp is also doing variations of the double-shell house that are closer to the original concept, but using fans to force the air flow (see diagram). At least, he intends that these houses use fans. So far the owners of the house in our photo haven't installed the fans. "They only spent $60 on electricity to heat the house last winter, so spending $200 on fans seems needless," Shipp reports.

How do these hybrid designs compare in cost, performance, and livability with super-insulated houses?

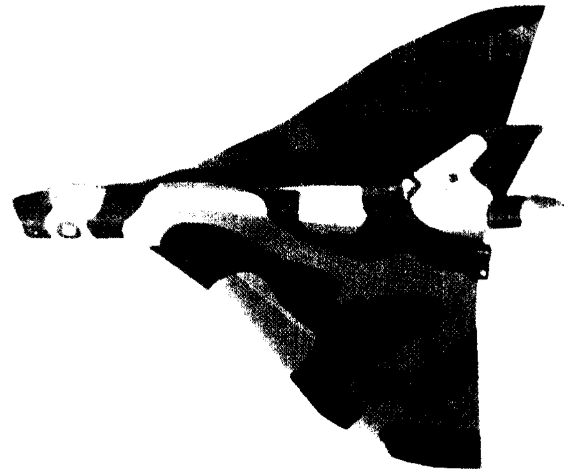
"The best-performing houses anywhere are the super-insulated houses," Mastin admits. "They are also the most cost-effective to build. But their obvious shortcoming is lack of light, views, and natural ventilation."

If you count the solarium as an extra expense (about the same per square foot as the rest of the house), Mastin's HGE-type houses cost a good bit more to build than super-insulated houses. "But if you compare the cost with that of a super-insulated house with a sunspace," Mastin says, "the only cost increase is for the double windows and their plenums—about $200 per window. And you don't have the cost or nuisance of window insulation."

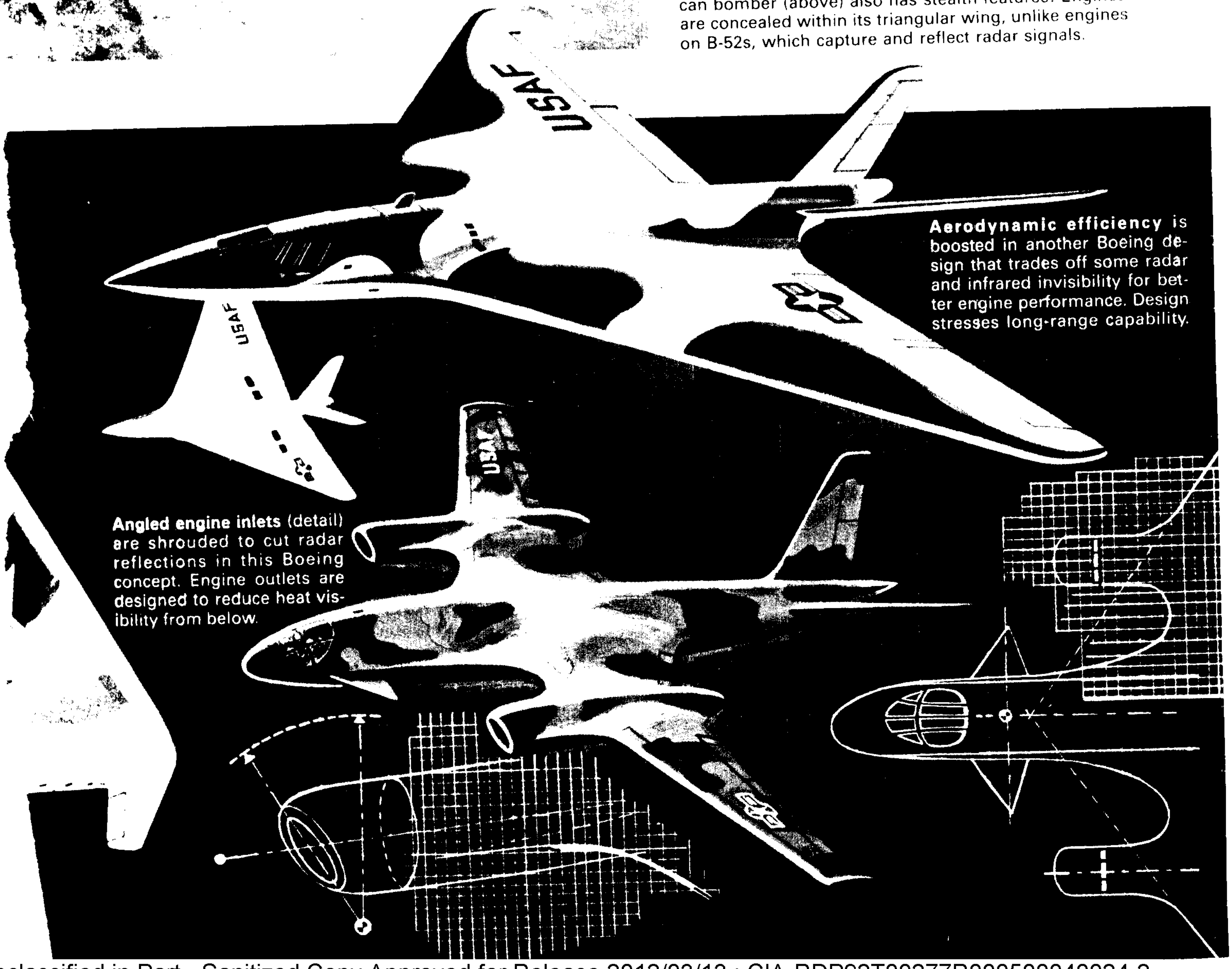
The auxiliary heat requirements for super-insulated houses generally come out to be even less than what the Brookhaven tests showed Mastin's house to need. Preliminary monitoring of one of Mastin's HGE houses, in Southington, Conn., suggests that its heat needs are in the same ballpark, though somewhat more than the most efficient super-insulated houses. More such data will be forthcoming. Mastin spent the past summer modifying his own house to make it more like the hybrid design (see opening page). Now Brookhaven has brought back the instruments and will remonitor the house this winter.

Just what type of house is the most livable is a highly personal matter. "I didn't want a strictly solar house because I didn't want to cut down all my trees," says Robert Heyd, gesturing toward a stand of stately oaks to the south of his house. "And I didn't want a super-insulated house without much window space."

The Brennans are delighted with the choice they made. "I checked out everything," says Kathy. "I visited some passive-solar houses with whole south-facing glass walls. They turned into an oven during the day, then cooled off just as fast at night. I checked out others that had a basement full of rocks, and some with water drums in the living room—that really turned me off. With all the other designs I read about, it seemed we had to give up something. This was the only one that had everything." PS

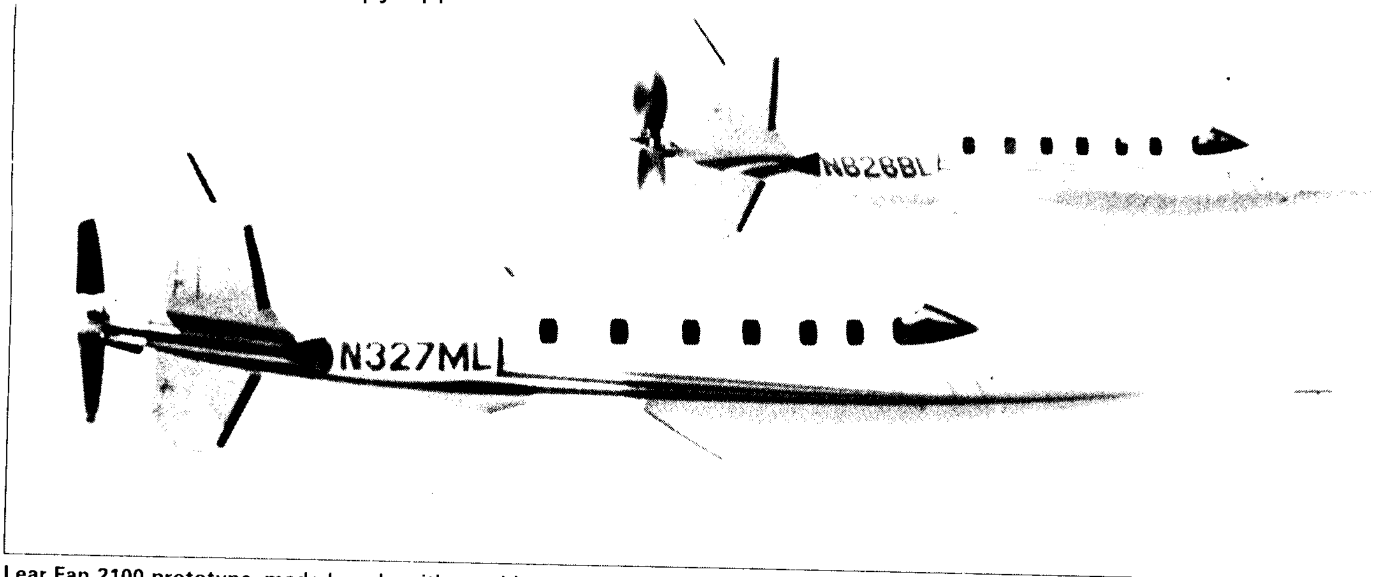


SR-71 Blackbird spy plane (left) is one of the earliest designs with anti-radar stealth concepts. A blue-black coating is thought to have radar-absorbing properties. The engines blend smoothly with the wings, and slanted tail fins minimize radar reflections. British Vulcan bomber (above) also has stealth features: Engines are concealed within its triangular wing, unlike engines on B-52s, which capture and reflect radar signals.



Aerodynamic efficiency is boosted in another Boeing design that trades off some radar and infrared invisibility for better engine performance. Design stresses long-range capability.

Angled engine inlets (detail) are shrouded to cut radar reflections in this Boeing concept. Engine outlets are designed to reduce heat visibility from below.



Lear Fan 2100 prototype, made largely with graphite composites, is a commercial aircraft design that's almost invisible to radar.

out of the tundra. Despite its size and speed, it created just a flicker on glowing scopes. It was no more than a hummingbird darting south.

But this bird, still a paper airplane that won't fly before 1987, will be no harmless little avian. The popular word used to describe it masks the most secret U.S. technology program in four decades:

Stealth.

This multi-billion-dollar development, already under way in a classified and guarded Northrup Corp. facility midway between two major Los Angeles freeways, is aimed at producing a new bomber that is virtually undetectable by radar. A secondary effort to produce a modified B-1 bomber with a low radar profile is under way at a Rockwell International plant in nearby Palmdale.

And a third project, by the Lockheed Corp., already has produced at least three prototype stealth fighters. Flying from a secret field near Groom Lake, Nev., and from Eielson AFB, Alaska, since 1979, two of these triangular-shape craft have crashed, but for reasons not connected to their strange design. The third reportedly continues to fly test missions in both extreme heat and cold.

Taken together, the Pentagon expects these futuristic aircraft to alter the balance of military power into the next century.

How will a bomber-size aircraft deceive radar that is itself state of the art? What new technology is on the drawing board to create a machine that will penetrate enemy airspace with impunity?

Some answers are emerging from this highly classified program. Others undoubtedly will remain among the nation's most tightly kept secrets. Briefings on stealth technology, when authorized by the Air Force, are sketchy. Even individuals allowed to talk insist that their names be concealed.

Even so, it was possible to put together a filtered look at how the best aeronautical engineers in the world are designing stealth-type aircraft. Some of the picture, necessarily, is informed speculation by experts. But much already is known.

Low-flying attack

The bomber, for instance, is being designed to fly intercontinental distances at low altitudes at about Mach 0.85. "High-altitude attack is not a wise idea because it gives the enemy a longer time to look at you on the way in," one observer said.

The Air Force itself discourages the word "stealth." It prefers the term "low observable" and calls Northrup's project the ATB, or advanced-technology bomber.

"When you talk about stealth," a high-ranking Air Force officer told me, "you're talking about the ability to offset the enemy threat to your penetration."

To do that takes an aircraft with a unique shape, built with materials and coatings that both absorb and deflect radar signals. It takes innovative designs to conceal jet engines within the aircraft body. And it takes a host of new electronics gear aboard the craft to isolate and confuse enemy radar.

But the first step is designing the aircraft itself. Air Force and industry officials stress that reducing radar cross section -the reflecting surface actually seen by radar-is the major factor in playing aerial hide-and-seek. Cross section is measured in square meters, as seen head-on by defense radars.

For instance, the ancient B-52 that remains our primary intercontinental bomber has a massive radar cross section of about 100 square meters. Its tall, vertical stabilizer and heavy body make it an ideal radar target. Even worse, its large wing-slung engine pods concentrate radar signals and echo them back with brilliant clarity.

A shrinking target

Rockwell's original B-1, which Jimmy Carter refused to build, produced a radar image of just 10 square meters. And the B-1B, now being reworked in a stealth version that will fly in 1985, echoes a cross section of just a single square meter.

That's a flashing alarm compared with the stealthy bomber on Northrup's drawing boards. It reportedly will have a radar cross section of one-millionth of a square meter. A hummingbird is bigger.

Designers will achieve this strikingly small radar cross section with a number of design innovations. For example, sharp edges and abrupt angles, often seen on aircraft wings and control surfaces, produce strong radar echoes. So there will be none on the new planes. Northrup's bomber will be a low-profile flying wing. (Significantly, Northrup also built the original B-49 Flying Wing, which first flew in 1947.) Tomorrow's stealth bomber will take the concept even further, expanding on the so-called blended-body concept provided by Rockwell's B-1 [PS, May '77]. Its wing-body leading edge will be smoothly rounded, and its delta shape will integrate fuselage, cockpit, and wing into a single flowing wedge. Engines will be buried inside the body, not hung out as tempting radar targets.

Northrup engineers also are wrestling with designs for the vertical stabilizer. Their first choice is to eliminate it completely. If computer analyses point up handling problems with that concept, Northrup may decide to use small twin stabilizers. They would be canted inward to deflect radar rather than echo it.

No information is available about overall size of this flying wing. But it is certain to be low-slung and squat, almost like a Frisbee or boomerang in proportions. All that will make radar sighting more difficult. Yet more is needed.

One solution is to eliminate metal wherever possible. Early versions of radar-absorbing materials, primarily carbon-and-fiberglass composites, were developed by Rockwell for the Hound Dog missile. That technology is being adapted for the stealth bomber.

Recent advances by a number of laboratories, including the Air Force Materials Laboratory at Wright Patterson AFB, Ohio, have led to composite materials that are stronger and lighter than steel or titanium yet do not reflect radar waves. A black fiber-reinforced graphite skin is reported to be the leading contender for Northrup's bomber.

With current technology, materials that absorb some electromagnetic radiation are bonded to stronger titanium. But Lockheed's super-secret stealth fighter is believed to be made largely of Fibaloy, a composite developed by Dow Chemical Co. Fibaloy includes glass fibers embedded in plastic and is said to be strong enough without metal backing to form both the fighter's skin and its main structural members.

The result is a 20,000-pound fighter not only stealthy, but small and light enough to be carried inside a C-5A transport.

And the Air Force is heavily committed to developing even better carbon composites. That leaves the stealth-

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bomber designers to consider their jet engines, which can't eliminate metal.

"Jet-engine intakes are high-visibility items for radar," one aeronautical expert told me. "To get enough air into an engine, you need big compressor sections up front. They're very balanced, built to close tolerances, and made of heavy metal."

With front-facing air intakes, that metal echoes radar like a beacon. But the new bomber will have concealed intakes, mounted flush beneath the flying wing. It also may employ a version of a new intake-tunnel configuration being developed for Rockwell's B-1B.

Called the zigzag tunnel, this innovation eliminates the straight-line air flow that also lets radar flash directly into the engine compressor. The new tunnel has twin channels with a series of carefully designed curves that minimizes radar reflections.

The expandable throat needed to reduce incoming air speed and prevent a compressor stall in a high-flying supersonic aircraft is gone. The result is a radar fooler. Signals entering the zigzag tunnel reflect back and forth at the curves, instead of echoing a bright reflection to a radarscope.

"We can do it because the B-1B is now a subsonic, low-altitude penetrator," an Air Force officer said. "There's no problem with stalls."

The new flying wing will add another innovation. Its jet-engine exhaust will be cooled and masked, exiting from smoothly faired thrust vents at the trailing edge. That won't affect radar but will help protect the stealth bomber from heat-seeking missiles or detection by infrared sensors.

Northrup's stealth aircraft also will benefit from radar-absorbing coatings first developed for Lockheed's legendary SR-71 Blackbird. That plane got its name from the inky-black coating that reduces its radar signature and camouflages it against the dark sky.

Details on newer coatings are highly classified. But Northrup is said to be including that technology in its flying wing.

B-1B accessories

Avionics will make up the rest of the fighter's approach to radar invisibility. While declining to discuss the electronics that will go into the flying wing, the Air Force provided some details on equipment for the low-observable B-1B.

First, the dish-type radar antenna in the nose of the craft is gone, replaced by a phased-array antenna that resembles a flat, oval plate. "The dish became a radar target itself in some instances," an Air Force official said.

The phased-array antenna never moves. It is angled generally forward, but its radiation is aimed electronically, and it doesn't reflect enemy signals. The system was adapted off the shelf from a radar employed in the F-16 fighter.

The Air Force and Rockwell also eliminated an antenna that ran down the B-1's back like a visible spine. That spine provided angles just made to echo radar. The antenna, part of a programmable defensive-avionics system, will be built directly into the aircraft.

The system is computer controlled and on-board programmable to seek and identify enemy radar or missiles. "These avionics are the current state of the art," the officer said. "They've been tested against surrogate Soviet systems and will defeat anything currently in their radar-antenna inventory and any upcoming threats," he confidently asserted.

The system being developed for Northrup's stealth plane is presumably even better.

"Radar cross section is only one aspect that's going to make a super-penetrator," the officer said. "The other half is the avionics. When you get the radar visibility down very small, you can start manipulating the radar signals so the enemy doesn't see you."

That means stealth-type aircraft will carry new electronic-countermeasure gear to identify a radar station, then transmit just the right signal to erase even the hummingbird speck from its scope. The kind of countermeasure equipment now in use must be powerful enough to obliterate the large radar signatures current aircraft produce. Still, radar operators frequently know something is happening, though maybe not what, when their scopes are jammed.

"If you can use just enough energy to foil each radar set, they won't even know you're there," the officer explained.

If current funding levels continue, the B-1B will be operational in 1986, with 100 of them flying by 1988. To protect against it, the Russians will have to spend five times as much on defenses as the aircraft cost the U.S., according to an Air Force source. And that's just the start. The Northrup stealth plane now is scheduled to be in the military inventory by 1992. "That will take another five-fold expenditure if they want to even think about stopping it," the officer said. PS