New Developments in Railcar Trucks

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ABSTRACT

In this paper the results of the development of the ASDP truck for heavy rail transit applications are discussed. The ASDP truck has a truck-frame-hung monomotor and a very soft secondary air suspension. Also, a number of options that have been developed for the basic Budd P-III railcar truck, of which some 10,000 have been built for transit, commuter, and main-line service, are discussed. The modifications or options that have been developed include a soft primary suspension, a steerable truck, a simplified secondary suspension, and a tilt truck for high-speed corridor operation.

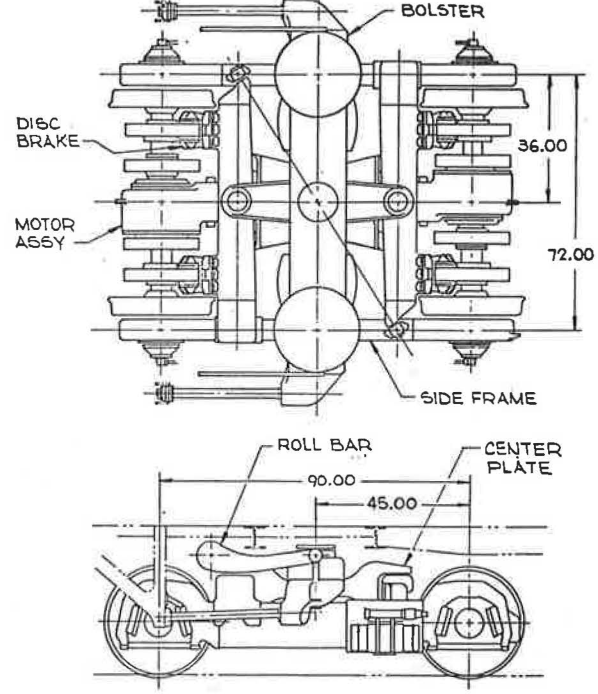

FIGURE 1 Monomotor truck.

In this paper the results of the development of the ASDP truck for heavy rail transit applications are discussed. Also discussed are a number of options that have been developed for the basic Budd P-III railcar truck.

ASDP TRUCK

The ASDP truck (Figure 1) is a monomotor truck with a very soft secondary suspension that was developed under an UMTA subcontract. The monomotor gearbox assembly is supported from the truck frame, thereby reducing the unsprung weight. The primary suspension uses a chevron-style rubber sandwich design in an outside bearing configuration. Two primary suspension spring rate sandwiches were used to investigate the effect on wayside vibration during tests. The secondary suspension is very soft around the operating height; however, the rate increases with travel from the mean position, which prevents overshoot.

The development of the ASDP truck, including static and fatigue tests, has been documented (1). Subsequently, one car set of trucks was fabricated, applied to one of the state-of-the-art cars (SOACs), and tested by the Budd Company at Pueblo, Colorado, under an UMTA contract. The ride data (Figure 2) indicated reduced vertical accelerations compared with the standard truck, as was forecasted in the computer simulations. Wayside data (Figure 3) also revealed the reduction in accelerations with the softer 60,000 lb/in. primary springs compared with the 180,000 lb/in. primary springs, as was forecasted by the Budd wayside/vehicle interaction computer simulation. This truck could be equipped with a Simotrac propulsion package.

P-III TRUCK

The P-III truck (Figures 4 and 5) was developed by the Budd Company more than 25 years ago. It was the first application of air springs for railcar trucks. The P-III truck features a direct load path from the car body through the air springs to the bolster and side bearers to the truck frame and wheels. The bolster rests on the twin side frames, which also serve as equalizers. The result is a simple, easy-to-maintain, three-piece truck. Approximately 10,000 trucks have been built for transit, commuter, and main-line service, even for the super-speed linear induction motor research vehicle (LIMRV), which established the world's speed record of 256 mph in 1972. The P-III truck has a stiff primary suspension with a spring rate of approximately 150,000 lb/in.

In general, the secondary suspension is soft vertically and laterally. A number of options have been developed recently for this basic P-III truck. These options retain the basic softer primary suspension or steering.

SOFT PRIMARY TRUCK

Data from the ASDP test and computer results from the Budd Company vehicle dynamics and right-of-way interaction simulations have indicated that small reductions in primary spring rate can result in large reductions in both rail forces and truck frame accelerations. One modification developed for the P-III truck is the soft primary P-III truck. The journal end of the truck frame has been redesigned (Figures 6 and 7) to accommodate a horseshoe-shaped elastomeric sandwich, which results in primary spring rates of approximately 25,000 lb/in. vertically and 60,000 lb/in. longitudinally. This arrangement provides controlled longitudinal motion of the wheels and can allow some steering in large radii curves. Prototype trucks were tested in a joint program with the National Passenger Railroad Corporation (Amtrak). Measurements of a train passing at 100 mph verified that the wayside accelera-

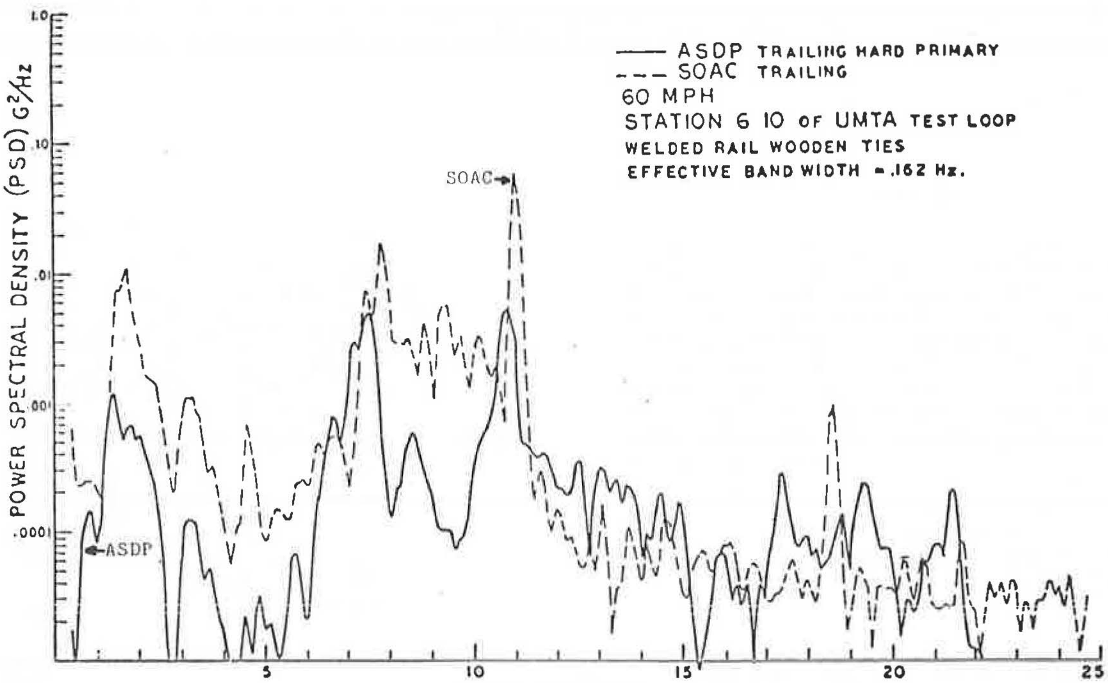

FIGURE 2 Comparison of ASDP to SOAC midcar vertical acceleration levels.

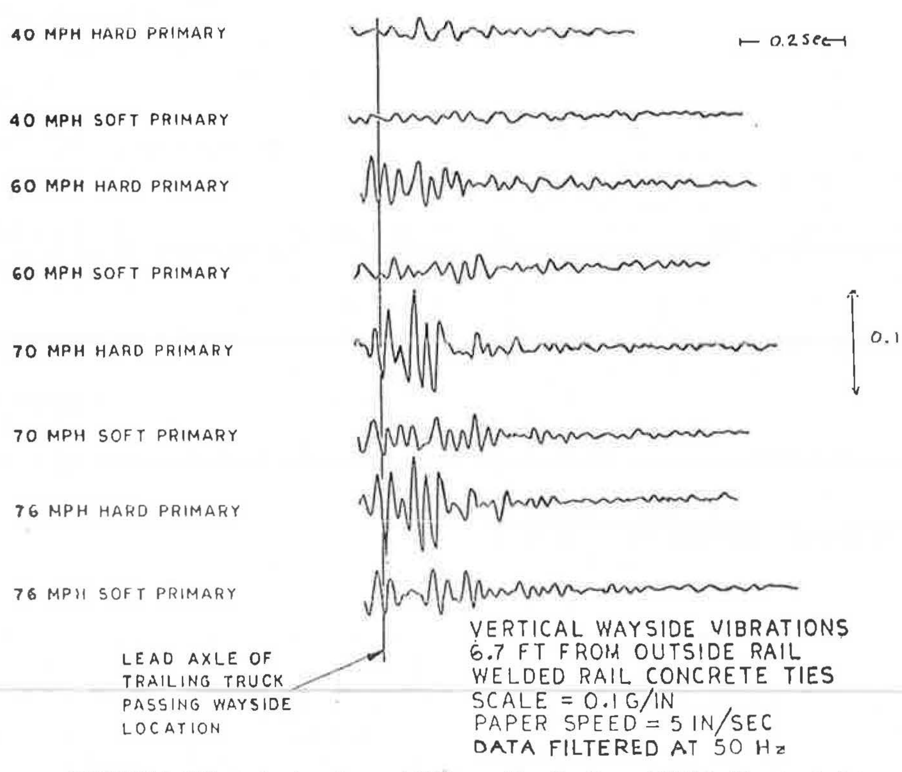

FIGURE 3 Effect of primaries on ASDP wayside vibrations, ASDP trailing truck data.

tions were indeed reduced by the softer primary suspension (Figure 8).

Data from the road tests with instrumented cars and trucks indicate a reduction in truck frame accelerations with the softer primary, as was also forecasted (Figure 9). Currently, the prototype trucks have accumulated more than 350,000 miles in the several years of revenue service. This design is now the standard truck for the Amfleet II cars.

A powered truck version of the soft primary was developed for the self-propelled M-1 Long Island Railroad (LIRR) cars. Initial tests also indicated that the accelerations of the frame were significantly reduced. This car has been in revenue service for more than 1.5 years and has accumulated approximately 100,000 miles, with essentially no flange wear.

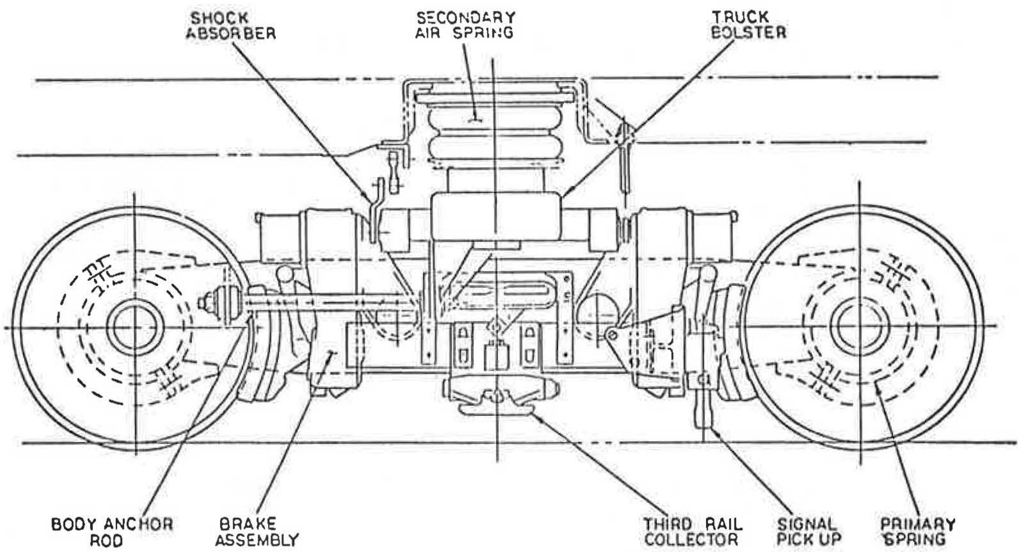

FIGURE 4 PATCO P-III truck (side).

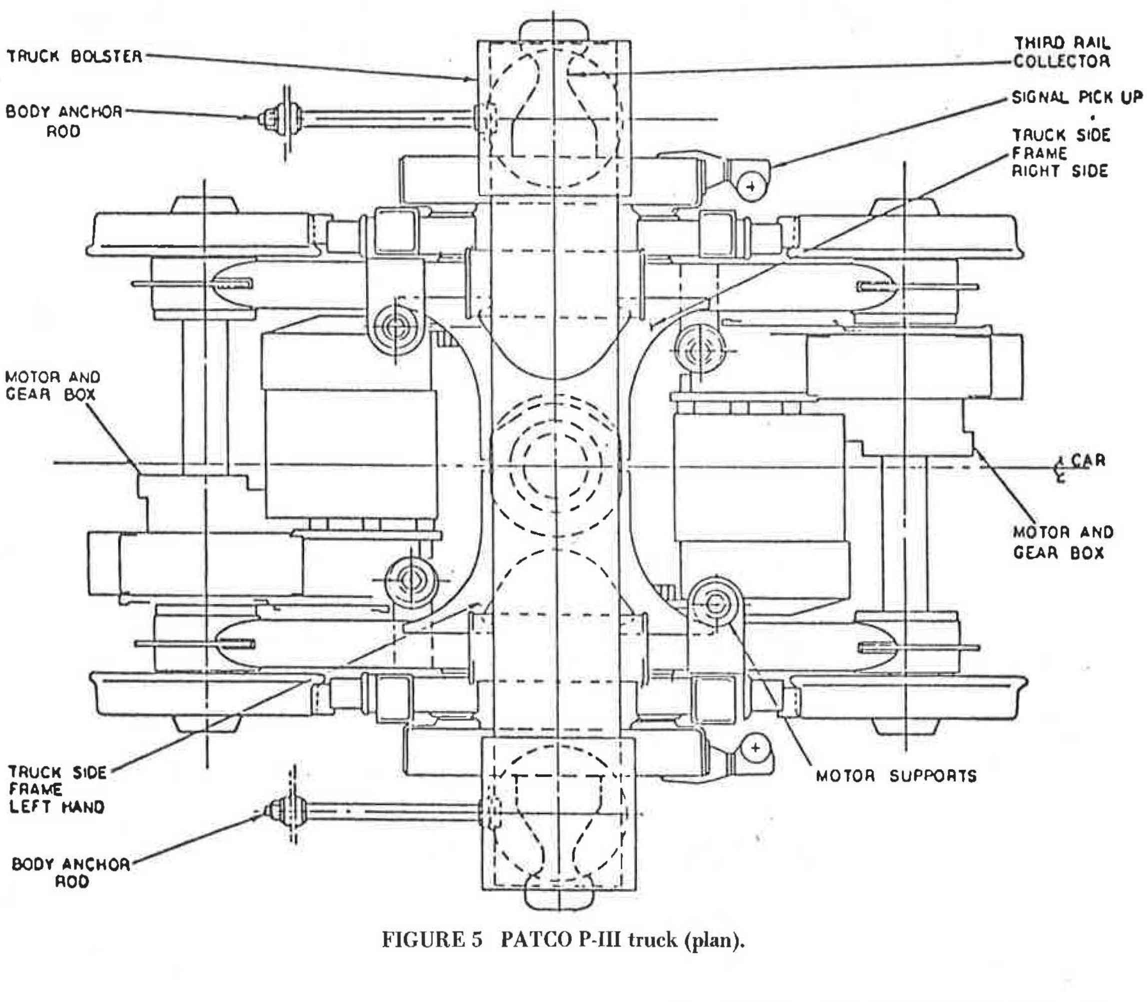

FIGURE 5 PATCO P-III truck (plan).

SOFT BUSHING TRUCK

Another modification reduces the primary stiffness both vertically and longitudinally without modifying the truck frame. This is accomplished by substituting a sculpted bonded bushing in place of the conventional hard primary bushing. The soft bushing modification, as it is called, had been tested in a cooperative effort with the Port Authority Transit Corporation (PATCO) for more than a year. The vertical spring rate is 70,000 lb/in. and the longitudinal rate is 40,000 lb/in. The modification has resulted in reduced wheel wear, especially on the face of the flange (Figure 10) when compared with the married car with the standard bushing (Figure 11).

This same principle has also been applied to the trucks on Washington Metro, although the trucks were

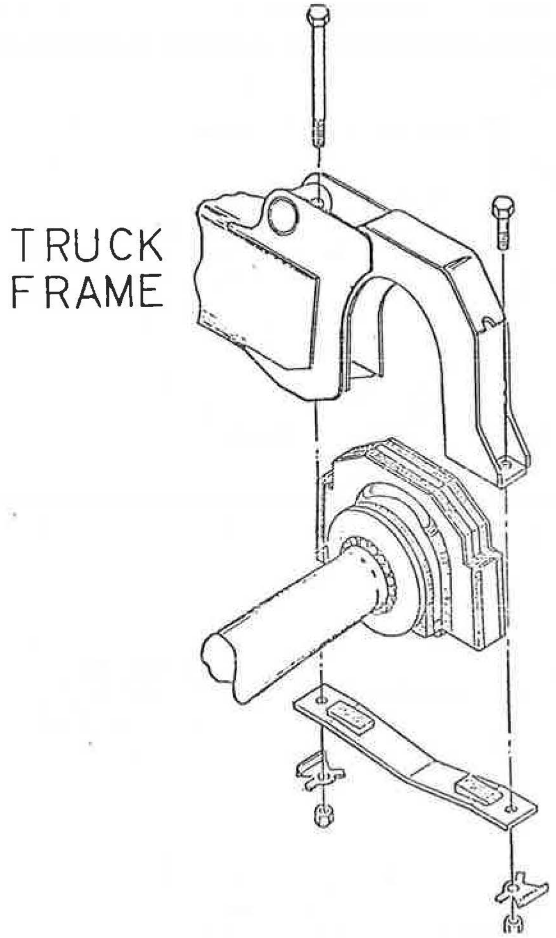

FIGURE 6 Soft primary.

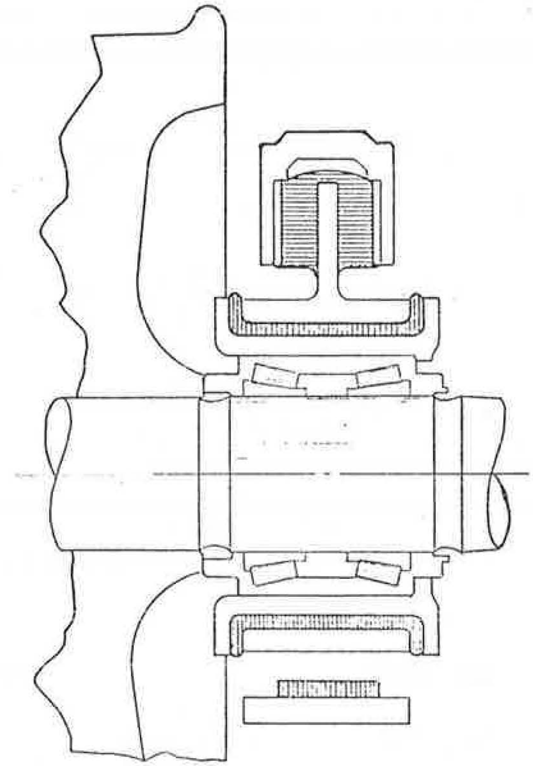

FIGURE 7 Primary suspension and journal assembly.

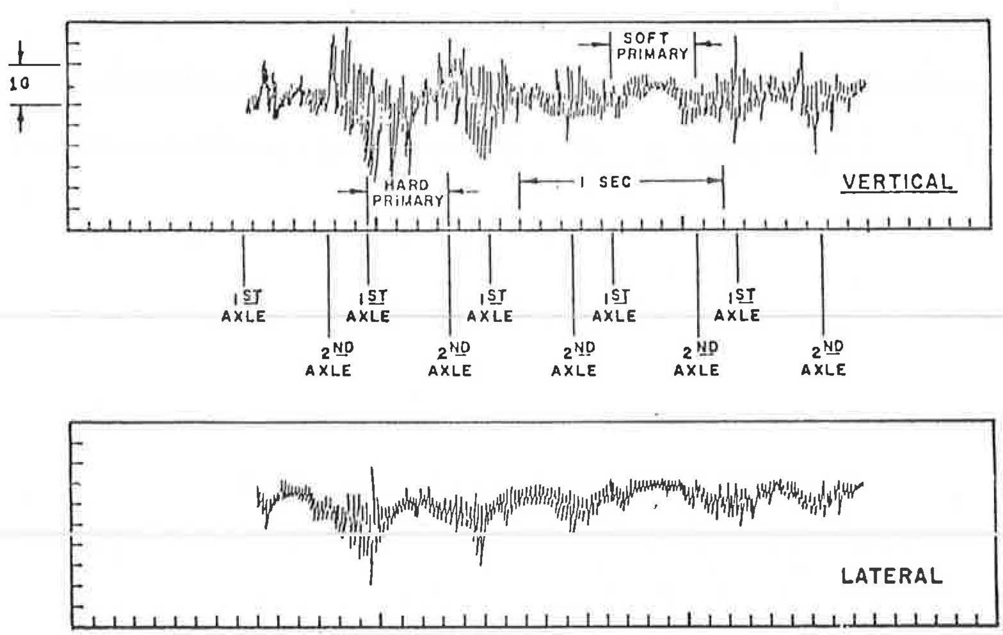

FIGURE 8 Soft primary wayside vibration data.

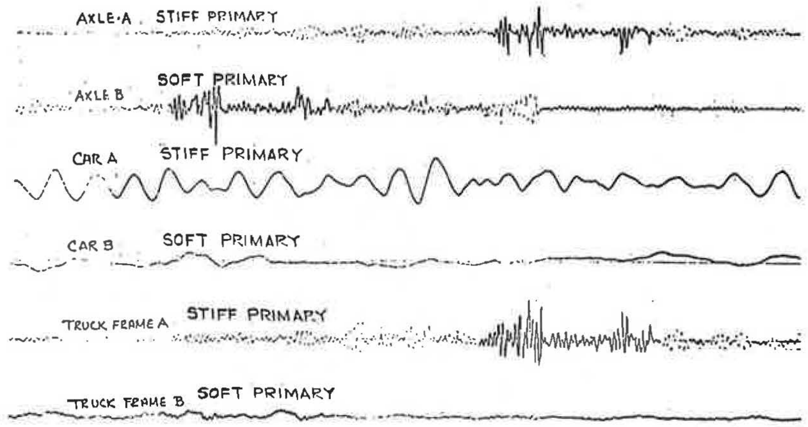

FIGURE 9 Soft primary tests.

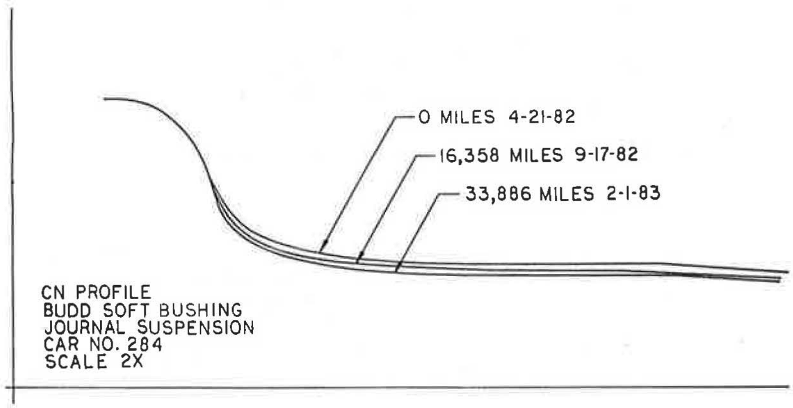

FIGURE 10 Wheel profile wear—soft bushing.

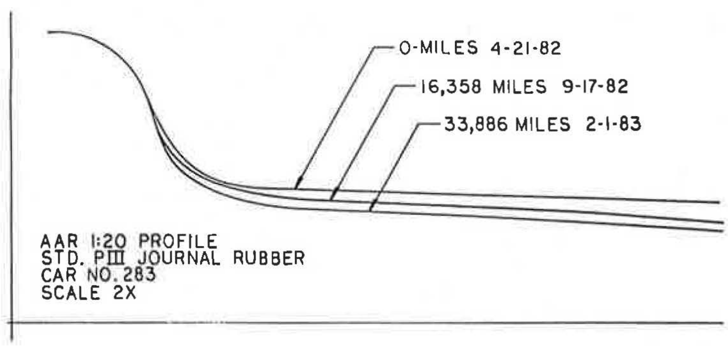

FIGURE 11 Wheel profile wear—standard car.

not produced by the Budd Company. In tests sponsored by UMTA (2), Budd soft bushings tested on Washington Metropolitan Area Transit Authority (WMATA) trucks reduced the lateral track forces in curves up to 75 percent (Figure 12). The soft bushings have been in revenue service at WMATA for more than 12 months with about 60,000 miles. One of the significant differences between the standard bushings and the replacement is lack of settlement (Figure 13). In the past year the settlement of the standard bushings on the married car has been continuing and is close to the condemning limit.

STEERABLE TRUCK

In conventional trucks the axles are constrained to be parallel, which results in wheel wear, rail wear, and noise in sharp curves. Allowing longitudinal compliance in the primary suspension, as in the soft primary of soft bushing truck, alleviates this condition somewhat. However, only with a steerable truck can the axles assume a radial position with respect to the truck in the tight curves.

The steerable truck, by reducing the angle of attack between the wheel and the rail, eliminates the noise and reduces track and wheel wear. A steerable version (Figure 14) of the P-III truck has been developed and extensively tested over the past few years. This program was a joint effort of UMTA, PATCO, and Budd. To accommodate tight curves, the axles, motors, and brakes are mounted on arms (Figure 15) that steer beneath the main truck frame

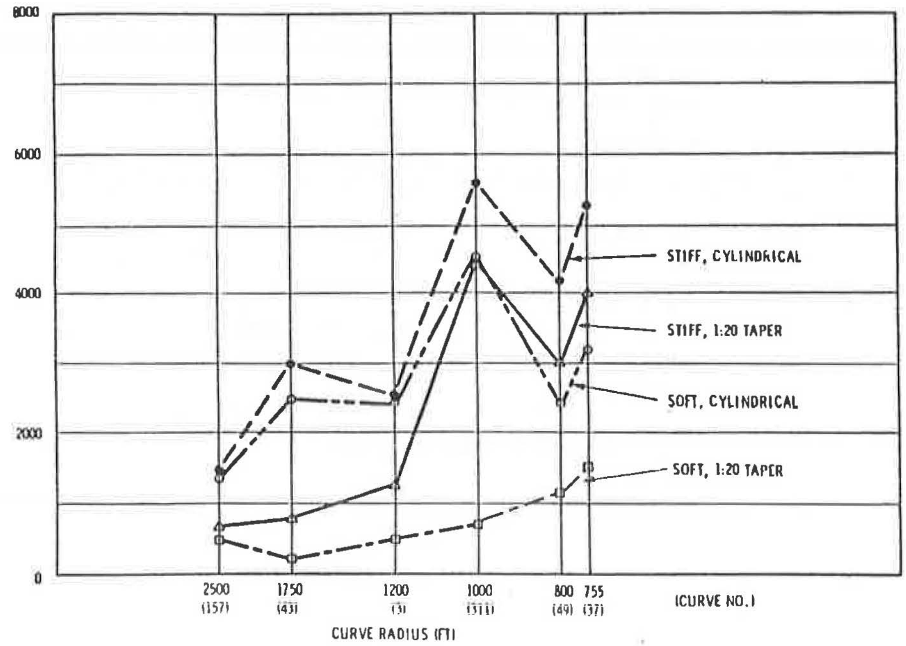

FIGURE 12 Results from WMATA truck tests (for balanced speed conditions).

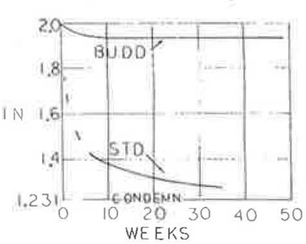

FIGURE 13 WMATA bushing settlement.

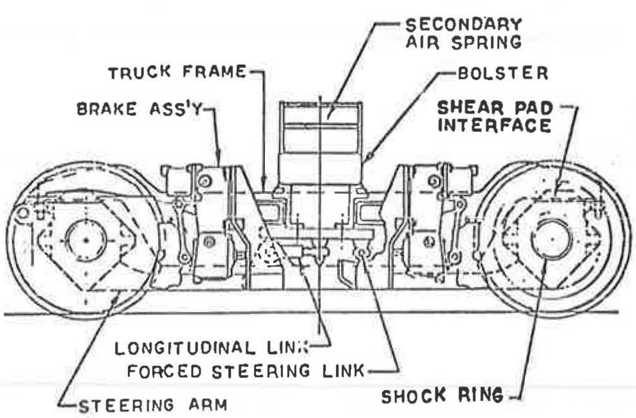

FIGURE 14 Steerable truck.

(Figure 16). The movement of the arms is controlled by the swivel of the bolster. The steerable trucks were tested extensively on the PATCO system and then placed in revenue service. A worn wheel contour is used with those tracks. There was essentially no flange wear in 50,000 miles (Figure 17).

The development of the steerable truck was based on nonlinear computer modeling (Figure 18). The unique dynamic simulation program allows the use of real-world nonlinear characteristics such as springs, sliders, wheel contours, and creep rates. It calculates forces and motions of all the components. The program was used to predict performance of the steerable truck, and, in subsequent testing, the predictions were confirmed (Figure 19).

SIMPLIFIED SECONDARY TRUCK

In high-speed applications of the P-III truck, a coil spring has been used in series with the air spring so that a safe and relatively comfortable passenger ride would be maintained in the event of unlikely failure of the air spring. Another modification developed in a joint program with the LIRR is the simplified secondary suspension system.

This modification eliminated the complexity of the steel spring in series, with the air spring maintaining the same spring rate. The modification uses a rubber spring with internal guidance in series with the air spring. This combination can be used in a vertical plane or inclined toward the center of the car. The current design on the LIRR is inclined. With this modification, the ride is free of the high-frequency disturbances that can be transmitted through the conventional steel spring and stabilizing links (Figure 20). In preliminary tests this design performed well, with or without shock absorbers (Figure 21). A test series is planned in the future to conduct a thorough evaluation of the need for shock absorbers with this design. The trucks have been in revenue service for 8 months.

TILT TRUCK

Another option for the P-III truck, which does not have transit or commuter car application, is the tilt truck. This option allows higher speeds around curves by tilting the car body. It is intended for high-speed corridor operation. The tilt truck uses a programmable roll bar to position the car body

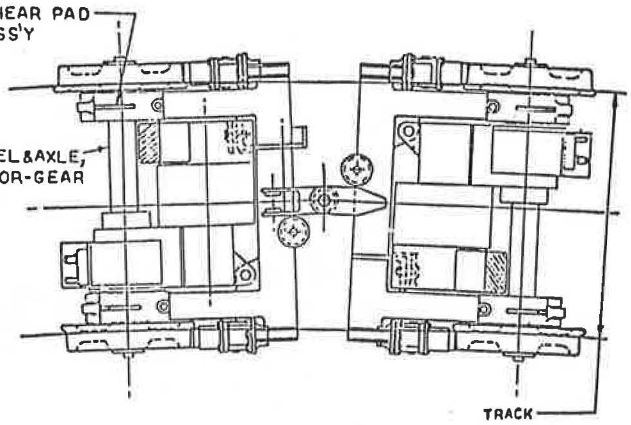

FIGURE 15 Steering arms (truck on radius track).

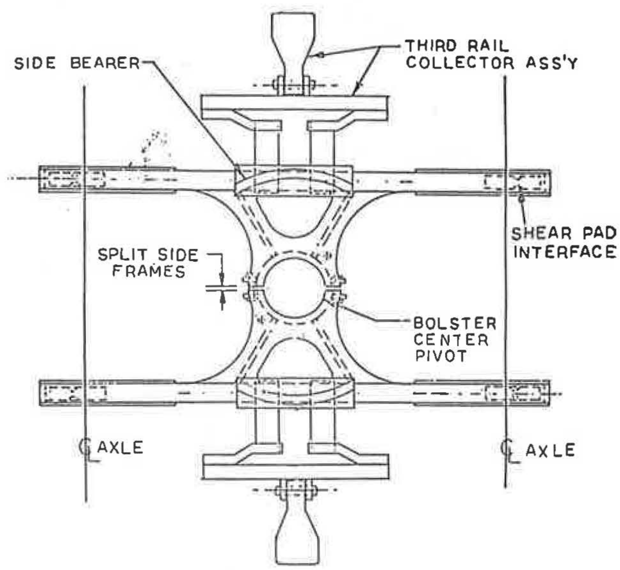

FIGURE 16 Steerable truck frame.

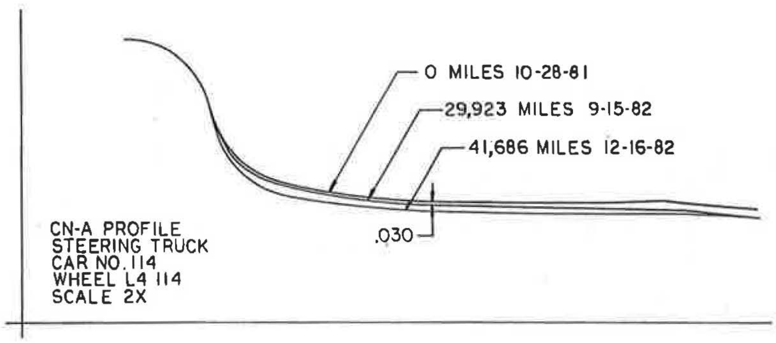

FIGURE 17 Wheel profile wear—steering truck.

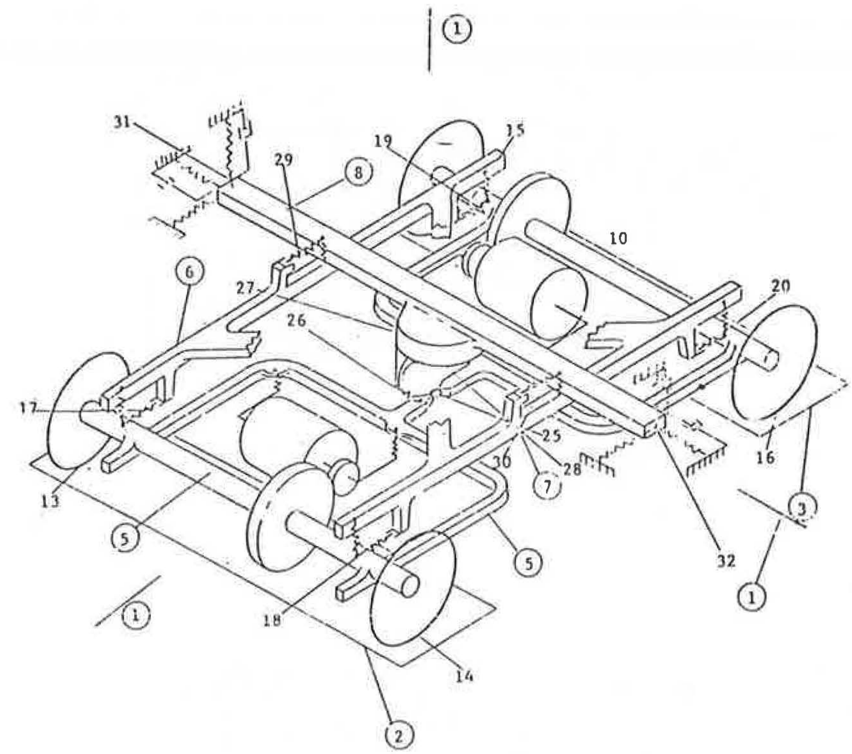

FIGURE 18 Steerable truck model.

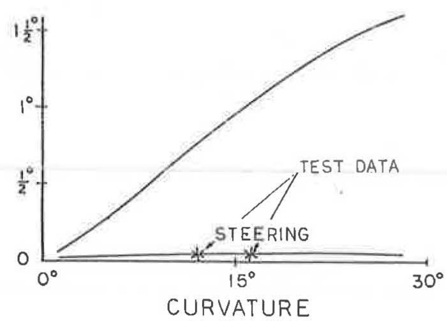

FIGURE 19 Calculated angle of attack.

(Figures 22-24). A pneumatic cylinder indexes the roll bar. The system has a simple on/off control actuated by lateral accelerometers. As the car enters a curve and the acceleration exceeds a predetermined limit, the tilt system is actuated. As the car leaves the curve the tilt system is deactivated as the acceleration drops below another preset level. The time required to tilt the car to the full position is determined by constricting the flow of air to the control cylinder. The actuation time is optimized for comfort for the typical spiral.

The tilt body system was developed by the Budd Company and demonstrated under a contract with the U.S. Department of Transportation with the cooperation of Amtrak. Two series of tests were conducted, and the system has been evaluated at both design and over-speed conditions. Figure 25 shows the typical reduction in car body lateral acceleration from 0.1 g in the control car to 0.04 g in the tilt body car during a 2- and 1.5-degree curve negotiation. The tilt system allows a 20 to 35 percent increase in speed around curves.

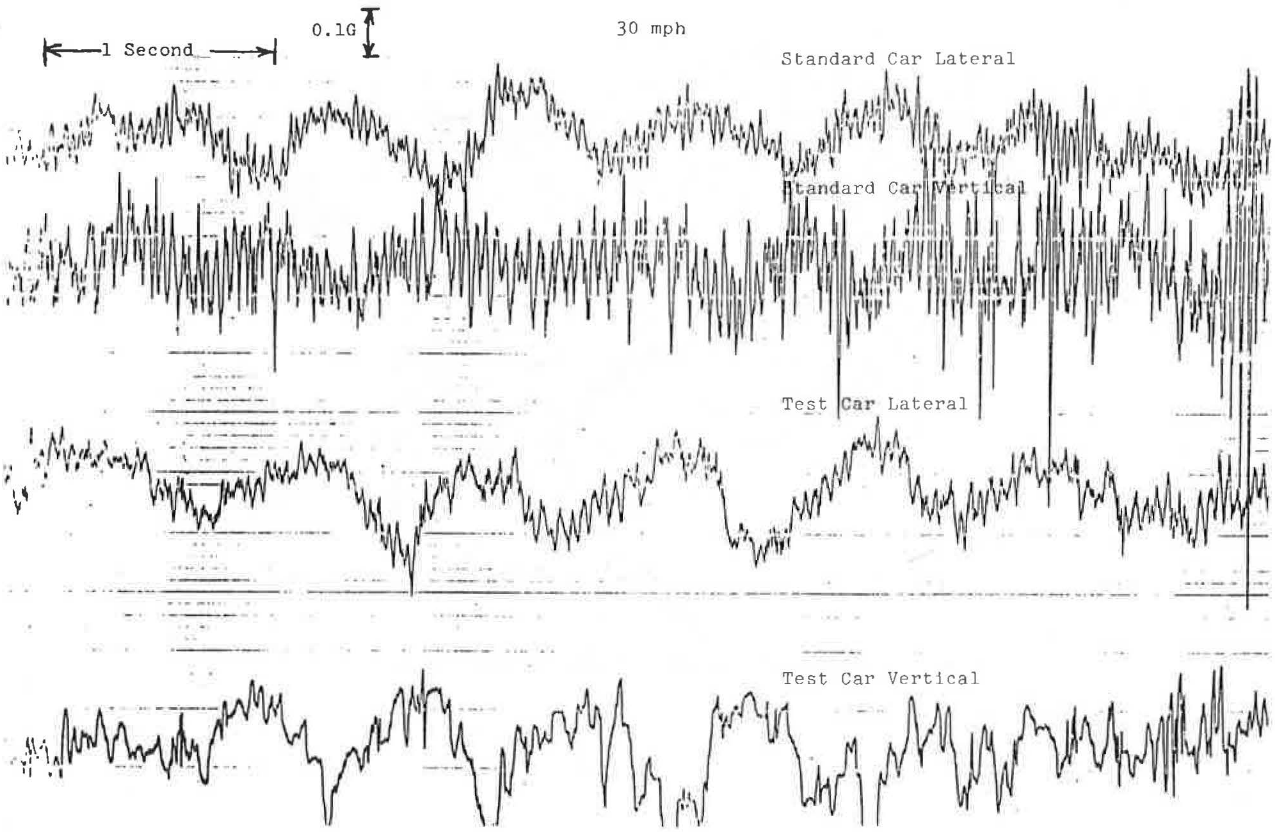

FIGURE 20 LIRR simplified secondary test.

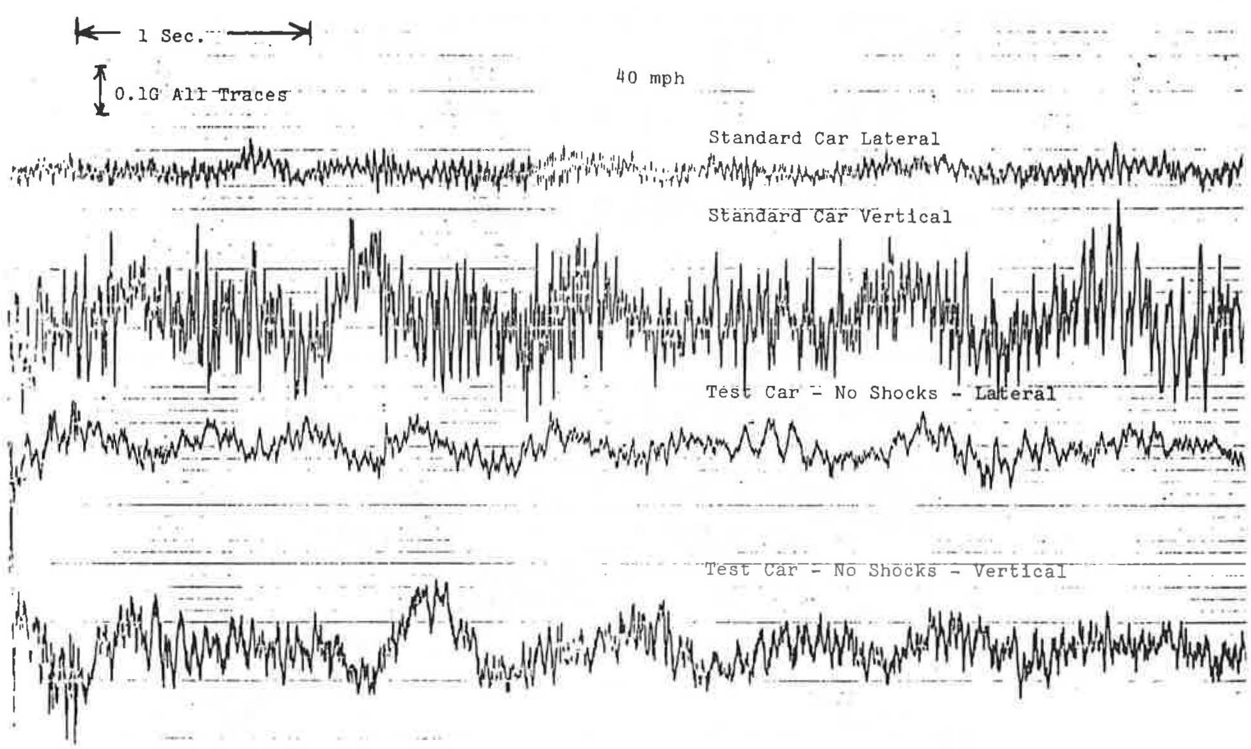

FIGURE 21 LIRR simplified secondary test (no shocks).

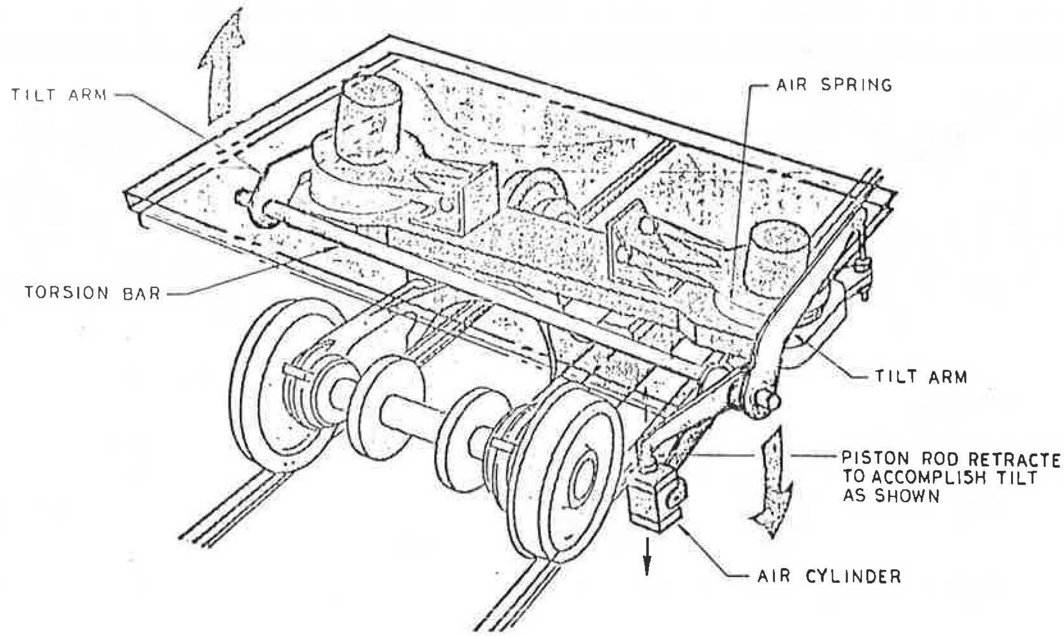

FIGURE 22 Tilt arm and torsion bar arrangement.

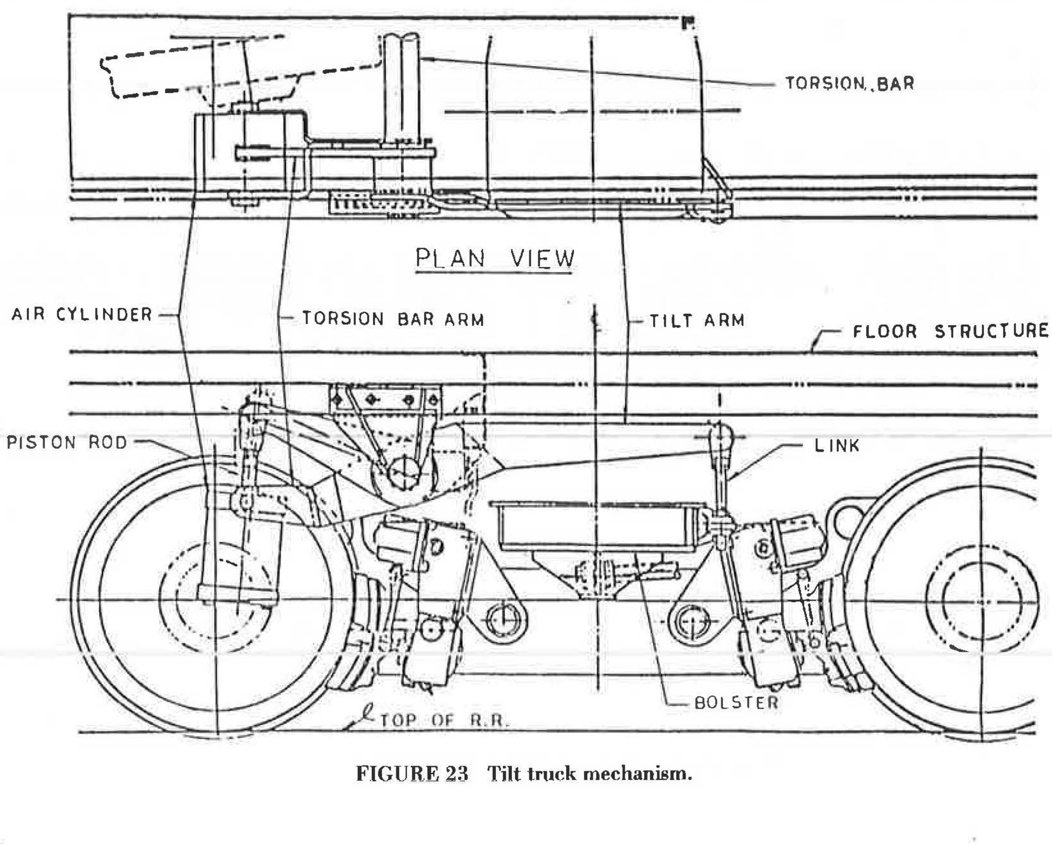

FIGURE 23 Tilt truck mechanism.

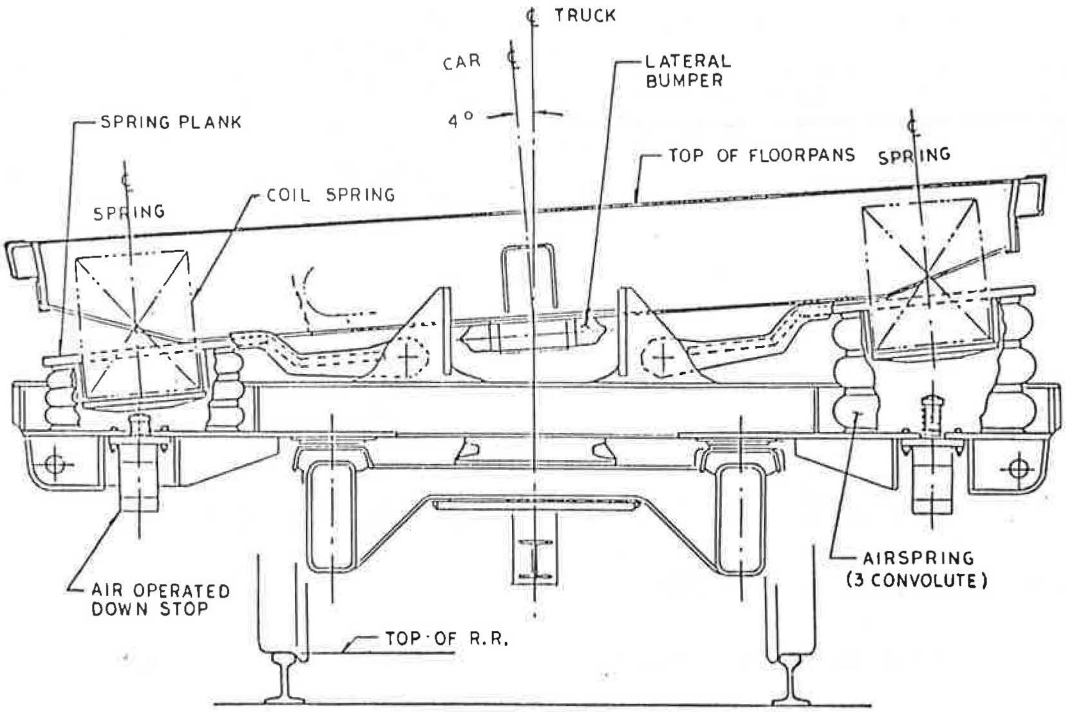

FIGURE 24 Transverse section through truck bolster.

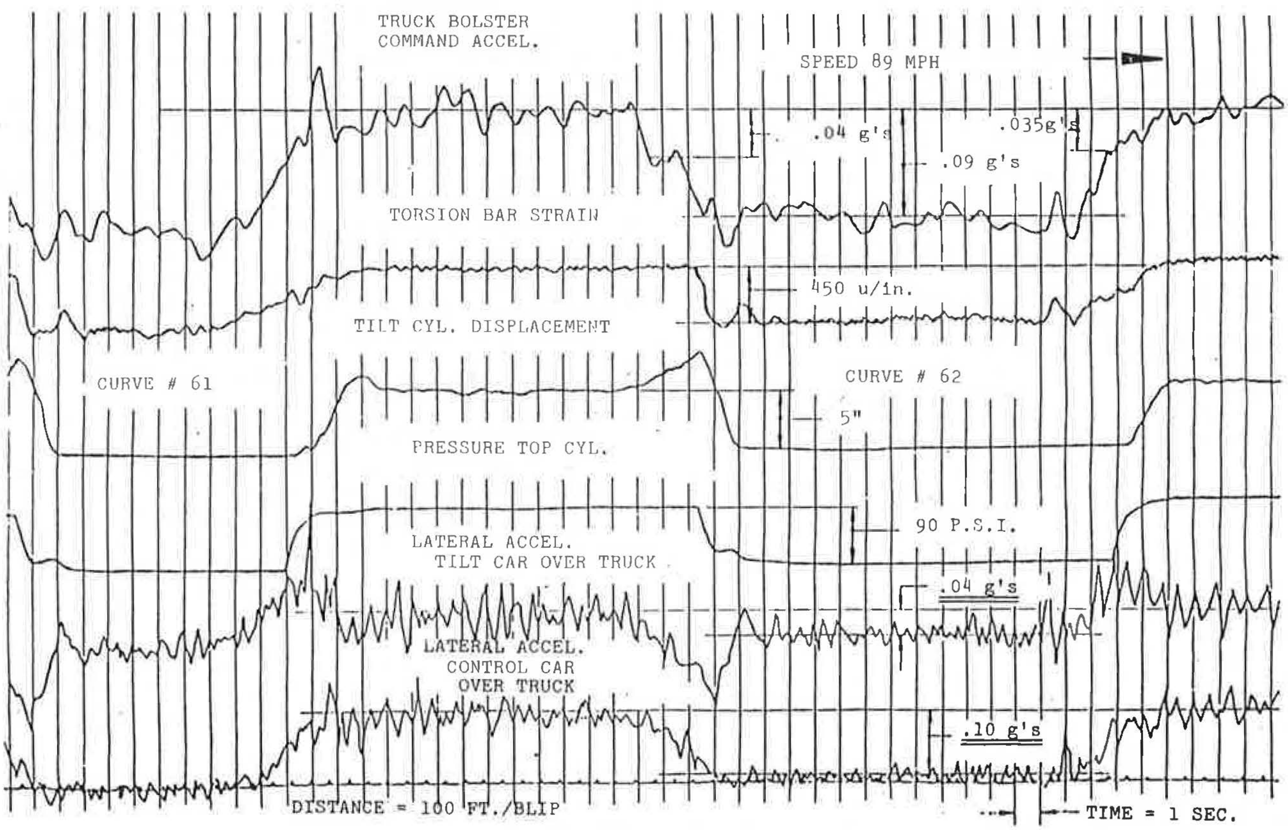

FIGURE 25 Amtrak-FRA tilt test.

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Computer-Assisted Technical Training for Railcar Maintenance Supervision

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ABSTRACT

In order to upgrade its training program for line supervisors (foremen), the Car Maintenance Department of the New York City Transit Authority hired a consultant in 1981 to (a) conduct a comprehensive needs analysis, (b) develop training materials for those areas identified by the analysis, and (c) develop an implementation plan. The project designed, developed, and implemented a comprehensive curriculum of 15 technical background courses for line supervisors. All courses are conducted by using an individualized, self-paced, mastery-based training methodology. In addition to the courses, a complete training management system has been designed and implemented. This system permits the management of the individualized instruction program, with complete tracking and testing of each trainee, together with appropriate permanent record keeping. Reception has been extremely positive both as to the value of the content of the courses and to the computer-based delivery methodology. Most trainees comment that they enjoy the interaction with the computer and they feel comfortable with the individualized, mastery-based methodology.

The Car Maintenance Department (CMD) is one of the four departments comprising the New York City Transit Authority's rapid transit group. It functions in coordination with the other three departments (Maintenance of Way, Transportation, and Stations) to provide rail rapid transit service to the people of metropolitan New York. Its mission as a member of the rapid transit team is to plan, manage, and maintain an effective and efficient CMD in order to continually make available to the Transportation Department the required quantity of safe, reliable, clean, and suitable revenue and nonrevenue cars within available resources.

In real terms the CMD is charged with the maintenance of 6,147 revenue cars, of which it must provide an average of 4,937 each day to make up the trains that serve the riding public. The allocation of resources and all CMD activities are conditioned by the requirement to meet daily service. When resources are limited, as they currently are, such resources are, and of necessity must be, allocated primarily to day-to-day activities that contribute directly to meeting daily service. This defines the basic, overriding constraint on all CMD operations (training included).

Although the pressure of daily service is real and the shortage of financial and other resources within the CMD during the past several years has been acute, the Department has nevertheless striven to implement such long-range programs as it could to provide the operational support to day-to-day maintenance activities. Chief among these are the car overhaul programs, which entail scheduled car overhaul and special retrofit projects to increase the reliability and enhancement of the fleet. Scheduled maintenance activities, which had to be virtually suspended following the New York City fiscal crisis during the mid-1970s, are now being reestablished. Furthermore, the investment in training represented by the program to be described in this paper constitutes another long-term effort to rebuild the base of the CMD operational structure.

In a survey of its training needs, CMD management had concluded that an appropriate point at which to focus initial training upgrade efforts was line supervision. This group represented a target population of manageable size, whose role in overall CMD operations was regarded as especially important.

A request for proposal (RFP) was sent out in October 1980 to a list of selected, qualified consultants to carry out the following tasks:

1. Conduct a comprehensive needs analysis,
2. Develop materials to train line supervisors in the areas of need identified in the front-end analysis, and
3. Develop an implementation plan for carrying out the training program.