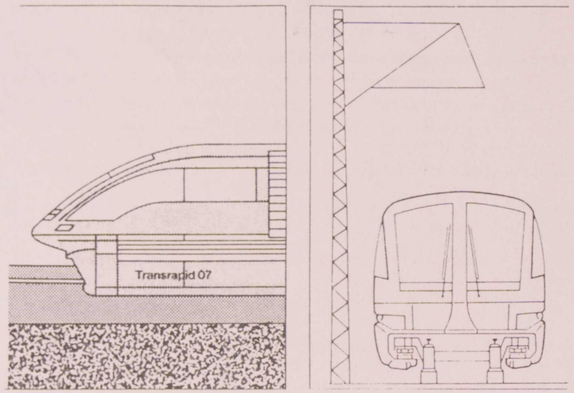


on-board computer. Note the overhead electric line, which has nothing to do with this type of train. However, German research is now sufficiently advanced to test "bivalent" tracks, which allow both maglev and normal electric trains on the same rails. Reliability tests on an experimental track are now in progress and the first pilot route may go into operation this year.

The levitation, then, is brought about magnetically; but what makes the train move forward? The principle of a three-phase motor of the most common type, loftily known as "asynchronous," more popularly as a "squirrel cage" motor. Its rotor has no electrical connections to the outside. The windings are all in the immobile stator, but the three-phase current flowing through them gives rise to a rotating magnetic field: if the rotor were a magnet, it would rotate to align itself with this rotating field.

And if it is not a magnet? It would rotate just the same, because the rotating field would induce currents in it, and currents have magnetic fields, so we have the same phenomenon as before. All you need is a conductor able to rotate on bearings. The simplest way to do that is with two rings joined by parallel bars — like the treadmill captive squirrels run in, hence the name "squirrel cage."

Now suppose the field were not rotating, i.e., reaching a maximum in successive coils placed round a rotor, but moving forward in a straight line, i.e. reaching a maximum in successive coils placed along a straight track. Then the magnet (or squirrel cage), barring other restraints, would chase after the magnetic field just as before, except that it would move forward rather than rotate. The arrangement, for reasons that should now be evident, is called a linear motor, and I would guess that is what is used in dog racing: the forward moving magnetic field attracts the hare, and the hare attracts the dogs; what attracts the spectators I have never fully understood.

There is a number of advantages in this type of train: it is noiseless, even when braking; it consumes less energy than orthodox electric trains at high speeds; and the absence of moving parts promises to make it easy to maintain. But the main advantage is speed.

Who needs it? The passengers of an air transportation system with ever more crowded airports, ever longer delays, and ever slower net speeds — if you include the time to and from the airport in making the calculation.

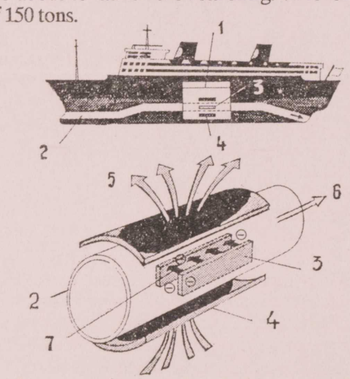
[*Source:* The German parts of the story come from *BMFT Journal,* a newsletter published by the W. German Federal Ministry of Research & Technology. It has not only brief news stories, but its pages also crawl with delightful monsters like the noun *Einsatzreifenachweis* (proof of maturity for deployment) or the

UNUSUAL TRANSPORTATION II

Squirrel cage or not, *all* electric motors work on the same principle: a force acts on a conductor when it is carrying a current through a magnetic field. (There are some other conditions, but I have embezzled them.)

Normally we think of conductors as pieces of metal such as wires, but anything that conducts a current (a flow of electrons) will do: a stream of water, for example. Water is not a terribly good conductor; in fact, unbeknownst to most people, distilled water (pure H_2O) is an insulator that does not conduct at all until one puts the slightest amount of impurities in it. Even sea water has a conductivity some ten million times lower than copper, and fresh water is another 100 times worse than that. Nevertheless, watery liquids do conduct, and I am reminded of a Czech worker in WWII who tried to sabotage a generator meant for the *Wehrmacht* by urinating into it, but was electrocuted instantly.

Could you not have a ship with a magnetic field, taking in water, passing a current through it, and have the resulting force expel it, propelling the ship by a water jet just like a plane is propelled by a gas jet? At least two countries, to my knowledge, are trying to do just that: the USSR and Japan. As you would expect, the Russians have a model in a pool (moving at 4.4 mph or about 3.5 knots), and the Japanese are about to launch the real thing: 72 ft long with a displacement of 150 tons.



I rely on a Soviet report (*Sotsialistich. industriya*, 2/25/88) and their picture, in which *2* is one of several channels taking in the water and accelerating it to be spewed out aft. The enclosure *1* is filled with liquid helium to make the windings *4* supplying the magnetic field (vertical arrows) superconductive. A current *7* flows from one electrode *3* to the other through the water, which will make it move in the direction *6*.

The Japanese call the vessel "Ship of Hope." The hope is that it will be more reliable than propulsion systems with moving parts, but mainly that fuel consumption (for generating the currents) will decline by no less than 40%.

UNUSUAL TRANSPORTATION III

The third item comes from Canada. It is an unmanned, propeller-driven plane with an electric motor for flight in the high atmosphere intended to take the place of far more expensive satellites in the fields of communication, broadcasting, crop and forestry monitoring, intelligence gathering, etc.

It has a wingspan of 15 ft, yet weighs only 11 lbs, for it does not need any fuel: the energy is beamed up from earth by microwaves and converted to electricity by "rectantennas" on a disc attached to the fuselage and on the wings. Rectantennas are plastic films incorporating semiconductors that will rectify (let flow only one way) the high-frequency currents induced by the microwaves incident on them. They thus convert electromagnetic waves directly into DC electricity to run the motor.

The first model flew last September for 20 minutes. (The launch was delayed for some weeks by a mouse that chewed up the balsawood frame.) The full-scale model, to be launched this year, will have a wingspan of 118 ft and will be able to fly for months at a time.

The idea of using radio waves to transmit power, not just signals, is one that has fascinated many scientists, including Nikola Tesla, ever since Heinrich Hertz discovered electromagnetic waves just one hundred years ago this month. The dream is now coming true due to lightweight materials and semiconductors; in the realm of light (identical with radio waves in everything but wavelength) the idea has already been realized, and may yet make freedom survive as a missile-destroyer in an American space shield.

What I find technically most interesting in the Canadian project is the absence of photoelectric solar cells to do the job with "free" energy. They are too expensive, too heavy, too inefficient and incapable of storage The overall efficiency of the microwave system — 6-8 kW on earth to deliver 150 W to the motor — is a ridiculous 2%, perhaps the poorest in all technology (even light bulbs have 3 to 5%). But the source is in human hands and we can double the delivered power by doubling the input; we do not have to rely on the dilute, diurnally variable, and unalterable flow from the sun.

In fact, the power density in the beam is 400 W/m^2, about 1/3 of the *total* solar power flux (at local noon), which is minute in the microwave band. (It was kept to this low value by sham-environmentalist fears about birds flying into the beam.) But the lousiest man-made efficiency in the world is still preferable to solar cells — not to mention the fact that the constraints on power density in the beam are purely political, with no relevant limits set by technology. Even under these constraints you could not do as well with the solar flux: you need a new sun — and one that shines at midnight. [*More:* "Beamed-power propulsion," *Amer. Scientist*, Mar/Apr. 1988.]

Meanwhile ARCO is rumored to have a 100 kW microwave-supplied reconnaisance in development.

Now to another aspect of robot planes. In a letter of fundamental importance (*Wall St. J.* 3/11, see also *Wash. Times* 4/7), physicist Jay Lubkin points out that NATO does have a weapon with which to counter the Soviets' overwhelming conventional might: "Remotely Piloted Vehicles" (RVPs, pilotless aircraft) that can destroy a comparatively small number of bridges and other choke points in Eastern Europe and cause a gridlock that would leave Soviet logistics in shambles. But since the treaty of Incredible Nevillesque Folly (INF) bans missiles (and air vehicles?) "capable of carrying nuclear weapons," it is possible that Neville Shultz will kill even this possibility along with the cruise missile.

SUPERCONDUCTIVITY: WHEN?

The windings of the Japanese electromagnets are submerged in liquid helium to avoid heating losses by making them superconductive. But now that the nitrogen barrier has been broken, why not use nitrogen, which is cheaper and easier to handle, and will make some materials superconductive at a "warm" 90°K?

Because the new materials are mostly ceramics which are brittle instead of malleable like copper, and because they lose their superconducting properties under relatively small current densities; and what little progress has been made to improve their properties (which are now inferior to conventional conductors in practically every aspect except superconductivity at low temperatures) has been achieved in particular laboratory samples by methods that do not yet translate into bulk production.

This is the reason why the nitrogen barrier has not yet been broken for applications like electromagnets; but there are other applicarions which may never profit from superconductivity even if the present difficulties are overcome. There are, for example, some industrial motors that run at an efficiency close to 98%, and it is unlikely that they will ever be immersed in anything for the extra 2%. Similarly, the costs of underground transmission lines immersed in liquid nitrogen are enormous; but the cost of transmission amounts to only about 15% of the total cost of electricity.

Science (4/1/88) and the popular press are now discovering these obstacles and limitations. Why did they not warn us a year ago, or when the Nobel Prizes were handed out?

Because they don't subscribe to an obscure little pink sheet out of Boulder, Colo [AtE May 87].

CORNY PORK AND ANTHRACITE

The administration of Jimmy Reagan the Weak-Kneed appears to be running out of issues on which to capitulate It has now given in even to Rep. R.J. Durbin (D-Ill.), who is rolling the big barrel of pork for corn growers, proposing even greater subsidies for making ethanol. Not satisfied with the present tax exemption, Durbin's bill, paradoxically attached to the Deficit Reduction Act, would require at least half of all gasoline sold in the US to contain 10% ethanol (made from corn). The bill is supported by 60 other congressmen, and the Congressional Research Service obediently came up with a report explaining its marvelous benefits ("grain consumption would increase. . . prices for most major farm products would rise. . .").

The minor flaws are that ethanol does *not* decrease CO and NOx emissions (except possibly at high altitudes), and it may well *increase* ozone emissions; the (doubtful) savings by reducing the subsidy could be achieved and surpassed by simply abolishing the subsidy; the costs (said the USDA as late as December) "are so large that ethanol production cannot be justified on economic grounds even if existing producers could get by with present subsidies;" and others. The major flaw is that if ethanol as an additive were all that good, it would not need to be forced on motorists by government guns, least of all by those of a government that beats itself in the breast about free markets.

But if the administration seeks further issues with which to ingratiate itself with the media, it must have noted a proposal made on March 18 by Rep. Gejdenson (D-Conn, pron. Gee-he's-dum) and Sharp (D-Ind.). They would impose mandatory efficiency standards on fluorescent light starters, forcing producers to use either copper wire and steel cores or solid state circuitry.

What are starters for, what are they made of now, and what difference would that make?

None of your business, you impudent rebel. The Hon. legislators have determined that this measure would save 7,000 MW and $21 billion in avoided power plant construction by the year 2,000, "the equivalent of 15 large coal plants or 7 nuclear plants." Are you suggesting that the consumer vote with his dollars for what suits him best, instead of having the politicians determine what is good for you and throwing the law at you when you think otherwise?

In checking the Hon. G & S arithmetic, I cannot get further than the equivalence of 14 coal-fired and 7 nuclear plants: I live between a nuclear plant of 300 MW and a coal-fired plant of several units with 1,200 MW each. I would nevertheless venture to guess that the calculation rates between absurd and insane. The real difference in efficiency (which is still no reason to use force) is between a light bulb (5%) and a fluorescent light (40%), even with a starter of a type to be outlawed by the Hon. G & S. I am reminded of a bright brain in Czechoslovakia who took the statistics of thick fog occurrences and calculated the millions saved to the Socialist Motherland by fitting all moving equipment in strip mines, hitherto idled by fogs, with infrared snooperscopes. The Socialist Motherland had no snooperscopes and the project was never realized, but the bureaucrats could find nothing wrong with the arithmetic, and the man collected the reward given for such patriotic proposals.

And there is more in the energy province of Pork Barrel Land. If the Hon. Patricia Schroeder claims the Pentagon is procuring $1,000 toilet seats, she is not in error: she is lying. The sum was paid for a toilet seat *mold* (with which to manufacture thousands of plastic toilet seats) and the price is not out of line. On the other hand, the Pentagon is buying 300,000 tons of high-grade coal (anthracite) in order to spread it 20 ft high over 45 acres. This should please Lovins, Nader and the Alliance to Conserve Energy, for it is a resource that will not be used: the Pentagon has coal coming out of its ears.

It is buying the stuff because Congress so decreed to please the Coal Lobby. Back in 1962, the upright reps from Pennsylvania's coal country persuaded Congress to make US bases in Germany burn no other but US coal, and it was carried across the Atlantic, if not to Newcastle, then at least to the Ruhr. By 1985 the coal-fired pollution by US bases, aptly exploited by the Greens, had become a major