US008711538B2

(12) **United States Patent**
Woodworth et al.

(10) **Patent No.: US 8,711,538 B2**

(45) **Date of Patent: Apr. 29, 2014**

(54) **EXTERNALLY GAPPED LINE ARRESTER**

(76) Inventors: **Jonathan Jay Woodworth**, Olean, NY (US); **Deborah Lynn Limburg**, Olean, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 357 days.

(21) Appl. No.: **13/253,362**

(22) Filed: **Oct. 5, 2011**

(65) **Prior Publication Data**

US 2012/0087055 A1 Apr. 12, 2012

Related U.S. Application Data

(60) Provisional application No. 61/390,218, filed on Oct. 6, 2010.

(51) **Int. Cl.**
H01C 7/12 (2006.01)
H01T 1/14 (2006.01)

(52) **U.S. Cl.**
USPC **361/127**; 361/125; 361/10; 361/11

(58) **Field of Classification Search**
USPC 361/127, 125, 10, 11
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,017,539 A * 1/1962 Robinson 361/125
3,474,995 A * 10/1969 Amidon et al. 248/218.4
5,172,297 A * 12/1992 Imakoma et al. 361/126
5,237,482 A * 8/1993 Osterhout et al. 361/117
5,400,207 A * 3/1995 Krause 361/117
5,426,555 A * 6/1995 Lundquist 361/117
2011/0216463 A1* 9/2011 Kester et al. 361/118

OTHER PUBLICATIONS

Woodworth, J., Arrester Disconnector, ArresterFacts 005, May 4, 2008, ArresterWorks, USA.
Woodworth, J., What is a Transmission Line Arrester, ArresterFacts 017, Mar. 6, 2009, ArresterWorks, USA.

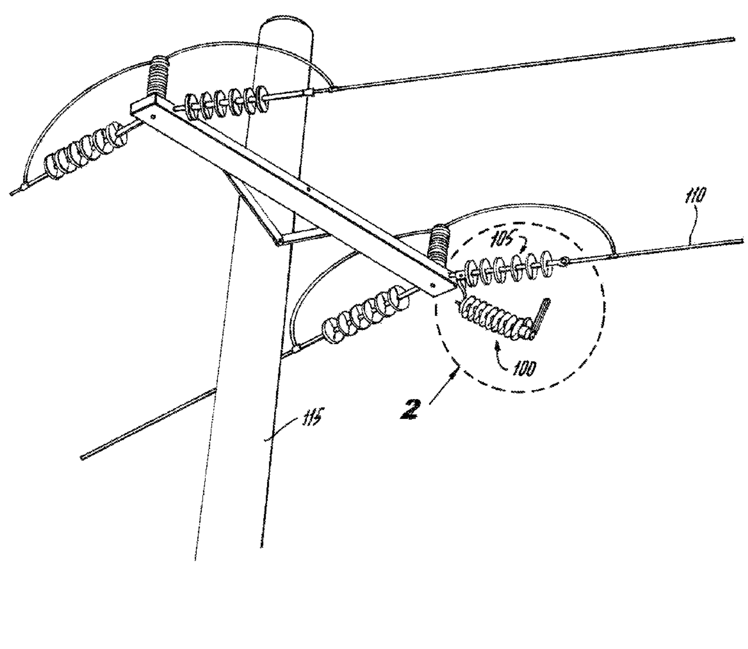
* cited by examiner

Primary Examiner — Rexford Barnie
Assistant Examiner — Zeev V Kitov
(74) *Attorney, Agent, or Firm* — Law Offices of Michael L. Wise, LLC

(57) **ABSTRACT**

An arrester for preventing an insulator supporting a power line from experiencing an electrical flashover comprises an electrode, a varistor, and a separating device. The electrode is spaced apart from the power line or a conductor that is electrically tied to the power line so as to define an external gap therebetween. The separating device, in turn, comprises two portions operative to separate from one another when the varistor experiences an electrical condition sufficient to cause the varistor to fail. The electrode, the external gap, the separating device, and the varistor are arranged in electrical series with one another and in electrical parallel with the insulator.

19 Claims, 4 Drawing Sheets



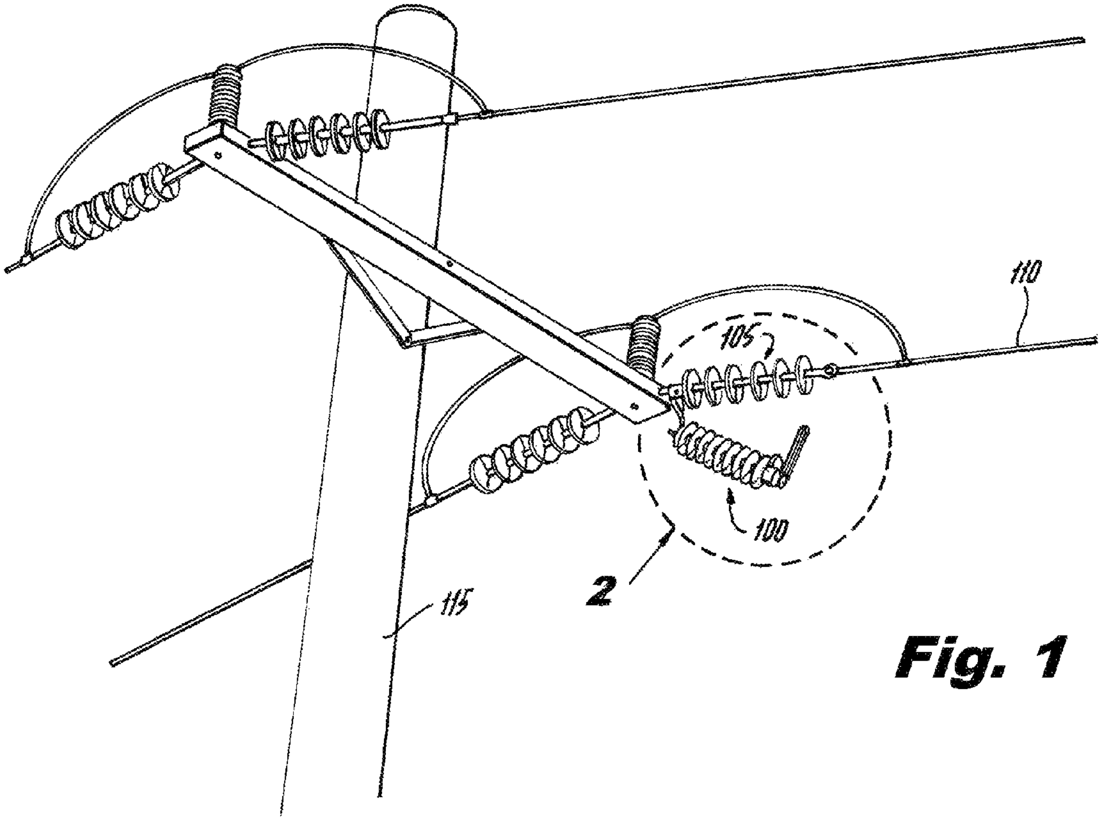

110
105
100
2
115

Fig. 1

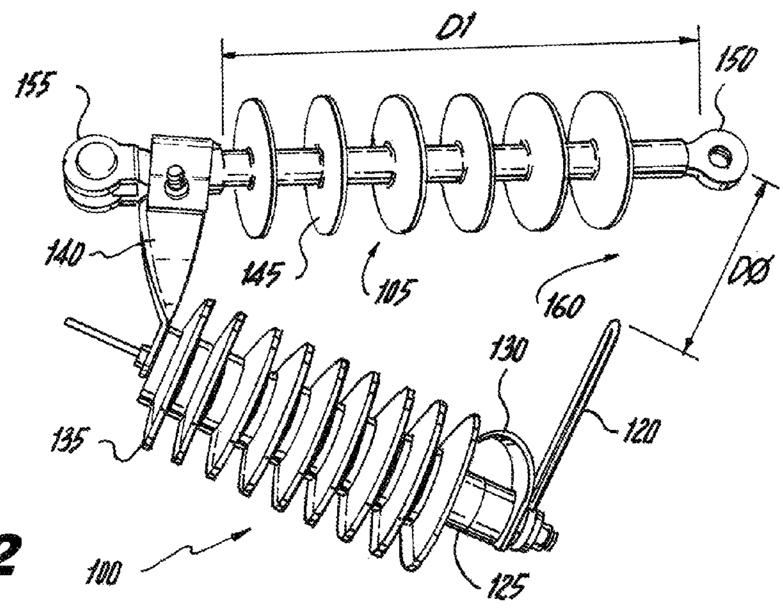

D1
155
150
140
145
105
160
DØ
130
135
120
100
125

Fig. 2

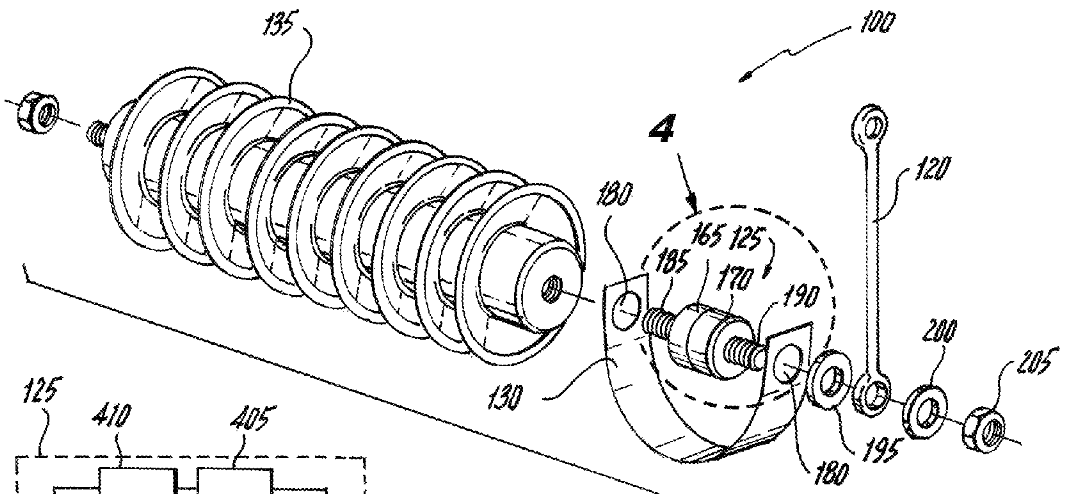


Fig. 3

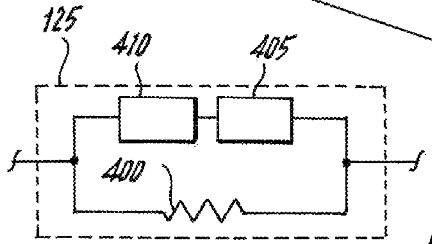


Fig. 4

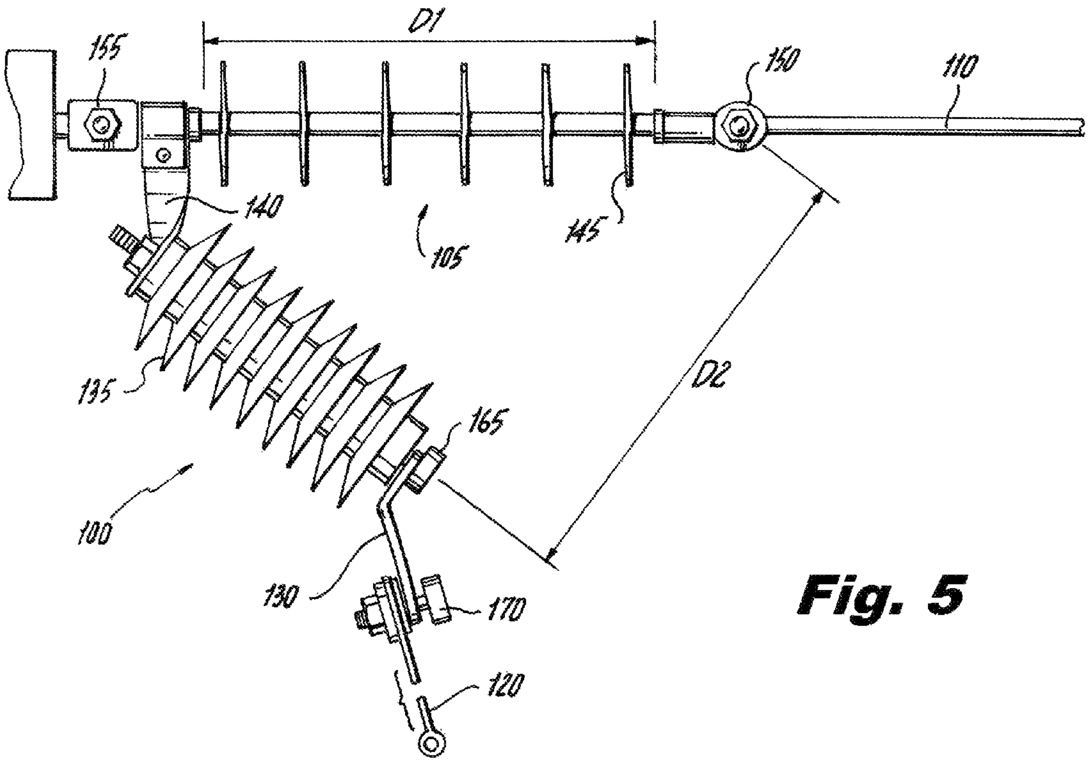


Fig. 5

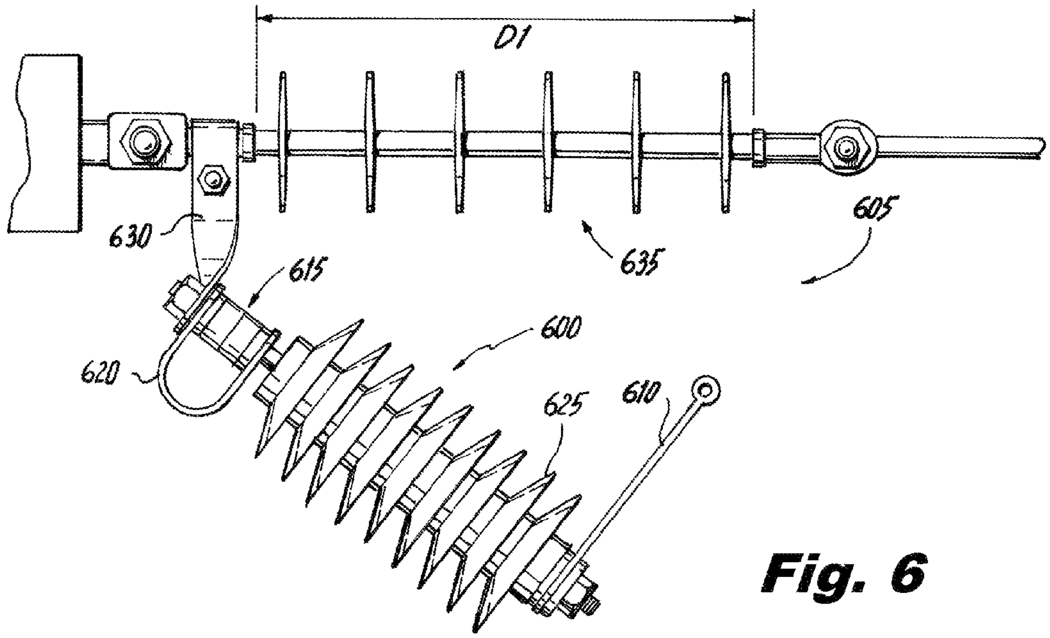

D1
630
615
620
600
625
610
635
605

Fig. 6

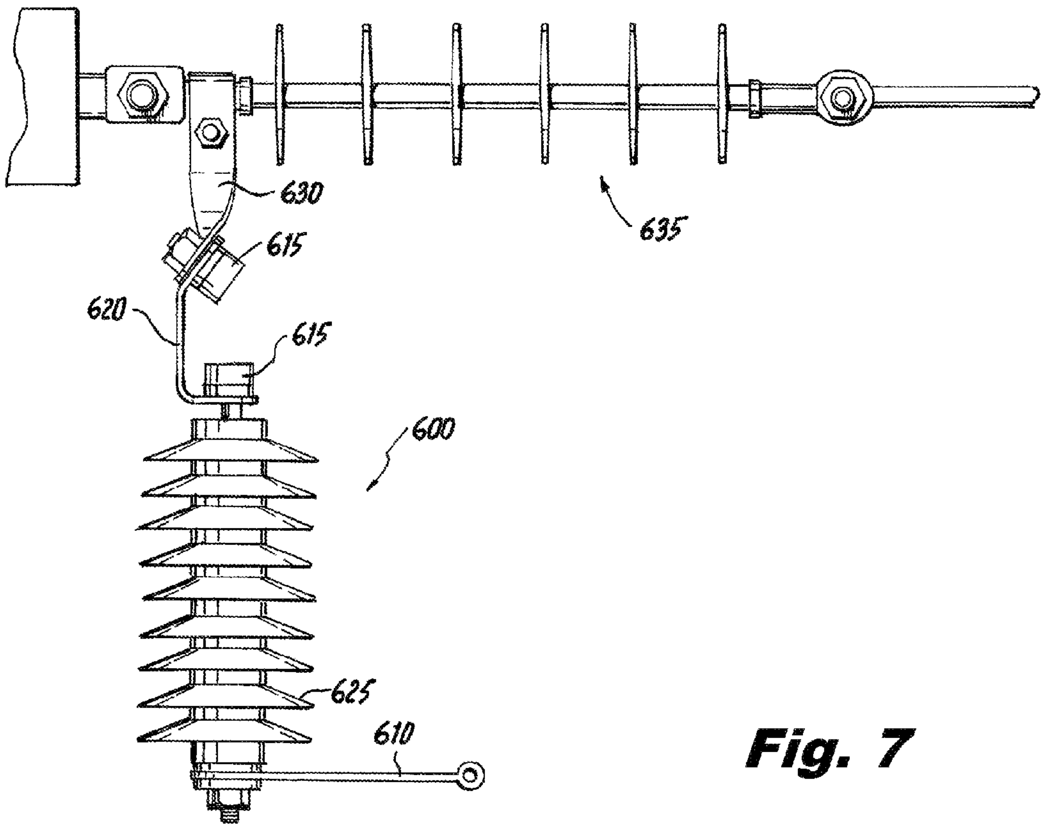

630
615
620
615
600
625
610
635

Fig. 7

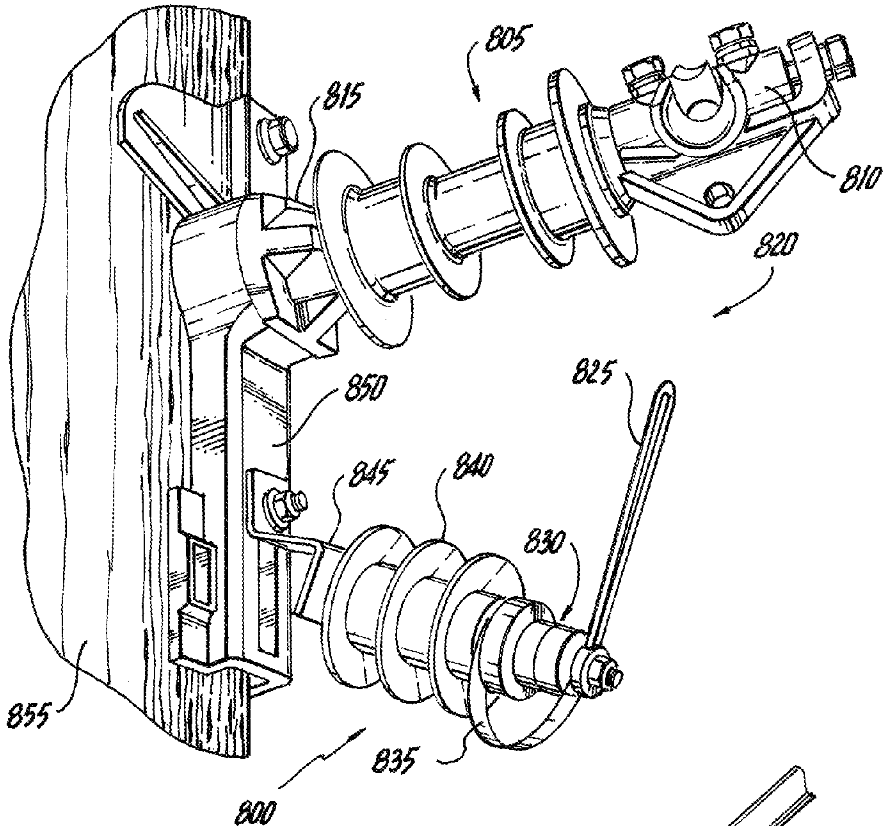

805
815
810
820
825
850
845
840
830
855
835
800

Fig. 8

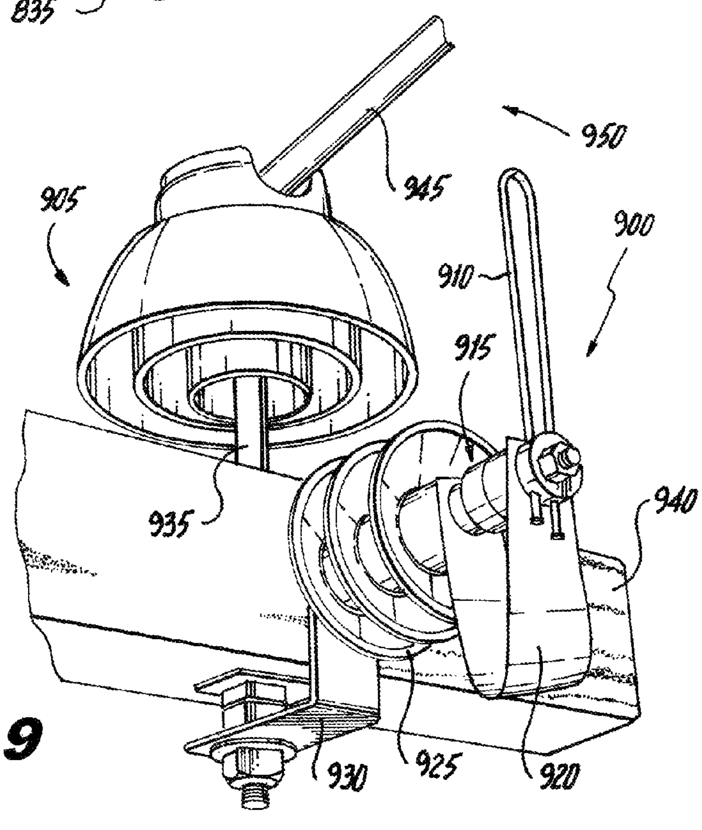

950
945
905
900
910
915
935
940
930
925
920

Fig. 9

EXTERNALLY GAPPED LINE ARRESTER

FIELD OF THE INVENTION

The present invention relates generally to high voltage electrical power station, transmission, and distribution systems, and, more particularly, to line arresters for use in protecting such systems.

BACKGROUND OF THE INVENTION

Externally Gapped Line Arresters (EGLAs) are a type of line arrester used to mitigate the effects of lightning strikes and electrical surges on electrical power line equipment. An EGLA is typically installed in electrical parallel with an insulator that acts to support a power line. With such an EGLA in place, lightning strikes or other types of voltage surges that might cause the insulator to experience flashover are instead diverted to the ground. Damaged equipment and service interruptions are thereby avoided.

While not utilized extensively in the United States, EGLAs have been in production and use in Japan and other foreign countries for several years. A typical EGLA comprises an external gap in series with a series varistor unit (SVU). The SVU, in turn, comprises non-linear metal oxide resistors (MORs) encapsulated in a polymer housing. Because of the non-linear behavior of MORs, the SVU exhibits high resistance at normal operating voltages, but rapidly becomes a low resistance pathway at higher applied voltages such as those produced by lightning strikes. The external gap, because it is arranged in series with the SVU, must spark over before the SVU can begin to conduct electricity.

Unfortunately, it is possible for an SVU in a conventional EGLA to experience a voltage condition during a lightning strike or other surge event sufficient to cause that SVU to fail and not revert back to its original high resistance state when the strike or surge is over. With such a failed SVU, system basic impulse level (BIL) is compromised and the EGLA no longer provides optimal protection for the equipment that it is intended to protect. Nevertheless, because SVUs are normally constructed with polymer housings for purposes of strength and explosion control, there is frequently no obvious outer indication that an SVU has failed. This makes the tracking down and repair of failed EGLAs particularly difficult for the utilities charged with maintaining that equipment.

SUMMARY OF THE INVENTION

Embodiments of the present invention provide EGLA designs that may be used to prevent insulators on utility poles from experiencing flashover as a result of lightning strikes or other electrical surge events.

In accordance with aspects of the invention, an arrester for preventing an insulator supporting a power line from experiencing an electrical flashover comprises an electrode, a varistor, and a separating device. The electrode is spaced apart from the power line or a conductor that is electrically tied to the power line so as to define an external gap therebetween. The separating device, in turn, comprises two portions operative to separate from one another when the varistor experiences an electrical condition sufficient to cause the varistor to fail. The electrode, the external gap, the separating device, and the varistor are arranged in electrical series with one another and in electrical parallel with the insulator.

Advantageously, the above-described embodiments provide several benefits over conventional EGLAs. Embodiments of the invention, for example: 1) provide a visual indication after an SVU failure; 2) allow the BIL of the insulator to be restored after an SVU failure to a value that it would have without a line arrester rather than being diminished; 3) do not allow parts to fall to the ground when an SVU failure occurs; and 4) may be configured for use with many different types of insulators.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will become better understood with regard to the following description, appended claims, and accompanying drawings where:

FIG. **1** shows a perspective view of a line arrester according to a first illustrative embodiment of the invention in association with an insulator on a utility pole;

FIG. **2** shows an enlarged perspective view of the FIG. **1** line arrester and insulator;

FIG. **3** shows an exploded perspective view of the FIG. **1** line arrester;

FIG. **4** shows a simplified schematic diagram of at least some of the elements within a separating device in the FIG. **1** line arrester;

FIG. **5** shows a perspective view of the FIG. **1** line arrester after an SVU failure;

FIG. **6** shows a perspective view of a line arrester according to a second illustrative embodiment of the invention in association with an insulator;

FIG. **7** shows a perspective view of the FIG. **6** line arrester after an SVU failure;

FIG. **8** shows a perspective view of a line arrester according to a third illustrative embodiment of the invention in association with an insulator on a utility pole; and

FIG. **9** shows a perspective view of a line arrester according to a fourth illustrative embodiment of the invention in association with an insulator on a utility pole.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will be described with reference to illustrative embodiments. For this reason, numerous modifications can be made to these embodiments and the results will still come within the scope of the invention. No limitations with respect to the specific embodiments described herein are intended or should be inferred.

FIGS. **1-3** show several views of a line arrester **100** in accordance with an illustrative embodiment of the invention. For purposes of illustration, the line arrester **100** is presented in association with an insulator **105** tasked with supporting a power line **110** on a utility pole **115**. FIG. **1** shows a perspective view of the line arrester **100** and the insulator **105** as they might be configured when installed on the utility pole **115**. FIG. **2** shows an enlarged perspective view of the line arrester **100** and the insulator **105**. Lastly, FIG. **3** shows an exploded perspective view of at least some of the elements of the line arrester **100** itself.

The illustrative line arrester **100** comprises an electrode **120**, a separating device **125**, a strap **130**, an SVU **135**, and a bracket **140**. In the present embodiment, the insulator **105** is what is commonly called a "dead end insulator," although this choice for the type of insulator is largely arbitrary. The insulator **105** comprises an insulator body **145** terminated at both ends by a respective conductive end fitting. As displayed in FIGS. **1** and **2**, the rightmost end fitting forms a line terminal **150**, while the leftmost end fitting forms an earth terminal **155**. When in use, the line terminal **150** is preferably attached to and electrically tied to the power line **110**. The earth terminal **155**, in contrast, is preferably tied to an earth (ground) potential.

Again referring to FIGS. **1-3**, one end of the electrode **120** is coupled to the separating device **125**, while the opposite end terminates in the air. The air-terminated end of the electrode **120** is precisely spaced apart from the line terminal **150**, defining an external gap **160** therebetween. The external gap **160** is characterized by a distance D**0**. Opposite the electrode **120**, the separating device **125** is coupled to the SVU **135**. The SVU **135**, in turn, is coupled to the bracket **140**, which, in this particular embodiment, ties that end of the line arrester **100** to the earth terminal **155** on the insulator **105**. The external gap **160**, the electrode **120**, the separating device **125**, the SVU **135**, and the bracket **140** are thereby arranged in electrical series with each other and in electrical parallel with the insulator **105**. Finally, the strap **130** spans between two ends of the separating device **125**.

The SVU **135** preferably comprises one or more non-linear resistors (i.e., varistors) that exhibit high resistances at normal applied voltages and much lower resistances at higher applied voltages such as those produced by lightning strikes. The non-linear resistors of the SVU **135**, may, for example, comprise one or more metal oxide elements such as, but not limited to, disks formed at least in part by zinc oxide. Commercial sources of suitable SVUs may include, for example, Hubbell Power Systems (Centralia, Mo., USA), ABB (Norwalk, Conn., USA), Siemens AG (Erlangen, Germany), and Cooper Power Systems (Dublin, Ireland). As described earlier, although generally robust, such SVUs may fail (i.e., enter a state wherein they are permanently in a lower resistance state) when exposed to extreme electrical conditions. Accordingly, the SVU **135** is preferably housed in a polymer housing to provide both weatherproofing and strength against electrically-induced explosions.

For electrical continuity between the electrode **120** and the SVU **135**, the separating device **125** preferably provides a low resistance pathway for electrical current until it is exposed to a voltage and associated current flow sufficient to cause the SVU **135** to fail. The separating device **125** may, for example, take the form of a conventional ground lead disconnector (also sometimes called an “isolator”). Such ground lead disconnectors are commercially available from, as just two examples, DHGate.com (Beijing, China) and Zhejiang Smico Electric Power Equipment Co., Ltd. (Zhejiang, China). FIG. **4** shows a simplified schematic diagram of at least some of the elements within the separating device **125**. The separating device **125** comprises a bypass element **400**, a heating element **405**, and a separation element **410**. During normal, steady state operations, electrical current is conducted primarily through the bypass element **400** and the heating element **405** is only nominally heated. When, in contrast, a lightning strike or other power surge occurs that is sufficient to cause the SVU **135** to fail, excessive fault current causes the heating element **405** to heat to a point where it activates the separation element **410**. The separation element **410** is preferably a small explosive device which is heat activated. The exploding separation device **410** acts to split the separating device **125** into two portions. In the present case, a first portion **165** remains attached to the SVU **135**, while a second portion **170** remains attached to the electrode **120**.

As will be further described below, the strap **130** is operative to span between the two portions **165**, **170** of the separating device **125** after the separating device **125** is activated. Accordingly, the strap **130** preferably comprises a flexible material of sufficient strength to support the weight of at least the second portion **170** and the electrode **120**. The strap **130** will also preferably be of a high enough electrical resistance to not act as a significant current pathway in electrical parallel with the separating device **125**, while also being sufficiently heat resistant to withstand any heat generated by the separating device **125** and any localized electrical arcing. Suitable materials for the strap **130** may include, as just two examples, Nomex® or Kevlar®, both available from DuPont (Wilmington, Del., USA).

FIG. **3** shows one manner in which the strap **130** can be secured to the separating device **125**, although this particular configuration is merely illustrative and ultimately any suitable means of attachment would still fall within the scope of the invention. In this non-limiting embodiment, the strap **130** comprises two holes **180** positioned proximate to the strap’s respective ends. A first threaded pin **185** emanating from the first portion **165** of the separating device **125** passes through one of these holes **180** and is screwed into the SVU **135**. A second threaded pin **190** emanating from the second portion **170** of the separating device **125** is passed through the other hole **180** in the strap **130** and, after passing through a first washer **195**, a hole in the electrode **120**, and a second washer **200**, is ultimately secured by a nut **205**. The second threaded pin **190** and associated securing hardware **195**, **200**, **205** thereby act to capture both the strap **130** and the electrode **120**.

Finally, the electrode **120** and the bracket **140** preferably comprise a conductive material such as brass, iron, aluminum, stainless steel, or the like.

Once so configured, the line arrester **100** may act to protect the insulator **105** from flashover between the line terminal **150** and the earth terminal **155**. If a voltage surge is of sufficient amplitude to spark over the insulator **105** across strike distance D**0**, the surge is instead diverted across external gap **160** into the SVU **135**, which almost instantly becomes a low resistance pathway. In this manner, the surge is directed into the bracket **140** and ultimately to the earth terminal **155** (i.e., ground potential), thereby bypassing the insulator **105** altogether. Assuming that the SVU **135** does not fail, the SVU **135** again returns to its high resistance state and cuts off the current flow after the surge charge has been reduced in amplitude, effectively ending the diversion event. The line arrester **100** remains intact and ready to divert additional surges as necessary.

If, instead, the electrical surge is sufficient to fail the SVU **135**, a very different sequence of events occurs. In response to the overloading of the SVU **135**, the separating device **125** preferably activates and separates into the first portion **165** and the second portion **170**, as detailed above. The first portion **165** of the separating device **125** remains coupled to the SVU **135**, while the second portion **170** remains coupled to the electrode **120**. Gravity or, alternatively, a non-conductive spring built into the separating device **125**, then causes the second portion **170** and the electrode **120** to fall away from the remainder of the line arrester **100** until their fall is arrested by the strap **130**. At the end of this sequence of events, the second portion **170** of the separating device **125** and the electrode **120** end up suspended from the first portion **165** of the separating device **125** by the strap **130**. Such a “failed” condition is shown in the perspective view in FIG. **5**.

Notably, the illustrative line arrester **100** provides several advantages when compared to a conventional EGLA. With the electrode **120** suspended below the remainder of the line arrester **100** after failure of the SVU **135**, as shown in FIG. **5**, the distance between the first portion **165** of the separating device **125** and the line terminal **150** becomes D**2**. Advantageously, if the distance D**2** is similar to or greater than the distance D1, as is preferable, the strike distance of the insulator **105** is again D1. In other words, the capacity of the insulator **105** to experience flashover is reset to the capacity of the insulator **105** to experience flashover without the line arrester **100**. Accordingly, the BIL of the system is reestablished to about what it would be without the line arrester **100**. In contrast, a conventional EGLA, arranged in a manner similar to the line arrester **100**, but without a separating device like the separating device **125**, would exhibit very different electrical characteristics. More particularly, despite an SVU failure, the electrode of the conventional EGLA would remain configured as it had been before the failure occurred. The external gap of the conventional EGLA would thereby be maintained even though the SVU had been overloaded and was in a permanent low resistance state. The external gap distance D0 of the conventional EGLA would then be the critical strike distance that governs the insulator **105**. As a result, in contrast to the line arrester **100**, system BIL with a conventional but failed EGLA would be substantially diminished because D0 is shorter than D1.

What is more, the illustrative line arrester **100** is also advantageous because the portions of the line arrester **100** suspended by the strap **130** after a failure, namely, the second portion **170** of the separating device **125** and the electrode **120**, provide an excellent visual indicator that the line arrester **100** has been overloaded, which is not present in conventional EGLAs. Such a visual indicator, which may be seen at substantial distances, makes the discovery and repair of failed line arresters such as the line arrester **100** substantially easier. At the same time, the strap **130** assures that no parts are allowed to depart the line arrester **100** and fall from the utility pole **115** when a failure occurs. Thus, people and property underneath the utility pole **115** are protected from falling objects.

FIG. **6** goes on to show a perspective view of a slightly modified version of the line arrester **100**, namely, a line arrester **600** in accordance with a second illustrative embodiment of the invention. In a manner similar to the line arrester **100**, the line arrester **600** comprises an external gap **605**, an electrode **610**, a separating device **615**, a strap **620**, a series varistor unit (SVU) **625**, and a bracket **630**. Here too, the external gap **605**, the electrode **610**, the separating device **615**, the SVU **625**, and the bracket **630** are arranged in electrical series with each other while being in electrical parallel with an insulator **635** that they act to protect.

Nevertheless, in the line arrester **600**, the separating device **615** and the strap **620** are coupled between the SVU **625** and the bracket **630** rather than being coupled between the SVU **625** and the electrode **610** in the manner of the line arrester **100**. Accordingly, upon failure of the SVU **625** and the activation of the separating device **615**, the SVU **625** and the electrode **610** end up suspended below the remainder of the line arrester **600**, as shown in the perspective view in FIG. **7**. For this reason, the strap **620** may need to be somewhat stronger than the strap **130**. That said, with the SVU **625** and the electrode **610** suspended in this manner, the critical strike distance for the insulator **635** again reverts to about D1, the value it would have been if the line arrester **600** had never been installed. At the same time, the suspended SVU **625** and the suspended electrode **610** act as excellent visual indicators of the failure, and, as before, no parts are allowed to drop from the utility pole **115** as a result of that failure.

While the previous two illustrative embodiments were described in terms of protecting a dead end type of insulator (i.e., insulators **105** and **635**), aspects of the invention may be utilized with a wide assortment of different types of insulators that are commonly mounted on utility poles. These include, but art not limited to post-type, suspension-type, pin-type, and crossarm-type insulators, and the like. Such insulators and other aspects of power transmission and distribution are described in, for example, A. R. Hileman, *Insulation Coordination for Power Systems*, Marcel Dekker, Inc., New York, 1999, which is hereby incorporated by reference herein.

FIG. **8**, for example, shows a perspective view of a line arrester **800** in accordance with a third illustrative embodiment of the invention. In this case, the line arrester **800** is configured to protect a horizontal post insulator **805** with a line terminal **810** and an earth terminal **815**. In a manner again similar to the line arrester **100**, the line arrester **800** comprises an external gap **820**, an electrode **825**, a separating device **830**, a strap **835**, an SVU **840**, and a first bracket **845**. The first bracket **845** is in electrical communication with the earth terminal **810** of the horizontal post insulator **805** through a second bracket **850**, which is directly attached to a utility pole **855** and is preferably tied to earth potential. Configured in this manner, the line arrester **800** functions in substantially the same manner as the line arrester **100** described in detail above.

As even another example, FIG. **9** shows a perspective view of a line arrester **900** in accordance with a fourth illustrative embodiment of the invention configured to protect a pin insulator **905**. Here, the illustrative line arrester **900** comprises an electrode **910**, a separating device **915**, a strap **920**, an SVU **925**, and a bracket **930**. The bracket **930**, in turn, is coupled to a pin **935** that passes through a crossbeam of a utility pole **940** and acts to form an earth terminal for the pin insulator **905**. A power line **945** is supported by the pin insulator **905** and combines with the electrode **910** to define an external gap **950**. Again, in such a configuration, the line arrester **900** functions in substantially the same manner as the line arrester **100**.

In closing, it should again be emphasized that the above-described embodiments of the invention are intended to be illustrative only. Other embodiments can use different types and arrangements of elements for implementing the described functionality, and these numerous alternative embodiments within the scope of the appended claims will be apparent to one skilled in the art. In addition, it is reiterated that all the features disclosed herein may be replaced by alternative features serving the same, equivalent, or similar purposes, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

Moreover, any element in a claim that does not explicitly state "means for" performing a specified function or "step for" performing a specified function is not to be interpreted as a "means for" or "step for" clause as specified in 35 U.S.C. §112, Paragraph 6. In particular, the use of "step of" in the claims herein is not intended to invoke the provisions of 35 U.S.C. §112, Paragraph 6.

What is claimed is:

1. An arrester for preventing an insulator supporting a power line from experiencing an electrical flashover, the arrester comprising:

an electrode, the electrode spaced apart from: (a) the power line, or (b) a conductor that is distinct from the power line, so as to define an external gap therebetween;

a varistor;

a separating device, the separating device comprising two portions operative to separate from one another when the varistor experiences an electrical condition sufficient to cause the varistor to fail; and

- a strap, the strap being continuous and defining two ends, each of the two ends coupled to a respective one of the two portions of the separating device;
- wherein the electrode, the external gap, the separating device, and the varistor are arranged in electrical series with one another and in electrical parallel with the insulator;
- wherein the strap is operative to span between the two portions of the separating device after the separating device separates into the two portions.

2. The arrester of claim **1**, wherein the strap is substantially flexible.

3. The arrester of claim **1**, wherein the strap is operative to allow one of the two portions of the separating device to be suspended from the other after the separating device separates into the two portions.

4. The arrester of claim **1**, wherein the strap is operative to allow at least the electrode to be suspended from one of the two portions of the separating device after the separating device separates into the two portions.

5. The arrester of claim **1**, wherein the strap is operative to allow at least the varistor to be suspended from one of the two portions of the separating device after the separating device separates into the two portions.

6. The arrester of claim **1**, wherein the arrester is arranged such that the electrode is coupled to the separating device, and the separating device is coupled to the varistor.

7. The arrester of claim **1**, wherein the arrester is arranged such that the electrode is coupled to the varistor, and the varistor is coupled to the separating device.

8. The arrester of claim **1**, wherein the insulator comprises a terminal that is tied to an earth potential.

9. The arrester of claim **1**, wherein the arrester is adapted for use on a utility pole.

10. The arrester of claim **1**, wherein the separating device comprises an explosive device.

11. The arrester of claim **9**, wherein the explosive device is heat activated.

12. The arrester of claim **1**, wherein the varistor comprises a series varistor unit.

13. The arrester of claim **1**, wherein the varistor is characterized by a higher resistance at a lower applied voltage, and a lower resistance at a higher applied voltage.

14. The arrester of claim **1**, wherein a capacity of the insulator to experience an electrical flashover after the separating device separates into the two portions is substantially equal to a capacity of the insulator to experience an electrical flashover without the arrester.

15. The arrester of claim **1**, wherein the varistor comprises one or more non-linear metal oxide resistors.

16. The arrester of claim **1**, wherein the insulator comprises at least one of a suspension-type, a post-type, a pin-type, and a crossarm-type insulator.

17. A method for preventing an insulator supporting a power line from experiencing an electrical flashover, the method comprising the steps of:

- positioning an electrode apart from: (a) the power line, or (b) a conductor that is distinct from the power line, so as to define an external gap therebetween;
- receiving a varistor;
- receiving a separating device, the separating device comprising two portions operative to separate from one another when the varistor experiences an electrical condition sufficient to cause the varistor to fail;
- receiving a strap, the strap being continuous and defining two ends;
- arranging the strap such that each of the two ends is coupled to a respective one of the two portions of the separating device; and
- arranging the electrode, the external gap, the separating device, and the varistor in electrical series with one another and in electrical parallel with the insulator;
- wherein the strap is operative to span between the two portions of the separating device after the separating device separates into the two portions.

18. An apparatus comprising:

- an insulator, the insulator supporting a power line;
- an electrode, the electrode spaced apart from: (a) the power line, or (b) a conductor that is distinct from the power line, so as to define an external gap therebetween;
- a varistor;
- a separating device, the separating device comprising two portions operative to separate from one another when the varistor experiences an electrical condition sufficient to cause the varistor to fail; and
- a strap, the strap being continuous and defining two ends, each of the two ends coupled to a respective one of the two portions of the separating device;
- wherein the electrode, the external gap, the separating device, and the varistor are arranged in electrical series with one another and in electrical parallel with the insulator;
- wherein the strap is operative to span between the two portions of the separating device after the separating device separates into the two portions.

19. The line arrester of claim **1**, wherein the conductor is electrically tied to the power line.

* * * * *