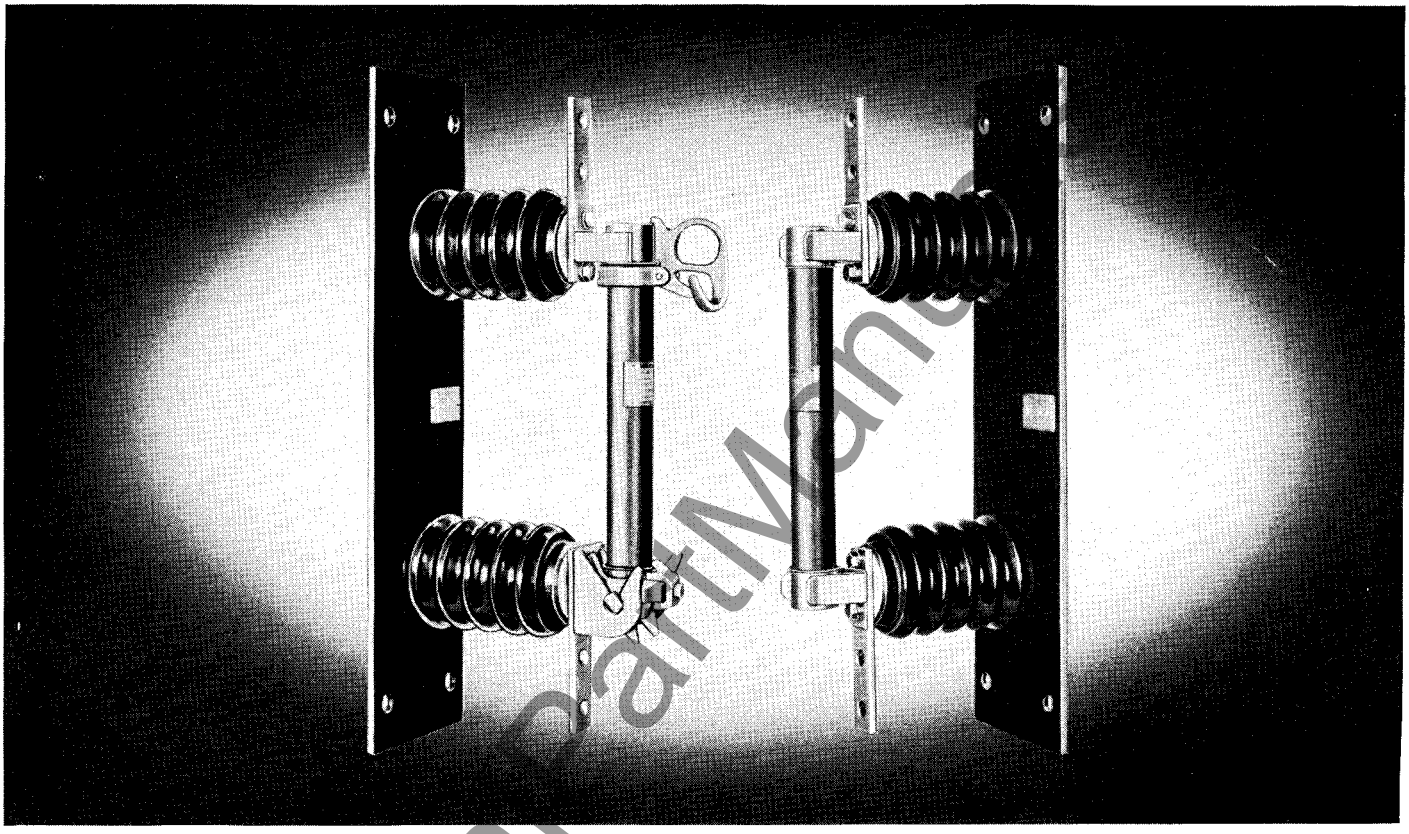
DESCRIPTIVE BULLETIN
36-340



DE-ION CURRENT-LIMITING POWER FUSE—TYPE BAL prevents short circuit currents from reaching their maximum value and thereby provides greater protective capacity for both the connected apparatus and the feeder system. The Type BAL fuse should be applied wherever it is necessary to limit short-circuit current on high-capacity systems or to control voltage during interruption to protect apparatus insulation:

- On potential transformers
- For small loads on high-capacity circuits
- On high-voltage motor starters

The Type BAL fuse also controls the surge voltage which is produced when the short-circuit current is limited. This surge voltage results from the system's released magnetic energy and is limited by the fuse to less than 160 percent of the peak system voltage.

POTENTIAL TRANSFORMER PROTECTION is an important use for current-limiting fuses. A complete line of Type BAL current-limiting potential transformer fuses of ½E-ampere rating is available from 2500 to 23,000 volts.

WESTINGHOUSE SPECIAL FEATURES

1. **EASY IDENTIFICATION OF BLOWN FUSE.** On fuses rated 2500 volts and above, a metallic disc projecting below the ferrule gives ready indication that the fuse has operated.
2. **COMPLETE HOOKSTICK OPERATION.** An ordinary hookstick serves for inserting, removing, and operating the disconnecting type fuse. No special device is needed.
3. **SINGLE TUBE ELEMENT COVERS ALL RATINGS.** Even the 200E rating is contained in a single tube.
4. **EASY REPLACEMENT OF FUSE FITTINGS** To replace a blown fuse, the fittings are simply removed from the fuse tube and clamped on a new fuse unit.
5. **FUSE IS ENCLOSED.** There is no flame discharge when the fuse operates.
6. **QUIET OPERATION.** Unit is enclosed for silent operation. Built-in condenser condenses steam evolved from boric acid during interruption of fault currents.

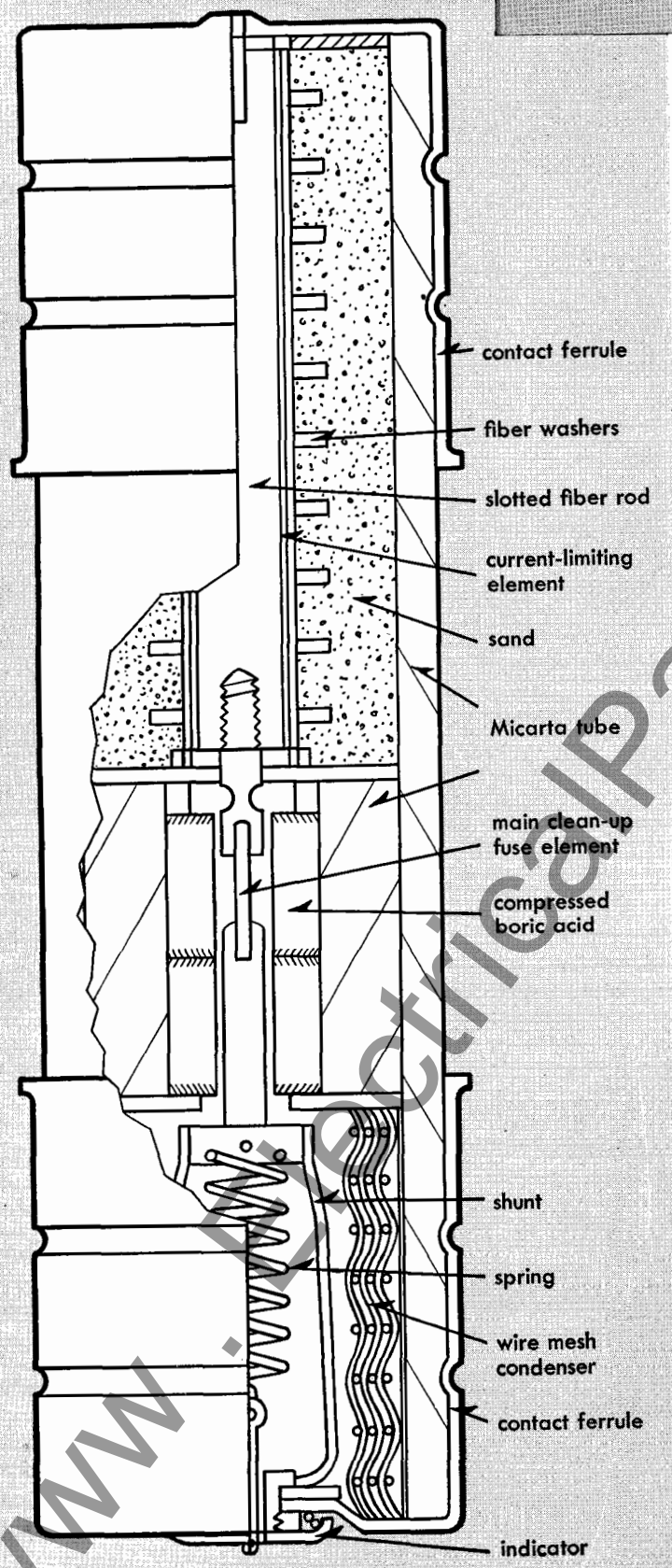
Supersedes Descriptive Bulletin 36-340, dated December, 1951
E/294/DB; D64-5E; C28-5J; Classified File

NOVEMBER, 1956

CONSTRUCTION

THE CURRENT-LIMITING ELEMENT consists of a number of silver wires placed in slots in a fibre rod. In the fuse this assembly is surrounded by sand, on which the silver vapor condenses when a high fault current causes the silver to melt.

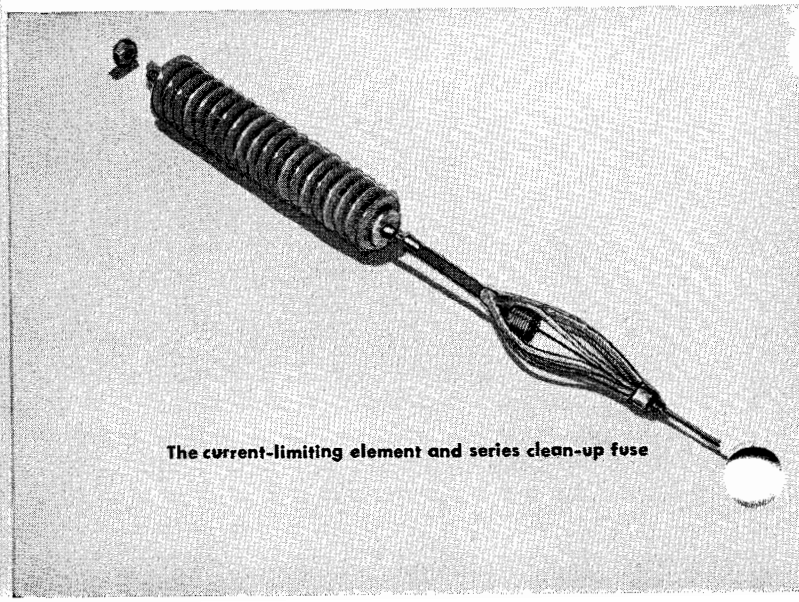
THE MAIN FUSE OR CLEAN-UP ELEMENT, which serves as the final interrupter of any fault current which blows the fuse, is connected in series with the current-limiting element. The fusible element itself is of the low-temperature type and is designed to give the desired time-current characteristics. This element is spring operated to insure positive separation of the fuse element on low fault current operations. This main fuse element operates in a small hole in solid compressed boric acid. Boric acid as an interrupting medium in fuses has an excellent record—for operation on both low and high-current faults.



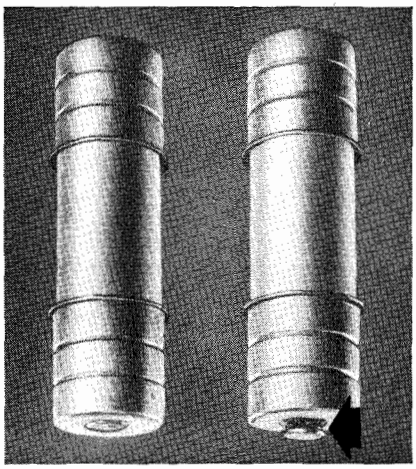
Cross section drawing showing component parts of a Type BAL fuse unit

FUSE REPLACEMENT SPARE UNITS

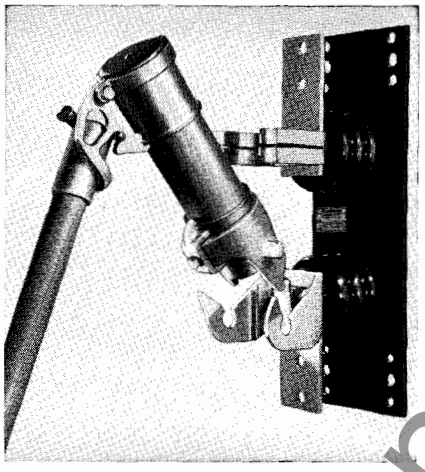
For installations of less than 12 Type BAL fuses, it is recommended that 100 percent spares be kept on hand so that replacement can be made with minimum delay. For larger quantities (of the same rating) the percentage of spares may be decreased as the number installed is increased.



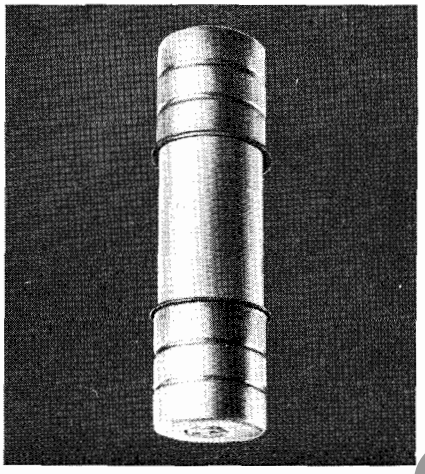
The current-limiting element and series clean-up fuse



METALLIC DISC projects below ferrule to indicate that fuse has operated.



HOOKSTICK serves for inserting, removing, and operating the disconnecting type fuse.



SINGLE TUBE ELEMENT covers all ratings, including the 200E rated fuse.

FUSE FITTINGS are easily removed from blown fuse, and clamped on a new fuse tube.

THREE-FOLD PROTECTION FOR POWER SYSTEMS

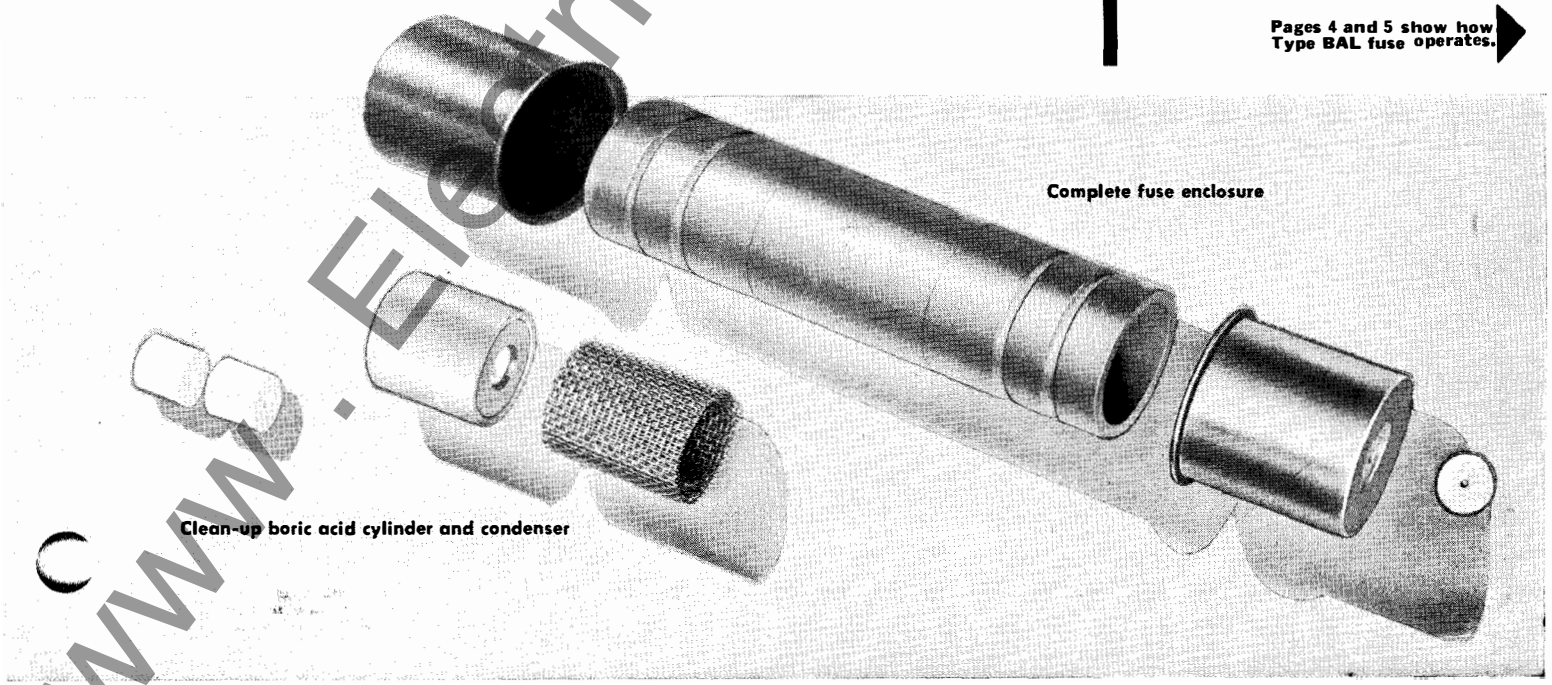
The Type BAL fuse is particularly adapted for connecting apparatus close to the generating source. For example, if a fault should occur in a potential transformer protected by BAL current-limiting fuses, three-fold protection is provided, because the fuse:

1 INTERRUPTS CURRENT. Whether the fault is of high or low magnitude, circuit interruption is positive. Main fuse element provides desired time-current characteristics . . . spring operation insures positive separation of fuse elements even on low fault currents.

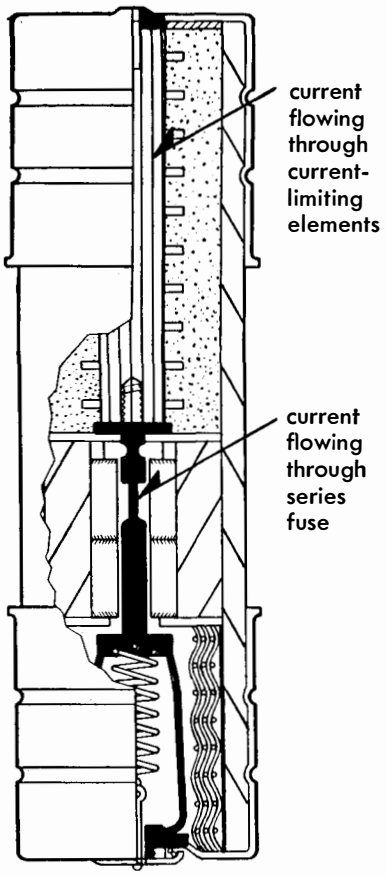
2 LIMITS FAULT CURRENT. The current-limiting feature of Type BAL fuse units limits the short-circuit current to a value which can be safely handled by the interrupting element of the fuse. This permits application of Type BAL fuses on systems having high short-circuit capacities where the lower interrupting capacity of non-current-limiting fuses would be inadequate. This also limits the magnitude of electromechanical stresses in the bus structure and cables.

3 LIMITS SURGE VOLTAGES. High surge voltages, incident to current limitation, are controlled by the voltage-limiting characteristics to a value which is safe for the system's insulation.

Pages 4 and 5 show how Type BAL fuse operates.



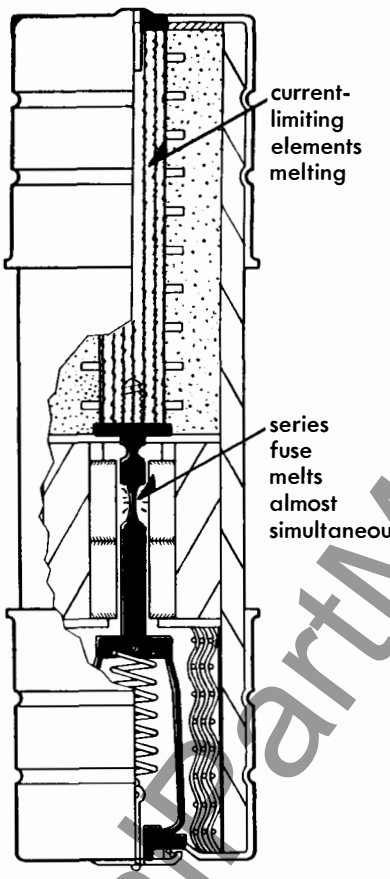
normal current flow



VOLTAGE

CURRENT

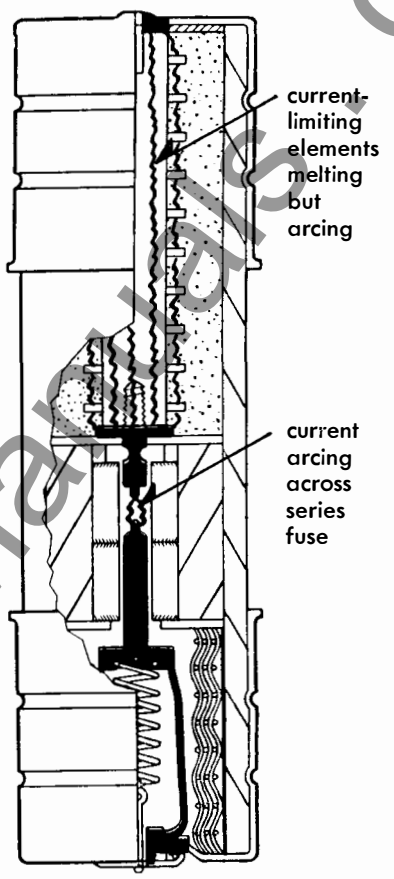
short circuit



VOLTAGE

CURRENT

series fuse melted



VOLTAGE

CURRENT

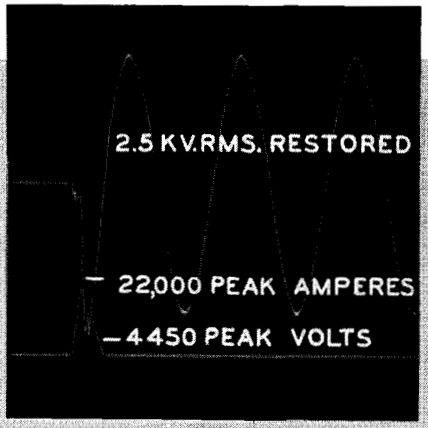
TWO-WAY FUSE OPERATION

THE MAGNITUDE OF FAULT CURRENT determines which of two ways the fuse operates. On low magnitude fault currents, the series fuse operates in the same manner as in the standard boric acid power fuse. The blast of steam from the boric acid de-ionizes and extinguishes the arc, while the copper screen condenses the steam to water. During this process the current-limiting elements do not melt and play no part in the interruption.

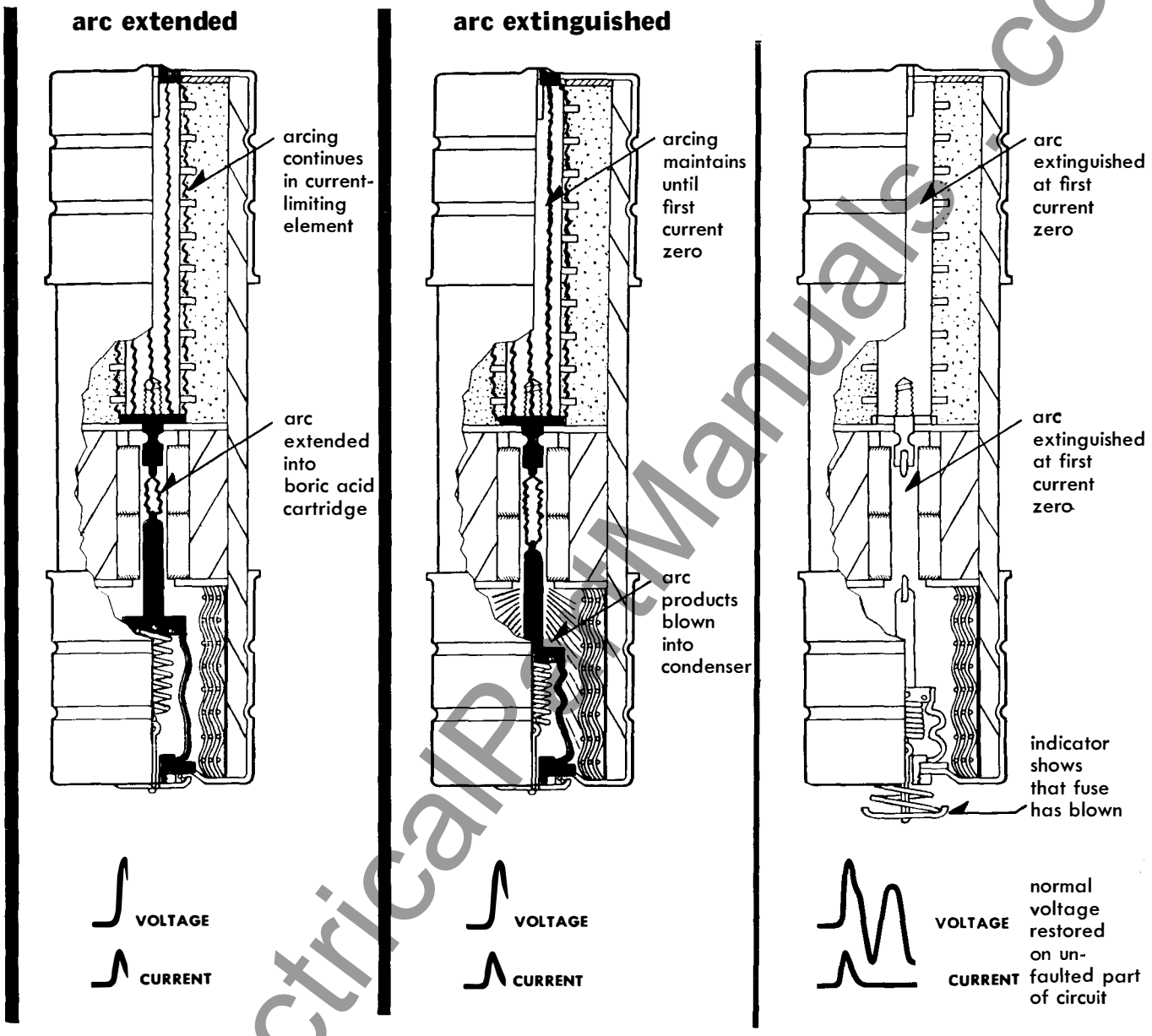
On heavy short-circuit currents, the current-limiting element of the fuse melts in a small fraction of a cycle. The fusion of the current-limiting elements in their restricted fibre slots generates a relatively high-arc voltage which prevents further rise in the fault current. Almost simultaneous with this action, the series fuse element melts and clears the fault current.

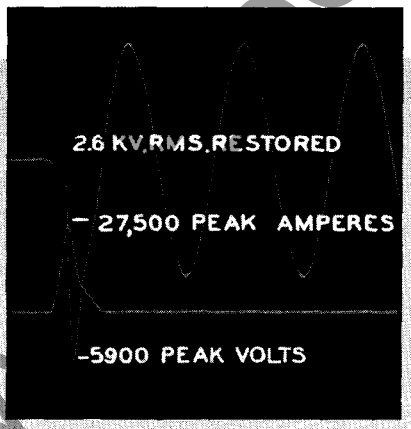
MAGNETIC OSCILLOGRAMS

of interrupting tests . . . on 2.5-Kv, 200-ampere, 2-element current-limiting fuse

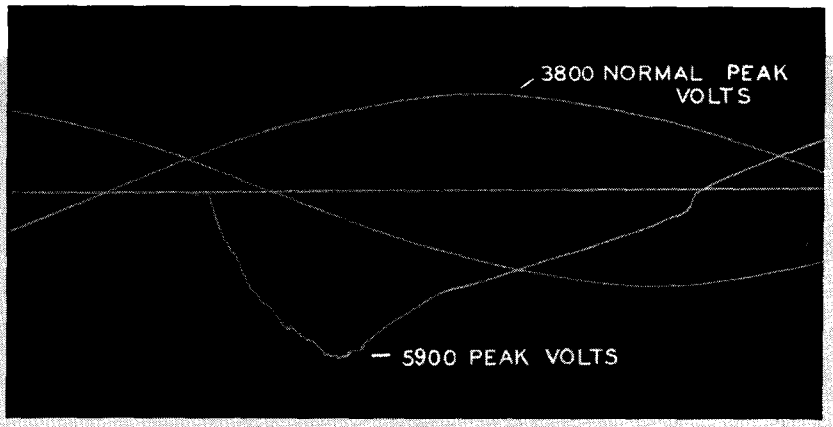


Test voltage, 2500 volts. Maximum system short-circuit current, 40,000 rms amperes. Short circuit applied to give symmetrical fault.



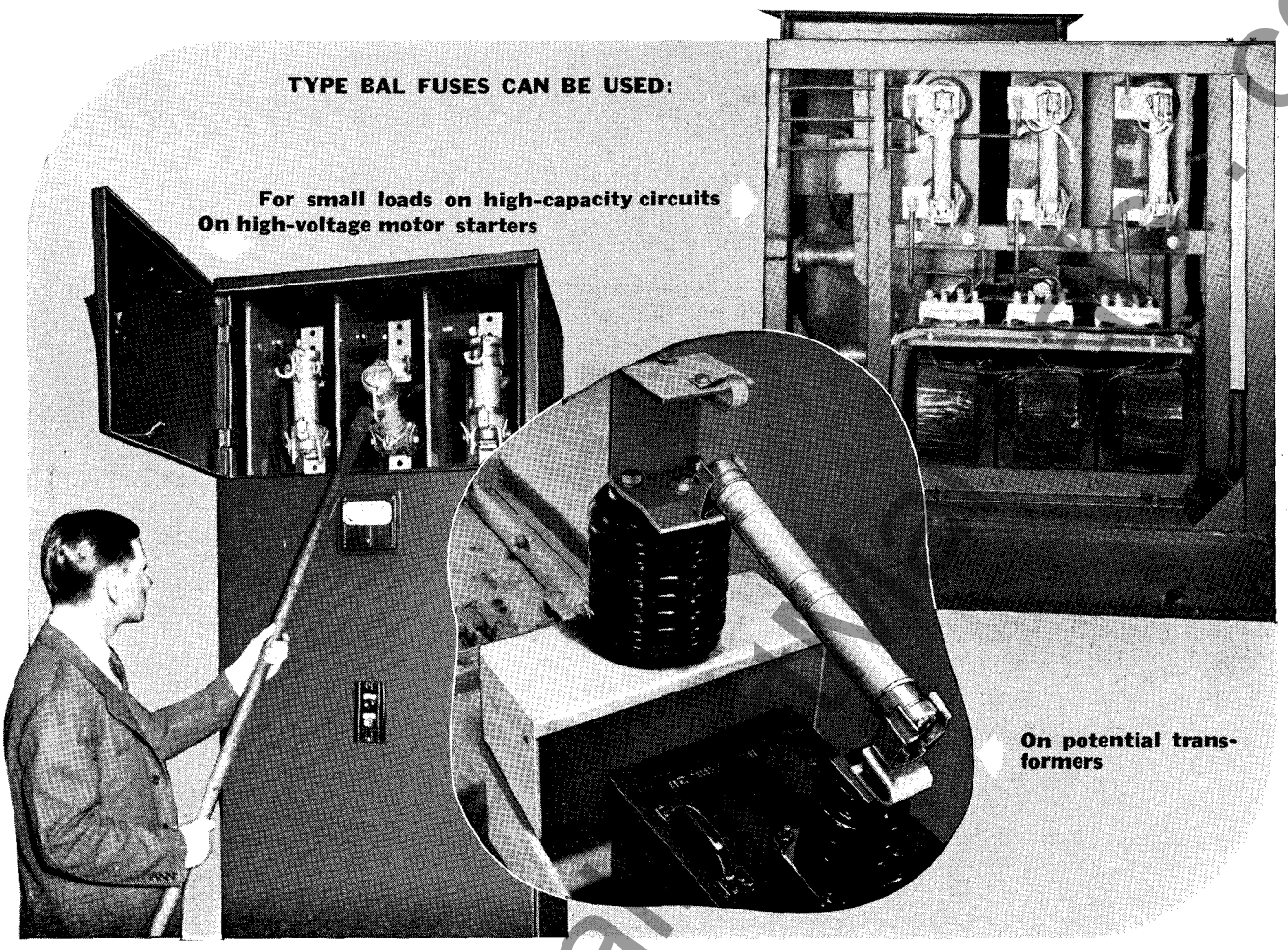


Test voltage, 2500 volts. Maximum system short-circuit current, 60,000 rms a peres. Short circuit applied to give asymmetrical fault. Note higher peak voltage and longer duration of current resulting in more severe duty.



Cathode Ray Oscillogram of voltage during interruption by 2.5-kv, 200-ampere fuse shown on magnetic oscillogram at left.

TYPE BAL FUSES CAN BE USED:



PERFORMANCE

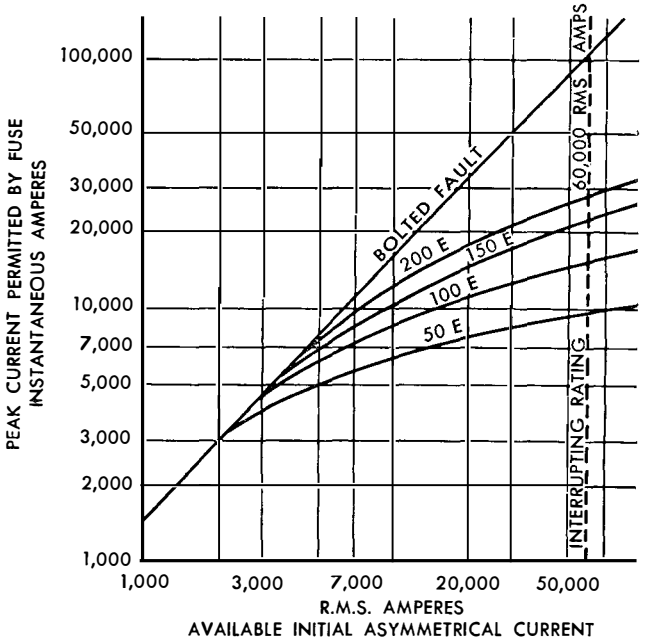
B.I.L. ∅ VOLTAGE RATING†	*CURRENT RATING	‡INTERRUPTING CAPACITY ASYMMETRICAL AMPERES
600	2E to 5E	100,000
2,500	½E to 200E	60,000
5,000	½E to 200E	60,000
7,500	½E to 100E	80,000
15,000 L or H	½E to 10E	130,000
	15E to 100E	50,000
23,000	½E	70,000

∅ Basic Impulse Insulation Levels.

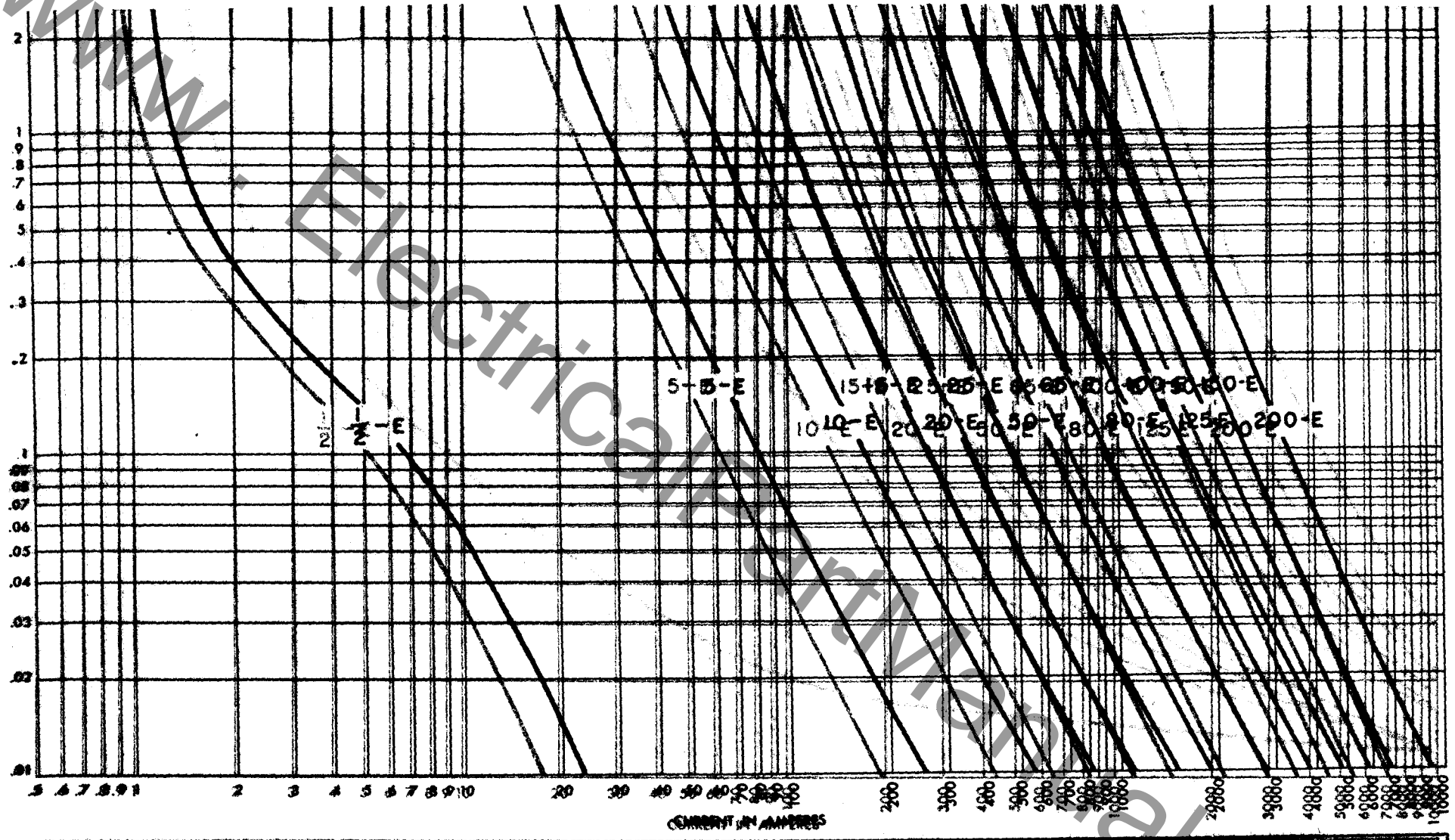
† CAUTION—Select fuse unit of nearest voltage rating above the line-to-line voltage. Do not over insulate with higher voltage rating fuse unit, as overvoltages may occur during interruption.

* Current ratings of BAL fuses are based on the NEMA "E" power fuse current rating standard. These requirements specify that fusible elements rated 100 amperes or below shall melt in 300 seconds at an rms current within the range of 200 to 240% of the continuous current rating of the fuse units. Fusible elements rated above 100 amperes shall melt in 600 seconds at an rms current within the range of 220 to 264% of the continuous rating of the fuse units.

‡ First ½ cycle rms including d-c component.



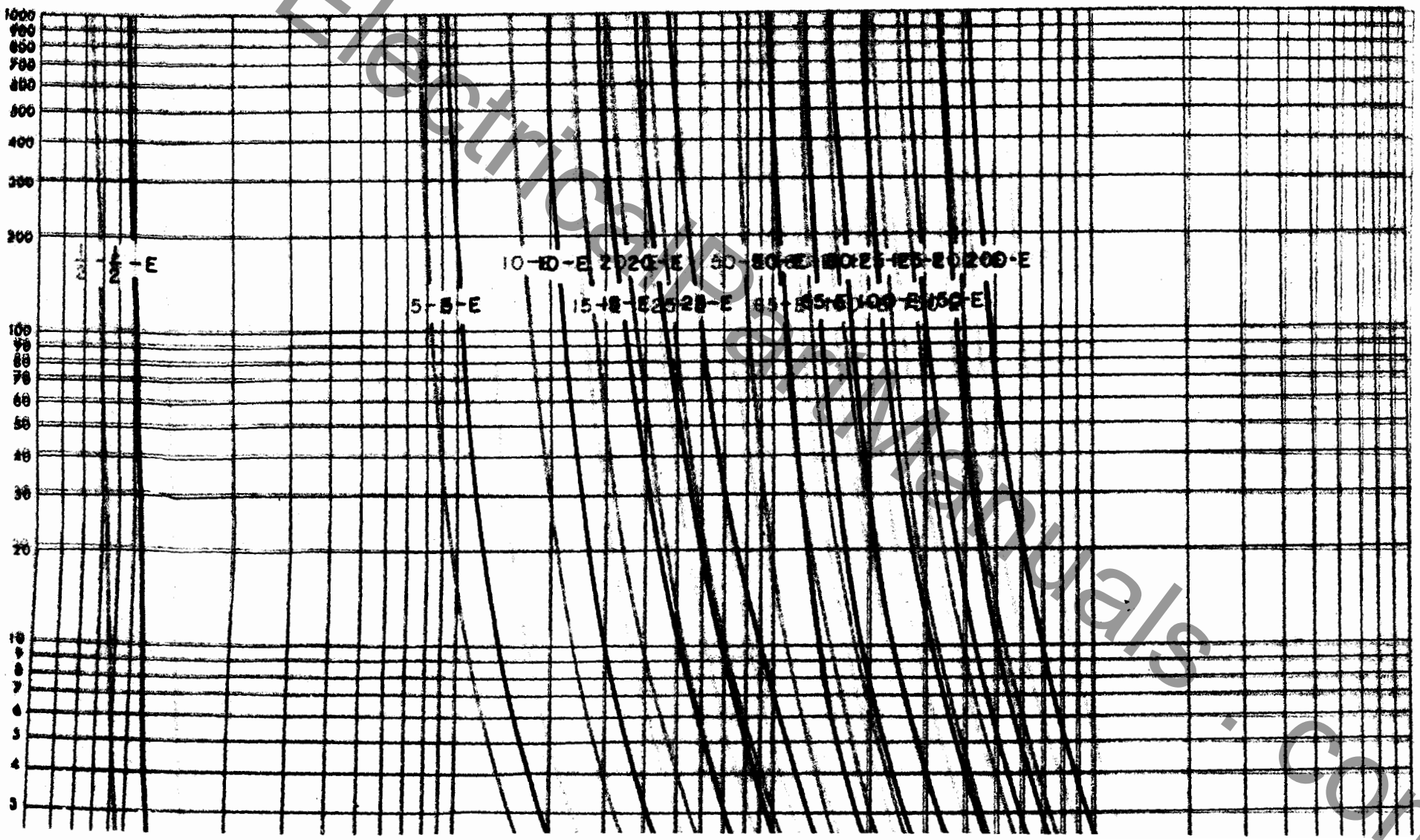
Current-limiting characteristic curves showing maximum fault current permitted by current-limiting element for all values of available short-circuit currents.



MINIMUM MELTING—CURRENT-CURRENT CHARACTERISTICS CURVES

WESTINGHOUSE TYPE EBALL FUSSES

CURVE NO. 21



INTERRUPTING RATINGS

FUSE RATING			INTERRUPTING RATING AT SYSTEM VOLTAGE									
FUSE VOLTAGE RATING †	CURRENT RATING	FREQUENCY RATING	2400 VOLTS		4160 VOLTS		6900 VOLTS		13,800 VOLTS		22,000 VOLTS	
			AMP.*	KVA‡	AMP.*	KVA‡	AMP.*	KVA‡	AMP.*	KVA‡	AMP.*	KVA‡
2,500	.5E	25-60	60,000	156,000	.....	.....	.....	.....	.....	.....	.....	.....
	15E to 200E	50-60	60,000	156,000	.....	.....	.....	.....	.....	.....	.....	.....
5,000	.5E to 10E	25-60	60,000	156,000	60,000	270,000	.....	.....	.....	.....	.....	.....
	15E to 200E	50-60	.....	.....	60,000	270,000	.....	.....	.....	.....	.....	.....
7,500	.5E to 5E	25-60	.....	.....	.....	.....	80,000	600,000	.....	.....	.....	.....
	15E to 100E	50-60	.....	.....	.....	.....	80,000	600,000	.....	.....	.....	.....
15,000 L or H	.5E to 10E	25-60	.....	.....	.....	.....	.....	.....	130,000	1,940,000	.....	.....
	10E to 100E	50-60	.....	.....	.....	.....	.....	.....	50,000	750,000	.....	.....
23,000	.5E	25-60	.....	.....	.....	.....	.....	.....	.....	.....	70,000	1,650,000

* Asymmetrical rms current (1.6 x symmetrical) at system voltage.

‡ Symmetrical 3-phase kva equivalent at system voltage, based on initial rms symmetrical amperes.

† **CAUTION**—Select fuse unit of nearest voltage rating above the line-to-line voltage. Do not over insulate with higher voltage rating fuse unit, as overvoltages may occur during interruption.

TYPE BAL FUSE INTERRUPTING RATINGS . . .

Are Based on Short-Circuit Current, Including Transient D-c Component

The BAL fuse is an inherently fast circuit-interrupting device. This must be taken into account when determining the required short-circuit interrupting rating.

The BAL fuse will interrupt currents of short-circuit magnitude in approximately ½ cycle measured from the instant of short circuit. During this ½ cycle, the calculated short-circuit current may be much higher than the sustained rms short-circuit current of the system at that point. The fuse must be capable of safely interrupting this transient current which might exist at the instant the fuse operates.

In an alternating-current circuit containing inductance, a sudden change in the a-c current is accompanied by a transient d-c component of current. The magnitude of this d-c component of current is a function of the a-c current before and after the change and the point on the cycle at which the change occurs. The decrement of the transient is a function of the inductance and resistance or losses of the circuit.

If a fault is suddenly established on a circuit, this d-c component can have a maximum peak value equal to the crest of the 60-cycle, short-circuit current of the system. This maximum transient is obtained if the fault occurs at voltage zero. Due to the system losses, this d-c component will die out to a low value in a few cycles. However, the fuse normally interrupts the short circuit in ½ cycle, and this d-c component of current must be taken into consideration in rating the fuse. If the decrement of the d-c component is neglected in this half cycle, the rms value of current would be 1.73 times the rms value of the 60-cycle component for the totally asymmetrical condition.

Experience has shown that there is some decrement in this first half cycle. For this reason, a ratio of 1.6 has been selected between the rms asymmetrical current and the symmetrical current. The fuse must be designed to interrupt the rms short-circuit current of the system on which the fuse is to be used.

HOW ASYMMETRICAL VALUE IS DETERMINED

This instantaneous rms asymmetrical value of short-circuit current, which the fuse must be designed to interrupt, is also often referred to as the rms symmetrical value including the d-c component. The asymmetrical value is obtained by multiplying the symmetrical value by 1.6. The symmetrical value of short-circuit current on a 3-phase system is determined by dividing the available 3-phase, short-circuit kva by the product of the system voltage and 1.73, the 3-phase factor. Fuses applied on this system should have an interrupting capacity of 1.6 times the system's symmetrical short-circuit current.

NOTE: The three curves attached to this page, covering minimum melting time, short time, and total clearing time for BAL fuses, are included for the purpose of co-ordination planning with respect to other apparatus.

LITERATURE REFERENCE

PRICES—See Price List 36-340

DIMENSIONS—See Dimension Section 36-340

WESTINGHOUSE ELECTRIC CORPORATION
EAST PITTSBURGH PLANT • SWITCHGEAR DIVISION • EAST PITTSBURGH, PA.
Printed in U.S.A.