Five Hundred Miles an Hour

An electromagnetic method of transporting you through a vacuum from New York to San Francisco in half a day

Professor Weinberg prepared the following article for POPULAR SCIENCE MONTHLY at the editor's request. It is the only one he has permitted to appear on the remarkable electromagnetic transportation system that he discussed before the Engineering Section of the American Association for the Advancement of Science.—EDITOR.

By Boris Weinberg

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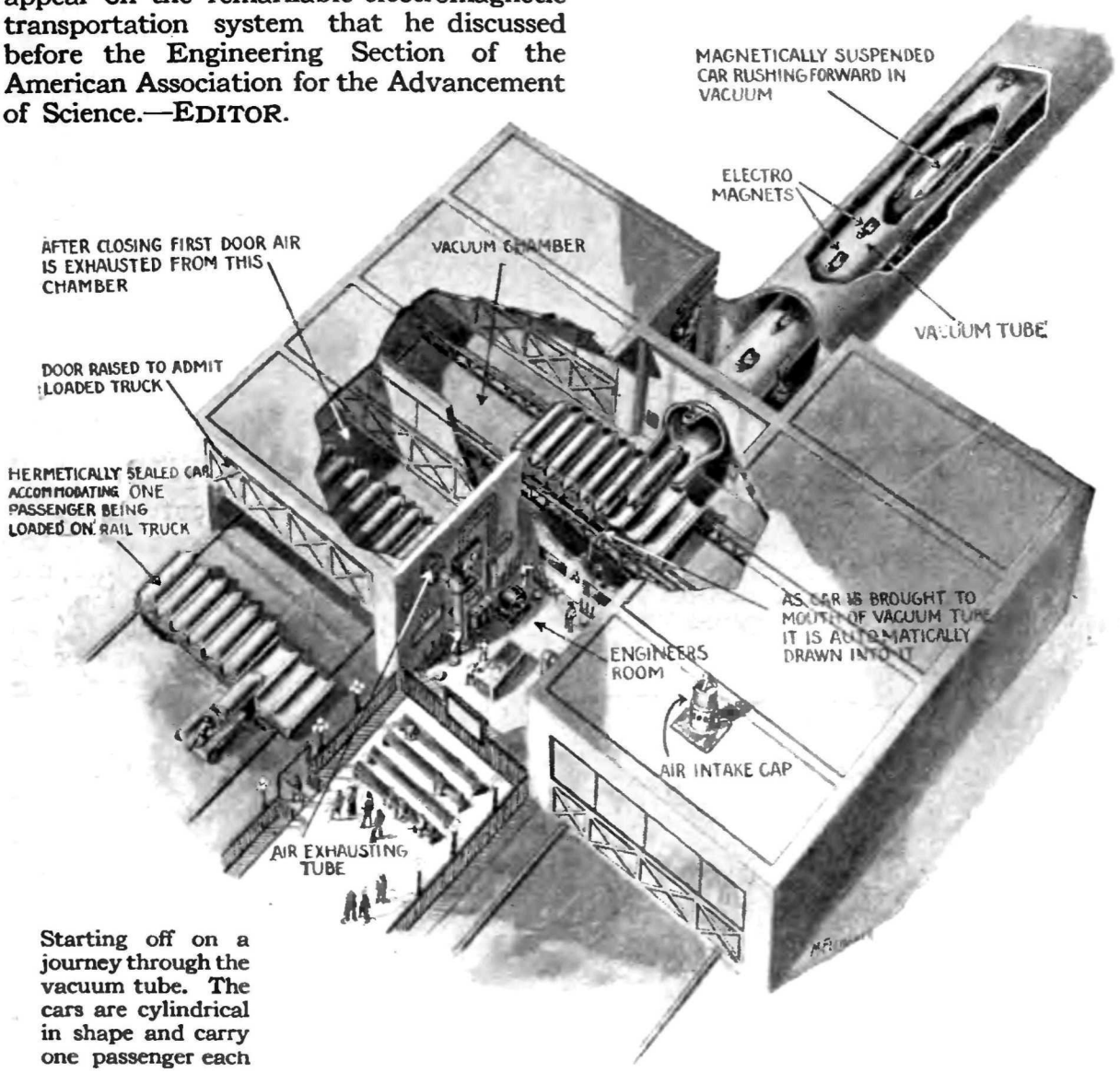


Starting off on a journey through the vacuum tube. The cars are cylindrical in shape and carry one passenger each

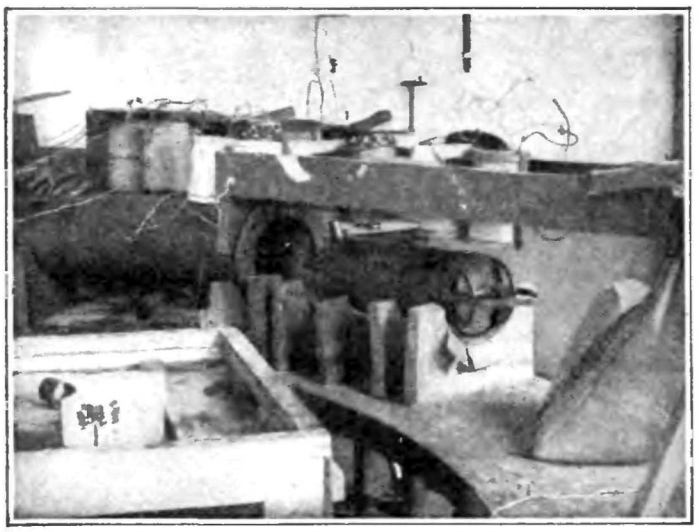
LIGHT travels at the rate of one hundred and eighty-six thousand miles a second. That is the highest velocity that theoretically can ever be attained not only by any material bodies, but even by isolated electrons—atoms of electricity. In comparison, racing aeroplanes which are credited with speeds of one hundred and fifty miles an hour, seem snail-like. The fastest artificial thing is a bullet as it leaves the muzzle of a rifle, although its speed is only three thousand miles an hour. Small as that is when compared with the velocity of light, still it proves that the railway train and the aeroplane by no means represent the limit of terrestrial possibilities.

To attain speed, however low, energy must be expended not only to start the motion of a body but to overcome the resistance of the air and friction against the train caused by gravitation. The resistance

of the air manifests itself more and more as speed is increased, so that each additional mile-an-hour of speed is purchased at additional waste of energy. Gravitation is constant. It pulls a moving object down to the earth, and sooner or later stops it.

How You Can Travel for Nothing

It is apparent that if we are to attain and maintain anything like the speed of a bullet we must remove the air and we must neutralize the attraction of gravitation, since it cannot be destroyed. If this is attained you need not expend energy to maintain the value of the velocity of the car—the principal waste of energy in all usual systems of locomotion—and you could travel indefinitely for nothing.



In his laboratory experiments, Prof. Weinberg used a copper tube ten inches in diameter, curved so that it returned into itself. The "car" is shown here—an iron cylinder running on wheels

A consideration of the subject led me to conduct laboratory experiments which show that it is possible to move a car at high speed in a tube from which the air has been partially exhausted—thus overcoming the obstacle opposed by air resistance—and to support that car, not on the usual rails but literally in space by means of electromagnets—thus neutralizing gravitation.

In these laboratory experiments I used a copper tube ten inches in diameter curved so that it returned into itself. The straight portion was wrapped with a long coil of insulated wire divided into sections to constitute as many solenoids—electromagnets without iron cores. By manipulating a system of switches I could send the current through these solenoids in rapid succession. The "car" was an iron cylinder running on wheels. It was magnetically sucked into the influence of the first solenoid, then into the next and in this way successively passed from one coil to the next. When the car had attained a velocity of four miles an hour in my experiments and was passing out of the influence of the last solenoid the current began to flow through the first. All the solenoids were placed on top of the copper tube and served to raise the car from the bottom of the tube. When this current was too weak the car would jump just slightly from the bottom of the tube; when it was too powerful the car would actually scrape the top of the tube and run touching, not the bottom but the "ceiling" of the tube; and when the current was of just the proper strength the car rose from the ground without touching the top wall and sped on to another electromagnet which, in the same way, kept it thus suspended in space. Every electromagnet was energized only during the time that the front of the car began to approach it and until the rear of the car had passed it. In this way the electromagnet merely lifted the car but did not change its velocity at all. The tube was connected with an air pump so that the air could be practically exhausted.

You Are the Only Passenger in the Car

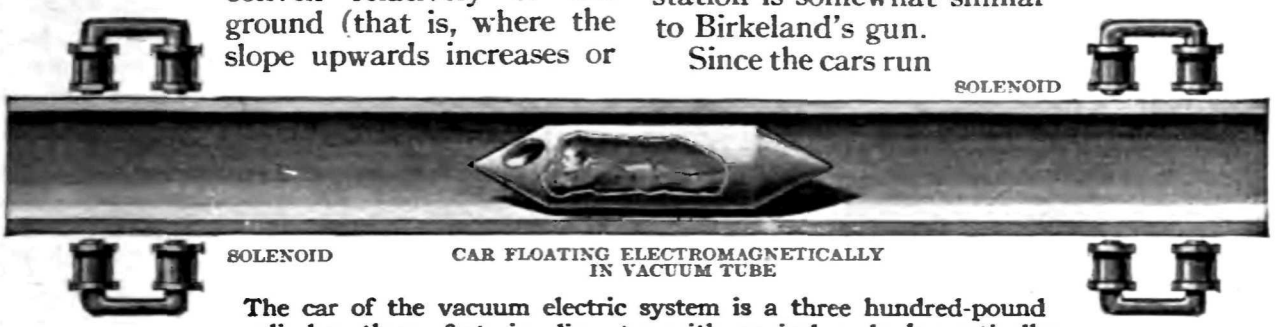
In imagining this principle applied, I must ask my readers to divorce themselves from all current conceptions of railways. The car of the vacuum electric system would be a three hundred pound iron cylinder three feet in diameter, with conical ends hermetically sealed. You enter that car and lie prone in it, its solitary passenger. The sustaining electromagnets are much bigger than those used in my experiments shown in the photographs, and they are spaced thirty feet apart and are successively fed with a powerful current for a fraction of a second.

The direction of motion of such a high-speed car cannot be easily changed. Imagine the difficulty of swerving a fifteen-inch projectile as it leaves the mouth of a naval gun! Like any railway the vacuum tube would have its curves. How are they to be rounded? I again utilize electromagnets. The distance between these electro-

magnets depends on the degree of curvature and their total number on the angle at which the curve is entered and left by the car.

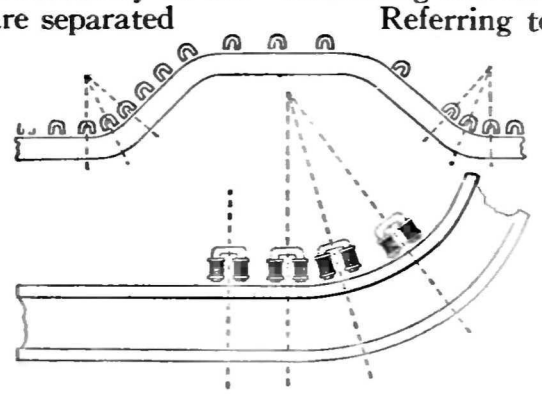
Rounding Curves at Five Hundred Miles an Hour

But the tube will be curved not only horizontally, like an ordinary railway: it will sometimes be bent up and sometimes down, as the nature of the country demands. In the part of the tube where it is convex relatively to the ground (that is, where the slope upwards increases or the slope downwards decreases) the sustaining electromagnets must be closer together than over the straightaway portions. Where the tube is convex relatively to the sustaining magnets they are separated by relatively greater distances.



The car of the vacuum electric system is a three hundred-pound cylinder three feet in diameter with conical ends hermetically sealed. You lie prone within it—its solitary passenger. There is no track. The car is really a free body sustained by electromagnets which are placed thirty feet apart

It is evident that the car is really a free body and as such it must gradually accentuate every departure of the rectilinear progressive motion. Since it is intended to travel at a very high speed, even the slightest change of the direction of motion or any rotation must be controlled so that it may not be wrecked. Even ordinary railway trains run off the track often enough. Here is a car which has no track but which should never be permitted even to touch the walls of the vacuum tube lest it be destroyed. Special devices must obviously be employed to prevent the car from swerving from a normal course. They would serve to energize supplementary electromagnets which would return the car to its proper course. It is superfluous to describe these supplementary safety devices in detail here.



The direction of motion of a high-speed car cannot be easily changed. But like any railway, the vacuum tube must have its curves. Electromagnets are placed at the proper side of the tube and spaced according to the degree of curvature

The Strange Stations that Must be Built

A long series of solenoids thrown into circuit when the front of the car approaches them and out of circuit when the middle of the car has passed their middle point constitutes the essential feature of a station which must be used by departing passengers. Professor Christian Birkeland, the distinguished Norwegian physicist, invented an electromagnetic gun, some years ago, in which the projectile was drawn forward by electromagnetic attraction. My station is somewhat similar to Birkeland's gun.

Since the cars run in a partial vacuum it follows that the passengers cannot pass into and out of normal surroundings without the aid of something like an airlock.

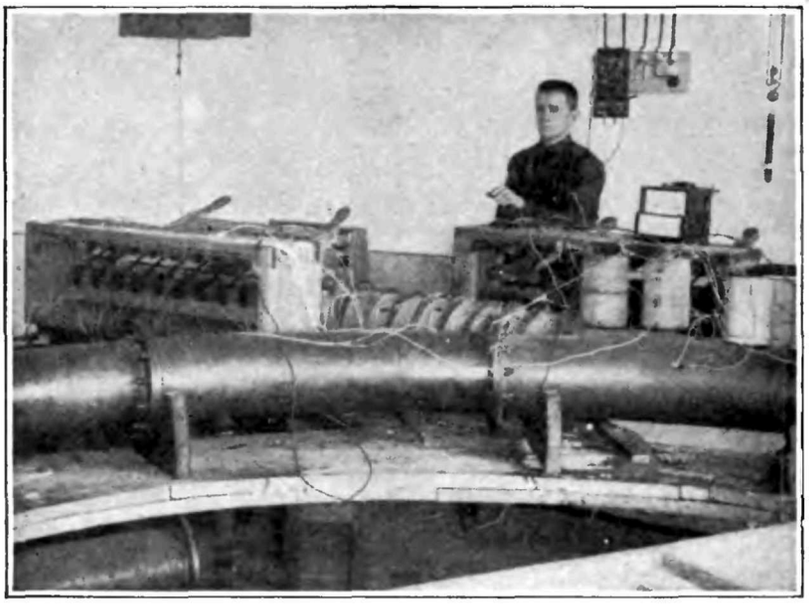
Referring to the accompanying diagram in which an airlock station—used only for departing cars—is depicted, it will be seen that there is a main chamber which communicates with the vacuum tube at one end. At this end a series of solenoids are mounted, and between are placed sustaining electromagnets. The main chamber is successively put in communication with several side airlocks which are used to increase the frequency with which cars may be started off in the tube. In the main chamber is a platform on which cars from the side airlocks may be rolled and which is moved on rails. When a car is just in front of the opening of the tube it automatically turns on the current of the first solenoid and is sucked into the tube. Thus car after car is drawn from the traveling platform at a rate which I have calculated may be as high as twelve a minute, the whole

proceeding being not unlike that of feeding cartridges from a belt or clip to a machine-gun.

A Car Can't Be Safely Stopped in Less Than Two Miles

The stations at which the cars arrive are similarly constructed. Each solenoid is energized at the moment when the middle of the car has passed its middle and is de-energized when the rear of the car has passed through. The stations must be some two miles long in order that the cars may be stopped gradually.

What will be the speed of such a system? My experiments have given me the data necessary to calculate the amount of attraction between the core of an electromagnet and an armature separated at a considerable distance from it, so that I have been able to fix the maximum speed attainable. That maximum depends on the maximum attractive force of the electromagnets which can be developed to overcome the centrifugal force on the curves.



This is the experimental apparatus which Prof. Weinberg used in working out the details of his proposed electromagnetic vacuum system of passenger transportation

Assuming electromagnets of reasonable size and currents of reasonable strength I found on the basis of my aforesaid experiments that with curves having a radius of two thousand feet it would hardly be possible to attain a speed of more than five hundred miles an hour. But think what that means! New York would be no more distant from Chicago than it is now from Philadelphia, so far as relative times are concerned. Florida might easily become a kind of winter Coney Island for all New York. A journey from New York to San Francisco would occupy only half a day.

Lifting an Ordinary Train off the Rails

While the vacuum tube is an electrical possibility, it is more likely that some method of transportation proposed here, or one like that proposed by Emile Bachelet a few years ago, will be more seriously considered first. Bachelet did not propose the propulsion of a car in a partial vacuum so as to cut down air resistance, but he did propose the idea of overcoming gravity by the use of alternating-current electromagnets. Every amateur electrician knows that an electromagnet through which an alternating current is passed has the curious property of repelling a light metal object brought near it. Bachelet intended to build his cars with aluminum bottoms. When the cars ran over the magnets successively they were to be repelled—literally lifted off the rails. The system is objectionable because very much power is wasted per mile (contrary to my system where the waste of energy is insignificant) and the passengers would be very uncomfortably heated by the action of the currents from below. In my opinion an electric system, such as that which I have here outlined, but without the vacuum tube and with approximate (not complete) neutralization of gravity would be safer, cheaper, and simpler. The loss in speed due to the resistance of the air would not be excessive if the cars were properly designed, and might be compensated for by cutting the electromagnets out just as the front of the car left them one after the other. In this way the electromagnets would not only sustain the car but would also accelerate its speed. Moreover it would be much simpler to run on wheels instead of moving freely through space, gravity being only so far neutralized that the wheels would barely touch the tracks and a pressure would be exerted that would be almost negligible.