



Control Rod Drive Control System

Chapter 6.2
B&W Cross-Training Course
R-326C

OBJECTIVES

1. State the purpose of the control rod drive control system.
2. State the functions of the following:
 - a) Safety rods
 - b) Regulating rods
 - c) Axial power shaping rods
 - d) Group power supply
 - e) Auxiliary power supply

OBJECTIVES

3. Explain how rotating motion of the control rod drive mechanism is achieved.
4. Explain the following terms:
 - a) Latching
 - b) Clamping
5. Explain how individual rod motion is achieved.
6. Describe how power is supplied to the control rod drive mechanism.

Control Rod Drive – Control System

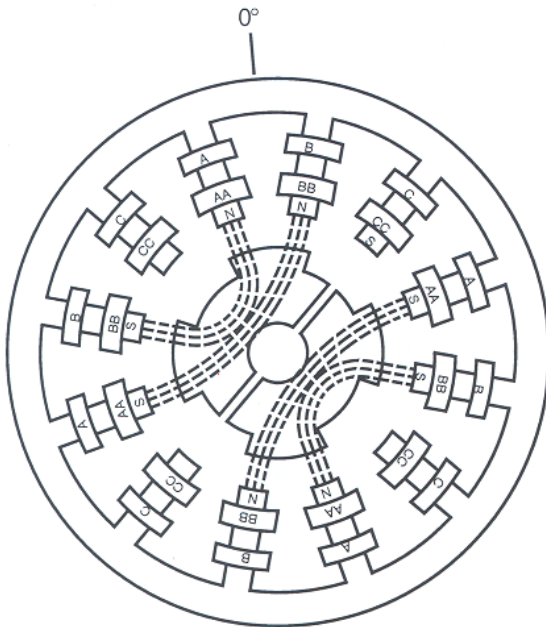
- Provides electrical power & command signals to insert and withdraw control rods.
- Can be manually controlled by operator OR auto control by ICS.
- Interrupts power to CRDM on protection signal allowing CRAs to drop into core.
 - o APSRs do not drop into core on trip.

Three Subsystems

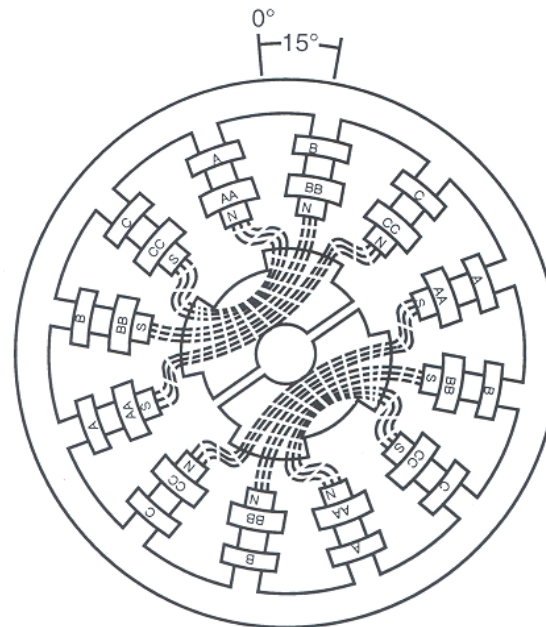
- Drive Mechanism
- Motor Control System
 - Microcomputer or Optical Disk Programmer
- System Logic Equipment.

Drive Mechanism

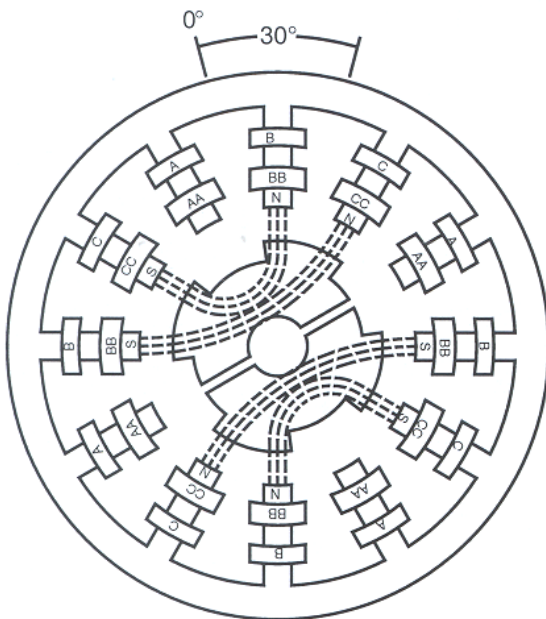
- 4-pole, 6-phase stator windings.
 - o When power is applied, adjacent poles are energized, creating a magnetic field.
 - 100 Vdc (rectified from 120 Vac) controlled by gating SCRs.
 - o Rotation accomplished by sequentially energizing the six phases. (2-3-2-3)
 - Creates shifting (rotating magnetic field).
 - Each shift is 15 deg of rotation.
 - o 2 phases are energized for holding rods stationary.
 - Only 1 phase required.



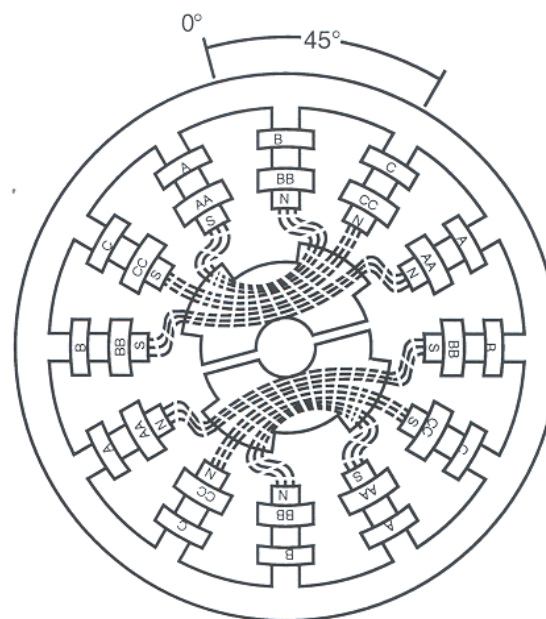
(1) PHASES A AND B ENERGIZED



(2) PHASES A, B, AND C ENERGIZED

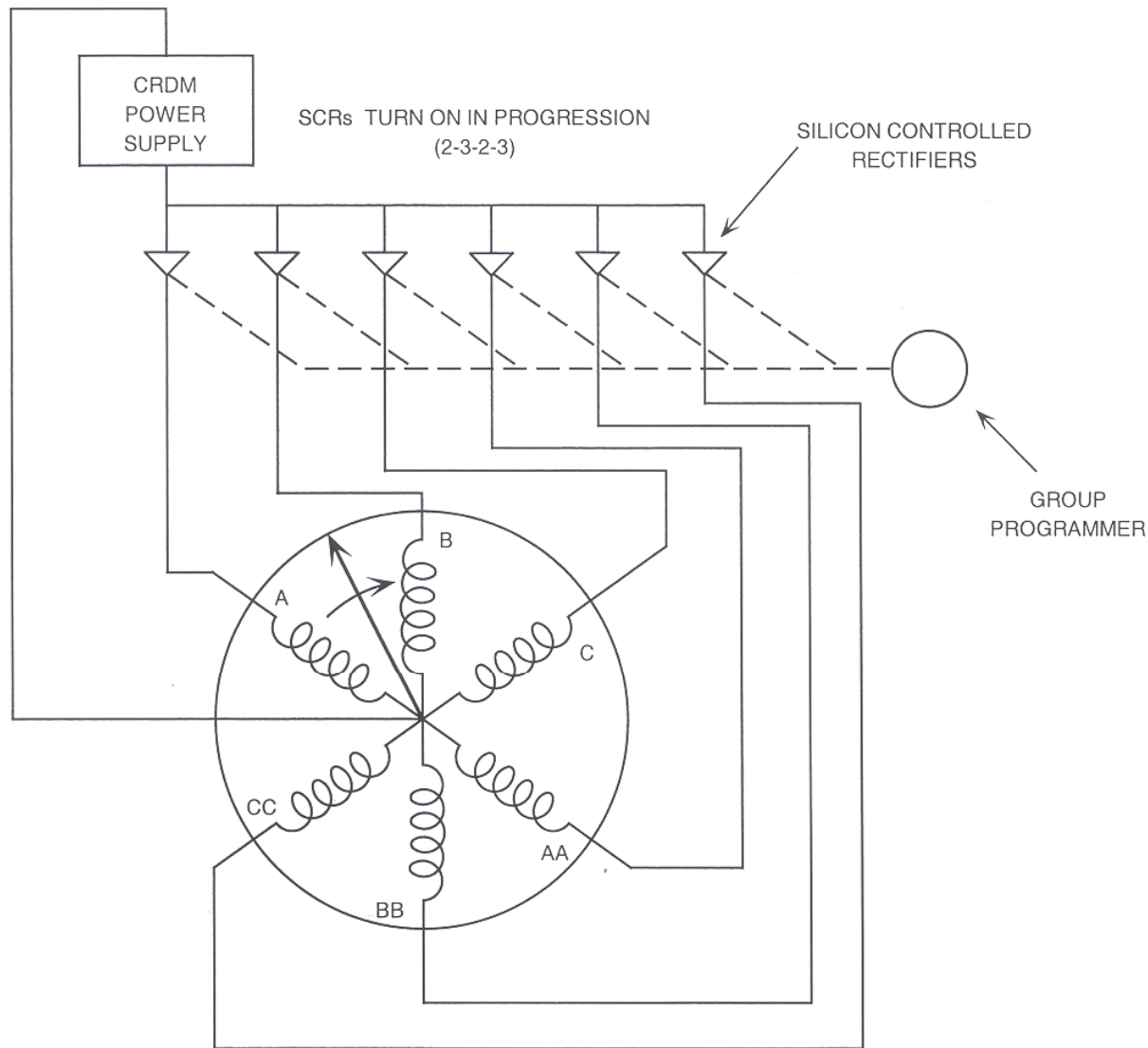


(3) PHASES B AND C ENERGIZED

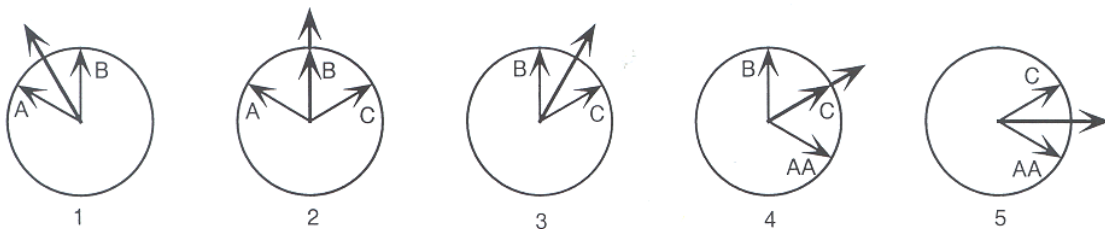


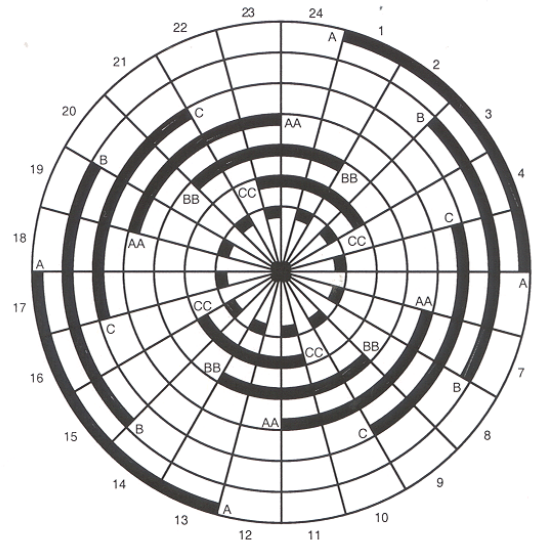
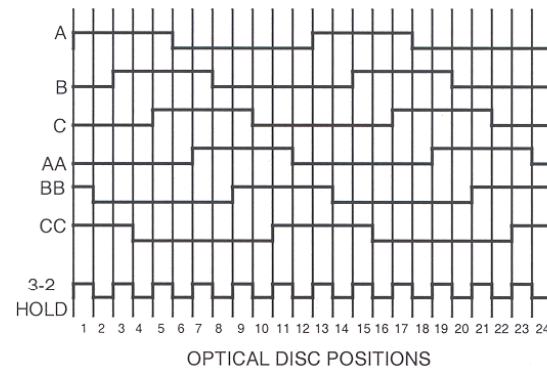
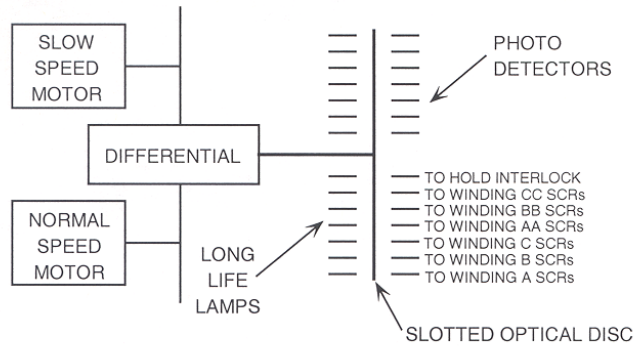
(4) PHASES B, C, AND AA ENERGIZED

Rotating Sequence Fig. 6.2-1



Rotating Magnetic Field
Fig. 6.2-2

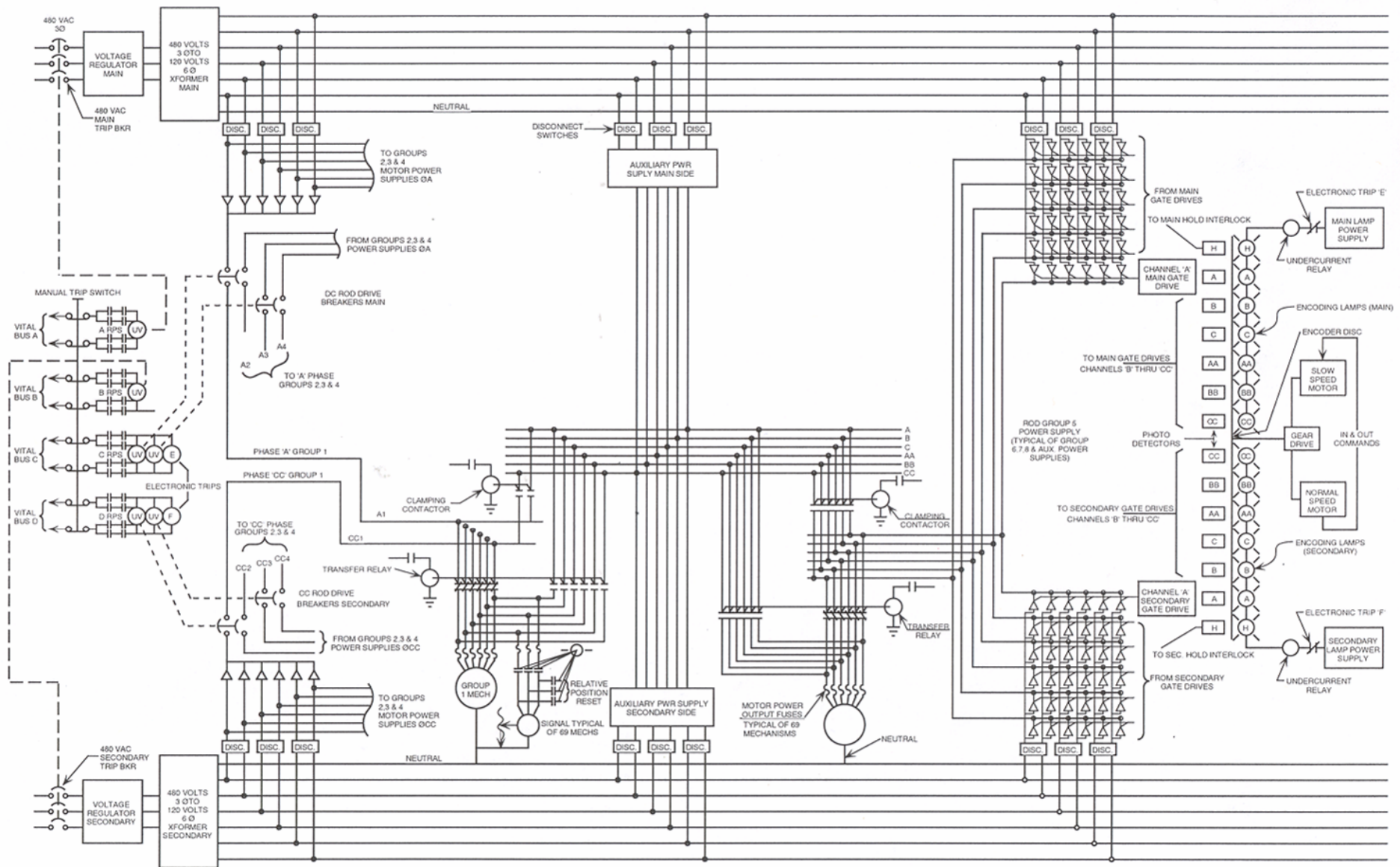




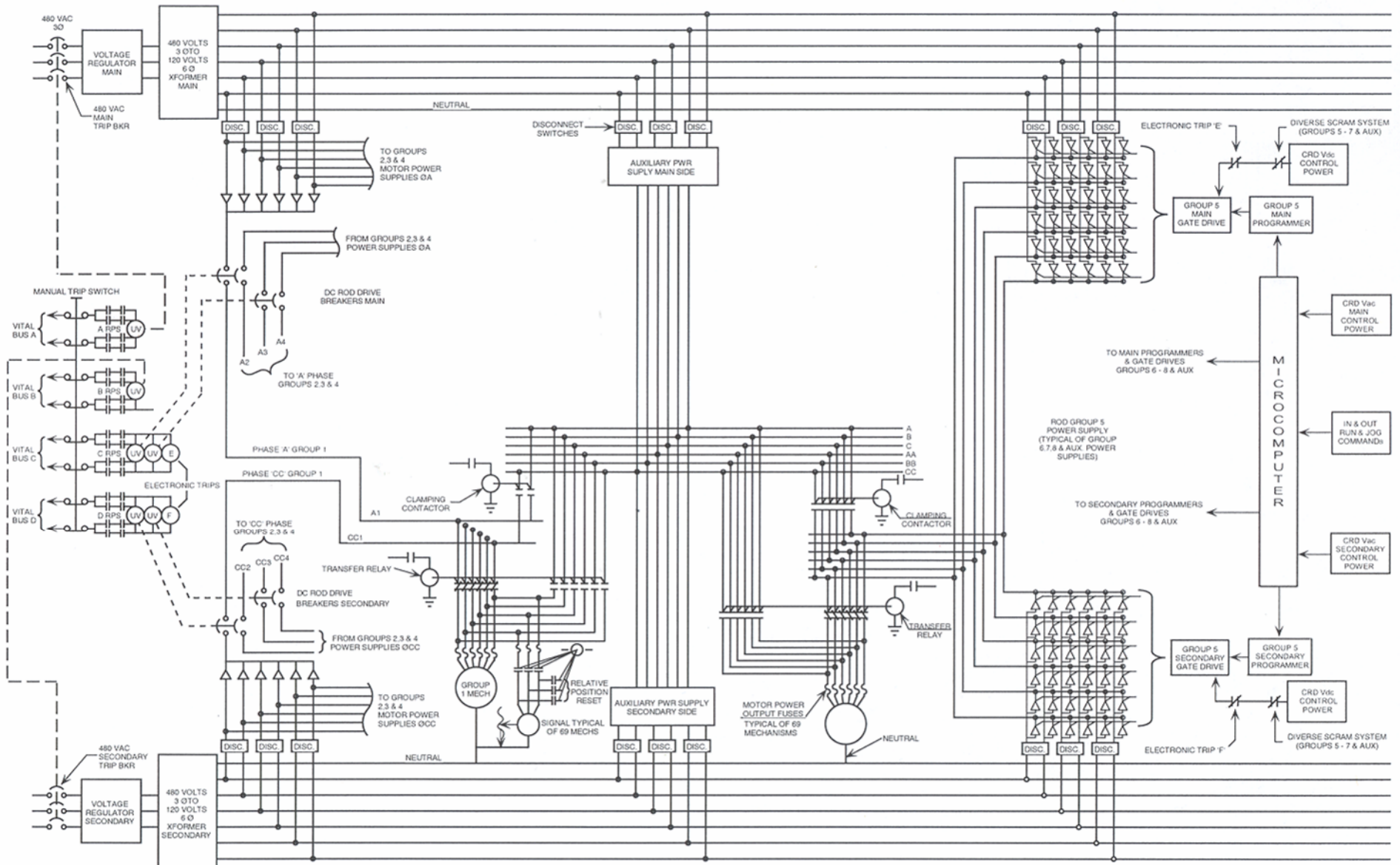
Motor Control
Diagram
Fig. 6.2-3

Motor Control System

- Purpose is to energize the stator windings at proper speed & direction of rotation.
 - Rods operate in auto by ICS or manually.
 - Speeds: 30 inch/min (RUN) or 3 inch/min (JOG).
- Consists of:
 - Programmers
 - ❑ Groups 5 – 8 and Auxiliary power supplies.
 - Control Rod Power Supplies
 - ❑ Groups 5 – 8 and Auxiliary power supplies.
 - Power Distribution



Control Rod Drive Control System (Optical Disc Programmer)
Fig. 6.2-4



Control Rod Drive Control System (Microcomputer Programmer)
 Fig. 6.2-4a

Programmer (1)

- The 2-3-2-3 sequencing of the stator phases is accomplished by:
 - Microcomputer Programmer or
 - Optical Disk Programmer

Programmer (2)

- Accepts input signals (ICS or Manual) and sends commands to group programmers and gate drive circuits.
 - o Groups 5 – 8 and Auxiliary.
 - o Redundant group programmers & gate drive circuits.
 - Main & Secondary
 - o Group programmers & gate drive circuits turn on (gate) the SCRs in the Power supplies.
 - 100 Vdc rectified from 120 Vac.
 - Groups 5 – 8 and Auxiliary power supplies.

Programmer (3)

- CRD Vdc Control Power supplies gating power to SCRs.
 - If control power interrupted, then gating power lost & SCRs “turns off.”
- Hold command w/ 2 phases energized when no operational commands.
 - If mechanism stops w/ 3 phases energized, a “jog in” signal is sent.
 - Stops when only 2 phases are energized.

Control Rod Power Supplies (1)

- Power to control rods from two separate AC power sources through two AC trip breakers:
 - Main (RPS- Channel A) & Secondary (RPS- Channel B).
 - 480 Vac, 3 phase stepped down to 120 Vac, 6 phase.
 - 120 Vac furnishes DC power supplies and Groups 5 – 8 and Auxiliary power supplies.
 - Separate power sources are 100% redundant.
 - Sometimes called redundant power supplies.

Control Rod Power Supplies (2)

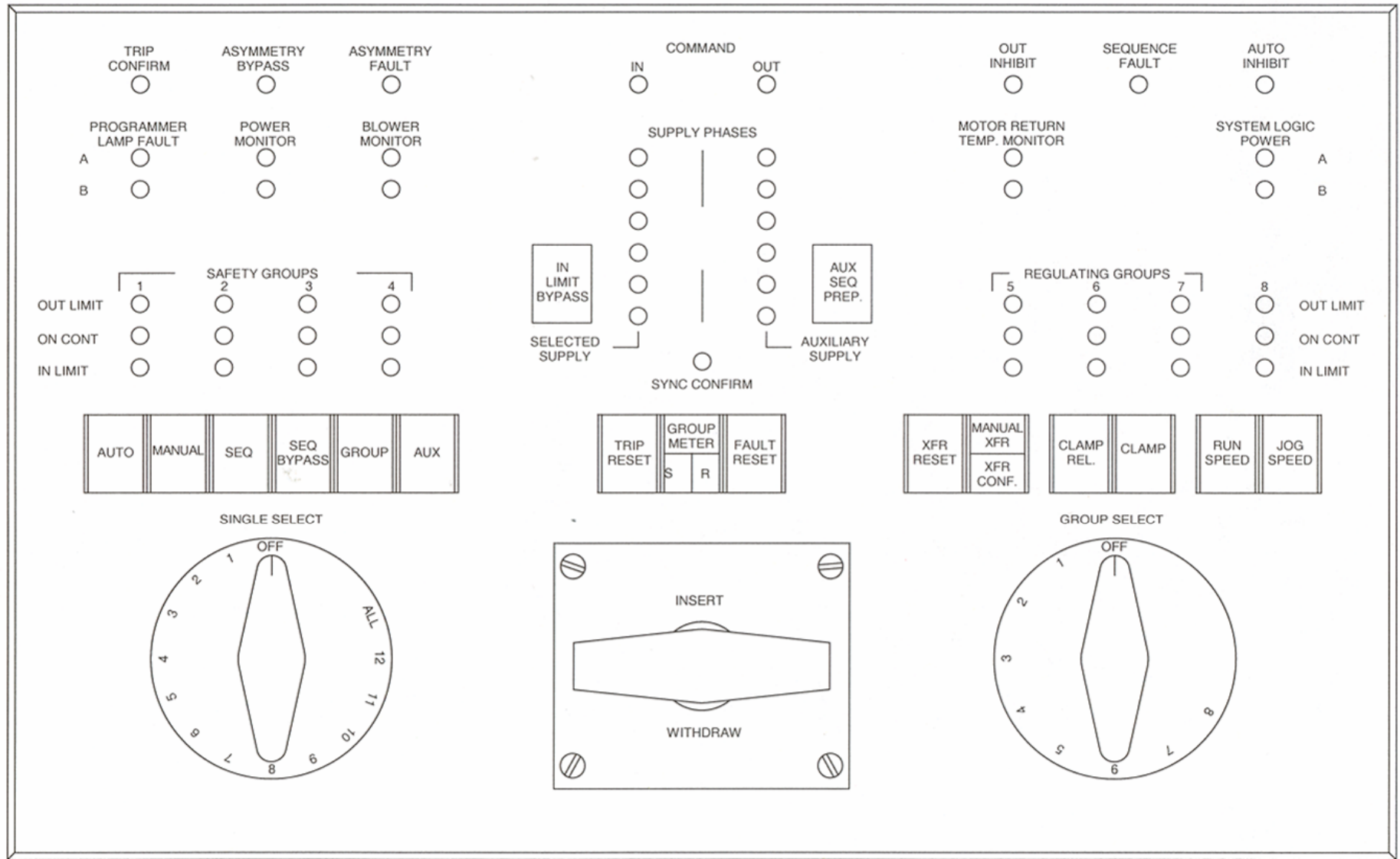
- **Groups 5 – 8 and Auxiliary Power Supplies**
 - Receives 6-phase, 120 Vac from both Main & Secondary sources.
 - Accepts commands from group programmers & gate drive circuits and “gates” SCRs to alternately energize windings to create a rotating field.
- **Auxiliary Power Supplies**
 - Can provide power to any rod or Group.
 - Used to position Safety Groups (1-4) during S/U.

DC Power Supplies

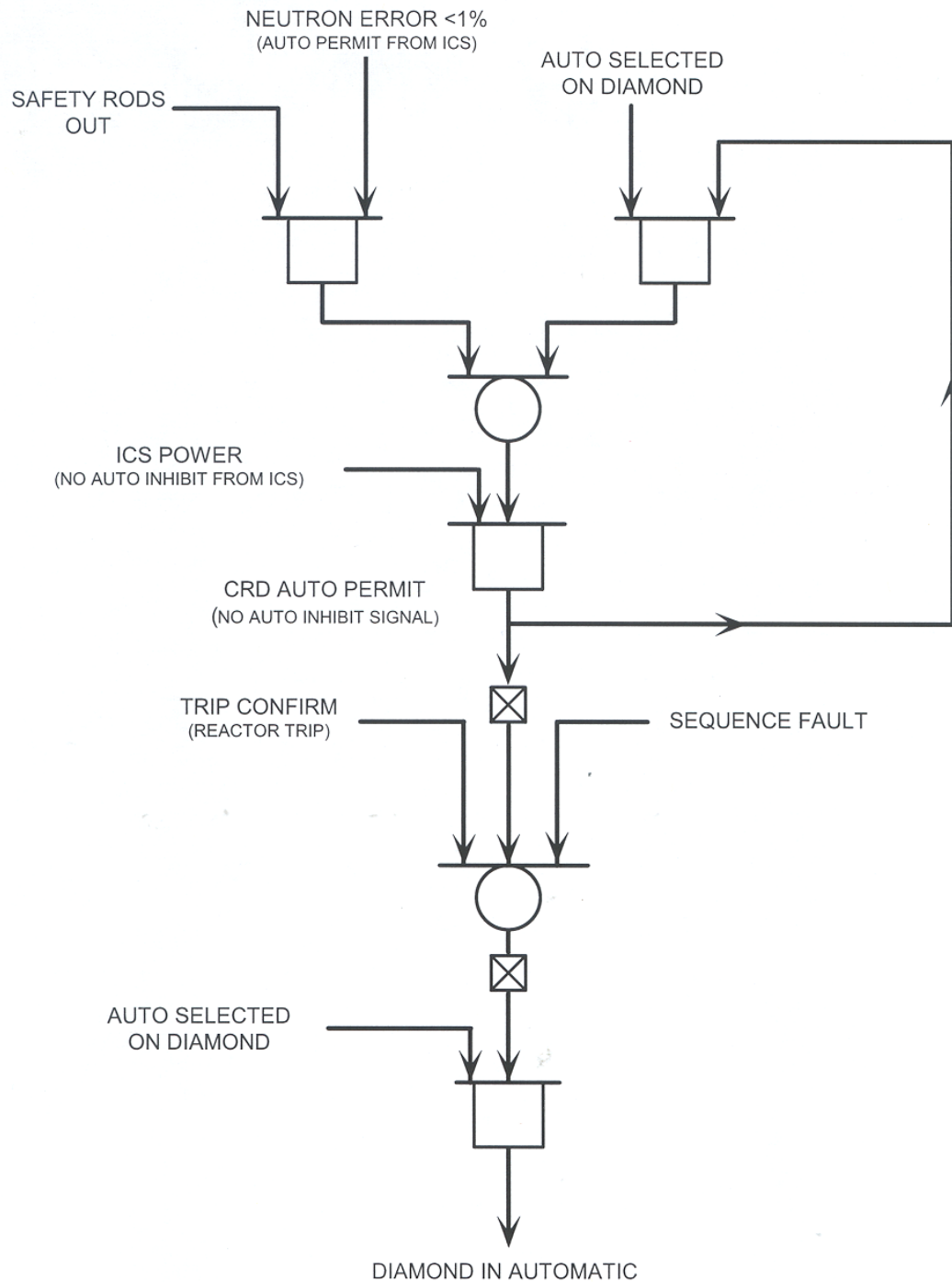
- Main & secondary DC power supplies provide hold power to safety groups (Groups 1 – 4).
 - Main DC power for phase A and Secondary DC power for phase CC.
 - DC power through DC rod drive breakers.
 - ❑ Main (RPS-Channel C) & Secondary (RPS-Channel D)
 - ❑ Electronic trip contactor E (Main CRD Vdc control power) & contactor F (Secondary CRD Vdc control power).

System Logic Equipment

- Consists of circuits which receive manual or auto commands and sends commands to motor control equipment to move rods.
- Performs functions like:
 - o Rod grouping
 - overlap & sequence of regulating rods
 - 25% overlap for regulating rods.
 - o Displaying rod position and limits
 - o Determining if Asymmetric Fault exists.
 - o Operator commands



Diamond Control Station (Fig. 6.2-5)



Control Rod
Drive Auto Logic
Fig. 6.2-6

Rx Trip (1)

- Two AC trip breakers:
 - Main (RPS- Channel A) & Secondary (RPS-Channel B).
- Two DC rod drive breakers.
 - Main (RPS-Channel C) & Secondary (RPS-Channel D)
 - ❑ Electronic trip contactor E (Main CRD Vdc control power) controlled by RPS-C.
 - ❑ Electronic trip contactor F (Secondary CRD Vdc control power) controlled by RPC-D.
 - ❑ Diverse Scram System (DSS) will interrupt CRD Vdc control power to Groups 5-7 and Auxiliary power supplies.

Rx Trip (2)

- Trip requires opening one breaker (AC trip or DC rod drive breaker w/ associated electronic trip contactor) in each power supply (main and secondary).
 - Logic called 1-out-of-2 used twice.
- Examples:
 - Only main AC trip breaker open.
 - Only secondary DC rod drive breaker w/ contactor F.
 - Main & secondary DC breakers open w/o electronic contactors opening.

Diamond Control Panel

- Used to manually position individual rods or groups of rods.
- Select auto or manual control.
- Clamp, latch, synchronize or manually transfer rods/groups.
- Provides indication of control rod operational status

Auto Rod Control (1)

- Auto Control must meet necessary conditions & permits and no inhibit signals present.
 - All four Safety Groups fully withdrawn.
 - Out Limit lights are on (Diamond).
 - Neutron error signal from ICS $< 1\%$
 - This is the Auto Permit from ICS.
 - ICS power available.
 - No auto inhibit from ICS.
 - CRD Auto Permit
 - No auto inhibit signal.
 - Auto inhibit light is off (Diamond).
 - Auto P/B selected on Diamond.

Auto Rod Control (2)

- Auto Control prevented by:
 - o Auto inhibit signal from CRD auto permit.
 - Auto inhibit light is on (Diamond).
 - o Reactor trip (trip confirm signal)
 - o Sequence Fault:
 - Regulating rods have $> 25\%$ overlap.
 - o Manual P/B selected on Diamond.