German industry tests 'super-train'

William Engdahl reports from Wiesbaden on the electromagnetic trains, nearing readiness for commercial use, which will be the fastest in the world.

The revolutionary technology of electromagnetic trains is currently in the advanced stages of prototype testing at a 12-mile-long test track in Emsland, in the Federal Republic of Germany. When commercialized, the Magnetbahn will be the world's fastest and smoothest train, capable of speeds up to 250 miles per hour.

Although results have not been officially publicized, the experimental train, known as Transrapid, has reached velocities of 180 mph. It operates on a friction-free concept, which has been under development since the late 1960s, and is the first train in the world operating which uses a synchronous long-stator motor, in which the guideway itself forms part of the motor driving the high-speed vehicle.

A consortium of seven of West Germany's advanced industry firms, led by the aerospace major Messerschmidt-Bölkow-Blohm (MBB) and the steel giant Thyssen-Henschel, have been developing the prototype test facility for a government R&D organization, IABG. The tests to date have completely confirmed the efficacy of the magnetic levitation concept, at experimental speeds up to 180 mph. Full-speed tests will be conducted this year, according to Günther Steinmetz, an engineer who for the past 10 years has been project leader, first at MBB, now with the special IABG consortium. The final 6-mile section of an 18-mile test track will be completed, permitting the maximum test speed of 250 mph.

This writer was a participant in a test in early December, in which the train attained speeds in excess of 150 mph with extraordinary quietness and smoothness. Because the train does not rely on wheel-rail friction contact, it has enormous advantages over other existing so-called fast trains. France has the TGV (*train à grande vitesse*) high-speed conventional rail train, presently operating in a 244-mile line from Paris to Lyon, which completes the trip in two hours at an average speed of 120 mph. Japan has a similar conventional "bullet" train. But both trains rely on conventional rail design, resulting in frictional wear as well as lower operating speed. The West German state railway, the Bundesbahn, is experimenting with a similar faster, though conventional, design. It would operate in the same velocity range as the French train.

The Transrapid operates by means of propulsion and braking which entirely rest on electromagnetic suspension of the vehicle, which securely hugs the guideway. The train is suspended above the guideway by a series of electromagnets which keep it elevated some 8-10 millimeters above the rail. Guidance magnets also keep the train equidistant on either side of the guideway. There is never a possibility of the train's flying off the guideway at high speed.

Iron-core electromagnets, each weighing more than 660 pounds, are at the heart of the maglev vehicle. Steinmetz explained that the arrangement of the magnets along the underside of the vehicle has been made in a modular fashion, to ensure maximum safety and reliability. The safety features of the train have been given extraordinary attention. The vehicle automatically stops if more than one of a group of eight magnets fail to function, or if more than one of a group of eight magnetic "wheels" or more than 15 of the total 120 "wheels" fails to operate properly. If any two adjacent magnets fail to function, the train also stops automatically.

There are a total of 64 magnets for levitation and 58 for guidance in the Transrapid test vehicle in Lathen. A secondary system suspends the cabin from four joint-coupled bogies, with soft airsprings with level control in the vertical direction and soft rubber springs in the horizontal direction. A hydraulic system further controls the "roll angle" of the cabin, ensuring that passengers feel only normal acceleration.

Three independent braking systems have been incorporated: normal friction-free braking via inverse magnetic propulsion; emergency braking via controlled settling on skid devices; and mechanical emergency braking via hydraulically controlled braking shoes acting on the guide rails. There is thus extremely high redundancy built into the maglev safety system.

The levitation magnets perform the three integrated tasks of levitation, propulsion, and power transfer to the vehicle. Steinmetz explained that the Transrapid incorporates a unique design for propulsion—the results of more than 10 years of experimentation with other, now discarded concepts. For example, an earlier short-stator motor design under development by Kraus-Maffei and MBB, in which the motor/stator

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is in the vehicle, was dropped in favor of the present Transrapid long-stator design, advocated by Thyssen-Hentschel. In effect, the circuit of the motor includes the actual track, hence the term "long-stator" motor.

Embedded within the guideway levitation rails are coil windings. Interaction between the electromagnetic levitation field and the three-phase current in the slots of the rail armature, produces propulsion or braking. Together, these make up a linear synchronous motor. This means that, instead of an extremely heavy power motor apparatus within the vehicle to deliver the required propulsion, incorporation of the rail guide as part of the motor means far less energy required to drive the vehicle and far lower aerodynamic drag than with the short-stator version.

While the vehicle is in motion, an alternating current voltage is induced, which is rectified and recharges the 440-volt batteries in the train. These batteries are needed to power the magnets for operating the vehicle at speeds below 60 mph. Tests have shown that the maglev Transrapid train entails primary energy consumption per passenger/mile of about 240 watts/hour, depending on speed and utilization.

Moving into operation

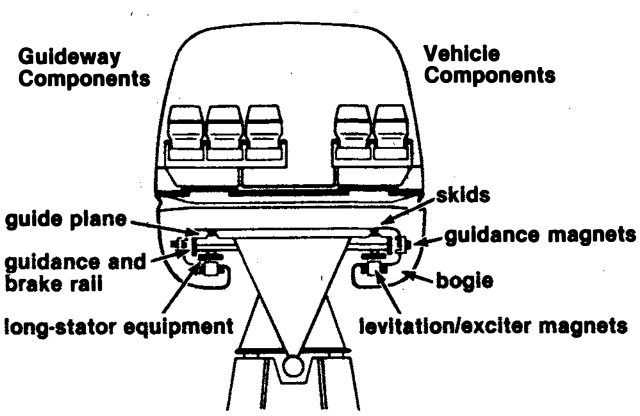
From the standpoint of experimental results, Steinmetz stressed that all basic problems have been solved. Component development for the system—magnets, special electronic systems, converters, computers, magnet drivers, and such—is expected to be complete. Already, Thyssen-Hentschel is working on significant improvements in its next-generation maglev design.

The advantages of the Transrapid maglev concept over existing train systems are considerable. Aside from the higher speed, making it optimal over all other transport, especially in ranges of 300-420 miles, the Transrapid guideway design avoids major problems encountered with conventional rail track. Among other things, there is no need to have extremely flat ground or roadbed, as with conventional high-speed trains like the French TGV.

The friction-free contactless running mode of the maglev train eliminates the noise from rolling and vibration of conventional rail-wheel transport.

Costs for installation of the new system have been calculated to be similar to that for modern high-speed rail lines. Investment includes vehicles, track, stations, junctions, power supply, and computer facilities. Studies of optimal European maglev track paths have already been carried out. One proposal being discussed in the West German Ministry for Research and Technology, is to construct the maglev dual track for high-speed transport from Hanover to Berlin.

Maglev trains will be able to utilize existing stations compatibly on dual-purpose track suitable for both conventional and maglev trains, making integration with existing rail grids optimal. Maintenance facilities can also be shared, further cutting costs. The prospective integration with existing rail grids can result in increased utilization of both systems, as efficiency overall increases.



Transrapid's 06 Maglev train, showing the principal lifting, guidance, and propulsion systems.

The Budd Company

The special guideway track sits on concrete or steel A-shaped support structures, normally at a height of 16-20 feet above the ground, spaced at intervals along the trackway of between 15 and 18 feet. This elevated guideway has the advantage of not encountering the "right-of-way" problems which would be entailed in cutting a new special roadbed through existing areas.

The large West German construction-engineering firm Dyckerhoff & Widmann of Munich has designed the concrete spans for the rail support system incorporated in the Emsland test facility. Although the amount of steel used in the special guideway is somewhat more than in conventional rail, the economics of the lower power required to propel the maglev system, and the approximate doubling of travel speed, more than compensate. The preliminary cost estimates for the Frankfurt-Paris route show highly competitive costs, with maintenance costs significantly lower than with the standard friction train.

The train is optimal for passenger transport in medium ranges and is also well-suited for high-cost, low-volume freight transport. Because of aerodynamic drag at high speeds, the cross-section area of the vehicle must be minimized, thus making it inefficient for bulk transport. Because it involves no takeoff and landing problems or ground transport from airport to city, it is far faster than air travel for medium-range distances.

Maintenance of the magnets is designed in a modular method so that units can simply be replaced when necessary. Recent advances in microcomputers have also allowed major advances in the electronics of the maglev guidance system to become practical.