SQUARE D

Overcurrent Protection Seminar

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Agenda

- Why we use overcurrent protective devices
- Circuit Breaker Design
- Electrical Design Alternatives
- Characteristic Curve Review
- Selective Coordination
- Withstand Ratings for Breakers

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Definition of Overload

- An overcurrent
- An unfaulted condition
- Normal current path
  - no unintentional path back to the source
- 125% to 600% of ampere rating

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Non-bolted Arcing Faults

- Free-burning arcs in uncontrolled conditions
- Generally start out low level
- Tend to travel along conductors
- If undetected, can result in higher level faults.

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Bolted Faults

- Occur under very controlled conditions
- Higher levels of short-circuit generated

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Two Types of Impedance (During an overcurrent condition)

- Static Impedance
  - Constant over time
- Dynamic Impedance
  - Changing or time dependent impedance
- As impedance changes, so do
  - System power factor
  - X/R ratio
  - Current response characteristics of the circuit

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Examples of Impedance

- Internal arc impedance increases with time
- As arc impedance increases, a change in system impedance will change the system power factor
- The arc impedance produces a current limiting effect on the current level

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Containing Dynamic Impedance

- **Bolted fault**
  - Dynamic impedance contained within the overcurrent protective device
- **Arcing fault**
  - One arc in system
  - One arc inside the overcurrent protective device

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Circuit Breakers

- **Circuit Breaker elements**

  A latch mechanism

  A copper current path

  A thermally-sensitive bimetal element and a pigtail

  A set of deionizing plates

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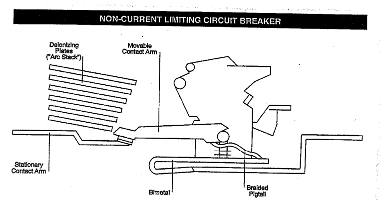
Non-Current Limiting Circuit Breaker



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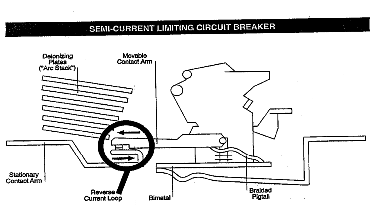
Semi-current Limiting Circuit Breaker



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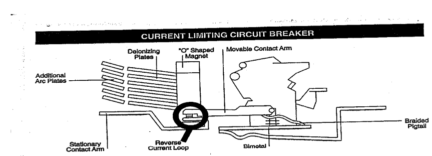
Current Limiting Circuit Breaker



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Circuit Breakers

- Circuit Breaker Performance
  - Non-current limiting circuit breakers
    - Large and heavy blades
  - Semi-current limiting --
    - Much thinner movable, smaller and lighter contacts, and reverse current loop
  - Current limiting --
    - "O"-shaped magnet and additional set of arc plates
  - Withstand rated --

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Electrical Designs

- Equipment selection process
- Basic design alternatives
- Difference between fully rated, series rated systems
- Facts about series-connected ratings

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Series Connected Rating

- The rating of two or more overcurrent protection devices -- such that the load-side device can be applied above its individual interrupting rating.

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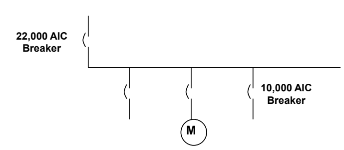
Series Connected Rating

- NEC 240.86.C
  - (1) Motors are connected on the load side of the higher-rated overcurrent device and on the line side of the lower-rated overcurrent device, and



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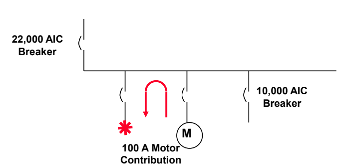
Series Connected Rating

- NEC 240.86.C
  - (2) The sum of the motor full-load currents exceeds 1 percent of the interrupting rating of the lower-rated circuit breaker.



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Equipment Selection

- Perform system analysis
- Select distribution equipment
- Specify preference for one of the design alternatives

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Selective Coordination

- Need for selective coordination
- Current limitation verses selective coordination

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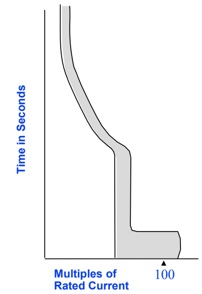
Reading a Trip Curve

- Graphic representation
  - Tripping time
    vs.
  - Current level
  - Shaded area -- possible trip
  - Note:
    - Header
    - EZ Amp Arrow
    - Log-log scale



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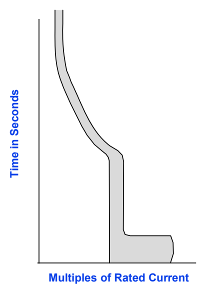
Reading a Trip Curve

- Manufacturing tolerances result in a tripping band bound by minimum and maximum values of total clearing time
  - Clearing time is the sum of:
    - Sensing time
    - Unlatching time
    - Operating time
    - Arcing time



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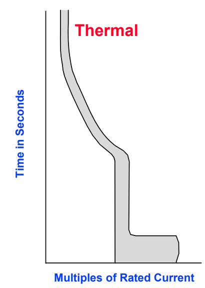
Thermal Tripping

- Bimetalic element responds to heat generated by the overcurrent
- Shown in the upper left portion of the trip curve
- Overload currents (1X to 6X)
- Inverse time - larger overcurrent opens the circuit breaker faster



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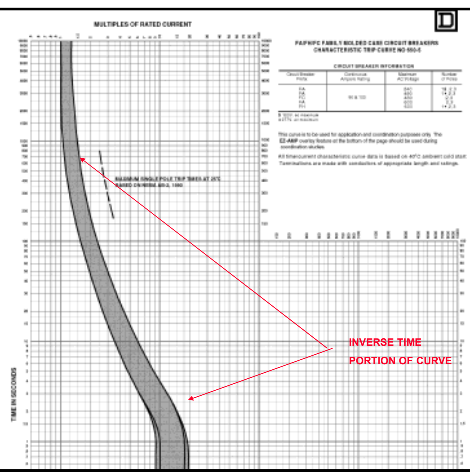

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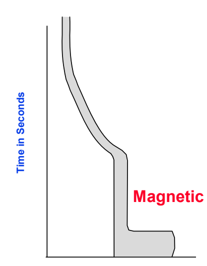
Instantaneous (Magnetic) Tripping

- Magnetic assembly responds to the current flow through the circuit breaker
- Shown in lower right portion of trip curve
- High level overcurrents (5x - 10x handle rating or higher)
- Trips instantaneously - no intentional time delay



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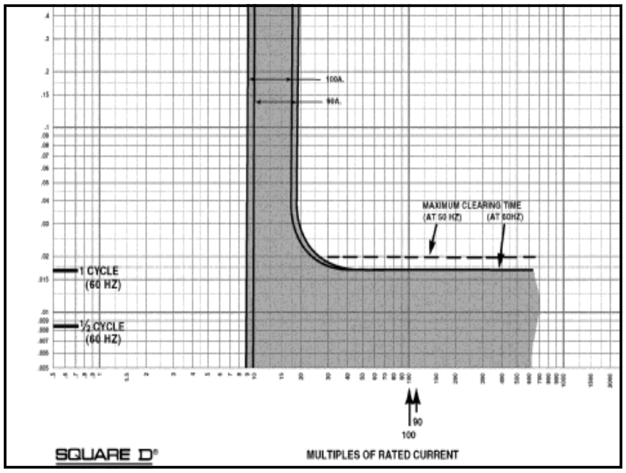

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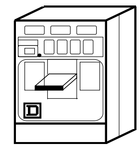
Device Characteristics

Electronic Trip Circuit Breakers

- **CTs sense current levels**
- **Microprocessor analysis of signal**
  - Adjustability
  - Accuracy



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Device Characteristics

Electronic Trip Circuit Breakers

- **Pickup Points** (given in multiples of "P")
  - Current level at which a trip signal is initiated
  - Adjustable
    - Interchangeable rating plug
    - Pickup switches
  - P = Sensor size x Rating plug multiplier
    - Ex. 1600A sensor and ARP075 >> 1600 x .75 = 1200

  ∴ P = 1200A

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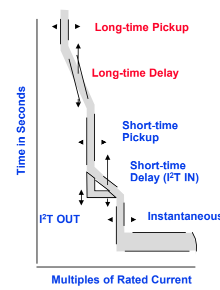
Trip Curves

Electronic Trip Circuit Breakers

- **Long-time pickup**
  - Simulates the bimetal in a thermal-magnetic circuit breaker
  - Reacts to overload conditions
  - Determines the current (amperage) the breaker will carry continuously
- **Long-time delay**
  - Sets the amount of time the circuit breaker will carry an overcurrent after long-time pickup is achieved



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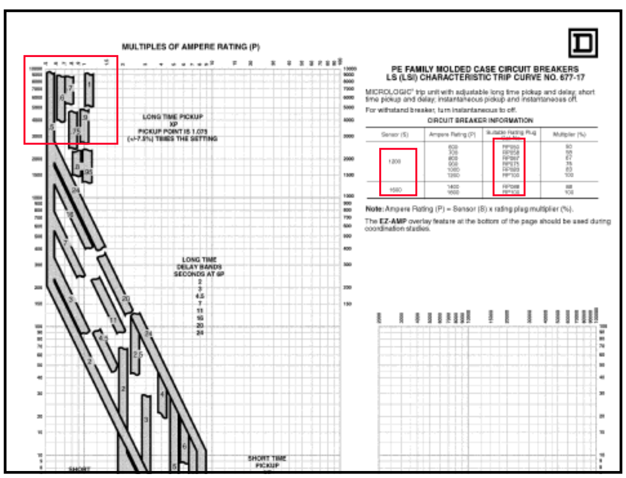

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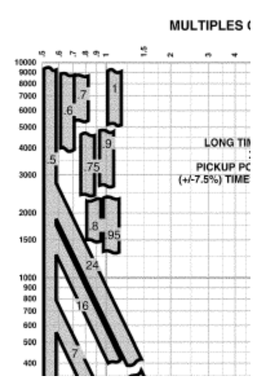

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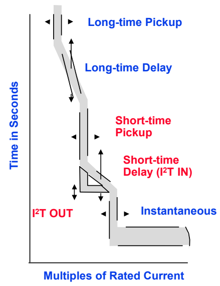
Electronic Tripping (continued)

- **Short-time pickup**
  - Allows circuit breaker to delay before tripping on higher level overcurrents to maximize coordination
- **Short-time delay**
  - MICROLOGIC - I^2T IN - Inverse time delay and I^2T OUT - Fixed time delay



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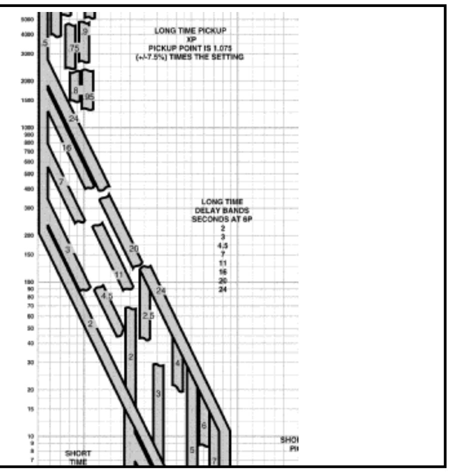

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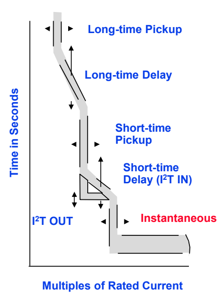
Electronic Tripping (continued)

- **Instantaneous pickup**
  - Simulates the magnetic characteristics of the thermal-magnetic circuit breaker.
  - Trips with no intentional time delay



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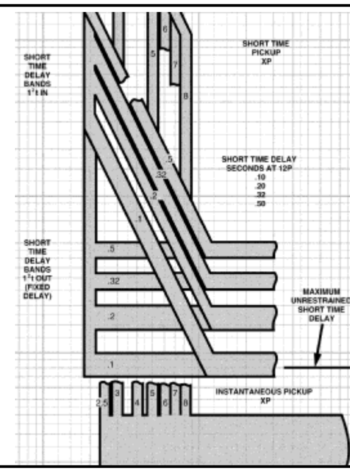

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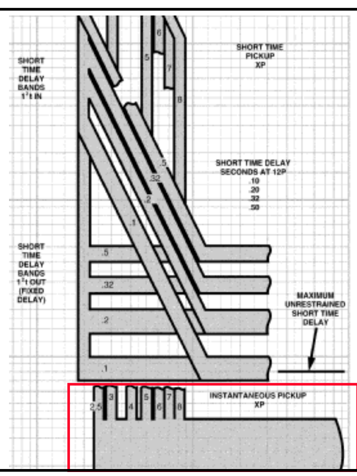

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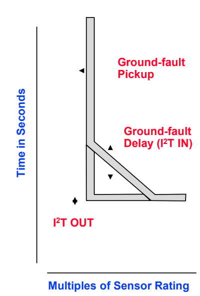
Ground-fault

- **Ground-fault pickup**
  - Determines the point that the circuit breaker will begin detecting a ground-fault current
- **Ground-fault delay**
  - <u>Full-function</u> trip units
    - I^2T IN and I^2T OUT
  - <u>Standard-function</u> trip units
    - I^2t OUT only



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Coordination

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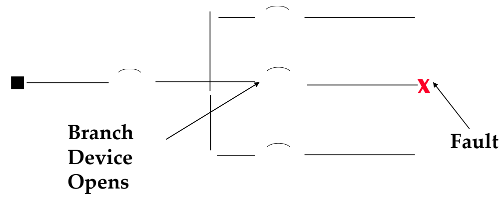
Selective Coordination

- Selective coordination is the process of localizing a fault to the overcurrent device closest to the fault.



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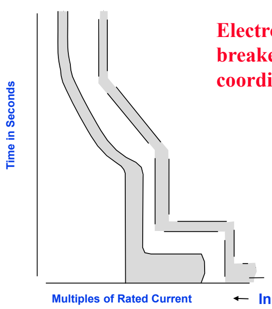
Selective Coordination



Electronic trip circuit breakers increase coordination potential

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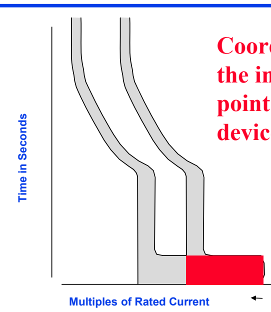
Selective Coordination



Coordination exists up to the instantaneous trip point of the upstream device.

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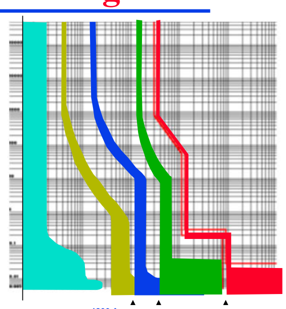
Short-Time Withstand Ratings

Load - 15 HP motor
Branch circuit breaker - 40 Amp FA thermal-magnetic
Panel circuit breaker - 150 Amp KA thermal-magnetic
Feeder circuit breaker - 800 Amp MJ thermal-magnetic
Main circuit breaker - 3000 Amp NW Electronic Trip



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Short-Time Withstand Ratings

- Short-time (30 cycle) Withstand Rating
  - ANSI/IEEE--Maximum RMS total current a CB can carry momentarily without electrical, thermal, or mechanical damage, or permanent deformation
  - NEMA AB 1-1993--The value of current assigned by the manufacturer that the device can carry without damage to itself, under prescribed conditions.

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Short-Time Withstand Ratings

The level of RMS symmetrical current that a circuit breaker can carry in the closed position for a specified period of time.

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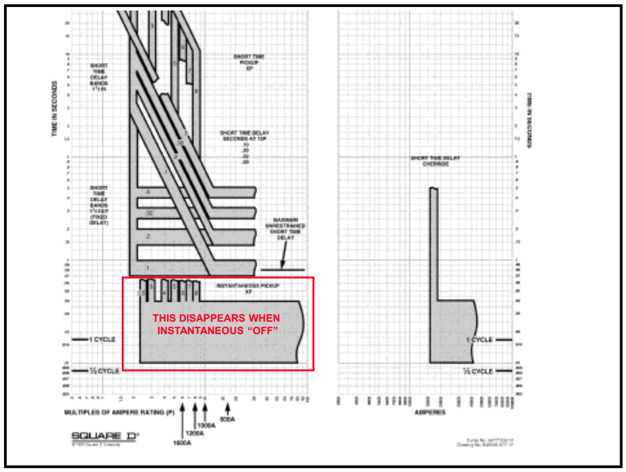

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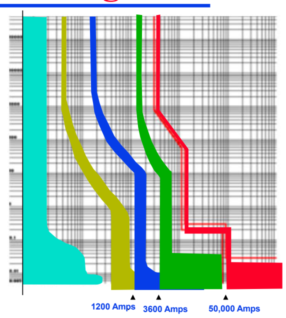
Short-Time Withstand Ratings

Load - 15 HP motor
Branch circuit breaker - 40 Amp FA thermal-magnetic
Panel circuit breaker - 150 Amp KA thermal-magnetic
Feeder circuit breaker - 800 Amp MJ thermal-magnetic
Main circuit breaker - 3000 Amp NW Electronic Trip



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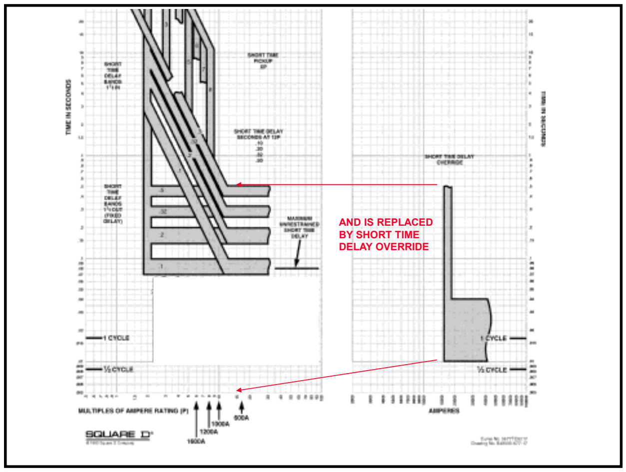

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Coordination

- NEC 700.27 & 701.18 Emergency (& Legally required standy) system(s) overcurrent devices shall be selectively coordinated with all supply side overcurrent protective devices.
  - Square D has a Data Bulletin 0100DB0403 which can assist in developing a fully coordinated distribution system using mainly electronic trip breakers.

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QUESTIONS?

THANK YOU FOR YOUR INTEREST

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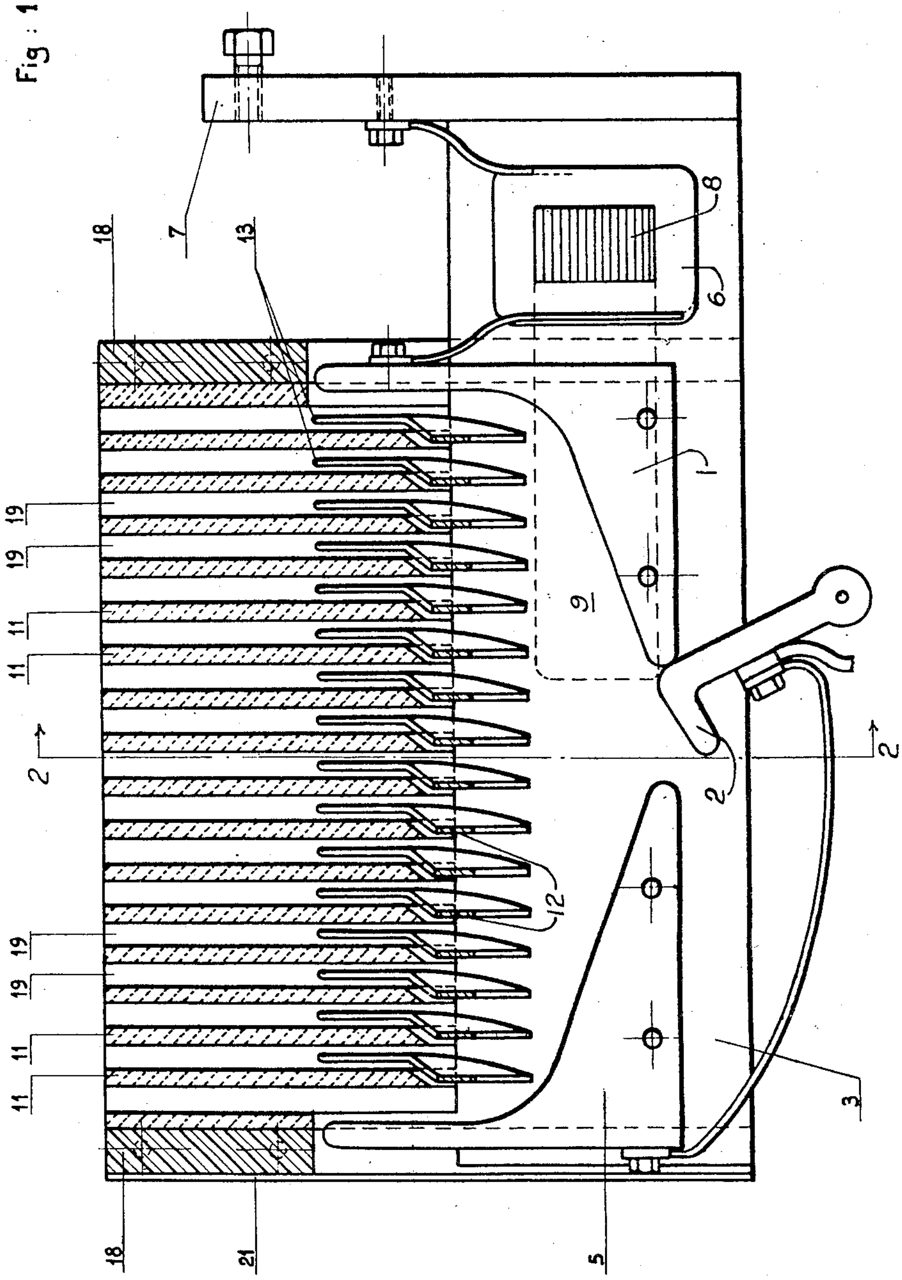
Feb. 9, 1954 A. LATOUR 2,668,890

DEVICE FOR EXTINGUISHING ELECTRICAL ARCS

Filed Oct. 3, 1950 3 Sheets-Sheet. 1

Fig : 1



Inventor
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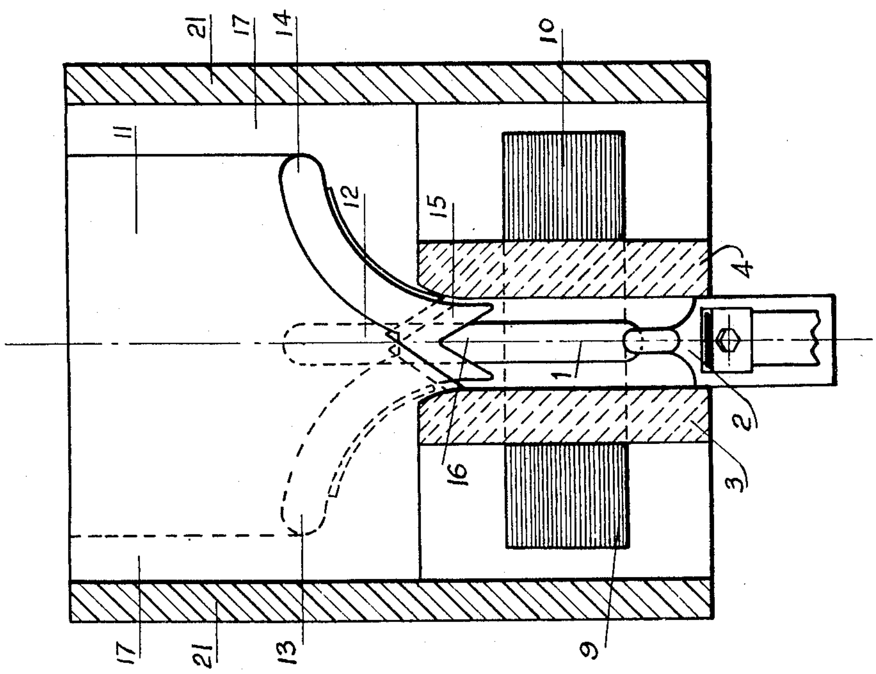
By Heinrich Hochschild
Attorney

Feb. 9, 1954 A. LATOUR 2,668,890

DEVICE FOR EXTINGUISHING ELECTRICAL ARCS

Filed Oct. 3, 1950 3 Sheets-Sheet 2

Fig: 2



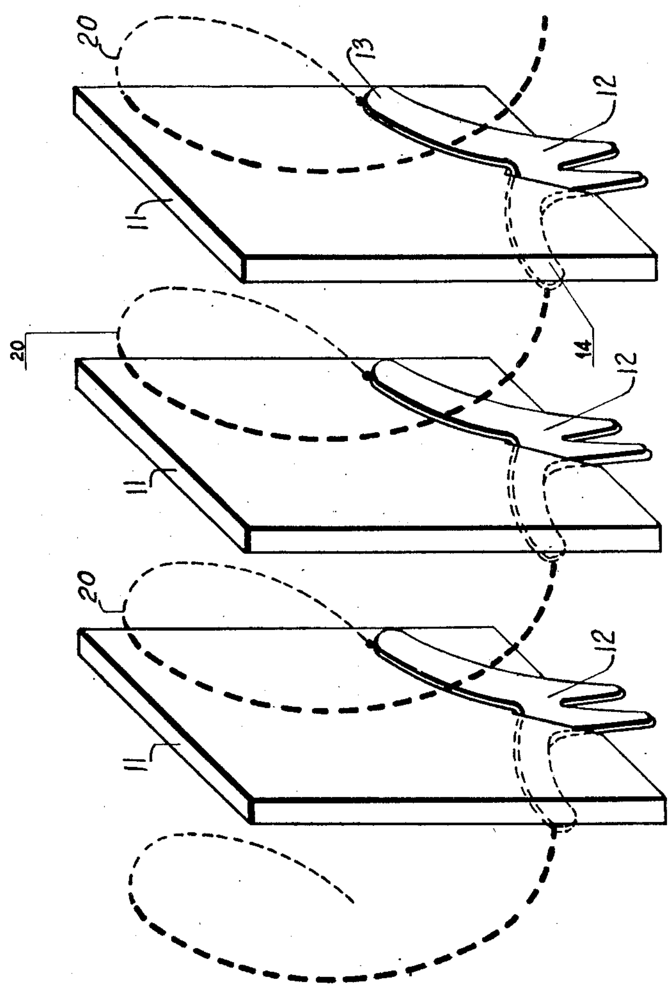
Inventor

André LATOUR

By Heinrich Hochschild

Attorney

Fig: 3



Inventor

André LATOUR

By Heinrich Hochschild

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Patented Feb. 9, 1954 2,668,890

UNITED STATES PATENT OFFICE

2,668,890

DEVICE FOR EXTINGUISHING ELECTRICAL ARCS

André Latour, Grenoble, France, assignor to The Etablissements Merlin & Gerin (Societe Anonyme), Grenoble, France, a corporation of France

Application October 3, 1950, Serial No. 188,148

Claims priority, application France October 13, 1949

7 Claims. (Cl. 200—144)

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The invention refers to circuit breakers of the type in which the arc is drawn between separable contact members contained in an arc formation chamber provided with means for expanding, until extinction, the arc into and within an arc extinguishing chamber contiguous with the arc formation chamber.

More particularly the invention is concerned with a development of an arc extinguishing chamber which makes possible in a circuit breaker to be employed for heavy currents and high voltages to expand or elongate peripherally the arc to a multiple of its initial length.

It is a further object of the invention to provide such a circuit breaker with arc extinguishing means which as to their dimensions are not limited by the dimensions and configuration of the circuit breaker proper but, contrariwise, allow for ready adaptation of the arc extinguishing means to the various requirements of voltage and current or power to be disconnected.

The device of the invention makes use of an arc extinguishing chamber which includes at least two parallel plates of insulating material, spaced apart from one another to leave a narrow space therebetween and disposed substantially transversely of the direction of separation of the contacts or the initial direction of the arc. It is a particular object of the invention to provide in this device the plates with linearly extended conductive elements or paths which not only draw a section of the arc into the space between the plates and turn it around into a position substantially perpendicular to its initial path but cause the section of the arc to expand peripherally to a loop of a length which is a multiple of the greatest distance between the conductive elements.

The device for extinguishing an electric arc to be drawn between separable contact members thus includes at least two plates of insulating material, spaced apart from each other to leave a narrow space therebetween and disposed substantially transversely of the direction of separation of the contacts, or the initial direction of the arc. Each plate is provided on both its faces with conductive elements or paths so disposed that they not only draw the arc into the narrow space, or the arc in sections into the narrow spaces between the plates, but turn the arc or the arc sections into a position parallel to the plates or substantially perpendicular to the plane of the arc as initially drawn, or perpendicular to the direction of separation of the contact members.

These conductive elements or paths of the invention are linearly extended and project into the space between the plates, laterally and along the surfaces of the plates, and terminate within the space at a point intermediate the entrance and the exit of the space and are so disposed upon opposite faces of each plate and upon the faces of opposite plates within each space so as to diverge relatively to each other.

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Through this arrangement the roots of the arc or arc sections progress into the space or spaces only part-ways until they reach the terminal points of the conductive elements or paths whereupon the arc or the arc sections will expand peripherally to a multiple of their lengths within the space or the spaces until extinction.

In the arrangement of this arc extinguishing device where an arc extinguishing chamber is contiguous to an arc formation chamber wherein the arc is ignited or drawn by interruption of the current, the arc formation chamber may consist of two parallel insulating plates between which the contacts of the switch are located, the insulating plates with the contacts therebetween being placed between the branches of a magnetic circuit in the shape of a horseshoe. This magnet, owing to the narrow air gap within which the contacts are disposed between the insulating plates, is capable of driving the ignited arc with great force into the arc extinguishing chamber.

This chamber consists of a certain number of insulating plates and conductive elements or paths which in the form hereinafter illustrated are generally in the shape of a V, its branches or legs embracing or straddling the individual insulating plates and extending along both sides and faces of the insulating plates which themselves are extended transversely of the initial path of the arc. These conductive elements are so placed that in the space between neighboring plates conductive elements on opposite faces diverge relatively to each other.

In this manner, on its way out of the arc formation chamber, the ignited arc is split into as many sections as there are conductive elements or paths plus one, and each section on its travel along the branches or legs of the conductive elements or paths is turned around an angle of about 90° with relation to the axis of the initial arc. Conductive elements alternating with arc sections thus form from that very moment a veritable solenoid which through its electrodynamic effect brings a powerful blow out action on each one of the elementary arc sections which now are easily displaced and extended in the spaces between each two insulating plates.

The invention and its mode of application

Data Bulletin

Circuit Breaker Characteristic Trip Curves and Coordination
Class 0600

TRIP CURVES AND COORDINATION

A coordination study is an organized effort to achieve optimum electrical distribution system protection by determining the appropriate frame sizes, ampere ratings and settings of overcurrent protective devices. When an overcurrent occurs in a properly coordinated distribution system, only the protective device nearest the fault will open. Lack of coordination between overcurrent devices can result in upstream devices opening, needlessly interrupting electrical distribution in other parts of the system.

Circuit breaker operating characteristics are graphically presented on time/current characteristic curves commonly called trip curves. To determine if proper coordination exists between molded case circuit breakers, a comparison of circuit breaker characteristic trip curves is necessary.

CIRCUIT BREAKER TRIP CURVES

The tripping characteristics of molded case circuit breakers can be represented by a characteristic tripping curve that plots tripping time versus current level. The curve shows the amount of time required for a circuit breaker to trip at a given overcurrent level.

Manufacturing tolerances result in a curve that is a band bound by minimum and maximum values of total clearing time. Total clearing time is the sum of the circuit breaker's sensing time, unlatching time, mechanical operating time and arcing time. For currents in excess of 125% of the circuit breaker rating at an ambient of 40°C, the circuit breaker will automatically open the circuit within limits specified by the band.

These limits are derived from actual test data and are within the limits established in Underwriters Laboratories Standard 489 for proper conductor protection.

See Figure 1 for an example of a thermal-magnetic circuit breaker trip curve.

Thermal Tripping Characteristics

The upper-left portion of each trip curve displays the circuit breaker's thermal response. On low-fault current levels, up to the magnetic tripping level, thermal tripping occurs when a bimetal conductor in the breaker responds to heat associated with the overcurrent. The bimetal conductor deflects, de-latching the mechanism and mechanically causing the circuit breaker to trip and open the circuit. The larger the overload, the faster the breaker will operate to clear the circuit (referred to as inverse time characteristics).

Magnetic Tripping Characteristics

The lower right portion of the curve displays the magnetic tripping response of the circuit breaker. This takes place when overcurrents of sufficient magnitude operate an integral magnetic armature which de-latches the mechanism. Magnetic tripping occurs with no intentional time delay.

The magnetic limits of Square D residential and industrial 100 A and smaller frame thermal-magnetic breakers are factory set at the time of manufacture and are non-adjustable. Thermal-magnetic circuit breakers 250 A frame and larger have an instantaneous magnetic trip which in most cases is adjustable from 5 to 10 times the circuit breaker's ampere rating. A single magnetic adjustment on the face of each circuit breaker sets the limits of the magnetic trip mechanism, which simultaneously adjusts all poles of the two or three pole breaker to the same magnetic trip level.

The tolerance on the nominal instantaneous trip levels on the HI setting are within the range of ±20% and within ±25% when on any other setting.

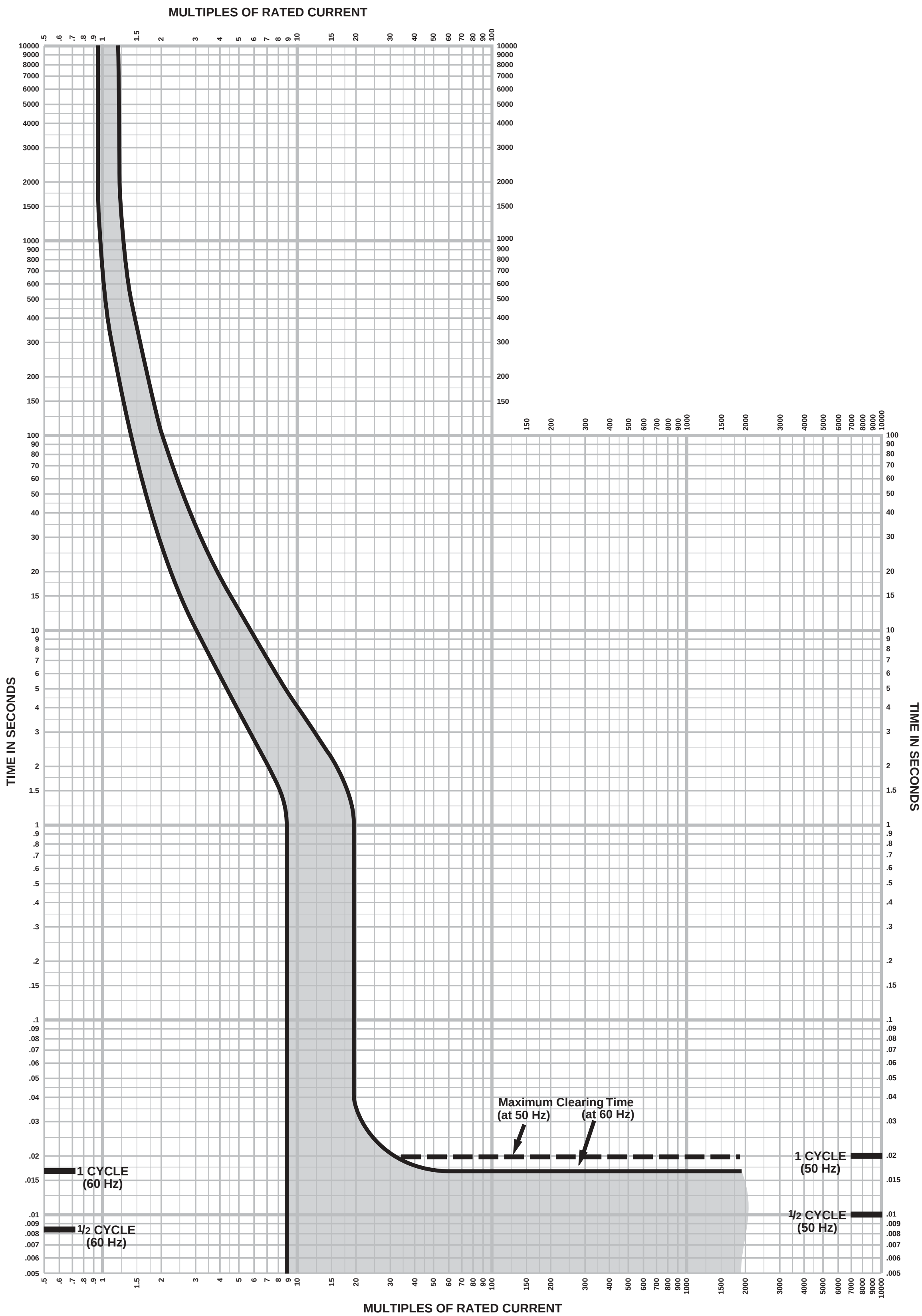

Figure 1: Thermal-magnetic Time/Current Characteristic Curve

Electronic Tripping Characteristics

Electronic trip circuit breakers are characterized by their adjustability. By adjusting the settings of the available trip unit functions, different tripping characteristics can be achieved.

Figure 2 shows various discrete segments of the trip curve that can be adjusted on an electronic trip circuit breaker. The following paragraphs describe the functions, their adjustments and how they affect the trip curve.

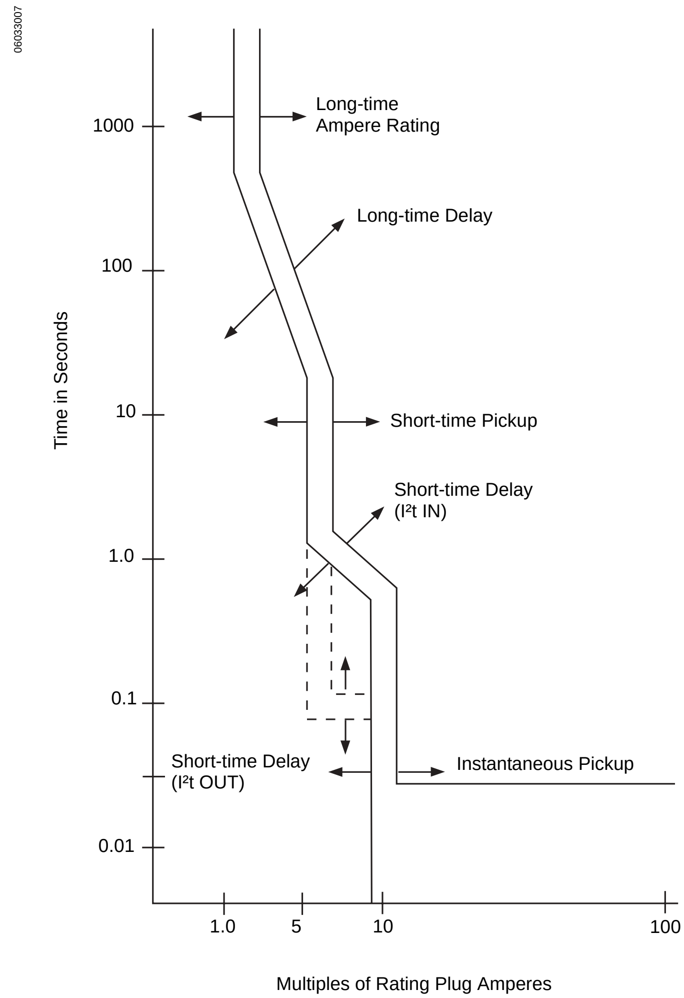

Figure 2: Electronic Trip Characteristic Curve

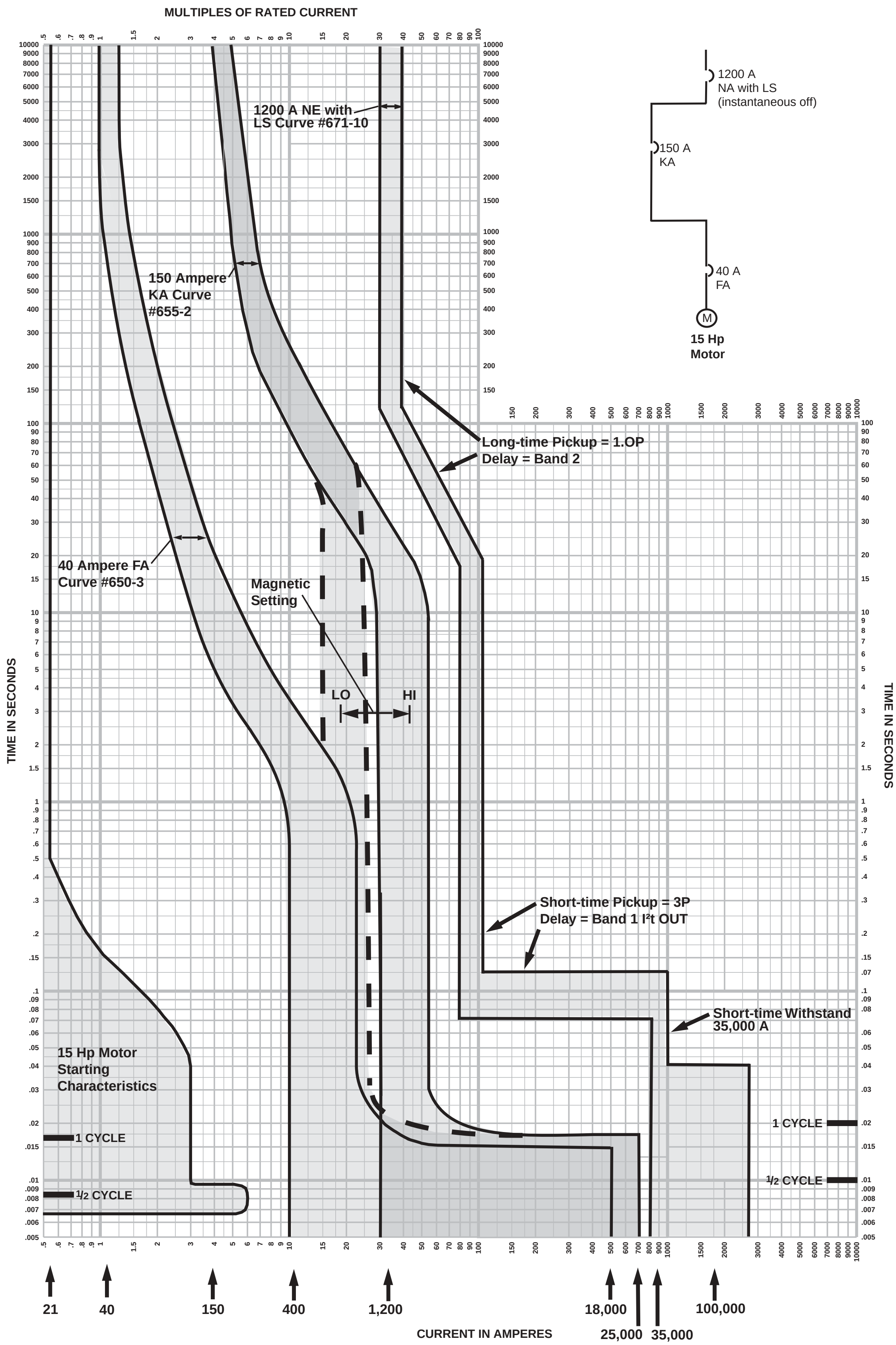

Figure 11: FA 40 A, KA 150 A and NE 1200 LS Circuit Breakers and Motor Coordination