DIRECT-ACTING TRIP DEVICES FOR K-LINE® CIRCUIT BREAKERS

DESCRIPTION

Direct-acting trip devices are an integral part of the circuit breaker. They are used as a means of automatically opening the breaker under abnormal current conditions. This serves to protect connected electrical equipment from damage due to excessive current flowing for excessive periods of time. Such a device is shown in Fig. 1.

The basic direct-acting trip device used on the K-225-2000 circuit breakers consists of a series operating coil, a magnetic structure and means of introducing time delay restraint to the tripping armatures. The time delay may be in the form of a sealed fluid displacement dashpot and/or a mechanical escapement disc. Means are provided for adjustment of these various elements to give the required operating characteristics to the overcurrent trip device.

The direct-acting trip device is mounted on a sturdy insulating base molding which in turn is supported on the metal frame of the circuit breaker. This base molding is designed to afford easy removal of the trip device from the rear of the circuit breaker.

The series operating coil must include a sufficient number of turns so that the product of the current flowing in the coil and the number of turns fall within the operating magnetic requirements of the device. The series operating coil may consist of one or more turns of copper. The cross-section of each turn must be sufficiently large so as to carry the rated current of the given coil continuously without exceeding a temperature rise which would damage adjacent insulation.

The K-3000 and K-4000 direct-acting trip device has the magnet structure in the form of a U to encircle the lower current stud of the breaker. The device is attached directly to the base molding of the breaker. Otherwise all operating principles apply to both.

The operating magnet consists of a clapper-type design with a stationary magnet structure acting on one or two movable pivoted armatures. The series coil turns are interlinked with the magnetic circuit so as to establish a magnetic flux in the magnet iron when current flows in the coil. The operating face of the armature is so shaped as to provide a magnetic force over a relatively long operating stroke.

The trip device may include either one or two armatures pivoting on a common pin. One of these armatures may be such that its pole-face area is of sufficient size as to provide adequate magnetic force to give operation at the minimum currents for which the device is rated. This broad armature we will identify as armature No. 1. The other armature construction identified as No. 2 has a narrower pole area for operation on currents far above the minimum rating of the coil. The use of either or both of these armatures will be determined by the required operating characteristics.

The fluid-displacement time delay dashpot is used to give time delay measurable in seconds, minutes and hours and consist of a wafer-type piston moving within a sealed cylinder containing a silicone fluid. The piston is linked by a series of levers to the No. 1 armature. A tripping motion of this armature will move the piston downward within the cylinder. This motion is retarded by the pressure of the delay fluid beneath the piston. With a given force from the armature upon the piston, the speed of the piston motion is dependent upon how rapidly the fluid can be displaced up past the piston perimeter. This retards the armature in its tripping stroke. The fluted sections in the cylinder wall are provided to allow acceleration of the piston after an adjustable length of retarded stroke.

These flutes then allow free displacement of the fluid to the top of the piston, thereby reducing the retardation on the piston. A flapper-type relief valve is mounted on the bottom of the piston in such a manner that it closes over a relief orifice on the downward stroke of the piston and opens on the upward stroke. This allows a retardation effect on the armature in a tripping direction but a free motion in a reset direction of the armature.

Silicone fluid is used because of its low change in viscosity with change of fluid temperature. Therefore the time delay of a device using silicone is less subject to temperature change.

The mechanical escapement provides time delay as measurable in milliseconds and is used to delay tripping on the circuit breaker on high fault current flow. It is connected to the armature which we have identified as No. 2. The time delay of this device is obtained due to the retardation of an oscillating verge acting to control the speed of rotation of an escapement wheel. This wheel is operated through a series of gears from an operating crank on the side of the assembly and which is rotated when the No. 2 armature moves either in a trip direction or in reset direction. The degree of time delay of

DIRECT-ACTING TRIP DEVICES (Cont.)

this device can be adjusted within three time delay bands by changing the angle of rotation of the operating crank.

A nameplate is mounted on the front cover indicates the calibration markings. Each armature carries an adjustable trip screw which engages the circuit breaker tripper bar when the armature has completed its upward stroke. A flexibly supported weight mounted on the armatures is used to minimize the pulsations of the magnetic forces due to the alternating character of the load current and serves to reduce noise and wear from the armature vibrations.

The above elements of the direct-acting trip device may be combined in different forms to obtain various operating characteristics of the direct-acting trip device to suit the requirements of a given application. These different combinations are indicated in the following table.

TYPES OF DIRECT-ACTING TRIP DEVICES

Type Designation	Functional Description	Time-Current Characteristic Curve Numbers	Calibration Range			Components			
			Long-Time Pickup (in per cent Rating)	Short-Time Pickup (in per cent Rating) ‡	Std. Instantaneous Trip Pickup (in per cent Rating)	Fluid Displacement Dashpot	Mechanical Escapement Timer	Armature No. 1 (Broad)	Armature No. 2 (Narrow)
OD-3▲ & 300	Dual Magnetic (General Purpose)	*TD-6693	50 to 125	—	500 to 1500†	Yes	No	Yes	Yes
OD-4 & 400	Dual Selective (Without Instantaneous)	*TD-6694	80 to 160	400 to 1000		Yes	Yes	Yes	Yes
OD-5 & 500	Dual Selective (With Instantaneous)	*TD-6695	80 to 160	400 to 1000	500 to 1500†	Yes	Yes	Yes	Yes
OD-6 & 600	Dual Magnetic (Special)	*TD-6695	80 to 160	-	500 to 1500†	Yes	No	Yes	Yes
OD-7 & 700	Instantaneous Trip (High Range)	—	-	-	500 to 1500†	No	No	No	Yes
OD-8 & 800	Instantaneous Trip (Low Range)	—	-	-	80 to 250	No	No	Yes	No
OD-9 & 900	Selective Trip Only (With Instantaneous)	TD-6699	-	400 to 1000	500 to 1500†	No	Yes	Yes	Yes
OD-10 & 1000	Selective Trip Only (Without Instantaneous)	TD-6699	-	400 to 1000	-	No	Yes	No	Yes

▲The OD-3 is also the standard trip device for the K-DON® circuit breaker.

*Reproducible copies TD curve numbers available upon request.

‡200 to 500% is available for special applications.

†500 to 1500% is for OD-3,5,6,7 and 9, on breakers up to K-2000. 500 to 1200% only is available on OD-300, 500,600,700 and 900 on K-3000 and K-4000 breakers.

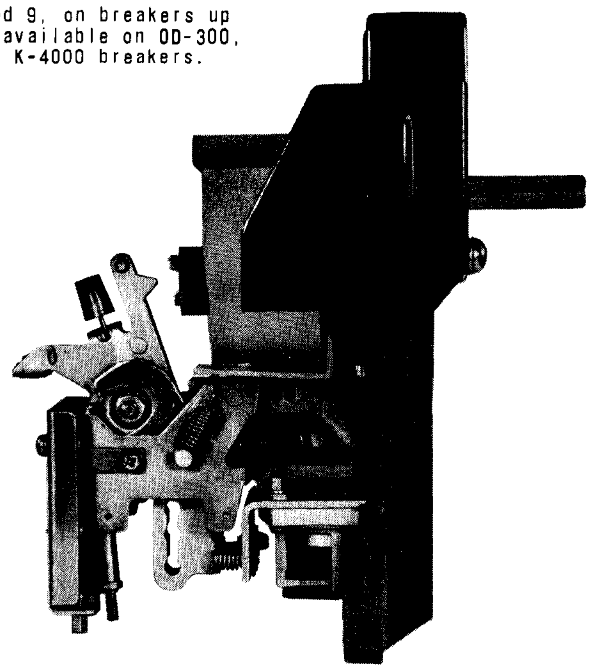

Fig. 1
Cut-away of OD-3 (general purpose) direct-acting trip device for K-Line Circuit Breakers

DIRECT-ACTING TRIP DEVICES (Cont.)

TYPE OD-3 & OD-300 DUAL MAGNETIC (General Purpose)

Present American Standards for Low-Voltage Power Circuit Breakers include twenty-seven overcurrent trip coil ratings.

Several groups of these coil ratings use the same coil construction. These groups can be combined so that one assigned coil rating will give a greater range of calibration adjustment than is possible under standards. Each group is given a coil rating which represents the maximum current which that coil can carry without exceeding the temperature rise permitted by existing standards. This arrangement has been given the descriptive name of "Expanded Range" tripping.

An example of "Expanded Range" tripping is a trip device which has a maximum continuous rating of 400 amperes and has a calibrated trip setting as low as 250 amperes. This device is suitable for use where a standard 300 ampere coil rating calibrated down to 80% would previously have been used. The same device is also suitable for current up to a maximum of 400 amperes continuous current flow and a calibration of 500 amperes.

The twenty-seven coil ratings are now replaced by twelve "Expanded Range" trip ratings which are simple to apply and provide tremendous flexibility for load growth.

Early circuit breakers had instantaneous tripping only. They were set at a current value equivalent to the coil ratings and as long as the electrical system produced no surges, this setting was adequate. Obviously, momentary overloads did occur and the only solution to false tripping was to increase calibration settings. The practical calibration range for trip devices was then in the ratio of 2 to 1 and so the maximum calibration was standardized at 200% of coil rating. Setting a trip device up to 200% of the circuit breaker rating relieved the false tripping problem, but close protection for the distribution system components was lost and the breaker itself ceased to be self-protecting since the setting exceeded the current which the circuit breaker could safely carry continuously.

The basic need was for time-delay and not higher calibration settings, but the electrical industry was accustomed to putting in a fuse or a heater of a higher current rating if the motor would not start. The same concept was applied to calibration of circuit breakers.

The habit of using 100% to 200% calibration was hard to break. When new trip devices with adequate time delay like the OD-1 finally appeared, the range dropped to 80% to 160%. However, circuit breakers had calibration points of 140% and 160% which were hazardous since the breaker set that high is definitely not self-protecting.

The K-Line circuit breakers have taken the lead in providing circuit breakers with calibrations which provide more elastic protection to electrical equipment.

They accomplish this by:

(a) Eliminating the present conventional calibrations of 140% and 160% of coil rating. The maximum setting provided is 125%. This restricts the setting of the protective device by 125% in which areas of current values for the insulation of both the circuit breaker and the connected electrical equipment will be exposed to injurious temperature rises. Any transient current surges such as will occur in switching, starting motors, and on welding circuits, will be taken care of by the time-delay element of the overcurrent device.

(b) The minimum calibration of the device has been extended downward from the present conventional calibration of 80% down to one approximately 50% of the coil rating. This permits the device to be set very close to the current setting which provides optimum protection to the specific electrical circuit in which the circuit breaker is connected.

(c) The greater calibration range thus provided on the OD-3 overcurrent trip device also allows the selection of a current rating which will permit the setting to be increased at any time because of future expansion in the electrical system.

The time-current characteristics of the OD-3 & OD-300 overcurrent trip device is shown in TD-6693. The OD-3 & OD-300 device is set at the factory according to the curve shown in TD-6693. This time setting is indicated on the face plate of the trip device by a scribe mark opposite "TIME". If other time delays are required then the time delay adjustment may be changed either toward "HI" or toward "LO" to increase or decrease the time delay respectively. The minimum time delay obtainable approaches zero time delay. The maximum time delay obtainable is undefined but will usually not exceed 80 seconds with current at 600% of calibration point. This type adjustment on a test-trial basis only.

The OD-3 & OD-300 Fluid Displacement Overcurrent Trip supersedes the Dual Thermal Trip which has previously been applied by the I-T-E Circuit Breaker Company for protection of motor circuits.

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DIRECT-ACTING TRIP DEVICES (Cont.)

Historically, much of the thermal device used was based on the fact that adhesion disc timers did not give sufficient delay. When the thermal trip first came out, it was the only device giving enough delay to get motors started. Much of the feeling which exists in favor of the thermal is based on a comparison with the adhesion disc timer. A comparison of the thermal with a fluid displacement device like the OD-3 will show that displacement devices can give time delays even longer than the thermal trip device.

It is true that the thermal trip can distinguish between a hot and a cold start while the OD-3 & OD-300 can not. This advantage is often off-set by the small mass of the thermal trip element cooling much faster than the windings of the motor. In addition, modern motors are likely to be limited on a hot start by the thermal limitations of the rotor rather than stator temperature and the calibrations of the protective device should be flexible enough to be set to provide protection for either the rotor or stator windings.

One advantage often claimed for thermals is their ability to add up successive overloads on motors. Since the thermal element is not a replica relay of the motor, this claim has little merit. The thermal trip element dissipates its heat much more rapidly than that of the great mass of motor windings.

In addition to the above, the OD-3 & OD-300 trip device has the following advantages:

(a) Long time delay pickup is independently adjustable and once set does not vary widely with temperature setting or the time setting
(b) Instantaneous pickup is independently adjustable and can be matched to the motor inrush current value.
(c) Time delay is independently adjustable without disturbing either the instantaneous or the time delay pickup settings.
(d) The time delay of the OD-3 & OD-300 device is relatively constant with temperature, in the range of 25-55C.
(e) The complete adjustability of the OD-3 & OD-300 allows for better coordination with motor heating characteristics.

The device has been tested for wearability on a simulated welding circuit based on oscillograms of a typical load. The device has gone well over 4,000,000 operations without excessive wear, noise or false tripping. It is recommended that the OD-3 & OD-300 overcurrent trip device can be used in preference to the types described below. Its time-current characteristics were selected as providing the most universal protection for all classes of electrical equipment.

TYPE OD-4 & OD-400 DUAL SELECTIVE TRIP

This direct-acting trip device combines the fluid displacement type long time-delay with mechanical escapement short time delay to provide a composite time delay device in which it is possible to closely control the time delay over a range of current values from normal load current to the full interrupting current rating.

This allows the direct-acting trip devices of circuit breakers in series to be set so as to permit selective tripping of the circuit breaker closest to the fault. Thus maximum continuity of electrical service may be provided where such continuity is mandatory.

The time current characteristics of the OD-4 & OD-400 are shown in TD-6694. It should be observed that four distinct adjustments are provided. One adjustment controls the value of minimum current at which the fluid displacement will operate. Another controls the minimum current at which the mechanical displacement element will operate. A third adjustment regulates the amount of time delayed given by the fluid displacement while a fourth establishes the time delay present in the mechanical escapement device. By means of these adjustments, the time characteristics of the direct-acting trip can be formed so as to be selective with equipment preceding it in the electrical system and with the equipment connected after.

The calibrations available on the OD-4 & OD-400 are indicated in TD-6694. It can be seen that the overcurrent pickup adjustments are adjustable 80% to 160% of continuous current coil rating. Delayed fault tripping is adjustable from 400% to 1000%‡ of the continuous current rating. All three long time delay bands are calibrated on this device to afford flexibility in setting in the field. The short time delay is also field adjustable to the three bands in the time current curves. No instantaneous tripping is provided on the OD-4 & OD-400 direct-acting trip unit.

TYPE OD-5 & OD-500 TRI-SELECTIVE TRIP

This Tri-Selective Trip device is similar to the OD-4 & OD-400 except that an instantaneous trip characteristic is added to the long-time delay and the short-time delay functions provided on the OD-4 & OD-400. The adjustments of the long-time delay element and the short-time delay element of the OD-5 & OD-500 are exactly

‡ See note on page 5.

DIRECT-ACTING TRIP DEVICES (Cont.)

the same as the OD-4 & OD-400. The adjustments of the instantaneous trip are to be based upon 500% to 1500%* of the current rating of the coil. The time current characteristics of the OD-5 & OD-500 are shown in TD-6695.

TYPE OD-6 & OD-600 DUAL-MAGNETIC TRIP

This Dual-Magnetic Trip differs from the OD-3 & OD-300 Dual Magnetic Trip in that the OD-6 & OD-600 provides timecurrent characteristics and adjustments which conform more closely to present American Standards than does the OD-3 & OD-300. This device has been made available for those rare instances wherein the customer is insistent in his specifications requiring American Standards of 80% to 160% long time pickup and three distinct long time delay bands. The time current characteristics are shown in TD-6695.

TYPE OD-7 & OD-700 INSTANTANEOUS TRIP (High Range)

This direct-acting trip device provides instantaneous tripping within the current range of 500% to 1500%* of coil current rating. It is used primarily in those instances where protection from short circuit currents only is required.

TYPE OD-8 & OD-800 INSTANTANEOUS TRIP (Low Range)

This direct-acting trip devices provide instantaneous tripping within the current range of 80% to 250% of coil current rating. This device is used in those special instances where rapid tripping at low currents is desirable. These instances include d-c motor and generator circuits.

TYPE OD-9 & OD-900 SELECTIVE TRIP (With Instantaneous)

This selective direct-acting trip is provided with short-time delay and instantaneous trip elements. The long-time delay has been omitted. The short time delay pickup current is adjustable from 400% to 1000%‡. The instantaneous trip is adjustable from 500% to 1500%*. This device is to be applied in those cases where selectivity is desirable only on intermediate fault tripping. The time current characteristics of the OD-9 & OD-900 are shown in TD-6699.

TYPE OD-10 & OD-1000 SELECTIVE TRIP (Without Instantaneous)

This selective direct-acting trip is similar to the OD-9 & OD-900 except that it is not provided with an instantaneous trip element. The short-time delay pickup current is adjustable from 400% to 1000%‡ of coil current rating. This device applies in such cases where selectivity is desirable over a full range of fault currents up to the maximum interrupting current rating of the circuit breaker. The time current characteristics of the OD-10 & OD-1000 are shown in TD-6699.

The above classification of types of direct-acting devices has been based upon the physical construction entering into obtaining the basic operating characteristics described. Any modifications of these characteristics will probably mean a modification of the individual elements of the basic type and will entail additional costs. Such modification should be avoided whenever possible.

*500% to 1200% on the OD-300,500,600,700 and 900. (K-3000 & K-4000 breakers)

‡200% to 500% is available for special applications.

DRAWOUT MECHANISM FOR K-LINE CIRCUIT BREAKERS

INTRODUCTION

In order to make the K-Line circuit breakers mobile for operation, testing, storage, maintaining and removal from its switchboard compartment, a four position drawout unit has been made an integral part of the breaker design. Such an arrangement is shown in Fig. I. During the moving of the circuit breaker to and from the basic four positions, interlocking provisions have been made to prevent moving of the circuit breaker when the circuit breaker mechanism is in the closed position.

The same interlocks prevent closure of the circuit breaker when positioned between the basic operation positions.

The drawout cradle is a separate unit which can readily be inserted into a switchboard compartment. This cradle is assembled in the compartment by four mounting bolts in the bottom of the unit. The rear of this cradle forms a steel isolation barrier between the circuit breaker and the bus compartment of the switchboard.

In the CONNECTED or operating position, the circuit breaker's primary and control electrical circuits are so engaged as to perform their functions of carrying load currents to provide protection for the equipment and afford switching means of that circuit.

In the TEST position, the operator is permitted to safety test and inspect the circuit breaker and its associated electrical control circuits without disturbing the primary electrical system.

In the DISCONNECTED position, the circuit breaker is completely isolated electrically and may be safely stored in this position when the primary circuit is to remain de-energized for some definite period. The withdrawal mechanism may be padlocked in this position to prevent being manipulated by unauthorized persons.

The WITHDRAWN position permits the removal of the circuit breaker from the compartment, for ease of maintenance, or parts replacement, and transferring the circuit breaker to a more essential load circuit because of more effective load dispatching.

The operator is fully protected from contact with live parts by a completely dead-front design, complemented with dependable and reliable visual indications which show when the circuit breaker is in any of the four basic positions. The position indicator can be seen on the upper left side plate of the cradle housing and a cooperating pointer on the right-front breaker frame. Provisions are also furnished to permit padlocking the breaker in the open position in any of the basic locations, and the breaker can be left in TEST or DISCONNECTED positions with doors closed for safety, or for storage, and as protection against dust or moisture. It also serves to prevent operation by unauthorized personnel. In these positions, the door may be opened for inspection without disturbing the locking provisions.

DESCRIPTION AND OPERATION

Drawout Contacts

The primary separable contacts are sturdy and self-aligning which provide positive electrical contact engagement between the circuit breaker separable contacts and the stationary separable contacts.

Silver-to-silver contacts are furnished. Positive electrical contact is made through the use of heavy compression springs bearing upon a group of individual contact fingers, thus affording multiple contact areas. Strong insulating moldings provide protection from accidental voltage failures. In the TEST, DISCONNECTED and WITHDRAWN positions of the circuit breaker, the primary contacts of the circuit breaker are safely isolated from the primary circuits of the system. The primary separable contacts are engaged only in the CONNECTED position of the circuit breaker.

The secondary contacts are compact contacts which are used to provide connection from the internal circuit breaker control circuits to the external control circuits. They can be furnished so that they are engaged only in the CONNECTED or only in the TEST position. They are disengaged in the DISCONNECTED and WITHDRAWN positions. These contacts ordinarily are continually engaged in the CONNECTED and TEST positions. The connection in the TEST position provides means whereby the circuit breaker control circuits can be electrically tested with the primary circuits isolated.

If the circuit breaker primary separable contacts separate when carrying load current, the contacts will be called upon to perform a function for which they are not designed-the interrupting of an electrical circuit. Under such conditions, the resulting arcing will badly erode the contact surfaces, and the ionized gases generally will provide a conducting path between terminals of opposite electrical polarity. Thus, serious fault currents will be permitted to flow, which could cause extensive damage to the whole switchboard. For this reason safety interlocking is furnished which will prevent changing the circuit breaker position without

DRAWOUT MECHANISM (Cont.)

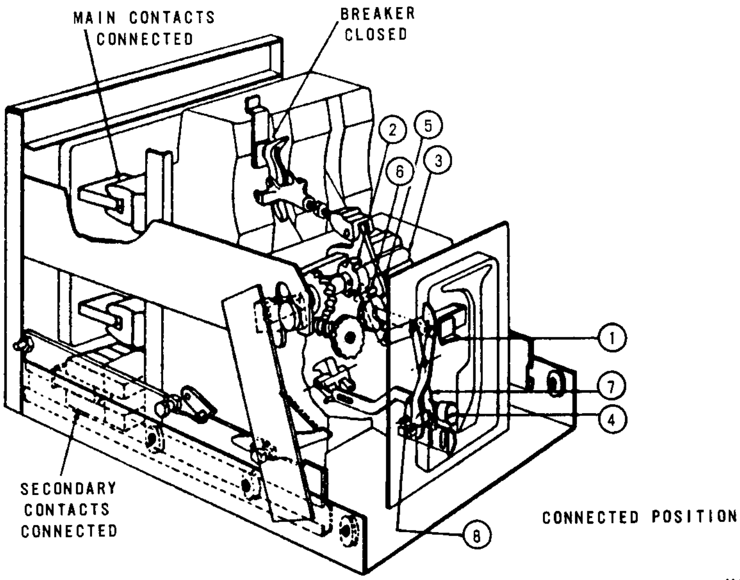


Fig. 1(a)

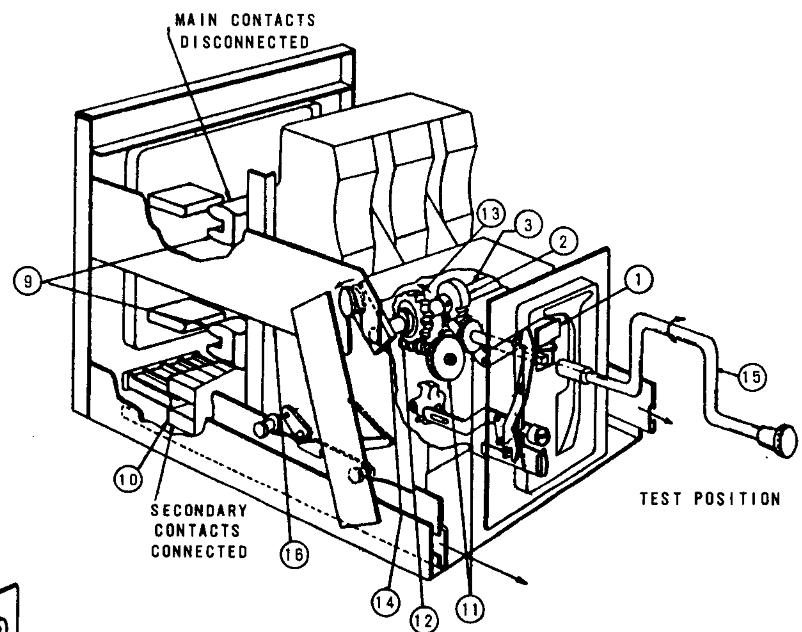


Fig. 1(b)

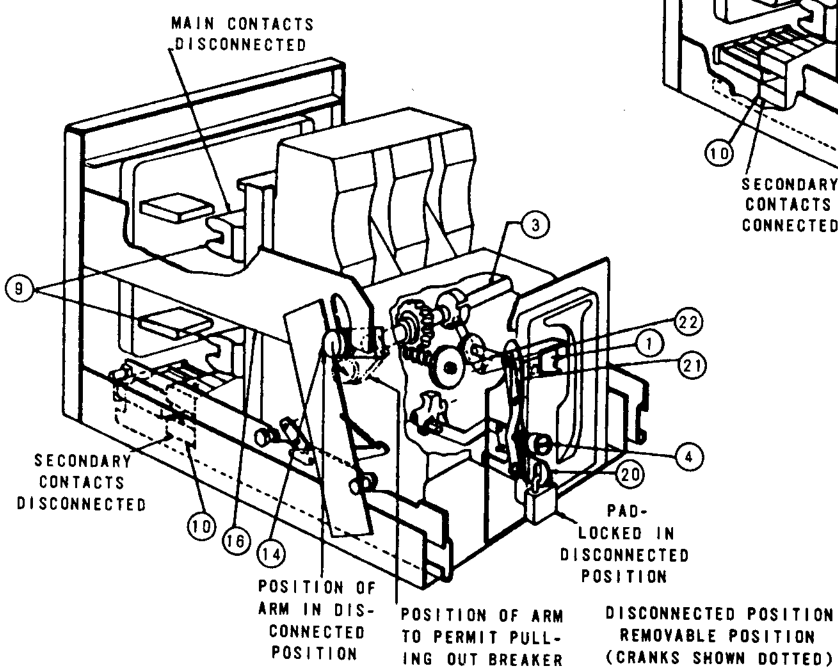


Fig. 1(c)

DRAWOUT MECHANISM (Cont.)

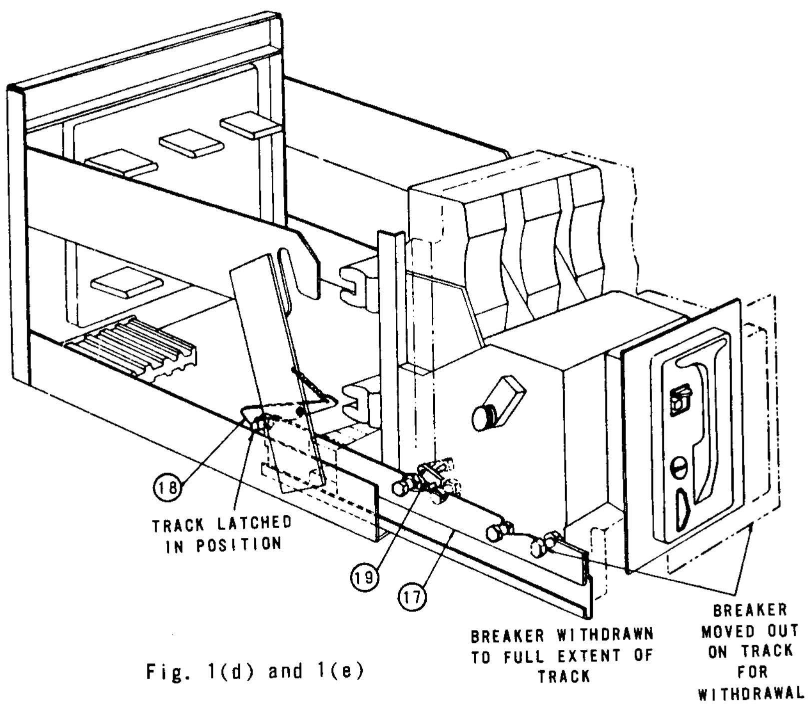


Fig. 1(d) and 1(e)

LEGEND
1. Shutter
2. Cam
3. Gear shaft
4. Trip button
5. Jack shaft
6. Pin (jack shaft)
7. Link
8. Bell crank
9. Separable contacts (main)
10. Separable contacts (secondary)
11. Gears
12. Worm drive
13. Worm wheel
14. Crank arms
15. Crank handle
16. Cradle housing bars
17. Tracks
18. Latch (track)
19. Latch (breaker)
20. Lockout plate (padlock)
21. Lever
22. Pin

first tripping open circuit breaker contacts.

The drawout mechanism on the K-3000 and K-4000 circuit breakers is similar to the K-225 to K-2000 breaker, with the following exceptions:

1. Tracks must be pulled down prior to racking
2. The mechanism has positive stops in all positions
3. Replacing the drawout shutter is a lever that is raised when the breaker is open to allow racking.

Racking Operation (Fig. 1(b))

The means of racking the breaker from one position to another is done by inserting a hand crank into an escutcheon opening and rotating this crank (15). A normally-closed shutter is interlocked to prevent movement of the circuit breaker drawout mechanism when the circuit breaker contacts are closed.

Should the operator in cranking from one position to another remove the crank when the circuit breaker is between positions, the shutter (1) will be held up by cam (2) on shaft (3). This cam is so positioned on the shaft to allow the shutter (1) to be raised and lowered only in the CONNECTED, TEST and DISCONNECTED positions of the circuit breaker. The circuit breaker cannot be closed while the shutter is raised. This provides a definite interlock which guards against the circuit breaker being closed unless properly positioned.

A ground contact maintains electrical contact from the CONNECTED to the TEST position, thus providing continued safety to the operator from contact with hazardous voltages.

It requires fourteen turns of the hand crank to reach TEST position from the CONNECTED position. Six additional turns is required to reach the DISCONNECTED position, and five more turns to the WITHDRAWN position.

Connected Position

Figure 1(a) shows the circuit breaker in the CONNECTED position. At this point, the shutter (1) can not be raised unless the circuit breaker contacts are tripped open. This is done by pushing in the trip button (4). Rotation of the jack-shaft (5) to open position of the circuit breaker contacts, moves interference pin (6) which permits raising the shutter. While the shutter is raised, the circuit breaker is held in a maintained trip-free position through link (7) and bell crank (8). This prevents the circuit breaker from being closed when the drawout mechanism is in a position for moving the circuit breaker from one position to the other.

Test Position

Rotating the drawout hand crank counter-clockwise moves the circuit breaker to TEST position Fig. 1(b). In this stage, the main separable contacts (9) are disconnected, while the second-ary separable contacts (10) are still connected.

DRAWOUT MECHANISM (Cont.)

Through a series of gears (11), worm drive (12), worm wheel (13), gear shaft (3) and crank arms (14) the rotation of the drawout crank handle is transformed into linear motion of the circuit breaker as the crank arms (14) move against the cam surfaces in the cradle housing (16). Removal of the crank in TEST position allows the shutter to drop, thereby releasing the interlock system. The circuit breaker may now be closed electrically or manually since the secondary control contacts are still connected. In this position, the various devices on the circuit breaker and their associated electrical circuits can be checked and tested without disturbing the primary electrical system.

Disconnected Position

Continued rotation of the crank from TEST position to DISCONNECTED position as shown in Figure 1(c) serves to disconnect the main contacts (9) and the secondary contacts (10) which leaves the circuit breaker electrically isolated but still retained in the cradle (16) by the arms (14) being interlocked with the cam surfaces of the cradle bars.

This position is used to provide storage of the circuit breaker when the electrical circuit which it serves is to remain de-energized.

Withdrawn Position (Figs. 1(c) and 1(d))

From the DISCONNECTED position, a continued counter-clockwise rotation of the crank will turn the shaft (3) so arms (14) are clear of cradle bars (16) and the circuit breaker and tracks (17) out to the position shown in Figure 1(d). This shows the withdrawn track latched in position against the cradle support and latch (18). The track is held in this position, while the circuit breaker is removed from the tracks.

Prior to racking the circuit breaker in, the tracks are released from these latches by press-

In the fully WITHDRAWN position, the circuit breaker may be inspected or it may readily be removed from its cradle. By lifting the retaining latches (19), the circuit breaker may be pulled forward and out of the retaining notches to the fully extended position where it may be readily removed by a simple vertical lift.

Padlocking (Fig. 1(c))

The circuit breaker may be padlocked in the CONNECTED, TEST or DISCONNECTED position by removing the crank and pushing in trip button (4) which then permits pulling out the lockout plate (20). This exposes a slot to which one to three standard padlocks may be attached to lock the circuit breaker in the tripped position, and also to lock the circuit breaker in a definite chosen position relative to the cradle. Locking between positions is prevented by lever (21) which interlocks lockout plate (20) with shutter (1) by pin (22) so that the circuit breaker can not be padlocked unless the shutter is closed.

STORED-ENERGY OPERATING MECHANISM

BASIC REQUIREMENTS OF STORED-ENERGY CLOSING MECHANISMS

1. Adequate closing power
2. High contact speed in closing
3. Trip-free operation with high speed opening
4. Ease and simplicity of operation
5. Long life and low maintenance
6. Compact size

The stored energy mechanism accepts a predetermined amount of energy from the operator and then releases this energy to close and latch the breaker contacts closed. The operator may supply the energy at any desired rate, but the energy cannot be released to close the contacts until the predetermined amount of energy has been supplied. After the required energy has been released, the operator can in no way impede the "snap-action" closing of the breaker.

The stored energy closing mechanism must perform four basic steps in its normal cycle of operation, as follows:

1. Receive and store energy supplied by the operator.
2. Release and transform this energy into a closing force on the breaker contacts.
3. Latch the breaker in a closed position.
4. Allow the breaker to trip under fault or other specified conditions.

The functions listed above are illustrated in photographs attached. These photographs present, in phantom form, the principal parts of the circuit breaker involved in the operation of the manually-operated stored energy closing mechanism. Also attached is a perspective view, Figure 1 of the manual-operated spring-close mechanism. This view is shown with the mechanism ready to be charged by the operator, preparatory to closing of the circuit breaker contacts.

Manual Stored Energy Closing Mechanism

The circuit breaker must be open and the closing handle must be in the reset position, shown in Figure 2, before breaker closing operation may be initiated. The following sequence of operations then occur within the mechanism as the operator pulls downward on the closing handle:

Figure 2 shows the breaker in the open position with the closing mechanism springs ready to be charged so as to subsequently close the circuit breaker contacts.

In Figure 3 it is shown that the operator supplies the stored closing energy by a single downward thrust of the operating handle (1). This handle acts as a lever and forces the hand closing cam (2) to rotate in a clockwise direction. This action extends the closing springs (3) downward. Continued motion of the operating handle extends the springs until sufficient energy is stored. This stored energy is ultimately used to vigorously force the breaker contacts closed. At some late part of the downward motion of the operating handle, a pin on the hand closing cam engages a camming surface of the hold-up latch (4) and rotates the latch in a counter clockwise direction. The continued extension of the closing springs have meanwhile forced the first stage closing cam (5) to tend to turn in a clockwise direction, being restrained from moving downward by the left-hand roller carrier (6) which in turn is prevented from moving by the latch surface of the hold-up latch and the positioning of the primary latch (7). When the hold-up latch continues to pivot, by the downward motion of the operating handle the roller carrier is permitted to slip by the latching surface of the hold-up latch.

Figure No. 4 shows where the exertion of pressure of the closing springs on the first stage closing cam with the release of the latch roller carrier in a counter clockwise direction being pivoted about the center roller of the roller carrier resting on the latch surface of the primary latch. The other end of the roller carrier moves upward forcing the jackshaft cam (8) to rotate in a clockwise direction very rapidly, moving the contact arm assembly (9) into closed position with regard to the stationary contact structure (10). The prop latch

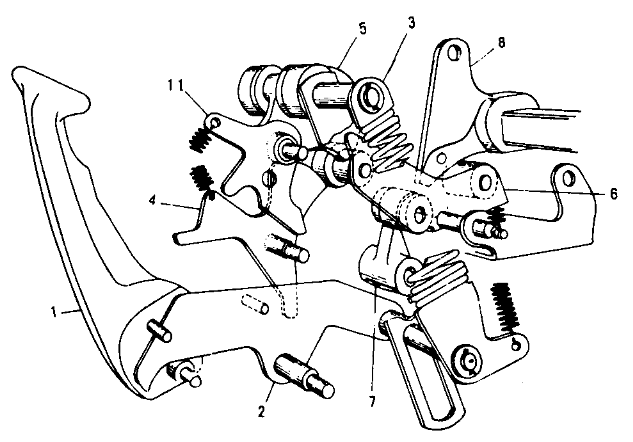


Fig. 1 - Mechanism ready to be charged by operator preparatory to closing of the circuit breaker contacts.

STORED-ENERGY MECHANISM (Cont.)

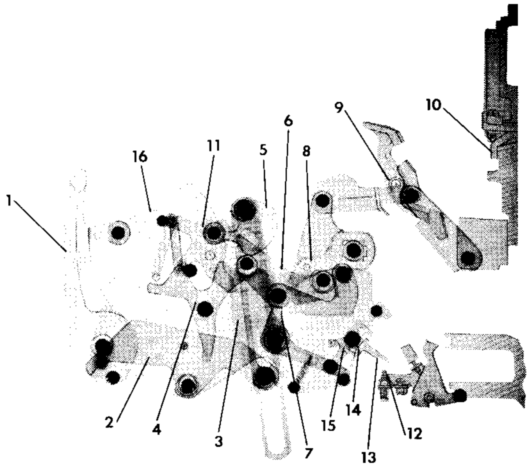


Fig. 2 - Open position.

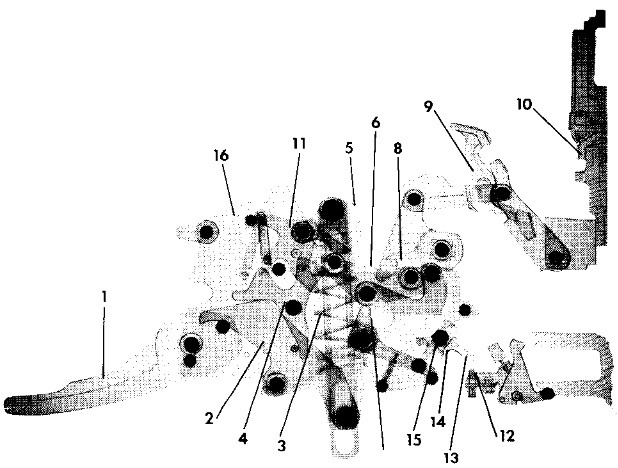


Fig. 3 - Open position with spring almost fully charged just before latch release.

(11) meanwhile has been rotated in a counter clockwise direction by the downward motion of the first stage closing cam, latching the roller carrier, which in turn holds the breaker contacts in the closed position. Figure 5 shows where the operating handle, after being released by the operator, will then return to the normal position.

Figure 6 shows the tripping of the circuit breaker by overcurrent trip devices. This automatic trip of the breaker starts action when the overcurrent armature trip screw (12) strikes the tripper (13) on tripper bar (14), rotating it. This in turn releases the latch on the latch bar assembly (15). This action, at the same time, allows the primary latch to rotate in a counter clockwise direction, releasing the support under roller carrier and allowing it to move in a downward direction being guided in the diagonal slot in the mechanism housing (16) under the influence of the opening springs of the circuit breaker. The jackshaft will then rotate in a counter clockwise direction thus opening the circuit breaker contacts. The mechanism then resets automatically to the conditions shown in Figure 2 by the action of an auxiliary spring pulling the roller carrier assembly back to supported position on primary latch.

Figure 7 shows the hand trip operation done by manual pressure applied to the hand trip button on face plate of the breaker. This moves a link that cams the latch bar assembly in a counter clockwise direction, thereby releasing the primary latch and allowing it to rotate in the same direction, unlatching the roller carrier, therefore giving same action as is accomplished in automatic tripping of the circuit breaker.

The stored energy closing mechanism thus provides a safe, positive, and economical method of attaining high speed closing with manually operated low voltage power circuit breakers.

Electrical Stored-Energy Closing Mechanism

In addition to the manually-operated spring-closed mechanism described above, there is also available a motor-operated spring-close mechanism which is operable from a remote location by means of an electrical contact.

This motor-operated spring-close mechanism is similar in principle to the manually-operated spring-close mechanism described and pictured in preceding text. It differs only in that the closing-springs are charged by means of a small, fractional horsepower electric motor. The speed of this motor is geared down to provide the proper speed most suited to operate the closing mechanism.

The springs are charged immediately upon application of the control power by the energization of the motor circuit through limit switches on the closing-spring linkage and on the circuit breaker. The closing springs are held in this charged position, by a holding latch, until released by the energization of a small electromagnetic solenoid. The release of this latch then allows the spring to exert a thrust to close the circuit breaker contacts.

Electrical circuits are furnished which allows the circuit breaker to be closed and opened from a remote location by means of a control switch.

STORED-ENERGY MECHANISM (Cont.)

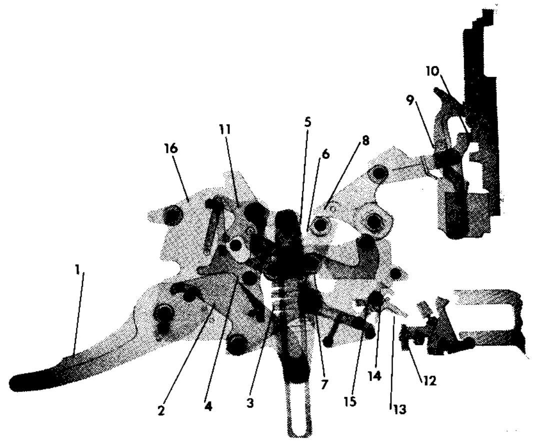


Fig. 4 - Closed position just after close of contacts.

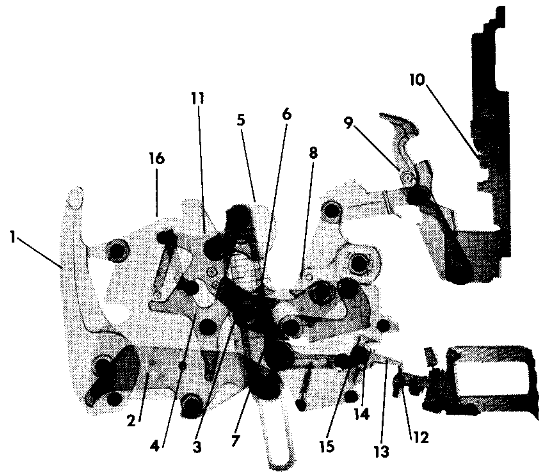


Fig. 6 - Overcurrent trip just after trip operation.

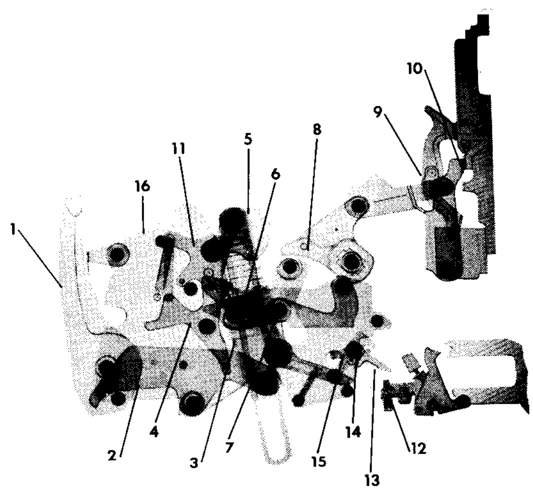


Fig. 5 - Closed position with closing spring and operating handle back to normal position.

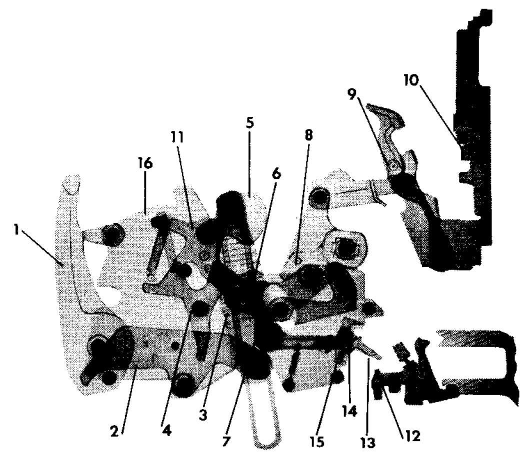


Fig. 7 - Hand trip just after trip operation.

ESCUTCHEON OPERATING FEATURES FOR K-LINE CIRCUIT BREAKERS

Manual and electrically operated K-Line circuit breakers are provided with an extendible escutcheon face plate. This escutcheon provides a central area for the controls which are mounted directly on the circuit breaker. The controls for manually operated circuit breakers, Fig. 1, included in the escutcheon face plate are: (a) a nameplate giving the various ratings assigned to that particular type of circuit breaker, (b) the manual operating handle, (c) the manual trip rod extension, (d) the OPEN and CLOSED position indicator, (e) the automatic trip indicator with optional facilities for alarm indication and for lockout and (f) a means for padlocking the circuit breaker in the CONNECTED, TEST or DISCONNECTED positions.

The controls for the electrically operated circuit breakers, Fig. 2, are the same as the manually operated circuit breakers except for the absence of the manually operated handle and the presence of (g) closing spring charging indicator (h) cutoff-switch for the motor electrical circuit, (j) electrical close push button switch and (k) manual close lever.

The manual and electrically closed drawout circuit breaker escutcheon also contains the interlocked shutter for insertion of the drawout crank.

A self-aligning plate immediately behind the escutcheon face plate is used to exclude dust from the circuit breaker compartment. On drawout type circuit breakers, the escutcheon face will protrude through the front door of the compartment when the circuit breaker is in the TEST and DISCONNECTED positions. In these positions, the dustplate still functions to exclude dust.

(A) CIRCUIT BREAKER NAMEPLATE (Figs. 1, 2 & 3)

The circuit breaker nameplate contains information regarding (1) the manufacturer's name and address, (2) type of circuit breaker design, (3) serial number of circuit breaker, (4) continuous current rating of frame size, (5) interrupting current at rated voltages, (6) voltage and frequency.

The actual continuous current rating of a given circuit breaker is established by the continuous current rating of the overcurrent trip coil.

(B) MANUAL CLOSING HANDLE (Fig. 1)

The manual closing handle is a T-shaped lever used to charge the closing spring and release energy of these springs to close the circuit breaker in a downward thrust.

(C) MANUAL TRIP BUTTON (Figs. 1, 2 & 3)

The manual trip button is a push rod which is used to manually trip open the circuit breaker mechanism.

(D) CIRCUIT BREAKER POSITION INDICATOR (Figs. 1, 2 & 3)

The circuit breaker position indicator is a mechanical visual means of showing whether the circuit breaker contacts are in the OPEN or CLOSED position.

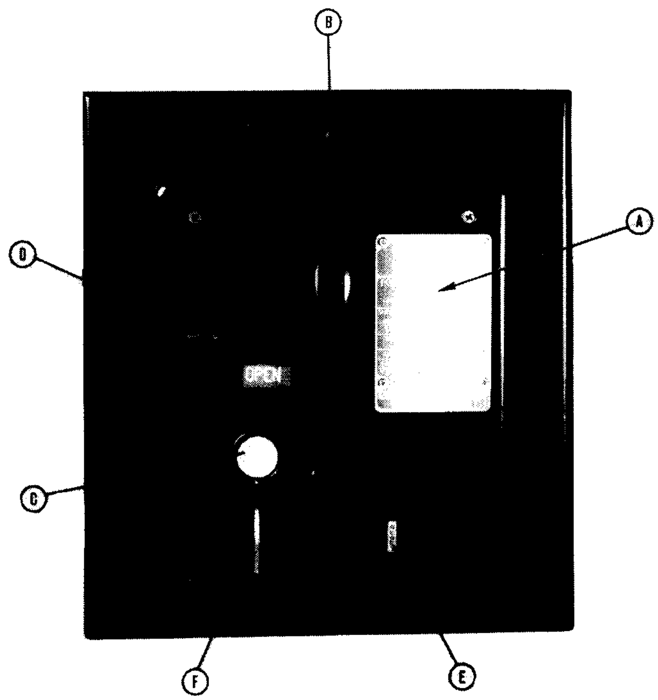


Fig. 1 - Escutcheon for Manually Operated K-225 to K-2000 Circuit Breakers.

(E) AUTOMATIC TRIP INDICATOR (Figs. 1, 2, 3 & 4)

The automatic trip indicator is provided as standard equipment on the K-Line circuit breakers and is used to indicate the operation of direct-acting trip device. This device is an indicator only and does not prevent the circuit breaker reclosing.

The device consists mainly of a spring loaded trip indicator with its associated latch linkage. Upon an overcurrent trip operation, the tripper bar causes an extension to release the indicator latch which allows the indicator to protrude from the front plate.

The automatic trip indicator may be reset after each trip indication by pushing back into its

ESCUTCHEON FEATURES (Cont.)

normal latch position. The operator should investigate the cause of tripping before resetting the automatic trip indicator and subsequent reclosing the circuit breaker after an outage which results in an operation of the indicator.

Automatic Trip Alarm Contacts (Hand Reset)

An alarm switch for electrical indication, which is optional, shows when automatic tripping has occurred. This is accomplished by adding a precision snap switch to the automatic trip indicator assembly. The camming surface of the automatic trip indicator actuates the roller on the alarm switch which in turn causes a normally open contact to close on overcurrent trip. The alarm contact is manually reset. A normally closed contact is also available which will open on an overcurrent trip operation.

Automatic Trip Lockout (Hand Reset)

An additional device (which is also optional) may be added to the automatic trip device which serves to mechanically prevent reclosing the circuit breaker after an automatic trip operation. This device consists of the addition of a lockout plate to the automatic trip indicator assembly. Upon an overcurrent trip operation, the tripper bar will cause the tripper to release the automatic trip indicator latch which allows the indicator link to move forward. Rotation of the latch carrying the lockout plate prevents the tripper bar from resetting. When the trip indicator is pushed in the circuit breaker mechanism can then be operated to close the circuit breaker contact.

(F) PADLOCKING DEVICE (Figs. 1, 2 & 3)

All K-Line circuit breakers are equipped with means of padlocking the circuit breaker mechanism in a trip-free position. This is accomplished by the use of a locking plate to maintain the manual trip rod in a tripping direction when the locking plate is held forward by one or more padlocks. To obtain the condition for padlocking the circuit breaker in the open position, the manual trip rod is first pushed inward, thus rotating the tripping latch of the circuit breaker mechanism. Then the padlock plate is pulled out and the padlock inserted into the vertical slot. In this position, the mechanism is maintained trip free and the contact arm can not be moved toward the closed position.

On circuit breaker equipped with drawout mechanism, the padlocking device is associated with the drawout interlocking mechanism so that the circuit breaker can not be moved from any of its three basic drawout positions of CONNECTED, TEST or DISCONNECTED with the padlocking in effect.

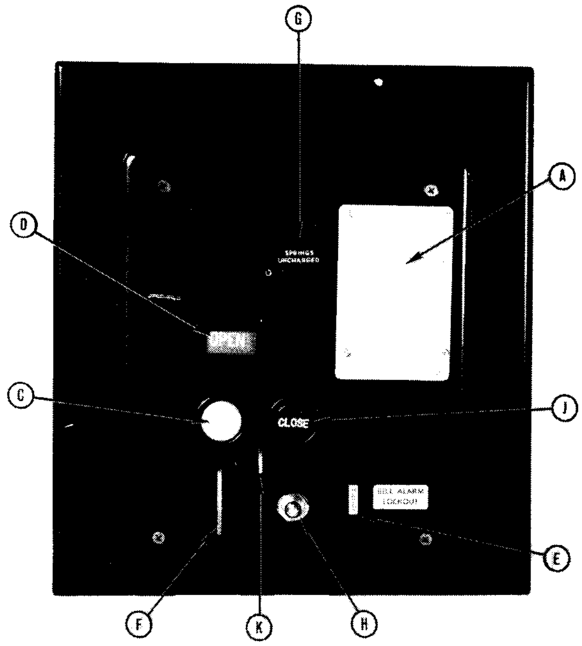


Fig. 2 - Escutcheon for Electrically Operated K-225 to K-2000 Circuit Breakers.

(G) CLOSING SPRING CHARGE INDICATOR (Figs. 2 & 3)

Under normal operating conditions, the closing springs are automatically charged after each tripping operation. However, there are occasions when the springs will be in a discharged state. Therefore, it is desirable that means be available to indicate the charged or uncharged condition of the closing springs. This is accomplished by a visual flag seen through an aperature in the escutcheon plate. The flag is marked CHARGED and UNCHARGED.

(H) MOTOR CUT-OFF SWITCH (Figs. 2 & 3)

The motor cut-off is a single pole, single-throw toggle type switch connected in series with the charging motor circuit and is used to disconnect the motor circuit from the voltage source. This cut-off switch is used (1,) when it is desirable to prevent automatic recharging of the closing springs just prior to placing the circuit breaker out of service for maintenance and (2,) for control wiring dielectric test. The motor must be disconnected for the 1500 volt test and subsequently tested at 900 volts.

ESCUTCHEON FEATURES (Cont.)

(J) ELECTRICAL CLOSE PUSH BUTTON (Figs. 2 & 3)

The electrical close push button is used to electrically close the circuit from the escutcheon. This contact is connected in series with the latch release coil. Energizing the latch release coil allows the charged springs to close the circuit breaker.

(K) MANUAL CLOSE LEVER (Figs. 2 & 3)

The manual close lever is provided on all electrically operated circuit breakers to provide a safe means of closing the breaker without control power. The closing springs are charged manually and released by operating the close lever, with the compartment door safely closed.

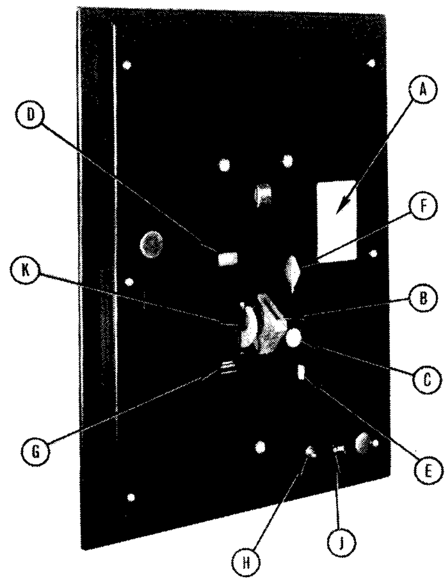


Fig. 3 - Escutcheon for Electrically Operated K-3000 and K-4000 Circuit Breakers.

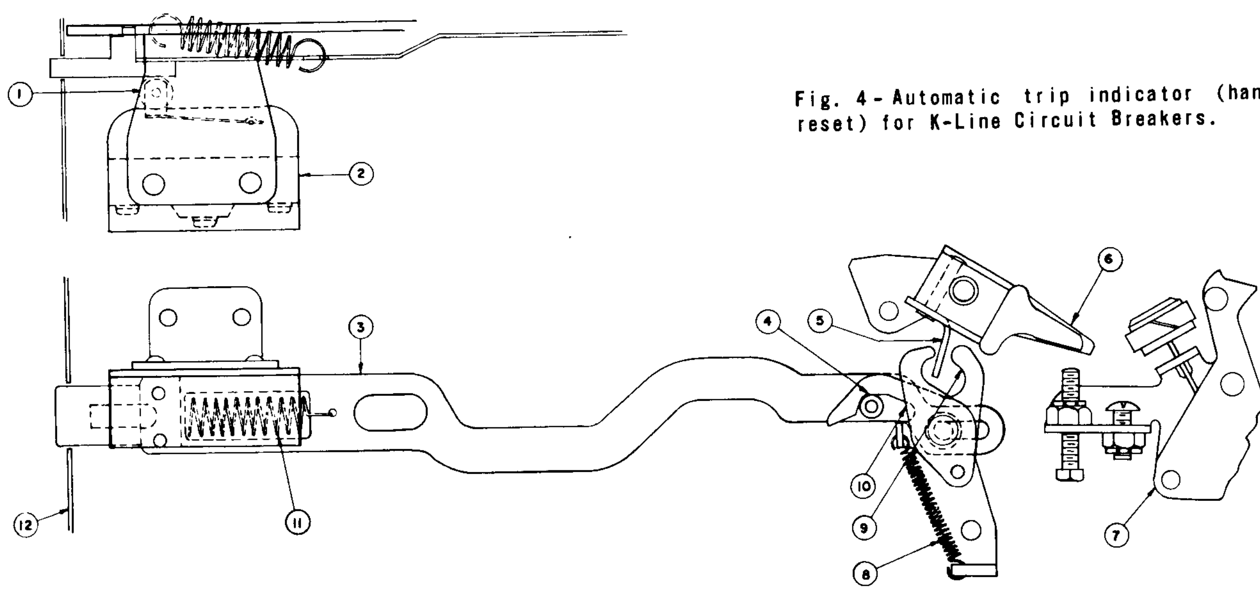


Fig. 4 - Automatic trip indicator (hand reset) for K-Line Circuit Breakers.

LEGEND

1. Roller (alarm switch)
2. Alarm switch
3. Trip indicator
4. Roller (trip indicator)
5. Tripper (tripper bar)
6. Tripper bar
7. Overcurrent trip armature
8. Spring (indicator latch return)
9. Latch
10. Lock-out plate
11. Spring (trip indicator return)
12. Front plate (breaker)

KEY INTERLOCK FOR K-LINE STATIONARY MOUNTED CIRCUIT BREAKERS

GENERAL

The key interlock, Figure 1, for K-line stationary mounted circuit breakers is a simple mechanical device which may be used for the following applications:

1. One circuit breaker may be locked in a maintained trip-free position. This is frequently used to insure that the circuit breaker cannot be closed during a maintenance operation by non-authorized personnel.
2. A transformer secondary circuit breaker may be interlocked with a primary disconnect switch so that the disconnect switch cannot be opened or closed unless the circuit breaker is in the open position.
3. Two circuit breakers may be interlocked so that one may be closed while the other remains open, or both circuit breakers may be open at the same time. This condition is useful when a common load bus is fed from two alternate sources of power.
4. More elaborate interlocking schemes may be established between three or more circuit breakers. These applications should be referred to the factory.

DESCRIPTION AND OPERATION

Basically, the key interlock as shown in Figure 3, is a key lock consisting of an extendible locking bolt (1) and a block lever (9) locked to trip link bell crank (7).

The device is located and mounted to the left hand side of the escutcheon box (2) so that the lock cylinder (4) protrudes partly through the circuit breaker front sheet (8) or front door as the case may be.

To operate the device, the circuit breaker trip button (6) is depressed and held in while the interlock key is turned clockwise. The key may then be removed and inserted into the lock on the coordinated device. Meanwhile, the initial circuit breaker will be locked in the trip-free position until the key is reinserted and turned counter-clockwise.

When the trip button (6) is pushed in, an actuating trip link (11) moves backwards to rotate a latch bar stud (12) which in turn releases the circuit breaker trip-free latching mechanism. A triangular bell crank (7) pivoted to trip link (11) has a serrated staked stud (10) on which is clamped an adjustable block lever (9). The opposite corner carries a spring stud (5) to which is hooked an extension spring (3) for

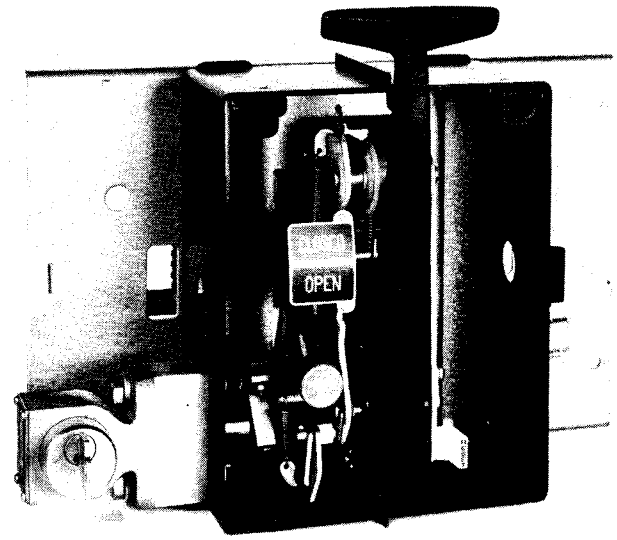


Fig. 1 - Key Interlock for K-Line Stationary Mounted Circuit Breakers.

resetting the trip button (6) when released by the key lock bolt (1).

When the trip link (11) is set in motion by depressing the trip button (6), the bell crank (7) is caused to rotate counter-clockwise which permits the operator to extend the interlock bolt by turning the interlock key. This blocks the raised lever (9) until the key is reinserted and turned counter-clockwise to withdraw the bolt (1). The spring (3) resets the trip button (6) to normal position so that the circuit breaker may now be closed.

The design of the key interlock is such that the interlock and its attachments may be readily added to the stationary mounted K-Line circuit breakers in the field. Instructions and drilling dimensional drawings will be furnished on request with the order for the key interlock.

The drilling of the front sheet or front door to accommodate the lock cylinder of the key interlock is shown in Figure 2. This drawing is to be used when the interlock or its adaptor is furnished with the circuit breaker.

To expedite delivery and to facilitate coordination the I-T-E Circuit Breaker Company, Philadelphia can furnish the interlock mounting adaptor, with the understanding that the customer will purchase the key interlock directly from the Greensburg Division of I-T-E Circuit Breaker Company, located in Greensburg, Pennsylvania.

The key interlock used on the K-225, K-600, K-1600 and K-2000 is Type B2E (two inch initial bolt extension-key removable with bolt extended).

KEY INTERLOCK FOR K-LINE STATIONARY MOUNTED (Cont.)

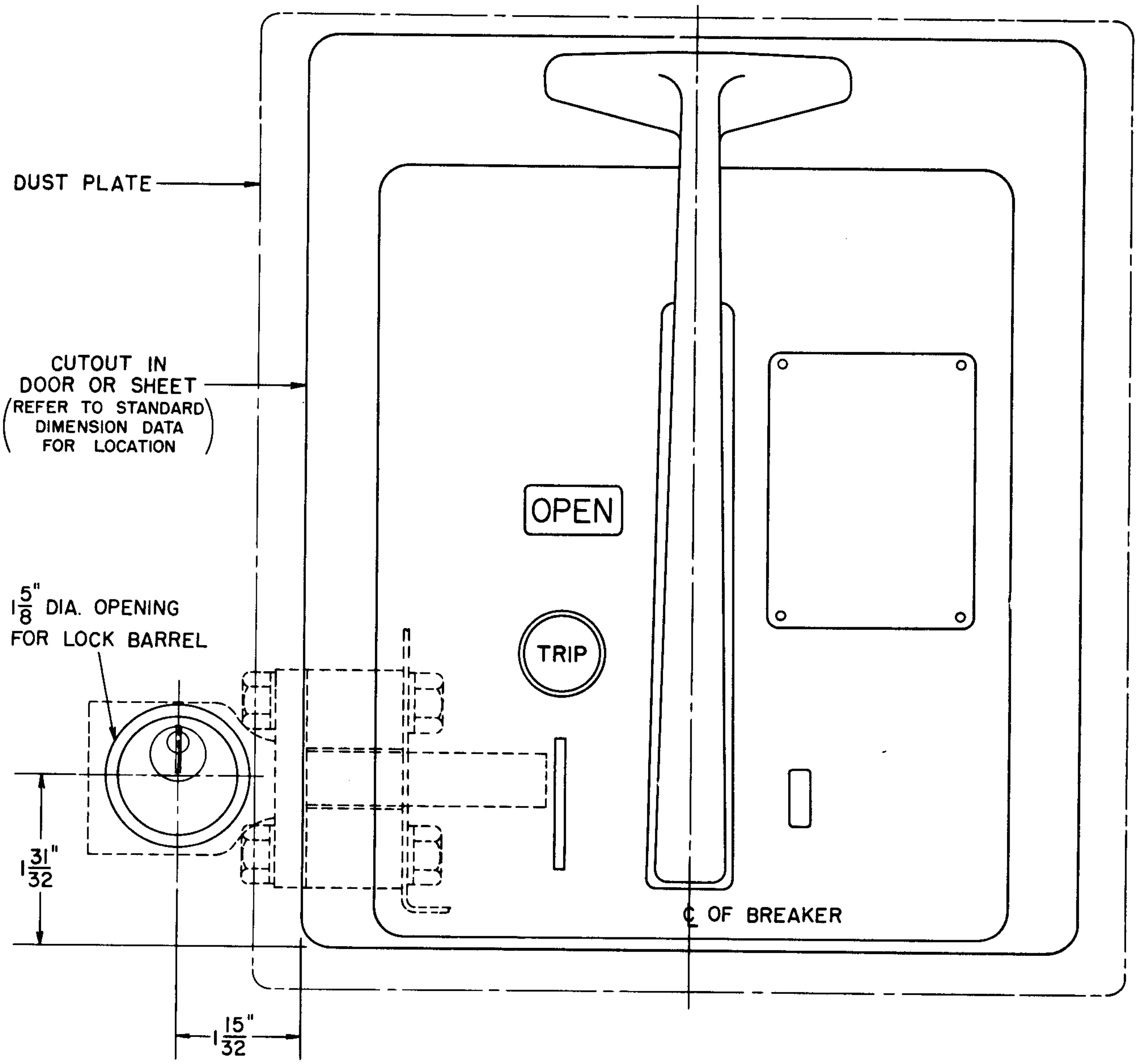
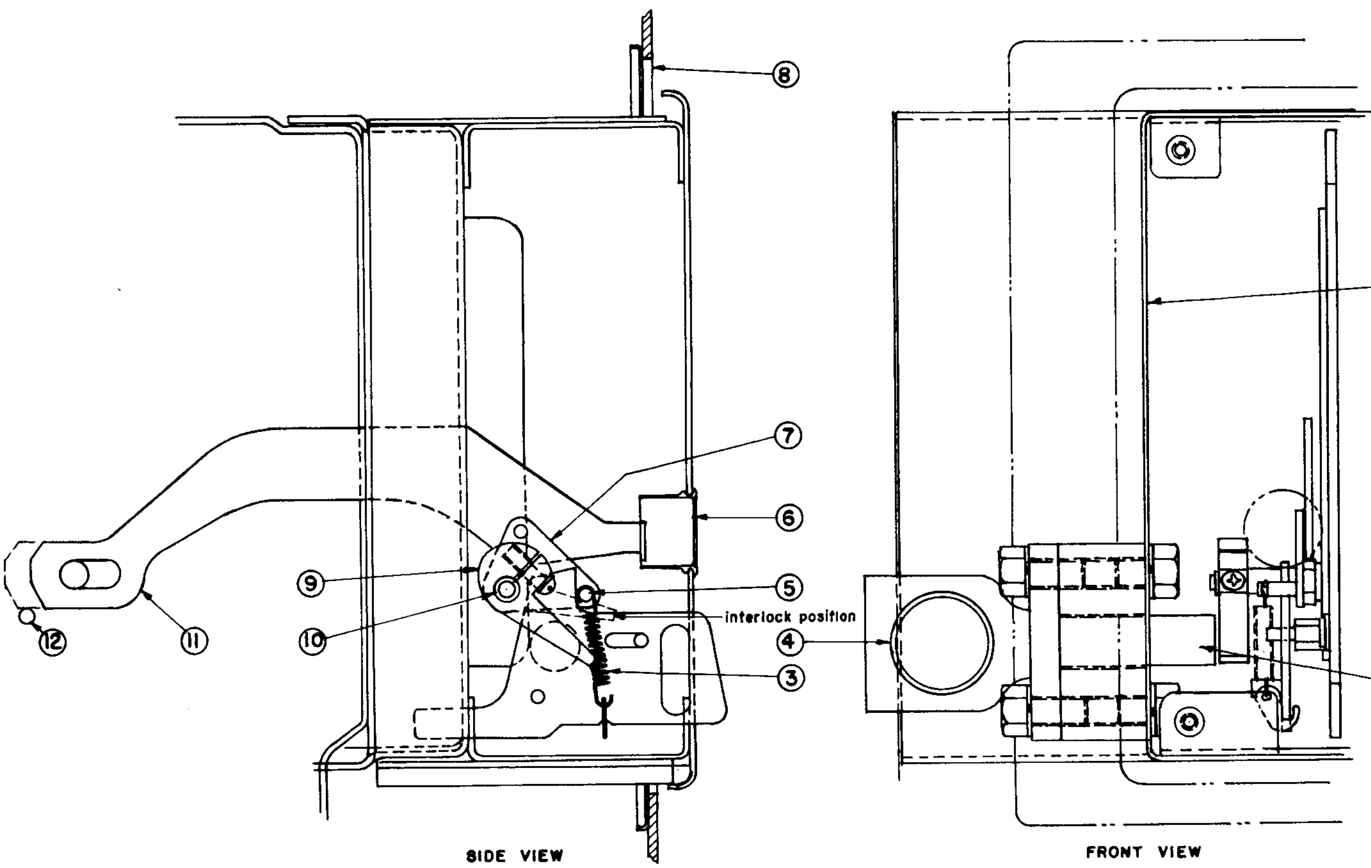


Fig. 2 - Key Interlock Arrangement for K-225, K-600 and K-1600 Circuit Breakers. Stationary Mounting Switchboard Type.

1. Trip button must be depressed tripping the circuit breaker, and held in until the key is turned to open position.
2. When key is turned to the open position, the projection of the bolt blocks trip lever and holds the trip button "In", thus making the circuit breaker trip free both manually and electrically.
3. Key is removable only when interlock bolt is in the projected position (breaker open).

Note: The interlock adapter is designed for Key Interlock type B2E-2 inch bolt projection.

KEY INTERLOCK FOR K-LINE STATIONARY MOUNTED (Cont.)



1. Key Interlock Bolt
2. Escutcheon Box
3. Spring
4. Key Interlock
5. Stud (Spring)
6. Trip Button
7. Bell Crank
8. Front Sheet
9. Block Lever
10. Stud (Block Lever)
11. Trip Link
12. Stud (Latch Bar)

Fig. 3-Mechanical Schematic of Key Interlock for K-Line Stationary Mounted Circuit Breakers.

KEY INTERLOCK MECHANISM FOR K-LINE DRAWOUT-TYPE CIRCUIT BREAKERS

GENERAL

The key interlock as used for K-Line drawout circuit breakers is a device applied to two or more movable parts, which prevents or allows a movement of one part only when another part is locked in a predetermined position. Such a device is shown in Figures 1 and 2.

The interlock system as applied to the associated equipment permits operation of the equipment only in a pre-arranged sequence. Conversely, the system prevents the equipment from violating the sequence in any way.

Primarily, the interlock is a safety device to provide safe working conditions. The interlock can also protect against damage to expensive and complex industrial machinery. An added incentive for the use of the interlock comes from increasing safety legislation and reductions in insurance rates when such a safety device is used.

Fundamentally, the key interlock is positive in action, which makes the controlled equipment absolutely inoperative at the correct point in the sequence. The device is difficult to defeat and must not be capable of being defeated. Visual indication is provided by the position of an actuating plunger.

On a key interlock, the key is removable only in a predetermined position. In an interlocking system on the other hand, locking operations are compulsory, since the key(s) can be removed only after the equipment has been locked.

The key interlock system contains two basic elements. One element is the simple, rugged lock which does the physical work. The other element consists of the linkage making up the interlocking system.

The lock itself is heavy-duty six-pin, tumbler model having a housing of heavy bronze with a locking bolt of 5/8 inch diameter Everdur rod. The interlock unit operates on the principle that the key can be removed only when the locking bolt is in a pre-determined position.

The key interlock for the K-Line drawout-type circuit breakers may be installed in the field with minor alterations to the front door, compartment and circuit breaker. These are shown in application drawings furnished upon request. Where the cradle and key interlock mechanism is being used in a compartment other than that of this company's manufacture, contact the I-T-E Circuit Breaker Company for information.

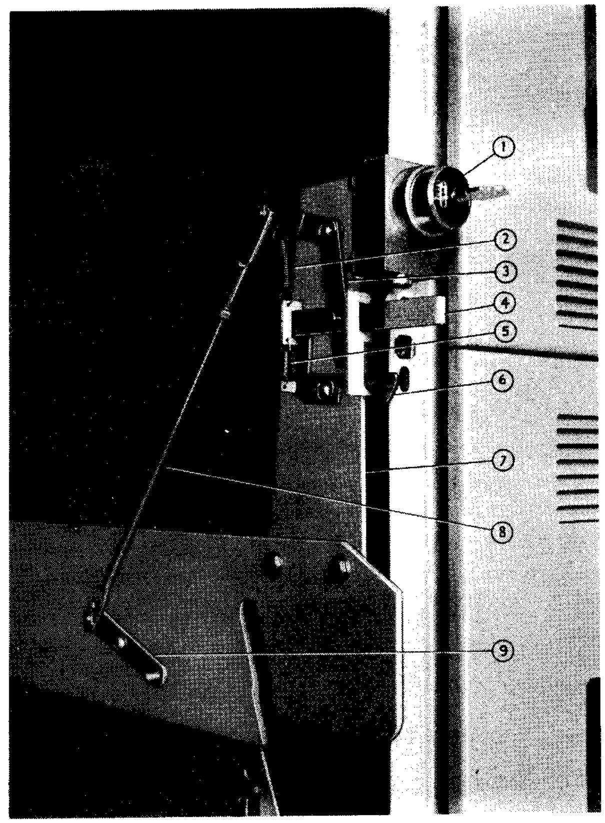


Fig. 1 - Key interlock mechanism for K-Line drawout circuit breaker.

Key interlocks can be furnished in two types as follows:

1. For one key lock application the Kirk Key Key Interlock-Type F (X) $\frac{1}{4}$ inch-E per Dwg. No. 146480-F is used.
2. Should two key locks be required the Kirk Key Interlock-Type M2F (X) $\frac{1}{4}$ inch-E per Dwg. No. 147400-F would apply.
   The key interlock assembly may be applied as follows:
   (a) Key Interlock-with one lock.
   (b) Key Interlock-with two locks.
   (c) Key Interlock-with door interlock.
   (d) Door Interlock only.

The key interlock with one or two locks (items (a) and (b) will only lock the circuit breaker in the trip-free position. However, the door may be opened.

The key interlock with one lock and a door interlock (item (c), allows the circuit breaker to be locked in the trip-free position only after the door latch has been released.

KEY INTERLOCK FOR K-LINE DRAWOUT-TYPE (Cont.)

A door interlock (item (d) is such that the front door of the compartment, which houses the circuit breaker, can not be opened until the circuit breaker has been tripped open. However, this does not prevent closing the circuit breaker with the door in the open position.

Each application for the above interlocks will not operate unless the circuit breaker mechanism is first tripped open by the manual "TRIP" button.

DESCRIPTION AND OPERATION

The device is located at the upper right-hand corner of the switchboard compartment as shown in Figure I. When the front door is closed the only elements in view are the plunger and key interlock. The key interlock is used to hold the circuit breaker in a maintained trip-free position when the plunger is pushed in. One or two locks may be used and the key(s) is removable when the locking bolt is extended.

Basically, the key interlock mechanism, as shown in Figure I, consists of a lock (I) plunger (4), door latch (6), reset springs (2) and (5), cranks (3) and (9) and connecting rod (8). There is no fastening between the upper and lower system of links. The device does not interfere with normal drawout operations and functions independently from the circuit breaker tripping operation

The plunger (4) has limited lateral motion which causes a crank (3) to rotate on its pivotal stud. This crank cams against a latch (6) which allows the front door to be opened only when the circuit breaker contacts are opened.

When the plunger (4) is pushed in, the motion is transmitted to crank (9) through the adjustable rod (8). The pin on the crank cooperates with part (10) of figure (2), which operates through internal linkage to depress the trip latch. This maintains the circuit breaker in a trip free position and will not allow the contacts to close.

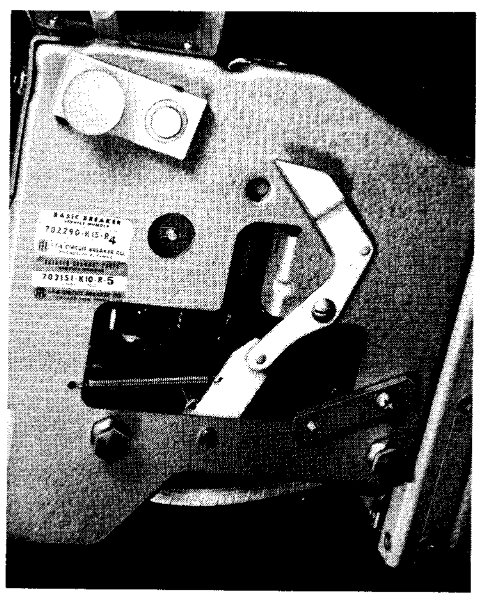


Fig. 2 - View showing K-Line drawout circuit breaker right hand side frame, trip cam and trip lever actuator for interlock mechanism.

UNDERVOLTAGE TRIP DEVICE FOR K-LINE® CIRCUIT BREAKERS*

INTRODUCTION

The electrically-reset undervoltage trip device as furnished on the K-Line circuit breaker is a single-phase device which automatically trips the circuit-breaker mechanism on a decrease in the line voltage below a predetermined range.

As in the case of overcurrent tripping, the automatic trip indicator will indicate tripping of the circuit breaker by the undervoltage trip device unless special provisions are made.

A K-Line undervoltage trip device may be furnished to operate on a-c circuits (60, 50, or 25 cycles) or on dc. This device may be furnished either for instantaneous trip operation or with adjustable time-delay tripping of 0-15 sec.

The undervoltage trip device as shown in Figure 1 is an integral unit which may be readily added to the circuit breaker either at the factory or in the field.

DESCRIPTION AND OPERATION

The undervoltage trip device is a compact and sturdy device which consists of the following:

1. Basic mounting structure.
2. Operating magnet and armature structure.
3. Operating coils.
4. Operating adjustment (factory set).
5. Time-delay adjustment (not calibrated).
6. Trip Linkage
7. Time-delay dashpot

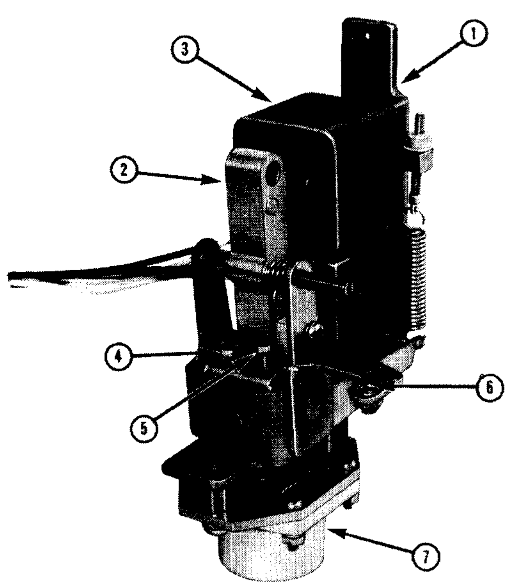


Fig. 1 - A-C undervoltage trip device with time delay.

The operating coils provided for various standard service voltages together with operating data are listed below:

TABLE I

Nominal Service Voltage	Current at Rated Volts Amperes	Minimum Pick-up Voltage Value	Dropout Voltage Values	
			Minimum	Maximum
125 V dc	.17	100	37	75
250 V dc	.086	200	75	150
115 V ac	.48	92	39	69
230 V ac	.24	184	69	138
480 V ac	.12	384	144	288

It should be noted that a series resistor is provided for both D-C coils. This resistor is by-passed in the de-energized position by a small normally-closed cutout switch. When the armature has picked up, this contact opens and inserts the resistor in series with the operating coils. This provides protection for continuous energization of the coil and to obtain the proper voltage drop-out range.

Instantaneous

For instantaneous undervoltage trip device the time-delay dashpot is omitted. This device will permit closing of the circuit breaker at voltages greater than 80% of the rated value and will trip the circuit breaker should the line voltage drop below the tripping range indicated in Table I. Should the voltage on the coils fall below this value, the armature is released and its movement is transmitted through a trip lever to rotate the trip latch of the operating mechanism. Any attempt to reclose the circuit breaker with less than 80% of the rated voltage existing across coil terminals will result in a trip-free operation of the mechanism.

Time Delay

The undervoltage trip with time delay (as shown) is similar to the instantaneous trip construction with the addition of the time-delay dashpot. This is used when desired to hold the circuit breaker closed for a time interval following a voltage failure. If normal circuit conditions do not return during this time interval, the circuit breaker will trip in its customary manner. The time interval is adjustable from 0 to 15 seconds at zero voltage. Any attempt to reclose the circuit breaker with less than 80% of the rated voltage existing across the coil terminals will also result in a trip-free operation of the mechanism.

*Includes K-DON® and KSP™

UNDERVOLTAGE TRIP DEVICE (Cont.)

The time-delay dashpot is supported from the bottom of the magnet frame. It is essentially the same type as the dashpot used on the OD devices. The time delay thus provided is dependent upon the distance the piston moves through the silicone oil. The time is increased or decreased by turning the adjusting stud which changes the length of the stroke. The adjusting stud is not calibrated.

SHUNT TRIP DEVICE FOR K-LINE® CIRCUIT BREAKERS*

INTRODUCTION

The shunt trip device, as used on the K-line circuit breakers, is used to trip the circuit breaker electrically by means of an electrical contact from a remote control station. This tripping contact may be in a form of a simple pushbutton switch contact or it may be a contact in an elaborate relay scheme.

Tripping energy for the shunt trip is usually in the form of a storage battery, control power transformer, or a d-c generator source.

The K-Line shunt trip as shown in Fig. 1 is a compact and simple unit which operates directly upon the mechanism latch. This insures dependable, trouble-free tripping of the circuit breaker contacts. Ready attachment of the shunt trip device provides convenient addition or replacement. One design of shunt trip is used on the entire line, which simplifies the stocking of replacement units.

DESCRIPTION AND OPERATION

Principle component parts of the K-Line shunt trip are:
(a) Magnet structure including plunger
(b) Operating coil
(c) Tripping linkages
(d) Tripping adjusting rod

The magnet structure is essentially a solenoid type design and is constructed of a cylindrical plunger operating in a U-shaped magnet frame. Energizing the coil (9) Fig. 2 causes the plunger (8) to mover upward. This motion is transferred by linkage (7) to the trip rod (5) which serves to rotate the mechanism latch (3) in a tripping direction. The operating coil (9) is bobbin-wound, and covered with a thermo-setting glass tape. This provides a sturdy compact moisture-excluding construction. Type "T" lead wires are furnished.

The tripping adjustment is made from above by means of a screw driver. A nylon lock-nut (6) is used to maintain this adjustment. The surface area on the bottom of the trip rod (5) is extra large to insure positive engagement with the mechanism latch trip extension (4). The extension spring (2) is used to return the plunger (8) to its normal de-energized position.

The shunt trip device is always located on the lefthand side of the circuit breaker mechanism. The device is readily and securely attached to the side plate (1) by a key extension and one fastening screw.

*Includes K-DON® and KSP™

CURRENT REQUIREMENTS

The current requirements of the shunt trip at various nominal voltages and the corresponding voltage range through which they must operate are:

Nominal Control Voltages	Nominal Current K-225 to K-2000	Nominal Current K-3000 & K-4000	Operating Range
48 Volt dc	3.14	5.0	28-60
125 Volt dc	1.3	2.0	70-140
250 Volt dc	.65	1.0	140-280
115 Volt ac	6.5	10.0	50-125
230 Volt ac	1.15	1.84	190-250

Fig. 1 - Shunt trip device for K-Line Circuit Breakers.

It should be observed, that the operating coil is designed for intermittent duty, and that the operating current is interrupted by a normally open contact on the auxiliary switch of the circuit breaker. Starting from zero, the time to trip open the circuit breaker contacts by the shunt trip device is approximately

SHUNT TRIP DEVICE (Cont.)

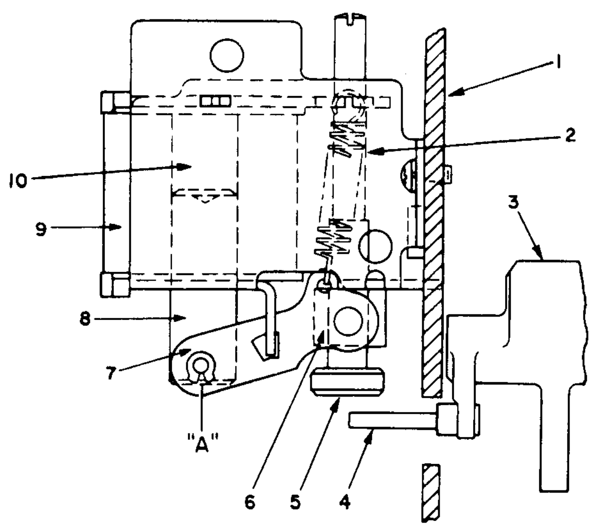
0.0167 seconds. The total time of current flow in the operating coil is approximately 0.022 seconds.

FACTORY TESTS

Each shunt trip device is factory tested for proper operation over the required voltage range, and for proper insulation by means of dielectric tests.

REPLACEMENT PARTS

The shunt trip device for K-Line circuit breaker is an integral designed unit. If for any reason, part of the unit must be changed, then it is recommended that a complete new trip unit be installed. We recommend this policy, because of the "staked" construction used in the assembly of the unit.



LEGEND

1. L. H. mechanism side plate
2. Spring (trip link)
3. Latch bar (mech.)
4. Trip extension (latch bar)
5. Trip adjusting rod
6. Lock-nut
7. Trip link
8. Plunger
9. Operating coil
10. Magnet frame

Fig. 2 - Shunt trip device for K-Line Circuit Breakers.

AUXILIARY SWITCHES FOR K-LINE CIRCUIT BREAKERS

INTRODUCTION

The auxiliary switch is a contact device operated mechanically by the circuit breaker to effect electrical circuits for closing, tripping and signaling purposes.

Auxiliary switches, as used on the K-Line circuit breakers, are front connected switches with double break rotary contacts. These switches may be furnished as 4 and 8 contacts as shown in Fig. 1.

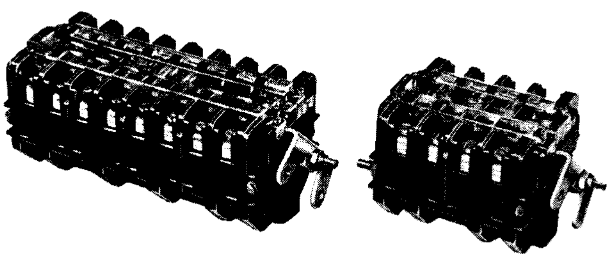


Fig. 1 - Four and eight contact auxiliary switches for K-Line circuit breakers.

These switches are mounted on a shelf straddled between the breaker side frames and in front of the arc extinguishers. Linkage from the auxiliary switch to an arm on the jack shaft operate these switches. These links are on the right and left hand side of the breaker just inside the breaker side frames. The auxiliary switches are readily mounted on the shelf and additions may be made as required. Refer to Fig. 2.

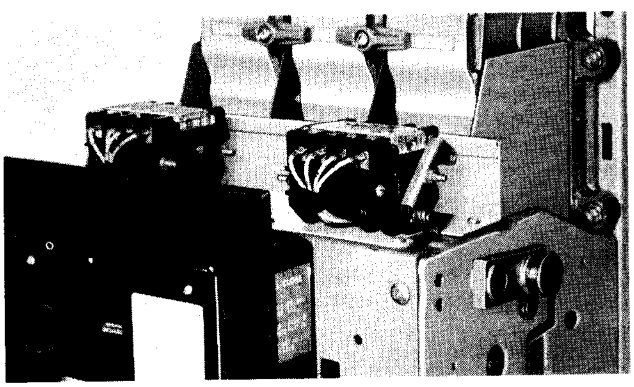
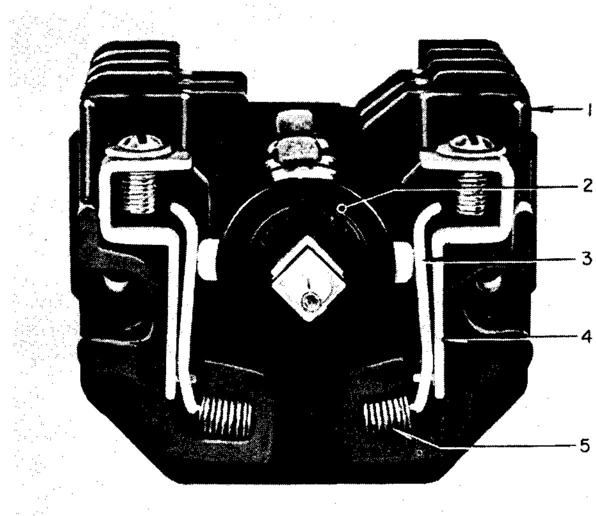


Fig. 2 - Method of mounting auxiliary switches on shelf for K-Line circuit breakers.

The switch itself is groups of built up sections as in Fig. 3 enclosing the contact structure consisting of movable and stationary contacts. The movable contacts rotate with a common shaft and operate in sequence as assembled. These contacts may be assembled so that they may be closed when the circuit breaker is closed "a" or closed when the circuit breaker is open "b". Any contact can be changed as "a" to "b" or "b" to "a" type of contact.



1. Contact Molding
2. Rotating Contact Assembly
3. Movable Contact
4. Stationary Contact
5. Contact Spring

Fig. 3 - Auxiliary switch with end molding cover and operating crank removed.

RATINGS

The switch can carry 40 amperes continuously with limitations in interrupting as indicated in Table I. Two contacts are sometimes placed in series for operating on highly inductive D-C circuits. The interrupting ratings given below are also indicated on the transparent cover of the switch.

TABLE I - Interrupting Ratings

Circuit Voltages		Maximum Amperes
AC	115 240 480 600	30 20 10 7
DC	125 250 600	10# 5# 0.5#

Inductive load current corresponding to the interruption of the trip coil circuit of a breaker

AUXILIARY SWITCHES (Cont.)

DESCRIPTION

It is not necessary to remove the cover to check the condition or operating sequence of the contacts, since the contacts are visible through the transparent cover.

The individual body moldings interlock and nest into each other; and the cover can only be positioned one way. The movable and stationary contacts are easily removed but require following certain assembly procedures. These procedures are described in detail in the I-T-E Instruction Bulletin IB-5504.

Contacts are defined as "a" or "b" depending upon their position when the circuit breaker contacts are open. The contacts are arranged as "a" or "b" when crank-arm is in the position it occupies with the circuit breaker open.

Rotation of the shaft opens a normally closed "b" contact when the circuit breaker closes and closes a normally open "a" contact. Contact operation is reverse when the circuit breaker opens so that "b" contacts close and "a" contacts open.

Opening the circuit breaker rotates the switch shaft. The normally-closed "b" contacts open when the breaker closes. The normally-open "a" contacts close when the circuit breaker closes. As the breaker opens, the "b" contacts close, and the "a" contacts open.

Basically, a four-contact auxiliary switch consists of two end moldings, four stationary contact moldings with contacts and retainers, two bearing moldings, one cover molding, one shaft and necessary hardware.

Each additional contact for the eight-contact auxiliary switch consists of one interphase molding, one stationary contact molding with contacts, two rotating contact assemblies, a longer shaft and cover.

The stationary contact structure is positioned and held in place by cavities in the base moldings. The contact making finger is a silver-plated finger biased into contact with the rotating member by a reliable contact spring. The design is such as to afford maximum contact wipe, constant contact pressure, low contact resistance and low frictional wear. The terminal screws for external connections are included in the stationary contact structure and the molding design provides maximum electrical clearance for the control circuit potential. Switch terminals are identified by raised numbers on the cover molding.

The rotating contact assembly consists of silver-plated brass contacts held in place by a lock ring on a molded support bushing. This assembly is positioned on a square shaft which rotates on end molding bearings.

The rotating contacts may be furnished in the form of standard contacts or as special "early-make" or "late-break" type contacts.

Standard contacts "a" and "b" always have their long axis coincide with the diagonals of the square shaft. The corner of the shaft in turn mesh with the center notch of each set on the contact support.

The advanced contacts "a" and "b", which may be "early-make" or "late-break", will have the diagonals of the square shaft 22.5 degrees either side of the diagonals of the square shaft. The corner of the shaft mesh in the outside notch of each set on the contact support.

Therefore, when mounting auxiliary switches or changing individual contacts, the crank-arm of the auxiliary switch should be maintained in this position. The switch is actuated by a link connecting the auxiliary switch crank-arm with the jack shaft arm of the circuit breaker.

RENEWAL PARTS

Replacement of entire auxiliary switches is recommended for installation on circuit breakers. When ordering complete switches, specify the number of contacts.

PRODUCTION TESTING - LOW-VOLTAGE POWER CIRCUIT BREAKERS
APPLICABLE TO K-LINE AC, K-LINE DC, K-DON AND KSP

All low voltage circuit breakers shipped from the factor undergo a series of testing and inspection procedures to insure high quality of workmanship and of circuit breaker performance in the field. Since circuit breakers are basically designed to protect human life and to prevent damage to electrical equipment, it is essential that each circuit breaker be rigidly inspected and tested for correct performance.

Production tests are performed on each circuit breaker before shipment. Modern, up-to-date testing equipment is utilized for accuracy and reliable measurements in the inspection, calibration and testing. Qualified testers with many years of testing experience insure that each individual circuit breaker will perform as it is designed to perform. In addition, each breaker is inspected to verify that it complies with the specific order for which it was manufactured.

Production tests shall include the following:
(1) Control and secondary wiring check test
(2) Dielectric withstand test
(3) Mechanical operation test
(4) Calibration test (not applicable to KSP)

CONTROL AND SECONDARY WIRING CHECK TEST

Control and secondary wiring are checked to make sure that all connections have been made correctly. Devices and relays, if used, are checked by actual operation where feasible. Those circuits for which operation is not feasible are checked for continuity.

DIELECTRIC WITHSTAND TEST

Dielectric tests are made on each circuit breaker after final assembly has been completed.

The dielectric test is applied as follows:
(1) With circuit breaker in the open position, apply 2,200 volts (1,000 volts plus twice 600 volts):
  (a) Between live parts, including both line and load terminals, and metal parts that are normally grounded.
  (b) Between line terminals and load terminals.
(2) With circuit breaker in the closed position, apply 2,200 volts:
  (a) Between live parts and metal parts that are normally grounded.
  (b) Between terminals of different phases.
(3) With circuit breaker in either open or closed position, apply 1,500 volts:
  (a) Between control circuit and metal parts that are normally grounded. If the circuit breaker control circuit includes a motor, the motor may be disconnected during the dielectric test on the concircuit and subsequently tested, in place, at its specified dielectric withstand voltage, but at no less than 900 volts.

Dielectric failure is indicated when the leakage current resulting from the failure is sufficient to trip open the small breaker in the test equipment.

MECHANICAL OPERATION TEST

Electrically operated circuit breakers are given the following no-load operational tests:
(1) Five closing and five opening operations at minimum control voltage.
(2) Five closing, five opening, and five trip-free operations at maximum control voltage.
(3) Two operations to check antipumping, which is performed in the following manner.
  (a) Apply uninterrupted control power to the closing circuit.
  (b) Trip the circuit breaker. The circuit breaker is to remain open until closing circuit power has been interrupted and then restored.
(4) If other devices, electrical or mechanical, are used, they are checked for proper functioning. Such devices are to include key interlocks, mechanical interlocks, electrical interlocks, padlocking, racking mechanisms, etc.

Manually operated circuit breakers -
(1) Manually operated circuit breakers are given five closing and five opening operations
(2) When shunt trip is used, the circuit breaker is opened by means of the shunt trip a minimum of five times at the minimum control voltage specified for the coil.
(3) The circuit breaker is given five trip-free operations.
(4) If other devices, electrical or mechanical, are used, they are checked for proper functioning. Such devices include key interlocks, mechanical interlocks, electrical interlocks, padlocking, racking mechanism, etc.

CALIBRATION TEST

The most important calibration test is that of adjusting and setting of the direct acting trip device so as to afford reliable overcurrent protection of the electrical equipment connected

PRODUCTION TESTING - LOW-VOLTAGE POWER CIRCUIT BREAKERS (Cont.)

to the circuit breaker terminals. These calibration tests may include the following steps where applicable:

(1) Calibrate and set the pickup of the long-time delay element.
(2) Calibrate the delay of the long-time element.
(3) Calibrate and set the pickup of the instantaneous trip element.
(4) Calibrate and set the pickup of the short-time delay element.
(5) Calibrate and set the delay of the short-time trip element.

DESIGN TESTING - LOW-VOLTAGE POWER CIRCUIT BREAKERS (Cont.)
APPLICABLE TO K-LINE AC, K-LINE DC, K-DON AND KSP

Design tests are made to determine the adequacy of the design of a particular type, stvle, or model of a circuit breaker to meet its assigned ratings and to operate satisfactorily under normal service conditions or under unusual conditions if specified. Design tests are made only on representative circuit breakers to substantiate the ratings assigned to all circuit breakers of a particular design. Where circuit breakers are to be used in enclosures, the design test is made with the breaker in its enclosure.

Design tests on low voltage power circuit breakers include the following:
(1) Dielectric withstand test
(2) Continuous current test
(3) Short-time current test (applicable to K-line AC only)
(4) Short-circuit current interrupting test
(5) Making current test (applicable to K-line AC only)
(6) Latching current test (applicable to K-line AC only)
(7) Endurance performance test
(8) Switching current test (applicable to KSP only)

DIELECTRIC WITHSTAND TEST

Dielectric withstand tests on circuit breakers are made to determine the ability of the insulation to withstand overvoltages.

A 60-cps alternating sinusoidal voltage whose rms value is equal to the specified voltage is used.

The dielectric test is applied as follows:
(1) With circuit breaker in the open position, apply 2,200 volts (1,000 volts plus twice 600 volts):
    (a) Between live parts, including both line and load terminals, and metal parts that are normally grounded.
    (b) Between line terminals and load terminals.
(2) With circuit breaker in the closed position, apply 2,200 volts:
    (a) Between live parts and metal parts that are normally grounded.
    (b) Between terminals of different phases.
(3) With circuit breaker in either open or closed position, apply 1,500 volts:
    (a) Between control circuit and metal parts that are normally grounded. If the circuit-breaker control circuit includes a motor, the motor is disconnected during the dielectric test on the control circuit and subsequently tested, in place, at 900 volts.

CONTINUOUS CURRENT TESTS

The continuous current test is made to insure that the circuit breaker can carry its rated continuous current without exceeding the allowable temperature rise. A circuit breaker equipped with a direct-acting trip device is tested with a coil having a current rating equal to the continuous current rating of the circuit breaker frame size.

Three-pole circuit breakers are tested using a three-phase circuit.

SHORT-TIME CURRENT TEST

The short-time current test is made to verify the ability of the circuit breaker to carry fault currents for a short time period, when applied without direct-acting trip devices.

With the circuit breaker in the closed position, the short-time current is applied and maintained for two periods of one-half second each with a fifteen-second interval of zero current between the one-half second periods.

SHORT-CIRCUIT CURRENT INTERRUPTING TEST

The interrupting tests are made on circuit breakers to determine their ability to close, carry, and interrupt currents within their assigned ratings.

Types of tests:
(1) A single-phase test with line-to-line voltage equal to rated maximum voltage applied across one pole and with the current equal to or greater than 87 percent of the short-circuit current rating.
(2) Three-phase tests with line-to-line voltage equal to rated maximum voltage and the average of the three-phase current equal to or greater than the applicable short-circuit current rating.

K-don only:
(3) A three-phase test with line-to-line voltage equal to rated maximum voltage and the average of the three-phase current equal to the rated short-circuit current of the circuit breaker element frame size.

DESIGN TESTING - LOW-VOLTAGE POWER CIRCUIT BREAKERS

Each test consists of an open operation followed after a 15-second* interval by a close-open operation. If time-delay tripping devices are used, the tripping on each opening shall be delayed by the associated tripping devices.

After performance of an interrupting duty cycle at its short-circuit rating, the circuit breaker will be in the following condition:

(1) Mechanical - It will be substantially in the same mechanical condition as before the test.

(2) Electrical - It will be capable of withstanding a dielectric test of 60 percent of the standard test voltage. The circuit breaker will be capable of carrying rated continuous current, but not necessarily without exceeding rated temperature rises and will be capable of operating automatically within specified time limit at the 300 percent calibration point.

MAKING CURRENT

The circuit-breaker making current capability is demonstrated by the ability of the circuit breaker to pass the short-circuit current duty cycle (open - 15 second interval - close-open) test.

LATCHING CURRENT

The ability of a circuit breaker that is not equipped with a direct-acting instantaneous trip element to meet its latching current capability is demonstrated by the ability of the circuit breaker to pass the short-circuit current duty cycle (open - 15 second interval - close-open) test.

SWITCHING CURRENT TEST - KSP ONLY

The power service protector is to be capable of switching current equal to 1200 percent of its rated continuous current.

This test is made with the fuses replaced by links. It will be run under the same conditions as the short circuit current interruption tests but at the lesser value of current.

The power service protector will be capable of performing three 3-phase closing and opening operations without maintenance.

ENDURANCE PERFORMANCE TEST

Endurance performance tests are made on circuit breakers to determine their ability to operate satisfactorily in usual service without excessive servicing or maintenance.

The electrical endurance test is made with rated continuous current, rated maximum design voltage, and rated control voltage, and will not necessitate the repair or replacement of any functional parts prior to completion.

The mechanical endurance test is made at no load and with rated control voltage, and will not necessitate the repair or replacement of any functional parts prior to completion.

At the end of the test, the circuit breaker will be capable of meeting all its continuous current and voltage ratings, and one opening test at rated short-circuit current.

APPLICABLE STANDARDS

The K-Line of circuit breakers and the many variations are designed and tested in accordance with the following standards.

Basic K-Line AC	
American Standard:	C37.13-1963
	C37.15-1954
	C37.16-1963
	C37.17-1962
NEMA Standard:	SG3-1965, Part 13
K-Line DC(gen. purpose)	SG3-1965, Part 14
K-Don	SG3-1965, Part 28
KSP	SG3-1965, Part 29

*For K-DON and KSP the time interval is the time that it takes to replace fuses and reset anti-single-phase device.