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(54) **AIR INSULATED ISOLATION GAP COMPRESSIBLE DIAPHRAGM**

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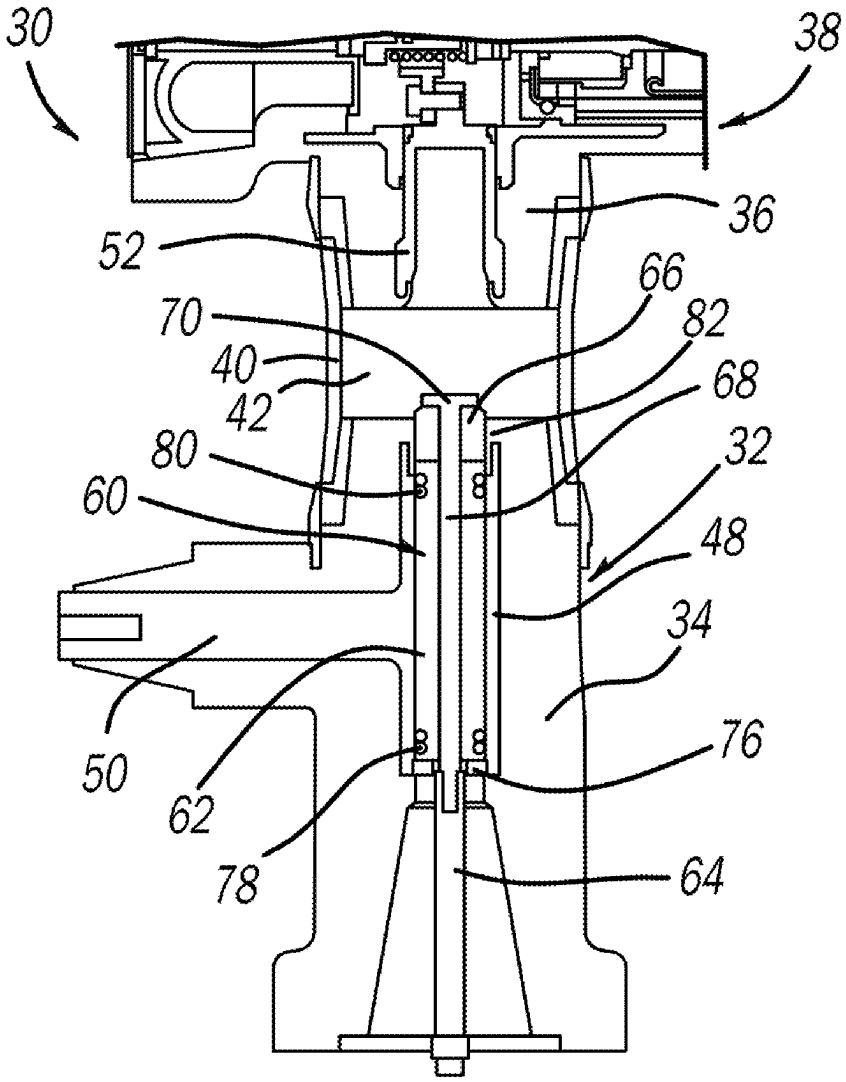
(57) **ABSTRACT**

A switch including an upper housing, a lower housing, a contact pin slidable between and within the upper and lower housings, an open chamber between the upper and lower housings and a viewing window surrounding the chamber. The contact pin is positioned in the chamber and is visible through the window when the switch is in the closed position and is positioned within the lower housing and not visible through the window when the switch is in the open position. The switch further includes an insulative plug coupled to the contact pin and being configured to provide electrical isolation between the contact pin and an upper contact when the switch is in the open position.



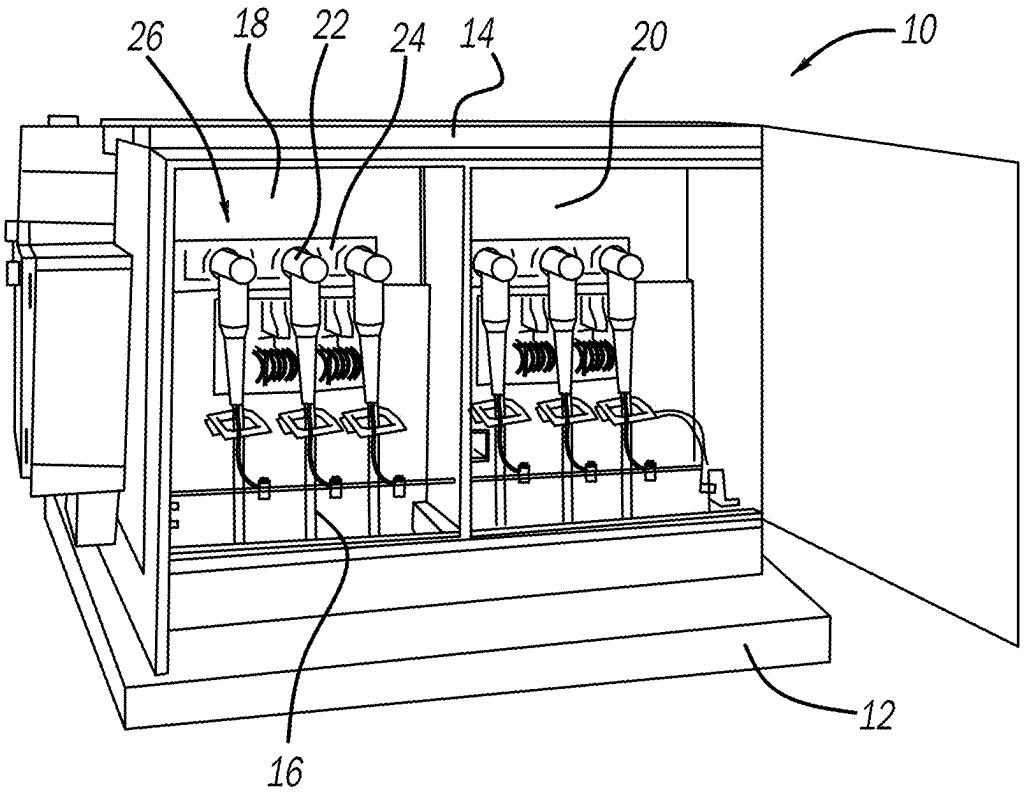


FIG. 1

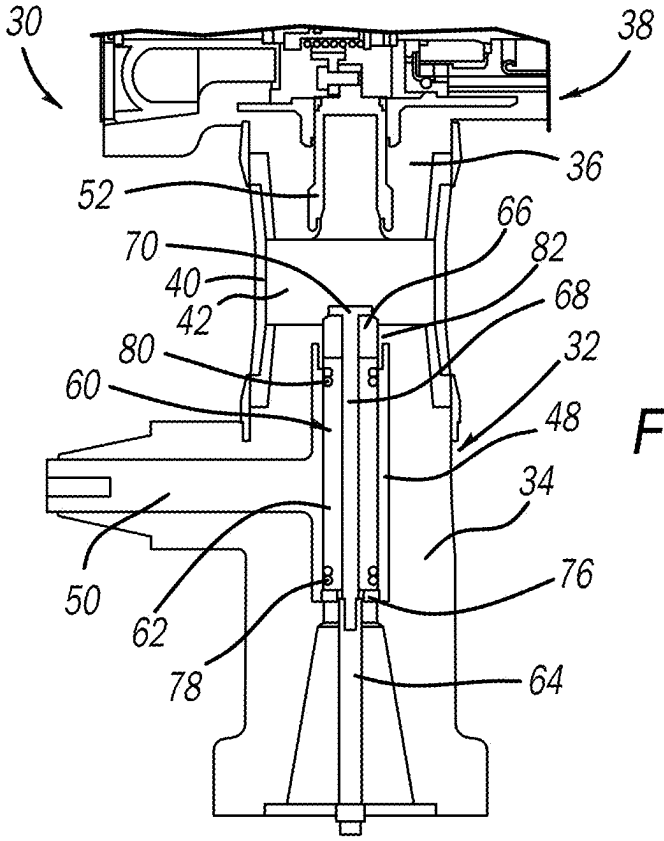

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FIG. 2

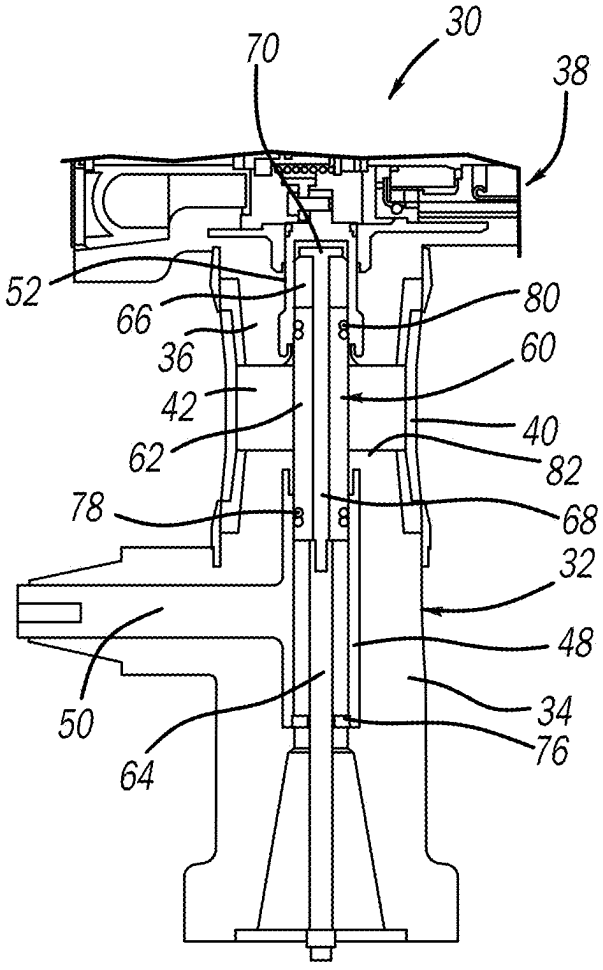
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FIG. 3

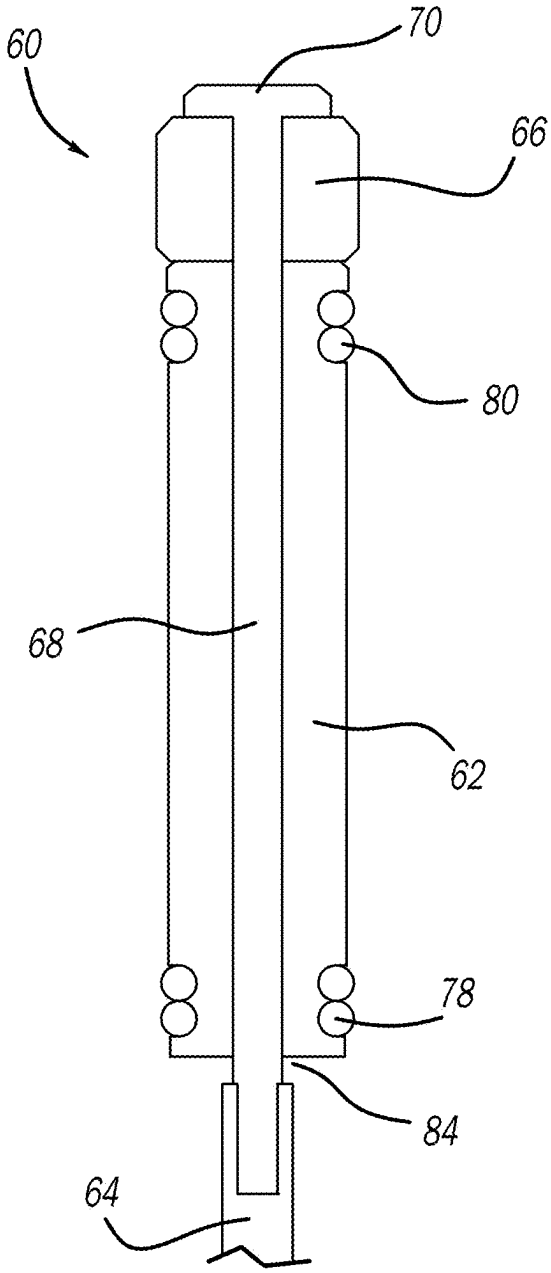

FIG. 4

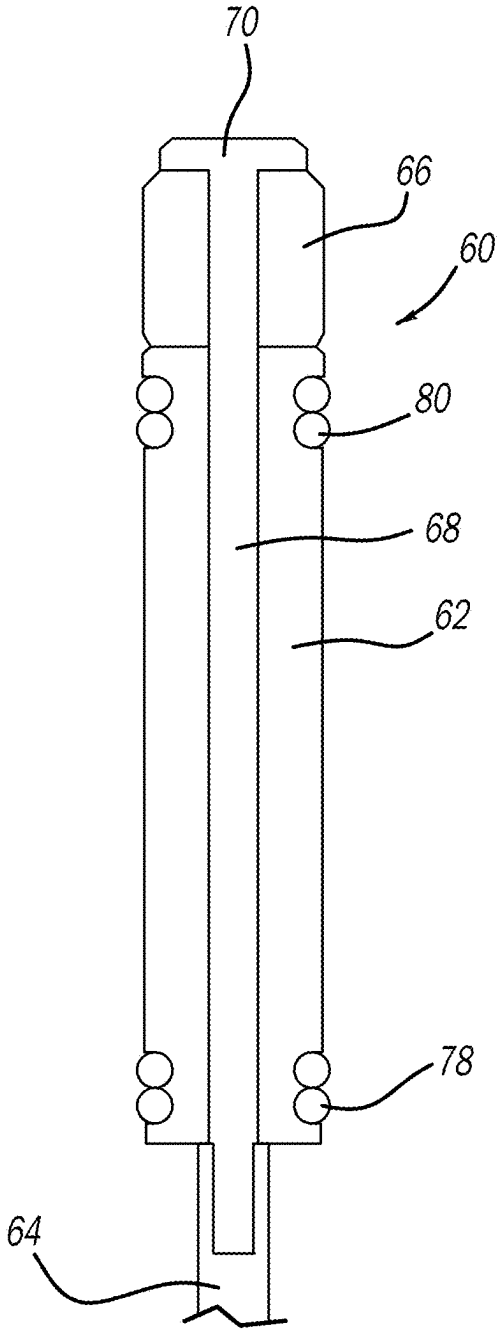

FIG. 5

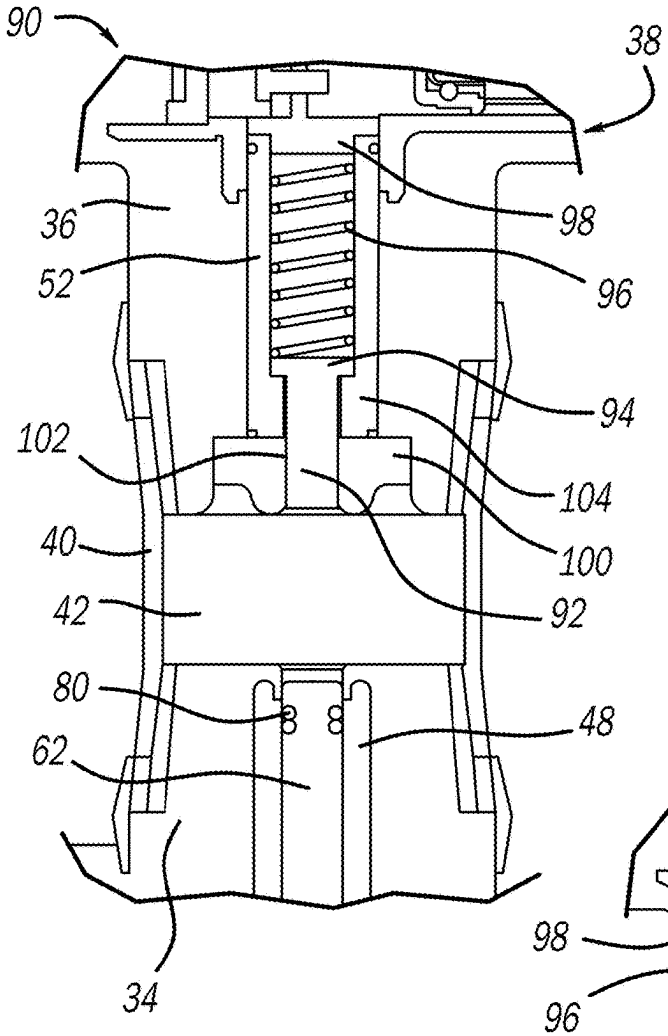
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FIG. 6

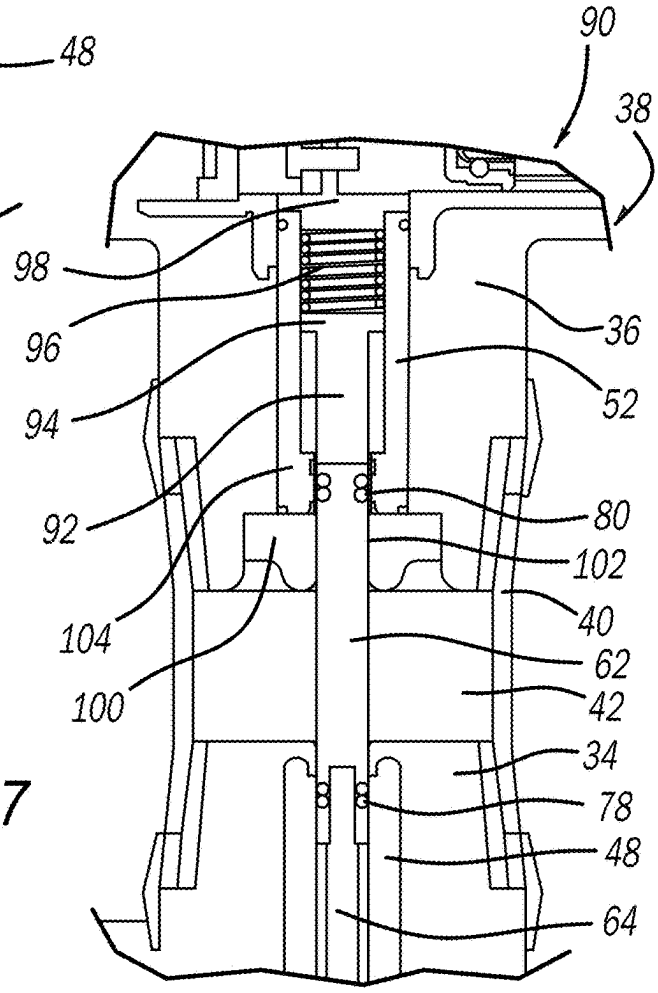
90
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FIG. 7

AIR INSULATED ISOLATION GAP COMPRESSIBLE DIAPHRAGM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of priority from the U.S. Provisional Application No. 63/552,706, filed on Feb. 13, 2024, the disclosure of which is hereby expressly incorporated herein by reference for all purposes.

BACKGROUND

Field

[0002] This disclosure relates generally to a switch including a dielectric plug providing increased dielectric strength between switch contacts when the switch is in an open position and, more particularly, to a switch including a compressible dielectric plug.

Discussion of the Related Art

[0003] An electrical power distribution network, often referred to as an electrical grid, typically includes power generation plants each having power generators, such as gas turbines, nuclear reactors, coal-fired generators, hydro-electric dams, etc. The power plants provide power at a variety of medium voltages that are then stepped up by transformers to a high voltage AC signal to be connected to high voltage transmission lines that deliver electrical power to substations typically located within a community, where the voltage is stepped down to a medium voltage for distribution. The substations provide the medium voltage power to three-phase feeders including three single-phase feeder lines that carry the same current but are 120° apart in phase. Three-phase and/or single phase lateral lines are tapped off of the feeder that provide the medium voltage to various distribution transformers, where the voltage is stepped down to a low voltage and is provided to loads, such as homes, businesses, etc.

[0004] Power distribution networks of the type referred to above include switching devices, breakers, reclosers, interrupters, etc. that control the flow of power throughout the network. Some of these components are enclosed in external housings that are mounted on, for example, a concrete pad, or mounted underground, and are generally referred to herein as switchgear. Switchgear typically operate at medium voltage power and include switches to which cables are connected to route power in the power distribution network from, for example, certain power sources to certain loads. The number and type of switchgear are application specific to the particular power network.

[0005] Various switchgear designs allow the switches therein to be remotely controlled and/or allow a lineman to manually change the state of the switches. Sometimes these switches include a visible isolation gap that allows the lineman to visually determine whether the switch is open or closed as a safety feature. When the switch is open, a suitable insulating dielectric needs to be maintained between the switch contacts to prevent arcing therebetween. Air and other gases can operate as such a dielectric, but they have a limited dielectric strength. It is generally desirable to reduce the size of the switch, which often requires the use of specialized dielectric materials, such as a silicon fluid, having a greater dielectric strength than air or other gases. However, it is also desirable to reduce the complexity of the switch, which reduces the desire to use such specialized dielectric materials.

SUMMARY

[0006] The following discussion discloses and describes a switch including a dielectric plug providing increased dielectric strength between switch contacts when the switch is in the open position. The switch includes an upper housing including an upper female contact, a lower housing including a lower female contact, and a cylindrical contact pin including an upper end and a lower end, where the contact pin is slidable between and within the upper and lower housings, and makes electrical contact with the upper and lower contacts when the switch is in a closed position and disengages the upper contact when the switch is in an open position. The switch also includes an open chamber between the upper and lower housings and a viewing window surrounding the chamber and being coupled to the upper and lower housings, where the contact pin is positioned in the chamber and is visible through the window when the switch is in the closed positioned and is positioned within the lower housing and not visible through the window when the switch is in the open position.

[0007] In one embodiment, the switch also includes an insulative rod extending through the insulative plug and the contact pin and protrudes from both of the upper and lower ends of the contact pin, where the insulative rod includes a plate coupled to an end of the insulative rod extending from the upper end of the contact pin, and where the plug is a compressible plug and is positioned between the upper end of the contact pin and the plate and the upper housing includes an interface. The switch also includes a stop ring positioned within the lower housing, where the drive rod extending through the stop ring. The drive rod is actuated to pull the insulative rod through the stop ring so that the contact pin disengages the upper contact and the contact pin is pulled into the lower housing and the lower end of the contact pin engages the stop ring which causes the insulative plug to axially compress between the plate and the first end of the contact pin and radially expand into the interface.

[0008] In another embodiment, the insulative plug is a rigid plug and includes a top plate and is in contact with the upper end of the contact pin when the switch is in the closed position, the upper housing includes a housing stop member, the upper contact includes a contact stop member and the drive rod is rigidly secured to the lower end of the contact pin. The switch further includes a return spring positioned between the housing stop member and the top plate of the plug, and a flexible diaphragm positioned within the upper housing and including a central bore, where the return spring is under compression and the contact pin extends through the central bore when the switch is in the closed position. The drive rod is actuated to pull the drive rod so that the contact pin disengages the upper contact and the contact pin is pulled into the lower housing, which causes the return spring to drive the insulative plug into the bore in the diaphragm and causes the top plate to contact the contact stop member.

[0009] Additional features of the disclosure will become apparent from the following description and appended claims, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is an isometric view of a pad mounted switchgear;

[0011] FIG. **2** is a cut-away, cross-sectional type view of a switch that can be used in the switchgear shown in FIG. **1** including a compressible insulative plug, where the switch is shown in the open position;

[0012] FIG. **3** is a cut-away, cross-sectional type view of the switch shown in FIG. **2** in the closed position;

[0013] FIG. **4** is a side view of a slidable switch assembly separated from the switch shown in FIG. **2** including a male contact pin and the compressible insulative plug shown in the open position;

[0014] FIG. **5** is a side view of the slidable switch assembly shown in FIG. **4** in the closed position;

[0015] FIG. **6** is a cut-away, cross-sectional type view of a switch that can be used in the switchgear shown in FIG. **1** including a compressible insulative diaphragm and a rigid insulative plug, where the switch is shown in the open position; and

[0016] FIG. **7** is a cut-away, cross-sectional type view of the switch shown in FIG. **6** in the closed position.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0017] The following discussion of the embodiments of the disclosure directed to a switch including a compressible dielectric plug providing increased dielectric strength between switch contacts when the switch is in the open position is merely exemplary in nature, and is in no way intended to limit the invention or its applications or uses. For example, the switch described herein has particular application for use in switchgear. However, as will be appreciated by those skilled in the art, the switch will have other applications.

[0018] FIG. **1** is an isometric view of a known air-insulated elbow mounted switchgear **10** positioned on a concrete pad **12**. For purposes of the discussion herein, the switchgear **10** is intended to represent any switchgear, pad mounted or otherwise, that includes any suitable configuration of components and devices configured in an outer housing **14** that provide switching and disconnecting of and between one or more electrical cables **16** coupled thereto that are part of an electrical distribution network. In this specific non-limiting example, six of the cables **16** are coupled to a front part of the switchgear **10** and six more of the cables (not shown) are coupled to a back part of the switchgear **10**, where three of the cables **16** at the front and the back part are provided on one side **18** of the switchgear **10** and three of the cables **16** at the front and back part are provided on another side **20** of the switchgear **10**. Each of the cables **16** is coupled to a T-body connector **22** that is electrically coupled to switches in the switchgear **10** at cable attachment points **24** at an upper location **26** on the switchgear **10**. It is noted that the T-body connector **22**, typically used for a 600 amp connector, is shown by way of a non-limiting example in that any suitable cable connector can be used, such as a 200 amp elbow connector.

[0019] FIGS. **2** and **3** are cut-away, cross-sectional type views of an isolating pole unit or switch **30** that can be used in the switchgear **10**, where the switch **30** is shown in an open position in FIG. **2** and in a closed position in FIG. **3**. The switch **30** includes a body **32** having a lower housing **34**, an upper housing **36** secured to switch elements **38**, and a viewing window **40** open to a chamber **42** positioned between the lower housing **34** and the upper housing **36**. A lower female contact **48** is positioned in the lower housing **34** and is electrically coupled to a connector **50** and an upper female contact **52** is positioned in the upper housing **36**. A slidable switch assembly **60** is slidably positioned within the body **32** and includes a cylindrical male conductive contact pin **62**, an insulating drive rod **64** coupled to a bottom end of the pin **62**, a cylindrical compressible insulative plug **66** coupled to a top end of the pin **62** and an insulating compression rod **68** having a top plate **70** extending through the plug **66** and the pin **62** and into the rod **64**, where the rod **68** is rigidly coupled to the rod **64**. The plug **66** can be made of any insulative and compressible material, such as rubber, suitable for the purposes discussed herein. The bottom end of the contact pin **62** engages a stop ring **76** and the rod **68** extends through the ring **76** when the switch **30** is in the open position. Slidable contacts **78** are provided around the bottom end of the pin **62** and make contact with the lower female contact **48** and slidable contacts **80** are provided around the top end of the pin **62** and make contact with the upper female contact **50** when the switch **30** is in the closed position.

[0020] An interference fit is provided between an inner diameter of the insulative plug **66** and an outer diameter of the compression rod **68** to create a solid dielectric joint therebetween. A clearance fit is provided between the contact pin **62** and the compression rod **68** to allow for independent movement of the rod **68** within the pin **62** during the switch closing and opening operations. As will be discussed in further detail below, when the switch **30** opens, the insulative plug **66** is compressed between the top plate **70** and the top end of the pin **62** in an axially direction so that it expands in a radially direction and compresses against an interface **82** in the lower housing **34** to provide additional dielectric strength. This allows the chamber **42** to be filled with a suitable gas, such as air, and still provide enough dielectric integrity to prevent arcing between the contact pin **62** and the upper female contact **52** over a minimal gap therebetween.

[0021] FIGS. **4** and **5** are side views of the slidable assembly **60** separated from the switch **30**, where the assembly **60** is in the open position in FIG. **4** and is in the closed position in FIG. **5**. The insulative plug **66** is shown compressed in FIG. **4** illustrating that the pin **62** and the rod **68** separate and a compression gap **84** is created between the bottom of the pin **62** and the top of the rod **68**. The insulative plug **66** is not compressed in FIG. **5**.

[0022] When the switch **30** is in the closed position, the male contact pin **62** contacts the upper and lower female contacts **52** and **48** and the uncompressed insulative plug **66** is resting between the top plate **70** of the insulated compression rod **68** and the male contact pin **62**. The contact pin **62** is visible in the window **40** indicating that the switch **30** is closed. When the switch **30** is opened, an actuator (not shown) pulls the rod **64** downward and thus the rod **68** downward through the lower female contact **48** so that the contact pin **62** disengages the upper female contact **52**. The contact pin **62** stops its downward movement when it contacts the stop ring **76** in the lower section of the lower female contact **48**. The pin **62** is no longer visible in the window **40** thus indicating that the switch **30** is in the open position. When the contact pin **62** stops moving, the insu-

lating compression rod **68** continues to move downward, compressing the insulative plug **66** in the axial direction between the plate **70** and the pin **62** and causing it to expand radially. The compressible insulative plug **66** continues to expand in the radial direction until it is compressed against the interface **82** in the lower housing **34** thereby creating electrical isolation between the male contact pin **62** and the upper female contact **52**. This also allows the chamber **42** to be filled with a suitable gas, such as air, and still provide enough dielectric integrity to prevent arcing between the contact pin **62** and the upper female contact **52** over a minimal gap therebetween. A compliance mechanism (not shown) is located between the insulating rod **64** and the actuator and ensures that the plug **66** is compressed with a pre-determined constant force.

[0023] When the switch **30** is in the open position the male contact pin **62** is resting on the stop ring **76**, the insulative plug **66** is compressed between the plate **70** and the pin **62**, and the contact pin **62** is not visible in the window **40**. When the switch **30** is closed, the insulating compression rod **64** translates up independently of the pin **62** for the length of the compression gap **84**. This decompresses the plug **66** and allows it to return to its uncompressed state. The upper face of the insulating drive rod **64** engages the bottom of the male contact pin **62** causing it to move up. The assembly **60** continues to move upward until the male contact pin **62** and upper female contact **52** are electrically connected. The pin **62** is now visible in the window **40** indicating that the switch **30** is in the closed position.

[0024] FIGS. **6** and **7** are cut-away, cross-sectional type views of a switch **90** that can be used in the switchgear **10**, where the switch **90** is shown in the open position in FIG. **6** and in the closed position in FIG. **7**, and where like elements to the switch **30** are identified by the same reference number. In this embodiment, the compressible insulative plug **66**, the insulating compression rod **68** and the stop ring **76** are removed. Alternately, a cylindrical rigid insulative plug **92** having a top plate **94** and a slightly larger diameter than the pin **62** is positioned on top of and engages the contact pin **62**, a return spring **96** is positioned between the top plate **94** of the plug **92** and a stop member **98** and an annular compressible insulative diaphragm **100** is provided on top of the chamber **42**, where the pin **62** extends through a central bore **102** in the diaphragm **100**. When the switch **90** is moved from the closed position to the open position, the drive rod **64** is pulled downward to translate the pin **62** downward so that the pin **62** disengages the upper female contact **52** and is pulled into the lower housing **34**. The spring **96** pushes the plug **92** into the diaphragm **100** until the top plate **94** engages a flange **104** in the upper female contact **52**. The rod **64** continues to pull the pin **62** downward so that is disengages from the plug **92** and is no longer visible in the window **40** indicating that the switch **90** is open.

[0025] When the switch **90** is in the closed position the male contact pin **62** contacts the upper and lower female contacts **52** and **48**, and the rigid insulative plug **92** is pressed inside the upper female contact **52** by the male contact pin **62**. When the switch **90** is opened, the insulating drive rod **64** and the male contact pin **62** translate downward allowing the plug **92** to slide inside the diaphragm **100** under the force of the return spring. The plug **92** reaches its final position when the top plate **94** contacts the flange **104** on the inside of the upper female contact **52**. The return spring preload applied to the plug **92** ensures that it will remain in that position. The outside diameter of the plug **92** is larger than the diameter of the bore **102**, which creates an interference fit thereby creating electrical isolation between the male contact pin **62** and the upper female contact **52**. After the plug **92** reaches its final position, the male contact pin **62** continues its downward translation until it is completely positioned within the lower housing **34**.

[0026] When the switch **90** is in the open position, the rigid insulative plug **92** is inserted inside the compressible insulative diaphragm **100**. When the switch **90** is closed, the male contact pin **62** translates up contacting the bottom end of the plug **92**. The male contact pin **62** continues to translate up while pushing the plug **92** out of the diaphragm **100** and into the upper female contact **52** against the bias of the spring **96**. The upward motion of the male contact pin **62** and the plug **92** stops at a predetermined position where the male contact pin **62** and the upper and lower contacts **52** and **48** are connected electrically. It is important to note that the section of the male contact pin **62** that contacts the diaphragm **100** in the closed position has a reduced diameter to prevent the diaphragm **100** from stretching.

[0027] The foregoing discussion discloses and describes merely exemplary embodiments of the present disclosure. One skilled in the art will readily recognize from such discussion and from the accompanying drawings and claims that various changes, modifications and variations can be made therein without departing from the spirit and scope of the disclosure as defined in the following claims.

What is claimed is:

1. A switch comprising:

a first housing including a first contact;

a second housing including a second contact and an interface;

a contact pin including a first end and a second end, the contact pin being slidable between and within the first and second housings, and making electrical contact with the first and second contacts when the switch is in a closed position and disengaging the first contact when the switch is in an open position;

an insulative rod extending through the contact pin and protruding from both of the first and second ends of the contact pin, the insulative rod including a plate coupled to an end of the insulative rod extending from the first end of the contact pin;

a drive rod rigidly secured to an end of the insulative rod extending from the second end of the contact pin; and

an insulative plug positioned between the first end of the contact pin and the plate, the insulative rod extending through the plug, wherein the drive rod is actuated to pull the insulative rod so that the contact pin disengages the first contact and the contact pin is pulled into the second housing which causes the insulative plug to axially compress between the plate and the first end of the contact pin and radially expand into the interface.

2. The switch according to claim **1** further comprising an open chamber between the first and second housings and a viewing window surrounding the chamber and being coupled to the first and second housings, the contact pin being positioned in the chamber and being visible through the window when the switch is in the closed positioned and being positioned within the second housing and not visible through the window when the switch is in the open position.

3. The switch according to claim 2 wherein the chamber is filled with an insulative gas.

4. The switch according to claim 3 wherein the gas is air.

5. The switch according to claim 1 further comprising a stop ring positioned within the second housing, the drive rod extending through the stop ring, wherein the compression rod is pulled through the stop ring and the second end of the contact pin engages the stop ring when the switch is put in the open position which causes the drive rod to separate from the second end of the contact pin and the insulative plug to axially compress between the plate and the first end of the contact pin.

6. The switch according to claim 1 wherein the contact pin is a cylindrical pin, the insulative plug is a cylindrical plug and the first and second contacts are female contacts.

7. The switch according to claim 6 wherein an interference fit is provided between an inner diameter of the insulative plug and an outer diameter of the compression rod to create a solid dielectric joint therebetween.

8. The switch according to claim 1 wherein the switch is an isolating pole unit employed in switchgear.

9. A switch comprising:

a first housing including a housing stop member and a first contact having a contact stop member;

a second housing including a second contact;

a contact pin including a first end and a second end, the contact pin being slidable between and within the first and second housings, and making electrical contact with the first and second contacts when the switch is in a closed position and disengaging the first contact when the switch is in an open position;

a rigid insulative plug including a top plate and being in contact with the first end of the contact pin when the switch is in the closed position;

a return spring positioned between the housing stop member and the top plate of the plug, the return spring being under compression when the switch is in the closed position;

a flexible diaphragm positioned within the first housing and including a central bore, the contact pin extending through the central bore when the switch is in the closed position; and

a drive rod rigidly secured to the second end of the contact pin, wherein the drive rod is actuated to pull the drive rod so that the contact pin disengages the first contact and the contact pin is pulled into the second housing which causes the return spring to drive the insulative plug into the bore in the diaphragm and causes the top plate to contact the contact stop member.

10. The switch according to claim 9 further comprising an open chamber between the first and second housings and a viewing window surrounding the chamber and being coupled to the first and second housings, the contact pin being positioned in the chamber and being visible through the window when the switch is in the closed positioned and being positioned within the second housing and not visible through the window when the switch is in the open position.

11. The switch according to claim 10 wherein the chamber is filled with an insulative gas.

12. The switch according to claim 11 wherein the gas is air.

13. The switch according to claim 9 wherein the contact pin is a cylindrical pin, the diaphragm is an annular diaphragm, the insulative plug is a cylindrical plug and the first and second contacts are female contacts.

14. The switch according to claim 13 wherein an outer diameter of the plug is larger than a diameter of the bore so as to create an interference fit therebetween and creating electrical isolation between the contact pin and the first female upper contact.

15. The switch according to claim 9 wherein the switch is an isolating pole unit employed in switchgear.

16. A switch comprising:

a first housing including a first female contact;

a second housing including a second female contact;

a cylindrical contact pin including a first end and a second end, the contact pin being slidable between and within the first and second housings, and making electrical contact with the first and second contacts when the switch is in a closed position and disengaging the first contact when the switch is in an open position;

an open chamber between the first and second housings and a viewing window surrounding the chamber and being coupled to the first and second housings, the contact pin being positioned in the chamber and being visible through the window when the switch is in the closed positioned and being positioned within the second housing and not visible through the window when the switch is in the open position;

an insulative plug coupled to the first end of the contact pin and being configured to provide electrical isolation between the contact pin and the first female contact when the switch is in the open position; and

a drive rod coupled to the contact pin and being actuated to open and close the switch

17. The switch according to claim 16 further comprising an insulative rod extending through the insulative plug and the contact pin and protruding from both of the first and second ends of the contact pin, the insulative rod including a plate coupled to an end of the insulative rod extending from the first end of the contact pin, wherein the plug is a compressible plug and is positioned between the first end of the contact pin and the plate and the first housing includes an interface, and wherein the drive rod is actuated to pull the insulative rod so that the contact pin disengages the first contact and the contact pin is pulled into the second housing which causes the insulative plug to axially compress between the plate and the first end of the contact pin and radially expand into the interface.

18. The switch according to claim 17 further comprising a stop ring positioned within the second housing, the drive rod extending through the stop ring, wherein the compression rod is pulled through the stop ring and the second end of the contact pin engages the stop ring when the switch is put in the open position which causes the drive rod to separate from the second end of the contact pin and the insulative plug to axially compress between the plate and the first end of the contact pin.

19. The switch according to claim 16 wherein the insulative plug is a rigid plug and includes a top plate and is in contact with the first end of the contact pin when the switch is in the closed position, the first housing includes a housing stop member, the first contact includes a contact stop member and the drive rod is rigidly secured to the second end of the contact pin, the switch further comprising a return spring positioned between the housing stop member and the top plate of the plug, and a flexible diaphragm positioned within

the first housing and including a central bore, the return spring being under compression and the contact pin extending through the central bore when the switch is in the closed position, wherein the drive rod is actuated to pull the drive rod so that the contact pin disengages the first contact and the contact pin is pulled into the second housing which causes the return spring to drive the insulative plug into the bore in the diaphragm and causes the top plate to contact the contact stop member.

20. The switch according to claim **16** wherein the chamber is filled with an insulative gas.

* * * * *