ABSTRACT: A current-limiting circuit breaker is provided with a new and improved contact-operating assembly having a contact rod operatively joined to a tubular operating shaft by an axially extending stepped connector fixedly received within the rod and slidably retained by the operating shaft to permit limited relative movement between the operating shaft and the contact rod of the assembly. A spring mounted within the tubular shaft acts on the connector and may be adjusted independently of shaft movement.
ARMATURE-CONTACT ROD CONNECTION FOR CURRENT-LIMITING BREAKER

BACKGROUND AND SUMMARY OF THE INVENTION

The present invention relates generally to electric circuit breakers and is more particularly concerned with circuit breakers of the "current-limiting" type having linearly movable contact-operating assemblies.

Recently electric circuit breakers have been developed which combine conventional manual and automatic operation with an un fused high-speed current interruption capability. Typical of such circuit breakers which have proved particularly effective in combining the conventional and current-limiting means for causing opening of the contacts is the structure disclosed in U.S. Pat. No. 3,384,845 issued on May 21, 1968 to Johnson et al. and assigned to the same assignee as the present invention. As set forth in that patent, the current-limiting circuit breaker is provided with a linearly movable contact-operating assembly operatively associated with both a conventional operating mechanism and a high-speed solenoid operator. The assembly includes a contact rod supportably mounting an armature of the solenoid operator and a tubular operating shaft connected to the contact rod by means of a spring-biased lost-motion connection consisting of an elongated slot within which is slidable received a transversely extending roll pin. As can be appreciated, high-speed operation of the assembly by the solenoid places substantial stresses on the assembly particularly at the lost-motion connection. Additionally, a spring utilizing hereofore prevents adjustment of the spring-biasing force without also varying the wear allowance of the assembly.

Accordingly, it is an object of the present invention to provide a new and improved current-limiting circuit breaker having a linearly movable contact-operating assembly including an axially extending lost-motion connector promoting greater reliability of operation and positive driving engagement between the armature and the tubular operating shaft during opening of the contacts under high short circuit current conditions.

It is another object of the present invention to provide a new and improved current-limiting circuit breaker of the type described which incorporates a new and improved axial connection between the operating shaft and the contact rod of the contact-operating assembly. The connection provides greater convenience of assembly and a neater, more pleasing appearance while at the same time assuring adjustability of contact pressure without variation in the wear allowance.

Other objects will be in part obvious and in part pointed out more in detail hereinafter.

Briefly stated, these and related objects are accomplished in accordance with the present invention by incorporating into a current-limiting circuit breaker a new and improved contact-operating assembly having a contact rod operatively joined to a tubular operating shaft by an axially extended stepped connector fixedly received within the rod and slidable retained by the operating shaft to permit limited relative movement between the operating shaft and the contact rod of the assembly. A spring mounted within the tubular shaft acts on the connector and may be adjusted independently of shaft movement.

A better understanding of the invention will be obtained from the following detailed description and accompanying drawings which set forth an illustrative embodiment and are indicative of the way in which the principle of the invention is employed.

BRIEF DESCRIPTION OF THE DRAWINGS

In the Drawings:

FIG. 1 is a side elevational view, partly broken away and partly in section, illustrating a portion of the internal mechanism of a current-limiting circuit breaker incorporating the features of the present invention;

FIG. 2 is an enlarged partial side elevational view, partly broken away and partly in section, illustrating the relative positioning of the contact-operating assembly of FIG. 1 during normal closed-circuit operation;

FIG. 3 is a view similar to FIG. 2 showing the position of the contact-operating assembly after response to a high-level short circuit current condition but prior to full trip operation of the circuit breaker's conventional operating mechanism; and

FIG. 4 is a view similar to FIG. 3 showing the position of the contact-operating assembly when the circuit breaker is manually set at its OFF position.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to the drawings in greater detail wherein like reference numerals indicate like parts throughout the several figures, the invention is illustrated as embodied within a current-limiting circuit breaker having a generally rectangular housing 12 including an insulating cover 14 provided with an elongated central aperture 18 through which extends a manually operated handle 18. Although the housing 12 encloses three separate and individual poles extending longitudinally along the breaker, the mechanism associated with only one of the three poles will be described in order to provide greater ease of understanding and clarity of description. It will, of course, be understood that manual operation of the handle 18 will effect simultaneous opening and closing of the circuits controlled by the breaker while automatic operation of one circuit will cause a corresponding open circuit condition within the entire circuit breaker.

Referring specifically to FIGS. 1 and 2, a pair of spaced stationary contacts 22 are shown as fixedly mounted on separate arc runners 24 within the housing 12. The contacts 22 are positioned within an arc-initiating chamber 26 and are electrically connected through suitable conductive straps to line and load terminals 23, 30, respectively, positioned at opposite ends of the circuit breaker. A pair of complementary movable contacts 34 operatively connected to a linearly movable contact-operating assembly, generally designated by the numeral 36, reciprocally move toward and away from the stationary contacts 22 between open and closed circuit positions. A trip unit 38 supported within the housing 12 adjacent the load terminal 30 is electrically connected to one of the stationary contacts 22 by a trip unit strap 40 and is mechanically connected to the linearly movable contact assembly 36 through a conventional overcenter operating mechanism 42 operatively associated with the handle 18.

It will be appreciated that the manual and automatic operation of the current-limiting circuit breaker of the present invention is substantially the same as that described in the aforementioned Johnson et al. U.S. Pat. No. 3,384,845. Accordingly, when the manually operated handle 18 is moved out of its ON position shown in FIG. 1 toward its OFF position, the overcenter operating mechanism 42 will cause a common tie bar 46 to rotate clockwise as viewed in FIGS. 1 and 2. During this movement a high-speed connecting plate 48 connected to the assembly 36 will move with the tie bar 46 as an armament between the opposite end of slot 52 in plate 48. In this manner, the entire linearly movable contact-operating assembly 36 is drawn to the right as viewed in FIGS. 1 and 2 until it assumes the open circuit position illustrated in FIG. 4.

When the circuit breaker is in the ON position shown in FIGS. 1 & 2 and a low value short circuit current conditions occurs, the trip unit 38 will release a reposable latch 54 thereby permitting a shift in the overcenter operating mechanism 42 and opening of the contacts in substantially the same manner as indicated for the movement of the handle 18 to its OFF position. As set forth in the aforementioned Johnson et al. U.S. Pat. No. 3,384,845, during high-level short circuit conditions the slot 130 in connection plate 48 permits movement of the contacts to an open circuit position by the
Referring particularly to the embodiment of FIGS. 2-4, the linearly movable contact-operating assembly 36 includes an elongated tubular operating shaft 58 extending from the mechanism 42 axially through the central aperture 60 of the solenoid operator 56. The shaft 58 is operatively connected to the mechanism 42 by an adjustable linkage 62 secured by the pin 64 to the connecting plate 48 for movement therewith. The linkage 62 includes an insulated plug member 66 threadably received within one end of the tubular operating shaft 58 and an axially projecting bifurcated connecting link 68 threadably received within the plug member 66.

Spaced from the operating shaft 58 and in substantial coaxial alignment therewith is a solid contact rod 72 having a contact carrier 74 of a generally tapered shape fixedly mounted on its forward end. As shown, the carrier 74 supports the movable contacts 34 on the flat angularly disposed end surfaces 76 thereof for movement toward and away from stationary contacts 22 mounted on the arc runners 24. The opposite end of contact rod 72 is provided with a hub portion 82, FIG. 2, of reduced cross section forming a shoulder 84 against which is secured a thin heat fin 86 disposed normal to the axis of the contact rod. Mounted on the hub portion 82 adjacent the heat fin is a generally cylindrical armature 88 for the solenoid operator 56, the armature 88 including a radially extending flange 90 in intimate surface contact with a flat face of the dischike heat fin 86. The armature 88 is fixedly secured to the contact rod and is disposed in telescopic parallelism relationship with the end of the operating shaft adjacent the contact rod.

In accordance with the present invention a threaded connector of stepped configuration is secured within both the operating shaft 58 and the contact rod 72 and maintains the shaft and rod in close, relatively movable relationship while providing a lost-motion connection therebetween. The connector extends axially of both the shaft and the rod and includes an enlarged head portion 94 positioned within the tubular shaft 58 for interfering engagement with an inwardly projecting lip 96 located on the end of shaft 58 opposite linkage 62. The head portion 94 is of sufficient size relative to the portion defined by lip 96 to prevent removal thereof from the shaft in the direction of the contact rod 72. Integral with but spaced from the head portion 94 is a stem portion 98 fixedly received within the axial extending aperture 100 provided in the hub portion 82 of the contact rod. An elongated, generally cylindrical shank portion 102 integrally connects the head portion 94 and stem portion 98 of the connector, the shank portion being of a size capable of being slidably received within the communicating portion defined by the inwardly projecting lip 96 of the operating shaft. The shank portion 102 is substantially uniform in cross section along its length and of greater diameter than the stem portion 98 so as to provide a retaining shoulder 106 which bears against the radial flange 90 of the solenoid armature 88 urging it into retained engagement with the heat fin 86. Thus, both the heat fin 86 and solenoid armature 88 are fixedly secured to the contact rod 72 and retained thereon for movement with the rod through the cooperative action of the rod's shoulder abutment 84 with the retaining shoulder 106 of the connector.

As will be appreciated, movement of the armature 88 by the solenoid operator 56 will be effective to simultaneously drive the contacts out of a closed circuit position, the solenoid being designed to cause movement of the armature upon the occurrence of a high-level short circuit current condition.

Mounted within the tubular operating shaft 58 and extending longitudinally thereof from the plug member 66 is a contact spring 108 which operatively bears against the head portion 94 of the connector urging it toward engagement with the shaft's inwardly projecting lip 96. It is an advantageous feature of the present invention that the biasing force of spring 108, and therefore the contact pressure to be overcome by the solenoid 56, can be adjusted without requiring movement of the shaft 58 relative to the contact rod 72. As mentioned hereinbefore, the movable contacts can be readily moved into a closed circuit position by manually moving the operating lever 18 from the OFF position to the ON position. When the manually operated handle is in the OFF position the compression spring 108 urges the head portion 94 of the connector into firm abutting engagement with the inwardly projecting lip 96 of the operating shaft, as shown in FIG. 4. However, as the linearly movable contact-operating assembly 36 is moved to the left toward the closed circuit position shown in FIGS. 1 and 2 the movable contacts 34 come into abutting engagement with the stationary contacts 22. Continued movement of the overcenter operating mechanism 42 causes the operating shaft 58 to slidably move along the shank portion 102 of the connector against the bias of spring 108 thereby further loading the spring and assuring firm positive contact between the movable and stationary contacts of the circuit breaker. Thus, as shown in FIGS. 1 and 2, a wear gap, indicated by the numeral 112, is provided between the inwardly projecting lip 96 of the operating shaft 58 and the head 94 of the connector. As can be appreciated, the gap 112 can be varied in size and the loading of the spring 108 can be adjusted by appropriately axial movement of linkages 116 and 118 in this way greater control can be exercised over the contact pressure and thus over the force which must be generated within the solenoid to cause separation of the contacts. Additionally, as can be clearly seen, the forces acting within the movable contact assembly are substantially concentrated along the axis of the assembly while avoiding a transversely extending connection between the operating shaft and the contact rod.

Upon the occurrence of a high-level short circuit current condition across the circuit breaker the energized solenoid 56 attracts the magnetically responsive armature 88 causing rearward movement thereof to the right as viewed in the drawings. It will be appreciated that only the force exerted by the loaded spring 108, which is less than that of the overcenter operating mechanism 42, need be overcome by the solenoid to cause opening of the contacts. The high-speed operation of the solenoid operator 56 causes rapid rearward movement of the armature 88, contact rod 72 and those members fixedly connected thereto. This action, of course, causes additional loading of the compression spring 108 and rapidly brings the radially extending flange 90 of the connector's thread to engagement with an inwardly projecting lip 96 on the operating shaft. In this manner the armature 88 directly drives the operating shaft 58 rearwardly causing the high-speed connecting plate 48 to rotate to the phantom position illustrated in FIG. 2 against the bias of its retaining spring 114.

Thus, the solenoid will drive assembly 36 into the position shown in FIG. 3. However, as mentioned in the Johnson et al. U.S. Pat. No. 3,384,845, the slot 130 in plate 48 permits this rapid movement without interference from the slower-moving overcenter operating mechanism 42. Although the short circuit current condition will be effective to cause the trip unit 38 to release the releasable latch 54 and trip the overcenter mechanism 42, it will be appreciated that the opening of the contacts is not delayed so as to await activation of the trip unit. Of course, the open circuit condition of the tripped circuit breaker will deactivate the solenoid and permit the spring 108 to drive the head portion 94 of the connector into the rest position shown in FIG. 4 in abutting engagement with the lip 96.

As can be seen from the foregoing detailed description, the present invention provides a stepped axially aligned connector between the operating shaft and the contact rod of a linearly movable contact-operating assembly. This construction provides reliability of operation and enables direct driving engagement between the flange 90 of the armature and the operating shaft 58 during high-speed operation. Additionally, the assembly provides a neater appearance and permits greater adjustability and control over the contact pressure during closed circuit operation.
As will be apparent to persons skilled in the art, various modifications, adaptations and variations of the foregoing specific disclosure can be made without departing from the teachings of the present invention.

What we claim is new and desire to secure by Letters Patent of the United States is:

1. An electric circuit breaker comprising:
   a. a support;
   b. a pair of relatively movable contacts mounted on the support for movement between open and closed circuit positions;
   c. a linearly movable contact-operating assembly comprising:
   d. an elongated operating shaft spaced from the contacts;
   e. a linearly extending contact rod operatively positioned intermediate the contacts and the operating shaft, said rod being fixedly connected to at least one of said contacts for movement therewith between open and closed circuit positions, said shaft being generally in axial alignment with the rod;
   f. an axially extending connector joining the operating shaft to the contact rod while permitting limited relative movement therebetween;
   g. said connector having an axially extending stepped configuration including a central shank portion positioned within the space between the contact rod and the operating shaft and a pair of terminal connecting portions on opposite ends of the shank portion for secure retention by the rod and shaft respectively.

2. The electric circuit breaker of claim 1 wherein the operating shaft is a tubular member provided with an inwardly extending projection at an end thereof, the connector is secured to the contact rod and has an enlarged head portion in interfering engagement with the projection for retention of the head portion within the shaft.

3. The circuit breaker of claim 1 including a current-responsive drive member operatively connected to the relatively movable contacts for movement thereof to an open circuit position upon the occurrence of predetermined current conditions through the contacts; the connector having a stem secured to the contact rod, an enlarged head portion spaced from the rod and movably connected to the operating shaft and a retaining shoulder spaced from the head portion for retaining the drive member in fixed spaced relationship to the head portion.

4. The circuit breaker of claim 1 including a high-speed drive member fixedly secured to the contact rod for moving the contacts to an open circuit position upon the occurrence of predetermined current conditions through the contacts, the operating shaft having an abutment on the end thereof, said drive member having a shaft-driving face portion in spaced relationship with the operating shaft for movement into driving engagement with the abutment upon the occurrence of said predetermined current conditions.

5. The electric circuit breaker of claim 1 wherein the contact rod includes a shoulder abutment, the circuit breaker including a drive member mounted on the contact rod adjacent the shoulder abutment, the connector having a stem portion secured to the contact rod and an elongated shank portion including a retaining shoulder abutting the drive member and cooperating with the shoulder abutment on the contact rod for confinably retaining the drive member therebetween in fixed relationship to the contact rod.

6. The circuit breaker of claim 1 including a generally cylindrical solenoid armature in telescopically slidable relationship with the operating shaft, the armature having a radial shaft-driving flange normally biased into spaced relationship with the operating shaft for movement into driving engagement therewith upon the occurrence of predetermined current conditions.

7. The electric circuit breaker of claim 1 wherein the operating shaft is a tubular member provided with an inwardly projecting lip defining a communicating port of reduced cross section at the end of the shaft adjacent the contact rod, the connector is secured to the contact rod and has an enlarged head portion positioned within the tubular shaft in interfering engagement with the inwardly projecting lip for retention of the head portion within the shaft and an elongated shank portion freely extending through the communicating port and including a retaining shoulder spaced from the head portion, the circuit breaker including a solenoid armature confinably retained on the contact rod by the retaining shoulder and spring means adjustably mounted within the tubular shaft for acting against the head portion and urge it toward engagement with the inwardly projecting lip.

8. The electric circuit breaker of claim 1 wherein the contact rod includes an axially apertured hub portion of reduced cross section providing a shoulder abutment, the operating shaft is a tubular member provided with an inwardly projecting lip defining a communicating port of reduced cross section at the end of the shaft adjacent the contact rod; the connector includes a threaded stem portion threadably received within the axially apertured of the hub portion, an enlarged head portion positioned within the tubular shaft in interfering engagement with the inwardly projecting lip for retention of the head portion within the shaft and an elongated shank portion integrally joining the stem and head portions, said shank portion freely extending through the communicating port for axial movement relative to the shaft and including a retaining shoulder spaced from the head portion, the circuit breaker including a high-speed current-responsive drive member mounted on the hub portion, said retaining shoulder abutting the drive member and cooperating with the shoulder abutment on the contact rod for confinably retaining the drive member therebetween in fixed relationship to the contact rod.

9. The circuit breaker of claim 8 wherein the high-speed current-responsive drive member is a generally cylindrical solenoid armature mounted in telescopically slidable relationship with the operating shaft, the circuit breaker including a spring mounted within the tubular shaft for urging the armature away from the shaft, the armature including a radial flange normally spaced from the lip of the tubular shaft for movement into driving engagement therewith against the bias of the spring upon the occurrence of predetermined current conditions.