# BRENNAN'S Mono-Rail Car

Design of Professors Crew and Tatnall,
Northwestern University.

Manufactured Under License of Letters Patent
of the United States, No. 796,893,
August 8, 1905, Granted to
Louis Brennan,
England

MANUFACTURED EXCLUSIVELY BY

## CENTRAL SCIENTIFIC COMPANY

345 to 351 WEST MICHIGAN ST.,
CHICAGO

5/673

# No. 950 Model of Brennan's Mono-Rail Car

THIS model embodies the gyrostatic arrangement employed by Mr. Louis Brennan for the purpose of balancing a car upon a single rail, when the center of gravity of the car is above the rail. It is described by Prof. Perry in "Nature" for March 12, 1908, page 447, and by Prof. W. S. Franklin in "The Popular Science Monthly" for July, 1909, page 20. The design which we are placing on the market is that of Professors Crew and Tatnall, of Northwestern University.

Brennan's invention consists substantially of the following features (see diagram, page 8):

(a) Two gyrostats or flywheels are used, mounted side by side, as shown in the cut, and spinning in opposite senses. The precessional couple due to the turning of the car in rounding a curve is equal and opposite for the two gyrostats and the upsetting torque arising from this source is thus eliminated.

(b) The two gyrostats are mounted in separate frames, and each of these frames is provided with bearings at the top and bottom so that it may rotate slightly about a vertical axis. The frames are, however, geared together in such a way that they are compelled to rotate in opposite senses.

(c) The whole system of gyrostats and supporting frames is carried upon a horizontal axis running lengthwise of the car, i. e., parallel to the track. The center of gravity of the system lies in this supporting axis, so that the system is in neutral equilibrium with regard to gravity.

(d) Attached to the sides of the car itself are four small horizontal plates or "shelves," two on each side. As seen by a person facing either side of the car, one of these shelves extends toward the right from the central or undisturbed position of the projecting end of the gyrostat shaft. The second shelf is lower than the first, and extends toward the left. When the car begins to fall over, so that one side rises, one of two things will always happen. Should the gyrostat on that side be so oriented about its vertical axis that the projecting end of its shaft lies over the upper shelf, this shelf will rise until it touches the rotating shaft. This shaft, on account of friction, then begins to roll along the shelf, thus hurrying on the precession about the vertical axis. The second gyrostat shares this increased precession, but in the opposite sense. The opposite precessions of the two oppositely spinning gyrostats thus unite their torque about a fore-and-aft axis, causing the shaft to press down on the shelf, righting the car.

On the other hand, should the orientation of the gyrostats be such that the shaft is not immediately over its shelf, then the lower shelf will rise against an idle roller attached to the gyrostat frame, and the precessional

torque thus brought into play will not only prevent the car from tipping farther, but will swing the gyrostats around until the live shaft is again over the upper shelf, when a righting torque is immediately brought into action.

As a result of these processes, taking place first on one side of the car and then on the other, the center of gravity of the whole car is kept oscillating very slightly about a point directly over the rail.

The magnitude of the righting torque due to precession depends, at any instant, upon the angular momentum of the gyrostat wheels and upon the rate at which their angle of precession is changing. Let $I$ denote the sum of the moments of inertia of the two wheels, $W$ their angular velocity of spin, and $w$ the angular velocity with which the direction of the axis of spin is changing. Then the righting torque, $L$, is at right angles to the axis of the angular momentum of the wheels, $IW$, at right angles also to the axis of precession, and is numerically equal to their vector product.

$$L = IW.w.$$

In the model, the gyrostats are speeded up to about 2,500 r. p. m., by means of a geared crank. The energy thus stored is sufficient to balance the car for ten or fifteen minutes. If the car is placed on a short section of a track, the latter may be jerked sidewise, or suddenly rotated like a turntable, without upsetting the car, or throwing it off the track. If a load be added to one side of the car, that side will rise so as to maintain the center of gravity over the track. A load of five to ten pounds can be added safely, and the car with this load will be tilted to a large angle, and operate as without a load.

Curves may be rounded and the car may be run on a wire rope.

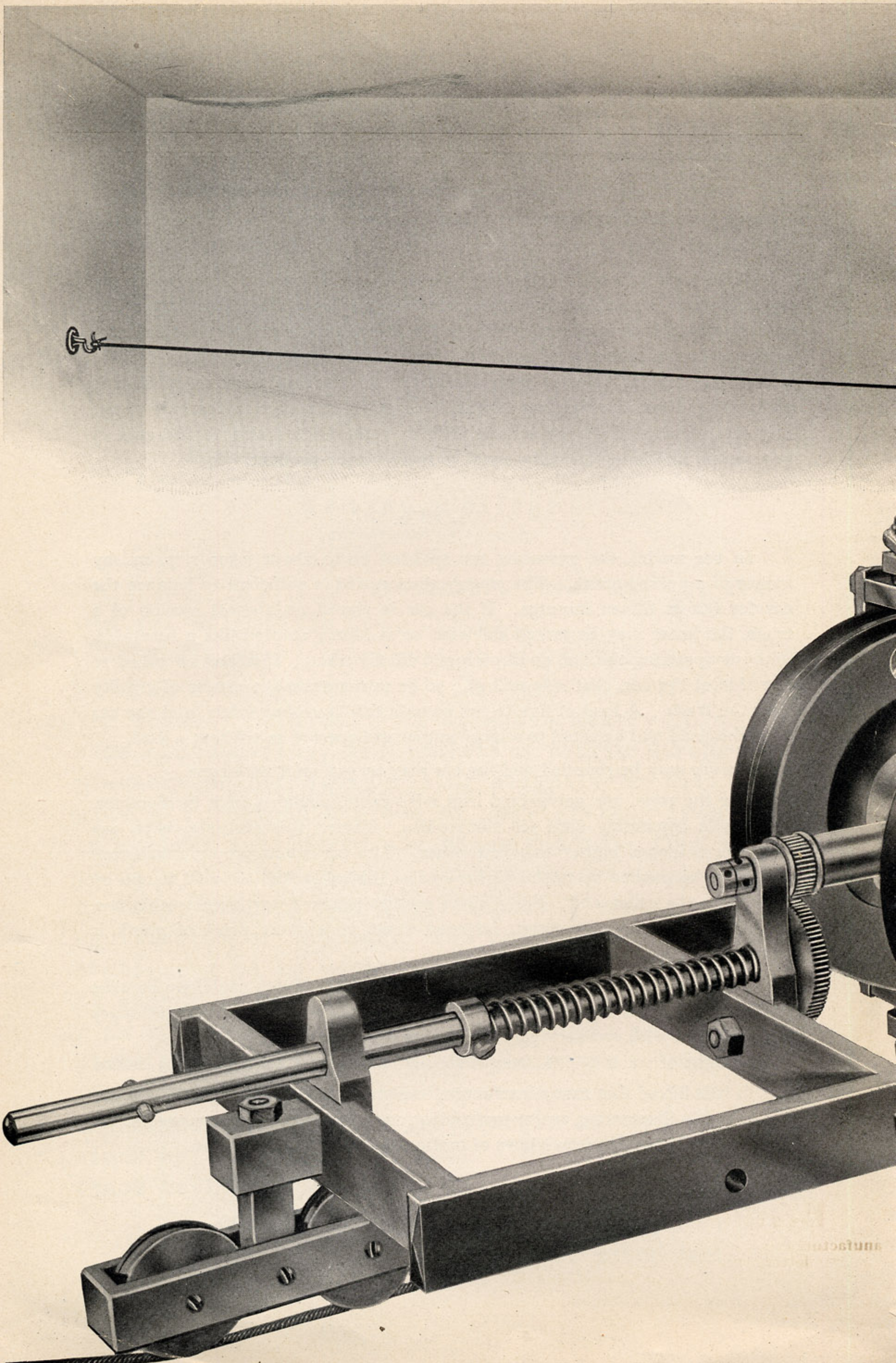
For the rope, use galvanized iron wire cable, about $\frac{1}{8}$-inch in diameter, such as is commonly used for clothes-line. Fasten this securely, with one end 6 or 8 inches higher than the other. The car when properly balanced may then be pushed up to the higher end of the cable, and allowed to run by gravity to the other end. For a short section of track, for lecture-table use, an iron rod, $\frac{1}{4}$-inch diameter, fastened down to a short piece of plank is convenient.

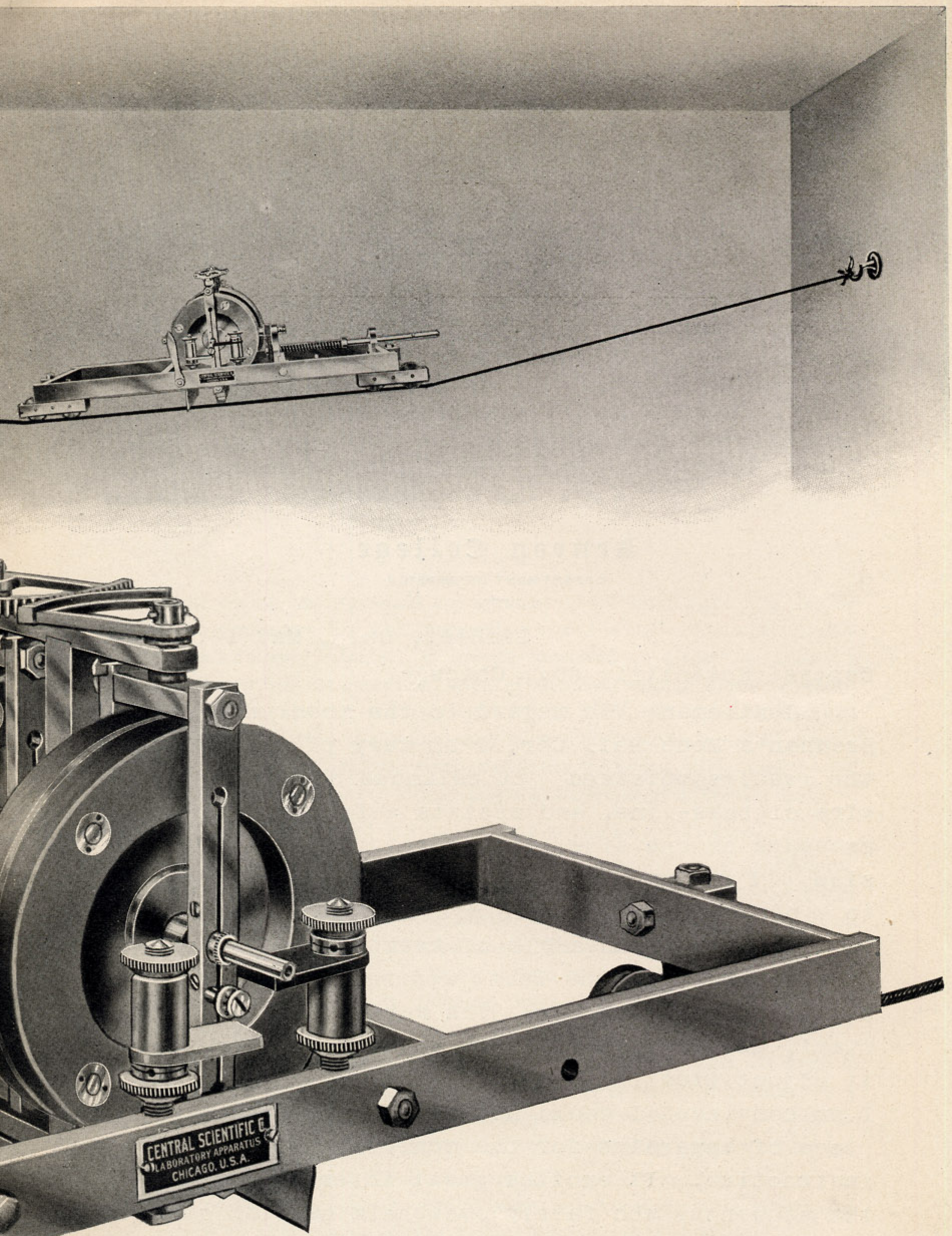
To prevent serious injury to the car by falling off the cable, we provide with each car two stout chains with hooks. This is purely a precautionary measure, and with ordinary care the chains may be omitted.

Weight of car is 28 lbs., length 20 inches, diameter of gyrostats 5 inches.

It is believed that many instructors in physics or engineering will find this car useful in illustrating vector multiplication, angular momentum, precession, and, indeed, all of Newton's laws of motion for the case of rotation.

**Price, With Suitable Support, $150.00**






MODEL OF

# Brennan's Mono-Rail Car

Manufactured by CENTRAL SCIENTIFIC COMPANY, under license of letters patent of the United States, No. 796,893, to Louis Brennan.

b

## Lehigh University

DEPARTMENT OF PHYSICS

South Bethlehem, Pa.,
May 10, 1909

Central Scientific Co., Chicago.

Dear Sirs: I have received your Mono Rail Car and I find that it operates with entire satis faction. Yours very truly,

W. S. FRANKLIN.

---

## Kenyon College

DEPARTMENT OF PHYSICS

Gambier, Ohio, May 13, 1909

Central Scientific Co., Chicago.

Gentlemen: In regard to the model of Brennan's Mono-Rail Car, I am very pleased with the results obtained It balances neatly on a wire clothes-line, and resists a fairly strong pressure on one side, rising slightly on that side. I clamped a piece of quarter-inch iron rod to a plank and jerked the plank suddenly from side to side through an angle of twenty-five degrees or more, without the least apparent effect on the equilibrium of the car. The car is very easy to start, and it is a pleasure and a wonder to see it adjust itself to its load like a live thing. I am convinced I could not have bought any other piece of apparatus for the money so valuable and instructive. It excites great interest among the students, who fairly overwhelm me with questions as to "Why it works." Am having a curved track built for the car.

Yours very truly,

FRANK L. HITCHCOCK.

## Haverford College

DEPARTMENT OF PHYSICS

Haverford, Pa., May 11, 1909

Central Scientific Co., Chicago.

Dear Sirs: I take great pleasure in recommending your model of Brennan's Mono-Rail Car. Its performance has been very satisfactory, and wherever it has been shown it has created universal interest.

The parts are so arranged as to show clearly the principles of construction and operation so that the physical principles involved are readily made clear to those even who are not familiar with the subject.

I have taken great pleasure in exhibiting the car at Haverford College, Bryn Mawr College and the University of Pennsylvania.

Yours very truly,

FREDERICK PALMER, Jr.

---

## Indiana University

DEPARTMENT OF PHYSICS

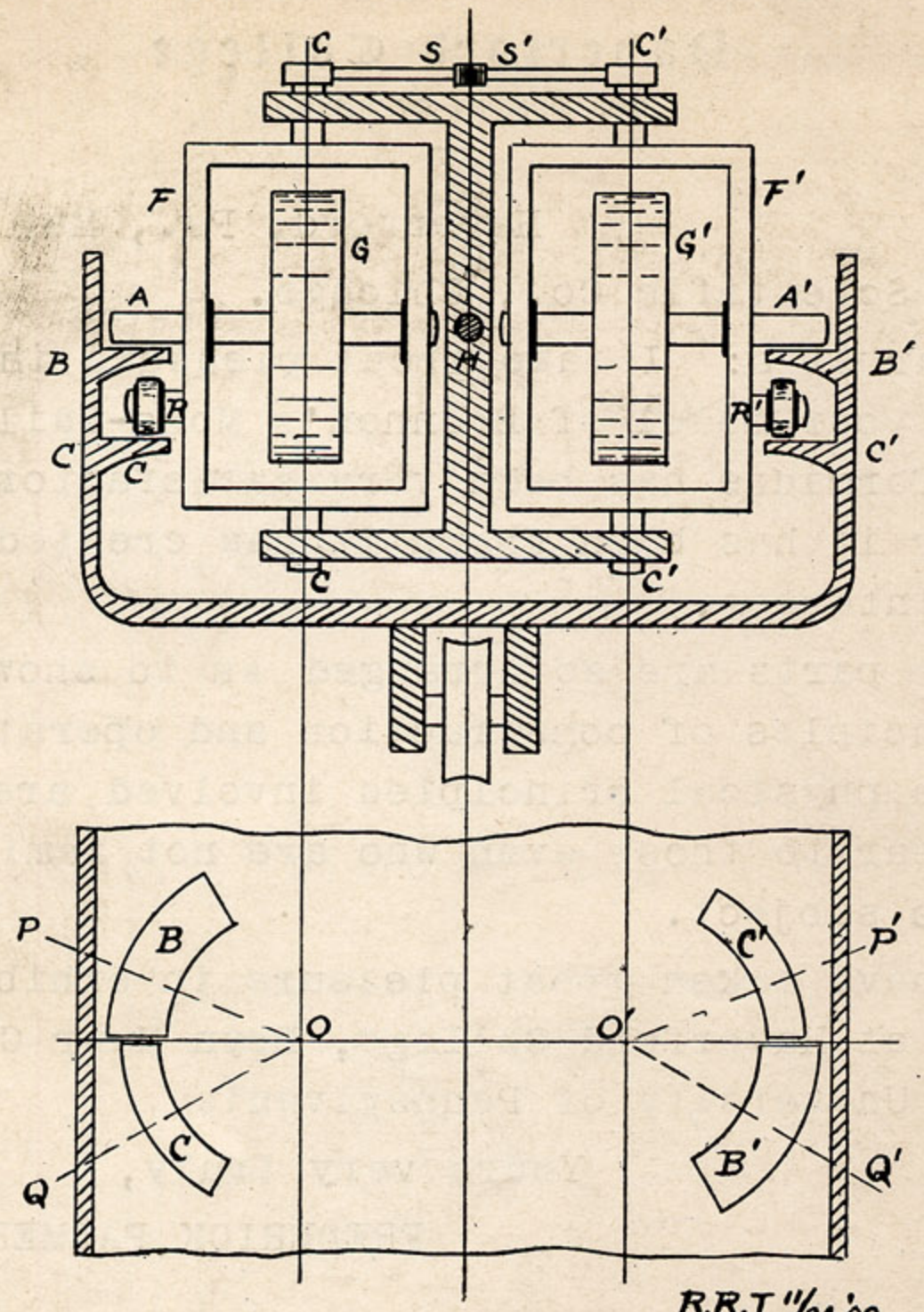
Bloomington, Indiana, May 11, 1909

Central Scientific Co., Chicago.

Gentlemen: I have tested your working model of Brennan's Mono-Rail Car and find it satisfactory in every respect. It is easy to manipulate and shows gyroscopic action better than any other apparatus I am acquainted with. It is of the greatest value in studying dynamics of rotating bodies.

Yours very truly,

V. A. SUYDAM.




## Diagram of Brennan's Mono-Rail Car.

$G$, $G^1$, gyrostats, each mounted with ball bearings in a frame $F$, $F^1$, which in turn is capable of rotation about a vertical axis $C$, $C$, or $C^1$, $C^1$.

$S$, $S^1$, geared sectors attached to frame $F$, $F^1$.

$H$, section of horizontal axis supporting the framework in which the gyrostats are mounted. The entire gyrostatic system is capable of slight rotation about this axis.

$A$, $A^1$, rotating shaft of gyrostats.

$R$, $R^1$, idle rollers attached to gyrostat frames.

$B$, $B^1$, shelves attached to body of car. Either shaft may engage the corresponding live axis $A$, by rotation of car or gyrostat framework about $H$.

$C$, $C^1$, shelves engaging the idle rollers $R$, $R^1$.

$OP$, $O^1P^1$, simultaneous positions of shafts $A$, $A^1$.

$OQ$, $O^1Q^1$, another pair of simultaneous positions of shafts $A$, $A^1$.


# CENTRAL SCIENTIFIC COMPANY,

**CHICAGO.**