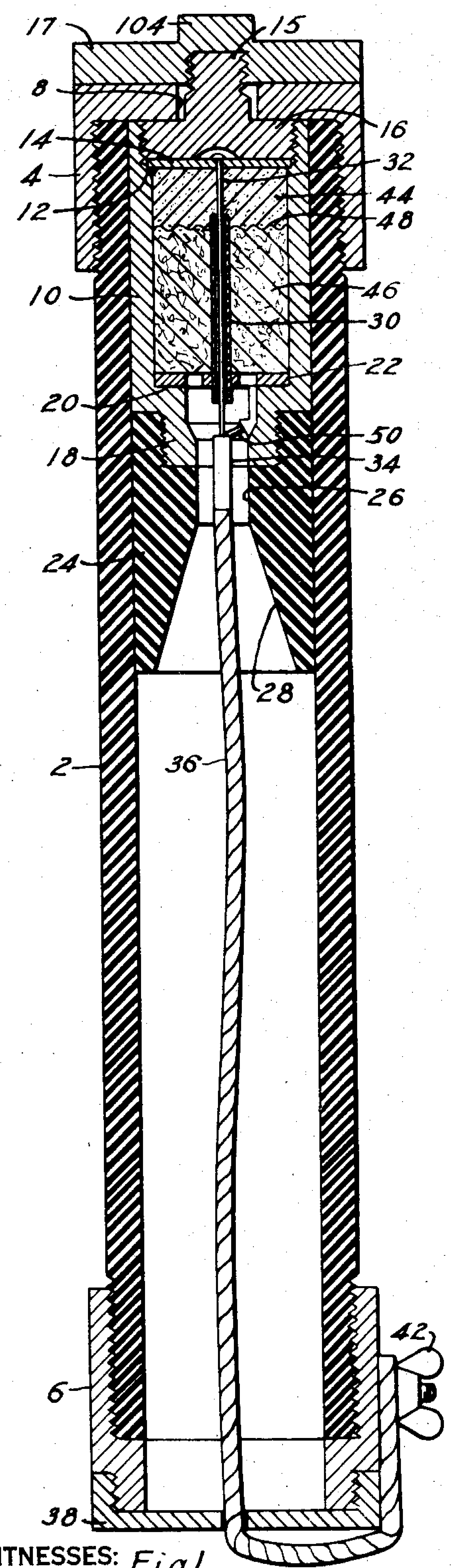
March 7, 1944. H. L. RAWLINS 2,343,422

GAS BLAST CIRCUIT INTERRUPTER

Filed Feb. 20, 1940 2 Sheets-Sheet 1



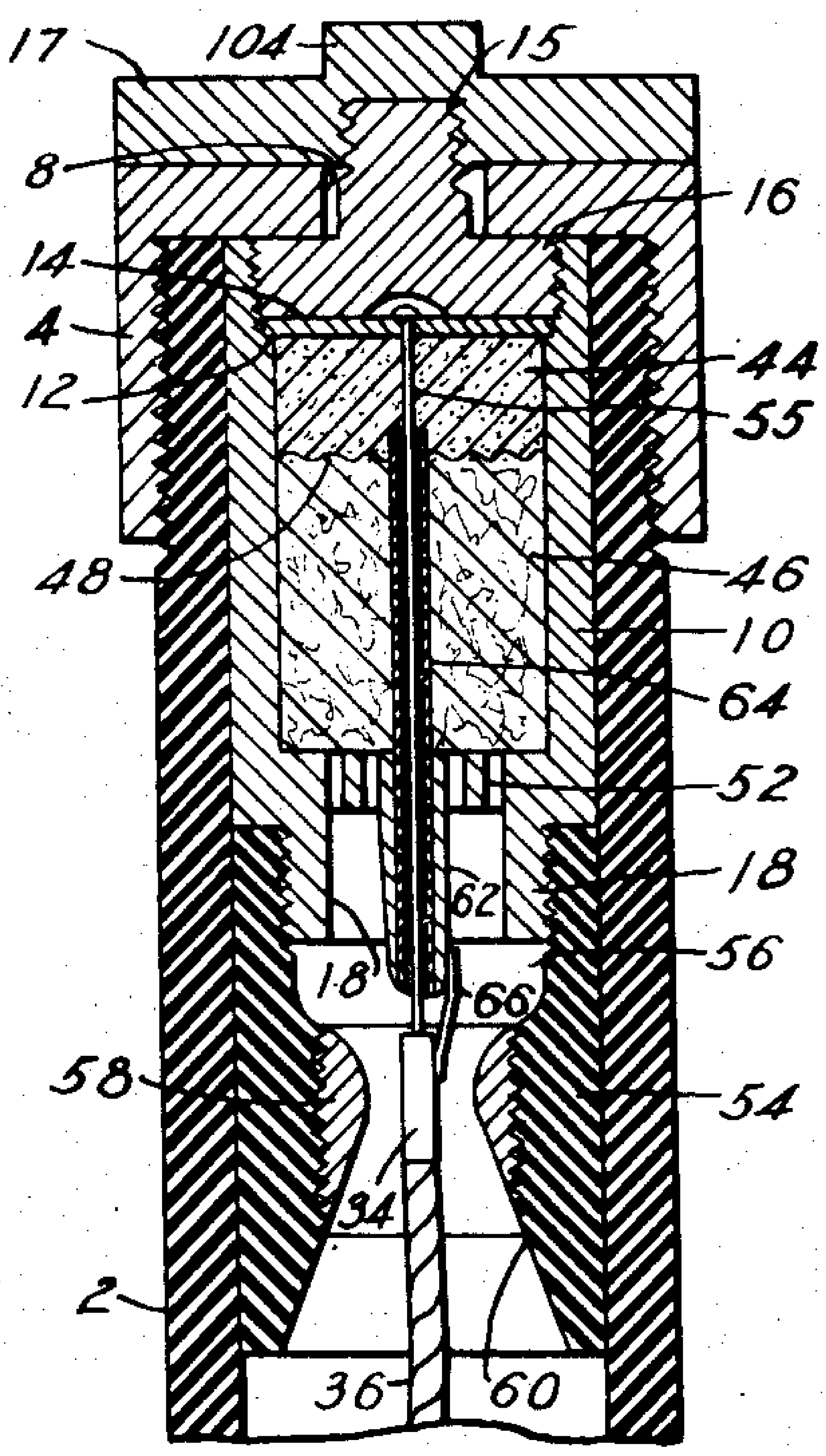
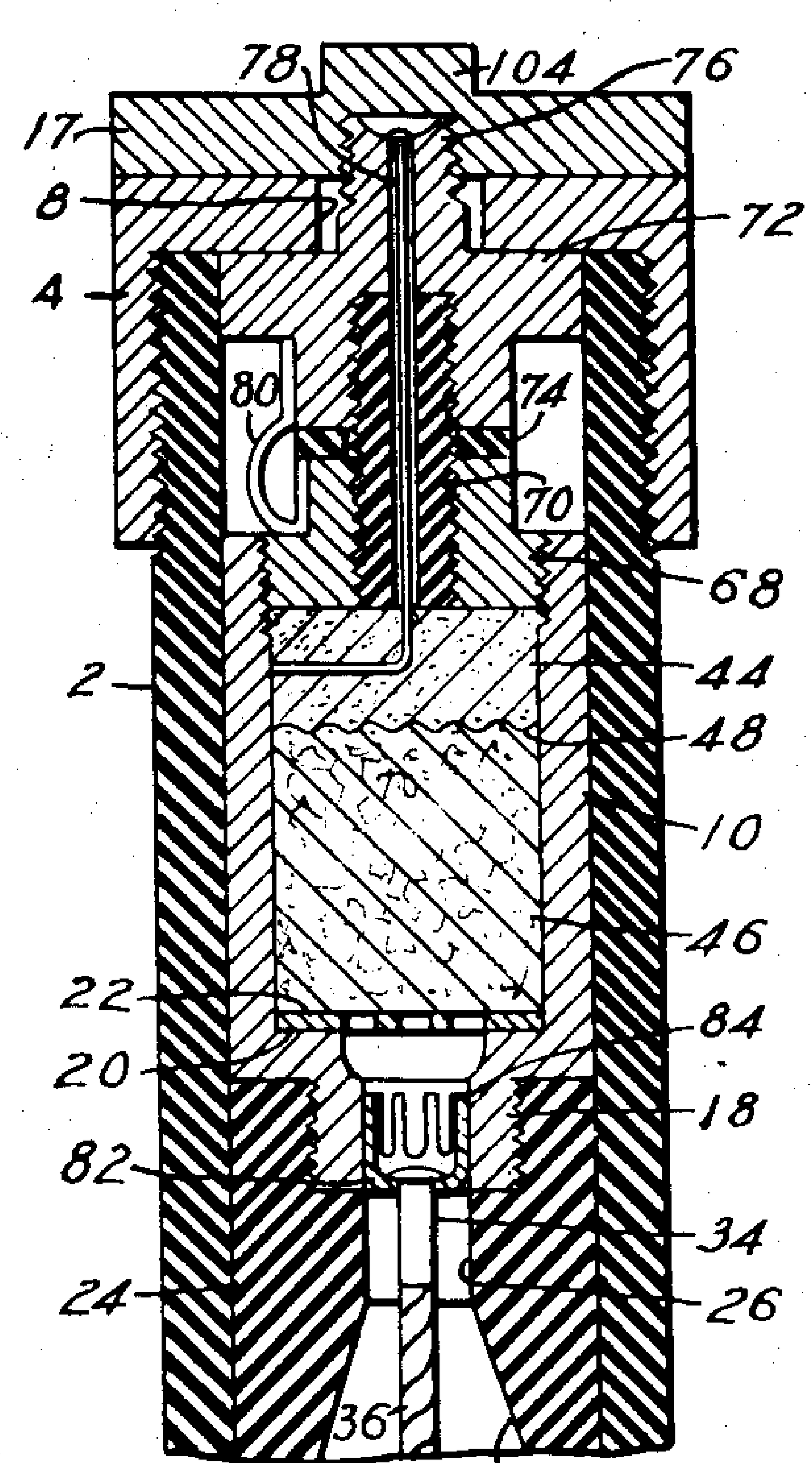


Fig.2.



WITNESSES: Fig.1.

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Fig.3.

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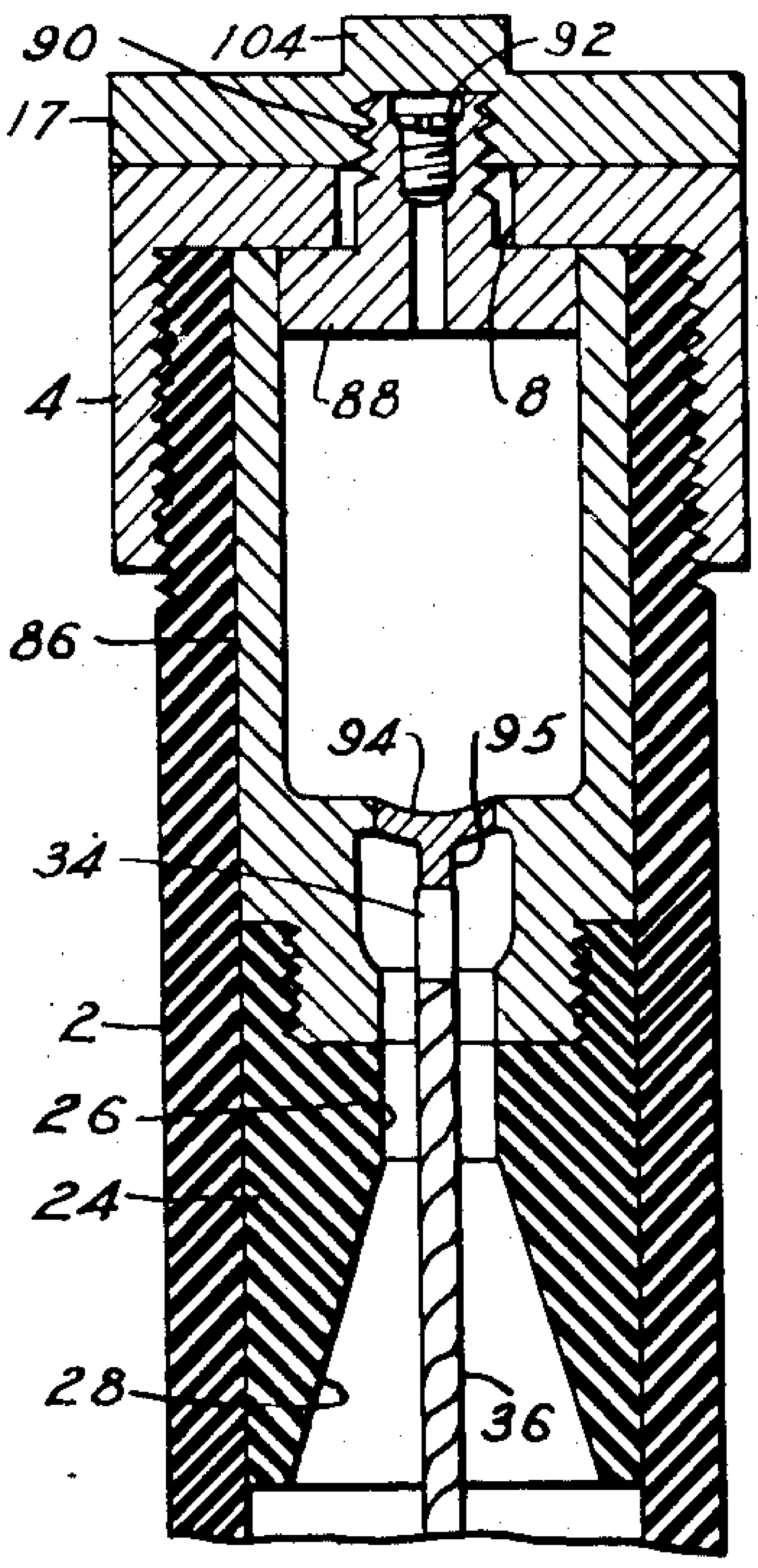

Fig. 4.

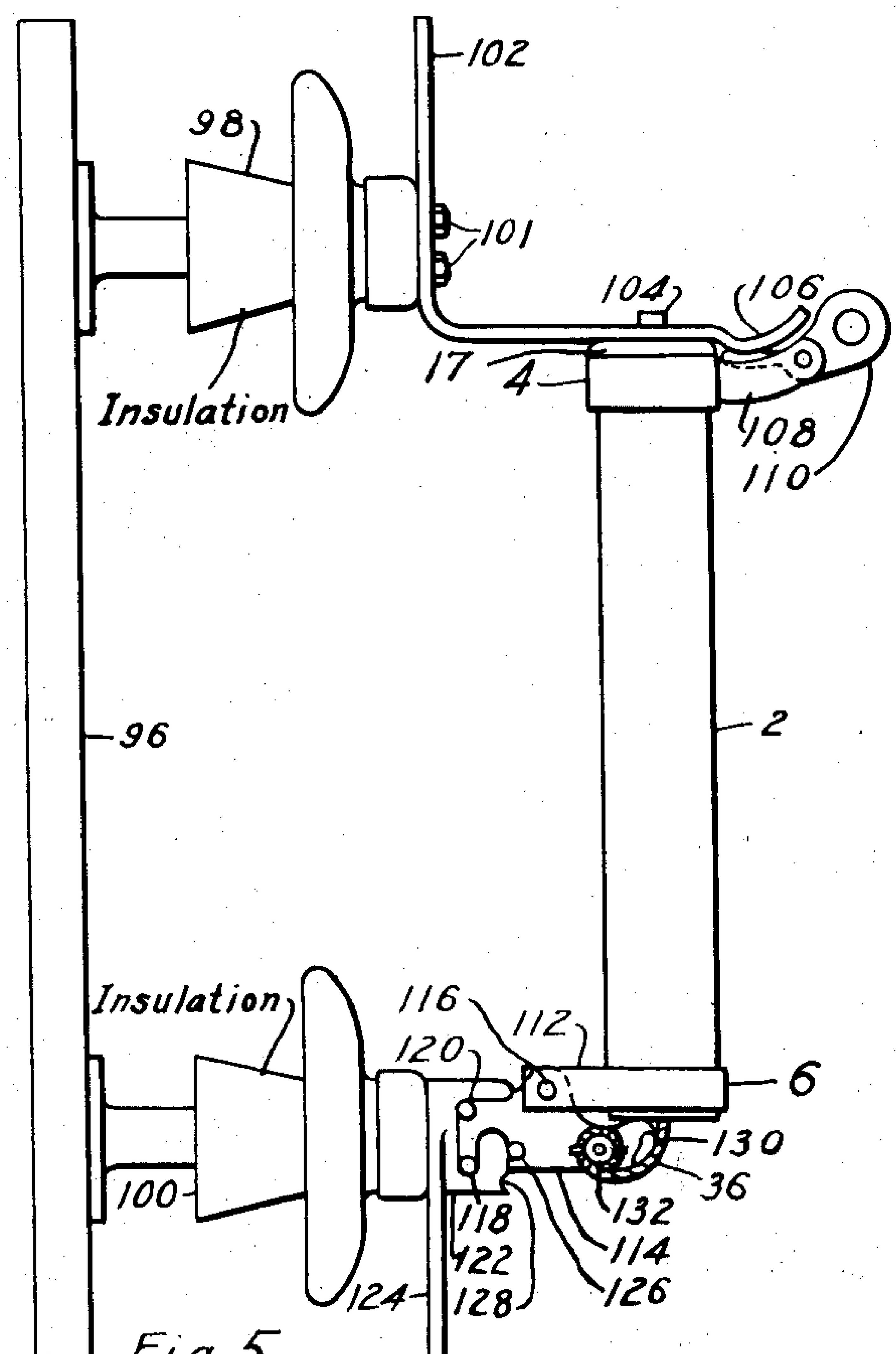

Fig. 5.

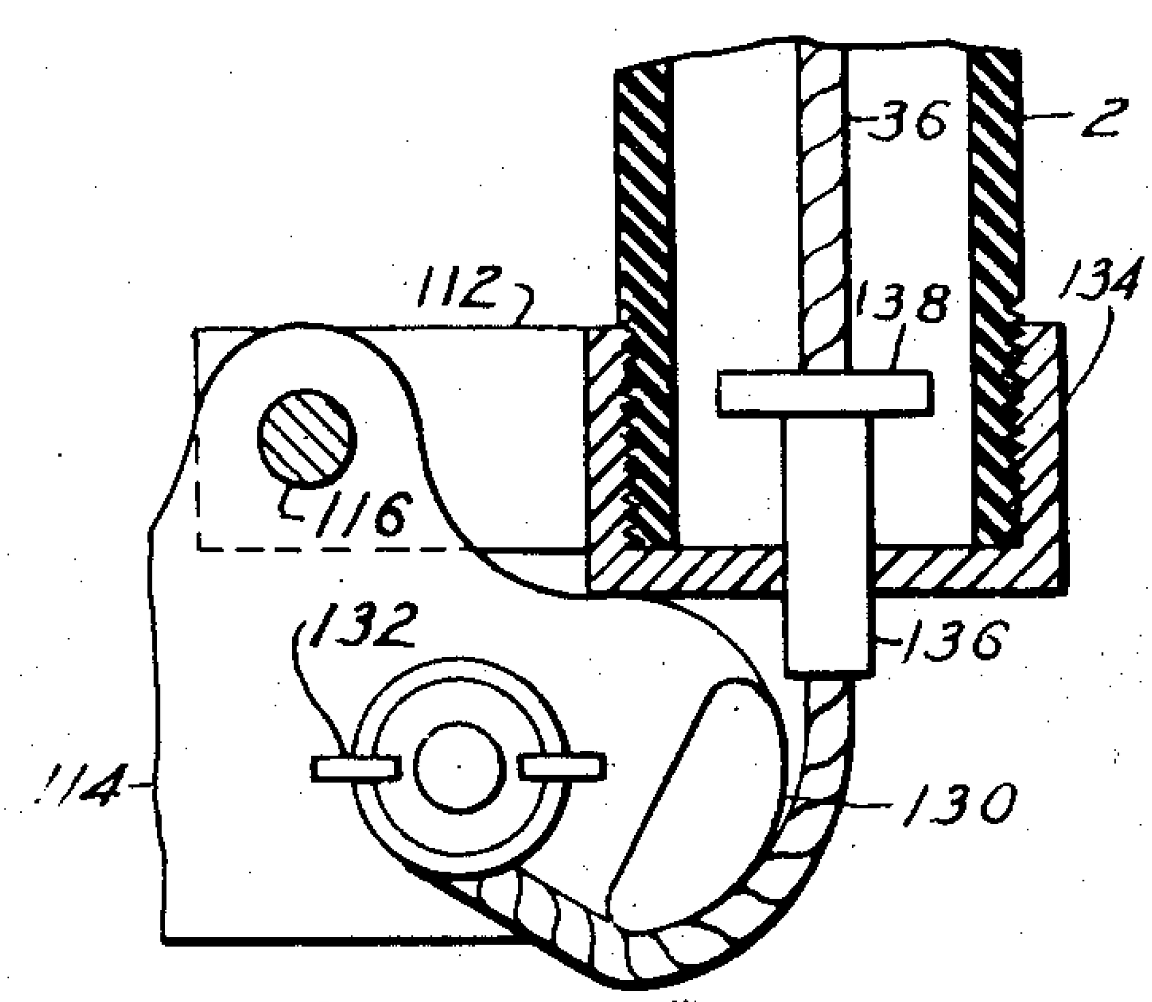

Fig. 6.

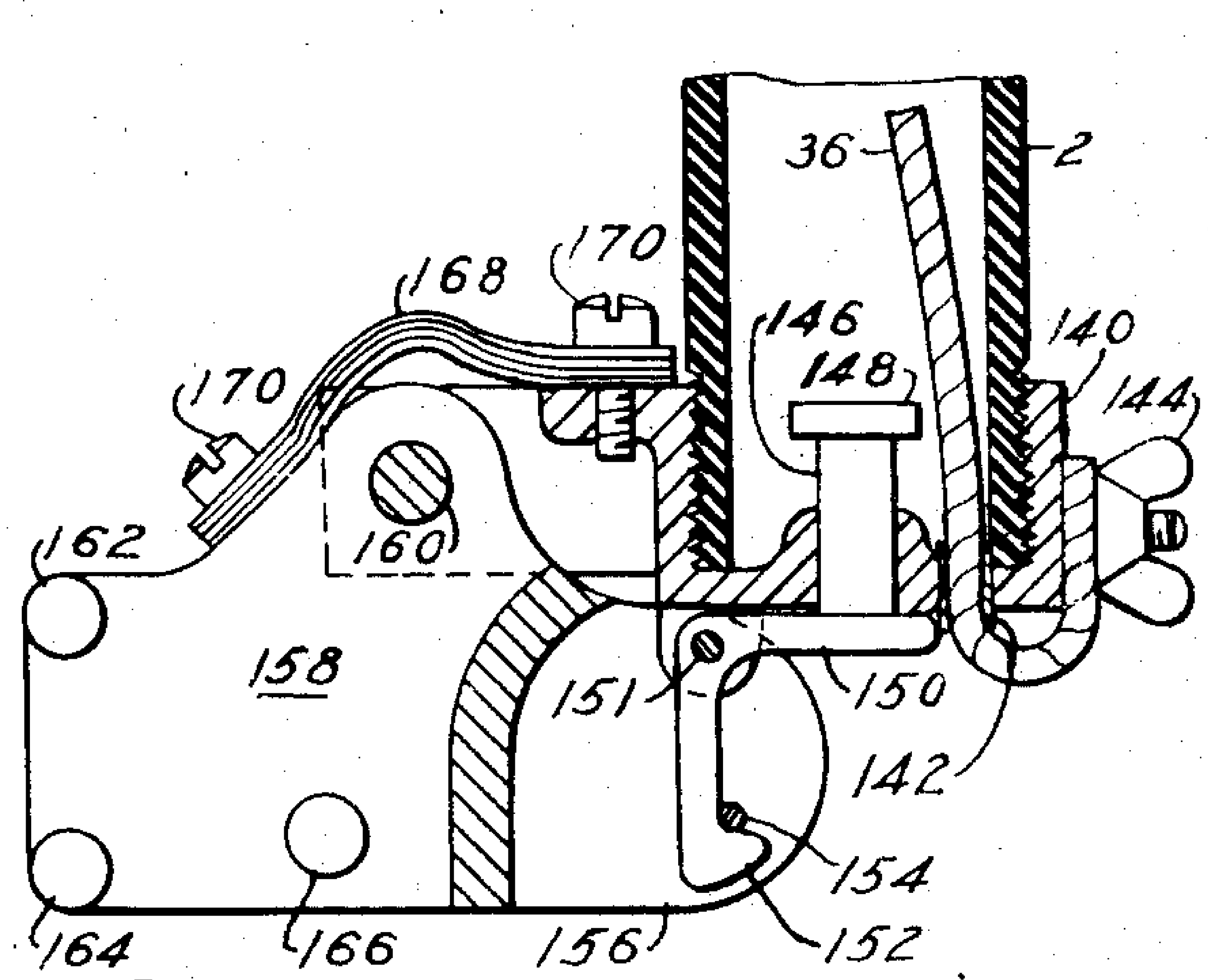

Fig. 7.

WITNESSES:

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UNITED STATES PATENT OFFICE

2,343,422

GAS BLAST CIRCUIT INTERRUPTER

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Application February 20, 1940, Serial No. 319,896

25 Claims. (Cl. 200—120)

My invention relates generally to electric circuit interrupting devices, and more particularly to such devices which are capable of automatically interrupting an electric circuit upon the passage therethrough of currents above a predetermined value, and to the manner of extinguishing electric arcs formed thereby.

In a circuit interrupter where it is necessary to interrupt currents of different magnitudes, it is desirable to provide a single means for extinguishing the arcs formed, which will operate in a quick and efficient manner irrespective of the current magnitude of the arc. Electric arcs may be efficiently extinguished by the use of a blast of cool, un-ionized gas played through the arc stream to cool and deionize the same. Such a gas blast may be derived from an independent source of compressed gas, or it may be generated by the arc itself by its action on a gas evolving material. To obtain arc extinguishing gas from an outside source involves in addition to the interrupter and outside source, suitable connections therebetween, constructed so as to be automatically operable to deliver gas when an arc is struck. Self-generated gas interrupters eliminate such additional structure and attendant complexities, but the quantity of gas generated is usually dependent upon the current magnitude of the arc.

One object of my invention, therefore, is to provide a circuit interrupter of the self-generated gas blast type which is capable of producing a relatively large quantity of cool, unionized arc extinguishing gas independently of the current magnitude of the arc formed.

Another object of my invention is to provide in a circuit interrupter of the gas blast type, a novel arcing chamber construction having means for advantageously directing arc extinguishing gas through the arc.

Another object of my invention is to provide a circuit interrupter having incorporated therein a potential source of arc extinguishing gas which is released in response to the striking of an arc, and wherein the amount of such gas released is independent of the current magnitude of the arc formed.

Another object of my invention is to provide a novel form of fuse wherein a fusible element acts to release a supply of arc extinguishing gas which, in turn, operates to open separable contacts and extinguish the arc formed at said contacts.

Another object of my invention is to provide a novel form of circuit interrupter having separable contacts, with a supply of arc extinguishing gas in a manner such that the gas is operable to separate said contacts and extinguish the arc formed.

Another object of my invention is to provide a circuit interrupter of the type described embodied in a fuse which is constructed and arranged so as to automatically drop out of its associated circuit when the fuse blows.

Still another object of my invention is to provide a totally enclosed fuse of the type described which is so constructed and arranged as to automatically drop out of its associated circuit in response to blowing of the fuse.

A further object of my invention is to provide a circuit interrupter having means associated therewith for producing relatively large quantities of gas by chemical action, together with means for cooling such gas and directing it into the arc path of the interrupter to extinguish the arc.

Another object of my invention is to provide a circuit interrupter of the type described, having novel gas generating means associated therewith in the form of a replaceable unit.

Another object of my invention is to provide a fuse construction having a novel replaceable refill unit construction which includes fusible means and gas generating means.

These and other objects of my invention will become more apparent upon consideration of the following specification of preferred embodiments thereof taken in connection with the attached drawings, in which:

Figure 1 is a longitudinal section through a fuse illustrating one embodiment of my invention;

Fig. 2 is a partial longitudinal sectional view of a fuse illustrating another embodiment of my invention;

Fig. 3 is a view similar to Fig. 2 and illustrating a still further embodiment of my invention;

Fig. 4 is a sectional view similar to Figs. 2 and 3 and illustrating another modification of my invention;

Fig. 5 is a side view illustrating a fuse which may be constructed in accordance with my invention and one manner of mounting the same in engagement with a pair of line contacts;

Fig. 6 is a partial, central, longitudinal crosssection view of the lower portion of a fuse and a part of its mounting means, and illustrating a modification of the mounting illustrated in Fig. 5;

Fig. 7 is a view similar to Fig. 6 showing a further modified form of fuse mounting means.

Referring to the drawings, in Figure 1 I have shown a fuse comprising an insulating tube 2 which may be of fiber, porcelain, glass or any other insulating material. The tube 2 is provided with upper and lower terminal ferrules 4 and 6, respectively, threadedly engaged with the threaded ends of fuse tube 2. The upper fuse terminal ferrule 4 is in the form of a cap provided with a central opening 8 for receiving a portion of a fuse refill unit for securing the same in position in the fuse tube 2. The fuse illustrated in Fig. 1 is constructed with a readily replaceable refill unit which may be easily and quickly renewed when the fuse blows. The refill unit includes a tubular metallic member 10 having an interiorly threaded upper end portion forming in the member 10, a shoulder 12 on which is seated a metallic supporting disk 14 of conducting material. The disk 14 is secured in position in the tubular member 10 by means of an end closure plug 16 threadedly engaged in the upper end of the tubular member 10, and having a reduced upwardly projecting portion 15 extending through the aperture 8 in end terminal cap 4 of fuse tube 2, which portion is threaded to cooperate with the clamping member 17 which acts to secure the refill unit in operative position within fuse tube 2.

The lower portion of the tubular member 10 of the refill unit is reduced as at 18, to provide a shoulder 20 upon which is seated a perforated partition member 22. The lower reduced end 18 of the tubular member 10 is exteriorly threaded for cooperation with a tubular insulating throat member 24, which may be of any desired insulating material such, for example, as fiber or a molded insulating material. As shown in Fig. 1, the tubular throat member 24 is provided with a substantially cylindrical bore 26 adjacent to and forming an extension of the bore of the reduced end 18 of tubular member 10, and with an outwardly flaring exit portion 28. An insulating tube 30, of fiber or the like, is positioned in a central aperture through the perforated end closure disk 22 and extends upwardly within the tubular member 10 to a position spaced from the supporting disk 14 for receiving a high resistance fusible wire 32 therein. The wire 32, which may be of any desired high resistance fusible alloy, such as nickel-chromium alloy or the like, has its upper end anchored to the supporting disk 14 in any desired manner, as by being soldered within an aperture in the disk as shown, and its lower end is secured in a conducting sleeve 34 as by soldering or the like, and the sleeve is in turn connected to the upper end of a flexible conductor 36. The conductor 36 may be of any suitable flexible conducting material preferably of a stranded copper wire construction.

The conductor 36 extends downwardly through the insulating fuse tube 2 and through an aperture provided in an end cap 38 threadedly mounted on the lower fuse terminal ferrule 6. The flexible conductor 36 is then bent about the end cap 38 to be secured to the end ferrule 6 as by the thumb nut 42.

Within the upper portion of the tubular member 10 of the refill unit, and in engagement with the high resistance fusible wire 32, I provide gas generating material 44 which may be gun powder, gun cotton, or any other desired type of explosive or semi-explosive material, or highly combustible material which is adapted to evolve relatively large quantities of hot gas upon combustion. In the lower portion of the tubular member 10 and separated from the gas generating material 44 as by a metallic screen 48, I provide cooling means 46, which may be in the form of metal shavings, or a gas evolving material which is capable of evolving relatively cool un-ionized gases when subjected to heat, such, for example, as boric acid, fiber, synthetic resins, or the like. If desired, of course, the cooling medium 46 may comprise a mixture of metal shavings and such gas evolving material. The sleeve 34 which is secured to the upper end of the flexible conductor 36 is also connected to the reduced portion 18 of the tubular member 10 of the refill unit, by means of a short section 50 of a calibrated relatively low resistance fusible wire.

The circuit through the fuse extends from the upper terminal ferrule 4 and clamping disk 17, through the end closure plug 16, and then in parallel circuits, one of which extends through the tubular member 10 to the reduced portion 18 thereof, and fuse link 50, to the flexible conductor 36 and the lower terminal ferrule 6. The high resistance fuse wire 32 is in parallel with the fuse link 50 and with the tubular member 10, since it is electrically connected between end closure plug 16 by way of the supporting disk 14 to the sleeve 34 on the upper end of flexible conductor 36. Thus it is seen that I have provided two fusible wires in parallel; however, inasmuch as the wire 32 is of relatively high resistance and the fusible section 50 is of relatively low resistance, the greater part of the current through the fuse will pass through fusible section 50 around high resistance fuse wire 32.

In operation, when the current through the fuse exceeds a value predetermined by the short fusible section 50, this fusible section will melt and the current through the fuse will be transferred through the high resistance fusible wire 32. This, in turn, will melt practically instantaneously following the fusion of the fusible section 50, and heat generated thereby will ignite the gas generating material 44 in the upper end of the tubular member 10. Gases which are generated by explosive or semi-explosive material usually have a relatively high temperature and therefore in passing downwardly through the tubular member 10 these gases will be cooled by the cooling material 46 in the lower portion of the tubular member 10 and escape through the perforated end closure disk 22 into the passage 26 and thence downwardly in the fuse tube. Where cooling means 46 of gas evolving material is employed, the heat of combustion of material 44 and the heat contained in the hot gases evolved will cause evolution of arc extinguishing gas from such material 46 which will also pass down through perforated closure disk 22. After the high resistance fuse wire 32 has blown the arc will obviously be reestablished between the sleeve 34 on the upper end of the flexible conductor 36 and the closely adjacent portion 18 of the tubular member 10. The gases then in passing downwardly through the fuse will pass through the arc and tend to expel the upper end of the flexible conductor 36 from the passage 26 in the insulating member 24. It should be noted that the reduced lower end 18 of the tubular member 10, together with the insulating member 24, form a restricted or Venturi passage therethrough. This is particularly advantageous since the arc is struck substantially in the throat portion 26 of the Venturi passage where the highest gas pressure will be concentrated to quickly blow out the arc and expel the upper end sleeve of the flexible conductor 36 from proximity to the tubular member 10. This action will extinguish the arc by supplying relatively cool unionized gas in a blast through the arc, and by drawing out the arc, to thereby increase the arc voltage, by blowing the sleeve 34 on the flexible conductor 36 downwardly away from the tubular extension 18.

In connection with the blowing of the fuse shown in Fig. 1, it should be noted that three successive arcs are struck, and that the current is successively shifted from one path through the fuse to another, and then back to the first path. This occurs as follows: When the fusible section 50 blows, the main portion of the current flowing through the fuse is suddenly transferred to the high resistance fusible wire 32 and no current flows through the shunt path provided by the tubular member 10 and fusible section 50 which has, of course, been blown. Substantially instantaneously thereafter the high resistance fusible wire 32 blows and the current is then shifted back to the shunt path provided by the tubular member 10 through the reduced lower end 18 thereof and across the gap to the sleeve 34 on the upper end of the flexible conductor 36. It should be noted that the high resistance fusible wire 32 acts to relieve the strain on the short fusible section 50 as well as serving to ignite the gas generating material 44 with which it is in contact.

After the fuse is blown, it is possible to easily refill the fuse by removing the lower end cap 38 and releasing the flexible conductor 36 from the thumb screw 42, and then unscrewing the clamping disk 17, whereupon the entire refill unit comprising all the parts supported within the fuse tube 2 may slide out of the lower end of the tube. In inserting a new refill unit, this may be merely slid into the lower end of the tube until the projecting portion 15 on the closure disk 16 projects from the aperture 8 in the upper fuse terminal cap 4, whereupon the clamping disk 17 may be secured to the projection 15, and the lower fuse cap 38 threaded over the flexible conductor 36 and screwed into position, and the flexible conductor 36 may then be clamped to the lower fuse ferrule 6 by the thumb nut 42.

The fuse illustrated in Fig. 1 is substantially totally enclosed and the lower portion of the fuse tube 2 is utilized as an expansion chamber for the gases generated and also as a cooling chamber therefor. However, if desired the lower end cap 38 of the fuse may be omitted entirely if the fuse is to be employed in locations where there is no objection to the emission of ionized gases into the atmosphere.

In Fig. 2 I have illustrated a slightly modified form of fuse which, however, has several features in common with the fuse described in connection with Fig. 1, and therefore, like reference numerals will be used to indicate like parts.

The tubular member 10 in this embodiment of my invention is generally similar to that previously described, differing therefrom in that it is provided witth an integral perforated bottom closure 52, having an integral, depending, centrally positioned electrode 62 extending outwardly of the lower end of the reduced portion 18 of the tubular member 10. Threadedly engaged with the reduced portion 18 of the tubular member 10 is a tubular insulating throat member 54, forming with the portion 18 of the tubular member 10, a relatively enlarged space 56 adjacent to the lower end of the reduced portion 18, and having a restricted portion, which may be formed by an insert 58 threadedly engaged in the insulating throat member 54. The inner contour of the passage through the throat member 54 then flares outwardly as at 60, to provide as in the previously described embodiment, a restriction in the gas passageway to form a substantial Venturi passage therethrough. The inset 58 provided for the insulating throat member 54 may be of any desired material, preferably some heat resistant material such as metal or an insulation material or the like. The electrode 62 integral with the tubular member 10 is connected to the sleeve 34 on the upper end of the flexible conductor 36, by a short calibrated fusible section 66. The electrode 62 is also provided with a central, longitudinally extending bore in which is received an insulating tube 64 similar to the tube 30 described in connection with Fig. 1, for receiving a relatively high resistance fusible strain wire 55 similar to the wire 32 disclosed in connection with the embodiment of my invention shown in Fig. 1. The tubular member 10 in this embodiment of my invention contains gas generating material 44 and cooling means 46 as in the previously described embodiment.

The operation of the fuse shown in Fig. 2 is much like that described in connection with the fuse shown in Fig. 1, and hence will not be repeated in great detail. The main difference in operation of this fuse resides in the fact that the gas blast is directed peripherally around the arcing electrode 62. The arc will be drawn, in this embodiment of my invention, between the electrode 62 and the sleeve 34 on the flexible conductor 36. Hence the gases will be directed around the electrode 62 and then converge through the restricted portion of the arc passage provided by the liner 58, and then may expand outwardly in the flared portion 60 of the passage.

The gas passage in this embodiment of my invention, it will be noted, may be termed a Venturi passage as in the embodiment illustrated in Fig. 1. It should be noted that the gases passing through the arc between the terminal 62 and the sleeve 34 will be crowded together into a high pressure region provided by the restricted lining 58. This will also tend to reduce the cross-section of the arc and thereby aid in extinguishing the same. The order of blowing of the fusible section 66, and the high resistance fusible wire 55, and the final striking of an arc between the terminal 62 and sleeve 34, is the same as that previously described in connection with the embodiment shown in Fig. 1. Similarly, this fuse may be refilled in exactly the same manner as that previously described.

In Fig. 3 I have shown a form of fuse where the fusible elements proper are remote from the point at which the arc is finally struck and extinguished, and wherein the gases generated also operate to separate the arcing terminals to draw out the arc. Many of the parts of the fuse shown in Fig. 3 are similar to those described in connection with Figs. 1 and 2, and hence like reference numerals will be used here to designate like parts. In this form of fuse I have provided, as shown in Fig. 3, a tubular metallic member 10 having gas generating material and cooling means 44 and 46 therein as in the previous embodiments. However, I have provided the upper end of the tubular member 10 with an end closure plug 68 having a centrally interiorly threaded aperture therein, in which is secured an insulating screw 70 for securing the end fitting 72 thereto in insulating relation. An insulating washer 74 is provided between the fitting 72 and the closure plug 68 to insure electrical isolation of these parts. The screws 70 and washer 74 may be of any desired insulating material such as fiber or the like. The fitting 72 has a reduced projection 76 which is adapted to be received in the aperture 8 in the upper fuse terminal cap 4, for cooperation with the clamping disk 17 to secure this refill unit in proper position within the fuse tube. The fitting 72 and insulating screw 70 are provided with aligned, substantially central bores for the reception of a high resistance fusible wire 78 having its upper end secured to the upper end of the projection 76 of the fitting 72, as by soldering or the like, and having its lower end extending through the gas generating material 44 and being fixed to the inner side wall of the tubular member 10. A calibrated low resistance fuse wire section 80 connects the fitting 72 with the end closure plug 68 to provide a circuit in parallel with the high resistance fuse wire 78. The reduced lower end portion 18 of the tubular member 10 is provided with an insulating throat 24, and a flexible conductor 36 has the end sleeve 34 thereon received in an aperture in the base of a generally cup-shaped contact member 82, made of any desired resilient conducting material, and having the sides thereof split as shown in Fig. 3 to provide resilient contacting fingers 84. As is apparent from Fig. 3, the contact 82 substantially closes the gas passage through the lower end of the tubular member 10 and the insulating throat 24, and the contact 82 is frictionally retained in position by the outwardly biased spring fingers 84.

In operation, the fuse of this embodiment of my invention, similar to those previously described, first opens the circuit through the short fusible section 80, and transfers the current through the device to the high resistance fusible wire 78. This wire is melted and acts to ignite the gas generating material 44 which builds up a gas pressure within the tubular member 10 of a value sufficiently great to force the cup-shaped terminal 82 downwardly through the passage 26 and out through the lower end of the insulating throat member 24, to thereby interrupt the circuit through the fuse and extinguish the arc formed.

It should be noted that in all the embodiments of my invention thus far described the interruption of the circuit by one or more fusible elements is utilized to initiate the action of gas generating material, to provide a supply of gas for extinguishing the arc formed, and that the amount of gas generated is entirely independent of the current value of the arc established and will be substantially the same for each interruption of the fuse. In the embodiment of my invention shown in Fig. 3 the gas generated is additionally utilized to build up a pressure to separate two terminals of the circuit through the fuse, and this pressure will be the same irrespective of the current value of the arc formed. In other words, the fuses thus far disclosed are capable of acting with equal efficiency to extinguish arcs, and therefore to interrupt the circuit, whether the arcs formed are of a high or low current value.

In Fig. 4 I have illustrated a fuse similar in many respects to the embodiments previously described but which utilizes a source of compressed gas which is released upon blowing of the fuse, and the released gases are directed through the arc formed to extinguish the same. Inasmuch as the structure shown in Fig. 4 has many parts in common with the structures previously described, like reference numerals will be used to designate like parts. In place of the tubular member 10 utilized in the fuses of the previously described embodiments of my invention, I have provided a tubular member 86 having an end plug 88 secured in the upper end thereof, as by welding, brazing, or the like. The end closure plug 88 is provided with a reduced projection 90 for extension through the opening 8 in the upper fuse terminal cap 4, to cooperate with the clamping disk 17 to secure this refill unit in operative position within the fuse. The end closure plug 88 is provided with a substantially central bore extending to the outer end of the projection 90, and which may be sealed by the threaded sealing plug 92. The lower end of the tubular member 86 is provided with an aperture which is closed by a fusible plug 94, and which in turn is connected by a short calibrated fusible section 95 to the sleeve 34 on the upper end of the flexible conductor 36. The tubular member 86 is provided with an insulating throat member 24 to provide a restricted or Venturi gas passage similar to that shown in Figs. 1 and 3. The tubular member 86 is adapted to be filled before sealing, with a gas under pressure such, for example, as air or the like.

In operation, when the current through the fuse exceeds a predetermined value the fusible section 95 melts and an arc is struck to the fusible plug 94 which will, in turn, melt and thereby provide an opening in the lower end of the tubular member 86 through which the stored compressed gas may escape. When the fusible section 95 and plug 94 melt, an arc is struck from the adjacent portion of the tubular member 86 to the sleeve 34 on the flexible conductor 36. Obviously, gases escaping from the lower aperture in the tubular member 86 will necessarily be directed through the arc formed and will also tend to expel the flexible conductor 36 in the same manner described in connection with the embodiment of my invention shown in Fig. 1. It should be noted also, that this fuse may be renewed by removing a blown refill unit and inserting a new one in the same manner as in the previously described embodiments.

In Fig. 5 I have shown a mounting for a fuse which may be utilized for supporting any of the fuses described heretofore, and which mounting is designed so that upon blowing of the fuse, the fuse tube terminals are released from engagement with respect to at least one line contact, and the fuse tube proper is supported so that it is movable in response to blowing of the fuse to move at least one of its terminals out of engagement with respect to at least one of the line contacts.

As shown in Fig. 5, a pair of insulators 98 and 100 are secured in spaced relation on a supporting member 96. The upper insulator 98, as appears in Fig. 5, is provided with a substantially L-shaped resilient contact and terminal member 102, one leg of which is secured to the cap of the insulator 98 as by the machine screws 101, and the other leg of which extends substantially horizontally and is provided with an aperture for receiving the projection 104 on the clamping disk 17 of the fuse, and is up-turned at its outer end as at 106. The upper fuse ferrule may be provided with a pair of outwardly extending spaced supporting arms 108 for pivotally supporting therebetween a releasing lever 110. The lever 110 is apertured as shown for the insertion of a hook stick or other operating member, and as appears from Fig. 5 is adapted to release the upper end of the fuse from the contact member 102 when the lever 110 is rotated in a clockwise direction about its pivot. Such movement of the release lever 110 acts to raise the outer end 106 of the contact 102 out of engagement with the projection 104 on the upper fuse ferrule cap 4. With the fuse pivotally mounted at its lower end, it is obvious that the fuse may be moved in a generally counterclockwise direction to become reengaged with the contact member 102 since the projection 104 on the fuse will engage with the outer up-turned end 106 of the contact 102 and cam the same upwardly to permit the projection 104 to ride along the under surface of the contact 102 until it becomes aligned with the aperture therein, when it will be latched in the position shown in Fig. 5. The vertical arm of the contact 102 as seen in Fig. 5, may serve as a terminal portion for the connection of a line conductor thereto.

The lower fuse ferrule 6 is provided with a pair of spaced inwardly extending arms 112 for pivotally supporting therebetween, as by a pivot pin 116, an intermediate portion of a supporting lever 114. The inner end of the lever is provided with lower opposed trunnions 118 adapted to be received in notches provided in the sides of a split contact member 122 secured to the outer end of the lower insulator 100. The contact 122 is provided with an integral downwardly extending terminal portion 124 for connection of a line conductor thereto. The inner end portion of lever 114 is also provided with upper opposed positioning lugs 120 adapted to properly position the lever with respect to the contact 122, and also is provided with intermediate opposed stop lugs 126 adapted to engage concave stop portions 128 provided on the contact, as will be hereinafter described. The fuse link 36 is adapted to extend out of the lower end of the fuse tube and over a lateral projection 130 on the outer end of the supporting lever 114 and be secured to the lever as by a thumb nut 132.

In operation, when the fuse blows the flexible conductor 36 will be released within the fuse tube 2 and accordingly will no longer support the outer end projection 130 of the supporting lever 114. The fuse tube and lever are then freed for relative movement and the fuse tube may drop downwardly under the influence of gravity and the force exerted by the resilient contact 102, to disengage its upper projection 104 from the contact member 102 before the downward movement of lever 114 is stopped by engagement of the stop lugs 126 thereon with the stop recesses 128 provided on the contact 122. The fuse tube 2 is then free to rotate about pivot 116 in a clockwise direction outwardly of and away from the upper contact 102 to thereby introduce a large air gap in the circuit.

The release of the flexible conductor 36 may be aided by the gas pressure developed within the fuse and as shown in Fig. 6, the flexible conductor 36 may have secured thereto a relatively rigid piston-like member 136 proportioned to closely fit in an aperture in the lower terminal fuse cap 134. The piston member 136 is preferably provided with an upper flange portion 138 within the fuse tube to limit downward movement thereof. It will be obvious that with the construction shown in Fig. 6 the gas pressure developed within the fuse tube will positively move the piston member 136 and consequently the lower end of the flexible conductor 36 downwardly to permit the fuse tube to be disengaged from its upper contact 102. This may be advantageous to prevent possible fouling of the lower opening through which the flexible conductor 36 extends, and to positively insure movement at least at the lower end of this conductor instead of merely relying upon the force of gravity. Moreover, this construction provides a totally enclosed dropout fuse construction.

In Fig. 7 I have shown a slightly modified form of connection between a supporting lever 158, generally similar to the supporting lever 114 described in connection with Figs. 5 and 6 and adapted to be supported on a contact similar to the contact 122 of Fig. 5, and the lower end of a fuse tube. The fuse tube in this embodiment of my invention is provided with a lower end cap 140 having an eccentric or offset opening provided with a bushing 142 through which passes the lower end of the flexible conductor 36 to be secured to the end cap 140 as by a thumb nut 144. The end cap 140 is provided with a central aperture for receiving a piston member 146 proportioned to relatively closely and slidably fit within the aperture through the end cap. The piston 146 is also provided with a flange 148 within the fuse tube to limit outward movement of the piston. In the normal position of the fuse the lower end of the piston 146 is adapted to engage one arm of a bell crank lever 150, pivoted as at 151, between spaced depending supporting ears integral with the lower fuse cap 140. The other arm of the bell crank lever 150 is formed into a hook shape at its outer end for engagement with a pin 154, extending between the sides 156 of the split outer end of supporting lever 158. The supporting lever 158, similar to the lever 114 previously described, is provided with positioning lugs 162, trunnions 164, and stop lugs 166, similar to the corresponding lugs and trunnions on lever 114. In addition, the lever 158 is electrically connected to the lower fuse terminal cap 140 by a flexible shunt 168 suitably secured to the lever and terminal cap, as by the screws 170. Lever 158 is pivotally mounted between spaced pivot supporting arms integral with the lower fuse terminal cap 140, as by the pivot pin 160.

In the operation of this embodiment of my invention, it is apparent that normally the lever 158 is latched against movement relative to the fuse tube 2 by a positive latching means 150, 152, which is independent of the flexible conductor 36, and therefore independent of the fusible means within the fuse tube. The lever 158 and fuse tube 2 are released for relative movement upon blowing of the fuse, solely by the gas pressure developed within the fuse tube acting upon the piston member 146, which is moved outwardly thereby, to rotate the bell crank lever 150 in a clockwise direction about its pivot 151 and thereby out of latching engagement with respect to the pin 154 on the lever 158. The fuse tube may then drop down and out of the circuit as described in connection with the fuse shown in Fig. 5.

From the foregoing it should be apparent that I have devised new and improved means for utilizing a highly combustible or explosive material for generating gas for extinguishing an electric arc, particularly in a fuse, by cooling the gas given off before introducing it into the arc stream. I am thereby enabled to obtain a predetermined amount of gas in a blast through the arc irrespective of the current value of the arc established. As stated above, the fuse in any of its embodiments may be either closed or have one end open. Also, it should be apparent that I have provided a totally enclosed fuse construction which is adapted to drop out of its associated circuit, or disengage at least one terminal thereof from a line contact to insert a relatively large air gap in the circuit. Furthermore, the drop-out movement of such an enclosed drop-out fuse may be initiated by the gas pressure developed in the fuse, or the gas pressure may be utilized to release a latch holding the parts in the circuit, and this pressure utilized for assisting the drop-out operation in my improved fuse construction is entirely independent of the current interrupted, and hence may be of a predetermined value which will be efficient and reliable in operation under all conditions. Therefore, by providing a gas generating material which can be depended upon to produce a constant quantity of gas irrespective of the current values interrupted by the fuse, it is possible not only to use such gas for extinguishing and attenuating an arc, but also to use the same source of gas to build up a pressure to reliably operate means for releasing the fuse from its associated circuit. Also the gas generating unit and fusible unit of my improved fuse construction in all the embodiments thereof are designed to be replaceable as a unit within a fuse tube, and to be releasably secured therein by relatively simple operations.

The features of cooperation of my novel fuse with the particular mountings shown in Figs. 5 to 7, as well as the mountings per se are claimed in my copending application Serial No. 488,621, filed May 27, 1943, and assigned to the same assignee as this invention.

Having described preferred embodiments of my invention in accordance with the patent statutes, I desire that it be interpreted as broadly as possible and that it be not limited to the particular embodiments disclosed herein, inasmuch as it will be obvious, particularly to persons skilled in the art, that many changes and modifications may be made in the particular structures disclosed without departing from the broad spirit and scope of my invention. Therefore, I desire that the following claims be interpreted as broadly as possible and that they be limited only by what is expressly stated therein and by the prior art.

I claim as my invention:

1. In a circuit interrupter, means for interrupting the circuit therethrough to establish an arc, means of a material independently capable of evolving predetermined relatively large quantities of hot gases independent of the current magnitude of said arc, means for initiating said gas evolution upon operation of said interrupting means to open the circuit, means for cooling said evolved gases, and means for guiding said gases past said cooling means and thereafter through the arc.

2. In a circuit interrupter, means for interrupting the circuit therethrough to establish an arc, means of a combustible material capable of evolving relatively large quantities of hot gases as products of said combustion, means for igniting said combustible material upon operation of said interrupter, means for cooling said gaseous products of combustion, and means for guiding said gases past said cooling means and thereafter through the arc.

3. In a circuit interrupter, means for interrupting the circuit therethrough to establish an arc, means of a material independently capable of evolving predetermined relatively large quantities of hot gases independent of the current magnitude of said arc, means for initiating said gas evolution upon operation of said interrupting means to open the circuit, means for cooling said evolved gases including material capable of evolving relatively cool un-ionized gas when in proximity to said hot gases, and means for guiding said hot gases past said cooling means and thereafter through the arc.

4. In a circuit interrupter, means for interrupting the circuit therethrough to establish an arc, means of a highly combustible material capable of evolving relatively large quantities of hot gases as products of combustion, electrical means for igniting said combustible material in response to operation of said interrputing means to interrupt the circuit, means for cooling said hot gases, and means for conducting said gases past said cooling means and thereafter through the arc formed by said interrupting operation of said interrupting means.

5. In a circuit interrupter, arc passage means, means for striking an arc in said passage means, a source of arc extinguishing gas remote from said passage means, means energized by the arc struck in said passage means to liberate gases from said source, means for directing gases from said source through said passage means to extinguish the arc formed therein, and the arc struck by said interrupter being confined solely to said passage means.

6. In a fuse, main fusible means connecting a pair of arcing terminals, a relatively high resistance ignition fusible means in parallel with said main fusible means, means of combustible material capable of producing relatively large quantities of gas as a product of combustion and positioned so as to be ignited by said ignition fusible means, and means for directing said gases between said terminals, whereby upon blowing of said main fusible means, said ignition fusible means blows and said terminals are subjected to a gas blast, in said sequence.

7. In a circuit interrupter, a pair of spaced arcing terminals defining an arcing space therebetween, means of combustible material capable of producing relatively large quantities of gases as a product of combustion and located remote from said arcing space, means for striking an arc in said space between said terminals and including ignition means positioned adjacent said combustible material to ignite said combustible means in response to the striking of an arc in said arcing space, and means for guiding said combustion gases through said arcing space to extinguish the arc.

8. In a fuse, a pair of spaced arcing terminals defining an arcing space therebetween, means of combustible material capable of producing relatively large quantities of gases as a product of combustion and located remote from said arcing space, fusible means for striking an arc between said terminals in said arcing space and including a fusible portion positioned adjacent said

combustible material to ignite said combustible means in response to the striking of an arc in said arcing space, and means for guiding said combustion gases through said arcing space to extinguish the arc.

9. A circuit interrupter including, in combination, separable contacts for interrupting the circuit and establishing an arc, an arc passage for said contacts having a restricted portion adjacent said contacts through which at least one of said contacts moves in drawing an arc, means for supplying an arc extinguishing fluid to the end of said passage away from the direction of movement of said one contact, and a flaring outlet for the other end of said passage.

10. A circuit interrupter including, in combination, means forming an arc passage having an intermediate restricted portion, separable contacts for interrupting the circuit and establishing an arc longitudinally of said passage, means for supplying an arc extinguishing fluid to one end of said passage in a zone surrounding one of said contacts, and a Venturi outlet for said passage.

11. A circuit interrupter including, in combination, separable contacts for interrupting the circuit and establishing an arc, an arc passage having a restricted portion adjacent said contacts, one of said contacts forming a displaceable obstruction in said passage, means for supplying an arc extinguishing fluid under pressure to one end of said passage, and a flaring outlet for the other end of said passage, whereby said one contact is displaced out through said outlet by said arc extinguishing fluid.

12. A circuit interrupter including, in combination, a pair of separable contacts for interrupting the circuit and establishing an arc, an arc passage for said contacts with one of said contacts mounted at one end of said passage in fixed spaced relation relative to the walls of said passage, the other of said contacts being movable towards the other end of said passage to establish an arc, and means for supplying an arc extinguishing fluid under pressure in the space between said one contact and said passage for movement about said one contact and through said passage in response to separation of said contacts.

13. A fuse refill unit, including a container of electrical conducting material having attaching means and terminal means at one end thereof, tubular means of insulating material forming an arc passage secured to the other end of said container, a second terminal extending out the open outer end of said passage, means including a fusible element connecting said container and second terminal, means in said container capable of evolving an arc extinguishing gas under pressure in response to fusion of said fusible element, and the other end of said container communicating with said arc passage.

14. A fuse refill unit, including a container having attaching means and terminal means at one end thereof, means of combustible, gas forming material in said container adjacent said one end thereof, cooling means positioned in said container between said gas forming means and the other end of said container, tubular means forming an arc passage secured to the other end of said container, a second terminal extending out the open end of said passage, means including a fusible element connecting said terminals, said fusible means including means for igniting said combustible material in response to fusion of said fusible element, and the other end of said container communicating with said arc passage.

15. In a fuse, an insulating fuse tube having terminals adjacent opposite ends thereof, a container of electrical conducting material detachably secured in said tube adjacent one end thereof in conductive relation to the corresponding one of said terminals, gas generating material in said container, tubular means of insulating material forming an arc passage secured to said container in said tube and communicating with the interior of said container, fusible means in said tubular means adapted to open the circuit and initiate operation of said gas generating means, said fusible means being connected between said container and the other of said terminals, and all of said parts being detachable from said tube and terminals as a unit.

16. A fuse refill unit including a container of conducting material having attachment and terminal means at one end thereof, and a tubular extension at the other end thereof, tubular means of insulating material connected to said extension and forming a continuation thereof to provide an arc passage, a second terminal in said passage, means including a fusible element connecting said second terminal to said container extension, means in said container capable of evolving an arc extinguishing gas in response to fusion of said fusible element, and said arc passage communicating with the interior of said container.

17. In a circuit interrupter, an interrupter chamber having an opening, means for establishing an arc adjacent said opening in a position to be engaged by gases flowing out through said chamber opening, means in said chamber of a material capable of evolving a predetermined amount of hot gases independent of the current magnitude of said arc, cooling means in said chamber interposed between said gas evolving material and said opening, and means for initiating gas evolution by said gas evolving means in response to the striking of an arc, whereby said arc is subjected to a blast of cool gas to extinguish the same.

18. In a circuit interrupter, an interrupter chamber having an opening, means for establishing an arc with at least a portion in said opening, means in said chamber of a material capable of evolving a predetermined amount of hot gases independent of the current magnitude of said arc, cooling means in said chamber interposed between said gas evolving material and said opening, and means for initiating gas evolution by said gas evolving means in response to the striking of an arc, whereby said arc is subjected to a blast of cool gas to extinguish the same.

19. In a circuit interrupter, an interrupter chamber having an opening, means of insulating material forming an arc passage extending outwardly from said opening, means for establishing an arc with at least a portion of the arc in said passage at least when a blast of gas passes out through said passage, means in said chamber of a material capable of evolving a predetermined amount of hot gases independent of the current magnitude of said arc, cooling means in said chamber interposed between said gas evolving material and said opening, and means for initiating gas evolution by said gas evolving means in response to the striking of an arc, whereby said arc is subjected to a blast of cool gas to extinguish the same.

20. In a circuit interrupter, an interrupter chamber having an outlet passage extending

therefrom, said passage having an intermediate restricted portion and a flared outlet, means in said chamber of a material capable of evolving a predetermined amount of hot gases independent of the current magnitude of said arc, cooling means in said chamber interposed between said gas evolving material and said outlet passage, means movable through said passage for striking an arc longitudinally of said passage, and means for initiating gas evolution by said gas evolving means in response to the striking of an arc, whereby said arc is subjected to a blast of cool gas to extinguish the same.

21. In a circuit interrupter, a pressure container for an arc extinguishing gas under pressure, means of insulating material forming an arc passage secured at one end to said container, means for establishing an arc in said passage and concurrently establishing an opening in said container at said one end of the arc passage to cause a blast of gas through the arc to extinguish the same.

22. In a circuit interrupter, a pressure container for an arc extinguishing gas under pressure, means of insulating material forming an arc passage secured at one end to said container, said container having a fusible terminal wall portion at said one end of said passage, a terminal secured to said wall portion and movable through said passage upon fusion of said wall portion by the gas released from said container to extinguish the arc.

23. In a fuse, main fusible means connecting a pair of arcing terminals, a relatively high resistance ignition fusible means mechanically and electrically connected in parallel with said main fusible means so as to relieve the strain on said main fusible means, means of combustible material capable of producing relatively large quantities of gas as a product of combustion and positioned so as to be ignited by said ignition fusible means, and means for directing said gases between said terminals, whereby upon blowing of said main fusible means, said ignition fusible means blows and said terminals are subjected to a gas blast, in said sequence.

24. In a fuse, separable contacts and fusible means serially connected in the circuit, an arc passage having a restricted portion adjacent said contacts, one of said contacts forming a displaceable obstruction in said passage, means responsive to fusion of said fusible means for supplying a predetermined quantity of arc extinguishing gas under pressure to one end of said passage independent of the current magnitude of the arc, whereby said one contact will be displaced through said passage upon fusion of said fusible means to draw an arc of predetermined length irrespective of the magnitude of the current interrupted.

25. In a fuse, separable contacts and fusible means serially connected in the circuit, means responsive to fusion of said fusible means for liberating a predetermined quantity of arc extinguishing gas under pressure independent of the current magnitude of the arc, means associated with at least one of said contacts responsive to said gas pressure for separating said contacts, and means for guiding said gas through the arc drawn between said contacts.

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