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MARTIN MARIETTA

West Valley Transfer Cart Control System Design Description

E. C. Bradley
R. I. Crutcher
J. W. Halliwell
M. S. Hileman
M. R. Moore
R. N. Nodine
F. R. Ruppel
R. I. Vandermolen

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MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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Environmental Restoration and Waste Management Program

WEST VALLEY TRANSFER CART CONTROL SYSTEM DESIGN DESCRIPTION

E. C. Bradley
Robotics & Process Systems Division

R. I. Crutcher
J. W. Halliwell
M. S. Hileman
M. R. Moore
R. N. Nodine
F. R. Ruppel
R. I. Vandermolen
Instrumentation and Controls Division

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Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
managed by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
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ABSTRACT

Detail design of the control system for the West Valley Nuclear Services Vitrification Facility transfer cart has been completed by Oak Ridge National Laboratory. This report documents the requirements and describes the detail design of that equipment and control software. Copies of significant design documents including analysis and testing reports and design drawings are included in the Appendixes.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the contributions of the following people whose efforts are also exhibited in this report. Allen Blalock was the lead engineer for cart control system electronics design and performed radiation testing and prototype hardware testing. Jerry Stapleton was the lead engineer for the control module enclosure and facility antenna mechanical design. Charles Slater performed the shielding analysis for the control module enclosure. The designers responsible for preparing the drawing package include Bob Maples, Karen Cutshaw, Mike Cutshaw, Elaine Cooper, Saundra Shelton, Shirley Shugart, Gene Keith, Doug Bailes, Kevin Farley, Michelle Hollis, and Don Rainey. In addition, Rick Meigs and John Victor, West Valley Nuclear Services, cooperated throughout the effort by providing information on cart design and interface design and by providing guidance and feedback on the control system design as it progressed.

1. INTRODUCTION

The West Valley Demonstration Project is sponsored by the United States Department of Energy (DOE) and is located at the former Nuclear Fuel Services reprocessing plant site at West Valley, New York. The primary objective of the project is to solidify high-level waste (HLW) stored in underground tanks into a form suitable for transportation and disposal. DOE has selected vitrification as the method of solidification and borosilicate glass as the waste form.

The existing HLW was produced from the chemical reprocessing of approximately 640 t of spent nuclear fuels. The waste was discharged to underground storage tanks. These tanks currently hold a total volume of about 2165 m^3 (572,000 gal) of liquid HLW.

After preliminary treatment steps, the liquid HLW will be transferred to the Vitrification Facility. The waste slurry will be continuously fed to the vitrification melter, where the waste and molten glass mixes and homogenizes. After some time, the glass will be poured into disposal canisters. The canisters will cool and be temporarily sealed for external decontamination. The seal will then be removed and replaced with a dust cover. The canister will then be ready for transfer to the former Chemical Process Cell (CPC) for interim storage.

The main purpose of the transfer cart is to transfer the empty canisters into the Vitrification Cell (VC) and filled canisters from the VC to interim storage in the CPC. Other future uses of the transfer cart have also been identified.

The design of the transfer cart has been a joint effort by West Valley Nuclear Services (WVNS) and Oak Ridge National Laboratory (ORNL). Generally, ORNL has been responsible for the design of the transfer cart control system, and WVNS has been responsible for the balance of the transfer cart design. The complete scope of the transfer cart control system design is defined in later sections of this report, which covers the design requirements and design description. In addition, this report documents design verification activities performed by ORNL during completion of the detail design.

2. DESIGN REQUIREMENTS

The design requirements for the transfer cart control system were provided by WVNS via formal communication. These requirements are contained in two documents: (1) West Valley Demonstration Project, Design Criteria, General CTS Component Design Criteria, Doc. No. WVNS-DC-011, revision 4, revision date May 11, 1987, and (2) West Valley Demonstration Project Design Basis, Vitrification Facility Transfer Cart, revision 2, revision date November 26, 1991. Additional requirements specific to the control system design were documented in a formal communication from ORNL to WVNS at the beginning of the design. This section contains a summary of significant design requirements for the transfer cart control system.

2.1 SCOPE

The scope of the transfer cart control system includes all electrical and controls equipment needed for operation of the transfer cart. This includes on-cart controls, on-cart batteries, battery charging system electrical components, control signal transmission equipment, remote antennas, and operator controls.

2.2 FUNCTIONAL REQUIREMENTS

The transfer cart shall be designed to move a load of four filled canisters (10.4 t) plus the cart from the VC to the CPC with adequate reserve capacity. Additional capacity for loads up to 25 t shall be provided to handle vessels and load-test weights. The cart shall be designed to operate on the existing rail design between the VC and the CPC. The size of the cart and all components on the cart shall fit within all the existing design door openings. The cart shall be designed for individual drives for each of the four drive wheels to increase redundancy while decreasing maintenance difficulties. The cart shall be remotely operable from various ex-cell positions using general area remote closed-circuit television (CCTV) and shielded viewing windows. No CCTV cameras or monitors are required in the transfer cart design.

2.3 ELECTRICAL

The cart shall be powered with no trailing umbilicals. (This requirement ultimately means battery power and wireless controls. The cart must operate on the existing rail design, which has no provision for fixed power conductors. Also, because of door discontinuities and radiation levels in existing cells, new construction to add power and signal transmission in the floor is not feasible.)

The cart shall be capable of having the battery pack recharged without removing it from the cart. The charging location will be a permanent installation in the Equipment Decontamination Room (EDR). The connection and disconnection shall be automatic as the transfer cart passes through the charging location. The batteries should also be capable of being charged off the cart at a separate location.

The cart battery pack shall be designed and wired so that it can be removed and reinstalled remotely. The container for the battery pack should be sealed and decontaminable. The battery pack shall be designed so that it can be removed from its container and disposed of as nonradioactive waste.

2.4 INSTRUMENTATION AND CONTROLS

The cart on-board electrical controls shall be designed in an enclosure so that they can be removed and reinstalled remotely. All on-board controls shall be modularized as much as possible and be capable of remote removal as a unit using only the overhead crane and impact wrench. Two auxiliary remotely controlled power outlets shall be provided to allow use of dc powered tools from the transfer cart.

Battery voltage shall be monitored over the remote control data transmission system. The battery pack shall be instrumented to remotely indicate the state of battery charging and discharging. Motor current shall also be monitored over the remote control data transmission system for all four drive motors. The cart shall have capability to detect over/under current draw for the drive motors and be remotely reset if required.

Two control stations shall be provided to operate the cart. One station shall be located on the north wall of the VC, and an additional station shall be provided at the north CPC viewing window. Interlocks shall be provided to use one station at a time and not permit the cart to be operated from both stations at the same time. However, one control function shall be operable from either control station. Both control stations shall have an emergency kill control which shall be operable from either station at all times during operation.

Basic controls shall provide for controlled cart movement in either direction. All cart control switches shall be spring-returned to off. When the spring-return control switch is released and power is shut off to the drive wheels, the cart should stop within 6 in. at maximum speed with a full canister load. The operation of the cart shall be interlocked so that the cart cannot be energized while any of the following door control systems are energized; operation of the following doors shall also be interlocked so that they cannot be energized while the transfer cart is energized.

- Transfer tunnel to VC door
- Transfer tunnel to EDR doors
- EDR/CPC shield door

A logic function shall be provided which will initiate an audible warning when the transfer cart is being driven toward any door that does not have a fully open limit switch indication. The cart control system shall be designed to accommodate the existing penetrations for antenna placement.

2.5 OPERATIONAL REQUIREMENTS

The transfer cart operates in the VC, transfer tunnel, EDR, and CPC, as shown in Fig. 2.1. A rack with the capacity to carry four canisters will normally be installed on the frame of the cart. When it is necessary to move equipment other than the canisters, a new fixture(s) will be required in lieu of the rack. The charging location shall be located in EDR, where viewing of the cart is possible using the EDR crane-mounted CCTV. The cart will remain at the charging location until

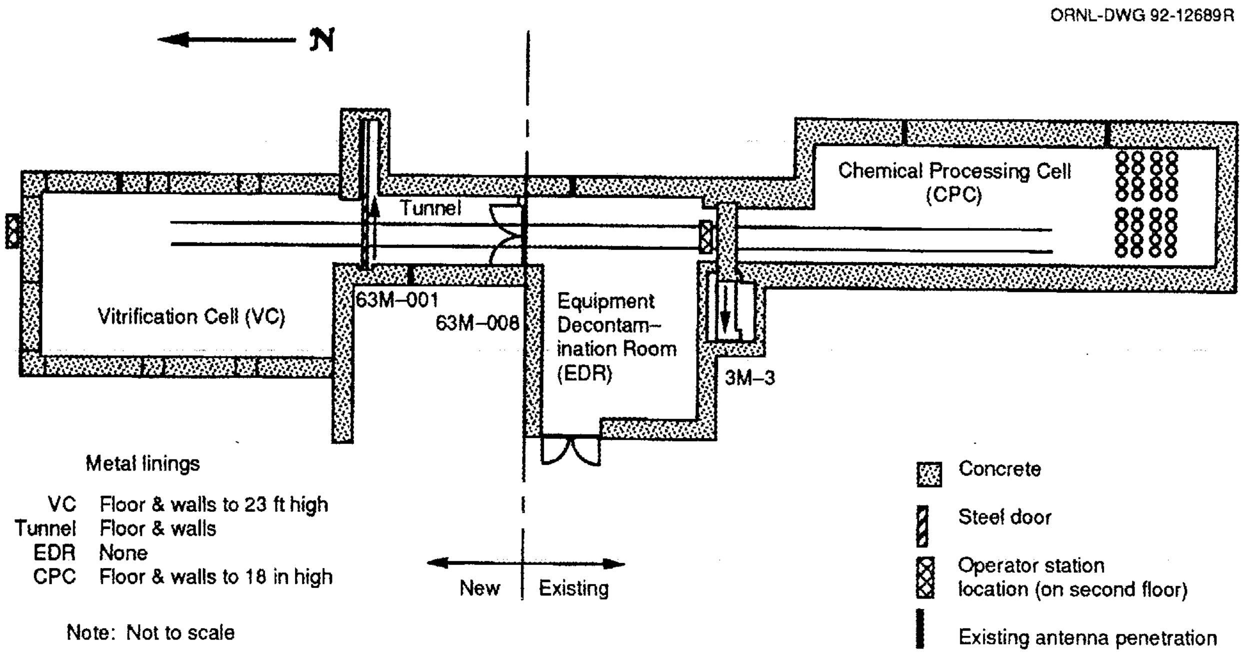

Fig. 2.1. West Valley Demonstration Project transfer cart cell plan.

called upon for service. The empty canister loading station should be, if possible, at the same location in the EDR.

Normal operation of the transfer cart system is to move empty canisters into the VC and move full canisters from the VC to the CPC. The steps required to do this are summarized as follows:

1. When the canisters are ready for transfer, the cart will be taken from the EDR through the transfer tunnel to the VC. The operator will open the doors to the transfer tunnel, move the cart into the transfer tunnel, and then close the doors. The operator will then open the door to the VC and move the cart to the north end of the rails in the VC. The operator will then close the VC door.

2. The operator will load four canisters into the rack from an interim storage rack in the VC pit using the VC crane. This operation could take up to 2 h.

3. The operator will open the VC door to the transfer tunnel and move the cart to the transfer tunnel and stop it. The operator will close the VC door and then open the transfer tunnel doors to the EDR. The operator will then move the cart to the EDR, stop, and close the transfer tunnel doors. The operator will then open the EDR/CPC shield door and move the transfer cart into the CPC. Once the cart is in the CPC, the EDR/CPC shield door will be closed. During these steps the operator(s) could move about to the various viewing positions, as necessary, or the CCTV system could be utilized.

4. The operator will unload the canisters using the CPC crane. The operator will then move the cart back to the charging location in EDR and close all shield doors.

When moving new empty canisters into the cell, the operator will load four empty canisters onto the cart in the EDR. After loading, the cart will be moved through the transfer tunnel into the VC as described previously. After being unloaded, the cart will be moved again to the charging location in the EDR.

2.6 ENVIRONMENT

The design radiation field is 10,000 rad/h in the cell in close proximity of the canisters and diminishes to approximately 0.010 rad/h at the charging location in the EDR. Temperature will range from 20 to 120°F, and relative humidity will range from 10 to 90%. Nitric acid vapor content in the air will be up to 100 ppm during off-normal conditions.

2.7 MATERIALS

The metals for all in-cell equipment shall adequately resist a decontamination process. Stainless steels are preferred. No uncontained organic materials shall be used on the cart. Wires and electrical components shall resist the radiation exposure or be shielded to provide a life of 5 years in the Vitrification Facility.

2.8 MAINTENANCE AND REMOTE MAINTENANCE

The system shall be designed to operate for a minimum of 5 years without maintenance. All materials used on the cart shall be designed for 5 years of operation without maintenance in a radiation environment resulting from the integrated dose. The total accumulated dose goal is 10^7 rad.

3. SIGNAL TRANSMISSION ASSESSMENT

The method of communicating control signals to the cart is the most critical aspect of the overall design of the cart control system. Because of metal linings on the facility cell walls, radio frequency (rf) signal nulling will result from multipath reflections of the transmitted rf signal. Multipath reflections cause amplitude degradation of the signal. The Instrumentation and Controls division of ORNL has worked with similar systems in the past. During system conceptual design, an assessment of available options was undertaken and the best choice was selected for detail design. This section summarizes the assessment.

3.1 OPTIONS

Various options for the transmission system were examined in order to choose the best all-around system. The options included direct links, leaky coax systems, directive rf systems, and omni-directional rf links. The omni-directional transmission system was selected as the best system. The following sections discuss each of the systems that were examined and their respective advantages and disadvantages.

3.1.1 Umbilical Cord

The umbilical cord (or tether line) consists of an attached cable between a controlling station and the cart. The umbilical cord would avoid all radiated signal problems such as multipath and interference from other sources. However, the umbilical cord was not chosen because, in this application, there will be doors that are closed both behind and ahead of the cart. Umbilical cords had been used on earlier versions of the transfer cart, and there were frequent problems with the doors cutting the umbilical. Also, the requirements document for the project states that this option should not be used.

3.1.2 Leaky Coaxial Cable

The leaky coaxial arrangement consists of a series of cables, placed parallel to the tracks, that radiate energy through their shields. The receiving system on the cart obtains the desired information from this radiated energy. The leaky coaxial arrangement would be less susceptible to problems such as multipath and interference from other sources than would antenna-to-antenna systems. But, according to previous surveys, remote maintainability is a problem since the coaxial line must be segmented into removable lengths (of about 3 m), which greatly adds to the number of electrical/mechanical connections that must be maintained. Also, since part of the Vitrification Facility includes an existing radioactively contaminated cell, new construction is not feasible. Remote installation of the cable would be required and would be extremely difficult.

3.1.3 Directive Antenna Link

A directive antenna link consists of both receiving and transmitting antennas that radiate energy in a relatively narrow beamwidth. This arrangement requires that the antennas be aligned in order to establish a transmission path. A directive antenna link with a beamwidth of only a few degrees can be used to greatly reduce the problem of multipath reflections. The transmission systems that operate at frequencies above about 1 GHz allow a greater information bandwidth. At these frequencies, parabolic dishes, which are inherently directive antennas, are normally used. A directive antenna link requires equipment such as parabolic dishes and steering mechanisms. The dishes would take up more space on the cart than would antennas such as monopoles, especially at frequencies of about 10 GHz. The antenna systems would require steering because a fixed directive link is not allowed because of the interfering doors. This steering would require much more complex hardware, cost, and maintenance. If even higher frequencies such as 90 to 100 GHz are selected to reduce size, the hardware would cost an estimated $60,000 more than a 10-GHz system.

3.1.4 Omni-directional Antenna Link

The omni-directional antenna link, which has been selected for this project, consists of receiving and transmitting antennas that radiate energy equally in all directions. The omni-directional antennas are normally quarter-wave monopoles or half-wave dipoles which are very simple both mechanically and electrically. Since they radiate equally in all directions there is no need to steer the antennas. At a frequency of about 1 GHz (which would be sufficient for the needed information bandwidth of this project), the antennas are about 6 in. long or less. The antennas and associated hardware are standard equipment and are relatively inexpensive. The omni-directional antennas combined with the metal-lined walls, however, produce many multipath reflections, which degradate the received signal. These types of antennas are normally only used at frequencies of a few gigahertz or less; thus, they limit the information bandwidth that can be used.

3.2 LITERATURE SURVEY

The literature that discusses multipath reflections, especially in metal-lined cells, has been researched in order to give a more thorough basis for omni-directional transmission. The report written by Burgess et al.[1] discusses the allowable bandwidth for a given carrier frequency in a metal-lined cell. The theory deals with a metal-lined tunnel similar to the transfer tunnel through which the West Valley cart will travel. The equations show the different modes that propagate in this highly reflective environment. Although there is significant distortion because only relatively narrow bandwidths are needed for the required data rates, the distortion is not a problem. Transmission in the larger cells where the cart is farther from the reflecting surfaces will not be as critical in nature, although there will still be attenuation due to multipath reflections.

3.3 TESTS

Tests were performed to show that a bandwidth of about 1 MHz on a carrier of 1 GHz would be feasible inside a structure such as the transfer tunnel, since its metal floors and walls make it the worst case area for multipath degradation.

3.3.1 Test Procedure

The tests performed transmitted a carrier frequency of about 1 GHz in a completely metal-lined room that is 4.58 m long × 3.65 × m wide 2.46 m high (i.e., all dimensions are much greater than a wavelength). Both directive and omni-directional transmitting antennas were used with a monopole receiving antenna. Both frequency modulation (FM) and amplitude modulation (AM) were used, and the output of a receiver was examined to note the distortion of the transmitted information as well as the signal strength. The transmitting and receiving antennas were placed in various combinations of locations both near the walls and in the middle of the room. The antennas were also placed so that there was not a line-of-sight transmission path.

An impulse generator was used to generate the broad spectrum, and a spectrum analyzer was used to show the frequency response of the antenna-to-antenna link in the metal-lined room. The impulse generator produces energy of an equal amplitude across a large span of frequencies. The received frequency spectrum from a radiated impulse shows the characteristic frequency response of the transmission system.

3.3.2 Test Results

The tests indicate that FM transmission of about 1-MHz bandwidth is feasible for a metal-lined room of dimensions much greater than one wavelength at about 1 GHz. Also, it was noted that when the antennas were placed 30 cm or less from the wall, nulls would occur over various portions of the frequency band but never over more than one-third of the desired spectrum. Thus, using a combination of wideband FM as well as a diversity receiving system (explained later) should be adequate for data transmission.

3.4 DESCRIPTION OF PROPOSED SYSTEM

3.4.1 Antenna System

As shown in Fig. 3.1, the basic system is based on omni-directional transmission. The stationary antenna will be a dipole, and the mobile antenna system will consist of two dipole antennas mounted on the cart. Although there will be many reflections from the stainless steel cell walls, the system can be designed to overcome this problem. The reflections are called multipaths and cause amplitude degradation of the signal. The multipath problem is overcome by employing one or more of the following: (1) diversity receiving in which more than one antenna is used, (2) filtering that minimizes the data transmission error rate, and (3) wideband FM that spreads the information over a larger bandwidth.[2]

The carrier frequency will be 915 MHz, which will allow the use of standard hardware and antennas that are practical in size. (Dipoles would be 16.4 cm long, and monopoles would be half the length of the dipoles.) The carrier frequency will be in the industrial, scientific, and medical assigned range of 902 to 928 MHz.

3.4.2 Communication System

The communication system will use a bandwidth of about 1 MHz with FM. This relatively narrow bandwidth allows the use of omni-directional transmission in a reflective environment. This bandwidth should be sufficient to accommodate a 1- to 2-kHz data rate, some encoding for error correction, and some wideband spreading of the transmitted energy to better utilize the transmission channel in a reflective environment. FM will be used instead of AM since the

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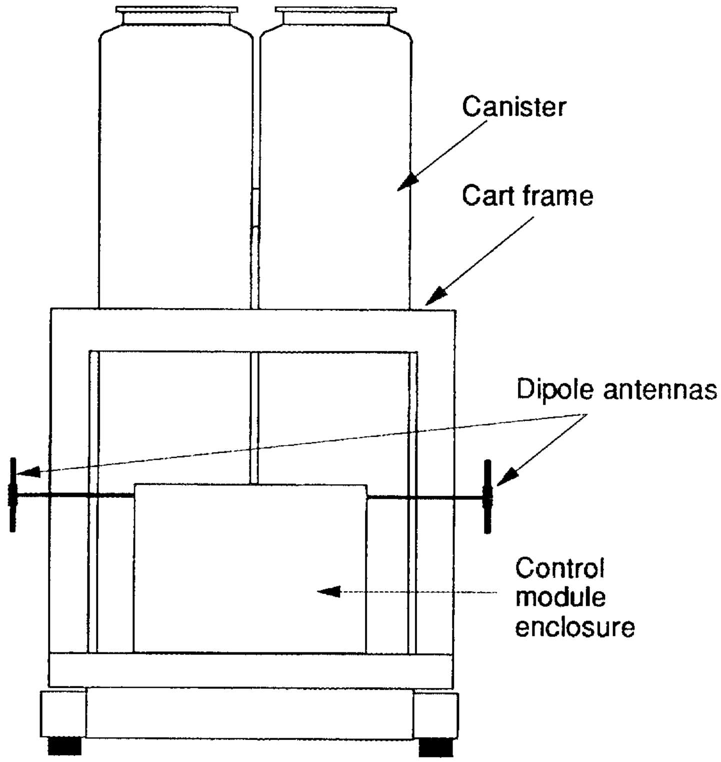

Fig. 3.1. Mounting of dipole antennas on cart.

reflections will produce an effective AM distortion of the signal to which FM detection will be less susceptible. Also, FM is less susceptible to other noise sources such as welding equipment.

As mentioned before, there will be two dipole antennas on the transfer cart. These antennas will be placed at the extremities of the cart envelope so that line-of-sight transmission will be maintained as much as possible. The redundancy is two-fold in that it allows the receivers to pick either antenna based on which one is receiving the stronger signal and it provides a backup in case one antenna becomes inoperative. The signals will be compared, and the stronger will be used for obtaining the information.

4. SYSTEM OVERVIEW

The communications system introduced in the previous section, although a major component, is part of a larger overall system. Figure 4.1 shows the major equipment in this design. Major equipment items include the transfer cart control module enclosure, the battery charger, the north and south operator's pendants, the engineer's console, and facility antennas. Facility systems are discussed in Sect. 5; the communications system for both the facility and the cart, in Sect. 6; the cart electronics system, in Sect. 7; mechanical features of the cart control module enclosure, in Sect. 8; and software of both facility and cart systems, in Sect. 9.

The design is a combination of off-the-shelf components and specially designed equipment. Early on in the design we recognized that a radiation-tolerant, battery-powered communications system did not exist commercially and therefore must be specially designed. Special interfacing cart electronics were also designed. However, a commercially available embedded controller was identified and radiation tested for use on the cart. On the facility side, the other side of the communications system to match the cart side was specially designed. A unique requirement (the ability to switch charging polarity of the cart batteries) led to a specially designed battery polarity interface circuit. The control pendants, although based on a commercially available hand-held pendant, have a specially designed circuit board and faceplate decal. The programmable logic controller (PLC), the engineer's console computer, and the battery charger are all commercially available.

Drawing Q-6340-001 provides an overview of system functionality, as expressed in Instrument Society of America symbology.[3] The tag names on the drawing show how individual points are referred to at the engineer's console. All design drawings can be found in Appendix E.

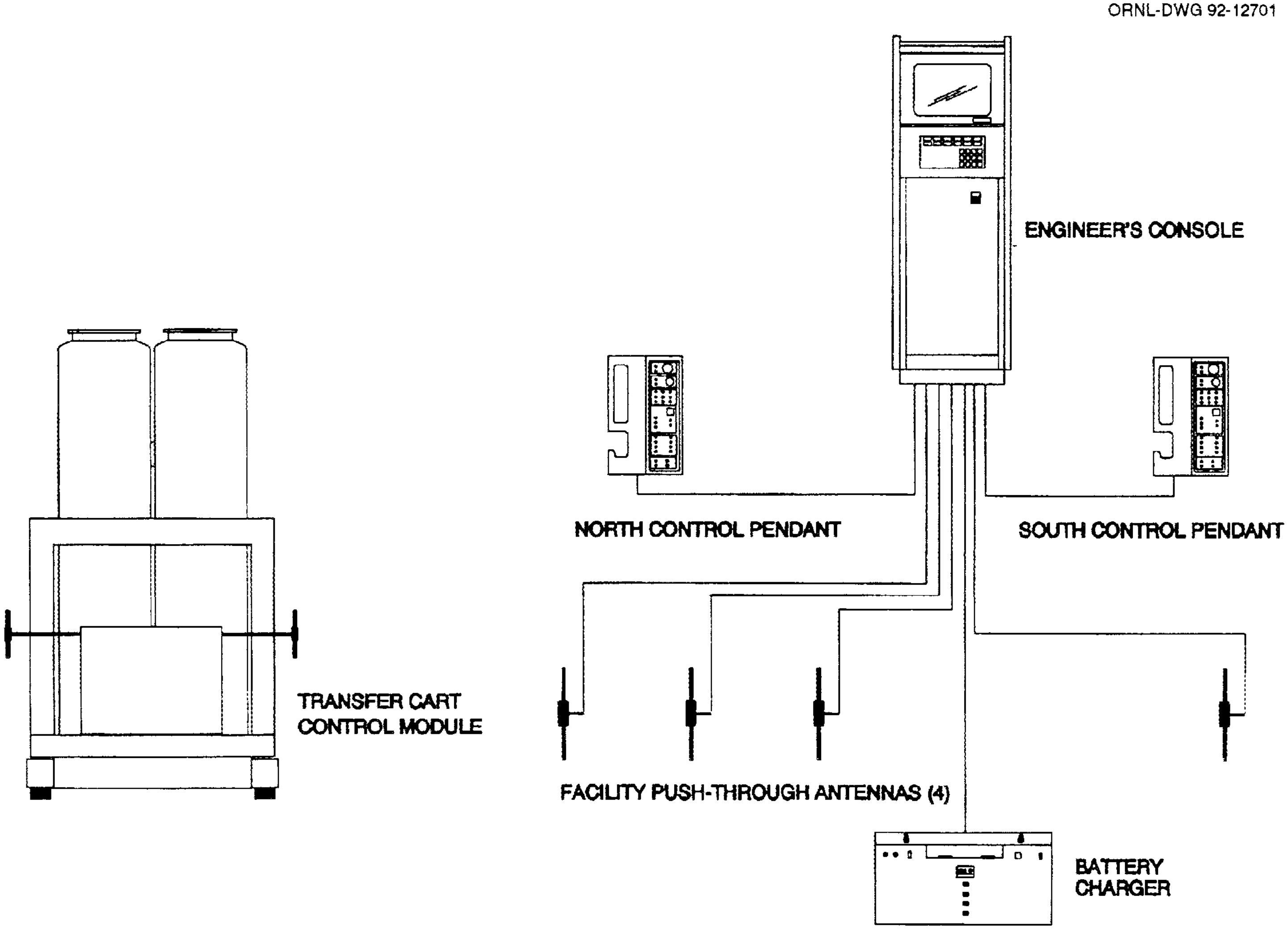

Fig. 4.1. Overview of transfer cart control system.

5. FACILITY SYSTEMS

Facility systems include the control pendants, the engineer's console (which houses the engineer's console computer, the PLC, communications equipment, and ancillary equipment), the battery charger and its interface, and cell door limit switch interfaces. The facility communications system is described in Sect. 6. The descriptions of the remaining systems are included in this section.

5.1 CONTROL PENDANTS

Operation of the cart will be controlled by one of two hand-held control pendants (see Fig. 5.1). One pendant will be located near the north viewing window of the VC, and the other will be located near the north viewing window of the CPC. The functionality of both are the same. The control pendants consist of switches, light-emitting diodes (LEDs), and an audible alarm. The switches and LEDs are divided among functional blocks on the front face of the pendant. The audible alarm is mounted on the top side of the pendant. The push-button switches are used for operator command inputs, and the LEDs are for visual status indication. An oversized emergency stop button is provided for stopping the cart and battery charger from either pendant. A three-position, return-to-center rocker switch is provided for cart drive. ORNL will provide a metal-photo decal which will be placed on the face of the Rose Enclosures model 2950 hand-held pendant. Drawings Q-6340-120 through Q-6340-123 document the pendant design.

The cart control system operates in two basic modes: (1) battery charging and (2) cart operation. In the battery charging mode, the cart is disabled completely; sending commands to the cart will have no effect, and the cart will not report status of any of its normally monitored variables. In the cart operation mode, the battery cannot be charged unless it is located at the charging shoes (described in Sect. 5.4). A description of the cart operation using the control pendants is included in Appendix F.

A printed circuit board (see Dwg. Q-6340-123) provides a backup for mounting LEDs and push-button switches. Other components mounted on the board include resistors in series with the switches to provide debounce filtering of the switch contacts (see Dwg. Q-6340-122). Filtering is provided through the resistor and capacitance of the multiconductor cable. After installation, additional capacitors could be added, if necessary, at the engineer's console side of the cable for additional filtering. The board also houses two capacitors in parallel with the audible alarm to reduce high-frequency noise from appearing on the multiconductor cable that connects the pendant with the engineer's console. The filtering is used to reduce the possibility of spurious noise appearing as an input to the PLC. Finally, compression terminal blocks are mounted on the circuit board to terminate the multiconductor cable.

Internal components not mounted on the printed circuit board include the audible alarm, the emergency stop switch, and the station select key switch. A metal-photo decal will be provided by ORNL to insert in the front recess of the pendant. In addition to showing the functionality of the pendant, the decal will be used as a guide for drilling the LEDs and switch holes.

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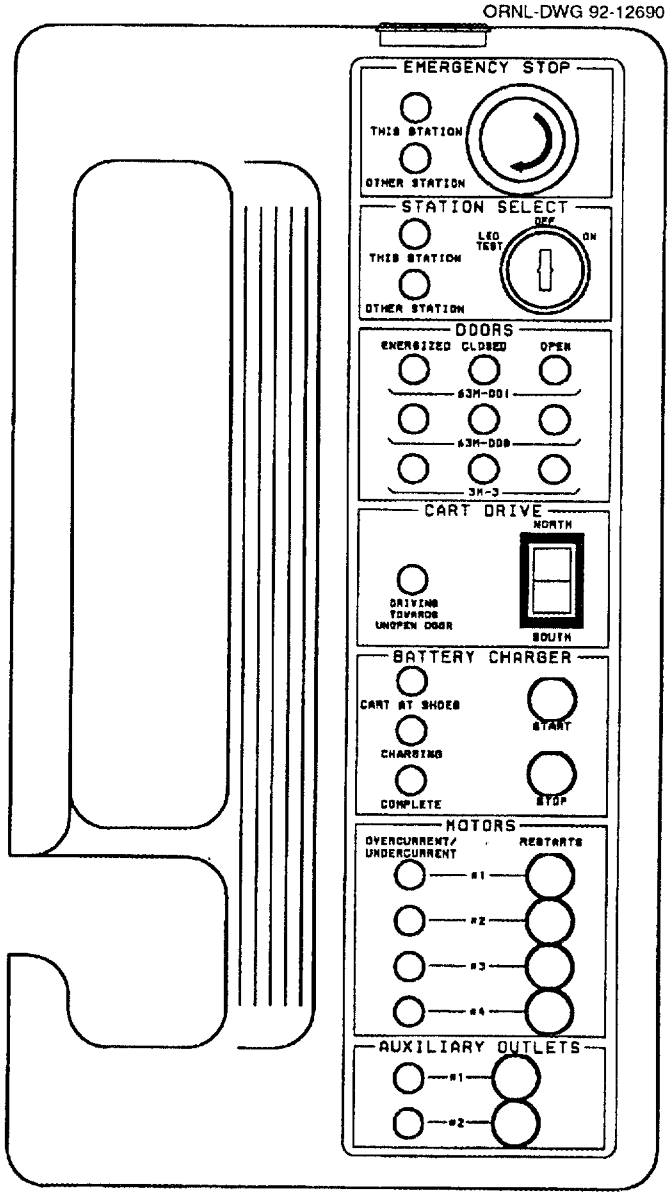

Fig. 5.1. Operator's control pendant.

When not in use the pendant can be hung from its junction box, as shown in Dwg. Q-6340-125. A 50-conductor cable will interconnect the control pendant to the PLC, which is mounted in the engineer's console, as described in the next section. Typical wiring of the pendants is shown in Dwg. Q-6340-126.

5.2 PLC

The PLC selected for this application is an Allen-Bradley PLC 5/15. Because of previous experience with Allen-Bradley at the West Valley site, West Valley personnel requested that Allen-Bradley be used as much as possible for control hardware. In the Allen-Bradley family, the PLC 5/15 model provides the lowest price per functionality ratio for this application. Besides the typical digital interfacing, this application is somewhat unique for a PLC in that it requires interfacing to the battery charger through an RS-232 link. The Allen-Bradley 5/40 model features direct interfacing to RS-232, but its much higher cost is prohibitive. Through the present architecture, the 5/15 interfaces directly to the Prolog communications controller (which is described in Sect. 6.8) using the Prolog 7514 interface card. The PLC uses the Prolog RS-232 interface to communicate to the battery charger. An early decision to base the rf boards on the STD bus also precluded using the Allen-Bradley PLC for the communications controller. Furthermore, high-speed communications tasks must be coordinated closely by the communications controller and may not have been possible in the PLC ladder logic because of the complicated functionality (see Sect. 6.8).

The PLC is the heart of the control system through which all control activities are coordinated. It will interface to both control pendants through digital input/output (I/O) modules, to the communications controller over the PLC's remote I/O link and a Prolog 7514 Allen-Bradley interface card in the communications controller, and to the engineer's console computer over the Data Highway Plus link and a Sutherland-Shultz 5136 SD interface card in the engineer's console computer. The PLC also interfaces to the cart orientation key switch, to the facility doors, and to the enable/disable input of the battery charger interface through the PLC's digital I/O.

The PLC will physically reside in the engineer's console in a 19-in. rack. Rack modules include the PLC 5/15 (1785-LT) processor with a 1785-MJ EEPROM, four 1771-OBD digital output modules, three 1771-IBD digital input modules, and a 1771-P4S power supply. The EEPROM module provides retention of the operating program and current values of variables in the event of a power loss.

Special ladder-logic software which will run on the PLC is described in Sect. 9. A listing of the logic should be referred to for further details of the ladder logic. The engineer's console computer will be used to modify, download, and monitor ladder logic running on the PLC.

5.3 ENGINEER'S CONSOLE COMPUTER

The engineer's console computer resides in the engineer's console assembly, as shown in Fig. 5.2. The engineer's console computer will be the engineer's window into the control system. Through the computer, an engineer can monitor cart activity and data, whether current or historical, and operational status of the control pendants, doors, and battery charger. A commercial man/machine interface software package, Intouch, has been used to develop the engineer/control system interface. In addition, the computer can modify and download ladder logic in the PLC. It can also modify, compile, and download programs to the Prolog communications controller. A switch in the back of the engineer's console will allow the battery charger to interface directly to the engineer's console computer through one of its serial communications ports. In this mode, configuration parameters of the battery charger can be interrogated and changed and it would be possible to operate the battery charger in this mode even in situations when the control pendant, the PLC, or the communications controller had failed. The engineer's console computer will be capable of trending any of its inputs and providing alarm outputs based on the input value. It will also be capable of performing mathematical and logical operations on the cart data.

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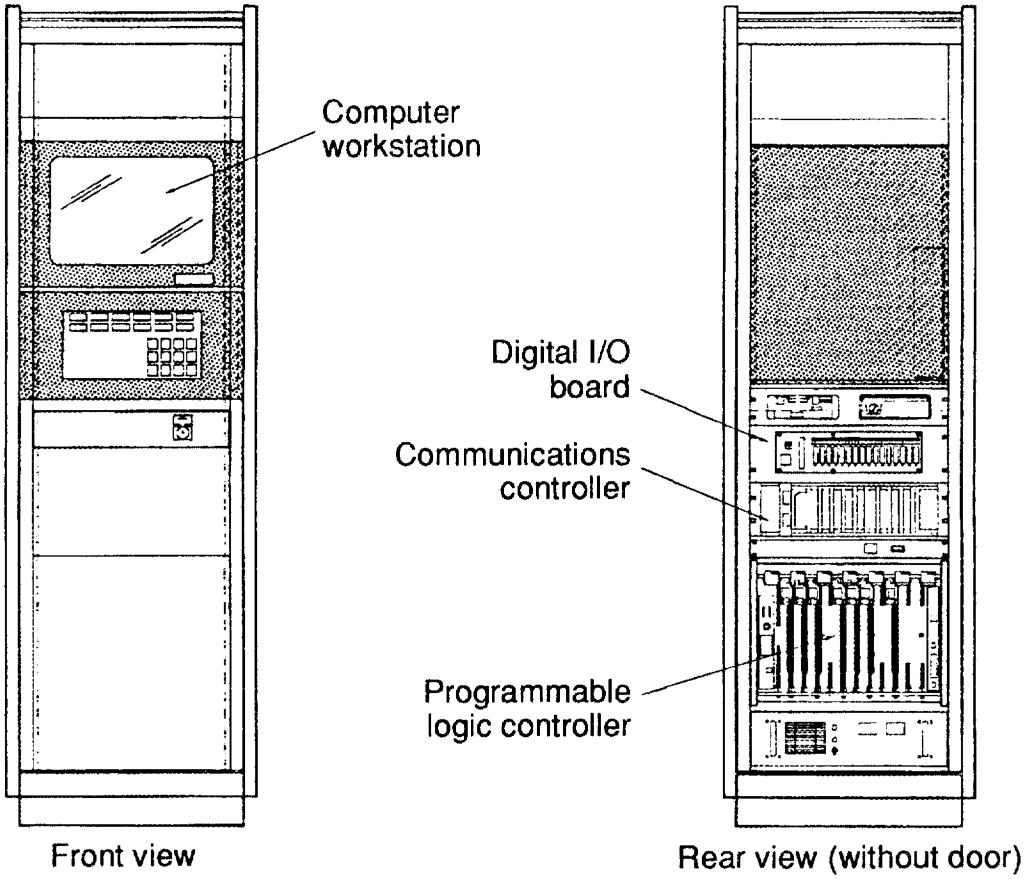

Fig. 5.2. Engineer's console.

The computer will be using the Windows operating environment. The Intouch man/machine interface software operates exclusively on this platform. Furthermore, the terminal program supplied with Windows can be used to communicate with the communications controller or the battery charger while Intouch is logging data from the cart. Teledenken ladder logic software was used to develop the prototype system at ORNL. Because the Teledenken software does not operate under the Windows platform, a Windows-based ladder logic development software package should be used to take advantage of the Windows operating environment. ICOM is a vendor of Windows-based ladder logic development software for the Allen-Bradley PLC; however, it is not clear whether ICOM supports the Sutherland-Schultz 5136 SD interface card. Both the man-machine interface software (Intouch) and the ladder logic software use this interface card. Furthermore, the ladder logic software would have to be converted to use the ladder logic developed for the prototype system, and both systems would have to be able to convert to or from the Allen-Bradley 6200 series standard. Because none of these conversions have been attempted, the conservative choice would be to use Teledenken for the final system and run it as a nonWindows application on the engineer's console computer.

A Nematron model IWS-5386DX is specified for use as the engineer's console computer; however, we suggest that the latest technology processor at the time of procurement be bought, as technology in this field changes rapidly. The Nematron is an industrially rugged computer with a shock-mounted disk drive, NEMA 12 sealing, and optically isolated communications ports. It has a 19-in. VGA color monitor and an 80386DX 25-MHz processor. The unit should be bought with the highest capacity hard disk drive at the time of procurement, at least 8 MB of random access memory (RAM), an 80387 math coprocessor, and a 3.5-in. diskette drive. Because the unit will be operating under the Windows environment, a trackball is recommended as a pointing device. However, as presently configured, no trackball was specified for the system. All of the Windows features should still be accessible through keystrokes; if, however, a trackball is desired, options should be investigated for interfacing a trackball to the unit. A bus interface should be used since two of the computer's serial ports are being used already.

The computer is equipped with a front-panel function keyboard for routine operations. More intense diagnostic or maintenance operations can be performed by folding down the panel, which exposes a full-function QWERTY-style keyboard.

The computer interfaces to the PLC with a Sutherland-Schultz 5136 SD card located in one of the computer's expansion slots. Both Intouch and the ladder logic development software (Teledenken for the prototype) use this card for hardware interfacing. If a different ladder logic development software package is bought, it must be compatible with the Sutherland-Schultz card.

See Dwgs. Q-6340-102 through Q-6340-106 for details of the engineer's console assembly. See Sect. 9 for a description of the engineer's console man/machine interface software.

5.4 BATTERY CHARGER

The battery charger specified and tested for this project is an Exide ERBC 24/30. It is a unique battery charger in that it features a microprocessor for interfacing to the control system. Start and stop commands are issued to the battery charger, and status variables for battery charging current, voltage, and temperature are returned to the control system. The Prolog communications controller is the primary interface between the control system and the battery charger. However, a polarity interface circuit is also located between the battery charger and the batteries. The primary purpose of this circuit is to reverse charging polarity when the cart has been reversed on the tracks. Another key feature of the interface circuit is that it provides an emergency stop function that is available both locally and through the control system. See Sect. 5.5 for a description of this circuit. A second identical battery charger will be provided to maintain a spare battery in a float charge condition.

Connection of the battery charger to the cart occurs through a set of spring-loaded shoes designed by WVNS. The charge shoes will be located on the floor between the cart track rails and are designed to interface with a set of charging plates mounted on the bottom of the cart control module enclosure. A description of the circuitry connected to the cart-mounted charging plates is given in Sect. 7.3. A limit switch, to be provided by WVNS, will indicate when the cart is in the charge location. A typical charging sequence is described in Appendix F.

5.5 BATTERY CHARGER INTERFACE CIRCUIT

As described in the previous section, the battery charger interface circuit provides two major functions. First, the interface allows the polarity of the cart charging shoes to be reversed, and second, the interface provides an emergency stop function physically located near the battery charger. The charger interface is constructed in a Hoffman continuous hinge clamp cover box which will be mounted above the EDR near the battery charger. The interface uses solid state switches to control charge shoe polarity and to interrupt the charge circuit in the event of an emergency stop. Two control inputs, polarity and on/off control, from the engineer's console pass through a terminal block mounted in the interface box to drive circuits located on the battery charger polarity manager printed circuit board. The drive circuits control the state (on/off) of four independent high-current solid state switches and four independent low-current switches, as shown in Fig. 5.3. The drive circuits also provide for proper switch sequencing and an "all switches off" emergency stop condition. The high-current switches control the actual charge output lines from the battery charger, and the low-current switches control the charger voltage sense lines.

Assembly and wiring diagrams for the battery charger interface are given in Dwgs. Q-6340-131 and Q-6340-132 respectively. A schematic of the battery charger polarity manager circuit board is given in Dwg. Q-6340-135. The battery charger polarity manager printed circuit board layout and parts list are given in Dwgs. Q-6340-136 and Q-6340-137 respectively.

5.6 DOOR INTERFACES

Each door will be monitored for three conditions: (1) door open, (2) door closed, and (3) door energized. Dry switch contacts must be provided by WVNS to interface to the I/O system which will power each circuit with a nominal 24-V power supply. In addition, the PLC is capable of disabling all doors from operating when the cart is operating. Three outputs are provided from the PLC, which must be interfaced to the door actuation circuit using interposing relays designed by West Valley.

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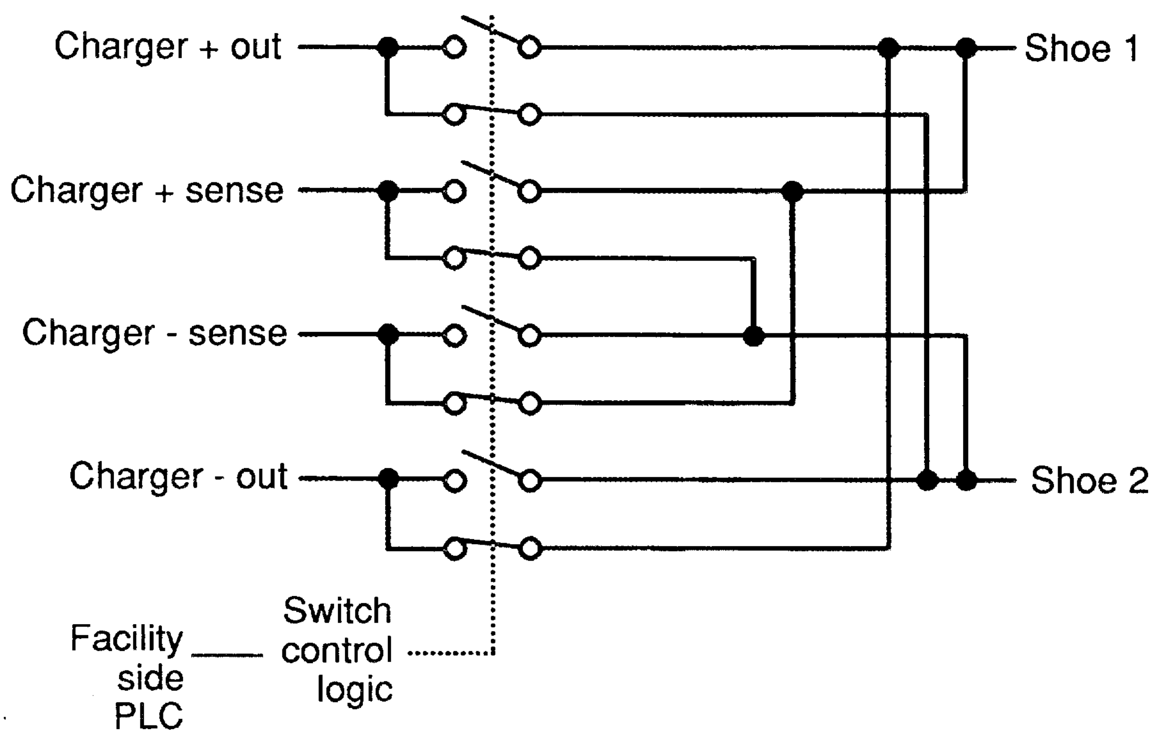

Fig. 5.3. Charger polarity control switching.

6. COMMUNICATIONS SYSTEM DESIGN

The communications system will provide a wireless, bidirectional, digital data link between the facility and the transfer cart. Because cell walls and floors contain a significant amount of metal lining, signal multipath will occur. The communications system is designed to overcome problems associated with multipath reflections such as signal nulling at node cancellation locations. The system employs two cart antennas so that if one antenna is positioned in a null, the other antenna will be selected in the receive mode. Additionally, wide-band frequency modulation is used to avoid problems associated with narrow-band signal attenuation. This technique allows a portion of the spectrum to be lost to multipath while retaining much of the signal energy. Further multipath immunity is introduced through multiple facility antennas required for the cart to travel among four cells, each of which may be isolated by doors. While the cart is being driven, the door between the originating cell and the destination cell will be open and two facility antennas will be available to communicate with the cart. The system will automatically select the facility antenna with the stronger received signal. Additionally, a manual override allows an engineer at the engineer's console to inhibit any cell transmitter that generates multipath while the connecting doorway is open. Rationale for the selection of the design is presented in Sect. 3.

A major concern in the hardware design of the cart communications system is that equipment located on the cart must withstand a total integrated radiation dose of 10^7 rad. The communications system was designed around components of known radiation tolerances based on previous radiation testing experiments and operating experience gained from other designs.

The following sections give general descriptions of the various circuits used in the facility and cart transceiver systems. Refer to Dwgs. Q-6340-150 and Q-6340-250 for block diagrams of the facility communications system and the cart communications system respectively. Block diagrams of each circuit are included in this section, and the detailed schematic diagrams are provided in Appendix E.

6.1 FACILITY TRANSMITTER CIRCUIT

The facility transmitter circuit is responsible for converting the digital data from the communications controller computer to an FM rf carrier and distributing the rf to the transmit amplifiers at each of the four cell locations. A block diagram of the facility transmitter is shown in Fig. 6.1. The circuit acquires a digital message packet from the communications biphase encoder/decoder board. The biphase signal is processed through a modulation amplifier that allows adjustment of both the rf carrier frequency and the FM signal deviation. The modulation amplifier drives a voltage-controlled oscillator (VCO) that has a carrier frequency of 915 MHz in the industrial, scientific, and medical (ISM) band. Deviation of the carrier is adjusted to ±10 MHz around the carrier.

The VCO output is buffered and amplified before being split into four identical signal channels. Each channel is amplified to a level of approximately +7 dBm (decibels referenced to 1 mW) to drive a coaxial cable to the facility transmit/receive board at each of the four cell

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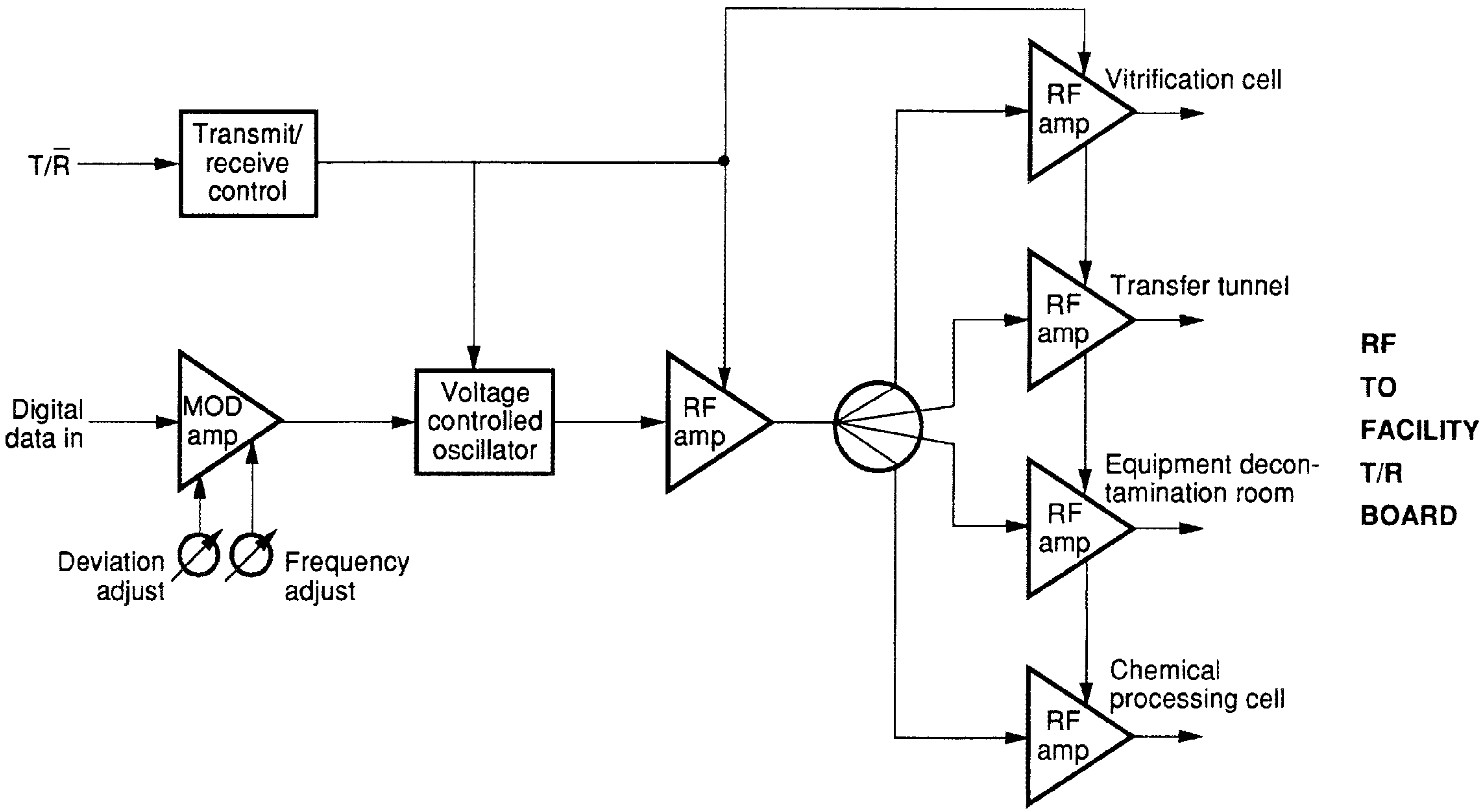

Fig. 6.1. Facility transmitter.

locations. A transmit/receive control signal is supplied by the facility communications microprocessor. This control signal activates the VCO and rf amplifiers during the transmit mode and deactivates them during the receive mode. A schematic diagram for the facility transmitter is given in Dwg. Q-6340-170. The circuit board is housed in a card cage in the engineer's console.

6.2 FACILITY TRANSMIT/RECEIVE CIRCUIT

The facility transmit/receive circuit provides the power amplifier drive to the antenna during the transmit mode and functions as the receiver preamplifier in the receive mode. Figure 6.2 shows a functional block diagram of the circuit. A control signal from the communications controller through the Opto 22 digital I/O panel (described in Sect. 6.8) determines whether the circuit functions in the transmit mode or in the receive mode. This control signal is brought to the cell interface as a 24-V signal on a twisted-shielded pair line and is buffered through an optical isolator for noise and transient immunity. The optical isolator drives a control circuit that powers the transmit amplifier during the transmit mode and powers the receive amplifiers during the receive mode. The fail-safe condition for loss of control places the system in the receive mode. The system is also placed in the receive mode during an emergency stop condition to eliminate the possibility of transmitting drive commands to the cart in the emergency stop mode.

In the transmit mode, the facility cell interface is supplied with a 915-MHz FM signal from the facility transmitter board. The rf signal is amplified through a power amplifier and applied to an rf circulator that routes the output to the cell antenna. The facility transmitter supplies approximately 100 mW of rf power to the antenna but is capable of driving higher levels if required.

During the receive mode, rf energy from the cart transmitter is received by the facility antenna and is applied to the circulator. The circulator routes the signal through an rf switch to a low-noise amplifier circuit. The signal is further boosted through a driver amplifier (a total amplification of 40 dB) that supplies the signal through a coaxial cable to the facility antenna switch in the engineer's console.

Electronics for the facility transmit/receive circuit consist of both a printed circuit board and connectorized rf components. The optical isolator, local power supply regulators, and power switching transistors are located on the circuit board. The rf transmit power amplifier, circulator, rf switch, and receive amplifiers are connectorized modules interconnected by SMA coaxial cables. Power and control for each of these modules is provided from the printed circuit board.

Identical transmit/receive modules will be located on the opposite side of each cell wall from their respective cell antennas. Antennas will be located in the VC, the tunnel, the EDR, and the CPC. Each module connects to the communications controller microprocessor in the engineer's console through a 24-V power cable, a control cable, a transmit coaxial cable, and a receive coaxial cable. The four modules are normally operated together in either the transmit or receive modes. The communications microprocessor, on command from an engineer at the engineer's console computer, can inhibit the transmit command to any cell, allowing a transmitter to be taken off line should communications problems occur due to multipath from two antennas when the cart is in the doorway between two cells.

The schematic diagram for the facility transmit/receive circuit is shown in Dwg. Q-6340-175. Drawing Q-6340-151 provides the assembly and parts placement for the printed circuit board and connectorized components of the circuit.

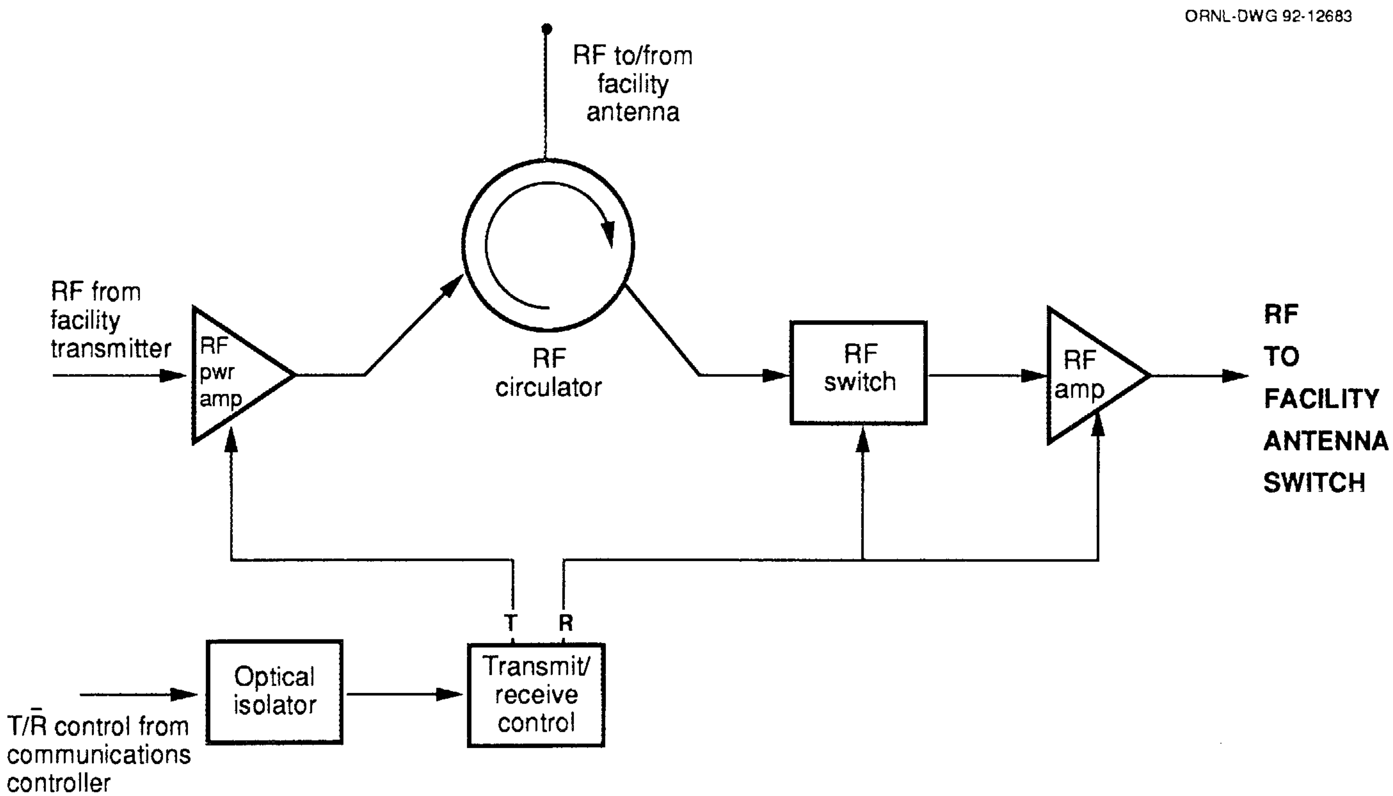

Fig. 6.2. Facility transmit/receive circuit.

6.3 FACILITY ANTENNA SWITCH CIRCUIT

The facility antenna switch circuit determines the strongest of the four rf receive signals from the cells. The board then passes this signal to the facility receiver board. A block diagram of the facility antenna switch circuit is shown in Fig. 6.3.

The rf inputs to the board come from each of the facility transmit/receive circuits over a length of coaxial cable. Radio frequency circuitry on the board is identical for each of the four signal paths. Tracing the signal through one of the paths, the board first filters the rf input with a bandpass of 902 to 928 MHz to remove out-of-band signals and interference. The signal is split with one path routed to an rf switch and the other to an rf amplifier. The amplified signal is processed through an rf amplitude detector that provides a voltage output proportional to the rf power level.

The output of each detector is buffered and compared to the level of the other three channels through a matrix of voltage comparators. The state of each comparator is processed through digital control logic to activate the appropriate electronic rf switches to route the strongest signal to the facility receiver. The control logic allows voting among all inputs, not just among adjacent cell antennas. Therefore, proper receive antenna selection is possible when operating in a degraded mode with one facility antenna or transmit/receive module inoperative.

The control logic performs an additional function that is not obvious from the block diagram. The amplitudes from the rf detectors are constantly changing, and the comparators switch to indicate the highest level signal. The control logic must inhibit the rf switches from changing during the transmission of a data packet if digital errors are to be avoided. The inhibit function is implemented by clocking a latch from the rising edge of the first carrier signal that occurs after the local transmitter shuts off. In operation, a logic signal resets the latch when the local system is switched into the receive mode. The level from each rf detector is compared against a threshold that is set above normal background noise. When the cart transmitter turns on, the detector output on the facility antenna switch exceeds the preset threshold and the status of the antenna-to-antenna comparators is locked into the system. The rf switches activate the antenna that receives the strongest signal at the beginning of the transmission. The switches stay in this position until the cart transmission has ended, avoiding the switching of antennas during the middle of a data packet. If the active antenna drops into a signal null, the system will switch to a stronger antenna at the beginning of the next receive cycle.

A schematic diagram for the facility antenna switch circuit is given in Dwg. Q-6340-180. The number of parts dictated that the circuit be implemented on two printed circuit boards. The rf circuits, level detectors, buffers, and rf switches are found on board Dwg. Q-6340-181A, and the comparators, voting logic, and inhibit circuits are on board Dwg. Q-6340-181B. Both circuit boards are housed in a card cage in the engineer's console.

6.4 FACILITY AND CART RECEIVER CIRCUITS

The rf receiver circuit converts the 915-MHz FM signal to a baseband representation of the biphase digital data signal. The same circuit design is used for both the facility and the cart receivers. Figure 6.4 shows a block diagram of the receiver.

The receiver board follows the antenna control board in both the facility and cart systems. The 915-MHz rf signal feeds into an automatic gain control (AGC) block that maintains an optimum signal level for the receiver even though the rf fluctuates due to both multipath and distance between transmitting and receiving antennas. The AGC consists of an electronic attenuator followed by an rf amplifier that provides 20 dB of dynamic range control. The attenuator and amplifier stages are then repeated, bringing the total AGC range to 40 dB. The output of the second rf amplifier is split and sampled by an rf amplitude detector that provides a voltage level

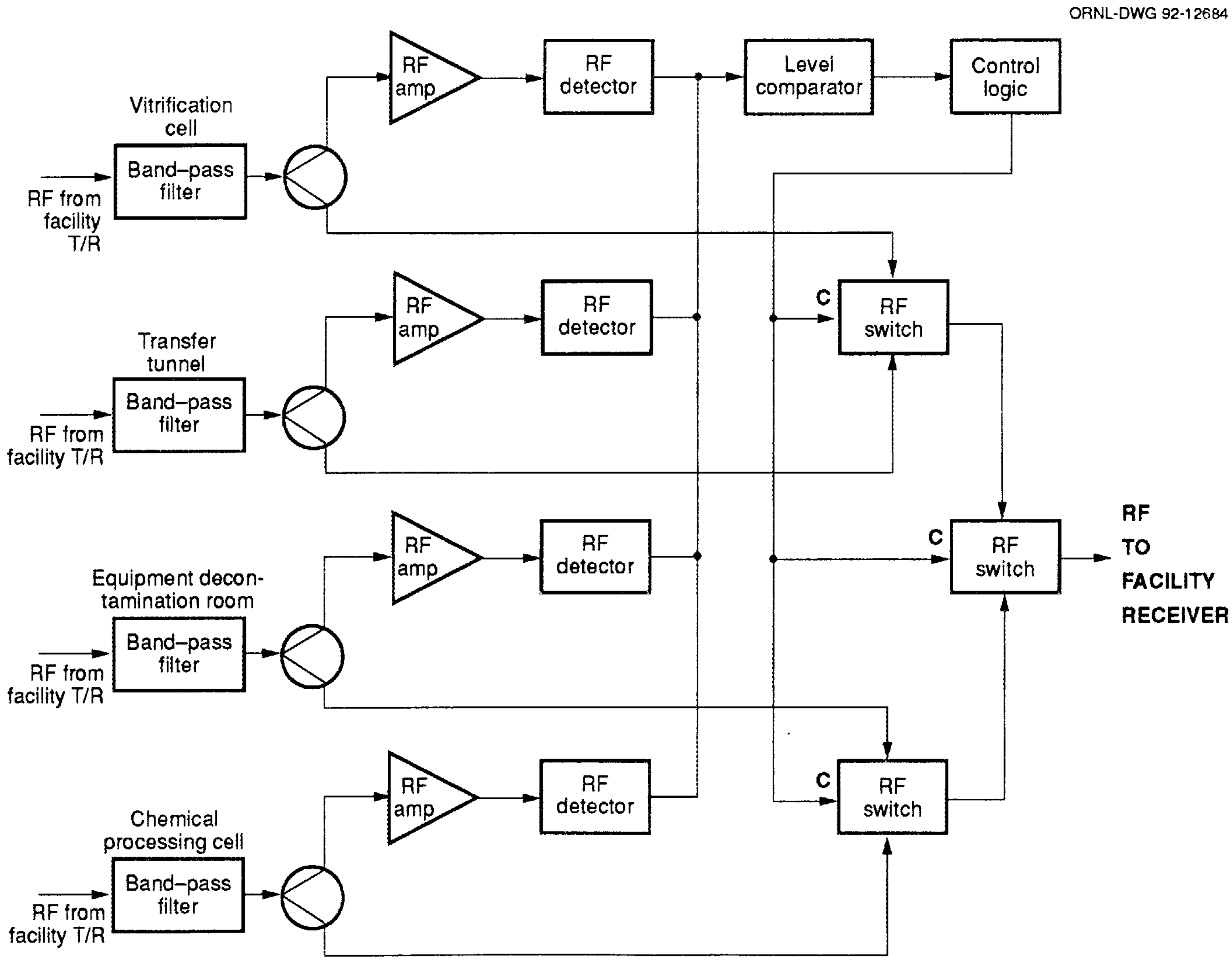

Fig. 6.3. Facility antenna switch.

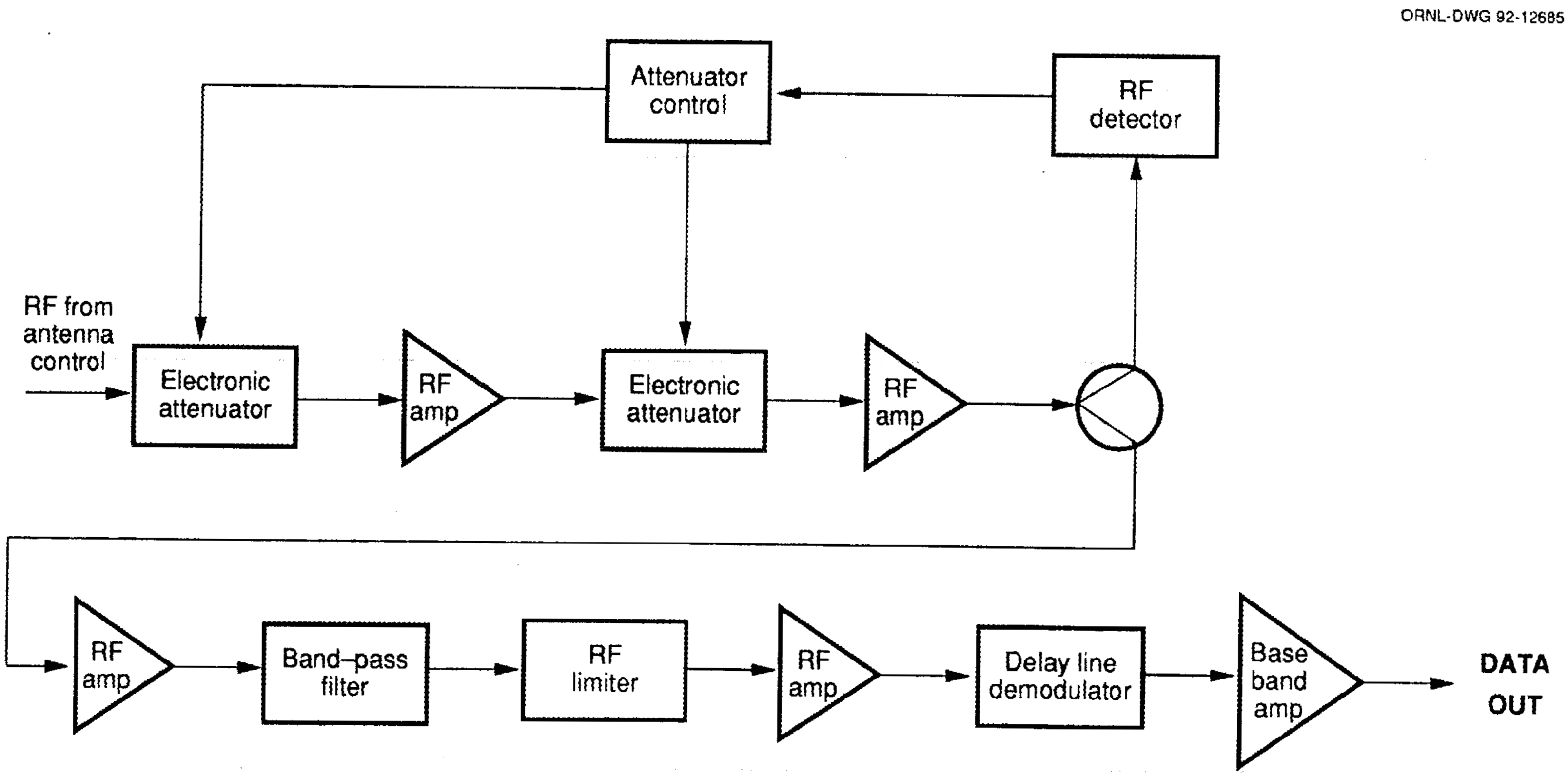

Fig. 6.4. Facility/cart receiver.

proportional to the rf level. This voltage is amplified and applied through a feedback loop to control the electronic attenuators.

The output from the AGC is further amplified before being applied to a bandpass filter that removes any rf energy that is not within the 902- to 928-MHz band. The signal is then applied to an rf limiter that removes fast amplitude fluctuations which would be detected as incidental AM on the signal. The output of the limiter is further amplified before being applied to the demodulator.

The delay line demodulator consists of a signal splitter, a coaxial delay line, and a balanced mixer. The signal is essentially multiplied with a delayed version of itself to produce a voltage that is proportional to the frequency shift of the rf signal. The output is low-pass filtered to remove the residual carrier and squared terms of the mixing process before being amplified by a baseband amplifier. The amplifier output is sent to the communications biphase encoder/decoder board for conversion to a true digital signal.

A schematic diagram for the facility/cart receiver is given in Dwg. Q-6340-260. The circuit board for the facility receiver is housed in a card cage in the engineer's console computer, while the circuit board for the cart receiver is housed in a card cage inside the lead shielded enclosure on the cart.

6.5 CART ANTENNA CONTROL CIRCUIT

The cart signal comparison circuit, also called the cart antenna control, receives rf signals from the two cart antennas, selects the stronger signal, and passes it to the receiver circuit. A block diagram of the circuit is shown in Fig. 6.5. This circuit combines the functions of antenna transmit/receive control and receive antenna selection. When the transmit/receive control line is in the transmit position, the lower rf switch connects the transmitter output to Antenna 2. The rf switches remove the input signals from both rf receiver amplifiers when in the transmit mode. Because the two cart antennas are located in close proximity to one another, transmitting from both would produce a directional pattern that could degrade the signal received by the facility antennas. Additionally, there is no way of determining the best transmitting antenna as the cart moves through signal nulls. Furthermore, the cart-to-facility data are not considered as critical as the facility-to-cart data, and a single transmitting antenna is considered sufficient.

In the receive mode, the rf from each antenna is routed through the rf switches to the respective low-noise rf amplifiers and the rf circuitry on the board becomes identical for the two signal paths. Each signal is amplified by 40 dB and passed through a filter with a bandpass of 902 to 928 MHz to remove out-of-band signals and interference. The signal is split with one path routed to an rf switch and the other to an rf amplifier. The amplified signal is processed through an rf amplitude detector that provides a voltage output proportional to the rf power level.

The output of each detector is compared against the level of the other signal. The comparator determines the position of the electronic rf switch that routes the stronger signal to the cart receiver. The control block performs the additional function of locking the rf switch once the transmission begins. Because the amplitudes from the rf detectors are constantly changing, the comparator will switch to the higher-level signal. The control logic must inhibit the rf switch from changing during data packet transmission to avoid data errors. The inhibit function is implemented by clocking a latch from the rising edge of the first carrier signal that occurs after the local transmitter shuts off. In operation, a logic signal resets the latch when the local system is switched into the receive mode. The level from each rf detector is compared against a threshold that is set above the normal background noise level. When the facility transmitter turns on, the detector output on the cart antenna switch exceeds the preset threshold and the status of the antenna comparator is locked into the system. The rf switch activates the antenna that receives the strongest signal at the beginning of the transmission. The switch stays in this position until the

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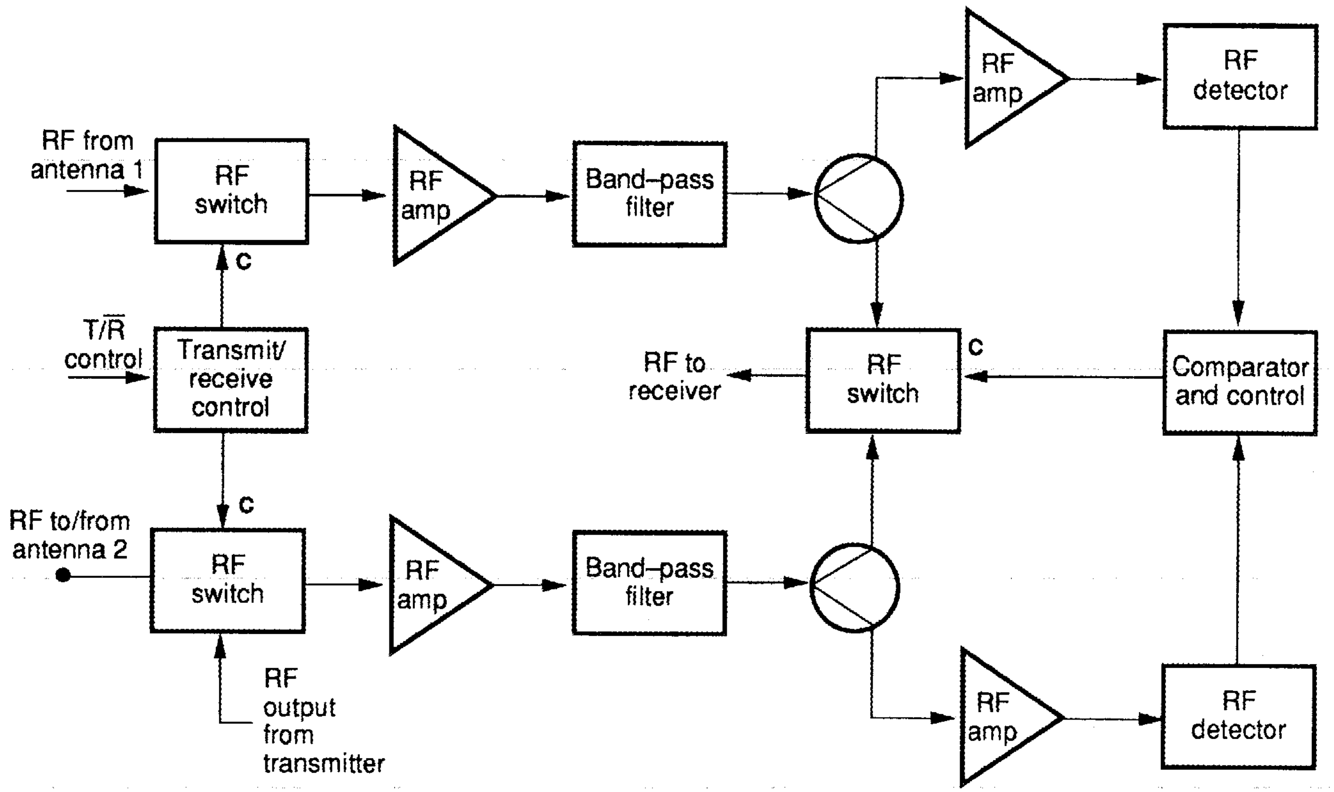

Fig. 6.5. Cart antenna control.

facility transmission has ended, avoiding the switching of cart antennas for the duration of the data packet. If the active antenna drops into a signal null, the system will switch to the stronger antenna at the beginning of the next receive cycle (a maximum of ~1-s duration).

A schematic diagram for the cart antenna control circuit is given in Dwg. Q-6340-265. The circuit board is housed in a card cage inside the lead shielded enclosure on the cart.

6.6 CART TRANSMITTER CIRCUIT

The cart transmitter circuit converts the digital data from the cart microprocessor to an FM rf carrier that is suitable for transmission to the facility cell antennas. A block diagram of the cart transmitter is shown in Fig. 6.6. The circuit acquires a digital message packet from the communications biphase encoder/decoder board. The biphase signal is processed through a modulation amplifier that allows adjustment of both the rf carrier frequency and the deviation of the FM signal. The modulation amplifier drives a VCO with a carrier frequency of 915 MHz in the ISM band. Deviation of the carrier is adjusted to ±10 MHz around the carrier.

The VCO output is buffered through an attenuator and rf amplifier to isolate the oscillator from load variations that could pull the frequency. The rf signal is then amplified by a power amplifier to generate a level of +17 dBm (50 mW) of rf power. The rf output from the transmitter board is routed through the cart antenna control board to the cart antenna. A transmit/receive control signal is supplied by the cart communications microprocessor to activate the VCO and rf amplifiers during the transmit mode and deactivate them during the receive mode.

A schematic diagram for the cart transmitter is given in Dwg. Q-6340-270. The circuit board is housed in a card cage inside the lead shielded enclosure on the cart.

6.7 BIPHASE ENCODER/DECODER

The biphase encoder/decoder for the communications link for the transfer cart is designed to convert 8-bit parallel data into a biphase-encoded serial stream for transmission across an rf link and then decode the serial biphase back into 8-bit parallel data at the other end of the link. Two versions of the encoder/decoder board were designed: one for the facility end of the communications link and one for the cart end of the link. The two boards are almost identical; the differences are limited mainly to those circuits and functions that were required to accommodate the different needs of the facility and cart computers. A schematic diagram for the facility-side board is shown in Dwg. Q-6340-185, and the cart-side board is shown in Dwg. Q-6340-290.

The encoder/decoder uses the biphase-L encoding format for the serial data stream. Biphase was selected because of its widespread use and because there are several devices on the market that contain the encoding and decoding circuits on a single chip. Of these circuits, the DP8342/8343 encoding/decoding pair, from National Semiconductor, was selected because it has been used previously in radiation-tolerant designs and has repeatedly demonstrated gamma tolerance in excess of 10^7 rad. Its baud rate can be set for any rate up to 3.5 Mbaud, but for this instance a rate of 125 kbaud has been set as a good tradeoff between data rate and bandwidth.

The encoder/decoder transmission format is of the packet type, in which the data is sent in coherent bursts rather than in a continuous fashion. The packet format lends itself to bidirectional communications and to digital control systems since it facilitates hand-shaking routines. It also is essential for transmitting data at a baud rate that is significantly higher than the I/O throughput of the sending/receiving device, which for the transfer cart is an STD-based microprocessor. Since the burst-type transmission requires that all of the data be immediately available for transmission, the entire packet must be stored in the input stage of the encoder and likewise in the output stage of the decoder. The size of the input/output storage circuits limits the packet size for this system to 48 bytes. There is also a provision for a special two-byte packet that will cause the decoder to

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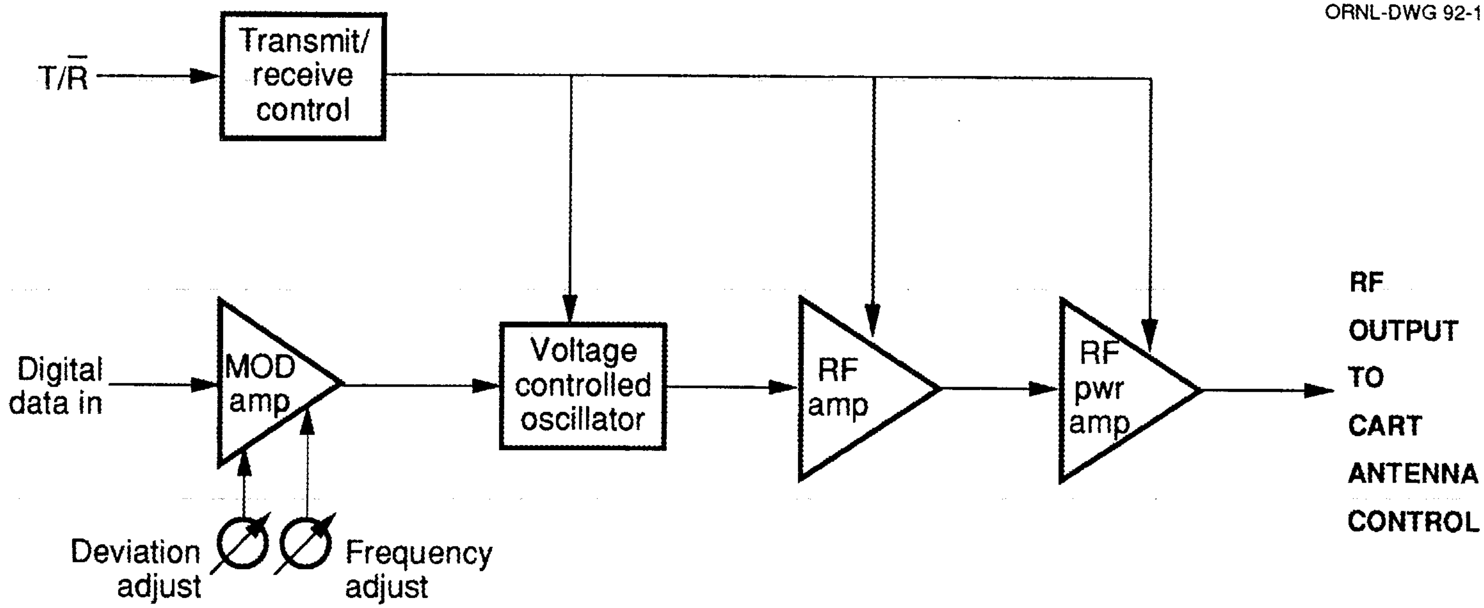

Fig. 6.6. Cart transmitter.

generate a reset pulse that can be used to remotely reset the equipment on the decoder end of the link. The reset will also reinitialize the decoder circuitry. This remote reset function is implemented only on the cart version of the encoder/decoder board; it is not a desirable feature on the facility version of the board.

The encoder/decoder is designed to interface directly to a microprocessor circuit or computer via three 8-bit ports such as in the 8255-type interface chip or an 8255-based I/O card. It is divided into two major functional blocks: the biphase encoder and the biphase decoder.

6.7.1 Interface Protocol

The facility encoder/decoder requires five control signals from the facility communications controller computer (BYTE1, SI, /TX, RST, and /RD) and eight bits of bidirectional data. It generates five status signals (DATRDY, OR1, ERRFLG, FSTBT, and IR) for use by the facility communications controller computer.

The cart encoder/decoder requires five control signals (BYTE1, SI, TX, RST, and RD) and eight bits of bidirectional data. It generates five status signals (ERRFLG, OR1, IR, FSTBT, and DATRDY). The T/R control line and the ANTSTAT status line feed directly to the link hardware and do not affect the encoder/decoder.

For transmission of data, four control steps are required. The first step is to test the status signal IR, which is derived from the input stage of the encoder. A logic high on this line indicates that the input stage is ready to accept data.

The second step is to write the first byte of data into the encoder. This step is treated separately from the rest of the data because a flag bit, called BYTE1, must be written with the first byte. The data is asserted and BYTE1 is driven high at the same time, and both are then clocked into the input stage by a positive-going pulse on the facility board's SI control line or a negative-going pulse on the cart board's SI control line. The data is then deasserted, and BYTE1 is driven low. BYTE1 remains low for the rest of the packet, being used only for marking the very first data byte.

The third step is to write the remaining bytes of data into the encoder, which is done in the same manner as writing the first byte except that BYTE1 stays low. Each time a new byte is to be written, IR should be checked to make sure it is high. A low indicates that the input stage is not ready to accept data, either because of a malfunction in the encoder or because the packet is too large to fit in the input storage section of the encoder.

The fourth step is to assert TX low (high for the cart version) after the last data byte has been entered into the encoder. This will initiate the encoder and transmit the data. TX must be returned to the deasserted state before the next packet is sent.

The encoder encodes the data two bytes (16 bits) at a time, adding one byte of the cyclic redundancy check (CRC) code to every two bytes of data. If an odd number of bytes is entered, the encoder will append a null byte to the last byte to make a full pair. Thus if four bytes of data are entered, the encoder will divide the four data bytes into two pairs and add a CRC byte to each pair, transmitting six bytes of information. Three bytes of data will be divided into two pairs, the first being the first two data bytes and the second being the third byte plus a null byte. The total number of bytes transmitted will also be six bytes. The CRC byte will be stripped off in the decoder, but the null byte will be appended to the data.

To generate the remote reset pulse, only two bytes of data need be sent. Both bytes must match the reset code set in the decoder circuit. Since the reset generator searches for an 8-bit data pattern in both bytes in a data byte pair, it is possible for random data to trigger a reset pulse if steps are not taken to prevent both bytes in any given data byte pair from matching the reset code. Two identical bytes that match the reset code and are consecutive but are not paired by the encoder will not trigger a reset.

A high on DATRDY indicates that data have been received by the decoder and are waiting to be read. OR1 should also be high and indicates that the output buffers [first-in, first-out (FIFOs)] contain data. Driving /RD low (high for the cart version) will assert the data onto the data bus (D0-D7), and its rising (falling) edge will cause the next available byte to be present in the output stage of the decoder. DATRDY will also be reset to the low condition with the first transition on /RD and will remain low until a new packet of data is decoded. The OR1 signal will go low with the /RD signal, so OR1 must be checked for a high level before the byte is read. OR1 will continue to return to the high state until the last byte has been read.

A high on the ERRFLG signal indicates an error in the current or previous byte. This signal will only be valid for even-numbered bytes, which are the second bytes in the encoded pairs. Thus when reading the even-numbered bytes, this signal must be checked to make sure that the data is valid. If it is high, the byte being read and the byte that came before it should be discarded unless an error-correction routine is being implemented in the host microprocessor.

The RST signal should be asserted high to reset the encoder/decoder. A power-up reset is advisable, as is a reset before writing each packet to the encoder.

6.7.2 Biphase Encoder

The following circuit descriptions are for the facility version of the encoder/decoder. Component numbers for the cart version are in brackets (reference Dwgs. Q-6340-185 and Q-6340-290).

The biphase encoder block appears in the top half of the encoder/decoder schematics. Its major functional sections are (1) the input FIFO, composed of U2, U4, U6A, and U6B [U14, U15, U23A, and U23B]; (2) the parallel-to-serial conversion stage, U5 [U16]; (3) the CRC generator, U16 [U25]; (4) the control section, composed of U9, U10, and U17 [U21, U22, U32, and U34A]; (5) the output FIFO stage, composed of U18, U19, and U20 [U1, U2, and U9]; (6) the biphase encoding stage, composed of U1 and U8 [U3 and U8]; and (7) the timebase section, composed of U14C, U27, and U31 [U28, U29C, and U33].

6.7.2.1 Input FIFO stage

The input FIFO stage of the biphase encoder block serves three functions. First, it provides temporary storage of the 8-bit parallel data to minimize problems with converting an irregular parallel flow into a regular serial flow. Second, it serves as a synchronizing buffer between two digital systems which are, potentially, at very different clock rates. Third, it allows the transmission data rate to vary greatly from the rate at which the parallel data is written to the encoder. The FIFO itself is composed of U2 and U4 [U14 and U15], which are C67402 64 × 5 asynchronous FIFOs. Like the DP8342/8343 encoder/decoder pair, the C67402 has been used extensively in radiation-tolerant designs and has repeatedly operated normally beyond 10^7 rad. U6A [U23A] performs a logical AND on the input ready (IR) status outputs from the two FIFOs, and U6B [U23B] performs a logical AND on the output ready (OR) signals for use by U9 [U22].

6.7.2.2 Parallel-to-serial converter

The parallel-to-serial converter consists of U5 [U16], which is a 74LS166 parallel-load shift register. It is under the control of U9 [U21], which toggles the parallel-load enable input every 8 clock cycles for the two data bytes in the pair while the encoder is transmitting. When the CRC byte is ready to be inserted into the serial stream, the parallel-load signal does not toggle, which then causes the data to be all zeroes.

6.7.2.3 CRC generator

The CRC generator is U16 [U25], a 9401/8X01 CRC generator/checker chip. Its output, the CRC byte for each data byte pair, is generated from the serial output of U5 [U16] and is clocked out when its CWE input is driven low. The output is fed to U9 [21] in the control section. Detailed timing diagram appears in Fig. 6.7.

6.7.2.4 Control section

The control section consists of U9, U10, and U17 [U21, U22, U32, and U34A]. U9 [U21] is the heart of the control section and generates most of the signals that cause the encoder to operate. It monitors the input FIFO stage and the output of U17 [U32] and uses the signals from these sections to pair the data bytes, generate and insert the CRC byte, and load the composite stream into the output FIFO stage for transmission. U10 [U22] is used primarily as a modulo-24 counter. Its count output is fed to U9 [U21], which uses it to monitor its location in the encoding process. U9 [U21], in turn, enables and disables the counter in U10 [U22]. U17 [U32] is a latch that guarantees that the /TX signal will last for a minimum of two clock transitions so that U9 [U21] will always be able to see it.

When a data packet is first written to the encoder by the computer, the OR outputs of the input FIFOs will go high, as will the B1 signal, which is the BYTE1 flag marking the first byte in the packet. If the B1 flag does not go high along with the OR signal, U9 [U21] will clock out data bytes from the FIFO until B1 and OR are both high or until the FIFO is emptied. The STRT signal from U17 [U32] is used as the trigger to initiate the encoding cycle. A negative [positive] pulse on the /TX control line will set U17 [U32], causing STRT to rise for at least two clock edges. The high on all three signals starts U9 [U21], which, in turn, starts U10 [U22]. As U10 [U22] counts from 0 to 24, U9 [U21] decodes the count and from it generates the encoder control signals. The detailed timing can be found in Fig. 6.7. At the count of 24, U9 [U21] checks its status lines from the input FIFO stage and will either continue encoding (if more data resides in the FIFO) or quit (if the data is gone). U9 [U21] also inserts the CRC code into the data by enabling the CRC generator and switching the CRC output into the serial stream.

6.7.2.5 Output FIFO stage

The serial data/CRC stream from U9 [U21] is fed to U20 [U1], the serial-to-parallel converter in the output FIFO stage. U20 [U1] is an 8-bit, serial-in, parallel-out shift register whose parallel output goes to the input pins of U18 and U19 [U2 and U9], which make up the FIFO. U9 [U21] then generates a shift-in pulse at 8-bit intervals to clock the output of U20 [U1] into U18 and U19 [U2 and U9].

6.7.2.6 Biphase encoder stage

The output of U18 and U19 [U2 and U9] are then fed to U8 [U3], which is the DP8342 biphase encoder chip. U1 [U8] controls the transfer of data from the FIFO to the encoder. U8 [U3] adds a synchronization bit and a parity bit into the serial stream during encoding for a total of 10 bits per 8-bit byte, so the data will be read out of the FIFOs at a lower rate than it is being written in by U9 [U21].

Thus for this stage there is no reason to store the entire packet in the FIFO; U1 [U8] starts transferring data from the FIFO into the encoder as soon as it reaches the outputs of the FIFO. U8 [U3] disables the biphase decoder (U24 [U10]) during transmission by raising its transmitter-active output.

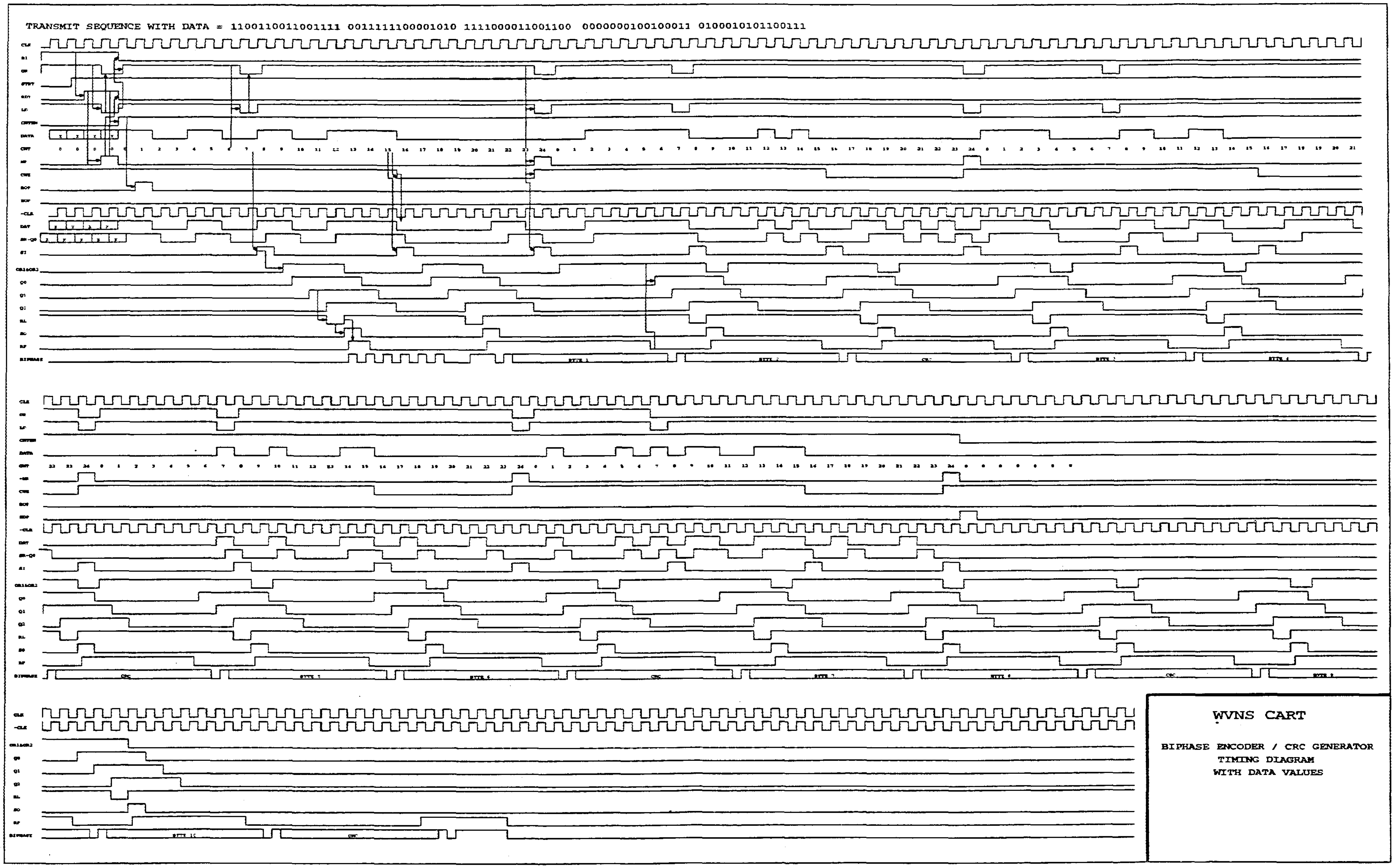

Fig. 6.7. Biphase encoder/CRC generator timing diagram with data values.

6.7.2.7 Timebase section

The timebase section, U27, U31, and U14C [U28, U33, and U29C], generates the two clock waveforms that are needed to operate the encoder/decoder circuit. U27 [U28] is a dual in-line package oscillator running at a frequency that is 16 times the serial transmission bit rate. In this case U27 [U28] is 2.0 MHz. U31 [U33] divides the output of U27 [U28] by 2 and by 16. The divide-by-2 output is used by U8 [U3] in the encoder and by U24 [U10] in the decoder. The divide-by-16 output is buffered by U14C [U29C] and is used to drive all of the other clocked circuits with the exception of U20 [U1] in the encoder and U13 [U24] in the decoder. These two chips must be on the alternate clock phase because the CRC generator chips U16 and U21 [U25 and U30] are falling-edge triggered and U20 [U1] and U13 [U24] must be in phase with them.

6.7.3 Biphase Decoder

The biphase decoder block appears in the lower half of the encoder/decoder schematic, and its detailed timing diagram appears in Fig. 6.8. Its major functional sections are (1) the input comparator, U32 [U6]; (2) the DP8343 biphase decoder chip, U24 [U10]; (3) the input storage FIFO and associated circuits, composed of U15, U23, U25, and U30 [U5, U11, U12, and U20]; (4) the parallel-to-serial converter, U22 [U19]; (5) the control section, composed of U28 and U29 [U26 and U27]; (6) the CRC checker, U21 [U30]; (7) the serial-to-parallel converter, made of U12 and U13 [U17 and U24]; (8) the output storage section, composed of U3, U7, U11, U6C, U26A, U14E, U14F, and U26B] [U4, U7, U13, U23C, U29E, U31A, U31B, U34A, and U34B]; and (9) the remote reset comparator U18 (cart version only).

6.7.3.1 Input comparator

The input comparator stage converts the incoming biphase waveform from the rf receiver into a TTL (transistor-transistor level) signal. The comparator is an LM161 high-speed TTL-output comparator. The biphase signal is terminated with a 4.7-kΩ resistor and applied to the noninverting input of the comparator; the reference voltage, taken from the 10-kΩ trimmer R12 [R4], is applied to the inverting input. The reference voltage ranges from about +2 V to about −2 V. Since the differential input limit of the LM161 is about 5 V, care should be taken to ensure that the difference between the biphase signal from the receiver and the reference voltage does not exceed ±5 V. Limiting the input to ±3 V will ensure that this condition is met. The output of the comparator is a differential TTL signal taken off pins 9 and 11 of the comparator.

6.7.3.2 Biphase decoder

The biphase decoder chip, U24 [U10], converts the differential biphase signal from U32 [U6] into its constituent 8-bit bytes.

6.7.3.3 Input storage FIFO

The input storage FIFO is very similar to the other FIFO stages in the encoder/decoder. It is composed of two C67402 64x5 FIFOs arranged in parallel. U23 and U30 [U11 and U5] transfer the data from the biphase decoder chip to the FIFOs. U30 [U5] is used primarily as a pulse synchronizer/stretcher to ensure that the status flags from the decoder chip are of sufficient length and are timed correctly. In the case of the data available (DA) signal from the 8343, the purpose of U30 [U5] is more correctly described as ensuring that the period between active states of the signal is longer than 1 clock cycle, rather than ensuring that the signal's active states are long

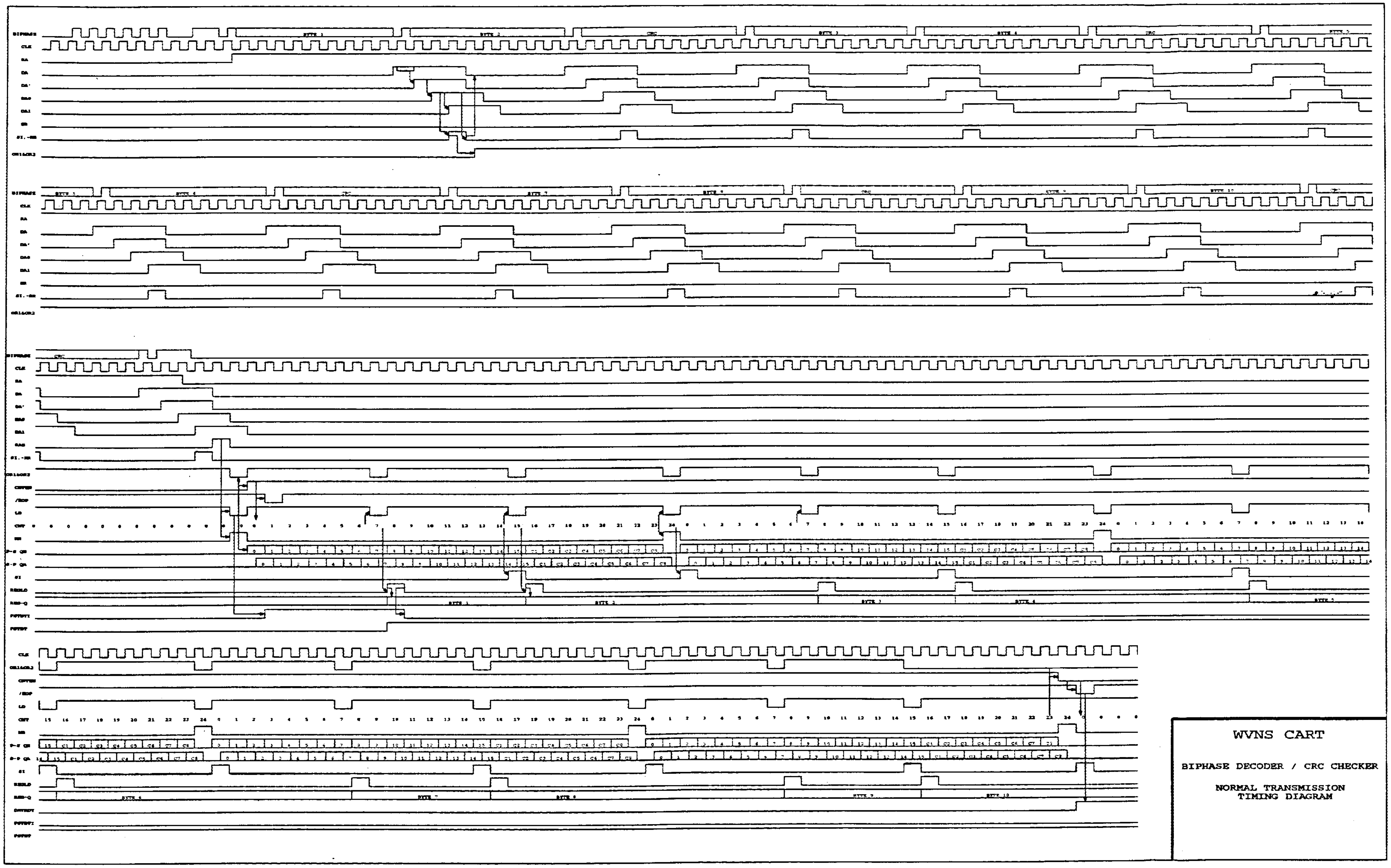

Fig. 6.8. Biphase encoder/CRC checker normal transmission timing diagram.

enough, since there is one situation in which the period between two successive active states can be considerably less than 1 clock cycle of the system clock. U23 [U11] derives a register read (RR) pulse and a FIFO shift in (SI) pulse from the DA signal. These two signals conspire to transfer the incoming data bytes from the decoder to the FIFO. The RAE signal, which is used by the control section to initiate its sequence, is derived from the receiver active (RA) signal from the 8343. It rises for 1 clock cycle at the end of the data packet, triggered by the falling edge of the RA signal.

6.7.3.4 Parallel-to-serial converter

The parallel-to-serial converter, U2322 [U19], is a 74LS166 parallel-load shift register. The control section causes it to load every 8 clock cycles while the decoder block is active, using a single-cycle, low pulse on the load input. U14D [U29D] inverts the LD signal for use by the FIFO, causing it to shift out the next available byte on the falling edge.

6.7.3.5 Control section

The control section is composed of two programmable array logics (PALs), U29 [U27], which is the same counter PAL used in the encoder block, and U28 [U26], which is the primary control circuit in the decoder. The operation of the control section is similar to that of the encoder block's control section. The control sequence is initiated by the positive pulse on RAE from U23 [U11]. U28 [U26] then initiates U29 [U27] and decodes its count into a series of control pulses that first cause U22 [U19] to load every 8 clock cycles, then load the data into the temporary holding register U12 [U17] after it has been reconverted to parallel form by U13 [U24], then check the status of the error flag from the CRC checker at the appropriate time, and then write the data into the output FIFO until the end of the packet is reached.

An ancillary circuit to the control section is the first byte flag circuit, composed of U14F and U26B [U34C and U31B]. This circuit uses the beginning-of-packet (/BOP) and the end-of-packet (/EOP) signals from U29 [U27] to flag the first byte from each packet. The flag is written into the output FIFOs along with the first byte, and appears at their output as the FSTBT output status signal to the computer. These signals allow more than one packet to be stored in the output section at one time by separating the packets.

/BOP will pulse low for 1 clock cycle when a transmission is first received by the decoder, and /EOP will pulse low for 1 clock cycle at the end of the transmission. In the cart version /EOP is also made available to the antenna control printed circuit board in the link hardware via J3.

6.7.3.6 CRC checker

The CRC checker, U21 [U30], is a 9401/8X01 CRC generator/checker chip. This is the same IC that is used by the encoder to generate the CRC word, but in the decoder usage it is used to monitor the received data stream rather than insert a CRC word into the data. After each 16 bits of data plus their 8-bit checkword has been entered, U21 [U30] will generate an error indicator flag to signify whether or not an error was detected. U28 [U26] in the control section monitors this flag and takes appropriate action if an error was detected. Timing details are in shown in Figs. 6.8 and 6.9.

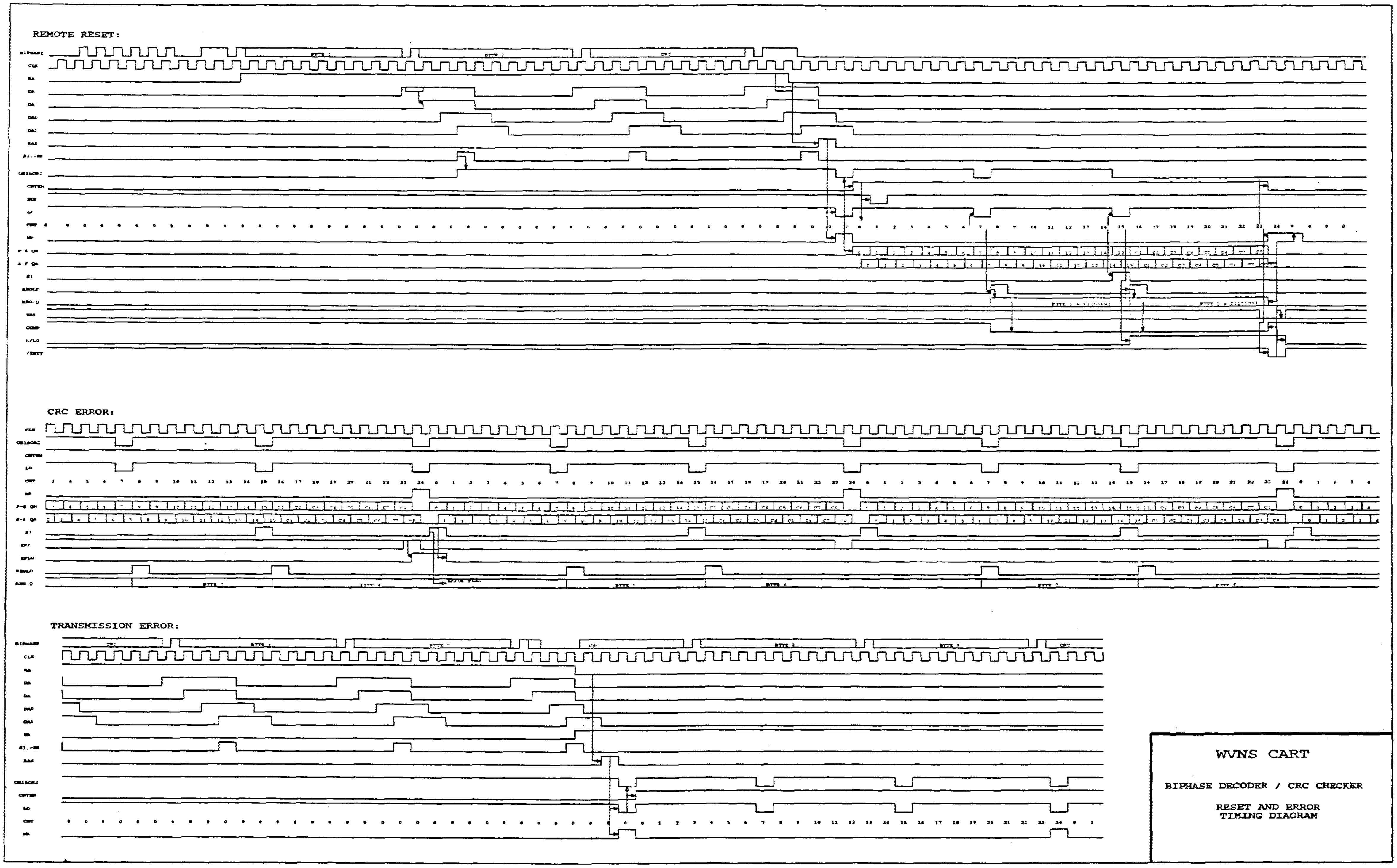

Fig. 6.9. Biphase decoder/CRC checker reset and error timing diagram.

6.7.3.7 Serial-to-parallel converter

U12 and U13 [U24 and U17] make up the serial-to-parallel converter section, which converts the serial data stream from the parallel-to-serial converter section back to its parallel form. In terms of the flow of data through the decoder circuits, the conversion to serial and back to parallel is not expressly needed; however, the CRC checker does need serial data, and the delay induced by the parallel-to-serial and serial-to-parallel conversions actually simplifies the timing requirements of the decoder. The delay is needed because the CRC check is completed only after the entire 24-bit data/CRC combination has been run through U21 [U30], and in order to align the error flag with the data before it is entered into the output storage section, the parallel data must be delayed by a minimum of 24-bit cells, which would require one extra register and its associated control lines and timing. U13 [U24] is a serial-input, parallel-output, shift register which is clocked by the inverted phase of the system clock. U12 [U17] is clocked by the control section and delays the data from U21 [U30] by 8 bits so that by the time the second of the two data bytes must be written to the output storage section, the error flag will have been received and will be ready to be entered along with the data. The CRC byte is not clocked into U12 [U17], although it is converted to parallel form by U13 [U24].

6.7.3.8 Output storage section

The output storage section stores the data bytes as they are clocked into U12 [U17]. U3 [U7] isolates the output of the FIFOs from the tri-state bus. When data are first clocked into the FIFOs their OR outputs go high, causing the output of U6C [U23C] to rise and signalling that a packet has been received. A negative pulse on /EOP will reset U26A [U31A], signifying that the packet has been decoded and checked for errors. Once /EOP is received, the data can be read out of the FIFO by pulling /RD low [high], which enables the outputs of U3 [U7], asserting the first data byte onto the bus. /RD must remain low [high] during the read operation. After the read operation is completed for each byte, /RD must be returned high [low] because its rising [falling] edge after being inverted by U14E causes the next data byte in the FIFO to be clocked out. OR1 will fall during the period in which /RD is asserted and will return high only if another data byte is ready to be read out of the FIFO. If OR1 does not return to the high state, the byte just read was the last one in the packet. The ERRFLG output from the FIFO is valid only while the even-numbered data bytes are at the FIFO output and should not be read with the odd-numbered bytes.

6.7.3.9 Remote reset (cart only)

The remote reset pulse is generated by the control section from the output of the remote reset comparator U18, which is an 8-bit TTL comparator. The reset code is set via the 16-pin header (arranged in an 8- by 2-pin grid) that feeds the Q-inputs of U18. For reliability purposes the pins of the header should be wire-wrapped in lieu of using jumpers. The output of the comparator is used by U26, which looks at the signal at a specific point in the decoding process to determine whether a reset pulse should be generated. If the first byte in a two-byte encoding pair matches the reset code, the RFLG output of U26 latches high. If the second byte in the pair also matches the code and the CRC checker does not detect an error in either byte, U26 will generate a single active-low reset pulse (/INIT) that is 1 clock cycle (8 μs) in length. /INIT is then driven by U29F to turn on Q1, which pulls down the PBRESET line on the computer's bus. /INIT also feeds back to reset the decoder circuitry via U23D. If the second data byte does not match the reset code or if the CRC checker detects an error, U26 will reset RFLG and write the two data bytes to the output storage section.

6.8 FACILITY COMMUNICATIONS SYSTEM CONTROLLER

A single-board computer is designed to (1) handle communications encoding and decoding tasks, (2) coordinate high-speed data passage, (3) switch on and off the facility transmit/receive units, (4) interface to the engineer's console computer, and (5) provide data buffers for serial data transmissions. The computer will use a STD bus and be mounted in a 19-in. card cage in the engineer's console, as shown in Dwgs. Q-6340-102 and Q-6340-103.

The control processing unit (CPU) is a Prolog Model 100, 12-MHz computer with 512 kB of memory and a breakout board with two RS-232 ports. The CPU uses a disk operating system (DOS) so that software development time is minimized. There is a battery-backed RAM disk card, Prolog 7715A-03, that will hold 256 kB. A Prolog 7514 card interfaces the communications controller computer to the Allen-Bradley's remote I/O network. In this manner, PLC I/O points are emulated in the Prolog computer. The facility encoder/decoder card, described in Sect. 6.7, mounts in one slot of the communications controller STD rack. It interfaces to the Prolog computer through a Prolog 7508 digital interface card. The same 7508 card also interfaces to Opto-22 digital I/O modules that are used to switch the facility antennas on and off, and to receive antenna usage status from the rf system. The Opto-22 modules are mounted on another 19-in. panel in the back of the engineer's console.

6.9 FACILITY ANTENNAS

The facility antennas, shown in Fig. 6.10, are dipole antennas which are designed to fit within existing cell penetrations. The antennas fold to fit inside a 1 1/4-in.-ID straight-through penetration. Four of the facility antennas will be used. The facility antenna assembly is shown in Dwg. X3E020097A113. The main components of the antenna assembly are the base, antenna, insulator, spring, shaft, pin, collar and corrugated hose.

The base is machined out of PEEK (polyetheretherketone) thermoplastic, which also has good radiation tolerance. The base needs to be an insulator in order to not affect the transmissive properties of the dipole antenna. The shaft, made of 304 stainless steel, is pressed into the end of the base for mounting the antenna.

Each dipole antenna has two 1/8-in.-diam by 4-in.-long antenna rods of 304 stainless steel. Small copper tabs are silver soldered onto the end of the antenna rods. The coaxial cable leads are soldered to each of the copper tabs. These are then epoxied into the insulator. The insulator is also made of PEEK. The insulator fits over the shaft on the base and pivots to fold and deploy the antenna. A torsion spring is used to provide the force to deploy the antenna. A pin is also pressed into the base to provide a positive stop for the correct position of the deployed antenna.

The corrugated hose is made of 316 stainless steel. It is used to push the antenna through the cell penetration to deploy it in-cell and is also used as a conduit for the coaxial cable. The stainless steel collar is used to attach the corrugated hose to the base. Once inserted into the cell, the dipole antenna unfolds and deploys to the vertical orientation for signal transmission with the cart.

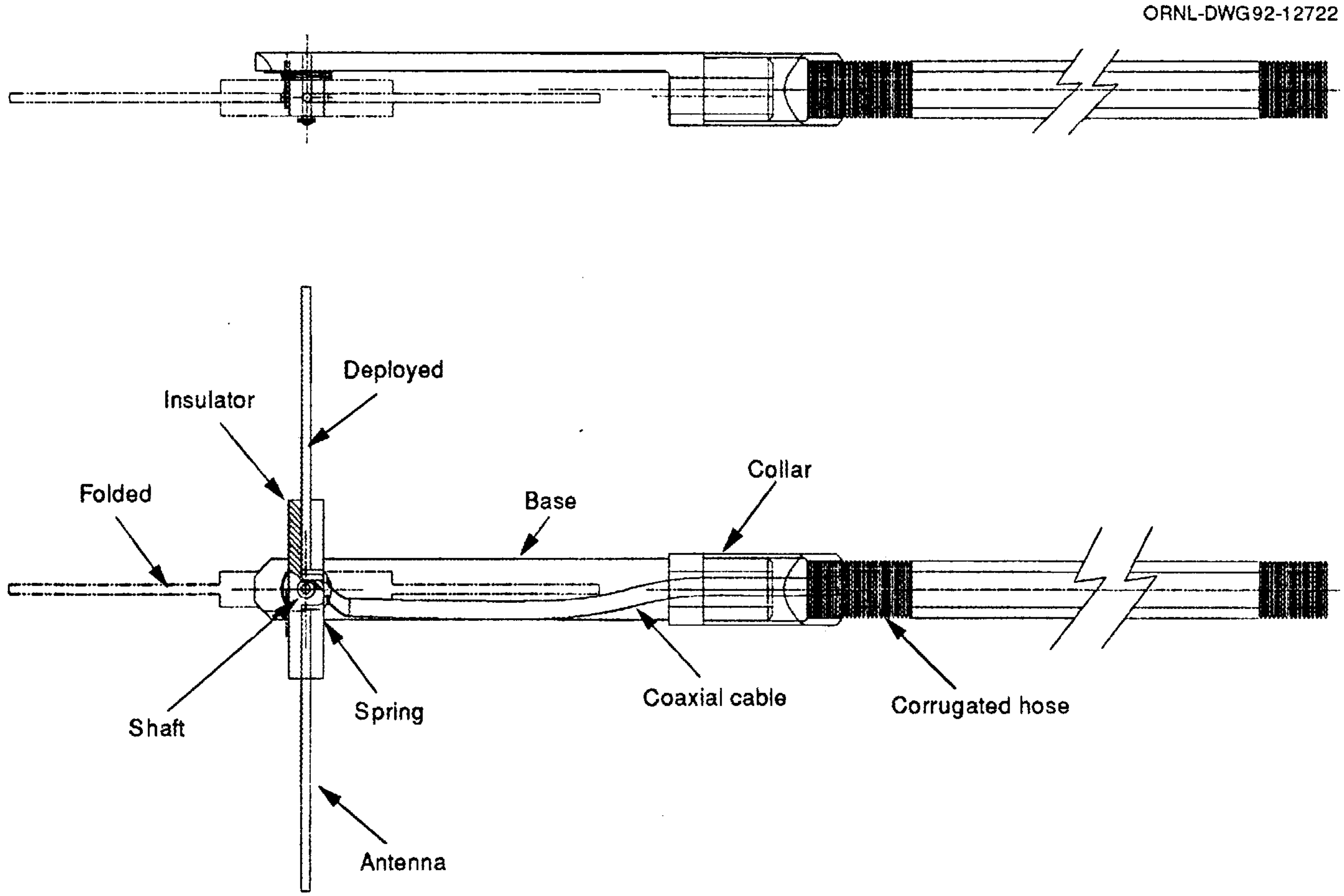

Fig. 6.10. Facility antenna.

7. CART ELECTRONICS SYSTEM

This section describes all cart-mounted electronics systems except for the communications hardware. Figure 7.1 shows the basic layout of printed circuit cards in the cart electronics system. Note that only the WinSystems and interface module boards are discussed in this section. The remaining boards (communications system boards) are covered in Sect. 6. A wiring diagram of the cart electronics is given in Dwg. Q-6340-215.

7.1 SYSTEM CONTROLLER

The system controller is based on the STD bus using an embedded controller manufactured by WinSystems Inc. The embedded controller card, a WinSystems single-board computer (Model LPM-SBC40R-8-BAT), uses an Intel 8086 microprocessor with the WinSystems read-only memory (ROM) disk operating system. In order to provide additional digital I/O lines, the single-board computer is fitted with a piggyback I/O expansion board (WinSystems model number SBX-PIO). Section 9.4 provides a detailed description of the cart control software and communication protocols.

The system controller is designed to withstand a 10^7 rad total integrated dose using a lead shielding enclosure. See Appendix B for information on the radiation test of the system controller. A diagram showing the system hardware configuration is given in Dwg. Q-6340-247.

7.1.1 Interface-to-Cart Communications System

The system controller decodes, processes, and responds to commands from the cart communications system and passes data from the cart electronics system through the cart communications system to the facility system. The system controller is tied to the communications system via the cart biphase encoder/decoder. This connection is made through the SBX-PIO digital I/O card and provides the system controller with decoded data from the facility system and allows the system controller to send encoded data to the facility system. Connections are also made from the system controller through the SBX-PIO card to the communications system transmit/receive switching circuitry. Timing of receive/transmit cycles are software controlled (see Sect. 9.4 for a discussion of the controller software routines).

7.1.2 Interface to Motor Drives

The system controller provides control signals, direction control, and pulse-width modulation signals to the motor drives via the cart controller interface board. The pulse width modulation signal allows software control of cart speed. If the system controller receives a motor overcurrent trip signal from the controller interface, an error message will be sent to the facility system (via the communications system) to notify the cart operator of the problem. The operator has the option of sending a command that will re-enable the tripped motor drive. If the abnormal

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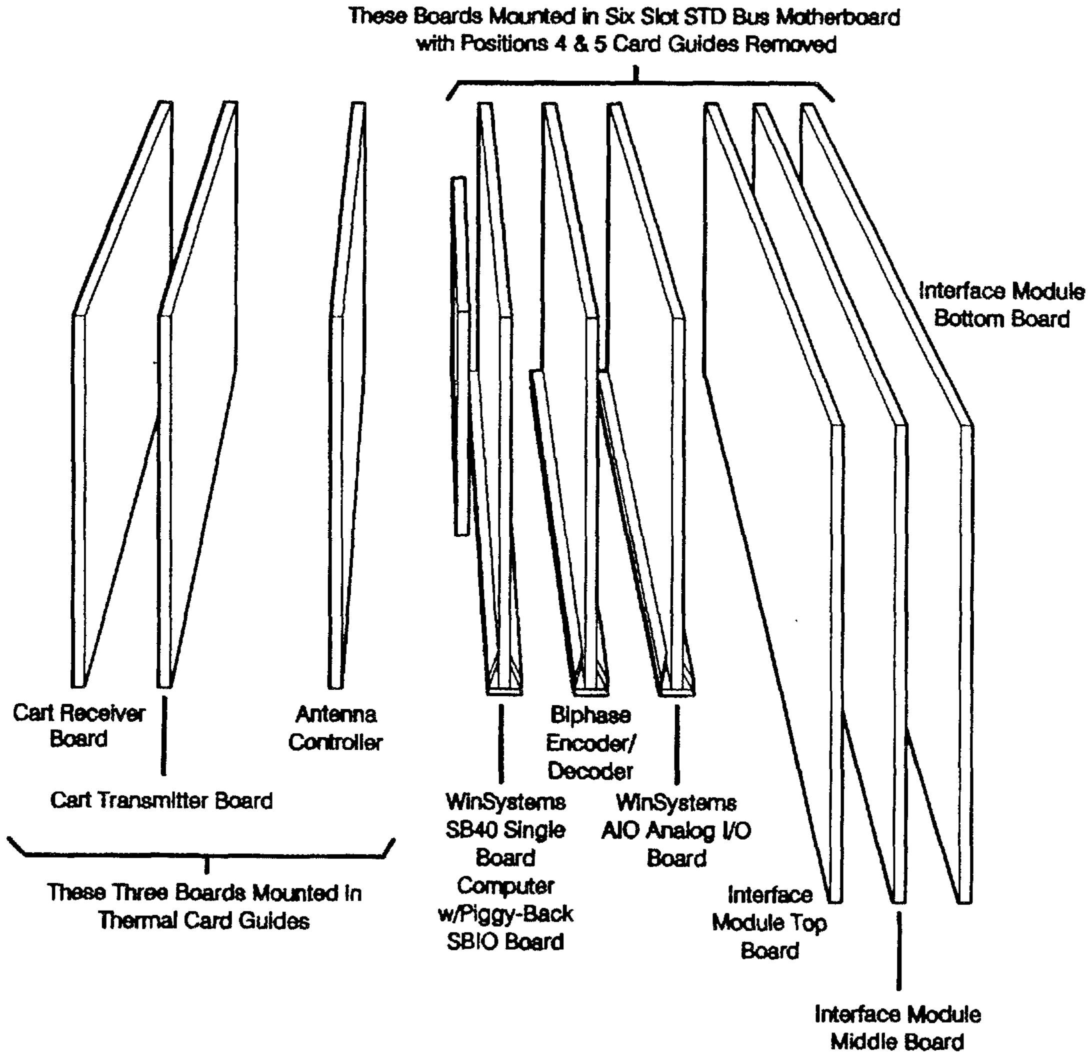

Fig. 7.1. Cart electronics rack card arrangement.

condition persists, the particular motor drive will again be disabled and the operator notified. Note that while motors are controlled by the system controller, the motor overcurrent trip and motor disabling circuits are located on the controller interface board (see Sect. 7.3) and are being directly activated by an overcurrent condition.

7.1.3 Interface to Analog-to-Digital Converter

Data from the analog-to-digital (A/D) converter must be controlled, received, and stored for transmission by the system controller. The A/D converter is located in the STD-bus section of the cart electronics, and communication with the A/D is accomplished through the STD interface. See Sect. 9.5 for a description of signals processed by the A/D converter.

7.1.4 Interface to Cart Interface Module

Much of the signal processing and high-current switching for the cart is carried out by the cart interface module, which is described in Sect. 7.3. The system controller is tied to the interface module through 14 lines of digital output and 7 lines of digital input. The system controller also has access to 17 analog signals via the A/D converter board from the controller interface.

Digital signals to the interface are the remote outlet controls, fan control, motor direction control, motor resets, and pulse-width modulation signals for each motor. Digital signals from the interface are the door limit switch detected, outlet trip signals, motor trip signals, and the interface module ID.

Analog signals from the interface are the controller temperature, battery compartment temperature, outlet voltage signals, outlet current signals, motor voltage signals, motor current signals, battery voltage signal, and battery current signal.

7.2 MOTOR DRIVES

The motor drive circuit is a standard H-bridge type MOSFET drive. Drive signals for the solid state switches are provided by Maxim driver integrated circuits located on the controller interface board (see Sect. 7.3). Signals for the motor drives originate in the system controller board and are buffered by the controller interface board. A separate motor drive circuit board is provided for each motor.

The motor drive circuit schematic, parts placement and layout, is given in Dwg. Q-6340-235. The parts list for the motor drive is given is Dwg. Q-6340-236.

7.3 CART INTERFACE MODULE

The cart interface module controls battery power distribution during charging and provides buffering for all current shunts and voltage signals, buffering for the temperature sensors located in the battery and controller compartments, motor and outlet overcurrent trips and resets, buffering for the threshold detector switch, a controller identification (ID) output, current shunt span calibration signals, a drive signal to the fans, and motor drive signals. A functional block diagram for the controller interface is shown in Fig. 7.2. Section 7.1.4 has a detailed list of signal lines from the controller interface module to the system controller. A schematic drawing of the overall wiring for the interface module is given in Dwg. Q-6340-215.

The cart interface module is composed of three separate circuit boards which are colocated in the cart electronics rack assembly. Since the boards are configured in a stacked arrangement, they are referred to as the top, middle, and bottom interface boards in documentation. The schematic diagram, printed circuit board layout, and parts list for the interface module top board are given in Dwgs. Q-6340-220 through Q-6340-224. The schematic diagram, printed circuit board layout, and parts list for the interface module middle board are given in Dwgs. Q-6340-225 through Q-6340-229. The schematic diagram, printed circuit board layout and parts list for the interface module bottom board are given in Dwgs. Q-6340-230 through Q-6340-233.

7.3.1 Battery Switching During Charging

The cart system controller and other cart electronic systems are de-energized by the interface module during battery charging. Charging is initiated when a voltage greater than the battery voltage is sensed on the charging shoes. Note that the voltage must be of the proper polarity for

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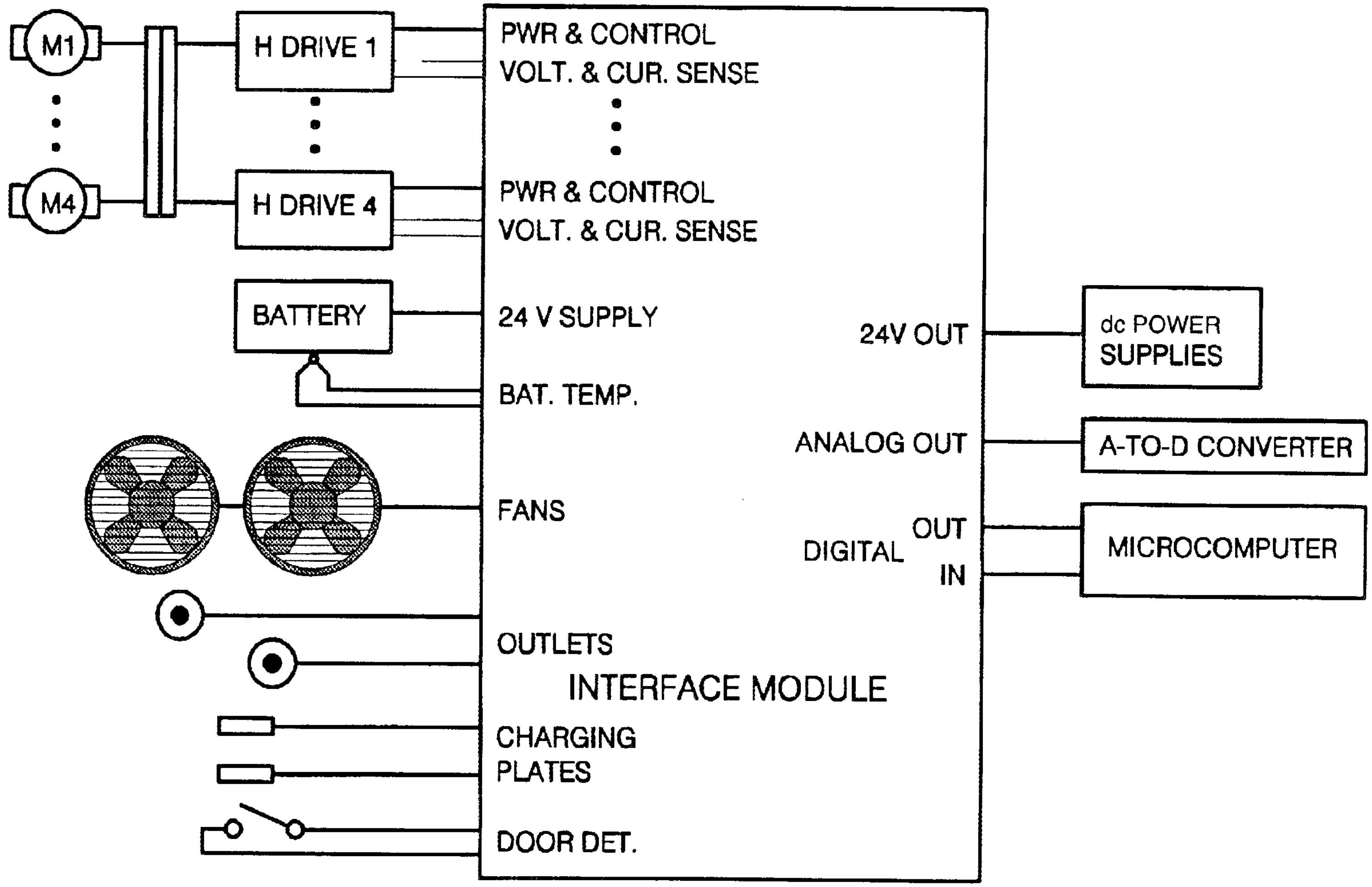

Fig. 7.2. Cart controller interface module block diagram.

the controller interface to allow charging. Once charging is initiated, it is terminated only when the current from the charger is less than a programmed level (~80 mA). This is accomplished by a high-gain current monitor located in the battery and charger interface circuit (see Dwg. Q-6340-222) which allows detection of the battery charging current. Switching is accomplished as shown in Fig. 7.3.

7.3.2 Current Shunt and Voltage Buffers

All current shunt and voltage signals passed to the A/D converter card are buffered in the interface module. The buffers are built using the Precision Monolithics AMP-03 unity gain differential amplifier. Input protection is provided by a resistor/voltage clamp circuit at the input of each buffer. Buffer schematics are given in Dwg. Q-6340-232.

7.3.3 Temperature Monitors

Two temperatures are monitored in the cart electronics enclosure. These are the battery compartment temperature and the cart controller temperature. Figure 7.4 shows a block diagram of the temperature measurement system. The battery compartment temperature is measured with a Type E thermocouple washer ring which is mounted under the negative battery electrical terminal contacts. The cold junction compensation for the thermocouple and controller temperature are both measured by the same solid state temperature sensor located on the interface module board. As indicated in the figure, the controller temperature is used to control fan operation. A schematic for the temperature monitoring circuit is given in Dwg. Q-6340-227.

7.3.4 Overcurrent Trips

The output signal from each motor and outlet current shunt is sensed after buffering. A threshold detection circuit is used to produce a digital signal that causes any motor or outlet to be disabled if the current exceeds a resistor programmed level. The trip condition is latched, causing the motor or outlet to remain disabled until reset by the system controller. Resets from the system controller are received via the communication system from the engineer's console. A schematic for the fault detection circuit is given in Dwg. Q-6340-227.

7.3.5 Threshold Detector Switch

The threshold detection switch actuation is sensed via a pull-up resistor located on the interface module board. The signal from the pull-up resistor is passively buffered prior to being passed to the system controller from the interface board. The detector switch buffer schematic is given in Dwg. Q-6340-227.

7.3.6 Controller ID

A 2-bit (0 to 3) controller ID number is user programmed by a two-section dip switch (S1) located on the top interface module board. This allows each electronics enclosure to be identified and addressed independently by the facility system.

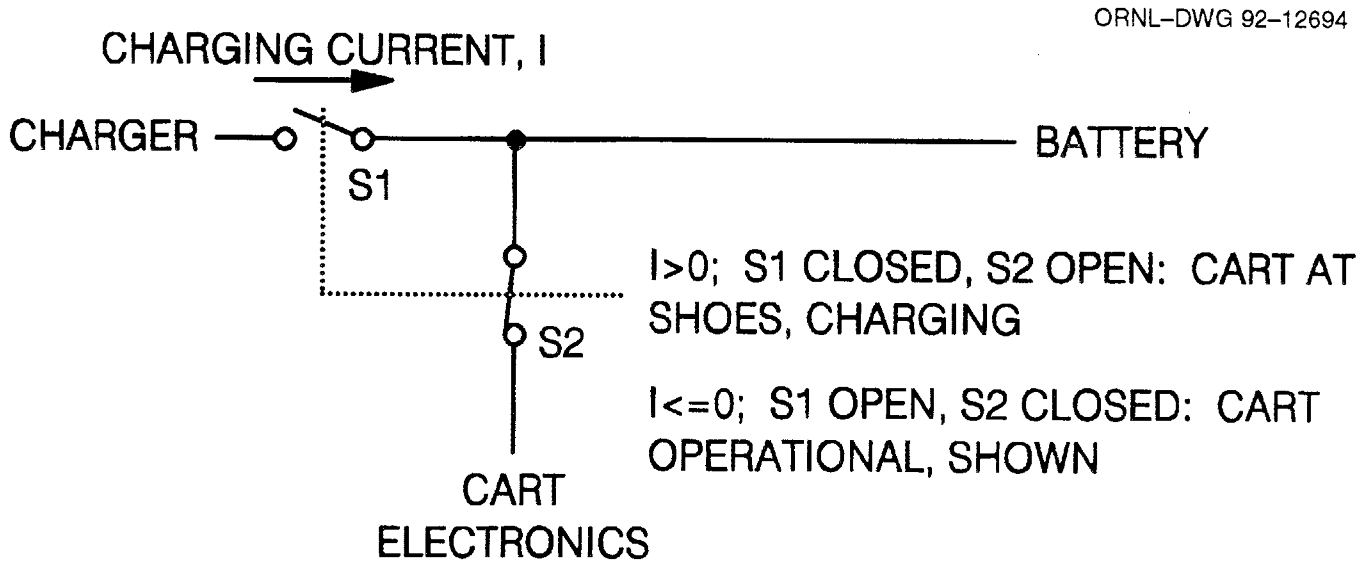

Fig. 7.3. Cart charging switch control.

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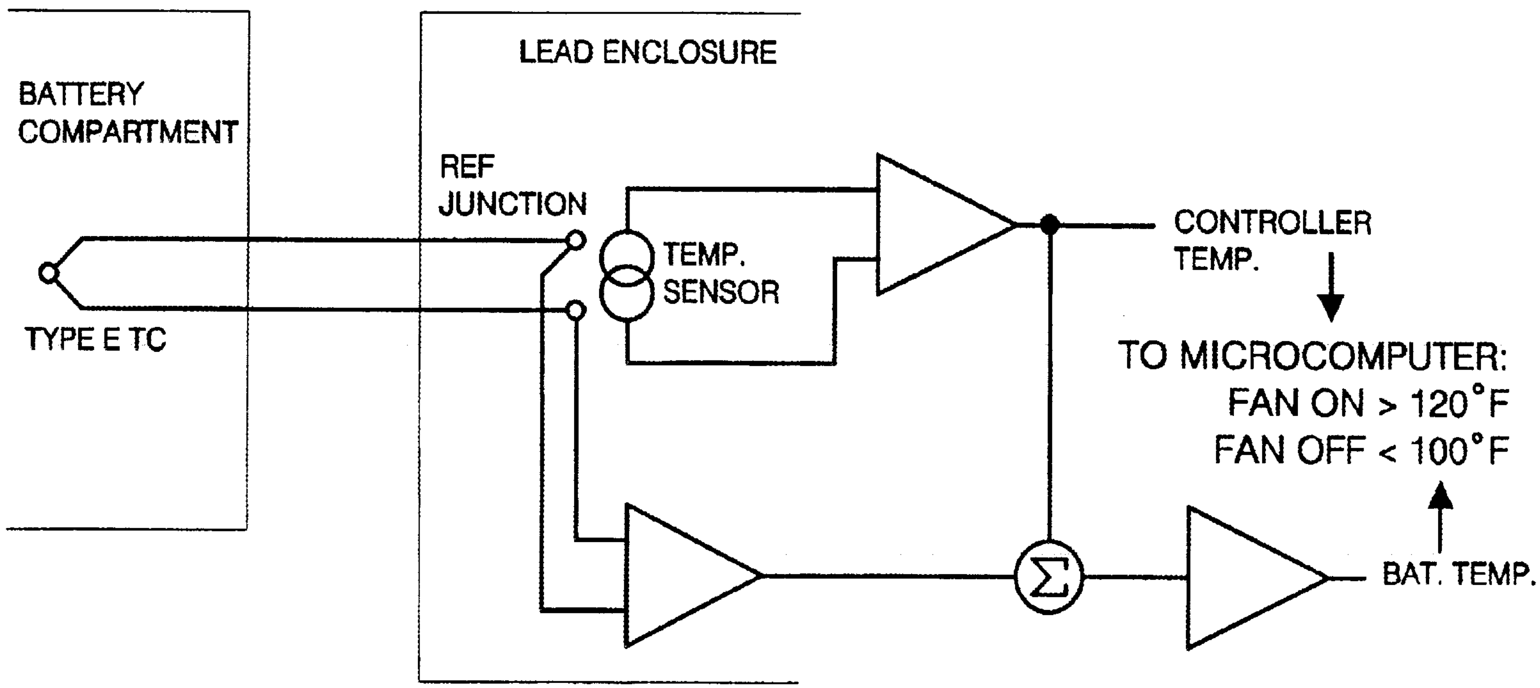

Fig. 7.4. Temperature monitors.

7.3.7 Current Shunt Span Calibration

Figure 7.5 shows a block diagram of the current shunt span calibration circuit. The 5-A precision current source is successively applied to each motor and outlet current shunt. The system controller uses the known 5-A signal to compute the span coefficient for each current channel used in all subsequent current logging. An out-of-range reading will cause the system controller to flag a current channel as bad. Calibration occurs at system bootup and after a system reset is issued by the engineer's console via the communications system. A schematic for the shunt span calibrator is given in Dwg. Q-6340-232.

7.3.8 Fan Control

The fan is controlled by the system controller through the interface module. A software routine in the system controller monitors the controller enclosure temperature from the interface module turning the fan on at 120°F. The fan is cycled off at 100°F. A buffer on the interface module provides drive to the fan. See Dwg. Q-6340-227 for a diagram of the fan interface circuit.

7.3.9 Motor Drives

For each motor drive there are independent control and overcurrent trip signals. Independent signals are used for each motor drive to prevent one failed motor drive from affecting the other motor drives. The motor drive is a standard H-bridge-type drive. Pulse-width modulation signals from the system controller are used to drive the H-bridge through the controller interface based on the motor direction command signals. Motor drive schematics are given is Dwg. Q-6340-223.

7.4 A/D CONVERTER SYSTEM

The A/D converter is a WinSystems Model LPM-AIO-DC. All data transfers to and from the converter occur over the STD bus. See Sect. 9.5 for a description of signals processed by the A/D converter.

7.5 DOOR THRESHOLD LIMIT SWITCH

The door threshold limit switch is used to detect door threshold crossing during cart motion. The threshold limit switch provides a contact closure when activated by a door threshold. The contact closure is buffered by the cart interface module to protect the system controller. Details for the threshold limit mounting are given in Dwg. X3E-020097-A102.

7.6 BATTERY

The final cart design will use two Powersonic Model PS-12400, 40 A-h 12-V batteries wired in series. Based on data obtained during testing of these batteries (see Appendix C), they are capable of providing roughly 2.92 MJ for a 1.75-A cart idle current at 20°F. From measurements made during prototype testing, we estimate that the cart will consume roughly 2 A during idle. Derating (linearly) for 2-A operation and assuming that only 80% of battery energy will be available at the end of battery life gives an available battery energy of 2.05 MJ. For a 2-A idle current, cart energy consumption is summarized in Table 7.1. Therefore, the Powersonic batteries should provide for more than 2 typical cart cycles (4.5-h duration per cycle) or an operating time margin of 5 h.

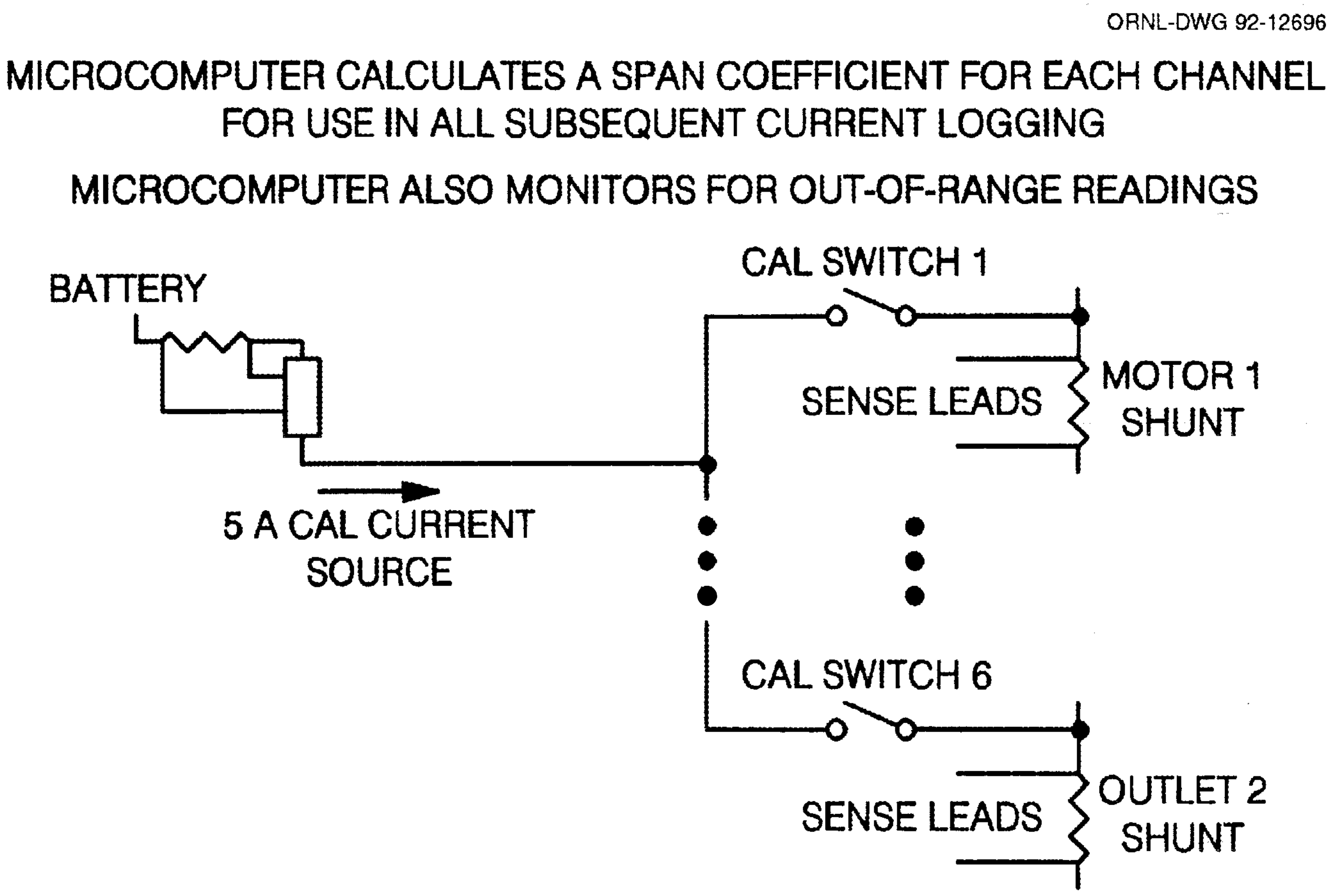

Fig. 7.5. Current shunt span calibration.

Table 7.1. Summary of cart energy requirements for 1 cycle based on prototype testing

Operation	Time (min)	Drive power (W)	Electrical power (W)	Total power (W)	Energy (kJ)
Idle time	255	0	50	50	765
Moving, no load	6.96	92.9	50	142.9	59.7
Moving, full load	7.47	251	50	301	135
Totals	269.4				960

8. CONTROL MODULE ENCLOSURE ASSEMBLY

The control module enclosure assembly contains all of the on-cart controls and electrical equipment to perform all of the cart control functions within a single assembly. The control module enclosure assembly is designed as a remotely replaceable module. The assembly is held in place on the cart by two captive bolts which can be operated by a remote impact wrench. The lifting bail is provided for remote handling by the crane for removal and installation. Alignment guides will be provided on the cart design by WVNS for gross positioning of the assembly. These should provide alignment of the assembly for coupling of the remote electrical connector. A dowel pin in the remote electrical connector provides the final alignment of the assembly. All of the electrical connections between the control module enclosure assembly and the transfer cart are contained in this connector. In the event of failure of any of the cart controls, the entire module can be removed and replaced remotely using only the crane and impact wrench.

Two views of the control module enclosure assembly are shown in Fig. 8.1 and in Martin Marietta Energy Systems Engineering Dwg. X3E020097A102, "WVNS Vitrification Facility Transfer Cart Control Module Enclosure Assembly." The subassemblies included in the control module enclosure assembly are listed as follows and are described in the following sections.

1. Enclosure module
2. Battery compartment assembly
3. Front cover and threshold limit switch
4. Bail assembly
5. Antenna assemblies
6. Shielded electronics enclosure
7. Remote electrical connector assembly
8. Battery charging plate and insulator

The drawings referred to in the following descriptions are Martin Marietta Energy Systems Engineering drawings and are contained in Appendix E.

8.1 ENCLOSURE MODULE

The enclosure module weldment is shown in Dwg. X3E020097A103. The enclosure is an all-welded structure made up of 1/2- and 3/8-in.-thick 304 stainless steel plate. The enclosure design provides two separately sealed compartments. The upper space is for the batteries, which are in a sealed compartment attached to the top cover. The lower space is for electronics which require shielding from the radiation. Both of these are described in more detail below.

The stainless steel enclosure is completely sealed to prevent moisture or nitric acid vapor from entering the electronics or battery compartments. Covers over the top and front compartments are sealed with O-rings. O-ring grooves are machined into the sealing surfaces of the covers. The top cover serves a double purpose as (1) an enclosure for the top and (2) the top of the battery

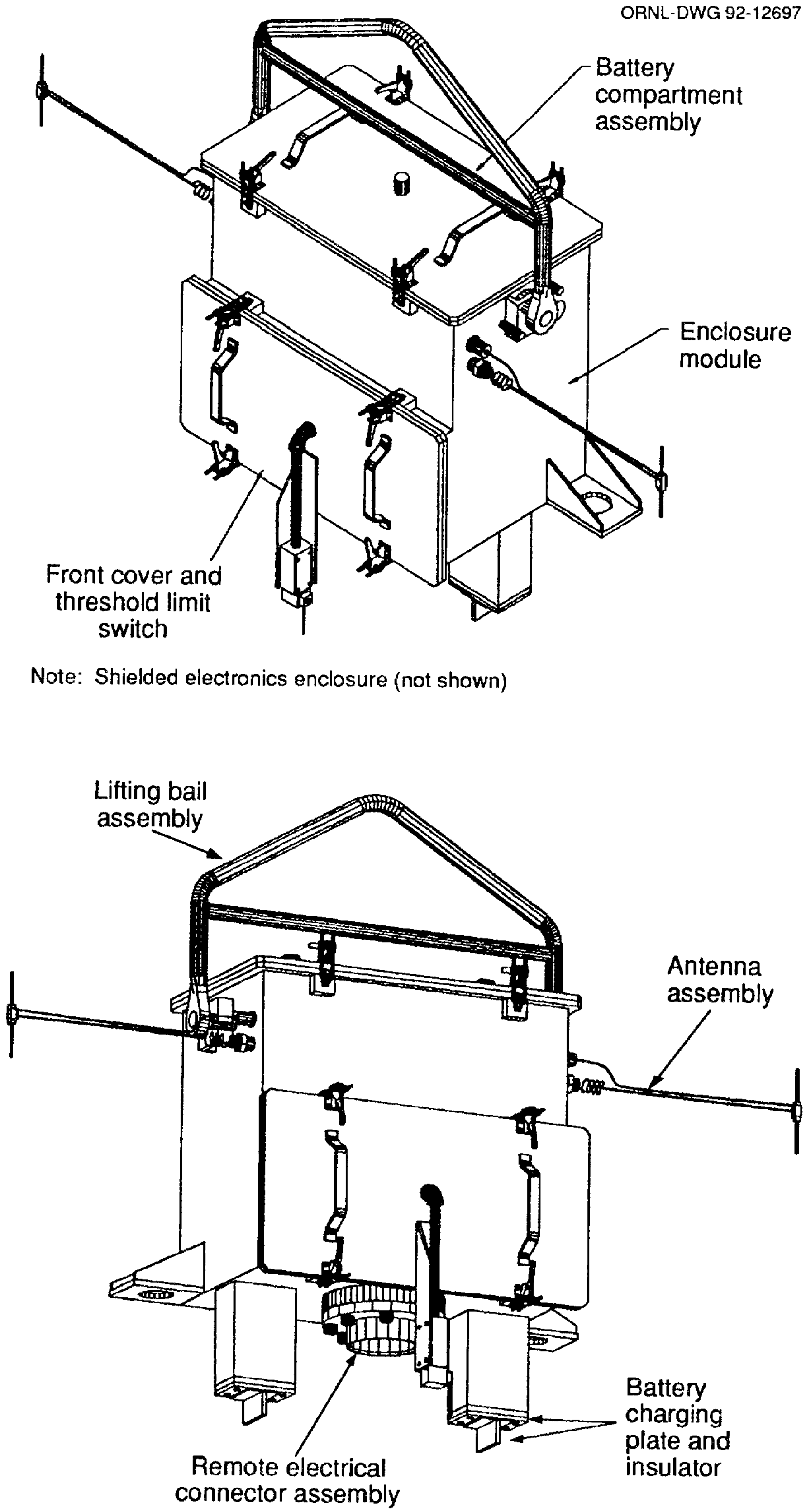

Fig. 8.1. Two views of the control module enclosure assembly.

compartment. The front cover can be removed to provide access to the wiring harness and the motor driver circuit boards. Each cover is held in place by locating pins and four toggle action clamps for easier maintenance. All components on this assembly and within the enclosure are designed to be contact maintained.

On the bottom of the enclosure, two legs, fabricated from rectangular stainless steel tube, extend down for mounting the battery charging plates. The mounting location for the remote electrical connector is located between the legs on the bottom of the enclosure. Access holes are provided in the bottom of the enclosure for cabling to each leg and to the electrical connector. The electrical connector and charging plates are bolted to the enclosure and are sealed with O-rings.

A false bottom and partition are provided inside the enclosure to locate and support the shielding enclosure. The false bottom provides space for routing the cable harness under the shield enclosure to the remote electrical connector and to each of the charging plates.

On each side of the enclosure near the top are two electrical connectors and a stainless steel boss for mounting the antenna. The electrical connectors are Lemo-type bulkhead connectors, hermetically sealed to the enclosure, with all wiring inside the enclosure. The connector nearest the antenna boss is for the antenna cable. The other connector is for the auxiliary electrical outlet. The antenna mounting boss is welded to the side of the enclosure and has internal threads for the antenna to screw into.

On each side near the bottom of the enclosure are the mounting locations for the captured remote hold-down bolts.

8.2 BATTERY COMPARTMENT ASSEMBLY

The battery compartment assembly is a sealed stainless steel enclosure composed of the Enclosure Module top cover and a battery box. The battery compartment assembly is shown in Dwg. X3E020097A105. The battery box is fabricated of 7-gage 304 stainless steel sheet. The battery box is fastened to the top cover using 24 1/4-in.-diam by 3/4-in.-long studs welded to the underside of the top cover.

A small high-efficiency particulate air filter is provided in the top cover of the assembly to vent hydrogen which may be generated during recharging of the batteries. Two handles are also provided on the top cover to facilitate handling for removal or replacement of the battery module. As mentioned previously, the battery compartment assembly is fastened to the enclosure module by four toggle action clamps on the cover. Two locating pins are used to position the top cover on the enclosure.

Inside, the compartment will contain two 12-V, 40-A-h sealed lead-acid rechargeable batteries. An Amphenol/Bendix bulkhead connector is provided in the end of the battery box for connection to the controls wiring harness while keeping the battery enclosure sealed. Also inside the compartment at one end is a lead shield block encased within 7-gage stainless steel. This block is located directly above the ventilation hole in the shield enclosure to help shield the electronics within the shield enclosure.

8.3 FRONT COVER AND THRESHOLD LIMIT SWITCH

The front cover provides access to the wiring harness and the motor driver circuit boards. The front cover also supports the threshold limit switch. The front cover and threshold limit switch are shown in Dwg. X3E020097A106. The front cover is 3/8-in.-thick stainless steel plate. The sealing surface of the plate is machined with a groove for an O-ring seal. The external surface of the cover has two handles for removal or replacement. As mentioned previously, the front cover is fastened to the enclosure module by four toggle action clamps. Two locating pins are used to position the cover on the enclosure.

The threshold limit switch is used to detect door threshold locations to correct errors in the cart position algorithm. The threshold limit switch is mounted on a stainless steel angle bracket welded to the front cover. This bracket positions the limit switch trip lever at the elevation of the door thresholds. A 1/2-in.-diam stainless steel pipe coupling penetrates the front cover for the limit switch cable. The pipe coupling is welded to the front cover, and the cable is sealed in conduit from the coupling to the limit switch. A connector is provided in the limit switch cable inside the front cover to ease removal of the cover.

8.4 BAIL ASSEMBLY

The lifting bail assembly is provided at the top of the enclosure to allow the facility crane to lift the entire assembly for remote removal or replacement. The bail assembly is shown in Dwg. X3E020097A106. The bail assembly consists of the bail, bail mounting bracket, and hinge pin.

All of the bail assembly parts are fabricated from 304 stainless steel. The bail is a weldment of 1 1/2-in. pipe, 1-in. pipe, and a rod end. The bail mounting bracket has a hole for the hinge pin and stops to hold the bail somewhat vertically for pickup by a crane hook. The hinge pin is inserted through a hole in the mounting bracket and is welded into the bail. The mounting bracket will be located at the center of gravity of the Control Module Enclosure Assembly and welded.

8.5 ANTENNA ASSEMBLIES

Two dipole antenna assemblies are provided, one on either side of the enclosure. The cart antenna assembly is shown in Dwg. X3E020097A111. The antennas extend past the edge of the transfer cart for line-of-sight communications with the facility antennas. The antennas have a vertical orientation. See Sect. 3 for details on the cart communication system. The antenna assembly consists of the spring arm weldment, lock nut, antenna, insulator, antenna bracket and coaxial cable.

The spring arm weldment consists of a 3/16-in.-diam spring arm welded into a threaded fitting. The antenna bracket is 16-gage stainless steel and is welded on the other end of the spring arm. The lock nut assembles onto the threaded fitting, which screws into the boss on the enclosure module. All of these components are 304 stainless steel.

Each dipole antenna has two 1/8-in.-diam by 4-in.-long antenna rods of 304 stainless steel. Small copper tabs are silver soldered onto the end of the antenna rods. The coaxial cable leads are soldered to each of the copper tabs. These are then epoxied into the insulator. The insulator is made of PEEK thermoplastic, which also has good radiation tolerance. The insulator is pinned to the antenna bracket with a stainless steel spring pin.

8.6 SHIELDED ELECTRONICS ENCLOSURE

Electrical components not capable of withstanding 10^7 rad are protected in a shielded enclosure with the equivalent shielding of 3 orders of magnitude of reduction. The shielded enclosure is made up of lead encased in a stainless steel liner. The shielded enclosure weldment is shown in Dwg. X3E020097A112. The shielded enclosure weldment consists of three parts: the side shield, the top shield, and the base shield.

All three parts of the shielded enclosure weldment are of similar design. They provide a shield wall thickness of 2.62 in. of lead, lined with 11-gage 304 stainless steel sheet. The base shield, the main shield enclosure, provides a volume of approximately 18 in. long × 11 in. wide × 10.5-in. deep for installing the cart control electronics. The top of the base shield enclosure is open to insert the electronics rack. Another opening is provided on the side of the base shield for routing of the wiring harness. The side shield fits adjacent to the base shield and provides shielding over the side opening and space for the wiring harness. The top shield fits in the top of the base shield and rests on a ledge inside the side walls of the base shield. It has two handles to remove the lid for access to the electronics rack. The top shield also has a small opening for ventilation only. This opening is located above a cooling fan in the electronics rack to circulate air through the electronics and within the enclosure module. The top of the electronics rack is designed to rest on the ledge of the side walls and is held in place by the weight of the top shield.

8.7 REMOTE ELECTRICAL CONNECTOR ASSEMBLY

The control module enclosure assembly interfaces with the transfer cart via the remote electrical connector assembly on the bottom surface. The remote electrical connector is a Hanford Purex-type connector and is shown in Dwg. X3E020097A107. The remote electrical connector assembly consists of the flange, insulator, plug pins, and pin connectors.

The flange is machined from 304 stainless steel. The insulator is a Lexan plate which bolts to the flange. It provides an array of nine plug pins; two pins for each of the four drive motors on the cart plus one for cart ground. The pin connectors are threaded onto the back side of the plug pins. The wiring is soldered into the pin connectors. The pin connectors are sized to handle approximately 90 A, which exceeds the motor stall current. The pins and the insulator are both sealed within the flange using room temperature vulcanization seal compound. The flange bolts to the enclosure and seals with an O-ring.

8.8 BATTERY CHARGING PLATE AND INSULATOR

The battery charging plate and insulator are mounted on the bottom legs of the enclosure. They are positioned to contact the floor mounted charging shoes located between the rails. The battery charging plate and insulator are shown in Dwg. X3E020097A109.

The battery charging plate is a weldment of two 3/8-in.-thick 304 stainless steel plates forming a "T" shape. A 1/4-in.-diam stud is welded to the top plate for the electrical terminal. The insulator plate is 3/4-in.-thick ABS plastic. The charging plate bolts to the insulator plate, with the terminal extending through the insulator. The insulator bolts to the bottom of the enclosure legs and seals with an O-ring seal. The wiring and electrical connections are sealed inside the enclosure legs.

9. SOFTWARE DESCRIPTION

This section describes the system software design for the transfer cart control system. Software will be part of the design of four components of the control system: (1) the engineer's console computer, (2) the PLC, (3) the facility communications controller, and (4) the cart controller. Sections 9.1–9.4 describe software in each of these systems. Drawings that should be referenced in these sections include Dwgs. Q-6340-110, 111, 112, 160, and 210. Section 9.5 describes the communications protocol and command definitions used to communicate between the facility and cart systems.

The software described in this section is low-risk type. The control and data acquisition software is used to physically operate the cart and to generate operating and maintenance diagnostic data. Failure of the cart software can result in only one of two cart failure modes: (1) failure of the cart to operate or (2) unexpected cart operation. For the first mode, cart failure would only impact facility operations associated with waste canister transfer and result in delayed operations. For the second mode, failure of any software described here will not harm personnel, the environment, or equipment. The cells in which the cart travels are not usually occupied by personnel, with the exception of the EDR, where maintenance personnel may enter for maintenance of the cart. Slow speed of the cart and sweeps around the lower portion of the cart lower the probability that maintenance personnel would be injured by unexpected motion of the cart. Impacts on the environment are not foreseen in any mode of failure because the canisters which contain vitrified waste are held in place on the cart with guides and would not be disrupted in the case of a collision. Equipment that could possibly be impacted by the cart in the case of a runaway cart are cell doors and stops located at the ends of the tracks. Both the doors and the stops can withstand the full impact of the cart at its maximum design speed.

9.1 ENGINEER'S CONSOLE COMPUTER INTERFACE SOFTWARE

Refer to flow chart Dwg. Q-6340-110. Software will be running at the engineer's console, an industrially rugged IBM-compatible computer, to provide a man-machine interface between the engineer and the transfer cart control system. The interface software will be Intouch, a commercially available program that has been configured specifically for this application. The engineer will be able to request data trending, alarm and event summaries, and cart status displays from the computer. The computer will log historic data to disk at specific intervals including motor current and voltage; battery current, voltage, and temperature; auxiliary outlet voltage and current; and percent usage of system antennas. Furthermore, the engineer will be able to enter certain cart system commands into the computer that will be processed by the PLC. These commands consist of changing the ID of the cart electronics system with which to communicate, disabling individual facility antennas, requesting a reboot of the cart computer, and increasing or decreasing cart speed. The engineer's computer is not essential to the operation of the cart. Although it is important to log data for diagnostic and operational reference reasons, the cart can operate through use of the operator's pendants without the engineer's computer. Refer to Appendix F for typical operations that can be performed at the engineer's console.

9.2 FACILITY PLC SOFTWARE

The Allen-Bradley PLC is the master of the cart control system. It directs the operation of all other system components either directly through its own hardwired inputs and outputs or through use of the facility communications controller. Software running on the PLC has been defined in a fundamental fashion in Dwgs. Q-6340-111 and Q-6340-112. Algorithms that require more explanation than provided in the drawings are described here. A ladder logic listing should be referenced for more detail.

9.2.1 Cart Position Calculation

The cart position calculation is based on which direction the cart is driving and the duration of the drive request from the operator's pendant. The position will be reported in feet from facility charging shoes to the cart's threshold limit switch. Positive position refers to distance north of the charging shoes, while negative position refers to distance south of the charging shoes, as shown in Fig. 9.1. In the figure, A is the distance to door 63M-001, B is the distance to door 63M-008, H is home position, and C is the distance to door 3M-3 (a negative distance). A timer will be used to produce a pulse every 4 s when a valid drive command is in effect. To provide greater resolution, this may be changed to ten pulses every 4 s. At a nominal cart speed of 15 ft/min, the cart travels 1 ft every 4 s. Therefore, the timer pulse can be used by a counter to count the number of feet the cart has moved. By combining a count-up block with a count-down block, the calculated distance can be made to increase and decrease based on cart direction and cart drive commands.

9.2.1.1 Corrections

The cart position algorithm is based on the duration of the cart drive request and the nominal speed of the cart. It is necessary to have correction capability in the cart distance calculation for three reasons: (1) the cart speed will change based on cart load, (2) an acceleration period will occur before reaching nominal cart speed, and (3) the cart will coast after the drive command ceases.

Two correction modes will be used in the cart position algorithm. The first mode is based on resetting the position when the cart is at the charging shoes. The second mode is based on resetting the cart position to the distance of door thresholds from home position by noting when the cart's limit switch is actuated by the door thresholds.

- Home position. The home position will be confirmed by input from the charging shoes limit switch. When the cart-at-shoes input is received by the PLC, all timers and counters associated with the cart position algorithm will be reset. The position reference point on the cart is the door threshold limit switch. This switch is ~1 ft from the charging plates; therefore, the home position reported will be either ±1 ft, depending on which direction the cart is oriented.

- Door thresholds. Whenever the cart passes a door threshold, the threshold switch attached to the cart will actuate. Since the PLC should know the approximate vicinity of the cart, it can use the door threshold signal to correct its cart position variable to the actual distance of the door it is passing. The reported distance will be from the home position to the cart's limit switch. If the cart is reversed while the limit switch is on a threshold, the correction will still occur but it will be off by the length of the threshold.

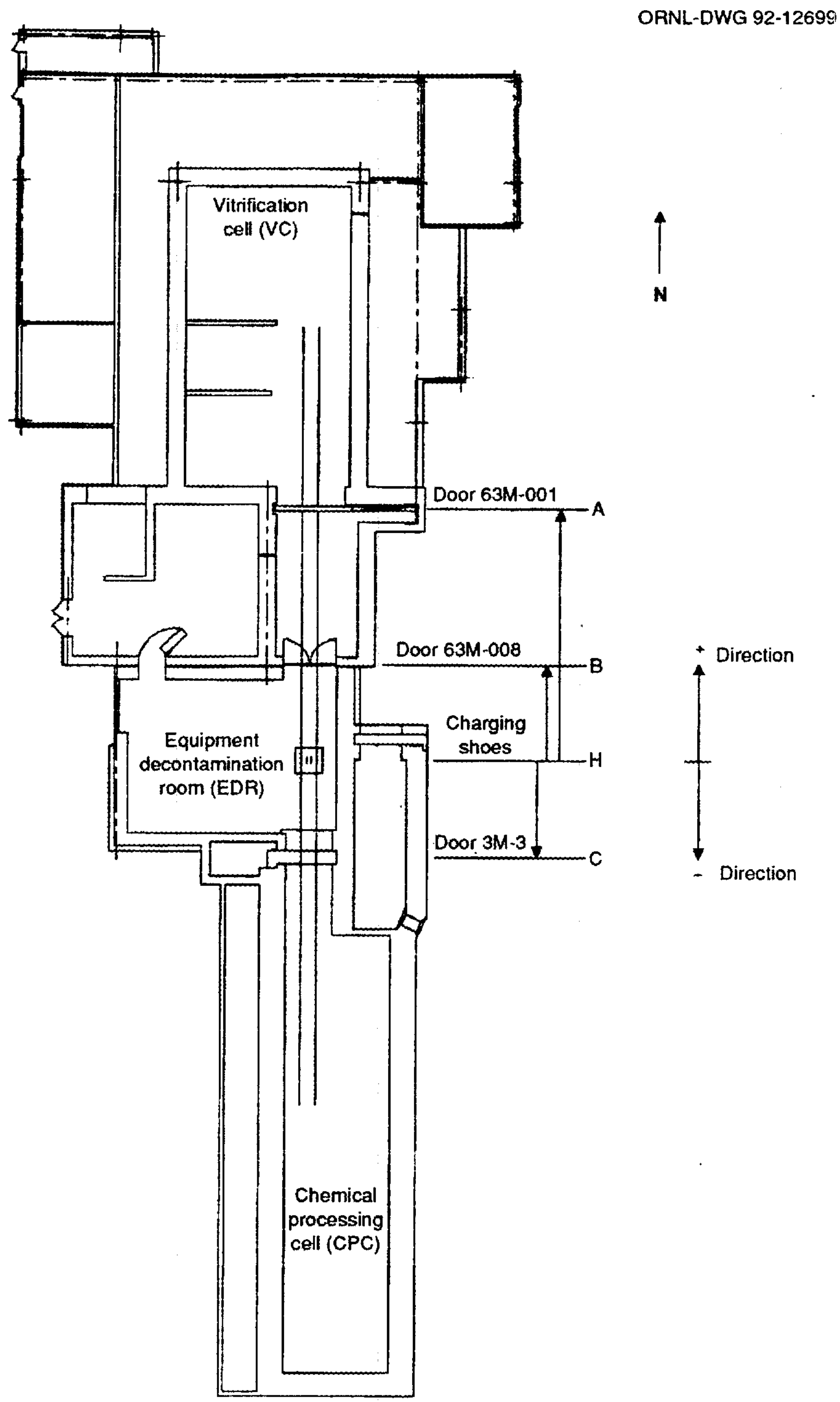

Fig. 9.1. Cart distance definitions for position algorithm.

9.2.1.2 Driving toward unopen door alarm

The cart control system is required to notify the operator when the cart is approaching an unopen door. The cart position algorithm is used to perform this task, but it reports the distance of the limit switch from the charging shoes. Therefore, it is necessary to compensate the cart position for the distance between the limit switch and either the front or back of the cart, depending on which direction the cart is headed. The compensation must also be based on the orientation of the cart. Except for when the cart is driving southward to doorway 63M-008, all alarm distances will be the same (~4 ft from the door). However, when driving southward to doorway 63M-008, the alarm distance must be increased to ~10 ft from the door since these doors will swing toward the cart. Therefore, it is necessary for the PLC to determine to which door and in which direction the cart is approaching.

9.2.2 Battery State of Charge

Three cart battery parameters are used to determine the battery state of charge: (1) voltage, (2) current, and (3) temperature. Energy removed from the battery in a given time period can be determined by multiplying battery voltage by battery current. Testing of the batteries specified for the cart system has shown that at 20°F the batteries can provide ~2.18 MJ of energy before reaching the low-voltage cut-off level. Using this number as the starting value, all subsequent energy usage values are subtracted from this initial value. The energy provided by the batteries as a function of temperature follows the Arrhenius equation but in our range of temperatures is very linear. Using the energy produced by the tested batteries at room temperature and the energy produced at 20°F, a factor of 7 kJ/°F is found. Therefore, the temperature correction factor is added to the instantaneous battery state of charge to obtain the temperature-compensated state of charge.

When the battery is charging, similar calculations can be performed except that energy is added instead of subtracted. However, since the battery has internal losses, more energy will be used charging the battery than what actually appears as the battery's charge level. Because of this, an uncompensated energy level of 2.18 MJ is the maximum that the state-of-charge indication is allowed to read. This level can be reached in two ways. The first method is that the batteries are on charge full time, and the calculation of energy added gradually sums up to this maximum. The second method is that the battery charge current reaches a trickle flow of ~60 mA, indicating full charge. The second method is useful if a new set of batteries are placed in the cart. Because the history of the new batteries is not known to the control system, charging to the point that the charger goes to trickle charge will indicate that the batteries are fully charged.

9.3 FACILITY COMMUNICATIONS CONTROLLER SOFTWARE

Refer to flow chart Dwg. Q-6340-160. Tasks performed by the facility communications controller can be split into two categories: (1) battery charger communications and (2) rf transceiver communications. Since these two modes are mutually exclusive, the controller can dedicate itself to one mode at a time. The PLC will switch the facility communications controller between battery charge mode and transceiver mode. The facility communications controller is a Prolog embedded microprocessor system with an Allen-Bradley interface card, Model 7514, which provides an interface to the PLC's remote input/output. Discrete bits as well as 8-bit bytes containing raw, unscaled analog data will be passed between the Prolog controller and the PLC.

9.3.1 Battery Charger Communications

After every cycle of the cart, the cart will return to the charging shoes to recharge the cart batteries. The cart will remain on float charge until it is needed again. When in the charge mode, cart systems are disabled. The purpose of the facility communications controller in the battery charging mode will be to interface the battery charger to the PLC. The battery charger, Exide Model ERBC 24/30, is equipped with an RS-232 communications line which enables it to pass charging data to the facility communications controller. The communications link is bidirectional in that commands can also be passed to the charger for starting and stopping the charging sequence. To initiate charging, it is necessary to enter the charger's monitor mode. A *START* command is issued, but it is not acted upon until exiting from the monitor mode. In the way the charger is designed, the charger would normally start and provide status reports at either 15-min or 1-h intervals. However, in this application, we would like to know whether charger current is flowing immediately to provide feedback to the PLC that charging is active. Therefore, we must re-enter the monitor mode, where we can request charging data immediately. If the reported charging current is above a minimum threshold, we stay in monitor mode and periodically request charging data from the charger and pass it to the PLC. When a valid stop charge command is received from one of the operator's pendants, the communications controller turns off the battery charger and switches to the transceiver mode.

9.3.2 Transceiver (Tx/Rx) Communications

In the transceiver mode, the communications controller interfaces to the facility rf transceiver system. At ~0.1-s intervals, the facility rf system will transmit to the cart rf system. The commands will originate in the PLC. The protocol and commands are defined in Sect. 9.5. At ~1-s intervals, the facility communications controller will pass a command for the cart to return cart data to the facility. The facility rf system will then be switched to receive this data. When the facility communications controller receives the data, it will place it in shared memory with the PLC and return to the transmit mode.

9.4 CART CONTROLLER SOFTWARE

Refer to flow chart Dwg. Q-6340-210. The cart controller software will run on the WinSystems embedded controller. Note that the cart electronics are disconnected when the batteries are charging; therefore, the cart controller will not be powered, and this software will not be running. When the cart is powered up (or after a HARD BOOT command is issued from the facility) the system will be initialized and calibration checks will be performed on the system A/D converters. After initialization, the cart controller will run an endless loop.

The first step in the loop is for the cart controller to read and store system data points. It will then act on the data it receives. For instance, if the cart electronics temperature is high, it will switch on the cart fan.

9.4.1 Data Packet Status

The next step is to check for a communications packet from the facility. Three modes are envisioned for cart drive and auxiliary outlet switching based on the status of the data packet.

9.4.1.1 Valid data packet received

When a valid data packet is received that contains either a cart drive command or an auxiliary outlet enable command, the commands will be acted upon. When a valid data packet is received that does not include a drive command nor outlet enable command, the cart motors and auxiliary outlets will immediately be disabled.

9.4.1.2 Bad data packet received

If a bad data packet is received and the previous data packet did not contain a drive command nor outlet enable command, no drive or outlet will be enabled. However, if a bad packet is received and the previous valid packet included a drive command or outlet enable command, the cart drive or outlet enable will be continued for a short interval. If after this interval bad data packets are still being received, the auxiliary outlets will be disabled. However, if in the cart drive mode, the cart will go into a null location avoidance routine. In this routine, the cart motors will stay enabled for a short period, as discussed later, to continue to drive the cart in an attempt to move out of an rf signal null location. However, the cart will not be allowed to move farther than the maximum stopping distance (6 in.) stated in the project design basis. It is estimated that with the dynamic braking provided by the cart motor controllers, the maximum distance the cart will roll after the motor drive is disabled is 1 in. That distance allows a maximum roll distance of 5 in. before issuing a stop command. Then, at the nominal cart speed of 15 ft/min (3 in./s), the maximum time delay before disabling motor drivers is 1.67 s. To ensure that the cart will roll through a signal null location, the cart should be allowed to roll at least the quarter wavelength of the communications system. At the communications carrier frequency of 915 MHz, the quarter wavelength is 3.23 in. Therefore, if the cart is allowed to go at least 3.23 in., the minimum delay that should be used in this routine (at the nominal cart speed) is 1.08 s. In summary, the delay provided by the null location avoidance routine should be between 1.08 and 1.67 s. The additional distance moved by using the routine should be enough to drive the cart out of the rf signal null.

9.4.1.3 No data packet received

If no data packet is received and the previous valid data packet did not include a drive command or outlet enable command, no drive command or outlet enable command will be passed to the cart. However, if the previous valid data packet included a cart drive request or outlet enable command, the cart drive or outlet enable will be continued for a short interval. After this interval, if no data packet is received, the cart will stop and the outlets will be disabled. The duration of the interval is expected to be ~0.3 s, which should stop the cart well within the maximum stopping distance requirement.

Finally, the cart controller will check for a report status command from the facility. If this command is received, the cart controller will switch the rf system to transmit, transmit the status packet, and return to the receive mode.

9.5 COMMUNICATIONS PROTOCOL AND COMMAND DEFINITIONS

The transmission of data and commands between the transfer cart and the facility control system requires additional processing over that provided by the control system biphase encoder/decoder hardware. This additional processing is performed in software by the transmitting and receiving microprocessor systems and made possible by a communications protocol. A communications protocol is a technique for organizing bytes of binary data into a structured data packet for transmission and reception. Using a protocol provides the software mechanism for detecting communication errors in addition to the hardware error detection for tagging data packets as intended for a particular receiver and transmitting raw data (e.g., such as might be read from A/D converters). This results in significantly reducing the risk of the raw data causing decoding errors at the receiving end.

9.5.1 Reasons for Using a Communications Protocol

Since there can be two cart communication systems in operation simultaneously (one operating and one on standby) it is necessary to provide a means for each individual cart electronic system to determine if a received command is intended for it. The communications protocol has an ID byte reserved for this purpose. When a cart electronic system receives a command that requires transmission of data back to the facility computer, the system's hardware-jumpered ID number is read and compared to the ID contained in the received data packet. If the two IDs compare, then the command will be performed; otherwise, the command is ignored. Since it is conceivable that the electronic hardware that provides the local cart system ID could fail, only commands that request transmission of status data are subject to this test. This precaution was taken to reduce the number of items that, when failed, would result in a stranded cart. This scenario works because it does not matter if a cart system on standby performs any of the other commands since it has no motors connected. On the other hand, more than one cart system transmitting simultaneously will cause garbled transmission to the facility.

If the various A/D readings taken by the active cart's internal controller are transmitted back to the facility without the using a protocol, there is a high probability that the cart system on standby will interpret the data as a valid ID followed by a valid command. This could cause the standby system to start transmitting data while the on-line cart system is transmitting. The communications protocol places the ID byte in a predetermined position in the transmitted packet and frames the data bytes with predetermined values. This makes it possible for the receiving end to perform tests on packets to greatly reduce the probability of false decoding.

A third justification for using a communications protocol is that the number of bytes in each transmitted packet can be included as information in the packet. The CRC circuit used in the hardware to test for communication errors requires 16-bit data for correct operation. If an odd number of bytes are transmitted, the CRC circuit at the transmit end will append a null data byte to the end of the packet to produce a 16-bit value. The number of bytes sent as information in the transmitted packet enables the receiving end to detect these null bytes and strip them off.

9.5.2 Description of the Communications Protocol

The communications protocol for the transfer cart is described below. Under this protocol, all data and command bytes will be transmitted in a packet format using the following structure.

9.5.2.1 Transmitted data

A graphical representation of a transmitted packet is shown below with the first byte starting at the left. The definition of each byte is explained in the following paragraphs.

NCHAR	STX	STX	ID	$DATA_1$---$DATA_{(NCHAR-3)}$	ETX	ETX	CKSUM

Number of characters. The first byte transmitted will be the number of bytes in the packet represented as an 8-bit binary number. This byte field will be referred to as the mnemonic NCHAR. The byte count is the actual number of bytes transmitted including NCHAR and CKSUM.

Head of data frame. The second and third bytes will always be the ASCII code for the start of the text and will be referred to as the mnemonic STX.

ID byte. The fourth byte is designated as the identification byte and will reflect the intended receiver of the packet. This byte is referred to as the mnemonic ID. Five ID bytes are defined in the following table.

Table 9.1. Cart ID byte definitions

ASCII	Hex	Binary	Description
*	0x2A	00101010	Cart 1 ID character
U	0x55	01010101	Cart 2 ID character
%	0x25	00101001	Cart 3 ID character
p	0x70	01110000	Cart 4 ID character
f	0x66	01100110	Facility ID character

Data fields. The next field of the packet is the data field where the transmitted data or commands are stored. This is a variable length field and can range from 1 to 41 bytes long. The maximum number of bytes contained in a transmitted packet must not exceed 48 because the hardware FIFO buffers used in both the transmit and receive circuits are 48 bytes deep. The packet protocol has an overhead of 7 bytes, leaving a maximum of 41 bytes available for data or commands. In the case of transmitting multiple commands to the cart, the ordering of the commands in the data field determines the priority of execution (i.e., the commands are executed in the order they are received, starting with the first data byte.)

Tail of data frame. Byte position NCHAR – 2 and NCHAR – 1 will always be the ASCII code for end of text referred to as the mnemonic ETX.

Check sum. Byte position NCHAR will always be the check sum of all the previous bytes and will be referred to as the mnemonic CKSUM. The check sum is calculated by simply adding each byte to an initial 8-bit value of 0 and ignoring overflows. The receiving end performs the identical operation on the received packet and compares the answer to the transmitted check sum.

9.5.2.2 Received data

The following steps can be applied to test a received data packet for errors. Steps 1 and 2 are mandatory. Step 3 can be used for an even higher level of confidence that a good packet has been received without data corruption.

Number of characters. First, test to determine the number of characters sent (NCHAR) is an odd or even number. Because the biphase hardware uses 16-bit technology to perform the CRC on transmitted and received data, the board will add a null byte to the end of the packet if an odd number of bytes is transmitted by the biphase board. This null byte will cause the receiving process to receive one more byte than was in the original packet. If NCHAR is odd and the actual number of characters received is NCHAR + 1, then subtract 1 from the number of characters received and assume the correct number was received. If the number of characters received (NCHAR) is an even number, then NCHAR should equal the number received.

Check sum. Calculate the check sum of the received data packet by doing a modulo 256 sum of all the bytes in the packet except the last byte (CKSUM). This sum must equal the CKSUM value in the last byte if the data packet is to be considered a good packet.

Data frame. To help ensure against the unlikely occurrence of a compounded data corruption which results in a correct CKSUM calculation even though an error has occurred, test that the data frame is correct. The second and third bytes in the packet must be equal to STX, and the bytes at NCHAR − 1 and NCHAR − 2 must be equal to ETX.

9.5.3 Exception to Communications Protocol

An exception to the packet protocol occurs when a HARD BOOT command must be sent to the cart from the facility. If the cart's microprocessor control system becomes locked in a nonresponsive state, it will not execute commands sent from the facility. To recover from this condition, the receiver portion of the digital communications circuit is equipped with a hardware reset function. This function will reset the microprocessor system by forcing the reset line low on the computer bus. This feature is implemented in the receiver hardware by comparing for two consecutive occurrences of a predefined 8-bit pattern in the incoming byte stream. This pattern must occur on an odd/even byte boundary, and the comparison is made only on the incoming data to the cart and not on outgoing data nor does the facility receiver have this feature. Because of this, raw data being transmitted from the cart will not trigger false hardware resets. The HARD BOOT command is executed by sending a minimum of six pairs of the reset code, starting with the first byte. The reset will probably occur on the first or second pair, but six pairs are sent to ensure that the reset code is detected. The extra pairs are of no consequence since the receiver hardware is also reset, which results in the additional pairs being cleared out. The reset code has been defined as the hexadecimal value F0. The 8-bit binary pattern for this value is 11110000. The following diagram depicts the HARD BOOT data packet. The dip switch on the cart biphase encoder/decoder, which determines this reset code, should be set to this value (See Sect. 6.7.3.9).

F0	F0	F0	F0	F0	F0	F0	F0	F0	F0	F0	F0

9.5.4 Facility Commands to Cart

Table 9.2 defines the commands the facility can send to the cart.

Table 9.2. Facility commands to the cart

CMD char	Hex value	Description of command
>	3E	Drive forward
<	3C	Drive backward
X	58	Report status
A	41	Reset Motor 1
B	42	Reset Motor 2
C	43	Reset Motor 3
D	44	Reset Motor 4
0	30	Enable Outlet 1
1	31	Enable Outlet 2
N	4E	Null packet
+	2B	Increase speed
-	2D	Decrease speed
T	54	Acknowledge door threshold

The Drive forward, Drive backward, Enable Outlet 1, and Enable Outlet 2 commands must be sent repeatedly to remain active. If one of these commands is in effect and three consecutive valid transmissions are received without the command present or if communications to the cart stops for more than 0.3 s, the command will be canceled. The other commands are executed only once when received and must be retransmitted before they will be executed again. The Increase speed and the Decrease speed commands increase or decrease the cart speed by a small amount each time they are executed. This speed change will remain in effect until changed by another speed change command or until the cart is reset or powered off.

The Increase speed and Decrease speed commands are not system requirements for this project but have been added for convenience. We anticipate that the pulse-width-modulated signal used for motor speed control will require modifications to obtain the desired nominal cart speed of 15 ft/min. Without the capability to change this speed from the engineer's console, the programmable read-only memory (PROM) of the cart control system would have to be reprogrammed each time a new speed set point is tried—an exercise that may take several iterations during cold testing. By having this capability, the speed set point can be adjusted to the appropriate level remotely during cold testing and the final value then programmed into the cart PROM only once. At that time, if the ability to increase or decrease speed is no longer needed, it can be removed from the software (no hardware modification is required in either case).

Below is a graphical representation of a communication packet sent to Cart 1 commanding continued forward motion, reset Motor 2, and requesting a cart status report. The first row is the packet in mnemonic form, and the second row contains the actual hexadecimal values sent in the correct byte order.

NCHAR	STX	STX	*	>	B	X	ETX	ETX	CKSUM
0A	02	02	2A	3E	42	58	03	03	16

9.5.5 Cart System Status Report

Table 9.3 defines the returned data packet from the cart after the facility has requested a status report. Byte No. 22, status bit flags, contains information based on the state of the individual bits. These bits flags are defined in Table 9.4, where LSBit and MSBit refer to least significant and most significant bits respectively.

Table 9.3. Cart system status report

Byte No.	Contents	Description
1	NCHAR	Number of bytes in packet
2	STX	ASCII start of text (0x02)
3	STX	ASCII start of text (0x02)
4	ID	Facility ID (ASCII character f)
5	DATA1	Motor 1 voltage
6	DATA2	Motor 2 voltage
7	DATA3	Motor 3 voltage
8	DATA4	Motor 4 voltage
9	DATA5	Motor 1 current
10	DATA6	Motor 2 current
11	DATA7	Motor 3 current
12	DATA8	Motor 4 current
13	DATA9	Battery voltage
14	DATA10	Battery current
15	DATA11	Battery temperature
16	DATA12	Outlet 1 voltage
17	DATA13	Outlet 2 voltage
18	DATA14	Outlet 1 current
19	DATA15	Outlet 2 current
20	DATA16	Electronics enclosure temperature
21	DATA17	Percent usage of Antenna 1
22	DATA18	Status bit flags
23	DATA19	ID of sender (*, U, %, or p)
24	ETX	ASCII end of text (0x03)
25	ETX	ASCII end of text (0x03)
26	CKSUM	Modulo 256 sum of bytes 1 to 25

Table 9.4. Cart status bit flags

Bit position	Definition
LSBit	Door threshold detect
1	Motor 1 overcurrent trip
2	Motor 2 overcurrent trip
3	Motor 3 overcurrent trip
4	Motor 4 overcurrent trip
5	Outlet 1 overcurrent trip
6	Outlet 2 overcurrent trip
MSBit	Calibration shunt error

10. SUMMARY AND CONSIDERATIONS

This report documents the design of a control system for the West Valley transfer cart at the time detailed hardware design and prototype testing are complete. Software has been developed to the stage that it was used for integrated hardware testing, but more development will be required to bring it to the level of being ready for the entire control system and to work out some problems that surfaced during integrated hardware testing. The results of the hardware testing indicate that the system should operate as designed. However, minor modifications will almost surely be necessary when the control system is tested and installed at the West Valley site.

All design and operating personnel should be aware of subtleties in the control system design that may or may not present a problem at some phase of operation. Some of these points were discussed in design review meetings and are included herein only for formal documentation. Other points also developed during integrated testing. The considerations are listed somewhat in order of priority.

1. Absence of cart stop switch. The transfer cart was designed with only two cart modes: run and battery charge. If the cart is abandoned for a long period of time, its battery will discharge and it will be unable to drive itself back to the battery charger.

2. Facility antenna design. There are tradeoffs to be made between the rf characteristics, the flexibility, and the rad hardness of the push-through rods for the facility antennas. Some rf measurements have been performed in a laboratory that show that the first choice for materials and cables did not have sufficient rf characteristics (there were many reflections from a design with an aluminum base). Other materials and cables have been specified in the final design, but time did not allow for the fabrication and testing of the system. More time may be needed either in the lab or at the facility to verify the optimum antenna system.

3. Engineer's console data retention. If the control system does not receive new incoming data from the cart, the memory will retain old values of variables. This could be confusing in that it may make it appear that the cart is still operating normally when it fails to transmit new data. It may be necessary to zero the values when no new data is received to avoid this confusion. This condition also occurs when the cart ID is changed and no other cart system is active.

4. Cart diversity antenna minimum switching rate. Because switching logic of the cart antennas is triggered on the rising edge of the first facility carrier that occurs after the cart transmitter has shut off, the cart reception signal cannot be switched between cart antennas any faster than the carrier pulse rate of the facility rf system. At present, the facility carrier stays active for almost 1 s, and then switches off to allow reception of the cart status signal. Therefore, although command messages are sent to the cart every 0.1 s, the cart is unable to switch between its receiving antennas any faster than once every 1 s. Given the many design features

to prevent a signal null from stopping the cart, this does not present a major problem at this time.

5. Emergency stop functionality. Because the emergency stop function eliminates communications with the cart, requests for cart data cannot be sent. Therefore, during an emergency stop condition, cart status is no longer known. Only two operating modes are provided for the cart: battery charging and cart operation. It is not desirable to kill the cart since, then, there would be no way to restart it remotely. When emergency stopped, the cart will be in an idle mode, not completely dead.

6. Door interfacing fail safety. When a door is energized, it prevents all cart operation. Fail-safe circuitry of the door-energized inputs should be addressed to ensure that a failed door energized status will prevent cart operation. Limit switch circuits which indicate an open door should be addressed in a similar manner, as they are used to warn when the cart is approaching an unopen door.

7. Engineer's console heat load. No formal heat loading analysis was performed on the engineer's console. The cabinet contains much heat-producing equipment. A fan was specified for cooling, but its effect at keeping the cabinet below reasonable temperatures for the electronic equipment is not known.

8. Cart reboot command. The cart reboot command will reboot any electronics rack that is on-line. For example, if communication to a spare electronics rack is desired and a cart reboot command is given, the cart reboot command will also reboot the operating cart electronics rack.

9. Facility antenna disable function. If a facility antenna is disabled, the engineer must remember to reenable it later—there is no alarm or flag to remind him to do so. If it is always necessary to disable an antenna when the cart is at a certain position, the PLC could be programmed to disable and then reenable the antenna.

10. Engineer's console trackball. Because the engineer's console software is Windows based, it would be more operator efficient to have a trackball as a pointing device. However, as configured, no trackball was specified for the system. All of the Windows features should still be accessible through keystrokes, but if after the unit is installed it becomes obvious that a trackball is needed, options should be investigated for interfacing a trackball to the unit. Since two serial ports are already being used on the computer, a bus trackball should be specified.

11. Cart speed control. Although the cart speed can be changed at the engineer's console, the speed is not retained by the cart microprocessor after a cart reboot. After cold testing, the nominal cart speed should be programmed into the cart microprocessor PROM so that it is the default after booting up.

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APPENDIX A
ANALYSIS OF THE SHIELDING DESIGN FOR THE WEST VALLEY FACILITY VITRIFICATION CART

C. O. Slater
ORNL Engineering Physics and Mathematics Division

May 31, 1991

INTRODUCTION

In an April 1991 meeting, a proposed shielding design for the West Valley Vitrification Facility cart was discussed. The shielding thickness was determined using a handbook estimate of the attenuation of the dominant gamma-ray source. Following a modification to the initial shielding design, detailed calculations were performed to verify the adequacy of the shielding design. Results of the analysis are presented.

SHIELDING DESIGN

The modified shielding design is shown in Fig. A.1. Important dimensions are noted on the figure. The main areas of concern are the shield openings where radiation may stream into the cavity housing electronics and batteries. Section B-B shows the top opening and Section C-C shows a lower side opening. Dimensions for each opening are given in Sections C-C and B-B, respectively. The cavity dimensions are shown in Section A-A. The shielding material is steel-encased lead.

RADIATION SOURCE

The background radiation source is about 10^3 rad/hr and is due to waste in the canisters. The radionuclide inventory in an average canister in 1990 is shown in Table 1. The source for the shielding calculations was obtained first by inputting the Curie inventories of the major isotopes (those with greater than 200 Curies) into the ORIGEN/S computer code to calculate the gamma-ray spectrum in the 18-group energy structure used in the shielding calculations. Next, the ORIGEN gamma-ray source was used as input for a 1-D cylindrical ANISN calculation for one of the canisters, which is described in Fig. A.2. The 1-D ANISN cylindrical surface flux was then adjusted using dose conversion factors to give 10^3 rad/hr on the surface of the cart. An isotropic angular flux was assumed. Table 2 shows the energy group structure, ORIGEN spectrum, the ANISN surface flux, the dose conversion factors, and the surface flux (with the ANISN spectrum) that gives a 10^3 rad-Si/hr dose rate.

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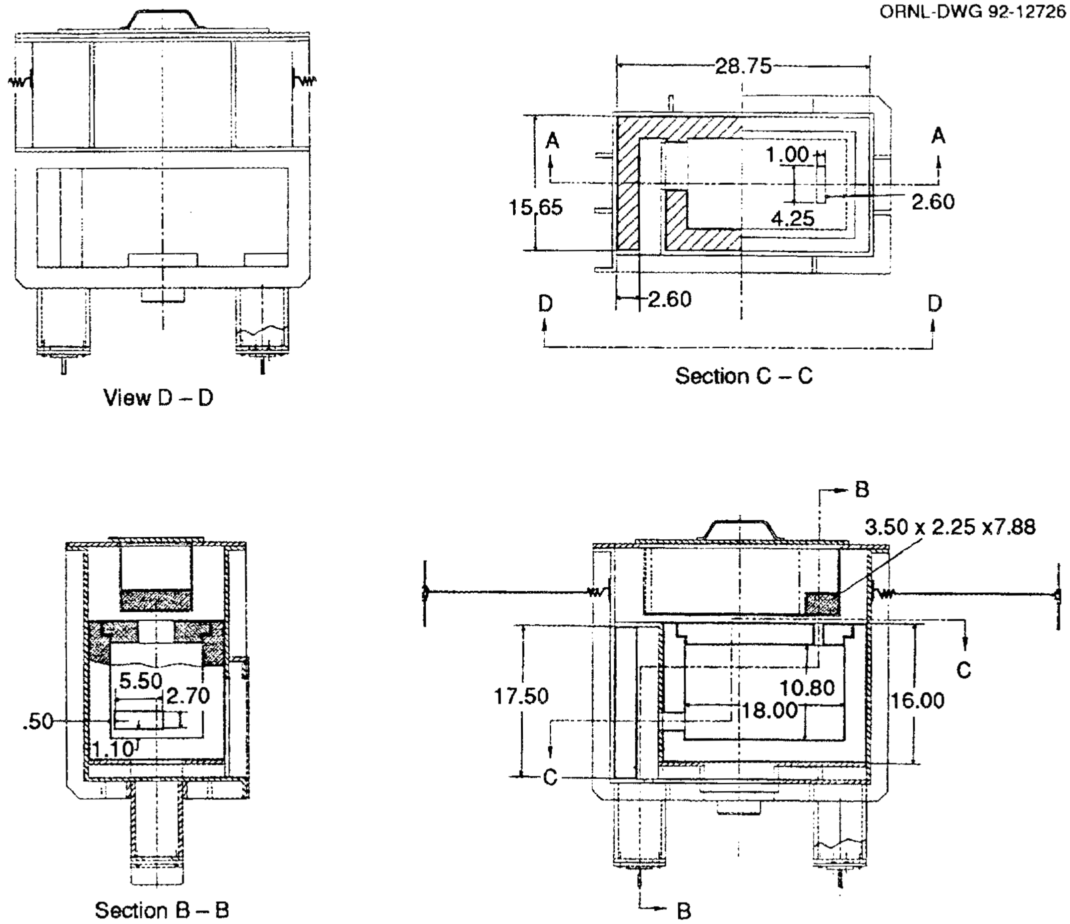

Note: Dimensions in inches

Fig. A.1. Proposed shielding design for the West Valley Vitrification Facility cart.

Table 1. Radionuclide inventory for an average West Valley Nuclear Services cãnister for the year 1990

Isotope	Activity (Curies)
3-H	0.00
14-C	0.00
55-Fe	2.76
59-Ni	0.42
63-Ni	30.18
60-Co	3.03
79-Se	0.01
90-Sr	26,330.25
90-Y	26,337.24
93-Zr	1.07
93m-Nb	0.72
99-Tc	0.43
106-Ru	0.06
106-Rh	0.06
107-Pd	0.04
125-Sb	28.55
125m-Te	7.00
126-Sn	0.41
126m-Sb	0.41
126-Sb	0.06
129-I	0.00
134-Cs	20.33
135-Cs	0.63
137-Cs	28,341.24
137m-Ba	26,811.19
144-Ce	0.00
144-Pr	0.00
147-Pm	345.02
151-Sm	331.40
152.Eu	1.43
154-Eu	375.11
155-Eu	93.68
232-Th	0.01
233-U	0.04
234-U	0.02
235-U	0.00
236-U	0.00
237-Np	0.09
238-U	0.00
238-Pu	32.58
239-Np	1.36
239-Pu	6.39
240-Pu	4.68
241-Pu	316.95
241-Am	209.91
242-Pu	0.01
242-Am	1.16
242m-Am	1.17
242-Cm	0.96
243-Am	1.36
243-Cm	0.53
244-Cm	30.04
245-Cm	0.00
246-Cm	0.00

Canister Radiation Source Information

for WVNS Canisters

Source Geometry on Transfer Cart

Four canisters located on 26" centers

23.7" diameter by 94.8" tall right cylinder source region

Surrounded with 3/16" 304L Stainless Steel

Source Density

2.7 gm/cc

Fig. A.2. Characteristics of the West Valley Nuclear Services canisters.

Table 2. Energy Dependent Data Used in the Analysis of the West Valley Vitrification Facility Cart's Shielding Design

Upper Energy Group	ORIGEN (MeV)	Dose gammas/s	ANISN Surface Response[b]	Surface Flux[a] for 10^3 rad/hr Flux[a]	Dose Rate
1	11.0	1.718	1.2767-5[c]	-	0.0
2	8.0	2.683+01	8.3884-6	-	0.0
3	6.0	4.111+02	6.1319-6	-	0.0
4	4.0	1.376+03	4.4006-6	-	0.0
5	3.0	1.869+03	3.5289-6	-	0.0
6	2.5	3.285+09	2.9820-6	5.0951+0	3.2970+3
7	2.0	4.345+11	2.4185-6	6.1009+2	3.9478+5
8	1.5	8.892+12	1.8266-6	1.1274+4	7.2955+6
9	1.0	1.324+13	1.3252-6	1.6489+4	1.0670+7
10	0.7	1.042+15	9.5663-7	9.1293+5	5.9075+8
11	0.45	3.199+13	6.6280-7	4.5835+5	2.9659+8
12	0.3	7.526+13	4.0334-7	6.9855+5	4.5202+8
13	0.15	7.403+13	2.6835-7	1.3823+5	8.9448+7
14	0.1	8.502+13	3.0092-7	1.6932+4	1.0956+7
15	0.07	1.287+14	5.2081-7	7.1817+2	4.6472+5
16	0.045	1.849+14	1.1560-6	3.6567+0	2.3662+3
17	0.03	1.504+14	2.6596-6	-	0.0
18[d]	0.02	6.199+14	8.1349-6	-	0.0

[a] Units are gammas/cm^2.s.

[b] Units are rad-Si/hr.

[c] Read as 1.2767 x 10^{-5}.

[d] Lower energy boundary is 0.004 MeV.

CALCULATIONS AND RESULTS

Two DORT 2-D X-Y discrete ordinates calculations were performed to confirm the adequacy of the shield design. A calculation using an elevation view of the cart (Section B-B of Fig. A.1) was performed to assess gamma-ray streaming through the top opening of the shield to the cavity. Similarly, a calculation based on a plan view of the cart (Section C-C of Fig. A.1) assessed gamma-ray streaming through the lower side opening of the shield to the cavity. The calculations are conservative in that the openings through the shield are infinite in the third dimension. Such openings should permit more gamma rays to stream into the cavity than would enter if the third dimension of the opening were finite.

Results of the calculations are shown in Figs. A.3 and A.4. The figures show isodose rate contours in the shield and within the cavity. As mentioned earlier, the calculations used an isotropic angular flux as a surface source. The flux had been adjusted to give a 10^3 rad/hr dose rate at the surface. However, since only half of the flux was directed into the cart, the figures show about 500 rad/hr dose rate at the surface of the cart. The important result is the reduction of the dose rate by the shield. For the top opening, Fig. A.3 shows about a factor of 500 reduction, while Fig. A.4 shows slightly greater than a factor of 1000 reduction for the side opening. Although the calculation for the top opening does not give the desired factor of 1000 reduction within all of the cavity, such a reduction can be achieved by locating sensitive equipment at least 6 cm from the top of the cavity. In both cases the dose reduction is at least a factor of 1000 relative to the background dose rate of 1000 rad-Si/hr. Thus, the shielding design appears to be adequate.

SUMMARY

Conservative DORT 2-D X-Y discrete ordinates calculations were performed for the West Valley Vitrification Facility cart. A goal of a factor of 1000 reduction in the dose rate in the cavity relative to background appears to have been achieved by the proposed shielding design. More detailed confirmatory calculations should not be necessary.

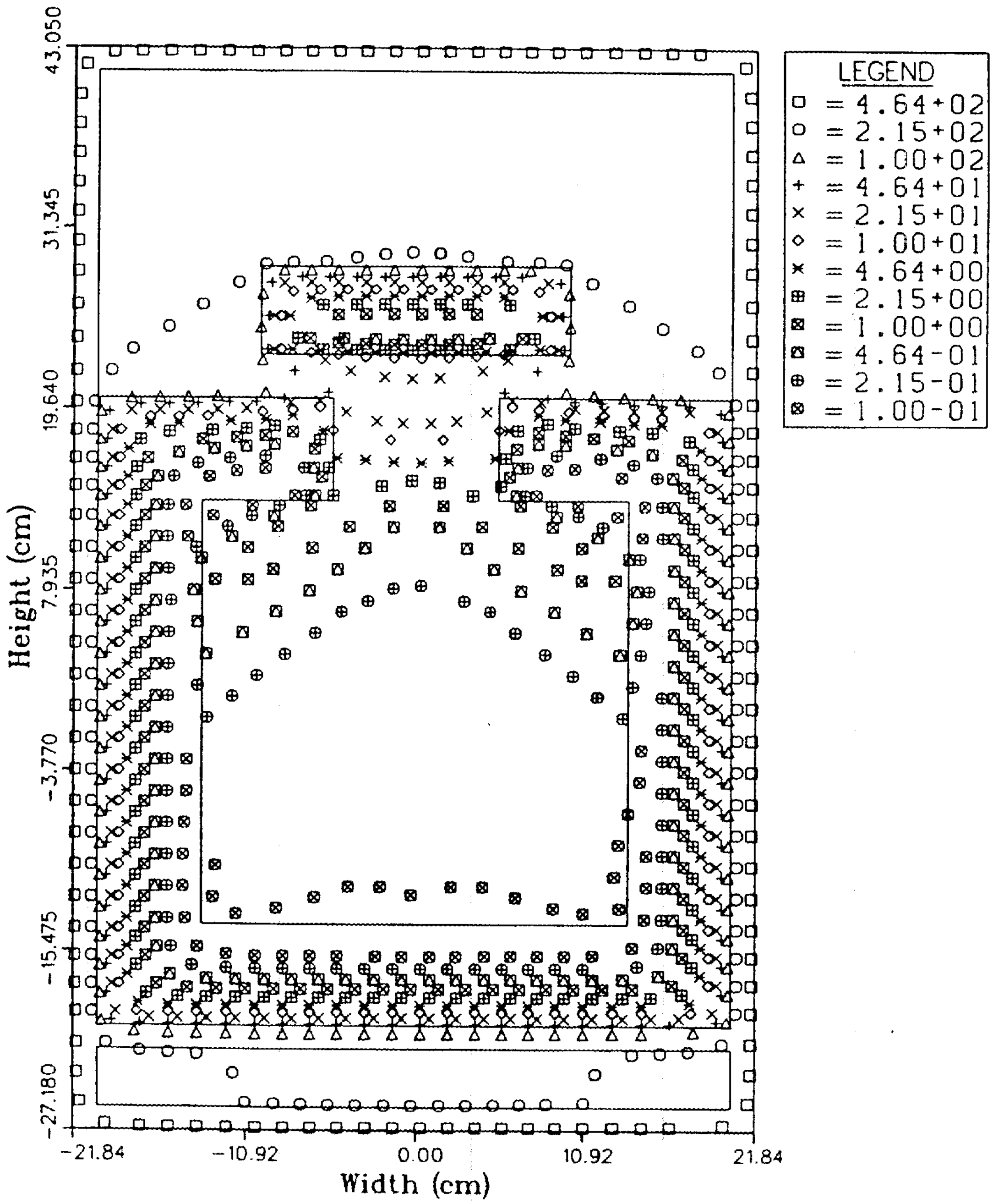

Fig. A.3. Gamma-ray isodose rate contours (rad-Si/hr) for an elevation view model of the West Valley Vitrification Facility cart (Sect. B-B of Fig. A.1).

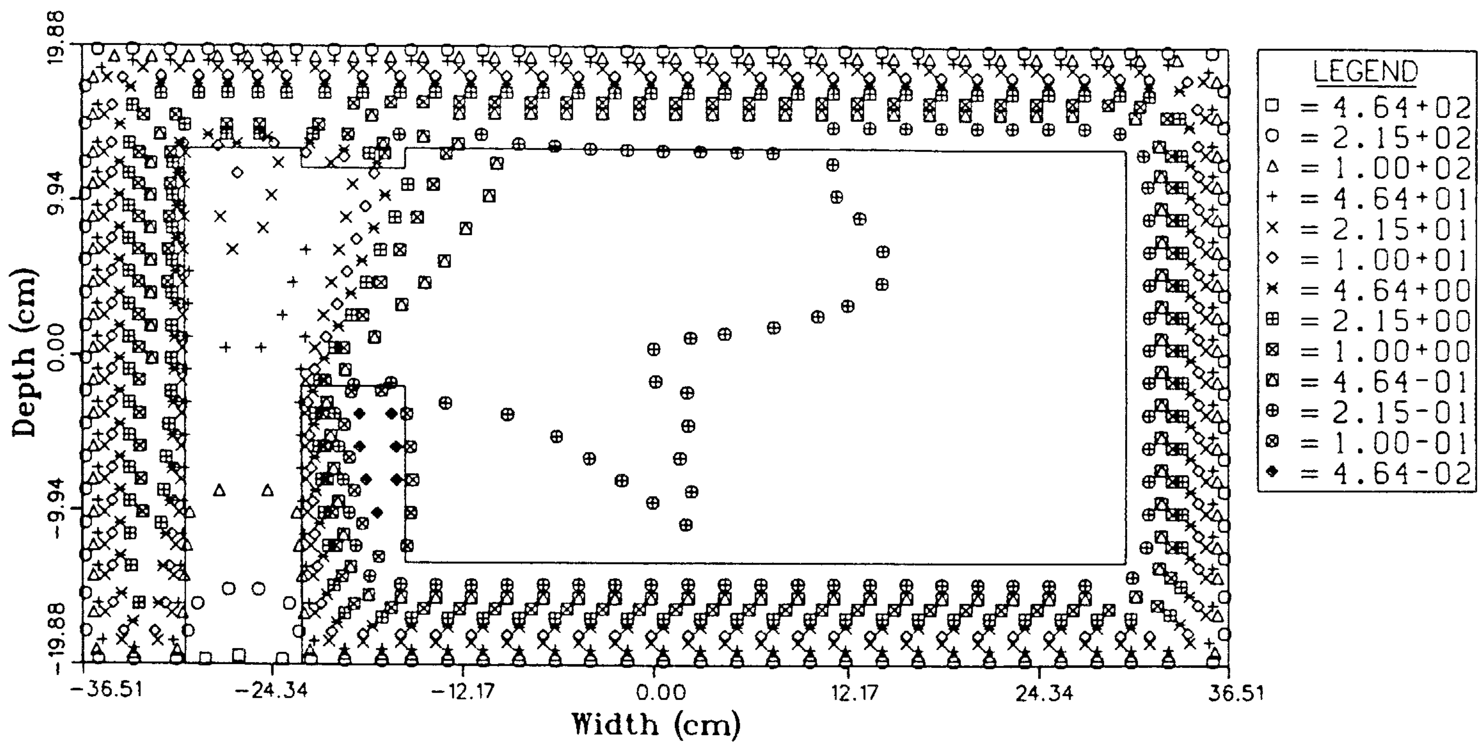

Fig. A.4. Gamma-ray isodose rate contours (rad-Si/hr) for a plan view model of the West Valley Vitrification Facility cart (Sect. C-C of Fig. A.1).

APPENDIX B
RADIATION TEST REPORT

1. INTRODUCTION

The purpose of the radiation testing that was performed at Argonne National Laboratory (ANL) during the week of September 9, 1991, was to test certain electronic components that will be used in the West Valley transfer cart project. During the five-year design life-time of the cart, the electronics in their shielded enclosure are expected to see a total integrated dose (TID) of about 10 krad. Certain components (mainly metal-oxide semiconductor transistor-based electronic devices) that will be used in the cart electronics have radiation withstand capabilities in this same order of magnitude, and thus further evaluation of their radiation tolerance was warranted. Results of the testing indicate a high probability that the cart electronics will survive their five-year design life.

2. EQUIPMENT IRRADIATED

Equipment involved in the test can be divided into three categories. The first category was designated test equipment and includes equipment not irradiated, but used to monitor the function of other equipment that was irradiated. The second category is equipment designated as operational irradiated equipment. This equipment was energized and monitored during irradiation. The third category, non-operational irradiated equipment, identifies the equipment to be irradiated in a de-energized state; i.e., equipment to be neither functioning nor monitored during irradiation.

Operational irradiated equipment was exposed to a steady gamma field of approximately 10 krad per hour. Test plans called for this equipment to be exposed to 100 krad total integrated dose (TID) or until failure of the equipment, whichever occurred first. Proper equipment locations and shielding for the desired exposure rates were determined by ANL personnel who made dosimeter measurements prior to the equipment being irradiated.

Table B.1 contains a list of the operational irradiated equipment. Both electronic assemblies from WinSystems failed before the 100 krad TID was obtained. During the exposure period, the functionality of the assembly was automatically monitored and logged by test equipment external to the radiation field. From the time stamp on the logging record, the TID which failure occurred was determined.

Table B.1 Operational Irradiated Equipment

Description	Manufacturer	Serial No.
Single Board Computer	Winsystems LPM-SBC40R-8 with ROM-DOS System	1032046
Analog-to Digital Converter (ADC) Board	Winsystems LPM-AIO	71572
Power Rack	Winsystems CC8-WM-PS100	1012821
SBIO 48 Digital I/O	Winsystems SBX-PIO SBC Piggy-Back Board	0102864
Single Board Computer	Winsystems LPM-SBC40R-8 with C-Thru-ROM System	1032046

The non-operational irradiated equipment was exposed to a steady gamma field of approximately 1 krad per hour, for an intended TID of 10 krad. Actual exposure for this equipment was 12 krad TID with about a ±20% measurement uncertainty. These components consisted of several ORNL-designed electronic cards sized to fit on the STD-bus that will be used for the cart electronics and several loose integrated circuits (ICs) and electronic devices. Table B.2 contains a description of the non-operational irradiated equipment components. These components were not tested or powered during the exposure period. They were functionally tested at ORNL prior to and after the exposure.

Table B.2 Non-operational Irradiated Equipment.

Description	Manufacturer/Part Number
IC, Bipolar Comparators	LM393
IC, Bipolar Op-Amp	OP-215
IC, Bipolar Op-Amp	AD708
IC, CMOS Power MOS Driver	Maxim, MAX626
Rectifier HexFETS	IRFD9120
Rectifier HexFETS	IRFD120
Prototype Cart Biphase Encoder/Decoder	ORNL

3. TEST SET-UP

The irradiation was performed at the ANL gamma facility using their Cobalt-60 gamma source. Test equipment used to monitor the electronics was a signal generator, a personal computer used as a data acquisition system (DAS) and data storage, Metrabyte analog and digital input hardware, and associated cabling. Prior to exposing the electronics to radiation, ANL personnel used cobalt glass dosimetry and shielding as required to determine where to position the two Winsystems STD-bus electronics systems in order to receive the desired dose rate of approximately 10 krad per hour. Likewise, cobalt glass dosimetry and shielding were used to determine a suitable location for the non-operational equipment so that it was exposed to a dose rate of approximately 1 krad.

Cables were then routed from the control room to the radiation source cell in order to make the necessary electrical connections to the DAS PC, signal generator and the two rack assemblies. This cabling was necessary in order to monitor and log the operation of these assemblies. A CRT monitor, located in the control room with the DAS PC, was used to display real time data to verify that the DAS and rack assembly were operating properly before and during the irradiation testing. All operational irradiated equipment was verified to be operational prior to being exposed to the gamma source.

Figure B.1 is a block diagram depicting the relative location of the test equipment and irradiated equipment in the test cell and in the control room. This diagram also shows the interconnections between the personal computer data acquisition system and the equipment being irradiated.

4. FUNCTIONAL TESTING AND SETUP OF OPERATIONAL EQUIPMENT

The test equipment signal generator was set up to operate in a free-running mode. The frequency of the generator output was adjusted to be ~ 0.001 Hz. The generator output wave form was selected to be sinusoidal with an approximate 4 V peak-to-peak amplitude and an approximate 2.5 V dc offset such that the signal ranged from ~ 0.5 - 4.5 V with respect to ground. This signal was sent to the WinSystems ROM-DOS analog input/output board and also to an analog input on the Metrabyte DAS PC analog input board.

During irradiation testing, the ROM-DOS single board computer was loaded with a C program to control the analog-to-digital converter (ADC) on the WinSystems analog input/output (AIO) card and record the 12-bit equivalent of the signal generator output voltage. It performed this conversion at a rate much greater than the signal generator frequency, making the change from one reading to the next very small. Following each reading from the ADC, the ROM-DOS microprocessor was programmed to drive 12 of its digital outputs on the piggy-back board with the binary coded value of the signal generators analog voltage read by the ADC. These 12 digital outputs were then monitored by a Metrabyte digital input card in the control room and were read by the DAS PC. In this way the binary code on the digital outputs represented the signal generator output voltage in real time except for a slight delay.

The DAS PC would periodically monitor the signal generator output voltage (via the Metrabyte analog input card) and the binary value of the signal generator output sent from the ROM-DOS single board computer (via the Metrabyte digital input card) and log this information to disk at one-minute intervals. Later analysis of the data would be used to determine within a one-minute interval when something failed

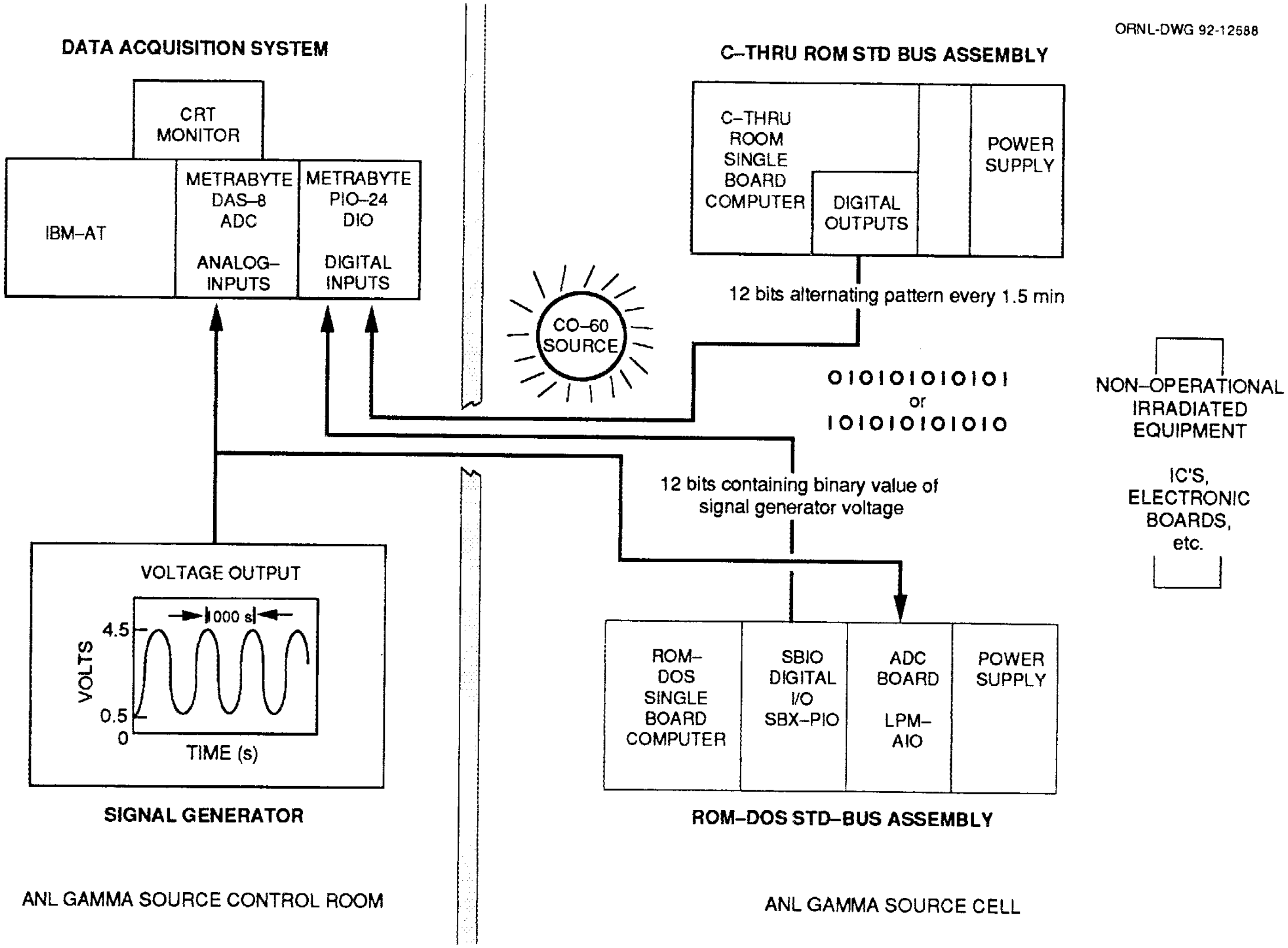

Fig. B.1. Equipment arrangement for radiation test.

on the ROM-DOS assembly. Failure of the ROM-DOS assembly occurs whenever the logged value of the analog level from the ROM-DOS rack assembly does not match the value read by the DAS within a reasonable tolerance. Failure can be due to rack assembly power supply malfunction, analog board malfunction or microprocessor malfunction.

The second STD rack assembly contained the C-thru ROM single board computer system. This computer system was loaded with a C program to drive 12 of its digital outputs with alternating values of 101010101010 (Decimal: 2730) and 010101010101 (Decimal: 1365). The digital outputs were programmed to change values once every 1.5 minutes. These 12 digital outputs were also sent to the Metrabyte digital input card in the control room via ribbon cable from the source cell to the control room and were monitored by the DAS PC. The DAS PC monitored these digital inputs and logged them to disk at one minute intervals. A discrepancy in the digital outputs or failure to alternate in values would indicate a failure on the C-thru ROM single board computer system.

A CRT monitor was used to display the signal generator output, and the digital outputs from both single board computer systems. This allowed real time monitoring of the single board computer outputs. Upon failure of either single board computer system, irradiation testing was halted to prevent further irradiation of the damaged system. Upon removal of the failed equipment, irradiation testing was then continued.

5. SETUP AND TESTING OF NON-OPERATIONAL EQUIPMENT

Prior to irradiation testing, identification, and functional verification testing of individual items to be irradiated as non-operational irradiated equipment was performed and documented at ORNL. For example, regular functional testing results tabulated for each prototype card and chip; curve tracer results for each solid state electronic device; and resistance, capacitance, and various pertinent measurements for each passive device were collected for comparison with these same type of measurements made after the irradiation.

At ANL, the non-operational irradiated equipment cards and electronic devices where positioned and shielded in the exposure area to receive a dose rate of approximately 1 krad per hour. Glass cobalt dosimeters were used to verify the TID.

6. SUMMARY

The radiation test on key components of the cart controller system was performed at Argonne National Laboratory. The test went as planned per the *Cart Controller Radiation Test Plan*, dated September 5, 1991.

The non-operational irradiated equipment which was irradiated in a static mode, i.e. unpowered, survived a total dose of about 12 krad, indicated by cobalt glass dosimetry with about a $\pm 20\%$ measurement uncertainty. Measurements made at ORNL after this testing showed all static equipment survived without measurable affects.

The two CMOS single board computer assemblies were irradiated while their operation was monitored by the external DAS. These systems were irradiated to failure, presumably caused by radiation degradation. The C-THRU ROM single board computer system, running directly from a compiled C program, failed about 50 minutes into the radiation test, or after a dose of about 9.2 krad with about a ±20% measurement uncertainty. The other single board computer system (ROM-DOS), similar in hardware design, but with an imbedded IBM DOS firmware operating system, failed after a dose of about 46 krad (±20% measurement uncertainty) accumulated in about 4 hours and 50 minutes. In either case, however, the very high dose rate of the test compared to that of the cart service conditions makes the test extremely conservative. Survivability to 9.2 krad in 50 minutes indicates a very high probability of survivability to 10 krad in 5 years.

Both single board computer systems were sent back to WinSystems to allow them to diagnose, identify, and repair the failed systems. Their diagnostics indicated a CMOS RAM chip (Hyundai HY62C256LP-10) failed on the C-THRU ROM single board computer. This board failed at 9.2 krad total integrated dose (TID). The Hyundai IC is used only on the C-THRU ROM single board computer.

An Altera EP32OPI PAL IC failed on the ROM-DOS single board computer, and all Maxim DG508A CMOS analog multiplexer IC's failed on the WinSystems AIO board. The ROM-DOS single board computer and the analog I/O board failed at 46 krad TID—it is not clear which failed first.

It has been decided to use the ROM-DOS processor board in the cart electronic design. Since this processor survived 46 krad TID during testing at Argonne, it should easily meet the 10 krad TID over 5-year project design specification. This processor is also easier to program, and changes can be made to it easier than the C-THRU ROM processor.

APPENDIX C
BATTERY EVALUATION AND TEST RESULTS

1. INTRODUCTION

Reliability of the WVNS transfer cart is of major importance. A cart failure during operation would prevent the transfer of waste canisters from the VC to the CPC storage area. Since storage area in the VC is limited to four canisters, operation of the vitrification process would be halted by the cart failure.

A major factor in cart reliability will be the battery system. The battery system must provide sufficient power to the cart to allow it to communicate with the facility computer and to power the cart drive motors for the duration of cart usage. Loss of power to the motors or to the cart control system would completely disable the cart. In order to insure that the battery will not be responsible for a cart failure due to lack of capacity, a battery assembly has been tested under loading conditions approximating those of the cart. Testing of the battery has provided data regarding the battery discharge profile and capacity.

2. TEST OVERVIEW

2.1 BATTERY REQUIREMENTS

Due to the voltage requirements of the cart telemetry system and drive motors, a 24 V battery will be used. The 24 V battery will consist of two 12 V, 25-40 A-h batteries wired in series. Batteries wired in series operate at equal current. If the load is drawing 10 A from the 24 V battery assembly, each of the 12 V batteries "sees" a 10 A load current. This load current sharing allows for the testing of a single 12 V battery. Testing a single battery has the advantage of requiring a much smaller dynamic load and charging system. One consequence of using a single 12 V battery is that all test data reflects half the energy that would be delivered by a 24 V battery.

Four separate batteries have been used in testing. Two Gates Energy Products, 12 V, 25 A-h batteries (referred to as Gates A and B) and two Powersonic, 12 V, 40 A-h batteries (referred to as Powersonic A and B). The Gates cells were tested since these batteries were used in cart preliminary design[1]. Recent ORNL test data[2] has shown that Powersonic batteries perform better than the Gates cells in a radiation environment. For this reason, the Powersonic batteries have been tested as our primary candidate for use in the final cart design.

2.2 DISCHARGE PROFILE

The batteries were tested using a simulated cart discharge profile. This consisted of a controlled current discharge profile being applied to the battery over a period of several hours. The discharge profile was designed to approximate the battery loading during a cart operation cycle. Since the exact current requirements of the cart are not known at this time, tests at more than one idle current level were conducted. The initial tests used a cart idle current of 1.75 A. A second abbreviated set of tests were conducted with an idle current of 3.0 A. The discharge current profile was produced using a Hewlett-Packard model 6060A electronic load. The load was controlled by an IBM-PC through a general purpose interface bus (GPIB) interface. Battery current and voltage were be monitored during the discharge. Energy delivered by the battery has been computed from this data. Following the discharge, the battery was fully charged using a standard cyclic charge (battery charged at 2.45 volts per cell until charge current approaches zero amps). Battery charging voltage and current were monitored to establish the charging characteristics of the battery, total energy returned to the cell, and the time required to recharge the battery.

Figure C.1 shows the battery discharge current profile used in testing for a 1.75 A idle current. Figure C.2 shows the battery discharge current profile used in testing for a 3.0 A idle current.

2.3 TEST HARDWARE

Figure C.3 shows the hardware set up to be used in discharge testing. Table C.1 contains a listing of the test hardware and pertinent data for each item in Figure C.3. Figure C.4 shows the hardware set up used for battery charge monitoring. Table C.2 contains a listing of the test hardware and pertinent data for each item in Figure C.4. Calibration of all test equipment is documented in Table C.3.

Table C.1 Instrument Data for Fig. C.3.

Item	Description	Purpose/Other Information
IBM PC	IBM PC-AT computer	Performs data logging, display, and storage.
GPIB interface	National Instruments AT-GPIB.2	Instrument control and data acquisition through IEEE-488 bus. Serial No. 18694.
HP-6060A	Hewlett-Packard Electronic Load	Provides computer controlled current discharge profile. Also digitizes voltage and current for use by computer. Serial number 3032A-01043. Instrument is new and under factory calibration.
Battery under test	Sealed lead-acid battery	Gates Energy Products 25 Ah or Powersonic 40 Ah battery

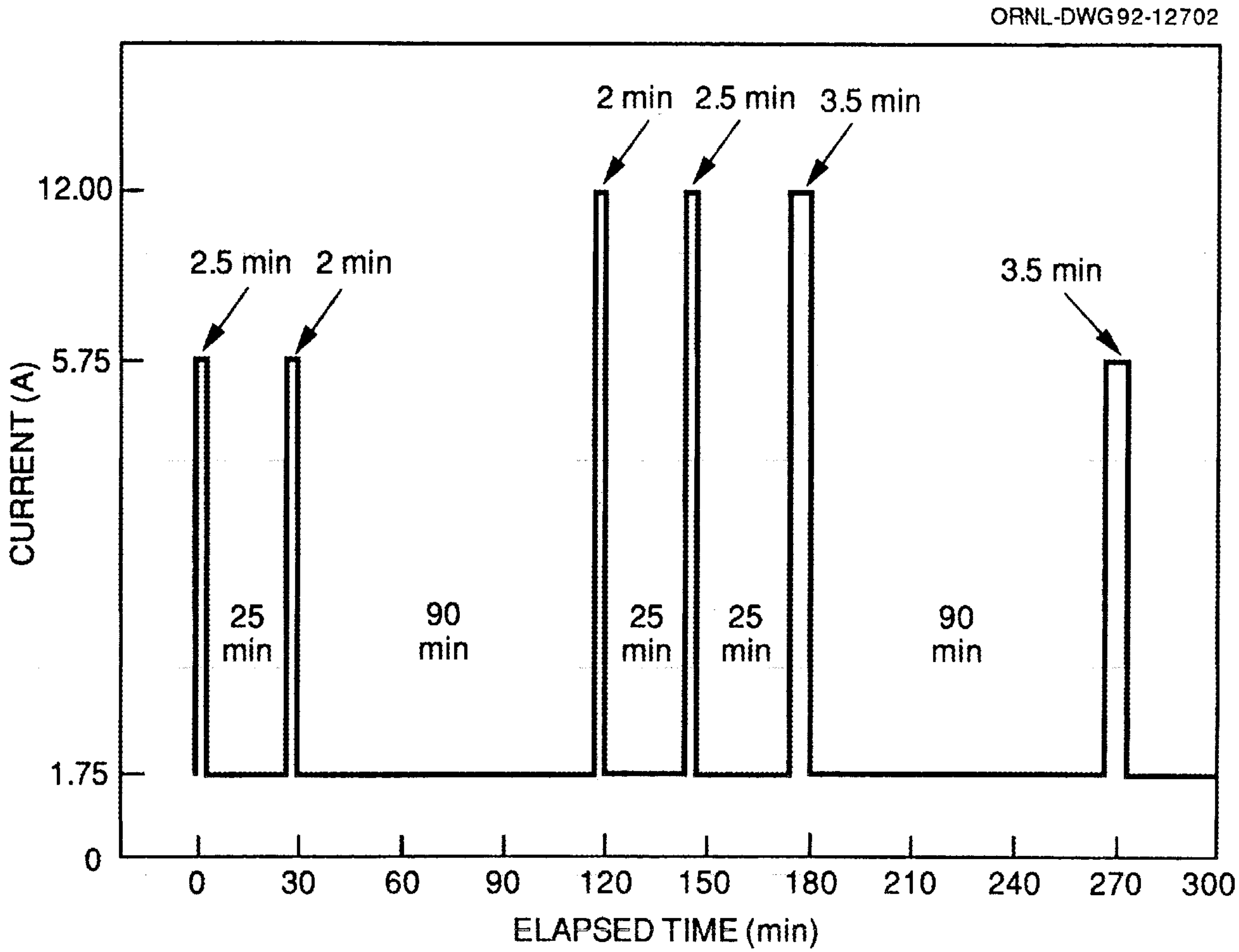

Fig. C.1. Battery discharge current profile (idle current = 1.75 A).

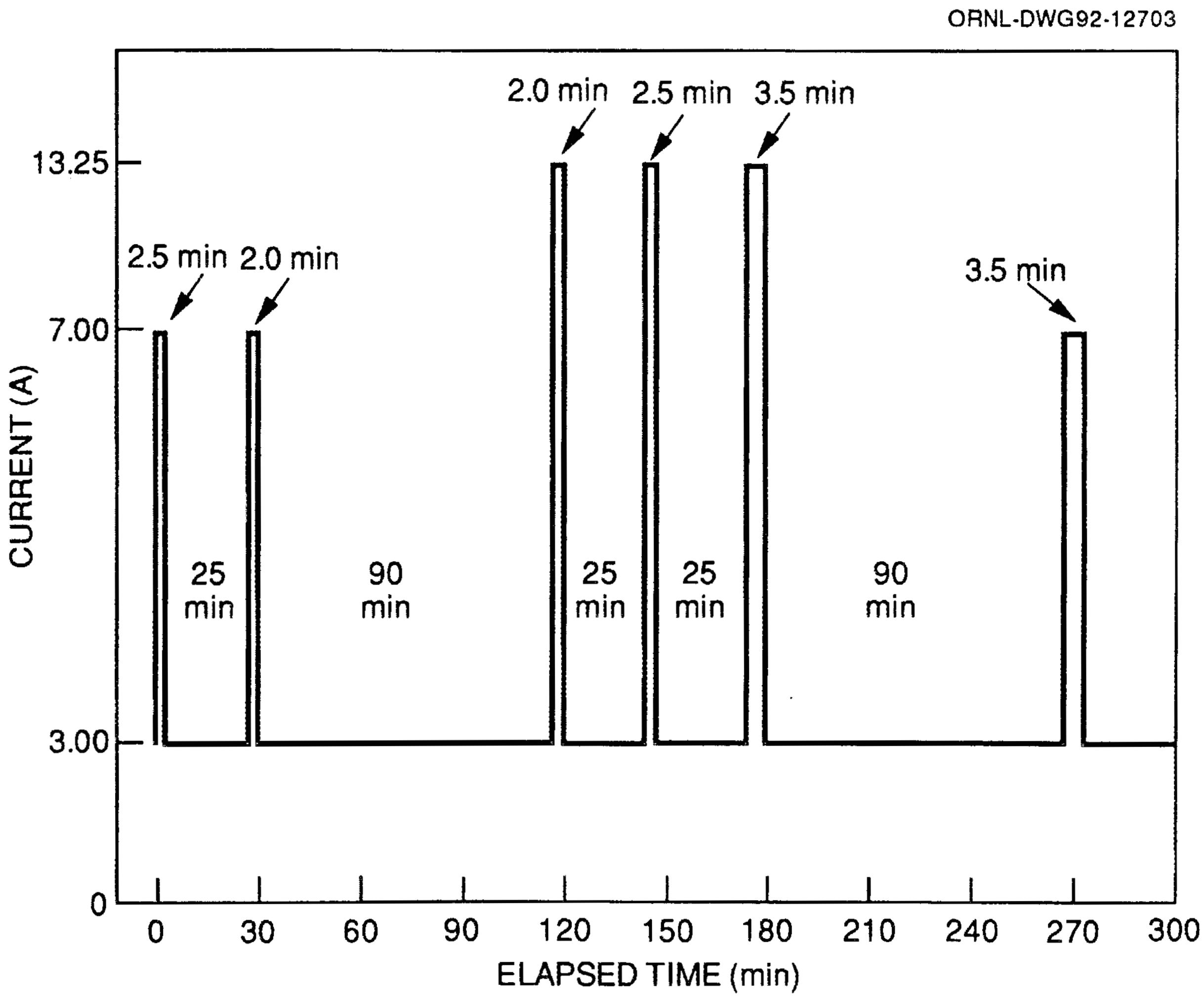

Fig. C.2. Battery discharge current profile (idle current = 3.0 A).

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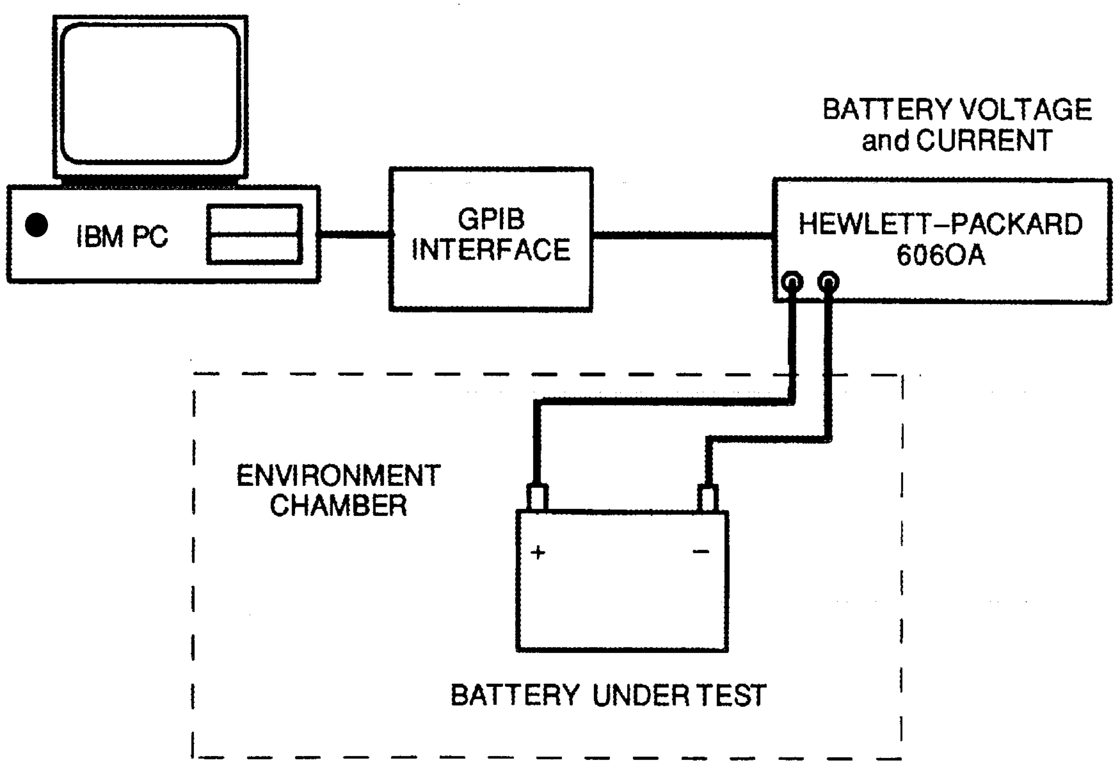

Fig. C.3. Discharge test configuration.

Table C.2 Instrument Data for Fig. C. 4.

Item	Description	Purpose/Other Information
IBM PC	IBM PC-AT computer	Performs data logging, display, and storage.
GPIB interface	National Instruments AT-GPIB.2	Instrument control and data acquisition through IEEE-488 bus. Serial number 18694.
Fluke 45, A	Fluke model 45 multimeter	Provides digitized output of voltage from current shunt. Serial number 5115012. Unit is new and under factory calibration.
Fluke 45, B	Fluke model 45 multimeter	Provides digitized output of voltage from current shunt. Serial number 5115032. Unit is new and under factory calibration.
Current shunt	Sensitive Research	Current shunt. 50 mV at 30 A. Serial number 934108. Resistance to be verified by ORNL calibration lab.
14.7 V, 10 A supply	Kepco model BOP 20-10M	Current shunt. 50 mV at 30 A. Serial number 934108. Resistance to be verified by ORNL calibration lab.
Battery under test	Sealed lead-acid battery	Gates Energy Products 25 A-h or Powersonic 40 A-h battery.

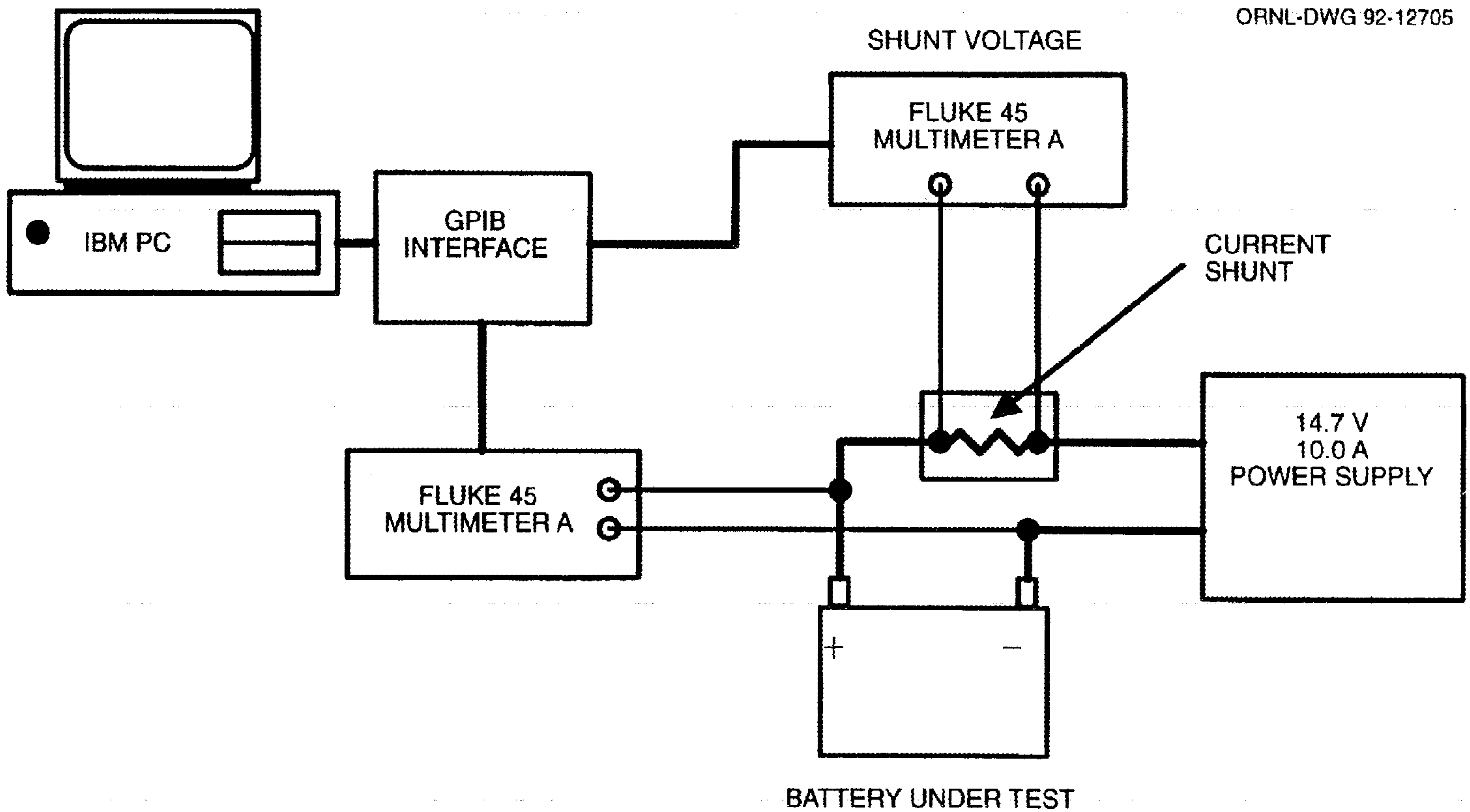

Fig. C.4. Charging test configuration.

Table C.3 Instrument Calibration Data

Instrument	Calibration
FLUKE model 45 multimeter. Serial number 5115012.	Unit is new and under factory calibration.
FLUKE model 45 multimeter, Serial number 5115032.	Unit is new and under factory calibration.
CURRENT SHUNT Sensitive Research Current shunt. Serial number 934108.	Calibrated by ORNL metrology group. Certification Report ID IC2084. Resistance =0.00170 Ω.
Kepco model BOP 20-10M Power supply. Serial number E122801.	No calibration required (voltage and current are externally monitored).
Hewlett-Packard Model 6060A. Serial number 3032A-01043.	Instrument is new and under factory calibration.

2.4 TEST ENVIRONMENT

Tests were conducted at room temperature and at 20°F. An environment chamber was used to chill the batteries to 20°F prior to, and during, the low temperature tests. The low temperature tests represent worst case conditions for battery performance during a discharge (high temperatures will impact battery life, but do not limit, and may enhance, the single cycle discharge performance of the battery). A limited number of test cycles were carried out at room temperature (nominally 70°F) as a reference for "normal" battery performance.

2.5 DATA LOGGING AND DOCUMENTATION

All test data and pertinent notes about tests were logged on an IBM-PC, with data files being stored on the PC's hard drive. Data was transferred to floppy disks on a daily basis. Initial data plots were be generated using Lotus 123 software in order to monitor progress of tests. Control of data logging was be done with a general purpose data logging program developed by I&C personnel. The code is written in Microsoft Quickbasic. Summary plots shown in section 3.5 of this document were generated with Microsoft Excel 3.0.

3. TEST RESULTS

3.1 REVISED CART ENERGY REQUIREMENTS

A revised energy requirement for the cart has been computed. Using data computed in the cart initial design[1] combined with an updated cart current requirements data allows the new cart energy requirement to be computed. Tables C.4, C.5 and C.6 show a summary of these calculations. From these tables it can be seen that the cart battery must be capable of providing 0.830 MJ of energy under all anticipated cart operation scenarios for an idle current of 1.75 A. This number will be used as a figure of merit in analyzing the 1.75 A battery test results. For the 3.0 A idle current, 1.31 MJ of energy is required. This number will be used as a figure of merit in analyzing the 3.0 A battery test results. Note that these energy values are for a 24 V battery. All test data must be multiplied by a factor of 2 to correct for use of a single 12 V battery when comparing data with figures given in Tables C.4, C.5, and C.6.

Table C.4 Cart Idle Current Requirements

System Element	Current (mA)	Voltage (V)	Power (W)
System Controller	100	5	0.5
Communications system	2090	15	31.3
Analog to Digital Converter	100	15	1.5
Multiplexer	100	15	1.5
Motor Drive 1	50	24	1.2
Motor Drive 2	50	24	1.2
Motor Drive 3	50	24	1.2
Motor Drive 4	50	24	1.2
Battery/Charger Interface	100	24	2.4
			Total = 42.0

Table C.5 Summary of Cart Energy Requirements (for 1.75 A idle current).

Operation	Time (min)	Drive power (W)	Electrical power (W)	Total power (W)	Energy (kJ)
Idle time	255	0	42.0	42.0	643
Moving, no load	6.96	92.9	42.0	134.9	56.3
Moving, full load	7.47	251	42.0	293	131
Totals	269.4				830

Table C.6 Summary of Cart Energy Requirements (for 3.0 A idle current).

Operation	Time (min)	Drive power (W)	Electrical power (W)	Total power (W)	Energy (kJ)
Idle time	255	0	72.0	72.0	1100
Moving, no load	6.96	92.9	72.0	165	68.9
Moving, full load	7.47	251	72.0	323	145
Totals	269.4				1314

3.2 ROOM TEMPERATURE TESTS

Typical room temperature data for the Gates Energy Products batteries are shown in Figures C.5 and C.6. Typical room temperature data for the Powersonic batteries are shown in Figures C.7 and C.8. For room temperature tests at low idle current (1.75 A), the Gates batteries provided an average energy of 0.776 MJ (equivalent to 1.55 MJ at 24 V) during a discharge. The Powersonic batteries provided an average energy of 1.84 MJ (equivalent to 3.68 MJ at 24 V) during a discharge for low idle current. For the Gates cell, that gives an energy delivered to energy required ratio of 1.87 for low idle current. For the Powersonic batteries the ratio is 4.43 for low idle current. For room temperature operation of the cart, the Gates and Powersonic batteries are acceptable for 1.75 idle current.

3.3 LOW TEMPERATURE (20°F) TESTS

Typical 20°F temperature data for the Gates Energy Products batteries are shown in Figures C.9, C.10, C.11, and C.12. Typical 20°F temperature data for the Powersonic batteries are shown in Figures C.13 and C.14. For low temperature tests the Gates batteries provided an average energy of 0.798 MJ (equivalent to 1.60 MJ at 24 V) during a discharge at low idle current (1.75 A) and 0.708 MJ (equivalent to 1.42 MJ at 24 V) for high idle current (3.0 A). The Powersonic batteries provided an average energy of 1.46 MJ (equivalent to 2.92 MJ at 24 V) during a discharge for low idle current and 1.09 MJ (equivalent to 2.18 MJ at 24 V) for high idle current (3.0 A). For the Gates cell, that gives an energy delivered to energy required ratio of 1.93 for low idle current and 1.08 for high idle current. For the Powersonic batteries the ratio is 3.52 for low idle current and 1.66 for high idle current. For low temperature operation of the cart, Gates batteries are marginally acceptable for 1.75 and 3.0 A idle currents and the Powersonic batteries are acceptable at both 1.75 and 3.0 A idle currents.

3.4 BATTERY CHARGING

Typical battery recharging data for the Powersonic batteries are shown in Figures C.15 and C.16. The amount of energy returned to the cell is 2.75 MJ, which is consistent with the battery test discharges (additional energy is required to overcome battery losses during recharge). It takes approximately 7 h

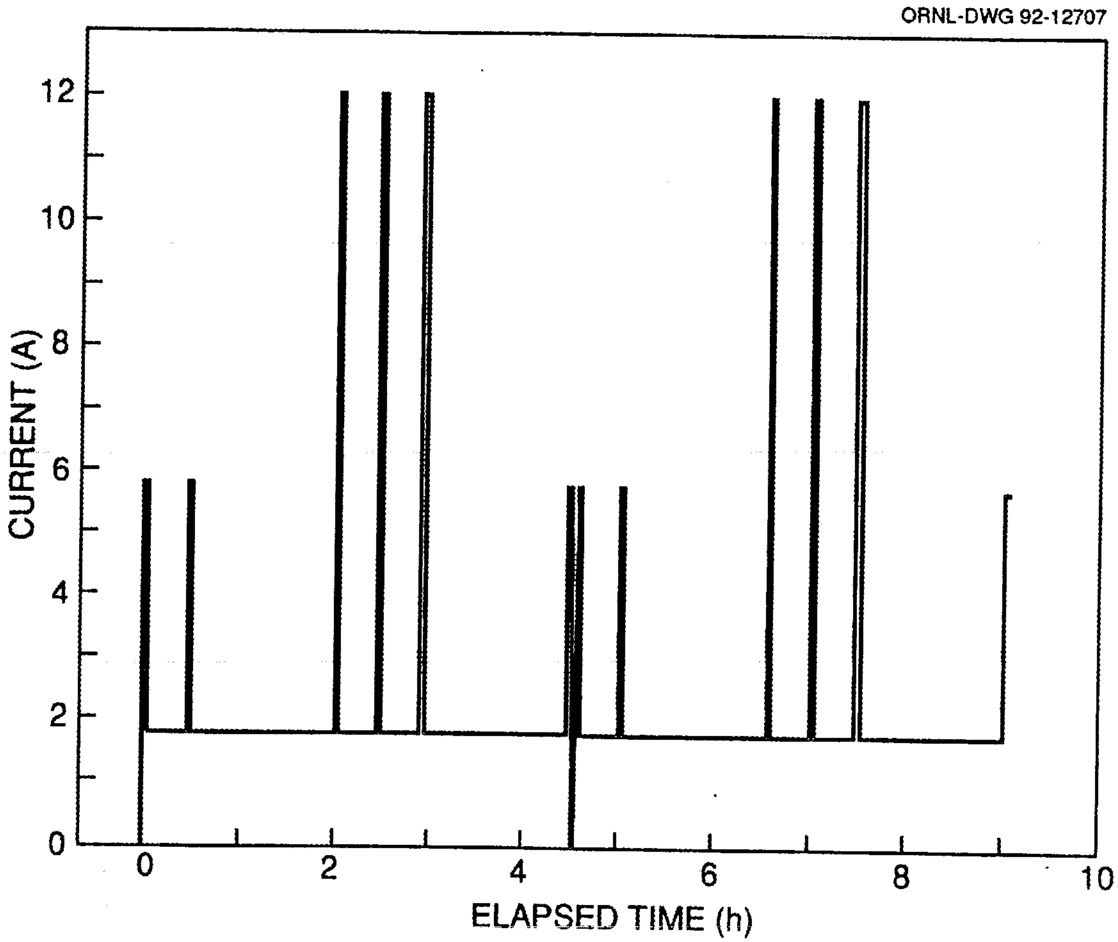

Fig. C.5. Gates Battery A current profile room temperature test.

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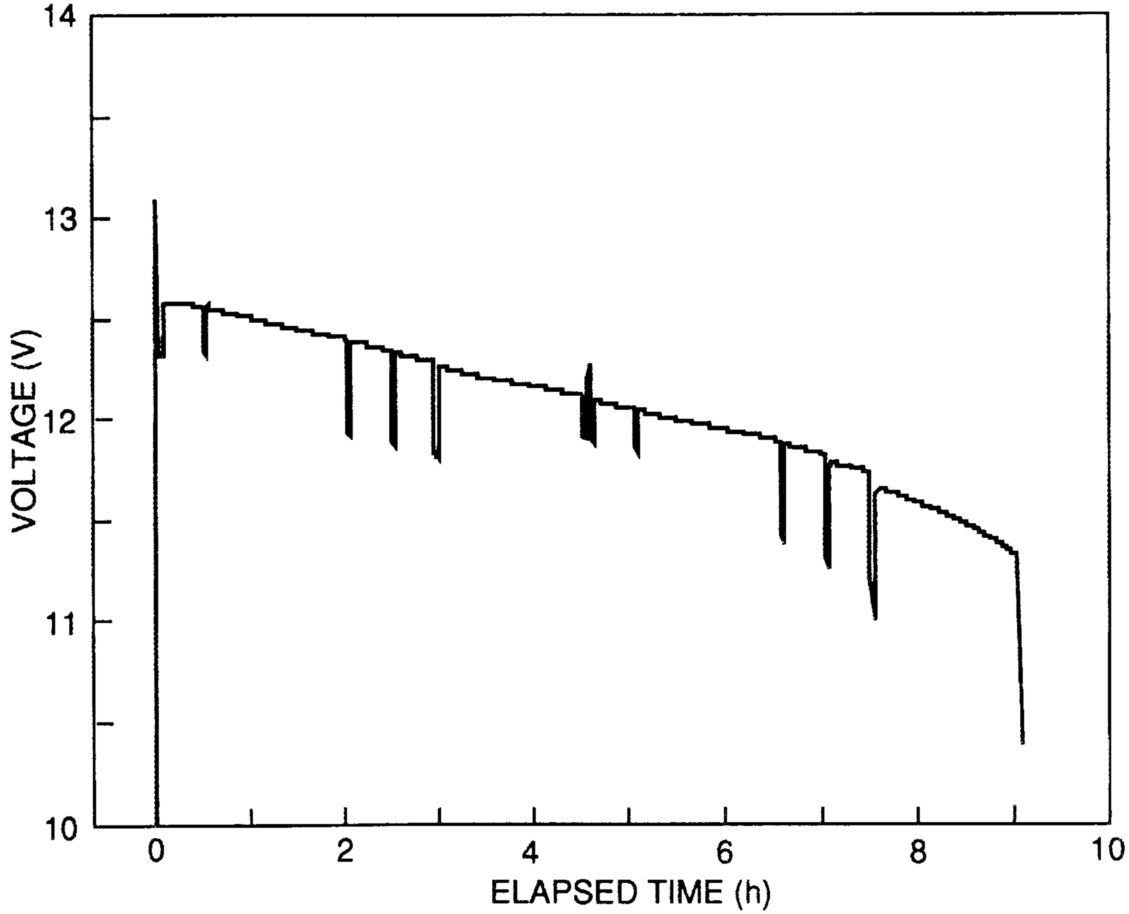

Fig. C.6. Gates Battery A voltage profile room temperature test.

ORNL-DWG 92-12709

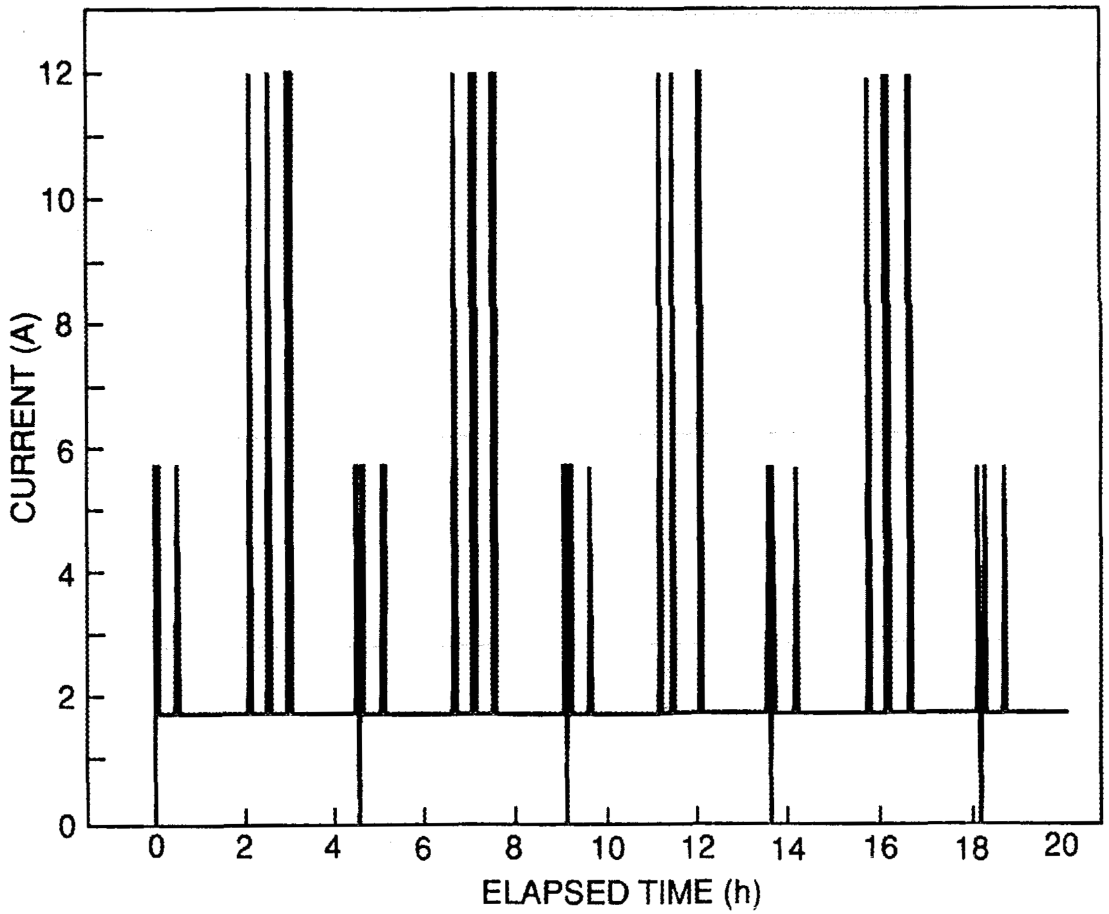

Fig. C.7. Powersonic Battery A current profile room temperature test.

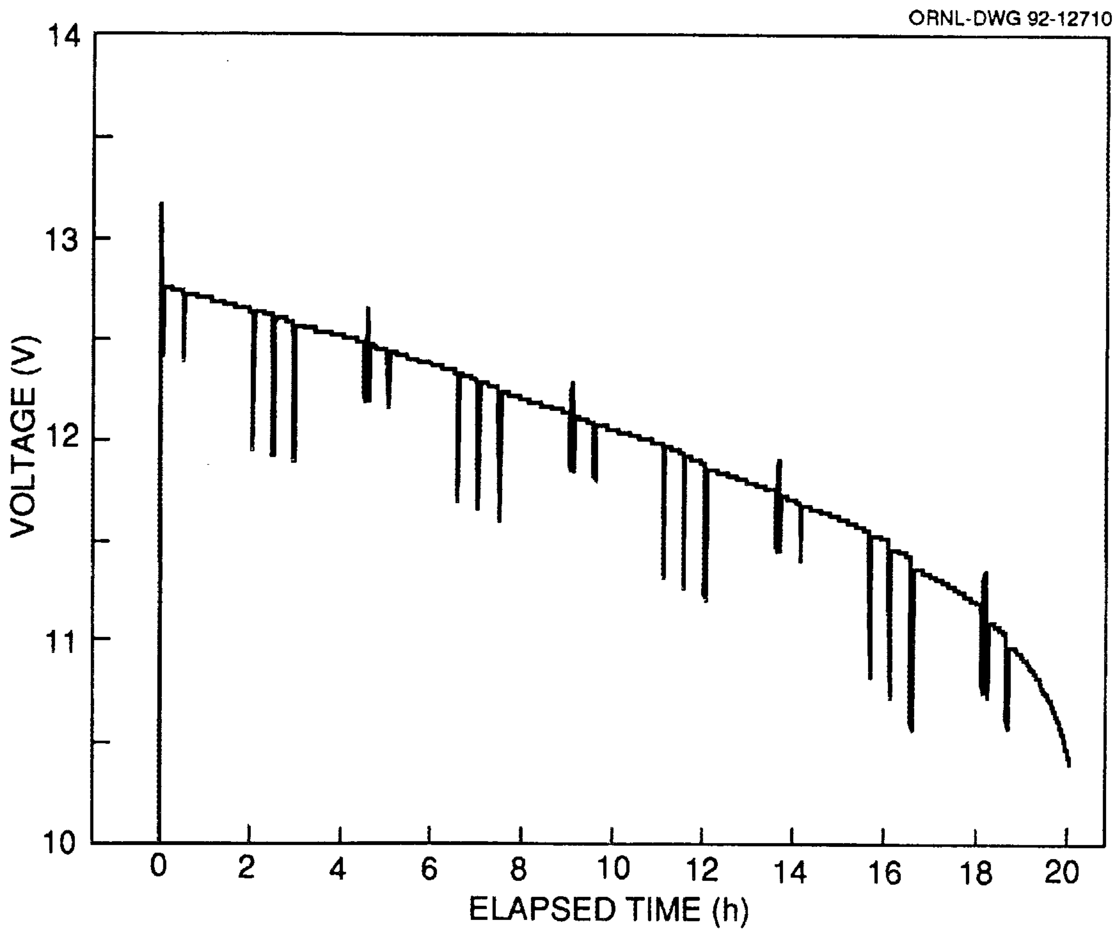

Fig. C.8. Powersonic Battery A voltage profile room temperature test.

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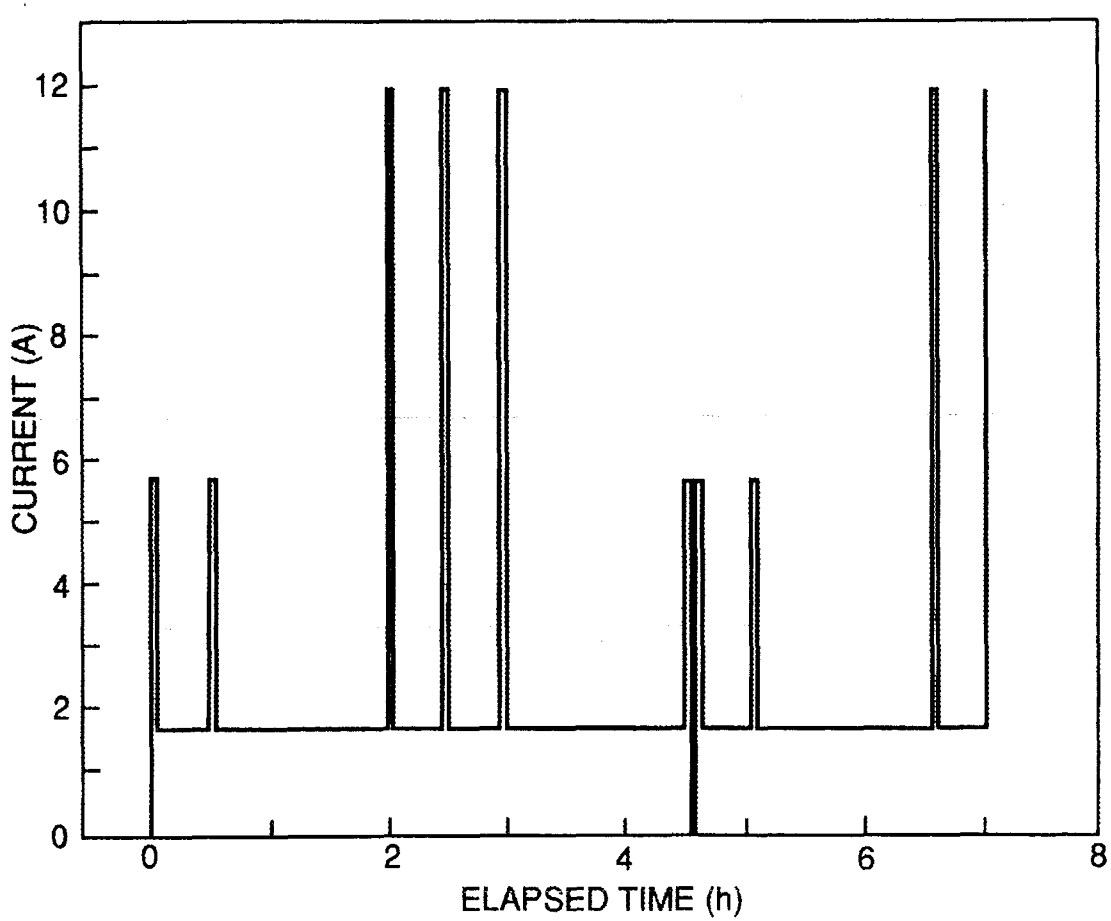

Fig. C.9. Gates Battery A current profile 20°F test.

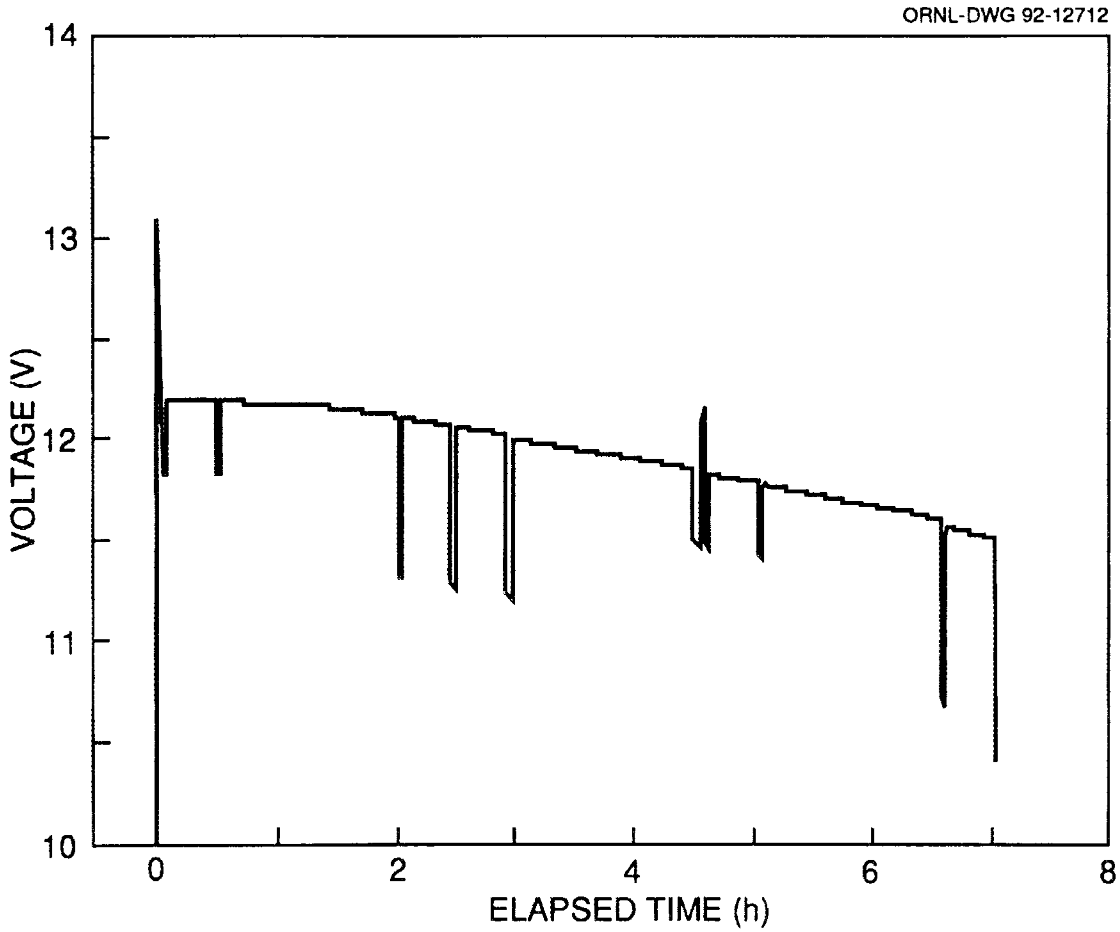

Fig. C.10. Gates Battery A voltage profile 20°F test.

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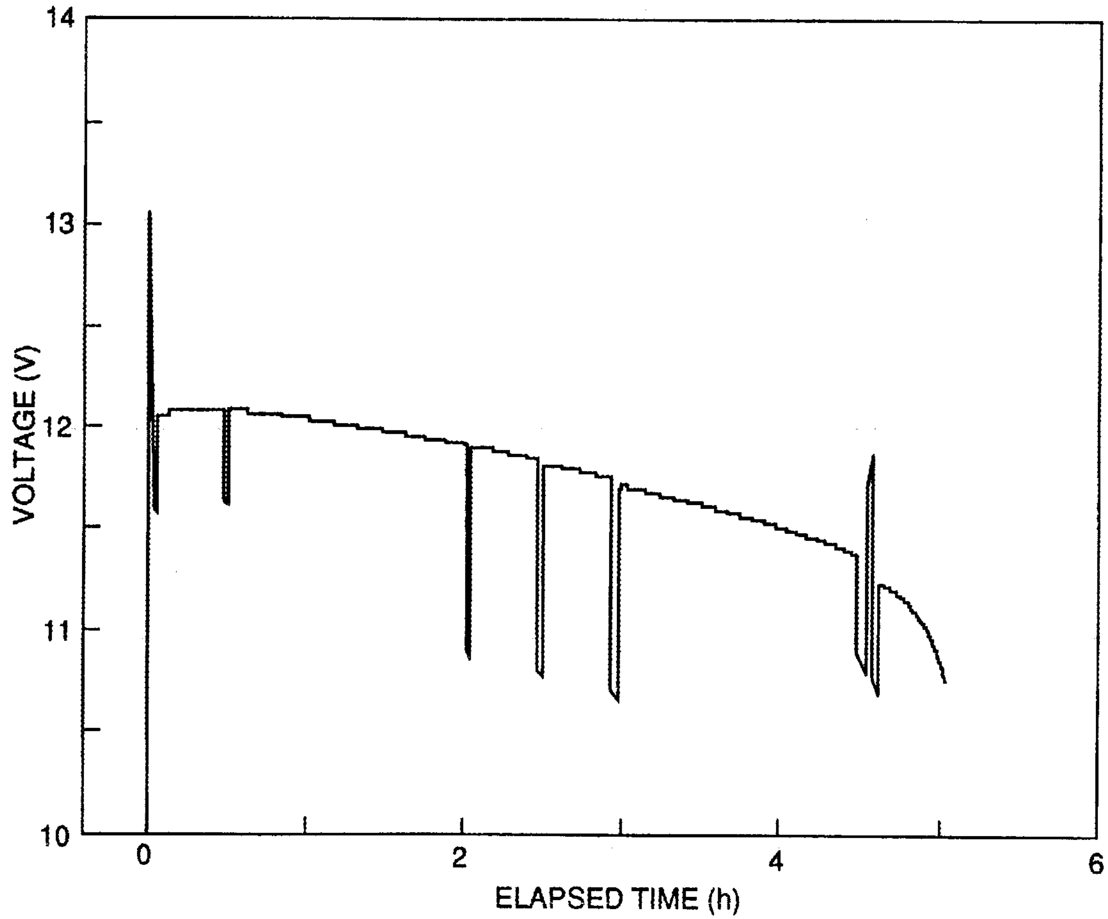

Fig. C.11. Gates Battery B current profile 20°F test.

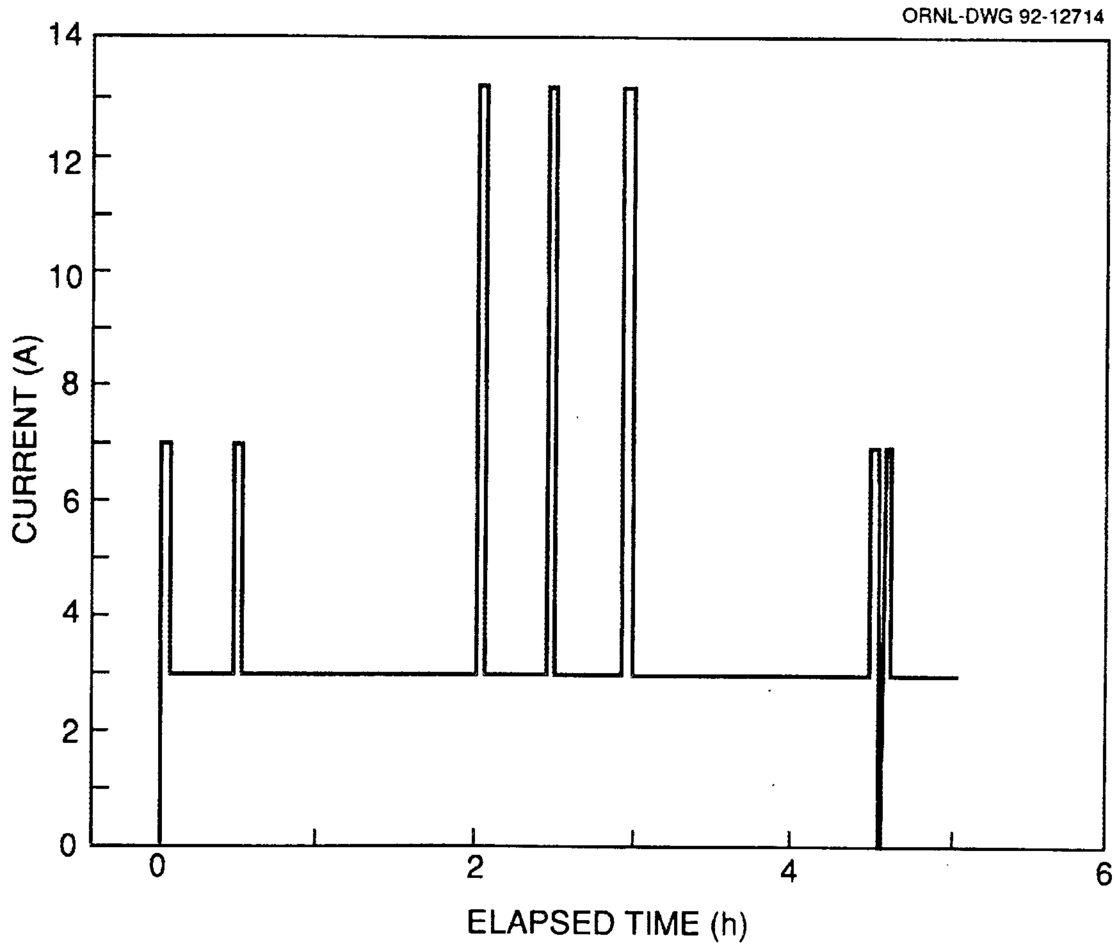

Fig. C.12. Gates Battery B voltage profile 20°F test.

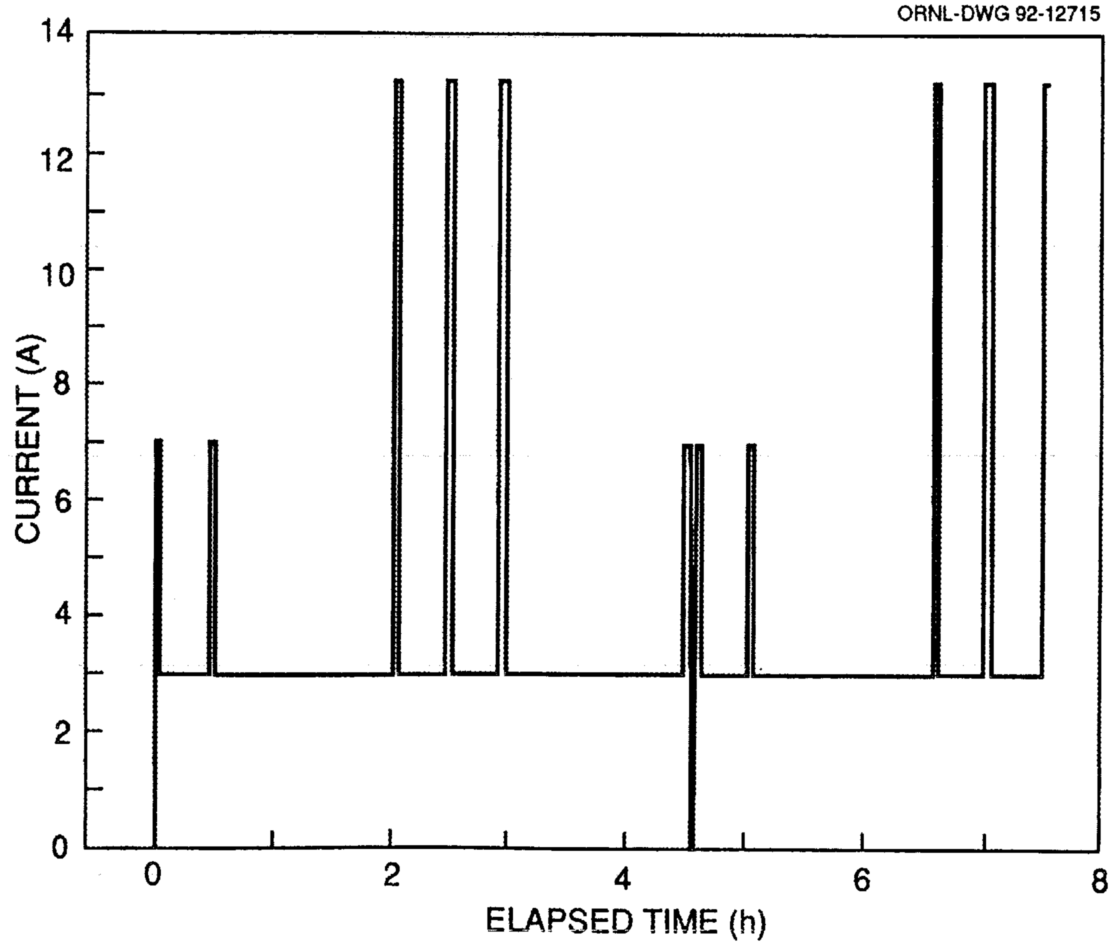

Fig. C.13. Powersonic Battery A current profile 20°F test.

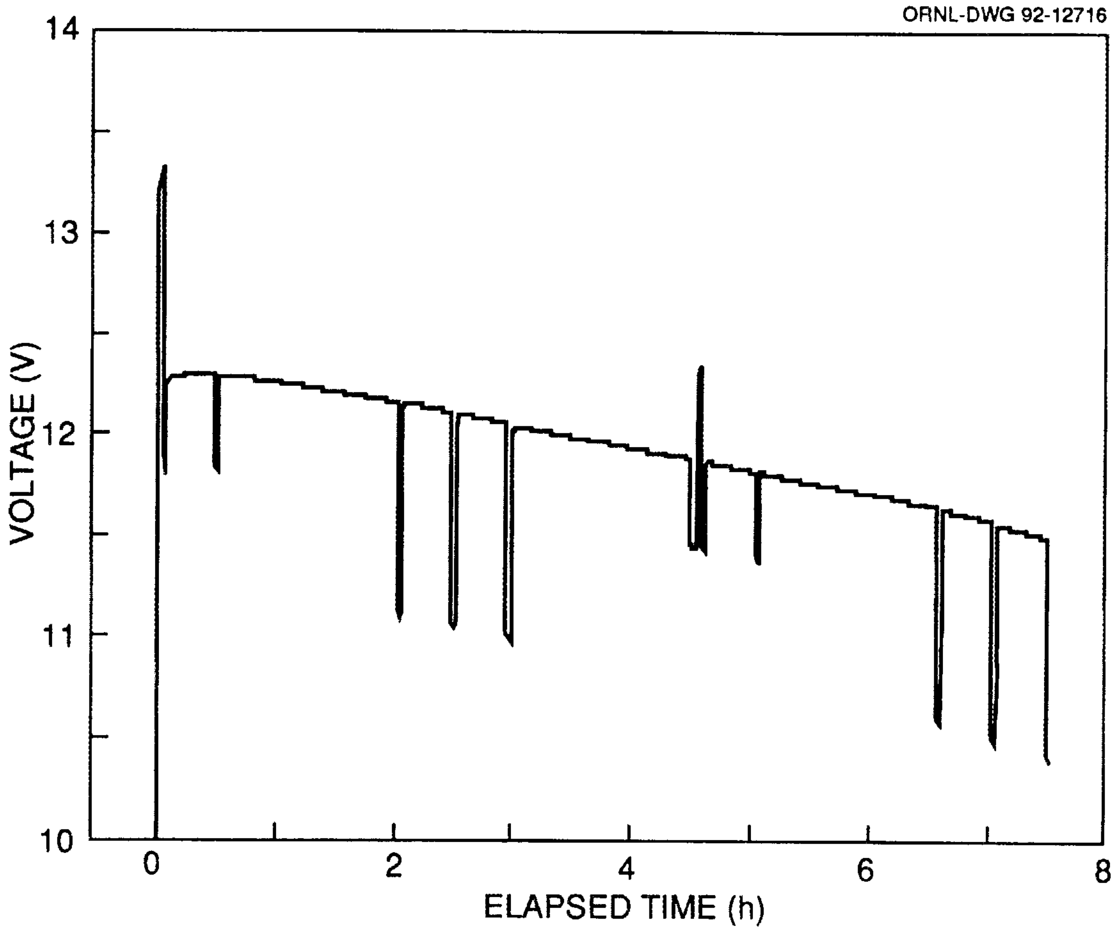

Fig. C.14. Powersonic Battery A voltage profile 20°F test.

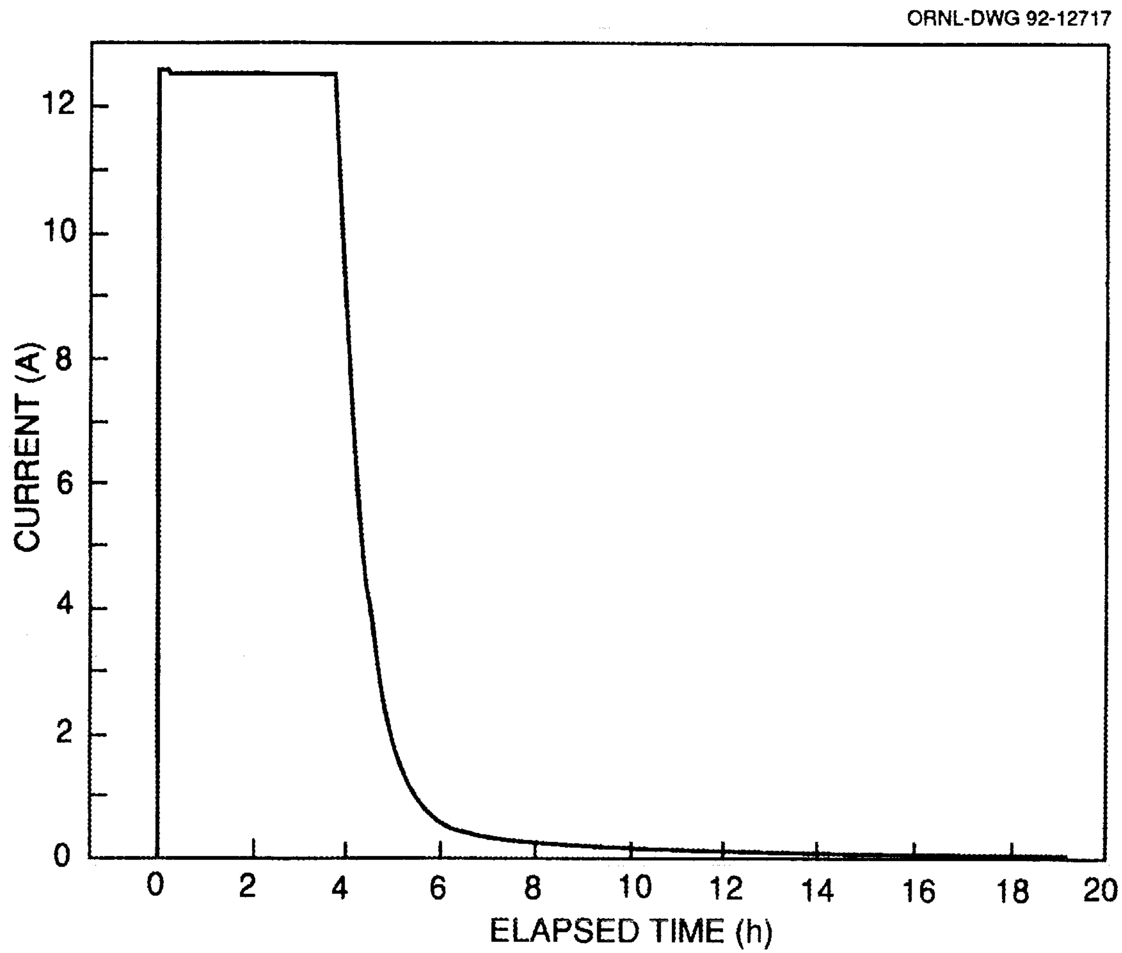

Fig. C.15. Powersonic Battery A current trend, charging cycle.

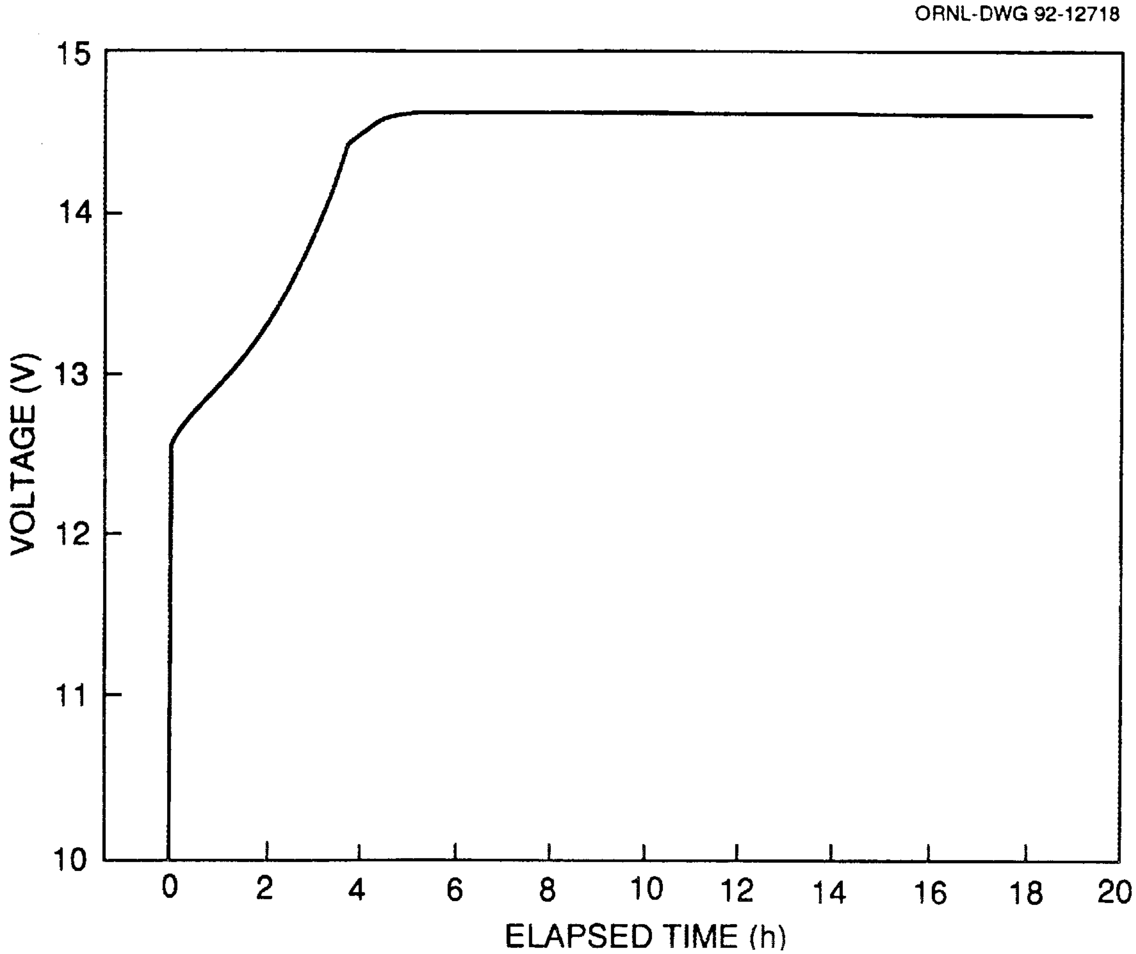

Fig. C.16. Powersonic Battery A voltage trend, charging cycle.

to provide a full charge after the Powersonic battery has delivered roughly 1.6 MJ to a test load (equivalent to 3.2 MJ at 24 V). The trickle current which flows at the end of charge is approximately 60 mA.

3.5 SUMMARY

The tests conducted for this report have shown that the Gates batteries tested are marginally acceptable for use in the cart design for a cart idle current of less than 3.0 A. The Powersonic batteries tested to be acceptable for use in the cart design at up to 3.0 A idle current. The Gates batteries would probably provide for 1.5 cart cycles at end of life and 20°F for a 1.75 A idle current (assuming that the battery has 20% less capacity at end of life) and slightly less than 1 cycle at 3.0 A idle current. In comparing data sets there appears to be some inconsistency with the data for the Gates batteries. The computed total energies for the various discharges varied much more than the values found for the Powersonic batteries. Reviewing the voltage traces during discharge revealed a problem with our method of terminating a discharge. The high current voltage drop for the Gates battery was much larger near the end of battery life which caused the discharge to terminate (voltage less than 10.5 V) earlier than necessary. For the Gates batteries a more accurate comparison of battery performance can be had by comparing data over the same time interval or by allowing termination of the discharge only during the idle current periods.

The Powersonic batteries should have sufficient capacity, even at 20°F and end of life to operate the cart for 2.5 cycles for a 1.75 A idle current (again, assuming that the battery has 20% less capacity at end of life) and slightly more than 1 cycle at 3.0 A idle current and end of life.

Figure C.17 shows a typical discharge profile energy and current versus elapsed time for a Powersonic battery at 1.75 A idle current. Periods of high current operation only account for roughly 13% of the total time the cart can operate. Battery life for the cart remaining idle during the full operation time would be about 18 h (this value is computed by extending the idle current line slope from the origin of the plot in Figure C.17 out to the energy level where battery operation terminated in the test) for the Powersonic battery at a 1.75 A idle current.

Figure C.18 shows the energy returned to the battery and current during charging for a Powersonic battery. From this graph it can be seen that 94% of the energy accepted by the battery is transferred in the first 5 h of charging (for a charger limited to roughly 10 A). Only 6% of the 2.75 MJ accepted by the battery is transferred between 5 and 13 h of elapsed time. For a cart operated over a single cycle, it would be possible to recharge the battery in much less than 5 h since the amount of energy removed from the battery would be a factor of two or more smaller than for the data shown.

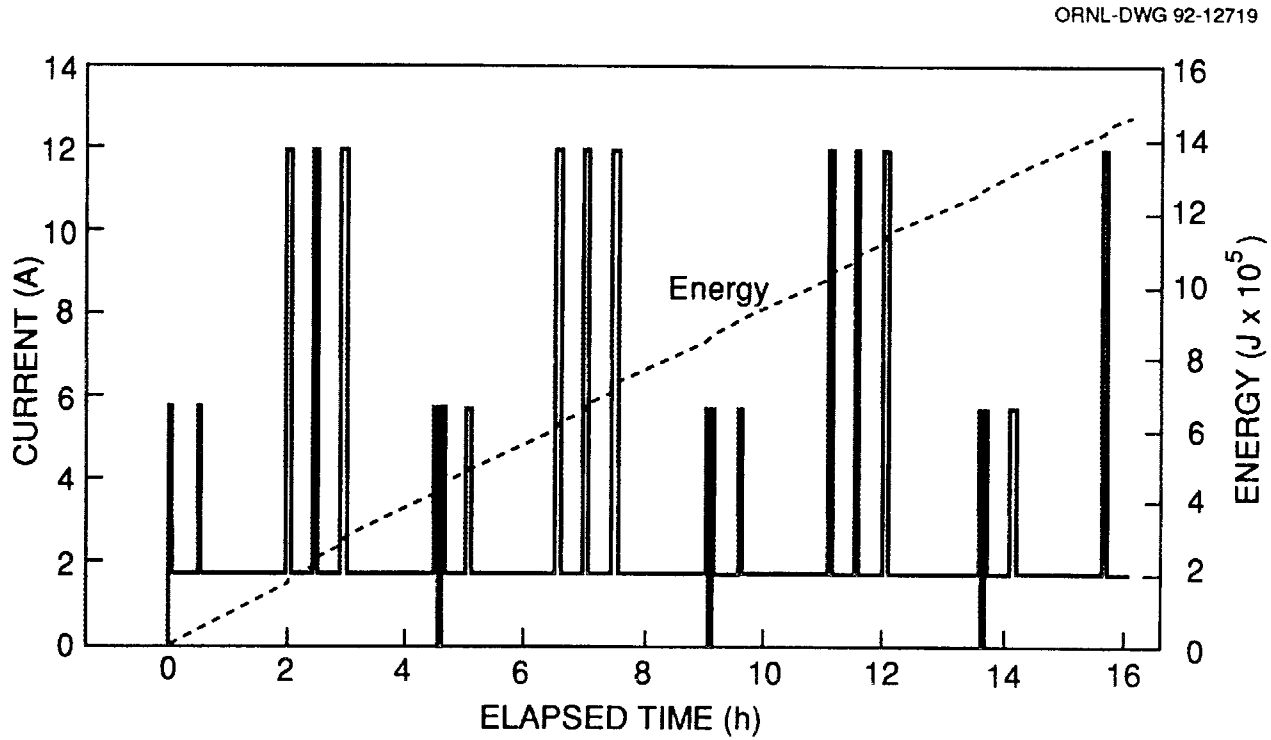

Fig. C.17. Powersonic Battery A discharge energy and current.

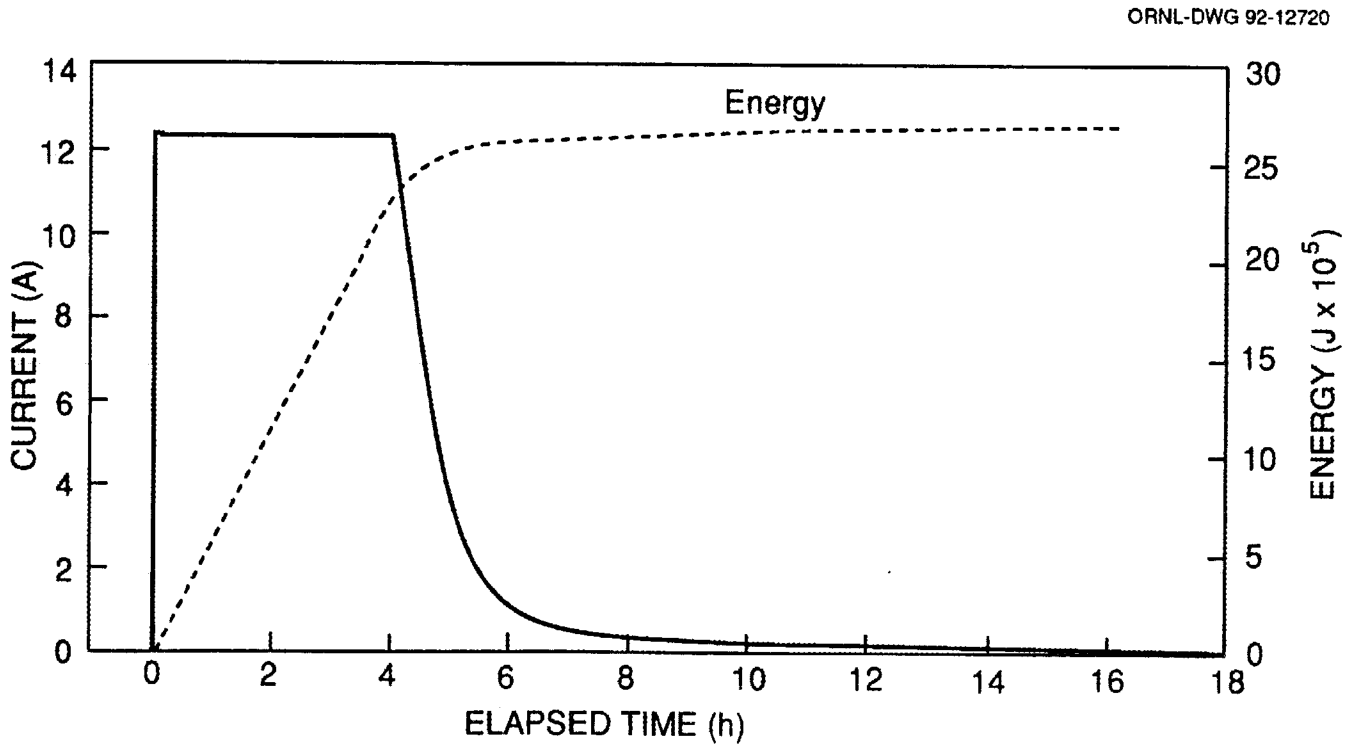

Fig. C.18. Powersonic Battery A energy returned and current during battery recharging vs elapsed time.

REFERENCES

1. "Preliminary Control System Design Description," West Valley Demonstration Project, Vitrification Facility Transfer Cart, December 21, 1990.

2. Weil, Brad. ORNL. Verbal communication, May, 1991.

APPENDIX D
PROTOTYPE HARDWARE TESTING

1. INTRODUCTION

The purpose of this appendix is to document testing of the prototype system hardware and software for the subject control system which occurred in early 1992. The intent of the testing was to perform a system-wide test of the prototype hardware. Testing of each component had already been done before the system test began. The overall functionality of the system was under test. For example, in the motor test, a button was pushed on the control pendant and motor operation was witnessed. Many parts of the system had to be operating for these functions to occur.

2. COMPONENTS

Prototype hardware that was tested is listed in the following table. It was arranged as shown Figure D.1. The whole system including rf system was tested, but at first the communications protocol was tested by a hard-wired link between the facility side and cart side equipment as shown by the dotted line in the figure. Software, which is part of the design and which was also tested in this procedure, was running in the programmable logic controller, the engineer's console computer, the facility-side STD-based controller, and the cart-side STD-based controller.

Table D.1. Prototype Hardware for Functional Test

Component	**Make and Model or Reference Drawing**
Operator's Control Pendant	Q-6340-120
Programmable Logic Controller	
Processor	Allen-Bradley PLC 5/15
Digital Inputs Board	Allen-Bradley 1771-IBD
Digital Output Boards (2)	Allen-Bradley 1771-OBD
Simulation Modules (2)	Allen-Bradley 1771-SIM
Engineer's Console Computer	Gateway 486/33C
Interface Card	Sutherland-Shultz 5136 SD
Facility-side STD-based Controller	
Processor	Prolog 7870-01
Memory	Prolog 7715A-03
Digital Interface	Prolog 7508
Allen-Bradley Interface	Prolog 7514
Encoder/Decoder	Q-6340-187

Component	**Make and Model or Reference Drawing**
Maintenance/Programming Computer	IBM AT
Facility-side rf cage Facility Antenna Switch Facility Antenna Switch Facility Transmitter Facility/Cart Receiver	 Q-6340-181A Q-6340-181B Q-6340-171 Q-6340-261
Digital Interface Board Digital Output Module Digital Input Module	Opto-22 PB16H Opto-22 ODC5 Opto-22 IDC5B
Facility Transmit/Receive Circuit	Q-6340-175
Battery Charger	Exide ERBC 24/30
Battery Charger Polarity Manager	Q-6340-135
Monopole Antennas (3)	N/A (steel rods cut to length with groundplanes)
Cart-side rf Cage Facility/Cart Receiver Cart Transmitter Cart Antenna Controller	 Q-6340-261 Q-6340-271 Q-6340-266
Cart-side STD-based controller Processor Digital I/O Analog I/O Interface Cart Encoder/Decoder	 Winsystems SBC40A Winsystems SBX-PIO Winsystems LPM-AIO-DC Q-6340-220,225,230 Q-6340-291
Maintenance/Programming Terminal	C. Itoh CIT 101
Batteries (2)	Powersonic PS-12400
Motor	Pacific Scientific BA3618-7009-9-48C
Motor Controller	Q-6340-235
Limit Switch	Microswitch 1LS1
Thermocouple	Type E thermocouple wire

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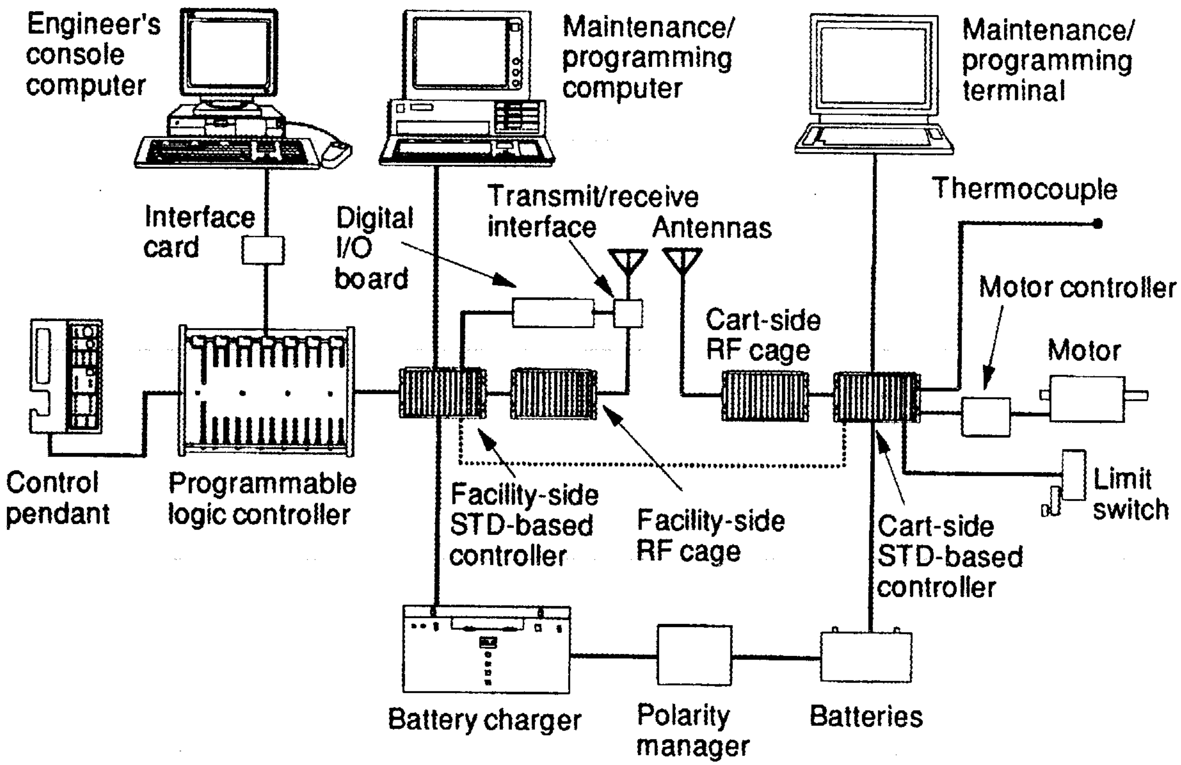

Note: Dotted line indicates temporary hard-wired communications link before RF system was brought on line.

Fig. D.1. Equipment arrangement for integrated system testing.

3. FUNCTIONAL TESTS

Functional test results reported here have been arranged into three categories: functions initiated from the control pendant, functions initiated from the engineer's console, and functions initiated from the cart system. The following information is given for each functional test: functional test title, test description, expected result, witnessed result, considerations, test performer, and date of test. Considerations are given to point out subtleties of each function that may not be apparent on the surface or to point out efforts that should be undertaken later.

Functional Test:

Emergency Stop

Test Description:

An emergency stop switch is provided on the control pendant. Unlike all other functions on the pendant (except for the LED test), the emergency stop function does not require the station to be enabled before it is active.

Expected Result:

The emergency stop should prevent cart drive, motor resets, auxiliary outlet operation, and stop all communications with the cart system. It should also stop battery charging if it is in effect.

Witnessed Result:

While the battery charger was active (and cart electronics inactive), the emergency stop button was pushed. Battery charging ceased and the cart electronics reactivated. The emergency stop LED of the control pendant lit, and further requests for other operations resulted in the LED flashing.

While the cart motor drive was active, the emergency stop button was pushed. The cart motor stopped rotating and further communications with the cart ceased (telemetry data was no longer active).

Consideration:

Because the emergency stop function eliminates communications with the cart, requests for cart data cannot be sent. Therefore, during an emergency stop condition, cart status is no longer known.

Because there are only two operating modes of the cart—battery charging and cart operation—there is no way to "kill" the cart. When emergency stopped, the cart will be in an idle mode, not completely dead.

Tested by: F. R. Ruppel

Date: 2-3-92

Functional Test:
Control Station Select

Test Description:
Only one control station will be enabled at one time. The selection is on a first-come, first-served basis by the use of a keyswitch on the control pendant.

Expected Result:
With no other station enabled, the operator should be able to enable his station by inserting a key and rotating it to the on position. The LED for this station should light. If another user is already enabled, it should not be possible to enable another station.

Witnessed Result:
With no other station was selected, the station select keyswitch was turned to the on position. The LED for this station lit and functions were enabled from the operator's pendant. The station select keyswitch was turned off, and the input which indicates when the other control pendant is selected was enabled. Attempts to select this control station were ineffective. The LED for the other station flashed, indicating that it was selected.

Consideration:
Since the station select is key operated, distribution of keys should be administered only to operators qualified to operate the cart and battery charger. It should not be allowed for an operator to walk away from the control pendant without taking the key with him.

Tested by: F. R. Ruppel

Date: 1-9-92

Functional Test:
LED Test

Test Description:
Each control pendant will have a feature of testing its own LEDs and audible alarms to confirm their operation.

Expected Result:
Each LED of the control pendant should begin flashing, regardless of previous state, when the keyswitch is rotated to the LED test position. The audible alarm should sound also.

Witnessed Result:
The keyswitch was turned to the LED test position. All LEDs flashed and the audible alarm sounded. When the key was returned to the off position, the LEDs ceased flashing, returned to their previous state, and the audible alarm was silent.

Consideration:
To perform the LED test, the keyswitch must be rotated to the LED test position. If the station is currently enabled, it will be disabled when going to the LED test mode. If a second operator at the other station is waiting to enable his station, he may enable it while the first operator goes to LED test mode, thus locking out the first operator.

Tested by: F. R. Ruppel

Date: 1-9-92

Functional Test:
Door LEDs

Test Description:
LEDs are provided for door open, door closed, and door energized for all three doors in the cart path.

Expected Result:
The LED should reflect the input for all door states.

Witnessed Result:
Inputs were simulated for door open, door closed, and door energized for doors 63M-001, 63M-008, and 3M-3. Each LED reflected its appropriate status.

Consideration:
When a door is energized, it prevents any cart operation. Fail safe circuitry of the door energized inputs should be addressed to assure that a failed door energized status will also prevent cart operation. Likewise, when the cart is driving within a certain distance of an unopen door, the operator will be notified. Fail safe circuitry of the door open limit switches should be addressed also.

Tested by: F. R. Ruppel

Date: 1-10-92

Functional Test:
Motor Drive

Test Description:
Using the control pendant, it should be possible to drive the motor clockwise and counterclockwise by using the drive north/drive south button. The appropriate motor voltage and current should appear on engineer's console display.

Expected Result:
Motor should rotate when north drive button pushed on control pendant and rotate in opposite direction when south drive button pushed. Engineer's console should read motor voltage and current.

Witness Result:
All motors indicated 0.0 A and -1.0 V at the engineer's console display when the motor was not running. (The -1.0 V is an offset error that was later corrected.)

Motor #1 indicated +13.1 V and 0.4 A when the south drive button was pushed and -15.0 V and 0.4 A when the north drive button was pushed.

Motor #2 indicated +14.0 V and 0.5 A when the south drive button was pushed and -16.1 V and 0.5 A when the north drive button was pushed.

Motor #3 indicated +14.0 V and 0.6 A when the south drive button was pushed and -15.9 V and 0.6 A when the north drive button was pushed.

Motor #4 indicated +13.6 V and 0.6 A when the south drive button was pushed and -15.3 V and 0.6 A when the north drive button was pushed.

Consideration:
As set up in hardware and software, motor voltages are reported either positive or negative depending on rotation direction. For historical logging, this will indicate which direction the motor was rotating at any given time. However, if historical values of average absolute voltage are desired, or any other absolute measurement, the data will have to be modified.

Tested by: F. R. Ruppel and A. V. Blalock

Date: 1-7-92

Functional Test:

Battery charging

Test Description:

Battery charging is one of the more complex operations performed by the operator.

Expected Result:

From the control pendant, the operator should be able to start and stop charging after the cart-at-shoes input is enabled and if the cart is not driving. The emergency stop switch should stop charging. Charging variables should be displayed on the engineer's console. Cart electronics should disable when charging commences. Polarity to the cart batteries should be switchable by the cart orientation switch.

Witnessed Result:

Charging was initiated by pressing the charge start button on the control pendant. The battery charger started and data was read at the engineer's console as follows: external voltage - 24.4 V, internal voltage - 24.7 V, current - 1.9 A, external temperature - 87.1°F, internal temperature - 86.7°F. The battery charging sequence was stopped by pressing the control pendant emergency stop button. The charger stopped and the cart system started. Charging was reinitiated and the charger was stopped again, this time by pressing the stop charging button on the control pendant. The next day, a full charge was given to the batteries. When charge current dropped below 0.08 A, the charging complete light on the control pendant lit up

When the cart orientation switch was changed, polarity to the cart batteries reversed.

Consideration:

The cart orientation switch should be under strict administrative control since it also controls charging polarity. Attempting to charge the batteries with polarity reversed could harm equipment.

Tested by: F. R. Ruppel

Date: 2-3 and 2-4-92

Functional Test:
Control Pendant Undercurrent Alarms

Test Description:
This procedure tests the motor undercurrent alarm at the control pendant. This alarm is designed to indicate to the operator when a wheel is free-wheeling. Use the control pendant to drive the motor; ensure that the motor current is monitored by the cart electronics and transmitted to the facility-side control system.

Expected Result:
During a low motor current condition, motor LEDs should flash after a 2 s time delay.

Witnessed Result:
Motor #1 was started with no load (current = 0.4 A). After 2 s, motor #1 LED flashed at the control pendant. When the motor was loaded, (current = 1.2 A) the LED stopped flashing.

Motor #2 was started with no load (current = 0.5 A). After 2 s, motor #1 LED flashed at the control pendant. When the motor was loaded, (current = 1.3 A) the LED stopped flashing.

Motor #3 was started with no load (current = 0.7 A). After 2 s, motor #1 LED flashed at the control pendant. When the motor was loaded, (current = 1.3 A) the LED stopped flashing.

Motor #4 was started with no load (current = 0.6 A). After 2 s, motor #1 LED flashed at the control pendant. When the motor was loaded, (current = 1.2 A) the LED stopped flashing.

Consideration:
The low current threshold is set at 1 A. During actual cart testing, this value may need to be adjusted in the PLC ladder logic to correctly reflect a free-wheeling current threshold.

Tested by: F. R. Ruppel and A. V. Blalock

Date: 1-7-92

Functional Test:
Motor trips

Test Description:
Each motor circuit has a hardware trip to protect cart electronics and the cart battery from excessive currents. A Hewlett-Packard 6060A programmable load was connected to simulate high currents.

Expected Result:
Each motor circuit should trip when current exceeds 25 A. The overcurrent LED on the control pendant should light for that motor. The hardware trip should stay in effect until the motor restart button for that motor is depressed on the control pendant.

Witnessed Result:
By using the programmable load, 25 A was applied to the motor #1 circuit. The circuit tripped and the motor #1 LED on the control pendant lit. The 25 A load was deenergized and the restart switch on the control pendant was depressed. After about a 1 s pause, the motor #1 LED went off. When the cart drive button was depressed, the motor circuit energized.

Note: This functional test was not completed for motors #2-4 because the trip function did not operate correctly. During later redesign efforts of the cart interface board, design problems were uncovered and corrected that prevented these motors from tripping.

Consideration:
When a motor restart is attempted from the control pendant, there is a short pause (1-2 s) before the motor-tripped LED goes off because of the round-trip time associated with processing the request on the facility side, transmitting the command to the cart, resetting the motor circuit on the cart, returning the new cart status to the facility, and reading the new cart status signal on the facility side.

Tested by: A. V. Blalock and F. R. Ruppel

Date: 1-31-92

Functional Test:
Auxiliary outlet operation/telemetry

Test Description:
Operation of the cart auxiliary outlets is controlled by the control pendant. Voltage and current readings of the auxiliary outlets are available at the engineer's console display.

Expected Result:
Each auxiliary outlet should be controlled individually from the control pendant. Appropriate voltage and current readings should be read at the engineer's console display.

Witnessed Result:
Auxiliary outlet #1 was enabled from the operator's pendant. The engineer's console indicated 22.6 V and 0 A (there was no load on the outlet, hence no current)

Auxiliary outlet #2 was enabled from the operator's pendant. The engineer's console indicated 0 V and 30 A. A software error was found that interchanged the voltage and current readings. This was corrected later.

Consideration:
The auxiliary outlet button must remain depressed the entire time it is desired to enable the auxiliary outlet.

Tested by: A. V. Blalock and F. R. Ruppel

Date: 1-30-92

Functional Test:

Cart ID selection

Test Description:

The cart control system has the capability of communicating to one of up to four different cart electronics racks. A two-position DIP switch on the interface board of the cart electronics rack assigns the cart ID.

Expected Result:

The cart should respond to all commands received at all times regardless of cart ID with the exception of the return status command. (See Section 9 of the main report for an explanation.) The cart status should be transmitted back to the facility only when the cart ID of the electronics rack matches the cart ID byte contained in the received packet.

Witnessed Result:

From the engineer's console, the cart ID of the cart electronics being tested was enabled. Communication with the cart were maintained and telemetry of cart variables was continuously updated. When the cart ID was changed at the engineer's console, the cart variables no longer updated. However, when requested by the control pendant, the cart motor would operate in this mode.

Consideration:

If the control system does not receive new incoming data, the memory will retain old values of variables. This could be confusing; it may be necessary to zero the values when no new data is received.

Tested by: F. R. Ruppel

Date: 1-3-92

Functional Test:
Motor Speed Control

Test Description:
At the engineer's console, a means exists of increasing or decreasing the speed of the cart motors.

Expected Result:
The speed of the motor should change when the increase or decrease button is depressed at the engineer's console.

Witnessed Result:
Using the engineer's console display, the cart speed window was selected. The decrease speed button was depressed several times in succession. The speed of the cart motor was noted to decrease by noting the decrease in pitch and visually noting a decrease in shaft velocity. The cart speed increase button was depressed and the motor speed was noted to increase by noting an increase in motor pitch and visually noting an increase in shaft speed.

Consideration:
The motor controller duty cycle will default to the default value after the cart computer is rebooted. Therefore, any adjustments made will be lost. The speed adjustment feature was installed mainly for testing purposes and may need to be taken out when the cart goes into operation. (The default value can be reset in software if necessary for the desired nominal cart speed.)

Tested by: F. R. Ruppel

Date: 1-23-92

Functional Test:
Cart reboot

Test Description:
At the engineer's console there is means to reboot the cart controller in the event that proper communications with the cart fails or cart operation is deemed erratic.

Expected Result:
When the reboot button of the engineer's display is actuated the cart controller should reboot.

Witnessed Result:
The cart reboot button on the engineer's console was selected and activated. A maintenance terminal was attached to the cart computer. When the reboot button was activated, a reboot was verified by the maintenance terminal display showing the boot-up message and reactivating the count. (The cart program has a counter that counts the seconds since last booted.)

Consideration:
The cart reboot command will reboot any electronics rack that is on-line. For example, if it is desired to communicate to a spare electronics rack (on the battery charger), remember that if a cart reboot command is given, it will also reboot the operating cart electronics rack.

Tested by: M. R. Moore, R. I. Vandermolen, and F. R. Ruppel

Date: 1-20-92

Functional Test:
Facility Antenna Control

Test Description:
Through the engineer's console, the engineer should have the capability to disable each facility antenna individually. This functionality is provided in the event that transmitting from more than one facility antenna causes rf signal nulls. In that case one main antenna would be chosen for cart communications and the interfering antenna would be disabled.

Expected Result:
By using the engineer's console computer, all four facility antennas should be able to be disabled and enabled.

Witnessed Result:
The rf system was hardwired from the facility side to the cart side with coax, simulating the CPC antenna. When the CPC antenna was enabled at the engineer's console, the cart motor operated. When the CPC antenna was disabled, the cart motor did not operate. The procedure was repeated for the VC, tunnel, and EDR antennas.

Consideration:
If an antenna is disabled, the engineer will have to remember to reenable it later—there is no alarm of flag to remind him to do so. If it is found that it is always necessary to disable an antenna when the cart is at a certain position, the programmable logic controller could be programmed to disable and then reenable the antenna.

Tested by: M. R. Moore and F. R. Ruppel

Date: 1-13-92

Functional Test:
Calibration current

Test Description:
When the cart controller first boots up, it goes through a calibration cycle. First it checks zero values of variables that should be at zero (motor and auxiliary outlet voltages and currents). Next a 5 A calibration current is applied through the motor and auxiliary outlet current measuring circuits to allow a span calibration.

Expected Result:
Since the 5 A calibration current will be based on hand selected components, it is not likely that exactly 5 A will be produced from the prototype circuit with random parts selection. The most important item to be checked is whether the calibration current flows in each circuit after the cart controller is booted up.

Witnessed Result:
Calibration shunt currents for the motors were 4.68 A each. Calibration shunt currents for the auxiliary outlets were 4.71 A each. The motor currents were measured directly and the auxiliary outlet currents were measured by measuring the voltage across a 0.01Ω shunt.

Consideration:
The shunt currents were not exactly 5 A because hand selection of components will be necessary to achieve exactly 5 A.

Tested by: A. V. Blalock and F. R. Ruppel

Date: 2-1-92

Functional Test:

Cart fan operation

Test Description:

A fan will be used to cool cart electronics when temperatures exceed a given threshold. Since the temperature of cart electronics is monitored by the cart controller, the same temperature input can be used to actuate the fan on and off.

Expected Result:

The cart fan should be enabled at 120°F rising and disabled at 100°F falling.

Witnessed Result:

The electronics enclosure temperature sensor was heated with a heat gun. At 141°F the fan was enabled. When the sensor was allowed to cool, the fan was disabled when the temperature reached 119.6°F. (Note: a software offset error was later corrected to allow the fan to come on at 120°F and turn off at 100°F.)

Consideration:

There is no status signal that positively confirms the status of the fan. An indirect method to determine this is to note the electronics temperature. If it is within the fan-operation window, it is probably on.

To conserve battery charge, the fan should run as little as possible. During cart testing, it may be found that the current fan operation window can be changed some to help conserve energy, but still keep the electronics rack cool enough.

Tested by: A. V. Blalock and F. R. Ruppel

Date: 2-1-92

Functional Test:

Cart position correction.

Test Description:

Software in the facility programmable logic controller calculates cart position relative to the battery charging station. (See Section 9 of the main report for a description of this algorithm.) The position indication is based on cart direction, duration of drive request, and nominal cart speed. Problems are foreseen with using this method, therefore correction points were built into the algorithm to indicate when the cart is passing a facility door threshold. When the cart limit switch actuates, it will be at a door.

Expected Result:

When the position indicates a distance within a certain tolerance of a facility door and the limit switch actuates, the position indication should correct to the distance to that door once (further actuations of the limit switch are ignored).

Witnessed Result:

North to 3M-3 The position indication was allowed to reach -24; when the limit switch was actuated, the indication corrected to -20.

North to 63M-008 The position indication was allowed to reach 17; when the limit switch was actuated, the indication corrected to 20.

North to 63M-001 The position indication was allowed to reach 55; when the limit switch was actuated, the indication corrected to 53.

South to 63M-001 The position indication was allowed to reach 62; when the limit switch actuated, the indication corrected to 54.

South to 63M-008 The position indication was allowed to reach 36; when the limit switch actuated, the indication corrected to 20.

South to 3M-3 The position indication was allowed to reach -22; when the limit switch was actuated, the position corrected to -20.

Note: When the limit switch was actuated away from the doors, no correction occurred.

Consideration:

Values used in this algorithm should be modified as necessary during cart testing to match the physical dimensions of the facility as close as possible.

Tested by: F. R. Ruppel

Date: 1-20-92

Functional Test:
Cart antenna diversity

Test Description:
One of the features of the cart communications system to help prevent rf signal nulling from interfering with communications is the cart antenna diversity selection scheme. In this scheme two cart antennas are monitored for signal strength. The antenna with the greater signal strength is chosen to be used for signal reception.

Expected Result:
By changing the field around one antenna, it should be possible to cause the antenna controller to switch that antenna on and off. The cart antenna usage reading on the engineer's console should reflect the switching.

Witnessed Result:
The antenna usage was read out at the engineer's console. By walking in front of the cart antennas, antenna usage values ranged from 0 to 100%.

Consideration:
The cart can switch receiving antennas only once per second. If the cart drives into a null, it will take a full second before antennas switch.

Tested by: R. I. Crutcher and F. R. Ruppel

Date: 1-23-92

Functional Test:

Cart temperature telemetry

Test Description:

The cart electronics monitor the temperature of the cart battery to aid in determining the state of charge of the battery. The cart electronics also monitor the temperature of the electronics rack to provide a cold junction compensation for the battery thermocouple and to actuate the rack fan on and off with temperature.

Expected Result:

Monitor the temperature as reported on the engineer's console of the two points. Since the final version of hardware will be based on special hand-selected components, the prototype version is not expected to be very accurate.

Witnessed Result:

The cart battery temperature, as read on the engineer's console, was 73.3°F. The electronics enclosure temperature read 76.5°F. The temperature from an independent, calibrated type T thermocouple readout instrument read 72°F.

Consideration:

High accuracy temperature readings were not obtained because in the final hardware version, it will be necessary to hand select components for a good tolerance. Furthermore, the circuit was not designed for high accuracy, but for a rough indication of temperature to be used by the battery state-of-charge indication.

Tested by: A. V. Blalock and F. R. Ruppel

Date: 1-30-92

Functional Test:

Auxiliary outlet trips

Test Description:

A Hewlett-Packard 6060A programmable load was placed in the auxiliary outlet circuit to allow large amounts of current to flow.

Expected Result:

When current through the auxiliary outlet circuit exceeds 25 A, a hardware trip should become effective. The LED associated with the auxiliary outlet should flash. To reset the outlet, the operator would have to let up on the control pendant button and then depress again. If the high current condition is no longer in effect, the trip will clear.

Witnessed Result:

Each auxiliary outlet was turned on from the control pendant. Current to the circuit was raised. When a current of 25 A was applied to each circuit, each circuit tripped and the LED flashed on the pendant. After the trip, the reset button was pushed and the outlets reset.

Consideration:

The auxiliary outlets, when tripped, will automatically try to reset when the operator depresses the outlet button again. This logic is different than the motor reset logic, where a motor remains tripped until is requested to restart.

Tested by: A. V. Blalock and F. R. Ruppel

Date: 1-31-92

APPENDIX E
DRAWINGS

West Valley Nuclear Services Vitrification Facility
Transfer Cart Control System Drawing List

Rev. 4, 5/7/92

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West Valley Transfer Cart Drawing List

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103	Engineer's Console Subassemblies
105	Engineer's Console Wiring Diagram #1
106	Engineer's Console Wiring Diagram #2
110	Engineer's Console Computer Flow Chart
111	Operator Stations Logic Diagram #1
112	Operator Stations Logic Diagram #2
120	Control Pendant Enclosure Diagram
121	Control Pendant Metalphoto Decal
122	Control Pendant LED Etched Wiring Board Schematic
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123 sht 2	Control Pendant Board Drill Master & Front Parts Placement
125	Control Pendant Junction Box Assembly
126	Typical Control Pendant Wiring
131	Battery Charger Interface Box Assembly
132	Battery Charger Interface Box Interconnection Wiring Diagram
135	Battery Charger Polarity Manager Board Schematic
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172	Facility Transmitter Parts List
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INSTRUMENTATION AND CONTROLS DRAWINGS (Q-6340 SERIES)

Cart Systems	
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205	Enclosure Assembly
210	Cart Controller Flow Chart
215	Electronics Enclosure Wiring Diagram
220	Interface Module, Top Board, Parts Placement
221	Interface Module, Top Board, Layout
222	Interface Module, Top Board, Functional & Battery Interface Schematic
223	Interface Module, Top Board, Motor Control Schematic
224	Interface Module, Top Board Parts List
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231 sht 2	Interface Module, Bottom Board Layout, Solder Side
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233	Interface Module, Bottom Board Parts List
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240	Cart Wiring Schedule
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245	Cart Electronics Rack Mechanical Details
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101 sht 1	Control Module Interface Control Drawing
101 sht 2	Control Module Interface Control Drawing
102 sht 1	Control Module Enclosure Assembly
102 sht 2	Control Module Enclosure Assembly
103 sht 1	Control Module Enclosure Weldment
103 sht 2	Control Module Enclosure Weldment
104	Control Module Enclosure Details
105	Control Module Battery Compartment Assembly
106 sht 1	Control Module Detail Sheet No. 1
106 sht 2	Control Module Detail Sheet No. 1
107	Control Module Remote Connector Assembly
108 sht 1	Control Module Remote Connector Details
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109	Control Module Detail Sheet No. 2
110	Control Module Detail Sheet No. 3
111 sht 1	Control Module Antenna Assembly
111 sht 2	Control Module Antenna Assembly
112	Control Module Shielded Enclosure Weldment
113	Facility Antenna Assembly
114	Facility Antenna Details
115	Facility Antenna Details

REFERENCE DRAWINGS | NUMBER

MARTIN MARIETTA — MARTIN MARIETTA ENERGY SYSTEMS, INC.

CONTROL SYSTEM
DRAWING INDEX

WEST VALLEY TRANSFER CART

TOLERANCES UNLESS OTHERWISE SPECIFIED	
DRAWN BY	K.F.CUTSHAW
ENGINEER	F.R.RUPPEL 5/92
APPROVED	J.W.STAPLETON 5/92
FILE DATE	6/3/92
FILE POINT	HC-1 EC-1
SHT. OF	1 1
SCALE	N/A
ID	I & C
NUMBER	Q-6340-000

FRACTIONS ± 1/64"
DRAWING APPROVALS | DATE

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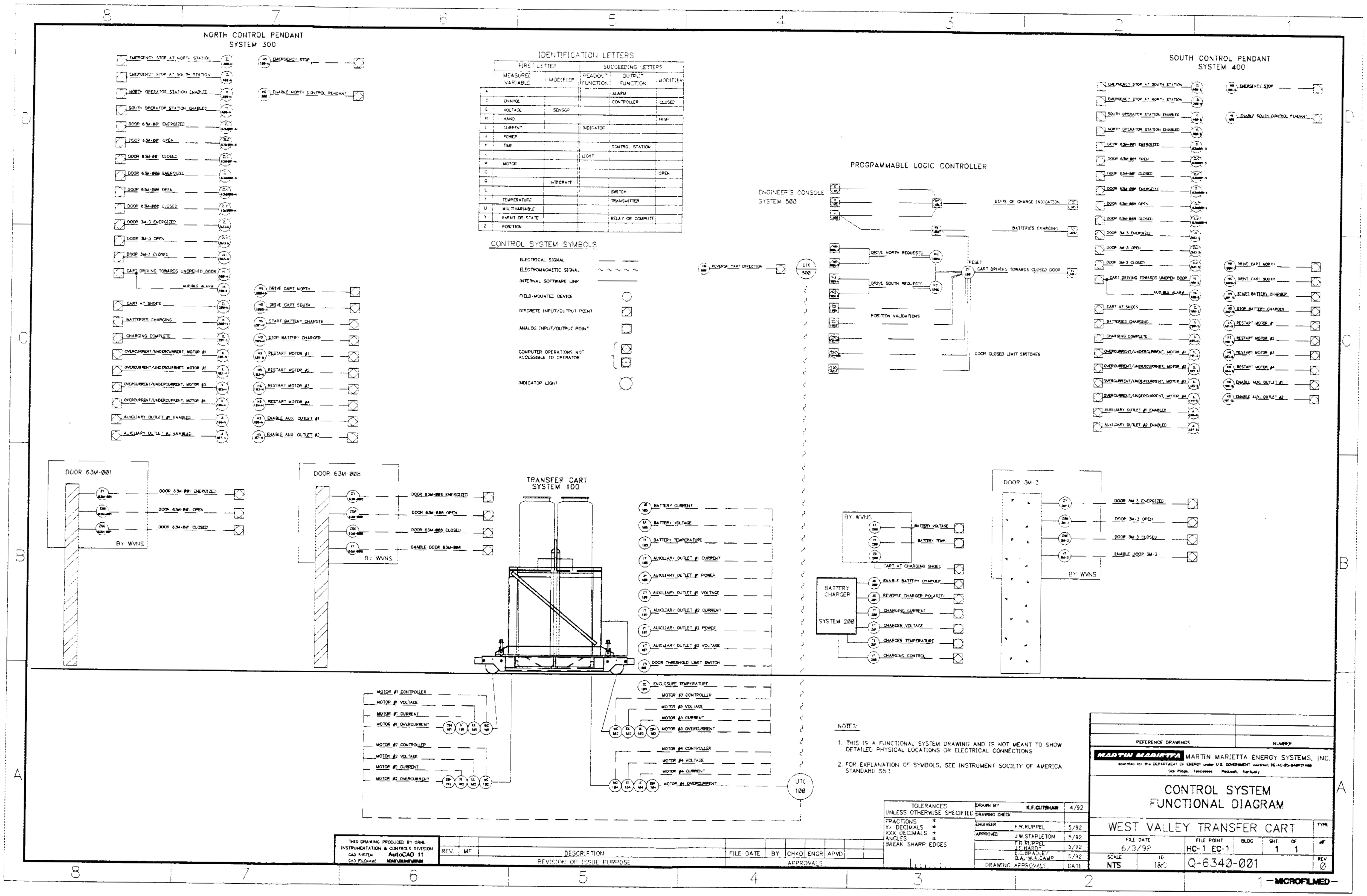
NORTH CONTROL PENDANT
SYSTEM 300
SOUTH CONTROL PENDANT
SYSTEM 400
IDENTIFICATION LETTERS
CONTROL SYSTEM SYMBOLS
PROGRAMMABLE LOGIC CONTROLLER
ENGINEER'S CONSOLE
SYSTEM 500
TRANSFER CART
SYSTEM 100
DOOR 63M-001
DOOR 63M-008
DOOR 3M-3
BY WVNS
BATTERY CHARGER
SYSTEM 200
UTC
100
NOTES:
1. THIS IS A FUNCTIONAL SYSTEM DRAWING AND IS NOT MEANT TO SHOW DETAILED PHYSICAL LOCATIONS OR ELECTRICAL CONNECTIONS
2. FOR EXPLANATION OF SYMBOLS, SEE INSTRUMENT SOCIETY OF AMERICA STANDARD S5.1
TOLERANCES
UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES
DRAWN BY K.F.CUTSHAW 4/92
DRAWING CHECK
ENGINEER F.R.RUPPEL 5/92
APPROVED J.W.STAPLETON 5/92
F.R.RUPPEL
J.E.HARDY 5/92
E.C.BRADLEY
Q.A.-W.A.CAMP 5/92
DRAWING APPROVALS
DATE
REFERENCE DRAWINGS
NUMBER
MARTIN MARIETTA
MARTIN MARIETTA ENERGY SYSTEMS, INC.
CONTROL SYSTEM
FUNCTIONAL DIAGRAM
WEST VALLEY TRANSFER CART
FILE DATE 6/3/92
FILE POINT HC-1 EC-1
SHT. 1 OF 1
SCALE NTS
ID I&C
Q-6340-001
REV 0
REV. MF DESCRIPTION FILE DATE BY CHKD ENGR APVD
REVISION OR ISSUE PURPOSE
APPROVALS
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AutoCAD 11
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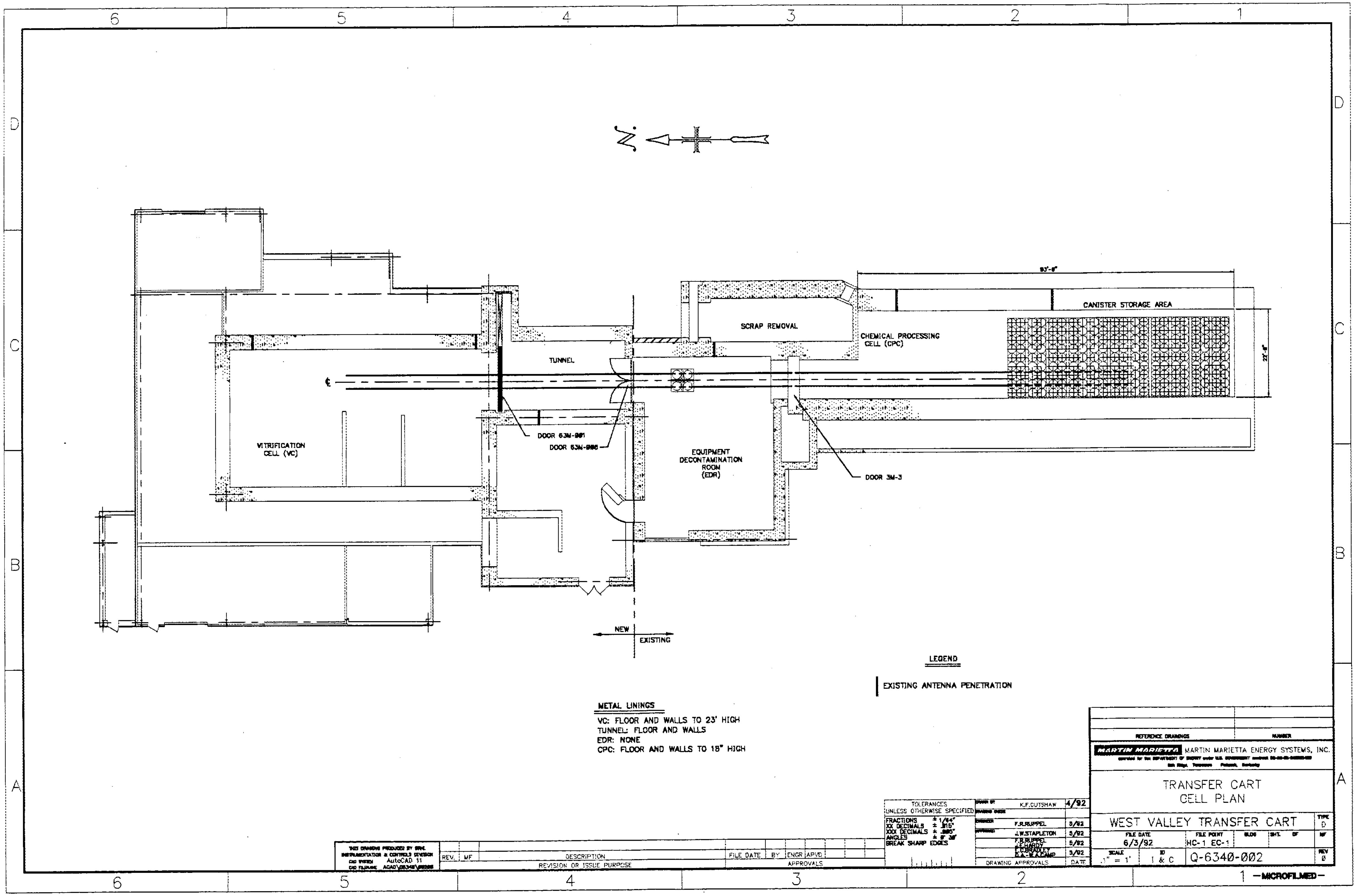
N
CANISTER STORAGE AREA
SCRAP REMOVAL
CHEMICAL PROCESSING CELL (CPC)
TUNNEL
VITRIFICATION CELL (VC)
EQUIPMENT DECONTAMINATION ROOM (EDR)
DOOR 63M-001
DOOR 63M-006
DOOR 3M-3
NEW
EXISTING
LEGEND
EXISTING ANTENNA PENETRATION
METAL LININGS
VC: FLOOR AND WALLS TO 23' HIGH
TUNNEL: FLOOR AND WALLS
EDR: NONE
CPC: FLOOR AND WALLS TO 18" HIGH
REFERENCE DRAWINGS
NUMBER
MARTIN MARIETTA
MARTIN MARIETTA ENERGY SYSTEMS, INC.
TRANSFER CART
CELL PLAN
WEST VALLEY TRANSFER CART
TOLERANCES
UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/64"
BREAK SHARP EDGES
K.F.CUTSHAW 4/92
F.R.RUPPEL 5/92
J.W.STAPLETON 5/92
DRAWING APPROVALS
DATE
FILE DATE 6/3/92
FILE POINT HC-1 EC-1
TYPE D
I & C
Q-6340-002
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FILE DATE
BY
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AutoCAD 11
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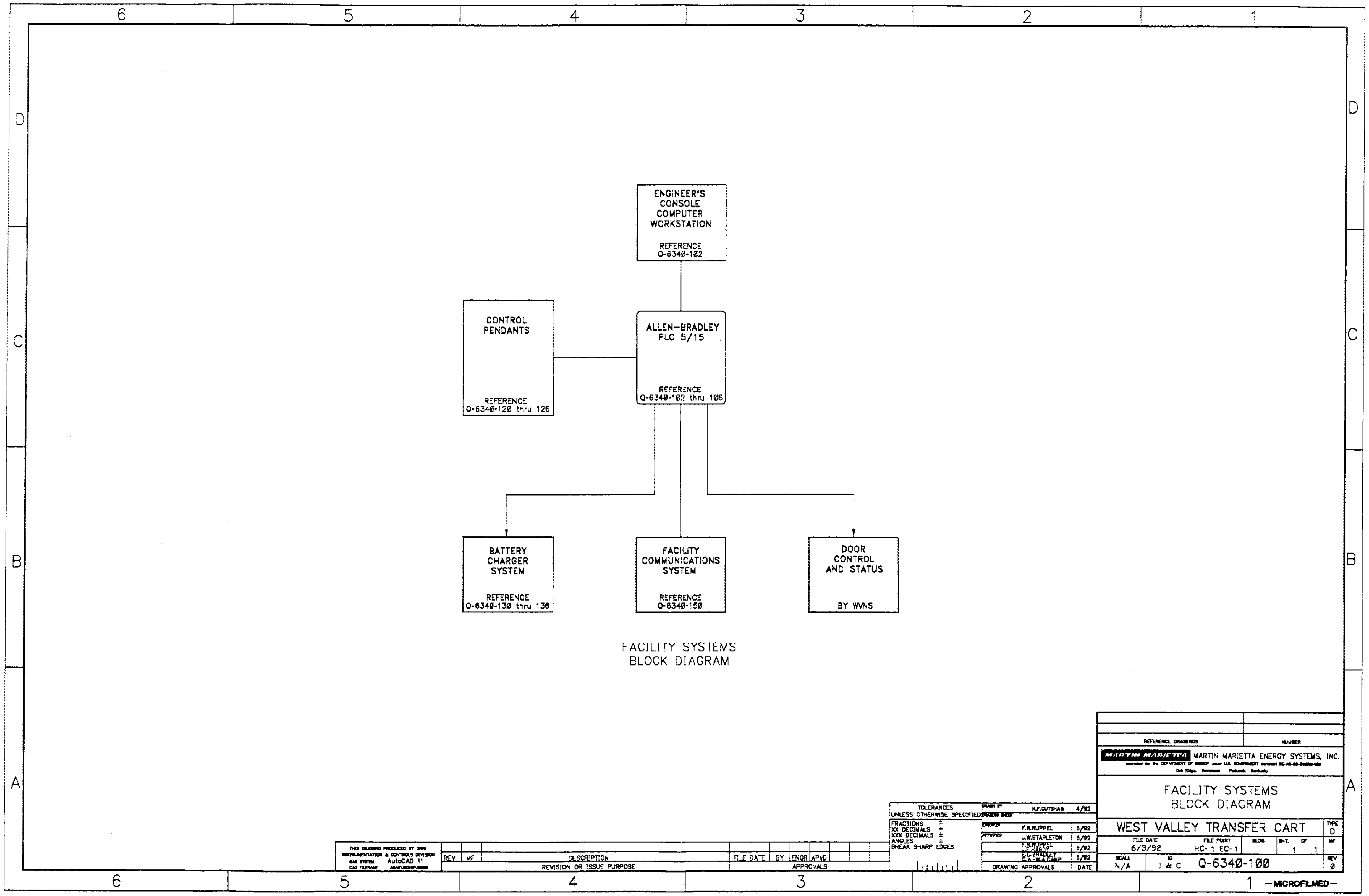
ENGINEER'S CONSOLE COMPUTER WORKSTATION
REFERENCE Q-634Ø-1Ø2
CONTROL PENDANTS
REFERENCE Q-634Ø-12Ø thru 126
ALLEN-BRADLEY PLC 5/15
REFERENCE Q-634Ø-1Ø2 thru 1Ø6
BATTERY CHARGER SYSTEM
REFERENCE Q-634Ø-13Ø thru 136
FACILITY COMMUNICATIONS SYSTEM
REFERENCE Q-634Ø-15Ø
DOOR CONTROL AND STATUS
BY WVNS
FACILITY SYSTEMS BLOCK DIAGRAM
REFERENCE DRAWINGS
NUMBER
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FACILITY SYSTEMS BLOCK DIAGRAM
WEST VALLEY TRANSFER CART
TYPE D
FILE DATE 6/3/92
FILE POINT HC-1 EC-1
SHT. 1 OF 1
SCALE N/A
I & C
Q-634Ø-1ØØ
REV Ø
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES
DRAWN BY K.F.CUTSHAW 4/92
F.R.RUPPEL 5/92
APPROVED J.W.STAPLETON 5/92
5/92
5/92
DRAWING APPROVALS
DATE
AutoCAD 11
REV.
MF
DESCRIPTION
REVISION OR ISSUE PURPOSE
FILE DATE
BY
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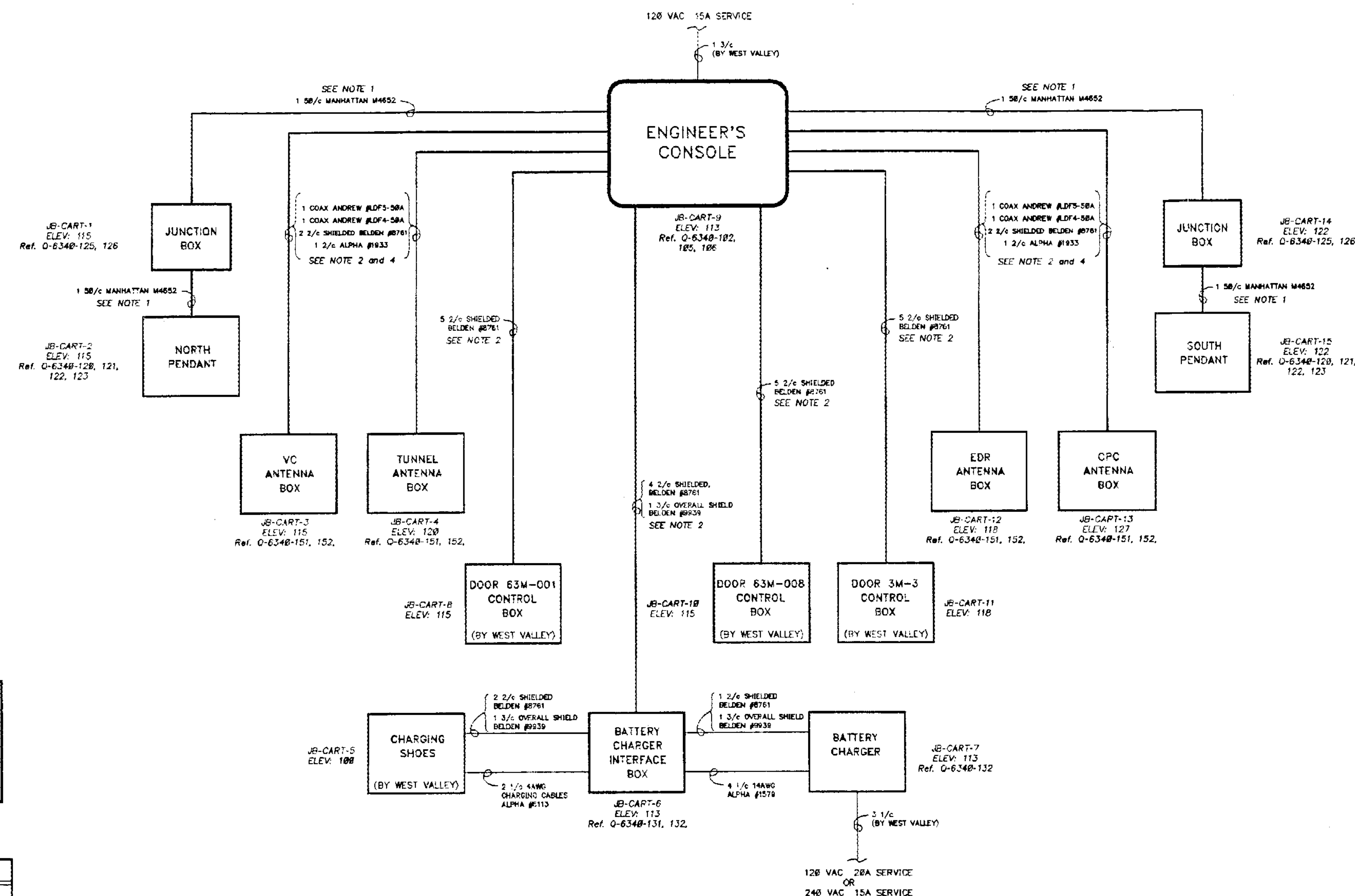
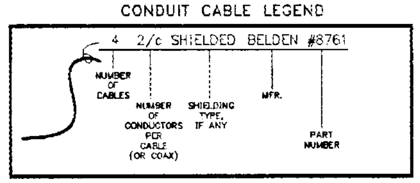


CONDUIT CABLE LEGEND



CABLE SPECIFICATIONS

MFR.	PART No.	TYPE	CABLE O.D.(in)
ALPHA	1579	SINGLE CONDUCTOR	0.17
ALPHA	1953	2 CONDUCTOR	0.33
ALPHA	6113	SINGLE CONDUCTOR	0.42
ANDREW	LDF4-50A	COAX	0.63
ANDREW	LDF5-50A	COAX	1.09
BELDEN	8761	SHIELDED TWISTED PAIR	0.18
BELDEN	9939	3 CONDUCTOR OVERALL SHIELD	0.20
MANHATTAN	M4652	50 CONDUCTOR OVERALL SHIELD	0.49

NOTES:

1. *Multiconductor cable includes 7 spare conductors.*
2. *Includes 1 spare 2/c shielded twisted pair.*
3. *Space high-level wiring and conduit a minimum of 12 inches from wiring and conduit shown on this drawing. If high-level lines must cross closer, cross at right angles. See IEEE 518-1982 for recommended installation practices.*
4. *Minimum bend radius of LDF5-50A cable is 10 inches. Minimum bend radius of LDF4-50A cable is 5 inches.*

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CAD SYSTEM AutoCAD 11
CAD FILENAME ACAD\06340\10100

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TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES

DRAWING APPROVALS		DATE
DRAWN BY	K.F.CUTSHAW	2/28/92
DRAWING CHECK		
ENGINEER	F.R.RUPPEL	2/28/92
APPROVED	J.E.HARDY	3/2/92
	E.C.BRADLEY	3/11/92
	Q.A.-W.A.CAMP	3/92

REFERENCE DRAWINGS	NUMBER

MARTIN MARIETTA ENERGY SYSTEMS, INC.
operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

FACILITY CONDUIT AND CABLING REQUIREMENTS

WEST VALLEY TRANSFER CART

FILE DATE	FILE POINT	BLDG	SHT.	OF	MF
6/3/92	HC-1 EC-1		1	1	

SCALE	ID	NUMBER	REV
N/A	I&C	Q-6340-101	0

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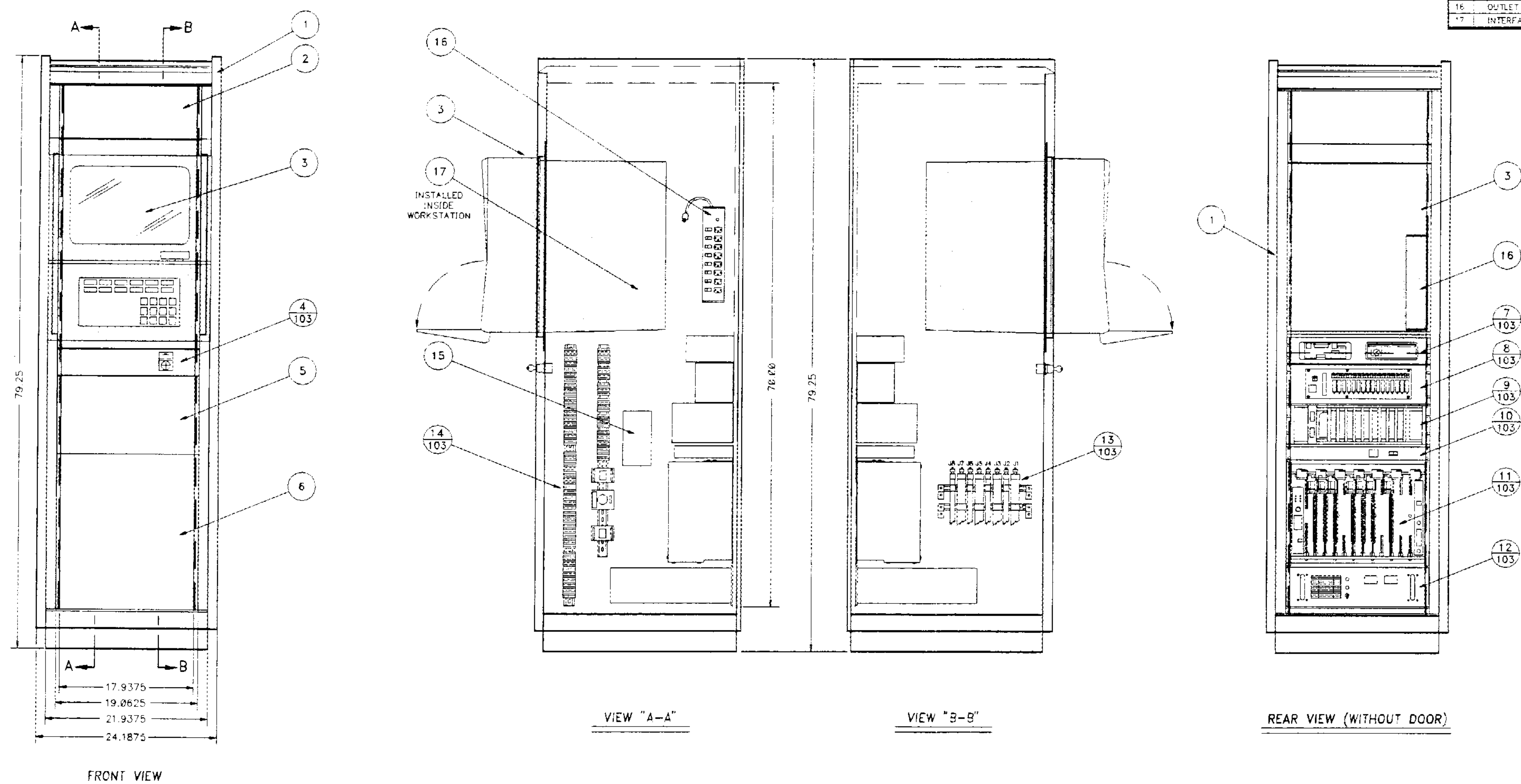
ENGINEER'S CONSOLE PARTS LIST

ITEM	DESCRIPTION	MANUFACTURER	PART No.	DWG. No.
1	ENCLOSURE	BUD	E-2030RB	Q6340-102
2	PANEL, 7"	BUD	PA1104LG	Q6340-102
3	WORKSTATION	NEMATRON	IWS-5830Ox W/ MTG-R06 RACK MOUNT KIT	Q6340-102
4	SWITCH PANEL			Q6340-103
5	PANEL, 10 1/2"	BUD	PA1106LG	Q6340-102
6	PANEL, 21"	BUD	PA1112LG	Q6340-102
7	BREAK OUT PANEL			Q6340-103
8	I/O PANEL			Q6340-103
9	STD PANEL			Q6340-103
10	FAN	UNITRAK	F-0800-E-4	Q6340-103
11	PLC PANEL			Q6340-103
12	POWER LINE CONDITIONER	ELGAR	6006B	Q6340-103
13	CABLE CLAMPS			Q6340-103
14	TERMINAL BLOCKS			Q6340-103
15	POWER SUPPLY	SORENSEN	KRE 150-24	Q6340-102
16	OUTLET STRIP	SPC TECH.	BAC-818-2640-BS	Q6340-102
17	INTERFACE CARD	SUTHERLAND-SHULTZ	S136-SD	Q6340-102



REFERENCE DRAWINGS	NUMBER
WIRING DIAGRAM	Q-6340-105, 106
SUBASSEMBLIES	Q-6340-103

MARTIN MARIETTA ENERGY SYSTEMS, INC.
operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC-[illegible]
Oak Ridge, Tennessee Paducah, Kentucky

ENGINEER'S CONSOLE ASSEMBLY

WEST VALLEY TRANSFER CART

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES

DRAWN BY	K.F.CUTSHAW	4/7/92
DRAWING CHECK	NOTE: PLOT 1=8	
ENGINEER	F.R.RUPPEL	5/92
APPROVED	J.W.STAPLETON	5/92
	F.R.RUPPEL J.E.HARDY	5/92
	E.C.BRADLEY Q.A.-W.A.CAMP	5/92
DRAWING APPROVALS		DATE

FILE DATE 6/3/92 — FILE POINT HC-1 EC-1 — BLDG — SHT. OF — TYPE — MF
SCALE 1/8"=1" — ID I&C — Q-6340-102 — REV Ø

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CAD SYSTEM AutoCAD 11
CAD FILENAME ACAD\Q6340\102

REV | MF | DESCRIPTION — REVISION OR ISSUE PURPOSE | FILE DATE | BY | CHKD | ENGR | APVD — APPROVALS

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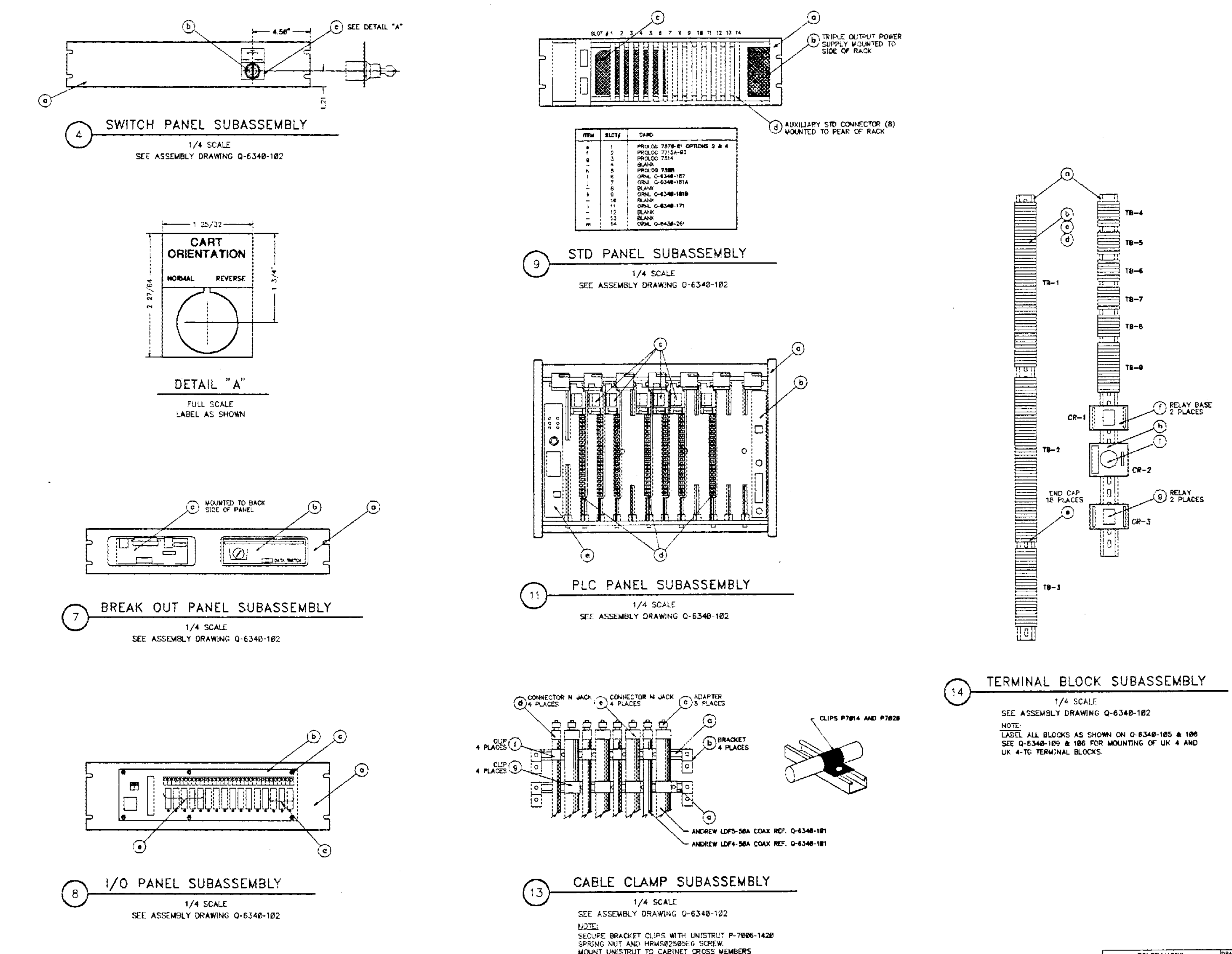

PARTS LIST

ITEM	DESCRIPTION	REQ'D	MANUFACTURER	PART No.
4a	PANEL, 3 1/2"	1	BUD	PA 1102 LG
4b	KEY SWITCH	1	ALLEN-BRADLEY	800T-H33B
4c	LEGEND PLATE	1	ALLEN-BRADLEY	800T-X559JE
7a	PATCH PANEL	1	L-COM	PR35P-SB0
7b	SWITCH BOX	1	L-COM	DTS2512-2LM
7c	BREAKOUT PANEL	1	PROLOG	BP-01 (included w/ Item 9e)
	#4-40 x 3/4" SCREW	3	SPC TECHNOLOGY	SBH-0440-048-SN
	1/2" HEX SPACER	3	SPC TECHNOLOGY	HTA-4-500
	#4 WASHER	3	SPC TECHNOLOGY	WLI-04-017-SC
	#4-40 NUT	3	SPC TECHNOLOGY	NH-0440-006-SN
8a	PANEL CHASSIS	1	BUD	CB-1372
8b	I/O PANEL	1	OPTO 22	PB-16H
8c	#6-32 x 1" SCREW	4	SPC TECHNOLOGY	SRH-0632-064-SN
	#6 WASHER	4	SPC TECHNOLOGY	WLI-06-018-SC
	#6-32 NUT	4	SPC TECHNOLOGY	NH-0632-007-SN
8d	INPUT MODULE	3	OPTO 22	IDC5D
8e	OUTPUT MODULE	5	OPTO 22	ODC5
9a	CHASSIS	1	WINSYSTEMS	CC6-RM-PS70 options 1,2,3,4
9b	POWER SUPPLY	1	SORENSEN	KFD 40E-02 SC triple output
9c	MOTHERBOARD	1	WINSYSTEMS	MB-6 (included w/ Item 9c)
9d	STD CONNECTOR	8	VECTOR	R656-1
9e	SINGLE BOARD COMPUTER	1	PROLOG	7870-01 OPTIONS 2 &4
9f	RAM DISK CARD	1	PROLOG	7715A-03
9g	ALLEN-BRADLEY INTERFACE CARD	1	PROLOG	7514
9h	TTL I/O BOARD	1	PROLOG	7508
9i	FACILITY ENCODER/DECODER	1	ORNL	Q-6340-187
9j	FACILITY ANTENNA SWITCH#1	1	ORNL	Q-6340-181A
9k	FACILITY ANTENNA SWITCH#2	1	ORNL	Q-6340-181B
9l	FACILITY TRANSMITTER	1	ORNL	Q-6340-171
9m	CART/FACILITY RECEIVER	1	ORNL	Q-6340-261
11a	CHASSIS	1	ALLEN-BRADLEY	1771-A3
11b	POWER SUPPLY	1	ALLEN-BRADLEY	1771-P45
11c	OUTPUT MODULES	4	ALLEN-BRADLEY	1771-OBD
11d	INPUT MODULES	3	ALLEN-BRADLEY	1771-IBD
11e	PROCESSOR W/EPROM	1	ALLEN-BRADLEY	1785-LT W/ 1785-MJ
13a	CHANNEL	2	UNISTRUT	P-7000
13b	BRACKET	4	UNISTRUT	P-7347
13c	ADAPTOR	8	L-COM	SMA JACK TO N PLUG, BA34
13d	CONNECTOR N JACK	4	ANDREW	L44N
13e	CONNECTOR N JACK	4	ANDREW	L45N
13f	CLIP	4	UNISTRUT	P7014
13g	CLIP	4	UNISTRUT	P-7020
14a	MOUNTING RAIL	2	PHOENIX CONTACT	NS 35/7.5
14b	TERMINAL BLOCK	108	PHOENIX CONTACT	UK 4
14c	TERMINAL BLOCK	52	PHOENIX CONTACT	UK 4-TG
14d	COMPONENT PLUG	52	PHOENIX CONTACT	ST-BE
14e	END CAP	18	PHOENIX CONTACT	E/UK
14f	RELAY BASE	2	PHOENIX CONTACT	EM2-RELS-K2-G-24
14g	RELAY	2	POTTER & BRUMFIELD	KHU17D11
14h	RELAY BASE	1	PHOENIX CONTACT	RMOB-JR-2-24
14i	RELAY	1	POTTER & BRUMFIELD	CDD38-30014

REFERENCE DRAWINGS	NUMBER
WIRING DIAGRAM	Q-6340-105, 106
ENG. CONSOLE ASSEMBLY	Q-6340-102

MARTIN MARIETTA ENERGY SYSTEMS, INC.
operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract [illegible]
Oak Ridge, Tennessee Paducah, Kentucky

ENGINEER'S CONSOLE SUB-ASSEMBLIES

WEST VALLEY TRANSFER CART

FILE DATE	FILE POINT	BLDG	SHT. OF	MF
6/3/92	HC-1 EC-1			

SCALE	ID	DRAWING NO.	REV
NOTED	I&C	Q-6340-103	0

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES

DRAWING APPROVALS		DATE
DRAWN BY	K.F.CUTSHAW	3/20/92
DRAWING CHECK		
ENGINEER	F.R.RUPPEL	4/92
APPROVED	J.W.STAPLETON	5/92
	F.R.RUPPEL J.E.HARDY	5/92
PLOT 1=4	E.C.BRADLEY Q.A.-W.A.CAMP	5/92

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		REVISION OR ISSUE PURPOSE					

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CAD FILENAME ACAD\Q6340\103

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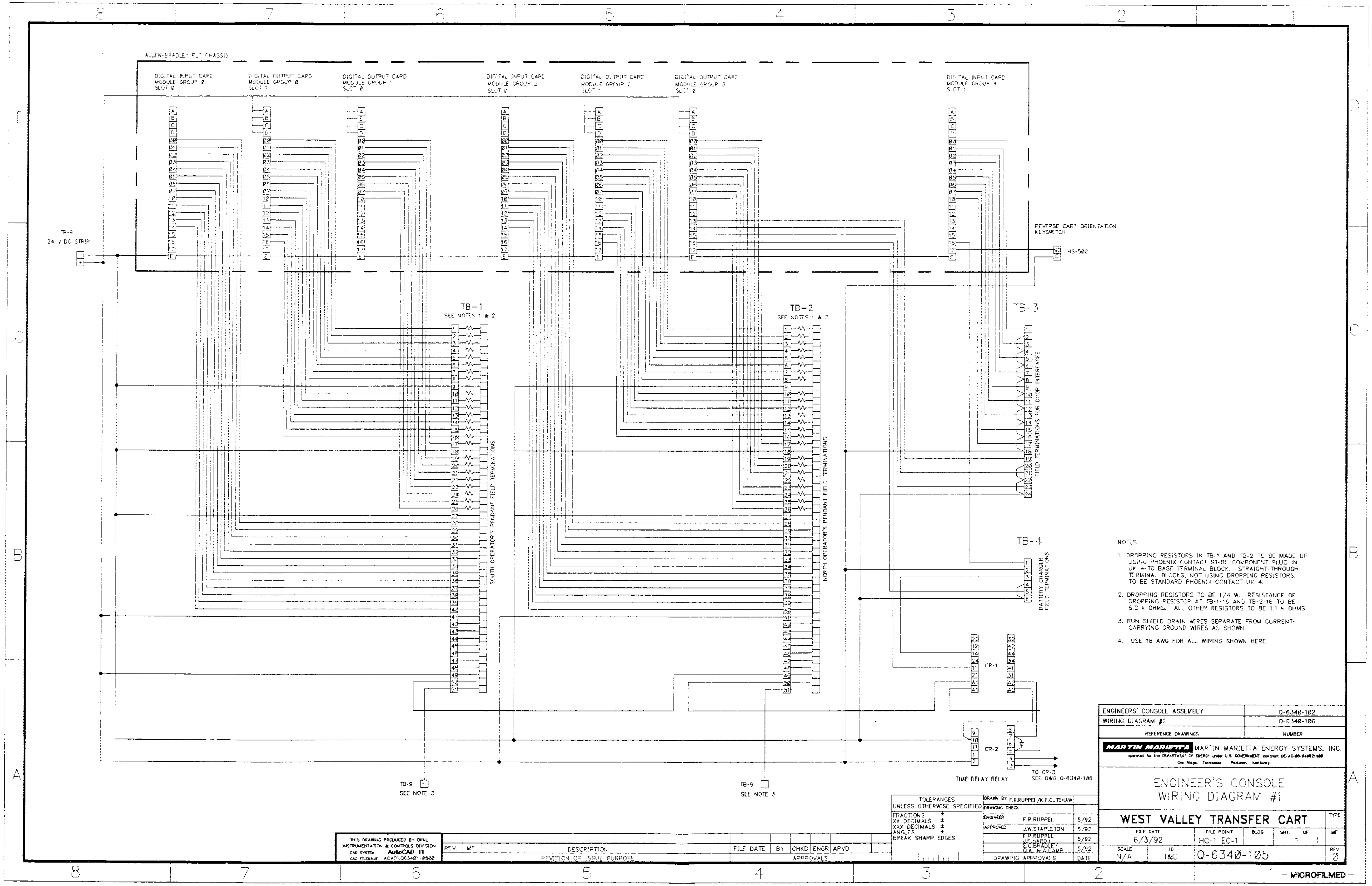
ALLEN-BRADLEY PLC CHASSIS
DIGITAL INPUT CARD MODULE GROUP 0 SLOT 0
DIGITAL OUTPUT CARD MODULE GROUP 0 SLOT 1
DIGITAL OUTPUT CARD MODULE GROUP 1 SLOT 2
DIGITAL INPUT CARD MODULE GROUP 2 SLOT 0
DIGITAL OUTPUT CARD MODULE GROUP 2 SLOT 1
DIGITAL OUTPUT CARD MODULE GROUP 3 SLOT 2
DIGITAL INPUT CARD MODULE GROUP 4 SLOT 1
TB-9
24 V DC STRIP
REVERSE CART ORIENTATION KEYSWITCH
HS-500
TB-1
SEE NOTES 1 & 2
SOUTH OPERATOR'S PENDANT FIELD TERMINATIONS
TB-2
SEE NOTES 1 & 2
NORTH OPERATOR'S PENDANT FIELD TERMINATIONS
TB-3
FIELD TERMINATIONS FOR DOOR INTERFACES
TB-4
BATTERY CHARGER FIELD TERMINATIONS
CR-1
CR-2
TIME-DELAY RELAY
TO CR-3
SEE DWG Q-6340-106
TB-9
SEE NOTE 3
TB-9
SEE NOTE 3
NOTES
1. DROPPING RESISTORS IN TB-1 AND TB-2 TO BE MADE UP USING PHOENIX CONTACT ST-BE COMPONENT PLUG IN UK 4-TG BASE TERMINAL BLOCK. STRAIGHT-THROUGH TERMINAL BLOCKS, NOT USING DROPPING RESISTORS, TO BE STANDARD PHOENIX CONTACT UK 4.
2. DROPPING RESISTORS TO BE 1/4 W. RESISTANCE OF DROPPING RESISTOR AT TB-1-16 AND TB-2-16 TO BE 6.2 k OHMS. ALL OTHER RESISTORS TO BE 1.1 k OHMS.
3. RUN SHIELD DRAIN WIRES SEPARATE FROM CURRENT-CARRYING GROUND WIRES AS SHOWN.
4. USE 18 AWG FOR ALL WIRING SHOWN HERE.
ENGINEERS' CONSOLE ASSEMBLY Q-6340-102
WIRING DIAGRAM #2 Q-6340-106
REFERENCE DRAWINGS NUMBER
MARTIN MARIETTA
MARTIN MARIETTA ENERGY SYSTEMS, INC.
ENGINEER'S CONSOLE
WIRING DIAGRAM #1
WEST VALLEY TRANSFER CART
FILE DATE 6/3/92
FILE POINT HC-1 EC-1
SHT. 1 OF 1
SCALE N/A
ID I&C
Q-6340-105
REV 0
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES
F.R.RUPPEL 5/92
J.W.STAPLETON 5/92
5/92
5/92
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CAD SYSTEM AutoCAD 11
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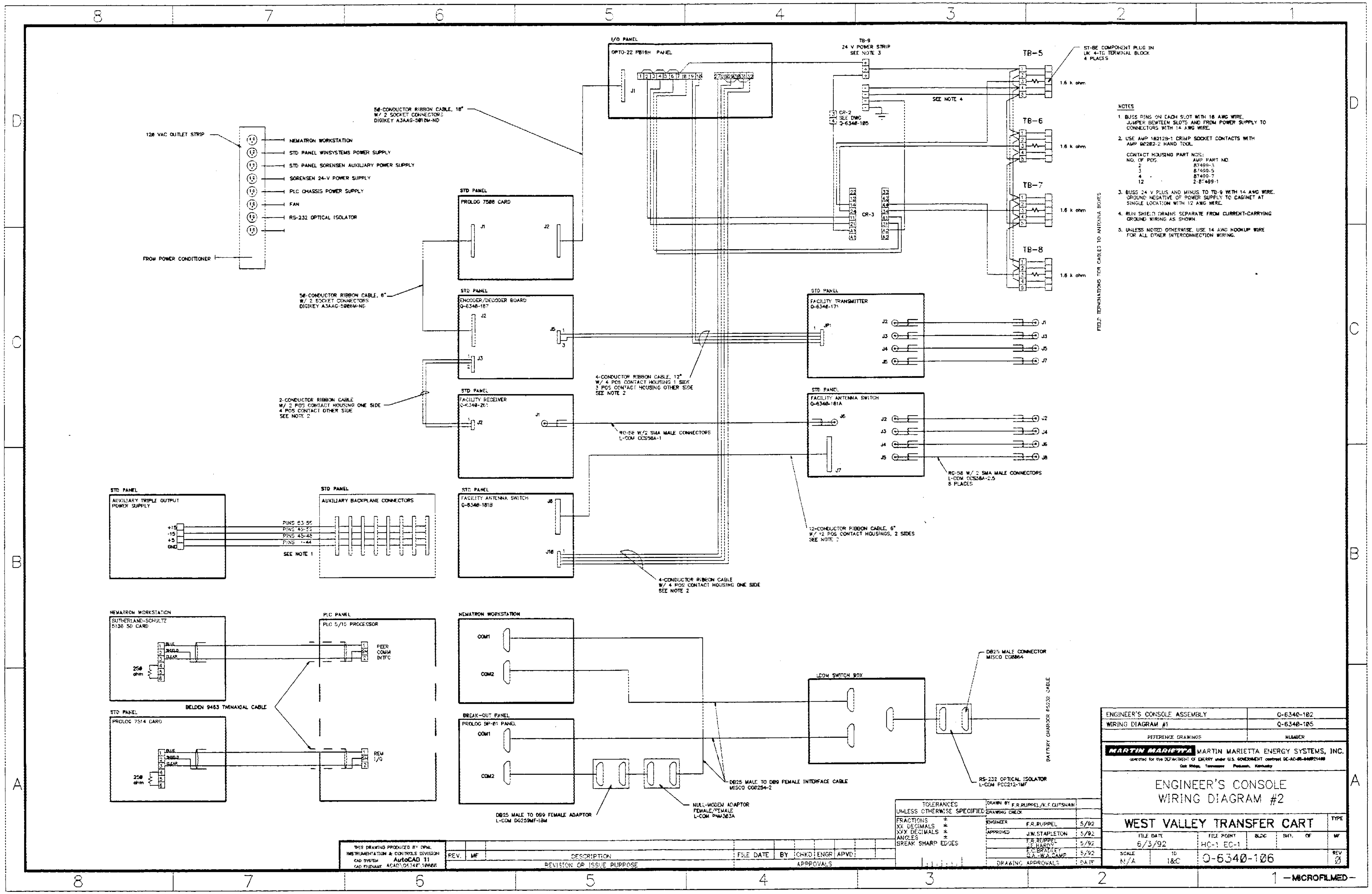
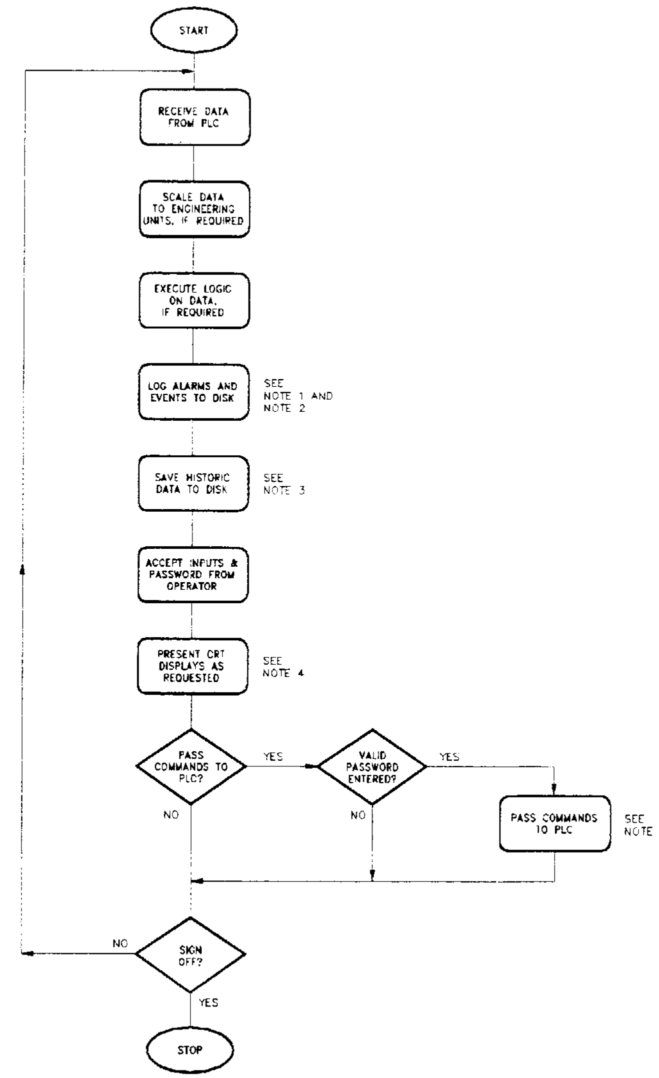

I/O PANEL
OPTO-22 PB16H PANEL
TB-9
24 V POWER STRIP
SEE NOTE 3
TB-5
TB-6
TB-7
TB-8
1.6 k ohm
ST-BE COMPONENT PLUG IN
UK 4-TG TERMINAL BLOCK
4 PLACES
SEE NOTE 4
CR-2
SEE DWG
Q-6340-105
CR-3
FIELD TERMINATIONS FOR CABLES TO ANTENNA BOXES
NOTES
1. BUSS PINS ON EACH SLOT WITH 16 AWG WIRE. JUMPER BEWTEEN SLOTS AND FROM POWER SUPPLY TO CONNECTORS WITH 14 AWG WIRE.
2. USE AMP 162128-1 CRIMP SOCKET CONTACTS WITH AMP 90202-2 HAND TOOL.
CONTACT HOUSING PART NOS.:
NO. OF POS. AMP PART NO.
2 87499-3
3 87499-5
4 87499-7
12 2-87499-1
3. BUSS 24 V PLUS AND MINUS TO TB-9 WITH 14 AWG WIRE. GROUND NEGATIVE OF POWER SUPPLY TO CABINET AT SINGLE LOCATION WITH 12 AWG WIRE.
4. RUN SHIELD DRAINS SEPARATE FROM CURRENT-CARRYING GROUND WIRING AS SHOWN.
5. UNLESS NOTED OTHERWISE, USE 14 AWG HOOKUP WIRE FOR ALL OTHER INTERCONNECTION WIRING.
120 VAC OUTLET STRIP
NEMATRON WORKSTATION
STD PANEL WINSYSTEMS POWER SUPPLY
STD PANEL SORENSEN AUXILIARY POWER SUPPLY
SORENSEN 24-V POWER SUPPLY
PLC CHASSIS POWER SUPPLY
FAN
RS-232 OPTICAL ISOLATOR
FROM POWER CONDITIONER
50-CONDUCTOR RIBBON CABLE, 18"
W/ 2 SOCKET CONNECTORS
STD PANEL
PROLOG 7500 CARD
50-CONDUCTOR RIBBON CABLE, 6"
W/ 2 SOCKET CONNECTORS
STD PANEL
ENCODER/DECODER BOARD
Q-6340-187
STD PANEL
FACILITY TRANSMITTER
2-CONDUCTOR RIBBON CABLE
W/ 2 POS CONTACT HOUSING ONE SIDE
4 POS CONTACT OTHER SIDE
SEE NOTE 2
4-CONDUCTOR RIBBON CABLE, 12"
W/ 4 POS CONTACT HOUSING 1 SIDE
3 POS CONTACT HOUSING OTHER SIDE
SEE NOTE 2
STD PANEL
FACILITY RECEIVER
STD PANEL
FACILITY ANTENNA SWITCH
Q-6340-181A
RG-58 W/2 SMA MALE CONNECTORS
RG-58 W/ 2 SMA MALE CONNECTORS
8 PLACES
12-CONDUCTOR RIBBON CABLE, 6"
W/ 12 POS CONTACT HOUSINGS, 2 SIDES
SEE NOTE 2
STD PANEL
AUXILIARY TRIPLE OUTPUT POWER SUPPLY
STD PANEL
AUXILIARY BACKPLANE CONNECTORS
SEE NOTE 1
STD PANEL
FACILITY ANTENNA SWITCH
Q-6340-181B
4-CONDUCTOR RIBBON CABLE
W/ 4 POS CONTACT HOUSING ONE SIDE
SEE NOTE 2
NEMATRON WORKSTATION
SUTHERLAND-SCHULTZ
PLC PANEL
PLC 5/15 PROCESSOR
PEER COMM INTFC
NEMATRON WORKSTATION
COM1
COM2
BELDEN 9463 TWINAXIAL CABLE
STD PANEL
PROLOG 7514 CARD
REM I/O
BREAK-OUT PANEL
LCOM SWITCH BOX
DB25 MALE CONNECTOR
MISCO CG8864
BATTERY CHARGER RS232 CABLE
RS-232 OPTICAL ISOLATOR
L-COM PCC212-1MF
DB25 MALE TO DB9 FEMALE INTERFACE CABLE
NULL-MODEM ADAPTOR
FEMALE/FEMALE
DB25 MALE TO DB9 FEMALE ADAPTOR
ENGINEER'S CONSOLE ASSEMBLY Q-6340-102
WIRING DIAGRAM #1 Q-6340-105
REFERENCE DRAWINGS NUMBER
MARTIN MARIETTA ENERGY SYSTEMS, INC.
ENGINEER'S CONSOLE
WIRING DIAGRAM #2
WEST VALLEY TRANSFER CART
TOLERANCES
UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES
DRAWN BY F.R.RUPPEL/K.F.CUTSHAW
DRAWING CHECK
ENGINEER F.R.RUPPEL 5/92
APPROVED J.W.STAPLETON 5/92
DRAWING APPROVALS DATE
FILE DATE 6/3/92
FILE POINT HC-1 EC-1
SCALE N/A
ID I&C
Q-6340-106
REV Ø
REV. MF DESCRIPTION FILE DATE BY CHKD ENGR APVD
REVISION OR ISSUE PURPOSE APPROVALS
AutoCAD 11
MICROFILMED



NOTE 1 – TYPICAL ALARMS
- HIGH MOTOR CURRENT
- LOW MOTOR CURRENT
- HIGH BATTERY TEMPERATURE
- HIGH ELECTRONICS TEMPERATURE
- LOW BATTERY STATE OF CHARGE
- BATTERY CHARGER ERROR

NOTE 2 – TYPICAL EVENTS
- EMERGENCY STOP
- CART COMPUTER REBOOTED
- NORTH STATION ENABLED
- SOUTH STATION ENABLED
- ENGINEER'S CONSOLE SIGN ON/OFF

NOTE 3 – TYPICAL HISTORIC DATA
- MOTOR CURRENT AND VOLTAGE
- BATTERY CURRENT, VOLTAGE, AND TEMPERATURE
- AUXILIARY OUTLET VOLTAGE AND CURRENT
- PERCENT USAGE OF ANTENNAS

NOTE 4 – TYPICAL CRT DISPLAYS
- DATA TABLES
- PICTORIALS
- TRENDS
- ALARM SUMMARIES

NOTE 5 – TYPICAL PLC COMMANDS
- DISABLE SELECTED FACILITY ANTENNA
- REBOOT CART COMPUTER
- SELECT CART I.D. WITH WHICH TO COMMUNICATE

THIS DRAWING PRODUCED BY ORNL INSTRUMENTATION & CONTROLS DIVISION
CAD SYSTEM AutoCAD 11

REV.	MF	DESCRIPTION	FILE DATE	BY	CHKD	ENGR	APVD
		REVISION OR ISSUE PURPOSE	APPROVALS				

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES

DRAWING APPROVALS		DATE
DRAWN BY	F.R.RUPPEL/K.F.CUTSHAW	
DRAWING CHECK		
ENGINEER	F.R.RUPPEL	5/92
APPROVED	J.W.STAPLETON	5/92
	F.R.RUPPEL / J.E.HARDY	5/92
	E.C.BRADLEY / Q.A.-W.A.CAMP	5/92

REFERENCE DRAWINGS | NUMBER

MARTIN MARIETTA ENERGY SYSTEMS, INC.
operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC-05-84OR21400
Oak Ridge, Tennessee   Paducah, Kentucky

ENGINEER'S CONSOLE COMPUTER FLOW CHART

WEST VALLEY TRANSFER CART

FILE DATE	FILE POINT	BLDG	SHT.	OF	MF
6/3/92	HC-1 EC-1		1	1	

SCALE	ID	DRAWING NO.	REV
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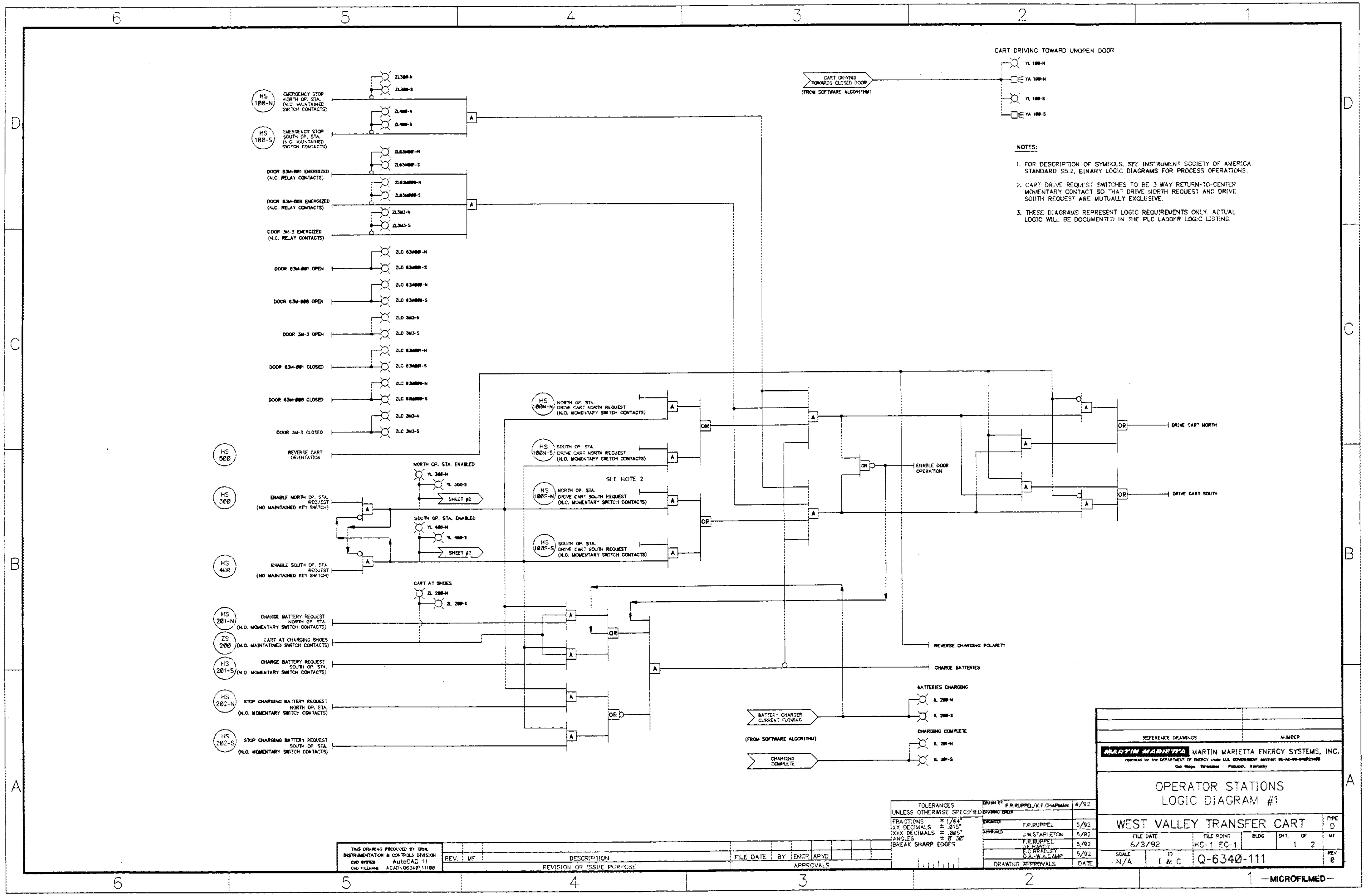
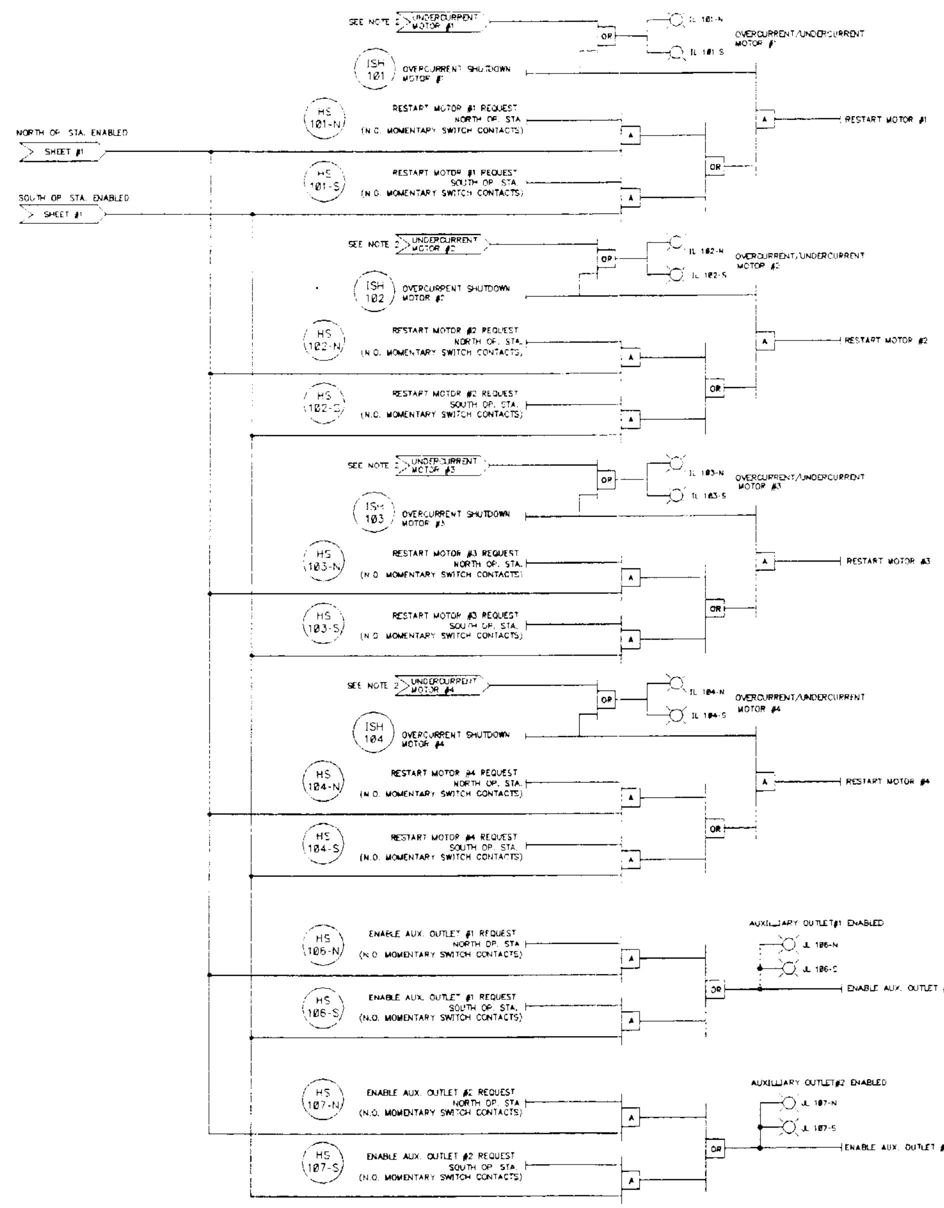

CART DRIVING TOWARD UNOPEN DOOR
NOTES:
1. FOR DESCRIPTION OF SYMBOLS, SEE INSTRUMENT SOCIETY OF AMERICA STANDARD S5.2, BINARY LOGIC DIAGRAMS FOR PROCESS OPERATIONS.
2. CART DRIVE REQUEST SWITCHES TO BE 3-WAY RETURN-TO-CENTER MOMENTARY CONTACT SO THAT DRIVE NORTH REQUEST AND DRIVE SOUTH REQUEST ARE MUTUALLY EXCLUSIVE.
3. THESE DIAGRAMS REPRESENT LOGIC REQUIREMENTS ONLY. ACTUAL LOGIC WILL BE DOCUMENTED IN THE PLC LADDER LOGIC LISTING.
SEE NOTE 2
DRIVE CART NORTH
DRIVE CART SOUTH
ENABLE DOOR OPERATION
REVERSE CHARGING POLARITY
CHARGE BATTERIES
BATTERIES CHARGING
CHARGING COMPLETE
REFERENCE DRAWINGS
NUMBER
MARTIN MARIETTA ENERGY SYSTEMS, INC.
OPERATOR STATIONS
LOGIC DIAGRAM #1
WEST VALLEY TRANSFER CART
TOLERANCES
UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/64"
XX DECIMALS ± .015"
XXX DECIMALS ± .005"
ANGLES ± 0° 30'
BREAK SHARP EDGES
DRAWN BY F.R.RUPPEL/K.F.CHAPMAN 4/92
F.R.RUPPEL 5/92
APPROVED J.W.STAPLETON 5/92
DRAWING APPROVALS
DATE
FILE DATE 6/3/92
FILE POINT HC-1 EC-1
SHT. 1 OF 2
SCALE N/A
ID I & C
Q-6340-111
TYPE D
REV 0
—MICROFILMED—

6 5 4 3 2 1

D



C

B

A

NOTES:

1. FOR DESCRIPTION OF SYMBOLS, SEE INSTRUMENT SOCIETY OF AMERICA STANDARD S5.2, BINARY LOGIC DIAGRAMS FOR PROCESS OPERATIONS.
2. MOTOR UNDERCURRENT SIGNALS WILL ORIGINATE FROM COMPARATOR IN PLC.

REFERENCE DRAWINGS	NUMBER

MARTIN MARIETTA — MARTIN MARIETTA ENERGY SYSTEMS, INC.

OPERATOR STATIONS
LOGIC DIAGRAM #2

WEST VALLEY TRANSFER CART

TOLERANCES UNLESS OTHERWISE SPECIFIED	
FRACTIONS	± 1/64"
XX DECIMALS	± .015"
XXX DECIMALS	± .005"
ANGLES	± 0° 30'
BREAK SHARP EDGES	

DRAWN BY	F.P.RUPPEL/K.F.CUTSHAW	4/92
ENGINEER	F.R.RUPPEL	5/92
APPROVED	J.W.STAPLETON	5/92
	F.R.RUPPEL	5/92
	J.C.BRADLEY	5/92
DRAWING APPROVALS		DATE

FILE DATE	FILE POINT	BLDG	SHT.	OF	TYPE
6/3/92	HC-1 EC-1				D

SCALE	ID	NUMBER	REV
N/A	I & C	Q-6340-112	0

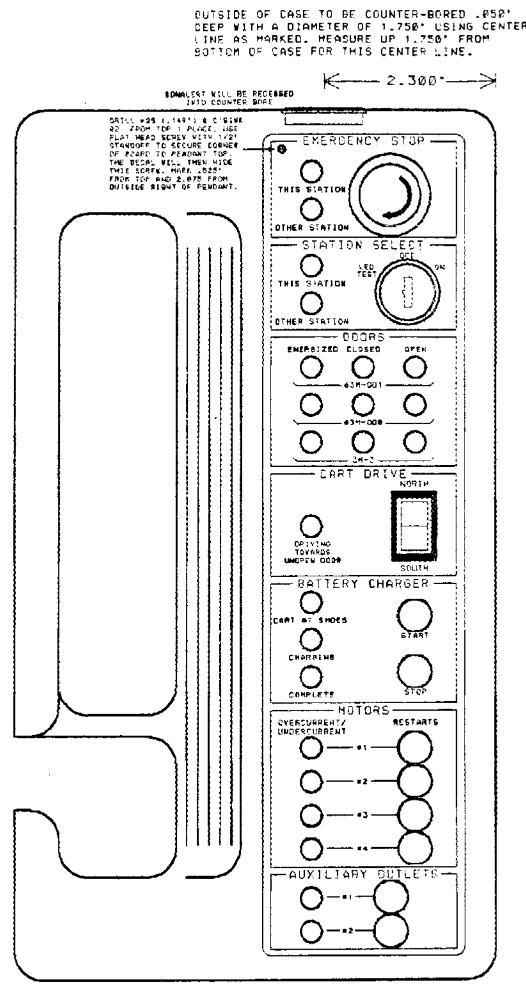
THIS DRAWING PRODUCED BY GRAL INSTRUMENTATION & CONTROLS DIVISION
CAD SYSTEM AutoCAD 11
CAD FILENAME ACAD\Q6340\112

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
		REVISION OR ISSUE PURPOSE			APPROVALS	

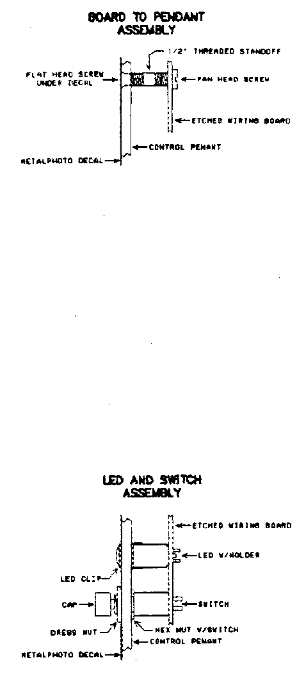
6 5 4 3 2 1

— MICROFILMED —

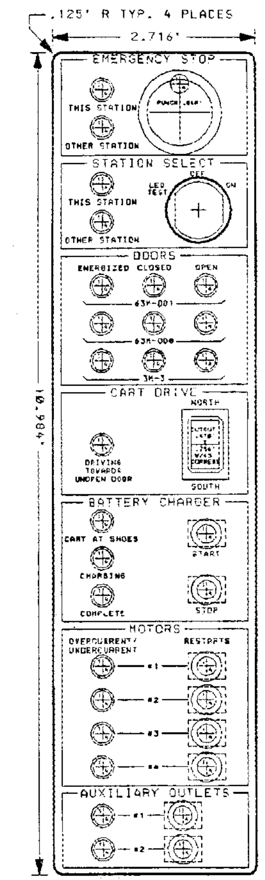
QUANITY	PART NUMBER	DESCRIPTION	MANUFACTURER
1 EA.	29500100	MOBILE HAND HELD MACHINE CONTROL UNIT 2950	ROSE ENCLOSURES
1 EA.	N/A	METALPHOTO DECAL	FABRICATE PER ORNL DWG. #Q-6340-121
1 EA.	N/A	ETCHED WIRING BOARD	FABRICATE PER ORNL DWG. #Q-6340-123
23 EA.	IDI5331HI	LIGHT EMITTING DIODE, RED	INDUSTRIAL DEVICES, INC.
23 EA.	IDI4304MC	LED MOUNTING CLIP	INDUSTRIAL DEVICES, INC.
1 EA.	PW3M53	LARGE EMERGENCY STOP SWITCH, DPST	MICROSWITCH INC.
2 EA.	PW3CE	N.C. CONTACT BLOCK	MICROSWITCH
8 EA.	8121SY4V3GE	SWITCH, MOMENTARY PUSH BUTTON, SPDT	C&K
8 EA.	8018	CAPS, SNAP LOCK, BLACK FOR PUSHBUTTON SWITCH	C&K
8 EA.	7760	DRESS NUT	C&K
4 EA.	MSTBV 1.5/9-G	PCB OPEN END HEADER 9 CONTACTS	PHOENIX
4 EA.	MVSTBR 1.5/9-ST	PLUGGABLE TERMINAL BLOCK 9 CONTACTS	PHOENIX
1 EA.	MSTBV 1.5/14-G	PCB OPEN END HEADER 14 CONTACTS	PHOENIX
1 EA.	MVSTBR 1.5/14-ST	PLUGGABLE TERMINAL BLOCK 14 CONTACTS	PHOENIX
1 EA.	B127J11ZQ22M	SWITCH, ROCKER ARM TYPE, MOMENTARY ON-MAINTAINED OFF-MOMENTARY ON, SPDT	CUTLER-HAMMER
1 EA.	SNP 428	SONALERT, CONTINUOUS TONE, SNAP IN PANEL MOUNT, CASE STYLE B	SONALERT/MALLORY
13 EA.	500 OHM, 1/4W	RESISTOR, CARBON, 5%	ALLEN-BRADLEY
1 EA.	T330C106K025AS	CAPACITOR, TANTULAM, 10MF, 25DCWV	KEMET
1 EA.	1C25Z5U104M050B	CAPACITOR, CERAMIC, .1MF, 25DCWV	SPRAGUE
9 EA.	140-1305-02	SPLIT LUG, BRASS	CAMBRIDGE THERMIONIC
1 EA.	Y100-82-4-C-3-03-N-81-E	KEYLOCK SWITCH	C&K



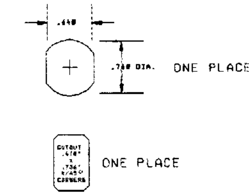
ITEM #1
MOBILE HAND HELD MACHINE CONTROL UNIT 2950 FRONT VIEW WITH DECAL IN PLACE



METALPHOTO DECAL SHALL REPLACE ALUMINUM FACE PLATE WHICH COMES WITH THE UNIT. DECAL CAN SERVE AS A TEMPLATE FOR MARKING HOLES AND CUTOUTS TO BE MADE TO UNIT. ALL LEDS ARE TO RED IN COLOR.



ITEM #2
METALPHOTO DECAL



NOTES:
1. MATERIAL TO BE .020" THICK ANODIZED ALUMINUM SHEET, METALPHOTO WITH ADHESIVE BACKING.
2. FINISHED DECAL SHALL HAVE JET BLACK LETTERING AND CLEAR ANODIZED ALUMINUM BACKGROUND.
3. DIRECTION OF MILL LINES SHALL BE PARRALLEL TO THE MAJOR DIMENSION.
4. FINISH MUST BE FREE OF SCRATCHES, BURRS, AND SHARP EDGES ON FRONT SIDE.
5. A MYLAR FILM NEGATIVE WILL BE SUPPLIED BY THE COMPANY FOR DIRECT COPYING.
6. MAXIMUM TOLERANCE OF HOLES TO BE WITHIN .015" OF INDICATED CENTERS.
7. TRIM DECAL TO DIMENSIONS SHOWN.

REFERENCE DRAWINGS	NUMBER
METALPHOTO DECAL FILMWORK	Q-6340-121 R0

MARTIN MARIETTA ENERGY SYSTEMS, INC.
operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

CONTROL PENDANT ENCLOSURE DIAGRAM W/METALPHOTO DECAL

WEST VALLEY TRANSFER CART

TYPE: MD

TOLERANCES UNLESS OTHERWISE SPECIFIED	DRAWING APPROVALS		DATE
FRACTIONS ±	DRAWN BY	H.D. CUTSHAW	11/91
XX DECIMALS ±	DRAWING CHECK		
XXX DECIMALS ±	ENGINEER	F.R.RUPPEL	5/92
ANGLES ±	APPROVED	J.W.STAPLETON	5/92
BREAK SHARP EDGES		F.R.RUPPEL J.F.HARDY	5/92
		E.C.BRADLEY C.A.-W.A.CAMP	5/92

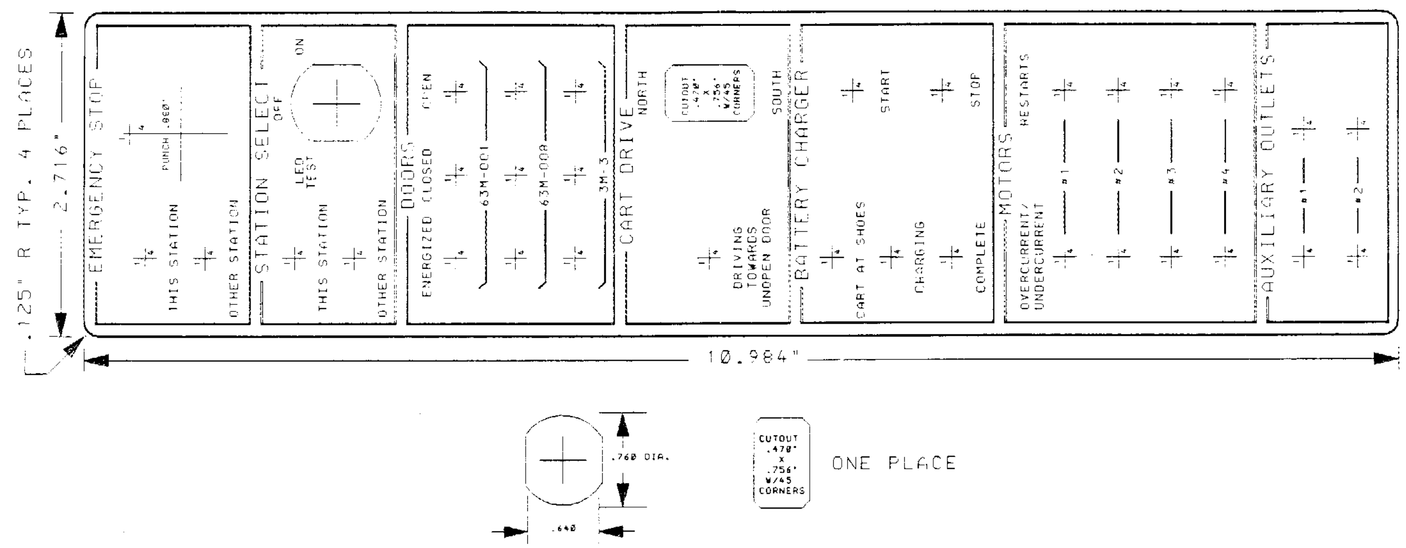
FILE DATE	FILE POINT	BLDG	SHT.	OF
6/3/92	HC-1 EC-1	3500	1	1

SCALE	ID	DRAWING NO.	REV
1:1	I&C	Q-6340-120	1

THIS DRAWING PRODUCED BY ORNL INSTRUMENTATION & CONTROLS DIVISION
CAD SYSTEM AutoCAD 11
CAD FILENAME ACAD\Q6340\120

REV. | MF | DESCRIPTION REVISION OR ISSUE PURPOSE | FILE DATE | BY | CHKD | ENGR | APVD | APPROVALS

—MICROFILMED—



NOTES:

1. MATERIAL TO BE .020" THICK ANODIZED ALUMINUM SHEET. METALPHOTO WITH ADHESIVE BACKING.
2. FINISHED DECAL SHALL HAVE JET BLACK LETTERING AND CLEAR ANODIZED ALUMINUM BACKGROUND.
3. DIRECTION OF MILL LINES SHALL BE PARALLEL TO THE MAJOR DIMENSION.
4. FINISH MUST BE FREE OF SCRATCHES, BURRS, AND SHARP EDGES ON FRONT SIDE.
5. A MYLAR FILM NEGATIVE WILL BE SUPPLIED BY THE COMPANY FOR DIRECT COPYING.
6. MAXIMUM TOLERANCE OF HOLES TO BE WITHIN .015" OF INDICATED CENTERS.
7. TRIM DECAL TO DIMENSIONS SHOWN.

REFERENCE DRAWINGS	NUMBER

MARTIN MARIETTA — MARTIN MARIETTA ENERGY SYSTEMS, INC.

operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC-05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

CONTROL PENDANT
METALPHOTO DECAL

WEST VALLEY TRANSFER CART — TYPE MP

FILE DATE	FILE POINT	BLDG	SHT.	OF
6/3/92	HC-1 EC-1	3500	1	1

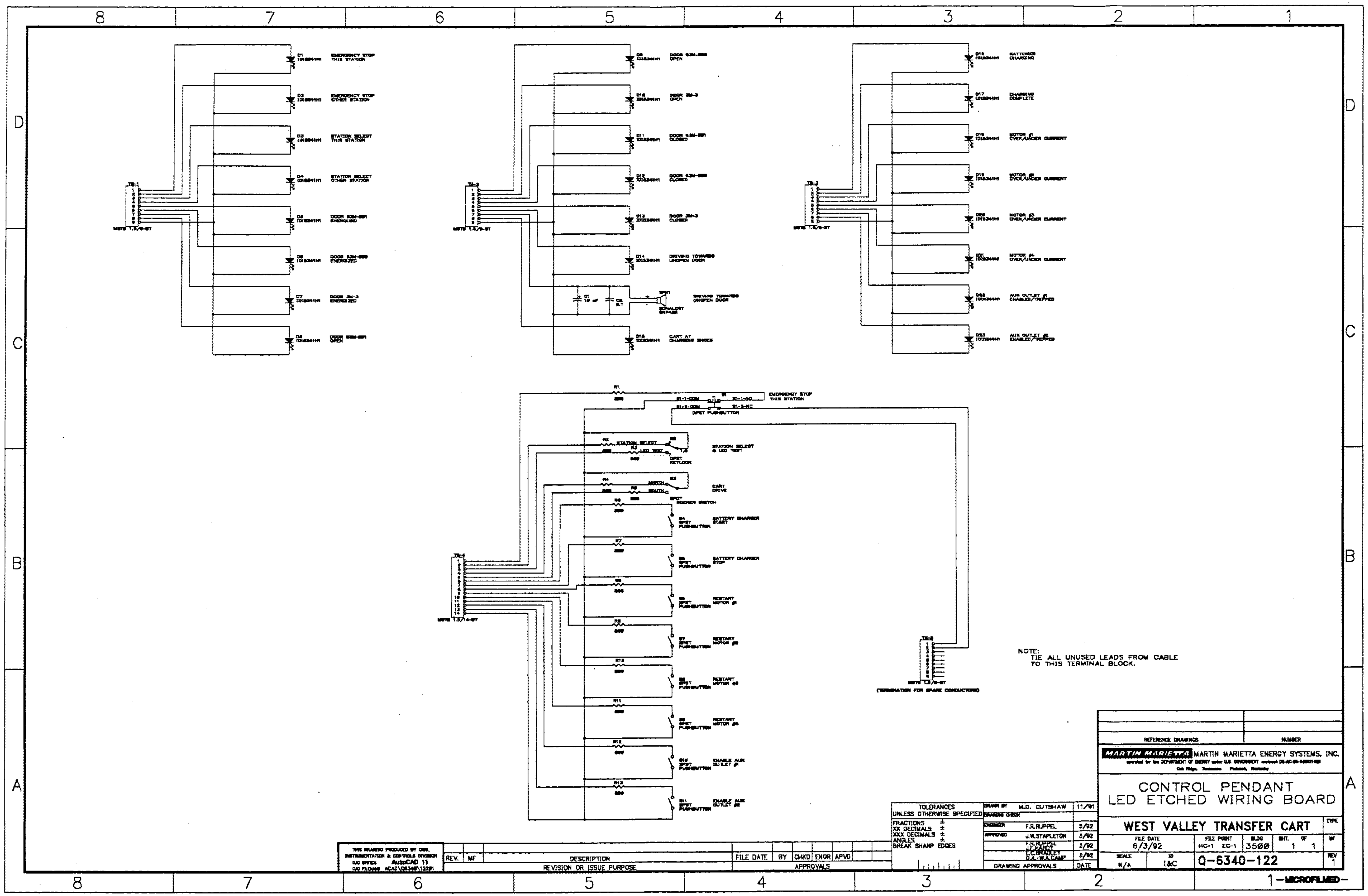
SCALE	ID		REV
1:1	I&C	Q-6340-121 -MICROFILMED-	1

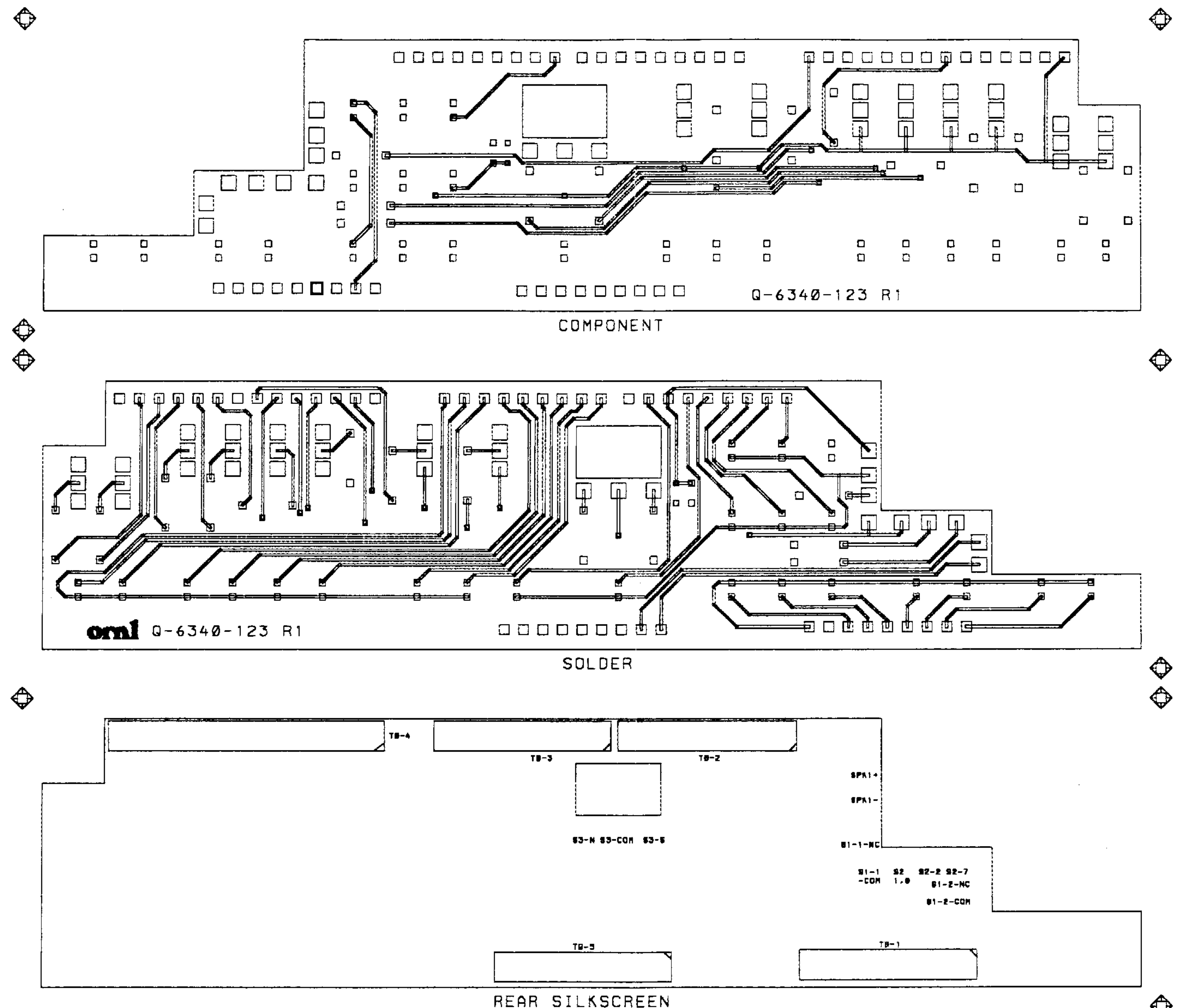
TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS	±	1/64"
XX DECIMALS	±	.010"
XXX DECIMALS	±	.005"
ANGLES	±	0 30'
BREAK SHARP EDGES		

DRAWING APPROVALS		DATE
DRAWN BY	M.D. CUTSHAW	8/91
DRAWING CHECK		
ENGINEER	F.R.RUPPEL	4/91
APPROVED	J.E.HARDY	5/92
	W.STAPLETON	5/92
	C.BRADLEY	5/92
	A-W. CAMP	5/92
	R.RUPPEL	5/92

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
		LAYOUT METALPHOTO DECAL				
DRAWN WITH PERSONAL 870		REVISION OR ISSUE PURPOSE	APPROVALS			


NOTE:
TIE ALL UNUSED LEADS FROM CABLE
TO THIS TERMINAL BLOCK.
REFERENCE DRAWINGS
NUMBER
MARTIN MARIETTA ENERGY SYSTEMS, INC.
CONTROL PENDANT
LED ETCHED WIRING BOARD
WEST VALLEY TRANSFER CART
TOLERANCES
UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES
M.D. CUTSHAW 11/91
F.R.RUPPEL 5/92
J.W.STAPLETON 5/92
DRAWING APPROVALS
DATE
FILE DATE
6/3/92
HC-1 EC-1
3500
1 1
SCALE
N/A
I&C
Q-6340-122
REV
1
REV.
DESCRIPTION
REVISION OR ISSUE PURPOSE
FILE DATE
BY
CHKD
ENGR
APVD
APPROVALS
AutoCAD 11
-MICROFILMED-



REFERENCE DRAWINGS	NUMBER

MARTIN MARIETTA ENERGY SYSTEMS, INC.
operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC-05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

CONTROL PENDANT ETCHED WIRING BOARD

WEST VALLEY TRANSFER CART

TYPE: PC

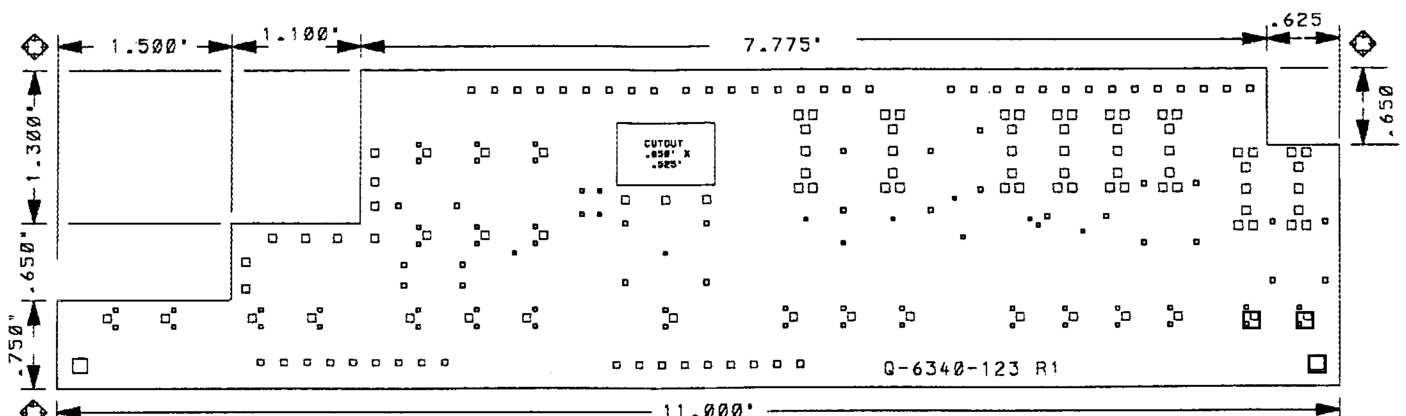
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0 30'
BREAK SHARP EDGES

DRAWING APPROVALS		DATE
DRAWN BY	M.D. CUTSHAW	8/91
DRAWING CHECK		
ENGINEER	F.R.RUPPEL	4/92
APPROVED	J.W.STAPLETON	5/92
	E.C.BRADLEY J.E.HARDY	5/92
	Q.A.-W.A.CAMP	5/92

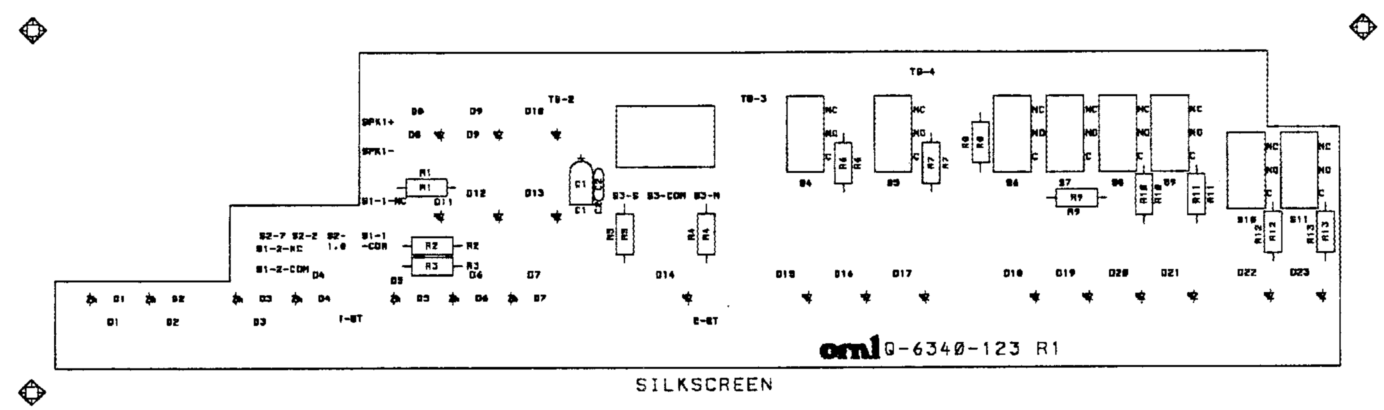
FILE DATE	FILE POINT	BLDG	SHT.	OF
	HC-1 EC-1	3500	1	2

SCALE	ID		REV
1:1	I&C	Q-6340-123	1

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH PERSONAL 870		REVISION OR ISSUE PURPOSE	APPROVALS			



DRILL MASTER



SILKSCREEN

NOTES:

1. MATERIAL TO BE .0625 IN THICK EPOXY FIBERGLASS TYPE FR4. PER MIL-P-13949/4. SPECIFIC DESIGNATION SHALL BE FL-GFP-0625-C1/1-B-2-C. OFF-WHITE COLOR PREFERRED.
2. ALL HOLES WITH LANDS ON BOTH SIDES OF THE BOARD SHALL BE 100% PLATED THRU. COPPER PLATING INSIDE THE HOLES SHALL BE .001" MINIMUM IN ACCORDANCE WITH MIL-C-14550. FRONT TO REAR REGISTRATION TO BE WITHIN .005".
3. CLEAN AND SOLDER PLATE ALL COPPER IN ACCORDANCE WITH MIL-P-81728.THE FUSED TIN-LEAD SHALL BE .0003 INCH THICK MINIMUM.
4. AFTER PROCESSING, ETCHED BOARDS TO BE FREE OF VOIDS AND SCRATCHES.
5. DO NOT USE THIS DRAWING AS A WORK SHEET. MASTER NEGATIVE(S) OF WIRING WILL BE SUPPLIED BY ORNL.
6. LIMIT ON ALL DIMENSIONS .015 IN UNLESS OTHERWISE NOTED.
7. HONE ALL EDGES SMOOTH.
8. MATERIAL REQUIRED: 36.8 SQ. IN..
9. HOLE LOCATION TOLERANCE .005 IN.
10. NOTCHES: 3-DIMENSIONS ON DRAWING.
11. DIMENSIONS OF ALL HOLES NOTED TO THE RIGHT ARE FINISHED HOLE DIAMETERS AFTER PLATING THRU.

HOLE SIZE			QUAN.
▪	#70	.020 IN DIAMETER	12
▫	#65	.035 IN DIAMETER	48
▫	#60	.040 IN DIAMETER	26
□	#55	.052 IN DIAMETER	50
□	#51	.067 IN DIAMETER	35
□	#49	.073 IN DIAMETER	56
□	1/8	.125 IN DIAMETER	5

REFERENCE DRAWINGS	NUMBER

MARTIN MARIETTA — MARTIN MARIETTA ENERGY SYSTEMS, INC.

operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC-05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

CONTROL PENDANT ETCHED WIRING BOARD

WEST VALLEY TRANSFER CART

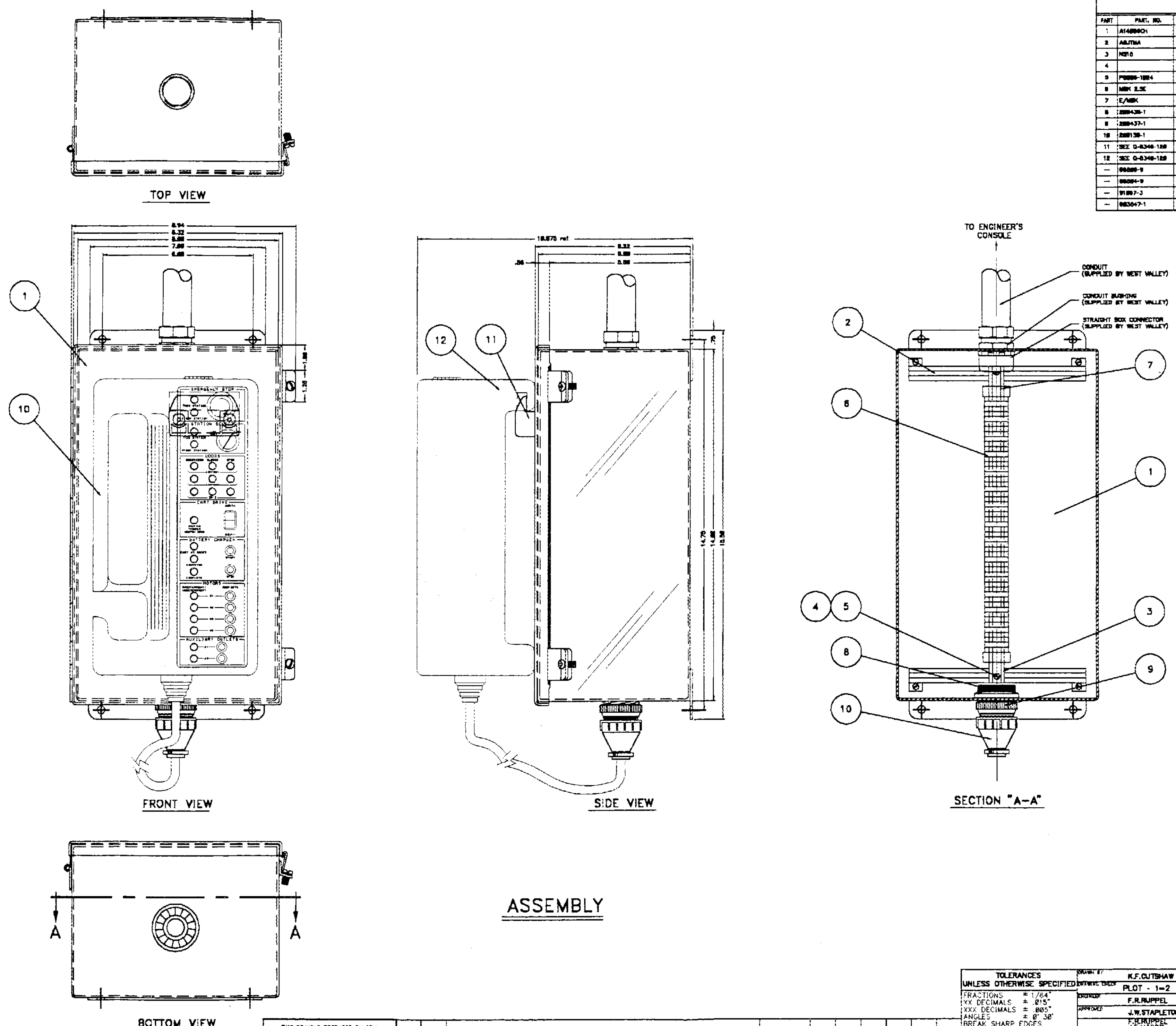
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0 30'
BREAK SHARP EDGES

DRAWN BY	M.D. CUTSHAW	8/91
DRAWING CHECK		
ENGINEER	F.R. RUPPEL	4/92
APPROVED	J.W.STAPLETON	5/92
	J.E.HARDY E.C.BRADLEY	5/92
	Q.A.-W.A.CAMP	5/92
	DRAWING APPROVALS	DATE

TYPE	FILE DATE	FILE POINT	BLDG	SHT.	OF	MF
PC		HC-1 EC-1	3500	2	2	

SCALE	ID		REV
1 : 1	I&C	Q-6340-123	1

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH PERSONAL 870		REVISION OR ISSUE PURPOSE	APPROVALS			



PARTS LIST

PART	PART. NO.	REQD.	DESCRIPTION	SIZE	MANUFACTURER (ADDRESS)
1	A14864CH	1	CONTINUOUS HINGE CLAMP COVER BOX	14" x 8" x 6"	HOFFMAN ENG. CO., ANOKA, MN 55303
2	ABJTMA	2	BRACKET		HOFFMAN ENG. CO., ANOKA, MN 55303
3	NS15	1	RAIL		PHOENIX CONTACT, HARRISBURG, PA
4		2	SCREW	#10-24x1/2LG.	UNISTRUT, WAYNE, MI OR EQUAL
5	P3006-1004	2	SPRING NUT	#10-24	UNISTRUT, WAYNE, MI OR EQUAL
6	MBK 2.5E	51	TERMINAL STRIP		PHOENIX CONTACT, HARRISBURG, PA
7	E/MBK	2	END CLAMP		PHOENIX CONTACT, HARRISBURG, PA
8	206436-1	1	RECEPTACLE		AMP INC., HARRISBURG, PA
9	206437-1	1	PLUG		AMP INC., HARRISBURG, PA
10	206138-1	1	CABLE CLAMP		AMP INC., HARRISBURG, PA
11	SEE Q-6340-128	1	MOUNT (INCLUDED WITH PENDANT)		
12	SEE Q-6340-128	1	PENDANT		
—	66685-9	A/R	PINS		AMP INC., HARRISBURG, PA
—	66684-9	A/R	SOCKETS		AMP INC., HARRISBURG, PA
—	91067-3	1	INSERTION/EXTRACTION TOOL		AMP INC., HARRISBURG, PA
—	603647-1	1	CRIMP TOOL		AMP INC., HARRISBURG, PA

REFERENCE DRAWINGS	NUMBER
CONDUIT & CABLING	Q-6340-101
BOX WIRING	Q-6340-126
PENDANT	Q-6340-128

MARTIN MARIETTA ENERGY SYSTEMS, INC.
operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC-05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

CONTROL PENDANT JUNCTION BOX ASSEMBLY

WEST VALLEY TRANSFER CART

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/64"
XX DECIMALS ± .015"
XXX DECIMALS ± .005"
ANGLES ± 0° 30'
BREAK SHARP EDGES

DRAWING APPROVALS		DATE
DRAWN BY	K.F.CUTSHAW	4/92
DRAWING CHECK	PLOT - 1=2	
ENGINEER	F.R.RUPPEL	5/92
APPROVED	J.W.STAPLETON	5/92
	F.R.RUPPEL J.E.HARDY	5/92
	E.C.BRADLEY D.A.-W.A.CAMP	5/92

TYPE D | FILE DATE 6/3/92 | FILE POINT HC-1 EC-1 | BLDG | SHT. 1 OF 1 | MF
SCALE HALF | ID I & C | Q-6340-125 | REV 0

THIS DRAWING PRODUCED BY ORNL INSTRUMENTATION & CONTROLS DIVISION CAD SYSTEM AutoCAD 11

REV. | MF | DESCRIPTION REVISION OR ISSUE PURPOSE | FILE DATE | BY | ENGR | APVD APPROVALS

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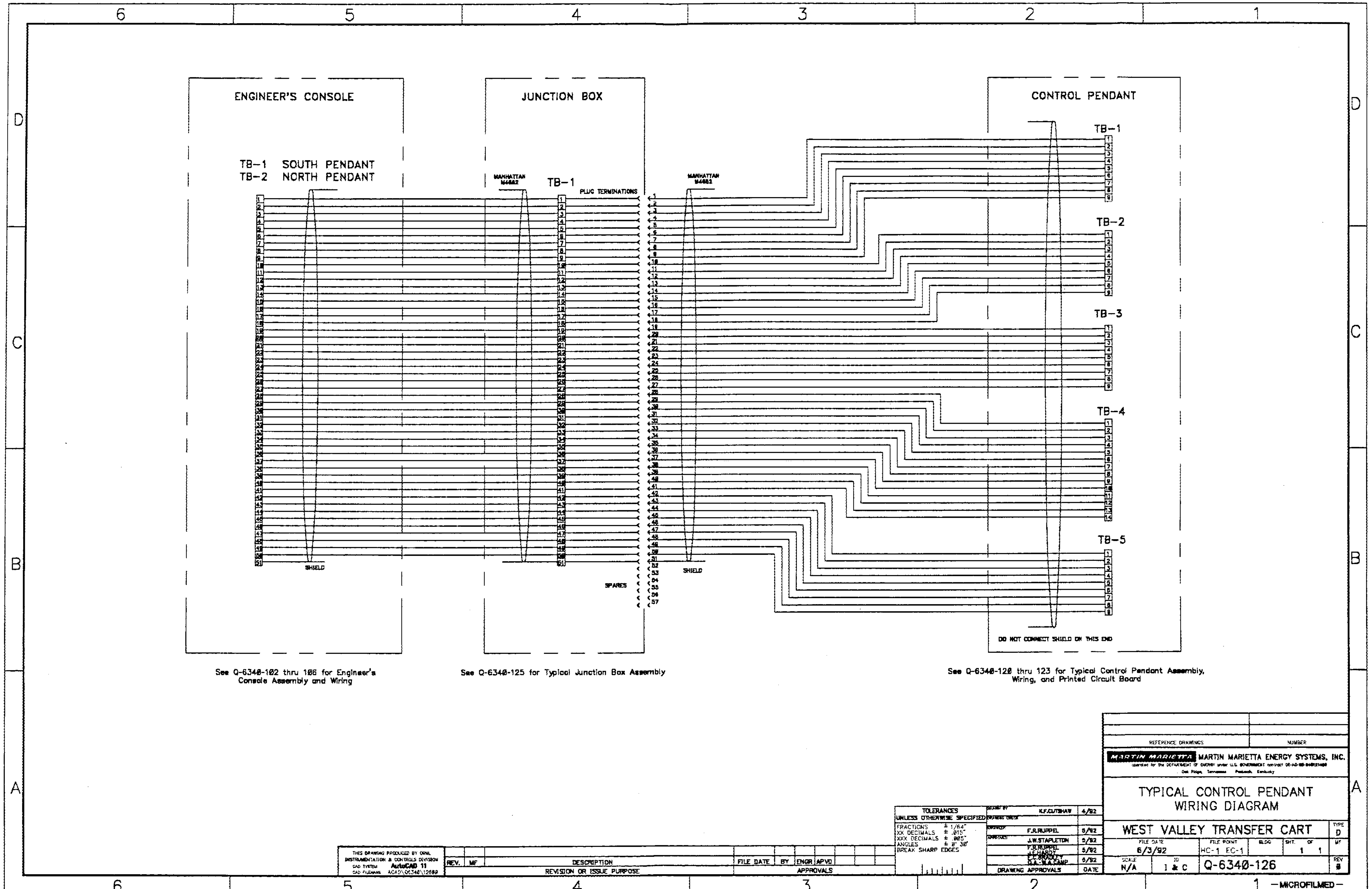
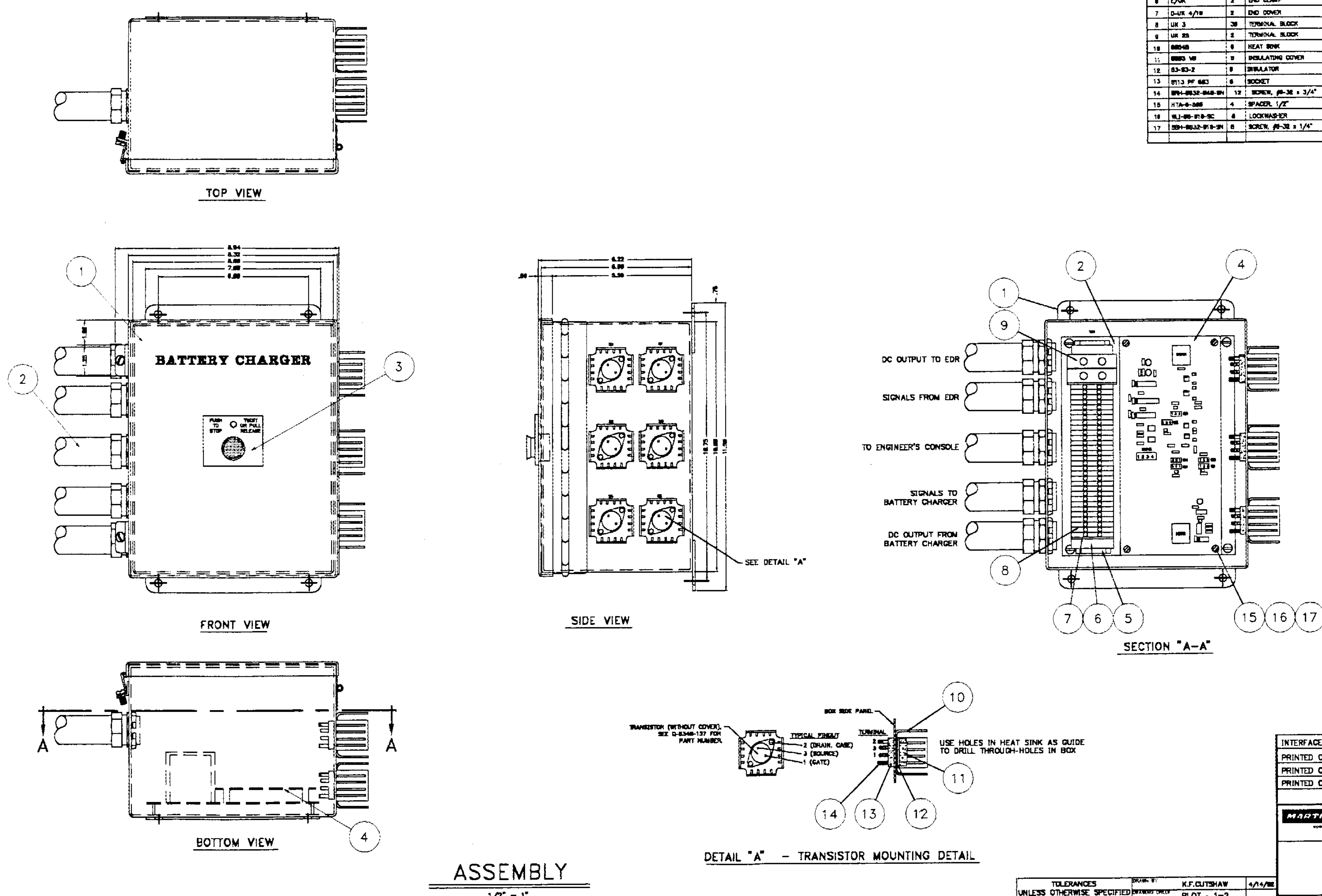

ENGINEER'S CONSOLE
TB-1 SOUTH PENDANT
TB-2 NORTH PENDANT
SHIELD
JUNCTION BOX
MANHATTAN M4482
TB-1
PLUG TERMINATIONS
SPARES
MANHATTAN M4482
SHIELD
CONTROL PENDANT
TB-1
TB-2
TB-3
TB-4
TB-5
DO NOT CONNECT SHIELD ON THIS END
See Q-6340-102 thru 106 for Engineer's Console Assembly and Wiring
See Q-6340-125 for Typical Junction Box Assembly
See Q-6340-120 thru 123 for Typical Control Pendant Assembly, Wiring, and Printed Circuit Board
REFERENCE DRAWINGS
NUMBER
MARTIN MARIETTA ENERGY SYSTEMS, INC.
TYPICAL CONTROL PENDANT WIRING DIAGRAM
WEST VALLEY TRANSFER CART
TYPE D
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/64"
XX DECIMALS ± .015"
XXX DECIMALS ± .005"
ANGLES ± 0° 30'
BREAK SHARP EDGES
K.F.CUTSHAW 4/92
F.R.RUPPEL 5/92
J.W.STAPLETON 5/92
DRAWING APPROVALS
DATE
FILE DATE 6/3/92
FILE POINT HC-1 EC-1
SHT. 1 OF 1
SCALE N/A
ID I & C
Q-6340-126
REV
REV.
DESCRIPTION
REVISION OR ISSUE PURPOSE
FILE DATE
BY
APPROVALS
AutoCAD 11
-MICROFILMED-



PARTS LIST

PART	PART. NO.	REQD.	DESCRIPTION	MANUFACTURER
1	A1[illegible]CH	1	CONTINUOUS HINGE CLAMP COVER BOX	HOFFMAN
2	[illegible]	1	PANEL	HOFFMAN
3	[illegible]	1	EMERGENCY STOP SWITCH	ALLEN-BRADLEY
4	Q-6340-136	1	PRINTED CIRCUIT BOARD	OAK RIDGE NATIONAL LABORATORY
5	NS 35/7.5	1	RAIL	PHOENIX CONTACT
6	E/UK	2	END CLAMP	PHOENIX CONTACT
7	D-UK 4/10	2	END COVER	PHOENIX CONTACT
8	UK 3	38	TERMINAL BLOCK	PHOENIX CONTACT
9	UK 25	2	TERMINAL BLOCK	PHOENIX CONTACT
10	[illegible]	6	HEAT SINK	THERMALLOY
11	[illegible]	6	INSULATING COVER	THERMALLOY
12	[illegible]	6	INSULATOR	THERMALLOY
13	[illegible]	6	SOCKET	THERMALLOY
14	[illegible]	12	SCREW, #6-32 x 3/4"	SPC TECHNOLOGY
15	HTA-6-[illegible]	4	SPACER, 1/2"	SPC TECHNOLOGY
16	[illegible]	6	LOCKWASHER	SPC TECHNOLOGY
17	[illegible]	6	SCREW, #6-32 x 1/4"	SPC TECHNOLOGY

REFERENCE DRAWINGS	NUMBER
INTERFACE BOX INTERCONNECTION	Q-6340-132
PRINTED CIRCUIT SCHEMATIC	Q-6340-135
PRINTED CIRCUIT BOARD LAYOUT	Q-6340-136
PRINTED CIRCUIT BOARD PARTS LIST	Q-6340-137

MARTIN MARIETTA ENERGY SYSTEMS, INC.
operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC-05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

BATTERY CHARGER INTERFACE BOX ASSEMBLY

WEST VALLEY TRANSFER CART

TYPE D | FILE DATE 6/3/92 | FILE POINT HC-1 EC-1 | BLDG | SHT. 1 OF 1 | SCALE HALF | ID I & C | Q-6340-131 | REV 0

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/64"
XX DECIMALS ± .015"
XXX DECIMALS ± .005"
ANGLES ± 0° 30'
BREAK SHARP EDGES

DRAWING APPROVALS		DATE
DRAWN BY	K.F.CUTSHAW	4/14/92
DRAWING CHECK	PLOT - 1=2	
ENGINEER	F.R.RUPPEL	5/92
APPROVED	J.W.STAPLETON	5/92
	F.R.RUPPEL J.E.HARDY	5/92
	E.C.BRADLEY Q.A.-W.A.CAMP	5/92

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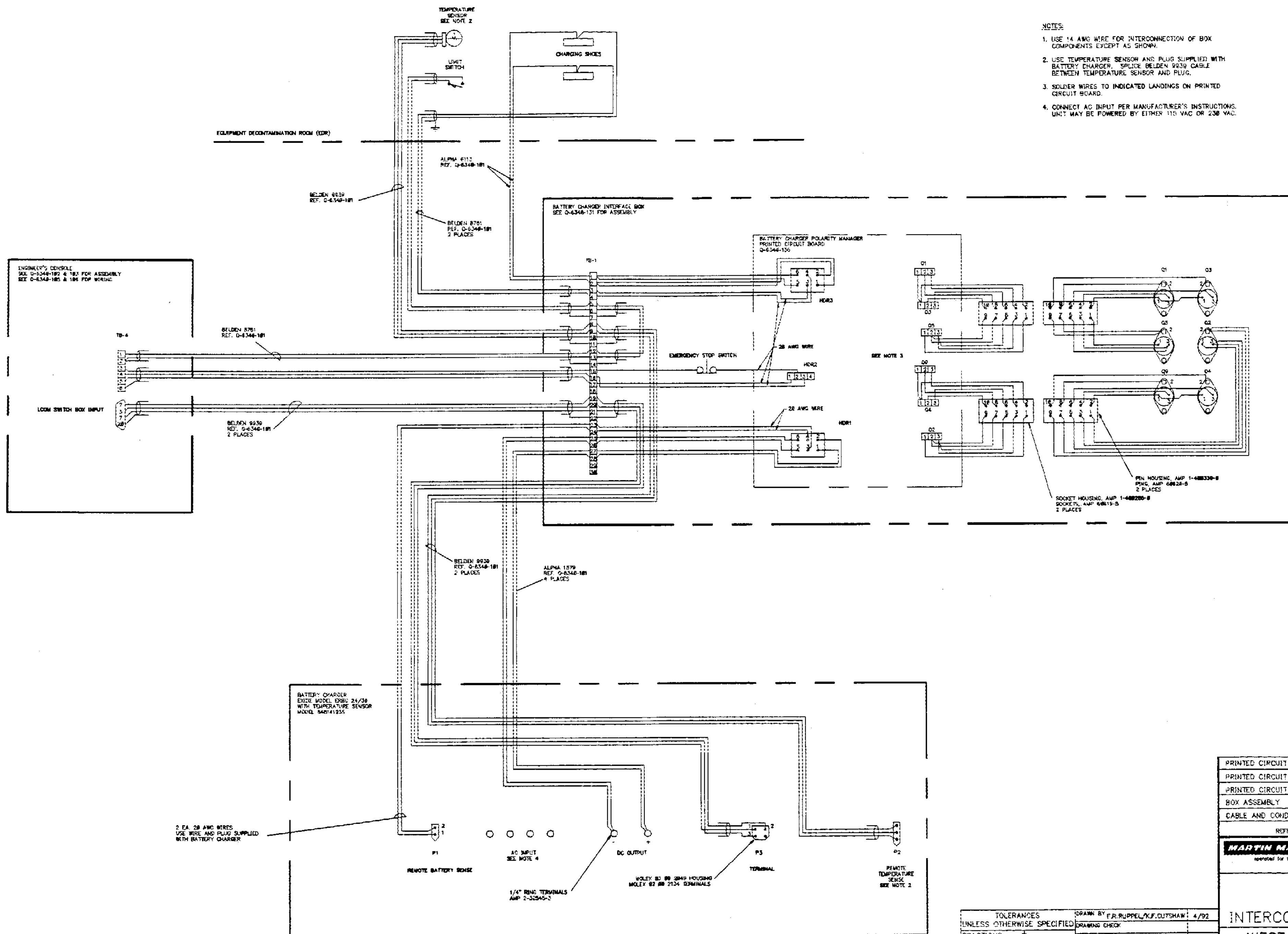
CAD SYSTEM AutoCAD 11
CAD FILENAME ACAD\Q6340\13180

REV. | MF | DESCRIPTION — REVISION OR ISSUE PURPOSE | FILE DATE | BY | ENGR | APVD — APPROVALS

— MICROFILMED —



NOTES:

1. USE 14 AWG WIRE FOR INTERCONNECTION OF BOX COMPONENTS EXCEPT AS SHOWN.
2. USE TEMPERATURE SENSOR AND PLUG SUPPLIED WITH BATTERY CHARGER. SPLICE BELDEN 9939 CABLE BETWEEN TEMPERATURE SENSOR AND PLUG.
3. SOLDER WIRES TO INDICATED LANDINGS ON PRINTED CIRCUIT BOARD.
4. CONNECT AC INPUT PER MANUFACTURER'S INSTRUCTIONS. UNIT MAY BE POWERED BY EITHER 115 VAC OR 230 VAC.

REFERENCE DRAWINGS	NUMBER
PRINTED CIRCUIT BOARD SCHEMATIC	Q-6340-135
PRINTED CIRCUIT BOARD LAYOUT	Q-6340-136
PRINTED CIRCUIT BOARD PARTS LIST	Q-6340-137
BOX ASSEMBLY	Q-6340-131
CABLE AND CONDUIT REQUIREMENTS	Q-6340-101

MARTIN MARIETTA ENERGY SYSTEMS, INC.

BATTERY CHARGER INTERFACE BOX INTERCONNECTION WIRING DIAGRAM

WEST VALLEY TRANSFER CART

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES

DRAWING APPROVALS		DATE
DRAWN BY	F.R.RUPPEL/K.F.CUTSHAW	4/92
DRAWING CHECK		
ENGINEER	F.R.RUPPEL	5/92
APPROVED	J.W.STAPLETON	5/92
	F.R.RUPPEL J.E.HARDY	5/92
	E.C.BRADLEY C.A.-W.A.CAMP	5/92

FILE DATE	FILE POINT	BLDG	SHT.	OF	TYPE
6/3/92	HC-1 EC-1		1	1	MF

SCALE	ID		REV
N/A	I&C	Q-6340-132	Ø

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CAD SYSTEM AutoCAD 11
CAD FILENAME ACAD\Q6340\132.DWG

REV.	MF	DESCRIPTION REVISION OR ISSUE PURPOSE	FILE DATE	BY	CHKD	ENGR	APVD

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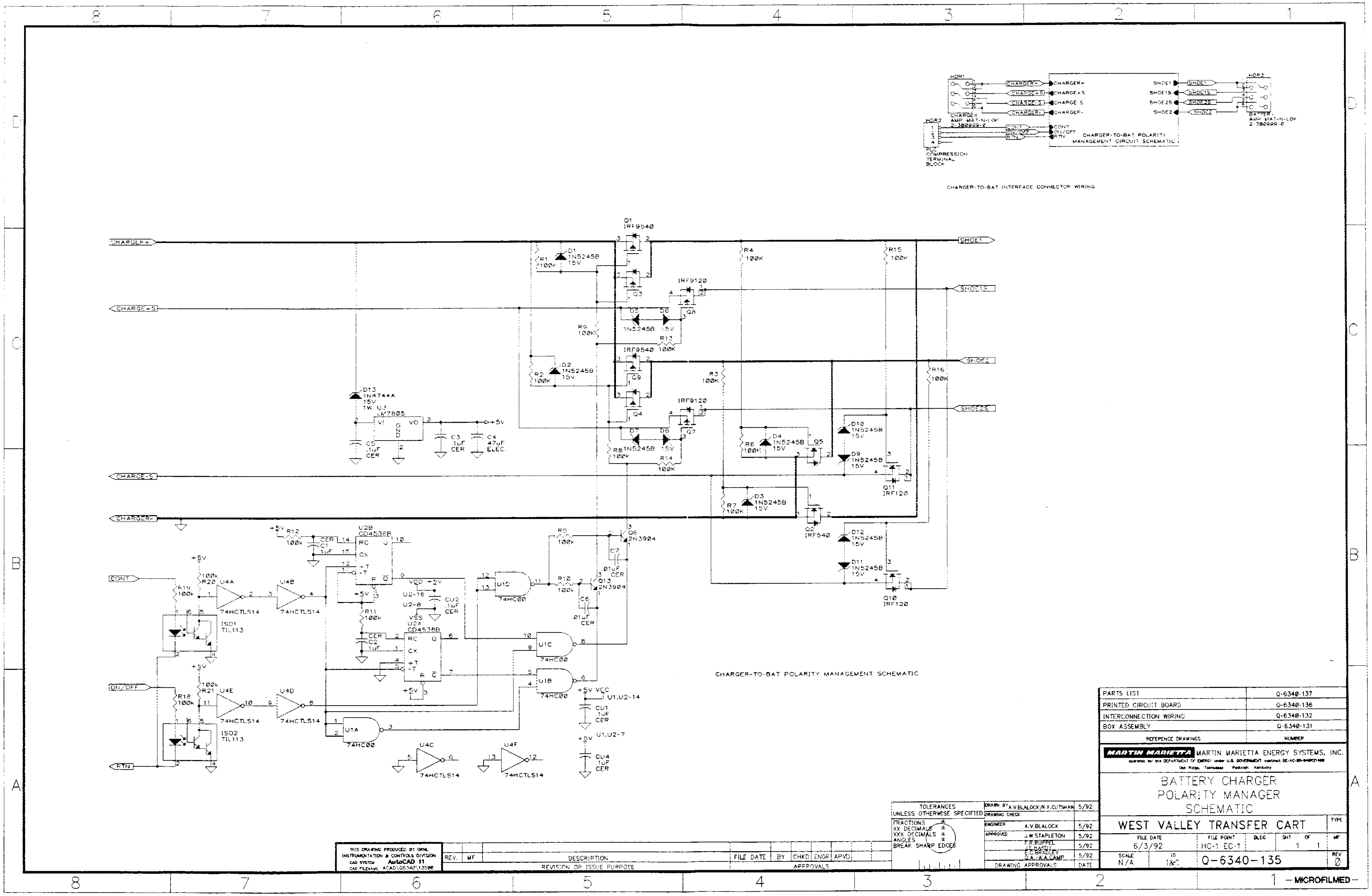
CHARGER-TO-BAT INTERFACE CONNECTOR WIRING
CHARGER-TO-BAT POLARITY MANAGEMENT SCHEMATIC
PARTS LIST Q-6340-137
PRINTED CIRCUIT BOARD Q-6340-136
INTERCONNECTION WIRING Q-6340-132
BOX ASSEMBLY Q-6340-131
REFERENCE DRAWINGS NUMBER
MARTIN MARIETTA ENERGY SYSTEMS, INC.
BATTERY CHARGER
POLARITY MANAGER
SCHEMATIC
WEST VALLEY TRANSFER CART
TOLERANCES UNLESS OTHERWISE SPECIFIED
DRAWN BY A.V.BLALOCK/K.F.CUTSHAW 5/92
ENGINEER A.V.BLALOCK 5/92
APPROVED J.W.STAPLETON 5/92
F.R.RUPPEL 5/92
DRAWING APPROVALS DATE
FILE DATE 6/3/92
FILE POINT HC-1 EC-1
SHT. 1 OF 1
SCALE N/A
Q-6340-135
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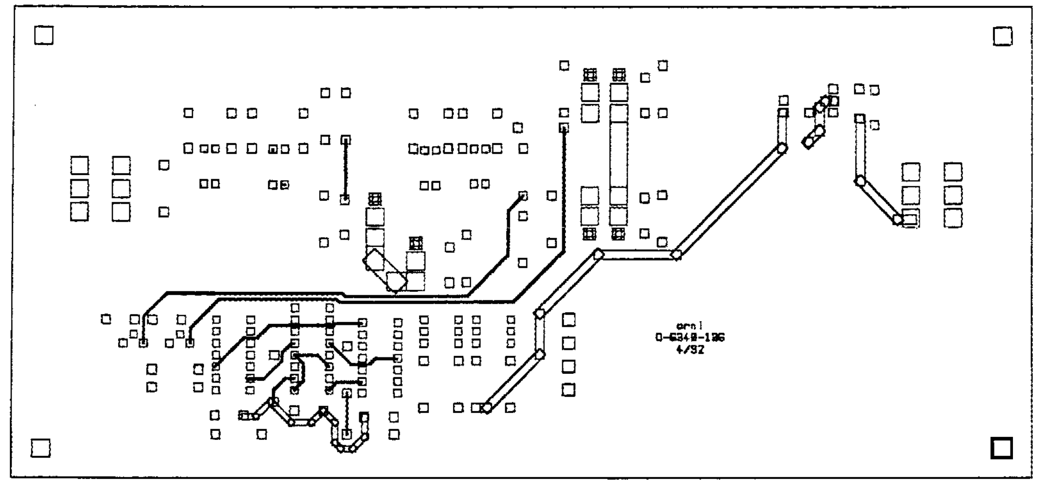
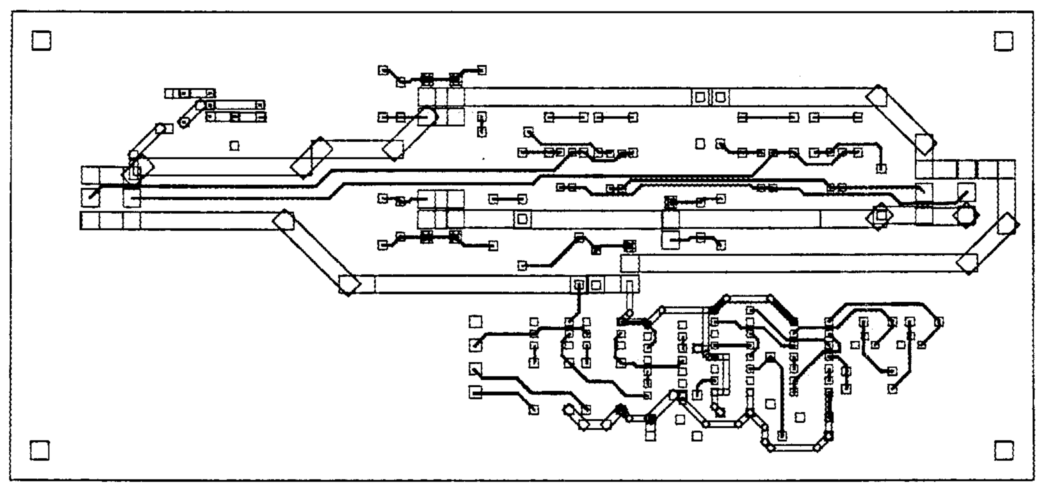
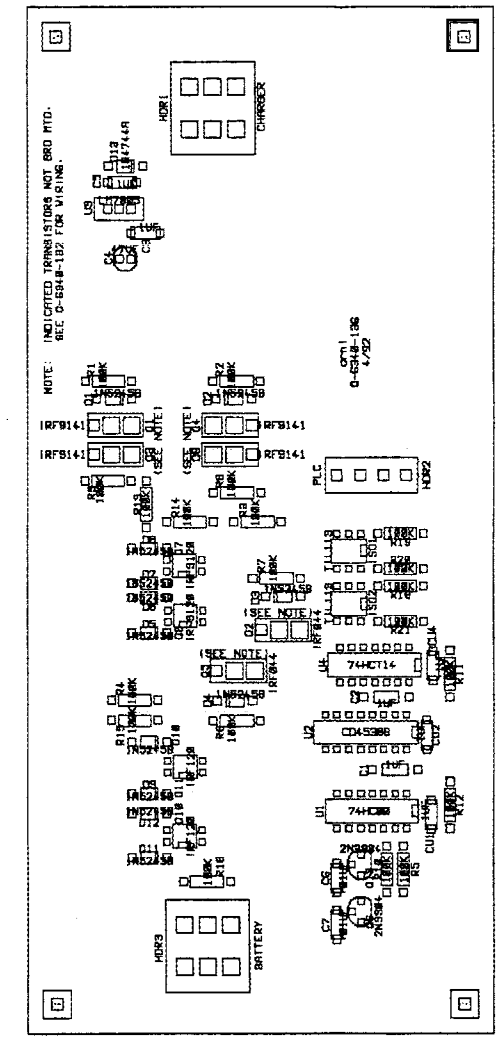


COMPONENT SIDE



SOLDER SIDE



REFERENCE DRAWINGS	NUMBER

MARTIN MARIETTA ENERGY SYSTEMS, INC.

operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC-05-84OR21400

Oak Ridge, Tennessee Paducah, Kentucky

BATTERY/CHARGER
POLARITY MANAGEMENT
PRINTED CIRCUIT BOARD

WEST VALLEY TRANSFER CART

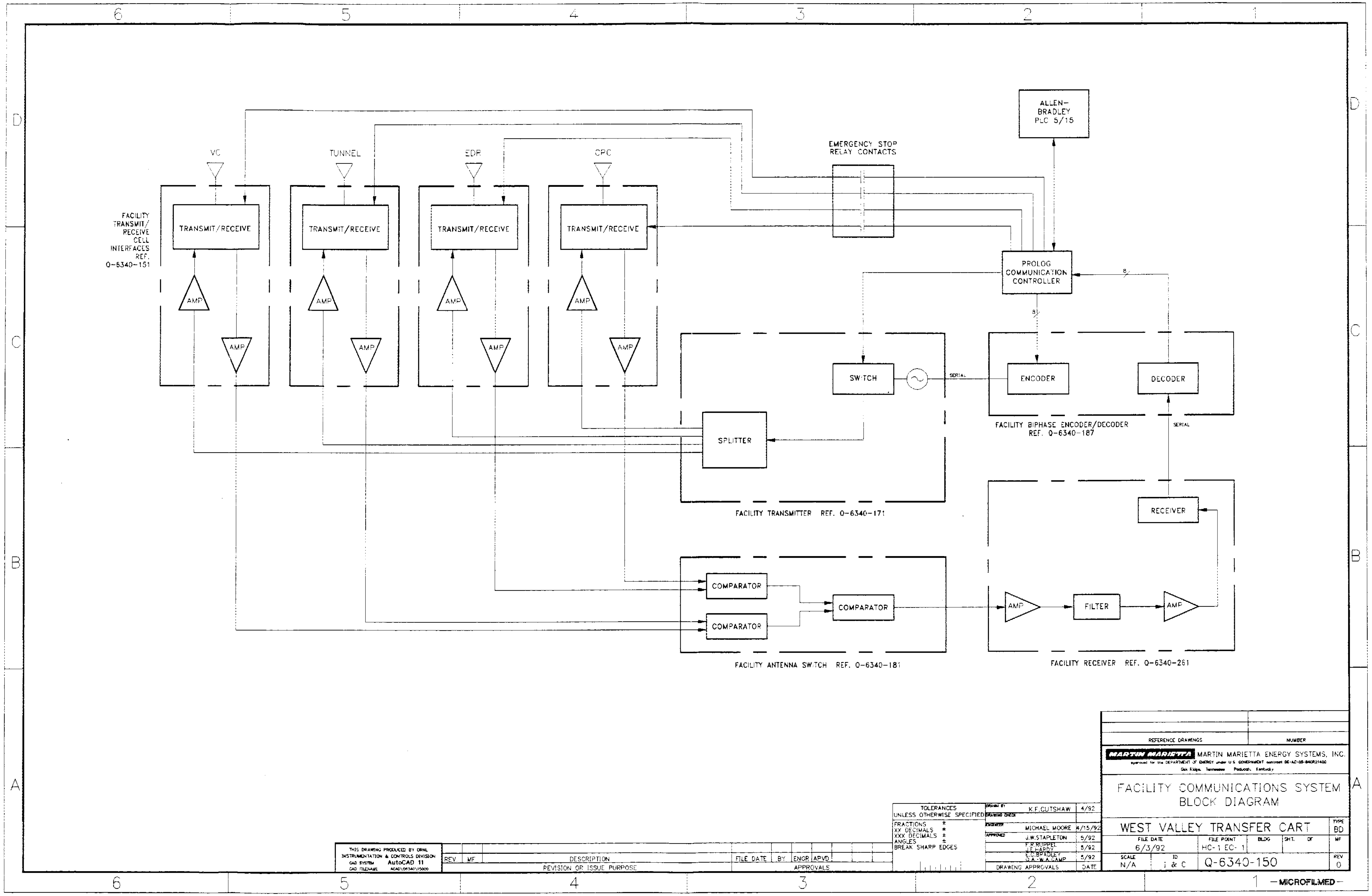
TYPE	FILE DATE	FILE POINT	BLDG	SHT.	OF	SCALE	ID	NUMBER	REV
PC		HC-1 EC-1	3500	1	1	1 : 1	I&C	Q-6340-136	0

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0 30'
BREAK SHARP EDGES

DRAWN BY	A.V. BLALOCK	4/92
DRAWING CHECK		
ENGINEER	A.V. BLALOCK	5/92
APPROVED	J.W.STAPLETON	5/92
	F.R.RUPPEL J.E.HARDY	5/92
	E.C.BRADLEY Q.A.-W.A.CAMP	5/92
	DRAWING APPROVALS	DATE

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH PERSONAL 870		REVISION OR ISSUE PURPOSE	APPROVALS			


VC
TUNNEL
EDR
CPC
FACILITY TRANSMIT/ RECEIVE CELL INTERFACES REF. 0-6340-151
TRANSMIT/RECEIVE
TRANSMIT/RECEIVE
TRANSMIT/RECEIVE
TRANSMIT/RECEIVE
AMP
EMERGENCY STOP RELAY CONTACTS
ALLEN-BRADLEY PLC 5/15
PROLOG COMMUNICATION CONTROLLER
SWITCH
SERIAL
ENCODER
DECODER
FACILITY BIPHASE ENCODER/DECODER REF. 0-6340-187
SPLITTER
FACILITY TRANSMITTER REF. 0-6340-171
RECEIVER
COMPARATOR
COMPARATOR
COMPARATOR
FILTER
FACILITY ANTENNA SWITCH REF. 0-6340-181
FACILITY RECEIVER REF. 0-6340-261
REFERENCE DRAWINGS
NUMBER
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FACILITY COMMUNICATIONS SYSTEM BLOCK DIAGRAM
WEST VALLEY TRANSFER CART
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES
K.F.CUTSHAW 4/92
MICHAEL MOORE 4/15/92
J.W.STAPLETON 5/92
DRAWING APPROVALS
DATE
THIS DRAWING PRODUCED BY ORNL INSTRUMENTATION & CONTROLS DIVISION
CAD SYSTEM AutoCAD 11
REV
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DESCRIPTION
REVISION OR ISSUE PURPOSE
FILE DATE
BY
ENGR
APVD
APPROVALS
6/3/92
N/A
I & C
Q-6340-150
BD
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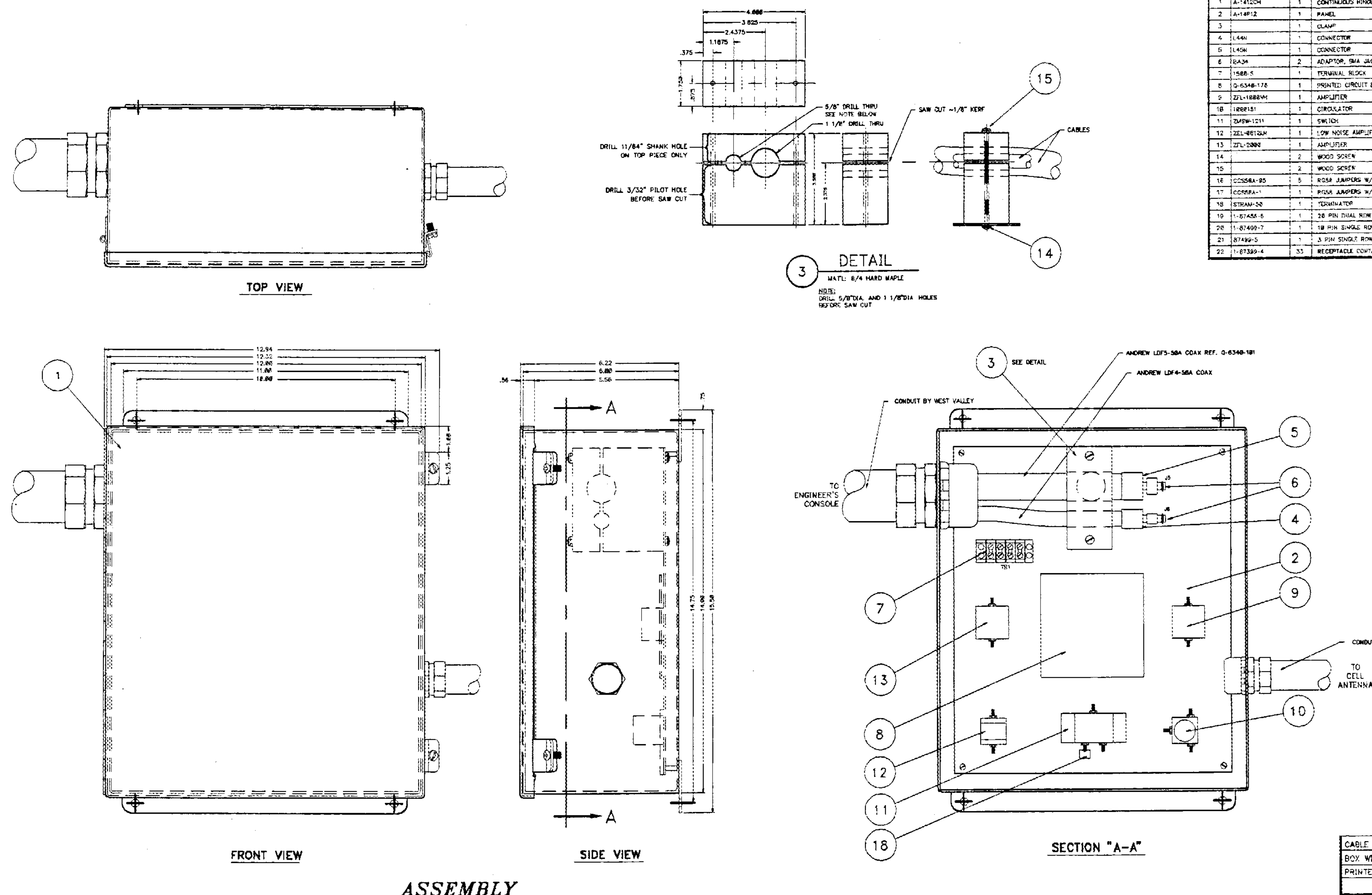
MICROFILMED



PARTS LIST

PART	PART. NO.	REQD.	DESCRIPTION	SIZE	MANUFACTURER (ADDRESS)
1	A-1412CH	1	CONTINUOUS HINGE CLAMP COVER BOX	14" x 12" x 6"	HOFFMAN ENG. CO., ANOKA, MN 55303
2	A-14P12	1	PANEL	12.75" x 10.88"	HOFFMAN ENG. CO., ANOKA, MN 55303
3		1	CLAMP		SEE DETAIL, THIS DRAWING
4	L44N	1	CONNECTOR		ANDREW
5	L45N	1	CONNECTOR		ANDREW
6	BA34	2	ADAPTOR, SMA JACK TO N PLUG		L-COM
7	1500-5	1	TERMINAL BLOCK		CURTIS
8	Q-6340-175	1	PRINTED CIRCUIT BOARD		OAK RIDGE NATIONAL LABORATORY
9	ZFL-1000VH	1	AMPLIFIER		MCL
10	1000151	1	CIRCULATOR		TRAK
11	ZMSW-1211	1	SWITCH		MCL
12	ZEL-0812LN	1	LOW NOISE AMPLIFIER		MCL
13	ZFL-2000	1	AMPLIFIER		MCL
14		2	WOOD SCREW	#8 x 1" LG.	
15		2	WOOD SCREW	#8 x 2" LG.	
16	CCS58A-05	5	RG58 JUMPERS W/SMA CONNECTORS	6"	L-COM
17	CCS58A-1	1	RG58 JUMPERS W/SMA CONNECTORS	12"	L-COM
18	STRAM-50	1	TERMINATOR		MCL
19	1-87456-6	1	20 PIN DUAL ROW CONTACT HOUSING		AMP
20	1-87499-7	1	10 PIN SINGLE ROW CONTACT HOUSING		AMP
21	87499-5	1	3 PIN SINGLE ROW CONTACT HOUSING		AMP
22	1-87309-4	33	RECEPTACLE CONTACTS		AMP

NOTES:

1. SEE Q-6340-175 AND 152 FOR INTERCONNECTION WIRING.
2. USE AMP HAND TOOL 90202-2 FOR CRIMPING CONTACT HOUSING RECEPTACLE CONTACTS.

REFERENCE DRAWINGS	NUMBER
CABLE & CONDUIT REQUIREMENTS	Q-6340-101
BOX WIRING	Q-6340-152
PRINTED CIRCUIT BOARD	Q-6340-175

MARTIN MARIETTA ENERGY SYSTEMS, INC.
operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

TYPICAL ANTENNA BOX ASSEMBLY

WEST VALLEY TRANSFER CART

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/64"
XX DECIMALS ± .015"
XXX DECIMALS ± .005"
ANGLES ± 0° 30'
BREAK SHARP EDGES

DRAWING APPROVALS		DATE
DRAWN BY	K.F.CUTSHAW	3/30/92
DRAWING CHECK	PLOT - 1=2	
ENGINEER	F.R.RUPPEL	5/92
APPROVED	J.W.STAPLETON	5/92
	F.R.RUPPEL / J.E.HARDY	5/92
	E.C.BRADLEY / D.A.-W.A.CAMP	5/92

FILE DATE 6/3/92 | FILE POINT HC-1 EC-1 | BLDG | SHT. 1 OF 1
SCALE HALF | ID I & C | Q-6340-151 | REV 0

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CAD SYSTEM AutoCAD 11
CAD FILENAME ACAD\063401\151.DWG

REV. | MF | DESCRIPTION / REVISION OR ISSUE PURPOSE | FILE DATE | BY | ENGR | APVD / APPROVALS

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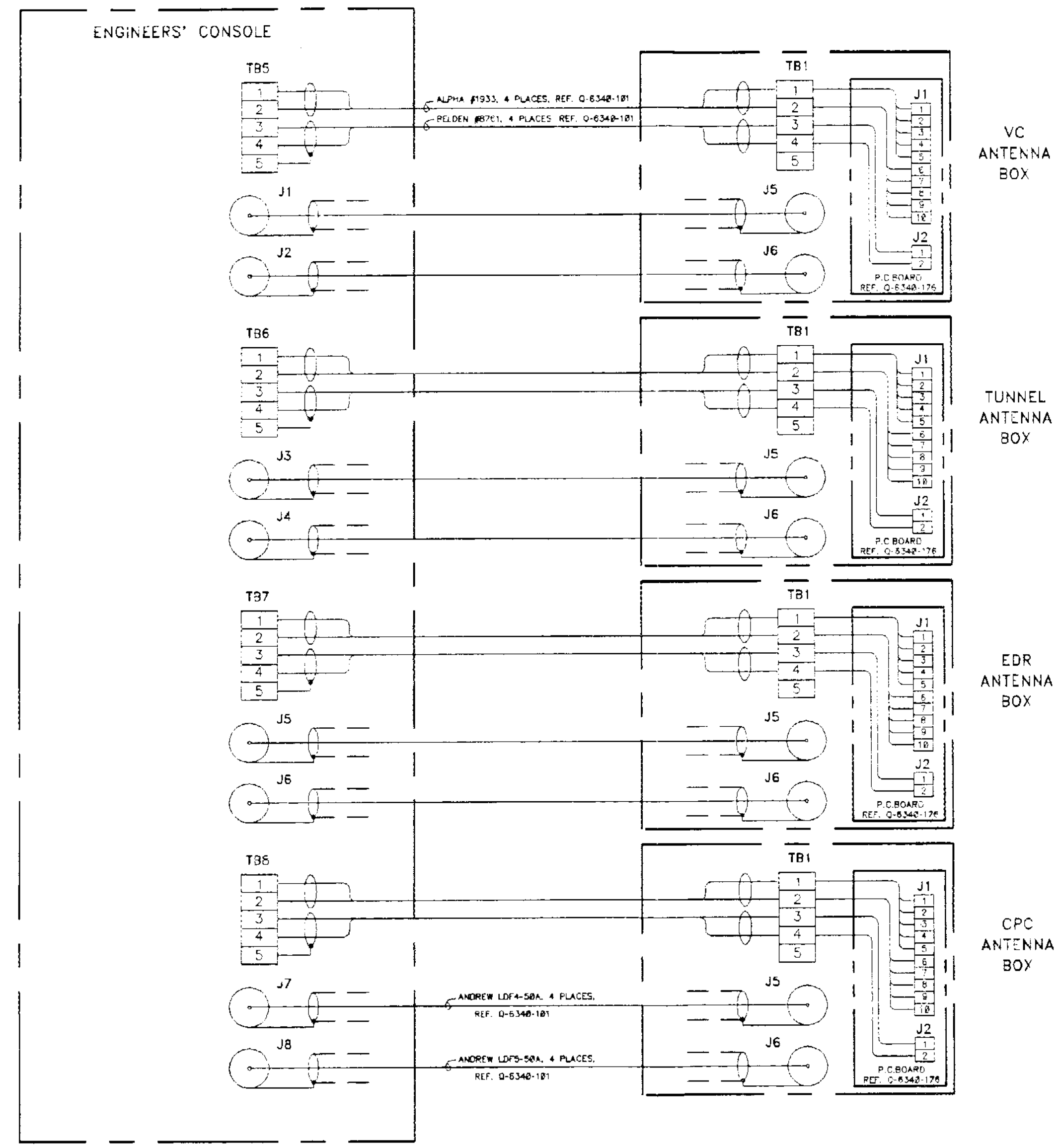

NOTES:

1. SEE Q-6340-175 FOR INTERCONNECTION WIRING.
2. USE 20AWG HOOKUP WIRE FOR BOX INTERCONNECTION.

REFERENCE DRAWINGS	NUMBER
CABLE & CONDUIT REQUIREMENTS	Q-6340-101
P.C.BOARD & INTERCONNECTION	Q-6340-175
BOX ASSEMBLY	Q-6340-151

MARTIN MARIETTA ENERGY SYSTEMS, INC.

Oak Ridge, Tennessee   Paducah, Kentucky

ANTENNA BOX
WIRING DIAGRAM

WEST VALLEY TRANSFER CART

DRAWN BY	K.F.CUTSHAW	3\27\92
DRAWING CHECK		
ENGINEER	F.R.RUPPEL	5/92
APPROVED	J.W.STAPLETON	5/92
	F.R.RUPPEL / J.E.HARDY	5/92
	E.C.BRADLEY / Q.A.-W.A.CAMP	5/92
DRAWING APPROVALS		DATE

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES

FILE DATE	FILE POINT	BLDG	SHT.	OF
6/3/92	HC-1 EC-1		1	1

SCALE	ID		REV
N/A	I&C	Q-6340-152	Ø

REV.	MF	DESCRIPTION	FILE DATE	BY	CHKD	ENGR	APVD
		REVISION OR ISSUE PURPOSE			APPROVALS		

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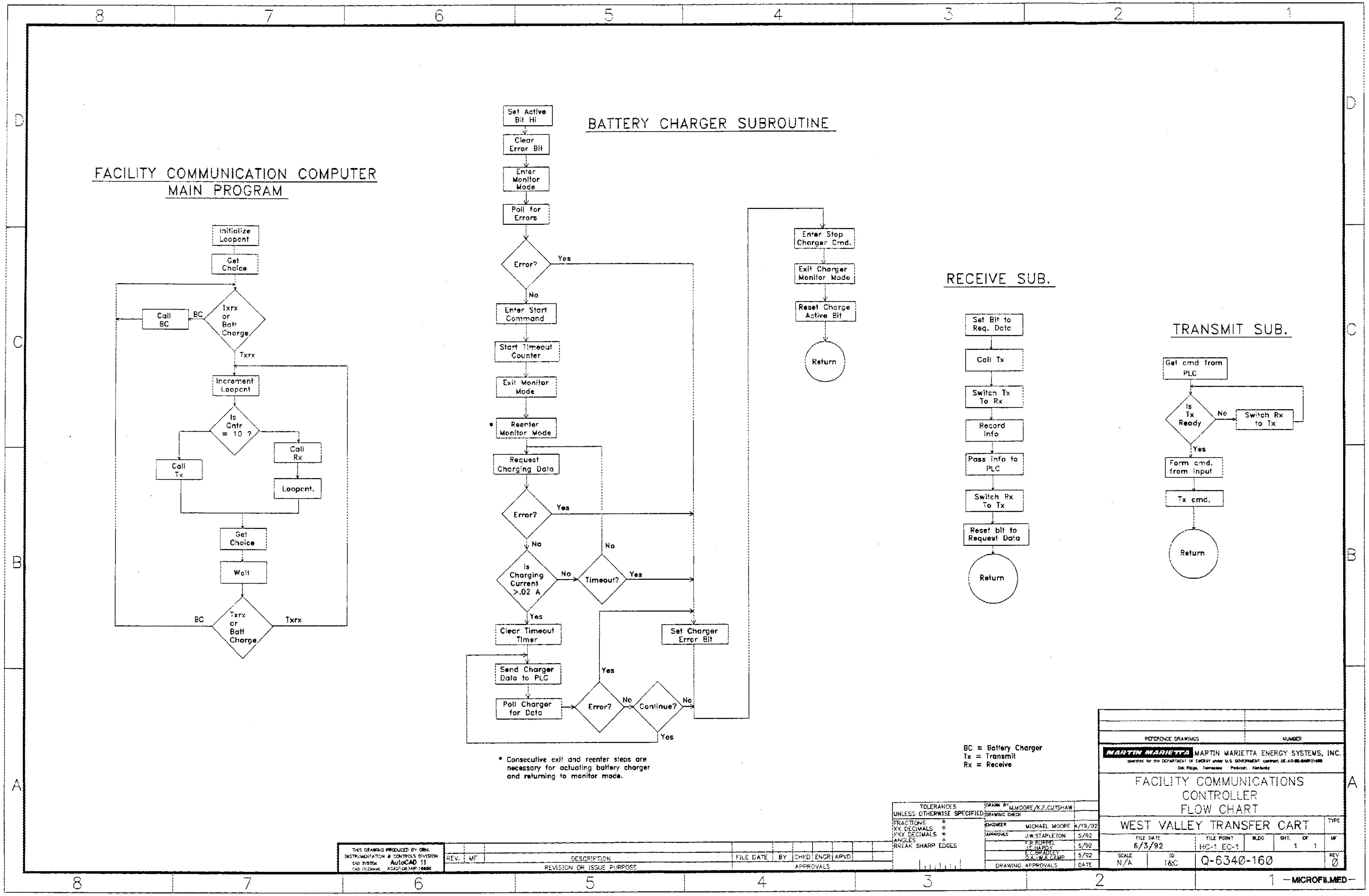
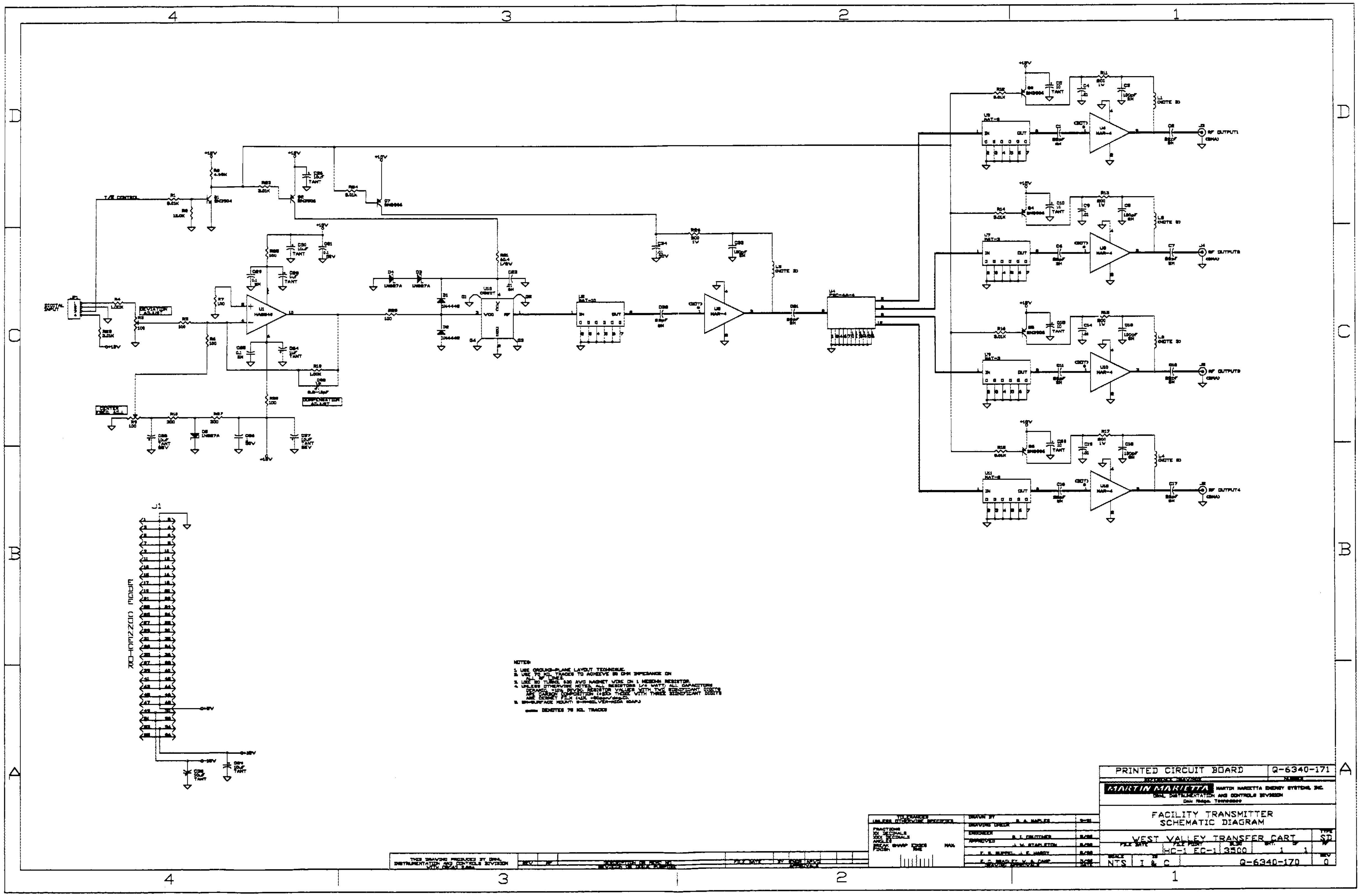
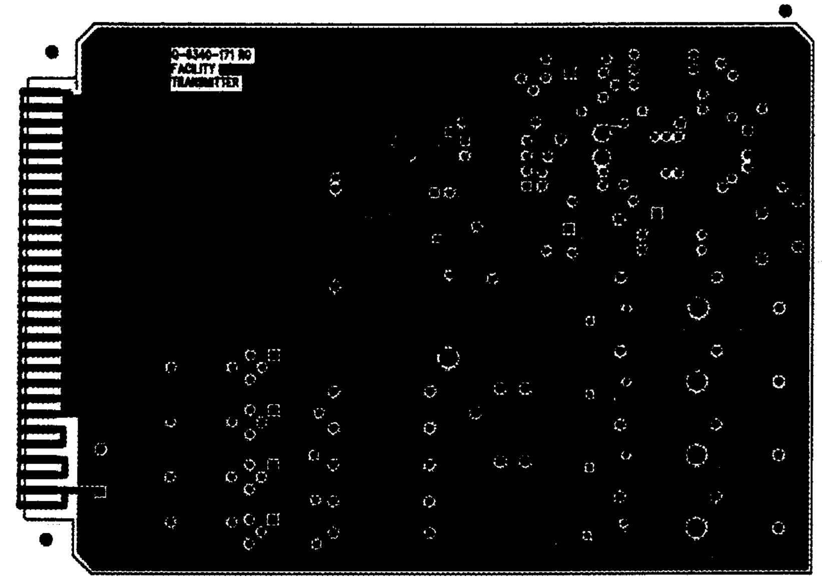
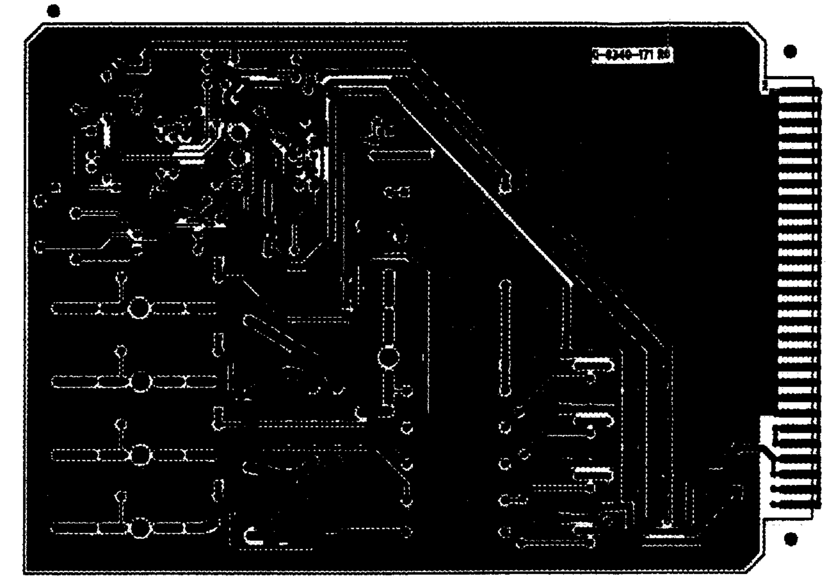

FACILITY COMMUNICATION COMPUTER MAIN PROGRAM
Initialize Loopcnt
Get Choice
Txrx or Batt Charge
Call BC
BC
Txrx
Increment Loopcnt
Is Cntr = 10 ?
Call Tx
Call Rx
Loopcnt.
Get Choice
Wait
Txrx or Batt Charge
BC
Txrx
BATTERY CHARGER SUBROUTINE
Set Active Bit Hi
Clear Error Bit
Enter Monitor Mode
Poll for Errors
Error?
Yes
No
Enter Start Command
Start Timeout Counter
Exit Monitor Mode
Reenter Monitor Mode
Request Charging Data
Error?
Yes
No
Is Charging Current >.02 A
No
Timeout?
Yes
No
Yes
Clear Timeout Timer
Set Charger Error Bit
Send Charger Data to PLC
Poll Charger for Data
Error?
No
Continue?
No
Yes
Yes
Enter Stop Charger Cmd.
Exit Charger Monitor Mode
Reset Charge Active Bit
Return
* Consecutive exit and reenter steps are necessary for actuating battery charger and returning to monitor mode.
RECEIVE SUB.
Set Bit to Req. Data
Call Tx
Switch Tx To Rx
Record Info
Pass Info to PLC
Switch Rx To Tx
Reset bit to Request Data
Return
TRANSMIT SUB.
Get cmd from PLC
Is Tx Ready
No
Switch Rx to Tx
Yes
Form cmd. from input
Tx cmd.
Return
BC = Battery Charger
Tx = Transmit
Rx = Receive
REFERENCE DRAWINGS
NUMBER
MARTIN MARIETTA
MARTIN MARIETTA ENERGY SYSTEMS, INC.
Oak Ridge, Tennessee Paducah, Kentucky
FACILITY COMMUNICATIONS CONTROLLER FLOW CHART
WEST VALLEY TRANSFER CART
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES
DRAWN BY M.MOORE/K.F.CUTSHAW
DRAWING CHECK
ENGINEER MICHAEL MOORE 4/19/92
APPROVED J.W.STAPLETON 5/92
F.R.RUPPEL J.E.HARDY 5/92
E.C.BRADLEY C.A.-W.A.CAMP 5/92
DRAWING APPROVALS DATE
FILE DATE 6/3/92
FILE POINT HC-1 EC-1
BLDG
SHT. 1 OF 1
SCALE N/A
ID I&C
Q-6340-160
REV Ø
TYPE
THIS DRAWING PRODUCED BY ORNL INSTRUMENTATION & CONTROLS DIVISION
CAD SYSTEM AutoCAD 11
REV. MF
DESCRIPTION
REVISION OR ISSUE PURPOSE
FILE DATE BY CHKD ENGR APVD
APPROVALS
MICROFILMED

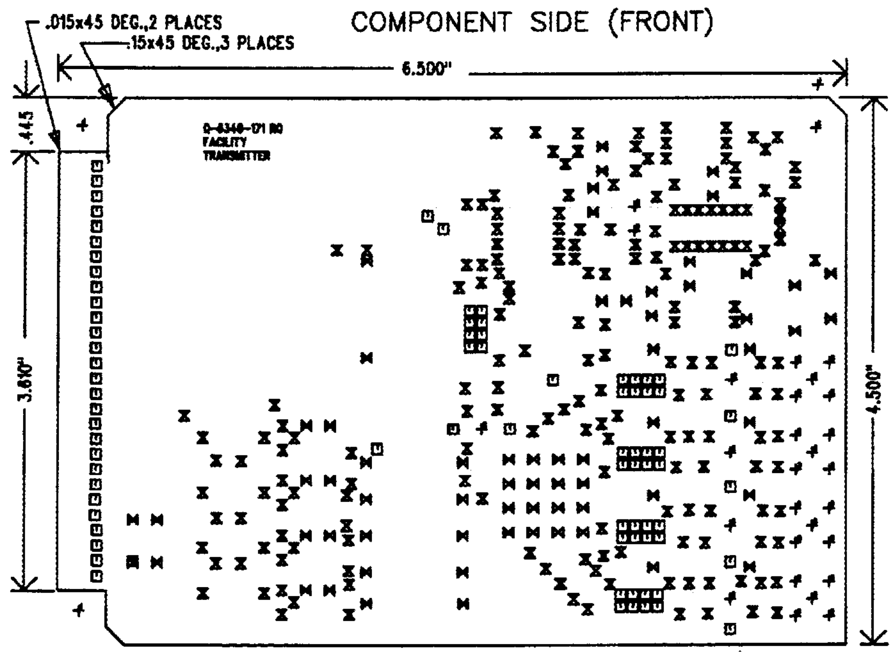

PRINTED CIRCUIT BOARD
Q-6340-171
MARTIN MARIETTA
FACILITY TRANSMITTER
SCHEMATIC DIAGRAM
WEST VALLEY TRANSFER CART
SD
HC-1 EC-1
3500
NTS
I & C
Q-6340-170
0
NOTES:
1. USE GROUND-PLANE LAYOUT TECHNIQUE.



COMPONENT SIDE (FRONT)

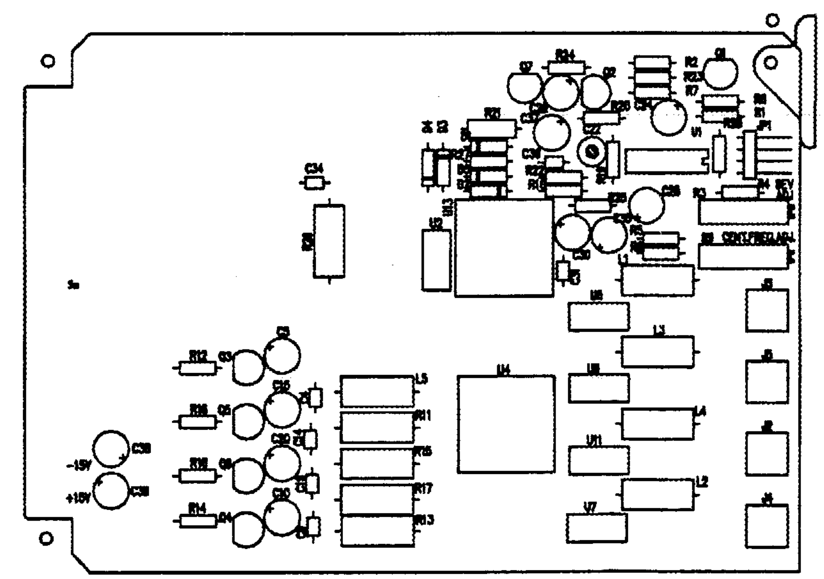


CIRCUIT SIDE (REAR)



SIZE	QTY	SYM
28	83	□
35	192	⧗
40	66	⋈
52	22	B
93	1	E
125	3	I
152	5	K

DRILL MASTER



SILK SCREEN FOR FRONT

NOTES:

1. MATERIAL TO BE .062" THICK EPOXY FIBERGLASS TYPE FR4, PER MIL-P-13949/4. SPECIFIC DESIGNATION SHALL BE FL-GFP-062-C-1/1-B-2-B.
2. ALL HOLES WITH LANDS ON BOTH SIDES OF THE BOARD SHALL BE 100% PLATED THRU. COPPER PLATING INSIDE THE HOLES SHALL BE .001" THICK MINIMUM IN ACCORDANCE WITH MIL-C-14550. FRONT TO REAR REGISTRATION TO BE WITHIN .003".
3. CLEAN AND SOLDER PLATE ALL COPPER, EXCEPT CONNECTOR CONTACTS, IN ACCORDANCE WITH MIL-P-81728. THE FUSED TIN-LEAD SHALL BE .0003 INCH THICK MINIMUM. CONNECTOR CONTACTS SHALL BE PLATED TO A MINIMUN THICKNESS OF .0002 INCH WITH A LOW STRESS NICKEL WHICH CONFORMS TO QQ-N-290, CLASS 2, THEN OVER PLATED WITH GOLD PER MIL-G-45204 TO A THICKNESS NO LESS THAN .00005 INCH NOR MORE THAN .0001 INCH.
4. AFTER PROCESSING, ETCHED BOARDS TO BE FREE OF VOIDS AND SCRATCHES.
5. DO NOT USE THIS DRAWING AS A WORK SHEET. MASTER(S) OF ARTWORK WILL BE SUPPLIED BY ORNL.
6. LIMIT ON ALL DIMENSIONS .015 INCH UNLESS OTHERWISE NOTED.
7. HONE ALL EDGES SMOOTH.
8. MATERIAL REQUIRED: 30 SQ. IN..
9. HOLE LOCATION TOLERANCE .005 INCH.
10. NOTCHES: 7
11. DIMENSIONS OF ALL HOLES NOTED BELOW ARE FINISHED HOLE DIAMETERS AFTER PLATING THRU.

REV.	MF	DESCRIPTION OR MEMO NO.	FILE DATE	BY	ENGR	APVD
		REVISION OR ISSUE PURPOSE	APPROVALS			

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES

DRAWING APPROVALS	DATE
R. A. MAPLES	2-92
R.I. CRUTCHER	2-92
R.I. CRUTCHER	4-92
J.W. STAPLETON	5-92
F.R. RUPPEL, J.E. HARDY	5-92
E.C. BRADLEY, QA-W.A. CAMP	5-92

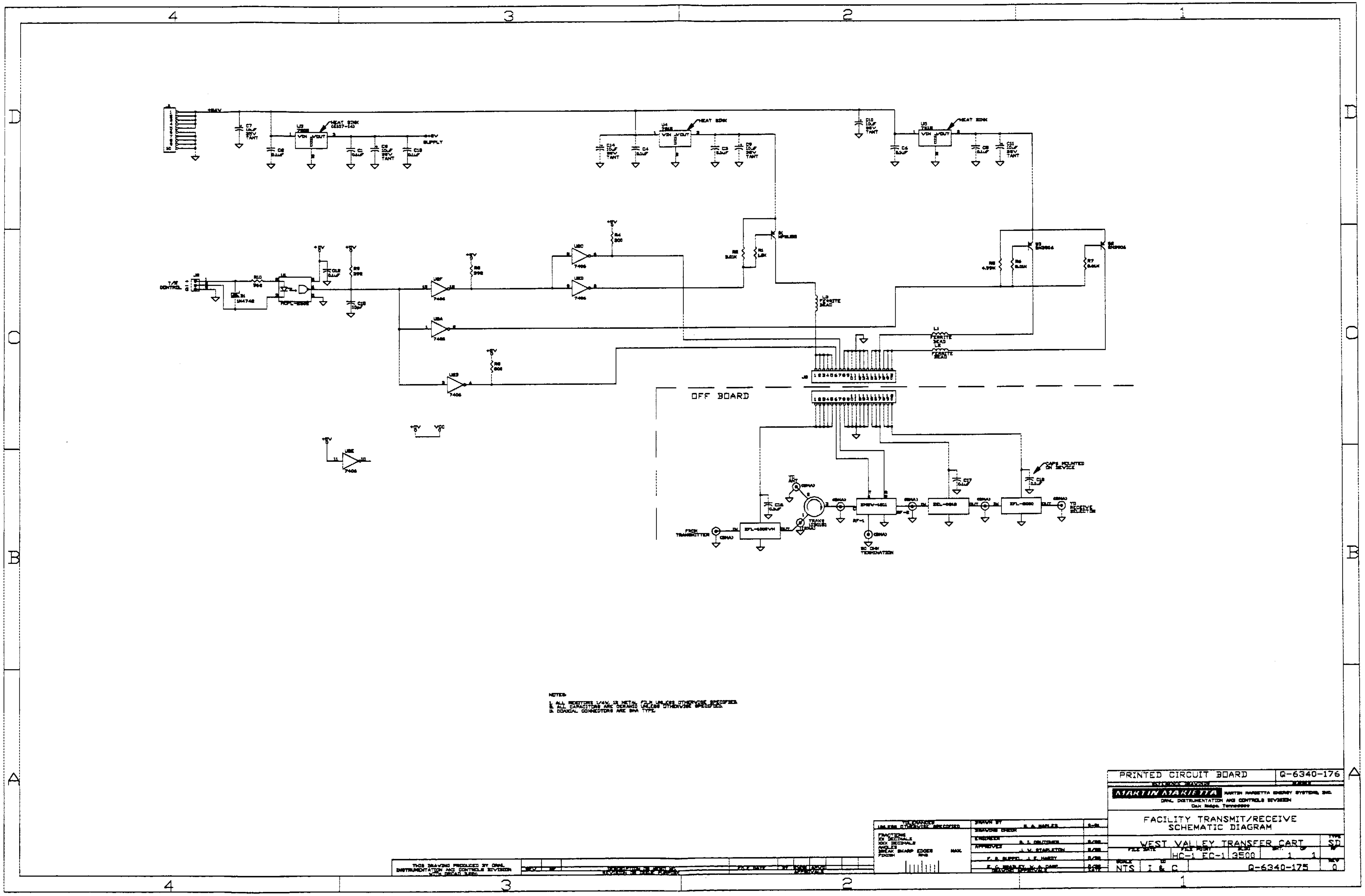
REFERENCE DRAWINGS | NUMBER

MARTIN MARIETTA — MARTIN MARIETTA ENERGY SYSTEMS, INC.

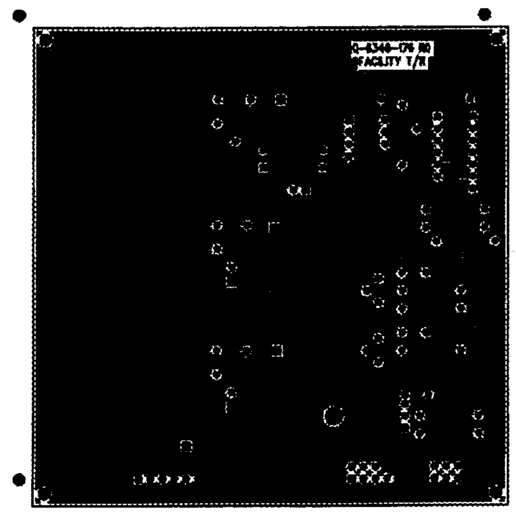
FACILITY TRANSMITTER PRINTED CIRCUIT BOARD

WEST VALLEY TRANSFER CART

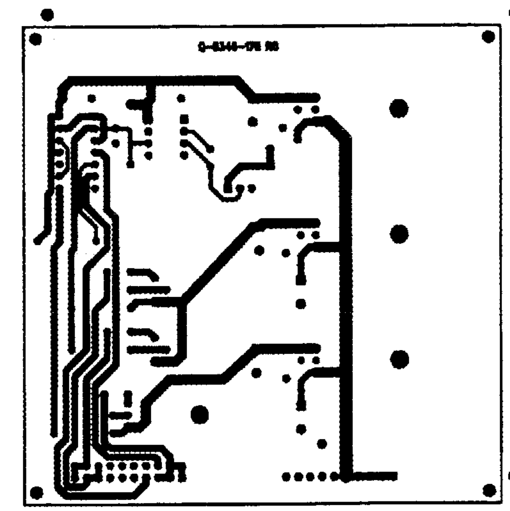
TYPE	FILE DATE	FILE POINT	BLDG	SHT.	OF	SCALE	ID	NUMBER	REV
PC		HC-1 EC-1	3500	1	1	FULL	I&C	Q-6340-171	0



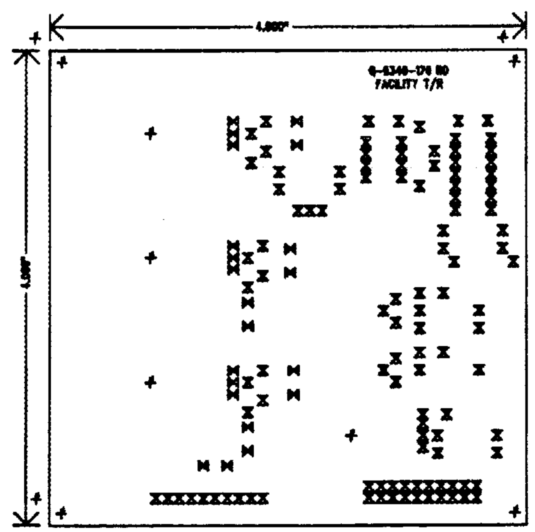
OFF BOARD
PRINTED CIRCUIT BOARD
Q-6340-176
MARTIN MARIETTA
FACILITY TRANSMIT/RECEIVE
SCHEMATIC DIAGRAM
WEST VALLEY TRANSFER CART
SD
HC-1 EC-1
3500
1
1
NTS
I & C
Q-6340-175
0



COMPONENT SIDE (FRONT)

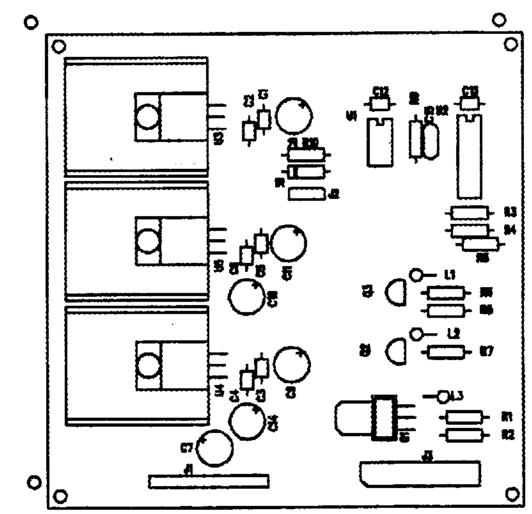


CIRCUIT SIDE



SIZE	QTY	SYM
35	110	⧗
40	21	⋈
125	11	|

DRILL MASTER



SILK SCREEN FOR FRONT

NOTES:

1. MATERIAL TO BE .062 IN THICK EPOXY FIBERGLASS TYPE FR4, PER MIL-P-13949/4. SPECIFIC DESIGNATION SHALL BE FL-GFP-062-C-1/1-B-2-B.
2. ALL HOLES WITH LANDS ON BOTH SIDES OF THE BOARD SHALL BE 100% PLATED THRU. COPPER PLATING INSIDE THE HOLES SHALL BE .001" MINIMUM IN ACCORDANCE WITH MIL-C-14550. FRONT TO REAR REGISTRATION TO BE WITHIN .003".
3. CLEAN AND SOLDER PLATE ALL COPPER IN ACCORDANCE WITH MIL-P-81728.THE FUSED TIN-LEAD SHALL BE .0003 INCH THICK MINIMUM.
4. AFTER PROCESSING, ETCHED BOARDS TO BE FREE OF VOIDS AND SCRATCHES.
5. DO NOT USE THIS DRAWING AS A WORK SHEET. MASTER NEGATIVE(S) OF WIRING WILL BE SUPPLIED BY ORNL.
6. LIMIT ON ALL DIMENSIONS .015 IN UNLESS OTHERWISE NOTED.
7. HONE ALL EDGES SMOOTH.
8. MATERIAL REQUIRED:16 SQ. IN..
9. HOLE LOCATION TOLERANCE .005 IN.
10. DIMENSIONS OF ALL HOLES NOTED BELOW ARE FINISHED HOLE DIAMETERS AFTER PLATING THRU.

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH		REVISION OR ISSUE PURPOSE	APPROVALS			

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0° 30'
BREAK SHARP EDGES

DRAWING APPROVALS	DATE
DRAWN BY R.A. MAPLES	10-91
DRAWING CHECK R.I. CRUTCHER	2-92
ENGINEER R.I. CRUTCHER	4-92
APPROVED J.V. STAPLETON	5-92
F.R. RUPPEL, J.E. HARDY	5-92
E.C. BRADLEY, GA-W.A. CAMP	5-92

REFERENCE DRAWINGS | NUMBER

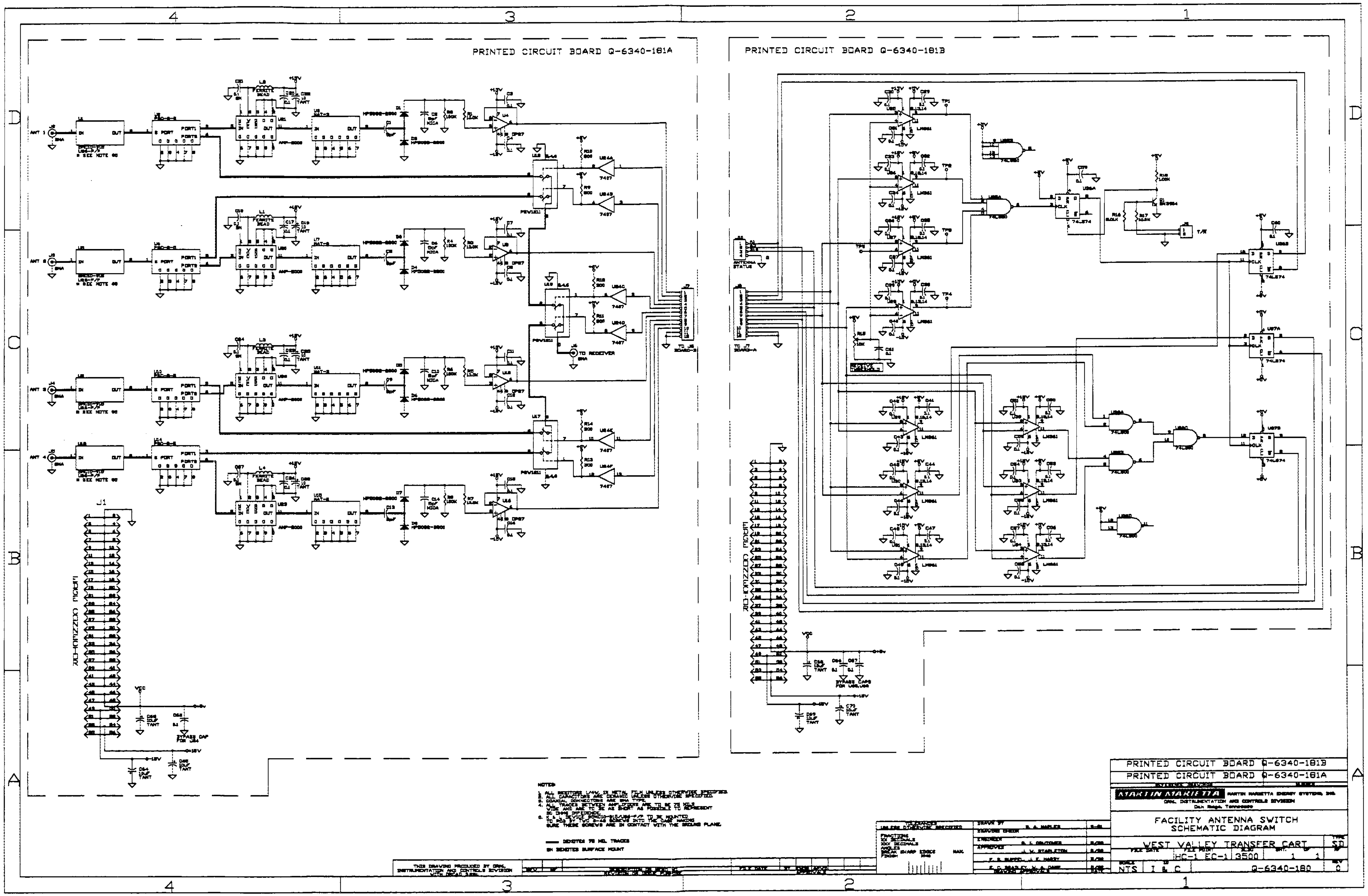
MARTIN MARIETTA ENERGY SYSTEMS, INC.

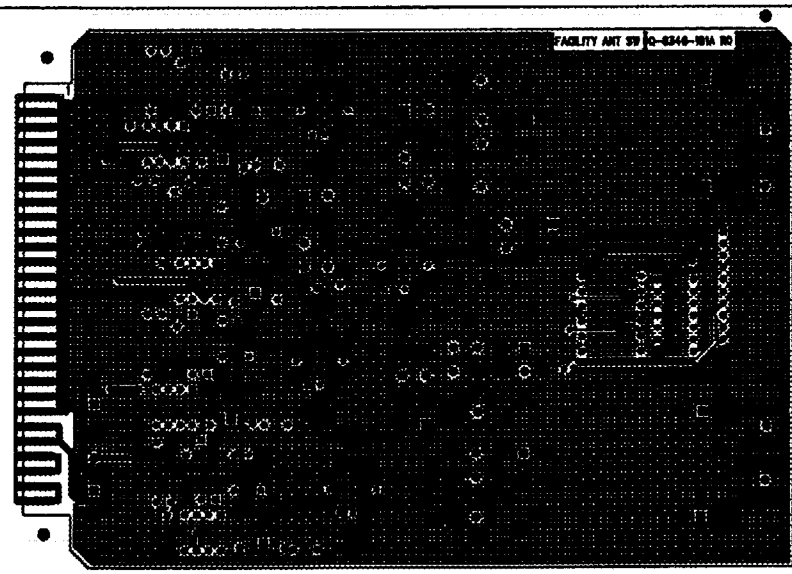
operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

FACILITY TRANSMIT/RECEIVE
CELL INTERFACE
PRINTED CIRCUIT BOARD

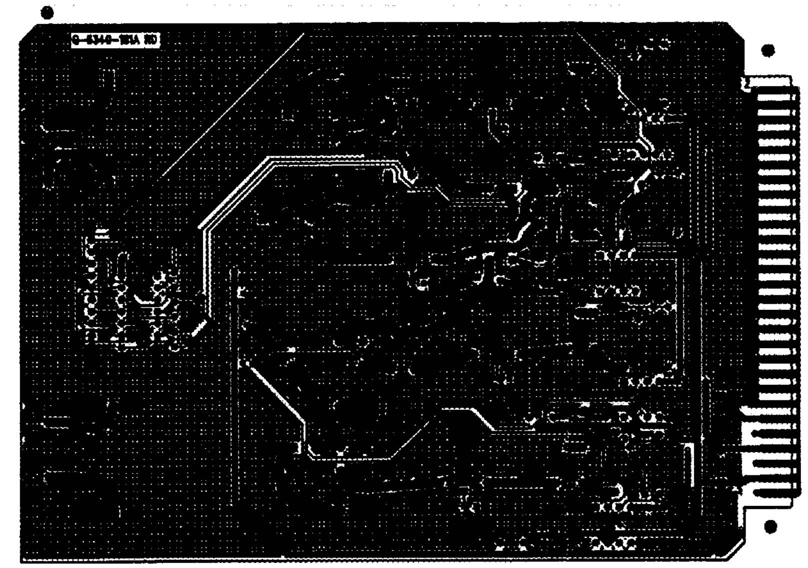
WEST VALLEY TRANSFER CART

TYPE: PC
FILE DATE:
FILE PRINT: HC-1 EC-1
BLDG: 3500
SHT. 1 OF 1
SCALE: 1 : 1
I&C
Q-6340-176
REV: Ø

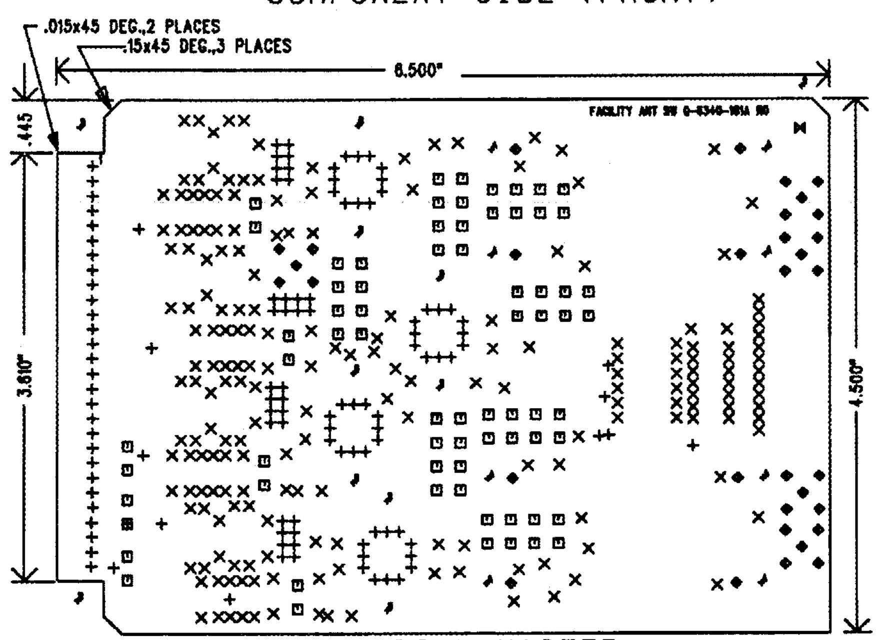

PRINTED CIRCUIT BOARD Q-6340-181A
PRINTED CIRCUIT BOARD Q-6340-181B
ANT 1
ANT 2
ANT 3
ANT 4
TO RECEIVER
J1
PRINTED CIRCUIT BOARD Q-6340-181B
PRINTED CIRCUIT BOARD Q-6340-181A
MARTIN MARIETTA
FACILITY ANTENNA SWITCH
SCHEMATIC DIAGRAM
WEST VALLEY TRANSFER CART
SD
HC-1 EC-1
3500
1
1
NTS
I & C
Q-6340-180
0



COMPONENT SIDE (FRONT)

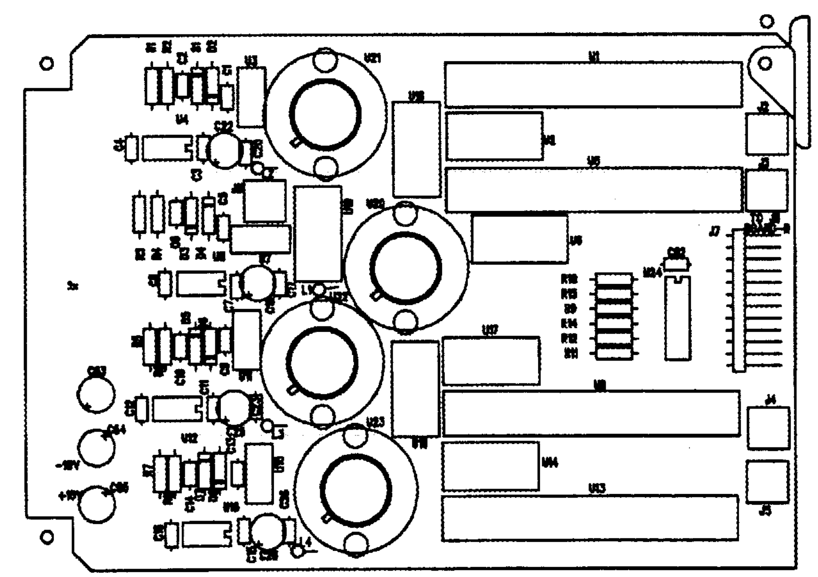


CIRCUIT SIDE



DRILL MASTER

SIZE	QTY	SYM
28	123	+
35	261	X
40	70	⊡
48	33	◈
93	1	⋈
107	8	A
125	11	B



SILK SCREEN FOR FRONT

NOTES:

1. MATERIAL TO BE .062 IN THICK EPOXY FIBERGLASS TYPE FR4, PER MIL-P-13949/4. SPECIFIC DESIGNATION SHALL BE FL-GFP-062-C-1/1-B-2-B.
2. ALL HOLES WITH LANDS ON BOTH SIDES OF THE BOARD SHALL BE 100% PLATED THRU. COPPER PLATING INSIDE THE HOLES SHALL BE .001' MINIMUM IN ACCORDANCE WITH MIL-C-14550. FRONT TO REAR REGISTRATION TO BE WITHIN .003'.
3. CLEAN AND SOLDER PLATE ALL COPPER, EXCEPT CONNECTOR CONTACTS, IN ACCORDANCE WITH MIL-P-81728.THE FUSED TIN-LEAD SHALL BE .0003 INCH THICK MINIMUM.CONNECTOR CONTACTS SHALL BE PLATED TO A MINIMUM THICKNESS OF .0002 INCH WITH A LOW STRESS NICKEL WHICH CONFORMS TO QQ-N-290, CLASS 2, THEN OVER PLATED WITH GOLD PER MIL-G-45204 TO A THICKNESS NO LESS THAN .00005 INCH NOR MORE THAN .0001 INCH.
4. AFTER PROCESSING, ETCHED BOARDS TO BE FREE OF VOIDS AND SCRATCHES.
5. DO NOT USE THIS DRAWING AS A WORK SHEET. MASTER(S) OF WIRING WILL BE SUPPLIED BY ORNL.
6. LIMIT ON ALL DIMENSIONS .015 IN UNLESS OTHERWISE NOTED.
7. HONE ALL EDGES SMOOTH.
8. MATERIAL REQUIRED:30 SQ. IN..
9. HOLE LOCATION TOLERANCE .005 IN.
10. NOTCHES: 7
11. DIMENSIONS OF ALL HOLES NOTED BELOW ARE FINISHED HOLE DIAMETERS AFTER PLATING THRU.

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH		REVISION OR ISSUE PURPOSE	APPROVALS			

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0° 30'
BREAK SHARP EDGES

DRAWING APPROVALS	DATE
DRAWN BY R.A. MAPLES	2-92
DRAWING CHECK R.I. CRUTCHER	2-92
ENGINEER R.I. CRUTCHER	4-92
APPROVED J.V. STAPLETON	5-92
F.R. RUPPEL, J.E. HARDY	5-92
E.C. BRADLEY, GA-V.A. CAMP	5-92

REFERENCE DRAWINGS	NUMBER

MARTIN MARIETTA ENERGY SYSTEMS, INC.

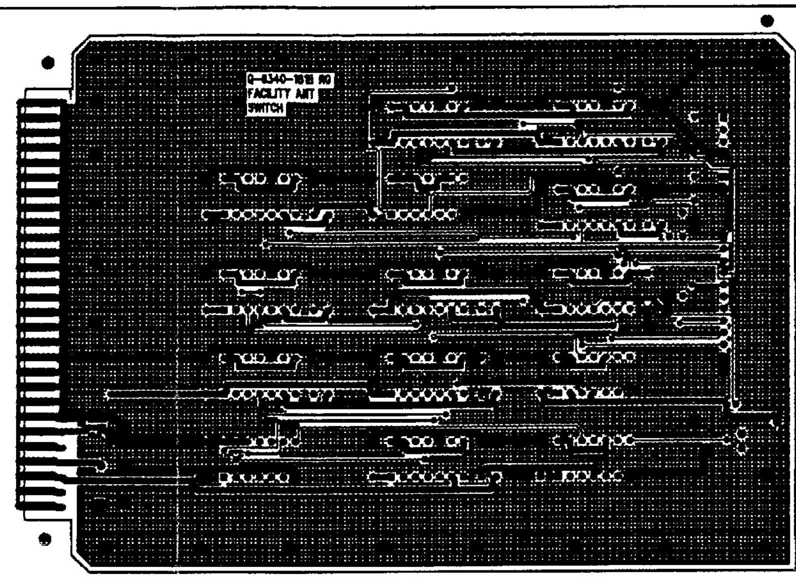
FACILITY ANTENNA SWITCH
PRINTED CIRCUIT BOARD

WEST VALLEY TRANSFER CART

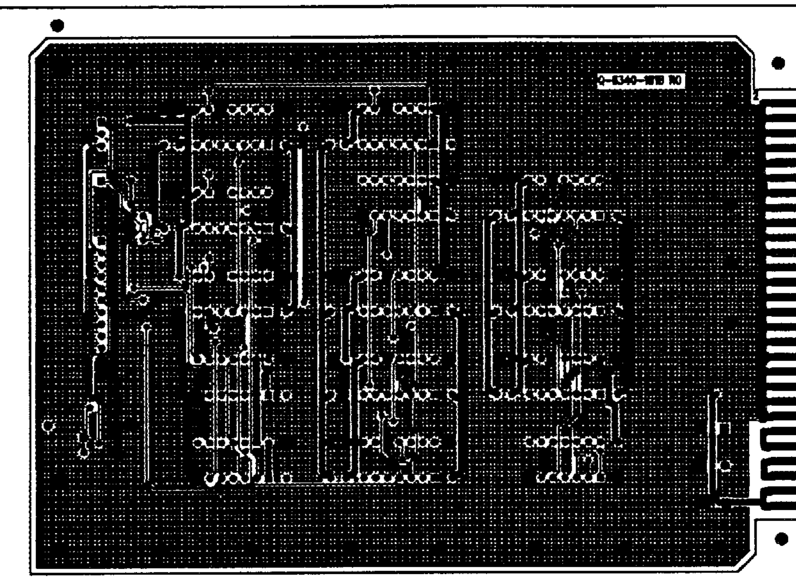
TYPE: PC

FILE POINT	BLDG	SHT.	OF
HC-1 EC-1	3500	1	1

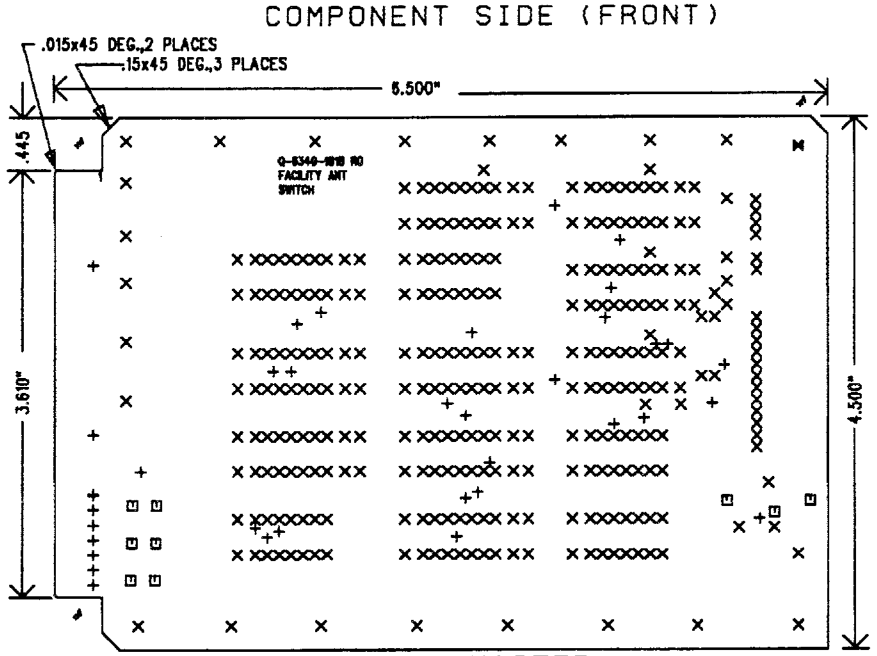
SCALE	ID	DWG NO.	REV
1:1	I&C	Q-6340-181A	0



COMPONENT SIDE (FRONT)

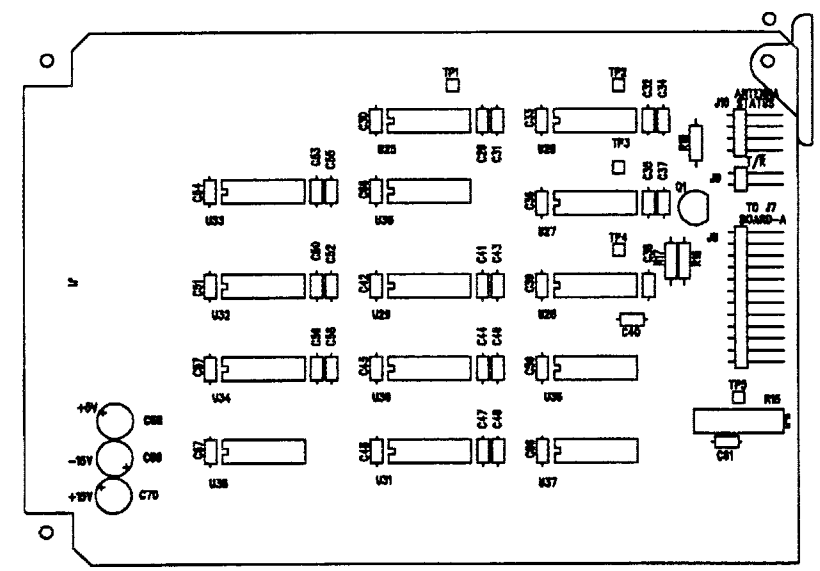


CIRCUIT SIDE



DRILL MASTER

SIZE	QTY	SYM
28	37	+
35	320	X
40	9	⊡
93	1	⋈
125	3	A



SILK SCREEN FOR FRONT

NOTES:

1. MATERIAL TO BE .062 IN THICK EPOXY FIBERGLASS TYPE FR4, PER MIL-P-13949/4. SPECIFIC DESIGNATION SHALL BE FL-GFP-062-C-1/1-B-2-B.
2. ALL HOLES WITH LANDS ON BOTH SIDES OF THE BOARD SHALL BE 100% PLATED THRU. COPPER PLATING INSIDE THE HOLES SHALL BE .001" MINIMUM IN ACCORDANCE WITH MIL-C-14550. FRONT TO REAR REGISTRATION TO BE WITHIN .003".
3. CLEAN AND SOLDER PLATE ALL COPPER, EXCEPT CONNECTOR CONTACTS, IN ACCORDANCE WITH MIL-P-81728.THE FUSED TIN-LEAD SHALL BE .0003 INCH THICK MINIMUM.CONNECTOR CONTACTS SHALL BE PLATED TO A MINIMUN THICKNESS OF .0002 INCH WITH A LOW STRESS NICKEL WHICH CONFORMS TO QQ-N-290, CLASS 2, THEN OVER PLATED WITH GOLD PER MIL-G-45204 TO A THICKNESS NO LESS THAN .00005 INCH NOR MORE THAN .0001 INCH.
4. AFTER PROCESSING, ETCHED BOARDS TO BE FREE OF VOIDS AND SCRATCHES.
5. DO NOT USE THIS DRAWING AS A WORK SHEET. MASTER(S) OF WIRING WILL BE SUPPLIED BY ORNL.
6. LIMIT ON ALL DIMENSIONS .015 IN UNLESS OTHERWISE NOTED.
7. HONE ALL EDGES SMOOTH.
8. MATERIAL REQUIRED:30 SQ. IN..
9. HOLE LOCATION TOLERANCE .005 IN.
10.NOTCHES: 7
11.DIMENSIONS OF ALL HOLES NOTED BELOW ARE FINISHED HOLE DIAMETERS AFTER PLATING THRU.

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH		REVISION OR ISSUE PURPOSE	APPROVALS			

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0° 30'
BREAK SHARP EDGES

DRAWING APPROVALS	DATE
DRAWN BY R.A. MAPLES	2-92
DRAWING CHECK R.I. CRUTCHER	2-92
ENGINEER R.I. CRUTCHER	4-92
APPROVED J.W. STAPLETON	5-92
F.R. RUPPEL, J.E. HARDY	5-92
E.C. BRADLEY, QA-V.A. CAMP	5-92

REFERENCE DRAWINGS	NUMBER

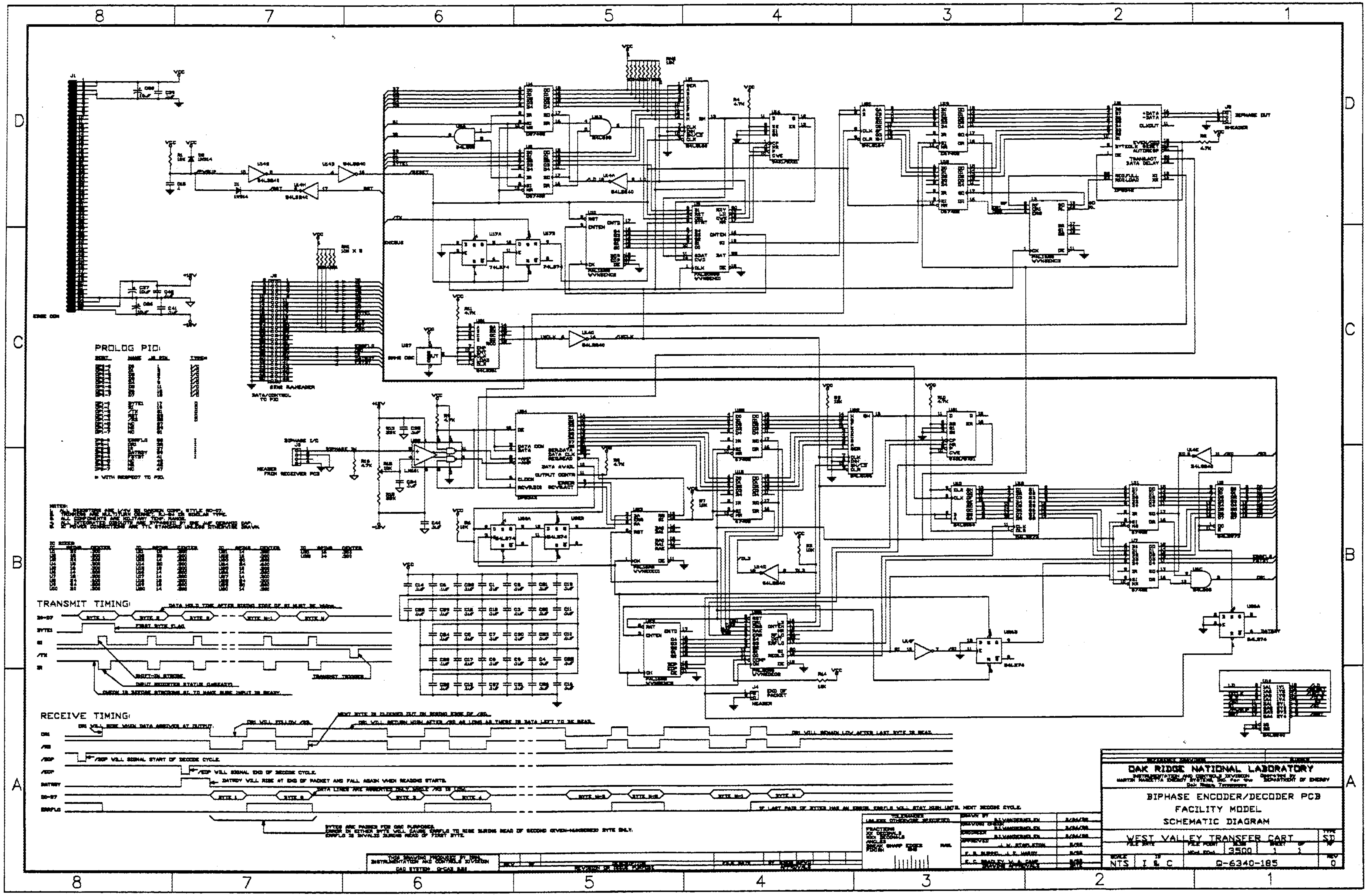
MARTIN MARIETTA MARTIN MARIETTA ENERGY SYSTEMS, INC.

operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC-05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

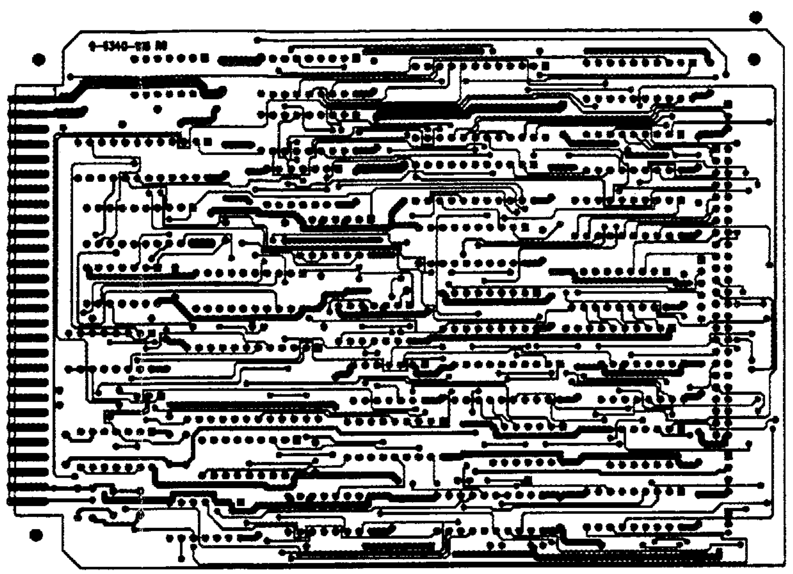
FACILITY ANTENNA SWITCH
PRINTED CIRCUIT BOARD

WEST VALLEY TRANSFER CART

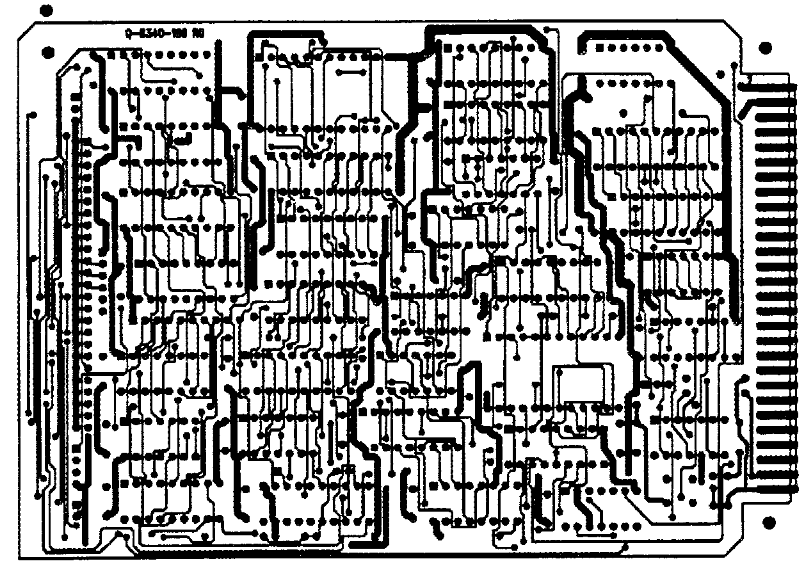
TYPE	FILE DATE	FILE POINT	BLDG	SHT.	OF	SCALE	ID	NUMBER	REV
PC		HC-1 EC-1	3500	1	1	1 : 1	I&C	Q-634Ø-181B	Ø



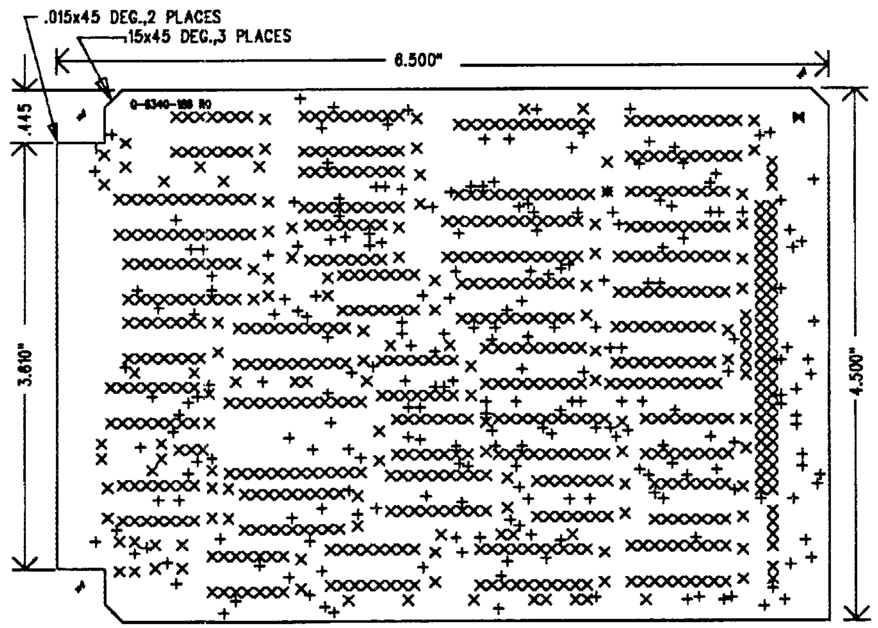
PROLOG PIO:
TRANSMIT TIMING:
RECEIVE TIMING:
OAK RIDGE NATIONAL LABORATORY
BIPHASE ENCODER/DECODER PCB
FACILITY MODEL
SCHEMATIC DIAGRAM
WEST VALLEY TRANSFER CART
SD
3500
NTS
I & C
D-6340-185
0



COMPONENT SIDE (FRONT)

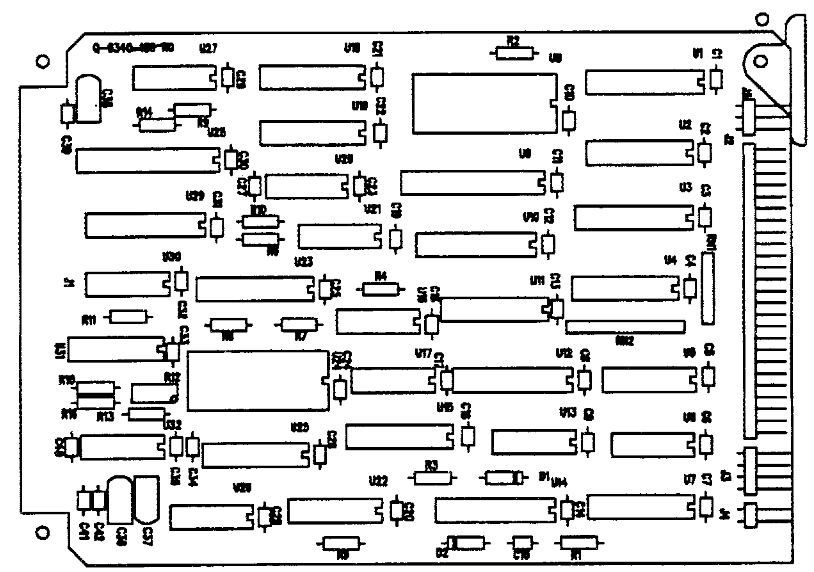


CIRCUIT SIDE



SIZE	QTY	SYM
28	235	+
35	784	X
93	1	⋈
125	3	A

DRILL MASTER



SILK SCREEN FOR FRONT

NOTES:

1. MATERIAL TO BE .062 IN THICK EPOXY FIBERGLASS TYPE FR4, PER MIL-P-13949/4. SPECIFIC DESIGNATION SHALL BE FL-GFP-062-C-1/1-B-2-B.
2. ALL HOLES WITH LANDS ON BOTH SIDES OF THE BOARD SHALL BE 100% PLATED THRU. COPPER PLATING INSIDE THE HOLES SHALL BE .001" MINIMUM IN ACCORDANCE WITH MIL-C-14550. FRONT TO REAR REGISTRATION TO BE WITHIN .003".
3. CLEAN AND SOLDER PLATE ALL COPPER, EXCEPT CONNECTOR CONTACTS, IN ACCORDANCE WITH MIL-P-81728.THE FUSED TIN-LEAD SHALL BE .0003 INCH THICK MINIMUM.CONNECTOR CONTACTS SHALL BE PLATED TO A MINIMUN THICKNESS OF .0002 INCH WITH A LOW STRESS NICKEL WHICH CONFORMS TO QQ-N-290, CLASS 2. THEN OVER PLATED WITH GOLD PER MIL-G-45204 TO A THICKNESS NO LESS THAN .00005 INCH NOR MORE THAN .0001 INCH.
4. AFTER PROCESSING, ETCHED BOARDS TO BE FREE OF VOIDS AND SCRATCHES.
5. DO NOT USE THIS DRAWING AS A WORK SHEET. MASTER(S) OF WIRING WILL BE SUPPLIED BY ORNL.
6. LIMIT ON ALL DIMENSIONS .015 IN UNLESS OTHERWISE NOTED.
7. HONE ALL EDGES SMOOTH.
8. MATERIAL REQUIRED:30 SQ. IN..
9. HOLE LOCATION TOLERANCE .005 IN.
10.NOTCHES: 7
11.DIMENSIONS OF ALL HOLES NOTED BELOW ARE FINISHED HOLE DIAMETERS AFTER PLATING THRU.

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH PADS-2000		REVISION OR ISSUE PURPOSE	APPROVALS			

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0° 30'
BREAK SHARP EDGES

DRAWING APPROVALS		DATE
DRAWN BY	R.A. MAPLES	3-92
DRAWING CHECK	R.I. VANDERMOLEN	4-92
ENGINEER	R.I. VANDERMOLEN	4-92
APPROVED	J.W. STAPLETON	5-92
	F.R. RUPPEL, J.E. HARDY	5-92
	E.C. BRADLEY, QA-W.A. CAMP	5-92

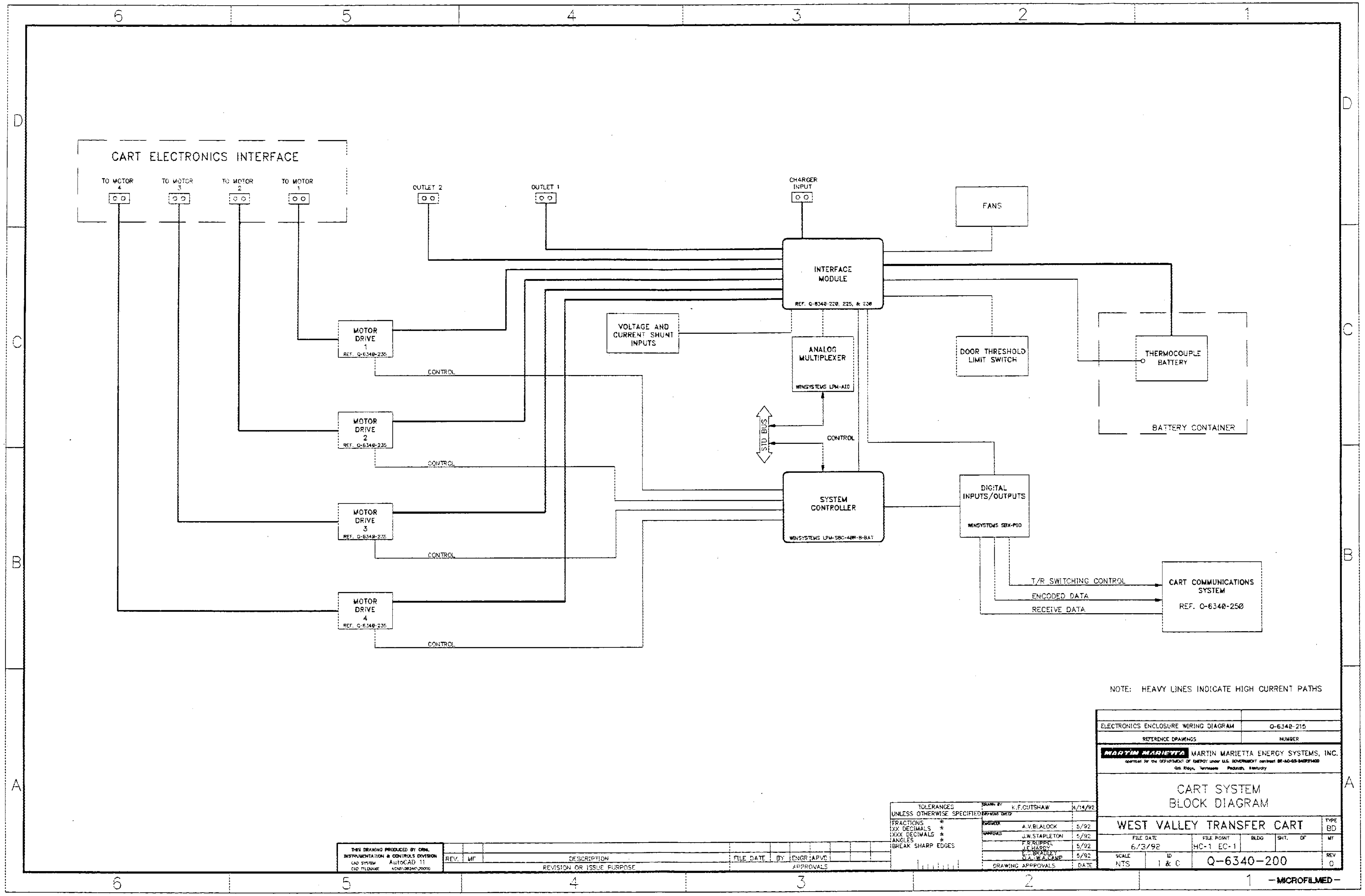
REFERENCE DRAWINGS	NUMBER

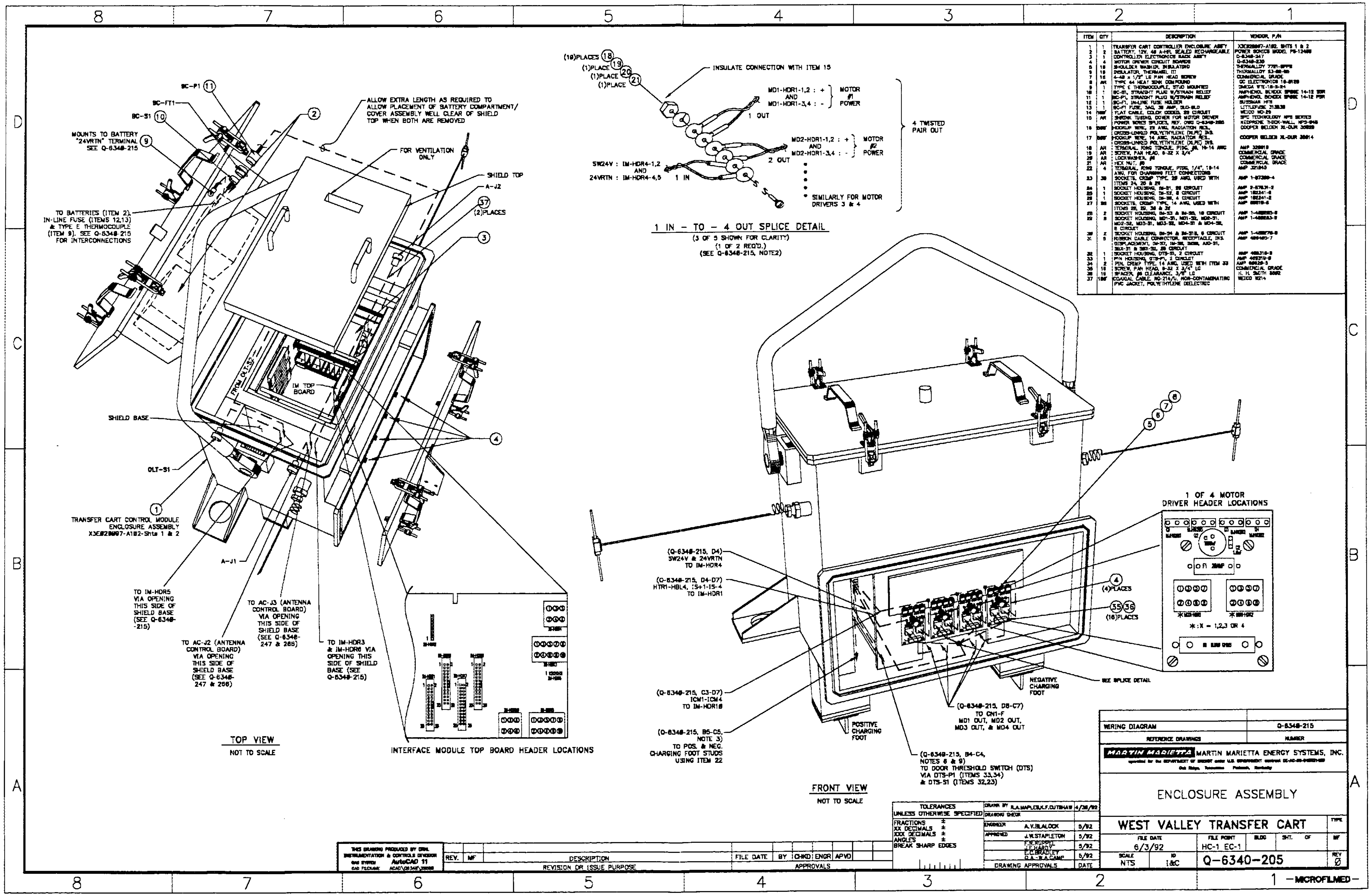
MARTIN MARIETTA ENERGY SYSTEMS, INC.

BIPHASE ENCODER/DECODER
PRINTED CIRCUIT BOARD
FACILITY MODEL

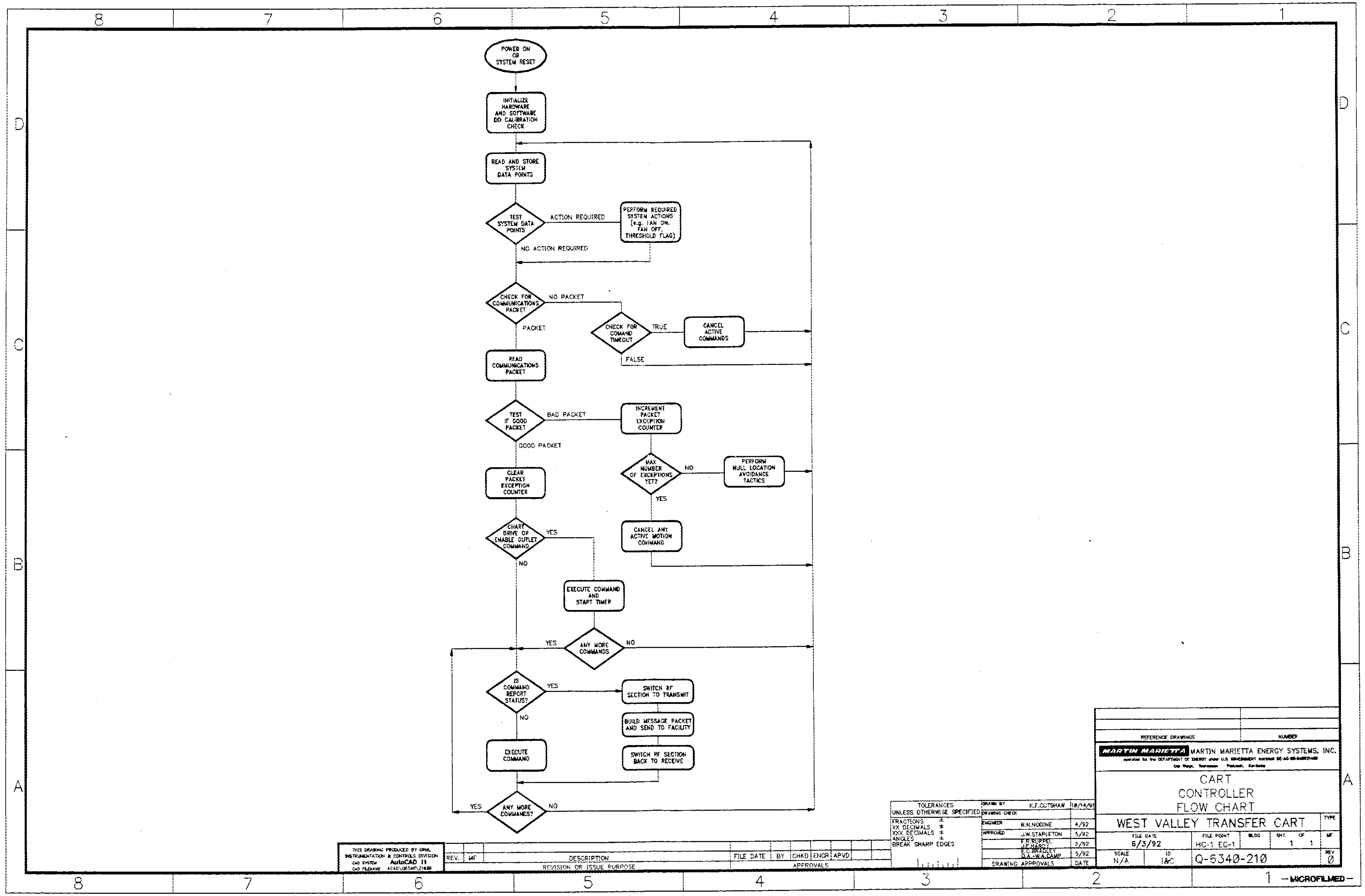
WEST VALLEY TRANSFER CART

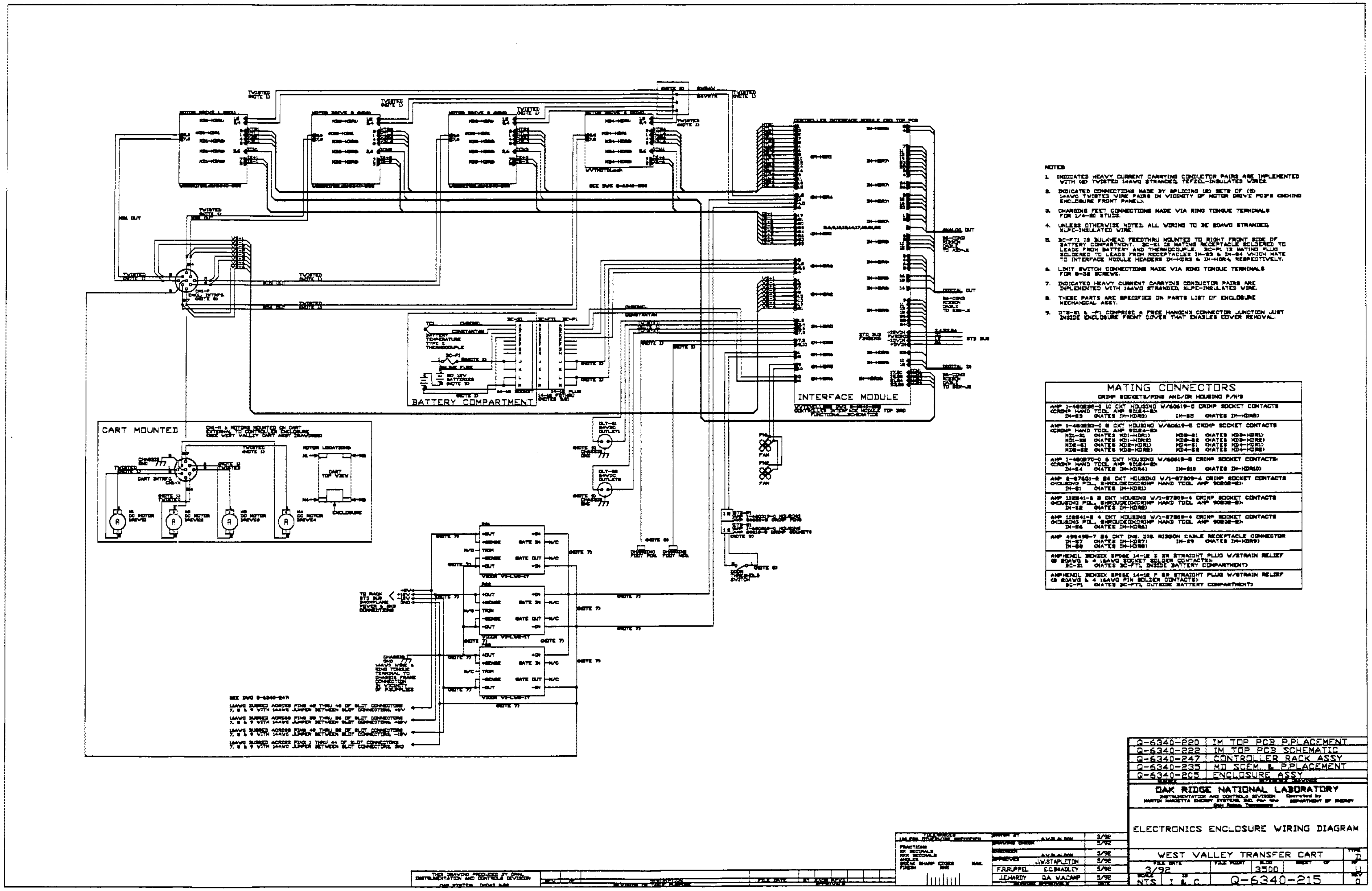
TYPE	FILE DATE	FILE PRINT	BLDG	SHT.	OF	SCALE	ID	NUMBER	REV
PC		HC-1 EC-1	3500	1	1	1 : 1	I&C	Q-6340-186	Ø

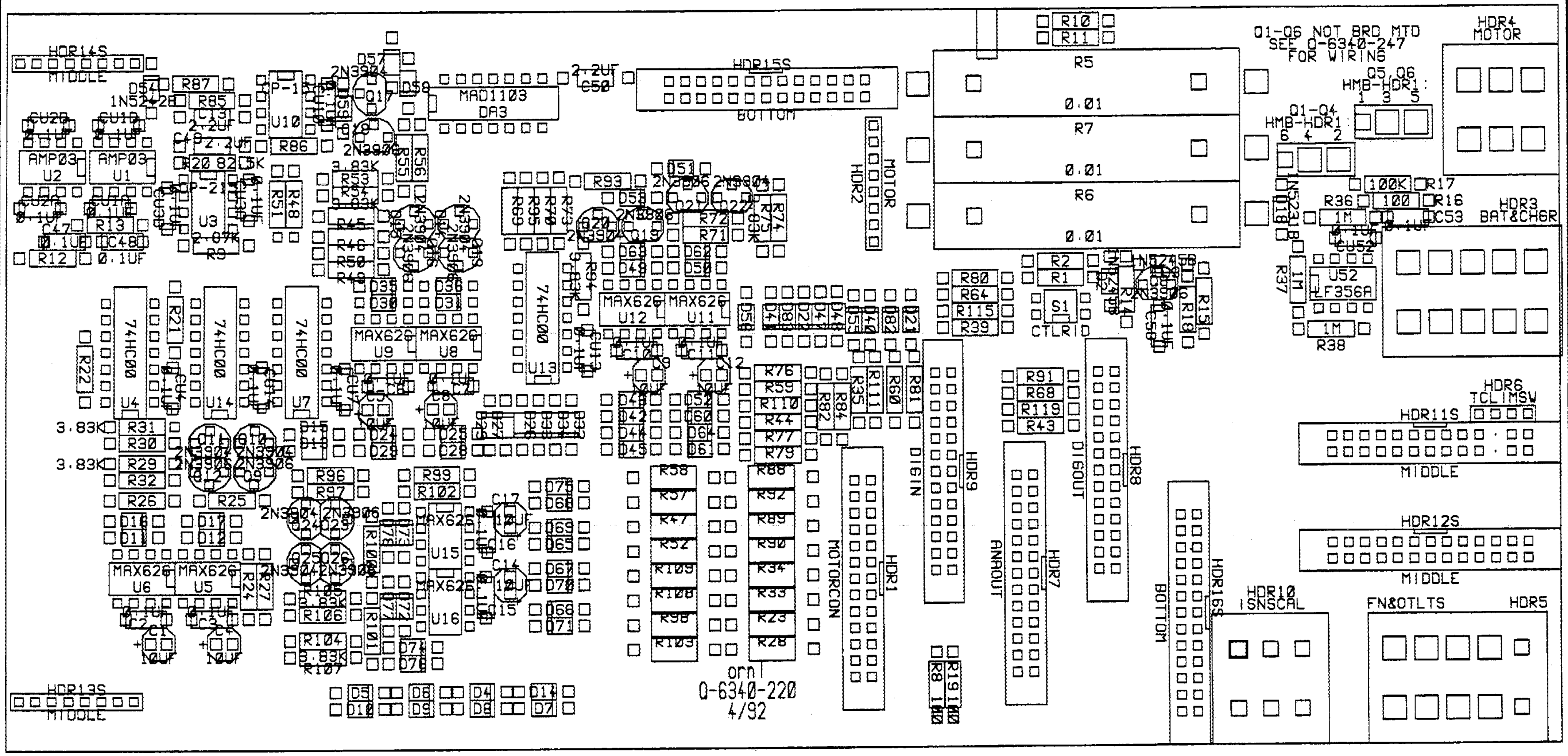

CART ELECTRONICS INTERFACE
TO MOTOR 4
TO MOTOR 3
TO MOTOR 2
TO MOTOR 1
OUTLET 2
OUTLET 1
CHARGER INPUT
FANS
INTERFACE MODULE
MOTOR DRIVE 1
MOTOR DRIVE 2
MOTOR DRIVE 3
MOTOR DRIVE 4
CONTROL
VOLTAGE AND CURRENT SHUNT INPUTS
ANALOG MULTIPLEXER
STD BUS
SYSTEM CONTROLLER
DOOR THRESHOLD LIMIT SWITCH
THERMOCOUPLE BATTERY
BATTERY CONTAINER
DIGITAL INPUTS/OUTPUTS
T/R SWITCHING CONTROL
ENCODED DATA
RECEIVE DATA
CART COMMUNICATIONS SYSTEM
REF. Q-6340-250
NOTE: HEAVY LINES INDICATE HIGH CURRENT PATHS
ELECTRONICS ENCLOSURE WIRING DIAGRAM
Q-6340-215
REFERENCE DRAWINGS
NUMBER
MARTIN MARIETTA ENERGY SYSTEMS, INC.
CART SYSTEM
BLOCK DIAGRAM
WEST VALLEY TRANSFER CART
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES
K.F.CUTSHAW 4/14/92
A.V.BLALOCK 5/92
J.W.STAPLETON 5/92
F.R.RUPPEL
J.E.HARDY 5/92
E.C.BRADLEY
Q.A.-W.A.CAMP 5/92
DRAWING APPROVALS
DATE
FILE DATE 6/3/92
FILE POINT HC-1 EC-1
SCALE NTS
ID I & C
Q-6340-200
TYPE BD
REV 0
REVISION OR ISSUE PURPOSE
APPROVALS
-MICROFILMED-



ITEM	QTY	DESCRIPTION	VENDOR, P/N
1	1	TRANSFER CART CONTROLLER ENCLOSURE ASS'Y	X3E20007-A102, SHTS 1 & 2
2	2	BATTERY, 12V, 40 A-HR, SEALED RECHARGEABLE	POWER SONICS MODEL PS-12400
3	1	CONTROLLER ELECTRONICS RACK ASS'Y	Q-6340-247
4	4	MOTOR DRIVER CIRCUIT BOARDS	Q-6340-230
5	16	SHOULDER WASHER, INSULATING	THERMALLOY [illegible]
6	16	INSULATOR, THERMASIL III	THERMALLOY [illegible]
7	16	4-40 x 1/2" LG PAN HEAD SCREW	COMMERCIAL GRADE
8	AR	TYPE 44 HEAT SINK COMPOUND	GC ELECTRONICS 10-8109
9	1	TYPE E THERMOCOUPLE, STUD MOUNTED	OMEGA WTE-18-S-24
10	1	BC-S1, STRAIGHT PLUG W/STRAIN RELIEF	AMPHENOL BENDIX [illegible] 14-12 SSR
11	1	BC-P1, STRAIGHT PLUG W/STRAIN RELIEF	AMPHENOL BENDIX [illegible] 14-12 PSR
12	1	BC-F1, IN-LINE FUSE HOLDER	BUSSMAN HFB
13	1	BC-F1 FUSE, 3AG, 30 AMP, SLO-BLO	LITTLEFUSE 313030
14	[illegible]	FLAT CABLE, COLOR CODED, 20 CIRCUIT	WEICO WC-20
15	AR	SHRINK TUBING, COVER FOR MOTOR DRIVER POWER WIRES SPLICES, REF. DWG Q-6340-205	SPC TECHNOLOGY NPS SERIES NEOPRENE THICK-WALL, NPS-048
16	[illegible]	HOOKUP WIRE, 20 AWG, RADIATION RES., CROSS-LINKED POLYETHYLENE (XLPE) INS.	COOPER BELDEN XL-DUR [illegible]
17	[illegible]	HOOKUP WIRE, 14 AWG, RADIATION RES., CROSS-LINKED POLYETHYLENE (XLPE) INS.	COOPER BELDEN XL-DUR 30014
18	AR	TERMINAL, RING TONGUE, PIDG, #8, 16-14 AWG	AMP [illegible]
19	AR	SCREW, PAN HEAD, 8-32 X 3/4"	COMMERCIAL GRADE
20	AR	LOCKWASHER, #8	COMMERCIAL GRADE
21	AR	HEX NUT, #8	COMMERCIAL GRADE
22	4	TERMINAL, RING TONGUE, PIDG, 1/4", 16-14 AWG, FOR CHARGING FEET CONNECTIONS	AMP 321043
23	30	SOCKETS, CRIMP TYPE, 20 AWG, USED WITH ITEMS 24, 25 & 26	AMP 1-87309-4
24	1	SOCKET HOUSING, IM-S1, 20 CIRCUIT	AMP 2-87631-2
25	1	SOCKET HOUSING, IM-S2, 8 CIRCUIT	AMP 102241-6
26	1	SOCKET HOUSING, IM-S8, 4 CIRCUIT	AMP 102241-2
27	[illegible]	SOCKETS, CRIMP TYPE, 14 AWG, USED WITH ITEMS 28, 29, 30 & 32	AMP [illegible]
28	2	SOCKET HOUSING, IM-S3 & IM-S9, 10 CIRCUIT	AMP 1-[illegible]
29	8	SOCKET HOUSING, MD1-S1, MD1-S2, MD2-S1, MD2-S2, MD3-S1, MD3-S2, MD4-S1 & MD4-S2, 8 CIRCUIT	AMP 1-[illegible]
30	2	SOCKET HOUSING, IM-S4 & IM-S10, 6 CIRCUIT	AMP 1-[illegible]
31	5	RIBBON CABLE CONNECTOR, RECEPTACLE, INS. DISPLACEMENT, IM-S7, IM-S8, [illegible], AXO-S1, SBX-S1 & SBX-S2, 20 CIRCUIT	AMP [illegible]-7
32	1	SOCKET HOUSING, DTS-S1, 2 CIRCUIT	AMP [illegible]
33	1	PIN HOUSING, DTS-P1, 2 CIRCUIT	AMP [illegible]
34	2	PIN, CRIMP TYPE, 14 AWG, USED WITH ITEM 33	AMP [illegible]
35	16	SCREW, PAN HEAD, 8-32 X 3/4" LG	COMMERCIAL GRADE
36	16	SPACER, #8 CLEARANCE, 3/8" LG	H. H. SMITH [illegible]
37	[illegible]	COAXIAL CABLE, RG-214/U, NON-CONTAMINATING PVC JACKET, POLYETHYLENE DIELECTRIC	WEICO 9214


POWER ON OR SYSTEM RESET
INITIALIZE HARDWARE AND SOFTWARE DO CALIBRATION CHECK
READ AND STORE SYSTEM DATA POINTS
TEST SYSTEM DATA POINTS
ACTION REQUIRED
PERFORM REQUIRED SYSTEM ACTIONS (e.g. FAN ON, FAN OFF, THRESHOLD FLAG)
NO ACTION REQUIRED
CHECK FOR COMMUNICATIONS PACKET
NO PACKET
PACKET
CHECK FOR COMAND TIMEOUT
TRUE
FALSE
CANCEL ACTIVE COMMANDS
READ COMMUNICATIONS PACKET
TEST IF GOOD PACKET
BAD PACKET
GOOD PACKET
INCREMENT PACKET EXCEPTION COUNTER
MAX NUMBER OF EXCEPTIONS YET?
NO
YES
PERFORM NULL LOCATION AVOIDANCE TACTICS
CANCEL ANY ACTIVE MOTION COMMAND
CLEAR PACKET EXCEPTION COUNTER
CART DRIVE OR ENABLE OUTLET COMMAND
YES
NO
EXECUTE COMMAND AND START TIMER
ANY MORE COMMANDS
YES
NO
IS COMMAND REPORT STATUS?
YES
NO
SWITCH RF SECTION TO TRANSMIT
BUILD MESSAGE PACKET AND SEND TO FACILITY
SWITCH RF SECTION BACK TO RECEIVE
EXECUTE COMMAND
ANY MORE COMMANDS?
YES
NO
THIS DRAWING PRODUCED BY ORNL INSTRUMENTATION & CONTROLS DIVISION
CAD SYSTEM AutoCAD 11
REV. MF DESCRIPTION FILE DATE BY CHKD ENGR APVD
REVISION OR ISSUE PURPOSE
APPROVALS
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES
DRAWN BY K.F.CUTSHAW 10/14/91
DRAWING CHECK
ENGINEER R.N.NODINE 4/92
APPROVED J.W.STAPLETON 5/92
F.R.RUPPEL J.E.HARDY 5/92
E.C.BRADLEY D.A.-W.A.CAMP 5/92
DRAWING APPPOVALS DATE
REFERENCE DRAWINGS NUMBER
MARTIN MARIETTA
MARTIN MARIETTA ENERGY SYSTEMS, INC.
CART
CONTROLLER
FLOW CHART
WEST VALLEY TRANSFER CART
TYPE
FILE DATE 6/3/92
FILE POINT HC-1 EC-1
BLDG
SHT. 1 OF 1
MF
SCALE N/A
ID I&C
Q-6340-210
REV Ø
— MICROFILMED —


NOTES
MATING CONNECTORS
CART MOUNTED
BATTERY COMPARTMENT
INTERFACE MODULE
Q-6340-220 IM TOP PCB P.PLACEMENT
Q-6340-222 IM TOP PCB SCHEMATIC
Q-6340-247 CONTROLLER RACK ASSY
Q-6340-235 MD SCEM. & P.PLACEMENT
Q-6340-205 ENCLOSURE ASSY
OAK RIDGE NATIONAL LABORATORY
ELECTRONICS ENCLOSURE WIRING DIAGRAM
WEST VALLEY TRANSFER CART
3/92
3500
NTS
Q-6340-215



REFERENCE DRAWINGS	NUMBER

MARTIN MARIETTA ENERGY SYSTEMS, INC.
operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC-05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

INTERFACE MODULE
TOP BOARD
PARTS PLACEMENT

WEST VALLEY TRANSFER CART

TYPE: PC

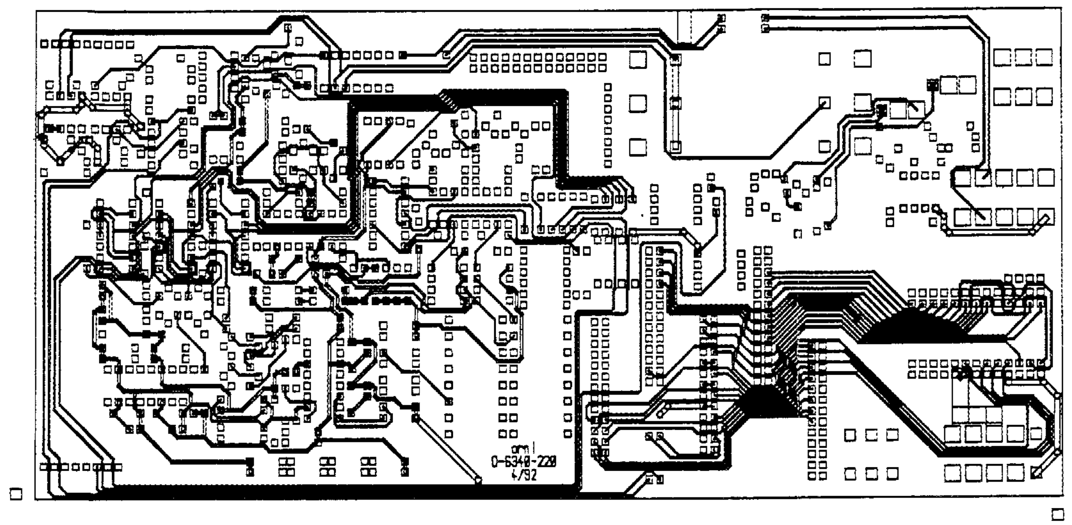
FILE DATE	FILE PRINT	BLDG	SHT.	OF
	HC-1 EC-1	3500	1	1

SCALE	ID		REV
2:1	I&C	Q-6340-220	0

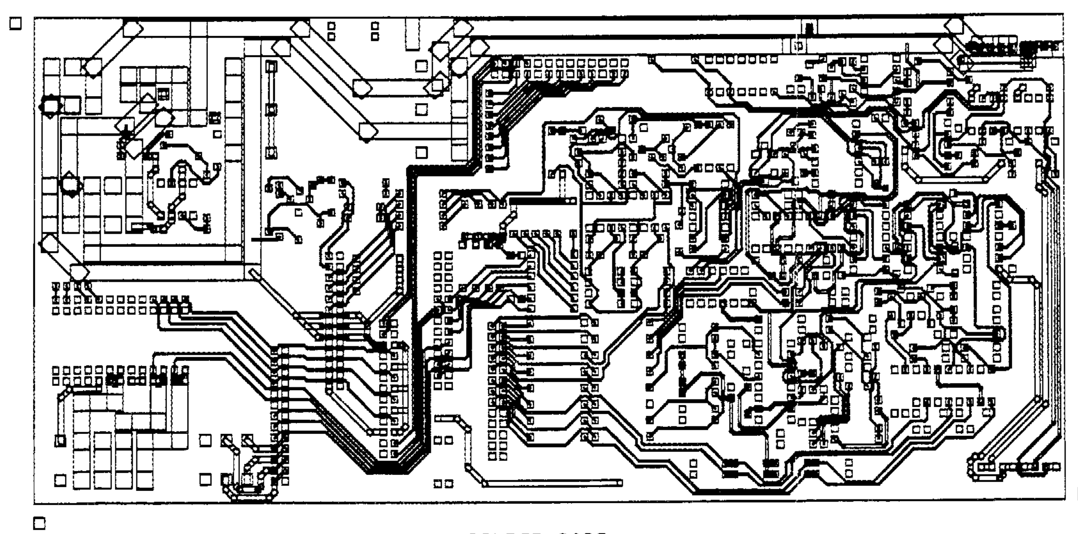
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0 30'
BREAK SHARP EDGES

DRAWN BY	A.V. BLALOCK	4/92
DRAWING CHECK		
ENGINEER	A.V. BLALOCK	
APPROVED		
DRAWING APPROVALS		DATE

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH ORCAD PCB		REVISION OR ISSUE PURPOSE	APPROVALS			



COMPONENT SIDE



SOLDER SIDE

REFERENCE DRAWINGS	NUMBER

MARTIN MARIETTA — MARTIN MARIETTA ENERGY SYSTEMS, INC.

operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC-05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

INTERFACE MODULE
TOP BOARD LAYOUT

WEST VALLEY TRANSFER CART

TYPE	FILE DATE	FILE POINT	BLDG	SHT.	OF	MF
PC		HC-1 EC-1	3500	1	1	

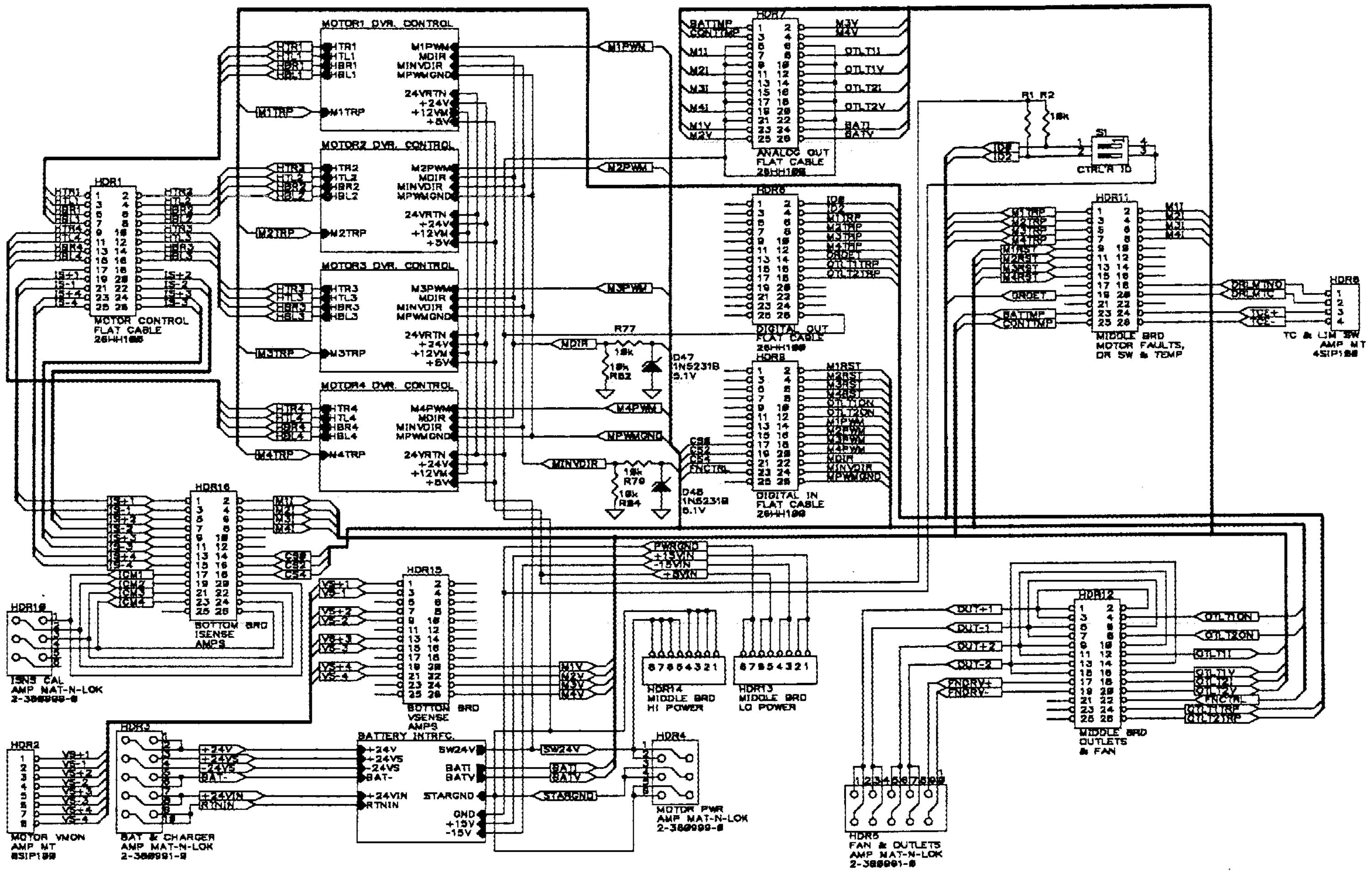
SCALE	IS	NUMBER	REV
1 : 1	I&C	Q-6340-221	0

TOLERANCES UNLESS OTHERWISE SPECIFIED

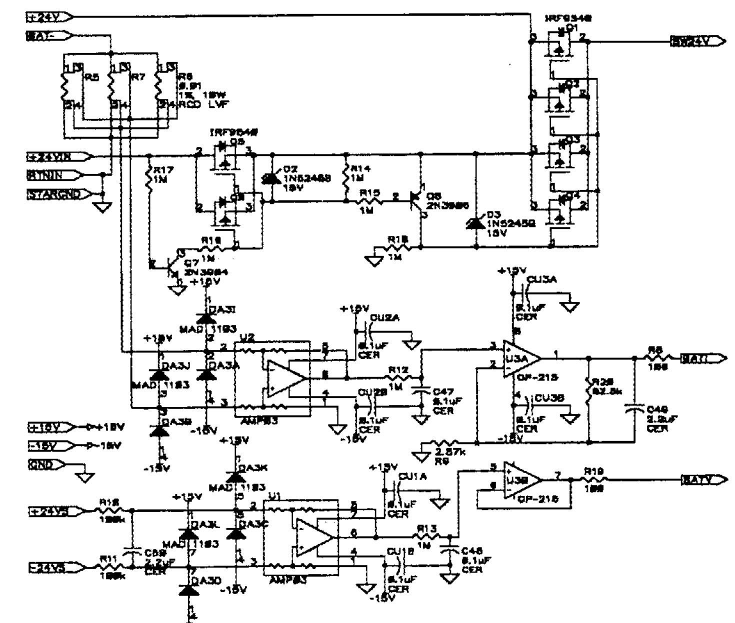
FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0° 30'
BREAK SHARP EDGES

DRAWN BY	A.V. BLALOCK	4/92
DRAWING CHECK		
ENGINEER	A.V. BLALOCK	
APPROVED		
DRAWING APPROVALS		DATE

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH PERSONAL 870		REVISION OR ISSUE PURPOSE	APPROVALS			



FUNCTIONAL SCHEMATIC



BATTERY INTERFACE SCHEMATIC

MARTIN MARIETTA ENERGY SYSTEMS, INC.

INTERFACE MODULE
TOP BOARD FUNCTIONAL
& BATTERY INTERFACE SCHEMATICS

WEST VALLEY TRANSFER CART

TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRACTIONS ±	DRAWN BY A.V.BLALOCK	3/92
XX DECIMALS ±		
XXX DECIMALS ±	A.V.BLALOCK	5/92
ANGLES ±	J.W.STAPLETON	5/92
BREAK SHARP EDGES	F.W.RUPPEL / J.E.HARDY	5/92
	E.T.BRADLEY / D.A.SILACAMP	5/92
	DRAWING APPROVALS	DATE

FILE DATE 6/3/92 — FILE POINT HC-1 EC-1 — SHT. 1 OF 1

SCALE N/A — I&C — Q-6340-222 — REV Ø

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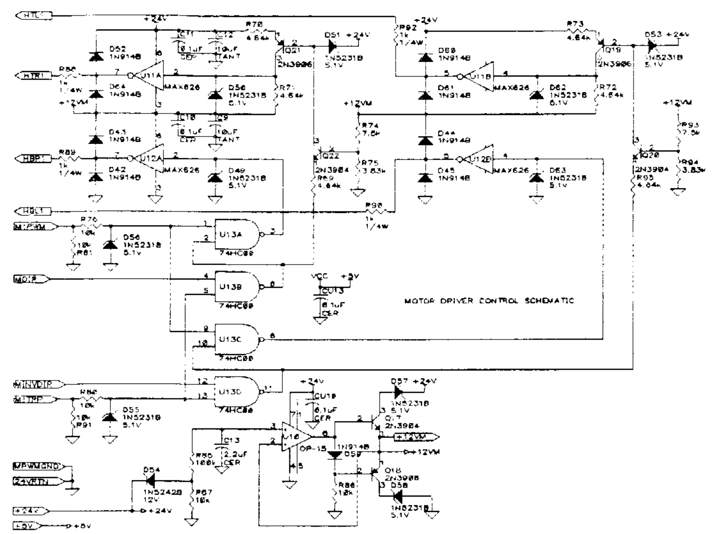

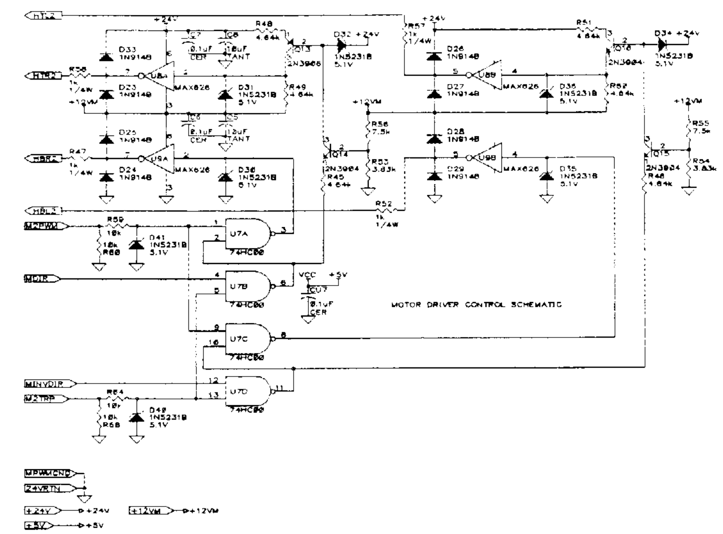

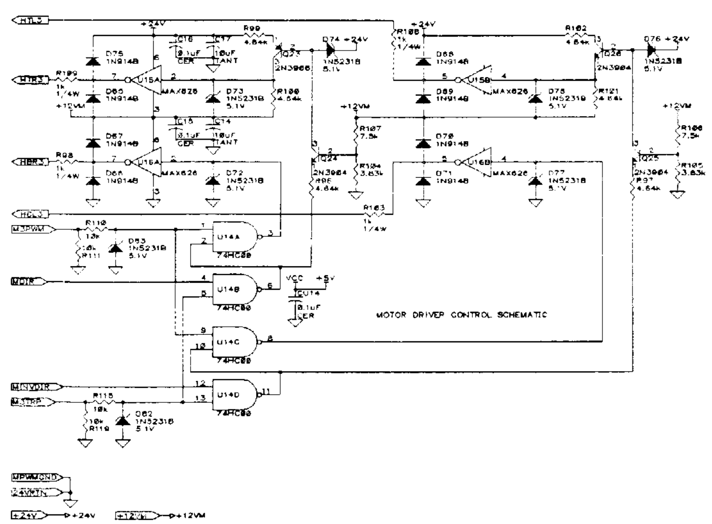

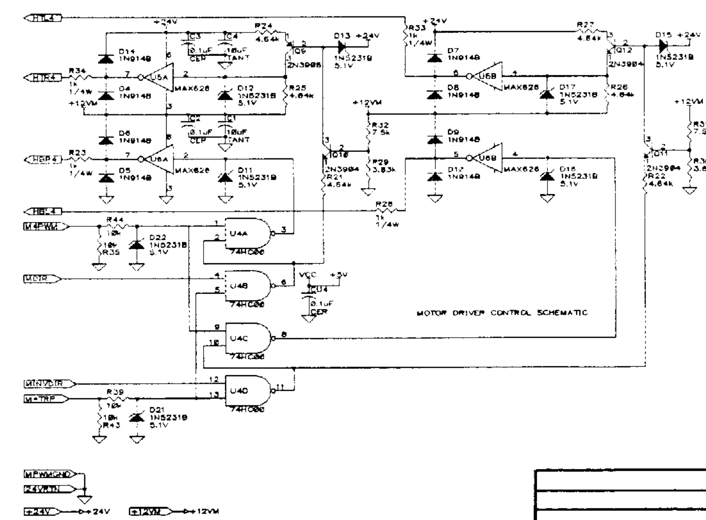

REFERENCE DRAWINGS	NUMBER

MARTIN MARIETTA ENERGY SYSTEMS, INC.

INTERFACE MODULE
TOP BOARD
MOTOR CONTROL SCHEMATICS

WEST VALLEY TRANSFER CART

FILE DATE	FILE POINT	BLDG	SHT.	OF
6/3/92	HC-1 EC-1		1	1

SCALE	ID		REV
N/A	I&C	Q-6340-223	Ø

TOLERANCES UNLESS OTHERWISE SPECIFIED		
DRAWN BY	A.V.BLALOCK	3/92
DRAWING CHECK		
ENGINEER	A.V.BLALOCK	5/92
APPROVED	J.W.STAPLETON	5/92
	F.B.KOPPEL / J.F.HARDY	5/92
	E.C.BRADLEY / D.A.-W.A.CAMP	5/92
	DRAWING APPROVALS	DATE

FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES

REV.	MF	DESCRIPTION	FILE DATE	BY	CHKD	ENGR	APVD
		REVISION OR ISSUE PURPOSE	APPROVALS				

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CAD FILENAME ACAD\Q6340\22300

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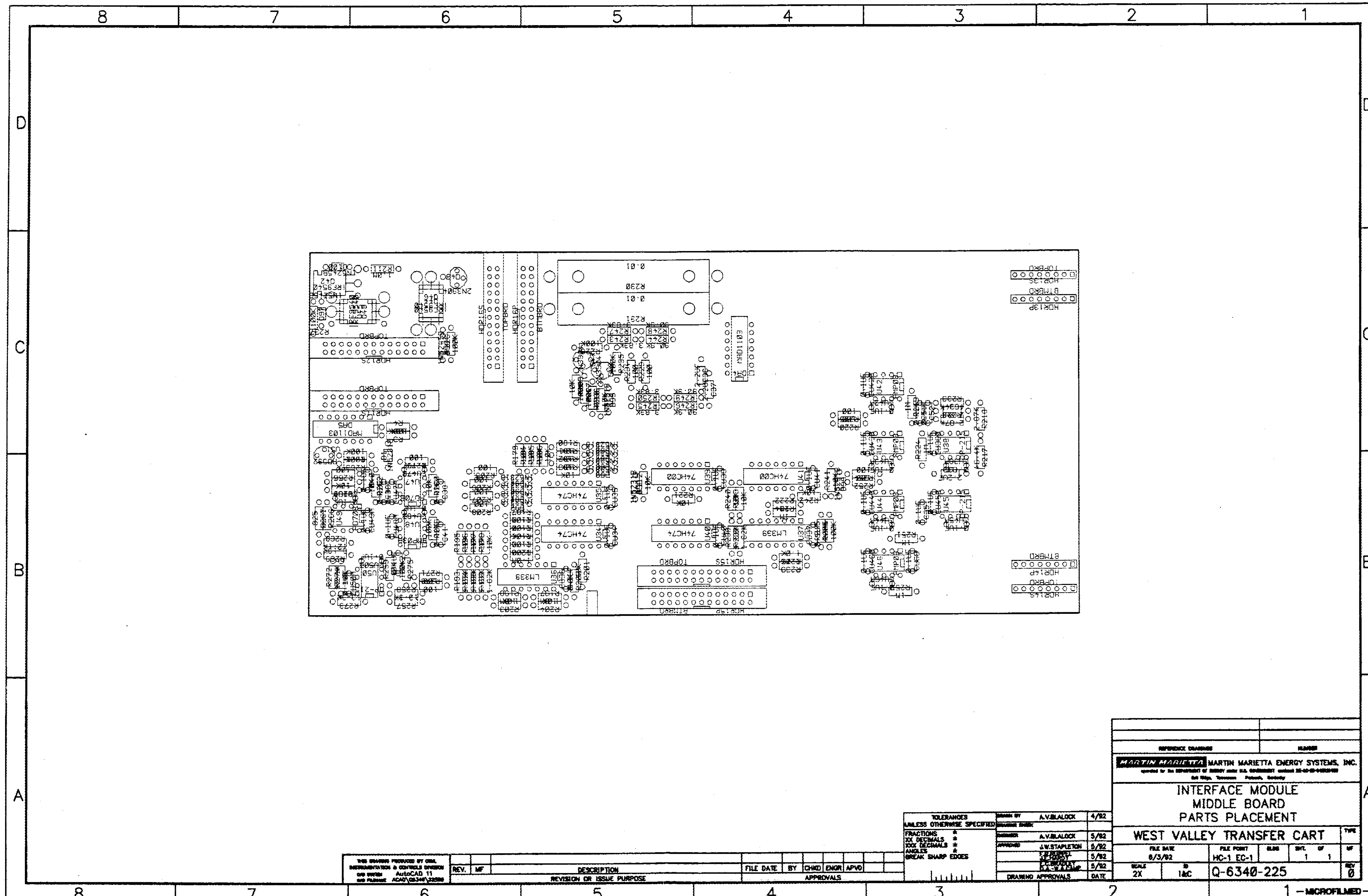
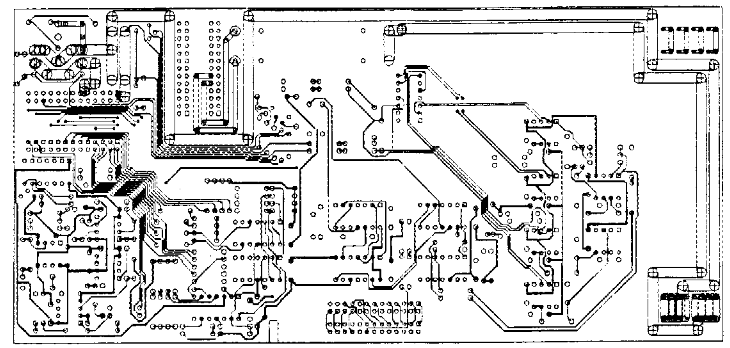
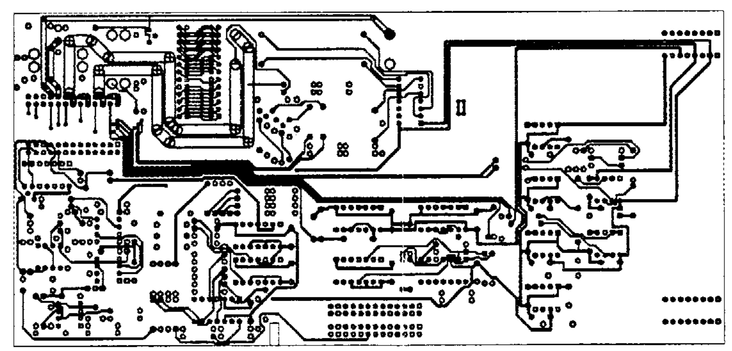

MARTIN MARIETTA ENERGY SYSTEMS, INC.
INTERFACE MODULE
MIDDLE BOARD
PARTS PLACEMENT
WEST VALLEY TRANSFER CART
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES
A.V.BLALOCK 4/92
A.V.BLALOCK 5/92
J.W.STAPLETON 5/92
DRAWING APPROVALS
DATE
6/3/92
HC-1 EC-1
1 1
2X
I&C
Q-6340-225
Ø
AutoCAD 11
REV.
MF
DESCRIPTION
REVISION OR ISSUE PURPOSE
FILE DATE
BY
CHKD
ENGR
APVD
APPROVALS
—MICROFILMED—





INTERFACE MODULE
MIDDLE BOARD
LAYOUT

WEST VALLEY TRANSFER CART

MARTIN MARIETTA ENERGY SYSTEMS, INC.

REFERENCE DRAWINGS | NUMBER

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES

DRAWING APPROVALS		DATE
DRAWN BY	A.V.BLALOCK	4/92
DRAWING CHECK		
ENGINEER	A.V.BLALOCK	5/92
APPROVED	J.W.STAPLETON	5/92
	P.S.KOPPEL J.E.HANDY	5/92
	E.C.BRADLEY D.A.-W.A.CAMP	5/92

FILE DATE	FILE POINT	BLDG	SHT. OF	MF
6/3/92	HC-1 EC-1		1 1	

SCALE	ID		REV
FULL	I&C	Q-6340-226	0

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CAD SYSTEM AutoCAD 11
CAD FILENAME ACAD\Q6340\Z3000

REV. | MF | DESCRIPTION — REVISION OR ISSUE PURPOSE | FILE DATE | BY | CHKD | ENGR | APVD — APPROVALS

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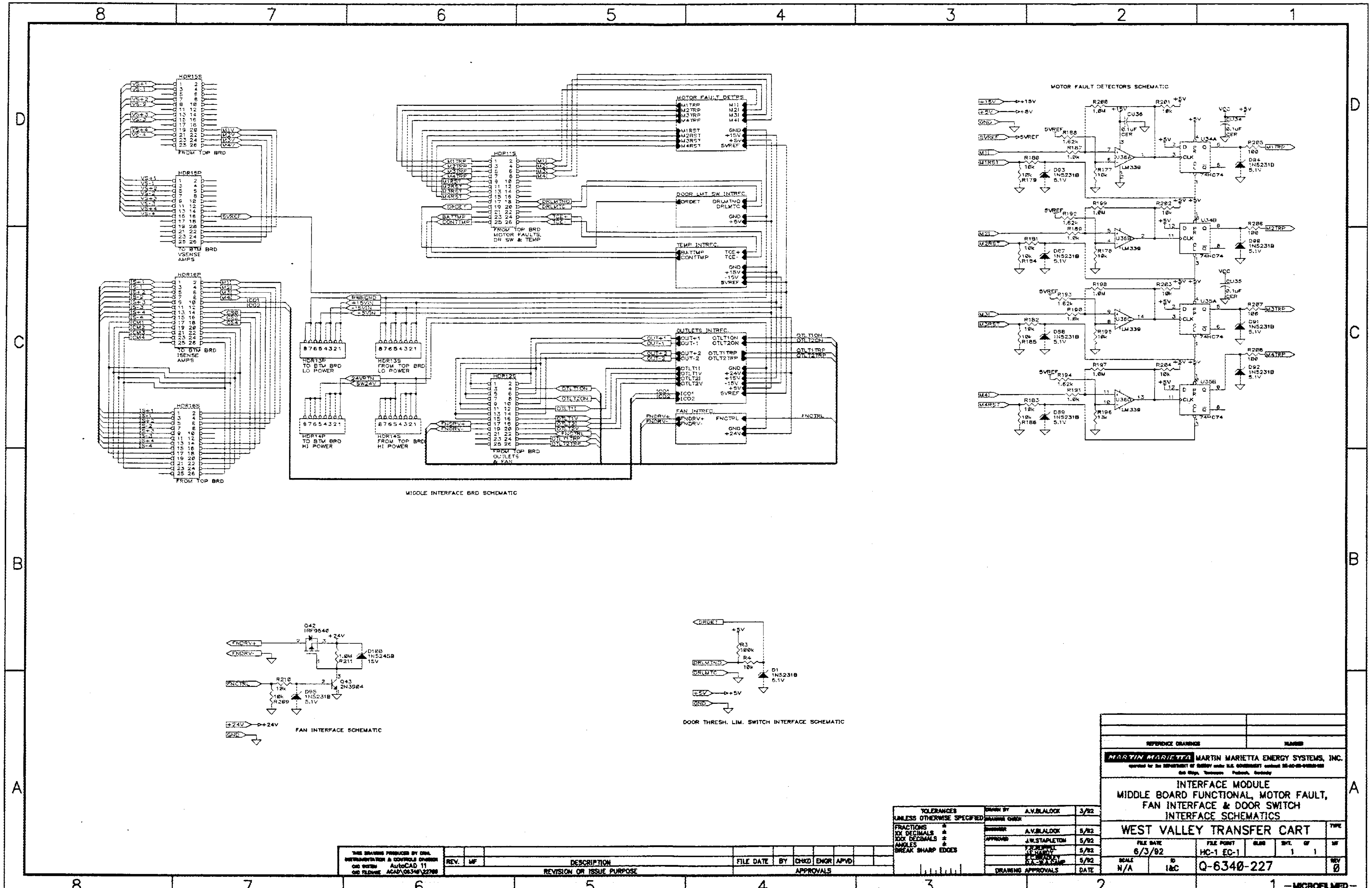
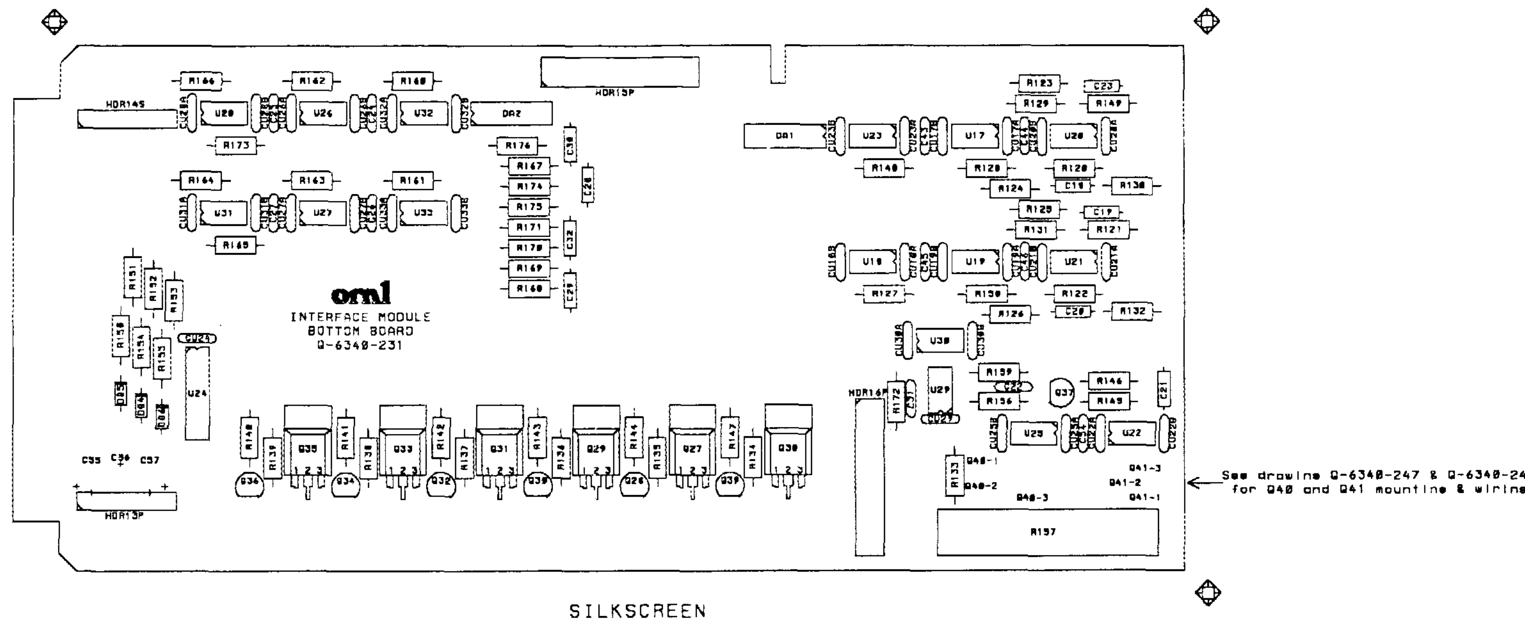

MOTOR FAULT DETECTORS SCHEMATIC
MIDDLE INTERFACE BRD SCHEMATIC
FAN INTERFACE SCHEMATIC
DOOR THRESH. LIM. SWITCH INTERFACE SCHEMATIC
MARTIN MARIETTA ENERGY SYSTEMS, INC.
INTERFACE MODULE
MIDDLE BOARD FUNCTIONAL, MOTOR FAULT,
FAN INTERFACE & DOOR SWITCH
INTERFACE SCHEMATICS
WEST VALLEY TRANSFER CART
TOLERANCES UNLESS OTHERWISE SPECIFIED
DRAWN BY A.V.BLALOCK 3/92
A.V.BLALOCK 5/92
APPROVED J.W.STAPLETON 5/92
DRAWING APPROVALS
DATE
FILE DATE 6/3/92
HC-1 EC-1
SHT. 1 OF 1
SCALE N/A
I&C
Q-6340-227
REV Ø
AutoCAD 11
DESCRIPTION
REVISION OR ISSUE PURPOSE
APPROVALS
—MICROFILMED—



SILKSCREEN

REFERENCE DRAWINGS	NUMBER
PARTS LIST	Q-6340-233
LAYOUT	Q-6340-231
SCHEMATIC	Q-6340-232

MARTIN MARIETTA ENERGY SYSTEMS, INC.

operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC-05-84OR21400

Oak Ridge, Tennessee Paducah, Kentucky

INTERFACE MODULE, BOTTOM BOARD
PARTS PLACEMENT

WEST VALLEY TRANSFER CART

TYPE	FILE DATE	FILE POINT	BLDG	SHT.	OF	RF
PC		HC-1 EC-1	3500	1	1	

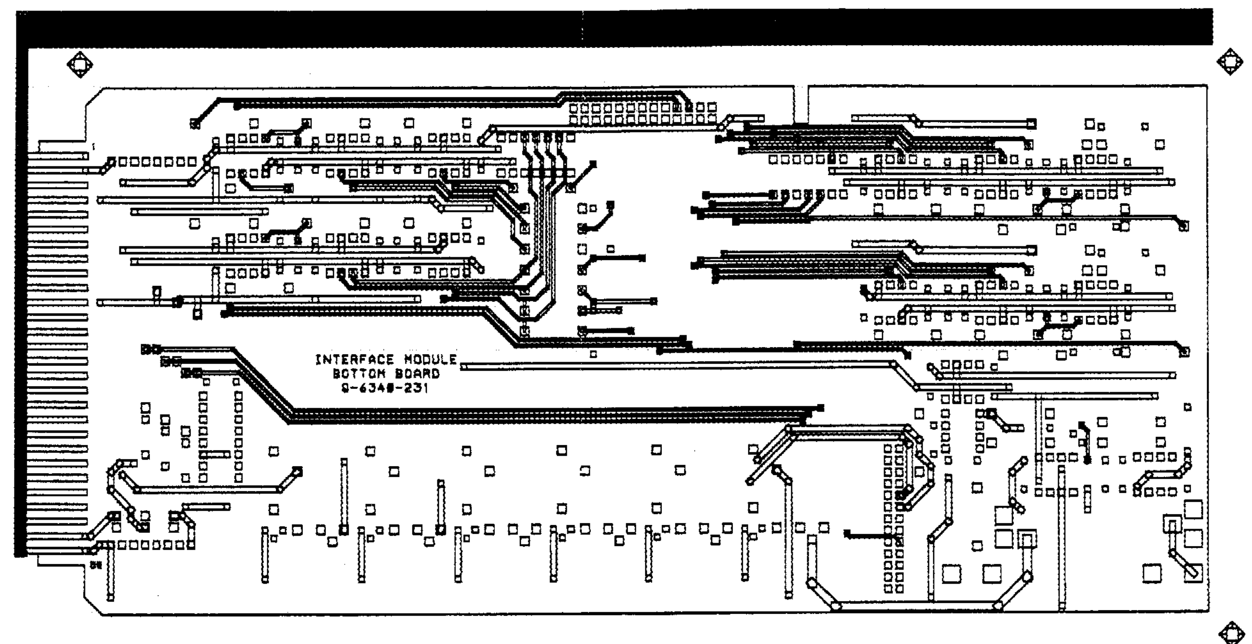
SCALE	ID		REV
1 : 1	I&C	Q-6340-230	0

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0 30'
BREAK SHARP EDGES

DRAWING APPROVALS	DATE
DRAWN BY M.D. CUTSHAW	4/92
DRAWING CHECK	
ENGINEER A.V. BLALOCK	5/92
APPROVED J.W.STAPLETON	5/92
E.C.BRADLEY J.E.HARDY	5/92
F.R.RUPPEL Q.A.-W.A.CAMP	5/92

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH PERSONAL 87D		REVISION OR ISSUE PURPOSE	APPROVALS			



COMPONENT

PARTS PLACEMENT	Q-6340-230
REFERENCE DRAWINGS	NUMBER

MARTIN MARIETTA ENERGY SYSTEMS, INC.

operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC-05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

INTERFACE MODULE, BOTTOM BOARD
LAYOUT, COMPONENT SIDE

WEST VALLEY TRANSFER CART

TYPE: PC

FILE DATE	FILE POINT	BLDG	SHT.	OF
	HC-1 EC-1	3500	1	2

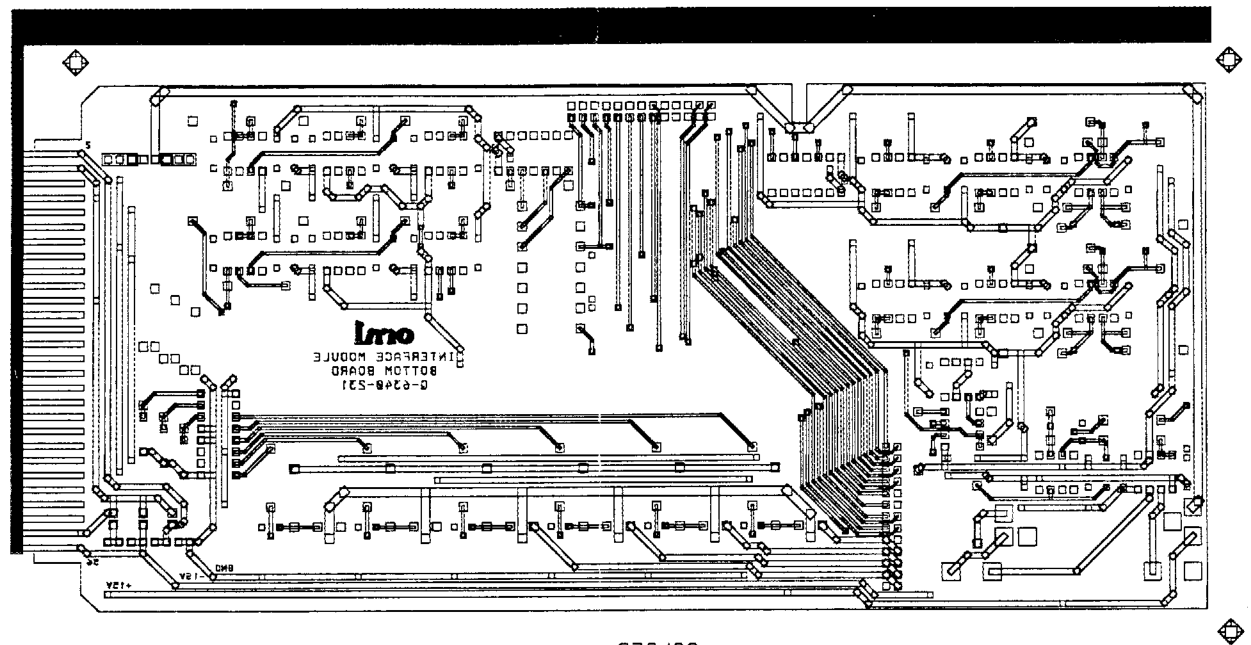
SCALE	ID		REV
1 : 1	I&C	Q-6340-231	0

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0°30'
BREAK SHARP EDGES

DRAWN BY	M.D. CUTSHAW	4/92
DRAWING CHECK		
ENGINEER	A.V. BLALOCK	5/92
APPROVED	J.W.STAPLETON	5/92
	F.R.RUPPEL E.C.BRADLEY	6/92
	J.E.HARDY Q.A.-W.A.CAMP	5/92
	DRAWING APPROVALS	DATE

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH PERSONAL GTD		REVISION OR ISSUE PURPOSE		APPROVALS		



PARTS PLACEMENT	Q-634Ø-23Ø
REFERENCE DRAWINGS	NUMBER

MARTIN MARIETTA | MARTIN MARIETTA ENERGY SYSTEMS, INC.

operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC-05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

INTERFACE MODULE, BOTTOM BOARD LAYOUT, SOLDER SIDE

WEST VALLEY TRANSFER CART

TYPE: PC

FILE DATE	FILE POINT	BLDG	SHT.	OF
	HC-1 EC-1	35ØØ	2	2

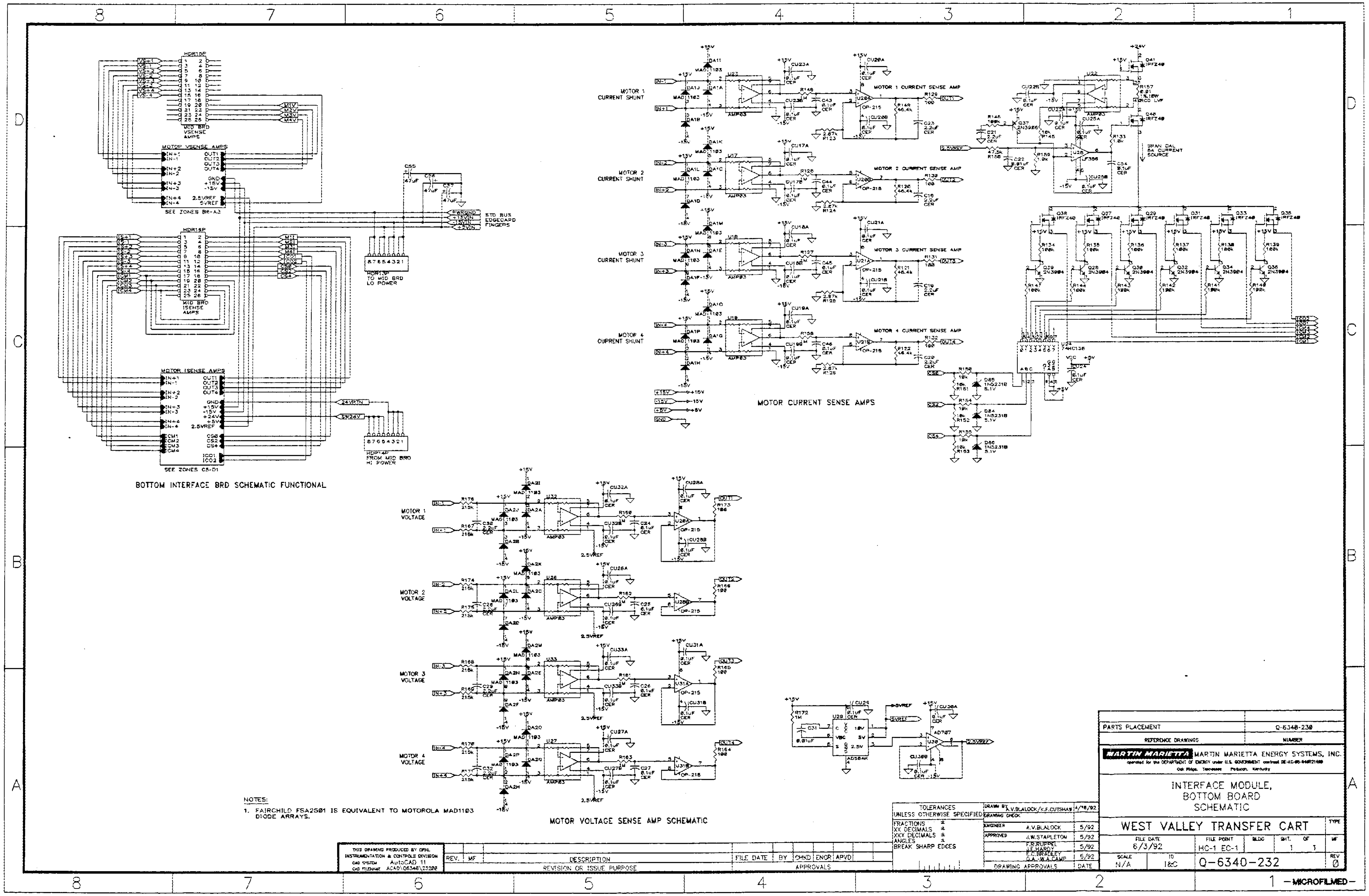
SCALE	ID		REV
1 : 1	I&C	Q-634Ø-231	Ø

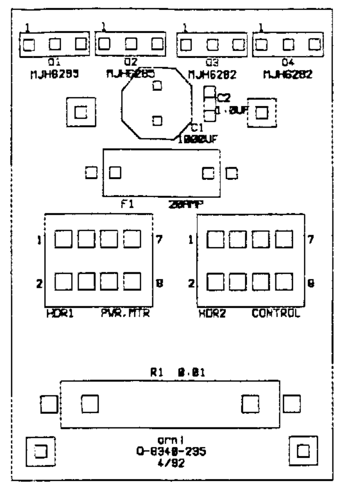
TOLERANCES UNLESS OTHERWISE SPECIFIED

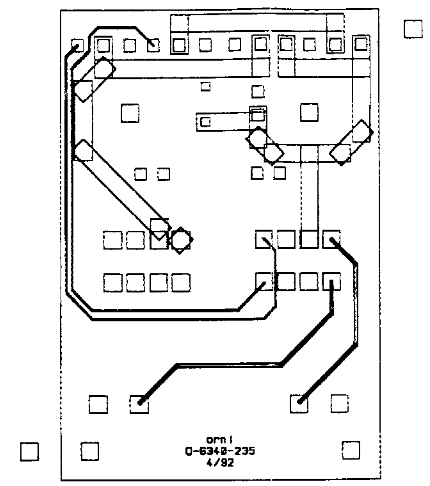
FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0 30'
BREAK SHARP EDGES

DRAWING APPROVALS	DATE
DRAWN BY M.D. CUTSHAW	4/92
DRAWING CHECK	
ENGINEER A.V. BLALOCK	5/92
APPROVED J.W.STAPLETON	5/92
E.C.BRADLEY F.R.RUPPEL	5/92
J.E.HARDY Q.A.-W.A.CAMP	5/92

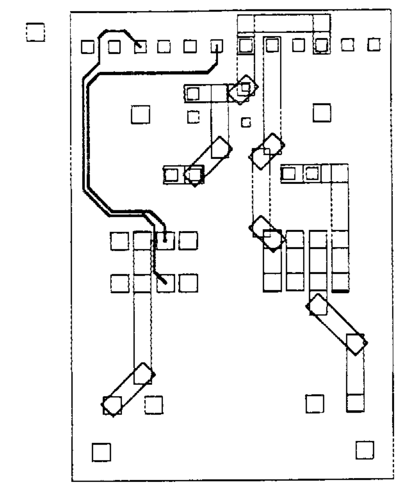
REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH PERSONAL #70		REVISION OR ISSUE PURPOSE	APPROVALS			


BOTTOM INTERFACE BRD SCHEMATIC FUNCTIONAL
MOTOR VSENSE AMPS
MOTOR ISENSE AMPS
MOTOR CURRENT SENSE AMPS
MOTOR VOLTAGE SENSE AMP SCHEMATIC
MOTOR 1 CURRENT SHUNT
MOTOR 2 CURRENT SHUNT
MOTOR 3 CURRENT SHUNT
MOTOR 4 CURRENT SHUNT
MOTOR 1 VOLTAGE
MOTOR 2 VOLTAGE
MOTOR 3 VOLTAGE
MOTOR 4 VOLTAGE
NOTES:
1. FAIRCHILD FSA2501 IS EQUIVALENT TO MOTOROLA MAD1103 DIODE ARRAYS.
PARTS PLACEMENT
Q-6348-230
REFERENCE DRAWINGS
NUMBER
MARTIN MARIETTA ENERGY SYSTEMS, INC.
INTERFACE MODULE, BOTTOM BOARD SCHEMATIC
WEST VALLEY TRANSFER CART
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES
DRAWN BY A.V.BLALOCK/K.F.CUTSHAW 4/16/92
ENGINEER A.V.BLALOCK 5/92
APPROVED J.W.STAPLETON 5/92
F.R.RUPPEL J.F.HARDY 5/92
E.C.BRADLEY O.A.-W.A.CAMP 5/92
DRAWING APPROVALS
FILE DATE 6/3/92
FILE POINT HC-1 EC-1
SHT. 1 OF 1
SCALE N/A
ID I&C
Q-6340-232
REV 0
DESCRIPTION
REVISION OR ISSUE PURPOSE
APPROVALS
MICROFILMED

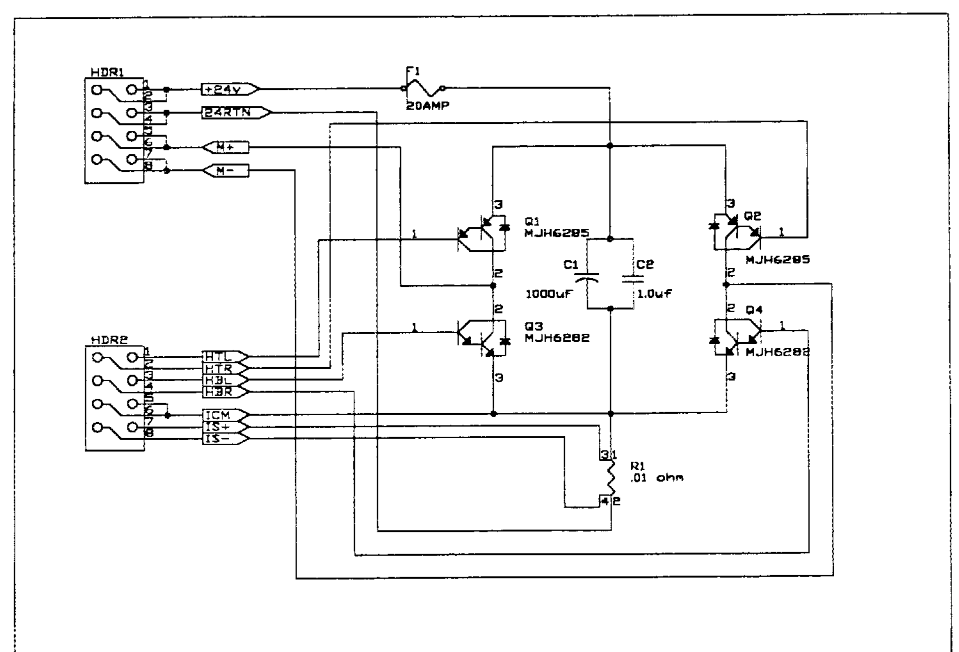




COMPONENT SIDE



SOLDER SIDE



REFERENCE DRAWINGS	NUMBER

MARTIN MARIETTA ENERGY SYSTEMS, INC.

operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC-05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

MOTOR DRIVER
PARTS PLACEMENT,
LAYOUT & SCHEMATIC

WEST VALLEY TRANSFER CART

TYPE	FILE DATE	FILE POINT	BLDG	SHT.	OF
PC		HC-1 EC-1	3500	1	1

SCALE	ID		REV
1 : 1	I&C	Q-6340-235	0

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0 30'
BREAK SHARP EDGES

DRAWN BY	A.V. BLALOCK	4/92
DRAWING CHECK		
ENGINEER	A.V. BLALOCK	5/92
APPROVED	J.W.STAPLETON	5/92
	J.E.HARDY F.R.RUPPEL	5/92
	E.C.BRADLEY Q.A.-W.A.CAMP	5/92
	DRAWING APPROVALS	DATE

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH PERSONAL 870		REVISION OR ISSUE PURPOSE		APPROVALS		

CART ELECTRONICS WIRING SCHEDULE

CONNECTOR	PIN #	NAME	TO LOCATION	CONNECTOR	PIN #	TYPE WIRE/CABLE	AWG
			INTERFACE MODULE Q-6340-320				
IM-HDR 1							
	1	HTR1	MOTOR DRIVE 1	MD1-HDR2	2	XLPE INS.	20
	3	HTL1	MOTOR DRIVE 1	MD1-HDR2	1	XLPE INS.	20
	5	HBR1	MOTOR DRIVE 1	MD1-HDR2	4	XLPE INS.	20
	7	HBL1	MOTOR DRIVE 1	MD1-HDR2	3	XLPE INS.	20
	19	IS+1	MOTOR DRIVE 1	MD1-HDR2	7	XLPE INS.	20
	21	IS-1	MOTOR DRIVE 1	MD1-HDR2	8	XLPE INS.	20
	2	HTR2	MOTOR DRIVE 2	MD2-HDR2	2	XLPE INS.	20
	4	HTL2	MOTOR DRIVE 2	MD2-HDR2	1	XLPE INS.	20
	6	HBR2	MOTOR DRIVE 2	MD2-HDR2	4	XLPE INS.	20
	8	HBL2	MOTOR DRIVE 2	MD2-HDR2	3	XLPE INS.	20
	20	IS+2	MOTOR DRIVE 2	MD2-HDR2	7	XLPE INS.	20
	22	IS-2	MOTOR DRIVE 2	MD2-HDR2	8	XLPE INS.	20
	10	HTR3	MOTOR DRIVE 3	MD3-HDR2	2	XLPE INS.	20
	12	HTL3	MOTOR DRIVE 3	MD3-HDR2	1	XLPE INS.	20
	14	HBR3	MOTOR DRIVE 3	MD3-HDR2	4	XLPE INS.	20
	16	HBL3	MOTOR DRIVE 3	MD3-HDR2	3	XLPE INS.	20
	24	IS+3	MOTOR DRIVE 3	MD3-HDR2	7	XLPE INS.	20
	26	IS-3	MOTOR DRIVE 3	MD3-HDR2	8	XLPE INS.	20
	9	HTR4	MOTOR DRIVE 4	MD4-HDR2	2	XLPE INS.	20
	11	HTL4	MOTOR DRIVE 4	MD4-HDR2	1	XLPE INS.	20
	13	HBR4	MOTOR DRIVE 4	MD4-HDR2	4	XLPE INS.	20
	15	HBL4	MOTOR DRIVE 4	MD4-HDR2	3	XLPE INS.	20
	23	IS+4	MOTOR DRIVE 4	MD4-HDR2	7	XLPE INS.	20
	25	IS-4	MOTOR DRIVE 4	MD4-HDR2	8	XLPE INS.	20
	17	NC					
	18	NC					
IM-HDR 2							
	1	VS+1	MOT'R CONN'R	CN1-F	1	XLPE INS.	20
	2	VS-1	MOT'R CONN'R	CN1-F	2	XLPE INS.	20
	3	VS+2	MOT'R CONN'R	CN1-F	4	XLPE INS.	20
	4	VS-2	MOT'R CONN'R	CN1-F	3	XLPE INS.	20
	5	VS+3	MOT'R CONN'R	CN1-F	6	XLPE INS.	20
	6	VS-3	MOT'R CONN'R	CN1-F	5	XLPE INS.	20
	7	VS+4	MOT'R CONN'R	CN1-F	7	XLPE INS.	20
	8	VS-4	MOT'R CONN'R	CN1-F	8	XLPE INS.	20
IM-HDR 3							
	1	24V+FEED	BATTERY COMP.	BC-P1	J	XLPE INS.	14
	2	24V+FEED	BATTERY COMP.	BC-P1	K	XLPE INS.	14
	3	24V+SENSE	BATTERY COMP.	BC-P1	C	XLPE INS.	14
	4	24V-SENSE	BATTERY COMP.	BC-P1	D	XLPE INS.	14
	5	24VRTN	BATTERY COMP.	BC-P1	L	XLPE INS.	14
	6	24VRTN	BATTERY COMP.	BC-P1	M	XLPE INS.	14
	7	24+VIN	CHRG FOOT POS.	1/4"STUD		XLPE INS.	14
	8	24+VIN	CHRG FOOT POS.	1/4"STUD		XLPE INS.	14
	9	RTNIN	CHRG FOOT NEG.	1/4"STUD		XLPE INS.	14
	10	RTNIN	CHRG FOOT NEG.	1/4"STUD		XLPE INS.	14
IM-HDR 4							
	1	SW24V	SPLICE, SW24V			XLPE INS.	14
	2	SW24V	SPLICE, SW24V			XLPE INS.	14
	3	SW24V	POWER SUPPLY		24VIN	XLPE INS.	14
	4	24VRTN	POWERSUPPLY		RTN	XLPE INS.	14
	5	24VRTN	SPLICE, 24VRTN			XLPE INS.	14
	6	24VRTN	SPLICE, 24VRTN			XLPE INS.	14
IM-HDR 5							
	1	OUT +1	24V OUTLET NO.1	OLT-S1	1	XLPE INS.	14
	2	OUT +1	24V OUTLET NO.1	OLT-S1	1	XLPE INS.	14
	3	OUT -1	24V OUTLET NO.1	OLT-S1	2	XLPE INS.	14
	4	OUT -1	24V OUTLET NO.1	OLT-S1	2	XLPE INS.	14
	5	OUT +2	24V OUTLET NO.2	OLT-S2	1	XLPE INS.	14
	6	OUT +2	24V OUTLET NO.2	OLT-S2	1	XLPE INS.	14
	7	OUT -2	24V OUTLET NO.2	OLT-S2	2	XLPE INS.	14
	8	OUT -2	24V OUTLET NO.2	OLT-S2	2	XLPE INS.	14
	9	FN DRV+	(2) FANS		1	XLPE INS.	14
	10	FN DRV-	(2) FANS		2	XLPE INS.	14

CART ELECTRONICS WIRING SCHEDULE

CONNECTOR	PIN #	NAME	TO LOCATION	CONNECTOR	PIN #	TYPE WIRE/CABLE	AWG
IM-HDR 6							
	1	DRLMTNO	DOOR DET. SWITCH	DTS-P1	1	XLPE INS.	14
	2	DRLMTC	DOOR DET. SWITCH	DTS-P1	2	XLPE INS.	14
	3	TCE+	BATTERY COMP.	BC-P1	A	CHROMEL	
	4	TCE-	BATTERY COMP.	BC-P1	B	CONSTANTAN	
IM-HDR 10							
	1	ICM1	MOTOR DRIVE 1	MD1-HDR2	5,6	XLPE INS.	14
	2	ICM2	MOTOR DRIVE 2	MD1-HDR2	5,8	XLPE INS.	14
	3	ICM3	MOTOR DRIVE 3	MD1-HDR2	5,8	XLPE INS.	14
	4	ICM4	MOTOR DRIVE 4	MD1-HDR2	5,6	XLPE INS.	14
	5	NC					
	6	NC					
IM-HDR 7	RIBBON	CABLE,26CKT	ANALOG OUT	AIO-J1			26
IM-HDR 8	RIBBON	CABLE,26CKT	DIGITAL OUT	SBX-J1			26
IM-HDR 9	RIBBON	CABLE,26CKT	DIGITAL IN	SBX-J2			26
			MOTOR DRIVER BOARDS Q-6340-235				
			MOTOR DRIVE #1				
MD1-HDR1							
	1	24V+	SPLICE, SW24V		1	XLPE INS.	14
	2	24V+	SPLICE, SW24V		1	XLPE INS.	14
	3	24VRTN	SPLICE, 24VRTN		5	XLPE INS.	14
	4	24VRTN	SPLICE, 24VRTN		3	XLPE INS.	14
	5,6	M+	MOT'R CONN'R	CN1-F	1	XLPE INS.	14
	7,8	M-	MOT'R CONN'R	CN1-F	2	XLPE INS.	14
MD1-HDR2							
	1	HTL	INTERFACE MODULE	IM-HDR 1	3	XLPE INS.	20
	2	HTR	INTERFACE MODULE	IM-HDR 1	1	XLPE INS.	20
	3	HBL	INTERFACE MODULE	IM-HDR 1	7	XLPE INS.	20
	4	HBR	INTERFACE MODULE	IM-HDR 1	5	XLPE INS.	20
	5,6	ICM	INTERFACE MODULE	IM-HDR 10	1	XLPE INS.	14
	7	IS+1	INTERFACE MODULE	IM-HDR 1	19	XLPE INS.	20
	8	IS-1	INTERFACE MODULE	IM-HDR 1	21	XLPE INS.	20
			MOTOR DRIVE #2				
MD2-HDR1							
	1	24V+	SPLICE, SW24V		2	XLPE INS.	14
	2	24V+	SPLICE, SW24V			XLPE INS.	14
	3	24VRTN	SPLICE, 24VRTN		4	XLPE INS.	14
	4	24VRTN	SPLICE, 24VRTN			XLPE INS.	14
	5,6	M+	MOT'R CONN'R	CN1-F	4	XLPE INS.	14
	7,8	M-	MOT'R CONN'R	CN1-F	3	XLPE INS.	14
MD2-HDR2							
	1	HTL	INTERFACE MODULE	IM-HDR 1	4	XLPE INS.	20
	2	HTR	INTERFACE MODULE	IM-HDR 1	2	XLPE INS.	20
	3	HBL	INTERFACE MODULE	IM-HDR 1	8	XLPE INS.	20
	4	HBR	INTERFACE MODULE	IM-HDR 1	6	XLPE INS.	20
	5,6	ICM	INTERFACE MODULE	IM-HDR 10	2	XLPE INS.	14
	7	IS+2	INTERFACE MODULE	IM-HDR 1	20	XLPE INS.	20
	8	IS-2	INTERFACE MODULE	IM-HDR 1	22	XLPE INS.	20
			MOTOR DRIVE #3				
MD3-HDR1							
	1	24V+	SPLICE, SW24V		2	XLPE INS.	14
	2	24V+	SPLICE, SW24V		1	XLPE INS.	14
	3	24VRTN	SPLICE, 24VRTN		6	XLPE INS.	14
	4	24VRTN	SPLICE, 24VRTN		3	XLPE INS.	14
	5,6	M+	MOT'R CONN'R	CN1-F	6	XLPE INS.	14
	7,8	M-	MOT'R CONN'R	CN1-F	5	XLPE INS.	14
MD3-HDR2							
	1	HTL	INTERFACE MODULE	IM-HDR 1	12	XLPE INS.	20
	2	HTR	INTERFACE MODULE	IM-HDR 1	10	XLPE INS.	20
	3	HBL	INTERFACE MODULE	IM-HDR 1	16	XLPE INS.	20
	4	HBR	INTERFACE MODULE	IM-HDR 1	14	XLPE INS.	20
	5,6	ICM	INTERFACE MODULE	IM-HDR 10	3	XLPE INS.	14
	7	IS+3	INTERFACE MODULE	IM-HDR 1	24	XLPE INS.	20
	8	IS-3	INTERFACE MODULE	IM-HDR 1	26	XLPE INS.	20

CART ELECTRONICS WIRING SCHEDULE

CONNECTOR	PIN #	NAME	TO LOCATION	CONNECTOR	PIN #	TYPE WIRE/CABLE	AWG
			MOTOR DRIVE #4				
MD4-HDR1							
	1	24V+	SPLICE, SW24V		2	XLPE INS.	14
	2	24V+	SPLICE, SW24V			XLPE INS.	14
	3	24VRTN	SPLICE, 24VRTN		4	XLPE INS.	14
	4	24VRTN	SPLICE, 24VRTN			XLPE INS.	14
	5,6	M+	MOT'R CONN'R	CN1-F	7	XLPE INS.	14
	7,8	M-	MOT'R CONN'R	CN1-F	8	XLPE INS.	14
MD4-HDR2							
	1	HTL	INTERFACE MODULE	IM-HDR 1	11	XLPE INS.	20
	2	HTR	INTERFACE MODULE	IM-HDR 1	9	XLPE INS.	20
	3	HBL	INTERFACE MODULE	IM-HDR 1	15	XLPE INS.	20
	4	HBR	INTERFACE MODULE	IM-HDR 1	13	XLPE INS.	20
	5,6	ICM	INTERFACE MODULE	IM-HDR 10	4	XLPE INS.	14
	7	IS+4	INTERFACE MODULE	IM-HDR 1	23	XLPE INS.	20
	8	IS-4	INTERFACE MODULE	IM-HDR 1	25	XLPE INS.	20
			CART COMMUNICATIONS BOARDS				
			CART RECEIVER Q-6340-260				
J1	CTR	RFIN	CART ANT CTRLLR	J5	CTR	SMA COAX	
	SHLD	RFIN		J5	SHLD		
J2	CTR	OUT	CART ENC/DEC	J4	CTR	SMA TO 2 SOCKET SIP	
	SHLD	OUT		J4	SHLD		
			CART ANTENNA CONTROL Q-6340-265				
J2	CTR	ANT1 RX	ANTENNA 1	HE COAX LEMO	CTR	SMA COAX	
	SHLD	RTN	ANTENNA 1	HE COAX LEMO	SHLD	SMA COAX	
J3	CTR	ANT2 RX	ANTENNA 2	HE COAX LEMO	CTR	SMA COAX	
	SHLD	RTN	ANTENNA 2	HE COAX LEMO	SHLD	SMA COAX	
J4	CTR	RF OUT	CART TX	J3	CTR	SMA COAX	
	SHLD	RTN	CART TX	J3	SHLD	SMA COAX	
J5	CTR	RFIN	CART RX	J1	CTR	SMA COAX	
	SHLD	RTN	CART RX	J1	SHLD	SMA COAX	
J6	1	T/R IN	CART ENC/DEC	J3	1	XLPE INS.	20
J6	2	RTN	CART ENC/DEC	J3	2	XLPE INS.	20
J6	3	EOP RESET	CART ENC/DEC	J5	1	XLPE INS.	20
J6	4	ANTSTAT OUT	CART ENC/DEC	J3	3	XLPE INS.	20
J6	5	T/R OUT	CART TX	J2	3	XLPE INS.	20
J6	6	RTN	CART TX	J2	4	XLPE INS.	20
			CART TRANSMITTER Q-6340-270				
J2	1	BI PHASE IN	CART ENC/DEC	J1	1	XLPE INS.	20
J2	2	RTN	CART ENC/DEC	J1	3	XLPE INS.	20
J2	3	T/R IN	CART ANT CTRL	J6	5	XLPE INS.	20
J2	4	RTN	CART ANT CTRL	J6	6	XLPE INS.	20
J3	CTR	ANT2	CART ANT CTRL	J4	CTR	SMA COAX	
J3	SHLD	RTN	CART ANT CTRL	J4	SHLD	SMA COAX	
			CART ENCODER/DECODER Q-6340-280				
J1	1	BIPHASE OUT	CART TX	J2	1	XLPE INS.	20
J1	3	RTN	CART TX	J2	2	XLPE INS.	20
J2	RIBBON	DIG I/O	SBC40 uP BRD	J2			20
J3	1	T/R IN	CART ANT CTRL	J6	1	XLPE INS.	20
J3	2	RTN	CART ANT CTRL	J6	2	XLPE INS.	20
J3	3	EOP	CART ANT CTRL	J6	3	XLPE INS.	20
J3	4	ANTSTAT IN	CART ANT CTRL	J6	4	XLPE INS.	20
J4	1	BIPHASE IN	CART RX	J4	1	XLPE INS.	20
J4	2	BIPHASE IN	CART RX	J4	2	XLPE INS.	20
J5	1	EOP RESET	CART ANT CTRL	J6	3	XLPE INS.	20
J5	2	RTN	CART ANT CTRL	J6	2	XLPE INS.	20

REFERENCE DRAWINGS	NUMBER
ENCLOSURE WIRING	Q-6340-215

MARTIN MARIETTA ENERGY SYSTEMS, INC.

CART WIRING SCHEDULE

WEST VALLEY TRANSFER CART

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES

DRAWING APPROVALS		DATE
DRAWN BY	A.V.BLALOCK,K.F.CUTCHAW	12/20/91
DRAWING CHECK		
ENGINEER	A.V.BLALOCK	5/92
APPROVED	J.W.STAPLETON	5/92
	F.R.RUPPEL, J.E.HARDY	5/92
	E.C.BRADLEY, G.A.VANKAMP	5/92

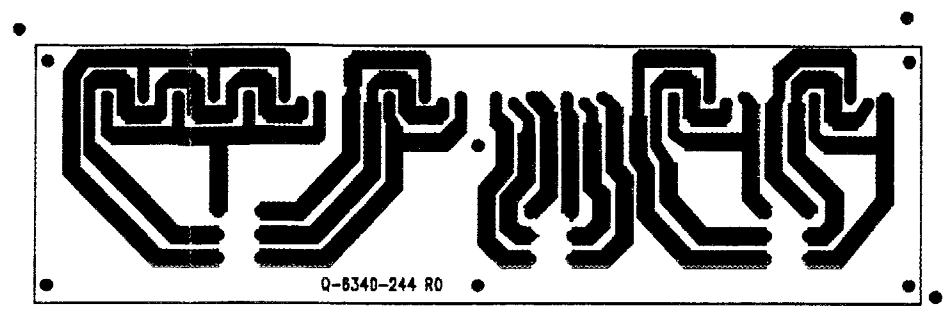
FILE DATE	FILE POINT	BLDG	SHT. OF	MF
6/3/92	HC-1 EC-1			

SCALE	ID	DRAWING NO.	REV
N/A	I&C	Q-6340-240	0

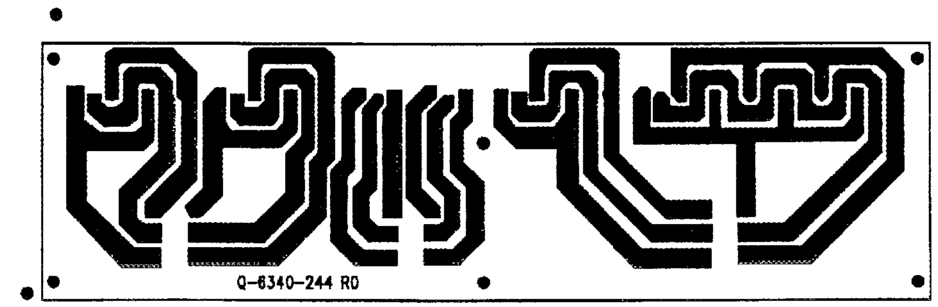
REV.	MF	DESCRIPTION	FILE DATE	BY	CHKD	ENGR	APVD
		REVISION OR ISSUE PURPOSE			APPROVALS		

THIS DRAWING PRODUCED BY ... INSTRUMENTATION & CONTROLS DIVISION CAD SYSTEM AutoCAD 11

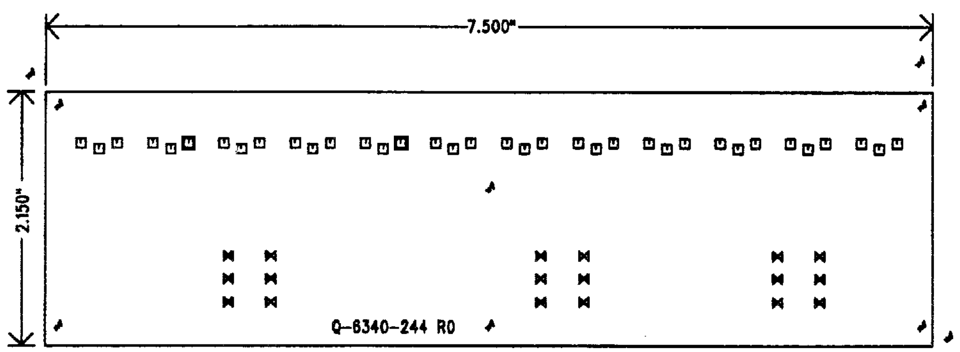
— MICROFILMED —



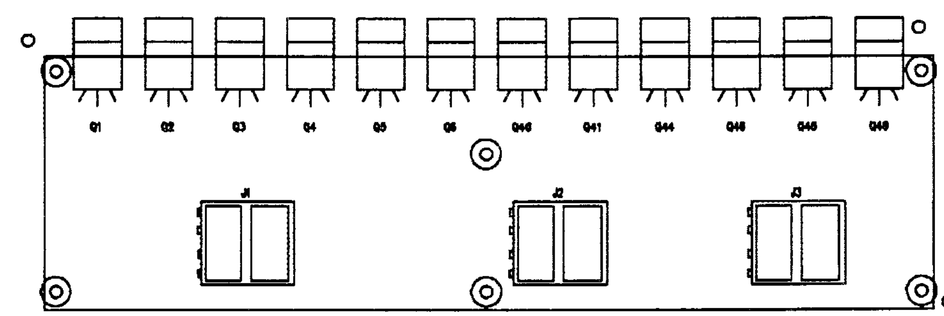
COMPONENT SIDE (FRONT)



CIRCUIT SIDE



DRILL MASTER



SILK SCREEN FOR FRONT

SIZE	QTY	SYM
40	36	⊡
70	18	⋈
125	9	A

NOTES:

1. MATERIAL TO BE .062 IN THICK EPOXY FIBERGLASS TYPE FR4, PER MIL-P-13949/4. SPECIFIC DESIGNATION SHALL BE FL-GFP-062-C-1/1-B-2-B.
2. ALL HOLES WITH LANDS ON BOTH SIDES OF THE BOARD SHALL BE 100% PLATED THRU. COPPER PLATING INSIDE THE HOLES SHALL BE .001" MINIMUM IN ACCORDANCE WITH MIL-C-14550. FRONT TO REAR REGISTRATION TO BE WITHIN .003".
3. CLEAN AND SOLDER PLATE ALL COPPER IN ACCORDANCE WITH MIL-P-81728.THE FUSED TIN-LEAD SHALL BE .0003 INCH THICK MINIMUM.
4. AFTER PROCESSING, ETCHED BOARDS TO BE FREE OF VOIDS AND SCRATCHES.
5. DO NOT USE THIS DRAWING AS A WORK SHEET. MASTER NEGATIVE(S) OF WIRING WILL BE SUPPLIED BY ORNL.
6. LIMIT ON ALL DIMENSIONS .015 IN UNLESS OTHERWISE NOTED.
7. HONE ALL EDGES SMOOTH.
8. MATERIAL REQUIRED: 17 SQ. IN..
9. HOLE LOCATION TOLERANCE .005 IN.
10. DIMENSIONS OF ALL HOLES NOTED BELOW ARE FINISHED HOLE DIAMETERS AFTER PLATING THRU.

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH PACE-2000		REVISION OR ISSUE PURPOSE	APPROVALS			

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0° 30'
BREAK SHARP EDGES

DRAWING APPROVALS		DATE
DRAWN BY	R.A. MAPLES	3-92
DRAWING CHECK	A.V. BLALOCK	3-92
ENGINEER	A.V. BLALOCK	5-92
APPROVED	J.W. STAPLETON	5-92
	F.R. RUPPEL, J.E. HARDY	5-92
	E.C. BRADLEY, GA-V.A. CAMP	5-92

REFERENCE DRAWINGS	NUMBER

MARTIN MARIETTA ENERGY SYSTEMS, INC.

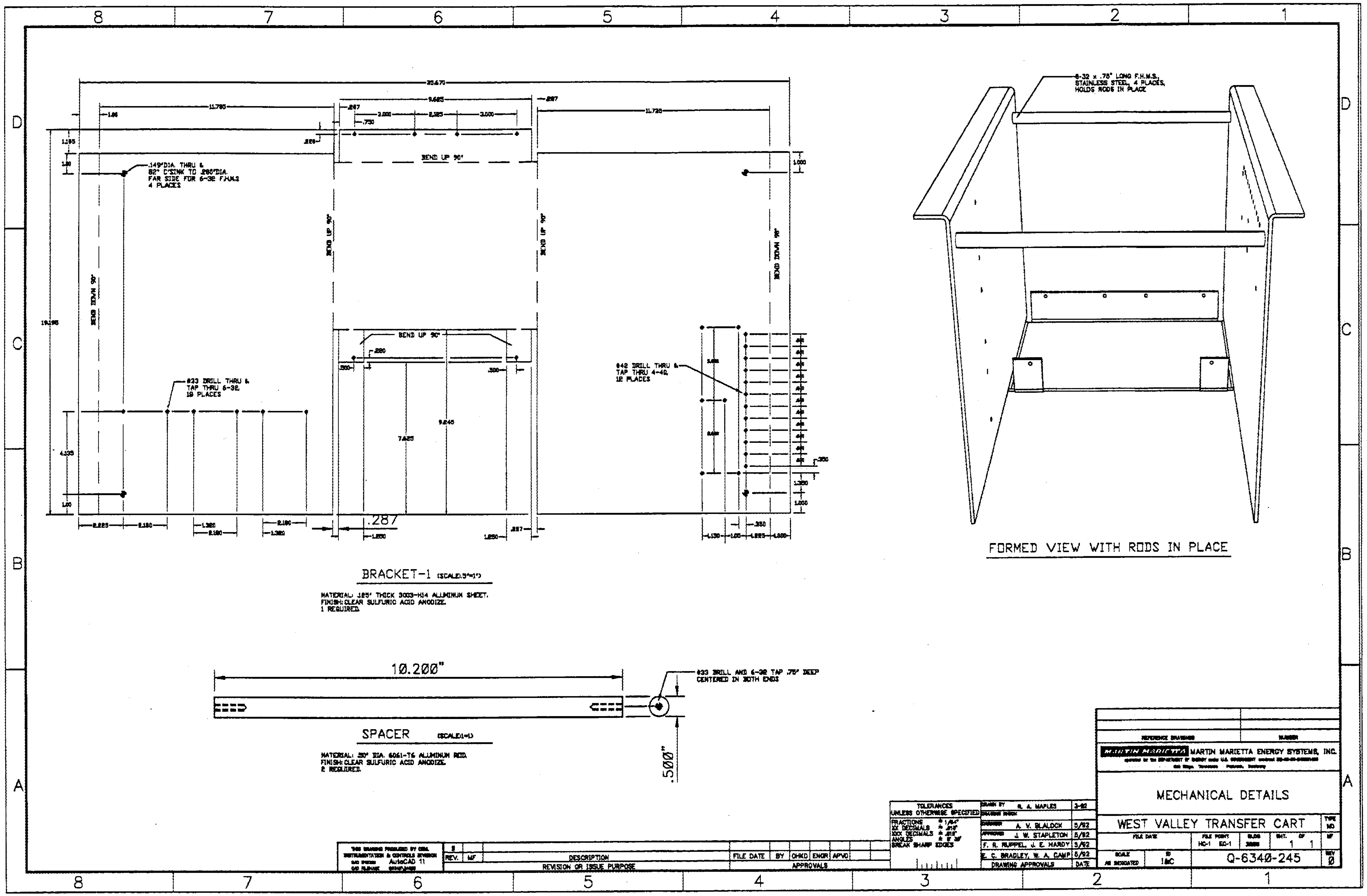
operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

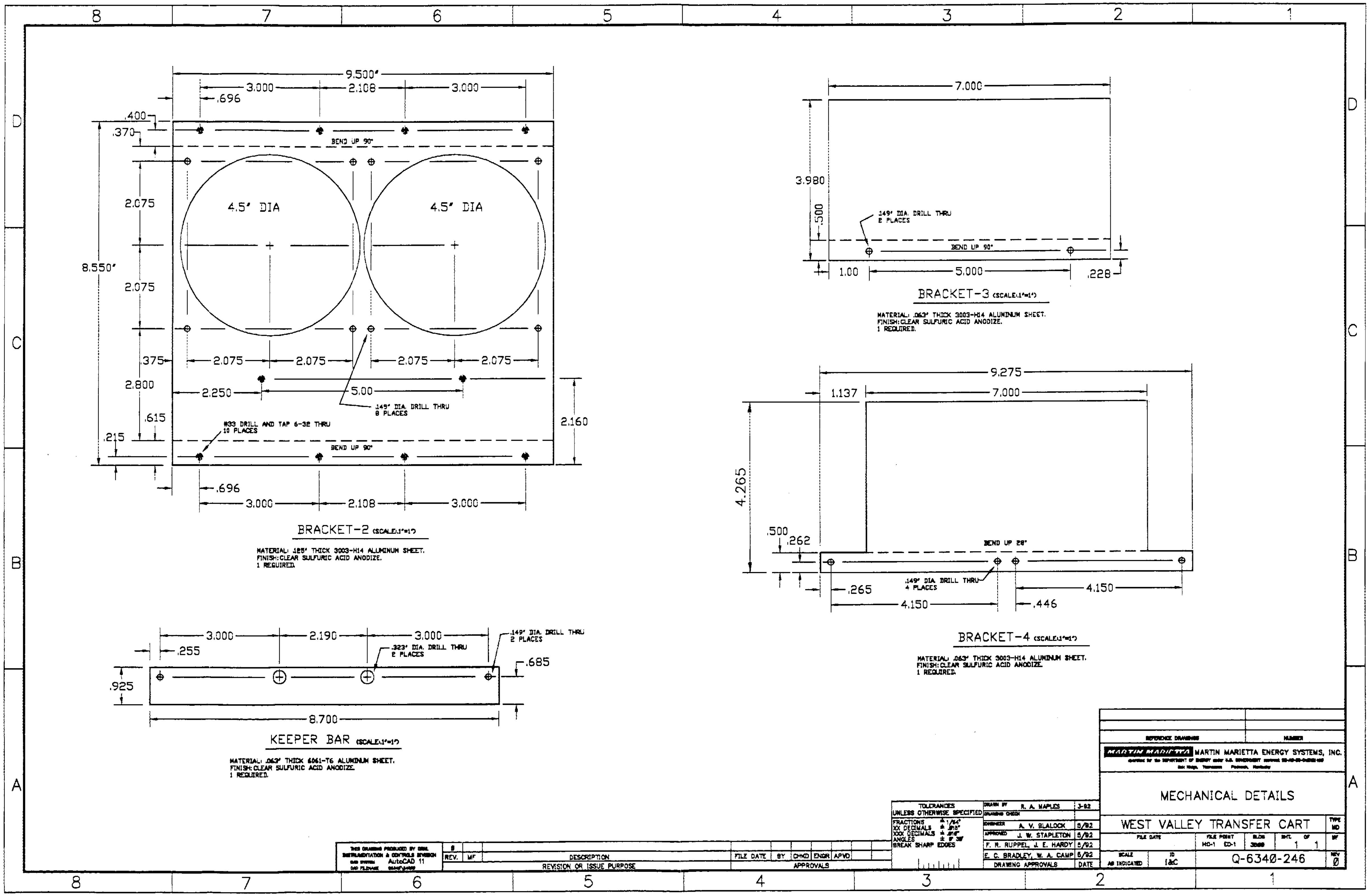
HEXFET MOUNTING
PRINTED CIRCUIT BOARD

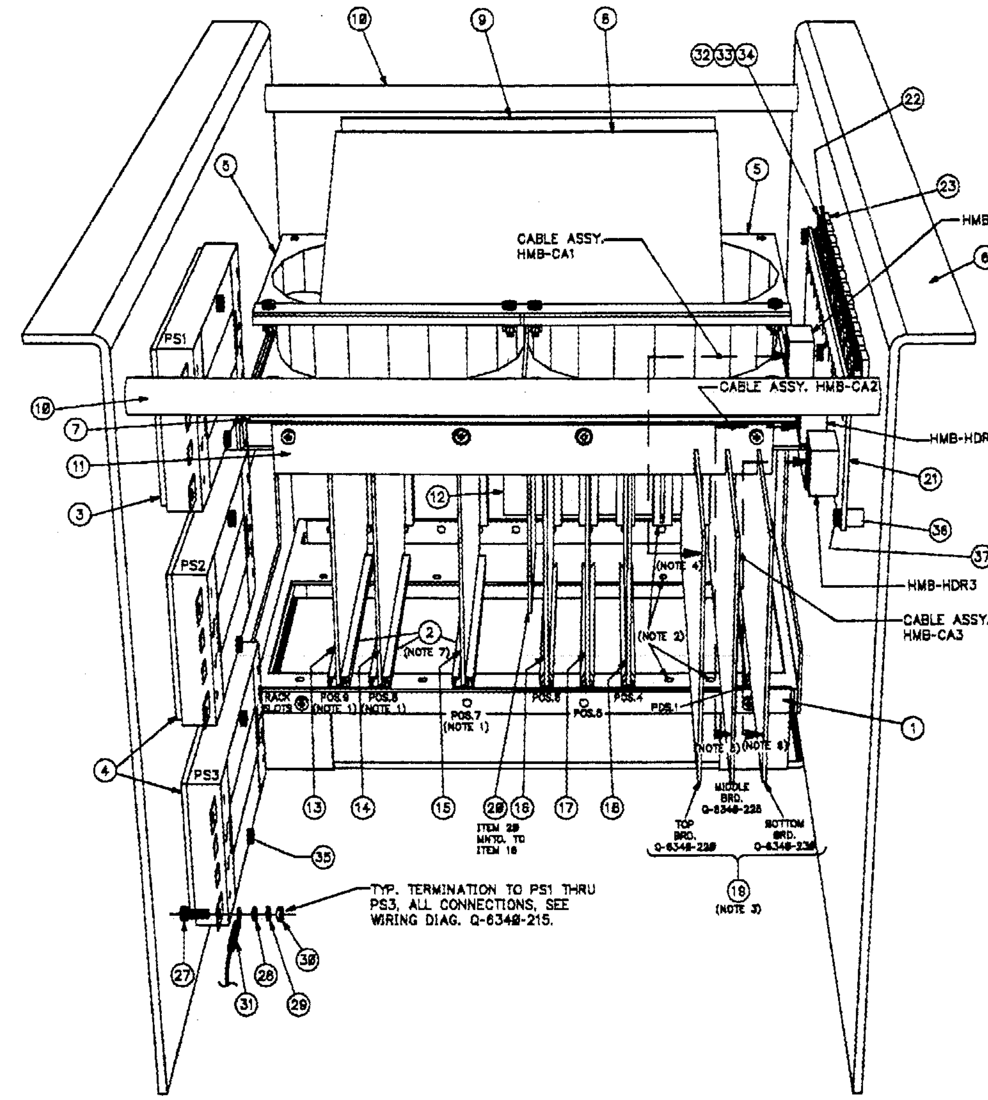
WEST VALLEY TRANSFER CART — TYPE: PC

FILE DATE	FILE POINT	BLDG	SHT.	OF	MF
	HC-1 EC-1	3500	1	1	

SCALE	ID		REV
1 : 1	I&C	Q-634Ø-244	Ø


BRACKET-1
MATERIAL: .125" THICK 3003-H14 ALUMINUM SHEET.
FINISH: CLEAR SULFURIC ACID ANODIZE.
1 REQUIRED.
BEND UP 90°
BEND DOWN 90°
.287
10.200"
.500"
#33 DRILL AND 6-32 TAP .75" DEEP
CENTERED IN BOTH ENDS
SPACER
MATERIAL: .50" DIA. 6061-T6 ALUMINUM ROD.
FINISH: CLEAR SULFURIC ACID ANODIZE.
2 REQUIRED.
FORMED VIEW WITH RODS IN PLACE
MARTIN MARIETTA ENERGY SYSTEMS, INC.
MECHANICAL DETAILS
WEST VALLEY TRANSFER CART
TOLERANCES
UNLESS OTHERWISE SPECIFIED
R. A. MAPLES
A. V. BLALOCK
J. W. STAPLETON
F. R. RUPPEL, J. E. HARDY
E. C. BRADLEY, W. A. CAMP
DRAWING APPROVALS
DATE
Q-6340-245
DESCRIPTION
REVISION OR ISSUE PURPOSE
APPROVALS
AutoCAD 11


BRACKET-2 (SCALE:1"=1")
MATERIAL: .125" THICK 3003-H14 ALUMINUM SHEET.
FINISH: CLEAR SULFURIC ACID ANODIZE.
1 REQUIRED.
4.5" DIA
4.5" DIA
BEND UP 90°
.149" DIA. DRILL THRU 8 PLACES
#33 DRILL AND TAP 6-32 THRU 10 PLACES
9.500"
8.550"
BRACKET-3 (SCALE:1"=1")
MATERIAL: .063" THICK 3003-H14 ALUMINUM SHEET.
FINISH: CLEAR SULFURIC ACID ANODIZE.
1 REQUIRED.
.149" DIA. DRILL THRU 2 PLACES
BEND UP 90°
BRACKET-4 (SCALE:1"=1")
MATERIAL: .063" THICK 3003-H14 ALUMINUM SHEET.
FINISH: CLEAR SULFURIC ACID ANODIZE.
1 REQUIRED.
.149" DIA. DRILL THRU 4 PLACES
BEND UP 28°
KEEPER BAR (SCALE:1"=1")
MATERIAL: .063" THICK 6061-T6 ALUMINUM SHEET.
FINISH: CLEAR SULFURIC ACID ANODIZE.
1 REQUIRED.
.323" DIA. DRILL THRU 2 PLACES
.149" DIA. DRILL THRU 2 PLACES
MARTIN MARIETTA ENERGY SYSTEMS, INC.
MECHANICAL DETAILS
WEST VALLEY TRANSFER CART
TOLERANCES UNLESS OTHERWISE SPECIFIED
BREAK SHARP EDGES
DRAWN BY R. A. MAPLES 3-92
A. V. BLALOCK 5/92
J. W. STAPLETON 5/92
F. R. RUPPEL, J. E. HARDY 5/92
E. C. BRADLEY, W. A. CAMP 5/92
DRAWING APPROVALS
SCALE AS INDICATED
I&C
Q-6340-246
AutoCAD 11
DESCRIPTION
REVISION OR ISSUE PURPOSE
APPROVALS



ITEM	QUAN	PART	MANUFACTURER/PART NO.
1	1	CARD CAGE	UNITRAK NO. STD87-12
2	6	HEAT SINK CARD GUIDE	UNITRAK NO. KGBC375-S-5.5-L-S
3	1	5V POWER SUPPLY	VICOR NO. VI-L-10-IY
4	2	15V POWER SUPPLY	VICOR NO. VI-L-12-IY
5	2	24V FAN	PAPST NO. 4414
6	1	BRACKET-1	DWG. Q-6340-245
7	2	BRACKET-2	DWG. Q-6340-246
8	1	BRACKET-3	DWG. Q-6340-246
9	1	BRACKET-4	DWG. Q-6340-246
10	2	ROD (SPACER)	DWG. Q-6340-245
11	1	KEEPER BAR	DWG. Q-6340-246
12	1	6 SLOT STD BUS BACKPLANE	WIN SYSTEMS MB6 MOTHERBOARD
13	1	CART RECEIVER BOARD	DWG. Q-6340-261
14	1	CART TRANSMITTER BOARD	DWG. Q-6340-271
15	1	CART ANTENNA CONTROLLER	DWG. Q-6340-266
16	1	SINGLE BOARD COMPUTER	WIN SYSTEMS LPM-SBC40R-8-BAT
17	1	BIPHASE ENCODER/DECODER	DWG. Q-6340-291
18	1	ANALOG I/O BOARD	WIN SYSTEMS LPM-AIO-DC
19	1	INTERFACE MODULE ASSY	DWGS Q-6340-220,-225,-230
20	1	DIG. I/O PIGGY-BACK BRD	WIN SYSTEMS SBX-PIO
21	1	HEXFET MOUNTING BRD	DWG. Q-6340-244
22	12	INSUL. SHOULDER WASHER	THERMALLOY 7721-7PPS
23	12	TO-220 INSULATOR	THERMALLOY 53-77-9AC
24	3	SOCKET HOUSING, 8 POS.	AMP 1-480270-0
25	18	CRIMP SOCKETS	AMP 60619-5
26	1 LOT	#14 AWG STRANDED IRRADIATED POLYEOLEFIN	ALPHA 7046
27	AS REQ	#6-32 BND.H.M.S.	USER CHOICE
28	AS REQ	#6 PLAIN WASHER	USER CHOICE
29	AS REQ	#6 LOCK WASHER	USER CHOICE
30	AS REQ	#6-32 HEX NUT	USER CHOICE
31	AS REQ	#6 STUD R. TNGUE TERM	USER CHOICE
32	12	#4-40 F.H.M.S.	USER CHOICE
33	12	#4 LOCKWASHER	USER CHOICE
34	12	#4-40 HEX NUT	USER CHOICE
35	6	#6-32x.75" LONG B.H.M.S	USER CHOICE
36	6	.25"O x .25"L #6 SPACER	USER CHOICE
37	6	#6-32x.437" LONG B.H.M.S	USER CHOICE

NOTES:

1. RACK SLOT POS'S. 7, 8, & 9 WIRED INDIVIDUALLY TO POWER SUPPLIES PS1, PS2, & PS3. SEE WIRING DIAGRAM Q-6340-215.
2. SIX SLOT STD. BUS BACKPLANE BEHIND SLOT POS'S. 1 THRU 6. POS'S. 2 & 3 NOT CONNECTEED & ASSOCIATED CARD GUIDES REMOVED.
3. TOP BOARD PLUGS INTO MIDDLE, MIDDLE PLUGS INTO BOTTOM, & BOTTOM BOARD PLUGS INTO POSITION 1 OF STD. BUS BACKPLANE (ITEM 12).
4. THIS END OF HMB-CA1 SOLDERED TO TOP BOARD, SEE Q-6340-220.
5. THIS END OF HMB-CA2 SOLDERED TO MIDDLE BOARD, SEE Q-6340-225.
6. THIS END OF HMB-CA3 SOLDERED TO BOTTOM BOARD, SEE Q-6340-230.
7. CUT 1/2" FROM ONE END OF THERMAL GUIDES.

REFERENCE DRAWINGS	NUMBER
MECHANICAL DETAILS	Q-6340-246
MECHANICAL DETAILS	Q-6340-245
PRINTED CIRCUIT BOARD	Q-6340-244

MARTIN MARIETTA ENERGY SYSTEMS, INC.

CART ELECTRONICS RACK ASSEMBLY

WEST VALLEY TRANSFER CART

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/64"
XX DECIMALS ± .015"
XXX DECIMALS ± .005"
ANGLES ± 0° 30'
BREAK SHARP EDGES

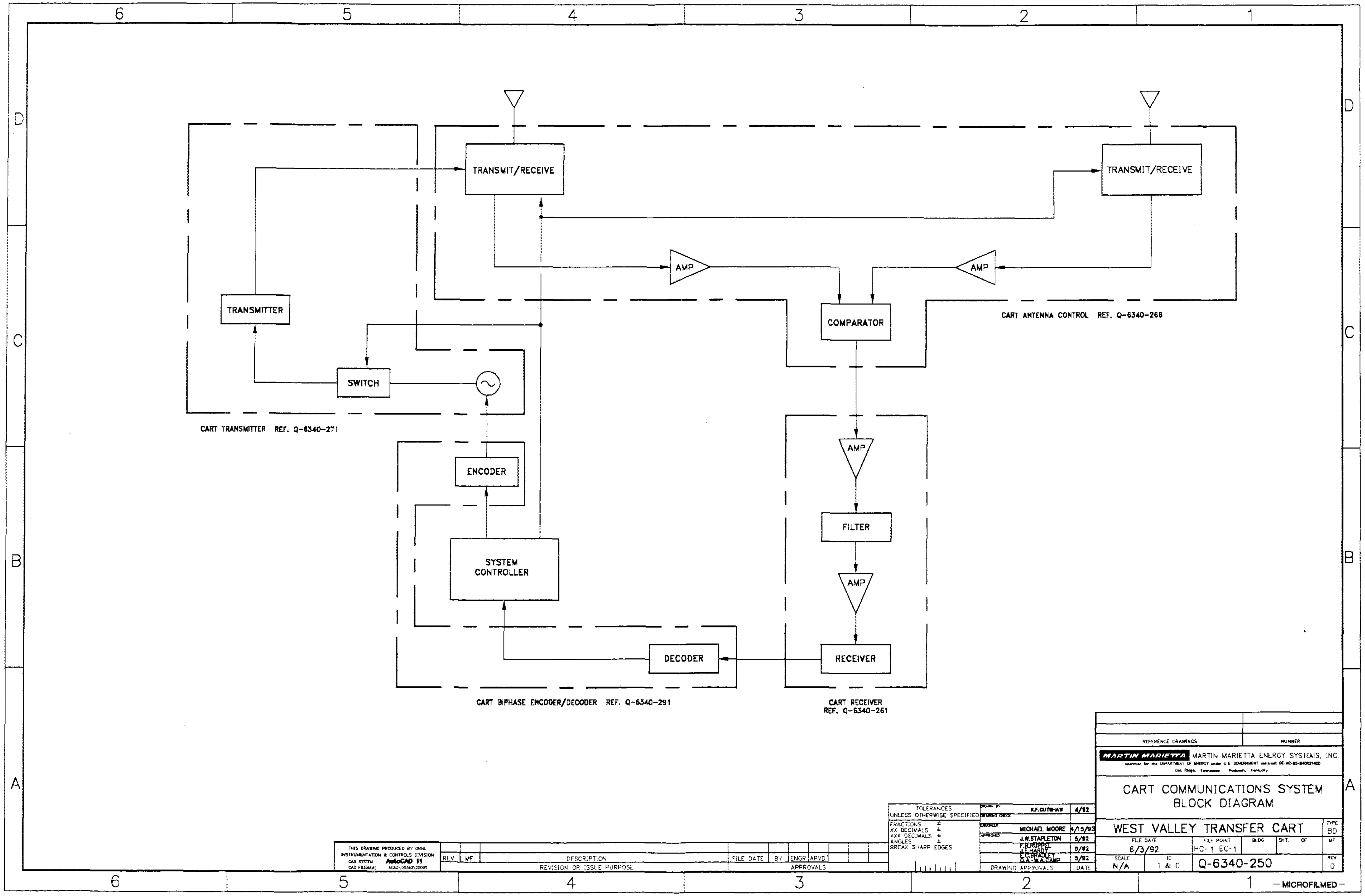
DRAWING APPROVALS	DATE
DRAWN BY R. A. MAPLES	3-92
A. V. BLALOCK	5/92
APPROVED J. W. STAPLETON	5/92
F. R. RUPPEL, J. E. HARDY	5/92
E. C. BRADLEY, W. A. CAMP	5/92

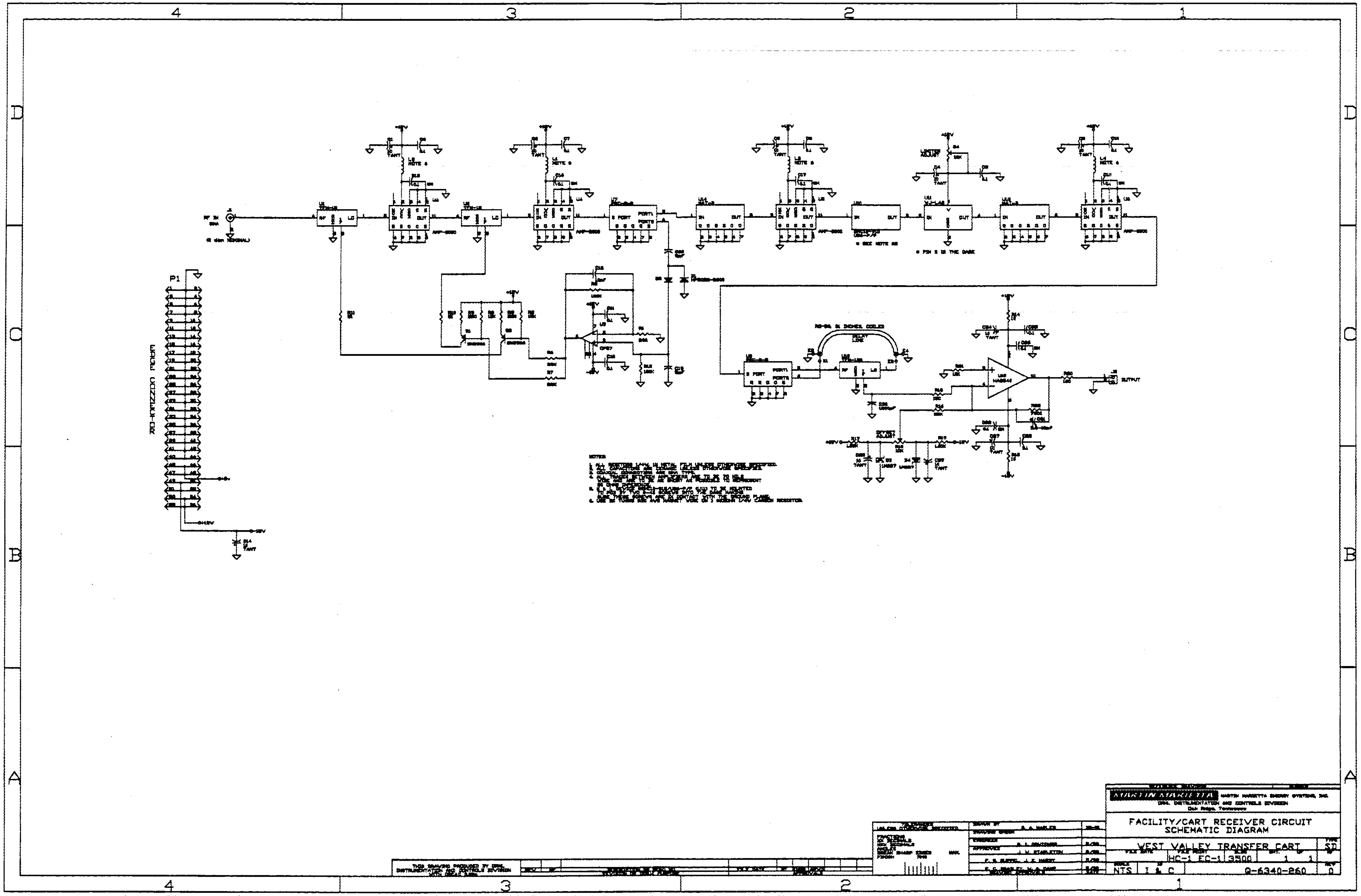
FILE POINT HQ-1 ED-1 SHT. 1 OF 1

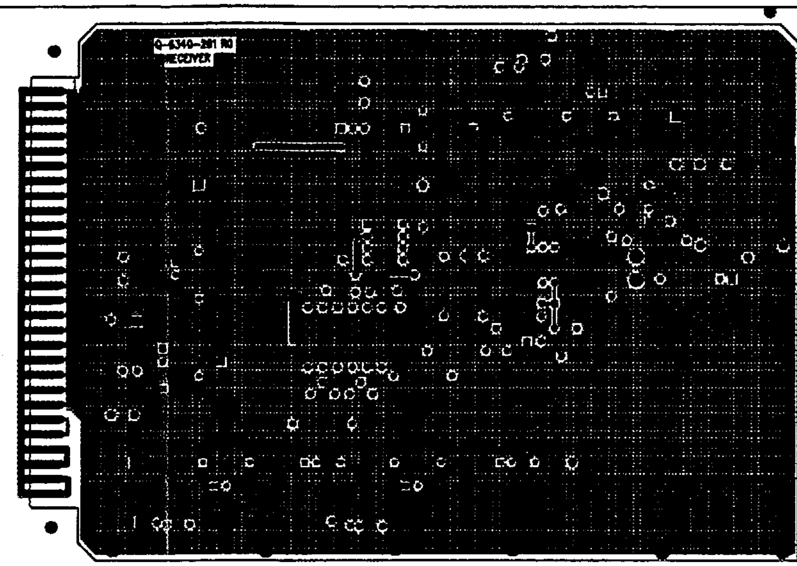
SCALE NTS I&C Q-6340-247 REV 0

REV.	MF	DESCRIPTION REVISION OR ISSUE PURPOSE	FILE DATE	BY	CHKD	ENGR	APVD

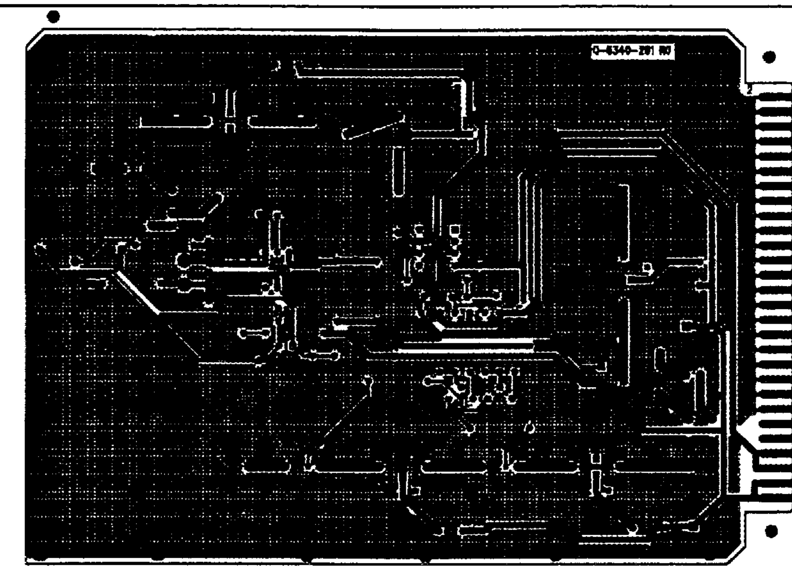
THIS DRAWING PRODUCED BY ORNL INSTRUMENTATION & CONTROLS DIVISION AutoCAD 11


TRANSMIT/RECEIVE
TRANSMIT/RECEIVE
AMP
AMP
TRANSMITTER
COMPARATOR
CART ANTENNA CONTROL REF. Q-6340-268
SWITCH
CART TRANSMITTER REF. Q-6340-271
ENCODER
AMP
FILTER
SYSTEM CONTROLLER
AMP
DECODER
RECEIVER
CART BIPHASE ENCODER/DECODER REF. Q-6340-291
CART RECEIVER REF. Q-6340-261
REFERENCE DRAWINGS
NUMBER
MARTIN MARIETTA
MARTIN MARIETTA ENERGY SYSTEMS, INC.
CART COMMUNICATIONS SYSTEM
BLOCK DIAGRAM
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
XX DECIMALS ±
XXX DECIMALS ±
ANGLES ±
BREAK SHARP EDGES
DRAWN BY K.F.CUTSHAW 4/92
ENGINEER MICHAEL MOORE 4/15/92
APPROVED J.W.STAPLETON 5/92
F.R.RUPPEL J.E.HARDY 5/92
E.C.BRADLEY O.A.-W.A.CAMP 5/92
DRAWING APPROVALS
DATE
WEST VALLEY TRANSFER CART
TYPE BD
FILE DATE 6/3/92
FILE POINT HC-1 EC-1
BLDG
SHT. OF
MF
SCALE N/A
ID I & C
Q-6340-250
REV 0
REV. MF DESCRIPTION REVISION OR ISSUE PURPOSE FILE DATE BY ENGR APVD APPROVALS
AutoCAD 11
—MICROFILMED—

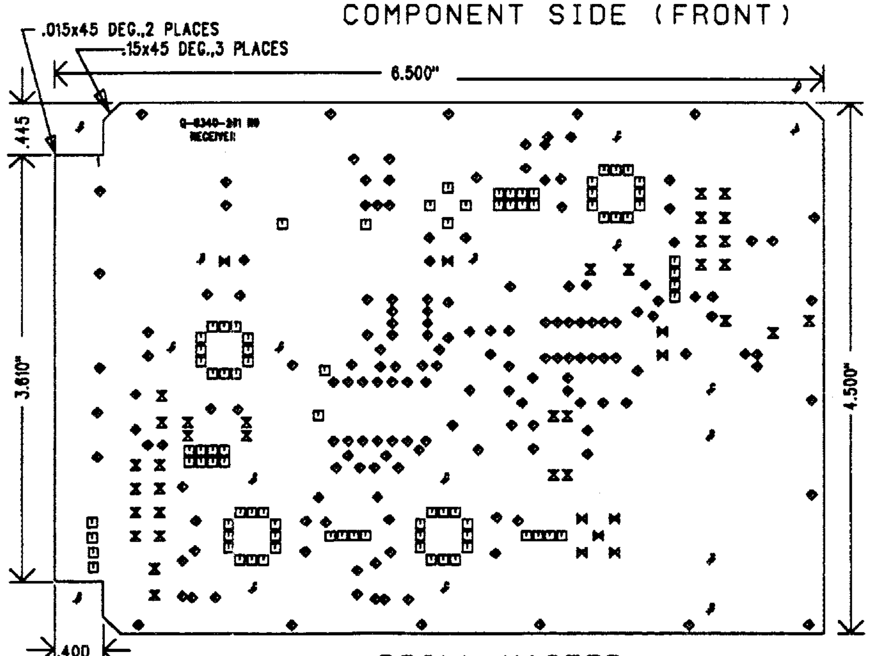

FACILITY/CART RECEIVER CIRCUIT
SCHEMATIC DIAGRAM
WEST VALLEY TRANSFER CART
SD
HC-1 EC-1
3500
1
1
NTS
I & C
Q-6340-260
0
P1
OUTPUT
RF IN
RG-174 31 INCHES COILED



COMPONENT SIDE (FRONT)

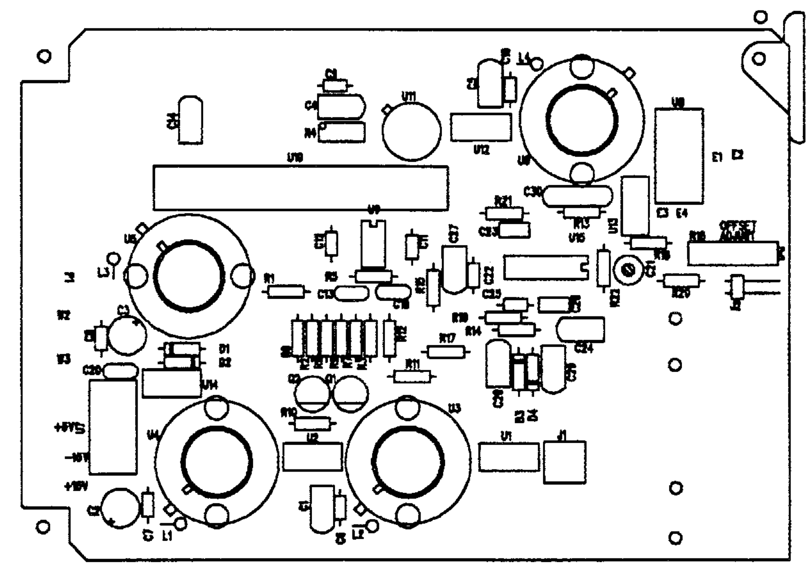


CIRCUIT SIDE



DRILL MASTER

SIZE	QTY	SYM
28	88	□
35	171	◇
40	33	X
46	8	⋈
93	1	A
107	2	B
125	15	C



SILK SCREEN FOR FRONT

NOTES:

1. MATERIAL TO BE .062 IN THICK EPOXY FIBERGLASS TYPE FR4, PER MIL-P-13949/4. SPECIFIC DESIGNATION SHALL BE FL-GFP-062-C-1/1-B-2-B.
2. ALL HOLES WITH LANDS ON BOTH SIDES OF THE BOARD SHALL BE 100% PLATED THRU. COPPER PLATING INSIDE THE HOLES SHALL BE .001" MINIMUM IN ACCORDANCE WITH MIL-C-14550. FRONT TO REAR REGISTRATION TO BE WITHIN .003".
3. CLEAN AND SOLDER PLATE ALL COPPER, EXCEPT CONNECTOR CONTACTS, IN ACCORDANCE WITH MIL-P-81728.THE FUSED TIN-LEAD SHALL BE .0003 INCH THICK MINIMUM.CONNECTOR CONTACTS SHALL BE PLATED TO A MINIMUN THICKNESS OF .0002 INCH WITH A LOW STRESS NICKEL WHICH CONFORMS TO QQ-N-290, CLASS 2, THEN OVER PLATED WITH GOLD PER MIL-G-45204 TO A THICKNESS NO LESS THAN .00005 INCH NOR MORE THAN .0001 INCH.
4. AFTER PROCESSING, ETCHED BOARDS TO BE FREE OF VOIDS AND SCRATCHES.
5. DO NOT USE THIS DRAWING AS A WORK SHEET. MASTER(S) OF WIRING WILL BE SUPPLIED BY ORNL.
6. LIMIT ON ALL DIMENSIONS .015 IN UNLESS OTHERWISE NOTED.
7. HONE ALL EDGES SMOOTH.
8. MATERIAL REQUIRED:30 SQ. IN..
9. HOLE LOCATION TOLERANCE .005 IN.
10. NOTCHES: 7
11. DIMENSIONS OF ALL HOLES NOTED BELOW ARE FINISHED HOLE DIAMETERS AFTER PLATING THRU.

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH PACS-2000		REVISION OR ISSUE PURPOSE	APPROVALS			

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0° 30'
BREAK SHARP EDGES

DRAWN BY	R.A. MAPLES	4/92
DRAWING CHECK	R.I. CRUTCHER	4-92
ENGINEER	R.I. CRUTCHER	4-92
APPROVED	J.V. STAPLETON	5-92
	F.R. RUPPEL, J.E. HARDY	5-92
	E.C. BRADLEY, QA-V.A. CAMP	5-92
	DRAWING APPROVALS	DATE

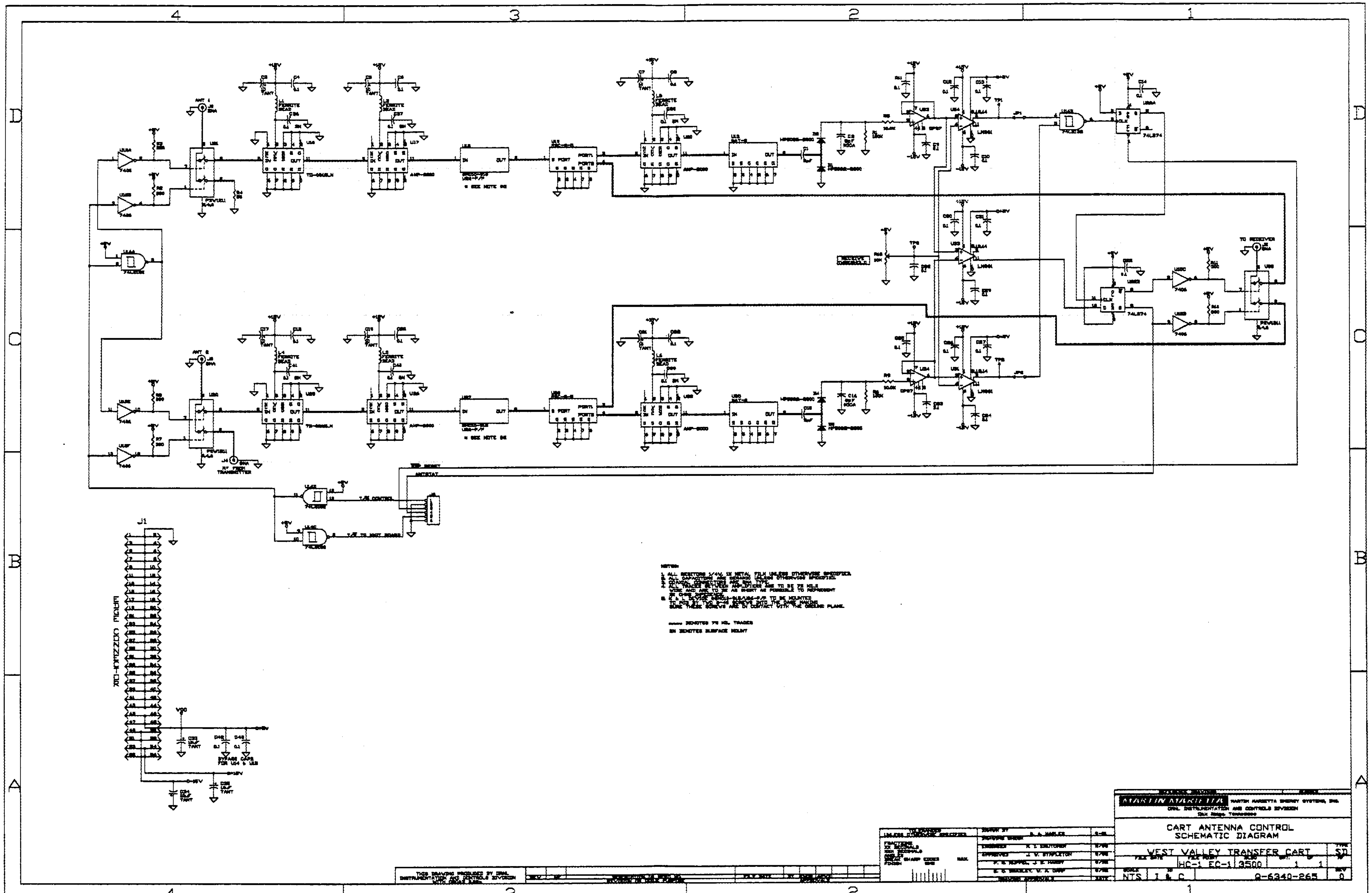
REFERENCE DRAWINGS	NUMBER

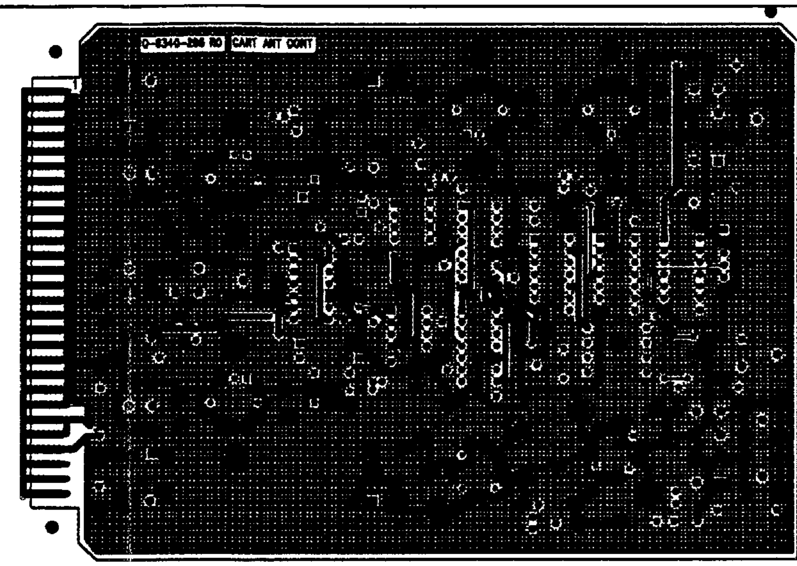
MARTIN MARIETTA ENERGY SYSTEMS, INC.

FACILITY/CART RECEIVER
PRINTED CIRCUIT BOARD

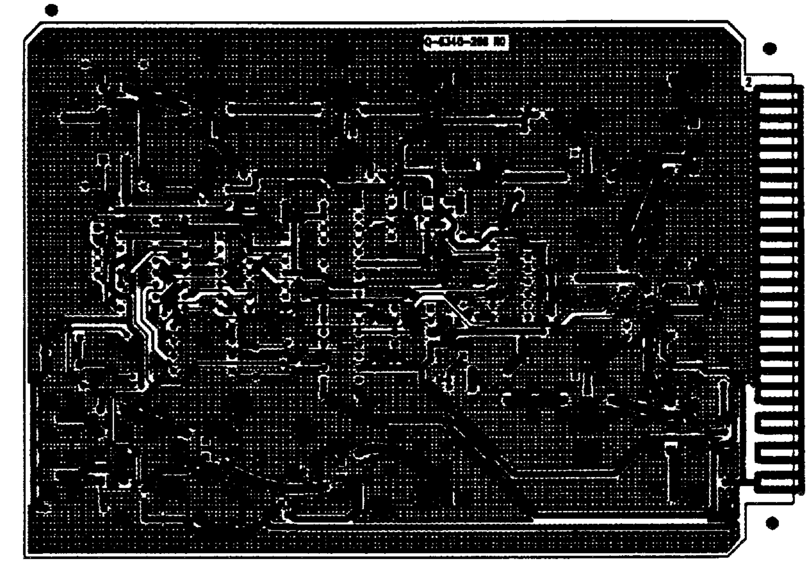
WEST VALLEY TRANSFER CART

TYPE	FILE DATE	FILE POINT	BLDG	SHT.	OF	SCALE	ID	DWG NO.	REV
PC		HC-1 EC-1	3500	1	1	1 : 1	I&C	Q-6340-261	Ø

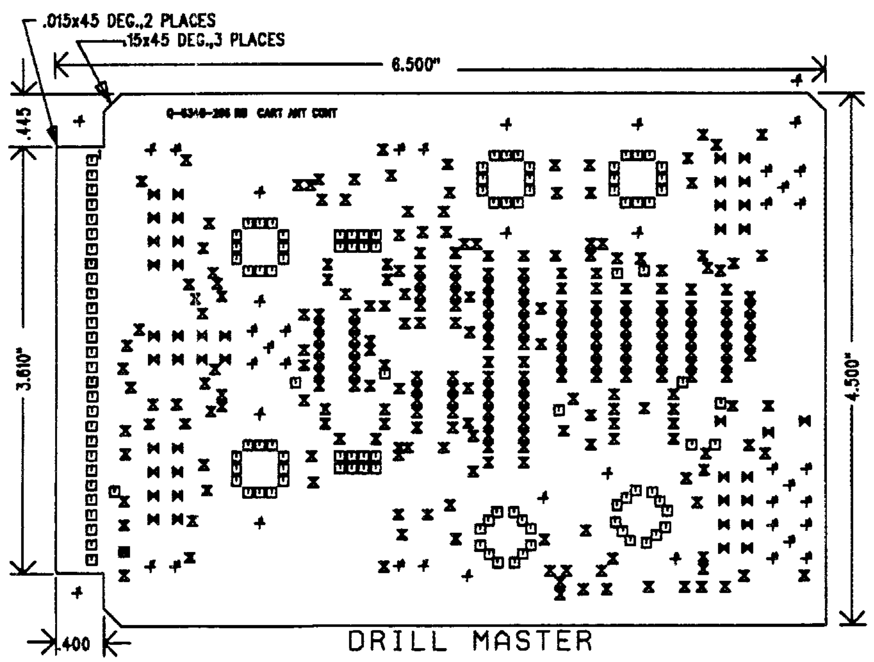

CART ANTENNA CONTROL
SCHEMATIC DIAGRAM
WEST VALLEY TRANSFER CART
SD
HC-1 EC-1
3500
1 1
NTS
I & C
Q-6340-265
0
J1



COMPONENT SIDE (FRONT)

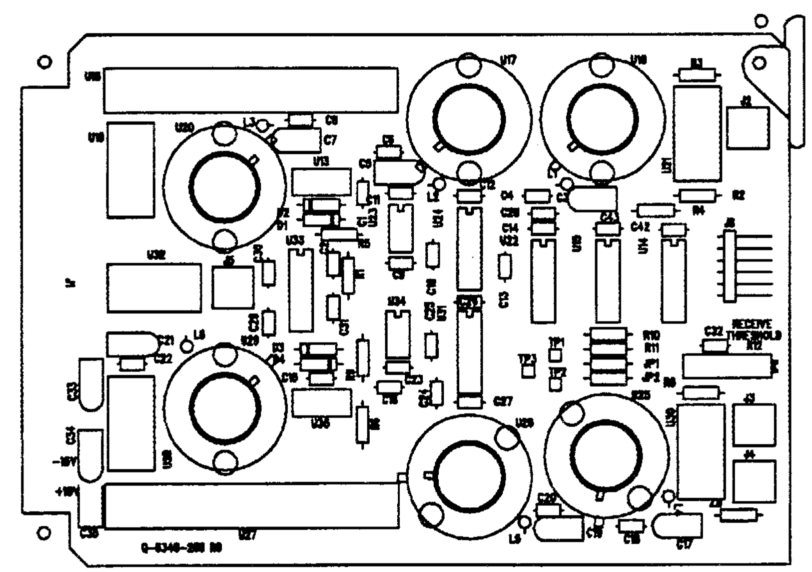


CIRCUIT SIDE



DRILL MASTER

SIZE	QTY	SYM
28	132	⊡
35	261	⧗
40	43	⋈
46	24	A
93	1	E
107	4	F
125	15	I



SILK SCREEN FOR FRONT

NOTES:

1. MATERIAL TO BE .062 IN THICK EPOXY FIBERGLASS TYPE FR4. PER MIL-P-13949/4. SPECIFIC DESIGNATION SHALL BE FL-GFP-062-C-1/1-B-2-B.
2. ALL HOLES WITH LANDS ON BOTH SIDES OF THE BOARD SHALL BE 100% PLATED THRU. COPPER PLATING INSIDE THE HOLES SHALL BE .001" MINIMUM IN ACCORDANCE WITH MIL-C-14550. FRONT TO REAR REGISTRATION TO BE WITHIN .003".
3. CLEAN AND SOLDER PLATE ALL COPPER, EXCEPT CONNECTOR CONTACTS, IN ACCORDANCE WITH MIL-P-81728.THE FUSED TIN-LEAD SHALL BE .0003 INCH THICK MINIMUM.CONNECTOR CONTACTS SHALL BE PLATED TO A MINIMUN THICKNESS OF .0002 INCH WITH A LOW STRESS NICKEL WHICH CONFORMS TO QQ-N-290, CLASS 2, THEN OVER PLATED WITH GOLD PER MIL-G-45204 TO A THICKNESS NO LESS THAN .00005 INCH NOR MORE THAN .0001 INCH.
4. AFTER PROCESSING, ETCHED BOARDS TO BE FREE OF VOIDS AND SCRATCHES.
5. DO NOT USE THIS DRAWING AS A WORK SHEET. MASTER(S) OF WIRING WILL BE SUPPLIED BY ORNL.
6. LIMIT ON ALL DIMENSIONS .015 IN UNLESS OTHERWISE NOTED.
7. HONE ALL EDGES SMOOTH.
8. MATERIAL REQUIRED:30 SQ. IN..
9. HOLE LOCATION TOLERANCE .005 IN.
10. NOTCHES: 7
11. DIMENSIONS OF ALL HOLES NOTED BELOW ARE FINISHED HOLE DIAMETERS AFTER PLATING THRU.

REV.	MF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH PAGE-GEMS		REVISION OR ISSUE PURPOSE	APPROVALS			

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0° 30'
BREAK SHARP EDGES

DRAWN BY	R.A. MAPLES	4/92
DRAWING CHECK		
ENGINEER	R.I. CRUTCHER	4-92
APPROVED	J.W. STAPLETON	5-92
	F.R. RUPPEL, J.E. HARDY	5-92
	E.C. BRADLEY, QA-W.A. CAMP	5-92
	DRAWING APPROVALS	DATE

REFERENCE DRAWINGS	NUMBER

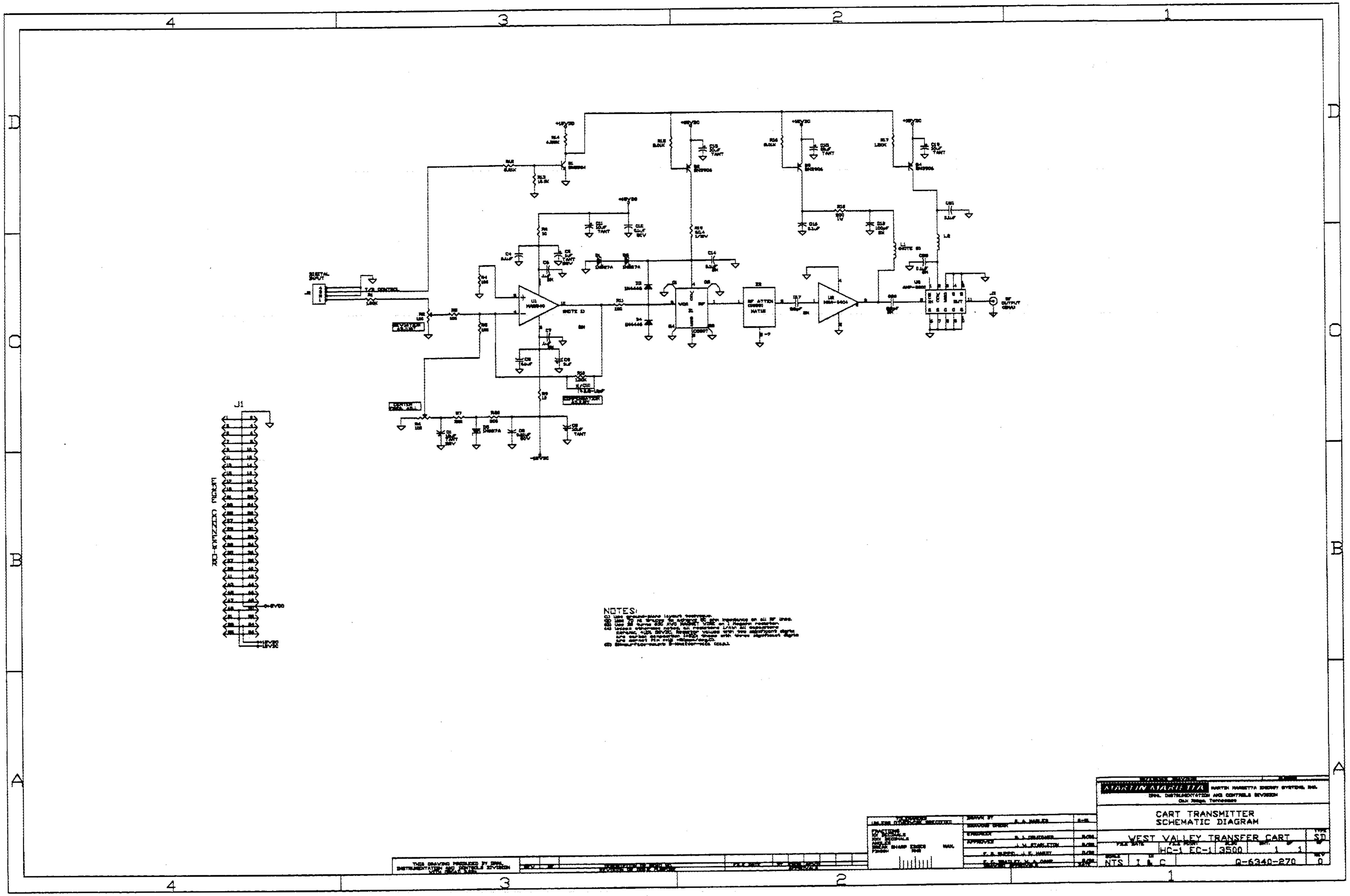
MARTIN MARIETTA ENERGY SYSTEMS, INC.

operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

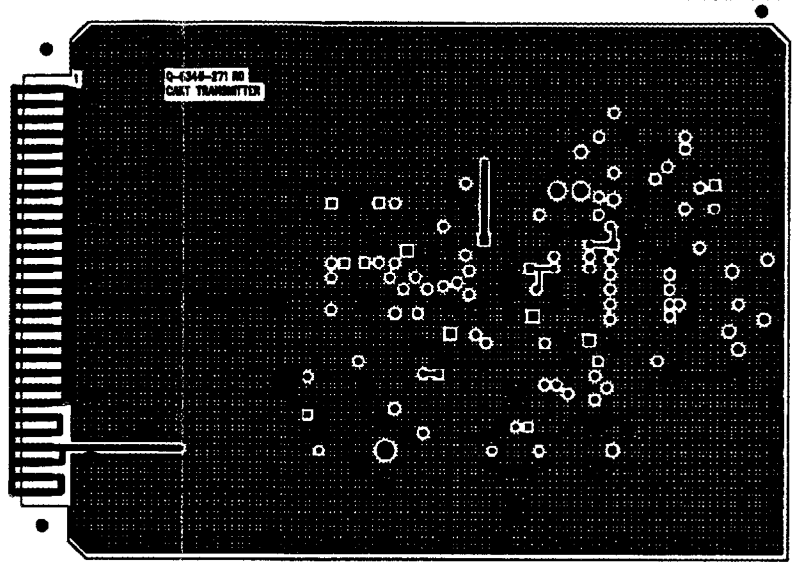
CART ANTENNA CONTROL
PRINTED CIRCUIT BOARD

WEST VALLEY TRANSFER CART

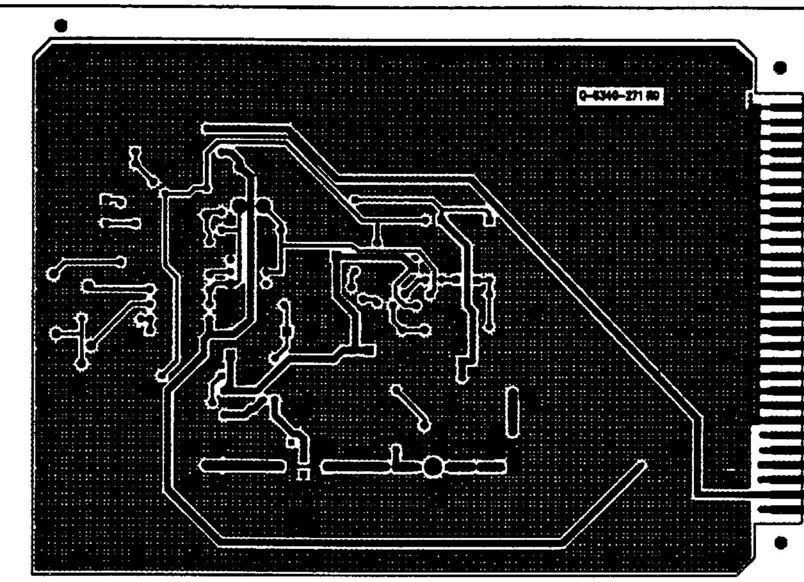
TYPE	FILE DATE	FILE POINT	BLDG	SHT.	OF	SCALE	IS	NUMBER	REV
PC		HC-1 EC-1	3500	1	1	1 : 1	I&C	Q-6340-266	Ø



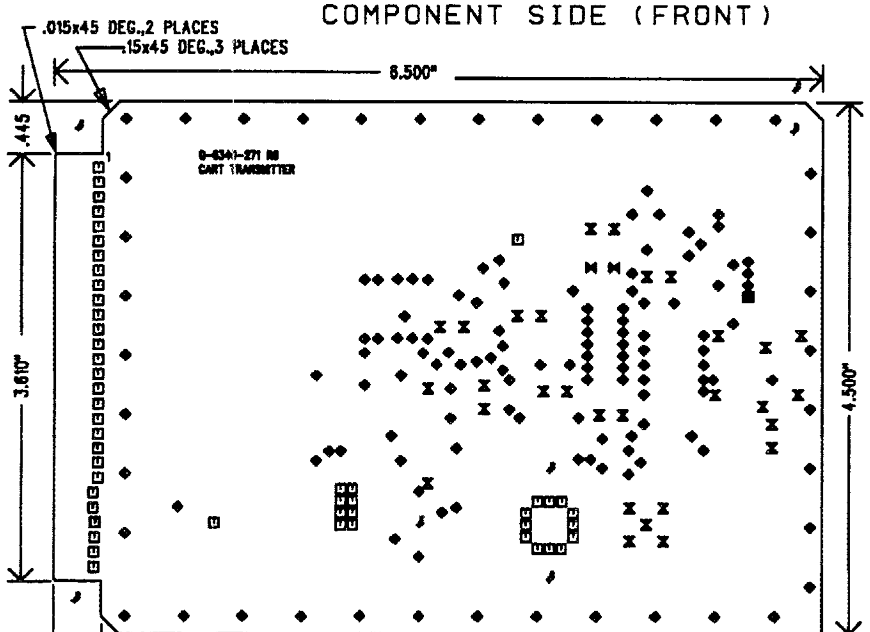
NOTES:
J1
CART TRANSMITTER
SCHEMATIC DIAGRAM
WEST VALLEY TRANSFER CART
HC-1 EC-1
3500
SD
NTS
I & C
Q-6340-270
0



COMPONENT SIDE (FRONT)

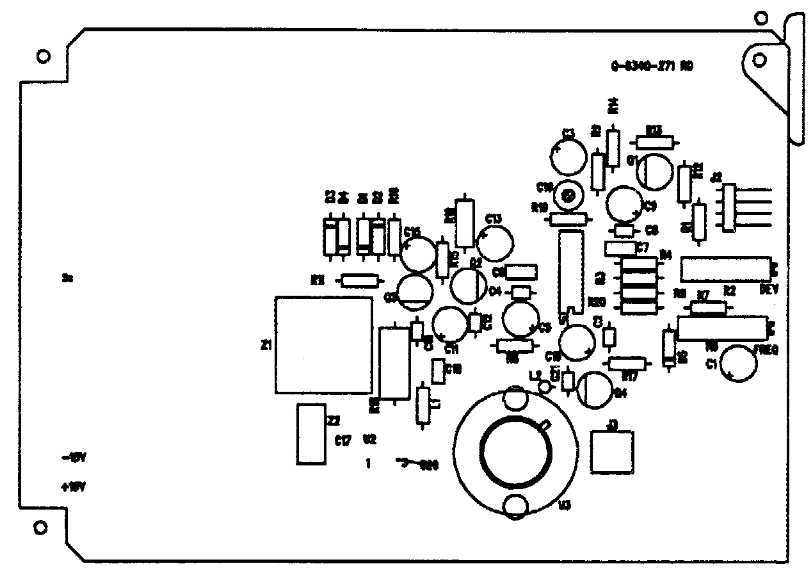


CIRCUIT SIDE



DRILL MASTER

SIZE	QTY	SYM
28	55	□
35	146	◇
40	29	⧗
52	2	⋈
93	1	B
125	5	C
152	1	E



SILK SCREEN FOR FRONT

NOTES:

1. MATERIAL TO BE .062 IN THICK EPOXY FIBERGLASS TYPE FR4, PER MIL-P-13949/4. SPECIFIC DESIGNATION SHALL BE FL-GFP-062-C-1/1-B-2-B.
2. ALL HOLES WITH LANDS ON BOTH SIDES OF THE BOARD SHALL BE 100% PLATED THRU. COPPER PLATING INSIDE THE HOLES SHALL BE .001" MINIMUM IN ACCORDANCE WITH MIL-C-14550. FRONT TO REAR REGISTRATION TO BE WITHIN .003".
3. CLEAN AND SOLDER PLATE ALL COPPER, EXCEPT CONNECTOR CONTACTS, IN ACCORDANCE WITH MIL-P-81728.THE FUSED TIN-LEAD SHALL BE .0003 INCH THICK MINIMUM.CONNECTOR CONTACTS SHALL BE PLATED TO A MINIMUM THICKNESS OF .0002 INCH WITH A LOW STRESS NICKEL WHICH CONFORMS TO QQ-N-290, CLASS 2, THEN OVER PLATED WITH GOLD PER MIL-G-45204 TO A THICKNESS NO LESS THAN .00005 INCH NOR MORE THAN .0001 INCH.
4. AFTER PROCESSING, ETCHED BOARDS TO BE FREE OF VOIDS AND SCRATCHES.
5. DO NOT USE THIS DRAWING AS A WORK SHEET. MASTER(S) OF WIRING WILL BE SUPPLIED BY ORNL.
6. LIMIT ON ALL DIMENSIONS .015 IN UNLESS OTHERWISE NOTED.
7. HONE ALL EDGES SMOOTH.
8. MATERIAL REQUIRED:30 SQ. IN..
9. HOLE LOCATION TOLERANCE .005 IN.
10.NOTCHES: 7
11.DIMENSIONS OF ALL HOLES NOTED BELOW ARE FINISHED HOLE DIAMETERS AFTER PLATING THRU.

REV.	NF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH PADS-2000		REVISION OR ISSUE PURPOSE	APPROVALS			

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0° 30'
BREAK SHARP EDGES

DRAWN BY	R.A. MAPLES	4/92
DRAWING CHECK		
ENGINEER	R.I. CRUTCHER	4-92
APPROVED	J.V. STAPLETON	5-92
	F.R. RUPPEL, J.E. HARDY	5-92
	E.C. BRADLEY, QA-W.A. CAMP	5-92
	DRAWING APPROVALS	DATE

REFERENCE DRAWINGS	NUMBER

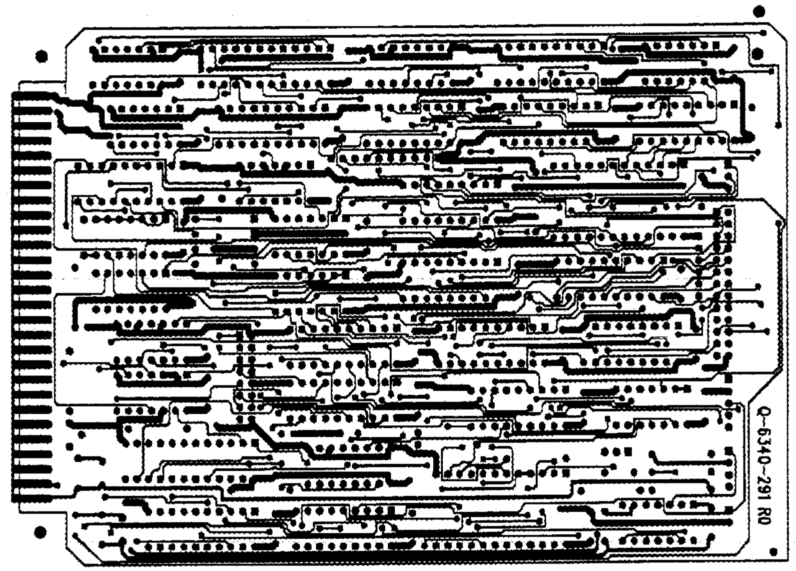
MARTIN MARIETTA ENERGY SYSTEMS, INC.
operated for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC05-84OR21400
Oak Ridge, Tennessee Paducah, Kentucky

CART TRANSMITTER
PRINTED CIRCUIT BOARD

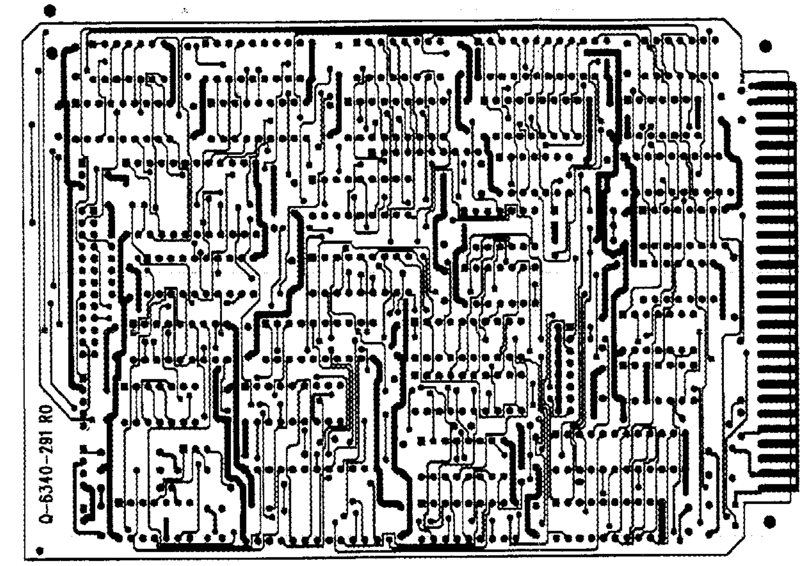
WEST VALLEY TRANSFER CART — TYPE: PC

FILE DATE	FILE POINT	BLDG	UNIT.	OF
	HC-1 EC-1	3500	1	1

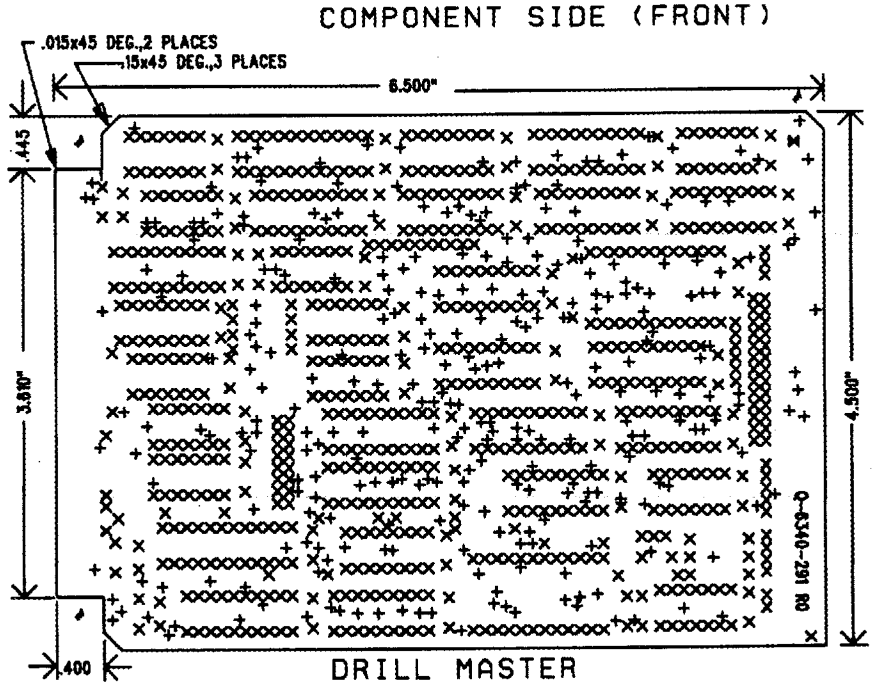
SCALE	ID		REV
1 : 1	I&C	Q-6340-271	Ø



COMPONENT SIDE (FRONT)

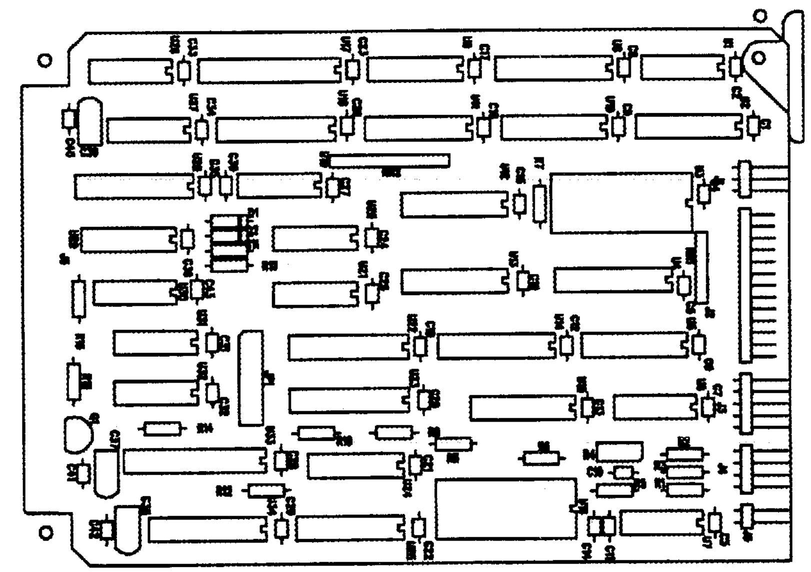


CIRCUIT SIDE



DRILL MASTER

SIZE	QTY	SYM
28	285	+
35	801	X
83	1	⋈
125	3	A



SILK SCREEN FOR FRONT

NOTES:

1. MATERIAL TO BE .062 IN THICK EPOXY FIBERGLASS TYPE FR4, PER MIL-P-13949/4. SPECIFIC DESIGNATION SHALL BE FL-GFP-062-C-1/1-B-2-B.
2. ALL HOLES WITH LANDS ON BOTH SIDES OF THE BOARD SHALL BE 100% PLATED THRU. COPPER PLATING INSIDE THE HOLES SHALL BE .001" MINIMUM IN ACCORDANCE WITH MIL-C-14550. FRONT TO REAR REGISTRATION TO BE WITHIN .003".
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7. HONE ALL EDGES SMOOTH.
8. MATERIAL REQUIRED:30 SQ. IN..
9. HOLE LOCATION TOLERANCE .005 IN.
10. NOTCHES: 7
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REV.	NF	DESCRIPTION	FILE DATE	BY	ENGR	APVD
DRAWN WITH		REVISION OR ISSUE PURPOSE	APPROVALS			

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/64"
XX DECIMALS ± .010"
XXX DECIMALS ± .005"
ANGLES ± 0° 30'
BREAK SHARP EDGES

DRAWING APPROVALS	DATE
DRAWN BY R.A. MAPLES	3-92
DRAWING CHECK	
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E.C. BRADLEY, QA-W.A. CAMP	5-92

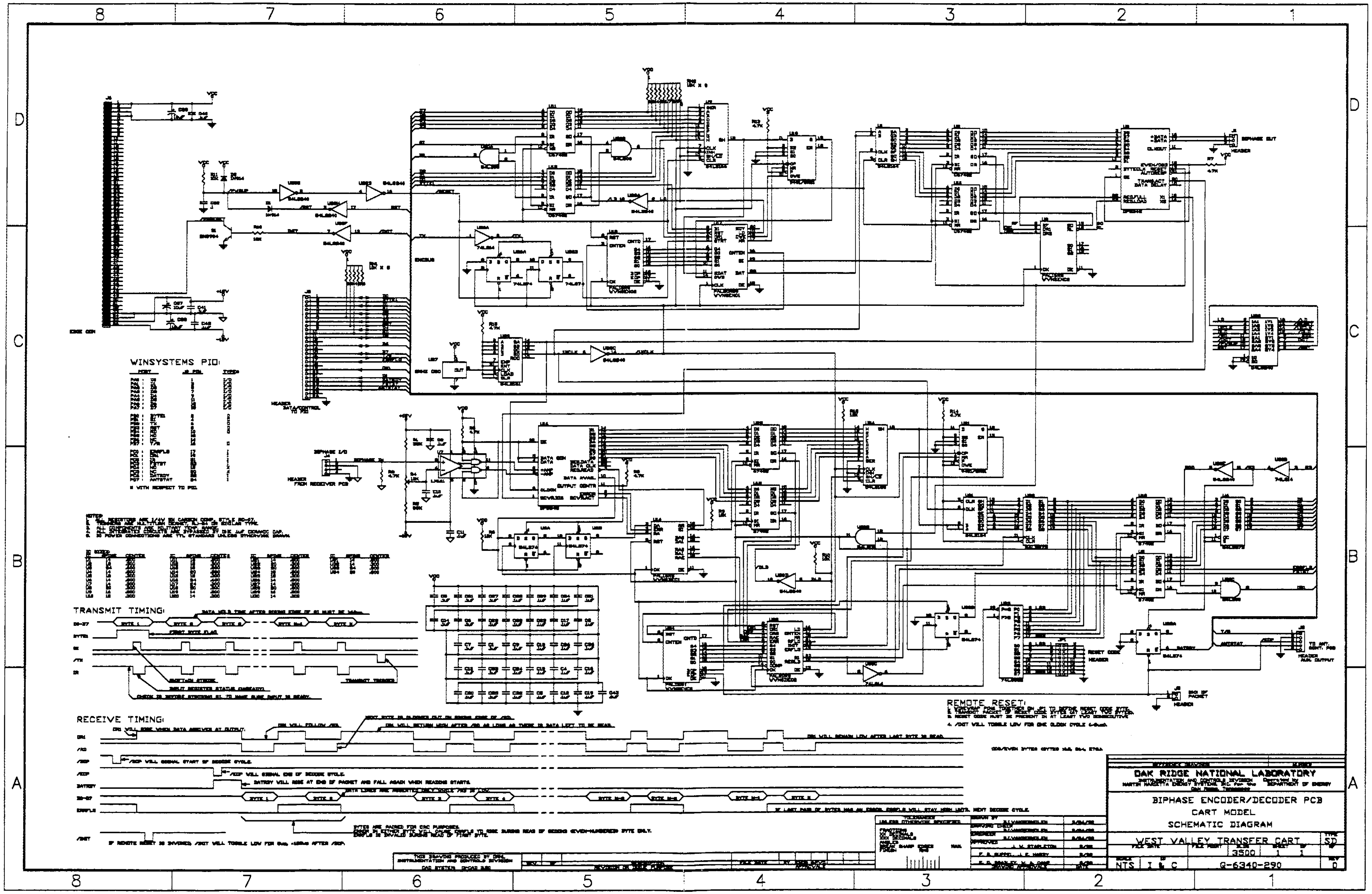
REFERENCE DRAWINGS	NUMBER

MARTIN MARIETTA ENERGY SYSTEMS, INC.

BIPHASE ENCODER/DECODER
PRINTED CIRCUIT BOARD
CART MODEL

WEST VALLEY TRANSFER CART

TYPE	FILE DATE	FILE POINT	BLDG	SHT.	OF	SCALE	IN	NUMBER	REV
PC		HC-1 EC-1	3500	1	1	1 : 1	I&C	Q-6340-291	Ø



WINSYSTEMS PIO
TRANSMIT TIMING
RECEIVE TIMING
REMOTE RESET
OAK RIDGE NATIONAL LABORATORY
BIPHASE ENCODER/DECODER PCB
CART MODEL
SCHEMATIC DIAGRAM
WEST VALLEY TRANSFER CART
SD
3500
1
1
NTS
I & C
Q-6340-290
0

WVNS encoder controller
Equations for Module wvnsenc1

Device enc1

- Reduced Equations:

```
!ld := (!b1 & !cnten & or & rst
      # or & q0 & q1 & q2 & !q3 & q4 & rst
      # or & !q0 & q1 & q2 & !q3 & !q4 & rst
      # ld & or & rdy & rst);


mr := (q0 & q1 & q2 & !q3 & q4 # !mr & rdy # !rst);

si := (q0 & q1 & q2 & !q3 & rst # q0 & q1 & q2 & !q4 & rst);

!cwe := (!q0 & !q3 & q4 & rst
       # !q1 & !q3 & q4 & rst
       # !q2 & !q3 & q4 & rst
       # q0 & q1 & q2 & q3 & !q4 & rst);


dat = (cwd & !cwe # cwe & sdat);

!rdy := (!rst
       # !ld & mr & rdy
       # cnten & !rdy
       # !rdy & !strt
       # !or & !rdy
       # !b1 & !rdy);


!cnten := (cnten & !rst
         # cnten & !or & q0 & q1 & q2 & !q3 & q4
         # !cnten & !mr
         # !cnten & !rdy
         # !cnten & ld);
```

Reference Drawings:

Facility Biphase Encoder/Decoder Schematic	Q-6340-185
Facility Biphase Encoder/Decoder Printed Circuit Board	Q-6340-186
Facility Biphase Encoder/Decoder Parts List	Q-6340-187
Cart Biphase Encoder/Decoder Schematic	Q-6340-290
Cart Biphase Encoder/Decoder Printed Circuit Board	Q-6340-291
Cart Biphase Encoder/Decoder Parts List	Q-6340-292

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QA W A CAMP	5/92	
DRAWING APPROVALS	DATE	

MARTIN MARIETTA

MARTIN MARIETTA ENERGY SYSTEMS, INC.
ORNL INSTRUMENTATION AND CONTROLS DIVISION
Oak Ridge, Tennessee

PAL DOCUMENTATION
WVNS ENC1

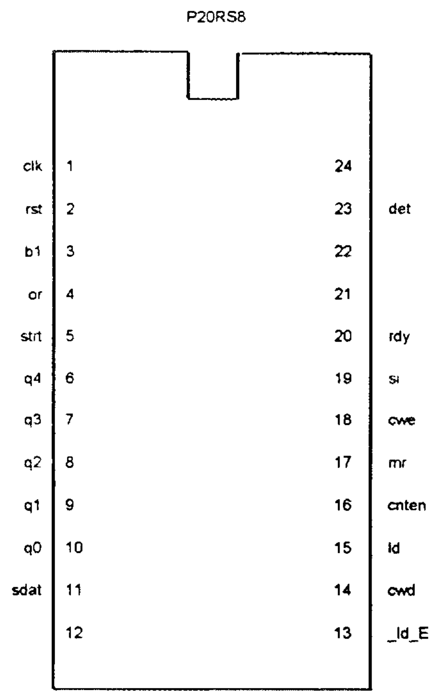
WEST VALLEY TRANSFER CART — PL

FILE DATE | FILE POINT | BLDG | SHT 1 OF 2 | MF

ID I&C | Q-6340-020

WVNS encoder controller
Chip diagram for Module wvnsenc1

Device enc1



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DRAWING CHECK			
ENGINEER	R I VANDERMOLEN	4/92	
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	E C BRADLEY	5/92	
QA	W A CAMP	5/92	
			WEST VALLEY TRANSFER CART — PL
			FILE DATE — FILE POINT — BLDG — SHT 2 OF 2 — MF
DRAWING APPROVALS		DATE	ID I&C — Q-6340-020

WVNS encoder counter
Equations for Module wvnsenc2

Device enc2

- Reduced Equations

```
!cntd := (!cnten);

!bop := (!cntd & cnten & rst);

!eop := (cntd & !cnten & rst);

!q4 := (q0 & q1 & q2 & q3 & q4
      # !q0 & !q1 & !q2 & q3
      # !rst
      # !q0 & !q4
      # !q1 & !q4
      # !q2 & !q4
      # !q3 & !q4);


!q3 := (!rst
      # !q0 & !q1 & !q2 & q4
      # !q0 & !q3
      # !q1 & !q3
      # q0 & q1 & q2 & q3
      # !q2 & !q3);


!q2 := (!rst # !q0 & !q2 # q0 & q1 & q2 # !q1 & !q2);

!q1 := (!rst # q0 & q1 # !q0 & !q1);

!q0 := (!rst
      # !q1 & !q2 & q3 & q4
      # q0
      # !cnten & !q1 & !q2 & !q3 & !q4);
```

Reference Drawings:

Facility Biphase Encoder/Decoder Schematic	Q-6340-185
Facility Biphase Encoder/Decoder Printed Circuit Board	Q-6340-186
Facility Biphase Encoder/Decoder Parts List	Q-6340-187
Cart Biphase Encoder/Decoder Schematic	Q-6340-290
Cart Biphase Encoder/Decoder Printed Circuit Board	Q-6340-291
Cart Biphase Encoder/Decoder Parts List	Q-6340-292

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APPROVED	J W STAPLETON	5/92	PAL DOCUMENTATION WVNS ENC2
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	J E HARDY	5/92	
	E C BRADLEY	5/92	
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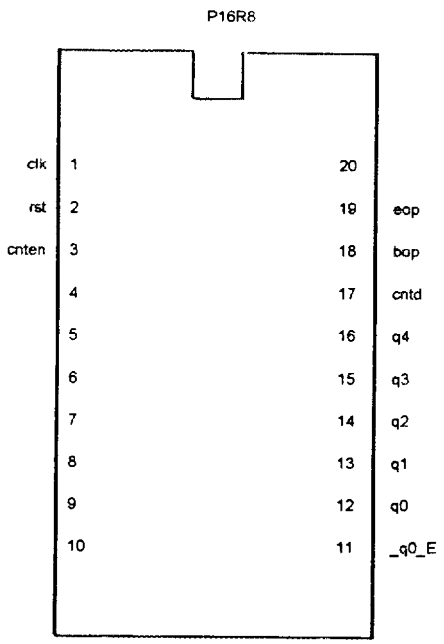
			WEST VALLEY TRANSFER CART — PL
			FILE DATE — FILE POINT — BLDG — SHT 1 OF 2 — MF
DRAWING APPROVALS		DATE	ID I&C — Q-6340-021

WVNS encoder counter
Chip diagram for Module wvnsenc2

Device enc2



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DRAWING CHECK		
ENGINEER R I VANDERMOLEN	4/92	
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F R RUPPEL	5/92	
J E HARDY	5/92	
E C BRADLEY	5/92	
QA W A CAMP	5/92	
		WEST VALLEY TRANSFER CART — PL
		FILE DATE — FILE POINT — BLDG — SHT 2 OF 2 — MF
DRAWING APPROVALS	DATE	ID I&C — Q-6340-021

WVNS biphase encoder controller
Equations for Module wvnsenc3

Device enc3

- Reduced Equations:

```
!q0 := (rf # !or2 # !or1);

!q1 := (!q0);

!q2 := (!q1);

!rf := (q1 & !q2);

!so := (rf);
```

Reference Drawings:

Facility Biphase Encoder/Decoder Schematic	Q-6340-185
Facility Biphase Encoder/Decoder Printed Circuit Board	Q-6340-186
Facility Biphase Encoder/Decoder Parts List	Q-6340-187
Cart Biphase Encoder/Decoder Schematic	Q-6340-290
Cart Biphase Encoder/Decoder Printed Circuit Board	Q-6340-291
Cart Biphase Encoder/Decoder Parts List	Q-6340-292

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	J E HARDY	5/92	
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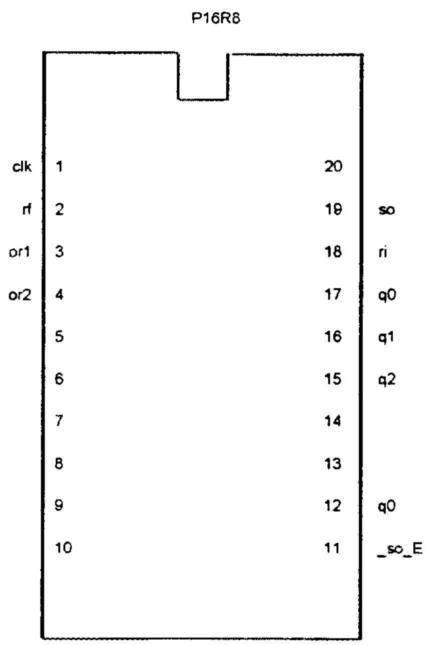
			WEST VALLEY TRANSFER CART — PL
			FILE DATE / FILE POINT / BLDG / SHT 1 OF 2 / MF
DRAWING APPROVALS		DATE	ID I&C — Q-6340-022

WVNS biphase encoder controller
Chip diagram for Module wvnsenc3

Device enc3



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ENGINEER R I VANDERMOLEN	4/92	
APPROVED J W STAPLETON	5/92	**PAL DOCUMENTATION** **WVNS ENC3**
F R RUPPEL	5/92	
J E HARDY	5/92	
E C BRADLEY	5/92	
QA W A CAMP	5/92	
		WEST VALLEY TRANSFER CART — PL
		FILE DATE — FILE POINT — BLDG — SHT 2 OF 2 — MF
DRAWING APPROVALS	DATE	ID I&C — Q-6340-022

WVNS decoder fifo controller
Equations for Module wvnsdec1

Device dec1

- Reduced Equations:

```
!rr := (da0 & !da1 & !err & rst);

!si := (!rst # err # da1 # !da0);

!rae := (!ra1 # ra0);

!da0 := (!rst # err # !da);

!da1 := (!rst # err # !da0);

!ra0 := (!ra);

!ra1 := (!ra0);
```

Reference Drawings:

Facility Biphase Encoder/Decoder Schematic	Q-6340-185
Facility Biphase Encoder/Decoder Printed Circuit Board	Q-6340-186
Facility Biphase Encoder/Decoder Parts List	Q-6340-187
Cart Biphase Encoder/Decoder Schematic	Q-6340-290
Cart Biphase Encoder/Decoder Printed Circuit Board	Q-6340-291

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DRAWING CHECK			
ENGINEER	R I VANDERMOLEN	4/92	
APPROVED	J W STAPLETON	5/92	PAL DOCUMENTATION WVNS DEC1
	F R RUPPEL	5/92	
	J E HARDY	5/92	
	E C BRADLEY	5/92	
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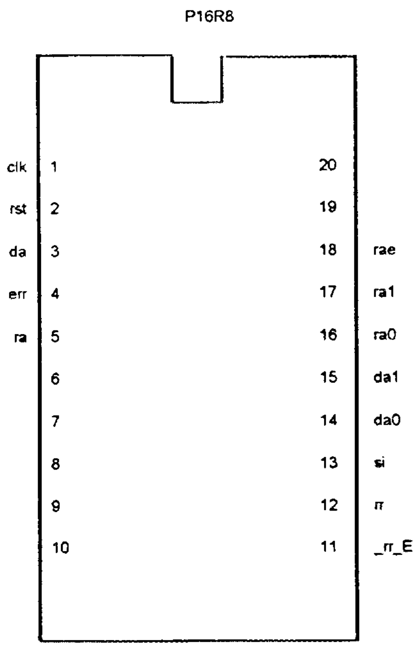
			WEST VALLEY TRANSFER CART — PL
			FILE DATE / FILE POINT / BLDG / SHT 1 OF 2 / MF
DRAWING APPROVALS		DATE	ID I&C — Q-6340-023

WVNS decoder fifo controller
Chip diagram for Module wvnsdec1

Device dec1



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ENGINEER	R I VANDERMOLEN	4/92
APPROVED	J W STAPLETON	5/92
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ORNL INSTRUMENTATION AND CONTROLS DIVISION
Oak Ridge, Tennessee

PAL DOCUMENTATION
WVNS DEC1

WEST VALLEY TRANSFER CART — PL

FILE DATE | FILE POINT | BLDG | SHT 2 OF 2 | MF

ID I&C — Q-6340-023

WVNS decoder / crc checker controller
Equations for Module wvnsdec2
Device dec2

- Reduced Equations:

```
  !regld := (!q0 # !q1 # !q2 # q4 # !rst);

  !ld := (or1 & or2 & q0 & q1 & q2 & !q3 & q4 & rst
       # or1 & or2 & !q0 & q1 & q2 & !q4 & rst
       # or1 & or2 & !q0 & !q1 & !q2 & !q3 & !q4 & rae & rst);

  !mr := (!q0 & q4 & rst
       # !q1 & q4 & rst
       # !q2 & q4 & rst
       # q3 & rst
       # q0 & !q4 & rst
       # q1 & !q4 & rst
       # q2 & !q4 & rst
       # !q4 & !rae & rst);

  !si := (!rst # q0 # q1 & q4 # q2 & q4 # !q3 # !q1 & !q4 # !q2 & !q4);

  !init := (!comp & !err & q0 & q1 & q2 & !q3 & q4 & rflg);

  !cnten := (!rst
         # cnten & !or2 & q0 & q1 & q2 & !q3 & q4
         # cnten & !or1 & q0 & q1 & q2 & !q3 & q4
         # !cnten & ld);

  !erflg := (!rst
         # erflg & si
         # !erflg & !err
         # !erflg & !q0
         # !erflg & !q1
         # !erflg & !q2
         # !erflg & q3
         # !erflg & !q4);

  !rflg := (!rst
       # !q0 & !q1 & !q2 & q3 & q4
       # comp & !rflg
       # !q0 & !rflg
       # !q1 & !rflg
       # !q2 & !rflg
       # !q3 & !rflg
       # q4 & !rflg);
```

Reference Drawings:

Facility Biphase Encoder/Decoder Schematic	Q-6340-185
Facility Biphase Encoder/Decoder Printed Circuit Board	Q-6340-186
Facility Biphase Encoder/Decoder Parts List	Q-6340-187
Cart Biphase Encoder/Decoder Schematic	Q-6340-290
Cart Biphase Encoder/Decoder Printed Circuit Board	Q-6340-291
Cart Biphase Encoder/Decoder Parts List	Q-6340-292

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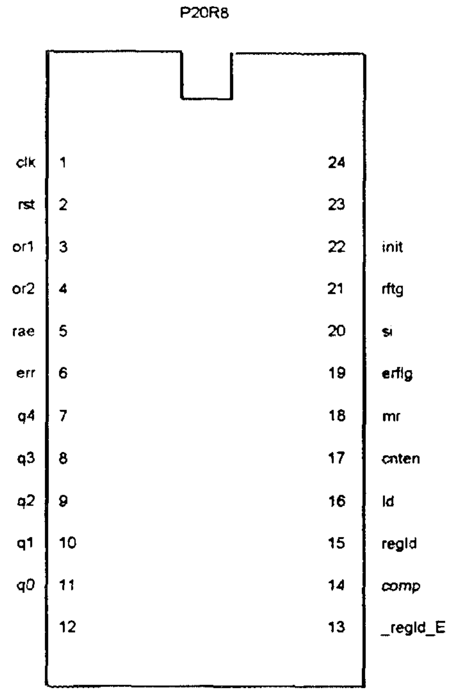
ENGINEER	R I VANDERMOLEN	4/92	
APPROVED	J W STAPLETON	5/92	PAL DOCUMENTATION WVNS DEC2
	F R RUPPEL	5/92	
	J E HARDY	5/92	
	E C BRADLEY	5/92	
QA	W A CAMP	5/92	
			WEST VALLEY TRANSFER CART — PL
			FILE DATE / FILE POINT / BLDG / SHT 1 OF 2 / MF
DRAWING APPROVALS		DATE	ID I&C — Q-6340-024

WVNS decoder / crc checker controller
Chip diagram for Module wvnsdec2

Device dec2



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DRAWING CHECK		
ENGINEER	R I VANDERMOLEN	4/92
APPROVED	J W STAPLETON	5/92
	F R RUPPEL	5/92
	J E HARDY	5/92
	E C BRADLEY	5/92
QA	W A CAMP	5/92
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MARTIN MARIETTA MARTIN MARIETTA ENERGY SYSTEMS, INC.
ORNL INSTRUMENTATION AND CONTROLS DIVISION
Oak Ridge, Tennessee

PAL DOCUMENTATION
WVNS DEC2

WEST VALLEY TRANSFER CART — PL

FILE DATE | FILE POINT | BLDG | SHT 2 OF 2 | MF

ID I&C | Q-6340-024

Item	Quantity	Reference	Part	Vendor
1	2	C1,C2	1uF	Sprague 2C37Z5U105M050B
2	5	CU1,CU2,C3,CU4,C	.1uF	Sprague 1C25Z5U104M050B
3	1	C4	47uF	Panasonic ECE-A1HU470
4	2	C6,C7	.01uF	Sprague 1C25Z5U103M050B
5	12	D1,D2,D3,D4,D5,D6,D7,D8, D9,D10,D11,D12	1N5245BPH Zener, 15V	Philips
6	1	D13	1N4744A Zener	
7	2	ISO1,ISO2	TIL113 Optoisolator	TI
8	2	HDR1,HDR2	2x3 Header	AMP 2-380999-0
10	4	Q1,Q3,Q4,Q9	IRF9141	International Rectifier
11	2	Q2,Q5	IRF044	International Rectifier
12	2	Q6,Q13	2N3904	
13	2	Q7,Q8	IRF9120	International Rectifier
14	2	Q10,Q11	IRF120	International Rectifier
15	20	R1,R2,R3,R4,R5,R6,R7,R8, R9,R10,R11,R12,R13,R14, R15,R16,R18,R19,R20,R21	100k, 1/8W, 1% tol, Metal Film	
16	1	HDR2	PLC	Wieland 25.350.3453
17	1	U1	74HC00N	National
18	1	U2	CD4538BE	Harris
19	1	U3	LM7805CT	National
20	1	U4	74HCT14N	National

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DRAWING CHECK		
ENGINEER	A V BLALOCK	4/92
APPROVED	J W STAPLETON	5/92
	F R RUPPEL	5/92
	J E HARDY	5/92
	E C BRADLEY	5/92
QA	W A CAMP	5/92
DRAWING APPROVALS		DATE

MARTIN MARIETTA

MARTIN MARIETTA ENERGY SYSTEMS, INC.

ORNL INSTRUMENTATION AND CONTROLS DIVISION

Oak Ridge, Tennessee

BATTERY CHARGER POLARITY MANAGER PARTS LIST

WEST VALLEY TRANSFER CART | PL

FILE DATE | FILE POINT | BLDG | SHT 1 OF 1 | MF

ID I&C | Q-6340-137

Item	Quantity	Reference	Part	Vendor
1	10	C1,C2,C6,C7,C11,C12 C16,C17,C21,C32	22 pF 50 V surface mount ceramic monolithic	
2	4	C3,C8,C13,C18	100 pF 50 V surface mount ceramic monolithic	
3	6	C4,C9,C14,C19,C23,C34	0.01 uF 50 V ceramic monolithic	
4	10	C5,C10,C15,C20,C26, C30,C35,C37,C38,C39	10 uF 35 V tant ECS-F1VE106K	Panasonic
5	1	C22	2.8-12 pF variable 24AA021	Mouser
6	2	C24,C28	1 uF 35 V tant ECS-F1VE105K	Panasonic
7	4	C25,C29,C31,C36	0.1 uF 50 V ceramic monolithic	
8	1	C33	100 pF 50 V surface mount ceramic monolithic	
9	2	D1,D2	1N4448 diode	
10	3	D3,D4,D5	1N827A diode	
11	4	J2,J3,J4,J5	SMA rt angle 142-0299-001	EF Johnson
12	1	JP1	4-pin rt angle header	
13	5	L1,L2,L3,L4,L5	20-T #30 AWG magnet wire on 1 megohm 1/2 W carbon resistor	
14	1	Q1	2N3904 transistor	
15	6	Q2,Q3,Q4,Q5,Q6,Q7	2N3906 transistor	
16	8	R1,R12,R14,R16,R18,R23, R24,R28	3.01 k-ohm, 1%, 1/4 W	
17	1	R2	4.99 k-ohm, 1%, 1/4 W	
18	2	R3,R9	100 ohm pot 76PR100	Beckman
19	1	R4	1.00 k-ohm, 1%, 1/4 W	
20	6	R5,R6,R7,R20,R22,R25	100 ohm, 1%, 1/4 W	
21	1	R8	10.0 k-ohm, 1%, 1/4 W	
22	2	R10,R27	301 ohm, 1%, 1/4 W	
23	5	R11,R13,R15,R17,R26	200 ohm, 1%, 1 W	
24	1	R19	1.00 k-ohm, 1%, 1/4 W	
25	1	R21	60.4 ohm, 1%, 1/2 W	
26	1	U1	HA2540 op amp	Harris
27	1	U2	MAT-10 attenuator	Mini-Circuits
28	5	U3,U6,U8,U10,U12	MAR-4 amplifier	Mini-Circuits
29	1	U4	PSC-4A-4 splitter	Mini-Circuits
30	4	U5,U7,U9,U11	MAT-3 attenuator	Mini-Circuits
31	1	U13	C580T oscillator	Z-Comm

DRAWING APPROVALS		DATE
DRAWN BY		
DRAWING CHECK		
ENGINEER	R I CRUTCHER	4/92
APPROVED	J W STAPLETON	5/92
	F R RUPPEL	5/92
	J E HARDY	5/92
	E C BRADLEY	5/92
QA	W A CAMP	5/92

MARTIN MARIETTA — MARTIN MARIETTA ENERGY SYSTEMS, INC.
ORNL INSTRUMENTATION AND CONTROLS DIVISION
Oak Ridge, Tennessee

FACILITY TRANSMITTER
PARTS LIST

WEST VALLEY TRANSFER CART — PL

FILE DATE | FILE POINT | BLDG | SHT 1 OF 1 | MF

ID I&C — Q-6340-172

Item	Quantity	Reference	Part	Vendor
1	11	C1,C2,C3,C4,C5,C6,C12, C13,C16,C17,C18	0.1 uF 50 V ceramic monolithic	
2	6	C7,C8,C9,C10,C11,C14	10uF 35 V tantalum ECS-F1VE106K	Panasonic
3	1	C15	10pF 5% silver mica	
4	1	D1	1N4742A diode	
5	1	J1	10-pin straight header	
6	1	J2	3-pin straight header	
7	1	J3	20-pin dual-row straight header	
8	3	L1,L2,L3	ferrite bead EXC-ELSR35S	Panasonic
9	1	Q1	MPSU55 transistor	
10	2	Q2,Q3	2N3906 transistor	
11	1	R1	1.0 k-ohm, 1%, 1/4 W	
12	3	R2,R6,R7	3.01 k-ohm, 1%, 1/4 W	
13	2	R3,R4	301 ohm, 1%, 1/4 W	
14	1	R5	4.99 k-ohm, 1%, 1/4 W	
15	2	R8,R9	392 ohm, 1%, 1/4 W	
16	1	R10	562 ohm, 1%, 1/4 W	
17	1	U1	HCPL-2602 optical isolator	HP
18	1	U2	7406 integrated circuit	
19	1	U3	7805 voltage regulator	
20	2	U4,U5	7815 voltage regulator	
21	2	N/A	THM 6106 heat sink	Thermalloy
22	1	N/A	THM 6107-14 heat sink	Thermalloy

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ENGINEER	R I CRUTCHER	4/92	
APPROVED	J W STAPLETON	5/92	FACILITY TRANSMIT/RECEIVE CELL INTERFACE PARTS LIST
	F R RUPPEL	5/92	
	J E HARDY	5/92	
	E C BRADLEY	5/92	
QA	W A CAMP	5/92	
			WEST VALLEY TRANSFER CART — PL
			FILE DATE — FILE POINT — BLDG — SHT 1 OF 1 — MF
DRAWING APPROVALS		DATE	ID I&C — Q-6340-177

Item	Quantity	Reference	Part	Vendor
1	8	C1,C2,C5,C6,C9,C10,C13, C14	5 pF 5% silver mica	
2	48	C3,C4,C7,C8,C11,C12,C15, C16,C17,C20,C23,C26,C29, C30,C31,C32,C33,C34,C35, C36,C37,C38,C39,C40,C41, C42,C43,C44,C45,C46,C47, C48,C49,C50,C51,C52,C53, C54,C55,C56,C57,C58,C59, C60,C61,C62,C66,C67	0.1 uF 50 V ceramic monolithic	
3	4	C18,C21,C24,C27	0.1 uF 50 V surface mount ceramic monolithic	
4	10	C19,C22,C25,C28,C63, C64,C65,C68,C69,C70	10 uF 35 V tant ECS-F1VE106K	Panasonic
5	8	D1,D2,D3,D4,D5,D6,D7,D8	HP5082-2800 diode	Hewlett-Packard
6	5	J2,J3,J4,J5,J6	SMA rt angle 142-0299-001	EF Johnson
7	2	J7,J8	12-pin rt angle header	
8	1	J9	2-pin rt angle header	
9	1	J10	4-pin rt angle header	
10	4	L1,L2,L3,L4	ferrite bead EXC-ELSR35S	Panasonic
11	1	Q1	2N3904 transistor	
12	5	R1,R3,R5,R7,R17	10.0 k-ohm, 1%, 1/4 W	
13	4	R2,R4,R6,R8	100 k-ohm, 1%, 1/4 W	
14	6	R9,R10,R11,R12,R13,R14	301 ohm, 1%, 1/4 W	
15	1	R16	3.01 k-ohm, 1%, 1/4 W	
16	1	R18	1.00 k-ohm, 1%, 1/4 W	
17	1	R15	10 k-ohm pot 76PR10K	Beckman
18	5	TP1,TP2,TP3,TP4,TP5	1-pin straight header	
19	4	U1,U5,U9,U13	5MC10-915-U26-P/P	K & L Filter
20	4	U2,U6,U10,U14	PSC-2-5 splitter	Mini-Circuits
21	4	U3,U7,U11,U15	MAT-3 attenuator	Mini-Circuits
22	4	U4,U8,U12,U16	OP27 op amp	PMI
23	3	U17,U18,U19	PSW1211 switch	Mini-Circuits
24	4	U20,U21,U22,U23	AMP-2000 amplifier	Mini-Circuits
25	1	U24	7407 integrated circuit	
26	10	U25,U26,U27,U28,U29,U30, U31,U32,U33,U34	LM361 integrated citcuit	
27	1	U35	74LS20 integrated circuit	
28	2	U36,U37	74LS74 integrated circuit	
29	1	U38	74LS00 integrated circuit	
30	4	N/A	2240B heat sink	Thermalloy

DRAWN BY		MARTIN MARIETTA — MARTIN MARIETTA ENERGY SYSTEMS, INC. ORNL INSTRUMENTATION AND CONTROLS DIVISION Oak Ridge, Tennessee
DRAWING CHECK		
ENGINEER R I CRUTCHER	4/92	
APPROVED J W STAPLETON	5/92	**FACILITY ANTENNA SWITCH PARTS LIST**
F R RUPPEL	5/92	
J E HARDY	5/92	
E C BRADLEY	5/92	
QA W A CAMP	5/92	
		WEST VALLEY TRANSFER CART — PL
		FILE DATE — FILE POINT — BLDG — SHT 1 OF 1 — MF
DRAWING APPROVALS	DATE	ID I&C — Q-6340-182

Item	Quantity	Reference	Part	Vendor
1	38	C1,C2,C3,C4,C5,C6,C7,C8, C9,C10,C11,C12,C13,C14, C16,C17,C18,C19,C20,C21, C22,C23,C24,C25,C26,C27, C28,C29,C30,C31,C32,C33, C34,C35,C39,C40,C41,C42	.1uF	
2	1	C15	.1	
3	3	C36,C37,C38	10uF	
4	2	D1,D2	1N914	
5	1	J1	EDGE CON	
6	1	J2	25X2 R.A.HEADER	
7	2	J3,J4	HEADER	
8	1	J5	3HEADER	
9	8	R1,RN2,R3,R5,R6,R7,R12, R14	10K	
10	7	R2,R4,R8,R9,R10,R11,R16	4.7K	
11	2	R13,R15	33K	
12	1	RN1	10K X 5	
13	1	U1	PAL16R8 WVNSENC3	ORNL Q-6340-022
14	4	U2,U4,U18,U19	C67402	
15	1	U3	54LS373	
16	2	U5,U22	54LS166	
17	1	U6	54LS08	
18	4	U7,U11,U15,U25	67402	
19	1	U8	DP8342	
20	1	U9	PAL20RS8 WVNSENC1	ORNL Q-6340-020
21	2	U10,U29	PAL16R8 WVNSENC2	ORNL Q-6340-021
22	1	U12	54LS273	
23	2	U13,U20	54LS164	
24	1	U14	54LS240	
25	2	U16,U21	9401/8X01	
26	1	U17	74LS74	
27	1	U23	PAL16R8 WVNSDEC1	ORNL Q-6340-023
28	1	U24	DP8343	
29	2	U26,U30	54LS74	
30	1	U27	2MHZ OSC	
31	1	U28	PAL20R8 WVNSDEC2	ORNL Q-6340-024
32	1	U31	54LS161	
33	1	U32	LM161	

DRAWN BY		
DRAWING CHECK		
ENGINEER R I VANDERMOLEN	4/92	
APPROVED J W STAPLETON	5/92	
F R RUPPEL	5/92	
J E HARDY	5/92	
E C BRADLEY	5/92	
QA W A CAMP	5/92	
DRAWING APPROVALS	DATE	

MARTIN MARIETTA — MARTIN MARIETTA ENERGY SYSTEMS, INC.
ORNL INSTRUMENTATION AND CONTROLS DIVISION
Oak Ridge, Tennessee

FACILITY BIPHASE ENCODER/DECODER
PARTS LIST

WEST VALLEY TRANSFER CART — PL

FILE DATE | FILE POINT | BLDG | SHT 1 OF 1 | MF

ID I&C | Q-6340-187

Item	Quantity	Reference	Part	Vendor
1	8	C1,C4,C5,C8,C9,C12,C14,C17	10 uF 35 V tant ECS-FIVE106K	Panasonic
2	24	CU1A,CU1B,C2,CU2A,CU2B, C3,CU3A,CU3B,CU4,C6,C7, CU7,C10,CU10,C11,CU13, CU14,C15,C16,C47,C48, CU52,C53,C58	0.1 uF 1C25Z5V104M050B	Sprague
3	3	C13,C49,C50	2.2 uF 3C37Z5U225M050B	Sprague
4	2	D2,D3	1N5245B	
5	33	D4,D5,D6,D7,D8,D9,D10, D14,D23,D24,D25,D26,D27, D28,D29,D33,D42,D43,D44, D45,D52,D59,D60,D61,D64, D65,D66,D67,D68,D69,D70, D71,D75	1N914B	
6	37	D11,D12,D13,D15,D16,D17, D18,D21,D22,D30,D31,D32, D34,D35,D36,D40,D41,D47, D48,D49,D50,D51,D53,D55, D56,D57,D58,D62,D63,D72, D73,D74,D76,D77,D78,D82, D83	1N5231B	
7	1	D54	1N5242B	
8	1	DA3	MAD1103, diode array	Motorola
9	1	HDR1	87586-9	AMP
10	1	HDR2	102202-5	AMP
11	1	HDR3,HDR5	2-380991-0	AMP
12	1	HDR4,HDR10	2-380999-0	AMP
13	1	HDR6	S-1211-4	Digikey
14	1	HDR7,HDR8,HDR9	1-87227-3	AMP
15	4	HDR11,HDR12,HDR15,HDR16	1-103183-1	AMP
16	2	HDR13,HDR14	103176-5	AMP
17	6	Q1,Q2,Q3,Q4,Q5,Q6	IRF9540	
18	7	Q8,Q9,Q13,Q18,Q19,Q21, Q23	2N3906	
19	12	Q10,Q11,Q12,Q14,Q15,Q16, Q17,Q20,Q22,Q24,Q25,Q26	2N3904	
20	24	R1,R2,R35,R39,R43,R44, R59,R60,R64,R68,R76,R77, R79,R80,R81,R82,R84,R86, R87,R91,R110,R111,R115, R119	10 kohm 1/8 W 1% metal film	
21	3	R5,R6,R7	0.01 ohm LVF10 10 W 1%	RCD

DRAWN BY			MARTIN MARIETTA — MARTIN MARIETTA ENERGY SYSTEMS, INC. ORNL INSTRUMENTATION AND CONTROLS DIVISION Oak Ridge, Tennessee
DRAWING CHECK			
ENGINEER	A V BLALOCK	5/92	
APPROVED	J W STAPLETON	5/92	**INTERFACE MODULE, TOP BOARD PARTS LIST**
	F R RUPPEL	5/92	
	J E HARDY	5/92	
	E C BRADLEY	5/92	
QA	W A CAMP	5/92	
			WEST VALLEY TRANSFER CART — PL
			FILE DATE — FILE POINT — BLDG — SHT 1 OF 2 — MF
	DRAWING APPROVALS	DATE	ID I&C — Q-6340-224

Item	Quantity	Reference	Part	Vendor
22	3	R8,R16,R19	100 ohm, 1/8 W, 1%, metal film	
23	1	R9	2.87 kohm, 1/8 W, 1%, metal film	
24	4	R10,R11,R17,R85	100 kohm, 1/8 W, 1%, metal film	
25	8	R12,R13,R14,R15,R18,R36, R37,R38	1 Mohm, 1/8 W, 1%, metal film	
26	1	R20	82.5 kohm, 1/8 W, 1%, metal film	
27	24	R21,R22,R24,R25,R26,R27, R45,R46,R48,R49,R50,R51, R69,R70,R71,R72,R73,R95, R96,R97,R99,R100,R101,R102	4.64 kohm, 1/8 W, 1%, metal film	
28	16	R23,R28,R33,R34,R47,R52, R57,R58,R88,R89,R90,R92, R98,R103,R108,R109	1 kohm, 1/8 W, 1% metal film	
29	8	R29,R30,R53,R54,R75,R94, R104,R105	3.83 kohm, 1/8 W, 1%, metal film	
30	8	R31,R32,R55,R56,R74,R93, R106,R107	7.5 kohm, 1/8 W, 1%, metal film	
31	1	S1	2-435640-9	AMP
32	2	U1,U2	AMP03FP	PMI
33	1	U3	OP215EZ	PMI
34	4	U4,U7,U13,U14	74HC00N	
35	8	U5,U6,U8,U9,U11,U12,U15, U16	MAX626MJA	Maxim
36	1	U10	OP15EZ	PMI
37	1	U52	LF356AN	National

DRAWN BY			MARTIN MARIETTA — MARTIN MARIETTA ENERGY SYSTEMS, INC. ORNL INSTRUMENTATION AND CONTROLS DIVISION Oak Ridge, Tennessee
DRAWING CHECK			
ENGINEER	A V BLALOCK	5/92	
APPROVED	J W STAPLETON	5/92	INTERFACE MODULE, TOP BOARD PARTS LIST
	F R RUPPEL	5/92	
	J E HARDY	5/92	
	E C BRADLEY	5/92	
QA	W A CAMP	5/92	
			WEST VALLEY TRANSFER CART — PL
			FILE DATE — FILE POINT — BLDG — SHT 2 OF 2 — MF
DRAWING APPROVALS		DATE	ID I&C — Q-6340-224

Item	Quantity	Reference	Part	Vendor
1	4	C33,C34,C36,C37	2.2uF	Sprague 3C37Z5U225M050B
2	36	CU34,C35,CU35,CU36,CU37, C38,CU38A,CU38B,C39,CU39, C40,CU40,C41,CU41,C42, CU42A,CU42B,CU43A,CU43B, CU44A,CU44B,CU45A,CU45B, CU46A,CU46B,CU47A,CU47B, CU48A,CU48B,CU49A,CU49B, CU50A,CU50B,C51,C52,CU68	0.1uF	Sprague 1C25Z5U104M050B
3	12	D1,D87,D88,D89,D90,D91, D92,D93,D94,D95,D96,D99	1N5231BPH Zener, 5.1V	Philips
4	3	D97,D98,D100	1N5245BPH Zener, 15V	Philips
5	2	DA4,DA5	MAD1103	Motorola
6	4	HDR11P,HDR12P,HDR15P,HDR16P	26 Pin Header	AMP 1-87227-3
7	2	HDR13P,HDR14P	8 Pin Header	AMP 87224-8
*8	4	HDR15S,HDR16S	26 Socket Header	AMP 1-103183-1
*9	2	HDR13S,HDR14S	8 Socket Header	AMP 103176-5
10	5	Q42,Q44,Q45,Q46,Q49	IRF9540	International Rectifier
11	3	Q43,Q47,Q48	2N3904	National
12	14	R3,R40,R215,R226,R227, R228,R235,R236,R237,R255, R261,R263,R275,R276	100k, 1/8W, 1% tol, Metal Film	
13	30	R177,R178,R179,R180,R181, R182,R183,R184,R185,R186, R195,R196,R201,R202,R203, R204,R209,R210,R212,R213, R221,R240,R241,R242,R259, R260,R262,R264,R265,R274	10k, 1/8W, 1% tol, Metal Film	
14	6	R4,R187,R189,R190,R191,R216,R239	1.0k, 1/8W, 1% tol, Metal Film	
15	6	R188,R192,R193,R194,R232, R238	1.62k, 1/8W, 1% tol, Metal Film	
16	5	R197,R198,R199,R200,R211	1.0M, 1/8W, 1% tol, Metal Film	
17	14	R205,R206,R207,R208,R220, R225,R229,R234,R252,R254, R256,R270,R271,R277	100, 1/8W, 1% tol, Metal Film	
18	6	R214,R219,R222,R224,R251, R253	1M, 1/8W, 1% tol, Metal Film	
19	2	R217,R233	46.4k, 1/8W, 1% tol, Metal Film	
20	2	R218,R223	2.87k, 1/8W, 1% tol, Metal Film	
21	2	R230,R231	0.01, 1%, 10W, RCD LVF	
22	4	R243,R245,R247,R250	3.83k, 1/8W, 1% tol, Metal Film	
23	4	R244,R246,R248,R249	90.9k, 1/8W, 1% tol, Metal Film	
24	3	R257,R268,R272	12.1k, 1/8W, 1% tol, Metal Film	
25	2	R258,R273	13.3k, 1/8W, 1% tol, Metal Film	
26	1	R266	68.1, 1/8W, 1% tol, Metal Film	
27	1	R267	825, 1/8W, 1% tol, Metal Film	
28	1	R269	6.19k, 1/8W, 1% tol, Metal Film	
29	3	U34,U35,U40	74HC74N	National
30	2	U36,U37	LM339AJ	National
31	3	U38,U45,U50	OP215EZ	PMI
32	2	U39,U41	74HC00N	National
33	5	U42,U43,U44,U46,U48	AMP03FP	PMI
34	2	U47,U49	AD708BQ	Analog Devices
35	1	U51	AD592CN	Analog Devices

* NOTE: items 8 & 9 are mounted to solder side of PCB

DRAWN BY			MARTIN MARIETTA ENERGY SYSTEMS, INC. ORNL INSTRUMENTATION AND CONTROLS DIVISION Oak Ridge, Tennessee
DRAWING CHECK			
ENGINEER	A V BLALOCK	5/92	
APPROVED	J W STAPLETON	5/92	INTERFACE MODULE, MIDDLE BOARD PARTS LIST
	F R RUPPEL	5/92	
	J E HARDY	5/92	
	E C BRADLEY	5/92	
QA	W A CAMP	5/92	
			WEST VALLEY TRANSFER CART — PL
			FILE DATE / FILE POINT / BLDG / SHT 1 OF 1 / MF
DRAWING APPROVALS		DATE	ID I&C — Q-6340-229

Item	Quantity	Reference	Part	Vendor
1	9	C18,C19,C20,C21,C23,C28, C29,C30,C32	2.2uF	Sprague 3C37Z5U225M050B
2	2	C22,C31	0.01uF	Sprague 1C25Z5U103M050B
3	41	CU17A,CU17B,CU18A,CU18B, CU19A,CU19B,CU20A,CU20B, CU21A,CU21B,CU22A,CU22B, CU23A,CU23B,C24,CU24,C25, CU25A,CU25B,C26,CU26A, CU26B,C27,CU27A,CU27B, CU28A,CU28B,CU29,CU30A, CU30B,CU31A,CU31B,CU32A, CU32B,CU33A,CU33B,C43, C44,C45,C46,C54	0.1uF	Sprague 1C25Z5U104M050B
4	3	C55,C56,C57	47uF	Panasonic ECE-A1HU470
5	3	D84,D85,D86	1N5231BPH	Philips
6	2	DA1,DA2	MAD1103	Motorola
7	4	HDR15P,HDR16P	26 Pin Header	AMP 1-87227-3
8	4	HDR13P,HDR14P	8 Pin Header	AMP 87224-8
9	8	Q27,Q29,Q31,Q33,Q35,Q38, Q40,Q41	IRFZ40	International Rectifier
10	6	Q28,Q30,Q32,Q34,Q36,Q39	2N3904	
11	1	Q37	2N3906	
12	4	R120,R121,R122,R149	46.4k, 1/8W, 1% tol, Metal Film	
13	4	R123,R124,R125,R126	2.87k, 1/8W, 1% tol, Metal Film	
14	9	R127,R128,R148,R158,R160, R161,R162,R163,R172	1M, 1/8W, 1% tol, Metal Film	
15	8	R129,R130,R131,R132,R164, R165,R166,R173	100, 1/8W, 1% tol, Metal Film	
16	2	R133,R159	1.0k, 1/8W, 1% tol, Metal Film	
17	13	R134,R135,R136,R137,R138, R139,R140,R141,R142,R143, R144,R146,R147	100k, 1/8W, 1% tol, Metal Film	
18	7	R145,R150,R151,R152,R153, R154,R155	10k, 1/8W, 1% tol, Metal Film	
19	1	R156	47.5k, 1/8W, 1% tol, Metal Film	
20	1	R157	0.01, 1%, 10W, RCD LVF	
21	8	R167,R168,R169,R170,R171, R174,R175,R176	215k, 1/8W, 1% tol, Metal Film	
22	9	U17,U18,U19,U22,U23,U26, U27,U32,U33	AMP03FP	PMI
23	4	U20,U21,U28,U31	OP215EZ	PMI
24	1	U24	74HC138N	National
25	1	U25	LF356AN	National
26	1	U29	AD584KH	Analog Devices
27	1	U30	AD707BQ	Analog Devices

DRAWN BY			MARTIN MARIETTA — MARTIN MARIETTA ENERGY SYSTEMS, INC. ORNL INSTRUMENTATION AND CONTROLS DIVISION Oak Ridge, Tennessee
DRAWING CHECK			
ENGINEER	A V BLALOCK	5/92	
APPROVED	J W STAPLETON	5/92	INTERFACE MODULE, BOTTOM BOARD PARTS LIST
	F R RUPPEL	5/92	
	J E HARDY	5/92	
	E C BRADLEY	5/92	
QA	W A CAMP	5/92	
			WEST VALLEY TRANSFER CART — PL
			FILE DATE — FILE POINT — BLDG — SHT 1 OF 1 — MF
	DRAWING APPROVALS	DATE	ID I&C — Q-6340-233

Item	Quantity	Reference	Part	Vendor
1	1	C1	1000uF	Panasonic ECA-1HFQ102
2	1	C2	0.1uF	Panasonic ECF-F1H104ZF5
3	1	F1	20AMP, 3AG	
4	2	HDR1,HDR2	4X2 Header	AMP 350212-2
5	2	Q1,Q2	MJH6285 PNP	Motorola
6	2	Q3,Q4	MJH6282 NPN	Motorola
7	1	R1	.01 ohm, 1%, 10W, RCD LVF	

DRAWN BY		
DRAWING CHECK		
ENGINEER	A V BLALOCK	5/92
APPROVED	J W STAPLETON	5/92
	F R RUPPEL	5/92
	J E HARDY	5/92
	E C BRADLEY	5/92
QA	W A CAMP	5/92
DRAWING APPROVALS		DATE

MARTIN MARIETTA

MARTIN MARIETTA ENERGY SYSTEMS, INC.
ORNL INSTRUMENTATION AND CONTROLS DIVISION
Oak Ridge, Tennessee

MOTOR DRIVER
PARTS LIST

WEST VALLEY TRANSFER CART — PL

FILE DATE | FILE POINT | BLDG | SHT 1 OF 1 | MF

ID I&C — Q-6340-236

Item	Quantity	Reference	Part	Vendor
1	10	C1,C2,C3,C4,C5,C14,C24, C27,C28,C29	10 uF 35 V tant T1M106K035P0Y	Mallory
2	9	C6,C7,C8,C9,C10,C11,C12, C22,C25	0.1 uF 50 V ceramic monolithic	
3	1	C13	10 pF 5% silver mica	
4	6	C15,C16,C17,C18,C23,C26	0.1 uF 50 V surface mount ceramic monolithic	
5	2	C19,C20	5pF 5% silver mica	
6	1	C21	2.8-12 pf variable 24AA021	Mouser
7	1	C30	1200 pF 5% silver mica	
8	2	D1,D2	HP5082-2800 diode	Hewlett-Packard
9	2	D3,D4	1N827A diode	
10	1	J1	SMA rt angle 142-0299-001	EF Johnson
11	1	J2	2-pin right angle header	
12	4	L1,L2,L3,L4	ferrite bead EXC-ELSR35S	Panasonic
13	2	Q1,Q2	2N3906 transistor	
14	1	R1	392 ohm, 1%, 1/4 W	
15	2	R2,R3	10 k-ohm, 1%, 1/4 W	
16	1	R4	10 k-ohm pot, 66W-R10K	Beckman
17	2	R5,R12	100 k-ohm, 1%, 1/4 W	
18	2	R6,R7	33.2 k-ohm, 1%, 1/4 W	
19	2	R8,R9	221 ohm, 1%, 1/4 W	
20	2	R10,R11	51.1 ohm, 1%, 1/4 W	
21	3	R13,R20,R21	150 ohm, 1%, 1/4 W	
22	2	R14,R15	10 ohm, 1%, 1/4 W	
23	1	R16	20 k-ohm, 1%, 1/4 W	
24	2	R17,R19	1.00 k-ohm, 1%, 1/4 W	
25	1	R18	10 k-ohm pot, 76PR10K	Beckman
26	1	R22	7500 ohm, 1%, 1/4 W	
27	2	U1,U2	TFM-15 mixer	Mini-Circuits
28	4	U3,U4,U5,U6	AMP-2000 amplifier	Mini-Circuits
29	2	U7,U8	PSC-2-5 splitter	Mini-Circuits
30	1	U9	OP27 op amp	PMI
31	1	U10	5MC10-915-U26-P/P	K & L Filter
32	1	U11	WJ-L42 limiter	Watkins-Johnson
33	2	U12,U14	MAT-3 attenuator	Mini-Circuits
34	1	U13	TFM-150 mixer	Mini-Circuits
35	1	U15	HA2540 op amp	Harris
36	1	W1	RG-58, 31 inches, coiled	
37	4	N/A	2240B heat sink	Thermalloy

DRAWN BY			MARTIN MARIETTA ENERGY SYSTEMS, INC. ORNL INSTRUMENTATION AND CONTROLS DIVISION Oak Ridge, Tennessee
DRAWING CHECK			
ENGINEER	R I CRUTCHER	4/92	
APPROVED	J W STAPLETON	5/92	FACILITY/CART RECEIVER PARTS LIST
	F R RUPPEL	5/92	
	J E HARDY	5/92	
	E C BRADLEY	5/92	
QA	W A CAMP	5/92	
			WEST VALLEY TRANSFER CART — PL
			FILE DATE — FILE POINT — BLDG — SHT 1 OF 1 — MF
DRAWING APPROVALS		DATE	ID I&C — Q-6340-262

Item	Quantity	Reference	Part	Vendor
1	4	C1,C2,C15,C16	5 pF 5% silver mica	
2	9	C3,C5,C7,C17,C19,C21, C33,C34,C35	10 uF 35 V tant T1M106K035P0Y	Mallory
3	24	C4,C6,C8,C9,C10,C11,C12, C13,C14,C18,C20,C22,C23, C24,C25,C26,C27,C28,C29, C30,C31,C32,C42,C43	0.1 uF 50 V ceramic monolithic	
4	6	C36,C37,C38,C39,C40,C41	0.1 uF 50 V surface mount ceramic monolithic	
5	4	D1,D2,D3,D4	HP5082-2800 diode	Hewlett-Packard
6	4	J2,J3,J4,J5	SMA rt angle 142-0299-001	EF Johnson
7	1	J6	6-pin right angle header	
8	2	JP1,JP2	jumper	
9	6	L1,L2,L3,L4,L5,L6	ferrite bead EXC-ELSR35S	Panasonic
10	2	R1,R6	100 k-ohm, 1%, 1/4 W	
11	6	R2,R3,R7,R8,R10,R11	301 ohm, 1%, 1/4 W	
12	1	R4	50.1 ohm, 1%, 1/4 W	
13	2	R5,R9	10.0 k-ohm, 1%, 1/4 W	
14	1	R12	10 k-ohm pot, 76PR10K	Beckman
15	3	TP1,TP2,TP3	1-pin straight header	
16	2	U13,U35	MAT-3 attenuator	Mini-Circuits
17	1	U14	74LS132 integrated circuit	
18	1	U15	7406 integrated circuit	
19	2	U16,U25	TO-0812LN amplifier	Mini-Circuits
20	4	U17,U20,U26,U29	AMP-2000 amplifier	Mini-Circuits
21	2	U18,U27	5MC10-915-U26-P/P	K & L Filter
22	2	U19,U28	PSC-2-5 splitter	Mini-Circuits
23	3	U21,U30,U32	PSW1211 switch	Mini-Circuits
24	1	U22	74LS74 integrated circuit	
25	2	U23,U34	OP27 op amp	PMI
26	3	U24,U31,U33	LM361 integrated circuit	
27	6	N/A	2240B heat sink	Thermalloy

DRAWN BY		
DRAWING CHECK		
ENGINEER R I CRUTCHER	4/92	
APPROVED J W STAPLETON	5/92	
F R RUPPEL	5/92	
J E HARDY	5/92	
E C BRADLEY	5/92	
QA W A CAMP	5/92	
DRAWING APPROVALS	DATE	

MARTIN MARIETTA — MARTIN MARIETTA ENERGY SYSTEMS, INC.
ORNL INSTRUMENTATION AND CONTROLS DIVISION
Oak Ridge, Tennessee

CART ANTENNA CONTROL PARTS LIST

WEST VALLEY TRANSFER CART — PL

FILE DATE | FILE POINT | BLDG | SHT 1 OF 1 | MF

ID I&C — Q-6340-267

Item	Quantity	Reference	Part	Vendor
1	6	C1,C3,C11,C13,C15,C19	10 uF 35 V tantalum ECS-F1VE106K	Panasonic
2	1	C2	0.01 uF 50 V ceramic monolithic	
3	5	C4,C8,C12,C16,C21	0.1 uF 50 V ceramic monolithic	
4	2	C5,C9	1 uF 35 V tantalum ECS-F1VE105K	Panasonic
5	2	C6,C7,C14,C22	0.1 uF 50 V surface mount ceramic monolithic	
6	1	C10	2.8-12 pF variable 24AA021	Mouser
7	2	C17,C20	22 pF 50 V surface mount ceramic monolithic	
8	1	C18	100 pF 50 V surface mount ceramic monolithic	
9	3	D1,D2,D5	1N827A diode	
10	2	D3,D4	1N4446 diode	
11	1	J2	4-pin rt angle header	
12	1	J3	SMA rt angle 142-0299-001	EF Johnson
13	1	L1	20-T #30 AWG magnet wire on 1 megohm 1/2 W carbon resistor	
14	1	L2	ferrite bead EXC-ELSR35S	Panasonic
15	1	Q1	2N3904 transistor	
16	3	Q2,Q3,Q4	2N3906 transistor	
17	2	R1,R10	1.00 k-ohm, 1%, 1/4 W	
18	2	R2,R6	100 ohm pot 66W-100	Beckman
19	4	R3,R4,R5,R11	100 ohm, 1%, 1/4 W	
20	2	R7,R20	301 ohm, 1%, 1/4 W	
21	2	R8,R9	10 ohm, 1%, 1/4 W	
22	3	R12,R15,R16	3.01 k-ohm, 1%, 1/4 W	
23	1	R13	10.0 k-ohm, 1%, 1/4 W	
24	1	R14	4.99 k-ohm, 1%, 1/4 W	
25	1	R17	1.50 k-ohm, 1%, 1/4 W	
26	1	R18	200 ohm, 1%, 1 W	
27	1	R19	60.4 ohm, 1%, 1/2 W	
28	1	U1	HA2540 op amp	Harris
29	1	U2	MSA-0404 amplifier	Avantek
30	1	U3	AMP-2000 amplifier	Mini-Circuits
31	1	Z1	C580T oscillator	Z-Comm
32	1	Z2	MAT15 attenuator	Mini-Circuits
33	1	N/A	2240B heat sink	Thermalloy

DRAWN BY		
DRAWING CHECK		
ENGINEER	R I CRUTCHER	4/92
APPROVED	J W STAPLETON	5/92
	F R RUPPEL	5/92
	J E HARDY	5/92
	E C BRADLEY	5/92
QA	W A CAMP	5/92
	DRAWING APPROVALS	DATE

MARTIN MARIETTA — MARTIN MARIETTA ENERGY SYSTEMS, INC.
ORNL INSTRUMENTATION AND CONTROLS DIVISION
Oak Ridge, Tennessee

CART TRANSMITTER PARTS LIST

WEST VALLEY TRANSFER CART — PL

FILE DATE | FILE POINT | BLDG | SHT 1 OF 1 | MF

ID I&C — Q-6340-272

Item	Quantity	Reference	Part	Vendor
1	39	C1,C2,C3,C4,C5,C6,C7,C8, C9,C10,C11,C12,C13,C14, C15,C16,C17,C18,C19,C20, C21,C22,C23,C24,C25,C26, C27,C28,C29,C31,C32,C33, C34,C36,C40,C41,C42,C43, C53	.1uF	
2	1	C30	.1	
3	3	C37,C38,C39	10uF	
4	2	D1,D2	1N914	
5	6	J1,JP1,J2,J3,J4,J5	HEADER	
6	1	J6	EDGE CON	
7	1	Q1	2N3904	
8	2	R1,R5	33K	
9	7	R2,R3,R7,R8,R13,R14,R15	4.7K	
10	7	R4,R6,R9,R10,R11,R12,R16	10K	
11	1	RN1	10K X 5	
12	1	RN2	10K X 9	
13	2	U1,U21	54LS164	
14	4	U2,U10,U11,U12	C67402	
15	1	U3	DP8342	
16	1	U4	54LS373	
17	4	U5,U13,U15,U25	67402	
18	2	U6,U32	54LS74	
19	1	U7	LM161	
20	1	U8	PAL16R8 WNSENC3	ORNL Q-6340-022
21	2	U9,U24	54LS166	
22	1	U14	PAL16R8 WNSDEC1	ORNL Q-6340-023
23	1	U16	DP8343	
24	1	U17	PAL20RS8 WNSENC1	ORNL Q-6340-020
25	2	U18,U34	PAL16R8 WNSENC2	ORNL Q-6340-021
26	2	U19,U31	9401/8X01	
27	1	U20	54LS08	
28	1	U22	54LS273	
29	1	U23	74LS682	
30	1	U26	74LS74	
31	1	U27	2MHZ OSC	
32	1	U28	54LS240	
33	1	U29	54LS161	
34	1	U30	74LS14	
35	1	U33	PAL20R8 WNSDEC2	ORNL Q-6340-024

DRAWN BY		
DRAWING CHECK		
ENGINEER	R I VANDERMOLEN	4/92
APPROVED	J W STAPLETON	5/92
	F R RUPPEL	5/92
	J E HARDY	5/92
	E C BRADLEY	5/92
QA	W A CAMP	5/92
DRAWING APPROVALS		DATE

MARTIN MARIETTA — MARTIN MARIETTA ENERGY SYSTEMS, INC.
ORNL INSTRUMENTATION AND CONTROLS DIVISION
Oak Ridge, Tennessee

CART BIPHASE ENCODER/DECODER PARTS LIST

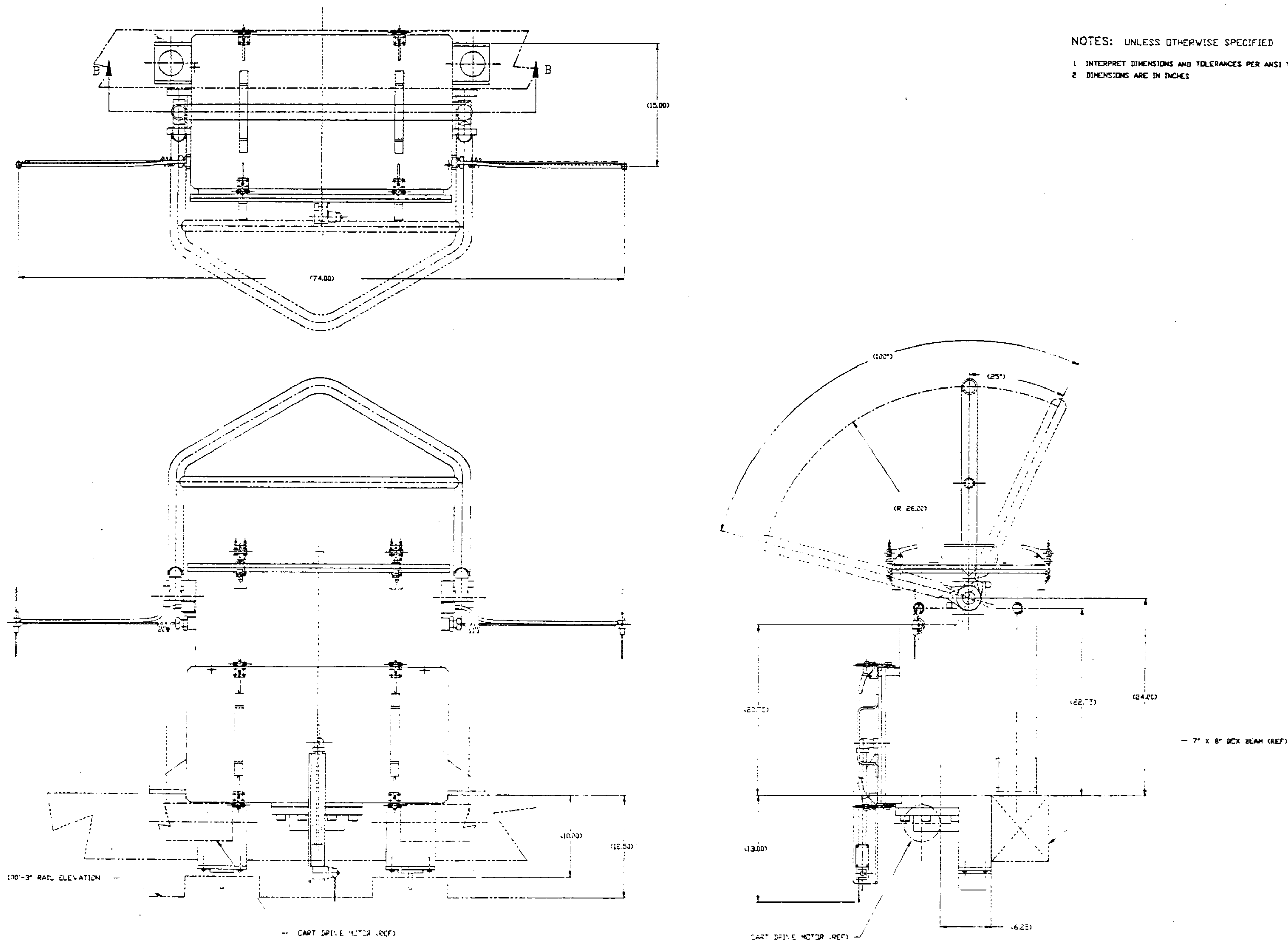
WEST VALLEY TRANSFER CART — PL

FILE DATE | FILE POINT | BLDG | SHT 1 OF 1 | MF

ID I&C — Q-6340-292

NOTES: UNLESS OTHERWISE SPECIFIED

1 INTERPRET DIMENSIONS AND TOLERANCES PER ANSI Y14.5M
2 DIMENSIONS ARE IN INCHES



CERTIFIED FOR CONSTRUCTION

DO NOT REVISE MANUALLY

DES J.W. STAPLETON 2/92
DRW K. L. FARLEY 2/92

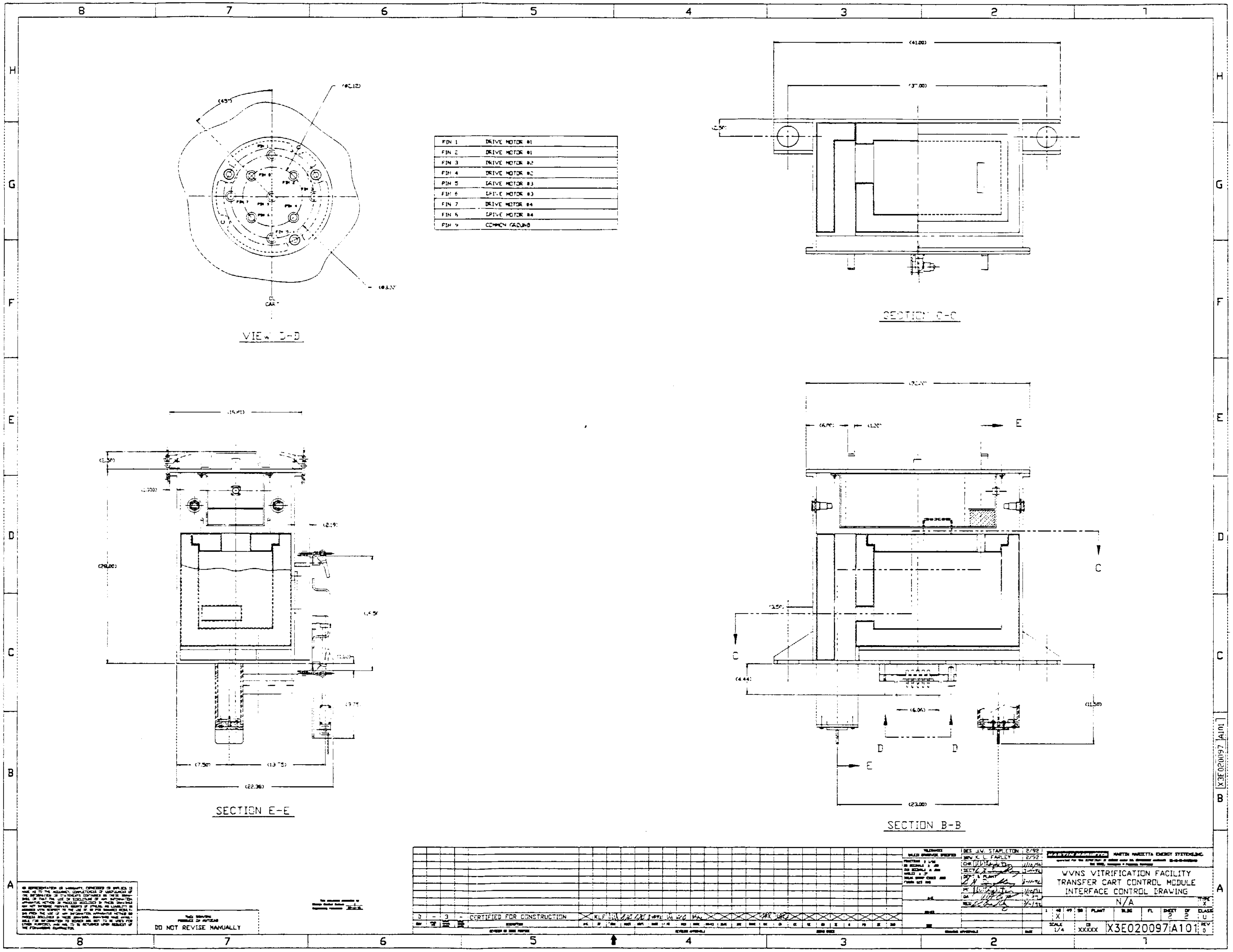
MARTIN MARIETTA ENERGY SYSTEMS, INC.

WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
INTERFACE CONTROL DRAWING

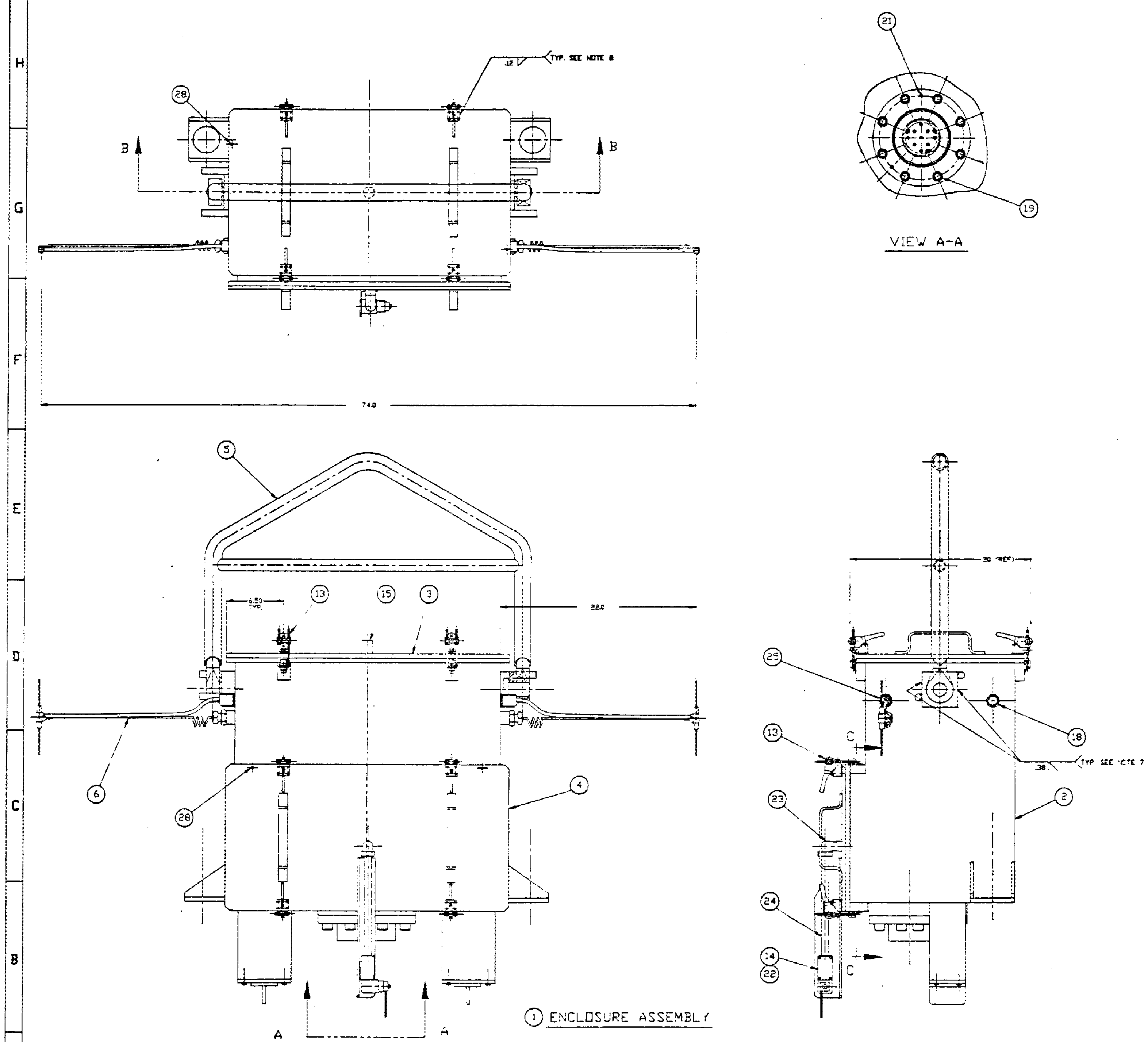
N/A

SHEET 1 OF 2

SCALE 1/4 ID XXXXX X3E020097A101 REV 0



VIEW D-D
SECTION C-C
SECTION E-E
SECTION B-B
PIN 1 DRIVE MOTOR #1
PIN 2 DRIVE MOTOR #1
PIN 3 DRIVE MOTOR #2
PIN 4 DRIVE MOTOR #2
PIN 5 DRIVE MOTOR #3
PIN 6 DRIVE MOTOR #3
PIN 7 DRIVE MOTOR #4
PIN 8 DRIVE MOTOR #4
PIN 9 COMMON GROUND
(41.00)
(23.00)
(22.36)
DO NOT REVISE MANUALLY
CERTIFIED FOR CONSTRUCTION
DES J.W. STAPLETON 2/92
DRW K. L. FARLEY 2/92
MARTIN MARIETTA ENERGY SYSTEMS, INC.
WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
INTERFACE CONTROL DRAWING
N/A
SHEET 2 OF 2
SCALE 1/4
XXXXX
X3E020097 A101
REV 0



NOTES: UNLESS OTHERWISE SPECIFIED

1 INTERPRET DIMENSIONS AND TOLERANCES PER ANSI Y14.5M
2 DIMENSIONS ARE IN INCHES
3 INTERPRET WELDING AND NONDESTRUCTIVE EXAMINATION SYMBOLS PER ANSI/AWS A2.4.
4 USE PROCEDURES, WELDERS, WELDING OPERATORS AND TACKERS QUALIFIED PER AWS B2.1.
5 VISUALLY INSPECT ALL WELDS PER AWS D14.4, PART E, CLASS III.
6 WELD INSPECTORS QUALIFIED PER AWS QC-1-88.
7 LOCATE BAIL ASSEMBLY (FIND # 5) NEAREST TO CENTER OF GRAVITY PRIOR TO WELDING AT ASSEMBLY.
8 LOCATE DESTACO CLAMPS (FIND # 13) PRIOR TO WELDING AT ASSEMBLY.
9 APPLY TYPE 44 HEAT SINK COMPOUND, NEWARK STOCK #002763, TO ITEM 26 BEFORE ASSEMBLY WITH ITEM 2
10 LOCATE ITEM 28 IN ITEM 2 FROM ITEM 3 AND ITEM 4. ITEM 28 TO BE PRESS FIT IN ITEM 2.
11 RTV SEAL WITH DOW-CORNING #732 CLEAR
12 LOCATE ITEM 21 FROM ITEM 10 FOR PRESS FIT IN ITEM 2.

NOTE	QTY	CAGE CODE	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	FIND NO
10	4			.250x1.00 DOWEL	300 SERIES SST	ANSI B5.20	28
	8			.25-20X.75 HHCS	300 SERIES SST		27
9	1		X3E020097A109-6	PLATE			26
	2			RECEPTACLE PSA-4E-250-SLLC95	LEMO USA INC SANTA ROSA, CA 95406		25
	1			.50 SCH 40 12" NIPPLE	304 SST		24
	1			.50 STREET ELBOW	304 SST		23
	4			.25-20x.62 SHCS	300 SERIES SST	ANSI B18.3	22
12	2			.375x1.50 DOWEL	300 SERIES SST	ANSI B5.20	21
11	16			.25-20X1.25 HHCS	300 SERIES SST	ANSI B18.2.1	20
	8			.75-10x1.75 SHCS	300 SERIES SST	ANSI B18.3	19
	2			RECEPTACLE PSA-4E-302-SLL	LEMO USA INC SANTA ROSA, CA 954061		18
	1			O-RING #02-263	E740-75	AS-568A	17
	1			O-RING #02-252	E740-75	AS-568A	16
	1			HEPA FILTER NUCFIL-052	NFT INC. GOLDEN, CO 80401		15
	1			MICRO SWITCH #1LS1-4N STN.STL.	MICRO SWITCH FREEPORT, IL 61032		14
	8			DESTACO CLAMP # 334-SS	DE-STA-CO TROY, MI 48007-2800		13
11	2		X3E020097A109-1	BATTERY CHG PLATE			12
11	2		X3E020097A109-5	CHARGING SHOE INSULATOR			11
	1		X3E020097A107-1	REMOTE CONNECTOR ASSEMBLY			10
	1		X3E020097A112-3	SHIELD, BASE			9
	1		X3E020097A112-2	SHIELD, TOP			8
	1		X3E020097A112-1	SHIELD, SIDE			7
	1		X3E020097A111-1	ANTENNA ASSEMBLY			6
	2		X3E020097A106-1	BAIL ASSEMBLY			5
	1		X3E020097A106-5	COVER			4
	1		X3E020097A105-1	BATTERY COMPARTMENT ASSEMBLY			3
	1		X3E020097A103-1	ENCLOSURE			2
	AR		-1	ENCLOSURE ASSEMBLY			1

← NEXT ASSEMBLY — PARTS LIST

DES J.W. STAPLETON 2/92
DRW K. L. FARLEY 2/92

MARTIN MARIETTA ENERGY SYSTEMS, INC.

WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
ENCLOSLURE ASSEMBLY

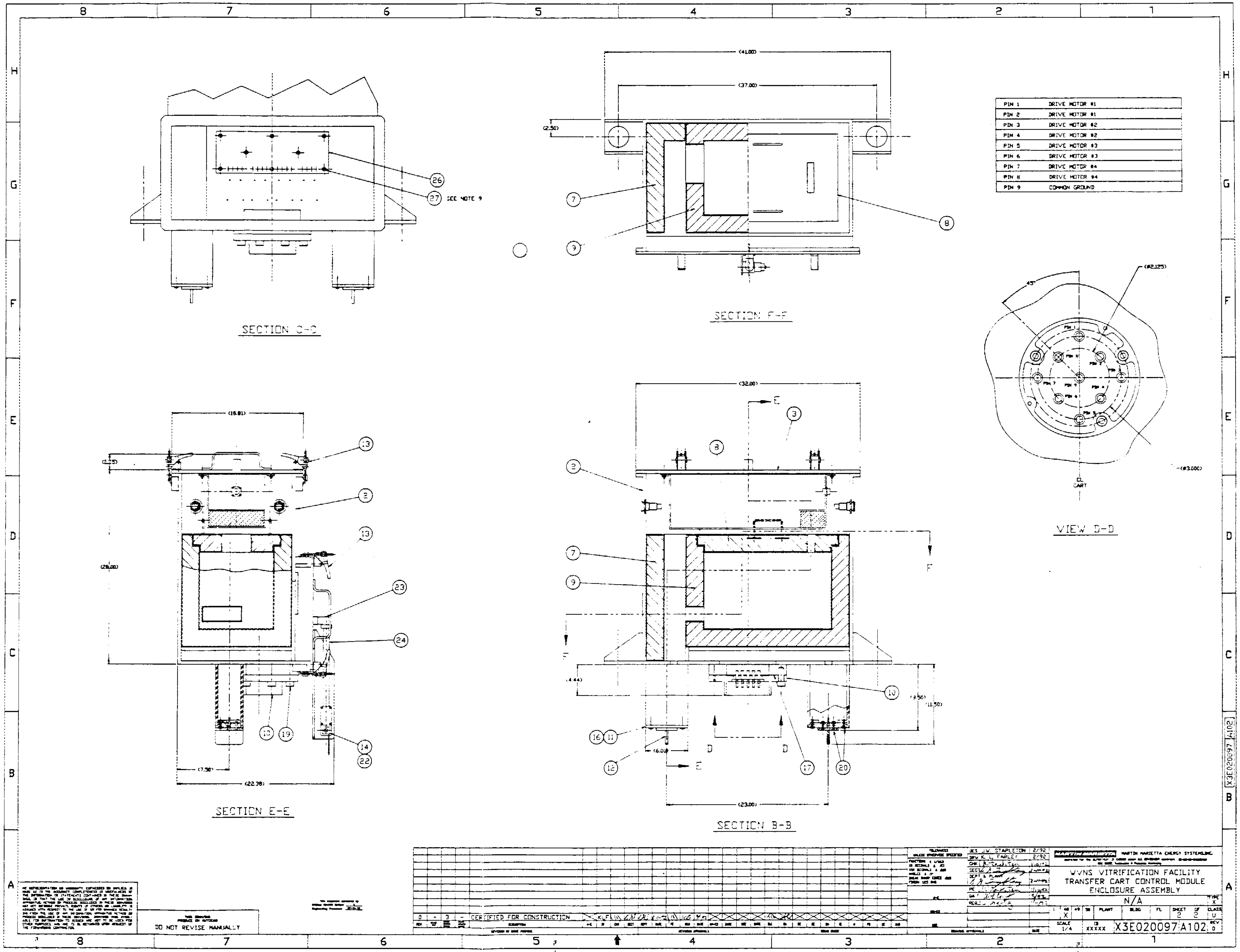
N/A

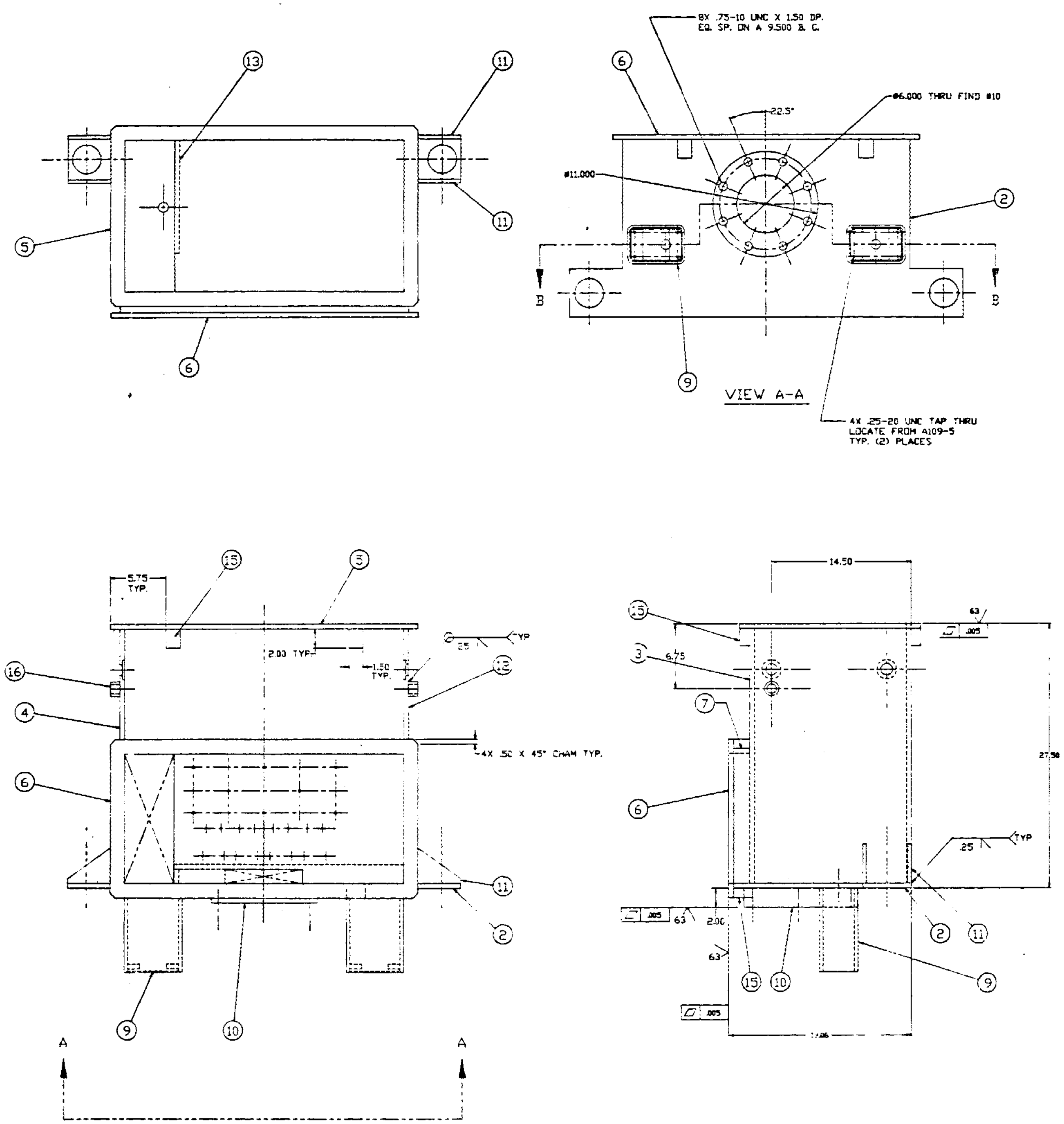
SHEET 1 OF 2

SCALE 1/4 — XXXXX — X3E020097 A102

CERTIFIED FOR CONSTRUCTION

DO NOT REVISE MANUALLY


SECTION C-C
SECTION F-F
VIEW D-D
SECTION E-E
SECTION B-B
(41.00)
(37.00)
(32.00)
(23.00)
(22.38)
(16.81)
(7.50)
SEE NOTE 9
PIN 1 DRIVE MOTOR #1
PIN 2 DRIVE MOTOR #1
PIN 3 DRIVE MOTOR #2
PIN 4 DRIVE MOTOR #2
PIN 5 DRIVE MOTOR #3
PIN 6 DRIVE MOTOR #3
PIN 7 DRIVE MOTOR #4
PIN 8 DRIVE MOTOR #4
PIN 9 COMMON GROUND
DO NOT REVISE MANUALLY
CERTIFIED FOR CONSTRUCTION
DES J.W. STAPLETON 2/92
DRW K. L. FARLEY 2/92
MARTIN MARIETTA ENERGY SYSTEMS, INC.
WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
ENCLOSURE ASSEMBLY
N/A
SCALE 1/4
XXXXX
X3E020097 A102
REV 0



NOTES: UNLESS OTHERWISE SPECIFIED

1 INTERPRET DIMENSIONS AND TOLERANCES PER ANSI Y14.5M
2 DIMENSIONS ARE IN INCHES
3 INTERPRET WELDING AND NONDESTRUCTIVE EXAMINATION SYMBOLS PER ANSI/AWS A2.4.
4 USE PROCEDURES, WELDERS, WELDING OPERATORS AND TACKERS QUALIFIED PER ASW B2.1.
5 VISUALLY INSPECT ALL WELDS PER AWS D14.4, PART E, CLASS III.
6 WELD INSPECTORS QUALIFIED PER AWS QC-1-88.
7 NORMALIZE FIND #1 PRIOR TO FINAL MACHINING.

QTY	CAGE CODE	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	FIND NO
AR			WELD FILLER METAL		AWS ER 308	17
2		X3E020097A109-7	BOSS			16
8		-15	1" X 1.5" BAR	304 SST		15
1		-14	FLOOR	.50 THK. STN. STL. UNS 30400	ASTM A240	14
1		-13	RIB			13
1		X3E020097A104-5	SIDE PLATE			12
4		-11	GUSSET	.38 THK. STN. STL. UNS 30400		11
1		-10	FLANGE	2.00 THK. STN. STL. UNS 30400		10
2		-9	RECT. TUBE	6 X 4 .38 WALL UNS 30400	ASTM A554	9
4		-8	MTG PL	.50 THK. STN. STL. UNS 30400	ASTM A240	8
1		-7	FLG. SUPT.			7
1		-6	FRONT FLG.			6
1		-5	TOP FLANGE			5
1		X3E020097A104-4	SIDE PLATE			4
1		X3E020097A104-3	FRONT PLATE			3
1		X3E020097A104-2	BOTTOM PLATE			2
AR		-1	ENCLOSURE			1

NEXT ASSEMBLY

PARTS LIST

DO NOT REVISE MANUALLY

0 - 3 - CERTIFIED FOR CONSTRUCTION

DES J.W. STAPLETON 2/92
DRW K. L. FARLEY 2/92

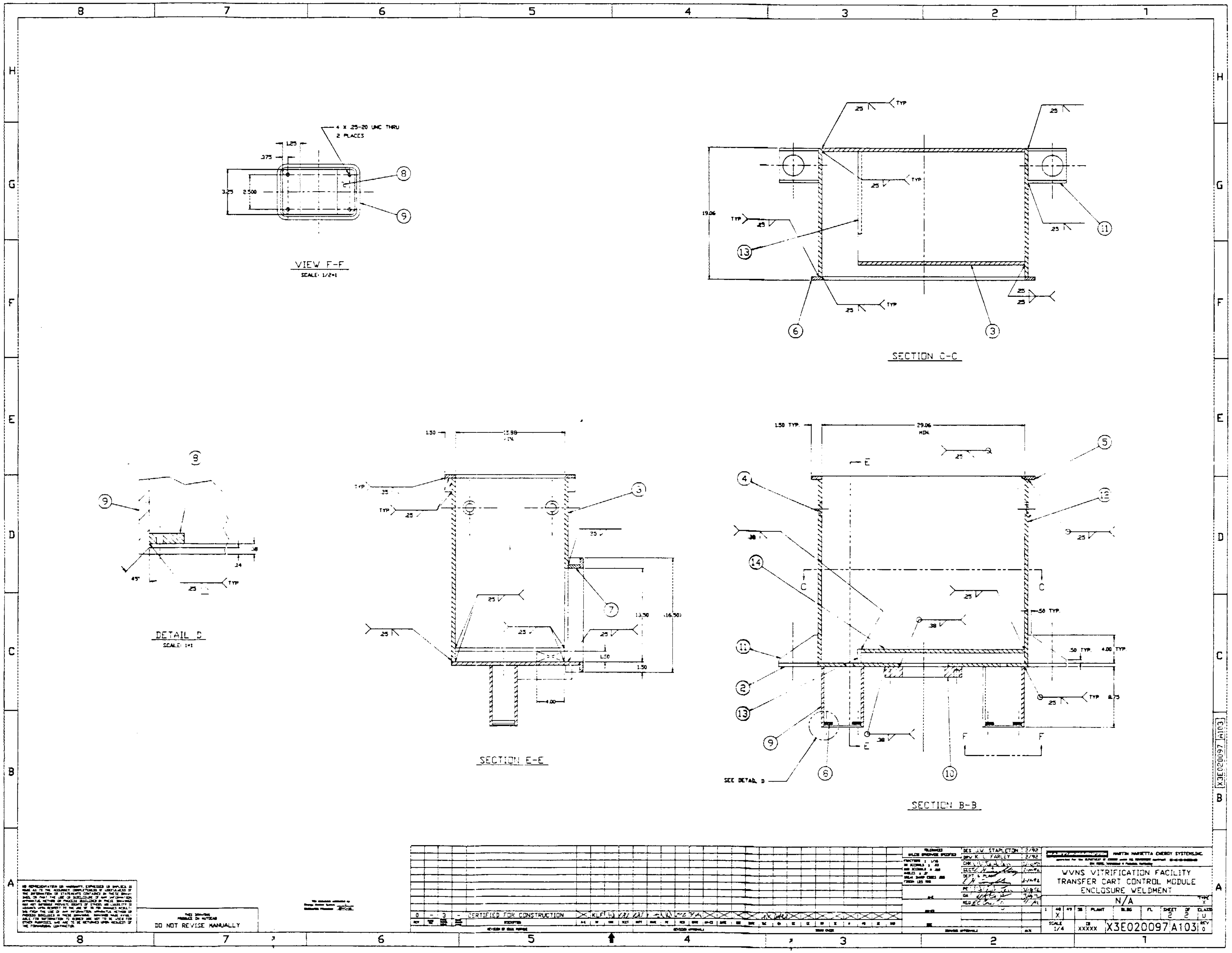
MARTIN MARIETTA ENERGY SYSTEMS, INC.

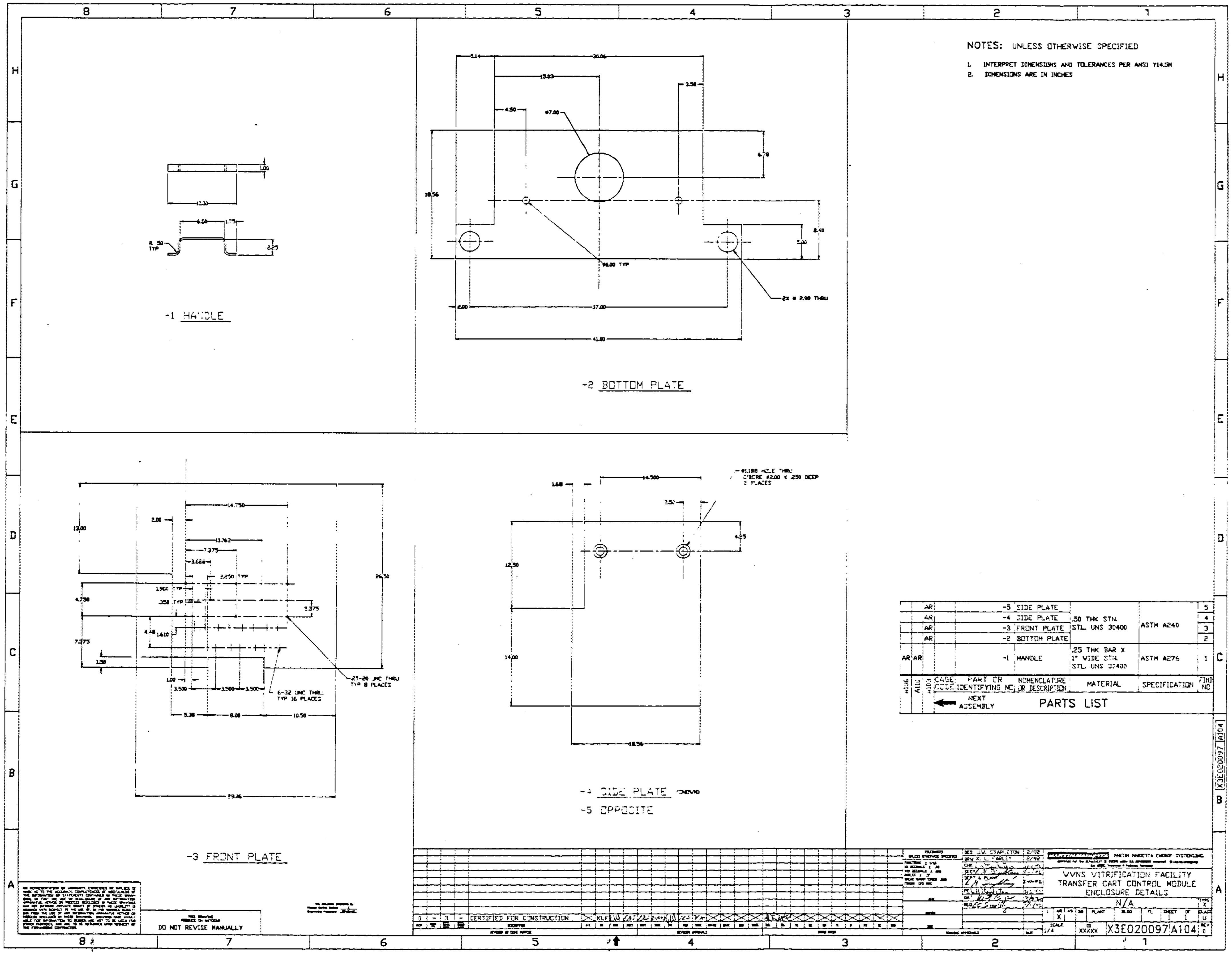
WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
ENCLOSURE WELDMENT

N/A

TYPE X | SHEET 1 OF 2 | CLASS U

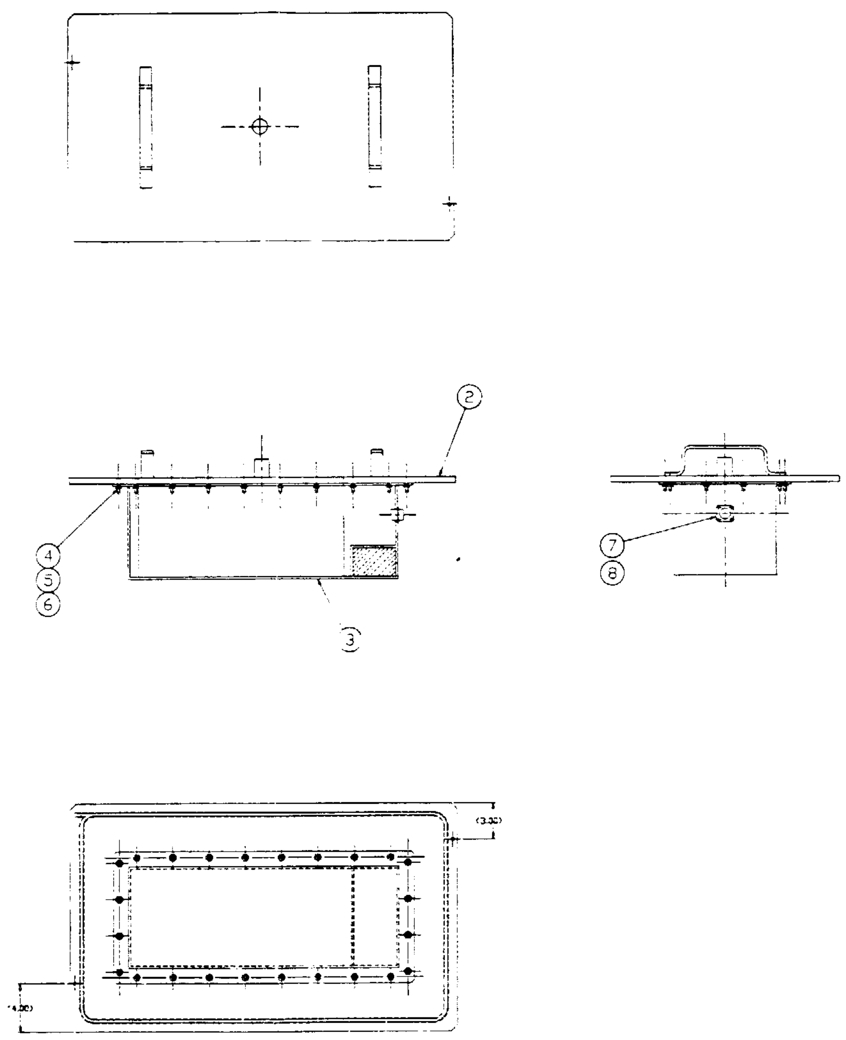
SCALE 1/4 | XXXXX | X3E020097 A103 | REV 0


4 X .25-20 UNC THRU
2 PLACES
VIEW F-F
SCALE: 1/2=1
SECTION C-C
DETAIL D
SCALE: 1=1
SECTION E-E
SECTION B-B
SEE DETAIL D
29.06
MIN.
1.50 TYP.
19.06
13.50
(16.50)
4.00
CERTIFIED FOR CONSTRUCTION
DO NOT REVISE MANUALLY
DES J.W. STAPLETON 2/92
DRW K. L. FARLEY 2/92
MARTIN MARIETTA ENERGY SYSTEMS, INC.
WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
ENCLOSURE WELDMENT
N/A
SHEET 2 OF 2
CLASS U
SCALE 1/4
XXXXX
X3E020097 A103
REV 0


NOTES: UNLESS OTHERWISE SPECIFIED
1. INTERPRET DIMENSIONS AND TOLERANCES PER ANSI Y14.5M
2. DIMENSIONS ARE IN INCHES
-1 HANDLE
-2 BOTTOM PLATE
-3 FRONT PLATE
-4 SIDE PLATE
-5 OPPOSITE
2X ⌀ 2.90 THRU
6-32 UNC THRU TYP 16 PLACES
.25-20 UNC THRU TYP 8 PLACES
PARTS LIST
-5 SIDE PLATE
-4 SIDE PLATE
-3 FRONT PLATE
-2 BOTTOM PLATE
.50 THK STN. STL. UNS 30400
ASTM A240
-1 HANDLE
.25 THK BAR X 1" WIDE STN. STL. UNS 30400
ASTM A276
CAGE CODE
PART OR IDENTIFYING NO
NOMENCLATURE OR DESCRIPTION
MATERIAL
SPECIFICATION
FIND NO
NEXT ASSEMBLY
DES J.W. STAPLETON 2/92
DRW K. L. FARLEY 2/92
MARTIN MARIETTA ENERGY SYSTEMS, INC.
WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
ENCLOSURE DETAILS
N/A
SCALE 1/4
XXXXX
X3E020097 A104
CERTIFIED FOR CONSTRUCTION
DO NOT REVISE MANUALLY

NOTES: UNLESS OTHERWISE SPECIFIED

1. INTERPRET DIMENSIONS AND TOLERANCES PER ANSI Y14.5M
2. DIMENSIONS ARE IN INCHES
3. LOCATE 6-32 TAPPED HOLES IN ITEM 3 FROM ITEM 7



(1) BATTERY COMPARTMENT ASSEMBLY

QTY	CAGE CODE	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	FIND NO
4		-8	#6-32 X .25 LG FHMS	300 SERIES SST		8
1		-7	BULKHEAD CONNECTOR # SPB-14-12-PS	AMPHENOL/BENDIX		7
1		-6	GASKET, 1/16 THK, EP			6
24		-5	WASHER,LOCK, 300 SERIES SST		ANSI B18.21.1	5
24		-4	NUT, 1/4-20 UNC 300 SERIES SST		ANSI B18.2.2	4
1		X3E020097A110-2	BATTERY BOX			3
1		X3E020097A110-1	COVER			2
X		-1	BATTERY COMPARTMENT ASSEMBLY			1

NEXT ASSEMBLY — PARTS LIST

0 | 3 | CERTIFIED FOR CONSTRUCTION

DES J.W. STAPLETON 2/92
DRW K. L. FARLEY 2/92

MARTIN MARIETTA ENERGY SYSTEMS, INC.

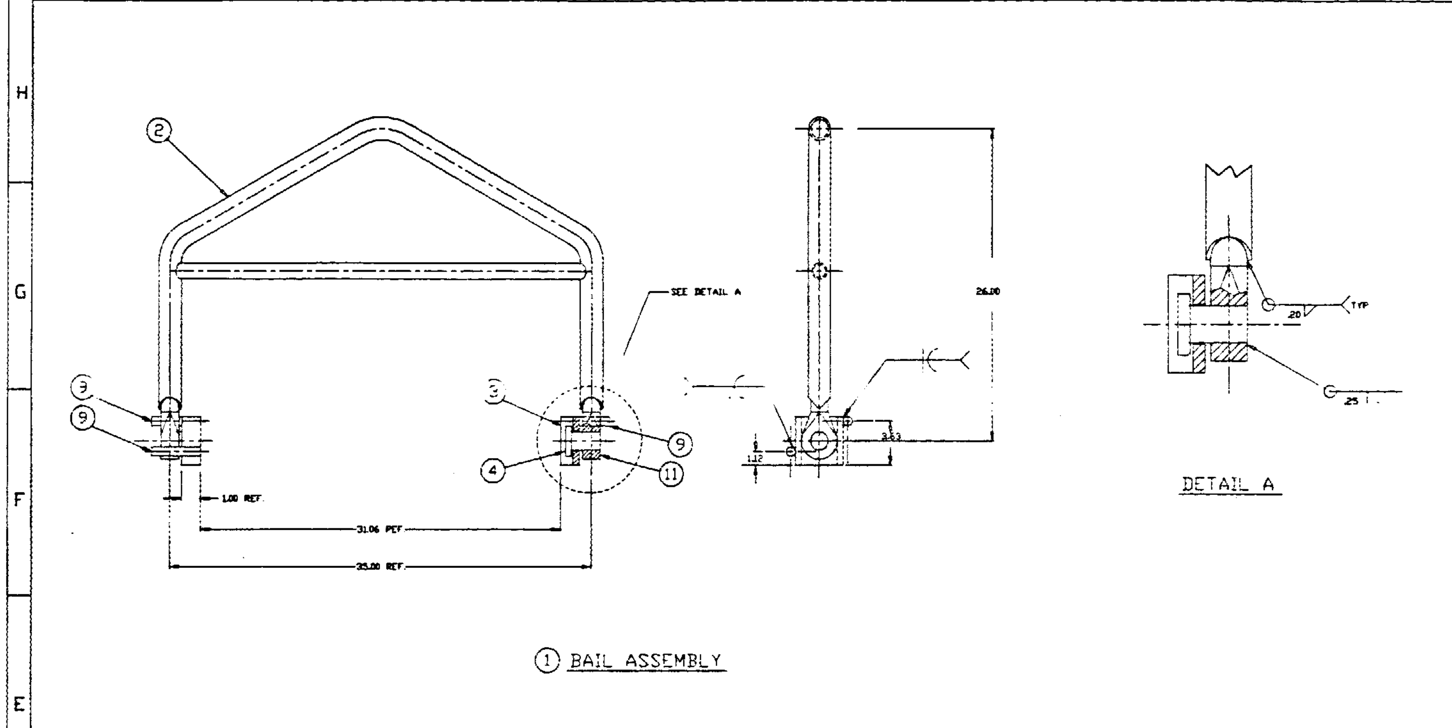
WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
BATTERY COMPARTMENT ASSEMBLY

N/A — TYPE X

48	49	50	PLANT	BLDG	FL	SHEET	OF	CLASS
X						1	1	U

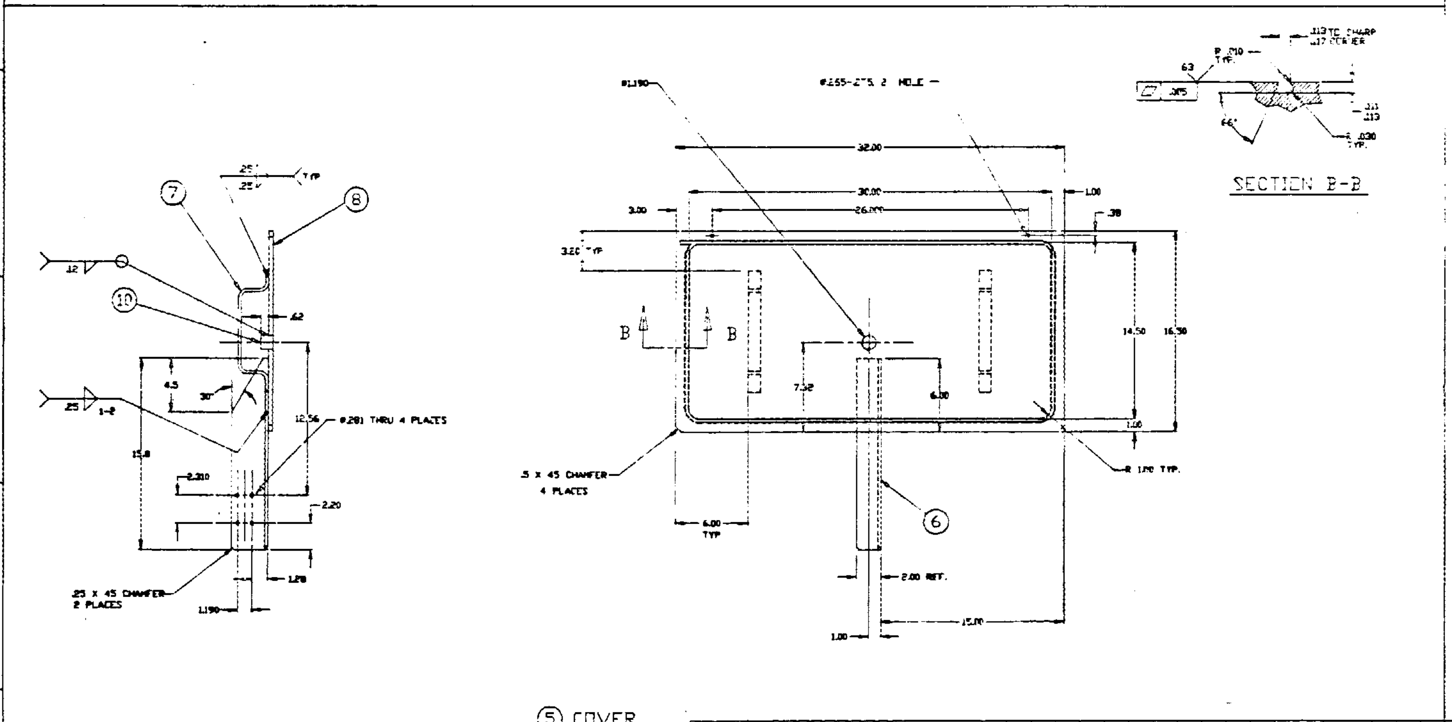
SCALE 1/4 — ID XXXXX — X3E020097A105 — REV 0

DO NOT REVISE MANUALLY



NOTES: UNLESS OTHERWISE SPECIFIED

1. INTERPRET DIMENSIONS AND TOLERANCES PER ANSI Y14.5M
2. DIMENSIONS ARE IN INCHES
3. INTERPRET WELDING AND NONDESTRUCTIVE EXAMINATION SYMBOLS PER ANSI/AWS A2.4.
4. USE PROCEDURES, WELDERS, WELDING OPERATORS AND TACKERS QUALIFIED PER AWS B2.1.
5. VISUALLY INSPECT ALL WELDS PER AWS D14.4, PART E, CLASS III.
6. WELD INSPECTORS QUALIFIED PER AWS QC-1-88.



A106-1				CAGE CODE	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	FIND NO
	AR	AR	AR			WELD FILLER METAL		AWS ER 308	14
		4A			-13	PIPE 1" SCH 40	304 SST		13
		AP			-12	PIPE 1-1/2" SCH 40	304 SST		12
			2		-11	ROD END	304 SST		11
	1				-10	HALF COUPLING 1/2" NPT	STL. UNS 30400		10
			4		-9	STOP	⌀ .75 BAR STN. STL. UNS 30400	ASTM A276	9
	1				-8	PLATE, 3/8" THK	.375 THK STN. STL. UNS 30400	ASTM A240	8
	2				A104-1	HANDLE			7
	1				-6	L-ANGLE	2 X 3 X .25 STN. STL. UNS 30400	ASTM A276	6
AR					-5	COVER	.375 THK STN. STL. UNS 30400	ASTM A240	5
			2		-4	PIN	304 SST		4
			2		-3	BAIL MTG. BRKT.	304 SST		3
			1		-2	BAIL			2
AR					-1	BAIL ASSEMBLY			1

NEXT ASSEMBLY

PARTS LIST

THIS DRAWING PRODUCED BY AUTOCAD

DO NOT REVISE MANUALLY

0 - 3 - CERTIFIED FOR CONSTRUCTION

DES J.V. STAPLETON 2/92

DRW K. L. FARLEY

MARTIN MARIETTA ENERGY SYSTEMS, INC.

WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
DETAIL SHEET NO. 1

N/A

TYPE X

SHEET 1 OF 2

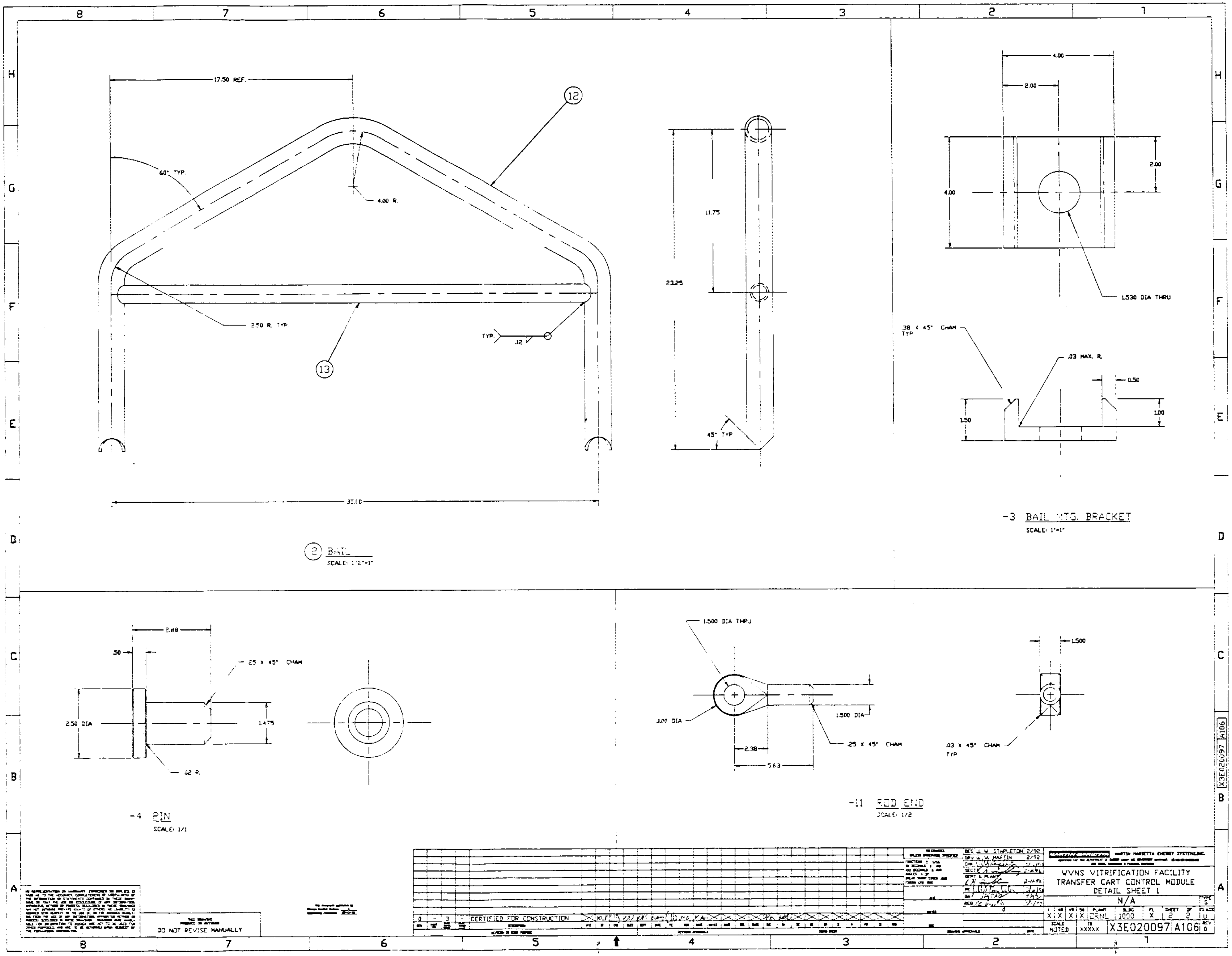
CLASS U

SCALE 1/4

ID XXXXX

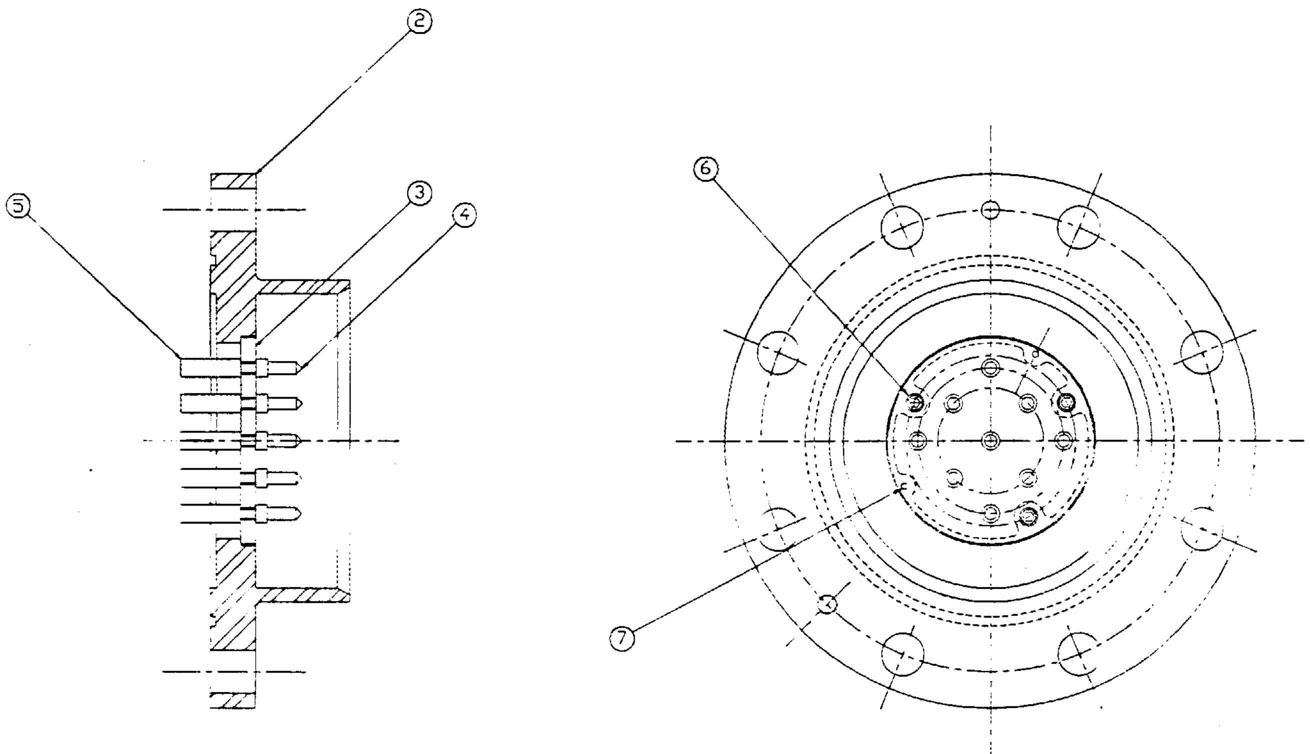
X3E020097 A106

REV 0


17.50 REF.
60° TYP.
4.00 R.
2.50 R. TYP.
TYP.
.12
11.75
23.25
45° TYP
32.00
② BAIL
SCALE: 1/2"=1"
4.00
2.00
2.00
4.00
1.530 DIA THRU
.38 X 45° CHAM TYP
.03 MAX. R.
0.50
1.50
1.20
-3 BAIL MTG. BRACKET
SCALE: 1"=1"
2.88
.50
.25 X 45° CHAM
2.50 DIA
1.475
.02 R.
-4 PIN
SCALE: 1/1
1.500 DIA THRU
3.00 DIA
1.500 DIA
.25 X 45° CHAM
2.38
5.63
1.500
.03 X 45° CHAM TYP
-11 ROD END
SCALE: 1/2
DO NOT REVISE MANUALLY
CERTIFIED FOR CONSTRUCTION
J. W. STAPLETON 2/92
A. W. MARTIN 2/92
MARTIN MARIETTA ENERGY SYSTEMS, INC.
WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
DETAIL SHEET 1
N/A
X3E020097 A106
ORNL
1000
NOTED
XXXXX

NOTES: UNLESS OTHERWISE SPECIFIED

1. INTERPRET DIMENSIONS AND TOLERANCES PER ANSI Y14.5M.
2. DIMENSIONS ARE IN INCHES.
3. RTV SEAL WITH DOW-CORNING #732 CLEAR
4. LOCATE ITEM 7 FROM ITEM 3 WITH PRESS FIT IN ITEM 2



1 REMOTE CONNECTOR ASSEMBLY

		CAGE CODE	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	FIND NO
4	2		-7	PIN, Ø.125, 300 SERIES SST			7
3	3		-6	SHCS, 1/4-20 X .75 LG. 300 SERIES SST			6
	9		A108-6	CONNECTOR, 90 AMP			5
	9		A108-5	PLUG, 90 AMP			4
3	1		A108-4	INSULATOR			3
	1		A108-1	FLANGE			2
	AR		-1	REMOTE CONNECTOR ASSEMBLY			1

A102-1 ← NEXT ASSEMBLY

PARTS LIST

THIS DRAWING PRODUCED IN AUTOCAD
DO NOT REVISE MANUALLY

0 - 3 - CERTIFIED FOR CONSTRUCTION

DES J. W. STAPLETON 2/92
DRW K. L. FARLEY 2/92
CHK
SECT
DEPT & PLANT
PE
QA
REQ

MARTIN MARIETTA ENERGY SYSTEMS, INC.

WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
REMOTE CONNECTOR ASSEMBLY

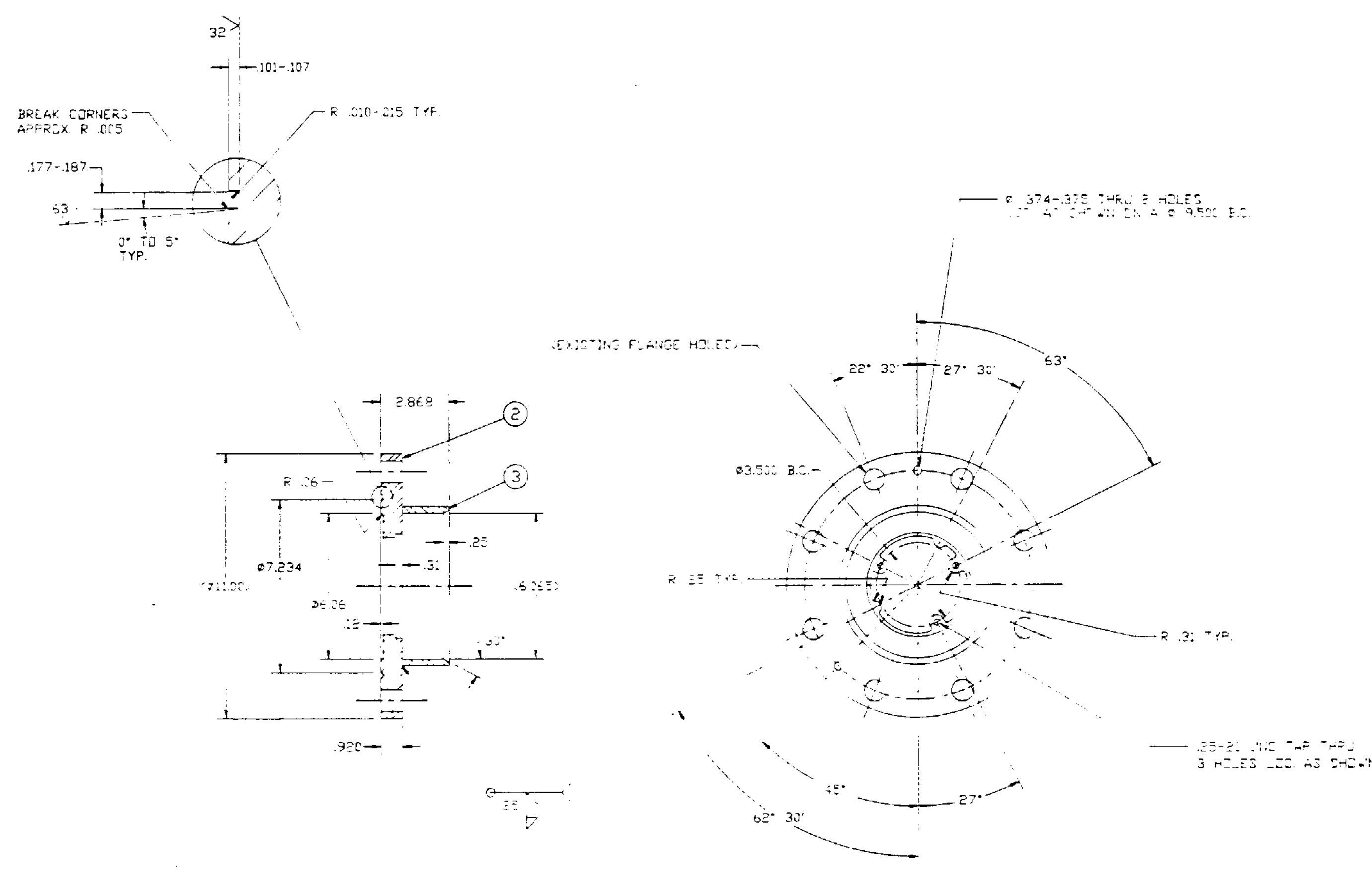
N/A

1	48	49	50	PLANT	BLDG	FL	SHEET	OF	CLASS
X	X	X	X	XXXX	XXXX	X	1	1	X

SCALE 1/1 | XXXXX | X3E020097 | A107 | REV 0

NOTES: UNLESS OTHERWISE SPECIFIED

1. INTERPRET DIMENSIONS AND TOLERANCES PER ANSI Y14.5M.
2. DIMENSIONS ARE IN INCHES.
3. MODIFY BLIND FLANGE AS SHOWN.
4. SILVER PLATING SHALL BE DEPOSITED BY AN ELECTROPLATING PROCESS PER ASTM B253 AND ASTM B281.
5. SILVER PLATE TO BE .0002 IN. THK MINIMUM AFTER MACHINING. ALL DIMENSIONS ARE PRIOR TO SILVER PLATING EXCEPT THREADS WHICH MUST BE A CLASS 2 FIT AFTER PLATING.



1 FLANGE

		CAGE CODE	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	FIND NO.
	AR			WELD FILLER METAL		AWS ER 308	7
4 5	AR			CONNECTOR, 90 AMP			6
	AR			PLUG, 90 AMP (MODIFIED)	HUGIN INDUSTRIES INC. LOS ALTOS, CA. 94022		5
	AR			INSULATOR	LEXAN		4
	1		6"IPS, SCH. 40	PIPE	STN. STL.TYPE 304		3
3	1		6"IPS.CLASS 150	FLANGE, BLIND	STN. STL.TYPE 304	ANSI B16.5	2
	AR		-1	FLANGE			1

NEXT ASSEMBLY — PARTS LIST

DES. J. W. STAPLETON 2/92
DRW. C. V. MARTIN 2/92

MARTIN MARIETTA ENERGY SYSTEMS, INC.

WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
REMOTE CONNECTOR DETAILS

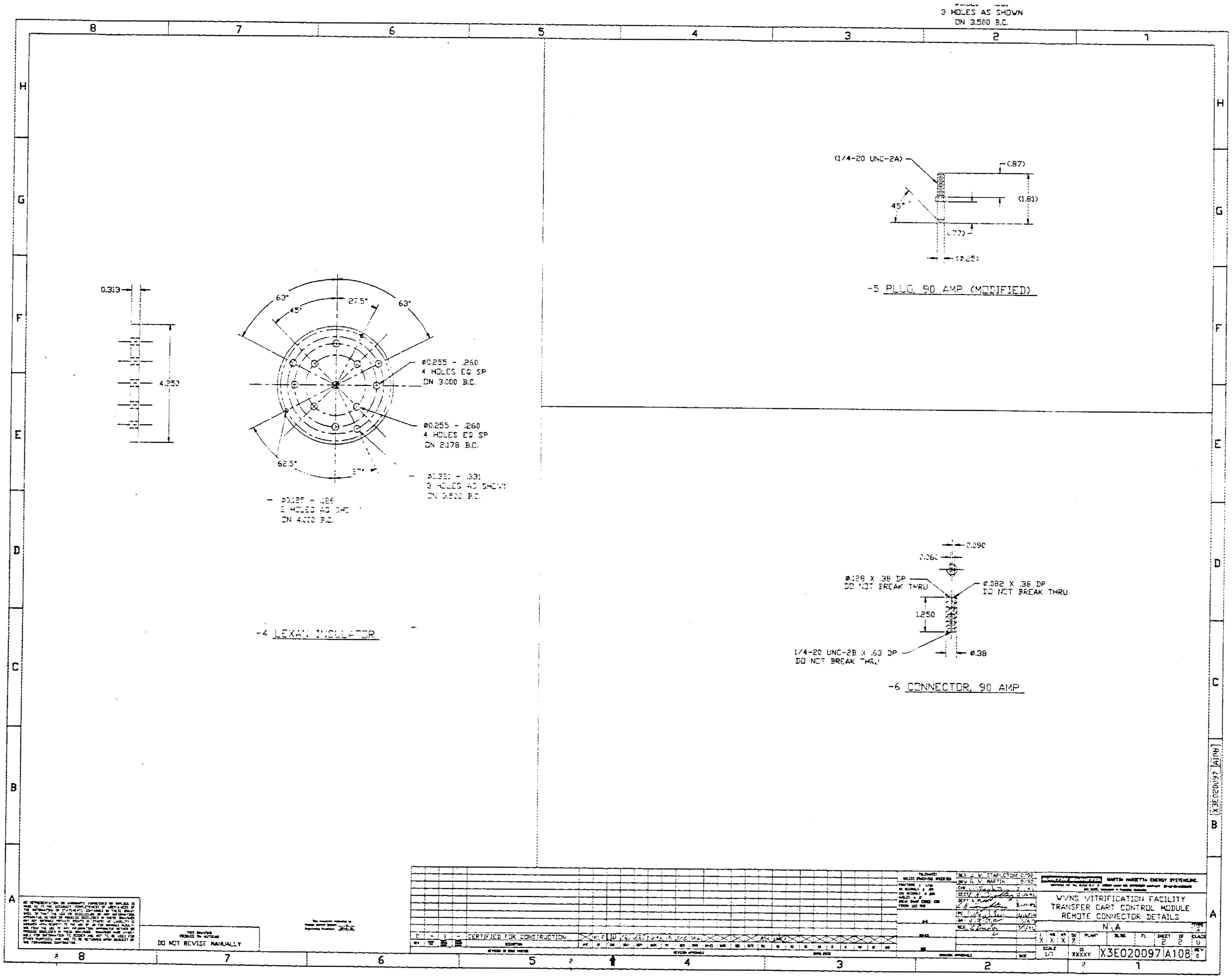
N/A

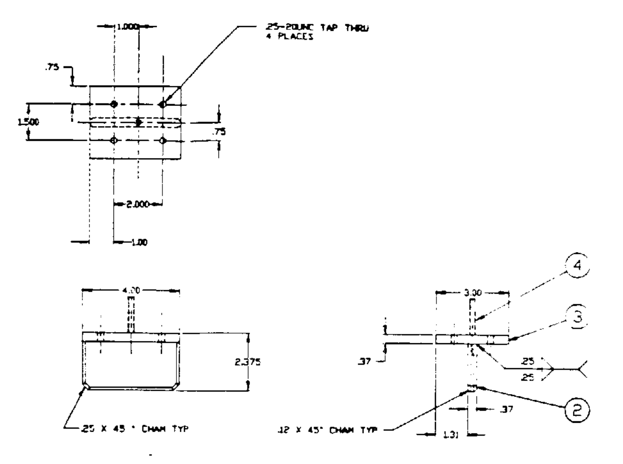
PLANT	BLDG	FL	SHEET	OF	CLASS
XXXX	XXXX	X	1	2	X

SCALE 1/2 — ID XXXXX — X3E020097 A108 — REV 0

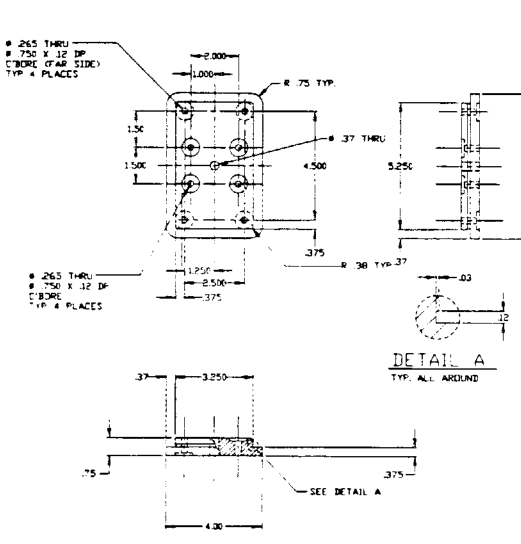
DO NOT REVISE MANUALLY

CERTIFIED FOR CONSTRUCTION


3 HOLES AS SHOWN
ON 3.500 B.C.
(1/4-20 UNC-2A)
(.87)
(1.81)
45°
(.77)
(Ø.25)
-5 PLUG, 90 AMP (MODIFIED)
0.313
4.250
63°
27.5°
45°
63°
Ø0.255 - .260
4 HOLES EQ SP
ON 3.000 B.C.
Ø0.255 - .260
4 HOLES EQ SP
ON 2.178 B.C.
62.5°
-4 LEXAN INSULATOR
0.090
0.060
Ø.128 X .38 DP
DO NOT BREAK THRU
Ø.082 X .38 DP
DO NOT BREAK THRU
1.250
1/4-20 UNC-2B X .63 DP
DO NOT BREAK THRU
Ø.38
-6 CONNECTOR, 90 AMP
CERTIFIED FOR CONSTRUCTION
DO NOT REVISE MANUALLY
DES J. W. STAPLETON 2/92
DRW G. W. MARTIN 2/92
MARTIN MARIETTA ENERGY SYSTEMS, INC.
WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
REMOTE CONNECTOR DETAILS
N\A
SHEET 2 OF 2
SCALE 1/1
XXXXX
X3E020097 A108
REV 0
X3E020097 A108



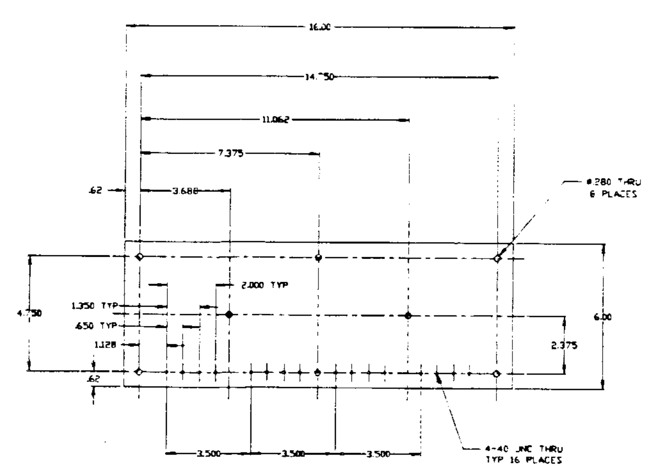
(1) BATTERY CHARGING PLATE



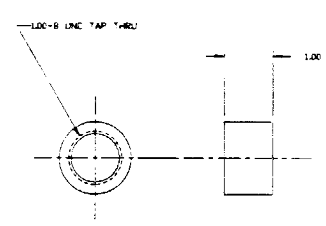
-5 CHARGING SHOE INSULATOR

NOTES: UNLESS OTHERWISE SPECIFIED

1 INTERPRET DIMENSIONS AND TOLERANCES PER ANSI Y14.5M
2 DIMENSIONS ARE IN INCHES
3 INTERPRET WELDING AND NONDESTRUCTIVE EXAMINATION SYMBOLS PER ANSI/AWS A2.4.
4 USE PROCEDURES, WELDERS, WELDING OPERATORS AND TACKERS QUALIFIED PER AWS B2.1.
5 VISUALLY INSPECT ALL WELDS PER AWS D14.4, PART E, CLASS III.
6 WELD INSPECTORS QUALIFIED PER AWS QC-1-88.



-6 PLATE



-7 BOSS

SCALE: 1/1

AR	1		-7	BOSS	⌀ 1.5 RCD STL UNS 30400		7
AR			-6	3/8" PLATE	1100 AL ALY		6
AR			-5	CHARGING SHOE INSULATOR	.75 THK. ABS	ASTM D1788 GRADE 3-5-5	5
	1		-4	WELD STUD .25-20UNC X 1.5 LG. 304 SST			4
	1		-3	PLATE	.375 THK STN. STL UNS 30400	ASTM A240	3
	1		-2	PLATE	.375 THK STN. STL UNS 30400	ASTM A240	2
AR	X		-1	BATTERY CHARGING PLATE			1
A103-1	A102-1	CAGE CODE	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	FIND NO

NEXT ASSEMBLY — PARTS LIST

DO NOT REVISE MANUALLY

0 - 3 - CERTIFIED FOR CONSTRUCTION

DES J. W. STAPLETON 2/92
DRW K. L. FARLEY 2/92

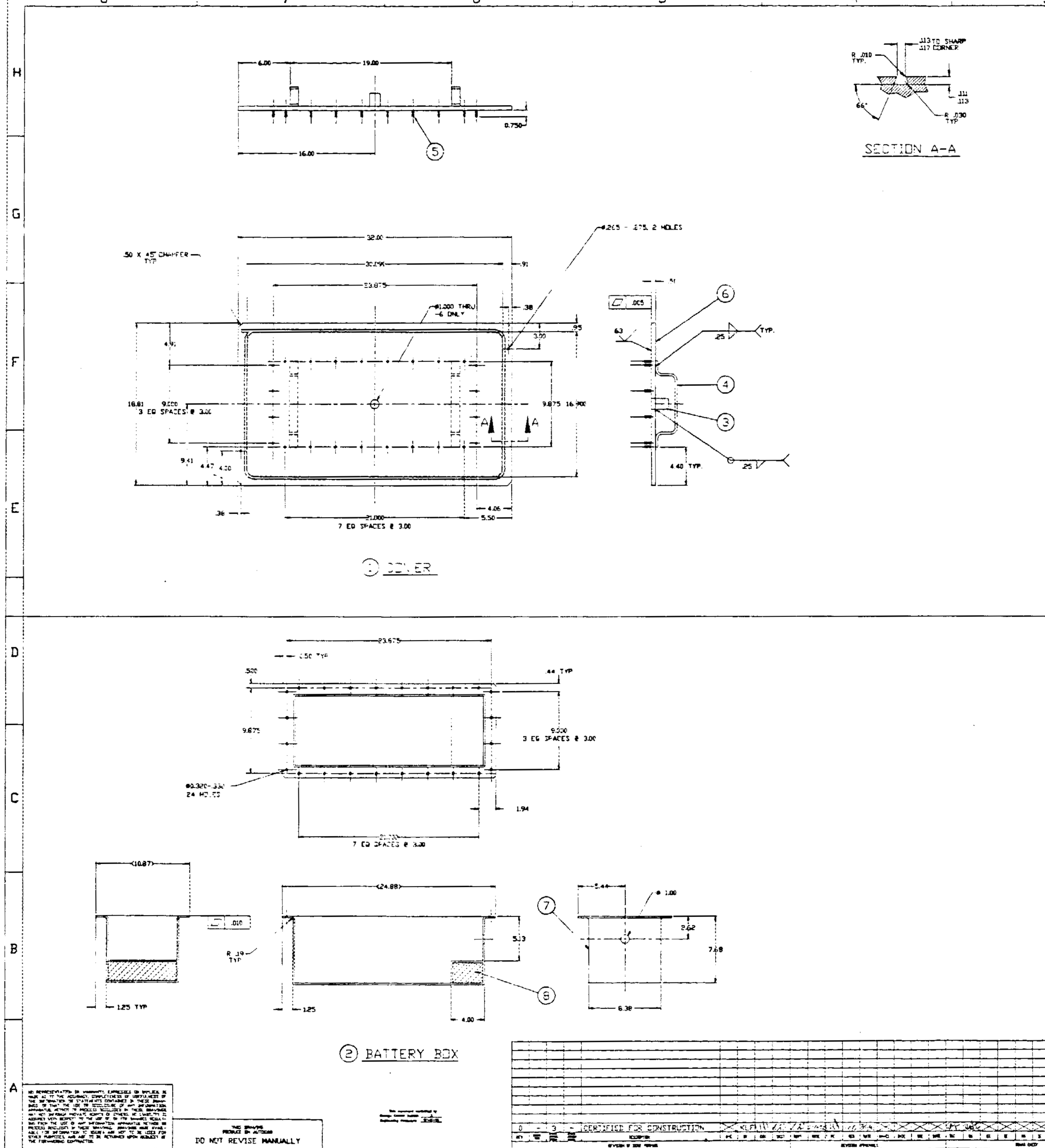
MARTIN MARIETTA ENERGY SYSTEMS, INC.

WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
DETAIL SHEET NO. 2

N/A

1	48	49	50	PLANT	BLDG	FL	SHEET	OF	CLASS
X	X	X	X	XXXX	XXXX	X	1	1	U

SCALE 1/2 — XXXXX — E3E020097 A109 — REV 0



NOTES: UNLESS OTHERWISE SPECIFIED

1 INTERPRET DIMENSIONS AND TOLERANCES PER ANSI Y14.5M
2 DIMENSIONS ARE IN INCHES
3 OPTIONAL CONSTRUCTION FOR PART NO. -2 TO BE FORMED & WELDED OR PIECE WELDED THEN LEAD FILLED.
4 INTERPRET WELDING AND NONDESTRUCTIVE EXAMINATION SYMBOLS PER ANSI/AWS A2.4.
5 USE PROCEDURES, WELDERS, WELDING OPERATORS AND TACKERS QUALIFIED PER ASW B2.1.
6 VISUALLY INSPECT ALL WELDS PER AWS D14.4, PART E, CLASS III.
7 WELD INSPECTORS QUALIFIED PER AWS QC-1-88.

		CAGE CODE	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	FIND NO.
	AR		-8	LEAD		ASTM B74C	8
	AR		-7	SHEET	7 GA. STN. STL. UNS 30400	ASTM A240	7
	1		-6	PLATE	.50 THK. STN. STL. UNS 30400	ASTM A240	6
	24		-5	WELD STUDS .25-20UNC X.75 LG. 300 SERIES SST			5
	2		A104-1	HANDLE			4
	1		-3	3/4" NPT FULL CPLG.	304 SST		3
AR	X		-2	BATTERY BOX			2
AR	X		-1	COVER			1

A102-1 — NEXT ASSEMBLY — PARTS LIST

DES. J.W. STAPLETON 2/92
DRW. K. L. FARLEY 2/92

MARTIN MARIETTA ENERGY SYSTEMS, INC.

WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
DETAIL SHEET NO. 3

N/A

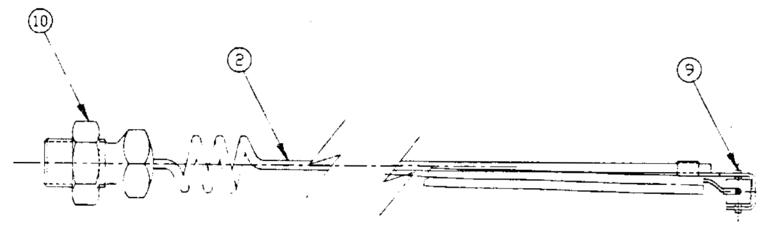
SCALE 1/4 — XXXXX — X3E020097A110 — REV 0

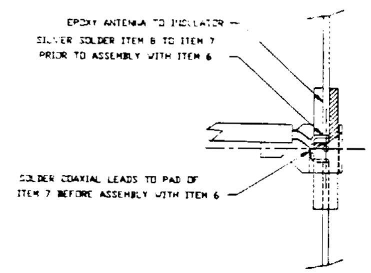
SHEET 1 OF 1

CERTIFIED FOR CONSTRUCTION

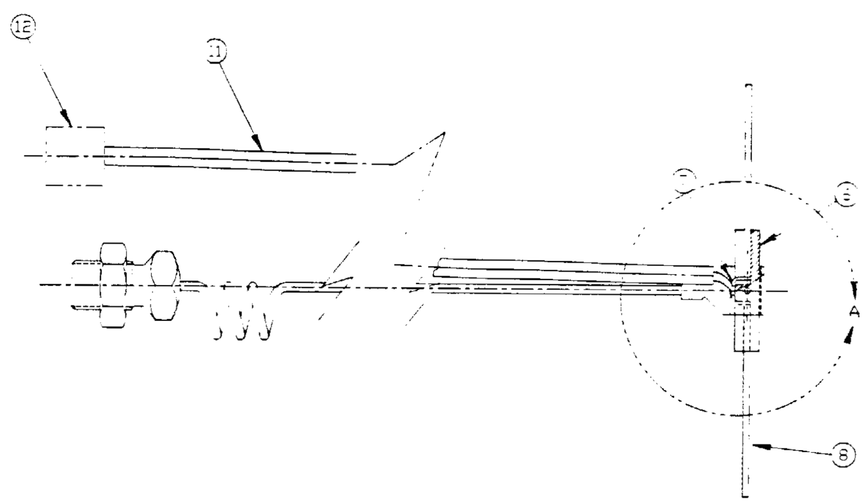
NOTES: UNLESS OTHERWISE SPECIFIED

1. INTERPRET DIMENSIONS AND TOLERANCES PER ANSI Y14.5M.
2. DIMENSIONS ARE IN INCHES.





DETAIL A



(1) ANTENNA ASSEMBLY

QTY			CAGE CODE	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	FIND NO
AR				-13	WELD FILLER METAL		AWS ER 308	13
	1			-12	PLUG FFA-4E-250-SLAC95	LEMO USA INC SANA ROSA, CA 95406		12
	AR			-11	COAXIAL CABLE ø.375			11
	1			-10	1" LOCK NUT, 300 SERIES SST			10
	1			-9	1/8" SPRING PIN, 400 SERIES SST			9
	2			X3E020097A115-2	ANTENNA			8
	1			X3E020097A115-1	TAB			7
	1			X3E020097A114-2	INSULATOR			6
1				-5	WIRE, ø 3/16	304 SST	ASTM A313-87	5
1				-4	FITTING			4
1				-3	BRACKET	16 GA. 304 SST		3
X	1			-2	SPRING ARM WELDMENT			2
AR	X			-1	ANTENNA ASSEMBLY			1
A102-1	-2	-1						

NEXT ASSEMBLY

PARTS LIST

DO NOT REVISE MANUALLY

CERTIFIED FOR CONSTRUCTION

DES J. W. STAPLETON 2/92
DRW K. L. FARLEY 2/92
CHK
SECT
DEPT & PLANT
PE
QA
REG

MARTIN MARIETTA ENERGY SYSTEMS, INC.

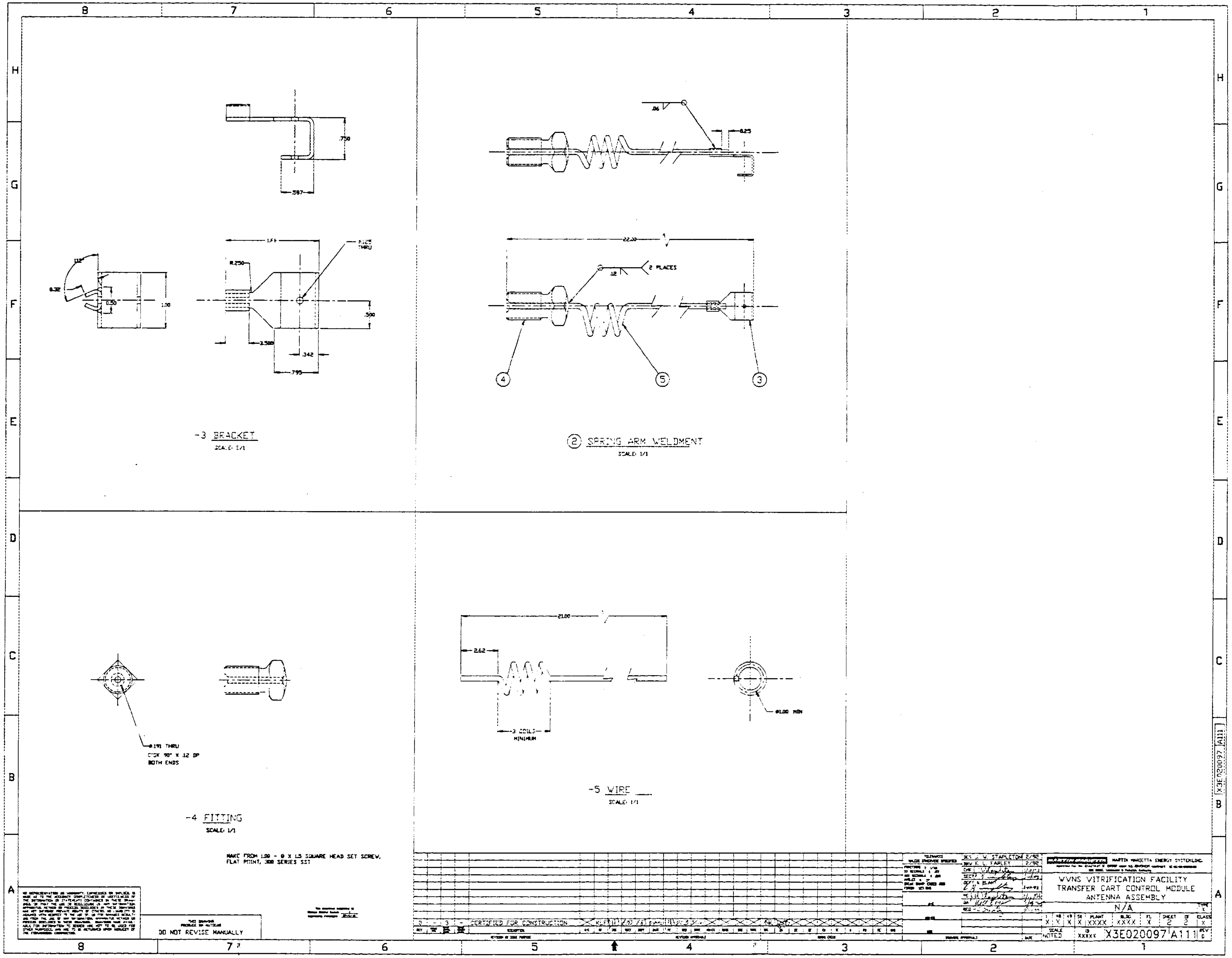
WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
ANTENNA ASSEMBLY

N/A

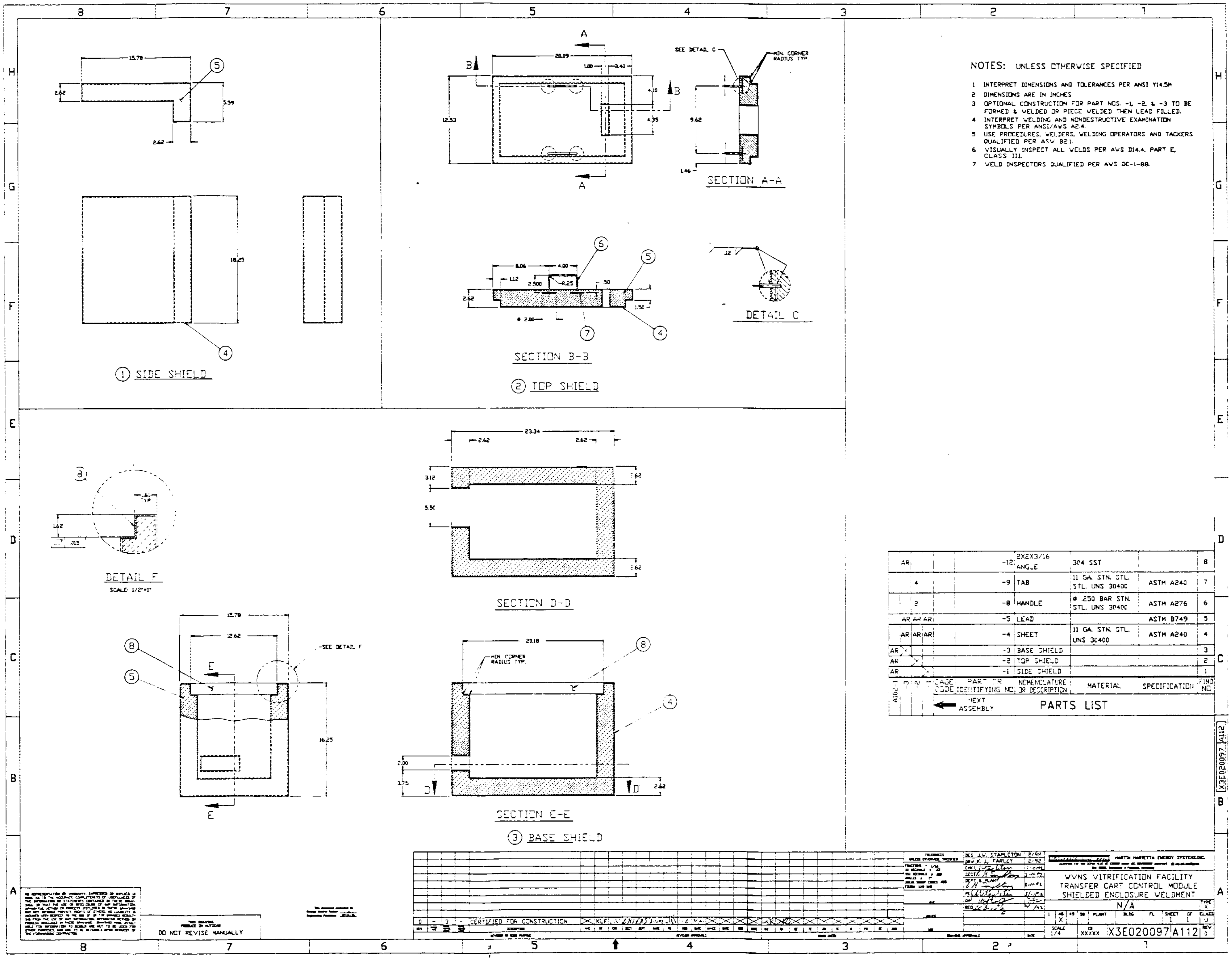
1	48	49	50	PLANT	BLDG	FL	SHEET	OF	CLASS
X	X	X	X	XXXX	XXXX	X	1	2	X

SCALE 1/1 | ID XXXXX | X3E020097 | A111 | REV 0

X3E020097 A111

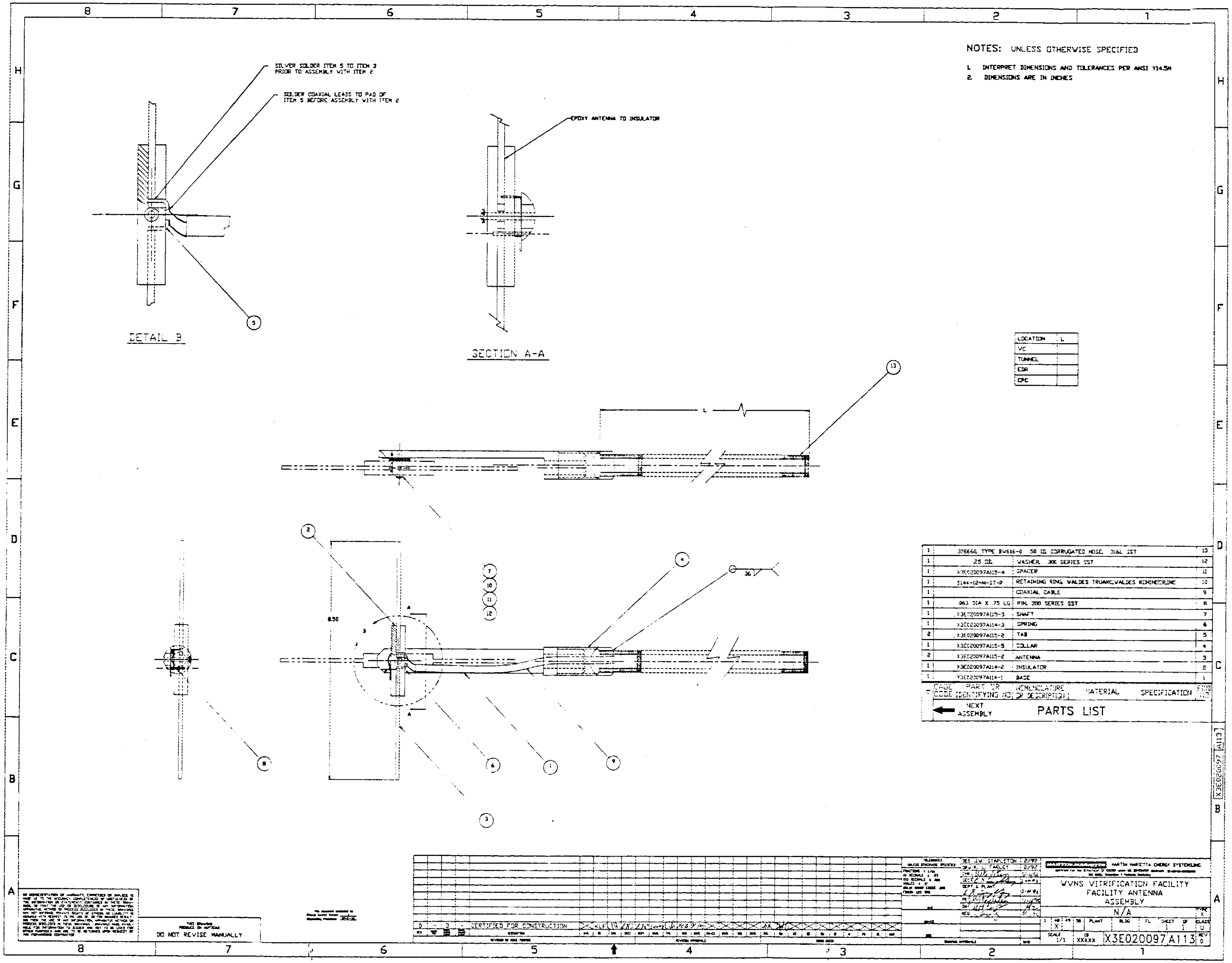


-3 BRACKET
SCALE: 1/1
2 SPRING ARM WELDMENT
SCALE: 1/1
2 PLACES
-4 FITTING
SCALE: 1/1
MAKE FROM 1.00 - 8 X 1.5 SQUARE HEAD SET SCREW, FLAT POINT, 300 SERIES SST
-5 WIRE
SCALE: 1/1
3 COILS MINIMUM
BOTH ENDS
DO NOT REVISE MANUALLY
CERTIFIED FOR CONSTRUCTION
MARTIN MARIETTA ENERGY SYSTEMS, INC.
WVNS VITRIFICATION FACILITY
TRANSFER CART CONTROL MODULE
ANTENNA ASSEMBLY
N/A
X3E020097 A111



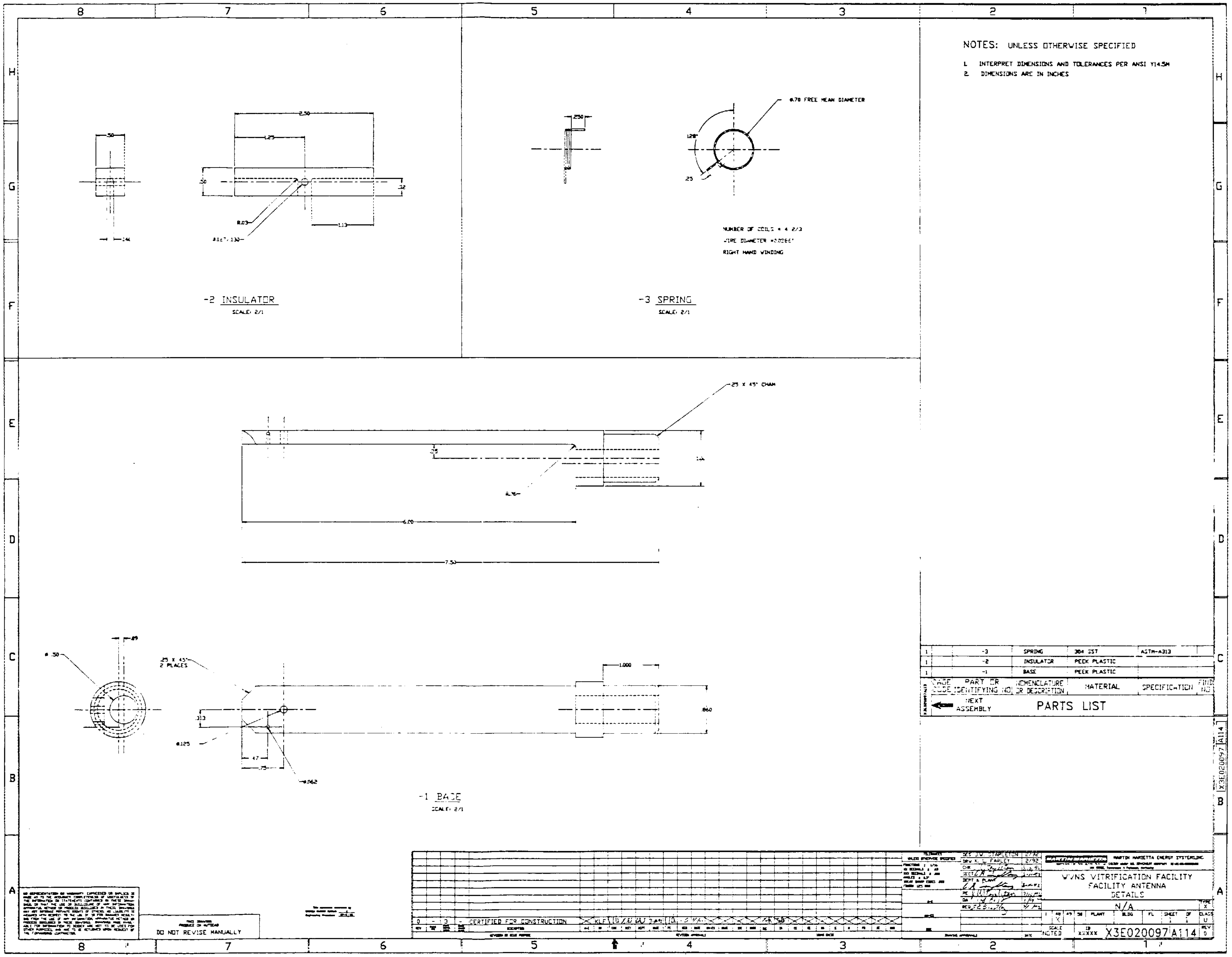
A102-1	-3	-2	-1	CAGE CODE	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	FIND NO.
AR					-12	2X2X3/16 ANGLE	304 SST		8
		4			-9	TAB	11 GA. STN. STL. STL. UNS 30400	ASTM A240	7
		2			-8	HANDLE	⌀ .250 BAR STN. STL. UNS 30400	ASTM A276	6
	AR	AR	AR		-5	LEAD		ASTM B749	5
	AR	AR	AR		-4	SHEET	11 GA. STN. STL. UNS 30400	ASTM A240	4
AR					-3	BASE SHIELD			3
AR					-2	TOP SHIELD			2
AR					-1	SIDE SHIELD			1

NEXT ASSEMBLY — PARTS LIST



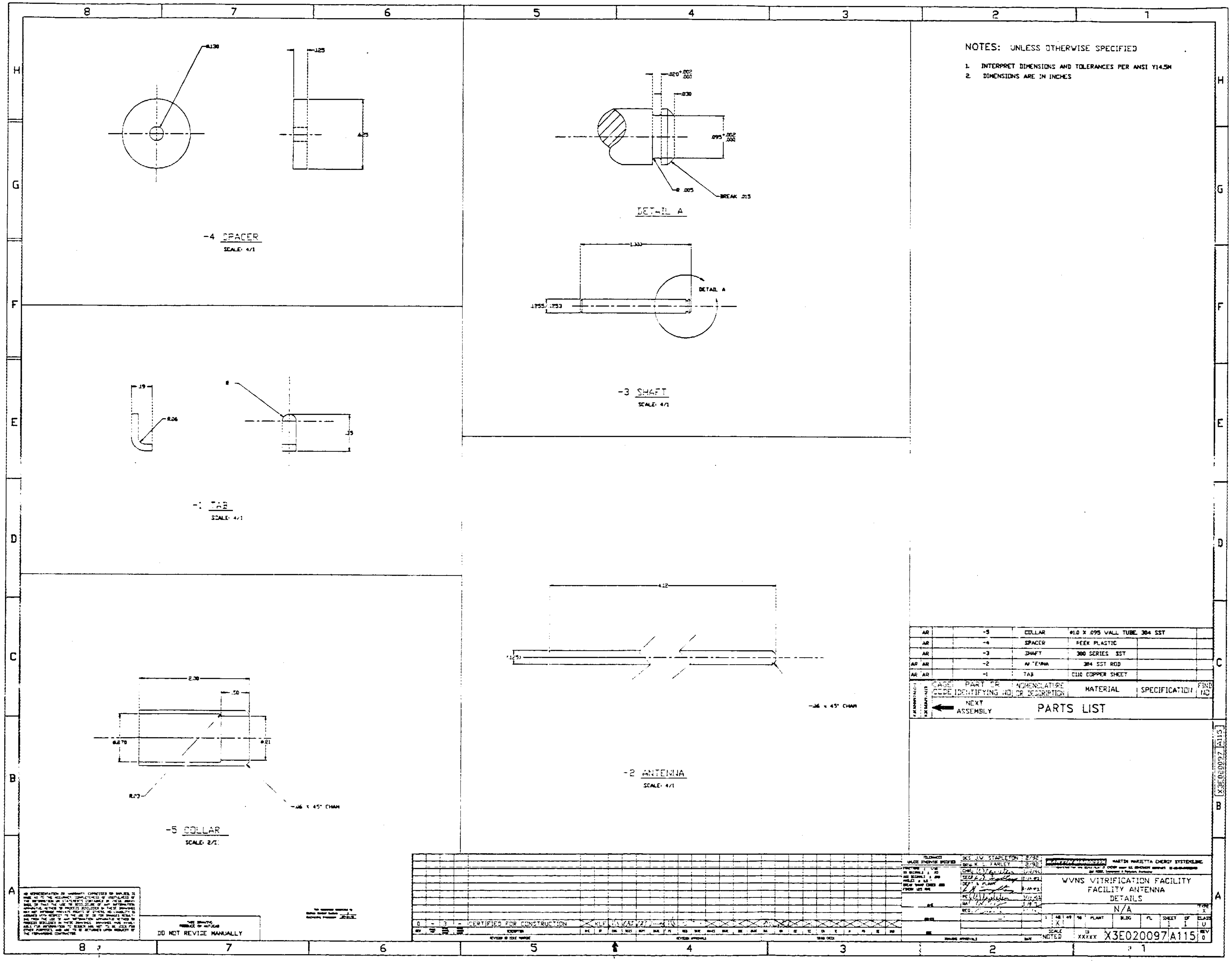
1		308660, TYPE BW616-0 .50 I.D. CORRUGATED HOSE, 316L SST				13
1		.25 O.D.	WASHER, 300 SERIES SST			12
1		X3E020097A115-4	SPACER			11
1		5144-12-H-ST-P	RETAINING RING, WALDES TRUARC/WALDES KOHINOOR,INC			10
1			COAXIAL CABLE			9
1		.063 DIA X .75 LG	PIN, 300 SERIES SST			8
1		X3E020097A115-3	SHAFT			7
1		X3E020097A114-3	SPRING			6
2		X3E020097A115-2	TAB			5
1		X3E020097A115-5	COLLAR			4
2		X3E020097A115-2	ANTENNA			3
1		X3E020097A114-2	INSULATOR			2
1		X3E020097A114-1	BASE			1
T	CAGE CODE	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	FIND NO

NEXT ASSEMBLY — PARTS LIST



1		-3	SPRING	304 SST	ASTM-A313	
1		-2	INSULATOR	PEEK PLASTIC		
1		-1	BASE	PEEK PLASTIC		
	CAGE CODE	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	FIND NO.

NEXT ASSEMBLY — PARTS LIST


NOTES: UNLESS OTHERWISE SPECIFIED
1. INTERPRET DIMENSIONS AND TOLERANCES PER ANSI Y14.5M
2. DIMENSIONS ARE IN INCHES
-4 SPACER
SCALE: 4/1
DETAIL A
BREAK .015
DETAIL A
-3 SHAFT
SCALE: 4/1
-1 TAB
SCALE: 4/1
-2 ANTENNA
SCALE: 4/1
-5 COLLAR
SCALE: 2/1
.06 X 45° CHAM
AR | -5 | COLLAR | Ø1.0 X .095 WALL TUBE 304 SST
AR | -4 | SPACER | PEEK PLASTIC
AR | -3 | SHAFT | 300 SERIES SST
AR AR | -2 | ANTENNA | 304 SST ROD
AR AR | -1 | TAB | C110 COPPER SHEET
CAGE CODE | PART OR IDENTIFYING NO | NOMENCLATURE OR DESCRIPTION | MATERIAL | SPECIFICATION | FIND NO
NEXT ASSEMBLY
PARTS LIST
DES J.V. STAPLETON 2/92
DRN K. L. FARLEY 2/92
MARTIN MARIETTA ENERGY SYSTEMS, INC.
WVNS VITRIFICATION FACILITY
FACILITY ANTENNA
DETAILS
N/A
SCALE NOTED
XXXXX
X3E020097 A115
REV 0
CERTIFIED FOR CONSTRUCTION
DO NOT REVISE MANUALLY

APPENDIX F
OPERATIONS-MANUAL INPUT

1. INTRODUCTION

The purpose of this appendix is to provide preliminary input to the operations manual for the West Valley transfer cart control system. This information is preliminary and should be updated at the completion of the fabrication and testing of the equipment. The final operation manual will be prepared by West Valley Nuclear Services, Inc., manager of the West Valley Demonstration Project.

2. CONTROL PENDANTS

The control pendant is depicted in drawing Q-6340-120. It is a hand-held unit through which all basic operations of the cart will be controlled. Two control pendants are used, one at the north operator's station and one at the south operator's station. The functionality of both are the same.

2.1 OPERATION

The cart control system operates in two basic modes: (1) battery charging and (2) cart operation. During battery charging mode, the cart is disabled completely; sending commands to the cart will have no effect, and the cart will not report status of any of its normally monitored variables. During cart operation mode, the battery cannot be charged unless it is located at the charging shoes.

The control pendant consists of switches, light-emitting diodes (LEDs), and an audible alarm. The switches and LEDs are divided among functional blocks on the front face of the pendant. The audible alarm is mounted on the top side of the pendant. The following sections describe operation of the control pendants, organized by functional blocks.

2.1.1 Emergency Stop

The emergency stop switch is a maintained-contact type. Depressing the switch will cause the cart to stop, disable the battery charger, and prevent any further operation of both. To undo the emergency stop condition, the red knob must be rotated clockwise. Two LEDs indicate status of emergency stops. If an emergency stop exists at this station, the top LED is lit. If an emergency stop exists at the other station, the bottom LED is lit. It is not necessary for the control pendant station to be enabled before activating an emergency stop. If the operator attempts to request an action that is inhibited by an emergency stop, the LED(s) corresponding to the emergency stop in effect will flash.

2.1.2 Station Select

The control pendant station is selected by a keyswitch. The key can be inserted and removed in the 12 o'clock position only. Inserting and rotating the key clockwise attempts to select the station for use. If the other station is not enabled, the station will be selected. Otherwise, it will not be enabled. The LEDs in this block indicate the status of station selection. The top LED is lit if this station is enabled and the bottom LED is lit if the other station is enabled. If the operator attempts a control pendant function other than emergency stop without first enabling the station, the station select LED will flash. If the operator attempts to select this station and the other station is already selected, the other station LED will flash. If the key is inserted and turned counterclockwise, an LED test occurs. This test consists of flashing each LED on and off regardless of its previous state. The audible alarm will be sounded continuously during this test.

2.1.3 Doors

Door status is given by a matrix of nine LEDs. For each of the three cell doors, status of door energized, door closed, and door open is given. If the operator attempts to drive the cart when a door is energized, the door-energized LED for that door will flash to indicate that cart drive is interlocked while a door is energized. If the operator attempts to drive the cart in close vicinity to an unopen door, the door-open LED for that door will flash, indicating that the door is not fully open.

2.1.4 Cart Drive

Cart drive is controlled by a three-way, return-to-center, momentary contact, rocker switch. Pressing the top of the switch requests the cart to drive north. Pressing the bottom of the switch requests the cart to drive south. If the operator is driving the cart in close vicinity to an unopen door, the LED in this block will flash, the corresponding door-open LED will flash, and the audible alarm will sound.

2.1.5 Battery Charger

Two momentary contact, pushbutton switches and three LEDs are provided for control and status of the battery charger. The start switch will attempt to start the battery charger. Before this operation is permitted, the cart must be located at the charging shoes. This permissive is indicated by the cart-at-shoes LED. If the operator attempts to charge the batteries and the cart is not at the charging shoes, this LED will flash. When an appropriate start command has been issued the charging LED will begin to flash at a slow rate. This indicates that a valid charge command has been accepted, but that charging has not actually begun. It will take a few seconds to issue the start command to the battery charger and check to see if current is flowing. When current has begun to flow in the charging circuit, the charging LED will light steadily. If an error occurs with the charger, the charging LED will flash at a more rapid frequency than when charging is first initiated. Also, if another cart operation is attempted—but not allowed—during charging, the charging LED will flash rapidly. When the battery has been charged fully, the charging-complete LED will light. It is anticipated that the battery will remain on a float charge for long periods of time. Therefore, it is not necessary to stop charging when the charging-complete LED light first lights. When it is desired to operate the cart or disable charging for some other reason, the stop pushbutton is depressed.

A typical charge sequence will proceed as follows:

- Operator drives cart to charge location. Cart charging plates actuate cart-at-shoes limit switch. Corresponding LED lights on control pendant.
- Operator requests battery charging by pressing the charge button on the control pendant.
- Programmable logic controller sets output to communications controller that a charge is requested and begins flashing charge light on control pendant at slow rate to indicate that a valid charge request has been made, but that charging has not commenced yet. Communications controller initiates conversation with battery charger, issues start command, and polls charger for charging data. Charger begins charging and monitors battery for current, voltage, and temperature status. Cart electronics deactivate when voltage at charging plates exceeds battery voltage. Communications controller reads status variables from battery charger and passes them to the programmable logic controller. When programmable logic controller verifies that charging current is flowing, it lights the charging light on the control pendant steadily.
- The programmable logic controller monitors charging current, voltage, and temperature. When it has determined that a full charge has been given to the batteries, it lights the charging-complete LED on the control pendant.
- When the cart is required for another transfer, the operator presses the stop charging button on the control pendant. The programmable logic controller sets an output to the communications controller to disable charging and flashes the charging light on the control pendant at a slow rate to indicate that a valid operator command has been issued, but that charging has not stopped yet. Communications controller issues command to battery charger to stop charging. Battery charger stops charging. Cart electronics are reactivated when no charging current exists. Programmable logic controller confirms no charge current is flowing and turns off charging LED and charging complete LED on control pendant.
- Operator presses drive button on control pendant; cart drives away from charging shoes. Cart-at-shoes LED on control pendant goes off.

2.1.6 Motors

For each cart motor, an LED and a pushbutton are provided for status and restart control. During a motor undercurrent event, such as when a cart wheel is free wheeling, the LED will flash. For a motor overcurrent trip, the LED will light steadily. To attempt to restart the motor after an overcurrent trip, depress the restart pushbutton.

2.1.7 Auxiliary Outlets

For each auxiliary outlet, an LED and pushbutton are provided for status and control. To enable the auxiliary outlet, the momentary contact pushbutton is depressed and held for the duration that it is desired for the outlet to be active. When the outlet is active, the corresponding LED will light. If an overcurrent trip occurs, the LED will flash. To attempt to reset the outlet, the operator would let off of the pushbutton and then depress it again. If the operator attempts to charge the battery while an auxiliary outlet is enabled, the LED in this block will flash indicating that the battery cannot be charged until the auxiliary outlet is disabled.

2.2 LED LIGHTING SUMMARY

Because only limited information is available to the operator, the control pendant has been designed to feedback as much information as possible through the LEDs. The feedback includes information to tell the operator why a denied operation is being denied by the control system, such as if the operator attempts to begin battery charging but the cart is not at the charging shoes, the cart-at-shoes LED will flash. Table F.1 summarizes the meaning of the pendant LED operation.

Table F.1 Summary of Pendant LED Operation

LED	LIGHT STEADILY	FLASH
Emergency Stop This Station	during emergency stop at this station	when operation attempted during emergency stop at this station
Emergency Stop Other Station	during emergency stop at other station	when operation attempted during emergency stop at other station
Station Select This Station	when this station enabled	when operation attempted but this station not enabled
Station Select Other Station	when other station enabled	when operation attempted but other station enabled
Door Energized	when door energized	when cart drive attempted but door energized
Door Open	when door fully open	when approaching unopen door
Door Closed	when door fully closed	
Driving Towards Unopen Door		when approaching unopen door
Battery Charger Cart at Shoes	when cart is at charging shoes	when battery charge attempted but cart not at shoes
Battery Charger Charging	when batteries are charging	slow: when valid start or stop comand given but action not taken yet fast: when cart operation requested but batteries are charging
Battery Charger Complete	when batteries fully charged	
Motor Overcurrent/ Undercurrent	during motor overcurrent trip	when motor free-wheeling
Auxiliary Outlet	when outlet enabled	when outlet tripped

3. ENGINEER'S CONSOLE

The engineer's console is depicted in drawing Q-6340-102. It houses the workstation through which the engineer communicates to the cart control system. It also houses major facility-side control system components such as the Allen-Bradley programmable logic controller (PLC), the Prolog communications controller, and ancillary equipment.

3.1 OPERATION

Intouch, a man-machine interface will be running on the engineer's console computer. Through Intouch, the engineer can monitor and record cart variables and pendant activity and can modify limited system options. The workstation is the primary engineer's interface. However, a keyswitch on the front of the console is also provided for cart orientation. Following are descriptions of the operation of the cart orientation keyswitch and the Intouch man-machine interface.

3.1.1 Cart Orientation Keyswitch

A keyswitch is mounted on the front of the engineer's console to serve the purpose of changing the cart orientation status to the PLC. The same switch indicates that battery charging polarity must be reversed. This switch should be changed when the cart has been reversed on the tracks. It is very important that the engineer use this switch, as it is the control system's only way of determining which direction to drive the cart and what polarity to apply to the battery charging shoes.

3.1.2 Alarm and Event Summary

A window on the engineer's interface is dedicated to a summary of active alarms and events. This window can be used to indicate key items to the engineer such as cart ID selected, whether any facility antennas are disabled, what control pendant is selected, whether the battery charger or cart is active, which way the cart is oriented, etc. Alarms will also show such as motor over- and undercurrents, low battery voltage, approaching unopen door, etc. The alarms and events shown in this window are temporary—when the condition is no longer in effect, the line will disappear. However, a log of the alarm or event is saved to disk so that there is always a record of it.

3.1.3 Cart and Door Position

A pictorial representation of cart and door position is given in this window. The cart is shown on tracks, where north is left. The correct cart orientation should appear, and switching the cart orientation keyswitch should switch orientation of the cart on the screen. The position of the cart, as determined by the cart position algorithm in the PLC, is also given. Position of each door is shown. For doors 63M-001 and 3M-3, the door is shown by a solid rectangle covering the tracks when the door-closed limit switch is active. When the door-open limit switch is active, the rectangle slides off the tracks. When neither limit switch is active, the door is shown in a middle position. The same type logic applies to door 63M-008 except that two swinging doors are shown instead. When the PLC's door alarm is in effect, the door that the cart is approaching will flash in red.

3.1.4 Cart Status

Status of cart variables in numeric form is presented in this window. Values of motor and battery voltages and currents are listed as well as battery and electronics enclosure temperature.

3.1.5 Facility Antenna Control

To enable or disable facility antennas, the engineer calls up the facility antenna control window. This window has four buttons, one for each facility antenna. The text on each button shows the option available for each antenna, either *DISABLE* or *ENABLE*. To command an antenna on or off, the engineer would select the button with the tab key and depress the return key. The text on the button will toggle, always showing what the new option is. For example, if working with the VC antenna initially enabled, if the button is hit, the text will toggle from *DISABLE VC* to *ENABLE VC*.

3.1.6 Cart ID Selection

A total of four cart IDs are available to tag the main cart system, spare cart system, and spare electronics racks. By calling up the Cart ID Selection window, the engineer can select to which cart ID the facility communications system should direct its messages. Four buttons are presented with text corresponding to available options. If a given ID is currently active, selecting that button will have no effect. But selecting a new cart ID will change the message of the new cart ID button as well as the old cart ID button. For example, if cart ID #1 is currently active, the first button will read *#1 ACTIVE*, the second through fourth buttons will read *ACTIVATE #2*, *ACTIVATE #3*, and *ACTIVATE #4*. If the second button is selected with the tab key, and the return key is depressed, the text on buttons one through four will change to *ACTIVATE #1*, *#2 ACTIVE*, *ACTIVATE #3*, and *ACTIVATE #4*.

3.1.7 Real-Time Trends

Real-time trends of all cart variables are available. In many cases the trends are grouped into like variables, but the maximum number of plots per trend is four. For example all motor currents are shown on the same trend and all motor voltages are shown on another trend.

3.1.8 Historical Trends

It is possible to call up historical data that has been saved to disk by using the historical trend function.

3.2 MAINTENANCE

It is possible to enter maintenance modes on other system components by using the engineer's console workstation. The maintenance modes are described in the following sections.

3.2.1 Battery Charger

By using a terminal emulation program, the engineer can communicate directly with the battery charger, but first a switch box located in the rear of the engineer's console must be switched to connect the battery charger to the workstation computer rather than the Prolog communications controller. The battery charger can be reprogrammed, charger status can be displayed, and a past history of charging variables can be requested. If necessary the charger can be started and stopped from here also, although this task is normally done by the Allen-Bradley PLC through the Prolog communications controller by request from the control pendant.

3.2.2 Prolog Communications Controller

The terminal emulation program can also be used to communicate to the serial port of the Prolog communications controller. The controller has a maintenance mode that can be activated by doing this. Status of the controller is provided. It is also possible to download new programs to the controller in this mode.

3.2.3 Allen-Bradley PLC

The engineer's workstation can also be used to tie directly into the Allen-Bradley PLC. In this mode, the ladder logic of the PLC can be displayed online and modified if necessary. Inputs and outputs can be forced on and off. In addition to online modifications, a new program can be downloaded to the PLC.

4. CART CONTROLLER

The cart controller is a Winsystems single board computer. During normal operations the controller will communicate with the facility and its operation will be directed by either the operator at the control pendants or the engineer at the engineer's console. However, the controller does have a maintenance mode that enables interrogating operation of the cart controller locally.

4.1 MAINTENANCE MODE

To use the maintenance mode of the cart controller, a terminal must be connected to the cart controller's serial port. When connected in this manner, the cart controller enters an interactive test mode. In this mode local cart functions can be checked such as motor control, fan control, and auxiliary outlet control. Status information of all cart variables can be shown as well as shunt calibration information. A verification of communications packets can be done also.

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