ACUREX INNOVATIVE POINT FOCUS SOLAR CONCENTRATOR

OPERATION, SERVICE, MAINTENANCE, AND REPAIR MANUAL

March 1987

Acurex Project 7749
Contract No. DE-FC04-85AL23711

For

Department of Energy
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, NM 87115

By

Acurex Corporation
Environmental Systems Division
485 Clyde Avenue
P.O. Box 7044
Mountain View, California 94039

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SECTION 1

INTRODUCTION

This document provides descriptions and operating instructions for the Acurex Innovative Point-Focus Solar Concentrator (IC) installation at Sandia National Laboratories in Albuquerque, New Mexico. The IC was designed and built by Acurex Corporation under a Cooperative Agreement with the United States Department of Energy (DOE).

This document is divided into three main parts: Section 2 provides a system installation description, Section 3 provides operating instructions and Section 4 provides service, maintenance and repair instructions.

Care, regular service, and maintenance are recommended to provide fault free operation.

This manual alerts operators, service and maintenance personnel to points of particular importance, regarding safety and proper practices. These points are identified with notes stating:

- Warning
- Caution
- Attention, and
- Note

Safety warnings must be strictly observed to prevent injury to personnel and damage to equipment.

The terms "Warning" and "Caution" are used if incorrect observance or nonobservance of operating instructions, job instructions, specified procedures and the like may result in an injury or a serious accident.

SECTION 2

INNOVATIVE POINT FOCUS SOLAR CONCENTRATOR SYSTEM DESCRIPTION

2.1 ACCUREX INNOVATIVE SOLAR CONCENTRATOR INSTALLATION, ALBUQUERQUE, NEW MEXICO.

Site specific aspects of the design of this particular IC were tailored to conditions at Sandia National Laboratories (SNL) Distributed Receiver Test Facility (DRTF) at Kirtland AFB, Albuquerque New Mexico. Figure 2-1 shows the IC site.

Foundation design is site specific. The IC foundation design for DRTF is based on soil samples and information provided by SNL.

Another feature particular to this installation is the method of resetting the control system. Pressing a keylocked button on the side of the drive control unit (DCU) forces inspection of the concentrator after system lockout. Forced inspection promotes safe operation and encourages developing a thourough understaning of the workings of this concentrator in an experimental setting. For a mature system in an operating field of many modules, the design would use a different reset method. For information on the specific interfaces of this system, see Section 2.1.4, IC Interfaces.

2.1.1 IC General Arrangement

Figure 2-2 shows a scale model of the Innovative Concentrator. The DCU, Hydraulic Power Unit (HPU), and Battery Enclosure, which are not shown in Figure 2-2, are mounted to the Drive Support Unit. Figure 2-3 shows a layout of the system interfaces.

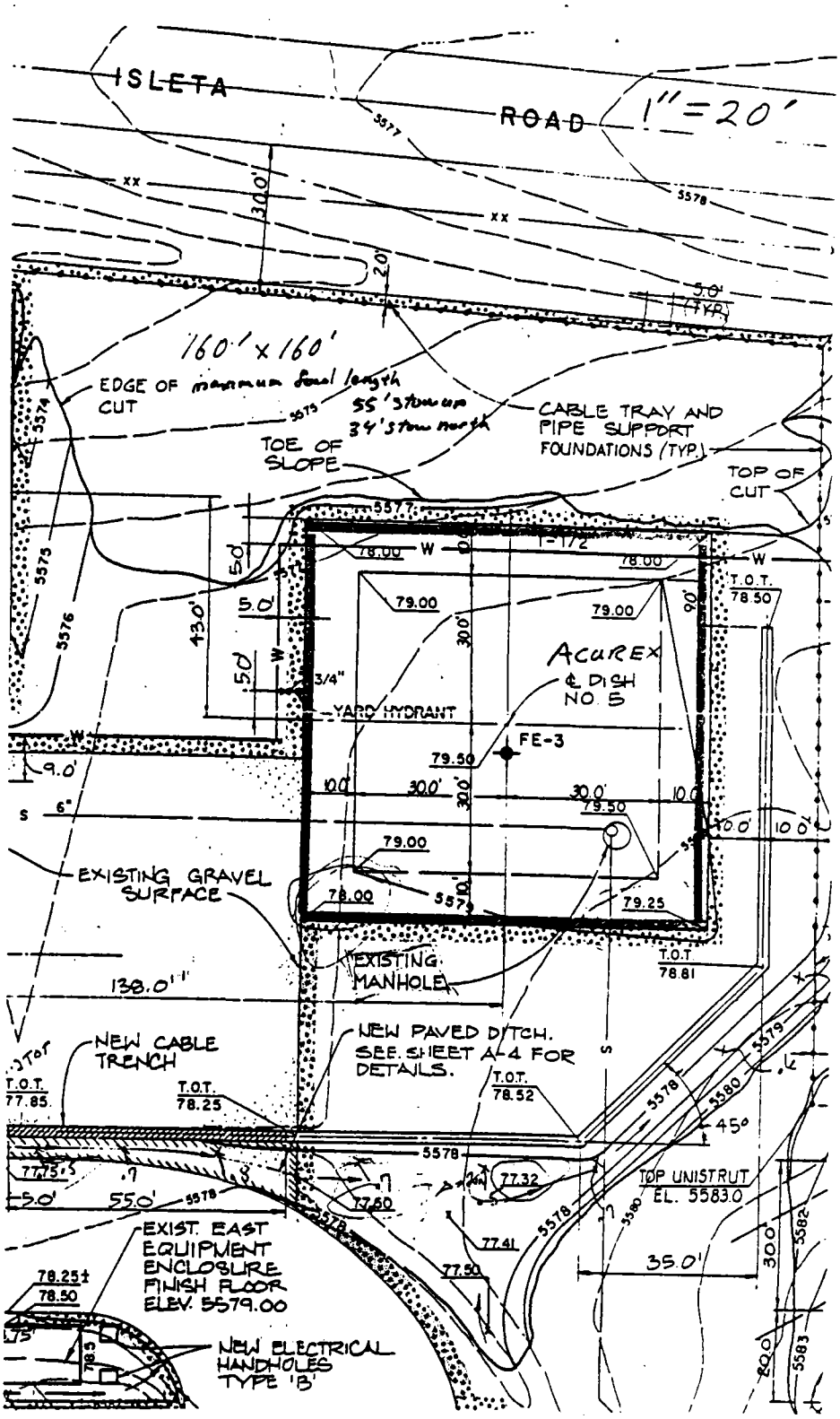


Figure 2-1. Acurex Innovative Concentrator Location

2.1.2 Control System Overview

Drawings 7749I400 and I401 are block diagrams of the power and control systems, respectively. The central control computer in the control room provides operator interface and ephemeris calculations. The manual control station provides manual control of the concentrator when enabled by the computer. Programmable Logic Controllers, PLC-1 and PLC-2, and control logic and electronics in the DCU implement the control algorithm. Hydraulic cylinders move the concentrator as directed by the control system.

2.1.3 IC Design Features

The most important and innovative feature of the Innovative Concentrator, in terms of cost reduction, is the structural integration of stamped sheet-metal reflective panels with the panel support (dish) structure. The reflective panels are designed to help carry wind and weight loads, thus minimizing redundant load-bearing structure.

Other key features of the concentrator are:

- 15m dish diameter
- Microprocessor-based on-dish controls and hydraulic drive system using standard industrial grade products
- PCA support structure isolated from the panel support structure -- transmits the high PCA-induced moments directly to the drive support structure
- Tilted azimuth bearing (tilted 10° to the north) -- allows continuous tracking in subtropical regions, such as Hawaii, when the sun is north of zenith

2.1.4 IC Interfaces

Figure 2-3 shows the IC Interface layout. Figure 2-4 depicts the IC System AC power interface Disc-1. Cables C-1 and C-2 of Appendix M show the

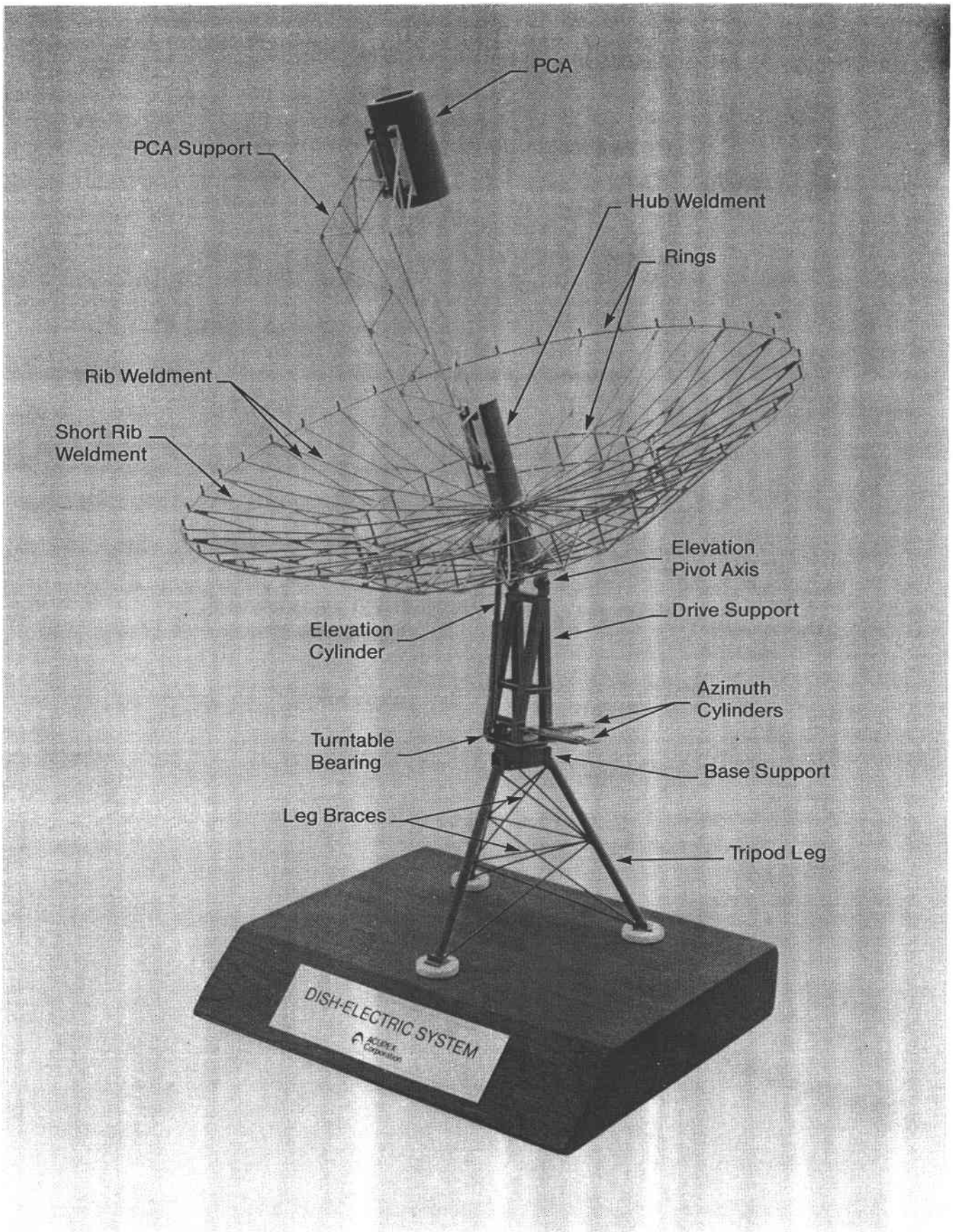


Figure 2-2. Major Subsystems and Components of Innovative Concentrator

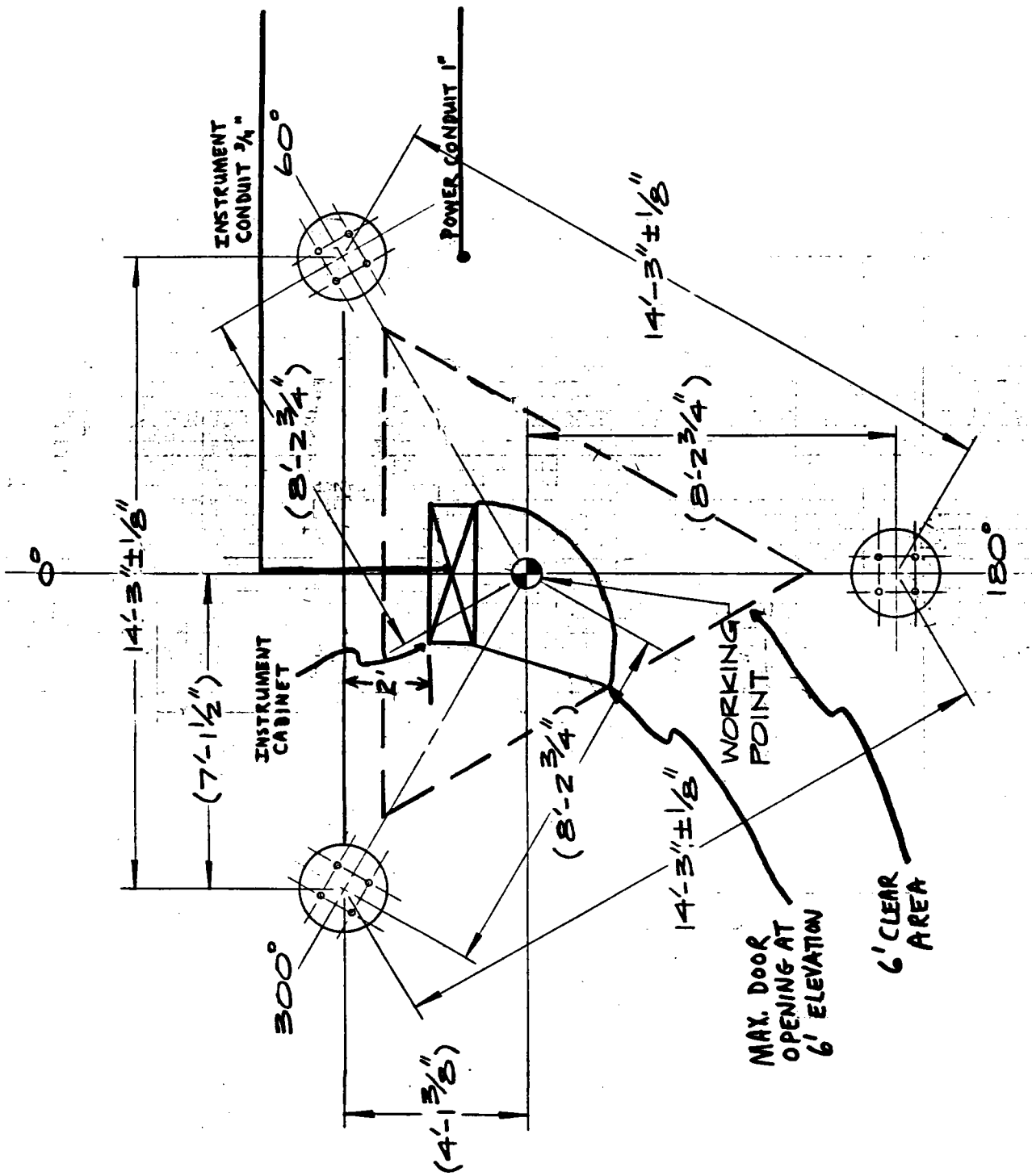


Figure 2-3. IC Interface Layout

power connections to the system via Disc-1. Refer to Drawing 7749E304, Cable and Conduit Block Diagram, for cable description.

Figure 2-5 depicts the IC control wiring interface JB-1. Cables C-3 and C-4 of Appendix M show the control connections.

For a description of the foundation and other aspectes of the system and its interface to the particular site, see Sections 2.1 and 2.2.2.7.

2.2 CONCENTRATOR SYSTEM DESCRIPTION

2.2.1 Central Control System

The essential elements of the IC are the central control computer, the control system alarm indicator, and the central control interfaces.

2.2.1.1 Central Control Computer

The central control computer is an IBM-PC with two floppy disk drives and 64 K-bytes of storage. The monitor is an Amdek 310A, featuring amber display for decreased eye fatigue. The printer is an Epson FX85 parallel printer. The control computer system is located in the control building.

The IBM-PC is augmented by a parallel communications card for RS-232 communications and an AST I/O plus minicard battery-backed clock card.

2.2.1.2 Central Control Alarm Indicator

The central control alarm indicator (IL-412) is located in the control building near the central control computer. It indicates alarm conditions including the following: AC power loss, high wind conditions and control system failure.

2.2.1.3 Central Control Interfaces

Central control interfaces include keyboard/screen operator interface and current-loop interface to the concentrator DCU.

Figure 2-6 shows a sample display of the operator interface to the central control computer. The screen shows the date, present mode, and time

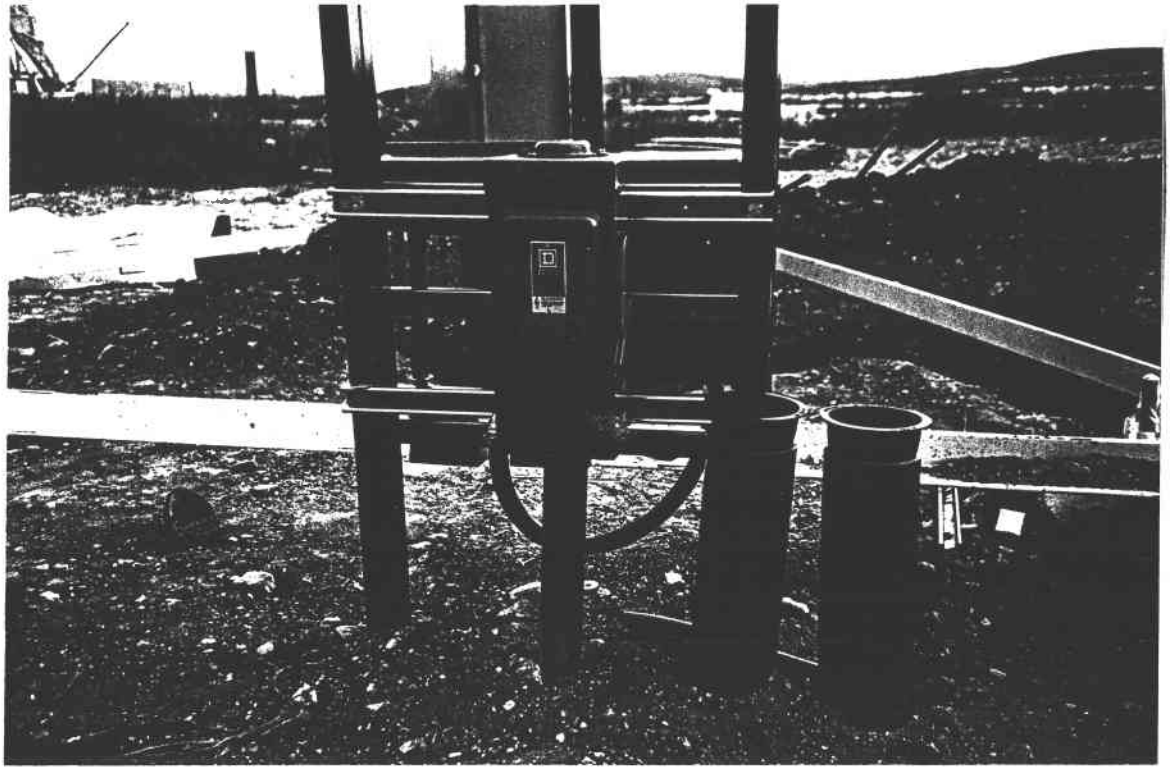


Figure 2-4. IC System AC Power Interface

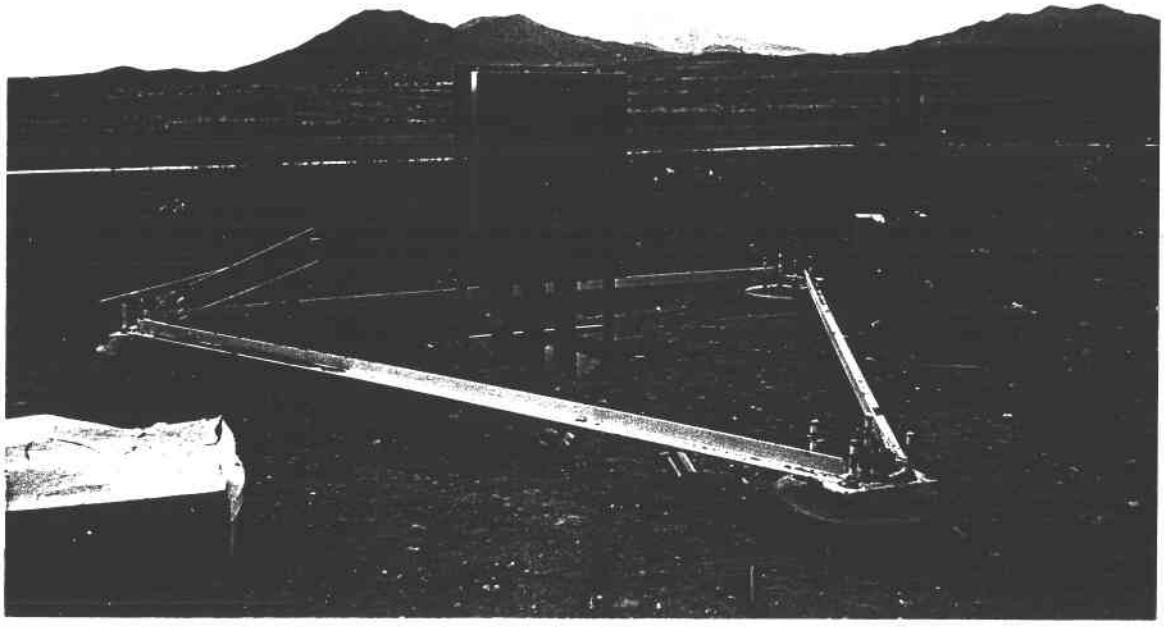


Figure 2-5. IC Control Wiring Interface

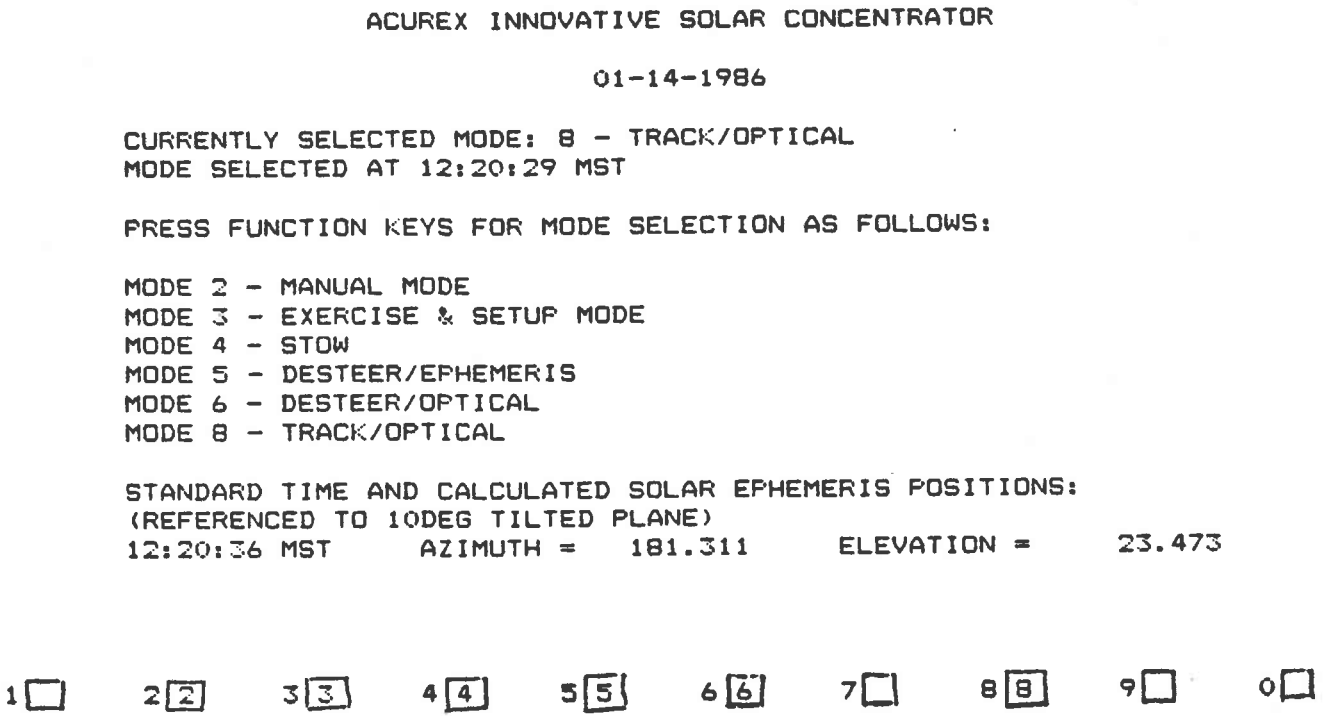


Figure 2-6. IBM-PC Sample Display

the present mode was selected. It displays continuously updated time and solar position information, and lists the operator-selectable modes. The operator selects modes by pressing the function key corresponding to the desired mode.

The current-loop interface to the DCU uses a Black Box 101-4Q CL410 adapter to convert the IBM PCs RS-232 output to a 20 mA current loop. (See Appendix A). This current loop carries status and ephemeris information from the IBM PC in the control room to the Siemens-Allis Automation MC-8 programmable logic controller (PLC-1) in the DCU.

2.2.2 On-Dish Systems

2.2.2.1 Reflective Panels

The reflector of the Acurex Innovative Concentrator is comprised of 40 outer panels and 20 inner panels. Each panel consists of silvered polymer film laminated to the fron panel sheet which is bonded to a stamped hat-section back panel. In order to ensure long life for the prototype, the surface to which the silvered film is laminated is prepared with an acrylic paint. The fron and back panesl are made from aluminized deep draw-quality, aluminum-killed cold-rolled steel. The adhesive used to bond the fron and back panels is Pliogrip 6000 series, a 2-part urethane produced by Ashland Chemical.

Figure 2-7 illustrates the method by which the reflective panels are joined to each other and to the ribs of the panel support structure. All mounting holes are accurately drilled or punched at the factory, using drill fixtures or numerical machining methods, prior to assembly. This includes the panel support structure ribs.

Panels are fastened to each other with a lap joint between adjoining panels. An offset is provided on one edge of each back panel in order to

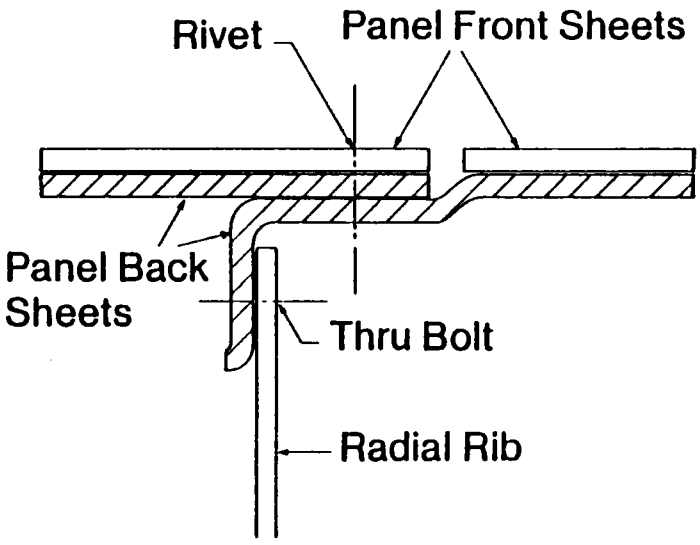


Figure 2-7. Inter-Panel and Rib Interfaces

achieve a continuous, even reflective surface. A similar joint is provided between inner and outer panels, the offset being provided at the outer edge of the inner back panel. Rivet holes are provided at 6-in. intervals along the interpanel joint to provide, when assembled, an integrated dish.

Attachment to the panel support structure rib is through a "weak" flange that will not transmit small deflections or inaccuracies in the structure to the reflector. This flange is through-bolted or rivetted to the radial rib. Both the offset and flange are formed with the back panel ribs during stamping.

2.2.2.2 Support Structure

The Innovative Concentrator support structure consists of the following four subassemblies:

- PCA Support
- Panel Support
- Drive Support
- Tripod and Support

These are shown in Figure 2-2.

2.2.2.2.1 PCA or Receiver Support Structure

The PCA support consists of two tubular truss weldments (legs) which are joined at the central hub of the panel support. The truss consists primarily of 3-in. square tubing.

Rails to which the PCA can be clamped are provided at the PCA-end of each leg. The rails will accommodate PCA's 4 to 5 feet in diameter and will allow longitudinal adjustment for proper location of the receiver aperture at the concentrator focal plane.

2.2.2.2.2 Dish Support Structure

The primary elements of the panel support are the ribs, central hub and rings. The 20 repeating rib truss weldments radiate from the central hub and resist back-wind loads. In addition there are 20 short ribs which, along with the 20 main rib truss members, support the outer panels. Front loads are resisted by the integrated panel assembly, once installed on the panel support.

The central hub is a 30-in. O.D. tube and is the central connection member for the PCA support, the 20 main rib truss members and the elevation pivot.

Two inner rings and one outer ring tie the panel support ribs together. Circumferential adjustment of the ribs is provided by bolts which attach the ribs to the rings.

2.2.2.2.3 Drive Support Structure

The drive support is the interface between the articulated portion of the dish and the base structure. The drive support, tilted at 10°, rotates on the azimuth axis. It is to be an open structure consisting of plates, angles and gussets, as shown in Figure 2-2.

2.2.2.2.4 Support Leg Structure

The tripod and base support is a stationary tripod structure and is the interface between the azimuth bearing and the foundation. The portion which supports the bearing directly is a plate weldment. The tripod legs and braces are tubular members. Double-nut adjustment and subsequent grouting is provided at the foundation.

2.2.2.3 Drive System

The Innovative Concentrator drive system utilizes hydraulic cylinders and a medium pressure (3000 psi) hydraulic system to position the dish in both

azimuth and elevation coordinates. The hydraulic components incorporated in the design are standard, existing, mass-produced components, assembled into a design which is unique in the control strategy employed.

2.2.2.3.1 System Configuration

Although the hydraulic components specified for the Acurex Innovative Concentrator design are standard, the overall concept and control strategy is unique. The hydraulic circuits are presented in schematic form in Figures 2-8 and 2-9. Note in Figure 2-8 that azimuth rotation is accomplished by placing two hydraulic cylinders at 90° to one another, such that they work on a common crank arm.

The control system concept requires the dish to move about each axis in response to commands from either the optical trackers or a control computer, in an "on-off" mode of operation. The hydraulic system responds by turning the required hydraulic pump motor on only when movement is required, with the directional control valve momentarily pulsed and latched in the correct position. Therefore, no pump "dead-heading" occurs and no parasitic system pressure drops are present. In essence, the hydraulic cylinders are direct-coupled to the pump outputs, and thus act as a hydrostatic transmission for converting the high-speed output of the electric drive motor to the high-torque (high force) output of the hydraulic cylinders.

Focus and defocus slew movement is provided in the elevation axis by Pumps P3 and P4 (in the event that either pump fails, the remaining pump serves alone as a half-capacity backup). The control strategy requires a brief slew speed movement into and out of focus to limit the dwell time of the sun spot on the receiver aperture lip. The drive system therefore must provide a much higher than average speed for a short duration to accomplish the slew maneuver; the hydraulic system accomplishes short-term accelerated

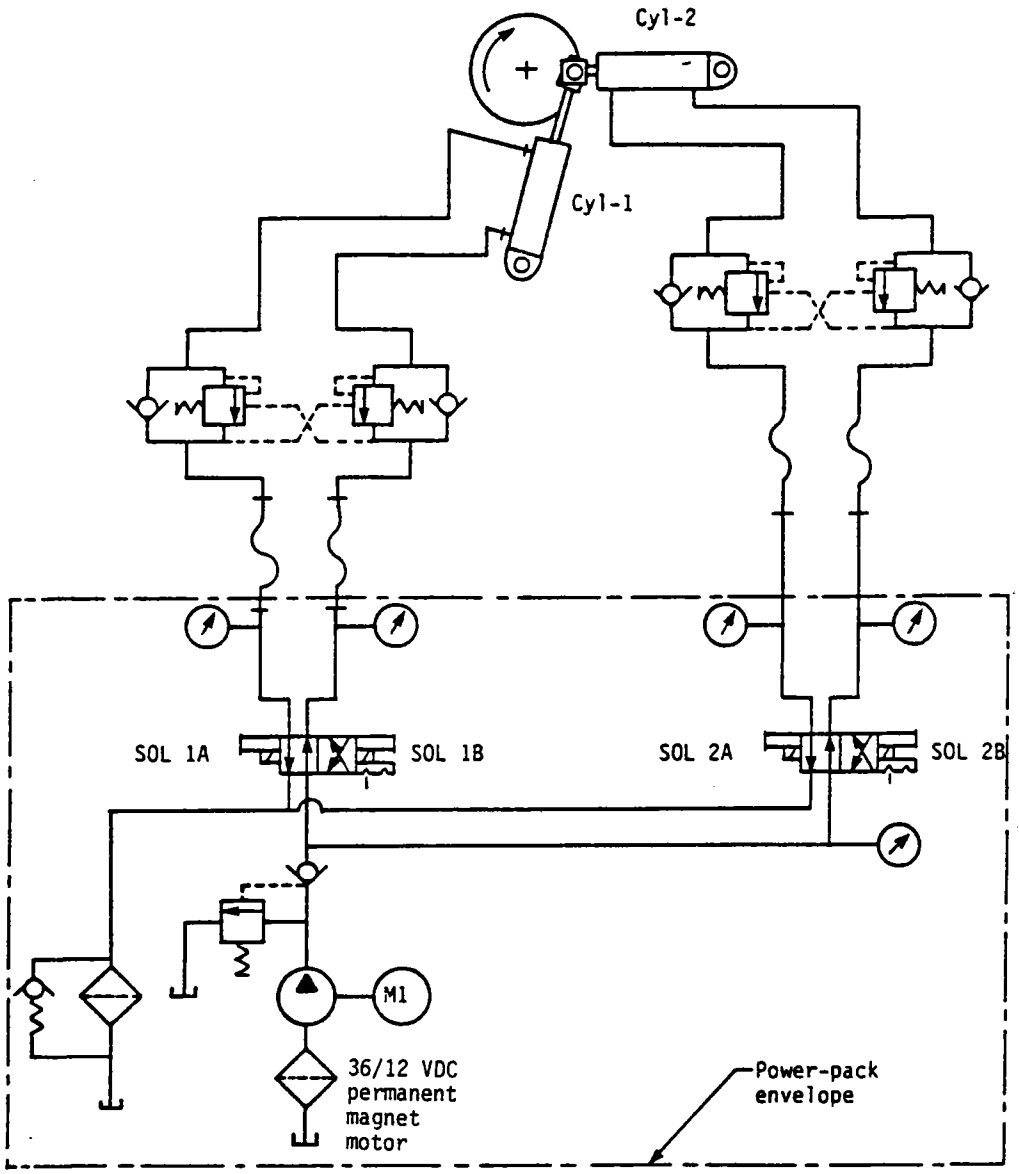


Figure 2-8. Azimuth Hydraulic System Schematic

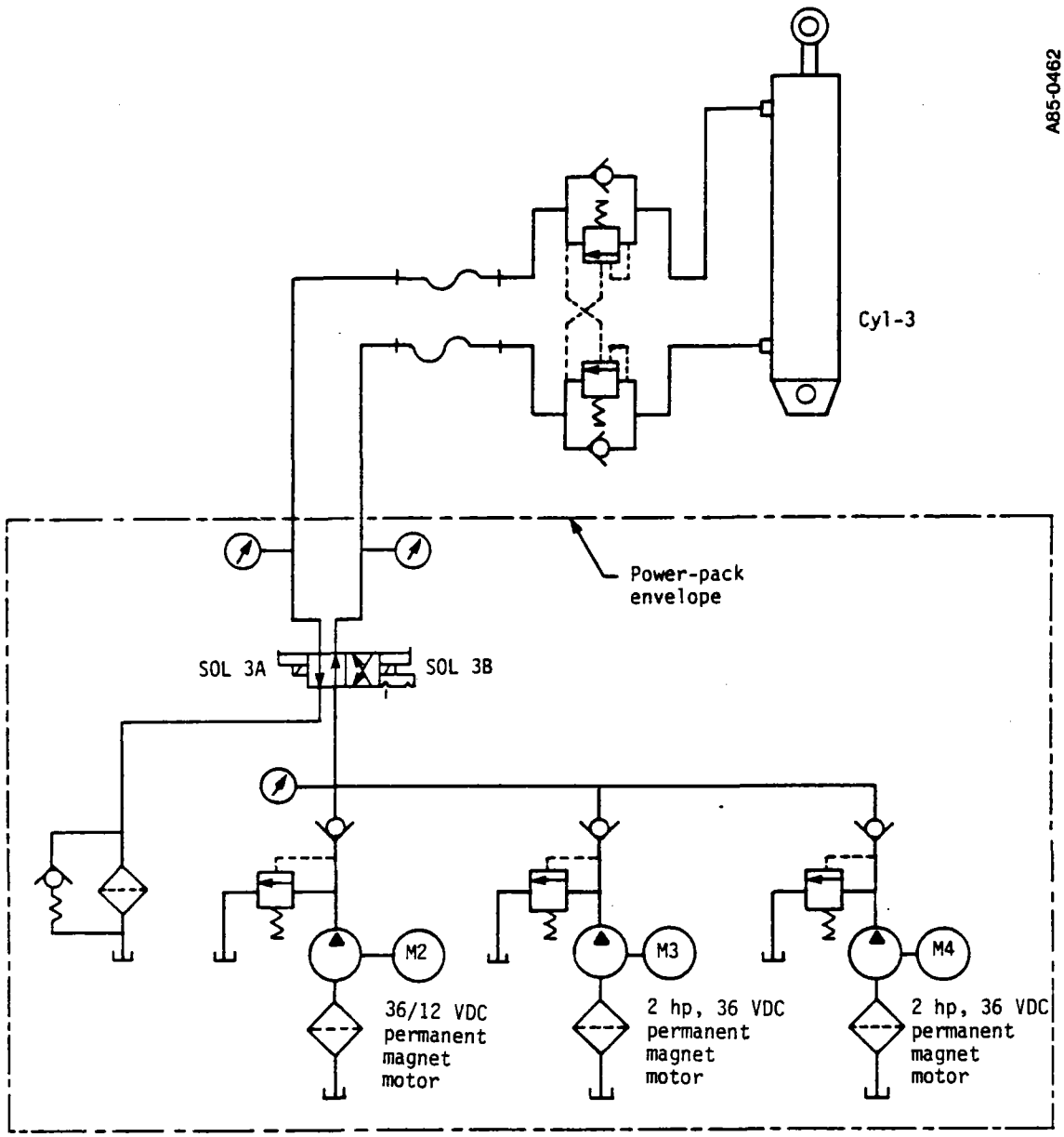


Figure 2-9. Elevation Hydraulic SYstem Schmatic

movement by increased fluid flowrate, requiring no change in sizing pressure rating the system's components. Pumps P1 and P2 have dual speed capability and provide tracking in azimuth and elevation, as well as slew to stow capability.

2.2.2.3.2 Main Bearings

The main azimuth bearing is a large diameter, slow speed, intermittent rotation, gearless turntable bearing, manufactured by Rotek, according to Acurex Specification 774903SP Rev. 3. It is described in Appendix N.

The main elevation bearings are Morse Sealmaster ERCI-307 with contact seal. They are described in Appendix O.

2.2.2.3.3 Hydraulic Cylinders

The prime movers for both the elevation and azimuth axes are Prince Mfg. double-acting hydraulic cylinders. Table 2-1 summarizes the characteristics of the cylinders, which are described in Appendix R. Acurex Specification 7749-06SP describes the hydraulic cylinders in greater detail. Appendix P describes tracking pumps P1 and P2, which are Oildyne 634-746, Model 3SP-*W-NVSN. Appendix Q describes slew pumps P3 and P4, which are Oildyne 634-765, Model 4SP69-*W-NVSN.

2.2.2.3.4 Hydraulic Power Unit

The two tracking speed pumps and two slew speed pumps (four pumps total) are mounted on a common baseplate and sump. The control valves and pressure relief valves are mounted on the same baseplate, forming a complete hydraulic power package referred to as the HPU. The primary power requirement for the HPU is 220 VAC, single phase, 20 amperes.

Table 2-1. Hydraulic Cylinder Specifications

	Maximum Operating Force (lb)	Maximum Holding Force (lb)	Cylinder Size (in.)	Bore Size (in.)
Azimuth (2)	65,000	85,000	6	3
Elevation	105,000	93,000	7	5

2.2.2.4 Concentrator Electrical, Instrumentation, and Control System

2.2.2.4.1 General

The electrical, instrumentation, and control system consists of optical trackers, limit switches, position encoders, batteries, DCU, and associated equipment. Acurex drawings 7749I400 and 7749I401 show block diagrams of the power and control systems, respectively.

2.2.2.4.2 Trackers and Electronics

The optical trackers and tracker electronics consist of two Mann-Russell ST-1 Dual Axis Tracking Kits, with the electronics custom-mounted in the weather resistant tracker electronics enclosure. The tracking hardware is further described in Appendix B.

2.2.2.4.3 Limit Switch Assemblies

The limit switches are Allen Bradley 802M limit switches with Allen Bradley 802MC-WIA roller levers. They are described in Appendix C.

2.2.2.4.4 Position Encoders

The position encoders are Astrosystems Durapot wiperless potentiometer HDC-1000A-1 with a heavy-duty NEMA 12 transducer HST26A and separate electronics with 0 to 10VDC output and clockwise shaft rotation. They are described in Appendix D. The separate electronics are mounted in the DCU.

2.2.2.4.5 Battery Power Supply and Enclosure

The batteries are Marathon 12-PMF-50 and 12-PMF-100 lead acid batteries. They are described in Appendix E. They are enclosed in a Hoffman A36H3012GQRLP fiberglass enclosure with louvers.

The batteries provide 12V power to the control system and slew pumps and 36V power to the tracking pumps. Drawing 7749I400 shows a block diagram of the power system.

2.2.2.4.6 DCU

The DCU contains the logic and control electronics for operating the IC. It also contains the battery chargers which charge the batteries described above. The control system block diagram 7749I401 shows an overview of the DCU and other control equipment interactions.

The programmable logic controller, PLC-1, is the brains of the IC control system. It is a Siemens-Allis Automation MC-8, described in Appendix F. It coordinates inputs from field sensors, commands from the manual control station, and ephemeris and command mode information from the central computer, to control the concentrator hardware via relay logic.

The programmable logic controller, PLC-2, is a Siemens-Allis automation I^2R, described in Appendix G. It serves as a watchdog to verify PLC-1 functionality and to stow the concentrator in case PLC-1 fails.

The battery chargers are Stored Energy Systems 12V battery charger FC-12-6 (BC-1, BC-2, and BC-3) and 36V battery charger FC-36-3 (BC-4). They are described in Appendix H.

The relays and logic are fully detailed in drawing 7749E305. The relay logic is designed to provide consistent and safe system operation under a wide variety of conditions including AC power failure and component failure. The

relays are Potter and Brumfield R10-E1-P-4-V185 and R10-E1-P4-115V and Crydom D1D40 and D1240.

The circuit breakers are Allen Bradley rail mounted 1492-G050 and 1492-G150.

2.2.2.4.7 Manual Control Station

The pendant-hung Manual Control System is located at the back of the concentrator drive support. It provides control mode selection and display as well as manual control of the concentrator position.

Operation of the manual control station is described in Section 3.3.3

2.2.2.4.8 Cable Track

The cable track is Gortite Gortrac Model L-200. It is described in Appendix I. The Gortac provides a pathway for cables between the fixed tripod and the moving drive support structure.

2.2.2.4.9 Fused Disconnect Switch

The disconnect switch (DISC-1) is an ITE model NRH-321 two-pole, two-fuse 240 VAC 30A heavy-duty outdoor NEMA3R safety switch. It contains two 20A fuses, Bussman FRNR or equivalent. It also contains two GE model V275ME250 metal oxide varistors (MOVs) to protect the control system from power line transients.

2.2.2.4.10 Grounding

Ground connections are tied to the Sandia DRTF grounding grid (see Drawing 7749E304, conduit and cable block diagram). The ground connection for the transformer and control system electronics is provided via the disconnect enclosure DISC-1 and cables C-2 and C-21. The structure is grounded separately by cables C-21 and C-22.

2.2.2.5 Electrical and Control Interfaces

The conduit and cable block diagram, drawing 7749E304, shows an overview of the electrical and control interfaces between the IC and Sandia's power and control systems.

Grounding interfaces to the DRTF grounding grid are described in Section 2.2.2.5.10.

Power connections to the DCU for 1ϕ, 240V, 60 Hz, 15A service are made via fused disconnect DISC-1 by cables C-1 and C-2.

Control connections to the DCU are made through cables C-3 an C-4, which contain eight shielded pairs with an overall shield. Control connections are listed in Table 2-2.

2.2.2.6 Foundation

The Innovative Concentrator foundation consists of three poured-in-place concrete piers, each 2 ft in diameter and 20 ft deep. The design, specific to the DRTF site, is based upon soils data from the report prepared for the site entitled "Geotechnical Investigation Report, Solar Dish Installation, Kirtland, AFB, Albuquerque, New Mexico; SHB Job No. E83-1179," by Sergent Hauskins and Beckwith, submitted to Sandia on December 7, 1983.

The foundation is designed to satisfy the requirements of the soils conditions at Sandia's DRTF, satisfy the load conditions of the concentrator system (including PCA), and permit rapid alignment of the tripod legs.

Table 2-2. Control Connections

Conductor	Conductor No.	Function
1 red	157	Current loop (RED+)
1 blk	158	Current loop (RXB+)
2 red	165	Wind signal N.C.
2 blk	37	Wind signal COM
3 red	412	IL & HS COM
3 blk	40	IL-412
4 red	195	HS-195
4 blk	197	HS-197
5 red	--	Spare
5 blk	--	Spare
6 red	--	Spare
6 blk	--	Spare
7 red	--	Spare
7 blk	--	Spare
8 red	--	Spare
8 blk	--	Spare

SECTION 3

INNOVATIVE SOLAR CONCENTRATOR OPERATION

3.1 INTRODUCTION

The IC operator interfaces are the central control computer, manual switches in the control room, and the pendant manual control station, located at the rear of the drive support of the concentrator. In addition, the central control computer, PLC-1, and PLC-2 are all continuously monitoring various parameters to assure safe operation of the concentrator.

3.2 SAFETY AND SAFETY PROCEDURES

Follow all safety precautions in this and referenced documents, in addition to standard safety practices and common sense. Refer to and follow the established safety procedures detailed in the DRTF Safe Operating Procedures: SOP for the Distributed Receiver Test Facility and for the Test Bed Concentrators," and to "Addendum to DRTF Safe Operating Procedures for Acurex Innovatve Point Focus Solar Concentrator."

Take proper precautions for safety according to location, such as wearing a hard hat in the concentrator field and using a safety belt at elevated locations on the concentrator. Any work around batteries involves particular electrical, chemical, and fire precautions outlined in the battery instructions listed in Appendix E.

For maintenance requiring personnel to be on the concentrator structure, lock out the control system power when use of the controls is not needed. To do this, insert the key in the locking pushbutton on the side of the DCU, depress the red pushbutton, and lock the pushbutton in the off (depressed) position. Remove the key to insure lockout. Remember that the batteries are the main supply of electrical power; therefore, shutting off the AC power does NOT remove power to the system. Any work inside electrical enclosures requires disconnecting battery power where necessary to remove power to the enclosure, if removal of power is required. In such case, use adequate rubber gloves or other protection when handling live circuits, and do not leave disconnected live leads unprotected. See Appendix E for particular precautions around the batteries.

When work on the concentrator requires the control computer to be in a particlar mode for safety (e.g., Mode 2, manual control), cover the keyboard with an appropriate sign, such as, "CONCENTRATOR IN MANUAL MODE. DO NOT OPERATE KEYBOARD." Do not leave the concentrator in manual mode (central control computer keyboard, Mode 2) unattended.

Work on the hydraulic system must be performed only with the concentrator in the maintenance stow ("Stow North") position and the batteries disconnected.

The concentrator reflects and concentrates intense sunlight. This is true especially when it is focussed on the sun, but also in all modes of operation or stow. Wear sunglases, do not look directly at bright spots, and take all due precautions to prevent eye injury and burning of personnel, equipment, or structures.

3.3 CONTROL SYSTEM AND OPERATING MODES

3.3.1 General

The IBM PC central control computer in the control room is the main operator interface for central control. In addition, there are manual switches for maintenance stow and desteer, located above the control computer.

Local control is provided by the manual control station, which hangs as a pendant from the back of the concentrator drive structure.

The MC-8, PLC-1, coordinates field sensor inputs and operator interfaces to control the workings of the concentrator via relay logic. PLC-2 acts as a watchdog to stow the system in case of PLC-1 failure. The relay logic defaults to manual control in case of relay failure.

Two of the control system's operating modes are alarm modes. The alarm modes are not user selectable. Mode 0 is the watchdog stow mode, indicating that either PLC-1 or PLC-2 has failed. Mode 1 is the AC power loss or high wind stow alarm. Either alarm mode causes the concentrator to stow facing upwards.

To reset the control system, go outside and inspect the concentrator for damage or problems (see Section 4.1.11, Visual Inspection of IC). When ready to proceed, unlock the keyed pushbutton on the side of the DCU and press the pushbutton to turnoff power to the control system. Then, release the pushbutton to turn on control system power, and lock the pushbutton in the released (power on) position. Return the key to its authorized storage location.

The purpose of this procedure is to insure at least a visual inspection of the concentrator before resetting the control system.

3.3.2 Control Operating Modes

The operator can choose from six user-selectable operating modes, as shown in the sample computer display in Figure 2-1. To select a mode, press the special function key corresponding to the desired mode number (Modes 0 and 1 are alarms, which are not user-selectable. See Section 3.3.1).

Mode 2, the manual mode, transfers control to the manual control station. Manual control is discussed in Section 3.3.3.

Mode 3, the exercise setup mode, exercises the concentrator's hydraulic systems. Selection of the mode first puts the system in vertical stow, facing upwards. Then the concentrator moves in a boxlike path of up, clockwise, down, and counterclockwise, with each side of the "box" being 4.5°.

Mode 4 is maintenance, stow. Selection of this mode stows the concentrator facing.

The solar tracking, Modes 5 through 8, interact as described below the descriptions of the modes themselves.

Mode 5 is the desteer/ephemeris mode. "Desteer" is defined here as following the sun's azimuth at an elevation 5° higher than the sun's elevation. In Mode 5, the concentrator follows the ephemeris coordinates computed by the central control computer but 5° in elevation above the calculated sun position.

Mode 6 is the desteer/optical mode. Selection of this mode causes the concentrator to follow the desteer optical tracker, which is aligned to orient the concentrator 5° in elevation above the actual sun position.

Mode 7, the track/ephemeris mode, is not user-selectable. In Mode 7 the concentrator follows the calculated ephemeris coordinates as an intermediate step toward optical solar tracking.

Mode 8 is the track/optical mode. In Mode 8, the concentrator follows the focus optical tracker, aligned to focus the concentrator on the sun.

The tracking modes interact as follows. From any of the nontracking Modes (2, 3, and 4), entering a selected tracking mode proceeds in numerical order of the tracking mode number. For example, if the operator selects Mode 8 from Mode 3, first the concentrator enters Mode 5 until it acquires the desteer/ephemeris position. Then it enters Mode 6 for a trial period in desteer/optical mode.

If after 10 seconds the position from optical tracking is not within tolerance of the ephemeris calculation, the concentrator is reset to Mode 5 to start the procedure again. Otherwise, it slews into focus and enters Mode 7, track/ephemeris. This mode serves to "fine tune" the concentrator position according to the calculated ephemeris position.

Once the concentrator is properly oriented for focus according to the ephemeris calculations, it enters Mode 8, track/optical. It tracks optically from then on, unless the actual position comes out of tolerance with the calculated ephemeris position (which is constantly updated). In such a case, control goes back to Mode 7, track/ephemeris, to position the concentrator at the calculated ephemeris position, at which point control re-enters Mode 8, track/optical. If this fallback process happens more than three times within 100 program loops (approximately 60 to 100 seconds), the concentrator is locked out of focus and goes to desteer/optical.

Leaving focus (like entering focus) is always accomplished by slewing between focus and desteer positions. The focus lockout is reset when the operator selects a nonfocus mode (Mode 6 or less). After selecting a nonfocus mode to reset a focus lockout, the operator may select Mode 8 again to focus the concentrator. In all of the nontracking modes, PLC-1 monitors the

concentrator position, compares it to the ephemeris position, and slews the concentrator up if it enters a region in or beneath a 4.5° "box" around the sun. This feature protects against damage from inadvertent focusing or near-focusing of the concentrator.

Note that the screen displays the currently selected mode. In situations such as focus-lockout (actual mode = 6, selected mode = 8) or manual control (actual mode is selected by manual control station, selected mode = 2 to enable manual control station), the displayed (selected) mode is not the actual mode chosen by PLC-1 in the DCU, which controls the concentrator. Also, after the calculated sun elevation falls below 10°, above the 10°, tilted plane of the concentrator, only Modes 2, 3, and 4 may be selected, and higher modes fall back to Mode 4 (stow).

In addition to the selected mode and mode menu, the central control computer screen displays the standard time (i.e. not daylight savings time) and calculated solar azimuth and elevation referenced to the 10° tilted plane of the concentrator drive bearing (a plane with an angle of 10° to the horizontal, facing due South).

3.3.3 Manual Control

The main method of manual control of the IC is via the manual control station. In addition to the normal operating modes selectable on the manual control system, manual switches are provided for maintenance stow and desteer.

Select Mode 2 on the central control computer to activate the manual control station.

When the manual control station is first activated, it is in Mode 2, manual control. In this mode, the manual switches for CW/CCW and UP/DOWN are active. The operator can use them to position the concentrator in any allowed

position (PLC-1 does not allow positioning of the concentrator in or beneath a zone of within 4.5° of the sun).

In addition to manual positioning of the concentrator, the operator may specify any of the user-selectable modes (described in Section 3.3.2) from the manual station. Simply position the mode select switches according to the binary pattern described on the side panel of the manual control station, and push the "enter mode" button. Hold the button until the mode display indicators update to reflect the new mode.

Read the indicators in the same manner as the mode select switches, using the binary pattern on the side of the manual control station. Note that the mode display indicators on the manual control station display the actual operating mode in use by PLC-1, while the central computer displays the mode selected by the computer keyboard, which PLC-1 may override. To deactivate the manual control pendant, simply select a mode other than Mode 2 (manual control) from the central computer.

3.3.4 Central Control Computer Program

The central control computer program is listed in Appendix J.

The central control computer, an IBM-PC, serves two main functions. First it serves as a keyboard interface for operators in the control room, and it generates continually updated solar ephemeris calculations. Second, it sends operating mode and ephemeris information to PLC-1 via current loop. It sends one word per second, alternating between mode, azimuth, and elevation.

3.3.5 PLC-1 and PLC-2 Programs

The PLC-1 program is listed in Appendix K. PLC-1 is a Siemens-Allis Automation MC-8 programmed in SYBIL 6, which is similar to BASIC with analog and digital I/O statements.

PLC-1 monitors the current loop communications from the central control computer, the manual control station, alarms for high wind and AC power loss, and concentrator position feedback. It selects a mode of operation based on these inputs and displays this mode on the manual station. PLC-1 controls the position of the concentrator either directly (via digital outputs to relay logic and hydraulics) or by enabling manual or optical tracker control. In all cases it monitors and compares actual concentrator position and calculated solar position to avoid inadvertent focus or near-focus of the concentrator.

The PLC-2 program is listed in Appendix L. PLC-2 is a Siemens-Allis Automation I^2R, programmed in SYBIL 5.

PLC-2 serves as a watchdog for PLC-1. Once in each PLC-1 program cycle, there is a handshake with PLC-2. If PLC-1 fails to handshake within 60 seconds, PLC-2 turns on the alarm indicator and puts the concentrator in alarm stow, facing up.

3.4 FAILURE MODES

Interaction of IC components was designed to minimize problems resulting from single component failure.

Failure of the central control computer or its current loop communication system would interrupt execution of PLC-1's code, which would cause PLC-2 to stow the concentrator after 60 seconds. Failure of the PLC-1 processor would have the same result. Failure of PLC-2 would cause PLC-1 to stow the concentrator immediately.

Position encoder failure would cause false positioning of the concentrator with the concentrator in focus, false positioning would cause disagreement between the position feedback and the ephemeris calculations, which would cause PLC-1 to attempt correction of position and then force the system to the desteer mode. Tracker failure would cause similar results.

Failure of the limit switch (LS-1 or LS-2) would cause wrong choices of solenoid valve position by the azimuth quadrant selection relay logic, which would disrupt azimuth drive functions. Failure of LS-3, 4, 5, or 6 would have no effect as single failures, but removes end-of-travel feedback to PLC-2 (which acts on PLC-1 failure) and to the control logic, where it is a backup against position feedback/PLC-1 control loop failure.

Failure of a solenoid valve (or of a solid state relay controlling a solenoid valve) would cause a drive cylinder to operate only in one direction regardless of control system commands to change direction, which would disrupt tracking and drive functions.

Hydraulic pump/motor failure would cause disruption of tracking and drive functions. If the concentrator were in focus at the time of disruption of drive functions, disagreement between position feedback and ephemeris calculations would cause PLC-1 to attempt correction of position and then force the system to the desteer mode. Leaving focus under such circumstances involves slewing elevation up out of focus using redundant slew pumps.

Manual control station failure would affect only the manual mode, which is enabled/disabled via the central control computer keyboard failure of battery charger 1 or 2, or their corresponding batteries would diminish performance of concentrator slewing and eliminate 12V operation of azimuth or elevation drives, respectively. Failure of battery charger 4 or battery 4 would eliminate 36V tracking. Failure of batter charger 3 or battery 3 would cause control system power to come from battery charger 2, which is wired with diodes as a backup.

SECTION 4

SERVICE, MAINTENANCE, AND REPAIR

4.1 SERVICE AND MAINTENANCE

4.1.1 General

The Innovative Solar Concentrator is designed to provide reliable operation with scheduled maintenance. The system has been designed to use commercially available, nationally serviceable parts from major equipment suppliers.

4.1.2 Service and Maintenance Schedule

Table 4-1 provides an inspection and preventative maintenance schedule. A maintenance log should be kept to document both scheduled and unscheduled maintenance.

4.1.3 Service and Maintenance Procedures

Use standard procedures and observe all applicable safety precautions (see Section 3.2) in performing service and maintenance work.

Refer to appropriate parts of Section 4 for procedures on service and maintenance of most equipment. Inspect any remaining equipment for obvious damage and verify that it functions properly.

4.1.4 Cleaning and Care of Reflective Surface

The reflective surface should be inspected as often as necessary, at least once per quarter. Particularly look for delamination and corosion, especially at film edges.

Table 4-1. Inspection, Service, and Maintenance Schedule

Item	Monthly	Quarterly	Annual	Biannual
IBM control computer and peripherals	See manufacturers' literature			
DISC-1				X
Circuit breakers in DCU			X	
Fuses in DCU		X		
Locking handswitch on DCU		X		
Batteries		X		
Battery chargers	X			
PLC-1, PLC-2, relay logic, and manual control station		X		
DC-1 and DC-2			X	
Limit switches		X		
Position encoders		X		
Optical trackers		X		
Stow alarms		X		
P1 and P2		X		
P3 and P4		X		
Solenoid valves		X		
Hydraulic cylinders		X		
Gortrac cable tray			X	
Structure			X	

If delamination is found, cut out the delaminated section of film with an X-acto knife and use 1/2 inch FEK tape to stop further delamination and cover the effected area. Be sure the tape covers the edges of the remaining film.

4.1.5 Greasing of Bearings

Proper lubrication of bearings is essential to smooth operation and long bearing life. Greasing of the azimuth and elevation bearings is described in Appendices N and O, respectively.

4.1.6 Inspection of Cylinders

Inspect the cylinders as often as necessary, at least once per quarter. Particularly look for galling on cylinder rods, leaks and loose fittings, and severe corrosion. Appendix R describes their maintenance.

4.1.7 Inspection and Service of Hydraulic Power Unit

Daily inspection of readily visible hydraulic components for obvious leaks is recommended prior to operation of the concentrator, at least during the initial months of operation.

Remove the HPU cover and thoroughly inspect the HPU as often as necessary, at least once per quarter (but weekly at first). Particularly look for hydraulic fluid level and condition, leaks and loose fittings, loose electrical connections, and severe corrosion. The most important problem to look for is leakage of internal components and seals.

Fix any leaks or other problems immediately. Appendix P describes the maintenance of pumps P1 and P2. Appenix Q describes the maintenance of pumps P3 and P4.

4.1.8 Cleaning and Adjustment of Solar Sensors

Proper adjustment and periodic cleaning of the optical sensors are essential to proper operation of the concentrator in the track/optical and desteer/optical modes.

Installation and cleaning instructions are listed in Appendix B (sheet B-163). The focus tracker head should be adjusted to align the concentrator in focus on the sun. The desteer tracker head should be adjusted such that the concentrator tracks the sun's azimuth, but at an elevation of 5° above the sun's elevation.

4.1.9 Inspection and Adjustment of Limit Switch and Position Encoder Assemblies

The limit switch and position encoder assemblies should be inspected as needed, not less than once per year.

To verify limit switch operation, put the central control computer in Mode 2, manual control. Attach a notice to the computer, covering the keyboard, stating "Concentrator Maintenance in Progress. Do Not Operate keyboard." While standing on the drive platform with manual control station in hand, move the concentrator manually in each of the four directions, one at a time, and manually operate the corresponding limit switch to verify that the concentrator stops moving.

CAUTION

TAKE ALL DUE CARE AND PRECAUTIONS WHEN STANDING ON THE DRIVE PLATFORM, ESPECIALLY WHEN THE CONCENTRATOR IS MOVING. HARD HAT AND SAFETY BELT ARE REQUIRED.

Refer to Appendix D for manufacturer's information on the position encoders. To verify position encoder operation, first move the concentrator to azimuth and elevation coordinates (0,0), i.e., facing due North and 10°

below the horizon. Check the azimuth and elevation output voltages in the DCU, component block D (Azimuth terminals 310, common 345; Elevation 330, common 345).

WARNING

IN ADDITION TO PRECAUTIONS DUE TO HEIGHT, INCLUDING HARD HATS AND SAFETY BELTS, TAKE ALL DUE ELECTRICAL PRECAUTIONS WHENEVER THE DCU IS OPEN. BECAUSE THE CONTROL SYSTEM IS BATTERY-POWERED, TURNING OFF AC POWER TO THE DCU WILL NOT TURN OFF POWER TO ALL COMPONENTS. (SEE SECTION 3.2.)

Verify that both output voltages equal zero (+0.01V,-0.00V). See Section 4.4.4 if encoder zeroing is required.

Verify output similarly at the extremes of position, with output voltage = (3600/4096) x 10V x (position in degrees/360)). If it is necessary to adjust span, adjust potentiometers R312 and R333 (of CB-D of the DCU) for azimuth and elevation, respectively, to obtain the proper output voltages at component block D, azimuth terminals 311, common 345; elevation 331, common 345. Secure any adjusted potentiometer(s) with silicone seal to maintain its proper position.

4.1.10 Inspection and Service of Batteries and Battery Chargers

Inspection of the batteries and battery chargers at least every 3 months is strongly recommended. For inspection and service of batteries, follow procedures and safety precautions listed in Appendix E. For inspection and service of battery chargers, follow procedures and safety precautions listed in Appendix H.

4.1.11 Visual Inspection of IC

The Innovative Concentrator is a newly developed prototype piece of equipment. Special care with any such equipment is necessary to limit the consequences of unanticipated events or failures. Since the reliability of the equipment has not been proven, it is recommended that special precautions be taken to detect possible failure modes as early as possible by initially increasing the number of inspections from those expected once the system can be judged mature.

It is recommended that the following inspections be carried out prior to operation of the concentrator, at least on a daily basis, until the confidence level has increased to warrant the reduction in the number of inspections.

- Walk-around inspection of the concentrator to detect:
  - -- Leaks in the hydraulic system
  - -- Loose hardware
  - -- Open cabinet or electrical enclosure doors; moisture intrusion
  - -- Frayed hoses or kinked electrical conductors
  - -- Evidence of binding of the structure during movement
  - -- Broken retaining rings or loose shafts
  - -- Discoloration of paint or structural members due to heating
  - -- Undue wear
  - -- Any unusual item

Any one of the above observations may lead, if not corrected, to significant operation or safety problems. Some problems could lead to more serious problems than others. The most serious problem would occur when the concentrator is tracking the sun in the on-sun condition and suddenly fails leaving the concentrator stationary. Redundancies have been built into the

system to prevent such an occurrance provided some obvious precautions are not ignored. An example of a possible failure mode is a low oil level in the oil reservoir which supplies oil to all pumps. A low oil level may starve all pumps and cause the concentrator to be "frozen" in the stationary mode. An alarm is provided to alert the operator to this condition well ahead of this occurrence; however, a small oil leak detected by visual inspection may be the first indication that repair prior to operation is needed aside from other environmental considerations. The oil reservoir holds a minimum of 30 gallons. The level alarm is given at 15 gallons. Pump starvation may occur starting at the 10-gallon level.

4.1.12 Corrosion Protection

If any inspection discloses corrosion, take steps to correct it and to limit its growth. Apply touch-up paint to painted areas, oil any areas in need of oil, and care for the reflective surface according to Section 4.1.4.

Metal parts associated with the battery enclosure are particularly susceptable to corrosion. Treat them in accordance with Appendix E and observe safety precautions listed in Section 3.2.

4.2 TROUBLESHOOTING

4.2.1 General

Section 4.2.2 describes particular faults and remedies for the IC. The operator should also use the following sources for troubleshooting.

Item	Reference Source
Control system	Acurex drawing package E series drawings
Individual equipment	Vendor literature provided in Appendices A through I
Software	Code listings provided in Appendices J through L
Electrical connection of equipment	Connection diagrams provided in Appendix M

WARNING

CONDUCT ALL TROUBLESHOOTING ACTIVITIES WITH ALL DUE SAFETY PRECAUTIONS. REFER TO SECTION 3.2.

4.2.2 Faults and Remedies

Table 4-2 is a troubleshooting guide for the IC.

4.3 REMOVAL AND INSTALLATION OF COMPONENTS

4.3.1 General

Use all due precaution in removing and installing components. See Section 3.2 for safety procedures.

4.3.2 Removal and Installation of Major Structural Components

Removal and installation of major structural components requires major disassembly of the concentrator, including removal of the dish before removing any other major structural components. This requires a 100-ton crane with 40 ft. boom extension.

WARNING

OBSERVE ALL STANDARD SAFETY PROCEDURES FOR MOVING HEAVY EQUIPMENT, IN ADDITION TO SAFETY PROCEDURES OUTLINED IN SECTION 3.2. MOVEMENT OF THE DISH IN HIGH WIND IS EXTREMELY DANGEROUS. BE CERTAIN TO SUFFICIENTLY SECURE THE DISH AND OTHER LARGE COMPONENTS DURING LIFTING AND WHEN THEY ARE NOT ATTACHED TO THE STRUCTURE/FOUNDATION.

4.3.3 Removal and Installation of Batteries

The batteries are located in the battery enclosure. Their layout and electrical connections inside the enclosure are depicted in drawing #7749E307. Electrical connections to the battery enclosure are shown in Appendix M, sheets 8 and 9.

WARNING

HANDLING BATTERIES REQUIRES SPECIAL SAFETY PRECAUTIONS. CONSULT SECTION 3.2 AND APPENDIX E.

Table 4-2. Innovative Solar Concentrator Troubleshooting Guide

Problem	Cause	Corrective Action
Trouble Light IL-412 is on	PLC failure	Check PLC-1 and PLC-2
	HPU oil level low	Check HPU oil level
	PLC-1 hung up by communications loop	Check central control computer and communications loop
	PLC-1 otherwise occupied in control function and PLC-2 alarmed	Check position encoders and slew movement
No power to a particular component	Blown fuse	Replace fuse. All fuses in DCU are 1A, 250V (AGC1) except FU-38, -44, -46, and -48, which are 3A.
System will not start or collector is stowed	Alarm lockout	Remedy alarm condition Reset control system (see Section 3.3.1.)
	Control computer off	Check control computer Reset control system
	Control system malfunction	Check fuses, PLC-1, PLC-2, and associated equipment in DCU
	Battery (ies) is/are dead	Check batteries, connections chargers, fuses to chargers (see Appendices E and H).
	Maintenance stow switch is selected	Turn off switch in control room
Collector is erratic or cannot track sun	Tracker failure	Verify operation of alignment of trackers (see Section 4.1.8).
	Position encoder failure (secondary problem in optical modes, primary problem in other modes)	Check position encoders (see Section 4.1.9).
	Desteer switch is selected	Turn off switch in control room
	Other control/ drive system problem	Check relay logic, HPU and drive system.
Manual control station does not work	Control computer mode	Select Mode 2, manual control, on computer keyboard
	Other	See heading "Collector Will Not Start"

To remove the batteries, carefully disconnect each connection, taking care to avoid electrical shock or short circuiting batteries. If battery acid has leaked, neutralize it with an appropriate mild alkali such as baking soda and rinse the affected area with clean water. Remove the batteries, taking care to avoid contact with battery acid or the electrical terminals. Store them in a safe area according to Appendix E. To install the batteries, be sure that the battery enclosure is clean and dry inside. Install the batteries and connect them according to drawing #7749E307, Appendix M, sheets 8 and 9, and Appendix E.

4.3.4 Removal and Installation of Limit Switches

To facilitate the removal and installation of limit switches, position the concentrator such that none of the limit switches are operated. (If this is not possible, take care to hold the limit switches securely when removing or installing them.) Remove them by unbolting them from their brackets. When disconnecting the wiring from the DCU, take all due precautions (such as locking out control power -- see Section 3.2). Wiring at the limit switch is permanent, factory-sealed epoxy.

To install limit switches, mount them in place and wire them as their predecessors were wired (see cable connection diagrams C-10 through C-15, Appendix M). Verify operation as described in Section 4.1.9.

4.3.5 Removal and Installation of Position Encoder Assemblies

To remove a position encoder, first release it from the bellows which attaches to its shaft. Then unbolt its enclosure from its mounting bracket. Simply disconnect the cannon connector to disconnect it electrically. For manufacturer's information see Appendix D. Follow all appropriate safety practices (see Section 3.2).

To install a position encoder, connect the cannon connector and bolt the encoder enclosurer to its mounting bracket (see Drawing #7749E302). Following the procedure in Section 4.4.4, carefully set the mechanical zero of the encoder to read 0 volts when the concentrator's azimuth or elevation (as appropriate) is zero. (Azimuth 0 = due North; elevation 0 = 10° below horizon when azimuth is North).

WARNING

PROPER MECHANICAL ZEROING OF THE POSITION ENCODER IS ESSENTIAL TO SAFE AND RELIABLE OPERATION OF CONCENTRATOR

4.3.6 Removal and Installation of Solar Sensors and Electronics

To remove the solar tracker heads from their mounting brackets, unscrew their mounting bolts . Do not attempt to remove the factory-installed cable from the tracker head. Disconnect the cable (C-16 or C-17) at the tracker electronics enclosure instead. See Appendix B for manufacturer's information. See Section 3.2 for safety information. To remove the tracker electronics enclosure, disconnect its cable C-18 at the DCU. Then unbolt the tracker electronics enclosure from the dish support on which it is mounted.

To install the tracker electronics enclosure, mount it to its support on the dish and wire it according to connection diagram C-18. Mount the tracker heads on their brackets and connect their cables according to connection diagrams C-16 and C-17, Appendix M. See Section 4.1.8 for adjustment of the sensors.

4.3.7 Removal and Installation of Hydraulic Components

Removal of cylinders is a major operation (see Section 4.3.2). Removing or installing the elevation cylinder requires a 100 ton crane with 40 ft boom extension to hold the dish, while another crane removes or installs

the cylinder. Removing/installing the azimuth cylinder(s) requires securing the dish so that it is not free to rotate.

The counter balance valves are part of the cylinders themselves. They cannot be removed from the cylinders unless the concentrator is in a stable position.

WARNING

DO NOT ATTEMPT TO REMOVE/INSTALL/SERVICE THE COUNTERBALANCE VALVES WITHOUT ADEQUATELY POSITIONING AND SECURING THE CONCENTRATOR FOR STABILITY

To remove/install counterbalance valves in the elevation cylinder, the concentrator should be facing down; for those in the azimuth cylinders, the azimuth cylinders, the concentrator should be facing north (because of the 10° tilted plane of the concentrator).

Because the cylinders contain counterbalance valves and thus are self-locking, it is acceptable to simply remove hydraulic components other than the cylinders and counterbalance vlaves. Before removing such components, put the concentrator in an appropriate position for the maintenance work to be done.

4.3.8 Removal and Installation of Electronic Components

Remove and install electronic components in accordance with drawings #7749E300, - E301, -E305, and Appendix M, cable connection diagrams. Observe all applicable safety procedures, especially removal of power to the DCU (see Section 3.2) before working on the DCU or any electronic components.

WARNING

FAILURE TO FOLLOW SAFETY PROCEDURES OUTLINED IN SECTION 3.2 MAY RESULT IN PERSONNEL INJURY OR EQUIPMENT DAMAGE

Be certain that all power to a component is off, before removing or installing it. Do not leave loose wires hanging in the DCU with bare ends.

4.4 FUNCTIONAL TEST

4.4.1 General

Functional tests are important as part of periodic inspection, maintenance and repair (see Section 4.0). In addition, functional tests should be conducted to verify equipment performance at any time malfunction or substandard performance is suspected for a given component.

Observe all due safety precautions as outlined in Section 3.2.

4.4.2 Ampacity Tests

Refer to Appendix E (especially page 12) for ampacity test procedure.k Follow all safety precautions in Section 2.3 and Appendix E.

4.4.3 Travel Circuit Adjustment and Testing

The travel limit adjustment is built into the concentrator. The adjustment of the limits during startup should not require further adjustment. However, should adjustment be required, change the threaded locknut adjustment of the clevis (azimuth) or red end (evaluation) on the drive cylinders. This offsets the start/stop positions, but does not change the travel distance. This adjustment requires several men and/or special equipment.

To test the travel limits, use the track speed motors (P1 and P2) to run the concentrator against its mechanical travel limits. This will require removal and re-installation of the corresponding limit switch (see Section 4.3.4). The limit switches stop movement of the concentrator before it reaches the mechanical stops.

WARNING

DO NOT USE THE SLEW PUMPS (P3 AND P4) TO RUN THE CONCENTRATOR AGAINST THE STOPS. CONCENTRATOR DAMAGE AND DANGER TO PERSONNEL MAY RESULT.

When testing the azimuth travel limits, the 3000 psi cutoff will build up gradually and stop the system. When testing the elevation travel limits, the stops inside the cylinder stop motion.

4.4.4 Encoder Alignment, Zero Adjustment and Testing

Position encoders hould be installed according to Section 4.3.5. Refer to Appendix D for manufacturers information on the position encoders.

to align the encoder shafts, first move the concentrator to its zero azimuth and elevation coordinates, i.e., facing due North and 10° below the horizon. It is essential that the concentrator be positioned accurately (to within 0.1° or better) during mechanical zeroing, to insure safe and reliable operation of the concentrator in subsequent operation.

Connect a digital voltmeter to the appropriate terminals in the DCU, component block D (Azimuth terminals 310, common 345; Elevation 330, common 345), to read the encoder output voltage.

WARNING

SEE SECTION 3.2 FOR SAFETY PROCEDURE. TURNING OFF CONTROL SYSTEM AC POWER DOES NOT DISABLE BATTERY POWER TO DCU COMPONENTS

Carefully turn the encoder shaft until the output voltage reading at the corrsponding terminals equals zero (+0.01V, - 0.00V). If this is impossible by hand, it may be necessary to connect the encoder shaft to the concentrator (via its bellows), move the concentrator until the encoder output voltage equals zero, carefully loosen the encoder shaft connection to the concentrator, reposition the concentrator to its zero position, and tighten the encoder shaft connection to the concentrator, yielding zero output voltage at the concentrator's zero position. An alternate method is to adjust the encoder shaft to a small positive tenth of a degree error (e.g. +0.10V, +0.20V, +0.30V etc) with the concentrator at its exact zero position, tighten

the encoder shaft connection to the concentrator; and modify the PLC-1 code to subtract out this error each time it reads the particular transducer. (This requires a software development system including EPROM burner and is beyond the scope of this manual).

Once the encoders are accuretly zeroed mechanically, the span adjustment can be made. Attach a digital voltmeter to the appropriate terminals in the DCU, component block D (Azimuth terminals 311, common 345, Elevation 331, common 345), to read the span voltage.

Position the concentrator to its limits of travel, approximately 100° of travel in elevation and 310° azimuth. It is essential either to move the concentrator to these travel limits exactly (± 0.01°) or to accurately determine its position and use the co-ordinates in the following formula to determine span voltage:

Span Voltage = (3600/4096) x 10Vx (position in degrees/360)
= 0.02441 x position in degrees

For 100.0° elevation travel, span voltage = 2.44V.
For 310.0° azimuth rotation, span voltage = 7.57V.

With the concentrator positioned accurately at its limits of travel, adjust potentiometers R312 and R333 (of CB-D of the DCU) for azimuth and elevation spans respectively. Once each potentionmeter is accurately spanned, secure it with silicone seal to maintain its proper position.

To test the position encoders, accurately position the concentrator in its zero positions and verify that the voltages equal zero (+0.01V, - 0.00V) at DCU component block D, Azimuth terminals 331, common 345. Then move the concentrator to its limits of travel and verify that the span voltage is correct according to the procedure above.

4.4.5 Solar Sensor Adjustment and Testing

To adjust the solar sensors, first be sure that the tracker heads are paralle to their respective mounting bases. Then fine-adjust the corresponding cards in the tracker electronics enclosure, using a manlift and taking all due safety precautions.

The potentiometers and LED's across the top of each Mann-Russell tracker electronics card have the following functions, from left to right (facing the card, with the pots and LED at the top):

Night return adjustment
Night return indicator
Synthetic track cloud cover adjustment
Synthetic track indicator
Synthetic track movement adjustment
Elevation window adjustment
Elevation balance adjustment
Down indicator
Up indicator
Left indicator
Right indicator
Azimuth balance adjustment
Azimuth balance adjustment

The potentiometer in the middle of the board controls the synthetic tracking base time, which is factory set for 4 minutes and should not be adjusted.

For azimuth (or elevation) adjustment, the window adjustment determines the deadband between left and right (or up and down) movement. The balance adjustment balances the cell levels, to fine-tune the pointing direction of the concentrator. (The other potentiometers, which should not require a re-adjustment after startup, are described later in this section).

To adjust the desteer sensors, select sensors, mode 2, manual control, on the central control computer, and use the manual station to select mode 6 desteer/optical. Adjust the desteer electronics card in the tracker electronics enclosure using a manlift.

WARNING

IT IS DANGEROUS TO BRING THE CONCENTRATOR SIGNIFICANTLY CLOSER TO FOCUS THAN TH 5° OFFSET DESTEER POSITION WITHOUT ACTUALLY FOCUSING IT. TAKE ALL DUE PRECAUTIONS FOR EQUIPMENT AND PERSONNEL.

Adjusting the focus sensors is much more critical than adjusting desteer, both in need for accurate adjustment and in importance of safe procedure. Adjust the focus sensors after adjusting the desteer sensors. Using the manual control station, select mode 8, focus/optical. The concentrator will first focus on the calculated ephemeris position, and then will move to its optical focal point.

Observe the positioning error, if any, and immediately de-focus the concentrator before trying an adjustment to the focus electronics card.

WARNING

THE CONCENTRATOR REFLECTS INTENSE CONCENTRATED SUNLIGHT. WEAR SUNGLASSES, DO NOT LOOK DIRECTLY AT BRIGHT SPOTS, AND TAKE ALL DUE PRECAUTIONS TO PREVENT EYE INJURY AND BURNING OF PERSONNEL, EQUIPMENT, OR STRUCTURE

Continue this iterative adjustment process until the concentrator is tuned to optimum optical focus.

Syntehtic Track parameters are set during startup and should not require further adjustment. Should they require adjustment, proceed as follows. Before positioning the concentrator near the sun, cover the nylon lenses of the tracking heads with black electrical tape to shade them. Select manual mode (mode 2) on the control computer and on the manual control station. In the DCU, jumper conductor 231 to conductor 37 (common) at PLC-1 module DO2(12). to activate tracker control.

WARNING

TAKE ALL DUE PRECAUTIONS WORKING INSIDE THE DCU TO AVOID PERSONNEL INJURY OR EQUIPMENT DAMAGE. BATTERY POWER IS ON WHETHER OR NOT AC IS ON.

To adjust the desteer synthetic track movement adjustment, jumper DCU conductor 227 to 37 at PLC-1 module DO2(12) to power the desteer electronics. Adjust the synthetic track movement adjustment potentiometer on the desteer electronics card in the tracker electronics enclosure such that the concentrator moves 1° clockwise in azimuth every 4 minutes. To adjust the focus synthetic track movement adjustment, remove the jumper in the DCU from 227 to 37, jumper 228 to 37, and adjust the focus electronics card similary.

WARNING

JUMPERING CONNECTIONS IN THE DCU OVERRIDES BUILT-IN SAFETY FUNCTIONS AND SHOULD BE DONE ONLY BY QUALIFIED PERSONNEL UNDER FAVORABLE CONDITIONS. AVOID BRINGING THE CONCENTRATOR NEAR FOCUS WHEN JUMPERS ARE USED. REMOVE ALL JUMPERS FROM DCU AND MASKS FROM THE TRACKER HEADS BEFORE PROCEEDING.

The synthetic track cloud cover adjustment is also set at startup and should require no further adjustment. It controls the light threshold at which the synthetic track mode takes over. It can be adjusted simply under conditions of varying light, using their synthetic track indicator to determine when the synthetic track mode is in effect.

The night return adjustment is redundant in this system and should be left at its least sensitive setting.

4.4.6 Hydraulic Power Unit Tests

The hydraulic system is designed to be able to generate and control 3000 psi pressure. To verify this capability, run the concentrator against its mechanical limits of travel. See Section 4.4.3 for procedure and safety

information (in addition to Section 2.3 safety procedure). Test the system against all four stops: azimuth, clockwise and counterclockwise; and elevation, up and down. Verify that the hydraulic pressure reaches approximately 3000 psi.

If the pressure does not reach 3000 psi, there are two likely causes.

(1) If the relief valve setting is wrong, simply adjust it to 3000 psi.

(2) If not, the pump is probably worn and should be repaired or replaced.

4.4.7 Electronic Control Unit Tests

When testing electrical and electronic equipment, take all due safety precautions (see Section 3.2).

WARNING

TURNING OFF AC POWER DIES NOT TURN OFF BATTERY POWER TO THE DCU AND DC COMPONENTS

Test the battery chargers in accordance with Appendix H. Functionality of the chargers is critical to system functionality.

Testing the central control computer is not necessary, almost all of the computer's failure modes would stop keyboard interaction immediately and initiate system stow within 60 seconds, illuminating indicator IL-4/2.

Test the wind stow by initiating a wind stow contact opeining. This can be easily done by disconnecting (and later re-connecting) the red wire of the red/blue pair on the IC field connection board in the control room behind the red wire of the red/blue pair on the IC field connection board in the control room behind the computer cabinets. This should cause IL-412 to light and the concentrator to stow. Reset the system as described in Section 3.3.1.

Test the AC power loss stow by turning off AC power to the concentrator at DISC-1. This should have the same effect as the wind stow test described above.

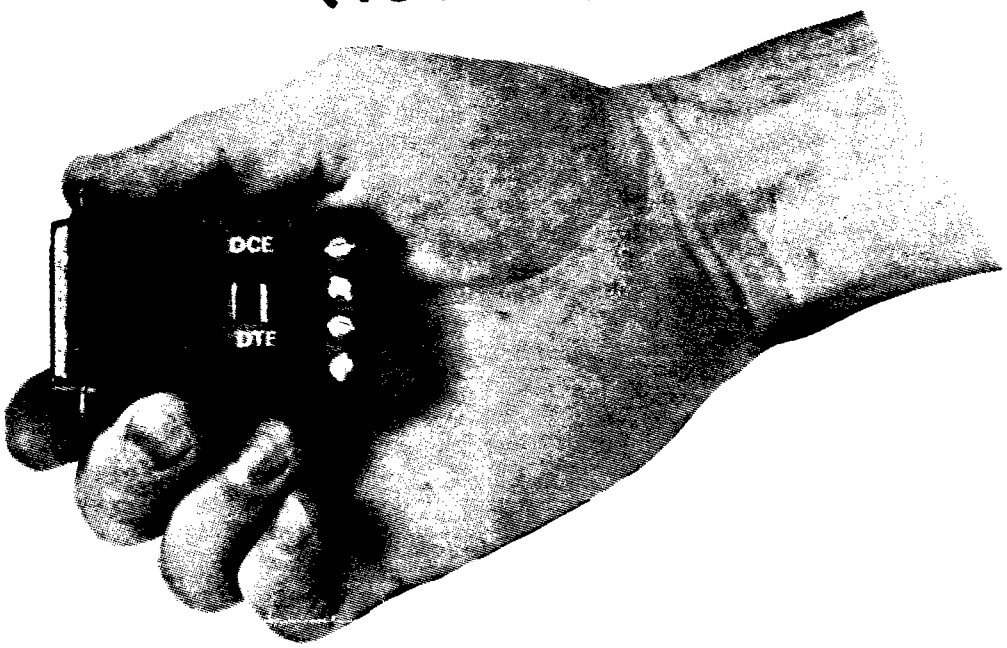
To test the rest of the control electronics, select mode 2 manual control, at the central computer keyboard. Select each user-selectable mode to exercise the various control functions of the concentrator. Focus only when safety and other pertinent factors permit. Do not leave the concentrator in manual mode (central control computer mode 2) unattended.

APPENDIX A

BLACKBOX RS-232 TO CURRENT LOOP CONVERTER

EIA/CURRENT LOOP INTERFACE

(101-4Q)



* Small, interface powered EIA RS-232/20mA current loop converter unit for installations with limited space
* DCE/DTE switch for simple configuration
* Optically isolated for RS-232 signal protection
* Separate current loop power supply available

SPECIFICATIONS:

Power - Unit Operating Power; provided by EIA interface: Pin 6 when configured for connection to DCE, Pin 20 when configured for connection to DTE
Current Loop Power - provided external (20mA, 24 VDC max.); or use BLACK BOX PS150 power supply
Size - 2.1" W x 1.8" L x .6" H Weight - 3 oz.
Enclosure - Black, plastic
Interface - RS-232C/V.24, DCE or DTE (switchable); 20mA current loop
Connectors - RS-232: (1) DB25P (male);
Current Loop: (1) four position screw terminal strip
Mode of Line Operation - Passive, 20mA current loop

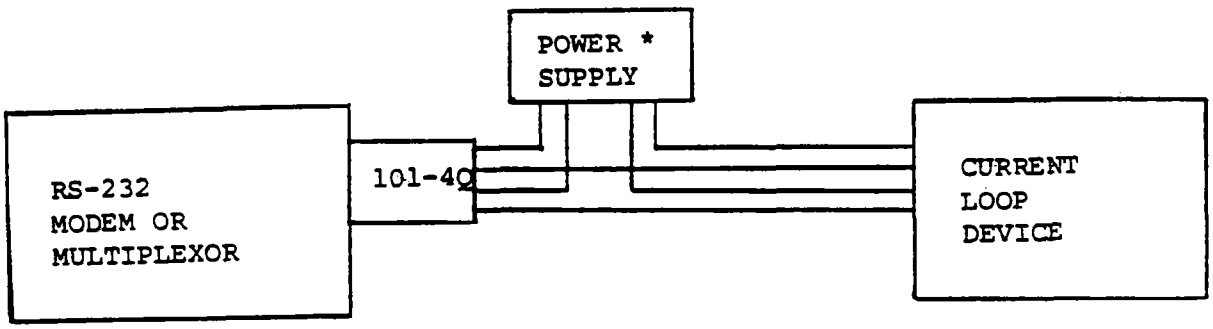
CUSTOMER SUPPORT INFORMATION

Call our technical support specialist to discuss your application. We have a 30 day money-back guarantee.
For technical support call: (412) 746-5565 8:30 a.m. to 6:00 p.m. (Eastern)
To order call: (412) 746-5530 8:00 a.m. to 8:00 p.m. (Eastern)
Mail Order: **BLACK BOX Corporation**, Mayview Road at Park Drive, Box 12800, Pittsburgh, PA 15241

1.0 GENERAL

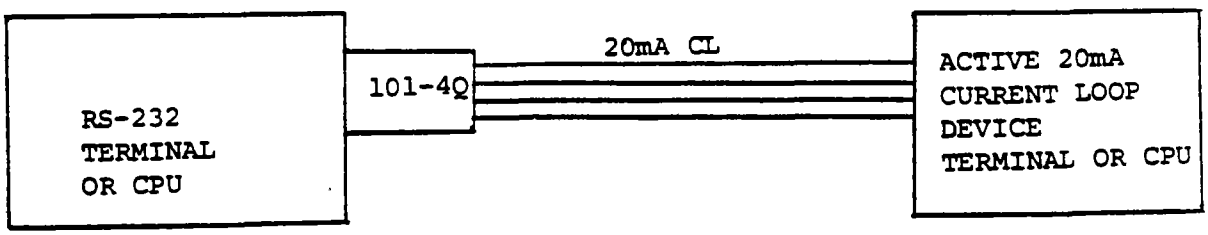
The BLACK BOX™ EIA <--> Current Loop adapter (101-4Q) is intended for use in interfacing terminals with RS-232C ports to neutral current loops. The 101-4Q allows data transmission by current flow rather than by voltage level as defined by EIA - RS-232. Current flowing (closed loop) represents a MARK signal and no current flowing represents a SPACE signal. The 101-4Q functions as a passive device in neutral current loop environments operating at a maximum current of 20mA and a maximum loop voltage of 24 VDC. Operating power for the 101-4Q is derived from pin 6 when the DCE/DTE switch is in the DCE position, and derived from pin 20 when the DCE/DTE switch is set on DTE. A power supply is available from BLACK BOX (PS150) that is capable of providing loop power to up to 40 current loops.

Figure 1A 101-4Q Application
(101-4Q configured for attachment to DCE device; External Power Supply)



* Power may come from an active device in loop in which case power supply is not necessary, as shown below.

Figure 1B 101-4Q Application
(101-4Q configured for attachment to DTE device; active current loop device in loop)



2.0 INSTALLATION

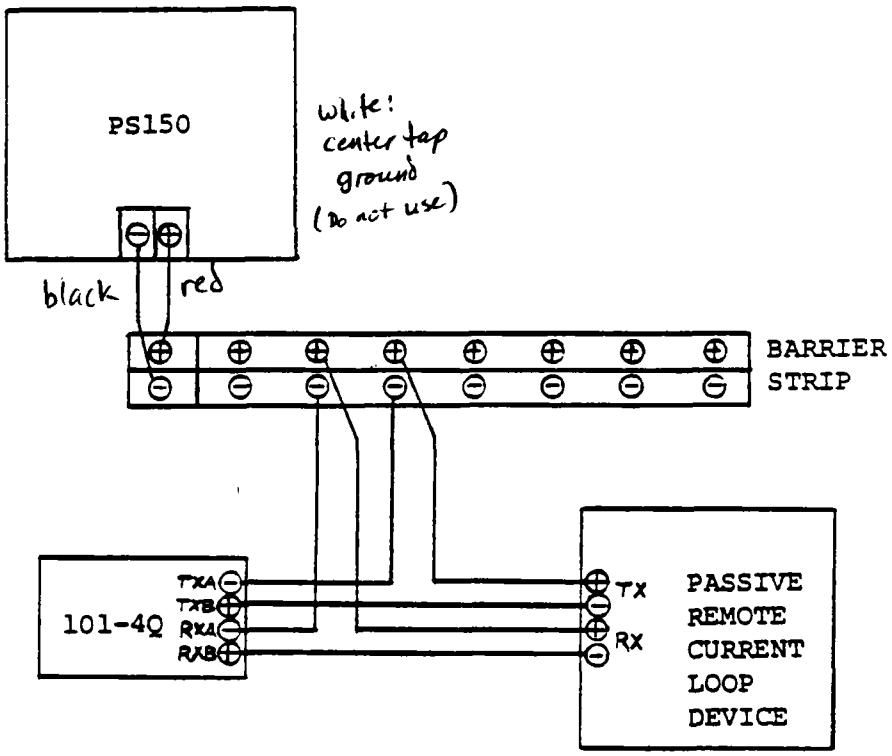
The 101-4Q is easily installed by completing the current loop between the adapter, power supply, and other devices in the loop. Each loop, transmit and receive, must be independently connected for full duplex operation, and must be connected in a complete circuit observing polarity markings on adapter and power supply.

Use figure 2a when using an external power supply. Reference figure 2b when an active device is in the loop.
NOTE: The 101-4Q terminals are labeled on the case as follows:

TXA - Transmit Negative
TXB - Transmit Positive
RXA - Receive Negative
RXB - Receive Positive

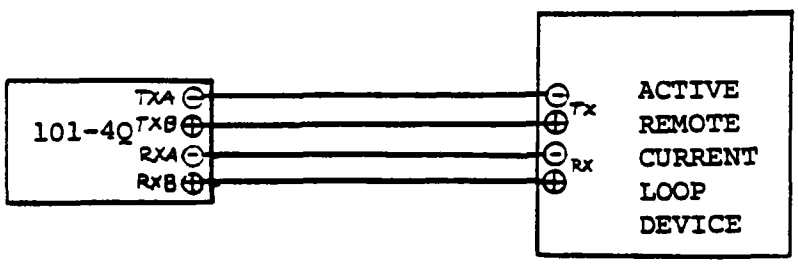
Figure 2-1 101-4Q Installation

2A Installation with External Power Supply



Note: The above drawing shows the 101-4Q used in conjunction with the BLACK BOX PS150 power supply and a barrier strip. The barrier strip must isolate + and - pairs for proper operation of more than one loop per power supply. The PS150 provides unregulated 12 VDC at 1A; sufficient to power 40 current loops.

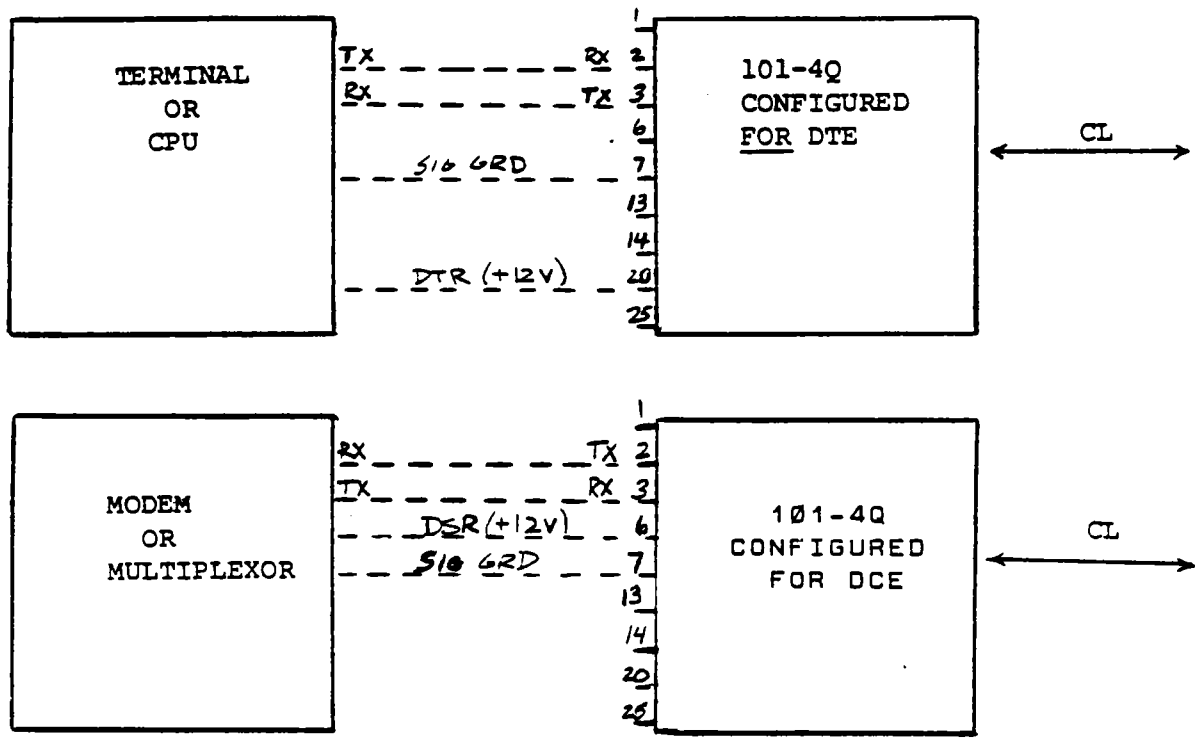
2B Installation with Active Device in Loop



3.0 RS-232 INTERFACE

The 101-4Q has a male RS-232C connector configurable for attachment to either DCE or DTE devices. When the switch on the top of the 101-4Q is set to "DCE", the unit is configured for attachment to a DCE device (modem or multiplexor); the "DTE" setting configures the 101-4Q for attachment to a terminal or CPU.

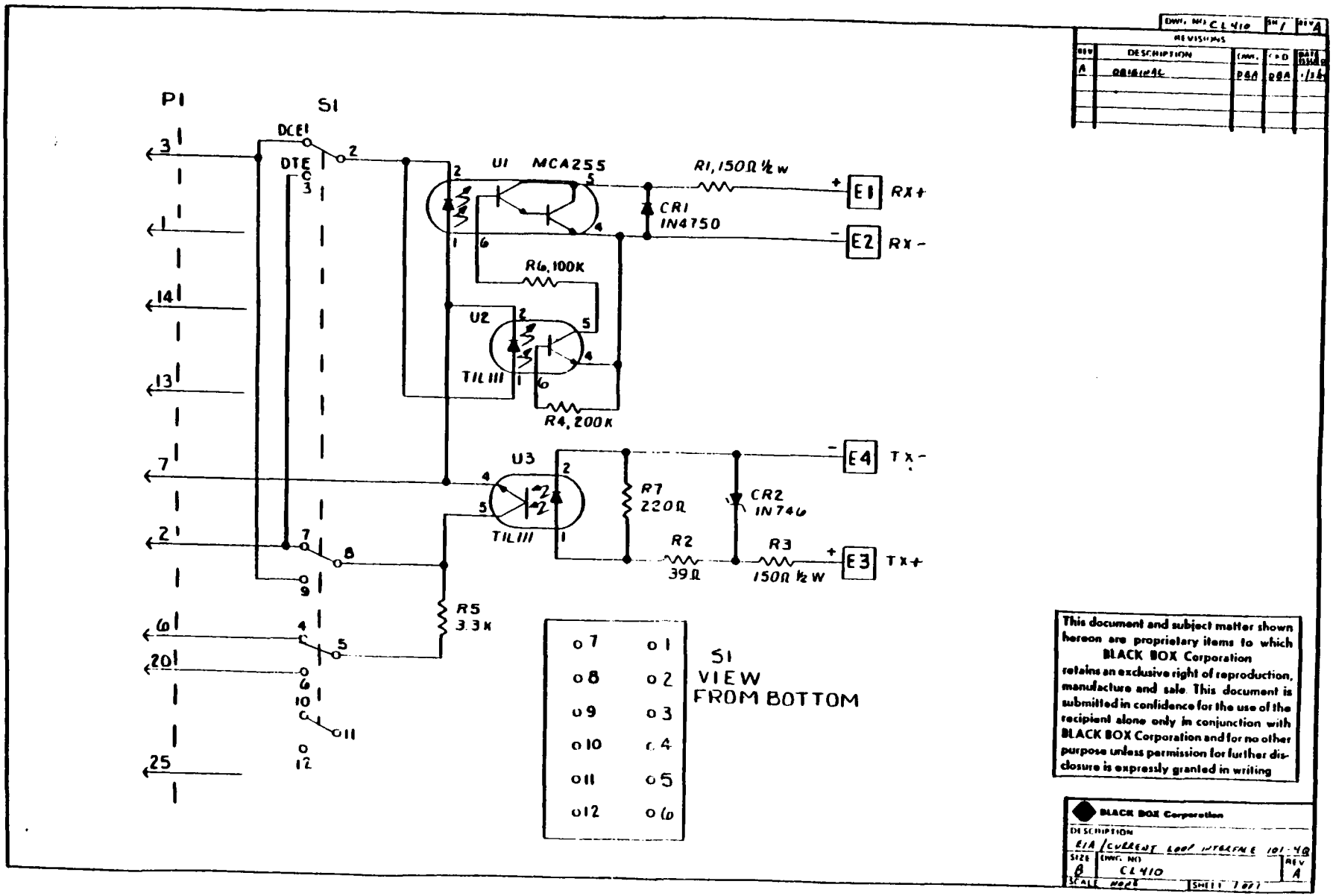
RS-232 INTERFACE



Current Loop Reverse Polarity Protection

Transmit: A diode is incorporated across the transmit current loop pair so that if they are inadvertently reversed, current will flow in the circuit but the transmit switch is protected.

Receive: A diode is incorporated across the receive current loop pair so that inadvertent reversal will cause loop current to flow, but the receiver will not detect current and will indicate a continuous "spacing" condition to the attached device.



SCHEMATIC OF EIA/CURRENT LOOP INTERFACE 101-4Q

MANN-RUSSELL MARK IV ST-2

DUAL AXES TRACKING SYSTEM

The MARK IV ST-2 DUAL AXES TRACKING SYSTEM is composed of three components:

1. Sensor
2. Electronic Module
3. Manual-Automatic Pendant

The Dual Axes Tracker may be employed by those who wish to track in whichever mode (Axis or Elevation) they need by just leaving inoperative the operating leads normally connected in the circuitry to the unused mode. The factory can be of help in this regard.

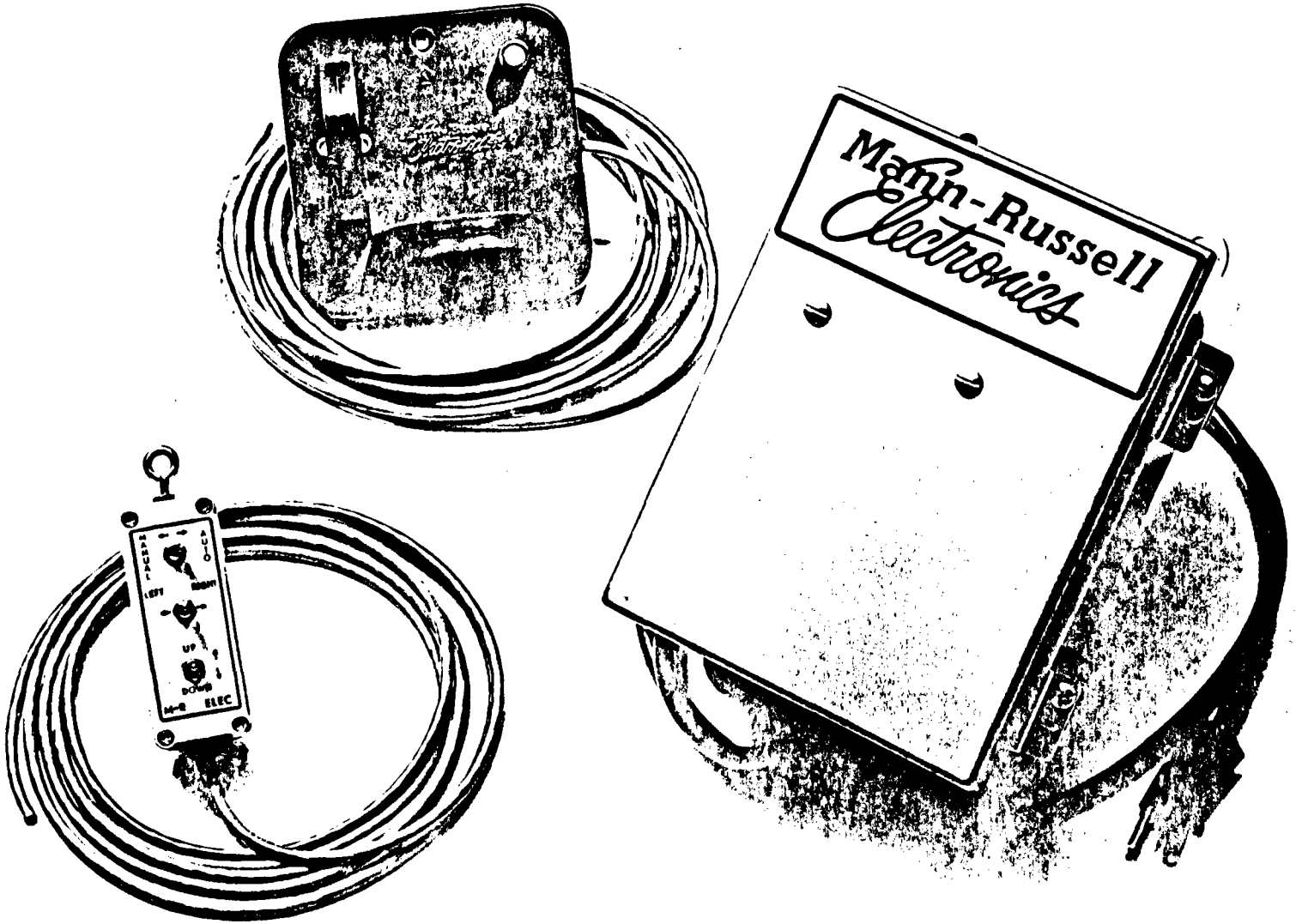
Under most circumstances the Dual Axes Tracker can be customer-installed but operating in some atmospheres and particularly if the gear train is sloppy careful adjustment must be adhered to in order to insure accurate and repetitive tracking. A factory man will assist you if you find it necessary, at very reasonable rates.

The Sensor is a shadow-band device utilizing photo conductive cells as the sensors. A fifth cell is located on the moulded head as the "Light Meter" to measure the incident light. Through logic circuitry it will switch to a synthetic track mode in cloud cover conditions. Synthetic Track Logic incorporates a timed circuit causing movements of 1/4° per minute - the approximate movement (Azimuth) of the Sun. The Sensor also supplies the signal to initiate rotation of the carriage to its Sunrise position at Sunset.

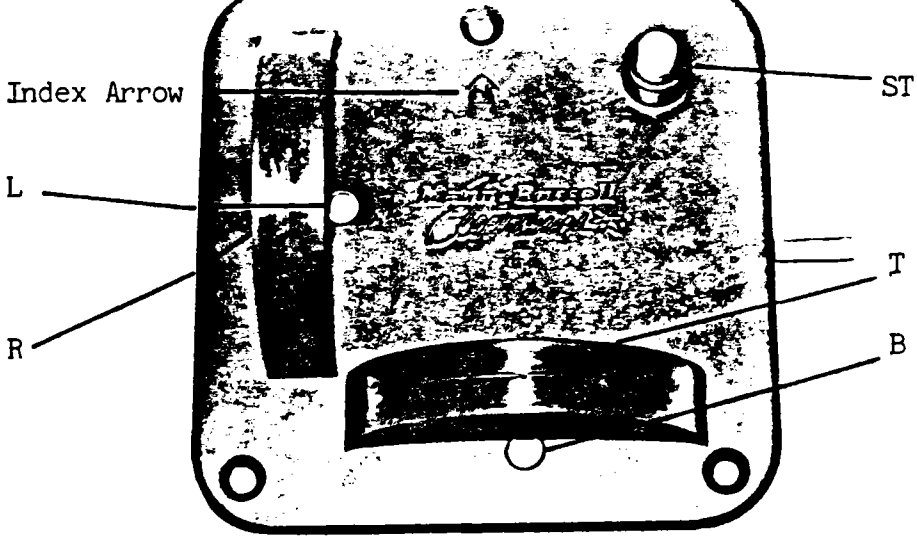
The electronic control circuitry includes the input power supply, the CMOS Logic Circuit and a drive motor interface. It is housed in an oil-tight JIC enclosure. The unit is designed for 110VAC input which is transformed to 24VAC that supplies power through the reversing interface to the motors. (Not supplied.) The 24VAC also feeds the regulated 12VDC Logic Supply. The interface will handle a total of 2A continuous and 4A intermittent at 24VAC. At this voltage Class II Wiring can be used reducing potential voltage hazard on the collector. Various voltages can be handled by selection of a different transformer. The board can be "jumpered" to supply 110VAC through the interface to 110VAC motors or contactors if this is required. Fifty Hertz is not a problem to the operation.

The circuit will accept several emergency-type sensors,for example, one in the closed loop circulation system, for over-temperature, and one in the storage tank, etc. If the sensor is activated it will cause the collector to reverse (Azimuth) track approximately four seconds to defocus the collector. It will hold this position until the condition normalizes. The Manual-Automatic Pendant allows manual override of the system.

Tracking accuracy of 1/10 of one degree has been obtained with drive motor speeds producing movement of 8° - 9° per minute, and a reasonably tight gear train.



MANN-RUSSELL ELECTRONICS, INC.
1401 Thorne Road Tacoma, Washington 98421



ST-3 SENSOR HEAD

The Sensor Head contains five photocells in a complete molded sealed assembly with 16-feet of 6 conductor shielded cable. Three 10-24 X 1" flat head stainless steel screws with nuts and lock washers are supplied for mounting.

INSTALLATION: The Sensor Head should be mounted on the array so the flat base is on the same plane as the array and the arrow indexes to the earth true north axis.

Care should be taken when tightening the screws to prevent any distortion to the head.

The loose end of the cable will attach to the terminal strip at the top of the ST-2 Card with terminal identification and wire colors as follows:

ST-2 TERMINAL			SENSOR WIRE COLOR
ST	(Synthetic Track)	=	White
10V	(10V Positive)	=	Red
T	(Top Cell for Elevation)*	=	Green
B	(Bottom Cell for Elevation)*	=	Brown
R	(Right Cell for Azimuth)*	=	Blue
L	(Left Cell for Azimuth)*	=	Black
-	(Supply Ground, Shield)	=	Yellow SH
DT	(De-Track)	=	Any number of normally open heat sensors can be connected between this terminal to Ground (-) Terminal.

* Physical Position of the cells standing behind the Head facing the Sun.

CLEANING: Cleaning requirements may vary depending on the type of environment in which these units are used. Use water and a mild detergent to clean the four photocells and the white nylon lens. A build-up of dirt could result in a loss of tracking accuracy. If the white nylon lens gets dirty, the unit could go into the Synthetic Track (ST) or Night Return (NR) mode earlier than normal.

MANN-RUSSELL ELECTRONICS, INC.

WARRANTY

Mann-Russell Electronics, Inc., warrants the Electronic Sun Tracking Control System and/or Sub-components of their manufacture against original defects of parts, material or workmanship for a period of three (3) months from date on installation, which date will establish successful operation.

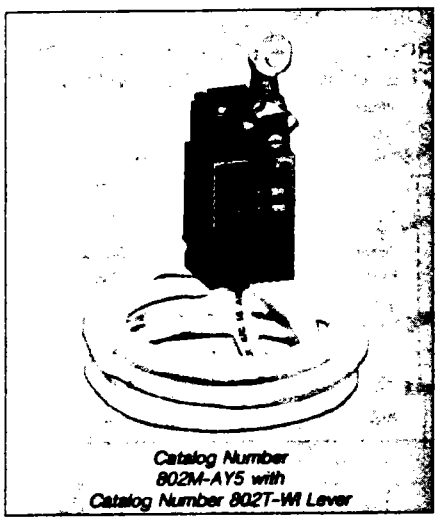
Any defective component will be replaced or repaired within the warranty period with final determination as to whether the part or material thereof is actually defective rests with Mann-Russell Electronics, Inc. Said warranty covers parts, material and if required, repairs performed at Mann-Russell's plant only with all shipping charges to be paid by the Buyer.

Any component found to be damaged as a result of improper maintenance, abuse, incorrect operational procedures, acts of God and unauthorized mechanical or electrical changes will void this warranty.

No warranty of end product is made and liability of seller is limited to repair or replacement of the component and DOES NOT EXTEND to consequential damages including personal injuries.

No other warranty expressed or implied shall exist between Buyer and Seller.

3-12-82



Catalog Number 802M-AY5 with Catalog Number 802T-W1 Lever

DESCRIPTION — The Bulletin 802M compact pre-wired limit switch is factory sealed to meet the demanding requirements for NEMA Types 1, 4, 6P and 13 enclosures. Outstanding features designed into the switch make it easy to install and economical to use.

APPLICATIONS — The Bulletin 802M is designed for dry and wet applications. The superior sealing system has been developed to protect the switch from dust, dirt and fluids normally found in industrial environments. The device has been subjected to and passed harsh environmental testing such as alternately drenching with a liquid and exposing to dust and abrasive grit with the switch operating 250 times per minute.

The switch is often used in applications subject to washdowns, streams of coolant, or occasionally submerged in fluids commonly found on machines or in industrial processes. This limit switch is being used successfully in High Water Content Fluid (HWCF) applications. Refer to the nearest district sales office for applications where potentially corrosive fluids are of a particular concern.

SEALING SYSTEM — The cable entrance and wire strands are epoxy sealed to prevent against liquids entering or wicking into the switch. The interface between the operating head and base is sealed with a VITON™ quad ring. The operating shaft for lever type switches is sealed with a patented 3-way seal made of VITON. Push type switches have a VITON boot that prevents against oil and other foreign material from entering the mechanism. A flexible diaphragm seal between the operating head and the switch body isolates the switch against the entrance of contaminants. After prewiring, the cover is factory installed and epoxy sealed.

CONSTRUCTION — The body and operating head of the Bulletin 802M prewired limit switch are constructed from a glass filled DIALLYL PHTHALATE (DAP). This material is characterized by excellent dimensional stability and is resistant to moisture and numerous chemicals.

The Bulletin 802M switch also capitalizes on the corrosion-resistant properties of the operating shaft, operating rod, and roller pin which are made of Type 303 stainless steel. The operating head mounting screws and adaptor mounting foot are made of steel. They are plated and have a chromate finish to resist corrosion.

The basic switching mechanism has double-throw, double-break, snap action contacts with minimum contact bounce. The switch is pre-wired and factory sealed with STO■ cable. An optional Brad-Harrison connector can also be supplied. Refer to modifications on Page 271.

INSTALLATION — Although physically smaller, the Bulletin 802M switch can be interchanged with a Bulletin 802T front mounted lever operated switch by using the mounting foot adaptor included. Cam tracking characteristics from the top mounting hole of the Bulletin 802M switch are identical to the Bulletin 802T non-plug-in rotary operated switch line.

Time saving factory pre-wiring makes the switch economical to use. Internal wiring by the installer is eliminated. No separate cable grip or cable to purchase. Merely connect the STO■ cable to a junction box.

LEVER TYPE SWITCHES — These switches are operated by means of a lever which is clamped to a knurled shaft extending from the operating head. These devices can be easily field converted to clockwise, counterclockwise, or both directions of operation without any loose parts. Total travel is 90° in either direction. Operating heads are interchangeable and can be mounted in any of four positions 90° apart for maximum flexibility. The head is interlocked with the base unit to resist accidental shearing.

Lever type switches can be equipped with a variety of operating levers: roller lever, adjustable roller lever, micrometer adjustment roller lever, rod lever, one-way rod or roller lever and fork lever. These can be used interchangeably on all lever type switches.

PUSH TYPE SWITCHES — These switches are actuated by means of a rod or plunger located on the top or side of the operating unit. Pushing the plunger into the head causes the contacts to operate. Two types of plungers are available: rod and roller. Push type switches are supplied in spring return construction.

TEMPERATURE RANGE — 0°C to +80°C (+32°F to +180°F). Minimum temperature based on the absence of freezing moisture or water.

■ STO is a common identification of this cable. The more complete identification of the cable used on the Bulletin 802M is STOOW-A which incorporates an oil resistant jacket and conductor insulation, for indoor and outdoor use.

CONTACT RATINGS — All units have double-break fine silver contacts rated for control circuit as follows:

2-CIRCUIT DEVICES						
Maximum AC Contact Rating Per Pole 50 or 60 Hz						
NEMA Rating Designation	Maximum Voltage	Amperes		Continuous Carrying Current (Amperes)	Voltamperes	
		Make	Break		Make	Break
A600 A300	120	60	6.00	10	7200	720
A600 A300	240	30	3.00	10	7200	720
A600 —	480	15	1.50	10	7200	720
A600 —	600	12	1.20	10	7200	720
Maximum DC Contact Rating Per Pole						
P150	125 250	1.1 —		5.0	138	

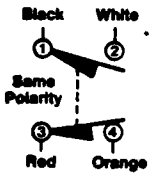
4-CIRCUIT DEVICES						
Maximum AC Contact Rating Per Pole 50 or 60 Hz						
NEMA Rating Designation	Maximum Voltage	Amperes		Continuous Carrying Current (Amperes)	Voltamperes	
		Make	Break		Make	Break
B300	120 240	30 15	3.00 1.50	5 5	3600 3600	360 360

™ DuPont Trademark

PRE-WIRED FACTORY SEALED LIMIT SWITCHES

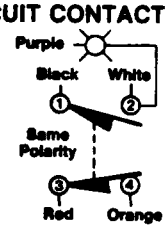
WIRING DIAGRAMS SHOWING CONTACT CONFIGURATION AND TERMINAL WIRE COLOR CODE

STANDARD LIMIT SWITCH

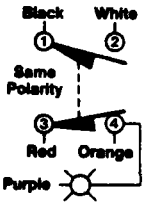


STANDARD LIMIT SWITCH WITH NEON INDICATING LIGHT OPTION

2 CIRCUIT CONTACT BLOCK

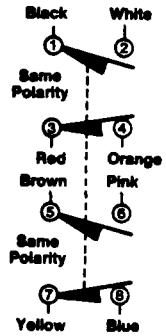


Wired to N.O. (White) Wire

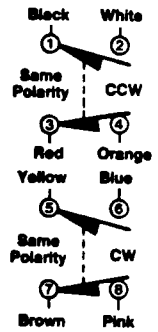


Wire to N.C. (Orange) Wire

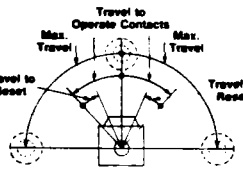
4 CIRCUIT CONTACT BLOCK



NEUTRAL POSITION LIMIT SWITCH



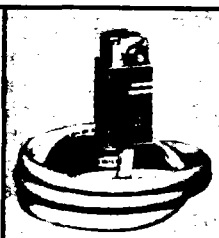
LEVER TYPE ● SPRING RETURN



— Note —

Contacts of Catalog Number 802M-AY5, 802M-ATY5, 802M-HY5 and 802M-HTY5 operate when lever is moved in either direction.

Contacts of Catalog Number 802M-A15, 802M-A1Y5, 802M-H1Y5, 802M-H1Y5, 802M-A2Y5, 802M-A2TY5, 802M-H2Y5 and 802M-H2TY5 operate when lever is moved in one direction. See target table below. These devices can be field converted to clockwise, counterclockwise or both directions of operation without loose parts.



Complete Switch Without Lever■

Operating Head Only

Switch Only■

No. of Circuits	LEVER MOVEMENT CONTACT OPERATION	Operating Torque (Max.)	Travel to Operate Contacts (Max.)	Maximum Travel	Travel To Reset Contacts (Max.)	Catalog Number	Price	Catalog Number	Price	Catalog Number	Price
2 Circuit	Clockwise or Counterclockwise	3 In.-Lbs.	15°	90°	6°	802M-AY5	$78	802M-AX	$30	802M-XY5	$48
		5 In.-Lbs.	8°	90°	4°	802M-HY5	82	802M-HX	34		
	Clockwise	3 In.-Lbs.	15°	90°	6°	802M-A1Y5	78	802M-A1X	30		
		5 In.-Lbs	8°	90°	4°	802M-H1Y5	82	802M-H1X	34		
	Counterclockwise	3 In.-Lbs.	15°	90°	6°	802M-A2Y5	78	802M-A2X	30		
		5 In.-Lbs.	8°	90°	4°	802M-H2Y5	82	802M-H2X	34		
4 Circuit	Clockwise or Counterclockwise	3 In.-Lbs.	15°	90°	6°	802M-ATY5	98	802M-AX	30	802M-XTY5	68
		5 In.-Lbs.	8°	90°	4°	802M-HTY5	102	802M-HX	34		
	Clockwise	3 In.-Lbs.	15°	90°	6°	802M-A1TY5	98	802M-A1X	30		
		5 In.-Lbs.	8°	90°	4°	802M-H1TY5	102	802M-H1X	34		
	Counterclockwise	3 In.-Lbs.	15°	90°	6°	802M-A2TY5	98	802M-A2X	30		
		5 In.-Lbs.	8°	90°	4°	802M-H2TY5	102	802M-H2X	34		

■ See modifications on Page 271 for factory installed pre-wired type STO cable in 8, 12 and 16 foot cable lengths.

LEVERS — See Page 301 for a complete listing of operating levers.

Dimensions — See Page 274

MODIFICATIONS

NEON INDICATING LIGHT —

Bulletin 802M pre-wired limit switches can be supplied with a neon indicating light. AC 208/240V, 50-60 Hz or 120V, 50-60 Hz, wired to one side of either the N.O. or N.C. contact with the second lead available as a 5th conductor for wiring flexibility. See Page 266 for Wiring Diagram.

To order, add the appropriate suffix listed in the table to the catalog number listed in the price tables on Pages 266 to 270.

Add **$12** list to the list price. **Example:** Catalog Number **802M-AY5** with a 120 volt indicating light wired across the N.O. contact would be Catalog Number **802M-AY5NF** at **$90** list.

AC-Voltage	Wired To■	Catalog Number Suffix
120 50/60 Hz	N.O. Contact	NF
	N.C. Contact	NC
240 50/60 Hz	N.O. Contact	N5F
	N.C. Contact	N5C

CABLE LENGTH — The factory installed pre-wired, type STO■ cable is normally supplied in 5-foot lengths. To order other lengths of STO■ cable, replace the suffix **"Y5"** in the catalog number listed in the price tables on Pages 266 to 270 with the listed modification catalog number suffix and add the price addition to the list price. **Example:** to order a lever type spring return switch with 8-feet of STO■ cable the catalog number would be **802M-AY8** list price **$84.**

Modification	Catalog Number Suffix	List Price Addition
8-foot cable	Y8	$ 6
12-foot cable	Y12	14
16-foot cable	Y16	22

5 PIN PLUG-IN RECEPTACLE■ — 2 CIRCUIT CONTACT BLOCK — To order a Bulletin 802M pre-wired limit switch with a receptacle in place of the 5-feet of STO■ cable, replace the letter **"Y5"** in the catalog number with the suffix **"J1"** and add **$15** to the list price. Maximum voltage rating for this receptacle is 250 Volt AC.

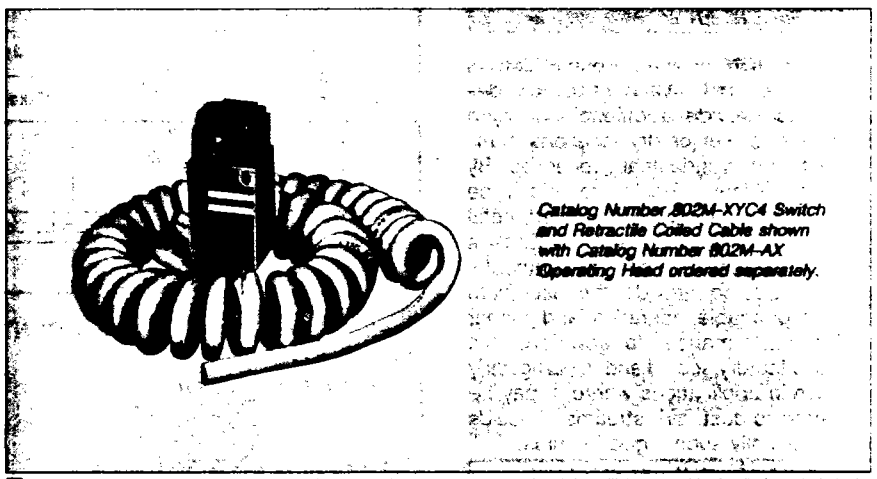
An appropriate female connector with cord are available through local Brad Harrison, CAM-LOK or Joy distributors.

9 PIN PLUG-IN RECEPTACLE■ — 4 CIRCUIT CONTACT BLOCK — To order a Bulletin 802M pre-wired limit switch with a receptacle in place of the 5-feet of STO■ cable, replace the letter **"Y5"** in the catalog number with the suffix **"J1"** and add **$25** to the list price. Maximum voltage rating for this receptacle is 250 Volt AC.

An appropriate female connector with cord are available through local Brad Harrison, CAM-LOK or Joy distributors.

COILED RETRACTILE CABLE — The Bulletin 802M 2 circuit pre-wired limit switch similar to Catalog Number 802M-XY5 is available with a retractile coiled STO■ cable. A 4 foot length of coiled cable can be extended to 20 feet and neatly retracts to avoid loose cable. Typical applications would include traverse type motion on a machine tool or moveable gates.

To order the switch with retractile cable specify Catalog Number **802M-XYC4** priced at **$93** list. The desired operating head and lever (if used) must be ordered separately.



■ If the indicating light is wired across the normally open contacts, the light will be on with the limit switch in its unoperated state. If the indicating light is wired across the normally closed contacts, the light will be off with the limit switch in its unoperated state.

■ STO is a common identification of this cable. The more complete identification of the cable used on the Bulletin 802M is STOOW-A which incorporates an oil resistant jacket and conductor insulation, for indoor and outdoor use.

■ A 5 pin plug-in receptacle is supplied to facilitate retrofitting existing installations. The normal ground wire pin is not required and is not connected inside the switch.

■ A 9 pin plug-in receptacle is supplied to facilitate retrofitting existing installations. The normal ground wire pin is not required and is not connected inside the switch.

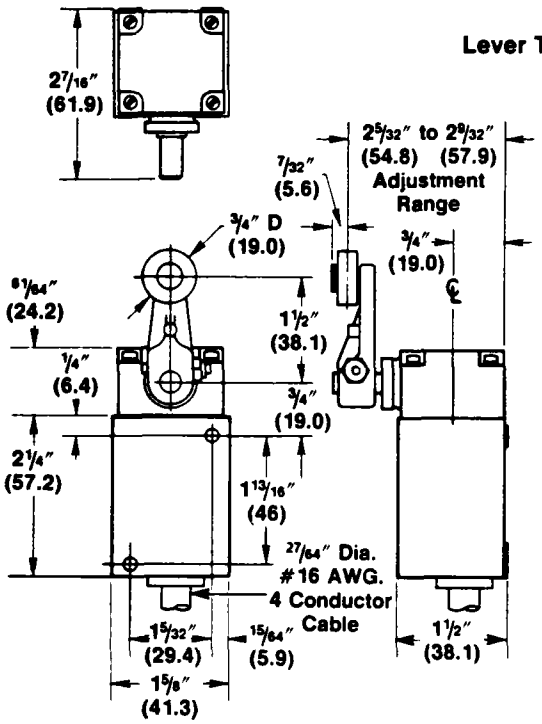
Dimensions — See Page 275

APPROXIMATE DIMENSIONS AND SHIPPING WEIGHTS

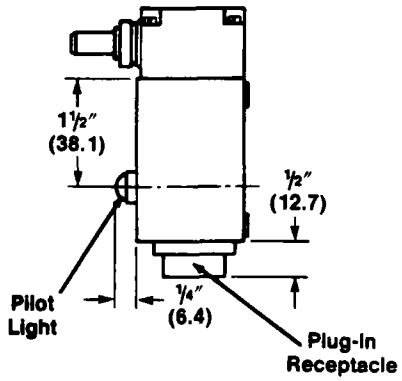
Note — Dimensions shown in parentheses are in millimeters.

2-Circuit

Lever Type

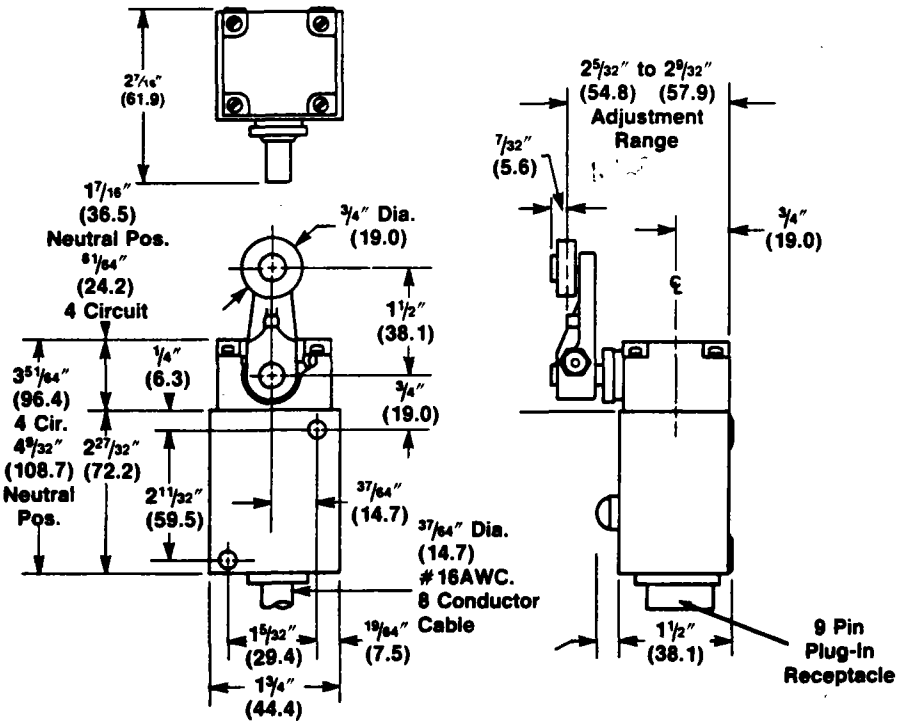


5 Pin Plug-In Receptacle and Neon Indicating Light Options



Shipping Weight 1 Lb. 3 Oz. (.53 Kg)

4-Circuit and Neutral Position



Approx. Shipping Weight: 2 Lbs. (.9 Kg)

For Corrosion-Resistant Pre-Wired Limit Switches

ROLLER LEVER					
Type	Material	Roller		Catalog Number	Price
		Diameter	Width		
 *1½" radius*	Type 316 stainless steel roller, roller pin and clamp pin. One-piece cast aluminum arm is protected with TUFRAM®■	¾"	¼"	802MC-W1A	$ 9
 *Adjustable 1³⁄₁₆"-3" radius*	Type 316 stainless steel roller, roller pin, clamp pin and adj. lever arm. Block is cast aluminum protected with TUFRAM®■	¾"	¼"	802MC-W2B	15

ROD LEVER				
Type	Material	Diameter	Catalog Number	Price
	Type 316 stainless steel Rod 5" Long. Block is cast aluminum protected with TUFRAM®■	⅛"	802MC-W3	$15
	Type 316 stainless steel Rod 11½" Long. Block is cast aluminum protected with TUFRAM®■	⁵⁄₆₄"	802MC-W3A	15
	Nylon Rod 12" Long. Block is cast aluminum protected with TUFRAM®■	¼"	802MC-W3C	20

■ TUFRAM is a synergestic coating which combines the advantages of anodizing with a controlled infusion of Teflon for added corrosion-resistance.

APPENDIX D

ASTROSYSTEMS DURAPOT POSITION ENCODERS

astrosystems, inc.

TECHNICAL MANUAL

DURAPOT

MODEL DC1000 SERIES

6 Nevada Drive, Lake Success, New York 11042 516-328-1600

CERTIFICATION

Astrosystems certifies that its products are thoroughly tested and inspected and meet applicable published specifications when shipped from the factory. The accuracy of all test equipment is traceable to the National Bureau of Standards.

WARRANTY

Astrosystems uses only the highest quality materials and workmanship in manufacturing. All products are guaranteed against defects in materials and workmanship for a period of ninety days from the invoice date. This warranty does not extend to any of our products which have been subjected to misuse, neglect, accident or improper installation or application, nor shall it extend to products which have been repaired or altered outside the factory without factory consent.

REPAIR POLICY

Technical Manuals are included to provide hook-up, interface and routine maintainance information.

Factory repair service is provided at rates which reflect parts and labor actually supplied. For service under warranty, please advise the factory of all pertinent details. The unit must be returned to the factory prepaid. We endeavor to repair and return all units in a timely manner from the date of receipt at the factory.

APPLICATION ASSISTANCE

Astrosystems maintains a staff of application engineers to assist customers in the use and application of its equipment. Please contact the factory for assistance.

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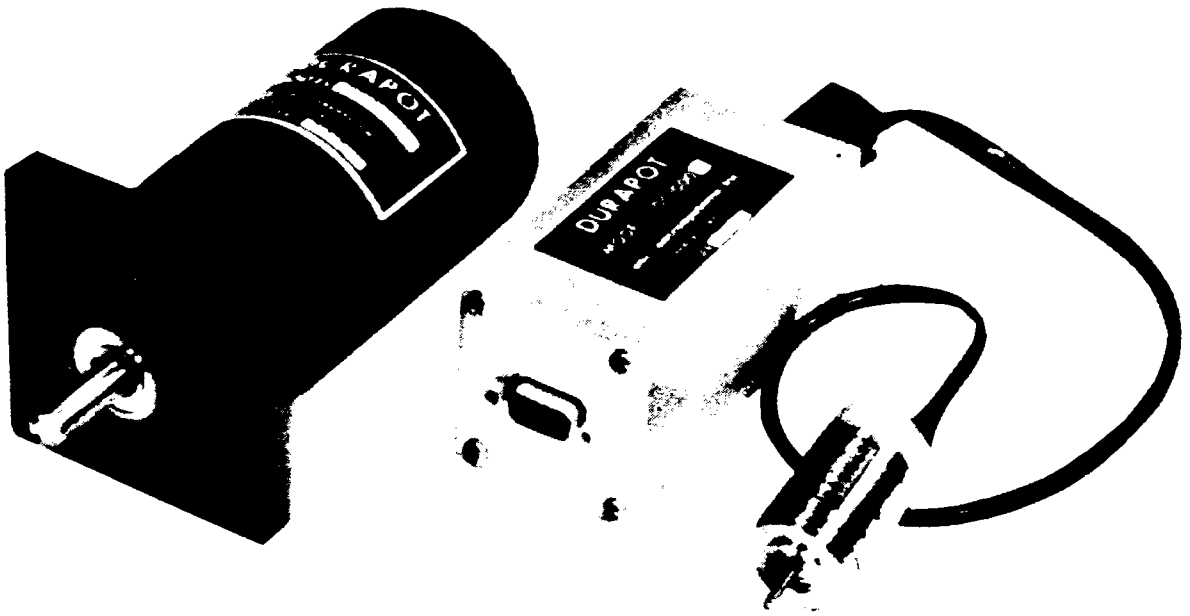


Durapot® Model DC1000 Series

SECTION 1
INTRODUCTION

1-1. SCOPE

This manual provides information regarding the operation and installation of the Astrosystems Durapot® (wiperless angular to d-c potentiometer), Model DC1000 Series. The Durapot is designed and manufactured by Astrosystems, Inc., 6 Nevada Drive, Lake Success, New York 11042.

1-2. PURPOSE OF EQUIPMENT

The Durapot is designed to measure mechanical motion and generate a linear analog direct-current voltage signal directly proportional to the angular displacement of the Durapot shaft. The Durapot unit is absolute; i.e., shaft angle position is continuously measured and available to the user. Primary power interruptions, regardless of duration, will not require re-start or re-zeroing of the unit in order to obtain valid data. Valid shaft angle data will automatically be available upon restoration of primary power. The Durapot is available with a wide range of options permitting utilization in many applications. Refer to Table 1-1 for options available. The basic Durapot consists of a NEMA-1 enclosure, integral electronics, a choice of DC outputs, and a choice of shaft rotation.

1-3. PRINCIPLE OF OPERATION

The Durapot consists of an electromagnetic single-turn rotary transducer to sense mechanical movement and solid-state electronics to provide excitation of the transducer windings and output signal conditioning. The solid-state electronics generates sine and cosine signals to excite the stator windings of the transducer to create a magnetic field. The magnetic field induces quadrature voltages in the transducer rotor windings which varies with the angular displacement of the rotor shaft. The induced voltages in the rotor windings are compared with the internal reference voltage of +10VDC generated by the solid-state electronics or an external reference voltage of no less than +5VDC nor greater than +12VDC. The solid-state electronics produces a DC voltage signal proportional to the angular displacement of the transducer shaft and the internal/external reference voltage. The equation, $V_{out} = (\theta/360^\circ) \times V_{ref}$, is utilized to determine the DC voltage output signal value (V_{out}) for a given shaft angle displacement (θ) by dividing the shaft angle

displacement in degrees (θ) by 360° and multiplying the resultant by the DC reference voltage (V_{ref}):

Examples -

If V_{ref} = +10V

(1) When θ = 45°,
then V_{out} = 45°/360° x 10V = 1.25VDC.

(2) When θ = 135°,
then V_{out} = 135°/360° x 10V = 3.75VDC.

1-4. MODEL DIFFERENCES

The Durapot, Astrosystems Model DC1000 series, is available in NEMA-1, NEMA-12, or NEMA-13 enclosures; and may be obtained with a choice of integral (built-in) or separate (remote) electronics; four different DC output voltage ranges; and the desired direction of shaft rotation. See Figure 1-1 for the model identification and selection chart.

1-5. ENCLOSURES. The Durapot is available in three enclosure type configurations: NEMA-1, a general purpose indoor type; NEMA-12 (HST-26 and HST-34), a heavy-duty, dust-tight and driptight indoor type; and NEMA-13 (HST-26U and HST-34U), a heavy-duty, oiltight and dust-tight indoor type.

1-6. ELECTRONICS. The Durapot is available with the solid-state electronics integral to the transducer in every type of enclosure with the exception of the NEMA-12 (HST-34) and NEMA-13 (HST-34) configuration. The separate solid-state electronics, remote from the transducer, is available with all model variations.

1-7. DC OUTPUT VOLTAGE RANGES. The Durapot is available in four different DC output voltage ranges: 0VDC to +10VDC, 0VDC to -10VDC, -5VDC to +5VDC, or -10VDC to +10VDC.

1-8. SHAFT ROTATION. The Durapot is available in clockwise or counterclockwise rotation, as viewed from the shaft end.

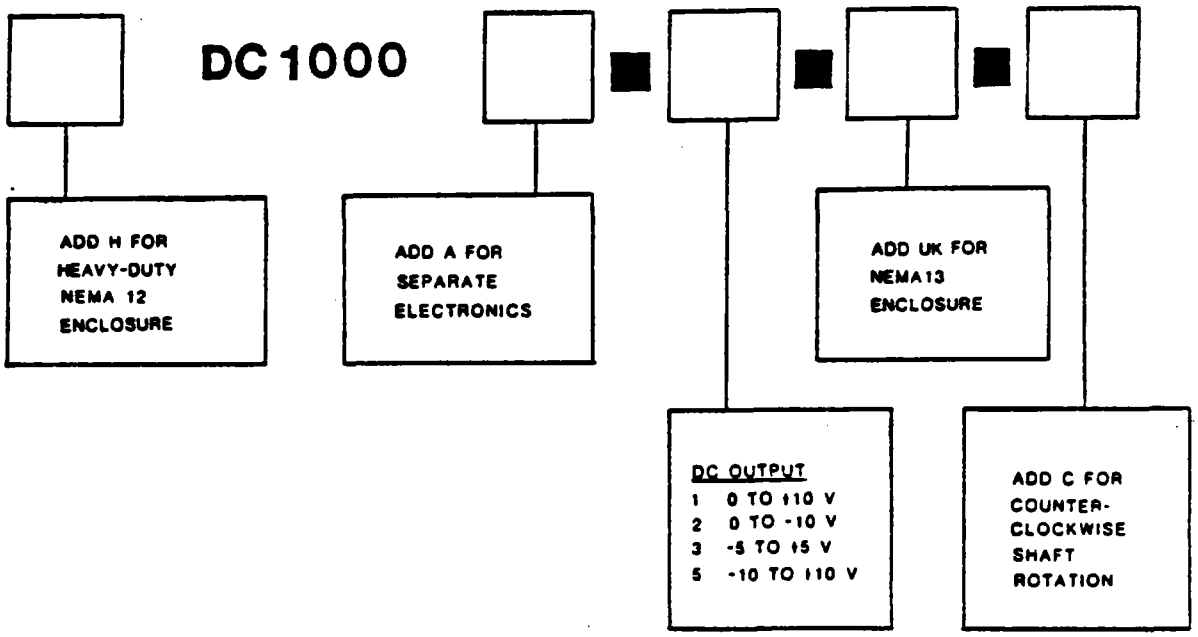


Figure 1-1. Model Identification and Selection

TABLE 1-1
DURAPOT OPTIONS

Enclosure	NEMA-1(ST-11)		NEMA-12 & -13(HST-26)		NEMA-12 & -13(HST-34)
Model	DC1000 DC1000A		HDC1000	HDC1000A	HDC1000A
Electronics	Internal	External	Internal	External	External
DC Output	0V TO +10V, 0V TO -10V, -5V TO +5V, OR -10V TO +10V				
Shaft Rotation	Clockwise(CW) or Counterclockwise (CCW)				

1-9. EQUIPMENT SPECIFICATIONS

The basic specifications for the Durapot are listed in Table 1-2.

TABLE 1-2
DURAPOT SPECIFICATIONS

Item	Specification
ROTATION	0° TO 359.99°
ACCURACY/LINEARITY	0.05%
OUTPUT VOLTAGE	
Internal Reference	0 VDC TO +10 VDC
External Reference (Customer Supplied)	+5 VDC< V_{ref} <+12 VDC
OUTPUT LOAD	
Signal Output	2K ohms max.
Internal Reference	10K ohms max.
INPUT IMPEDANCE (External Reference)	5K ohms
POWER REQUIREMENTS	±15 VDC at 50 mA, regulation +5%
ENVIRONMENTAL	
Operating Temperature Range	0°C TO 70°C
Shock	50 gs for 11 msec
Vibration	15 gs TO 500 Hz

SECTION 2
INSTALLATION AND OPERATION

2-1. INSTALLATION

This section contains specific installation instructions for the Durapot being used. Under no circumstances, should an attempt be made to install or interconnect the Durapot components without factory authorized instructions.

2-2. DURAPOT. The Durapot may consist of a transducer with an integral (built-in) solid-state electronics or a separate transducer and a separate (external/remote) solid-state electronics package. Where the solid-state electronics are built-in, only the transducer mounting instructions are required. The type of enclosure of the transducer will determine the environment in which it may be installed.

2-3. DURAPOT/TRANSDUCER MOUNTING. It is the customer's responsibility to interface the transducer to the device whose motion is to be monitored. The overall dimensions and mounting facilities of the transducers are shown in figure 2-1. The following recommendations, however, should be considered in order to facilitate installation and alignment of the transducer and to obtain to the maximum degree, the accuracy inherent within the Durapot system.

The transducer mounting bracket, plate, etc., should be substantially designed so as to minimize the detrimental effects of shock and vibration. Avoid the use of light gauge metals and long cantilevered mountings and to make sure that the mount is securely fastened to the frame of the machine.

The transducer shaft may be coupled to the shaft being monitored using any of the various flexible shaft couplings available, or by gear coupling, belt coupling, etc. In every case, avoid the introduction of backlash (lost motion) and utilize a coupling system that is compatible with the overall Durapot accuracy.

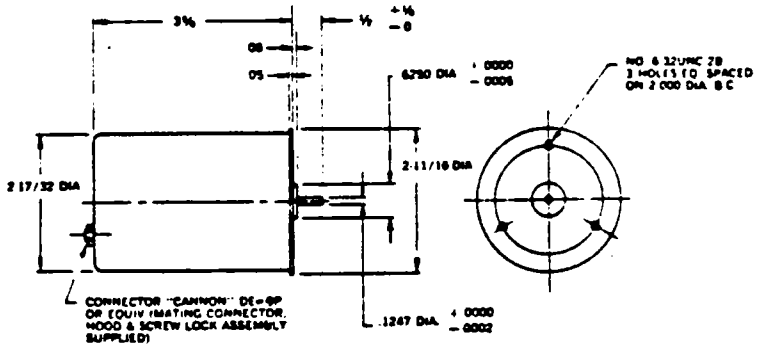
2-4. DURAPOT/TRANSDUCER ALIGNMENT. The Durapot/Transducer shaft and enclosure are scribed to indicate electrical zero.

NOTE

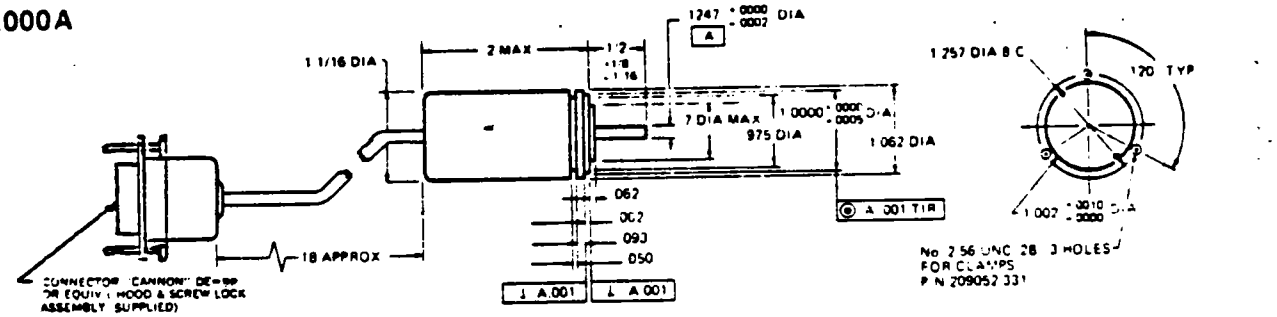
The coupling scheme must allow for initial mechanical zeroing to ensure precise transducer-machine shaft alignment.

NEMA 1 ST-11

DC1000 STANDARD

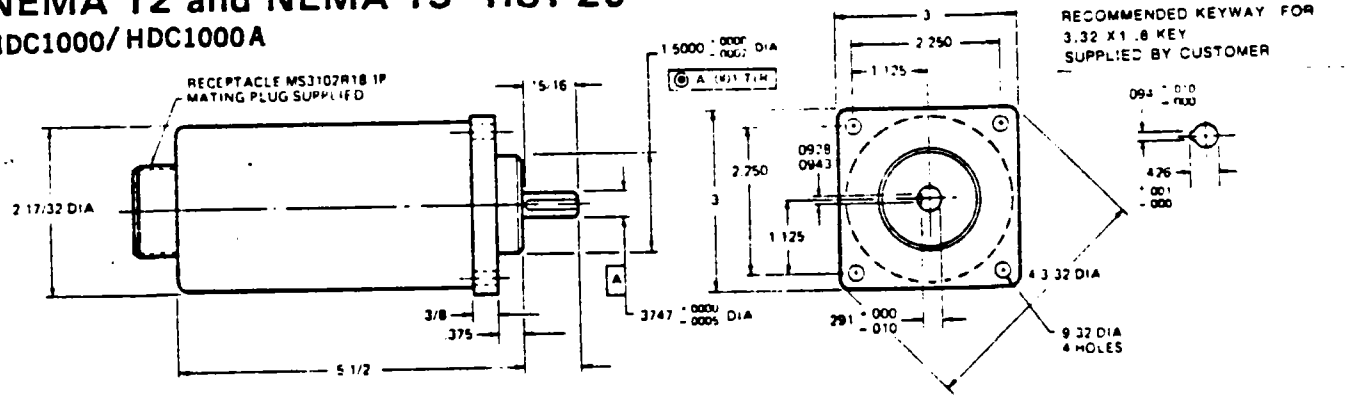


DC1000A



NEMA 12 and NEMA 13 HST-26

HDC1000/ HDC1000A



NEMA 12 and NEMA 13 HST-34

HDC1000A

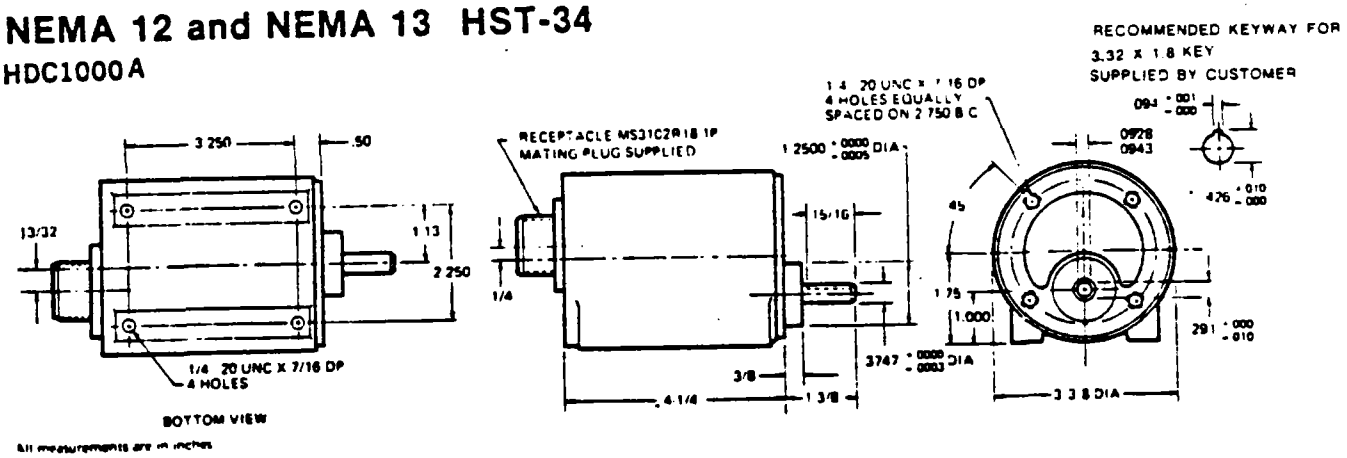


Figure 2-1. Durapot/Transducer Outline Dimensions and Mounting Facilities

It is imperative that the Durapot "zero" and the device coupling system "zero" be aligned accurately to ensure proper operation.

2-5. DURAPOT EXTERNAL SOLID-STATE ELECTRONICS. The external solid-state electronics is supplied, when applicable, with the Durapot system and is enclosed in a lightweight aluminum case. The case has been designed to facilitate mounting in any convenient location and in any physical orientation. The overall dimensions and mounting hole locations are shown in Figure 2-2.

Install the electronics:

1. Where there is adequate space on either end for the mating connectors and their cables.

2. Where the air:

   a. Is dry.
   b. Is as free as possible of corrosive gases, coolant and other kinds of spray, flying chips, dust and other foreign matter.
   c. Has an ambient temperature within the range of 0°C to 70°C.
   d. Has a relative humidity of less than 95 percent.

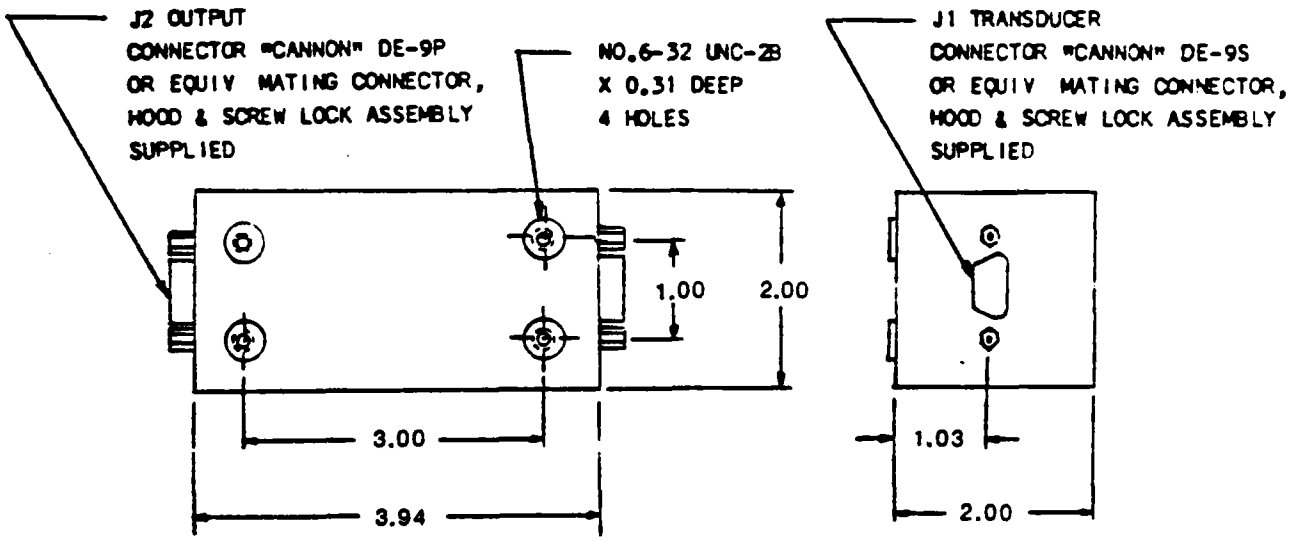
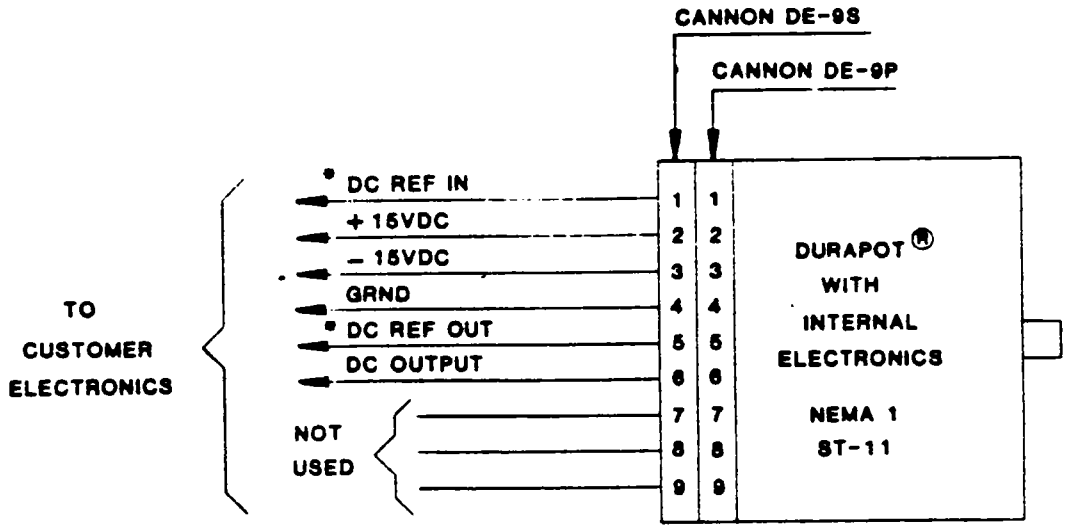


Figure 2-2. Durapot External Solid-State Electronics Outline Dimensions and Mounting Facilities

2-6. DURAPOT CABLING INSTRUCTIONS. The Durapot does not come equipped with interconnecting cables. However, the Durapot components are supplied with mating connectors, hood, and retaining hardware (where required), as standard equipment. It is the customer's responsibility to fabricate the interconnecting cables. The customer has the option, when fabricating the interconnection wiring, to use an externally generated DC reference voltage instead of the internally generated reference voltage. The internal reference voltage (+10VDC) is obtained by connecting pins 1 and 5 or B and J (as applicable). The external reference voltage (not less than +5VDC, and not greater than +12VDC) may be used instead by connecting to pin 1 or J (as applicable).

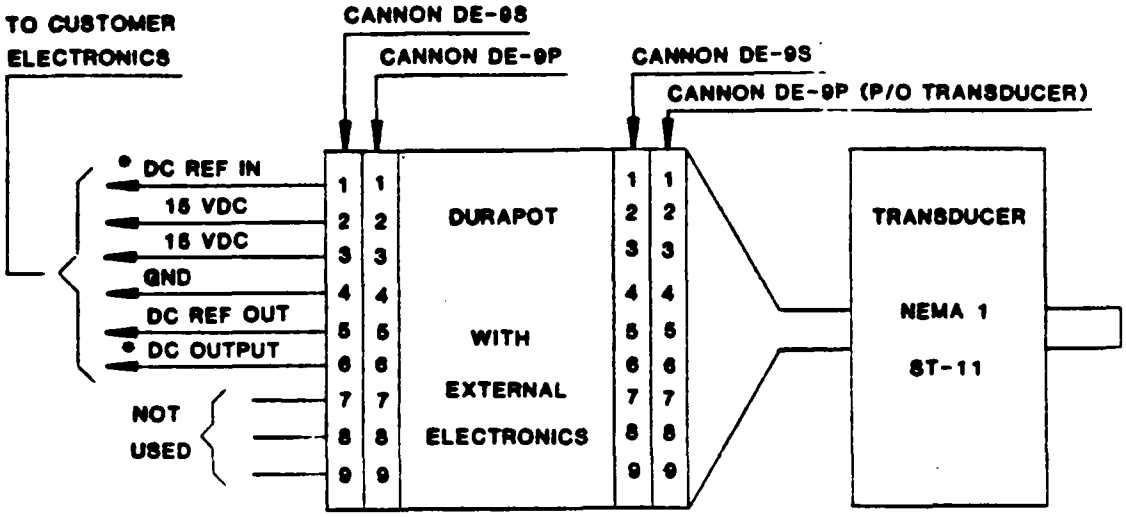
Reference should be made to the applicable interconnecting wiring diagram, Figures 2-3 through 2-6.



Note:

* For internally generated reference voltage (+10VDC), connect pins 1 & 5.

Figure 2-3. DC 1000 Interconnection Wiring Diagram



Note:

* For internally generated reference voltage (+10VDC), connect pins 1 & 5.

Figure 2-4. DC 1000A Interconnection Wiring Diagram

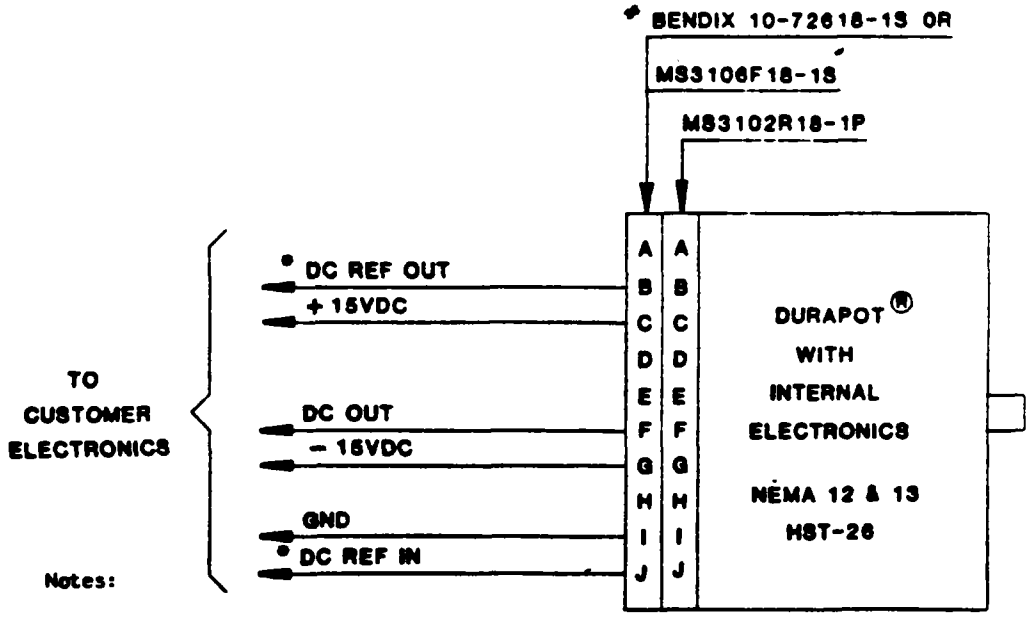
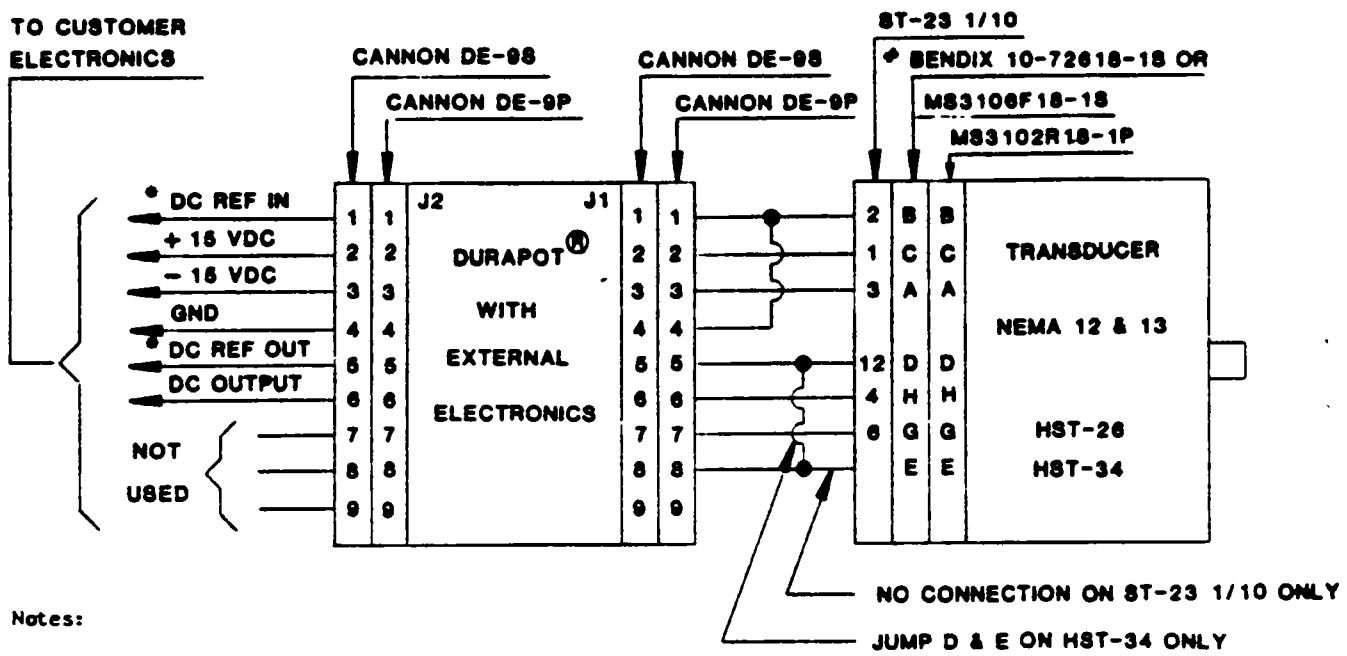


Figure 2-5. HDC1000 Interconnection Wiring Diagram



Notes:

* For internally generated reference voltage (+10VDC), connect pins 1 & 5.

Supplied with "UK" (NEMA 13) Series Transducer.

Figure 2-6. HDC 1000A Interconnection Wiring Diagram

SECTION 3
REPLACEABLE PARTS LIST

3-1. REPLACEABLE PARTS.

Replaceable parts for the Durapot are listed in Table 3-1. The parts list contains the part numbers of the replaceable transducers and electronics of the Durapot models using separate components only.

Table 3-1
REPLACEABLE PARTS LIST

Model	Transducer	Electronics
DC 1000A-1		100-3698-1
DC 1000A-2	100-3557-1	100-3698-2
DC 1000A-3		100-3898-3
DC 1000A-5		100-3698-5
HDC 1000A-1		100-3698-1
HDC 1000A-2	100-3473(HST-26)	100-3698-2
HDC 1000A-3	100-4990(HST-34)	100-3698-3
HDC 1000A-5		100-3698-5
HDC 1000A-1-UK		100-3698-1
HDC 1000A-2-UK	100-5148(HST-26)	100-3698-2
HDC 1000A-3-UK	100-5145(HST-34)	100-3698-3
HDC 1000A-5-UK		100-3698-5

OPERATING INSTRUCTIONS

FOR

LEAD ACID BATTERIES

SAFETY PRECAUTIONS

READ BEFORE INSTALLATION

Observe the following precautions at all times. Batteries are no more dangerous than any other equipment when handled correctly.

* Keep batteries upright.

* Acid is corrosive - wear protective clothing, rubber gloves and goggles when handling batteries and electrolyte.

* Do not allow metal objects to rest on the battery or fall across the terminals. Never wear rings or metal wrist bands when working on batteries.

* Do not smoke or permit open flames near batteries or do anything to cause sparks.

* Do not spill acid on the skin or clothing. If acid is spilled on the skin, wash immediately with copious amounts of clean water, then cover with dry gauze.

  If acid comes into contact with the eyes, flush with plenty of clean water.

  In all cases obtain immediate medical attention.

IMPORTANT NOTE!

CELLS SUPPLIED FILLED WITH ACID MUST BE PLACED ON FLOAT CHARGE OR GIVEN AN EQUALIZING OR FRESHENING CHARGE WITHIN 90 DAYS FROM THE DATE OF SHIPMENT. **FAILURE TO OBSERVE THIS REQUIREMENT COULD RESULT IN PERMANENT DAMAGE TO THE CELLS.**

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1. UNPACKING AND INSPECTION

Upon receiving a shipment of battery cells, it is advisable to open the shipping containers and carefully check the cells and hardware against the packing list.

The contents of each consignment are carefully inspected by MARATHON before shipment. Any damage should be reported immediately to the carrier and the damaged items retained for inspection by the carrier's representative.

For cells supplied filled and charged, check that the acid level in all cells is at the "MAX" line. Any spillage should be replaced with pure dilute sulfuric acid with the correct specific gravity (see Section 3).

It is essential that filled and charged cells be placed on charge within 90 days from the date of shipment. This is to prevent irreversible sulfation of the plates and permanent loss of battery capacity.

2. STORAGE

If the battery cannot be immediately installed, the cells should be stored in a clean, cool, dry room.

Cells supplied **filled and charged** should ideally be placed on float or trickle charge until required (see Section 6 for charging details). This charging should be carried out with the shipping containers open, or the cells unpacked, and with adequate ventilation to disperse the gases formed on charging.

If continuous charging is not possible, the battery should be given a freshening or equalize charge (see Section 6) at least every 90 days and when distilled water is added (see Section 8).

Cells supplied **dry charged** may be stored for an indefinite period, provided that they are adequately protected against condensation and the effects of high humidity.

3. FILLING DRY CHARGED CELLS

3.1 ACID

The following table gives specific gravity data at 77°F for fully charged cells with the electrolyte at the maximum level:

Nominal Sp. Gr.	Specific Gravity Range	Sp. Gr. for Filling Dry Charged Cells	Cell Type
1.210	1.205 - 1.215	1.205	SGL SGH
1.240	1.235 - 1.250	1.235	SD SDH PMF
1.270	1.260 - 1.280	1.265	SPF
1.300	1.290 - 1.310	1.295	*

*For special applications only.

Pure sulfuric acid diluted with distilled or deionized water to the correct specific gravity (see chart) is required for filling dry charged cells. If the acid has been provided by MARATHON, store it in a safe place until required. If acid is purchased locally, it should conform to Federal Specification OS-801C.

If concentrated acid has been obtained, it is essential for it to be diluted with distilled or deionized water **before** being put into the cells. Plastic mixing tanks are ideal for this purpose; if glass is used, care must be taken to limit temperature rises due to the heat produced in the mixing process. Do not use metallic mixing tanks.

3.1 ACID (Continued)

CAUTION: When mixing acid, always observe the following safety measures:

* Wear protective clothing, gloves and goggles whenever acid is handled.
* Make sure the mixing tank is perfectly clean before use.
* Put the water into the mixing tank first.
* **THEN** add the acid, slowly and cautiously, stirring continuously.
* **NEVER ADD WATER TO ACID OR IT WILL SPLASH DANGEROUSLY.**
* Allow the mixture to cool to room temperature before pouring it into the cells.

Concentrated acid is normally available with a specific gravity of 1.835 or 1.400 at 77°F. **DO NOT PUT CONCENTRATED ACID INTO THE CELLS OR THEY WILL BE RUINED.**

When mixing by volume, use the table below to determine the approximate number of parts of water to mix with one part of acid.

Initial	Final Sp. Gr.			
Sp. Gr.	1.205	1.235	1.265	1.295
1.835	4.2	3.6	3.1	2.7
1.400	1.1	0.8	0.6	0.4

Always check the specific gravity of the acid before filling the cells. Minor adjustments may be made by adding water to lower the specific gravity or by adding acid to raise the specific gravity.

3.2 FILLING THE CELLS

Use glass or plastic jugs and funnels for filling the cells. **DO NOT** use metallic vessels. Fill the cells to the "MAX" level line on the cell and leave to allow the acid to soak into the separators and plates.

3.2 FILLING THE CELLS (Continued)

After approximately 3 hours, top up with acid to the "MAX" level line.

The quantity of dilute acid required to fill each cell is given in Section 10.

When acid is obtained locally, we recommend that an additional 10% be purchased to allow for losses and spillage when mixing and filling.

It is recommended that the cells be filled with acid before installation on battery racks.

NOTE: Cells which have been filled on site must be given an initial charge as soon as possible, preferably within 24 hours of filling (see Section 6.1).

4. BATTERY ROOM REQUIREMENTS

The battery room should be dry, well ventilated and have its temperature as moderate as the climate will allow, preferably between 50°F (10°C) and 80°F (27°C).

DO NOT permit smoking or the use of open flames in the battery room.

Adequate ventilation is essential to prevent an accumulation of the gases given off during charge.

The battery will give the best results when working in a room temperature of 50°F (10°C) to 80°F (27°C), but will function satisfactorily when operating in temperatures between about 0°F (-18°C) and 125°F (52°C). High temperatures increase the performance, but decrease the life of the cells; low temperatures reduce the performance.

Do not allow direct sunlight to fall on any part of the battery.

4. BATTERY ROOM REQUIREMENTS (Continued)

If a rack is not supplied with the battery, suitable racks or shelves should be provided to support the cells. These should be arranged to provide easy access to each cell for inspection, watering and general servicing.

Suitable racks or shelves may be of wood or metal with a coating of acid resistant paint. If metal racks are used, they must be fitted with rubber, plastic or wooden insulators to prevent the cells coming into contact with the metal.

5. INSTALLATION

Make sure that all cell jars and covers are thoroughly clean and dry.

Clean the flat contact-making surfaces of the terminal posts with a soft clean rag. If there is evidence of acid having been spilled, the whole length of the posts should be wiped down with a rag which has been dipped into a non-caustic alkali solution, preferably dilute ammonia or baking soda. This will neutralize any acid on these parts. Do not allow any of this solution to get into the cells. Wipe the posts dry.

Lightly abrade the contact surfaces of the terminal posts, using a Scotchbrite pad or fine grit abrasive paper, to remove any surface oxidation. Wipe off any loose particles and cover the whole length of the post down to the cover with a thin coating of "No-Ox-Id" grease.

Batteries with cells or blocks weighing 75 lbs. or more are supplied with lifting straps. Separate instructions for the use of these items are supplied with each lifting kit.

WARNING: NEVER LIFT CELLS BY THE TERMINAL POSTS. ALWAYS USE LIFTING STRAPS, WHEN PROVIDED, TOGETHER WITH SUITABLE MECHANICAL LIFTING DEVICES, TO PREVENT INJURY TO PERSONNEL OR DAMAGE TO THE CELLS.

5. INSTALLATION (Continued)

Place the cells or blocks in position on the rack at the correct spacing which will accommodate the intercell connectors supplied. Most batteries have cells connected in a simple series arrangement, so the cells should be arranged to preserve the sequence: positive, negative, positive, negative throughout the whole battery.

For batteries on multiple section, double tier racks, start by placing cells or blocks on the lower tier on either side of the upright where the rack sections meet. Any unused rack space should be on the upper tier.

For batteries on stepped racks, leave any unused rack space on the back (top) step.

Prepare the connectors by lightly abrading the contact surfaces with a Scotchbrite pad or fine grit abrasive paper. DO NOT use a wire brush and be especially careful not to break through the lead plating.

Apply a light coating of "No-Ox-Id" grease to the contact-making areas of each connector. This is best done by carefully melting the grease and dipping connector ends (it is unnecessary to coat the central part of the connector).

Fasten the intercell and intertier connectors in place using the bolts, nuts and washers supplied. Before assembly, lightly smear "No-Ox-Id" grease on the surfaces of all hardware. Use the insulated wrenches supplied to tighten the parts firmly together. Care must be taken to avoid short circuiting the cells with any of the battery hardware.

When all the cells have been placed on the rack, fasten the intercell and intertier connectors in place using the bolts, nuts and washers supplied.

Apply an even coating of "No-Ox-Id" grease to all hardware before and after assembly. Use the insulated wrenches supplied to tighten the parts firmly together. Care must be taken to avoid short circuiting the cells with any of the battery hardware.

The recommended torque values for the connector bolts are as follows:

5. INSTALLATION (Continued)

SPR, PMF, SGL types	-	50 inch pounds
SD, SGH types	-	100 inch pounds
		100 inch pounds for terminals with single connectors
SDH types	-	150 inch pounds for terminals with double connectors

Make sure that the positive terminal of one cell is connected to the negative terminal of the next throughout the battery, leaving the main positive and negative terminals of the battery free for connection to the charging source. Take particular care to preserve the positive to negative sequence when using flexible intertier or interstep connectors between rows of cells.

Connect the positive terminal of the battery to the positive terminal of the charger and the battery negative to the charger negative.

Affix the cell number labels to the cell jars and covers making sure that the surfaces are dry and clean. It is usual to number the cells beginning with #1 at the positive end of the battery, numbering consecutively in the same order as the cells are connected electrically, through to the negative end of the battery.

6. CHARGING

6.1 INITIAL CHARGE

An initial or freshening charge must be given to all batteries before being put into service. This is particularly important for batteries which have been filled on site (see Section 3).

The preferred method, using constant voltage charges, is to charge the cells at a constant potential of 2.70 volts per cell.

After the cells have started to gas, the charge current should not be allowed to exceed the finishing rate shown in Section 10. Monitor the cell temperatures carefully and discontinue the charge if they exceed 110°F (43°C). Allow to stand on open circuit until the temperature falls to 100°F (38°C), at which point the charging process may be resumed.

6. INITIAL CHARGE (Continued)

The duration of the initial charge under the above conditions will be approximately 24 hours. For batteries which have been supplied in a filled and charged condition, a lower charge voltage (down to a minimum of 2.33 volts per cell) may be used, but this will extend the duration of the initial charge to as much as 100 hours.

The initial charge may be terminated when the specific gravity readings of all cells have remained constant for at least 2 hours.

6.2 CHARGING IN SERVICE

Most standby power batteries are charged by "float" or modified constant voltage chargers. The information in these instructions is based on this charging method. Details of battery operation from other charging sources may be obtained from MARATHON POWER TECHNOLOGIES, STANDBY BATTERY PRODUCTS.

Floating battery systems are those where the charger, the battery and the load are connected in parallel. The charger output voltage is set to a particular value and under normal conditions the applied charging voltage is maintained within very close limits.

Most float chargers have two adjustable charge voltages: the "equalize" setting (also known as "boost", "high rate" or "recharge") will restore the battery to a fully charged state within a relatively short period; the "float" setting will maintain the battery in a high state of charge with minimal water consumption.

The float voltage may be set between 2.15 and 2.25 volts per cell. The recommended setting is 2.23 volts per cell, which will maintain the battery in a fully charged state without the need for periodic equalize charges.

For float voltages between 2.23 volts per cell, periodic equalize charges should be given in accordance with the following table:

Float Voltage (per cell)	Equalizing Required At these Intervals
2.23	Never
2.20	Every 6 Months
2.17	Every 3 Months
2.15	Every Month

6.2 CHARGING IN SERVICE (Continued)

Equalizing is generally required when the total voltage spread between the cells is greater than 0.05V under float charging conditions.

Charging at the equalize setting is necessary for fast recharging after an emergency discharge. A short equalize charge is also required after addition of distilled water to make sure the acid and water are well mixed (see Section 8).

Equalizing may be carried out at voltage settings above 2.30 volts per cell. The maximum equalize voltage is generally determined by the maximum voltage which the system can tolerate. Normal values of equalize voltage are around 2.33-2.35 volts per cell.

The battery should not be subjected to a final charge current, during the gassing stage, of greater than the finishing rate shown in Section 10. This current corresponds to a charge voltage of approximately 2.7 volts per cell.

The length of equalize charging required will depend on the degree of discharge, temperature and float voltage level. The best guideline is to continue equalizing until the specific gravity of the acid in the pilot cell (see Section 8) has been constant for at least 2 hours.

7. SPECIFIC GRAVITY READINGS

When taking specific gravity readings, care must be taken to make sure that the electrolyte level in the cell to be measured is at the "MAX" line and that any distilled water added recently has been properly mixed in by equalizing for about 30 minutes.

The specific gravity of the electrolyte varies with temperature; consequently, hydrometer readings should be corrected as follows:

7. SPECIFIC GRAVITY READINGS (Continued)

For every 3°F above 77°F add 1 point (0.001 specific gravity) to the hydrometer reading.

For every 3°F below 77°F subtract 1 point (0.001 specific gravity) from the hydrometer reading.

When using a centigrade (degrees Celsius) thermometer, the equivalent correction is 1 point for every 1-1/2°C.

The specific gravity of the electrolyte in new cells should be as listed in Section 3.1. During the course of years there may be a slight fall in the maximum specific gravity values obtainable at the end of charge.

NEVER ADD ACID TO INCREASE SPECIFIC GRAVITY READINGS.

8. BATTERY CARE

8.1 GENERAL

Check the electrolyte levels in all cells regularly and if necessary top up with distilled or deionized water. Never allow the electrolyte level to fall below the "MIN" line. Do not overfill the cells. When water has been added, set the charger to "equalize" for about 30 minutes to help mix the electrolyte.

Keep the battery and surroundings clean and dry. Wipe the cells with a clean soft cloth dampened with clean water. If necessary, a small amount of mild detergent may be added to the cleaning water to remove any greasy film. Do not use scouring powders or solvents for cleaning plastic cells, as scratching or damage to the plastic could occur.

Make sure bolted connections are tight. Keep connectors, posts and bolted connections covered with "No-Ox-Id" grease for protection against corrosion.

8.1 GENERAL (Continued)

Should any corrosion of the connections occur because of spilled acid, etc., carefully remove corrosion products, thoroughly clean and neutralize with dilute ammonia or baking soda.

Dry the parts before liberally coating them with "No-Ox-Id" grease to protect from further corrosion. Do not let the neutralizing solution enter the cell.

GASES GIVEN OFF BY BATTERIES ON CHARGE ARE EXPLOSIVE!

DO NOT SMOKE OR PERMIT OPEN FLAMES NEAR BATTERIES OR DO ANYTHING TO CAUSE SPARKS.

Keep the battery at the proper charge voltage. Give the battery an equalize charge whenever necessary.

Whenever the battery is subjected to a discharge of more than 5 to 10 percent of its rate capacity, it should be recharged as soon as possible.

The room in which the battery is housed should be well ventilated and its temperature as moderate as the climate will allow. The temperature of the electrolyte should preferably never exceed 100°F (38°C).

8.2 CELL APPEARANCE

Examine all cells occasionally.

Healthy cells, when fully charged, show a marked contrast between the dark brown positive and the light gray negative plates. For cells in transparent jars (SD, SDH, SGL, SGH), it can be useful to inspect the appearance of each cell in the battery at regular intervals.

Any cells not showing a healthy plate coloration, or having a specific gravity or voltage noticeably lower than the other cells, or in which the plates gas unevenly or not at all, should be regarded as suspect. Such cells should be carefully examined for internal short-circuits, such as may be caused by small pieces of scale bridging across the plates. Such short-circuits should be removed or the cell may be ruined.

8.2 CELL APPEARANCE (Continued)

A period of charging will normally restore such cells to the condition of the remainder of the battery, but if it does not, expert advice should be obtained immediately from MARATHON POWER TECHNOLOGIES, STANDBY BATTERY PRODUCTS.

8.3 PILOT CELL

For regular monitoring of the battery condition, select one cell near the middle of the battery as a "pilot" cell (for batteries containing more than 60 cells, select one pilot cell for every 60 cells).

The electrolyte specific gravity of the pilot cell(s) will be indicative of the state of charge of the whole battery.

9. MAINTENANCE RECORDS

Written records should be kept of battery maintenance, so that long-term changes in battery condition may be monitored.

The following inspection procedures are recommended:

WEEKLY - Check and record the overall float voltage at the battery terminals (not at the charger!), and measure the pilot cell voltage.

MONTHLY - Record the battery voltage and the voltage, specific gravity and temperature of the pilot cell(s).

QUARTERLY - Record the voltage, specific gravity and temperature of all cells.

A sample maintenance record sheet is shown in the Appendix. Battery maintenance log books are available from MARATHON POWER TECHNOLOGIES, STANDBY BATTERY PRODUCTS.

It is good practice to give the battery a full discharge test at 5 year intervals until signs of degradation are observed or until the battery has reached 85 percent of its original capacity. Once this stage has been reached, yearly capacity tests should be conducted until the battery reaches the end of its useful life. See IEEE Standard 450-1980 for recommendations concerning test procedures and battery replacement criteria.

10. CELL DATA

10.1 PLANTE

Cell Type	Finishing Rate (amps)	Nominal Capacity (amp hrs.)	ELECTROLYTE Weight (lb)	Weight (kg)	Volume (gal)	Volume (lit)
SGL7	3.3	84	15	6.8	1.5	5.6
SGL9	4.4	112	14	6.3	1.4	5.2
SGL13	6.6	168	13	5.9	1.3	4.9
SGL17	8.7	224	21	9.5	2.1	7.9
SGL21	11	280	20	9.1	2.0	7.5
SGL29	15	392	30	14	3.1	12
SGL33	17	448	29	13	2.9	11
SGL25	13	336	32	14	3.2	12
SGH11	23	577	77	35	7.7	29
SGH13	27	692	73	33	7.1	27
SGH15	31	807	71	32	7.0	26
SGH17	36	923	68	31	6.8	26
SGH19	40	1038	66	30	6.6	25
SGH21	45	1153	90	41	9.0	34
SGH23	49	1269	88	40	8.7	33
SGH25	54	1384	86	39	8.5	32
SGH27	59	1500	115	52	11.4	43
SGH29	63	1615	113	52	11.1	42
SGH31	67	1730	110	50	10.8	41
SGH33	72	1845	108	49	10.6	40
SGH35	76	1960	137	62	13.5	51
SGH37	81	2077	135	61	13.3	50
SGH39	85	2192	132	60	13.1	50
SGH41	90	2307	130	59	12.9	49
SGH43	94	2421	143	65	14.3	54
SGH45	99	2537	141	64	14.0	53

10.2 LEAD SELENIUM (SD/SDH)

Cell Type	Finishing Rate (amps)	Nominal Capacity (amp hrs.)	ELECTROLYTE Weight (lb)	Weight (kg)	Volume (gal)	Volume (lit)
SD5	4	80	12	5.3	1.1	4.3
SD7	6	120	11	5.0	1.1	4.0
SD9	8	160	14	6.2	1.3	4.9
SD11	10	200	13	6.0	1.3	4.8
SD13	12	240	17	7.5	1.6	6.0
SD15	14	280	16	7.3	1.5	5.9
SD17	16	320	22	10.0	2.1	8.0
SD19	18	360	22	9.8	2.1	7.9
SD21	20	400	21	9.8	2.1	7.9
SD23	22	440	20	9.2	1.9	7.3
SDH13	24	480	30	14	2.9	11.0
SDH15	28	560	30	14	2.9	10.8
SDH17	32	640	42	19	4.0	15.2
SDH19	36	720	41	18	3.9	14.7
SDH21	40	800	39	18	3.8	14.2
SDH23	44	880	50	23	4.8	18.1
SDH25	48	960	48	22	4.6	17.6
SDH27	52	1040	47	21	4.5	17.1
SDH29	56	1120	58	26	5.5	20.9
SDH31	60	1200	56	26	5.4	20.5
SDH33	64	1280	55	25	5.3	20.0
SDH35	68	1360	54	24	5.2	19.6
SDH37	72	1440	92	42	8.9	33.6
SDH39	76	1520	91	41	8.7	33.1
SDH41	80	1600	90	41	8.6	32.6
SDH43	84	1680	88	40	8.5	32.1
SDH45	88	1760	87	39	8.3	31.6
SDH47	92	1840	86	39	8.2	31.1
SDH49	96	1920	84	38	8.1	30.6

10.3 UPS SERIES

Cell Type	Finishing Rate (amps)	Nominal Capacity (amp hrs.)	ELECTROLYTE Weight (lb)	Weight (kg)	Volume (gal)	Volume (lit)
SPR2	6	136	15	6.9	1.4	5.4
SPR3	9	204	13	5.8	1.2	4.6
SPR4	12	272	11	4.8	1.0	3.8
SPR5	15	340	18	8.0	1.7	6.3
SPR6	18	408	15	7.0	1.5	5.5
SPR7	21	476	23	10.5	2.2	8.3
SPR8	24	544	21	9.5	2.0	7.5
SPR9	27	612	19	8.5	1.8	6.7
SPR10	30	680	29	13.2	2.8	10.4
SPR11	33	748	28	12.6	2.6	9.9
SPR12	36	816	25	11.4	2.4	9.0
SPR13	39	884	26	12.4	2.6	9.8

10.4 TUBULAR PLATE MONOBLOCS

Cell Type	Finishing Rate (amps)	Nominal Capacity (amp hrs.)	ELECTROLYTE Weight (lb)	Weight (kg)	Volume (gal)	Volume (lit)
12PMF25	1.3	25	15	7.0	1.5	5.6
12PMF50	2.5	50	14	6.5	1.4	5.2
12PMF75	3.8	75	26	12.0	2.6	9.7
12PMF100	5.0	100	26	12.0	2.6	9.7
12PMF125	6.3	125	32	14.5	3.1	11.7
12PMF150	7.5	14[illegible]	31	14.0	3.0	11.3
6PMF200	8.8	192	35	16.0	3.4	12.9
6PMF250	10.0	240	35	16.0	3.4	12.9
6PMF300	11.3	288	31	14.0	3.0	11.3

Further information on lead acid batteries (Plante, lead selenium, low antimony and tubular types), nickel cadmium batteries and battery chargers may be obtained from:

MARATHON POWER TECHNOLOGIES
STANDBY BATTERY PRODUCTS
8301 Imperial Drive
Waco, Texas 76710

Phone: (817) 776-0650
TWX: 910-894-5203
Fax: (817) 776-6558

Marathon Power Technologies

QUARTERLY BATTERY MAINTENANCE REPORT

Period:_____ to _____, 19____

Battery Location:_____

Battery Type:_____ cells, type _____

Pilot Cell No.:_____ Are gravity readings temperature corrected? YES/NO

Weekly/Monthly Readings				
Date	Batt. Volts	Pilot Cell Volts	Pilot Cell Temp.	Pilot Cell Sp. Gr.

NOTE: Equalize battery for 30 min. after water addition. Do not take readings until battery has stabilized on float charge.

Water Added: Date_____, Qty_____
Date_____, Qty_____

Battery Discharged:

Date_____, Duration_____
Date_____, Duration_____

Battery Equalized:

Date_____, Duration_____
Date_____, Duration_____

Remarks:_____

_____

_____

Readings taken by:_____

Individual Cell Readings (to be recorded quarterly)

Date:_____, 19____

Time:_____ A.M./P.M.

Battery Voltage:_____V

Charge Current:_____A

Cell	Sp.Gr.	Volts	Cell	Sp.Gr.	Volts
1			31		
2			32		
3			33		
4			34		
5			35		
6			36		
7			37		
8			38		
9			39		
10			40		
11			41		
12			42		
13			43		
14			44		
15			45		
16			46		
17			47		
18			48		
19			49		
20			50		
21			51		
22			52		
23			53		
24			54		
25			55		
26			56		
27			57		
28			58		
29			59		
30			60		

Cell temps.:#1_____,#12_____,#24_____,
#36_____,#48_____,#60_____

APPENDIX F

MC-8 PROGRAMMABLE LOGIC CONTROLLER PLC-1

1.1 MECA SYSTEM

The MECA System is comprised of components specified for industrial applications and environments and has FCC Class A approval.

PM-1	Power Module	AI-4	Analog Input
MB-1	Motherboard	LI-1	Logic Input
MB-2	Motherboard	SC-1	Switch Closure Input
CB-1	Computer base	SC-3	Switch Closure Input
CB-2	Computer base	DI-1	Digital Input
MC-2	Microcomputer	DO-1	Digital Output
MC-4	Microcomputer	DO-2	Digital Output
MC-8	Microcomputer	LD-1	Load Driver Output
MX	Multiplexer	AO-1	Analog Output
MX-1	Multiplexer	LO-1	Logic Output
MX-2	Multiplexer		

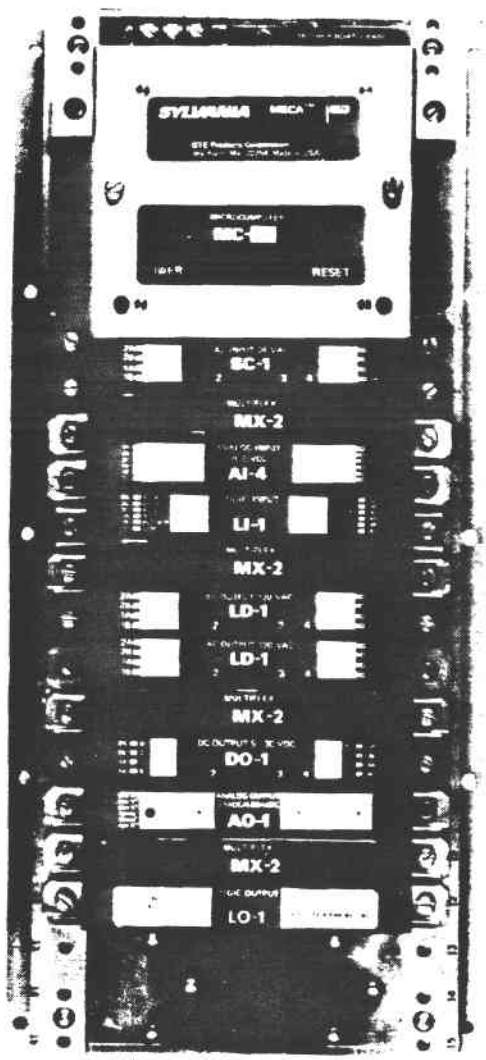


FIGURE 1-1: MECA SYSTEM

1.1.2 MOTHERBOARDS (MB-1 and ML-2)

The MB-1 Motherboard interfaces with the CB-1 or CB-2 computer base and Input/Output modules. It has terminals marked A, B and C for the power connections from the PM-1 MECA power module using the WH-3 cable. The MB-1 provides 15 module recepatcles numbered 1 through 15. Ten Input/Output modules may be used in any combination or motherboard position. Positions 2, 5, 8, 11 and 14 on the MB-1 are mounted off-center and are reserved for use by the multiplex modules. The other positions are for use by the Input/Output modules.

An MB-2 motherboard can be provided for system expansion. The MB-2 includes a pre-wired communication cable and connector that can be attached to the MB-1. Connection of the MB-2 is accomplished by removing two screws (located at each end of one side of an empty MB-1) and sliding the rail and hardboard to one side. Place the connector cable onto the cable cutout on the end of the MB-1 motherboard and plug the connector onto the PC card. Replace the side rail and hardboard and secure in place using the two screws.

NOTE: ATTACHMENT OF CONNECTOR WITH KEY INSERTED IN KEYWAY WILL ASSURE PROPER CONNECTION.

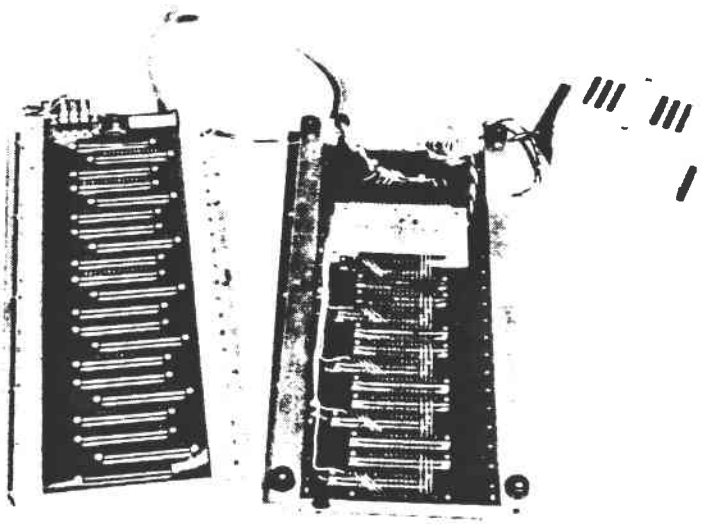


FIGURE 1-4: UNOCCUPIED MOTHERBOARD

MB-1 and MB-2

SPECIFICATIONS

Capacity:

* MB-1:

  1 Computer Base
  1 Microcomputer
  5 Multiplex Modules
 10 Input/Output Modules

* MB-2:

  7 Multiplex Modules
 14 Input/Output Modules

Electrical (MB-1/MB-2):

* FCC Class A Approval

* 3 connections (A, B and C) for PM-1 24 VAC center-tapped power supply

* MB-2 includes interface cable to MB-1

Environmental:

* Ambient Temperature (operation): - 20 °C to + 70 °C (-4 °F to + 158 °F)

* Ambient Temperature (storage): - 20 °C to + 85 °C (-4 °F to + 185 °F)

* Humidity: 20% to 90% non-condensing

Approximate Dimensions and Weight:

* 7-7/8" x 1" x 17/1/4" (W x H x D)
  (19.9cm x 2.5cm x 43.8cm)

* Mounting Hole Diameter: 0.218 inches

* 1.92 kilograms (4.23 pounds)

Mounting:

The side rails of the MB-1/MB-2 motherboards are specifically designed for maximum heat transfer. To ensure proper heat transfer, it is recommended that <u>all</u> mounting hole positions be utilized. The mounting holes accept #10 screws. See Application Note E 001.

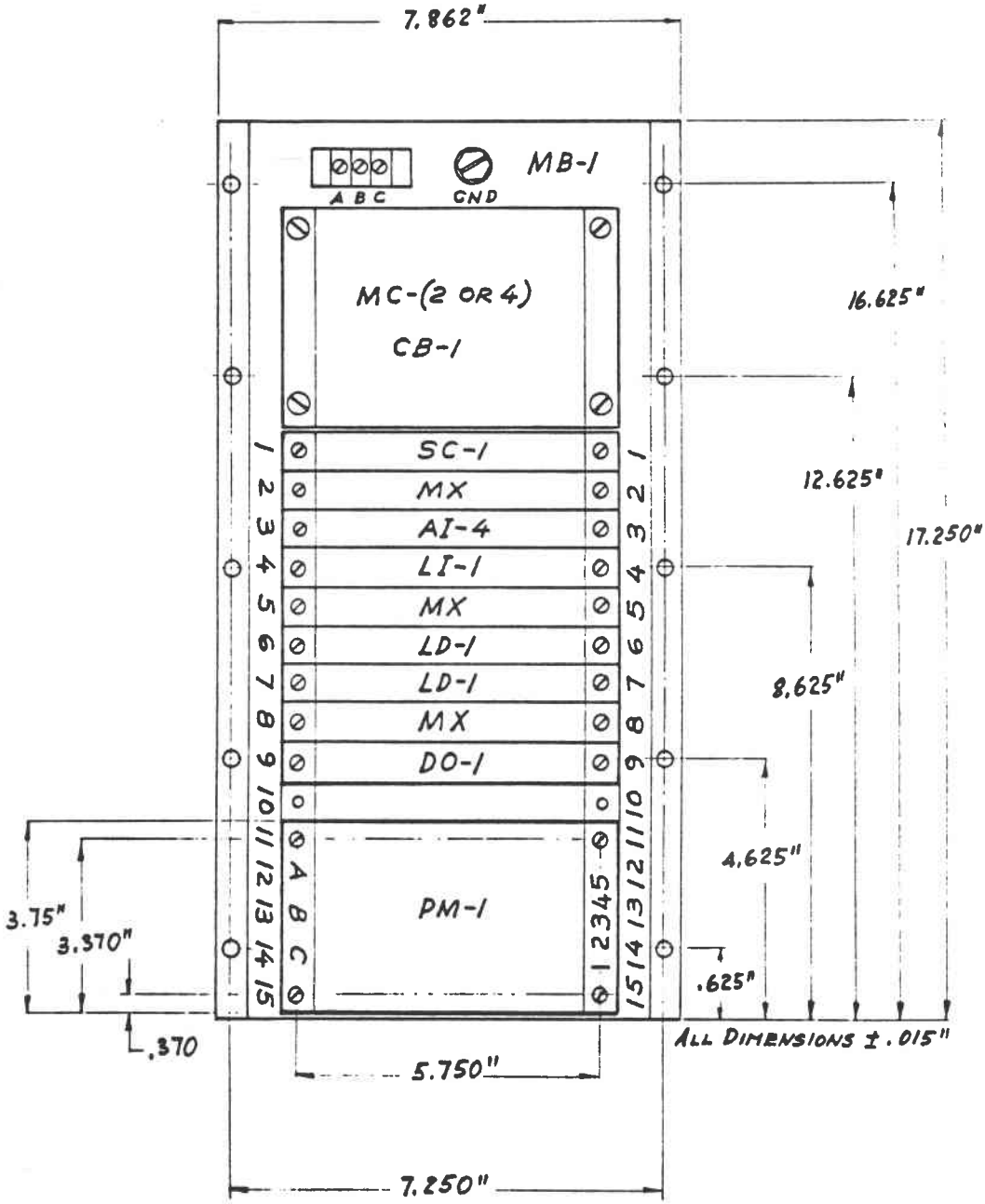


FIGURE 1-6: MECA MOUNTING DIMENSIONS

1.1.2 MOTHERBOARDS (MB-1 and MB-2) (CONT'D)

All of the modules which plug into the motherboard, except for the multiplex modules, are keyed; there is a keying slot in the printed circuit board connector between contacts. Each type of module has a different keying slot position. In addition, there is provision for putting a keying plug into a keyway of the motherboard connector -- this will make it possible to restrict a motherboard position for use by only one type of module. Refer to table 1-1. Keys (KE-15 for MB-1; KE-21 for MB-2) are supplied with each motherboard.

TABLE 1-1

I/O Module Key Positions

MODULE	KEY POSITION
MB-2	16-17 (Connector)
MX	No Key Required
MX-1	No Key Required
MX-2	No Key Required
AI-4	6-7
LI-1	4-5
SC-1	1-2, 5-6
SC-3	5-6
DI-1	9-10
DO-1	8-9
DO-2	1-2, 10-11
LD-1	7-8
AO-1	1-2, 12-13
LO-1	1-2, 13-14

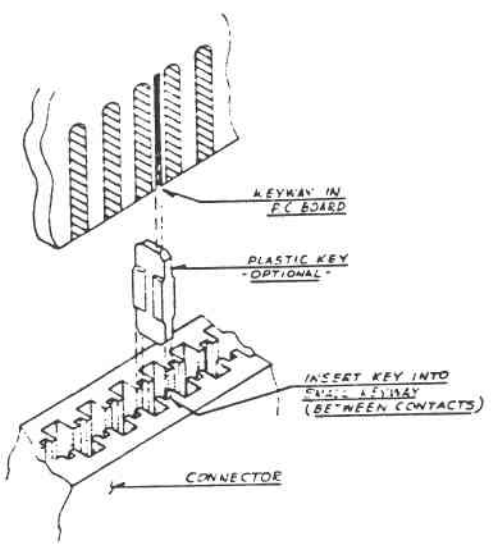


FIGURE 1-5: RECEPTACLE KEY

1.1.3 COMPUTER BASE (CB-1 and CB-2)

There are two types of **Computer Base Modules** available; the **CB-1** and the **CB-2.**

The **CB-1 Computer Base** is the original CB design and is the the mounting receptacle for the Microcomputer (MC-2 or MC-4) and has a fixed position on the MB-1 Motherboard. There are four (4) screws provided to mount the CB-1 securely to the motherboard heat sink frame.

The **CB-2 Computer Base** is an improved design with more current handling capability and **MUST be used with the MC-8 Microcomputer module.** The MC-2 and the MC-4 can be used with the CB-2 and will operate cooler because of the increased heat sink capability of the CB-2.

Both the CB-1 and the CB-2 provide terminals for the 20 milliamp current loop and battery backup. A 12-volt battery may be used to retain the RAM memory within the MECA system. Refer to application notes E 002 and E 003.

The 20 mA current loop cable (WH-1) must be connected with care to ensure that the red wire of the red/black pair is connected to the T+ (transmitter) terminal and the black wire to the T- terminal. The white wire of the white/black pair is attached to the R+ (receiver) terminal and the black wire to the R- terminal. T+ and T- are the top pair of terminals on both CB modules. The 20 mA current loop communication port is passive and requires an external current source to operate.

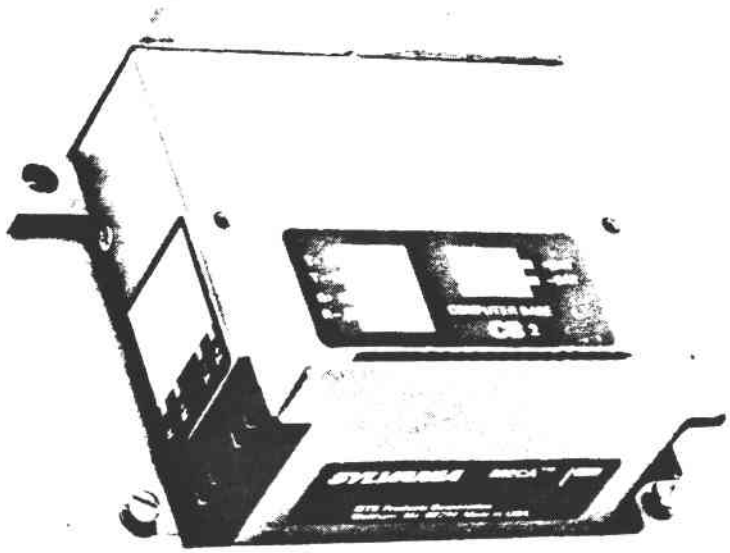


FIGURE 1-7: CB-2 COMPUTER BASE

CB-1/CB-2
SPECIFICATIONS

Communication:

* 20 mA Current Loop (Current Source must be provided)

* Transmitter: 40V, 300 mA maximum at 25°C, 1.5V maximum voltage drop

* Receiver: 3.5V, 85 mA maximum at 25°C

Electrical:

CB-1	CB-2
* Conforms to NEMA Noise Test, (NEMA #ICS2-230)	* SAME
* FCC Class A approval	* SAME
* Battery Back-up: 12VDC 200 mA Nominal, 400 mA Max.	* Battery Back-up: 12VDC 400 mA Nominal, 625 mA Max.
* Optical Isolation, 2500V	* SAME

Environmental:

* Ambient Temperature (operation): - 20 °C to + 70 °C (-4 °F to + 158 °F)

* Ambient Temperature (storage): - 20 °C to + 85 °C (-4 °F to + 185 °F)

* Humidity: 20% to 90% non-condensing

Wiring:

* Quick disconnect blades for terminal connections 0.187" x 0.031"

Appropriate Dimensions and Weight:

6-3/4" x 2-7/8" x 4-1/2" (W x H x D)
(17.1cm x 7.1cm x 11.4cm)

CB-1: 1.01 lb. (.458 Kg)
CB-2: 1.15 lb. (.524 Kg)

Mounting:

This module is designed for mounting on the MB-1 Mother Board using four #8 screws. The screws should be tightened securely to ensure good thermal transfer.

1.1.4.1 MICROCOMPUTER MODULE (MC-8)

The MC-8 Microcomputer Module consumes the same volume and space as its forerunners, the MC-2 and MC-4, but offers many additional features and product improvements:

- o Improved performance
- o Faster execution speed
- o More user memory (8k bytes)
- o Up to 249 Single Byte variables, in 8031 RAM memory, for use as: Array Elements, A(1) - A(255)
  Single Byte Variables or
  Double Byte Variable (WORD)
  Variable designations are A-Z, A0-A9 thru Z0-Z9
- o Added high level language features
- o 16 independent concurrent timers, timing in milliseconds, running independent of control program
- o Supports A0-1 and L0-1 I/O modules
- o Concurrent Input and Output communication during program execution
- o Switch Select: MX, MX-1, or MX-2
- o Switch Select: Baud Rate (1200 or 9600 bps)
- o Switch Select: Full Duplex or Half Duplex Communication

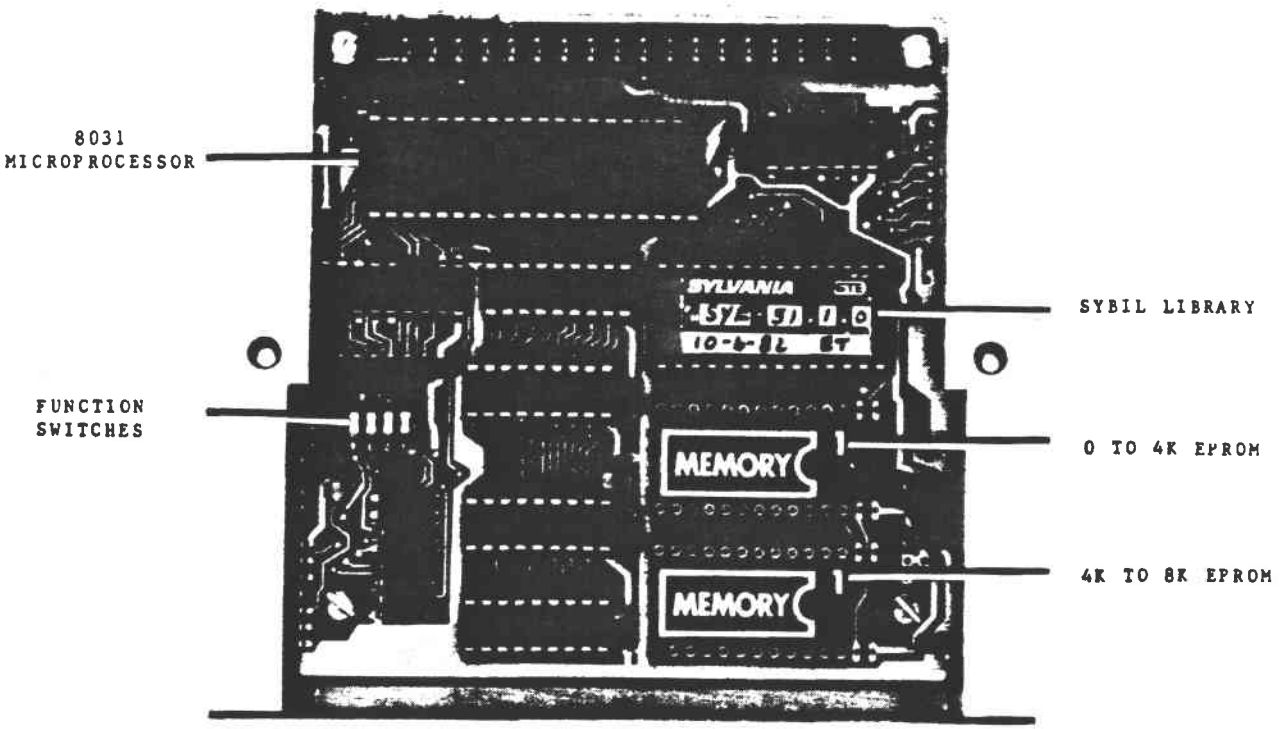


FIGURE 1-9A: MC-8 MICROCOMPUTER MODULE

The Central Processing Unit (CPU) is an Intel* Series MCS-51(R), type 8031; a control-oriented CPU with RAM and I/O. It's enhanced architecture offers:

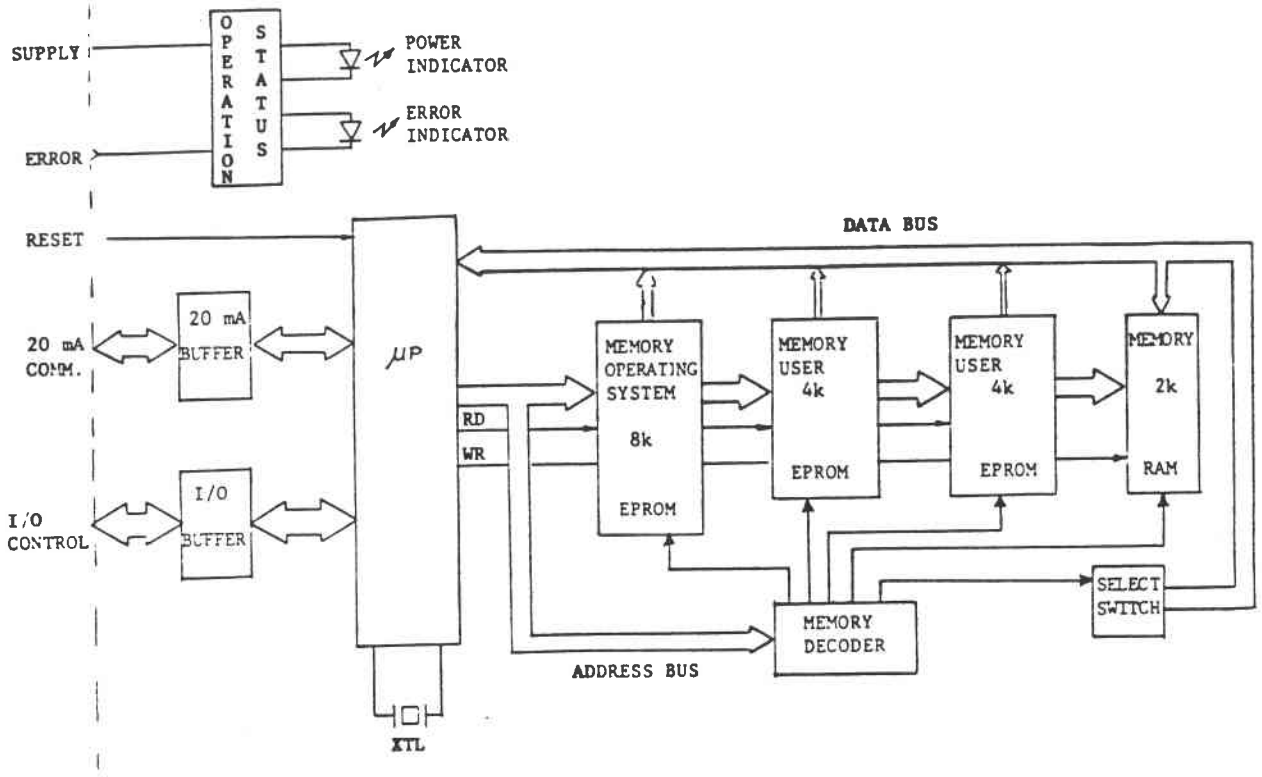


FIGURE 1-9B: MC-8 BLOCK DIAGRAM

* Intel series MCS-51(R) is a trade mark of Intel Corporation.

The MC-8 contains the **SYBIL Executive Library** on a non-volatile **EPROM, Type 2764** (Erasable Programmable Read Only Memory) and two **User EPROMS, Type 2732A**, offering up to an **8K Non-volatile Memory** (8192 bytes). It is programmed in **SYBIL** (SYlvania Basic Industrial Language); a high-level programming language that allows development of control programs in an easy to understand, English-like language.

The **Library EPROM, Type 2764**, with its larger memory will allow control of additional I/O module types (i.e., LO-1, AO-1, etc.).

Two **User EPROMs, Type 2732A**, offer a total of 8k non-volatile memory space and are programmed in SYBIL using the PG-2E Desk-Top Computer Programming System or the PPS-1 Portable Programming System.

Both computer systems are controlled by the popular **CP/M(R) (Control Program for Microcomputers)** operating system, which requires 64K RAM memory. **SYBIL Version 5.0 and 6.0** are CP/M compatible, program development software support packages that allow the user to enter, edit, compile and debug control applications in an efficient manner.

MC-8 DIP SWITCH SETTINGS

	OFF	ON
SW1	MX OR MX-1	MX-2
SW2	1200 BAUD	9600 BAUD
SW3	FULL DUPLEX	HALF DUPLEX
SW4	NOT USED	NOT USED

Communication with the MC-8, via the 20 mA current loop requires the following data format:

BAUD RATE	SELECTABLE
PARITY	ODD
START BIT	1
DATA BITS	7
STOP BITS	1
COMMUNICATION	SELECTABLE

MC-8 SPECIFICATIONS

General:

* Intel 8031 CPU
* Intel 2764 - 8K Byte Executive Library
* Intel 2732A - Two 4K Byte User EPROM's
* 11 MHz Processor Clock
* Switch selectable baud rate of 20 mA communication port
* Switch Selectable Multiplexers
* Switch Selectable Communication
* Real-Time Clock

Electrical:

* FCC Class A approval
* Noise Test, NEMA part #ICS2-230
* Status Indicator LEDs for Power and Reset
* Switch Selectable Multiplexers (MX, MX-1 or MX-2)
* Switch Selectable Baud Rate (1,200 or 9,600 bps)
* Switch Selectable Communication (Full or Half Duplex)
* **To be used with CB-2 only**

Environmental:

* Ambient Temperature (operating): 0 °C to 60 °C
  32 °F to 140 °F
* Ambient Temperature (storage): - 20 °C to 85 °C
  - 4 °F to 185 °F
* Humidity: 20% to 90%, non-condensing

Approximate Dimensions and Weight:

* 4-15/16" x 1" x 4-1/2" (W x H x D)
  (12.5cm x 2.54cm x 11.4cm)
* .43 pounds (.195 kg)

Mounting:

* 2 captive screws. Placed on top of CB-2 module.

1.1.5 Multiplex Modules (MX, MX-1, MX-2)

One Multiplex module is required for each pair of Input/Output modules. It provides control for eight (8) I/O points (2 I/O modules). The motherboard receptacle for the multiplex module is off-center to prevent accidental insertion. A multiplex module is necessary if an Input/Output module is plugged into an adjacent Input/Output receptacle. No wiring is required for the MX module.

There are three (3) multiplex modules available:

- **MX Module** was the original multiplex design which will not reset automatically at a power failure or brown-out. The power to the MECA System must be turned OFF for a moment to reset the total system.

- **MX-1 Module** is an improved MX module which provides automatic power reset, besides all other MX design features. It can be used on MECA Systems with the MC-2, MC-4 or MC-8 microcomputers if the MX selector switch on the MC-8 is set properly.

- **MX-2 Module** is a banked multiplexer design which operates at twice the speed of the MX-1 and has automatic power reset. **It must be used ONLY on MC-8-driven systems.**

NOTE: ONLY ONE TYPE OF MULTIPLEX MODULE CAN BE USED PER SYSTEM. DO NOT MIX MULTIPLEX MODULES.

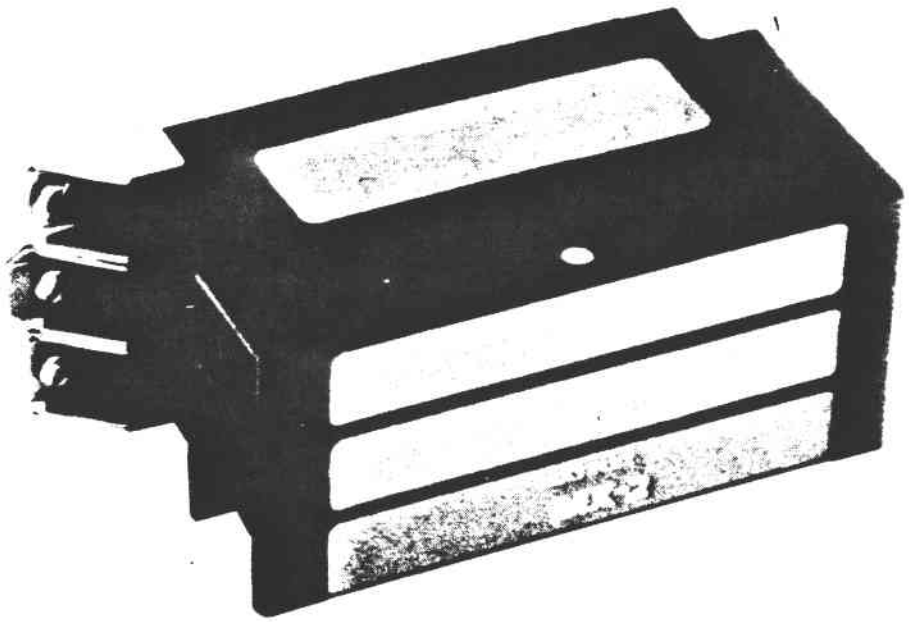


FIGURE 1-10: MULTIPLEX MODULES

MX, MX-1, MX-2

SPECIFICATIONS

Electrical:

* FCC Class A approval
* Noise Test: NEMA part ICS2-230

Environmental:

* Ambient Temperature (operating):

  - 20 °C to + 70 ° C (- 4 °F to + 158 °F)

* Ambient Temperature (storage):

  - 20 °C to + 85 °C (- 4 °F to + 185 °F)

* Humidity: 20% to 90% non-condensing

Approximate Dimensions and Weight:

* 6-1/2" x 3-1/4" x 3/4" (W x H x D)
  (16.5cm x 8.3cm x 1.9cm)
* .137 kilograms (.30 pounds)

Mounting:

This module is designed for mounting on the MB-1 and MB-2. A card edge on the bottom of the module provides the electrical connections. Two #8 captive screws secure the module to the MB-1 and MB-2. The screws should be tightened securely to ensure good thermal transfer.

1.1.6 INPUT MODULES

* AI-4 Analog Input (0 to +5 VDC)
* LI-1 Logic Input (TTL compatible)
* SC-1 Switch Closure Input (24 VAC)
* SC-3 Switch Closure Input (120 VAC)
* DI-1 Digital Input (5 to 30 VDC)

A variety of input modules are described below. These input modules can be placed in any I/O receptacle on either the MB-1 or MB-2 motherboard. In order to avoid improper operation, it is important to connect the input modules correctly to the operating equipment. It is good practice to keep the wire harness of all inputs separated from high-current-carrying power line installations.

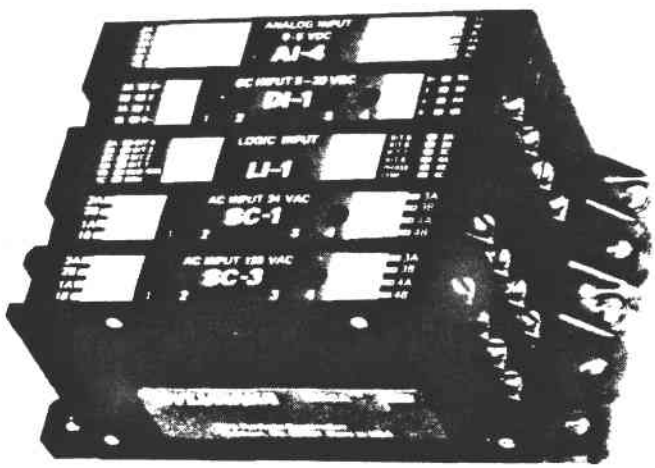


FIGURE 1-11: INPUT MODULES

Siemens-Allis Automation, Inc.
P.O. Box 9128
Waltham, MA 02254
(617) 466-3430

PRODUCT BULLETIN P-38
12 BIT ANALOG INPUT MODULES

Models AI-1/AI-2

General

The AI-1 and AI-2 are analog input modules with two 12 bit input channels, each. They are designed for precise measurement of analog signals from transducers or other voltage or current sources.

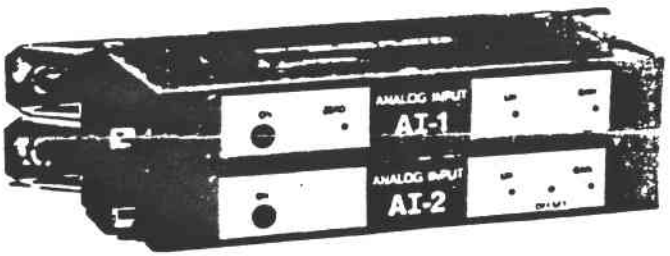


FIGURE 1:
12 BIT ANALOG INPUT MODULES

Features

- o Full 12 bit resolution
- o High speed (<200uSec A/D hardware conversion time)
- o 0.1% absolute accuracy
- o User selectable current/ voltage ranges:

  AI-1: 0 to 20mA
  0 to 5 volts
  0 to 10 volts

  AI-2: 4 to 20mA
  1 to 5 volts

- o Two channels per module for optimum utilization.
- o Optically isolated inputs

Description

The top of the AI-1(AI-2) module has an LED to indicate external power, and three potentiometers for calibration. A DA-15 connector on the side is used to interface the analog input signals, the external power supplies and the range/ mode select jumpers.

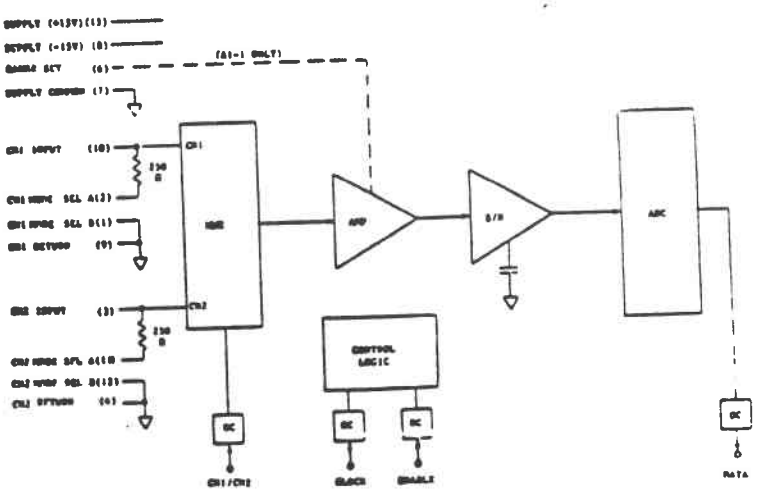


FIGURE 2:
AI-1/AI-2 BLOCK DIAGRAM

SPECIFICATIONS
12 BIT ANALOG INPUT MODULES
AI-1/AI-2

General

- o 12 bit resolution, 4096 increments (0-4095).
- o Two input channels/module (single-ended).
- o Refer to ECO Application Manual for installation, calibration, programming, etc.

Electrical

- o Input ranges (each channel can be programmed independently except 0 to 10V):

  AI-1: 0 to 20mA
  0 to 5V
  0 to 10V (both channels)
  AI-2: 4 to 20mA
  1 to 5V

- o Input impedance:
  >100 megohms (voltage mode)
  250 ohms (current mode)
- o Overvoltage protection:
  ±35VDC (power ON)
  ±25VDC (power OFF)
- o Overcurrent protection:
  ±28mA
- o Conversion time: <200uSec/channel
- o Drift (0°C to 60°C):
  ±45 ppm/°C
- o Absolute accuracy at 25°C
  ±0.1% FS ±1/2 LSB
  (Including linearity, gain, and offset errors)
- o Optical isolation:
  1500V RMS
- o External power supplies:
  +15VDC ±3% @ 70mA
  -15VDC ±3% @ 70mA
  Ripple < 3mV pp.

ENVIRONMENTAL

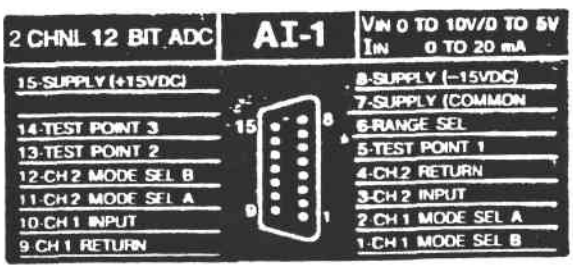
- o Operating temp. (ambient):
  0°C to +60°C
  (32°F to 140°F)
- o Storage temp. (ambient):
  -20°C to 85°C
  (-4°F to 185°F)
- o Humidity: 5% to 95%, noncondensing

APPROXIMATE DIMENSIONS AND WEIGHT:

- o 6-1/2 x 3-1/4 x 3/4in (WxHxD)
  (16.5 x 8.3 x 1.9cm)
- o 0.37lb (0.17kg)

MOUNTING

This module is designed for mounting on all ECO Mother Boards. A card edge on the bottom of the module provides the electrical connections. Two slots in the card edge allow keying for module position assignment. (Slots are located between terminals as follows: AI-1 2,3 and 11,12
AI-2 2,3 and 12,13
Two #8 screws secure the module to the Mother Boards. The screws should be tightened securely to ensure good thermal transfer.



*"6-SUPPLY COMMON" on AI-2

FIGURE 3:
DA-15 CONNECTOR PINOUT

	CHNL1 / CHNL2	J2-1 to J2-2	J2-11 to J2-12	J2-6 to J2-7
AI-1	0-10V / 0-10V	OPEN	OPEN	OPEN
AI-1	0-5V / 0-5V	OPEN	OPEN	SHORT
AI-2	1-5V / 1-5V	OPEN	OPEN	SHORT
AI-1	0-5V / 0-20mA	OPEN	SHORT	SHORT
AI-2	1-5V / 4-20mA	OPEN	SHORT	SHORT
AI-1	0-20mA / 0-5V	SHORT	OPEN	SHORT
AI-2	4-20mA / 1-5V	SHORT	OPEN	SHORT
AI-1	0-20mA / 0-20mA	SHORT	SHORT	SHORT
AI-2	4-20mA / 4-20mA	SHORT	SHORT	SHORT

Figure 3
Range/Mode Select Jumpers

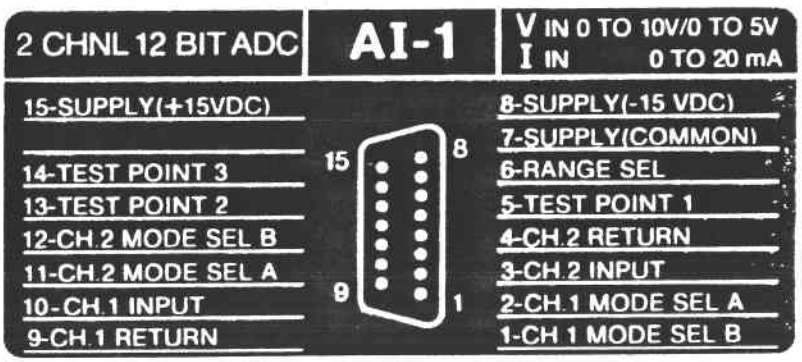


Figure 4
AI-1 Connector Pinout

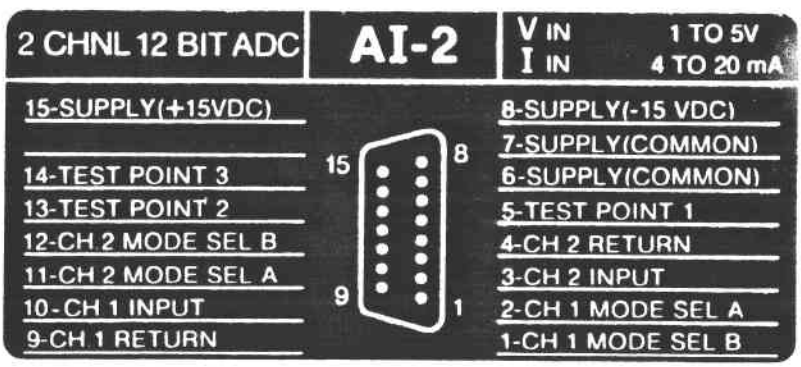
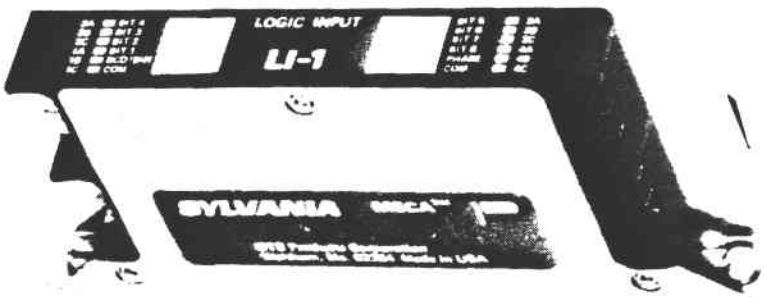


Figure 5
AI-2 Connector Pinout

1.1.6.2 LOGIC INPUT MODULE (LI-1)

The LI-1 Logic Input module is a general-purpose, 8-bit logic input module that monitors one 8-bit word. The word is interpreted as two 4-bit BCD codes, representing a number from 0 to 99.

By attaching the BCD/BIN terminal to the COM terminal, the word is interpreted as one binary code representing a number from 0 to 255. Leaving the BCD/BIN terminal open, defaults the module to the BCD mode. This module accepts inputs in the form of open collectors (or switch closures) referenced to the COM terminal with an open state representing a logic ZERO. By attaching the PHASE terminal to the COM terminal, an open state on the input represents logic ONE.



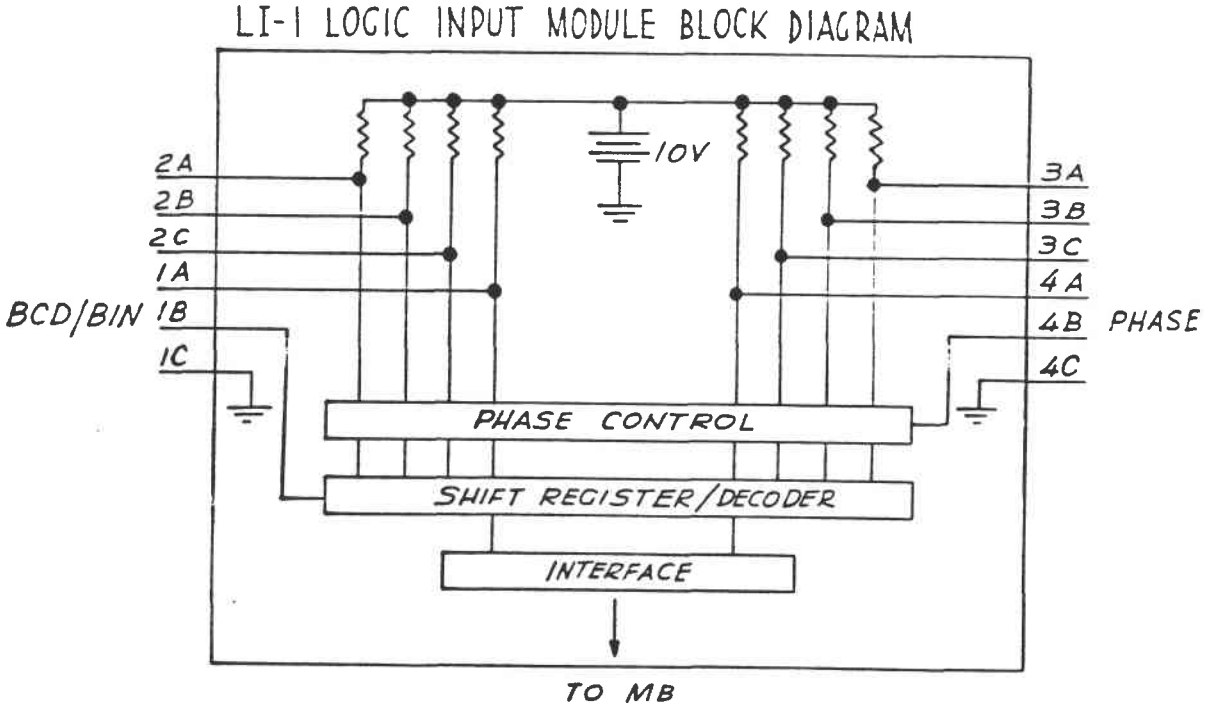
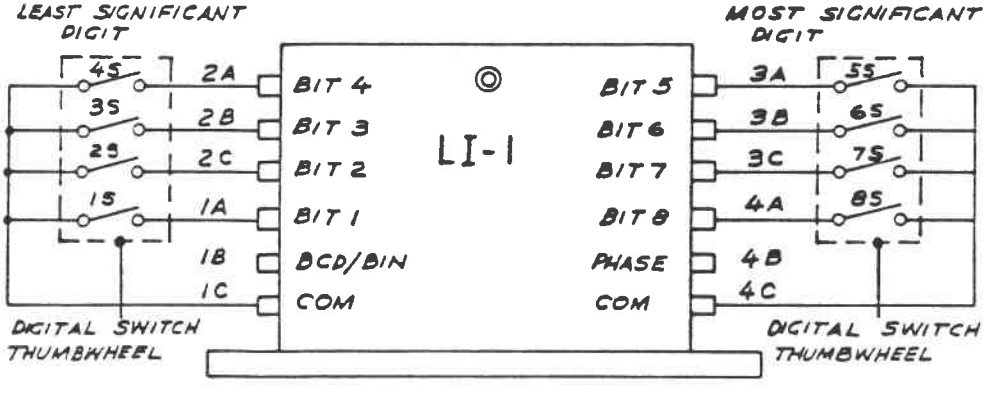


FIGURE 1-14: LI-1 LOGICAL INPUT MODULE

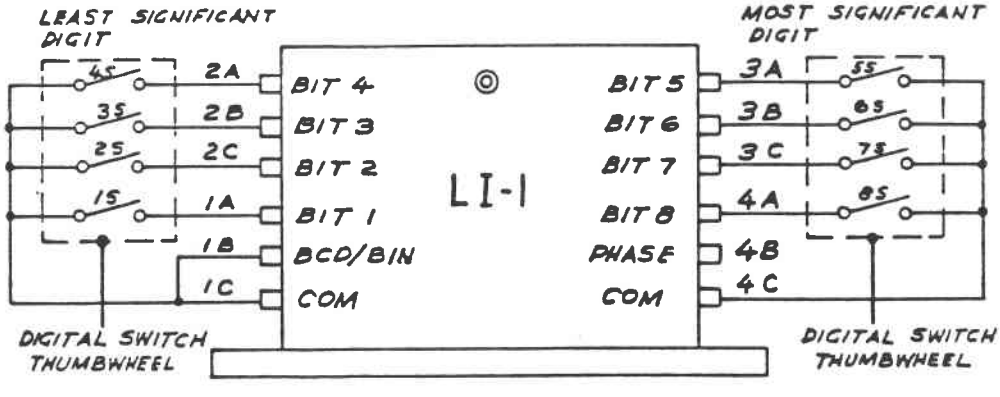
Wiring of LI-1:

This module has 0.187" x 0.031" quick-disconnect blades for terminal connections. The recommended wiring procedure is to first connect to the bottom terminal, then proceed up towards the top terminal. Typical switch closure wiring diagrams for inputs on both Binary and BCD form are shown in Figure 1-15.

CAUTION: THE COMMON ON THIS MODULE IS AN INTERNAL COMMON ONLY. WHEN CONNECTING ANY EXTERNAL COMMON AND/OR CHASSIS COMMON TO TERMINALS 1C AND 4C, CONSULT APP NOTE E 001.



BCD WIRING



BINARY WIRING

FIGURE 1-15: WIRING DIAGRAM LI-1 MODULE

LI-1

SPECIFICATIONS

Electrical:

* Negative True Logic, TTL Compatible
* Open Collector or Switch Input
* FCC Class A approval

Environmental:

* Ambient Temperature (operating):

  - 20 °C to + 70 °C (- 4 °F to + 158 °F)

* Ambient Temperature (storage):

  - 20 °C to + 85 °C (- 4 °F to + 185 °F)

* Humidity: 20% to 90% non-condensing

Approximate Dimensions and Weight:

* 6-1/2" x 3-1/4" x 3/4" (W x H x D)
  (16.5cm x 8.3cm x 1.9cm)
* .150 kilograms (.33 pounds)

Mounting:

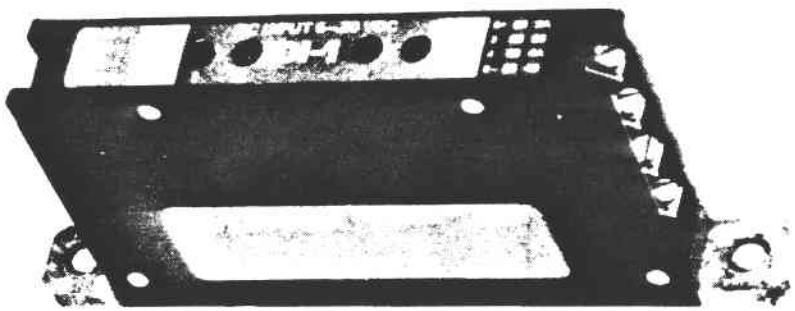
This module is designed for mounting on the MB-1 or MB-2 motherboards. A card edge on the bottom of the module provides the electrical connections. A slot in the card edge allows keying for module position assignment. Two #8 captive screws secure the module to the MB-1 or MB-2 motherboards. The screws should be tightened securely to ensure good thermal transfer.

1.1.6.4 DIGITAL INPUT MODULE (DI-1)

The DI-1 Digital Input Module has top-mounted LED status indicators and contains two independent pairs of optically isolated input circuits for sensing DC voltage. The input threshold voltage is two-thirds of the applied source during the low-to-high transition, and one-third of the applied source from the high-to-low transition.

This module sends a digital signal to the microcomputer with an input value of 0, indicating an "OPEN" switch; or a value of 1 indicating a "CLOSED" switch.

NOTE: AN EXTERNAL DC POWER SUPPLY OF 5 TO 30 VDC MUST BE PROVIDED TO OPERATE THIS MODULE. THE TERMINALS B+ AND B- (LOCATED ON EACH SIDE OF THE MODULE) ARE ISOLATED, ALLOWING THE USE OF TWO POWER SUPPLIES AT DIFFERENT VOLTAGE POTENTIALS.



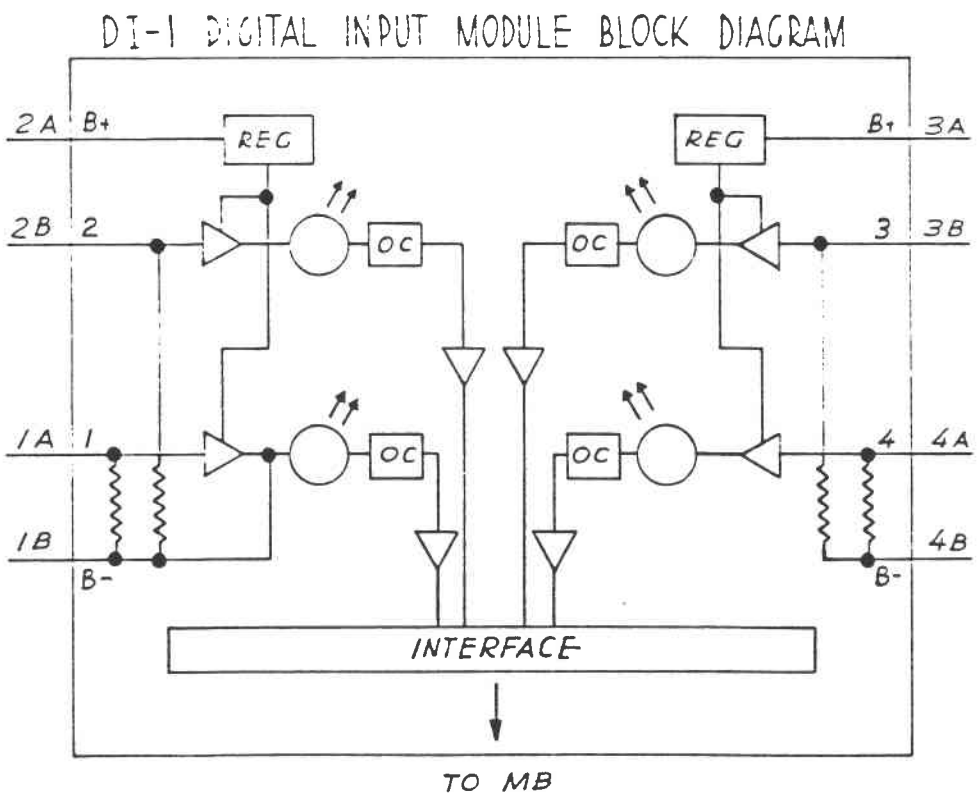
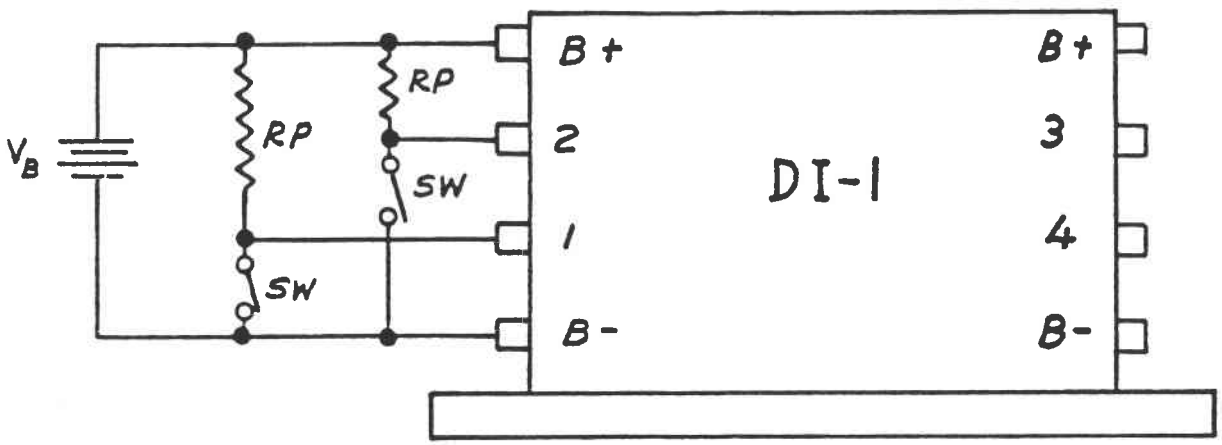


FIGURE 1-18: DIGITAL INPUT MODULE DI-1

Wiring of DI-1:

Two types of wiring connections may be made to this module. One type is a quarter-inch (.25") quick-disconnect blade. The other is a self-rising screw terminal pressure plate that will accept up to two #14 AWG copper wires. The recommended wiring procedure when using the screw terminals is to first connect to the bottom terminal, then proceed up towards the top terminal. Each side of the DI-1 module is isolated and will allow independent voltage sources.



R_p = Pull-up Resistor, which should be 10 k-ohms

FIGURE 1-19: WIRING DIAGRAM FOR DI-1 MODULE

DI-1

SPECIFICATIONS

DI-1 Input:

* 5 to 30 VDC
* 100 k-ohms input impedance
* 100 microseconds "ON" delay (maximum)
* 500 microseconds "OFF" delay (maximum)

Electrical:

* External DC supply, 5 - 30 VDC
* Optical Isolation, 2500 volts
* FCC Class A approval
* Noise Test, NEMA part ICS2-230

Environmental:

* Ambient Temperature (operating):

  - 20 °C to + 70 °C (- 4 °F to +158 °F)

* Ambient Temperature (storage):

  - 20 °C to + 85 °C (- 4 °F to + 185 °F)

* Humidity: 20% to 90% non-condensing

Approximate Dimensions and Weight:

* 6-1/2" x 3-1/4" x 3/4" (W x H x D)
  (16.5cm x 8.3cm x 1.9cm)
* .205 kilograms (.45 pounds)

Mounting:

This module is designed for mounting on the MB-1 or MB-2 motherboards. A card edge on the bottom of the module provides the electrical connections. A slot in the card edge allows keying for module position and assignment. Two #8 screws secure the module to the MB-1 or MB-2 motherboards. The screws should be tightened securely to ensure good thermal transfer.

1.1.7 OUTPUT MODULES

* DO-1 Digital Output (5 to 30 VDC)
* DO-2 Digital Output (10 to 50 VDC)
* LD-1 Load Driver Output (18 to 132 VAC)
* AO-1 Analog Output (0 to 5 VDC and 4-20 mA)
* LO-1 Logic Output Module (TTL compatible)

The DC and AC modules described in this section may be placed in any receptacle on the MB-1 or MB-2 Motherboards. It is good practice to keep the wire harness separated from high current power lines of the operating equipment.

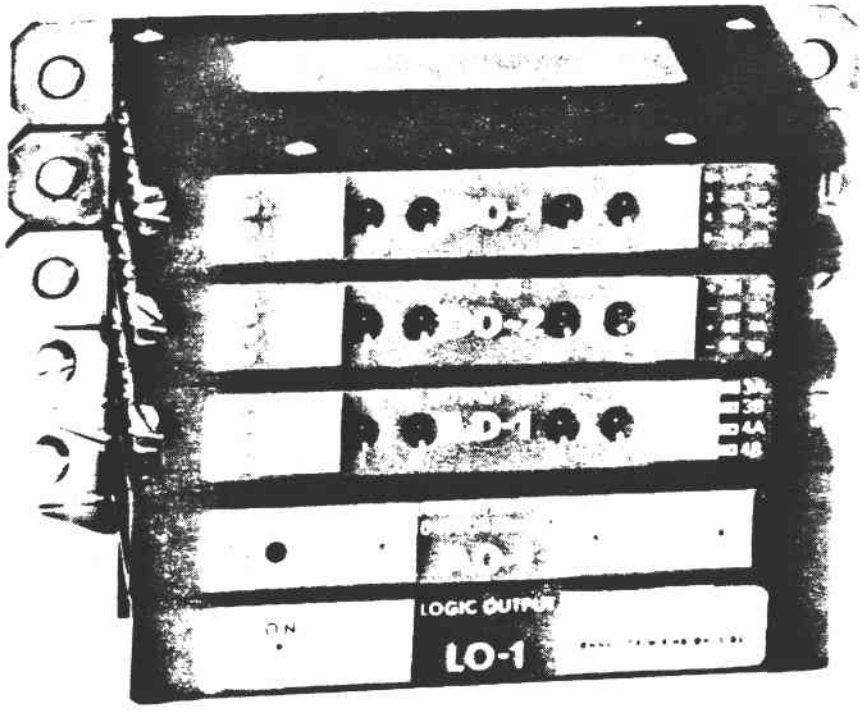


FIGURE 1-20: OUTPUT MODULES

1.1.7.2 DIGITAL OUTPUT MODULE (DO-2)

The DO-2 Output Module contains four independent, optically isolated, high power DC, solid-state switches. It has four top-mounted LED status indicators, one per switch. Contacts are normally open. Typical uses are switching DC or full-wave rectified AC for inductive or resistive loads.

NOTE: An external DC power source of 10 to 50 volts DC must be provided to operate this module. The four circuits are isolated from each other, allowing the use of power sources at different potentials.

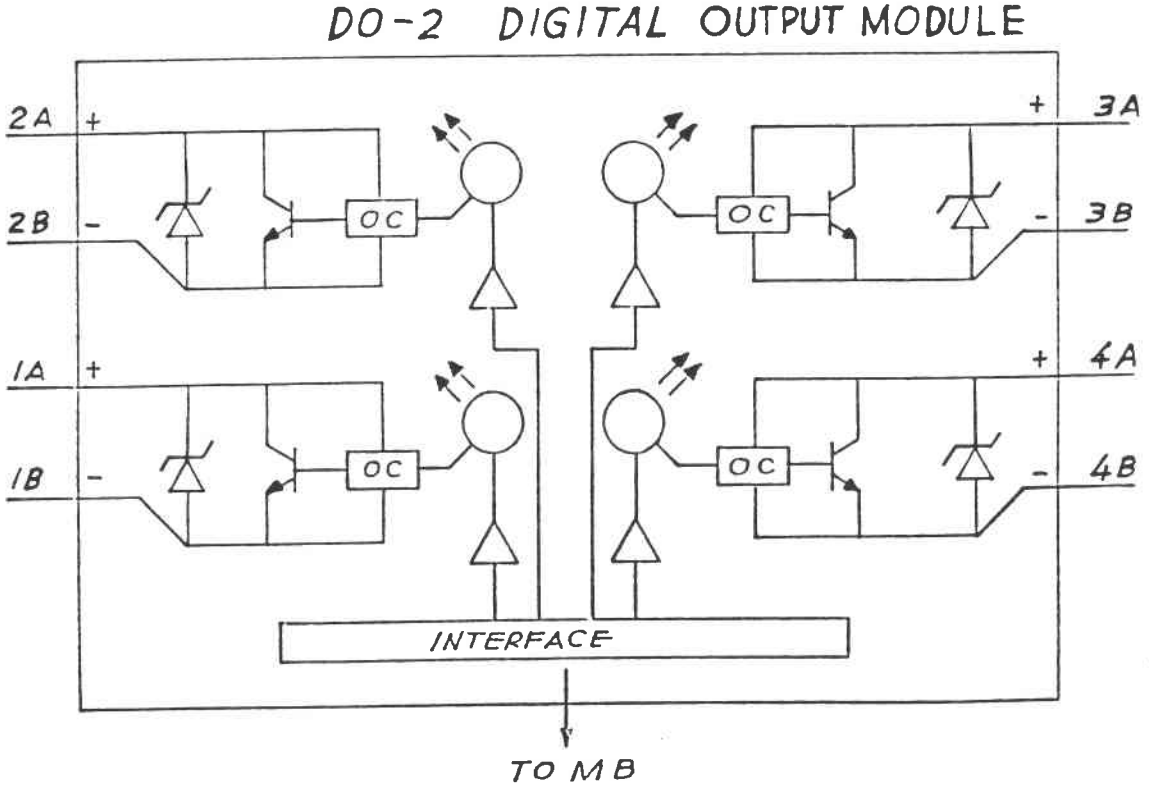


FIGURE 1-23: DO-2 DIGITAL OUTPUT MODULE

Wiring of DO-2:

Two types of wiring connections can be made to this module. One type is a quarter inch, quick-disconnect blade; the other is a self-rising screw terminal pressure plate that will accept up to two #14 AWG copper wires. The recommended wiring procedure when using the screw terminals is to first connect to the bottom terminal, then proceed upward to the top terminal.

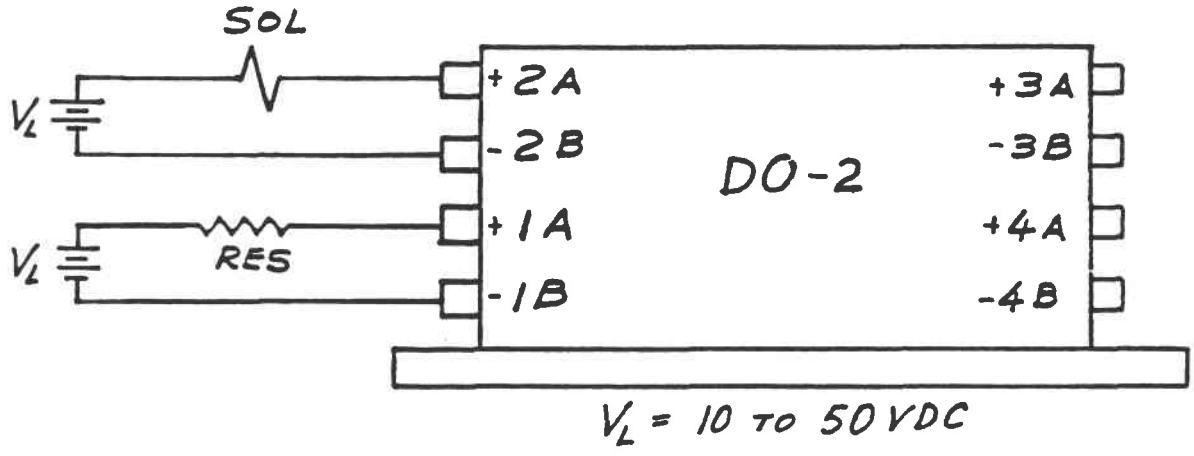


TABLE I

MODULE OUTPUT NUMBER	MAXIMUM OUTPUT OPTION #1	MAXIMUM OUTPUT OPTION #2
Output #1	1 amp	2 amp
Output #2	1 amp	0 amp
Output #3	1 amp	2 amp
Output #4	1 amp	0 amp

NOTES: **Be sure to observe polarity of voltage source: Contacts 1A, 2A, 3A and 4A require positive (+) polarity. Contacts 1B, 2B, 3B and 4B require common (-) polarity.**

SPECIFICATIONS

General:

* 10 to 50 volts DC -or- 50 volts peak pulsating DC maximum OFF voltage
* 1 amp per switch maximum, -or- 2 amps per side maximum, steady state current. See Table I.
* 2 volts at 2 amps, maximum, ON voltage
* 10 microamps, maximum, OFF state leakage
* Zener diode transient protection up to 150 watts of peak pulse power
* 100 watts per switch, DC operation
* 2.5 uSec ON Delay (maximum)
* 350 uSec OFF Delay (maximum)

Electrical:

* 10 to 50 volts DC, external DC source
* Optical Isolation: 2500 volts
* FCC Class A approval

Environmental:

* Ambient Temperature (operational): - 20 °C to 70 °C
* Ambient Temperature (storage): - 20 °C to 85 °C
* Humidity: 20% to 90%, non-condensing

Approximate Dimensions and Weight:

* 6-1/2" x 3-1/4" x 3/4" (W x H x D) (16.5cm x 8.3cm x 1.9cm)
* .205 Kilograms (.45 pounds)

Mounting:

This module is designed for mounting on the MB-1 and MB-2 motherboards. A card edge on the bottom of the module provides the electrical connections. A slot in the card edge allows keying for module position assignment. Two #8 pan head captive screws secure the module to the MB-1 or MB-2 motherboards. The screws should be tightened to ensure good thermal transfer.

1.1.7.4 ANALOG OUTPUT MODULE (AO-1)

The AO-1 Analog Output Module is an optically isolated, single channel, dual output module with **FULL** 8 bit capabilities. It is designed to handle many tasks in control applications at 0.39% resolution and ± 0.2% accuracy. It can simultaneously supply a 0 to +5 VDC output signal and a 4 to 20 mA signal when an operating voltage of 15 to 30 VDC* is applied.

The LED status indicator, mounted on the top of the Analog Output module, will emit light at various levels, depending on signal voltage (5VDC = high output) or 4 to 20 mA current levels (4 mA = low light output) if the 15 to 30 VDC source is active.

* See R_L vs. V_B curve

NOTE: REQUIRES THE MC-8 MICROCOMPUTER AND MX-2 MULTIPLEX MODULE NOT COMPATIBLE WITH THE MC-2 OR MC-4 MICROCOMPUTERS

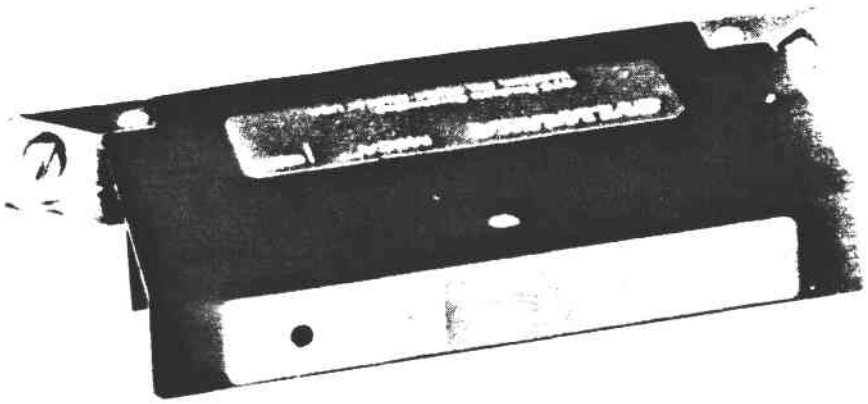
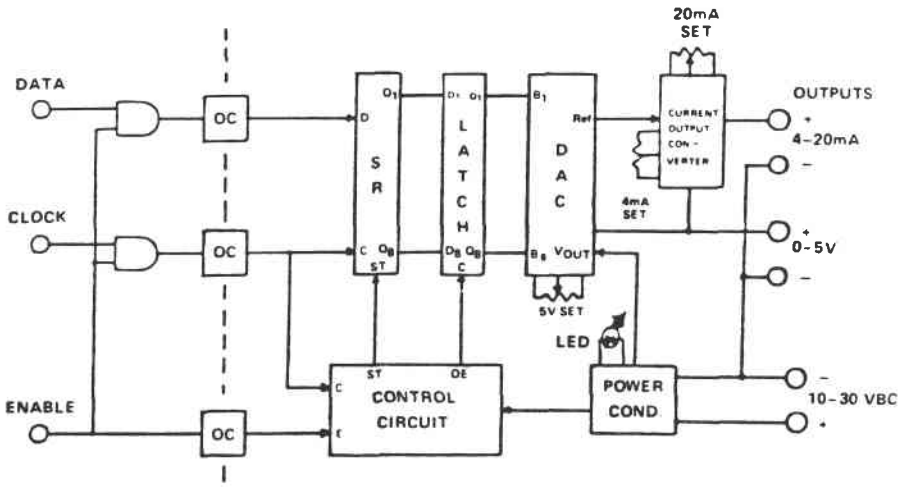
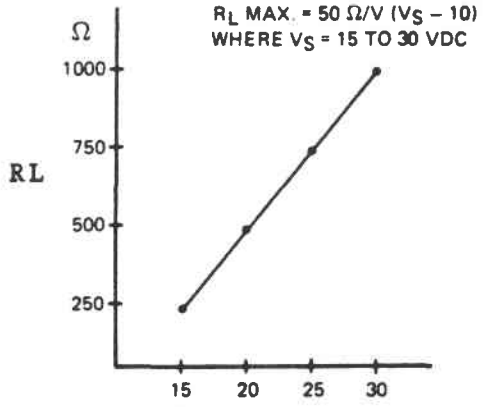


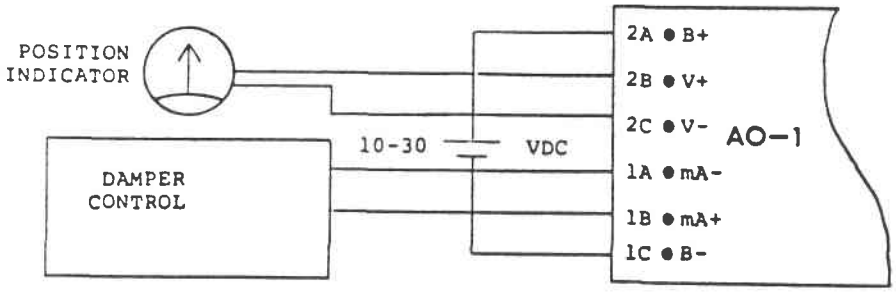
FIGURE 1-25A: ANALOG OUTPUT MODULE (AO-1)



AO-1 BLOCK DIAGRAM



4-20 mA LOAD LIMITATION



AO-1 WIRING DIAGRAM

See App. Note I/O 006 for field calibration procedure of AO-1.

AO-1
SPECIFICATIONS

General:

* 0 to 4.98V DC at 10 mA -- Battery Voltage V_B = 10 to 30VDC, 50 mA, maximum. Load R_L, minimum = 500 OHMS

* 4 to 20 mA Operation -- Battery Voltage V_B = 15 to 30VDC Load: 250 OHMS at 15VDC to 1000 OHMS at 30VDC R_L Max. = 50 /v (V_B -10)

* Resolution: Full 8 bits (0.39%) $\pm$ 1/2 LSB at 25 °C

* Accuracy: $\pm$ 0.2% @ 25 °C

* Temp Stability (0-60°C) Voltage Output $\pm$ 0.2% Current Output $\pm$ 0.5%

* Slew Rate Output: $\leq$ 10uSec (0.5V/uSec, 1.6 mA/uSec)

Electrical:

* Internal Power Supply: 24VAC center-tapped at 35 mA, max.
* External Power Supply: 15 to 30V DC at 50 mA, max.
* Power ON Reset
* Optical Isolation: 2,500 volts
* FCC Class A approval

Environmental:

* Ambient Temperature (operating): - 20 °C to + 70 °C - 4 °F to 158 °F

* Ambient Temperature (storage): - 20 °C to + 85 °C - 4 °F to + 185 °F

* Humidity: 20% to 90%, non-condensing

Approximate Dimensions and Weight:

* 6-1/2" x 3-1/4" x 3/4" (W x H x D)
* .33 pounds (.150 kg)

Mounting:

This module is designed for mounting on the MB-1 or MB-2 motherboards. A card edge on the bottom of the module provides the electrical connections. A slot in the card edge allows keying for module position assignment. Two #8 screws secure the module to the MB-1 or MB-2 motherboards. The screws should be tightened securely to ensure good thermal transfer.

1.1.7.5 LOGIC OUTPUT MODULE (LO-1)

The LO-1 Logic Output Module is an optically isolated, 8 bit data control module which compliments the existing Logic Input Module, LI-1. The LO-1 is an ideal module to directly communicate data to peripheral devices such as an LED display or dry contact relays. Up to four (4) BCD digits can be multiplexed and controlled with one (1) LO-1 module.

The LO-1 is capable of providing a Binary output value from 0 to 255. The LO-1 Module requires an external power supply between 10-30 volts DC. Connection to the LO-1 Module is via a DA-15 connector.

NOTE: REQUIRES THE MC-8 MICROCOMPUTER AND MX-2 MULTIPLEX MODULE NOT COMPATIBLE WITH THE MC-2 OR MC-4 MICROCOMPUTERS

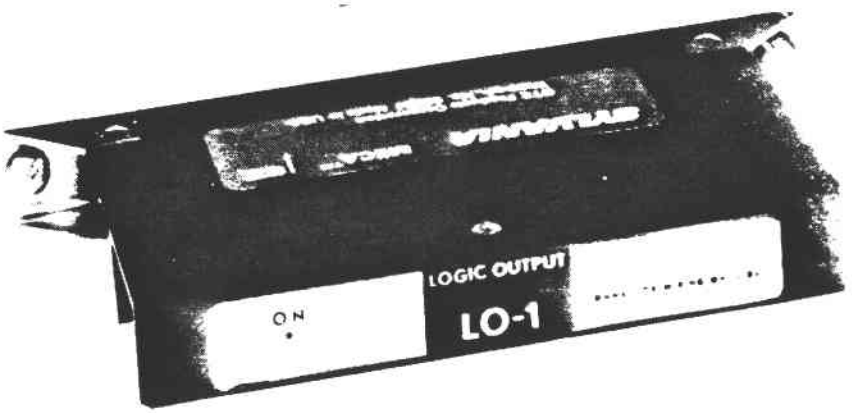


FIGURE 1-25B: LOGIC OUTPUT MODULE LO-1

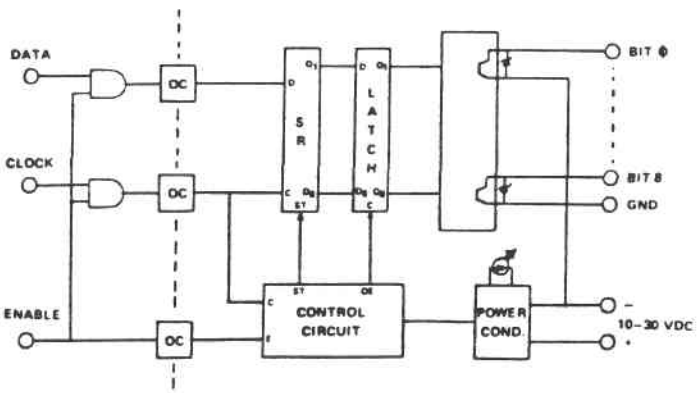
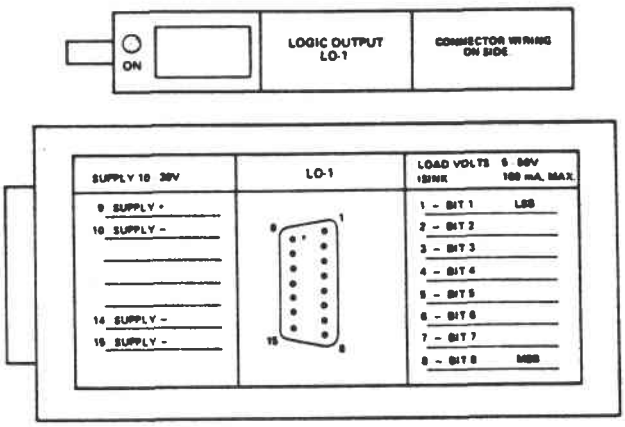
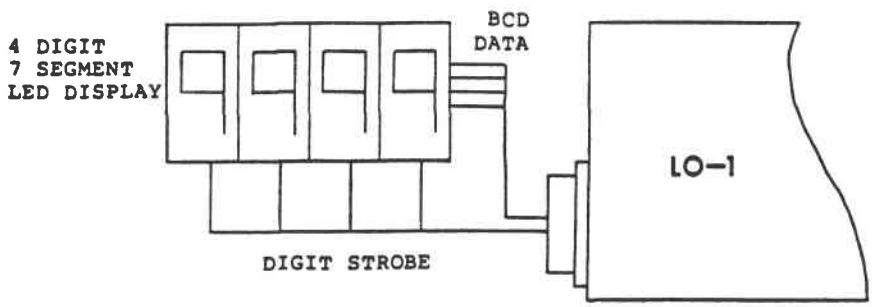


FIGURE 1-25C: LO-1 BLOCK DIAGRAM



DA-15 CONNECTOR



LO-1 WIRING

LO-1
SPECIFICATIONS

General:

* Negative True Logic, TTL-compatible
* 8-bit Resolution
* Optically Isolated

Electrical:

* Open collector output, 5 to 50VDC
* Sink Current, 100 mA, maximum
* On-State Voltage, 0.4VDC, maximum
* Conversion Time, 100 uSec
* Address Time, 100 uSec
* External Power Supply, 10 to 30 VDC, at 100 mA, maximum
* Output Voltage Surge Protected
* Open Collector
* DA-15 Connector
* FCC Class A approval
* 2500 Volts Optical Isolation

Environmental:

* Ambient Temperature (operating): - 20 °C to 70 °C
  - 4 °F to 158 °F
* Ambient Temperature (storage): - 20 °C to 85 °C
  - 4 °F to 185 °F
* Humidity: 20% to 90%, non-condensing

Approximate Dimensions and Weight:

* 6-1/2" x 3-1/4" x 3/4" (W x H x D)
  (16.5cm x 8.3cm x 1.9cm)
* .33 pounds (.150 kg)

Mounting:

This module is designed for mounting on the MB-1 or MB-2 motherboards. A card edge on the bottom of the module provides the electrical connections. A slot in the card edge allows keying for module position assignment. Two #8 screws secure the module to the MB-1 or MB-2 motherboards. The screws should be tightened securely to ensure good thermal transfer.

APPENDIX G

I^2R PROGRAMMABLE LOGIC CONTROLLER PLC-2

GTE Products Corporation
Electronic Control Operation
100 First Avenue
Waltham, MA 02254

I²R™ Product Bulletin P-24
24 VDC Stand-Alone

Model 1220

General

The I²R Stand-Alone (Model 1220) is a microprocessor based intelligent logic controller with 8 inputs and 4 outputs utilizing fast response circuitry.

Features

- 8 independent, optically isolated, low-voltage DC inputs
- 4 independent, optically isolated, low-voltage, high-current DC outputs
- 4 ten position BCD rotary switches
- 2 kilobyte user EPROM memory
- 4 field replaceable output transistors
- Slotted mounting holes for mounting on a standard tool relay rail
- Rugged industrial package

Description

The I²R Stand-Alone (Model 1220) functions as a Stand-Alone controller with 8 optically isolated, low-voltage DC inputs and 4 optically isolated, low-voltage, high current DC outputs. Also included, are 2 sets of 2 BCD rotary switches capable of providing any number from 0 to 9999 as a logic input. If I/O expansion is desired, the I²R Master should be considered.

P1	INPUTS	DI(4,1)
P2		DI(4,2)
P3		DI(4,3)
P4		DI(4,4)
P5		DI(6,1)
P6		DI(6,2)
P7		DI(6,3)
P8		DI(6,4)

MSD	LSD	MSD	LSD
☐	☐	☐	☐
LI(1)		LI(3)	

S1	OUTPUTS	DO(7,1)
S2		DO(7,2)
S3		DO(7,3)
S4		DO(7,4)

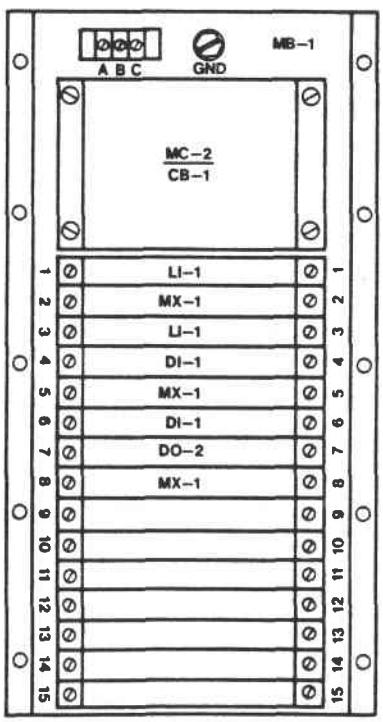


Fig. 1 I/O EQUIVALENTS

TM — Trademark of GTE Products Corporation

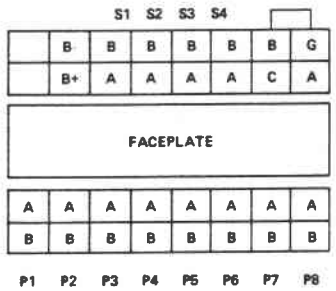
SYLVANIA Electrical Equipment GTE

SPECIFICATIONS
I²R Model 1220

TERMINAL DESIGNATIONS

TOP

TERMINAL DESIGNATION	FUNCTION	TERMINAL DESIGNATION	FUNCTION
B+, B- Pair	10-30 VDC		
S1-A, S1-B Pair	DC Output	A	24 VAC Power
S2-A, S2-B Pair	DC Output	B	24 VAC Center Tap
S3-A, S3-B Pair	DC Output	C	24 VAC Power
S4-A, S4-B Pair	DC Output	G	Chassis Ground



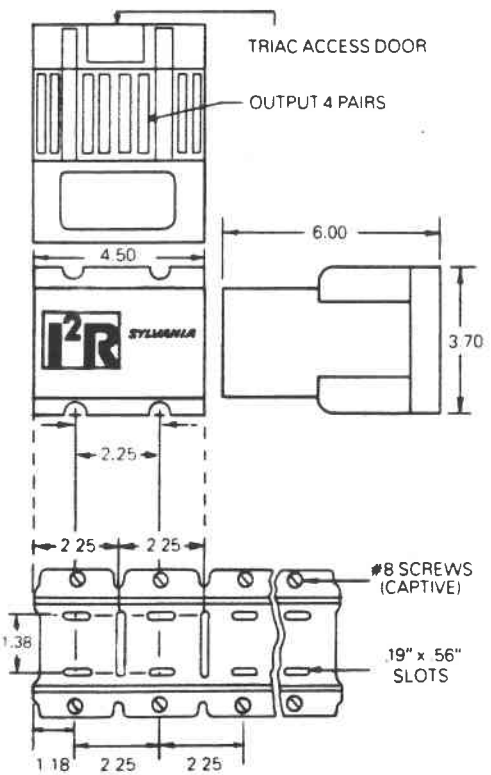
***NOTE:**
FOR BEST NOISE IMMUNITY, CONNECT POWER TERMINAL "B" TO GROUND TERMINAL "G" AS SHOWN.

BOTTOM

TERMINAL DESIGNATION	FUNCTION	TERMINAL DESIGNATION	FUNCTION
P1-A, P1-B Pair	DC Input	P5-A, P5-B Pair	DC Input
P2-A, P2-B Pair	DC Input	P6-A, P6-B Pair	DC Input
P3-A, P3-B Pair	DC Input	P7-A, P7-B Pair	DC Input
P4-A, P4-B Pair	DC Input	P8-A, P8-B Pair	DC Input

CAUTION: CONNECT + EXTERNAL SUPPLY TO TERMINALS "A"
CONNECT - EXTERNAL SUPPLY TO TERMINALS "B"

PHYSICAL DIMENSIONS



MOUNTING RAIL DIMENSIONS

POWER SUPPLY SPECIFICATIONS

AC Input Voltage	• 18-30 VAC, 10 VA max. 47-63 HZ
DC Input Voltage	• 10-30 VDC, 15 watts max.

MEMORY

Type	• UV-EPROM (Intel 2716 or Equivalent)
Size	• 2048 Bytes (2K)
Language	• SYBIL 4.3, 5.0

INPUTS

Number	• 8 Independent
Input Voltage	• 10-30 VDC
Input Current	• 9 mA @ 24 VDC
Turn ON Current	• ⟩ 3 mA DC
Turn OFF Current	• ⟨ 1.5 mA DC
Turn ON/OFF Time	• 500 uS typ, 700 uS max.
Input Resistance (Which will not cause turn ON)	• 30K ohm min. @ 30V
Isolation	• Optical, 1500V RMS

OUTPUTS

Number	• 4 Independent
Output Voltage	• 10-50 VDC
Output Current	• 2 AMPS per Output
Inrush Current	• 10 A for 10 mS
ON-State Voltage	• 1.5 VDC max.
OFF-State Leakage	• 10 uA max.
Turn ON Time	• 2.5 uS @ 24 V typ.
Turn OFF Time	• 350 uS @ 24 V typ.
Type	• Darlington Transistor
Isolation	• Optical, 500 V RMS
Transient Protection	• Zener Diode

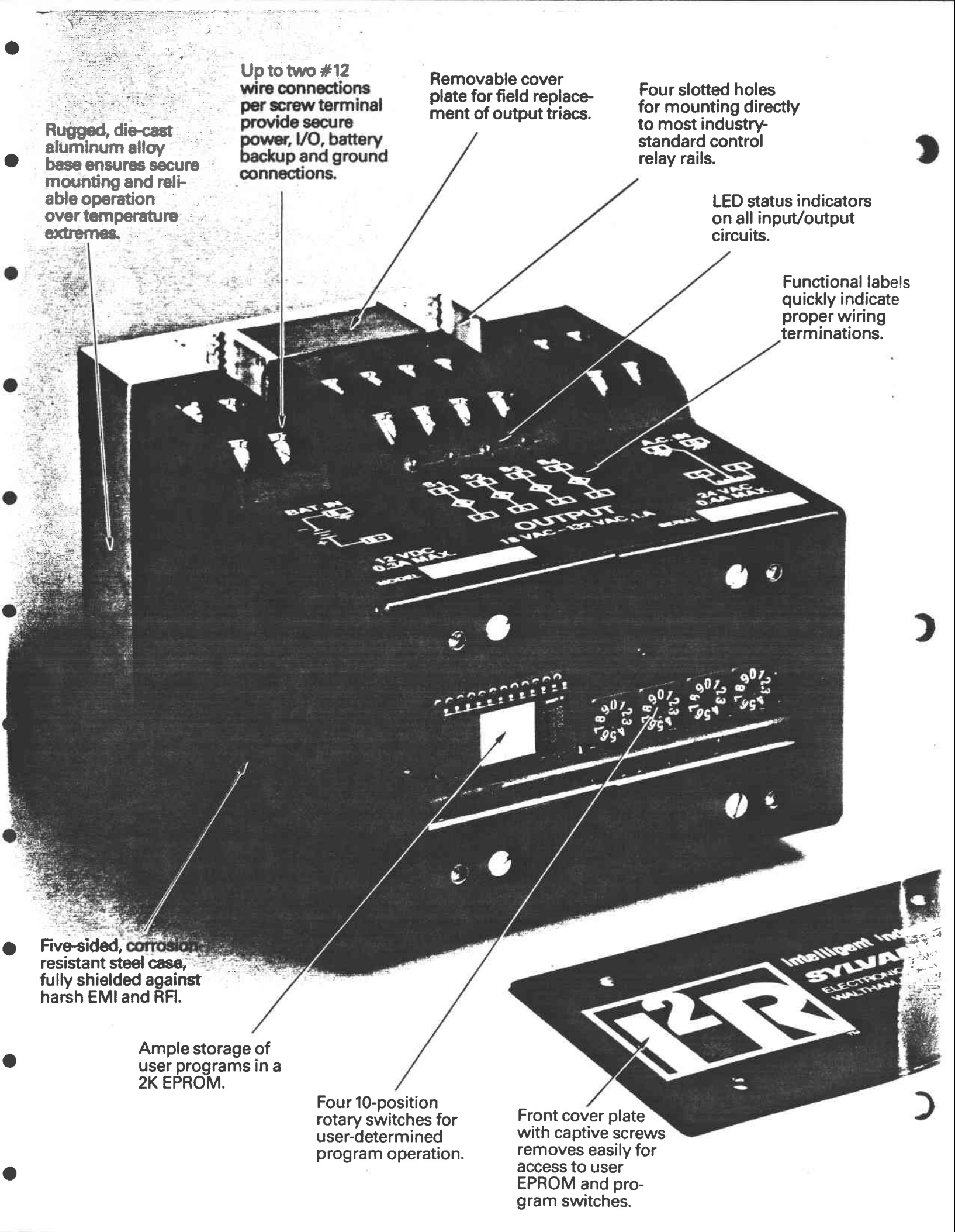
ENVIRONMENTAL AND PHYSICAL

Weight	• Less than 3.5 lbs.
Dimensions	
(In)	• 3.7H x 4.5W x 6.0D
(Cm)	• 9.4H x 11.4W x 15.3D
Operating Temp.	• -20°C to 60°C Ambient
Storage Temp.	• -20°C to 85°C Ambient
Humidity	• 5% to 95% Non-Condensing
Vibration	• Vibrated at 60 HZ, up to 5.5G's in all 3 Axis to up to 1 Min.
Shock	• MIL STD 810C-Procedure 1
Safety	• Designed to UL508
Noise	• Designed to NEMA ICS2-230
EMI/RFI	• Shielded on 5 sides and die-cast aluminum base
FCC	• Class A Approval
Isolation	• Designed to NEMA ICS1-109.21
Factory Burn-In	• Each Unit Operating for 8 hours at 60°C ambient temp.
Warranty	• 12 months

SYLVANIA Electrical Equipment GTE

INTELLIGENT INDUSTRIAL RELAY

The rugged, low-cost controller that's small like a relay but smart like a computer.


Rugged, die-cast aluminum alloy base ensures secure mounting and reliable operation over temperature extremes.
Up to two #12 wire connections per screw terminal provide secure power, I/O, battery backup and ground connections.
Removable cover plate for field replacement of output triacs.
Four slotted holes for mounting directly to most industry-standard control relay rails.
LED status indicators on all input/output circuits.
Functional labels quickly indicate proper wiring terminations.
Five-sided, corrosion-resistant steel case, fully shielded against harsh EMI and RFI.
Ample storage of user programs in a 2K EPROM.
Four 10-position rotary switches for user-determined program operation.
Front cover plate with captive screws removes easily for access to user EPROM and program switches.
BAT. IN
12 VDC 0.3A MAX.
OUTPUT
18 VAC – 132 VAC, 1 A
24 VAC 0.4A MAX.
SYLVA
ELECTRONIC
WALTHAM

THE I²R™ CONTROLLER PUTS PROGRAMMABLE POWER TO WORK IN THE RELAY ENVIRONMENT.

INTELLIGENT CONTROL.

The I²R™ (Intelligent Industrial Relay) Controller may look like a simple relay, but its high degree of built-in intelligence and programmable logic power distinguish it from ordinary relay systems. The I²R unit is a compact yet very powerful controller ready to work alone as a complete logic control system on a variety of small applications; or, in multiples to configure more complex control systems; or, as a dedicated, intelligent front-end processor to assist a larger host machine, such as GTE's MECA™ System.

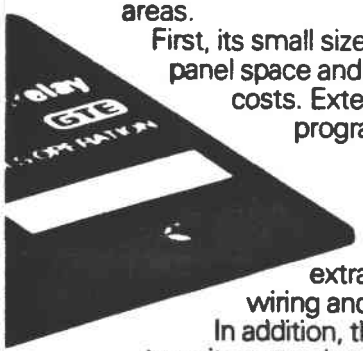
The I²R Controller's solid-state microprocessor logic offers you full 16-bit math and 2K of user memory, all programmed in SYBIL, a high-level yet easily understood programming language. Never before has this kind of programming power been available in such a conveniently small industrial package.

COMPACT SIZE.

The I²R Controller is comparable in size and shape to two standard machine tool control relays, yet it provides total system performance. The basic unit's 12 I/O's (8 in, 4 out) with optically isolated circuitry, up to 26 counters and timers, 2K user memory and four function-select switches are contained in a package with a footprint of less than *17 square inches.* Its unique space-saving design mounts directly on your standard relay rail among the existing control hardware, enabling you to conveniently configure your total control system package.

LOW COST.

In addition to the I²R Controller's attractively low price, its compact design and powerful intelligence will help you realize important savings in several areas.



First, its small size requires less of your costly panel space and reduces your overall wiring costs. External wires now become internal program statements.

Secondly, increased EMI and RFI shielding means the I²R Controller can work exactly where it's needed without extra protection, eliminating added wiring and extended cabling.

In addition, the 2K user memory allows you to write several applications in one EPROM and select the one you need, using the four-element switch array. This cuts your inventory costs and reduces re-programming time.

Most importantly, the I²R Controller's logic power will allow your operation to be more effective, more efficient and, thus, more productive.

INDUSTRIAL QUALITY.

The I²R Controller is designed to operate in severe industrial environments. The fully-enclosed steel housing minimizes contamination from dust that can degrade the performance of electronic circuitry. Radiated and conducted EMI and RFI are controlled by extensive shielding and internal filtering techniques. The thermal properties of the device have been carefully engineered to operate well over the full industrial range of 0°C to 60°C.

FLEXIBLE APPLICATIONS.

Applications for this powerful controller are as limitless as your imagination. For maximum flexibility, each I²R Controller has four 10-position mini-rotary switches which let you select up to 10,000 *unique* control programs, including independent operating modes, diagnostics and troubleshooting—all selected by simply turning a screwdriver. This flexibility makes the unit ideal for a variety of applications, from sensor monitoring, to small machine control, to dedicated system control—hundreds of control jobs, large and small.

SIMPLE OPERATION.

You don't need a degree in computer programming to customize the I²R Controller. Because it is compatible with the MECA,™ it utilizes Sylvania's Basic Industrial Language (SYBIL), an English-like programming language that is easily understood and rapidly applied. You can quickly change programs with a few simple keystrokes, or easily configure an entirely new application. Simplicity of operation means the I²R unit significantly reduces development and maintenance time.

™Trademark of GTE Products Corp.

FEATURES

A quick glance at the I²R Controller's features will show you why this compact powerhouse is rapidly changing the way industry thinks about control.

Industrial I/O Basic unit incorporates 8 optically-isolated switch closure inputs and 4 load-driving outputs.

Compact Size Requires less than 17 square inches of panel space.

Convenient Easy to install with 4 screws on a standard machine tool relay rail.

Economical Cost competitive with EM relays on small applications. Basic unit costs less than 4 installed relays.

Rugged Employs a unique, fully-shielded steel enclosure.

Independent A fully contained programmable logic controller capable of being the complete stand-alone system.

Easy to Use Programmed in an English-like language (SYBIL).

Expandable Designed to interface its own "Adder" for I/O expansion.

Reliable Fully solid-state design provides proven reliability and performance.

Easily Serviced Simply replace the unit, replace its EPROM, or utilize programmable switches to initiate diagnostics.

Fully Supported Product and service available nationally from a network of authorized GTE SYLVANIA Control Distributors.

APPLICATIONS

General

The I²R Controller may be used as a stand-alone control system; be combined with electro-magnetic industrial relays to offer a hybrid approach; or, be the smart front-end processor for a large computer-based controller or PC. It is one of the most powerful system building blocks available.

Small Machine Control

As a total control system for small machine applications, the unit can monitor a number of position sensors—proximity switches, photo detectors, etc.—and activate outputs such as motor starters, clutches and brakes.

Industrial Press Control

The controller can conveniently monitor the press slide to determine what sequence of operations is permissive at any portion of the cycle. Operator safety concerns would be implemented as program interlocks and sequence safeguards.

Smart Sensor Applications

Programmed to monitor up to 8 inputs, the controller will determine if an assembly (such as a package on a conveyor belt) is correctly positioned to meet a set of conditions.

Motor, Pump or Compressor Control

The controller can monitor start and stop sequences of a motor or pump system, along with temperature and pressure, to determine if certain conditions are met. Total motor control based on proper operating conditions, diagnostics and failure reporting can be supplied to an operator.

Annunciation

By monitoring the input and internal status sources, the I²R unit can activate lamps and other indicators to provide real-time operator information.

DETAILED FEATURES

- "Logic heavy" with 2K non-volatile user memory.
- Up to 26 counters and timers.
- Up to 26 16-bit registers.
- A broad range of timers driven by a real-time clock; 20 ms, sec., min., hours, and days intervals, eliminates the need to cascade timers.
- LED indicators on all I/O circuits.
- 16-bit arithmetic (add, subtract, multiply, divide, relational operators) and 16-bit counters.
- Immediate I/O control.
- User-defined programmable switches for up to 10,000 settings.
- Capable of being fully operated from battery backup.
- Inexpensive and reliable direct wiring.

Manufacturing/Material Handling Systems

The unit can manage the individual segments of a discrete parts assembly line. With a single controller at each station, part positioning can be controlled along with a subsequent sequence of pick and place operations. Limit switches, photo cells and other interlock detectors signal the arrival of the part. The I²R unit can then activate pneumatic solenoids, brakes, clutches, etc. Local operator annunciation can be via LED indicators or other industrial grade lamps. Operator pushbuttons would signal requests. The program select switches would make each controller interchangeable.

Relay Replacement

Because of its unique size, the I²R unit can directly replace industrial control relays. Panel space may be drastically reduced by building timers, counters and other logical control sequences into the I²R Controller. Up to 26 timers and counters may be replaced by a single I²R unit.

Wherever Panel Space is Limited

If panel space is a premium (such as when explosion-proof enclosures must be used), the savings in reduced panel costs often more than offsets the cost of an I²R unit.

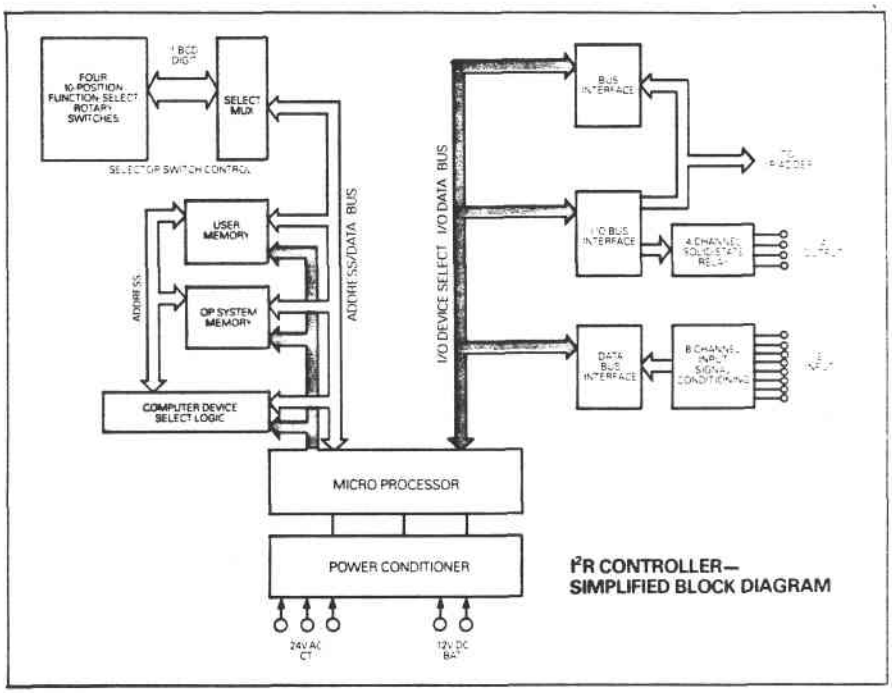
Machine Diagnostics

The I²R unit will monitor the state of inputs and provide alarming, annunciation and diagnostics for a machine, process or other application.

Included in the I²R Controller's package are a microcomputer with real-time clock, power conditioner, internal memory for both user and operating system programs, input signal conditioning and four solid-state relay outputs.

The microcomputer controls the unit's functions. The user customizes it with his own applications program stored in the user memory.

The 2K bytes of operating system provide the user with common software routines necessary for the high-level user program. Input signals are transformed into computer-compatible signals and transmitted via internal bus structure to the microcomputer.



I²R CONTROLLER— SIMPLIFIED BLOCK DIAGRAM

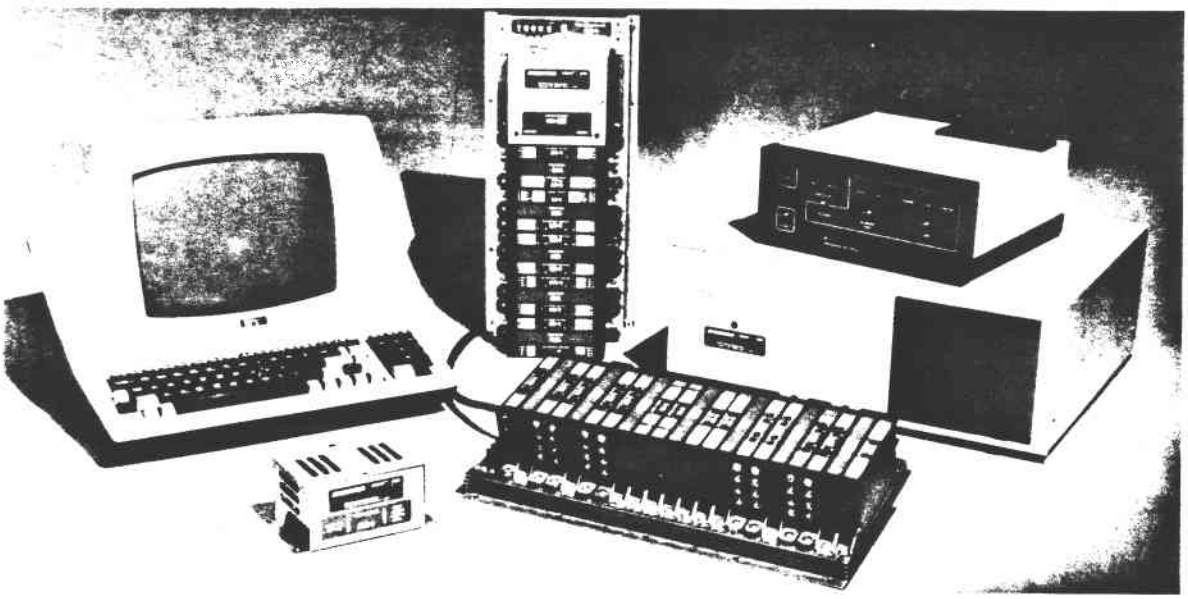
The microcomputer's user program determines the overall sequence of operation. The program may activate any or all of the solid-state relay outputs based upon the state of inputs, internal program status, results of computations or progression of time.

The user's program may read the input switch settings of the four function-select switches at any user-defined point of the sequence. A switch setting ranging from 0 to 9,999 may result in the microcomputer implementing an entirely different program or control algorithm.

Also provided through the bus structure is an interface to the I²R Adder for expanded input and output capability.

The power conditioner accepts either 24v ac or a 12v dc battery backup to operate the entire unit.

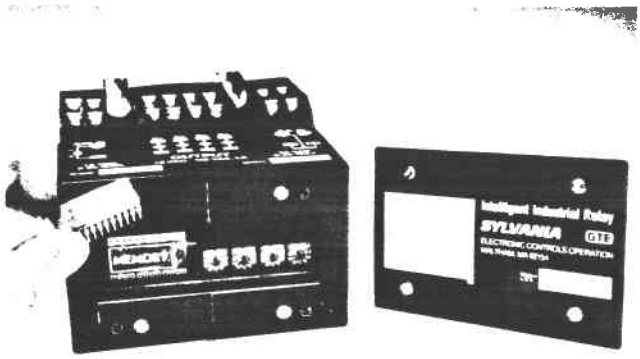
MECA™ SYSTEM



The MECA Programmable Control System is GTE SYLVANIA's larger electronic controller with up to 96 input and output circuits, including switch closure inputs, load-driver outputs, analog inputs and other standard industrial I/O modules.

Like the I²R Controller, the MECA utilizes SYBIL programming language for use by those unfamiliar with computer languages. An interactive CRT terminal with a standard typewriter keyboard is employed for direct access to the microcomputer's memory. Programs are typed and reviewed on the screen and then sent to the microcomputer for processing.

The MECA system allows the user to simulate and test a sequence before configuring the final program. The small, general purpose computer simulates and stores programs for future retrieval and modification. A programmable interface is used to burn-in a pre-tested program into the EPROM.



I²R CONTROLLER PROGRAM DEVELOPMENT

The program development technique is simple: configure the MECA System; develop the program using a standard MECA Development System; then, directly transfer the EPROM to the I²R unit for long-term application and field use. The MECA controller with standard modules is used as the development system and simulator for the I²R Controller.

Once configured to emulate the I²R unit, the MECA program is then interactively developed to create the final version of the user PROM using the CRT, computer programming system and programmable interface. When the EPROM is transferred to the easily accessible I²R memory socket, the controller will perform identically to the MECA Development System.

SPECIFICATIONS

I²R BASIC UNIT— ELECTRICAL SPECIFICATIONS

AC Input Voltage	• 18 to 28 Vac, 47 to 63 Hz
AC Input Current	• 0.4 A max.
DC Input Voltage	• 10-14 Vdc, 12 Vdc nominal
DC Input Current	• 0.3 A max.
User Memory Size	• 2048 8-bit bytes
Memory Type	• UV-EPROM (Intel 2716 or equivalent)

INPUTS

Number	• 8
Voltage Range	• 18 to 30 Vac or 10 to 30 Vdc
Input Current	• 10 mA ± 10% at 24 Vac • 5 mA ± 10% at 12 Vdc • 10 mA ± 10% at 24 Vdc
Turnon Time	• 10 Msec typ., 15 Msec Max. for Ac and Dc inputs
Input Resistance which will not cause turnon	• 30K Ohm min. at 32 Vac
Input Isolation	• 2500 VRMS

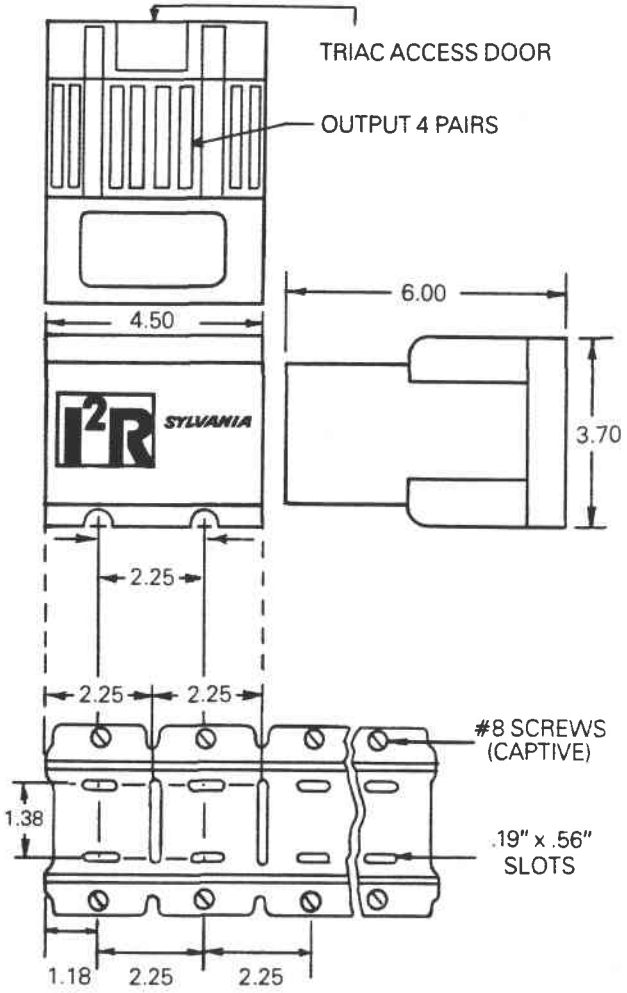
OUTPUTS

Number	• 4
Voltage Range	• 18 to 132 VAC
Output Current	• Total 2A S1 and S4 only; sum of all outputs less than 4.0A
Inrush Current	• 15A for 32 ms.
On State Voltage Drop	• 1.5 Vac max.
Off State Leakage	• 5 mA max.
Turnon Time	• 60 Hz, 8 ms. • 50 Hz, 10 ms.
Turnoff Time	• 60 Hz, 8 ms. • 50 Hz, 10 ms.
Type	• Zero crossing Triac output
Output Isolation	• 2500 VRMS

I²R BASIC UNIT— ENVIRONMENTAL AND PHYSICAL

Weight	• Less than 3.5 lbs.
Dimensions	
(In.)	• 3.7W x 4.5L x 6.0H
(Cm.)	• 9.4W x 11.4L x 15.3H
Operating Temp.	• 0° to 60°C Ambient
Storage Temp.	• −20°C to 85°C Ambient
Humidity	• 95% relative, non-condensing
Vibration	• Vibrated at 60Hz, up to 5.5G's in all 3 Axes for up to 1 min.
Shock	• MIL std-810C procedure 1
Factory Burn-In	• Each unit operating at 60°C Ambient for 8 hours
Warranty	• 12 Months
Safety	• Designed to UL508
Noise	• Designed to NEMA ICS 2-230
EMI/RFI	• Shielded on 5 sides and die-cast aluminum base.

PHYSICAL DIMENSIONS



MOUNTING RAIL DIMENSIONS

TERMINAL DESIGNATIONS

TOP—WIRING TERMINATIONS

TERMINAL DESIGNATION		FUNCTION
X, X	Terminal	Spares
B+, B−	Pair	12V dc Battery
S1-A, S1-B	Pair	Output Switch
S2-A, S2-B	Pair	Output Switch
S3-A, S3-B	Pair	Output Switch

TERMINAL DESIGNATION		FUNCTION
S4-A, S4-B	Pair	Output Switch
A	Terminal	24 Vac Power
B	Terminal	24 Vac Center Tap
C	Terminal	24 Vac Power
G	Terminal	Chassis Ground

	S_1	S_2	S_3	S_4				
REAR TERMINALS	X	B_-	B	B	B	B	B	G
FORWARD TERMINALS	X	B_+	A	A	A	A	C	A

FACEPLATE

FORWARD TERMINALS	A	A	A	A	A	A	A	A
REAR TERMINALS	B	B	B	B	B	B	B	B
	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8

BOTTOM—WIRING TERMINATIONS

TERMINAL DESIGNATION	FUNCTION
P1-A, P1-B Pair	AC/DC Input
P2-A, P2-B Pair	AC/DC Input
P3-A, P3-B Pair	AC/DC Input
P4-A, P4-B Pair	AC/DC Input

TERMINAL DESIGNATION	FUNCTION
P5-A, P5-B Pair	AC/DC Input
P6-A, P6-B Pair	AC/DC Input
P7-A, P7-B Pair	AC/DC Input
P8-A, P8-B Pair	AC/DC Input

ELECTRICAL EQUIPMENT CONTROL PRODUCTS

There are hundreds of other Sylvania control products with proven reliability, and compact economical design to meet your most exacting industrial need.

Starters & Contactors

A complete line of NEMA size starters 00 through 6 in open, enclosed and combination types supported by an impressive array of accessories and kits.

Also a new horsepower-rated starter type HP design for specific applications.

Industrial Control Relays

Three Distinct designs:

Type P6, 600 volt convertible cartridge relay for machine tools.

Type PM, 600 volt changeable contact for heavy-duty industrial control.

Type SM, 300 volt very small precision type control relay.

Heavy-Duty Pushbuttons

Type 100T—A rugged, reliable, 600 volt oil-tight line designed to perform in the most severe industrial applications.

Type 100M—The most complete and attractive 300 volt, 10 amp. pushbutton line available.

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Riverside, CA 92507
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2950 Ramona Avenue
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San Leandro, CA 94578
14895 E. 14th Street
(415) 352-3450
Santa Clara, CA 95050
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Orlando, FL 32809
7492 Chancellor Drive
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Tampa, FL 33607
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Cleveland, OH 44110
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Columbus, OH 43214
700 Morse Road
(614) 888-3428
Toledo, OH 43612
6517 Telegraph Road
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(405) 524-3641
Tulsa, OK 74114
3010 South Harvard
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(215) 363-0490
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(617) 777-1900

APPENDIX H

BATTERY CHARGERS

FC BATTERY CHARGER

Introduction: The SENS FC battery charger is a sophisticated battery charger. It features fully automatic operation including "Soft Start".

Upon Delivery: The package should be inspected for damage in transit. Any damage should be reported immediately to the carrier. We are not responsible for damage en route.

Installation: AWG #12 wire should be used for connection to the battery and AWG #14 should be used for connection to the AC line. This should be done by a qualified installer.

As soon as the battery is connected, the voltmeter should indicate battery voltage.

The charger should be located such that there is at least 6" (15cm) of free air space above and below it. If this simple precaution is not followed it could adversely affect the charger's reliability.

Operation: The front panel of a typical SENS FC charger is shown in figure 1. The front panel contains the AC and DC fuses, volt and ammeters and (optional) timed BOOST switch.

When power is applied to the charger it will be in the AUTOBOOST mode (for operation with a BOOST timer see section on MODELS WITH TIMED BOOST). Output current will be indicated on the ammeter.

AUTOBOOST....When the charger is turned on, it will be in the BOOST mode (see section on timed BOOST for definitions of FLOAT and BOOST). It will stay in the BOOST mode until the battery reaches the BOOST voltage setting. The charger will then AUTOMATICALLY switch to the FLOAT mode. It will hold the battery at the proper FLOAT voltage until the charger has a load on it that exceeds approximately 1/2 of the charger's rated output (this would occur when the battery is used to start an engine). It will then switch to the BOOST mode until it reaches the BOOST setting at which time it will again switch to the FLOAT mode. This eliminates the need to periodically BOOST the batteries to keep the cells at equal potential (see BOOST below).

****MODELS WITH TIMED BOOST****

When the timer is turned clockwise, the charger is in the BOOST mode. It will remain in the BOOST mode for the time indicated on the timer. It will then revert to the FLOAT mode.

FLOAT.....Holds the battery at "Float Voltage". This is the normal fully charged voltage of the battery.

BOOST.....Charges the battery to the "Boost Voltage" setting. This voltage is slightly higher than the FLOAT vlotage. Continued operation in the BOOST mode is not reccomended as it tends to boil away the electrolyte in the batteries. Periodic operation in this mode is however reccomended since it equalizes the the voltages of the various cells in the battery.

THEORY OF OPERATION

All SENS FC chargers utilize phase-controlled firing of silicon controlled rectifiers (SCR's) to obtain complete control over the charging voltage and current.

The circuit consists of ten circuit blocks.

Eight of these are on the printed circuit board. They are the ac supply, firing angle, strobe, voltage control, boost, current limit, soft start, and switching circuits.

AC supply.....The power for the control circuit, which is obtained through TB3 (pins 1 and 2) is rectified by diodes D1, D2, D10 and D11. It is filtered by C1.

Firing angle..The AC control voltage is also used as sync for the firing circuitry for the SCR's. A sawtooth is produced by discharging C2 through D4 and R1. C2 is charged by smooth DC obtained from R2 and is discharged at the end of each half cycle (ie. 120 times a second). This positive going sawtooth wave is coupled through C3 and R15 to pin 11 of IC1 (which is a quad-comparator). This quarter of the IC provides the actual drive for the SCR's. The other input of the IC (pin 10) is a changing DC voltage, thus if the DC voltage applied to pin 10 of the IC goes up, the output will switch states at a later time. This is due to the fact that the pin 10 input is compared to the sawtooth input at pin 11. Conversely, if the DC voltage present at pin 10 were to fall, then the output state change would occur at a sooner time in the AC cycle. C6 is used to store the potential at the input to the comparator at pins 10, 11 and 13.

Strobe.....One of the comparators (at pins 2,4, and 5) senses current and acts as a strobe to the voltage limit circuitry. This comparator's pin 5 is held at a constant low voltage and pin 4 is connected to the negative side of R47 (the shunt). Whenever there is a potantial accross R47, this comparator switches and prevents the voltage control comparators from having an effect. This means that the voltage control circuitry only operates when there is no current flow (between firings of the SCR's). Therefore the voltage control circuitry is not effected by the voltage drop that occurs between the battery charger and the batteries. The voltage control circuitry is only connected to the batteries when there is no current flow.

Voltage control..The comparator at pins 1,6, and 7 is the heart of the voltage control circuit. Pin 6 is connected to the FLOAT pot (R30). The voltage accross R30 is determined by D9, R38, R29 and R26. Pin 7 is held at a voltage controlled by the BOOST circuitry. The FLOAT voltage is the basic normal operating voltage of the battery charger, and under most circumstances. the potential at pin 7 is held steady. This will provide the battery with enough current to maintain FLOAT voltage.

Boost.....The comparator at pins 8,9, and 14 is the BOOST comparator. Pin 8 is held at a potential determined by D7 and D8. When a high current is demanded from the charger (when starting a motor) pin 2 of IC1 will go high and pull up pin 9 through R64 and R40. This places the unit in BOOST. The output of this comparator (pin 14) will also go high and pull up the wiper of R34. This is the BOOST voltage adjustment pot. It will pull up the voltage control comparator at pin 7. Thus it changes the reference for the voltage control circuit, charging the battery to a higher voltage setting.

Current limit..Current limit for the charger is obtained by using the voltage dropped accross R47 to charge C6 through R19 and R20. The current limit is set by R42, R43, R44 and R45 which discharge C6.

Soft start....On initial turn on, 'Soft Start' or a slow-start is the result of a network consisting of C4, R4 and D5. It pulls pin 10 up to a level which prevents the comparator from providing firing signals. As C4 charges, the voltage at pin 10 falls to the level on C6.

Switching.....The output of the comparator at pins 10,11, and 13 is connected to SCR's 1 and 2's gates. Only one of these will gate at a time however, depending on which half of the sine wave the input is in. Current is allowed to flow through these SCR's and is limited by R6 and R7. This provides the gate current required by the power SCR's (SCR3 and SCR4). The other half of the fullwave bridge is formed by diodes D12 and D13. The positive line is fed through R47 and brought off the board through TB1.

The other two circuit blocks are off the board. The are the AC input and DC output circuitry.

AC input.....The AC input circuitry is fused by F1 (F3 is also included in 220 and 440 volt models) and the AC potential reduced by transformer T1. T1 has two secondaries. One of these provides power to the control circuitry and is connected to it through connector TB3. The other secondary goes to the power circuitry on the PCB. It is connected through TB1.

DC output.....The DC output has two meters to monitor the charger's output. The ammeter is wired in series with the positive output lead and the voltmeter is wired in parallel with the output. Fuse F2 protects the charger in case of malfunction.

FC CHARGER ADJUSTING PROCEDURE

Th FC unit is factory adjusted. Field adjustments are normally unnecessary. In the event that it is necessary to make voltage adjustments, they are made as follow: (Due to the time required for the battery to respond to changes in voltage settings, adjustments should be made in small increments)

The FC charger is an automatic two rate (Auto Boost) charger, therefore the boost or high rate must be turned off before the float or low rate can adjusted:

1) Remove paper stickers from Potentiometers R-30 (float) and R-34 (boost)

2) Turn Boost "pot" fully counter clockwise

Now adjust the Float voltage:

3) Adjust Float "pot" in small increments until the battery reaches the desired voltage and the charger ammeter reads between 1 and 2 amps. The low rate is now set

Now adjust the Boost voltage:

4) Turn Boost "pot" fully clockwise

5) Remove AC power from the charger for a minute and then restore it (the charger will now be in the Boost or high rate mode)

6) Allow the batteries to charge until the desired boost voltage is reached.

7) Slowly turn the Boost "pot" counter clockwise until the charger Ammeter drops suddenly to zero.

TO THE USER OF THIS SENS BATTERY CHARGER

The SENS FC charger is completely automatic, thus will boost charge the battery at high rate until the battery is charged. Then it will decrease the charging voltage and current to a level adequate to maintain the battery in a fully charged state.

DO NOT ASSUME THAT THE CHARGER HAS FAILED IF THE OUTPUT CURRENT (AMPS) READS 0! During the transition from BOOST mode to FLOAT mode, the battery voltage is higher than the charger voltage so that no charging current will flow during this time. Once the battery voltage has fallen to the FLOAT level, the charger will put out a small amount of current.

HOW TO TELL IF THE CHARGER IS WORKING PROPERLY:

1. If the output amps are about the same as the rating of the unit, ie.,6 amps for an FC-12-6 or FC-24-6, and the battery voltage is slowly rising, the charger is in the automatic BOOST mode.

2. If the output amps are from 0 to 1 or 2 amps and the battery voltage is about 13.5 volts (for a 12 volt charger), 27 volts(for a 24 volt charger) or 36 volts (for a 32 volt charger), the charger is in the FLOAT mode.

3. If the output amps are 0 and the battery voltage is less than in (2), the charger or the AC input has failed.

4. If the output amps are at the rated output and stay at this level for several days, the charger may have failed or there may be a shorted cell in the battery.

****TROUBLE SHOOTING GUIDE****

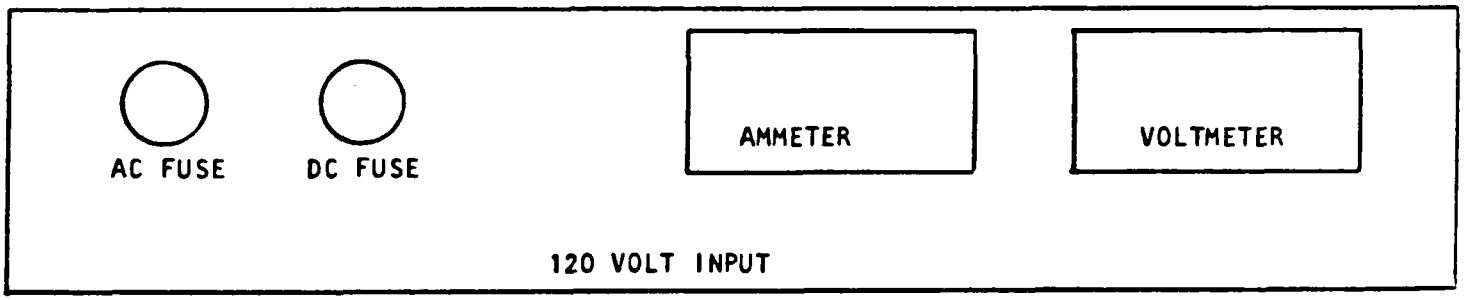
Trouble	Possible Cause	Test	Repair Procedure
No Output	AC Fuse Blown	Check Fuse	Replace Same
	DC Fuse Blown	Check Fuse	Replace Same
	No AC Power	Check Voltage	Restore Power
	Defective Transformer	Test #1	Replace Same
	Defective Control Circuit	Text #2	Replace Same
	Defective Ammeter	Check Ammeter	Replace Same
AC Fuse Only Blows	Defective Control Circuit	Test #2	Replace Same
	Defective Transformer	Test #1	Replace Same
AC and DC Fuses Blow	Defective Control Circuit	Test #2	Replace Same
Current Higher Than Normal	Defective Control Circuit	Test #2	Replace Same
Improper Regulation	Defective Control Circuit	Test #2	Replace Same

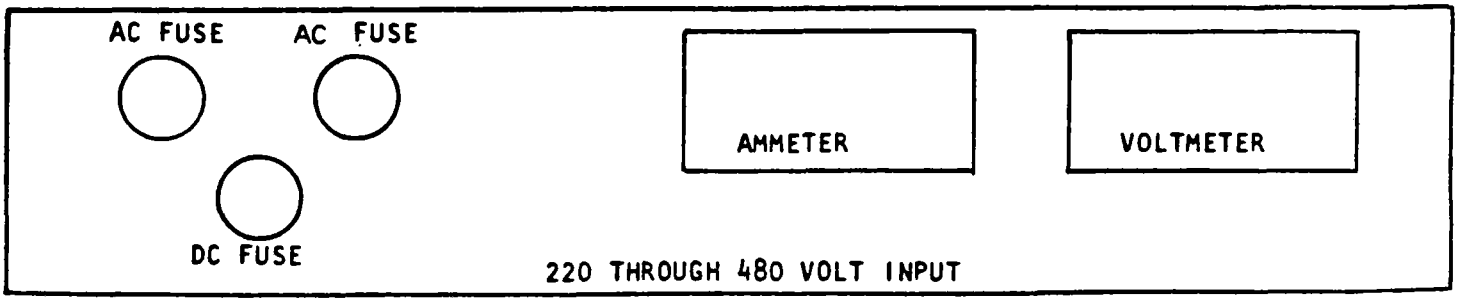
Test Number 1.

With tansformer leads disconnected, energize the transformer with the normal AC supply voltage. Measure power secondary voltage. It should be 1 1/2 or 2 times the normal battery voltage. Measure control secondary voltage. It should be approimately 10v.

Test Number 2

Due to the modest cost of the control circuit, it is recommended that the entire unit replaced rather than attempting to repair it. If the troubleshooting guide has not revealed any defective components, the Control Circuit should be replaced as a unit.





Resistors

R1	470	P-4412
R2	220K	P-4427
R3	220	P-4409
R4	1K	P-4413
R5	2.2K	P-4415
R6	10 2W	P-4618
R7	10 2W	P-4618
R8	1K	P-4413
R9	1K	P-4413
R10	10	P-4401
R11	10	P-4401
R12	2.2K	P-4415
R13	2.2K	P-4415
R14	47K	P-4423
R15	1M	P-4431
R16	Not Used	
R17	470	P-4412
R18	1K	P-4413
R19	2.2K	P-4415
R20	100K	P-4425
R21	150K	P-4426
R22	100K	P-4425
R23	4.7K	P-4417
R24	2.2M	P-4433
R25 12V	200K 1/8WMF 1%	P-4376
24V	200K 1/8WMF 1%	P-4376
32V	270K	P-4383

All values 1/4W 5% unless otherwise stated.
Omit R64 on models with timed BOOST.

R26 12V	200K 1/8W MF 1%	P-4376
24V	200K 1/8W MF 1%	P-4376
32V	270K	P-4383
R27	Not Used	
R28	5.6K	P-4381
R29	1.82K 1/8W MF 1%	P-4461
R30	10K Pot	P-4503
R31	1M	P-4431
R32	3.3K	P-4388
R33	22K	P-4421
R34	10K Pot	P-4503
R35	4.7K	P-4417
R36	270	P-4365
R37	1K	P-4413
R38	3.3K	P-4388
R39	100K	P-4425
R40	10K	P-4419
R41	Not Used	
R42	470K	P-4429
R43	750K	P-4346
R44	1M	P-4431
R45	2.2M	P-4433
R46	Not Used	
R47	Shunt	
R48 12V	200K 1/8W MF 1%	P-4376
24V	OMIT	
32V	OMIT	
R49 12V	200K 1/8W MF 1%	P-4376
24V	OMIT	
32V	OMIT	
R64	10	P-4401

Capacitors

C1	100uF/25v	P-5253
C2	.15uF Mylar	P-5097
C3	.022uF Mylar	P-5045
C4	10uF/25v	P-5235
C5	.027uF Mylar	P-5108
C6	10uF/25v	P-5235
C7	.01 uF disk	P-5079
C8 12v	.0047uF Mylar	P-5136
24v	.0047uF Mylar	P-5136
32v	.0039uF Mylar	P-5135

C9	100uF/25v	P-5253
C10	.1/100v Mylar	P-5004
C11	Not Used	
C12	.0047uF disk	P-5084
C13	Not Used	
C14	.022uF Mylar	P-5045
C15 12v	.0047uF	P-5136
24v	OMIT	
32v	OMIT	

Diodes

D1	1N4004	P-3006	D8	SELECTED	P-3152
D2	1N4004	P-3006	D9	Selected	P-3152
D3	1N4004	P-3006	D10	1N4004	P-3006
D4	1N4148	P-3083	D11	1N4004	P-3006
D5	1N4148	P-3083	D12	D2015L	P-3198
D6	1N4148	P-3083	D13	D2015L	P-3198
D7	SELECTED	P-3152			

Semiconductors

IC1	MC3302P	P-3325	SCR3	S1015L	P-3199
SCR1	C103B	P-3195	SCR4	S1015L	P-3199
SCR2	C103B	P-3195			

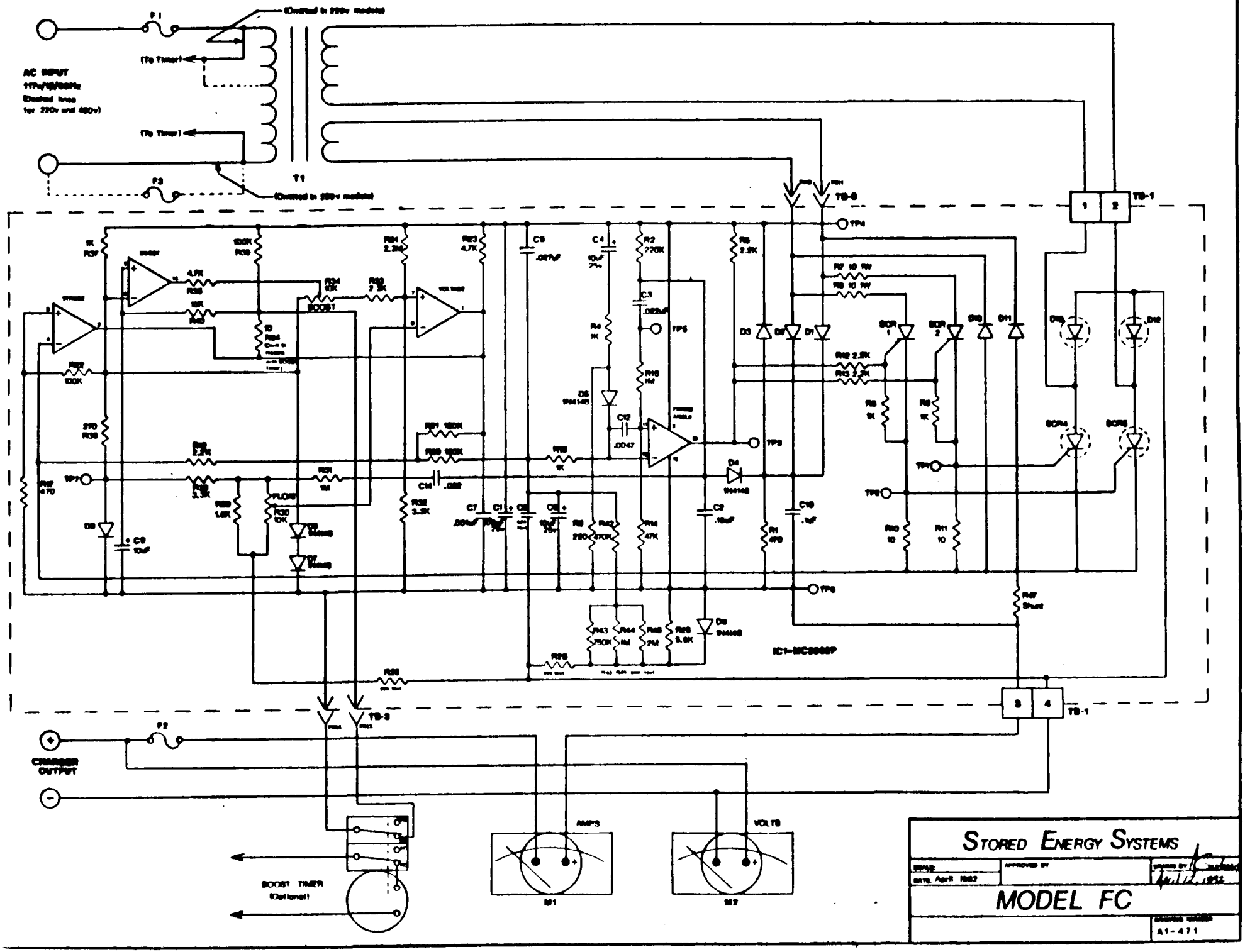
Misc.

TB1	4 Pin Kulka	TB3	Molex Masscon
TB2	Not Used		

	Transformer	Volt Meter	Ammeter	AC Fuse	DC Fuse
FC-12-6	P-6393	20v P-7290	10A P-7280	MDX-3	MDL-10
FC-12-10	P-6394	20v P-7290	15A P-7281	MDX-3.2	MDL-20
FC-24-6	P-6395	40v P-7291	10A P-7280	MDX-5	MDL-10
FC-24-10	P-6391	40v P-7291	15A P-7281	MDA-8	MDL-20
FC-32-6	P-6396	40v P-7291	10A P-7280	MDX-5	MDA-10
FC-32-10	P-6392	40v P-7291	15A P-7281	MDA-8	MDA-20

PRINTED CIRCUIT ASSEMBLIES

	STANDARD	WITH TIMER (EQUALIZE TIMER ON FRONT OF UNIT)
FC-12-6	P-2810	P-2811
FC-12-10	P-2815	P-2816
FC-24-6	P-2820	P-2821
FC-24-10	P-2825	P-2826
FC-32-6	P-2830	P-2831
FC-32-10	P-2835	P-2836


AC INPUT
F1
F3
T1
TB-2
TB-1
F2
CHARGER OUTPUT
BOOST TIMER
(Optional)
AMPS
VOLTS
M1
M2
SCR1
SCR2
SCR3
SCR4
SCR5
BOOST
FLOAT
Pwr Shunt
STORED ENERGY SYSTEMS
MODEL FC
A1-471

GORTRAC®
Cable And Hose Carrier Systems

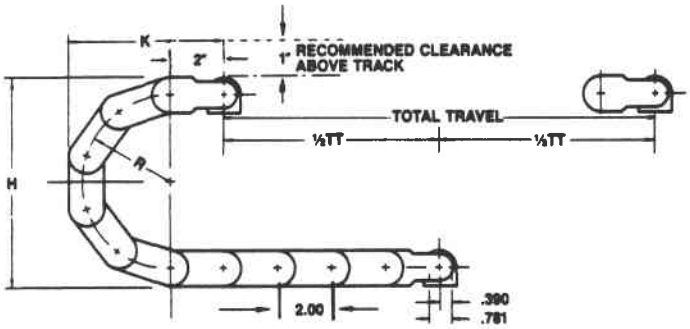
DESIGNED FOR:
MACHINE TOOLS, CRANES, INDUSTRIAL ROBOTS, MOBILE EQUIPMENT, STEEL MILL MACHINERY

- No pinchpoints
- Available in 5 sizes, 17 radii
- Eliminates hazards to operators
- Travels and widths to fit your requirements

GORTITE®

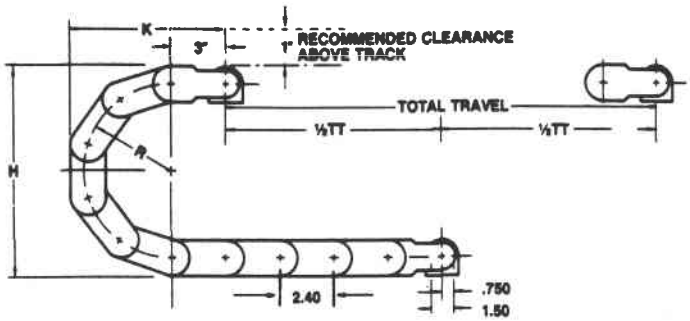
A and A Manufacturing Co. Inc.

GORTRAC WELDED LINK DESIGN



SB SERIES

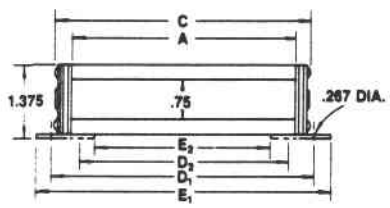
MODEL NO.	H HGT.	R RADIUS	K EXT.	CURVE LENGTH
SB 55	5.50	2.062	4.75	10.50



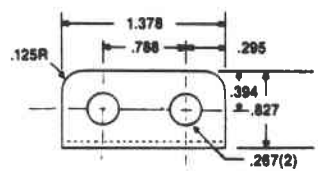
SC SERIES

MODEL NO.	H HGT.	R RADIUS	K EXT.	CURVE LENGTH
SC75	7.50	2.75	6.75	14.50
SC115	11.50	4.75	8.75	21.0
SC1325	13.25	5.625	9.625	24.0

SB SERIES — BAR CARRIER

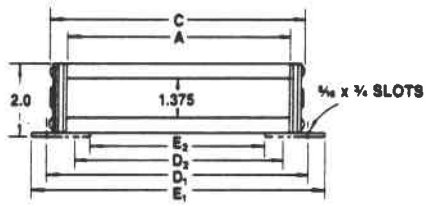


MOUNTING BRACKET

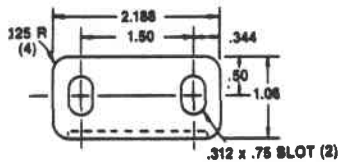


MOUNTING DIMENSIONS		SB
Carrier Width	A	—
Overall Track Width	C	A + .50
Mounting Holes, Brackets Outward	D_1	A + .843
Overall Width of Mounting Brackets	E_1	A + 1.625
Mounting Holes, Brackets Inward	D_2	A − .718
Distance Between Mounting Brackets	E_2	A − 1.50

SC SERIES — BAR CARRIER

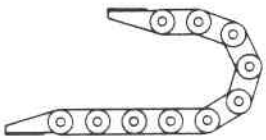


MOUNTING BRACKET

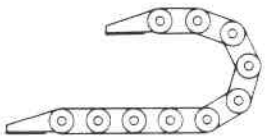


MOUNTING DIMENSIONS		SC
Carrier Width	A	—
Overall Track Width	C	A + .50
Mounting Holes, Brackets Outward	D_1	A + 1.0
Overall Width of Mounting Brackets	E_1	A + 2.0
Mounting Holes, Brackets Inward	D_2	A − 1.0
Distance Between Mounting Brackets	E_2	A − 2.0

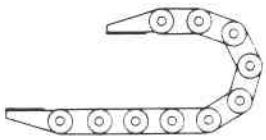
AVAILABLE MOUNTING BRACKET ARRANGEMENTS



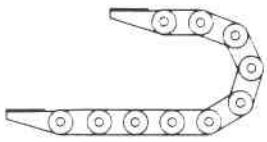
1



2



3



4

HOW TO ORDER OR FOR QUOTATION

(1) Determine diameter of largest cable or hose to be carried. Carrier hole size should be 1/8" larger than cable or hose diameter.

(2) Pick track radius best suited for your application. Bending radius of 8 x diameter of largest hose or cable is recommended.

(3) Allow 1/4" between edges of adjacent holes and 3/8" clearance at the ends of the carriers. If carrier width exceeds 12", allow 1/2" wide space in center of the carrier for fastener screw. With bar carriers, allow 1/8" between adjacent cables and 1/8" between cables and links.

Track Radius Preferred _____ In.

Gortrac Model No. _____ Sgl. Link _____ Dbl. Link _____

Max. Machine Travel Speed _____ In/Min.

Total Machine Travel _____ In.

Gortrac Length
(1/2 Travel + Curve Length) _____

Type of Carriers Preferred:
( ) Machined ( ) Bar ( ) Alternate Bar & Machined

Sketch of Hole Sizes & Locations enclosed _____ Yes _____ No

Carrier Width ("A" Dimension) _____ In.

Cable/hose Load _____ Lbs/Ft.

Mounting Brackets _____ Inward _____ Outward (2 Pair Supplied)

Mounting Bracket Arrangement 1 _____ 2 _____ 3 _____ 4 _____

ACCESSORY ITEMS

_____ Fixed Roller Supports _____ (Quantity Required)

_____ Carriage Support System _____ Single System _____ Double System
Manifold Length _____ In.

_____ Chip Guards _____ Top _____ Bottom

Date _____ For Quotation Only _____

Quantity Required _____

Date Required _____

Order Number _____

Company Name _____

Address _____

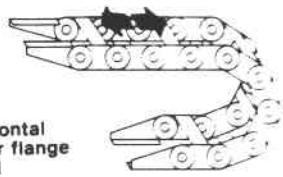
City _____

State _____ Zip _____

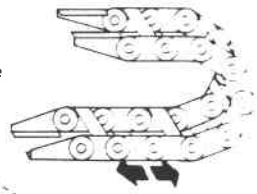
Attention _____

Phone _____

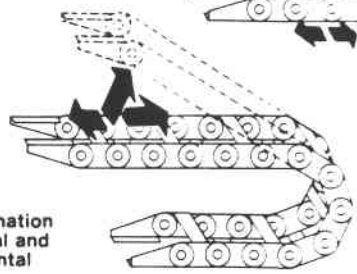
TYPES OF APPLICATIONS



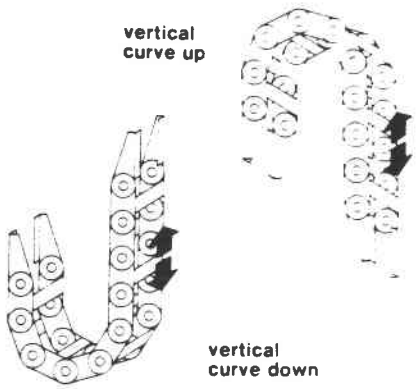
horizontal lower flange fixed



horizontal upper flange fixed



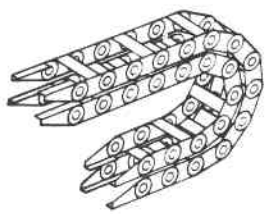
combination vertical and horizontal



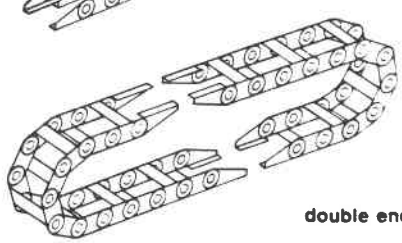
vertical curve up

vertical curve down

side mounted

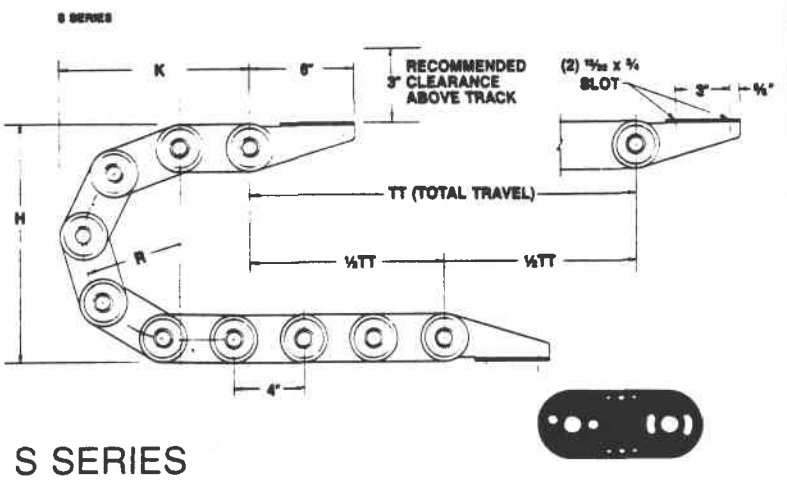


nested configuration



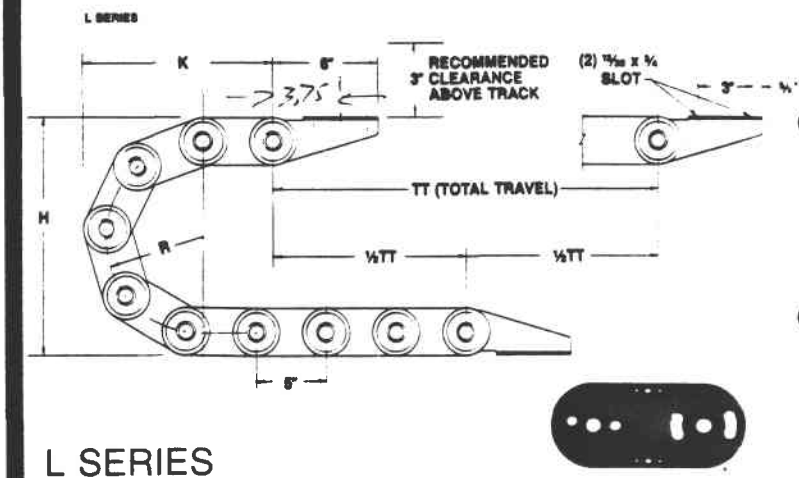
double ended

GORTRAC DOUBLE LINK DESIGN



S SERIES

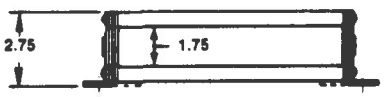
MODEL NO.	H HGT.	R RADIUS	K EXT.	CURVE LENGTH
S-135	13.5	5.375	10.75	24.00
S-170	17	7.125	12.5	30.00
S-200	20	8.625	14	36.00
S-245	24.5	10.875	16.25	42.00
S-275	27.5	12.375	17.75	48.00



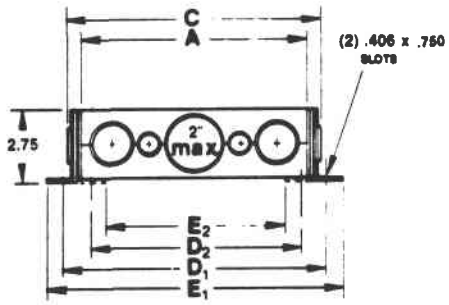
L SERIES

MODEL NO.	H HGT.	R RADIUS	K EXT.	CURVE LENGTH
L-200	20	8.125	15	36.00
L-275	27.5	11.875	18.75	48.00
L-350	35	15.625	22.5	60.00
L-415	41.5	18.875	25.75	70.00
L-525	52.5	24.375	31.25	88.00

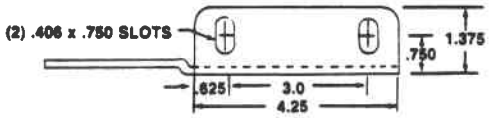
S SERIES — BAR CARRIER



MACHINED CARRIER

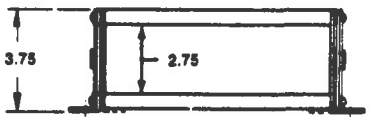


MOUNTING BRACKET

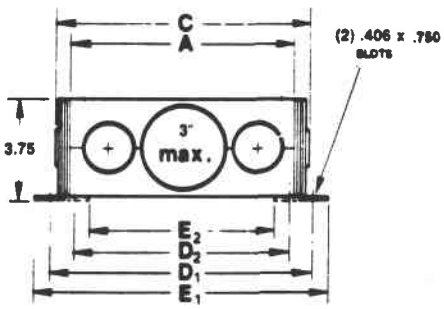


MOUNTING DIMENSIONS		S
Carrier Width	A	—
Overall Track Width	C	A+1.0
Mounting Holes, Brackets Inward	D_2	A−0.50
Distance Between Mounting Brackets	E_2	A−1.75
Mounting Holes, Brackets Outward	D_1	A+1.0
Overall Width of Mounting Brackets	E_1	A+2.0

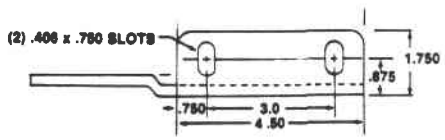
L SERIES — BAR CARRIER



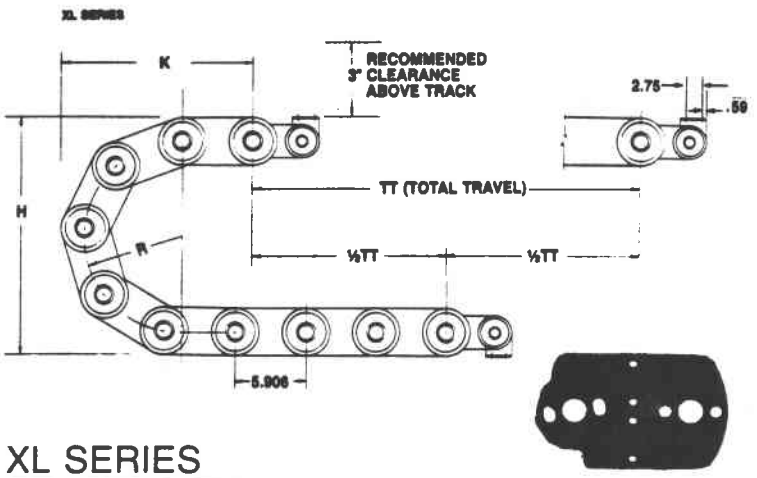
MACHINED CARRIER



MOUNTING BRACKET



MOUNTING DIMENSIONS		L
Carrier Width	A	—
Overall Track Width	C	A+1.0
Mounting Holes, Brackets Inward	D_2	A−0.50
Distance Between Mounting Brackets	E_2	A−1.75
Mounting Holes, Brackets Outward	D_1	A+1.0
Overall Width of Mounting Brackets	E_1	A+2.0

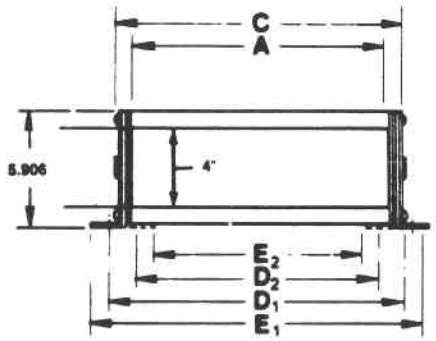


XL SERIES

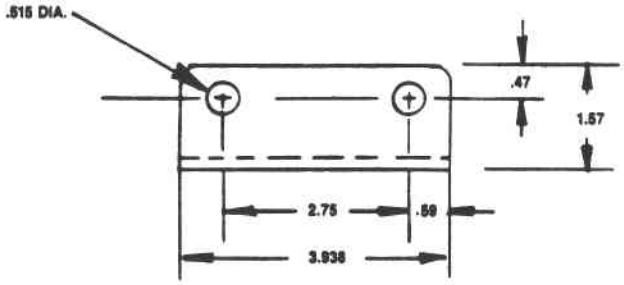
MODEL NO.	H HGT.	R RADIUS	K EXT.	CURVE LENGTH
XL-260	25.60	9.84	18.70	42.75
XL-375	37.40	15.75	24.60	61.00
XL-530	53.15	23.62	32.48	86.00

XL SERIES

BAR CARRIER

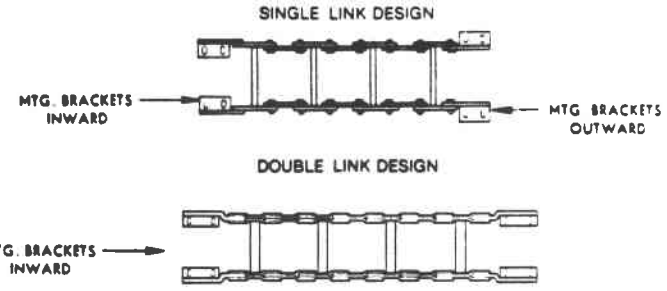


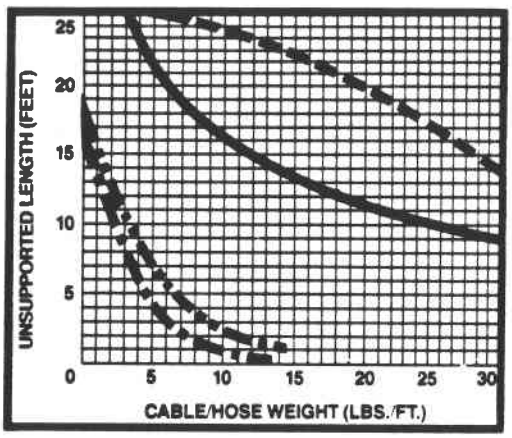
MOUNTING BRACKET



MOUNTING DIMENSIONS		XL
Carrier Width	A	—
Overall Track Width	C	A+1.0
Mounting Holes, Brackets Outward	D_1	A+2.25
Overall Width of Mounting Brackets	E_1	A+3.188
Mounting Holes, Brackets Inward	D_2	A−1.77
Distance Between Mounting Brackets	E_2	A−2.625

UNSUPPORTED SPAN VS. LOAD



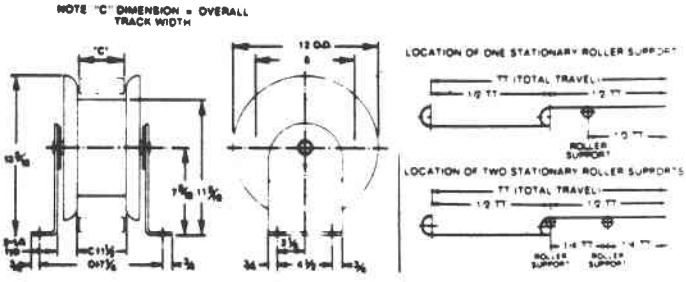


L-SERIES-DOUBLE LINK
S-SERIES-DOUBLE LINK
SC WELDED TRACK
SB WELDED TRACK

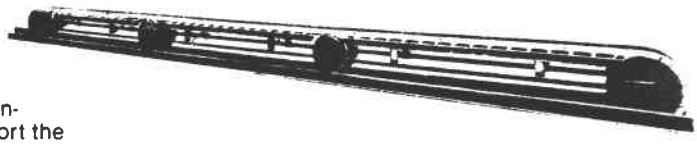
FOR SINGLE LINK ASSEMBLY, USE 1.3 THE WEIGHT LISTED FOR DOUBLE LINK ASSEMBLY

SUPPORT ROLLERS

Stationary support rollers are available for unsupported spans that exceed the maximum lengths shown on graph below. One support roller provides maximum travel 3 times the recommended unsupported lengths and 2 support rollers provide maximum travel 4 times the recommended unsupported lengths. Moveable support carriages are available for larger travels and higher speeds.



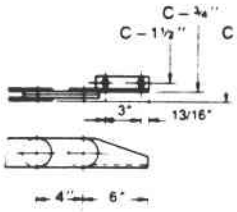
CARRIAGE SUPPORT SYSTEM

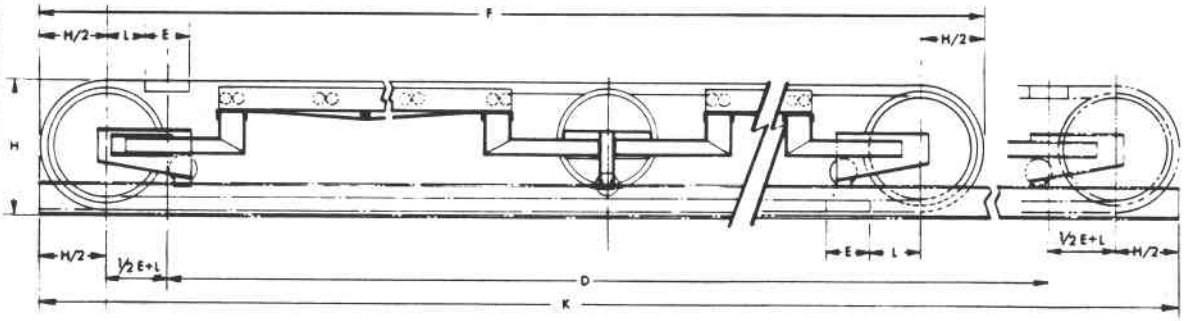


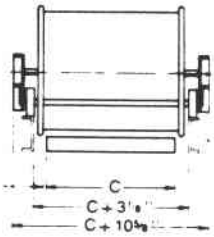
A rolling carriage support system is available for high speed applications or when the cable/hose load and travel exceed the limits available with fixed roller supports.

Unique Carriage Support System consists of major rollers and intermediate conveyor supports between the major rollers, which support the cable carrier for the complete length of travel. The entire system rolls on channels on the floor (or the crane bridge) and the system can be operated at any speed or load that is required.

C = Overall Track Width
D = Total Travel
E = Manifold Length (18" Min. Recommended)
F = Overall Length of Carrier System (D/2 + E + H + 2L)
H = Height of Carrier
K = Length of Support Channels (D + E + H + 2L) 2 Required 6" x 8.2 lb., Channel Supplied by Customer
L = Length Adjustment (7½" Max.)







GORTRAC® CABLE AND HOSE CARRIER

Unique link and pin system has no pinch points to pick up dirt or chips and eliminates all hazards to operating personnel. (Links are joined with large hardened steel pins which provide the bearing and lock point for exceptional strength and durability.)

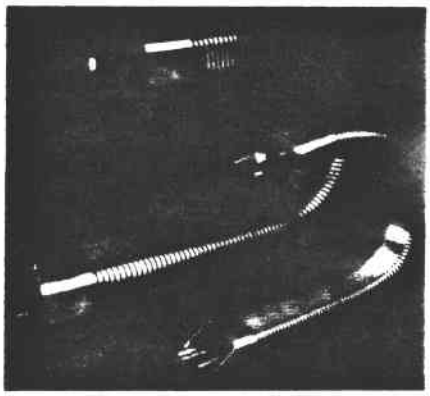
Cables are supported with either machined carriers or bar carriers with virtually no relative motion between the support points and the cable/hose to assure long life.

Carrier systems can be operated at speeds up to 60'/min. for machinery or machine tool applications and up to 450'/min. for overhead crane applications with the optional support carriage.

CHIP COVERS

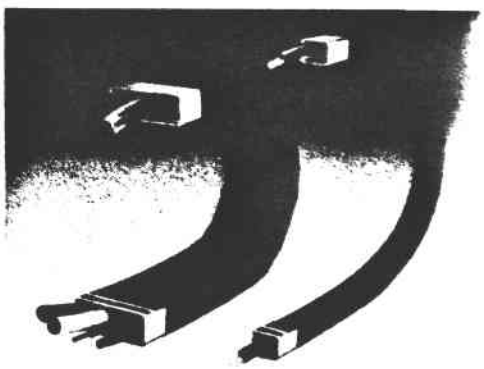
For applications where heavy chip loads, coolant or abrasive material are in contact with the cables hoses. Gortrac Cable Carriers can be supplied with chip guards for the top and bottom of the track.

The chip guard consists of a .020 SS strip and clips bolted to the side of the track to hold the covers in place.



Gortube® conduit type cable and hose carriers are available for applications requiring fully enclosed cable and hose protection with limited unsupported spans and cable/hose loads. Available in standard galvanized or black oxide finish. Request Bulletin GT-100.

New Welded Series Gortrac features all-welded construction. Because of its strength and light weight it is well-suited for mobile equipment and high-speed machinery application.



Nylatube cable and hose carriers are constructed of fiberglas reinforced nylon material, fully enclosed for protection in harsh environments on machine tools, industrial robots, mobile equipment and machinery operating at speeds up to 200 ft min. Request Bulletin NT-100.

A and A Manufacturing Co. Inc.
2300 South Calhoun Road
New Berlin, WI 53151 Phone 414-786-1500

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APPENDIX J

CENTRAL CONTROL COMPUTER PROGRAM

```
 10 REM ICCNTRL INNOVATIVE SOLAR CONCENTRATOR CONTROL PROGRAM
 20 REM REV 1.1 14NOV86 LES DOSS ACUREX/ESD
 30 REM COMPILE USING COMPILE6 V6.2 10/01/83 OR LATER VERSION
100 DECLARE S9,A,A1,A2,A3,E,E1,E2,E3,T8,D9=WORD
101 REM 20MACLWORD, AZ/EL ACT/IBM/DEL/CAL, DEST/OPT TIMER, EPH TRACK TOLERANCE
110 S=4 :REM STAT
120 S1=4 : S2=2 : S3=4 : S4=0 : S6=2 :REM STAT IBM/MAN/GOAL/OLD/MANBUF
130 F=0 : F1=0 :REM ACLOSSFLAG, WINDFLAG
131 F4=0 :REM FLAG FOR PRECISION TRACKING (VS. INITIAL TRAVEL INTO DESTEER)
132 F5=0 :REM DESTEERFLAG FOR TRACKING FAILURE. SELECT MODE <6 TO RESET.
133 F6=0 :REM FLAG TO BYPASS 3SEC TIMER AFTER DEST/OPT HAS BEEN ACQUIRED
134 H4=0 :REM HDWE MAINT STOW FLAG. PWR OFF/ON TO RESET
136 H6=0 :REM HDWE DESTEER FLAG. SELECT NEW COMMAND <7 TO RESET
140 C1=1 : C2=0 :REM PGM LOOP COUNTER & OPT/EPH FALLBACK COUNTER
150 A=AI1(6,1) : A1=A : E=AI1(6,2) : E1=E
190 GOSUB 2000
192 GOSUB 2000
200 GOSUB 2000 :REM 20MACL DECODE                              *** LOOPTOP ***
205 C1=C1+1 : IF C1>30 C1=1 : C2=0 :REM LOOP COUNT FOR OPT/EPH FALLBACK CTR
210 IF DI1(1,4)=1 S=0 : GOTO 900 :REM I^2R WATCHDOG
220 DO2(10,4)=1 : WAIT NIB=1
230 IF DI1(1,4)=0 S=0 : GOTO 900
240 DO2(10,4)=0
250 C=0 : A3=AI1(6,1) : E3=AI1(6,2) :REM          *** AI1(6) CALIBRATION ***
260 IF E3>1000 C=1
262 IF E3<1000 C=2 : IF E3=0 C=3
265 IF A3>3600 C=C+4
267 IF A3<3600 C=C+8 : IF A3=0 C=C+12
270 DO2(3)=C :REM CAL REF
290 IF S<2 GOTO 500 :REM ALARM LATCH
292 IF H4=1 GOTO 500 :REM HDWE MAINT STOW
300 IF F1=1 IF DI1(1,1)=1 S=1 : GOTO 900 :REM WIND       *** CHECK ALARMS ***
304 F1=0 : IF DI1(1,1)=1 F1=1
310 IF F=1 IF DI1(1,2)=1 S=1 : GOTO 900 :REM AC
320 F=0 : IF DI1(1,2)=1 F=1
350 IF S1<>2 S3=S1 : DO2(12,1)=1 : S2=2 : S6=2 : GOTO 380 :REM IBM MODESELECT
360 IF DI1(1,3)=0 S6=LI1(4) :REM MANUAL MODESELECT
362 IF DI1(1,3)=0 IF S6>1 IF S6<9 IF S6<>7 S2=S6
370 S3=S2
380 IF DI1(7,1)=0 H6=1 :REM HDWE DESTEER FLAG          *** FLAGS/STATGOAL ***
390 IF S3<7 H6=0 :REM HDWE DESTEER ONLY FROM FOCUS
391 IF H6=1 S3=6 :REM FORCE DESTEER FROM HDWE DESTEER FLAG
393 IF E1<150 IF S3>5 S3=5 :REM FORCE DESTEER/EPH FOR LOW SUN
394 IF S3<6 F5=0 :REM RESET DESTEERFLAG IF MODE<6 SELECTED
395 IF F5=1 S3=5 :REM DESTEERFLAG FOR TRACKING FAILURE
396 IF DI1(7,2)=0 H4=1 :REM HDWE MAINT STOW FLAG
397 IF H4=1 S3=4 :REM FORCE MAINT STOW FROM HDWE MAINT STOW FLAG
400 IF S3=S4 GOTO 500 :REM                      *** CHECK FOR NEW STATUS ***
410 S5=S : S4=S3 : S=S3
418 IF S3=3 S=4 :REM STOW BEFORE BEGINNING EXERCISE/SETUP
419 IF S5>5 IF S3>S5 S=S5 :REM GRADUAL FOCUSING SEQUENCE
420 IF S5<6 IF S3>5 S=5 :REM GRADUAL FOCUSING SEQUENCE
422 IF S<5 F4=0 : DO2(9,1)=0 :REM FLAG FOR COARSE TRACK, 36V TRACK
```

```
 430 GOSUB 2200 :REM STATDISPLAY
 440 DO2(10)=0 : DO2(12)=1 : DO2(13)=0
 460 IF S5=8 IF S3()7 GOTO 1800 :REM UNFOCUS
 470 IF S5=7 IF S3()8 GOTO 1800
 500 IF S)6 GOTO 600 :REM                    *** CHECK FOR INADVERTENT FOCUS ***
 505 IF A1=0 GOTO 600 :REM NIGHT
 510 A2=AI1(6,1)-A1 : IF A2(0 A2=-A2
 520 E2=AI1(6,2)-E1 : IF E2(0 E2=0
 530 IF A2(45 IF E2(45 GOTO 1800
 600 IF S(2 GOTO 920 :REM                    *** SELECT CODE USING STATUS S ***
 610 A=A1 : E=E1
 620 IF S=5 E=E+50 : GOTO 1200 :REM DESTEER/EPH
 630 IF S=7 GOTO 1200 :REM TRACK/EPH
 640 IF S=6 E=E+50 : DO2(12)=13 : GOTO 1400 :REM DESTEER/OPT
 650 IF S=8 DO2(12)=11 : GOTO 1450 :REM TRACK/OPT
 660 IF S=2 DO2(12)=0 : GOTO 200 :REM MANUAL/LOCAL CONTROL
 670 IF S=3 GOTO 1000 :REM EXERCISE/SETUP
 800 REM S=4 FALLS THROUGH HERE:             *** MAINT STOW ***
 810 D=0
 820 IF AI1(6,2))0 IF AI1(6,2)(3550 D=2 :REM ELDN
 830 IF AI1(6,1))0 IF AI1(6,1)(3550 D=D+8 :REM AZCCW
 850 DO2(13)=D
 870 IF S3=3 IF D=0 D=1 : S=3 : GOSUB 2200 :REM FOR STOW BEFORE EXERCISE/SETUP
 880 GOTO 200 :REM NORMAL STOW
 900 GOSUB 2200 :REM STATDISPLAY             *** ALARMSTOW INIT ***
 905 DO2(12)=1 :REM NO MANUAL CONTROL & NO TRACKERS
 907 DO2(9)=2 :REM 36V TRACK, IL-412 ON
 910 GOTO 200
 920 D=0 :REM                                *** ALARMSTOW ***
 930 IF AI1(6,2)(847 D=1 :REM ELUP TO 90 FROM HORIZON
 935 IF AI1(6,2))853 D=2 :REM EL DN TO 90
 940 IF AI1(6,1))1803 D=D+8 :REM AZCCW TO 180 (SOUTH)
 945 IF AI1(6,1)(1797 D=D+4 :REM AZCW TO 180
 950 DO2(13)=D
 955 IF AI1(6,2)(830 DO2(10)=6 :REM EL SLEW UP
 956 IF AI1(6,2))=830 DO2(10)=0
 960 GOTO 200
1000 IF D=1 IF AI1(6,2))450 IF AI1(6,2)(3550 D=4 :REM   *** EXERCISE/SETUP ***
1020 IF D=4 IF AI1(6,1))450 IF AI1(6,1)(3550 D=2
1040 IF D=2 IF AI1(6,2)(5 D=8
1045 IF D=2 IF AI1(6,2))3550 D=8
1060 IF D=8 IF AI1(6,1)(5 D=1
1065 IF D=8 IF AI1(6,1))3550 D=1
1080 DO2(13)=D
1090 GOTO 200
1180 C2=C2+1 : IF C2)3 F5=1 :REM            *** OPT/EPH FALLBACK CTR ***
1182 IF C2=1 C1=0
1190 GOTO 200
1200 DO2(12)=1 :REM TRACKER OFF             *** EPHEMERIS ***
1240 D9=0 : IF F4=0 D9=5 :REM +/- ACQ/TRACK TOLERANCES
1250 D=0 : A2=AI1(6,1)-A : E2=AI1(6,2)-E
1260 IF A2)D9 D=8 :REM DRIVE AZ CCW
1270 IF A2(-D9 D=4 :REM DRIVE AZ CW
1280 IF E2)D9 D=D+2 :REM DRIVE EL DN
1290 IF E2(-D9 D=D+1 :REM DRIVE EL UP
```

```
1300 DO2(13)=D
1310 IF F4=1 IF D<>0 GOTO 1250 :REM PRECISION TRACKING LOOP
1312 IF D=0 F4=1 : DO2(9,1)=1 :REM DESTEER POSITION ACQUIRED
1320 IF D=0 IF S<S3 S=S+1 : GOTO 1350 :REM GRADUAL STAT INCR
1330 GOTO 200
1350 GOSUB 2200 :REM STATDISPLAY                    *** EPH TO OPT TRANSITION ***
1360 IF S=6 T9=SEC : F6=0 :REM DESTEER TIMER
1370 GOTO 200
1400 IF F6=1 GOTO 1450 :REM (TIMER & BYPASS - DESTEER ONLY)     *** OPTICAL ***
1410 T8=SEC-T9 : IF T8<0 T8=T8+60
1420 IF T8<3 GOTO 200 :REM TIMER FOR DESTEER/OPTICAL TO FOCUS MODE
1440 F6=1 :REM BYPASS TIMER UNTIL COMING UP THROUGH DEST/EPH AGAIN
1450 A2=AI1(6,1)-A : IF A2<0 A2=-A2 :REM (CODE FOR BOTH TRACK & DESTEER)
1460 E2=AI1(6,2)-E : IF E2<0 E2=-E2
1470 IF A2>2 S=S-1 : GOTO 1180 :REM CHANGE TO EPH MODE IF NOT FOCUSED
1480 IF E2>2 S=S-1 : GOTO 1180
1500 IF S3>6 IF S=6 GOTO 1600 :REM GOTO FOCUS CODE FOR DEST/FOC TRANSITION
1510 GOTO 200
1600 S=7 : GOSUB 2200 :REM                                  *** FOCUS ***
1605 DO2(12)=1 :REM TRACKER OFF
1610 DO2(13)=2 : DO2(10)=6 :REM SLEW EL DOWN TO FOCUS
1620 E2=AI1(6,2)-E1 : IF E2<0 E2=-E2
1630 IF E2<2 DO2(10)=0 : DO2(13)=0 : GOTO 200 :REM STOP WHEN EL IN TOLERANCE
1640 GOTO 1620
1800 DO2(12)=1 :REM TRACKER OFF                             *** UNFOCUS ***
1820 DO2(13)=1 : DO2(10)=6 :REM SLEW EL UP
1830 E2=AI1(6,2)-E1
1840 IF E2<45 GOTO 1820 :REM SLEW UNTIL UNFOCUSED
1850 DO2(10)=0 : DO2(13)=0
1860 IF S=4 DO2(13)=8 :REM AZCCW FOR MAINT STOW
1865 IF S<2 DO2(13)=1 :REM ELUP FOR ALARM STOW
1870 GOTO 200
2000 INPUT S9 :REM STATWD FROM IBM        *** SUBROUTINE: STATUSWORD DECODE ***
2020 IF S9<0 RETURN :REM BAD STATUSWORD
2030 IF S9>5009 RETURN
2050 IF S9<1000 E1=S9+50 : RETURN :REM EL RANGE 0 TO 900 DEG*10, +5<HORIZ
2060 IF S9<5000 A1=S9-1000 : RETURN :REM AZ+1000 RANGE 1000 TO 4600 DEG*10
2070 S1=S9-5000 :REM STATIBM+5000 RANGE 5002 TO 5009
2080 IF S1=9 S1=4 :T.NIB=0:T.SEC=0:T.MIN=0:T.HRS=0: IF DAY>254 T.DAY=0
2090 RETURN
2200 DO2(15)=0 :REM                              *** SUBROUTINE: STATUS DISPLAY ***
2210 DO2(10,1)=1 : WAIT NIB=1 : DO2(10,1)=0 :REM CLR
2220 DO2(15)=S : WAIT NIB=1 :REM SET DISPLAY
2230 DO2(10)=1 : WAIT NIB=1 : DO2(10)=0
2250 RETURN
```

APPENDIX K

PLC-1 PROGRAM

```
10 REM IC.BAS    ACUREX/EED INNOVATIVE CONCENTRATOR CONTROL PROGRAM
20 REM REV 1.0 26SEP86   LES DOSS   ACUREX/ESD
98 REM
100 REM initialize constants
110 OPTION BASE 0
115 UP$=CHR$(30)
120 DIM CLDATA%(2) :REM 0=MODE,1=EL,2=AZ for 20mA current loop to MC8
130 DIM MODE$(9) :REM descriptions of modes for menu and printer
200 MODE$(0) = "STOW: WATCHDOG TIMER FAILURE "
202 MODE$(1) = "STOW: WIND OR AC LOSS ALARM  "
204 MODE$(2) = "MANUAL MODE                  "
206 MODE$(3) = "EXERCISE & SETUP MODE        "
208 MODE$(4) = "STOW                         "
210 MODE$(5) = "DESTEER/EPHEMERIS            "
212 MODE$(6) = "DESTEER/OPTICAL              "
214 MODE$(7) = "TRACK/EPHEMERIS              "
216 MODE$(8) = "TRACK/OPTICAL                "
218 MODE$(9) = "SYSTEM RESET AT MIDNIGHT     "
230 FOR I=2 TO 8 :REM set function keys
232     I$=STR$(I)
234     KEY I,I$
236     NEXT I
238 KEY 1,"  " : KEY 7,"  " : KEY 9,"  " : KEY 10,"  " : KEY ON
240 CLINDEX% = 2 :REM current loop data index; begin with status
300 OPEN "COM1:1200,N,8,1,CS,DS" AS #1 :REM 20mA current loop
498 REM
500 REM *** code returns here at midnight to initialize for the day ***
510 TBUF=TIMER :REM for 1sec intervals between 20mA communications
520 MODE% = 4  :REM system wakeup in maintenance stow mode
530 GOSUB 3000 :REM daily az/el initialization
532 GOSUB 3500 :REM compute el
534 GOSUB 4000 :REM compute az
540 GOSUB 2000 :REM display menu
698 REM
700 REM                    *** main program loop ***
750 GOSUB 4500 :REM mode select
760 CLDATA%(0) = MODE% +5000
765 IF TIMER)=TBUF+1 THEN TBUF=TIMER ELSE IF TIMER(TBUF GOTO 1000 ELSE GOTO 765
770 PRINT #1, USING "######";CLDATA%(0) :REM output to MC8 20mA loop
790 PRINT USING "\                                          \###.###\
\###.###";UP$+"       "+TIME$+" MST     AZIMUTH = ";AZDEG;"     ELEVATION = ";EL
DEG
800 GOSUB 3500 :REM compute el
810 CLDATA%(1) = INT(ELDEG *10)
812 GOSUB 4500 :REM mode select
815 IF TIMER)=TBUF+1 THEN TBUF=TIMER ELSE IF TIMER(TBUF GOTO 1000 ELSE GOTO 815
820 PRINT #1, USING "######";CLDATA%(1) :REM output to MC8 20mA loop
840 PRINT USING "\                                          \###.###\
\###.###";UP$+"       "+TIME$+" MST     AZIMUTH = ";AZDEG;"     ELEVATION = ";EL
DEG
850 GOSUB 4000 :REM compute az
860 CLDATA%(2) = INT(AZDEG *10+1000)
862 GOSUB 4500 :REM mode select
865 IF TIMER)=TBUF+1 THEN TBUF=TIMER ELSE IF TIMER(TBUF GOTO 1000 ELSE GOTO 865
870 PRINT #1, USING "######";CLDATA%(2) :REM output to MC8 20mA loop
890 PRINT USING "\                                          \###.###\
\###.###";UP$+"       "+TIME$+" MST     AZIMUTH = ";AZDEG;"     ELEVATION = ";EL
DEG
990 GOTO 700
```

```
990 REM
1000 TBUF=0 :REM       *** reset system at midnight ***
1005 MODE%=9 : GOSUB 2000 :REM reset MC8 clock
1010 CLDATA%(0) = MODE% +5000
1020 IF TIMER)=TBUF+1 THEN TBUF=TIMER ELSE GOTO 1020
1030 PRINT #1, USING "#####";CLDATA%(0) :REM output to MC8 20mA loop
1050 GOTO 500
1995 REM
1998 REM ------------------------------------------------------------------------
2000 REM subroutine: display menu
2010 CLS
2020 TSEL$=TIME$ :REM time of mode selection
2030 PRINT : PRINT TAB(22) "ACUREX INNOVATIVE SOLAR CONCENTRATOR"
2040 PRINT : PRINT TAB(35) DATE$
2050 PRINT : PRINT TAB(8) "CURRENTLY SELECTED MODE:" MODE% "- " MODE$(MODE%)
2060 PRINT TAB(8) "MODE SELECTED AT " TSEL$ " MST" : PRINT
2090 PRINT TAB(8) "PRESS FUNCTION KEYS FOR MODE SELECTION AS FOLLOWS:" : PRINT
2100 FOR X=2 TO 6
2110    PRINT TAB(8) "MODE" X "- " MODE$(X)
2120    NEXT
2130 PRINT TAB(8) "MODE 8 - " MODE$(8)
2140 PRINT
2145 PRINT TAB(8) "STANDARD TIME AND CALCULATED SOLAR EPHEMERIS POSITIONS:"
2146 PRINT TAB(8) "(REFERENCED TO 10DEG TILTED PLANE)"
2147 PRINT
2150 PRINT USING "\                                                \###.###\
 \###.###";UP$+"        "+TIME$+" MST      AZIMUTH = ";AZDEG;"      ELEVATION = ";E
LDEG
2200 RETURN
2998 REM ------------------------------------------------------------------------
3000 REM subroutine: daily initialization for ephemeris calculations
3010 DAY   =VAL(MID$(DATE$,4,2))
3020 MONTH =VAL(MID$(DATE$,1,2))
3030 YEAR  =VAL(MID$(DATE$,7,4))
3040 JDAY  =DAY :REM JULIAN DAY
3050 FEB=28 : IF YEAR/4=INT(YEAR/4) THEN FEB=29 :REM leap year
3060 FOR M=1 TO 12
3070 IF M)=MONTH THEN GOTO 3120
3080 ON M GOTO 3090,3110,3090,3100,3090,3100,3090,3090,3100,3090,3100,3090
3090   JDAY=JDAY+31 : GOTO 3120
3100   JDAY=JDAY+30 : GOTO 3120
3110   JDAY=JDAY+FEB
3120   NEXT M
3130 TWOPI=2*3.14159
3140 DEGRAD=TWOPI/360
3150 RADDEG=360/TWOPI
3200 BETA=TWOPI*((JDAY-81)/364) :REM earth pos in annual orbit in radians
3210 DELTA=23.45*DEGRAD*SIN(BETA) :REM declination angle in degrees
3220 EOT=(9.87*SIN(2*BETA) - 7.53*COS(BETA) - 1.5*SIN(BETA))/60 :REM EOT in hrs
 LIST
3230 LAT= 35+ 3/60 + 10 :REM site latitude in degrees plus 10deg N tilt
3240 LON=106+37/60 :REM site longitude in degrees
3250 SN=12-EOT+((LON-105)/15) :REM solar noon in local std time
3300 SINLAT=SIN(DEGRAD*LAT)
3310 COSLAT=COS(DEGRAD*LAT)
3320 SINDEL=SIN(DELTA)
3330 COSDEL=COS(DELTA)
3340 RETURN
3498 REM ------------------------------------------------------------------------
3500 REM subroutine: compute instantaneous solar elevation
3510 T$ =TIME$ :REM time from clock
3520 HR =VAL(MID$(T$,1,2))
3530 MIN=VAL(MID$(T$,4,2))
3540 SEC=VAL(MID$(T$,7,2))
3550 T=HR + MIN/60 + SEC/3600
3600 H=15*DEGRAD*(SN-T) :REM hour angle in radians; +=AM, -=PM
```

```
3610 SINEL=SINLAT*SINDEL + COSLAT*COSDEL*COS(H)
3620 COSEL=SQR(1-SINEL^2)
3710 EL=ATN(SINEL/COSEL)
3730 ELDEG=EL*RADDEG :REM solar elevation in degrees above horizon
3734 IF ELDEG<0   THEN ELDEG=0
3736 IF ELDEG>90  THEN ELDEG=90
3740 RETURN
3998 REM ------------------------------------------------------------------------
4000 REM subroutine: compute instantaneous solar azimuth (following el above)
4005 IF ELDEG=0 THEN AZDEG=0 : RETURN :REM sun below horizon
4010 SINAZ=-COSDEL*SIN(H)/COSEL
4020 COSAZ=SQR(1-SINAZ^2)
4030 AZ=ATN(SINAZ/COSAZ)
4040 AZDEG=AZ*RADDEG +180 :REM solar azimuth: N=0, E=90, S=180, W=270 degrees
4050 IF AZDEG<0   THEN AZDEG=AZDEG+360
4060 IF AZDEG>=360 THEN AZDEG=AZDEG-360
4070 RETURN
4498 REM ------------------------------------------------------------------------
4500 REM subroutine: accept new operating mode from keyboard
4540 INKEYBUF$=INKEY$ :IF INKEYBUF$="" GOTO 4590
4550 IF (INKEYBUF$<"2") OR (INKEYBUF$>"8") GOTO 4590
4552 IF INKEYBUF$="7" GOTO 4590  :REM track/eph not selectable
4560 MODE% = VAL(INKEYBUF$)
4580 GOSUB 2000 :REM display menu
4590 IF ELDEG=0 THEN IF MODE%>4 THEN MODE%=4 : GOSUB 2000 :REM sundown stow
4700 RETURN
```

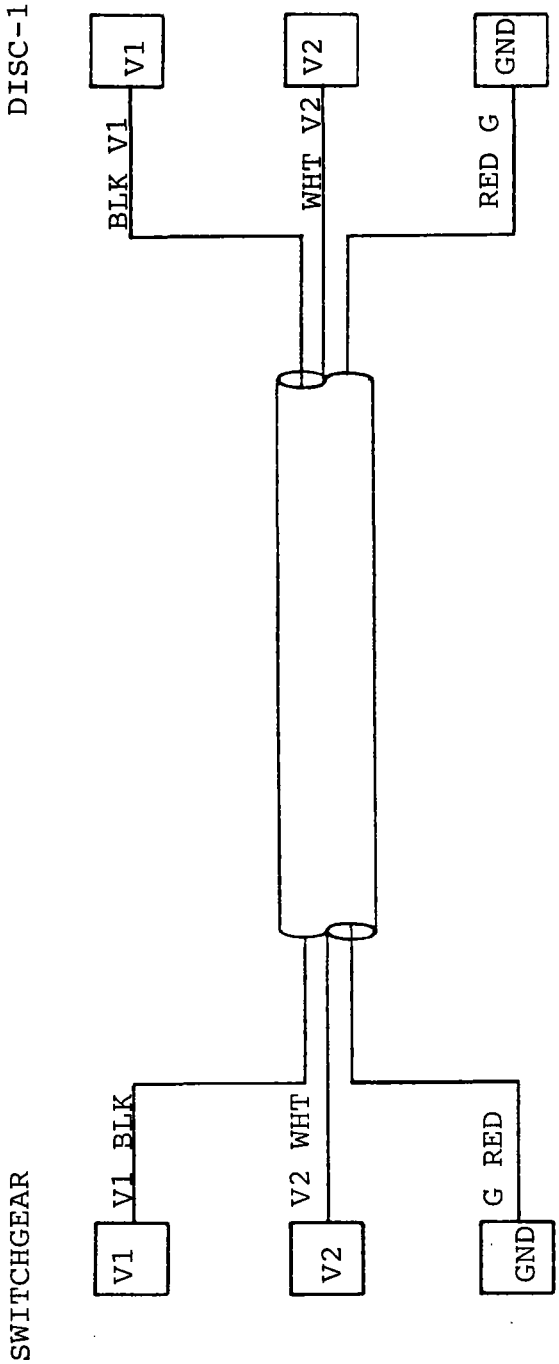
APPENDIX L

PLC-2 PROGRAM

```
 10 REM WDOG2 I^2R WATCHDOG PROGRAM
 20 REM ACUREX/EED INNOVATIVE SOLAR CONCENTRATOR
 30 REM REV 1.0 25SEP85 LES DOSS
 50 DO(7,4)=1
100 IF DI(6,1)=1 DO(7,4)=0 : GOTO 200
110 IF MIN>0 GOTO 500 :REM ALARM
120 GOTO 100
200 WAIT NIB=2
210 IF DI(6,1)=0 TIME MIN=0 : TIME SEC=0 : GOTO 50
220 T=SEC+10 : TIME SEC=T
230 IF MIN>0 GOTO 500 :REM ALARM
250 GOTO 50
500 DO(7,2)=1 :REM INDICATOR ON --- ALARM CODE ---
510 IF DI(4,2)=1 IF DI(4,4)=1 GOTO 700 :REM CHECK STOW
520 DO(7,1)=1 :REM SLEW EL UP
530 DO(7,3)=1 :REM SLEW AZ CCW
700 DO(7,4)=0
800 IF DI(4,4)=1 DO(7,1)=0 :REM EL LIMIT
805 IF DI(4,3)=1 DO(7,1)=0 :REM EL LIMIT
810 IF DI(4,2)=1 DO(7,3)=0 :REM AZ LIMIT
815 IF DI(4,1)=1 DO(7,3)=0 :REM AZ LIMIT
850 GOTO 800
```

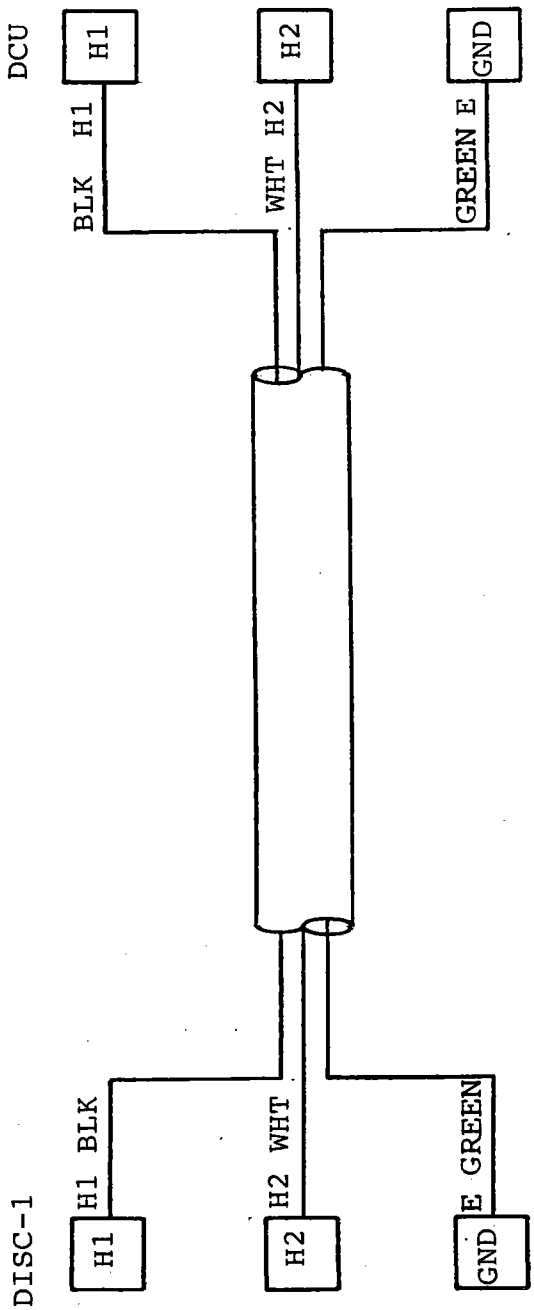
APPENDIX M

CABLE CONNECTION DIAGRAMS



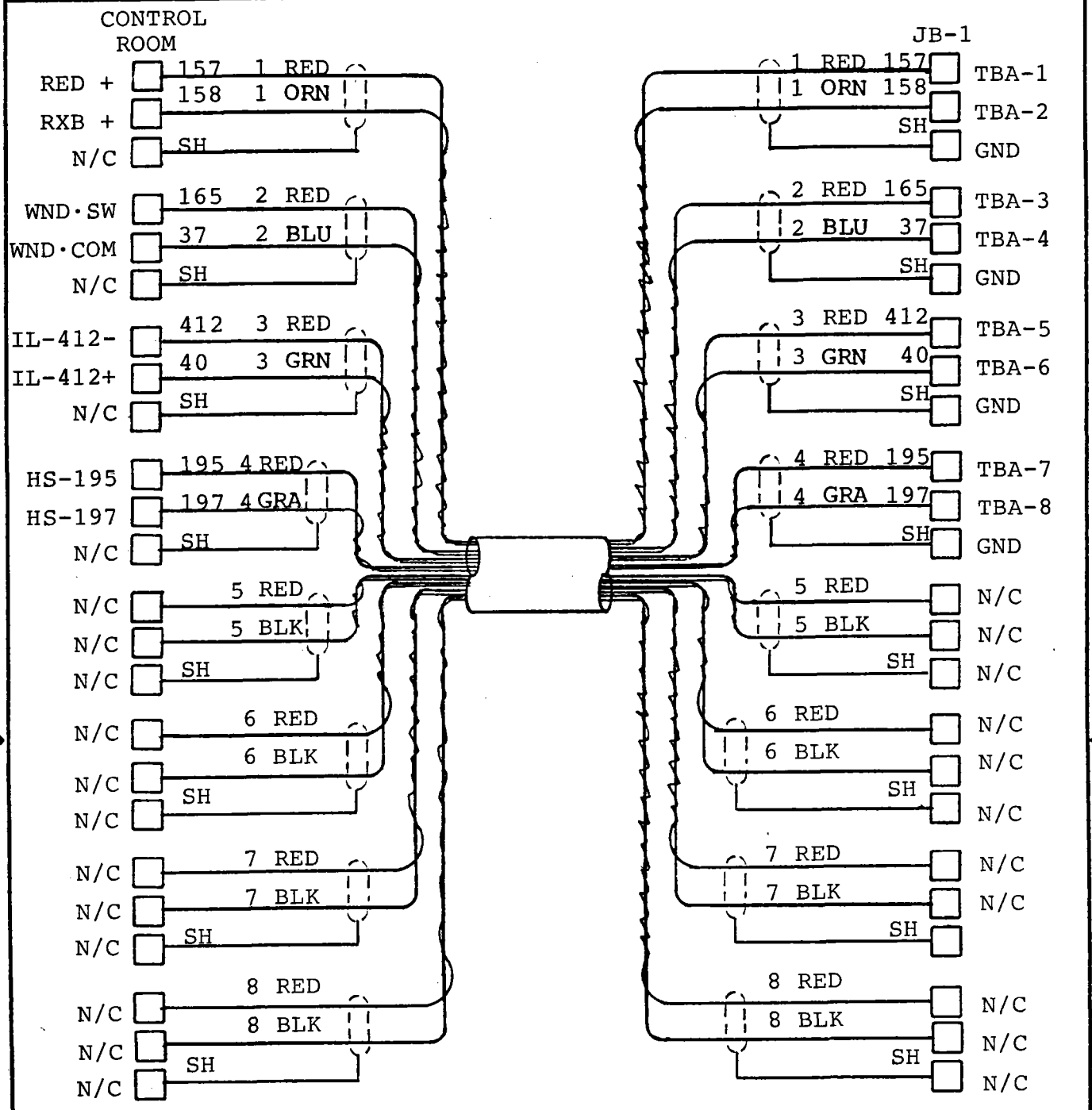
ACUREX Corporation	DOCUMENT TITLE	CABLE C-1 SWITCHGEAR TO DISC-1		
	SIZE A	CODE IDENT NO. 50726	DOCUMENT NO. 7749E308	REV A	SHEET 1 OF 2

Form EED-005 C 2/79



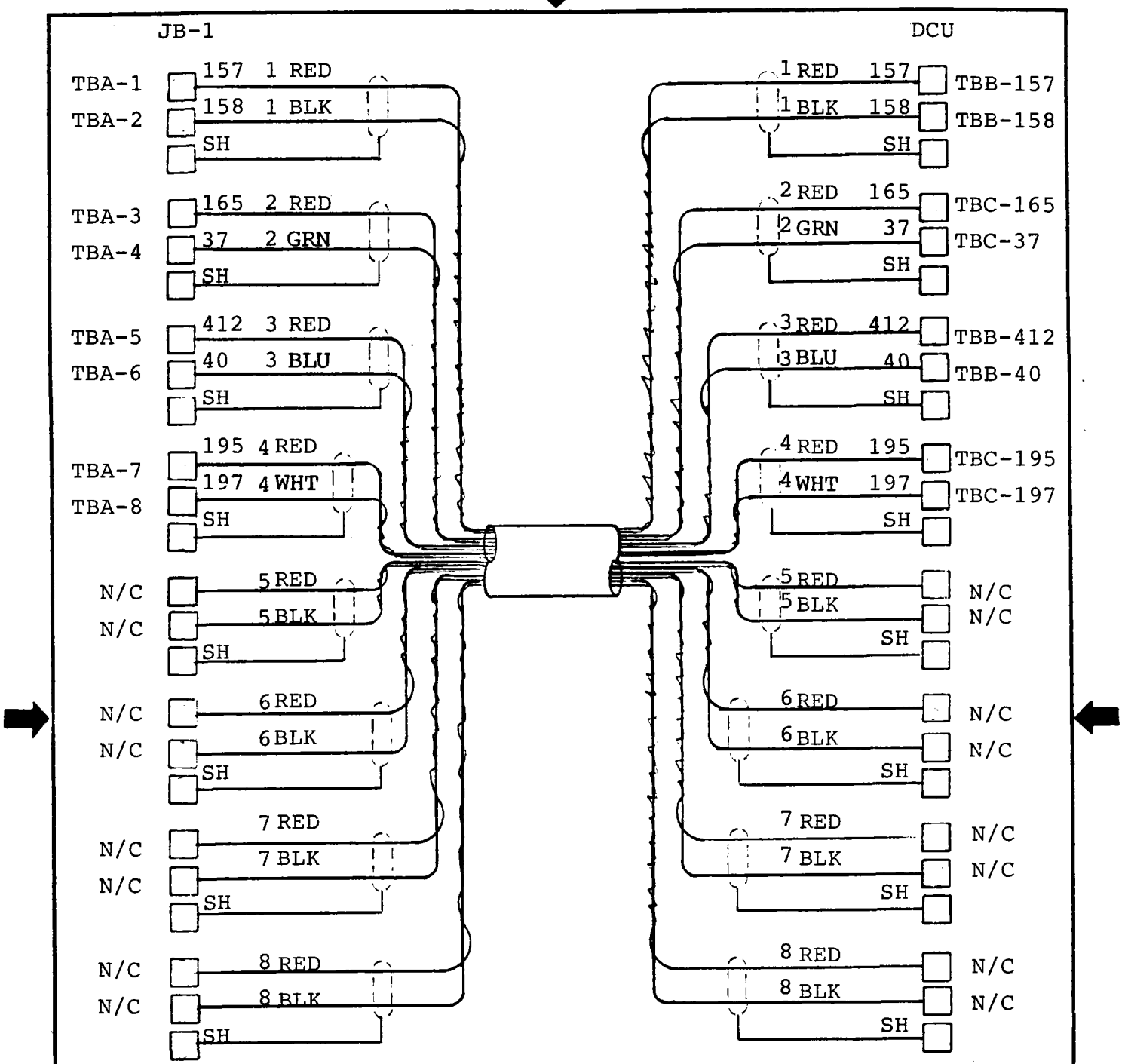
ACUREX Corporation	DOCUMENT TITLE	CABLE C-2 DISC-1 TO DCU		
	SIZE A	CODE IDENT NO. 50726	DOCUMENT NO. 7749E308	REV A	SHEET 2 OF

Form EED-005 C 2/79



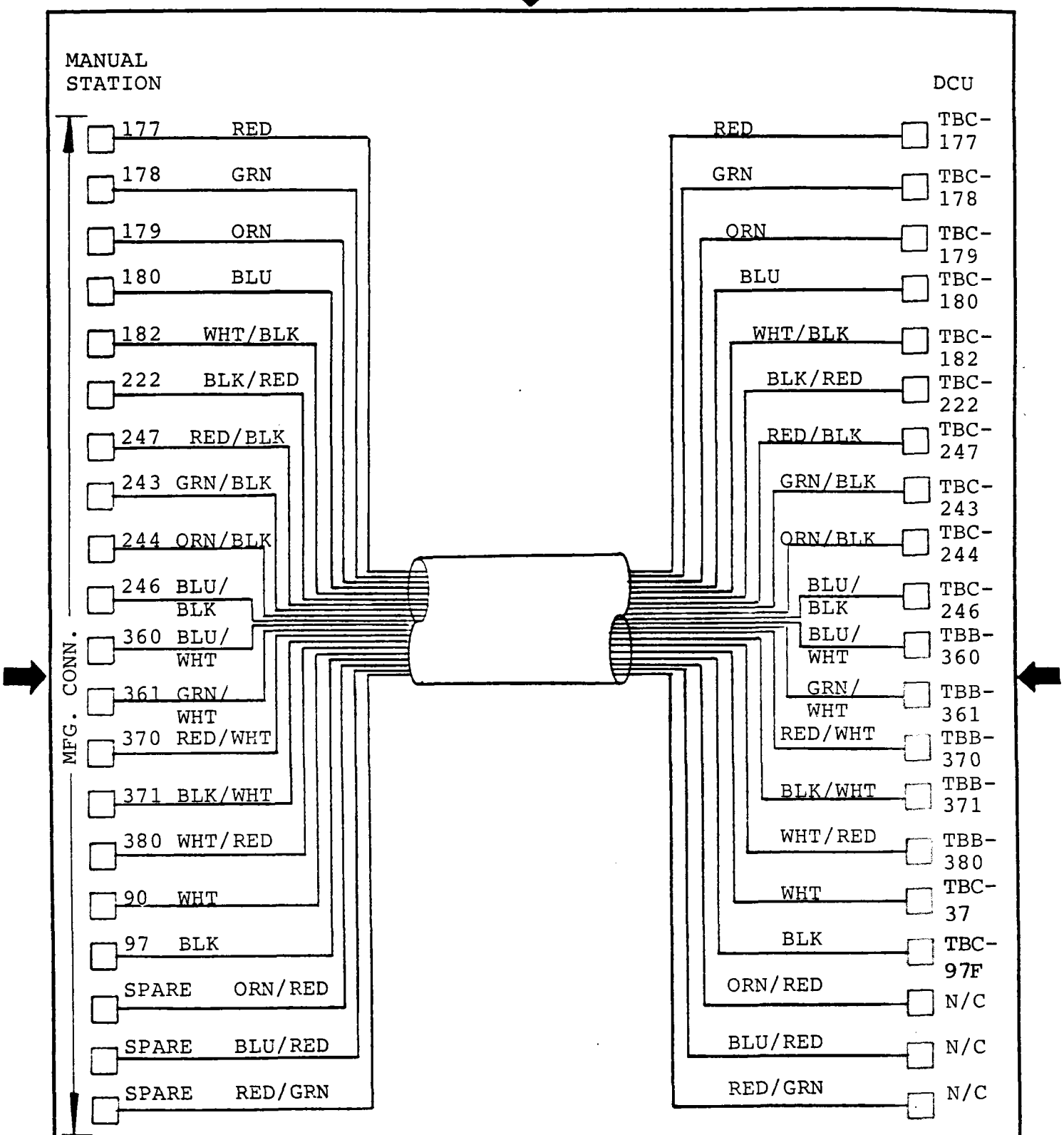
ACUREX Corporation	DOCUMENT TITLE	CABLE C-3 CONTROL ROOM TO JB-1			
	SIZE A	CODE IDENT NO. 50726	DOCUMENT NO. 7749E308	REV A	SHEET 3 OF

Form EED-005 C 2/79



ACUREX Corporation	DOCUMENT TITLE: CABLE C-4 JB-1 TO DCU				
	SIZE: A	CODE IDENT NO.: 50726	DOCUMENT NO.: 7749E308	REV: A	SHEET: 4 OF

Form EED-005 C 2/79



ACUREX Corporation

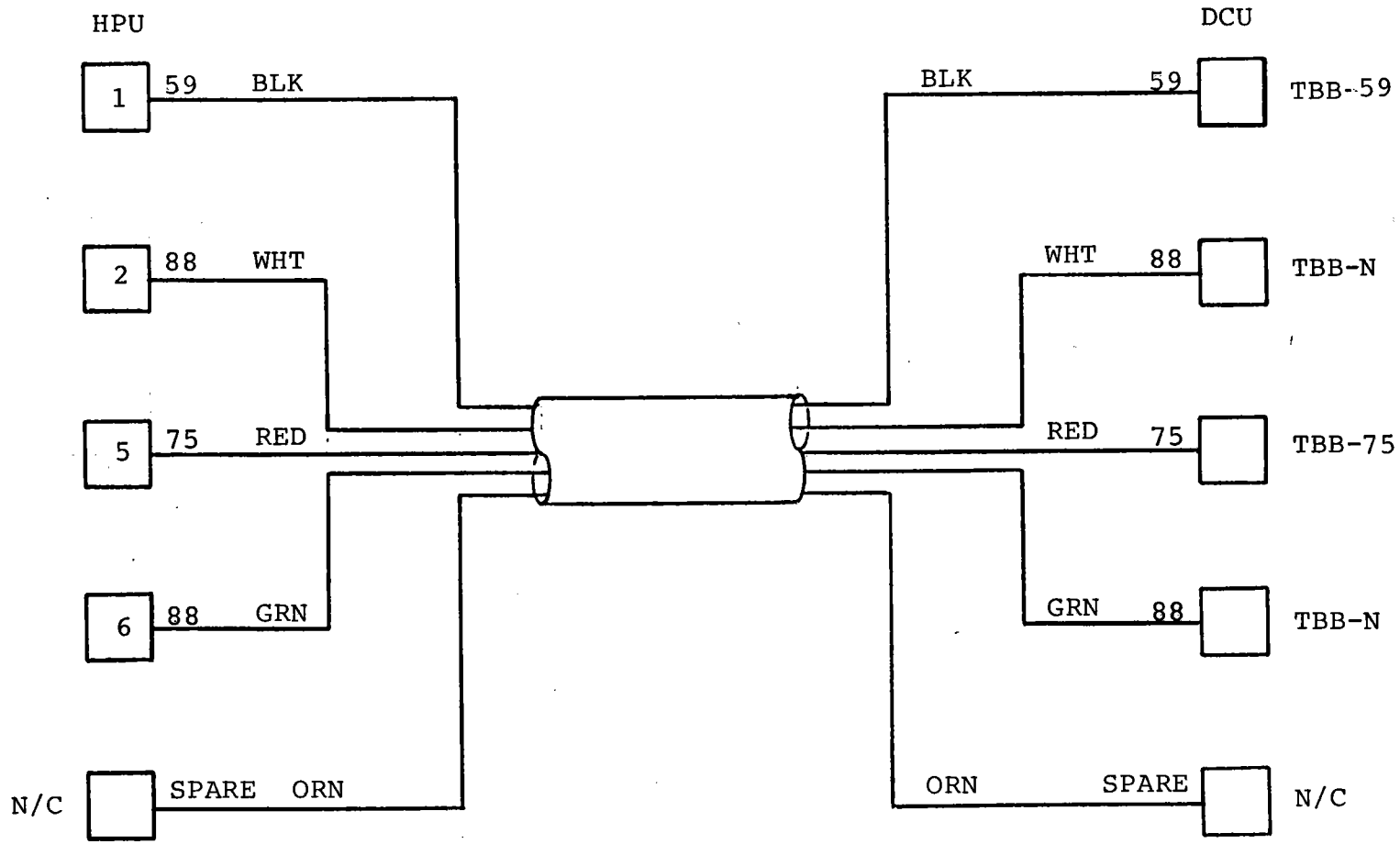
DOCUMENT TITLE	CABLE C-5 MANUAL STATION TO DCU			
SIZE	CODE IDENT NO.	DOCUMENT NO.	REV	SHEET
A	50726	7749E308	A	5 OF

Form EED-005 C 2/79

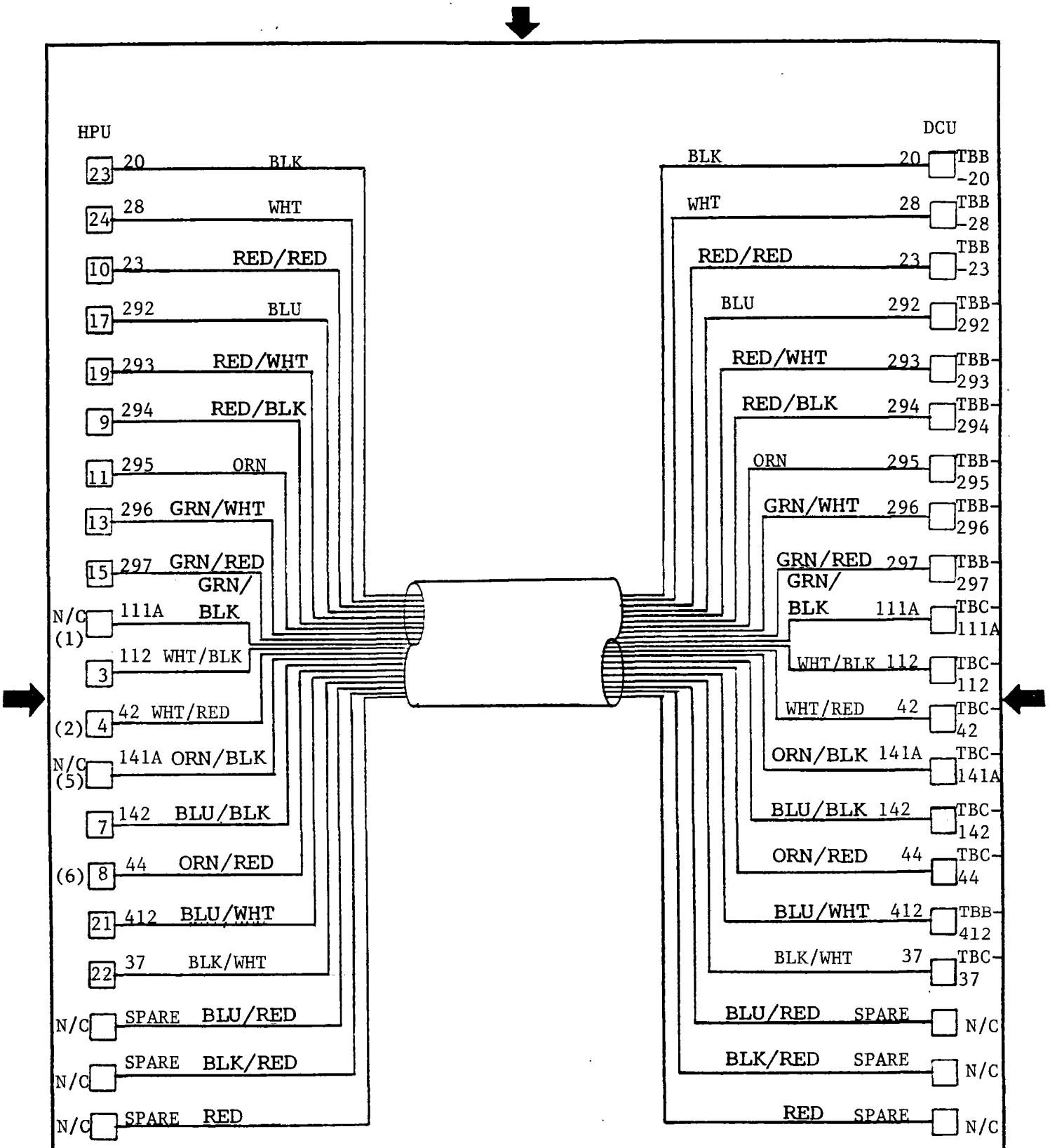
ACUREX Corporation

SIZE	CODE IDENT NO.	DOCUMENT NO.	REV	SHEET
A	50726	7749E308	A	6 OF

DOCUMENT TITLE: CABLE C-6 HPU TO DCU



Note:
Jumper HPU terminals 3 and 4 together and terminals 7 and 8 together.

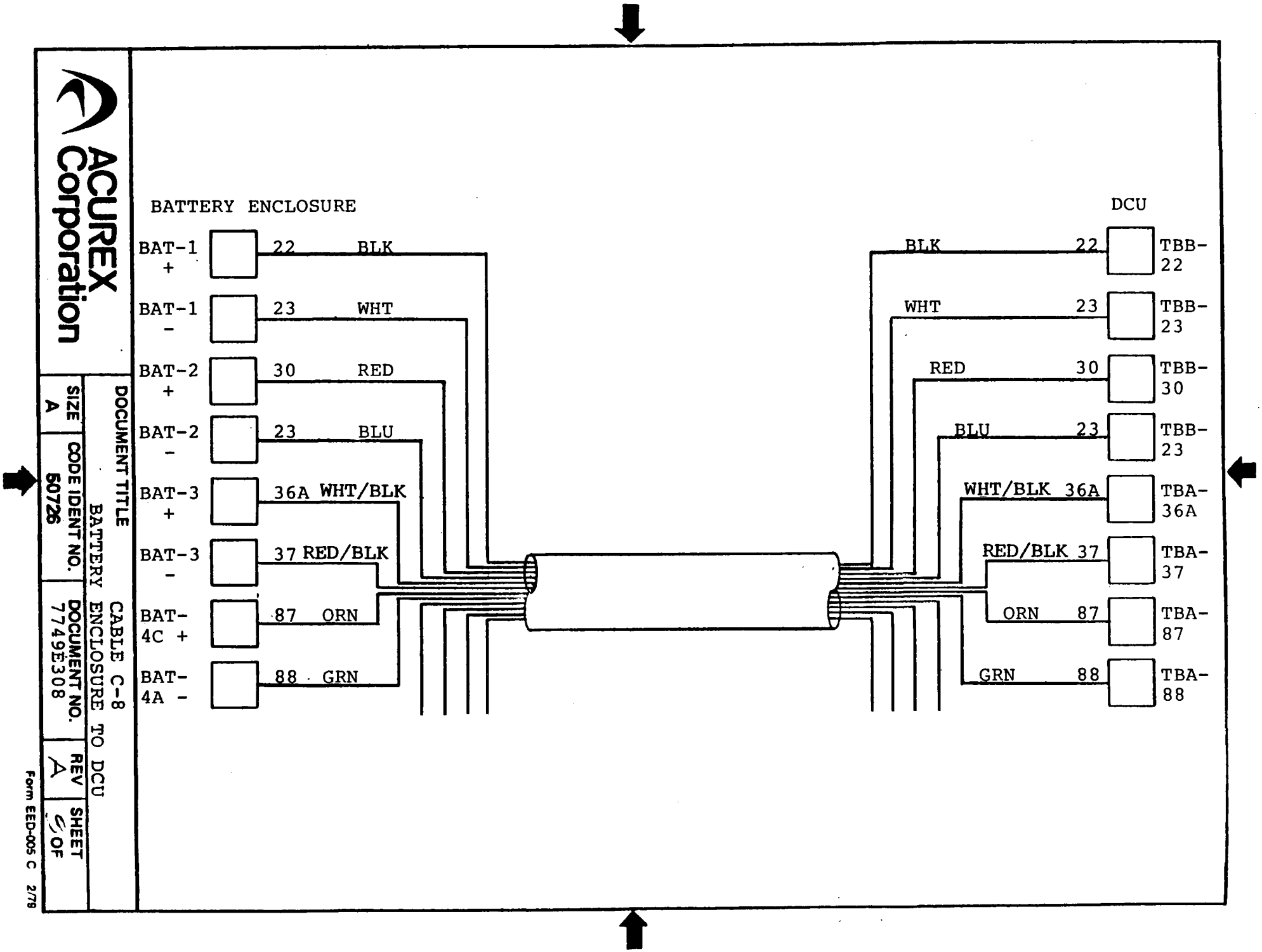


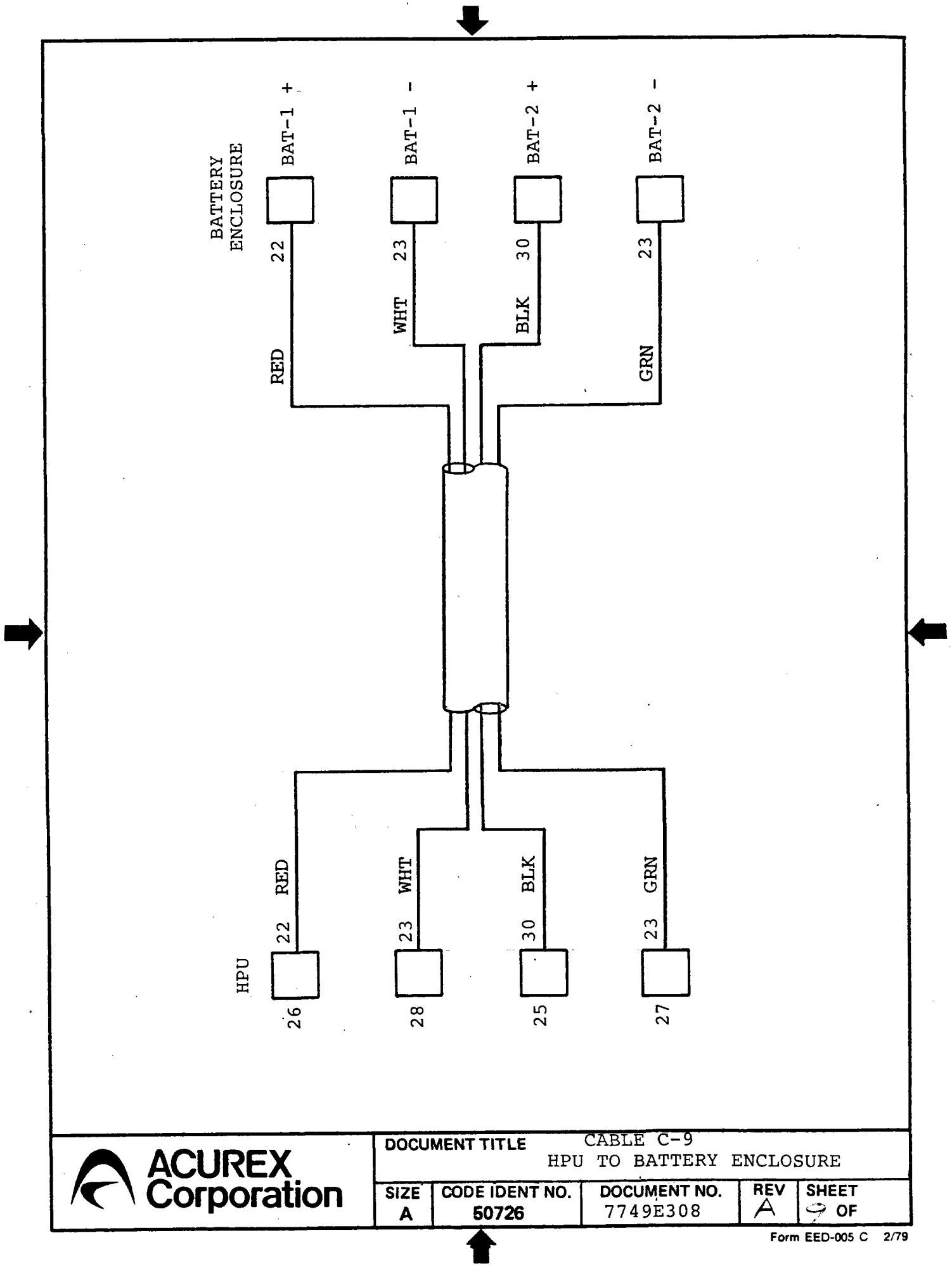
NOTE:

JUMPER HPU TERMINALS 10, 12, 14, 16, 18 AND 20 TOGETHER. TERMINAL CONNECTIONS IN PARENTHESES ARE TO BE COMPLETED ONLY AFTER HPU MOTOR CHANGE.

ACUREX Corporation

DOCUMENT TITLE	CABLE C-7 HPU TO DCU			
SIZE	CODE IDENT NO.	DOCUMENT NO.	REV	SHEET
A	50726	7749E308	A	7 OF


ACUREX Corporation
DOCUMENT TITLE
CABLE C-8
BATTERY ENCLOSURE TO DCU
SIZE A
CODE IDENT NO. 50726
DOCUMENT NO. 7749E308
REV A
SHEET 5 OF
Form EED-005 C 2/79
BATTERY ENCLOSURE
DCU
BAT-1 + 22 BLK
BAT-1 - 23 WHT
BAT-2 + 30 RED
BAT-2 - 23 BLU
BAT-3 + 36A WHT/BLK
BAT-3 - 37 RED/BLK
BAT-4C + 87 ORN
BAT-4A - 88 GRN
BLK 22 TBB-22
WHT 23 TBB-23
RED 30 TBB-30
BLU 23 TBB-23
WHT/BLK 36A TBA-36A
RED/BLK 37 TBA-37
ORN 87 TBA-87
GRN 88 TBA-88



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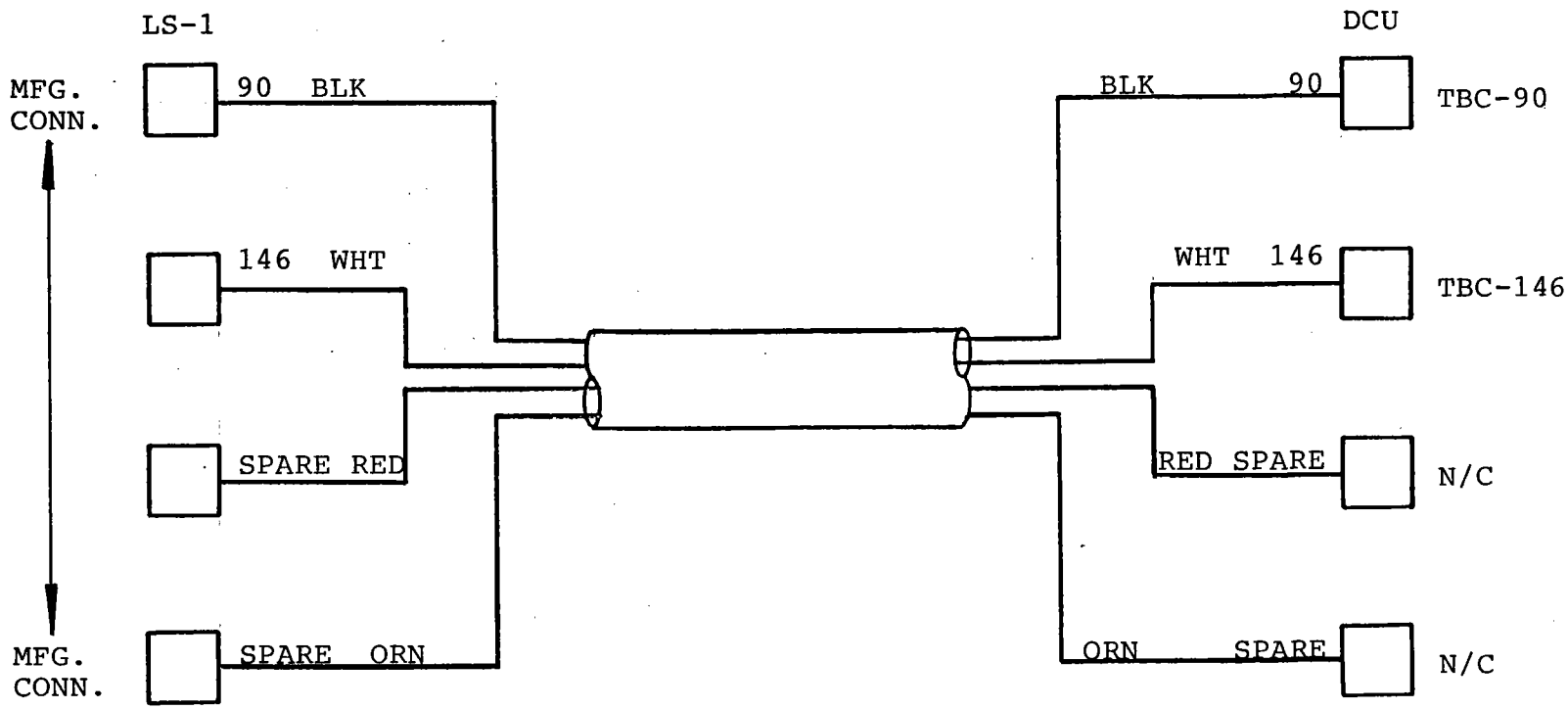

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LS-1 TO DCU

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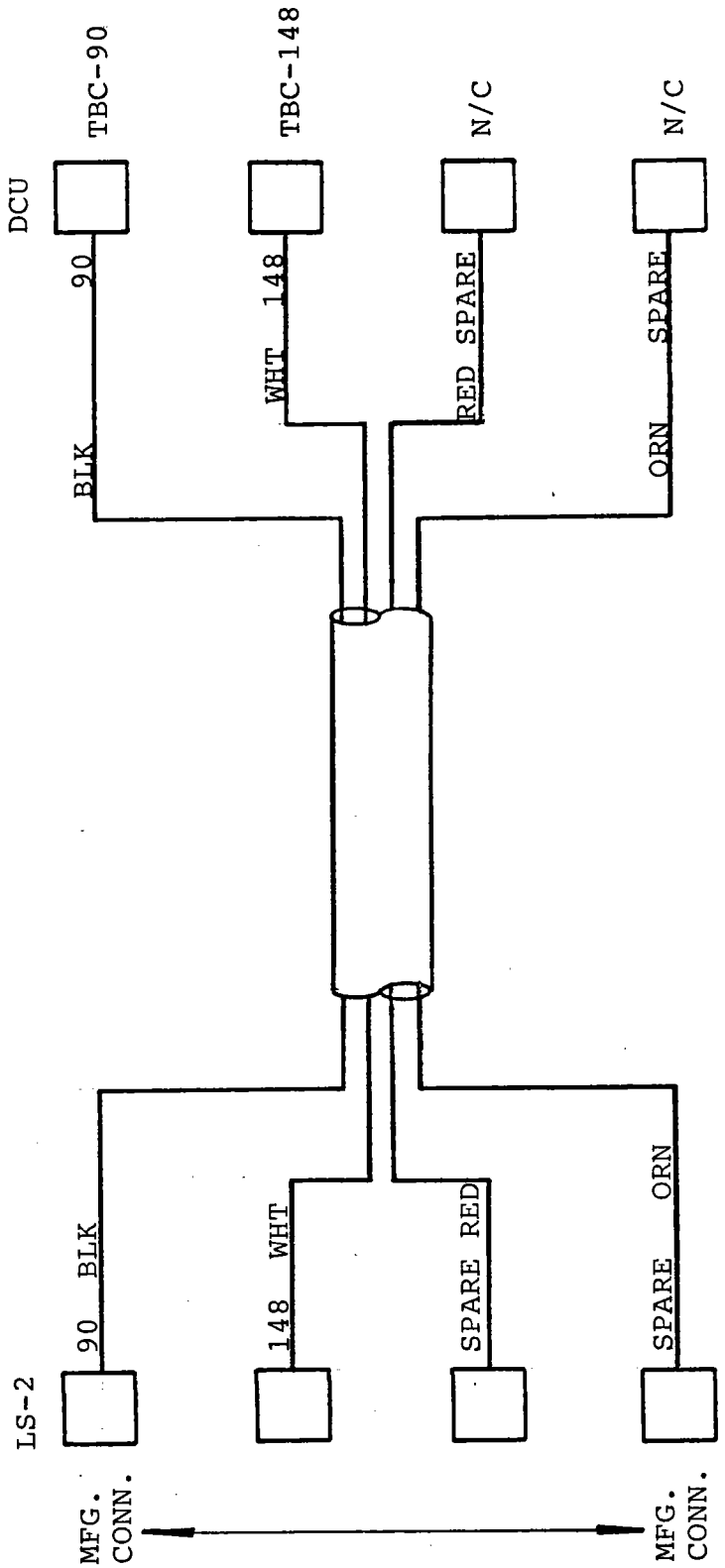

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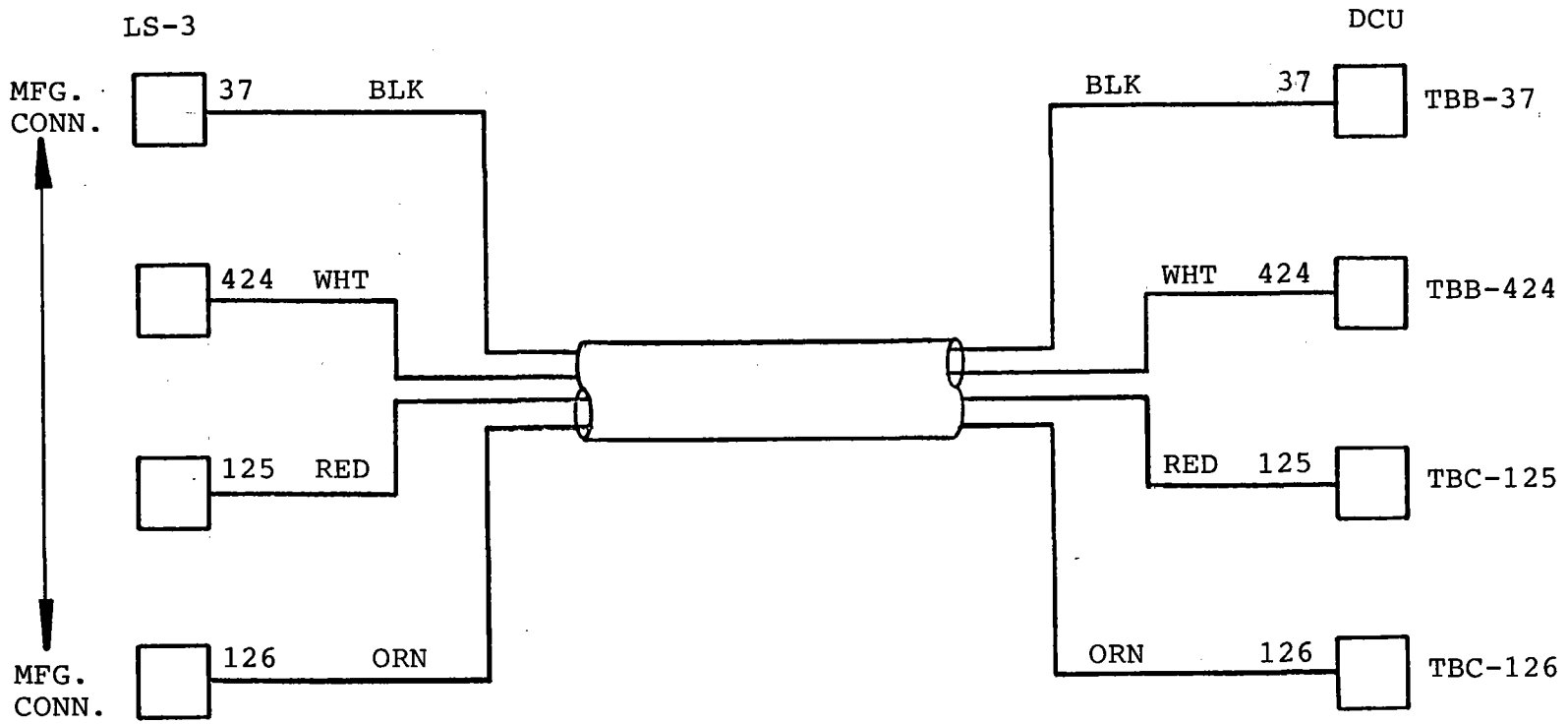

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LS-3 TO DCU

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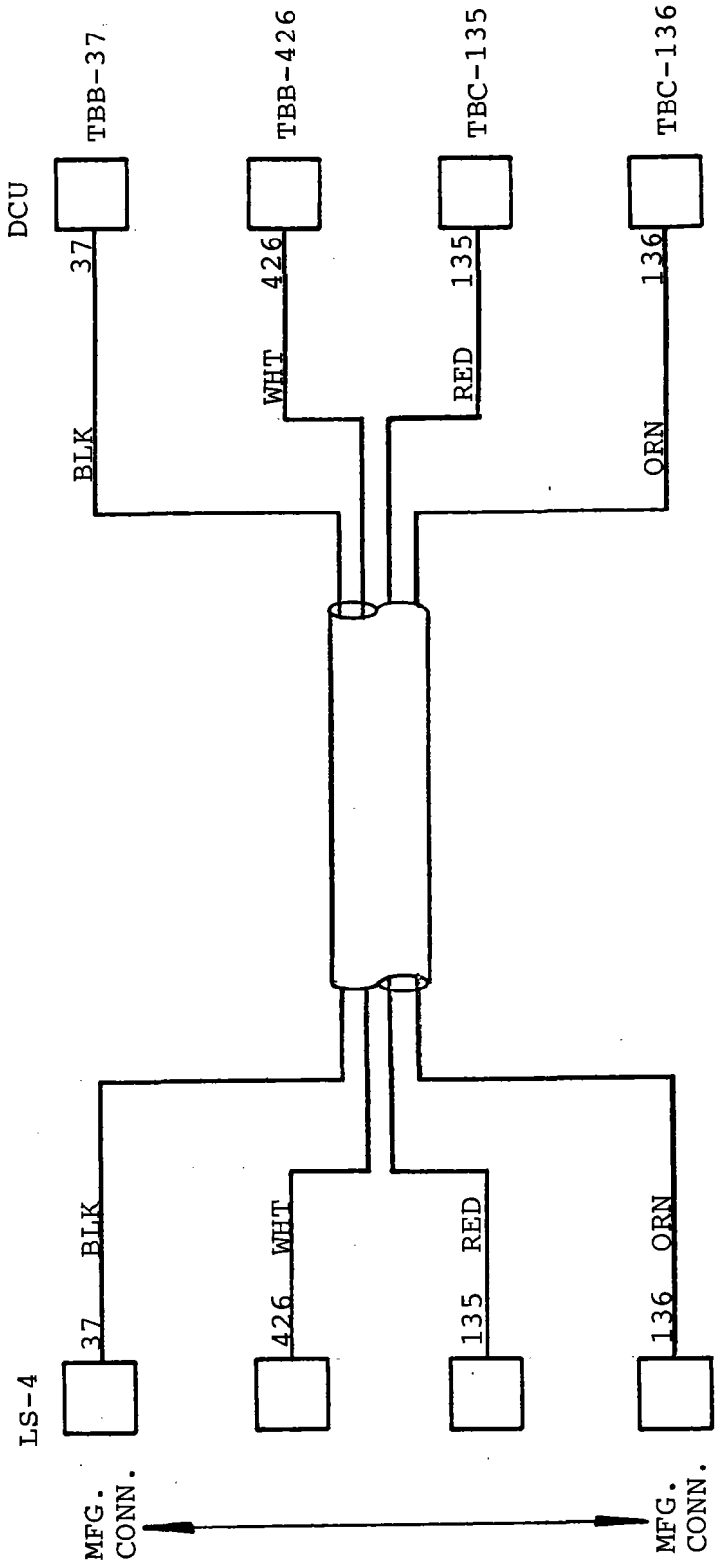

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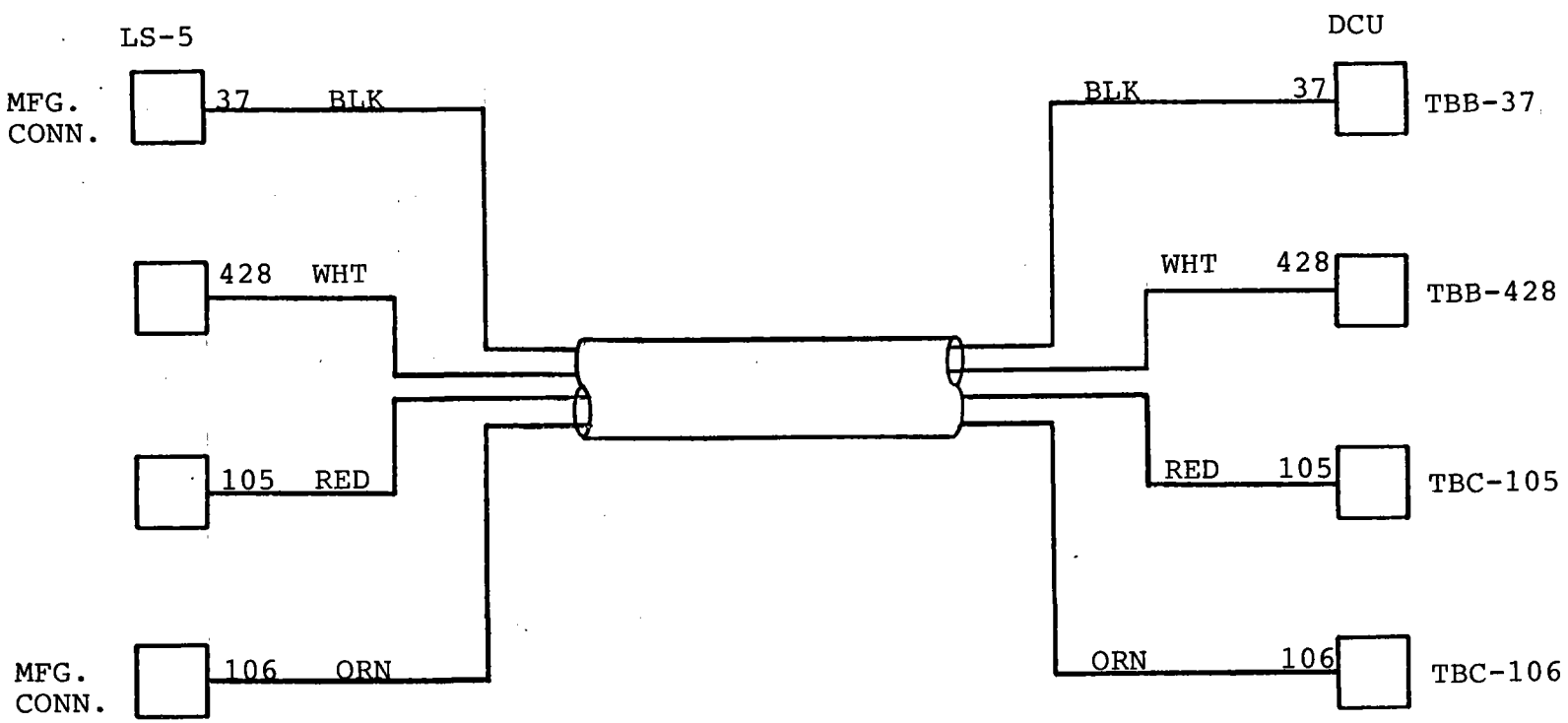

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LS-5 TO DCU

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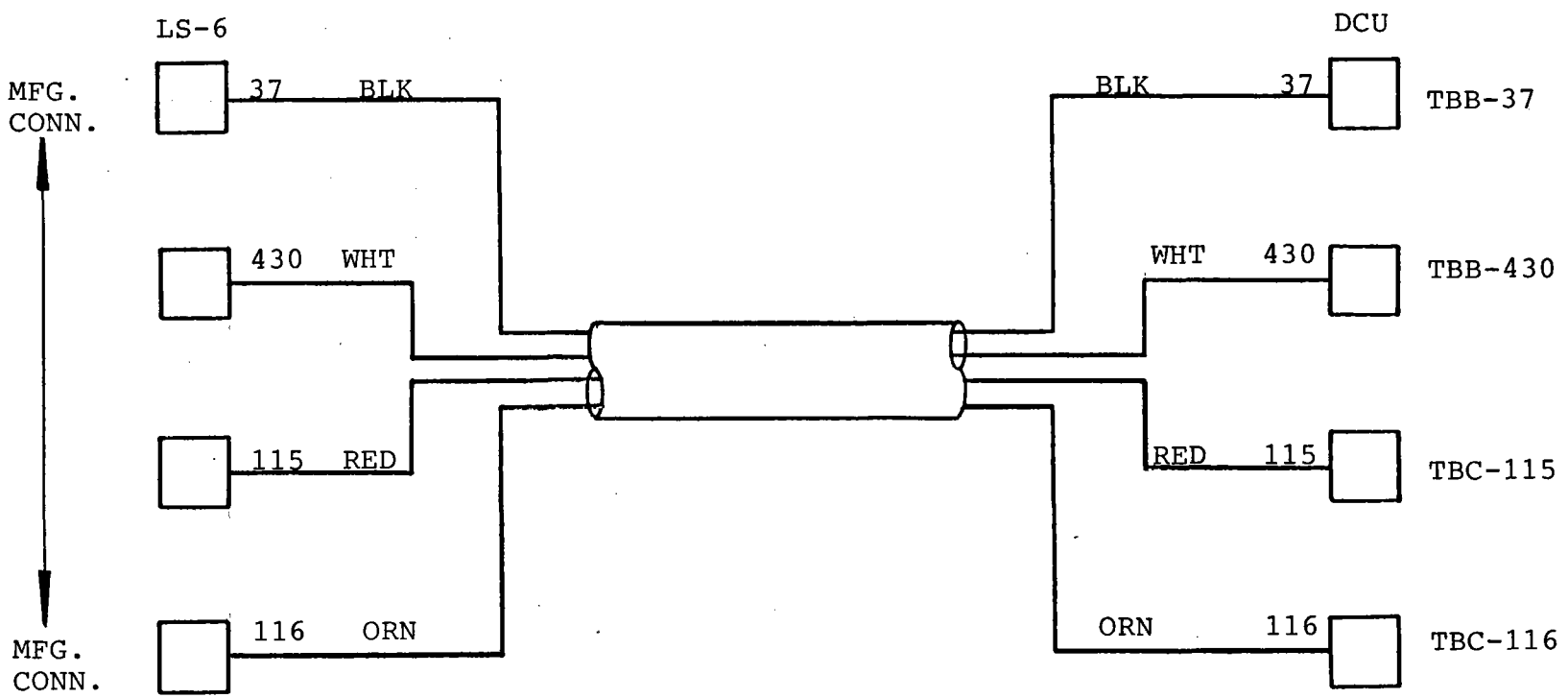

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DOCUMENT TITLE

CABLE C-15
LS-6 TO DCU

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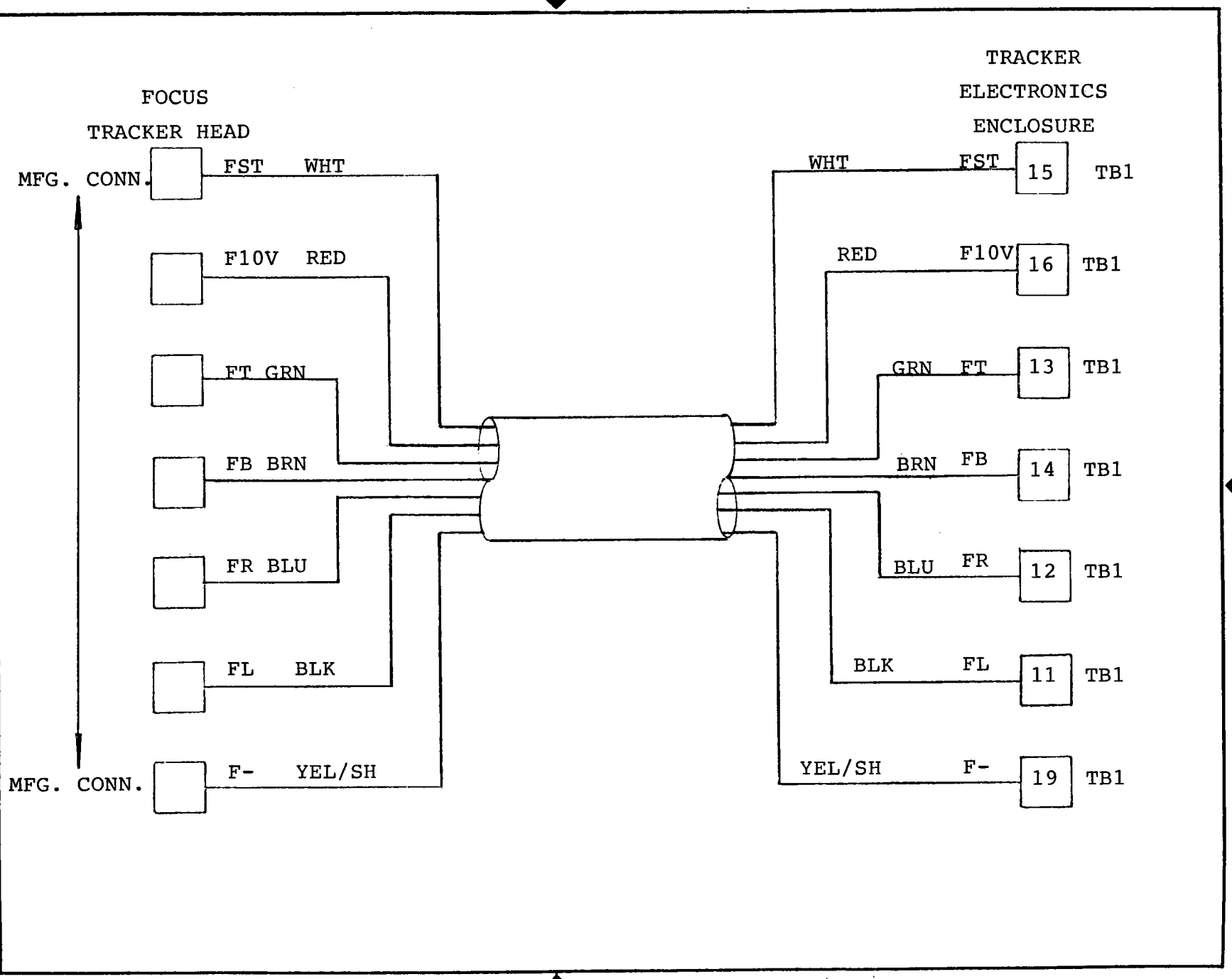

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DOCUMENT TITLE
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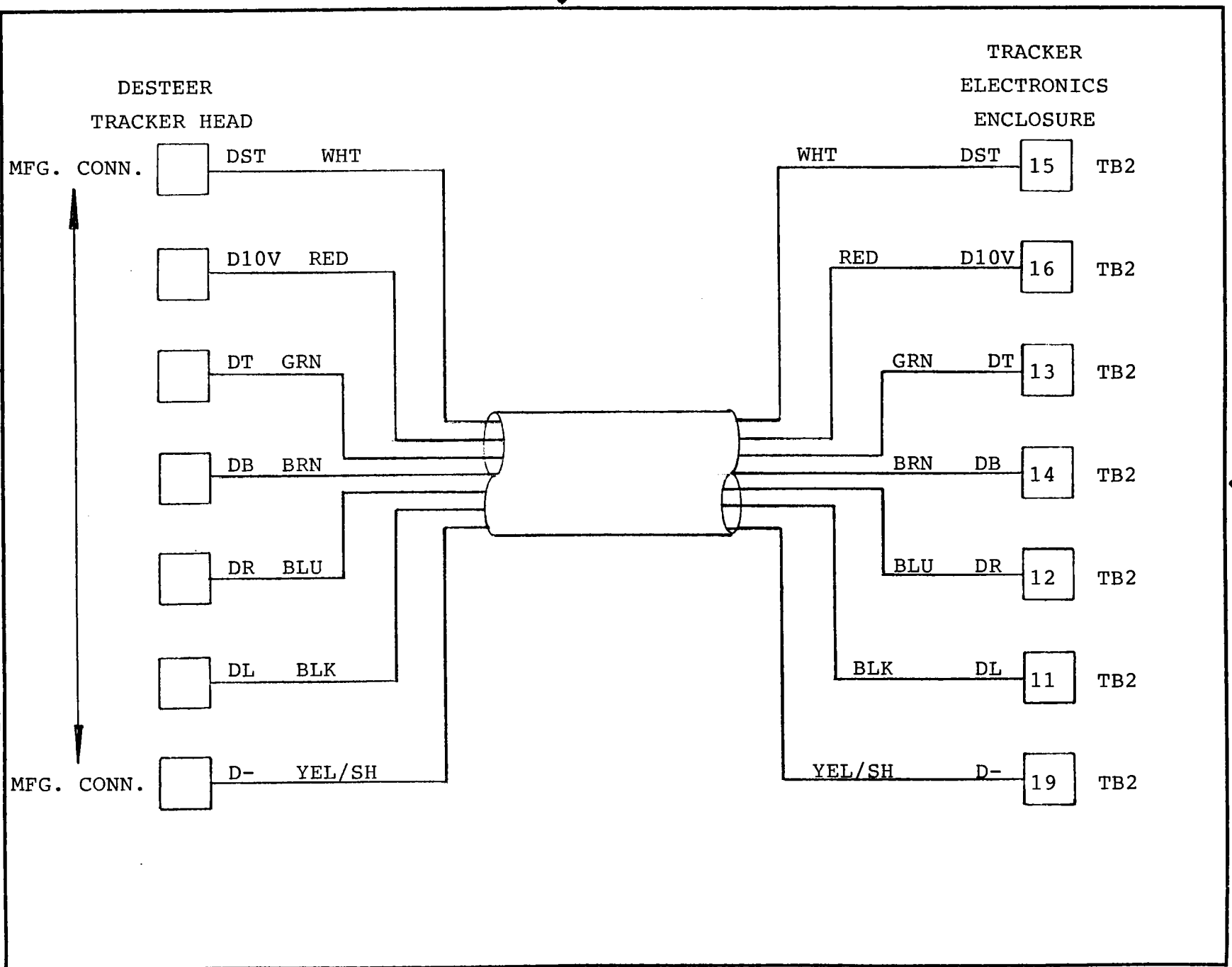

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DOCUMENT TITLE
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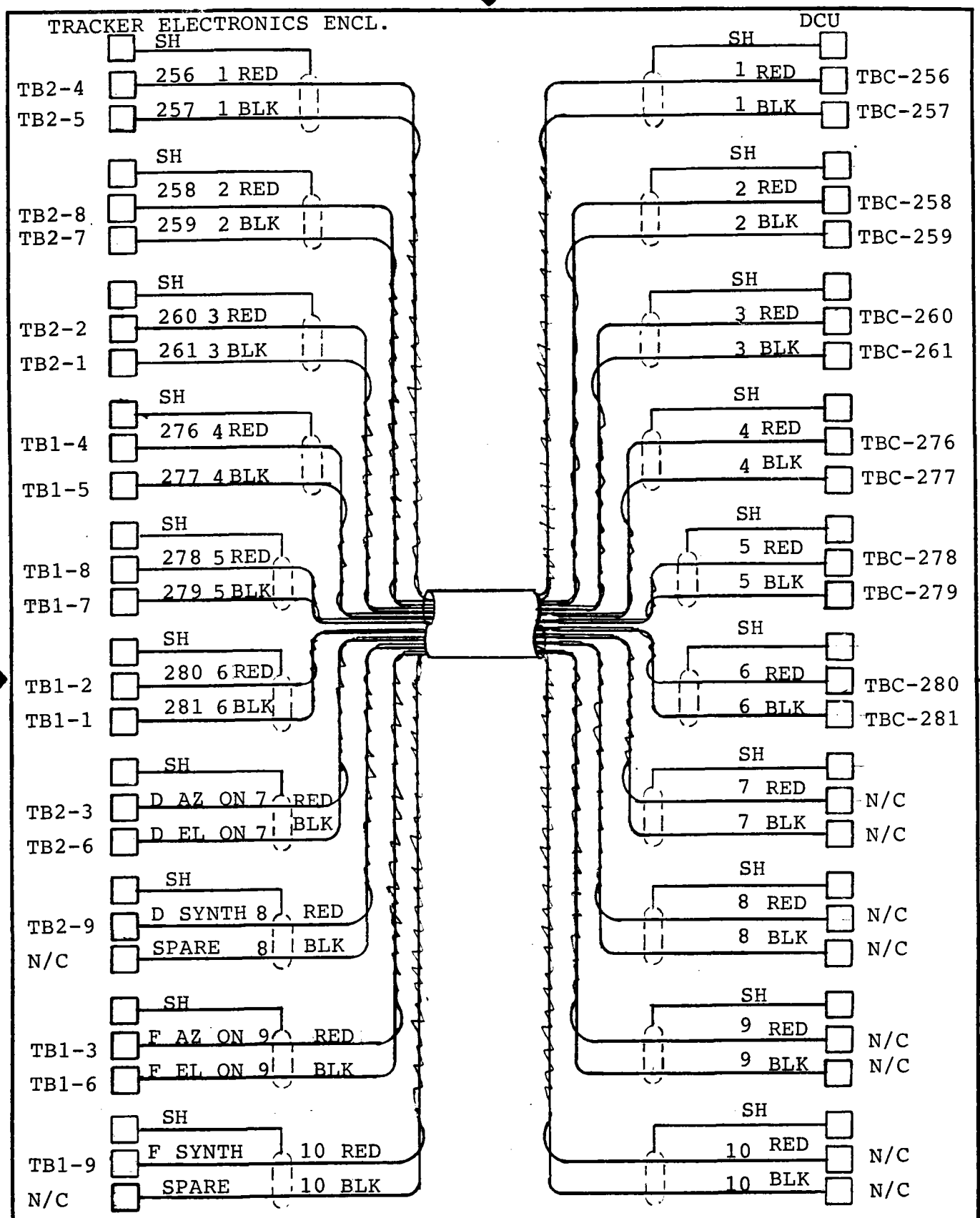

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TRACKER ELECTRONICS ENCLOSURE TO DCU				
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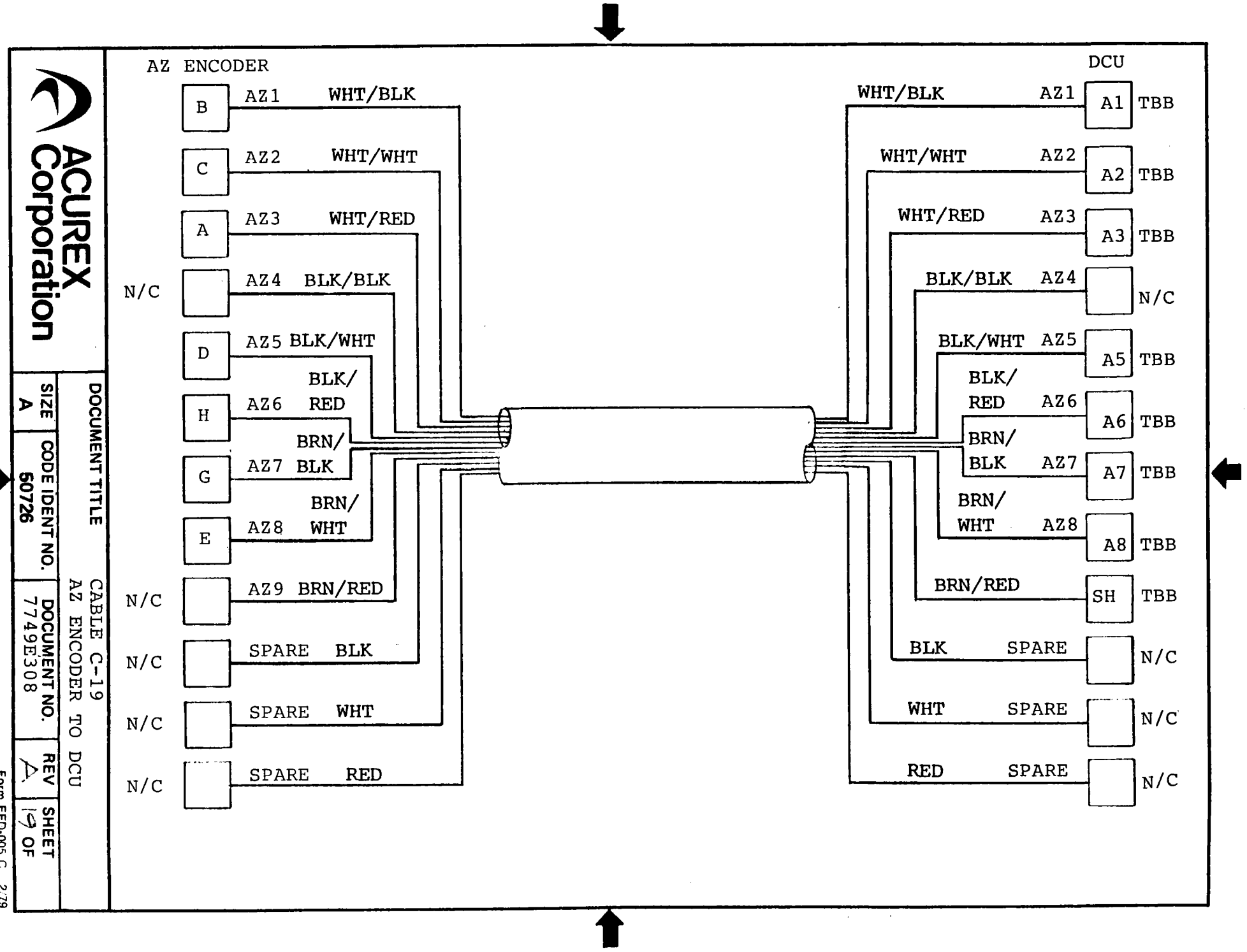

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DOCUMENT TITLE
CABLE C-19
AZ ENCODER TO DCU

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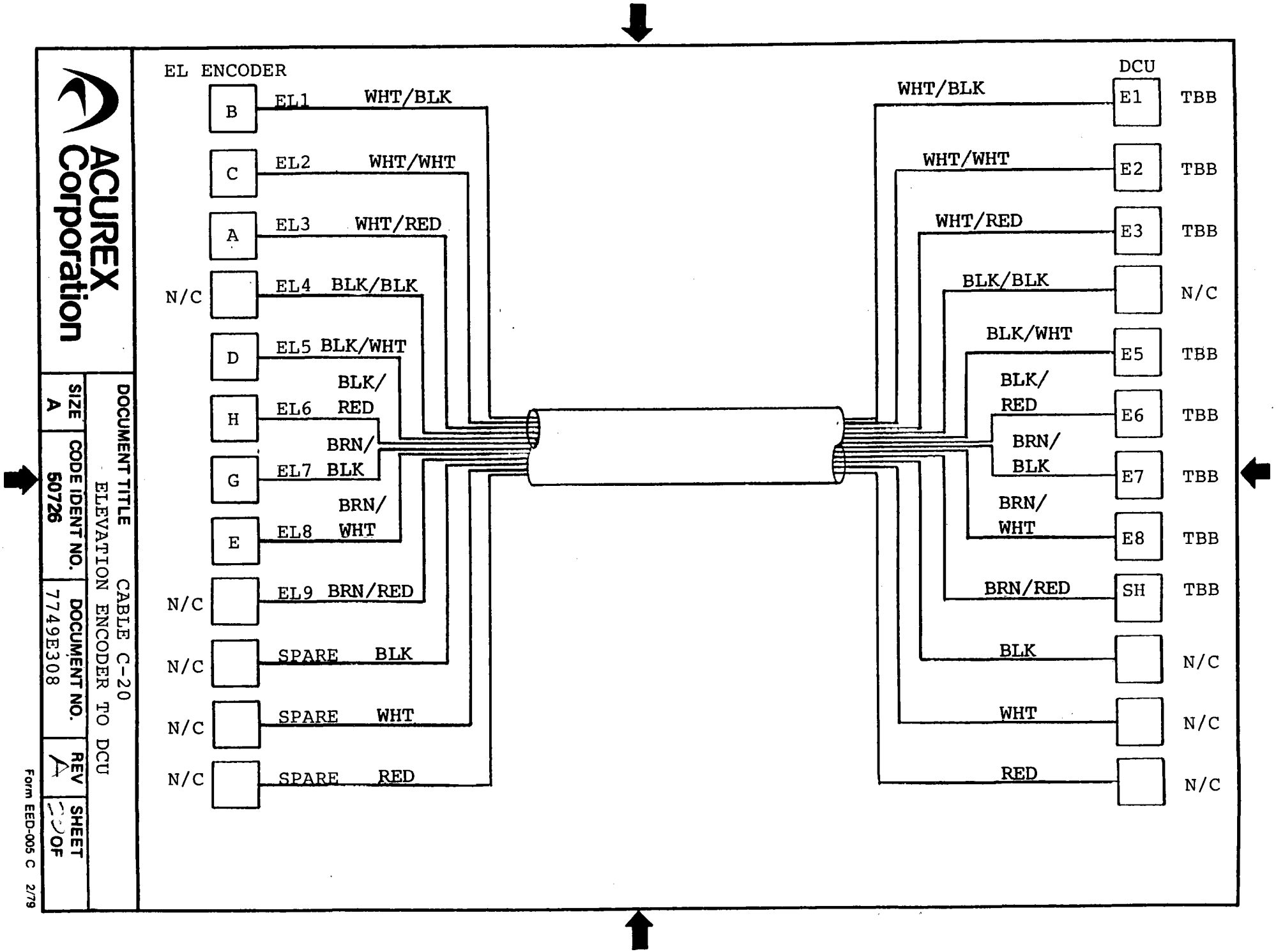
EL ENCODER
B
EL1 WHT/BLK
C
EL2 WHT/WHT
A
EL3 WHT/RED
N/C
EL4 BLK/BLK
D
EL5 BLK/WHT
H
EL6 BLK/ RED
G
EL7 BRN/ BLK
E
EL8 BRN/ WHT
N/C
EL9 BRN/RED
N/C
SPARE BLK
N/C
SPARE WHT
N/C
SPARE RED
DCU
WHT/BLK E1 TBB
WHT/WHT E2 TBB
WHT/RED E3 TBB
BLK/BLK N/C
BLK/WHT E5 TBB
BLK/ RED E6 TBB
BRN/ BLK E7 TBB
BRN/ WHT E8 TBB
BRN/RED SH TBB
BLK N/C
WHT N/C
RED N/C
ACUREX Corporation
DOCUMENT TITLE
CABLE C-20
ELEVATION ENCODER TO DCU
SIZE A
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DOCUMENT NO. 7749E308
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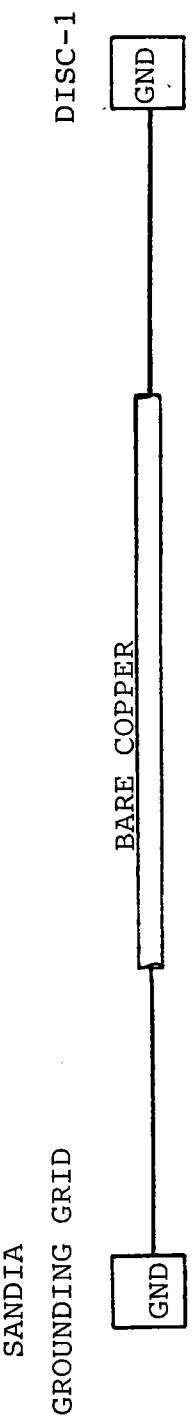

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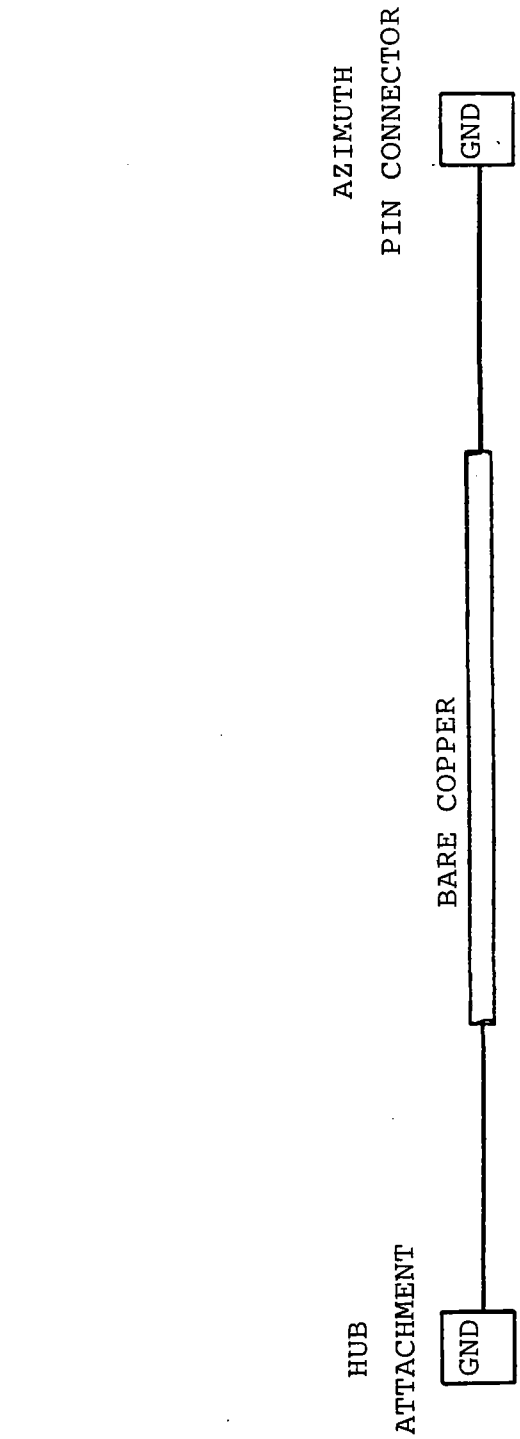

ACUREX Corporation

DOCUMENT TITLE	CABLE C-22 STRUCTURE GROUND			
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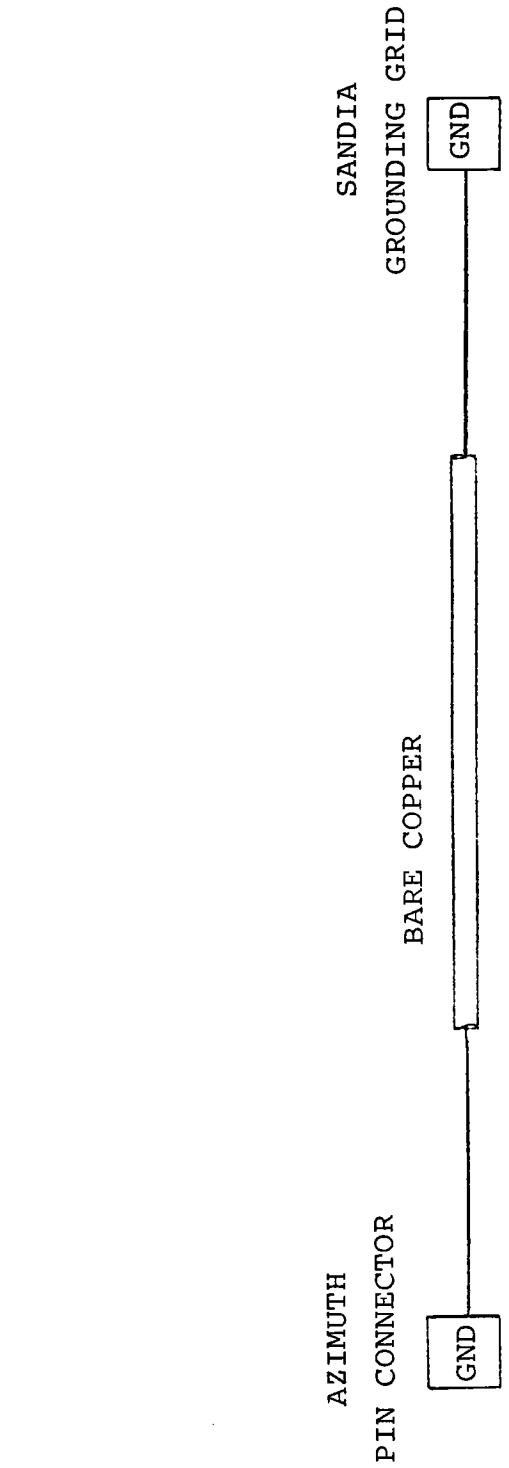

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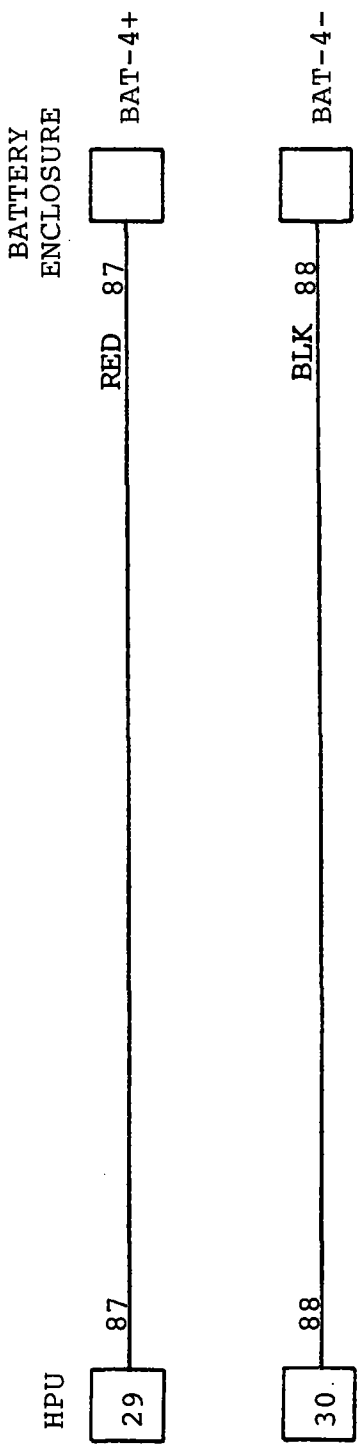

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APPENDIX N

ROTEK AZIMUTH BEARING

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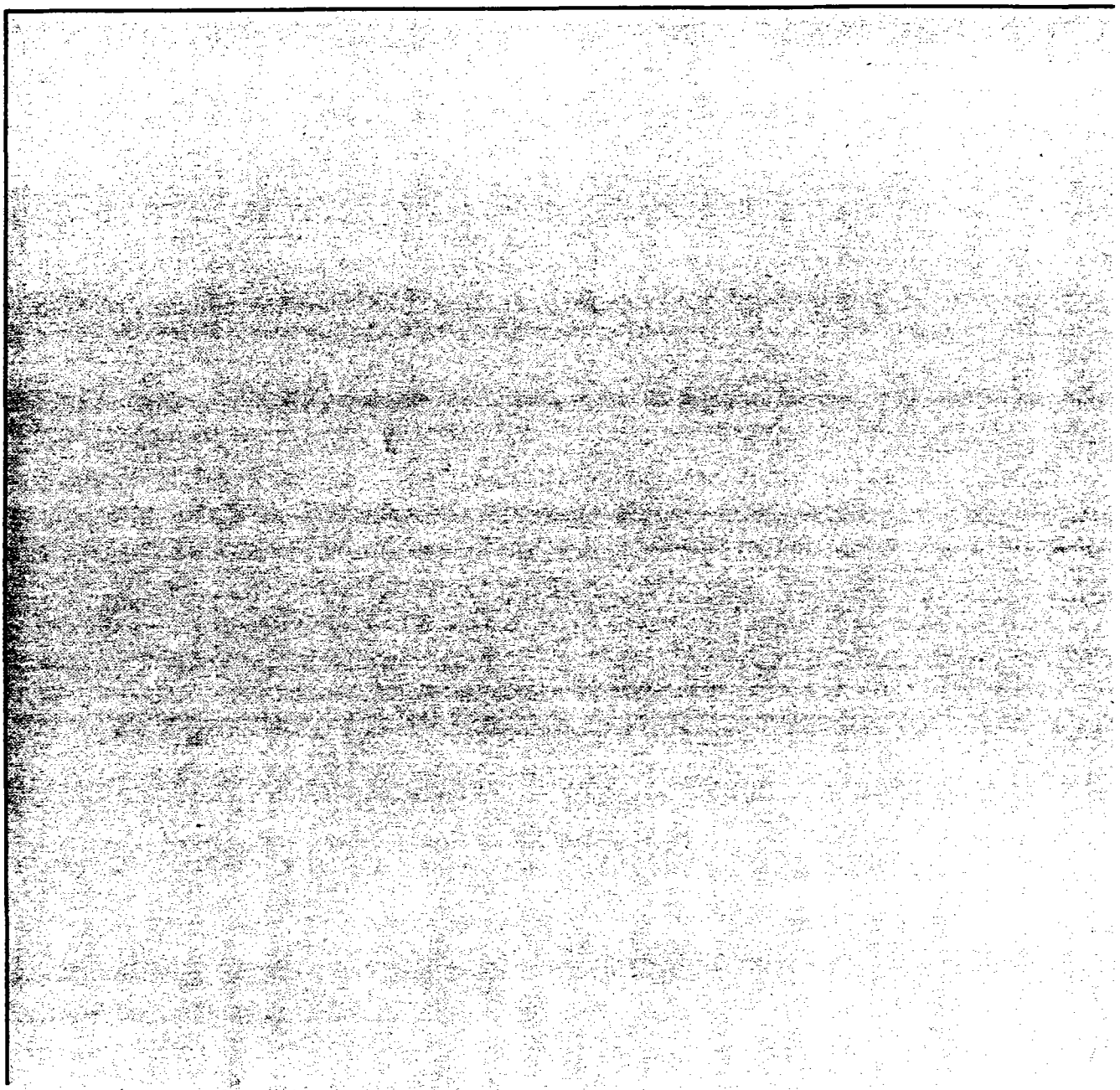

2.
Installation Manual 680

Introduction

Selecting a large-diameter bearing should be made in accordance with Rotek recommendations. Consult Rotek's most recent technical literature for selection procedures, or call Rotek and talk with an application specialist.

When selecting a bearing, double check the final machine design to see that the capacity of the bearing and fasteners has not been exceeded.

The satisfactory performance and life of large-diameter bearings depend on the design of the mounting structure, proper installation and maintenance.

This installation manual is furnished by Rotek as a guide to machine designers and manufacturers. For lubrication recommendations, consult the "Bearing Storage, Installation and Lubrication" booklet provided with this manual.

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Installation Manual on Fastening Bearings by welding available on request.

Revised May 1984
Supersedes all earlier editions

4.
Mounting Structure Requirements

There are no precise limitations in the out-of-flatness and rigidity of a bearing mounting surface that determine whether or not a particular bearing will function satisfactorily. The ideal mounting is infinitely rigid and perfectly flat. Although this ideal cannot be reached, there is no substitute for maximum uniform rigidity and optimum flatness. Localized concentration of stiff areas and extreme variations of stiffness over the circumference of the mounting structure should be avoided. For these reasons, we strongly recommend the use of a mounting ring, available from Rotek, as the mounting surface for the bearing.

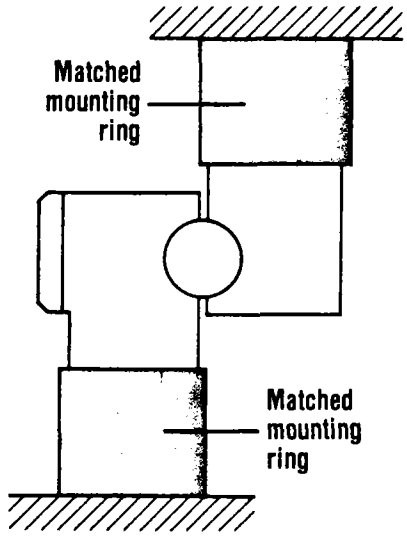
The entire mounting surface for the mounting ring must be machined after all fabrication of the structure is completed. Distortion of this machined surface will result if structural members are welded-on after surface machining. Rotek's recommendations for mounting surface error are shown in Table 1.

Increased rigidity of the mounting structure and improved surface accuracy will tend to enhance smoothness of operation, reduce friction, and increase bearing life. In any bearing the requirement for increased rigidity and accuracy becomes more critical under the following conditions:

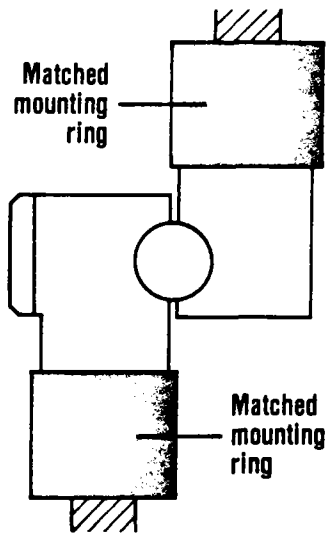
1. Increasing loads
2. Decreasing diameter
3. Thinner bearing section
4. Reduced internal clearance
5. Continuous or frequent rotation — as opposed to intermittent rotation
6. Applications where drive power is limited or minimum frictional torque is required for other reasons
7. Applications where minimum run-out is necessary
8. Roller bearings generally require better mounting structures than ball bearings

Where a bearing is mounted on a surface which is not reasonably flat, increased operating friction or premature fatigue failure can be expected as a result of unusually high ball or roller loads in localized areas.

Full interface support of the bearing is necessary to achieve rated load capacity and a long service life as well as to fully utilize the mounting bolt capacity.



Full interface support
Recommended



Partial interface support
Not recommended

Initial Mounting Surface Errors (out-of-flatness)

Table 1 provides maximum permissible values for out-of-flatness of the mounting structure, including the mounting ring, in most applications for various bearing designs.

Figure 1

The values for initial out-of-flatness given in Table 1 are the total of the errors measured in circumferential and radial directions (wavyness and tilt). The minimum arc over which the total error may occur is 90°. Furthermore, it must be approximately sinusoidal in form — there may be no abrupt irregularities in the mounting surfaces. Rotek wants to emphasize the tilt must be controlled because race geometry changes may cause premature bearing failure. This tilt should be limited to .001 inch/inch of bearing face width.

Table 1

Raceway diameter (inches)	Initial Mounting Surface Error (inches)		
	Double-row ball bearings	Single-row ball bearings	Triple-row roller bearings
Up to 40	0.008	0.006	0.004
40 to 60	0.010	0.0075	0.005
60 to 80	0.012	0.009	0.006
80 to 100	0.014	0.010	0.007
100 to 120	0.016	0.012	0.008
120 to 160	0.018	0.014	0.009
160 to 240	0.020	0.016	0.012

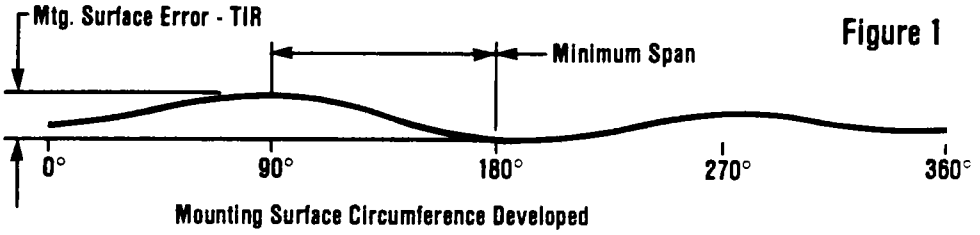


Figure 1

Deflection of Mounting Structure and Mounting Flange Under Load

In addition to the initial out-of-flatness errors as outlined above, the maximum deflection values in Table 2 may be tolerated by all styles of bearings.

As in the case of mounting surface error, the deflection of the mounting structure, including mounting ring, must not be localized since this may cause the balls or rollers to jam in the raceways. Therefore, the restrictions outlined in Figure 1 also apply for the rate of deflection over the circumference. Very substantial frictional torque may be expected in bearings subjected to the maximum deflections and flatness errors tabulated above. It is impractical to estimate the expected torque level. Rotek advocates the use of lower values than those shown in Tables 1 and 2 whenever practical.

Table 2

Raceway diameter (inches)	Maximum deflections under peak operating loads (inches)
40	0.024
60	0.030
80	0.040
100	0.052
120	0.064
140	0.080
160	0.100
180	0.120
200	0.144
220	0.168
240	0.192

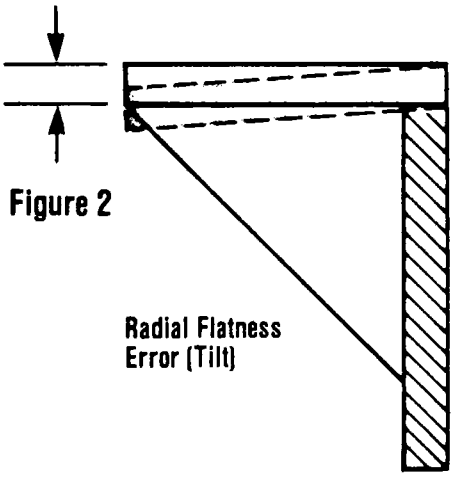


Figure 2

Figure 2

A quick way of measuring these out-of-flatness errors is to set the bearing in place without fastening it and check any existing gap with a feeler gage. If the actual mounting surface errors exceed the values in Table 1, Rotek recommends remachining.

6.
Mounting Structure Requirements

Access Holes for Filler Plug and Accessibility of Grease Fittings

Many styles of Rotek bearings are assembled by inserting the balls and spacers through a filler plug hole after which a plug is installed and secured by means of a retaining pin. The machine designer should consider providing an access hole in both the upper and lower mounting flanges to facilitate removal of the pin and filler plug, should this become necessary. See Figure 6. The Rotek proposal drawing shows the location of the pin.

Users are cautioned that removal of the retaining pin and plug will void the product warranty, unless performed with the express permission of Rotek.

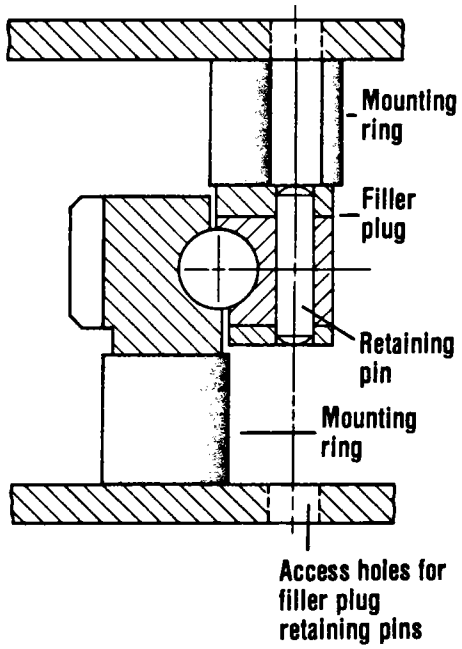
Extensions should be provided to facilitate relubrication through the bearing grease fittings. If the bearing can be rotated 720°, it is only necessary to lubricate the bearing through one grease fitting in each row of rolling elements. To ensure uniform distribution of grease throughout the bearing, the bearing should be rotated at least two complete revolutions while greasing. Extreme care must be taken when greasing and rotating any unit. Be sure that all personnel are clear of all moving parts of the machine during the rotating-greasing procedure. It is for this reason that we recommend installation of extension lines from the grease fitting locations to an area where the oiler will be safely clear of moving parts. For more information on the lubrication of Rotek bearings, see the copy of our "Bearing Storage, Installation, and Lubrication" booklet provided with this manual.

Checking Gear Backlash

The machine designer controls the amount of gear backlash in fixed center distance designs by specifying the location of the swing pinion with regard to the bearing mounting holes.

If the position of the either the swing drive or the bearing is adjustable (by means of oversize mounting holes, slots, etc.), the relative position must be adjusted to provide proper backlash between gear and pinion. On certain types of Rotek bearings the point of minimum gear clearance is marked with green paint covering two or three gear teeth. When installing such units on adjustable center applications, centers should be adjusted to provide minimum required backlash with the pinion engaging gear at the painted area. If the gears are not marked, backlash may be set by determining point of minimum backlash with Feeler Stock Gages and Setting for Low Limit.

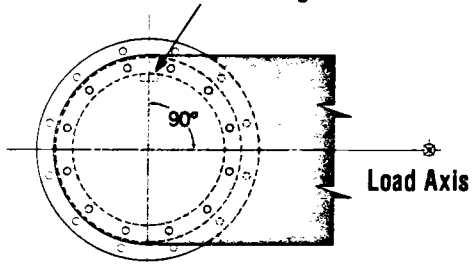
This procedure requires first bolting down the ungeared ring of the bearing to the structure carrying the pinion.



Recommended Position for Filler Plug and/or Hardness Gap on Rotating Ring

Most bearings have a small unhardened area in the raceway. In plug loaded rings this area is located at the plug. In rings without a plug, this area is stamped on the outer surface with the letter "S" for soft. The plug or soft area should be positioned 90° from the load axis when possible as indicated in Figure 3. In cranes or excavators this would put the plug or soft spot at the side of the machine on the ring which is connected to the upper structure.

Figure 3 Recommended position for filler plug or soft area on rotating race



Mounting Surface

Prior to mounting the mounting flange and the bearing, the mounting surfaces must be free of dirt, loose scale, burrs, chips, etc. Surfaces must be relatively smooth (125 to 250 micro-inch) and flat. Gaps resulting from an out-of-flat condition (see table 1) can close under high operating loads. This would reduce the distance from nut to bolthead, reducing or eliminating pretension and result in loosening the fastener or in leading to fatigue failure.

Stress in Fastening Members

The mounting bolts and mounting structures must be properly designed in order to transfer loads uniformly. Rotek strongly recommends supporting and fastening the bearing through the full 360° with equally spaced bolt patterns in both the stationary and rotating rings.

Stress in individual bolts will vary from one area to another. A strong, rigid, well-designed mounting structure and mounting flange will, however, help keep the stress variation to a minimum. A weak mounting structure will cause stress concentration which can result in failure of the fasteners and also of the bearing.

No bearing fastening method is secure if concentrated loading is tolerated.

There are many acceptable fabrication methods for developing a good, rigid structure. Box sections and well gusseted frames are the most common. Figures 4 and 5 show a comparison between adequate and weak flexible structures.

The use of high strength steels does NOT increase rigidity. Strain gaging of all highly stressed areas including weld bands and bolts is urged.

Figure 4

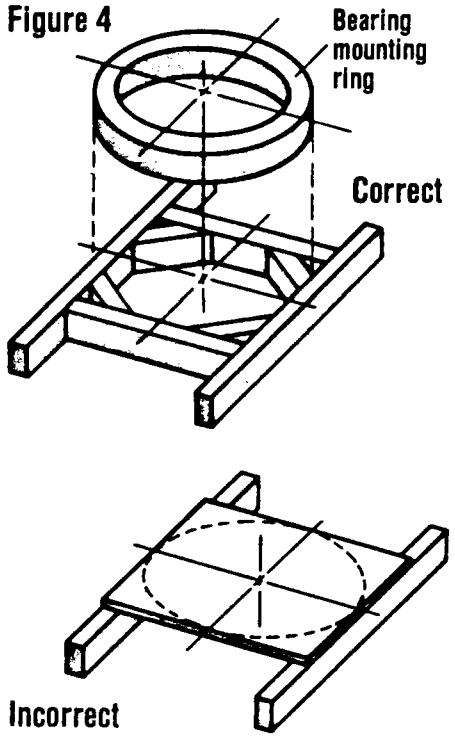
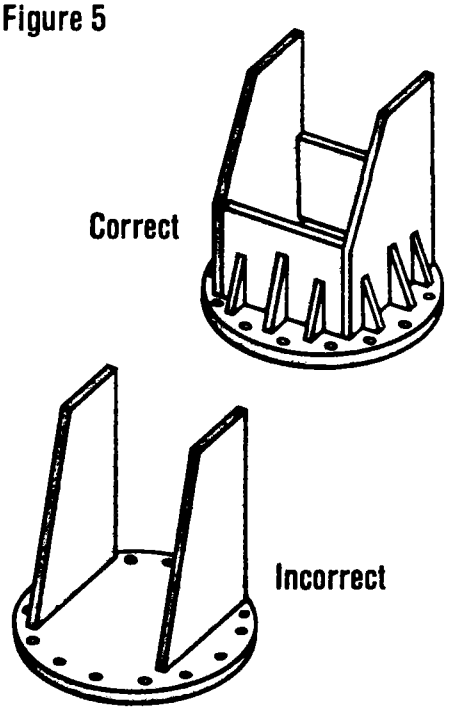


Figure 5



8.
Fastening Bearings with Bolts

Introduction

Rotek will recommend the size, quantity and spacing of the bolts in cooperation with the machine designer using methods outlined in S.A.E. Technical Paper No. 790906. Special consideration may be necessary for bolted joints where:

1. The bearing loads are "hanging" (tensile) in nature — not recommended for Series 1000 bearings.
2. The bolts are not equally spaced. (Stress measurements are recommended. These applications should be avoided.)
3. Materials other than steel are used in the joints or fastener.

The designer must make sure that all bolt holes provided in the bearing can be used for fastening bolts.

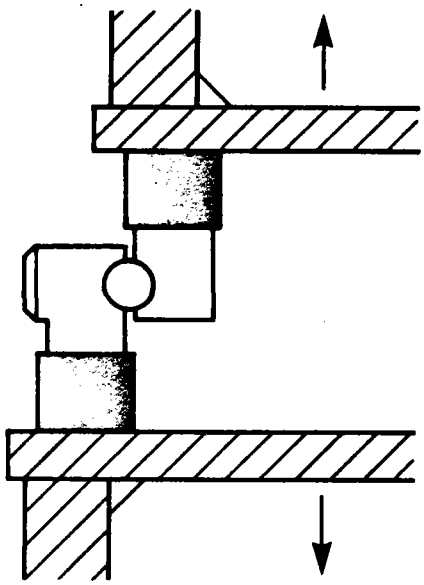
When installing the bearing, never force bolts into bolt holes. Jamming bolts in this way may cause distortion of the bearing. To avoid this, bolt holes in the mounting structure and mounting flange should be slightly enlarged if necessary.

Caution! Excessively large holes or extremely large chamfers make it difficult to maintain proper bolt preload.

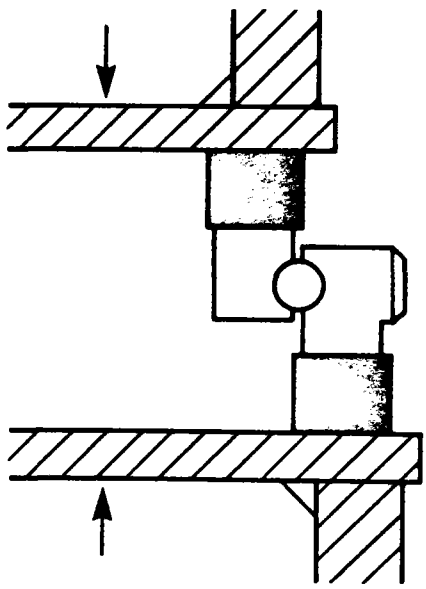
Preload in the mounting bolts allows enough frictional force to develop between the surfaces to make sure that the bearing will not shift in a radial direction under maximum radial loads. If radial loads are exceptionally high, locating pilots or other means of positioning the bearing may be required.

Dowel Pins or tightly fitting bolts may be used for transmitting radial force if the holes in the bearing ring and mounting ring are line reamed at assembly.

Long fasteners are always more desirable than short ones. The minimum effective (between exposed thread to under bolt head) length of a bearing mounting bolt should be at least five times its diameter. Since long bolts enlongate more than short ones under the same



Tensile load



Compressive load

preload, a smaller fraction of the total preload will be lost due to the unavoidable settling of the head and seating of the threads.

Through bolts with nuts are recommended over capscrews threaded into tapped holes. A tubular bushing with proper cross section and heat treatment may be used in place of hardened steel washers to achieve a more desirable length/diameter ratio of the fastener.

Preloading Bolts

A bolt must be properly prestressed if it is to function properly. It must be preloaded to a level which minimizes dynamic loading of the fastener. Loose or improperly preloaded bolts experience much higher fatigue stress levels than properly installed bolts and may fail in fatigue under dynamic loading. Rotek also recommends that the bolt preload be rechecked after the initial run-in period of the machine (50 operating hours) and periodically thereafter to ensure that proper prestress is maintained.

Regardless of the safety designed into the bolted joint by the engineer, the proper preload can only be developed by the man with wrench. In preloading bolts with a torque wrench, most of the tightening torque for a bolt is required to overcome friction. Since friction is dependent upon lubrication, finish, cleanliness, etc., we hesitate to recommend a particular torque for a given size bolt. We strongly urge that the following simple test, using representative fasteners, be performed:

Using the torque wrench, slowly and steadily tighten a fastener. As it is tightened, the torque increases at a rather uniform rate. When the yield point of the fasteners is reached, torque will level off. Note this torque reading. This test should be performed on several fasteners to obtain a good average. The test bolts must be discarded.

The minimum tightening torque should be 70% of the established average yield torque. Care must be taken to repeat the test if any change is made in fastener lubrication, finish, fit, etc.

Caution! Loose or improperly preloaded mounting bolts is one of the major causes of bearing failures.

Bolt Specification

Rotek bearings are normally designed to be used with high strength S.A.E. J429, Grade 8 (ASTM A490) alloy steel fasteners. Bolts with threads rolled after heat treating are preferred for their improved fatigue strength.

Nut Specification

The best nut for this application is the "Heavy Semi-Finished" type. When tightened, a nut both compresses and dilates. Threads of the nut tend to pull away from the bolt thread creating the need for the "heavy" wall thickness in the nut.

Use S.A.E. J995, Grade 8 (ASTM A563, Grade DH) nuts with S.A.E. J429, Grade 8 (ASTM A490) bolts. Be sure to use a nut that is long enough with enough threads and sufficient mechanical properties to withstand the ultimate tensile strength of the bolt. In other words, over-tightening should break the bolt rather than strip the threads in the nut.

Note: Be sure to obtain fasteners from a reliable vendor. Make sure that he is aware that they are to be heavily loaded so that proper quality control is exercised.

Coarse Threads vs. Fine Threads

In theory, fine threads will carry more load than coarse threads, all other things being equal. However, most authorities agree that coarse threads have greater resistance to stripping than fine threads and can be more heavily torqued. This is especially true of high strength bolts. Coarse threads require fewer revolutions to tighten and have less tendency to cross thread.

When a coarse thread fastener fails it will usually break and the mechanic will easily recognize it. However, in a fine thread nut, if torqued too tightly, a crack may develop in the first thread without being noticed. Under operating loads this crack may spiral up the thread and finally result in stripping the entire thread.

Rotek recommends the use of coarse thread fasteners.

Applicable Nut and Bolt Standards

Bolt	Nut	Hardened Washers
S.A.E. J429, Grade 8 ASTM A490	S.A.E. J995, Grade 8 ASTM A563, Grade DH	ASTM F436

Caution Note: Because of variations in mounting structure rigidity, caution must be exercised to be sure that localized loading of mounting bolts does not exceed safe limits. We strongly recommend that bolt stresses be measured by strain gaging. If excessive stresses are encountered, the structure must be modified or additional fasteners utilized.

Locking Devices and Washers

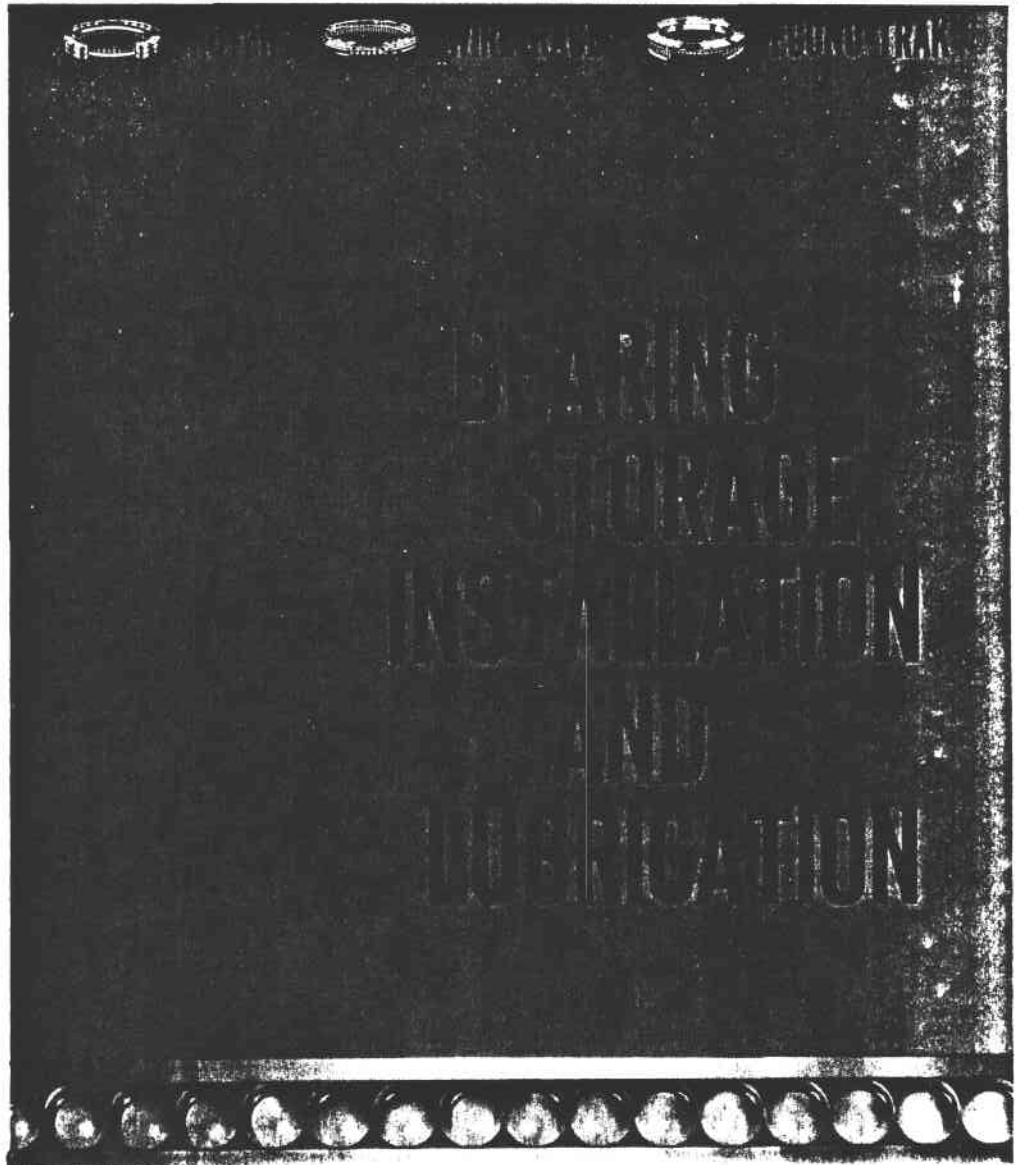
Probably the best device to prevent fasteners from loosening is the friction developed between the male and female thread by proper pretensioning. Hardened steel washers (ASTM F436) should be used under the bolthead and the nut for the following three reasons:

1. To provide a flat, smooth, hard surface against which to tighten the bolthead or nut, thus giving uniform torque measurement.
2. To prevent embedding the hard bolthead or nut into the softer steel mounting or bearing.
3. To distribute the high bolt load over a wider area and prevent surface crushing of the connected material.

Spring lockwashers are of doubtful value. Once the screw has loosened to the point where the washer acts as a spring, it is too loose for safety. Rotek does not recommend this type of washer.

Rotek does not recommend other mechanical locking devices because they prevent the necessary periodic rechecking of the proper bolt preload.

The use of chemical type locking compounds between threads distorts subsequent bolt torque checking, therefore, these compounds should be used with caution.



NOTE:
The Bearing Storage, Installation and Lubrication manual is primarily designed for personnel who are actually installing the bearings. Design engineers should request our Manual 680 for complete installation instructions.

Rotek
The big bearing people

LUBRICATION

Periodic lubrication is necessary to insure long life and proper performance. The required frequency of lubrication varies with the type of equipment and amount of usage. Some recommendations for lubricants are given below.

Typical recommendations for greasing intervals vary according to operating conditions. Generally the following lubrication intervals are recommended:

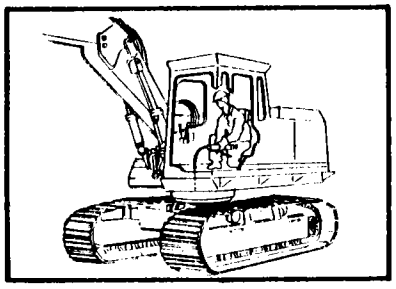
Ball bearings under light service	Every 100 operating hours
Ball bearings under heavy service or for a production type of application (e.g., excavators, grab cranes, magnet cranes, etc.) or where a high degree of reliability is required.	Every 40 operating hours
Roller bearings	Every 40 operating hours

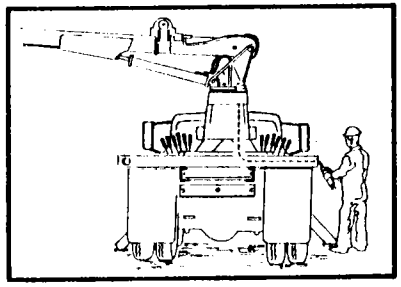
Use shorter intervals between greasings in tropical areas or where there is high humidity, dust, or wide ranges in temperature, or when there is continuous rotation.

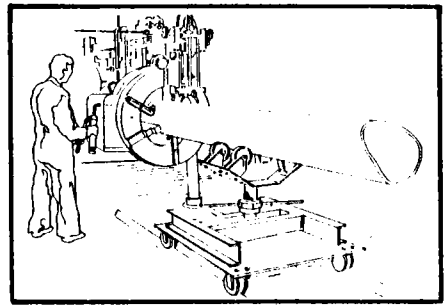
Each Rotek bearing is equipped with one or more grease fittings. Models equipped with two or three rows of fittings should be greased in each row. To insure uniform distribution of grease throughout the bearing, the machine should be rotated at least two complete revolutions while greasing. When complete rotation is impractical, grease may be pumped into each fitting, rotating the device back and forth as far as possible as each fitting is greased. For bearings with integral gears, lubricate gear as recommended above and as necessary to prevent metal-to-metal contact.

⚠ **CAUTION:**

Extreme care must be taken when greasing and rotating any unit. Be sure that all personnel are clear of all parts of the machine during the rotating-greasing procedure. We recommend installation of an extension line from the grease fitting location to an area where the oiler will be safely clear of moving parts. Following are three examples of suggested extension arrangement.







Extension fittings and lines are widely available from local distributors of lubrication equipment such as Alemite.

ALL EQUIPMENT SHOULD BE GREASED AT LEAST TWICE YEARLY REGARDLESS OF AMOUNT OF USAGE.

The bearing should be lubricated immediately after installation. Before storing a machine, new or used, thoroughly lubricate so that clean grease can be seen venting at the seals. This procedure should be repeated periodically at least twice a year or in line with climatic conditions. Uninstalled bearings stored outside, or in especially humid environments, require the same attention as bearings mounted upon machines.

Some recommended lubricants are shown below:

	SHELL	EXXON	TEXACO	MOBIL	UNION	SUN
RACE	ALVANIA EP #2	RONEX WB	MULTIFAK EP #2	MOBILUX EP #2	UNOBA EP #2	PRESTIGE 742 EP
GEAR	CARDIUM EP Compound C	SURRETT Fluid 30	CRATER 2x Fluid 3x Fluid	MOBILTAC E	GEARITE Hvy	GEAR Compound #407

Under extremely dusty or dirty conditions, sufficient grease should be added to flush out contaminated grease. Under less severe conditions, add grease until it appears at the seal. The metal nameplate illustrated below, which is affixed to many styles of bearings, provides lubrication instructions suitable to most applications. Extra plates are available on request for installation on equipment.

LUBRICATION INSTRUCTIONS—Lubricate bearing through fittings every one hundred operating hours (or per machine manufacturer's recommendation). Above 32°F use No. 2 Extreme Pressure Grease such as Texaco Multifak EP 2. Below 32°F use No. 1 grade. Rotate while greasing until clean grease extrudes at seals. Lubricate gear with Texaco Crater Fluid or equivalent as required to prevent metal-to-metal contact. Check mounting bolt tightness periodically per machine manufacturer's recommendation.

SERIAL NO.

Rotek

INSTALLATION

Equipment Mounting Surfaces

Be sure that the mounting surface is free of weld spatter, chips, and other contaminants. Unpainted surfaces are preferred. The bearing should be mounted on a machined, flat, rigid surface. The mounting hole locations must match those of the bearing or distortion will result. Excessive distortion caused by unflat mounting surfaces or insufficiently rigid structures will result in high friction and reduced bearing life. The installation may be checked by rotating the device. If friction increases as mounting bolts are tightened, the bearing should be removed and the mounting surface checked for proper flatness.

⚠ **CAUTION:**

FOR DETAILED INSTALLATION PROCEDURES TO AVOID ACCIDENTS, REFER TO ROTEK'S INSTALLATION MANUAL 680 WHICH IS AVAILABLE UPON REQUEST.

⚠ **CAUTION:**

S.A.E GRADE 8 BOLTS AND NUTS ARE TO BE EMPLOYED.

Mounting Bolts

Most Rotek models require the use of S.A.E. Grade 8 bolts and nuts. These may be identified by the six radial lines on the bolt heads. Although, with the exception of the head markings, these high strength bolts look very much like ordinary bolts, they are many times stronger. Installation personnel using unmarked, or improper grade bolts should check with the appropriate engineering personnel before proceeding with such an installation. Machines assembled with improper bolts present dangerous hazards.

SAE GRADE 8

Mounting Bolt Torque

Mounting bolts must be tightened with sufficient torque to reach at least 70% of bolt yield strength. Installers should check with Engineering if a tightening torque value has not been established. Hardened steel flat washers are recommended. Lock washers are not recommended.

In most applications some seating of bolt threads and mounting surfaces will occur during initial hours of machine operation. Bolts should be retightened after initial break-in period. Periodic checking and retightening of fasteners is urged regardless of any locking devices which might be used. Seating of threads may lead to loss of bolt tension even though the cap screw or the nut has not rotated.

FAILURE TO KEEP BOLTS PROPERLY TIGHTENED MAY LEAD TO FATIGUE FAILURE OF BOLTS AND CONSEQUENT MACHINE DAMAGE.

⚠ **CAUTION:**

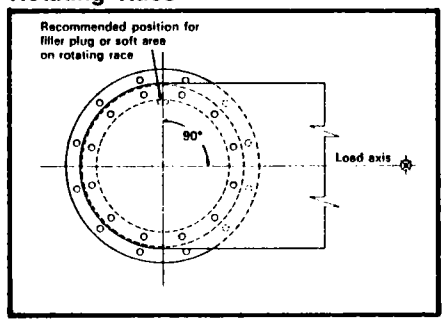
ALWAYS KEEP MOUNTING BOLTS PROPERLY TIGHTENED.

⚠ **CAUTION:**

WELD ONLY THOSE BEARINGS EQUIPPED WITH WELD BANDS.

FOR PROPER INSTALLATION PROCEDURES TO AVOID ACCIDENTS, REFER TO ROTEK'S INSTALLATION MANUAL 680 WHICH IS AVAILABLE UPON REQUEST.

Recommended Position for Filler Plug and/or Hardness Gap on Rotating Race

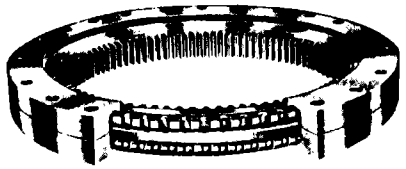


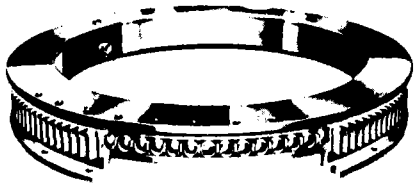
Most bearings have a small unhardened area in the raceway. In plug loaded races this area is at the plug. In split race bearings, where there is no plug, the area is stamped with the letter "S" for soft. The plug or soft area should be positioned 90° from the load axis when possible as indicated in the above diagram. In cranes or excavators this would put the plug or soft spot at the side of the machine on the race which is connected to the upper structure.

Checking Gear Backlash

Amount of gear backlash is controlled by the machine designer in fixed center distance designs by the specification of mounting holes and swing pinion position.

If the position of either the swing drive or the bearing is adjustable (by means of oversize mounting holes, slots, etc.) it is necessary to adjust the relative position in order to provide proper backlash between gear and pinion. On certain types of Rotek bearings the point of minimum gear clearance is marked with green paint covering two or three gear teeth. When installing such units on adjustable center applications, centers should be adjusted to provide minimum required backlash with the pinion engaging gear at the painted area. If the gears are not marked with paint, backlash may be set at any convenient point.





STORAGE

Store horizontally in original package in a dry area until installation. Guard against excessive floor or rack loading. Rotek bearings are protected at the factory by internal lubricants and external surface protection.

During prolonged periods of time (one year or more) all lubricants tend to deteriorate. Bearing condition should be checked periodically. If corrosion is apparent, unpack, lubricate with fresh corrosion-resistant grease and repack. Be sure to rotate bearing while lubricating.

Rotek Rotek Incorporated
Aurora, Ohio 44202
The big bearing people Telephone: (216) 562-3111 Telex: 098-6448

WARRANTY

Rotek Incorporated warrants each Rotek product to be free from defects in material and workmanship under normal use and service and to conform to any specification furnished by Rotek in writing. This Warranty extends only to the first purchaser from Rotek. NO OTHER WARRANTY, WHETHER EXPRESS, IMPLIED OR STATUTORY, OF MERCHANTABILITY, INFRINGEMENT, FITNESS FOR A PARTICULAR PURPOSE, OR OTHERWISE, SHALL EXIST IN CONNECTION WITH THE SALE OR USE OF ANY ROTEK PRODUCT. All claims under this Warranty must be made in writing and delivered to Rotek prior to the expiration of one year from the date of shipment of the product by Rotek or be barred. Upon receipt of a timely claim, Rotek shall have the option either to inspect the product while in Purchaser's possession or to request Purchaser to deliver the product to Rotek at its factory or other designated site, at Purchaser's expense, for inspection by Rotek. Rotek shall repair, or at its option, replace, free of charge, any product which it reasonably determines to be in breach of this Warranty, and Rotek shall ship the repaired or replacement product to Purchaser f.o.b. point of shipment; provided, however, that if in Rotek's judgment circumstances are such as to preclude the remedying of a breach of this Warranty by repair or replacement, Rotek shall refund to purchaser, by issuance of credit or otherwise, any part of the purchase price of the product theretofore paid to Rotek.

Any installation, operation, use, maintenance or application of any Rotek product other than according to the capacities, conditions, loadings and instructions published by Rotek or approved in writing by Rotek's Engineering Department, or the substitution in or with any product of integral, reciprocating or related parts not approved in writing by Rotek, shall void the Warranty. Without limiting the generality of the foregoing, with respect to Rotek products having plug retaining screws and split race retaining screws which are sealed, removal of seal and/or removal of plug or separating of split races will void warranty unless performed with the express permission of Rotek.

It is expressly agreed that repair or replacement, or refund of purchase price, of products shall be the exclusive remedy for any breach of this Warranty or any other claim in respect of Rotek products, whether based upon contract, warranty or negligence. Without limiting the generality of the foregoing, Rotek shall not be liable for removal or installation costs, downtime, damage to other property, loss of business or profits or any similar or dissimilar incidental or consequential damages.

THIS WARRANTY MAY NOT BE MODIFIED OR CHANGED IN ANY WAY NOR MAY ANY OTHER WARRANTY BE GRANTED UNLESS SUCH CHANGE OR OTHER WARRANTY IS EVIDENCED IN WRITING SIGNED BY AN OFFICER OF ROTEK.

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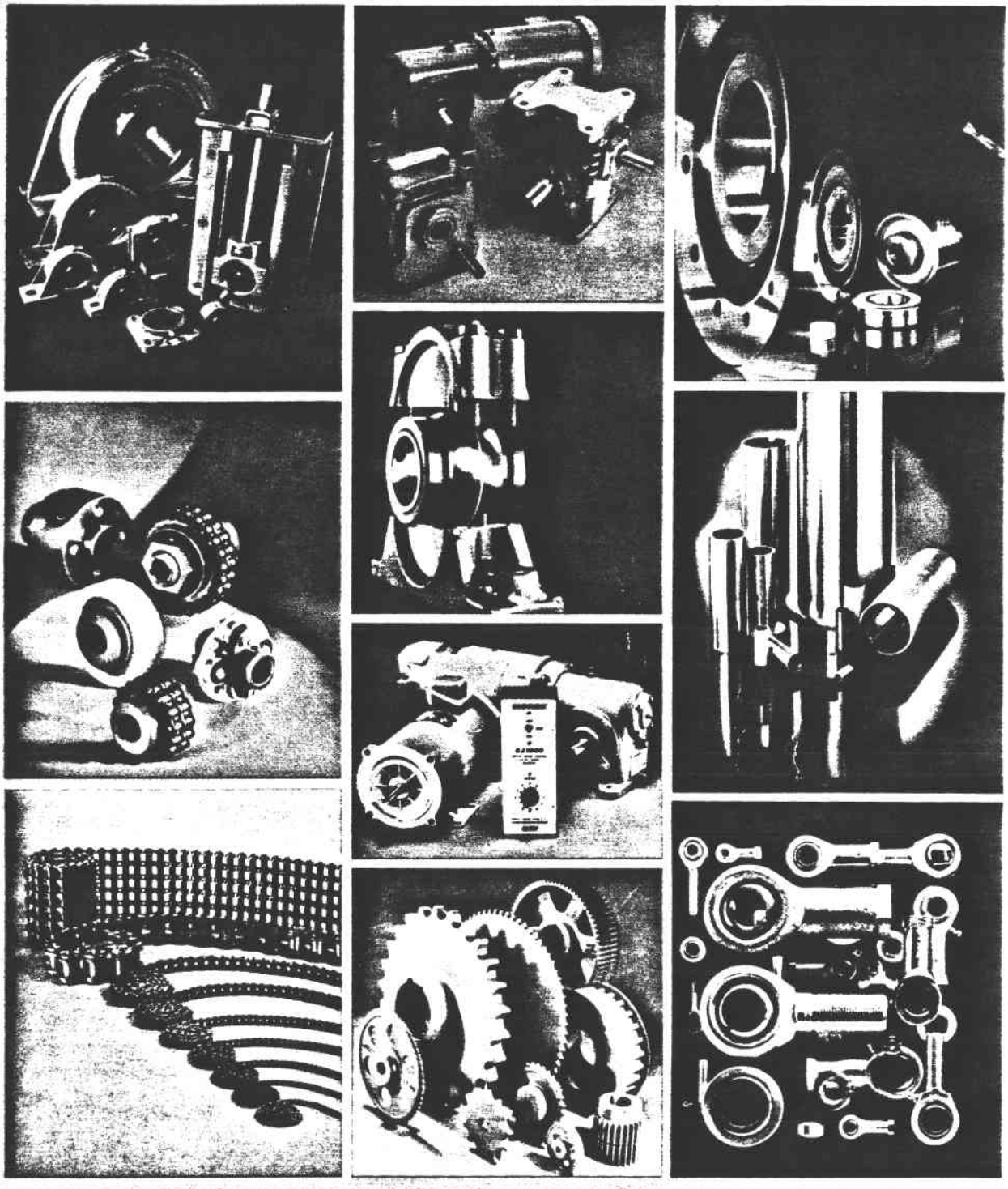
APPENDIX O

MORSE SEALMASTER ELEVATION BEARINGS

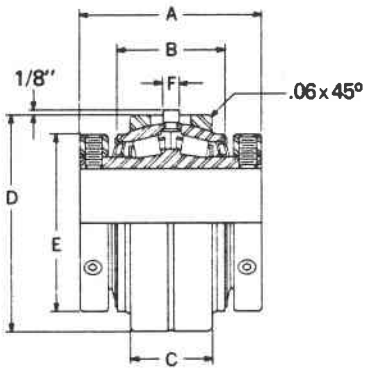
BORG WARNER®

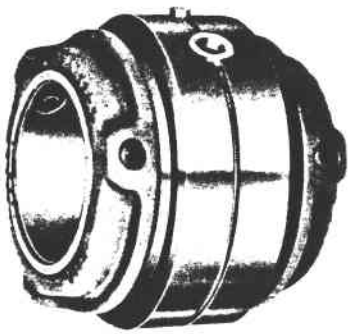
Morse® Power Transmission Products



Morse Industrial Products Division
Transmission Components Group
Borg-Warner Corporation

ERCI SERIES CYLINDRICAL CARTRIDGE INSERTS AND PILLOW BLOCK HOUSINGS





FELT SEAL. STANDARD. Positive sealing for low, medium, and high speed operation.

SINGLE LIP CONTACT SEAL. Available on all sizes. Recommended where moisture conditions prevail.

The ERCI series of steel cylindrical roller bearing cartridge units is designed for mounting in a cylindrical bore for a wide range of general machine applications.

Units are equipped with Timken® roller bearings which are factory adjusted, grease lubricated, and sealed. They have full self-aligning capability.

When used as a "fixed" bearing, provision must be made for locating outer ring in housing to prevent lateral movement. Provision for lubrication is recommended utilizing holes in cartridge O.D. located 30° on either side of the alignment pin. Recommended housing bore is nominal, +.002", −.000".

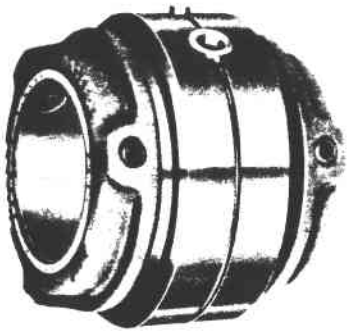
ERCI cylindrical cartridge units are replacement cartridges for ERPB expansion type pillow blocks. The centrifugal felt-lined flinger seal is standard while the shielded contact seal is optional without additional charge.

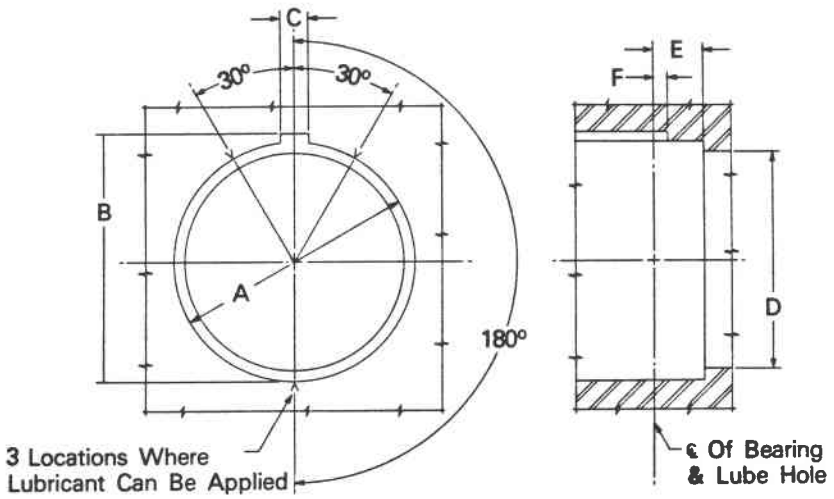
	Shaft Diam. In.	CYLINDRICAL CARTRIDGE INSERT (1)					DIMENSIONS IN INCHES						BASIC DYNAMIC LOAD RATINGS			Max. Speed
		STANDARD SEAL		Approx. Weight Lbs.	CONTACT SEAL								Life Capacity in Lbs. @ 500 RPM–3000 Hours		Capacity in Lbs. @ 1,000,000 Revs.	
		Unit No.	Unit Part Number		Unit No.	Unit Part Number	A	B	C	D +.000" −.003"	E	F	Radial	Thrust		
F	2¼	ERCI-204	550158	10.0	ERCI-204C	550828										
F	2 7/16	ERCI-207	550159	9.0	ERCI-207C	550829	4.00	2.38	1.80	4.782	3.94	.38	7400	2570	28500	2000
F	2½	ERCI-208	550160	8.8	ERCI-208C	550830										
F	2 11/16	ERCI-211	550161	13.0	ERCI-211C	550831										
F	2¾	ERCI-212	550162	12.7	ERCI-212C	550832	4.50	2.50	2.00	5.376	4.75	.38	8100	3270	31200	1750
F	2 15/16	ERCI-215	550163	11.7	ERCI-215C	550833										
F	3	ERCI-300	550164	11.5	ERCI-300C	550834										
F	3 3/16	ERCI-303	550165	22.0	ERCI-303C	550835										
F	3 7/16	ERCI-307	550167	20.2	ERCI-307C	550837	5.00	3.00	2.25	6.595	5.50	.50	13600	6000	52500	1500
F	3½	ERCI-308	550168	19.7	ERCI-308C	550838										
F	3 15/16	ERCI-315	550169	30.0	ERCI-315C	550839	6.25	4.00	3.13	7.189	6.00	.50	18800	8050	72500	1250
F	4	ERCI-400	550170	29.5	ERCI-400C	550840										
F	4 15/16	ERCI-415	550173	55.0	ERCI-415C	550843	7.25	4.50	3.75	9.063	7.31	.50	32000	13200	123000	1000
F	5	ERCI-500	550174	53.8	ERCI-500C	550844										

F Designates units normally available from stock with Standard Felt Seals. For delivery information on units not designated as normally available from stock, contact nearest Morse Service Center.

Installation alignment correction if ± 3 degrees equal to .052" per inch.

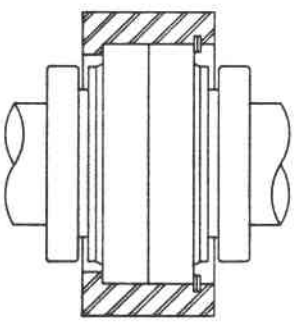
CYLINDRICAL CARTRIDGE UNITS SERIES ERCI



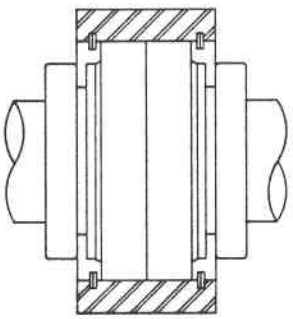


HOUSING BORE DIMENSIONS to ACCOMODATE CARTRIDGE INSERTS						
Shaft Dia.	"A" Dim. +.002/−.000	"B" Dim. +.01/.00	"C" Dim. +.01/−.00	"D" Dim. ± .01	"E" Dim. ± .01	"F" Dim. Min. ± .005
2¼ 2 7/16 2½	4.782	5.01	.56	4.38	1.02	.56
2 11/16 2¾ 2 15/16 3	5.376	5.50	.56	5.12	1.16	.56
3 3/16 3 7/16 3½	6.595	6.89	.75	6.00	1.28	.65
3 15/16 4	7.189	7.46	.75	6.62	1.75	.72
4 15/16 5	9.063	9.34	.75	8.50	2.06	.75

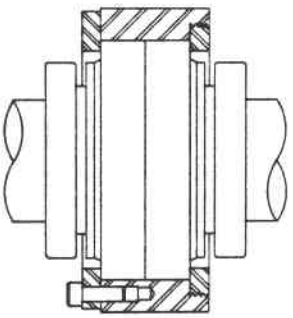
TYPICAL HOUSING INSTALLATIONS



Cartridge Fixed Between Shoulder & Snap Ring



Cartridge Set For Expansion And Held Between Snap Rings



Cartridge Fixed Between Two Types Of Collars

SEALMASTER ROLLER BEARINGS
INSTALLATION & MAINTENANCE
INSTRUCTIONS

Morse
MORSE INDUSTRIAL CORPORATION
SUBSIDIARY OF EMERSON ELECTRIC CO.
ITHACA, NEW YORK 14850

FORM
9246-002
Effective
March, 1983

BORE AND SHAFT TOLERANCES

All Morse Sealmaster roller bearing races have bore diameters for a sliding or snug fit over the shaft. They are easily and symmetrically locked to the shaft by means of locking collars with double cup point setscrews. Bearing bore and shaft tolerances are shown in Table 1.

TABLE 1

RECOMMENDED SHAFT TOLERANCES		
Shaft Diameters (Inches)	Bearing Bore Tolerance	Recommended Shaft Tolerance
1-3/16 - 1-7/16	+.0010-.0000	+.0000-.0005
1-1/2 - 3	+.0010-.0000	+.0000-.0010
3 - 3-15/16	+.0020-.0000	+.0000-.0010
4 - 4-15/16	+.0020-.0000	+.0000-.0015

The life of the bearing will be improved by fitting the bearing with a light press fit on the shaft.

MOUNTING INSTRUCTIONS

Prior to securing the unit to the shaft, make certain that shafting is free of burrs. Slide the unit onto the shaft to the point desired for mounting and bolt the unit to the supporting base. To prevent bearing damage avoid hammering on the ends of the inner race. After bolting the unit to the support, tighten the self-locking setscrews securely onto the shaft. Recommended torques for tightening the setscrews are shown in Table 2.

TABLE 2

DOUBLE LOCKING COLLAR SETSCREW TIGHTENING TORQUE		
Shaft Size (Inches)	Tightening Torque (Inch Pounds)	(Foot Pounds)
1-3/16-1-11/16	108	9
1-3/4 - 2-1/2	180	15
2-11/16 -3-1/2	408	34
3-15/16 - 4	876	73
4-7/16 -4-15/16	1440	120

CARTRIDGE INSERT

General: This cartridge is for use in Morse housing or in Morse approved OEM applications only. No other use is authorized. This part is covered by one or more of the following U.S. patents:

3,773,397	3,829,182	3,891,286	3,937,538
3,794,393	3,845,999	3,912,412	3,977,740
3,807,819	3,850,485	3,918,776	3,981,550

Removal & Replacement:
To remove the cartridge from the housing, remove the housing assembly cap bolts and lift off the top housing half so that the shaft plane can be adjusted to allow removal of the cartridge. When replacing the cartridge insert, first check to assure that the rubber grommet is properly seated in the lube hole. Then position the cartridge lock pin so that it lines up with the lock pin slot in the housing. BE SURE the lock pin is not put in the lube hole. The shaft can be returned to its normal position and the housing can then be reassembled by tightening the cap bolts. Cap bolt tightening torques are shown in Tables 3, 4, 5, & 6. Locking collars can be reaffixed to the shaft by tightening the setscrews to the torques shown above. (See Table 2.)

MORSE INDUSTRIAL CORPORATION

TORQUE VALUES FOR ASSEMBLING HOUSING HALVES

TABLE 3

PILLOW BLOCK HOUSING		
Shaft Size (Inches)	Tightening Torque	
	(Lbs.Inches)	(Lbs. Feet)
1-3/16 - 1-1/4	204	17
1-3/8 - 2-3/16	372	31
2-1/4 - 3	900	75
3-3/16 - 4-1/2	3192	266
4-15/16 - 5	4728	394

TABLE 4

FLANGE BEARING HOUSING		
Shaft Size (Inches)	Tightening Torque	
	(Lbs.Inches)	(Lbs.Feet)
1-3/16 - 2	372	31
2-3/16 - 3	900	75
3-7/16-3-15/16	1800	150

TABLE 5

PILOTED FLANGE HOUSING				
Shaft Size (Inches)	Outside Bolts		Inside Bolts	
	(Lb-Ins.)	(Lb-Ft.)	(Lb-Ins.)	(Lb-Ft.)
1-3/16 -2	204	17	48	4
2-3/16 -3	588	49	96	8
3-3/16 -4	900	75	204	17
4-7/16 -5	1800	150	900	75

TABLE 6

EXPANSION PILLOW BLOCK HOUSING		
Shaft Size (Inches)	Tightening Torque	
	(Lb-Ins.)	(Lb-Ft.)
1-3/4-2-3/16	372	31
2-1/4 - 3	900	75
3-3/16-3-1/2	3192	266
3-15/16-4-1/2	1800	150
4-15/16 - 5	3192	266

LUBRICATION

All Morse Sealmaster roller bearings are prelubricated at the factory with a lithium soap grease which is compatible with multi-purpose grease readily available from local suppliers. The factory lubrication conforms to NLGI grade 2 consistency and is suitable for an operating temperature range of -20° F. to + 250° F.

For extremely dirty or wet applications with shaft speeds below 200 RPM, completely fill the bearing prior to running.

Proper relubrication is important to the life of the bearing. A general relubrication guide is shown in Table 8. The bearing should be relubricated while rotating, the grease pumped in slowly until a bead forms around the seals. If necessary to relubricate while idle, refer to relubrication Table 7 for maximum grease capacity for various size bearings.

TABLE 7

LUBRICATION OF MORSE ROLLER BEARINGS	
Shaft Size (Ins.)	Recommended Relube Grease Charge (Ozs.)
1-3/16-1-1/4	.10
1-3/8-1-7/16	.22
1-1/2-1-11/16	.32
1-3/4-2	.50
2-3/16	.55
2-1/4-2-1/2	.65
2-11/16-3	.85
3-3/16-3-1/2	1.25
3-15/16-4	2.50
4-7/16-4-1/2	3.10
4-15/16	4.75

TABLE 8

RECOMMENDED RELUBRICATION FREQUENCY			
Speed	Temperature	Cleanliness	Greasing Interval
100 RPM	Up to 125° F.	Clean	6 months
500 RPM	Up to 150° F.	Clean	2 months
1000 RPM	Up to 210° F.	Clean	2 weeks
1500 RPM	Up to 210° F.	Clean	Weekly
Any Speed	Up to 150° F.	Dirty	1 wk. to 1 mo.
Any Speed	Over 150° F.	Dirty	Daily to 1 wk.
Any Speed	Any Temperature	Very Dirty	Daily to 1 wk.
Any Speed	Any Temperature	Extreme conditions	Daily to 1 wk.

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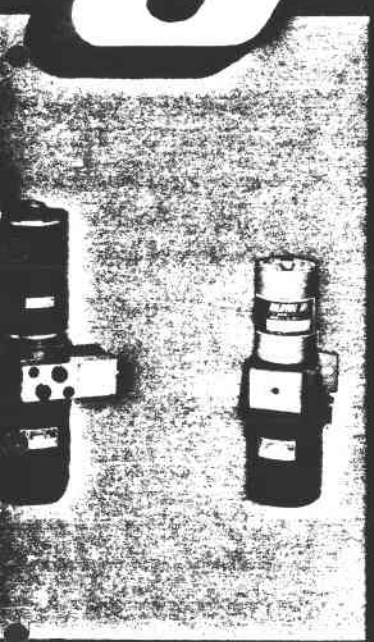
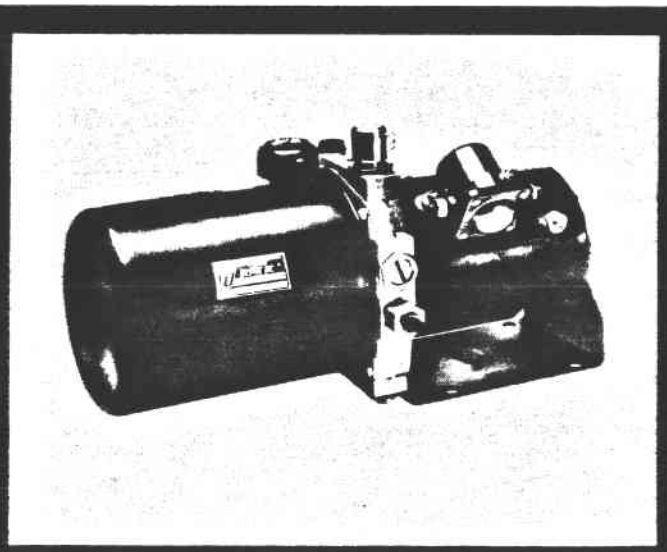
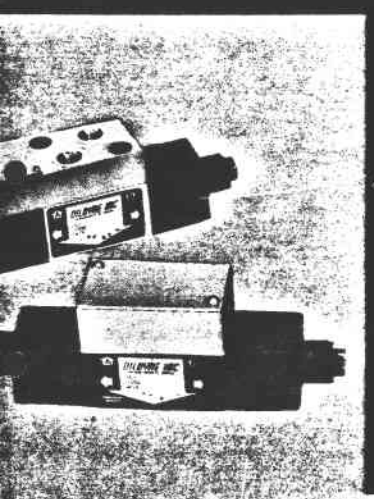
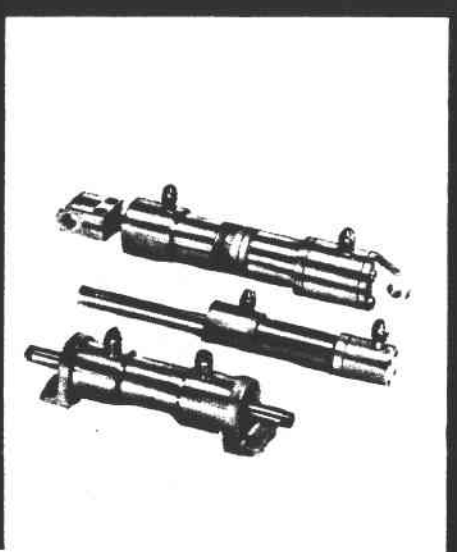








"SPECIALISTS IN COMPACT FLUID POWER"

OILDYNE
DIVISION OF COMMERCIAL
SHEARING, INC.

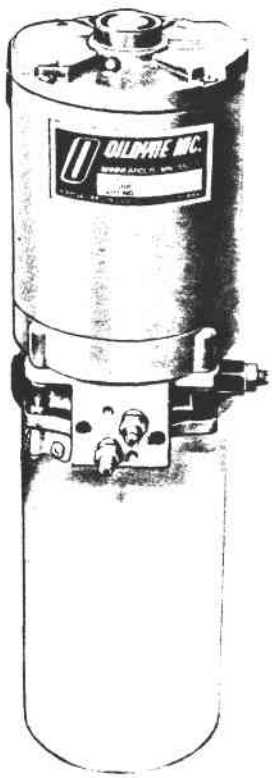
330 series
power units

STANDARD OR REVERSIBLE POWER UNITS

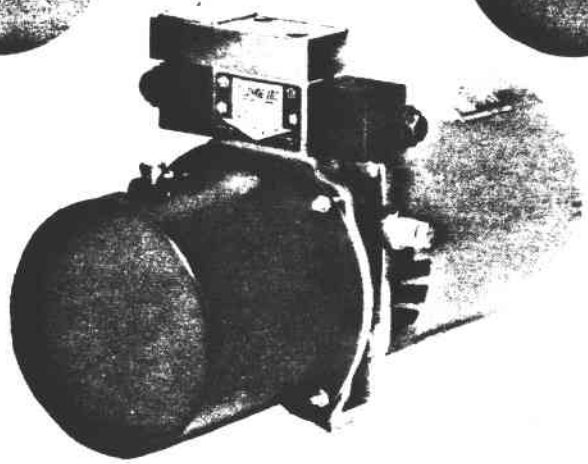
STANDARD SINGLE DIRECTION UNIT

STANDARD UNIT WITH 4-WAY DIRECTIONAL CONTROL VALVE

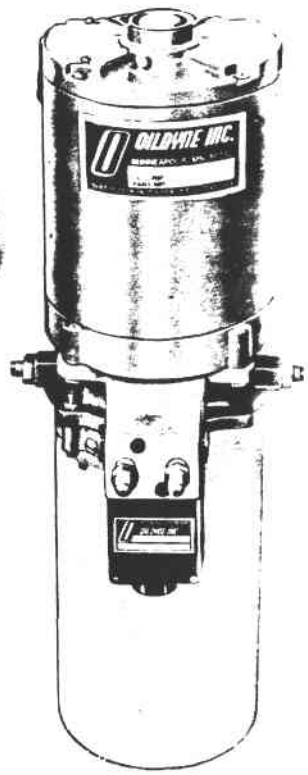
REVERSIBLE UNIT WITH P.O. CHECK AND PRESSURE SWITCH



TO 3000 PSI
2 GPM



VERTICAL OR HORIZONTAL



QUIET RUNNING

RUGGED DUTY

- INTEGRAL DESIGN WITH BUILT-IN VALVING OR EXTERNAL 4-WAY VALVE
- EXTERNALLY ADJUSTABLE INTEGRAL RELIEF VALVES
- HEAVY DUTY DESIGN WITH LOW NOISE LEVEL
- COMPACT DESIGN — FITS IN AREAS AS SMALL AS 8" x 8" x 17"
- RESERVOIR SIZES FROM 1/2 GAL. TO 5 GAL.
- 4 PUMP SIZES — 1/4 GPM TO 2 GPM
- MOTOR SELECTION TO 2 HP—AC—DC—AIR
- UNIQUE DESIGN BUT FLEXIBLE TO MEET CUSTOMER REQUIREMENTS

330 SINGLE DIRECTION POWER UNITS

This unit provides a conventional approach to hydraulic circuitry, producing a one-way source of hydraulic power.

Typical Applications:

(1) Accumulator charging

(2) One-way rotation hydraulic motors

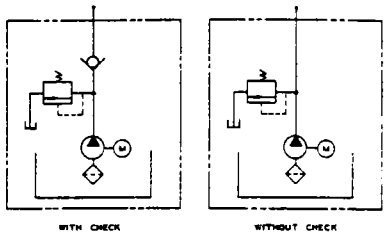
(3) Servo valve operators

(4) Multiple function circuits with external directional or sequence valves

(5) One cylinder reciprocation where the number of reversals per minute requires external directional valving

(6) Pressurized lube systems

JIC SYMBOL



330 REVERSIBLE POWER UNITS

Hydraulic flow reversals automatically occur with rotation reversals of the pump and driving motor.

FORWARD ROTATION – Hydraulic fluid is sucked into the gear pump over the check valve on the lower left, as shown in the diagram. The right hand side is now the discharge (pressure) side and flow directions are as shown by the arrows. The check valve, at lower right, stops discharge flow from escaping to the reservoir.

In order for this discharge flow to enter the cylinder, the control spool is shifted to the left by pressure flow as shown. In this position, the cylinder port is connected to discharge flow (pressure) and the cylinder ram moves to the left as indicated. The pressure relief valve at the right limits the maximum pressure that can be applied in the forward direction circuit. At maximum selected pressure, the hydraulic fluid is bypassed to the reservoir by the return tube at the right.

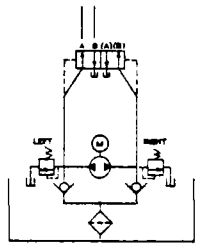
Fluid from the rod end of the cylinder flows through the control spool directly back to the reservoir through the center return tube only.

REVERSE ROTATION — When pump rotation is reversed, the right side (diagram B) is now the suction side and the left side is now the discharge (pressure) side. The control spool is shifted to the right by pressure flow and discharge (pressure) flow enters the rod end of the cylinder to retract the cylinder ram as indicated. The pressure relief valve at the left limits the maximum pressure selected for the reverse circuit.

As the cylinder piston travels toward the blind end of the cylinder it is forcing more fluid out of the cylinder than is entering the cylinder at the rod end, due to different displacement areas (and volume) of the rod end vs. the blind end. The larger the piston rod is, the greater the area and volume difference will be.

The return flow from the cylinder passes through the control spool directly back to the reservoir through the center return tube only. Note that regardless of rotation and flow, the return flow does not enter the suction side of the pump. High volume return flows cannot "choke" the pump or cause system malfunction.

STANDARD UNIT SCHEMATIC



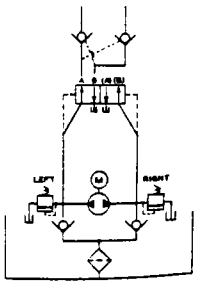
REVERSIBLE NON-LOCKING PILOTED FLOW

330 REVERSIBLE LOCKING POWER UNITS

REVERSIBLE LOCKING UNITS – Reversible locking units operation is the same as standard reversible units, as shown at right, except these units have an integral dual pilot check valve as shown in the reversible locking circuits, in diagrams C & D.

When the pump is stopped on these locking units, the cylinder is locked in position. This is due to the self centering of the piston in the P.O. check causing both checks to seat and to remain locked until the pump is re-started in forward or reverse rotation. Reverse rotation moves the piston unseating the ball check on the return side while the ball check on the pressure side reacts as a normal check allowing the flow to enter the cylinder.

LOCKING UNIT SCHEMATIC



REVERSIBLE LOCKING - PILOTED FLOW

HOW IT OPERATES

STANDARD SINGLE DIRECTION UNIT

SINGLE DIRECTION UNIT WITH 4-WAY VALVE

With motor running, gears are rotated creating a partial vacum into which oil from the reservoir flows. This flow of oil then proceeds around the pump gears and is available to the system. The return line connection provides the means to return oil from the system.

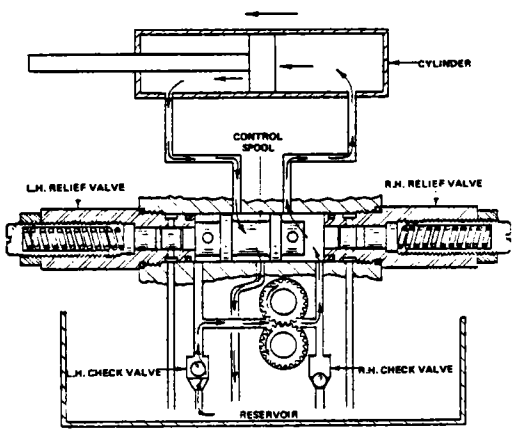
This compact power package with the one pressure outlet port and one return to tank port also contains an internal relief valve which is externally adjustable. Many single hydraulic circuits require nothing more to accomplish the desired function.

Manifold mounting of single or multiple 4-way valves to this standard unit increases the circuit capability to cover multiple functions. Pilot operated check valves and pressure switches can also be manifold mounted to the unit to provide "holding" circuit capability and automatic response to pressure settings.

HOW IT OPERATES

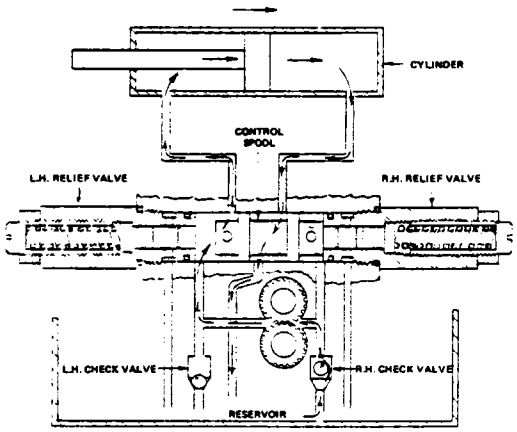
FORWARD ROTATION

(A)



REVERSE ROTATION

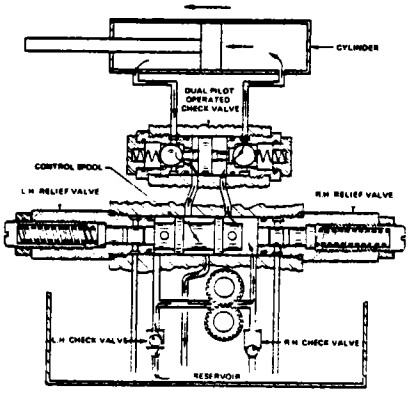
(B)



HOW IT OPERATES

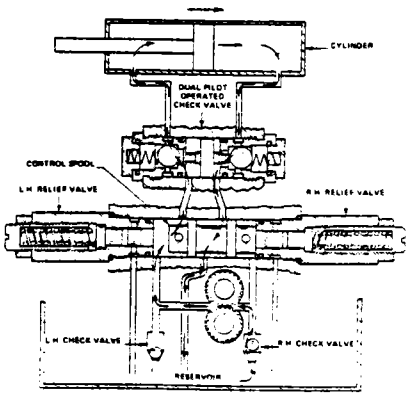
FORWARD ROTATION

(C)



REVERSE ROTATION

(D)



SPECIFICATIONS AND PERFORMANCE

FLOW – PRESSURE – RECOMMENDED MOTOR H.P.

PUMP SIZE	QUICK INDEX	NOM-INAL GPM	3450 R.P.M. 500 PSI	750 PSI	1000 PSI	1250 PSI	1500 PSI	1750 PSI	2000 PSI	2500 PSI	3000 PSI
.270	H.P.	½	1/4	1/3	1/2	1/2	3/4	3/4	1*	1	1.5
	FLOW-CIPM		129	128	127	126	125	124	123	122	120
.530	H.P.	1	1/3	1/2	3/4	1	1.5*	1.5	1.5	2	
	FLOW-CIPM		253	252	250	249	247	246	244	242	
.790	H.P.	1½	3/4*	1	1.5*	1.5	2*	2			
	FLOW-CIPM		376	373	371	368	367	365			
1.000	H.P.	2	3/4*	1.5*	1.5	2*	2				
	FLOW-CIPM		483	480	476	473	470				

PUMP SIZE	QUICK INDEX	NOM-INAL GPM	1725 R.P.M. 500 PSI	750 PSI	1000 PSI	1250 PSI	1500 PSI	1750 PSI	2000 PSI	2500 PSI	3000 PSI
.270	H.P.	¼	1/6	1/4	1/4	1/4	1/3	1/3	1/2*	1/2	3/4*
	FLOW-CIPM		65	64	63	63	62	61	60	58	57
.530	H.P.	½	1/4	1/3*	1/2*	1/2	3/4*	3/4	3/4	1	1
	FLOW-CIPM		126	125	125	124	123	122	121	119	118
.790	H.P.	¾	1/3*	1/2*	3/4*	3/4	1*	1			
	FLOW-CIPM		189	187	185	184	184	183			
1.000	H.P.	1	1/2	3/4*	3/4	1	1				
	FLOW-CIPM		241	239	237	236	235				

(* INDICATES NEXT LOWER H.P. CAN BE USED WITH 1.25 S.F.)

HOW TO ORDER CODE

3TT7 - 13L - DVSD

330 POWER UNIT

CIRCUIT TYPE
- W — WITH CHECK
- N — CONSTANT FLOW (NO VALVE)
- R — REVERSIBLE
- L — REVERSIBLE LOCKING W/PILOT OPERATED CHECK
- S — SINGLE SOLENOID 4-WAY

DOUBLE SOLENOID 4 WAYS
- C — CLOSED 1-C SPOOL
- O — OPEN 2-C SPOOL
- T — TANDEM 3-C SPOOL
- F — FLOAT CENTER 7-C SPOOL

ADDITIONAL OPTIONS
- A — FLOAT LEVEL SWITCH
- C — PRESSURE GAUGE
- D — OIL LEVEL SIGHT GAUGE
- E — SIDE RETURN
- N — NONE

UNIT TYPE
- S – STANDARD
- X – EXPLOSION PROOF

RESERVOIR SIZE
- 12 – 150 CU/IN
- 13 – 280 CU/IN
- 8 – 3 GAL
- 14 – 5 GAL*
- * INCLUDES SIGHT LEVEL GAUGE

MOUNTING POSITION
- H – HORIZONTAL
- V – VERTICAL

PRESSURE SWITCH
- S – SINGLE
- D – DUPLEX
- N – NONE

PUMP SIZE
- 2—.270 (.036 CIPR)
- 5—.530 (.071 CIPR)
- 7—.790 (.107 CIPR)
- 10—1.000 (.135 CIPR)

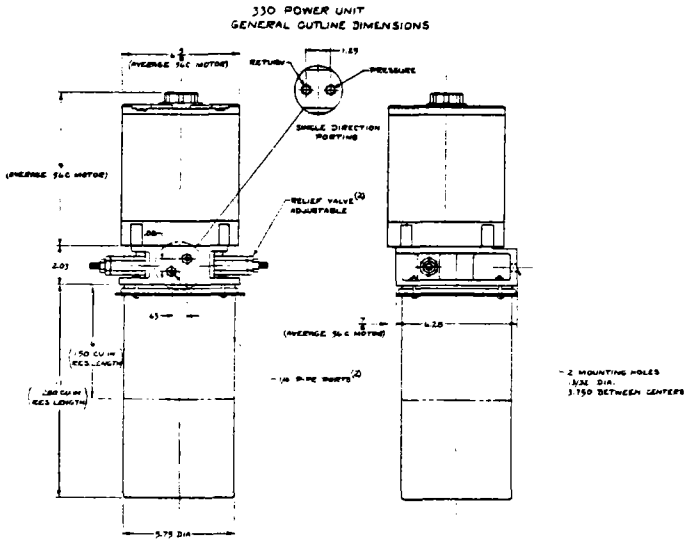
MOTORS
INDUCTIVE TYPE - 60 CYCLE
DUAL VOLTAGE 115/230 1Ø
DUAL VOLTAGE 230/460 3Ø

H.P.	RPM	PHASE	OPEN CODE	TEFC CODE
1/3	1725	1	OA	TA
1/3	1725	3	OB	TB
1/3	3450	1	OG	TG
1/3	3450	3	OH	TH
1/2	1725	1	OC	TC
1/2	1725	3	OD	TD
1/2	3450	1	OM	TM
1/2	3450	3	OT	TT
3/4	1725	1	OE	TE
3/4	1725	3	OF	TF
3/4	3450	1	ON	TN
3/4	3450	3	OU	TU
1	1725	1	OJ	TJ
1	1725	3	OK	TK
1	3450	1	OP	TP
1	3450	3	OW	TW
1½	1725	1	OL	TL
1½	1725	3	OO	TO
1½	3450	1	OQ	TQ
1½	3450	3	OX	TX
2	1725	3	OR	TR
2	3450	1	OS	TS
2	3450	3	OY	TY

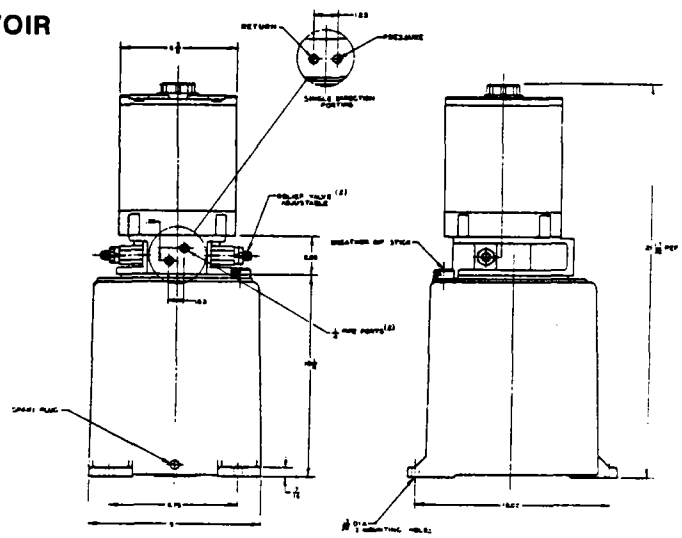
DC MOTORS - CONSULT FACTORY

RELIEF VALVES INCLUDED AS STANDARD
SPECIFY PRESSURE SETTINGS OF ALL RELIEF VALVES & PRESSURE SWITCHES
CONSULT FACTORY WHEN USING OIL OTHER THAN STANDARD INDUSTRIAL HYDRAULIC OIL
OTHER MOTORS, INCLUDING DC ARE AVAILABLE UPON RECOMMENDATION FROM THE FACTORY

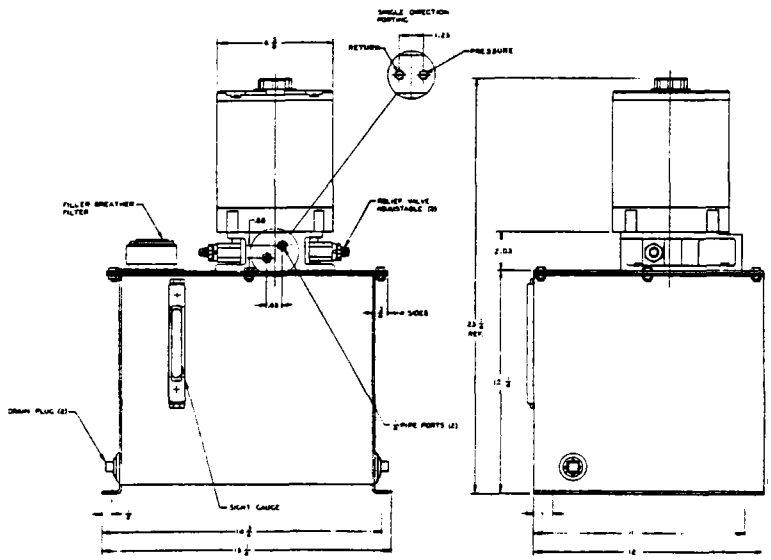
GENERAL OUTLINE DIMENSIONS



280 CUBIC INCH ROUND RESERVOIR

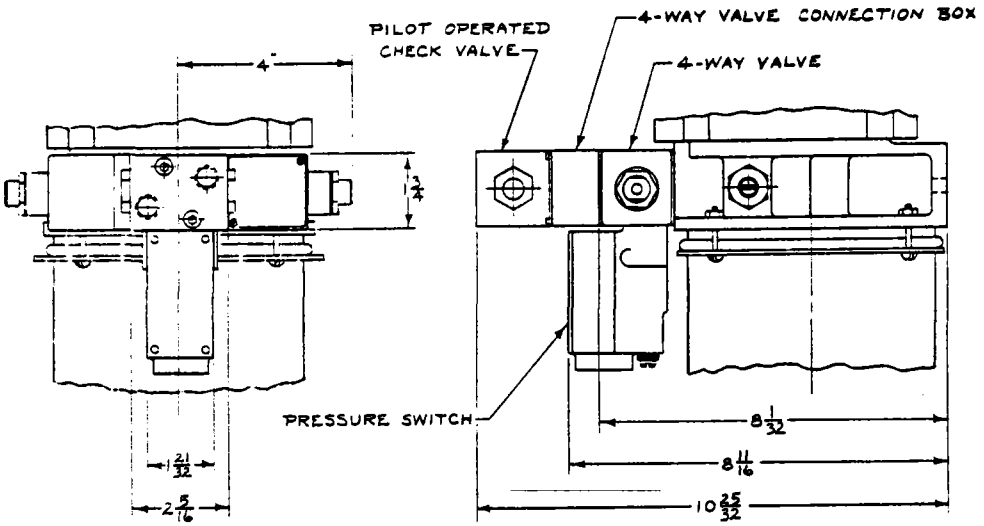


3 GALLON RESERVOIR

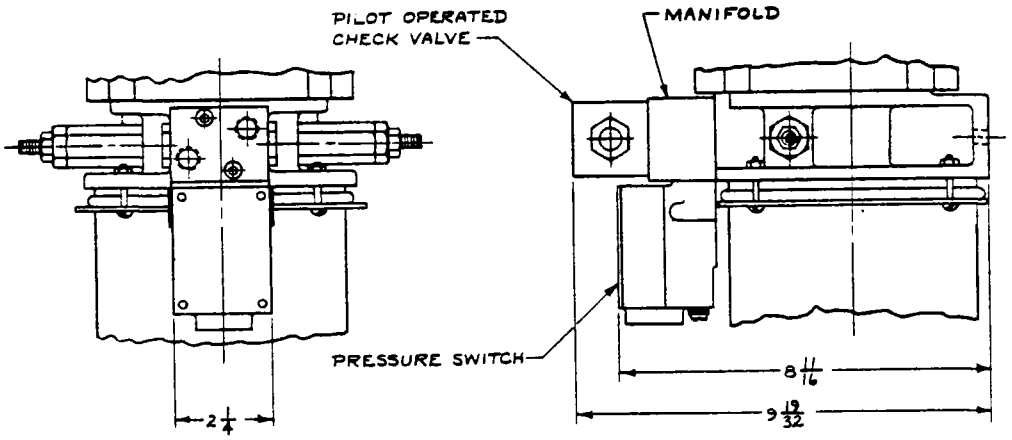


5 GALLON RESERVOIR

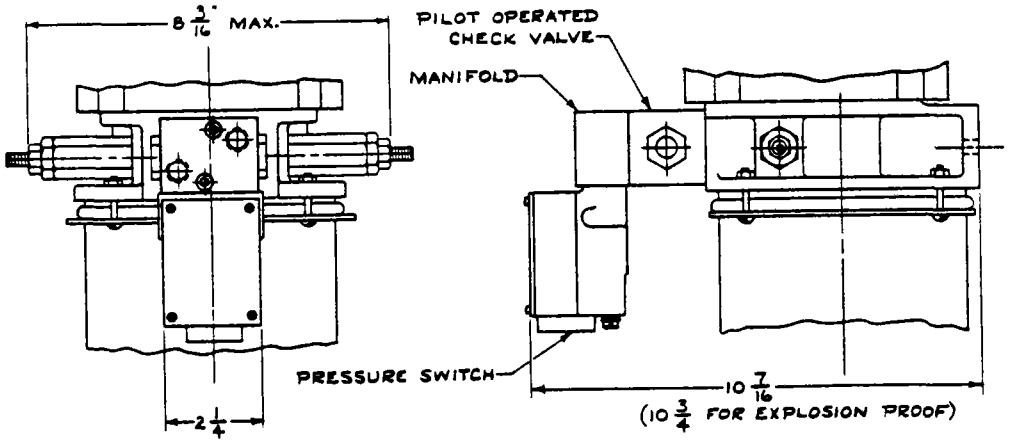
OUTLINE DRAWINGS FOR OPTIONAL FEATURES



SINGLE DIRECTION WITH 4-WAY VALVE, SINGLE PRESSURE SWITCH & DUAL PILOT OPER. CHECK



REVERSIBLE WITH DUPLEX PRESSURE SWITCH (NON-MONITORING) & DUAL PILOT OPERATED CHECK



REVERSIBLE WITH DUPLEX PRESSURE SWITCH (MONITORING) & DUAL PILOT OPERATED CHECK

START-UP PROCEDURE

FOLLOW DIRECTIONS CAREFULLY (IMPROPER START-UP CAN CAUSE DAMAGE TO UNIT)

1. FILL UNIT WITH CORRECT HYDRAULIC FLUID.

   ALL STANDARD UNITS CAN BE USED WITH:
   OILDYNE NO. 15, 18 OR 31. HYDRAULIC TRANSMISSION FLUID TYPE (ATF).
   ANY HIGH QUALITY HYDRAULIC OIL WITH VISCOSITIES OF 150 SSU @ 100° F
   TO 350 SSU @ 100° F THAT HAS PROPERTIES SIMILAR TO AMERICAN OIL COMPANY
   RYKON 15-25-OR-31.

   NOTE: IF SPECIAL FLUIDS ARE REQUIRED, UNIT IS TAGGED WITH THIS
   INFORMATION. (THIS INFORMATION IS ALSO GIVEN ON PACKING PAPERS.)

2. MAKE CERTAIN THE MOTOR IS WIRED CORRECTLY. (MOTOR WIRING DATA IS ON THE MOTOR NAME PLATE OR IS INSIDE THE WIRING BOX COVER.)

3. WITH BOTH PUMP PORTS OPEN, (NOT CONNECTED TO FLUID LINES), MOMENTARILY JOG THE UNIT IN ONE DIRECTION. IF HYDRAULIC FLUID DOES NOT FLOW FREELY FROM EITHER PORT, JOG THE UNIT IN THE OPPOSITE DIRECTION. REPEAT THIS PROCESS UNTIL FLUID FLOWS FREELY FROM EACH PORT ACCORDING TO ROTATION. UNIT IS NOW PROPERLY PRIMED AND CAN BE CONNECTED TO YOUR HYDRAULIC CIRCUIT.

4. WHEN CIRCUIT COMPONENTS, (CYLINDERS, ETC.), ARE BEING FILLED FROM THE UNIT, MAKE CERTAIN THE OIL TANK ON THE UNIT IS NOT EMPTIED MORE THAN 1/2 CAPACITY. REFILL TANK AS REQUIRED WHEN TANK IS LOW.

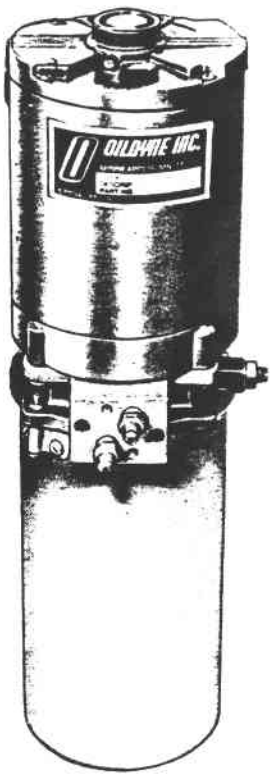
5. LOOKING AT THE UNIT WITH MOTOR ON TOP AND PORTS FACING YOU, THE RIGHT-HAND PORT PRESSURE IS CONTROLLED BY THE RIGHT-HAND RELIEF VALVE AND VICE-VERSA. IF THE RELIEF VALVE PRESSURE SETTINGS SPECIFIED ARE NOT EQUAL, THE HIGH PRESSURE PORT IS AT THE RIGHT. THE RIGHT-HAND PORT SHOULD BE CONNECTED TO THAT SIDE OF YOUR CIRCUIT REQUIRING THE HIGHEST PRESSURE.

INSTRUCTION BULLETIN 330 SERIES

STANDARD SINGLE DIRECTION UNIT

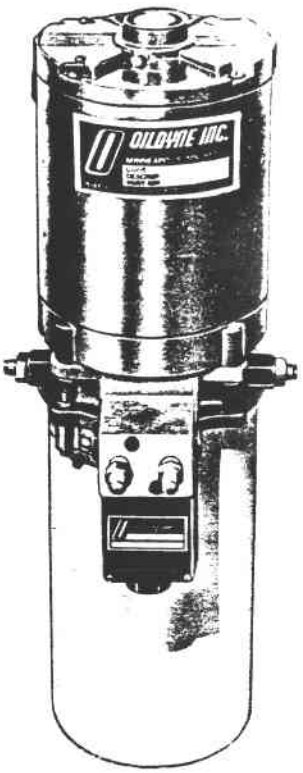
STANDARD UNIT WITH 4-WAY DIRECTIONAL CONTROL VALVE

REVERSIBLE UNIT WITH P.O. CHECK AND PRESSURE SWITCH



TO 3000 PSI
2 GPM

VERTICAL OR HORIZONTAL



QUIET RUNNING

RUGGED DUTY

INSTALLATION PROCEDURE

1. Mount the Unit securely in a vertical position with the motor up, unless specified for horizontal mounting as shown in the code description. (See Page 3). Horizontally mounted units have a filler/breather on the reservoir.

2. Fill the reservoir with Oildyne type 15, 18, or 31 hydraulic fluid, or any high-grade hydraulic oil with viscosities of 150 SSU- 350 SSU at 100° F.

3. Wire the power unit as shown on page 2.

OILDYNE
DIVISION OF COMMERCIAL SHEARING, INC.

Specialists in Compact Fluid Power

4301 QUEBEC AVE. N.
MINNEAPOLIS, MN 55428
Tel. (612) 533-1600
TWX: 910-576-2687

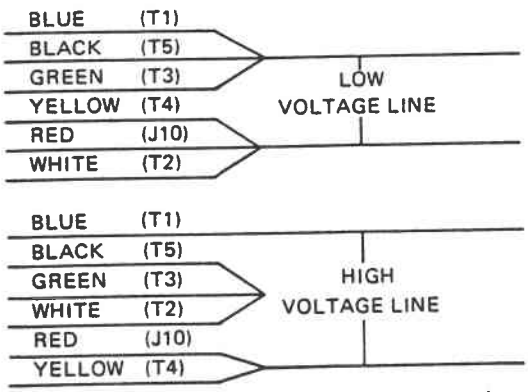
WIRING INSTRUCTIONS

Wire the motor according to the motor manufacturer's instructions. These are shown on the motor nameplate or inside the wiring box cover.

Single direction units have a rotation arrow on them. Be certain the motor rotates in the proper direction.

Examples are shown below:

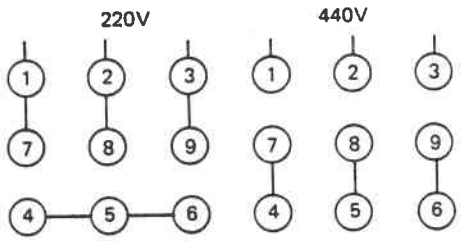
SINGLE PHASE MOTORS



Wiring diagrams shown for single direction and reversible pumps (R.H. port). For reversible pumps (L.H. port) interchange black (T5) and red (J10) leads.

CAUTION: On single direction pumps, do not reverse motor or pump will be damaged.

THREE-PHASE MOTORS



1. Connect line leads to (1) (2) (3)
2. To reverse rotation, interchange two-line leads.

START UP PROCEDURE

NOTE: Before starting the power unit, make certain the reservoir is full of oil.

SINGLE DIRECTION POWER UNIT (One externally adjustable relief valve)

1. Jog the motor and check its rotation with the rotation decal on the motor.
2. After the entire system has been filled, the reservoir should be at least half full of oil.
3. The relief valve and pressure switches (if so equipped) are factory set, but are externally adjustable.

REVERSIBLE POWER UNIT (Two externally adjustable relief valves)

1. With both pump ports open (not connected to fluid lines), momentarily jog the unit in one direction. If hydraulic fluid does not flow freely from either port, jog the unit in the opposite direction. Repeat this process until fluid flows freely from each port according to rotation. Unit is now properly primed and can be connected to your hydraulic circuit.
2. After the entire system has been filled, the reservoir should be at least half-full of oil.
3. The relief valves and pressure switches (if so equipped) are factory set. but are externally adjustable. To adjust the relief valves, look at the unit with the motor on top and the ports facing you. The right hand port pressure is adjusted by turning the adjusting screw on the right-hand relief valve, and vice-versa for the left-hand port. The right-hand port should be connected to the side of the circuit requiring the highest pressure.

HELPFUL HINTS

- Don't operate the unit without the recommended fluid in the reservoir.
- Don't run the unit over 165° F. A fluid temperature of 100° to 120° F. is ideal for the best operation of the unit. At higher operating temperatures, always have a minimum viscosity of 100 SSU.
- Set the relief valve at the lowest pressure required for system operation to minimize heat build-up and energy loss.
- To insure top performance, keep the reservoir, filter, and oil clean. Check at regular intervals and change oil in the system every 1,000 hours for normal usage (120° F. operating temperature), and more frequently for higher operating temperatures.

CODE DESCRIPTION

HOW TO ORDER CODE

3TT7 - 13L - DVSD

330 POWER UNIT

MOTORS
INDUCTIVE TYPE - 60 CYCLE
***NONE**

H.P.	RPM	PHASE	OPEN CODE	TEFC CODE
1/3	1725	1	OA	TA
1/3	1725	3	OB	TB
1/3	3450	1	OG	TG
1/3	3450	3	OH	TH
1/2	1725	1	OC	TC
1/2	1725	3	OD	TD
1/2	3450	1	OM	TM
1/2	3450	3	OT	TT
3/4	1725	1	OE	TE
3/4	1725	3	OF	TF
3/4	3450	1	ON	TN
3/4	3450	3	OU	TU
1	1725	1	OJ	TJ
1	1725	3	OK	TK
1	3450	1	OP	TP
1	3450	3	OW	TW
1½	1725	1	OL	TL
1½	1725	3	OO	TO
1½	3450	1	OQ	TQ
1½	3450	3	OX	TX
2	1725	3	OR	TR
2	3450	1	OS	TS
2	3450	3	OY	TY

DC MOTORS - CONSULT FACTORY

CIRCUIT TYPE

W — WITH CHECK
N — CONSTANT FLOW (NO VALVE)
R — REVERSIBLE
L — REVERSIBLE LOCKING W/PILOT OPERATED CHECK
S — SINGLE SOLENOID 4-WAY
DOUBLE SOLENOID 4 WAYS
C — CLOSED 1-C SPOOL
O — OPEN 2-C SPOOL
T — TANDEM 3-C SPOOL
F — FLOAT CENTER 7-C SPOOL

RESERVOIR SIZE

12 – 150 CU/IN
13 – 280 CU/IN
8 – 3 GAL
14 – 5 GAL*
* INCLUDES SIGHT LEVEL GAUGE

PUMP SIZE

2 — .270 (.036 CIPR)
5 — .530 (.071 CIPR)
7 — .790 (.107 CIPR)
10 — 1.000 (1.000 CIPR)

ADDITIONAL OPTIONS

A – FLOAT LEVEL SWITCH
C – PRESSURE GAUGE
D – OIL LEVEL SIGHT GAUGE
N – NONE
E – SIDE RETURN

UNIT TYPE

S – STANDARD
X – EXPLOSION PROOF

MOUNTING POSITION

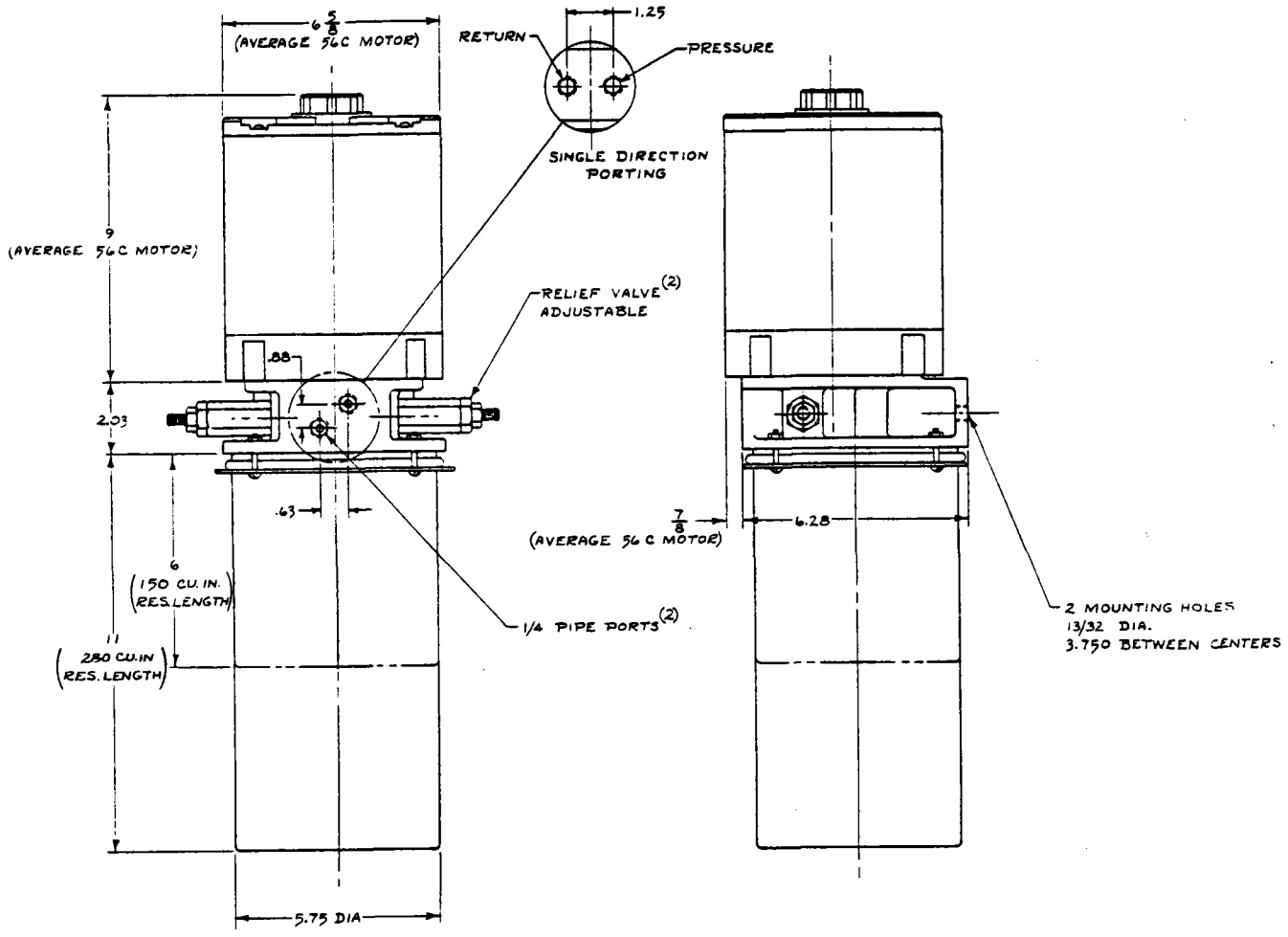
H – HORIZONTAL
V – VERTICAL

PRESSURE SWITCH

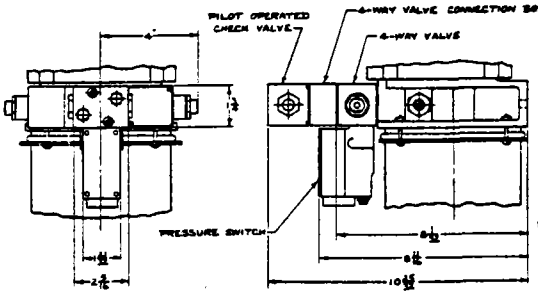
S – SINGLE
D – DUPLEX
N – NONE

DIMENSIONS

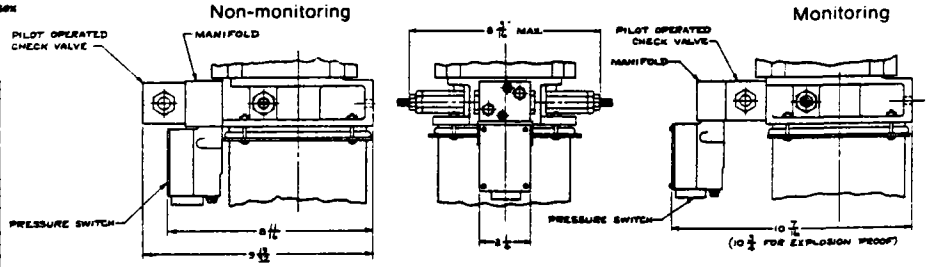
OUTLINE DRAWINGS FOR OPTIONAL FEATURES



SINGLE DIRECTION UNIT WITH 4-WAY VALVE, SINGLE PRESSURE SWITCH AND DUAL PILOT OPERATED CHECK VALVE

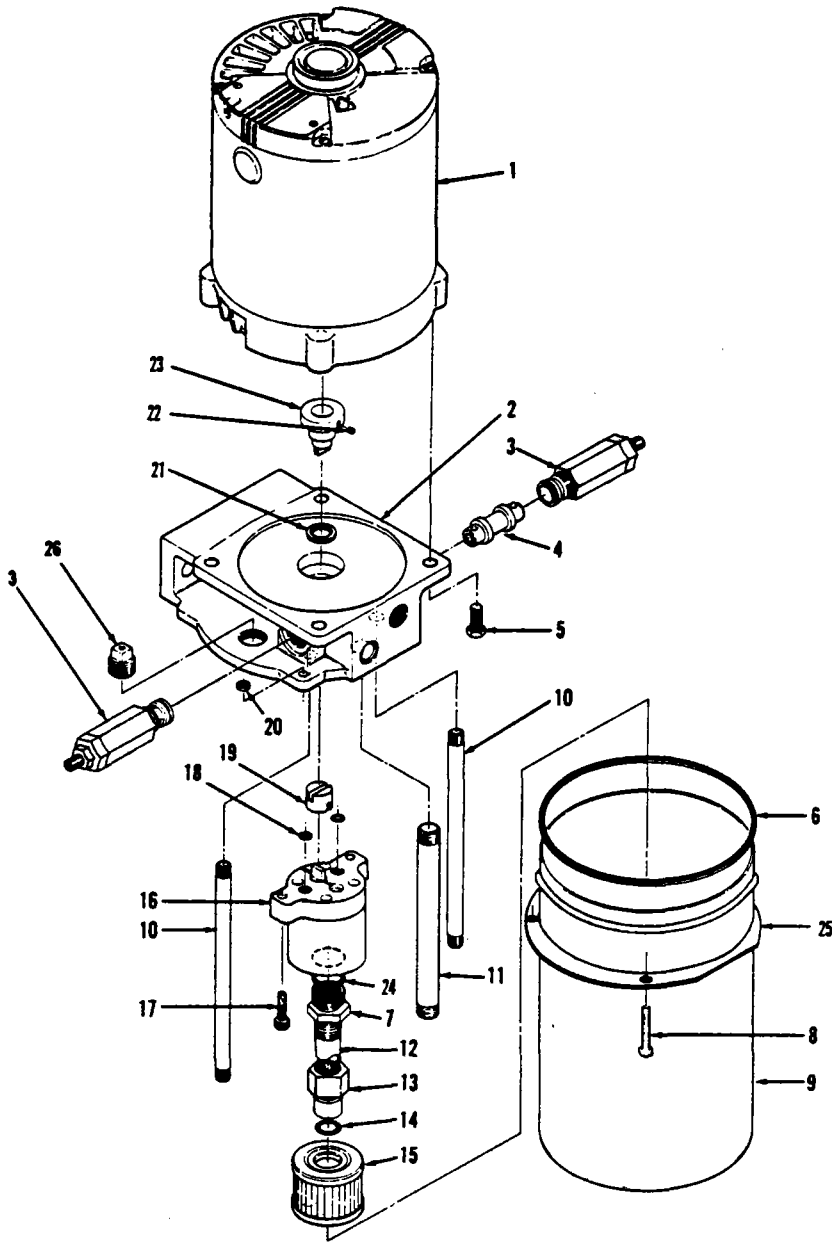


REVERSIBLE UNIT WITH DOUBLE PRESSURE SWITCH AND DUAL PILOT OPERATED CHECK VALVE



RESERVOIR SIZES

NO.	OIL REQUIRED	DESCRIPTION OF TANK	DIAMETER	HEIGHT	WIDTH	DEPTH
12	150 Cu. In.	Cylindrical Drawn Aluminum	5.75"	6"	N.A.	N.A.
13	280 Cu. In.	Cylindrical Drawn Aluminum	5.75"	11"	N.A.	N.A.
8	3 Gal.	Rectangular Cast Aluminum	N.A.	10¼"	9"	9"
14	5 Gal.	Rectangular Welded Steel	N.A.	12.13"	12.15"	11.25"



330 SERIES POWER UNITS STANDARD OR REVERSIBLE

Item No.	Part No.	Description	Qty. Req.
1	* *	MOTOR	1
2	* *	ADAPTER	1
†3	* *	RELIEF VALVE ASSEMBLY	2
4	359551	SHUTTLE SPOOL (Reversible Only)	1
5	409221	BOLT, HEX HD., 3/8-16 x 7/8 IN.	4
6	409850	GASKET	1
7	360732	HEX REDUCER BUSHING	1
8	410175	SCREW, NO. 10-32 x 1¼ IN.	4
9	* *	RESERVOIR	1
10	409875	PIPE NIPPLE, ⅛ x 8 IN.	2
11	409867	PIPE NIPPLE (Reversible Only) ¼ x 8 IN.	1
12	409876	PIPE NIPPLE, ½ x 6 IN.	1
13	360244	SUCTION STRAINER ADAPTER	1

Item No.	Part No.	Description	Qty. Req.
14	405226	O-RING (113-70)	1
15	409071	FILTER	1
16	* *	BASIC PUMP	1
17	400787	CAP SCREW, SOC. HD., ¼-28 x 1 IN.	2
18	409051	O-RING (010-90)	2
19	359673	COUPLING	1
20	403395	HEX NUT, NO. 10-32	4
21	409892	OIL SEAL	1
22	410437	SET SCREW, SOC. HD., ¼-28 x 3/8 IN.	1
23	359672	SHAFT ADAPTER	1
24	408569	O-RING (118-70)	1
25	360239	RETAINING RING	1
26	359656	BREATHER PLUG (VERTICLE ONLY)	1

* When ordering spring, please specify relief valve setting or spring range.
** Please specify code description of the power unit when ordering these items.
† One (1) each necessary for single direction, two (2) each for reversible direction.

PARTS ORDERING

Supply the following information when ordering parts or requesting information:

1. Complete Power Unit Code and Part Number as shown on Oildyne Nameplate.
2. Quantity, six-digit part number and description of parts as shown on Page 5.
3. Motor Nameplate information is required if a replacement motor is ordered.

FACTORY REPAIR

Oildyne maintains a complete repair facility for your convenience. To have your unit factory repaired, return to the address on the front with a complete explanation of the problem.

WARRANTY

Oildyne equipment is guaranteed against defects in materials and workmanship. All equipment manufactured and sold by this company, which is found to be defective in either materials or workmanship, will be repaired or replaced upon the manufacturer's option. Any equipment that has been misused, abused, altered, worn out, or used for any purpose other than that for which it was intended, will not be covered by this guarantee. Final determination of defects will be made at the factory.

OILDYNE
DIVISION OF COMMERCIAL SHEARING, INC.

Specialists in Compact Fluid Power

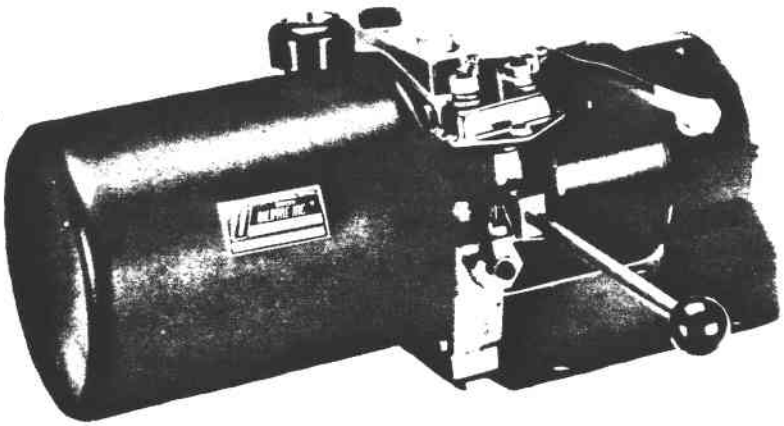
4301 QUEBEC AVE. N.
MINNEAPOLIS, MN 55428
Tel. (612) 533-1600
TWX: 910-576-2687

APPENDIX Q

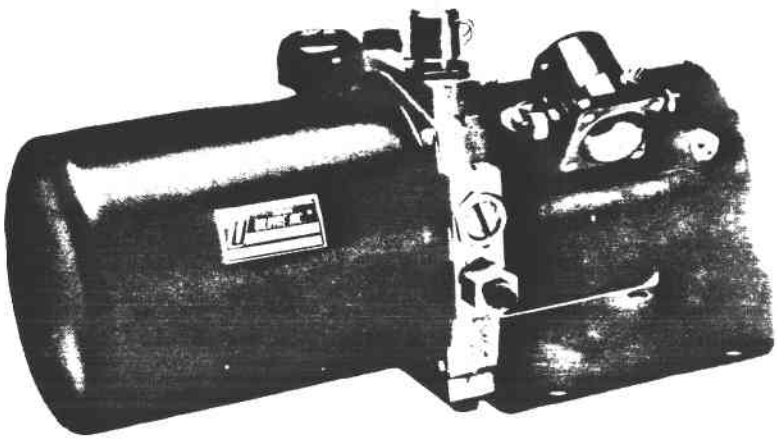
OILDYNE PUMPS P3 AND P4

OILDYNE
DIVISION OF COMMERCIAL SHEARING, INC.

425 SERIES DC POWER UNITS



WITH MANUAL OPERATED RELEASE VALVE



WITH SOLENOID OPERATED RELEASE VALVE

ALSO AVAILABLE WITH 4-WAY VALVE OR INTEGRAL CHECK VALVE CIRCUIT.

- Designed for use on mobile equipment with a 12 volt electrical system.
- System ideal for applications in which a load is lifted and held such as tailgates, hay bale loaders, aerial ladders, fork lifts, etc.
- Wide selection of options — can be tailored to meet your system needs.
- Pressures to 3000 PSI.
- Vertical or horizontal mounting.
- Extra return port provided on most versions.

SPECIFICATIONS

ELECTRICAL — 12 VDC series wound motor, grounded case, intermittent duty — supplied with motor starter.

Release solenoid is intermittent duty — 50% duty cycle, 11 min. max. on time.

PUMP — Spur gear, 5 sizes ½ GPM to 3 GPM (see the performance curves)

FILTRATION — 100 mesh suction screen (149 micron)

RESERVOIR — ½ gallon, 1 gallon 1½ gallon and 2½ gallon.

FLUID — Recommended: standard automatic transmission fluid or standard hydraulic fluid with viscosity ratings suitable to climatic conditions.

VALVING —

RELIEF VALVE — An integral relief valve that is externally adjustable up to 3000 PSI is standard on all units.

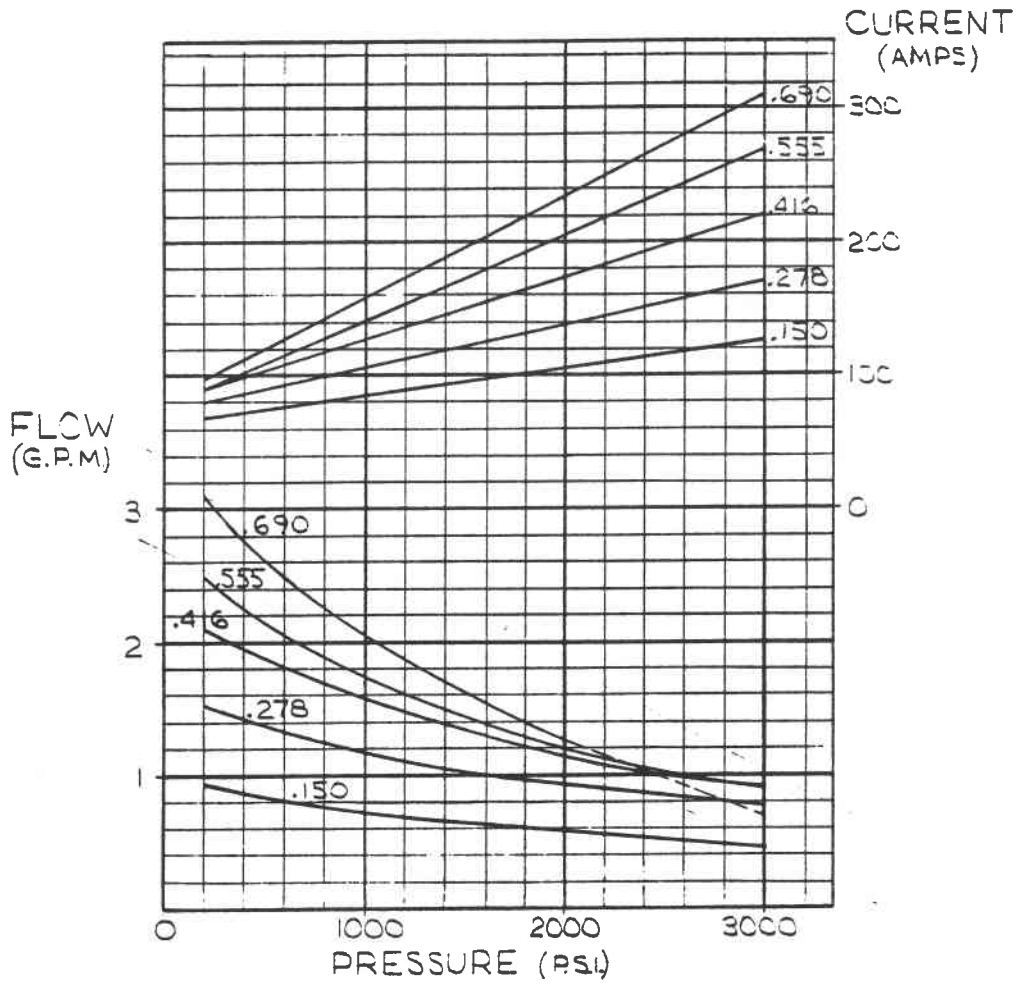
CHECK VALVES — Power units are available with or without a holding check for the discharge port.

RELEASE VALVES — Manual or solenoid release valves are available on units with holding checks.

MANUAL RELEASE — The manual release and the motor starter are operated by a common lever. Actuating the lever upward starts the motor causing the pump to deliver oil against a load. Releasing the lever shuts the motor off and allows the holding check to seat. Actuating the lever down, releases the load. The rate at which the load returns or the return flow rate, is controlled by the position of the lever. (See dimensional drawings).

SOLENOID RELEASE — The solenoid release is a pilot operated valve with an integral flow control valve. The return flow control operates similar to a needle valve and must be preset. It is not adjustable during actuation. When the solenoid release is supplied the solenoid motor starter is also supplied. Minimum adjustable flow — 50 CIPM at 3000 PSI.

4-WAY VALVE — A four way valve can be manifold mounted on the power unit. Double solenoid 3 position and single solenoid 2 position valves are available. The 3 position spools that are available are shown on the dimensional drawing (open, closed, tandem, and float center).



HOW TO ORDER CODE

4S27 — 05M — NHSN

4-425 POWER UNIT
WITH RELIEF VALVE

MOTOR
S—12V DC SINGLE DIRECTION
WITH STARTER

PUMP SIZE
15—.150 (.038 CIPR)
27—.278 (.069 CIPR)
41—.416 (.104 CIPR)
55—.555 (.139 CIPR)
69—.690 (.173 CIPR)

RESERVOIR SIZE
05 — ½ GAL.
10 — 1 GAL.
15 — 1½ GAL.
25 — 2½ GAL.

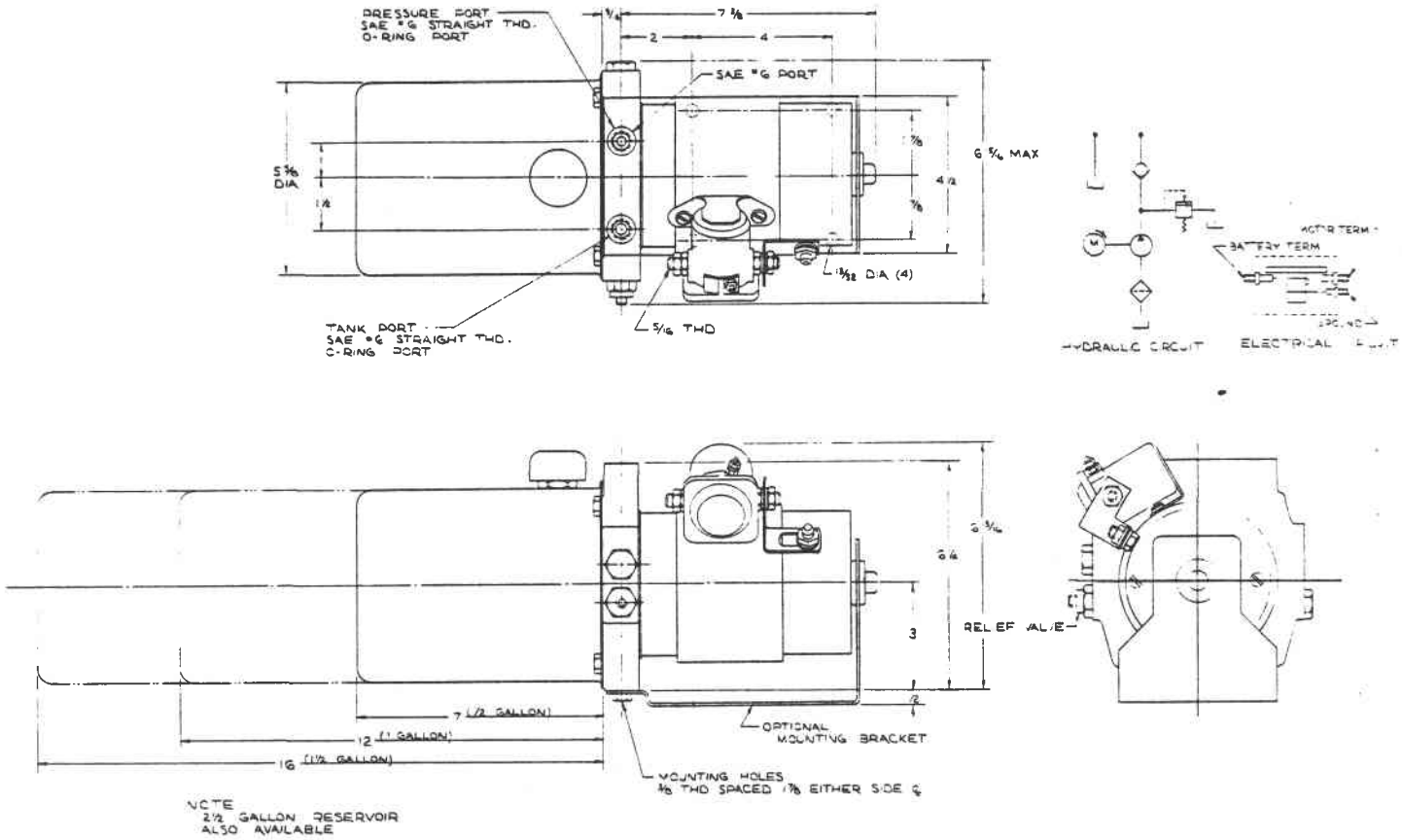
CIRCUIT TYPE
N — WITHOUT HOLDING CHECK VALVE
W — WITH HOLDING CHECK VALVE
M — MANUALLY OPERATED RELEASE WITH CHECK VALVE (LEVER OPTIONAL)
E — SOLENOID OPERATED RELEASE VALVE WITH CHECK
S — SINGLE SOLENOID 4-WAY
DOUBLE SOLENOID 4-WAYS
C — CLOSED 1-C SPOOL
O — OPEN 2-C SPOOL
T — TANDEM 3-C SPOOL
F — FLOAT CENTER 7-C SPOOL

PRESSURE SWITCH
N — NONE
S — AVAILABLE ONLY ON SPECIAL UNITS

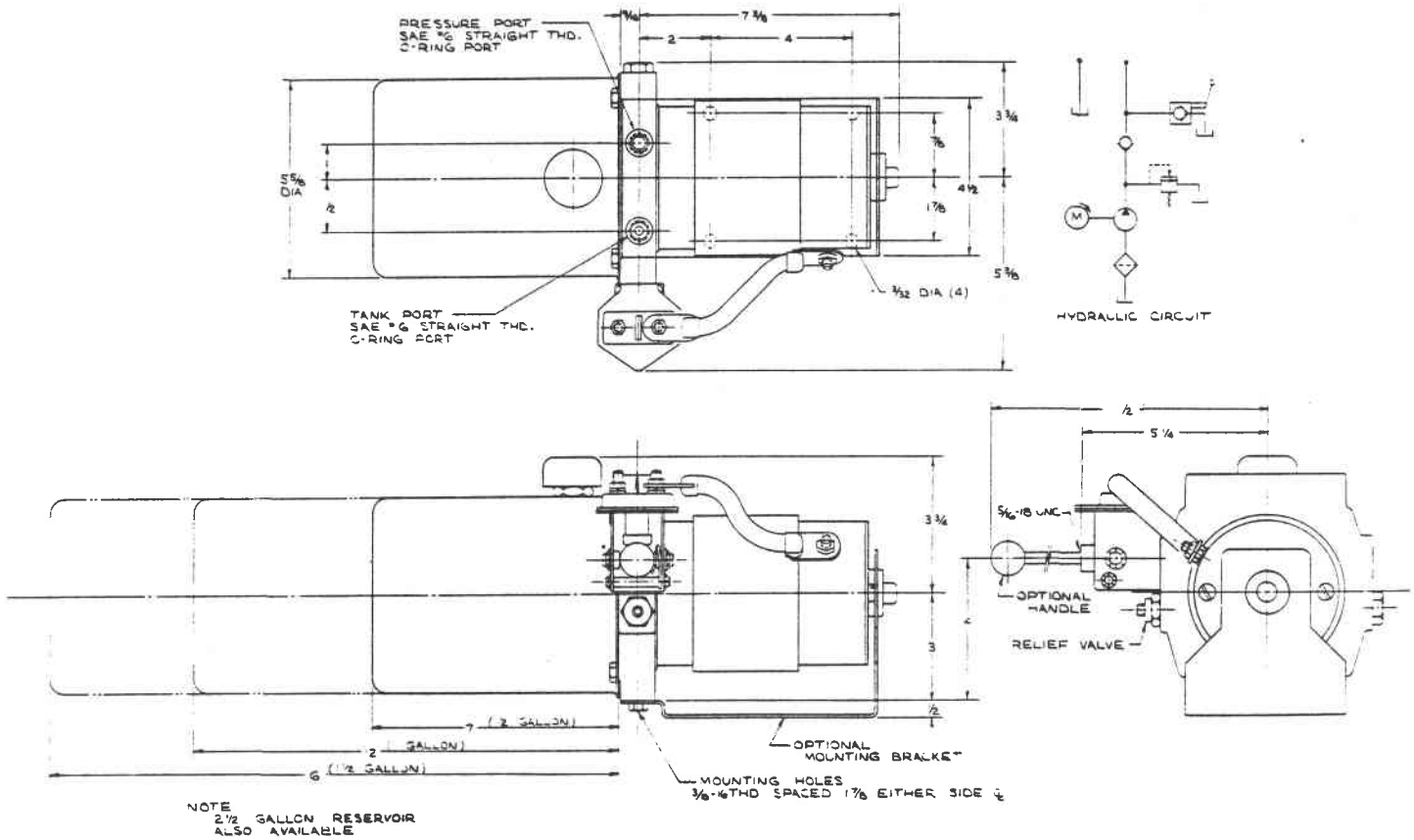
MOUNTING
H — HORIZONTAL
V — VERTICAL

ELECTRICAL
S — STANDARD 12V DC

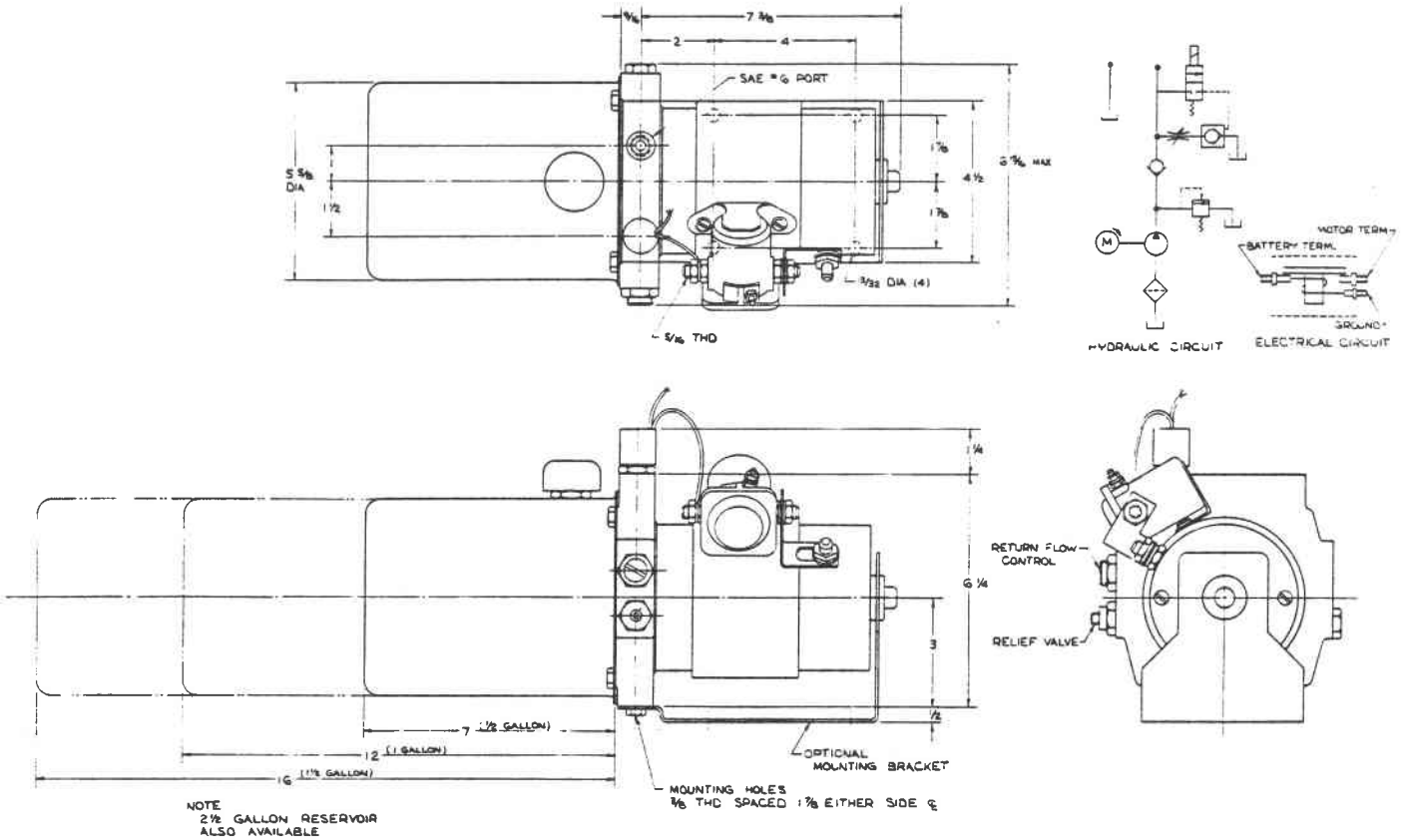
OPTIONS
N — NONE
D — SIGHT GAUGE
M — MOTOR MOUNTING BRACKET
L —LEVER FOR MANUAL RELEASE



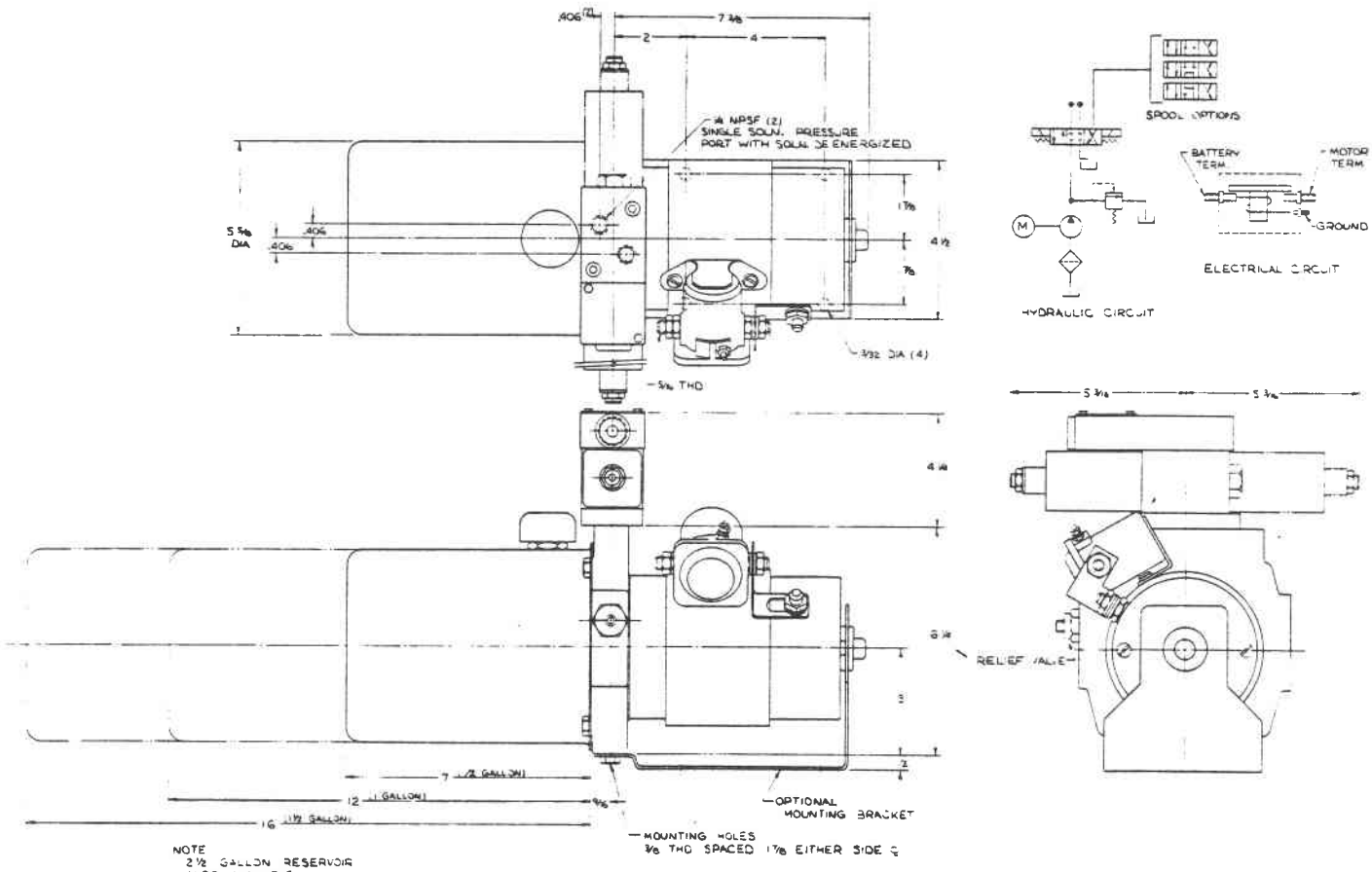
425 12V DC POWER UNIT WITH CHECK VALVE



425 12V DC POWER UNIT WITH MANUALLY OPERATED RELEASE VALVE



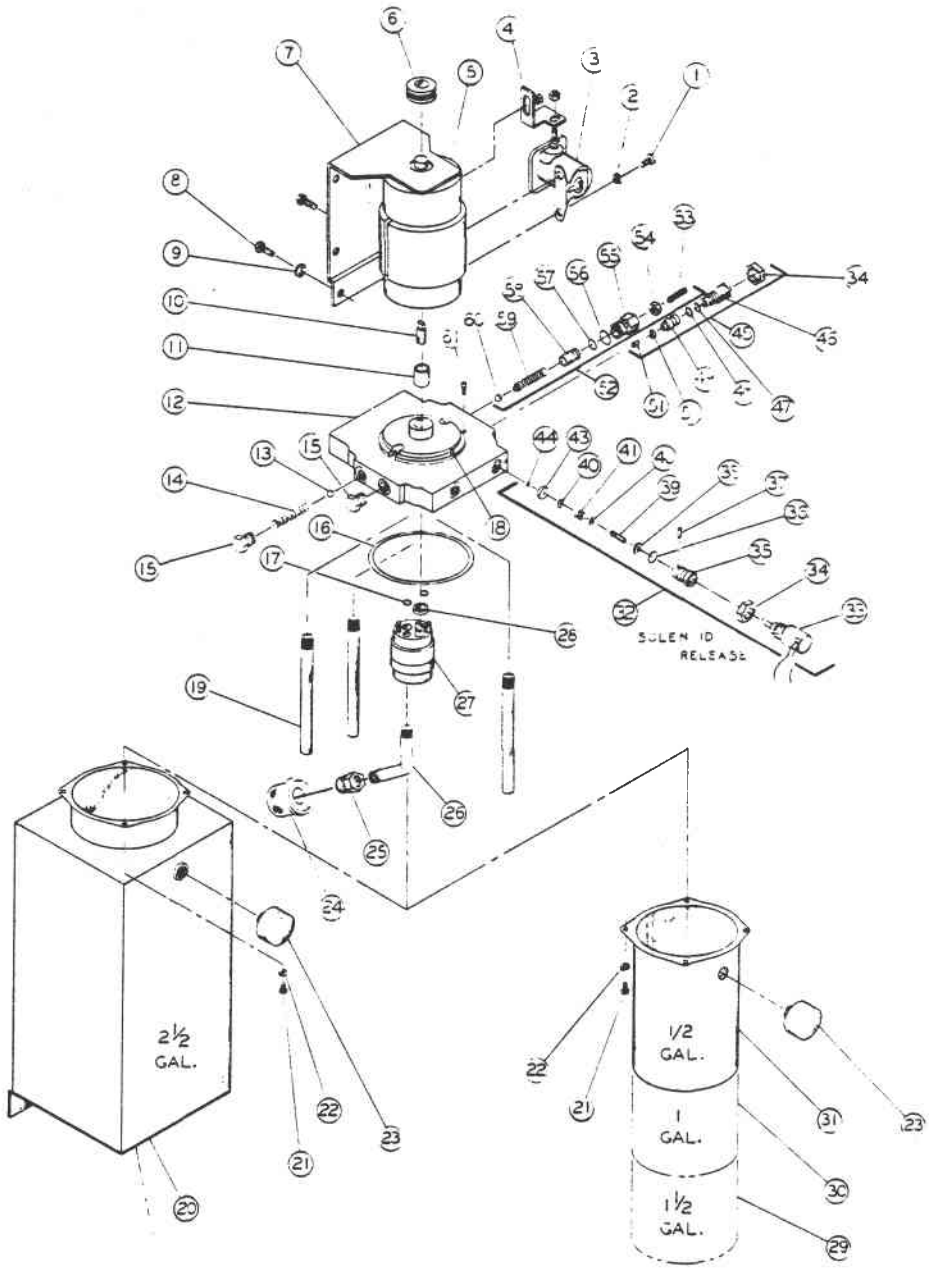
425 12V DC POWER UNIT WITH SOLN. OPERATED RELEASE



425 12V DC POWER UNIT WITH 4 WAY VALVE

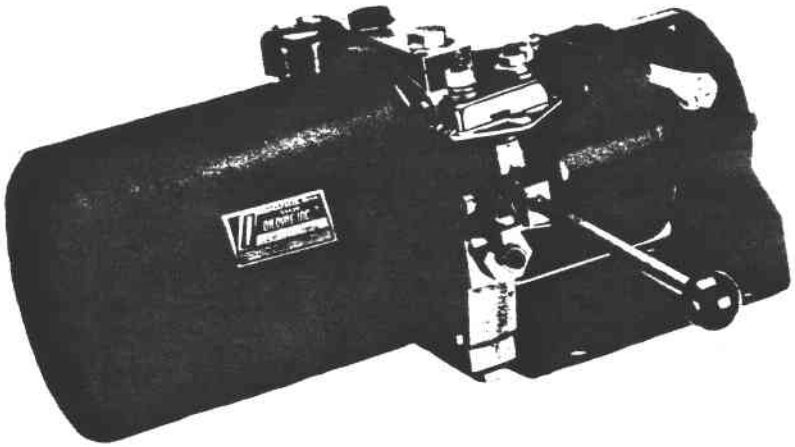
EXPLODED VIEW — SOLENOID OPERATED RELEASE VALVE UNIT

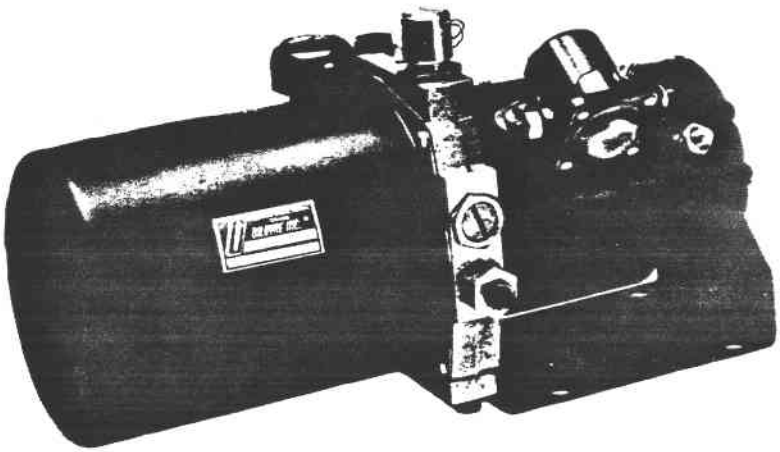
EXPLODED VIEWS OF OTHER CIRCUITS ARE SHOWN IN THE 425 SERIES INSTRUCTION BULLETIN



INSTRUCTION BULLETIN

425 SERIES DC POWER UNITS





INSTALLATION PROCEDURE

MOUNTING

The power unit should be mounted using the 4 mounting holes in the bracket or the two holes in the casting. The bracket is recommended where the unit is subject to shock and vibration loads. When the 1-1/2 gallon reservoir is used additional support may be needed for the reservoir if vibration and shock loads are severe. Horizontal units should be mounted with the bracket down. For other horizontal positions, consult the factory. The unit should be mounted so that the relief valve, flow control valve (solenoid release) and filler breather are easily accessible and protected as much as possible from the weather.

WIRING - GENERAL

The positive terminal of the battery should be connected to the starter switch on the unit by a minimum length of #4 battery cable. Make other electrical connections per the dimensional drawings.

MANUAL RELEASE UNIT

On power units with the manual release, the lever is optional or the customer can install his own linkage to activate the cam. (See dimensional drawings.) There is an adjustment on the release mechanism (Item 78 and 79 of the service parts list). Adjusting the screw will set the maximum return flow rate by limiting the travel of the plunger (80).

SOLENOID RELEASE UNIT

A power unit with a solenoid release valve is designed to be operated with a 3 position SPDT Toggle Switch, minimum 4 amps. (Not supplied with the power unit.) Refer to Figure 1 for electrical connections.

The return flow control valve can only be adjusted when the system pressure is at zero. The valve should be set by turning the adjustment all the way in and backing out 1/4 turn to try. Turning the adjustment in reduces flow rate and turning out increases flow rate. Caution should be used at high pressures, small changes in the setting can make a large change in the flow restriction.

4-WAY VALVE UNIT

The two cylinder ports are located on top of the valve and the electrical connections are made in the electrical box on the valve.

ALL UNITS - GENERAL INSTRUCTIONS

After the hydraulic lines and electrical connections are made, fill the reservoir with automatic transmission fluid or a good quality hydraulic oil having a viscosity index that is suitable for the climatic conditions in which the unit will be operated.

Before tightening all of the fittings, bleed the air from the system by cycling the unit. Be sure to jog the motor until fluid is being discharged from the pump.

The relief valve is set at the factory to the pressure requested by the customer. It can be adjusted in the field. The maximum adjustable pressure is 3000 psig. (The relief valve should not be adjusted higher than 2000 psi if the .690 pump is used.)

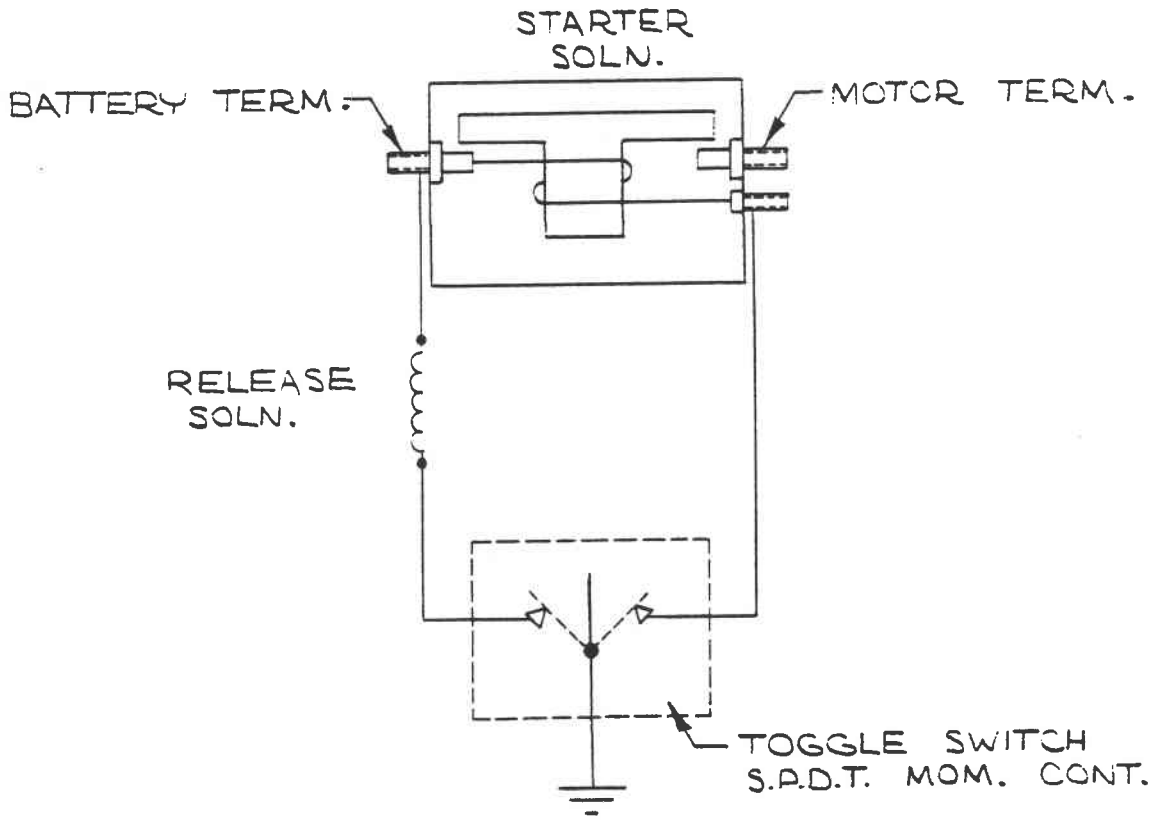
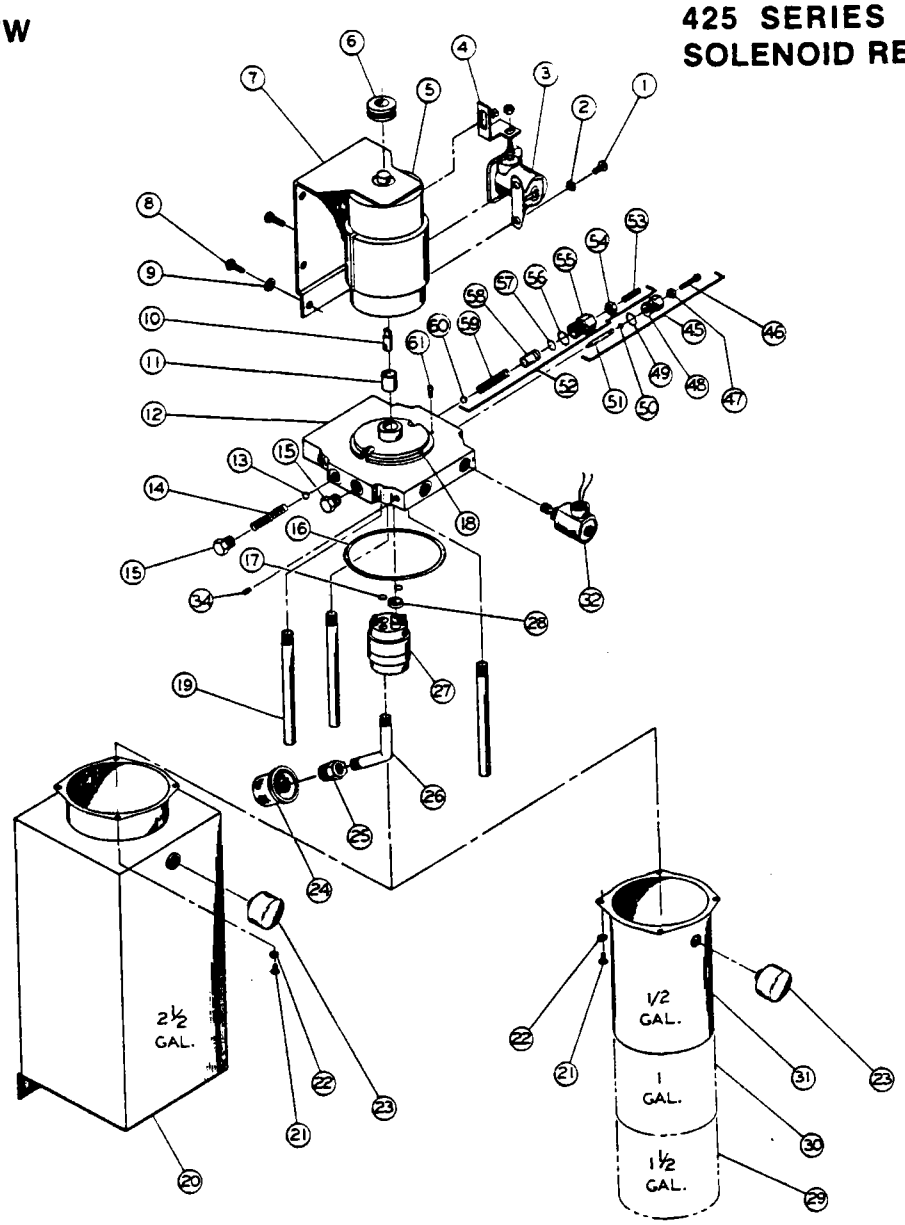


FIG # 1

EXPLODED VIEW

425 SERIES POWER UNIT WITH SOLENOID RELEASE CIRCUIT

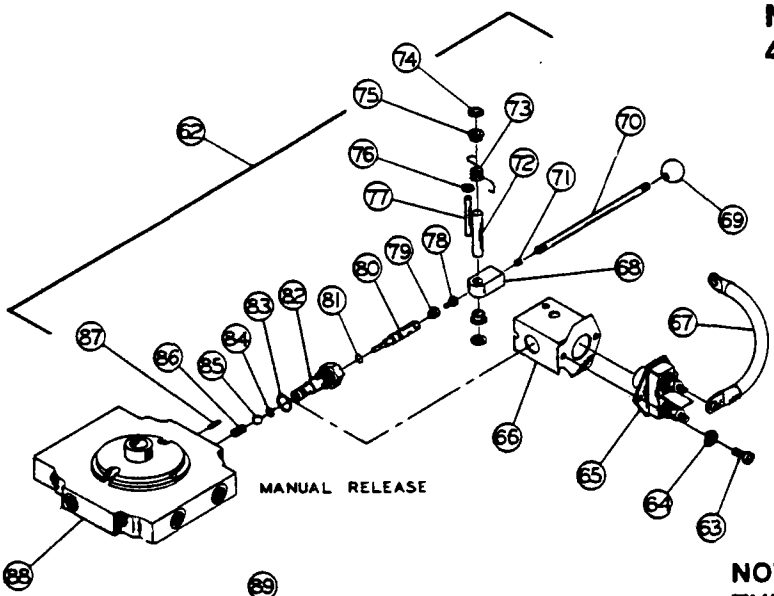


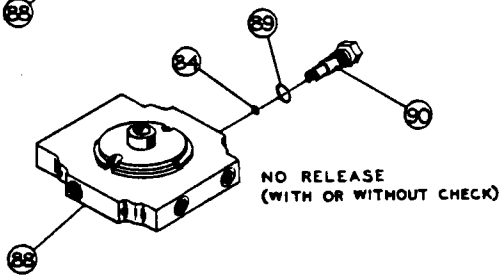
Reference #	Part #	Description	Quantity
1	410591	1/4-20 x 3/8" Sl. Pan Hd. Cs.	2
2	400906	1/4" Lockwasher	2
3	410585	Solenoid (Not with Manual Release)	1
4	410592	Connector (Not with Manual Release)	1
5	410563	Motor	1
6	410524	Grommet	1
7	410520	Mounting Bracket	1
8	400725	3/8-16 x 3/4 Hex. Hd. Cap Sc.	2
9	400907	3/8" Lockwasher	2
10	361291	Coupling	1
11	410525	Bearing	1
12	205508	Adapter	1
13	490405	11/32" Steel Ball (Not with 4-way)	1
14	410554	Spring, Check Valve (Not with 4-way)	1
15	409275	SAE #6 Hex Plug	1*
16	410526	O-Ring (252-70) (Res. Seal)	1
17	409005	O-Ring (011-90)	2
18	490811	Roll Pin	1
19A	361504	Return Pipe (with all Horiz units & Vertical 1/2 Gal Res)	1**
19B	361492	Return Pipe (with Vertical 1 Gal Res)	1**
19C	361493	Return Pipe (with Vertical 1½ & 2½ Gal Res)	1**
20	773748	Reservoir, 2½ Gallon	1
21	410559	#10-32 x 3/8 Hex Hd Cap Sc.	4
22	410248	#10 Lockwasher	4
23	410586	Filler Breather	1
24	410542	Filter	1
25	409976	Hex Reducer Bushing	1
26	361491	Suction Pipe (All Horiz Res. & Vertical 1/2 Gal Res)	1
26	361492	Suction Pipe (Vertical 1 Gallon Reservoir)	1
26	361493	Suction Pipe (Vertical 1½ & 2½ Gal Res)	1
27	631500	Basic Pump .150	1
27	631501	Basic Pump .278	1
27	631502	Basic Pump .416	1
27	631503	Basic Pump .555	1
27	631504	Basic Pump .690	1
28	410694	Oil Seal	1

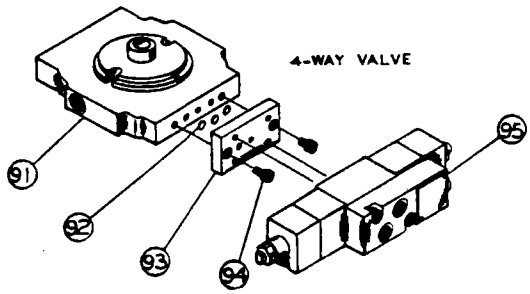
Reference #	Part #	Description	Quantity
29	410519	Reservoir, 1½ Gal	1
30	410518	Reservoir, 1 Gal	1
31	410517	Reservoir, ½ Gal	1
32	410978	Solenoid Release Valve	1
34	410977	1/16 Pipe Plug	1
45	773998	Flow Control & Check Valve Assembly	1
46	400787	Adjusting Screw 1/4-28 x 1 S.H.C.S.	1
47	410721	Locknut	1
48	362239	Adjustment Plug	1
49	410728	O-Ring (908-70)	1
50	401279	O-Ring (008-70)	1
51	362401	Restrictor	1
52	773742	Relief Valve Assembly (with all units)	1
53	410558	5/16-18 x 1" Soc. Hd. Set Sc.	1
54	409843	5/16-18 Hex Nut	1
55	361317	Retainer	1
56	405393	O-Ring (908-90)	1
57	401272	O-Ring (012-70)	1
58	361318	Spring Guide	1
59	409016	Spring	1
60	401066	5/16" Steel Ball	1
61	409214	#6-32 x 3/8 Soc. Hd. Cap Sc.	1
62	773747	Manual Release Assembly	1
63	410591	1/4-20 x 3/8 Sl. Pan Hd. Screw	2
64	400906	1/4" Lockwasher	2

EXPLODED VIEWS

MANUAL RELEASE CIRCUIT
NO RELEASE CIRCUIT
4-WAY VALVE CIRCUIT







NOTE: THESE VIEWS SHOW ONLY THE ADDITIONAL PARTS WHICH ARE USED IN PLACE OF THE SOLENOID RELEASE PARTS SHOWN ON THE PREVIOUS PAGE.

Reference #	Part #	Description	Quantity
65	410636	Starter Switch	1
66	410627	Bracket, Switch Mounting	1
67	410635	Battery Cable	1
68	361544	Cam	1
69	410634	Knob	1
70	361546	Lever	1
71	400863	5/16-18 x 1/4 Set Screw	1
72	361545	Cam Shaft	1
73	410628	Spring	1
74	410631	Shaft Retainer	2
75	410633	Nylon Bearing	2
76	410632	Shaft Retainer	2
77	361547	Stop Shaft	1
78	410559	#10-32 x 3/8 Hex Hd. Sc	1
79	403395	#10-32 Hex Nut	1
80	361543	Release Valve Plunger	1
81	401273	O-Ring (010-70)	1
82	361542	Release Valve Body	1
83	490308	O-Ring (018-70)	1
84	407328	O-Ring (012-90)	1
85	401066	5/16 Dia Steel Ball	1
86	410630	Spring	1
87	490811	Roll Pin	1
88	205539	Adapter	1
89	493127	O-Ring (019-70)	1
90	361549	Plug	1
91	205536	Adapter	1
92	407328	O-Ring (012-90)	3
93	361537	Adapter Plate	1
94	410641	5/16-18 x 1/2" Soc. Hd. Cap Sc.	2
95	(Consult Factory)	4-Way Valve	1

* Quantity is (2) with Solenoid Release Units
** Quantity is (4) with Solenoid Release Units
** Quantity is (2) with 4-Way Valve Units

CODE DESCRIPTION

4S27—05M—NHSN

4 - 425 Power Unit
With Relief Valve

MOTOR
S - 12V DC Single
Direction With
Starter

PUMP SIZE
15—.150 (.038 CIPR)
27 - .278 (.069CIPR)
41 - .416 (.104CIPR)
55 - .555 (.139CIPR)
69 - .690 (.173CIPR)

RESERVOIR SIZE
05 - ½ Gal
10 - 1 Gal
15 - 1½ Gal
25 - 2½ Gal

CIRCUIT TYPE
N — WITHOUT HOLDING CHECK VALVE
W — WITH HOLDING CHECK VALVE
M — MANUALLY OPERATED RELEASE WITH CHECK VALVE (LEVER OPTIONAL)
E — SOLENOID OPERATED RELEASE VALVE WITH CHECK
S — SINGLE SOLENOID 4-WAY
DOUBLE SOLENOID 4-WAYS
C — CLOSED 1-C SPOOL
O — OPEN 2-C SPOOL
T — TANDEM 3-C SPOOL
F — FLOAT CENTER 7-C SPOOL

PRESSURE SWITCH
N - None
S - Available Only
On Special Units

MOUNTING
H - Horizontal
V - Vertical

ELECTRICAL
S - Standard 12V DC

OPTIONS
N - None
D - Sight Gauge
M - Motor Mounting
Bracket
L - Lever For
Manual Release

TROUBLE SHOOTING

PROBLEM	CAUSE	SOLUTION
NO FLOW	- Pump not primed; air trapped in system	- Loosen fitting and cycle unit to bleed air
	- Suction screen plugged	- Remove reservoir, clean screen
	- Low oil level	- Fill reservoir
LOW FLOW	- Low voltage to motor	- Charge battery, clean electrical connections; use larger battery cable; improve motor ground
	- Relief valve set too low	- Adjust relief valve setting
	- Release valve leaking	- Check adjusting screws; remove and clean
	- Pump worn	- Replace pump
CHECK VALVE DOES NOT HOLD	- Dirt	- Remove checks and clean (#13, #45, #62)
	- Seal leakage (solenoid release)	- Replace spool seal #48
	- Leakage past poppet seat (solenoid release)	- Remove and clean solenoid release assembly (#32)
MOTOR DOES NOT RUN	- Loose electrical connection	- Clean and tighten all electrical connections
	- Starter solenoid (#3) burned out	- Replace solenoid starter
	- Manual starter (#65) not making contact	- Depress plunger with screw driver to test
	- Poor ground of motor case	- Clean mounting for good contact
	- Burned out motor	- Replace motor

DISASSEMBLY INSTRUCTIONS

When disassembling be careful to keep dirt out of the system. Before disassembling be sure that all pressure has been bled from the hydraulic lines. (The solenoid release may be manually activated by removing the solenoid coil, 33, and pulling on the solenoid core.)

It may be helpful to remove a hydraulic line and pump the reservoir dry before starting disassembly.

The cable from the battery should be disconnected before starting to eliminate the possibility of accidently shorting out the battery.

MANUAL OPERATED RELEASE VALVE

1. Remove starter switch (65), lever (70) and set screw (71) (5/32 allen wrench).
2. Remove shaft retainers (74) (76) so that parts 68-77 may be removed.
3. Use 1" socket to remove the release valve body (82).
4. Clean and inspect parts before reassembly, checking to make sure that the area where the ball (85) seats on the release valve body (82) is clean and free of scratches.

SOLENOID OPERATED RELEASE VALVE

After bleeding all pressure from the system:

A. Flow Control and Check Assembly (45)

1. Remove cap screw (61) and adjusting screw #46.
2. Remove spool (49) by threading 10-24 x 2" long screw into the spool and pulling it from the bore.
3. Check the condition of seal (48) and seat (50) replace if worn or damaged. Clean orifice in spool insert and reassemble. (Dirt in the orifice will cause the valve to malfunction.)

B. Solenoid Release Assemble (32)

1. Remove the solenoid coil (33). The core is threaded into the poppet (39).
2. Using a large screwdriver, remove the poppet retainer (35). Parts 36-40 are an assembly, (do not disassemble unless damaged).
3. The poppet seat (43) may be removed with a magnet. Clean the seat orifice and check for seat and poppet damage or wear. (Poppet must seal on seat.)

C. Reassembly of Solenoid Release

1. Apply grease to O'ring (44) to make certain it stays in position and assemble seat (43) into bore.
2. Assemble poppet retainer assembly (35) and tighten against seat (43).
3. Assemble solenoid core into poppet and tighten.
4. Assemble the solenoid coil turning it until it "bottoms out" against the solenoid core. Then back the coil out 3/4 turns and lock in place with the lock nut (34).

Removing other assemblies can be done by following the service parts list. For information on the four way valve contact the factory, or Oildyne's TP Line Directional Control Valve literature.

WARRANTY

Oildyne equipment is guaranteed against defects in materials and workmanship. All equipment manufactured and sold by this company, which is found to be defective in either materials or workmanship, will be repaired or replaced upon the manufacturer's option. Any equipment that has been misused, abused, altered, worn out, or used for any purpose other than that for which it was intended, will not be covered by this guarantee. Final determination of defects will be made at the factory.

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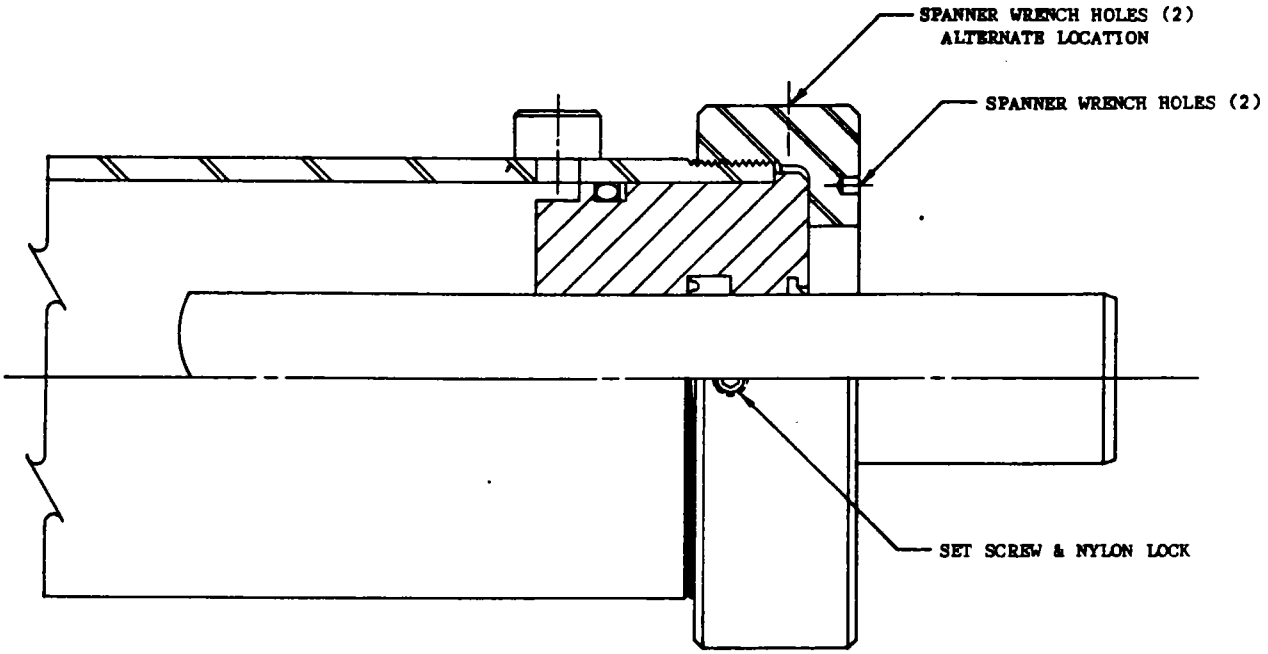
APPENDIX R

PRINCE HYDRAULIC CYLINDERS

GLAND CAP/DISASSEMBLY - ASSEMBLY PROCEDURE



With the cylinder removed from machine, cleaned, retracted, and drained of oil, proceed as follows:

1. Secure cylinder in a vise or other method to prevent rotation. Insure immediate area is clean so parts can be layed out.

2. Loosen set screw in gland if applicable. Remove gland cap with spanner wrench or strap wrench by unthreading.

3. Remove the rod assembly from cylinder. Take care not to damage threads or rod.

4. To remove gland from rod assembly, either remove rod end fitting (clevis) or piston. Then slide gland off rod.

5. Remove all seals from piston and gland.

6. Inspect parts for damage (nicks, scratches, cracks and etc.) If you have questions contact Prince Engineering (712) 277-4061.

Before assembly install new seals on piston and gland. Insure all parts are free of contamination (dirt, etc.)

GLAND CAP/DISASSEMBLY - ASSEMBLY PROCEDURE

ASSEMBLY

1. Coat ID of gland with light grease and replace on rod. Replace piston if removed and secure.

2. Coat OD of piston and seal area on gland with light grease. Apply light coat of hydraulic oil to ID of tube. Insert rod assembly into tube taking care not to damage threads, rod or seals.

3. Replace gland cap. (If applicable replace nylon plugs.) Tighten with spanner wrench or strap wrench.

4. Test cylinder - cylinder is now ready for reassembly in machine. If you have any problem contact Prince Engineering (712) 277-4061.