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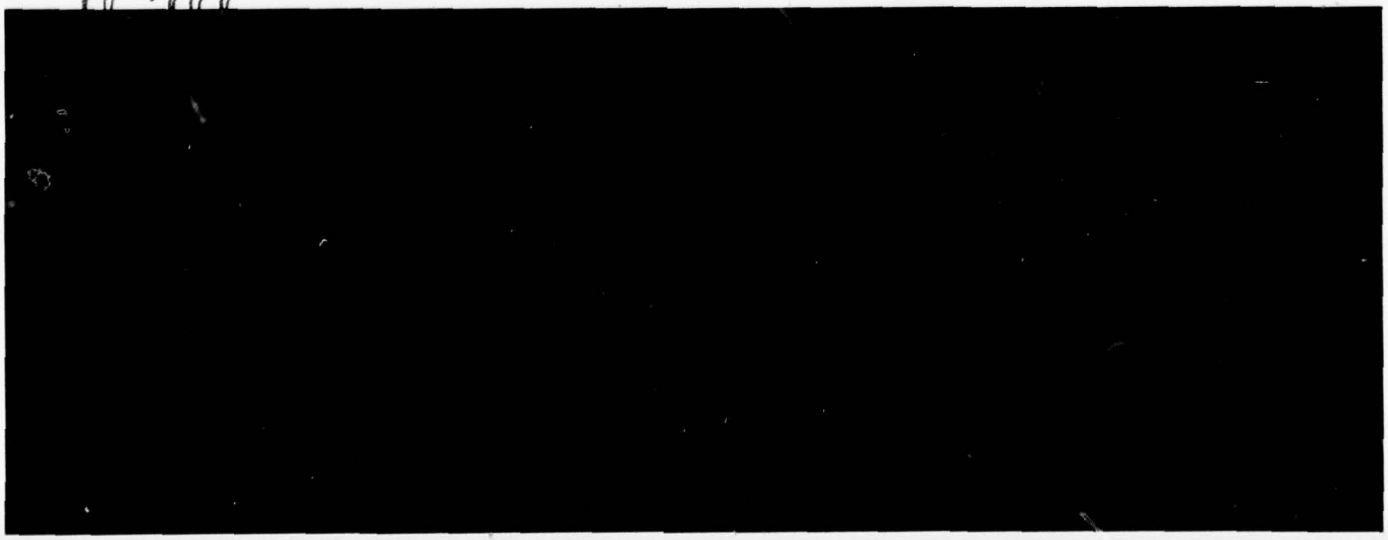
FINAL REPORT

ANALYSIS OF SWITCH SETTINGS IN THE 8"/55 MK 71 MOD 0 GUN MOUNT

June 1976

Prepared for
NAVAL ORDNANCE STATION
LOUISVILLE, KENTUCKY
under Contract N00197-74-C-0314

ARINC RESEARCH CORPORATION



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This report is a summary of the analyses of switch setting combinations in the control circuitry of the 8"/55 Mark 71 Mod 0 Gun Mount that might result in unsafe conditions for equipment or personnel.

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Specific Task Assignment No. 8

by

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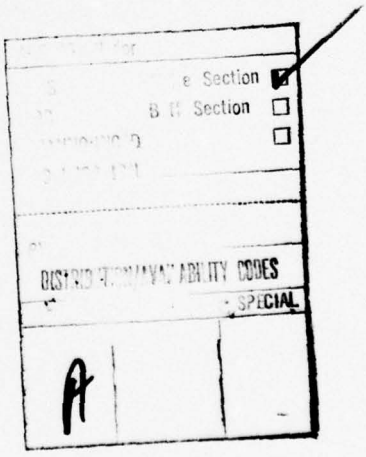
FOREWORD

This report is a summary of the analyses of switch setting combinations in the control circuitry of the 8"/55 Mark 71 Mod 0 Gun Mount that might result in unsafe conditions for equipment or personnel.



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SECTION I

OVERVIEW

1. INTRODUCTION

The Lightweight 8"/55 Mk 71 Mod 0 Gun Mount has been developed in prototype form. This mount has been expanded from its original design as a 175 MM weapon to an eight-inch bore. TECHEVAL and a limited OPEVAL were conducted at the Naval Weapons Laboratory (now Naval Surface Weapons Center, Dahlgren Laboratory), Dahlgren, Virginia. The mount is now undergoing at-sea OPEVAL trials aboard the USS HULL, DD-945.

In the course of these tests, the mount has received some damage, believed to have been partly the result of misconfigured switch settings or a sequencing of switches by the operator, which was never intended or anticipated by the manufacturer.

Under the terms of Specific Task Assignment No. 8 of Contract N00197-74-C-0314 with the Gun System Engineering Center (GSEC) at the Naval Ordnance Station, Louisville (NOSL), Kentucky, ARINC Research Corporation was tasked to analyze the effects of switching on the electronic control of the 8"/55 Mk 71 Mod 0 Gun Mount and to identify combinations of sequences that could result in damage.

In accordance with the contract provisions, the report was formatted in two sections. The first section presents an overview of the analysis, including a summary and conclusions. The second section provides the detailed results of the analyses, listing major control functions within the mount that are affected by the operation of the manual switches.

2. SUMMARY

This portion of the report presents an overview of the work undertaken, including the approach and the assumptions used in performing the analysis. Findings that identify the potential problem areas are presented.

2.1 Approach

The purpose of the safety analysis of Mk 71 Mod 0 manual switches is to identify the direct control that operator-accessible switches have over the activation and deactivation of individual gun mount functions and to determine how inadvertent (or improper) switching affects mount operational safety. It is recognized that many switches cause mount activity through interlock-logic circuits which indirectly enable or disable each function. This switch setting analysis is limited to the isolated examinations of each major mount function, in each of the mount's possible operational modes. Analysis at this level provides enough information to identify which switch settings cannot cause safety problems and, therefore, establishes which functions, circuits, and switches should be subjected to more detailed analysis. For cases in which a function's control is limited to direct manual switch control, this analysis provides all the necessary information to substantiate operational safety conditions.

All work in this study was based on the electrical schematics of NAVSEA OP 4116, Volume 4, Change 3, which reflects revisions to the electronic controls as of 1 March 1976. All referenced drawings numbers in this report are schematics from this OP. From these schematics, each of the major Mk 71 Mod 0 equipment control functions was identified by the electrical relay or solenoid that initiates or causes mount machinery motion. Switch inputs were examined for their effect on each control function. These control functions are listed in Table 1 on page 6, and each pertinent one is addressed in one of the function summaries in Section II.

In the analysis of each mount function the following assumptions were made:

- Interlock logic circuitry used in the Mk 71 Mod 0 is adequate to keep the mount operation safe under normal conditions, but it is dependent on manual switch positioning.
- Interlock logic circuitry ensures that each solenoid- or relay-controlled function operates safely to completion once it is initiated.

- Mount personnel are in physically safe areas during mount function activations.

- All relays mounted on printed circuit boards (PCXX-KK designated relays) only establish interlock logic inputs; they do not directly cause function activation.

- In switching to or from the SIMULATE mode of mount operation, the switching of the SIMULATE MODE SELECTOR (SMX19) does not cause safety problems because the CONTROL SELECTOR SWITCH (SMS1) must be in the OFF position. When OFF, the CONTROL SELECTOR (SMX1) is assumed to disable all loading system functions, that is:

  - AUTO LOAD
  - STEP LOAD
  - AUTO UNLOAD
  - STEP UNLOAD
  - STEP EXERCISE
  - STEP STRIKEDOWN
  - STEP OFFLOAD

- The gun mount's overall operational mode is considered further selectable to specify SIMULATE mode (SMX19), DIRECT LOAD (SMX17), NORMAL LOAD (SMX18), and GUIDED PROJECTILE mode (automatically set by chosen ammunition type).

- The mount functions for the Mk 71 Mod 0 Strikedown Hoist, as given in Drawing No. 2625610, do not require analysis because they are not included in the production version of the Mk 71 Mod 0.

- Power to all mount components in each function remains normal; that is, abnormal power failures to or between selected components are not considered.

2.2 Findings

While specific unsafe conditions were not identified by this study, certain potential problems were identified. A summary of functions and findings is presented in Table 1. These potential problems in some cases interact with the logic-circuit controls and in other cases do not involve switch inputs. The potential problems identified are:

- SMF1 (Firing Safety Switch) in conjunction with the remote-firing order from CIC, or SMF2 (Local Firing Switch), could result in inadvertent or deliberate unauthorized firing of the gun (see Section II, function KCF2). Redesigning SMF1 or making SMF2 a key-type switch would reduce the potential problem.

- With the gun in the GUIDED-PROJECTILE mode, switching TRAIN AND ELEVATION CONTROL (SMY1) or OPERATION SELECTOR SWITCH (SMS2) can drop GUIDED PROJECTILE mode from the mount logic (see Section II, function KCY4). This appears to be a potential problem, depending on when the transition takes place in the equipment cycling, and warrants further investigation.

- Switching HOIST RAISE (SMH1) in the STEP-LOAD mode could retract the hoist pawl if the hoist is up and the hoist pawl is not clear of the cradle (see Section II, function LHH2-LC2). This appears to be a potential problem and warrants further investigation.

- The breech block can be opened by pressing the BREECH OPEN switch (SMB1) in the STEP-LOAD mode. In the case of a live round or misfire, with a hot gun condition, serious damage could result from a cook-off with the breech open. The probability of all of these events occurring in sequence to result in damage is small, but consideration should be given to the possibility of occurrence.

- An apparently minor item associated with the hoist pawl retraction function is reflected in Drawing No. 2625620, where an AND-gate input is unidentified. On that schematic printed circuit card 75, pin 35, does not give any indication of the signal involved. The identified portions of the input appear to make the function reasonably safe. However, final judgment must be reserved until that input is identified. The AND-gate output also drvies solenoid LHH2-LC2, Hoist Pawl Retract, as shown on Drawing No. 2625617.

- Although not directly caused by the gun's manual switches, a possible unsafe condition associated with the switches was identified. If the gun were operating in REMOTE mode (SMY1) and the Fire Director System synchro signals were somehow lost without interrupting the 400-Hz synchro supply voltage, the gun train and elevation system apparently could drive from noise on the input lines. This could cause the gun to make violent excursions in train and elevation. In the local firing mode (SMF1), the mount could go "in synchronization" with the noise signals during unsafe pointing angles. Firing could occur if the firing circuit were enabled at the remote location at that time. GSEC engineers confirm the possibility of these conditions, but they indicate that there has been no recorded occurrence.

3. CONCLUSIONS AND RECOMMENDATIONS

The conclusions resulting from this study are:

- No distinctly unsafe conditions have been identified.
- Certain potential safety areas have been identified (see summary in Part 2.2, "Findings").

The recommendations resulting from this study are that the potential problem areas be explored* further to ascertain the exact impact they may have on gun operation.

*Further detailed circuit analysis has been authorized under Specific Task Assignment No. 1 of Contract N00197-76-C-0141.

Table 1. MK 71 MOD 0 8"/55 MAJOR CONTROL FUNCTIONS (WITH MANUAL SWITCH INPUTS)

Designation	Name	Findings
ARY1	Train and Elevation Electronic Servo Control - Main Chassis	No problem found
ARP1	Fuze Setter Amplifier	Not investigated
KCF2	Firing ordered	Potential problem
KCF3	Ready to fire	No problem found
KCF4	"B" Emergency Firing Circuit	Minor potential problem
KCF5	"A" Emergency Firing Circuit	Minor potential problem
KCP1	Fuze Setter Engaged	Potential problem
KCP2	Remote Fuze Order	No problem found
KCP3	External Director Order	No problem found
KCY1	Stow	No problem found
KCY2	Remote	No problem found
KCY3	Test	No problem found
KCY4	Guided Projectile Load Position Ordered	Potential problem
KCZ1 thru KCZ8	Power Circuit Relays	Not investigated
KPE1	Elevation Motor Contactor	No problem found
DPT1	Train Motor Contactor	No problem found
KPX1	Upper Accumulator Motor Contactor	No problem found
KPX4	Lower Accumulator Motor Contactor	No problem found
KPX7	Upper Emergency Motor Contactor	No problem found
KPX10	Lower Emergency Motor Contactor	No problem found
KTE1	Elevation Pressure Cutout	No problem found
KTF1	Firing Ordered	Potential problem
KTT1	Train Pressure Cutout	No problem found
KTZ1	Line to Ground	Not investigated
LHB1-LC1	Open Breech Block	Potential problem
LHB1-LC2	Close Breech Block	No problem found
LHC1-LC1	Lower Cradle	No problem found
LHC1-LC2	Raise Cradle	No problem found
LHC2-LC1	Cradle Pawl Retract (at Hoist)	No problem found
LHC2-LC2	Cradle Unlatch (at Hoist)	No problem found
LHE1-LC1	Release Elevation Brake	No problem found
LHE2-LC1	Retract Elevation Plunger for Zones 1 and 2	No problem found No problem found
LHE2-LC2	Retract Elevation Plunger for Zone 2 (High Zone)	No problem found
LHH1-LC1	Hoist Raise	No problem found
LHH1-LC2	Hoist Lower	No problem found

(continued)

Table 1. (continued)

Designation	Name	Findings
LHH2-LC1	Hoist Pawl Extend	No problem found
LHH2-LC2	Hoist Pawl Retract	Potential problem
LHH3-LC1	Position Hoist for Short Round	No problem found
LHH3-LC2	Position Hoist for Long Round	No problem found
LHJ1-LC1	Strikedown Hoist Clutch Unlatched	Not investigated
LHJ1-LC2	Strikedown Hoist Clutch Latched	Not investigated
LHJ2-LC1	Strikedown Hoist Raise	Not investigated
LHJ2-LC2	Strikedown Hoist Lower	Not investigated
LHJ3-LC1	Strikedown Hoist Pawl Extend	Not investigated
LHJ3-LC2	Strikedown Hoist Pawl Retract	Not investigated
LHJ4-LC1	Round Centering Snubbers and Latch Extended	Not investigated Not investigated
LHJ4-LC2	Round Centering Snubbers and Latch Retracted	Not investigated Not investigated
LHL1-LC1	Magazine Index Unlatch and Engage Clutch	No problem found
LHL2-LC2	Magazine Index	No problem found
LHL3-LC1	Retract Station 1 Stop	No problem found
LHL3-LC2	Retract Station 1 and 2 Stop	No problem found
LHL4-LC1	Clip Unlatch to Magazine	No problem found
LHL4-LC2	Clip Unlatch to Hoist	No problem found
LHL5-LC1	Clip Shuttle to Magazine	No problem found
LHL5-LC2	Clip Shuttle to Hoist	No problem found
LHL6-LC1	Round Centering Mechanism and Latch Extended	No problem found
LHL6-LC2	Round Centering Mechanism and Latch Retracted	No problem found
LHL7-LC2	Short Shuttle Velocity Selector	No problem found
LHM1-LC1	Empty Case Tray Raise	No problem found
LHM1-LC2	Empty Case Tray Lower	No problem found
LHM2-LC1	Empty Case Ejector and Cradle to Slide Latch Retract	No problem found
LHM2-LC2	Empty Case Ejector Extend	No problem found
LHR1-LC1	Rammer Retract	No problem found
LHR1-LC2	Extend Rammer	No problem found
LHT1-LC1	Train Brake Release	No problem found
LHT2-LC1	Train Plunger for Zones 1 and 2	No problem found
LHX1-LC2	Upper Accumulator Dump	No problem found
LHX2-LC2	Lower Accumulator Dump	No problem found

SECTION II

DETAILED ANALYSIS

This section contains an analysis of each important control function that led to the conclusions of Section I. The information in this section consists of three types. The first comprises narratives of the effects switches may have on the functions controlled in the mount. These narratives are arranged in alphanumerical order by the designation of the final control element (relay or solenoid). A schematic drawing number is referenced with each narrative for a given function.

The second type of information is supplied only for the convenience of the reader; it is a reproduction of the manual switches on the front of the EP2 Panel as shown in OP 4116, Volume 2, Figure 3-2.

The third type of information is a reproduction of the schematic drawings referenced in the narratives; it is also presented solely for the convenience of the reader. These schematics are arranged in numerical order.

Train and Elevation Electronic Servo-Control Main Chassis

Logic control circuits provide two inputs to the Train and Elevation Servo Control; one provides an enable signal to the amplifers, and the other enables the synchronized indicator.

Normal operations of these logic circuits occur during all AUTO or STEP operations, SMS1-1 or SMS1-3 low. During mount operations, ARY1 activation is also controlled by SMY1, the Train and Elevation Control Switch. ARY1 logic activation for each position of SMY1 is as follows:

SMY1 in STOW Position

- Amplifier enable -- controlled by all nonmanual inputs.
- Synch-indicator enable -- cannot be activated because KCY1-2 is high as a result of SMY1 being in STOW.

SMY1 in REMOTE Position

- Both amplifier and synch-indicator enables are controlled by nonmanual inputs.

SMY2 in LOCAL Position

- Both amplifier and synch-indicator enable signals are controlled by nonmanual inputs.

SMY1 in TEST Position

- Amplifier enable -- controlled by nonmanual inputs and SMT16, the Train Amplifier Signals switch.
  - SMT16-1 (Normal) causes activation when the Train Brake is released, SIT3-1 low.
  - SMT16-1 (Energize) causes activation without regard to the Train Brake status.
- Sync-Indicator enable -- controlled by nonmanual inputs and SMT16 and SMT17, the Train Compensator Switch.
  - SMT17-1 causes activation whenever SMT16-1 or SMT16-3 is low, in the normal or energized positions.

Safety Considerations

- During normal mount operation, ARY1 circuits cannot be accidentally activated by any single mispositoned switch.

- Switching SMY1 to TEST and SMT16 to energize may cause the inadvertent activation of ARY1 logic under normal mount operating conditions. However, since SMY1 is on the EP2 Panel and SMT16 is on the EP3 Panel, the possibility of these switches accidentally being placed in these positions at the same time is remote.

- Switching SMY1 to STOW at any time during normal mount operation causes deactivation of the ARY1 sync-indicator.

- Switching SMY1 to STOW always causes deactivation of the ARY1 sync-indicator and may deactivate the amplifier enable circuit.

- During train and elevation testing, switching SMT17 out of normal causes deactivation of the ARY1 sync-indicator circuit.

Dwg. 2625626-3 MANUAL SWITCH CONTROLS KCF2

Firing Ordered

Control of KCF2 activation is attained directly through three manual switches: SMF1 (REMOTE or LOCAL firing), SMF2 (LOCAL FIRING SWITCH), and the remote firing switch located in the Weapon Control Center.

During all mount operational modes, either the remote firing switch in weapon control and SMF1 in REMOTE or SMF2 closed and SMF1 in LOCAL will activate KCF2. Since KCF2 activation requires two switches in each case, the possibility of accidentally ordering firing is small. However, firing may occur if the remote firing switch in the weapon control is closed and it becomes necessary for the mount operator to switch SMF1 from SAFE to LOCAL or LOCAL to SAFE. Under these conditions, accidental firing may occur when SMF1 passes through REMOTE.

As recommended in Naval Ordnance Station/Louisville letter 50331:RLK; lcb of March 1976, the position reversal of REMOTE and LOCAL on SMF1 would eliminate accidental firing in the situation described above. Beyond that, strict procedural control and perhaps changing SMF1 to a keyed switch are ways to prevent accidental mount firing.

Ready to Fire

KCF3 activation is required in order to fire in all nonemergency situations. In all modes of operation, activation of KCF3 is controlled by interlock logic signals and the Firing Safety Switch, SMF1. This switch must be in either the LOCAL or the REMOTE position to activate KCF3 during all but SIMULATE operations. In SIMULATE operation, SMF1 must be in either the SAFE or the AREA CONTROL position.

Although under certain circumstances KCF3 is controllable by one switch, SMF1, logic interlocks and firing-circuit switch interlocks make it improbable that switching of SMF1 can cause inadvertent firing. It is more likely that accidental switching of SMF1 will deactivate KCF3 and prevent nonemergency firing.

"B" Emergency Firing Circuit

KCF4 activation is required in order to fire using the "B" Emergency Firing Circuit. Logic interlock signals and SMF1 in the EMERGENCY FIRE position cause KCF4 activation.

By design, KCF4 activation is accomplished with minimum interlock checking and switch setting so that the gun may be fired quickly in an emergency in spite of most firing circuit failures. There is little likelihood that accidental activation of KCF4 will cause firing, because SMF2 must also be closed for the mount to fire. To retain the capability for firing under emergency conditions, mount operational procedures must ensure proper usage of SMF1 and SMF2. Making SMF2 a key lock switch would almost certainly prevent accidental firing.

Dwg. 2625626-2 MANUAL SWITCH CONTROLS KCF5

"A" Emergency Firing Circuit

KCF5 activation is required in order to fire using the "B" Emergency Firing Circuits. Logic interlock signals and SMF1 in the EMERGENCY FIRE position cause KCF5 activation.

By design, KCF5 activation is accomplished with minimum interlock checking and switch setting so that the gun may be fired quickly in an emergency in spite of most firing circuit failures. There is little likelihood that accidental activation of KCF5 will cause firing, because SMF2 must also be closed for the mount to fire. To retain the capability for firing under emergency conditions, mount operational procedures must ensure proper usage of SMF1 and SMF2. Making SMF2 a key lock switch would almost certainly prevent accidental firing.

Dwg. 2625616-3 MANUAL SWITCH CONTROLS KCP1

Fuze Setter Engaged

KCP1 indicates when the fuze setter is engaged to a fuze. In all modes of gun mount operation, KCP1 activation is controlled by logic inputs and SMP1, the Fuze Setter Switch. Additionally, for fuze setter testing, SMP11-1 (Fuze Setter Engaged) is required for mount operation, SMP1 must be in either its SAFE or its RUN position, and, for fuze setter testing, SMP1 must be in the TEST position.

During mount operation, switching SMP1 from SAFE or RUN position to OFF will cause deactivation of KCP1. Switching SMP1 from OFF to SAFE or RUN will activate KCP1 only when the proper logic inputs are present in KCP1 logic circuitry. Switching both SMP1 to TEST and SMP11 to SIMULATE FUZE SETTER ENGAGED always causes activation of KCP1. Inadvertent switching of SMP1 and SMP11 to accidentally activate KCP1 is unlikely; nevertheless, the logic circuits that energize KCP1 should be altered to ensure that KCP1 is not activated for testing under improper mount equipment conditions.

The prototype gun does not contain a Fuze Setter. The foregoing discussion is thus academic, since the production gun may contain a totally different Fuze Setter design. However, this analysis should be considered if the present logic will be used with the production Fuze Setter.

External Fuze Setter Director Order

Selection of an external fuze setter director order requires three switches: SMY12 to LOCAL (train and elevation control), SMY15 to FUZE SETTER, and SMY14 to EXTERNAL. Once Selected, SMY15 is bypassed through a switch on KCP3 itself. Therefore, only SMY12 and SMY15 are needed to maintain KCP3 activation.

Inadvertent activation of KCP3 is unlikely because it cannot occur unless three switches are out of position. Further, accidental KCP3 activation should, by itself, not cause mount safety problems. When activated, KCP3 can accidentally be deenergized by the inadvertent switching of SMY12 or SMY15. However, accidental turn-off of KCP3 should not cause safety problems because it is used for mount testing only.

Dwg. 2625602-3 MANUAL SWITCH CONTROL KCY1

Stow

The activation of KCY1 is controlled only by MSY1, the Train and Elevation Control Switch. With SMY1 in the STOW position, KCY1 is energized and causes the mount to train and elevate into the stowed position.

SMY1 in STOW appears to override all other train and elevation orders; inadvertently switching of SMY1 to STOW can cause an otherwise ready-to-fire mount to aim its barrel unsafely. However, there are interlocks in the firing circuits that prevent the mount from firing in the LOCAL or REMOTE modes after it has been ordered to STOW. Moving SMY1 to STOW should not cause any safety problems.

Dwg. 2625602-3 MANUAL SWITCH CONTROLS KCY2

Remote

Activation of KCY2 is controlled solely by SMY1, the Train and Elevation Control Switch. With SMY1 in the REMOTE position, KCY2 is activated and the mount accepts train and elevation orders from the ship fire control system.

Although REMOTE can be ordered by the inadvertent repositioning of just one switch, SMY1, this should not cause the mount to be unsafe. When the mount is not being fired and there is accidental switching to REMOTE, the fire control system will usually not be energized and no orders to train and elevate will be received. With the mount loaded for firing, the fire control system will normally be in use and, when switched to REMOTE, the mount will receive "safe" train and elevation orders.

Test

The activation of KCY3 is controlled by one switch, SMY1, the Train and Elevation Control Switch. When KCY3 is activated, the mount is set to accept train and elevation orders from a test (dummy) director system.

If SMY1 is advertently switched to TEST during normal mount operations, the gun should be safe because the test director will not be generating train and elevation orders. During mount testing, if SMY1 is accidentally switched from TEST, the mount should not be receiving train and elevation orders and therefore should be safe.

Guided Projectile Load Position Ordered

KCY4 activation is controlled by logic inputs and two manual switches. The Guided Projectile Load Position is ordered whenever SMS2 is in the UNLOAD, OFF, or LOAD positions; SMY1 is in the REMOTE, LOCAL, or TEST positions; there is no projectile in the breech; and a reduced-charge powder case is selected.

During guided projectile REMOTE-LOAD mount operations, it is most likely that the inadvertent switching of SMY1 or SMS2 will drop the mount out of the guided projectile mode of operation. If either SMY1 is switched from REMOTE to STOW or SMS2 is switched from LOAD to EXERCISE (assuming that PC19-K4 cannot activate KCY4 by itself), then the Guided Projectile Load Position Order is dropped. This situation should not establish unsafe operational conditions unless machinery cycles that require KCY4 activation do not stop when KCY4 is deenergized. Inadvertent selection of reduced-charge ammunition during normal mount operation could cause the Guided Projectile Load Position to be ordered. If this occurs, mount operations should remain safe because regular ammunition can be loaded in the Guided Projectile Load Position.

Dwg. 2625605-1 MANUAL SWITCH CONTROL KPE1

Elevation Motor Control

During normal mount operations, KPE1 is kept energized by logic inputs and the following manual switches: SMS4-2 (All Motors Stop not depressed), SME1-2 (Elevation Stop not depressed), and SMF1-2 (Safety Switch not at SAFE). In addition, when the elevation control is being tested (SMY1 to TEST), SMY11, the Power Failure T&E test switch, must be at NORMAL. In order to start the Elevation Motor, the mount must be in either the OFF or the STEP control mode (SMS1-1 or SMS1-3), SMS5 (All Motors Start) or SME2 (Elevation Motor Start) must be depressed, and all switches for KEP1-maintained activation must be as stated above.

In all situations, accidental elevation motor start is unlikely because of the large number of required switch setting and logic inputs. However, the inadvertent switching of any switches required to keep KPE1 energized will cause KEP1 to deenergize. This should not cause any safety problems, because all these switches are "safety switches" and are deliberately included in the KEP1 logic circuits to allow quick shutdown of the elevation motor.

Dwg. 2625602-1 MANUAL SWITCH CONTROLS KPT1

Train Motor Contractor

During normal mount operations KPT1 is kept energized by logic inputs and the following manual switches: SMS4-2 (All Motor Stop not depressed), SMT1-2 (Train Stop not depressed), and SMF1-2 (Safety Switch not at SAFE). In addition, when the train control is being tested (SMY1 to TEST), SMY11, the Power Failure T&E test switch, must be at NORMAL. In order to start the Train Motor, the mount must be in either the OFF or the STEP control mode (SMS1-1 or SMS1-3), SMS5 (All Motors Start) or SMT2 (Train Motor Start) must be depressed, and all switches for KPT1-maintained activation must be as stated above.

In all situations, accidental train motor start is unlikely because of the large number of required switch settings and logic inputs. However, the inadvertent switching of any one of the switches required to keep KPT1 energized will cause KTE1 to deenergize. This should not cause any safety problems, because all of these switches are "safety switches" and are deliberately included in the KPT1 logic circuits to allow quick shut-down of the train motor.

Dwg. 2625608-1 MANUAL SWITCH CONTROLS KPX1

Upper Accumulator Motor Contactor

During mount operations, keeping KPX1 energized requires the Upper Accumulator Safety Switch, SMX16, to be at RUN; the All Motors Stop, SMS4, not to be depressed; the Upper Accumulator Stop, SMX13, not to be depressed; and other logic interlock inputs. To energize KPX1, the mount must be in either the OFF or the STEP control mode (SMS1-1 or SMS1-3), the All Motors Start (SMS5-1) or Upper Accumulator Start (SMX14-1) must be depressed, and all switches required to keep KPX1 energized must be as stated above.

In all situations, accidental activation of the Upper Accumulator Motor Contactor is unlikely because of the large number of required switch settings and logic inputs. However, the inadvertent switching of any one of the switches required to keep KPX1 energized will cause KPX1 to deenergize. This should not cause any safety problems, because of all of these switches are "safety switches" and are deliberately included in the KPX1 logic circuits to allow quick shutdown of the upper accumulator motor.

Lower Accumulator Motor Contactor

During mount operations, keeping KPX4 energized requires the Lower Accumulator Safety Switch, SMX15, to be at RUN; the All Motors, Stop, SMS4, not to be depressed; the Lower Accumulator Stop, SMX13, not to be depressed; and other logic interlock inputs. To energize KPX4, the mount must be in either the OFF or the STEP control mode (SMS1-1 or SMS1-3), the All Motors Start (SMS5-1) or the Lower Accumulator Start (SMX12-1) must be depressed, and all switches required to keep KPX4 energized must be as stated above.

In all situations, accidental activation of the Lower Accumulator Motor Contactor is unlikely because of the large number of required switch settings and logic inputs. However, the inadvertent switching of any one of the switches required to keep KPX4 energized will cause KPX4 to deenergize. This should not cause any safety problems, because all of these switches are "safety switches" and are deliberately included in the KPX4 logic circuits to allow quick shut-down of the lower accumulator motor.

Dwg. 2625608-4 MANUAL SWITCH CONTROLS KPX7

Upper Accumulator Emergency Motor Contactor

During mount STEP control operations (SMS1 to STEP), KPX7 can be energized when the Upper Accumulator Motor Contactor, KPX1, is not energized. To keep KPX7 energized, the Upper Emergency Motor Toggle, SMX20, must not be at STOP, the Upper Accumulator Safety Switch (SMX16) must be at RUN, and interlock logic inputs must be correct. In order to energize KPX7, the Upper Emergency Motor Toggle, SMX20, must be at START and all other switches and logic required to keep KPX7 energized must be as stated above.

Whenever the mount is in the STEP mode of operation and the Upper Accumulator Motor Contactor is not energized but not set to be SAFE, KPX7 may be activated by the inadvertent switching of SMX20 to START, and it will remain energized until SMX20 is switched to STOP, the Upper Accumulator Safety Switch (SMX16) is switched to SAFE, or SMS1 is switched to either OFF or AUTO. The ease with which KPX7 can be energized may cause maintenance safety problems because KPX7 is not deactivated by any of the mount motor stop switches. During normal mount operations in the STEP mode, KPX7 cannot be energized. Since KPX7 is used only in emergency situations, accidental deactivation should not cause any safety problems.

Lower Accumulator Emergency Motor Contactor

During mount STEP control operations (SMS1 to STEP), KPX10 can be energized when the Lower Accumulator Motor Contractor, KPX4, is not energized. To keep KPX10 energized, the Lower Emergency Motor Toggle, SMX21, must not be at STOP and the Lower Accumulator Safety Switch, SMX15, must be at run. To energize KPX10, the Lower Emergency Motor Toggle, SMX21, must be at START and all other switches must be set for KPX10 energize as stated.

Whenever the mount is in the STEP mode of operation and the Lower Accumulator Motor Contactor is not energized but not set to SAFE, KPX10 may be activated by the inadvertent switching of SMX21 to START, and it will remain energized until either SMX21 is switched to STOP, the Lower Accumulator Safety Switch is switched to SAFE, or SMS1 is switched to either OFF or AUTO. The ease with which KPX10 can be energized may cause maintenance safety problems because KPX10 is not deactivated by any of the mount motor stop switches. During normal mount operations in the STEP mode, KPX10 cannot be energized. Since KPX10 is used only in emergency situations, accidental deactivation should not cause any safety problems.

Dwg. 2625605-4 MANUAL SWITCH CONTROLS KTE1

Elevation Pressure Normal

Continuous activation of KTE1 during all modes of operation requires interlock logic signals and the Elevation Motor Stop Switch, SME1, not depressed. Initial energizing of KTE1 requires depressing either the Elevation Motor Start Switch, SME2, or the All Motors Start Switch, SMS5. Inadvertent switching of SMS5 or SME2 when KTE1 is off will cause KTE1 activation only if logic interlocks are correct; and inadvertent switching of SME1 with KTE1 activated will cause KTE1 to deenergize. These switchings should not cause safety problems, because of the logic interlocks and the intended uses of these three switches.

Dwg. 2625626-3 MANUAL SWITCH CONTROLS KTF1

Firing Ordered

See KCF2, since KCF2 is the only requirement for KTF1.

Dwg. 2625602-3 MANUAL SWITCH CONTROLS KTT1

Train Pressure Normal

Continuous activation of KTT1 during all modes of operating requires interlock logic signals and the Train Motor Stop Switch, SMT1, not depressed. Initial energizing of KTT1 requires depressing either the Train Motor Start Switch, SMT2, or the All Motors Start Switch, SMS5. Inadvertent switching of SMS5 or SMT2 when KTT1 is off will cause KTT1 activation only if logic interlocks are correct; and inadvertent switching of SMT1 with KTT1 activated will cause KTT1 to deenergize. These switchings should not cause safety problems, because of the logic interlocks and the intended uses of these three switches.

Dwg. 2625623 MANUAL SWITCH CONTROLS LHB1-LC1

Open Breech Block

Activation of LHB1-LC1 to cause breech opening occurs when interlock logic inputs are correct and manual switches are positioned as follows:

- AUTO LOAD
  - SMS1 to AUTO and SMS2 to LOAD (guided projectile ammunition only)
- STEP LOAD
  - SMS1 to STEP, SMS2 to LOAD, and SMB1 depressed (guided projectile ammunition only)
  - SMS1 to STEP, SMS2 to LOAD, SMB1 depressed, and SMF1 to AREA CONTROL or SAFE
- STEP EXERCISE
  - SMS1 to STEP, SMS2 to EXERCISE, SMF1 to AREA CONTROL, and SMB1 depressed
- SIMULATE (AUTO)
  - SMS1 to AUTO, SMS2 to LOAD, and SMX19 (Simulate Mode Selector) depressed
- SIMULATE (STEP)
  - SMS1 to STEP, SMS2 to LOAD, SMX19 depressed, and SMB1 depressed

The Open Breech Block solenoid, LHB1-LC1, cannot be activated during any UNLOAD, STRIKEDOWN, or OFF LOAD operations.

Switch setting changes affect LHB1-LC1 activation as follows:

- SMS1 and SMS2 set the mount's operational mode. Changing either switch changes the requirements for LHB1-LC1 activation. Inadvertent switching of either of these switches should not cause safety problems, because all modes are guarded with interlock switches to check mount status for breech opening.

- When depressed, SMB1 requests LHB1-LC1 to activate and open the breech when the proper conditions are met for each STEP operational mode. Since each STEP mode has safety checks for breech opening, inadvertent pressing of SMB1 cannot cause LHB1-LC1 to activate when breech opening would be unsafe.
- It should be noted that a series of unfavorable conditions could result in a hazardous condition. The operator could open the breech by depressing SMB1 (in STEP-LOAD mode). If the gun was "hot" from previous firings and a misfire occurred, or the firing circuit was interrupted for some reason after the ramming of a live round, then the powder case could "cook-off", resulting in serious damage if the breech block was open. It is not likely that all of these events would occur; however, the possibility does exist.
- Switching SMF1 to AREA CONTROL allows LHC1-LC1 activation during STEP LOAD and STEP EXERCISE operations, and moving it to SAFE allows LHC1-LC1 activation during STEP LOAD. Switching SMF1 to these positions can cause breech opening only if SMB1 is simultaneously depressed. This is highly unlikely and in any case is safe. Switching SMF1 out of these two positions cannot cause breech opening.
- Switching SMX19 to SIMULATE or dropping it out of SIMULATE also requires SMS1 to be switched to the OFF position. Inadvertent changes in SMX10 cannot by themselves cause breech opening.

Close Breech Block

Activation of LHB1-LC2 to cause breech closing occurs when interlock logic inputs are correct and manual switches are positioned as follows:

- AUTO LOAD and SIMULATE AUTO LOAD
  - SMS1 to AUTO and SMS2 to LOAD
- STEP LOAD and SIMULATE STEP LOAD
  - SMS1 to STEP, SMS2 to LOAD, and SMB2 depressed
- *STEP EXERCISE*
  - SMS1 to STEP, SMS2 to LOAD, and SMB2 depressed

The Close Breech Block solenoid, LHB1-LC2, cannot be activated during any *UNLOAD, STRIKEDOWN, or OFF LOAD operations.*

Switch setting changes affect LHB1-LC2 activation as follows:

- SMS1 and SMS2 set the mount's operational mode; changing either switch changes the requirements for LHB1-LC2 activation. Inadvertent changes in these switches cannot by themselves cause breech closing.
- When depressed in the STEP LOAD of EXERCISE modes, SMB2 requests LHB1-LC2 activation when the proper logic interlock conditions are present. Inadvertent pressing of SMB2 should not cause the breech to close at an unsafe point in the mount's cycle.

Dwg. 2625621-3 MANUAL SWITCH CONTROL LHC1-LC1

Lower Cradle

Activation of LHC1-LC1 to cause cradle lower occurs when interlock logic inputs are correct and manual switches are positioned as follows:

- AUTO LOAD AND UNLOAD, and SIMULATE AUTO
  - No switches other than mode switches

- STEP LOAD, STEP EXERCISE, STEP UNLOAD, AND SIMULATE STEP
  - SMC1, the Cradle Lower Switch, depressed

The Lower Cradle solenoid, LHC1-LC1, cannot be energized during STRIKEDOWN and OFF LOAD operations.

Switch setting changes affect LHC1-LC1 activation as follows:

- SMS1 and SMS2 set the operational mode of the mount, and changing either of these two switches shifts the requirements for cradle lowering to one of the situations shown above. Switching from STEP to AUTO may cause immediate LHC1-LC1 activation, but only under safe conditions.

- SMC1 is required to be depressed for LHC1-LC1 activation in all STEP modes of operation. If SMC1 is depressed in NON-STEP modes, LHC1-LC1 cannot activate. During STEP Modes, interlock logic prevents LHC1-LC1 activation under unsafe mount equipment conditions.

- SMX19 must be depressed, along with SMS1, to OFF in order to switch into and out of the SIMULATE mode. Inadvertent switching in either direction is unlikely; and if it does occur, the mount will be in the OFF condition. While it is in OFF, no loading function activations should occur. Within the SIMULATE mode, switching from AUTO to STEP operation may cause immediate LHC1-LC1 activation, but only under safe conditions.

Dwg. 2625621-1 MANUAL SWITCH CONTROLS LHC1-LC2

Raise Cradle

Activation of LHC1-LC2 to cause cradle raise occurs when interlock logic inputs are correct and manual switches are positioned as follows:

- AUTO LOAD and SIMULATE AUTO LOAD
  - No switches other than mode switches
- STEP LOAD and EXERCISE and SIMULATE STEP LOAD and EXERCISE
  - SMC2, the Cradle Raise Switch, depressed

The Cradle Raise solenoid, LHC1-LC2, cannot be activated during STRIKEDOWN or OFF LOAD operations.

Switch setting changes affect LHC1-LC2 activation as follows:

- SMS1 and SMS2 switchings change the operational mode. Any inadvertent movement of these two switches shifts the requirements for cradle raising to one of the situations shown above. Switching from STEP to AUTO modes may cause immediate LHC1-LC2 activation, but only under safe conditions.
- SMC2 is required to be depressed for LHC1-LC2 activation in all STEP modes of operation. If SMC2 is depressed in non-STEP modes, LHC1-LC2 will not be activated. In STEP modes, interlock logic prevents LHC1-LC2 activation under unsafe mount equipment conditions.

Cradle Pawl Retract (at Hoist)

Activation of LHC2-LC1 to cause cradle pawl retraction (at hoist) occurs when interlock logic inputs are correct and manual switches are set as follows:

- AUTO UNLOAD and SIMULATE AUTO UNLOAD
  - .. No switches other than mode switches
- STEP UNLOAD, STEP EXERCISE, SIMULATE STEP UNLOAD, and SIMULATE STEP EXERCISE
  - .. SMH1, the Lower Hoist switch, depressed

The Cradle Pawl Retract solenoid, LHC2-LC1, cannot be activated during any LOAD, STRIKEDOWN, and OFF LOAD operations.

Switch setting changes affect LHC2-LC1 activation as follows:

- SMS1 and SMS2 switching changes the mount's operational mode of operation. Interlock logic for each allowed operational mode should prevent unsafe LHC2-LC1 activation or deactivation through mode changes.
- SMH1 is required to be depressed in STEP UNLOAD and STEP EXERCISE modes of operation for LHC2-LC1 activation. In these modes interlock logic should prevent unsafe LHC2-LC1 activation, and in other modes SMH1 cannot cause activation of this solenoid.

Dwg. 2625621-1 MANUAL SWITCH CONTROLS LHC2-LC2

Cradle Unlatch (at Hoist)

Manual switch control requirements for this solenoid are the same as for LHC1-LC2.

Release Elevation Brake

Activation of LHE1-LC1 requires logic interlock inputs to be correct and manual switches to be positioned as follows:

- AUTO UNLOAD, STEP UNLOAD, STEP LOAD, STEP EXERCISE, and SIMULATE

  - SMY1 must be at TEST, LOCAL, or STOW to energize LHE1-LC1 when the mount is not assigned (PC124-K5 high). LHE1-LC1 will remain activated after being energized as long as the elevation motor and amplifier are ready and the mount is in either AUTO or STEP.

Switch setting changes affect LHE1-LC1 activation as follows:

- SMS1 and SMS2 changes should not affect LHE1-LC1 once it is activated, except for switching SMS1 to OFF, which will cause LHE1-LC1 to deenergize. This should not cause any safety problems, because no loading system or elevation function can occur with SMS1 to OFF.

- SMY1 changes have no impact on LHE1-LC1 once it is activated.

Dwg. 2625605-3 MANUAL SWITCH CONTROLS LHE2-LC1

Retract Elevation Plunger for Zones 1 & 2

No manual switches control LHE2-LC1 activation or deactivation.

Dwg. 2625605-3 MANUAL SWITCH CONTROLS LHE2-LC2

Retract Elevation Plunger for Zone 2 (high zone)

No manual switches control LHE2-LC2 activation or deactivation.

Dwg. 2625619 MANUAL SWITCH CONTROLS LHH1-LC1

Hoist Raise

Activation of LHH1-LC1 requires logic interlock signals to be correct and manual switches to be positioned as follows:

- AUTO LOAD, AUTO UNLOAD, SIMULATE AUTO LOAD, and SIMULATE AUTO UNLOAD
  - No switches except mode switches
- STEP LOAD, STEP UNLOAD, STEP EXERCISE, SIMULATE STEP LOAD, and SIMULATE STEP UNLOAD
  - SMH2, Raise Hoist Switch, depressed

The Hoist Raise solenoid, LHH1-LC1, cannot be activated during STRIKEDOWN and OFF LOAD operations.

Switch setting changes affect LHH1-LC1 activation as follows:

- SMS1 and SMS2 changes alter the interlock requirements for LHH1-LC1 activation. Switching SMS1 from STEP to AUTO may cause LHH1-LC1 activation whenever the logic is satisfied for AUTO operation activation. This should not present safety problems, because the interlock logic should allow activation only under safe mount equipment conditions.
- SMH2 causes LHH1-LC1 activation when logic interlocks are satisfied and the mount is in STEP operation. When not in STEP, SMH2 cannot cause LHH1-LC1 activation. Inadvertent switching of SMH2 should not cause safety problems, because the interlock logic requirements should allow LHH-LC1 activation only under safe mount equipment conditions.

Dwg. 2625620 MANUAL SWITCH CONTROLS LHH1-LC2

Hoist Lower

Activation of LHH1-LC2 requires interlock logic to be correct and manual switches to be positioned as follows:

- AUTO LOAD or AUTO UNLOAD, and SIMULATE AUTO LOAD or SIMULATE AUTO UNLOAD
  - No manual switches except mode switches
- STEP LOAD, STEP UNLOAD, or STEP EXERCISE: and SIMULATE STEP LOAD, SIMULATE STEP UNLOAD, or SIMULATE STEP EXERCISE
  - SMH1, Lower Hoist switch, depressed

The Hoist Lowering solenoid, LHH1-LC2, cannot be activated during any STRIKEDOWN or OFF LOAD operation.

Switch setting changes affect LHH1-LC2 activation as follows:

- SMS1 and SMS2 set the mount's operational mode. Changes in either switch alter the logic requirements for LHH1-LC2 activation. In all LOAD and UNLOAD operations, switching from STEP to AUTO may cause LHH1-LC2 activation when all logic inputs are correct. This should not present any safety problems, because the interlock logic should prevent activation under unsafe equipment conditions.
- SMH1 causes LHH1-LC2 activation in all STEP modes whenever all logic interlock inputs are correct. Inadvertent pressing of SMH1 should not cause LHH1-LC2 to activate when unsafe equipment conditions exist. SMH1 cannot cause LHH1-LC2 activation in AUTO Modes of operation.

Hoist Pawl Extend

Activation of LHH2-LC1 requires logic interlock inputs to be correct and manual switches to be positioned as follows:

- AUTO LOAD, AUTO UNLOAD, SIMULATE AUTO LOAD, and SIMULATE AUTO UNLOAD
  - No manual switches except mode switches
- STEP LOAD, STEP UNLOAD, STEP EXERCISE, and SIMULATE STEP
  - SMH2, Hoist Raise Switch, depressed
  - SMH1, Hoist Lower Switch, depressed (UNLOAD only)

The Hoist Pawl Extend solenoid, LHH2-LC1, cannot be activated during STRIKEDOWN or OFF LOAD operations.

Switch setting changes affect LHH2-LC1 activation as follows:

- SMS1 and SMS2 changes alter logic interlock and switch requirements for LHH2-LC1 activation. Switching SMS1 from STEP to AUTO may cause LHH2-LC1 activation, but only under conditions established as safe by interlock inputs.
- SMH1 and SMH2 changes cause LHH2-LC1 activation in STEP modes when the interlock's logic is satisfied. Inadvertent switching of SMS1 or SMS2 should not cause safety problems in the STEP mode. They have no impact on LHH2-LC1 activation in the AUTO or OFF positions of SMS1.

Hoist Pawl Retract

Activation of LHH2-LC2 requires correct logic interlock inputs and manual switches positioned as follows:

- AUTO LOAD and UNLOAD, and SIMULATE AUTO LOAD and UNLOAD
  - No switches except mode switches
- STEP LOAD, STEP UNLOAD, STEP EXERCISE, and SIMULATE STEP
  - SML4, Shuttle to Magazine, depressed
  - SML3, Shuttle to Hoist, depressed
  - SMH1, Lower Hoist, depressed (LOAD and EXERCISE only)
- STEP OFFLOAD
  - No switches except mode switches
- ALL MODES
  - SMK2, Replenishment Hoist Raise, depressed
- HOIST LOWER SEQUENCE

Switch setting changes affect LHH2-LC2 activation as follows:

- SMS1 and SMS2 changes the mount operational mode and LHH2-LC2 energize requirements as given above. In all modes of operation, LHH2-LC2 activation is guarded by interlock logic, but in the STEP OFF LOAD mode these interlocks are minimum. Inadvertently switching SMS2 to OFF LOAD while in the STEP mode may cause unexpected LHH2-LC2 activation and pose a safety problem.
- SML4 and SML3 cause LHH2-LC2 to activate in STEP modes of operation. Inadvertent switching of these switches has no effect in the AUTO or OFF positions of SMS1 and does not appear to present a safety problem in the STEP mode because of interlock input requirements to LHH2-LC2.

- SMH1 causes LHH2-LC2 to activate in the STEP LOAD and EXERCISE modes of operation. In the LOAD mode, inadvertent switching of SMH1 may cause ammunition to drop down the Hoist, which is extremely unsafe. No interlock checks are made to determine if ammunition is resting on the Pawl when SMH1 is depressed and the Hoist is in the UP position.

- SMK2 causes LHH2-LC2 to activate in all operational modes if the Hoist is down. Although inadvertent switching of SMK2 may cause LHH2-LC2 activation, there appear to be no safety problems, because at that time the round would be resting on the base of its clip in the prototype gun. If this logic is not modified, it could cause a problem in the production gun configuration.

Position Hoist for Short Round

Activation of LHH3-LC1 takes place when a change from long to short ammunition is ordered and the mount is operating in either the AUTO or the STEP mode of operation -- SMS1 switch functions. No activation of LHH3-LC1 is possible when SMS1 is in the OFF position. With SMS1 in the OFF position, repositioning of the Hoist is not possible.

Position Hoist for Long Round

Activation of LHH3-LC2 takes place when a change from short to long ammunition is ordered and the mount is operating in either the AUTO or the STEP mode of operation. With SMS1 in the OFF position, repositioning of the Hoist is not possible.

Magazine Index Unlatch and Engage Clutch

Activation of LHL1-LC1 requires logic interlock signals to be correct and manual switches to be positioned as follows:

- AUTO LOAD, and SIMULATE AUTO LOAD
  - No switches except mode switches
- STEP LOAD, STEP EXERCISE, STEP STRIKEDOWN, or STEP OFF LOAD; and SIMULATE STEP LOAD
  - SML2, CW Index Switch, depressed

The magazine index unlatch and engage clutch, LHL1-LC1, cannot be activated during any UNLOAD operation.

Switch setting changes affect LHL1-LC1 activation and deactivation as follows:

- SMS1 and SMS2 changes alter LHL1-LC1 interlock logic requirements. Switching SMS1 from STEP to AUTO will cause LHL1-LC1 activation when all interlock inputs are satisfied. This should not cause safety problems, because the interlock inputs will allow activation only under safe mount equipment conditions.
- SML2 causes LHL1-LC1 activation when the mount is operated in STEP and logic interlocks are satisfieid. Inadvertent switching of SML2 when SMS1 is in OFF or AUTO has no impact on LHL1-LC1 activation. In STEP, SML2 switching can cause activation only when logic interlocks are correct, and this should not present any safety problem.

Dwg. 2625613-1 MANUAL SWITCH CONTROLS LHL2-LC2

Magazine Index

Activation of LHL2-LC2 requires logic interlock signals to be correct and manual switches to be positioned as follows:

- AUTO LOAD, AUTO UNLOAD, SIMULATE AUTO LOAD, and SIMULATE AUTO UNLOAD
  - No switches except mode switches
- STEP LOAD and SIMULATE STEP LOAD
  - No switches except mode switches
- STEP UNLOAD, STEP EXERCISE, STEP STRIKEDOWN, STEP OFF LOAD, and SIMULATE STEP UNLOAD
  - SML1, the CCW Index switch, depressed

Switch setting changes affect LHL2-LC2 activation as follows:

- SMS1 and SMS2 changes alter the interlock requirements for LHL2-LC2 activation. Switching SMS1 from STEP AUTO UNLOAD will cause LHL2-LC2 activation when all interlock inputs are satisified. This should not cause safety problems, because the interlock logic will allow activation only under safe mount equipment conditions.
- SML1 causes LHL2-LC2 activation when the mount is operated in the STEP mode and logic interlocks are satisfied. Inadvertent switching of SML1 when SMS1 is in the AUTO position or SMS1 is at STEP and SMS2 is at LOAD cannot cause LHL2-LC2 activation. In STEP UNLOAD, switching SML1 can cause activation only when logic interlocks are correct, and this should not present any safety problems.

Dwg. 2625614-1 MANUAL SWITCH CONTROLS LHL3-LC1

Retract Station 1 Stop

Activation of LHL3-LC1 requires logic interlock signals to be correct and manual switches to be positioned as follows:

- AUTO LOAD, AUTO UNLOAD, SIMULATE AUTO LOAD, and SIMULATE AUTO UNLOAD
  - No switches except mode switches
- STEP LOAD, STEP UNLOAD, STEP EXERCISE, STEP STRIKEDOWN, STEP OFF LOAD, and SIMULATE STEP
  - SML3, Shuttle to Hoist, depressed

Switch setting changes affect LHL3-LC1 activation as follows:

- SMS1 and SMS2 changes alter LHL3-LC1 interlock logic requirements. Switching SMS1 from STEP to AUTO will cause LHL3-LCC1 activation when all interlock inputs are satisfied. This should not cause safety problems, because the interlock inputs will allow activation only under safe mount equipment conditions.
- SML3 causes LHL3-LC1 activation when the mount is operated in STEP and logic interlocks are satisfieid. Inadvertent switching of SML3 when SMS1 is on OFF or AUTO has no impact on LHL3-LC1 activation. In STEP, SML3 switching can cause activation only when logic interlocks are correct, and this should not present any safety problem.

Dwg. 2625614-1 MANUAL SWITCH CONTROLS LHL3-LC2

Retract Station 1 and 2 Stop

Activation of LHL3-LC2 requires logic interlock signals to be correct and manual switches to be positioned as follows:

- AUTO LOAD, AUTO UNLOAD, SIMULATE AUTO LOAD, AND SIMULATE AUTO UNLOAD
  - No switches except mode switches
- STEP LOAD, STEP UNLOAD, STEP EXERCISE, STEP STRIKEDOWN, STEP OFF LOAD, and SIMULATE STEP
  - SML3, Shuttle to Hoist, depressed

Switch setting changes affect LHL3-LC2 activation as follows:

- SMS1 and SMS2 changes alter LHL3-LC2 interlock logic requirements. Switching SMS1 from STEP to AUTO will cause LHL3-LCC2 activation when all interlock inputs are satisfied. This should not cause safety problems, because the interlock inputs will allow activation only under safe mount equipment conditions.
- SML3 causes LHL3-LC2 activation when the mount is operated in STEP and logic interlocks are satisfied. Inadvertent switching of SML3 when SMS1 is on OFF or AUTO has no impact on LHL3-LC2 activation. In STEP, SML3 switching can cause activation only when logic interlocks are correct, and this should not present any safety problem.

Dwg. 2625614-3 MANUAL SWITCH CONTROLS LHL4-LC1

Clip Unlatch to Magazine

Activation of LHL4-LC1 requires interlock logic signals to be correct and manual switches to be positioned as follows:

- AUTO LOAD, AUTO UNLOAD, SIMULATE AUTO LOAD, and SIMULATE AUTO UNLOAD
  - No switches except mode switches
- STEP LOAD, STEP UNLOAD, STEP EXERCISE, SIMULATE STEP LOAD, and SIMULATE STEP UNLOAD
  - SML4, Shuttle to Magazine Switch, depressed
- STEP STRIKEDOWN and OFF LOAD
  - SML3, Shuttle to Hoist Switch, depressed

Switch setting changes affect LHL4-LC1 activation as follows:

- SMS1 and SMS2 changes alter LHL4-LC1 interlock logic requirements. Switching SMS1 from STEP to AUTO will cause LHL4-LC1 activation when all interlock inputs are satisfied. This should not cause safety problems, because the interlock inputs will allow activation only under safe mount equipment conditions.
- SML4 causes LHL4-LC1 activation when the mount is operated in STEP and logic interlocks are satisfied. Inadvertent switching of SML4 when SMS1 is on OFF or AUTO has no impact on LHL4-LC1 activation. In STEP, SML4 switching can cause activation only when logic interlocks are correct, and this should not present any safety problems.
- SML3 causes LHL4-LC1 activation during STRIKEDOWN and OFF LOAD operations. When not operating in STRIKEDOWN or OFF LOAD, SML3 has no impact on LHL4-LC1 activation. In STRIKEDOWN and OFF LOAD, SML3 activates LHL4-LC1 only when logic inputs allow. Inadvertent switching of SML3 should not cause safety problems, because it will activate LHL4-LC1 only under safe equipment conditions.

Dwg. 2625614-2 MANUAL SWITCH CONTROLS LHL4-LC2

Clip Unlatch to Hoist

Activation of LHL4-LC2 requires logic interlock signals to be correct and manual switches to be positioned as follows:

- AUTO LOAD, AUTO UNLOAD, SIMULATE AUTO LOAD, and SIMULATE AUTO UNLOAD
  - No switches except mode switches
- STEP LOAD, STEP UNLOAD, STEP EXERCISE, SIMULATE STEP LOAD, AND SIMULATE STEP UNLOAD
  - SML3, Shuttle to Hoist switch, depressed
- STEP OFF LOAD and STRIKEDOWN
  - SML4, Shuttle to Magazine, depressed

Switch setting changes affect LHL4-LC2 activation as follows:

- SMS1 and SMS2 changes alter LHL4-LC2 interlock logic requirements. Switching SMS1 from STEP to AUTO will cause LHL4-LC2 activation when all interlock inputs are satisified. This should not cause safety problems, because the interlock inputs will allow activation only under safe mount equipment conditons.
- SML4 causes LHL4-LC2 activation during STRIKEDOWN and OFF LOAD operations. When not operating in STRIKEDOWN or OFF LOAD, SML4 has no impact on LHL4-LC2 activation. In STRIKEDOWN and OFF LOAD, SML4 activates LHL4-LC2 only when logic inputs allow. Inadvertent switching of SML4 should not cause safety problems because it will activate LHL4-LC2 only under safe equipment conditions.
- SML3 causes LHL4-LC2 activation when the mount is operated in STEP and logic interlocks are satisfied. Inadvertent switching of SML3 when SMS1 is on OFF or AUTO has no impact on LHL4-LC2 activation. In STEP, SML4 switching can cause activation only when logic interlocks are correct, and this should not present any safety problems.

Dwg. 2625614-4 MANUAL SWITCH CONTROLS LHL5-LC1

Clip Shuttle to Magazine

No direct manual switches operate to activate LHL5-LC1 except mode switches.

Dwg. 2625614-4 MANUAL SWITCH CONTROLS LHL5-LC2

Clip Shuttle to Hoist

No direct manual switches operate to activate LHL5-LC2 except mode switches.

Round Centering Mechanism and Latch Extended

Activation of LHL6-LC1 requires logic interlock signals to be correct and manual switches to be positioned as follows:

- AUTO LOAD, AUTO UNLOAD, SIMULATE AUTO LOAD, AND SIMULATE AUTO UNLOAD
  - No switches except mode switches
- STEP LOAD, STEP UNLOAD, STEP EXERCISE, SIMULATE STEP LOAD, AND SIMULATE STEP UNLOAD
  - SML3, Shuttle to Hoist switch, depressed
  - SML4, Shuttle to Magazine switch, depressed
  - SMH1, Lower Hoist switch, depressed (exercise only)
- DIRECT UNLOAD
  - No switches except mode switches (SMX17 depressed)

Switch setting changes affect LHL6-LC1 activation as follows:

- SMS1 and SMS2 changes alter the requirements for LHL6-LC1 activation. Switching SMS1 from STEP to AUTO will cause LHL6-LC1 activation when all interlock inputs are satisfied. This should not cause safety problems, because the interlock inputs will allow LHL6-LC1 activation only under safe mount equipment conditions.
- SML3 causes LHL6-LC1 activation when the mount is operated in STEP and logic interlocks are satisfied. Inadvertent switching of SML3 when SMS1 is on OFF or AUTO has no impact on LHL6-LC1 activation. In STEP, SML3 switching can cause activation only when logic interlocks are correct, and this should not present any safety problem.
- SML4 causes LHL6-LC1 activation when the mount is operated in STEP and logic interlocks are satisfied. Inadvertent switching of SML4 when SMS1 is on OFF or AUTO has no impact on LHL6-LC1 activation. In STEP, SML4 switching can cause activation only when logic interlocks are correct, and this should not present any safety problem.

- SMH1 causes LHL6-LC1 activation when the mount is operated in STEP and logic interlocks are satisfied. Inadvertent switching of SMH1 when SMS1 is on OFF or AUTO has no impact on LHL6-LC1 activation. In STEP SML1 switching can cause activation only when logic interlocks are correct, which should not present any safety problem.

- SMX17 causes LHL6-LC1 activation when logic interlock inputs are satisfied and SMS2 is at UNLOAD. Inadvertent switching of SMX17 may cause LHL6-LC1 activation but only when logic inputs allows. This should prevent safety problems because the logic should allow LHL6-LC1 activation only under safe mount conditions.

Dwg. 2625618 MANUAL SWITCH CONTROLS LHL6-LC2

Round Centering Mechanism and Latch Retracted

Activation of LHL6-LC2 requires interlock logic signals to be correct and manual switches to be positioned as follows:

- AUTO UNLOAD
  - No switches except mode switches
- STEP UNLOAD
  - SMH1, Lower Hoist Switch, depressed

Activation of LHL6-LC2 is not possible for LOAD or EXERCISE functions. STRIKEDOWN and OFF LOAD operation activation are controlled by other discussed functions.

Switch setting changes affect LHL6-LC2 activation as follows:

- SMS1 and SMS2 changes alter the requirements for LHL6-LC2 activation. Switching SMS1 from STEP to AUTO will cause LHL6-LC2 activation when all interlock inputs are satisfied. This should not cause safety problems, because the interlock inputs will allow LHL6-LC2 activation only under safe mount equipment condition.
- SML1 controls LHL6-LC2 activation during STEP UNLOAD operations only. In all other modes SML1 cannot cause LHL6-LC2 activation. In STEP UNLOAD inadvertent switching of SML1 will activate LHL6-LC1 only when logic interlocks are satisfied. This should not cause safety problems, because interlocks should prevent LHL6-LC2 activation under unsafe equipment conditions.

Short Shuttle Velocity Selector

No direct manual switches operate to activate LHL7-LC2 except mode switches.

Dwg. 2625624-1 MANUAL SWITCH CONTROLS LHM1-LC1

Empty Case Tray Raise

Activation of LHM1-LC1 is controlled by logic interlock signals and manual switches positioned as follows:

- AUTO LOAD and SIMULATE AUTO LOAD
  - No switches except mode switches
- STEP LOAD, STEP EXERCISE, and SIMULATE STEP LOAD
  - SMM1, Raise Empty Case Tray Switch, depressed

The Empty Case Tray Raise solenoid, *LHM1-LC1, cannot be activated* during STRIKEDOWN or OFF LOAD operations.

Switch setting changes affect LHM1-LC1 activation as follows:

- SMS1 and SMS2 changes alter LHM1-LC1 interlock logic requirements. Switching SMS1 from STEP to AUTO will cause LHM1-LC1 activation *when all interlock inputs are satisfied.* This should not cause safety problems, because the interlock inputs will allow activation only under safe mount equipment conditions.
- SMM1 causes LHM1-LC1 activation when the mount is operated in STEP and logic interlocks are satisfied. Inadvertent switching of SMM1 when SMM1 is on OFF or AUTO has no impact on LHM1-LC1 activation. In STEP, SMM1 switching can cause activation only when logic interlocks are correct, and this should not present any safety problems.

Dwg. 2625624-2 MANUAL SWITCH CONTROLS LHM1-LC2

Empty Case Tray Lower

Activation of LHM1-LC2 is controlled by logic interlock signals and manual switches positioned as follows:

- AUTO LOAD and SIMULATE AUTO LOAD
  - No switches except mode switches
- STEP LOAD, STEP EXERCISE, and SIMULATE STEP LOAD
  - SMM2, Lower Empty Case Tray Switch, depressed

The Empty Case Tray Lower solenoid, LHM1-LC2, cannot be activated during STRIKEDOWN or OFF LOAD operations.

Switch setting changes affect LHM1-LC2 activation as follows:

- SMS1 and SMS2 changes alter LHM1-LC2 interlock logic requirements. Switching SMS1 from STEP to AUTO will cause LHM1-LC2 activation when all interlock inputs are satisfied. This should not cause safety problems, because the interlock inputs will allow activation only under safe mount equipment conditions.
- SMM2 causes LHM1-LC2 activation when the mount is operated in STEP and logic interlocks are satisfied. Inadvertent switching of SMM2 when SMS1 is on OFF or AUTO has no impact on LHM1-LC2 activation. In STEP, SMM2 switching can cause activation only when logic interlocks are correct, and this should not present any safety problems.

Retract Empty Case Ejector
and Cradle Latch to Slide

Activation of LHM2-LC1 is controlled by logic interlock signals and manual switches positioned as follows:

- AUTO LOAD and SIMULATE AUTO LOAD
  - No switches except mode switches
- STEP LOAD, STEP EXERCISE and SIMULATE STEP LOAD
  - SMM3, Empty Case Ejector Retract Switch, depressed

The Empty Case Ejector Retract solenoid, LHM2-LC1, cannot be activated during STRIKEDOWN or OFF LOAD operations.

Switch setting changes affect LHM2-LC1 activation as follows:

- SMS1 and SMS2 changes alter LHM2-LC1 interlock logic requirements. Switching SMS1 from STEP to AUTO will cause LHM2-LC1 activation when all interlock inputs are satisfied. This should not cause safety problems, because the interlock inputs will allow activation only under safe mount equipment conditions.
- SMM3 causes LHM2-LC1 activation when the mount is operated in STEP and logic interlocks are satisfied. Inadvertent switching of SMM3 when SMS1 is on OFF or AUTO has no impact on LHM2-LC1 activation. In STEP, SMM3 switching can cause activation only when logic interlocks are correct, and this should not present any safety problems.

Dwg. 2625625 MANUAL SWITCH CONTROLS LHM2-LC2

Empty Case Ejector Extend

Activation of LHM2-LC2 is controlled by logic interlock signals and manual switches positioned as follows:

- AUTO LOAD and SIMULATE AUTO LOAD
  - No switches except mode switches
- STEP LOAD, STEP EXERCISE and SIMULATE STEP LOAD
  - SMM4, Empty Case Ejector Extend Switch, depressed

The Empty Case Ejector Extend solenoid, LHM2-LC2 cannot be activated during STRIKEDOWN or OFF LOAD operations.

Switch setting changes affect LHM2-LC2 activation as follows:

- SMS1 and SMS2 changes alter LHM2-LC2 interlock logic requirements. Switching SMS1 from STEP to AUTO will cause LHM2-LC2 activation when all interlock inputs are satisfied. This should not cause safety problems, because the interlock inputs will allow activation only under safe mount equipment conditions.
- SMS4 causes LHM2-LC1 activation when the mount is operated in STEP 4 and logic interlocks are satisfied. Inadvertent switching of SMM1 when SMS1 is on OFF or AUTO has no impact on LHM2-LC2 activation. In STEP, SMM4 switching can cause activation only when logic interlocks are correct, and this should not present any safety problems.

Dwg. 2625622-2 MANUAL SWITCH CONTROLS LHR1-LC1

Rammer Retract

Activation of LHR1-LC1 is controlled by logic interlock signals *and manual switches positioned as follows:*

- AUTO LOAD and SIMULATE AUTO LOAD
  - No switches except mode switches
- STEP LOAD, STEP EXERCISE, and SIMULATE STEP LOAD
  - SMR1, Rammer Retract Switch, depressed

The Rammer Retract solenoid, LHR1-LC1, cannot be activated during STRIKEDOWN or OFF LOAD operations.

Switch setting changes affect LHR1-LC1 activation as follows:

- SMS1 and SMS2 changes alter LHR1-LC1 interlock logic requirements. Switching SMS1 from STEP to AUTO will cause LHR1-LC1 activation when all interlock inputs are satisfied. This should not cause safety problems, because the interlock inputs will allow activation only under safe mount equipment conditions.
- SMR1 causes LHR1-LC1 activation when the mount is operated in STEP and logic interlocks are satisfied. Inadvertent switching of SMR1 when SMS1 is on OFF or AUTO has no impact on LHR1-LC1 activation. In STEP, SMR1 switching can cause activation only when logic interlocks are correct, and this should not present any safety problems.

Dwg. 2625622-1 MANUAL SWITCH CONTROLS LHR1-LC2

Extend Rammer

Activation of LHR1-LC2 requires logic interlock signals to be correct and manual switches to be positioned as follows:

- AUTO LOAD and SIMULATE AUTO LOAD
  - No switches except mode switches (for regular ammunition)
  - SMX2, Single Load Order switch, depressed (Guided Projectile Operation) only
  - SMX3, Continuous Load Order switch, depressed (Guided Projectile Operation only)
- STEP LOAD, STEP EXERCISE, and SIMULATE STEP LOAD
  - SMR2, the Rammer Extend switch, depressed

The Extend Rammer Solenoid, LHR1-LC2, cannot be activated during UNLOAD, STRIKEDOWN, or OFF LOAD operations.

Switch setting changes affect LHR1-LC2 activation as follows:

- SMS1 and SMS2 changes alter the interlock requirements for LHR1-LC2 activation. Switching SMS1 from STEP to AUTO may cause LHR1-LC2 activation whenever the logic is satisfied for AUTO operation activation. This should not present safety problems, because the interlock logic should allow activation only under safe mount equipment conditions.
- SMR2 causes LHH1-LC2 activation when logic interlocks are satisfied and the mount is in STEP operation. When not in STEP, SMR2 cannot cause LHR1-LC2 activation. Inadvertent switching of SMR2 should not cause safety problems, because the interlock logic requirements should allow LHR1-LC2 activation only under safe mount equipment conditions.

- SMX2, SMX3, and SMX1 (LOAD ORDER OFF Switch) determine whether ammunition is to be loaded one at a time as requested, continuously, or not at all. These switches have no direct impact on LHR1-LC2 activation except during AUTO LOAD with Guided Projectile ammunition. In this mode, switching to SMX2 or SMX3 from SMX1 can cause LHR1-LC2 activation when interlock inputs are correct, and this should not cause safety problems because the interlocks should allow LHR1-LC2 activation only under safe mount equipment conditions. Inadvertently switching to SMX1 at any time should halt all loading activity and prevent LHR1-LC2 activation.

Dwg. 2625602-2 MANUAL SWITCH CONTROLS LHT1-LC1

Train Brake Release

No manual switches affect LHT1-LC1 except mode switches. Activation of LHT1-LC1 requires logic interlock signals to be correct and the mode control switches to be set for other than STRIKEDOWN or OFFLOAD operations. Logic interlocks should allow LHT1-LC1 activation only under safe mount equipment conditions. Inadvertent switching of SMS1 or SMS2 should not cause safety problems.

Dwg. 2625602-3 MANUAL SWITCH CONTROLS LHT2-LC1

Train Plungers for Zones 1 & 2

No manual switches control LHT2-LC1 activation or deactivation.

Dwg. 2625608-1 MANUAL SWITCH CONTROLS LHX1-LC2

Upper Accumulator Dump

Activation of LHX1-LC2 is caused by switching the Upper Emergency Motor Toggle, SMX20, to STOP, depressing the All Motors Stop Switch, SMS4, or switching the Upper Accumulator Motor Switch to STOP under all mount operation modes. Inadvertent switching of any of these switches should not cause safety problems. They are purposely placed in the LHX1-LC2 circuit to allow quick accumulator pressure reduction in emergency situations.

Dwg. 2625608-2 MANUAL SWITCH CONTROLS LHX2-LC2

Lower Accumulator Dump

Activation of LHX2-LC2 is caused by switching the Lower Emergency Motor Toggle Switch, SMX21, to STOP, depressing the All Motor Stop, SMS4, and depressing the STOP Lower Accumulator Motor, SMX11, under all operational modes. Inadvertent switching of any of these switches should not cause safety problems. They are deliberately placed in the LHX2-LC2 circuit to allow quick accumulator pressure reduction in emergency situations.

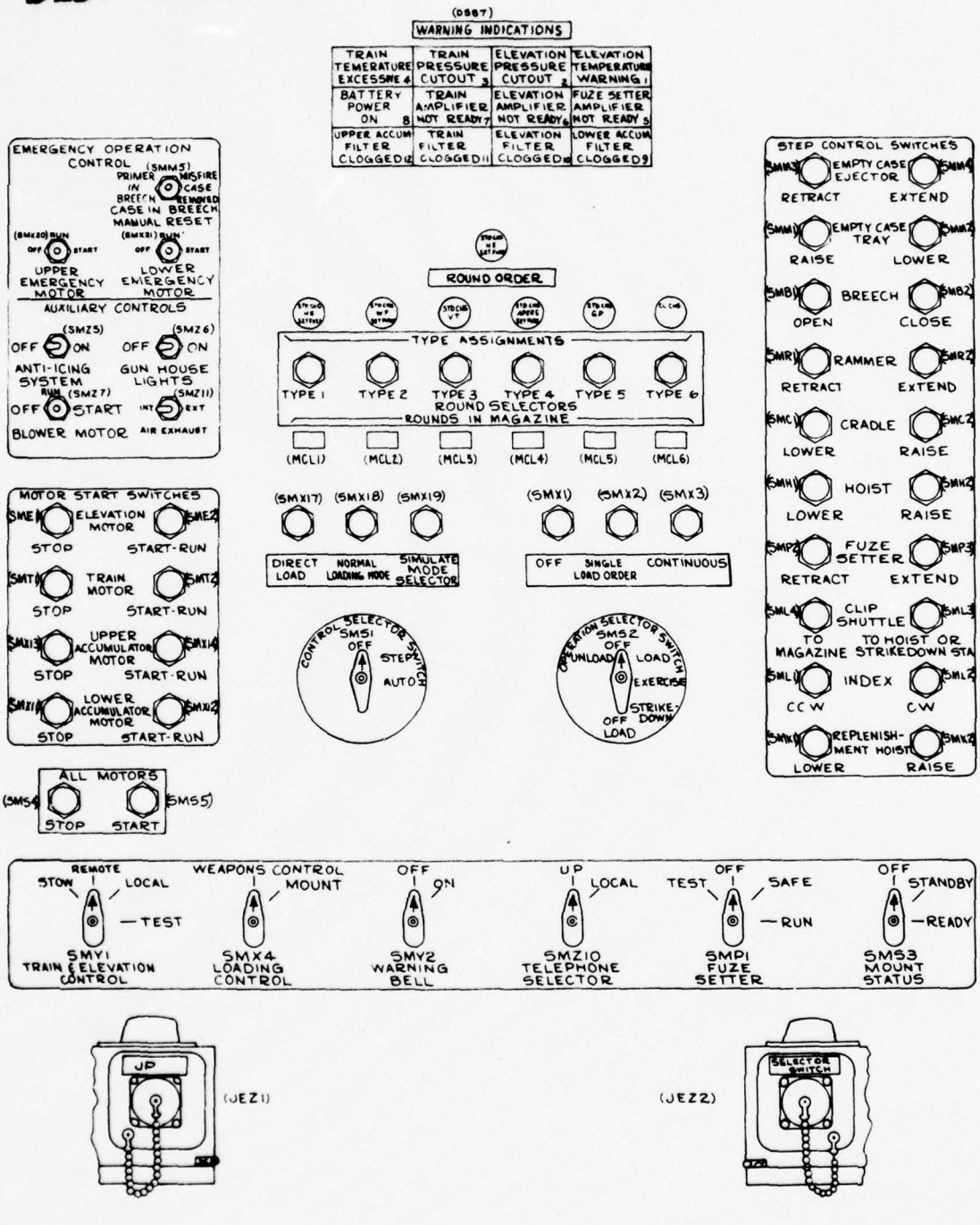
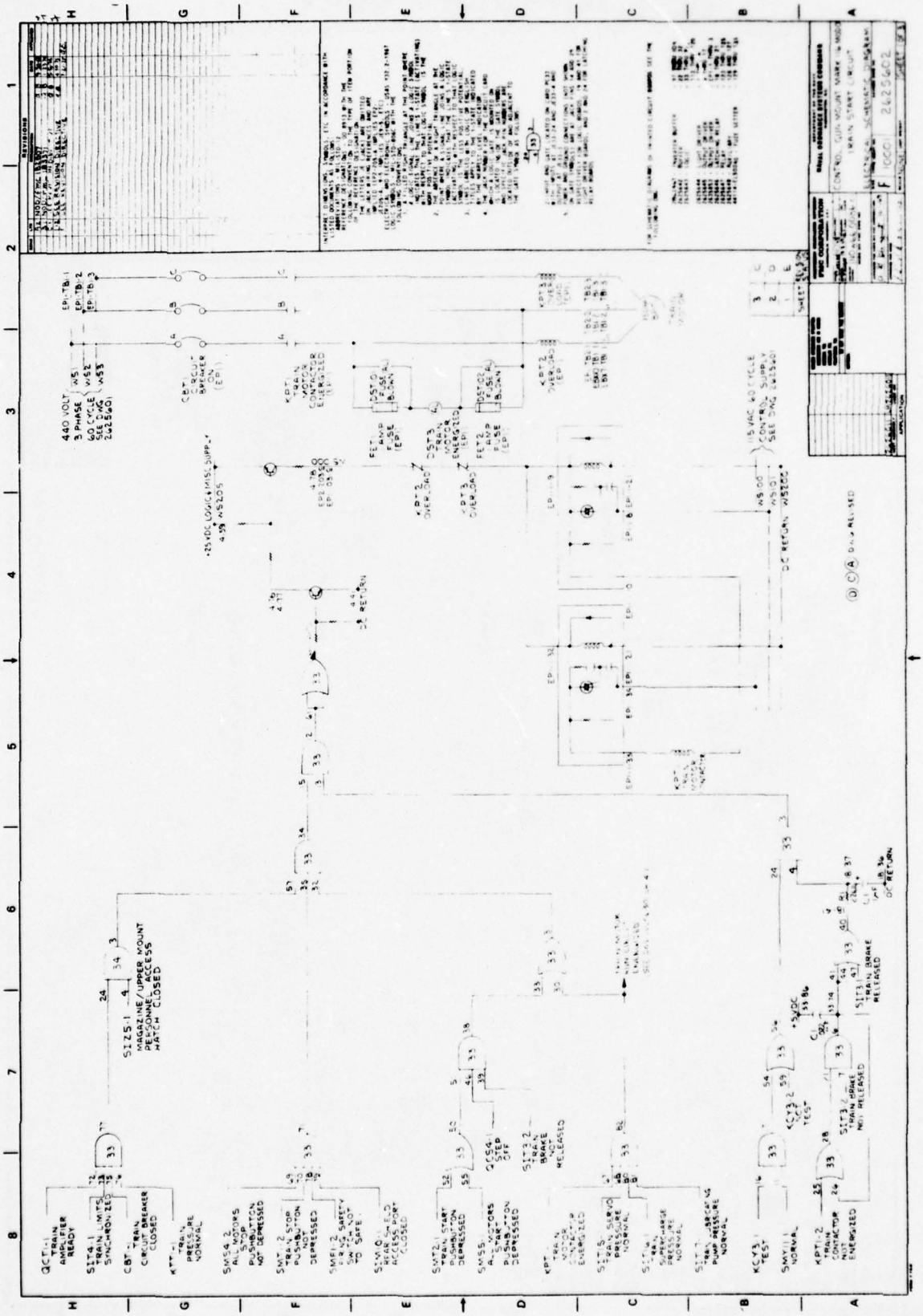
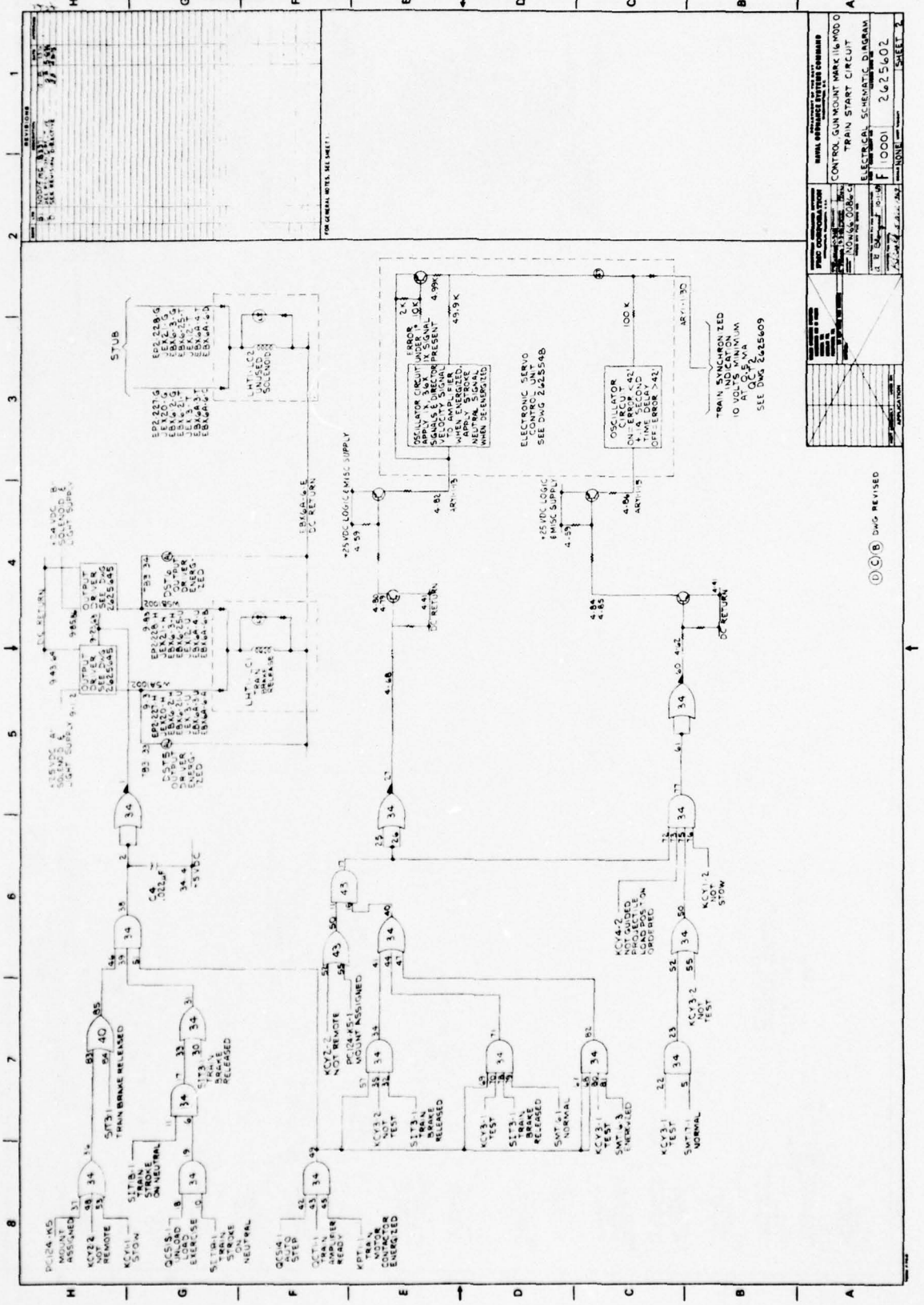
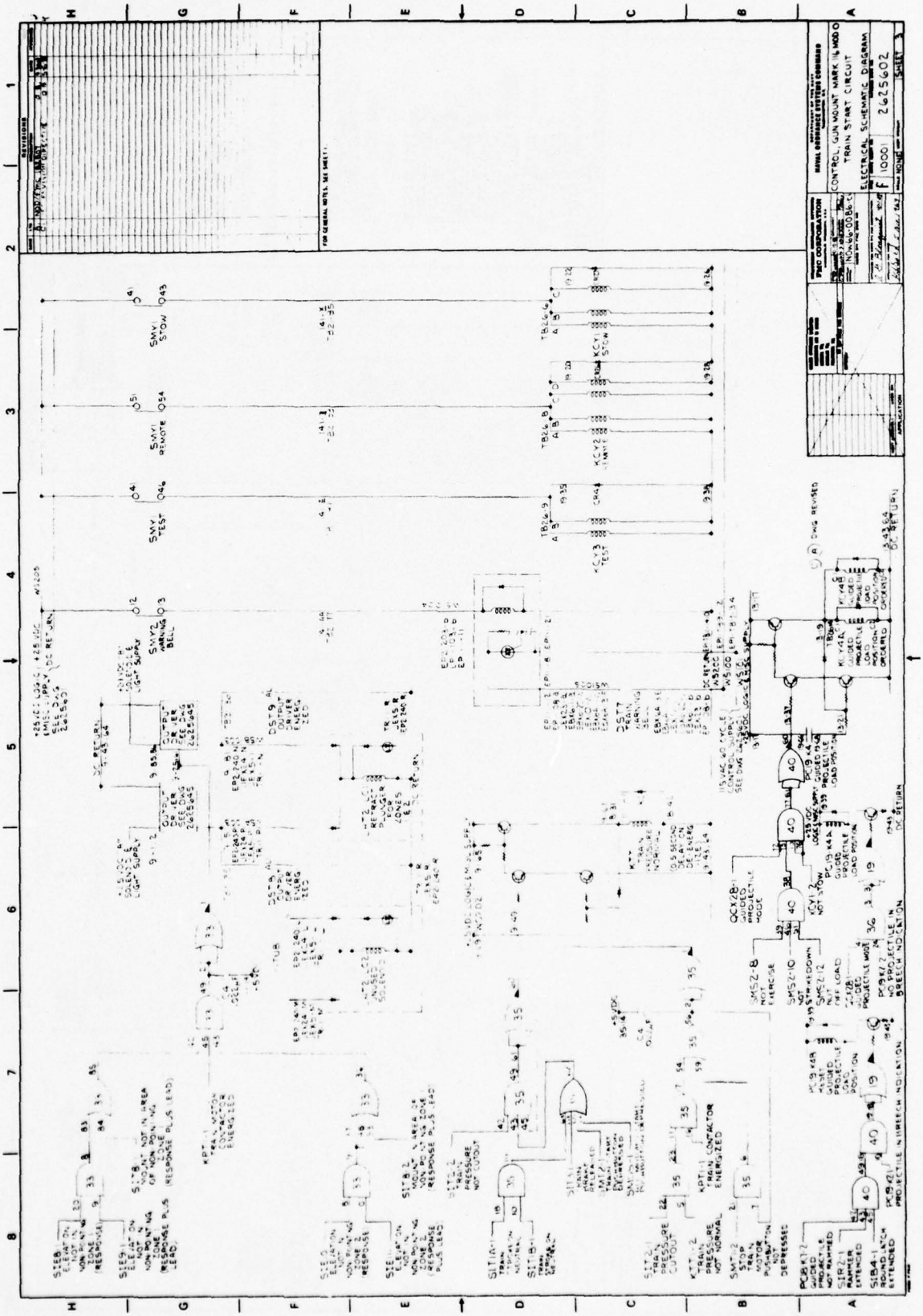
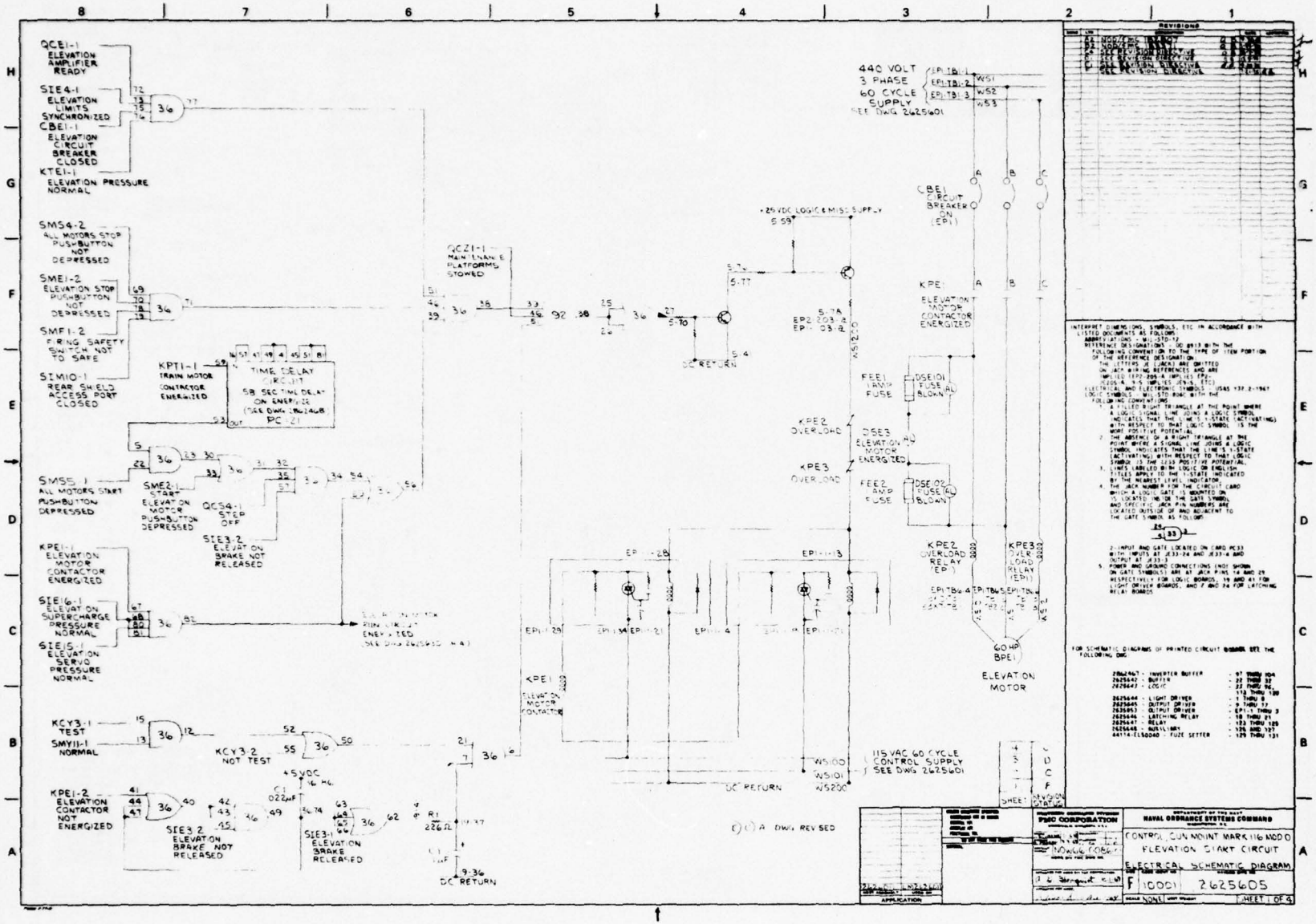


Figure 3-2. Control Panel EP2 (Sheet 3)









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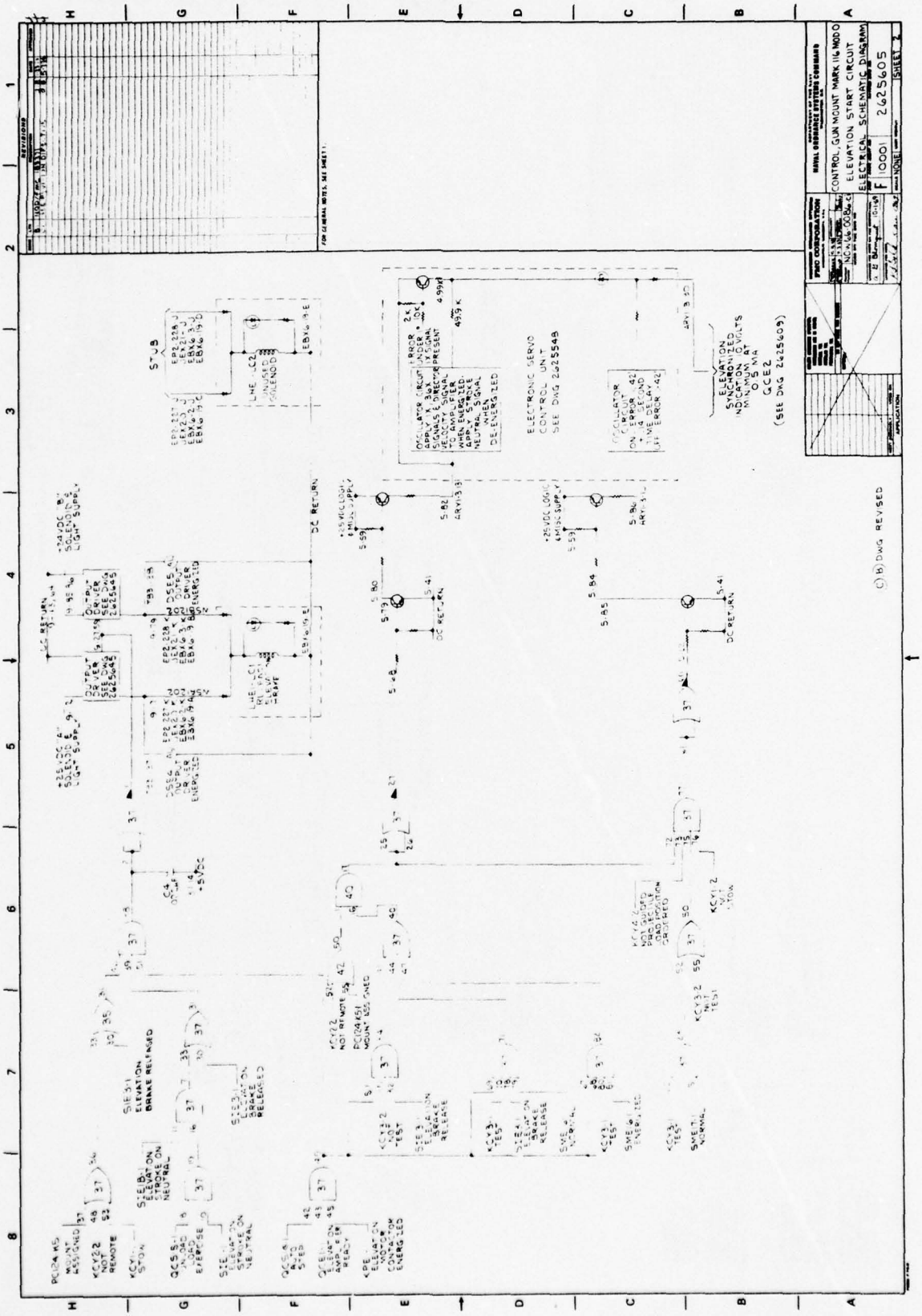

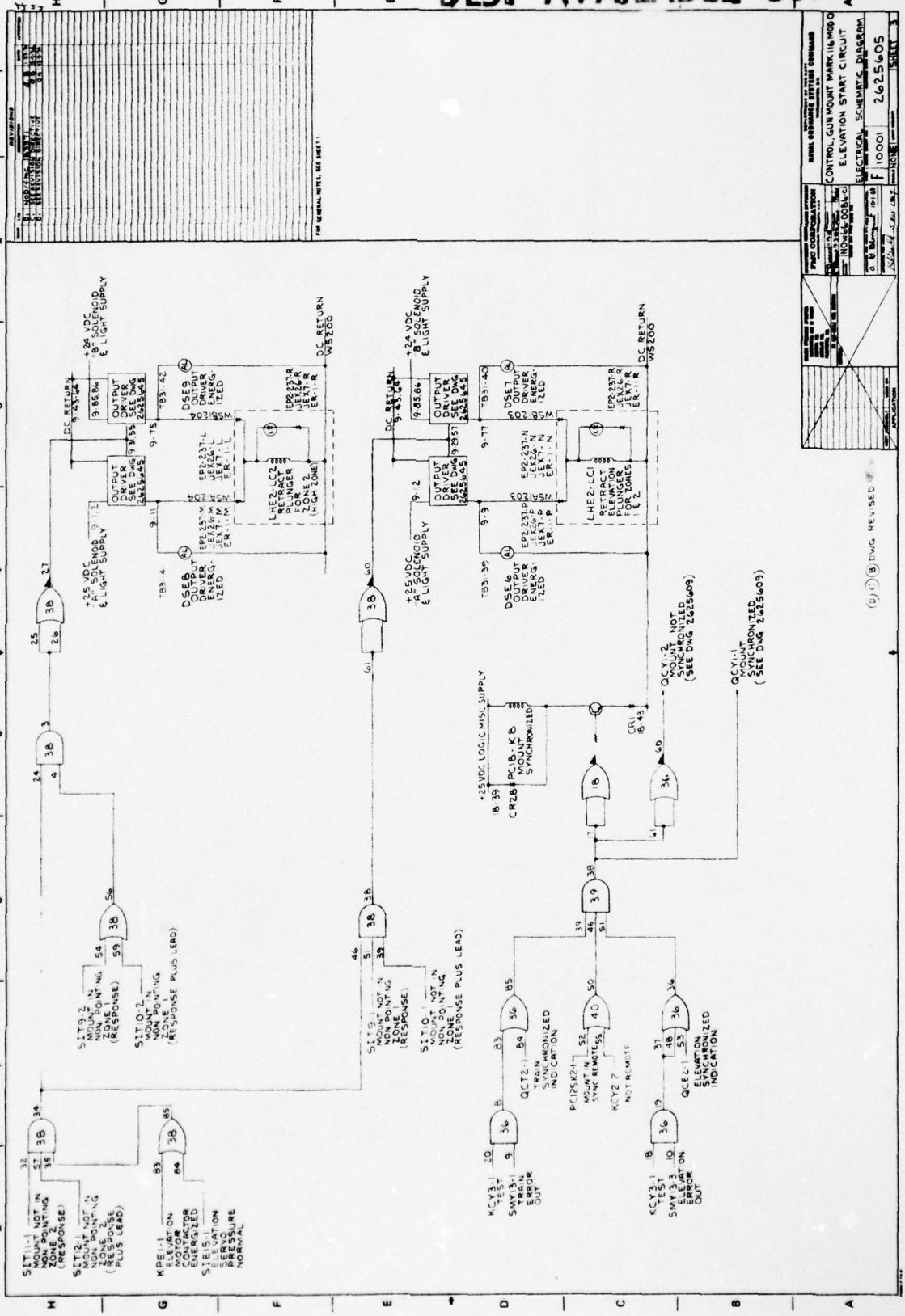

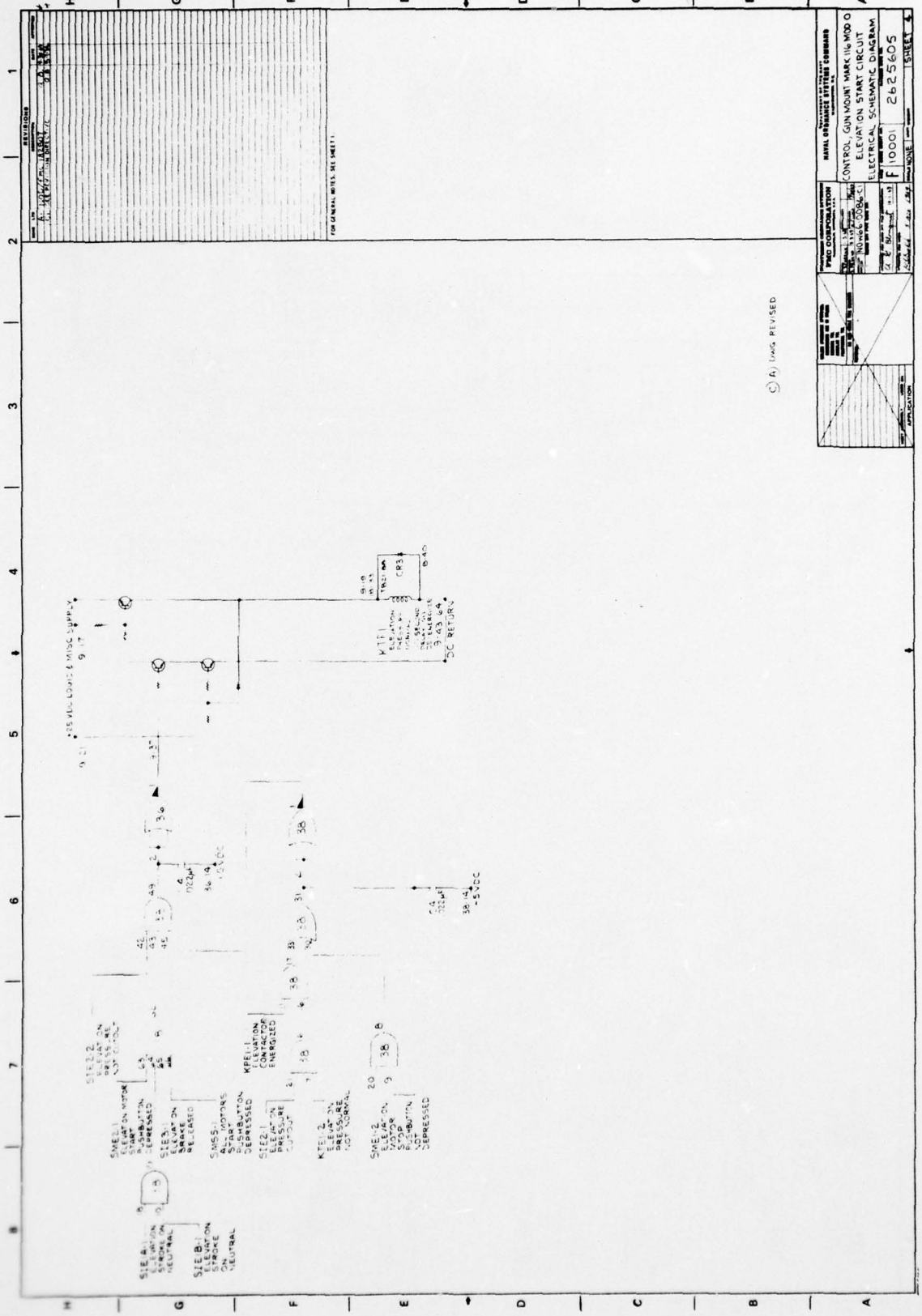

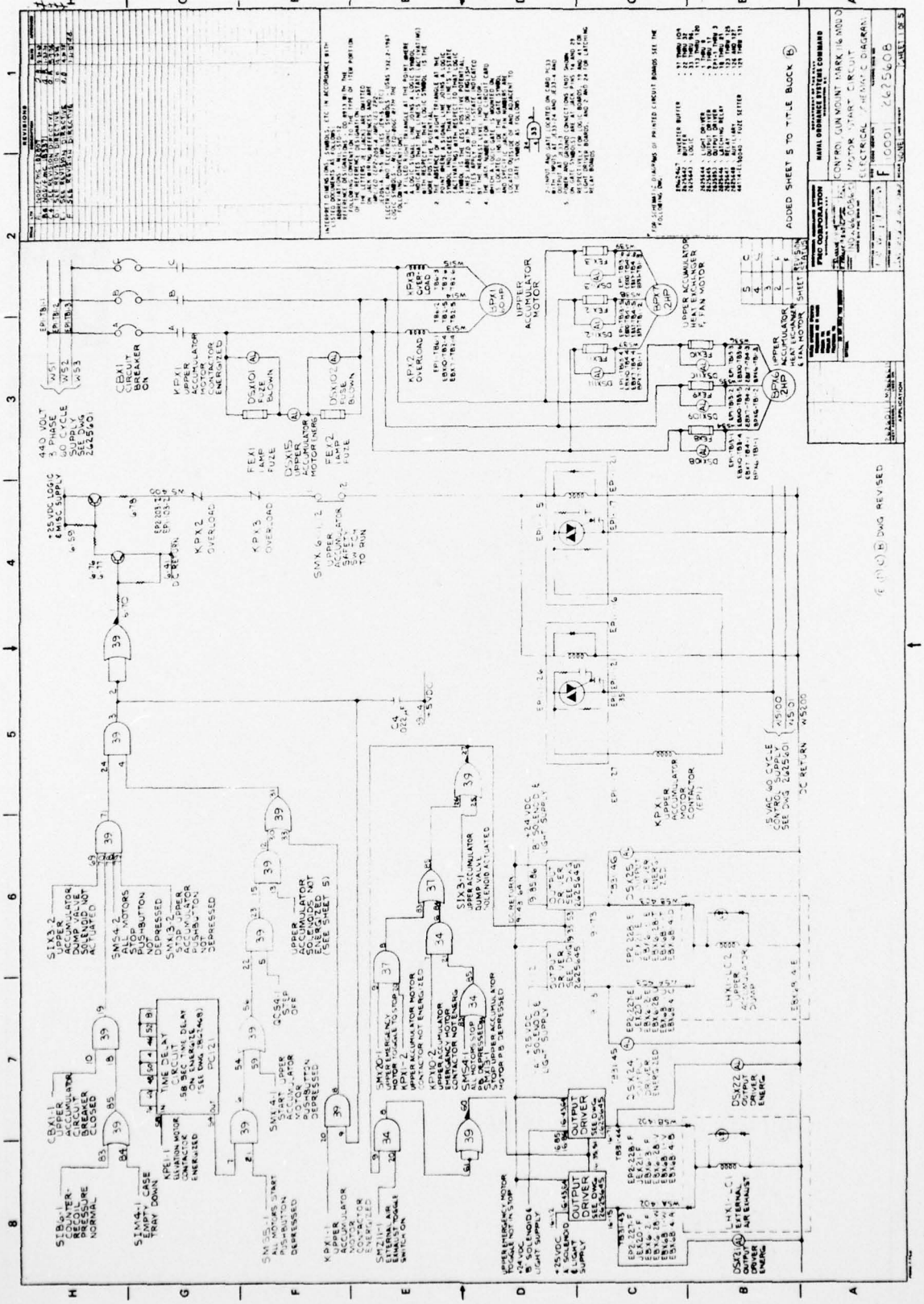

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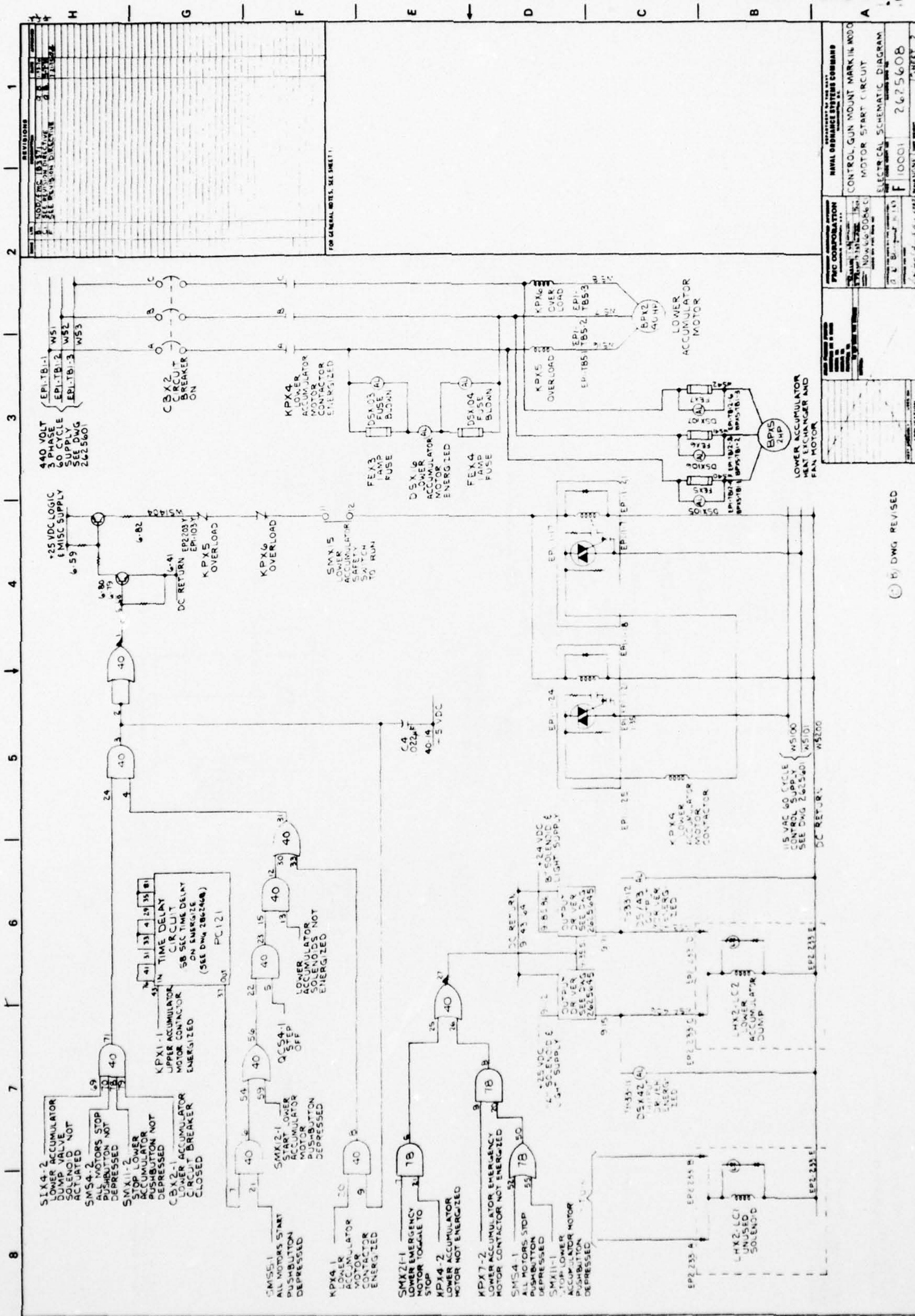

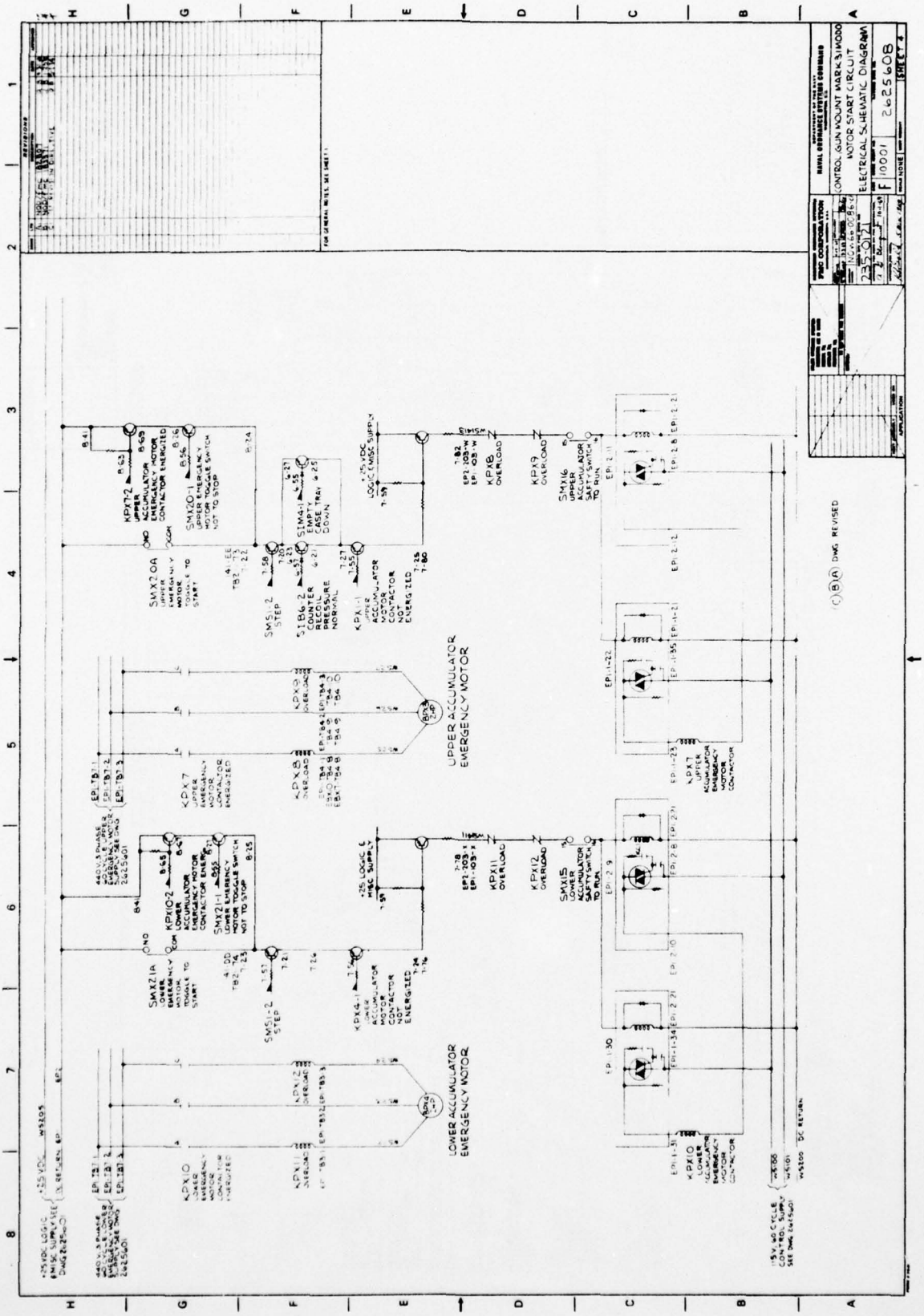

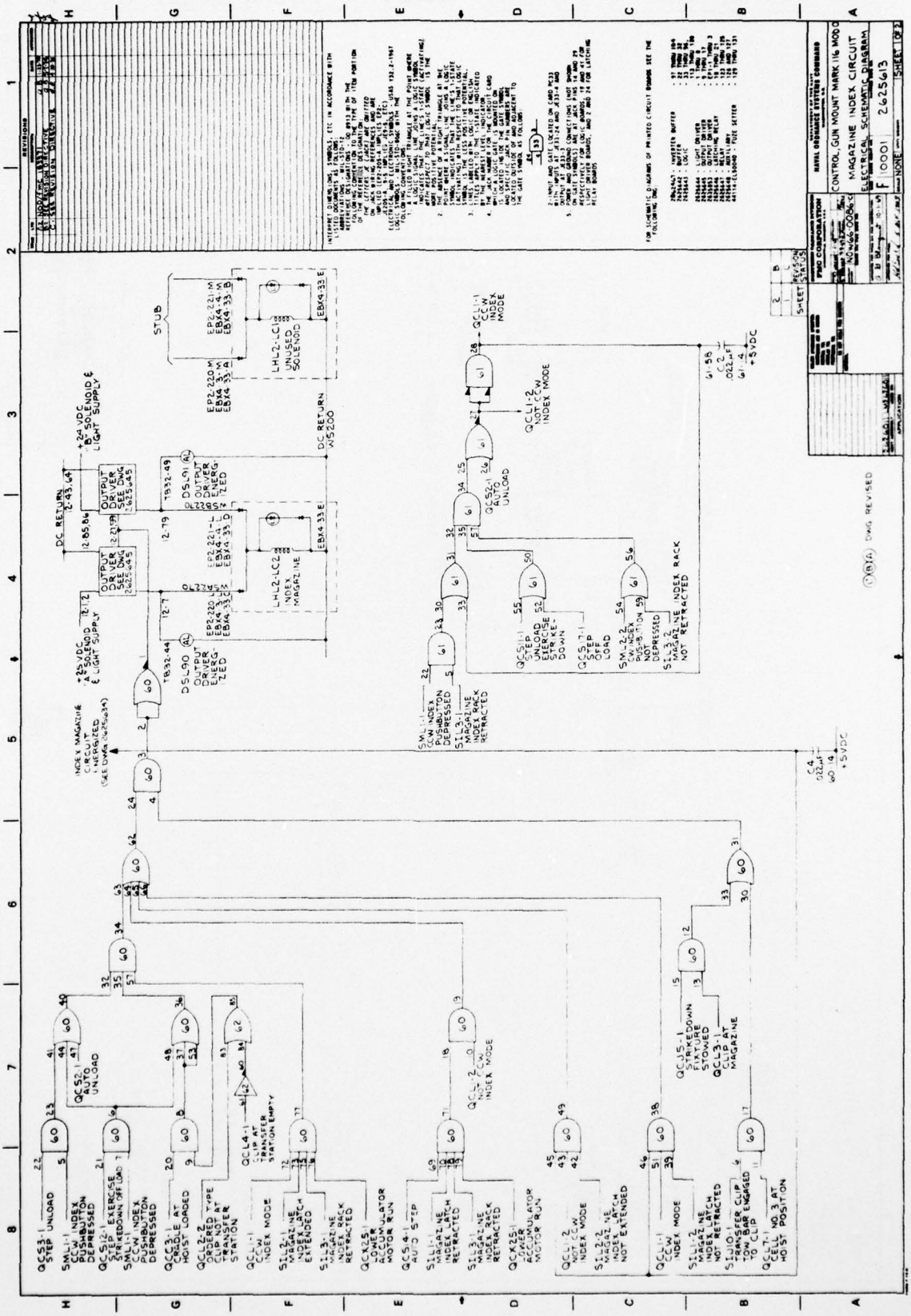

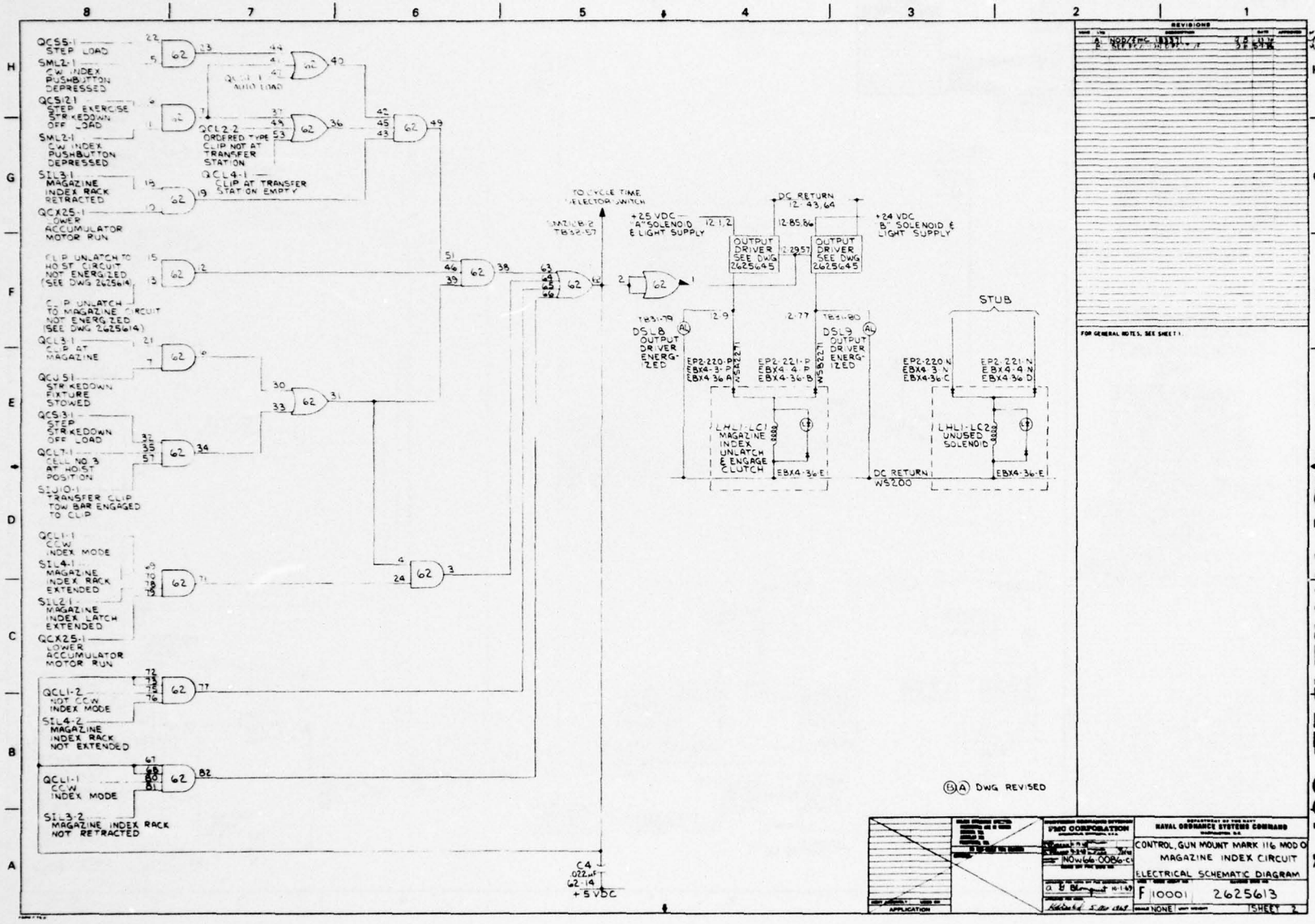

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