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American National Standard (ANSI)

IEEE Std C37.11-1997(R2003)

(Revision of ANSI Std C37.11-1979)

IEEE Standard Requirements for Electrical Control for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

Sponsor
Switchgear Committee
of the
IEEE Power Engineering Society

Reaffirmed 9 December 2003
Approved 20 March 1997
IEEE Standards Board

Approved 20 August 1997
American National Standards Institute

Abstract: Standard requirements for all types of electrical control circuits for ac high-voltage breakers rated above 1000 V are given. This standard is applicable for any type of power-operated mechanism and for both ac and dc control power. Only basic control elements of the circuit breaker, including reclosing where required, are included in this standard. Devices or circuits for protective relaying, special interlocking, etc., are not included.
Keywords: ac high-voltage circuit breakers, alarm circuits, auxiliary contacts, auxiliary switch, closing, control schemes, electrical control, grounding, heater circuits, metal-clad switchgear, metal-enclosed switchgear, motor circuits, opening, re-closing, tripping

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ISBN 1-55937-917-0

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Introduction

(This introduction is not a part of IEEE Standard Requirements for Electrical Control for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.)

This standard is a revision of ANSI Std C37.11-1979. This revision is editorial in nature. There are no substantive changes in Figures 1 through 8, nor of the requirements. The purpose is to bring this standard up-to-date and in line with present-day requirements for ac high-voltage power circuit breakers and to bring it into agreement with IEEE Std C37.100-1992 , *IEEE Standard Definitions for Power Switchgear.*

As reflected in the title, this standard applies to ac high-voltage circuit breakers rated on a symmetrical current basis. A wide variety of control schemes is now in use by companies. Many of these users consider it essential that their particular scheme be continued so as to maintain unified operating practices within their company. It has been necessary, therefore, to set up certain preferred arrangements for wiring at the circuit breaker. These arrangements, in effect, constitute standards for production of the circuit breakers. They are, however, sufficiently versatile to permit the majority of users to connect the circuit breaker to their external circuits to achieve the required control scheme without changing the internal wiring of the circuit breaker. Diagrams of typical operating connections are included in this standard to demonstrate this versatility.

This standard includes only the basic control elements of the circuit breaker, including reclosing where required. It does not include devices or circuits for protective relaying, special interlocking, etc., since these are dependent upon the specific application of a particular circuit breaker. This standard is not intended to preclude the possibility of obtaining, as additional equipment, such devices or circuits, including auxiliary switches in excess of the specified minimum requirements, where necessary in a specific application.

It is not intended that the standard be considered inflexible as to future change. Future developments in both application and manufacturing, as well as further study of existing requirements, should result in revision and expansion of the standard.

The explanatory notes that appear in small type are included to give the user of this standard the reason or background for certain requirements.

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This standard was first developed by the Committee on Power Circuit Breaker Control and the Committee on Electric Switching and Switchgear of the Association of Edison Illuminating Companies. The present revision was prepared by the Working Group for the High-Voltage Circuit Breaker Subcommittee of the IEEE Switchgear Committee. The Working Group included the following members:

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IEEE Standard Requirements for Electrical Control for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

1. Overview

1.1 Scope

This standard applies to all types of electrically controlled ac high-voltage circuit breakers rated above 1000 V. This standard applies for any type of power-operated mechanism and for both ac and dc control power. Only the basic control elements of the circuit breaker, including reclosing where required, are included in this standard. This standard does not include devices or circuits for protective relaying, special interlocking, etc., since these are dependent upon the specific application of a particular circuit breaker.

1.2 Purpose

The purpose of this standard is to establish basic requirements for ac high-voltage power circuit breaker control schemes so that users and manufacturers can effect engineering and production economies by reducing the multiplicity of special control schemes that are specified in the absence of standards.

2. References

This standard shall be used in conjunction with the following publication. When a standard is superseded by an approved revision, the revision shall apply.

IEEE Std C37.100-1992, IEEE Standard Definitions for Power Switchgear (ANSI).[1]

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3. Functional requirements

The basic functional requirements of the control scheme for a circuit breaker include the following:

a) The circuit breaker mechanism shall make one complete closing operation, including automatic cutoff of closing power, after an initiating control device has operated and the first device in the control scheme has responded, even though the contacts of the initiating control device are opened before the circuit breaker closing operation is completed.

NOTE — This requirement ensures that, after the closing operation has been initiated, a seal-in circuit will be provided, where necessary, so that the closing operation will be completed automatically, even though the operator releases the control switch before the circuit breaker is completely closed.

Some circuit breakers achieve complete closing by electromechanical means, even if the closing signal has been removed before the closing operation is complete.

Control schemes in which the seal-in circuit or the equivalent is disconnected or made inoperative are objectionable because of the hazard to circuit breaker performance.

There are some definite purpose circuit breakers, with mechanisms specially designed to be able to open and interrupt safely, even during a closing operation, (i.e., before the circuit breaker has fully closed). Circuit breakers of this type are not subject to this requirement.

b) Only one closing operation of the circuit breaker mechanism shall result from each close signal of an initiating control device, even though the circuit breaker trips while the initiating control device is still in the closed position.

NOTE — This requirement ensures that the circuit breaker will not "pump" if it trips during a closing operation. The trip operation may be due to a fault or a failure to latch.

1) The control scheme may allow reclosing in the event that control power is interrupted while the initiating control device remains closed. For example, reclosing is not disabled when the control circuit is intentionally opened and closed while checking for grounds.

2) The control scheme should not allow reclosing in the event that control power is lost or reduced in voltage as a result of the closing operation, while the initiating control device remains closed. A typical example is the case in which control power is obtained from the primary power system. When the circuit breaker closes into a fault, the primary power system voltage is reduced, and subsequently the control power voltage is also reduced.

NOTE — With maintained-contact type initiating devices, such as pressure switches, fluid-level switches, etc., lockout relays or other devices are necessary to prevent reclosure if control power is interrupted during, or subsequent to, a circuit breaker tripping operation while the initiating closing device remains closed.

c) When power is removed from the closing control circuit during or after an incomplete closing operation, all electrically operated devices in the control circuit shall reset to the normal circuit breaker open position, except for those devices requiring a supply of control power in order for them to assume their normal circuit breaker open position.

NOTE — This requirement ensures that, if the control power supply is removed during an incomplete closing operation, all the control devices will restore to the normal circuit breaker open position so that an additional operation of the master control device will be required to close the circuit breaker. The reference to devices that require a supply of control power to assume their normal circuit breaker open position relates to control schemes that employ a reverse "Y" relay control.

d) When the circuit breaker is in the closed position, the operation of a close control device shall not result in an operation of the circuit breaker mechanism.

NOTE — This requirement ensures against unnecessary mechanical operation of the circuit breaker mechanism, with accompanying shock and possibility of trip-out.

e) When a closing operation of a circuit breaker utilizing stored energy, such as air, oil, or charged spring, etc., cannot be completed because of the absence of an adequate supply of stored energy, all actuating devices in

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the control circuit shall remain in the normal circuit breaker open position when the initiating close control device is operated.

f) When the interrupting capability of a circuit breaker is dependent on gas density or gas pressure, and that capability is inadequate or would become inadequate as a result of a closing operation, both closing and opening operations of that circuit breaker shall be prevented.

NOTE — Manufacturers can make available additional switches to initiate an alarm or tripping of a closed circuit breaker when the dielectric strength can not be maintained or suitable isolation accomplished, and before the interrupting capability becomes inadequate.

g) When the dielectric strength or interrupting capability of a circuit breaker is dependent on gas density or gas pressure, a switch shall be provided to initiate an alarm before the dielectric strength or interrupting capability becomes inadequate.

NOTE — Manufacturers can make available additional switches to initiate suitable isolation before the dielectric strength becomes inadequate.

h) If a circuit breaker operating mechanism is mechanically trip-free, and intended for automatic reclosing service, or if it may be damaged when closing with the mechanism in a non-latched position, then the closing release shall not operate, even if a signal to close is given, unless the trip-free mechanism is in the latched position.

i) The alarm circuits that monitor pressure shall be designed to avoid nuisance alarms due to transient pressure changes, when the circuit breaker is operated with normal operating pressures.

j) For circuit breakers that are capable of individual pole operation, pole disagreement tripping should be provided when the three poles are intended to be gang-operated together.

4. Devices and auxiliaries

The following devices or auxiliaries shall be included in each circuit breaker as indicated:

NOTE — When the circuit breakers are the drawout type, some devices and auxiliaries may be located within the switchgear assembly rather than on the drawout element.

a) A manually operated control circuit disconnecting device of the visible-break type, such as a knife switch or a pullout fuse block, shall prevent both remote and local electrical operation of the circuit breaker, and shall open both polarities of the circuit together.

NOTE — The purpose of a visible-break type disconnecting device is that a visual open break in the circuit can be made for safety reasons. Single-pole fuses are not an acceptable means of disconnection since these entail the following inconveniences in operation:

— Require holders for the removed fuses

— Can allow unintended single-pole energizing of the circuit

— Are subject to failure if the fuse clips are spread repeatedly for removal and reconnection of fuses

In Figures 1 through 8, both sides of the ac power control circuits and auxiliary connections (e.g., heaters) are illustrated as fused. This arrangement is intended to define standard numbering for many cases. It is assumed that the user and the manufacturer will apply fundamental safety rules requiring the grounded sides of ac circuits to be solidly connected and, therefore, not fused.

When dc power is used for both closing control devices and tripping devices, the user should provide or specify a separate disconnecting device in the trip circuit if the user elects not to carry the trip circuit through the disconnecting device provided for the closing circuit.

b) When ac power is used for closing and dc power is used for tripping, an additional two-pole manually operated control disconnecting device of the visible-break type, such as a knife switch or a pullout fuse block, shall prevent both remote and local electrical tripping of the circuit breaker, and shall simultaneously open

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both sides of the circuit. This device may be combined with the device specified in item a) to form a four-pole device.

c) Overcurrent protection devices for the ungrounded sides of the closing power circuit shall be connected to, or made integral with, the disconnecting device specified in item a).

NOTE — Separate overcurrent protection devices have been omitted from the trip circuit because most users either:

1) Do not protect trip circuits, or;

2) Use protective devices external to the circuit breaker, or;

3) Connect the trip circuit through the closing circuit protective devices.

d) In addition to the auxiliary switch contacts normally required for proper control of the circuit breaker operation and its indicating lights, as a minimum, the following extra auxiliary switch contacts shall be provided for utilization in the user's control circuits:

1) Circuit breaker NOT intended for use in metal-clad switchgear:

— Two "a" contacts (open when the circuit breaker main contacts are open, and closed when the circuit breaker main contacts are closed) and two "b" contacts (closed when the circuit breaker main contacts are open, and open when the circuit breaker main contacts are closed).

2) Circuit breaker intended for use in metal-clad switchgear:

— Two "a" contacts and two "b" contacts when closing and tripping power are dc.

— One "a" contact and one "b" contact when closing power is ac and tripping power is dc.

Where necessary to meet specific requirements, auxiliary switch contacts in addition to those specified may be made available by installing supplementary devices.

e) When heaters are supplied, a manually operated disconnecting device with overcurrent protection shall be connected in the power supply to the heaters. This disconnecting device shall simultaneously open all source connections to the heater. Overcurrent protection devices for the ungrounded sides of the circuit shall be connected to each pole of, or made integral with, the disconnecting device.

In an enclosed switchgear assembly, only one set of disconnecting and overcurrent protection devices need be furnished for all heaters.

f) When an individual motor is used for charging springs or for running a gas compressor or a hydraulic pump, etc., a manually operated disconnecting device of the visible-break type shall be connected in the power supply to the motor. The disconnecting device shall simultaneously open all source connections to the motor. Overcurrent protection devices for the ungrounded side of the circuit shall be connected to each pole of, or made integral with, the disconnecting device.

g) When an electrically operated regulating valve is used to maintain pressure levels in a system using air or other fluid, a two-pole manually operated disconnecting device of the visible-break type and one two-pole or two single-pole overcurrent protection devices shall be connected in the supply to the regulating valve.

5. Wiring requirements

The wiring requirements for a circuit breaker include the following:

a) Each circuit breaker shall be wired so that the individual components of the control circuit are electrically grouped, terminated, and identified with numerals as shown in Diagram A of Figures 1 through 8, as applicable for the particular type of circuit breaker.
Figures 1 through 8, inclusive, apply to circuit breakers as shown in Tables 1 and 2.

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Table 1— Circuit breaker intended for use in metal-clad switchgear

Closing power	Closing control	Tripping control	Figure
dc	dc	dc	1
ac	ac	dc	2
ac	ac	Capacitor trip	3
ac	dc	dc	4

Table 2— Circuit breaker not intended for use in metal-clad switchgear

Closing power	Closing control	Tripping control	Figure
dc	dc	dc	5
ac	ac/dc	dc	6
ac	ac	Capacitor trip	7
Pneumatic/hydraulic	dc	dc	8

b) The terminals intended for the user to connect the external control circuit wiring, and the terminals intended for making connections between control circuit groups, include the following:

1) Terminals for control circuit components specified in item a) above.

2) Terminals for the extra auxiliary switches specified in Clause 4., item d).

3) Terminals for the heater circuits and the individual motor circuits identified by numerals in Figures 1 through 8, inclusive.

These shall be readily accessible, closely grouped, and conveniently arranged for making connections between control circuit groups and for making connections to user's external wiring.

Further, the terminals of any auxiliary switch contacts in addition to those specified in Clause 4., item d), that may be available due to manufacturer's standard assemblies, or that may be supplied to meet user's specifications, should also be readily accessible, closely grouped, and conveniently arranged for making connections.

c) Circuit breakers forming part of switchgear cubicles, or for use in metal-clad switchgear, that have all of the control and protective features self-contained, are exempt from the provisions of having closely grouped terminals convenient for making user's external connections.

NOTE — Terminals in Notes E, F, and G in Figure 8 are identified with suffix A, for additional pressure and temperature devices and trip circuits to meet user's specifications. This does not mean that these additional terminals must be physically located adjacent to the terminals without suffixes and provided on all circuit breakers, whether or not they are required.

d) Before shipment, the manufacturer shall install the necessary removable jumpers between the various terminals so that when the circuit breaker is received, it will be operative after installation of the user's remote connections.

The proposal submitted to a purchaser in connection with an order for circuit breakers shall indicate the jumpers that the manufacturer plans to install before shipment, unless otherwise specified by the purchaser. Typical arrangements of jumpers are shown in Diagram B of Figures 1 through 8, inclusive, to illustrate some of the commonly used control schemes that are possible when the circuit breaker is wired in accordance with these standard schemes.

e) When only one terminal of a coil is connected continuously to a supply bus, that terminal should be connected to negative on dc circuits or to neutral (when available) on ac circuits.

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f) When control contacts are provided in heater circuits, the control contacts shall be connected to an ungrounded source conductor.

g) For circuit breakers equipped with dual trip releases, the control circuits for each trip coil shall be electrically independent. Loss of control power to one of the trip circuits shall not affect the function of the other trip circuit. Simultaneous operation of both trip releases shall trip the circuit breaker.

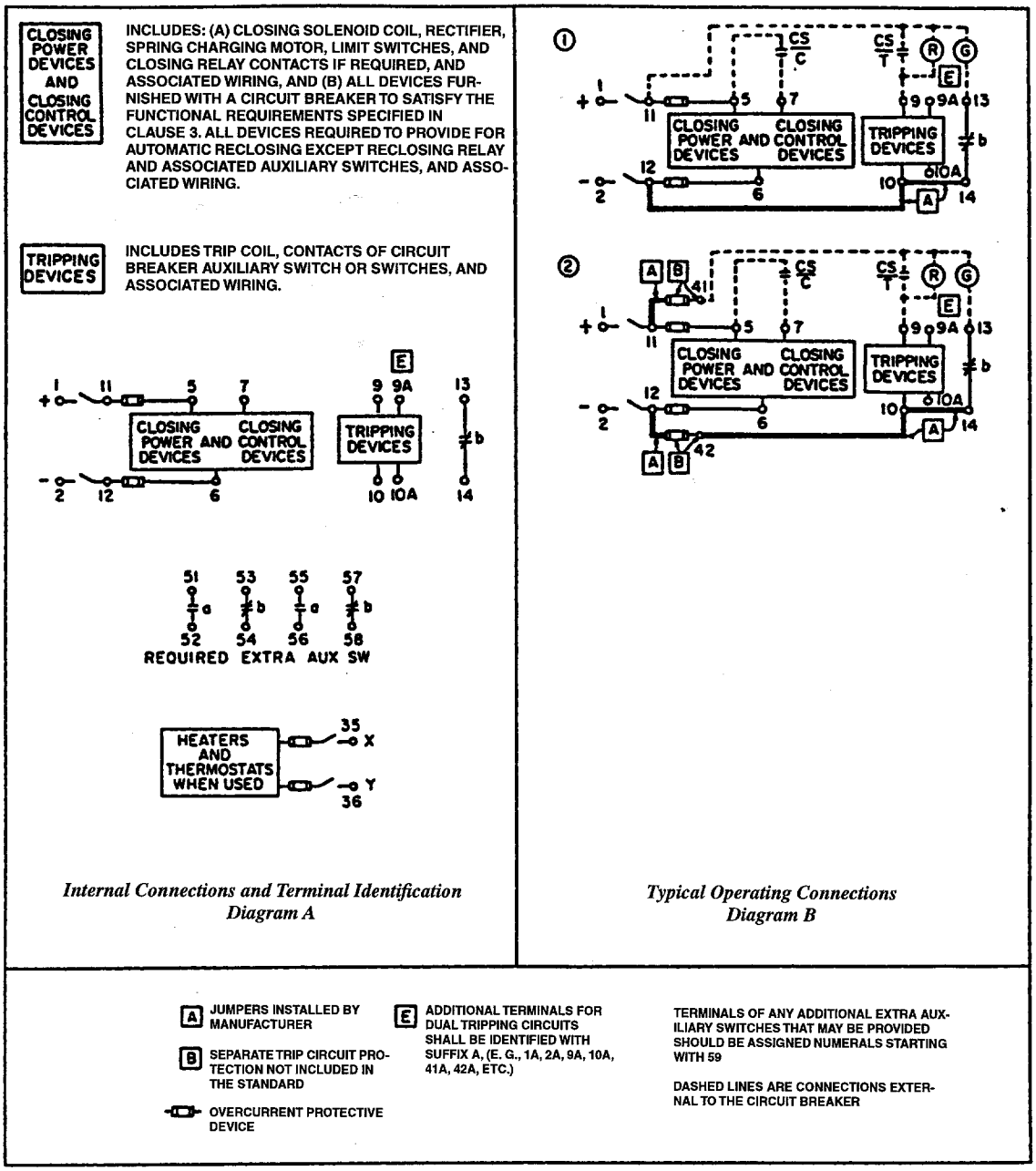


Figure 1— Circuit breaker intended for use in metal-clad switchgear, where the closing power is dc; the closing control is dc; the tripping control is dc

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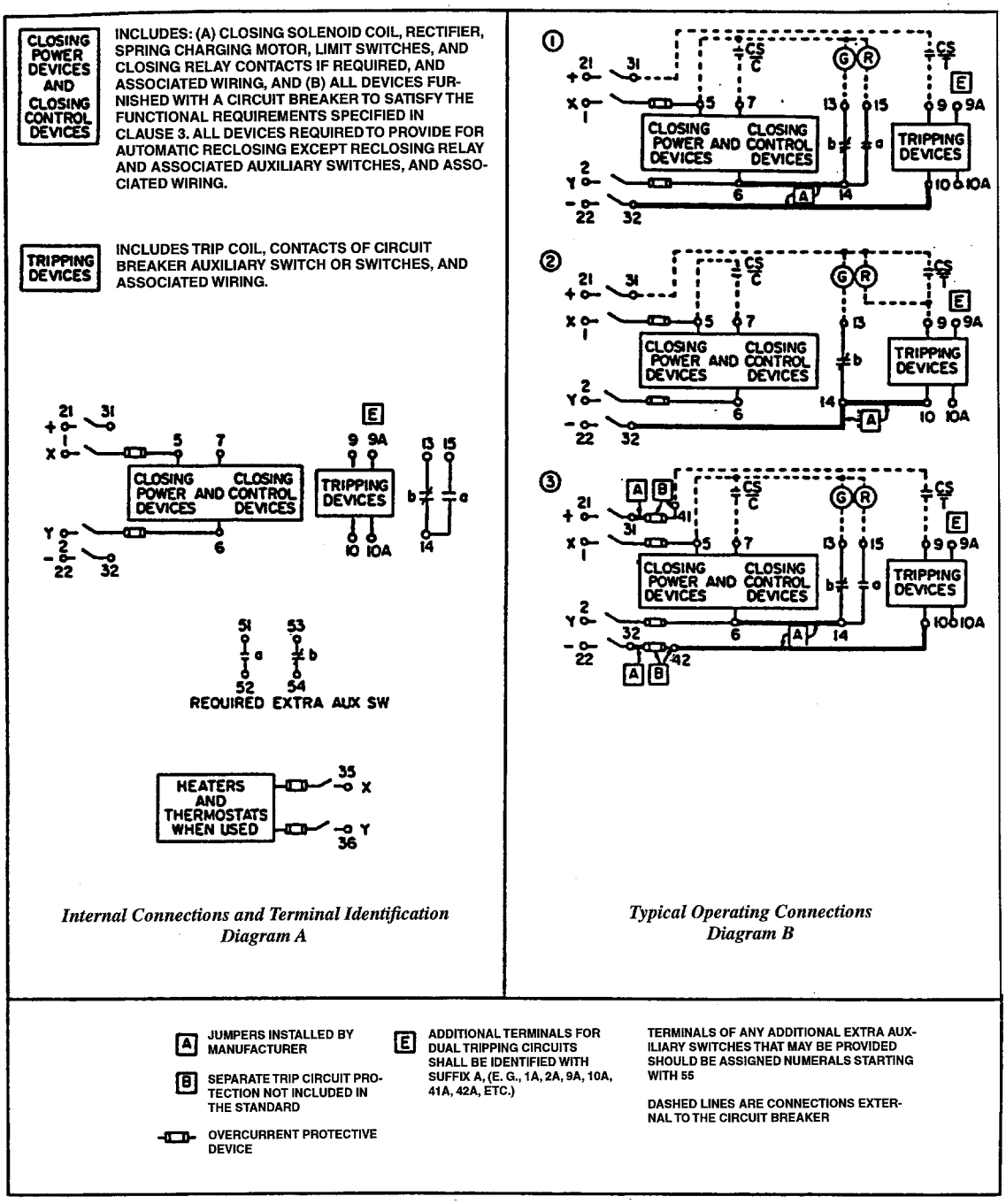


Figure 2— Circuit breaker intended for use in metal-clad switchgear, where the closing power is ac; the closing control is ac; the tripping control is dc

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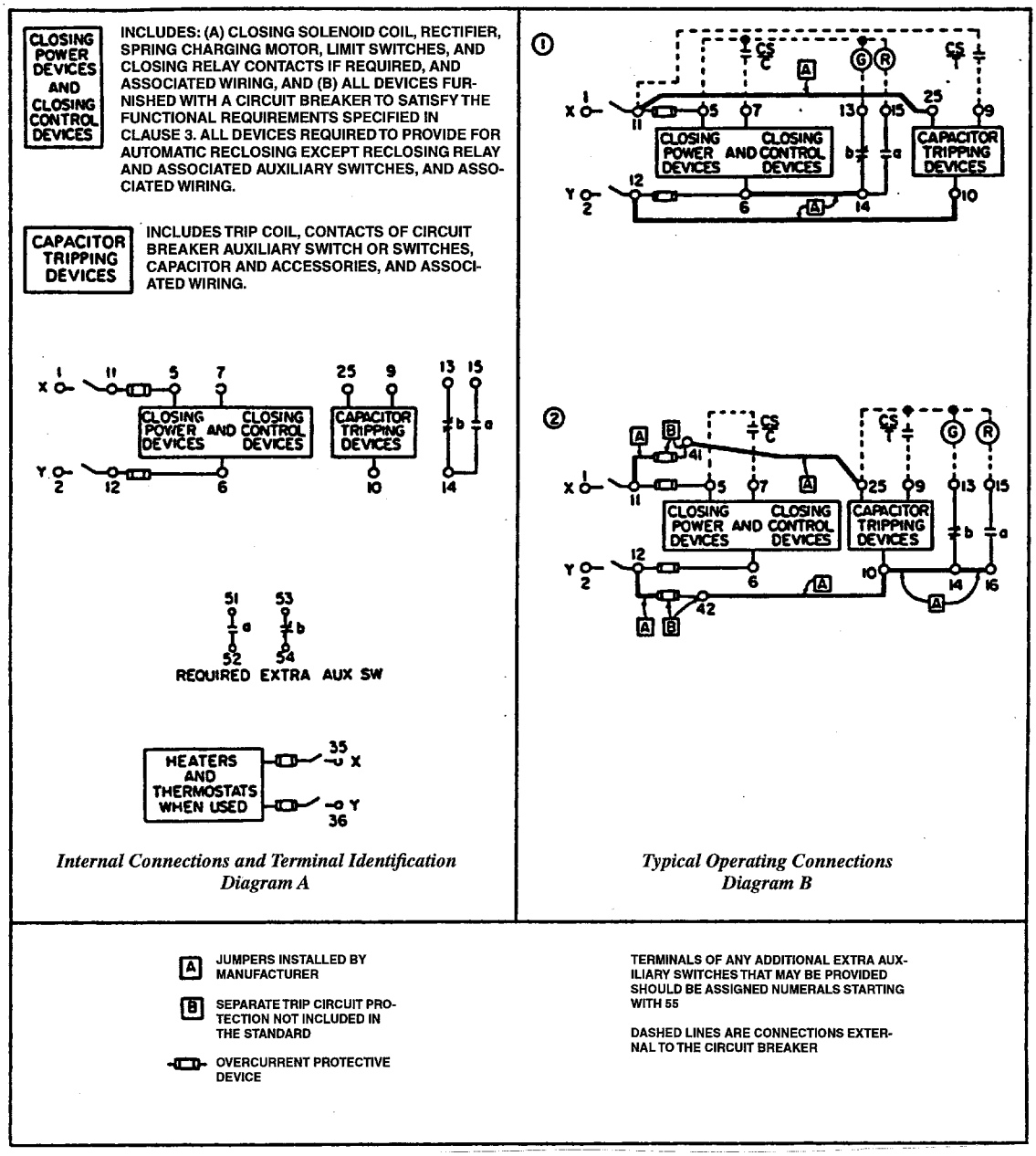


Figure 3— Circuit breaker intended for use in metal-clad switchgear, where the closing power is ac; the closing control is ac; the tripping control is by capacitor tripping devices

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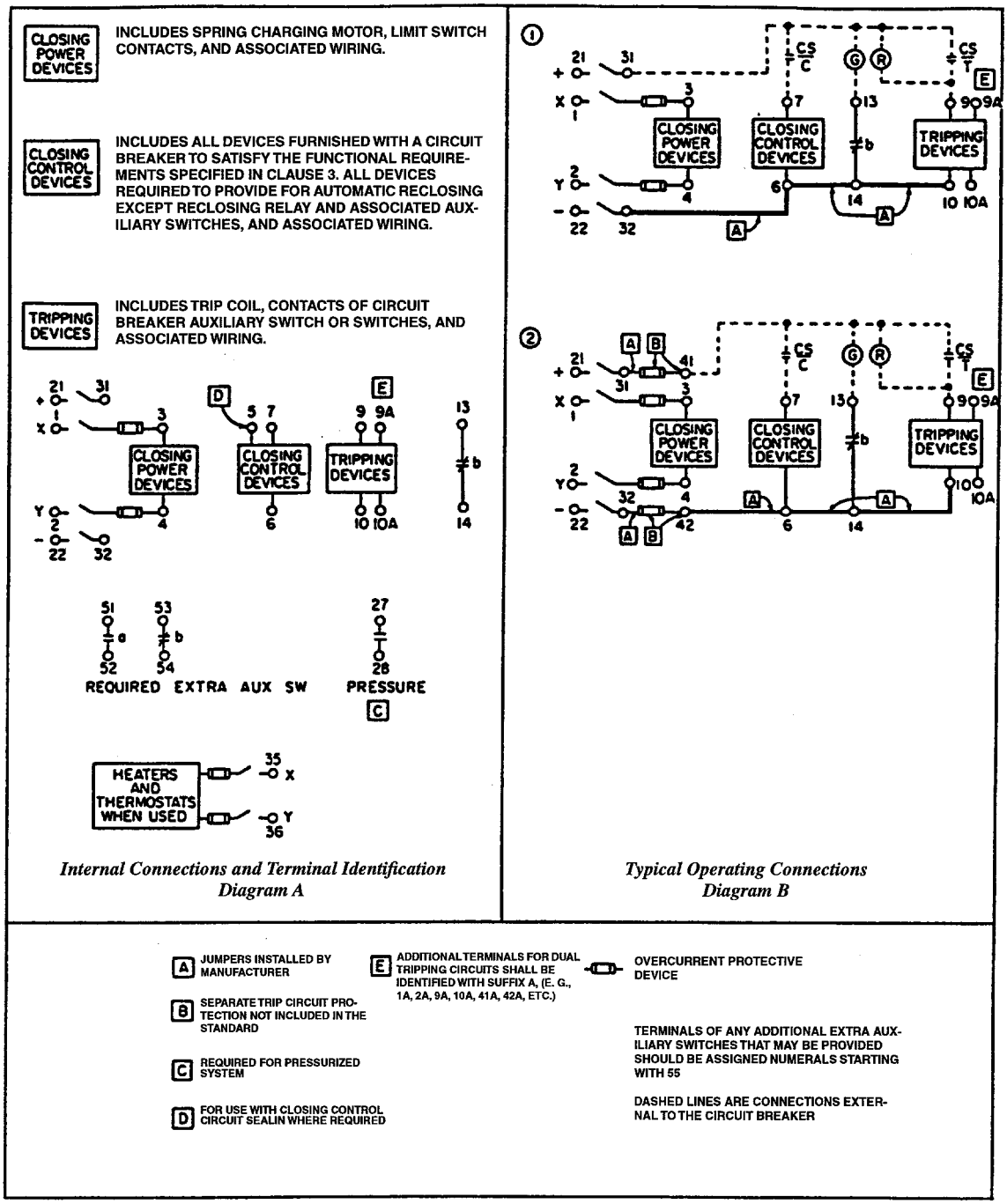


Figure 4— Circuit breaker intended for use in metal-clad switchgear, where the closing power is ac; the closing control is dc; the tripping control is dc

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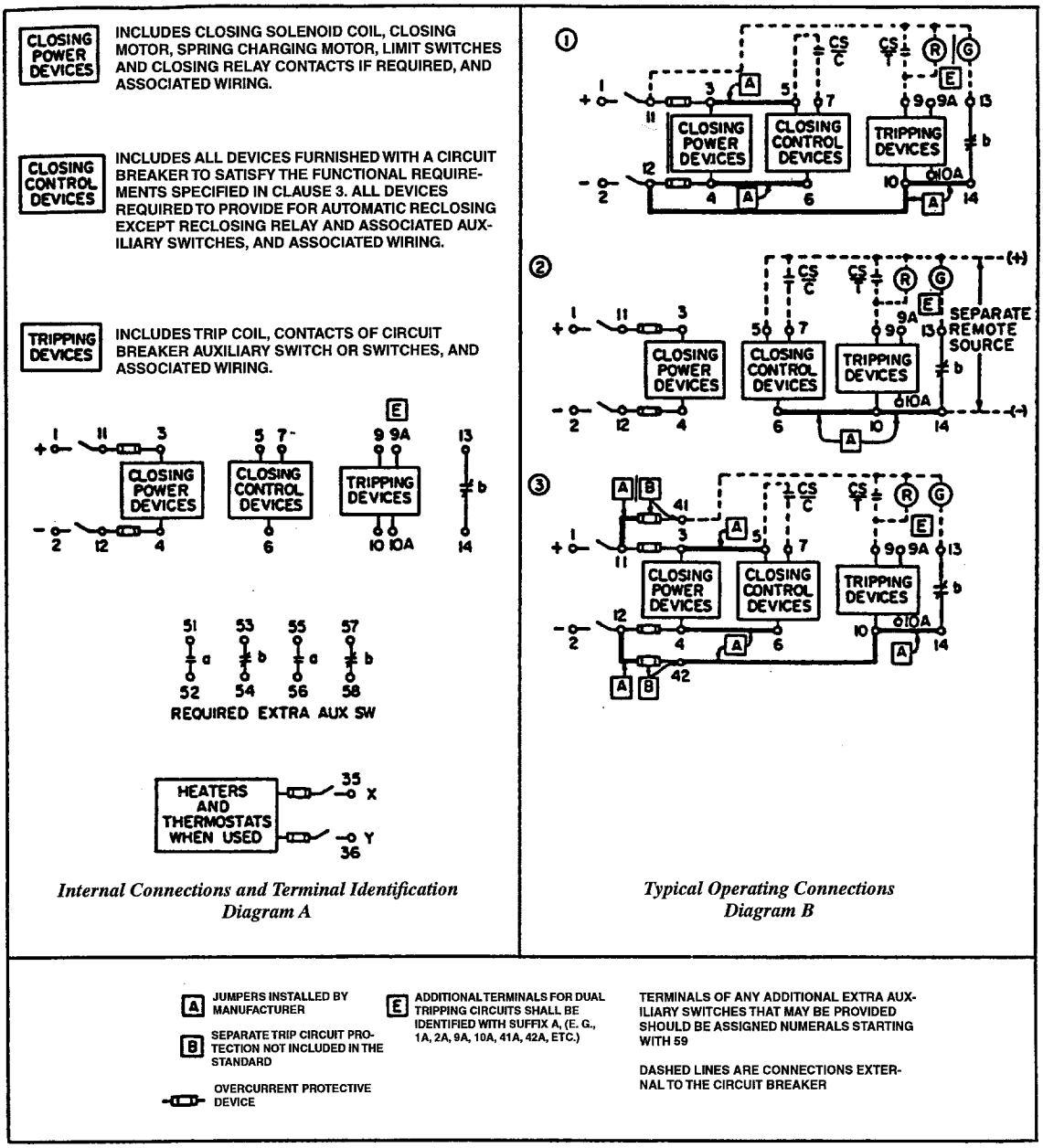


Figure 5— Circuit breaker NOT intended for use in metal-clad switchgear, where the closing power is dc; the closing control is dc; the tripping control is dc

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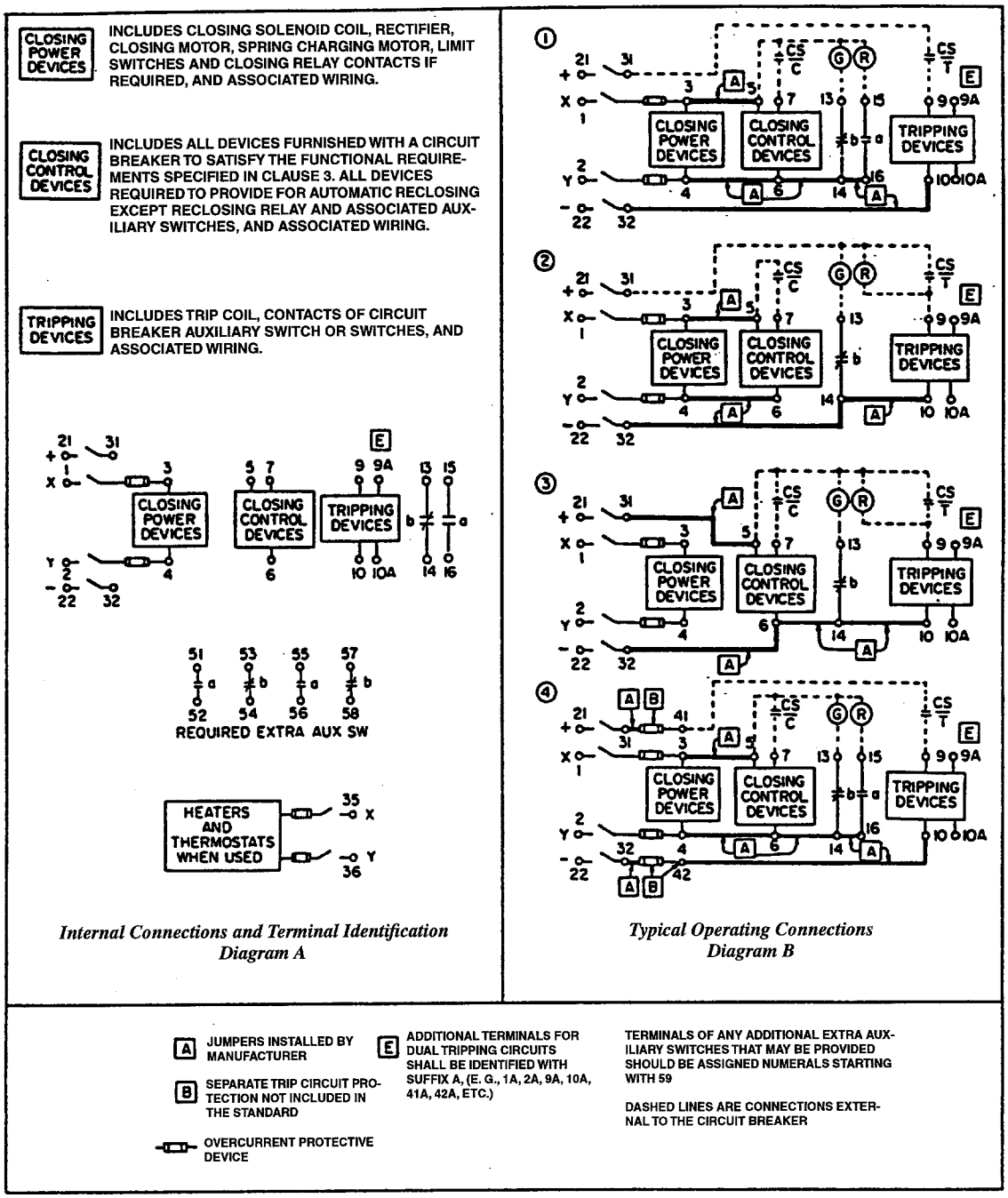


Figure 6— Circuit breaker NOT intended for use in metal-clad switchgear, where the closing power is ac; the closing control is ac or dc; the tripping control is dc

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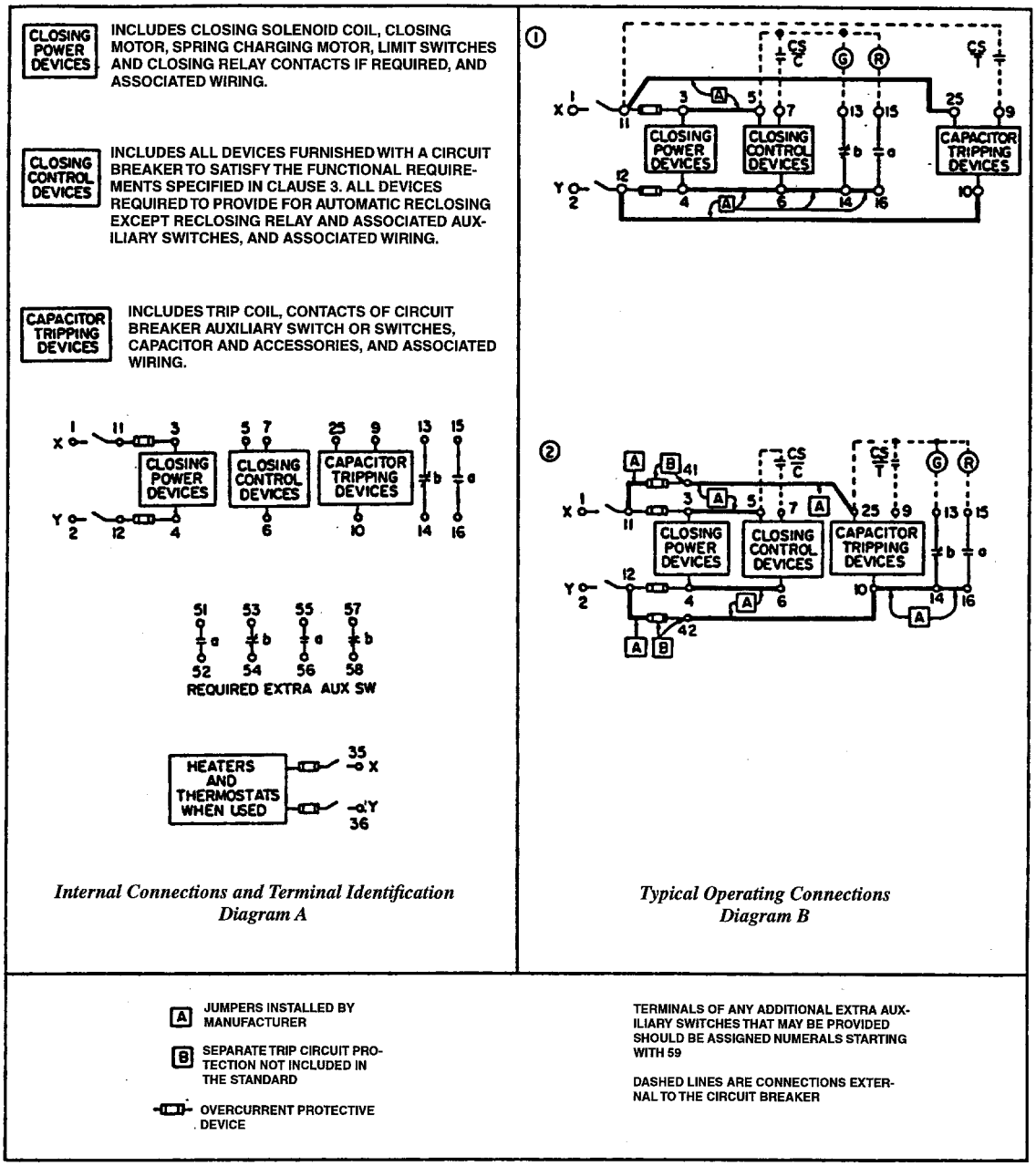


Figure 7— Circuit breaker NOT intended for use in metal-clad switchgear, where the closing power is ac; the closing control is ac; the tripping control is by capacitor tripping devices

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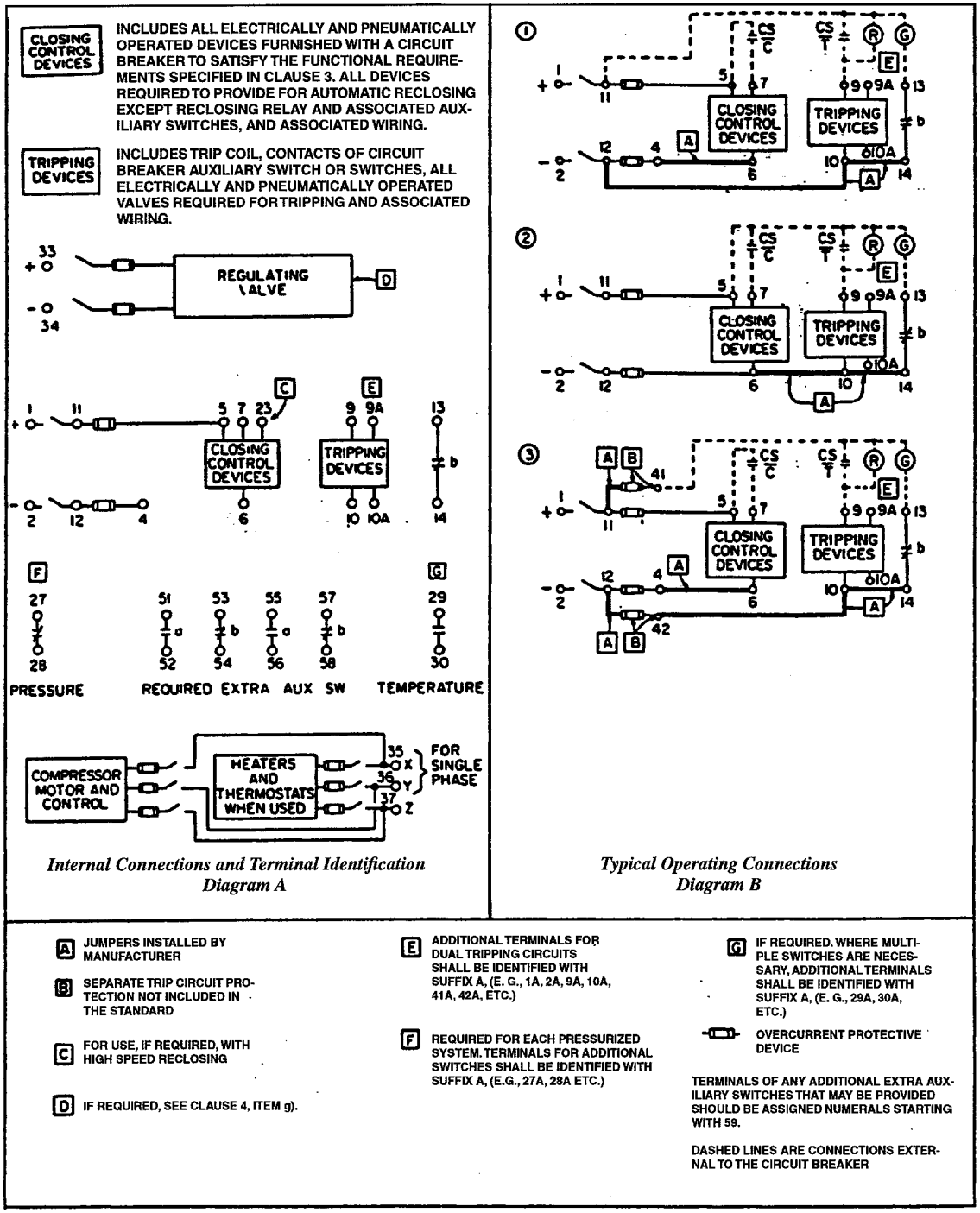


Figure 8— Pneumatically—or hydraulically—operated circuit breaker NOT intended for use in metal-clad switchgear, where the closing control is dc; the tripping control is dc

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