BACHELET'S FRICTIONLESS RAILWAY AT BASIS A TECH IDEA*

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Much interest has recently been manifested in certain experiments performed in England by an American inventor, Mr. Emile Bachelet. These experiments have demonstrated that it is possible to construct a type of train which remains out of contact with any road-bed or guides whatever—in other words, which virtually floats in the air. Although only a model has so far been tried, the results apply equally well to the case of a train large enough to carry passengers.

The raising, or levitating, of this new type of train is accomplished, briefly, by the repulsion of a metallic (non-magnetic) road-bed, or guide-way, by means of alternating current electro-magnets in the cars to be raised above this road-bed. Propulsion forward or backward

*"Model of the Flying Train." Under this heading in the *Boston Sunday Globe*, May 31, 1914, there appeared a picture of the inventor, in his laboratory, exhibiting a model of the "Flying Train," with this comment:

"The flying train has become the talk of nations. Since the first description of Mr. Emile Bachelet's invention appeared in these dispatches, its fame has spread from England to France, Holland, Germany, and even to far away Japan.

The laboratory at Saffron Hill, with its glittering instruments and its tense electrical atmosphere, is filled daily from morning until night with a distinguished throng of visitors, many of them representing powerful official interests.

The Admiralty and the War Office have sent special commissioners and experts to make a close inspection of the invention.

Dr. Harold Spitta, bacteriologist to the King, Sir David Salomons, the famous scientist, and Mr. Otto Belt, the financier, were others who lost count of time, as they stood engrossed in Mr. Bachelet's repeated and patient demonstrations of his appliances.

Among early callers were two representatives of the Japanese Government, and Lord Edward Grosvenor, while Mr. Gray, chief engineer of the Marconi Company, was also an interested observer."

is effected by a dragging or "sucking" of the cars through solenoids—the force being exerted between the solenoids and iron bands which are fastened to the outside of the cars.

The method obviously possesses wonderful capabilities of speed, which are amply substantiated by the performance of the model. Mr. Bachelet claims that a speed of five hundred miles per hour could be realized with a train of practical size, this high speed being made possible by the absence of various mechanical difficulties, and especially by the absence of friction of moving wheels.

Although Mr. Bachelet's claim may, at first sight, seem extravagant, it actually does not give the method credit for the speed it is capable of developing. This will be evident at once from a consideration of air-resistance. The retardation due to air-resistance varies as the *square* of the velocity of the train. Hence, at very high speeds, the loss of energy due to this cause will *transcend in importance all other* losses.

At velocities approaching five hundred miles an hour, the loss due to air-resistance will be enormous. If, however, the train were to travel in a tube from which the air had been exhausted there would be no frictional loss whatever, and the speed could be made as great as desired, with a comparatively small expenditure of energy.

In this case, however, it would be necessary to keep the *rate* of increase of speed below a certain maximum—which maximum is the acceleration that can be borne with comfort by the passengers. No data concerning this maximum acceleration are available. It seems likely, nevertheless, that a constant acceleration much exceeding that due to gravity—(*i. e.*, 32 ft./sec^2) could hardly be borne with comfort.

We arrive, then, at the conclusion that the actual limit of rapid transit, which we cannot reasonably hope to exceed, will be obtained by a method of propulsion similar to that of Mr. Bachelet, in an exhausted tube; the speed increasing at the rate of about 30 ft./sec^2 until half the distance has been traversed (when the velocity will, of course, be tremendous), and thereafter decreasing at the same rate until the destination has been reached.

The possibilities of this method of travel are startling. For example, with an acceleration of approximately 10 ft./sec^2, a running-time from Boston to New York of ten minutes is perfectly possible. Furthermore, the greater the distance to be traversed, the shorter, in proportion, will be the running-time. Not even the aeroplane can hope to compete with this mode of rapid-transit, and there can be no doubt that a method of travel of this sort will be adopted, as soon as the demand for excessively high speeds becomes sufficiently great.

It may, therefore, interest the reader to learn that the above principles—namely, the use of electro-magnets for supporting a car in space above a road-bed, and for obtaining propulsion; the use of an exhausted tube; and the idea of a continually-increasing speed, were all understood at the Worcester Polytechnic Institute several years before Mr. Bachelet patented the use of alternating-current electro-magnets in a car for purposes of levitation, and of solenoids at intervals along a road-bed for purposes of propulsion, March 19, 1912.

It happened in this way. During the writer's freshman year, Professor Coombs gave as a theme topic, "Traveling in 1950." The writer considered the above method as that most likely to be in use on the date in question, and read a description of it before the class, Dec. 20, 1904.

In the theme, levitation and forward propulsion were both considered as attainable by direct-current magnets, the use of which, in balancing the car, was described in detail.

Later, in January, 1906, the ideas expressed in the theme were incorporated in a short story, entitled "The High-Speed Bet." This story served to demonstrate, to the writer's complete satisfaction, the scepticism of editors towards new methods of travel.

An indication of the soundness of the scientific principles involved in the story was, nevertheless, obtained in the following way. An article was submitted to the *Scientific American*, in which was described in detail the method of propulsion by direct-current magnets, it being further shown that if losses due to rolling-stock and air-resistance were eliminated, as explained in the story, the running-time from Boston to New York could be as short as ten minutes.

This article was accepted, condensed, and published as an editorial, under the caption "The Limit of Rapid Transit," in the *Scientific American* for November 20, 1909. The reader is referred to this article for a more extended discussion of the question of acceleration than is here given.

In view of the above facts, it is believed that "The High-Speed Bet" which follows, may, without regard to literary merit, be of interest to readers of the JOURNAL, not only in-so-far as it is a description of things which will inevitably be experienced when the demand for extreme speeds becomes sufficiently urgent, but also for the reason that it was written over four years before Mr. Bachelet first applied for a patent on his apparatus, April 2, 1910.

THE HIGH-SPEED BET.

It was a rainy afternoon in late November, 1948. A party of four men had assembled around a table in the quarters of the Engineers' Club of New York, and were doing their best to neutralize dreariness with animated discussions. The properties of a new structural steel kept the ball of conversation rolling for a time, but the depression was not entirely overcome until the talk drifted to the topic of rapid-transit.

The leader of the conversation, Mr. Maurice Sibley, was pre-eminently a genius. He was not only a success in practical engineering, but some of his ideas were so far in advance of those of his contemporaries, that he was called "visionary." No one denied, however, that he could be highly entertaining. This afternoon he was at his best. His convincing manner and his forceful argument brought listeners from other tables; and, to those who heard him, nothing seemed impossible. One of the men, however, Charles Adams, did not accept all Mr. Sibley's statements of the wonders in rapid travel which would astonish the next generation,—but he said nothing. Mr. Sibley finally raised the enthusiasm of his listeners to such a pitch that when he boldly declared that in ten years they would be able to travel from Boston to New York in ten minutes, no one replied but Mr. Adams.

"That's a good one, Maurice," he said. "Why don't you write it up? It would make a pretty good story."

"You'll not laugh," said Sibley, "when you take the trip yourself, some day."

"Um—no," replied Adams, ironically. "*When* I do!"

"You may say what you please, but I know what I'm talking about," Sibley retorted, "and I'll bet you one thousand dollars to a cent that ten years from to-day you can make the trip in *ten minutes!*"

This was more than the rest of the party could stand, and everyone but Sibley shouted with laughter.

"Oh, laugh a whole week if you want to," said Sibley, a little nettled, when he could make himself heard, "but I mean it."

The incident was not forgotten, and the "High-Speed Bet," as it was soon called, remained a standing joke at the Club for several weeks.

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Over nine years had passed, and each one had brought changes. There were changes in the fortunes of Sibley and Adams. Sibley had risen continuously, and was still rising. Adams had gone the other way. He was in the plight of many professional men—men who really have ability, but who are so absorbed in their work that they neglect to think of what the world ought to pay for their services. Just now he was considerably worried. He had borrowed heavily,—so heavily that he could not risk what he had by borrowing more. And yet, if he did not, he could not give his son the post-graduate year in the engineering college, as he had promised. It was surely a dilemma. "But," Adams kept repeating to himself, "there must be some way out of it."

Cities had changed as well as men. Boston and New York had grown with especially striking rapidity, and their boundaries were approaching each other. In fact, changes had taken place to such an extent that there was a movement on foot to combine both cities into one municipality. One thing, however, kept the cities distinct,—it was distance. And thus rapid-transit became the question of the day. The running-time had been shortened again and again. Trains were running at the frightful speed of 180 miles an hour, but with great waste of energy, and much danger. The people were not satisfied; greater speed with greater safety was their demand. Most insatiable were the rich and influential men.

Now, where there are millions, there must surely be a way. Five years back, Maurice Sibley had come forward with a promise of shortening the running-time, and reducing the danger to a minimum, if given complete control of the undertaking and backed by sufficient funds. The authorities, at first, refused to discuss such an unheardof thing, but Mr. Sibley, armed with his convincing manner and phenomenal reputation as a scientist and engineer, finally drove opposition to the wall. He promised nothing really definite, and so there began a period of guessing, which did not end until November 15, 1958, when the "Rapid-transit Tube" was opened between New York and Boston, running in almost an air-line from the heart of one city to the heart of the other.

At 9.15 on the morning of that memorable day, the party which was to travel in the first car assembled in the station near the old Boston Common. It was a gathering of distinguished engineers and public officials, with a few friends of those in highest authority. Maurice Sibley had asked our friend, Charles Adams, to be one of the party, much to the latter's surprise. Excitement was at a high pitch when they descended by a flight of iron stairs to the level of the tube. Nothing very astonishing was seen—only part of a tube which looked like a large steam boiler, about ten feet in diameter, across one end of the white-enameled room, with an opening in the side—large enough to admit one person—through which could be seen the illuminated interior of the car. One by one they walked through the opening and seated themselves in the narrow, high-backed chairs. The interior resembled that of a Pullman car, but it was cylindrical in shape, with a narrow metal floor, and had no windows. It was evident that everything had been sacrificed for lightness and rigidity. But the most peculiar features were metal, box-shaped, affairs near each end of the car,—one overhead, and one on each side somewhat above the middle.

After all were seated, Mr. Sibley walked to the forward end and addressed the party.

"Before we start," he said, "I wish to explain, in as few words as possible, the plan which underlies this mode of travel. In the first place, there is a vacuum in this tube throughout its entire length. How to produce the vacuum was one of the most perplexing questions of the entire problem. It was finally obtained by first passing burning charcoal through the tube until all the oxygen had been converted into carbon dioxide, and then passing—upon rails which will be used hereafter only in case of accident —cars supporting screens containing charcoal, filling the bore of the tube. Throughout this charcoal ran pipes containing liquid hydrogen. Nearly all the remaining gases were condensed in the pores of the charcoal,—even the inert elements such as argon.

"The method by which air is prevented from entering the tube deserves mentioning. No gasket is used around the door through which you just entered. There is a plate of copper attached to the car, covered with a thin layer of a fusible alloy with a high electrical resistance. The tube is of iron at this point. Now, when we wish to fasten the car to the tube, we bring them together by suitable clamping, and pass a strong current through the door and casing. The fusible alloy melts—the current is turned off—the alloy hardens,—and then the door is opened, the car being electrically welded to the tube. In starting off, as you will see in a moment, the door is shut and clamped, the current passed through for a moment, then shut off, and the car unclamped from the tube and pushed away. You see, the alloy has a chance to cool in contact with the copper, which is not heated to such an extent as the iron, and when the car moves away, the alloy—which unites to some extent with the copper where it touches—clings to the cooler surface, namely, to that of the car.

"Just a word or so regarding propulsion, and we are off. From those metal boxes, of which you see three at each end of the car, there project strong electro-magnets, actuated by a number of specially constructed storage battery cells beneath the floor. The car is propelled, in brief, by the repulsion between these magnets and three rows of similar magnets placed in the sides and roof of the tube from one end to the other. The point of most intense magnetization of these magnets in the rows at the sides is a little farther from the car than the similar point of the side magnets of the car, the object being to prevent all pitching. The magnets vary in length, being longer nearer the middle of the tube; and, although they require considerable power, this is furnished cheaply by a battery of wave motors off the Long Island coast.

"It does not require much investigation to see the wonderful capabilities of speed which this mode of travel offers. As the magnets at the sides of the car are strongly repelled by those projecting from the tube immediately below them, the whole car is lifted, so that there is no material in contact with it,—in fact it would require considerable force to press the car down in contact with this row of magnets. But, besides, the magnets in the tube just back of those mentioned are operated at the same time, and these give the push which urges the car forward. You see that friction is utterly done away with, and that there is almost no limit to the speed that can be attained —provided enough power is at command.

"Of course, the current flows in the magnets of the tube only as we pass them; and this action is controlled by small governing magnets beneath the floor at each end of the car. They operate little clutches which close the circuits of the magnets in the sides of the tube, and also the circuits of those in the row on the roof of the tube, when the car moves too high. But you will see for yourselves how this works in practice."

He motioned to an official who stood beside the door. The man shut the door, clamped it tight, and then switched on a current of electricity, but only for a moment. Then he pulled a long lever and the car moved sidewise with a slight jar. Mr. Sibley started a machine which purified the air and replenished the oxygen. It set up a slight draft through the car. With one hand he held his watch, and with the other turned a small hand-wheel.

"Just twenty minutes of ten, gentlemen," was all he said, as he hurried to his seat beside Mr. Adams.

Scarcely had the wheel been turned when everyone was jerked backward, just as when a car starts suddenly, but it did not stop, and they were forced against the backs of the seats with a continuous pressure. After a few minutes the backward pressure ceased; all the chairs turned on pivots in the floor until they faced in the opposite direction. Once more the same pressure was experienced, but this time it acted toward the other end of the car.

Mr. Sibley, in explaining this to Mr. Adams, said, "It is really the simplest thing in the world, if you remember those old formulas for accelerated motion. The pressure against the backs of the seats is simply due to a forward acceleration of 11.6 feet per second each second. This makes the velocity increase until, at the middle of our journey, we are travelling with a velocity of 3,500 feet per second! Then we reverse the chairs and gradually slow up until we reach New York."

Even while he was explaining this, the pressure ceased, and the car seemed to be running on rails. At last it stopped. Mr. Sibley opened his watch and startled everyone by saying, "I hope all are satisfied, for we have made two hundred miles in nine minutes and fifty-seven seconds."

While the official was welding the door casing to the tube and opening the door, Sibley received a perfect shower of congratulations from every side; and as the party stepped into the New York station, shouts of excitement were heard outside the building. But Sibley escaped from the uproar by the stairway as soon as he could. As he passed Adams, he thrust an envelope into the latter's hand, much to the astonishment of everyone. Adams, in surprise, hurriedly opened it, and found—ten one hundred dollar bills. For a brief moment, he was speechless. What good fortune! He had a chance now of recovering what he had lost, and he could do what he had promised his son without anyone's being the wiser for what had happened.

But, then, remembering the nature of the bet, he called up to Sibley,

"Here, Maurice, I can't take this. Why, it wasn't a real bet, at all, and, besides, it is I who lose."

"Oh," a voice from the landing called back, "don't take the trouble to refuse, Charles, it'll not do the least bit of good."