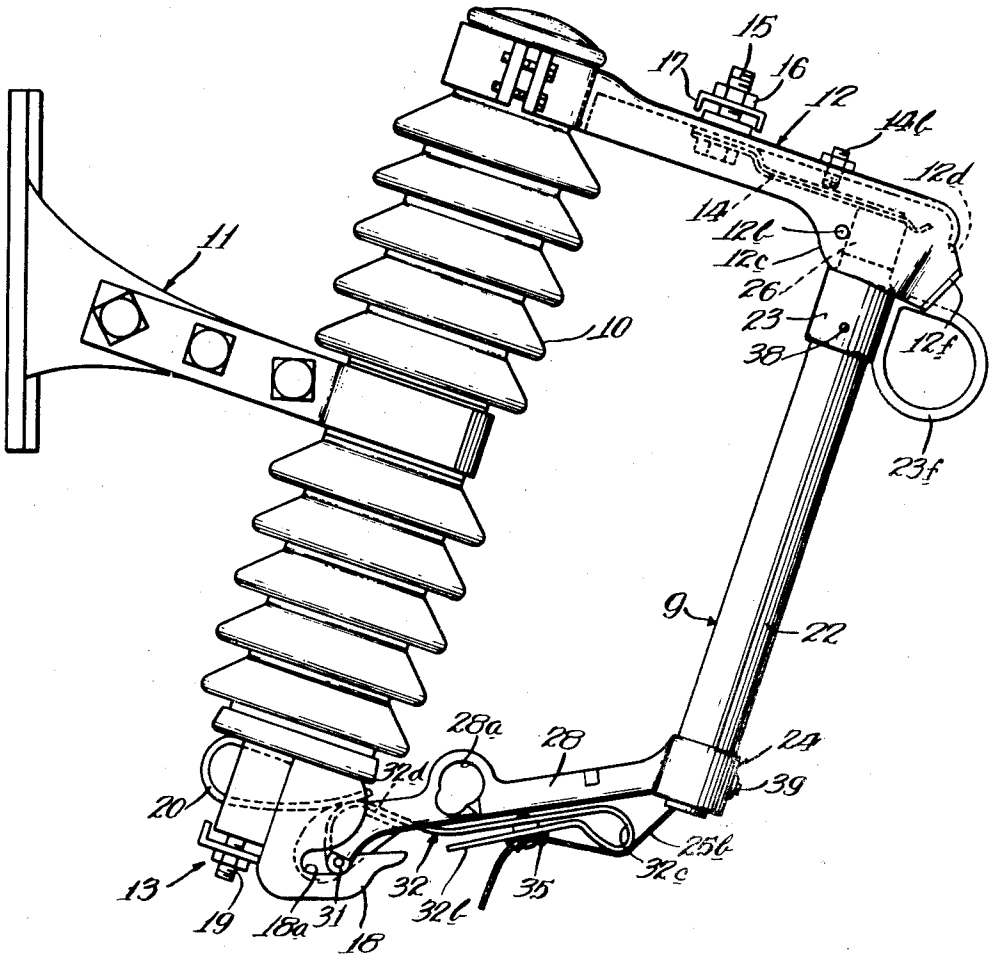
June 24, 1958 E. H. YONKERS 2,840,668

FUSE ASSEMBLY FOR CUTOUTS

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Fig. 1.

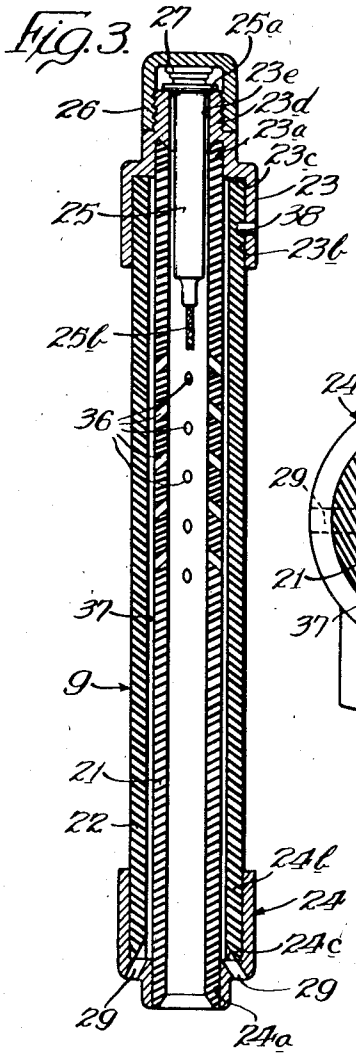


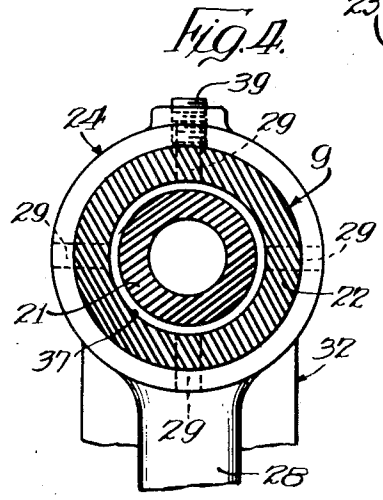
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FUSE ASSEMBLY FOR CUTOUTS

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FUSE ASSEMBLY FOR CUTOUTS

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3 Sheets-Sheet 3

Fig. 5

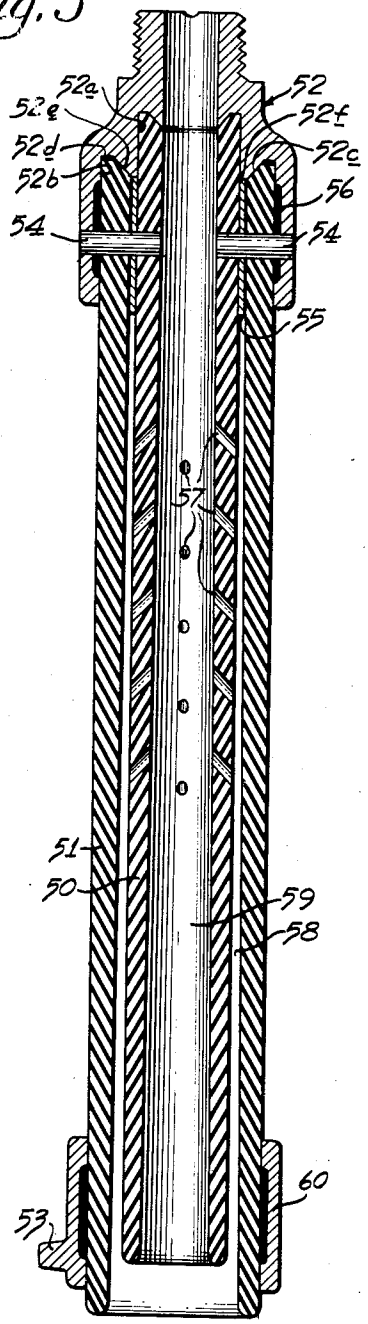
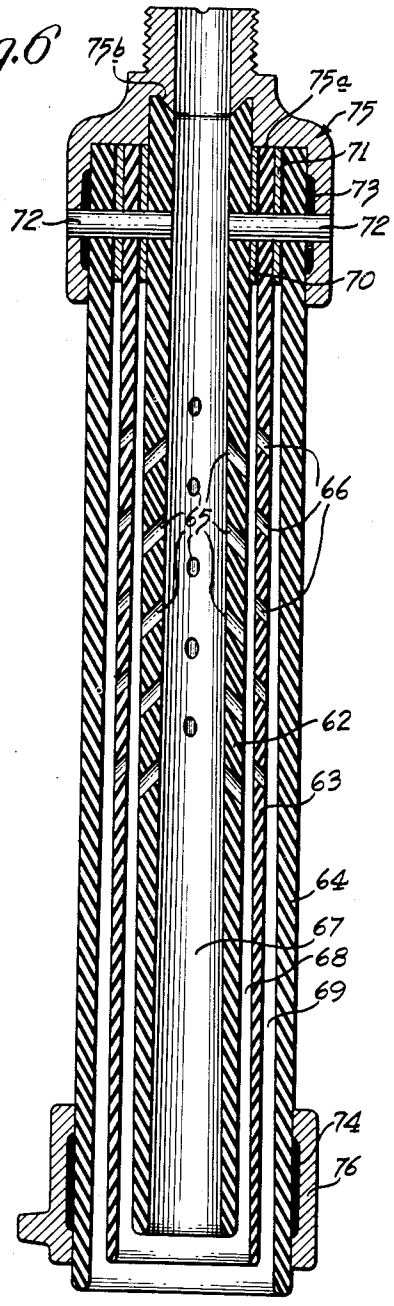


Fig. 6



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2,840,668

FUSE ASSEMBLY FOR CUTOUTS

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Application February 24, 1956, Serial No. 567,596

33 Claims. (Cl. 200—127)

The present invention relates to fuse cutouts and more particularly to an improved fuse assembly having a wide range current interrupting capacity, which may easily and quickly be mounted upon or detached from the spaced terminals of the insulator assembly.

This application is a continuation-in-part of copending application, Serial No. 344,771, filed March 26, 1953.

Recently, the trend in the design of power distribution systems has been toward systems having higher and higher fault current capacities. This has created a demand for fused cutouts which are capable of interrupting very high fault currents as well as fault currents of smaller magnitudes. Conventional cutouts of standard construction do not have the interrupting capacity to handle the heavier fault currents. Specifically, the gas pressure built up within the fuse tube of a conventional cutout when the cutout is called upon to interrupt excessively heavy fault currents may cause splitting of the fuse tube, or the reaction from the pressure may cause fracture of the cutout insulator, distortion of the terminal fitting against which the reaction force is exerted, or blow off of the fuse assembly end fitting against which the reaction force is exerted. Such gas pressure build up in the fuse tube can, of course, be reduced by using larger fuse tubes having internal bore diameters. If this expedient is resorted to, however, the effectiveness of the cutout in interrupting small fault currents is materially reduced.

Accordingly, it is an object of the present invention to provide an improved cutout and more particularly an improved fuse assembly for use in cutouts.

It is another object of the invention to provide an improved fuse assembly for cutouts which is capable of satisfactorily interrupting fault currents over a wide range of magnitudes, including exceedingly high fault currents, without damage to the fuse assembly or the insulator assembly upon which the fuse assembly is detachably mounted.

In accordance with another and more specific object of the invention, facilities are provided for relieving the gas pressure developed in the fuse tube of a fuse assembly incident to the arc development within the tube which occurs during a circuit interrupting operation, thereby to extend the fault current interrupting capacity of the assembly.

It is still another object of the invention to provide an improved heavy fault current interrupting fuse assembly for cutouts, which may be used interchangeably with fuse assemblies of standard construction having lower interrupting capacities in a cutout of given commercial construction.

A further object of the present invention is to provide a fuse assembly for a cutout capable of interrupting high fault currents and discharging ionized gases from one end in one direction only so as to minimize the chance of starting flash-overs associated with the cutout in normal use.

Another object of the present invention is to provide a fuse assembly for a cutout capable of interrupting very high fault currents having a plurality of unidirectional gas discharging passageways for relieving the gas pressure developed within the fuse assembly incident to or development within the tube upon interruption of very high fault currents.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings, in which:

Fig. 1 is a side view of an improved cutout including one embodiment of a fuse assembly characterized by the features of the present invention;

Fig. 2 is an enlarged side view of the fuse assembly of Fig. 1 showing the assembly detached from the insulator assembly of the cutout;

Fig. 3 is a sectional view taken along the lines 3—3 of Fig. 2;

Fig. 4 is a sectional view taken along the lines 4—4 of Fig. 2;

Fig. 5 is a sectional view of another embodiment of the fuse assembly; and

Fig. 6 is a sectional view of still another embodiment of the fuse assembly.

Referring now to the drawings, the present invention is there illustrated in its three embodiments in an improved fuse assembly **9** which forms a part of a fused cutout of the improved form disclosed and claimed in United States Patent No. 2,493,433, granted January 3, 1950, to the present applicant. As shown in Fig. 1, the insulator assembly of the cutout comprises a petticoat insulator **10** having a center zone longitudinally thereof clampingly embraced by a bracket **11** which may be utilized in supporting the cutout upon a pole or another suitable supporting structure in such position that the insulator **10** is tilted slightly with respect to the vertical. At its respective upper and lower ends, the insulator **10** is provided with spaced apart upper and lower terminals indicated generally at **12** and **13**, respectively, and between which the fuse assembly **9** is adapted to be detachably supported.

For a description of the structural details of the upper and lower terminals **12** and **13**, reference may be had to the above identified patent. Briefly, however, the upper terminal **12** extends outwardly from the upper end of the insulator **10** at right angles thereto and is comprised of a conductive channel member of U-shaped cross section throughout its length. At the laterally extended end thereof, the terminal member **12** is provided with downwardly extending hood skirts **12***c*, the upper portions of which are arranged in meeting engagement with an overhanging lip **12***d* extending downwardly from the top or base portion of the channel member **12**. At their outer ends, the hood skirts **12***c* terminate in flared lips **12***f* which function to guide the upper end of the fuse assembly **9** within the space defined by the hood skirts **12***c* incident to rotation of the fuse assembly **9** to its closed circuit position. To prevent the upper end of the fuse assembly from being moved beyond a predetermined point longitudinally of the skirts **12***c* as the assembly is swung into its closed circuit position, a stop pin **12***b* is provided which extends transversely between the two identified skirts. This pin is arranged to coact with a retaining element in the form of a double leaf spring catch member **14** to restrain the fuse tube assembly **24** against drop out movement to the open circuit position thereof. At one end, the two leaves of the spring **14** are anchored to the under side of the terminal member **12**, by means of a terminal screw **15**, which is threaded through a re-enforced top side portion of the terminal member. Upward movement of the retaining element **14** is limited by an adjustable stop screw **14***b* threaded

through the top wall of the terminal member 12 to engage the element 14 intermediate its ends. A clamping washer 17 and nut 16 threaded onto the screw 15, may be utilized to establish line wire connections with the upper terminal member 12.

All parts of the lower terminal 13 of the cutout are of course, made of a conductive metal. These parts include a pair of spaced apart hinge pieces 18 having elongated and aligned trunnion receiving seats 18*a* formed therein, a line terminal assembly 19 and a U-shaped tensioning spring 20 having one end fixedly connected to one of the parts of the terminal assembly 13 and the other end extending between the spaced apart hinge pieces 18. With the cutout mounted upon a suitable supporting structure so that it occupies the intended operating position illustrated in Fig. 1 of the drawings, the trunnion seats 18*a* formed in the hinge pieces 18 are disposed in a substantially horizontal plane.

Referring now more particularly to Figs. 2, 3 and 4 of the drawings, one embodiment of the present improved fuse assembly is there illustrated as comprising an inner fuse tube 21 and an outer fuse tube 22 which extend between and are held in spaced apart relationship by upper and lower contact members or end fittings 23 and 24, so that an annular gas passage 37 is formed between the outer surface of the inner tube 21 and the inner surface of the outer tube 22. The inner tube 21 is formed entirely of pressed fiber or the like, having good arc extinguishing gas evolving properties. The outer tube 22, on the other hand, comprises an inner layer also formed of pressed fiber or the like, having good arc extinguishing gas evolving properties and an outer layer of Bakelite impregnated paper having excellent insulating and weather resistant properties. As best shown in Fig. 3, the upper contact member or end fitting 23 is provided with two longitudinally spaced bores 23*a* and 23*b* for receiving the respective upper ends of the inner and outer tubes 21 and 22. These bores are connected by an internal shoulder 23*c* against which the upper end of the outer tube 22 abuts. A pin 38 driven into aligned openings in the wall of the member 23 and the outer wall of the tube 22 is utilized to maintain the parts 21, 22 and 23 in assembled relationship. The contact member 23 is also provided with a head portion 23*d* having an internal bore 23*e* of the same diameter as the internal bore of the inner fuse tube 21 for receiving a fuse link 25. This head portion of the contact member 23 is provided with external threads for receiving an internally threaded cap 26 which is used to close the upper end of the inner tube 21 and to hold the head 25*a* of the fuse link 25 in seating engagement with the top surface of the contact member head portion 23*d*. The cap 26 is of inverted cup-shaped configuration and has a small compression spring 27 mounted upon the inner surface of the top wall thereof which is utilized to press the head 25*a* of the fuse link 25 into seating engagement with the top end of the contact member 23 as the cap 26 is threaded onto the head portion 23*d* of the contact member 23.

At their lower ends, the tubes 21 and 22 are supported by the lower contact member or end fitting 24 which includes a laterally extending and conductive supporting arm 28. More specifically, and as best shown in Fig. 3, the lower contact member 24 is provided with longitudinally spaced bores 24*a* and 24*b* for respectively receiving the lower ends of the fuse tubes 21 and 22. These bores are connected by an internal shoulder 24*c* against which the lower end of the tube 22 abuts. A set screw 39 threadedly received within an opening in the wall of the member 24 engages the outer wall of the tube 22 to maintain the parts 21, 22 and 24 in assembled relationship. For the purpose of venting the annular gas passage 37 to the atmosphere, vent ports or openings 29 are drilled through the lower wall of the member 24 at several points around the circumference thereof in the manner best shown in Figs. 3 and 4 of the drawings.

The laterally extending and conductive supporting arm 28 is of inverted T-shaped cross section throughout the major portion of its length. At its extended end, the arm 28 is forked to provide spaced apart end pieces 30 having oppositely directed trunnions 31 projecting outwardly therefrom which are receivable within the slotted hinge pieces 18 of the insulator assembly to seat upon the trunnion seats 18*a*. Between the transversely spaced end pieces 30 of the arm 28, there is supported a fuse pigtail extracting arm 32. More specifically, the pivoted end of the arm 32 is fixedly connected to a pivot pin 33 which is journaled in aligned openings in the trunnions 31. The main part of the arm 32 is bent into the configuration shown in Fig. 2 of the drawings to have parallel extending intermediate and return bent portions 32*a* and 32*b*, a loop shaped end bridge 32*c* and a camming portion 32*d* which is engageable with the free end of the spring 20 as the fuse assembly 9 is rotated into its closed circuit position after the trunnions 31 are engaged with the trunnion seats 18*a* of the hinge pieces 18. A brace 40 connected between the pin 33 and the arm 32 in the manner illustrated in Fig. 2 is provided to prevent distortion of the shape of the camming portion 32*d* of the arm 32. Intermediate the ends of the arm 32, means comprising a headed tie post 34 are provided for securely connecting the pigtail conductor 25*b* of the fuse link 25 to the arm 32. Specifically, the post 34 is fixedly mounted upon the intermediate portion 32*a* of the arm 32 and extends downwardly through a slot opening in the return bent portion 32*b* of the arm. At its extended end, the post 34 fixedly supports a curved pigtail retaining head 35, which in cooperation with the arm portion 32*b* serves fixedly to connect the pigtail conductor 25*b* to the arm 32.

In order to provide for switch stick manipulation of the hinged trunnions 31 into engagement with the trunnion seats of the hinge pieces 18, the upstanding center part of the T-shaped supporting arm 28 is enlarged at a point adjacent the forked outer end of the arm to provide for the formation of an opening 28*a* therein into which the hook of a switch stick may be inserted. Similarly, the upper contact member 23 of the fuse assembly 9 is provided with an integrally formed loop portion 23*f* into which the hook of a switch stick may be readily inserted to permit use of a switch stick in swinging the fuse tube assembly into and out of its closed circuit position.

From the above explanation, it will be apparent that when the fuse assembly is detached from the terminals 12 and 13 of the insulator assembly, the supporting arm 28 and the extracting arm 32 are freely rotatable relative to each other. When it is desired to fuse the assembly 9, the terminal cap 26 is unscrewed from the head portion 23*d* of the contact member 23 and a fuse link 25 inserted within the chamber or bore of the inner fuse tube 21 so that the pigtail conductor 25*b* thereof projects out of the open lower end of the tube 21. Following this operation, and with the extracting arm 32 firmly held against the supporting arm 28, the projecting part of the conductor 25*b* is carried over the bridge portion 32*c* of this arm and wrapped around the post 34 beneath the head 35 while the arm portion 32*b* is depressed toward the arm 32*a*. With the conductor 25*b* tensioned slightly over the loop portion 32*c* of the arm 32, the arm portion 32*b* is released, so that that portion of the pigtail conductor 25*b* which is wrapped around the post 34 is clamped between the arm portion 32*b* and the head 35. Thus, the pigtail conductor 25*b* is provided with a non-slip connection to the tie post 34 and serves to hold the arm 32 in firm engagement with the underside of the supporting arm 28. After the described operations are completed, the terminal cap 26 may be threaded onto the head portion 23*d* of the upper contact mem-

ber 23 until the cap rim abuts the upper shoulder of the contact member head portion 23*d*, thereby to establish the exact desired distance between the top of the cap and the axis of the trunnions 31. As the cap 26 is screwed onto the head portion 23*d* of the upper contact member 23, the spring 27 is compressed to clamp the head 25*a* of the fuse link tightly against the upper end of the contact member 23.

A switch stick having its hook engaged with the opening 28*a* of the arm 28 may be utilized to engage the trunnions 31 of the fuse assembly 9 with the trunnion seats 18*a* of the hinge pieces 18 in assembling the fuse assembly 9 upon the insulator assembly. Likewise, the hook of the switch stick may be engaged with the loop portion 23*f* of the upper contact member 23 for the purpose of rotating the use assembly into its closed circuit position. As the fuse assembly 9 is rotated in a counter clockwise direction to its closed circuit position, the free end of the biasing spring 20 rides up the camming portion 32*d* of the extracting arm 32 and in so doing reacts between the extracting arm 32 and its support to perform three functions. First, it forces the trunnions 31 forward along the seats 18*a* toward the noses of the hinge pieces 18, thereby to position the end cap 26 for interlocking engagement with the retaining spring 14. Secondly, it biases the bridge portion 32*c* of the extracting arm 32 away from the supporting arm 28 to tension the pigtail conductor 25*b* and hence, the fusible element within the fuse link 25. Thirdly, it functions to force the trunnions 31 into pressure engagement with the forward ends of the trunnion seats 18*a*, thereby accurately to center the upper end of the fuse assembly 9 relative to the front or entrance opening between the lips 12*f* of the upper terminal member 12. As the end cap 26 moves between the lips 12*f* and the skirts 12*c* of the upper terminal member 12, it engages and rides beneath a catch portion 14*a* of the retaining spring 14 until it is brought to bear against the stop pin 12*b*. As the end cap 26 is moved into engagement with the stop pin 12*b*, the lip 14*a* of the retaining spring 14 drops over the edge of the cap 26 to latch the assembly 9 in its closed circuit position. With the fuse assembly 9 in this position, a fused current path is provided between the terminals 12 and 13 which extends from the terminal member 12 by way of the retaining spring 14, the contact member 23, the fusible element of the link 25, the pigtail conductor 25*b*, the extracting arm 32 to the terminal assembly 13.

So long as current flow over the described conductive path between the terminals 12 and 13 does not exceed the rated current carrying capacity of the link 25, the fusible element within the link 25 serves mechanically to hold the extracting arm 32 in its set position against the underside of the supporting arm 28. When, however, this fusible element is subjected to a fault current, such that it is called upon to carry current in excess of its rated capacity, it is ruptured to relieve the holding force imposed upon the extracting arm 32 through the pigtail conductor 25*b*. As a consequence, the spring 20, in reacting between the supporting insulator 10 and the camming portion 32*d* of the arm 32 functions rapidly to rotate the arm 32 downwardly about the pivot pin 33 thereby to withdraw the pigtail conductor 25*a* from the lower end of the fuse tube 25. As the arm 32 is rotated to a position approximately normal to the supporting arm 28, the camming portion 32*d* thereof tends to move away from the spring 20 thus relieving the force holding the trunnions 31 at the forward ends of the trunnion seats 18*a*. As this force is relieved, the retaining spring 14 in thrusting downward upon the end cap 26 combines with gravity pull on the assembly 9 to slide the trunnions 31 to the left along the trunnion seats 18*a*. As a result, the distance between the trunnions 31 and the retaining spring 14 is increased until a point is reached where the catch 14*a* no longer engages the side of the end cap 26. Thus, the fuse assembly 9 is released for downward pivotal drop out motion about the axis of the trunnions 31 under the influence of gravity pull on the assembly.

As will be understood by those skilled in the art, incident to rupture of the fusible element within the link 25 an arc is developed between the upper end of the pigtail conductor 25*b* and the remnant of the fusible element within the fuse link 25, which is rapidly elongated as the pigtail conductor 25*b* is withdrawn from the bore of the inner fuse tube 21 under the influence of the extracting arm 32. This arc development within the inner fuse tube 21 results in contacting of the arc with the inner walls of the fuse tube with the result that the arc is cooled and arc extinguishing gases are released from the inner walls of the tube 21. The heat generated by the confined arc also results in an extremely rapid rise in the gas pressure within the tube 21, which has the effect of blowing the arc out as the gases are rapidly expelled from the lower end of the tube. The extent of the temperature rise within the tube 21 and hence the extent of the pressure rise within the tube increases as a function of the magnitude of the fault current being interrupted. In other words, the heavier the fault current the greater the gas pressure built up within the tube 21. This rise in gas pressure is, of course, desirable since it results in rapid expulsion of ionized particles from the lower end of the tube and hence, enhances the rapidity of arc extinction. However, expulsion of the gases from the lower end of the tube 21 obviously sets up reaction forces which are exerted through the end cap 26 against the outer end of the elongated upper terminal member 12. It has been found that when a standard single tube fuse assembly is called upon to interrupt fault currents of the order of 5,000 amperes, for example, the gas pressures developed in the fuse tube become high enough to cause splitting of the fuse tube, or to develop reaction forces which may result in distortion of the upper terminal member 12, blowing off of the end fitting 23, or fracturing of the insulator 10.

In order to obviate the problems outlined in the preceding paragraph, the double tube arrangement comprising the inner and outer tubes 21 and 22 is provided so that two gas expulsion passages are formed, namely the gas expulsion passage within the inner tube 21 and the annular passage 37 between the two tubes 21 and 22. These two passages are both vented to the atmosphere at the same end of the assembly 9 and are in gas flow communication with each other through vent openings 36 drilled through the walls of the tube 21 at points intermediate the ends of the tubes 21 and 22. More specifically, five sets of aligned vent ports 36 are provided through the wall of the tube 25 in the region of maximum gas pressure development within the tube during a circuit interrupting operation of the cutout. The sets of ports 36 are equally spaced around the tube 21 and each port extends downwardly from the inner surface of the tube to the outer surface thereof at an angle of approximately 45° relative to the tube wall.

With the described dual gas passage arrangement, a portion of the hot arc extinguishing gases generated during a fault current interrupting operation pass from the central gas discharge passage within the tube 21 through the vent ports 36 to the passage 37 and are discharged to the atmosphere through the vent ports 29. As a consequence, the reaction force exerted against the end fitting 23 and the end of the terminal member 12 are substantially reduced to a value which will not cause blow off of the end fitting or damage to the terminal member 12 or the insulator 10. In addition, the gases are cooled to aid in deionization thereof as they pass through the ports 36 into the passage 37. Moreover, in passing into the passage 37 the gases develop a pressure within this passage against the outer walls of the inner tube 21 which opposes the pressure being exerted against the inner walls

of the tube 21 by the gases remaining in this tube. As a consequence, the pressure load on the inner tube 21 and hence, the tube bursting forces are materially reduced. It has been found, for example, that when a fuse assembly 9 of the improved form illustrated in Figs. 2, 3, and 4, is substituted for a standard single tube fuse assembly in a cutout of the improved construction illustrated in Fig. 1, the cutout is easily capable of interrupting fault currents in excess of 10,000 amperes without any apparent damage either to the fuse assembly or the insulator assembly.

One of the important features of this embodiment of the invention pertains to the relative dimensioning of the ports 36 and the outer gas passage 37. Thus, if the total cross sectional area of the ports 36 and the cross sectional area of the passage 37 are too large, such that gases may easily flow from the inner gas passage within the tube 21 to the passage 37, the interrupting ability of the fuse assembly on fault currents of small magnitude is substantially impaired. This is true for the reason that the larger overall gas discharge capacity of the two passages mitigates against the arc coming in contact with the walls of the tubes 21 and 22 and also against desired rapid expulsion of the ionized gases from the passages. It is important, therefore, to so proportion the dimensions of the ports 36 and the passage 37 that the desired pressure relief is obtained when the fuse assembly is called upon to interrupt very large fault currents, without impairing to too great a degree the gas pressure build up which occurs within the inner passage when the fuse assembly 9 is called upon to interrupt fault currents of smaller magnitude. It has been found experimentally that these two requirements are satisfactorily met by maintaining the total cross sectional area of the ports 36 less than the cross sectional area of the outer passage 37 and less than the cross sectional area of the inner passage within the tube 21. By way of specific example, it has been found that satisfactory fault current interruption over a wide range of fault current magnitudes is obtained by employing a fuse structure in which the total cross sectional area of the ports 36 is .136 square inch, the cross sectional area of the gas passage in the inner tube 21 is .150 square inch, the cross sectional area of the outer gas passage 37 is .172 square inch and the total cross sectional area of the vent ports is equal to the sum of the cross sectional areas of the two passages, or .322 square inch.

In accordance with other aspects of the present invention, and as best shown in Figs. 5 and 6, the tubes in the fuse assembly may be increased in number and fixedly secured between the upper and lower contact members by improved means other than described above with reference to the first embodiment. in the second embodiment of the present invention shown in Fig. 5, inner and outer tubes 50 and 51, respectively, are disposed between upper and lower contact members 52 and 53, respectively, which are generally similar in design and function to the upper and lower contact members 23 and 24 of the first embodiment. The lower contact member 53 is not secured to both of the tubes 50 and 51, but only to the outer tube 51. More specifically, the inner tube 50 is fixedly secured solely to the upper contact member 52 in such a manner as rigidly and freely to suspend the inner tube 50 concentrically within the outer tube and the lower contact member, thereby to define an annular gas discharge passageway 58 between the tubes 50 and 51 in addition to the gas discharge passageway 59 defined by the bore of the tube 50. In particular, the upper contact member 52 is provided with two longitudinally spaced bores 52*a* and 52*b* for receiving the respective upper ends of the inner and outer tubes 50 and 51. The internal bores 52*a* and 52*b* are interconnected by a somewhat annular shoulder 52*c* which has a generally horizontal surface 52*d* and an inclined surface 52*e* cooperating to define a groove for seating the upper end surface of the external tube 51 together with a second generally horizontal portion 52*f*. The contact member 52 is provided with an externally threaded portion 52*g* for engagement with a cap like that shown at 26 in Fig. 3. This cap effectively covers the upper end of the contact 52 and closes the gas passageway 59 formed within tube 50.

The ends of the hollow tubes 50 and 51 are adapted to be seated against the ends of the bores 52*a* and 52*b* and are maintained in assembled relationship with the contact member 52 by means of pins 54 driven into aligned openings in the walls of the members 52, 51 and 50 in the manner shown. The inner and outer tubes 50 and 51 are retained in aligned spaced relationship by a sleeve 55 encircling the tube 50 and having its upper end abutted against the horizontal portion 52*f* of the connecting shoulder 52*c*. The sleeve 55 is provided with radially extending apertures for accommodating the pins 54 in order to hold the sleeve in assembly with the tubes 50 and 51. In addition to the fastening action afforded by the pins 54, the outer tube 51 is rigidly secured to the upper contact member by means of a suitable bonding material 56, preferably an epoxide resin activated by a catalyzer agent, which occupies the space between the outer surface of the tube 51 and the inner surface of the contact member 52 along the longitudinal abutting annular areas thereof. If an epoxide resin is used as the bonding material and this resin is activated in situ with a catalyzer, a solid weld fusing the outer tube 51 to the upper contact member 52 is obtained within an hour after the resin is catalyzed. The same procedure and bonding agent is used to bond the sleeve 55 to the inner surface of the outer tube 51 and to affix the upper end of the sleeve to the contact member 52. The use of two attaching means in the manner described insures that the upper contact portion of the fuse assembly will not blow off during rated operation of the assembly.

As in the first embodiment of the invention, the inner tube 50 is provided with a set of equally spaced radially inclined ports 57. The ports, inclined at approximately 45° in the inner tube 50, cause an upward thrust on the tube so that under the severest operating conditions it is easily retained in place by the mounting means described above. As shown, the lower end of the inner tube 50 is terminated inside of the outer tube 51 in a manner such that the gas discharge passageway 58 is vented directly to the atmosphere. This arrangement is highly desirable inasmuch as a fully open gas discharge passageway 58 is provided which is entirely free from any structural element that might impede the expulsion of the gases generated within the fuse assembly during operation thereof.

For the reasons stated above, the lower end of the inner tube 50 is not attached to the lower contact member 53. The lower contact member 53 is, however, rigidly attached to the outer tube 51 along substantially the entire longitudinal inner surface of the member 53 by means of a bonding material like that employed with the upper contact 52, which material fuses the member 53 and the tube 51 together as indicated at 60.

In general, the overall dimensions of the individual tubes 50 and 51, the ports defined in the inner tube 50, and the gas discharging passageways are substantially identical to the dimensions of the corresponding components of the first embodiment of the fuse assembly shown in Fig. 3, with one exception. In order to facilitate expulsion of generated gases and to reduce the pressure build-up within the fuse assembly, the longitudinal internal bores in either or both of the tubes 50 and 51 may be tapered in such a manner as to provide downwardly diverging gas discharge passageways. As an example, in a 78 kv. fuse assembly rated to carry 100 amperes continuously with a 10,000 ampere interrupting ability, the longitudinal bore in the inner tube 50 has an internal diameter of 7/16" at its upper end tapering outwardly to 9/16" at its lower end. The longitudinal bore in the outer tube 51 may be similarly tapered with the larger diameter

at the bottom. In addition to relieving generated gas pressures incident to arc development within the fuse assembly, the tapered bore in the tube **50** aids the escape of fuse link components which must be ejected ahead of the gases. Moreover, the larger diameter at the bottom of the bore in the tube **51** permits the expansion of the tubes as a result of moisture entering their exposed lower ends, thereby preventing the blocking of the annular gas passageway **58**. While the entire length of the bore in the tube **51** has been illustrated as being tapered, in some cases it may be desirable to taper only the lower portion of the tube to provide the beneficial results described above.

In accordance with the third embodiment of the present invention, shown in Fig. 6, there is provided a fuse assembly having three concentric tubes disposed between the upper and lower contact members, in contrast to the two concentric tubes of the first and second embodiments. These tubes **62**, **63** and **64**, like the tubes **21** and **22** of the first embodiment are formed entirely of pressed fibre or the like, having good arc extinguishing gas evolving properties. As is well known in the art, whenever cutouts are required to operate at higher voltages, the gas pressures generated within the fuse assemblies during an interruption increase accordingly. To effectively decrease these resulting high pressures, three concentric tubes, namely the inner tube **62**, the intermediate tube **63** and the outer tube **64**, are disposed between upper and lower contact members **75** and **76**. The inner tube **62** and the intermediate tube **63** are each provided with radially disposed gas discharge ports **65** and **66** inclined at approximately 45° and extending generally downward from the interior of each tube to its exterior. The set of ports **65** and **66** are each disposed in rows which are staggered with respect to each other. In this manner, three gas discharge passageways **67**, **68** and **69** are defined, the first passageway **67** being defined by the longitudinal bore of the inner tube **62**, the second passageway **68** being defined by the annular air gap between the inner tube **62** and the intermediate tube **63** and communicating with the inner bore **67** through the gas discharge ports **65**, and the third passageway **69** being defined by the annular air gap between the intermediate tube **63** and the outer tube **64** and communicating with the second gas discharge passageway **68** through the gas discharge ports **66**. As is evident from a comparison of Figs. 5 and 6, the radial ports defined in the tubes have a somewhat larger cross sectional area than the corresponding radial ports defined in the tubes of the embodiment shown in Fig. 5, but, nonetheless, the total of the cross sectional area of each set of radial ports is less than the cross sectional area of the gas discharging passageways **68** and **69**. As indicated hereinbefore, it is important to retain this relationship of area to obtain the desired pressure relief when the fuse assembly is called upon to interrupt very large fault currents without impairing the gas pressure build-up which occurs within the inner gas discharging passageway when the fuse assembly interrupts fault currents of smaller magnitude.

Since the 45° radial ports **65** and **66** create and maintain an upward thrust for urging the inner tube **62** and the intermediate tube **63** against the upper contact **75**, it is possible to provide the long unimpeded gas passages required for the higher voltages without having to resort to heavy expensive mounting structures. It should be understood that in the operation of an expulsion current interrupter it is not necessary to expel all the ionized gases, but only necessary to deionize the gases which remain in the space between the elements of the current-carrying circuit which are separated to initiate interruption of the current. This so-called expulsion interruption is only applicable to alternating current since the deionization process requires a momentary cessation of the ion producing effect of arc current and voltage. In other words, when the alternating fault current passes through zero (120 times per second in the case of 60 cycle power current) the ions which comprise the arc-path commence to recombine into insulating gas molecules at a high rate of speed. The speed of recombination is a function of temperature and proximity of non-ionized matter of any kind. Hence, if the arc is extended in a fibre tube, the heat of the arc releases unionized water vapor which has a momentum effect continuing during the passage through current zero, thereby diluting the ionized gases and speeding up their recombination, and at the same time increasing pressure within the tube which causes the expulsion of both ionized and non-ionized gases.

Accordingly, the extended fibre surfaces of the tubes **62**, **63** and **64** accelerate the above-mentioned processes and, in addition, reduce pressures in the neighborhood of the arc by permitting expansion and cooling as the generated gases are permitted to pass into the second and third gas discharge passageways **68** and **69**, through the ports **65** and **66**, respectively. The structure of this fuse assembly effectively cushions or reduces substantially the sharp upward thrust encountered in the conventional single vent fuse tube where all of the generated gases are ejected through the single tube at extremely high velocity.

In the embodiment of the fuse assembly shown in Fig. 6, the three tubes **62**, **63** and **64** are inserted into a cavity **60***a* of the upper contact member **75** and are maintained in assembled and abutting relationship with respect to the upper contact by means of pins **72** driven through aligned openings in the walls of the upper contact member **75** and the tubes **62**, **63** and **64**. Specifically, the upper ends of tubes **63** and **64** abut against a horizontal shoulder **75***a* in the contact **75** while the tube **62** has its upper end seated within an appropriately shaped groove **75***b* offset somewhat from the shoulder **75***a*. In order to maintain the tubes **62**, **63** and **64** in spaced, concentric relationship, there are provided sleeves **70** and **71** respectively disposed between the tubes **62** and **63** and between the tubes **63** and **64**. The upper and lower contact members **75** and **76** are fused to the outer tube **64** as indicated in Fig. 6 at **73** and **74**, respectively, by means of a suitable bonding material of the type described above. In addition, bonding material is employed to seal the sleeve **70** to the tube **63** and to seal the sleeve **71** to the tube **64**. Consequently, the tubes **62** and **63** are suspended from the upper contact **75** with their lower ends spaced from the lower contact member **76**. The three tubes are of such length that they terminate in tiered relationship wherein tube **62** terminates within the tube **63** and the tube **63** in turn terminates within the tube **64**.

In order to relieve the gas pressure build-up within the fuse assembly and to assist the ejection of the combustible fuse link components ahead of the ionized and non-ionized gases, the longitudinal bores of the tubes **62**, **63** and **64** are preferably tapered in such manner that a plurality of downwardly diverging gas discharging passageways are provided. The enlarged diameters of the lower ends of the bores in the tubes again prevents moisture induced expansion or the like from blocking or obstructing the gas discharge passages. Again, it should be recognized that, while the entire lengths of each of the bores is illustrated as being tapered, in some cases it may be desirable to taper only the lower portion of the bore in each of the tubes **63** and **64**. Manifestly, the sets of communicating ports reduce the pressure in the region of the fault current arc by permitting expansion and cooling of the generated gases through the communicating ports into the multiple discharging passages, thereby relieving pressures in the fuse assembly which might otherwise reach destructive levels before the inner tube is cleared of partially combustible fuse linkage.

It will be readily appreciated that there has been provided in the embodiment of the invention shown in Fig. 6 a plurality of individually vented gas discharging passages to enable the fuse assembly to operate at much higher voltages without requiring heavy and expensive high pressure structures. Moreover, it has been deter-

mined that the fuse assembly incorporating the features described above is practically indestructive even though it is functioning to interrupt high fault currents.

While different embodiments of the present invention have been described, it will be understood that various modifications may be made therein which are within the true spirit and scope of the invention as defined in the appended claims.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A fuse assembly for cutouts, comprising a pair of spaced contact members engageable with the terminal members of the cutout, and a structure of dielectric material supported between said contact members, said structure including parts formed of gas evolving material defining two elongated and concentrically arranged gas discharge passages both of which are closed at one end of the assembly and are vented to the atmosphere at the other end of the assembly, and having a plurality of interconnecting ports therebetween at points intermediate the ends thereof for transmitting gas evolved upon arc development in the inner one of said passages from said one passage to the outer one of said passages, the total cross-sectional area of said ports being less than the cross-sectional area of the outer one of said passages.

2. The fuse assembly of claim 1 wherein said structure comprises a pair of tubes arranged one within the other and at least the inner of which is formed of gas evolving material, wherein said contact members are each provided with longitudinally spaced bores of different diameters for receiving the respective upper and lower ends of said tubes to hold said tubes concentrically one within the other so that a gas discharge passage is formed therebetween, and wherein one of said members is provided with at least one opening therethrough for venting said passage to the atmosphere.

3. The fuse assembly defined by claim 2 wherein upper and lower contact members are provided each having longitudinally spaced bores of different diameters for receiving the respective upper and lower ends of said tubes, the upper of said contact members being provided with an internal shoulder extending between the longitudinally spaced bores of said upper contact member which closes the upper end of the gas discharge passage and the lower of said contact members being provided with openings therethrough for venting said passage to the atmosphere.

4. A fuse assembly for cutouts, comprising a pair of spaced contact members engageable with the terminal members of the cutout, and a structure of dielectric material supported between said contact members, said structure including concentric tubes formed of gas evolving material, means carried by at least one of said contact members for fixedly spacing apart said tubes, thereby defining a plurality of concentric gas discharge passages, means adjacent to the other of said contact members for individually venting each of said discharge passages directly to the atmosphere, and means in at least one of said tubes defining a plurality of ports interconnecting said passages for transmitting gas evolved upon arc development within one of said passages from said one passage to another of said passages.

5. A fuse assembly for cutouts, comprising a pair of spaced contact members engageable with the terminal members of the cutout, and a structure of dielectric material supported between said contact members, said structure including parts formed of gas evolving material defining two elongated and concentrically arranged gas discharge passages both of which are closed at one end of the assembly and are individually vented to the atmosphere at the other end of the assembly, and having a plurality of interconnecting ports therebetween at points intermediate the ends thereof for transmitting gas evolved upon arc development in the inner one of said passages from said one passage to the outer one of said passages.

6. A fuse assembly for cutouts, comprising a pair of spaced contact members engageable with the terminal members of the cutout, and a structure of dielectric material supported between said contact members, said structure including parts formed of gas evolving material defining two elongated and concentrically arranged gas discharge passages, means for individually and directly venting one end of each of said passages to the atmosphere, said structure having a plurality of interconnecting ports between said passages at points intermediate the ends thereof for transmitting gas evolved upon arc development in the inner one of said passages from said one passage to the outer one of said passages.

7. The structure defined by claim 6 wherein the total cross-sectional area of said ports is less than the cross-sectional area of the outer one of said passages.

8. A fuse assembly for cutouts, comprising a pair of tubes arranged one within the other and at least the inner of which is formed of gas evolving material and defines a first gas discharge passageway, upper and lower contact members engageable with the terminal members of the cutout, means for securing both of said tubes to the upper contact member in spaced apart relationship in order to hold said tubes concentrically one within the other, thereby forming a second gas discharge passage therebetween, means at the lower end of said tubes for individually venting said passages to the atmosphere, and the inner of said tubes having a plurality of ports through the wall thereof at points spaced intermediate the ends of said tube for transmitting gas evolved upon arc development within said first passage to said second passage.

9. The fuse assembly of claim 1 wherein said structure comprises a pair of tubes arranged one within the other and at least the inner of which is formed of gas evolving material, means for securing both of said tubes to the upper contact member in spaced apart relationship in order to hold said tubes concentrically one within the other, and means in said lower contact member for separately venting the lower end of each of said passageways directly to the atmosphere.

10. A fuse assembly for cutouts, comprising a pair of tubes arranged one within the other and at least the inner of which is formed of gas evolving material, upper and lower contact members engageable with the terminal members of the cutout, and means securing each of said tubes to the upper contact member in spaced apart relationship in order to hold said tubes concentrically one within the other so that a gas discharge passage is formed therebetween, the upper of said contact members being provided with structure abutting the upper end of said inner tube, the inner of said tubes having a plurality of ports through the wall thereof at points intermediate the ends of said inner tube for transmitting gas evolved upon arc development within said inner tube to said passage, said ports being inclined downwardly from the interior to the exterior of the inner tube so that the gas flow therethrough produces an upward thrust urging the inner tube against said structure.

11. The structure defined by claim 10 wherein the total cross-sectional area of said ports is less than the cross-sectional area of said gas passage.

12. A fuse assembly for cutouts comprising a pair of tubes arranged one within the other and at least the inner of which is formed of gas evolving material and provides a first gas discharge passageway, upper and lower contact members engageable with the terminal members of the cutout, and means securing each of said tubes to the upper contact member in spaced apart relationship in order to hold said tubes concentrically one within the other so that a second gas discharge passageway is formed therebetween, the lower end of each of said passageways being vented directly to atmosphere, the upper of said contact members being provided with structure abutting the upper end of said inner tube, the inner of

said tubes having a plurality of ports through the wall thereof at points intermediate the ends of said inner tube for transmitting gas evolved upon arc development within said inner tube to said second passage, said ports being inclined downwardly from the interior to the exterior of the inner tube so that the gas flow therethrough produces an upward thrust urging the inner tube against said structure.

13. The structure defined by claim 12 wherein the total cross-sectional area of said ports is less than the cross-sectional area of the second passage.

14. A fuse assembly for cutouts comprising a pair of tubes arranged one within the other and at least the inner of which is formed of gas evolving material, upper and lower contact members engageable with the terminal members of the cutout, and means for securing each of said tubes to the upper contact member in spaced apart relationship in order to hold said tubes concentrically one within the other so that a gas discharge passage is formed therebetween, the inner of said tubes having a plurality of ports through the wall thereof at points intermediate the ends of said tube for transmitting gas evolved upon arc development within said inner tube to said passage, said ports being inclined downwardly from the interior to the exterior of the inner tube so that the gas flow therethrough produces an upward thrust urging the inner tube against said upper contact member.

15. A fuse assembly for cutouts, comprising a pair of tubes arranged one within the other and at least the inner of which is formed of gas evolving material, and upper and lower contact members engageable with the terminal members of the cutout and each secured to the outer tube, the upper contact member being provided with longitudinally spaced bores of different diameters for respectively receiving the upper end of the inner and outer tubes to hold said tubes concentrically one within the other so that a gas discharge passage is formed therebetween, said upper contact member being provided with a first internal shoulder extending between the longitudinally spaced bores of said upper contact member for abutting the upper end of said outer tube and a second internal shoulder in abutting relationship with the upper end of the inner tube, the inner of said tubes having a plurality of ports through the wall thereof at points intermediate the ends of said tubes for transmitting gas evolved upon arc development with said inner tube to said passage, said ports being inclined downwardly from the interior to the exterior of said inner tube so that gas flowing therethrough produces an upward thrust directing said inner tube against said second shoulder.

16. The structure defined by claim 15 wherein the total cross-sectional area of said ports is less than the cross-sectional area of said passage.

17. The fuse assembly of claim 1 wherein said structure includes at least three concentric tubes of gas evolving material defining concentrically arranged gas discharge passages.

18. The fuse assembly of claim 17 wherein said three concentrically arranged fuse tubes are secured to said contact members in spaced apart relationship, and wherein, each of said discharge passages are individually and directly vented to atmosphere.

19. The fuse assembly of claim 18 wherein one end of each of said fuse tubes is fixedly secured to and in engagement with one of said contact members to close one end of each of said gas discharge passages and the evolved gas is vented to the atmosphere at the other end of each of said gas discharge passages.

20. The fuse assembly of claim 18 wherein said fuse tubes are so dimensioned that each of the gas discharge passages has a progressively increasing cross-sectional area toward its vented end for facilitating expulsion of evolved gases within said fuse assembly.

21. The fuse assembly of claim 18 wherein said interconnecting ports are inclined downwardly from the interior to the exterior of the tube in which they are formed.

22. The fuse assembly of claim 21 wherein the interconnecting ports in each tube are inclined at approximately 45° and are disposed in longitudinal rows, the ports in one tube being staggered with respect to the ports in an adjacent tube.

23. In a fuse assembly for cutouts of the type including spaced contact members engageable with the terminal members of said cutout, an outer dielectric member fixedly interconnected between said spaced contact members, at least one inner dielectric member disposed within and concentrically of said outer member to define therebetween a gas discharge passage; means for securing both said inner and outer members to one of said contact members in spaced apart relationship so that an inner member is freely suspended and has a free end spaced from said outer dielectric member in order to vent said gas discharge passage and permit escape of gas evolved within said fuse assembly.

24. A fuse assembly for cutouts, comprising a pair of spaced contact members engageable with the terminal members of the cutout, and a structure of dielectric material including inner and outer fuse tubes at least the inner of which is formed of gas evolving material, the outer tube being engageable with both of said spaced contact members and the inner tube being attached to only one of said contact members and being freely suspended with its free end spaced from said outer tube, means for maintaining said tubes in concentric spaced relationship, said inner and outer tubes defining therebetween a gas discharging passage vented to the atmosphere at the end thereof adjacent to the free end of said inner tube, said inner tube having defined therein at least one interconnecting port for transmitting gas evolved upon arc development in said fuse assembly to said gas discharging passage.

25. The fuse assembly of claim 24 wherein said port is inclined toward the vented end of said passage from the interior to the exterior of the inner tube.

26. The fuse assembly of claim 24 wherein said dielectric members are so dimensioned that said gas passage has a greater cross-sectional area at its vented end.

27. A fuse assembly for cutouts, comprising a plurality of tubes telescopically arranged and at least the inner of which is formed of gas evolving material, an upper contact member provided with longitudinal bores of different diameters for receiving the upper ends of said tubes, a lower contact member having a bore for receiving therein the lower end of the outermost of said tubes, means for fixedly securing said tubes to said upper contact member in spaced apart concentric relationship such that gas discharging passages are defined by said tubes each having one end directly vented to the atmosphere at a point adjacent said lower contact, each tube with the exception of the outermost tube having defined therein ports for interconnecting said passages to permit flow of evolved gas, each tube except the outermost tube being freely suspended from said upper contact member and having free ends spaced apart to directly vent each of said passages to the atmosphere.

28. The fuse assembly of claim 27 wherein said ports are inclined toward the vented end of said passage from the interior to the exterior of the inner tube.

29. The fuse assembly of claim 4 wherein the outer of said tubes is supported from both of said contact members and an inner tube is suspended from only one of said contact members and is spaced from the other of said contact members.

30. The fuse assembly of claim 4 wherein said structure includes an outer and an inner tube which cooperate to define outer and inner gas discharge passages, said ports being defined in said inner tube only and the total cross sectional area of said ports being less than the cross sectional area of said outer gas discharge passage.

31. The fuse assembly of claim 29 wherein said tubes define outer and inner gas discharge passages which are individually and directly vented to the atmosphere adjacent said other contact member.

32. The fuse assembly of claim 31 wherein said tubes are so dimensioned that each of said gas discharge passages has a progressively increasing cross sectional area toward its vented end for facilitating expulsion of evolved gases.

33. The fuse assembly of claim 30 wherein said ports are inclined toward the vented end of said outer passage from the interior to the exterior of the inner tube.

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