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Wiring for the Secure Storage Module for the Plutonium Protection System

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DISCUSSION

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WIRING FOR THE SECURE STORAGE MODULE

Introduction

The Plutonium Protection System (PPS) is an item protection system that demonstrates advanced storage concepts which integrate detection and delay elements with careful monitoring and control of operational procedures. In addition, the accountability, operations, and security centers are physically separated to reduce the vulnerability to the insider threat. Organization of the PPS is illustrated in Figure 1. There are five components in the PPS which are interconnected via a data communications network:

- The Storage Vault is an Item Control Area (ICA) in which advanced detection and delay elements are utilized to reduce the vulnerability to insider and forced entry threats. Personnel access is carefully controlled, and the three control centers continually interact to assure only the proper movement of material.
- The Container Module Packaging (CMP) room is an ICA which provides the point of entry to the PPS; i.e., material is packaged into standardized containers in preparation for storage. For this demonstration, the CMP room is under the direct control of the Material Operations Center; in an actual application, its structure would be similar to that of the vault, with access control and the three control center interaction.
- The Material Operations Center (MOC) is a control center whose responsibility is to monitor and control all operations involving the movement of items in the system.
- The Material Accountability Center (MAC) is a control center whose responsibility is to maintain the accountability of all items in the system.
- The Security Operations Center (SOC) is a control center whose responsibilities are to monitor and respond to all alarms in the system and to control personnel access to various parts of the system.

Movement of material between the ICAs is accomplished in a secure fashion by means of a Secure Transport Module (STM) which is essentially a minivault on wheels. The STM must be securely docked at a port in the wall of the ICA before material can be loaded/unloaded. The actual transport of material is carefully timed to minimize the time available for tampering or diversion.

Figure 1. Plutonium Protection System Organization

The focal point of the PPS is the vault which includes a personnel entry corridor, alarm and assessment components, a protected computer, and a storage room that contains Secure Storage Modules (SSMs).¹ The first three items carefully control access to the storage area, while the SSM provides physical barriers and alarms to detect any attempt to gain unauthorized access to the stored items once entry to the storage area is achieved. Figure 2 illustrates how the PPS has been set up in the Sandia Systems Integration Laboratory.

Figure 2. Plutonium Protection System/Systems Integration Laboratory

The SSM consists of four concrete cubicles, each housing a carousel containing 35 storage locations in seven layers of five positions each. The storage locations are staggered so that the door assembly restricts access to one location at a time. Specially designed Container Modules (CMs) are used to house the stored plutonium metal or oxide. Each CM is instrumented with an electronics package that contains several analog sensors to monitor state-of-health such as temperature and the "bulge" of the inner can.

Each CM also communicates digital identification numbers to the PPS. The SSM contains many electromechanical devices to turn the carousels, lock the doors and to sense door and carousel position. The CM lock mechanism and the status lamps are also part of the SSM functional package.

These devices are operated by the PPS through a microcomputer and several hardware interface chassis which are all located in the electronic enclosure in the upper part of the SSM.

The wiring discussed in this report is used to interconnect all the above equipment in an SSM.

Summary

The wiring for the SSM is divided into two major subsystems: the logic subsystem and the power subsystem. The logic subsystem uses flat ribbon cables and printed wiring cards for low-level signal distribution. Its primary purpose is to provide communications from the Container Modules (CMs) directly to the microcomputer² in the SSM Controller. The wiring is grouped to handle four functions:

- Input/output data lines that are in parallel with all CMs which are used to transfer such information as static and dynamic IDs, thermistor readouts, "bulge" readout, and various timing waveforms.
- CM presence, as determined by a continuity loop from a separate input on the microcomputer to each individual CM connector.
- CM power enable which provides a CM selection capability by the use of an individual wire to each CM electronics.
- Solenoid monitors for the deadbolts that lock the CMs into the carousel.

The power subsystem uses conventional cables and does not generally handle signals of less than 30 volts. The 110V ac power is routed to all equipment in the Electronic Enclosure and to cubicle cooling fans. Wiring for drive power and monitor signals for the carousel stepper motors, deadbolts, and CM-locking solenoids are provided, as well as for the annunciator status lights and tamper switches.

The Logic Subsystem

The logic signals are carried on flat ribbon-cables from the micro-computer through gland assemblies to the individual carousels as shown in

Figure 3. Each gland assembly distributes the signals while providing a means of isolating the hot and possibly contaminated carousel air from the electronic enclosure (Figure 4). Additional flat ribbon-cables connect to the carousel side of the gland assembly and carry the signal down to the seven junction boxes (JB) inside each carousel. The JB printed circuit (PC) cards (Figure 5) then distribute these signals to the Bendix connectors used by the CMs. A set of wires tie to switches which monitor the solenoid armatures which lock the CM tangs in place (Figure 6). This circuit and its resulting digital word is often called the "tang mask". There is a special test box which can be used to monitor this function.

Logic signals are further divided into the four following groups by specific function:

- Parallel input/output (I/O) data lines to all CMs; Drawing CK-T42646.
- Continuity lines to individual CMs; CK-T50214.
- Power enable lines to individual CMs; CK-T50215.
- Solenoid monitor circuit; CK-T41953.

Parallel CM Data Lines

The microcomputer sends out serial dynamic IDs to the CMs¹ and reads back parallel eight-bit ID words. It also puts out clock pulses for the CM shift register and a four-bit parallel address word for the CM's internal memory select logic. The serial dynamic code is labeled "S DAT 1" at the microcomputer on the left of drawing CK-T42646 and "AUTHENTICATION CODE IN" at the Container Module on the right side. The serial clock pulses are labeled "SCP" at the microcomputer and "SHIFT REG. CLOCK" at the CM. The CM memory select lines are labeled "CC1B1" through "CC1B8" on the left and "ROM ADDRESS A, B, C, D" on the right side. Note that line "D" or "CC1B8" represents the high order or most significant bit (MSB).

The eight-bit parallel data lines going from the CM to the microcomputer are labeled "M1B1C8" thru "M1B8C8" at the microcomputer and "DATA OUT E0" thru "DATA OUT E7" at the CM connector. E7 or M1B8C8 is the MSB.

Figure 3. SS-1 Signal (Ribbon) Cable Routing

Figure 4. Gland Assembly Perspective

Figure 5. Junction Box Partial Assembly

Figure 6. SSM Power Wiring

When the serial dynamic code is loaded into the CM shift register, it is loaded MSB and most significant digit (MSD) first, LSB and LSD last. Connector CJ5 serves the first two carrouseles (1 and 2 counting from left) and CJ6 serves carrouseles 3 and 4, which splits up the driving load. The 51-ohm resistors in the clock and serial data lines control cross-talk noise and line reflections by slowing down the pulse rise times.

While the printed wiring board T40421 interconnects the purely digital signals directly, it also properly routes the analog signals. The analog signals are brought to connector CP4 on the analog-to-digital converter/multiplexer (ADC/MUX) chassis by flat ribbon-cable T49297 which wanders between the T40421 cards in each of the four gland assemblies. As shown in CK-T42646, each of these cards is differently connected with jumpers so that the analog signals and the analog grounds are kept separate between carrouseles.

The analog signal functions are labeled at the ADC/MUX as follows:

- Thermistor on the electronics card -- ELECT. TMTR.
1 thru 4
- Thermistor on the Pu food pack can -- CAN. TMTR.
1 thru 4
- Bulge sensor on food pack can -- LINEAR POT 1 thru 4

The Numerals 1 to 4 on the labels are the carrousel reference number.

Originally the 5.7-V line supplied power to each gland assembly and JB, but now it is a monitor line.

CM Continuity Line (CK-T50214)

A single, separate wire runs from pin W of each CM connector to a separate pin number of the microcomputer. These continuity lines flag the Plutonium Protection System (PPS) whenever a CM is plugged in or removed and, additionally, the microcomputer sets up mask words in its memory to cover the 140 different can positions. The circuit diagram is

self-explanatory; however, when tracing out the wiring, note that the flat ribbon-cable that connects the gland assemblies to the JBs interleaves the continuity signals with the CM power enable signals (below).

CM Power Enable Lines (CK-T50215)

The CM power enable signals are also called can select (CS) in the microcomputer. These signals come from open collector 1 of 16 decoders in the microcomputer. The signals "pull down" the low side of the relay coil inside each CM. As with the continuity lines (above), a separate wire goes to each CM connector. The schematic is self-explanatory.

Solenoid Monitor Circuits

These circuits, and the resulting computer data words, are often called tang masks. These circuits monitor the armature of each solenoid which engages the CM tang in each carrousel. The signals are encoded by diode matrices at each JB and by using jumper wires at each gland assembly (CK-T41953). The JB at each carrousel level interfaces the five CM tang solenoid monitor switches at that level. A diode matrix (TIDM268J) is used at each JB to encode the switch closure so that a binary encoded number will be placed on the parallel lines of cable C going to the microcomputer. This number represents the CM slot number in the carrousel (1 through 35). Consequently, the diode matrix has to be different at each of the seven levels. Drawing T46365 shows the exploded patterns for the seven levels. Note that the pattern alphabetic markings are not sequential with JB level. Table I lists the pattern and its corresponding CM number.

The system works reliably although the zero logic level of 0.65 to 0.75 volts is close to the maximum zero level required for input into the transistor-transistor logic (TTL) microcomputer. This forward-diode voltage will decrease as the temperature rises.

TABLE I
Tang Mask Matrix Patterns

Slot CM No.	Tang Mask	JB Positions						
None	C0							
1	C1	1						
2	C2			1				
3	C3		1					
4	C4				1			
5	C5	2						
6	C6			2				
7	C7		2					
8	C8				2			
9	C9	3						
10	CA			3				
11	CB		3					
12	CC				3			
13	CD	4						
14	CE			4				
15	CF		4					
16	D0				4			
17	D1	5						
18	D2			5				
19	D3		5					
20	D4				5			
21	D5					1		
22	D6						1	
23	D7							1
24	D8					2		
25	D9							2
26	DA						2	
27	DB					3		
28	DC							3
29	DD						3	
30	DE					4		
31	DF							4
32	EO						4	
33	E1					5		
34	E2							5
35	E3						5	
Junction Box Level		1	2	3	4	5	6	7
Diode Matrix Pattern (DMP)		A	C	B	D	E	G	F

NOTE: Each JB has five positions, numbered 1 through 5 clockwise around the JB. Thus, JB Position 1 of JB Level 1 activates, with its DMP, CM Slot 1 and Position 5 of JB Level 6 activates CM Slot 35.

The solenoid monitor switches are open when the tang solenoid armatures (called tangs) are down. If any single tang is up, that monitor switch will close and pull down the corresponding bit lines to generate the proper CM number. If more than one tang is up at one time, a wrong number will be generated that will be the bit "ORed" combination of the two individual tang masks.

The tang mask consists of six lines that are encoded by the diode matrices plus two unused inputs which are tied to a high state. Thus, when no tangs are pulled, all eight lines are high and the tang mask will read a hexadecimal FF₁₆. If the tang for CM position 3₁₀ is raised, the mask will read C3₁₆ (1100,0011). If the tang for CM position 34₁₀ is raised, the mask will read E2₁₆ (1110,0010). To convert from the tang mask reading to the decimal position number, first subtract C0₁₆ (1100,0000). This exercise is important during troubleshooting to locate a defective switch, a tang that is hung up, or a bad connector. A special test box labeled "ADC and TANG TESTER" can help to identify tang mask problems quickly.

Each diode matrix retains two sets of diodes intact so that lines 16 and 18 on the flat ribbon-cable C (T41448) will be pulled low if any tang is not fully down. Line 18 is carried through to the microcomputer (CP14) to act as an alarm or diagnostic if any tang in the entire SSM is not down.

Wire 16 on cable C is connected to one of four lines going to the microcomputer, depending upon the carousel involved. Thus, a low on this line identifies the carousel whose tang is raised. This jumper is in the gland assembly on PC card number T40422-002. If tangs in more than one carousel are raised at the same time, the tang mask will be wrong but the carousels are identified unambiguously.

Finally, an input test line allows testing of all outputs of the diode matrix. Unfortunately, it would, at the same time, test all diodes in every matrix in the SSM, so it is not used. It must either be left disconnected or tied to +5 volts. A misaligned connector somewhere in the

system can pull this line low and thus pull all of the CM tang number lines low (mask = C0). This line is wire 10 of cable "C".

The switches used to generate the tang masks have gold cross-bar contacts to allow reliable logic-level switching.

Tang Mask Annunciator

A special audio oscillator on the front of the SSM bay sounds a tone whenever any tang armature is not fully down. This annunciator is particularly useful when the material handler is inserting a CM into the carousel and has no other reliable indication that the tang armature is properly engaged. It also has a set of four LEDs to identify which is the offending carousel.

This annunciator is described schematically on CK-T55300 and is connected in parallel into the flat ribbon-cable going to GJ18 of the microcomputer. The 5-volt power connection is connected to the microcomputer power supply terminal strip.

CM Power Wiring

Also shown on schematic CK-T41953 is the 5.7-volt and power return lines for the CM connectors. These power connections are broken out on PC card T40422-002 where a separate flat ribbon-cable picks up both circuits. Multiple pins minimize voltage drop due to contact and flat ribbon wire resistance. Adapter cable T49286 connects to the 5.7-volt power supply located in the SSM, above carousel 2. The power supply is actually adjusted for 5.9 volts rather than 5.7 to take care of losses due to cable resistance and higher-than-normal voltage drop across the CM power diode.

Control and Switch Monitor Signals

A few additional flat ribbon-cables carry logic-level data between the microcomputer and the ADC/MUX, the AC controller, and the Motor Drive Chassis. These cables are also shown in outline on the SSM interconnecting diagram (WD-T37032). The cables are all pin-to-pin since they are of flat ribbon design; the pin and signal designations however, are found on

the chassis schematics involved. Schematic drawing numbers are included on the top drawing WD-T37032.

SSM Power Wiring

These cables are conventional, i.e., not flat ribbon and generally carry 30-V signals and 110-V ac power connections to the electromechanical hardware. The following functions are covered by the power wiring:

- 110-V ac power distribution
- SSM POWER ON light
- Electronics enclosure tamper switches
- Carrousel annunciator lights
- Solenoid power
- Waist dead-bolt power and monitor switches
- Cubicle door magnetic tamper switches
- Cubicle door dead bolts
- Stepper moto. drive
- Cubicle cooling fan power.

110-Volt ac Power Distribution

The primary 110-volt ac power is routed to the electronic enclosure in conduit from the vault breaker-box. This power terminates in a four-plex mounted inside the end wall of the electronics enclosure. A 6-foot outlet strip is mounted on the rear wall of the enclosure and provides unswitched power to the microcomputer power supply, the ADC/MUX,⁴ the AC Controller Chassis,⁵ two cooling fans in the enclosure, and the eight cubicle cooling fans.

SSM Bay Light

This is turned on by the AC Controller Chassis whenever plutonium is to be physically moved. A standard 110-volt ac plug connects to a computer-activated duplex on the AC Controller Chassis.⁴

Electronics Enclosure Tamper Switches

These are microswitches mounted behind the enclosure-door security bolts. Their location is shown in mechanical drawing AY-T37012.¹ They are connected into three sets of series-wired switches shown in schematic CK-T55444. The microswitches for the 12 top switches are wired between TBI-12 and TBI-16 (36 volts hot) on the AC Controller Chassis.⁵ The eight left-hand bottom switches are wired to TBI-13 and the four at right-hand bottom are wired to TBI-14. TBI-15 is for a spare circuit. The AC Controller Chassis not only switches the ac power to the lights, motors, and solenoids, but it also monitors most switch closures at 36 volts and converts the information to logic levels for use by the microcomputer.

Carrousel Annunciator Lights

These four sets of 28-volt lights (see CK-T55445) inform the material handler of the status of the SSM during a transaction. The wiring passes through cooling holes in the electronics enclosure and terminates on TBI and TB2 of the AC Controller Chassis.⁵

Solenoid Power

The 110-volt ac power to the CM tang solenoids is controlled by the microcomputer via the AC Controller Chassis. Three conditions must be satisfied before any single solenoid may be activated:

- The ac power to the dead bolt and solenoid isolation transformer must be selected
- The microcomputer must select the desired carrousel and upper or lower section
- The proper storage location of the carrousel must be at the door, and the waist dead bolt in and locked

The last condition is met by a set of 20 push-button switches installed inside the carrousel, behind the waist-bolt locking-holes in the carrousel waist. Whenever the waist dead-bolt is fully seated in a carrousel locking-hole, it activates a switch that completes the circuits to the upper and lower CM solenoids at that location.

Although the waist switches select both the upper and lower tang solenoids, the computer will select only the appropriate set.

CAUTION: The solenoids will overheat if left on more than 30 seconds.

Waist Dead-Bolt Power and Monitor Switches

The waist dead bolt is a 110-volt ac powered unit with built-in monitor switches. It is in a locked, extended position when not energized. This unit contains a full-wave rectifier that reduces hum and vibration and increases bolt pulling power. There are two coils, one high power (1.3 A) to retract the dead bolt, and one low power (0.1 A) to keep it retracted. The dead bolts can be thus left retracted indefinitely. The waist dead-bolt is activated by microcomputer command to the AC Controller. Drawing CK-T55486 illustrates the wiring.

The waist dead-bolt has two monitor switches. One of them is the BUL (bolt unlocked) switch and its normally-open contacts close when the waist bolt is fully retracted and the carousel is free to turn. The BL (bolt locked) switch has its normally-open contacts closed when the dead bolt is fully extended into one of the carousel waist holes. One function is not necessarily the opposite of the other. There is an intermediate state when the waist dead-bolt is neither fully locked or unlocked. This occurs when the carousel has been turning and is nearing the desired location. The dead bolt, which has been retracted, is now released and the dead-bolt armature falls against the side of the carousel waiting for a waist locking hole to come by. In this state neither the BL nor the BUL switch is closed; this condition puts out a logical "1" to the computers on both the BUL and BL lines.

This same state may occur when the system tries to retract the dead bolt before turning the carousel. The software must examine these switches to see if the dead bolt is indeed clear of the carousel. These monitor switches, in contrast to most of the mechanical status switches in the system, are not designed for "dry" or logic-level switching. Therefore, the system is designed to test these switch closures with a 10-mA

closed-circuit current and 30 to 36 volts open-circuit voltage. The only exceptions to this rule are in the solenoid monitor switches, described above, which have special gold cross-bar contacts for low-voltage logic-level switching.

Cubicle Door Magnetic Tamper Switches

These magnetic switches sense the opening of the carousel doors. They consist of a pair of tiny reed switches mounted in the door frame, with the actuating magnet being mounted in the edge of the door. This magnet is adjusted so that only one of the reed-switches is closed by the magnetic field. This switch is designated the output contact as labeled in CK-F55486. The second reed-switch is mounted a little further back in the casing and requires a stronger magnetic field to close. This switch is the tamper switch and activates if someone substitutes an external field that is a little too powerful (Figure 7). All of the SSM magnetic tamper switches are monitored in the same way.

WARNING: These contacts occasionally stick closed when mounted in magnetic material.

Figure 7. Circuit for Magnetic Tamper Switches

The output lead is common to both switches and, through a 1-K resistor, connects to the switch-monitor transistor in the AC Controller. When the door is closed, contact is made to the 36-volt supply through a second 1-K resistor. This is the normal state for a secure door and results in a zero in the computer switch-mask word. If a tamper magnet is too strong, the tamper switch closes and shorts the output lead to ground. This gives the same output as an open door (logical "1").

Cubicle Door Dead Bolts

The door dead bolts are constructed and operated similarly to the waist dead bolts (CK-T51486) with the same pull-in and holding coil arrangement. However, these units have a door-position switch (DPS) which holds power on the coils whenever the door is open. This allows the computer to remove external power to the dead bolt, yet have it remain retracted until the operator closes the door. In this case, computer power is removed when the yellow ACTION light (operator annunciator light) comes on. The computer system then sends logic-level signals to the AC Controller Chassis⁵ where an optically coupled Triac[™] closes the 110-volt circuit to the dead bolt.

These door dead bolts have only one BL monitor switch. Thus, if the door is slightly ajar (bolt resting on the edge of the door), the microcomputer (SSM controller) will be aware of the situation. The magnetic door switch should be mounted so as to show an open door if the door is open far enough to let the dead bolt move to its fully extended position.

Stepper-Motor Drive

Schematic CK-T55473 shows the cabling arrangement for the carousel stepper motors. Pulses for the stepper motors are generated by programmable timers in the microcomputer, so that the stepper-motor speed can be computer-controlled. These pulses are sent out on data lines (called CW or CCW) to the Motor Drive Chassis⁶ where they are amplified and sequenced by commercial PC cards made by the Slo-Syn division of the Superior Electric Co. A large (75-watt) 1.5-ohm resistor limits the current through the motor windings when the motor is stopped or is being stepped slowly. Actually, a stalled stepper generates less heat than one that is stepping quickly (hysteresis losses).

This 1.5-ohm resistor has been mounted near the motor at the bottom of the carousel where it can receive cool air. Limit switches have also been mounted here to turn off the stepper pulses going to the motor drive

card. Although the wiring is in place, these switches are not and should not be connected because of the nature of the stepper-motor system. A motor receiving power pulses will generate about the same heat losses whether turning or stalled. On the other hand, if no pulses are applied to the motor stepper-amplifier, steady dc current will flow through the windings and result in maximum dissipation in the current-limiting resistor.

During a failure simulation test, a stalled stepper motor has been left on for 6 hours with no resulting damage to motor or resistor.

Cubicle Cooling Fan Power

A pair of 100-CFM, "muffin" fans at the bottom of each carousel under the front panel door assembly, help cool the CMs and their load of heat-producing radiological material. Although some concern exists that a fan failure could lead to overheating of the carousel and the CMs, experimental evidence suggests that a significant air flow exists through the carousel due to the chimney designed behind the electronics enclosure, even with the fans stopped.³

Failure of both fans will cause an additional temperature increase of 13°C when the carousel is loaded with 35 CMs with a 35-watt rating each. Failure of only one fan would cause an increase in CM temperatures that could be detected by an appropriate system program which would analyze the data from periodic inventories. Power for these fans is routed through cables (CK-T55473) which ultimately plug into the power strip in the electronics enclosures.

Carousel Position Potentiometers

Precision potentiometers generate analog voltages for position feedback data to the microcomputer. These 3-inch diameter Bourne units are wirewound for radiation hardness and have a linearity tolerance of 0.1 percent. They are mounted on the top of the same interface compartment that holds the printed circuit gland-assembly. A 0.25-inch diameter shaft with two bellows-type instrumentation couplings are used to mechanically

drive the pot shafts from the carrousel. These potentiometers may be connected directly to connector CJ2 on the ADC/MUX chassis.⁴ This chassis supplies the +5-volt excitation to the potentiometers and digitizes the analog signal upon command from the microcomputer.

Alternately, the potentiometers may be connected to a "potentiometer trim" chassis mounted on top of the ADC. In this modification, the excitation for each potentiometer is individually trimmed for "span" as well as "offset" to further improve the accuracy and reliability of the carrousel rotation function.

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APPENDIX
SSM Referenced Drawings

SSM Interconnecting Diagram (WD-T37032)
PC Board, Continuity-Address Splitter Card (T40419)
PC Board, Continuity/Address Splitting (T40420)
PC Board, Analog Breakout (T40421)
PC Board, Solenoid Code Distribution (T40422)
Wiring Diagram, Junction Box (WD-T40524)
Ribbon Cable, CM Data (T41947)
Ribbon Cable, Solenoid Monitor (T41948)
Ribbon Cable, Upper Can Control (T41949)
Ribbon Cable, Lower Can Control (T41950)
Schematic, Microprocessor to Solenoid Monitor Switches (CK-T41951)
Schematic, SSM Communications to CM (CK-T42646)
Diode Matrix, Carrousel Junction Box (CK-T46305)
Schematic, Continuity Loop Microprocessor to CM (CK-T50214)
Schematic, Power Enable Microprocessor to CM (CK-T50215)
Schematic, Tang Mask Annunciator (CK-T55300)
Schematic, Tamper Switch Wiring, Electronic Enclosure (CK-T55444)
Schematic, Annunciator (overhead status lamps) (CK-T55445)
Schematic, Carrousel Stepper Motor and Fans (CK-T55473)
Schematic, SSM Carrousel Door and Waist Bolt (CK-T55496)

SSM Interconnecting Di

8. SUPPLIER WILL BE FURNISHING CIRCUIT MASTER FOR PLAIN DRILLING, 50-T40419-0000.
9. ALL CHANGES MADE ON THIS DRAWING AFFECTING THE ETCHED PATTERN MUST ALSO BE MADE ON 50-T40419-0000.

NOTES:

1. NO DIMENSIONS THIS SIDE UNLESS INDICATED BOTH SIDES.
2. DRILLING DIM. CIRCULAR FOR 50-T.
3. PLY. .005 WIDE AND HAS AN .000 WIDE.
4. CLEARANCE IS .005.
5. ETCH CHARACTER ON BOARD IS .0004 WIDE AND .0004 HIGH.
6. ADDRESSER DOES NOT PRODUCE 0.0004 TWO-LEAD PATTERN.
7. NEW LAMINATED PLASTIC SHEET 1.02 COMP. CLAD, 50% WIDE, 50% HIGH, 50% WIDE, 50% HIGH, 50% WIDE, 50% HIGH.

PC Board, Continuity-Address Splitter Card (T40419)

- NOTES

1. NEW CONCRETE THIS TIME BROADLY INDICATES BOTH SIDES
2. DAMMED BLUE CONCRETE FOR TIME
3. PATH NOT WIDE AND HAS A WIDE OPEN SPACE
4. (CLEARANCE IS NOT)
5. EVEN CONCRETE ON BOTH SIDES OF THE ROAD
6. (THE ROAD IS NOT WIDE)
7. THE ROAD IS NOT WIDE AND HAS A WIDE OPEN SPACE
8. THE ROAD IS NOT WIDE AND HAS A WIDE OPEN SPACE

PC Board, Analog Breakout (T40421)

- NOTES:
1. RED CIRCUMSTY THIS SIDE. GROUND WORKS THIS SIDE.
 2. DANGER! OLIVE CIRCUMSTY FOR SIDE.
 3. PAY TO THE SIDE AND HOLD THE GROUND.
 4. CLEARANCE IS 100.
 5. THE CIRCUMSTY IS 100 AND 100 IS 10000.
 6. THE CIRCUMSTY IS 100 AND 100 IS 10000.
 7. THE CIRCUMSTY IS 100 AND 100 IS 10000.

PC Board, Solenoid Code Distribution (T40422)

NOTES:

1. GENERAL REQUIREMENTS AND DRAWING INTERPRETATIONS PER Y00000
2. PERMANENTLY MARK EACH CONNECTOR WITH CONNECTOR NUMBER ALLEGATIONS PER Y00000, CLASS A-Z.
3. CONNECTORS MUST BE ASSEMBLED ONTO CABLE BY USING PROPERLY ADJUSTED SCOTCHFLEX PRESS 6000, AVAILABLE FROM JSC COMPANY.
4. INSTALL POLARIZATION KEY (ITEM 2) BETWEEN PWS 103 ON ALL CONNECTORS.
5. MARK PART NO. PER SC8000 LOCATE APPROPRIATELY AS SHOWN.

Ribbon Cable, Ch Data (T41947)

NOTES.

1. GENERAL REQUIREMENTS AND DRAWING INTERPRETATIONS PER 000000.
2. PERMANENTLY MARK EACH CONNECTOR WITH CONNECTOR NUMBER DESIGNATIONS PER 000000, CLASS A-2.
3. CONNECTORS MUST BE ASSEMBLED INTO CABLE BY USING PROPERLY ADVISED TECHNICIAN PER 150000, AVAILABLE FROM 3M COMPANY.
4. INSTALL POLYMERIZING KEY (ITEM 1) BETWEEN PINS 507 ON PL1 THRU PCT AND PINS 103 ON P0.
5. MARK PART NO. PER 250000, LOCATE APPROXIMATELY AS SHOWN.

Ribbon Cable, Solenoid Monitor (T41948)

5. INSTALL POLARIZING PIN (ITEM 2) BETWEEN PINS 3 & 5 ON ALL CONNECTORS.
- ▶ MARK PART NO. PER 99100. LOCATE APPROXIMATELY AS SHOWN.

NOTES:

1. GENERAL REQUIREMENTS AND DRAWING INTERPRETATIONS PER 990000.
2. PERMANENTLY MARK EACH CONNECTOR WITH CONNECTOR NUMBER DESIGNATIONS PER 991100, CLASS A-2.
3. CONNECTORS MUST BE ASSEMBLED ONTO CABLE BY USING PROPERLY ADJUSTED SCOTCHLEX PRESS #3440, AVAILABLE FROM 3M COMPANY.
4. SEPARATE STRIP OF 10 CONDUCTORS AND CUT DIAGONALLY SO THERE WILL BE NO DANGER OF CUTTING REMAINING CONDUCTORS.

Ribbon Cable, Lower Can Control (T41950)

MSBLS - MULTIMETER BUS - CHANNEL 5
MSBIS - MULTIMETER BUS - CHANNEL 6

Schematic, Microprocessor to Solenoid Monitor Switches (CK-T41953)

1. FOR INFO NEW YORK: 100-107703 1-424-
SEE NY-107703

22-B1 - CAN CONTROL ADDRESS: BIT 1
 22-B2 - CAN INPUT BIT: CHANNEL 0

word:

- ▶ USE INVESTIGATED CROCHET 124 FROM PART 06, THUNDER, THOMAS INSTRUMENTS INC. MODIFY 05 0000.
- ▶ MAKE PATTERN 124 FOR VIBROGLASS A-2-B BLOWY LETTERS WITH COVERCONTI USING .006 PITCH BORN CHARACTERS VIBROGLASSING COLOR. LOCAL IN CONTACT BORN.

Diode Matrix, Carrousel Junction Box (CK-T46365)

C4 CARD CH-41-1520		MICROPROCESSOR 753716				
CN NO.	CARDQUESET 1 C-13	CARDQUESET 2 C-14	CARDQUESET 3 C-15	CARDQUESET 4 C-16	CARDQUESET 5 C-17	CARDQUESET 6 C-18
1	DP2-1	DP2-2	DP2-3	DP2-4	DP2-5	DP2-6
2	DP2-7	DP2-8	DP2-9	DP2-10	DP2-11	DP2-12
3	DP2-13	DP2-14	DP2-15	DP2-16	DP2-17	DP2-18
4	DP2-19	DP2-20	DP2-21	DP2-22	DP2-23	DP2-24
5	DP2-25	DP2-26	DP2-27	DP2-28	DP2-29	DP2-30
6	DP2-31	DP2-32	DP2-33	DP2-34	DP2-35	DP2-36
7	DP2-37	DP2-38	DP2-39	DP2-40	DP2-41	DP2-42
8	DP2-43	DP2-44	DP2-45	DP2-46	DP2-47	DP2-48
9	DP2-49	DP2-50	DP2-51	DP2-52	DP2-53	DP2-54
10	DP2-55	DP2-56	DP2-57	DP2-58	DP2-59	DP2-60
11	DP2-61	DP2-62	DP2-63	DP2-64	DP2-65	DP2-66
12	DP2-67	DP2-68	DP2-69	DP2-70	DP2-71	DP2-72
13	DP2-73	DP2-74	DP2-75	DP2-76	DP2-77	DP2-78
14	DP2-79	DP2-80	DP2-81	DP2-82	DP2-83	DP2-84
15	DP2-85	DP2-86	DP2-87	DP2-88	DP2-89	DP2-90
16	DP2-91	DP2-92	DP2-93	DP2-94	DP2-95	DP2-96
17	DP2-97	DP2-98	DP2-99	DP2-100	DP2-101	DP2-102
18	DP2-103	DP2-104	DP2-105	DP2-106	DP2-107	DP2-108
19	DP2-109	DP2-110	DP2-111	DP2-112	DP2-113	DP2-114
20	DP2-115	DP2-116	DP2-117	DP2-118	DP2-119	DP2-120
21	DP2-121	DP2-122	DP2-123	DP2-124	DP2-125	DP2-126
22	DP2-127	DP2-128	DP2-129	DP2-130	DP2-131	DP2-132
23	DP2-133	DP2-134	DP2-135	DP2-136	DP2-137	DP2-138
24	DP2-139	DP2-140	DP2-141	DP2-142	DP2-143	DP2-144
25	DP2-145	DP2-146	DP2-147	DP2-148	DP2-149	DP2-150
26	DP2-151	DP2-152	DP2-153	DP2-154	DP2-155	DP2-156
27	DP2-157	DP2-158	DP2-159	DP2-160	DP2-161	DP2-162
28	DP2-163	DP2-164	DP2-165	DP2-166	DP2-167	DP2-168
29	DP2-169	DP2-170	DP2-171	DP2-172	DP2-173	DP2-174
30	DP2-175	DP2-176	DP2-177	DP2-178	DP2-179	DP2-180
31	DP2-181	DP2-182	DP2-183	DP2-184	DP2-185	DP2-186
32	DP2-187	DP2-188	DP2-189	DP2-190	DP2-191	DP2-192
33	DP2-193	DP2-194	DP2-195	DP2-196	DP2-197	DP2-198
34	DP2-199	DP2-200	DP2-201	DP2-202	DP2-203	DP2-204
35	DP2-205	DP2-206	DP2-207	DP2-208	DP2-209	DP2-210
36	DP2-211	DP2-212	DP2-213	DP2-214	DP2-215	DP2-216
37	DP2-217	DP2-218	DP2-219	DP2-220	DP2-221	DP2-222
38	DP2-223	DP2-224	DP2-225	DP2-226	DP2-227	DP2-228
39	DP2-229	DP2-230	DP2-231	DP2-232	DP2-233	DP2-234
40	DP2-235	DP2-236	DP2-237	DP2-238	DP2-239	DP2-240
41	DP2-241	DP2-242	DP2-243	DP2-244	DP2-245	DP2-246
42	DP2-247	DP2-248	DP2-249	DP2-250	DP2-251	DP2-252
43	DP2-253	DP2-254	DP2-255	DP2-256	DP2-257	DP2-258
44	DP2-259	DP2-260	DP2-261	DP2-262	DP2-263	DP2-264
45	DP2-265	DP2-266	DP2-267	DP2-268	DP2-269	DP2-270
46	DP2-271	DP2-272	DP2-273	DP2-274	DP2-275	DP2-276
47	DP

CS - CAN SELECT

R CARD		MICROFILMED - 20		T31021		GUND B551 M-JR-04 (1978)		T31021	
R-161615		T31021		T31021		PRINTED W/IR-45 DO T30498		T31021	
1	SP2-1	30	SP2-7	71	SP2-41	115	B11-6	1	SP2-1
2	SP2-10	42	SP2-30	75	SP2-43	116	B11-10	2	SP2-10
3	SP2-43	44	SP2-34	79	SP2-5	114	B11-24	3	SP2-43
4	SP2-2	45	SP2-45	83	SP2-16	115	B11-15	4	SP2-2
5	SP2-16	52	SP2-3	87	SP2-36	122	B11-11	5	SP2-16
6	SP2-3	53	SP2-20	73	SP2-45	116	B11-20	6	SP2-3
7	SP2-21	46	SP2-46	81	SP2-02	116	B11-24	7	SP2-21
8	SP2-13	45	SP2-42	81	SP2-30	115	B11-40	8	SP2-13
9	SP2-37	51	SP2-7	83	SP2-20	124	B11-4	9	SP2-37
10	SP2-3	37	SP2-24	78	SP2-43	117	B11-27	10	SP2-3
11	SP2-11	47	SP2-12	81	SP2-02	111	B11-31	11	SP2-11
12	SP2-18	47	SP2-12	81	SP2-02	111	B11-31	12	SP2-18
13	SP2-37	49	SP2-43	74	SP2-45	113	B11-18	13	SP2-37
14	SP2-35	43	SP2-5	68	SP2-26	111	B11-7	14	SP2-35
15	SP2-10	35	SP2-10	70	SP2-4	113	B11-19	15	SP2-10
16	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	16	SP2-46
17	SP2-43	47	SP2-44	74	SP2-16	117	B11-37	17	SP2-43
18	SP2-30	41	SP2-1	66	SP2-22	121	B11-7	18	SP2-30
19	SP2-18	45	SP2-3	70	SP2-30	122	B11-5	19	SP2-18
20	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	20	SP2-46
21	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	21	SP2-46
22	SP2-47	43	SP2-7	34	SP2-35	123	B11-9	22	SP2-47
23	SP2-4	42	SP2-21	67	SP2-44	114	B11-22	23	SP2-4
24	SP2-10	45	SP2-43	75	SP2-45	116	B11-20	24	SP2-10
25	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	25	SP2-46
26	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	26	SP2-46
27	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	27	SP2-46
28	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	28	SP2-46
29	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	29	SP2-46
30	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	30	SP2-46
31	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	31	SP2-46
32	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	32	SP2-46
33	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	33	SP2-46
34	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	34	SP2-46
35	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	35	SP2-46
36	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	36	SP2-46
37	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	37	SP2-46
38	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	38	SP2-46
39	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	39	SP2-46
40	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	40	SP2-46
41	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	41	SP2-46
42	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	42	SP2-46
43	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	43	SP2-46
44	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	44	SP2-46
45	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	45	SP2-46
46	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	46	SP2-46
47	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	47	SP2-46
48	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	48	SP2-46
49	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	49	SP2-46
50	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	50	SP2-46
51	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	51	SP2-46
52	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	52	SP2-46
53	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	53	SP2-46
54	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	54	SP2-46
55	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	55	SP2-46
56	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	56	SP2-46
57	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	57	SP2-46
58	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	58	SP2-46
59	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	59	SP2-46
60	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	60	SP2-46
61	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	61	SP2-46
62	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	62	SP2-46
63	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	63	SP2-46
64	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	64	SP2-46
65	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	65	SP2-46
66	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	66	SP2-46
67	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	67	SP2-46
68	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	68	SP2-46
69	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	69	SP2-46
70	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	70	SP2-46
71	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	71	SP2-46
72	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	72	SP2-46
73	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	73	SP2-46
74	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	74	SP2-46
75	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	75	SP2-46
76	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	76	SP2-46
77	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	77	SP2-46
78	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	78	SP2-46
79	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	79	SP2-46
80	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	80	SP2-46
81	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	81	SP2-46
82	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	82	SP2-46
83	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	83	SP2-46
84	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	84	SP2-46
85	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	85	SP2-46
86	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	86	SP2-46
87	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	87	SP2-46
88	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	88	SP2-46
89	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	89	SP2-46
90	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	90	SP2-46
91	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	91	SP2-46
92	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	92	SP2-46
93	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	93	SP2-46
94	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	94	SP2-46
95	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	95	SP2-46
96	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	96	SP2-46
97	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	97	SP2-46
98	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	98	SP2-46
99	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	99	SP2-46
100	SP2-46	43	SP2-16	70	SP2-4	113	B11-19	100	SP2-46

Schematic, Power Enable Microprocessor to CM (CX-T50215)

Schematic, Tang Task Annunciator (CK-755300)

NOTES:

1. SWITCHES S1 THRU S24 ARE SHOWN WITH BOLTS DISENGAGED.
2. SWITCHES ARE BZ-2RQ1-A2 FROM MICROSWITCH.

Schematic, Tamper Switch Wiring, Electronic Enclosure (CK-T55444)

CAROUSEL NO	CABLE LENGTH
1	6.5 FT.
2	5.5 FT.
3	4.5 FT.
4	5.5 FT.

Schematic, Annunciator (overhead status lamps) (CK-T55445)

Schematic, Carrousel Stepper Motor and Fans (CK-T55473)

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