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RAIL BUS
TEST OBSERVATIONS
ON THE
BOSTON AND MAINE RAILROAD

JANUARY TO FEBRUARY, 1980

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16. Abstract

This report summarizes the characteristics of the Leyland Experimental Vehicle (LEV-1) and the test program conducted on the Boston and Maine Railroad from January to February, 1980. It contains an introduction and review of the program, a brief summary of the test results, and generalized conclusions of the program including areas which might be studied further in the interest of promoting rail service of this nature using a lightweight rail vehicle.

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1.0 OVERVIEW

This overview will serve as a summary of the report describing the Leyland Experimental Vehicle (LEV-1) test program. It contains an introduction and review of the program, a brief summary of the test results, and generalized conclusions of the program including areas which might be studied further in the interest of promoting rail service of this nature.

1.1 Review

1.1.1 LEV-1 Vehicle

"Railbus" vehicles were tested and evaluated in revenue service in North American railroad service as far back in time as the 1920's and as recently as the 1950's (Figure 1-1). Although these vehicles often operated on excellent track the suspension systems were not sufficiently developed to provide a good ride.

The LEV is a project initiated by British Rail Research in England to produce a low cost vehicle by combining a highly developed bus body design with modern railroad suspension technology. The LEV-1 has a two axle railcar type underframe supporting an eight-section modular bus body (Figure 1-2).

The 18.75 ton vehicle is controlled from cabs located at each end and powered by a 200hp Leyland 510 diesel bus engine which drives one axle. The engine, the fully automatic transmission, and the final drive unit with integral reversing gears are mounted on the underframe.

The brake system is air operated with cable actuated tread brakes. The service brake is controlled by pneumatic valves located in each cab and the parking brake is a spring loaded actuator applied by a loss of air pressure or controlled by a lever in the active cab. A compressor driven by the diesel engine supplies compressed air to three pneumatic systems with four reservoirs; two for the service brake, one for the parking or "spring" brake and one for the auxiliary systems. Each reservoir is equipped with an automatic drain system to bleed trapped water. The throttle, transmission, horn, bell, windshield wipers, and doors are powered by compressed air.

An alternator is belt driven by the diesel engine. The batteries are charged through a control unit and can be isolated by a switch located behind the driver in one of the control cabs.

The vehicle is heated by the engine coolant which is passed through radiators on the basis of thermostatic demand in the passenger compartment. A ventilation system adds fresh air to the heated air in the winter and provides fresh air in the summer. The LEV has no air conditioning system.

The two passenger entrance doors are located at diagonal corners opposite the control cab. The air operated folding doors can be controlled from either cab or by manual valves located on the inside above each door or on the outside beside each door.

The passenger seats are conventional two passenger bus seats with two experimental types of upholstery and with handles on the backs. Straps and handrails are provided to assist passengers moving or standing in the vehicle. The driver's seats swivel and are capable of adjustment up, down, forward and backward.

The diesel engine is protected by a fire extinguisher system which can be activated by breaking a glass located on either side of the outside of the vehicle or on the inside behind the cab at one end. Hand held fire extinguishers are located at the front of the aisle on each end. An alarm system warns of excessive heat under the vehicle.

A timer-controlled, oil-fired supplemental heater can be used to warm engine cooling water prior to start-up. This permits quick start-up after shutting down the engine for long layovers during cold weather. This fuel conserving device also hastens the warming of the passenger compartment.

1.1.2 Purpose of Tests

The LEV vehicle was developed in England and tested on the British Rail system. The LEV-1 was an early prototype used to evaluate the suspension system. Due to inherent differences between the U.S. and British railroads, prior to the construction of a revenue demonstration vehicle for use in the U.S., a test of the suspension design in the U.S. railroad environment was desirable. In addition, other performance parameters were to be evaluated in conjunction with the suspension testing; i.e., acceleration, braking, noise, and fuel consumption. The response of a signal system to a light weight two axle vehicle was also evaluated.

The data collected in these tests were to be used to provide guidelines for application to the revenue service demonstration vehicle.

1.1.3 Test Sites

The Boston and Maine (B&M) Railroad provided two basic test areas: the high-speed class 6 track on the upgraded Northeast Corridor (NEC) between Boston and Attleboro, MA, and the class 3 track between Lowell, MA and Concord, NH.

The NEC test area construction was primarily track of continuous welded rail on concrete ties. This area was used to evaluate the high speed performance of the suspension system and to collect acceleration and braking data. Although most of the track has been recently reworked with concrete ties, some of the older interlockings have not been upgraded. These areas, the wooden culverts, and the insulated joints at signals caused noticeable transient input to the carbody. There were no grade crossing in this test area.

The test area north of Boston between Lowell MA and Concord, NH, was track primarily of bolted rail on wood ties. The area had been recently upgraded to prepare for the recently initiated passenger service. The rail joints caused regular inputs which were felt in the car body. Turnouts and occasional surface conditions caused more severe inputs. There was also a variety of grade crossing protective devices and signal systems in this test area.

1.2 Tests

The following discussion presents a brief summary of the tests which are documented more thoroughly in Section 6 Test Results.

The noise level exterior to the vehicle as well as in the passenger compartment was measured while travelling on jointed rail. The measured levels were within the requirement of EPA and FRA standards.

The sound level of the horn was 81 dB(A) at 100 ft., much lower than the FRA proposed minimum level of 96 dB(A).

Exhaust emissions were not measured during the test.

The averaege fuel consumption in 1254 miles of travel was 5.3 miles/U.S. gallon.

The four speed transmission has a dual range of gear changing speeds. Figure 1-3 displays the results of acceleration tests in each of the two gear changing speed ranges.

Stopping distance was measured from various initial speeds as shown in Figure 1-4. Both modes of brake application, "service" and "parking", were evaluated. The added points shown were made on different days.

The British Rail representatives indicated that they were satisfied with the ride quality data collected during the test period. The FRA will be provided with a British Rail report after the data are reduced.

During several days of testing FRA and B&M signal specialists observed the response of the signal system and grade crossing protective devices to the presence of the vehicle. In the NEC test area there were several momentary cases when the signal system lost the vehicle. In one case the vehicle was not detected for a long period of time due to a moderately rusty rail condition. On a few occasions in the territory north of Boston, the "approach lit" signals ahead of the vehicle did not light, an indication that the presence of the LEV-1 was not detected by the signal system. On other occasions there were momentary periods when the vehicle was not fully detected by the grade crossing protection. In one case the light stopped flashing and the guard arms raised as the vehicle approached the crossing and the system continued to behave erratically as the LEV-1 crossed the highway.

1.3 Conclusion

The general "feeling" conveyed by the riders was favorable based upon the appearance of the interior and the wide windows. Although there were a few adverse comments about the ride quality most of the comments were favorable. The ride quality of the longer demonstration vehicle should be improved over the LEV-1.

There were several adverse comments about the difficulty of boarding the vehicle from the ground. The British Rail representative advised that the demonstration vehicle will be designed to accommodate the high platforms that are to be installed at each station stop specifically for the demonstration vehicle.

As a result of the analysis of the signal response data it is understood (see Appendix B) that the carrier will operate the demonstration vehicle under absolute block conditions and within the Operating Rules for RDC equipment;

> "Single unit rail diesel cars are permitted to operate over all lines where permitted by engine limitations and must approach all crossings equipped with automatic protection prepared to stop unless protection is seen to be working".

When the demonstration vehicle is received the signal and grade crossing tests should be rerun prior to the start of revenue service in order to determine whether or not these restrictions are required.

The British Rail representatives were satisfied that the recorded test data would provide useful information. They were disappointed in the fuel consumption results and plan to investigate the fuel used in their earlier tests compared to the fuel used in these tests.

The British Rail representatives also indicated that they will:

1) Modify the horn to suit FRA specifications.

2) Investigate the possibility of providing more heat to the windshield for defogging.

3) Provide a fuel tank which can be filled more easily.

4) Investigate a windshield washer design which provides a more dependable flow of fluid.

5) Resolve the wheelslip circuit problem which causes the brakes to release when radio transmitters on the vehicle are keyed to transmit.

In order to fully develop the operating potential of the British Rail/Leyland Rail buses the signal system compatibility problem must be solved. Railroad operation under absolute block rules is a severe constraint and speed reduction at grade crossings in preparation for stopping will also be very detrimental to schedules. It would be highly desirable to investigate the problem in order to develop an appropriate solution which would assure that a lightweight vehicle will be recognized by the signal system.

The suspension tests described in this report were conducted with new wheels with a worn tread profile. Although wheel wear will have less effect upon the suspension response when this contour wears, it would be desirable to monitor the ride quality of the demonstration vehicle after some revenue mileage has be accumulated. In addition, the effect of operating with unbalanced or conventional U.S. wheels would provide useful data on the effect on ride quality.

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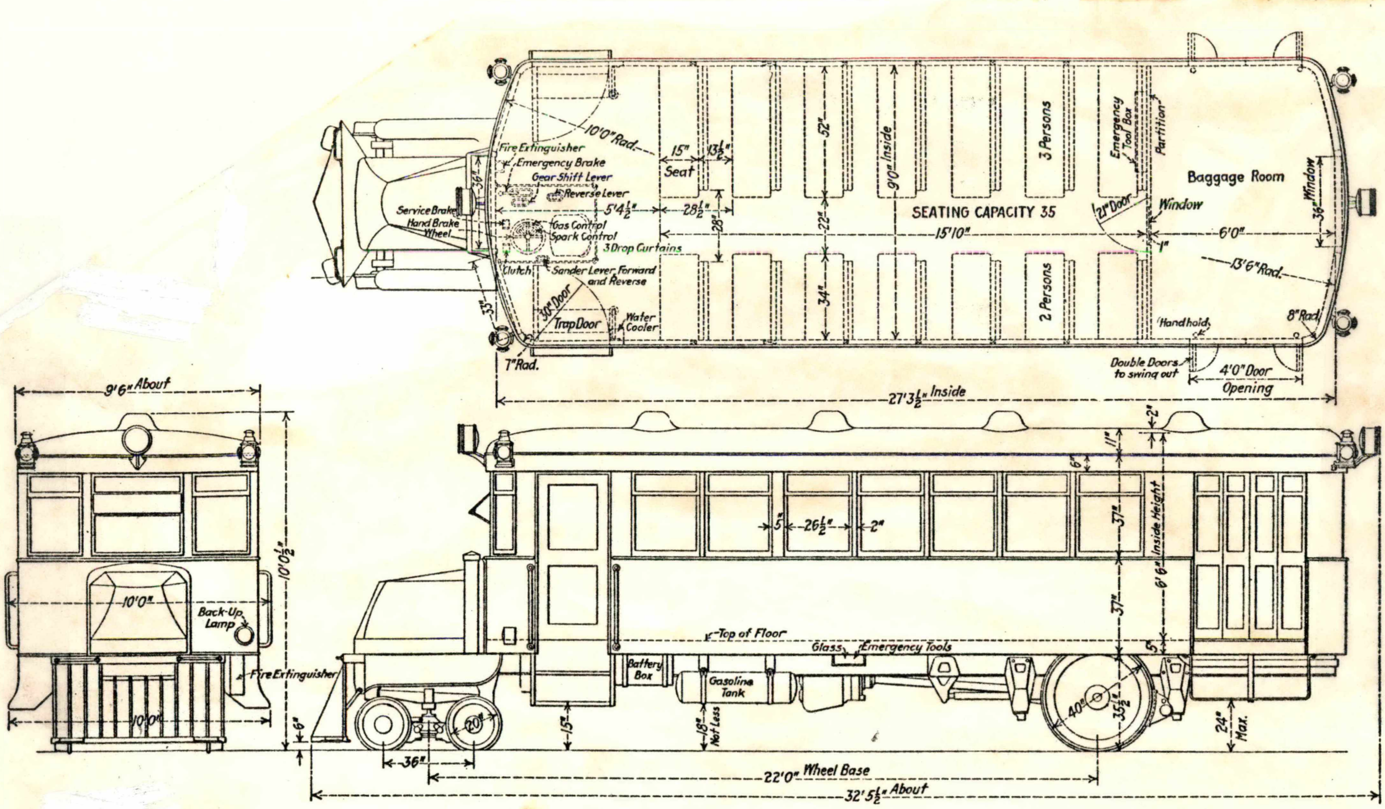

Plan End and Side Elevation of Mack Rail Car

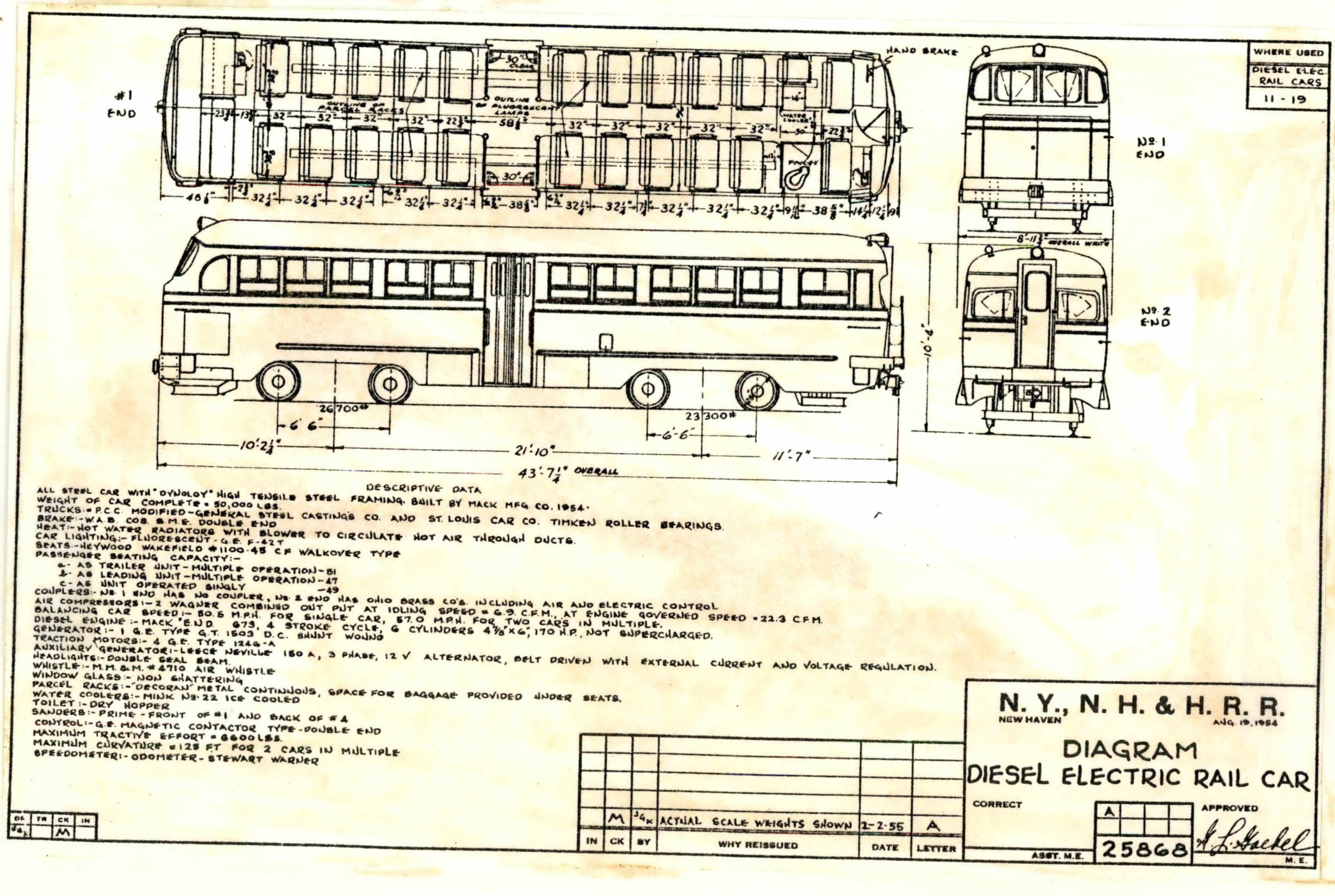

Figure 1-1 Mack Rail Busses of 1922 and 1954

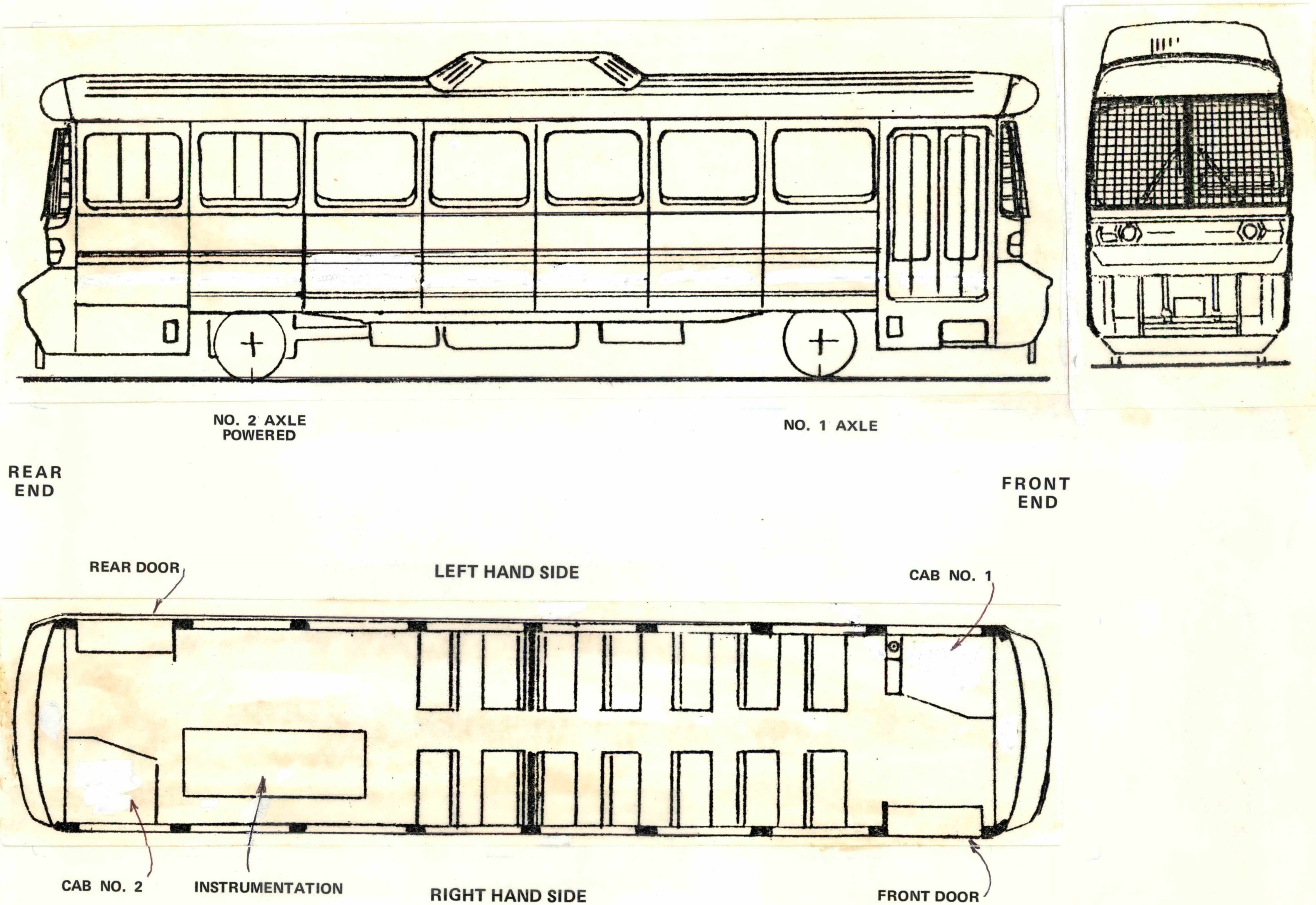

FIGURE 1 – 2 LEV – 1 LAYOUT

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Figure 1-3 LEV-1 Acceleration

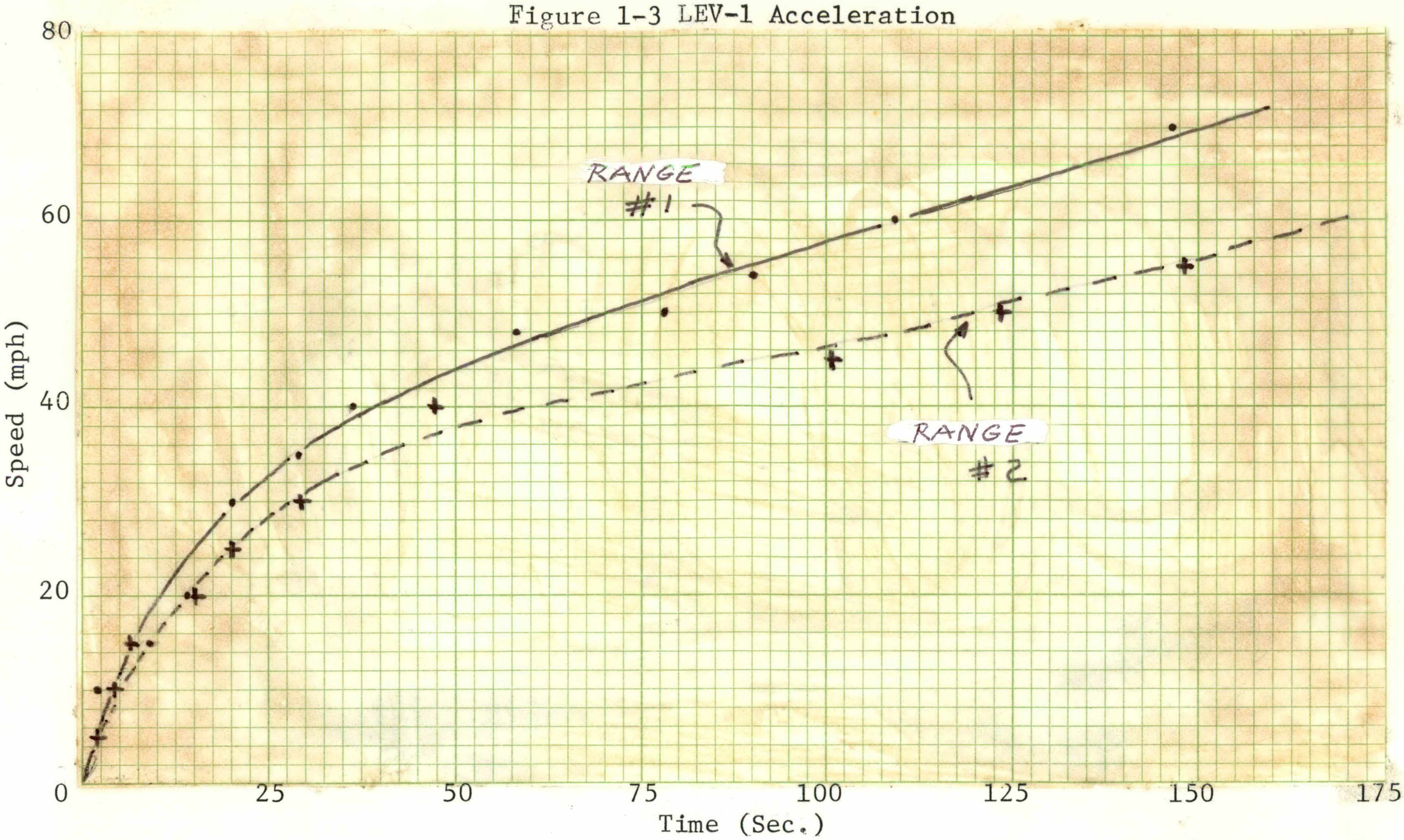
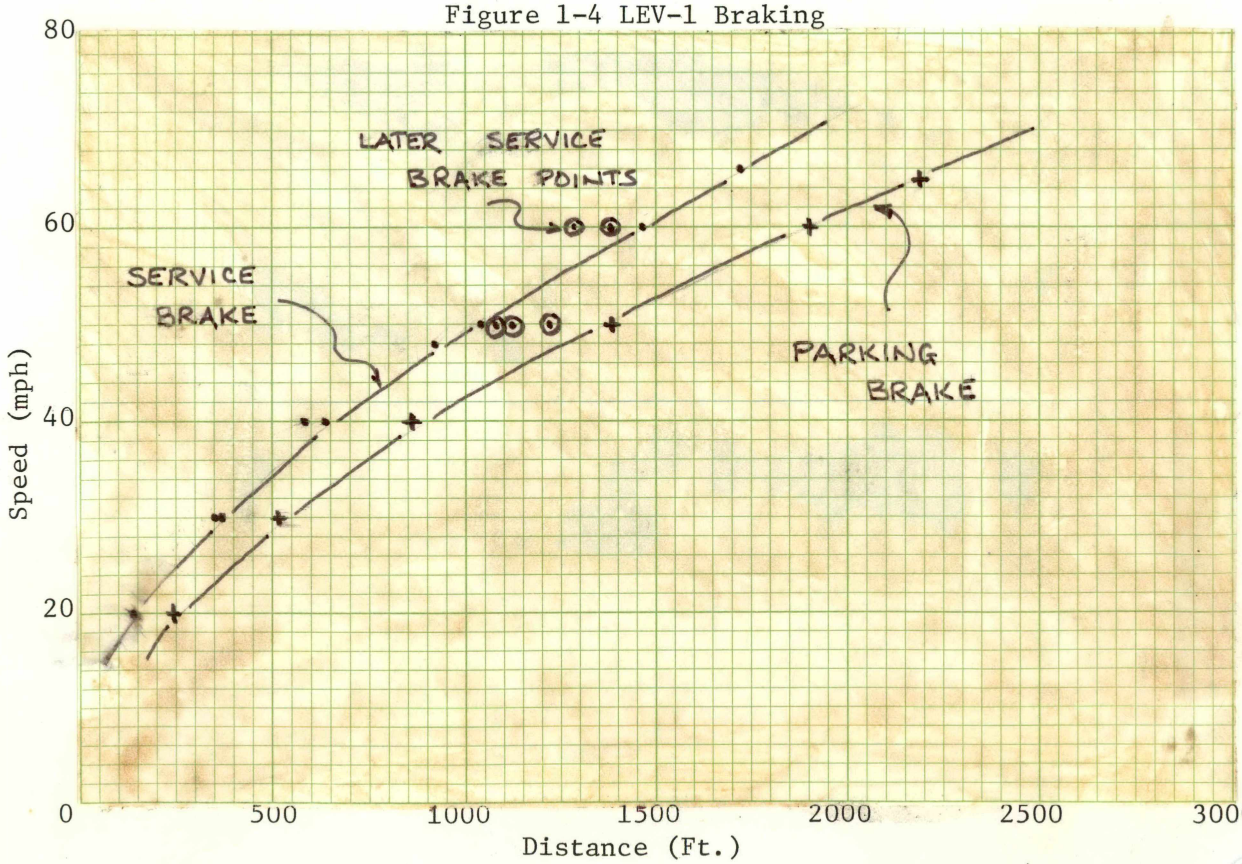


Figure 1-4 LEV-1 Braking



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2.0 INTRODUCTION

2.1 Background

2.1.1 History

There has been an interest in single unit, self-propelled cars in the U.S. for almost as long as there has been passenger service. By avoiding the use of a relatively large, separate locomotive, service could be provided more economically (and more profitably) on lightly traveled routes.

Efforts to produce self-propelled cars date from the 1850's with numerous designs for steam driven cars. Experimental applications involving internal combustion engines date as far back as the mid-1880's when street car lines were trying to improve on the horse, however, electrification of street car lines solved their problem. Railroad interest in self-propelled cars varied through the years but was greatly revived following World War I with the loss of traffic to the automobile and increasing costs of operating locomotive-hauled trains in the face of inflation.

Ironically many of the first self-propelled car designs in the 1920's were quite small, being city bus designs equipped with flanged wheels. These proved to be too small for the traffic loads on the lines which the railroads felt were worth saving, therefore larger vehicles were developed which were more the size of interurban cars.

Limitations on mechanical transmissions led to the adoption of electric transmissions using existing electric railroad components. This "gas-electric" car concept (later diesel-electric) evolved further into the light weight and often articulated streamliners which were introduced in the 1930's in an effort to entice passengers back to the rails.

In the northeastern part of the U.S. the New York, New Haven, and Hartford (N.H.) and the Boston and Maine (B&M) were two railroads which pioneered the use of self-propelled cars. Equipment used by these lines has spanned the complete range in size from Brill and Mack railbuses to articulated streamliners such as the stainless steel "Flying Yankee" on the B&M (built by Budd) and the aluminum "Comet" on the N.H. (built by Goodyear-Zeppelin). On both of these railroads the operations requiring the use of the smallest vehicles were the first to be abandoned in the face of automobile competition. Even during the depression, the popularity of the automobile surged while rail traffic declined sharply.

It is of interest to compare some of the early bus-derivative vehicles with the 18.75 ton, 200 Hp, nominally 40 seat LEV-1. The early Brill models of 1923 included a 14 1/2 ton, 38 seat bus powered by a 68 horsepower engine. A larger engine was also offered as an option. The most

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recent rail buses were built for the N.H. by Mack in 1954, had a seating capacity of 47, and even had a small toilet. These vehicles weighed approximately 25 tons and rode on modified PCC streetcar trucks. All ten vehicles were equipped with a 170 horsepower Mack diesel engine with electric transmission to four streetcar-type traction motors, giving a rated top speed of 50.5 mi/h. They were equipped with an end door at one end to permit two-unit operation. Unfortunately the service for which they were purchased was abandoned at the time of their delivery. Several survived as Sperry Rail Service cars while most were lost at sea while being shipped to Spain.

Several problem areas with single car railroad operations were identified previously in the course of service experience. One such drawback to rail bus service is excessive labor cost under existing contracts of providing a two-man crew, as compared with a single operator for a highway bus.

Another major concern is the technical problem of shunting signal track circuits so the signal system is aware of the presence of the vehicle. This problem has plagued even heavier one-car trains such as the large gas-electrics and the Budd RDC and SPV-2000. This situation becomes even more acute with the lighter bus-type vehicles, especially if only two axles are provided. In the past, some RDC's were equipped with a special circulating current circuit which improved wheel to rail electrical contact. To achieve this, the pedestals of one axle in one truck were insulated and alternating current of 400 Hz was circulated between the two axles through the rail. This served to break down high resistance contact between wheels and rails and improve conduction of the track circuit current. While this overcame the problem, the additional complexity led to a search for a more simple solution. Since part of the wheel to rail contact problem was attributed to the use of disc brakes without benefit of tread brakes, an arrangement of iron "wheel scrubber" shoes riding in constant contact with the tread of each wheel was tried. This proved sufficiently workable that it has been applied to most RDC's.

On the Pennsylvania Railroad, gas electric cars were often operated with a cabin car (caboose) to increase the number of axles available for signal shunting.

2.1.2 Current Program

The State of New Hampshire, through a grant from the United States Department of Transportation, Federal Railroad Administration, has contracted with the Boston and Maine Corporation for a two-year rail bus demonstration program. The purpose of the project is to test and evaluate low-cost, fuel-efficient rail vehicles in a long distance commuter environment. A part of the project will include operation of daily conventional passenger service over the same route between Concord and Boston (Figure 4-1) to determine passenger attitudes toward the service. The route between Concord and Boston offers ideal conditions for the experiment and the results can be extrapolated to other Section 403-B type service within the United States.

The initial phase of the demonstration project was to test a British Rail/Leyland Experimental Vehicle (the LEV-1) in order to collect engineering data necessary to modify the passenger carrying demonstration vehicle for possible operation in the United States. The LEV-1 is a non-passenger carrying research vehicle made up of a Leyland bus body mounted on a special rail undercarriage and suspension system. The vehicle has two single axles, attached to the vehicle through only a primary level of suspension. It is 39' 4 1/2" (12 m) long and weighs 18 3/4 tons (17 Mg). It is operated independently as a single unit from a cab at either end without provision for multiple unit operation.

Because the LEV was constructed as a research tool for British Rail it does not meet some of the U.S. passenger equipment design practices. Modifications to conform to American practices, such as installation of stub E-64 type automatic couplers at each end were incorporated. Some other U.S. practices were evaluated and judged inappropriate for inclusion on the research vehicle, because it was to be tested in the U.S. only under absolute block conditions with special protection of the entrance of the track and at highway grade crossings, under a controlled, non-revenue passenger environment. A waiver on certain safety appliances and design practices was requested and granted.

In the judgement of the FRA, it was highly desirable to use this research vehicle to collect technical data on the U.S. track structure before design parameters for the follow-on revenue passenger carrying vehicle were finalized. European practice is to construct track with opposing rail joints as compared to the staggered rail joint track used in the United States. The dynamic input to the suspension system is quite different for these two cases and adjustments to the primary spring and damper systems may be required.

The technical approach to the test program entailed instrumenting the suspension system of the LEV-1 and testing it on various track structures, ranging from class 6 down to class 3. The initial set of runs, conducted on CWR and concrete ties, served to obtain a good data base and to establish a safe operating envelope. Subsequent tests resulted in data collection on CWR and wood ties, high quality bolted rail and wood ties. All of these track test conditions were found on routes over which the B&M operates. The higher quality test trackage is located between Boston and Providence and the class 3 trackage is located between Concord and Boston.

2.2 Objective

The purpose of this project was to test the LEV-1 vehicle in the U.S. railroad environment to determine the suitability of the suspension characteristics, to evaluate the response of the railroad signal system to the presence of the vehicle, and to determine certain other performance parameters (acceleration, brake distance, noise, fuel consumption, etc.).

These data will be used as guidelines in the manufacture of a revenue, passenger, demonstrator railbus for U.S. application.

2.3 Report

This report is organized as follows:

a. Statement of test objectives.

b. Description of LEV and it's subsystems with photographs.

c. Description of the test sites with photographs.

d. Assessment of design features compared to present U.S. commuter rail vehicles.

e. Description of test plan and instrumentation.

f. Assessment of available test data:

   1. Noise Monitored by FRA and data furnished.

   2. Emissions Monitored by FRA and data furnished.

   3. Fuel Consumption-Data collected during the test.

   4. Acceleration and Braking.

   5. Ride Quality - Defined as the available data permitted or as personal judgments of the observers.

   6. Signal System Compatability - Assessment of the available data from the performance of the vehicle during the signal system test.

   7. Wheel/Rail Interaction - Assessment of available data.

The background and test objectives are provided as Sections 2.1 and 2.2, respectively. The present U.S. commuter vehicle selected for the comparison required of "d" is the Pullman-

Standard built car operating in push-pull service in the Massachusetts Bay Transportation Authority's (MBTA) Boston to Concord Service.

In this report the description of the test plan and instrumentation, required by "e.", is combined with the individual test results in Section 6. Wheel/Rail Interaction ("f.7") and Ride Quality, ("f.5") are combined and included in Section 6.6 of this report.

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3.0 VEHICLE DESCRIPTION

3.1 Overall Arrangement

3.1.1 General

As previously indicated the LEV-1 was configured as a research and test vehicle and used for testing in the U.S. railroad environment. Since it was not intended as a revenue demonstration vehicle, several of the details of design and components in construction were either prototype material or deviations from preferred practice. The LEV-1 vehicle consists of a railroad underframe which contains suspension and auxiliary systems and supports a bus body assembled with eight modular sections. Six of the modules are identical intermediate sections and two modules are ends with the operating cabs and doorways.

The vehicle was ocean transported from England to New York City and from New York to Billerica, Massachusetts by highway trailer as shown in Figure 3-1. At Billerica Shop, the vehicle was removed from the highway trailer (Figures 3-2 and 3-3). The axle drive and wheelset unit (Figures 3-4 and 3-5) was applied to the car at the Billerica Shop. Figure 3-6 shows the powered wheelset after application. The vehicle was inspected and serviced. Fuel and oil were added and U.S. couplers applied. Since a frame for the FRA cab certificates was not provided, the documents were placed in a plastic folder and taped to the panel above the front windshield. The assembled vehicle is shown in Figures 3-7 and 3-8.

3.1.2 Body - Interior

3.1.2.1 Floor Plan

The LEV-1 floor arrangement provided an operating cab at each end and diagonally opposing doorways (Figure 3-9). In the center of the vehicle, there are partitions which divide the passenger area so that fixed seats face the operating end of each half of the vehicle. This conforms with the original bus components wherein the seats face the driver (forward).

The floor in the seating area was covered with a striped orange or rust brown carpet and in the entrance areas with dark colored rugs. These rugs may prove to be difficult to clean in view of the lack of ash trays and trash container. Figure 3-10 is a view of the interior and Figure 3-11 shows the entrance area. In England the bus floors are usually covered with a rubber mat.

(3-1)

3.1.2.2 Control Cabs

The diagonally opposing control locations each contain a seat and control console (Figure 3-12). The engineman's seat has a lever to lock it in the forward position or to unlock it to rotate toward the exit area (Figure 3-13). Other controls elevate the seat, slide it back and forth and tilt it.

Figure 3-13 also shows the battery isolation switch located behind the seat on the front end of the vehicle. On the rear end of the vehicle (Figure 3-14) B&M radio equipment was installed.

To the left of the enginemen, there are lighting controls and the ignition key switch (Figure 3-15). In addition, as shown in Figure 3-16, there are controls for the windshield wipers and the parking brake. The lever with the spherical knob is the throttle (Figure 3-17). Above the throttle, at the front end of the vehicle, there is a timer to start the supplemental heater to preheat the engine cooling water to assist in cold start-up. The service brake (Figure 3-18) is located on the opposite side of the instrument panel.

On the instrument panel there are a number of warning lights, a speedometer, pressure gauges, a horn control and the reverser. The overall layout of the instrument panel is provided in the LEV-1 instruction manual, Appendix A, Figures 5 and 6.

Access to the equipment within the instrument panels is permitted by removing the covers shown in Figures 3-19 and 3-20. The upper portion of instrument panel can be raised after loosening two screws (Figure 3-21).

It was noted that on occassions late in the afternoon when the sun was still bright but low in the sky, the instrument warning lights appeared to be lighted. Although there are no curtains on the side windows the engineman is provided with a curtain on the front window which can be pulled down to offer partial shading from direct sunlight. There is a black roll curtain behind the engineman and a black accordian curtain at the angled panel beside him to reduce windshield reflections from the passenger lighting at night (Figure 3-22).

A telephone arrangement allows communication between the two operating cabs (Figure 3-23). One button in the handset provides a tone for attracting the attention of the individual in the other cab. This feature was important for providing communication between cabs since the B&M radio was available only at one end of the vehicle. Thus, when the radio was at the trailing end of the vehicle, the brakeman could relay instructions back to the operating cab.

3.1.2.3 Passenger Seats

The vehicle was equipped with 14 pairs of seats installed with one style on the right side of the vehicle and another style on the left (Figure 3-24). One style (Figure 3-25) had a fabric surface with no padding on the horizontal seat back handrail. The other style (Figure 3-26) had a vinyl surface with a padded handrail. The two different styles were applied in order to assess opinions and develop a preference for use in the demonstration vehicle. The backs of all of the seats (Figure 3-27) are metal.

The seats are 15" (381 mm) deep and 35" (889 mm) wide. The pitch between adjacent seats is 28-1/8" (714 mm) and the aisle is 20" (508 mm) wide. The seats are 16-1/2" (419 mm) and the handle on the seat back is 35-3/4" (908 mm) above the floor.

There are no ashtrays on the seats nor are there other provisions for ashtrays or trash disposal in the vehicle.

3.1.2.4 Heat and Ventilation

Interior heating is provided from engine cooling water diverted from the undercar radiator in response to temperature sensing devices located near the engineman's compartment. The cooling water is circulated to the roof-mounted heater elements and back through pipes in the vertical members located at the center partition (Figure 3-28). When the heat is called for the insulated exterior of the vertical conduit is warm (not hot) to the touch.

The heating radiators and the ventilation intake are contained in the cupola on the top of the railbus (Figure 3-29). Access to the radiators is through a center ceiling partition which is easily removed (Figure 3-30 and 3-31). As shown in Figure 3-31, there is additional equipment located under eave panels including electrical wiring and control (Figure 3-32) and blower and water valve switches (Figure 3-33).

Heated air is circulated throughout the car body by ducts located in the ceiling. There are small slots in recesses in the ceiling panels which permit distribution of the heated air along the length of the car body. At the extreme ends of the car body, there is a small rubber-edged deflector which directs a portion of the air stream toward the windshield for defogging. A handle for this control is located above the engineman's seat at the ends of the LEV-1.

It was necessary to use the supplemental heater to maintain the interior temperature on very cold days. Leakage around the door gaskets and the uninsulated floor areas contributed to the problem of keeping the car warm on cold days - particularly when traveling at speeds above 50 mph.

In severely cold weather the source of windshield defrosting heat obtained from the ends of the car heating system may not be adequate. As a result, the British Rail representative advised that the heating system would probably be modified for the demonstration vehicle.

3.1.2.5 Lights

The interior fluorescent lights are located above the center aisle as shown in Figure 3-34. At the removable ceiling panel for access to the heating equipment and at an adjacent panel there is a void in the lighting. This results in less lighting for the center of car seats.

The ceiling lights extend to the front of the vehicle (Figure 3-34). At night this light above the control area caused a reflection on the front windshield. To extinguish the light above the control area it was necessary to extinguish half of the lights in the vehicle since they are wired in a staggered pattern. This resulted in the passenger area being inadequately lighted. In England lights are not provided above the operator.

3.1.2.6 Windows

The large windows (Figure 3-35) offer an attractive interior which is particularly desirable when operating on the scenic B&M right of way. The description "TRIPLEX TOUGHENED" and DOT specification numbers were imprinted on all of the glass contained in the vehicle as noted below:

Windshields:	Door and Side Windows:	Behind Cab:
D132 AGTP GS80 IGM 0804 VSP DOT 17-M31-AS1	D90 IGM 0792 VT DOT 17-M6-AS2	D90 IGM 0792 VT DOT 17-M4-AS2

This material, which is specified for highway applications, does not meet the requirements of FRA Part 223 for glazing.

The windows are glazed with a rubber molding and cannot be opened.

The windshields have a protective metal screening as shown in Figures 3-35, 3-37, and 3-38. This screening, applied at B&M's suggestion, was provided to protect the operator from flying debris. Unfortunately, it made cleaning of the windshield difficult.

A windshield washer arrangement is provided with the air operated windshield wipers. Access to the wiper motors and the washer bottle is through the hinged compartment doors on the interior ends of the vehicle (Figure 3-39). It was observed, while washing the windshield, that if more than a nominal amount of fluid was required, the system does not to recharge fast enough to prevent air from exhausting instead of washer fluid.

3.1.2.7 Doors

The vehicle is equipped with folding doors that, even when open, do not extend beyond the exterior clearance line of the car (Figure 3-40). The doors are pneumatically controlled with air motors (Figure 3-41) located at their lower edges. Interior controls are located at both operator's consoles and by protected buttons above the center of each door (Figures 3-42 and 3-43).

3.1.3 Body - Exterior

3.1.3.1 Doors

The doors are located at diagonally opposite corners (Figure 3-44). Exterior protected operating buttons are located as shown in Figures 3-45 and 3-46.

The entrance to the vehicle consists of a lower step (Figure 3-47) and an entrance platform - both inside the doors. The platform is located 39-3/8 inches above the rail and the lower step at 18 inches. Boarding the LEV-1 requires stepping on the lower step while reaching into the vehicle to grasp the handrail and raising one foot to the platform while pulling with the hand on the interior rail.

The British Rail representative indicated that this awkward method of boarding would not prevail in the demonstration vehicle. He was of the opinion that new platforms would be provided at each station and the vehicle entrance would be designed to accomodate the platforms.

In England most platforms are 915 mm (36 inches) or 1100 mm (43.3 inches) above the top of rail. The

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demonstration LEV floor height is approximately 1000 mm (39-3/8 inches). The Amtrak standard for platform height is 48" (1220 mm) (Dwg. No. 70051-A), 8-5/8" (220 mm) higher than the LEV floor.

Amtrak standards also locate the platform 67" (1700 mm) from the centerline of the track. The LEV-1 is only 96-3/4" (2457 mm) wide. Thus there would be a gap of 18-5/8" (473 mm) between the standard high platform and the LEV-1 unless some special provision is made. The British Rail representative advised that the width of the demonstration vehicle at the entrance would be adjusted to suit the platform.

3.1.3.2 Body Materials

The bus body is mild steel with an aluminum alloy roof. The basic parts in the construction are shown in the exploded view provided in the British Rail information (Figure 3-48). The external panels are pressed steel fastened with high strength rivets. This design permits damaged panels and frames to be easily replaced.

The internal lining panels are a plastic laminate and the floor is a 12 mm (0.47 inch) fire resistant resin bonded plywood, faced with a layer of slip resistant material. A British Rail representative advised that insulation is provided in the sides and roof.

In the construction of LEV-1 only the front module is for a left hand drive. The rear end is a right hand drive module modified for the left hand cab.

The rounded "brow" above the windshield and the cowling above and beside the coupler and air hoses (Figure 3-44) provide streamlining. The British Rail representative advised that there was a significant reduction in aerodynamic drag after this streamlining was applied.

3.1.3.3 Stenciling

The vehicle was stenciled with the designation "LEV-1" and "FRONT" or "BACK" in the center of the ends of the vehicle. There were specifications "16.8 Tonnes" and "12.4 M X 2.45 M" on the ends. On the side there are car numbers, "RDB975874", and identifications of the lifting points, the coolant filler and the fuel filler.

3.1.3.4 Lights

The exterior lighting shown in Figure 3-49 consists of two assemblies at each end which include single-element, sealed beam headlights and white and red marker lights (Figure 3-50). The marker lights use small baseless bulbs which are installed by pushing them into friction fit sockets (Figure 3-51). The back of the lighting assembly can be reached by removal of one of interior covers as shown in Figure 3-52.

The marker lights are wired so that when the white is "on" at one end, the red is "on" at the other. Tower operators frequently advised that the lights were reversed for the direction of travel since they were not wired into the headlight or reverser circuity which could force proper selection.

Beside each door is a backlighted panel with the wording shown in Figure 3-53.

3.1.4 Underframe

3.1.4.1 Structure

Figure 3-54 is a view of one of the trucks with the surrounding skirting removed. The railroad underframe located directly above the truck is identified. The bus body is above the underframe. Elastomer pads (Figure 3-55) are located above the trucks at each of the four corners of the vehicle for providing isolation of the bus body from the underframe. Within this assembly there is a metal pin which provides a longitudinal and lateral stop of the body relative to the underframe. There is also a vertical downward stop within the pad.

Vertical upward travel of the body relative to the underframe is constrained by a pin and lug arrangement. The parallel lugs (Figure 3-56) extend from the body down toward a single lug (Figure 3-57) mounted on the underframe. The pin permits slight vertical travel to prevent binding in the longitudinal plane within the isolation pads. There are two lug and pin arrangements located at the center of the vehicle, equidistant from the longitudinal centerline.

3.1.4.2 Couplers

The underframe extends from one end of the LEV-1 to the other and a coupler is mounted at each end between the lugs as shown in Figure 3-58. The top lug is attached with four bolts and the bottom is welded.

No uncoupling device or hand holds were provided with the coupler. To prevent the coupler from swinging on the lugs, a chain was connected from the top-operating mechanism to brackets (Figure 3-44).

A "snowblade" (pilot) is mounted to the end plate of the underframe and extends toward the rails (Figures 3-59 and 3-60). Its use was not required during the test period.

3.1.4.3 Undercoating

The underside of the bus body is coated with a thermal insulation which was described by British Rail as "fire resistant" as shown in Figure 3-61. Although the foam generally covered wiring and the metal and plastic pneumatic piping, there were a number of pneumatic or electrical components where the foam was omitted (Figure 3-62) so they would be accessible for maintenance.

3.2 Functional Systems

3.2.1 Propulsion

The power source for the LEV-1 is a horizontal (flat) Leyland Model 510 diesel engine (Figure 3-63). The engine speed is controlled pneumatically from a valve actuated by the throttle (Figure 3-17).

The intake air is filtered through a paper element in the cannister shown in Figure 3-64. A pressure gauge on the filter indicates its status by showing a high differential pressure when the filter is dirty and should be replaced.

A horizontal cooling fan (Figure 3-65) is mounted below the radiators to cool the engine. This fan is driven by an hydraulic motor and controlled by thermal demand. During cold weather a portion of the engine cooling water is diverted into the radiators provided above the car for the passenger compartment heating.

The engine exhausts through an expansion box and a muffler into a downward deflector as shown in Figure 3-66.

The drive system is described in the LEV-1 manual, Appendix A. The diesel engine drives a fluid clutch which is inside the round housing shown in Figure 3-67. This fluid clutch has a centrifugally operated mechanical stop or "lock-up" to reduce slipping and improve efficiency. A drive shaft with a universal coupling connects the fluid clutch to a free-wheeling device which prevents the engine from being driven by the vehicle (Figure 3-68). Safety support brackets are located between the fluid clutch and the transmission (Figure 3-69).

The free-wheeling device is connected by a universal coupling to a standard Leyland DMU type R14 gear box (Figure 3-70). A support cable is provided under the gear box as a safety measure. The gear changes are fully automatic and for test purposes, the vehicle was supplied with two speed ranges with gear change points as follows:

Range	Gear Shift	Shift Speed
Low	1st to 2nd	14 mph
	2nd to 3rd	26 mph
	3rd to 4th	40 mph
High	1st to 2nd	16 mph
	2nd to 3rd	30 mph
	3rd to 4th	45 mph

The transmission control signal is derived from a 60 pulse per wheel revolution signal picked-up by a probe in the journal box (Figure 3-71). The signal is sent to a pair of electrical control modules mounted behind the engineman in the front cab (Figure 3-72). The modules condition the signals and develop logic functions to control the transmission gear shift points and to prevent undesired reverser operation. (At standstill the reverser operation was usually followed by a jerk as the gears engaged.)

The gear changes are pneumatically activated by valves mounted near the transmission (Figure 3-73).

The RF28 final drive unit (Figure 3-74) is connected with universal couplings to the transmission. On one side of the final drive unit there is a reaction lug (Figure 3-75) connected to the underframe through the resilient coupling shown in Figure 3-76. The final drive unit contains the reverse gears which are pneumatically controlled and electrically actuated from the instrument panel. The reverser pneumatic control valve is located near the transmission control valve.

For towing purposes, the final dirve unit can be disengaged by the handle shown in Figure 3-75.

3.2.2 Pneumatic and Braking

The braking system incorporates a service air brake and a spring actuated parking brake. Figure 3-77 shows the control handle for the spring parking brake and Figure 3-78 shows the service brake valve. Two dual-pressure gauges are provided for reading service brake cylinder pressure at the controlling end of the vehicle, the parking brake reservoir pressure and the front and rear service brake reservoir pressures. When the brakes are released the service brake reservoirs and the auxiliary reservoir should be charged to 105-120 psi with no brake cylinder pressure. With a full service application the brake cylinder pressure is 80 psi.

The service brake valve is a graduated design, i.e. the pressure in the brake cylinder is increased as a function of the handle position.

To apply the service brake, pressure is introduced to the cylinders located at each axle (Figure 3-79). The cylinders operate through levers which load the cables of the clasp brake linkage arrangement shown in Figure 3-80. The brake cables are connected to the top of the brake levers (Figure 3-81) which press the brake shoes (Figure 3-81) against the wheel treads.

When the system pressure is low (72 psi), the spring brake will automatically load the cables. This provides a safety or back-up feature if air pressure is lost. The spring brake may be manually released by turning the knob on the back of the brake cylinder, Figure 3-79. This knob was found to be difficult to operate unless the parking brake had been released by restoration of air pressure in the system.

The parking brake may also be applied from the controlling cab by operation of the control handle previously discussed.

Each of the four air reservoirs is equipped with an automatic drain valve (Figure 3-82). The reservoirs are mounted above the structural members of the underframe.

The source of air pressure is a compressor driven by the diesel engine. A condenser unit and an alcohol evaporator are incorporated to prevent water from collecting and icing the air system during cold weather. A schematic of the braking system is provided in the operating manual, Appendix A.

When towed, release of the parking brake is provided by means of the brake pipe and main reservoir trainlines shown in Figures 3-83. The brake can also be applied in tow with a valve in the cabinet at the end of the vehicle (Figure 3-84). Instructions for setting up the brake system for towing are provided under the cover of the battery box (Figure 3-85).

A wheel slip feature which requires signals from the axle-box probes will release the brakes if a wheel begins to slide. Details of this system were considered proprietary by British Rail.

3.2.3 Suspension

The suspension system includes springs and dampers mounted on each end of the two single axle trucks (Figure 3-86) and isolation pads located between the underframe and body (Figures 3-86 and 3-87). This suspension was derived from R&D efforts on the APT.

The truck springs (Figure 3-88) are conventional helical coil springs with the following parameters:

Outside Diameter	-	7.13 inches (181 mm)
Bar Diameter	-	1.0 inches (25 mm)
Total Turns	-	8
Light Car Spring Height		
Front	-	12.8 inches (325 mm)
Rear	-	11.63 inches (295 mm)
Travel		
Total	-	5.51 inches (140 mm)
Free to Light Car	-	3.54 inches (90 mm)

Vertical and horizontal Koni hydraulic dampers are mounted at each axle box as shown in Figures 3-89 and 3-90. The horizontal damper has a reservoir located above the cylinder on one end of the unit.

A ground cable is connected between the underframe and the axle-box on the powered axle of the vehicle only (Figure 3-88). On the unpowered axle, a cable was provided but not connected (Figure 3-86).

Lugs are provided at one end of each axle-box (Figure 3-91) for connection to a longitudinal rubber sandwich spring (Figure 3-92) which is attached to the underframe (Figure 3-93) through an anchor rod.

The vertical spring rate is set by the vertical rate of the coil springs and the lateral spring rate by the lateral characteristics of the coil springs. The longitudinal or yaw spring rate is determined by the resilient rubber sandwich mounted on the underframe.

The maximum travel in all directions except upward is restrained by a simple structural member located in the center of the axle box (Figure 3-94). Vertical downward motion is stopped by the rectangular housing striking the axle-box. Lateral and longitudinal motion is limited by contact between the vertical pin and the sides of the housing. There is no stop for upward vertical (wheel-unloading) travel. The maximum displacements are as follows:

Vertical Downward	-	2.36 inches (60 mm) Idler Axle
" "	-	1.18 inches (30 mm) Drive Axle
Lateral	-	$\pm$ 1.65 inches ($\pm$42 mm)
Longitudinal	-	$\pm$ 0.47 inches ($\pm$12 mm)

These dimensions were measured while the LEV-1 was standing over a pit in the Billerica Shop. Verbally the travel dimensions were given as 50 mm (1.97 inches) vertical downward travel and 36 mm (1.42 inches) total lateral travel.

Two 5 mm thick rubber pads are attached inside of the stop housing (Figure 3-94). These pads function to soften oversolid lateral travel. at one axle the pad was missing and in other cases the pads were loose. There were a few light scuffing marks on the stop box or pin to indicate that on occasion the travel limits had been reached.

The 780 mm (30.7 inch) wheels have a modified UIC single-point profile which includes a 1:40 taper at the rim. The wheels are dynamically balanced with weights bolted to the plate (Figures 3-95 and 3-96).

3.2.4 Electrical

An engine-driven alternator (Figure 3-97) supplies electrical power for the vehicle. The four batteries, Chloride Model 451, have a six volt, 195 ampere hour rating with a short term rating of 385 ampere hours for three minutes. A domestically available alternative is Keystone type GRP-AC 6 volts.

The batteries are mounted in a convenient compartment at one corner of the vehicle on a swing-out tray (Figure 3-98 and 3-99). The battery isolating switch shown in Figure 3-13 provides a disconnect between the batteries and the electrical system.

3.2.5 Fire

In the interior of the vehicle hand held fire extinguishers are located in a compartment at each end (Figure 3-100).

Under the car a fire extinguisher (Figures 3-101 and 3-102) is mounted so that it will discharge toward the engine when activated. This system can be actuated from "Break-the-Glass" units located on either side of the car (Figure 3-103) or behind the engineman at the front end of the vehicle (Figure 3-72).

The fire control unit mounted behind the engineman at the front cab contains a test of continuity for an ignition device which sets off an explosive charge to release the foam. This control unit has an alarm to indicate overheated sensors below the car. The foam can be released automatically or manually depending upon a switch setting.

3.2.6 Supplemental Heater

A Webasto supplemental water heater is mounted on the underframe near the front wheel set (Figures 3-104 and 3-105). It is a fuel oil fired device which heats engine cooling water to warm the passenger compartment and diesel engine prior to start-up in cold weather. The exhaust for the heater is located near the front truck on the right hand side as shown in Figure 3-86.

This heater can be preset to begin heating at a predetermined time prior to the requirement for engine start. Instructions for the device are contained in the LEV operating manual, Appendix A, page 9.

3.2.7 Horn and Bell

Dual pneumatic horns are mounted at each end of the vehicle below the underframe (Figure 3-106). A console mounted horn control operates one horn with an upward motion and the other with a downward motion (Figure 3-107). The enginemen regularly used the dual horns for grade crossings and there were several occasions when the low air pressure alarm light was activated during the period the horn was being sounded.

On the front end of the vehicle the original bus horn is mounted under the plate with the "L" (Figure 3-50). This horn can be operated from only the front cab with a button on the console (Figure 3-16).

A bell was installed on the underframe between the rear end and the #2 axle (Figure 3-108). The control valve was mounted at the back of the instrument rack.

3.3 <u>Operation</u>

3.3.1 Engineman

In the previous discussion and photographs there were several references to the engineman's control equipment. The LEV-1 operating manual provides further information, Appendix A. It was generally felt by the enginemen that the controls were easy to learn and simple to use.

It was observed on several occasions that transmission from the fixed or portable radios on the vehicle caused the brakes to release by activating the wheel slip system. On grades the vehicle would move until the radio transmission ended. Application of the parking brake did not prevent this untoward event unless the service brake was released after the parking brake was applied.

The crews learned a procedure for changing operating ends without moving the control key:

1). Turn on key at one end
2). Release the air brake
3). Isolate the dead man switch
4). Set the reverser to the opposite position for operation from the other end.
5). Walk to the other end.

When the vehicle was operated from the end without the control key, the parking brake at that end became inoperative.

Although the dead man foot switch was often cut-out completely, the crews preferred the box type foot switch in the rear cab to the standard British Rail pedal in the front cab.

Pulsation of the speedometer indicating points when the vehicle was stopped raised questions from the crew. This was due to anomalies of the circuitry and, although it did not pose an operational problem, it will be corrected on the demonstration vehicle.

3.3.2 Brake Shoe Replacement

To replace the brake shoes, it is necessary to first remove the two metric bolts located at the top of the brake beam (Figure 3-109). The brake beam can then be separated from the cable connector and pulled away from the wheel. The metric bolt and pin arrangement can then be loosened and the brake shoe can be removed and replaced. This procedure is difficult without a pit.

3.3.3 Supplemental Heater

On the LEV-1, the supplemental heater is disconnected when the battery isolating switch is open. It was necessary to leave the battery switch closed at night when the supplemental heater was to be used. As a result all other electrical loads must be manually disconnected from the system. The British Rail representative advised that in the demonstration vehicle, the supplemental heater controls would be placed on the battery side of the isolation switch.

3.3.4 Lifting

A hinged cover located near each axle box provides access to the lifting lugs (Figure 3-110). After raising the cover, a guide and fulcrum are exposed (Figures 3-111 and 3-112). Horizontal bars can be placed in this arrangement for lifting the vehicle as shown in Figures 3-3 and 3-5.

3.3.5 Towing

Towing instructions are contained in the LEV-1 operating manual, Appendix A. To release the brakes for towing it is necessary to either apply air to the brake pipe and main reservor trainlines or to turn the release knob on the rear of each brake cylinder. In addition, it is necessary to set up the service brake by repositioning three valves as shown in the instructions on the cover of the battery box. Finally the axle drive unit must be disengaged for towing. To manually release the spring brakes and disengage the axle drive unit it is necessary to reach under the car.

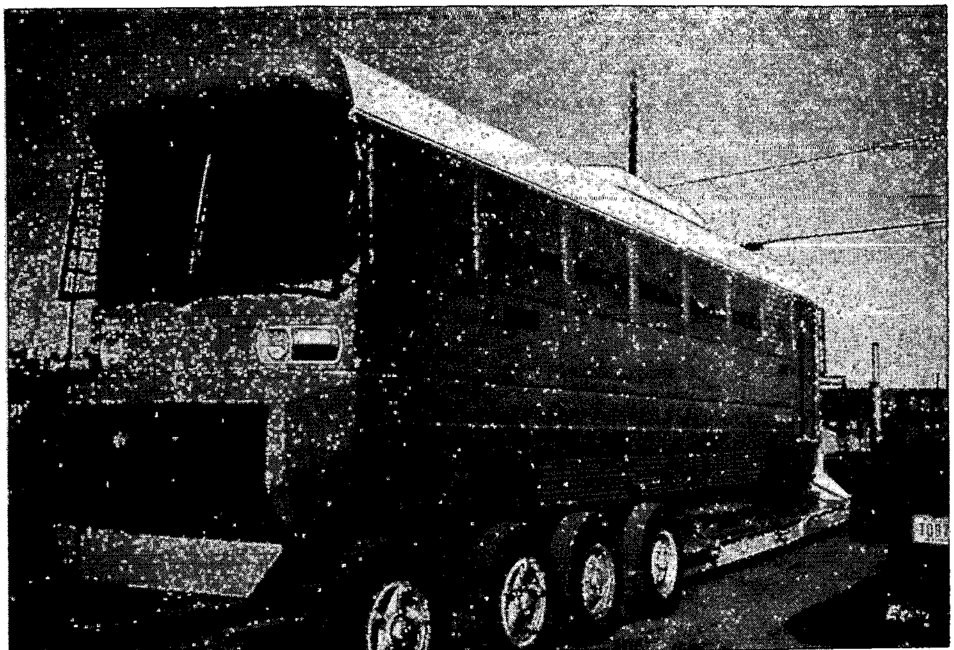


Figure 3-1

LEV-1 on a Highway Trailer

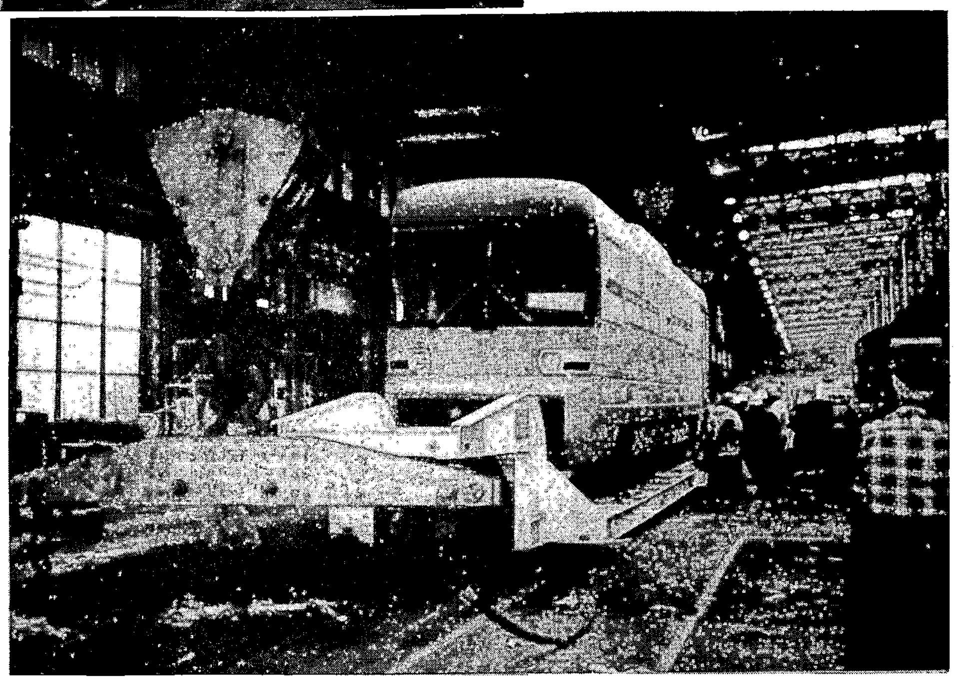


Figure 3-2

LEV-1 and Highway Trailer in the B&M Billerica Shops

Figure 3-3

Lifting the LEV-1 with an Overhead Crane

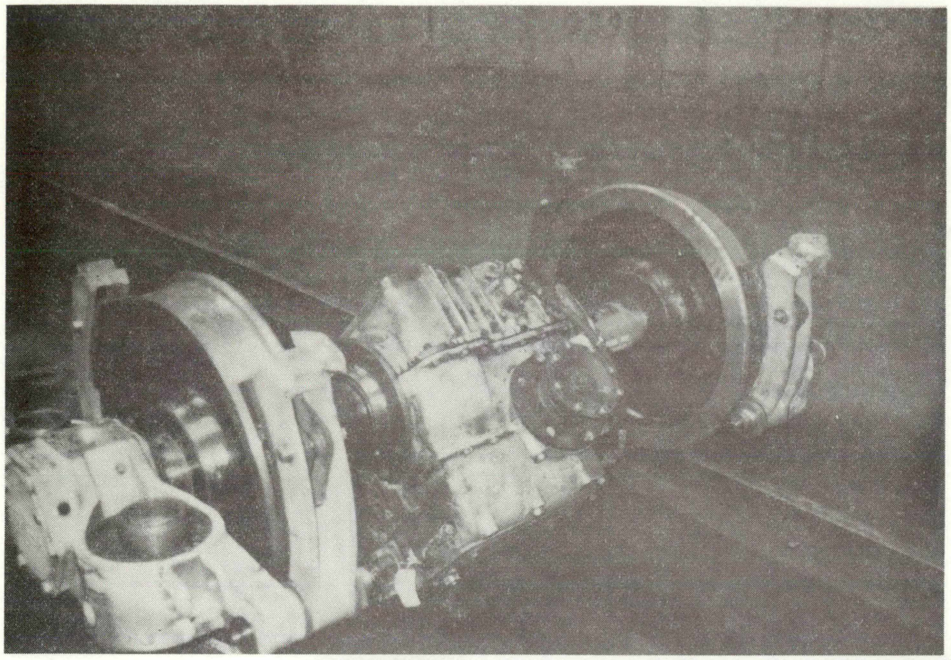


Figure 3-4

Axle Drive Unit
and Wheelset

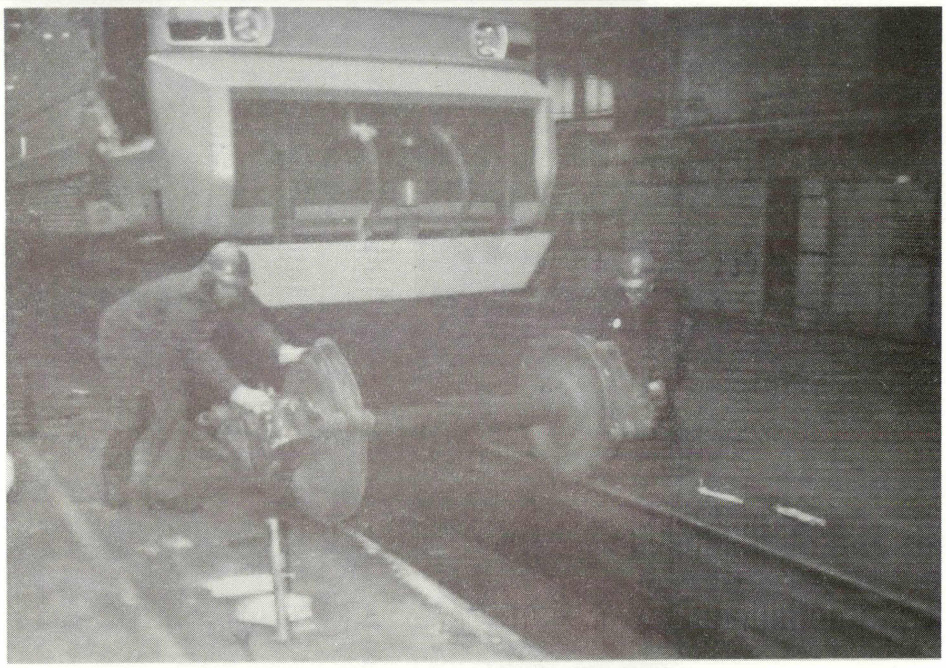


Figure 3-5

Removing the Non-
Powered Wheelset

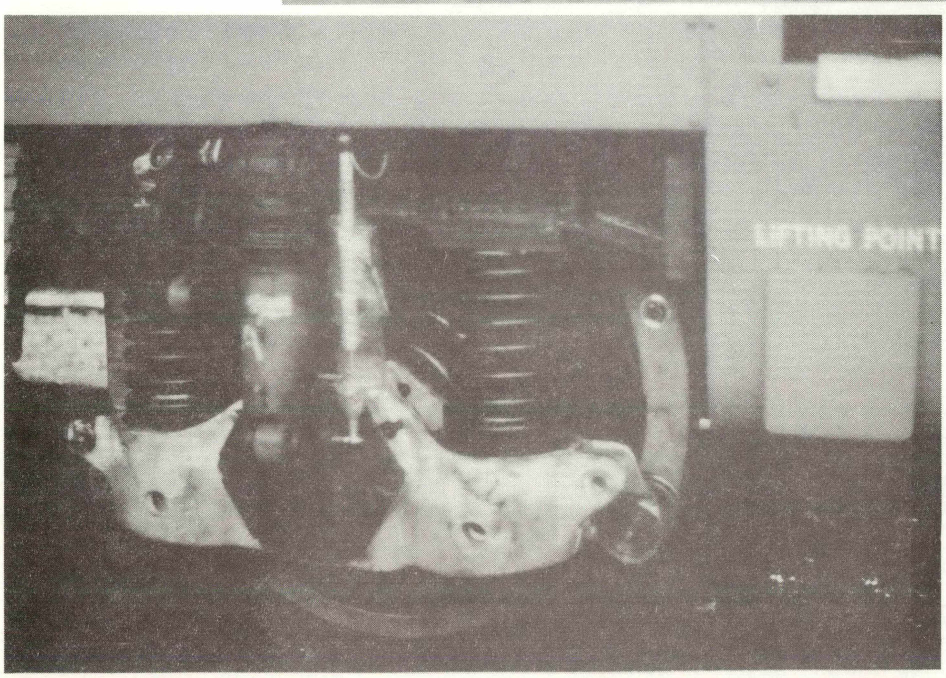


Figure 3-6

Powered Wheelset
Applied to LEV-1

Figure 3-7

LEV-1 on B&M, North of Lowell, Mass.

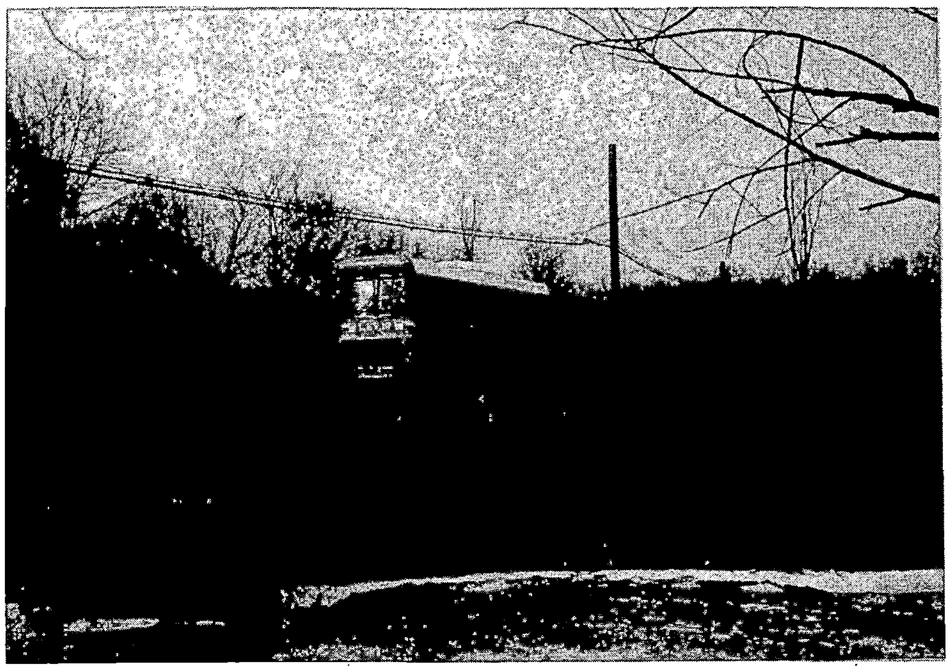


Figure 3-8

LEV-1 on B&M, North of Lowell, Mass.

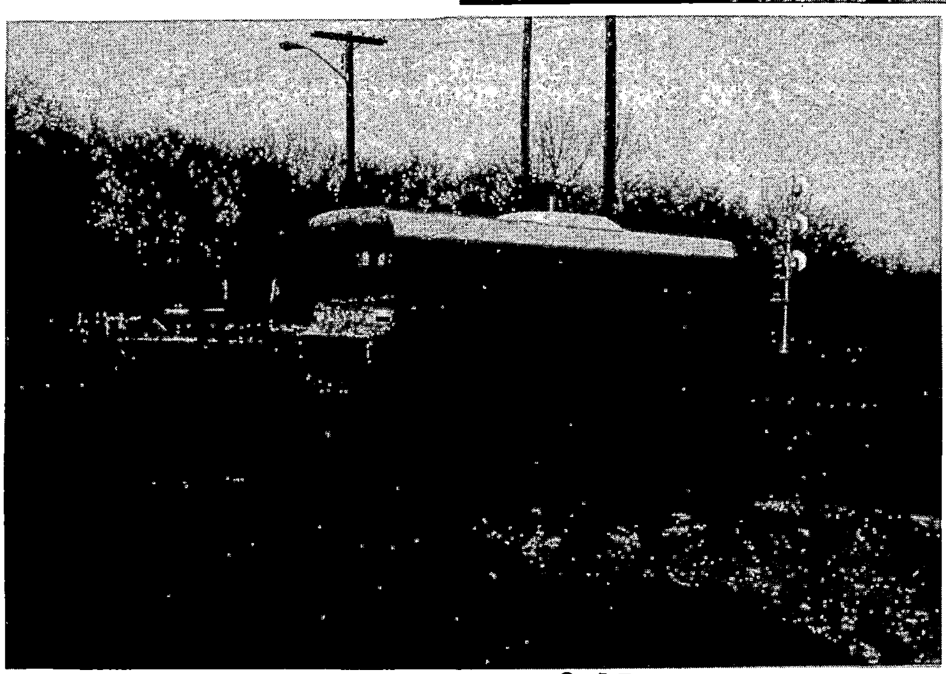


Figure 3-9

Doorway at Far End of the Vehicle

(37)

Figure 3-10

Interior Looking Toward the Front End

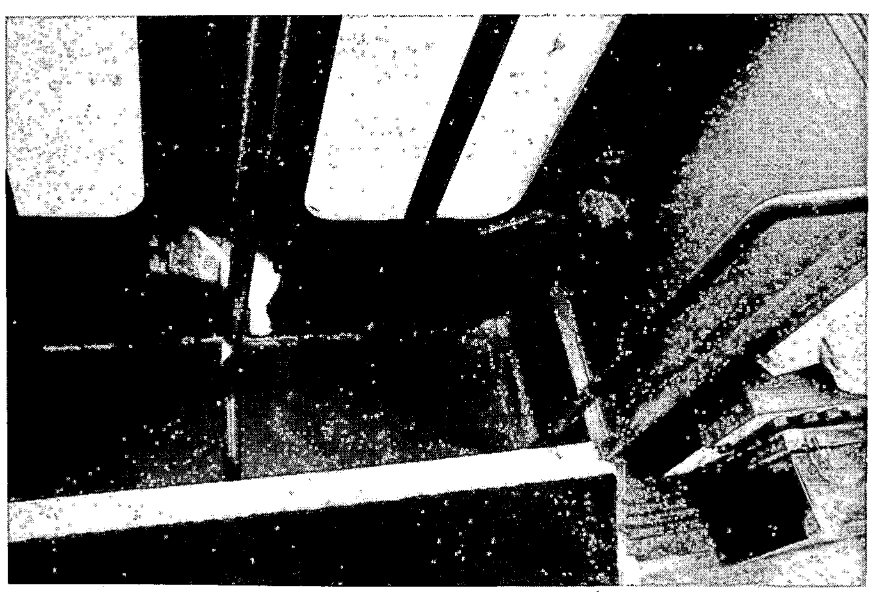


Figure 3-11

Entrance Area

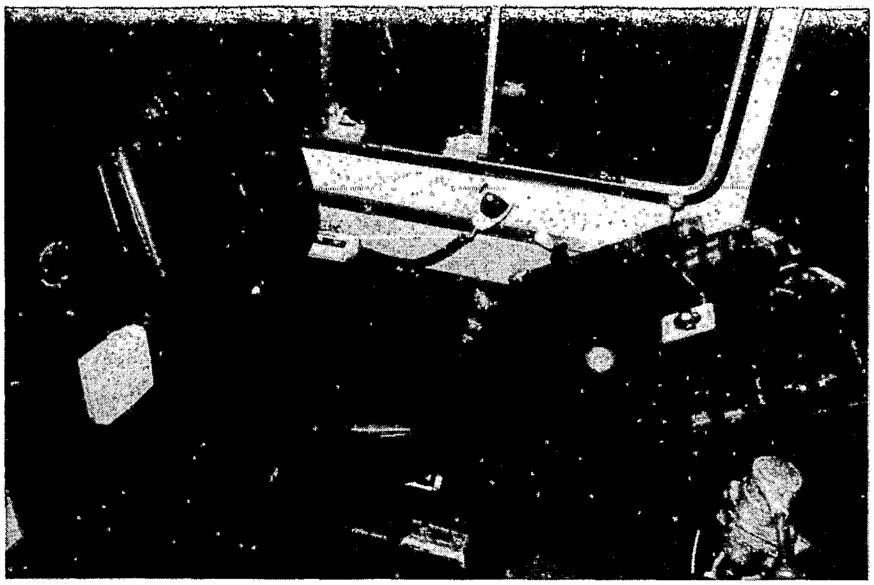


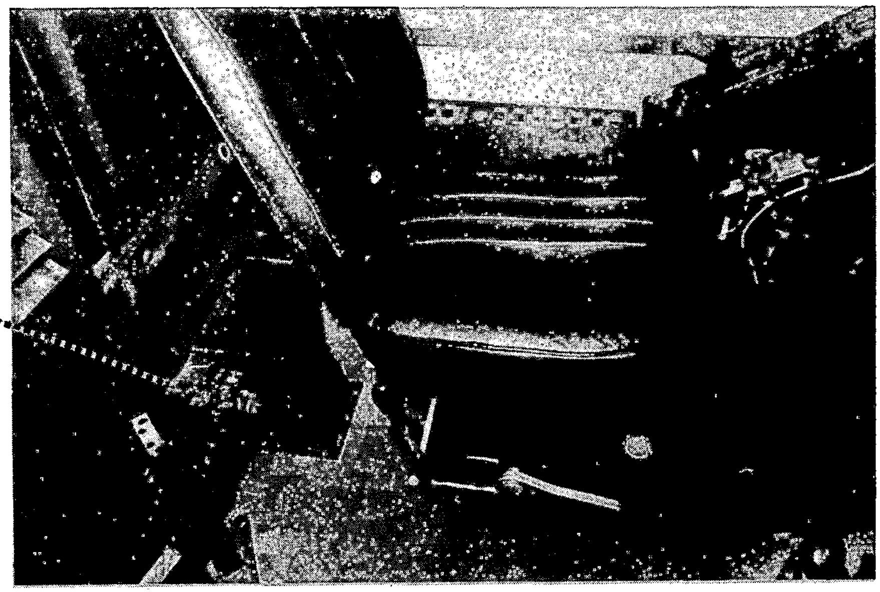
Figure 3-12

Seat and Control Console

Figure 3-13

Seat in Front Cab

Battery Isolation Switch



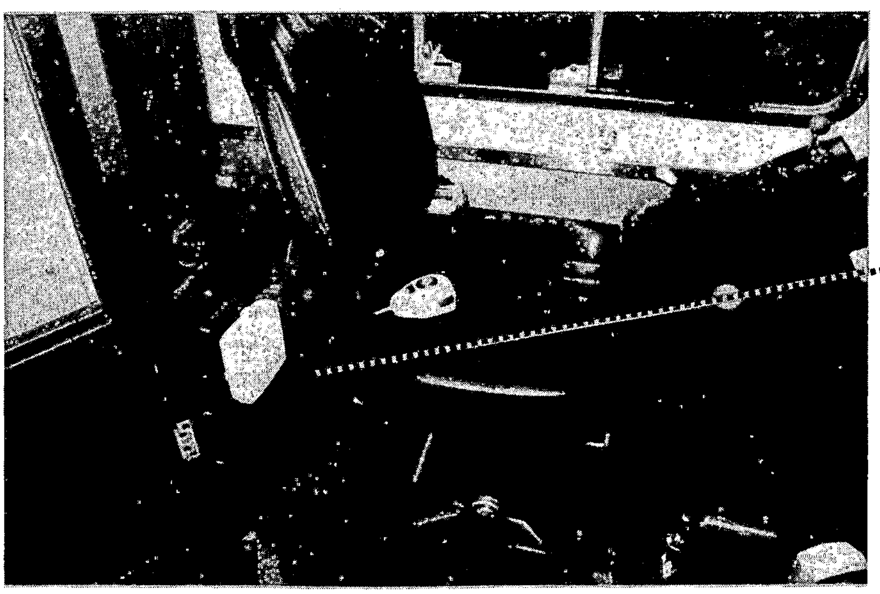


Figure 3-14

Seat in Rear Cab

B&M Radio

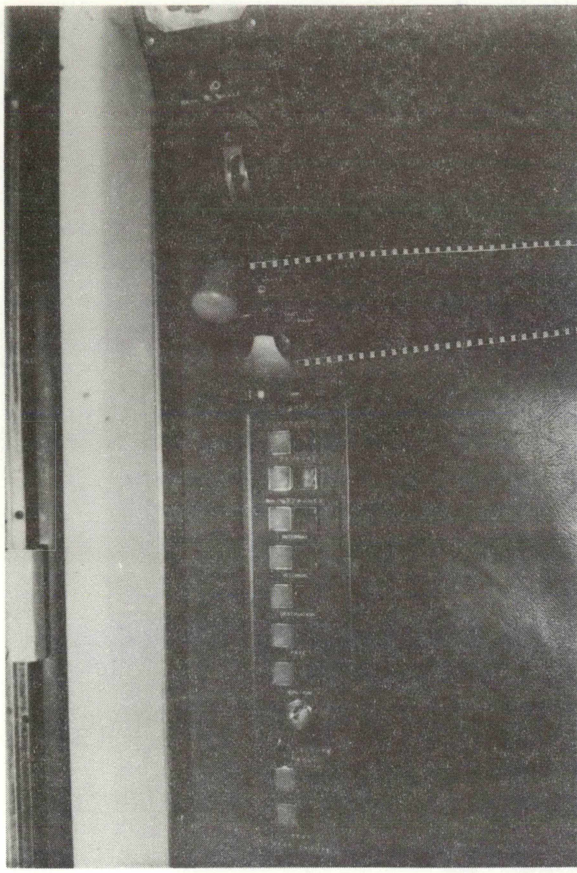


Figure 3-15

Front Cab - Left Hand Side

Parking Brake

Windshield Washer

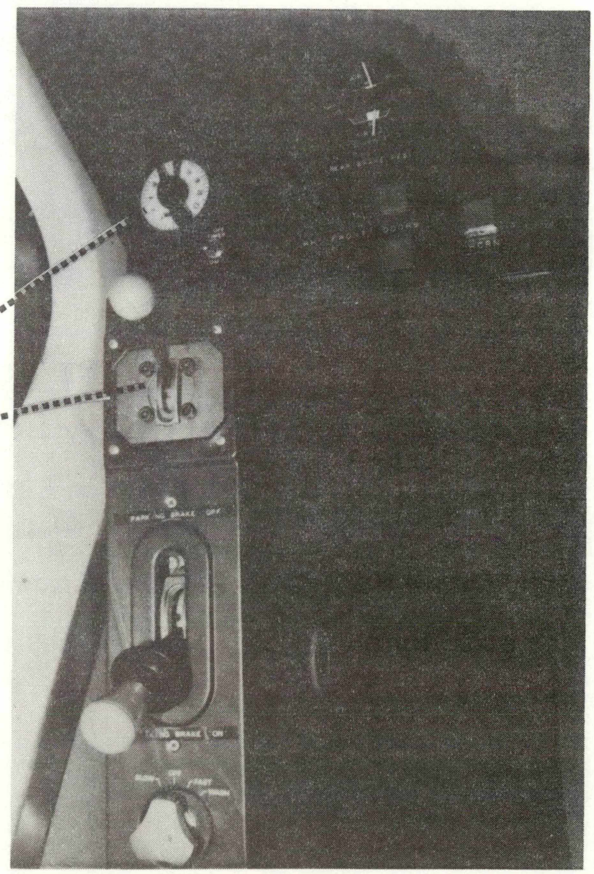


Figure 3-16

Front Cab - Left Hand Side

Supplemental Heater

Throttle

40

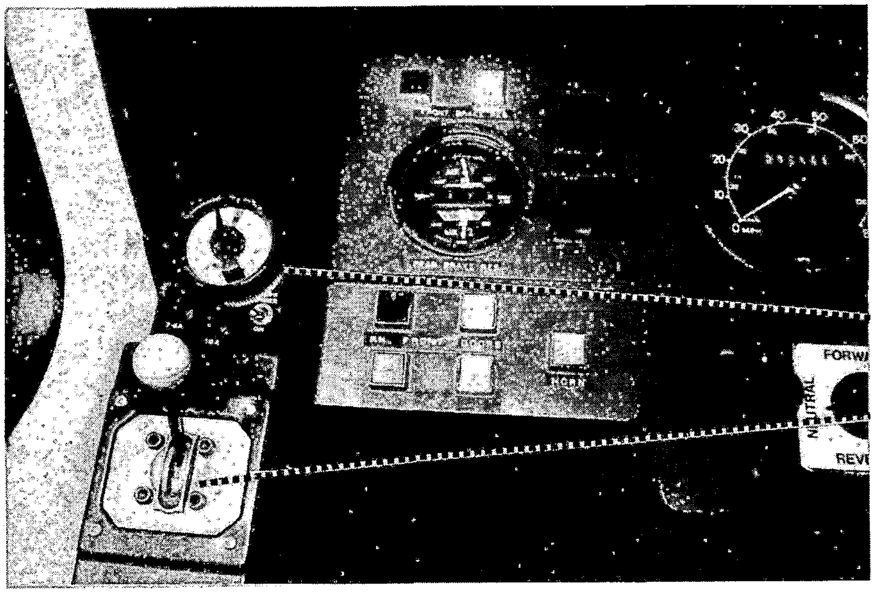


Figure 3-17

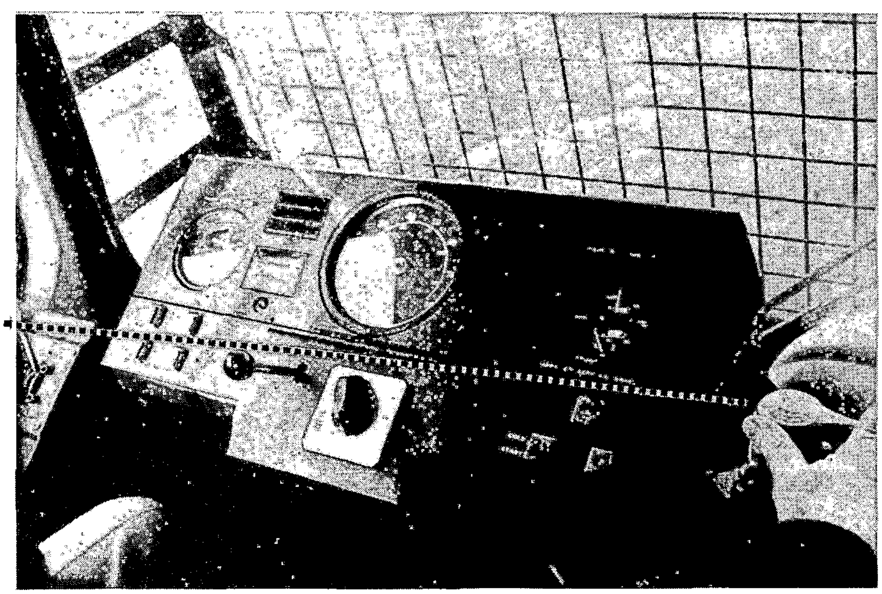
Front Cab - Throttle and Supplemental Heater Control

Supplemental Heater Control

Throttle

Figure 3-18

Rear Cab Engineman Operating the Service Brake Valve



41

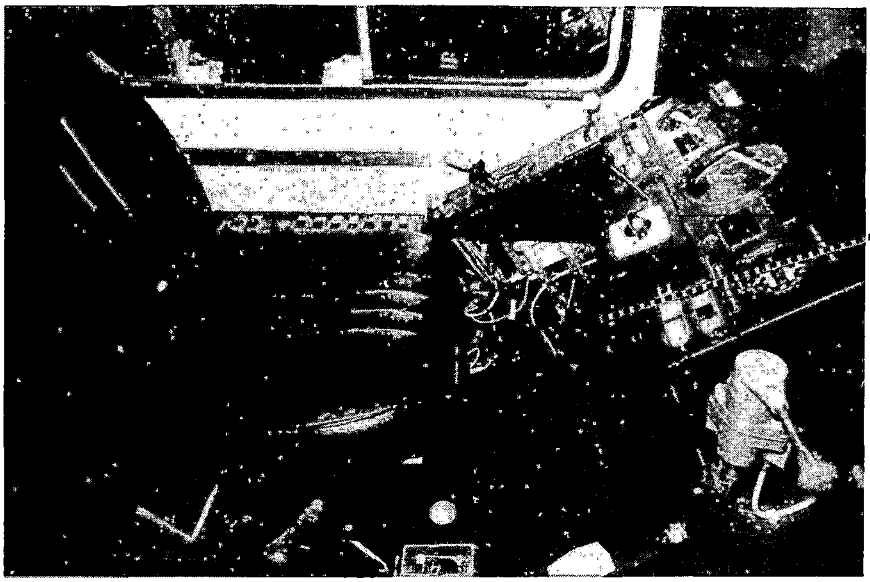


Figure 3-19

Front Cab - Panel Removed for Servicing

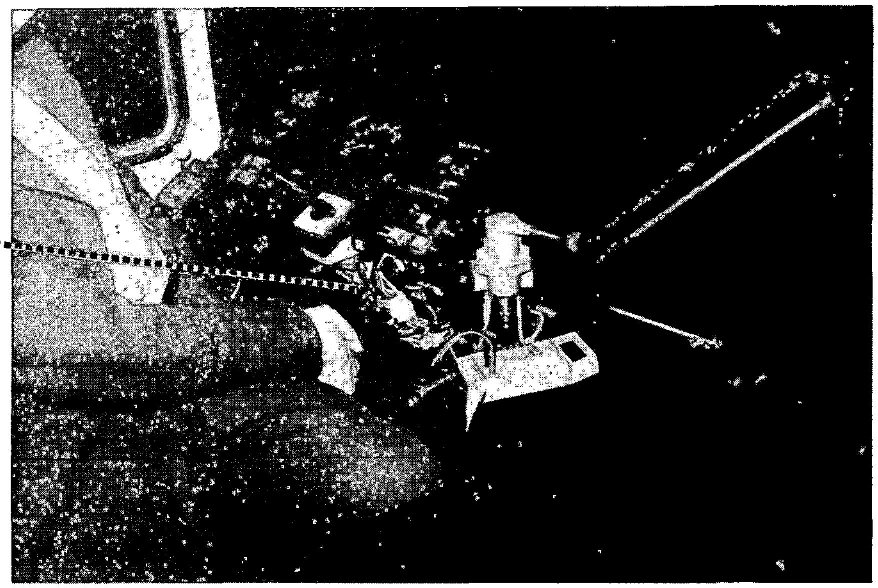


Figure 3-20

Front Cab - Lower Instrument Panel Removed for Servicing

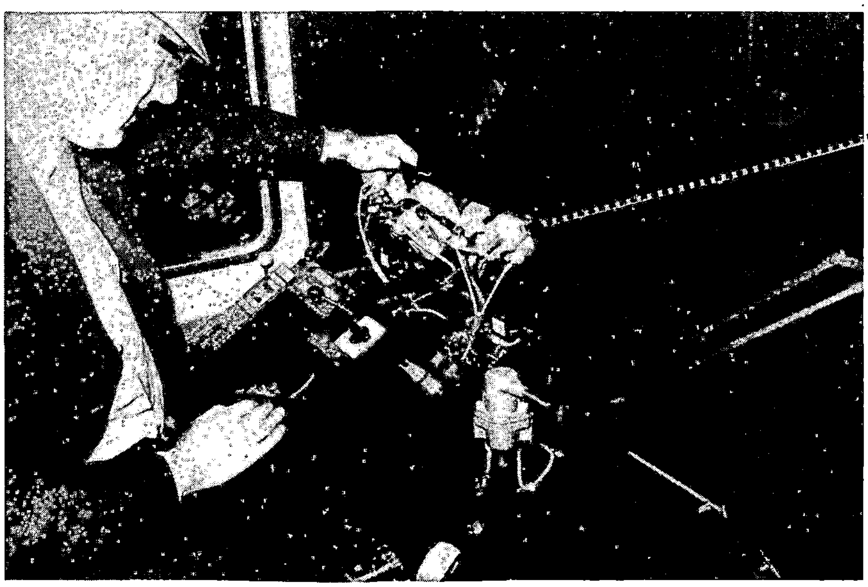


Figure 3-21

Front Cab - Instrument Panel Raised for Servicing

(42)

Figure 3-22

Shades Behind Operating Cab

Roll Shade

Accordion Shade

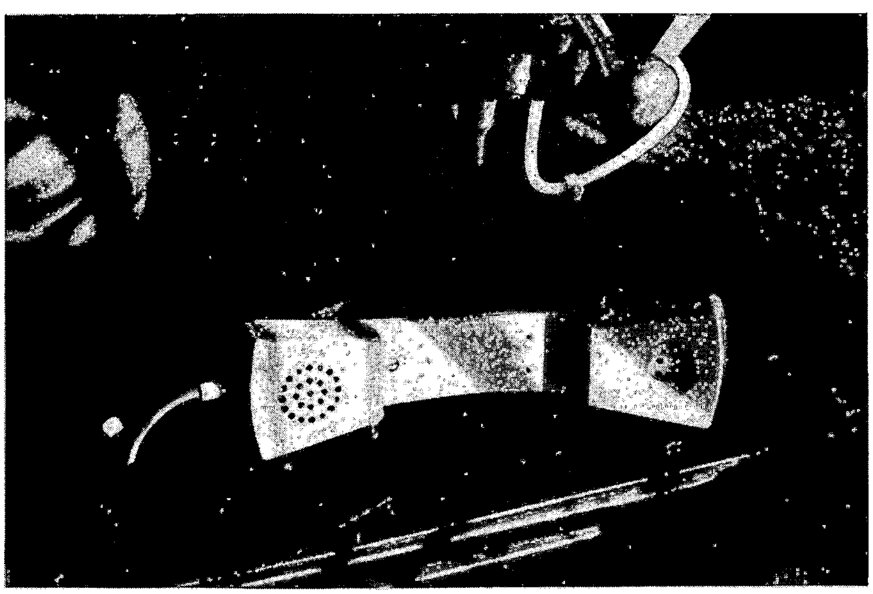


Figure 3-23

Internal Communication Handset

(43)

Figure 3-24

Interior Looking
Toward the Rear

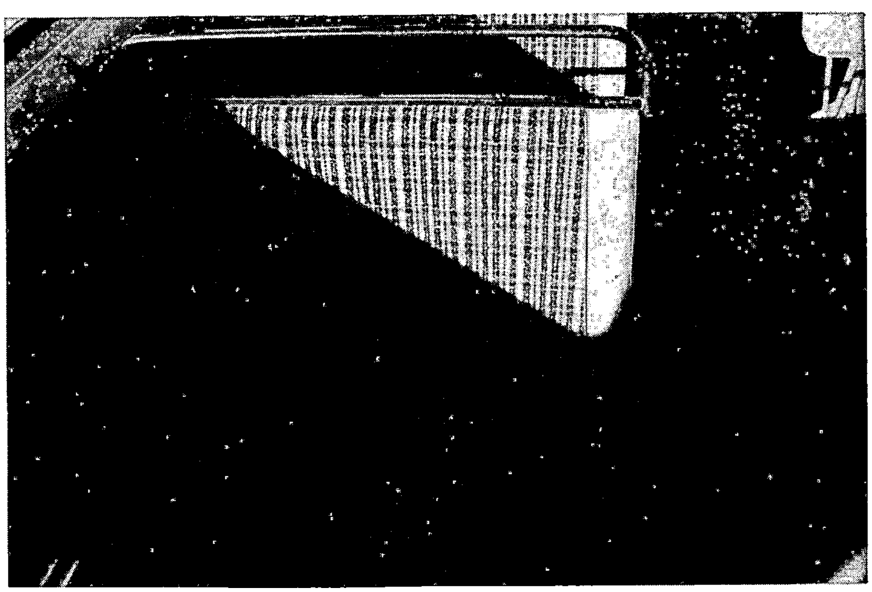


Figure 3-25

Fabric Seat
Covering

44

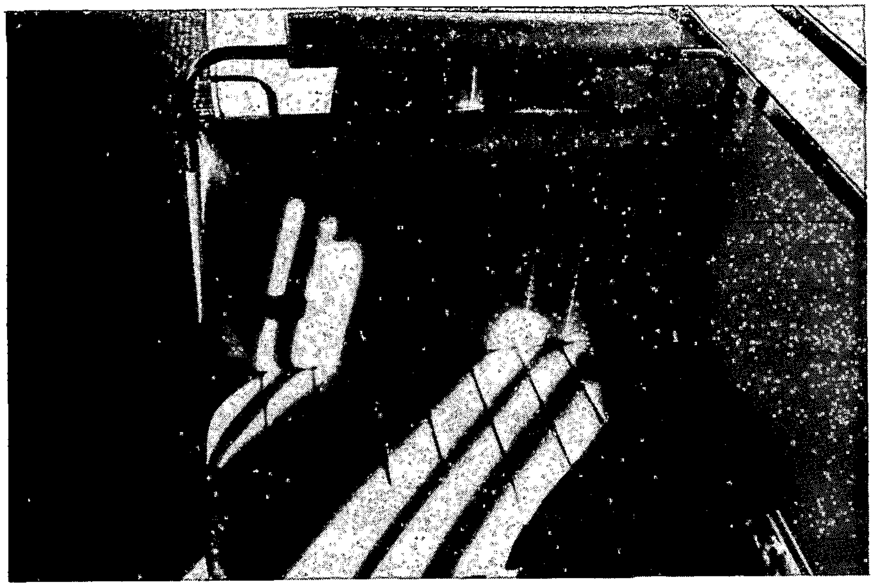


Figure 3-26

Vinyl Seat Covering

Figure 3-27

Metal Seat Backing

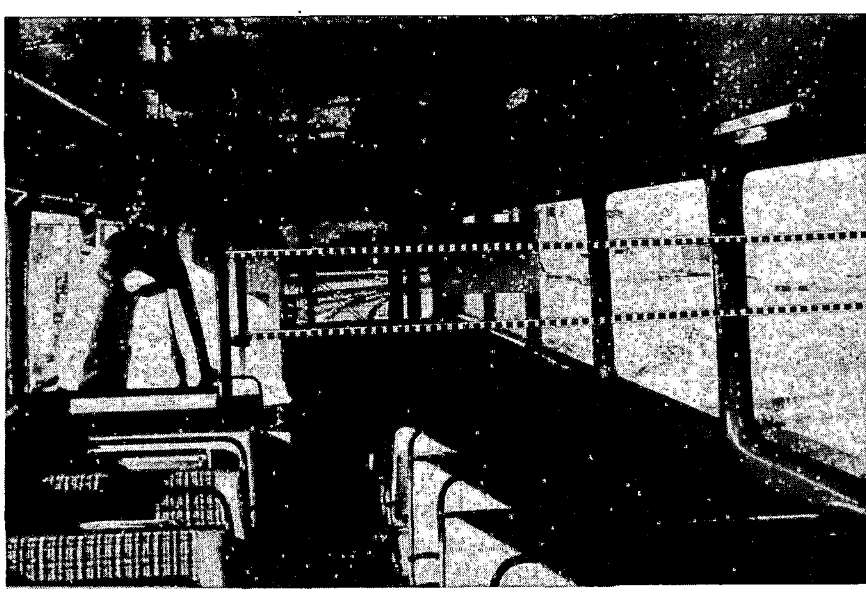


Figure 3-28

Center Partition

Vertical Rails

Handholds

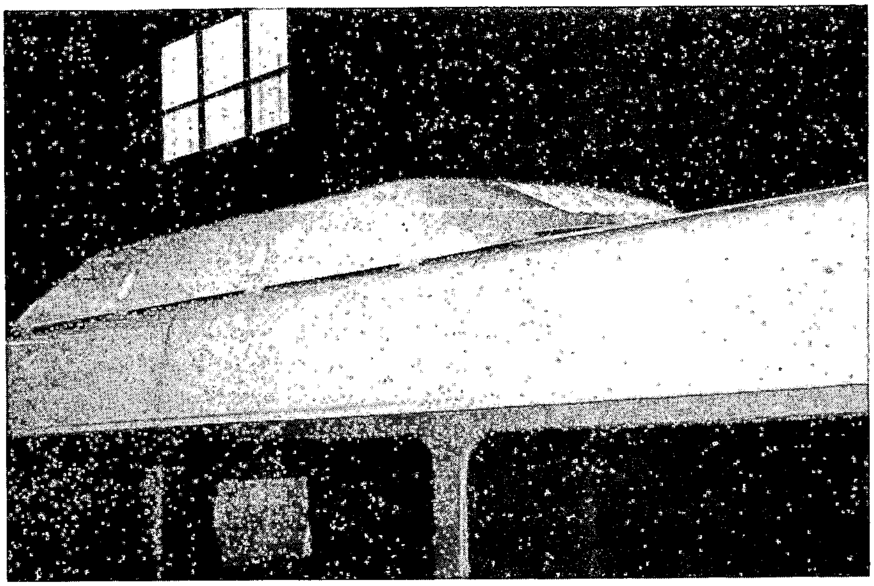


Figure 3-29

Top of Vehicle

Figure 3-30

Equipment Under Center Ceiling Access Cover

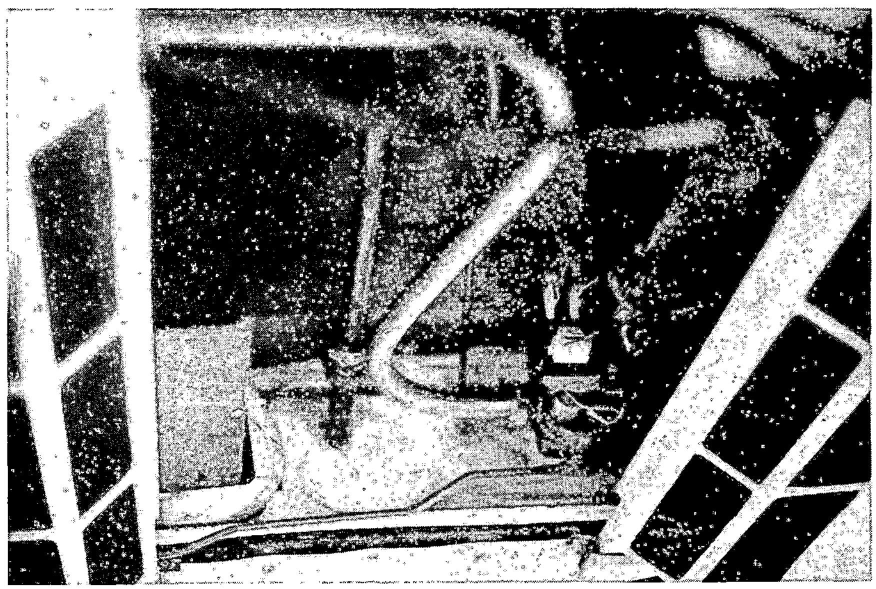


Figure 3-31

Temperature Control Equipment Covers Removed

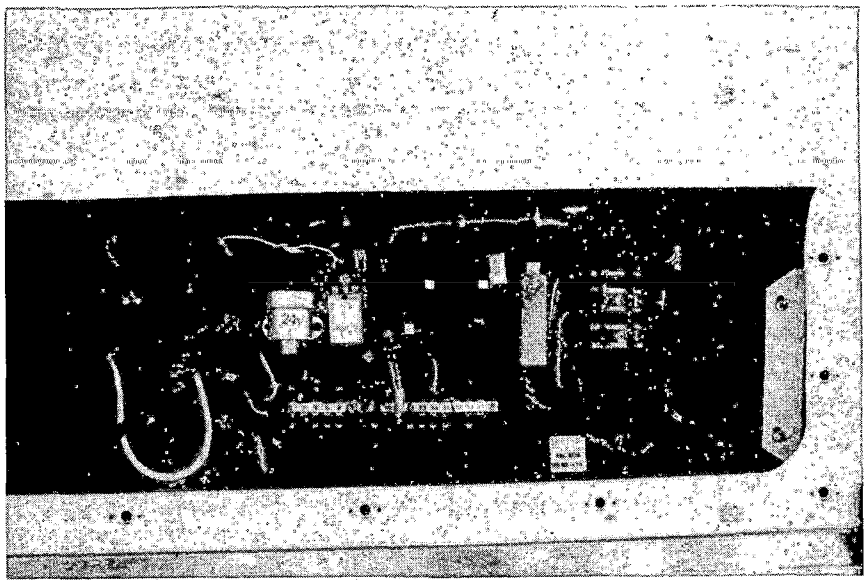


Figure 3-32

Electrical Equipment Under Side Eaves Access Cover

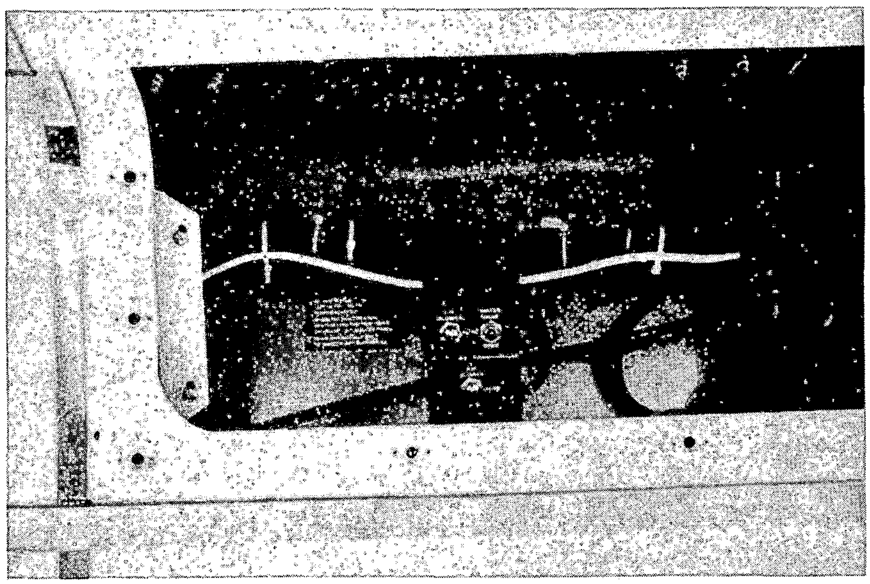


Figure 3-33

Switches Under Eave Access Cover

Figure 3-34

Interior Florescent Lighting

Figure 3-35

Side View Showing Large Windows

Figure 3-36

LEV-1 Approaching B&M Main Line from Billerica Shops

Figure 3-37

Windshield Protector

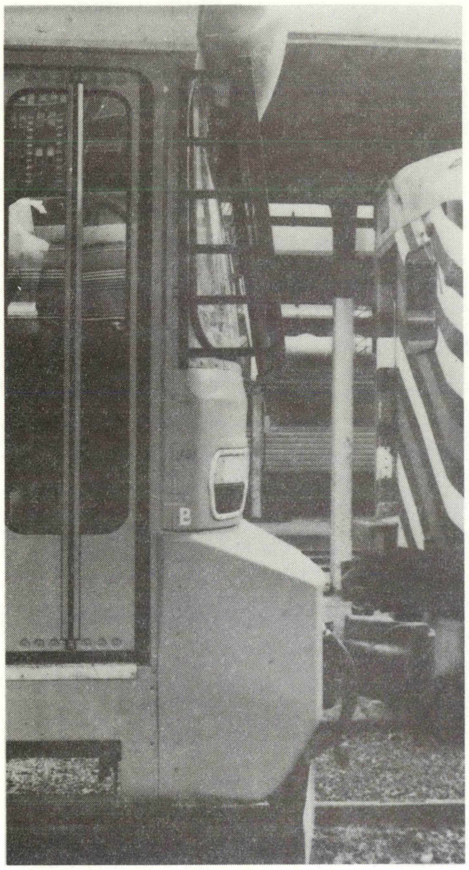


Figure 3-38

Side View of
Windshield Protector

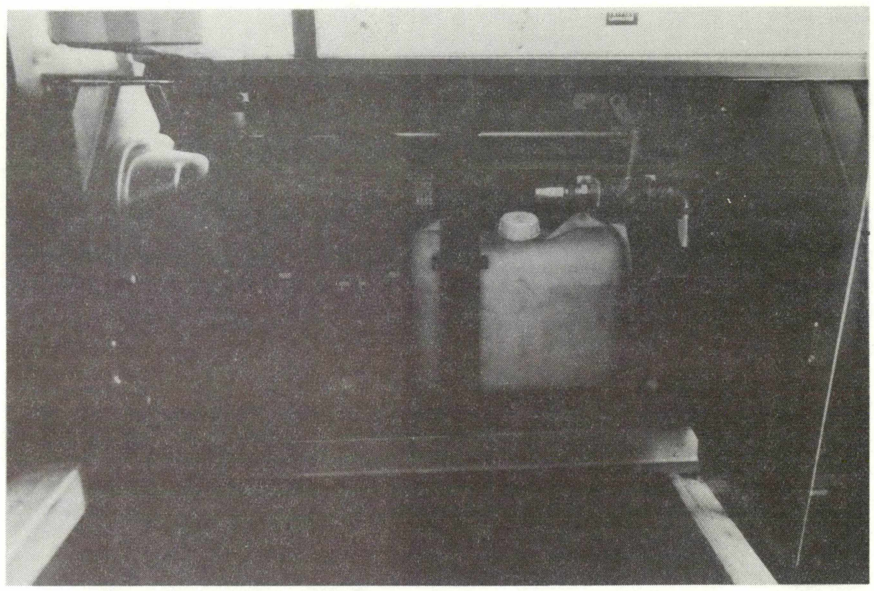


Figure 3-39

Front Interior
Cabinet

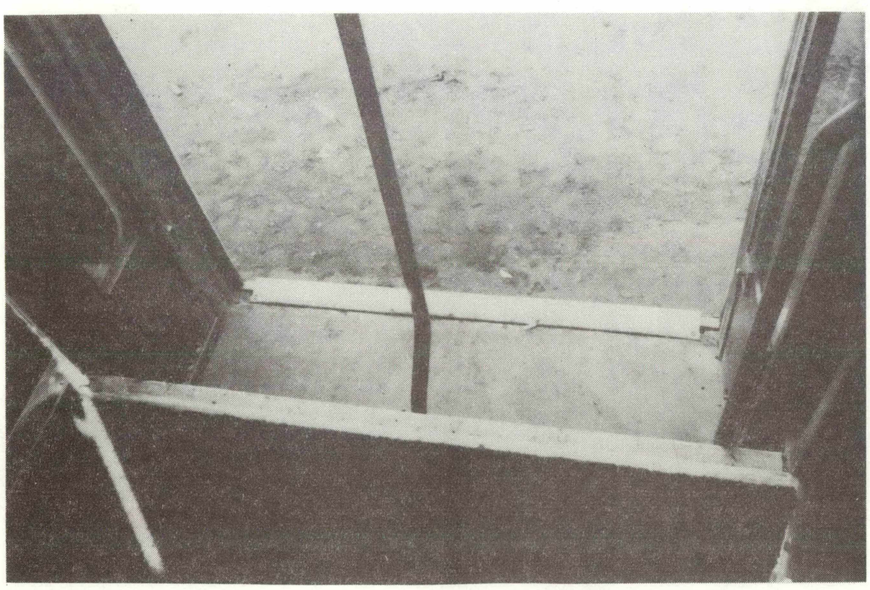


Figure 3-40

Doors Folded into
Interior Recess

49

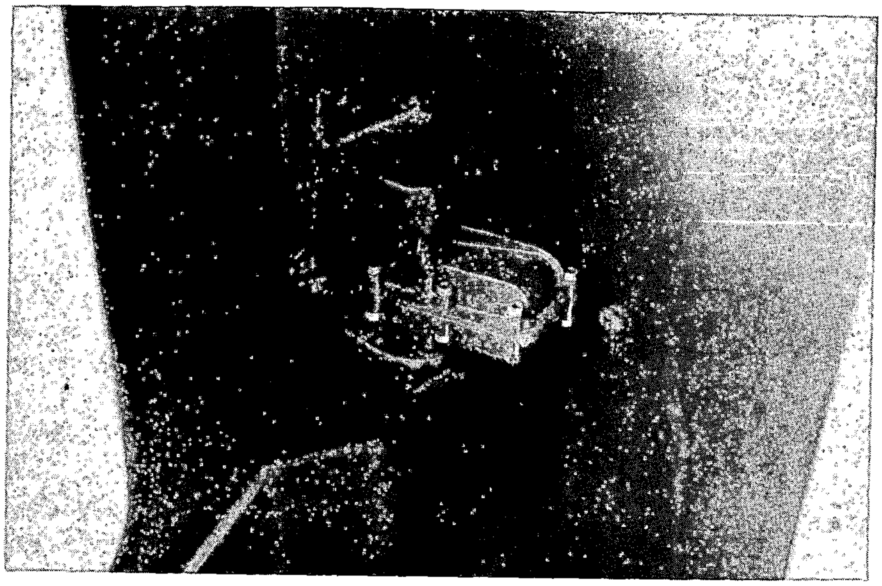


Figure 3-41

Door Operating Motor

Figure 3-42

Interior View Looking Toward Operating Panel above the Door

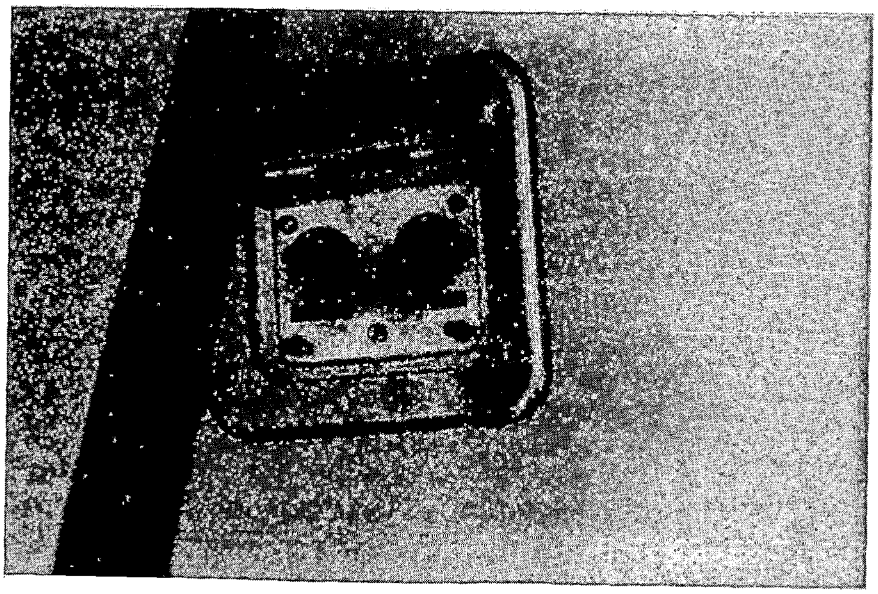


Figure 3-43

Inside Door Operating Panel

(52)

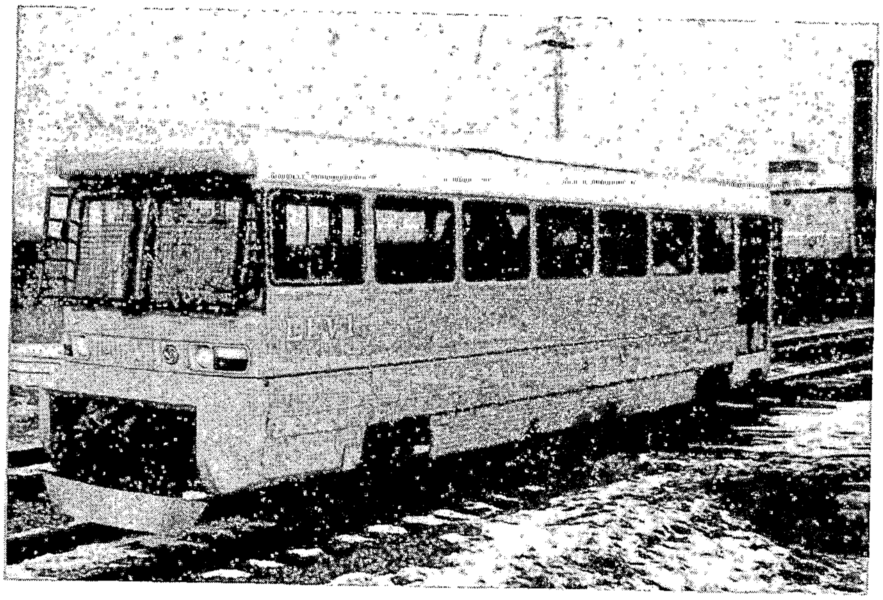


Figure 3-44

Exterior View of
LEV-1

Figure 3-45

Doors

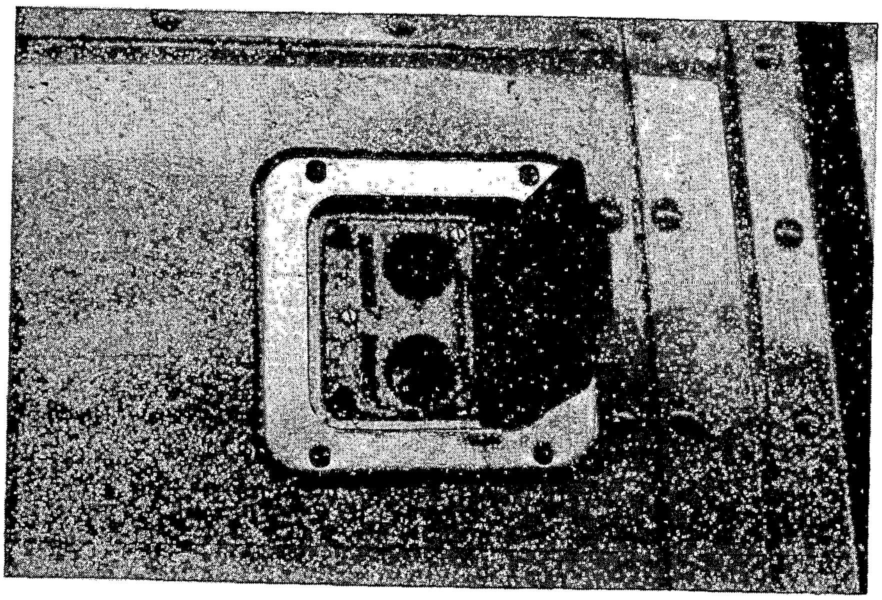


Figure 3-46

Outside Door
Operating Panel

Figure 3-47

Entrance

Floor Height

Platform

Lower Step

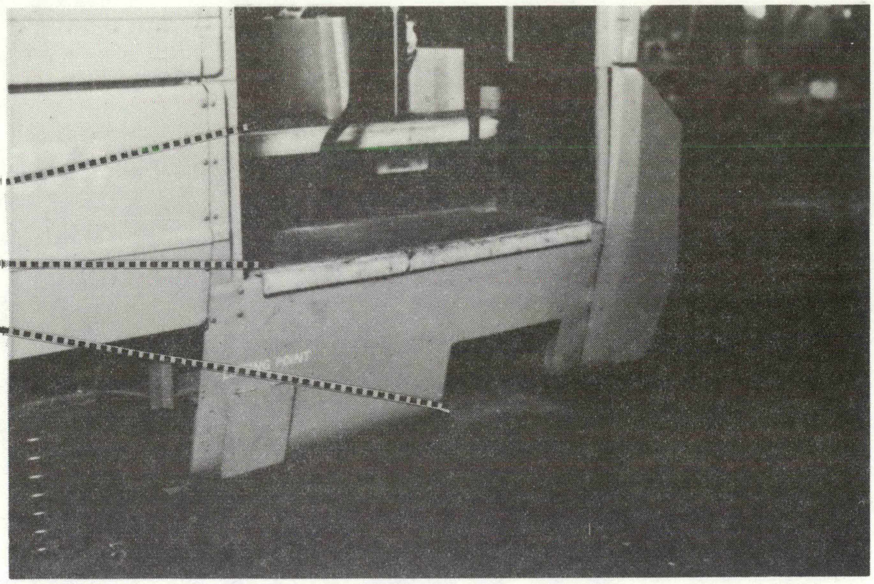
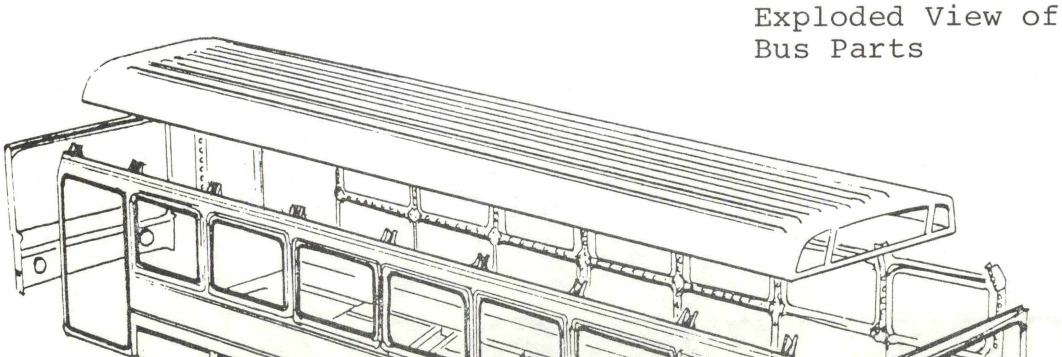


Figure 3-48

Exploded View of
Bus Parts



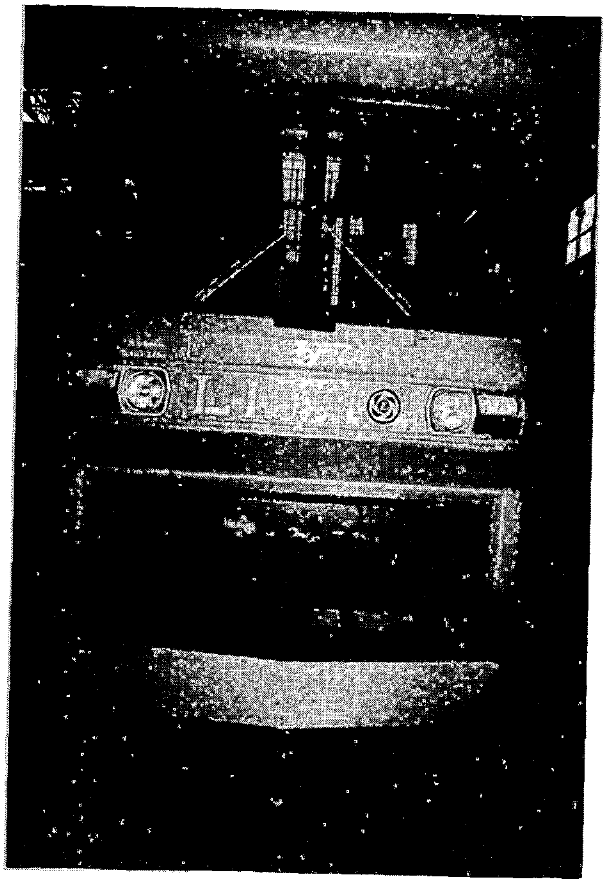


Figure 3-49

View of Rear
End of LEV-1

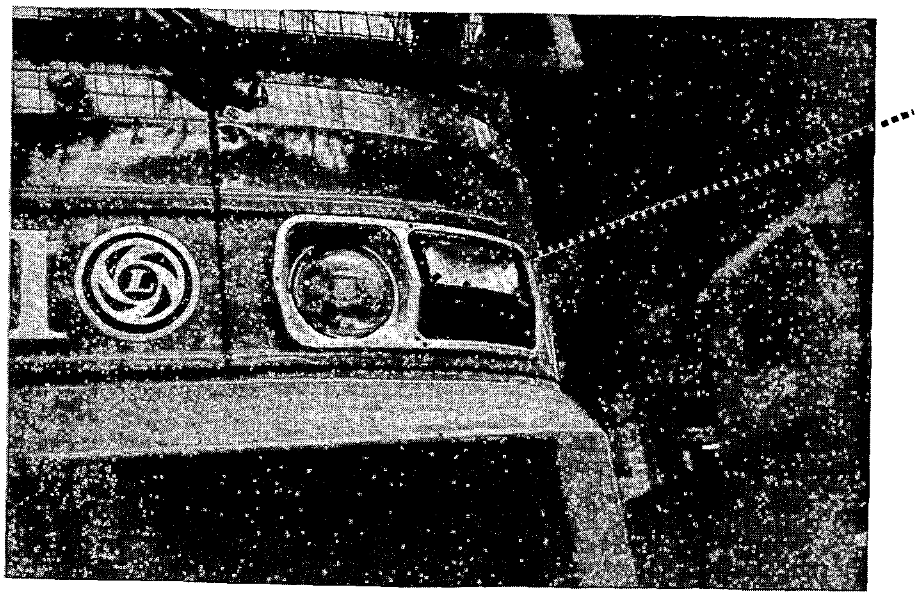


Figure 3-50

Exterior Light Assembly

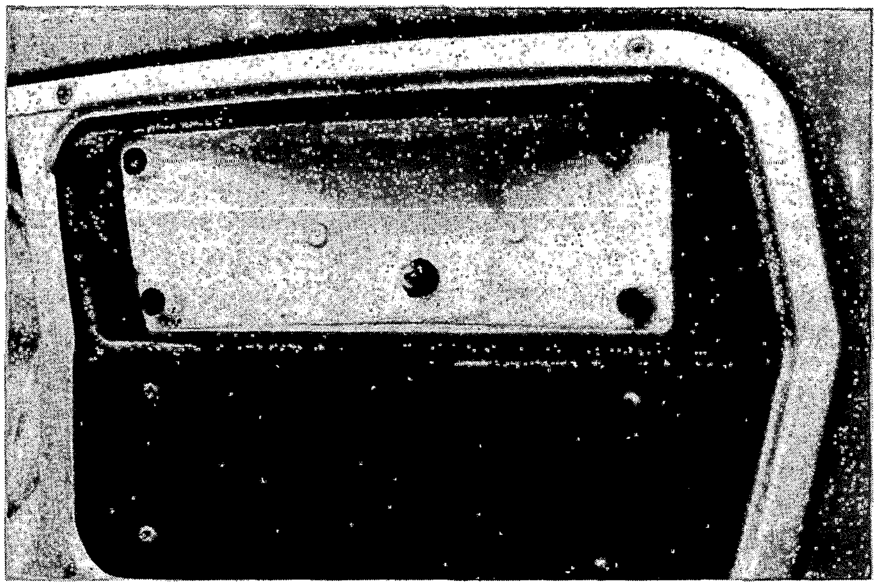


Figure 3-51

Light Assembly with Clear Marker Lens Removed

Figure 3-52

Interior View of Back of Light Assembly

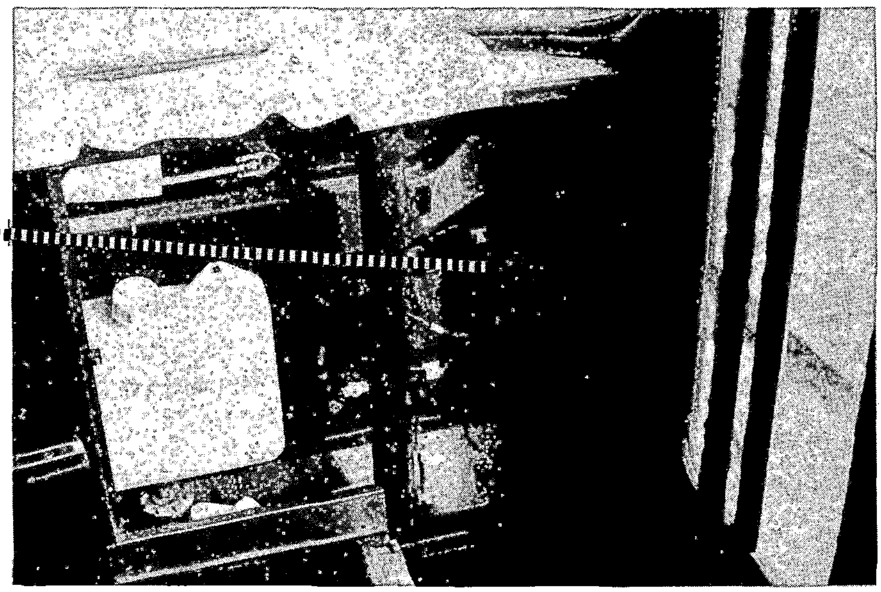


Figure 3-53

Exterior Sign

54

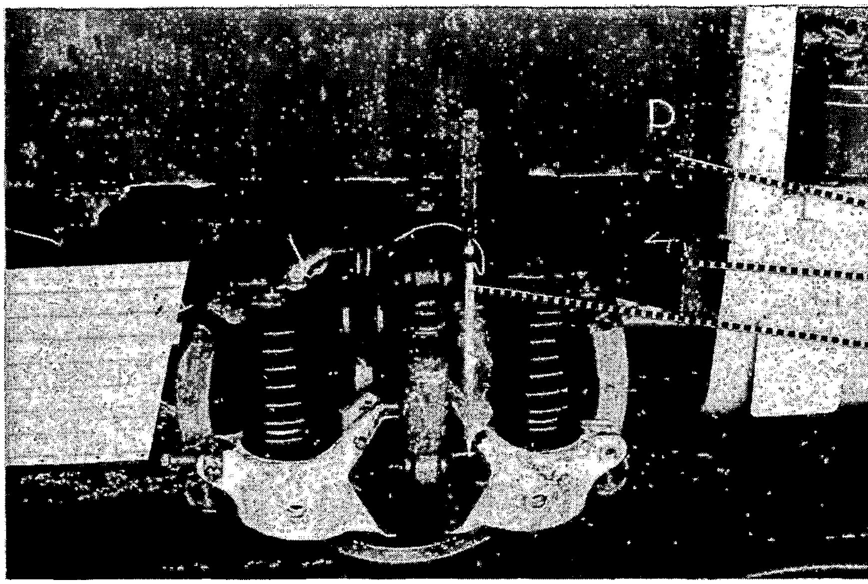


Figure 3-54

Skirting above Rear Left Truck Removed

Bus Body

Railroad Underframe

Vertical Displacement Transducer

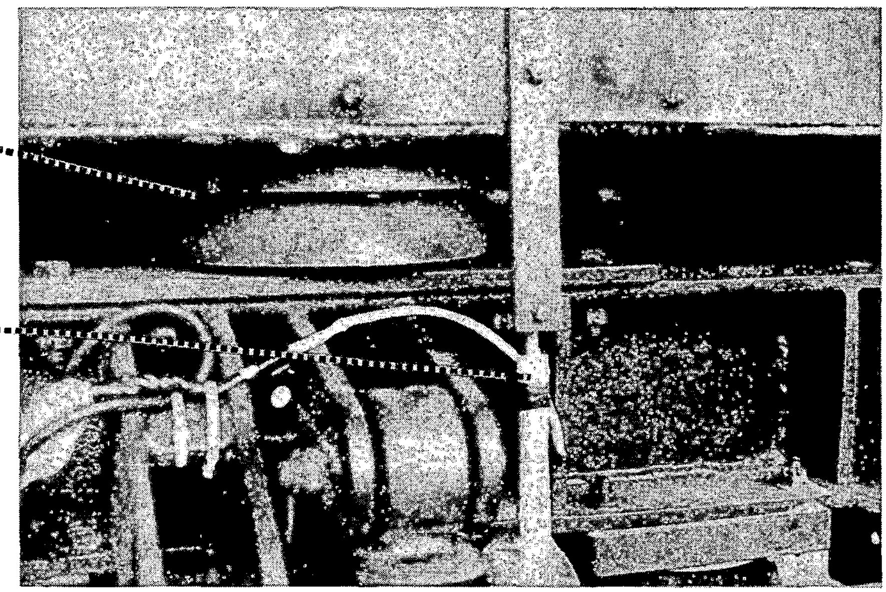


Figure 3-55

Isolation Pad

Vertical Displacement Transducer Connection

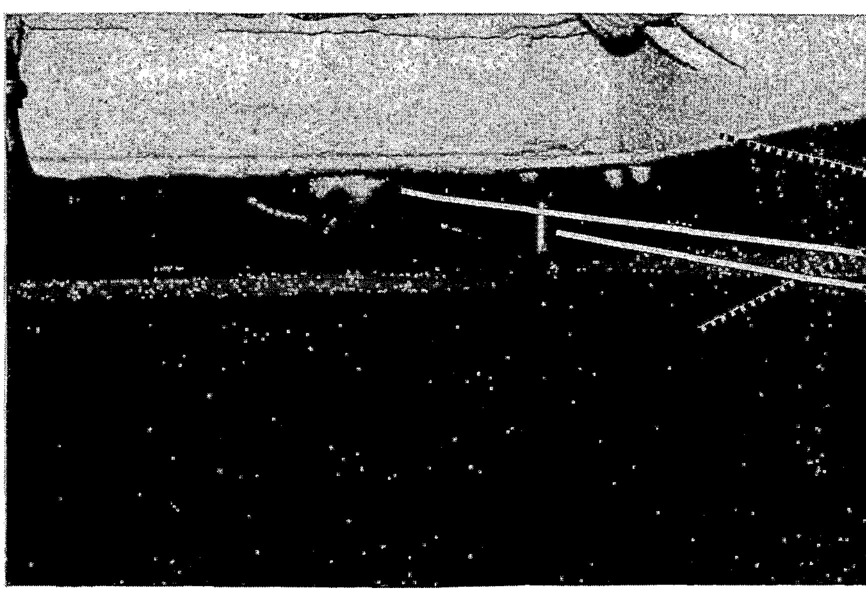


Figure 3-56

Undercar View between Bus Body (Top) and Underframe (Bottom) showing the Connection Lugs and Displacement Transducer

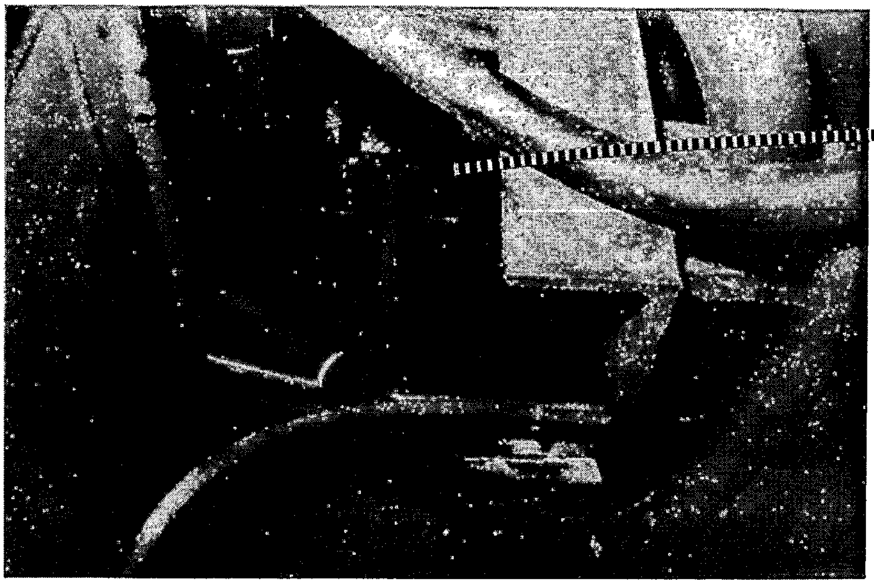


Figure 3-57

Bottom View of Body Connection

Figure 3-58

Coupler

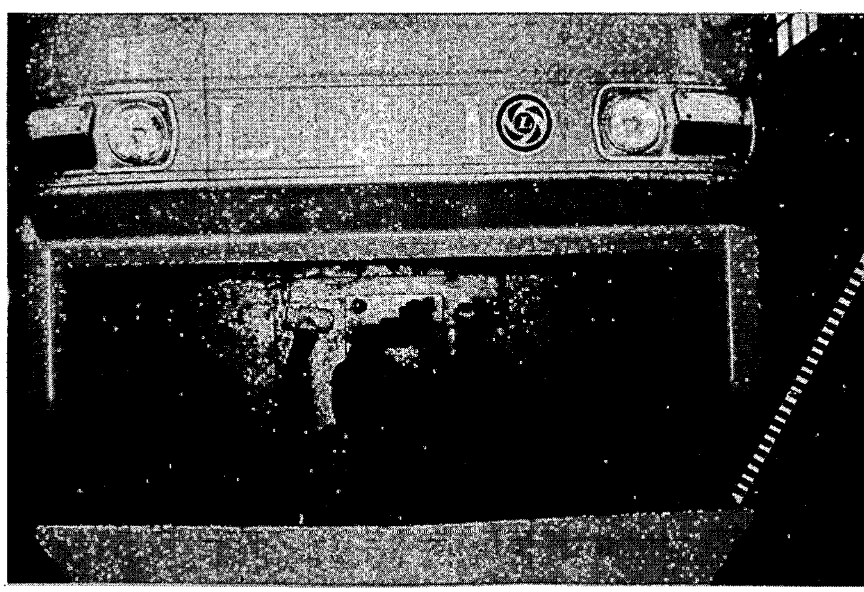


Figure 3-59

Snowblade

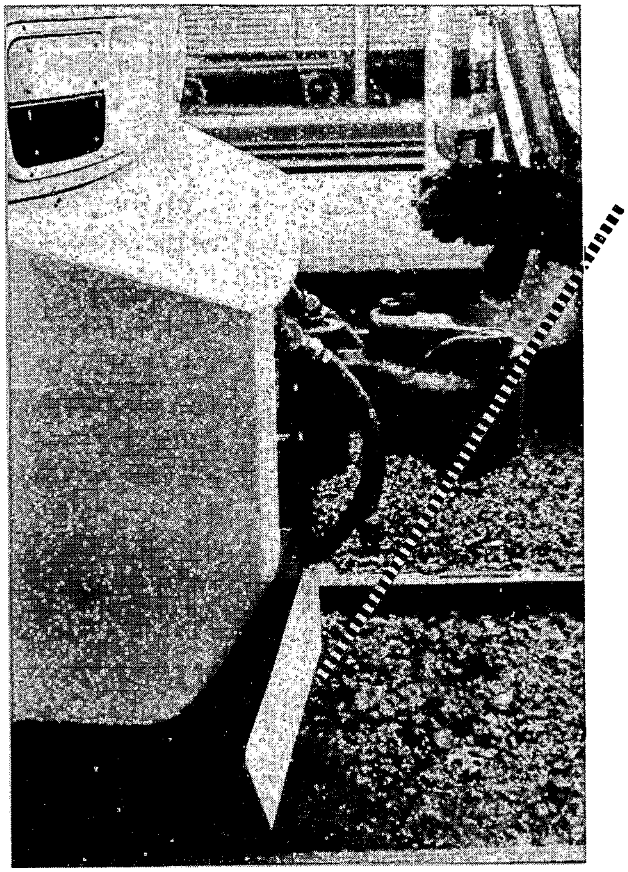


Figure 3-60

Side View of Rear End
Showing the Snowblade

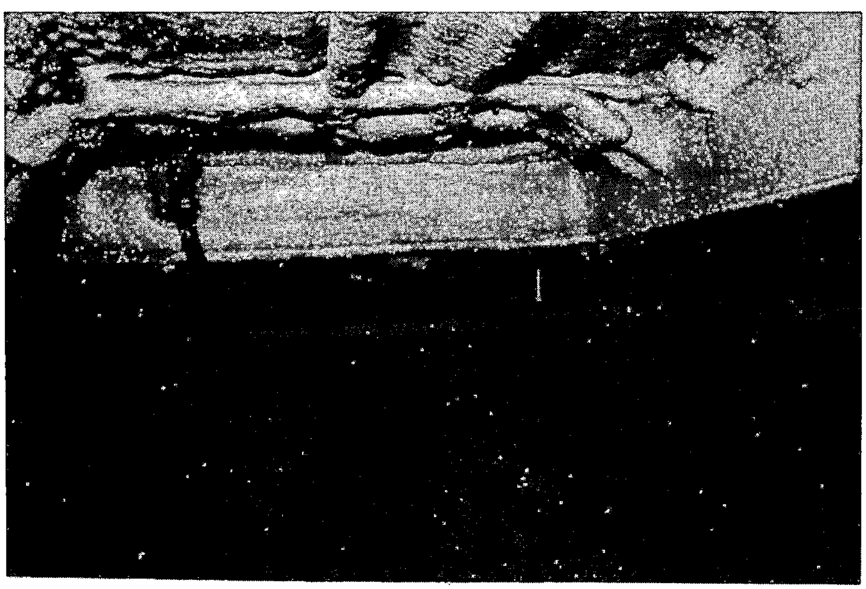


Figure 3-61

Undercar View
Showing Insulation

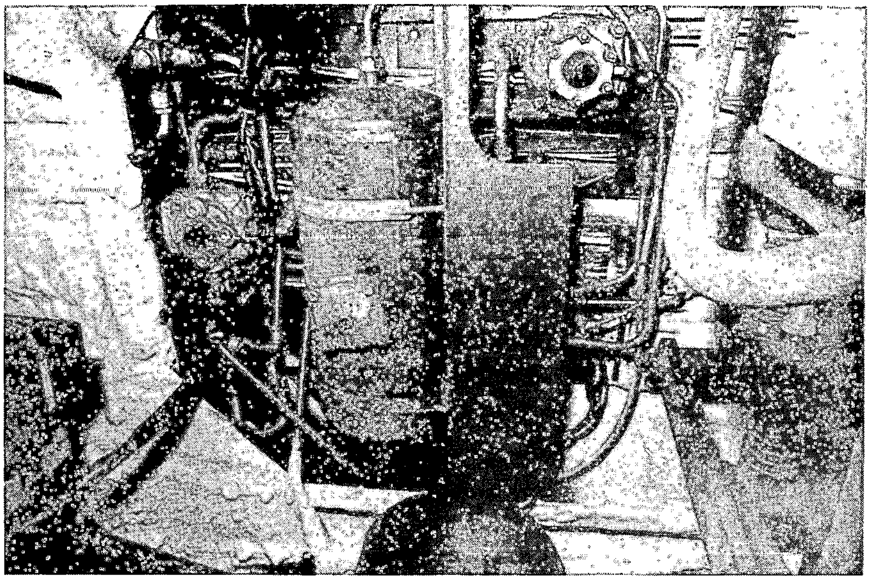
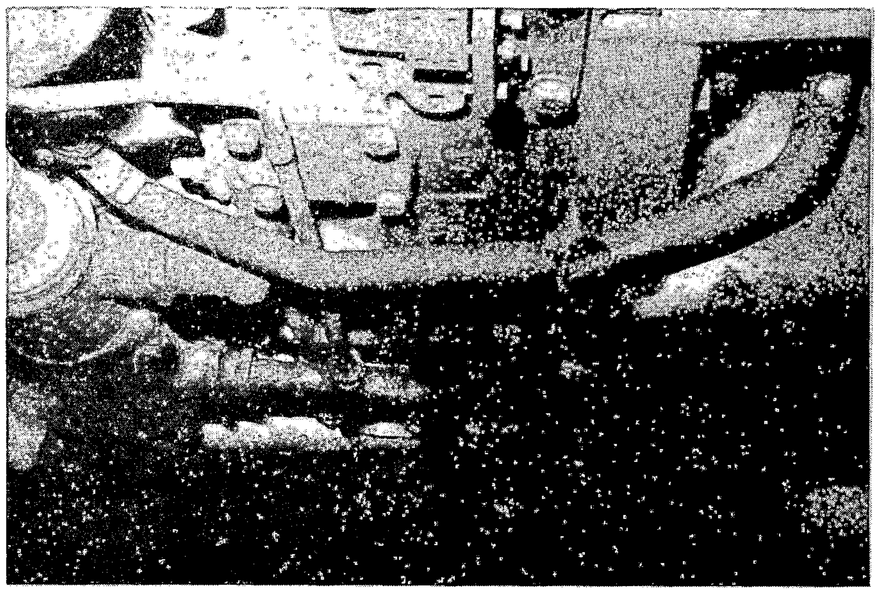


Figure 3-62

Undercar View of Piping, Wiring, Plastic Tubing and Pneumatic Equipment not Coated with Insulation

Figure 3-63

Leyland Diesel Engine



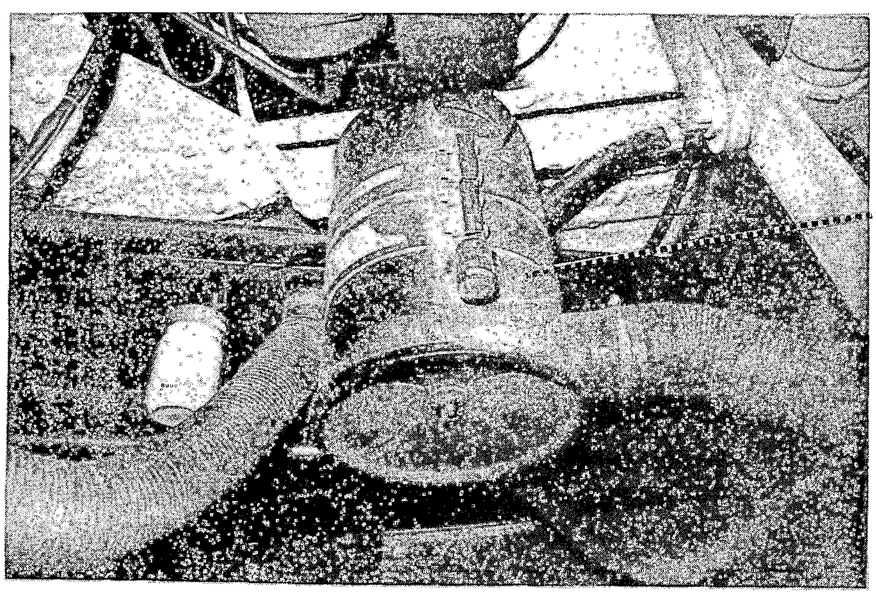


Figure 3-64

Diesel Engine Air Intake Filter

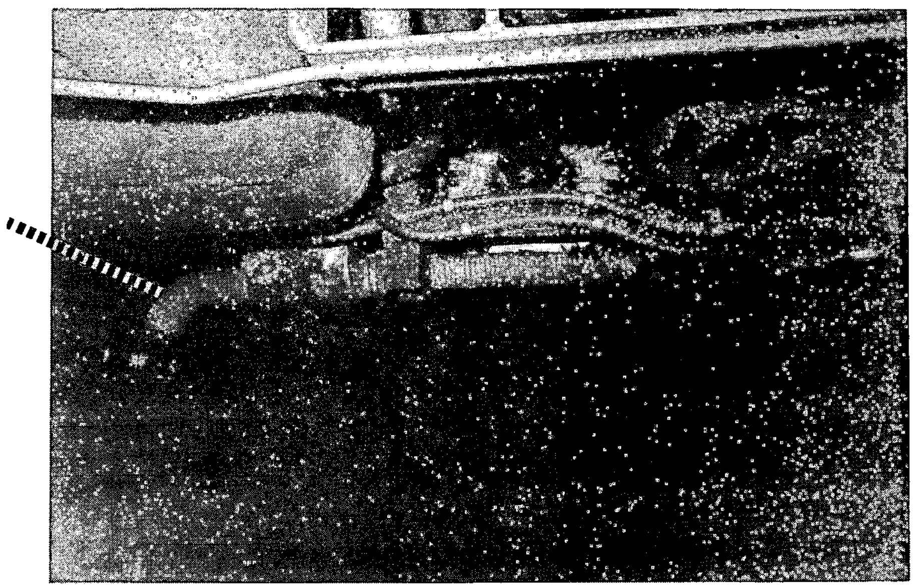
58

Figure 3-65

Horizontal Cooling Fan

Figure 3-66

Diesel Engine Exhaust



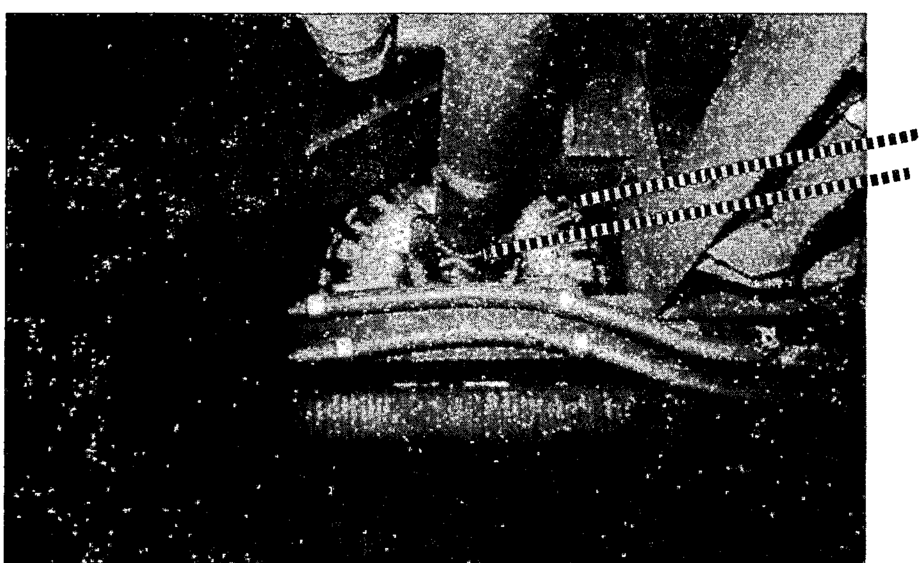


Figure 3-67

Fluid Clutch and Drive Shaft

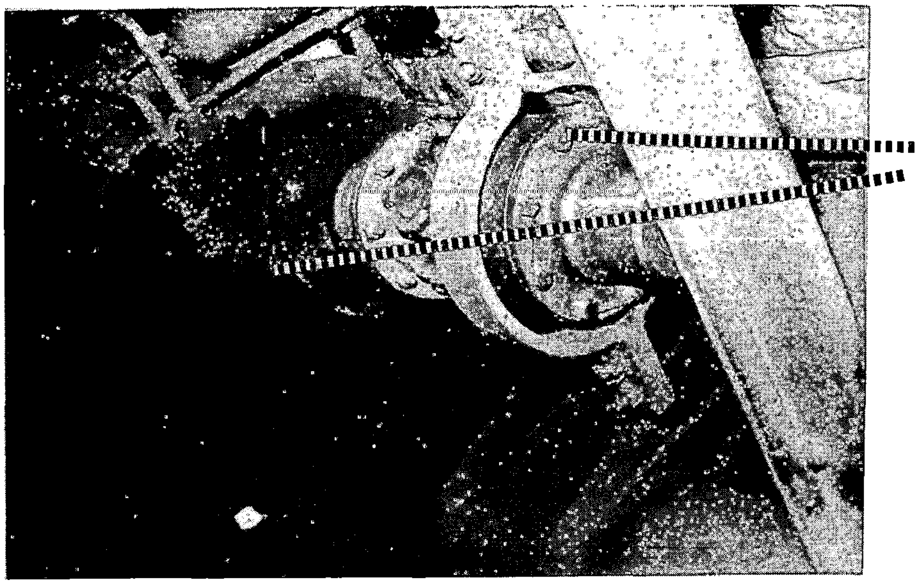


Figure 3-68

Free Wheeling Device and Transmission

Figure 3-69

Safety Support Brackets

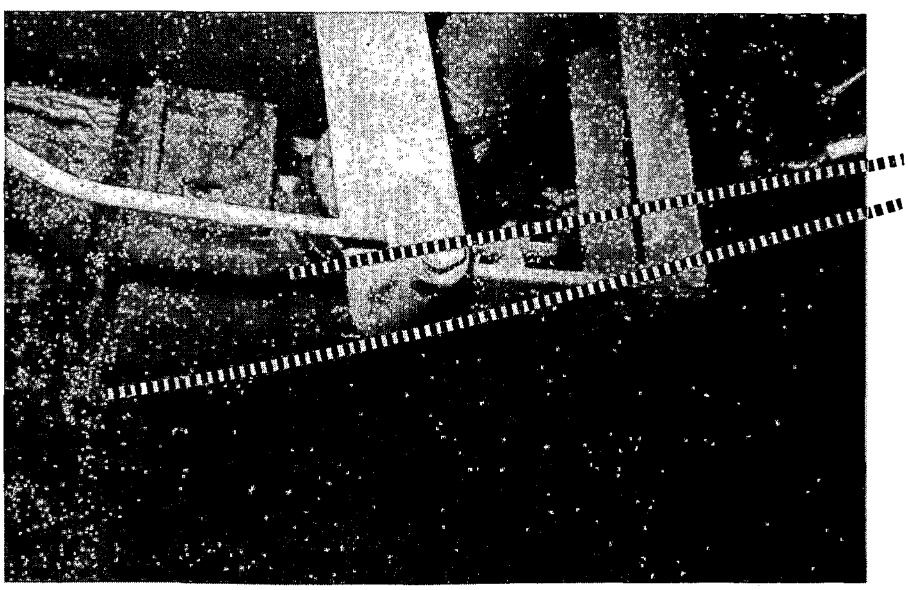


Figure 3-70

Leyland Gear Box and Safety Cable

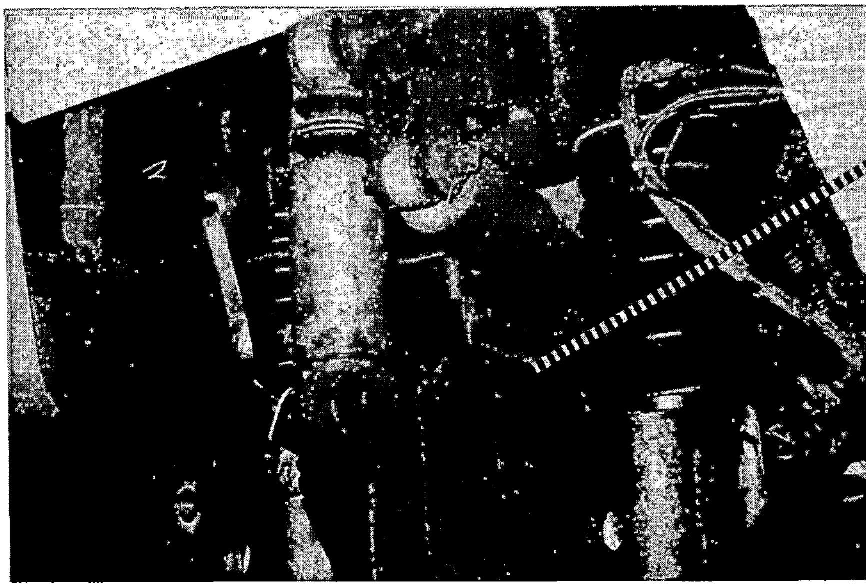


Figure 3-71

LEV-1 Truck Showing the Wheel Rotation Probe

Figure 3-72

View Behind the Front Cab Showing the P.A. Speakers, Transmission Control Boxes, Fire Control Box and the Container of Torpedos (Detonators)

61

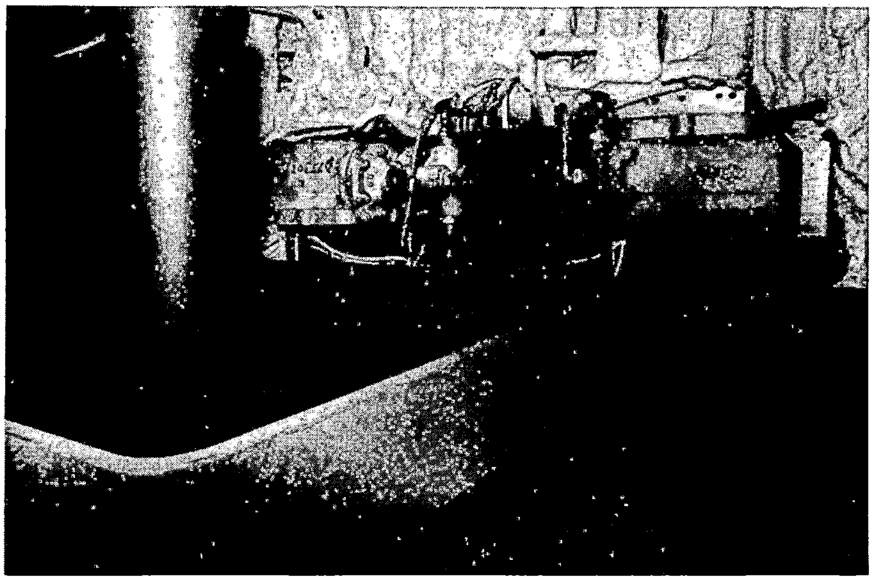


Figure 3-73

Electrical to Pneumatic Valves for Transmission and Reverser

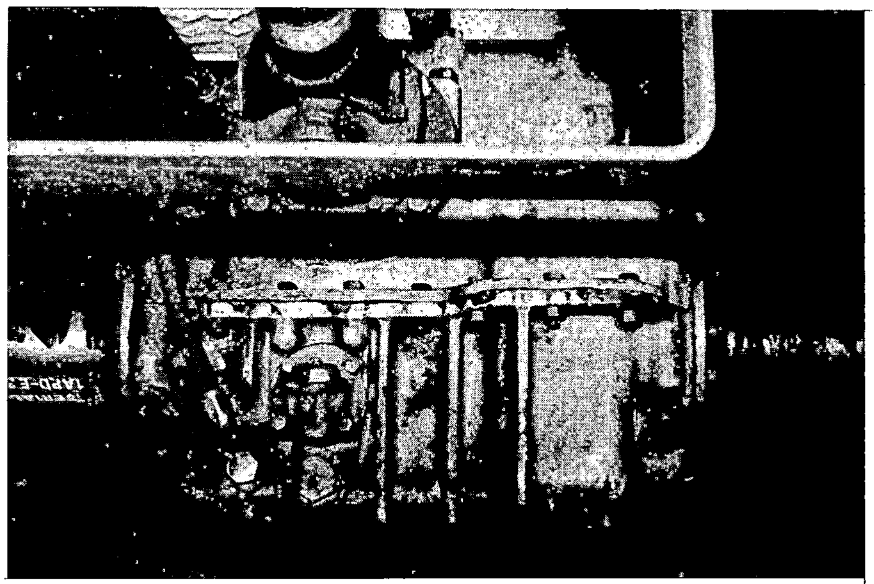


Figure 3-74

Final Drive Unit - Drive End

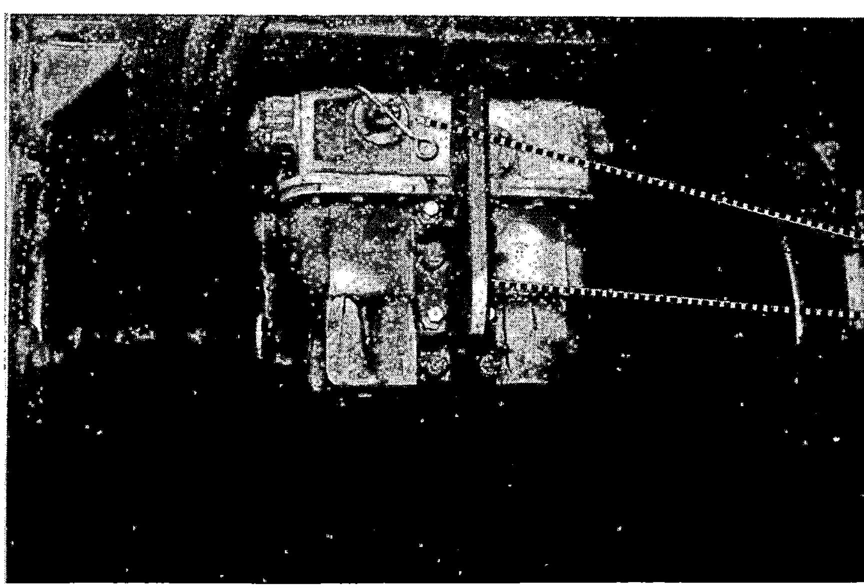


Figure 3-75

Final Drive Unit - Rear End

Disengage Handle

Reaction Lug

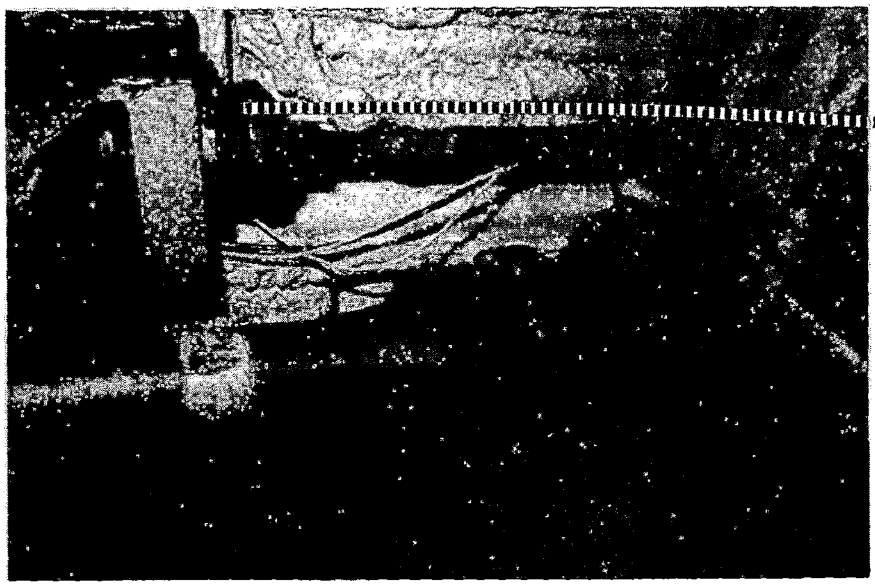
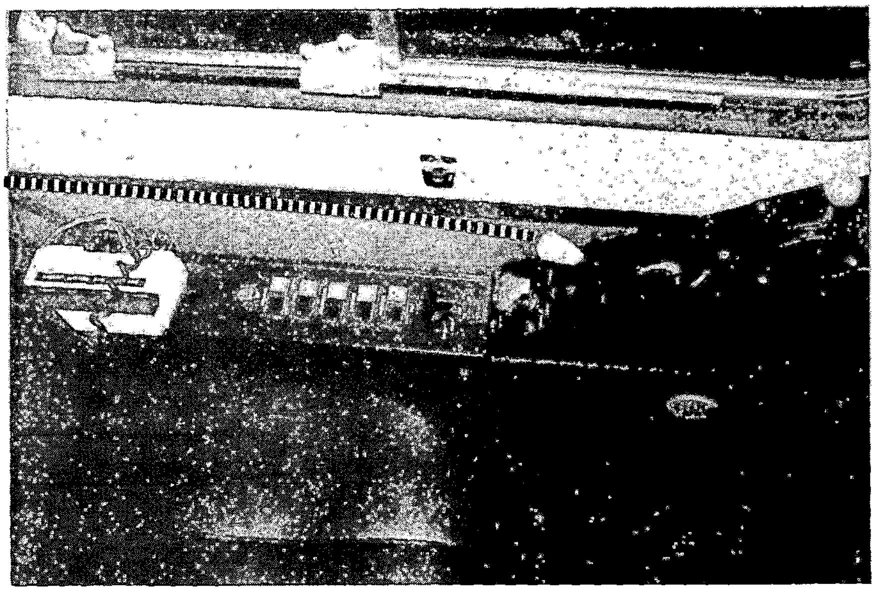


Figure 3-76

Final Drive Unit - Resilient Underframe Connection

Figure 3-77

Spring Parking Brake Control



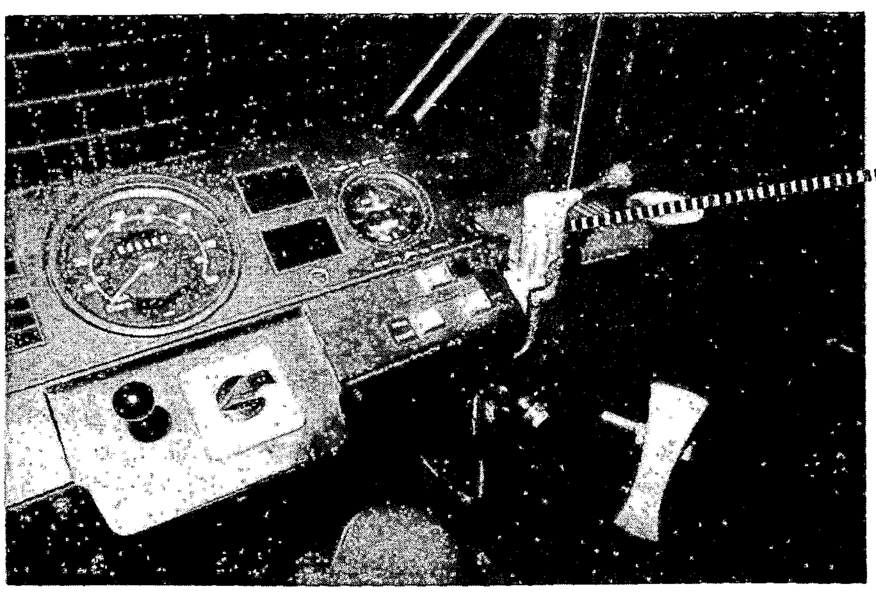


Figure 3-78

Service Brake Valve

63

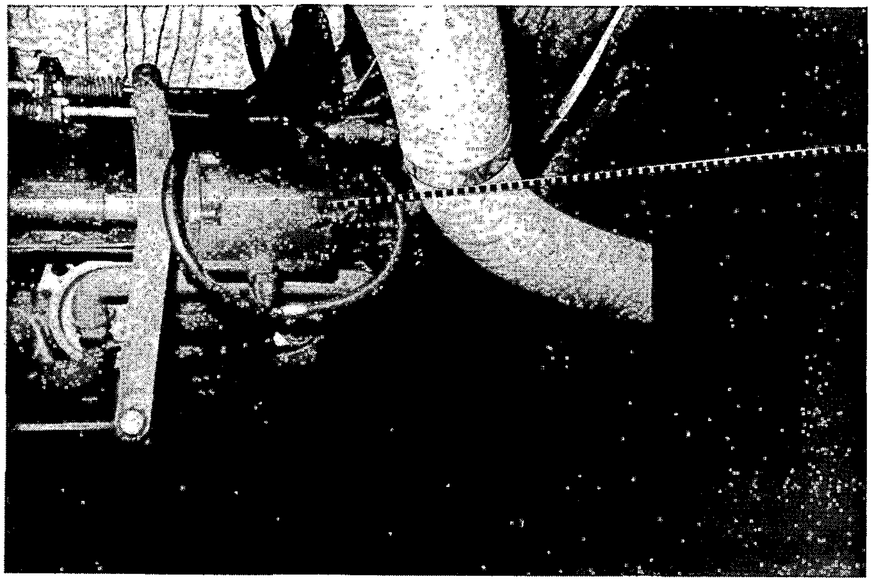
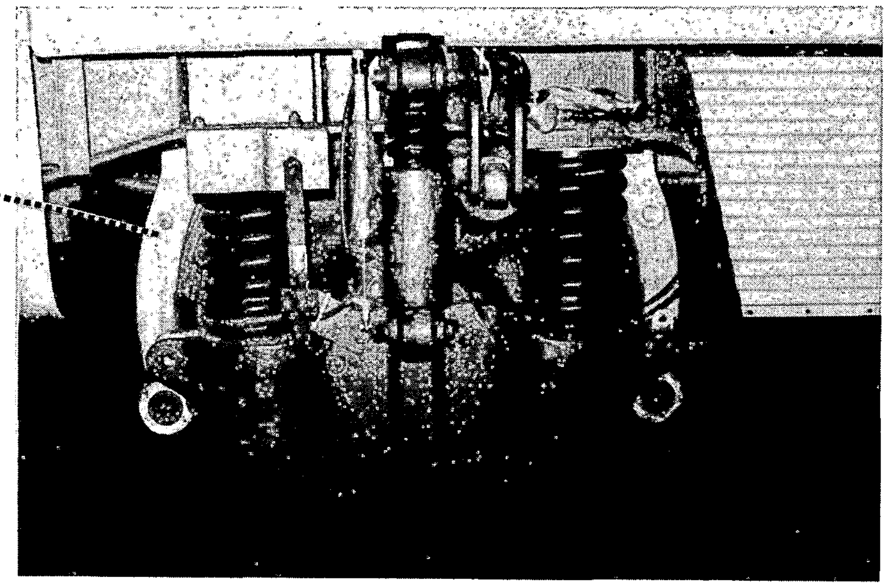


Figure 3-79

Brake Cylinder

Figure 3-80

Front Truck Showing the Brake Levers



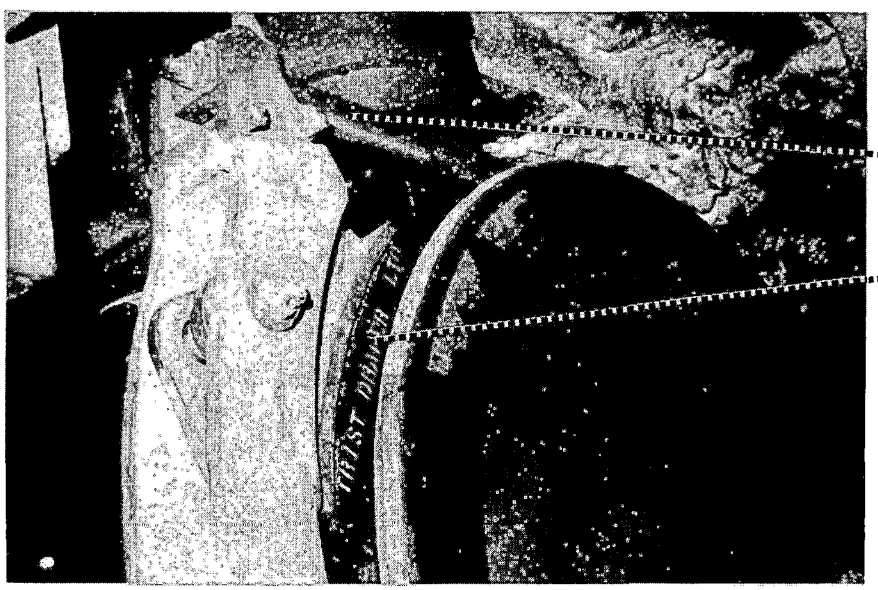


Figure 3-81

Brake Cable to Brake Lever Connection

Brake Shoe

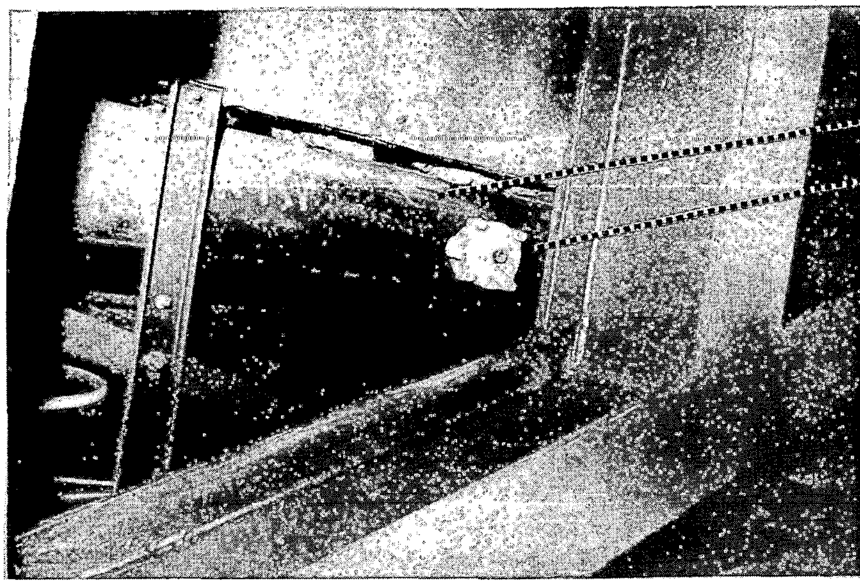


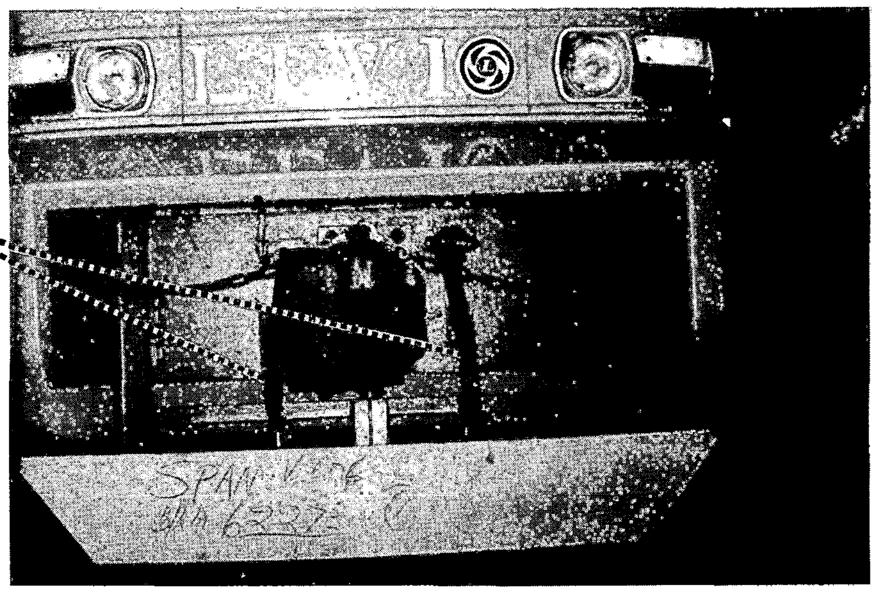
Figure 3-82

Pressure Reservoir and Water Drain Valve

Figure 3-83

LEV-1 End

Trainlines



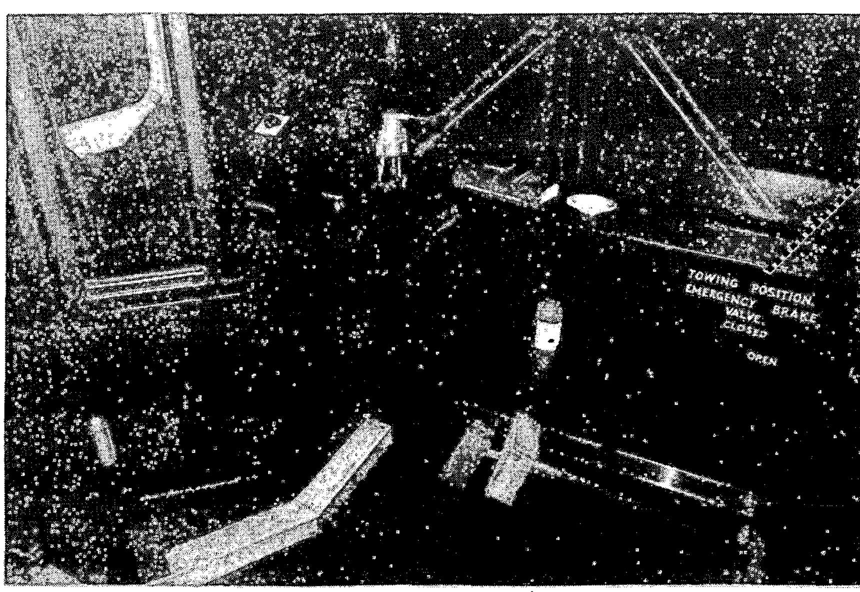


Figure 3-84

Towing Instructions

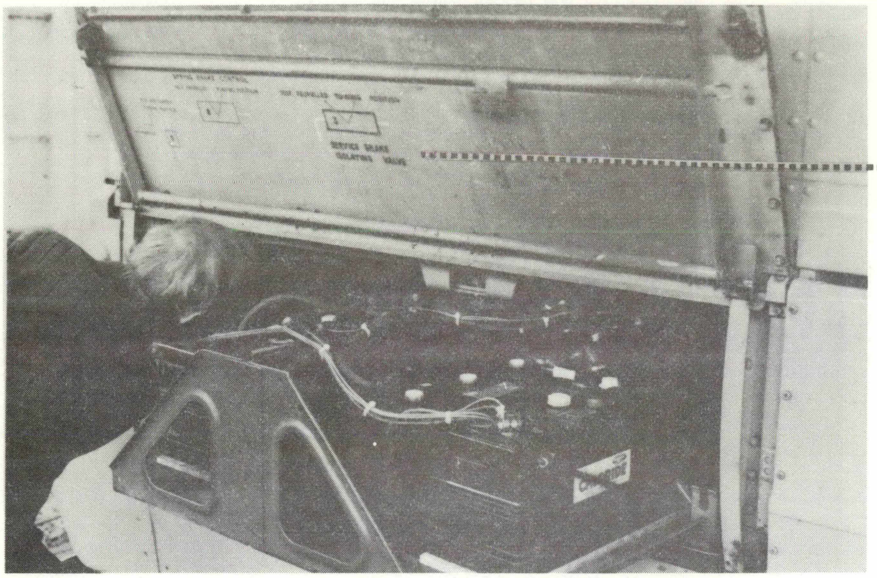


Figure 3-85

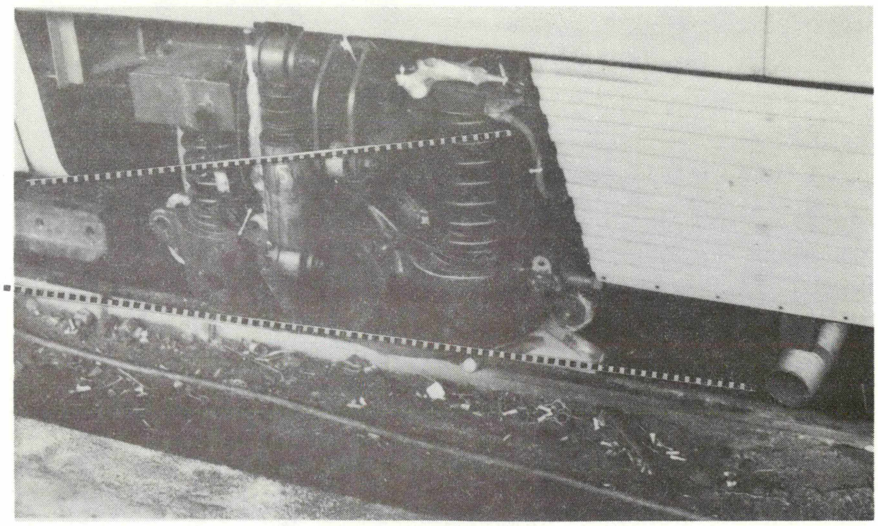
Service Brake Towing Instructions

Figure 3-86

Front Right Hand Truck

Disconnected ground Cable

Supplemental Heater Exhaust



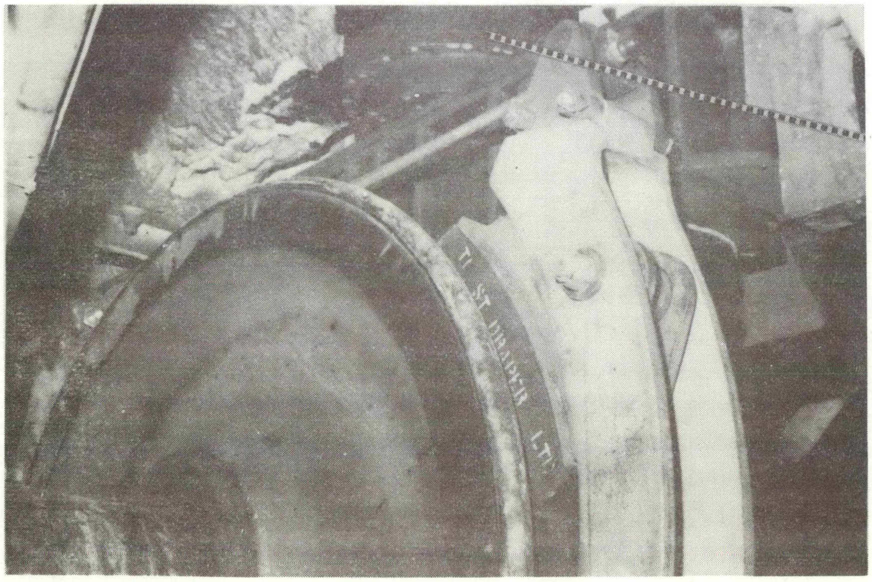


Figure 3-87

Isolation Pad

66

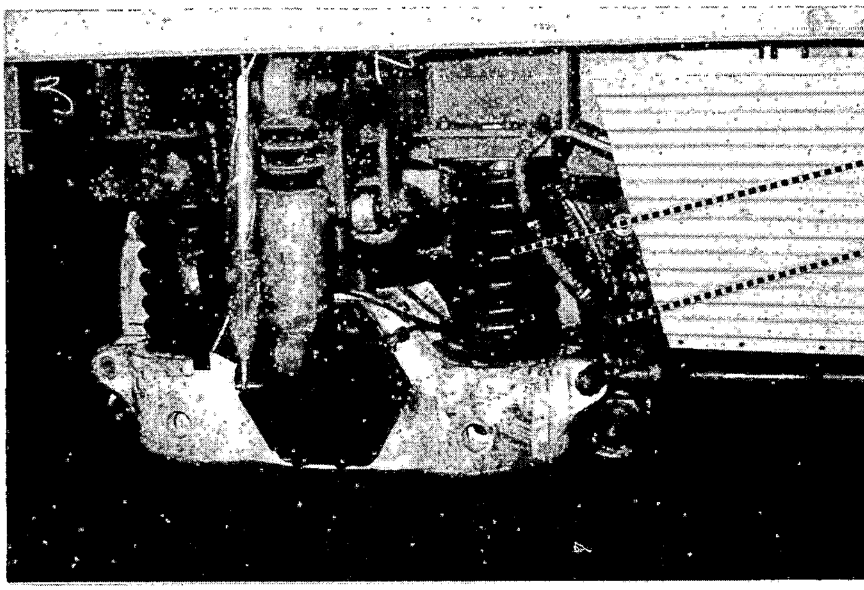


Figure 3-88

Rear Right Hand Truck - Helical Springs

Ground Cable

Figure 3-89

Front Left Hand Truck - Vertical Damper and Lateral Travel Transducer

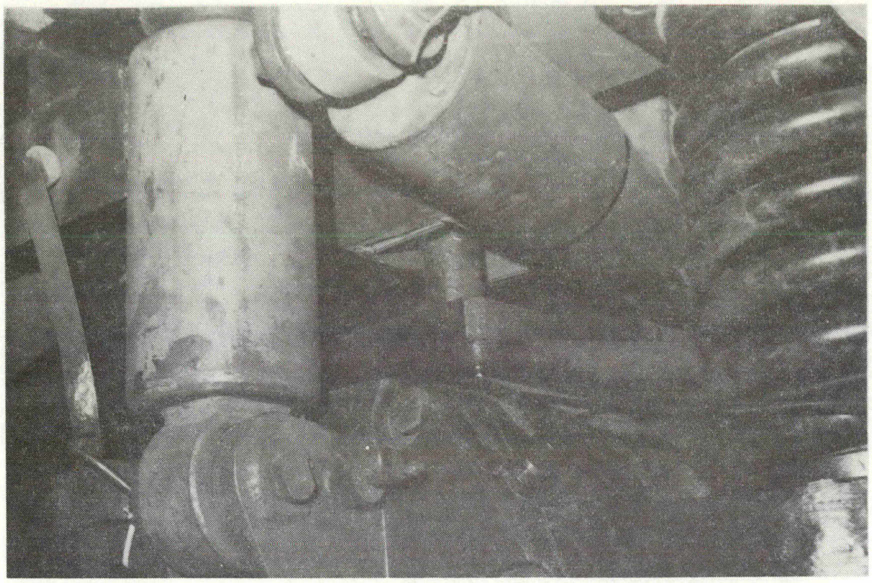
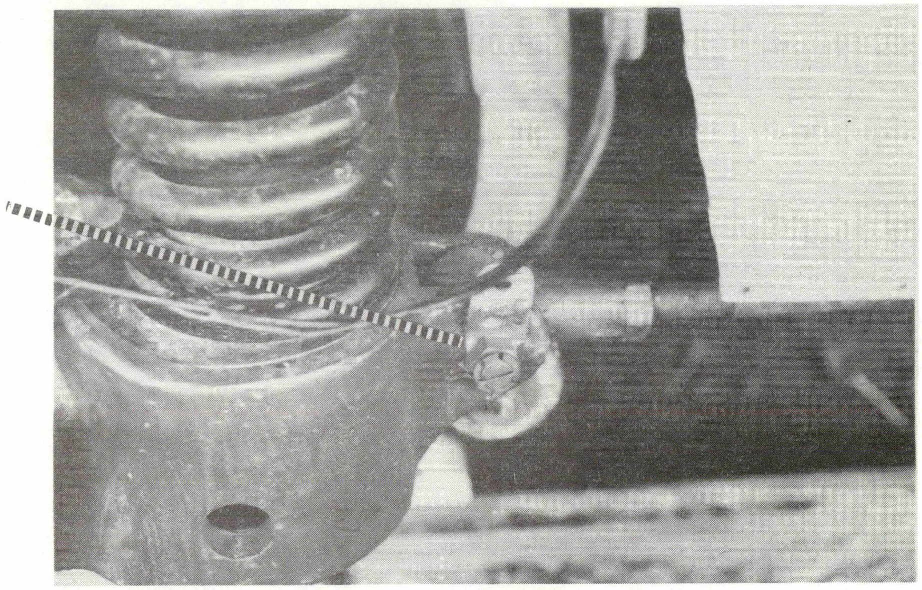


Figure 3-90

Lateral Damper and Travel Stop

Figure 3-91

Truck to Body Spring Attachment



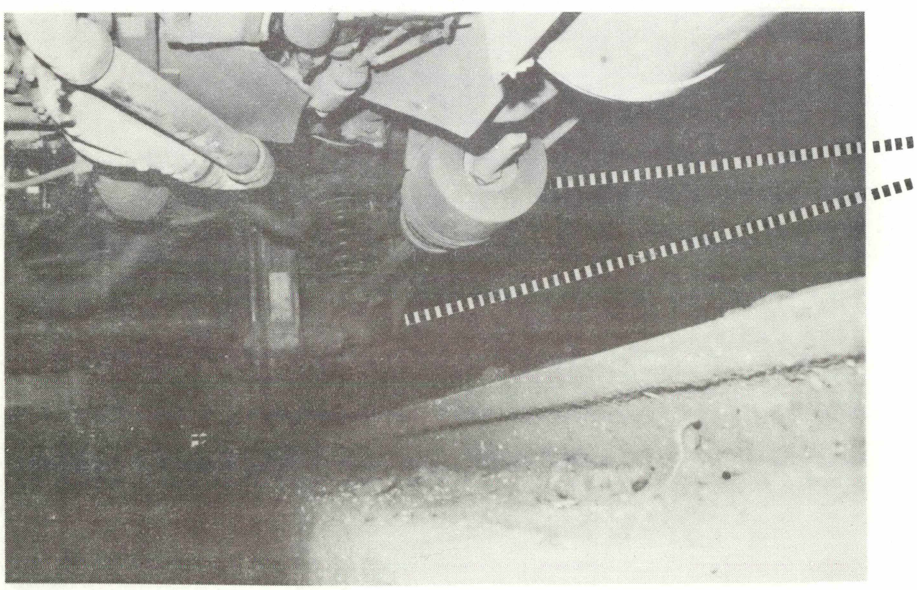


Figure 3-92

Body Spring and Truck

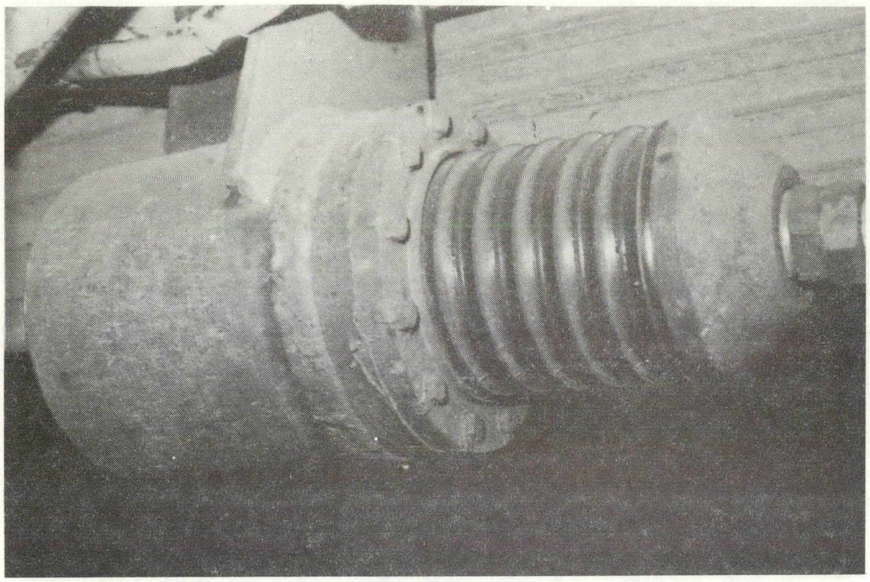


Figure 3-93

Body Spring

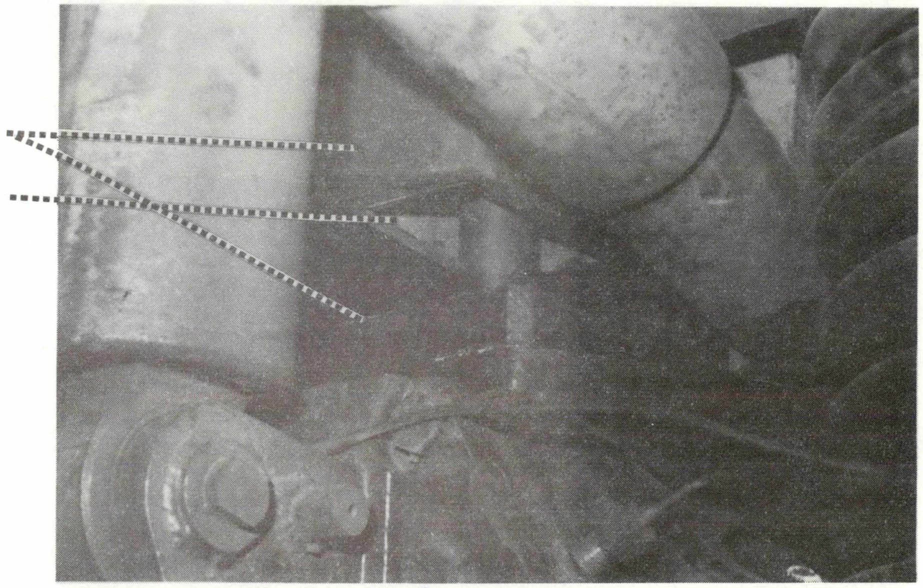


Figure 3-94

Overtravel Stop

Resilient Pad

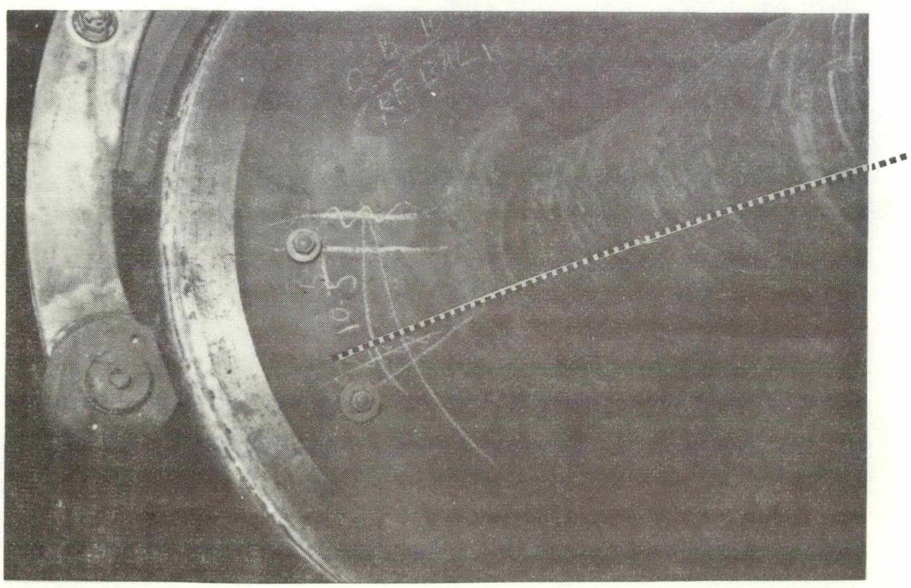


Figure 3-95

Wheel Balancing
Marking and Bolts

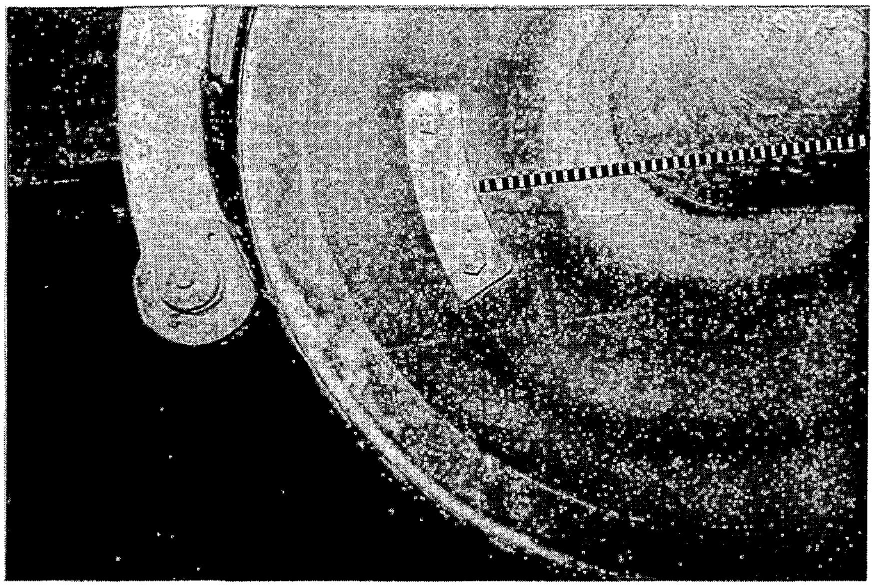


Figure 3-96

Wheel Balance Weight

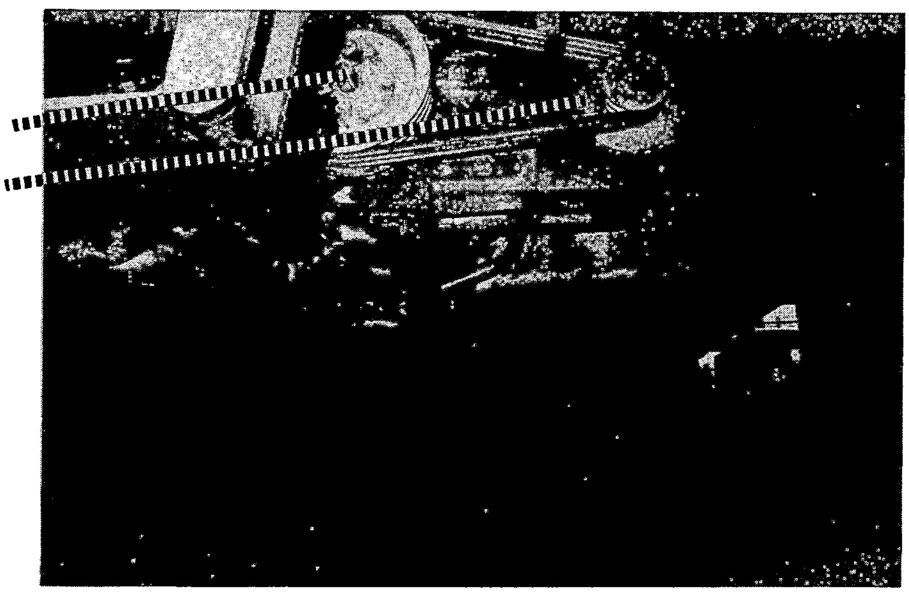


Figure 3-97

Diesel Engine and Alternator

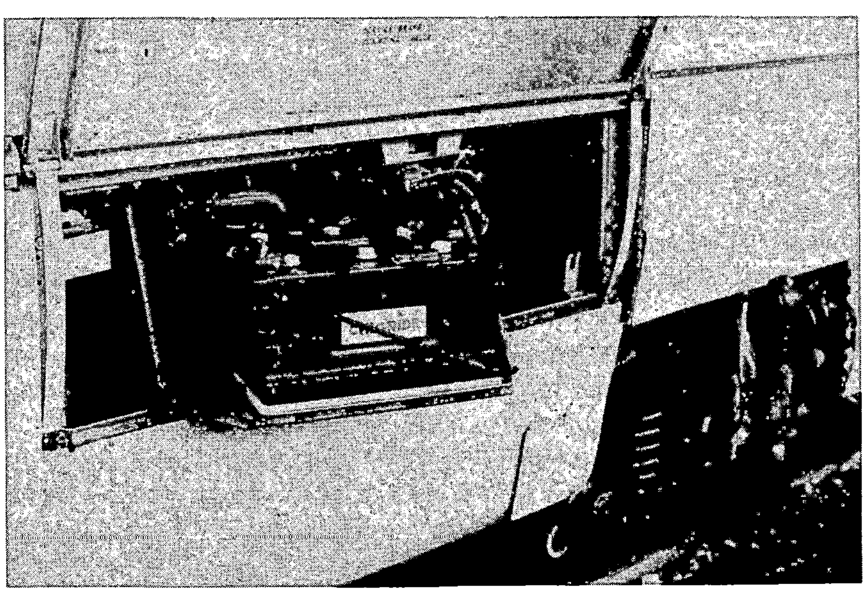


Figure 3-98

Battery Tray Partially Swung Out

76

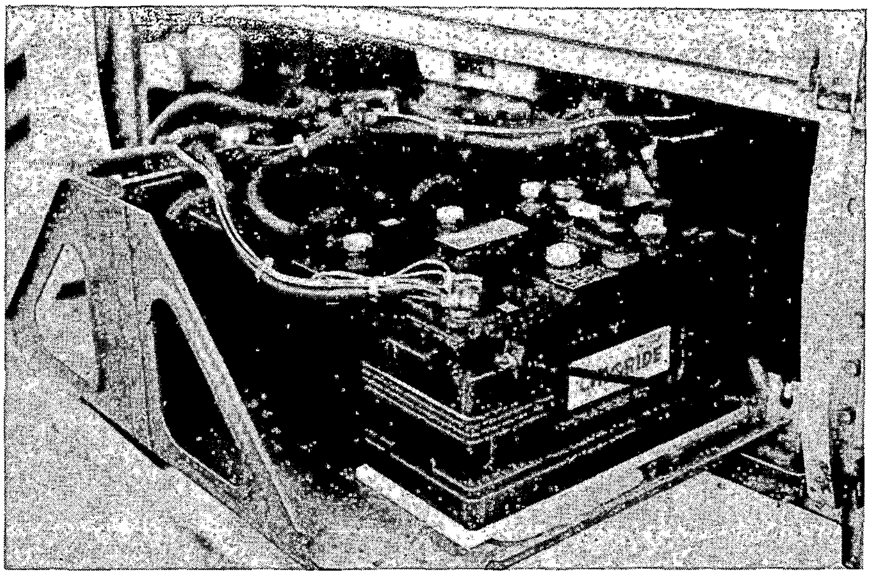


Figure 3-99

Battery Tray
Swung Out

Figure 3-100

Hand Held Fire
Extinguisher

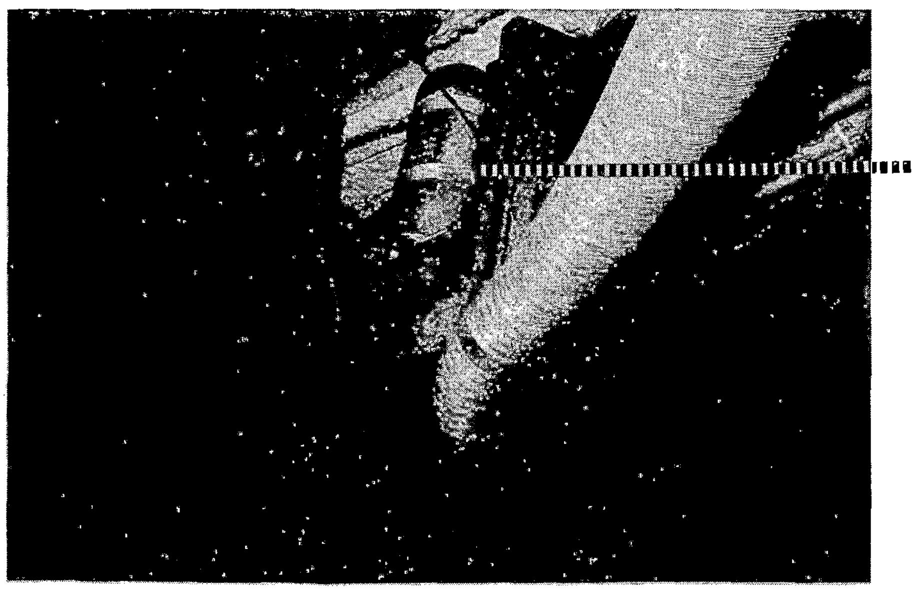


Figure 3-101

Undercar Fire
Extinguisher

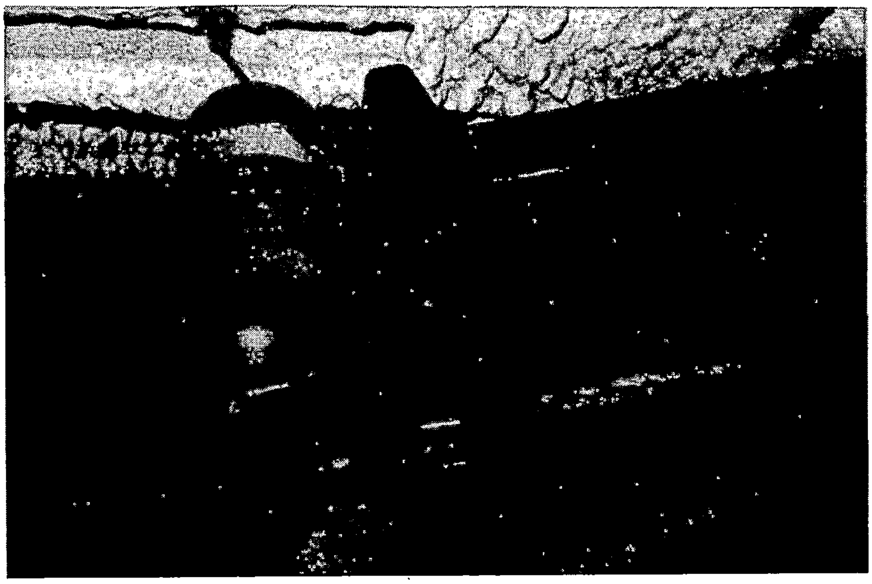


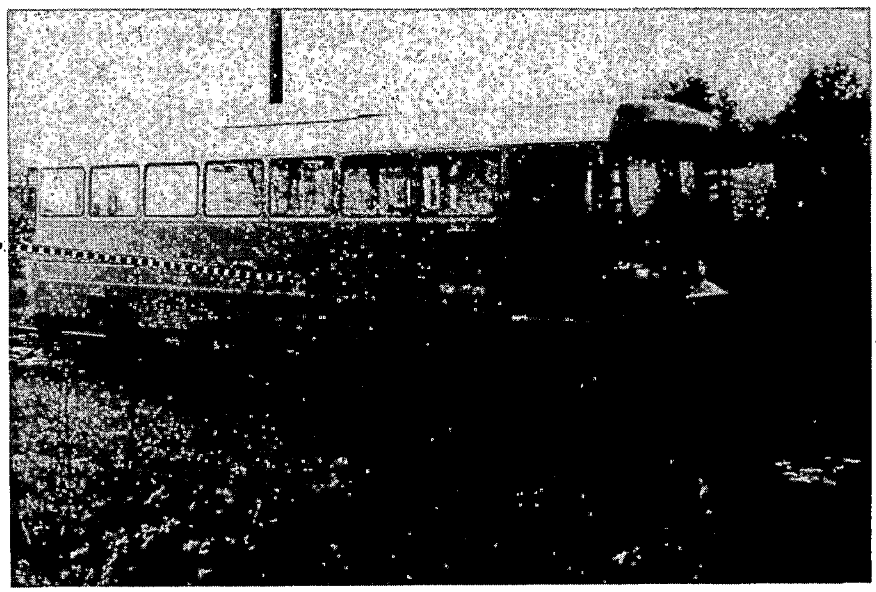
Figure 3-102

Undercar Fire Extinguisher

Figure 3-103

LEV-1 at Nashua, NH

"Break the Glass" extinghisher



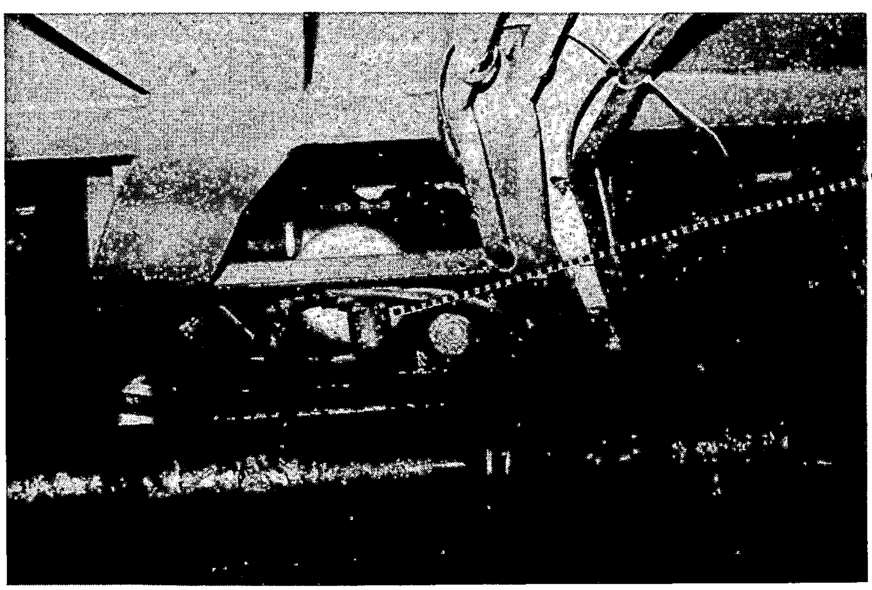


Figure 3-104

Supplemental Heater - View from Front End of LEV-1

(72)

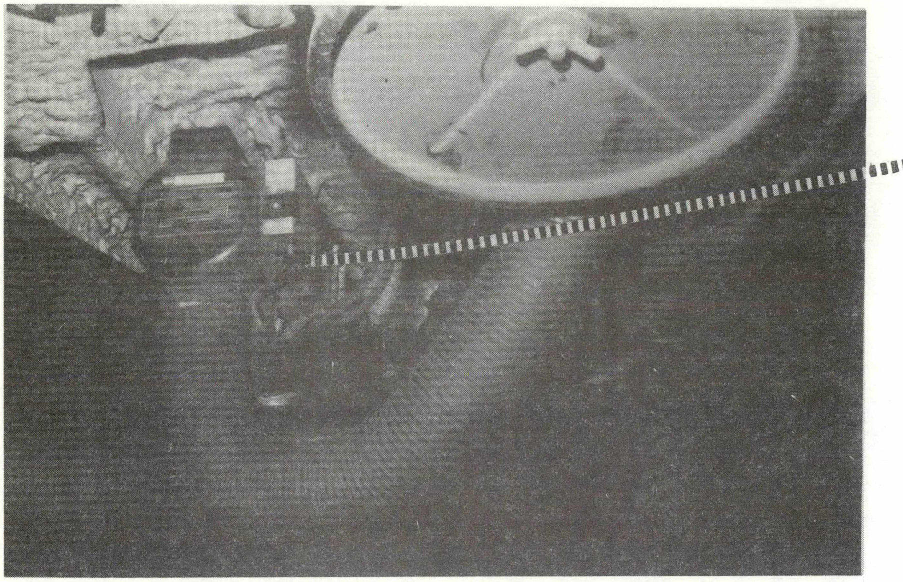
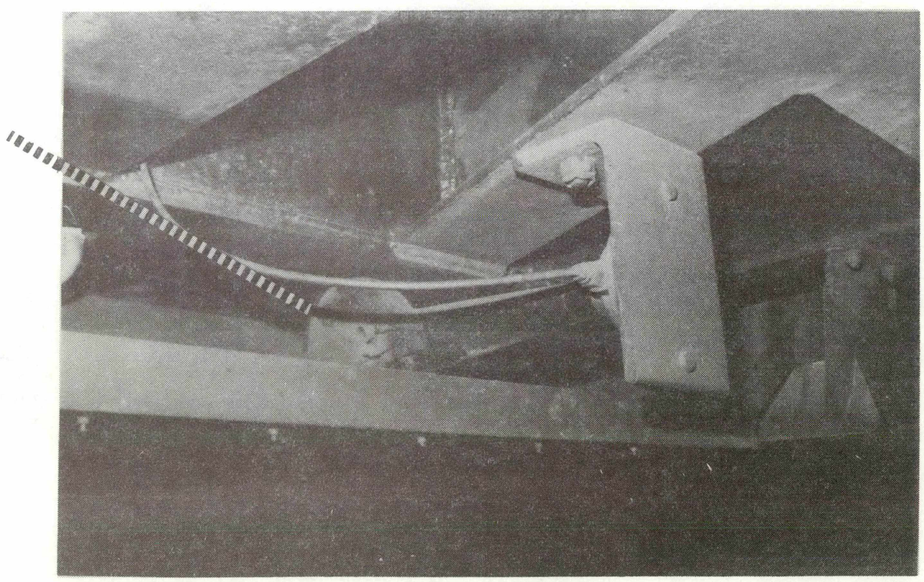


Figure 3-105

Supplemental Heater - View from Center of Vehicle

Figure 3-106

Horn



73

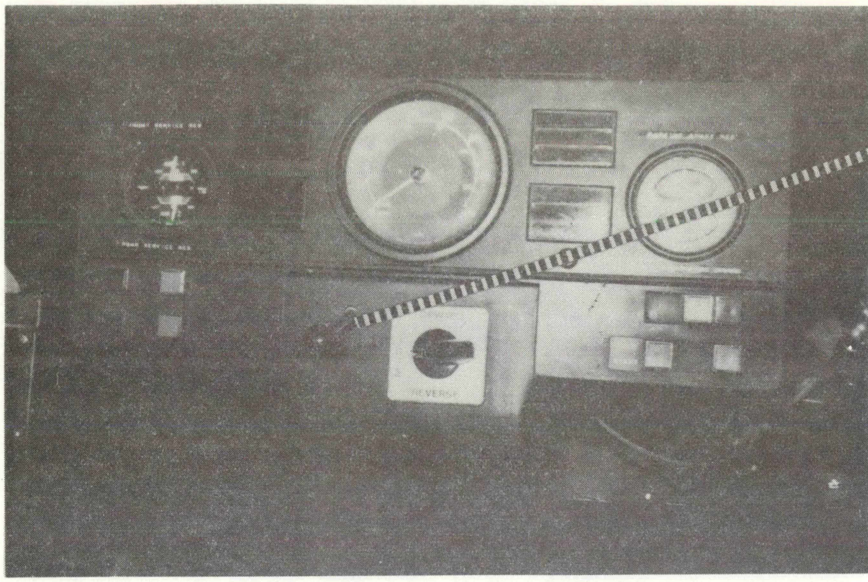


Figure 3-107

Horn Control

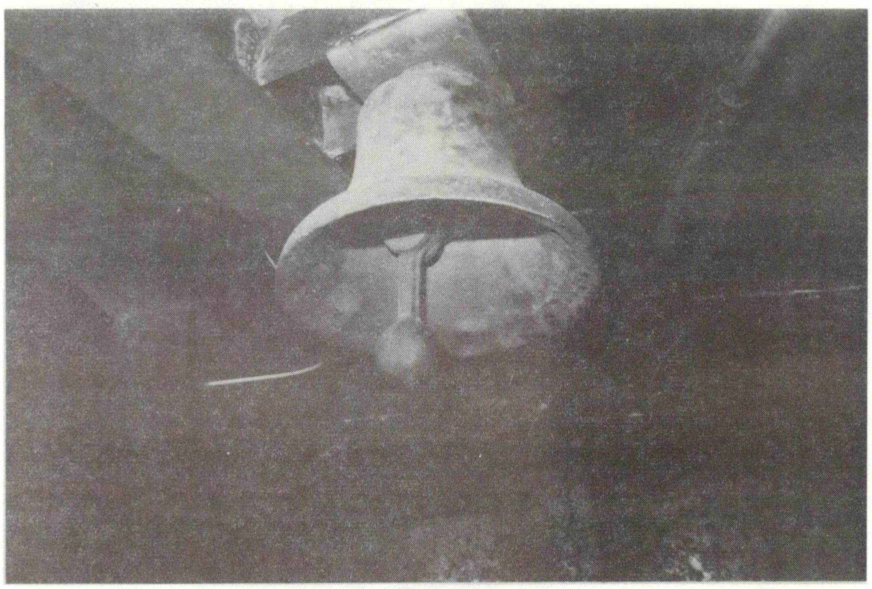


Figure 3-108

Bell

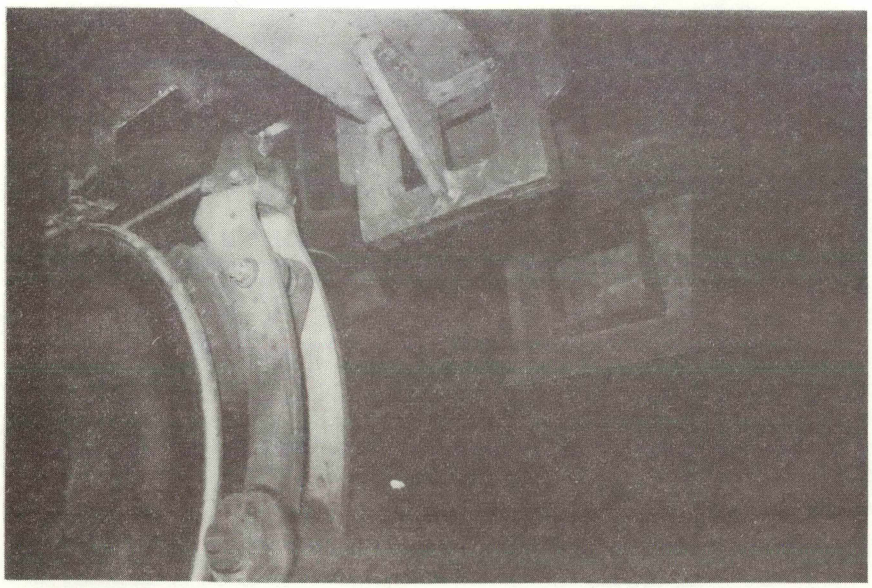


Figure 3-109

Brake Beam and Shoe

74

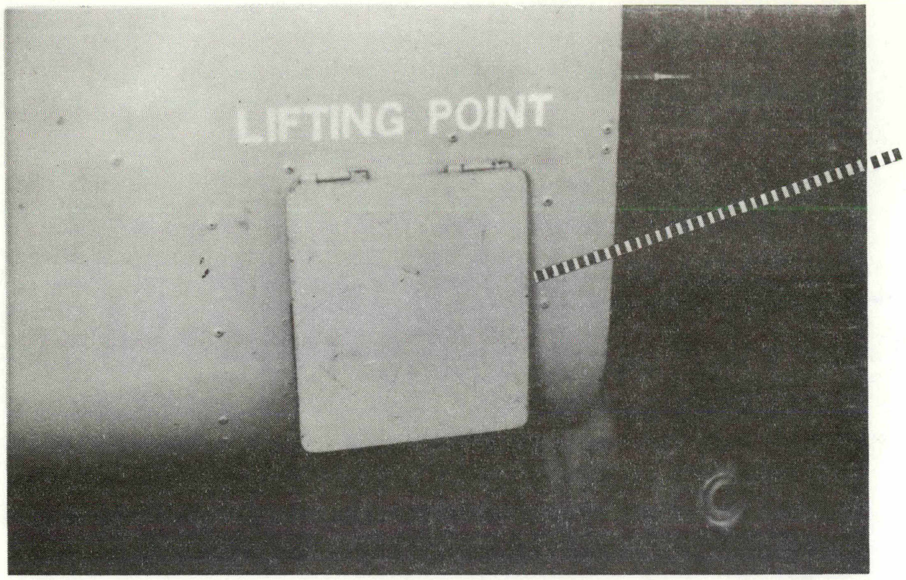
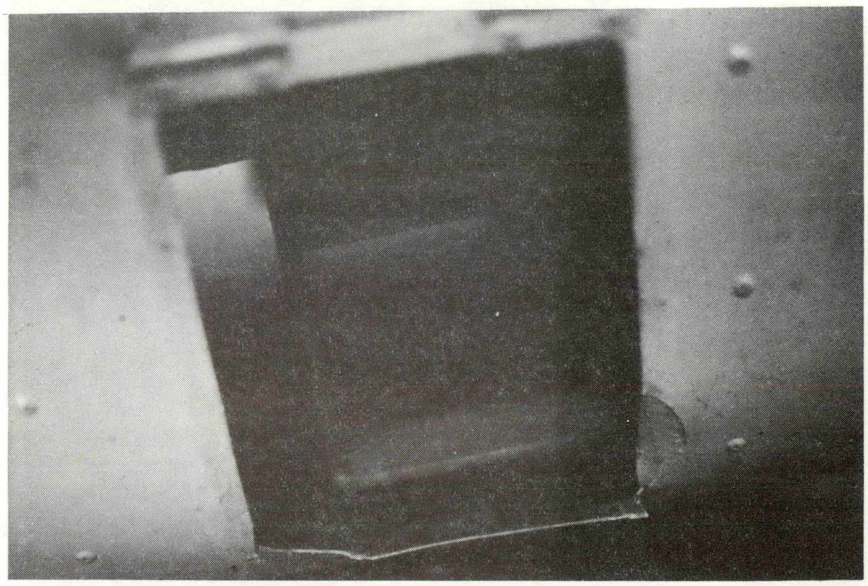


Figure 3-110

Hinged Cover

Figure 3-111

Cover Open



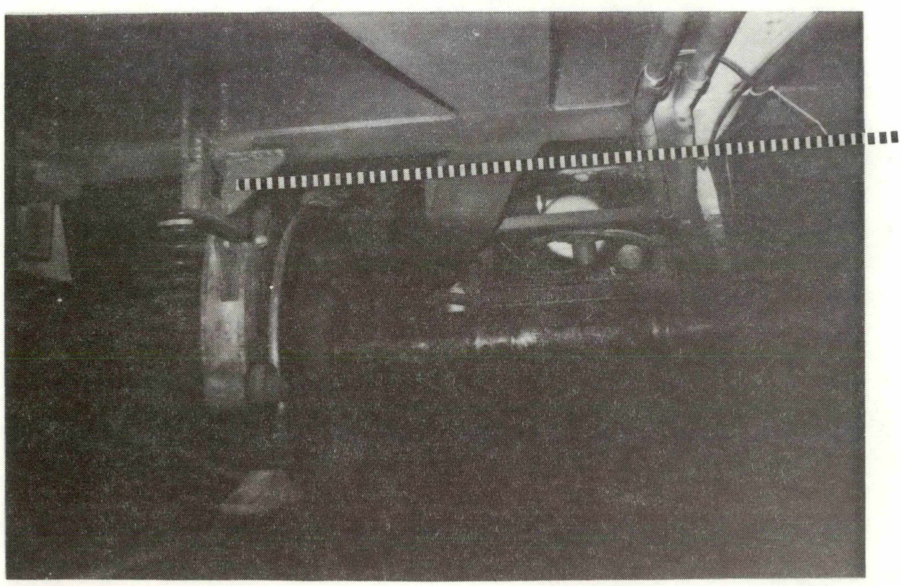


Figure 3-112

Lifting Fulcrum

4.0 Test Sites

4.1 General

The two U. S. track conditions prescribed for the test were:

1). High Speed - Class 6 Track - Continuous Welded Rail on Concrete Ties.

2). Medium Speed - Class 3 Track - Bolted Rail on Wood Ties.

These conditions provide the extreme range of track environment upon which an LEV type vehicle would be expected to operate. The specific test areas selected on the Boston and Maine Railroad are as shown in Figure 4-1.

The Class 6 track for high speed testing is on the Northeast Corridor (NEC), west of Boston between Readville, MA, and the Rhode Island State line. The majority of suspension testing was between Readville or Canton and Attleboro, MA. The initial acceleration and braking tests were conducted near Attleboro and the final acceleration tests were run near Readville.

The more important test site for evaluation of the LEV-1 suspension was north of Boston between Lowell, MA, and Concord, NH. This is the territory where the demonstration vehicle is expected to operate in revenue service.

4.2 North of Boston

A track chart of the B&M's New Hampshire route between Boston, MA and Concord, NH is provided (Figure 4-2). The dual mileposts identify the distance to White River Junction (WRJ) on one side and the distance to Boston (B) on the other side. Since the distance between WRJ and Boston is 143 miles the total of two milepost readings will always equal this value.

The B&M time table pages governing the operation in this territory are reproduced in Figure 4-3.

Generally, the track construction is of bolted rail (Figure 4-4) although there is a short section of welded rail north of Nashua, NH. All of the ties are wood. The roadbed has recently been upgraded in anticipation of the Boston - Concord service which was initiated during the test program.

Between Lowell, MA and Concord, NH there are twenty-one protected grade crossings (Figures 4-5 through 4-7) which provided an opportunity to evaluate the effect of the LEV-1 on the grade crossing track circuits.

77

The type of signal system is shown in the timetable (Figure 4-3). The block limits (Figure 4-8) are listed in Figure 4-9.

Although the entire territory between Lowell, MA and Concord, NH was traversed several times, two specific areas were used for the major part of the suspension system data collection. The first was North of Nashua and between the "Tie Plant" and Merrimack South (milepost B-40.78 to B-46.09). The second was between milepost B-29 and B-33 (initially B-37 was the northern limit).

The territory north of Lowell has wooden ties with staggered bolted joints (Figure 4-10). Frequently, perhaps every one or two rail lengths, several new ties and been installed. Beside the track in some locations, there were piles of old ties indicating recent track work (Figure 4-11).

In many areas the right-of-way parallels the river (Figure 4-12). The route passes through Manchester, NH (Figure 4-13) where several of the protected grade crossings are located. At Hooksett, NH, the tracks cross the river (Figure 4-14) over a bridge on a curve. The automatic signal system ends a short distance south of Concord, NH (Figure 4-15).

4.3 Northeast Corridor

Figure 4-16 is a track chart of the NEC between the Rhode Island state line and Boston's South Station. The track immediately west of Boston has bolted rail and wood ties (Figure 4-17). East of Readville Transfer the recently upgraded track changes to welded rail on concrete ties (Figure 4-18). Speed limits in the area have been gradually increasing. Amtrak Boston Division Bulletin number 1-99 (Figure 4-19) issued during the LEV-1 test program shows the speeds allowed at that time.

The selected test track begins near Canton Junction (Figure 4-20) and runs east to Attleboro (Figure 4-21). Tests were conducted in the normal direction of traffic on Track #2. A typical test run starts at milepost 214 (Figure 4-22) and proceeds east to the station at Canton Junction on the concrete ties. The interlocking west of Canton Jct. (Figure 4-22) has wood ties. A section of bolted rail and wood tie track on a bridge is shown in Figure 4-23.

The braking test site was on the eastbound track starting at milepost 200 (Figure 4-24). This is tangent track beginning on an ascending grade of 0.20 percent and changing to 0.07 descending prior to the overhead bridge at milepost 200.4.

Several general types of track conditions caused noticeable excitation to the suspension system as evidenced by deteriorating ride quality:

78

1. Overhead Bridges of the type shown at a distance in Figure 4-24. (Poor drainage or lack of head room to properly surface the track.)

2. Culverts under the track (Figure 4-25) where the ties changed from concrete to wood and back to concrete.

3. Undergrade bridges (Figure 4-26).

4. Turnouts (Figure 4-27).

5. Opposing insulated joints (Figure 4-28).

6. Interlockings (Figure 4-29).

Figures 4-30 and 4-31 are typical scenes from the NEC.

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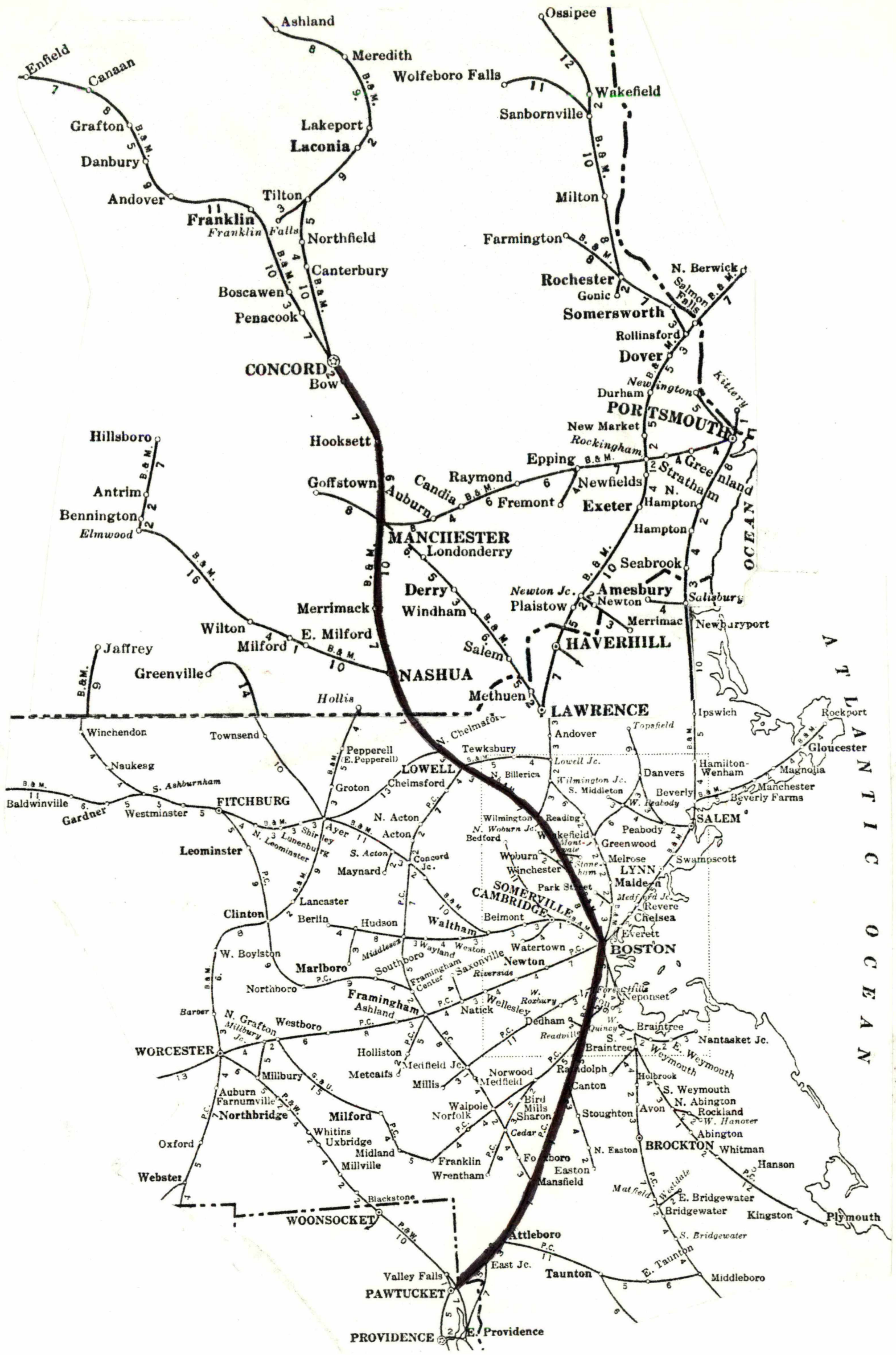


Figure 4-1

Map of Test Areas on the Boston and Main Railroad

EXPLANATION

OF SYMBOLS USED ON TRACK CHARTS.

GENERAL

Track Scales
Turntable
Roundhouse
Engine House
Water Tank
Water Column
Section House
Coaling Station
Passenger Station
Freight "
Pass. and Frt. "
Passenger Shelter
Telegraph Office in Station
" " " Tower
Stgr. Tank. D=Diesel Oil, or G=Gasoline, or D.G. Both.
Road Crossing at Grade
" " under "
" " over "
Private Road Crossing
Farm Crossing
Yard Limit Sign
Section Foreman's Limits — 122 | 123
Motor Car
Alinement — N
Milepost - Actual Location
" Theoretical " Dotted
Longitudinal drains

SIGNALS

AUTOMATIC — INTERLOCKING — DWARFS
SEMAPHORES

AUTOMATIC — APPROACH — INTERLOCKING — DWARFS
COLOR LIGHT

Train Order
Station Signals
Ball Signal
Flag Stop Signal
Grade Signal

BALLAST

Crushed Rock
Washed Gravel
Gravel
Local Gravel & Sand
Sand
Cinders

TRACK OILERS

Meco Automatic Flange Oiler — M
Racor " " "
Ardco " " "
Moore & Steele " " " — MS
Sesmo " " "

RAIL

Regular - Below 100#
" 100# and over
Medium Manganese — MM

TIE PLATES

Partly Tie Plated
Fully "
Plates Lagged to Ties

JOINTS

4 Hole Angle Bars	4 AB
4 Hole Continuous	4C
4 Hole Weber	4W
4 Hole Head Free Toeless	4 HFT
4 Hole Heafie	4H
4 Hole & 6 Hole Toeless	4T 6T

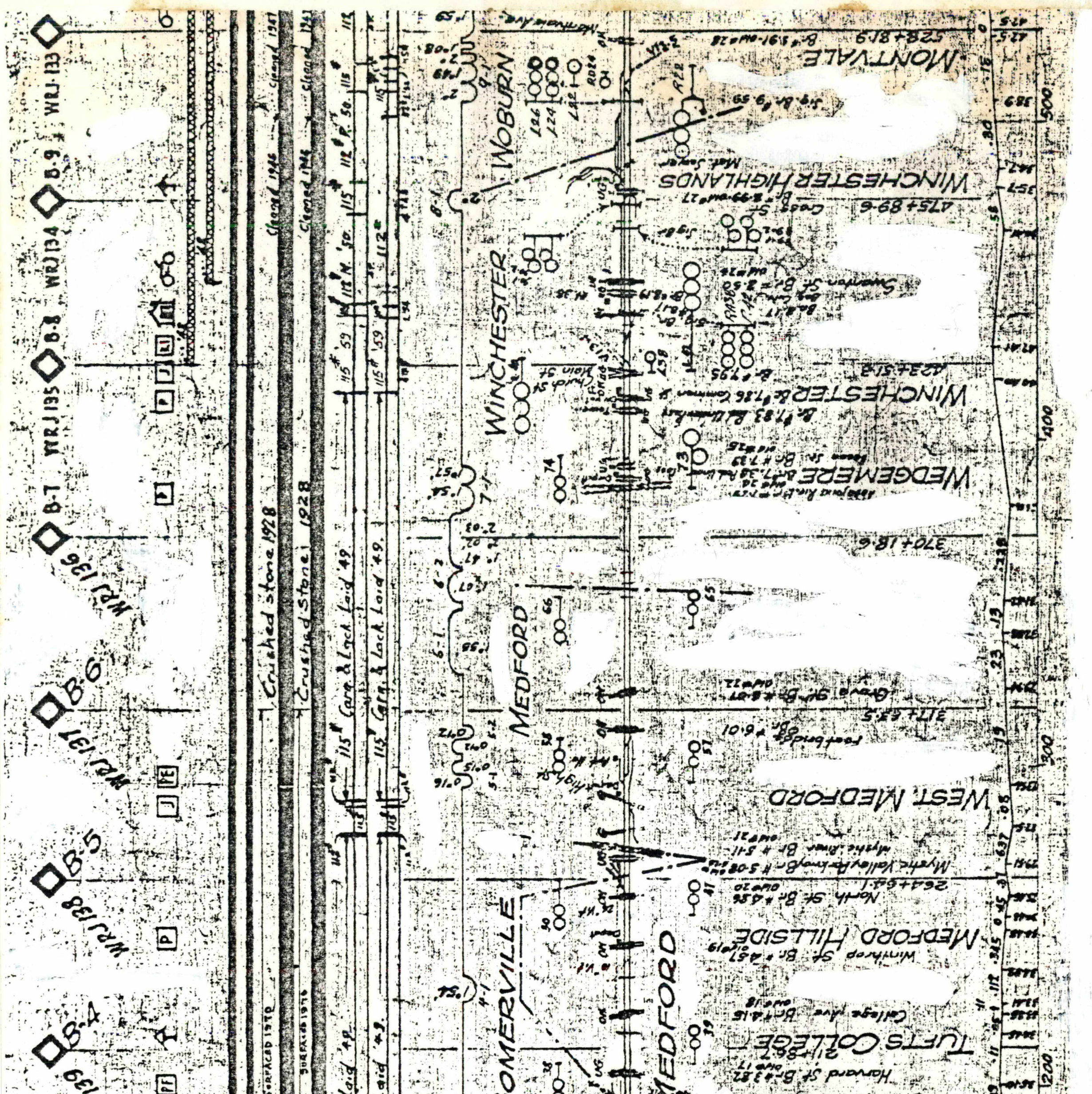
WELDING

Strip — S
Modified — M
Butt — Butt

- SCALES -

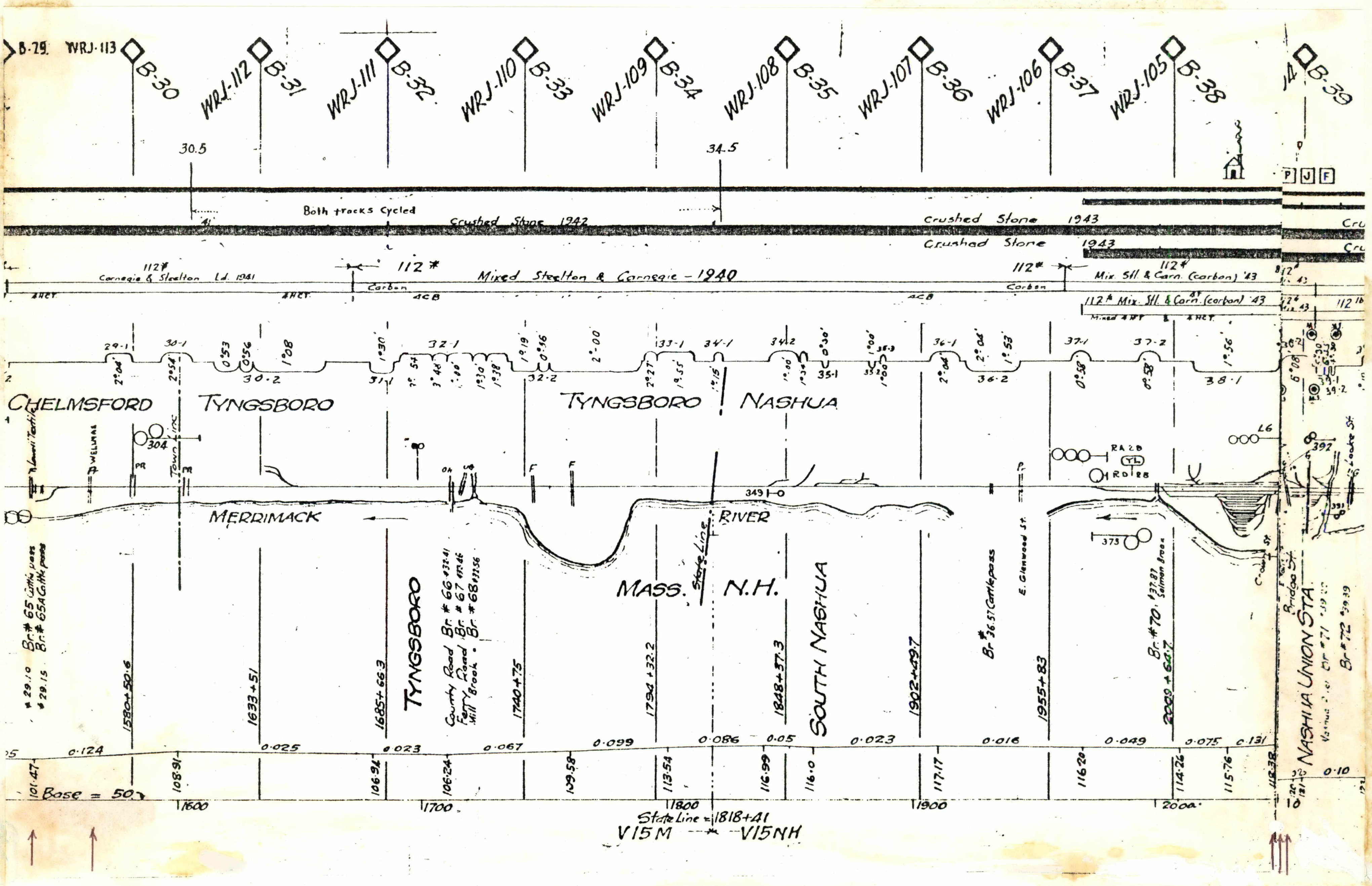
Hor. - 1 inch = 4000 ft. - For Tracks - Profile - Alinement - etc.
Vert. - 1 inch = 120 ft. for Profile only.

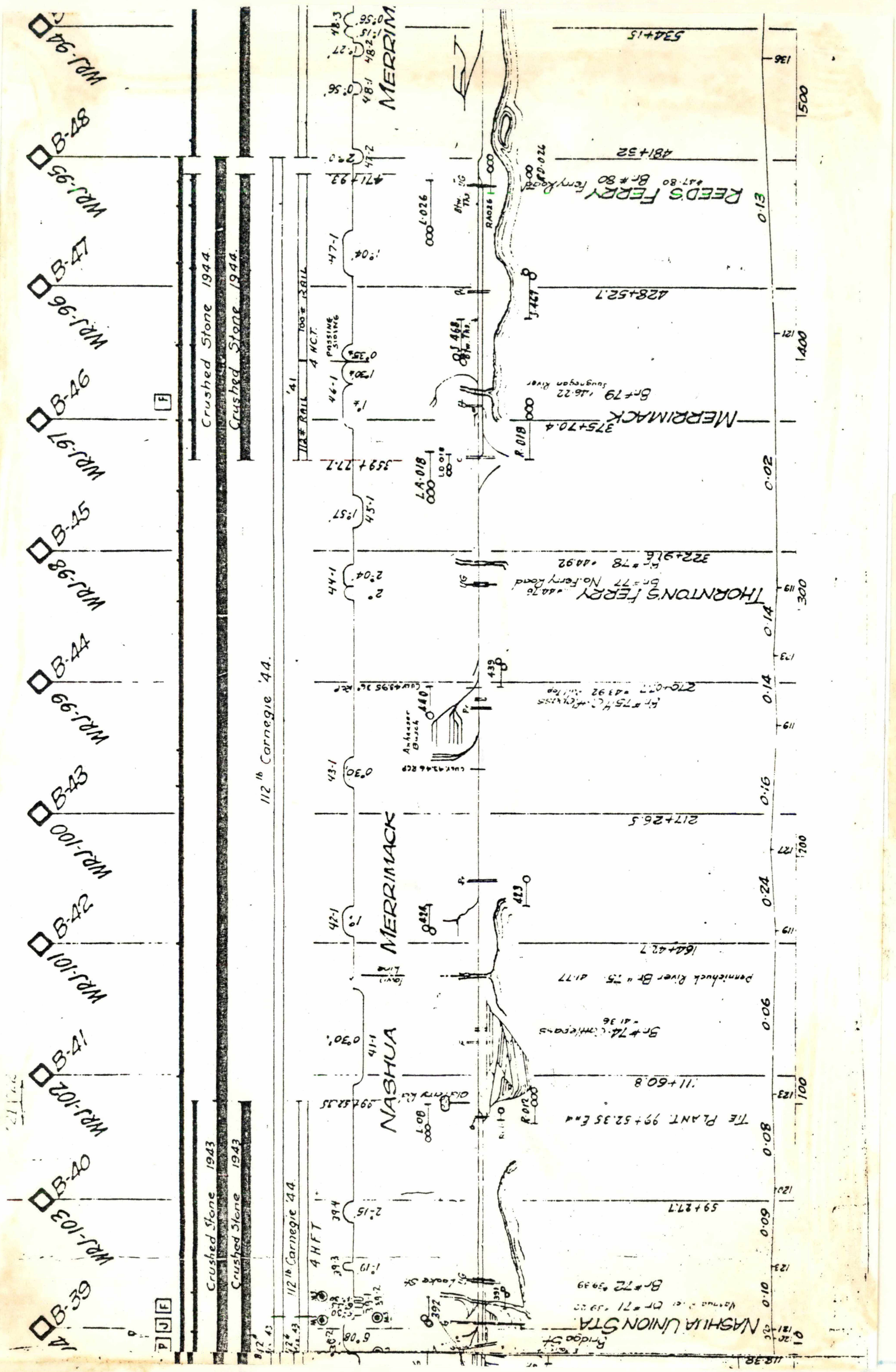
Numbers on Grade Line show the percent of rise or fall.

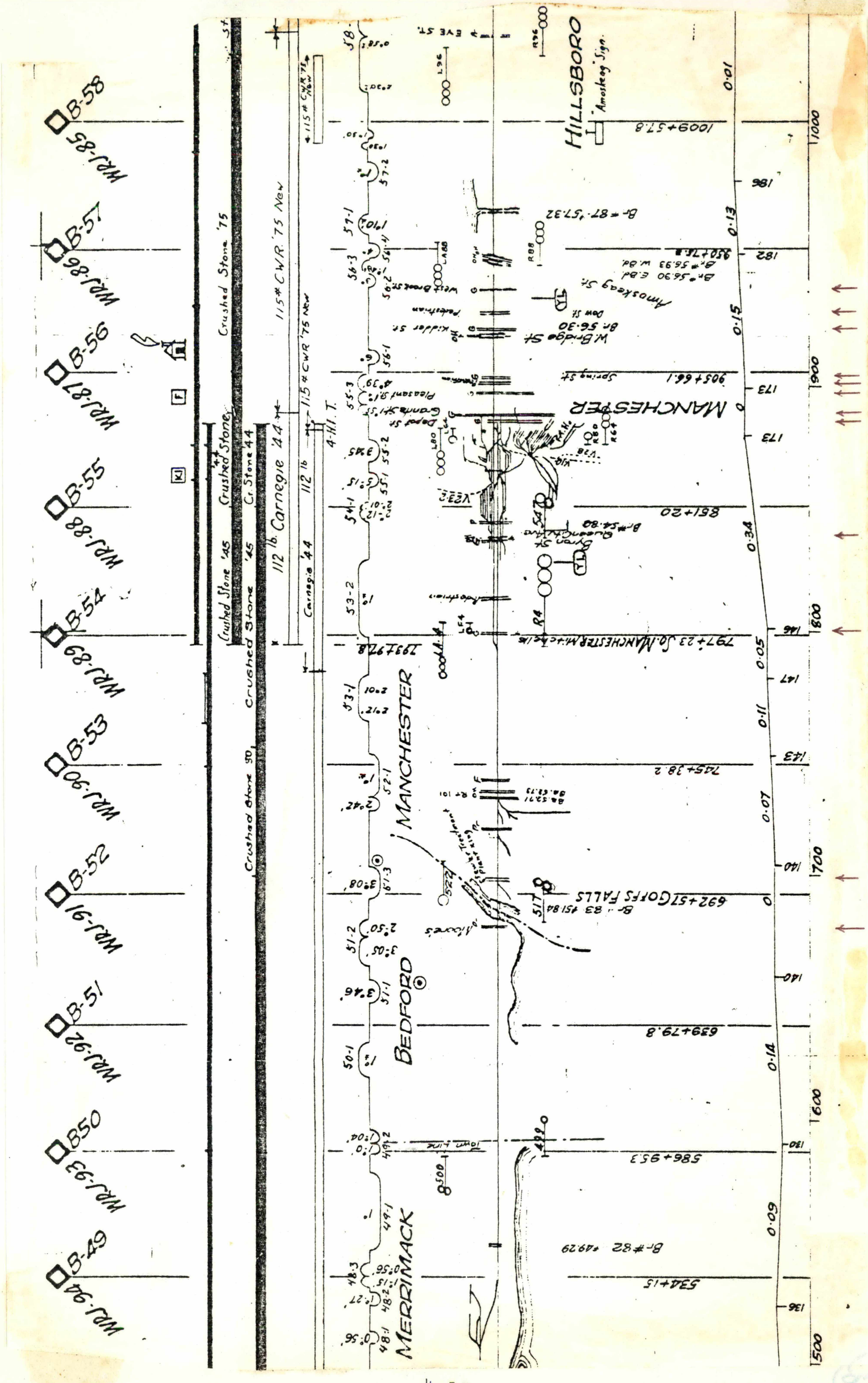

MONTVALE
WINCHESTER HIGHLANDS
WINCHESTER
WEDGEMERE
WEST MEDFORD
MEDFORD HILLSIDE
TUFTS COLLEGE
NO. SOMERVILLE
SOMERVILLE JCT.
WINTER HILL
WOBURN
MEDFORD
SOMERVILLE
Crushed Stone 1928
Crushed Stone 1928

82

4-9

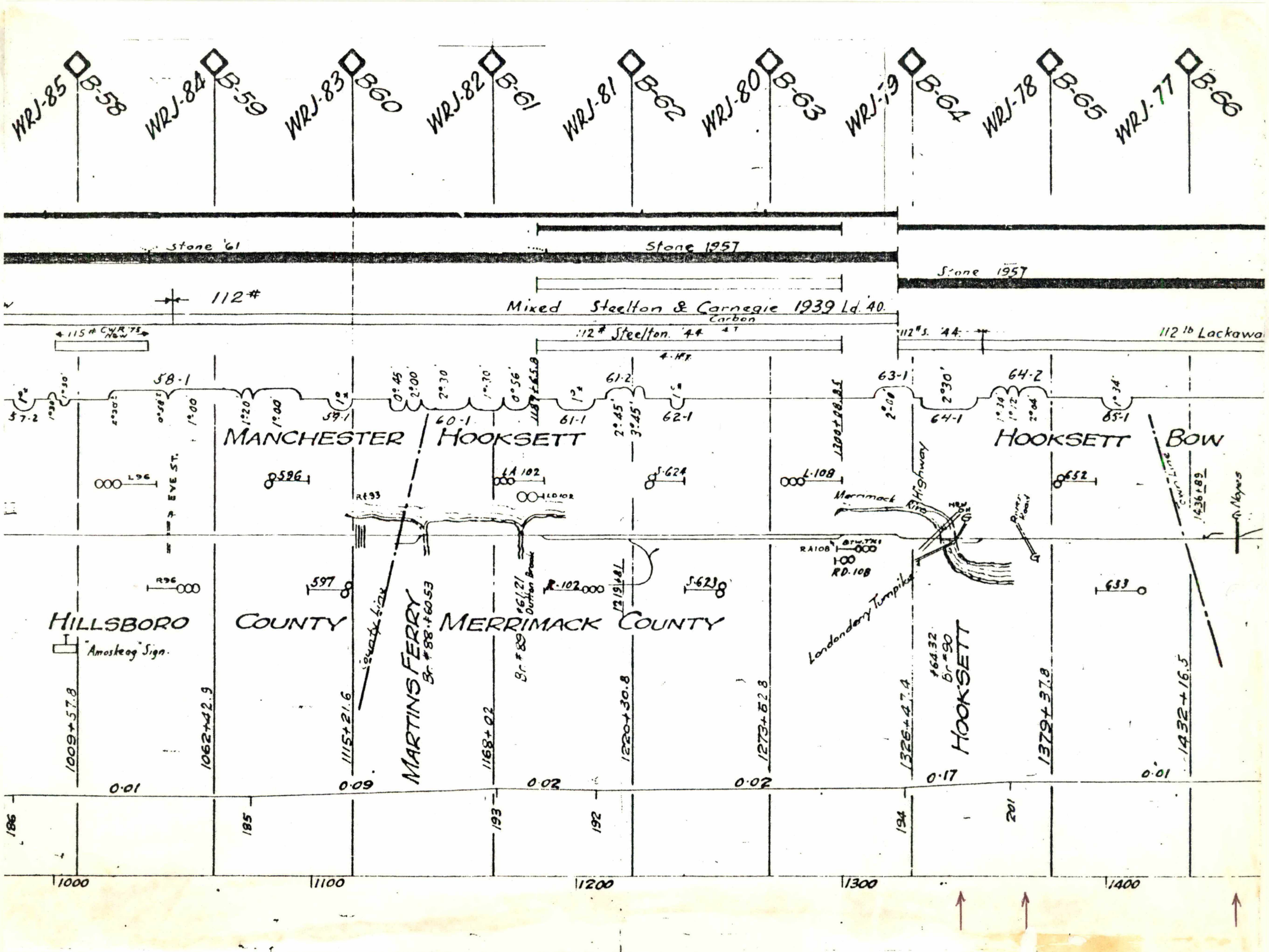

B-29
WRJ-113
B-30
WRJ-112
B-31
WRJ-111
B-32
WRJ-110
B-33
WRJ-109
B-34
WRJ-108
B-35
WRJ-107
B-36
WRJ-106
B-37
WRJ-105
B-38
B-39
30.5
34.5
P J F
Both tracks cycled
Crushed Stone 1942
Crushed Stone 1943
Crushed Stone 1943
112#
Carnegie & Steelton Ld. 1941
112#
Mixed Steelton & Carnegie - 1940
Carbon
ACB
112#
Carbon
112#
Mix. Stl. & Carn. (carbon) '43
112# Mix. Stl. & Carn. (carbon) '43
29-1
30-1
30-2
31-1
32-1
32-2
33-1
34-1
34-2
35-1
36-1
36-2
37-1
37-2
38-1
CHELMSFORD
TYNGSBORO
TYNGSBORO
NASHUA
304
Town Line
PR
349
MERRIMACK
RIVER
State Line
MASS.
N.H.
RA 28
YL
RD 88
373
392
L6
Br.# 65 Cattle pass
Br.# 65A Cattle pass
29.10
29.15
1580+50.6
1633+51
1685+66.3
TYNGSBORO
County Road Br.# 66 #32.41
Ferry Road Br.# 67 #32.46
Mill Brook Br.# 68 #32.56
1740+75
1794+32.2
1848+57.3
SOUTH NASHUA
1902+49.7
Br.# 36.51 Cattlepass
E. Glenwood St.
1955+83
Br.# 70 #37.87 Salmon Brook
2009+64.7
Bridge St.
NASHUA UNION STA.
Br.# 72 #39.39
0.124
0.025
0.023
0.067
0.099
0.086
0.05
0.023
0.016
0.049
0.075
0.131
0.10
101.47
108.91
106.92
106.24
109.58
113.54
116.99
116.0
117.17
116.20
114.26
115.76
118.38
Base = 50
1600
1700
1800
1900
2000
State Line = 1818+41
V15M
V15NH


WRJ-94
B-48
WRJ-95
B-47
WRJ-96
B-46
WRJ-97
B-45
WRJ-98
B-44
WRJ-99
B-43
WRJ-100
B-42
WRJ-101
B-41
WRJ-102
B-40
WRJ-103
B-39
WRJ-104
Crushed Stone 1944
Crushed Stone 1944
Crushed Stone 1943
Crushed Stone 1943
112 lb Carnegie '44
112 lb Carnegie '44
4 HFT
112# RAIL
100# RAIL
PASSING SIDING
MERRIM.
MERRIMACK
MERRIMACK
NASHUA
REED'S FERRY
Br # 80 Ferry Road
MERRIMACK
Br # 79 Souhegan River
THORNTON'S FERRY
Br # 77 No. Ferry Road
Br # 78
Anheuser Busch
Pennichuck River Br # 75
Br # 74
TIE PLANT 99+52.35 End
NASHUA UNION STA.
Br # 72
Bridge St
534+15
481+32
428+52.7
375+70.4
322+91.6
270+07.7
217+26.5
164+42.7
111+60.8
59+27.7

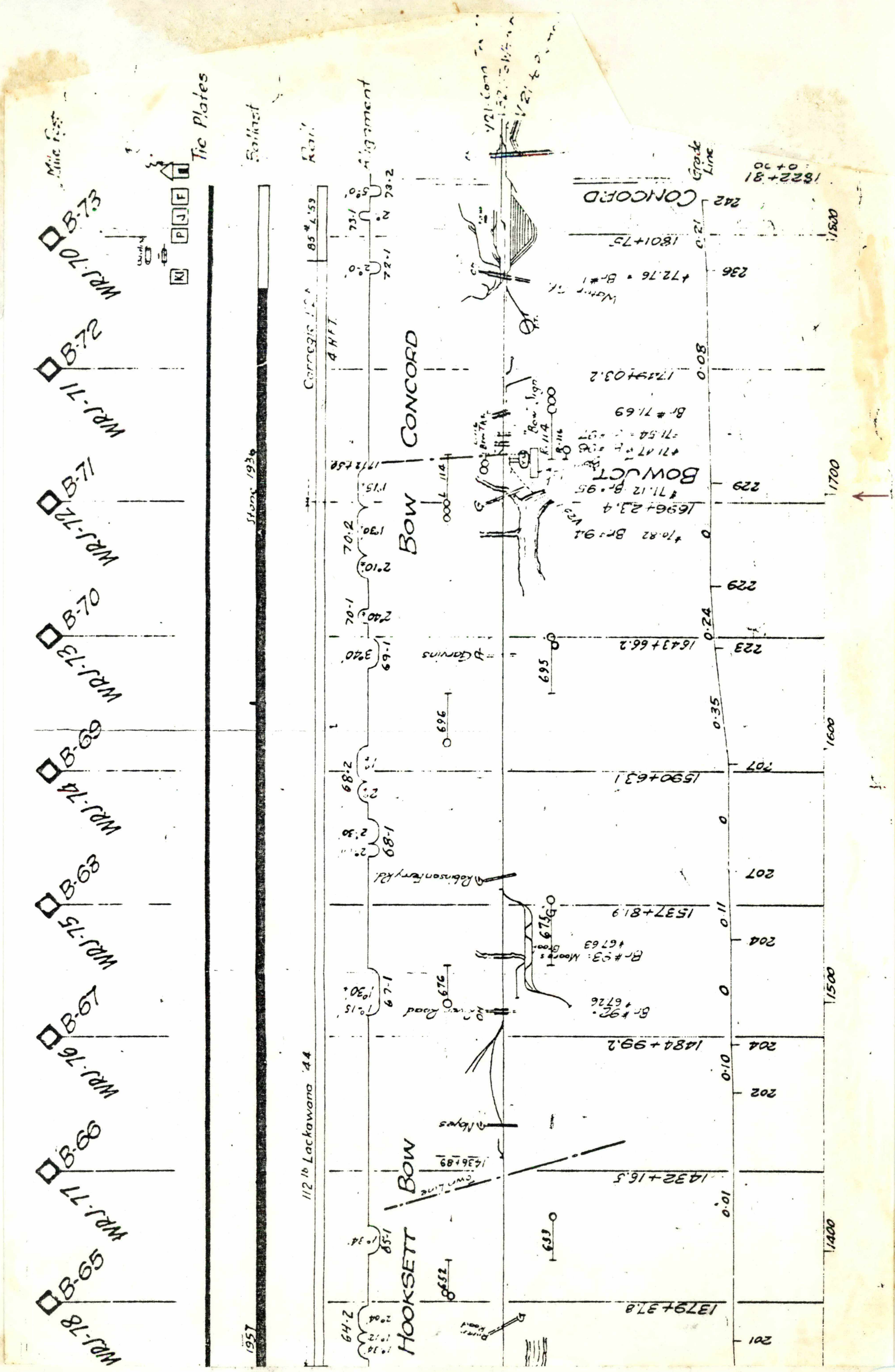


B-58
B-57
B-56
B-55
B-54
B-53
B-52
B-51
B50
B-49
WRJ-85
WRJ-86
WRJ-87
WRJ-88
WRJ-89
WRJ-90
WRJ-91
WRJ-92
WRJ-93
WRJ-94
Crushed Stone '75
115# CWR '75 New
Crushed Stone '45
112 lb. Carnegie '44
Crushed Stone '90
HILLSBORO
"Amoskeag" Sign.
1009+57.8
950+78.8
905+66.1
MANCHESTER
861+20
797+23 So. MANCHESTER
745+38.2
692+57 GOFFS FALLS
639+79.8
586+95.3
534+15
MANCHESTER
BEDFORD
MERRIMACK
Amoskeag St.
W. Bridge St.
Spring St.

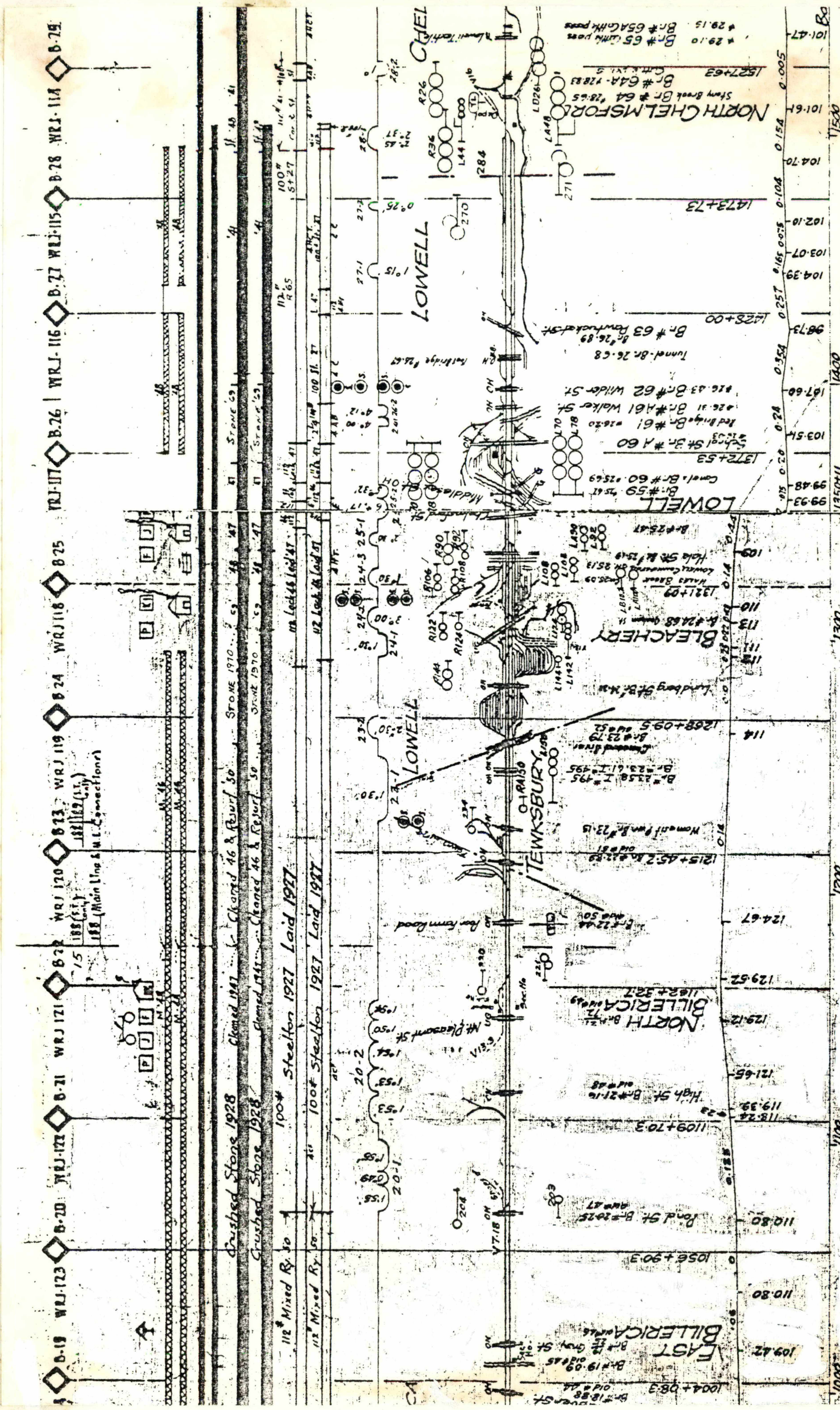
4-12

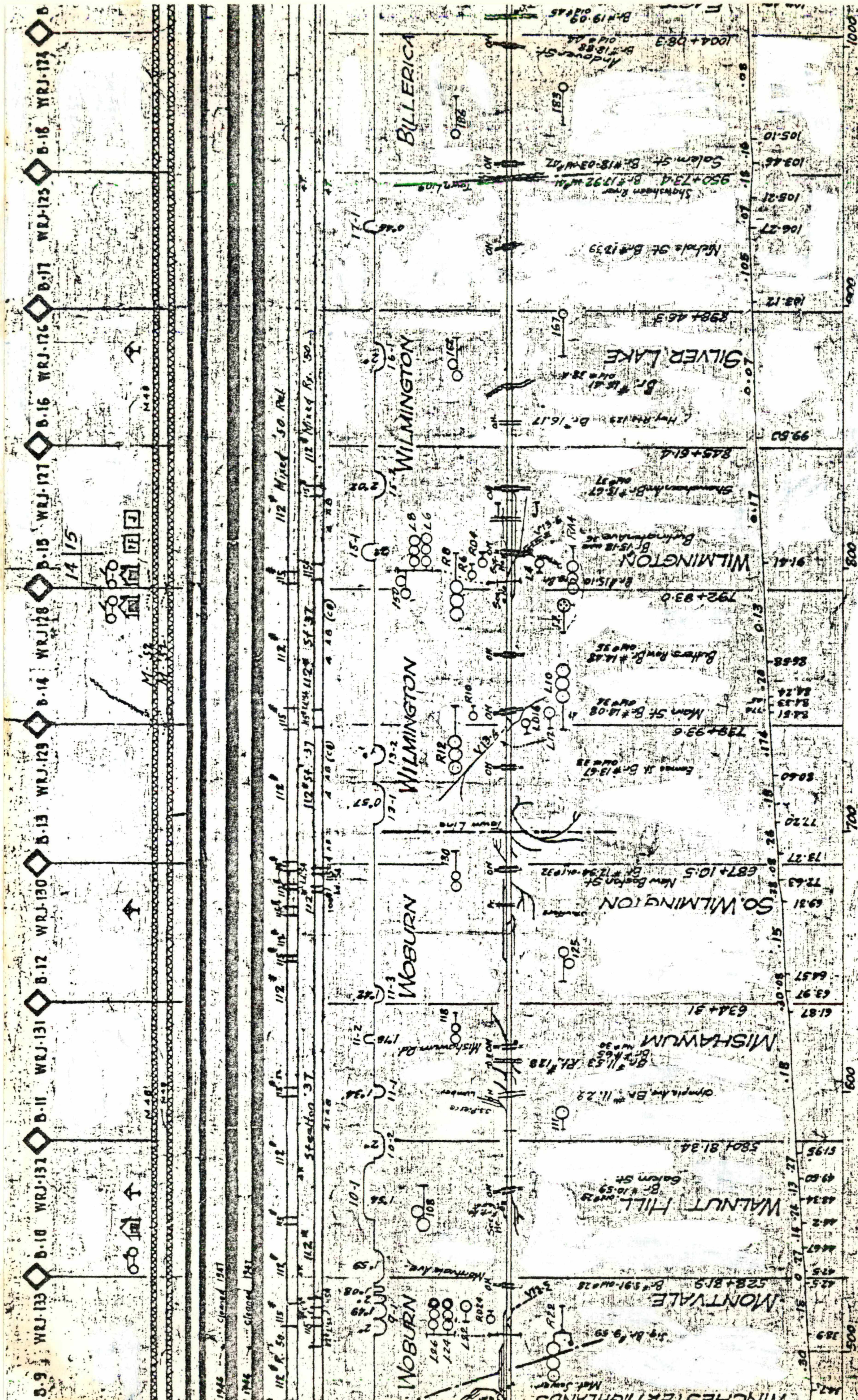

WRJ-85 B-58
WRJ-84 B-59
WRJ-83 B60
WRJ-82 B-61
WRJ-81 B-62
WRJ-80 B-63
WRJ-79 B-64
WRJ-78 B-65
WRJ-77 B-66
Stone '61
Stone 1957
Stone 1957
112#
Mixed Steelton & Carnegie 1939 Ld. 40.
Carbon
115# CWR '75 New
112# Steelton '44
112# S. '44
112 lb Lackawa
58-1
60-1
61-1
61-2
62-1
63-1
64-1
64-2
65-1
MANCHESTER
HOOKSETT
HOOKSETT
BOW
EVE ST.
L96
S96
LA 102
S-624
L-108
652
Merrimack River
Highway
R96
597
R-102
S-623
633
RA108
RD-108
HILLSBORO COUNTY
MERRIMACK COUNTY
County Line
Town Line
"Amoskeag" Sign.
Rt 93
MARTINS FERRY
Br. #88 +60.53
Br. #89
Dutton Brook
Londonderry Turnpike
HOOKSETT
Br. #90
Noyes
1009+57.8
1062+42.9
1115+21.6
1168+02
1220+30.8
1273+52.8
1326+47.4
1379+37.8
1432+16.5
0.01
0.09
0.02
0.02
0.17
0.01
186
185
193
192
194
201
1000
1100
1200
1300
1400

87


Mile Post
Tie Plates
Ballast
Rail
Alignment
Grade Line
WRJ-70 B-73
WRJ-71 B-72
WRJ-72 B-71
WRJ-73 B-70
WRJ-74 B-69
WRJ-75 B-68
WRJ-76 B-67
WRJ-77 B-66
WRJ-78 B-65
Stone 1936
1957
112 lb Lackawana '44
4 HFT
HOOKSETT
BOW
CONCORD
BOW JCT
CONCORD
1379+37.8
1432+16.5
1484+99.2
1537+81.9
1590+63.1
1643+66.2
1696+23.4
1801+75
1822+31
Robinson Ferry Rd
Garvins
1500
1600
1700
1800

84


EAST BILLERICA
NORTH BILLERICA
TEWKSBURY
LOWELL
BLEACHERY
NORTH CHELMSFORD
Crushed Stone 1928
100# Steelton 1927 Laid 1927
112# Mixed Ry. 50
Cleaned 46 & Resurf. 50
Stone 1970
B.19
WRJ.123
B.20
WRJ.122
B.21
WRJ 121
B.22
WRJ 120
B.23
WRJ 119
B.24
WRJ 118
B.25
WRJ-117
B.26
WRJ-116
B.27
WRJ-115
B.28
WRJ-114
B.29


BILLERICA
WILMINGTON
SILVER LAKE
WOBURN
SO. WILMINGTON
MISHAWUM
WALNUT HILL
MONTVALE
WINCHESTER HIGHLANDS

90

NEW HAMPSHIRE ROUTE MAIN LINE

SPECIAL INSTRUCTIONS

14. ENGINE WHISTLE SIGNALS

Engine whistle signals are modified as follows:
X-indicates rule modification

Location	Crossing	Direction	OMIT 14 (l)	OMIT 14 (m)	Sount 14 (m)	Notes
Boston – South Wilmington	All	Both	X	X		1
South Wilmington	Private Crossing at New Boston St.	Both			X	
So. Wilmington – N.H. Stateline	All		X			1
Nashua – Old Worcester Line	Seventh St. to Crown St., Incl.	Both	X			1
Westboro	Twin State Sand and Gravel	Both			X	2
White River Jct.	Nutt St. – on lead	Both	X			1

NOTE 1. Except in cases of emergency.
NOTE 2. Whistling required only between 0700 hours and 1700 hours.

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NEW HAMPSHIRE ROUTE MAIN LINE CONT.

33. PUBLIC CROSSINGS

Protection will be provided as follows:

X-indicates method of operation

G – Gates must be lowered.

S – All moves over crossing must be stopped within 50 feet of crossing and a member of crew protect.

A – Approach crossing prepared to stop unless signals are seen to be in operation.

SP – Where stop posts are located, trains or engines intending to pass over the crossing must come to a full stop and then consume 20 seconds from stop post to crossing after crossing protection has started to operate.

CC – Trains or engines intending to pass over crossing must stop within 50 feet of crossing and consume 20 seconds after protection has begun to operate before passing over crossing.

CO – Circuitry has been installed to automatically interrupt crossing protection when trains or engines are using switches within the operating distances (XC Posts) of the crossing. Trains and engines must approach crossing protection prepared to stop unless protection is seen to be operating.

Location	Track	Crossing	G	S	A	SP	CC	CO	Notes
W. Medford	All	High St.							6
Winchester Highlands	Industrial Park	Holton Street		X					
South Wilmington	Usen Canning	New Boston Street		X					1
South Wilmington	Industrial Park	Woburn Street				X			
Wilmington	Siding	Sweetheart Plastics					X		
No. Woburn Junction	former Woburn Loop	Eames Street				X			
Billerica Shop	All	Main Crossing		X					
North Chelmsford	Main	Wotton Road (Private)							2
Nashua	All	Bridge Street							3
Manchester	Northward and Southward passing tracks	Byron Street				X			
Concord	former Stonehill Branch	New England Box. Co. (Priv. Crossing)		X					4
Concord	former Stonehill Branch	Prison Crossing		X					5
Concord to White River Junction	Main	All			X				

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NEW HAMPSHIRE ROUTE MAIN LINE CONT.

33. PUBLIC CROSSINGS CONT.

NOTE 1. 4 M.P.H. over New Boston St. Crossing.

NOTE 2. Rule 33 of General Special Instructions applies. Southward freight trains stopped at home signal will stop north and clear of this crossing. Northward trains performing work at Southwells will leave train south of and clear of this crossing.

NOTE 3. Between 0700 hours and 0830 hours daily, except Sundays, all train and engine movements must approach this crossing prepared to stop clear.

NOTE 4. Rule 33 of General Special Instructions applies.

NOTE 5. A member of crew must operate the manually-controlled highway crossing signals.

NOTE 6. Southward trains making station stop and consuming in excess of two (2) minutes will automatically release crossing protection. When departing station, after crossing protection has been released, train will stop short of crossing and not proceed until gates are down.

Northward trains making station stop must clear crossing a sufficient distance (approximately fifty (50) feet) with rear car, and ascertain that gates have begun to raise before stopping.

Crossing-tender will be on duty at High Street between 0700 hours and 2300 hours, daily.

83. TRAIN REGISTER

White River Jct. Yard – Maintained by operator during on duty time. All trains must register during period operator not on duty. No operator on duty between 0700 hours and 1500 hours Saturday and Sunday.

93. YARD LIMITS

Located as follows:

Location	Between	and	Notes
Boston	Boston	MP 6.1	
Montvale	Montvale	North Woburn Jct.	
Wilmington	Wilmington	MP 16	
No. Billerica	MP 20	MP 22.4	
Lowell	MP 22.4	Bleachery	
Nashua	MP 37.6	Tie Plant	
Manchester	MP 54.6	Manchester Interlocking	
Concord	Beginning of Main Track	Boscawen	
Lebanon	MP 137	Westboro – End of Main Track	

99. EXCEPTION TO GENERAL SPECIAL INSTRUCTION RULE 99

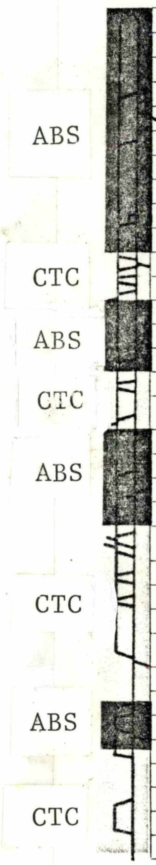
Light engines moving with current of traffic between Tower A Interlocking and Winter Hill Interlocking are relieved from complying with rule 99.

104. SWITCHES

Billerica Shop – The so-called "Bootleg" track in back of the shop is designated as a running track and all switches leading from this track must be properly lined and locked.

White River Jct. – Normal position of crossover at North end of Connecticut River Bridge is when set for movements from former main track to the South Wye.

Figure 4-3 (page 2 of 4)

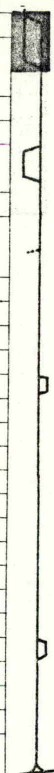


INTERLOCKING	INTERLOCKING AND TRAIN ORDER OFFICE	RADIO CHANNEL	NEW HAMPSHIRE ROUTE MAIN LINE BOSTON TO WHITE RIVER JCT. STATIONS	DISTANCE FROM BOSTON	APPROXIMATE CAR CAPACITY OF SIDING	NOTE
			Boston	.00		
X	X	C	Tower A	0.30		1
			Mystic Junction	1.85		
X			Winter Hill R – Tower X	2.42		
			Somerville Junction (Freight Cut-Off)	2.81		
			North Somerville	3.56		
			Tufts College	4.01		
			Medford Hillside	4.58		
			West Medford	5.48		
			Wedgemere	7.34		
X	X	C.2	Winchester (Woburn Branch)	7.82		
X			Montvale R – Winchester (Stoneham Branch)	9.76		
			Walnut Hill	10.48		
			Mishawum	11.65		
			South Wilmington	12.74		
X			North Woburn Junction R – Winchester	13.97		
X			Wilmington R – Winchester (Wilmington Jct. Branch)	15.20		
			Silver Lake	16.60		
			Billerica Shop	20.25		
			North Billerica (Billerica Branch)	21.79		
X			South Lowell	23.32		
X	X		Bleachery R – Lowell Tower (Lowell Branch)	24.66		
X			Lowell 2 R – Lowell Tower	25.36		
X			Western Ave. R – Lowell Tower	25.90		
			Middlesex	27.28		
X			North Chelmsford R – Lowell Tower (Stony Brook Branch)	28.55		
			Tyngsboro	32.11		
X			Nashua South R – Lowell Tower	37.43		
U			Nashua (Hillboro Branch)	38.96		
X			Tie Plant R – Billerica	40.78		
			Thornton's Ferry	44.73		
X			Merrimack South R – Billerica	46.09	180	
X			Reed's Ferry R – Billerica	47.78		
			Goffs Falls	52.03		

CONTINUED

NEW HAMPSHIRE ROUTE MAIN LINE CONT.

INTERLOCKING	INTERLOCKING AND TRAIN ORDER OFFICE	RADIO CHANNEL	STATIONS	DISTANCE FROM BOSTON	APPROXIMATE CAR CAPACITY OF SIDING	NOTE
X			South Manchester R – Billerica	53.93		
X			Manchester (Goffstown Branch) (Portsmouth Branch) (M & L Branch) R – Billerica	55.68		
X			Amoskeag South R – Billerica	56.90		
X			Amoskeag North R – Billerica	58.90		
X			Martins North R – Billerica	61.45	185	
X			Hooksett South R – Billerica	63.58		
X			Bow R – Billerica	71.30		
			End of Main Track } OTHER THAN MAIN TRACK	71.30		
			Concord (GOODWIN RR)	73.36		
			Begin Main Track	73.70		
			Penacook	79.91		
			Boscawen	82.65		
			Gerrish	86.57		
			Franklin	91.99		
			Halcyon	98.20	87	
			Andover	102.54		
			Potter Place	104.32		
			Gale	105.51		
			Converse	108.24		
			Danbury	111.67		
			Grafton	116.85		
			Cardigan	118.65		
			Canaan	124.87		
			Pattee	129.24		
			Enfield	131.66		
			Macoma	134.25	75	
			Lebanon	138.30		
			Westboro	142.55		
			End of Main Track	142.70		
	P		*White River Jct.* (C.V. Ry) (Conn River Route Main Line) (Berlin Route Mainline)	142.92		2



The direction Boston to White River Junction is Northward (outward)

NOTE 1. Draw 1 – is protected by semi-automatic color light dwarf interlocking signals and by power operated gates controlled from Tower "A."

A warning whistle will sound a single long blast just prior to opening drawbridge.

ABS Absolute Block Signal
CTC Centralized Traffic Control

Figure 4-3 (page 1 of 4)

NEW HAMPSHIRE ROUTE MAIN LINE CONT.

104G. SPRING SWITCHES

Location	Switch Connects	Normal Position	Notes
Nashua South	End of Double Track	Single Track to Northward Track	1
Tie Plant	End of Double Track	Single Track to Southward Track	1
South Manchester	End of Double Track	Single Track to Northward Track	1
Concord (north of station)	Yard and former Main Track	former Main Track	
	former White Mt. Branch and former Main Track	former Main Track	
White River Jct.	South Wye and Berlin Route M.L.	Berlin Route M.L.	

NOTE 1. Within Interlocking limits.

107. PROTECTION OF PASSENGERS (See General Special Instructions Rule 107).

Outward trains entering main track at junction points outside Boston will be notified by Train Dispatcher. Train Director or Operator in charge.

107. STATION SIGNALS

Wilmington (Northward Only)

109. BULLETIN BOARDS

Boston –	North Station Engine Terminal Mystic Jct. Yard Office Yard 21 Office
Lowell –	Passenger Station Yard Office
Nashua –	Yard Office
Manchester –	Yard Office
Concord –	Yard Office
White River Jct. –	Yard Office Passenger Station C.V. Yard Office

NEW HAMPSHIRE ROUTE MAIN LINE CONT.

110. Speed Restrictions

New Hampshire Route Main Line

Between	Tracks (Includes All Main Tracks Unless Otherwise Specified)	M.P.H. Pass.	Frt.
Maximum – Boston and Lowell		**50**	**40**
North Station and Draw No. 1		10	10
Draw No. 1 and Former Hoosac Tunnel Diamond		15	15
Drafts backing into North Station between end of platform and bunter		8	8
Former Hoosac Tunnel Diamond and Winter Hill		35	35
Medford Hillside and College Ave. Bridge (#4.15)		25	25
MP 4.7 and College Ave. Bridge (#4.15)	Southward	20	20
West Medford, Over High Street Crossing			30
West Medord, Between Station and Mystic Valley Parkway Bridge (5.08)			25
Montvale, Between Montvale Ave. Bridge (9.91) and a Point One-Quarter Mile North of This Bridge		40	
So. Wilmington, Crossing New Boston St. on Usen Sidetrack			4
Wilmington, Between South end of Curve at Station and North End of Curve at First Overhead Bridge (15.67) North of Station		40	

NEW HAMPSHIRE ROUTE MAIN LINE CONT.

110. SPEED RESTRICTIONS CONT.

Between	Pass.	Frt.
Maximum – Lowell and Bow	**40**	**40**
Lowell, Between South End of Station Platform and Western Ave.	30	30
Middlesex, at Signal Bridge Just North of Wilder St. Bridge	15	15
North Chelmsford, North Wye	15	15
South Nashua, Between MP B-34 and MP B-36	30	30
Nashua South, Through Spring Switch	30	30
Nashua, Between Crown St. crossing and Nashua River Bridge (39.22)	30	25
Merrimack Passing Track	25	25
Merrimack, Pole Plant Crossing	25	25
Goffs Fall, Between MP B-52 and MP B-54	20	20
Manchester, Between Interlocking and Amoskeag North Interlocking	25	25
Hooksett, Passing Track	15	15
Bow, Between Interlocking and Merrimack Farmers Exchange Crossing – **Southward** Trains Only	25	25
Maximum – Concord and Westboro	**25**	**25**
Canaan, Ledges (Cannan Summit) 2 Miles South of Canaan	10	10
Mascoma, Ledge 1¼ Mile south of Mascoma	0	10
Between Bank St. and Jones Crossing	20	20
Westboro, Over Crossing Serving Twin State Sand and Gravel Between 0500 and 1600 Hours **Northward** Trains Only	15	15
Westboro, Overhead Bridge No. 142.45 and W.R. Jct.	10	10
White River Jct., all Wye Tracks	10	10
White River Jct., Over Nutt St. Crossing on Yard Track	5	5
White River Jct. Yard	10	10

Figure 4-3 (page 3 of 4)

D-151. DESIGNATION AND USE OF TWO OR MORE MAIN TRACKS

Two Tracks

Between	and
Boston	North Chelmsford
Nashua South	Tie Plant
South Manchester	Manchester

211. CLEARANCE

Concord, N.H. – Southward trains will not leave Concord, N.H. until permission has been obtained from Train Dispatcher.

White River Jct. – No train or engine will leave without Clearance Form A, except trains operating between White River Jct. and Concord, N.H.

221. TRAIN ORDER SIGNALS

Lowell – Governs mainline trains only.

LOCATIONS WHERE BLOCK SIGNAL, AUTOMATIC BLOCK SIGNAL, CENTRALIZED TRAFFIC CONTROL, OR CAB INDICATOR RULES ARE IN EFFECT:

X-INDICATES RULES IN EFFECT

Column 1 – (251) Rules for movement of trains in the same direction by Block Signals, rules 251-254, inclusive.

Column 2 – (ABS) Automatic Block Signal System, rules 501-522, inclusive.

Column 3 – (CTC-Directional Track) Centralized Traffic Control System, rules 265-278, inclusive.

Column 4 – (CTC-Neutral Track) Centralized Traffic Control System, rules 265-278, inclusive.

Column 5 – (Cab Indicator) Automatic Cab Indicator, rules 400-412, inclusive.

Between	and	Track	1	2	3	4	5	
See column description code			251-254	ABS	CTC Directional Track	CTC Neutral Track	Cab Indicator	Notes
Boston	Winchester	Northward & Southward	X	X				
Winchester	Montvale	Northward & Southward		X		X		
Montvale	North Woburn Junction	Northward & Southward	X	X				
North Woburn Junction	Wilmington	Northward		X	X			1
North Woburn Junction	Wilmington	Southward		X		X		
Wilmington	Bleachery	Northward & Southward	X	X				
Bleachery	North Chelmsford	Northward & Southward		X		X		
North Chelmsford	Nashua South	Single		X		X		
Nashua South	Tie Plant	Northward & Southward		X				
Tie Plant	South Manchester	Single		X		X		
South Manchester	Manchester	Northward & Southward		X				
Manchester	Bow	Single		X		X		

NOTE 1. Directional tracks may be used in reverse direction as provided by rules 266 and 271 (a) and at restricted speed when authorized by the operator.

NEW HAMPSHIRE ROUTE MAIN LINE CONT.

272C. SIDINGS NOT TO BE USED TO CLEAR MAIN TRACK

Location	Track
No. Chelmsford	Southwell's Courrier Citizen Family Products
South Nashua	Continental Homes former Ferroflex siding
Merrimack	Nashua Corp. Budweiser (south gate) Star Industries House (Jones Chemical) Hume Pipe (sand track)
Goffs Falls	Foster Beef
Bow	Merrimack Farmers Warehouse

665. UNATTENDED INTERLOCKINGS – ELECTRIC SWITCH LOCKS

Instructions for operation of electric switch locks or hand operated switches at the following locations are shown on inside of door to electric lock:

Nashua

(WARNING): When it is found necessary to operate push button releases to unlock switches, care must be used to be reasonably certain that no approaching train is close since operation of push button will set any clear signal to stop and may there by give an approaching train a stop home signal after it passed a clear approach.

FREIGHT TRAIN OPERATION

West Medford, Mass.

Container Corp. has flashing safety lights on their platform.

Indications:

Red: Tracks are being worked by railroad crews.

Green: Tracks are **not** being worked by railroad crew. OK to load cars.

Conductors on trains switching this plant will notify shipping office before work is started and when it is completed, so they can change indications on flashing safety lights.

North Chelmsford

Southwell Co. Siding – Plate "C" cars will not clear awning on bunter end of this track. Any such cars to be placed on this track must be second rear or set on platform just to clear crossing.

Bow, N.H.

Crews setting off cars at Public Service Co., of New Hampshire must not leave cars to block crossing located about 125 feet south of derail. Engines are not permitted to operate through the dumping shed at his location.

Merrimack, N.H.

Engines larger than GP-7 or GP-9 either single or coupled with another GP-7, GP-9, must not be operated on McElwain's track. Engines switching this track must not exceed five (5) miles per hour rounding curve.

Trains Performing work on Merrimack Sand and Gravel Corp. track with more than one unit of power, of any type, must use stretcher cars account curvature.

South Nashua

Trains with more than one unit of power switching the track serving the Hampshire Chemical Company must use stretcher cars account curvature.

LOCOMOTIVE RESTRICTIONS AND MAXIMUM CAR WEIGHTS

Territory	Maximum Weight in Car and Lading	Locomotive Restrictions (Single or in Multiple)
Boston – White River Jct.	263,000	None
Concord, N.H. – Stonehill	263,000	None

Figure 4-3 (page 4 of 4)

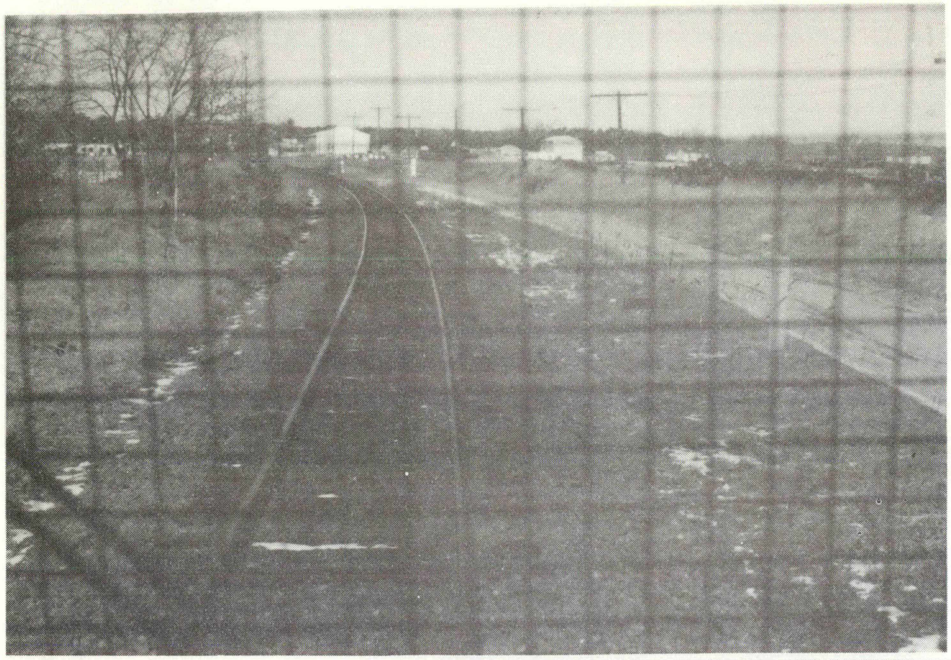


Figure 4-4

Class 3 Track on B&M North of Lowell, MA

Figure 4-5

LEV-1 on Protected Grade Crossing with Flashers & Guard Arms

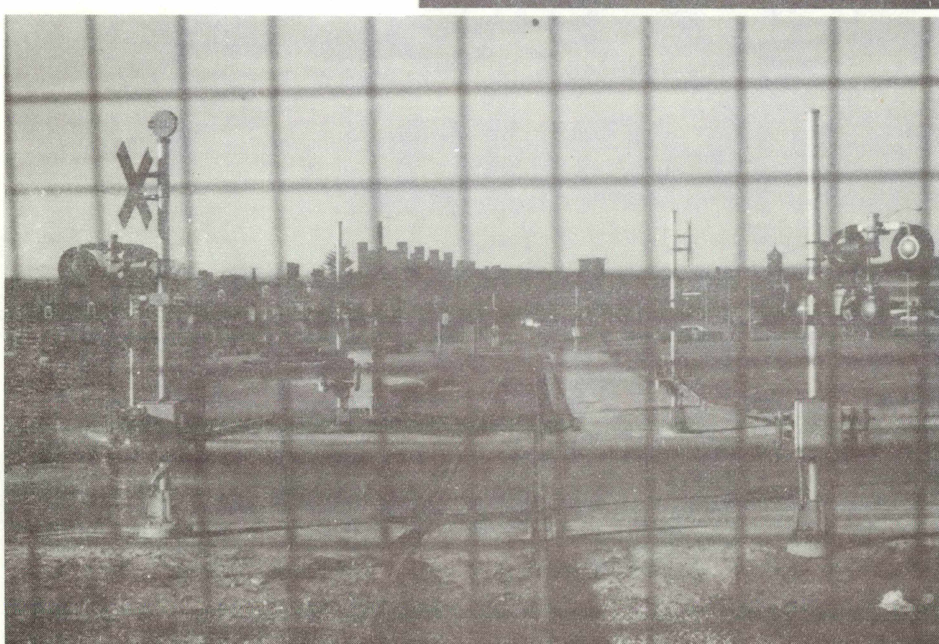


Figure 4-6

Grade Crossings in Manchester, NH

PROTECTED GRADE CROSSINGS BETWEEN LOWELL, MA AND CONCORD, NH

Community		Crossing Identity		Protection
N. Chelmsford	-	Wotton Land	-	Flasher and Guard Arms
N. Chelmsford	-	Wellman Park	-	Flashers
Nashua	-	Crown Street	-	Flashers and Guard Arms
Nashua	-	Hollis Street	-	Flashers and Guard Arms
Nashua	-	Bridge Street	-	Flashers and Guard Arms
		Moores Crossing	-	Flashers and Guard Arms
		Pine Island Crossing (Sewerage Plant)	-	Flashers and Guard Arms
		Dunbar Street (Winston Road)	-	Flashers and Guard Arms
		Byron Street	-	Flashers and Guard Arms
Manchester	-	Depot Street	-	Flashers and Guard Arms
Manchester	-	Granite Street	-	Flashers and Guard Arms
Manchester	-	Pleasant Street	-	Flashers and Guard Arms
Manchester	-	Pedestrian Crossing #1	-	Flashers
Manchester	-	Spring Street	-	Flashers and Guard Arms
Manchester	-	Kidder Street	-	Flashers and Guard Arms
Manchester	-	Pedestrian Crossing #2	-	Flashers
Manchester	-	West Brook Street	-	Flashers and Guard Arms
Hooksett	-	Old Londonderry Turnpike	-	Flashers and Guard Arms
Hooksett	-	River Road	-	Flashers
		Noyes Road	-	Flashers
Bow	-	Old River Road	-	Flashers and Guard Arms

FIGURE 4-7

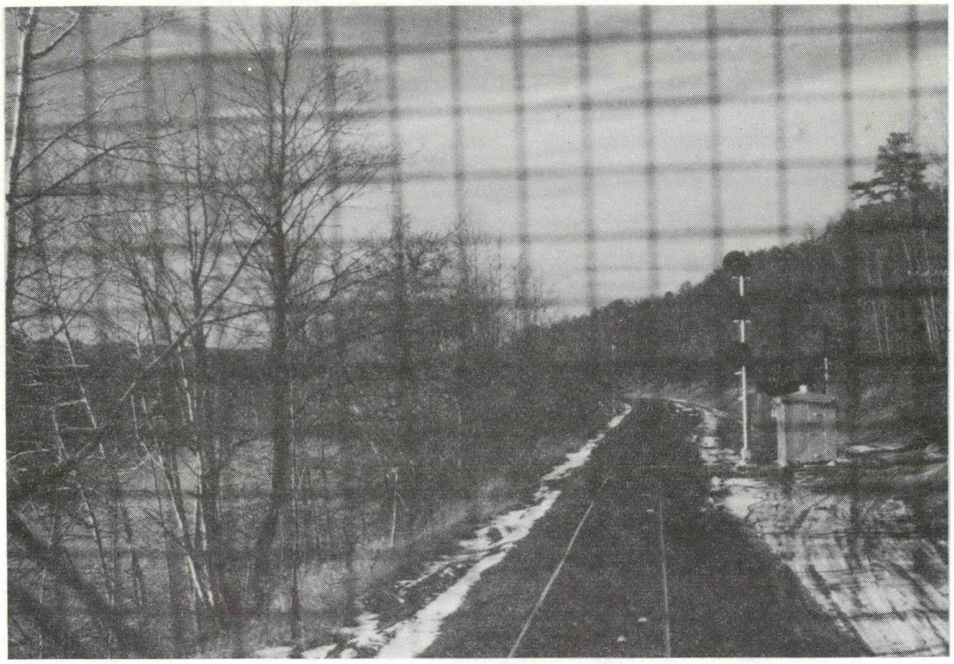


Figure 4-8 Block Limit at a Siding

96

BLOCK LIMITS

NORTH STATION BOSTON to CONCORD, N.H.

Milepost	Block Length (Miles)	Location
0.00		N. Station
	7.82	
7.82		Winchester
	1.94	
9.76		Montvale
	2.98	
12.74		South Wilmington
	10.58	
23.32		South Lowell
	5.23	
28.55		N. Chelmsford
	8.88	
37.43		Nashua South
	3.35	
40.78		Tie Plant
	5.31	
46.09		Merrimack South
	1.69	
47.78		Reed's Ferry
	6.15	
53.93		South Manchester
	1.75	
55.68		Manchester
	3.22	
58.90		Amoskeag North
	2.55	
61.45		Martins North
	2.13	
63.58		Hooksett South
	7.72	
71.30		Bow
	2.06	
73.36		Concord

FIGURE 4-9

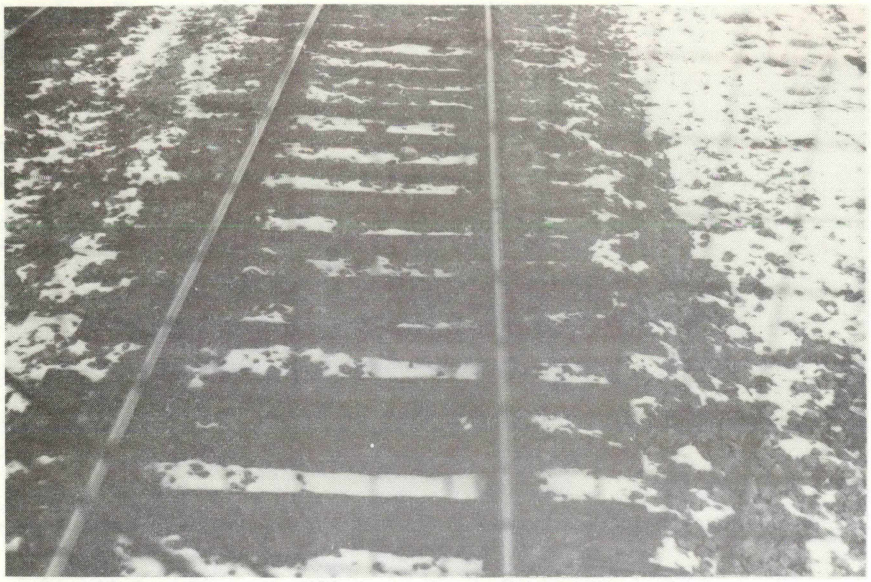
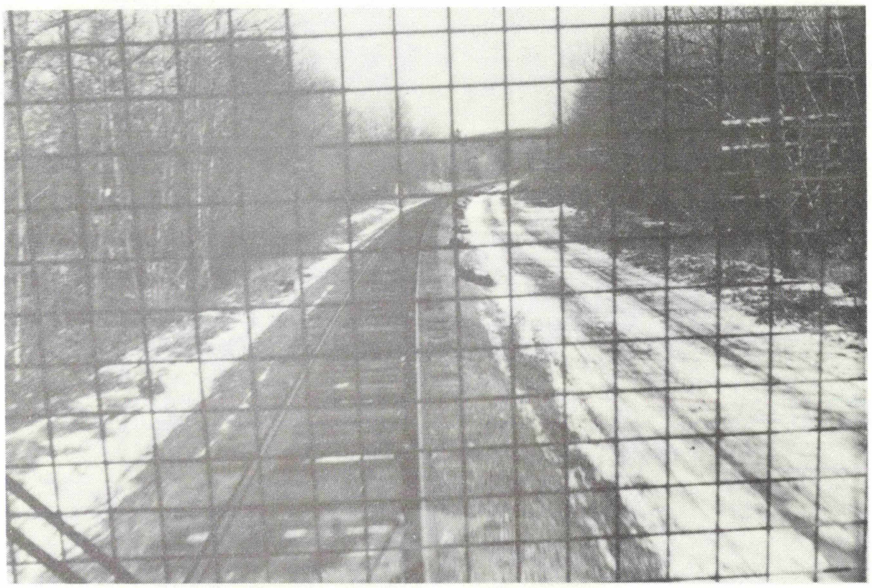


Figure 4-10

Bolted Rail on Wood Ties

Figure 4-11

Old Ties at Side of Track



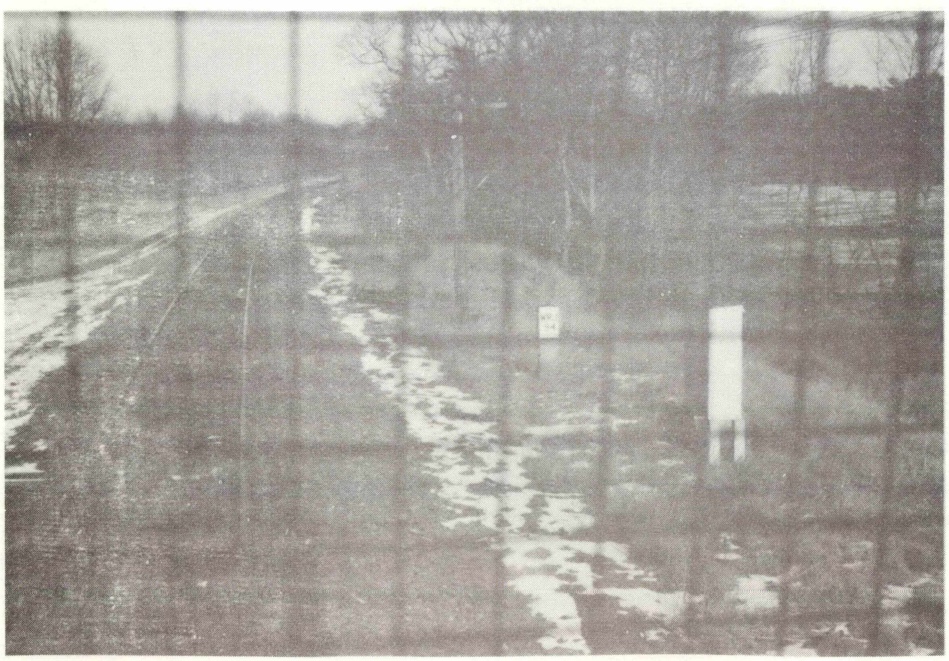


Figure 4-12

Track at Milepost WRJ-94

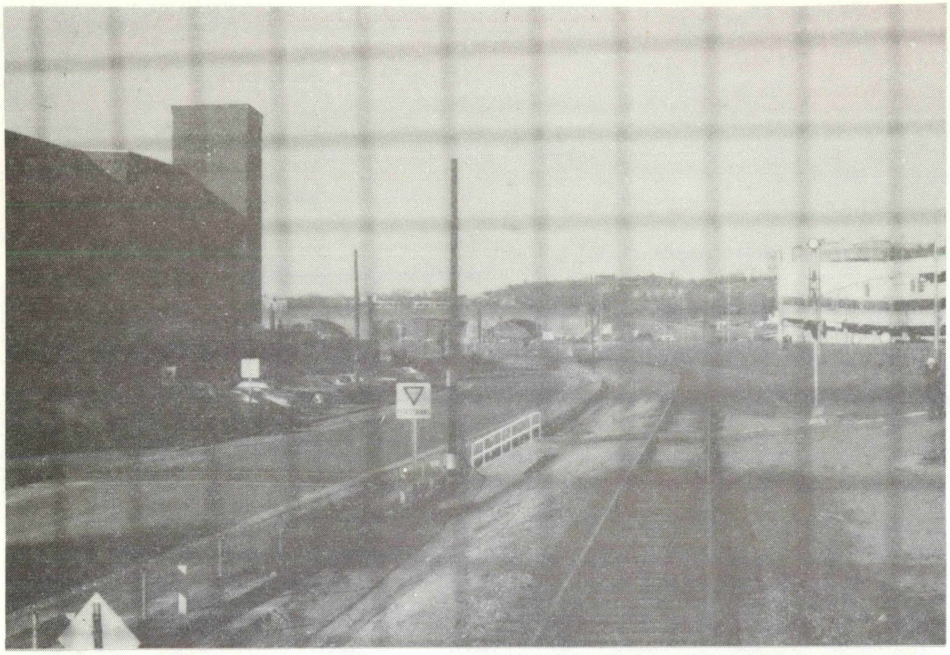


Figure 4-13

Pedestrian Crossing in Manchester, NH, with Flashing Lights

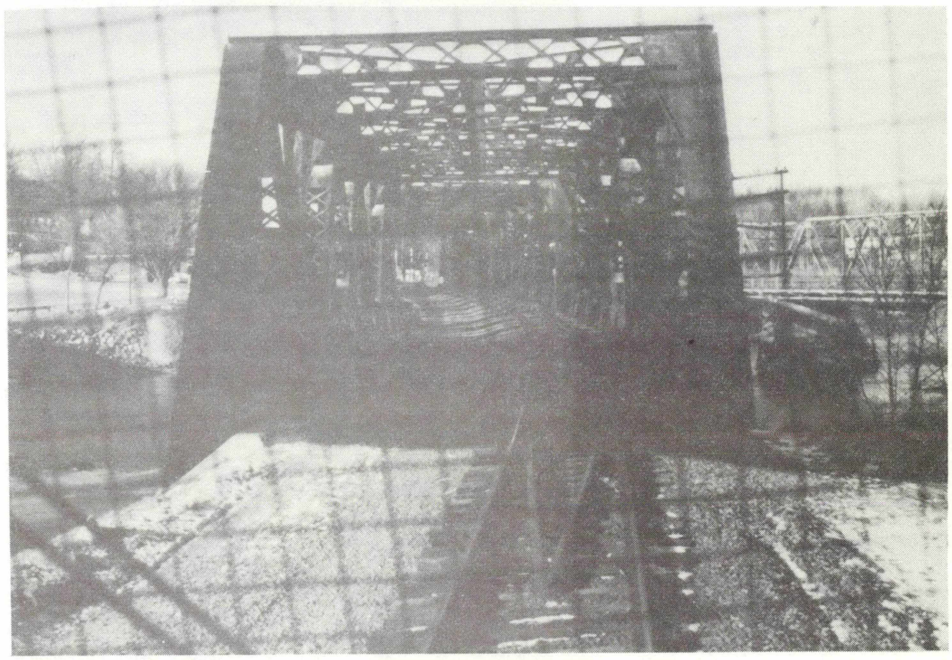


Figure 4-14

Bridge at Hooksett, NH.

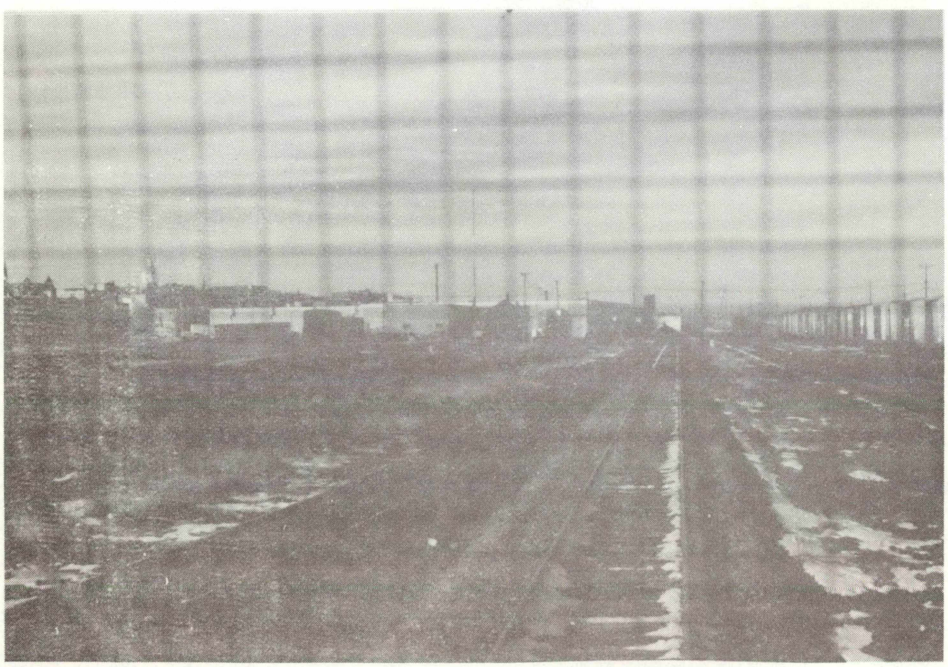


Figure 4-15

Approaching Concord NH Station

99

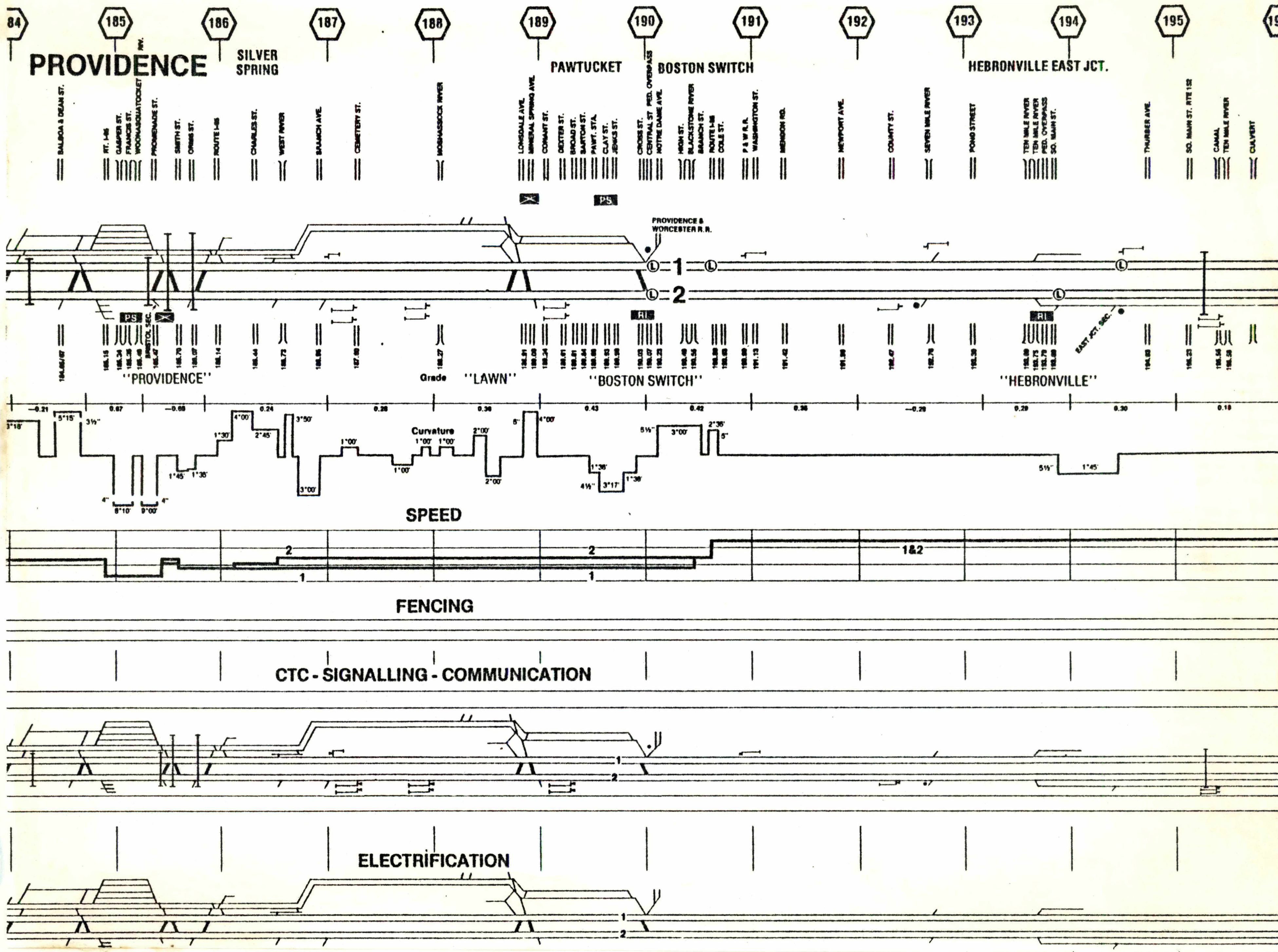


Figure 4-16 (page 1 of 4)

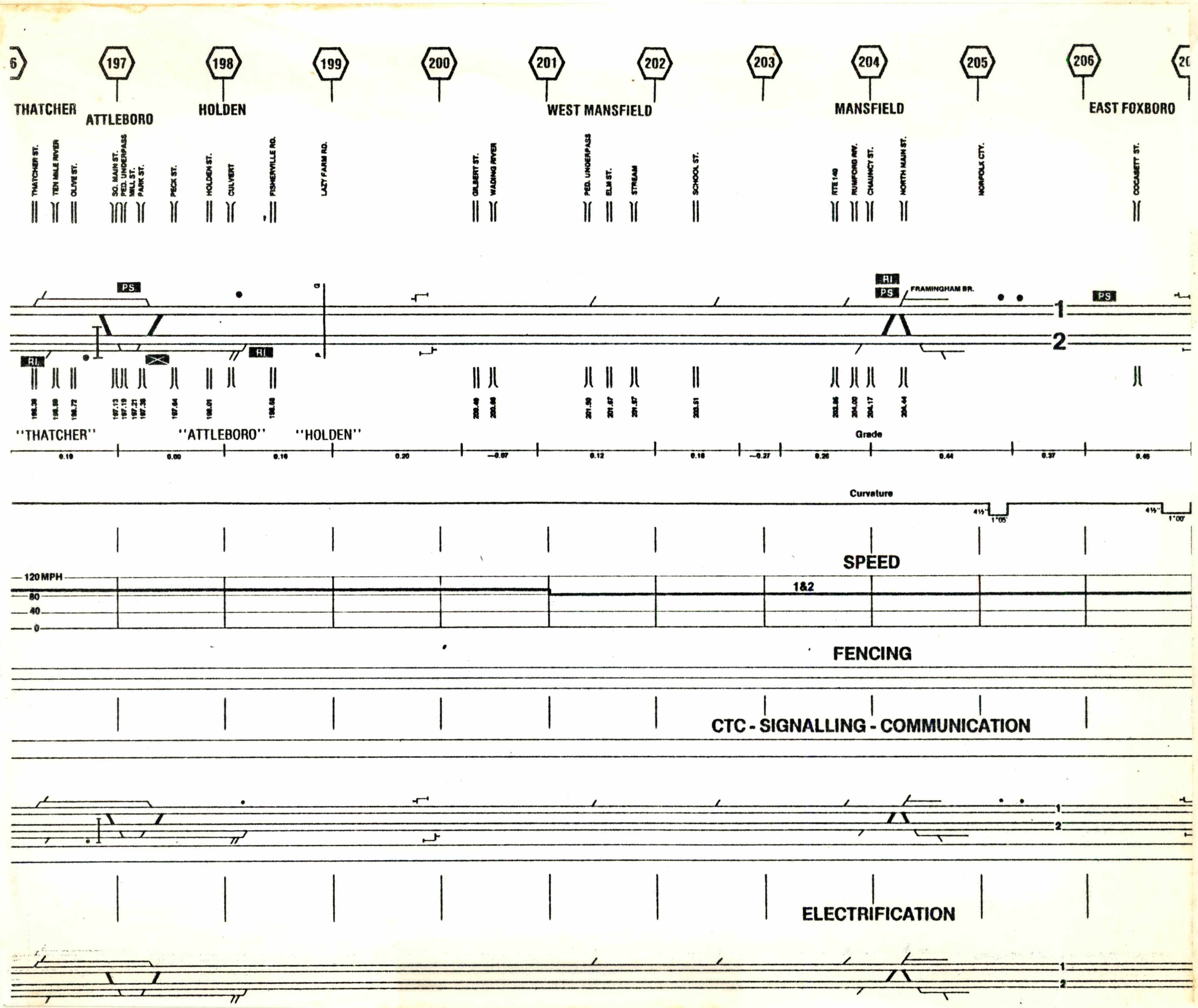


Figure 4-16 (page 2 of 4)

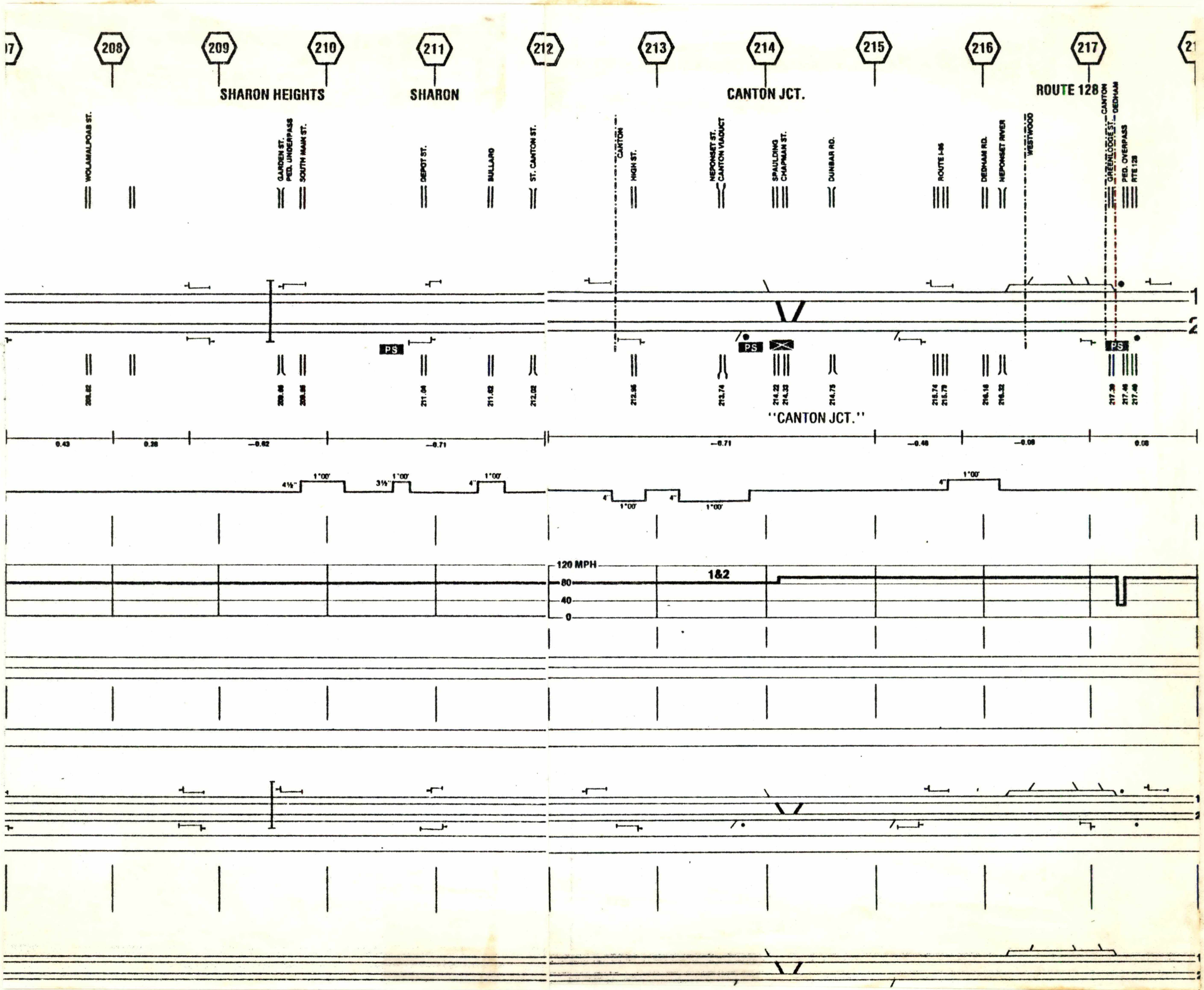


Figure 4-16 (page 3 of 4)

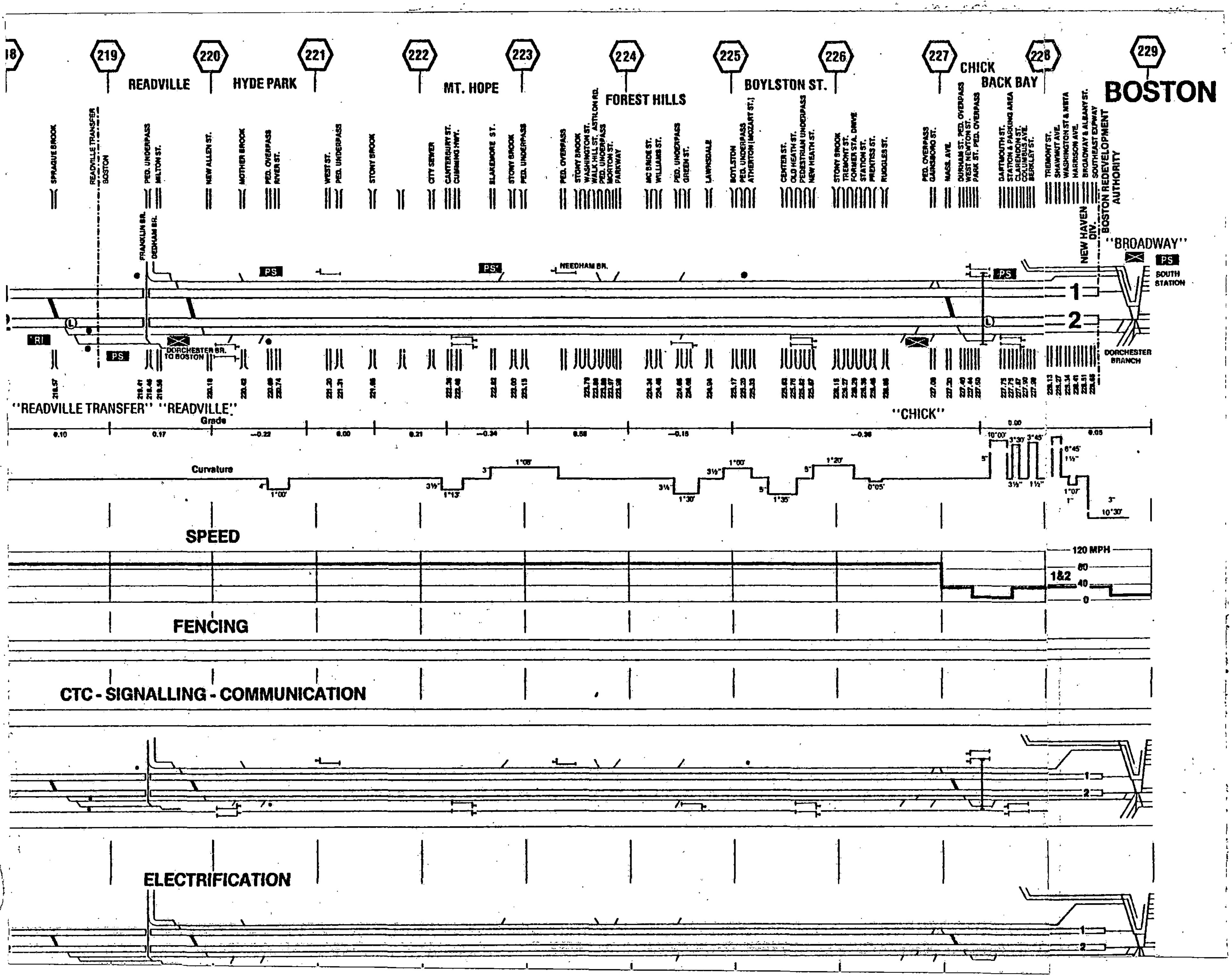


Figure 4-16 (page 4 of 4)

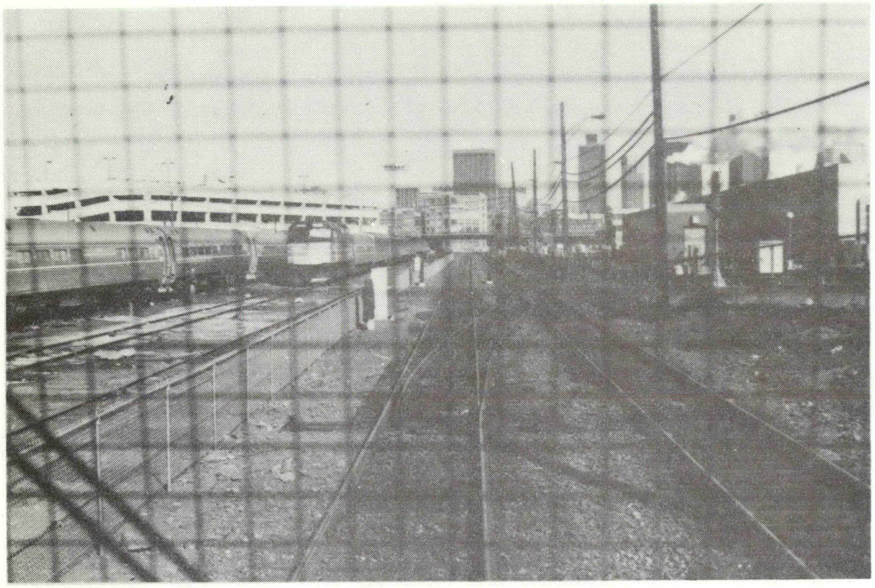
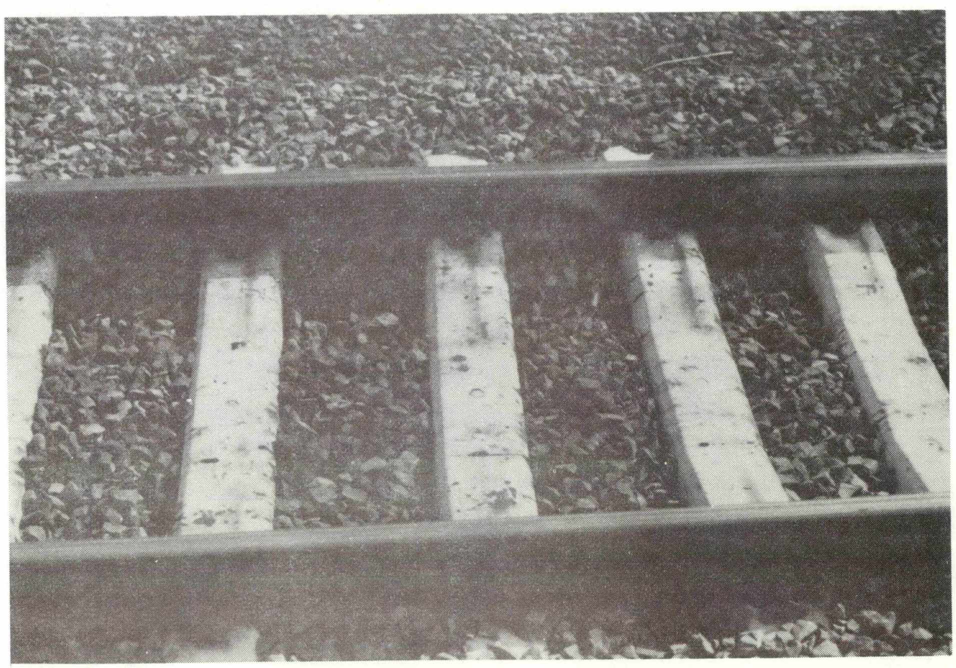


Figure 4-17

NEC West of Boston

Figure 4-18

Concrete Ties



NEC 10

Amtrak

NORTHEAST CORRIDOR

BOSTON DIVISION

Boston, Massachusetts
January 31, 1980

BULLETIN ORDER NO.1-99

Effective 12:02 A.M., Sunday, Feburary 3, 1980

(a) SPEEDS
PASSENGER TRAINS AND FREIGHT TRAINS
MAXIMUM SPEEDS, UNLESS OTHERWISE RESTRICTED

MAIN LINE - BOSTON TO NEW HAVEN	OTHER TRACKS		No. 1 Track		No. 2 Track		No. 3 Track		No. 4 Track	
	Psgr	Frt	Psgr	Frt	Psgr	Frt	Psgr	Frt	Psgr	Frt
	MILES PER HOUR									
Boston and Tower 1 Interlocking Limits	15	10								
South Bay Interlocking Limits			25	25	25	25				
South Bay and Readville Transfer			60	40	60	40				
Readville Transfer and Holden			80	50	80	50				
Holden and Attleboro			80	50	80	50			30	30
Attleboro and Thatcher			80	50	80	50	30	30	30	30
Thatcher and Hebronville			80	50	80	50			30	30
Hebronville and Boston Switch			80	50	80	50				
Boston Switch and Providence			50	35	50	35				
Providence and Cranston			50	40	50	40				
Cranston and Bradford			80	50	80	50				
Bradford and Westerly			70	50	70	50				
Westerly and MP 137			80	50	80	50				
MP 137 and Palmers Cove			70	50	70	50				
Palmers Cove and Midway			70	50	70	50	30	25	25	25
Midway and Groton			60	50	60	50	30	25	25	25
Groton and Shaws Cove			25	25	25	25				
Shaws Cove and Nan			60	40	60	40				
Nan and Conn			75	50	75	50				
Conn and Old Saybrook			80	50	80	50				
Old Saybrook and Westbrook			80	50	80	50	25	25	25	25
Westbrook and Branford			80	50	80	50				
Branford and Mill River			70	50	70	50				
Mill River and Fair Street			35	35			35	35	35	35

Special Instruction 1157-C1, page 357, changed.

Posted at ______________ **By** ______________ **Time** ________ **M. Date** ____________ **19**___.

I hereby acknowledge receipt of Bulletin Order No. 1-99

Posted at ______________ **By** ______________ **Time** ________ **M. Date** ____________ **19**___.

To be detached and promptly forwarded to the General Superintendent

Figure 4-19

105

(b) SPEEDS
PASSENGER TRAINS
MAXIMUM SPEED OF TRAINS HAVING ENGINES AND EQUIPMENT AUTHORIZED
TO OPERATE IN EXCESS OF 80 MPH UNLESS OTHERWISE RESTRICTED

MAIN LINE - BOSTON TO NEW HAVEN	OTHER TRACKS	No. 1 Track	No. 2 Track	No. 3 Track	No. 4 Track
	MILES PER HOUR				
Boston and Tower 1 Interlocking Limits	15				
South Bay Interlocking Limits		25	25		
South Bay and Readville Transfer		60	60		
Readville Transfer and Route 128		80	80		
Route 128 and MP 205		95	95		
MP 205 and MP 200		100	100		
MP 200 and Holden		95	100		
Holden and Attleboro		95	100		30
Attleboro and Thatcher		95	100	30	30
Thatcher and MP 195		95	100		30
MP 195 and Hebronville		95	95		30
Hebronville and Boston Switch		95	95		
Boston Switch and Cranston		50	50		
Cranston and East Greenwich		80	80		
East Greenwich and Davisville		90	95		
Davisville and Kingston		100	100		
Kingston and MP 155		100	80		
MP 155 and MP 152		80	80		
MP 152 and Bradford		85	85		
Bradford and Westerly		70	70		
Westerly and MP 137		80	80		
MP 137 and Palmers Cove		70	70		
Palmers Cove and Midway		70	70	30	25
Midway and Groton		60	60	30	25
Groton and Shaws Cove		25	25		
Shaws Cove and Nan		60	60		
Nan and Conn		75	75		
Conn and Old Saybrook		90	90		
Old Saybrook and Westbrook		90	90	25	25
Westbrook and MP 95		80	80		
MP 95 and MP 82		90	80		
MP 82 and Mill River		70	70		
Mill River and Fair Street		35		35	35

Special Instruction 1157-Clb, page 362, changed.

Figure 4-19

(c) CURVES, BRIDGES, ETC.
PASSENGER AND FREIGHT TRAINS
MAXIMUM SPEED, UNLESS OTHERWISE RESTRICTED

MAIN LINE - BOSTON TO NEW HAVEN	MILES PER HOUR
Tower 1 Interlocking between Signal Bridge No. 7 and Signal Bridge No. 8	10
Canton Jct. Interlocking	40
MP (Bridge) 190.55	40
Curve between MP 190.4 and MP 190.3	50
Curves between MP 185.3 and MP 184.9	25
Providence Station Platform Limits	15
Curve between MP 136.4 and MP 135.9	60
Curve between MP 134 and MP 133.6	60
Curve between MP 132.5 and MP 132.1	55
Curve between MP 130 and MP 129.8	65
Curve between MP 129.6 and MP 129.3	60
Curve between MP 125.7 and MP 125.3	50
Curve between MP 124.3 and MP 124.1	50
Curve between MP 121.6 and MP 120.8	50
Curves between MP 112.8 and MP 112.2	65
MP 106.8 (Bridge 106.89)	55
Curve between MP 106.6 and MP 106.3	55
Curve between MP 102.2 and MP 102	70
Curve between MP 100.1 and MP 99.7	75
Curve between MP 94.8 and MP 94.4	75
Curve between MP 93.8 and MP 93	75
Curve between MP 87.5 and MP 87.2	70
Curve between MP 86 and MP 85.6	75
Curves between MP 81.7 and MP 81.1	55
Curve between MP 80.2 and MP 80	60
Curves between MP 78.5 and MP 77.9	60
Curves between MP 74.2 and MP 74.1	60

Special Instruction 1157-F1, page 370, changed.

Figure 4-19

(d) CURVES, BRIDGES, ETC.
PASSENGER TRAINS
MAXIMUM SPEED OF TRAINS HAVING ENGINE AND EQUIPMENT AUTHORIZED TO OPERATE IN EXCESS OF 80 MPH, UNLESS OTHERWISE RESTRICTED

MAIN LINE - BOSTON TO NEW HAVEN	MILES PER HOUR
Tower 1 Interlocking between Signal Bridge No. 7 and Signal Bridge No. 8	10
Canton Jct. Interlocking	40
Curve between MP 213.8 and MP 213	80
Sharon Platform Limits	80
Mansfield Platform Limits	80
Curve between MP 194.5 and MP 193.7	90
MP 190.5 (Bridge 190.55)	40
Curve between MP 190.4 and MP 190.3	50
Curves between MP 185.3 and MP 184.9	25
Providence Station Platform Limits	15
Curve between MP 160.5 and MP 159.7	90
Curve between MP 136.4 and MP 135.9	60
Curve between MP 134 and MP 133.6	60
Curve between MP 132.5 and MP 132.1	55
Curve between MP 130 and MP 129.8	65
Curve between MP 129.6 and MP 129.3	60
Curve between MP 125.7 and MP 125.3	50
Curve between MP 124.3 and MP 124.1	50
Curve between MP 121.6 and MP 120.8	50
Curves between MP 112.8 and MP 112.2	65
MP 106.8 (Bridge 106.89)	55
Curve between MP 106.6 and MP 106.3	55
Curve between MP 103.9 and MP 103.7	80
Curve between MP 102.2 and MP 102	70
Curve between MP 100.1 and MP 99.7	75
Curve between MP 94.8 and MP 94.4	75
Curve between MP 93.3 and MP 93	75
Curve between MP 91.6 and MP 91.3 No. 1 Track	85
Curve between MP 88.4 and MP 87.9 No. 1 Track	85
Curve between MP 87.5 and MP 87.2	70
Curve between MP 86 and MP 85.6	75
Curves between MP 81.7 and MP 81.1	55
Curve between MP 80.2 and MP 80	60
Curves between MP 78.5 and MP 77.9	60
Curve between MP 74.2 and MP 74.1	60

Special Instruction 1157-F1A, page 373, changed.

(e) MAIN LINE - BOSTON TO NEW HAVEN

Paragraph (h) of Bulletin Order No. 1-S98, Item 1 referring to Temporary Speed Restriction of 10 MPH between Signal Bridge No. 7 and East End Fort Point Channel Bridge, annulled.

R. J. DUGGAN
General Superintendent

Figure 4-19

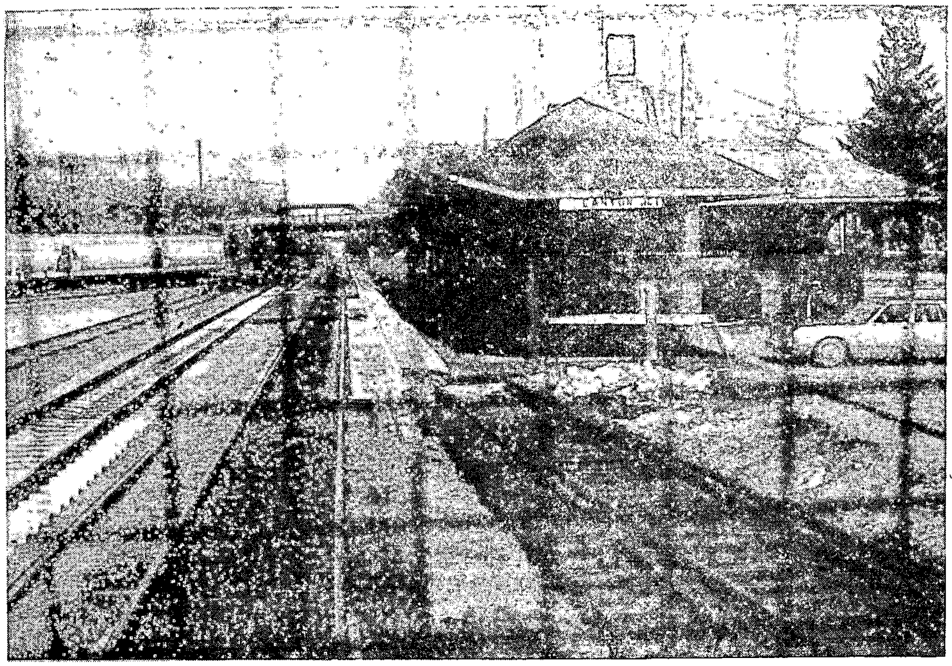


Figure 4-20

Station at Canton Jct.

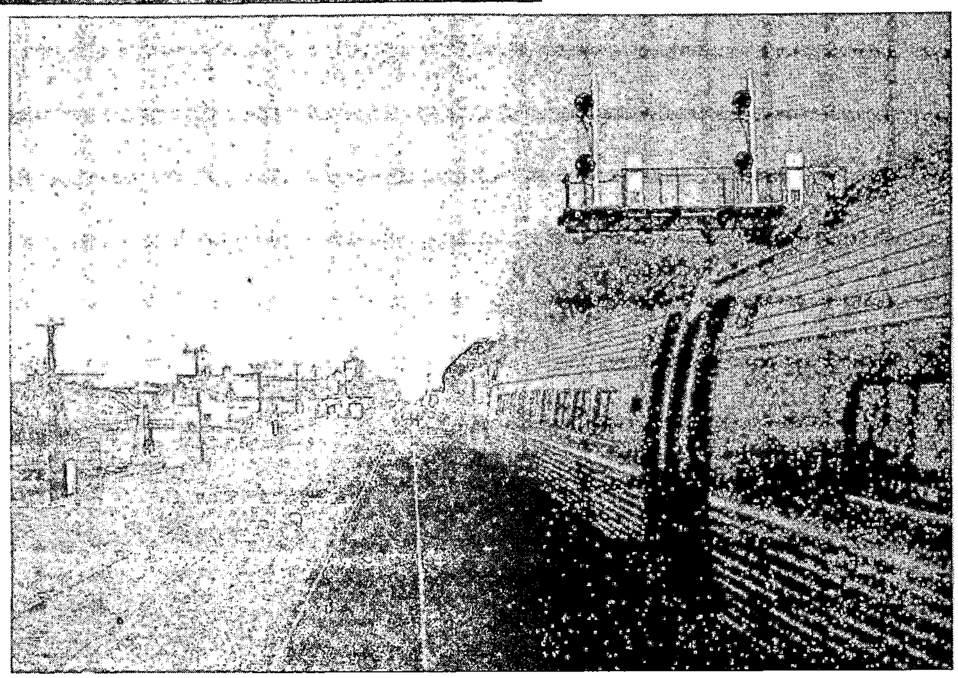


Figure 4-21

Passing Amtrak Train at Attleboro

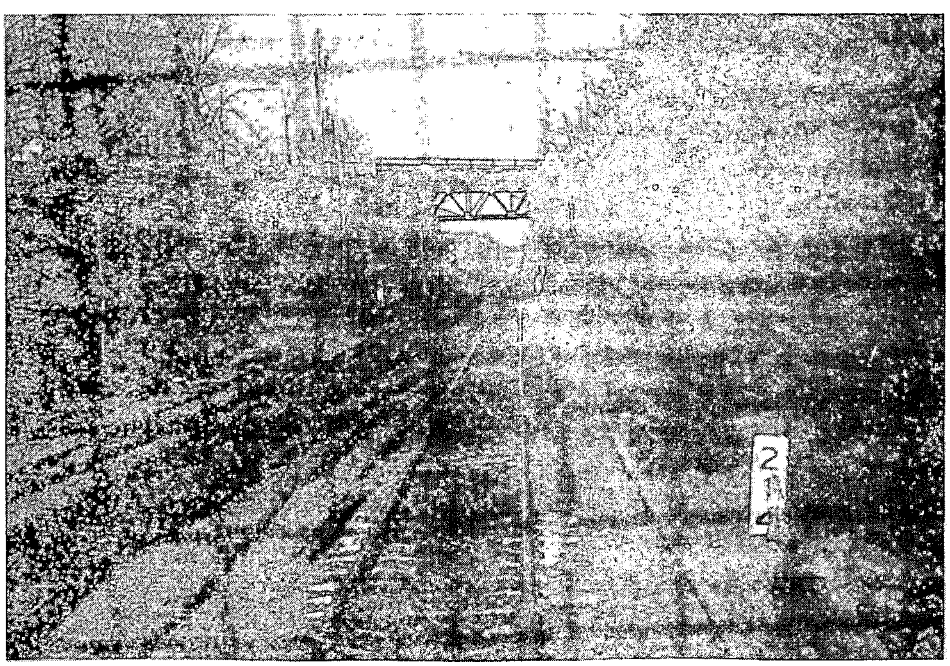


Figure 4-22

Interlocking at Milepost 214

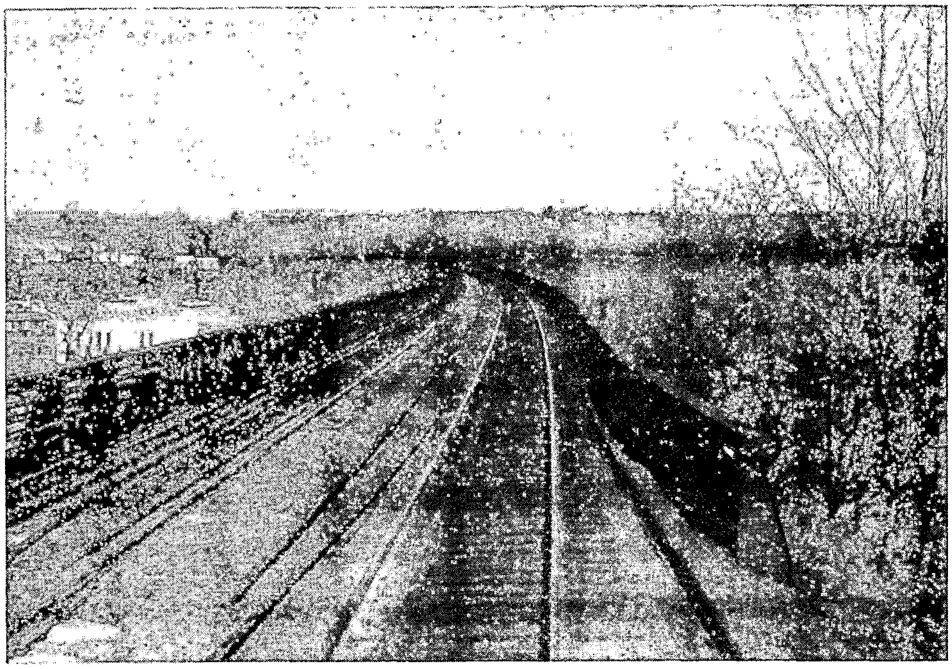


Figure 4-23

Bolted Rail and Wood Ties on a Bridge

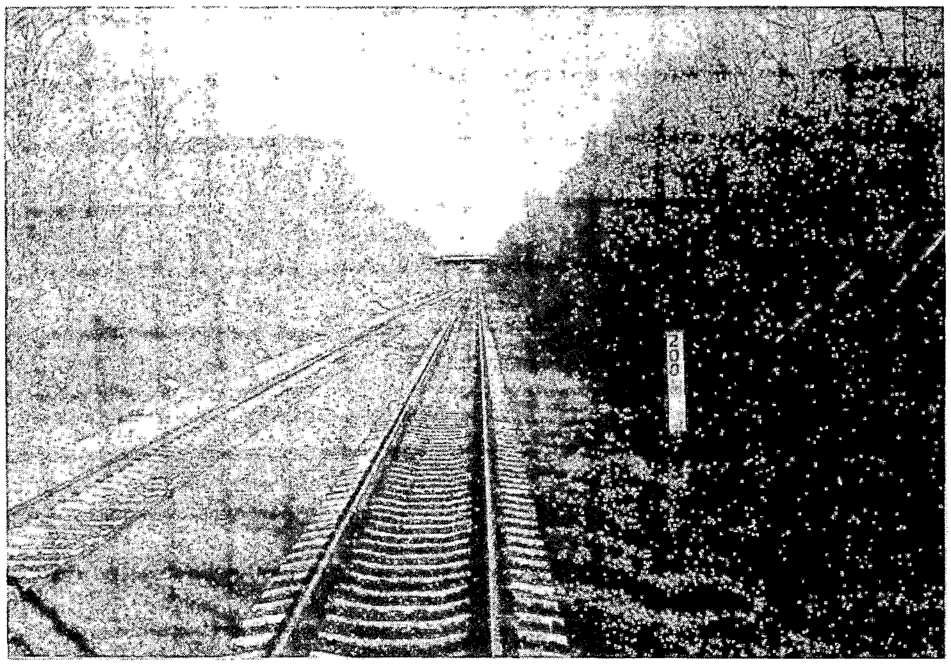


Figure 4-24

Brake Test Site

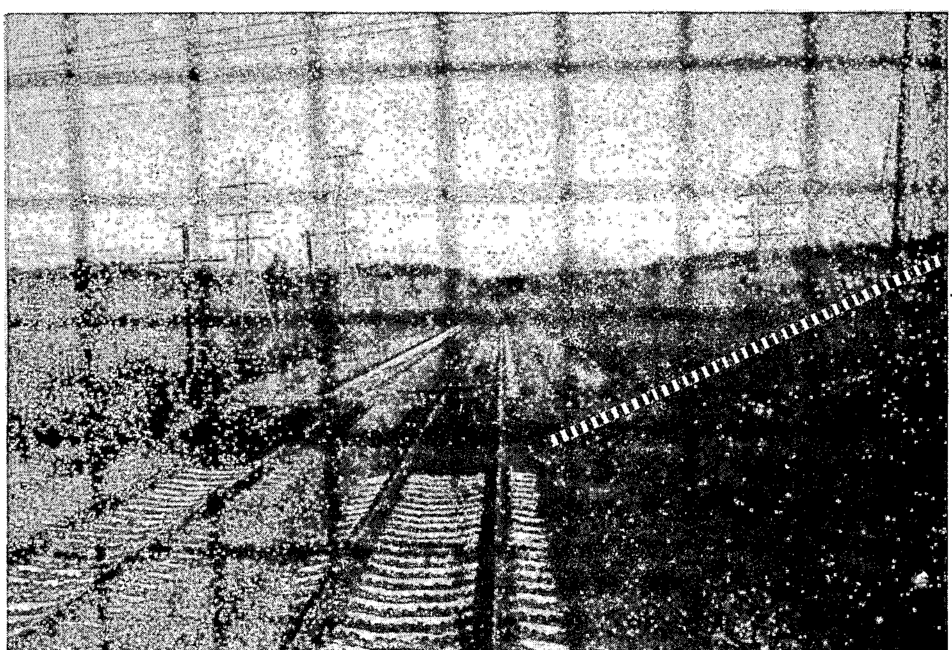


Figure 4-25

Culvert under the Tracks

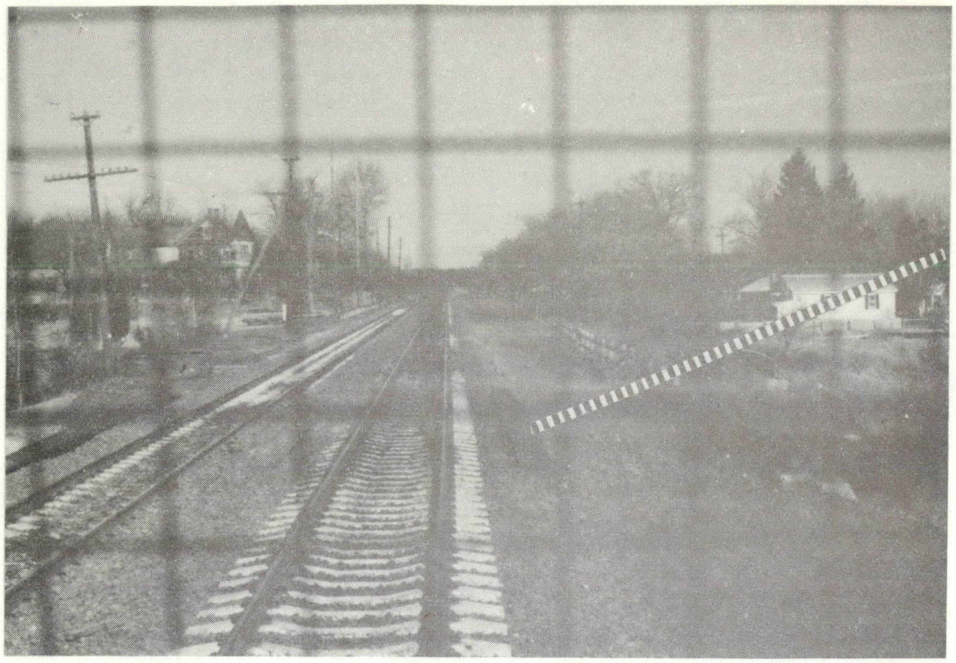


Figure 4-26

Road Crossing under the Tracks

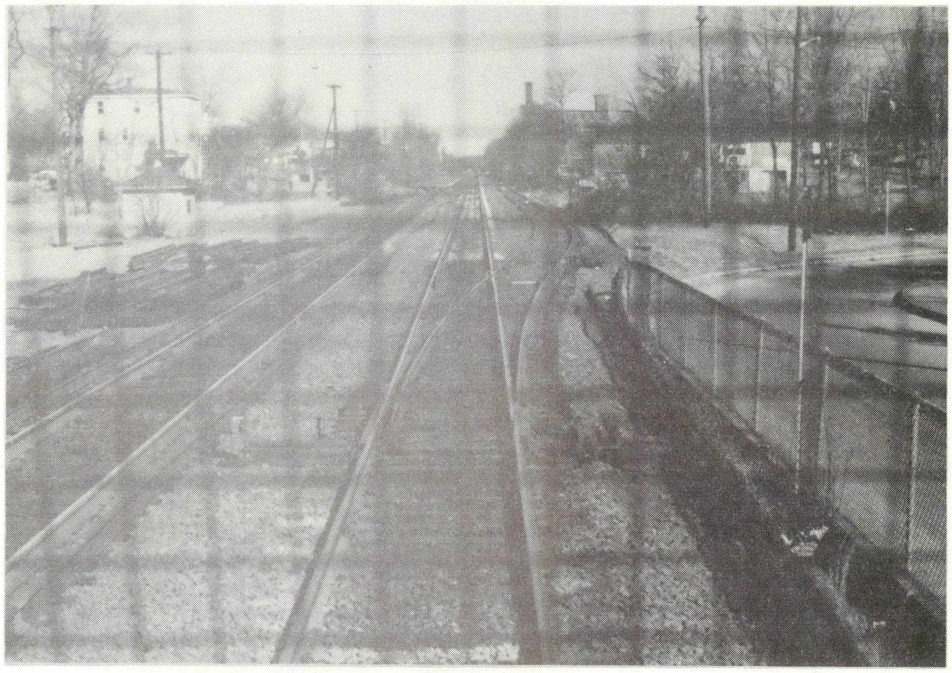


Figure 4-27

Switch for an Industrial Siding

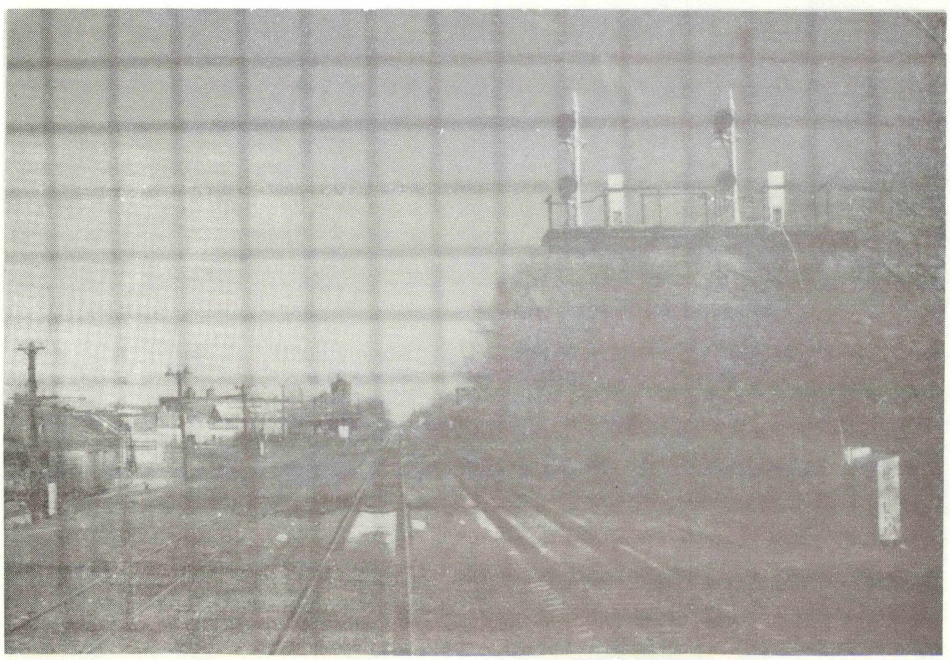


Figure 4-28

Signals West of Attleboro

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5.0 Comparison of LEV-1 with Existing Commuter Vehicles

The following tabulation compares the available knowledge of the LEV-1 with the specification requirements for MBTA's Pullman-Standard commuter cars now operating in B&M push-pull service. The commuter cars were built to the FRA strength requirements and AAR recommendations for vehicles operating in trains of 300 tons or more total train weight. The FRA requirements permit vehicles used in trains of less than 300 tons total train weight to be built to somewhat reduced buff and collision strength levels. It should be recognized that these standards are based on compatibility of equipment as well as the possibility of accidents involving both passenger and freight vehicles in mixed traffic situations such as that of the B&M.

Comparison of Railbus and Conventional Commuter Car

ITEM	COMMUTER VEHICLE	LEV-1
A. Structural Strength		
1. Compressive Load on Centerline of Draft (Without Permanent Deformation)	800,000 lbs.* (400,000 lbs.)	Unknown; Carbody can withstand 3g Longitudinal Acceleration
2. Compressive Load Midway Between Coupler and Buffer (at Half Yield Strength)	400,000 lbs.	Unknown.
3. Compressive Load 12" Above Centerline of Draft (Without Permanent Deformation)	500,000 lbs.	Unknown.
4. Collision Post Shear Strength from Bottom Underframe Connection to Level 13" Above Floor, Applied on Longitudinal C.L. $\pm$ 15°	300,000 lbs.* (200,000 lbs.)	Collision Posts Not Provided.
5. Collision Post Section Modulus	$\geq$ 24.375 in.^{3}	Collision Posts Not Provided.
6. Collision Post Top Connection	Sufficient to develop bending strength of Post.	Collision Posts Not Provided.
7. Anticlimb Capacity - Vertical Load (Up or Down) Resisted by Coupler, Buffer, & Carrier	100,000 lbs.* (75,000 lbs.)	Unknown.
8. Truck to Carbody Attachment Vertical Strength	Locking Center Pin to Lift Truck	Unknown.

ITEM	COMMUTER VEHICLE	LEV-1
9. Truck to Carbody Attachment Shear Strength in Horizontal Plane	250,000 lbs.* (250,000 lbs.)	Unknown.
10. Carline Section Modulus (Roof Area ÷ Summation of Section Moduli)	< 60	Unknown.
11. Side Section Modulus per Unit Length		
a) About Longitudinal Axis (Resistance to Lateral)	≥ 0.30	Unknown.
b) About Transverse Axis (Resistance to Longitudinal)	≥ 0.20	Unknown.
12. Materials		
a) Side Sheets	0.125" min.- Mild Steel	Mild Steel
b) Sub Floor	Metal	Plywood
c) Roof	0.050" min.- Mild Steel	Aluminum
d) Insulation	Non-Flammable Non-Corrosive Non-Hygroscopic	Unknown

* FRA Requirements for Vehicles in trains of 300 tons or over. FRA Requirements for Vehicles in trains of less than 300 tons total weight are shown in parenthesis.

B. Passenger Amenities

ITEM	COMMUTER VEHICLE	LEV-1
1. Seat Arrangement	2 & 2	2 & 2
2. Seat Pitch	33"	28-1/8"
3. Toilet	Retention Type in Control Trailers Only (25% of cars)	Toilet Not Provided.
4. Potable Water	All Cars	None
5. Interior Height	80" minimum	$>$ 82"
6. Interior Noise Level	80 mph: 70dB(A), 83dB(C) 0 mph: 62dB(A), 75dB(C)	40 mph: 74dB(A) in Center 90dB(A) in Cab

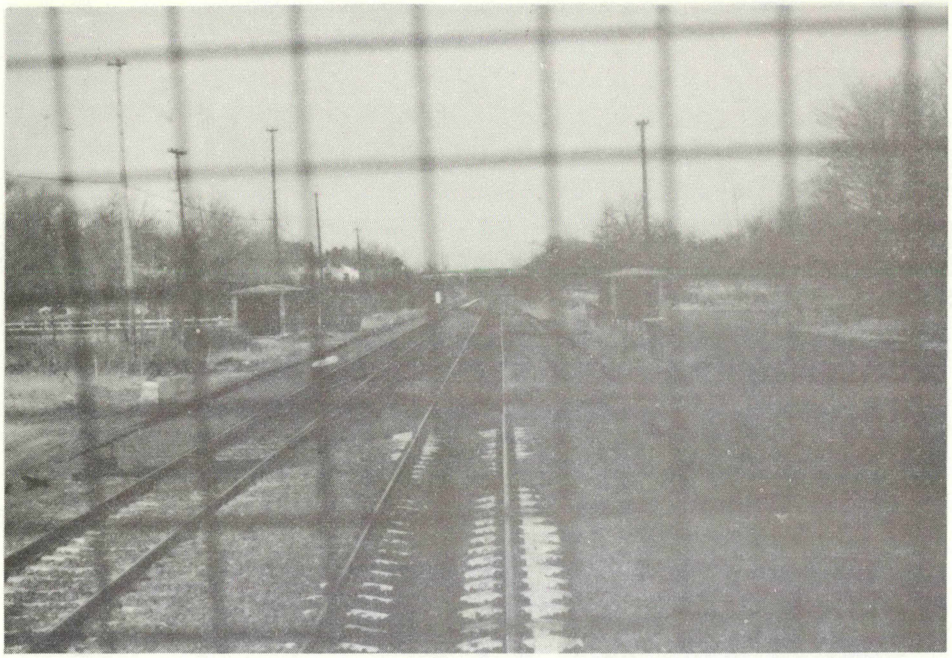

Figure 4-29

Interlocking

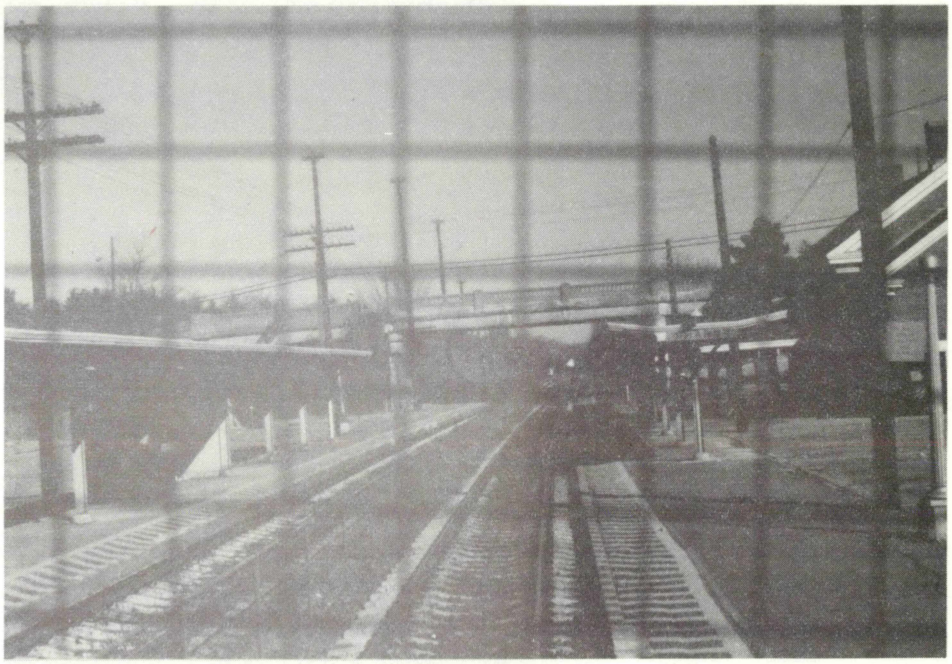

Figure 4-30

Sharon, MA Station

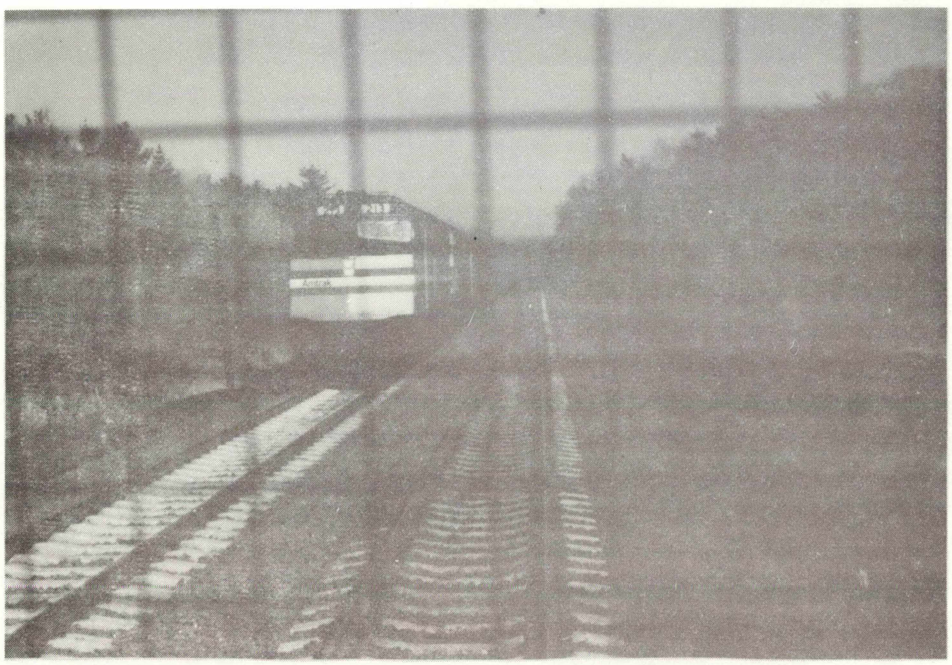

Figure 4-31

Passing Amtrak Train

ITEM	COMMUTER VEHICLE	LEV-1
c) Lateral	$< 0.060g$ $> 1\%$ of Time at Centerline of Car	Data Not Available.
d) Longitudinal	$< 0.02g$ $> 5\%$ of time except for T.E. Surge	Data Not Available.

E. Miscellaneous

1. Wayside Auxiliary Power	Connection for 480V, 3Ø, 60 Hz	None Provided.
2. Marker Lamps	Two, 60 W Red Sealed Beam Lamps	Not Sealed Beam - Very Small, Baseless, Automotime Bulbs.
3. Communications	Radio & P.A.	Radio Only (Applied by B&M).
4. Floor & Platform Height	60-1/2", +1/2", -0 High & Low Platform	39-3/8" - Low Platform Only.
5. Glazing	1/4" Polycarbonate Exterior, 1/4" Laminated Safety Glass Interior	DOT Specification for Highway Equipment.

ITEM	COMMUTER VEHICLE	LEV-1
7. Lighting at Seats	20 Ft-Candles on 45° Plane, 33" Above Floor	Unknown.
8. Lighting in Aisles	5 Ft-Candles	Unknown
C. Heating & Air Conditioning		
1. Heating Performance	75°F at -30°F Ambient & Maximum Speed	Unknown
2. Layover Heat	40°F at -20°F Ambient	Supplemental Heater Requires Battery Support.
3. Fresh Air Supply	12 CFM/Passenger at $\geq$ 0°F 10 CFM/Passenger at $<$ 0°F	Unknown.
4. Cooling Performance	75°F at 100°F Ambient 25°F Below Ambient Thereafter	Air Conditioning Not Provided.
D. Performance		
1. Service Brake Rate	From 1.25 mphps at 120 mph to 2.00 mphps at 70 mph & to Stop	From 2.00 mphps at 63 mph to 1.79 mphps at 30 mph & to Stop.
2. Emergency Brake Rate	2.5 mphps at 70 mph to Stop	Emergency Brake Not Provided.
3. Handbrake	Hold on 5% Grade	Parking Brake Data Not Available.
4. Ride Quality		
a) Conditions	Operation Over Track With PSD Equivalent to Run No. 5, FRA Report PR 394	Data Not Available.
b) Vertical	$<$ 0.055g $>$ 1% of Time at Centerline of Car	Data Not Available.

6.0 Test Results

6.1 General

Between January 19, 1980 and February 3, 1980, while the tests were being monitored, the individuals listed in Figure 6-1 rode the vehicle.

The following is a condensed log of the LEV operation and tests:

1/6/80 LEV-1 arrived at New York from England.

1/8/80 through 1/16/80 LEV-1 arrived by truck at Boston and Maine Shop in North Billerica awaiting insurance clearance.

1/17/80 Vehicle preparation began at noon.

1/18/80 Vehicle preparation completed and systems tested. LEV started toward South Station approximately 6:00 p.m.

1/19/80 LEV-1 arrived at Boston South Station at approximately 5:30 a.m. Minor servicing and purchase of additional batteries delayed start of test until 10:23 a.m. Returned to South Station at 4:10 p.m.

Test Sites:

Northeast Corridor as far West (South) as State Line (Rhode Island).

Test Equipment:

No magnetic tape recording; 12 Channel ultra-violet (U.V.) recorder ("Visicorder").

Test Conducted:

Braking, Track Circuit and Performance Tests.

Review of track quality:

1/20/80 LEV-1 left South Station at 9:50 a.m. and returned to South Station at 1:30 p.m. Moved to Billerica Shop in the late afternoon and evening.

Test Sites:

Northeast Corridor between Canton Junction and Attleboro.

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Test Equipment:

6-Channel U.V. recorder - Accelerometer Data.
12-Channel Magnetic Tape Recorder.

Test Conducted:

Ride quality:

Time	Test	Direction
1005	50 mph	Westbound
1059	50 mph	Eastbound
1124	60 mph	Westbound
1156	60 mph	Eastbound
1225	Maximum	Westbound Attainable Speed
1229	Maximum	Eastbound Attainable Speed*

*76 mph at MP 212 was maximum speed achieved.

1/21/80 LEV-1 serviced.

1/22/80 LEV-1 left the shop at 8:15 a.m. and proceeded to first test site between the tie plant (MP B-40.78) and Merrimack South. After several runs at first test site moved to the second test site between milepost B-29 and B-33. After test, vehicle returned to shop track at 3:15 p.m.

Test Sites:

North of Lowell, MA.

Test Equipment:

6-Channel U.V. recorder - Displacement Data.
14-Channel Magnetic Tape Recorder.

Test Conducted:

Ride quality between Merrimack South and the Tie Plant.

Time	Test	Direction
0950	60 mph	Northbound
1003	50 mph	Southbound (no data recorded)
1026	55 mph	Northbound
1034	55 mph	Southbound
1145	60 mph	Northbound

Time	Test	Direction
1200	60 mph	Southbound
1213	40 mph	Northbound
1224	40 mph	Southbound
1241	45 mph	Northbound

Ride quality between Milepost B-29 and B-33.

Time	Test	Direction
1328	45 mph	Southbound
1345	45 mph	Northbound
1356	50 mph	Southbound
1405	50 mph	Northbound
1413	40 mph	Southbound
1422	40 mph	Northbound
1436	40 mph	Southbound

1/23/80 LEV-1 left shop at 8:30 a.m. and proceeded to Concord, NH. At Concord, a delegation from New Hampshire State offices were picked up and vehicle returned to Nashua arriving at 1:51 p.m. where it was placed on siding in the station area.

Test Site:

Nashua, NH, to Concord, NH, and return.

Test Equipment:

6-Channel U.V. Recorder.
14-Channel Magnetic Tape Recorder.

Tests Conducted:

Ride quality:

Time	Test	Direction
0930	40 mph	Northbound
1235	60 mph	Southbound

FRA noise level tests:

1/24/80 LEV-1 and SPV-2000 cleaned and readied for static display at Nashua, NH and inaugaral run of MBTA service (F40 locomotive and five Pullman commuter cars) between Boston and Condord, NH.

1/25/80 Inaugaral Run.

1/26/80 & 1/27/80 LEV-1 held in Billerica Shop for minor maintenance and servicing.

1/28/80 LEV-1 left shop at 8:25 a.m. and proceeded to Concord, NH. Returned to Nashua at 3:10 p.m.

Test Site:

Lowell, MA to Concord, NH and return to Nashua, NH.

Test Equipment:

6-Channel U.V. Recorder.
14-Channel Magnetic Tape Recorder.

Tests Conducted:

Ride quality:

Time	Test	Direction
0950	Track Speed	Northbound
1158	Track Speed	Southbound

1/29/80 FRA Signal Investigations. One of three days designated for FRA Office of Safety to investigate shunting ability of vehicle. At 9:33 a.m. LEV-1 left siding at Nashua and proceeded to investigate response of grade crossing protection. Vehicle returned to siding in Nashua at 5:07 p.m.

Test Sites:

Protected grade crossings in vicinity of Manchester, NH.

- Dunbar Street
- Byron Street
- Depot Street
- Granite Street
- Pleasant Street
- Number 1 Pedestrian Crossing
- Spring Street

Test Equipment:

British Rail instrumentation was turned off during all signal investigations.

Tests Conducted:

Protected Grade Crossing investigation by FRA in vicinity of Manchester, NH.

50 mph Brake Test at Milepost B-50.

1/30/80 LEV-1 left Nashua siding at 8:50 a.m. and proceeded to Kidder Street where FRA signal investigations began. Vehicle returned to siding at Nashua at 5:25 p.m.

Test Sites:

Grade crossings in and North of Manchester, NH.

Moores Crossing
Pine Island Crossing
Kidder Street
West Brook Street
Old Londonderry Turnpike
River Road
Noyes Road
Old River Road, Bow

Tests Conducted:

FRA Grade Crossing protection and sampled track circuit investigation.

1/31/80 LEV-1 left Nashua at 9:25 a.m. and vehicle returned to siding in Nashua at 5:15 p.m.

Test Sites:

Grade crossings in Nashua, NH, and North Chelmsford, MA.

Crown Street
Hollis Street
Bridge Street
Wotton Lane
Wellman Park

Tests Conducted:

FRA grade crossing and sampled track circuit investigation.

2/1/80 Two days of ride quality and fuel economy data collection for British Rail. LEV-1 left Nashua Yard at 9:50 a.m. and proceeded to Concord and at 1:00 p.m. returned to South Nashua and began another trip to Concord. LEV-1 returned to Billerica Shops at 6:12 p.m.

Test Site:

North of Nashua.

Test Equipment:

6-Channel U.V. Recorder.
14-Channel Magnetic Tape Recorder.

Tests Conducted:

Ride Quality and fuel consumption data.

Time	Test	Direction
0953	Track Speed	Northbound
1100	Track Speed	Southbound
1318	Track Speed	Southbound

50 mph brake test at Milepost B-43.

2/2/80 LEV-1 serviced in morning and at 12:10 p.m. proceeded to Concord. At 3:30 p.m. proceeded south to Lowell and coupled to B&M locomotive #1576 and towed to engine house in Boston.

Test Site:

Billerica Shop to Concord, NH and back to Lowell, MA.

Test Equipment:

6-Channel U.V. Recorder.
14-Channel Magnetic Tape Recorder.

Tests Conducted:

Ride quality and fuel consumption data.

Time	Test	Direction
1228	Track Speed	Northbound
1539	Track Speed	Southbound

50 mph brake test at milepost B-43.

2/3/80 LEV-1 moved, under own power, from the engine house to South Station. At 10:30 departed South Station to NEC test area. Returned to Boston at 2:35 p.m.

Test Site:

Northeast Corridor.

Test Equipment:

6-Channel U.V. Recorder.
14-Channel Magnetic Tape Recorder.

Tests Conducted:

Ride Quality data:

Time	Test	Direction
1029	60 mph	Westbound-Boston to Canton Jct.
1114	45 mph	Westbound-Canton Jct. to Attleboro
1130	45 mph	Eastbound-Attleboro to Readville
1220	65 mph	Westbound-Readville to Attleboro
1317	Maximum Speed	Westbound-Readville to Attleboro
1343	Maximum Speed	Eastbound-Attleboro to Readville

Acceleration test at Milepost 218 (westbound)
60 mph braking test at milepost 200.

2/4/80 & 2/5/80 Vehicle serviced and cleaned.

2/6/80 Two special press runs between South Boston Station and Sharon, MA; one in the morning and one in the afternoon. After press runs LEV-1 returned to Billerica Shop for preparation for shipment back to England.

6.2 Noise

Noise measurements were taken on January 23, 1980 by a Railroad Occupational Safety and Health Specialist. His report is shown as Figure 6-2.

6.3 Emissions

Emission tests were not performed.

6.4 Fuel Consumption

The two LEV-1 fuel tanks have a combined capacity of approximately 119 U. S. gallons (95 Imperial gal.). On each side of the vehicle there is a fuel cap and pipe to the adjacent tank. The tanks are cross-connected at the bottom by a 1/2" pipe to permit equalization (Figures 6-3 and 6-4). Unfortunately the pipe was too small to allow rapid leveling of the tanks during the fueling process. Therefore, unless extreme care was exercised while fueling, there was no assurance that both tanks were completely filled.

Because the fuel fill device on LEV-1 was unconventional the locomotive fueling facility could not be used. When fueling at Billerica (Figure 6-5) a 55-gallon drum was first filled with diesel oil. Then an air activated pump was used to transfer the fuel from the drum to LEV-1. Since there was no fuel gauge, the consumption estimates were a rough judgment of the amount of liquid drawn from the drum. Fueling in the shop was slow enough to assure equalization of the two tanks.

6.5 Acceleration and Braking

The transmission control has the two speed ranges shown in Figure 6-6. The test for range #1 was conducted in several segments and combined to provide the data shown. For range #2 the speed was read verbally into a recorder as the run progressed. The tape was then played back as time was read by stop-watch. These data were plotted in Figure 1-3.

There are two braking modes, a graduated service air brake control and a spring actuated parking or "emergency" brake. The initial braking tests were conducted on the NEC at milepost 200 (Figure 6-7). The brake was applied as the vehicle passed the milepost and the stop distance was measured by tape. The time was measured with a stop watch. Paralleling these measurements, the speed was also recorded on the ultraviolet (U.V.) recorder and a wheel revolution counter in the vehicle instrumentation recorded the stopping distance to the nearest 10 meters. In subsequent braking tests the instrumentation was used as the data source. The later tests were run to determine whether the braking response changed during the test period. The data are listed in Figure 6-8 and plotted in Figure 1-4.

When the U.V. records from the first test were reviewed the velocity-time relationship of braking was linear throughout the entire range.

6.6 Ride Quality

The ambient conditions during the test were excellent considering the time of year and location. There was a light snow on 1/22/80, the only day with significant precipitation. Most days were cold with a chilling wind.

The individual elements of instrumentation are listed in Figure 6-9 and their locations are shown on the British Rail sketch Figure 6-10. The accelerometers were located above the trucks mounted on the passenger compartment floor (Figure 6-11). On one side at each end there was a single vertical accelerometer (Figure 6-12) and on the other side the vertical and lateral accelerometers were mounted on the same base plate (Figure 6-13). These were servo-accelerometers, Schaevitz model number A220-002 $\pm$2g.

Vertical displacements between the primary suspension and the car body were measured with transducers mounted between the axle boxes (Figure 6-14) and the car body (Figure 3-54 and 3-55). The primary lateral displacement was measured with the strain gage beam shown in Figure 6-15.

The signal conditioning units (Figures 6-16, 6-17 and 6-18) were each marked to indicate the transducer channel.

The twelve channel ultraviolet (U.V.) recorder (similar to a Visicorder) (Figure 6-19) was used only on the first day of testing (1/19/80). When the gasoline generator failed it was concluded that the six channel U.V. recorder (Figure 6-20) could be run from the inverter (Figure 6-21) fed by the vehicle batteries.

Figure 6-22 shows the control unit for the fourteen channel magnetic tape recorder (Figure 6-23).

Magnetic probes were located in axle boxes to provide a velocity signal (Figure 6-24).

The instrument rack was located behind the rear control cab (Figure 6-25).

The filters for the first six accelerometers and the first six displacment transducers listed on Figure 6-9 were two pole, 15 Hz units. The velocity transducers had a 3 Hz filter and the other channels were filtered to 35 Hz.

The U.V. chart speed was usually 10 mm/second. Accelerometer data were calibrated at 0.2 g's per cm and displacement at 20 mm travel per cm.

Usually the U.V. recorder was run simultaneously with the magnetic tape recorder. Because it is difficult to analyze ride quality from U.V. tape data, the magnetic tape data was promptly sent back to England for reduction and evaluation by British Rail. Therefore, only a few rough estimates of U.V. data were available for this report. British Rail will forward a complete report to FRA when all data have been reduced. A rough evaluation of the U.V. data made available by British Rail during the test period follows:

1/19/80 NEC - Poor track surface conditions, such as switches, rough rail surface, etc., caused 0.5g peak-to-peak vertical accelerations at about 1.3 Hz while running at higher speeds. At one very bad spot (MP 204), a 0.8g pp transient was encountered. Maximum recorded vertical spring travel was 36 mm pp ($\pm$ 18 mm) at a point where there was a 0.32 g pp vertical acceleration. Maximum recorded lateral spring travel was 10 mm pp ($\pm$ 5 mm) at 0.12 g pp.

Severe rail inputs were observed as the vehicle passed over bridges, turnouts and insulated signal joints and under highway overpasses. There was also one stretch of continuous welded rail with rough surface that performed like bolted rail.

1/22/80 North of Lowell, MA

A severe vertical input was experienced at the industrial switch near signal 424 (Figure 6-26). The tie plates of the switch were 1/2 inch below the bottom of the rail (Figures 6-27 and 6-28). The vehicle was heavy enough to lower the rail as it passed over the low ties. Data at severe inputs were difficult to interpret due to vibration of the floor panel following the transient excitation but a vertical of 0.55-0.60 g pp and lateral of 0.4 g pp was seen in one or two spots.

A slight yaw resonance was felt for a few seconds north of Billerica at 55-60 mph.

1/28/80 North of Nasua, NH

The lateral displacement at a turnout was 30 mm pp and the vertical displacement was 40 mm pp at a frequency of 1.3 to 2.0 Hz at speeds above 50 mph.

2/1/80 North of Nasua, NH

A bad turnout at 48 to 50 mph resulted in 44 mm pp vertical and 16 mm pp lateral motions at 1.5 Hz.

Slight pitch resonance was observed at approximately 1.5 Hz and diagonal-pitch (pitch & yaw) at nearly 2.0 Hz.

2/2/80 North of Boston

Between mileposts B-31 and B-32 at about 40 mph there was a severe vibration of the instrument panel.

2/3/80 Northeast Corridor

At 65 mph at a transition from concrete to wood ties the vehicle experienced a 40 mm pp vertical displacement with negligible lateral. South of milepost 205, on wood ties, there was a vertical of 40 mm pp for 0.25 seconds, and a lateral of 10 mm pp.

The worst lateral noted was 24 mm pp at slightly over 1.0 Hz.

6.7 Signal System Compatability

In simple terms, "steady-energy" railroad signal track circuits consist of voltages of opposite polarity applied to each rail (Figure 6-29). Paralleling this voltage, a relay coil is placed across the track. Normally when the track is unoccupied the relay is energized. When a vehicle enters the track it causes a short or "shunt" in parallel with the relay coil. The vehicle appearing to the circuit as a much lower resistance than the relay draws enough current from the rails to cause the relay to deenergize (drop out).

The other system, "coded" track circuits, operates with a slowly pulsating signal applied to the rails. In this case the relay alternately picks up and drops out in sequence with the coded track current when a vehicle is not shunting the track. The relay pick-up current is lower than its drop out current and the pick-up level can be more accurately calibrated. As a result the "coded" track circuit is more sensitive to the shunt since it may fail to pick-up on the next pulse. The B&M has both "steady energy" and "coded" track circuits within the test areas.

If the vehicle is too light or the rail surface is too contaminated to create a good short or "shunt", the relay may not drop out. In marginal cases the relay may "flip" (pick-up and drop out rapidly) as it sees a momentary loss of the shunt.

The LEV-1 was equipped with a proprietary "black box" designed to facilitate signal shunting. Although it may have been switched "on" during the early tests it was "off" during the FRA investigations of 1/29/80 through 1/31/80.

During most of the LEV-1 testing the momentary loss of shunt would have occurred without detection since no one was assigned to watch the response of the relay. During a few of the special signal tests, FRA or B&M signal people were assigned to carefully observe and measure the relay response. Appendix B is the report of FRA test results from investigations made north of Lowell, MA.

The following is a summary of reported comments on the signal system tests:

1/19/80 Leaving Boston's South Station on Track Number 1 there was a momentary loss of shunt noted in Tower One, Boston on Track Circuits 123, 125 and 129. At South Bay Interlocking on Track Circuit 2B the relay flipped several times indicating a loss of detection of the vehicle. At Readville Transfer on Track Number 1 in Circuit 1E, the relay also flipped a couple of times.

At Attleboro Tower on Track Number 2 in Track Circuit 2C, the relay picked up long enough to indicate a loss of vehicle detection to an observer.

(12-1)

At Attleboro while on Track Number 4, between the tower and Holden Street the track was not shunted. The rail was rusty.

1/20/80 There were no reported problems. (No signal personnel were watching the system).

1/22/80 There were no reported problems. (No signal personnel were watching the system).

1/23/80 When LEV-1 was at Martins North an operator watching the CTC board noted that the panel light flickered several times. The Budd SPV-2000 which was also tested in the same territory did not produce this erratic operation. On one track relay while testing with the SPV-2000, the LEV-1 had a significant track circuit current of 150MA while the SPV-2000 produced zero current. If the current increases to 300MA the relay will pick up as though there was no vehicle present.

1/28/80 There were no reported problems. (No signal personnel were watching the system.)

1/29/80 Grade Crossing Investigations

There were a number of occasions of short-term high current levels which indicated loss of shunt or no detection of the LEV-1. These incidents seemed to be associated with vehicle bounce (wheel unloading), since they occurred as the vehicle was experiencing noticeable vertical movement.

On a northbound move, the LEV-1 had difficulty shunting the home signal in Manchester.

1/30/80 Grade Crossing Investigations

There were a number of occasions of short-term high current levels to the relay coil which indicated a loss of the shunt.

1/31/80 Grade Crossing and Track Circuit Investigation

While running across the Crown Street Crossing in Nashua, at 40 mph the flashers and gates failed to operate. It was not determined whether the problem was the starting location of the vehicle on the crossing circuit or the shunting ability of the LEV-1.

2/1/80 The signal at Martins North failed to light on a northbound trip. On a southbound trip the crossing gate at Kidder Street in Manchester was slow to operate and two other gates were intermittant (guard arm lowered, raised and lowered).

2/2/80 Signal 695 south of Bow flashed on and off several times.

2/3/80 Signal problems at Reedville were not specifically attributed to the LEV-1.

INDIVIDUALS WHO RODE LEV-1 DURING THE TEST PERIOD

Amtrak

- Don Lacey
- Mike Pembrook
- Robert Powell
- Richard Rusnak

Boston and Maine Railroad

- Roger Bazon
- Ann Berry
- Jack Carbone
- Robert Carter
- Tom Cary
- Philip Deming
- Glen Finnegan
- D. Frazier
- Roland Grey
- Richard Hearst
- Frank Lenfest
- Joe MacEachern
- Phil Riley
- A. Russell
- Bob Silk
- Ron Stewart
- Jim Stoetzel
- Tom Trovato

British Rail

- Stewart Baker
- Derrick Brown
- Terry Chappell
- Martin Jones
- Reg Kniveton
- Tony Martin
- Jeff Prince
- Brian Smith
- Allan Wayte

British Vice Counsel

- John Schoefield

Budd Company

- Sam Madiera

Federal Railroad Administration

- Bob Abbott
- Paul Furman
- Bill Harsh
- Ed Hassel
- Myles Mitchell
- Jim Moffet
- Rolf Mowatt-Larssen
- John Nardone
- Dick Novotny
- J. F. Sheridan
- Jim Sottile
- Steve Urman

Leyland

- Terry Donnally
- Richard Hurd

Louis T. Klauder and Associates

- Terrey Hawthorne
- Dave Shore

Metropolitan Boston Transit Authority

- Wally Williams

New Hampshire

- Charles Chandler
- Deborah Coober
- Peter Gulz
- Meridith Kyriax

FIGURE 6-1

Form FRA F 8 (10-73)

UNITED STATES GOVERNMENT

Memorandum

DEPARTMENT OF TRANSPORTATION

FEDERAL RAILROAD ADMINISTRATION

DATE: FEB 1 1980

In reply refer to:

SUBJECT: Leyland Experimental Vehicle--
Noise Tests

FROM : Railroad Occupational Safety and Health Specialist

TO : Director, Office of Standards & Procedures

VIA : Chief, Operating Practices Division

In response to your request, I performed noise measurements on the subject vehicle on January 23, 1980. Three different tests were performed: (1) Exterior passby and idle tests to determine compliance with the EPA noise emission standards for locomotives; (2) interior measurements to assess crew occupational exposure and general comfort conditions; and (3) measurements of the audibility of the warning device to determine compliance with the FRA proposed minimum decibel requirement.

(1) EPA Standards (Exterior)

Tests were performed in Nashua on the New Hampshire Route Mainline (Boston Division of the B&M) between Mile Post #39 and 40. All clear zone requirements of the EPA regulations were satisfied. The wind velocity was less than 2 m.p.h. There was a trace covering of snow. The following sound levels were measured at both 50 and 100 feet.

Test No.	Speed	dB(A) at 100 ft.	dB(A) at 50 ft.
1	20	64	72
2	30	65	73
3	40	67	76
4	47	69	79
5	56	70	80
6	Neutral (Full Throttle)	66	75

Measurements at 100 feet were performed with a GenRad Type 1933 Precision Sound Level Meter while those at 50 feet were performed with GenRad Type 1545-C General Purpose Sound Level Meter. Both meters were set at the "FAST" response.

Figure 6-2 (page 1 of 3)

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The EPA standard for moving locomotives at 100 feet is 96dB(A) for pre-1980 units and 90dB(A) for post-1980 units. These limits apply at any speed.

The standard for stationary locomotive is 93dB(A) at any throttle setting and 73dB(A) at idle for pre-1980 units, and 87dB(A) and 70dB(A), respectively for post-1980 locomotives.

Discussion

As indicated by the above measurements, the LEV-1 is well within the EPA standards for moving and stationary locomotives. This is true in comparison with either the pre-1980 or the more stringent post-1980 limits. The diesel engine rated, at 200 h.p., is much smaller than those of the typical freight locomotives covered by the EPA standards. In addition, the unit is equipped with an exhaust silencer which further lowers noise emissions.

(2) Interior Measurements

To assess the interior noise environment, continuous readings were recorded at three different locations in the LEV using a GenRad Type 1945 Community Noise Analyzer. Recorded values are indicated in Tables 1, 2, and 3. (L(x) is the noise level exceeded x percent of the time during the measurement period. Lmax and Lmin are the maximum and minimum recorded sound levels during the measurement period. Leq is the energy-average equivalent level.)

Table 1, Rear end forward, approximately 12 inches from engineer's right ear, 30 minutes, Nashua to Concord average speed = 35 m.p.h. All levels in dB(A).

Lmax = 103	L20 = 77
L0.1 = 102	L50 = 69
L1 = 74	L90 = 61
L2 = 98	L99 = 58
L5 = 88	Leq = 85
L10 == 82	Lmin = 45

Table 2, Middle of Vehicle, Nashua to Concord, 30 minutes, average speed = 40 m.p.h. All levels in dB(A).

Lmax = 94	L20 = 75
L0.1 = 88	L50 = 70
L1 = 85	L90 = 62
L2 = 81	L99 = 61
L5 = 78	Leq = 74
L10 = 76	Lmin = 60

Table 3, Front end forward, approximately 12 inches from engineer's right ear, 30 minutes, average speed = 40 m.p.h., Concord to Nashua. All levels in dB(A).

Lmax	= 112	L20	= 76
L0.1	= 110	L50	= 73
L1	= 104	L90	= 67
L2	= 102	L99	= 62
L5	= 83	Leq	= 90
L10	= 78	Lmin	= 57

Discussion

Instantaneous readings with the GenRad Type 1565 Sound Level Meter, as well as cumulative readings with the Type 1954 Personal Noise Dosimeter, indicated that the interior noise levels were within the FRA proposed occupational exposure limit for locomotive cabs. (90dB(A) for 8 hours, 5dB doubling rate, 115dB(A) maximum.) I am unaware of an interior noise standard or guideline for general passenger comfort. Nevertheless, my subjective response was that the ride was fairly quiet and generally acceptable.

(3) Audible Warning Device

The FRA has proposed a minimum decibel level of 96dB(A) at 100 feet forward of the locomotive in its direction of travel. Measurements were taken to determine compliance with this requirement.

	Mode A	Mode B
50 feet forward-----	86dB(A)	88dB(A)
100 feet forward-----	81dB(A)	81dB(A)

As indicated, the "audibility" of the warning device is clearly unacceptable when compared with the FRA proposed minimum level. The device is a standard BR type air horn activated by two position control. Two chimes are suspended at each end from the bottom of the vehicle. The engineer has the option of actuating either chime, but not both (Mode A or Mode B).

Clearly, this type of design is not suitable for maximum sound propagation. Audible warning devices on U.S. locomotives are typically comprised of at least three chimes which sound simultaneously and are located on top of the unit with limited line-of-sight restrictions.

Stephen Urman

cc: Hassel
Novotny (RRD-22)

Figure 6-2 (page 3 of 3)

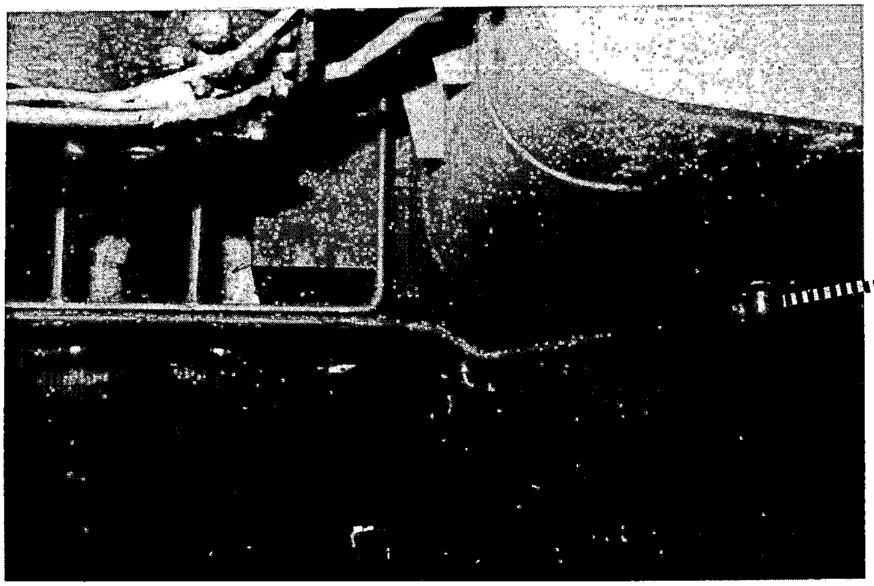

Figure 6-3

Right Hand Fuel Tank and Connection of Equalizing Pipe

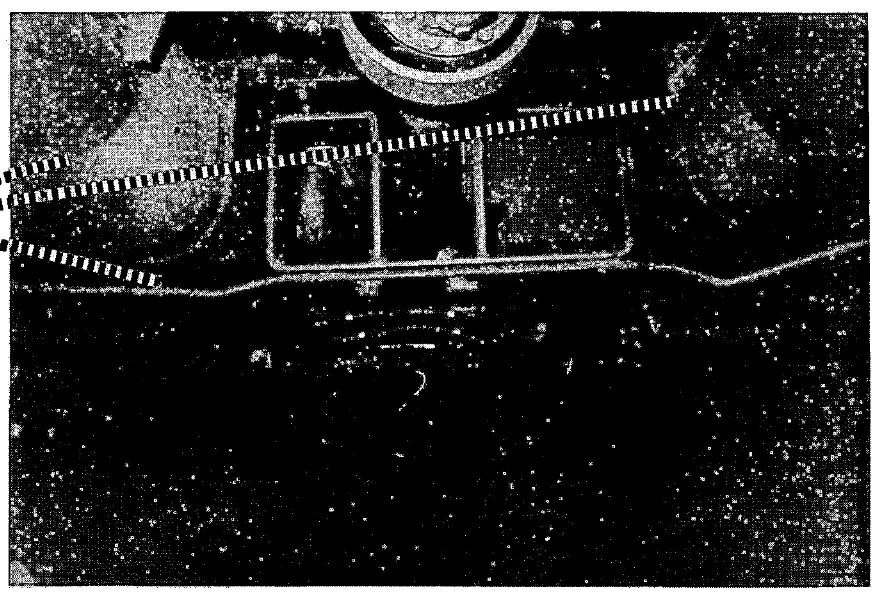

Figure 6-4

Fuel Tanks and Equalizing Pipe

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MILEAGE AND FUEL CONSUMPTION

	Start of Day Mileage	Fuel[6]	Incremental			Overall		
			Miles	gal	mpg	Miles	gal	mpg
1/18/80	5962	Filled at Billerica				0	0	-
1/20/80	6119	40 gal at S. Station[3]	157	40[2]	3.9	157[1]	40[2]	3.9
1/22/80	6289	30 gal at Billerica[3]	170	30	5.7	327	70	4.7
1/23/80	6417	25 gal at Billerica[3]	128	25	5.1	455	95	4.8
1/28/80	6569							
1/29/80	6664	37 gal at Nashua	247	37	6.7	702	132	5.3
1/30/80	6734							
1/31/80	6847							
2/1/80	6910	46 gal at Nashua	246	46	5.4	948	178	5.3
2/2/80	7079							
2/3/80	7216	60[4] gal at Boston Enginehouse	306	60	5.1	1254[5]	238	5.3
			1254	238				

1 - Included approximately 26 miles while being towed.
2 - Included approximately 24 hours of engine idling.
3 - Estimated - No fuel gauge.
4 - May have been overfilled compared to filling on 2/1/80.
5 - Included 26 miles while being towed with the engine idling.
6 - All volume in U.S. gallons.

FIGURE 6-5

ACCELERATION TEST RESULTS

1/19/80 Northeast Corridor MP-200
TRANSMISSION RANGE #1

Shift	Speed
1 to 2	16
2 to 3	30
3 to 4	45

Speed (mph)	Time (sec.)
0	0
10	2
15	9
20	14
30	20
35	29
40	37
48	68[1]
50	78[1]
54	90[2]
60	109[2]
65	144[2]

2/3/80 Northeast Corridor MP-218
TRANSMISSION RANGE #2

Shift	Speed
1 to 2	14
2 to 3	26
3 to 4	40

Speed (mph)	Time (sec.)
0	0
5[3]	2
10	4
15	6
20	15
25	20
30	29
40	47
45	101
50	123
55	143
60	230

---

1) Separate test runs.
2) Estimated - see text.
3) Wheel slip on start

FIGURE 6-6

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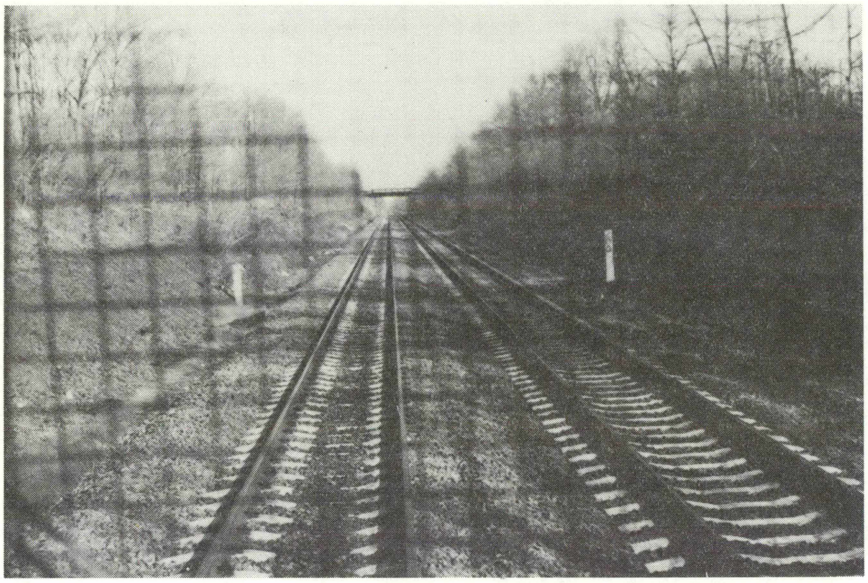

Figure 6-7 Brake Test Site

BRAKING TEST RESULTS

1/19/80 Northeast Corridor MP-200

- Full Service Brake -

Initial Velocity (mph)	Stopping Distance (Tape Measure) (ft)	Time (Stop Watch) (sec)	Instrumentation Stopping Distance (m)	(ft)
20	148	9		
30	368	16	110	361
40	591	20	190	623
48	914	27	280	919
50	1041	28	340	1120
60	1466	33	450	1480
66	1728	36	540	1770
40	640	22	200	656
30	362	16	110	361

- Parking Brake -

Initial Velocity (mph)	Stopping Distance (Tape Measure) (ft)	Time (Stop Watch) (sec)	Instrumentation (m)	(ft)
20	248	14		
30	519	20	170	558
40	854	28	260	853
50	1383	35	420	1380
60	1900	41	580	1900
65	2170	44	670	2200

1/20/80 Northeast Corridor MP-200 - 60 mph Full Service - 390 m (1280 ft)*.

1/29/80 North of Lowell - Milepost B-50 50 mph Full Service - 370 m (1210 ft)*.

1/30/80 North of Lowell - Milepost B-50 50 mph Full Service - 340 m (1120 ft)*.

2/1/80 North of Lowell - Milepost B-43 50 mph Full Service - 33 m (1080 ft)*.

2/3/80 Northeast Corridor MP-200 - 60 mph Full Service - 420 m (1380 ft)*.

* Measurements of stopping distance on 1/20/80 through 2/3/80 were performed by the British Rail instrumentation.

FIGURE 6-8

BRITISH RAIL INSTRUMENTATION

Transducers

Accelerometers - Body Vertical
- AX1-RHS Axle 1 - Right Hand Side
- AX1-LHS Axle 1 - Left Hand Side
- AX2-RHS Axle 2 - Right Hand Side
- AX2-LHS Axle 2 - Left Hand Side

Accelerometers - Body Lateral
- AX1-LHS Axle 1 - Left Hand Side
- AX2-LHS Axle 2 - Left Hand Side

Displacement LVDT - Body Vertical
- AX1-RHS Axle 1 - Right Hand Side
- AX1-LHS Axle 1 - Left Hand Side
- AX2-RHS Axle 2 - Right Hand Side
- AX2-LHS Axle 2 - Left Hand Side

Displacement - Strain Gage Beam
- AX1-RHS Axle 1 - Right Hand Side
- AX2-LHS Axle 2 - Left Hand Side

Miscellaneous -
- AX1 - Speed - Axle 1 - Wheel Slip Sensor
- Lateral Primary Suspension Displacement-Right Hand Side
- Lateral Primary Suspension Displacement-Left Hand Side
- Vertical Displacement-Solebar to Body-Right Hand Side
- Vertical Displacement-Solebar to Body-Left Hand Side
- Force in Truck Suspension Bar
- Vertical Engine Accelerations
- AX2-RHS Longitudinal Body Accelerations at Axle 2-Right Hand Side

Signal Conditioning

Data Acquisition, Ltd.
3 sets - DAPSU-2 Unit each with six DA-1410 Amplifiers

Data Storage

SE3012	12	Channel Ultraviolet Oscillograph (1/19/80 only)
SE3006	6	Channel Ultraviolet Oscillograph
RCA	14	Channel Magnetic Tape Recorder

Instrument Power Source

Gasoline driven alternator (1/19/80 only)
Inverter (Battery to 60 Hz)

FIGURE 6-9

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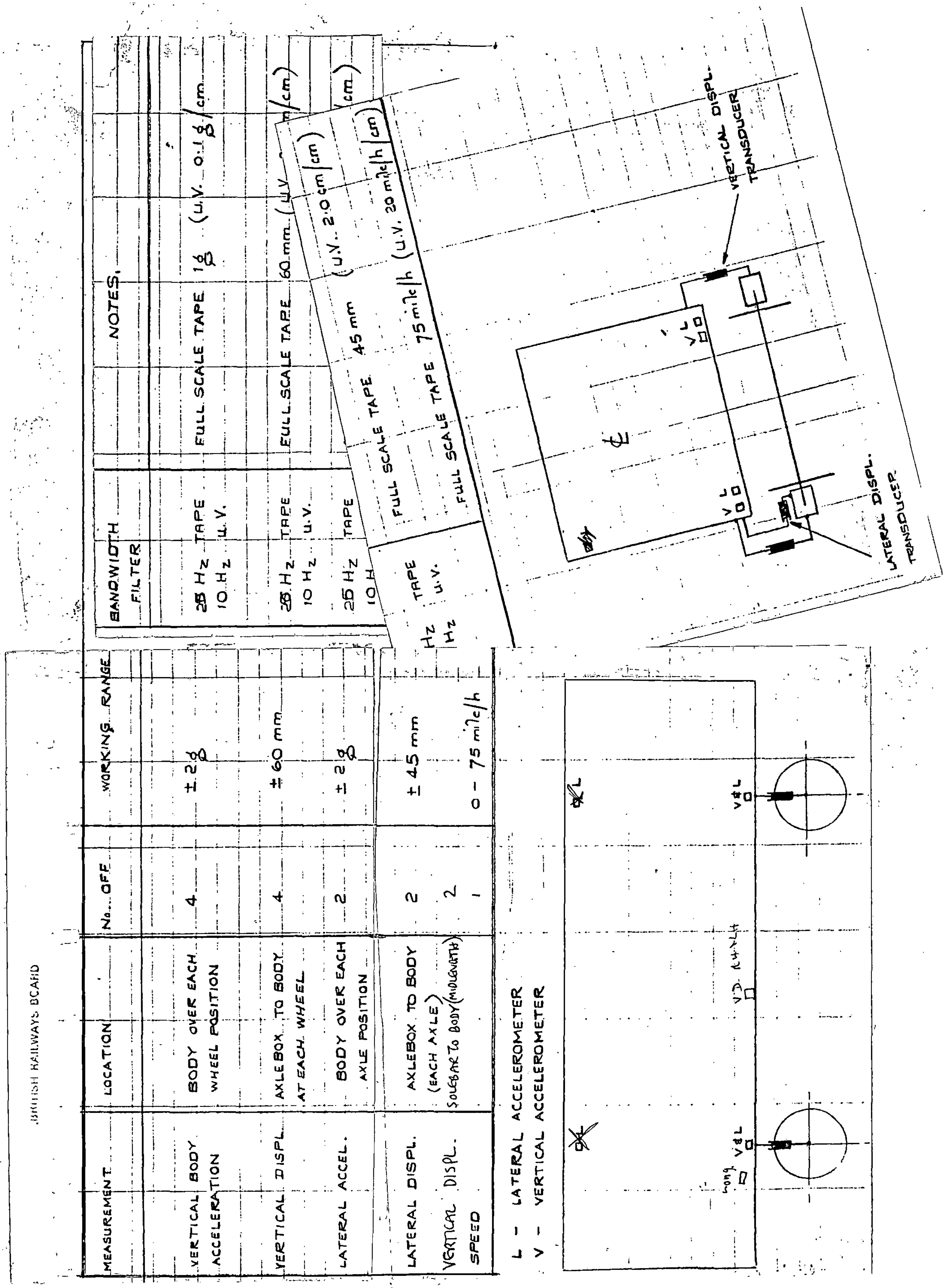

MEASUREMENT	LOCATION	No. OFF	WORKING RANGE	BANDWIDTH FILTER	NOTES
VERTICAL BODY ACCELERATION	BODY OVER EACH WHEEL POSITION	4	± 2g	25 Hz TAPE 10 Hz U.V.	FULL SCALE TAPE 1g (U.V. 0.1 g/cm)
VERTICAL DISPL.	AXLEBOX TO BODY AT EACH WHEEL	4	± 60 mm	25 Hz TAPE 10 Hz U.V.	FULL SCALE TAPE 60 mm (U.V. ... /cm)
LATERAL ACCEL.	BODY OVER EACH AXLE POSITION	2	± 2g	25 Hz TAPE 10 H...	... cm)
LATERAL DISPL.	AXLEBOX TO BODY (EACH AXLE)	2	± 45 mm	Hz TAPE Hz U.V.	FULL SCALE TAPE 45 mm (U.V. 2.0 cm/cm)
VERTICAL DISPL.	SOLEBAR TO BODY (MIDLENGTH)	2			
SPEED		1	0 - 75 mile/h		FULL SCALE TAPE 75 mile/h (U.V. 20 mile/h/cm)

Figure 6-10
Ride Quality Instrumentation

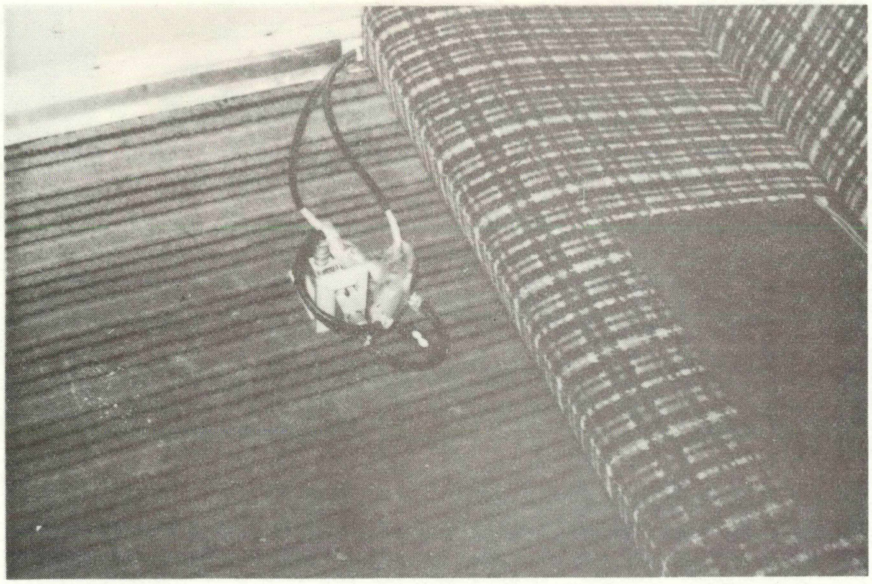

Figure 6-11

Lateral and Vertical Accelerometers

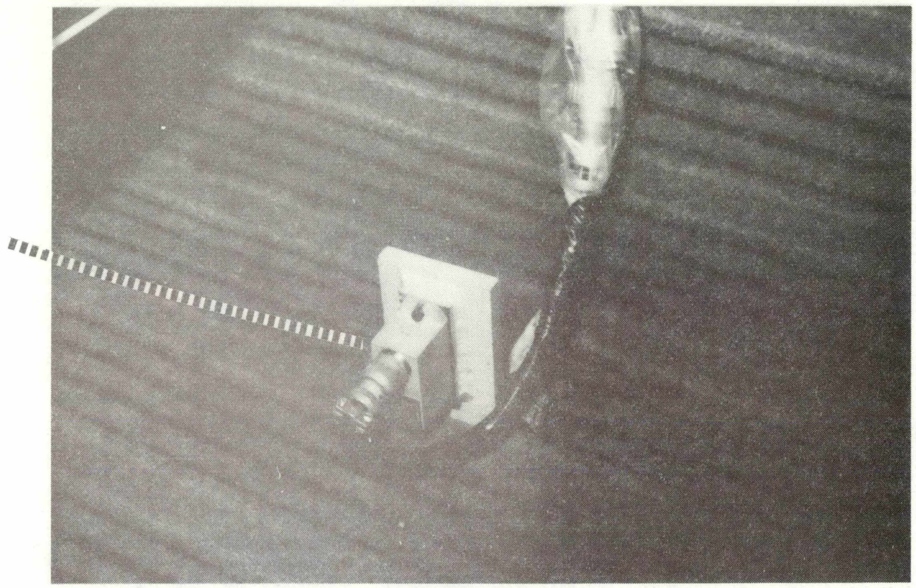

Figure 6-12

Vertical Accelerometer

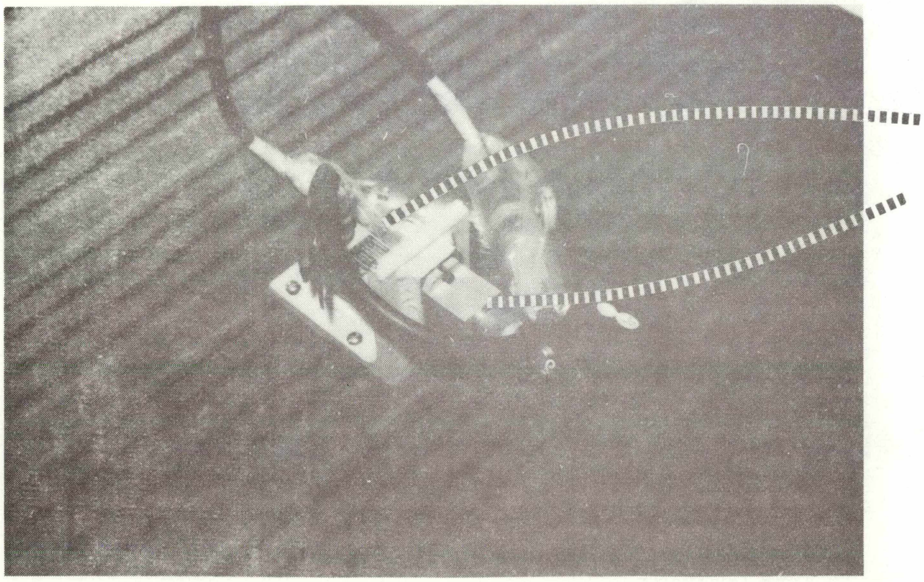

Figure 6-13

Close-up of Lateral and Vertical Accelerometers

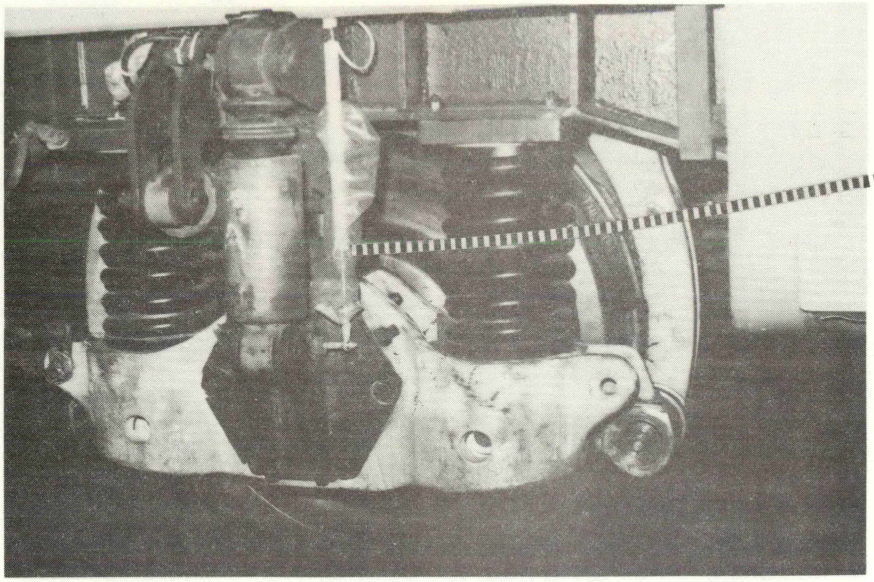

Figure 6-14

Vertical Displacement Transducer

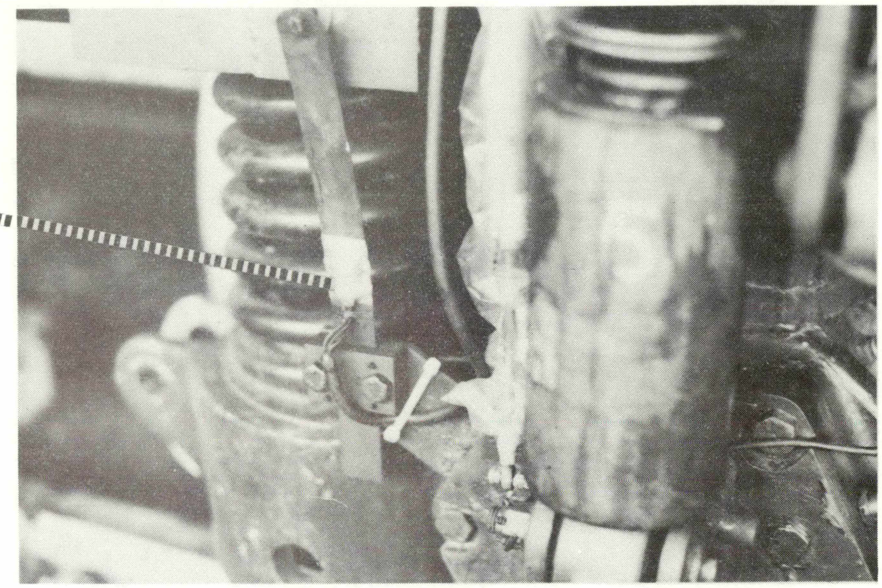

Figure 6-15

Lateral Displacement Transducer

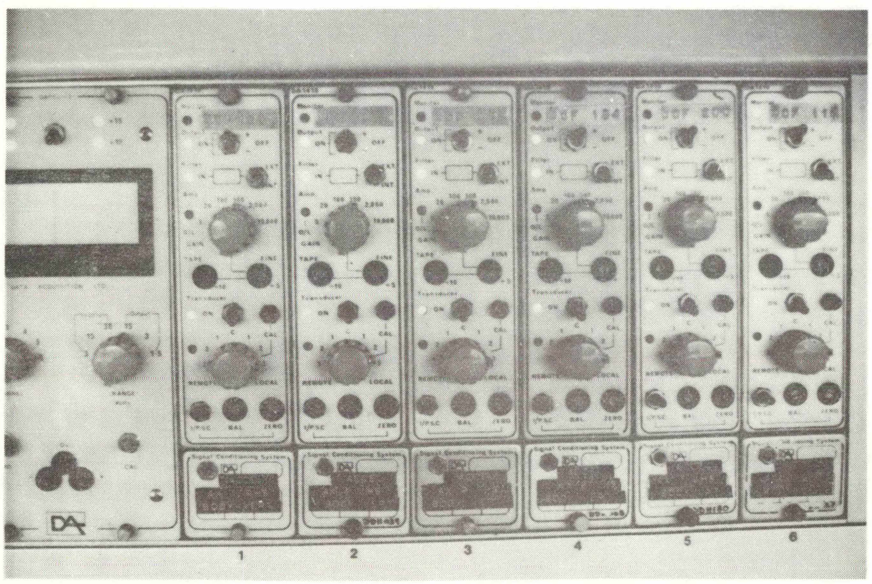

Figure 6-16

Signal Conditioning Units - Channels 1-6

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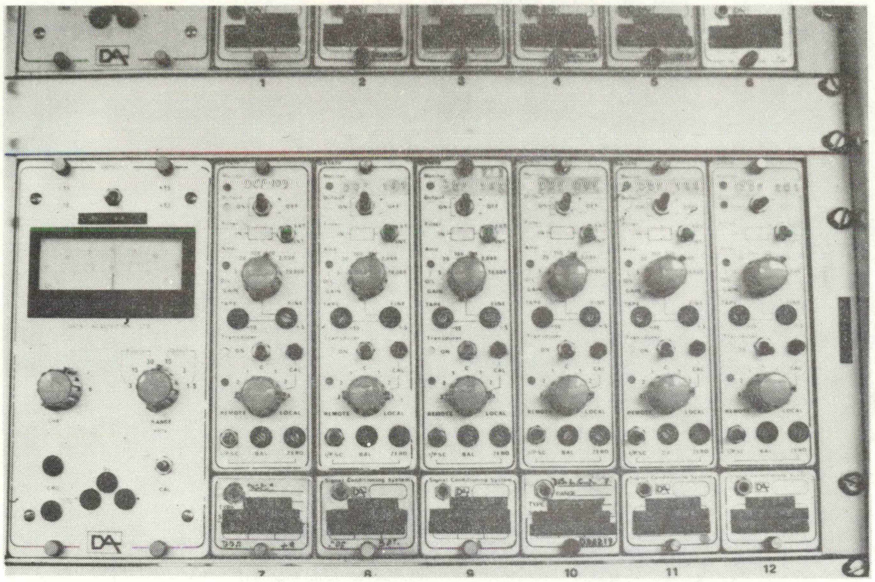

Figure 6-17

Signal Conditioning Units - Channels 7-12

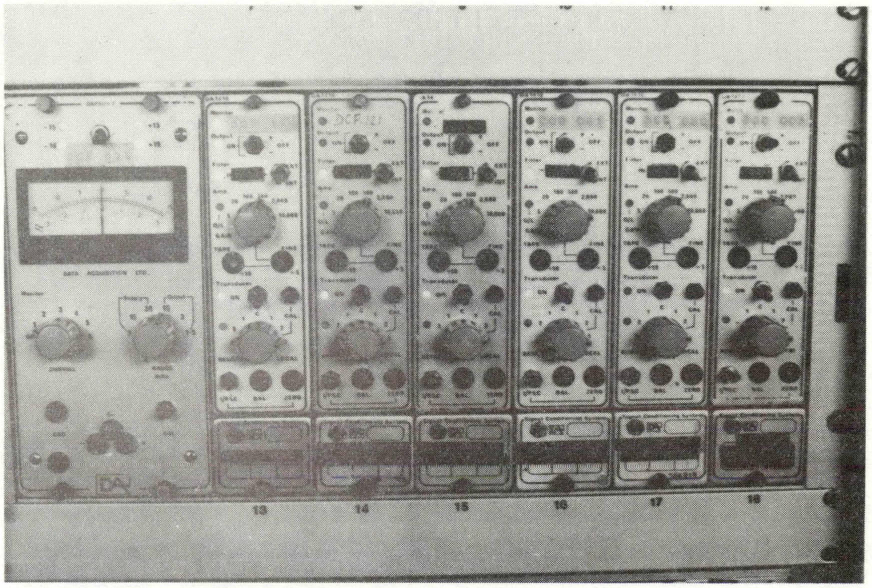

Figure 6-18

Signal Conditioning Units - Channels 13-18

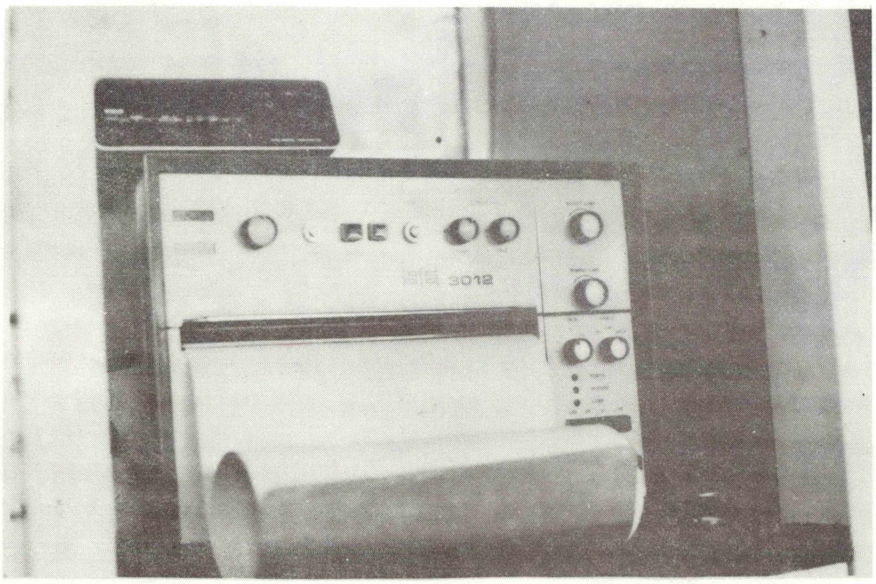

Figure 6-19

Twelve Channel Ultraviolet Recorder

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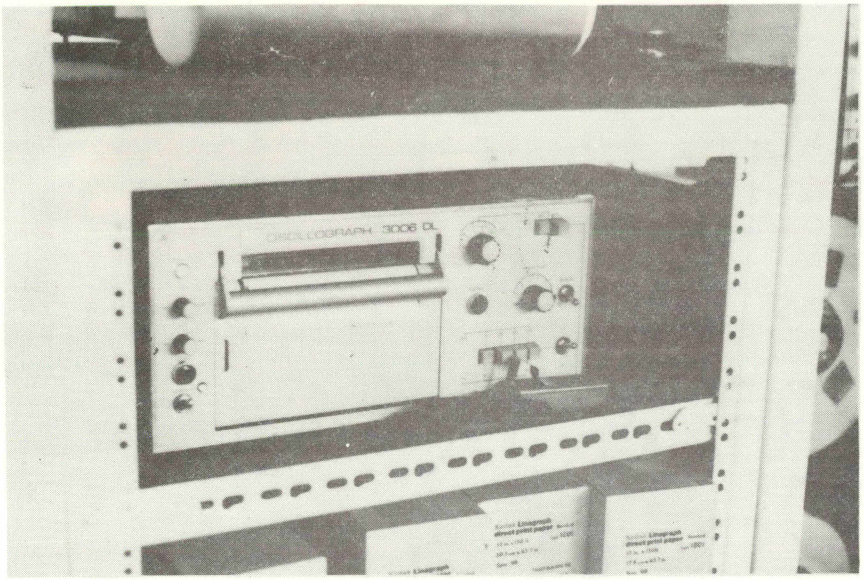
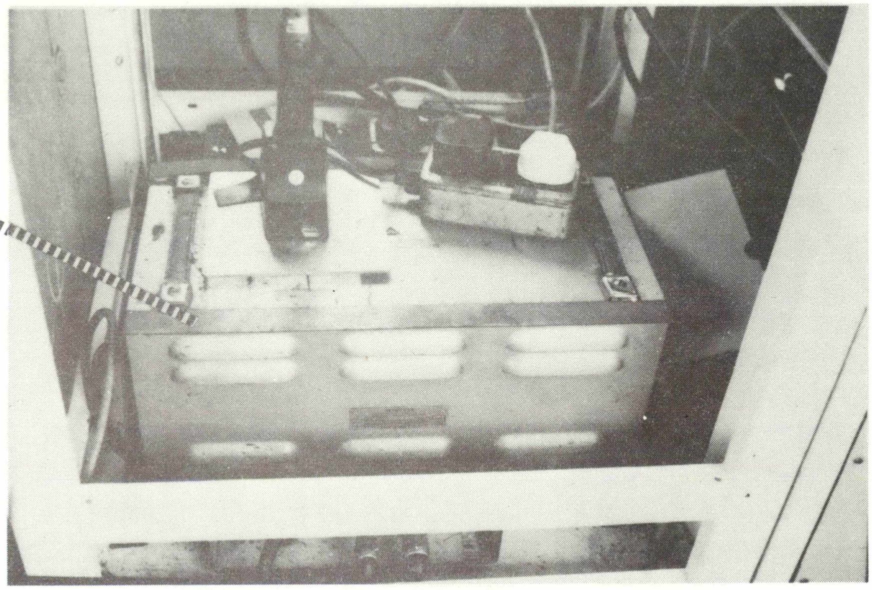


Figure 6-20

Six Channel
Ultraviolet Recorder

Figure 6-21

Inverter



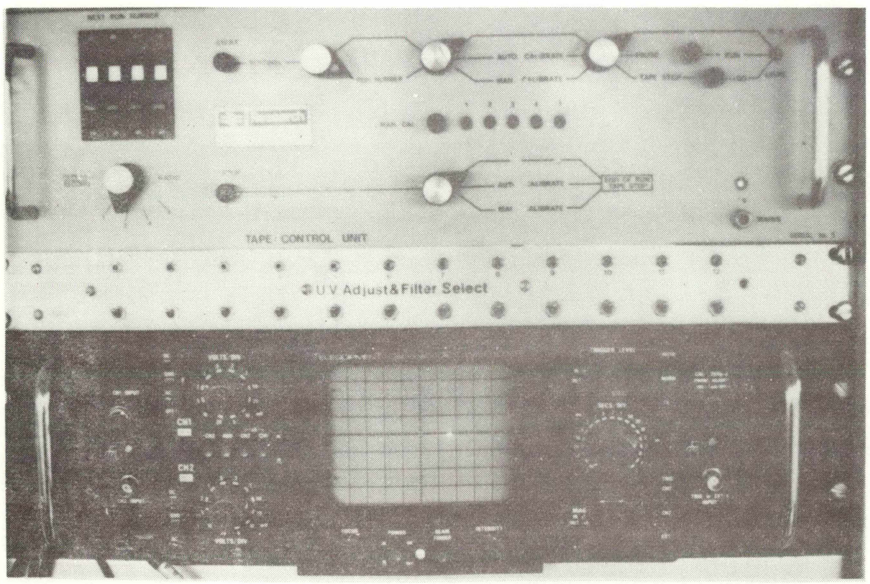


Figure 6-22

Tape Control Unit

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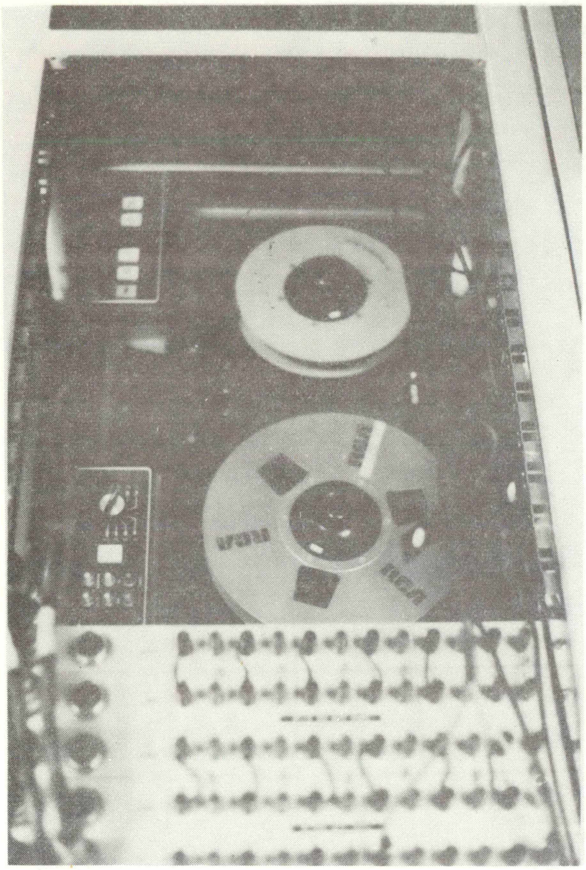


Figure 6-23

Magnetic Tape Recorder

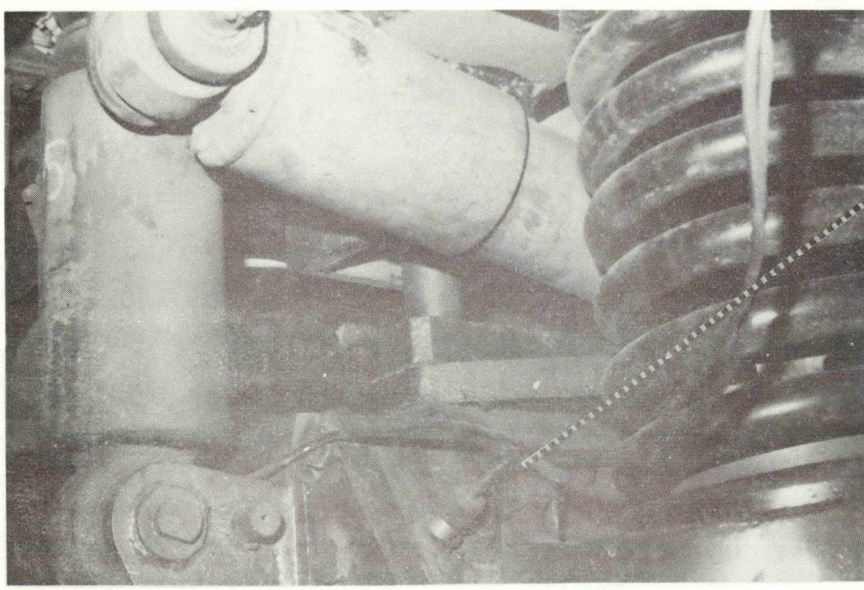


Figure 6-24

Axle-Box Probe

Figure 6-25 Instrumentation Crew

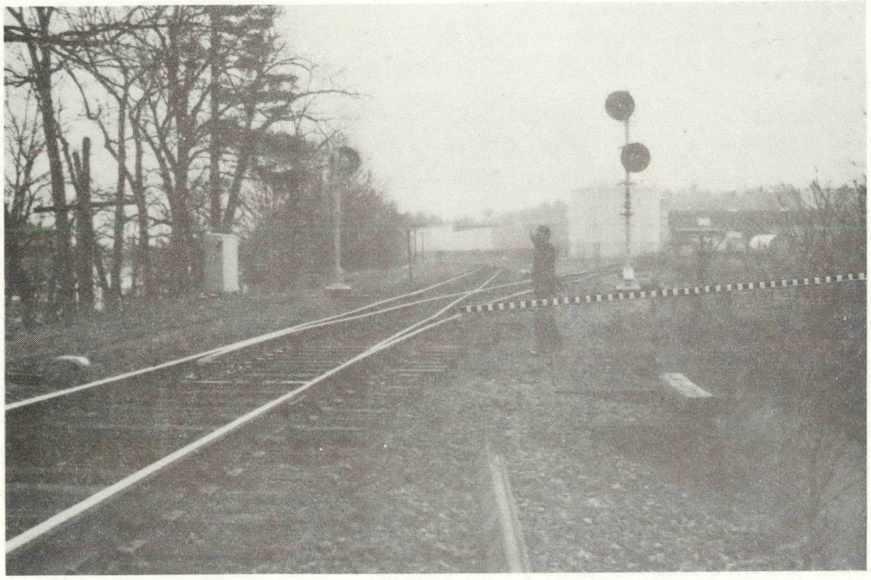


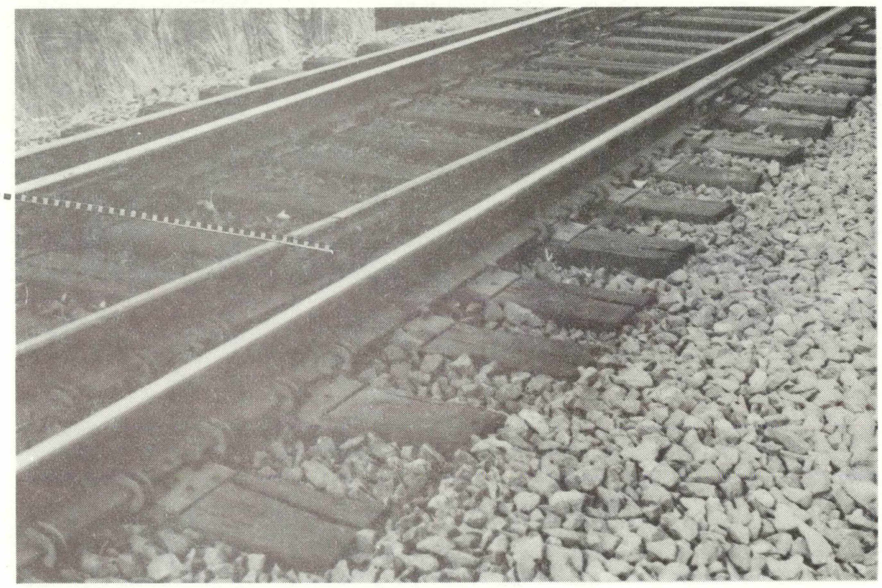
Figure 6-26

Switch at Signal 424

Low ties at insulated joints

Figure 6-27

Low Ties at the Insulated Joints



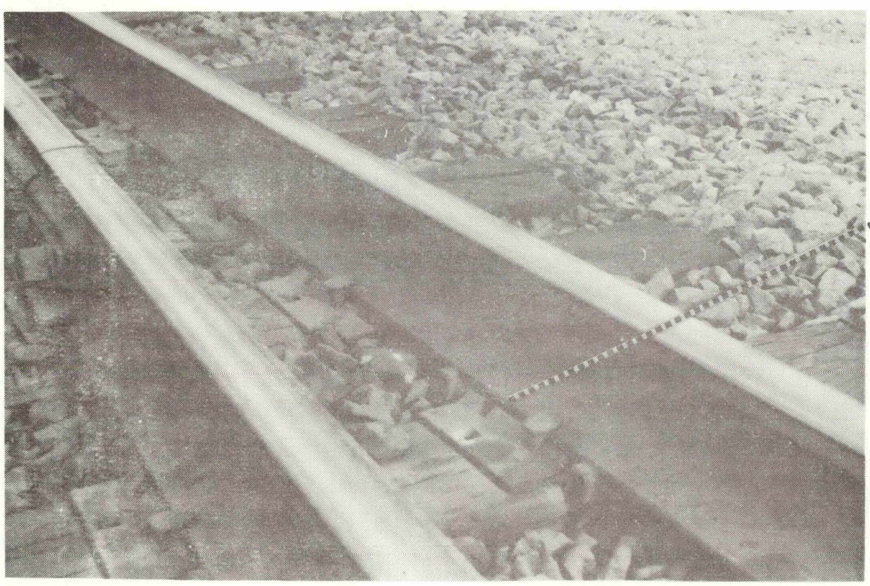


Figure 6-28

Rail above the Tie Plates

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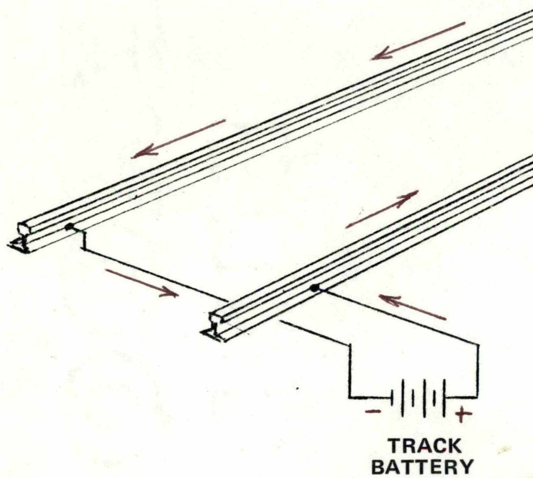
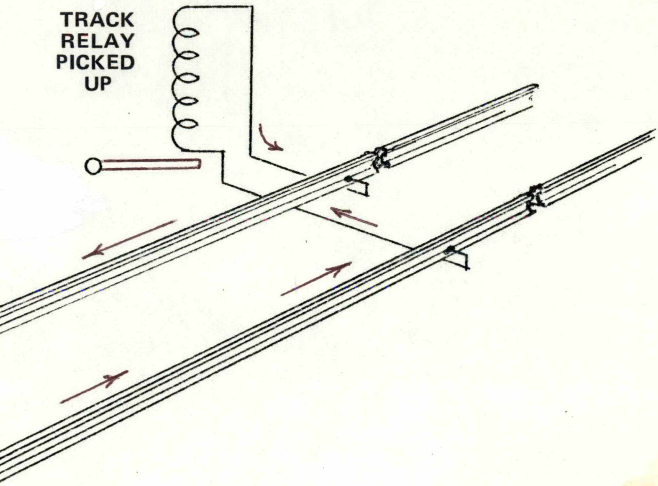
UNOCCUPIED

CURRENT FLOWS THROUGH RAILS OF ENTIRE SECTION FROM BATTERY TO RELAY




TRACK RELAY PICKED UP

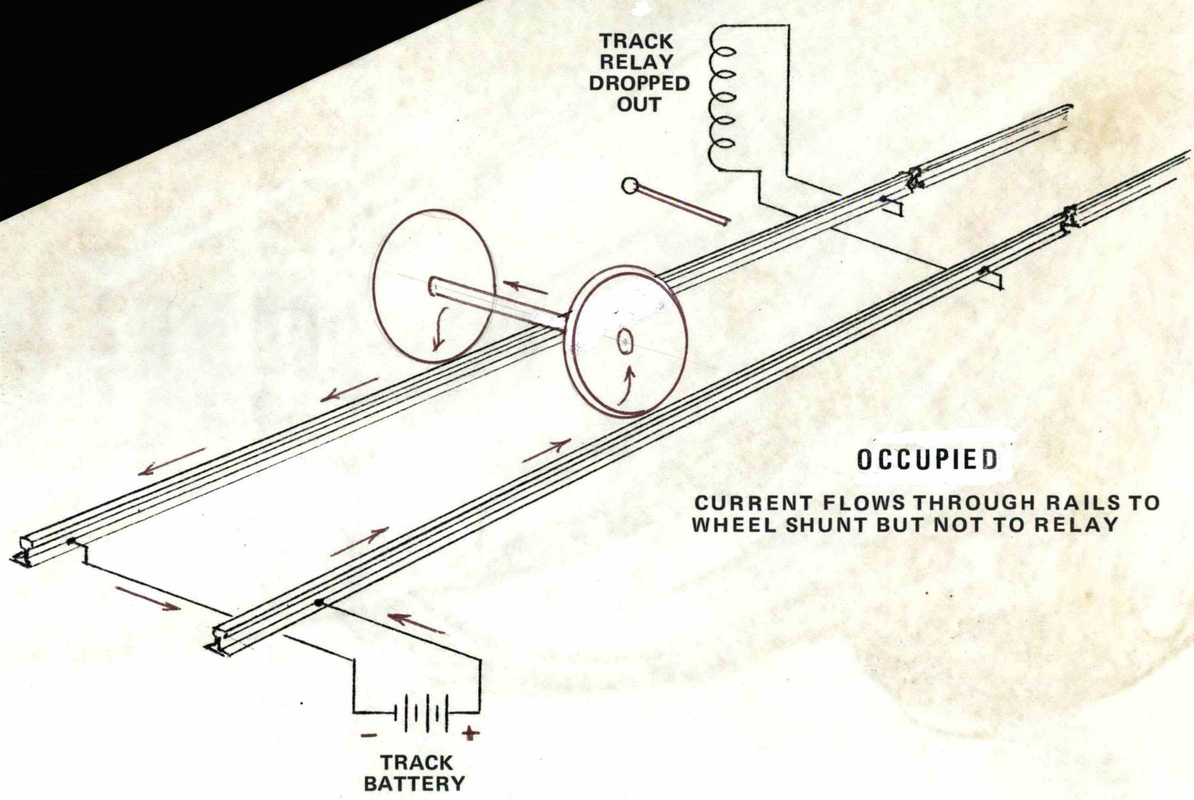


FIGURE 6 – 29
SIMPIFIED TRACK CIRCUIT

APPENDIX A

LEV
OPERATING MANUAL
ISSUE A

R & D DIVISION
DERBY
NOVEMBER 1979

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INTRODUCTION

The Leyland Experimental Vehicle (LEV) is a single power car which has been designed to investigate the feasibility of using alternative body structures and simple suspension arrangements for rail passenger vehicles. The bodyshell, built from Leyland Bus components, is mounted onto a separate rail underframe, designed to withstand appropriate buffing and coupling loads. A two axle suspension arrangement is used , incorporating flexicoil spring and hydraulic dampers.

Power is provided by a Leyland 510 horizontal diesel engine driving a standard DMU type R14 gearbox and RF28 final drive unit. Gearchanges are entirely automatic. Maximum speed is 75 m.p.h.

The braking system incorporates both a direct air brake and a spring applied Parking/Emergency brake. The braking force is applied to the axle mounted tread brakes by means of cables.

Standard LHD bus cabs are provided at each end of the vehicle and each incorporates the necessary driving controls and instruments. However, certain secondary controls such as lights and remote door operation are only available in Cab 1 at this time.

Because of the experimental nature of the vehicle, it is anticipated that vehicle preparation and fault location and rectification will be the responsibility of the Research technical staff who will be in attendance at all times during test running.

VEHICLE DATA

Vehicle Length	12 m (approx 40')
Vehicle Weight	17 tonnes Tare (37 000 lb)
	22 tonnes Gross Laden (48 000 lb)
Vehicle Width	2.5 m (8'2.1/2")
Height over Heater Pod	3.9 m (12'10") ARL
Maximum Permitted Speed	120 km/h (75 m/h)
Engine Power	149 kW (200 h.p)
Braking Rate (Service and Emergency)	6.1/2% g
No of Axles	2
Axles Powered	1
Doors	2 Double Folding Leaf
Door Actuation	Electrically From Cab Locally by air operated buttons
Compressor	15 cu ft/min
Alternator	100 Amps, 24 Volts

BRIEF TECHNICAL DESCRIPTION

(POWER AND TRANSMISSION):- (See Fig. 2)

The engine is a Leyland 510 horizontal diesel engine with a nominal rating of 200 h.p. Engine power is controlled by air pressure derived from a fully variable hand valve mounted in each cab. An engine driven compressor, alternator and hydraulic pump are included. The cooling system comprises a horizontally mounted radiator and thermostatically controlled, hydraulically driven cooling fan.

The engine output power is coupled to the gearbox via a fluid clutch and freewheel shaft. The fluid clutch is similar to the fluid flywheels used on most DMU vehicles but includes a centrifugal mechanical clutch to give a direct mechanical drive at high engine speeds. Two fuel tanks are provided with a total capacity of 95 gals.

The gearbox is a standard DMU R14 type but gearchanges will be made automatically. This is achieved by a control unit, mounted behind the driving cab which measures vehicle speed and initiates gearchanges at pre-determined times. The only gearbox control provided is a FORWARD-NEUTRAL-REVERSE switch mounted in the cab.

The final drive unit is a standard DMU RF28 type but with a modified gear ratio.

THE AIR SYSTEM

The engine driven compressor simultaneously feeds four reservoirs via a condenser unit and unloader valve. Reservoir pressure varies between 105 and 120 p.s.i. An alcohol evaporator is included to prevent icing in the air system during freezing weather. Separate reservoirs are provided for the front axle service brakes, the rear axle service brakes, the spring brakes and the auxiliary systems. The auxiliary reservoir supplies feeds for the gearbox and reversing controls, doors, windscreen wipers and washers and the horns.

THE BRAKE SYSTEM

An actuator located near each axle applies brake force to the axlebox mounted tread brake units via heavy duty Bowden type cables. The actuators are of the combined service brake/spring brake type. For the service section, hand brake valves, fitted in each cab apply air pressure to the actuators via relay valves. The spring brake section is used for parking and emergency use and is controlled from a hand valve fitted in each cab. Standard through air pipes are fitted for those occasions when the LEV is being towed as part of a train and connections can be made between these and the vehicle braking system to allow the vehicle to be automatically braked under emergency conditions.

ANCILLIARY SYSTEMS

The LEV is fitted with the following ancilliary systems:- Drivers Safety Device, Fire Prevention System, Pressure Ventilation and Heating Supplementary Water Heater, Wheel Slide Protection, Air Operated Doors, Petrol Driven Alternator Set for Instrumentation Power Supplies and Power cut-off

DRIVING CAB CONTROL LAYOUT

Plan views of the cab layout are shown in Fig. 5 and Fig. 6. The drivers seat is adjustable for fore and aft movement, height and backrest slope. The seat can also be swivelled to allow easier access to the cab. An opening light is fitted at the left hand side and an adjustable sun visor can be pulled down over the top part of the windscreen.

Battery Isolating Switch - CAB 1 ONLY

This switch is located behind the drivers seat and isolates all electrical power from the battery to the vehicle electrical systems. When switched on, the following systems can be energised:- External Running and Headlamps, Internal Saloon Lights, Instrument Lights, Supplementary Water Heater.

Master (Ignition) Switch:-

The master switch is a heavy duty version of the combined ignition and starter switches fitted to most modern cars and has four positions, STOP, OFF, ON and START. The OFF position is when the key is in the fore and aft position, and can be inserted or removed. The ON position, which switches on the remaining vehicle electrical systems not energised by the Battery Isolating Switch, is obtained by rotating the key clockwise. The START position is obtained by rotating the key further clockwise against spring pressure. In this position the starter motor is operated and when the key is released, it will return to the ON position. The engine can be stopped by rotating the key anti-clockwise from the OFF position against spring pressure.

On releasing the key, it will return to the OFF position. Note that should a key be already switched to ON in Cab 2, operation of Cab 1 Master Switch is rendered ineffective, and vice versa.

Engine Throttle Control

Engine power is air controlled and operated by this variable output, quadrant type hand valve. Engine idle position is in the forward position and the control must be pulled back to raise engine speed and power. Note that it will not be necessary to release the throttle during gearchanges. Note also that the control in Cab 2 is still operative whilst Cab 1 is in use and vice versa.

Parking/Emergency Brake Valve

The parking brake is of the spring type such that air pressure must be applied to the actuator unit in order to overcome the spring application and so release the brakes. Brakes released position is handle of the quadrant type control forward and brakes applied is with the handle back. In order to prevent accidental application, spring pressure within the valve must be overcome in order to apply brakes, the handle being kept in the fully applied condition by a mechanical latch. Because the spring brake has a similar brake force rating to the service brake, it can be used as an emergency brake. Note that whilst cab 1 is in use, Cab 2 Parking/Emergency Brake Valve is deactivated.

Service Brake Valve

The service brake is of the direct air type and is controlled by a hand valve mounted to the right hand side of the console. The control is of the rotary type and the brakes released is with the brake handle fully anti-clockwise. Clockwise rotation of the brake handle gives graduated increases in brake force up to maximum after approximately 90° movement. Note that the Service Brake Valve in Cab 2 is still operative whilst Cab 1 is in use and vice versa.

Forward-Neutral-Reverse Switch

This rotary type switch is mounted in the centre of the console. With the switch pointer in the Neutral position, the transmission system is de-activated by turning the switch to the Forward position, the vehicle will move cab forward on application of the throttle control. Assuming sufficient throttle is applied, the vehicle will accelerate to maximum speed without further alterations of control positions by the driver. With the switch in the reverse position, the same sequence will follow in reverse. Note that this control is de-activated in Cab 2 when Cab 1 is in use and vice versa.

Speedometer:-

A speedometer is fitted in the centre of the console and has a range of 0-80 m/h.

Air Gauges:-

2 double air pressure gauges are fitted on the console. They monitor Front Service Brake Reservoir, Rear Service Brake Reservoir, Spring Brake Reservoir and Applied Service Brake Pressure. Under normal conditions, the 3 reservoir gauge needles should be pointing approximately vertical with pressure readings of 105-120 p.s.i. (7-8 bar approx). The applied brake pressure gauge will read to a maximum of 80 p.s.i. Note that this gauge will only indicate the application of the adjacent service Brake Valve.

Horn:-

Standard BR type air horns are fitted controlled from a standard two position horn control mounted in the centre of the console.

Door Controls - CAB 1 ONLY

Each of the two doors can be separately controlled from the cab and two pairs of switches are provided on the left hand side of the console.

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Pressing a Red button opens the door and the Black button closes the door. In addition, emergency buttons are provided at each door position, to the side of the door externally and above the door internally.

Light Switches - CAB 1 ONLY

Light switches are mounted on the left hand side of the cab. The switches are slightly unusual in that each switch has a Red button and a Black button and the two are mechanically interlocked. Pressing the Black button down causes the Red button to rise and the appropriate lights to switch on. Pressing the Red button down causes the Black button to rise and the appropriate lights to switch off.

Running Lights - Forward:-

Gives two white lights at CAB 1 end and one red light at CAB 2 end.

Running Lights - Reverse:-

Gives one red light at CAB 1 end and two white lights at CAB 2 end.

Step/Panel Lights:-

Illuminates the door step wells and the instruments

Saloon Lights:-

Each switch controls half of the fluorescent lights in the vehicle.

Headlights:-

Either CAB 1 end or CAB 2 end headlights can be used when required.

Warning Lights:-

Rectangular shaped warning lights mounted on the console give warning of Low Oil Pressure, Low Charge, High Coolant Temperature, Low Air Pressure, Handbrake Applied and Door Open. In addition, a buzzer may sound under certain conditions.

Warning Light Test Switch - CAB 1 ONLY

This switch, when pressed, illuminates those warning lights which are not normally illuminated before the engine is started, to test the lamp filaments. Note that operation of this switch illuminates warning lights in both cabs simultaneously.

Cold Start Switch:-

This is used before attempting to start the engine, particularly in cold weather. Pressing the switch causes a small quantity of fuel to be vaporised in the engine inlet manifold and so assists starting. Generally the switch should be pressed for about 15 sec prior to starting and released when engine fires.

Drivers Safety Device:-

Cab 1 - A standard foot pedal is mounted on the cab floor and must be depressed at all times when Forward or Reverse are selected. If necessary the system can be isolated by turning the switch mounted under the tray to the right hand side of the console. The switch is in its normal position when the pointer is vertical and isolated when rotated 60^{o} clockwise.

Cab 2 - The Fott pedal is a standard bus throttle pedal and should be depressed until a "click" is heard or Felt. Isolation arrangements as Cab 1 except that the switch is a key operated type.

NB:- The Drivers Safety Device is coupled to the Parking/Emergency Spring Brake. This brake can only be released when a key has been inserted in either cab and switched to ON, thus providing an electrical Feed for the EP valve. (However see Towing Instructions later).

Windscreen Washer/Wiper:-

This control is mounted to the left hand side of the cab.

Intercom:-

This connects with a similar unit in the other cab. Press Green button to sound buzzer and Red button to talk.

Heater Control - CAB 1 ONLY

The LEV heater system comprises two heater packs mounted in the roof. Engine waste heat is pumped to the heaters and air blowers draw air through the heater matrices and into the saloon via ceiling mounted ducts. During warm weather, the water supply is cut off and ventilation only is provided.

In addition, a Webasto Supplementary Water Heater may be used to provide saloon and engine pre-heating and also to supplement engine waste heat output during very cold weather.

a) Operation with Supplementary Heater Switch OFF:-

Switch on Heater Blowers suing switch mounted on right hand side of control console. Blowers will operate when engine temperature is above 42^{o}C (108^{o}F)

b) Operation with Supplementary Heater Switched ON :-

Switch Supplmentary Heater on using switch mounted on left hand side above throttle control. Heater will operate whenever water temperature drops below 75^{o}C (167^{o}F) as indicated by illumination of the green sector on the timer unit. The Heater Blower switch (as a) above) can be left in off position whilst Supplementary Heater is in use. To switch off, return switch to OFF/TIMER position. Note that heater pumps run for 15 secs before heater ignition and 150 secs after switch off.

c) Operation of Supplementary Heater Using Timer:-

Ensure that Heater Blower switch is OFF. If immediate switch-on is required, turn the regulating handle on the timer clockwise beyond the green sector, then back to the right hand edge of the green sector. The green sector will be illuminated and the heater will run for 1 hour and then switch off automatically.

If delayed switch on is required, turn the rotating dial plate so that the graduation equivalent to the current time of day is coincident with the right hand side of the green sector. Rotate the regulating handle clockwise so that it points to the time of day required for switch on. The heater will then switch on at that time and run for 1 hour and then switch off automatically.

Notes on operation:-

1) For all heater operations, the battery isolating switch must be operated. Particularly when timer has been set overnight, ensure that no lights or other systems are switched on.

2) The blower motors in the roof mounted heaters consume nearly 50 Amps of battery current. Therefore ensure that the heating system is not run continuously for long periods without the engine being run.

3) Until further notice, operation of the supplementary heater will be the responsibility of technical staff only.

2. Check that the Driver Safety Device isolating switch is in the Normal position.

3. Carry out brake tests as follows:-

   a) Chock wheels to prevent vehicle movement

   b) Release Handbrake - Check visually that brake blocks are released.

   c) Apply cab service brake - Check visually that brake blocks are applied. Release cab service brake.

   d) Repeat c) in other cab

   e) To check operation of Drivers Safety Device, switch Direction Selector Switch to FORWARD. Note brakes are applied. Depress foot pedal and note brakes are released. Return Direction Selector Switch to NEUTRAL

   f) Apply Handbrake - Note visually that brake blocks are applied. Remove chocks from wheels.

To Proceed in the Forward Direction.

1. Check that the Handbrake is ON

2. Apply the Service Brake and release the Handbrake

3. Turn the Direction Selector Switch to FORWARD after depressing the foot pedal.

4. Release the Service Brake and open the Power Control gently. The vehicle will accelerate forward. The degree of power to be applied, particularly at low speeds, will be dependant on adhesion conditions. In general, above 1st gear, no adhesion problems are expected. Gearchanges will occur at approximately 16, 30, and 45 m/h but no action is required on the part of the driver. Note that under certain conditions, change up speeds may be altered by technical staff to approx 14, 26 and 40 m/h.

5. When required to stop, the Service Brake should be operated as necessary.

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VEHICLE PREPARATION - SELF PROPELLED OPERATION

Instructions apply to either cab except that certain controls are available in Cab 1 only.

To Start Engine:-

1. Check position of the following controls before attempting to start the engine:-

   Handbrake - ON

   Direction Selector Switch - NEUTRAL

   Service Brake Controls - RELEASED (Both Cabs)

2. Switch on Battery Isolating Switch. (In CAB 1) Switch Master (Ignition) Switch to ON.

   Check that the Oil Pressure and Charge Warning Lights are lit.

   Check remaining warning lights by pressing Test switch. (In Cab 1)

3. Press Cold Start switch for 15 sec.

4. Rotate Master Switch to START position. Engine should crank on Starter Motor. Release when engine has started. Release Cold Start switch.

5. Should engine fail to start after 5 sec of cranking, release starter switch and repeat Cold Start sequence. Note that after each attempt to start, the starter mechanism is automatically disabled for approximately 7 sec to allow the starter motor to stop. It should not be necessary to use the Cold Start switch when engine is hot or warm.

Before attempting to move:-

1. Check that all air gauges are up to the normal working pressure. If necessary the engine power control may be used to raise engine speed and so hasten this process. Check that air warning light is out.

6. In the event of no response from the Service Brake, the Parking/Emergency control should be operated to bring the vehicle to a halt, using the spring brake.

To Propel in the Reverse Direction

1. Check that the Handbrake is ON
2. Apply the Service Brake and release the Handbrake
3. Position a suitable member of staff in the other cab to act as Lookout and operate the service brake.

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VEHICLE PREPARATION - OPERATION UNDER TOWED CONDITIONS

Brakes:-

The LEV is fitted with standard BR through air pipes comprising Brake pipe (RED) and Reservoir pipe (YELLOW). Three valves are located in the battery compartment under Cab 1 (See Fig. 4). The Auxiliary Air Supply Valve allows the Reservoir pipe to be connect to the LEV air system. The Service Brake Isolating valve allows the LEV service brake to be isolated whilst being towed. The Spring Brake Control Valve allows the 72 p.s.i. normally present in the Brake to maintain the spring brakes in the released position. All three valves are marked "Self-Propelled" or "Towing Position". A fourth valve, mounted in a cupboard adjacent to Cab 1, allows the Brake Pipe to be exhausted under emergency conditions. Directions are painted on the outside of the cupboard door.

Note that when running as a towed vehicle, a normal automatic air brake actuation, resulting in a reduction of brake pipe pressure from 72 p.s.i. to 48 p.s.i. will cause only a slight application of the LEV spring brakes. However, an emergency application or vehicle breakaway will cause a full application of the LEV spring brakes.

Drawbars:-

LEV is fitted with the provision for three types of drawbar coupler.

a) Centre bar coupler :- This type is fitted on the top tailpin and bolted to the mating part as per Freightliner practice.

b) Hook type coupler:- One end fits to the tailpin and other fits to a standard locomotive hook. It is sometimes necessary to remove the locomotive shackle to achieve this.

c) Tightlock type coupler:- A modified version of this coupler can be fitted to the LEV between the top tailpin and the lower bracket assembly.

APPENDIX

LIST OF EQUIPMENT CARRIED ON LEV

1. Fixed equipment

   Fire protection system
   Fire extinguishers (2)
   First aid box
   Detonators and red flags
   Track circuit clips (2)

2. Loose equipment

   Tail lamp
   Emergency coupler
   Tool kit
   Crowbar

Check that equipment appropriate to the run is being carried prior to starting.

Final Drive Isolation:-

Before towing it is necessary to isolate the final drive unit mechanically. This is accomplished by pulling the isolating handle out (on Final Drive Unit), rotating 90°, and dropping it back into the deeper slots in the casing. At this point, the locking bar will not fall right down into its slot. Switch on battery isolator and insert key and switch ON. Switch drive successively from Neutral-Forward-Neutral-Reverse until the locking bar drops into its slots. Note that an air supply is required to operate the change direction mechanism and this operation is best done with the engine running or soon after the engine has been stopped.

PROCEDURE:-

1. Isolate final drive unit
2. Couple LEV to locomotive using appropriate drawbar and couple air pipes. If a reservoir pipe is not available it may be necessary to latch the LEV doors as they normally require an air supply to keep them closed.
3. Turn the three valves in Cab 1 battery compartment to Towing Position.
4. Carry out standard brake test using brake pipe valve at non-coupled end of LEV. Check that locomotive and LEV brakes operate. Repeat using emergency brake valve on LEV.
5. Train is ready to proceed.

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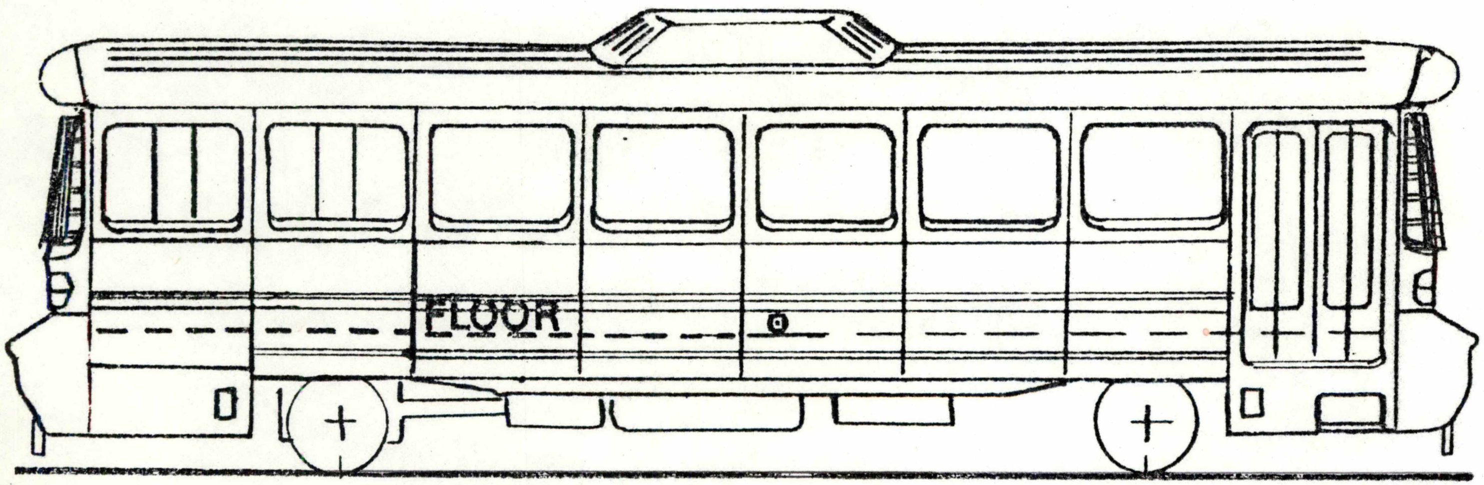
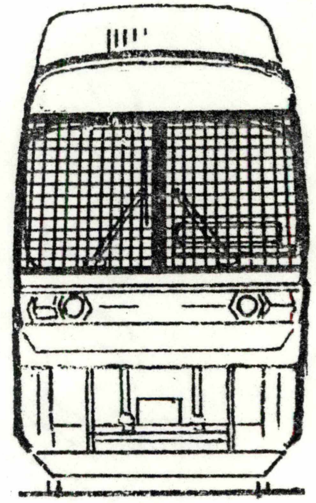
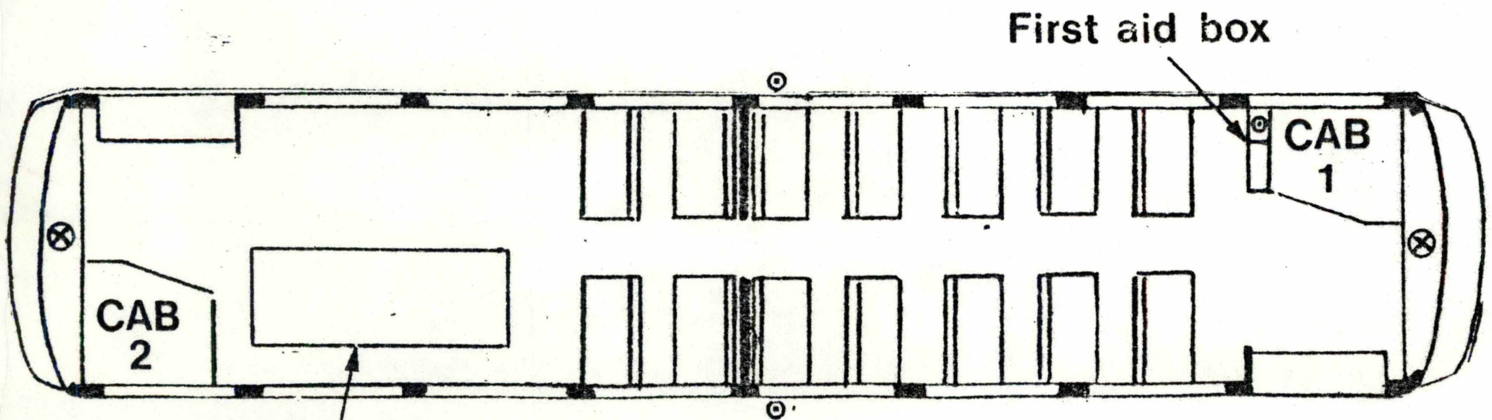
12 m. EXPERIMENTAL VEHICLE

Fig. 1





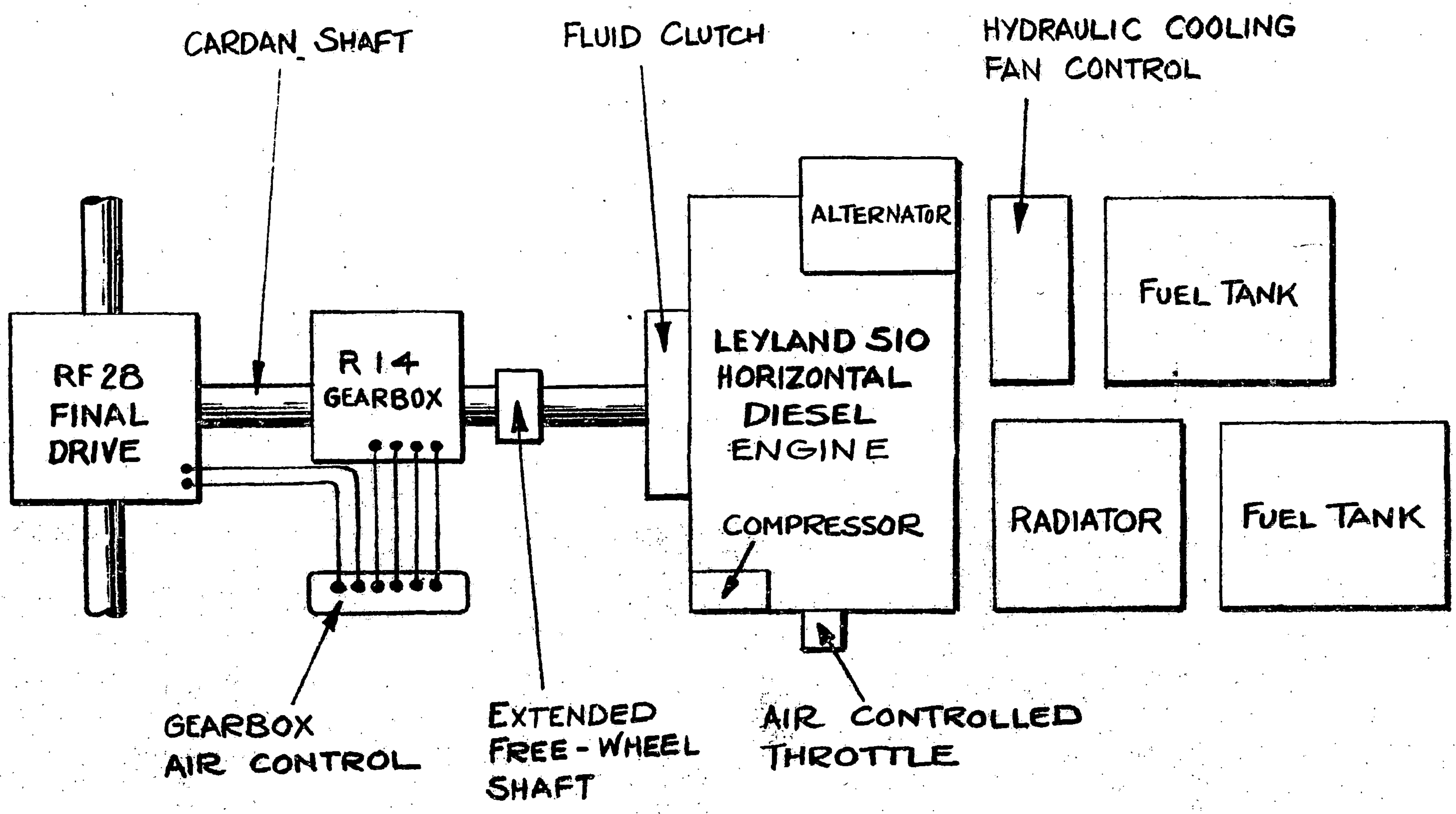


⊗ Fire extinguisher

⊙ Engine fire system switch

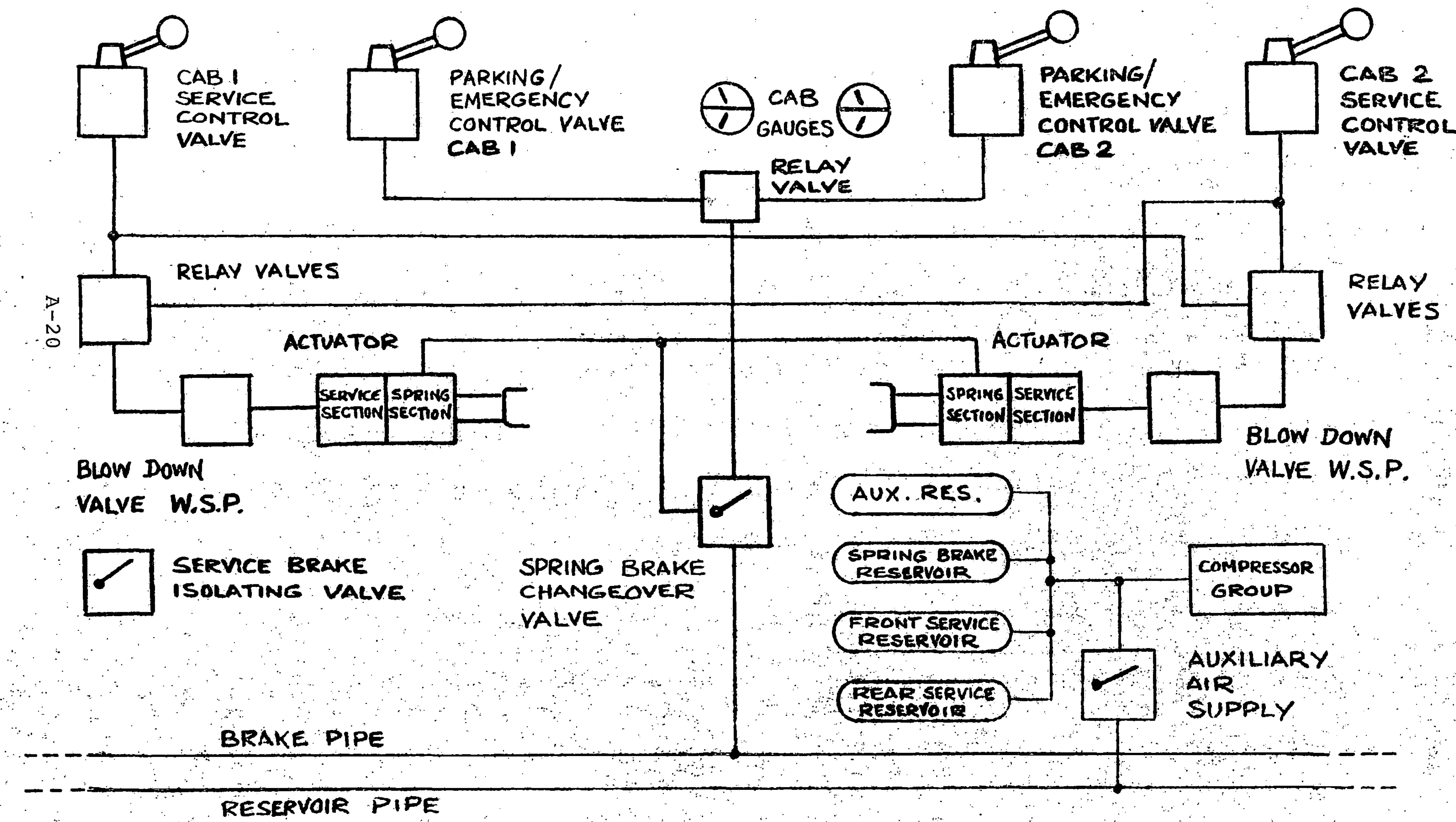
ENGINE AND TRANSMISSION LAYOUT

Fig. 2



BRAKE SCHEMATIC (SIMPLIFIED)

Fig.3



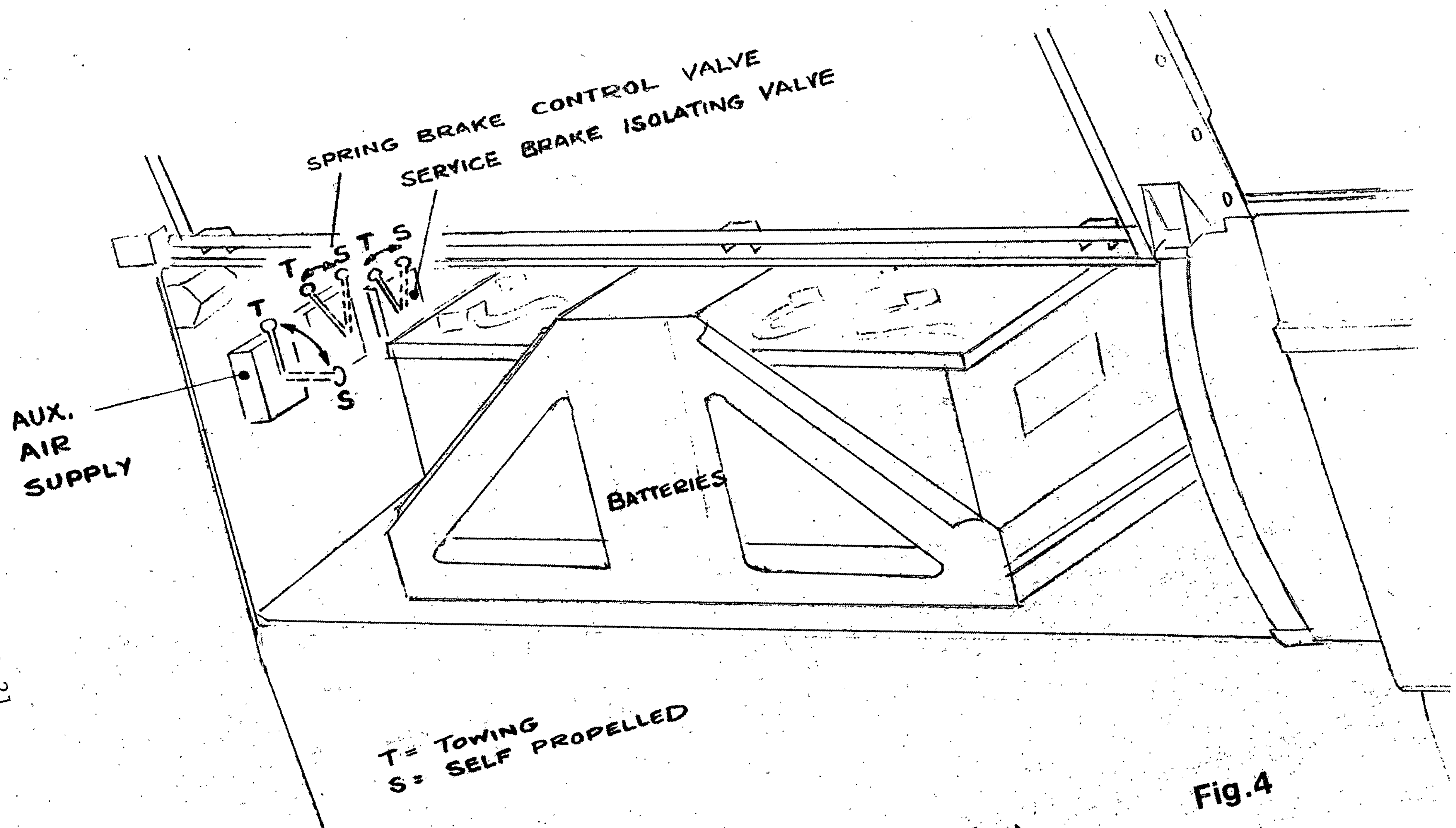
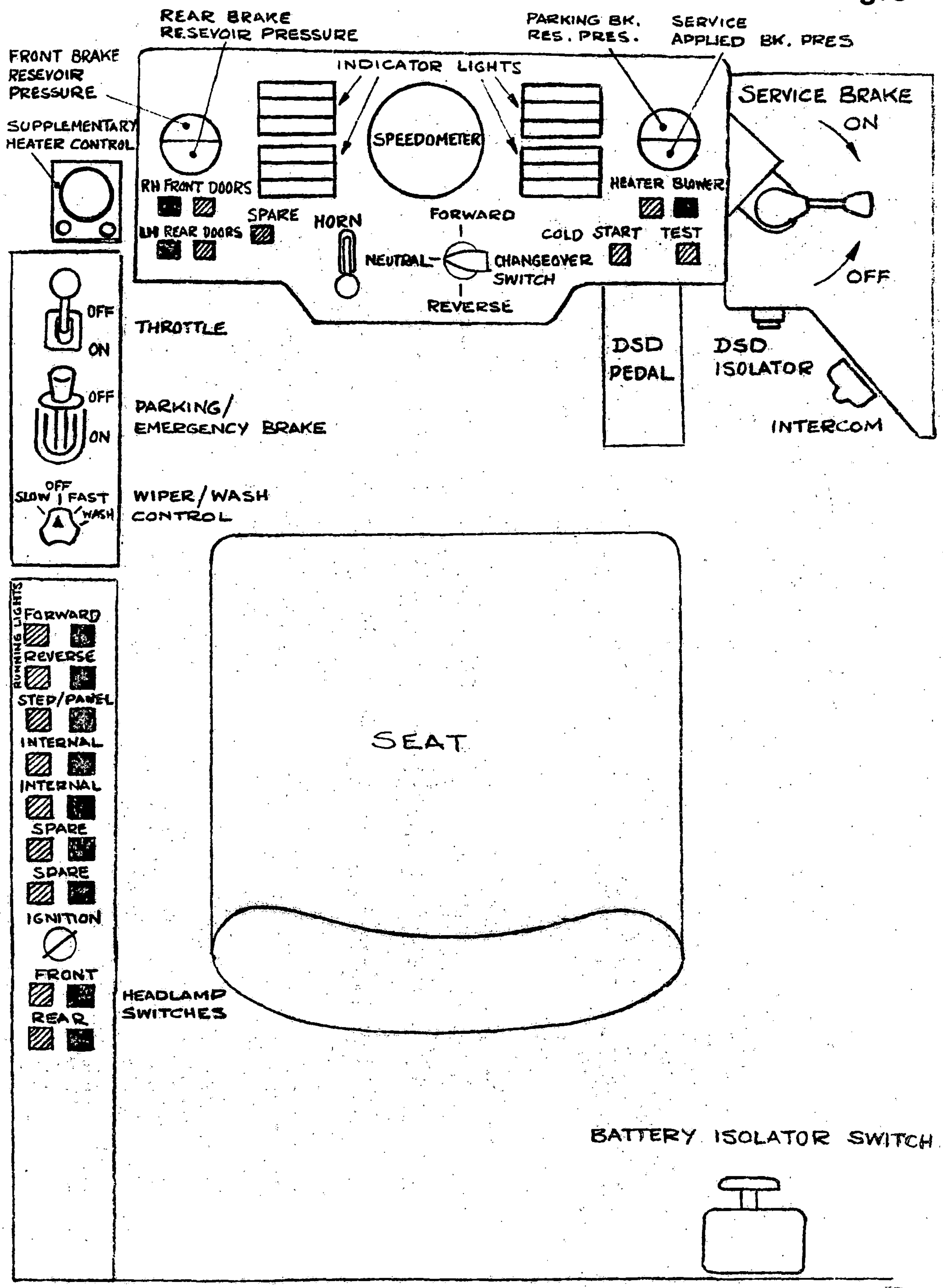


Fig.4

BRAKE SYSTEM CHANGEOVER VALVES (Under cab 1)

CAB 1 LAYOUT

Fig.5

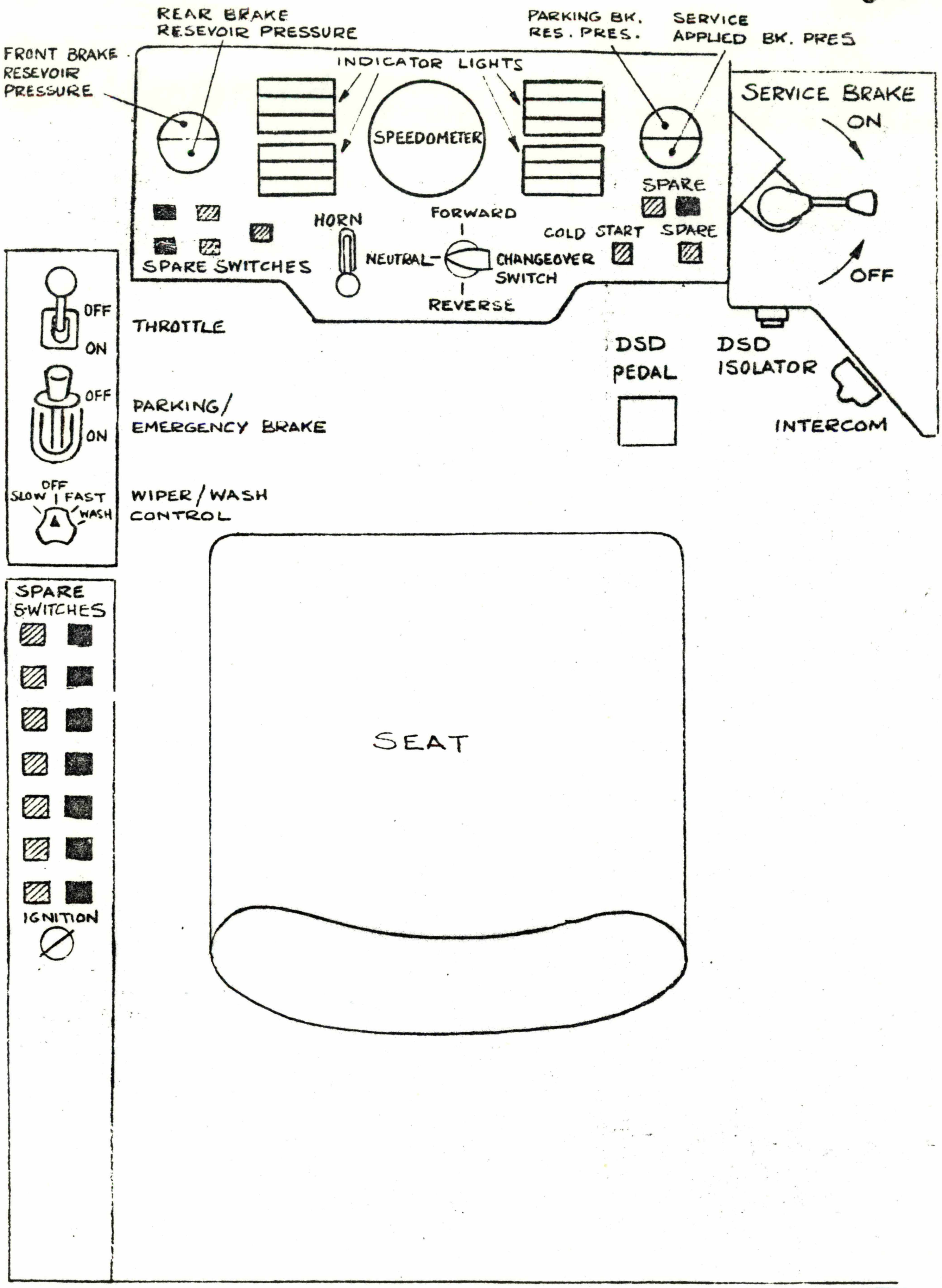


ON SWITCH (BLACK)

OFF SWITCH (RED)

CAB 2 LAYOUT

Fig.6



■ ON SWITCH (BLACK)

▨ OFF SWITCH (RED)

RailBus Test Observations on the Boston and Main Railroad, January to February 1980, US DOT, FRA, BT Hawthorne, RB Watson, 1980 -23-
Passenger Operations