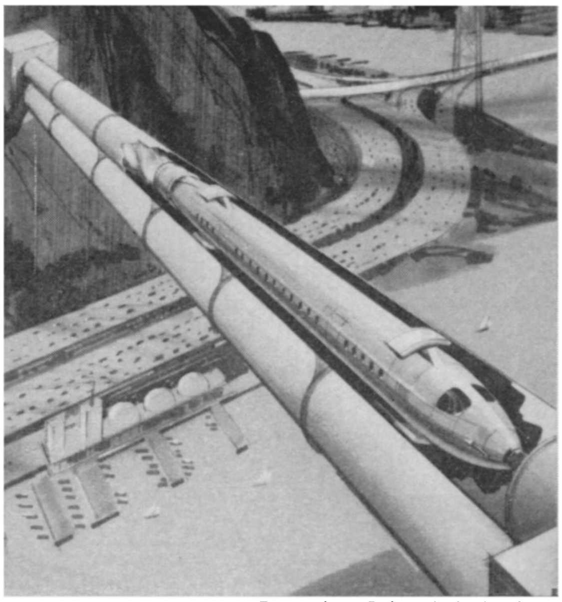

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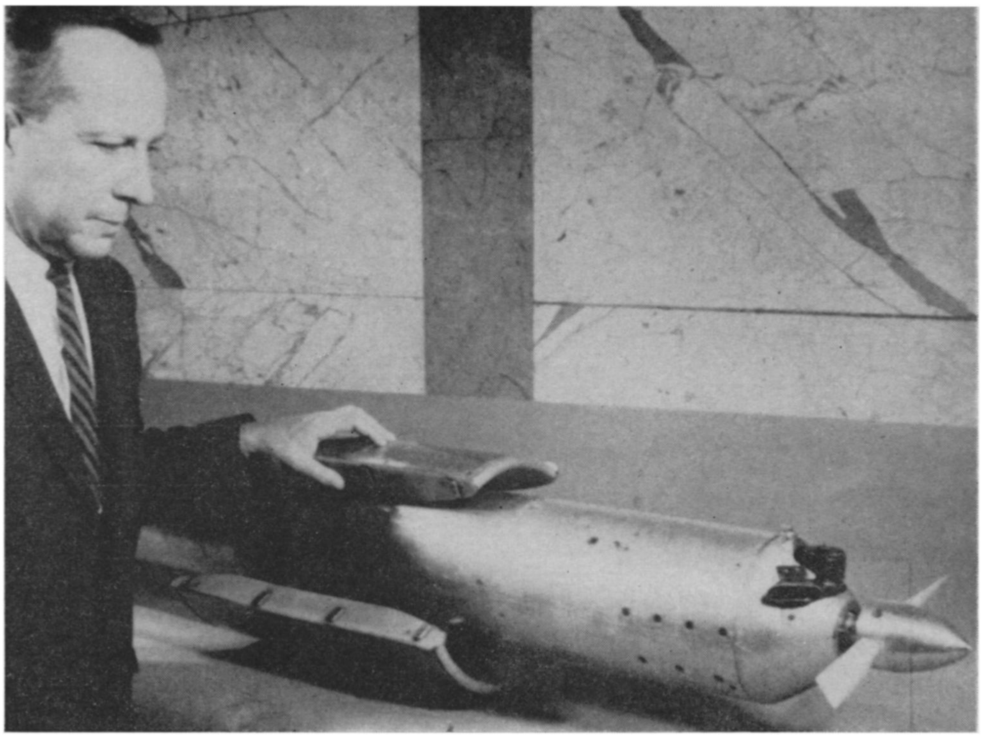
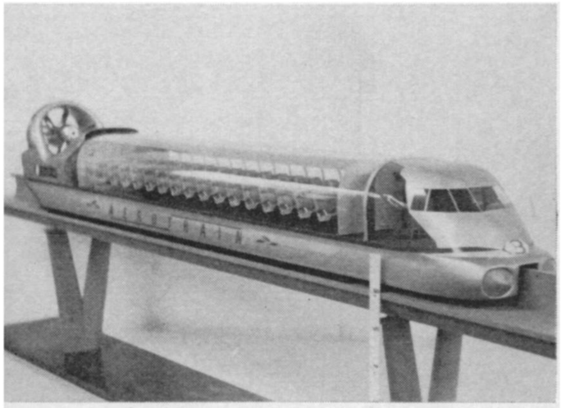
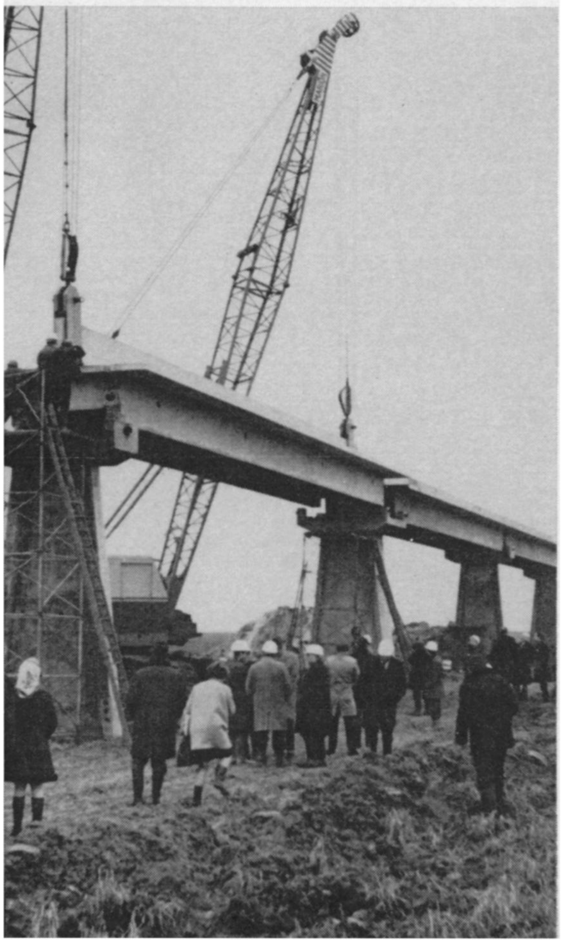


Tubeflight: transit via tube (top). Dr. Foa and tubeflight model. Model of French Aerotrain (below) and in construction.





TRANSPORTATION

Trains without wheels

Using the power of air and magnetism, engineers hope to create a new breed of superspeed train

by Edward Gross

If they could eliminate the friction of steel wheels against steel rails, engineers would have overcome the main reason planes go faster than trains. They would also have solved the alignment and vibration problems caused by rails and wheels that presently limit a train's speed to about 200 miles per hour.

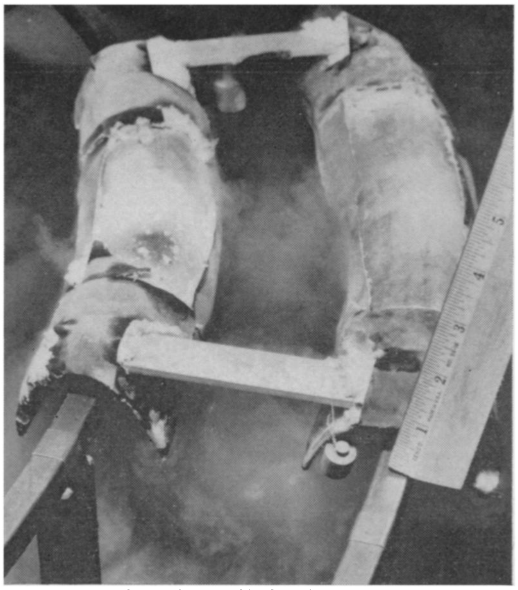
Such trains are already on the drawing boards and in experimental models, many with neither wheels nor rails.

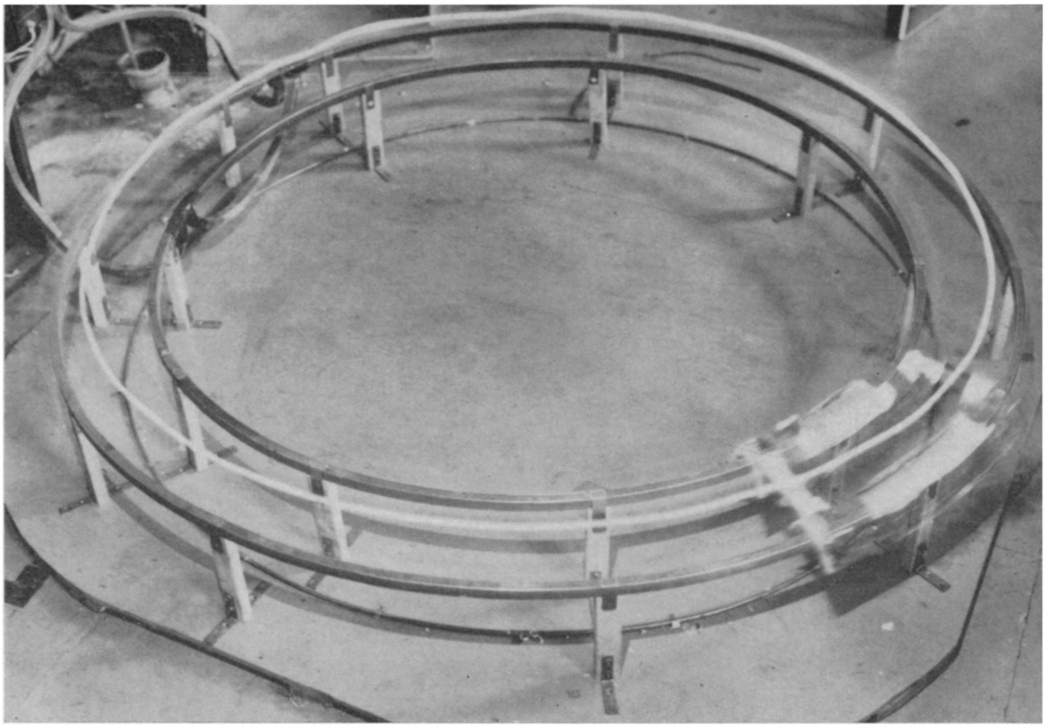
The Japanese are trying to overcome the friction barrier with rollers and by shaping the train like an airfoil (SN: 7/6, p. 10). But engineers in the U.S. and in Europe are working on suspending trains on a cushion of air and flying them over the ground at high subsonic speeds. By using this concept, present technology could push a Tracked Air Cushion Vehicle (TACV) at 400 miles per hour. A train suspended by magnetic forces might do as well. But so far, it is not being as well accepted.

Riding on a cushion of air is not new: In France, the scheme goes back to 1860, when Louis Girard conceived of an air-supported train. Air compressors were inefficient then, but by squirting water under a vehicle in place of air, Girard carried passengers 800 miles during the Paris World's Fair in 1889.

France's Aerotrain Company will soon be testing an 80-passenger vehicle based on the principle. Its one car will cruise at 155 miles per hour with a top speed of about 185 miles per hour. The Aerotrain, like all TACV's, eliminates the need for a heavy chassis because the weight is evenly distributed on air rather than concentrated on two points. A conventional railroad car supports its weight on a pair of undercarriage structures called bogeys, to which the suspensions and wheels are mounted.

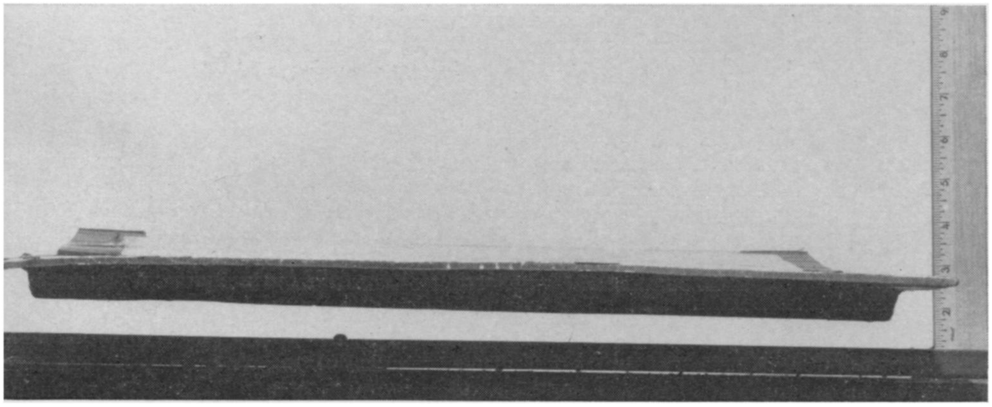
The French Aerotrain straddles an inverted T-bar, the bar fitting into a longitudinal slot in the train's underside. Cushions of air compressed by fans from a 720-horsepower aircraft turbine prevent the car from touching either the wall it straddles or the flat surface over which it rides. Rubber skirts on the sides of the car stabilize it. If the car rocks or slips to the side, air leaks out from under the skirt on one side, reducing the pressure there. The





Brookhaven National Laboratory

Magnetically suspended model (top) and time exposure of it in motion. Illustration of principle (below).



greater pressure on the other side then stabilizes the car.

A four-passenger version has attained speeds of 125 miles per hour with its turboprop engines and 180 miles per hour with rocket boosters, while a two-passenger vehicle has reached 250 miles an hour. Plans have been approved and construction started on a 12-mile test track between Orleans and Paris. As with all turbine and piston TACV's, the Aerotrain has a noise problem from its engines and a sway problem from the wind. Its high-speed mechanical problems have yet to be fully determined.

Across the channel, the British have been researching a tracked hovercraft based on the same principles as their cross-channel hovercraft. A small-scale model has been constructed so far. The vehicle would be suspended over a box-shaped track and have skirts hanging over the sides to seal its supporting air cushions.

In the U.S., the Department of Transportation is awarding contracts to domestic and foreign companies and universities to come up with a design for a 300-mile-per-hour TACV. Contracts with Grumman Aircraft Engineering Corporation and General Electric Company call for a single TACV by 1971. In this design, air pumps first suck air into an intake opening at the top rear of the vehicle. The air is compressed and forced through tubes along the body of the car. This high-pressure air is then forced out to lift the TACV off the ground. Turbojet engines propel the train, which is held in place by two cushions of air directed against the sides of a trough under the train.

An alternate to an air cushion suspension, but one which hasn't gained support at DOT, is a magnetically levitated vehicle (SN: 12/30/67, p. 637). Drs. James R. Powell and Gordon R. Danby of Brookhaven National Laboratory in Upton, N.Y., want to use the power of the repulsive forces generated by electromagnetic waves acting on a wire coil to keep a 150-passenger car suspended above a track consisting of two parallel rows of separate aluminum loops. Superconducting magnets in the form of loops in the underside of the train induce enough repulsive electromagnetic force in the aluminum track loops to keep a 70,000-pound car 6 to 12 inches above the ground.

An important requirement of such a train is self-stabilization. Under every track loop would be a loop which carries no current when the train is in a stable position. If the train deviates horizontally, because of wind for example, the superconducting loops of the train will induce a current in the stabilizing loops, which produce a force counter to the direction of deviation to push the train back to its original position. Despite the optimism of its developers, it was largely because of its inherent instability that DOT decided not to fund the magnetic system.

Says Dr. Powell, "If a ground system is economically attractive, the choice of which TACV or magnetic suspension is used will depend primarily on technical factors. We feel that magnetic suspensions will be very attractive because of their very strong inherent stability, smoothness of ride, lack of noise, ability to travel both in air and in low drag vacuum tunnels, and very reliable because of independent, multicircuit design."

Superconducting magnets are used because conventional electromagnets would have to be extremely heavy to generate the required forces. Superconductors have zero electrical resistance and can carry large amounts of current without power loss. However, since superconductors operate at extreme cold, a liquid helium refrigerator is required to cool the superconducting coils. Wheels would also be needed for stopping and starting. Train propulsion would be by magnetic interaction between the superconducting loops and track current loops supplied by a power line along the track.

Another advanced idea is pipeline travel, being pursued at Rensselaer Polytechnic Institute, with backing from

. . . Flying trains

the Department of Transportation and the Army. Called Project Tubeflight and headed by Prof. Joseph V. Foa, it employs jets to propel the vehicle. In addition, once the train is in motion, air is forced into scoops at the rear and ejected through angled nozzles that set it swirling like the blades of a propeller. The resulting vortex continuously pulls air from in front of the train between the tunnel walls and the train's sides, reducing the air pressure ahead of the train and improving the efficiency of the system.

In the tubeflight system, cruising speeds of 300 to 400 miles per hour are practical over runs of 25 to 250 miles, according to the Rensselaer researchers. Such a system could carry 10,000 to 12,000 passengers an hour per tube. According to Prof. Foa, the system, which could easily be automated, would be "far safer and more dependable than any existing mode of transportation."

He sees the tubeflight trains eventually hitting supersonic speeds of 1,500 to 2,000 miles per hour. Acceleration to these speeds would be made possible by a special guideway design and might be aided by linear induction motors, electromagnetic devices consisting of wound stator poles on the tube walls. A continuously reversing polarity generates a moving magnetic field, driving a metal plate on the vehicle.

The RPI researchers maintain that power requirements for supersonic flight with such a tube train are less than those for an airplane because the train has no fuel reserves or wing drag.

Work is being done at RPI to supply electric power to the train by transmitting it at microwave frequencies. The tube itself would act as a waveguide to keep the energy from being radiated outward and lost. The microwaves would be received by on-board antennas and fed to the motors driving the jet compressors.

"Tubeflight trains will probably replace most short-haul means of transportation between cities," says Prof. Foa. "They will make things better for airlines because they will permit relocation of the airports to safer locations and will relieve the congestion of the airways, thereby making air travel more attractive."

The big hold-up to a completed TACV or magnetic suspension system is the financial go-ahead, comments Dr. Powell. "Once a firm decision is made to build a system, I don't think it would be more than 10 years before you see high-speed ground transport systems. Those things which will determine which system is used are factors such as safety and consumer acceptability." ◇