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LOCOMOTIVE CAB DESIGN DEVELOPMENT
Volume IV: Recommended Design

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INTERIM REPORT

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16. Abstract
This report presents a synopsis of the background analyses leading to the design of a line haul locomotive crew compartment. The design was incorporated into a full scale mockup which was evaluated by a nationwide representation of locomotive engineers. The report includes an analysis of these evaluations and identifies those areas of the original design that are recommended for design refinement. Specifications are included for the design being recommended as a nationally acceptable crew station for line haul freight locomotives.

The reports in this series bear the general title: Locomotive Cab Design Development. The preceding volumes are:
Volume I: Analysis of Locomotive Cab Environment and Development of Cab Design Alternatives,FRA/OR&D-76/275.I,October 1976,206 p. PB-262-976.
Volume II: Operator's Manual,FRA/OR&D-76/275.II,October 1976,42 p. PB-264-114.
Volume III: Design Application Analysis,FRA/OR&D-76/275.III, October 1976,82 p. PB-264-115.
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PREFACE

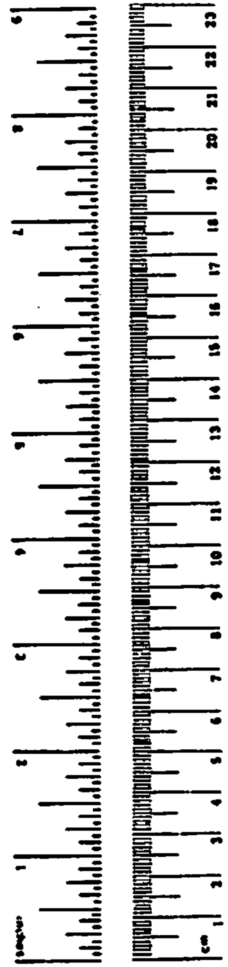
The purpose of Contract DOT-TSC-1330 is to extend and complete work initiated under Contract DOT-TSC-913. The total effort is aimed at the development of a locomotive design based on functional requirements derived from locomotive systems management and train handling experience, which will best provide a safe, efficient and habitable working environment. This document is a summary of the work performed under the contract spanning the period October 1974 through September 1977.

The author would like to acknowledge the assistance received during the study from John Jankovich, Donald Devoe, and Anne Story of the Transportation Systems Center; Norman Macdonald of the Electro-Motive Division of General Motors; the joint industry/labor/Government Locomotive Control Compart Committee; Edward McCulloch and the Brotherhood of Locomotive Engineers; Marshall Sage and the United Transportation Union; Frank Danahy and the Members of the Association of American Railroads; Mr.Joseph Spreng of ConRail and Mr. William McLean, Program Manager, Boeing Vertol, and all of the engineers, supervisory, and management personnel who have critiqued the design during various phases of development.

METRIC CONVERSION FACTORS

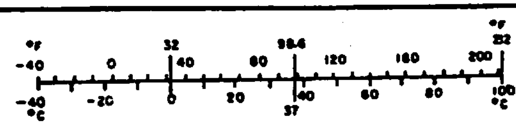
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1. EXECUTIVE SUMMARY

This report presents a design for a railroad locomotive cab that can satisfy the functional requirements for locomotive and train control until at least the year 1990.

Although railroad carriers and manufacturers are continually improving the safety and efficiency of train control by modifying and refining various features in current locomotive cabs, the Federal Railroad Administration has attempted to foster a significant advance in cab concepts by starting anew, forgetting present designs and traditional equipment. Therefore, this report represents the efforts of the Boeing Vertol Company to study the requirements of locomotive crew members – the information and control capabilities needed to handle the locomotives and trains expected to be operating on U.S. railroads during the next fifteen years and the protective and comfort features needed to assure safe location, and to design the controls, displays, and workplace best judged to fulfill these requirements.

This report presents the final recommended cab design. Two appendices document the extensive evaluation of a mockup of the cab by fifty experienced locomotive engineers and the modifications to the original design resulting from this evaluation.

The design was accomplished via the following sequence of steps:

- System analysis of the overall functions of a locomotive
- Analysis of the tasks of locomotive crew members
- Human factors analysis of crew station requirements
- Design development
- Support studies
- Preliminary design
- Mockup evaluation
- Recommended design.

The system analysis identified the missions that trains will be performing during the next fifteen years and the operational, geographic and climatic conditions under which they will be performed. Literature was reviewed, experts were consulted, operations were observed, and the information thus obtained was systematically analyzed and interpreted. As a result of this analysis, the decision was made to focus the design on the requirements of line-haul freight operations.

The task analysis translated the operations that trains will have to perform into the specific tasks that cab crew members will have to perform to accomplish the operations. This analysis also specified for each task the type and source of information, action requirement, and feedback necessary for task performance. This analysis was critical to the design process in assuring that every feature of the final design would be based on a demonstrated functional requirement.

The human factors analysis applied the established principles of human engineering (as documented in handbooks, standards, specifications, and experimental literature) and the expertise and experience of staff and consultants to the determination of the display, control, and workspace features necessary for the accomplishment of the identified tasks.

Design development first involved the selection of display and control devices judged by the design team to best meet the specified requirements. Individual instruments and devices were then grouped into panels; panels were combined into consoles, and consoles and appurtenances were arranged within the defined work area to comprise an idealized cab design. This process involved a large number of comparisons, trade-off evaluations, and design team deliberations, using such criteria as human engineering principles, safety requirements, structural interface constraints, soft mockup test results, and many other considerations to arrive at each design decision.

Four problem areas were complex enough to require special studies in support of the design effort. These areas were: occupant protection, structural integrity, reliability, and cost. The results of these studies provided additional guidelines for design decisions.

The net result of these efforts was a preliminary cab design that included detailed drawings, an explanatory text, a manual for cab operation, and a full-scale hard mockup of the entire cab. The details of the design process, the support studies, and the preliminary design have been documented in earlier volumes of this report series, and are summarized in Section 2 of this report.

To assess the acceptability of this proposed cab design, fifty experienced locomotive engineers subjected all details of the design (as shown in the mockup) to ratings and a critique. This nationwide sample of cab users unanimously rated the overall design as a definite improvement over existing cabs. Of the more than five thousand individual ratings obtained, eighty-four percent signified an improvement over current designs, ten percent signified a quality equal to today's designs, and only six percent signified some feature judged to be worse than current designs.

Every low rating was given intensive evaluation, and where the design team judged it appropriate, the design was modified to meet the objections. This process led to a refined design that is presented as the recommended design in Section 3 of this report. Details of the evaluation are given in Appendix A, and the consequent changes incorporated in the final design are specified in Appendix B.

The highlights of the recommended design are shown in Figures 1-1 and 1-2. Some of the major novel features are:

The main display and control console is located directly in front of the engineer in a semi-wraparound configuration.

For operating the locomotive in reverse, a reverse control panel is provided behind the engineer's seat.

Auxiliary functions are located on an overhead control panel.

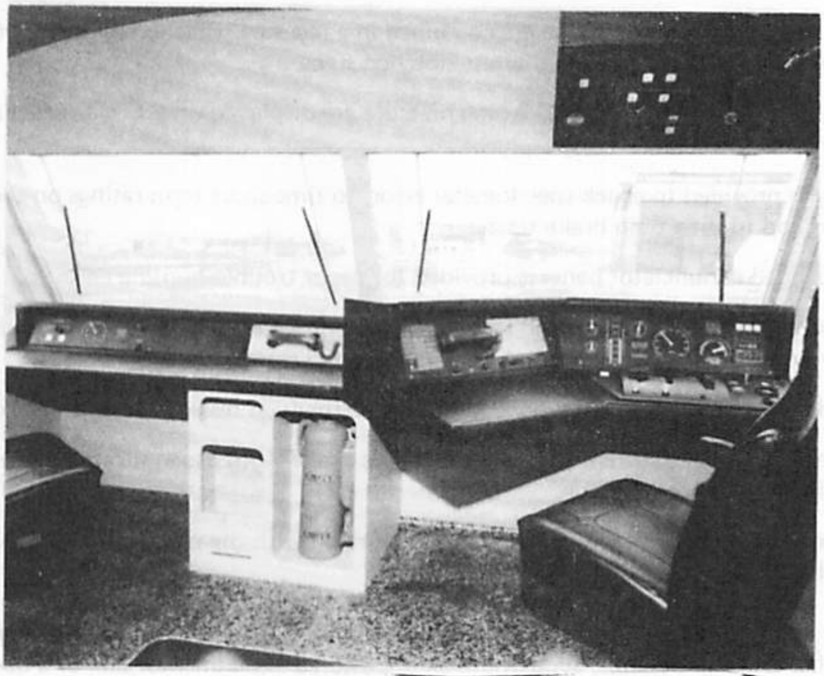

Figure 1–1. View of Cab Crew Area (Preliminary Mockup)

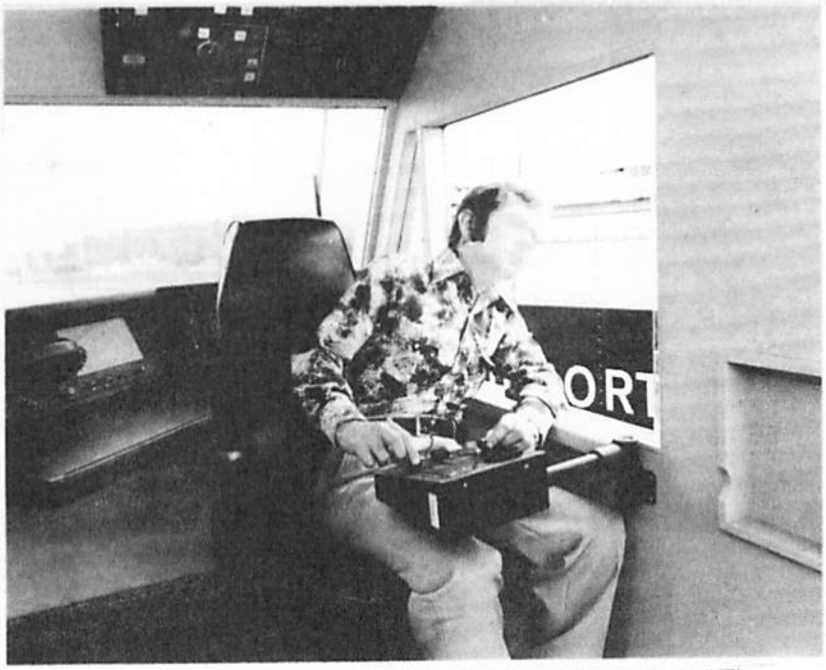

Figure 1–2. Reverse Control Panel (Preliminary Mockup)

The engineer's emergency brake is a separate control rather than a position on the train brake control.

The throttle and dynamic brake are combined in a recessed wheel control that provides continuous control rather than discrete notched steps.

The equalizing reservoir and brake pipe pressure are displayed on a single vertical tape instrument.

A timer is provided to check speedometer error, to time short term ratings on the power pointer, and to time train brake tests.

An expanded annunciator panel is provided for easier troubleshooting enroute.

Provision is made for an advanced train handling display to exploit developments in the rapidly expanding technology of computer-generated status displays.

A special auditory stimulus is provided to replace the loud hiss when the air brakes vent.

The automatic brake system and the locomotive brake system are autonomously controlled.

Radio controlled equipment functions are integrated with the primary locomotive controls.

This project effort lends itself to follow up with dynamic evaluation of the cab concept and features, either through dynamic simulation, an unpowered experimental cab, or a demonstator locomotive with the experimental cab. It is recommended that the reports of this program be used as a source of ideas and a guideline for design in any future effort aimed at improving or standardizing locomotive cabs.

2. PROGRAM OVERVIEW

2.1 INTRODUCTION

In 1971, the Locomotive Control Compartment Committee (LCCC) was formed, bringing together representatives of the government (Federal Railroad Administration), railroad management (Association of American Railroads), and labor (Brotherhood of Locomotive Engineers and United Transportation Union) to consider all aspects of safety in the locomotive cab. Although the LCCC was most concerned with identifying and correcting design deficiencies in currently operating cabs, its early deliberations also included the concept of developing a completely new cab design based on the work and safety requirements of the cab occupants. This idea was subsequently expressed by Jankovich (Reference 1) in his report on a survey of locomotive cabs prepared in support of the LCCC. "A second approach would be the construction of an entirely new design, with little or no regard to tradition, in order to develop an ideal control system to suit the operator optimally" (5, pp 129 f).

In response to this need for a fresh approach to the design of locomotive cabs, the Federal Railroad Administration sponsored a research program to develop a modern locomotive cab design based on the functional needs of the cab occupants, particularly the locomotive engineer, derived from their experience in train handling. The program was conducted by the Boeing Vertol Company under the technical direction of the Human Factors Branch of the Department of Transportation's Transportation Systems Center, under contracts DOT-TSC-913 and DOT-TSC-1330, covering the period October 1974 to February 1978.

This report is Volume IV in a series documenting the progress and findings of the Boeing Vertol program.* It presents the final design (Section 3) and the details of an evaluation of a preliminary design (Appendix A). The analyses leading to the preliminary design are documented in Volume I; details of the design are reported in Volumes I and II, and special studies performed in support of the design effort are reviewed in Volume II of this series.

2.2 PRODUCTION OF THE PRELIMINARY DESIGN

The steps followed in arriving at the recommended cab design are shown in Figure 2-1.

2.2.1 <u>System Analysis</u>

The system analysis was comprised of three parts: mission analysis, cab analysis, and fifteen-year projections. Based on design documents, research literature, interviews with designers and users, visits to manufacturers, and trips on operating locomotives, a systematic summary was derived that described what different jobs locomotives perform, what information is required

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Volume I: Analysis of Locomotive Cab Environment and Development of Cab Design Alternatives, FRA/OR&D-76/275.I, October 1976, PB 262976. **

Volume II: Operator's Manual, FRA/OR&D-76/275.II, October 1976, PB 264114.**

Volume III: Design Application Analysis, FRA/OR&D-76/275.III, October 1976, PB 264115. **

The reports will be referred to simply by the volume number throughout this report.

** NTIS Accession Number

to run locomotives on these various missions, what control actions are required in response to available information, what various displays and controls are provided in contemporary cabs, what provisions are made for the safety and comfort of cab occupants, and how all of these provisions are reflected in the various designs of locomotive cabs. In addition, an estimate was made of the changes in railroad operations and technology most likely to impact on cab designs up to 1990.

As a result of the system analysis, the decision was made to base the new design on the projected requirements for line-haul freight operations. It was recognized that passenger, yard, and road switching operations have their unique sets of functional requirements but that almost all of their significant requirements are also needs of the line-haul freight locomotive. Therefore a design for line-haul freights would be likely to encompass the needs of the other missions.

Details of the system analysis are documented in Volume I of this series.

2.2.2 Task Analysis

A three-step functional analysis of the future locomotive and its crew was performed. The first step defined the jobs to be performed by the locomotive as functions of operational and environmental constraints. For each of these jobs, the activities and options available to or required by the crew to meet the job requirements were defined. Finally, each activity was broken down into the individual tasks required to accomplish the function.

For each task identified in the functional analysis, an information and actions requirements analysis was performed. For each task, the type and source of information needed to accomplish the task, and the type and source of feedback needed to monitor accomplishment of the task were documented.

Details of the task analysis are recorded in Volume I of this series.

2.2.3 Human Factors Analysis

Display and control requirements were derived from the task analysis. A master list of all display requirements was prepared from the "source" columns in the information and feedback sections of the information/action analyses, including the type of display device judged most suitable and the space requirements for the device. A similar analysis of the "source" columns for action requirements yielded a list of control devices needed and their characteristics. The details of these analyses are reported in Volume I of this series.

2.2.4 Design Development

The process of developing a cab design involved selecting display and control devices from the lists developed as human factors criteria, combining these into panels, and combining the panels into consoles. The procedure involved many iterations, trade-off analyses, and reviews. It was guided by the principles of human engineering as published in the experimental literature, handbooks, military standards, and military specifications, combined with the expertise in human engineering and railroad technology represented by the training and experience of the

Boeing professional staff and expert consultants. Volume I of this series provides a detailed review of this procedure.

2.2.5 Support Studies

Critical design problems were explored in a series of special studies conducted in support of the principal design effort. These studies covered the following topics: occupant protection, structural integrity, reliability, and cost. The details of these studies are documented in Volume III of this series.

2.2.6 Preliminary Design

The design procedure described in Section 2.2.4, guided by the results of the support studies outlined in Section 2.2.5, led to a specific design representing the best judgment of the entire design team. A description of this preliminary design in text and drawings is included in Volume I of this series.

Instructions for operating a locomotive from a cab of the preliminary design were prepared, including step-by-step procedures keyed to detailed drawings of the display/control panels. This operator's manual constitutes Volume II of the series.

Finally, the preliminary design was incorporated in a full-scale hard mockup of the cab. The design and development of the mockup are documented in Volume III of the series.

2.3 MOCKUP EVALUATION

Recognizing that the people who must operate locomotives are the final judges of the adequacy of a cab's design, the Boeing Vertol design team arranged for twelve experienced locomotive engineers to visit the mockup and evaluate the design. Each evaluator, independently, was given a detailed briefing on the design followed by an item-by-item explanation of every feature of the design while in the mockup. The engineer was next asked to simulate a series of operations, including starting the engine, moving the train forward and backward, coupling, stopping, and responding to emergencies. Following this experience, the engineer was asked to rate every design item on a numerical rating scale and was given an opportunity to express personal opinions on the design.

The results of this preliminary evaluation demonstrated the value of the procedure, inspired confidence that the basic design was sound, and identified a number of features requiring design modification. However, the evaluators were all employees of one railroad; so to avoid any bias in the evaluation, it was decided to extend the evaluation over a broader sample of engineers. Therefore a second evaluation, identical in procedures to the first, was conducted with an additional thirty-eight evaluators, representing a broader sampling of age, physical characteristics, railroads, operating terrain, types of locomotive equipment, and other variables.

Of the more than 5,000 detailed ratings made by the fifty evaluators, 84 percent reflected the opinion that the rated feature was an improvement over the equivalent feature in today's cabs. Ten percent of the ratings signified that the quality of the new design was equal to that of contemporary equipment. Only six percent of the ratings reflected adverse opinions. The unsatisfactory ratings were all given special additional study and, if judged desirable, the preliminary design was appropriately modified.

The details of these evaluations, including sample characteristics, procedures, ratings, and comments are given in Appendix A of this report. The changes in the preliminary design are summarized in Appendix B.

The preliminary design as modified to reflect the improvements derived from the mockup evaluation constitutes the final recommended design, described in detail in Section 3.

3. RECOMMENDED DESIGN

3.1 INTRODUCTION

This section presents the recommended design based on the results of the mockup test and evaluation program. Individual railroads have, in many instances, differing operational requirements and these are usually reflected in their cab features and equipment. For this reason it is considered unlikely that the present design will appear intact universally in the next generation of locomotive cabs. Cab development will remain evolutionary. The present design, therefore, is conceived as a working design which serves to illustrate a methodology for arriving at any new final design. New locomotive manufacturers are appearing, and some of their locomotive designs reveal significant departures from traditional approaches to cab design. Government and industry are conducting studies of existing locomotive cabs that will affect future cab designs and development in areas such as noise, cab atmosphere, signalling, safety, protective glass, seating, occupant protection and structural crashworthiness. Amtrak has conducted a parallel study of passenger locomotive cabs and prepared a cab specification. This specification reflects, in part, some of the concepts developed in the present study for the freight environment that were applicable to passenger train cabs, confirming the utility of the new design. All of these developments will influence the design of future cabs; the present design should be evaluated in the context of these other research efforts. The recommended design is described in the following section.

3.2 CAB EXTERIOR

3.2.1 Crashworthiness

Figure 3-1 shows a top, side and front view of the locomotive cab. The profile of the cab was dictated by structural crashworthiness considerations. The principal structural characteristic is the deflection shield on the front of the cab. The purpose of the shield is to deflect an impacting vehicle up and over the locomotive cab. The deflected vehicle could be any kind of rolling stock up to and including another locomotive. A detailed discussion of the concept can be found in Reference 5. At the bottom of the shield there is an anti-climber attached to the locomotive underframe. The anti-climber is wedge-shaped to provide some deflecting capability to the side in the event of impact with a motor vehicle. Hand holds are provided to allow maintenance personnel easy access to various locomotive appurtenances such as the windows.

3.2.2 Rear View Mirrors and Flag Holders

Rear view mirrors and flag holders are shown on each side of the cab.

3.2.3 Windshield Wipers

The windshield wipers are pantograph type of provide good visibility through the windshields.

3.2.4 Horn

The horn is mounted forward on the roof of the cab. Sounds from the horn will not penetrate into the cab because the cab is acoustically treated.

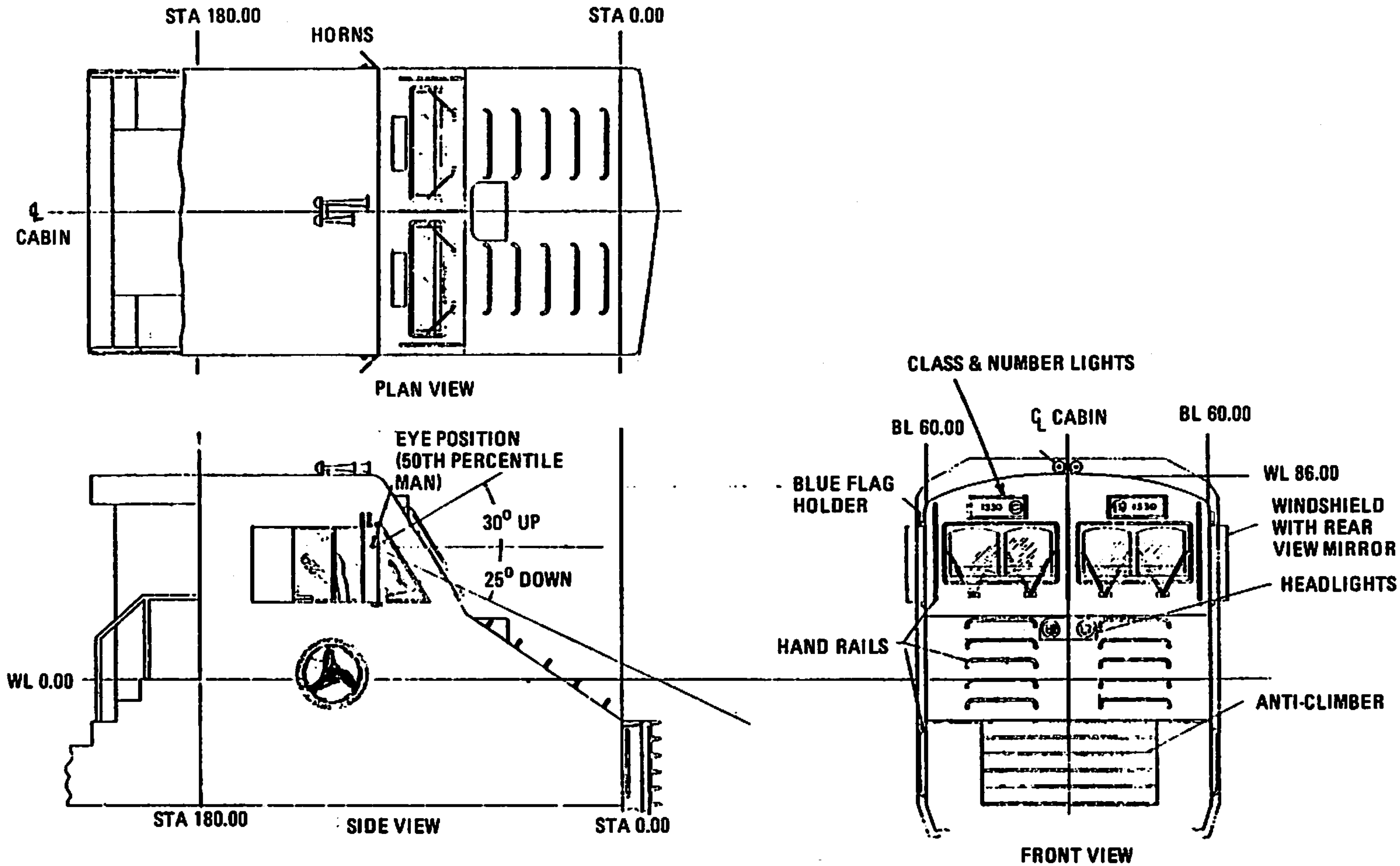

Figure 3–1. Cab Exterior

3.2.5 Headlights

Two headlights are shown mounted on the front of the cab. One is steerable.

3.3 CAB INTERIOR

3.3.1 Rear Wall

The rear wall of the locomotive cab is shown in Figure 3-2.

3.3.1.1 Rear Doors – Two rear doors are shown with recessed handles, sun shades and windshield wipers. The glass has electrical deicing and defogging. Durable seals are provided to prevent rain, snow, dirt and fumes from penetrating the cab area. The doors latch positively when closed and are positively retained to the outer cab wall when fully opened. The window glass is constructed so that it will not shatter and spray glass into the cab volume.

3.3.1.2 Refrigerator – A refrigerator is shown at the top of the left rear wall. It is positively latched when closed to keep from flying open in the event of severe slack action. The refrigerator is electrically powered and each shelf has a raised upper lip to prevent objects from flying out when the door is open. A light comes on when the door is open. The top shelf will contain cartons or cans of water for drinking. The bottom shelf is for food and beverages.

3.3.1.3 Storage Compartment – A storage compartment is located below the refrigerator. This compartment is positively latched when closed. It is lighted and contains a shelf and coat hooks. The shelf has a lip to prevent items from falling off in the event of severe slack action.

3.3.1.4 Low Voltage Cabinet – A low voltage cabinet, containing fuses and circuit breakers is located in the rear wall next to the refrigerator. The door to this cabinet is positively latched.

3.3.1.5 Maintenance Advisory Panel – A maintenance advisory panel is located underneath the low voltage cabinet. These annunciators indicate systems malfunctions on the locomotive that are of primary interest to maintenance personnel. The malfunctions displayed are those that the engineer can do little if anything about. He would note any malfunction indications on his post-trip report. Typical functions that would appear here include such things as turbo air pressure low, air filter clogged and fuel filter clogged. Options utilized will depend on type of locomotive.

3.3.1.6 Hot Plate – A hot plate is provided and located under the maintenance advisory panel for heating food and beverages. The heating elements are recessed and provide a secure hold for items being heated so that they do not fly out in the event of severe train action.

3.3.1.7 Lavatory Compartment – A lavatory compartment is located on the right side of the rear wall. The door is positively latched to prevent flying open in the event of severe train action.

The compartment includes a grill from an air comfort system, ventilator, overhead light and a floor drain so that the compartment can be flushed out with water for easy cleaning. A coat

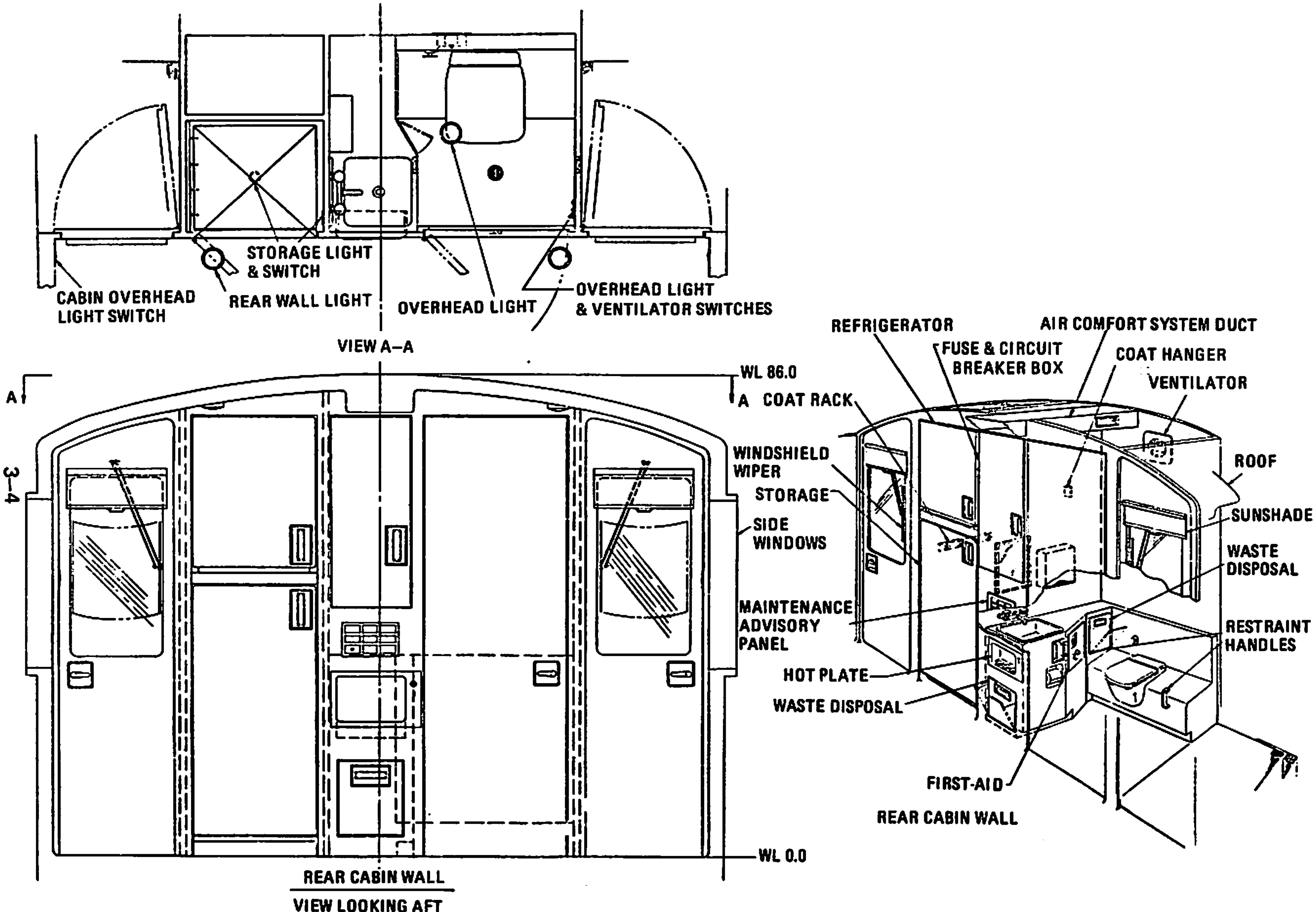

Figure 3–2. Cab Rear Wall

hanger is provided on the left wall. Also shown are first aid kit, waste disposal compartment, restraint handles, sink with hot and cold running water and a towel dispenser.

3.3.1.8 Lighting – Two lights are shown recessed in the ceiling for illuminating the area of the rear wall. Control of these lights is accomplished from either the engineer's or trainman's consoles.

3.3.1.9 Waste Disposal – A waste disposal compartment is shown under the hot plate. It is easily removed for trash disposal.

3.3.2 Cab Right Wall

The locomotive cab right wall is described below and shown in Figure 3-3.

3.3.2.1 Overhead Light Switch – A light switch is shown just inside the rear door at the right of the cab. Upon entering the cab, the engineer operates this switch to turn on the overhead light at the engineer's work console. The light may be extinguished by either the wall switch or a switch located on the overhead panel and discussed in 3.8.

3.3.2.2 Fire Extinguisher – A fire extinguisher is shown recessed in the wall below and to the left of the wall switch. It is positively restrained to prevent ejection into the cab.

3.3.2.3 Emergency Kit – An emergency kit is provided and shown to the left of the fire extinguisher. The kit is portable and contains fuses, torpedoes, and flags. The kit is positively secured to prevent ejection into the cab.

3.3.2.4 Speaker and Microphone – An auxiliary speaker and microphone is provided shown next to the engineer's side window. The microphone is push-to-talk. The push-to-talk button is floor mounted for operation with the foot. These devices provide convenient communications when the engineer is using the reverse control panel discussed in Section 3.7.

3.3.2.5 Brake Pipe Pressure Regulating Valve – A brake pipe pressure regulating valve is shown recessed under the engineer's side window. At this valve the pressure of the air delivered from the main reservoirs to the train brake system is reduced to the brake pipe pressure setting for a particular train. This pressure may vary from 70 to 110 psi. Turning the valve clockwise increases air pressure in the brake pipe and turning it counterclockwise decreases air pressure. The brake pipe pressure will be maintained at a particular setting against the effect of nominal brake pipe leakage.

3.3.2.6 Large Window – The engineer's large window has electrical defogging and deicing. A sun shade is provided (shown partially down in the drawing). The glass should not shatter on impact and no shards should be permitted in the cab. Seals are durable, and the window locks positively when closed or open in any position. Window guides are designed so that they do not deform or bind under normal usage and over temperature extremes.

3.3.3 Cab Left Wall

The locomotive cab left wall is shown in Figure 3-4 and is described below.

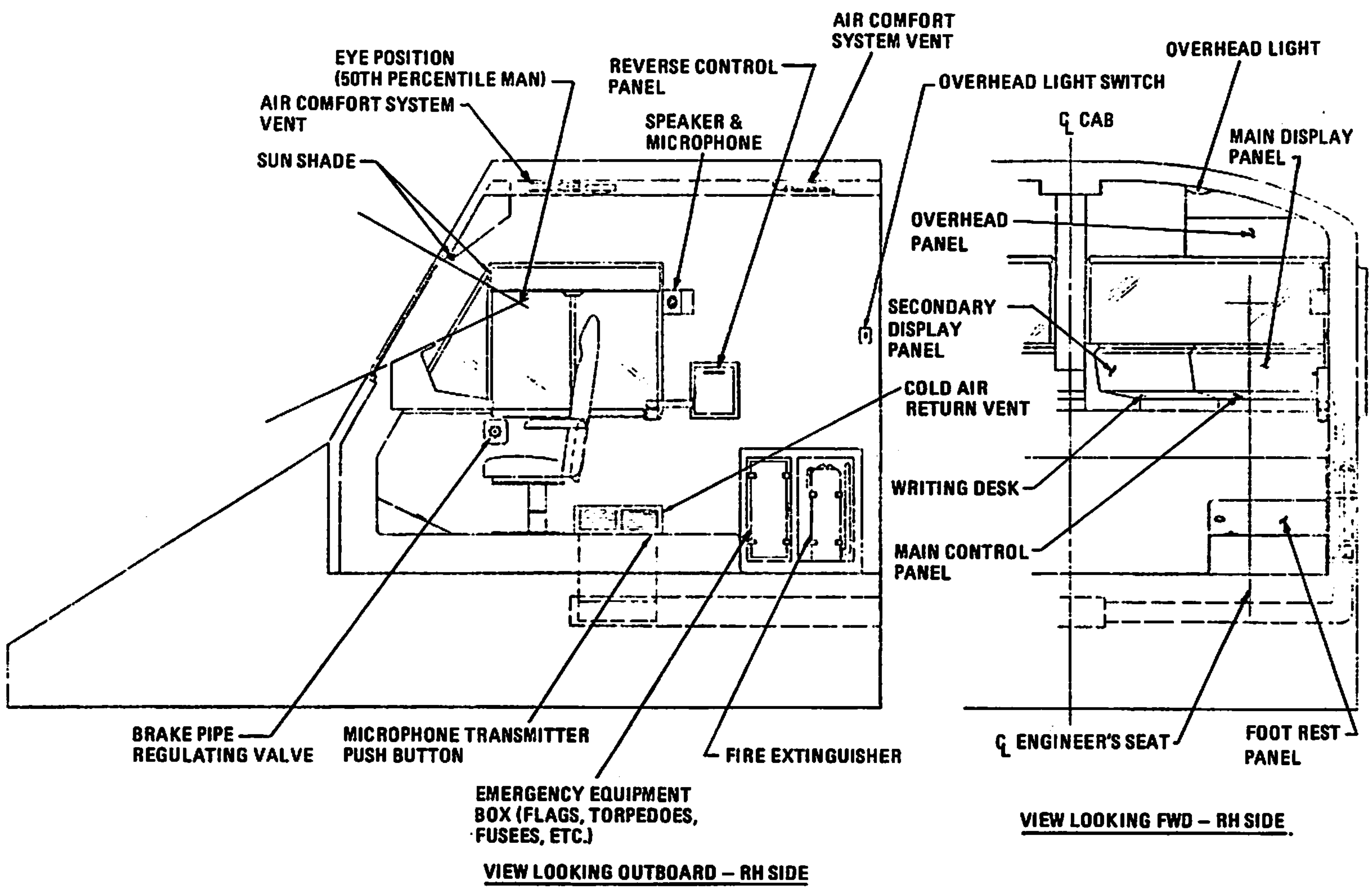

Figure 3–3. Right Side Wall

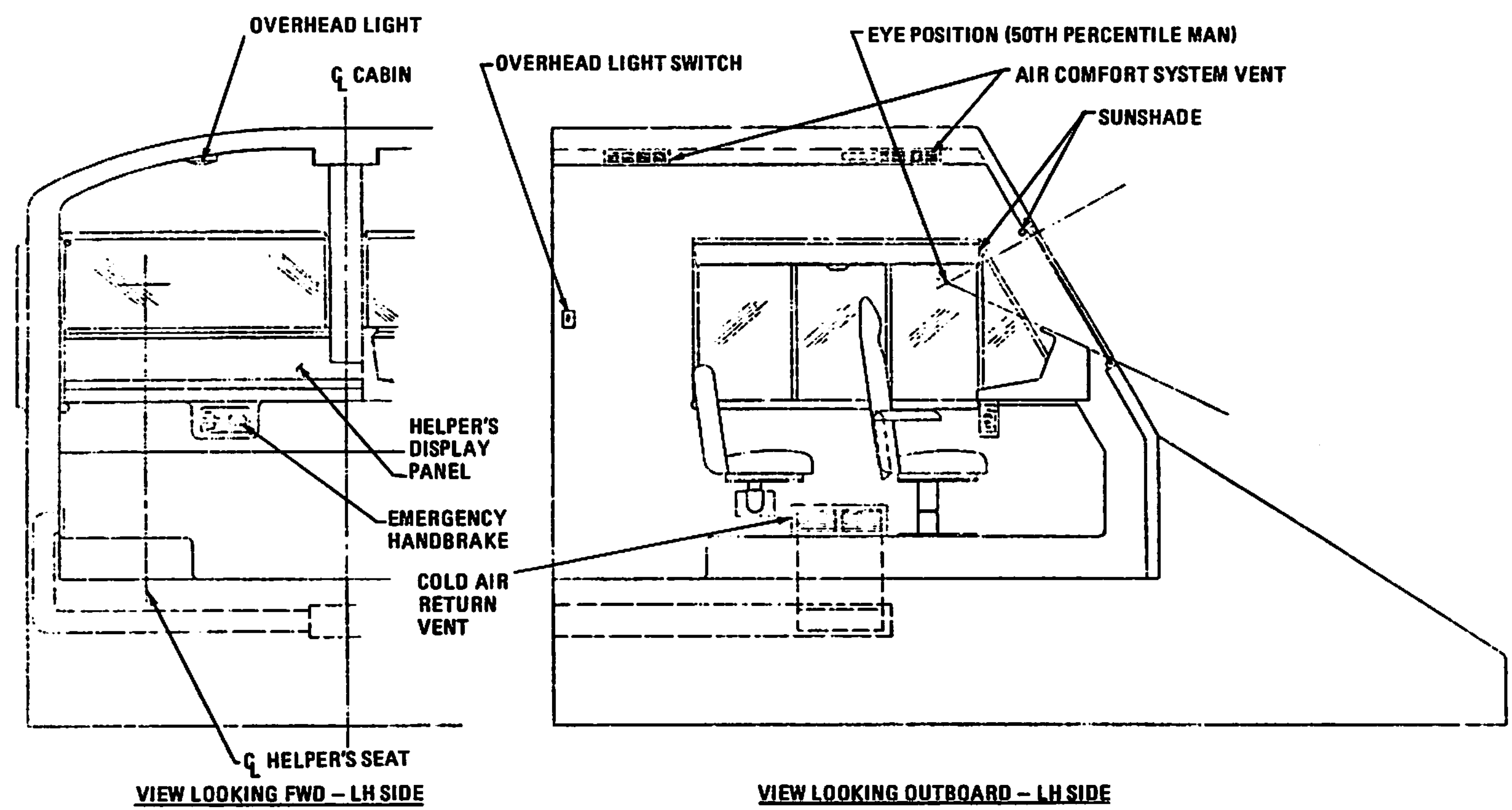

Figure 3–4. Left Side Wall

3.3.3.1 Trainman's Seat – A third seat is provided for an additional crewman. The seat is mounted on the cab wall as shown.

3.3.3.2 Overhead Light Switch – An overhead light switch is shown on the wall at the left. This switch turns the trainman's utility light, shown on the ceiling, on or off.

3.3.3.3 Large Window – The characteristics of the window are the same as the engineer's window on the right wall. This window, however, extends further aft than the engineer's window to provide visibility for the person in the third seat.

3.3.3.4 Acoustic and Thermal Environment – The dimensions of the structural cab members provide approximately 4 inches of space between the inner cab structure and the outer cab wall. This space is to be used for high quality acoustic and thermal insulation to provide a quiet, insulated cab.

3.3.3.5 Vibration – The cab design is modular. That is, it is constructed independently as a pod and inserted into cab structure during locomotive fabrication. The seats and consoles are isolated against vibration paths to the primary structure. The improved environment will lessen crew fatigue and be kinder to the instruments.

3.3.3.6 Air Comfort System – The air comfort system shown in Figures 3-3 and 3-4 provides the engineer the capability to select fresh air, humidified hot air or conditioned cool air to be supplied through vents on either side of the duct. The air return ducts are mounted on the bottom of the side walls, one on each side of the cab, to maximize air flow.

3.3.3.7 Cab Floor – The bilevel cab floor shown in Figures 3-5 and 3-7 has a covering of non-skid material. The intersections of the floor and walls are rounded so that debris will not collect in corners and provide for easy cleaning. A drain is provided in the floor so that the cab floor can be conveniently hosed down. The drain emplacement is sealed against leakage of air and fumes around it. The two levels are painted in high contrast colors to be easily discerned. The edge of the raised platform is coated with reflective materials for high visibility when entering the cab.

3.3.3.8 Cab Front Wall – The front end of the cab, Figure 3-6, is designed such that the windshields are flush with the outside of the collision posts, and the consoles and seats are positioned accordingly. As shown in Figure 3-6 this provides optimum visibility of the track directly in front of the locomotive. Also shown are the helper's display panel on the left and the engineers work station on the right. The engineer's work station is composed of a main display panel, a main control panel, secondary display panel, overhead panel, writing desk and foot rest. The details of these panels are discussed in separate sections. An emergency handbrake handle is shown recessed under the helper's work station. This is a pneumatic control used for emergency braking.

3.3.3.9 Front Windows – The front windows are electrically defogged and deiced. These functions are controlled from the engineer's work station. The windshield wipers are pantograph type, providing maximum visibility during inclement weather conditions. The glazing is a safety glass suitable to prevent foreign objects from penetrating the cab. In the event of

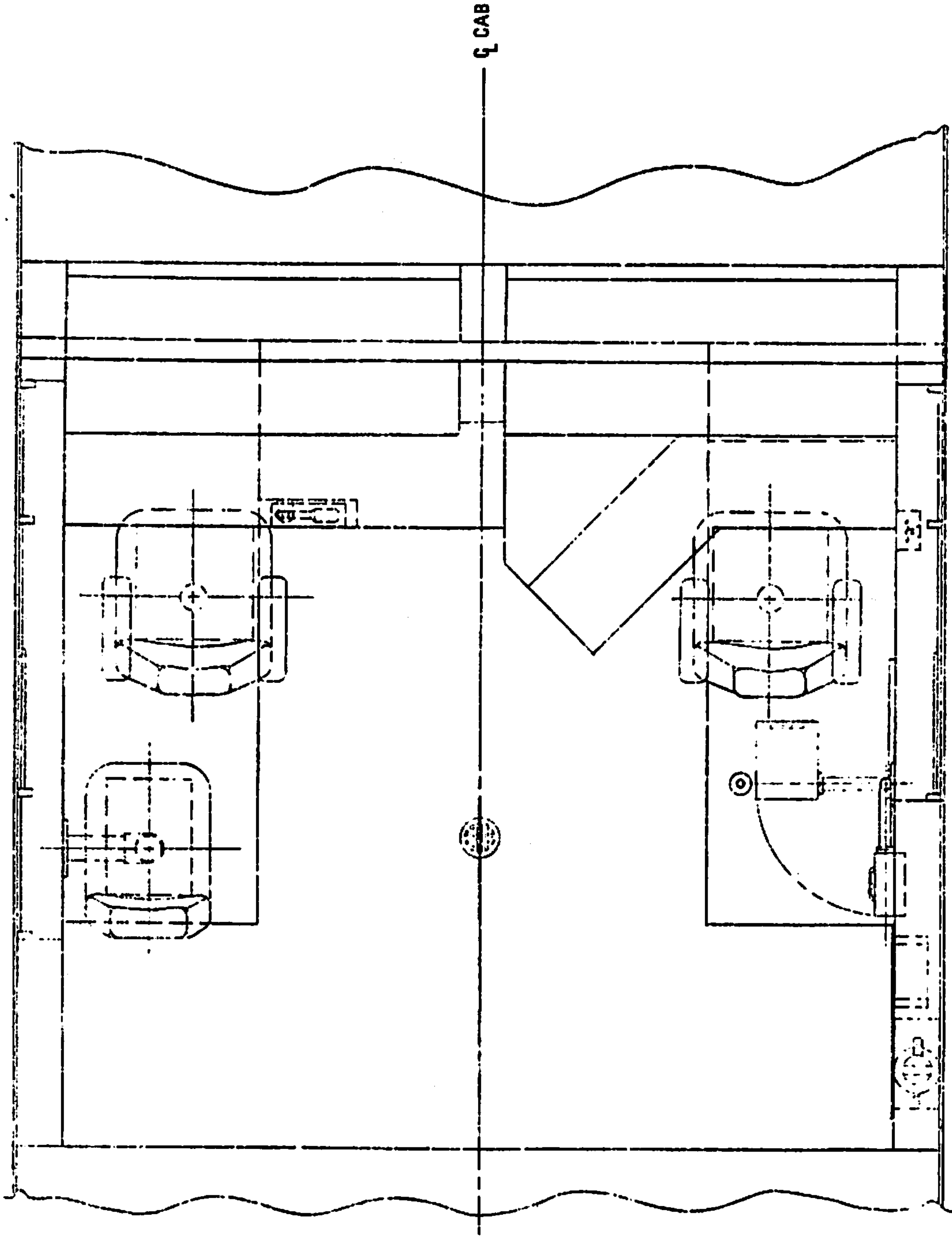

Figure 3–5. Plan View

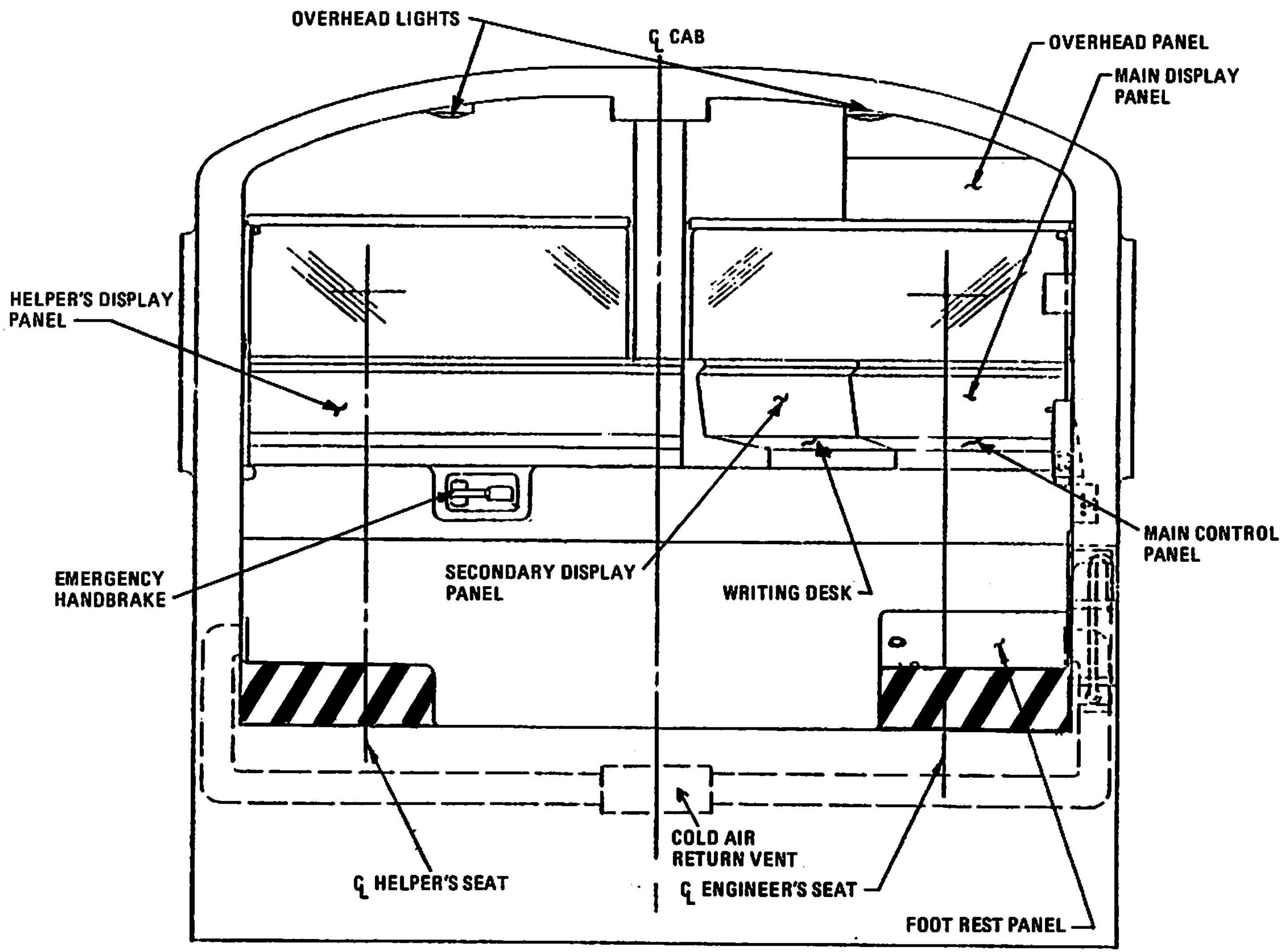

Figure 3–6. Front Wall and Consoles

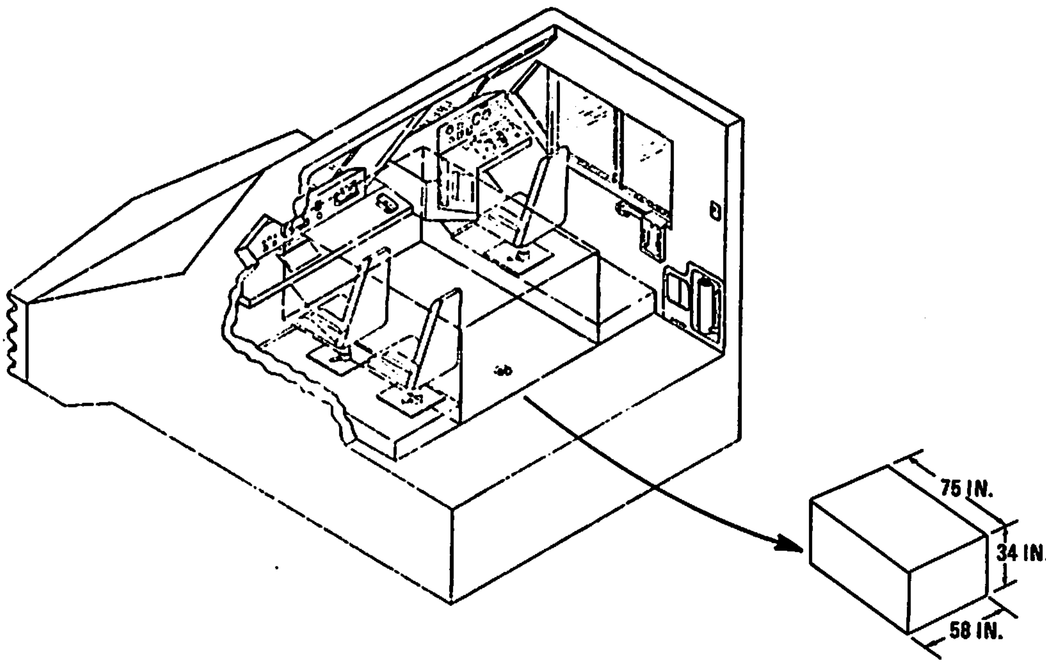

Figure 3–7. Crash Station

a collision, the windows will not pop into the cab. Each front window has a sun shade permanently attached to the window frame. The optical properties of the shade are designed to be compatible with wayside colored signal aspects.

3.3.4 Emergency Provision

3.3.4.1 Crash Station – As mentioned in the section on structure, the locomotive cab has been designed with a deflection shield. Also the concept of a crew crash station was evolved. In the secondary impact, the structure above the shield is subject to large deformations. Consequently, in the event of a collision, the crew should get down on the floor and protect their heads. The volume behind the shield, as shown in Figure 3-7, is the volume to be defended. References 5, 6, and 7 contain more detailed analyses of crew protection in collision environments.

3.4 MAIN DISPLAY PANEL

The main display panel contains the primary cab displays. It is located in front of the engineer's seat on the cab control desk. These displays are shown in Figure 3-8 and are:

1. Brake Pipe Air Flow
2. Main Reservoir Pressure
3. Equalizing Reservoir/Brake Pipe Pressures
4. Brake Cylinder Pressure
5. Emergency Brake ON
6. Brake Pipe Venting
7. Consist Alarm
8. Speedometer
9. Cab Signals
10. Power Indicator
11. Timer.

3.4.1 Brake Pipe Air Flow

The brake pipe air flow indicator is shown in the upper left hand corner of the figure. The indicator displays air flowing into the brake pipe on an arbitrary scale of 0 to 15 using the bottom pointer. This pointer will normally sit at a value corresponding to the brake pipe air leakage where pressure maintaining occurs. When the air brakes are released after a service reduction, the pointer will move to the right indicating the increased brake pipe demand for recharging the system. After the air is replenished the pointer will return to its previous value. A second pointer is provided. This is manually adjustable and is used to set in the leak rate determined by brake tests prior to a run. There is a light below the two pointers. It illuminates to alert the engineer whenever there is a significant change in demand. The flow gauge functions as an indicator of air brake system health.

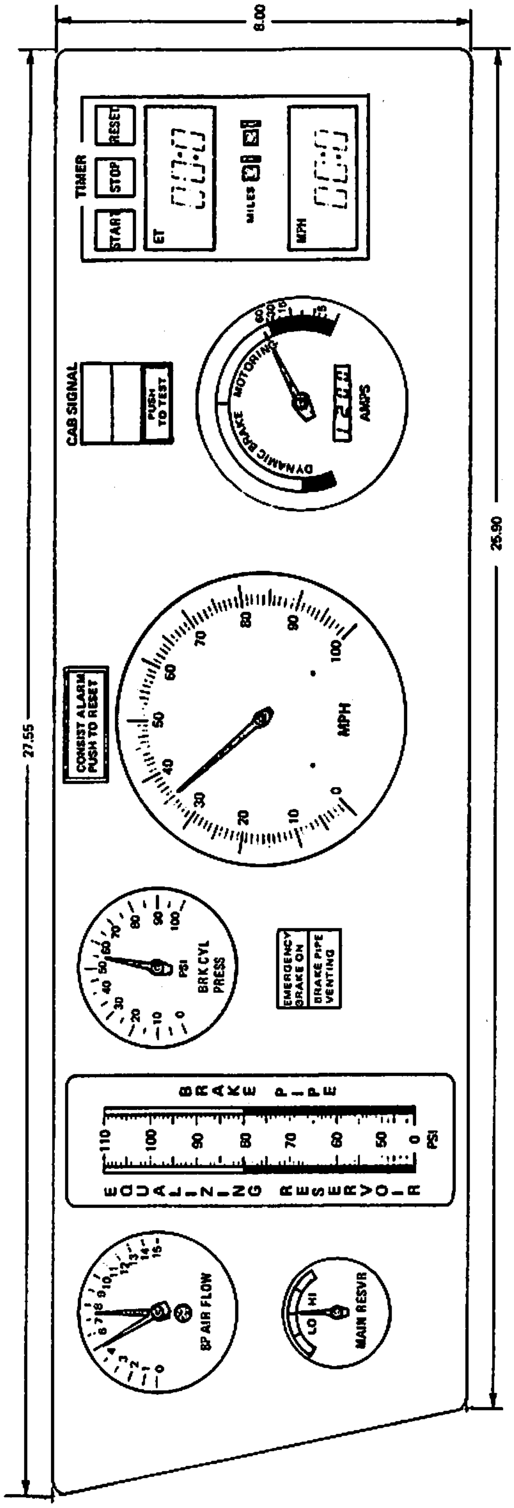

Figure 3–8. Main Display Panel

3.4.2 Main Reservoir Pressure

The main reservoir pressure indicator is shown beneath the flow meter. This qualitative indicator shows pressure in the main reservoir. The band between low and high is color coded green with red limit bands. When the pointer is in the green band the compressor is maintaining pressure within desired limits. For example, the compressor governor loads and unloads at 130 and 140 psi respectively. When the pointer is to the left in the red band this means that the pressure is too low and when it is in the red band to the right the pressure is too high.

3.4.3 Equalizing Reservoir/Brake Pipe Pressure

The equalizing reservoir and brake pipe pressure indicator is a dual vertical scale displaying equalizing and brake pipe pressures simultaneously. The moving tapes next to the numbered scale show the pressures in each of these systems. The tapes will rise as pressure increases and fall when pressure decreases. For example, a service reduction of 15 psi would cause the equalizing pressure tape to go to 65 psi. The brake pipe pressure tape would slowly reduce to equalization as the air is exhausted. The scale is calibrated in one psi increments from 50 to 110 psi. From 0 to 50 psi the scale is compressed so that each graduation is 10 psi.

3.4.4 Brake Cylinder Pressure

A brake cylinder pressure indicator is shown to the right of the equalizing reservoir/brake pipe pressure indicator. It has a scale reading from 0 to 100 psi calibrated in 5 psi increments. The indicator reads pressure in the locomotive brake cylinders as a result of manipulating the locomotive brake handle.

3.4.5 Emergency Brake

The red emergency brake annunciator illuminates when there is an emergency application of the air brakes whether intentional or unintentional. Coincident with the onset of the light there is an auditory signal that comes on and stays on until the light extinguishes. The annunciator light and tone will remain on until reset by the engineer as described in Section 3.6.

3.4.6 Brake Pipe Venting

A green light comes on to advise the engineer that the brake pipe is venting. The legend will illuminate while a service reduction is being made or an emergency brake application initiated and will remain illuminated until air is exhausted. An auditory signal distinct from the emergency signal will also come on.

3.4.7 Consist Alarm

In the present application, an auditory alarm comes on if either of two categories of events occur. First, the following malfunctions in any locomotive in the consist will cause the alarm to come on.

1. Traction motor hot
2. Excitation limit exceeded
3. Crankcase pressure low
4. Hot engine
5. No charge.

Second, the alarm will come on when a caution annunciator on the annunciator panel described in Section 3.6.1 comes on. These annunciators display conditions on the lead unit only in addition to the malfunctions listed above. The alarm can be silenced by pushing the button.

3.4.8 Speedometer

The speedometer is centrally located on the panel. Speed is calibrated in one mile per hour increments from 0 to 100 mph.

3.4.9 Cab Signals

The cab signals include two indicators upon which are projected either colored signals or geometric patterns. These signals govern movement of the train through the block the train is occupying. Below them is a push-to-test button for checking aspect operability.

3.4.10 Power

The power meter is shown to the right of the speedometer just below the cab signal. This indicator presents both qualitative and quantitative information to the engineer. When the locomotive is at idle the power pointer will be at the twelve o'clock position. When power is applied to the traction motors the pointer will move to the right through a blue coded zone which is the safe operational range. At the extreme right there is a red coded limit zone that denotes an avoid region because excessive current is applied to the traction motors. Short time ratings for traction motor loads are shown along the edge of the indicator for this region. These will vary in practice as a function of locomotive type.

The power pointer will rotate to the left when power is decreased until it reaches the twelve o'clock position. The power pointer will rotate to the left of the idle position when the locomotive is in dynamic braking. An orange zone denotes the safe operating range in dynamic braking. At the extrme left end of the orange zone there is a red range limit indicating that the dynamic brake is overloaded and thus, under normal circumstances, this region should be avoided.

A digital readout in amperes is shown at the bottom of the dial for use when knowledge of the specific current on the traction motors is required.

3.4.11 Timer

A timer is located on the right of the panel. This is a digital instrument used for time, speed and distance calculations. The timer may be used to check, for example, speedometer error, to time brake pipe leakage tests and to keep track of short time ratings on traction motor power. The following functions are provided:

START	–	Pushbutton to start timing action of calculator
STOP	–	Pushbutton to stop timing action of calculator
RESET	–	Elapsed time and speed readouts are reset to zero
ET	–	Elapsed time readout
MILES	–	Manual entry of distance traveled during elapsed time by use of the two thumbwheels
MPH	–	Average speed of locomotive during ET will be displayed when "STOP" button is pushed.

3.5 MAIN CONTROL PANEL

The main control panel is located under the main display panel directly in front of the engineer's seat on the cab control desk. Figure 3-9 illustrates the features on this panel and these are as follows and discussed below.

1. Stop all engines
2. Emergency Stop
3. Suppression
4. Horn/Bell
5. Train brake
6. Locomotive brake
7. Throttle/dynamic brake
8. Direction lever
9. Console lock
10. Headlight slew
11. Headlight control
12. Acknowledger
13. Sander
14. Reverse control panel.

3.5.1 Stop All Engines

The stop all engines function, located in the upper left hand corner is a guarded pushbutton used to stop all engines in the locomotive consist. The control is activated by lifting the hinged guard and depressing the pushbutton. The pushbutton will illuminate to signify that this function is active and the fuel pumps in each engine have been turned off.

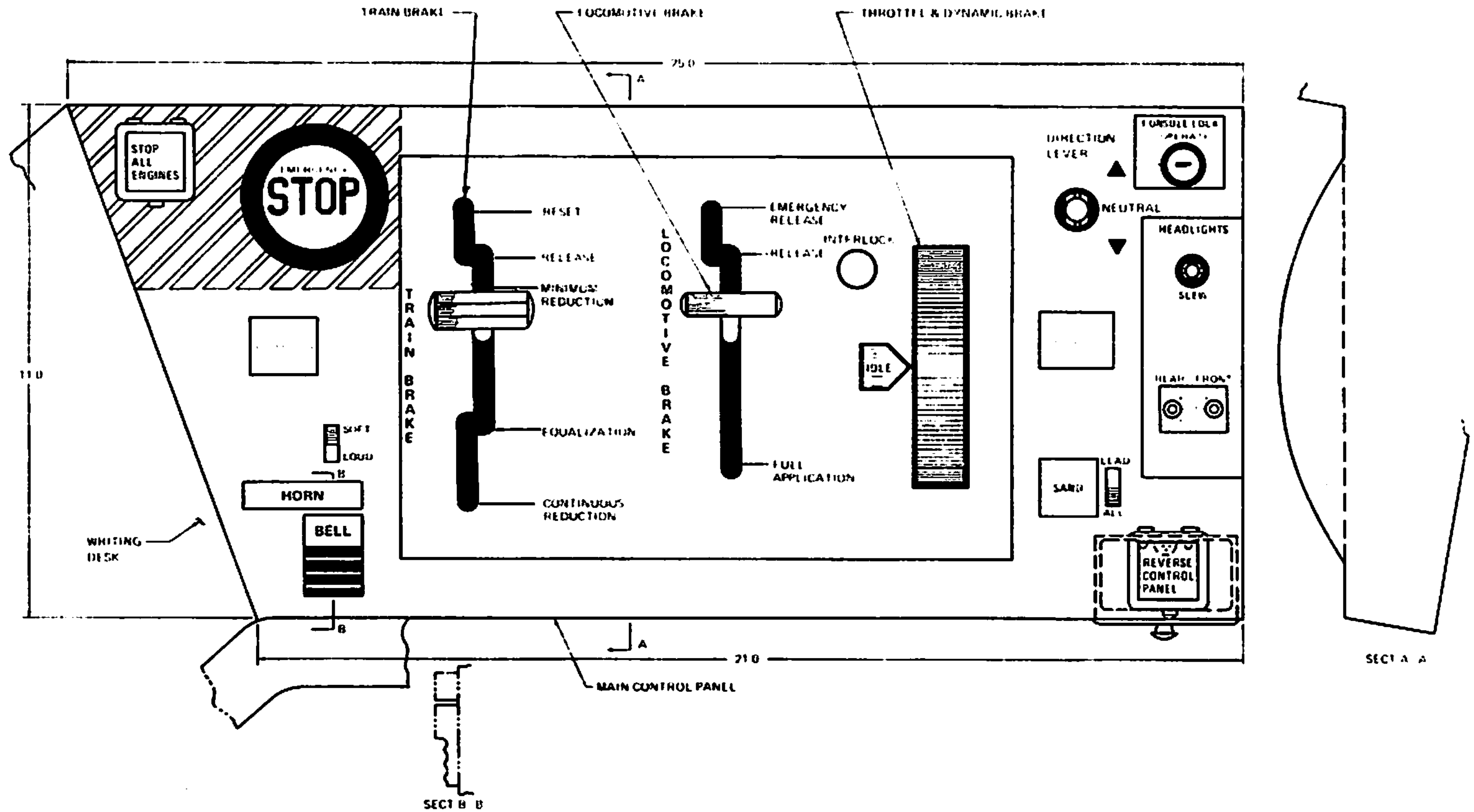

Figure 3–9. Main Control Panel

3.5.2 Emergency Stop

The emergency stop function, located to the right of the stop all engine function, is a large recessed button used to initiate an emergency brake application. Depressing the button initiates a full exhaust of air at a maximum rate from the brake pipe, and initiates a full service application of the locomotive brake. An emergency stop, once initiated, cannot be overridden.

3.5.3 Suppression

The suppression function, located beneath the emergency stop and to the left of the train brake, is a lighted push button used to suppress a penalty train brake application. In the event of a penalty application depressing the suppression button will allow application pressure to be restored at which time the light will go out.

3.5.4 Horn and Bell

The horn and bell are co-located at the lower left corner of the panel for one hand operation. The horn, bell or both can be selected. A two position switch permits selection of soft or loud for the horn.

3.5.5 Train Brake

The train brake is an octagonal-handled lever used to apply and release the brakes along the entire train including radio-controlled remote locomotives, but excluding locomotive brakes. Reading from top to bottom the functions are:

1. Reset
2. Release
3. Minimum reduction
4. Equalization
5. Continuous reduction.

3.5.5.1 Reset – The reset position is used to recover from an emergency brake application. The lever is placed in this position and left there until the emergency brake on annunciator is extinguished. This resets the electrical circuitry and the train can now be recharged. The lever must be moved through the gate to the left and fully forward.

3.5.5.2 Release – The release position is used for charging the brake pipe and releasing the brakes. This is the normal running position.

3.5.5.3 Minimum Reduction – The minimum reduction position is a detent and is reached by moving the lever rearward from release. A six to eight pound service reduction of brake pipe pressure will be obtained. Moving the lever out of detent further to the rear through the service range to equalization provides a continuous reduction in brake pipe pressure. Any desired reduction up to equalization can be obtained.

3.5.5.4 Equalization – The equalization position will permit full equalization to be obtained for any initial brake pipe setting from 70 to 110 psi. Equalization will occur, for example, with a brake pipe pressure of 70 psi with a 20 psi reduction in brake pipe pressure. With a 110 psi initial brake pipe charge equalization will occur with a 32 psi reduction of brake pipe pressure.

3.5.5.5 Continuous Reduction – A continuous reduction zone is provided to permit the brake pipe pressure to be reduced beyond full equalization to approximately zero psi. This is accomplished by moving the lever through the gate to the left and moving the lever further to the rear. This permits a continuous reduction through the continuous reduction range.

3.5.6 Locomotive Brake

The locomotive brake is a round handled lever used to control the locomotive air brakes. Reading from top to bottom it has the following functions:

1. Emergency release
2. Release
3. Full Application.

3.5.6.1 Emergency Release – The emergency release position is used to release the locomotive brakes in the event of an emergency brake application. The brake handle is moved to this position to reduce air pressure in the brake cylinders to approximately zero psi. If only a partial cylinder pressure buildup is required the lever is moved to the emergency release position and the brake cylinder gauge described in Section 3.4.4 is observed. When the desired pressure is obtained the lever is moved back to release which is inoperable during emergency braking.

3.5.6.2 Release – The release position is the normal running position. With the brake handle in this position no pressure can build up in the brake cylinder and the locomotive brakes are released. Moving the brake handle toward the full service position provided a continuous control for increasing pressure.

3.5.6.3 Full Application – Placing the brake lever in full application (rearmost position) fully applies the locomotive brakes and brake cylinder pressure is at a maximum.

3.5.7 Throttle and Dynamic Brake

The throttle and dynamic brake controller is a recessed handwheel as shown in Figure 3-9. It is used to apply power to the locomotive drive wheels or for dynamic braking. The throttle portion of the controller has raised ribs that are spaced closer together as the throttle is advanced. The idle position is flat and the dynamic brake portion grooved with the grooves spaced closer together as dynamic braking is increased.

3.5.7.1 Idle – In the idle position the locomotive engine is idling and no power or dynamic braking is being developed at the drive wheels. The indicator window next to the controller will display idle in white letters on a black background.

3.5.7.2 Power Settings – The controller is moved forward to increase power and speed. The indicator window will show control settings 1 through 8 with white numbers on a blue background. A pseudo detent is represented by a click at each throttle setting. The controller, however, can be set at any point continuously between 1 and 8 for fine tuning the throttle settings.

3.5.7.3 Dynamic Brake Interlock – The throttle dynamic brake interlock is located to the upper left of the controller. It is a pushbutton that must be depressed when going from idle into dynamic braking and from dynamic braking to idle. If the interlock is not depressed the controller can only be moved from idle to position 8.

3.5.7.4 Dynamic Brake Settings – The controller is moved rearward after depressing the interlock button to decrease speed by increasing braking. The legend SET UP will appear in the window with white letters on an orange background. A timing circuit forces a short delay to allow the voltage in the electrical system to decay before it is repositioned for dynamic braking. After this pause, moving the controller rearward from the set up position will increase dynamic braking. The indicator window will show numerals one through eight in white letters on an orange background. The controller permits continuous adjustment between settings. The dynamic brake settings also have a psuedo detent represented by a click at each corresponding notch setting.

3.5.8 Direction Lever

The direction lever is a lever lock toggle switch used to set the direction of travel of the locomotive. To set the direction of travel the lever must be pulled up from the panel and set in the proper position for movement as denoted by the arrows. To change direction or go to neutral the lever must again be pulled up from the panel. Change of direction can only be made when the throttle dynamic brake controller is idle.

3.5.9 Acknowledger

An acknowledger is provided as a pushbutton located beneath the direction lever, as shown in Figure 3-9, for use in areas where there is automatic train stop or cab signals. In the event that the lead locomotive passes over an inductor in approach to other than a clear signal or the cab signals show a restrictive aspect, the acknowledger button will light and an auditory stimulus will be presented. The acknowledger when depressed will terminate the sound and must be held until the light goes out. The switch is cyclic to prevent defeating the switch. In the event an acknowledgement is not made a penalty brake application will be initiated.

3.5.10 Sander

The sander control is a pushbutton used to manually apply sand to the locomotive wheels. The option is provided to sand under either the lead truck or the whole consist via the two position slider switch labeled lead/all. The sander is a latching sander when lead truck sanding. During whole consist sanding the sander will latch for a specified period of time and then shut off. The button will illuminate when sand is being applied either manually or automatically.

3.5.11 Console Lock

The console lock is a recessed, key-operated pushbutton used to secure the control panel against unauthorized use. A key is inserted and turned to the operate position to enable the circuitry to operate the controls. The button will pop up flush with the panel surfaces. To disable the controls, the button is pushed down.

3.5.12 Headlight Slew

The headlight slew is a three-position toggle switch used to steer one headlight left or right. The switch is spring loaded.

3.5.13 Headlight Control

The headlight controls are two toggle switches, one for the front light of the locomotive and one for the rear light. Each has three positions; on, dim and off.

3.5. 14 Reverse Control

A reverse control panel is provided in the cab and is discussed in Section 3.7.

To transfer control of the locomotive to this panel, a reverse control function has to be implemented with a guarded pushbutton. After performing the appropriate control setup procedures, lifting the guard and depressing the button will cause a light to come on signifying that the reverse control panel is operational.

3.6 SECONDARY DISPLAY PANEL

The secondary display panel is located to the left of the main display panel. The functions contained on this panel, and shown in Figure 3-10, are:

1. Annunciator Panel
2. Locomotive Isolation
3. Communication
4. Train Handling Display.

3.6.1 Annunciator Panel

An annunciator panel has been provided consisting of caution lights arranged from top to bottom in order of criticality and where practical functionally grouped. A lamp test function has also been provided as shown in the lower left corner of the panel. The caution lights work in conjunction with the consist alarm light described in Section 3.4.7. When the consist alarm comes on, one or more annunciators will light indicating an undesirable condition in the locomotive consist. Some examples are shown in Figure 3-11. There are three options when this occurs. The engineer can make a control input to correct an undesirable condition, such as wheel slip, or he can ignore the caution because it may be temporary, such as engine overheat in a tunnel, or he can isolate the offending unit.

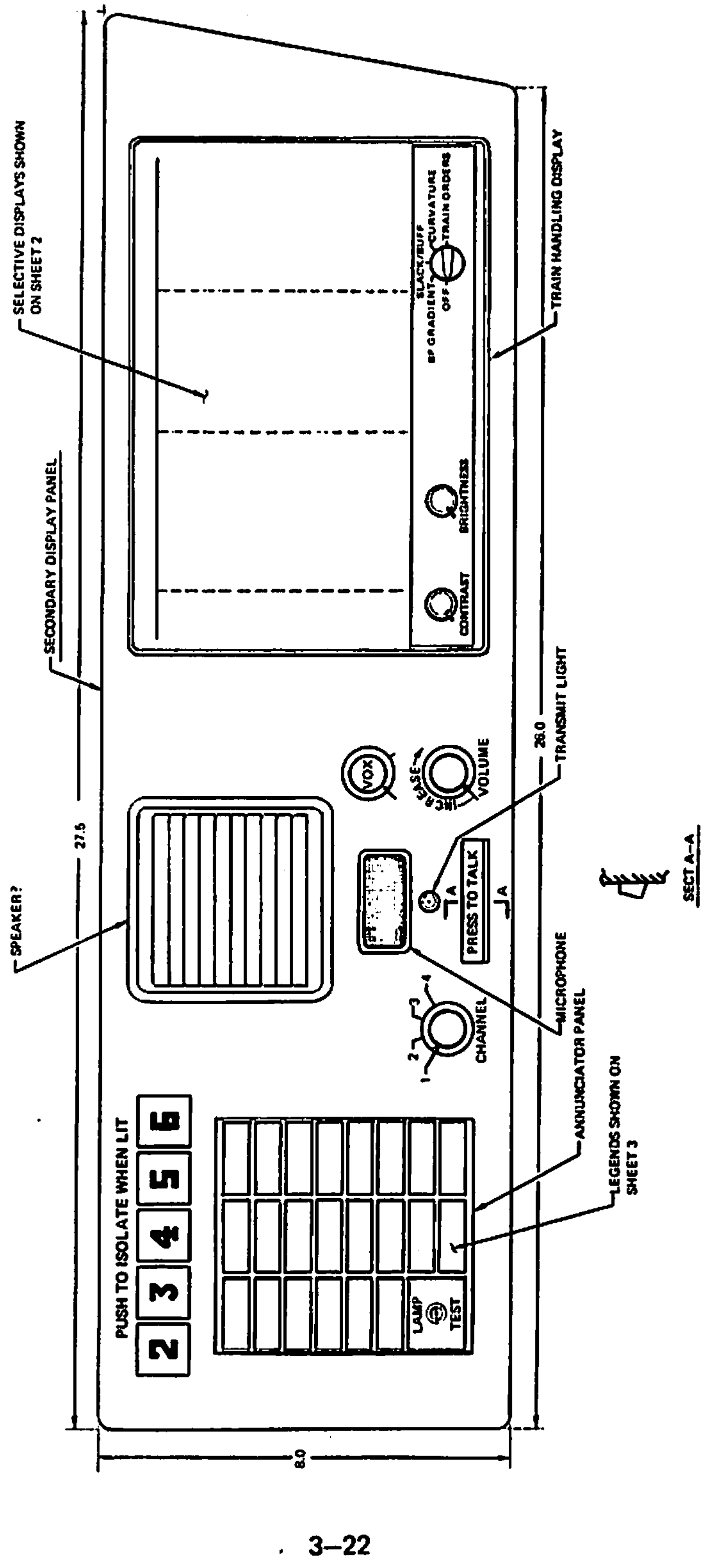

Figure 3–10. Secondary Display Panel

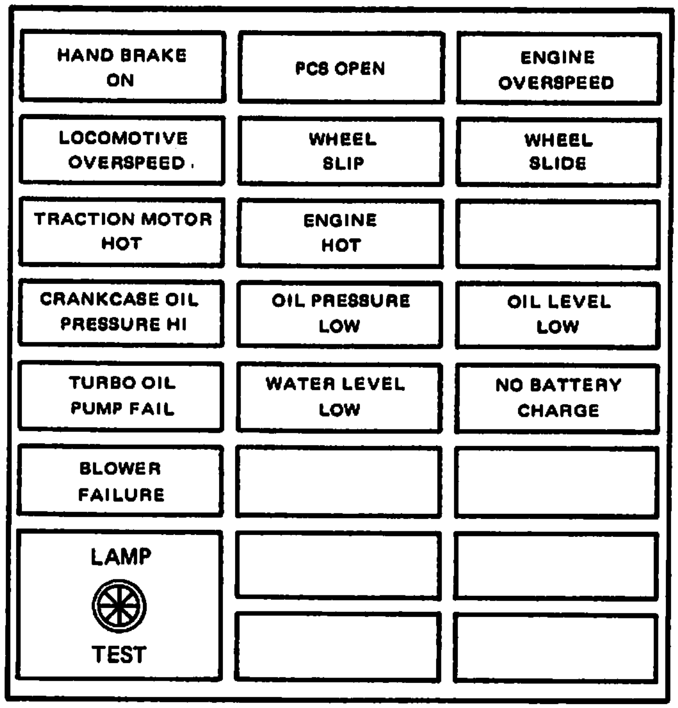

Figure 3–11. Secondary Display Panel – Annunciator Panel – Typical Annunciators

3.6.2 Locomotive Isolation

Five pushbutton switches are shown above the annunciator panel in Figure 3-10. These work in conjunction with the consist alarm light and annunciator panel. As stated in the previous section when the consist alarm light comes on one or more annunciator lights will illuminate indicating a malfunction or undesirable condition in the locomotive consist. One or more isolation switches will illuminate indicating which trailing unit (or units) is the offender. The offending locomotive can be isolated (taken off line) by depressing the lighted button. The light will extinguish and the unit will go to idle. If the malfunction is on the lead unit only the annunciator will illuminate and lead unit can be isolated via the run-isolate switch on the overhead panel discussed in Section 3.8.

3.6.3 Communications

The communications functions are used to communicate to caboose, dispatcher, other trains and wayside and are shown in the center of Figure 3-10. These functions are:

1. Speaker
2. Microphone
3. Press to talk
4. Transmit
5. Vox
6. Volume
7. Channel.

3.6.3.1 Speaker and Microphone

The speaker and microphone are mounted in the panel.

3.6.3.2 Press-to-Talk Switch and Transmit Light

A press-to-talk switch is located beneath the microphone. Depressing the switch actuates the microphone. The transmit light will illuminate whenever the microphone is active.

3.6.3.3 Vox

A vox control rotary switch is shown at the lower right of the speaker. The control allows the engineer to set a signal threshold to eliminate background noise during transmission.

3.6.3.4 Volume

A rotary control has been provided to increase or decrease speaker volume.

3.6.3.5 Channel

A channel selector has been provided for selecting the appropriate transmitting frequency.

3.6.4 Train Handling Display

The train handling display is a TV-type cathode ray tube (CRT) showing the train situation in real time. The train is shown as a heavy black line with the track grade below it. The train is stationary, but the grade profile moves under it from right to left giving the impression that the train is moving from left to right. The train, grade profile and numbered mile posts are always present on the display. Train length and weight distribution information are inserted into a mini-computer that drives the CRT display. The thickness of the line representing the train indicates train mass distribution. The heaviest part of the line indicates the heaviest part(s) of the train. In addition to the above features there are selectable optional real time displays, as shown in Figure 3-12.

3.6.4.1 Grade – Selecting track grade causes an alpha-numeric readout showing grade directly under the train and two miles ahead in percent. The numerical grade is followed by a U or D to indicate an up or down grade.

3.6.4.2 Draft/Buff – Selecting draft/buff causes the drawbar forces along the train to be displayed in graphic form directly under the train/grade indication. The graph consists of three dotted lines across the top, middle and bottom of the display. These lines indicate maximum allowable draft force, neutral and maximum allowable buff force respectively.

3.6.4.3 Brake Pipe Pressure Gradient – Selecting this option causes a graphic presentation of train-lined brake pipe pressure to appear under this train and track profile. Pressure scale in psi is displayed to the left of the graph. The graph is a line whose slope corresponds to changes in brake pipe pressure along the train.

3.6.4.4 Curvature – Selecting track curvature causes a graphic presentation of tangent and curved track to appear under the train and track profile. Curve severity is labeled in degrees of curvature for a 100 foot section of track. Mile post markings from the grade display aid in locating curve start and stop points.

3.6.4.5 Train Orders – The train handling display can also be used to display train orders as an adjunct to train orders that are written or verbally transmitted.

In addition to the display options, the following controls are provided:

ON-OFF	–	Toggle switch to turn TV on or off.
Contrast	–	The contrast between the display image and the background may be varied.
Brightness	–	Screen brightness may be varied from low to high to compensate for ambient light conditions.

3.7 REVERSE CONTROL PANEL

The reverse control panel is a swing-out control panel located on the right wall of the cab behind the engineman's seated position. The panel can be locked in either the 45 or 90 degree position. This panel is to be used when the locomotive is operated in reverse and using

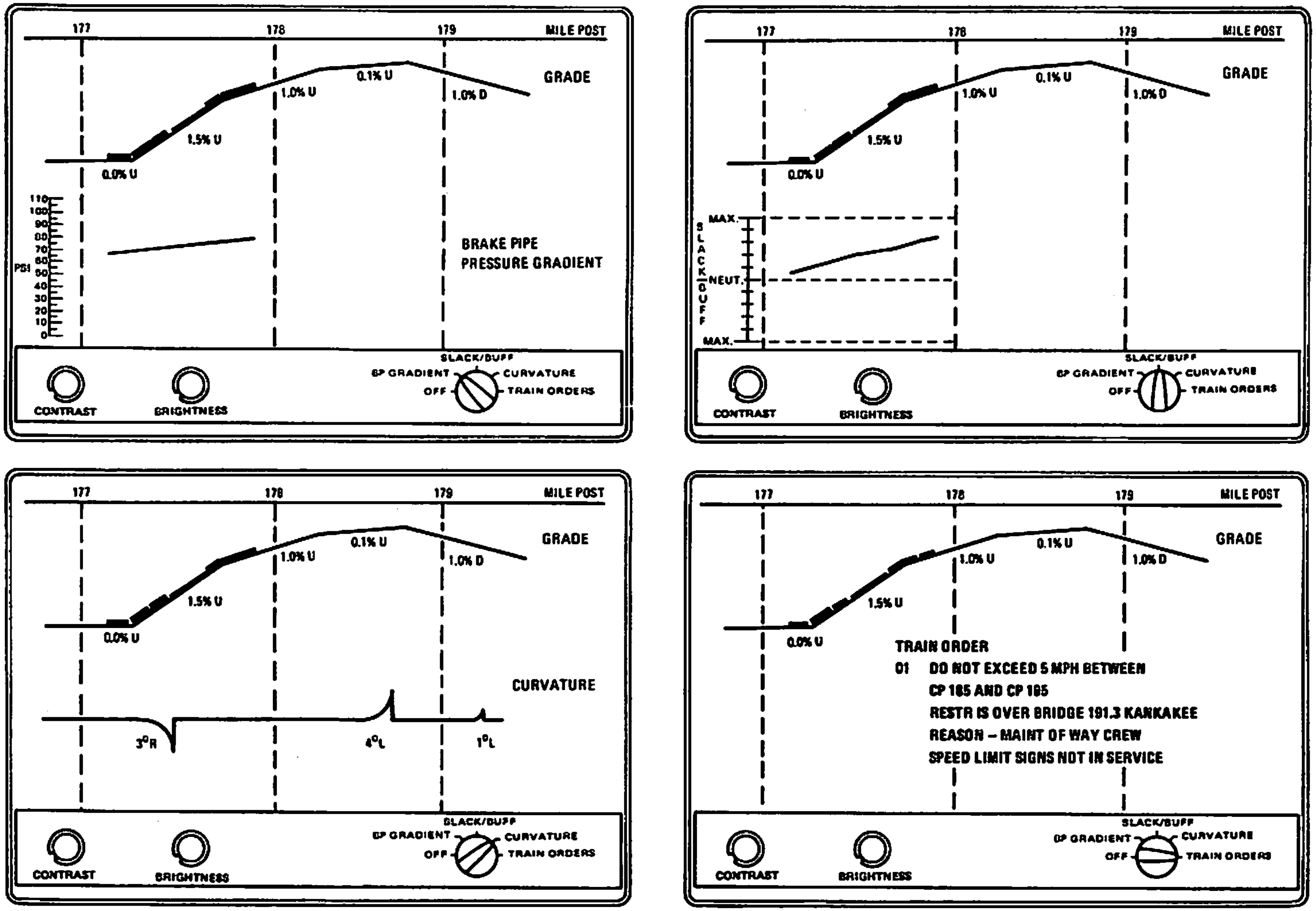

Figure 3–12. Secondary Display Panel – Train Handling Displays

the controls on the main control panel is inconvenient. The engineer's chair may be rotated 180° to take advantage of rearward vision through the windows in the rear doors. When not in us, the panel is recessed into the wall and held securely in place by a positive latch. Releasing the latch will allow the panel to swing out into position ready for use. The panel is activated by a pushbutton on the main control panel. The panel face is shown in Figure 3-13 and details are listed below.

3.7.1 Emergency Stop

The emergency stop control is identical to that on the main control panel.

3.7.2 Direction Lever

The lever locked toggle switch used to set direction of locomotive. It performs the same functions as the direction lever on the main panel.

3.7.3 Train Brake

This is a slide control to set brake pipe pressure. Positions provided are:

3.7.3.1 Release – This position releases train brakes and restores full brake pipe pressure and is identical to the function on the main control panel.

3.7.3.2 Minimum Reduction – This notched position applies minimum train brakes by reducing brake pipe pressure 6 to 8 psi and is identical to the function on the main control panel.

3.7.3.3 Service Range – A continuous service brake application range lies between "MIN REDUCT" and "EQUAL", exactly as on the train brake control on the main control panel.

3.7.3.4 Equalization – This function is identical to the main control panel.

3.7.4 Locomotive Brake

The slide control to set locomotive brake cylinder pressure is identical to the main control panel control except the emergency release item is omitted.

3.7.4.1 Release – The locomotive brakes are released and brake cylinder pressure will be reduced to zero. This feature is identical to the main control panel locomotive brake.

3.7.4.2 Service Range – A service brake application on the locomotive is available between "RELEASE" and "FULL APPLICATION". This feature is identical to the main control panel.

3.7.4.3 Full Application – This is the maximum brake cylinder pressure resulting in full service brake application on locomotive, and is identical to the main control panel function.

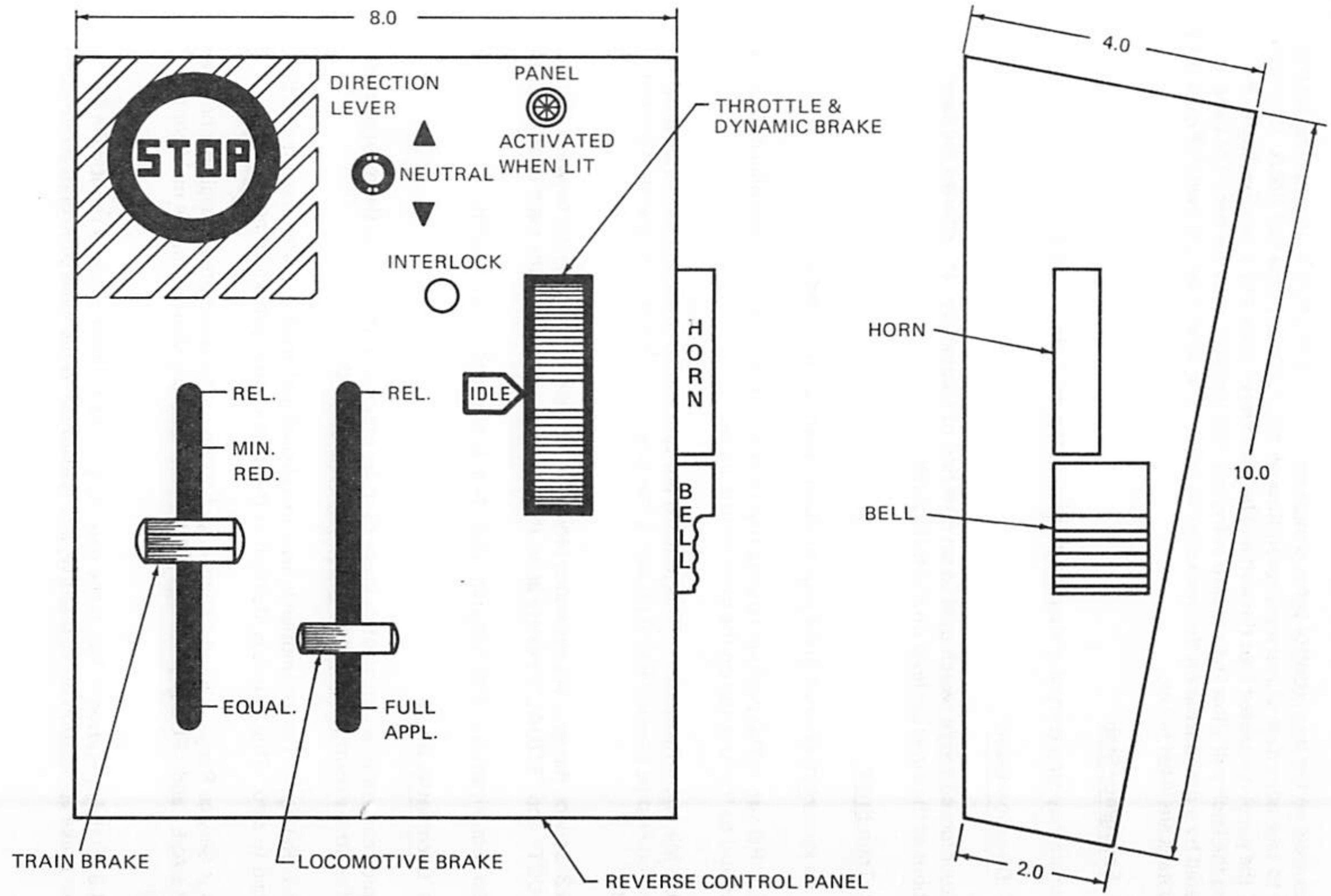

Figure 3–13. Reverse Control Panel

3.7.5 Panel Power Indicator Light

This light (located in upper right corner) is illuminated when the remote control panel is active. The panel is activated by a guarded push button on main control panel.

3.7.6 Controller

The controller is identical to that on the main display panel.

3.7.7 Horn and Bell

The horn and bell controls are identical to the main control panel except there is no soft or loud function.

3.8 OVERHEAD PANEL

The overhead control panel is located directly in front of the engineer above the windshield. The details of this panel are shown in Figure 3-14.

3.8.1 Dynamic Brake Cutout

The dynamic brake.cutout is a two position slide switch. Moving the switch to the out position makes the dynamic brake inoperative in the controlling unit without affecting other locomotives in the consist.

3.8.2 Generator Field

The generator field switch is a two position slide switch that turns the generator field in the main generator on and off.

3.8.3 Engine Run

The engine run switch is a two position slide switch. In the on position the switch couples the engine to the throttle control.

3.8.4 Fuel Pump

The fuel pump control is a two position slide switch that turns the fuel pump on and off.

3.8.5 Ground Relay Reset

This is a push button control that will light the word "RESET" when the ground relay must be reset. When the light comes on, it indicates the generator has unloaded and engine has returned to idle because of a high-voltage ground. When this occurs, pushing the button in and holding until the light goes out resets the ground relay.

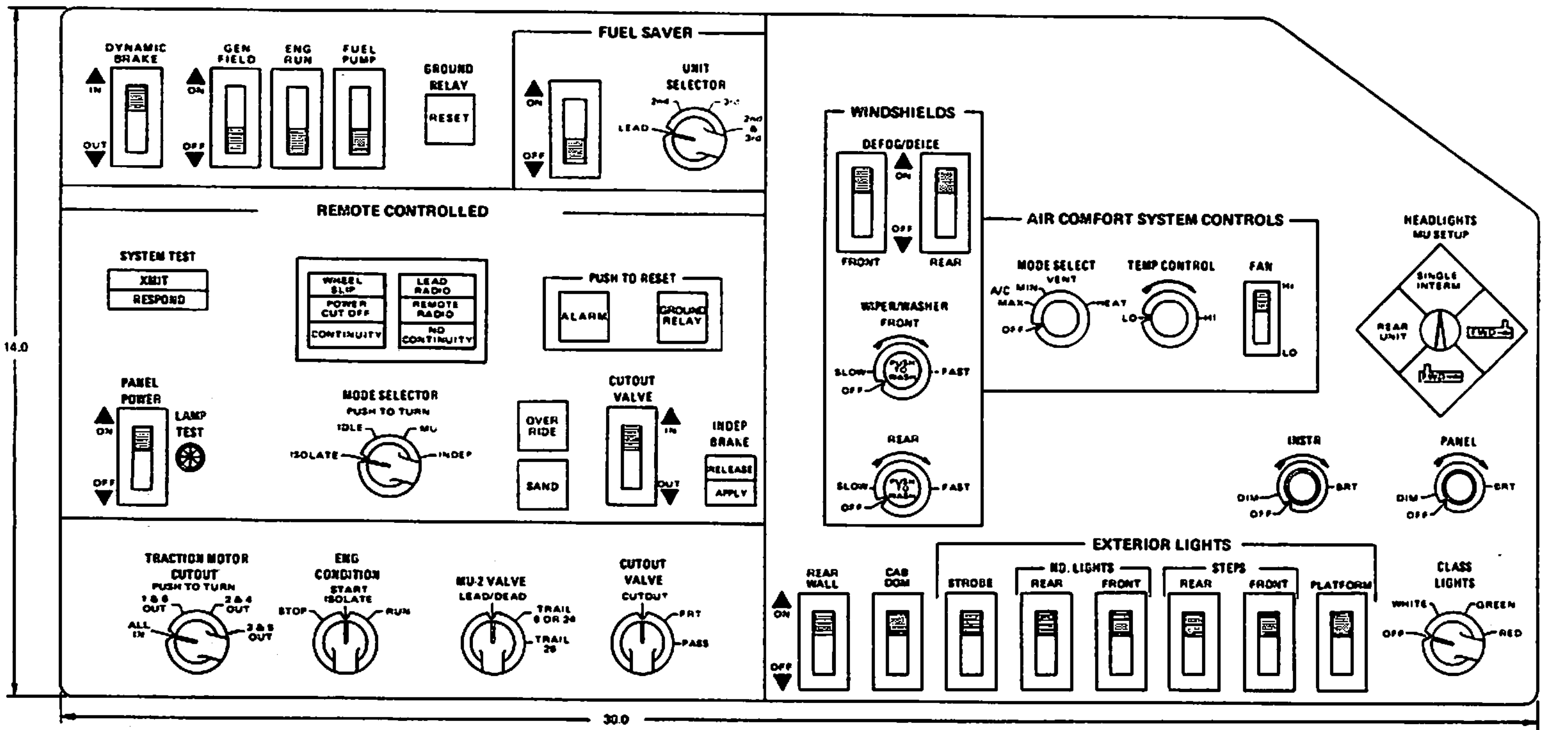

Figure 3–14. Overhead Control Panel

3.8.6 Fuel Saver

The fuel saver consists of a two position slider switch for turning the system on and off and a unit selector. When conditions are favorable, selecting one of the four positions will cause the selected unit or units to go to the notch 1 position of the throttle as a fuel economy measure. In the notch 1 position the unit is not off line and therefore dynamic braking is available.

3.8.7 Traction Motor Cutout

This four position rotary switch is used for cutting out a defective traction motor. Normally the switch will be positioned for all engines to be cut in. To cut out a traction motor, the ENGINE CONDITION switch should be placed in the start position. The traction motor cutout should be positioned to cut out the defective motor, and then the engine condition switch placed in run position.

3.8.8 Engine Condition

The engine condition is a three position rotary control with the following functions: Selecting the stop position shuts off the engine. Selecting the start isolate position starts the engine and permits the locomotive to idle but it will not respond to any control inputs. Selecting the run position permits the locomotive to respond to input commands.

3.8.9 MU-2 Valve

The MU-2 valve is a three position rotary switch that permits the locomotive air brake equipment to operate in multiple with 6, 24, and 26 brake equipment. The Lead/Dead position is selected when the locomotive is either the controlling locomotive in a consist or when the locomotive is hauled dead in the train. The trail 24 position is selected when the locomotive is used in multiple behind a unit equipped with 24 equipment. The trail 6 or 26 position is selected when the locomotive is used in multiple behind a unit equipped with 6 or 26 equipment.

3.8.10 Cutout Valve

This three position rotary selector is used to cut the brake valve in or out. The cutout position is used when the locomotive is a trailing unit and the airbrake equipment is receiving command inputs from another locomotive. It is also used to cut out the pressure maintaining equipment when making train brake tests to check brake system leakage. Selecting the freight position cuts the brake valve in. Selecting the passenger position permits a graduated release of the train brake when the train is in passenger service.

3.8.11 Windshields

Windshield controls are two two-position slider switches for defogging and deicing the front and rear windows, and two rotary controls for continuously varying wiper speed, front and rear, with a window wash capability.

3.8.12 Air Comfort System

The air comfort system controls consist of a selector, temperature control and fan. The selector control allows the engineer to select air conditioning, outside fresh air or heat. Air conditioning in the normal position is cooled, humidified fresh air. In the maximum position recirculated air may be used to cool down the cab. The fan is operable in either the high or low position when the selector switch is in any position but off. The temperature control provides a variable setting from low to high.

3.8.13 Headlights

The headlight MU setup switch is a four position rotary selector to set up headlights for multiple unit operation. The switch is set at the nine o'clock position if the locomotive is a rear unit in a multiple consist. The switch is set at the twelve o'clock position if the locomotive is a single or intermediate unit. The switch is set at the three o'clock position if the locomotive is moving short or no hood forward, and the switch is set at the six o'clock position if the locomotive is moving long hood forward.

3.8.14 Instrument Lights

The instrument lighting control is a rotary switch that turns panel instrument lights on and off and provides a dimming capability.

3.8.15 Panel Lights

The panel lighting control is a rotary switch that turns the legend lights on and off and provides a dimming capability.

3.8.16 Exterior Lights

The exterior lighting controls are by two position slider switches for various types of locomotive lighting.

3.8.17 Interior Lights

The interior lighting is controlled by two slider switches, one for lights in the ceiling over the rear wall, and one for the utility light mounted in the ceiling over the engineer and trainman's work stations.

3.8.18 Remotely Controlled Equipment

The remotely controlled equipment panel is used when one or more radio-controlled locomotives are inserted into a train. This panel contains the following functions:

1. Power and Lamp Test
2. System Test
3. Mode Selector
4. Annunciator Panel

5. Alarm
6. Ground Relay
7. Override
8. Sand
9. Cutout Valve
10. Independent Brake.

3.8.18.1 Power and Lamp Test – The power to the panel is energized by the panel power two position slider switch. A lamp test button is provided to check the panel lamp filaments.

3.8.18.2 System Test – The system test is a two position push button used to check the integrity of the radio transmit and receive functions. Depressing the button will illuminate the "XMIT" portion of the button, and a test signal is sent to the remote locomotive. The button is then released and the respond legend will momentarily illuminate. If either portion of the pushbutton does not illuminate, there is a malfunction in either the lead or remote radios.

3.8.18.3 Mode Selector – The mode selector is a push to turn rotary switch used to select the mode of operation of the remote units. These units can be isolated, returned to idle, operated MU or independently. When operated independently a second controller must be used. This controller is described in Section 3.9.

3.8.18.4 Annunciator Panel – The annunciator panel contains caution lights indicating RCE system malfunctions.

3.8.18.5 Alarm – The alarm is a pushbutton that is illuminated when there is a malfunction in the remote units. An auditory stimulus will come on coincident with the light. Pushing to reset will terminate the light and the tone.

3.8.18.6 Ground Relay – The ground relay is a push button that functions identically to the ground relay reset in the lead unit.

3.8.18.7 Override – The override function is a pushbutton that illuminates when depressed to keep remote consist in power or dynamic braking. It is used whenever radio communications between lead and remote units may be interrupted due to obstructions such as tunnels or cuts.

3.8.18.8 Sand – The sanding function is a pushbutton that illuminates when depressed to activate the sanding mechanism on the remote consist.

3.8.18.9 Cutout Value – The cutout value function is a two position slider switch to cut in or out the air regulating value in the remote consist.

3.8.18.10 Independent Brake – The independent brake function is a pushbutton that illuminates either the top or bottom legends. Depressing the button either releases or applies the locomotive brakes on the remote consist.

3.9 WRITING DESK

A utility desk has been provided to the left of the main control panel, as shown in Figure 3-15. The desk has a raised apron around the edge to prevent items from rolling off. The apron is padded and the corner is rounded. A recessed beverage holder and ashtray are shown on the left. A clip has been provided for holding papers, such as train orders. Two small lip lamps are provided to illuminate the desk. Shown at the right is the controller for the throttle and dynamic brake for RCE units when this mode of train operation is employed. This controller is identical to the controller on the main control panel.

3.10 TRAINMAN'S PANEL

The trainman's panel is located on the trainman's console. Details of the panel are shown in Figure 3-16. In the center of the panel is a speedometer that is identical to the one on the engineer's side of the cab. Cab signals are displayed to the right of the speedometer. In the upper left corner there is a pair of slider switches for controlling the lights at the rear wall and the overhead utility light. The rotary switch below that is used to adjust the brightness of the panel lights. The radio handset is located directly to the right of the trainman's panel.

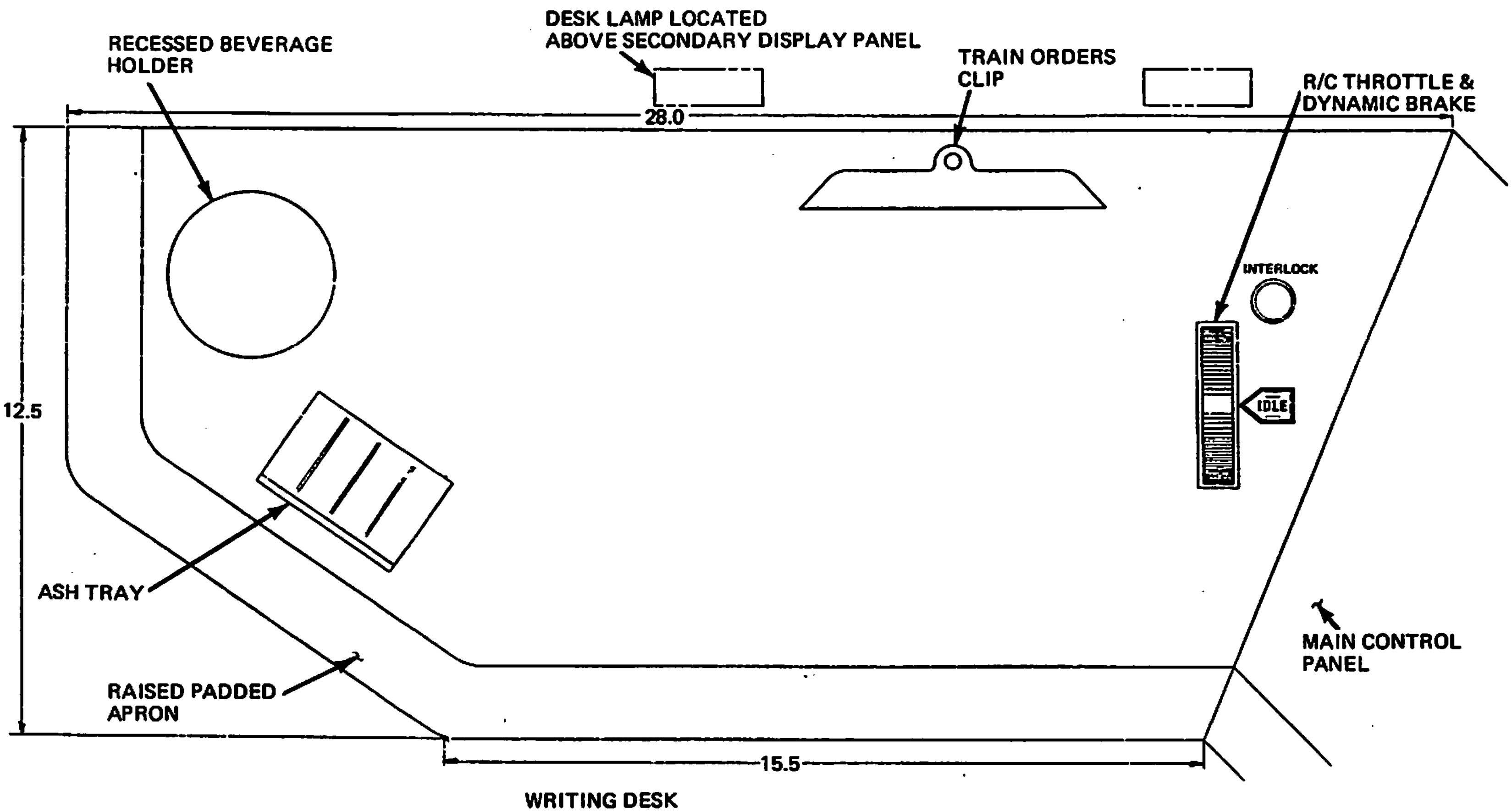

Figure 3–15. Writing Desk

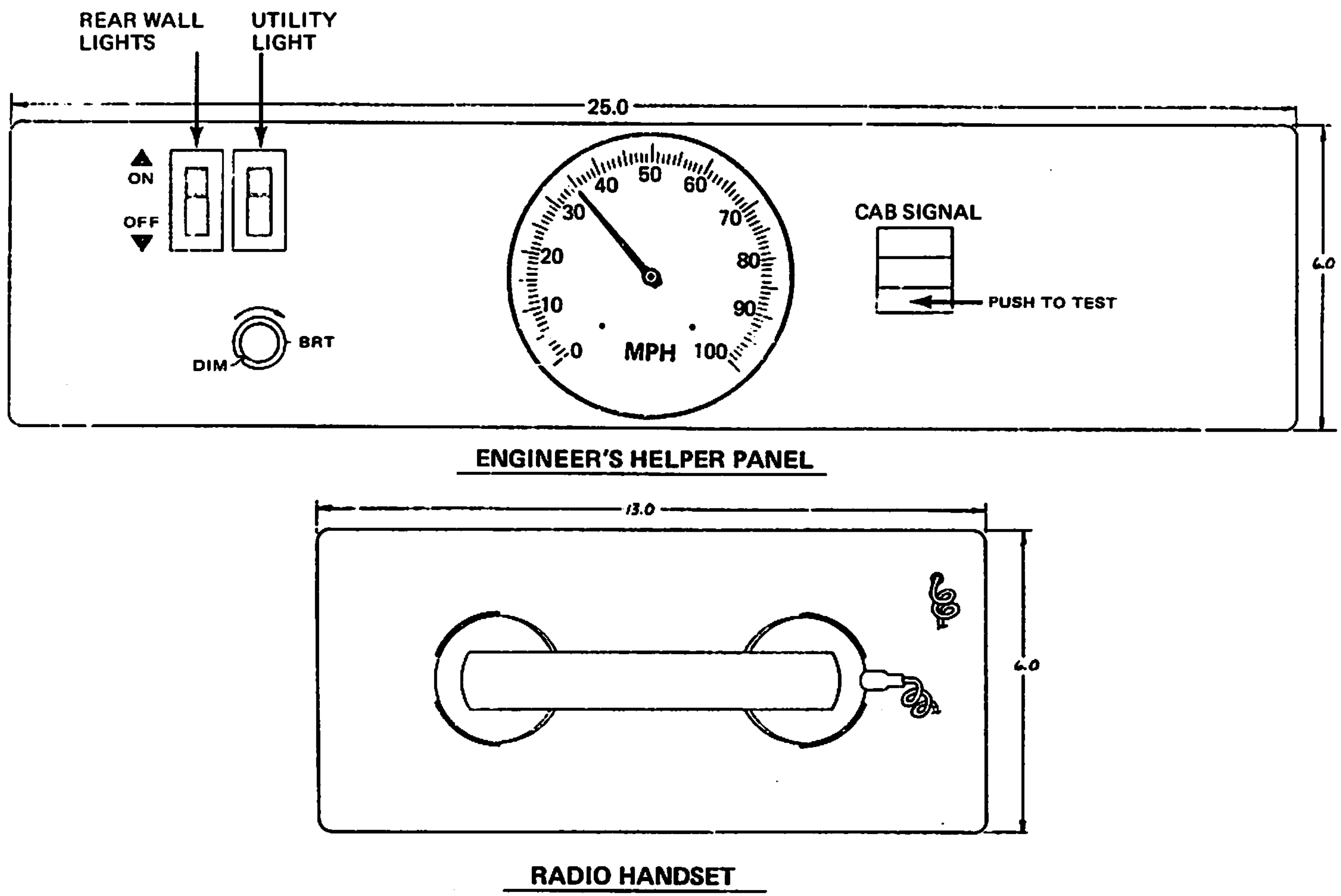

Figure 3–16. Trainman's Panel

4. CONCLUSIONS AND RECOMMENDATIONS

The recommended design for an advanced locomotive cab is considered to represent a significant improvement over current cab designs. Its various features constitute the combined best judgment of a team of designers, representing professional expertise and experience in locomotive design, railroad operations, and engineering psychology. Every feature was selected on the basis of a detailed analysis of the functional requirements of the cab occupants and after exhaustive exploration of alternatives. From the results of the mockup evaluation program it is apparent that a cab of this design would be enthusiastically accepted by the majority of locomotive crew members.

Although the objectives of this design effort have been met, additional evaluation will be required before the recommended cab, or any of its novel features, can be adopted for revenue service. The evaluation, encouraging as the results were, was based on a static mockup. Dynamic testing is now required to obtain judgments of design acceptability by evaluators while they are seeing, hearing, and feeling the responses of a real locomotive to control actions.

APPENDIX A
TEST AND EVALUATION

A.1 INTRODUCTION

A full-scale hard mockup of the preliminary design was constructed. This mockup provided the opportunity to study the concepts derived through task analysis in a controlled test setting using experienced locomotive engineers.

The test and evaluation program was performed in two phases. A preliminary mockup evaluation was accomplished during the period April 12 to April 28, 1976 using engineers from the former Penn Central Railroad. A second evaluation was accomplished during the period May through August 1977 using engineers selected nationally. The results of the test program are presented in the following sections.

A.2 ENGINEER SELECTION

The purpose of the research program is to provide a design suitable for use under diverse operational and environmental conditions encountered nationwide. Therefore, after the preliminary evaluation, evaluators were selected on a nationwide basis from among volunteers in cooperation with the Association of American Railroads (AAR), Brotherhood of Locomotive Engineers (BLE), and the United Transportation Union (UTU). To volunteer for the program the applicant filled out a questionnaire distributed through the aforementioned organizations. A sample questionnaire is shown in Figure A-1. Over fifteen hundred respondents nationwide completed the questionnaire. Thirty-eight were selected to participate in the evaluation and provided a representative mix of skills and experience distributed over the fixed sample size. These plus the twelve engineers who participated in the preliminary evaluation brought the total sample size to fifty.

The specific geographic locales from which the engineers were selected are shown in Figure A-2. The "dots" represent the preliminary evaluators from the northeast corridor, and the "stars" represent the additional thirty-eight.

Table A-1 summarizes the personnel characteristics of the preliminary evaluators, and Table A-2 those of the engineers nationwide. As shown, a wide range of anthropometric measures were provided. The Northeast participants were all highly qualified and operating or supervising in high-speed service on the Northeast Corridor. They represented a cross-section of experience from the New Haven Line, Harrisburg District, Washington, New York, and Philadelphia. All of the engineers were experienced in both freight and passenger service. Four of the engineers had experience on the mountainous terrain near Harrisburg and two were familiar with very early versions of radio-controlled equipment (RCE) for operating remote helper units. They had handled trains from a variety of cabs including electric, diesel electric, turbines and steam. One man, although not an operating engineer had thirty years of supervisory experience in locomotive cabs.

The thirty-eight engineers selected nationwide were equally well qualified. Table A-3 shows the distribution by age group over nine geographic areas for the thirty-eight nationwide

LOCOMOTIVE CAB DESIGN DEVELOPMENT

Those persons wishing to volunteer for inclusion in this program should complete the following questionnaire and return to the address shown below.

1. Name: ______________________ Age: ________

2. Position: ______________________

3. Address: ______________________

____

4. Home Phone: ______________________

5. Railroad: ______________________

6. How many years experience in line haul freight cabs? ________

7. List the locomotives you have worked in this past year.

____

____

8. Have you been to engineman school? ________

9. Have you had experience in a locomotive cab simulator? ________

10. Have you operated a radio controlled locomotive from a lead unit? ________

11. Have you operated a helper locomotive? ________

12. Have you operated a lead locomotive with one or more helper A units, B units, or slugs? ________

13. Have you worked on a locomotive with cab signals? ________

14. Have you ever worked with special train handling aids such as slack/buff indicators, train tonnage profiles or power force indicators? ________

15. Please circle the conditions under which you have worked. (You may circle as many as are appropriate.)

Environments	Terrains
hot	flat land
cold	undulating
humid	steep grades
dry	desert

Figure A–1. Locomotive Cab Design Development Questionnaire

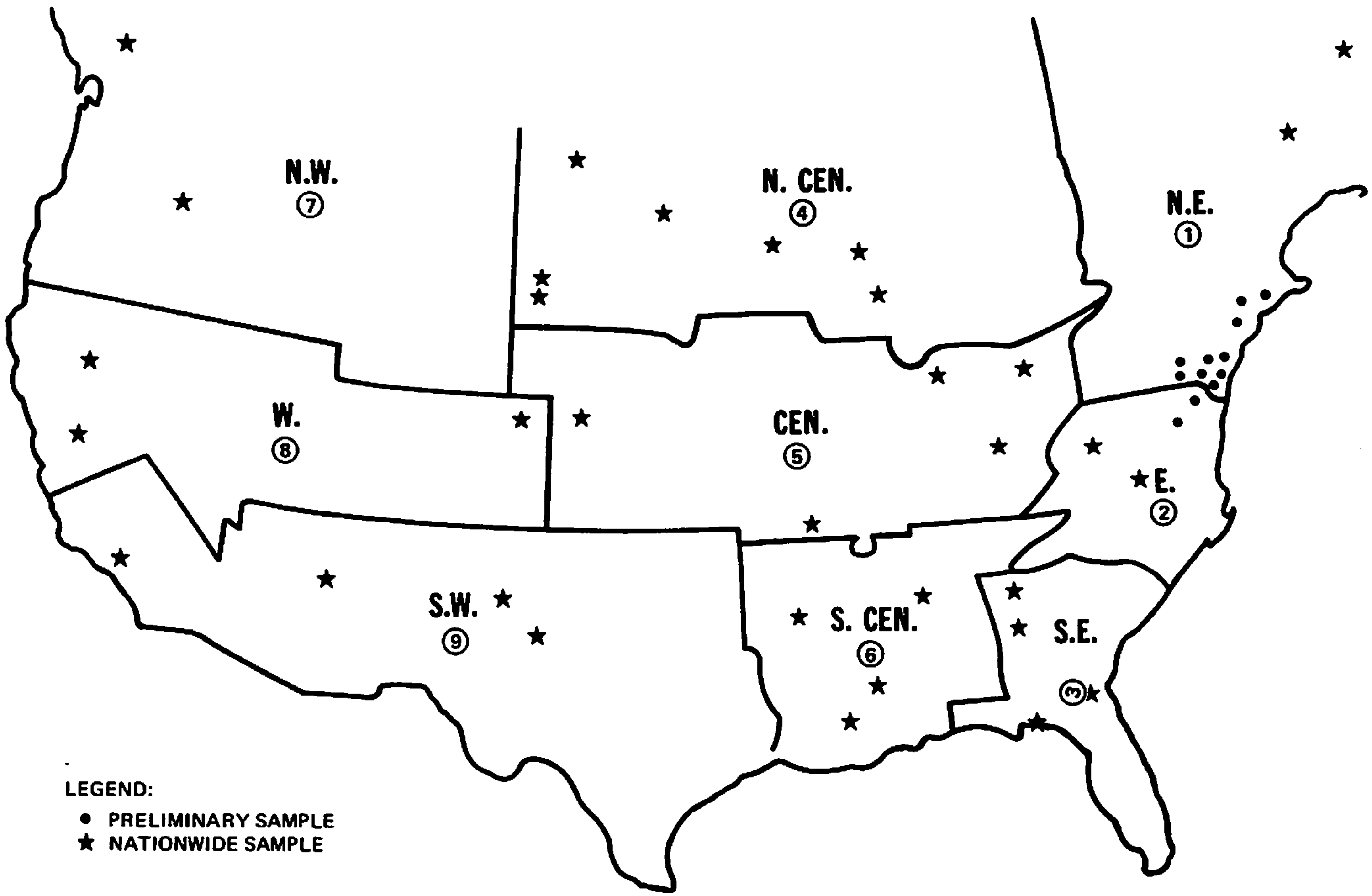

Figure A–2. Regions and Locals from Which Railroad Engineers Were Selected

Table A–1. Personal Characteristics – Preliminary Evaluators

Weight (Lb)	Height (In.)	Age	Vision	Years Exp	Pass.	Frt	Mtn	RCE
184	73	55	GL	21	13	8	No	No
170	69	58	GL	25	15	25	No	No
170	72	55	----	16	----	5	No	No
190	74	59	GL	30	----	----	Yes	Yes
170	72	32	—	6	6	6	Yes	No
155	68	55	----	35	20	15	Yes	No
155	69	56	----	20	10	8	No	No
197	75	60	----	21	15	5	No	No
163	68	57	----	20	10	10	No	No
205	72	37	----	3	3	3	No	No
255	71	53	----	30	20	19	No	No
215	74	54	----	27	27	27	Yes	Yes
				Range				
155-255	68-75	32-60	----	3-35	3-27	3-27	----	----

Table A–2. Personal Characteristics – National Sample

	Height (In.)	Weight (Lb)		Height (In.)	Weight (Lb)
1.	71	180	20.	68	142
2.	70	155	21.	70	205
3.	71	170	22.	70	164
4.	67	156	23.	71	195
5.	74	200	24.	71	168
6.	72	180	25.	72	253
7.	69	165	26.	71	196
8.	69	145	27.	72	235
9.	70	195	28.	69	185
10.	77	300	29.	71	170
11.	70	145	30.	66	145
12.	71	240	31.	69	170
13.	—	—	32.	69	160
14.	70	160	33.	70	172
15.	70	175	34.	72	210
16.	74	205	35.	71	195
17.	72	215	36.	70	145
18.	70	155	37.	75	270
19.	69	175	38.	73	193

Range

Height	66-77 In.
Weight	142-300 Lb

Table A–3. Age Distribution for each Geographic Locale

			Ages (Years)			
			20-29	30-39	40-49	Over 50
1.	Northeast	(2)	2	0	0	0
2.	East	(4)	0	0	3	1
3.	Southeast	(3)	1	0	1	1
4.	North Central	(6)	1	2	1	2
5.	Central	(6)	0	4	0	2
6.	South Central	(4)	1	0	1	2
7.	Northwest	(2)	0	0	1	1
8.	West	(5)	2	1	0	2
9.	Southwest	(6)	1	3	0	2
	Total	38	8	10	7	13
	Percent		21	26	18	34

evaluators. The ages are grouped in ten-year intervals. The total number in each age group is shown at the bottom of the appropriate column with the percent of the total sample indicated below.

Table A-4 shows the distribution of evaluators for the nine geographic locales and the climates they had worked in. The percentage of the sample in each category is shown below the column totals.

Tables A-5 and A-6 show the distribution of evaluators for the nine geographic locales and their operational experience. Percentage by category is shown below the column totals.

Table A-7 shows the distribution of evaluators for the nine geographic locales and their experience in years. The last three columns show the distribution of training and are engineers school, simulator, or both. The percentage by category is shown below the column totals.

A.3 TEST SITE

The mockup evaluations were performed at the Boeing Vertol test facility. The test facility included a room for briefings. The mockup was mounted on a wooden platform ten feet wide, twenty feet long, and four feet high as shown in Figure A-3.

The platform was placed over a single track industrial siding adjacent to railroad rolling stock to provide visual realism and perspective as shown in Figure A-4.

A.4 TEST PROCEDURES

Each evaluator spent one full day at the test site. Each was provided with a copy of an operator's manual explaining the function of the mockup controls, displays and appurtenances prior to the scheduled appearance at the test site.* Most stated that they had read it, and many had marked up the margins of the manual with questions and comments. Some had solicited comments from their associates on their operating divisions and arrived with lists of topics that they felt should be discussed for incorporation in a new locomotive cab design.

The valuation was performed in the following sequence:

1. Pretest Briefing
2. Evaluation
3. Post-Test Debriefing.

A.4.1 Pretest Briefing

The pretest briefing was conducted in three parts:

1. Introduction
2. Familiarization
3. Instructions.

* Locomotive Cab Design Development Volume II: Operator's Manual, Robinson, J., Piccione, D., Report No. FRA/OR&D-76/275.11, October 1976, PB264114

Table A–4. Climatic Conditions by Geographic Locale

			Climates			
			Hot	Cold	Humid	Dry
1.	Northeast	(2)	2	2	2	2
2.	East	(4)	4	4	4	3
3.	Southeast	(3)	3	3	3	3
4.	North Central	(6)	5	6	5	4
5.	Central	(6)	6	6	6	5
6.	South Central	(4)	4	3	4	2
7.	Northwest	(2)	2	2	2	2
8.	West	(5)	5	5	3	5
9.	Southwest	(6)	6	6	6	6
	Total	38	37	37	35	32
	Percent		97	97	92	84

Table A–5. Terrain Conditions by Geographic Locale

			Terrains			
			Flat	Undulating	Steep	Desert
1.	Northeast	(2)	1	2	1	0
2.	East	(4)	3	4	4	0
3.	Southeast	(3)	3	3	3	0
4.	North Central	(6)	4	5	6	1
5.	Central	(6)	6	6	6	1
6.	South Central	(4)	3	2	4	0
7.	Northwest	(2)	2	2	2	0
8.	West	(5)	5	5	5	2
9.	Southwest	(6)	5	6	5	3
	Totals	38	32	35	36	7
	Percent		84	92	95	18

Table A–6. Operating Experience by Geographic Locale

			MU Consist	Helper	RCE Slave	Cab Signal	Special Devices
1.	Northeast	(2)	2	1	0	0	0
2.	East	(4)	4	4	1	2	0
3.	Southeast	(3)	3	3	2	2	1
4.	North Central	(6)	5	5	4	3	2
5.	Central	(6)	6	4	4	2	1
6.	South Central	(4)	4	4	1	2	0
7.	Northweat	(2)	2	2	2	2	2
8.	West	(5)	5	4	2	2	3
9.	Southwest	(6)	6	5	4	1	2
	Totals	38	37	32	20	15	12
	Percent		97	84	53	39	32

Table A–7. Experience and Training in Years

			Experience				Engrg		
			1-10	11-20	21-30	31-40	School	Simulator	Both
1.	Northeast	(2)	2	0	0	0	2	1	1
2.	East	(4)	1	1	1	1	1	2	1
3.	Southeast	(3)	1	0	1	1	2	3	2
4.	North Central	(6)	2	1	2	1	4	2	2
5.	Central	(6)	2	2	1	1	2	2	2
6.	South Central	(4)	1	0	2	1	2	0	0
7.	Northwest	(2)	0	0	2	0	0	0	0
8.	West	(5)	2	1	0	2	2	3	2
9.	Southwest	(6)	3	0	2	1	4	4	4
	Total	38	14	5	11	8	19	17	14
	Percent		37	13	29	21	50	45	37

Figure A–3. Mockup Exterior View

Figure A–4. Visual Realism

A.4.1.1 Introduction – When the engineer arrived at the test site, approximately half an hour was spent in explaining the purpose of the study and getting the engineer relaxed. To provide an appropriate frame of reference, it was explained that the Locomotive Cab Design Development Program is being conducted as part of a research effort to evaluate new concepts in cab control/display arrangement design, operating procedures, general living and working environment, occupant protection, and general safety. It was also explained to the evaluators that their proficiencies were not being studied, but rather it was their collective experience in existing locomotive cabs that would provide the necessary expertise to develop a design that is utilitarian over a wide range of operating environments and conditions. They were encouraged to consider that someday they or their associates may have to operate a locomotive derived from the present design concepts, and, therefore to be as candid as possible during their critique. Thus, every effort was made to create an atmosphere in which the evaluators would feel that they could be as critical and subjective as possible, and that the test personnel were not looking for compliments nor would their feelings be hurt because of adverse criticism.

It cannot be emphasized enough that the initial introduction to the program was a very valuable feature of the test program. In fact, several people later said that they had experienced some apprehension as to what would be expected of them during their stay at the test site.

A.4.1.2 Familiarization with Design Concepts – The second part of the prebriefing consisted of an introduction to the mockup design concepts. Briefing materials included photographs, sketches, slides and documents, including the operator's manual. The evaluators were shown the slides, starting with an overview of the mockup exterior and crew work stations and ending with detail drawings of the controls and displays. After the presentation of the mockup design details, the evaluators were shown photographs of the General Motors Electromotive Division (EMD) clean cab mockup built at the request of the Locomotive Control Compartment Committee and told that the safety features developed under that program would be incorporated in the new cab design if appropriate.

They were shown photographs of various cab designs such as the ASEA electric locomotive recently tested by AMTRAK on the Northeast Corridor, the French Turbo-Train, and an EMD Export model to the Irish railways. This was done to illustrate that there are a variety of approaches to the solution of cab design problems, and to provide a context for the present design. Finally, some items of industry and government research in progress were shown, including train mass distribution graphs, the slack/buff indicator developed by TSC and the Train Handling Analyzer developed by Freightmaster. This was done to show that the state-of-the-art in government and industry railroad research would permit the development of a cab as described.

During the course of this informal briefing the engineer was asked his opinion on a variety of topics and was encouraged to ask questions and make comments.

A dialogue was established because all of the evaluators had strong and divergent views concerning at least some of the mockup features.

A.4.1.3 Test Instructions – The third part of the prebriefing concerned the evaluation process. The evaluator was told that he would be given the opportunity to inspect the mockup in every detail. He was told that he would be required to perform simulated locomotive and train handling procedures as contained in the Operator's Manual according to a prepared scenario. Upon completion of the mockup inspection and checkout procedures, he would be required to rate each mockup item. The ratings were done in the mockup to provide the engineer with the opportunity for a more detailed inspection of a feature prior to the assignment of a rating. The rating process is described in Section A.4.4.

A.4.2 Mockup Evaluations

Following the morning briefing, the engineer was taken to the cab mockup and walked around the outside. A brief description of the crashworthy design concept followed. The engineer was then taken into the mockup and spent some time familiarizing himself with the interior design shown in Figure A-5. He examined the lavatory compartment and noted its features. The engineer was then seated at the control console and worked the controls, which were moveable, and studied the static displays. A mission scenario had been prepared to provide the opportunity to exercise the design features according to the procedures described in the Operator's Manual. The content of the scenario was tailored to the conditions prevailing on each engineer's operating division or divisions. Although the scenario was enacted in the static mockup and therefore had limited realism, the engineer was able to get the feel of the location of displays, switches and controls.

A typical scenario follows: The engineer was told that the locomotive consist was at the roundhouse with the diesel engine shut down. He set up his controls, simulated starting the engines, released the hand brakes, made a brake and sander test, set up the lights and prepared to move to the ready track. A cab signal and an automatic train control test were performed. When on the ready track the engineer activated the reverse control panel to make a movement backward to the departure yard. The locomotive consist was then coupled to the waiting train and the air brakes were charged and tested. The engineer then took the train out onto the main track and picked up speed. He power-braked around a curve and used the train handling display as desired. After cresting a grade, he used dynamic braking on the descending grade. Regaining speed, he approached the terminal and reduced speed as he entered the yard. An unintentional emergency took place as the train negotiated a crossover. After recovering and entering the yard, he cut off his train, went to the diesel house and properly set up the locomotive controls before leaving the consist. The scenario provided an opportunity for the engineer to exercise the cab control features in a controlled sequence as he would when operating a standard production unit. Following the operational simulation, the engineer was asked to rate the design concepts. The ratings are discussed in Section A.4.4.

A.4.3 Post-Test Debriefing

Upon completion of the mockup ratings, the engineers were debriefed. This provided the opportunity to critique the design approach in its broader aspects, suggest improvements to the design, identify areas where further investigation might be required, and comment on the test procedures. It should be noted that, in effect, each engineer evaluated the design three times; first via sketches and drawings, second the physical mockup, and third, the ratings. Thus the opportunity was provided for the engineer to change his mind as details were better understood. Before they left, the engineers were told that if they had any additional comments after reflecting on the design, that they should feel free to convey them to the test team, and some did.

Figure A–5. Interior View – Looking Forward

A.4.4 Rating Scale

A facsimile of a part of the evaluation form and scale is shown in Figure A-6. The first column contains the mockup items that were rated. The second column contains the rating scale, and the third column is used for comments. The engineer was instructed to rate each item on the scale of 1 to 7 with a 1 being very inconvenient to use, while a 7 was most convenient to use. Four was designated a neutral anchor point roughly equivalent to present locomotives with which the engineer was familiar. That is, if a mockup feature was judged no better or worse than in present locomotives in terms of ease of use, it was rated a 4.

The engineer was instructed to write in the comment section the reason for a particular rating, either favorable or unfavorable.

A.5 TEST RESULTS

The fifty engineers ultimately participating in the mockup evaluation were selected from more than 1,500 volunteers for the program. They provided more than 350 manhours of formal evaluations. During this time over 5,000 individual ratings and 2,000 comments were made by the engineers and recorded for subsequent content analysis. The ratings and comments that were negative indicated that either the functional requirements were not satisfactorily met or a design deficiency was present in the mockup. Approximately six percent of the ratings fell into this category. The anomalous ratings and associated comments were examined carefully during the data analysis, and their significance was assessed. It is true that any group of experts is bound to disagree and the engineers were no exception. As expected, and evidenced in the ratings and comments, there was a wide range of opinions expressed on virtually every subject. However, no attempt was made to clinically weigh the judgment of one expert versus that of another; rather, each statement and (where appropriate) each rating was taken on merit and weighed against criteria developed through the task analysis and standard human engineering guidelines and specifications. This resulted in some revision of the functional criteria as a better understanding of road freight operations and locomotive cab designs evolved.

Part of the value of the test and evaluation program is that it provides analytical checks and balances between design concepts developed abstractly and real-world rail operating conditions. In this way design modifications were identified and implemented for incorporation into a final design suitable for further development.

A.5.1 Mockup Exterior

The engineers were generally pleased with the crashwothy concepts.* During the preliminary evaluations, the engineers stated that they did not miss a nose door and appreciated the lack of drafts and leaks which accompany any forward orifice. When asked if they missed the protection of the short hood, they said "no" because they were accustomed to Metroliners and MU equipment which affords little protection. They noted that the slanting windows

* A detailed description of locomotive structural crashworthiness concepts is contained in Locomotive Cab Design Development Volume III, Design Applications Analysis, Robinson, J., Report No. FRA/OR&D 76/275.111, October 1976, PB264115

MAIN CONTROL PANEL ITEM	RATING	COMMENT
6. Console Lock	(1) 2 3 4 5 6 7	Engr's will lose keys.
7. Bell Pushbutton Switch	1 2 3 4 5 6 (7)	Bell should be connected to go on with horn
8. Emergency Stop Pushbutton Switch	1 2 3 4 5 6 (7)	
9. Direction Lever Location	1 2 3 (4) 5 6 7	Lever must be wired so it will not reverse unintentionally locking wheels.
10. Direction Lever Locking	(1) 2 3 4 5 6 7	Direction lever may be held up and put in opposite direction

Figure A–6. Typical Cab Mockup Assessment Sheet offered good deflection possibilities against flying objects. Most of the engineers wanted the switchman's step on the right front corner of the locomotive, although a few preferred it located under the engineer's side window. They also liked the high cab conspicuity. On the basis of these comments, the briefing materials were modified to include a series of direct questions on these topics during the nationwide evaluations. The subsequent results are discussed below.

During the nationwide evaluations, thirty-one of the engineers fround the crashworthy concept satisfactory, two found the absence of a hood objectionable because of the protection afforded, and two thought a front door was needed to get from one unit to another. Three engineers stated that they would prefer to reserve judgment on crashworthiness until the concept has been demonstrated empirically under test conditions. Thirty engineers thought the switchman's step should be located at the forward end of the locomotive on the right hand side. One wanted it on the right aft end of the cab, another wanted a step on both sides of the cab, two thought it should be before the engineer's window, and one thought a step was not needed and that the rear ladder was sufficient. Several miscellaneous comments were offered by the evaluators. One man noted that the front coupler should either fold or hide away so that motor vehicles would not be impaled and dragged along the track. Five men noted that the front windshield should be flush with the outside of the collision posts to prevent snow and slush buildup and provide greater deflection capability. Two engineers expressed concern about the height of the cab indicating that it might induce exaggerated lateral action (sway). One man noted that the cab color should be highly visible and another noted that it should be standardized for the sake of public familiarity.

A.5.2 Mockup General Interior

The engineers were then taken into the mockup and spent time familiarizing themselves with the interior design as shown in Figure A-5.

The following series of photographs illustrate various facets of the mockup evaluation: Figure A-7 shows an engineer seated at the engineer's console at the design eye position facing forward with his right hand on the throttle/dynamic brake and his left hand on the train brake. This illustrates the relationship between the engineer and the forward and side windows. Figure A-8 shows the engineer looking back along the locomotive. His left hand is on the throttle/dynamic brake control. Note that it would be easy to look directly down at the ground from this position. Figure A-9 shows an engineer seated at the console with his left hand on the train brake and his right hand on the throttle/dynamic brake. The independent brake can be seen just to the right of the automatic brake. From this position the engineer has a view down to the track approximately eight feet ahead of the locomotive coupler. The overhead panel is legible to engineers wearing corrective lenses and all of the control functions are within easy reach.

Figure A-10 shows an engineer demonstrating how he would brake against power. Figure A-11 shows the engineer evaluating the secondary display panel and desk. His right hand is on the display select function of the train handling display. Figure A-12 shows an engineer looking back toward the rear of the consist while simulating the acknowledgement of a hand signal from the ground. His left hand is on the throttle.

Figure A–7. Forward Operation

Figure A–8. Rearward Operation

Figure A–9. Normal Operation

Figure A–10. Braking Operation

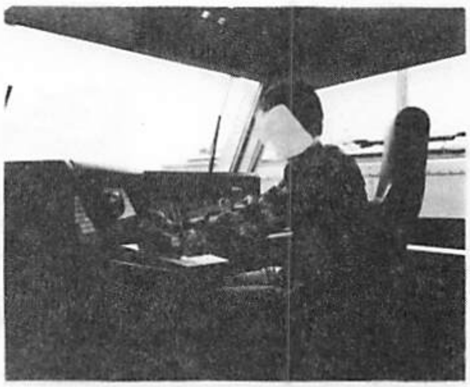

Figure A–11. Review Secondary Display

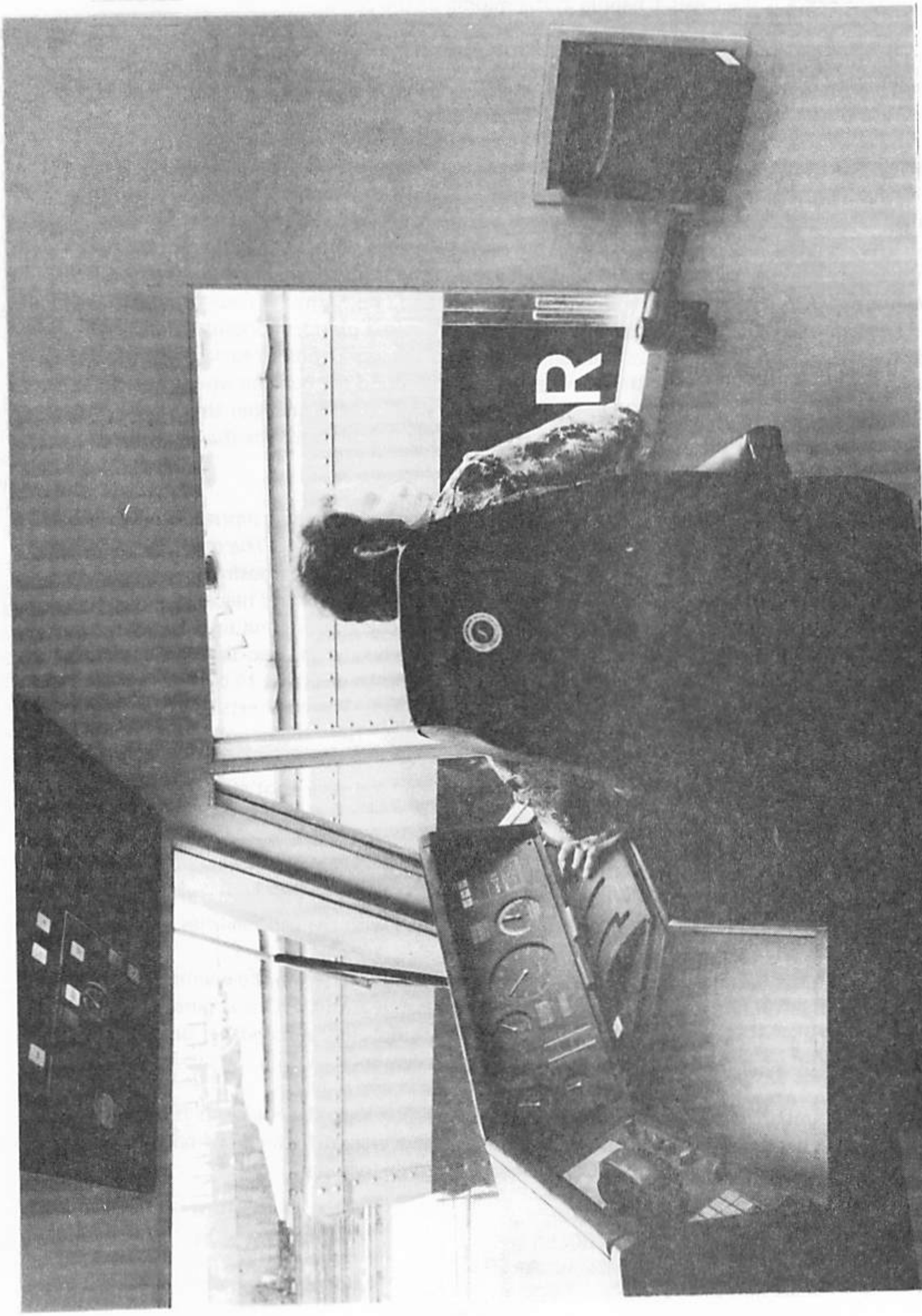

Figure A–12. Side and Rear Viewing

Figure A-13 shows the engineer evaluating the reverse control panel. He has the option in this case of using the panel while looking out of the side window or the window in the rear door. The engineer's right hand is on the throttle and his left hand is on the train brake. The independent brake is the small T handle in the middle of the panel.

Figure A-14 shows an engineer and a student engineer evaluating the helper's console. Note the breakaway armrest on the helper's seat. The pneumatic emergency brake handle is shown recessed at the lower right-hand corner of the photograph.

The engineers inspected the lavatory compartment and noted its features. During the preliminary evaluation, the engineers stated that they liked the light colored cab interior, although one man remarked that the aluminum interior in some Penn Central cabs was too light and glary. They did not feel that a helper's window was necessary on either side of the cab, and did not mind the blind spots. Most of the men wanted the third seat directly behind the helper's seat, a few wanted it in the middle of the cab, and one wanted it back against the rear wall. They all liked the high operating position and the raised platform because it got them out of the slush, water and drifts. They all appreciated the work console surface with a place for train orders and time tables. It was noted that a lip around the console would be desirable to keep objects from rolling off. One man suggested a small shelf just under the writing desk to store small items. All of the men wanted an adjustable rear view mirror that was vibration-proof.

Some of the engineers wanted a full length rear view mirror while others desired a glass wind vane with an adjustable mirror located either at the bottom or the top. The consensus was that brow lighting under the top lip of the secondary display panel was desirable, and that an additional utility light should be provided overhead at the engineer's and helper's work stations. This latter light should be controllable from both work stations and by additional switches located on the side walls near the rear doors. The engineers liked the instrument and panel lighting concepts. One man pointed out that it would be desirable to change light bulbs without the use of tools, especially Phillips-head screwdrivers. The engineers suggested various locations on and around the control consoles for an ashtray. Their major concern was that it should be in a place where ashes would not be blown up and about. Some men suggested that the foot rest be extended under the entire console and that a similar foot rest be installed at the helper's console.

Finally, several men emphasized that the whole cab concept would be self-defeating if all cab appurtances were not well maintained. Table A-8 shows the ratings obtained during the preliminary evaluations. The engineers were generally pleased with the cab facilities.

The trash container was downrated because it was located too far from the engineer's station. These two men felt that no one would open it in its present location. One engineer pointed out the importance of designing for ease of removal for emptying, and another observed that sharp corners and edges should not be exposed when it was open.

The stowage compartment was rated acceptable. Discussion with the engineers revealed agreement that the compartment should be lighted. There were differences of opinion as to whether shelves, coat hooks, bars, and/or hangers should be included.

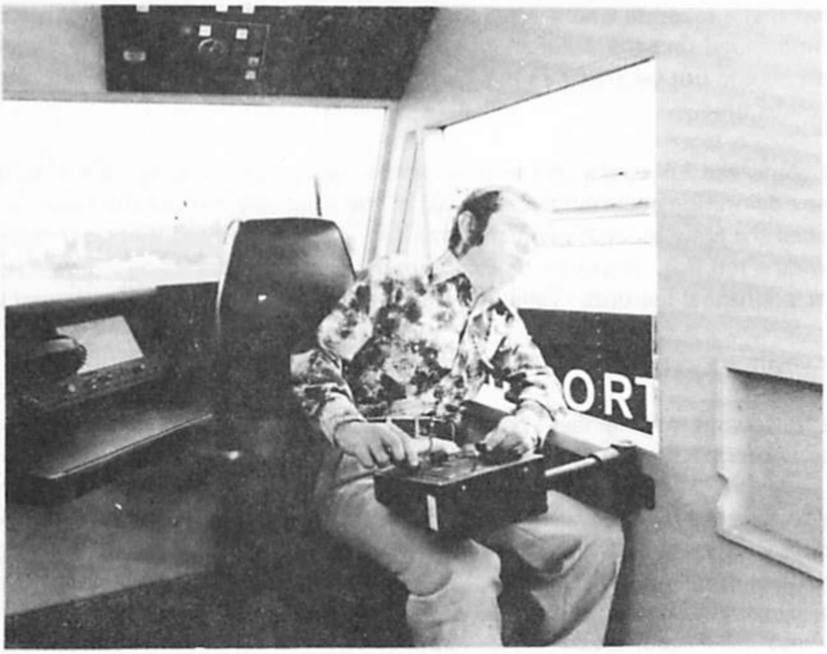

Figure A–13. Reverse Control

Figure A–14. Helper Console

The men all liked the refrigerator. One man thought the door should have a positive lock and not a magnetic gasket.

There was a wide range of opinions regarding the drinking water dispenser. Some engineers stated that a separate water dispenser was unnecessary or even downright undesirable. They recommended that the water should be in individual containers in the refrigerator. The container should not be plastic as the flavor of the plastic might be imparted to the water over a period of time.

The combined fusee rack and torpedo holder was generally acceptable as to location. However, some downrating occurred because two of the engineers wanted the fusees in a dispenser that allowed the crew to see how many remained. One man noted that no provision was made for stowing a red flag. Based on these preliminary findings the rating scale was expanded to include additional features. Table 5-9 shows the ratings by the nationwide sample.

The engineers were also generally pleased with the facilities.

The footrest at the engineer's console was judged to be a reasonable feature. One man downrated it because he thought it should be higher.

The seats in the mockup were not qualified for the railroad environment. They were standard camper van seats. They could be adjusted in the vertical plane, rotated 180°, and had fold down arm rests. It was explained that the present study was not concerned with a particular seat. However, an ideal seat was described that had features recommended in Reference 5. The seat was described as adjustable fore and aft and up and down to permit operators of different statures to position themselves in a posture that would allow reach to all the controls and optimum internal and external visibility. As shown in the table, the seating concept was rated highly by the engineers. The following significant comments and suggestions were received. Three engineers wanted the seat to be a ventilated type to prevent sweating. One engineer desired a fold down seat attached to the right cab wall. Two evaluators found the seat undesirable because a seat that was too comfortable would be likely to induce drowsiness. One engineer suggested that the seat should be adjustable laterally, that is, out away from the wall. One engineer noted that the high back feature would be undesirable for switching because of its visual obstruction. Finally, one engineer suggested that the aft adjustment be such as to allow the engineer to stand at the work station.

The foot actuated horn control, although acceptable to the majority of engineers, showed a wide range of variability in the ratings. Seven engineers expressed a preference for a modulated horn for town and country use. Six engineers commented that the floor button was an improvement because it freed the hands during high workload periods. One engineer expressed a desire to have a foot pedal rather than a button. Two engineers did not want a modulated horn, stating that they always wanted it to come on as loud as possible to alert would be trespassers. Six engineers stated that they preferred a hand actuated horn located on the main control panel instead of the floor button. Eight others thought that the horn should be accessible to any cab occupant. Eight commented that an additional hand actuated horn was needed that permitted operation while the engineer is standing. One wanted the horn proximate to and operable with the right foot and one suggested that the locomotive be equipped with a standardized chime distinctly recognizable to the public as a train.

Table A–8. Feature – Cab Facilities (Preliminary)

Item	Rating 1	2	3	4	5	6	7	Range
Trash Container	2	–	1	1	–	1	7	1-7
Stowage Compartment	–	–	–	1	3	2	6	4-7
Lavatory Compartment	–	–	–	–	–	1	11	6-7
Food Storage Refrigerator	–	–	–	–	–	1	11	6-7
Drinking Water Compartment	1	–	1	2	1	3	4	1-7
Fusee and Torpedo Holder	–	1	1	1	1	1	7	2-7

Table A–9. Feature – CAA Facilities (Nationwide)

Item	Rating 1	2	3	4	5	6	7	Range
1. Foot Rest	–	–	1	5	4	4	24	3-7
2. Seat	–	–	1	2	5	9	20	3-7
3. Horn	2	2	3	4	5	4	18	1-7
4. Writing Desk	1	–	–	–	1	6	30	1-7
5. Fusee/Torpedo	1	–	–	–	2	6	29	1-7
6. Trash Container	1	–	–	10	4	3	20	1-7
7. Stowage	–	–	–	2	1	7	23	4-7
8. Lavatory	1	–	–	2	4	4	27	1-7
9. Refrigerator	–	1	–	2	4	5	26	2-7
10. Drinking Water	–	1	2	2	4	3	26	2-7
11. Raised Platform	1	–	1	3	7	3	23	1-7
12. Wall Switches	–	–	–	–	6	5	27	5-7
13. Utility Lights	–	–	–	1	5	8	26	4-7
14. Console Lip Lights	–	–	–	1	5	4	28	4-7
15. Cab Color	1	–	1	4	6	10	16	1-7

The writing desk was acceptable. One engineer commented that the corners should be rounded, one said it wasn't needed, two thought it should be flat instead of slanted and eighteen agreed that it should have clips to hold such items as train orders and time tables.

The stowage compartment was acceptable to everyone. One engineer noted that the door should be positively latching, one said no door was required, one suggested a raised floor to keep items dry when snow and water get into the cab, and one disliked the compartment because of the potential for abuse by using it for storage of tools, hoses and drawbars.

The fusee/torpedo holder rack was acceptable. One engineer noted the absence of a place to stow a red flag and downrated the feature. Three suggested that a flagging kit be used and two wanted it located on the rear wall.

The lavatory compartment was acceptable. Two engineers commented that it should have an exit door directly to the outside of the cab for quick escape in the event of a collision. Two thought the compartment should be larger, one thought there should be padding on the inside of the door, two thought a window or vent to the outside was desirable, one mentioned that air flush toilets have been a problem, one thought there should be a mirror, and one thought the lavatory compartment should be located at the rear but behind the helper so that glare from the light would not distract the engineer. Finally, one engineer stated that the compartment should be fireproofed.

The bilevel concept was acceptable. Four engineers wanted the corner to the left rear of the engineer extended to preclude tripping when leaving the seat. One engineer thought the platform should be modified to accommodate the crash station. Two suggested that each level should be a different color for facilitating discrimination, and one thought the floor level should be lighted. Four engineers described the platform as hazardous, although only two of them rated it worse than a four.

The rear wall switches were acceptable to all of the engineers as were the overhead utility lights. Three commented that it would be useful for reading train orders.

The secondary console lip lights were acceptable. One engineer stated that they were not needed.

The interior cab color was rated acceptable. Five engineers stated that the color was too light and would prefer a darker color because cabs are so difficult to keep clean, and one specified that the color should be gray.

The refrigerator was rated acceptable. Two engineers commented that it was either unnecessary or unfeasible, two thought it was larger than needed and one wanted it relocated to the space occupied by the lavatory.

The drinking water dispenser was generally rated acceptable. Seven engineers stated a preference for individual cartons or cans of water instead of the cups and spigot. One engineer suggested that a very large water supply be available because he sometimes had to put out fires on his train.

Finally, one engineer thought that the high voltage cabinet circuit breakers should be available in the cab for ease of access. Seventeen stated that it should not be in the cab and they would not miss it. Seven engineers wanted the low voltage cabinet moved from the lavatory to the rear wall.

Visibility — Table A-10 shows the ratings of the cab windows in terms of visibility for the preliminary sample. As shown in the table entries, the visibility was favorably rated. Several engineers recognized that although the windows in the rear doors were larger than those found in today's production cabs, they were further back and thus the apparent size was the same and rated them accordingly.

Table A-11 shows the ratings of the windows for visibility by the national sample. Again, the visibility was generally rated acceptable. Seven engineers commented that glass must be ballistic tolerant safety glass, ten commented that the windshields needed a sun visor or shade tinted at the top, one commented that a deflector or some similar device was needed to defend against foreign objects. One engineer wanted the front windows securely mounted to locomotive structure. Two engineers suggested integral defrosting and deicing elements, four suggest that the front window should be flush with the cab exterior so that piles of snow would not be trapped. One engineer pointed out that sand blasting of the windows is a problem. One engineer noted that there should be more forward over-the-nose visibility to see the locomotive coupler. (Visibility to the track over-the-nose in the mockup is eight feet in front of the coupler.)

Visibility through the rear windows was acceptable.

The small side windows were generally acceptable. The unacceptable ratings were assigned because the engineers desired a venting window to exhaust smoke and fumes.

The large side windows were generally rated acceptable. One engineer suggested that slide tracks, sills and windows should be replaceable modules, and another thought the window sill should be padded, while one wanted an up and down slide action. Seven engineers stressed that the side windows should also be ballistic tolerant by using safety glass, four mentioned the desirability of sun shades, visors and a defog/deice capability or thermopane to combat fogging.

Sixteen engineers objected to the blind spots on each side of the cab behind the side windows, while eight felt that additional side windows were either undesirable or not needed.

Cab Emergency Provisions — Table A-12 shows the ratings of the mockup emergency provisions assigned during the preliminary evaluations. The two rear doors as shown in Figure 3-2 were very favorably received and no problems were forecast concerning leaving the cab under emergency circumstances. One man pointed out that the door moldings should be rounded to make it easy to sweep out the cab.

The side windows were well received. The low ratings were assigned because, although the windows are large enough to escape through, they are too high above the ground. Serious concern was expressed about jumping from a high place on a moving locomotive with the potential for serious injury.

Table A–10. Feature – Visibility (Preliminary)

Item	1	2	3	Rating 4	5	6	7	Range
Left Side Window	–	–	–	–	–	1	9	6-7
Left Front Window	–	–	–	–	–	1	10	6-7
Right Front Window	–	–	–	–	–	1	9	6-7
Right Side Window	–	–	–	1	–	1	9	4-7
Rear Window	–	–	–	2	–	2	7	4-7

Table A–11. Feature – Visibility (Nationwide)

Item	1	2	3	Rating 4	5	6	7	Range
1. Right Front Window	–	–	1	2	1	5	29	3-7
2. Right Small Window	–	–	2	4	5	8	18	3-7
3. Right Large Window	1	–	–	5	1	7	24	1-7
4. Rear Windows	–	–	–	8	2	8	20	4-7
5. Left Front Window	–	–	–	6	–	5	27	4-7
6. Left Small Window	–	–	2	4	4	10	18	3-7
7. Left Large Window	1	–	–	5	1	9	21	1-7

Table A–12. Feature – Emergency Provisions (Preliminary)

Item	1	2	3	Rating 4	5	6	7	Range
Rear Doors	–	–	–	–	–	2	8	6-7
Side Windows	1	–	–	1	–	1	9	1-7
Front Windshields	1	1	–	–	–	1	9	1-7
Roof Hatch	1	–	–	–	–	2	8	1-7
Fire Extinguisher Location	–	1	–	–	1	2	8	2-7
First Aid Kit Location	–	1	–	1	–	2	8	2-7

Most of the engineers rated the large front windows favorably for emergency escape. Two engineers were very concerned that the push-out feature of these windows would compromise window integrity in the event of an impacting object.

The roof emergency escape hatch was rated highly by the engineers. One downrated it because he thought it was unnecessary. It should be noted that the engineers were told that instructions for removing the hatch would be printed both inside and outside of the cab, either directly on the hatch or in close proximity.

The location of the recessed fire extinguisher was rated acceptable. One engineer did not want it in the cab at all.

Most of the engineers liked the location of the first aid kit in the lavatory compartment where they felt that it was least likely to be stripped. One engineer wanted it in the cab compartment where the fire extinguisher is located.

Table A-13 shows the summary of the ratings assigned to the emergency provisions during the nationwide evaluation. The two rear doors were acceptable to all of the engineers. One engineer preferred a side door for the helper or some sort of escape hatch to the side. One engineer desired two front doors.

The roof hatch was rated acceptable by most of the engineers. Several engineers were unenthused, primarily because they felt it was impractical.

The fire extinguisher was rated acceptable. One engineer downrated it because he thought two were needed; one dry and one wet.

The first aid kit was rated acceptable. Two engineers thought it should be located to the right of the helper's work station and one man thought it should be locked to prevent theft.

During the mockup evaluation a crash station concept was offered to the engineers. It was proposed that a survivable volume be provided (see Figure 3-7) in the event of a collision to protect the crew in the case of a locomotive sitting on top of the cab. The cab design assumes a structural concept of controlled collapse, wherein the cab would collapse to the level of the front window sill. The remaining volume constitutes a survivable volume and is designated the crash station. If a collision were imminent and there was not time to escape through doors, the crew would lie on the floor with their feet braced against the fire wall and their heads braced with their arms. This concept was well received by the engineers. Three men commented that they had little or no confidence in the concept unless proven in tests. The downrate occurred because one engineer wanted an enclosed space (such as the lavatory) sealed from flammable materials and with an escape chute to the ground. One engineer commented that rollover protection was a necessity in territories where washouts and rock slides are a common hazard.

Main Display Panel — Figure 3-8 shows the arrangement of the main display panel at the engineer's work station. The following functions are contained on this panel:

Table A–13. Feature – Emergency Provisions (Nationwide)

Item	Rating 1	2	3	4	5	6	7	Range
1. Rear Doors	–	–	–	1	5	3	29	4-7
2. Roof Hatch	1	1	1	3	1	5	26	1-7
3. Fire Extinguisher	–	–	1	7	2	6	22	3-7
4. First Aid Kit	1	–	–	7	5	1	24	1-7
5. Crash Station	–	1	–	4	1	3	29	2-7

1. Brake pipe air flow meter
2. Main reservoir pressure meter
3. Equalizing reservoir/brake pipe pressure meter
4. Brake cylinder pressure meter
5. Emergency brake on annunciator
6. Brake pipe venting annunciator
7. Consist alarm annunciator
8. Speedometer
9. Cab signals
10. Power/drawbar force indicator
11. Timer.

The preliminary ratings are shown in Table A-14.

Most of the engineers were not familiar with the brake pipe air flow meter. It was explained to the engineers that the meter would have an adjustable pointer in addition to the regular pointer to set in the value at which the brake system is fully charged. Some of the men who were familiar with brake pipe air flow gages wanted a caution light on or near the meter. This light would come on whenever the meter pointer deflected from the adjustable pointer. Some engineers queried the utility of the out portion of the scale and some wanted an in-scale of one to fifteen.

The main reservoir pressure gage elicited mixed opinions from the engineers although it was generally favorably noted. This seemed due to their unfamiliarity with present locomotive compressor systems and the insufficient capacity of the air compressor systems on some older locomotives; therefore, they preferred numbers (absolute value in psi) at both the high and low ends of the scale.

There was almost universal acceptance of the brake pipe pressure/equalizing reservoir vertical scale indicator. Some engineers questioned the 110 psi high resolution limit and it was pointed out that the indicator was designed for line haul freight use and that today's train air brake systems are sometimes charged up to this value. They pointed out that they run piggyback trains at 100 psi brake pipe pressure. The brake cylinder gage was rated generally acceptable. Again some engineers questioned the high upper limit of 120 psi. It was pointed out that some newer locomotives are at 90 psi and that readings higher than that would alert the locomotive crew to air from the main reservoir being applied directly to the locomotive brake cylinders.

The speedometer was very acceptable. A suggestion was made that provision be made so the engineer could recalibrate it. Most engineers expressed dissatisfaction with digital readouts for freight trains although they found them acceptable on metroliners. Some engineers did not like digital speedometers in any application. This is because digital speedometers are distracting. There is a tendency to look at it more than necessary with the attendant possibility for overcontrolling the train.

Table A–14. Feature – Main Display Panel (Preliminary)

Item	Rating 1	2	3	4	5	6	7	Range
Brake Pipe Air Flow Dial	–	–	–	1	1	1	9	4-7
Main Reservoir Pressure Dial	1	–	–	1	3	2	5	1-7
Equalizer Reservoir/Brake Pipe Pressure Gauge	–	–	–	1	–	1	10	4-7
Brake Cylinder Pressure Dial	–	–	–	2	1	1	8	4-7
Speedometer Dial	–	–	–	–	–	1	10	6-7
Power/Drawbar Force Dual Pointer Dial	–	–	–	–	–	3	9	6-7
Cab Signals	5	1	1	1	–	1	3	1-7
Consist Alarm Annunciator	–	1	–	–	–	2	8	2-7
Brake Condition Annunciators Lights	–	–	–	1	–	4	7	4-7
Timer	–	–	–	2	–	1	9	4-7

The function of the power/drawbar force indicator had been described to the engineers in considerable detail. The lack of numbers on the dial face was discussed and most engineers did not object. A few suggested numbers 1 through 10 as reference marks and several thought the functions should be on separate gages rather than a single duplex gage.

There was a wide variety of opinions concerning the cab signals. As shown in the table, they were rated unacceptable. The Penn Central engineers are somewhat special in that they have cab signals that are somewhat more elaborate than those found on other properties in most of the United States. The location of the signals and acknowledging devices was the subject of much concern. The signals were downgraded because they did not have enough aspects and were poorly located with respect to that which the engineers were accustomed. One engineer commented that the signals in their present location may be lost in the clutter of displays and therefore may not adequately attract attention. A suggestion was made that there should be a device for performing a cab signal test in the cab in addition to yard tests. If such a device were installed it could be connected with an acknowledger. One engineer suggested that the cab signals could be displayed on the CRT provided. Colored signal aspects, of course, could not be displayed on the CRT. It was also quickly apparent that the engineers missed the signal acknowledger to which they were accustomed. It was generally agreed that an acknowledging device was necessary in locomotive cabs operating where there is Automatic Train Control (ATC) to prevent unnecessary penalty applications of the brakes. The engineers had various opinions concerning the location of such a device. Some wanted it located either on the right or the left side of the main control panel. Some thought a foot pedal would suffice.

From a human factors viewpoint, the recommendation for the final design is that the acknowledger should be integrated rationally with the other display and control devices, and not simply placed where space happens to be available.

The consist alarm annunciator with reset feature was rated acceptable by all but one of the engineers. Some engineers, however, wanted the annunciator light divided into four sections. This was because they wanted to know whether the malfunction was in the first, second, third, or fourth and beyond units. In addition, some engineers expressed a desire to be able to isolate the second through the fourth units from the lead unit.

The brake pipe venting and emergency brake annunciators were rated acceptable. Most engineers appreciated the auditory cue associated with the onset of the light. It was also pointed out that the brake pipe venting annunciator would have an associated auditory cue that would remain on as long as the brake pipe was venting.

The timer was rated acceptable. Two engineers commented that it was unnecessary and one questioned the accuracy of such a device and felt that the engineer would have to calibrate it against his watch much as he calibrates the speedometer today.

Table A-15 shows the ratings assigned to the main display panel by the nationwide sample. The panel location and arrangement were rated acceptable.

The flow meter ratings were generally acceptably rated. Four engineers thought it was either undesirable or unnecessary. Fourteen engineers commented that a light was needed to alert

Table A–15. Feature – Main Display Panel (Nationwide)

Item		Rating 1	2	3	4	5	6	7	Range
1.	Panel Location	–	–	–	1	–	7	30	4-7
2.	Panel Arrangement	–	–	–	–	2	10	26	5-7
3.	Flow Meter	2	–	1	2	3	6	24	1-7
4.	Press Gauge	3	3	2	5	5	8	12	1-7
5.	ER/BP Pressure Meter	–	1	–	–	2	5	30	2-7
6.	Brake Cylinder	–	–	–	8	6	6	18	4-7
7.	Emergency Light	–	–	1	3	3	6	25	3-7
8.	BP Venting Light	–	–	–	–	4	5	29	5-7
9.	Consist Alarm	–	–	–	1	1	7	29	4-7
10.	Speedometer	–	–	–	4	2	5	27	4-7
11.	Pwr/DRB Force	2	–	2	2	3	5	24	1-7
12.	Cab Signals	–	–	–	4	3	4	20	4-7
13.	Timer	–	1	1	1	2	2	31	2-7

the engineers that the air flow was increasing beyond the rate set in with the adjustable pointer. Four engineers thought the adjustable pointer to set in leakage was a desirable feature, while three did not. One engineer thought that the meter should be larger and one stated that only an in-flow indication was needed.

The main reservoir pressure gage showed considerable variability in the assigned ratings. Twenty engineers commented that the gage needed numbers in psi. The stated that the exact pressure range was important information because the exact pressure may vary with a particular train configuration and numbers are useful for maintenance purposes. Two engineers stated that they preferred the present duplex gauges. One engineer thought that reference tic marks would suffice; one thought the gage should be larger, and another stated that if no numbers are to be used the green zone should begin at 15 psi over brake pipe pressure. It had been explained to the engineers that the transition from green to red at the low and high ends indicated the point at which the governor loaded and unloaded the compressor so as to maintain air pressure within the desired limits, usually 130 to 140 psi.

The equalizing reservoir/brake pressure meter was rated acceptable by all of the engineers except one. The consensus was that it was an improvement over the present duplex gages. One engineer stated a preference for the duplex gage that is now installed in locomotive cabs and one engineer preferred more resolution below 50 psi because sometimes a brake pipe reduction may be made down to 30 psi for braking very long trains of two-hundred or more cars.

The brake cylinder pressure gage was acceptable. One engineer desired operating range marks, one thought an audible tone was necessary to alert the engineer that there was an undesirable pressure buildup, and two thought the gage face should be larger.

The emergency brake light was rated generally acceptable. One engineer stated that the feature was undesirable and preferred air venting into the cab.

The brake pipe venting light was rated acceptable by all of the engineers, who appreciated the reduction in noise, pollution and dirt. One engineer commented that the rushing sound provided information about venting air velocity that the tone and light do not provide. One engineer suggested that the light and tone should be variable corresponding to varying velocities of venting air. One engineer wanted the light located next to the brake pipe gage, and one pointed out that the tone and light should be actuated by actual air exhausting and that false alarms should be avoided. It should be noted that in newer braking systems, such as the ABDIW with its local application feature, the duration of the vent in the cab may be very short.

The consist alarm light was rated acceptable by all of the engineers. Many found the present alarm bells objectionable. The prevailing comments indicated the need of an indication of which locomotive the malfunction was in, the nature of the malfunction, and the desirability of a reset capability from the lead unit. One engineer commented that the light was undesirable because it would be conducive to abusing the offending locomotive.

The speedometer was rated acceptable by all of the engineers. Two engineers stated that the speedometer should be calibrated to prevent tampering. One engineer suggested that the pointer taper to a finer point so as to not obscure digits. Three stressed the need for accuracy because speed limits are strictly enforced. One engineer did not want the speedometer driven from the lead wheels. Another wanted a low speed option giving readings where 10 mph equals 1 mph in the range of 1 to 10 mph. Still another evaluator thought this feature was unnecessary. One engineer reported that reflections in instrument glass is a problem in cabs. Finally, one engineer preferred a digital speedometer readable to tenths of a mile.

The power/drawbar force indicator was downrated by four engineers. Three engineers stated that the drawbar force indicator was not necessary. The major issue concerned the qualitative scale. Sixteen engineers judged that the gage should read amperes because it indicates the condition of an engine, and some railroad procedures refer to ampere readings. One engineer remarked that the power indicator was not needed with the drawbar information provided. Four engineers desired more reference marks, two thought the gage should be larger, one thought it should be smaller, and one thought the numbers were necessary for maintenance purposes. It was understood by these men that the locomotive consist drawbar forces were measured at the last coupler.

The cab signals did not generate the controversy among these engineers that they did during the preliminary evaluation by the Penn Central engineers. Twenty-six commented that the cab signals were in a good location. Two engineers commented that a warning of a more restrictive block ahead would be desirable and one engineer wanted the cab signals located next to the speedometer. Although many of these engineers had been in locomotives equipped with cab signals, only a few had much operating experience with them.

The timer was rated acceptable by most of the engineers. Seven stated that it was not needed.

Main Control Panel – Figure 3-9 shows the arrangement of the main control panel. The following functions are contained on this panel:

1. Sander Control
2. Train Brake Control
3. Independent Brake Control
4. Throttle/Dynamic Brake Control
5. Throttle/Dynamic Brake Interlock
6. Stop All Engines Control
7. Direction Control
8. Console Lock
9. Emergency Stop Control
10. Bell Control.

Tables A-16 through A-19 show the ratings of the train brake during the preliminary evaluation. The train brake lever location was rated generally acceptable; however, most of the engineers preferred the T handle to be higher from the surface of the panel so that their fingers would more comfortably fit around it. One engineer noted that he could not see the release label when the handle was in the release position. One engineer suggested that the

Table A–16. Feature – Train Brake (Preliminary)

Item	Rating							
	1	2	3	4	5	6	7	Range
Train Brake Lever	–	1	–	3	3	3	2	2-7
Reset Position	–	–	–	1	2	3	6	4-7
Release Position	–	–	–	3	1	3	5	4-7
Minimum Reduction Position	–	–	–	2	1	5	3	4-7
Service Range Position	–	–	–	2	2	3	5	4-7
Full Service Position	–	–	–	2	–	4	6	4-7
Suppression Position	–	1	–	2	–	4	5	2-7

Table A–17. Feature – Independent Brake (Preliminary)

Item	Rating							
	1	2	3	4	5	6	7	Range
Independent Brake Lever	–	–	–	1	1	5	5	4-7
Emergency Release	–	–	1	–	2	3	6	3-7
Automatic Release Position	1	–	–	–	1	2	8	1-7
Release Position	–	–	–	1	1	3	7	4-7
Full Service Position	–	–	–	1	1	3	8	4-7

Table A–18. Feature – Throttle/Dynamic Brake (Preliminary)

Item	Rating							
	1	2	3	4	5	6	7	Range
Throttle Dynamic Brake Handwheel	1	2	–	5	–	2	2	1-7
Idle Position	–	1	1	2	1	1	6	2-7
Power Settings	–	–	–	1	2	3	6	4-7
Dynamic Brake	–	–	1	3	–	2	5	3-7
Set Up Position	–	–	1	2	1	3	5	3-7
Dynamic Brake Settings	–	–	–	3	–	3	4	4-7
Interlock Pushbutton	–	–	–	3	1	1	7	4-7

Table A–19. Feature – Primary Controls (Preliminary)

Item	Rating 1	2	3	4	5	6	7	Range
Direction Lever	–	–	1	3	2	1	5	3-7
Forward Position	–	–	1	3	–	1	6	3-7
Neutral Position	–	–	1	2	–	2	7	3-7
Reverse Position	–	–	1	3	–	1	5	3-7
Emergency Stop Button	1	–	–	1	–	2	8	1-7
Bell Pushbutton	–	–	–	2	–	3	7	4-7
Console Lock Pushbutton	1	–	–	–	1	1	9	1-7
Feed Valve Knobs	–	–	–	1	–	3	8	4-7
Manual Sand Pushbutton	–	–	–	–	2	2	8	5-7
Reverse Control Panel Pushbutton Switch	–	–	–	1	–	2	9	4-7
Stop All Engines Pushbutton	–	–	–	–	1	–	11	5-7

automatic brake valve have a straight back movement rather than gates so that it would be distinctly different from the locomotive brake. Most engineers wanted the train brake labeled "automatic brake". Finally, one engineer wanted the release position to line up with the release position of the independent brake for easy reference. With the exception of the suppression position, the remaining positions were deemed satisfactory. The 2 rating was assigned to the suppression position by the same engineer who down rated the train brake lever for the same reason, namely, that the gate was not necessary.

The independent brake lever with its auto release position was well received by most of the engineers. One engineer commented that he liked the auto release position because it freed his hand during high workload periods and would be an aid when power braking. One engineer felt that the emergency release position was not necessary, while another thought that the automatic release should be spring loaded.

The throttle/dynamic brake was considered no improvement by the majority of the men. Some suggested that the interlock be moved so that it could not be accidently engaged with the palm of the hand. Some suggested that the window be made larger and provision be made for providing dirt-free or mar-proof material over the window. One engineer suggested a window on each side of the controller. Many of the engineers wanted the smooth surface of the dynamic braking portion of the wheel as rough as the present power portion and the power portion even rougher. The 1 rating was assigned by an engineer objecting to power settings differing from that to which he is accustomed. Another thought the dynamic braking and motoring should be controlled separately. The set up position should have a positive "snap-in" feel to it according to one engineer, and many felt that the device did not have an appropriate feel. One engineer thought that the reverse control panel throttle would be more appropriate as a set up control. One engineer stated that the wheel should have a pseudo click as an additional cue as the throttle/dynamic brake was advanced or retarded.

Generally, the direction lever was favorably rated. There were on objections to the lift to reposition feature, although some engineers wanted the positive lock feature in all three positions rather than just the neutral one. One engineer wanted the lever to have a higher (bat type) handle for a better grip. It should be recognized that the assumption underlying the use of the switch is that the engineer need only move the control in the direction that he desires to go. However, one incorrect setting, for example in yard duty, could have serious consequences in terms of the safety factors associated with locomotive movement. This possibility was examined during the test program as is discussed in the section concerning the reverse control panel. No one objected to the lighted arrows on the main control panel direction lever.

None of the engineers objected to the relocation of the emergency brake from the train brake controller to the right side of the control panel. However, one engineer did insist that the emergency stop should be a high resistance mushroom control and downrated the present device accordingly. A second engineer stated that he would prefer "Emergency Brake" as the label for this device rather than "Emergency Stop".

The bell pushbutton (latching) location was acceptable to the engineers.

The engineers were told that the regulating valve was located in a recessed compartment under the engineer's large side window. This location was rated acceptable by all of the engineers.

The reverse control panel pushbutton switch and the proposed position of the controls when making the changeover was rated acceptable.

The stop all engines pushbutton was rated acceptable by all of the engineers. One suggested that a placard be provided to remind the engineer that it is there.

It should be noted at this point that no provision was made to evaluate dead man pedals. Some locomotives today have them and some do not. The survey of trends for the next ten years indicates that the locomotive cab of the 1980s will not contain pneumatic foot pedals.

Table A-20 shows the ratings assigned to main control panel functions by the nationwide sample of engineers. The main control panel location and arrangement were rated acceptable by all the engineers except one who downrated the panel arrangement because he preferred the arrangement existing in present cabs.

The sander elicited a range of ratings from unacceptable to acceptable. Twenty-seven engineers stated that an option was required to sand either the lead truck only or all of the trucks in the locomotive consist. Two engineers thought the light should be more conspicuous (possibly flashing) to avoid depleting sand due to forgetfulness. Two thought a tone should be provided in addition to a light for the same reason. Eighteen engineers commented that a latching sander was desirable because it frees the hands during high workload periods. Four wanted the sander relocated to the right side of the panel so that the left hand could be dedicated to working the brakes. Three engineers wanted a latching sander only on the lead unit of the locomotive consist while one wanted to sand all trucks at all times. Two suggested a latching sander with a timed automatic shutoff feature (for example, 25 seconds). One engineer thought sand should be laid down under only the first two units in the consist.

The stop-all-engines function was favorably rated by all of the engineers except one who thought it was unnecessary because he would never use it. One engineer commented that when the function was used the diesel engines should shut down immediately, and another felt that the switch should not be guarded.

The reverse control panel button was generally acceptable to all of the engineers. One wanted it located to the left side of the panel and one wanted a second button to reactivate the main panel.

The console lock was downrated by four engineers. One wanted it relocated off the main panel to make room for something else, one disliked the procedure where the independent brake must be released to affect the transfer of control. Eight engineers stated that the lock and key was an undesirable feature with no real advantage because lost keys would be a problem. One engineer thought the rear doors should have locks and keys and that the door key should be the same as the console lock key while one thought the key should activate the generator field, engine isolate and transition lever.

The bell control was favorably rated. Five engineers wanted the horn and bell to always come on together, while nineteen wanted the functions to be independent. Five suggested that the engineer have the option of independent or combined operation. Two engineers wanted the

Table A–20. Feature – Main Control Panel (Nationwide)

	Item	Rating 1	2	3	4	5	6	7	Range
1.	Panel Location	–	–	–	–	2	10	26	5-7
2.	Panel Arrangement	1	–	–	–	6	11	20	1-7
3.	Sander	1	2	3	8	5	4	15	1-7
4.	Stop All Engines	–	1	–	5	2	6	24	2-7
5.	Reverse Control	–	1	–	2	2	6	7	2-7
6.	Console Lock	3	–	1	–	1	7	26	1-7
7.	Bell	–	1	–	4	2	7	24	2-7
8.	Emergency Stop	3	5	1	7	1	5	16	1-7
9.	Direction Lever	–	1	–	4	7	6	20	2-7
10.	Direction Lever Locking	1	2	2	1	–	8	20	1-7
11.	Direction Level Markings	–	1	1	7	5	8	15	2-7
12.	Train Brake Location	–	1	3	2	0	12	20	2-7
13.	Train Brake T-Handle	–	3	2	1	8	5	19	2-7
14.	Reset Position	1	–	–	4	5	8	20	1-7
15.	Release Position	–	–	–	7	1	9	21	4-7
16.	Min Red Position	–	–	–	6	2	2	27	4-7
17.	Full Ser Position	1	–	–	7	1	4	25	1-7
18.	Supp Position	–	–	–	6	4	6	22	4-7
19.	Independent Brake Lever Location	2	–	4	2	1	10	19	1-7
20.	Brake "T" Handle	1	–	1	1	6	9	18	1-7
21.	Emergency Release	1	–	2	6	1	7	21	1-7
22.	Auto Release	3	–	1	1	1	5	25	1-7
23.	Release	1	–	–	5	2	6	24	1-7
24.	Full Service	1	–	–	7	–	2	27	1-7
25.	Throttle/Dynamic Brake Control Location	–	–	2	4	–	6	26	3-7
26.	Window Location	–	–	–	6	2	8	22	4-7
27.	Interlock	1	–	–	2	3	9	23	4-7
28.	Idle Position	–	–	–	8	1	8	21	4-7
29.	Set-Up Position	–	1	–	8	–	8	19	2-7
30.	Power Settings	–	–	–	8	3	7	18	4-7
31.	Dynamic Brake Settings	–	–	–	8	4	9	15	4-7
32.	Regulating Valve	–	–	–	8	5	3	19	4-7

bell relocated to the left side of the panel so that it could not be confused with the emergency stop function. Nine engineers considered the latching feature a good idea.

The emergency stop function was greeted with mixed emotions. Sixteen engineers thought the recessed pushbutton was a desirable feature while five thought it was undesirable. One engineer wanted it located on the bottom edge of the main display panel glare shield, five wanted it relocated to the left side of the main control panel nearer to the train brake handle, while one engineer wanted it located on the main display panel. Two engineers wanted the emergency stop to have greater separation from the bell and other control functions. Five engineers objected to the recessed feature because the recess would collect dirt or might not be accessible enough, one thought it should be recessed more, one thought it should be larger and four preferred the emergency brake to be on the train brake control as it is now.

The direction lever was generally acceptable. The feature most appreciated (by seventeen engineers) was the fact that it avoids confusion with the throttle. Five thought the lever locking feature was desirable to prevent inadvertent reversals. Six engineers did not like the locking in neutral feature, feeling that the lever could inadvertently be moved to neutral. Two engineers thought a T handle was preferable. Five engineers thought that it was necessary to provide an interlock requiring that the throttle be placed in idle before changing direction. One engineer wanted the direction lever located close to the throttle for kicking cars, while ten thought it was too small and fragile, especially while wearing gloves. One engineer suggested locking in all three positions and one noted that it should be lighted and color-coded. One engineer wanted the lever relocated to his left, knee high. Three commented that the lettering was not clear enough, one thought the letters would wear off with time, and one commented that the metal would get very hot from the sun.

The train brake location was on the whole rated favorably. During this evaluation the following critical points were made. Seven engineers thought the T handle should be high enough to wrap their fingers around while three did not want them higher because they liked the feel of the arc under their hands. Five men thought that the capability should be provided to make a brake pipe reduction to 30 psi or below, because some railroads require it for more rapid braking with long, heavy trains and for releasing sticking brakes. Eight engineers stated they wanted an overreduction position (reduction greater than 23 psi) to allow more rapid braking and to obtain equalization at higher brake pipe settings. Fourteen engineers stated that the train and locomotive brake handles were too close together. One engineer preferred the cab he was used to. One engineer wanted the reset position located below the suppression position so that the action would be from reset forward to full service. Six engineers thought the brake handles should be more distinctly shape-coded for blind operation. Three engineers commented that the minimum reduction detent was a good feature, while one engineer thought the lever had too much control throw. Five engineers thought that automatic brake pipe compensation was a desirable feature. Under this concept, full equalization is always achieved regardless of initial brake pipe pressure setting. Four wanted the emergency brake included on the brake handle control, and one preferred a knob to a T handle. Two engineers thought the handle was too small. One engineer commented that the minimum reduction position was undesirable because 26L valves do not give constant reductions. One commented that a forced time delay would be desirable, that is, the handle could not be moved out of reset until the train was recharged after an emergency brake application. One engineer stated that the legends were unreadable because they were too close to the lever permitting the hand to obstruct them. Two engineers wanted the inner half of the T chopped off. This was their solution to the problem mentioned previously of the train and locomotive brake handles being too close together. One noted that a pushbutton such as used on "Locotrol" would be preferable, while another thought detents or gates should be provided at 8, 10, and 12 psi reduction positions. One engineer thought the train brake should be larger than the locomotive brake, and one wanted the train brake and independent brake handles reversed for "kicking cars". It can be seen that the engineers were very interested in the train brake and made many constructive suggestions and comments. As in the other systems discussed, although there was a diversity of opinion concerning specific details, the concept was favorably received.

The independent brake handle location was favorably rated by all the engineers except six. One engineer commented that the pull for braking action was good. Five thought the T handle should be higher, and twelve thought it was too close to the train handle. One man preferred the control found in existing cabs. Seventeen engineers commented that the auto-release feature was desirable because it frees the hand during high workload periods. Two thought the auto-release was undesirable and unsafe because engineers would forget that the independent brake was in the auto-release position and lose positive control. Two engineers thought the existing push down "bail off" feature was preferable to an emergency release position. Five engineers desired the capability of maintaining a given independent brake pipe pressure while varying the train brake application (for stopping bunched without dynamic braking, for example). One thought the control action should be from release forward to full service, auto-release and emergency release, and another thought a knob would be more appropriate than a T handle. One engineer thought the direction of the control movement should be reversed for continuity of control action when moving throttle to OFF. One man liked the two brake lever handles closer together, because he discovered that he could operate them simultaneously with one hand.

During the course of the study it became apparent that many of the problems encountered by the engineers with the air brake systems were caused by the necessity to bail off or actuate the independent brake when the automatic brake is applied. Some engineers said they plugged the independent brake handle so that it was always actuated. (It should be emphasized that this practice is in violation of operating rules.) Some problems were found associated with this practice. In some cases, the wedge slipped out unknown to the engineers and when an automatic reduction was made an unintended application of the locomotive brake occurred causing a severe run-in. In other cases the requirement to bail off, either to maintain a desired brake cylinder pressure or prevent a pressure buildup, tied up both hands during high workload periods. For these reasons the auto-release feature of the brake was generally favorably noted. However, one significant problem was encountered with this feature, and that was the procedure for maintaining partial locomotive brake cylinder pressure. It was recognized that the procedure described to the engineers was not optimum. As the test program progressed it was concluded that the optimum solution from an operational standpoint was to divorce the two braking system controls and design them to be completely independent. This idea was presented to the engineers and their comments below reflect their responses to the concept, keeping in mind that it is a radical departure from what they are used to. Five engineers preferred the train brake to be entirely independent from the locomotive brake and one engineer stated that he had thought of this idea years ago. One engineer thought the independent brake handle should be depressed to maintain brake cylinder pressure (as it is done now) and one thought the train brake should not be divorced entirely from the automatic brake, but could not give a reason why.

The automatic air regulating or feed valve was described as located recessed under the engineer's right window. This location was judged acceptable by all.

The throttle/dynamic brake control for the nationwide evaluation had raised ribs in the throttle regimen, a smooth surface in idle and grooves in dynamic braking. Both the ribs and grooves were spaced closer together as the control was advanced in throttle or retarded in dynamic braking. It was also explained that an audible click could be heard corresponding to the notch positions and that there would be a psuedo-dent so that the engineer could feel the control move through the numbered positions. All the engineers worked the control with a gloved hand. As shown in the table, the control location was rated generally acceptable by these engineers. The wheel was judged desirable or not objectionable by sixteen of the engineers, while three others stated that the location was good. Nine engineers stated that the wheel was objectionable or less desirable than a lever, knob or T handle. One engineer wanted it relocated between the two air brake handles to avoid confusing the brake handles. Seven engineers stated that the continuous setting capability should be in increments of one-half. One engineers suggested that the power settings should be associated with a variable audio intensity. Pertaining to the window, one engineer thought the window should be larger, one thought that the window should show a red background when in dynamic braking, one suggested a window on each side of the wheel, three thought it should be relocated for visibility (readability), one thought it should be labeled power or dynamic brake, and one suggested a location at the top of the wheel. Three engineers commented that there should be a forced ten second delay in the setup position because frequent abuses result in malfunctions of the dynamic brake. One engineer commented that the interlock button snagged his clothing, four thought that setup should be notched (detent) while one found the interlock between dynamic braking and power undesirable. One engineer objected to the grooves on the dynamic brake stating that he "felt lost" when wearing gloves. One commented that the lead unit should lead the trailing units by one throttle notch while another wanted the control of the throttle for at least 10 seconds after an emergency application of the air brakes not initiated by the engineer. One engineer commented that the interlock was unnecessary while one thought the throttle wheel had too much throw from idle to position eight. One engineer wanted the dynamic braking function to be implemented with a second control. Two engineers desired the capability to limit maximum power settings of a unit in the consist to six (for example), while operating the rest of the units in the number eight position. This feature is desirable with engines having alarm conditions such as overheating. The locomotive would not have to be shut down nor the entire consist limited to reduced power to avoid excessive damage to that engine. One engineer wanted a capability provided for setting the lead unit one notch below trailing units. Three engineers commented that the power range should have definite notches (detent) positions instead of the pseudo-notch click. One thought the interlock should be taller and bigger and one thought the interlock button should be relocated to the upper left side of the wheel to avoid inadvertently depressing it with the heel of the hand.

Engineers who operated high speed produce trains over undulating terrain liked the continuous throttle adjustment because they wouldn't have to jockey back and forth between notches as they do now. Engineers accustomed to long heavy unit trains run at low speeds stated they usually left the throttle at a particular setting and therefore were not enthusiastic about the variable control feature.

Overhead Panel – The overhead panel arrangement is shown in Figure 3-14. The following functions are contained on this panel:

1. Dynamic brake cutout switch
2. Generator field switch
3. Engine run switch
4. Fuel pump switch
5. Ground relay reset
6. Cab temperature control
7. Class light switch
8. Traction motor switch
9. Engine condition switch
10. MU-2 valve
11. Windshield wiper/washer control
12. Cutout valve
13. Exterior light switches
14. Headlight switches
15. Panel and instrument light switches
16. Radio control equipment panel.

The preliminary ratings are shown in Table A-21. The majority of the engineers liked the overhead panel. Those who wore bifocal glasses commented that, with the size lettering provided and the lighting, they had no difficulty reading the panel legends even without their glasses. Most commented that they wanted the two position sliding switches rotated 180° so that the on position was up rather than down as shown in Figure 3-14.

Some wanted the headlight dimming function moved from this panel to the main control panel and some wanted a foot button similar to an automobile with an indicator light. They commented that they liked the overhead panel as long as the switches provided were those that seldom have to be used. Some expressed the desire to be able to configure the locomotive rear class lights while seated at the control console. One man noted that the positions of the dynamic brake cutout switch were reversed. He recommended that all slide switches be in the on or off positions in the same direction. The engineers liked the MU-2 setup switch in preference to wordy placards. As the engineers were not familiar with contemporary radio controlled equipment and its operation, these functions were not rated.

Table A-22 shows the ratings of the overhead panel assigned by the nationwide sample of engineers. The panel arrangement and location were well received. As in the preliminary evaluation, 17 men commented that the slide switches should be reversed. One thought the

Table A–21. Feature – Secondary Display and Overhead Panel (Preliminary)

Item	Rating 1	2	3	4	5	6	7	Range
Radio	–	2	3	2	–	1	4	2-7
Train Handling Display	–	1	1	1	1	1	7	2-7
Annunciator Panel	–	–	–	–	–	1	10	6-7
Overhead Control Panel	–	–	1	1	–	2	8	3-7

Table A–22. Feature – Overhead Panel (Nationwide)

Item	Rating 1	2	3	4	5	6	7	Range
1. Panel Location	1	1	1	–	–	9	25	1-7
2. Panel Arrangement	1	–	–	3	2	13	18	1-7
3. DB Cutout	–	–	1	4	4	8	20	3-7
4. Gen Field	2	–	3	6	2	8	18	1-7
5. Engine Run	3	–	3	5	2	7	18	1-7
6. Fuel Pump	1	–	1	6	2	8	19	1-7
7. Ground Relay	–	1	2	6	4	7	18	2-7
8. Cab Temperature	–	–	–	1	1	6	29	4-7
9. AC/Heating	–	–	–	1	3	5	29	4-7
10. Class Lights	–	–	1	4	4	6	22	3-7
11. Traction Motor	1	–	–	3	4	6	23	1-7
12. Eng Condition	1	–	–	2	6	7	22	1-7
13. MU Set Up	1	–	–	3	7	7	20	1-7
14. Cutout Valve	2	–	1	3	7	6	19	1-7
15. Windshield Wiper	–	–	–	4	3	8	23	4-7
16. Wiper Washer	–	–	–	2	3	8	25	4-7
17. Exterior Lights	–	–	–	4	3	12	19	4-7
18. Dim Instruments	–	1	–	2	3	8	24	2-7
19. Dim Headlight	1	2	2	6	3	4	20	1-7
20. Setup Headlight	–	1	–	4	4	6	23	2-7
21. Slew	3	3	–	–	6	7	18	1-7
22. RCE Location	6	2	–	1	1	3	9	1-7
23. Arrangement	1	1	–	1	2	6	10	1-7
24. Caution Lights	2	–	–	2	2	2	13	1-7
25. Emerg Brake	6	1	–	–	2	2	9	1-7
26. Lamp Test	1	–	–	–	1	4	15	1-7
27. Train Brake	9	1	1	–	1	2	7	1-7
28. Indep Brake	5	–	–	2	1	2	9	1-7
29. Thrtle/DB	3	1	1	1	3	2	9	1-7
30. Interlock	2	–	–	2	2	4	8	1-7
31. Power/Force	1	1	–	–	2	5	9	1-7
32. Alarm	1	–	1	1	2	6	9	1-7
33. Ground Relay	1	–	1	1	2	3	11	1-7
34. Override	1	–	1	1	2	5	10	1-7
35. Sander	2	–	1	1	1	5	10	1-7
36. Feed Valve	2	–	1	3	2	4		1-7
37. System Test	1	–	–	–	2	4	13	1-7
38. MU/Ind Control	1	–	–	2	3	3	11	1-7
39. Power On	1	1	–	3	1	4	10	1-7

slider switch background should be color coded with black for off and white for on. One man wanted this panel interchanged with the secondary display panel and one wanted it back on the rear wall. One engineer suggested that the class light selector legends should read white-green-red because red is only used in emergency situations.

The ground relay reset pushbutton should contain a provision for a counter to record the number of resets. In newer locomotives the relay automatically resets three times. Two engineers thought a capability should be provided to manually reset the ground relay for the entire consist. Four engineers wanted a tone or bell to come on when this relay required a reset.

Nine engineers wanted the headlight switches located on the main control panel for convenience. One thought a foot button would be desirable and one commented that the headlight setup switch new location was a desirable improvement. The engineers were asked their opinion on mars, beacon and strobe lights. Twelve engineers thought a mars (oscillating) headlight was desirable, while two preferred beacon lights. Twenty-three engineers thought the headlight slew was a desirable feature for illuminating curves and inspecting passing trains, one engineer thought it was undesirable. One engineer wanted the dimmer and headlight slew switches interchanged. Two men commented that mars lights were undesirable, while one liked the mars light provided it could be set in manually. Five engineers suggested that a headlamp or light at least in emergency was needed and two thought the dimming switches were too close together.

The MU-2 switch was generally rated satisfactory, although one engineer wanted it lower.

The instrument panel rheostat was acceptable. One engineer wanted the function relocated to the main display panel.

The windshield wiper/washer and defog/deice functions were well received. Several men stated that the defog/deicer should be electric and not forced air because forced air is not adequate on current cabs.

The cutout valve was generally acceptable. Four men wanted the valve relocated to the main control panel, one engineer wanted it on the rear wall, one thought it should have a lock or seal and one wanted the capability to cutout trailing units from lead cabs.

The generator field switch was rated generally acceptable. Two engineers wanted it relocated between the engine run and fuel pump switches. One wanted it on the secondary display panel, and thought it needed more distinct shape coding, and one wanted a general reset capability for all units in a consist.

The engine condition switch was rated acceptable. One man wanted it relocated to the main control panel.

The remote consist control panel is shown in Figure 3-9. Functions contained on this panel are as follows:

1. Caution lights
2. Emergency brake

3. Lamp test
4. Train brake
5. Independent brake
6. Throttle/dynamic brake
7. Interlock
8. Power/force indicator
9. Alarm
10. Ground relay
11. Override
12. Sander
13. Feed (regulating) valve
14. System test
15. MU/Ind control
16. Power ON.

The ratings assigned by the nationwide sample of engineers are also shown in Table A-22. As shown in the ratings, considerable controversy was generated by this concept. Eight engineers wanted the whole panel relocated to the main console because these functions are vital when employed. Two engineers suggested relocating it to the main display panel. Eight engineers stated that only the throttle was used in the independent mode. One engineer felt that a continuity light was needed as well as a no continuity light. Three stated that the MU position was never used. One engineer thought that an engine shutdown capability from the lead unit was needed for slave units, in the event of fire in the slave unit. One engineer thought that a twenty-five minute override capability should be available during loss of radio contact. One engineer wanted the capability of regaining continuity from the lead cab because the present arrangement necessitates a trip back to the slave unit to reset. One man noted that the independent brake and throttle must be operated with one hand when reversing with head out of the window. Ten engineers stated that they would never use the remote air brake controls independently of the lead unit. Only consist bail-off capability is required. Two men commented that the train brake should not be notched, One man emphasized that the independent brake should never apply on remote consist units; it should apply on the lead unit only.

Six engineers thought that the independent control of the throttle and dynamic brake was a desirable feature while two stated that it was not used and undesirable. One individual commented that the independent brake window numbers were too small. One engineer thought that dynamic braking was undesirable while another thought that the setup position should be a positive detent. One engineer wanted the actual power and dynamic brake settings displayed in addition to commanded settings. One said the wheel was undesirable and two commented that the location was undesirable. One engineer suggested that the no continuity and power cutoff should be red annunciator lights.

Two engineers appreciated the capability to initiate an emergency application at remote consists simultaneously with an intiation at the lead unit. Seven men thought this was undesirable.

The drawbar force indicator was favorably received. One engineer thought this feature was not required while seven thought drawbar force should be displayed at both the front and rear of the remote consist because the helpers could be inserted in the middle of a long train. Two engineers thought the gage should be numbered and one was concerned that too many gages might overload the engineer.

The remote consist sander was favorably rated. One engineer thought the button should be white, two thought it should sand all trucks in the remote consist and one wanted a latching sander. It was apparent after the critique of this panel that considerable rethinking of the design was required.

Secondary Display Panel – The secondary display panel was favorably rated. The most controversial item was the communications handset. The layout of this panel is shown in Figure 3-10. The items on this panel are as follows:

1. Caution/advisory annunciators
2. Communications handset
3. Train handling display.

The preliminary sample ratings are also shown in Table A-21. Most of the engineers liked the idea of having all of the annunciators in one location within their field of view. Only one engineer preferred them on the rear wall where he was used to them. One man had the idea of dividing the functions into three vertical columns. The first column would contain annunciators indicating malfunctions that required almost immediate action, such as wheel slip, brake warning, PC light, etc.

The second column would cover items possibly requiring a response that could be deferred such as hot engine indication. The third column would consist of maintenance advisory annunciators signaling malfunctions such as clogged filters. One man thought that the covered maintenance advisory lights should be relocated to a separate maintenance panel and not be at the engineer's work station at all. The engineers were queried to determine their attitudes concerning inadvertent movement of the locomotive when the handbrake light is ON. Three options were offered to them:

1. Bell sounds when generator field switch is energized.
2. Bell sounds when throttle is opened to notch (1) and power is obtained.
3. Bell sounds when throttle is opened and no power is obtained.

Most of the men when asked this question stated that they preferred that no diesel power be allowed to develop when the hand brake is ON. One engineer wanted a bell to sound when the hand brake is ON and the generator field is energized. Finally, one man suggested that the annunciator panel display all malfunctions for all locomotives in the consist.

The radio was of considerable interest to the men. All of them liked the location but some did downgrade it for different reasons. It was necessary to explain to the men that the new cab would be much quieter than the ones they were accustomed to. Therefore, there would be little, if any, ambient noise to interfere with normal communications. If this were the case, the men preferred a push to talk built in microphone to the present handset because someone always wants to talk during high workload periods. It was also pointed out that if a handset was used that it would be on a theft-proof cord such as that found on public telephones. The handset, as shown, in the present design was deemed acceptable for use by other occupants of the cab if necessary. During discussions of railroad communications some men commented on the noticeable lack of communications discipline. They felt the radio, in practice, was often used like a citizens band and such extraneous chit-chat should be eliminated. Many felt that only engineers should have access to the radio. However, when they were reminded that there is a genuine need for other crewmen to have access to the radio in a freight locomotive cab, they agreed that a duplicate radio should be present near the left seat. One man commented that there should be separate passenger and freight channels and disciplined channel usage. A final comment was that the possibility of using a beeper to page the engineer should be explored in conjunction with a floor mounted push-to-talk control.

The train handling display was unfamiliar to the men. They expressed great interest in its operation, and all felt they would have to get used to it. Some men felt that it would be useful as a training device but would be turned off when the engineer became familiar with the territory. One man thought the device would be misused by management in that inexperienced men would be expected to use it and rely on it. The issue was also raised as to why the train handling display couldn't move vertically from bottom to top instead of left to right. Finally, one man noted that the CRT would be a good place to display positional cab signal aspects.

The secondary display panel was favorably rated by the nationwide sample as shown in Table A-23. The major comments concerning the annunciator panel were as follows. The handbrake on should be either red or amber, according to ten men, because green indicates a go condition. Two engineers thought the PCS light should be red. One wanted the wheel-slip indicator located near the throttle while another wanted it on the main display panel. Twenty one of the engineers felt very strongly that the annunciator should also identify malfunctions in trailing units and sixteen commented that the capability to isolate the unit should be provided from the engineer's seat. One man suggested a wheel slide light in addition to wheel slip. Two engineers desired an "excess speed" indication prior to penalty brake applications. One man stated that the oil filter light should not be covered because these filters may be changed in route.

The communication handset was generally favorably rated. Ten engineers liked the telephone handset because they thought it would be desirable and needed when looking out of the window. Eight engineers preferred to have a hand-held mike with console mounted speaker. One man wanted a second hand-held microphone for operations when looking out of the window particularly when using the reverse control panel. Eighteen engineers wanted a panel mounted speaker and receiver (push-to-talk) with lighted channel indications. Four engineers requested a floor mounted push-to-talk with console mounted speaker and receiver. One engineer noted that the handset should have a long cord for use when looking out of the window.

The train handling display was considered a desirable and useful feature by thirty-one of the engineers who stated that it should improve train handling. Fourteen engineers thought the

Table A–23. Feature – Secondary Display Panel (Nationwide)

	Item	Rating 1	2	3	4	5	6	7	Range
1.	Location	–	–	1	–	2	5	29	3-7
2.	Arrangement	–	–	–	2	4	3	27	4-7
3.	Caution/Advisory	–	–	1	2	1	6	27	3-7
4.	Communication	–	1	3	6	5	5	17	2-7
5.	Train Handling	–	–	–	1	1	4	30	4-7

draft/buff display was desirable while two did not think it was useful. Seventeen engineers thought the brake pipe pressure gradient and train order display were desirable options. One engineer commented that the display needed a glare shield, one thought that train orders should not be transmitted by radio, one commented that the system needed a track update capability and one wanted the track profile to show two miles in advance of the train.

Reverse Control Panel – Figure 3-13 shows the arrangement of the functions on the reverse control panel. Not shown are the horn and bell controls located on the right side of the control box. The functions are listed below and the individual ratings assigned during the preliminary evaluation shown in Table A-24.

1. Train brake
2. Independent brake
3. Throttle
4. Emergency stop
5. Direction lever
6. Horn
7. Bell
8. Light.

The reverse control panel was generally rated acceptable. Some engineers expressed concern that even though the panel was not designed for general main line reverse running (absence of air gages and speedometer, for example), they would be expected to operate the locomotive over an entire division with this panel just because of its presence. The limited operation possible with this panel should preclude such an expectation. Most engineers felt the handles were a little small and one man thought the emergency stop pushbutton should be located on the right side of the panel. Several engineers commented that due to the convenient location of the main controls, when leaning out the wide windows and looking back, the reverse control panel was unnecessary. Several stated that the automatic release position and the emergency release position on the independent brake were unnecessary in this application.

The same man who noted that the power settings on the main control panel were reversed from what he is accustomed to, downrated the throttle on the reverse control panel for the same reason. It was also noted that in the event of a failure the functions implemented on the panel should be fail-safe and that the suppression position on the train brake lever is not needed because Automatic Train Control (ATC) is inoperative when pushing freight cars on the Penn Central.

As stated earlier, the movement of the locomotive, particularly in yards and terminals, must be accomplished very carefully. While the panel was being evaluated, the engineers were asked if they preferred labels such as forward and reverse in addition to or in place of the lighted arrows. The men could foresee no problems with the arrows alone. However, when given a hand signal to back up (that is, move in the direction of the long hood), one engineer pulled the direction lever toward himself, thus initiating movement in the no hood direction.

Table A–24. Feature – Reverse Control Panel (Preliminary)

Item	Rating 1	2	3	4	5	6	7	Range
Emergency Stop Pushbutton	1	–	–	–	–	1	10	1-7
Direction Lever	–	–	1	1	2	2	6	3-7
Train Brake Control	–	–	1	3	–	2	6	3-7
Release Detent	–	–	–	2	–	2	8	4-7
Minimum Reduction Detent	–	–	–	3	–	2	7	4-7
Service Range Position	–	–	–	3	1	1	7	4-7
Full Service Position	–	–	–	3	–	2	7	4-7
Independent Brake Control	–	–	–	1	–	2	9	4-7
Emergency Release Position	1	–	–	–	–	2	7	1-7
Automatic Release Position	2	–	–	–	–	2	6	1-7
Release Position	–	–	–	1	–	2	7	4-7
Service Range Position	–	–	–	1	–	2	7	4-7
Full Service Position	–	–	–	1	–	2	7	4-7
Panel Power Indicator Light	–	–	–	1	–	2	9	4-7
Throttle Control	1	–	–	1	–	2	8	1-7

This could be disastrous in an operational situation. Therefore, it should be emphasized at this point that the engineers must be absolutely familiar with this and any other new device. Moreover, control devices must be designed so that an error is not catastrophic.

Table A-25 shows the individual ratings assigned to the reverse control panel by the nationwide sample. Although the majority of the assigned ratings are favorable, there was considerable variability for each of the items. In general, the concept was liked because it would be useful for coupling and short reverse or backup movements. Five engineers thought it would not be needed because backup movements are short. The downrating occurred for the following reasons: the number of engineers making the comment is shown in parentheses.

- should have power gage (2)
- should have speedometer at least from 0-20 mph (5)
- should have dynamic braking function (9)
- should have PC reset (1)
- should have sand button (2)
- control transfer procedure should not require full service train brake (2)
- should have air brake pressure gages (3)
- should be padded (1)
- should be adjustable in height (1)
- should standardize controls with main panel (1)
- should have headlight dim switch (3)
- should have capability of locking in any comfortable position (6).

The air brake controls were judged to be too close together by two engineers, and four thought the emergency stop button was undesirable and that the function should be located on the train brake lever. One engineer thought that the direction of throw of the independent brake should be reversed and that the release handle should have a detent. Two engineers preferred that the train brake have notches like the lever on the RCE and two wanted the train brake and the independent brake interchanged. One man noted that the train brake should have an emergency reset position and one commented on the need to maintain a constant brake cylinder pressure with an automatic brake application.

The emergency stop was judged as not needed by one engineer, four thought it should be on the train brake handle, and one thought that it should not be recessed.

The throttle was generally favorably rated. One man found the design objectionable, preferring a notched sliding knob, while another thought there was too much travel from positions one through eight. One thought the device should be taller (mushroom type).

The horn and bell located on the right hand side of the panel were favorably rated. Two men thought the horn should be at the rear of the panel next to the idle position of the throttle and downrated accordingly, and one engineer wanted the horn and bell to come on together.

Table A–25. Feature – Reverse Control Panel (Nationwide)

Item	Rating 1	2	3	4	5	6	7	Range
1. Location	2	–	–	1	4	7	24	1-7
2. Arrangement	1	–	1	3	7	5	21	1-7
3. Direction Lever	1	1	–	3	5	6	21	1-7
4. Emergency Stop	2	–	2	3	3	5	22	1-7
5. Panel Power	1	–	–	4	1	9	22	1-7
6. Train Brake	1	2	1	3	3	8	20	1-7
7. Ind. Brake	1	2	2	3	2	9	19	1-7
8. Throttle	1	3	1	1	2	9	20	1-7
9. Horn	1	–	1	2	1	12	21	1-7
10. Bell	1	–	1	2	1	12	21	1-7
11. 45 Degrees	2	1	–	5	5	5	19	1-7
12. 90 Degrees	2	–	–	3	5	7	22	1-7

The direction lever was downrated by two engineers, one thought it should be larger and one commented that it should not have a locking feature.

Trainman's Console – Figure 3-13 shows the functions on the trainman's console and the preliminary ratings are shown in Table A-26. The speedometer dial at the trainman's work station was judged by some engineers to be unnecessary, and therefore, it was downrated. The cab signals elicited much the same comments as those previously noted, and those had to do with concern that they were not correct aspects and not located high in the center of the cab as they were accustomed to. The light switch was downrated as nothing new. With one exception all of the men approved the independent heating and air conditioning control at the left seat work station. The exception preferred that the environmental control be under the sole management of the engineer. The emergency brake valve (not shown in the figure) was acceptable to all the men. The communication hand set was discussed previously.

The nationwise ratings are shown on Table A-27. Seven engineers thought the trainman's console should have a brake pipe venting light. One engineer thought that a separate windshield wiper was desirable. The speedometer showed some variability in the ratings. Three evaluators thought the speedometer was unnecessary, because it should not be the trainman's responsibility, three thought it necessary because the fireman is responsible for monitoring speed and three thought it should be in the center of the cab for the third crewman to see. Twelve engineers thought there should be a footrest and seven thought there shouldn't be one. Four engineers thought the emergency brake handle was adequate. Three engineers thought the communications set should be like a CB set with microphone and speaker while three thought a second set was not needed, and seven thought the present handset was adequate. One engineer suggested a flow meter or light to indicate when the brakes were released.

Finally, of the 50 engineers who rated the overall concept, all of them thought it was better than what they were used to in the field. Thirty assigned a maximum rating of seven, seventeen assigned a six and three assigned a five.

It should be pointed out that most of the engineers were quite enthusiastic about the project. Several engineers were so interested that the evaluation on occasion lasted two hours beyond the allotted time and one man missed his return flight in spite of several reminders that time was growing short. Many stated that they wished the cab was operational so that they could drive it around. On several occasions, engineers sought out the program manager to tell him of their interest and enthusiasm for the design concept and endorse the research program. Finally, several engineers wrote letters containing additional comments on the design and suggestions for further improvements. In summary, all the evaluators were highly motivated to contribute to an improvement in their work places, enthusiastic about the new design, and stated that although it was new and different they would not have any problems getting used to it.

CONCLUSIONS

The test program had two principal objectives: the first to gain an understanding of the problems facing locomotive engineers in the complex modern railroad operating environment

Table A–26. Feature – Trainman Console (Preliminary)

Item	Rating 1	2	3	4	5	6	7	Range
Speedometer Dial	2	1	–	1	1	1	6	1-7
Cab Signal Indicator	4	–	2	1	–	–	5	1-7
Lighting Switch	–	1	–	1	1	3	6	2-7
Heating/Air Conditioning Switch	1	–	–	–	–	1	9	1-7
Emergency Brake Valve	–	–	–	1	–	–	11	4-7
Communication Handset	2	1	1	1	–	1	6	1-7

Table A–27. Feature – Trainman Console (Nationwide)

Item	Rating 1	2	3	4	5	6	7	Range
1. Heat/AC	–	–	–	1	1	8	23	4-7
2. Speedometer	1	1	–	1	2	9	20	1-7
3. Cab Signals	–	–	–	–	2	4	23	5-7
4. Lighting Switch	–	–	–	2	2	9	21	4-7
5. Dimmer Switch	–	–	–	4	2	7	21	4-7
6. Communication	2	–	2	2	1	7	19	1-7
7. Emergency	–	–	–	3	2	5	24	4-7

and the second to developing a methodology for assessing new cab design concepts and defining problem areas.

The new cab design was liked by all the men and it is clear that the extensive evaluation by the engineers was an essential element in the design development process.

The engineers were generally enthusiastic and interested in the design concepts. The favorable attitudes and high ratings, however, may be influenced in part by the novelty of the concept and test situation generating a halo effect. Apparently no one has ever asked the engineers for suggestions on improving the work place although they had obviously discussed this topic among themselves. The halo phenomenon is widely recognized in the behavioral sciences and has been extensively discussed in literature. The phenomenon can be generally defined as a measurable positive change in attitude or behavior as a function of special attention or interest that occurs independently of the specific test situation. The possibility that the halo effect contributed in part to the ratings cannot be discounted in the present study. However, it is concluded that the ratings do reflect real differences in attitudes toward both existing designs and new concepts. This conclusion is based on the detailed examination of the comments made concerning the reasons a particular rating was assigned whether it was high or low. The engineers had very logical reasons in most cases. It should also be pointed out that during the preliminary evaluation when an engineer assigned a rating to a mockup item the rating was entered on the form by the test conductor. This procedure was followed because it was assumed that it would keep the conversation going, which for purposes of the preliminary study was a significant source of information to supplement the absolute value of the assigned rating. However, again a potential bias could be introduced into the study results because it could be equally assumed that had the engineer filled out the rating sheet privately both the ratings and the comments might have been quite different. The nationwide sample of engineers filled out the forms themselves. It should also be noted that every effort was made to remain objective and keep conditions as constant as possible; however, the test team was also learning as the evaluations progressed. For this reason a decision was made to avoid being so rigid as to preclude developing new information and modification of procedures if the situation clearly warranted it.

Finally, on the basis of the test data and subsequent analysis the preliminary design was modified. These modifications are discussed in Appendix B. The final detailed drawings are shown in Section 3.

APPENDIX B
CHANGES TO PRELIMINARY DESIGN

The preliminary mockup design was revised to a final recommended design based on analysis of the test results. This appendix presents a discussion of the design changes.

B.1 STRUCTURES

Structural concepts were obtained from Contract DOT/TSC-856, (Reference 11), Structural Survey of Classes of Vehicles for Crashworthiness, and comments made by the engineer evaluators. The principal structural change is the addition of a deflection shield on the front of the cab. The purpose of the shield is to deflect an impacting vehicle up and over the locomotive cab. This revised design is shown in Figure 3-1. The deflected vehicle can be either a car or a locomotive. The impact loads are transferred via framing members to the locomotive underframe which is the locomotive primary structure. Some deformation of the roof will occur but no penetration will be allowed into the crew's crash station depicted in Figure 3-7. At the bottom of the locomotive there is an anticlimber attached to the locomotive underframe. The anticlimber is wedge-shaped to provide some deflecting capability to the side in the event of impact with a motor vehicle.

B.2 CAB GENERAL INTERIOR

B.2.1 Cab Rear Wall

The rear of the locomotive cab design was revised to the configuration depicted in Figure 3-2. Changes to the preliminary design are described below.

B.2.1.1 Rear Doors – The two rear doors are shown with recessed handles, sun shades and windshield wipers. The glass has electrical deicing and defogging. Durable seals should be provided to prevent rain, snow, dirt and fumes from entering the cab area. The doors should latch positively when closed and be positively retained to the outer cab wall when fully open. The window glass should not shatter and be constructed so that shards of glass do not enter the cab volume.

B.2.1.2 Refrigerator – The refrigerator is shown at the top of the left rear wall. It is positively latched when closed to keep from flying open in the event of severe slack action. The refrigerator is electrically powered and each shelf has a raised upper lip to prevent objects from flying out when the door is open. A light comes on when the door is open. The top shelf will contain cartons or cans of water for drinking, replacing the recessed water dispenser in the preliminary design. The bottom shelf is for the crews' food and beverages. The introduction of cans or containers may present a problem of litter. An alternate way to store the water is in a large container such as those used for milk in cafeterias. Spigots or tops should be disposable because they will not be cleaned.

B.2.1.3 Storage Compartment – The storage compartment is located below the refrigerator. This compartment is positively latched when closed. It is lighted and contains a shelf and coat hooks. The shelf has a lip to prevent items from falling off in the event of severe slack action.

B.2.1.4 Low Voltage Cabinet – The low voltage cabinet, containing fuses and circuit breakers, is relocated from the lavatory compartment to the rear wall next to the refrigerator. The door to this cabinet is positively latched.

B.2.1.5 Maintenance Advisory Panel – The maintenance advisory panel is located underneath the low voltage cabinet. These annunciators indicate systems malfunctions on the locomotive and are of primary interest to maintenance personnel. The malfunctions displayed are those that the engineer can do little if anything about. He would note any malfunction indications on his post-trip report. Typical functions that would appear here include such things as turbo air pressure low, air filter clogged and fuel filter clogged. Options are available depending on type of locomotive.

B.2.1.6 Hot Plate – A hot plate is provided under the maintenance advisory panel for heating food and beverages. The heating elements are recessed and should provide a secure hold for items being heated so that they do not fly out in the event of severe train action.

B.2.1.7 Lavatory Compartment – The lavatory compartment is located on the right side of the rear wall. The door is positively latched to prevent flying open in the event of severe train action.

Improvements over the preliminary design include a grill from the air comfort system, a ventilator, an overhead light, and a floor drain so that the compartment can be flushed out with water for easy cleaning. A coat hanger is provided on the left wall.

B.2.1.8 Lighting – Two lights are shown recessed in the ceiling for illuminating the area of the rear wall. These lights are controlled from either the engineer's or trainman's console.

B.2.2 Cab Right Wall

The locomotive cab right wall was modified and the final configuration is described below and shown in Figure 3-3.

B.2.2.1 Utility Light Switch – A utility light switch is just inside the rear door at the right of the drawing. Upon entering the cab, engineer flips this switch to turn on the utility light over the engineer's work console. The light may be extinguished at either the wall switch or a switch located on the overhead panel.

B.2.2.2 Fire Extinguisher – A fire extinguisher is below and to the left of the wall switch recessed in the wall. It is positively restrained to prevent ejection into the cab.

B.2.2.3 Emergency Kit – An emergency kit is provided to the left of the fire extinguisher. The kit is portable and contains fusees, torpedoes, and flags. The kit is positively secured to prevent ejection into the cab.

B.2.2.4 Speaker and Microphone – An auxiliary speaker and microphone is provided next to the engineer's side window. The microphone is push-to-talk. The push-to-talk button is floor mounted for operation with the foot. These devices provide convenient communications when the engineer is using the reverse control panel.

B.2.2.5 Brake Pipe Pressure Regulating Valve – The brake pipe pressure regulating valve is recessed under the engineer's side window. At this valve the pressure of the air delivered from the main reservoirs to the train brake system is reduced to the brake pipe pressure setting for a particular train. These pressures may vary from 70 to 110 psi. Turning the valve clockwise increases air pressure in the brake pipe and turning it to the left decreases air pressure. At a particular setting the brake pipe pressure will be maintained against the effect of nominal brake pipe leakage. This location may require some additional study. With older locomotives engineers have occasion to use the feed valve for braking. This practice could under certain circumstances lead to a premature release of the train brakes and railroads do not recommend it. Recommended options are to relocate the valve to a less accessible location or to seal the unit at a predetermined setting. The design of the 26 brake system should not require use of the feed valve for controlling the train brakes. However, unlike older brake systems, the feed valve takes air directly out of the equalizing reservoir.

B.2.2.6 Large Window – The engineer's large window has electrical defogging and deicing. A sun shade is provided and shown partially down in the drawing. The glass should not shatter on impact and no shards should be permitted in the cab. Seals must be durable and the window must lock positively when closed or open in any position. Window guides must be designed so that they do not deform or bind under normal usage and over temperature extremes. Provision should be made for protecting the engineer from rain when the window is open.

B.2.3 Cab Left Wall

The locomotive cab left wall was modified as shown in Figure 3-4, and is described below.

B.2.3.1 Trainman's Seat – A third seat is provided for a third crewman. The seat is mounted on the cab wall as shown.

B.2.3.2 Utility Light Switch – A utility light switch is on the wall at the left. This switch turns on or off the trainman's utility light.

B.2.3.3 Large Window – The characteristics of the window are the same as the window on the left wall. This window, however, extends further aft than the engineer's window to provide visibility for the person in the third seat.

B.2.4 General Interior

Some modifications to the preliminary design were made to the general interior. These are discussed below and referenced in the drawings.

B.2.4.1 Acoustic and Thermal Environment – The dimensions of the structural cab members provide approximately 4 inches of space between the inner cab structure and the outer cab wall. This space is to be used for high-quality acoustic and thermal insulation to provide a quiet, insulated cab.

B.2.4.2 Vibration – The cab design is modular. That is, it is constructed independently as a pod and inserted into cab structure during locomotive fabrication. The seats and consoles will be isolated against vibration paths to primary structure. The improved environment will lessen crew fatigue and be kinder to the instruments.

B.2.4.3 Air Comfort System – The air comfort system shown in Figure 3-3 provides the engineer the capability to select fresh air, humidified hot air or conditioned cool air to be supplied through vents on either side of the duct. The air return ducts are mounted on the bottom of the side walls, one on each side of the cab. Further design development should consider electric strip heating as a back up system if the primary system fails. The advantage is that it can be trainlined, which is especially good if the lead unit has to be shut down.

B.2.4.4 Cab Floor – The bilevel cab floor is essentially unchanged from the preliminary design. The floor covering is made of non-skid materials. The intersections of the floor and walls are rounded so that debris will not collect in corners and provides for easy cleaning. A drain is shown in the floor so that the cab floor can be conveniently hosed down. The drain should be designed so that no drafts escape into the cab. The two levels are painted in high contrast colors to be easily discernable. The edge of the raised platform will be coated with reflective materials for high visibility when entering the cab.

B.2.4.5 Cab Front Wall – The front end of the cab was modified from that shown previously in preliminary designs. The most significant change was moving the windshields forward approximately five inches so that they are flush with the outside of the collision posts. The consoles and seats have been moved forward accordingly. This provides increased visibility of the track directly in front of the locomotive. Each crew station is padded at the leading edges and corners are rounded.

B.2.4.6 Front Windows – The front windows are electrically defogged and deiced. These functions are controlled from the engineer's crew station. The windshield wipers are pantograph type providing maximum visibility during inclement weather conditions. The glazing is a safety glass suitable to prevent foreign objects from penetrating the cab. In the event of a collision, the windows should not pop into the cab. The Federal Railroad Administration (FRA) is preparing regulations and specifications governing windows in locomotive cabs. These new specifications should prevail in the present cab design. Each front window has a sunshade permanently attached to the window frame.

B.2.4.7 Emergency Provisions

B.2.4.7.1 Crash Station – The locomotive cab has been designed with a deflection shield. To keep the cab superstructure within reason, the concept of a crew crash station was evolved. In a secondary impact the structure above the shield is subject to large deformations. Consequently, in the event of a collision, the crew should get down on the floor and protect their heads. The volume behind the shield, as shown in Figure 3-7, is the volume to be defended. This is a concept that did not appear in the preliminary design. References 5, 6 and 7 contain more detailed analyses of crew protection in collision environments. The flagging kit and fire extinguisher are relocated from the front of the cab to the cab wall behind the engineer.

B.2.4.7.2 Fire Protection – Flames from hydrocarbons and other gaseous fuels in the locomotive cab are a very real hazard and of utmost concern to the locomotive cab crews. To defend against fire, some countermeasures have been identified. The cab should be completely sealed to eliminate paths for fuels and gasses to enter. Materials should be selected for their fire retardant qualities. Military pilots and racecar drivers use NOMEX clothing and gloves. Investigation should be undertaken to devise a suitable jumpsuit for locomotive crews. Research into extinguishing agents along the lines of the Federal Aviation Administration's experimental program directed toward increasing survivability in air transportation fires should be undertaken. One agent, Halon 1301, has been shown to be more effective than carbon dioxide (C01), nitrogen or water vapor in quenching the flames of gaseous fuels. This and similar agents should be investigated for potential application in locomotive cabs.

B.3 ENGINEER'S CONSOLE

The controls, displays and general work station arrangement was revised from the preliminary design. These revisions are discussed below.

B.3.1 Brake Pipe Air Flow Meter

The air flow meter was revised to the configuration shown in Figure 3-8. The meter shows air flowing into the brake pipe on an arbitrary scale of 0-15, indicated by a moving pointer. There is an adjustable pointer that can be used to manually set in demand from the brake pipe due to brake pipe leakage. Below the pointers is a light. This light illuminates whenever there is a significant change in demand, for example a change in the leak rate or recharging after a brake pipe reduction. The pointers have been redesigned so that they do not mask the numbers.

B.3.2 Main Reservoir Pressure Meter

The main reservoir pressure meter is unchanged from the preliminary design. It is understood, however, that the low and high bands indicate where the compressor governor loads and unloads to maintain air pressure within desired limits, for example, 130 to 140 psi. The pointer has been redesigned to make it less obtrusive. Absolute pressure readings are on a gage in the air compressor control cabinet (not shown).

B.3.3 Equalizing Reservoir/Brake Pipe Pressure Indicator

The equalizing reservoir and brake pipe pressure indicator was revised to provide an upper limit on the scale of 110 psi.

B.3.4 Brake Cylinder Pressure Meter

The brake cylinder pressure meter was revised to show a scale upper limit of 100 psi. As line haul locomotives run at 45 psi with cast iron brake shoes and at 72 psi with composition brake shoes, this limit is more than adequate. The pointer has been redesigned to be less obtrusive. The scale limit of 100 psi may have to be revised if locomotives are used with a "parking brake" which dumps main reservoir pressure directly into the brake cylinder. An upper limit of 160 psi would be desirable under these circumstances.

B.3.5 Emergency Brake and Brake Pipe Venting Annunciators

These annunciators are unchanged from the preliminary design. It should be noted that the engineers considered the duration of the brake pipe venting a significant indicator of the condition of the brake pipe. It should be recognized that, with newer train air brake systems with local venting of the brake pipe, very little air will exhaust at the front end of the train.

B.3.6 Speedometer

The speedometer pointer has been redesigned so that it does not totally mask the digits. Some consideration should be given to the use of kilometers when additional development is undertaken.

B.3.7 Consist Alarm

The consist alarm is an aural tone that comes on whenever there is a malfunction in any locomotive in the consist. The alarm can be silenced by pushing the button. The malfunction will be indicated on the caution annunciator panel located on the secondary display panel.

B.3.8 Cab Signal Aspects

These are unchanged from the preliminary design with the exception of the addition of a lamp test function.

B.3.9 Power Indicator

The power indicator is revised from the preliminary design. The power and dynamic braking ranges are still qualitative; however, a digital readout has been added that indicates permissible amperage developed by the locomotive consist. The numbers are important in some operations. For example, in dynamic braking certain amperages should not be exceeded in certain speed regimes and may be a function of the number of powered axles. The drawbar force indicator was removed and is discussed in the section on the train handling display. The pointer was redesigned to be less obtrusive. The red limit mark in motoring will, in practice, vary with locomotive class. Although not shown in the recommended design, a rotary switch should be considered that would allow the engineer to select any traction motor in the consist for display on the power indicator.

B.3.10 Timer

The timer is unchanged from the preliminary design.

B.4 MAIN CONTROLS

The arrangement of the primary controls was changed from the preliminary design.

B.4.1 Console Lock

The console lock is unchanged from the preliminary design.

B.4.2 Direction Lever

The direction lever functions are unchanged. A large bat-type toggle replaces the standard toggle of the preliminary design to provide easier operation.

B.4.3 Headlight Slew

The headlight slew switch is relocated from the overhead panel to the main control panel. The switch is changed to a bat-type mounted so that its long axis is parallel to the panel. The switch is spring loaded to center.

B.4.4 Headlight Control

The headlight controls are relocated from the overhead panel in the preliminary design to the main control panel. These controls are two three-position toggle switches, one for the front lights and one for the rear lights.

B.4.5 Sander

The sander pushbutton is relocated to the right side of the panel and a two-position slide switch is added to provide the engineer with the option to select either lead truck sanding or all truck sanding regardless of the direction of movement. The sander is a latching sander when lead truck sanding. During whole consist sanding the sander will latch for a specified period of time and then shut off.

B.4.6 Reverse Control Panel

The reverse control panel function is unchanged from the preliminary design. It has, however, been moved to the lower right hand corner of the panel.

B.4.7 Ash Tray

A pull out type ash try was added as shown in the lower right hand corner of Figure 3-9.

B.4.8 Stop All Engines

The function of the stop all engines pushbutton is unchanged from the preliminary design. It has been relocated to the upper left hand corner of the main control panel so that it is more functionally related to other braking and emergency systems.

B.4.9 Emergency Stop

The function of the emergency stop button is unchanged from the preliminary design. It has been relocated to the upper left of the panel for reasons of functional grouping. When the train is working with RCE locomotives, depressing the button initiates an emergency from both the lead and remote units.

B.4.10 Horn and Bell

The horn and bell controls are located in the panel lower left corner. These functions have been modified from the preliminary design. These controls are designed so that the horn and bell can be activated independently or together with one hand. They are located on the left to provide access by other cab occupants such as an instructor with a student engineer. Above the horn is a two-position switch that allows the engineer to modulate the horn.

B.4.11 Train Brake

The train brake was changed from the preliminary design. The primary change is in braking philosophy. In the present design the train brake and the locomotive brake are independent. That is, applying the train brake has no effect on the locomotive brake as it does in air brake systems in production locomotive cabs. The equalization position replaces full service in the preliminary design. In this position full equalization will be obtained for any initial brake pipe setting from 70 to 110 psi. Recognizing that there are occasions when the engineer must dig deeper into the brake pipe (for example, when a full service reduction is desired before the train brakes have completely released), a continuous reduction position is added. This position allows the engineer, if circumstances warrant it, to reduce the brake pipe pressure to approximately zero in the rearmost position. The train brake also functions as the primary controller during RCE operations with remote locomotives. The remote consist control panel separate train brake, shown in the preliminary design, is eliminated. A service reduction initiates a brake pipe reduction from both the lead and remote locomotives. A potential interface problem may exist when hauling a locomotive dead in train. Capability must be provided to cut in brake control.

B.4.12 Locomotive Brake

The locomotive brake function is changed from the preliminary design. This brake is totally independent of the train brake; thus, there is no requirement to actuate (bail-off) the brake during normal service reductions of the train brake. The auto-release function of the preliminary design is eliminated. It is worth noting again some of the human factors considerations given to the design of the raised curved control panel. The use of the arc and curved surface from which the controls extend will aid the engineer because he can feel his control location while attending elsewhere. This feel would be lost if the handles were raised high enough to allow the engineers to wrap their fingers around it as some of them wanted to do.

This is significant when it is also kept in mind that the engineer will be subjected to frequent longitudinal accelrations and decelerations as well as lateral motion. With this slack action the engineer may be jerked and jostled. With higher T handles these forces might result in inadvertent movement of the brake controls, since the hand gripping the handle will not have the benefit of the stabilizing support which is provided by the arced panel with the T handles positioned closer to the surface. The human factors principle is that in an environment where the operator is subjected to acceleration forces all hand controls should be designed to provide support to the operator's forearm, requiring only wrist action if possible.

B.4.13 Throttle and Dynamic Brake

The throttle and dynamic brake functions are the same as those in the preliminary design but with some refinements. There is a psuedo-detent represented by a click at each corresponding notch setting of both the dynamic brake and the throttle. The throttle and dynamic brake interlock is located at the upper left of the controller. This interlock must be depressed when going from idle to set up position or vice versa.

B.4.14 Radio Controlled Equipment Throttle and Dynamic Brake

The throttle dynamic brake controller for radio controlled units is located to the left of the train brake as shown in Figure 3-15. The function of this controller is to provide independent throttling and dynamic brake control of RCE units. It is functionally identical to the main controller. On preliminary design drawings it was located on the overhead panel.

B.4.15 Safety Devices

Safety devices commonly found on locomotives are as follows:

a) Safety Control Foot Valve
b) Electronic Alertness Control
c) Automatic Train Stop (ATS)
d) Overspeed Control.

These safety devices stop a locomotive and train if the engineer fails to perform prescribed functions. A recent research paper contains a review of alerting techniques presently employed on the railroads (Reference 8) and some recommendations for further research. Most of the engineers thought that some kind of alertness control or deadman device was needed. None knew of any system that really works. It appears that the pneumatic foot valve is being used less frequently as new devices come on the market. An empirical study is needed to determine if indeed these devices work as advertised. One railroad is attempting such a study. They are buying half their locomotives with and half without foot valves. The study will evaluate whether any accidents are prevented because of the installation of such a device. Further research into this issue is warranted perhaps using a variety of alerters. No foot valve is included in the present design and any momentary operation of the primary train controls serves as an acknowledgment. An audible warning will sound during which an acknowledgment will prevent a penalty brake application. A time delay should be present (for example, thirty seconds). In the event of a penalty application of the brakes, a release of the brakes can be made by depressing the suppression button to the left of the train brake. The switch will light and remain lit until application pipe pressure is restored at which time the light will go out. Then the train brake may be placed in release and if the throttle/dynamic brake control has been placed in idle the PC will reset.

In areas where there is automatic train stop or where cab signals are used, the present design provides an acknowledging button to the right of the throttle/dynamic brake controller. In the event the lead locomotive passes over an inductor in approach to other than a clear signal or the cab signals show a restrictive aspect the acknowledger button will light. The acknowledger must be depressed and held until the light goes out. The switch is cyclic to prevent defeating the switch. In the event an acknowledgment is not made, a penalty brake application will be initiated. To recover from the penalty the suppression switch must be depressed.

Overspeed control is a safety device that causes a brake application when the locomotive exceeds the overspeed setting. If speed is exceeded a whistle will sound for a period of time before a penalty application is initiated. A penalty application may be avoided if, during the warning period, the engineer moves the train brake handle to the minimum reduction position.

If the warning period is exceeded the suppression button should be depressed. The legend will remain lighted until the application valve has reseated.

It should be noted that proliferation of auditory warnings should be avoided. A voice warning technique similar to those used in aircraft should be considered as a reasonable alternative.

B.5 SECONDARY PANEL

The secondary display panel is revised from the preliminary design drawings. The changes are described below.

B.5.1 Annunciator Panel

The annunciator panel has functions arranged from top to bottom in order of criticality. Items requiring immediate action such as PCS open or wheel slip/slide are located at the top. An addition to the recommended design is the pushbuttons at the top of the panel. These pushbuttons are used in conjunction with the consist alarm. When the consist alarm comes on, it indicates a malfunction in any locomotive in the lead consist including the first. The engineer pushes the consist alarm button to turn off the alarm. He then inspects the annunciator panel where the appropriate annunciator will be illuminated. If the engineer desires to isolate a unit, he can isolate the lead unit via the run-isolate switch on the overhead panel or isolate a trailing unit via the illuminated pushbutton.

B.5.2 Communication Set

The communications set is revised from the preliminary design. The new concept is a built-in speaker with VOX control requiring a certain amount of signal strength to turn the speaker on. Beneath the speaker is a panel mounted microphone with a press-to-talk function and an indicator light to signal a transmission.

B.5.3 Train Handling Display

The train handling display is unchanged from the preliminary design except in one respect. Figure 3-12 shows an additional display option for train orders. However, some additional statements concerning the use of the device is warranted. One important consideration is the elimination of the drawbar force indicator from the main control panel. This information is now displayed solely on the train handling display. The importance of this information in train handling cannot be emphasized enough. The drawbar force indication of the draft/buff display option has two limit markers; one for normal trains that may operate up to 240,000 pounds in buff and 250,000 pounds in draft, and one for unit trains that may operate at 340,000 pounds in buff and 350,000 pounds in draft. Drawbar force will also be displayed for remote units at both the front and rear ends.

With respect to on-board computer capability, some units run equipped with a computer and recorder for recording speed, throttle position, use of horn, etc. Consideration should be given to combining the functions of the train display and the "trip recorder" for a more comprehensive data history readout.

B.6 REVERSE CONTROL PANEL

Some modifications to the reverse control panel shown in preliminary drawings were made and are shown in Figure 3-13. The horn and bell located on the right side of the panel have been moved adjacent to each other for easy operation with one hand. The train brake and locomotive brake handles have been changed to be identical with the controls on the main control panel. The throttle/dynamic brake controller is modified to be identical to the controller on the main panel. Dynamic braking has been added to the controller.

B.7 OVERHEAD PANEL

The overhead panel was revised from the preliminary design and the changes are described below.

B.7.1 Remote Control Equipment (RCE)

The RCE equipment panel was revised from the preliminary design. As mentioned in Section 3.9 the primary RCE controls are adjacent to the lead consist controls on the primary control panel. The operating mode selector was modified to incorporate isolate, idle, multiple unit (MU) and independent operating functions. The annunciator lights now include a continuity as well as a no-continuity indication. It should be recognized that railroads employing RCE units operate them in diverse ways depending on type of terrain, train make up and operating philosophy. Therefore, in actual operation the specific functions implemented on this panel may vary and some railroads may prefer, for example, additional annunciators such as feed valve out or PC switch open.

B.7.2 Independent Brake Control

The independent brake control is modified to a pushbutton located at the lower right-hand corner of the panel. Depressing the button either releases or applies the independent brakes in the remote consist depending on the initial setting. The appropriate half of the button will illuminate. The primary function of this control is to park the train. No routine operational use of this function could be ascertained during the evaluation. The independent brake on the lead unit controls the independent brakes of the units in the lead consist only.

B.7.3 MU-2 Valve

The function of the MU-2 valve now should read lead/dead, trail 6 or 24, and trail 26 to correct an error in the preliminary design.

B.7.4 Air Comfort System

The air comfort system is modified from the preliminary design. It consists of a selector function, temperature control and fan. The selector control allows the engineer to select air conditioning, outside air or heat. Air conditioning in the normal position is cooled humidified fresh air. In the maximum position recirculated air may be used to cool down the cab. The fan is operable in either the high or low positions when the selector switch is in any position other than off. It is recommended that consideration be given to humidifying the air both in very cold and very warm dry climates.

B.7.5 Class Lights

The legends on the class lights control switch have been rearranged to reflect frequency of usage: that is, off, white, green, and red.

B.7.6 Strobe Light

It was apparent during the test and evaluation that some type of external visual warning is necessary. For the present design, a strobe light is recommended which is activated when the horn is turned on or an emergency brake application occurs. A reasonable alternative, based on the test results, would be a "MARS" or oscillating headlight.

B.7.7 Headlight Setup

The headlight setup switch placard is modified from the preliminary design by the addition of an arrow indicating setup position for short or no hood forward.

B.7.8 Slider Switches

The on/off positions of the two position slider switches are reversed from those shown in the preliminary design. By convention they are up for "on" and down for "off". A switch is added to turn the rear wall lights on and off and the legends on the dynamic brake switch now read "in" and "out".

B.7.9 Traction Motor Cutoff Switch

The functions on the switch are modified to correct an error in the preliminary design. The fourth position now reads 3 and 5 out.

B.7.10 Fuel Saver

Shown at the top of the panel is a fuel saver function. Because of the cost of energy, diesel fuel is a large part of the cost of shipping. Reference 9 describes a device for increasing the economy of fuel by providing the engineer with the capability to reduce the throttle setting of selected units in the locomotive consist to Notch 1 under circumstances where more horsepower is being developed than is needed. Figure 3-14 shows these control functions in the present cab design.

APPENDIX C
REPORT OF NEW TECHNOLOGY

Although no patentable items are claimed, this research and development study has produced an improved freight locomotive cab design. The significant improvements are to the crew work stations and general cab habitability. Specifically, the following items are noted:

1. functional arrangement of displays and controls
2. simplified train and locomotive braking
3. integration of RCE with locomotive controls
4. addition of a train handling display and minicomputer
5. addition of a reverse control panel
6. improved visibility
7. addition of a crash station
8. improved acoustic and vibration environment
9. improved protection against cab contaminents
10. redesign of cab rear wall and appurtenances.

These improvements should improve train handling and provide a safer and more livable cab environment.

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