THE SECRET SHIP

An experiment in seagoing stealth glides out of the black.

BY STUART F. BROWN

Sea Shadow has a top speed of 13 knots; the four-man crew enters through a hatch on the starboard side.

Think of a trilobite navigating the primordial ooze. Think of pyramids, cut gemstones, or the ironclad ship *Merrimac* that fought for the Confederacy in the American Civil War. And, of course, think of the F-117A stealth attack plane. The mysterious form that emerged from the military's secret world earlier this year brings all of these shapes to mind.

As the doors of a huge floating dry dock slid open in the waters off California's Santa Cruz Island, a black, faceted shape began to move into the open sea amid wisps of bluish exhaust smoke. Onlookers aboard a Coast Guard cutter noticed light-colored, submerged shapes beneath its steeply sloped edges. By the time the entire 160-foot craft was free of the structure, a row of windows could be seen in one of its pointy, four-surfaced ends. It was running in reverse.

This was the first public glimpse of *Sea Shadow*, a U.S. Navy test vessel unlike anything seen before. Its existence had been carefully concealed since 1986, when the Navy concluded a series of covert and costly nighttime sea trials. The need for a round of daylight testing, the Navy says, led to the decision to unveil the ship. There wasn't much choice; aircraft or offshore boaters would soon have spotted it.

If airplanes can be made difficult to detect by radar and other sensors, why not try applying stealth technology to a ship? The Navy began thinking this way in the late 1970s, when the ultra-secret Have Blue, a prototype for the Air Force F-117A, was proving elusive to radar during flight testing at the secure Groom Lake base in Nevada.

The Navy says *Sea Shadow* isn't the first of a new class of ship, but rather was built to test several aspects of maintaining stealthiness at sea, including low radar visibility, quietness to sonar sensors, and minimizing wake.

Sea Shadow's resemblance to the Black Jet used successfully in the Persian Gulf war is no coincidence. The two shapes are products of Lockheed Corp.'s Advanced Development Projects organization, also known as the Skunk Works. The Skunk Works applied its expertise in reducing radar signatures, then passed the project to the company's Missiles and Space division, which engineered and quietly constructed the craft inside the Hughes Mining Barge moored at Redwood City in the San Francisco Bay area.

Ballast tanks aboard the seagoing barge can be flooded, lowering the interior floor level until the stealth ship is afloat on its twin pontoons. The barge itself has an exotic history. It was used 20 years ago to conceal Lockheed's fabrication of a giant claw used by the ship *Glomar Explorer* in a CIA-funded project to retrieve a Soviet submarine sunk in waters 17,000 feet deep off Hawaii.

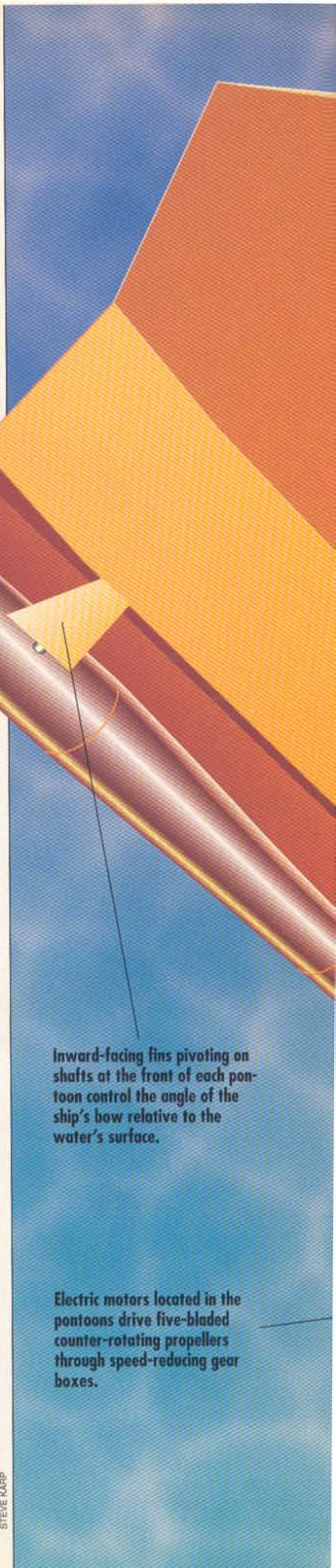
From the waterline down, *Sea Shadow's* appearance—details of which are classified—changes dramatically. The black ship's underwater shape is a SWATH (small waterplane-area twin hull) design. Modern SWATH technology was first developed in 1970 by Navy researchers, including Dr. Thomas Lang ["Dr. Lang's Amazing SWATH Boat," April '91], who was then head of the advanced concepts group at the Naval Ocean Systems Center in San Diego. The Navy's experience with its 1973 SWATH test ship SSP *Kaimalino* proved the hull-shaping technique to be low in drag and the most stable configuration known in rough seas. Further, noisy propulsion system components can be situated in places where their sound can be muffled.

A pair of submerged pontoons gives a SWATH ship its buoyancy. Running beneath the water's choppy surface layer, the pontoons cause far less of the seasickness-inspiring vertical motion inherent in traditional hull designs. The pair of thin struts connecting a SWATH ship's upper hull to the pontoons also have minimal waterplane, or cross-sectional area, and thus are little affected by waves at the surface. The underside of the cargo-carrying part of the ship actually rides well above the water.

Like a railroad locomotive, *Sea Shadow* uses diesel-electric propulsion. Its diesel engines are located in the upper hull and drive electric generators. Cables carry the current to a pair of quiet electric motors housed in the submerged pontoons, greatly reducing the ship's sonar signature.

Careful shaping of the pontoons and the counter-rotating propellers helps reduce drag and wake. Wake is a serious concern; even a wake invisible to the naked eye can appear as a bright trace trailing far behind a ship to a satellite equipped with synthetic aperture radar or with infrared sensors looking for the tiny local water temperature differences present in a churning wake.

One key wake-reduction method used in *Sea Shadow* is also applied to cutting drag in supersonic aircraft. By giving the ship's pontoon-supporting

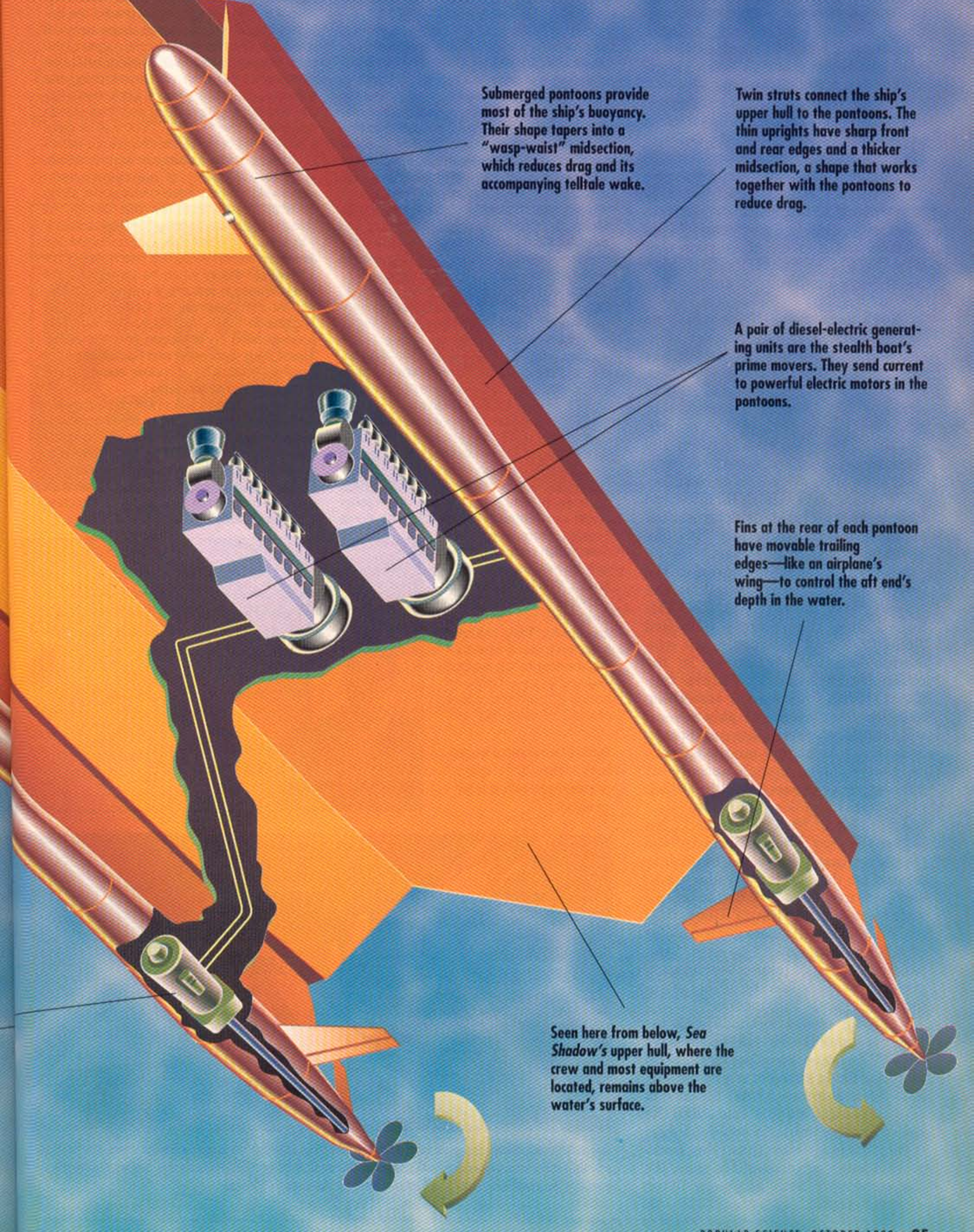


Inward-facing fins pivoting on shafts at the front of each pontoon control the angle of the ship's bow relative to the water's surface.

Electric motors located in the pontoons drive five-bladed counter-rotating propellers through speed-reducing gear boxes.

STEVE KARP

LIFTING THE VEIL ON *SEA SHADOW*



struts thick middles and thin front and rear edges and by pinching the centers of the pontoons in a "Coke bottle," or wasp-waist shape, cross-sectional area is kept nearly constant from stern to bow. The result is a great reduction in drag and in noise associated with a turbulent wake.

Another wake-reduction trick is using water-jet propulsion instead of propellers, as the Swedish Defense Material Administration has done in its Smyge ("stealthy") experimental naval vessel ["What's New," Oct. '91]. A hovering catamaran, or surface-effect ship, Smyge is currently being used to test a range of systems that may be placed in future Swedish Royal Navy small combat craft.

What to do with the lessons learned in the *Sea Shadow* project? The Navy says it has already reduced the radar cross section of the new *Arleigh Burke* class of destroyers by angling the surface of its tall superstructure inward. Warship designers had traditionally paid no attention to radar visibility. "Any type of ship is a very high reflector of radar," says Ben R. Rich, retired Skunk Works president, who worked on the *Sea Shadow* project. "It's like about 50 barns."

SWATH refinements proven in the program were incorporated in the Navy's first operational SWATH-hulled ship, the recently launched *Tagos-19*, a craft designed to tow submarine-detecting instruments in the rough North Atlantic. Future full-blown stealth ships looking something like *Sea Shadow* might play several roles in sea warfare. They could make undetected nighttime missile attacks on enemy fleets, launch antiaircraft missiles, or even carry stealthy attack helicopters in on-board hangars.

According to Rich, when Lockheed began the *Sea Shadow* project, the team discovered that scant basic data existed on the subject of radar in an ocean environment. "We had to build a radar facility on Santa Cruz that could measure the background noise of different sea states," he says. "And we built a little lake—a swimming pool—so we could see the effects of angularity on scale ship models."

Applying stealth methods with too heavy a hand can be dangerous, says Rich. "The ocean wave peaks show up on radar like a string of tracer bullets. And if the ship has a total absence of return, you get a blank spot—like the hole in a doughnut. So you don't ever want to be quieter than the background noise, or you could be seen. It's the same way with airplanes flying over the ground." PS

STEALTH'S RUSSIAN CONNECTION

The radars a stealth ship must elude typically emanate from hostile ships on the horizon. Designers at Lockheed Corp.'s Skunk Works carefully angled *Sea Shadow's* 11 external facets to send radar anywhere but back where it came from.

The tough part, however, was taming the unruly behavior of microwaves entering the archway beneath the ship, according to Ben R. Rich, who worked on the *Sea Shadow* project. "The biggest concern was the bounce effect of multiple reflections inside that cavity," says the now-retired Skunk Works head. "The water surface is a good reflector, and the radar wants to go forward and even out the back." The solution lay in a combination of careful surface contouring and the application of radar-absorbing coatings.

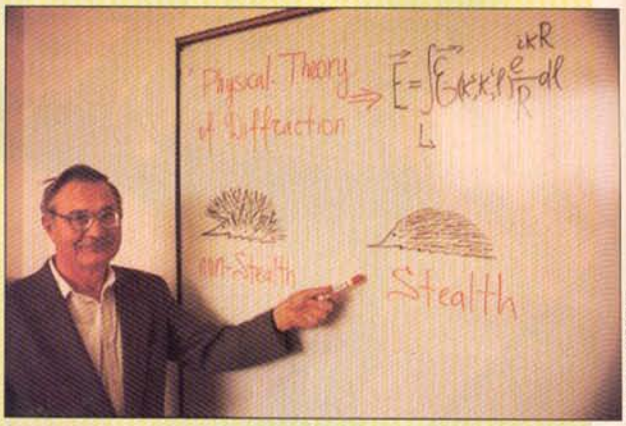
Lockheed has a software program called Echo for calculating radar reflection angles—and therefore the shapes required to manipulate them. Echo was critical to the shaping of *Sea Shadow* and the F-117A. Much of the software's computational clout came from an unwitting and unlikely source: the former Soviet Union.

In 1962, Russian physicist Pyotr Ufimtsev published a book that described algorithms he developed after becoming interested in airport safety problems caused by misleading radar reflections from nearby objects such as buildings. Eventually, the monograph was translated by the U.S. Air Force Foreign Technology Division, which concerns itself with tracking enemy technology. When engineers at Lockheed and Northrop Corp. tried out Ufimtsev's algorithms, they realized they had found a time-saving shortcut to the tedious trial-and-error process of building detailed scale models of airplanes and physically measuring their radar reflectivity.

Now they could accurately predict the behavior of a two-dimensional shape before it was built. The two-dimensional nature of the math is exemplified in the triangulated, flat surfaces of the craft developed using the software. Says Alan Brown, Lockheed's former director of engineering and chief stealth designer on the F-117A: "Pyotr's work gave a substantial boost to the company's efforts to analyze radar signatures mathematically." The availability of supercomputers, along with refined three-dimensional Echo software, now enables the design of stealthy shapes with compounded contours.

Ironically, Ufimtsev was unaware of the use American stealth designers had made of his 30-year-old theory when he traveled to the United States to assume a visiting professorship at the University of California at Los Angeles in 1991. At UCLA, Ufimtsev has been working on a second concept, called "Black Body Scattering and Radiolocation of Invisible Objects," that makes some people in the stealth field nervous.

Ufimtsev believes a phenomenon exists called shadow radiation, an electromagnetic scattering that occurs behind a stealthy object being illuminated by radar. Multiple, or bistatic, radar receiver antennas located on the ground or on satellites might succeed in picking up this shadow radiation and thereby negate stealth.—*S. F. B.*



Pyotr Ufimtsev uses hedgehogs to show how "spines," or radar rays, reflect from an object.

Specialized equations are used to predict the direction in which an incoming radar wave's reflected main spike and secondary backscatter will travel. A balanced stealth design angles the craft's surfaces to avoid any strong reflections back to the radar's source.