

March 21, 1961

S. I. LINDELL
CIRCUIT INTERRUPTER

2,976,381

Filed May 15, 1959

2 Sheets-Sheet 1

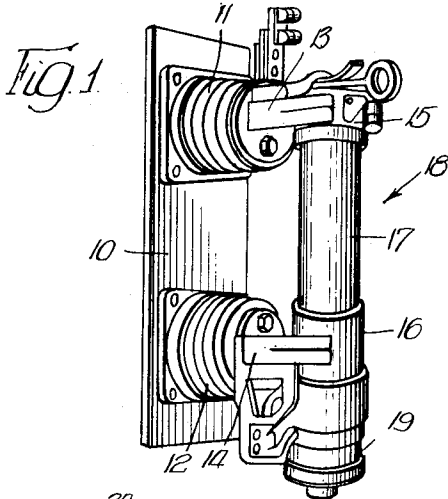
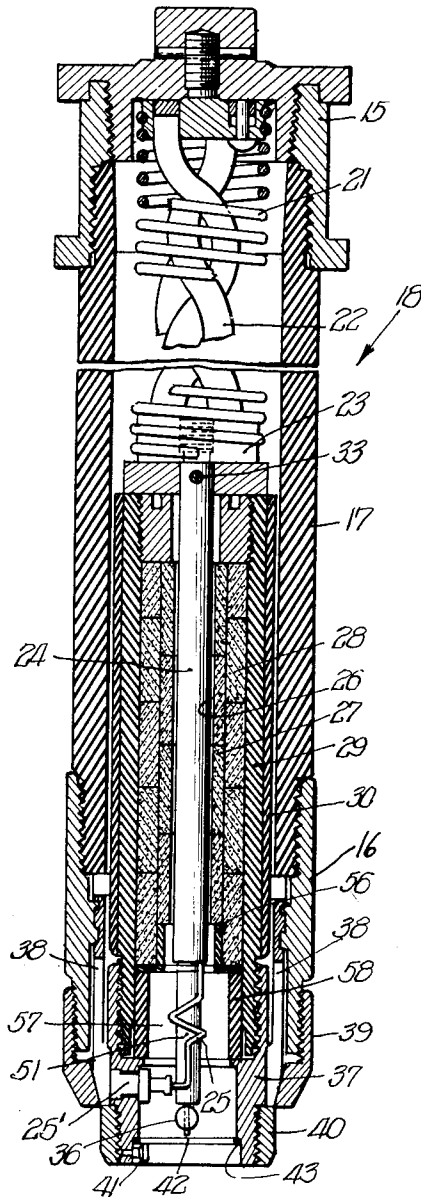
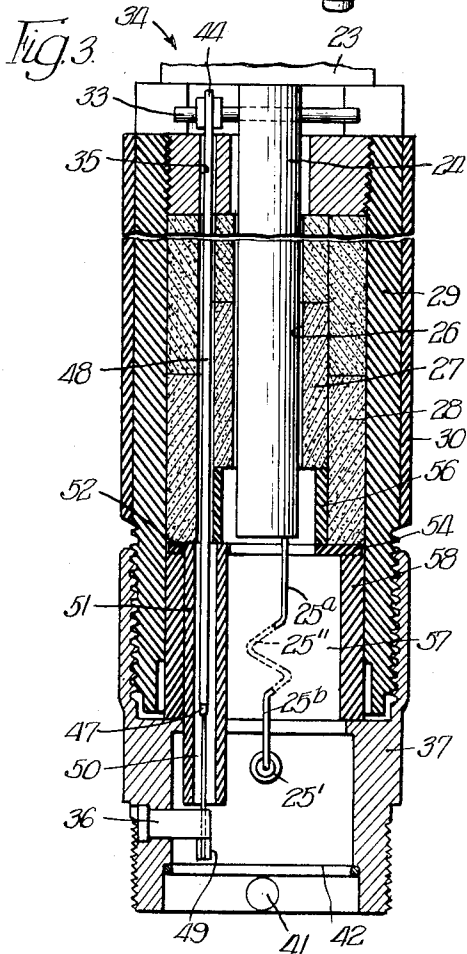


Fig. 2



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2 Sheets-Sheet 2

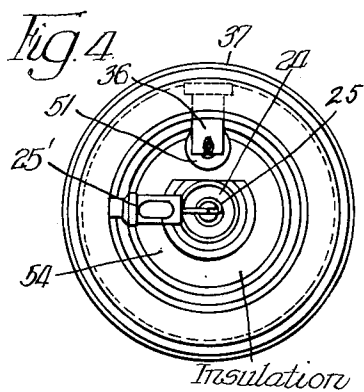


Fig. 5

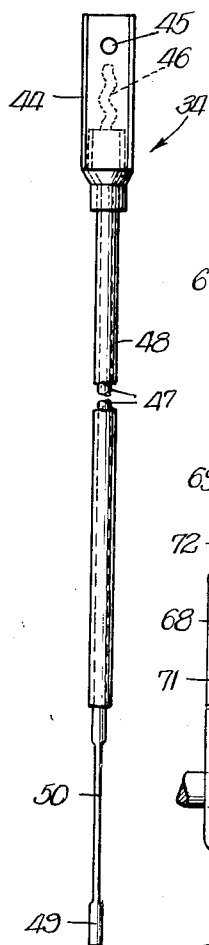


Fig. 8

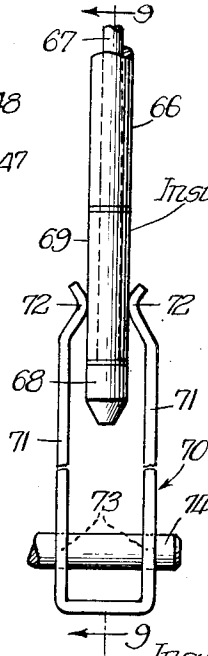


Fig. 6



Fig. 10

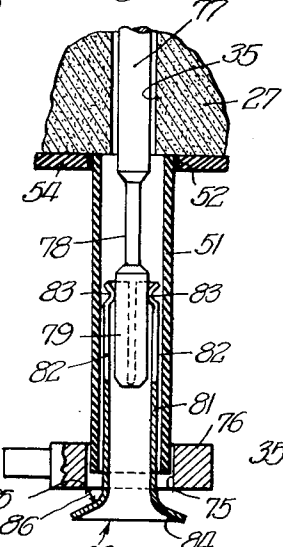


Fig. 9

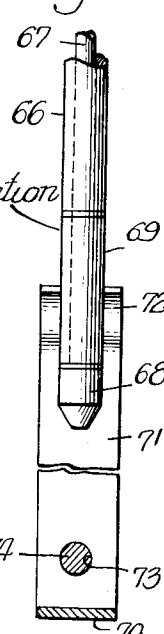
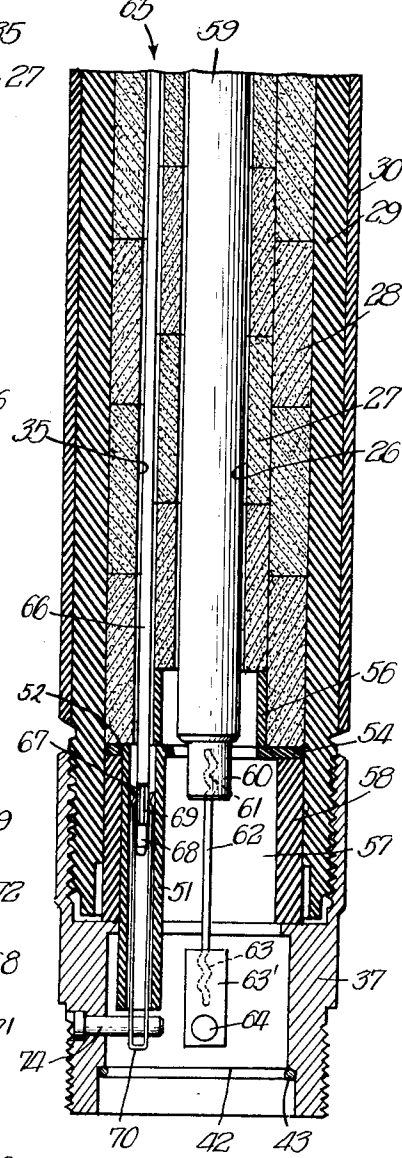


Fig. 7



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1

2,976,381

CIRCUIT INTERRUPTER

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16 Claims. (Cl. 200—120)

This invention relates, generally, to circuit interrupters and it has particular relation to high voltage circuit interrupters of the solid material type provided with a main bore and an auxiliary bore through the body of arc extinguishing material.

In the parallel bore fuses of the general type just referred to when called upon to interrupt high currents, an arc is established at the main rod-like terminal after the fusible element and the strain wire have blown. The high current arc is then established and extinguished in the main bore as the arcing terminal therein is moved by a spring attached to its inner end. In some types of such fuses an arc is also initially established at the severed ends of a strain element connected between the line terminal of the fuse and the end of an auxiliary terminal in the parallel auxiliary bore. An arc is maintained either at the main rod-like terminal while a shunt current destroys the strain element or the arc, if first struck at the ends of the strain element, is then quickly transferred to the main terminal when a cable in the auxiliary bore is fused out and the arc voltage builds up.

A fuse of the general type is shown in U.S. Patent No. 2,183,728, issued December 19, 1939. When relatively low fault currents are interrupted, the arc is initiated at the severed ends of the strain element and extended as the fuse holder spring contracts. At the same time the gap in the main bore is getting larger and thereby prevents restriking of the arc to the rod-like terminal as the arc voltage builds up with increasing gap in the auxiliary bore. In order to prevent excessive early build up of arc voltage in the auxiliary bore an insulated flexible conductor or cable is employed which extends part of the distance through the auxiliary bore from the arcing end. When the arc voltage builds up to a predetermined value, the insulation on the flexible conductor or cable is punctured. This puts a limitation on the arc voltage that can be built up since the gap between the auxiliary arcing terminal and the flexible conductor or cable is small. Thus the rod-like terminal can be moved further without restriking in the main bore in which low fault currents cannot be efficiently interrupted. Finally, on very low fault currents, the auxiliary arcing terminal is withdrawn from the end of the flexible conductor or cable to extend and interrupt the arc in the small bore.

In another well known type of parallel bore fuse the arc is struck first at the main terminal since the cable in the auxiliary bore is insulated from the line terminal or ferrule by an air gap. As the arc is extended in the main bore, arc voltage builds up and flashes over to the cable while it is still in contact with the auxiliary arcing rod.

There is a possibility that the flexible conductor or cable of such parallel bore fuses may be left in the auxiliary bore with a correspondingly small gap remaining after the complete movement of the spring and cable assembly has been effected thereby leaving a correspondingly small gap to withstand voltage surges that may be

2

applied to the circuit following the operation of the circuit interrupter and interruption of the circuit. On somewhat larger currents, the flexible conductor or cable may be partly or entirely expelled from the auxiliary bore with a correspondingly greater final isolating gap.

The foregoing shows, and experience indicates, that a reduced gap may occur in the parallel bore type of solid material fuse constructed in the manner heretofore considered entirely proper. When the solid material fuse is of the non-dropout type, this reduced gap following circuit interruption is particularly important. Since fuses of the parallel bore type normally are employed in non-dropout constructions, the importance of the reduced gap becomes more readily apparent.

On higher fault currents the flexible conductor or cable in the small or auxiliary bore may melt out and the arc is then maintained or shunted back to the main bore where it is extended and interrupted without destructive pressures between the receding end of the rod-like terminal and the stationary terminal at the arcing end of the fuse. Experience has shown, however, that even at high currents, strands of the flexible conductor or cable in the small or auxiliary bore that have been freed by fusion at the outer end may even tack weld to the auxiliary arcing rod or terminal and remain in the auxiliary bore as an extension of the auxiliary arcing rod. When this occurs, there is a corresponding appreciable reduction in the gap through the device and the voltage withstand value of the blown fuse unit is correspondingly reduced. Should dielectric break down occur in the auxiliary bore under any condition thereafter where the isolating gap is thus reduced (break down due to leakage current or voltage surge) the blown fuse unit may not be able to clear the resultant arc since there is no mechanical movement of the fuse terminals. The arc extinguishing structure then may be completely destroyed.

Accordingly, among the objects of this invention are: To provide a high voltage withstand value in a high voltage fuse of the parallel bore type after it has blown and cleared the circuit whereby there is little or no likelihood of subsequent flashover through the fuse when it is subjected to normal open circuit voltage surges; to provide an improved parallel bore arrangement in a solid material type of fuse to insure interruption of low current in the small auxiliary bore and the interruption of high current in the larger main bore without appreciable loss of gap distance in the auxiliary bore and resultant inadequate ability to withstand transient and normal frequency voltage and sustained open circuit voltage following interruption of fault current by the fuse device of either a high or a low value; to avoid the necessity for providing a flexible conductor or cable along side the auxiliary terminal in the small bore of a parallel bore type of fuse; to insulate and segregate the space where the arc is drawn by the auxiliary terminal from the space occupied by the main fusible element under low fault current interrupting conditions; to employ for this purpose an insulating barrier or tube that functions as an extension of the auxiliary bore; to extend the insulating tube beyond the middle portion of the main fusible element; to employ for the insulating tube a frangible material that may readily rupture under heat and pressure incident to interruption of high fault current; to form the insulating tube of ceramic material having substantially no gas evolving properties in order to reduce the liberation of carbon and to delay the generation of arc extinguishing vapor and building up of arc voltage until the main and auxiliary terminals have moved some distance to increase the gap at the main terminal; to provide a fusible section in the auxiliary terminal within the insulating tube and to employ the auxiliary terminal in com-

ination with a fusible element connected to the main rod-like terminal and to use the auxiliary terminal to restrain movement of the rod-like terminal; to restrain the movement of the terminals by a single element serving as a fusible element and a strain element and connected to the main rod-like terminal and to employ the auxiliary terminal for drawing an arc in the auxiliary bore under low fault current operating conditions and interrupting it in the auxiliary bore; to interpose an isolating gap within the insulating tube or at its outer end in the circuit through the auxiliary terminal in order to avoid a shunt path around the combination fusible and strain element under normal current carrying conditions; to provide sliding engagement with the auxiliary terminal after the gap has been closed until the arc is to be drawn in the small bore by separation of the terminals; and to provide for mechanically and electrically closing the gap through the auxiliary bore after the blowing of the combined fusible and strain element.

Other objects of this invention will, in part, be obvious and in part appear hereinafter.

This invention is disclosed in the embodiments thereof shown in the accompanying drawings and it comprises the features of construction, combination of elements and arrangement of parts that will be exemplified in the constructions hereinafter set forth and the scope of the application of which will be indicated in the appended claims.

For a more complete understanding of the nature and scope of this invention reference can be had to the following detailed description, taken together with the accompanying drawings, in which:

Figure 1 is a perspective view of a circuit interrupter in which the present invention is embodied;

Figure 2 is a longitudinal sectional view, at an enlarged scale, of the circuit interrupter shown in Figure 1;

Figure 3 is an enlarged longitudinal sectional view of the tubular arc extinguishing chamber of the replaceable fuse refill unit that is shown in a fuse holder in Figure 2 including the rod-like terminal, main fusible element and auxiliary rod-like terminal and fusible sections;

Figure 4 is a bottom plan view of the construction shown in Figure 2;

Figure 5 is a view, in side elevation, of the auxiliary terminal or strain element employed in the construction shown in Figures 2 and 3 of the drawings;

Figure 6 is a plan view of a frangible washer employed in the construction shown in Figures 2 and 3;

Figure 7 is a view, similar to Figure 3, showing a portion of the replaceable fuse refill unit in which a unitary or combined fusible element and strain wire is employed together with an auxiliary arcing rod that is insulated at one end from the circuit through the combined fusible and strain element;

Figure 8 is a view, in side elevation and at an enlarged scale, of the arcing end of the auxiliary terminal for the refill unit of Figure 7 showing how a contact clip cooperates therewith;

Figure 9 is a vertical sectional view taken along the line 9-9 of Figure 8; and

Figure 10 shows another modification of the invention.

Referring now particularly to Figures 1, 2 and 3 of the drawings, there is shown a circuit interrupter construction of the type and character employed in copending application Serial No. 787,481, filed January 19, 1959, and assigned to the assignee of this application. The present invention constitutes an improvement over the construction shown in this copending application. It will be noted that the reference character 10 designates a base which may be a metal base carrying upper and lower insulators 11 and 12. It will be understood that the length of the insulators 11 and 12 and their spacing apart depend upon the voltage of the system with which the present invention is employed. Upper and lower line contact clips 13 and 14 are carried by the insulators 11

and 12 at their outer ends for detachably receiving upper and lower terminals 15 and 16 that are mounted on the upper and lower ends of a tubular insulating housing or fuse holder 17 of a circuit interrupter that is indicated, generally, at 18. Associated with the lower terminal 16 is a condenser or muffler 19 which may be dispensed with under certain circumstances.

As shown in Figure 2 a coil tension spring 21 and a flexible cable or conductor 22 interconnect the upper terminal 15 and a spring and cable fastener 23 to which a rod-like terminal 24 is attached for movement upwardly through the tubular insulating housing 17 after a fusible element 25 blows. It will be noted that the fusible element 25 interconnects the lower end of the rod-like terminal 24 and a terminal fitting 25' which is mounted on a stationary terminal, to be described, that is connected directly to the lower terminal 16.

The rod-like terminal 24 substantially fills a relatively large bore 26 in a lining 27 of water evolving arc extinguishing material such as magnesium borate or a mixture of magnesium borate and boric acid or boric acid alone. The lining 27 can be formed of cakes or arc extinguishing material, as shown, or it can be continuous and tubular in form. Surrounding the lining 27 is a layer 28 of water evolving arc extinguishing material of the same character as the lining 27. Likewise it can be formed of cakes as shown, or it can be provided in the form of a continuous tube. The layer 28 of arc extinguishing material preferably is cemented in place, as described in the application above referred to, in a fiber sleeve 29 of high impact strength which provides sufficient resistance to radial bursting pressure that may be created under certain operating conditions. Overlying the fiber sleeve 29 is a cover 30 that preferably is formed of a phenolic condensation product.

The fusible element 25 is employed solely as a current measuring device to determine when the rod-like terminal 24 should be released for movement through the large bore 26 under the influence of the coil tension spring 21. It is desirable that means be provided for relieving the fusible element 25 of any tension stress. For this purpose a pin 33 extends through the upper end of the rod-like terminal 24 for electrical and mechanical connection to an auxiliary terminal or strain element, shown generally at 34. The auxiliary terminal or strain element 34 extends through a small or auxiliary bore 35 in the lining 27 parallel to the large bore 26. At its lower end the auxiliary terminal or strain element 34 is fastened to a strain wire pin 36 which extends radially inwardly from a stationary terminal or ferrule 37 that is threadably mounted on the lower end of the fiber sleeve 29. It will be recalled that the fusible element 25 is connected to a terminal fitting 25' and it will be noted that this fitting also extends radially inwardly from the stationary terminal 37. The arrangement is such that the auxiliary terminal or strain element 34, which extends through the small or auxiliary bore 35, relieves the fusible element 25 of any tension stress.

The construction shown in Figure 3 constitutes a refill unit and is arranged to be replaced in the tubular insulating housing 17 after it has blown and interrupted the circuit. In order to facilitate such replacement provision is made for threading the upper end of the rod-like terminal 24 into the spring and cable fastener 23. The stationary terminal or ferrule 37 is connected by contact fingers 38 to the lower terminal 16 at the lower end of the tubular insulating housing 17. A clamp nut 39 is threaded onto the lower end of the lower terminal 16 for maintaining good contact engagement between the contact fingers 38 and the stationary terminals 37 of the refill unit. A lock nut 40 is threaded on the lower end of the stationary terminal 37 and serves to hold the clamp nut 39 in place.

When the refill unit is to be positioned within the tubular insulating housing 17 the rod-like terminal 24 is

5

threaded into the spring and cable fastener 23 and then the assembly is dropped downwardly through the upper end of the tubular insulating housing 17. A cord or the like is connected to a stud anchor 41 that extends radially inwardly from the lower end of the stationary terminal or ferrule 37 and tension is applied to it to draw the refill unit through the tubular insulating housing 17 and past the contact fingers 38. Thereafter the clamp nut 39 is applied and finally the lock nut 40 secures the assembly in position. The lower discharge end of the stationary terminal 37 is closed by a frangible disc 42 that is held in place by a snap locking spring 43. It will be understood that the frangible disc 42 is readily blown out on operation of the circuit interrupter 18.

The construction of the auxiliary terminal or strain element 34 is shown more clearly in Figure 5 of the drawings. There it will be observed that the upper end is formed by a flattened tube 44 which is provided with an aperture 45 through which the pin 33 extends. The tube 44 is flattened onto a corrugated end 46 of the strain wire 47 which has relatively high strength such as a nickel chromium wire. Surrounding the strain wire 47 is a strain wire tube 48 that may be formed of relatively good conducting material such as copper. The upper end of the strain wire tube 48 is telescoped within the tube 44 and it is flattened onto it as well as onto the corrugated end 46 of the strain wire 47. At its lower end the strain wire 47 has a head 49 which interfits with the strain wire pin 36 and thus holds the auxiliary terminal or strain element 34 against upward movement under the influence of the coil tension spring 21. At its lower end the strain wire 47 is provided with a reduced section 50 which is calibrated to blow on flow therethrough of a predetermined amount of current. It will be understood that the circuit through the auxiliary terminal or strain element 34 is in parallel with the circuit through the fusible element 25. However, since the circuit through the auxiliary terminal or strain element 34 has a relatively high resistance as compared to the resistance of the circuit through the fusible element 25, the latter can function as a calibrated current carrying element for the current range for which the circuit interrupter 18 is intended to operate.

On the flow through the circuit interrupter 18 of a relatively low fault current that is sufficient to melt or blow the fusible element 25, only the central coiled portion 25' thereof, indicated by broken lines in Figure 3, is blown out leaving terminals 25a and 25b. The current flow then is transferred in its entirety to the auxiliary terminal or strain element 34 and the reduced section 50 is blown. This releases the coil tension spring 21 and it then moves the remaining portion of the auxiliary terminal or strain element 34 and the rod-like terminal 24 upwardly through the respective bores 35 and 26. Initially the arc is established between the lower remaining end of the strain wire 47 and the strain wire pin 36 or a remaining part of the reduced section 50 attached to the pin 36 on the stationary terminal or ferrule 37. Under the assumed circumstances, since the fault current is relatively low, it can be satisfactorily interrupted within the small bore 35. Because of the relatively small amount of current flow, and the large diameter of the bore 26, such an amount of fault current cannot be efficiently interrupted in the large bore 26. Accordingly, it is desirable that the small current arc be confined to the small auxiliary bore 35. Also, it is desirable that the arc or products of the arc incident to the blowing of the reduced section 50 be prevented from impinging upon the ends 25a and 25b of the blown fusible element 25 so as to prevent reestablishment of the arc therebetween.

In order to confine the flow of relatively low fault current to the path through the auxiliary terminal or strain element 34 for extinction in the small or auxiliary bore 35 after the reduced section 50 has been melted, a barrier is provided at the lower end of the auxiliary terminal or strain element 34 to segregate it from the

6

exhaust channel from the main bore 26. Preferably the barrier is in the form of a tube 51 which is arranged to constitute an extension of the small or auxiliary bore 35 and to extend therefrom well past the ends 25a and 25b of the blown fusible element 25. Preferably the tube 51 is formed of ceramic material so that gas generation and liberation of carbon incident to the blowing of the reduced section 50 are avoided when the small fault current arc is initially struck. One advantage of this is that the deionizing action is delayed until the small fault current arc is drawn into the small diameter or auxiliary bore 35 and assuring that the gap at the fusible element 25 has been enlarged to some extent before an appreciable arc voltage builds up in the auxiliary bore 35. However, the tube 51 can be formed of a gas evolving material, such as fiber, if that action is desired.

The tube 51 is formed of frangible material, such as ceramic material as noted, so that, while it remains intact to perform its function under low fault current interrupting conditions, on flow of higher fault current, the resulting heat and pressure may readily rupture it. This permits the arc to be reestruck promptly to the rod-like terminal 24 where it can be more efficiently extinguished in the large bore 26.

As indicated, the barrier in the form of a ceramic tube or sleeve 51 constitutes an extension of the lower end of the small or auxiliary bore 35. The upper end of the sleeve 51 is cemented, as indicated at 52, into an opening 53, Figure 6, in a frangible insulating washer 54 which has a large opening 55 that is arranged to register with the large bore 26, the opening 53 registering with the small or auxiliary bore 35. The frangible washer 54 is provided for holding a throat section 56 of the lining in place and permitting it to be readily expelled under a certain range of high fault current interrupting conditions.

It will be observed that the fusible element 25 is located within an arcing chamber or exhaust nozzle 57 that is formed by an insulating sleeve 58, preferably formed of relatively strong material, such as fiber, from which an arc extinguishing medium can be evolved. Also it will be observed that the frangible barrier or sleeve 51 extends through the arcing chamber 57, well past the ends 25a and 25b of the fusible element 25 and that it surrounds the principal portion of the reduced section 50 of the strain wire 47.

In operation, on the flow of a relatively low fault current sufficient to blow the fusible element 25, the central coil portion 25' thereof, as shown in Figure 3, is blown leaving the terminals 25a and 25b. The entire flow of current is promptly transferred to the auxiliary terminal or strain element 34 and the reduced section 50 is blown. As a result an arc is drawn between the lower end of the strain wire 47 within the barrier or sleeve 51 and the strain wire pin 36. The coil tension spring 21 promptly collapses and withdraws the rod-like terminal 24 and the remaining portion of the auxiliary terminal or strain element 34 into the respective bores 26 and 35. The arc voltage builds up and the arc is drawn within the barrier or tube 51 and into the small or auxiliary bore 35 which has sufficient size to interrupt it efficiently and yet is small enough to prevent continuation of the arc for more than a very limited time. In the meantime, the rod-like terminal 24 is being moved through the large bore 26 but no arc is drawn therein. Because of the frangible barrier or sleeve 51, the exhaust from the auxiliary bore 35 is positively directed away from the gap between the ends 25a and 25b of the fusible element 25 and thus a conducting path therebetween is not reestablished. Since no flexible conductor or cable extends from the strain wire pin 36 into the small or auxiliary bore 35 along side of the auxiliary terminal or strain element 34, there is no conducting path likely to be reestablished therein once the auxiliary terminal or strain element 34 has been with-

drawn by the coil tension spring 21 to extinguish the arc. The circuit interrupter 18, constructed in the manner described hereinbefore, when blown, will have a relatively high minimum voltage withstand value such that on subsequent subjection to high voltage surges, transient voltages or normal frequency recovery voltages, there is little likelihood of the arc being reestablished through either the main bore 26 or the small or auxiliary bore 35.

In the event that the current flow through the auxiliary or strain element 34 exceeds that which can be interrupted in the small or auxiliary bore 35, then the heat and pressure incident to such operation may be sufficient to destroy the frangible sleeve 51. As arc voltage builds up promptly, the arc is restruck or transferred to the rod-like terminal 24 or the current flow may never have been completely transferred under the assumed conditions to the auxiliary terminal or strain element 34, since the voltage drop along the path through the auxiliary terminal or strain element 34 may be relatively high. In either case the flow of relatively large fault current takes place through the rod-like terminal 24 as it moves and the arc incident thereto is drawn within the large diameter bore 26 where it can be efficiently extinguished. After the circuit has been interrupted in this manner, the blown fuse has a high voltage withstand value.

There are many instances where it is desirable to use the circuit interrupter 18 in a circuit where the normal current flow is relatively low and where separate fusible and strain elements cannot be used. An illustration of this is a circuit in which the normal current flow is of the order of 5 amperes or less. In such a case it is not feasible to employ the fusible element 25 in parallel with the auxiliary terminal or strain element 34. The reason for this is that the current division between the two paths would be such as to make it difficult to properly calibrate the fusible element. An acceptable design is not obtained merely by omitting the fusible element 25 and relying solely on the reduced section 50 of the strain wire 47. Because of the small diameter of the barrier or tube 51 and of the auxiliary bore 35 it is difficult to provide adequate terminals therein for dependable calibration of a fusible section.

However, it is desirable to provide for the interruption of relatively low fault current and also to provide in the same device for the interruption of relatively high fault current, even though the normal current flow through the circuit interrupter is of the order of 5 amperes.

With these operating conditions in mind, use can be made of the alternate construction shown in Figures 7, 8 and 9 of the drawings. Here the rod-like terminal 59 corresponds to the rod-like terminal 24, described hereinbefore, and it is arranged to move through the large bore 26. At its lower end the rod-like terminal 59 is provided with a tubular reduced diameter end section 60 that is deformed onto a corrugated end 61 of a combined fusible and strain element 62. The combined fusible and strain element 62 can be formed of a suitable high strength conductor such as a Nichrome wire. The lower end of the combined fusible and strain element 62 is corrugated as indicated at 63 and has a terminal 63' in the form of a tube deformed thereon. The terminal 63' is held in place by a terminal pin 64 which projects radially inwardly from the stationary terminal 37. It will be understood that the upward movement of the rod-like terminal 59 is prevented solely by the combined fusible and strain element 62. The entire force of the coil tension spring 21 is applied to the combined fusible and strain element 62 and because of the relatively large terminals 60 and 63' it can be calibrated quite accurately to blow under predetermined over current conditions and yet is capable of withstanding without change the flow of normal load current of the order of 5 amperes and below.

As pointed out above it is desirable to provide the

small or auxiliary bore 35 in the modified construction for use in a circuit in which the normal load current flow is relatively small. However, because of the relatively small amount of current flowing it is not feasible to employ a shunt circuit around the combined fusible and strain element 62. Accordingly, there is provided an auxiliary terminal 65 which is generally similar to the auxiliary terminal or strain element 34 previously described except that it is arranged so that none of the normal load current flows therethrough and it does not withstand any of the tension stress applied by the spring 21. The auxiliary terminal 65 includes a tube 66 which is similar to the tube 48 previously described and it surrounds a wire 67 which corresponds to the strain wire 47, also previously described. If desired, the tube 66 can be omitted and a solid copper rod can be employed since no tension stress is applied. However, at its lower end the wire 67 is provided with a head 68 and has an insulating sleeve 69 between it and the lower end of the tube 66. The reason for the insulating sleeve 69 is to insulate the auxiliary terminal 65 from the circuit through the combined fusible and strain element 62.

In order to complete the circuit through the auxiliary terminal 65 and to draw a relatively low fault current arc into the small or auxiliary bore 35, a contact clip, shown generally at 70, is provided. The contact clip 70 has arms 71—71 with inturned rounded portions 72—72 which bear against opposite sides of the insulating sleeve 69 which may be formed of ceramic material or other suitable insulating material. At their lower ends the arms 71—71 are apertured as indicated at 73 for receiving a contact pin 74 that extends radially inwardly from the stationary terminal 37. It will be observed that the barrier in the form of an insulating sleeve 51 extends from the frangible washer 54 in the manner previously described and surrounds the lower end of the auxiliary terminal 65 and the upper portion of the contact clip 70.

In the event that the flow of fault current is relatively low but sufficient to blow the combined fusible and strain element 62, then the rod-like terminal 59 is released and it moves upwardly under the influence of the coil tension spring 21. The arc incident to such operation is extinguished by being short circuited through the auxiliary terminal 65 as soon as it has moved far enough to bring the head 68 into contact with the end portion 72 of the arms 71. Continued movement of the rod-like terminal 59 and of the auxiliary terminal 65 in their respective bores 26 and 35 is accompanied by the drawing of a low fault current arc in the tube 51 and into the small or auxiliary bore 35 between the head 68 on the lower end of the wire 67 and the upper ends of the arms 71—71 of the contact clip 70. Under the assumed conditions the small fault current arc is extinguished in the small or auxiliary bore 35 and the rod-like terminal 59 and the auxiliary terminal 65 continue to move upwardly to the limits of their upward movement. In the blown condition a high voltage withstand value is provided through the fuse since the lower ends of the rod-like terminal 59 and of the auxiliary terminal 65 have moved to the upper ends of the respective bores 26 and 35.

In the event that the fault current arc is too large to be extinguished in the small or auxiliary bore 35, the heat and pressure incident to the drawing of the arc within the sleeve 51 may be sufficient to rupture it and cause the arc to transfer to the rod-like terminal 59 where it can be efficiently interrupted within the large bore 26. If the barrier or sleeve 51 is not ruptured the arc may be extended a short distance into the small or auxiliary bore 35 until the arc voltage reaches a value high enough to cause restriking to the terminal 59. On very high currents only a part of the current may be shunted momentarily through the auxiliary bore 35.

Figure 10 shows another embodiment of the invention for use in the construction shown in Figure 7 in lieu of the particular construction there shown, particularly as

illustrated in Figures 8 and 9 of the drawings. In Figure 10 the frangible barrier or ceramic sleeve 51 is shown as extending from the frangible washer 54 into aperture 75 in a contact pin 76, corresponding to the contact pin 74, and extending radially inwardly from the stationary terminal or ferrule 37. The contact pin 76 is formed of good conducting material such as brass and it will be understood that it is connected directly to the stationary terminal or ferrule 37. Extending downwardly through the small or auxiliary bore 35 in the lining 27 of water evolving arc extinguishing material is an auxiliary contact rod 77 the upper end of which is provided with a terminal, such as the flattened tube 44, Figure 5 for connection to the pin 33 which extends transversely of the main rod-like terminal 24 that moves upwardly through the large bore 26 when the circuit interrupter is required to operate and interrupt the circuit. The auxiliary contact rod 77 may be in the form of a length of copper wire since no tension stress is applied to it other than the stress sufficient to effect its movement upwardly through the small or auxiliary bore 35. Near its lower end the auxiliary contact rod 77 is provided with a reduced section 78 to provide a location where fusion may take place under certain circumstances. However, the reduced section 78 can be omitted and the auxiliary contact rod 77 continue without reduction to its lower end at the same cross section.

The lower end of the auxiliary contact rod 77 is provided with a contact section 79 that is circular in cross section. Cooperating with the contact section 79 of the auxiliary contact rod 77 is a tubular contact member 80 that is formed of good conducting material, such as brass. Such material also has some inherent resiliency. The tubular contact member 80 is provided with an intermediate cylindrical section 81 from the upper end of which contact fingers 82 extend. The contact fingers 82 are provided with curved upper ends which bear against and frictionally grip the outer surface of the contact section 79. At its lower end the tubular contact member 80 is provided with a flared head portion 84 that is spaced downwardly away from the contact pin 76 but is arranged to engage an annular contact surface 85 at the lower end of the aperture 75 when the tubular contact member 80 moves upwardly along with the upward movement of the auxiliary contact rod 77. The air gap between the flared head portion 84 and the contact surface 85 is indicated at 86. Because of this air gap 86 and the barrier or tube 51, which is formed of insulation, there is no circuit through the auxiliary contact rod 77 or through the small auxiliary bore 35 as long as the combined fusible and strain element 62, Figure 7, remains intact.

The operation of the modification shown in Figure 10 when combined with the construction shown in Figure 7 is similar to that described hereinbefore. On blowing of the combined fusible and strain element 62, the rod-like terminal 59 moves upwardly through the large bore 26 and the auxiliary contact rod 77 likewise moves upwardly through the small auxiliary bore 35. The arc is drawn between the end 60 of the rod-like terminal 59 and the terminal 63' or the remaining ends of the combined fusible and strain element 62 as the case may be. Since the contact fingers 82 frictionally grip the contact section 79, the tubular contact member 80 moves upwardly along with the auxiliary contact rod 77 until the air gap 86 is closed and the flared head portion 84 makes contact engagement with the contact surface 85 on the contact pin 76. At that time the arc between the rod-like terminal 59 and the terminal 63 is short circuited and the entire current flow is transferred to the auxiliary contact rod 77, it being assumed that a relatively low current arc is involved. Since the flared head portion 84 prevents further upward movement of the tubular contact member 80, its movement is arrested but the auxiliary contact rod 77 continues to move upwardly

and sliding contact is maintained between the contact section 79 and the curved upper ends 83 of the contact fingers 82. This sliding contact continues until the contact section 79 moves away from the upper ends of the contact fingers 82 whereupon the arc is reestablished and is drawn into the small or auxiliary bore 35 and there extinguished. The time required for disengaging the contact section 79 of the auxiliary contact rod 77 from the upper ends of the contact fingers 82 after the gap 86 has been mechanically and electrically closed is sufficient to insure that the arc drawn on blowing of the combined fusible and strain element 62 is extinguished even though the device is called upon to operate in a circuit having a relatively low power factor. The action takes place at such speed that the flared head portion 84 of the tubular contact member 80 remains in contact engagement with the contact surface 85 long enough to permit the arc to be drawn in the small or auxiliary bore 35 and extinguished.

On the flow of fault current which cannot be interrupted in the small or auxiliary bore 35, the operation proceeds as described hereinbefore with the transfer to the rod-like terminal 59 taking place with or without the destruction of the frangible barrier or ceramic sleeve 51, depending upon the violence of the circuit interrupting operation.

Since certain changes can be made in the foregoing constructions and different embodiments of the invention can be made without departing from the spirit and scope thereof, it is intended that all matters shown in the accompanying drawings and described hereinbefore small be interpreted as illustrative and not in a limiting sense.

What is claimed as new is:

1. An electric circuit interrupter comprising, in combination, a tubular insulating housing having at one end an arcing chamber and a stationary terminal, said housing providing lengthwise extending parallel large and small bores, a movable rod-like terminal substantially filling said large bore, means connected to one end of said rod-like terminal for moving it away from said stationary terminal, a fusible element in said arcing chamber connecting the other end of said rod-like terminal to said stationary terminal, a movable auxiliary terminal in said small bore connected at one end to said one end of said rod-like terminal and movable therewith and at the other end having means for establishing a gap by movement of said auxiliary terminal away from said stationary terminal and drawing an arc in said arcing chamber between said auxiliary terminal and said stationary terminal, and a stationary barrier formed wholly of insulating material in said arcing chamber between said arc drawing means and said fusible element whereby on final interruption of the circuit by said auxiliary terminal the arc products incident thereto are prevented from impinging on the ends of said fusible element when blown.

2. An electric circuit interrupter comprising, in combination, a tubular insulating housing having at one end an arcing chamber and a stationary terminal, said housing providing lengthwise extending parallel large and small bores, a movable rod-like terminal substantially filling said large bore, means connected to one end of said rod-like terminal for moving it away from said stationary terminal, a fusible element in said arcing chamber connecting the other end of said rod-like terminal to said stationary terminal, a movable auxiliary terminal in said small bore connected at one end to said one end of said rod-like terminal and movable therewith and at the other end having means for establishing a gap by movement of said auxiliary terminal away from said stationary terminal and drawing an arc in said arcing chamber between said auxiliary terminal and said stationary terminal, and a frangible tube formed wholly of insulating material and extending from said auxiliary bore into

said arcing chamber and surrounding said arc drawing means whereby on final interruption of relatively low fault current by said auxiliary terminal the arc products incident thereto are prevented from impinging on the ends of said fusible element when blown.

3. An electric circuit interrupter comprising, in combination, a tubular insulating housing having at one end an arcing chamber and a stationary terminal, said housing providing lengthwise extending parallel large and small bores, a movable rod-like terminal substantially filling said large bore, means connected to one end of said rod-like terminal for moving it away from said stationary terminal, a fusible element in said arcing chamber connecting the other end of said rod-like terminal to said stationary terminal, a movable auxiliary terminal in said small bore connected at one end to said one end of said rod-like terminal and movable therewith and at the other end having means for establishing a gap by movement of said auxiliary terminal away from said stationary terminal and drawing an arc in said arcing chamber between said auxiliary terminal and said stationary terminal, and a frangible tube formed wholly of insulating material and extending from said auxiliary bore through said arcing chamber beyond the ends of said fusible element and surrounding said arc drawing means whereby on final interruption of relatively low fault current by said auxiliary terminal the arc products incident thereto are prevented from impinging on the ends of said fusible element when blown and whereby on interruption of relatively high fault current said frangible insulating tube is ruptured by heat and pressure and the fault current arc is transferred to said rod-like terminal and extinguished in said large bore.

4. The invention, as set forth in claim 2, wherein the insulating tube is formed of ceramic material having no gas evolving properties.

5. The invention, as set forth in claim 2, wherein an insulating washer overlies the ends of the large and small bores and has openings registering therewith and the frangible insulating tube is cemented into the opening in said washer corresponding to said auxiliary bore.

6. An electric circuit interrupter comprising, in combination, a tubular insulating housing having at one end an arcing chamber and a stationary terminal, said housing providing lengthwise extending parallel large and small bores, a movable rod-like terminal substantially filling said large bore, means connected to one end of said rod-like terminal for moving it away from said stationary terminal, a fusible element in said arcing chamber connecting the other end of said rod-like terminal to said stationary terminal, a movable auxiliary terminal in said small bore connected at one end to said one end of said rod-like terminal and at the other end to said stationary terminal and acting to restrain movement of said rod-like terminal and relieving said fusible element of tension stress, said auxiliary terminal having a section of reduced cross section adjacent said stationary terminal that is blown following blowing of said fusible element accompanied by drawing of an arc, and a stationary barrier formed wholly of insulating material in said arcing chamber between the space where said arc is drawn and said fusible element whereby the products incident to said arc are prevented from impinging on the ends of the blown fusible element.

7. An electric circuit interrupter comprising, in combination, a tubular insulating housing having at one end an arcing chamber and a stationary terminal, said housing providing lengthwise extending parallel large and small bores, a movable rod-like terminal substantially filling said large bore, means connected to one end of said rod-like terminal for moving it away from said stationary terminal, a fusible element in said arcing chamber connecting the other end of said rod-like terminal to said stationary terminal, a movable auxiliary terminal in said small bore connected at one end to said one end

of said rod-like terminal and at the other end to said stationary terminal and acting to restrain movement of said rod-like terminal and relieving said fusible element of tension stress, said auxiliary terminal having a section of reduced cross section adjacent said stationary terminal that is blown following blowing of said fusible element accompanied by drawing of an arc, and a frangible insulating tube extending from said auxiliary bore into said arcing chamber and around said section of said auxiliary terminal of reduced cross section whereby on final interruption of relatively low fault current by said auxiliary terminal the arc products incident thereto are prevented from impinging on the ends of said fusible element when blown and whereby on interruption of relatively high fault current said frangible insulating tube is ruptured by heat and pressure and the fault current arc is transferred to said rod-like terminal and extinguished in said large bore.

8. An electric circuit interrupter comprising, in combination, a tubular insulating housing having at one end an arcing chamber and a stationary terminal, said housing providing lengthwise extending parallel large and small bores, a movable rod-like terminal substantially filling said large bore, means connected to one end of said rod-like terminal for moving it away from said stationary terminal, a fusible element in said arcing chamber connecting the other end of said rod-like terminal to said stationary terminal, a movable auxiliary terminal in said small bore connected at one end to said one end of said rod-like terminal and at the other end to said stationary terminal and acting to restrain movement of said rod-like terminal and relieving said fusible element of tension stress, said auxiliary terminal having a section of reduced cross section adjacent said stationary terminal that is blown following blowing of said fusible element accompanied by drawing of an arc, an insulating washer overlying the ends of said large and small bores and having openings registering therewith, and a frangible insulating tube extending from said auxiliary bore and cemented into the corresponding opening in said washer and projecting into said arcing chamber and around said section of said auxiliary terminal of reduced cross section whereby on final interruption of relatively low fault current by said auxiliary terminal the arc products incident thereto are prevented from impinging on the ends of said fusible element when blown and whereby on interruption of relatively high fault current said frangible insulating tube is ruptured by heat and pressure and the fault current arc is transferred to said rod-like terminal and extinguished in said large bore.

9. An electric circuit interrupter comprising, in combination, a tubular insulating housing having at one end an arcing chamber and a stationary terminal, said housing providing lengthwise extending parallel large and small bores, a movable rod-like terminal substantially filling said large bore, means connected to one end of said rod-like terminal for moving it away from said stationary terminal, fusible and strain element means in said arcing chamber connecting the other end of said rod-like terminal to said stationary terminal and acting to restrain movement of the former away from the latter, a movable auxiliary terminal in said small bore connected at one end to said one end of said rod-like terminal and extending at the other end into said arcing chamber, conductor means extending endwise from said auxiliary terminal into overlapping relation therewith in said arcing chamber, means preventing the flow of current through said conductor means and said auxiliary terminal as long as said fusible and strain element means remain intact until said rod-like and auxiliary terminals have moved through a predetermined distance away from said stationary terminal in response to blowing of said fusible and strain element means, and a stationary insulating barrier in said arcing chamber between said auxiliary terminal and conductor means on the one hand and said fusible and strain

13

element means on the other hand whereby on final interruption of the circuit by said auxiliary terminal the arc products incident thereto are prevented from impinging on the ends of said fusible and strain element means when blown.

10. An electric circuit interrupter comprising, in combination, a tubular insulating housing having at one end an arcing chamber and a stationary terminal, said housing providing lengthwise extending parallel large and small bores, a movable rod-like terminal substantially filling said large bore, means connected to one end of said rod-like terminal for moving it away from said stationary terminal, fusible and strain element means in said arcing chamber connecting the other end of said rod-like terminal to said stationary terminal and acting to restrain movement of the former away from the latter, a movable auxiliary terminal in said small bore connected at one end to said one end of said rod-like terminal and extending at the other end into said arcing chamber, contact means extending endwise from said auxiliary terminal into overlapping relation therewith in said arcing chamber, means providing a gap and thereby preventing the flow of current through said contact means and said auxiliary terminal as long as said fusible and strain element means remain intact and until said rod-like and auxiliary terminals have moved through a predetermined distance away from said stationary terminal in response to blowing of said fusible and strain element means, and an insulating tube in said arcing chamber enclosing the overlapping portions of said auxiliary terminal and contact means whereby on final interruption of the circuit by said auxiliary terminal the arc products incident thereto are prevented from impinging on the ends of said fusible and strain element means when blown.

11. An electric circuit interrupter comprising, in combination, a tubular insulating housing having at one end an arcing chamber and a stationary terminal, said housing providing lengthwise extending parallel large and small bores, a movable rod-like terminal substantially filling said large bore, means connected to one end of said rod-like terminal for moving it away from said stationary terminal, fusible and strain element means in said arcing chamber connecting the other end of said rod-like terminal to said stationary terminal and acting to restrain movement of the former away from the latter, a movable auxiliary terminal in said small bore connected at one end to said one end of said rod-like terminal and extending at the other end into said arcing chamber, conductor means extending from said stationary terminal into overlapping relation in said arcing chamber with said auxiliary terminal, insulating means between said conductor means and said auxiliary terminal whereby a circuit therethrough is established only after said fusible and strain element means blow and said rod-like and auxiliary terminals have moved through a predetermined distance away from said stationary terminal, and a stationary insulating barrier in said arcing chamber between said auxiliary terminal and conductor means on the one hand and said fusible and strain element means on the other hand whereby on final interruption of the circuit by said auxiliary terminal the arc products incident thereto are prevented from impinging on the ends of said fusible and strain element means when blown.

12. An electric circuit interrupter comprising, in combination, a tubular insulating housing having at one end an arcing chamber and a stationary terminal, said housing providing lengthwise extending parallel large and small bores, a movable rod-like terminal substantially filling said large bore, means connected to one end of said rod-like terminal for moving it away from said stationary terminal, fusible and strain element means in said arcing chamber connecting the other end of said rod-like terminal to said stationary terminal and acting to restrain movement of the former away from the latter, a movable

14

auxiliary terminal in said small bore connected at one end to said one end of said rod-like terminal and extending at the other end into said arcing chamber, conductor means extending from said stationary terminal into overlapping relation in said arcing chamber with said auxiliary terminal insulating means between said conductor means and said auxiliary terminal whereby a circuit therethrough is established only after said fusible and strain element means blow and said rod-like and auxiliary terminals have moved through a predetermined distance away from said stationary terminal, and a frangible insulating tube extending from said auxiliary bore into said arcing chamber and surrounding said auxiliary terminal and said conductor means whereby on final interruption of relatively low fault current by said auxiliary terminal the arc products incident thereto are prevented from impinging on the ends of said fusible and strain element means when blown and whereby on interruption of relatively high fault current said frangible insulating tube is ruptured by heat and pressure and the fault current arc is transferred to said rod-like terminal and extinguished in said large bore.

13. The invention, as set forth in claim 12, wherein the insulating means is in the form of a sleeve surrounding the auxiliary terminal and spaced from the other end thereof and the conductor means is in the form of a U-shaped spring clip with the ends of its arms engaging opposite sides of said insulating sleeve.

14. An electric circuit interrupter comprising, in combination, a tubular insulating housing having at one end an arcing chamber and a stationary terminal, said housing providing lengthwise extending parallel large and small bores, a movable rod-like terminal substantially filling said large bore, means connected to one end of said rod-like terminal for moving it away from said stationary terminal, fusible and strain element means in said arcing chamber connecting the other end of said rod-like terminal to said stationary terminal and acting to restrain movement of the former away from the latter, a movable auxiliary terminal in said small bore connected at one end to said one end of said rod-like terminal and extending at the other end into said arcing chamber, contact means extending endwise from said auxiliary terminal into overlapping relation therewith in said arcing chamber and movable therewith through a predetermined distance, means providing an air gap between said contact means and said stationary terminal and preventing the flow of current through said contact means and said auxiliary terminal as long as said fusible and strain element means remain intact and until said rod-like and auxiliary terminals have moved through said predetermined distance away from said stationary terminal in response to blowing of said fusible and strain element means, and an insulating tube in said arcing chamber enclosing the overlapping portions of said auxiliary terminal and contact means whereby on final interruption of the circuit by said auxiliary terminal the arc products incident thereto are prevented from impinging on the ends of said fusible and strain element means when blown.

15. An electric circuit interrupter comprising, in combination, a tubular insulating housing having at one end an arcing chamber and a stationary terminal, said housing providing lengthwise extending parallel large and small bores, a movable rod-like terminal substantially filling said large bore, means connected to one end of said rod-like terminal for moving it away from said stationary terminal, fusible and strain element means in said arcing chamber connecting the other end of said rod-like terminal to said stationary terminal and acting to restrain movement of the former away from the latter, a movable auxiliary terminal in said small bore connected at one end to said one end of said rod-like terminal and having a contact section at the other end extending into said arcing chamber, a contact sleeve having frictional contact engagement with said contact sec-

15

tion in said arcing chamber and extending endwise therefrom into spaced relation with said stationary terminal thereby providing an air gap therebetween preventing the flow of current through said contact sleeve and said auxiliary terminal as long as said fusible and strain element means remain intact and until said rod-like and auxiliary terminals have moved through a predetermined distance away from said stationary terminal in response to blowing of said fusible and strain element means whereupon said air gap is mechanically and electrically bridged and further movement of said contact sleeve is prevented, and a stationary insulating barrier in said arcing chamber between said auxiliary terminal and contact sleeve on the one hand and said fusible and strain element means on the other hand whereby on final interruption of the circuit by said auxiliary terminal the arc products incident thereto are prevented from impinging on the ends of said fusible and strain element means when blown.

16. An electric circuit interrupter comprising, in combination, a tubular insulating housing having at one end an arcing chamber and a cylindrical stationary terminal, a contact pin extending radially inwardly from said cylindrical stationary terminal, said housing providing lengthwise extending parallel large and small bores, a movable rod-like terminal substantially filling said large bore, means connected to one end of said rod-like terminal for moving it away from said stationary terminal, fusible and strain element means in said arcing chamber connecting the other end of said rod-like terminal to said stationary terminal and acting to restrain movement of the former away from the latter, a movable auxiliary

16

terminal in said small bore connected at one end to said one end of said rod-like terminal and having a contact section at the other end extending into said arcing chamber, a contact sleeve having frictional contact engagement at one end with said contact section in said arcing chamber and having a head at the other end in overlying spaced relation to said contact pin whereby an air gap is provided preventing the flow of current through said contact sleeve and said auxiliary terminal as long as said fusible and strain element means remain intact and until said rod-like and auxiliary terminals have moved through a predetermined distance away from said stationary terminal in response to blowing of said fusible and strain element means sufficient to cause said head to engage said contact pin and prevent further movement of said contact sleeve with said auxiliary terminal, and a stationary insulating barrier in said arcing chamber between said auxiliary terminal and contact sleeve on the one hand and said fusible and strain element means on the other hand whereby on final interruption of the circuit by said auxiliary terminal the arc products incident thereto are prevented from impinging on the ends of said fusible and strain element means when blown.

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