

A NEW TYPE OF RAILROAD CAR

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High speed in railroad operation is no novelty, nor is the achievement of passenger comfort with leisurely schedules. However, speed with comfort presents problems which have thus far been partially solved by extensive improvement in rail and roadbed, involving expensive track realignment and surfacing. Such changes merely to accommodate high speed with some degree of comfort surely are not economical, and therefore provoke the thought that a study of the riding problem, based on fundamental dynamics, might yield a truck and body suspension system which would provide comfort on ordinary track.

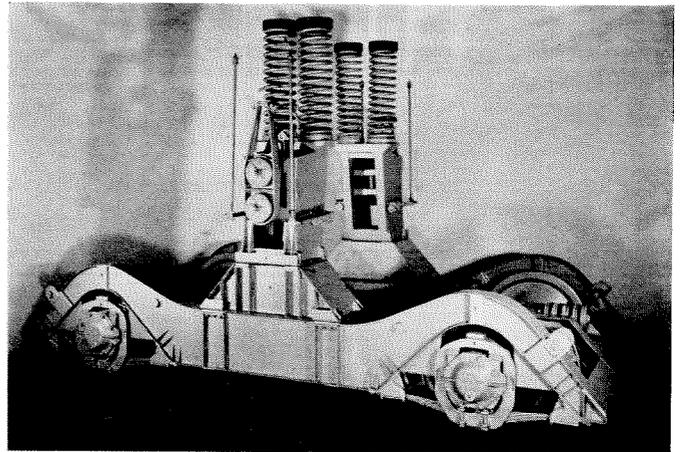
Such a study, stimulated by William Van Dorn, formerly associated with the aeronautics department of the California Institute, and sponsored by Cortlandt Hill, has resulted in a two car experimental train incorporating a new suspension system which has achieved signal success in a variety of road tests.

The suspension system, or method of mounting the car on the track, departs completely from standard practice. As can be seen in the Porter sketch (appearing on the cover of this issue) the car body floats on soft vertical coil springs in a plane above the center of gravity of the body. These springs permit, through horizontal deflection, all of the necessary truck motion relative to the body, this motion being positioned and controlled by a pair of horizontal links, elastically restrained by rubber, acting between the body and the truck frame at a height well above body center of gravity. A horizontal draft connection between the truck and the underbody structure provides the necessary longitudinal stability. Accordingly all of the necessary action of a standard swivel truck is provided without a center plate, side bearing, or swing hangers, thus eliminating lubrication and load concentration difficulties. The principal springing of the body, being above the center of gravity may be as soft as desired, and any tendency for body roll on curves is in the direction to correct for uncompensated side force on curves. This action of "bank" is in direct contrast to the behavior of a standard car and truck which lean outwardly on curves insufficiently superelevated. Likewise the lateral restraint of the car body in this new suspension system may be made to yield as low a frequency, or to be as soft as required since the action is not restricted as in a standard truck by swing hanger length and possible bolster travel within the truck frame. Then, for both the vertical and lateral motion simple shock absorbers are applied to damp resonance or harmonic oscillation.

The truck itself, a substantial fabricated structure, is supported on semi-elliptic springs carried by a journal box hanger which rests on rubber shear pads on the journal box

to permit a small transverse movement of the axle. The rubber likewise is valuable in preventing wheel noise transmission into the frame. Metallic slide guides or other frictional restraint in parallel with the springing system and rubber, have been entirely eliminated. However, the entire journal assembly is provided with guard flanges made like a loose pedestal guide to confine the journal box in the event of failure of rubber parts or springs. Safety, a minimum of weight, and quietness of operation have thus been incorporated in this truck design.

The body structure, in turn, adheres to the fundamentals of light weight, safety, and economy, qualities which are inherent in the monocoque or stressed-skin design employed. A uniform low floor level and low center of gravity add greatly to the stability; while the suspension system of the body, floating the body on soft springs, achieves a high degree of comfort.



Truck and Towers

It should be emphasized that this work on these new cars is definitely experimental and as a result many of the details and appointments which are necessary in modern trains have been omitted in order to get to the important work of developing the riding quality and other engineering characteristics of the cars. The weight of the cars is therefore low, only 65,000 pounds for the two car articulated unit complete with the three trucks. The standard steel car provided by the Santa Fe Railway for comparative riding tests weighs 176,000 pounds and furnishes striking evidence of the fact that great mass is not essential to a good ride.

Full trucks have a 9-foot wheelbase. A twelve-foot wheelbase of the articulate truck is possible because the load from the body is carried directly over each axle and thus the frame is subjected to no bending moments due to body load.

The articulate truck frame has been made separable so that cars articulated at both ends could be uncoupled and switched to provide flexibility in train make-up. All truck frames were fabricated from high strength steel arc-welded and stress-relieved. All wheels have a cylindrical tread and a diameter of 30 inches. Axles are hollow-bored and are fitted with ball bearing journals. A standard clasp brake system is employed. On the full trucks one air cylinder operates the shoes on all four wheels through a simple, fully equalized linkage; each half of the articulate truck has its own brake system with an air cylinder operating the shoes on two wheels. A very simple method of automatic slack adjustment is provided.

In the truck photograph it can be seen that the load is carried from the frame onto the ends of the leaf journal spring the center of which seats in a hanger surrounding the journal box. Vulcanized rubber pads at the top and sides of the journal box, by slight shearing deflection, allow the hanger to shift laterally and provide cushioning against side shock loads. Since, in service, there are no moving metallic contacts or sliding surfaces where wear or play can develop, the wheel axle, bearings, and frame are relieved of all shock and impact loads. Brake thrust, but not torque, is carried by the leaf spring which was designed for this duty.

The towers which carry the main suspension system in the body are bolted to the truck frame and form an integral part of it. These towers, like the frames, are fabricated of light-gauge high-tensile steel, arc-welded and stress-relieved.

The coil springs mounted on the towers carry the body with a static deflection of $8\frac{1}{2}$ inches, softer springing than is usually provided for railroad cars. These springs were specially designed to allow lateral as well as axial movement. The rubber-cushioned lateral restraint arm seen on the side of the tower connects to the body through a link located at a level about 20 inches above the center of gravity of the car body proper. This lateral control system has a very soft restraint at the center of its range and stiffens gradually as it is deflected by sustained side load. Longitudinal positioning of the truck is accomplished by a tubular draft link interconnecting and attached to both the truck and body by means of a new type of rubber buffer, which allows the required angular movement of the link and also provides cushioning for buff or draft loads. At the articulate truck these links carry the train draft load and at the full trucks take only braking and inertia loads. The system thus described incorporates no working joints carrying body loads nor are there any points where slack or wear can develop. These parts replace swing hangers, spring plank, bolster springs, bolster, bolster wear plates, center plate and side bearings in the usual truck construction. The hydraulic shock absorbers seen on the sides of the towers attach to the body through the long vertical links and serve to damp vertical and banking motions. On the top of each tower is

seen one hydraulic shock absorber connected to the lateral restraint arm.

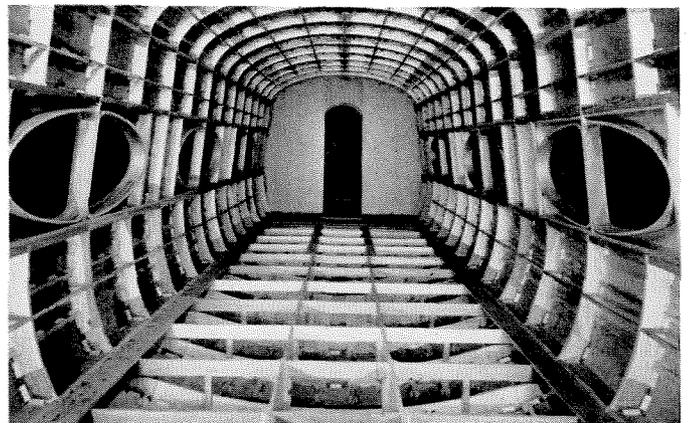
Rubber has been used in a number of important applications because of its well known elastic properties and because automotive and general mechanical applications have shown remarkable life in even very adverse conditions when such applications were properly designed with full regard for the loads and deflections imposed.

It will be seen, then, that a complete break has been made from traditional truck design in the interest of comfort and speed. Equally unorthodox practice has been followed in the car body construction in which the objective has been light weight consistent with strength and safety. The experience of modern aircraft manufacturers in developing structures of very high strength-weight ratios has been used in the design of the true "stressed-skin" or semi-monocoque body structure of these new cars. The characteristic feature of this type of structure is that the outer covering, or "skin", is used as a principal load-carrying element, suitably stiffened and supported. By proper design the skin is able to carry its load without the usual buckles, or "load-wrinkles."

The effectiveness of this type of structure is remarkably demonstrated by the experimental cars which are built of Douglas fir plywood. A static load test to twice the normal gross load has proved the strength and rigidity of these car bodies, which are also entirely free of the creaks and groans usually associated with wooden structures. Wood was used in the test cars merely as a convenient expedient in arriving at suitable means to test the trucks and suspension structure within a reasonable time and at a reasonable cost. The car bodies are thus definitely temporary in contrast to the trucks which have been engineered for permanent service.

Road tests of this new train unit have been made which include a variety of track conditions and operation. Simultaneous records of vertical and lateral ride have been made

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All-wood operable model being built, showing "stressed skin" construction. When completed, this was used for road tests.

RECENT BOOKS

(An abridgement of the list of "Recommended Reading" offered to members of the Alumni Association at the Humanities Seminar held in March, 1939.)

Novels

- Dorothy Baker, *Young Man with a Horn*.
Taylor Caldwell, *Dynasty of Death*.
John Dos Passos, *U.S.A.*
James T. Farrell, *No Star Is Lost*.
William Faulkner, *The Wild Palms*.
Ernest Hemingway, *To Have and Have Not*.
Sinclair Lewis, *The Prodigal Parents*.
Marjorie Kinnan Rawlings, *The Yearling*.
John Steinbeck, *The Grapes of Wrath*.
George R. Stewart, *East of the Giants*.
Elizabeth Bowen, *The Death of the Heart*.
Aldous Huxley, *Eyeless in Gaza*.
Virginia Woolf, *The Years*.
Andre Malraux, *Man's Hope*.
Thomas Mann, *Joseph and His Brothers*, *Young Joseph*,
Joseph in Egypt.
Eric M. Remarque, *Three Comrades*.
Jules Romains, *Men of Good Will*.
Gladkov, *Cement*.
Pilniak, *The Volga Falls to the Caspian Sea*.
Romanoff, *Three Pairs of Silk Stockings*.

Short Stories

- Ernest Hemingway, *The Fifth Column* (a play) and
the First Forty-Nine Stories.
John Steinbeck, *The Long Valley*.

Biography and Autobiography

- Richard E. Byrd, *Alone*.
Eve Curie, *Madame Curie*.
Marquis James, *Life of Andrew Jackson*.
Somerset Maugham, *The Summing Up*.
Antonina Vallentin, *Leonardo da Vinci: The Tragic Pursuit of Perfection*.
Carl Van Doren, *Benjamin Franklin*.

Plays

- Rachel Crothers, *Susan and God*.
Clifford Odets, *Rocket to the Moon*.
Robert E. Sherwood, *Abe Lincoln in Illinois*.
Thornton Wilder, *Our Town*.

Poetry

- T. S. Eliot, *Collected Poems*.
Robert Frost, *Collected Poems*.

Philosophy

- University of California Associates, *Knowledge and Society*.

Alfred N. Whitehead, *Modes of Thought*.

Psychology

- L. W. Crafts and others, *Recent Experiments in Psychology*.

Sigmund Freud, *The Basic Works of Sigmund Freud*.
(Translated by A. A. Brill. Modern Library.)

N. L. Munn, *Psychological Development*.

Mandel Sherman, *Mental Conflicts and Personality*.

L. M. Terman, *Psychological Factors in Marital Happiness*.

Religion

Theodore G. Soares, *Three Typical Beliefs*.

General

Eric T. Bell, *Man and His Lifebelts*.

Ralph Adams Cram, *The End of Democracy*.

Philip Guedalla, *The Hundred Years*.

Aldous Huxley, *Ends and Means*.

Oscar Lewis, *The Big Four* (Huntington, Stanford, Crocker, Hopkins).

Lin Yutang, *The Importance of Living*.

Anne Morrow Lindbergh, *Listen! The Wind*.

John Muir (Linnie M. Wolfe, ed.), *John of the Mountains*.

Lewis Mumford, *The Culture of Cities*.

Harold E. Stearns, *America Now. An Inquiry into Civilization in the United States by Thirty-Six Americans*.

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NEW RAILROAD CAR

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to compare the new equipment with coaches of standard type known to have good riding qualities. These comparisons include operation over fair track at speeds up to 80 miles an hour and on good track up to 94 miles an hour and demonstrate clearly the advantage of the new suspension system. However, no careful instrument measurements are necessary to demonstrate the important points which have been established and which contribute in no small way to passenger comfort. In these new cars, standing and walking about is accomplished with greater ease and with feeling of greater stability than in a standard six wheel truck club car, weighing six times as much as one of the new cars, which is a part of the test train. In fact, walking from one car to the other gives a comparison definitely favorable to the new equipment. Then, as the second outstanding difference, writing at a table in the new car is distinctly easier and the result more legible than that done in the standard car. The improvement is due primarily to the absence of harsh lateral acceleration so characteristic of standard equipment at high speed on indifferent track. Indeed, even in the tail of the new rear car, with its large overhang, objectionable lateral motion, or whipping is not experienced. And finally, a less spectacular but definitely welcome improvement offered by the new cars is the freedom from high frequency vibration or "jitter" so characteristic of high speed trains. Those annoying small vibrations which make reading difficult are not present with the new suspension system, a result which is another important element added to passenger comfort.