NBSIR 88-3786

MATERIAL HANDLING WORKSTATION, RECOMMENDED TECHNICAL SPECIFICATIONS FOR PROCUREMENT OF SYSTEMS

May 19, 1988

By:
Carl E. Wenger

U.S. DEPARTMENT OF COMMERCE National Bureau of Standards Gaithersburg, Maryland

MATERIAL HANDLING WORKSTATION
RECOMMENDED TECHNICAL SPECIFICATIONS
FOR PROCUREMENT OF COMMERCIALLY AVAILABLE EQUIPMENT

Carl E. Wenger

May 19, 1988

Certain commercial software and hardware systems are identified in this paper to adequately describe the systems under development. Such identification does not imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that the systems identified are the best available for the purpose.

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I. INTRODUCTION

1. PURPOSE OF THIS DOCUMENT

The purpose of this document is to provide specifications applicable in the procurement of material handling equipment to be used in an automated facility. The shop floor layout of the automated facility at NBS is shown in figure 1. The equipment includes Automatic Guided Vehicles (AGV) and an Automatic Storage and Retrieval System (ASRS).

2. AUDIENCE

The intended audience for this document are technical persons involved in procurement of material handling equipment for an automated facility.

3. CONTENTS FLOW

This document includes technical specifications used in the procurement of material handling equipment. Other related documents are "Material Handling Workstation Operator Manual, NBSIR 88-3785" and "Material Handling Workstation Implementation, NBSIR 88-3784". The first specification is an updated version of the specification used to procure an ASRS for the AMRF, and the second is a modified specification used to procure two AGVs for the AMRF.

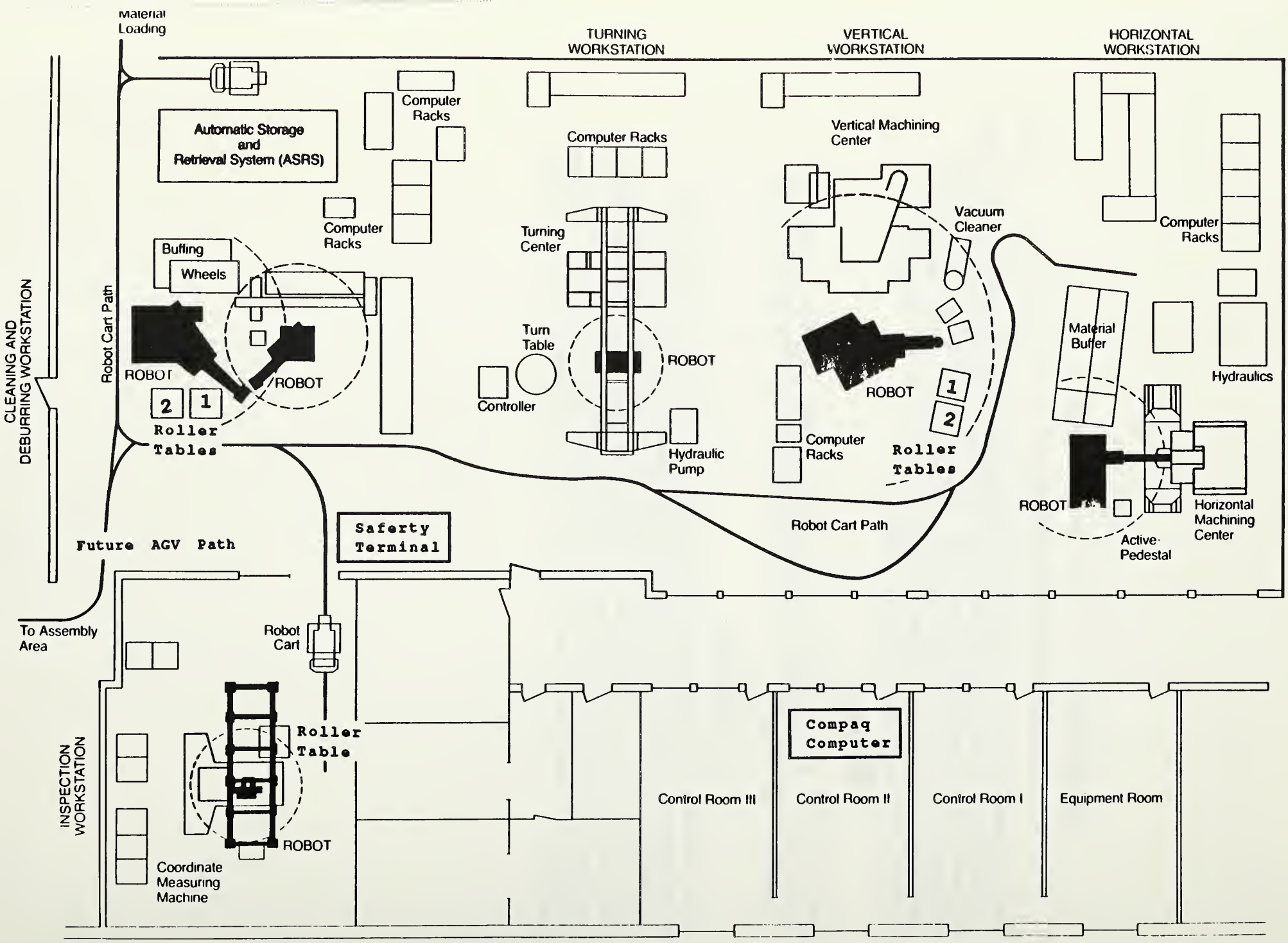


Figure 1. AMRF Floor Layout

II. ASRS SPECIFICATIONS

1. BACKGROUND

The Automatic Storage and Retrieval System (ASRS) will be used in an integrated material handling system which includes Automatic Guided Vehicles (AGVs). The ASRS will store manufacturing materials in trays and transfer the trays to and from the AGVs. The operation of the ASRS will be controllable by an external computer. The material handling equipment configuration is shown in figure 2.

The contractor shall deliver and install the system at the designated site. The system must be configured to perform the operations outlined above. The storage system shall be a vertical storage system.

2. FUNCTIONAL REQUIREMENTS

The ASRS shall be designed and engineered to meet the following requirements:

a. The system shall consist of identical modules for storing trays on shelves. Each module shall be capable of storing a minimum of 30 trays. The outer dimensions of each tray shall be 21 x 21 inches, and the average shelf spacing shall be 8 inches. The trays shall accommodate objects of up to 16 inches in height and 200 pounds weight.

b. The system shall automatically transfer the trays to and from a roller conveyor of an AGV. The system shall respond to storage and retrieval instructions for transferring trays between the AGV and the ASRS by manually entered keyboard commands or by an external control computer as described in section 4.2.

3. GENERAL DESCRIPTION

The ASRS shall be new and essentially one of the manufacturer's current standard models. The system shall consist of the necessary components and other supporting/auxiliary systems necessary to operate manually and automatically as an integral unit. Each module shall be capable of storing 30 trays, and inserting and removing the trays to and from an AGV. It shall perform all these operations under computer control and without an operator.

Equipment of the AMRF Material Handling Workstation

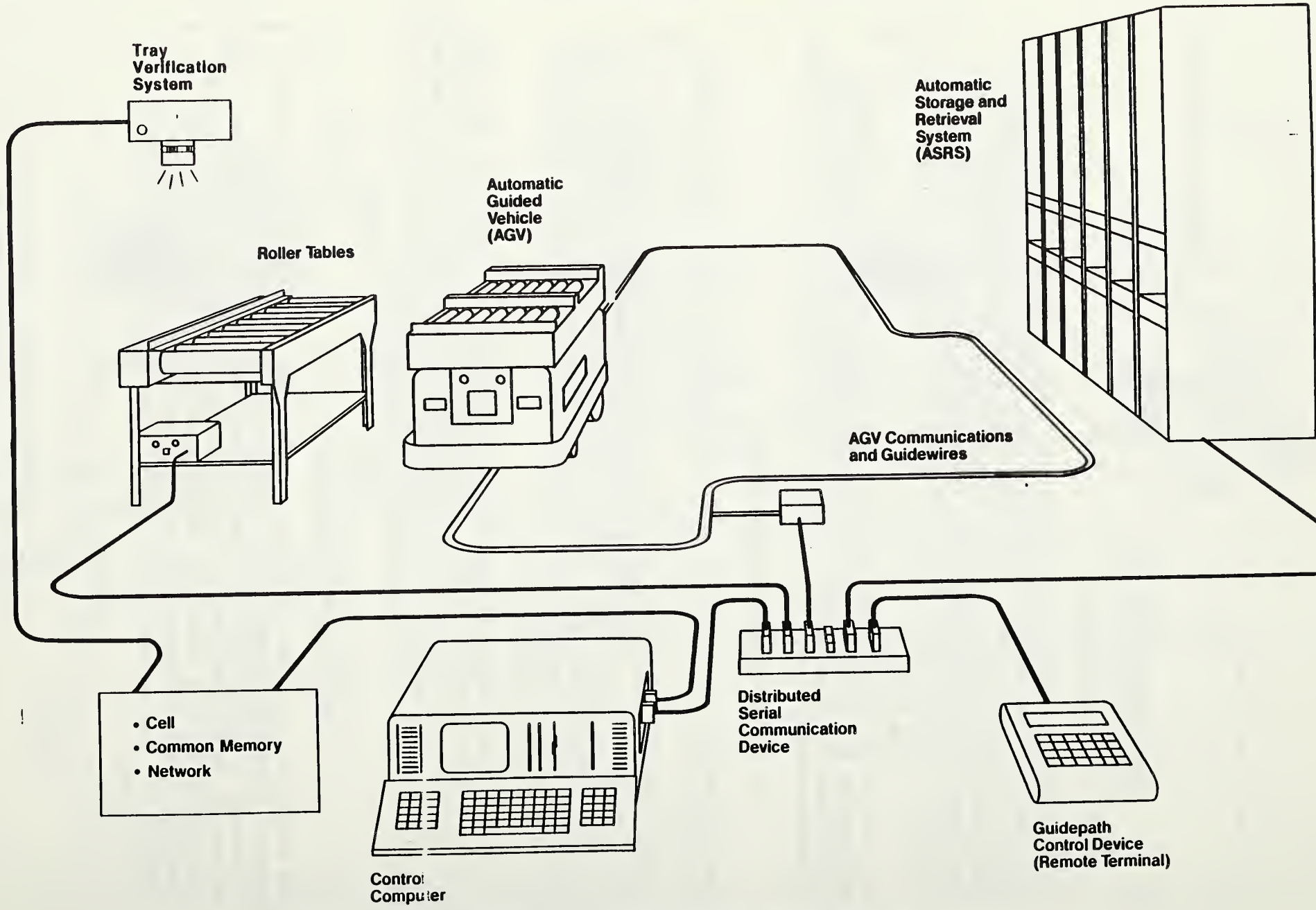


Figure 2. Material Handling Equipment

All parts of the system that are subject to wear, breakage, or distortion shall be accessible for adjustment, replacement, or repair.

4. DETAILED REQUIREMENTS

4.1. Construction Features

The storage system shall be so constructed that when installed and connected to power, it will be ready for operation. The system shall be constructed of parts which are without defects and free of repair. The structure shall be capable of withstanding all forces encountered during operation of the storage systems to its maximum rating, including a minimum tray loading of at least 200 pounds on each tray. During maximum loading, it must operate without permanent distortion.

4.1.1. Size

Each system module shall occupy a maximum floor space area of 6.75 feet in depth and 2.5 feet in width. The maximum height shall be 16 feet for a 30-tray module. If the modules are specified to hold less than 30 trays, the maximum height shall be reduced 4 inches for each tray less than 30. The conveyor of each module shall protrude a maximum of 6 inches from the front of the unit.

4.1.2. Positioning Repeatability

The ASRS shall have stopping repeatability within 1/8 inches aligned with respect to a fixed point for presenting trays to the AGV.

4.1.3. Conveyor Height

The system shall present trays to the AGV at a height of 32 inches. The height shall be adjustable from 28 to 34 inches.

4.1.4. Acceleration And Deceleration

The entire system shall have controlled acceleration and decelaration such that a solid, loosely positioned alumimum block 2 inches cube will not change position by more than 0.050 inches by any and all motion of the system.

4.1.5. Tray Holder Position Height

The tray shelves shall be manually adjustable between 4 (or 6) to 16 inches in 2 inch intervals by use of ordinary hand tools.

Height sensors shall prevent attempts to place trays containing oversize objects on the shelves.

4.1.6. Supporting System

Trays shall be provided for all storage locations in the system. The outside dimensions of each tray shall be 21 inches square and 2.5 inches in height. The trays shall be constructed such that when the tray is supported at the perimeter, a 200 pound steel block placed in the center of the tray will not cause permanent distortion. The trays shall have handle cutouts in the front and back only and shall not have cutouts in the sides.

4.2. Computer Control System

The ASRS shall include a local control computer capable of controlling the system and responding to commands from and providing status to an external control computer. The system shall store the tray in the location specified by the external computer.

4.2.1. Interface With The External Computer

It shall be possible for an external computer to control the actions and maintain status communications with the storage system control by RS-232 interface.

4.2.2. Command Execution

The system shall respond to external computer commands to: 1) transfer trays between selected shelfs and the conveyor, and 2) transfer a tray between the conveyor and the AGV. Sensors shall detect the presence of the AGV and disable tray transfer off the conveyor if the AGV is not present.

4.2.3. Status Feedback

The system shall provide status feedback to the external computer. The status data shall indicate whether the system is busy with a current operation or whether it is ready for another command. Error conditions shall be reported in the status data.

4.3. Manual Operation

Activation of all specified functions shall be possible by manual operation from a keyboard.

4.4. Electrical Power

The system shall be powered by 120 volt single phase.

4.5. Fastening Devices

All screws, pins, bolts, and similar parts shall be installed in such a manner as to prevent change of tightness. Those subject to removal or adjustment shall not be swaged, peened, staked, or otherwise permanently deformed.

4.6. Surfaces

All surfaces of parts shall be clean and free of sand, dirt, and extraneous materials. The appearance of the unit shall be in conformance with industry standards.

4.7. Safety Devices

Covers, guards, or other safety devices shall be provided for all parts of the system that present safety hazards.

4.8. Documentation

At least three copies of documentation for the complete system shall be supplied. This shall include operating and service manuals as well as mechanical drawings, and complete electronic and electrical schematics.

4.9. Contractor's Responsibility

The contractor shall provide and maintain an effective inspection plan which will assure that all components of the system conform to contract requirements whether manufactured or processed by the contractor, or procured from subcontractors or suppliers. The Government reserves the right to perform any inspections or tests necessary to assure that hardware and software conform to prescribed requirements.

4.10. Preshipment Examination

The Government reserves the right to examine the completed system before it is packaged for shipment to confirm that it meets the specified requirement contained herein.

4.11. Installation

The contractor shall install the complete system at the specified location. After installation, contractor shall conduct tests to

prove that the system operates in accordance with the specifications.

III. AGV SPECIFICATIONS

1. SIZE AND CONSTRUCTION

1.1. Vehicle Size

Overall dimensions (including the load-carrying and transfer mechanism) shall be approximately 2.5 feet wide by 5 feet long. The width of the vehicle shall be less than 3 feet.

1.2. Vehicle Weight

Overall weight is not critical. It should be approximately 1,000 pounds including the load-carrying and transfer mechanism.

1.3. Vehicle Construction

The construction shall be industrial quality, suitable for continuous use at full-load in a shop environment with a smooth concrete floor.

1.4. Propulsion System

The vehicle shall be self-propelled by a battery-powered electric motor. The vehicle, which may be either four- or three-wheeled (provided the vehicle can maintain stability under a reasonable nonsymmetrical load distribution), may be driven by either the front or rear wheels (or all wheels).

1.5. Battery and Charging System

The battery shall be an industrial type capable of supplying sufficient power to operate the vehicle continuously for at least eight hours, after no more than twelve hours of charging. The vehicle shall have an on-board battery charger. The charging system shall have capability to initiate charging automatically under software control or manually. At least two charging stations shall be included. The charging system shall be automatically regulated to prevent over-charging and shall have an over-current cutoff system. The battery shall be easily accessible for the purposes of checking fluid levels. A battery meter shall be installed on the vehicle to indicate the charge status of the battery.

2. LOAD-CARRYING CAPABILITIES

2.1. Mechanism

The vehicle shall be equipped with two independently powered roller beds which, when actuated, can move the trays from or onto the vehicle. The roller bed mechanism shall be capable of loading or unloading trays from both sides of the vehicle.

2.2. Size

Each roller bed shall be capable of carrying and transferring trays measuring 21 inches square by 2.5 inches high.

2.3. Height

The height of the roller bed shall be either fixed to 28 + or - 1/2 inch or adjustable from 26 to 32 inches.

2.4. Roller Speed

The speed of the roller or tray shall be between 25 and 30 feet per minute.

2.5. Load Capacity

The vehicle, equipped with the roller bed mechanism, shall be capable of carrying 500 pounds on the 21 x 21 inch load carrying tray. The load may be unevenly distributed.

3. GUIDANCE

3.1. Technique

The vehicle shall be capable of following a wire, taped to or buried in the floor, over which a guidance signal is transmitted. The wire sensor shall not require contact with the floor and the tracking tolerance shall be + or - 1/2 inch or better.

3.2. Turning Radius

The vehicle shall be capable of following a quide path turn with a radius as small as 24 inches.

3.3. Stopping at Load/Unload Stations

The vehicle shall be capable of stopping at locations to load or unload materials. These locations shall be defined by data input to the control computer. Changing of the station locations shall

not require modifications to the control software but only to input data. The vehicle shall be capable of stopping at these locations within a tolerance of + or - 1/4 inch or better. The vehicle shall also be capable of passing by these locations without stopping if no load transfer is required there.

3.4. Loss of Guidance Signal

Unless specifically commanded to do otherwise, the vehicle shall stop as soon as the guidance signal is lost or stopped. If the vehicle wanders off the guidance path more than 2 inches, the vehicle shall also stop.

3.5. Alternate Guide Paths

The vehicle shall be capable of switching to alternate guide paths when commanded to do so.

3.6. Multiple Vehicle Operation

The vehicle shall be capable of operating on the same guide path, at the same time, with other identical vehicles. The vehicle shall be capable of sensing that another vehicle is on a particular section of the guide path that it is about to enter and shall be capable of stopping before it enters that section.

4. VEHICLE OPERATION

4.1. Modes of Operation

The vehicle shall be capable of operating in both manual and automatic modes. In the manual mode, an operator shall be able to guide the vehicle to any desired location through the use of a hand-held control box. The operator shall also be able to control the speed of the vehicle and the auxiliary functions including the load transfer and battery charging mechanisms. In the automatic mode, the vehicle shall follow the guide path wire and perform the functions it is commanded to do without human intervention. The vehicle shall be capable of operating in a multi-vehicle system environment.

4.2. Vehicle Direction

The vehicle shall be capable of operating in both forward and reverse directions in both manual and automatic modes. The vehicle shall be capable of reversing direction at any point on the guide path.

4.3. Vehicle Speed

The vehicle shall be capable of traveling at any speed between 20 feet per minute (or less) and 200 feet per minute. The actual speed shall be variable and capable of being set manually by an operator or automatically by an external computer communicating with the vehicle control system. In operation, the vehicle shall smoothly accelerate or decelerate to the commanded speed. The exception to this is when an immediate stop is required.

5. VEHICLE CONTROL

5.1. Control Computer

The vehicle shall be equipped with an on-board microcomputer system capable of controlling the actions of the vehicle and communicating with an external computer. This microcomputer system shall be PC AT compatable and shall consist of an 80286 or 80386 type microprocessor. The computer hardware shall include a minimum of 640K of random access memory and a 360K floppy disk drive.

5.2. Card Enclosure

The control computer shall reside in a PC bus enclosure which shall be of such size to include all boards supplied by the manufacturer and at least one extra slot for a user supplied board. This enclosure shall be located on the vehicle in such manner that it is easy to access any board which is mounted inside it.

5.3. Vehicle Functions

The vehicle shall be capable of performing various functions which can be commanded by remote computer control. Below is a minimum list of functions which the vehicle must be able to perform without any modifications to the control software.

Start vehicle moving forward or reverse.

Stop vehicle immediately.

Stop vehicle after measured distance, or after sensing of specified number of optic sensors.

Extend or retract battery charging mechanism.

Read the station identification code of stations along the AGV path.

Perform specified pattern turns off the guide wire in forward and reverse directions.

Load and unload trays from both sides of the vehicle.

5.4. Remote Control of Vehicle Operations

The vehicle shall be capable of being remotely controlled by another computer. The vehicle shall be controlled by sending command messages to the vehicle through a wire on the floor or buried in the floor. The vehicle shall respond to all the commands as shown in Appendix A included in this specification. The vehicle shall be capable of operating in a multi-vehicle system and shall be capable of decoding the remote commands to determine which commands it is to execute and which commands are intended for other vehicles.

6. COMMUNICATIONS WITH AN EXTERNAL COMPUTER

6.1. Communications Data Link

The vehicle shall contain a modem transmitter/receiver using standard RS-232 communications. The link shall be made through a wire buried in the floor. The data transmission rate shall be a minimum of 300 baud. The communications link shall be capable of supporting communications to more than one vehicle and shall be capable of communicating new commands and vehicle status information at least once every second.

6.2. Status Feedback

The vehicle shall be capable of communicating information regarding its status over the link to the external computer. The information shall be updated at such a rate to permit status feedback to the external computer to be transmitted at least once every second in the form of the status message format as shown in Appendix A.

7. SAFETY DEVICES AND FEATURES

7.1. Safety Devices

The vehicle shall be equipped with safety devices to avoid collisions with obstacles or other vehicles. The safety devices shall operate with the vehicle moving in both the forward and reverse directions. The vehicle shall also be equipped with a warning light and alarm to signal that the vehicle is approaching or that it has stopped because of an obstacle. Vehicle shall have

push button switches which can pause and resume operation of the vehicle.

7.2. Other Safety Features

A warning light or alarm shall be activated in case of vehicle malfunctions, low battery charge, or passing emergency exits. The vehicle shall be equipped with a manual clutch or drive mechanism that can be manually disengaged in order to move the vehicle manually. Emergency stop buttons shall be installed on the vehicle at clearly visible locations and shall shut off all power to the vehicle at any time and apply the brake.

8. MISCELLANEOUS FEATURES AND AUXILIARY EQUIPMENT

8.1. Guide Path Equipment

The manufacturer shall provide the modems, line drivers, and wire necessary to construct the guide path wire system. The manufacturer shall provide all equipment necessary to mark defined points such as load/unload station, or guide path branch points. This equipment shall be installed by the purchaser using specified installation instructions and procedures supplied in writing by the manufacturer.

8.2. Operating Manuals

The manufacturer shall provide five copies of the operating and maintenance manuals for the vehicles. The manufacturer shall also provide any corrections or updates to the manuals in a timely fashion.

8.3. Drawings

The manufacturer shall provide two (2) sets of all mechanical and electrical drawings pertaining to the vehicle. Any drawing which is proprietary shall be so labeled by the manufacturer.

8.4. Parts and Spare Parts

A listing of all components and parts by part number, description and manufacturer shall be furnished. A complete recommended spare parts package and a list of its contents shall be provided including modular components of the control systems as well as mechanical parts subject to failure and wear.

A package of spare parts and wear parts for at least one year shall be provided with each vehicle.

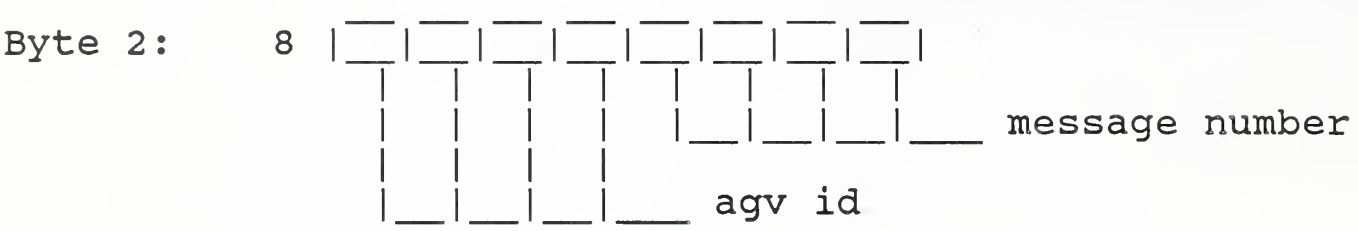
9. INSPECTION AND ACCEPTANCE

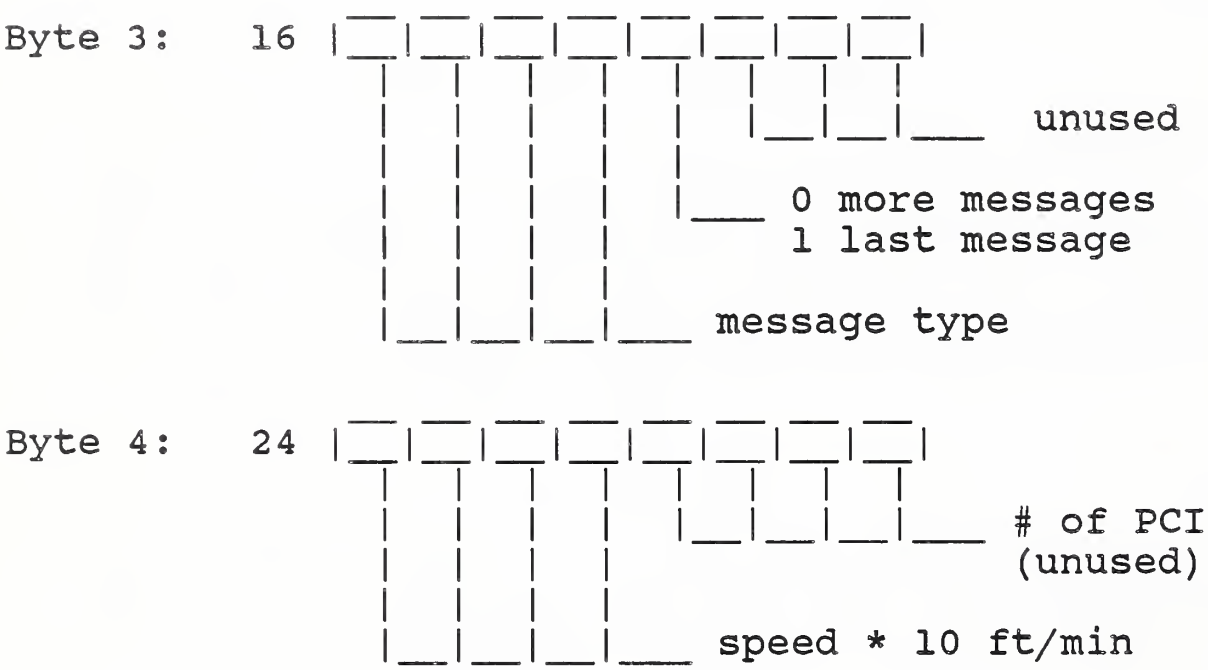
The manufacturer shall inspect and test the vehicle at their facility to prove that the equipment conforms to the requirements of this specification. Final acceptance shall be contingent upon the vehicle meeting this specification and performances after testing at the purchaser's facility.

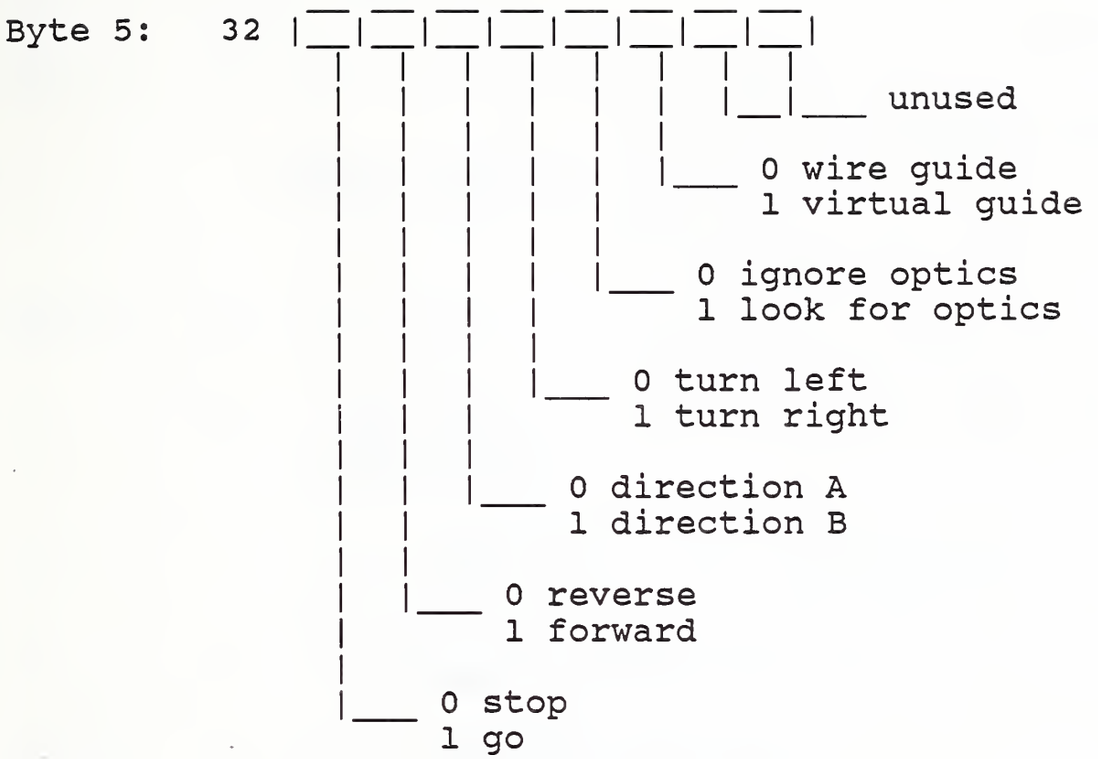
Appendix A: AGV Command and Status Message Formats

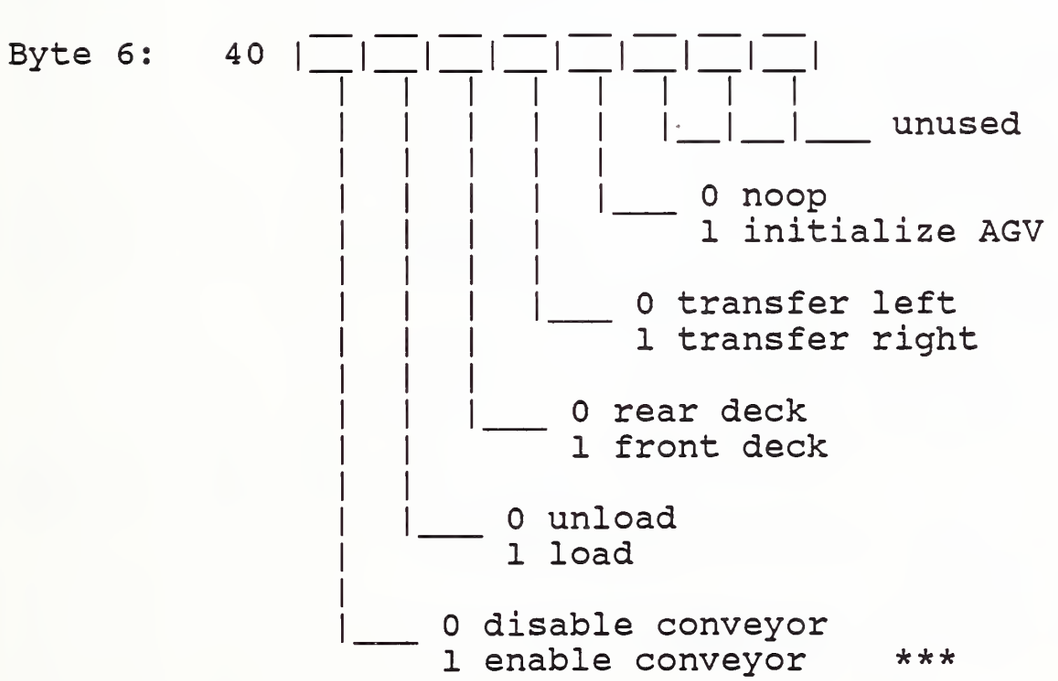
Note: For all messages, Byte 1 contains the value EE hex, and byte 7 is the checksum of bytes 2 through 6.

Type 0 Command Format



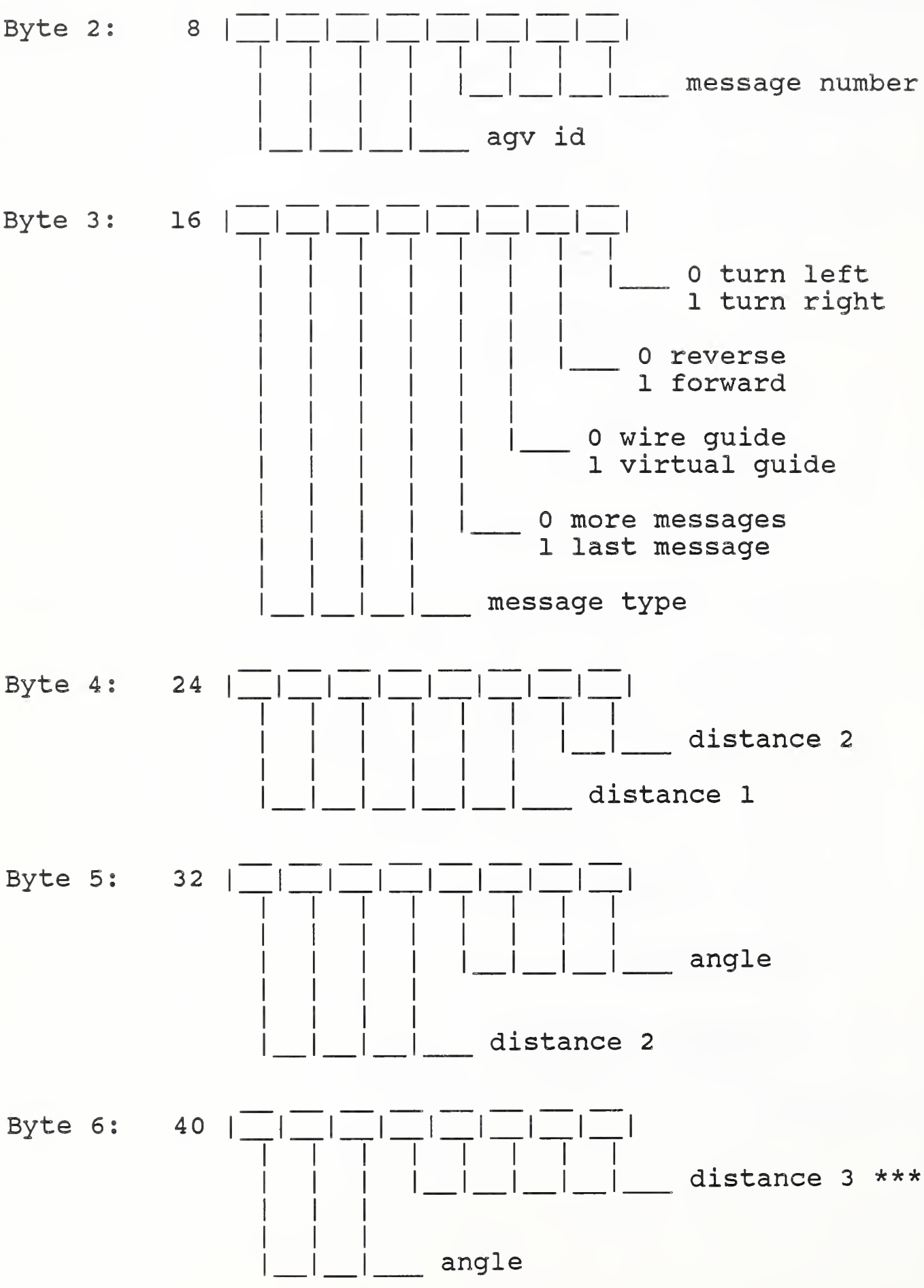






*** Command terminator

Type 1 Command Format



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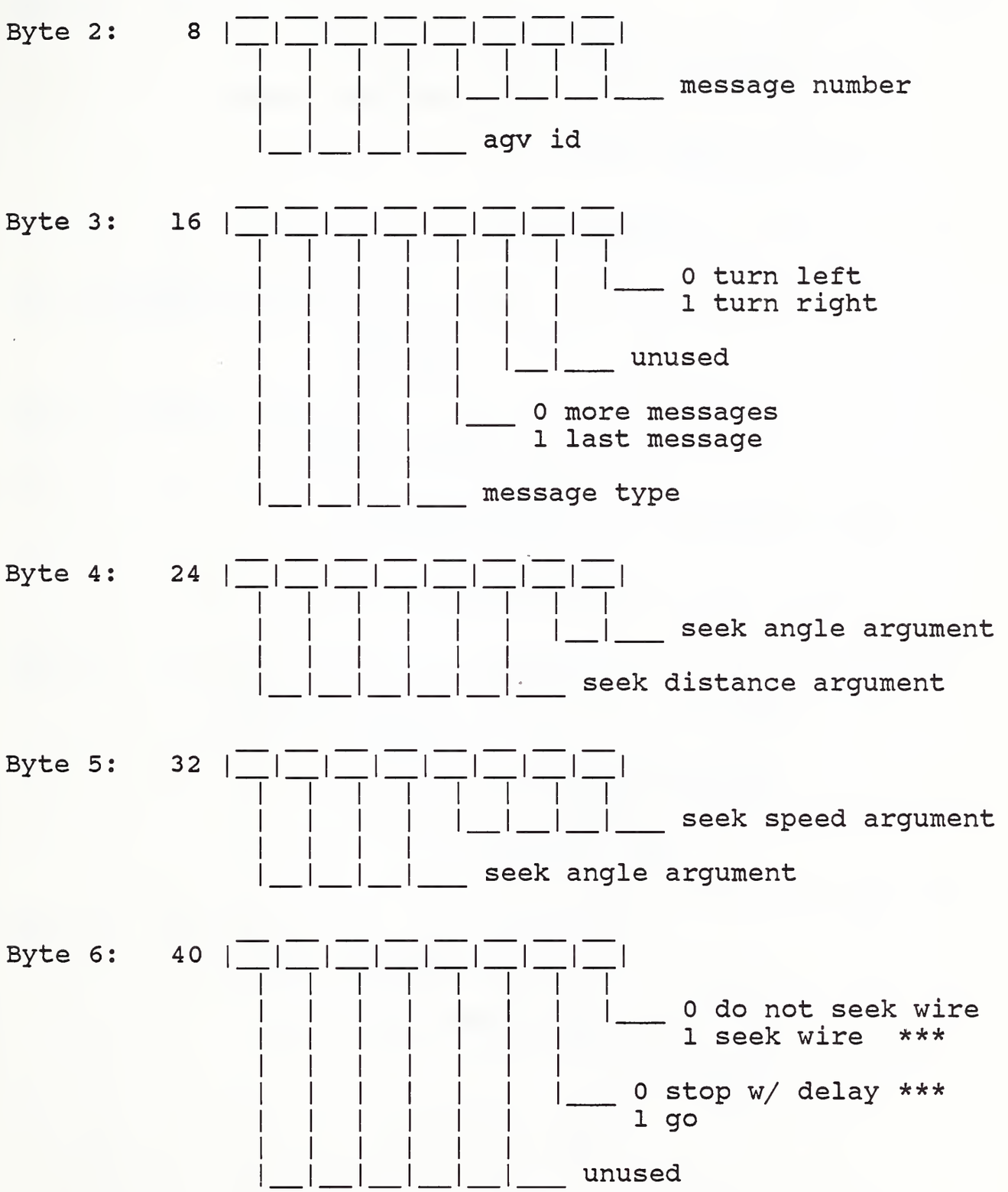

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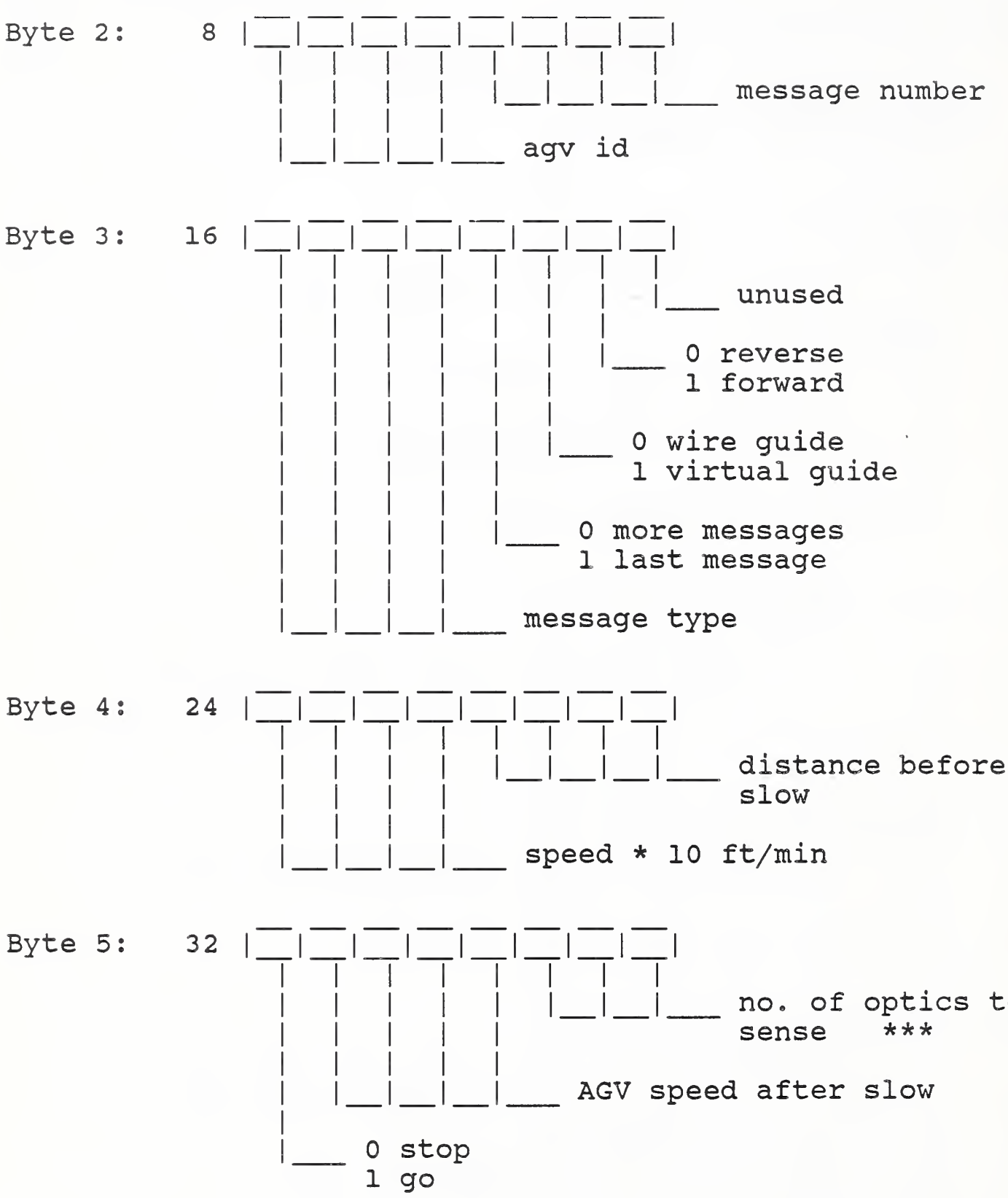
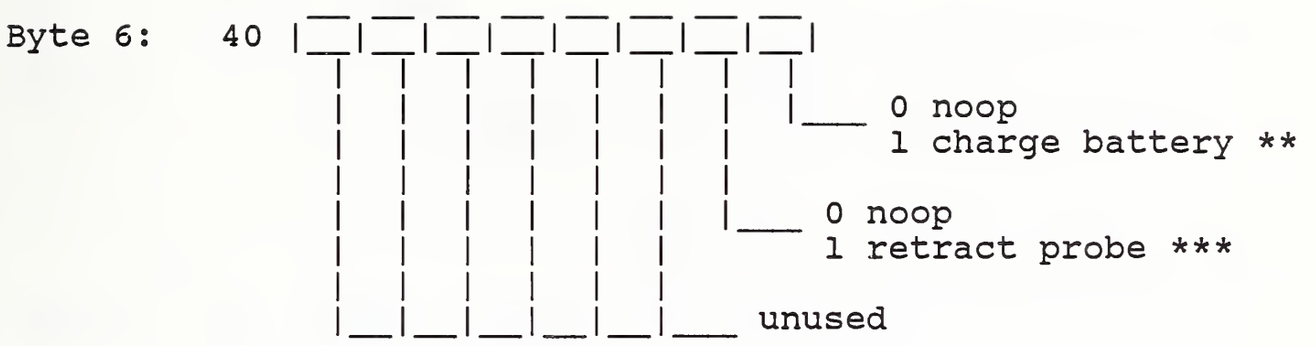
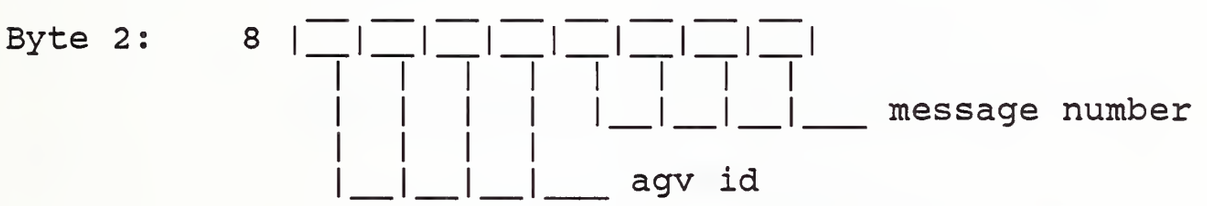
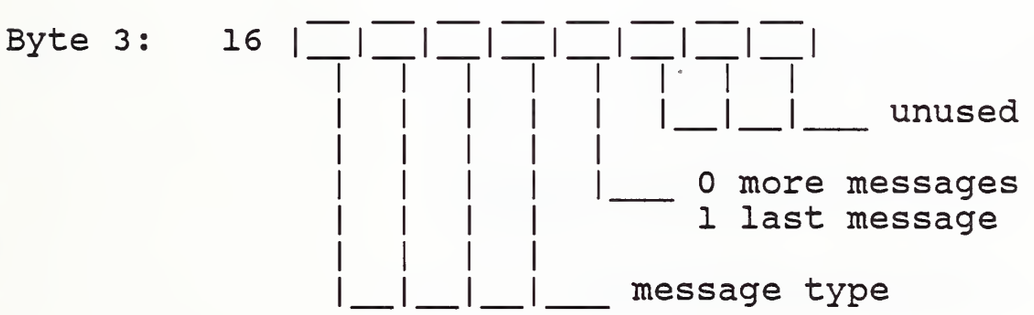


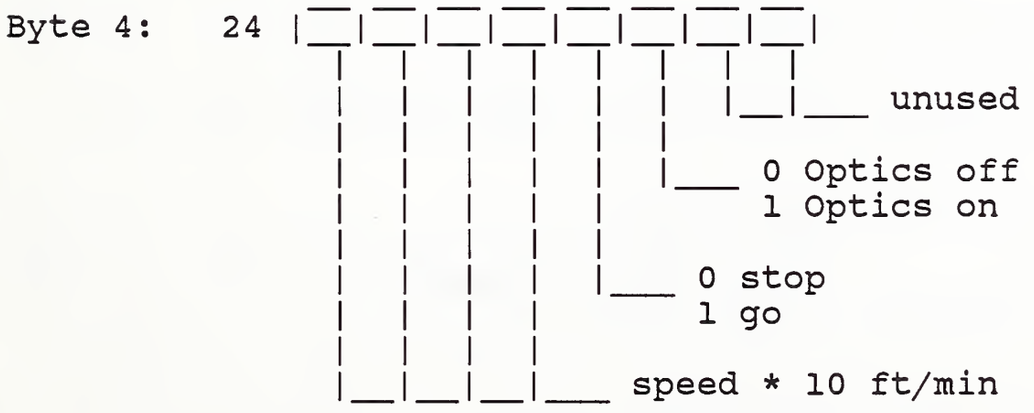


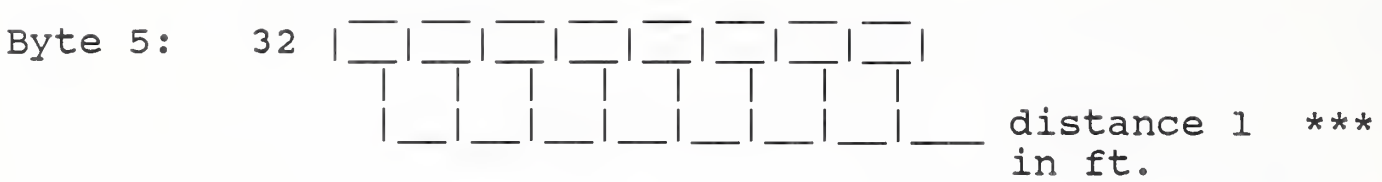
** End command sequence
*** Command terminator

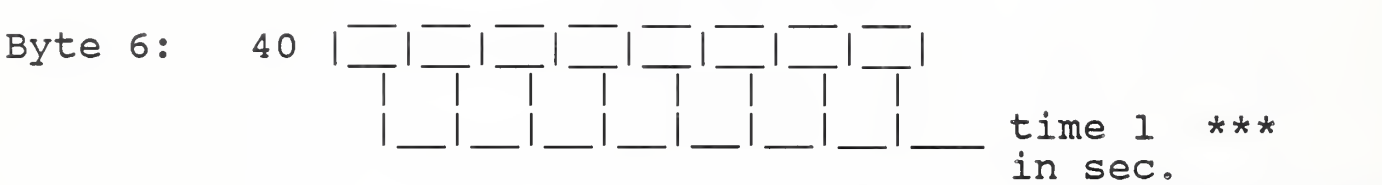
Type 4 Command Format





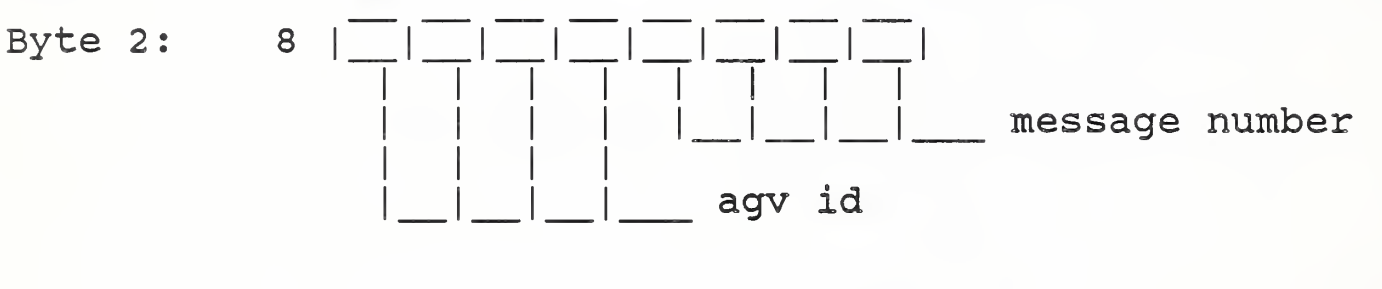


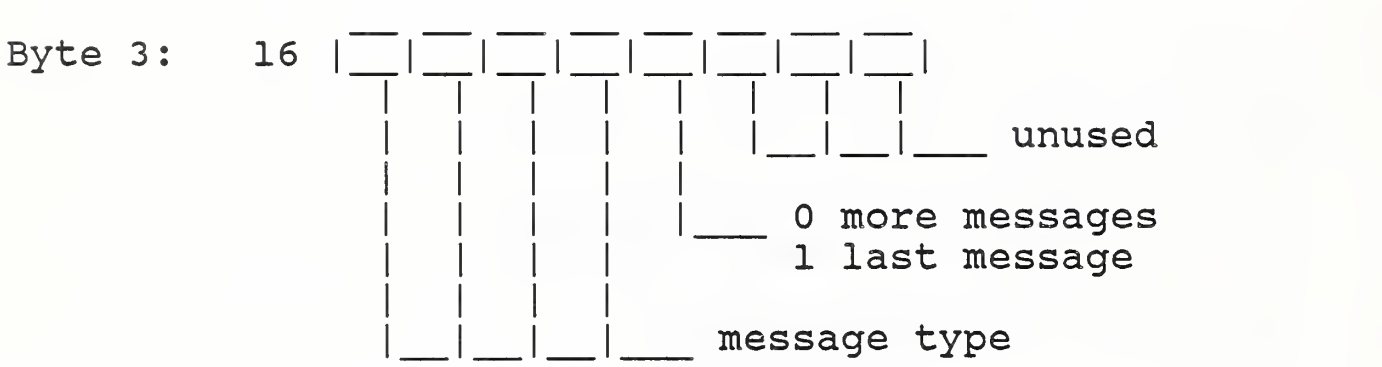


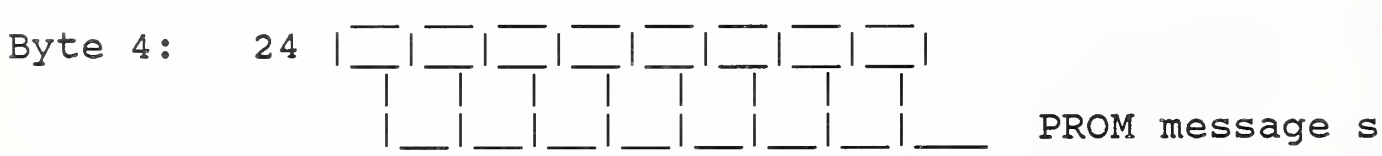


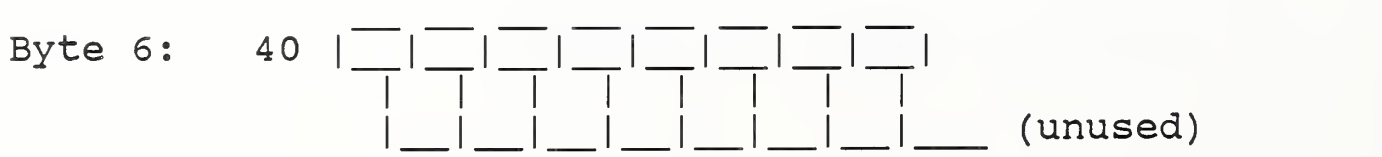
*** Command terminator

Type 5 Command Format









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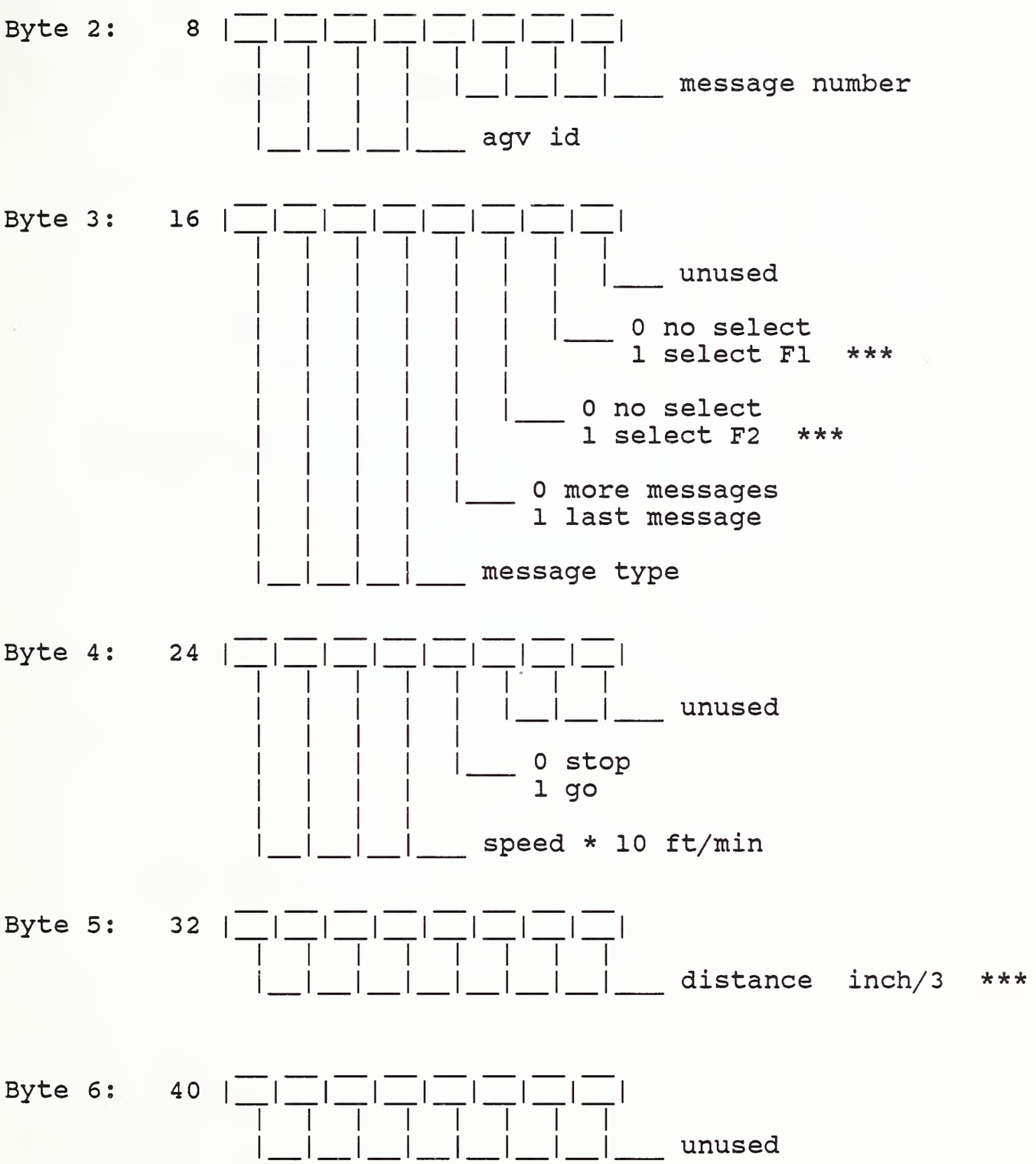
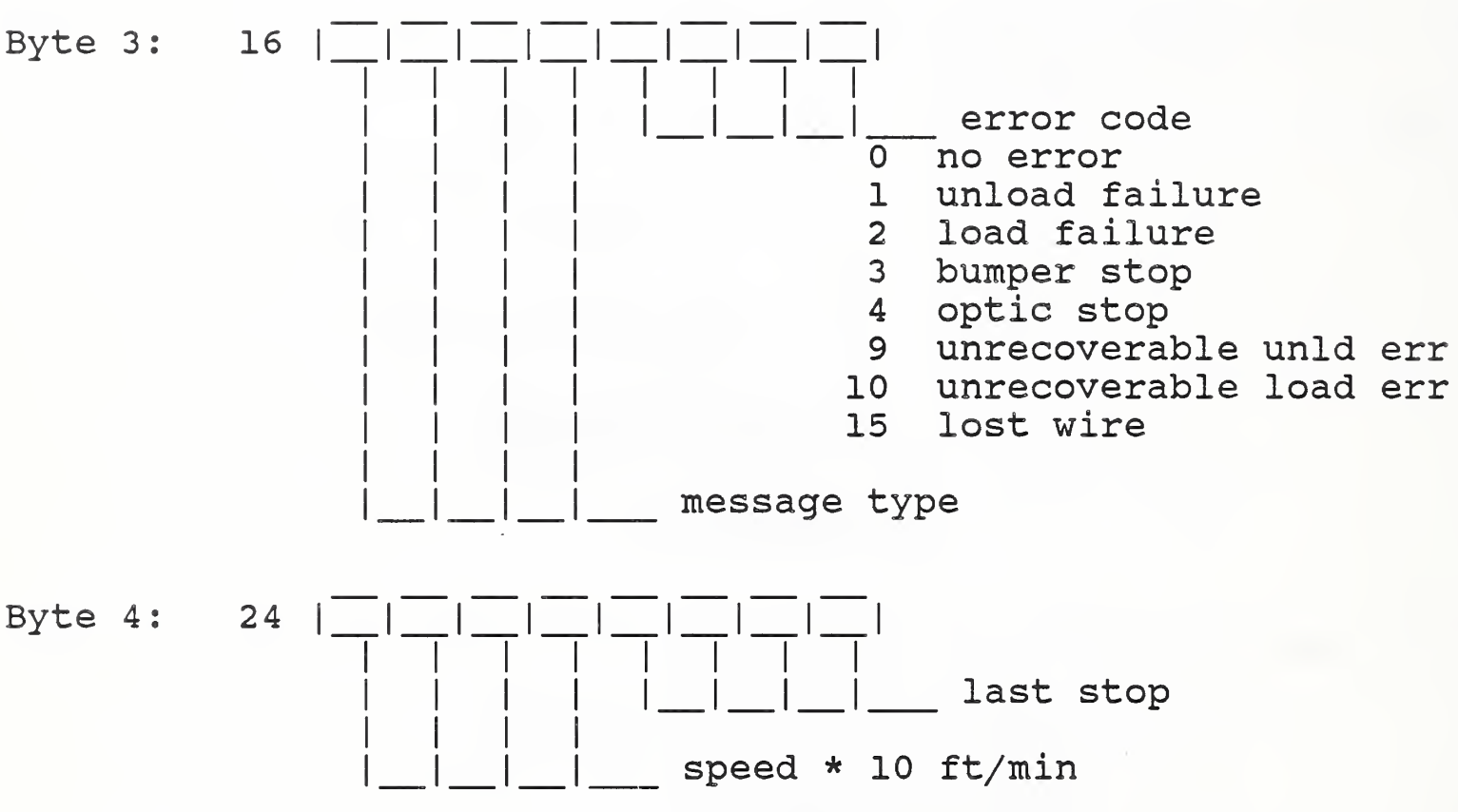
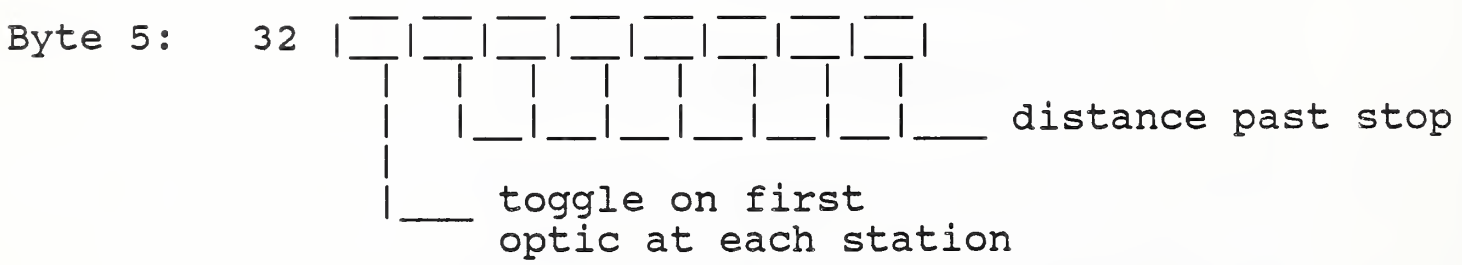


Type 14 Status Format





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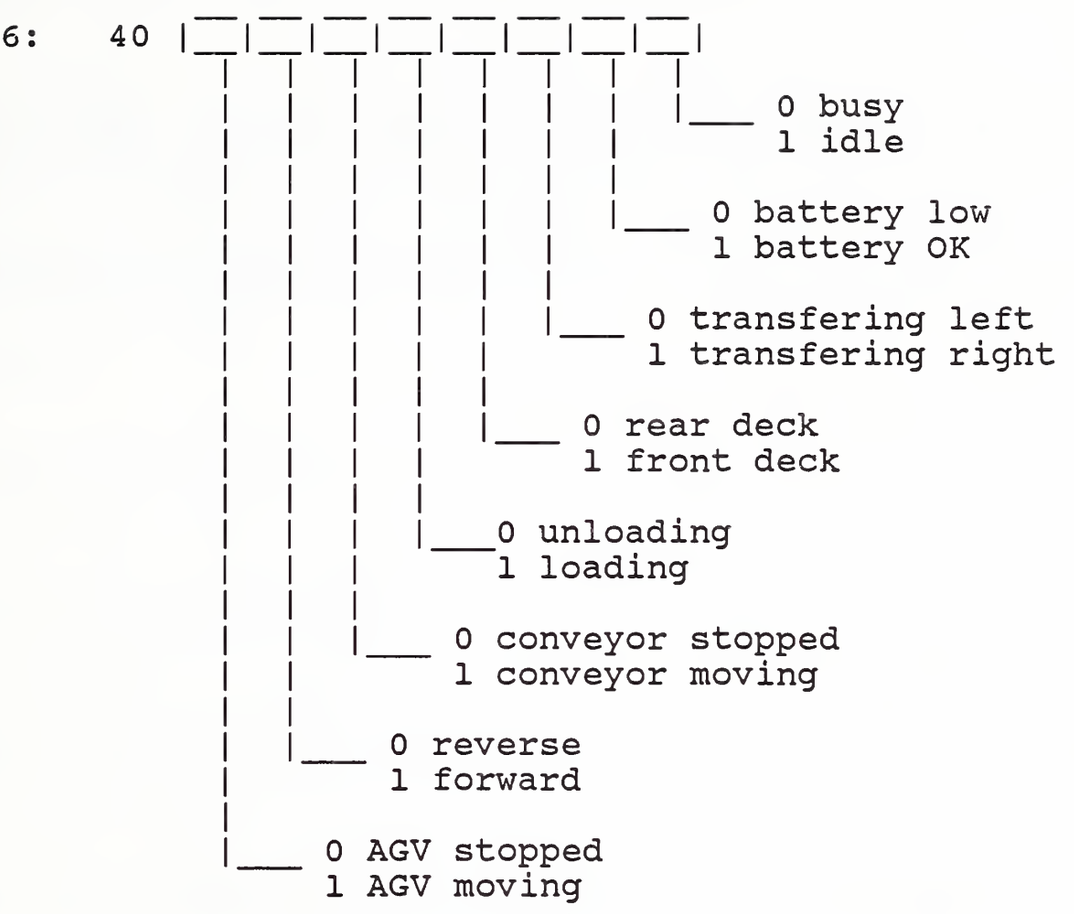
0 busy
1 idle
0 battery low
1 battery OK
0 transfering left
1 transfering right
0 rear deck
1 front deck
0 unloading
1 loading
0 conveyor stopped
1 conveyor moving
0 reverse
1 forward
0 AGV stopped
1 AGV moving

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5. AUTHOR(S)

Carl E. Wenger

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NATIONAL BUREAU OF STANDARDS
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WASHINGTON, D.C. 20234

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8. Type of Report & Period Covered

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS *(Street, City, State, ZIP)*

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)*

The purpose of this document is to provide specifications to be used in the procurement of material handling equipment to be used in an automated facility. The equipment specified includes Automatic Guided Vehicles (AGV) and an Automatic Storage and Retrieval System (ASRS).

12. KEY WORDS *(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)*

AMRF; manufacturing; Material Handling Workstation, specifications

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