

6.0 INTRODUCTION TO GE MAGNE-BLAST CIRCUIT BREAKERS

The Magne-Blast breaker is one of the most common breakers in Power Generation Stations throughout the country, regardless of fuel type, and is also used by large Commercial consumers.

Learning Objectives

Provide students with a basic understanding of the GE Magne-Blast and its purpose, operation and construction.

As a result of this lesson you will be able to understand:

1. The basic function of the Magne-Blast circuit breaker
2. How the Magne-Blast breakers are classed or grouped
3. How the breaker frame size method further identifies the breaker
4. The component attributes of the Magne-Blast breaker:
 - a. Mounting Arrangement
 - b. Primary Contacts and Arc Chutes
 - c. Electrical Devices including wiring
 - d. Mechanical and Safety Interlocks
 - e. Operating Mechanism
5. Basic understanding of common failure modes of Magne-Blast Breakers
6. Basic understanding of maintenance scheduling
7. Basic understanding of subcomponent replacement
8. Basic understanding of design upgrades for the Magne-Blast breakers
9. Proper lubrication type for Magne-Blast breakers
10. Basic understanding of routine maintenance using the Preventative Maintenance Manual for the Magne-Blast Circuit Breaker

6.1 WHAT IS A MAGNE-BLAST CIRCUIT BREAKER?

The Magne-Blast breaker is a removable and interchangeable device used to provide reliable control for electrical systems.

The Magne-Blast breaker was produced in several styles over the years, which include Vertical and Horizontal “Draw out” designs. Early in production, the breaker was an “ACB” (Air Circuit breaker) with a Solenoid operated mechanism. This design evolved into an “ACB” (Air Circuit breaker) with a Spring Charged operating mechanism.

The breakers are classed by Voltage class, Ampere size and Interrupting capacity. Its main purpose is to start or stop an electrical circuit when desired and to automatically stop the current flow when the current exceeds a predetermined value without causing damage to the load circuit or the circuit breaker.

6.2 HOW MAGNE-BLAST CIRCUIT BREAKERS ARE CLASSSED

The Magne-Blast breaker is available in many similar designs. The best way to identify a Magne-Blast Breaker is to read the nameplate. For example:

AM-4.16- 250, 1200 Amp

AM- Air Magnetic

4.160- Voltage Class

250-Interrupting Capacity (MVA)

1200 Amp- Maximum continuous amperage

6.2.1 Voltage Class: Magne-Blast Circuit breakers are grouped by voltage class that is normally defined as **MEDIUM**.

- Medium Voltage (5KV to 15KV): this includes 4.160 KV, 4.76 KV, 5 KV, 7.2 KV, 13.8 KV and 15KV models.

6.2.2 Ampere Size: Magne-Blast Circuit Breakers are grouped by “Frame Size” or “Ampere Size”. This is determined by the Load circuit the breaker controls under normal use. The 5 KV and 15KV breakers will commonly be 1200 Amp, 2000 Amp or up to 3000 Amp.

6.2.3 Interrupting Capacity: Magne-Blast Breakers are also grouped by its Maximum Interrupting capacity or MVA. 100MVA, 250MVA, 500 MVA, 750MVA, and 1000MVA. These capacities are found in both the 5KV and 15 KV design.

6.3 MAJOR COMPONENT ATTRIBUTES FOR THE MAGNE-BLAST BREAKER

Despite all the variety of the Magne-Blast breaker there are only two principal components, the operating mechanism and the breaker element or chassis. The chassis contains the primary contact assembly and bushings, interlocks and ground strap. In almost every case, the Magne-Blast Circuit breaker is a "Draw Out" type breaker. This means that the breaker is RACKED IN to its cubicle either Vertically or Horizontally by means of racking handle or lifting motor.

The types of operating mechanisms are as varied as the available designs. As the operating mechanism design changed GE changed the operating mechanism designation to differentiate between the mechanisms.

6.3.1 The primary contact assembly is the main current carrying part of the breaker. The assembly consists of all the barriers, arc chutes and puffer system. The six Primary bushings are mounted on top of the breaker chassis, behind the operating mechanism and include three LOAD and three LINE side bushings.

- Stationary Arcing Contacts (Figure 6-1)- Designed to take the arc when the breaker opens under load. Typically made of a Silver Tungsten or similar material. Arcing contacts always "MAKE" first and "BREAK" last. The Arcing contact is a "Jaw" type contact meaning that the movable portion slides into its stationary counterpart. The contacts are mounted on a single assembly with the main contacts on opposite sides of each other.
- Stationary Main Contacts (Figure 6-2) - Designed to carry the Primary load current. Usually made of Silver Cadmium Oxide. Main contacts "MAKE" last and "BREAK" first. The Main contacts are a "BUTT" type contact meaning that the main contacts make flat against each other when the breaker is CLOSED. They mount just in front of the Arcing contacts on a single assembly. The buffer blocks mount just below the main contacts on the assembly.
- Moving Contact Assembly- Consisting of Main contacts, Arcing contacts, Operating Rod and the Puffer Tube. The Moving Contact Assembly connects the "LINE" and "LOAD" bushings when the breaker is "CLOSED". The Moving contacts have mating sets of contacts called the stationary Arcing and Main contacts. The puffer tube is also connected to the Moving contacts as well as the Operating Rod that connects the Moving contact to the Operating Mechanism via a set levers and the jack bar.

- Arc chutes- Consists of Blow Out coils, Arc Runners, ceramic, and asbestos insulators. The Arc chute breaks up the Arc when the breaker OPENS under load by dividing the Arc into segments aided by a puff of air.
- Insulating barriers and cover- The Barriers isolate all the conductive parts of the breaker from each other and the breaker frame.

6.3.2 The Common Electrical Devices on the Magne-Blast Breakers consist of:

- Release Latch Monitoring Switch (Figure 6-3)- This switch if OPEN will not allow the breaker to CHARGE electrically. Ensures Close Latch is in the RESET position when CLOSED. Mounted under the operating mechanism, it is actuated by the close paddle connected to the close latch.
- Motor and Relay Switches (Figure 6-4) - usually consisting of three switches (2 N/O and 1 N/C) stacked together. They shut the Charging Motor off when the Closing Springs are fully CHARGED and provides a permissive path to the Spring Release Coil to CLOSE the breaker. Mounted on the left side of the operating mechanism the switches are actuated by the Timing cam connected to the crankshaft.
- Interlock Switches (Figure 6-5)- Provides remote indication that the breaker is RACKED IN. This switch if OPEN will not allow the breaker to CHARGE or CLOSE electrically. Mounted on the upper left side of the operating mechanism just behind the auxiliary switch. These switches are actuated by the positive interlock.
- Auxiliary Switch (Figure 6-5)- Provides remote indication of breaker status and a path to the Shunt Trip Coil, allowing the breaker to OPEN electrically. Can have up to 5 N/O and 5 N/C contacts in a single housing. The switch consists of both "A" and "B" contacts. "A" contacts are OPEN when breaker is OPEN and CLOSED when the breaker is CLOSED. "B" contacts do the opposite of "A" contacts. Mounted on the left side front of the operating mechanism they are actuated by a linkage connected to the jack bar and the OPEN/CLOSE indicator flag.
- Close Coil and Trip Coil- The close coil closes the breaker (Figure 6-6). The Trip coil opens the breaker (Figure 6-7). The Close and Trip coils

are usually the same physically but may be different electrically. The close coil mounts under the operating mechanism on the left side and operates a plunger to release the close latch.

The trip coil mounts inside the mechanism on the right side. It is connected to the tripper bar via the trip crank.

- Control Relay- The Control Relay, when energized, holds the closing circuit OPEN, until the springs are fully charged. It mounts under the operating mechanism on the left side on its own flexible shock plate (Can be seen in Figure 6-8).
- Charging Motor- The Charging motor charges the closing spring(s). Mounted below the operating mechanism on the front left side it is connected to a drive fitting and levers to the ratchet wheel (Can be seen in Figure 6-3).
- Secondary Disconnect Figure 6-9) - Provides the electrical interface between the cubicle and the breaker when the breaker is RACKED IN or OUT and all remote indications of breaker status. The secondary consists of 16 male plugs in a single housing. Mounts on the upper left side of the operating mechanism and mates with a female receptacle in the cubicle.
- There are many other options that are available for the Magne-Blast breakers such as additional Trip coils and switches.

6.3.3 Mechanical and Safety Interlocks

- Positive Interlock (Figure 6-10)- Provided between the breaker and the cubicle while the breaker is being raised or lowered in the CLOSED position. The breaker must be OPEN to raise or lower itself in the cubicle. The breaker will not operate until it is in the fully IN or OUT position. Mounted on the right side front of the chassis it has a rod that runs horizontally to the inside of the operating mechanism. Inside the mechanism it connects to blocking levers that mechanically keep the prop pin from propping on the latch while the breaker is in transition.
- Spring Discharge Interlock (Figure 6-11) - Discharges the Closing springs if they are charged when the breaker is rolled IN or OUT of the cubicle. Mounted on the left front side of the chassis the interlock lifts the tripper

bar and then the close latch mechanically, discharging the springs if required.

6.3.4 Operating Mechanism for the Magne-Blast Breaker

The Operating Mechanism is the workhorse of the Magne-Blast breaker. The mechanism contains all the mechanical latches, toggle assemblies, cams, rollers, levers and linkages required to OPEN and CLOSE the breaker. It is connected to the main contacts via 3 insulated linkages called the Operating Rods.

- There are several different styles of Operating Mechanisms for the Magne-Blast breakers.
 - The Solenoid mechanism was offered in several models: MS-9, MS-10 and MS-13. The “S” designates a solenoid-operated mechanism.
 - The Stored Energy mechanism: ML-11, ML-12 and ML-13. The “L” designated stored energy mechanism.

6.4 COMMON FAILURE MODES FOR THE MAGNE-BLAST BREAKER

Since all the major components of the 5KV and 15KV Magne-Blast Circuit breakers are so similar the common failure modes would be as well. Historically, there have been many issues with the Magne-Blast breaker in the nuclear industry.

6.4.1 NRC bulletins and Information Notices

There have been several NRC bulletins and Information Notices issued for this breaker model since the mid 1980's.

- IN # 84-29- Issued by the NRC to address the issue of the Teflon coated fiberglass bushings that were originally installed on the Magne-Blast breaker Operating Mechanism. The Teflon coated bushings would wear out quickly causing key adjustments to be out of specification. With enough wear the breaker would fail to CLOSE when desired. This notice led to the OEM (GE), to issue a SAL (Service Advisory Letter) for this problem. The SAL recommended changing the Teflon coated bushings with an Aluminum Bronze bushing.

- IN # 96-43- Issued by the NRC to address the hardened grease in the Operating Mechanism roller bearings. The notice also included a “Failure to Close” due to a weakened prop return spring.

The notice explained that the licensee did not follow the OEM recommendation for lubrication of the Operating Mechanism after 2 years instead the breaker wasn’t serviced for 6.5 years. The “Failure to Close” was related to a weak Prop return spring. This notice lead to another GE issued SAL to add an additional Prop Spring to the Prop Latch.

- Part 21 2000-04-0- Issued due to the failure of a Normally Closed switch used in the breaker Charging circuit, preventing the breaker from closing on demand. After this notice some plants reconfigured the charge circuit and eliminated the Normally Closed switch from the breaker. The OEM also has designed an alternate switch design to resolve this problem.
- Part 21 1995-01-9- Issued to address the broken Trip Crank arm. The breaker failed to OPEN when a Trip signal was sent to the breaker.

Since the breaker did not OPEN the Trip coil remained energized until the coil itself burned up. The reason for the failure was a bad weld on the Trip Crank arm that connects the Trip coil plunger to the Tripper bar. Due to this notice the licensee changed their maintenance procedure to inspect this critical part at every PM cycle. The OEM also improved the design to prevent this failure mode.

- IN # 90-41- Issued by the NRC to address a broken Prop return spring in the Operating Mechanism and a “Failure to Open” due to a Snap ring retainer coming off the pivot pin. The broken Prop return spring was examined and was found to have cracks at the “Hook” part of the spring. The OEM improved its production process and resolved the issue with the springs. The “Failure to Open” was determined to be due to a Snap ring that had fallen off the pivot pin. The breaker that failed had just been returned back to the licensee from the GE service shop after an overhaul. The GE shop then changed its procedure to include inspection of this vital area.
- Part 21 1996-77-0- Issued to address the bent Manual Trip handles for a Horizontal Magne-Blast breaker. While in service the breaker “Failed to Close” when the breaker was sent a close signal. Investigation revealed that the Trip paddle was bent in such a way that there was no gap between the Trip paddle and the Trip Latch. This kept the breaker in a mechanical “Trip Free” condition. The OEM has since changed the

operational configuration included a stronger paddle.

- Part 21 1999-24-3- Issued to address the “Failure to Close” due to the Tripper bar cotter key hitting a Latch Check switch mounting bracket.

Due to the close proximity of the Tripper Bar cotter key and the Latch Check Switch, it is essential that the cotter key be properly installed. To resolve this problem the licensee removed the switch, switch mounting bracket and the switch actuator lever on the tripper bar from all the breakers in service.

- IN # 94-54- Issued by the NRC to address the issue of a breaker “Failure to Close” during receipt inspection at the licensee facility from the OEM repair shop. The root cause of the failure was similar to the problem addressed by IN # 96-43. The addition of a second Prop spring resolved this problem.
- Part 21 1996-57-0- Issued to address cracks and flat spots on the Prop Latch. Upon receipt inspection the licensee found that the Prop Latch on two breakers was found to be cracked or chipped where the Prop Pin sits when the breaker is latched closed. The breaker did not fail to operate but with more damage to the Prop Latch surface, the potential to fail is very high.

The subject breakers were returned to the service company to replace the damaged latches.

6.4.2 Other breaker material issues.

- One of the most common failures for the Magne-Blast breakers is the control switches (Latch check, power bank switches, auxiliary switches, etc.). When using a Digital Multimeter, most switches on the Magne-Blast will read a high resistance (>1 Ohm). If the switches are retested with an Analog Meter (Simpson 260 or similar) it is likely they will read a lower resistance (<1 Ohm). The switches are a sealed type switch and cleaning the contacts directly is impossible. It is easier to replace the switches.
- The Primary Bushings and the Arc Chutes are problem areas. Due to there construction, they tend to absorb moisture especially in harsh environments.

6.5 MAINTENANCE SCHEDULING FOR THE MAGNE-BLAST BREAKER

Regular Maintenance is the key to reliability for the 5KV and 15KV Magne-Blast Circuit breakers and all other breaker types. All Nuclear Power plants have an Approved Maintenance Procedure for their circuit breakers. These procedures are usually based on the OEM Technical Manual. Plant PM Procedures are living documents and will change to include additional steps as the plant personnel find additional concerns while performing the PM. It would also include updates from SAL's. In most cases the OEM will recommend how often the PM cycle should be but environment plays a major role in determining the PM frequency, as does the number of breaker operations. The original tech manual maintenance for the Magne-Blast breaker from the OEM was as follows:

500 operations or six months-

- Remove covers
- Wipe down insulators
- Clean off the Arc Chutes

2,000 operations or six months-

- Remove covers
- Wipe down insulators
- Clean off the Arc Chutes
- Inspect Main Contacts
- Inspect Arcing Contacts
- Check Operating Mechanism Adjustments
- Inspect for loose or broken parts
- Check all switches

10,000 operations or six months-

- Remove covers
- Wipe down insulators
- Clean off the Arc Chutes
- Inspect Main Contacts
- Inspect Arcing Contacts
- Check Operating Mechanism Adjustments
- Inspect for loose or broken parts
- Check all switches
- Inspect Arc chutes for Arc burn
- Clean and inspect the Moving Contact pivot connection (Disassembly required)

20,000 operations or Five (5) years-

- Remove covers
- Wipe down insulators
- Clean off the Arc Chutes
- Inspect Main Contacts
- Inspect Arcing Contacts
- Check Operating Mechanism Adjustments
- Inspect for loose or broken parts
- Check all switches
- Inspect Arc chutes for Arc burn
- Clean and inspect the Moving Contact pivot connection (Disassembly required)
- Replace all worn parts
- Disassemble the Operating mechanism and re-lubricate all components, replace bad bushings as needed
- Disassemble the Stationary and Moving Contacts and re-lubricate all components, replace worn contacts as needed

The most of recommend checks are still applicable but the EPRI-GE breaker user groups and OEM's have reevaluated the periods between checks and there have been several recommended upgrades recommended by the GE to improve the breakers operation.

6.6 SUBCOMPONENT REPLACEMENT FOR THE MAGNE-BLAST BREAKER

During the PM cycle it is possible that some parts on the breaker will be found to be broken, bent, burnt, cracked or worn out. Replacement parts for most Magne-Blast breakers are readily available and are well supported by the OEM. Since there are so many variations to accessories for this breaker type it is important to reference the nameplate data and Operating Mechanism type to get the correct parts. If purchasing parts on the surplus market, be sure to specify whether the parts needed are "NEW" or "RECONDITIONED".

When the damaged parts are identified and corrective action is approved the task of installing the parts remains. Some OEM Technical Manuals are quite detailed providing step-by-step instructions on exactly how to replace the defective part. Unfortunately this is not always the case. The Magne –Blast breaker has instructions on replacing everything from the Arc Chutes, Contacts, front and rear Primary Bushings, all switches and the motor. Parts of the operating mechanism are also detailed in the OEM Technical Manual, for example, the Trip Shaft and Latch, Trip Latch Roller bearing, Closing latch, Close and Trip coils, etc. It is always important to be safe while working on any

breaker. Never get inside a breaker unless the closing and opening springs are discharged.

6.7 DESIGN UPGRADES FOR THE MAGNE-BLAST BREAKER

Since the Magne-Blast Breaker was first produced there have been some major changes in the design and upgrades for key parts of the breaker. The Magne-Blast breaker, like many other early designs, started production with a Solenoid Operated Mechanism. It was a simple design that utilized a large solenoid and a heavy slug that would raise a prop roller to close the breaker contacts. Once on prop the breaker will wait for an OPEN signal and open the Main Contacts. There are several other design upgrades for different parts of the breaker.

- In the Operating Mechanism the Teflon coated bushings were replaced with an Aluminum Bronze type bushings. The Teflon bushings were found in the Prop Latch, Toggle linkage, Charging Assembly, Driving and Holding pawls and breaker mechanism frame.
- In the Operating Mechanism there is a setscrew modification for the Ratchet wheel, Closing Cam, Timing Cam, Close Latch and Trip Latch. The newer design Set screws are self-locking and will not slip out after repeated operations.
- The Close Latch Return Spring was changed from an extension spring to a torsion spring.
- The Holding Pawls Pivot pin was redesigned from a pin with cotter keys on either end to shouldered pin retained by a bolt and flat washer.
- The Charge lever was redesigned when the Driving Pawl pivot pin was changed from a two cotter key arrangement to a shouldered pivot pin.
- The Primary contacts can now be retrofitted with Vacuum type contacts. Only minor modifications to the Operating Mechanism are needed.

6.8 LUBRICATION TYPE FOR THE MAGNE-BLAST BREAKER

There are different types of recommended Lubricants for the Magne-Blast breaker. Depending on the location of a particular component or sub-assembly would dictate what type of lubricant is required. It is always prudent to not mix and match different lubricants together. The following table identifies the location and proper lubricant for each component listed.

Parts	Lubrication at Maintenance Period
Al/Bronze prop bushing	Light Application of synthetic lubricating oil GE Specification, D6326A1, CAT # 0269A3691P520.
Trip shaft split-sleeve bearing in mechanism frame (<i>Teflon-impregnated bronze</i>)	Light Application of synthetic lubricating oil GE Specification, D6326A1, CAT # 0269A3691P520.
Square shaft bearings, sleeve bearings in links, panels, cranks (<i>Al-bronze</i>)	Light Application of synthetic lubricating oil GE Specification, D6326A1, CAT # 0269A3691P520.
Contact arm hinge joint cup bearing, hinge washers, stationary contact pivots	Wipe clean and apply thin coat of Mobil 28 (D6A15A1).
Roller/needle bearings	Light Application of synthetic lubricating oil GE Specification, D6326A1, CAT # 0269A3691P520.
Ground surfaces such as the center cam, outer cam, ratchet teeth and pawls (<i>originally coated with Black MoS2 dry lube</i>)	Spray a thin, uniform coat of 0269A3691P: 417 MoS2 dry lubricant.
Ground and hardened surfaces such as trip latch, closing latch prop, trip roller, center cam closing roller and the outer cam follower	Light Application of synthetic lubricating oil GE Specification, D6326A1, CAT # 0269A3691P520.
Silver plated main contacts, bushing disconnects and ground shoe	Wipe clean and apply light coat of Mobil 28 (D6A15A1).
Dashpot (Vacuum breakers only)	Check oil level and add oil if necessary. Fill to level of plughole inside of cylinder. Use GE D50H27 dashpot oil with the breaker in the CLOSED position.
Arcing contacts	Wipe clean and no lubrication on contact surface.
Moving main contacts	Wipe clean and apply a light coat of Mobil 28.
Jack Screws and lifting mechanism	Wipe clean and apply a light coat of Mobil 28.
Positive interlock	Wipe clean and apply a light coat of Mobil 28.

6.9 ROUTINE MAINTENANCE FOR THE MAGNE-BLAST BREAKER

The importance of routine maintenance has already been established for proper circuit breaker operation, additionally, it is important to have only properly trained and qualified personnel work on the Magne-Blast breakers.

Although these breakers can take a lot of abuse many of the problems were identified after an overhaul or maintenance cycle. During this training seminar, the objective is to utilize the PM Manual for the Magne-Blast breaker to help in understanding the function of the breaker.

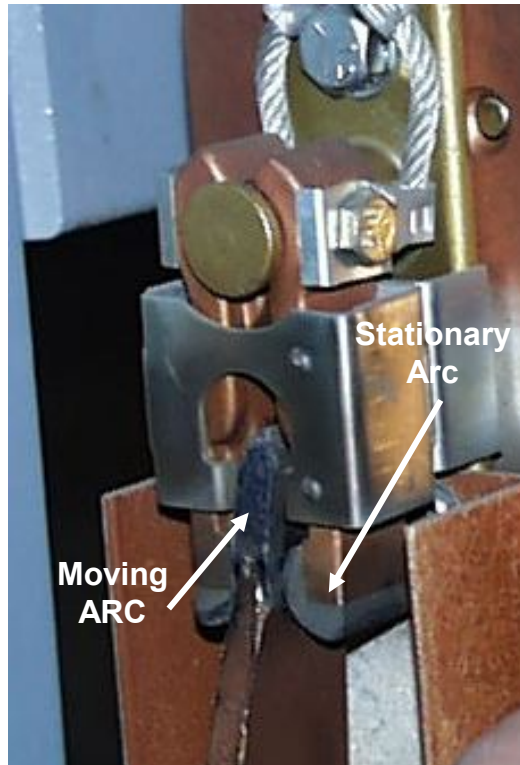


Figure 6-1 ARC Contacts

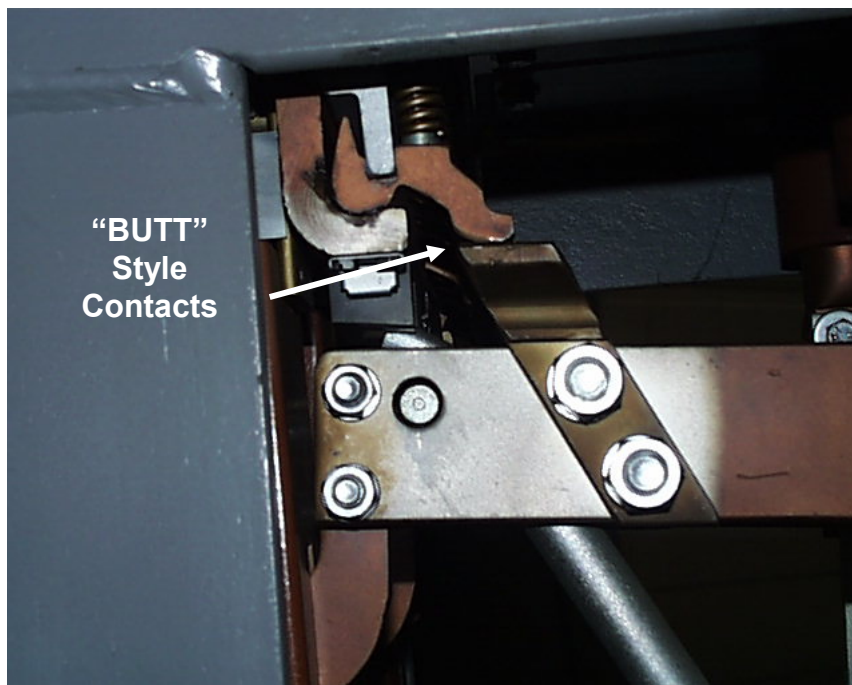


Figure 6-2 Main contacts

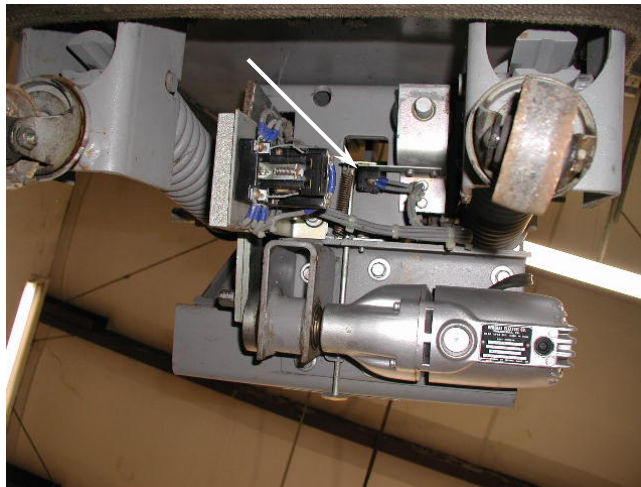


Figure 6-3. Close latch monitoring switch

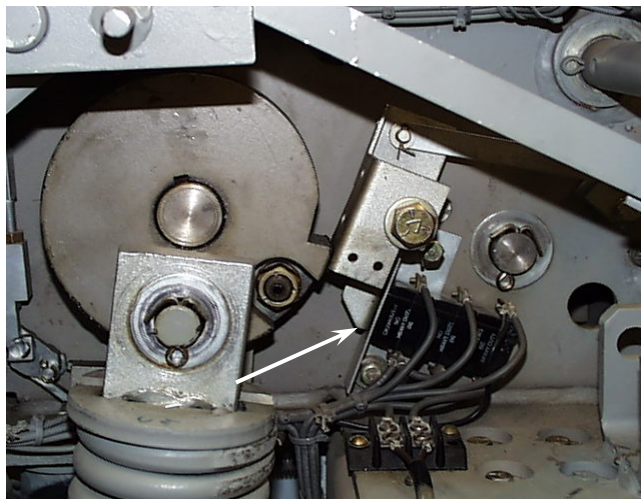


Figure 6-4. Motor and Relay Switches

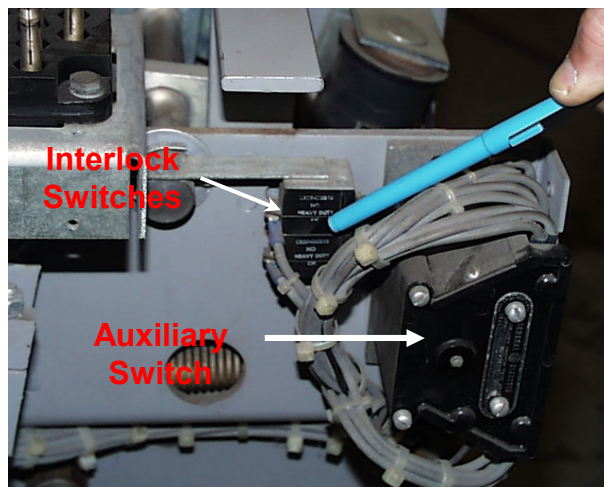


Figure 6-5. Interlock switches and Auxiliary switch



Figure 6-6. Close Coil

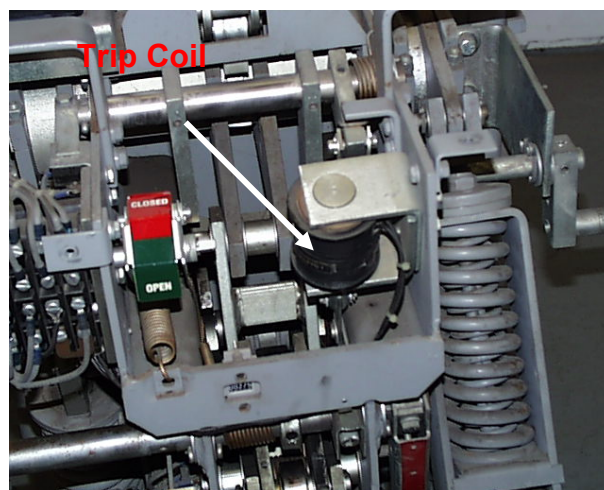


Figure 6-7 Trip Coil

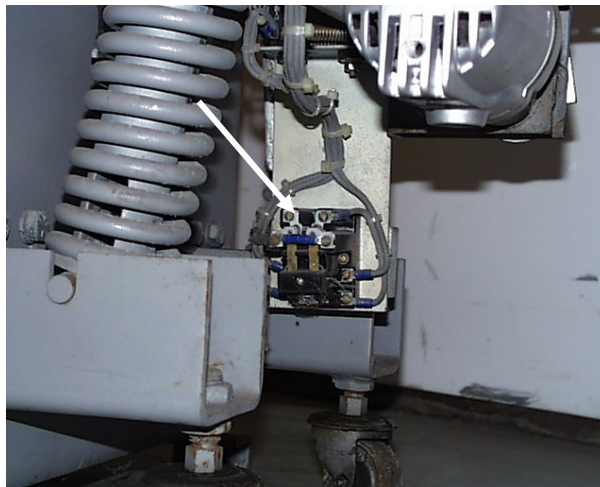


Figure 6-8 Control Relay

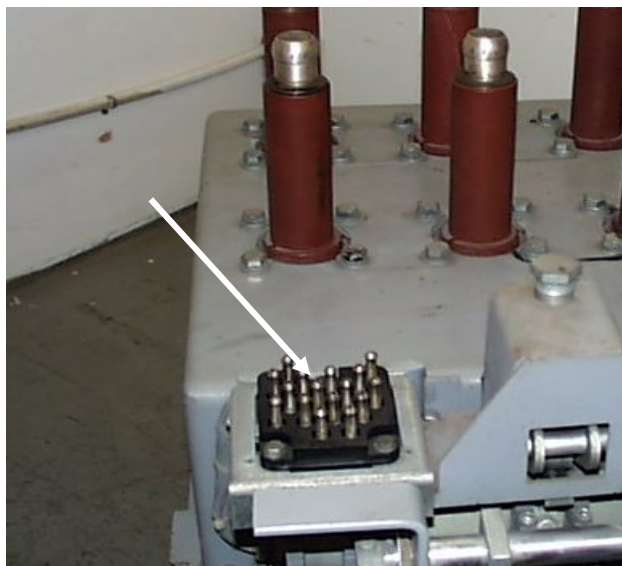


Figure 6-9 Secondary Disconnect

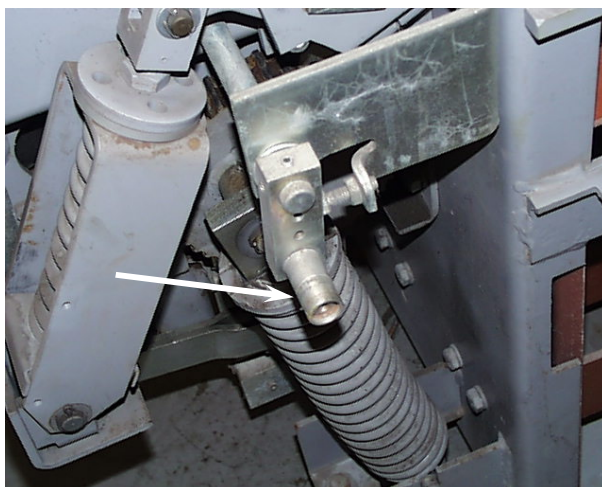


Figure 6-10 Positive Interlock

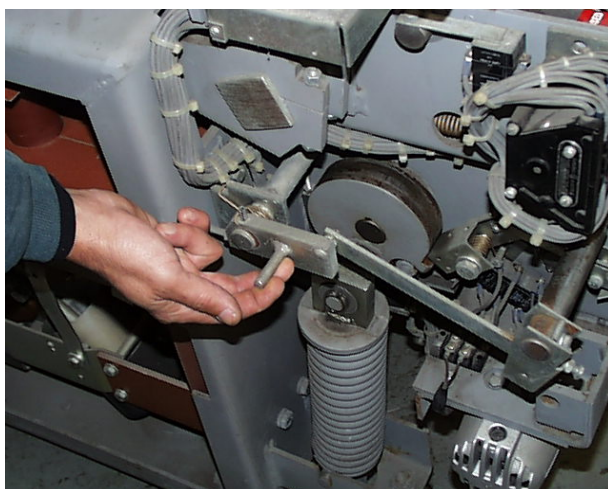


Figure 6-11 Spring Discharge Interlock