United States Patent

[11] **3,611,240**

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[21] Appl. No. **34,240**
[22] Filed **May 4, 1970**
[45] Patented **Oct. 5, 1971**
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[54] **DROPOUT FUSE**
20 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **337/169,** 337/178, 337/179, 337/220
[51] **Int. Cl.** **H01h 71/10**
[50] **Field of Search** 337/169, 170, 171, 175–180, 220, 158, 178

[56] **References Cited**

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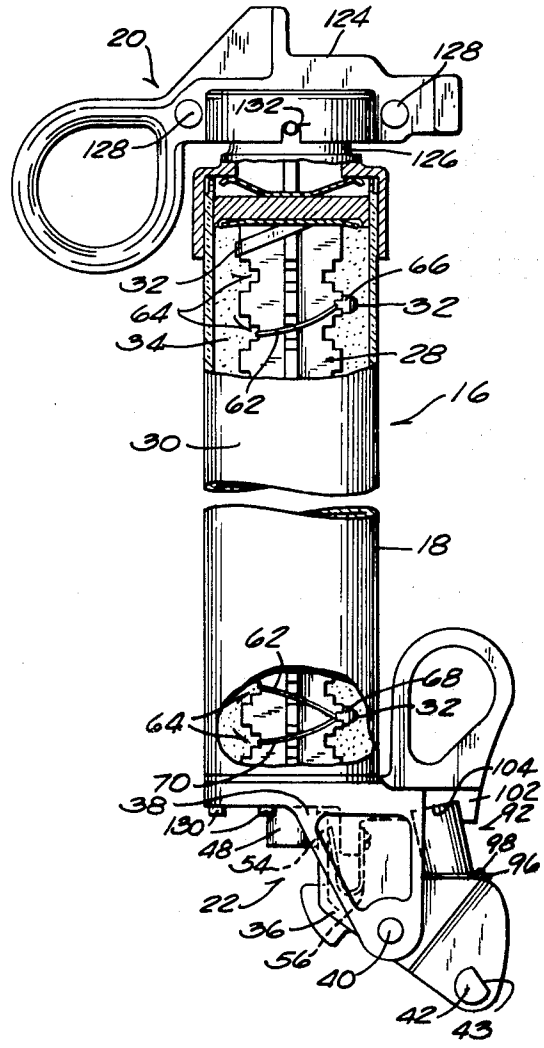
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ABSTRACT: An open type dropout fuse has full range fault clearing capability, with fuse operation being confined within the fuse tube. An explosive charge is used to hold the fuse in a closed circuit position and, upon detonation, releases the fuse for drop-open movement to physically open the circuit. An electric igniter for the explosive charge is switched in for detonation after fuse operation has been initiated within the fuse tube. Initial drop-open movement of the fuse is opposed to retard physical opening of the fuse.



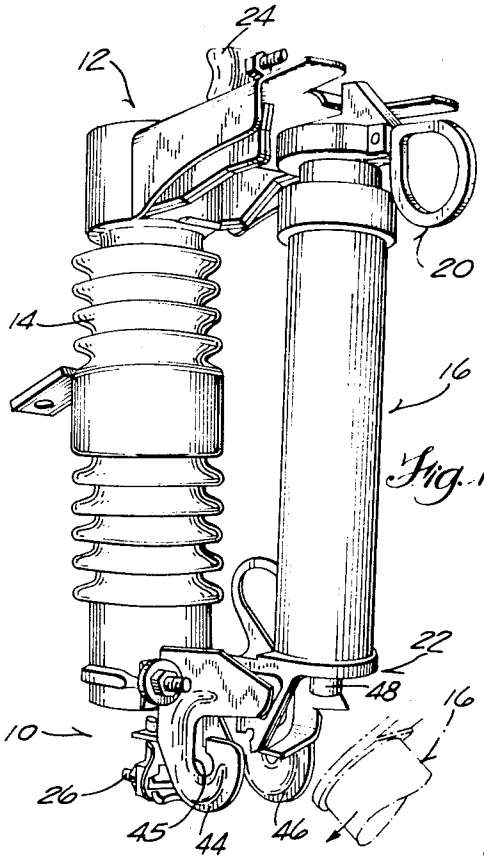


Fig. 1

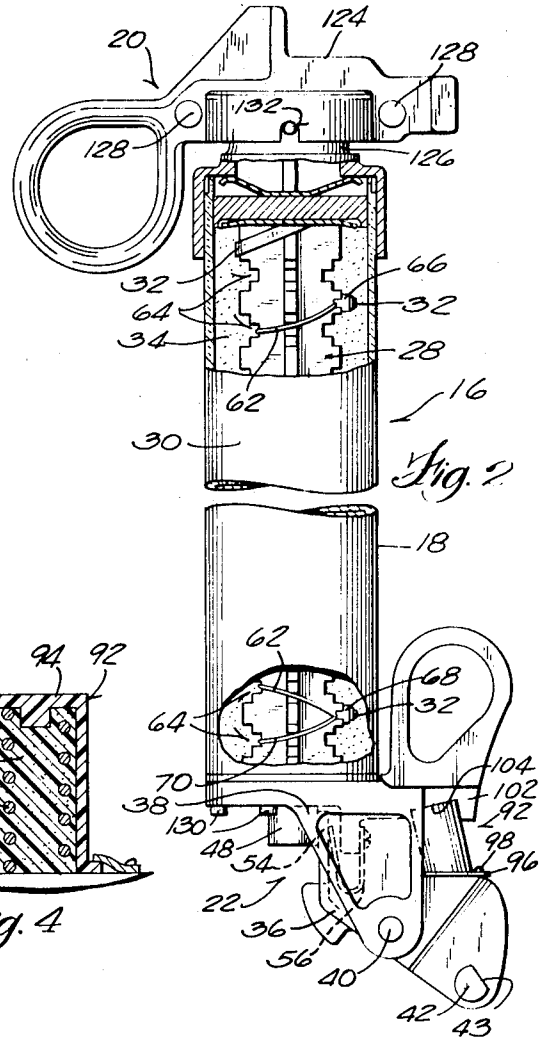


Fig. 2

Fig. 4

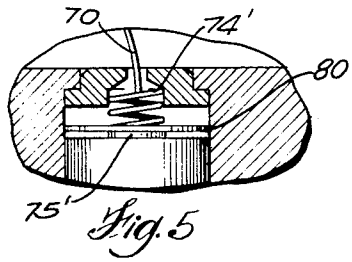


Fig. 5

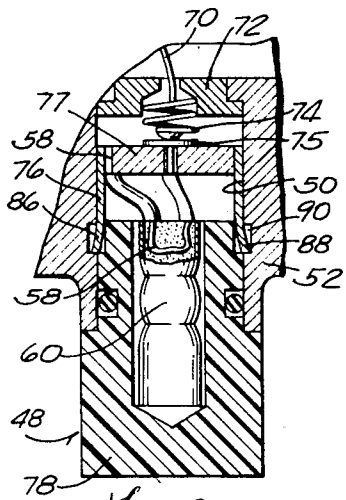
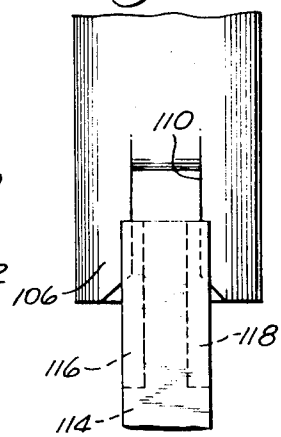


Fig. 3

Fig. 7



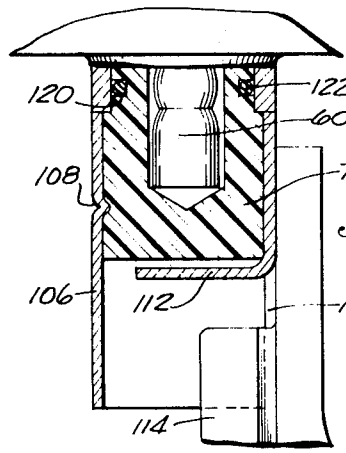


Fig. 6

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DROPOUT FUSE

This invention relates to fuse cutouts and, more particularly, to a current limiting fuse cutout having dropout capabilities.

Dropout fuses of both the open and enclosed type are well known in the electrical industry. U.S. Pat. No. 3,437,971, issued to Harvey W. Mikulecky and assigned to the assignee of this application, discloses and claims a fuse construction which has full range current clearing ability and does so wholly within the fuse tube without the noise and expelled hot gases and particles usually attendant operation of expulsion type fuses.

Among the general objects of this invention is to provide an advantageous dropout fuse; and, in its more specific aspects, to achieve fault clearing without creating a hazardous condition in the area of the fuse during operation and, moreover, to initiate dropout movement only after interruption and clearing has started, but insure adequate time for interruption and clearing before dropout occurs.

For the achievement of these and other objects, this invention contemplates a dropout fuse wherein drop-open movement is initiated by an explosive charge. The explosive charge is detonated in response to interruption and clearing operation of the fuse. A dashpot device opposes at least initial drop-open movement of the fuse so that adequate time is afforded for interruption to prevent a following arc being drawn during drop-open movement. In its more specific aspects, the fuse has the capability of full range clearing wholly within the fuse, silently and without exhausting hot gases, particles, and the like such as encountered in the operation of expulsion type fuses.

Other objects and advantages will be pointed out in, or be apparent from, the specification and claims, as will obvious modifications of the embodiments shown in the drawings, in which:

FIG. 1 is a perspective view of a fuse embodying this invention;

FIG. 2 is an enlarged view of the fuse assembly with parts broken away to better illustrate the fuse interior and operation of the explosive charge;

FIG. 3 is an enlarged view of area A illustrating the construction of the explosive charge;

FIG. 4 is an enlarged view of the dashpot device;

FIG. 5 is a partial view of an alternative embodiment;

FIG. 6 is a partial view of another alternative; and

FIG. 7 is a side view of the alternative of FIG. 6.

DESCRIPTION OF PREFERRED EMBODIMENT

With particular reference to the drawings, a dropout fuse, of the open type, embodying this invention is illustrated in FIG. 1. The dropout fuse includes a lower terminal assembly 10, an upper terminal assembly 12 and an electrical insulator 14. The upper and lower terminals are spaced and electrically isolated one from the other by the insulator. A fuse assembly 16 bridges the upper and lower terminals (the full line showing) and, in a manner to be described more completely hereinafter, in this position completes an electrical circuit between the upper and lower terminals and can drop-open (the dotted line showing in FIG. 1) to physically interrupt the circuit between the upper and lower terminals.

Structurally, the fuse assembly includes a fuse 18, an upper fitting and terminal assembly 20 and a lower fitting and terminal assembly 22. The fuse fitting and terminal assemblies make electrical contact with the upper and lower terminals supported by insulator 14 in establishing the electrical circuit of the fuse. Through conventional connections at connectors 24 and 26, the dropout fuse can be inserted in an electrical circuit for online protection.

The interior of fuse 18 is constructed and operates in much the same manner as the fuse disclosed in the above-identified patent to Harvey W. Mikulecky. A general description of the interior of the fuse and its operation will be made and reliance is placed on that patent should a more complete description of clearing capabilities and operation of the fuse become necessary.

Structurally, a core 28 made of gas evolving material such as disclosed in the aforementioned patent is supported centerally within outer tube 30. A fusible element 32 in the form of an apertured ribbon (wire fuse elements may also be used) is wound helically on the core and establishes a continuous electrical circuit through the fuse tube and between fuse fitting and terminal assemblies 20 and 22. The ribbon element can also be provided with an "M-spot" to assist in initiating fusion, the "M-spot" being conventional is not illustrated. If an abnormal condition appears on the line—low-fault, overload or high-fault current—the ribbon element will fuse drawing an arc. Depending upon the nature of the fault this may be a single arc at one place, i.e. the "M-spot," or may be a series of arclets along the length of the ribbon, or can result in instantaneous fusion of the ribbon element along its entire length. The resultant arc which is drawn, and the attendant high temperature, work on the core 28 which as a result evolves gas into the arc stream tending to deionize the arc stream and also blowing the arc into inert granular material 34, for example sand, surrounding the core. This blowing out of the arc into sand lengthens and cools the arc both of which assist in extinguishing the arc and clearing the circuit. This operation takes place wholly within fuse tube 30 and without the expulsion of hot gases or other particles.

As mentioned above, the fuse can be constructed in the manner taught in the aforementioned Mikulecky patent, the principal distinction being that the fuse structure disclosed in that patent was intended for indoor or enclosed use whereas the present fuse is intended for outdoor use and hence is modified to better accommodate such use, e.g. the fuse tube is sealed to make it watertight.

Although the fuse has the ability of interrupting and clearing a fault condition wholly within the fuse tube, it is also desirable to have the fuse drop-open to thereby physically break the bridging connection between the terminals 10 and 12 and avoid the possibility of tracking along the outside of the fuse assembly which might ultimately lead to flashover.

To accomplish drop-open operation, an explosive charge is provided in the assembly which functions in response to interruption and clearing operation within the fuse tube. The drop-open capability of the fuse will now be described with particular reference directed to the lower end of the fuse particularly lower fitting and terminal assembly 22.

As is perhaps best illustrated in FIG. 2, assembly 22 includes a flipper 36 and a fitting member 38 pivotally interconnected by hinge pin 40. Flipper 36 carries a pair of trunnions 42, only one illustrated in the drawing, which provide a pivotal engagement of the overall fuse assembly through engagement in slotted extensions 44 and 46 (see FIG. 1). Each trunnion has a flatted side 43 to permit entry into the pivot slot 45 of the extensions and subsequent locking in position. The pivotally interconnected fitting member 38 and flipper 36 provide a knuckle hinge with the entire assembly being capable of pivotal movement about trunnions 42 while the fitting member 38—together with the remainder of the fuse assembly—can have some relative movement with respect to the flipper.

Explosive charge 48 is carried at the lower end of fuse 18. The explosive charge, as will be described more completely hereinafter, is located in bore 50 in endpiece 52 closing the lower end of the fuse. The explosive charge projects from the lower end of the fuse for engagement with finger 54 of the flipper. In the position illustrated in FIG. 2, the flipper, or more generally the knuckle hinge formed by the flipper and fitting member 38, is in a cocked position so that fuse assembly 16 can be pivoted as a unit about trunnion 42 into and out of bridging engagement between upper and lower terminal assemblies 10 and 12 and will remain in the circuit closed position of FIG. 1.

Spring 56 is connected between the flipper and the fitting member and engages finger 54. The spring exerts a biasing force tending, in the orientation illustrated in FIG. 2, to pivot flipper 36 in a counterclockwise direction about the trunnions. The spring also provides the electric circuit transfer

between the fitting member **38** and the flipper **36** in the circuit of the fuse assembly and hence is preferably made of beryllium copper.

The weight of the fuse assembly and the bias of spring **56** exert a force in the assembly tending to cause counterclockwise rotation about trunnion **42**, and would also cause relative movement between the flipper and the remainder of the fuse assembly but for the explosive charge. Although spring **56** is used in initiating drop-open movement (the spring being there for electric circuit purposes it is advantageous to use it for this additional function), the weight of the fuse assembly alone could be used to initiate movement, or provide the biasing force; accordingly, bias in this application is used in a broad sense to denote forces produced other than solely by a spring, i.e. produced by gravity. Explosive charge **48** opposes this action, specifically opposes the bias of spring **56**, but when detonated the flipper **36** is released for movement. Upon detonation the explosive charge is blown from bore **50**, spring **56** imparts an initial force to the flipper tending to pivot the flipper in a counterclockwise direction about trunnions **42**. This pivotal movement will also carry hinge pin **40** and correspondingly fitting member **38** and the remainder of the fuse assembly downward, or with specific reference to hinge pin **40**, in a general counterclockwise direction about trunnion **42**. This initial action initiates the drop-open movement of the fuse. The pivotal opening movement continues until upper fitting and terminal assembly **20** is disengaged from upper terminal **12** and the fuse assembly falls completely open as illustrated by the dotted lines in FIG. **1**.

It is intended that the drop-open movement occur only when the fuse is called upon to clear a fault or overload condition. With that purpose in mind, the explosive charge is detonated in response to operation of the fuse assembly to interrupt and clear the fault condition. More specifically and with reference to FIG. **3**, a fine resistance wire **58** is embedded in the squib **60** of explosive material such as gun powder. Wire **58** is introduced into the electrical circuit of the fuse assembly after fuse operation has been initiated. To accomplish this, an auxiliary wire **62** is wound helically on core **28** in grooves **64** of the core. The auxiliary wire extends from a terminal clip **66** in the upper portion of the fuse tube to a terminal clip **68** disposed in the lower portion of the fuse tube. Both terminal clips are clamped on core **28**. Wire **70** extends from clip **68** through plug **72**, of electrical insulating material, in bore **50**. Wire **70** makes electrical contact with spring **74** which in turn makes electrical engagement with terminal **75** of the squib. Wire **58** is electrically connected at one end to terminal **75**, extends through squib **60** as illustrated in FIG. **3**, and has its opposite end frictionally held between washer **77** and brass cylindrical sleeve **76**. The brass sleeve makes electrical contact with the lower fitting and terminal assembly of the fuse through member **52**.

Clips **66** and **68** are spaced from ribbon **32** so that an airgap is defined in the circuit to the squib. This provides an open circuit to the squib until fusion of ribbon **32** starts. More specifically, when ribbon **32** fuses and an arc is drawn a voltage buildup occurs which will eventually break down the gap at the clips, for example clip **66**, at which point current is supplied to the wire **58** through wires **62**, **70** and spring **74**. Wire **58** is of a relatively high resistance, that is with respect to wires **62** and **70**, and will rapidly reach an ignition temperature for squib **60** and the squib is detonated. With this arrangement, the squib is detonated only after and in response to the start of the interruption and clearing cycle of the fuse assembly.

In operation, the auxiliary wire **62** and wire **70** will fuse but, due to the relative resistance values, this will not occur until after the squib has been detonated.

Detonation of squib **60** blows body **78** of the explosive charge out of bore **50** releasing the flipper to initiate the above-described drop-open movement.

An alternative arrangement for introducing an airgap in the circuit to igniter wire **58** is illustrated in FIG. **5**. In this arrangement a washer **80** is introduced between spring **74'** and terminal **75'**. This washer is made of suitable electrical insulating material but is also provided with a generally porous structure so that operation of the igniter depends again basically on the breakdown of a simple airgap. In this alternative embodiment, the internal wires such as wires **62** and **70** can either be spaced from the principal fusible element (ribbon **32**) or can be in electrical contact since the washer provides the necessary electrical insulation to insure operation of the squib only after initiation of the interruption and clearing operation of the fuse.

In cocking the knuckle hinge provided at lower fitting and terminal assembly **22**, the flipper is pivoted against spring **56** and explosive charge **48** is inserted in bore **50**. Sleeve **76** is provided with two ears **86** and **88**. These ears engage annular groove **90** in bore **50** as the explosive charge is inserted to lock it against withdrawal. This one-way connection for sleeve **76** has an additional advantage in that after detonation the sleeve remains in bore **50** to prevent accidental reuse of a blown fuse.

With the arrangement described to this point, the dropout fuse will function rapidly to clear the fault and also to physically open the cutout by moving the fuse assembly from the bridging engagement between terminals **10** and **12**. It has been observed that in some instances, particularly under low-fault current conditions where the arcing time may extend over a period of several seconds as opposed to several hertz as in the case of a high-fault, if drop-open movement is initiated too soon an arc will be drawn behind upper fitting and terminal assembly **20**. The drawing of this following arc is detrimental both from the standpoint of damage to the terminals and also because it creates the hazard of possible flashover and resultant failure to clear. To insure adequate time for clearing, the cutout is provided with a dashpot device which retards the drop-open movement sufficiently to permit clearing under predictable operating situations. More particularly, dashpot device **92** is connected between flipper **36** and fitting member **38** and is arranged to oppose relative movement between those two members. Structurally, the dashpot device includes an outer boot **94** of rubber. The rubber boot is fastened to flipper **36** by plate **96** and screws **98**. A compression spring **100** is located within the boot and the boot interior is filled with a silicon putty. The silicon putty **101** completely fills the interior of the boot and eliminates all airspaces. When the flipper is released by detonation of explosive charge **48**, dashpot device **92** must be compressed to permit relative movement between the fuse assembly, specifically fitting member **38**, and flipper **36**. The silicon putty provides a force opposing this relative movement and thus retards the drop-open action. Silicon putty is utilized because it offers resistance to compression and also because it maintains its characteristics over a wide temperature range. The dashpot device thus opposes initial drop-open movement but when the upper terminal and fitting assembly **20** has cleared the spring contact of the upper terminal **12** the fuse assembly falls freely and rapidly to the open position (dotted line showing FIG. **1**). After the drop-open movement, the compression spring returns the boot and the silicon putty to their original position.

The interior of the boot is completely filled to eliminate airspaces so as to provide uniform, predictable compression characteristics. It will also be noted that the dashpot device is positioned at an angle, engaging an angular face **104** on fitting **38** and is engaged by a lip **102** on the fitting. This arrangement is used so that any tendency of the boot and putty to kink during operation is minimized and the dashpot device is compressed in a generally straight compression of the putty and boot, the lip holds the dashpot device in engagement with fitting **36** during compression. In other words, compression occurs as a result of a generally axial force acting on the boot which tends to bow the boot and putty out uniformly, as opposed to actually bending, or kinking the boot walls.

The body **78**, made of phenolic, of the explosive charge is either expelled at a relatively high velocity from bore **50** or it is fractured in pieces which are thrown off from the fuse assembly. In some installations, this action may not be tolerable

and an alternative embodiment intended to protect the surrounding area form flying particles is disclosed in FIGS. **6** and **7**. In this alternative a stainless steel cylinder **106** is positioned on body **78**, suitably held in place by punch **108**. A groove **110** is provided in the cylinder by turning a tab **112**. Bumper **114** is generally provided on the flipper to act as a motion limiting stop. In this alternative, the bumper is undercut on both sides to provide grooves **116** and **118**. The walls of slot **110** register in grooves **116** and **118** so that when the explosive charge is detonated the body and cylinder are expelled from the bore but are held on the flipper by the interaction of the slot walls and grooves. The body is generally held together, fracturing its weakest point annular groove **120** which accommodates O-ring **122** provided for sealing purposes.

The overall assembly is also constructed so that all of the elements are reusable except for the blown fuse **18**. More particularly, terminal **124** of the upper terminal and fitting assembly **20**, is a split member clamped to fitting **126** by screws **128**. Similarly, fitting **38** is releasably connected to a fuse tube by screws **130**. The screws **130** orient the fitting **38** with respect to the fuse tube and a pin and slot arrangement **132**, the pin being carried by fitting **126** and the slot being provided in terminal **124**, orient the upper terminal **124** with respect to the lower terminal to insure proper drop-open movement.

Although this invention has been illustrated and described in connection with particular embodiments thereof, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

1. A dropout fuse comprising, in combination,
an upper terminal,
a lower terminal spaced and electrically isolated from said upper terminal,
a fuse assembly,
an upper terminal fitting on said fuse assembly for releasably engaging said upper terminal,
a lower terminal fitting on said fuse assembly spaced from said upper terminal fitting and pivotally connected to said lower terminal for pivotal movement relative thereto whereby said fuse assembly can be closed in bridging relation between said upper and lower terminals and is movable about said pivotal connection to an open position with said upper terminal and terminal fitting disengaged,
fusible means within said fuse assembly electrically connected between said upper and lower fittings,
said lower terminal fitting including a flipper member having said pivotal connection to said lower terminal and a fitting member carried by said fuse assembly and pivotally connected to said flipper member for movement with and relative to said flipper member,
spring mean engaged between said flipper and fitting members when said fuse assembly is in said bridging relation biasing said flipper member for movement in a direction urging said fuse assembly toward said open position,
an explosive charge carried by said fuse assembly and connected to said flipper member opposing said bias so that said fuse assembly is maintained in said bridging relation until said explosive charge is detonated whereupon said flipper member is released for movement by said spring means to initiate movement of said fuse assembly to said open position,
electrical igniter means responsive to operation of said fusible means to detonate said explosive charge,
and means connected between said flipper and fitting members and opposing relative movement therebetween to thereby retard movement of said fuse assembly to said open position.

2. The dropout fuse of claim **1** wherein said motion retarding means includes
an outer flexible enclosure,
a compression spring within said enclosure and extending between said fitting member and flipper member to be compressed during relative movement therebetween,
and silicon putty filling the interior of said enclosure.

3. A dropout fuse comprising, in combination,
first and second spaced and electrically isolated terminals,
a fuse assembly including a fuse tube characterized by including means for interrupting and clearing a fault condition within said fuse tube, and including spaced terminal means on said fuse tube connected to said interrupting and clearing means for connecting said fuse assembly in electrical circuit between said first and second terminals,
means connecting said fuse tube in bridging relation between said first and second terminals, for movement relative to said terminals in a direction out of said bridging position, and means producing a force biasing said fuse tube for movement in said direction,
an explosive charge carried by said fuse assembly and connected to said bias producing means and opposing said bias,
and means operatively connected to said interrupting and clearing means for igniting said explosive charge after said interruption and clearing has been initiated.

4. The dropout fuse of claim **3** including means connected to said fuse tube for retarding motion thereof in response to said bias.

5. The dropout fuse of claim **3** wherein said means connecting said fuse tube in said bridging relation includes a flipper connected to said fuse tube and first terminal for joint movement of said flipper and fuse tube relative to said first terminal in said direction,
and means connected to said flipper for providing said biasing force.

6. The dropout fuse of claim **5** including means connected to said fuse tube for retarding motion thereof in response to said bias.

7. The dropout fuse of claim **6** wherein said means for igniting said explosive charge comprises an electrical conductor in heat transfer relation with said explosive charge,
and including means for connecting said electrical conductor in circuit with said fault interrupting and clearing means and having an electrical gap therein so that operation of said fault interrupting and clearing device is initiated prior to completing a circuit to said electrical conductor.

8. The dropout fuse of claim **6**
including a fitting member connected to said fuse tube and to said flipper member for movement with and relative to said flipper member,
wherein said biasing means is connected between said fitting member and said flipper member,
and wherein said motion retarding means is connected between said fitting member and said flipper member.

9. The dropout fuse of claim **8** wherein said motion retarding means includes
an outer flexible enclosure,
a compression spring within said enclosure and extending between said fitting member and flipper member to be compressed during relative movement therebetween,
and silicon putty filling the interior of said enclosure.

10. A dropout fuse comprising in combination,
first and second spaced and electrically isolated terminals,
a fuse assembly including a fuse tube, fusible means within said tube, and spaced terminal means on said fuse tube and connected to said fusible means for connecting said fuse assembly in electrical circuit between and bridging said first and second terminals,
means including an explosive charge for holding said fuse assembly in position electrically connecting said first and second terminals through said fusible means and further operative upon detonation of said explosive charge to release said fuse assembly for drop-open movement,
said dropout fuse having a biasing arrangement normally urging said fuse assembly in the direction of drop-open movement,
said explosive charge positioned to oppose said drop-open movement and further characterized by including an electrically operated igniter,

and means for establishing an electrical circuit to said igniter for detonation of said explosive charge subsequent to fusion of said fusible means to release said fuse assembly for drop-open movement.

11. The dropout fuse of claim 10 including motion retarding means connected to said fuse assembly for retarding drop-open movement of said fuse assembly.

12. The dropout fuse of claim 10 including

a flipper connected to said fuse assembly,

spring mechanism connected to said flipper and biasing said flipper in a direction tending to pivot said fuse assembly out of said position bridging said first and second terminals,

and wherein said explosive charge is connected to said flipper opposing said bias to hold said flipper against said pivotal movement and to release said flipper for said pivotal movement when said explosive charge is detonated.

13. The dropout fuse of claim 10

wherein one of said terminal means includes a flipper member pivotally connected to said first terminal,

including a fitting member carried by said fuse tube and pivotally connected to said flipper member for joint movement therewith relative to said first terminal and pivotal movement relative to said flipper member,

including a spring mechanism connected between said fitting member and said flipper member and biasing said flipper member for movement about its pivotal connection to said first terminal in a direction tending to pivot said fuse assembly out of said position bridging said first and second terminals,

and wherein said explosive charge is carried by said fuse assembly and is connected to said flipper member opposing said bias to hold said flipper member against pivotal movement relative to said fitting member and to release said flipper member for response to said bias when said explosive charge is detonated.

14. The dropout fuse of claim 13

including means connected between said fitting member and said flipper member to oppose relative movement between said flipper member and fitting member and retard drop-open movement of said fuse assembly.

15. The dropout fuse of claim 13

wherein said first and second terminals comprise lower and upper terminals, respectively, and said fuse assembly extends generally vertical when bridging said upper and lower terminals,

including means defining an opening in the lower end of said fuse tube,

and wherein said explosive charge is disposed in said fuse tube opening and projects outwardly therefrom.

16. The dropout fuse of claim 15 wherein said spring mechanism also provides electrical connection in the circuit of said fuse tube.

17. The dropout fuse of claim 10

wherein said igniter comprises a conductor in heat transfer relation with said explosive charge,

wherein said means establishing said electrical circuit for said igniter includes means defining a gap in said igniter electrical circuit so that said circuit to said igniter is not established until fusion of said fusible means has begun.

18. The dropout fuse of claim 10 wherein said fuse assembly is characterized by including means for interrupting and clearing a fault condition within said fuse tube.

19. The dropout fuse of claim 10 including means connected to said explosive charge for holding said explosive charge generally intact and in said fuse assembly upon detonation.

20. The dropout fuse of claim 12 including means connected to said explosive charge for holding said explosive charge generally intact on said flipper upon detonation.