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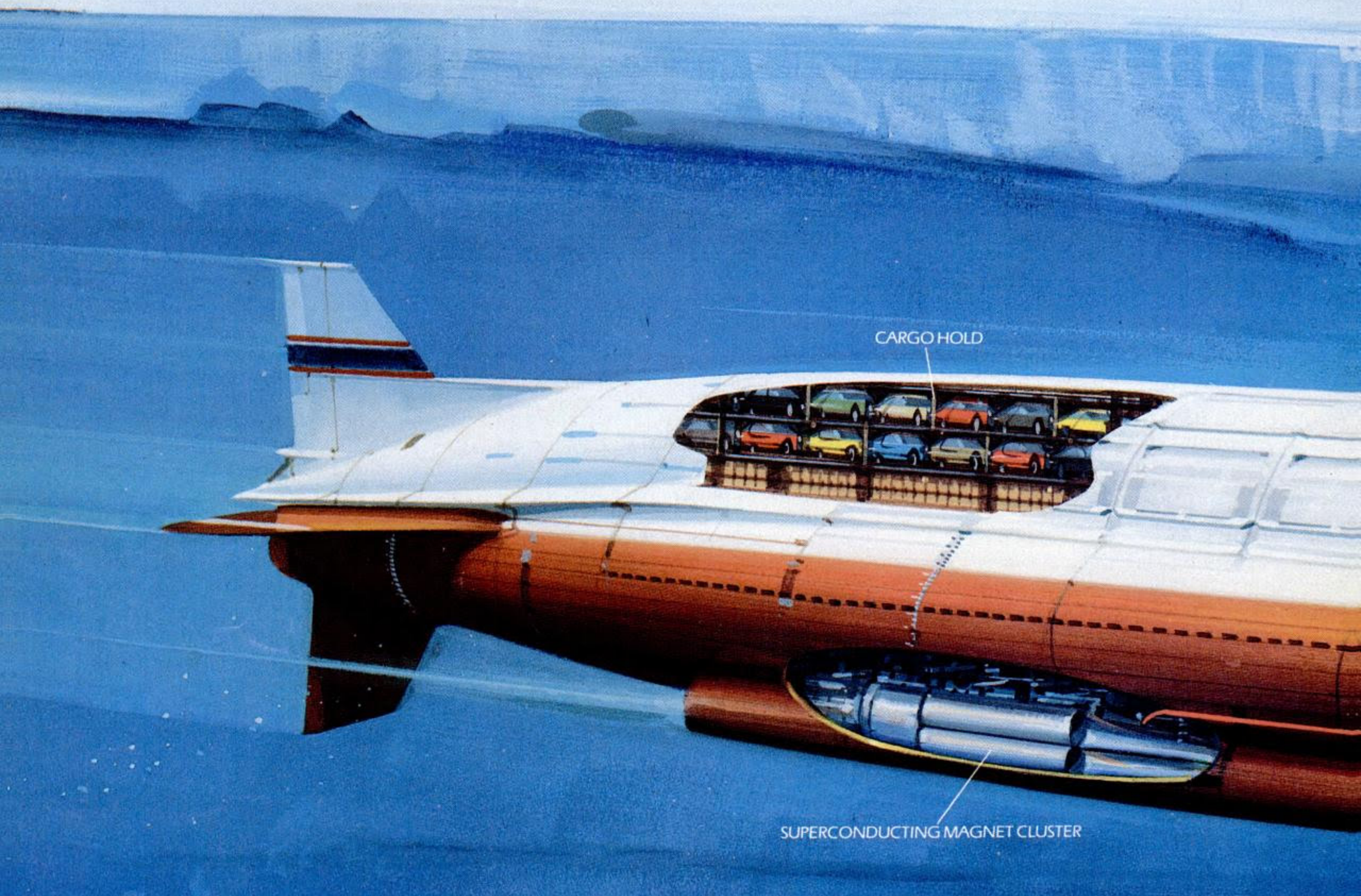
JET SHIPS

By replacing propellers with superconducting magnets, jet ships may one day ply the seas at 100 knots.

BY ABE DANE, Science/Technology Editor; PM Illustration by John Berkey



A VAST SHAPE darts beneath the polar ice flows, and is gone, as silent as a living creature, but far swifter. Clad in steel, and traveling at over 100 miles per hour, it leaves only a mistlike trail of bubbles in its wake. There are no great screws or turbines churning the water. In fact, there is no sign of any sort of propulsion system at all. Instead, the huge underwater freighter is thrust through the depths by an invisible force generated by water rushing through tubes enclosed in sponsons at the submarine's sides.

Futuristic as it sounds, the force powering this craft is actually so basic it is taught in high school science classes. Called Fleming's Left Hand Rule, this fundamental of electromagnetism states that the confluence of a magnetic field and an electric current passing through a fluid will cause the fluid to be propelled in one direction. It was not until recently, however, that the technologies existed to harness this phenomenon aboard a seagoing vessel. Now, in laboratories in Japan and the United States, systems known as magnetohydrodynamic (MHD) drive units are putting the Left Hand Rule to work in small models and experimental flow loops. The military is rumored to have been pursuing MHD research for years, to the point where an MHD drive played a key role in "The Hunt For Red October," a movie produced with unprecedented U.S. Navy cooperation and based on Tom Clancy's meticulously researched novel.

Japanese superships

Although the concept was first put forth in a 1961 patent by American scientist W.A. Rice, it is the Japanese who have made the greatest strides toward producing a practical MHD drive in the nonclassified world. A $40-million program funded by the Japanese Foundation for

Based on a JAFSA concept, a future subsea freighter carries cars from Japan to Europe under the polar ice cap.

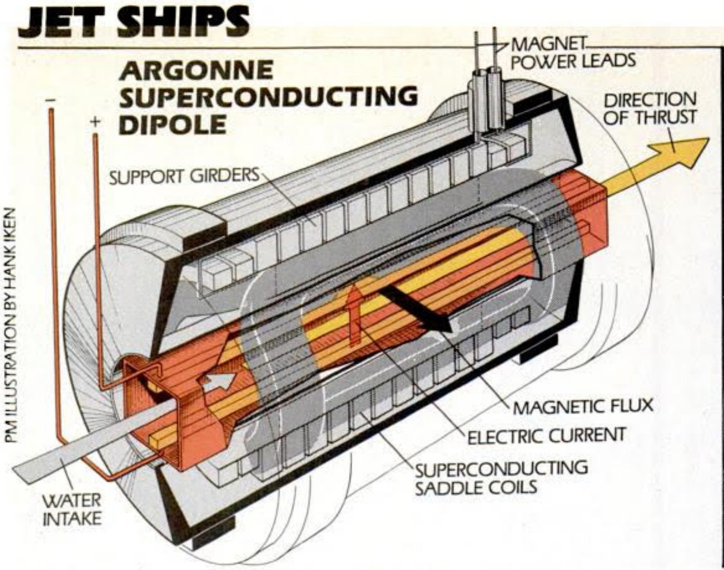
Shipbuilding Advancement (JAFSA) has produced a fully operational model 2 meters long. And this summer, they plan to launch a 150-ton, 90-ft.-long seagoing vessel called the *Yamato-1*.

Although this early design is expected to be capable of only 8 knots, and with relatively poor efficiency, MHD has the potential to excel in both these areas. "We don't have to worry about cavitation of propellers with the MHD system. Therefore, there is no limit on speed," says Dr. Michael Petrick, who oversees MHD research at the Argonne National Laboratory in Illinois. The Japanese predict MHD vessels will one day be able to travel from Yokohama to San Francisco in three days. Efficiency is potentially very high as well, increasing in proportion to the square of the intensity of the magnetic field. Thus, the success of MHD depends on the development of extremely powerful magnets light enough to be carried aboard a ship.

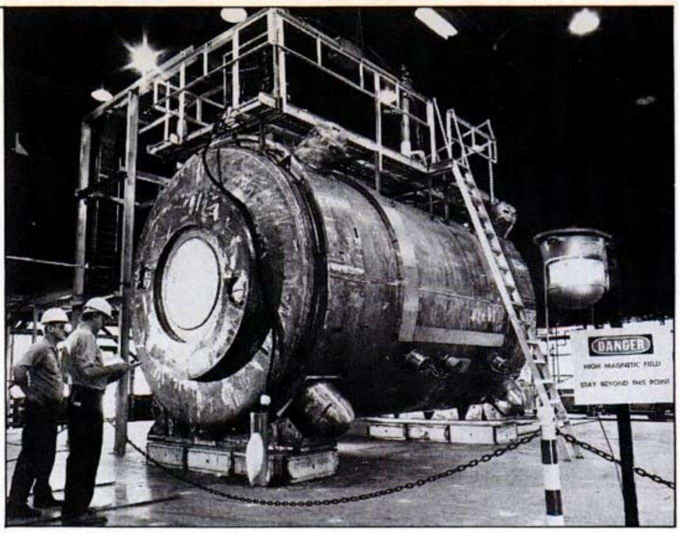
Progress in this area has surged ahead, thanks to improvements in superconducting materials that can be formed into the coils of electromagnets. And a quantum leap in affordability is on the horizon, if a way can be found to use new high-temperature yttrium-barium-copper oxide superconducting materials that could be cooled with liquid nitrogen, instead of expensive and difficult-to-handle liquid helium.

Power packages

As more compact, powerful and efficient magnets become available, the challenge shifts toward integrating them into a complete propulsion plant, incorporating cryostats to keep the magnets at superconducting temperatures, and a power supply to feed the magnets and charge the electrodes that pass the current through seawater. The Japanese have tried two basic approaches. The simplest is to install a powerful superconduct-



PM ILLUSTRATION BY HANK IKEN



ARGONNE NATIONAL LAB PHOTO

Argonne superconducting dipole (right) crisscrosses lines of magnetic flux and electric current to produce thrust (left).

ing magnet pointed straight down through the ship's bottom. Current from electrodes on the hull interacts with the magnetic field in the open water surrounding it. Although simple and efficient, this arrangement would cause tremendous magnetic disturbances that could interfere with sealife and other shipping.

Thus, JAFSA has embraced a more complex approach. *Yamato-1* will be powered by two jet pods slung along the underside of the vessel. Each pod will contain six cylindrical superconducting dipole magnets arranged in a ring around a central support. Water is drawn in through the front of the pod, and propelled through electrically charged ducts running through the center of each magnet, then jetted out the back. Reversing propulsion direction is as simple as reversing the current in the ducts.

Big American magnet

"The Japanese are using smaller magnets, but clustering them like the old days of clustered rockets," says Dr. Petrick. By contrast, the Argonne effort is focused on the largest superconducting dipole magnet in the world. Weighing about 200 tons, the magnet, which was originally built for experiments in electric power generation, is far too large for maritime use. The point of the Argonne research, however, is to learn about the effects of extremely powerful magnetic fields with an eye toward the day when such fields will be available from smaller magnets. "Our program provides an opportunity to leapfrog the Japanese in the scale and magnetic field strength of the MHD experiments," says Dr. Petrick.

Focused as they are on the electromagnetic phenomena at the heart of MHD propulsion, the Argonne team is making no effort to build a complete prototype propulsion system. Instead, they are placing the magnet in a 4-ft.-dia., 60-ft. × 25-ft. water loop—a sort of aquatic dynamometer that will let them scrutinize the magnet's performance in oceanlike conditions, without leaving the lab.

The jet age

If these experiments prove fruitful, Dr. Petrick sees a variety of uses for MHD systems on the horizon. They are already in use as pumping systems for the liquid-metal coolants used in some nuclear reactors. More exciting, of course, is the technology's potential in the area of shipping. Not only is there the advantage of high speed and great efficiency, but the lack of moving parts would also reduce maintenance. What's more, eliminating the need to link the power source with the propulsion system by a shaft or other mechanical means makes radical new hull configurations possible. JAFSA has produced a number of wild-looking concepts, including an airliner-shaped cargo submarine, and small waterplane hull (SWATH) passenger ships that ride on pairs of submerged pods containing MHD drives. Cargo submarines are a particularly intriguing possibility, according to Petrick, "because they would have less drag than surface vessels and could descend to avoid storms. Also, vessels used in marine biological research could benefit from quieter designs that would be less disruptive to sealife."

These and other possibilities continue to spur research that may one day make the propellers as obsolete as they once made the sail. **PM**

Tom Clancy's Caterpillar

"ENGAGE THE caterpillar," says Sean Connery, playing the grizzled veteran of the Soviet submarine corps, who captains the *Red October*. With that, the top-secret Soviet missile sub vanishes from the sonar monitors of the American attack sub *Dallas*, which has been shadowing her a few ship lengths behind.

The caterpillar is an MHD drive system running up the center of *Red October*'s hull, and, like most of the fascinating morsels of technology in the film, it is an idea with at least some basis in reality.

But would an MHD-propelled sub really be undetectable? The short answer is: Probably not.

Capt. James H. Patton Jr., a retired U.S. Navy sub commander who served as a technical consultant during the making of the movie "Red October," says he sees MHD as intriguing, but fraught with problems from a military standpoint. Although an MHD drive system could indeed be very quiet, and, thus, might thwart passive sonar arrays like those aboard American attack subs, the tremendous magnets would produce stray fields that would be relatively easy to pick up. Also, electric current running through the seawater would electrolyze it, producing a traceable trail of gas bubbles, particularly chlorine.

Still, the Navy will follow MHD research with interest. "Any self-respecting naval lab has looked at it," says Patton. "People keep their finger on the pulse." —*A.D.*

PARAMOUNT PICTURES PHOTO

Actor Sean Connery as Capt. Marko Ramius at the con of the *Red October*.