

Oct. 22, 1968

E. B. HEFT ET AL

3,407,368

CURRENT-LIMITING CIRCUIT BREAKER

Filed Nov. 25, 1966

3 Sheets-Sheet 1

FIG. 1

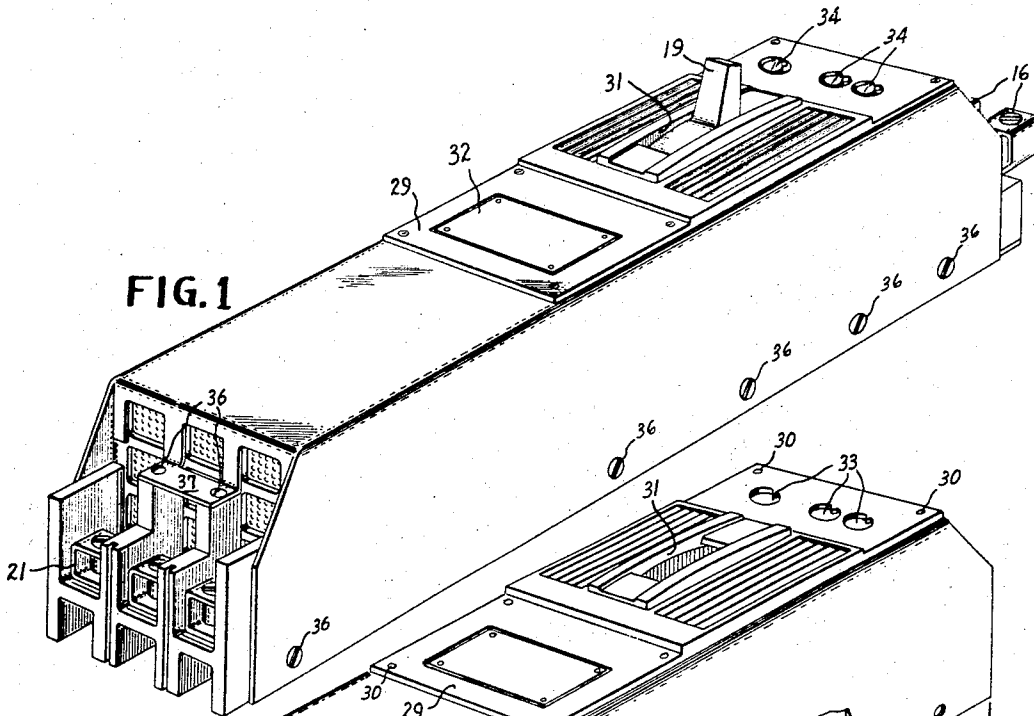
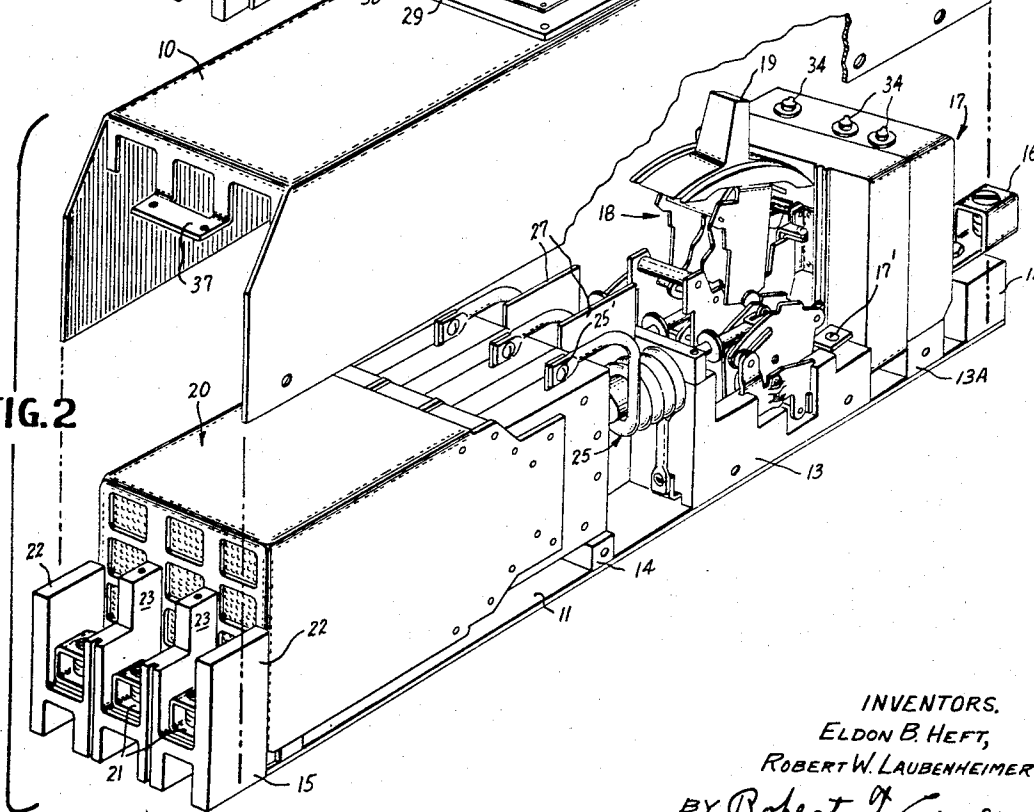


FIG. 2



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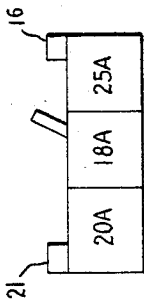


FIG. 4  
PRIOR ART

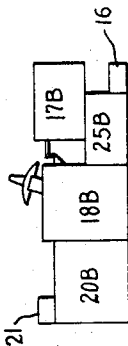


FIG. 5  
PRIOR ART

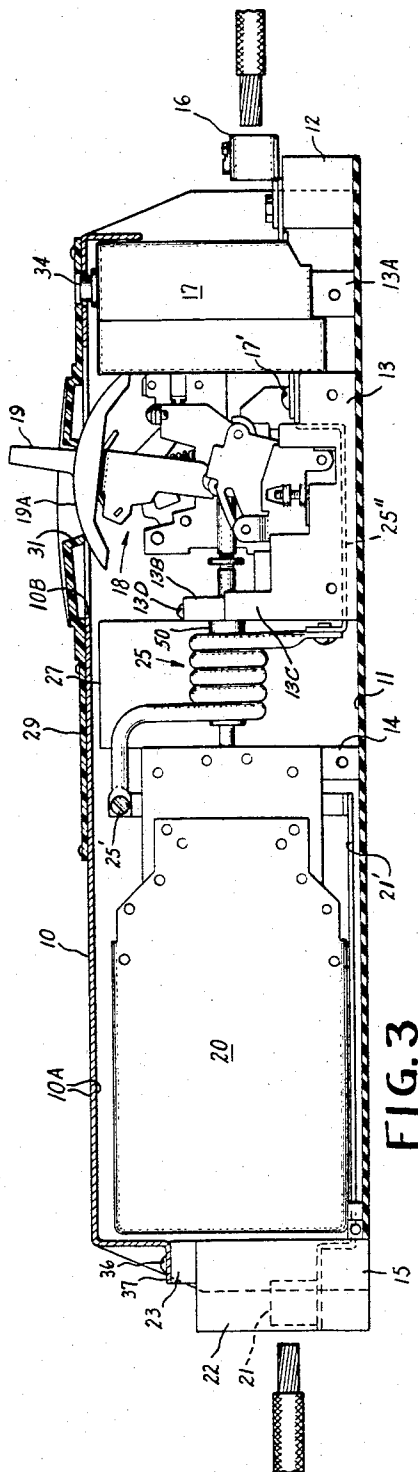


FIG. 3



FIG. 6  
PRIOR ART

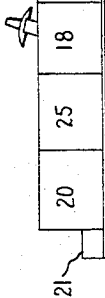


FIG. 7

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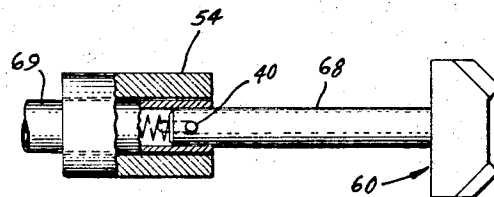
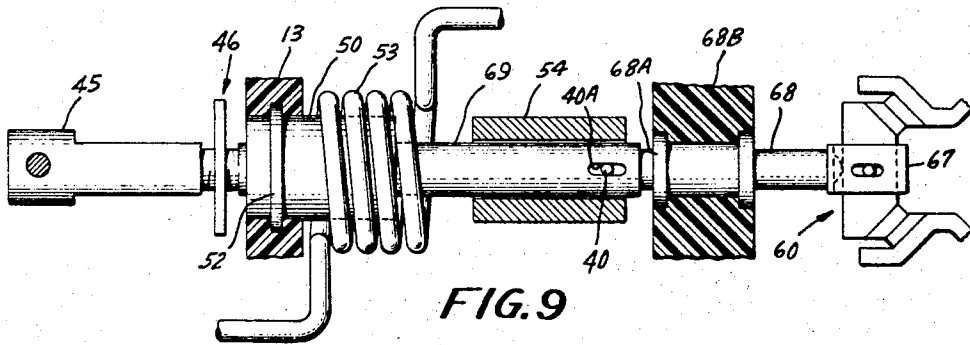
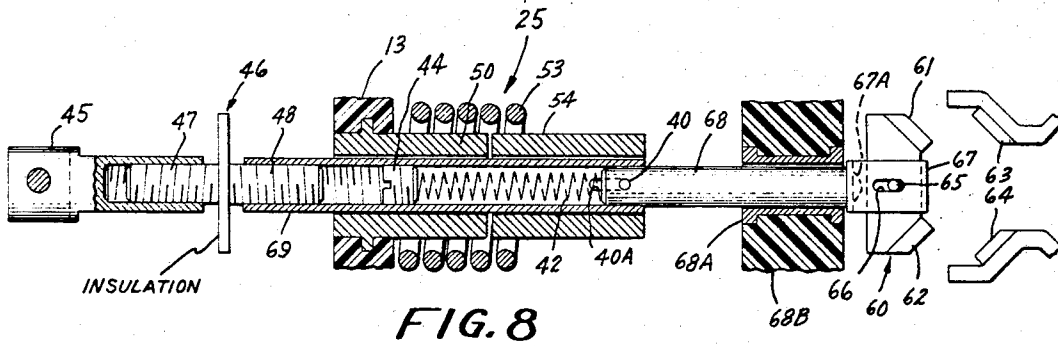
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CURRENT-LIMITING CIRCUIT BREAKER

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3 Sheets-Sheet 3



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**CURRENT-LIMITING CIRCUIT BREAKER**  
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Filed Nov. 25, 1966, Ser. No. 597,118  
7 Claims. (Cl. 335-16)

## ABSTRACT OF THE DISCLOSURE

An electric circuit breaker of the current-limiting type, including arc extinguishing means, manually operable latching-type operating mechanism for operating the contacts, current responsive trip means for causing release of the latch of the operating mechanism upon the occurrence of predetermined current conditions, and high-speed solenoid means positioned between the arc extinguishing assembly and the operating mechanism and operating on the contacts to open them on the occurrence of high short-circuit current conditions despite the non-release of the operating mechanism latch.

Our invention relates to electric circuit breakers, and more particularly to electric circuit breakers of the "current-limiting" type.

Electric circuit breakers of the "current-limiting" type, as referred to herein comprise at least one pair of relatively movable contacts and a main operating means which includes means for moving the contacts between open and closed circuit positions at will, and also means for automatically separating the contacts upon the occurrence of predetermined current conditions in the circuit, together with a supplementary or "high-speed" means for automatically moving the contacts to open circuit position on the occurrence of different current conditions in the circuit, regardless of whether the main mechanism has moved to open circuit condition or not. In effect, such circuit breakers include components corresponding to all the components utilized in a conventional non-current-limiting circuit breaker, and in addition, include means for opening the contacts at ultra-high speed on the occurrence of extremely high short-circuit current conditions. A current-limiting circuit breaker of the type referred to is shown in application Ser. No. 491,840, filed Sept. 30, 1965, by E. B. Heft and J. F. Johnson, and assigned to the same assignee as the present invention, now Patent No. 3,315,189, issued Apr. 18, 1967.

In accordance with the aforesaid patent application, the major components of the current-limiting circuit breaker disclosed therein are arranged in generally straight-line order on a common support, or within a common enclosure in the following order of arrangement: load terminal, high-speed opening means, main operating mechanism, main mechanism trip means, contacts-and-arc-chute, and line terminal.

While this arrangement makes possible a very compact over-all assembly, it has the disadvantage of positioning the conventional trip means, in effect, on the opposite side of the main operating mechanism from the position which it occupies in conventional circuit breakers, thus making it difficult to utilize existing trip unit assemblies in such current-limiting circuit breakers.

The arrangement of the aforesaid prior application, and also of other current-limiting circuit breakers known to applicant, also has the difficulty that it renders factory adjustment or calibration difficult in that it is more difficult to provide access to the adjusting means.

Also, it is a characteristic of the arrangements of the aforesaid prior art breakers that the relatively remote

positioning of the high-speed opening means makes direct connection of the high-speed opening means, for instantaneous opening action, difficult or requiring relatively long interconnecting means.

It is an object of the present invention to provide a current-limiting circuit breaker assembly of the type including all the components of prior art conventional circuit breakers, and in addition, a high-speed opening means, which circuit breaker is capable of utilizing a conventional prior art trip unit assembly.

It is a further object of the invention to provide an electric circuit breaker of the current-limiting type which is simple to construct and inexpensive to manufacture.

In accordance with the invention, an electric circuit breaker of the current-limiting type is provided which has the major components thereof supported on a substantially planar common support in the following sequential arrangement: load terminal, main mechanism trip unit assembly, main operating mechanism, high-speed opening device, contacts and arc chute assembly, line terminals. This arrangement places the main mechanism trip unit at the outer side or end of the main operating mechanism, and facilitates its installation, operation and adjustment. In addition, this arrangement places the high-speed solenoid immediately adjacent the arc chamber. In accordance with another aspect of the invention, advantage is taken of this positioning by connecting the armature of the high-speed solenoid directly to the movable contact member of the respective pole, with no lost motion or no significant lost motion therebetween, to assure the fastest possible opening movement of the contact by the armature.

The invention will be more fully understood from the following detailed description, and its scope will be pointed out in the appended claims.

In the drawings,

FIGURE 1 is a perspective view of a current-limiting circuit breaker incorporating the invention;

FIGURE 2 is a perspective view similar to FIGURE 1, showing the cover portion thereof in exploded relation;

FIGURE 3 is a side elevation view of the circuit breaker of FIGURE 1, the enclosing cover portion being broken away;

FIGURES 4-6 are diagrammatic representations of the arrangement of the major components of prior art current-limiting circuit breakers;

FIGURE 7 is a diagrammatic representation of the arrangement of the major components of the circuit breaker in accordance with the present invention;

FIGURE 8 is an enlarged sectional view of the contact rod assembly of the invention, the parts being shown in the open-circuit condition;

FIGURE 9 is a view similar to FIGURE 8, the parts being shown in the closed circuit condition, and

FIGURE 10 is a fragmentary view of a modified movable contact assembly.

Referring to the figures, the invention is shown as incorporated in an electric circuit breaker including a generally U-shaped cross-sectioned metallic sheet metal cover 10 and a generally planar insulating back plate 11. Supported on the back plate 11 are a plurality of spaced insulating block support members comprising a load terminal support block 12, a mechanism and trip unit support block 13 including a trip unit support portion 13A, a stationary contact and arc chute support block 14, and a combination line terminal and supplementary arc chute support block 15. The blocks 12-15 inclusive are fixedly mounted on the back plate 11 by suitable means, such as by means of screws, not shown.

The insulating block 12 supports a plurality of load terminals 16, there being one provided for each of the

3  
"pole chambers" of the circuit breaker. The embodiment illustrated is a three-pole circuit breaker and therefore there are three sets of line and load terminals.

The insulating block portion 13A supports a trip unit 17 which will be described in more detail later.

The main portion of the insulating block 13 supports a manual and automatic "main" operating mechanism designated generally by the numeral 18 and having an insulating handle 19. The insulating block 14 supports and positions the 3-pole stationary contact and arc chute and muffle assembly designated generally by the numeral 20.

The insulating block 15 supports and positions a plurality of line terminals 21, and includes upstanding barrier portions comprising outside barrier portions 22 at each side of the circuit breaker and intermediate barrier portions 23.

The main operating mechanism may be of any suitable type adapted to perform the required functions including (1) the manual opening and closing of the contacts, (2) the automatic opening of the contacts in response to release by the trip unit 17, and (3) automatic opening of the contacts, despite the non-release of the mechanism 18, upon the actuation of a high-speed tripping means such for example as the high-speed trip solenoid 25. The solenoids 25 of each of the poles are separated from each other by insulating barrier plates 27, see FIGURE 2. A mechanism of the type described, suitable for use herein, is disclosed and described in detail in co-pending application Ser. No. 596,637 filed Nov. 23, 1966 by J. F. Johnson and R. W. Laubheimer, and assigned to the same assignee as the present invention, now Patent No. 3,384,845, issued May 21, 1968.

The trip unit 17 includes means for causing release of a latch normally holding the operating mechanism 18 in latched position, comprising inverse current-time sensing means, such for example as a bimetallic strip, and magnetic means such as a solenoid (not shown). A trip unit of the type described is disclosed for example in Patent No. 3,264,435, K. W. Klein et al., issued Aug. 2, 1966, and assigned to the same assignee as the present invention.

The outer enclosure 10 is preferably constructed of metallic material such, for example, as steel, and includes an insulating coating 10A on all surfaces.

The cover member 10 has an opening 10B in the top wall thereof which is partially closed by an insulating shield member 29 rigidly affixed to the top wall of the cover by suitable means, such as by screws or rivets 30. If desired, other means of attaching the shield 29, may be utilized, such for example as chemical bonding. The shield 29 includes an aperture 31 of small size, through which the insulating handle 19 projects, the opening 31 being otherwise closed by the enlarged inner portion 19A of the handle 19. The insulating shield 29 also serves to support an identification plate 32 suitably attached thereto. The insulating plate includes a plurality of generally circular apertures 33 providing access to adjusting members 34 of the trip unit 17.

The various insulating blocks and the insulating shield 29 are preferably formed by molding, facilitating high production at relatively low cost. Since these parts are individually not of excessive dimension in any one direction, molding by conventional techniques is economically feasible and optimum materials can be selected for each function.

The current path through one pole of the circuit breaker will be described with reference to FIGURE 3. The current enters at the line terminal 21, passes through the elongated conductor 21' passing underneath the arc chute and muffle assembly 20, to relatively movable contacts contained within the chamber 20, not shown. From the movable contacts, the current passes to a terminal 25' of the solenoid 25, thence to the solenoid 25 and to a conductor strap 25" passing under the mecha-

nism 18 to the trip unit terminal 17'. The current then passes through the trip unit 17 to the load terminals 16. Upon the occurrence of predetermined current conditions, the current sensitive means within the trip unit 17 is actuated, causing release of the latched mechanism 18 and automatic opening of the circuit breaker contacts. Likewise, the occurrence of excessive current conditions causes actuation of the solenoid 25 before the conventional trip unit 17 can respond and direct opening of the movable contacts.

Although the supporting back plate 11 is not of relatively great thickness, required rigidity is provided by the interconnection of the generally U-shaped metallic cover 10 with the back plate 11 through the medium of the insulating blocks which are rigidly fixed to the back plate 11, the attachment of the cover 10 to these blocks being performed by suitable means, such for example as by screws 36, see FIGURE 1. The cover is also attached to the insulating block 15 at the end of the circuit breaker by screws 36 which attach the offset portion 37 of the cover to the top surfaces of the barrier 23.

The arrangement by which the various component sub-assemblies, comprising the trip unit 17, mechanism 18, solenoid 25, and contact and arc chute assembly 20 are separately housed or supported on a common back plate is disclosed and claimed in co-pending application Ser. No. 596,878, filed Nov. 25, 1966 by E. B. Heft and assigned to the same assignee as the present invention.

Referring to FIGURE 4, there is shown a diagrammatic representation of the arrangement of the components of a prior art current-limiting interrupter, as shown in co-pending application Ser. No. 457,557 filed May 21, 1965 by R. L. Hurtle and H. G. Willard and assigned to the same assignee as the present invention. It will be observed that the arrangement here comprises the sequence of: contact and arc chute assembly 20A, followed by main operating mechanism 18A, followed by the high-speed operating device 25A. This application does not disclose tripping or automatic opening means for the main mechanism.

In FIGURE 5 there is shown another arrangement of components in accordance with the prior art. In accordance with this arrangement, the contact and arc chute assembly 20B is placed at one side of the main operating mechanism 18B, while immediately adjacent the other side, the conventional trip unit 17B is placed adjacent the upper portion of the main operating mechanism, and the high-speed opening device 25B is placed below the conventional trip unit, adjacent the lower portion of the operating mechanism.

In FIGURE 6 there is shown still another arrangement in accordance with the prior art, as shown in the aforesaid application Ser. No. 491,840 filed Sept. 30, 1965, now Patent No. 3,315,189, by E. B. Heft and assigned to the same assignee as the present invention. In this arrangement trip means is added to the main operating mechanism of the aforesaid Hurtle and Willard application. In this case the sequence of parts is as follows: contacts and arc chute assembly 20C, main mechanism trip device 17C, main operating mechanism 18C, and high-speed opening device 25C.

It will be observed that in all of these forms the high-speed operating device is placed on the side of the operating mechanism opposite from the contacts and arc chute.

In accordance with the present invention, the high-speed opening device 25 is placed between the arc-chute and contact assembly 20 and the main operating mechanism portion 18, and the contact rod extends through the solenoid or high-speed operating device. This leaves the main mechanism trip device 17 free to be placed adjacent the "load" side of the operating mechanism, and the load terminals 16 adjacent the trip device 17. Thus the load end portion of the assembly follows the same general sequence as conventional circuit breakers, and

a trip unit construction may be used which is similar to the trip units which are used in conventional, that is non-current-limiting circuit breakers.

In addition, the arrangement of the parts in accordance with the present invention places the high-speed operating device closely adjacent the movable contacts, with no other parts necessary to be inter-connected between these two. This is important, since in a current-limiting circuit breaker the movable contact must be moved directly and at extremely high-speed by the high-speed operating device. The greater the number of inter-connections which are necessary to interpose between the high-speed operating device and the movable contacts, the more likelihood there is of loss of time or energy in the high-speed opening operation. In accordance with this aspect of the invention, the close placement of the solenoid 25 to the movable contact and arc chute assembly 20 is used to obtain a higher speed opening of the movable contacts by directly connecting the armature of the solenoid 25 to the movable contacts. The structure involved in this relation is shown in detail in FIGURES 8-10. Referring first to FIGURE 8, a movable contact member 60 is shown, carrying movable contacts 61 and 62 arranged to cooperate with relatively stationary contacts 63, 64, respectively. The contact member 60 carries a pin 65 extending transversely therethrough into aligned slots 66 in a generally U-shaped yoke member 67 fixedly attached to the end of a connecting piece or rod 68. A projection 67A is provided within the yoke member 67 adjacent the right portion thereof to facilitate rocking of the member 60 in order to adjust itself to the stationary contacts 63, 64.

The connecting member 68 extends into a tubular contact rod 69 and is connected thereto in lost motion fashion by means of the pin 40 fixedly attached to the connecting member 68 and extending into slots 40A in the tubular member 69. A compression spring 42 biases the rod member 68 outwardly of the tube 69, the other end of the spring 42 resting against an adjustable stop member or screw 44 which is threadedly engaged in the interior bore of the tubular member 69. Adjustment of the stop member 44 serves to vary the compression of the spring 42, and therefore the amount of contact pressure. The rod or tube 69 is connected to a contact actuating member 45 by means of an adjustable coupling member 46 having end portions 47 and 48 respectively extending into the members 45 and 69 respectively. The end portions 47 and 48 are threaded in opposite directions so that relative spacing between the members 47, 69 can be varied by rotating the coupling member 46 in the fashion of a turn buckle, thereby varying the overall length of the contact rod assembly.

A solenoid field piece or stator 50 is fixedly mounted in an insulating support portion of the block 13 by suitable means, such as by having a flange portion 52 thereof trapped in corresponding groove portions of cooperating separable portions 13B, 13C of the block 13 which are normally held together by suitable means such as by screws 13D. A winding 53 and a generally tubular armature 54 are also provided. The armature 54 is slidably supported on the tubular member 69 and is fixedly connected to the rod 68 by means of the aforesaid pin 40. The rod 69 is preferably made of non-magnetic material.

The rod 68 is slidably guided in a bushing 68A suitably mounted in an insulating portion of the contact and arc chute assembly portion 68B.

In FIGURE 9, the contacts are shown maintained in the closed condition by force exerted by the operating mechanism on the member 45 to the right as viewed in this figure. Upon the occurrence of extremely high short-circuit conditions, the solenoid winding 53 increases its pull on the armature 54 and attracts it toward the field piece 50. As soon as the armature 54 begins to move, the movable contact assembly 68, together with

the movable contact member 60 also moves. The initial movement compresses the spring 42 until the pin 40 reaches the ends of the slots 40A, after which time force is exerted directly on the contact assembly including the tube member 69 and the actuating member 45 in the contact-opening direction. This causes disconnection of the movable contact assembly, comprising the connector 45 and rod 69, from the contact operating means 18 by virtue of the "break-away" connection as disclosed in the aforesaid patent application S.N. 596,637.

In order to permit the movable contacts 61 and 62 to seat properly against the stationary contacts 63, 64, the movable contact member 60 is preferably supported as shown in FIGURES 8 and 9 with a small amount of rocking movement permitted between the contact assembly 60 and the yoke member 67. In cases where such alignment is not considered to present a problem, we may mount the contact assembly 60 directly rigidly onto the end of the rod 68 as shown in FIGURE 10.

It will be observed that by placing the solenoid 25 close to the movable contact assembly 60, only a short connecting piece 68, of relatively small size and mass, is required to connect the armature 54 to the movable contact assembly 60. This makes possible extremely high rates of acceleration in opening the contacts upon the occurrence of short-circuit conditions.

While the invention has been disclosed in only one particular embodiment, it will be obvious that a number of modifications thereof may readily be made. It is therefore intended by the appended claims to cover all such modifications as fall within the true spirit and scope of the invention.

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

1. A current-limiting electric circuit breaker comprising:

- (a) a support;
- (b) an arc chute and contact assembly supported on said support, said arc chute and contact assembly comprising at least one pair of separable contacts and arc extinguishing means adjacent thereto;
- (c) operating mechanism supported on said support and connected to said separable contacts, said operating mechanism comprising manually operable means for moving said contacts between open and closed circuit positions, a releasable member releasable to cause automatic movement of said contacts from said closed to said open circuit position, and latch means normally restraining said releasable member in said latched position;
- (d) current responsive trip means supported on said support and connected to said latch means for causing release of said releasable member upon the occurrence of predetermined current conditions in said circuit breaker;
- (e) a high-speed opening solenoid supported on said support and connected to said contacts and connected electrically in series with said contacts for causing opening of said contacts independently of said operating mechanism upon the occurrence of high short circuit current therethrough;
- (f) said high-speed opening solenoid being positioned on said support between said arc chute and contact assembly and said operating mechanism and said current responsive trip means being positioned on said support at the opposite side of said operating mechanism from said high-speed solenoid.

2. A current-limiting circuit breaker as set forth in claim 1, wherein said circuit breaker also comprises:

- (a) an operating rod and means connecting said operating rod to at least one of said separable contacts for movement of said contact between open and closed circuit position in response to movement of said rod;
- (b) means connecting said operating mechanism to

said rod to operate said rod between said open and closed circuit positions in response to movement of said operating mechanism, and

- (c) means connecting said high-speed opening means to said rod to cause opening movement of said contacts upon energization of said solenoid, said means connecting said solenoid to said rod being effective to cause opening movement of said operating mechanism in said closed circuit position.

3. A current-limiting circuit breaker as set forth in claim 2, wherein said operating rod extends from said contact and arc chute unit through said solenoid to said operating mechanism.

4. A current-limiting electric circuit breaker comprising:

- (a) a support;
- (b) at least one stationary electric contact supported on said support;
- (c) at least one movable contact supported on said support and movable into and out of engagement with said stationary contact;
- (d) manually operable mechanism supported on said support, said manually operable mechanism including a contact operating member;
- (e) means connecting said contact operating member to said movable contact, said connecting means comprising means providing a lost motion connection between said contact operating member and said contact member and spring means biasing said contact member away from said contact operating member;
- (f) an electric solenoid connected electrically in series with said contacts and including a movable armature;
- (g) means connecting said armature directly to said movable contact member for movement therewith at all times, and
- (h) said contact member being movable in circuit opening direction a small amount as permitted by said lost motion connection against the bias of said biasing means, movement of said contact member in said contact opening direction thereafter causing movement of said contact operating member by direct engagement therewith.

5. A current-limiting electric circuit breaker comprising:

- (a) a support;
- (b) an arc chute and contact assembly supported on said support, said arc chute and contact assembly comprising at least one pair of separable contacts and arc extinguishing means adjacent thereto;
- (c) operating mechanism supported on said support, said operating mechanism comprising manually operable means for moving said contacts between open and closed circuit positions and automatically

operable means for moving said contacts from said closed to said open circuit positions;

- (d) trip means supported on said support for causing opening action of said automatically operable means of said operating mechanism;

- (e) high-speed opening means supported on said support for causing opening of said contacts independently of said operating mechanism;

- (f) said arc chute and contact assembly, said high-speed opening means, said operating mechanism, and said trip means being sequentially disposed on said support in the recited order;

- (g) means interconnecting said operating mechanism and said contacts comprising a contact operating member connected to be operated by said operating mechanism and lost motion connecting means interconnecting said contact operating member and one of said separable contacts, and

- (h) said high-speed opening means comprising a winding connected electrically in series with said contacts and an armature, and means directly connecting said armature to said one of said contacts, said one of said contacts moving to separate said contacts upon movement of said armature in opening direction prior to movement of said contact operating member.

6. An electric circuit breaker as set forth in claim 5, wherein said circuit breaker also includes compression spring means between said contact operating member and said one of said contacts biasing said contact away from said contact operating member, said compression spring means being compressed by said operating mechanism in closed circuit condition of said contacts and providing contact pressure for said contacts.

7. An electric circuit breaker as set forth in claim 6, wherein said contact operating member comprises an elongated tubular member and said one contact member includes a rod-like portion received within said tubular member and said compression spring is positioned within said tubular member and acts on an end portion of said rod-like portion and on a stop carried by said tubular member.

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