2. SIGNALING SYSTEM

The principles and alternatives for a signaling system for a LRT system were discussed in Section B of the "North Corridor Alternative Analysis" (NCAA). The signaling system described in that report also applies to the Multi-Corridor Project, with the following exceptions:

2.1 General

(1) Since the Multi-Corridor Project does not include any mixed traffic (non-exclusive right-of-way) operation, the sections referring to this are not applicable.

(2) Wayside signals will be provided only at interlockings (areas including track switches and turnbacks).

(3) Full two-direction signaling of both tracks is recommended for selected areas (Union Station to Northgate Station and South Kirkland Station to Wilburton Station) in order to expedite off-normal operations in these critical areas under full cab signal protection.

(4) Reverse movements will be allowed in all other areas on a non-cab signal basis in which not more than a single train is allowed between adjacent wayside signals. This less convenient operation will have vital signal protection via the wayside signals at the interlockings, and safety will depend on observance by operating personnel of the signal aspects.

2.2 Automatic Train Protection (ATP) System

(1) Automatic train protection (ATP) is recommended for all portions using multi-code continuous cab signaling and overspeed protection. Automatic train operation (ATO) is not recommended; trains will be controlled at all times by the train operators. The ATP system will enforce safe speed limits down to 10 mph.

(2) The ATP system will include properly designed and implemented coded track circuits, onboard receivers and decoders, onboard speed governors, and propulsion brake interfaces.

(3) The coded track circuits may also provide fail-safe train occupancy detection or this may be provided by separate low- or high-frequency track circuits.

(4) The track circuits will be combined with AAR approved interlocking and traffic circuitry, speed control networks, wayside signals, approved switch and lock movements, and other necessary appurtenances to constitute a full ATP system meeting all AAR Signal Section standards.

(5) Train speed limits of 10 mph (default speed), 22 mph, 35 mph, and 53 mph are recommended in order to minimize headways and to provide safe operation at all locations.

(4) Dual-control heavy rail track switches are included. These are superior to the cranked-only light rail switches.

(5) The AC coded track circuit includes a phase-selective decoder and DC track relay for occupancy detection.

(6) The system includes a relay house at each station, at remote interlocking, and at intermediate locations, as listed, where distances between stations require the track circuit leads to be over 4,000 feet long. Generally, these can be located at the same places where intermediate substations are located. Non-interlocking stations are included in the intermediate count.

(7) Interlocking relay and circuit requirements follow the practice used by the San Francisco Municipal Railway.

(8) The system cables include a cable throughout for traffic locking purposes.

(9) Each interlocking location includes a local control panel.

(10) Central Control includes an integrated system for train monitoring, central control of routes, train tracking, and platform sign control. It also includes matrix type control console (or sensitive screen control) and either a system display board or CRT displays.

3. COMMUNICATION SYSTEM

3.1 Introduction

The communications system described below will be required for all corridors of the LRT system. The communications system includes the subsystems that provide the voice, video, and data communications necessary to operate and maintain the system under normal and emergency conditions. The subsystems include:

- o Radio
- o Public Address
- o Telephone
- o Closed Circuit Television
- o Digital Transmission System
- o Cable Transmission System.

A block diagram, Drawing No. COM-1, indicates the relationships among the subsystems. Each of these subsystems is described on the following pages, as well as the role of the communications system in Central Control. Included at the end of the section are tables that define the subsystem requirements for each corridor. The equipment identified and being proposed for use is similar to that used or proposed for use on transit systems in San Diego, Santa Clara, Orange County, and San Francisco.

3.2 Radios

Four radio channels, operating on different frequency bands allocated for land transportation radio service, will be used for voice communications for vehicle operations, maintenance, security, and emergency. The four channels will be available for any or all of these functions, as necessary.

Control of the radio for vehicle operations, yard and maintenance operations, security, and emergencies will be monitored at Central Control. Control consoles will provide access to all channels via redundant voice channels in the cable transmission system.

In the subsurface segments of each corridor, inline amplifiers and/or repeaters will energize a radiating antenna cable to provide continuous signal transmission.

Vehicles will be equipped with vehicular two-way radio units wired and equipped with frequency determining elements to allow operation on all channels.

3.3 Public Address

A public address (PA) subsystem located at designated passenger stations will consist of loudspeakers positioned throughout the station in strategic locations to ensure adequate coverage. A control panel and a

4. SUBWAY VENTILATION

All long subway configurations will need to be ventilated. For subway sections that include stations, both emergency ventilation and ventilation to maintain reasonable air quality will be required. It was assumed that ventilation shafts will be placed at each end of each station.

Because the tunnels will be separate single-track tunnels, the vent shafts should be located 100 to 150 feet into the tunnels from the ends of the platforms so that air will be drawn specifically along the tunnel in which the vent shafts are located. Each single bore at each station will have a fan shaft dedicated to it, and there will be one fan shaft on each side of each station.

For subway sections that do not include passenger stations, neither ventilation nor temperature control will be required under normal conditions, but ventilation will be required for emergency conditions. It is assumed that the ventilation shafts will be provided for each separate bore at approximately 1,500- to 2,500-foot spacing with at least two fans in each shaft.

5. FARE COLLECTION

5.1 Introduction

This section describes the fare collection system that will be used on the LRT system. Included below are a functional description of the system, functional design assumptions, equipment descriptions, and a table defining the equipment to be provided for each corridor. The fare collection system is a self-service, barrier-free system.

5.2 Functional Description

At each station, either on the platform or in the concourse or mezzanine areas, at least one ticket vending machine and a change machine will be provided. Depending on the station arrangement and projected passenger volume at the station, more vendors and change machines will be added. The vending machines will dispense tickets of varying value, depending on the length or number of fare zones to be crossed (it is assumed METRO's current zone fare system will be used but the machines will be adaptable to other fare concepts). The machine will also include a validator into which the user must insert his/her ticket. The validator imprints the date, time, and location codes on the ticket. METRO may wish to sell multiple ticket packages at outlets not located at the stations. These tickets will also require validation prior to boarding the train. Current METRO passes will not require validation as they have a defined time validity associated with them. Bus-to-LRT and LRT-to-bus transfers require policy determinations not yet made. For this study, free transfers are assumed; the transferee will be required to have a valid bus ticket or LRT ticket in his/her possession while on either vehicle following the transfer.

Passengers on board LRT trains must have a valid ticket or pass in their possession. METRO personnel in uniform will randomly inspect tickets and passes on board trains throughout the day. It is assumed that 35-40% of the riders will be inspected daily.

Passengers without valid tickets will be cited. While a policy needs to be established on the severity of the fine, the system used by the San Diego Trolley system is one example:

- o First time evaders are fined $20
- o Second time evaders are fined $50
- o Third time evaders are find $50, plus a mandatory court appearance.

The citations are similar in form to a traffic citation.

Certain communication/security functions are assumed to be included in the system. Each ticket vendor and change machine will have an intrusion alarm, which will be connected via the digital transmission system back to Central Control. In addition, it is assumed that each ticket vending area will be within the surveillance coverage of a closed circuit television camera whose pictures will be monitored at the security console in Central Control. Both of these communication systems are included in the communications system.

It is assumed that money collection from the ticket vendors and change machines will be by a contractor, such as Brink's or Loomis, who specializes in money collection. METRO may wish to establish a special money collection group, but for this study a contractor is assumed.

5.3 Functional Criteria

Certain performance requirements have been assumed in order to determine the number of ticket vendors, change machines, and ticket inspectors. They are as follows:

- Ticket vendors - One per platform, minimum; and two per location at high-volume stations (e.g., two at each mezzanine for subsurface stations and three per location at high-volume, off-street, center platform stations).

- Change machines - One per ticket vendor location. One change machine is sufficient to serve up to three ticket vendors.

- Ticket inspection rates - It is assumed that each inspector can check 120 tickets per hour. This presumes that checking will be done on a per car basis; the inspector can check many tickets in a short period then move to another car.

5.4 Equipment Description

The following is a description of the ticket vending machine proposed for the LRT system. This specific machine is the one being used on the San Diego Trolley System.

The exterior of the ticket machine is shown in Figures 4 and 5. A stainless steel exterior has proven to be durable and easy to clean. A system map and ticket purchasing instructions are on the front panel of each machine. A passenger must first press one of up to six buttons indicating which ticket type is to be purchased.

After the button is pressed, the window at the top right of the machine will display the amount to be paid, which must be deposited using exact change. As coins are deposited, the display counts down, showing the remaining amount owed. The machines accept nickels, dimes, quarters, half dollars, and Susan B. Anthony dollar coins, but they do not accept dollar bills. The ticket is vended through the tray at the bottom of the machine. On the left side of the machine is a slot for validating multi-ride tickets.

The machines are mounted on pedestals which include the cash box. Access to the ticket machine and the cash box are through separate doors, each requiring a different key. A third door at the bottom of the pedestal is opened by a third key and provides access to the power supply and a "silent alarm," which alerts Central Control if a machine is being tampered with.

The ticket machine has 10 major components or "modules." These and other features are shown in Figure 6 and 7 and described below.

- o Electronic central unit - Comprises the electronic controls and "brains" of the machine. Four printed circuit boards control the fare display, printer, program storage, and data collection.

- o Needleprinting - Mechanically cuts and prints tickets with type, date, time, and location codes.

- o Coin verifier - Identifies electrical, magnetic, and mechanical characteristics of the coins so that pennies, slugs, and foreign money are rejected.

- o Foreign body rejector - Automatically seals coin slot and protects against bent coins.

- o Power supply - Contains an AC to DC converter.

- o Cash box - Coins, when accepted by the verifier, drop into the base of the machine where the cash box is contained. (Cash box is not shown in Figures 6 and 7).

- o Price display - Provides a four-digit LCD display of ticket price and balance due.

- o Service keyboard and display - Is an internal input/out unit used to program the electronic central unit and to display error codes in case of machine failure.

- o Burglar alarm - Sounds when door is opened improperly and sets off a "silent alarm" to alert Central Control.

- o Validator (canceller) unit - Is a completely separate mechanical unit with its own power supply and electronic controls. The unit cuts a diagonal slice on an inserted multi-ride ticket and prints date, time, and location costs.

Each of the modules, except for the independent validator unit, is linked electronically to the electronic central unit. The central unit routinely records transactions, coin intake, and money errors. These statistics are used to verify cash box receipts and to estimate ridership figures for each station.

The electronic central unit will also attempt to self-diagnose any machine failures. Any failures that it is able to detect are displayed on the service display using a two-digit error code. Errors are classified as technical and administrative. Administrative errors are problems such as "no paper," "cash box full," or "coin jam," which require action but are not defects in the ticket machine. Technical errors usually are defects in the machinery such as "clock defective," coin tipper does not open," or "cutter blocked." The machine is not able to correctly self-diagnose all of its problems. Many printer failures reported as technical errors are problems such as "improperly fed paper" which are not actually machine defects. Also, some errors cannot be detected by the electronic central unit. Failures in the coin verifier and printer can occur without being diagnosed. Validator problems are never reported by the machine because it is a completely separate unit without self-diagnosing capabilities.

5.5 Equipment Requirements

The equipment quantities for each corridor are indicated on Table 3, Station Description.

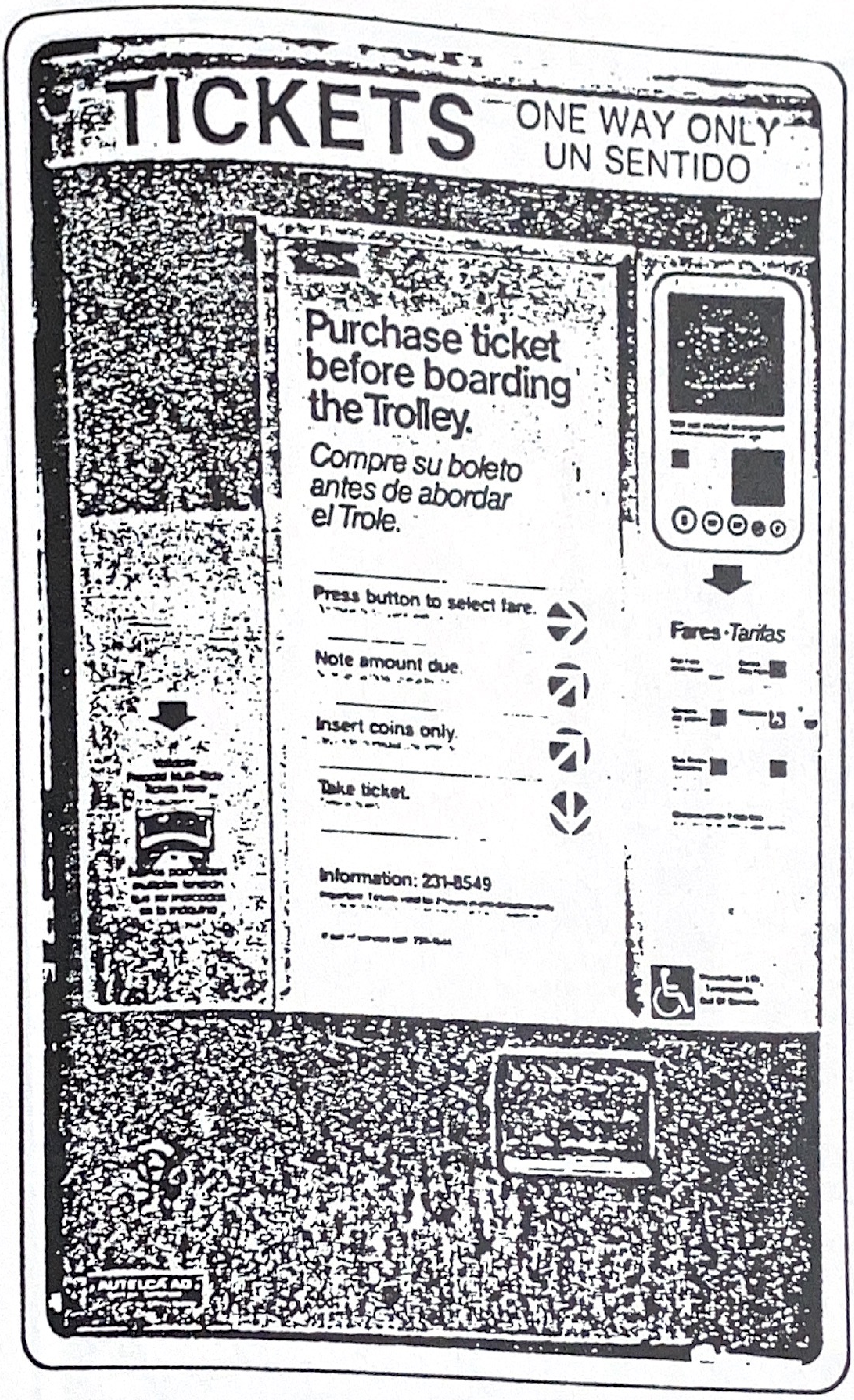

FIGURE 4
FRONT PANEL OF TICKET MACHINE