Will Mighty Magnets Protec Voyagers to Planets?

Applying the strange phenomenon of "superconductivity" in space flight promises shields against deadly radiation, gyros without friction, and other innovations in travel beyond the earth

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Frictionless gyros, midget computers, magnetic shields against deadly radiation—these are among the aids to space flight promised by a newly exploited principle known as "superconductivity."

Imagine a wire with zero electrical resistance. A current in an endless loop of it, once started, would flow forever. Coils without resistance might be expected to carry huge currents, and make superpowerful magnets possible.

Actually, many metals' resistance does vanish, at a few degrees above absolute zero. Called superconductivity, this strange phenomenon has been known for 57 years—but, until recently, efforts to apply it in supermagnets failed. As if breaking a spell, a magnetic field destroyed a metal's superconductivity. Then, in the 1960s, metals were found that stayed superconductive even in intense magnetic fields—compounds of the silvery metal niobium with tin, zirconium, or titanium [PS, Mar. '67].

Superconducting magnets of these new materials have reached field strengths of 140,000 gauss, and 300,000 gauss is considered possible. For comparison, strong non-superconductive electromagnets rarely exceed 20,000 gauss. The earth's magnetic field is half a gauss.

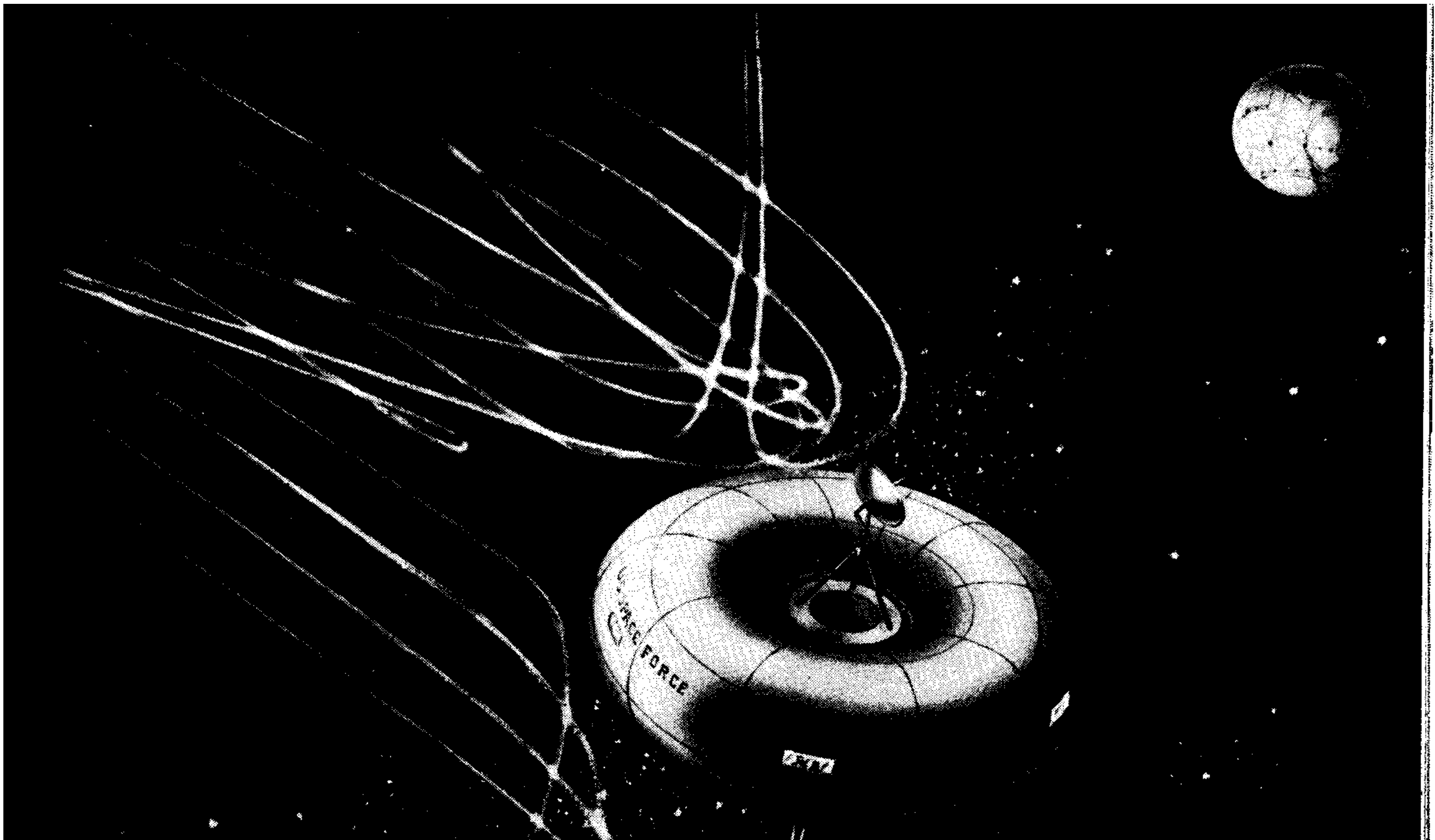
Comparatively light weight and low power needs make the new supermagnets and other superconductive devices attractive for applications in space:

Magnetic shielding. Safeguarding future interplanetary travelers from lethal radiation may well be the biggest-scale and most dramatic use.

Quite modest radiation shielding suffices for space ventures as brief as a week-long round trip to the moon. But a voyage of two or three years—say, to Mars—faces the hazard of "giant" solar flares occurring every few months. They will repeatedly bombard a spaceship with bulletlike protons, having awesome energies up to a billion electron volts. Successive exposures to this radiation could add up to a deadly dose.

We could armor a cabin thickly enough to counter the peril with a shielding material such as carbon, water, aluminum, or polyethylene. But if we do, we find the sheer weight of this "passive" shield one of the biggest items of the load we are trying to rocket to a planet and back. To that discouraging problem, it looks now as if superconductivity offers the answer—"active" shielding.

A magnetic shield, wielding a mighty superconducting magnet, is envisioned in several active-shielding studies made for the Air Force and for NASA. Pictured here is one version, proposed by Dr. Sidney W. Kash and Robert F. Tooper of the IIT Research Institute, Chicago. Built into a doughnut-shaped spaceship is a 50,000-gauss superconducting magnet—a cylindrical solenoid of niobium-tin,



Doughnut-shaped manned spaceship, pictured near Mars, wards off lethal solar protons (curved white trails) with huge built-in magnetic coil (below, left).

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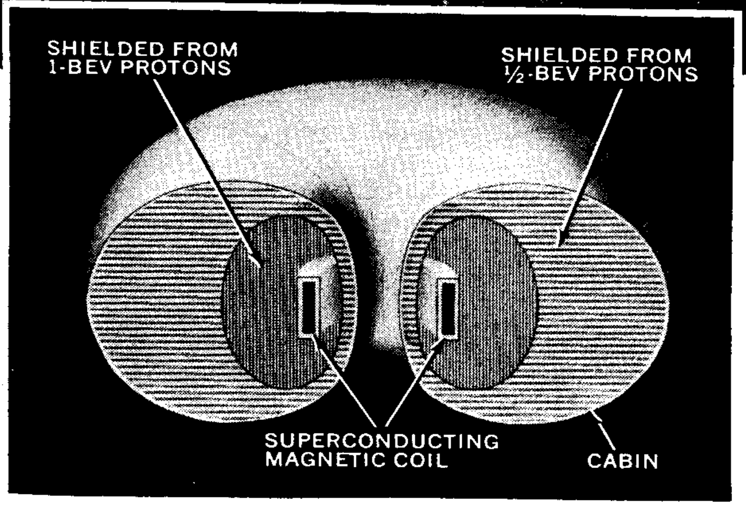
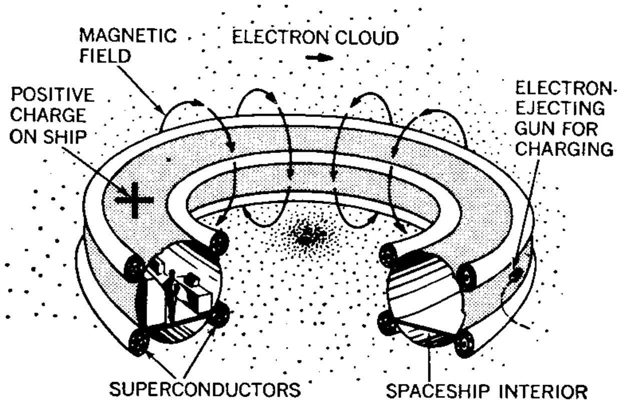


Sectional view shows magnetic shielding of pictured Mars spaceship, as envisioned by IIT Research Institute scientists. Superconductive magnet of 50,000 gauss could shield dark-shaded part of cabin (5,000 cubic feet) from protons with energy as high as one Bev, and rest from lower-energy ones.

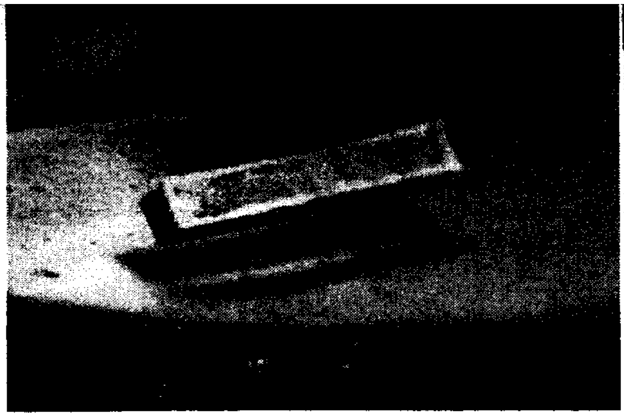


"Plasma shielding," an alternate plan, puts positive electric charge on craft to repel protons—and uses superconductive magnet's field to prevent approach of electrons that would destroy charge.

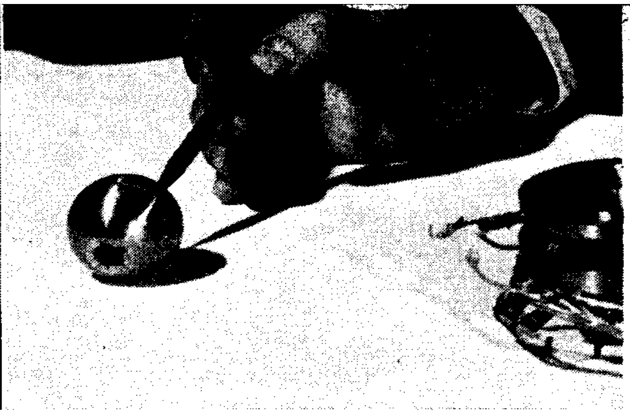
13 feet in diameter, kept chilled by a refrigerating system aboard.

Science-fiction writers are fond of imagining a "force field" that offers an invisible, impassable barrier against some menace. Here would be a real one. The potent magnetic field could deflect and ward off even the one-Bev protons of giant solar flares. In the Kash-Tooper study, the magnetic shielding would weigh about 10,000 pounds—compared to a million pounds of passive shielding, for equal protection.

The huge amount of energy stored in



"Levitation" is demonstrated by small bar magnet floating above superconductive lead dish, at NASA's Lewis Research Center in Cleveland, where much of NASA's advanced magnetics research is under way.



Gyro applies superconductivity. Golfball-size rotor of this experimental General Electric gyro spins without friction, supported solely by a magnetic field in a housing partly seen at far right.

a magnetic shield isn't something you put there just by flipping a switch. By one estimate, building it up might take 55 hours, using a 10-kilowatt power source (which the craft could then leave behind). So much energy in a coil could also be a weird hazard. Conceivably it could be disastrously released, melting or vaporizing part of the structure, if an accident destroyed the coil's superconductivity at any point. But designers see a way to play safe, by dividing the coil into many separate circuits.

"Plasma shielding." An alternative plan suggests a form of electrostatic shielding. If a spaceship's exterior could be kept positively charged, at a potential of some 300 million volts, that would repel the positively charged protons.

The catch is that negative-charged electrons in space, irresistibly lured by the positive charge, would flow to the ship and rapidly discharge it. Keeping it charged would therefore take a staggering 10 million kilowatts or so, nearly double the ultimate power of Grand Coulee! But a way around that, again applying superconductivity, is now seen:

Superconducting rings, encircling the ship, would create a magnetic barrier that attracted electrons couldn't cross. Instead, they would orbit around the ship in a cloud or plasma—for all the world like a circling swarm of voracious mosquitoes, eager to "bite" the craft (discharge it) but kept at a distance by its "Citronella" (magnetic field).

This "plasma shielding" should be even more weight-saving than "pure" magnetic shielding, says its proponent, Dr. Richard H. Levy of Avco-Everett Research Laboratory, Everett, Mass. A lower-strength magnetic field, probably less than 3,000 gauss, should prove sufficient.

Superconducting gyros. "Levitation" is made possible by certain superconducting metals' ability to act as a sort of magnetic insulator. They repel a magnetic field in such a way that the force will suspend an object stably in midair. This is strikingly demonstrated when a bar magnet, actually suspended on its own magnetic-field lines, floats above a superconducting lead dish cooled by liquid helium. (See photo.)

This magic-like principle of superconductive suspension has been successfully applied to gyroscopes. The floating gyro rotor, requiring no gimbals, spins without friction in a vacuum. Once brought up to speed, it runs for weeks with no further application of power. No eddy currents are induced in it, since the supporting magnetic field cannot penetrate it. Deflection angles are measured optically.

What results is a gyro many times more accurate than the best conventional ones. Its use may be foreseen, not only for missiles and missile-armed submarines, but also in space vehicles.

Computers for space. The propensity of many superconducting materials to "go normal" (lose their superconductivity) in a magnetic field has one useful and redeeming aspect. It permits their employment as contactless switching devices, called cryotrons. A cryotron consists of a thin-film "gate wire" and a "control wire," both superconductive. Send a current through the control wire, and its magnetic field kills the superconductivity of the gate wire, giving the effect of an on-off switch.

All basic types of electronic computers' circuits can be built from combina-

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Will Magnets Protect Space Voyagers?

[*Continued from page 100*]

tions of these microminiature switching units. The resulting computer, which is kept refrigerated in operation, is reduced to shoebox size and consumes extraordinarily little power—ideal qualities for space use. A cryotron computer and a superconducting gyro and accelerometer could make up a high-precision navigation system to help future astronauts find their way about the solar system.

More space uses for supermagnets. Suggested ways to apply superconducting magnets in space also include these:

- Magnetic docking may offer advantages over mechanical-coupling means.
- Forming a "magnetic window" in the hot plasma around a reentering spacecraft has been proposed, to avoid a communication blackout at that time.
- Magnetic braking could ease *g*-forces and heating during an interplanetary craft's high-speed entry into a planet's atmosphere. For the several minutes of the maneuver, a 10,000-gauss magnet could exert a substantial braking force, against an atmosphere made electrically conductive by the shock wave of entry.
- Ion and plasma space-propulsion engines under development, which use auxiliary magnetic fields, will have their performance improved by superconducting magnets. Ultimately they may draw their electric power from thermonuclear space-power plants, if efforts to harness nuclear fusion for power succeed; and superconducting magnets may aid the promising "magnetic-pinch" approach to that tantalizing goal.

The uncertain factor—man. Before astronauts take long journeys in magnet-using spaceships, we shall want to make sure whether prolonged exposure to intense magnetic fields could do them any harm. If so, we would have to keep the cabin relatively field-free; for magnetic shielding, such designs are available.

So far, not even experimenters with powerful magnets seem to have observed any untoward effects on humans. But more-intensive research, only lately begun with higher animals such as squirrel monkeys, is needed to settle the question beyond doubt. In these trials, superconducting magnets themselves should have an important part. PS