

NRC Medium Voltage Circuit Breaker Training



CHAPTER 3

CIRCUIT BREAKER ELECTRICAL COMPONENTS AND OPERATION

Learning Objectives



- Recognize and understand the function of electrical components used in the circuit breaker control circuit.
- Describe the function of the anti pump circuit.
- Understand the operation of the auxiliary switch “a” and “b” contacts.
- Understand the function of the protective relays and how they interface with the medium voltage circuit breaker to automatically trip (open) in the event of abnormal condition.
- Name the two common protection relays used on medium voltage breakers.

BASIC ELECTRICAL OPERATION



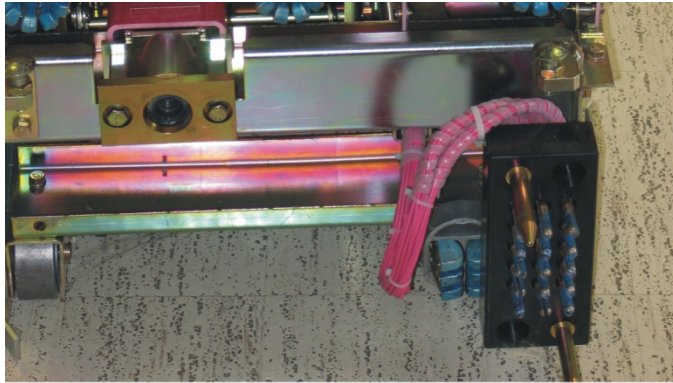
- The secondary disconnect provides power to the breaker electrical components
- The charging spring normally charges automatically
- The breaker can now be closed and opened from a local control switch on the breaker cubicle door or from a remote location (Control Room).

ELECTRICAL COMPONENTS



- Each breaker manufacturer operating mechanism design is different, but the electrical components required to operate the breaker all have similarities. Therefore, basic schematics for the control circuit for each manufacturer generally are similar as well.

Components of a stored energy electrical circuits

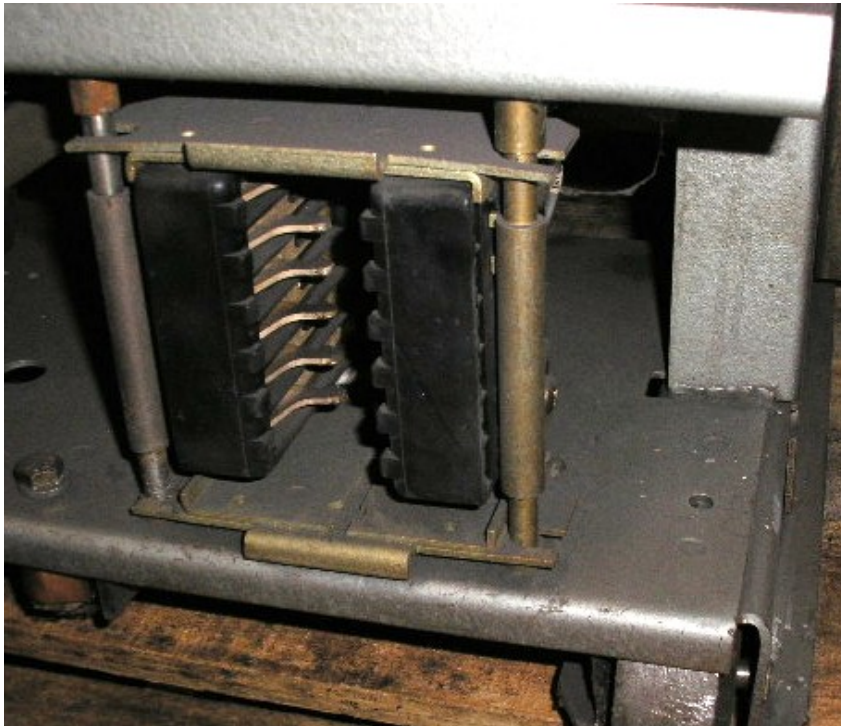


New 4160 VAC Vacuum breaker (back view)

- Secondary control Block or secondary



Components of a stored energy electrical circuits



- ABB HK Secondary disconnects

Components of a stored energy electrical circuits



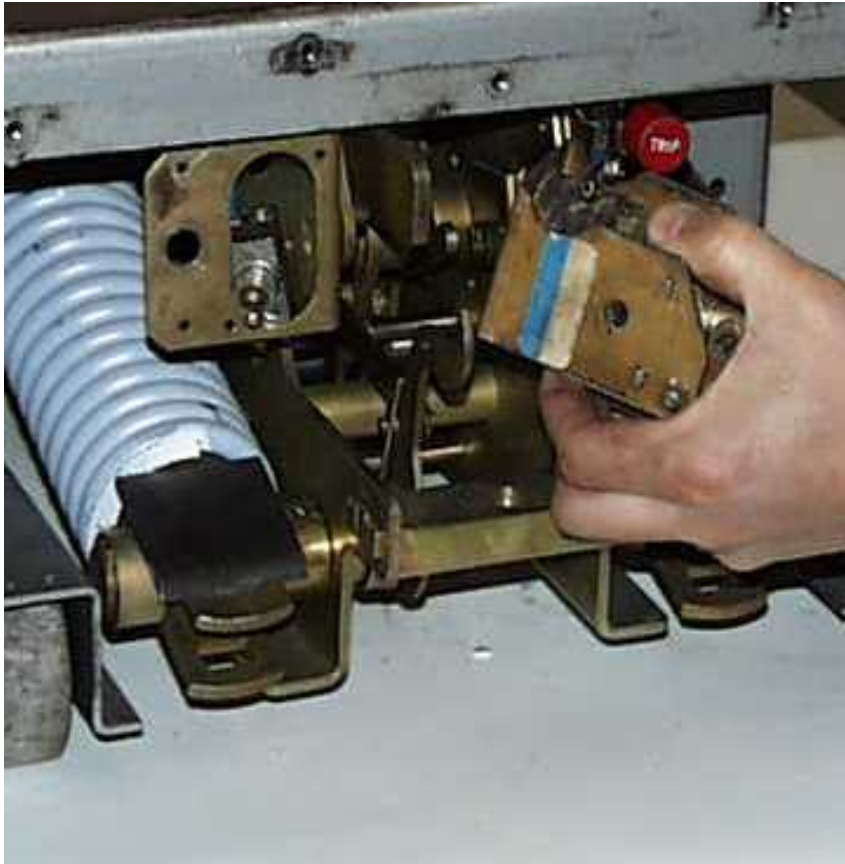
- Charging Motor

Components of a stored energy electrical circuits



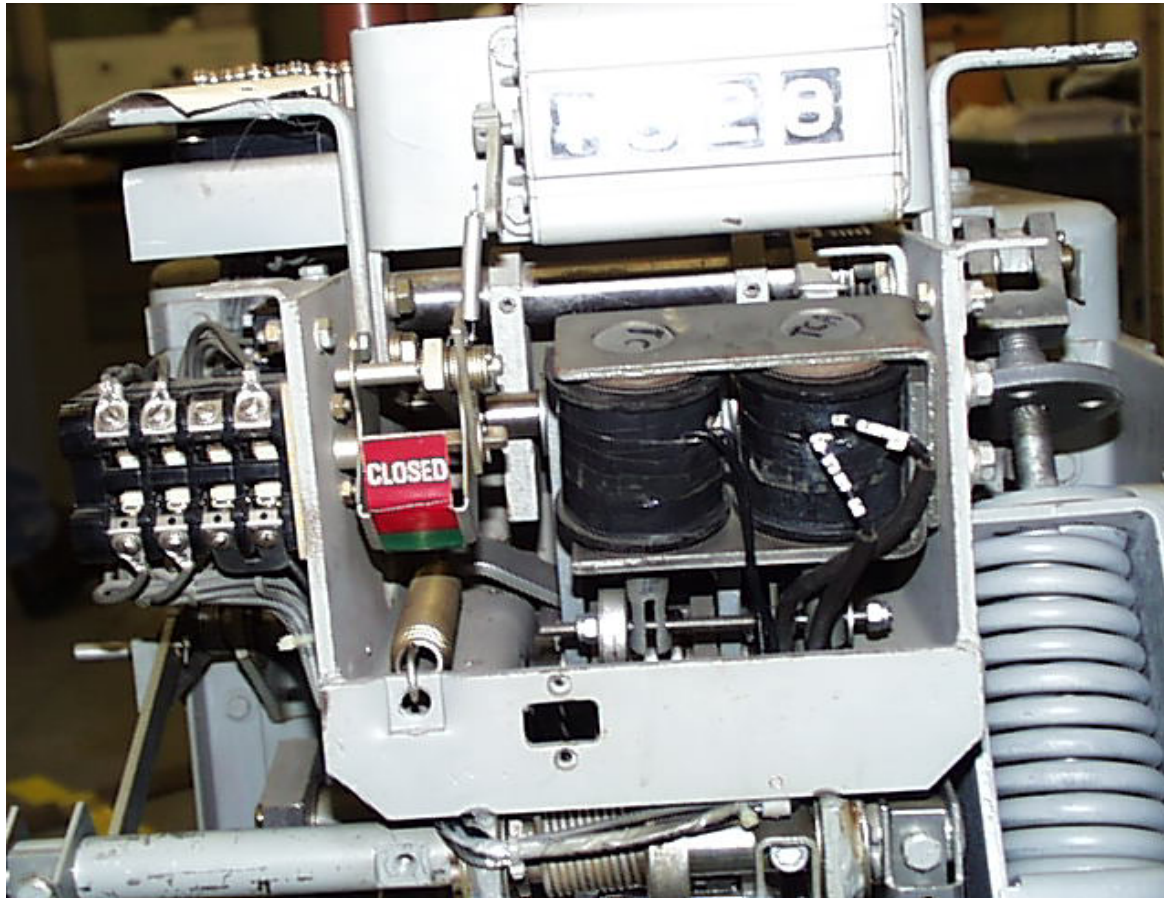
- Magne-Blast close coil located under the operating mechanism

Components of a stored energy electrical circuits



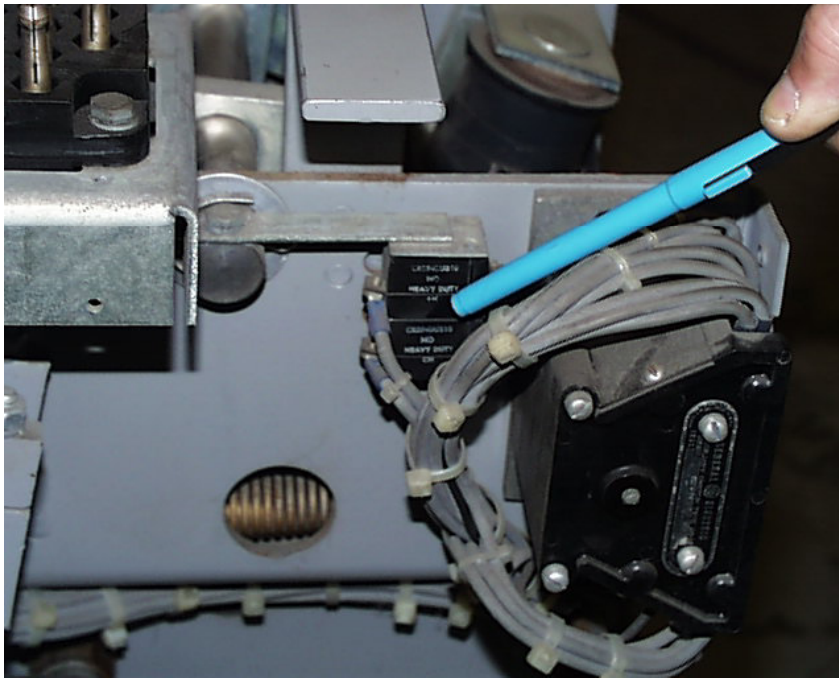
- ABB HK Close coil being removed from the breaker
- Located behind the front cover

Components of a stored energy electrical circuits



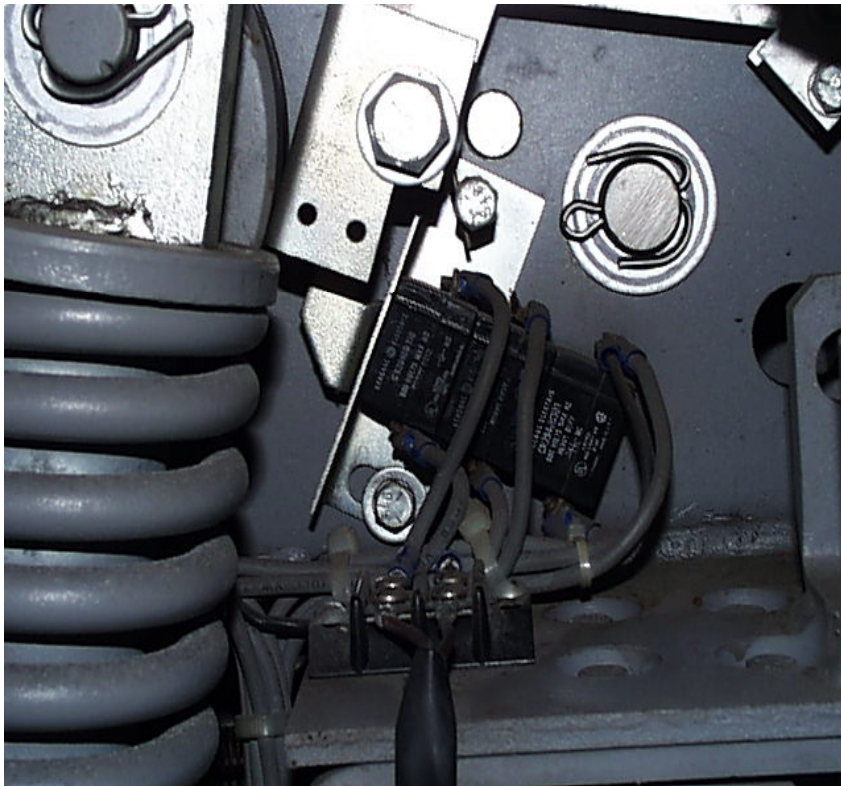
- Double trip coil design on a magne-Blast breaker

Components of a stored energy electrical circuits



- Auxiliary Switch (aux switch)
- And an interlock switch

Components of a stored energy electrical circuits



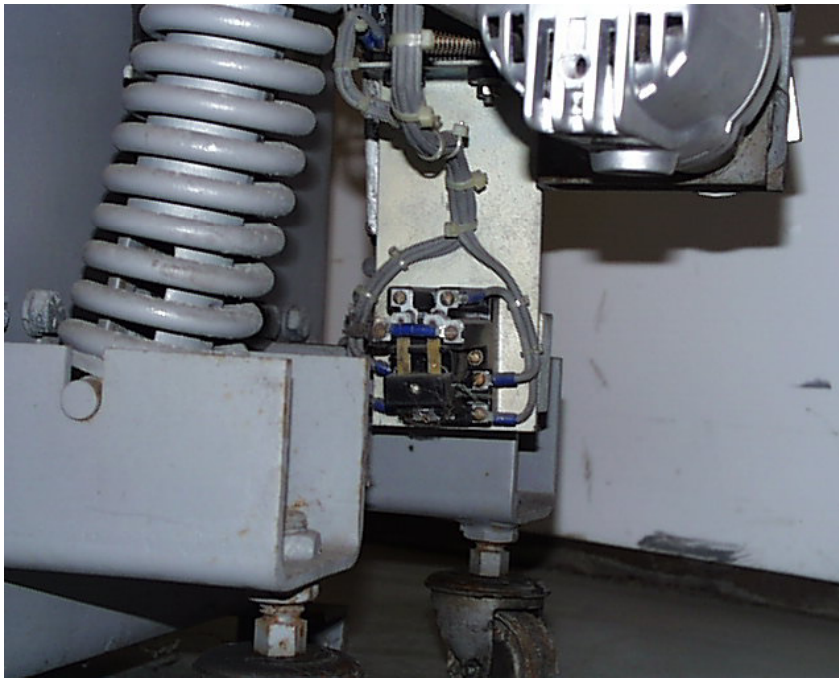
- Position Operated Switches
- Magne-Blast

Anti Pump Coil Or Relay



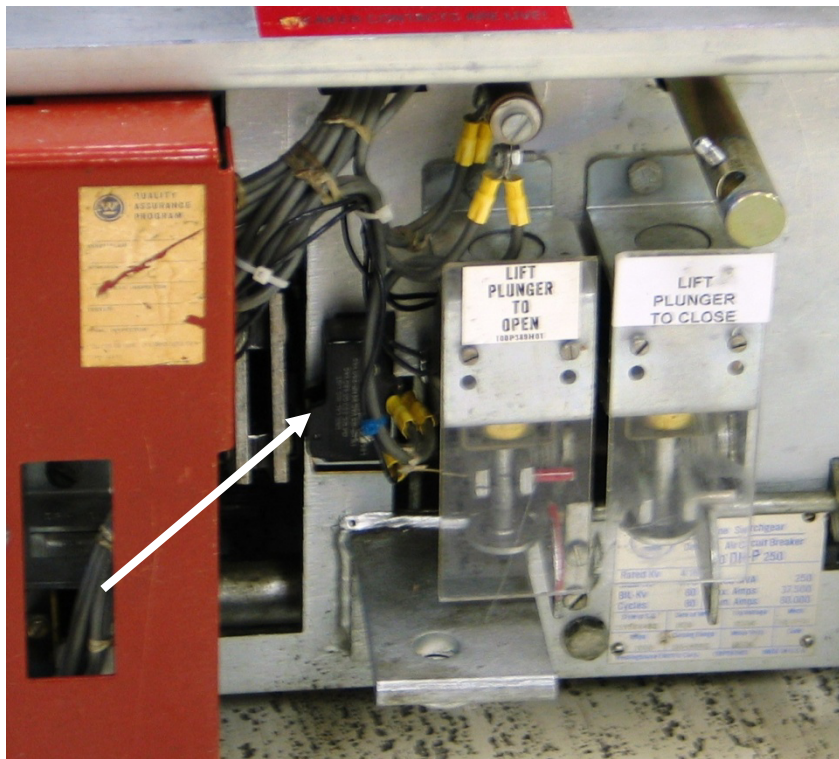
- Y Relay (Anti Pump): The Y relay is a parallel circuit to the spring release coil. The anti pump relay is energized at the same time as the close coil, this will open the normally closed Y contact in the close circuit.
- **The purpose of the Y Relay:** If the breaker does not close on the first attempt, and the close coil remains energized, the "Y Relay" provides a lock out to prevent the breaker from attempting another close. If the close signal is initiated but not removed the breaker has the potential to cycle through an endless close, trip, charge, close and trip cycle (Pumping). The Y coil opens the Y contact in the close circuit and as long as the close signal is present the breaker can't re-close.

Components of a stored energy electrical circuits



- Y/ Anti Pump Relay on a Magne-Blast breaker

Components of a stored energy electrical circuits



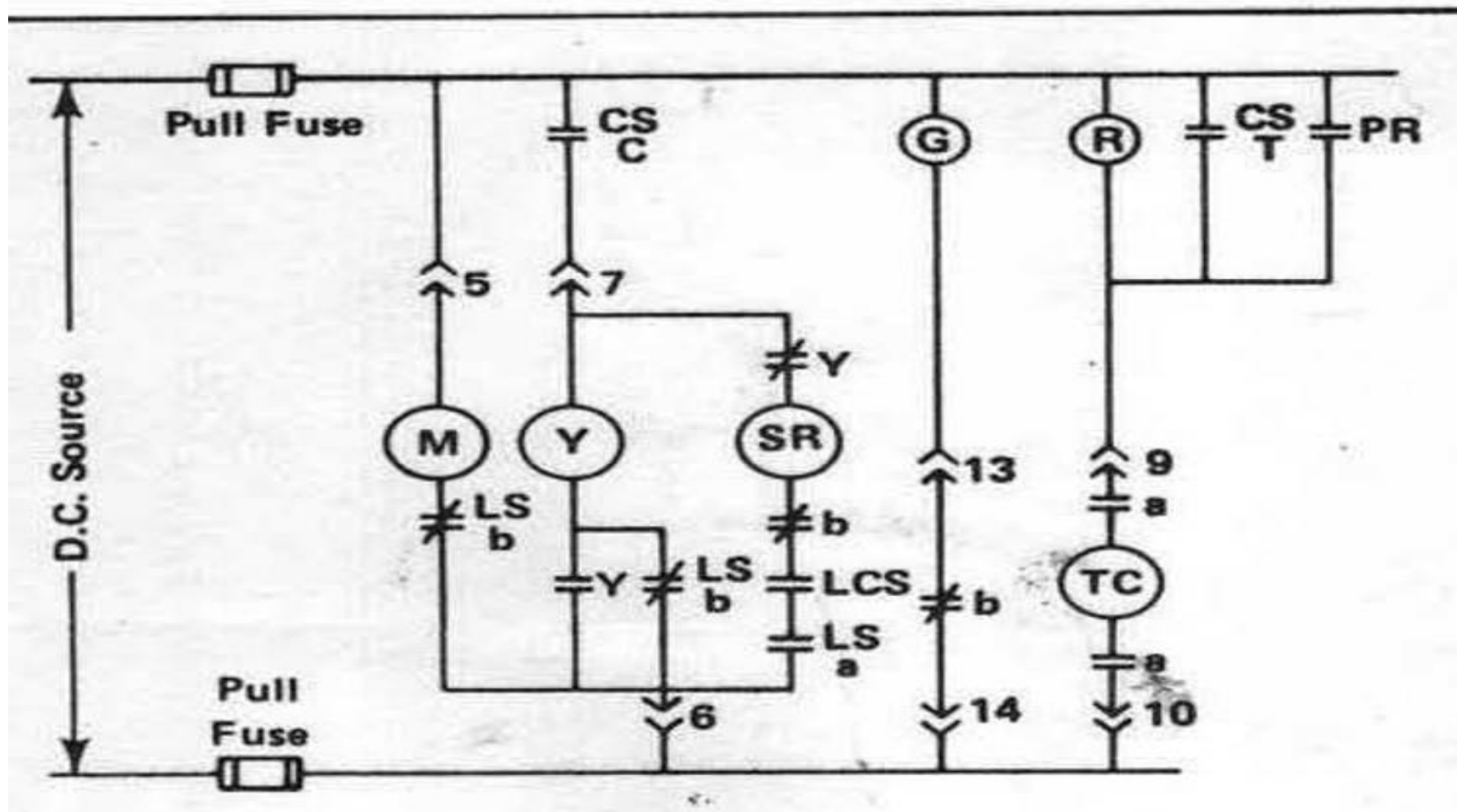
- Latch Check Switch:

Electrical Charging

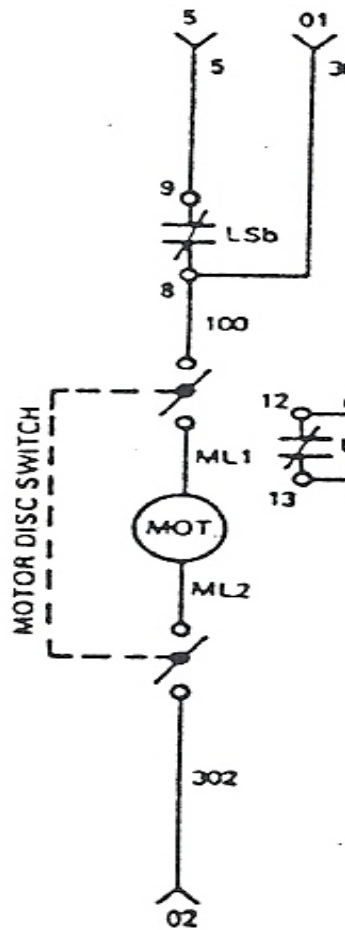


- The charging motor is in the skip tooth position of the ratchet wheel and stops pushing the mechanism.
- The closing prop/latch is engaged.
- The timing cam is in a position, which allows the motor, cut off bracket or actuator to move. This will actuate the switch contacts
- LSb, which opens the circuit to the charging motor disconnecting power to the charging motor. And
- LSa, which closes indicating that the motor has completed its charge.
- The trip latch moves to a set position in preparation for closing the breaker.
- The trip latch moving to the set position actuates the latch check switch LCS closing the contact and completing the circuit to the spring release coil (Close Coil).

ELECTRICAL OPERATING SEQUENCE DHP



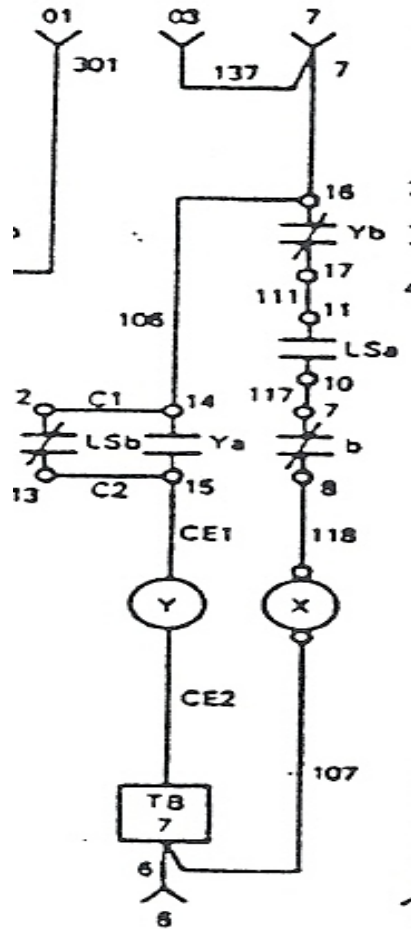
ELECTRICAL OPERATING SEQUENCE ABB HK



- The charging motor is energized pin 2 and 5 on the secondary disconnect

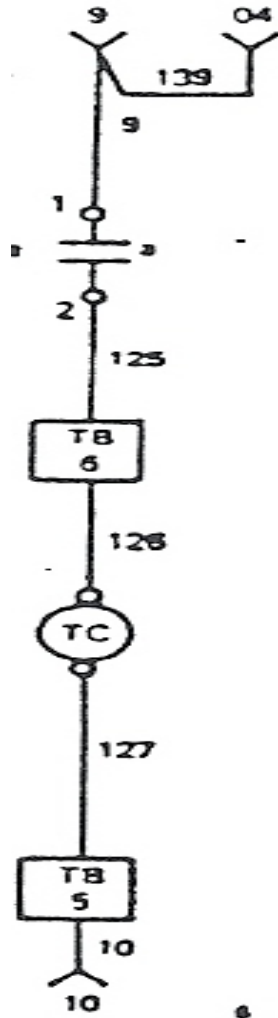
Fig. 8 - Typical

ELECTRICAL OPERATING SEQUENCE ABB HK



- Close coil is energized pin 6 and 7 on the secondary disconnect

ELECTRICAL OPERATING SEQUENCE ABB HK



- Close coil is energized pin 9 and 10 on the secondary disconnect

NRC Medium Voltage Circuit Breaker Training



CHAPTER 3A

CIRCUIT BREAKER ELECTRICAL COMPONENTS AND OPERATION

Learning Objectives



- Understand the function of the protective relays and how they interface with the medium voltage circuit breaker to automatically trip (open) in the event of abnormal condition.
- Name the two common protection relays used on medium voltage breakers.

Protective Relays



- Circuit breakers designed to operate below 600 volts use trip-units and/or series connected elements built directly into the circuit and are internal to the breaker. This design becomes impractical when dealing with higher voltages. Hence the protective relay is incorporated.

PROTECTIVE RELAYS



- By using transformers to reduce large currents and high voltages to lower ranges (usually 0-5 amps and 120 volts), very simple motors or electronic circuits can be used to externally control circuit breakers.

Types of Protective Relays



- Electromechanical/Induction:
Electromechanical relays can be classified into instantaneous (magnetic attraction) and time-delay (torque-controlled) units.

Electromechanical/Induction



- Instantaneous units: This type of relay unit may consist of a solenoid and plunger or a solenoid and a hinged armature. Magnetic attraction is the operating force.
- Time-delay units: This type of unit consists of an induction-disk or induction-cup that has a magnetic field applied to it by two poles of an electromagnet which produce eddy currents in the disk or cup generating torque on the moveable rotor. A very simple motor.

Solid-state Relay



- These relays use electronic components to provide protective functions similar to those provided by electromechanical relays. This style of relay employs discrete solid-state electronic components and has no moving parts.
- Most versions of solid-state relays are simple devices that provide a single function, such as voltage, current, frequency, or phase angle measurement similar to electromechanical relays.

Microprocessor (Numerical) Relay



- Microprocessor (Numerical): These devices provide multiple protective functions in a single unit.
- The basic protection principles remain the same. Microprocessor relays are also referred to as numerical relays because they calculate algorithms numerically
- Basic construction consists of a microprocessor, an AC signal data acquisition system, and memory components containing the relay algorithms, contact inputs to control the relay, and contact outputs to control other equipment. The algorithms and settings contained in the relay memory define the protection characteristics.

Instrument transformers



- The basic function is to change the magnitude (but not the nature) of primary voltage and current to secondary values to 120 volts and 5 or 1 amp where relays can be applied.
- When relays compare the sum or difference of two or more currents or the interaction of voltages and currents, the relative direction of the current must be known. The direction of current flow can be determined by knowing the instrument transformer polarity. Polarity markings are normally shown on instrument transformers.

Current Transformers:



- Current transformers are designed for connection in the primary circuit (either in series or around the primary circuit). The secondary current of the transformer bears a known relationship with the primary current.

Voltage Transformers



The purpose of the VT is to provide an isolated secondary voltage that is an exact proportionate representation of primary voltage. ANSI standards for accuracy are also established for VT's.

Common switchboard protective relay functions



- Over current relays
- Over-under voltage relays
- Directional relays
- Voltage or current balance relays
- Differential relays

Relays as applied to the Switchboard



- **Main Breaker protection**
- **Feeder circuit protection**
- **Relay coordination**
- **Bus differential protection**
- **Transformer protection**
- **Motor circuit protection**

Circuit breaker control



- Electro-mechanical and Solid-state relays: Trip output contacts are connected in the DC trip circuit of the relay or to the operating coil of a lockout device which is in turn connected to the breaker trip circuit.

Circuit breaker control



- Microprocessor relays: Microprocessor relays have multiple output contacts allowing direct trip control of the breaker for certain protection elements and/or lockout trip control for other selected elements. Outputs contacts may be connected in the closing circuit of the breaker allowing local or remote closing operations through the relay.

These relays are also equipped with input sensing circuits that can be connected to breaker auxiliary contacts or cell switches so the relay can monitor the breaker status (open/closed, connected/disconnected). Numerous inputs are accommodated in this type of relay allowing tremendous flexibility of control over a circuit breaker. Custom logic can be applied in the relay software for automatic operation of multiple circuit breakers.

Relay Settings



- Relay settings: The individual elements that make up a protective relay are adjustable. This is where sensitivity and selectivity are applied. The level of protection or pickup point is defined by a setting. If applicable a time delay may also be selected. Pickup settings options are usually one of two formats, secondary values or per-unit values.

Secondary values



- Example: An electromechanical time over current relay has a 300:5 CT connected to it. The pickup setting 3.3 is the current that will be measured at the relay terminals when 180 amps of primary current passed through the CT. At that time the induction disc will start to move.

Per-unit values



- A percentage of the CT rating
- Example: A microprocessor relay has a 300:5 CT connected to it. The per-unit value of the above setting (180 amps primary) is 0.6 x CT.

$$0.6 \times 300 = 180 \text{ amps primary}$$

$$0.6 \times 5 = 3 \text{ amps secondary}$$

Setting relays



- Electromechanical: Manually place screw in the desired tap on the relay. Turn time-dial to the desired delay band.
- Solid-state: Usually setting a dial on the face for the relay for the pickup and delay.
- Microprocessor: The easiest method is connecting a laptop to the relay with required communication cable and utilizing the manufacturer's software to install protection and logic settings. Settings files may be developed with OEM software without being connected to a relay.
- These files can then be installed directly into the relay without having to enter settings for each element individually.

Summary



Without the protective relay, the medium voltage circuit breaker is nothing more than a switch. It needs to be told when to close and when to open.

Technology offers us many new and innovative ways to do just that. Despite all these terrific ideas we still have relays that are 30-40 years old that need to remain in service. There is quite a broad range of protective devices one may encounter in a medium voltage switchboard. What we have shown today is only the tip of the iceberg. Protective relaying is a science all its own.